DIPLOMARBEIT

Proportionssysteme:
Vernakuläre versus Prestige-Architektur

Proportional systems:
vernacular versus prestige architecture

ausgeführt zum Zwecke der Erlangung des akademischen Grades eines Diplom-Ingenieurs / Diplom-Ingenieurin unter der Leitung

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KURZFASSUNG

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Vernakuläre und Prestigearchitektur unterscheiden sich in vielen qualitativen Aspekten: Gestaltung, Entwurfsverfahren, Baumaterialien usw. Die Frage, ob das Thema der Proportion hier Gegenpole verkörpert, war das Leitmotiv dieser Arbeit. Der derzeitige Mangel an Studien, die sich mit der Proportion in der vernakulären Architektur und dem anschließenden Vergleich mit der Prestigearchitektur befassen, ist der Anlass für diese Arbeit.

Die Hauptziele der Arbeit waren: Identifizierung eines proportionalen Ansatzes in der vernakulären und der Prestigearchitektur und, falls vorhanden, die Ermittlung von Gegensätzen zwischen ihnen; Untersuchung der Praxis einer „Formwiederholung" als angenommene Eigenschaft eines proportionalen Ansatzes; Hinterfragung der Dominanz prestigeträchtiger Verhältnisse (Goldener Schnitt, Silberner Schnitt, Ludolphsche Zahl) in der architektonischen Praxis. Die Struktur der Arbeit ist in zwei große Blöcke gegliedert, wobei der erste den theoretischen Hintergrund beleuchtet und der zweite die durchgeführten Analysen liefert. Stichproben der Studie wurden an Wohnhäusern des 19. Jahrhunderts in der alpinen und germanischen Region durchgeführt. Eine große Menge an Daten, aus den geometrischen Analysen der Gebäudeansichten gewonnen, wurde systematisch in eine *Microsoft Excel*-Tabelle extrahiert, aus der die Pivot-Tabellen und Diagramme abgeleitet wurden. Mit Hilfe von *Slicern* wurden die Daten je nach Bedarf weiter gefiltert. Diese Analysemethoden erwiesen sich als sehr effektiv und flexibel.

Die wichtigsten Ergebnisse sind in verschiedener Hinsicht überraschend. Trotz der aufgedeckten Gegensätze zwischen dem proportionalen Ansatz in der vernakulären und der Prestigearchitektur werden die ursprünglichen Erwartungen teilweise widerlegt. Die Dominanz prestigeträchtiger Verhältnisse bestätigt sich in keinem der beiden Fälle, und eine „Formwiederholung" ist selten. Stattdessen beweisen einfach zu konstruierenden Verhältnisse, wie das Quadrat (1:1) und das Doppelquadrat (1:2), ihre Bedeutung in der vernakulären wie auch in der Prestigearchitektur. Die Grundidee der Arbeit liegt in der Erkundung von Neuland sowie in der Aufdeckung von Diskrepanzen zwischen Architekturtheorie und -praxis. Einmal mehr zeigt sich hier die Bevorzugung der einfachsten Lösungen.

ABSTRACT

Keywords: vernacular architecture, prestige architecture, proportion, proportional systems, prestigious ratios, shape repetition, 19th-century, residential house

Vernacular and prestige architecture contrast in many qualitative aspects – architectural style, design process, building materials, etc. Whether or not the theme of proportion encompasses the contrasts between vernacular architecture and prestige architecture is the main focus of this thesis. The scarcity of studies touching on proportion in vernacular architecture, and the subsequent comparison with prestige architecture, accounts for the existence of this thesis.

The main aims of the thesis are: to attempt to identify a proportional approach in vernacular and prestige architecture and, if this is present, to determine contrasts between them; to explore the practice of "shape repetition" as an assumed quality of a proportional approach; to question the dominance of prestigious ratios (golden ratio, silver ratio, Ludolph's number) in architectural practice. The thesis is organized into two major blocks, the first exploring the theoretical background, and the second providing the performed analyses and a discussion thereof. The study sample consisted of residential houses of the 19th century in the Alpine and Germanic regions. A large amount of data obtained from the geometrical analyses of the building's elevations was systematically extracted into a *Microsoft Excel* table, from which the pivot tables and charts were derived. Using *slicers*, the data were further filtered, as needed. These analytical methods proved to be very effective and flexible.

Various aspect of the key findings are striking. For example, despite revealing contrasts between the proportional approach in vernacular architecture and that in prestige architecture, some of the expectations were disproved. The dominance of prestigious ratios was confirmed in neither case and "shape repetition" was found to be rare. Instead, the easy-to-construct ratios of the square 1:1, and the double square 1:2 declared their importance, in vernacular and prestige architecture, respectively. The importance of the thesis lies in the exploration of uncharted territory, as well as the exposure of discrepancies between architectural theory and praxis. Once again, architectural practice proved to favour the most straightforward solutions.

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INTRO DUCT ION

INTRODUCTION

"What is the rule that orders, that connects all things?"(Le Corbusier, 2004, p.26) – a question that occupied one of the most famous architects of the last century, Le Corbusier. The same question arises for me when I look at a beautiful building. There is *something* … *something* at first sight hidden, but intrinsic to its very essence. Could that *something* be proportion?

It was feeling that left even the great architectural historian James S. Ackerman speechless: "I really think there is something there [on the subject of proportion] although I do not know how to explain it"(qtd. in Cohen, 2014a, p.6).

The research I did for the paper *Substanziell dennoch latent* (Kaprinayova, 2020) that I wrote in 2020 only reinforced my interest in this regard. And although I had been fascinated by proportion for some time, the real trigger was an excursion to Milan in 2019, when I first visited *Casa della Memoria* designed by Baukuh. To meet the investor's strict demands for a low budget, there was no space for any extra ballast. Yet the building managed to evoke the feeling in me that *something* had been done just right. Again I asked myself – Is it the proportions?

This enchantment only grew when I began to see the interrelations between architecture and my beloved music through proportion. First came the rhythmical context, when I came across Peter Märkli's teachings about generating a unique scale of dimensions based on the divisions of the whole, since this principle is closely related to the elementary note lengths in music. "When we work at our office and somebody is new they first have to learn that you have to create eighths, sixteenths, thirty-twos, sixty-fourths… fundamentally values that are, you find out when you make small steps, only divided by even numbers"(qtd. in Schevers & Herrenberg, 2012, t.39:59). Second came the harmonic context, which is rooted in the creation of consonant intervals by dividing the strings in a prescribed ratio, as had already been discovered by Pythagoras in Ancient Greece. The more I dived deeper, the more bipolarities I found. And in the end, I had to admit that, despite the first apparent similarities, proportion in architecture and proportion in music are of different natures.

Nonetheless, my desire to uncover the hidden proportional structures of the buildings persisted, not only when I looked at prestige architecture, but even more so when I looked at vernacular architecture. I wondered whether some invisible (and unintentional) proportional laws could be at work here too?

All these ideas came together to produce this work. Based on the valuable inputs of my supervisor Ao.Univ.Prof. i. R. Dipl.-Ing. Dr.techn. Erich Lehner, I formulated the exact theme of my master thesis entitled *Proportional systems: vernacular versus prestige architecture*.

The idea to study the proportions of both vernacular and prestige architecture, and then to compare them, proved to be very productive, since the lack of studies in this direction is striking, especially with regard to vernacular architecture. (More on the current situation and the gap in the field of study is written in *State of the Art*.)

In order to make the research objectives achievable, a more specific target of interest had to be defined. Thus, the focus of the analyses is the residential vernacular and prestige architecture of the 19th century of the Alpine and the Germanic regions. These two regions have just enough similarities and dissimilarities to provide a fertile field for the intended task.

But what exactly is this thesis supposed to achieve? While on the one hand, the thesis aims at shedding more light on the historical background of proportion in architecture and other disciplines, the analyses themselves are intended to explore a proportional approach and related "shape repetition" (anticipated quality of the proportional approach by Scholfield) in both architecture types, as well as to question the prestigious ratios (golden ratio, silver ratio, Ludolph's number) in architectural practice much praised by scholars. In other words, whether or not the theme of proportion encompasses the contrasts between vernacular architecture and prestige architecture is the main focus of this thesis. The research questions connected to the analyses are further discussed in the chapter *Vernacular vs. Prestige Architecture: Introduction to Analyses/ Expectations*.

I expect to find great contrasts between both! (Primarily in the occurrence of prestigious ratios, which I expect to be decidedly greater in prestige architecture.) I also think, given the careful process of design in prestige architecture that "shape repetition" will be very widespread there, too. But let's come back to the hypothesis once the analyses are done…

To give more clarity for the reader, an outline of the thesis structure follows. The first part of the thesis is formed by the usual introduction chapters (*Abstract, Acknowledgements, Table of Contents, Introduction* and *State of the Art*), which present a general overview of the thesis.

The main part of the thesis, which is organized into two blocks, comes after – *Block A*, and *Block B*. *Block A* is an attempt to explore the theoretical and practical background of the proportional theme, while *Block B* displays the results of the analyses of proportion in vernacular architecture and prestige architecture.

Chapter 1 *Proportion: Historical Background* and chapter 2 *Proportion: Construction* are contained in *Block A*. As the name suggests, the historical background of proportion is the leading theme in Chapter 1, albeit from a transdisciplinary perspective (architecture, music, philosophy). Afterwards, a shift to a practical realm happens in Chapter 2, where proportional tools and construction techniques are at the foreground. In addition, we explore the issue of precision, looking at the discrepancies between intention and reality

in proportion.

Next, *Block B* consists of Chapter 3 *Vernacular vs. Prestige Architecture: Introduction to Analyses*; Chapter 4 *Vernacular Architecture: Analysis of Proportions*, Chapter 5 *Prestige Architecture: Analysis of Proportions*, and Chapter 6 *Vernacular vs. Prestige Architecture: Summary*. This block presents both a separate focus on proportions in vernacular and prestige architecture and a final comparison of the two. To be more specific, Chapter 3 lays out the flow of the analyses with a clear formulation of terminology, comparison of the idiosyncrasies of vernacular architecture and those of prestige architecture, the application of filters in the domain under study, and a further description of the methods used, expectations and valuable sources for the analyses. Chapter 4 provides the outcomes of the analysis of proportions in vernacular architecture only – focusing on the whole building and openings – with special attention paid to the prestigious and the (im)perfect square ratios. Chapter 5, on the other hand, is devoted solely to prestige architecture. Here, the same realities are observed, however, instead of the (im)perfect square, the double square ratio has its time in the spotlight. Finally, Chapter 6 gathers and binds the separate viewpoints of the previous analyses together, revisits the expectations, with new answers provided, and returns to Scholfield's ideas, which are further contemplated here.

Given the voluminous size of the performed geometrical analyses, the analyses themselves have been separated from their outcomes described in *Block B* and put in the *Appendix*. In addition, a *Bibliography* as well as a *List of Tables* and a *List of Figures* are included at the end of the thesis.

Lastly, a few words about the methodology of the study. The methodology used in *Block A* differs from the one used in *Block B*. While in *Block A*, theoretical background research prevails, the opposite is true in *Block B*, where individual, and comparative analysis, dominate. More on that in the chapter *Vernacular vs. Prestige Architecture: Introduction to Analyses/ Methods*.

At this point, it only remains for me to wish you a pleasant time discovering the fascinating realm of proportions in vernacular and prestige architecture…

STATE OF THE ART

STATE OF THE ART

When we put our focus on the study of proportions in vernacular and prestige architecture, we can observe two discrete tendencies. On the one hand, the theme of proportion has always played an integral role in prestige architecture, from classical times up to the present. It is true that in the 17th century, the *wave of resistance* against metaphysical connotations in proportional systems initiated by Claude Perrault (Perrault et al., 1708) shook its all-powerful significance, but, despite its several rises and falls, the theme of proportion in prestige architecture has retained its importance to this day (even if it is currently finding itself in another recession). On the other hand, the theme of proportion in vernacular architecture has been almost completely neglected, since scholarly interest in vernacular architecture is relatively recent. As the important worldwide protagonist of vernacular architecture, Paul Oliver, stated: "before the late 19th century most writings on the subject [of vernacular architecture] were embedded in travellers' and adventurers' accounts, sometimes included in reports for scientific expeditions but often as part of the record of individually motivated explorations", and he goes on to say: "as early as the turn of the century and noticeably since the 1930s, vernacular buildings in many countries have become objects of display, being collected in open-air museums"(Oliver, 1997, pp. xxiii, xxiv).

But let's look at the state of the art in an organised way, aiming first at the proportional systems in prestige architecture. As already stated, a shadow has fallen on the theme of proportion, thus I find it purposeful to start our narration in the middle of the last century when it was reaching another of its peaks of interest. But why was it so? An American architectural historian, James S. Ackerman, saw the reason as follows: "I think it was partly that it was very close to the end of the war. […] It had been so destructive that there was a sense of seeking some kind of principle of order in the universe", and he goes on to say: "I think that it became important to substitute the Beaux-Arts approach with something that was less arbitrary and less pseudohistorical [than] architecture based on ornament, and the proportions made it seem somehow fundamental and responding to human inner structure" (Cohen, 2014, pp.2,6).

In this context, I find the contributions of the French architect Le Corbusier and the British art historian, Rudolf Wittkower, highly valuable. While Le Corbusier, with his revolutionary proportional system he named *Modulor* (1948) concentrated his efforts on the practical realm of architecture, the Wittkower navigated the theoretical waters and with his numerous works, including the masterpiece *Architectural Principles in the Age of Humanism* (1949), significantly enriched the body of scholarly knowledge. The spark started by them ignited a general interest in the subject, leading to further publications, including Scholfield's *The Theory of Proportion in Architecture* (1958), Padovan's *Proportion: Science, Philosophy, Architecture* (2002), and Cohen's and Delbeke's *Proportional systems in the history of architecture: A Critical Reconsideration* (2018) deserves a place on this list. However, all of the cited works except Le Corbusier's *Modulor* focus on the theoretical history of proportion in architecture, neglecting to carry out proportional analyses. For me, this is a serious omission.

In addition to these valuable written contributions to the theme of proportion in prestige architecture, a number of international conferences also played their role and the key figures of Le Corbusier and Wittkower directly influenced one of the conferences — *De divina proportione*, held in Milan in 1951. It was here that Le Corbusier presented his *Modulor*. Unfortunately for him, it was not received with enthusiasm, and his presentation could be considered a debacle. (It was only later generations that rekindled curiosity in the *Modulor.)*

However, this conference was a pivotal point in the field of proportion in architecture in the last century. Encouraged by its legacy, sixty years later, the conference *Proportional Systems in the History of Architecture* was held in Leiden in 2011. The message of this conference was in a different spirit, as one of its main protagonists, Matthew A. Cohen strived to eliminate ambiguity from the term "proportion", stressing the importance of differentiating between *proportion-as-ratio* and *proportion-as-beauty* (Cohen, 2014b, p.1). In other words, in his opinion, proportion should not be understood as something mystical which contributes to the overall beauty of the building, but plainly as a certain equation between ratios. He even goes as far as to sarcastically describe advocates of the latter as *believers*. "Evidently these beauty-in-proportion believers believe that beauty generated by proportional systems emanates from great buildings of the past, causing all people to experience visual aesthetic pleasure" (Cohen, 2014b, p.3).

Probably the most cutting edge conferences in this regard are held by the Nexus platform, whose 14th meeting, *Nexus 2023: Relationships Between Architecture and Mathematics* will be held in Turin from 12 to 15 June 2023. Since 1996, the platform has dedicated space for study and discussion to a number of works by great architects such as Leon Battista Alberti, Andrea Palladio, Xenakis, Le Corbusier, Frei Otto, Frank Lloyd Wright, or Anna Bofill and Greg Lynn – and not only from the proportional perspective, but including other mathematical topics such as symmetry, fractals, etc. (About | Nexus 2023, n.d.).

Apart from the above-mentioned literature and conferences on this topic, proportion is at the periphery of interest of most contemporary architects. And although architects such as Matthew A. Cohen or Peter Märkli contemplate and explore the realms of proportion, they are few and far between, because most architects today do not give proportion a thought.

In the case of the proportion in vernacular architecture, the situation is even more serious and regrettable. Although there are international conferences on vernacular architecture, such as the *International Conference on Traditional Building, Architecture and Urbanism*, which has held annual meetings

since 2020 and whose fourth meeting will be held on 16 and 17 November 2023 (2023 International Conference, n.d.), so far, the theme of proportion has been completely left out (About the Conference, n.d.).

However, if we can become reconciled to the fact that studies on proportion in vernacular architecture are only in their infancy, and therefore if we shift our focus to general studies of vernacular architecture, we will be amazed by Paul Oliver's three-volume magnum opus entitled *Encyclopedia of vernacular architecture of the world* (Oliver, 1997c, 1997b, 1997a), which has lately been revised and expanded by Marcel Vellinga (Oxford Brookes University Editors, n.d.).

I consider the existence of my thesis to be justified, given the results of this brief summary of the current situation and the clear lack of studies on proportion in vernacular architecture. Thus, I am convinced that shedding light on proportional principles in vernacular and prestige architecture separately — and even more so their juxtaposition —would be a purposeful contribution to scholarly society. It should result in one of the first, if not the very first attempt in this direction. So, the objective of this thesis is to take the various isolated fields of studies in proportion and vernacular and prestige architecture and make them into an interconnected monument, rather than three individual solitaires.

In addition, I would be more than happy if my thesis could generate increased interest in the subject, as I think that proportion in architecture does not get the attention it deserves. I agree with James S. Ackerman, who replied to the question "Is there any aesthetic role to proportional systems in architecture?" in an interview with Matthew A. Cohen as follows: "Yeah, I think so. I think they have an impact" (qtd. in Cohen, 2014a, p.5). According to Cohen's statement – I am a *believer*.

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CHAPTER 1 // PROPORTION: HISTORICAL BACKGROUND

Our first insight into the realm of proportion will be via three points of interest. We will first focus on the historical background of proportion in architecture, then on music, and lastly, on philosophy. Although they are separate disciplines, the interrelation between them is very fascinating.

In order to understand the idea of various proportional systems, it is crucial to possess mathematical knowledge about means as well as progressions. Hence, we provide a brief introduction to arithmetic, geometric, harmonic means and progressions here. In mathematics, the mean (also median, mode), is "a quantity that has a value intermediate between those of the extreme members of some set" (Britannica Editors, 2016) and progression is "a succession of quantities in which there is a constant relation between each member and the one succeeding it" (Dictionary, n.d.).

When the first extreme (x) is exceeded by the mean (M) by about the same amount – the difference – as the mean is exceeded by the second extreme (y), the mean is arithmetical. Mathematically formulated: $y-M = M-x$. If only two extremes are known, the mean is calculated as $M = (x+y) / 2$. Arithmetic progression, e.g. 4, 8, 12, 16, …, is created by a succession of quantities interrelated by the arithmetic mean.

The geometric mean is formed when the first extreme (x) is to the mean (M), as the mean is to the second extreme (y). In mathematical terms: $x:M = M:y$, the same ratio of these pairs is called the common ratio. Using the formula $M = \sqrt{(x.y)}$, the mean is determined from two extremes. The succession of quantities bound by the geometric mean, e.g. 4, 8, 16, 32, …, builds a geometric progression.

Probably the hardest to grasp of this trio is the harmonic mean. "When the distance of two extremes [x, y] from the mean [M] is the same fraction of their own quantity" (Wittkower, 1960, p.200), we talk of a harmonic mean. In mathematical terms: $y / (y-M) = x / (M-x)$. This mean is calculated from two extremes as follows: $M = 2xy / (x+y)$. Harmonic progression, e.g. 1, 1/2, 1/3, 1/4, …, is the succession of quantities held by the harmonic mean. The special relationship between arithmetic and harmonic progression should be noted, as the harmonic progression is the reciprocal – the inverse – of the arithmetic progression.

ARCHITECTURE

Proportion in architecture – what a mystery… One which has kept us busy since ancient times. A mystery to which Ancient Greeks, Romans and probably even earlier civilizations like the Egyptians looked for a solution. It was commonly based on a belief that certain proportional systems were superior to others, that they were better. But is this really the case?

This chapter provides us with a brief history of proportional systems in architecture – because if we want to seek a new future, it is absolutely essential to know our past. This summary will present a number of different proportional systems which worked for the architects and the general public at their respective times. We will also follow the shift from a concept of absolute beauty springing from universal laws, to relative beauty stemming from topical traditions and customs. Although, how is it possible, despite this diversity in proportions, for us to still speak of *well-proportioned* architecture independent of the specific proportional system? Let us take Palladio's Villa La Rotonda and compare it with Le Corbusier's Unité d'Habitation in Marseille – each of these is based on a completely divergent proportional system, and nevertheless, both of them are well-proportioned. At this point, Wittkower's quote enunciates our new formulation assumption: "Nor is it possible to prove that one system of proportion is better than another or that certain proportions are agreeable and others not" (Wittkower, 1960, p.210).

Let us suppose that the answer lies elsewhere. Scholfield begins his book *The Theory of Proportion in Architecture* with an investigation of the relationships which are significant to the eye. He defines three aspects: firstly, when objects are of the same shape; secondly, when objects are of the same shape and size – which leads to symmetry and is a special form of the first aspect; and thirdly, when objects are of the same size, but a different shape – which is the least recognizable aspect of the three listed above (Scholfield, 1958, pp.5-6). Thus, it is not about the superiority of one proportion over another; rather, it is about the repetition of the same-shaped figures. As a consequence, architectural unity is achieved.

In general, proportional systems can be categorized into two families. One is the rational (also arithmetical, commensurable) proportional system family, based on the Pythagorean division of a string; the other is the irrational (also geometrical, incommensurable) proportional system family, rooted in the five Platonic bodies. The former encompasses proportional systems such as the Renaissance systems of Alberti or Palladio; the latter the golden ratio or Van der Laan's Plastic number proportional systems.

After this introduction, let us dive into history.

ANTIQUITY: GENESIS

Grasping the ideas formulated in Antiquity is essential for the investigation of proportional systems. Although there are notions that ancient Greeks owed a lot to Egyptian culture and that most of the ideas originated from Egypt (Panofsky, 1921), the absence of written evidence means that we begin with proportional *storytelling* by Greeks.

The matter of proportion was of special importance in ancient times, as it embodied omnipresent rules which organised both the macro- and the microcosm. The great ancient thinkers, philosophers and mathematicians such

as Pythagoras, Plato and Aristotle were occupied with their exploration. The relevance of these rules is unquestionable even today, and they provided a strong basis for the following proportional systems.

The genesis of proportional systems began with Pythagoras (~ 580 – 500 BC), a Greek philosopher and mathematician, whose concept of string division was fundamental for the rational (commensurable) proportional system family. To summarize (this will be discussed in more detail in the section entitled *Music)*, Pythagoras discovered a correlation between string division and the generation of consonant musical intervals. When a string is divided in the middle, ratio 1:2, an octave is produced; when in a ratio of 2:3, and 3:4, forming a perfect fifth and perfect fourth interval, respectively.

While Pythagoras believed that the number was the essence of everything, and its granular, discontinuous nature formed the world, his next discovery caused a conflict in his beliefs. The theorem $a^2 + b^2 = c^2$ formulating the relations between side-lengths in a right-angled triangle showed the existence of the hitherto unknown irrational numbers and shook the notion of the world created by discrete segments. Although, because of its controversial character, the discovery of irrational numbers was kept secret for some time, it was nevertheless essential for progress (Padovan, 2002).

And that progress came with Plato (427 – 347 BC), the Greek philosopher, student of Socrates and teacher of Aristotle, in whom the connection of both traditions – the rational and the irrational – was made. In the words of Richard Padovan, "he is a pivotal figure in this story, connecting Pythagoras with Alberti and Palladio, and indeed with Le Corbusier" (Padovan, 2002, p.96). In Plato's *Timaeus*, both traditions were articulated in the section about the creation of the world by demiurge. The *world – soul* corresponded to the rational, arithmetic, and the *world – body* to the irrational, geometric side of it.

The first, the creation of the *world – soul*, which is also discussed in the section entitled *Philosophy*, was based on the idea of Pythagorean string division. Demiurge split the mixture of Same – Different – Being in the following manner: "first he took one portion away from the whole, and then he took another, twice as large, followed by third, one and a half times as large as the second and three times as large as the first. The fourth portion he took was twice as large as the second, the fifth three times as large as the third, the sixth eight times that of the first, and the seventh twenty-seven times that of the first" (Platon and Zeyl, 2000, p.20). The result was the formation of double geometric progression, 1 – 2 – 4 – 8 and 1 – 3 – 9 – 27. As this sequence could also be written in a reverse "V"-shape, it was named after Greek letter *lambda* (λ).

The second, the creation of the *world – body*, provided a new perspective on the Pythagorean problem with irrational numbers. The five Platonic bodies – tetrahedron, hexahedron, octahedron, icosahedron and dodecahedron – the first four regular polyhedrons were considered to form the world's body and the fifth dodecahedron signified the *whole*. Plato assigned to his Platonic bodies the four elements of fire, air, water and earth while the dodecahedron was paired with the all-binding *ether*. However, why did the five Platonic bodies indicate the irrational, geometric tradition? The answer lies in their diagonals. Even in the simple cube, the hexahedron, the help of irrational numbers is needed, as the face diagonal with side-length 1 is equal to $\sqrt{2}$ and the body diagonal is equal to $\sqrt{3}$. The presence of irrational numbers in the remaining Platonic bodies was intrinsic to them..

The importance of arithmetic, harmonics and the most important geometric mean was undeniable in Plato's works. He stated that two extremes could be connected only through the third quantity, the mean. "The important point here is the function of proportion in *binding things together*" (Padovan, 2002, p.102).

Plato's disciple, Aristotle (384 – 322 BC), brought a shift in perspective, especially in the Middle Ages. Aristotle's ideas were not easily intelligible but once they were understood, they represented a bridge between various proportional theories. His concept of unity, standing for the smallest indivisible element of a system, was one of these ideas. In this connection, Padovan wrote: "Thus by applying the Aristotelian concept of the unit to various sequences of lines and planes we have generated all the principal proportion systems known to have been used in historical architecture: the whole-number Renaissance system, the Fibonacci and ϕ series, and the so-called *ad quadratum* and *ad triangulum* systems based on the square roots of two and three" (Padovan, 2002, p.128).

The Greek mathematician Euclid (~ 330 – 275 BC) made two notable contributions to proportional theory. First, Euclid closely examined five regular polyhedrons. The notion based on mathematical proofs was intended to provide a more comprehensive explanation of irrational numbers. Euclid provided an exhaustive explanation of this in his *Elements*. The second aspect related to Euclid's work was the golden ratio, or as he called it *division in extreme and mean ratio*. Although the true magnificent rebirth of the golden ratio came in the 19^{th} century, Euclid provided two geometrical sources of this ϕ figure – in the square inscribed in a semicircle and in the regular star-pentagon (or decagon).

Lastly, this genesis of proportional theory was completed by the Roman architect, Marcus Vitruvius Pollio (~ 80 – 15 BC). Building on the Greek tradition, Vitruvius summarised all necessary knowledge about architecture in his treatise *De Architecture – Ten books of architecture* – dedicated to the Roman emperor Augustus.

Book I and *Book III* were especially important with regards to the topic of proportion. Vitruvius defined the term proportion in this context. This differed from the modern definition, which combines the terms *symmetria* and *proportio* into one inclusive term: proportion. However, Vitruvius described both terms as follows: "Proportion is a correspondence among the measures of the members of an entire work, and of the whole to a certain part selected as standard. From this result the principles of symmetry" (Vitruvius and transl. Morgan, 1914, p.72), and "Symmetry is the proper agreement between the members of the work itself, and relation between the different parts and the whole general scheme, in accordance with a certain part selected as standard" (Vitruvius and transl. Morgan, 1914, p.14). In other words, proportion for Vitruvius signified the relation of the parts to the whole, while symmetry indicated the relation between parts.

The complementary character of arithmetical and harmonic scales became visible with Vitruvius' formation of measurement scales based on the human figure. While in the case of the arithmetical scale, the basic unit was equal to 1 and the whole was created as multiples of this basic unit, M-2M-3M-…-10M, the complementary harmonic scale began with the whole M and expressed the remaining measurements as its submultiples, M-M/2-M/3-…-M/10. Vitruvius never exceeded the 10^{th} member of a progression, rather he expressed it as submultiple of a submultiple or alternatively, a multiple of a multiple (Scholfield, 1958).

CHAPTER 1 // PROPORTION: HISTORICAL BACKGROUND

Vitruvius' ideas had an inestimable influence on the Renaissance perspective and even modern principles – hence Vitruvius' analogy between temple proportions and those of the human body, the human figure, became of special interest. The analogy between proportion in music and architecture, of which he was often mistakenly accused, was based on Scholfield's notions, on a misinterpretation of his thoughts.

MIDDLE AGES: GEOMETRY RULES

Historians disagree about the main principles in the proportional theory of medieval times. Some historians, such as Wittkower or Scholfield, argue that the Middle Ages obviously prioritized the geometric side of the Pythagorean-Platonic tradition: "While the Middle Ages favored Pythagorean-Platonic geometry, the Renaissance and post-Renaissance periods preferred the arithmetical side of the same tradition" (Wittkower, 1960, p.201), while others, such Padovan, do not see such a clear tendency: "The neat division, made by Wittkower, Scholfield and others, according to which Renaissance proportion was wholly metrical and rational, and Medieval proportion geometrical and irrational, proves to be greatly exaggerated, if not completely unfounded. […] In short, no one principle of proportion can be attributed with any confidence to any particular period" (Padovan, 2002, p.185). This controversy sprang from the lack of written evidence.

The principle-generalizing assumptions were usually made based on two gothic churches – the Milan Cathedral (begun 1386) and the Basilica of San Petronio in Bologna (begun 1390) (von Naredi-Rainer, 2001, p.217) – for which there is at least some documentation from that time. While there is no doubt that Gothic buildings were very difficult to build, in order to successfully accomplish their aims, the workers were divided into different construction huts. At the same time, the *know-how* held by the workers of each hut was kept secret from everyone else outside that particular hut. The number of different assumptions about their construction know-how is confusing nowadays, so more information would be needed to clearly formulate the proportional theory in the Middle Ages..

However, let us discuss the definite influences which had an impact on medieval architecture. One of these was the separation of the Roman Empire into the Western Roman Empire and the Eastern Roman Empire in 395 AD, which caused the Western Roman Empire to be cut off from precious sources of ancient Greek knowledge and eventually led to its stagnation and even retrogression. Although sources such as Vitruvius' *De Architecture* or Plato's *Timaeus* did not vanish completely, access to good quality translations was severely limited. As von Simon stated: "not the Greek original but only a garbled translation along with two commentaries…" (von Simon, 1964, p.26). The other impacts came from the realm of philosophy. Although Aristotle was considered the most influential philosopher of the European Middle Ages, his works only really became known in the thirteenth century, when Thomas of Aquino became interested in them. Until then, the treatises *De Ordine*, *De Musica*, by St. Augustine (354-430) and *De Musica*, *De Arithmetica*, by Boethius (480-524), were considered far more important (Padovan, 2002, p.178).

Although, as mentioned, there is an ongoing controversy about design principles in the Middle Ages, most historians, however, agreed that geometry took command. As summarised by Wittkower: "The equilateral triangle, the right-angled isosceles triangle, the square, the pentagon, and derivative figures like the octagon and decagon formed the basis of medieval aesthetics. The evidence is overwhelming that many medieval churches were built *ad quadratum* or *ad triangulum*. Also, the doubling or halving of the area of a square … received a wide application" (Wittkower, 1960, p.201). The methods named *ad quadratum* and *ad triangulum* superimposed upon the design the geometrical figure of a square and equilateral triangle, respectively. They acted as a regulative instrument for the form definition. Moreover, these geometrical methods made specific irrational numbers constructible – *ad quadratum* the square root of 2, as the diagonal of a square with side equal to 1 is √2; *ad triangulum* the square root of 3, as the height of an equilateral triangle with side equal to 2 is √3; and finally, the figure of star pentagon, which diagonal was related to the square root of 5.

Another significant aspect of the Middle Ages was number mysticism, where a specific symbolism was assigned to certain numbers, which meant that they were prioritized over other numbers. Two of these numbers, for instance, were the numbers "4" and "5", both rooted in the Vitruvian man. Number "4" symbolized the reality that the *well-proportioned* man could be inscribed in a square with four vertices and number "5", which stood for a star-pentagon with vertices resembling the one head, two hands and two legs of a human body.

The star-pentagon superimposed upon a human body was one of the drawings found in the sketchbook of the Medieval French architect Villard de Honnecourt (~1200 - 1235). Even though his work resulted in no proportional theory, interesting observations could be made. For example, it is one of the means by which Padovan supported his assumption that "number, not geometry, rules the Gothic world" (Padovan, 2002, p.180). He argued that the star-pentagon drawn by Honnecourt was distorted in such a way that the figure itself lost its meaning. On the other hand, what retained its importance was the number "5", signifying the man's one head and four extremities. Other preserved medieval works – the *Booklet on Pinnacles* (1486) and the *German Geometry* (1498) – were written by the German architect Matthäus Roritzer (~1435 - 1495). However, Padovan was very sceptical about the accuracy of the medieval methods described by Roritzer, since Roritzer's book focused on the methods used by the builders of Chartres, methods which had been formulated three centuries earlier. Furthermore, he wondered about the influence which Alberti's manuscript *On the Art of Building* might have left on Roritzer's works.

This chapter explored the multiple and sometimes contradictory perspectives on the Medieval theory of proportion. Unfortunately, it was not possible to provide the reader with more definite answers, as this would only be possible if new findings shed more light on the subject.

RENAISSANCE: ARITHMETIC RULES

Whereas, in the Middle Ages, we could only guess at the proportional theory due to lack of written evidence, the Renaissance left us many more written testimonies. The arithmetical side of the Pythagorean-Platonic tradition was held to be dominant by the majority of historians, including Wittkower, Scholfield, etc., although Padovan remained faithful to his opinion that differences be-

tween the proportional theory of the Middle Ages and that of the Renaissance had been exaggerated and in reality, they shared many similarities. Padovan also asserted Aristotle's ongoing influence.

The proportional theory of the Renaissance comprised several fields of interest – one of these was the later widely-criticised musical analogy (which is discussed in greater detail in the *Music* section As Scholfield wrote, "Renaissance owes to Vitruvius" (Scholfield, 1958, p.35). His ideas, including those that were misinterpreted, were ubiquitous in Renaissance thought, starting with objective beauty. It was believed that beauty could be achieved when specific principles were applied. These principles were directly associated with proportion. Moreover, the harmonic, arithmetic and geometric means described by Plato in his *Timaeus* grew in influence.

Leon Battista Alberti (1404-1472), the Italian Renaissance architect and writer who introduced the Renaissance musical analogy, supported the concept of objective beauty through his idea of *concinnitas*. He defined *concinnitas* as "the absolute and fundamental rule of Nature" and believed that "everything that Nature produces is regulated by the law of *concinnitas*, and her chief concern is that whatever she produces should be absolutely perfect" (qtd. in Padovan, 2002, p.213). According to Padovan, for Alberti, the application of nature's *concinnitas* on art resulted in beauty.

Another aspect of Renaissance proportional theory was the centrality of the human figure, thanks to Vitruvius' parallel between the proportions of a human being and a temple. The focus on the human figure was also a result of the strong desire for representation of human individuality, formed by one's own will and freedom of choice. The religious determinism which had prevailed in the Middle Ages retreated into the background, and the prevailing interest in the human figure gave rise to two approaches. According to Scholfield, "Alberti and Dürer were interested in measuring the actual human figure, just as architects were beginning to measure examples of the orders surviving from antiquity. Cardan and Leonardo experimented with mathematical systems of proportions whose utility could be tested out in the difficult task of fitting them to the human figure" (Scholfield, 1958, p.50).

Francesco Giorgi (1466-1540), the Italian Franciscan monk, put forth in his work *De harmonia mundi* from 1525 a variation on the double-progression lambda λ from Plato's *Timaeus*. Giorgi multiplied the original double-progression by a factor of 6 and he arrived at a new sequence of numbers, starting from 6: 6, 8, 9, 12, 16, 18, 24, 27, 32, 36, 48, 54, 81, 108, 162. It was a composite of the original and lambda λ multiplied by factor 6. Giorgi proposed his composite lambda λ series so as to eliminate proportional fractions in architectural design.

Doubtless, Leon Battista Alberti and Andrea Palladio (1508-1580) were the leading figures in Renaissance architecture. Unlike Alberti, who summarized his thoughts on proportion in *Ten books on Architecture* or *De re aedificatoria* (1452, printed in 1485), Palladio did not discuss his ideas on proportion in his *Four books on architecture ("I quattro libri dell'architettura")* (1570). (Although his dimensioned drawings give us an outline of his intentions.)

Let us discuss ratios, another interesting aspect of Palladio's design. Ratios used by Palladio were not only based on ratios of consonant intervals; his works also contained ratios such as 17:12, 7:4, 13:8, 15:11 and 26:15.

In his book, Padovan wrote "Lionel March argues that they are rational convergents or whole-number approximations for irrational proportions" – as "17:12 is a rational convergent for √2, 7:4 and 26:15 converge towards √3, and 13:8 is a Fibonacci ratio, and thus a rational convergent for ϕ" (Padovan, 2002, p.247) and Padovan also assumed that Palladio gave to each of his works a particular mathematical theme. If this unconventional belief was true or not, remains a mystery.

ENLIGHTENMENT: REJECTION AND QUESTIONING

The unstoppable progress in science represented *inter alia* by Newton's natural laws brought with it rejection and questioning regarding proportional systems in architecture. In Wittkower's words: "What mathematics gained as an abstract discipline from the seventeenth century on, it lost as a guiding principle in the field of aesthetics" (Wittkower, 1960, p.202). The idea of proportional metaphysical connotations which had prevailed until the 17th century could no longer be blindly accepted. In addition to the huge role played by the harsh critique of musical analogy, which is further discussed in the section *Music*, the other parts of the proportional theory did not remain untouched.

The shaking of deep-rooted views regarding proportion began with an academic argument between François Blondel and Claude Perrault. While François Blondel (1618-1686), a respected French architect and director of the *Académie Royale d'Architecture,* continued to adamantly defend the Pythagorean-Platonic tradition with reference to the great Renaissance architects Alberti and Palladio, Claude Perrault (1613-1688), a French architect and scientist, argued the necessity for separating beauty from proportion. And thus it was that Plato's ancient differentiation between absolute and relative beauty gained new sympathies (Plato and Frede, 1993).

Perrault's unambiguous antipathy to musical analogy extended to other aspects of proportional theory when he rejected the concept of absolute beauty ruled by specific proportions, instead providing a new association between beauty and traditions and conventions. Perrault distinguished two types of beauty as well as proportion, stating: "One must suppose two kinds of beauty in architecture and know which beauties are based on convincing reasons [positive and convincing beauty] and which depend only on prejudice [arbitrary beauty]". Positive and convincing beauty could be understood as a universal beauty, one "whose presence in works is bound to please everyone", while the arbitrary as relative: "that appear agreeable not by reasons within everyone's grasp but merely by custom" (Perrault, 1996, pp.50-51). He further defined two kinds of proportion, one that is "difficult to discern" and the other that is product of symmetry. Based on Perrault's words, it is possible to conclude that Perrault did not completely deny the proportional theory as such, but rather that he presented a new perspective more appropriate to the Age of Enlightenment.

Perrault's radical first step towards the *wave of resistance* to proportional theory based on metaphysical beliefs connecting the micro- and macrocosm quickly found new supporters. The Anglo-Irish philosopher George Berkeley (1685-1753) discussed in his dialogue *Alciphron* (1732) suitability as a source of beauty. He alleged that without being fit for purpose, an object could not be beautiful. The Scottish philosopher David Hume (1711-1776) went a step further when he ascribed beauty not to an object itself, but to the subjective perception of an observer. "Beauty lies in the eye of the beholder"

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(Padovan, 2002, p.293). Lastly, the perspective of Edmund Burke (1729 - 1797), the Irish politician and philosopher, should not left out. Burke's radical vision, as presented in his *Philosophical Enquiry into the Origin of Our Ideas of the Sublime and the Beautiful* (1756) dissociated proportion from beauty: "But surely beauty is no idea belonging to mensuration; nor has it anything to do with calculation or geometry"(Burke, 1998, p.85). And regarding the association made between Vitruvian man's proportions and architectural proportions, he called this a "forced analogy".

This turbulent age brought many other advocates of the *wave of resistance*, for instance, William Hogarth (1697-1764), Sir John Soane (1753-1837), and Archibald Alison (1757-1839). (However, their ideas are not going to be explored here in detail). I will close this chapter with a very apt quote from Wittkower: "They [proportion and beauty] were turned from absolute truths into phenomena of subjective sensibility" (Wittkower, 1960, p.202).

19th CENTURY: REBIRTH OF THE GOLDEN RATIO

After the failure which proportional systems experienced in the eighteenth century, manifesting in the strong denial of Renaissance theories on proportion, the nineteenth century had to bring in new tendencies regarding proportional systems.

Some of these tendencies tried to look beyond the Renaissance and explore ideas of the medieval Gothic or ancient Greece based on archaeological finds – its protagonists were called revivalists. Examples include Gothic revivalist R. W. Billings and his book *The Power of Form applied to Geometric Tracery* (1851), and Greek revivalist D. R. Hay with his *The Science of Beauty as developed in Nature and applied in Art* (1856).

Others favoured their own intuition over any theory. John Ruskin was considered the most distinctive figure of this tendency and presented his unconventional opinions in his publications such as *Modern Painters*, or *Seven Lamps of Architecture*. However, their potential was greater than their actual influence on the theory of proportion.

Lastly, the most powerful tendency for formulating a new proportional theory came with the glorification of the golden ratio. Scholfield wrote: "A fairly good case could be made out for the view that the nineteenth century actually discovered the golden section as an instrument of architectural proportion, however close earlier periods may have come to this discovery" (Scholfield, 1958, p.98). Given the dominant character of the golden ratio tendency in the nineteenth century, it is the theme of this chapter.

Golden ratio, also known as *extreme and mean ratio*, is a ratio expressing the division of a line into unequal parts in a way that the longer part is to the whole the same as the shorter part to the longer. Mathematically formulated: $(a+b) : a = a : b$. If b is equal to 1, than $a= (1+\sqrt{5})/2$ – it is an irrational number, named after the Greek letter ϕ, which is approximately 1.618… Although this *divine* ratio was already known in ancient Egypt (Fournier, 1957), and in ancient Greece it was mentioned in Euclid's *Book VI* of *Elements* (~ 300 BC) and rediscovered in later periods as well, e.g., in the contribution of Leonardo da Pisa – called Fibonacci–*Fibonacci series* in *Liber Abaci* (1202) or Luca Pacioli's treatise *De Divina Proportione* (1509), it was not until the nineteenth century that it became a central topic of proportion.

The key role in the rebirth of golden ratio was played by the German psychologist Adolf Zeising (1810-1876). His captivating *New Theory of the Proportions of the Human Body*, published in 1854, determined the next direction of the theory of proportion. The metaphysical approach to the matter of proportion which had been condemned in the Enlightenment began to regain power. It was Zeising who pointed out the golden ratio as the main principle valid in the micro- and the macrocosm, stating: "Diesem Ziel nachstrebend, glaube ich nun auch zu einem glücklichen Resultat gelangt zu sein und ein Grundgesetz [Golden Section] über die Verhältnisse der schönen Erscheinungen überhaupt und des menschlichen Körpers insbesondre entdeckt zu haben" ("In pursuit of this goal, I now believe I have reached a happy result and have discovered a basic law [golden ratio] about the relationships between beautiful phenomena in general and the human body in particular." Informal translation.) (Zeising, 1854, p.10). Even though not everyone was impressed by his "exaggerated and unscientific" (Scholfield, 1958, p.99) theory, the golden ratio cult became unstoppable in the century that followed.

Although Zeising's work was undoubtedly of great importance for the new tendency in the realm of proportion, it was the work of Gustav Theodor Fechner (1801-1887), the German psychologist, philosopher and physicist, which significantly contributed to its international expansion. His publications *Zur experimentalen Aesthetik* (1871) and *Vorschule der Aesthetik* (1876) described fundamentals the experimental aesthetics he had founded.

Fechner carried out various experiments on the golden ratio, in order to find out if it really possessed the intrinsic beauty that had been attributed to it. In addition to his most well-known experiment, which involved ten rectangles with the same area but different side ratios, starting with a square 1:1, continuing with an approximation of a golden ratio rectangle 21:34 and ending with an elongated rectangle 2:5 – he experimented also with horizontal and vertical lines, always including one line in a golden ratio. In the experiment on the one-dimensional lines, the golden ratio was not obvious, but it was dominant in the two-dimensional rectangles. In this experiment, the great majority of people interviewed marked the golden ratio rectangle and its surroundings as being the most appealing (Fechner, „Zur Experimentalen Aesthetik"). Later observations made by Bernard Bosanquet should be given special attention, as he pointed out that "the least deviation from symmetry has a far more decided unpleasantness than a proportionally much greater deviation from the golden section" (Bosanquet, 2005, p.383).

As mentioned, the golden ratio cult had plenty of devotees throughout the last centuries including Ernst Henszlmann with his *Théorie des proportions* (1860), Matila Ghyka with *Le Nombre d'Or* (1931), Charles Funck-Hellet with *De la proportion - L'équerre des maîtres d'oeuvre* (1951). Le Corbusier, who applied golden ratio principles to his proportional system *Modulor* (1948) or more recent advocates such as György Doczi with his *The Power of Limits: Proportional Harmonies in Nature, Art and Architecture* (1981) and Walther Bühler with his *Das Pentagramm und der Goldene Schnitt als Schöpfungsprinzip* (1996). Despite the topic of the golden ratio having been exhausted in academic discourse, it still remains of interest to the general public.

20th CENTURY: MODERN PRINCIPLES

The atmosphere around proportional systems in the twentieth century was ambiguous and confused. Although new proportional theories were still being

developed by architects and artists – let's name the most influential among them, such as *Dynamic Symmetry* by Jay Hambidge, *Modulor* by Le Corbusier and Hans Van der Laan's *Plastic Number* – the relevance of the subject continuously weakened. The last few attempts to generate lively academic discussion on the matter in the 1950s, such as the *First International Congress on Proportion in the Arts* in Milan from 27 to 29 September 1951 or *Meeting of the Royal Institute of British Architects* in London on 18 June 1958 were unable to reverse the downward trend in its relevance. "No one really believes any longer in the proportional systems"(Zevi, 1957, p.508), these words of Bruno Zevi, the director of the periodical *L'Architettura* and a participant at Milan's Congress, reflected the mood in society at the time.

The following paragraphs are devoted to presenting the above-mentioned proportional systems of the 20th century. According to Scholfield, they are modern irrational systems but with the sophisticated integration of analytical advantages (Scholfield, 1958, p.110).

THE CURVES OF LIFE

Although the 1914 work by British art critic and writer Theodore Andrea Cook (1867-1928), *The Curves of Life* did not offer a proportional theory, it must be mentioned here, as it is indispensable, providing the basis for the later theories – *Dynamic Symmetry* and *Modulor*. What is even more notable in this context is that Cook became the primary critic of *Dynamic Symmetry*.

The logarithmic spiral, about which he revealed "I found myself obliged to examine the forms of natural life ; and I learnt that this extraordinary and beautiful formation [logarithmic spiral] is to be seen throughout organic nature, from the microscopical foraminifera and from life forms even smaller still" (Cook, 1914, p. vii) formed the core of his fascination. Cook's perspective was noteworthy in that he did not consider the logarithmic spiral as a universal law but as an inevitable construct of the human mind, which "hungers for finality and definite conceptions" (Cook, 1914, p.24). This contribution was highly decisive for Hambidge's *Dynamic Symmetry.*

Cook's second contribution anticipated Le Corbusier's *Modulor*, which came a few decades later. He proposed a sliding scale of ϕ progression. A system in which any line drawn parallel between two initial lines divided in a golden ratio progression would be automatically divided in the same manner as well (Cook, 1914, pp.461-469). This idea was based on the work of William Schooling, who first proposed to translate a single golden ratio into an infinite progression (Cook, 1914, pp.441-447).

DYNAMIC SYMMETRY

Cook's interest in the logarithmic spiral paved the way for *Dynamic Symmetry*, a theory formulated by Jay Hambidge (1867-1924). Hambidge published multiple works that dealt with this topic: *Dynamic Symmetry* (1917), *Dynamic Symmetry: The Greek Vase* (1920), *Dynamic Symmetry as Used by Artists* (1923), and lastly, *The Parthenon and Other Greek Temples* (1924). The theory was presented in the periodical he edited, *Diagonal*, too.

But what did Hambidge mean by dynamic symmetry? First of all, it is important to clarity that for him, *symmetry* signified our term "proportion". He took nature as a model and made a distinction between *static symmetry* and *dynamic symmetry* – the former addressing the rigid form of regular geometrical figures organized in an orderly manner around a centre, which arose by the use of commensurable ratios and in nature was found in crystal forms, *radiolaria*, diatoms, flowers, and seed pods – and the latter, which characterized the infinite growth found in root square rectangles and incommensurable ratios, with the analogy in nature being the logarithmic spiral detected in shell growth or leaf distribution in plants (Hambidge, 1967).

Although Hambidge was not an architect, but rather an artist and writer, he developed his *Dynamic Symmetry* on the basis of detailed expertise of Greek vases. He wanted to prove his assumption that *Dynamic Symmetry* was a widely-used principle in ancient Greece. The results were positive, concluding that the great majority of the vases really were based on *Dynamic Symmetry* (Scholfield, 1958, p.118).

Two notable features of Hambidge's theory are *diagonal* and *application of areas*. *Diagonal* was used to designate similar geometrical figures, including the reciprocals of originals, and *application of areas* helped to divide the areas of rectangles "so that the division would be recognizable" (Hambidge, 1967, p.28).

This controversial theory attracted a sizeable dose of criticism, and Wittkower went as far as to call opponents of Hambidge's theory "sober-minded" (Wittkower, 1960, p.208), contrary to him. However, the most striking disapproval came from Theodore A. Cook, who had developed the very forerunner of *Dynamic Symmetry*. In his 1922 article entitled *A New Disease in Architecture*, Cook ridiculed Hambidge, calling him someone "who has an especially virulent form of the disease" (qtd. in Wittkower, 1960, p.208). He argued that beauty could not be achieved by such simple and childlike means.

And while the method of *Dynamic Symmetry* analysis was conceived with a focus on archaeological research, its practical application would be of a completely different nature, something which was acknowledged even by Hambidge.

MODULOR

Le Corbusier (1887-1965), real name Charles-Édouard Jeanneret-Gris, was one of the most influential architects of the last century, and gave a quite unique twist to the much-lauded golden ratio with his proportional theory, *Modulor*. His eponymous work was first published in 1948.

From a young age, Le Corbusier was interested in the intrinsic order he observed in nature. "What is the rule that orders, that connects all things?"(Le Corbusier, 2004, p.26) Le Corbusier eagerly asked himself. And it was no accident that Padovan called him a *Classical architect*, given his obvious fascination with Antiquity and its tendencies. In one letter, Le Corbusier even stated: "I agree, nature is ruled by mathematics, and the masterpieces of art are in consonance with nature; they express the laws of nature and themselves proceed from those laws" (Le Corbusier, 2004, pp.29-30). What a clear Pythagorean-Platonic vision!

As to the impact of writings by Vitruvius, Le Corbusier put at the centre of his proportional system the figure of a man, and carried out detailed examination of the figure's proportions. He discovered that the proportions of the man are ruled by two golden ratio series. He called them the blue and the red series, and the former is double the latter. For the establishment of this system, Le

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Corbusier needed only three features: "a man-with-arm-upraised" fitted in a double square, "the place of the right angle", and the golden ratio. Although the original intention was to create a "grid of proportions", the resulting *Modulor* resolved only the height dimension (Scholfield, 1958).

It took quite some time for Le Corbusier to arrive at the final version of *Modulor*. He began with a male figure of height of 175 cm. The problem was that the proportional system was too imprecise for the foot-and-inch system without being able to round up or down. Since the French architect also considered *Modulor* as a unification tool between two rival systems – the metric and the Imperial system – he had to come up with a different solution. This he arrived at with an idea to make the figure 6 feet (182 cm) high. To Le Corbusier's delight, the round figures were achieved.

The reason why Le Corbusier yearned to find unification between both measuring systems can be explained by the expression: standardization is paramount. Le Corbusier saw his *Modulor* as a mean for prefabrication and standardization – both of which were current topics at the time. As Wittkower argued, "the belief in systems of proportion in modern society is proportionate to the amount of industrial energy they generate" (Wittkower, 1960, p.212).

Despite *Modulor's* presentation at the Milan Congress in 1951 being referred to as a debacle, it was probably the most authoritative proportional system of the last century. A few criticisms have been directed towards this system, by authors such as Scholfield: "There has evidently been no attempt here to apply the Modulor to the determination of the dimensions of the building as a whole" (Scholfield, 1958, p.124); or my own objection about *Modulor's* lack of individuality (Kaprinayova, 2020, p.45). The fact that the *Modulor's* sole focus is on the height dimension, whereas architecture is performed in three-dimensional space should also be mentioned in this context.

PLASTIC NUMBER

The *plastic number*, a proportional system whose formulation took over several decades was ideated by a Dutch architect and Benedictine monk, Dom Hans van der Laan (1904-1991). Although he discovered it as early as 1928, it was first publicized in *Le nombre plastique* in 1960 – i.e. the number came before the theory.

Van der Laan's strongly-held belief in the senses and their cognitive competence was implemented in his theory formulation when he searched for an answer to the question: "What are the limits of our ability to differentiate spatial dimensions?" (Voet, 2016, p.4). His divergence from Plato's opinions, when Van der Laan valued the abstracted image perceived by the senses over the original object, made more space for abstraction in architecture. In the end, Van der Laan understood architecture as a means of abstraction and limitation which he considered essential for a human being to "feel altogether" in this "boundless world" (qtd. in Padovan, 2002, ch.2.5).

In order to confirm his assumptions, Van der Laan conducted an experiment in which he tasked his students with organizing pebbles of the same size into groups. In reality, Van der Laan provided them with a 'series' of 36 pebbles in increasing order of size, with a 1/25th difference in size between neighbouring pebbles. Students organized them into five groups, four groups of seven pebbles, and one group of one pebble. Since the ratio between the biggest pebble of one group to the biggest pebble of the next group was 4:3, the smallest difference perceivable by the eye was considered to be 1:4 and the biggest, 1:7.

This is a good demonstration of the ambiguity about whether the plastic number is rational or irrational in character. Although Van der Laan defined it as an irrational number and a result of a cubic equation $x + 1 = x^3$, equal to 1.3247…, almost without exception, he used the approximation given by the ratio 4:3 instead. He even established the *order of size* upon this ratio: 1 – 4:3 – 7:4 – 7:3 – 3 – 4 – 16:3 – 7. In practice, Van der Laan worked with *order of size* in three interconnected successive scales – calling them *measure systems* (Voet, 2016).

Even though there are a few doubts about Van der Laan's *plastic number* – specifically, why he used pebbles with a difference in size of exactly 1/25th and if a change in deviation would result in a different plastic number; or whether the smallest perceivable difference was for him always 1:4 regardless of the scale and absolute size of the object – his proportional system succeeded in relating not only parts to parts, but parts to the whole as well, unlike the proportional systems of other architects such as Alberti, Palladio, or Le Corbusier.

MUSIC

Although proportion in the music field is more present than one would expect, as the publication *Proportion und Ihre Musik* by Karlheinz Schüffler or the chapter *Harmonik als Wissenschaft* in the extensive master thesis by Klaus Hammer has shown, we will focus on its intersection with proportion in architecture. Therefore, topics such as overtones, scales and tonality have been left out.

The connective element between proportion in architecture and music is intervals, which we will discuss in more detail in this section: the discovery of the ratio relationship in intervals, their consonant or dissonant nature, application in mathematical figures such as Tetractys along with Senarius, and lastly the very theory of musical analogy, which has fuelled discussions in the academic field over the centuries.

INTERVALS

"The amount by which one note is higher or lower than another"(Cambridge Dictionary Editors, 2021) is called an interval. In other words, it is the pitch distance between two notes. If notes are played at the same time, the "harmonic" interval is created – if they are played one after the other, the "melodic" interval is created.

To understand the correlation between ratio and interval, we must turn to the significant discoveries of Pythagoras. For this purpose, Pythagoras used an ancient musical instrument – the monochord. This instrument, as its name suggests, consisted mostly of one string (Greek μόνος *mónos* = "alone, sole" and χορδή *chordí* = "string"), which was attached to a resonating body or table. Even multiple strings were called monochord if they were attached to the same resonating table and tuned to the same tone. Pythagoras discovered that dividing the string in a specific ratio produced the corresponding consonant interval. The division of the string in the ratios listed below created these intervals to the fundamental tone (tone produced by an undivided string): octave at the middle of the string, ratio 1:2, perfect fifth (the 5th) at two-thirds of the string, ratio 2:3, and perfect fourth (the 4th) at three-quarters of the string,

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ratio 3:4 (Hammer, 2005, pp.24-26). Together with the prime interval (unison), ratio of 1:1, these intervals were recognized as consonant in ancient Greece. As Padovan stated in his book *Proportion: Science, Philosophy, Architecture*, the ratios of consonant intervals later provided a connective bridge: "During the Italian Renaissance these ratios became the basis of architectural proportion" (Padovan, 2002, p.59).

Tone's one property worth mentioning is its octavation – the term for the repetitive character of the tone after one octave. It means that the same quality tone is produced every time, but played in higher or lower octave steps.

Let's apply this knowledge to a string with the same properties varying only in length. Thus, the fundamental tone produced by the vibrating string of length 1, when played is as follows: one octave higher corresponded to the vibrating string of length 1/2; two octaves higher to 1/4; three octaves higher to 1/8, and so forth. Naturally, movement in the opposite direction is also possible and results in playing the fundamental tone in lower octaves. One octave lower is produced by the vibrating string of length 2; two octaves lower with length 4; three octaves with length 8; etc. It is worth mentioning that the following geometric progression with the common ratio 1/2 is created by changing the string's length as follows: …8, 4, 2, 1, 1/2, 1/4, 1/8…

From the previous statements, it is clear that, by *layering* intervals sequentially, their exponential character is expressed by the mathematical operation of multiplication. For instance, the length of the vibrating string played two octaves higher from the fundamental tone would be calculated as 1/2 x 1/2 = 1/4.

The octave, also called a *diapason*, hence occupied a key position in the musical field because it contained every other interval in its range. The compound intervals exceeding the range of one octave can be understood as the specific interval above/below an octave. E.g., the compound 5th interval represents a perfect fifth (the 5th) above an octave.

Here, it is useful for us take a brief look at the topic of vibrating frequency. Because the length of the string and the vibrating frequency are intertwined in indirect proportion, the increase of one quantity results in the proportional decrease of the other quantity. Thus, the halving of the string gives the outcome of doubled vibrating frequency. The length of the string ratio of 1:2 and vibrating frequency ratio of 2:1 are the representations of the same interval, demonstrated in the example of an octave (Schüffler, 2020, p.XXII). This relationship applies to any fundamental tone.

So far, only the Pythagorean consonant intervals have been mentioned – these are also referred to as *perfect* intervals – octave 1:2, perfect fifth 2:3, perfect fourth 3:4 and unison 1:1. (However, even a piece of music that is easy to play consists of a much-varied range of intervals.) In addition to consonant intervals, the dissonant ones exist as well. In simple terms, the first are concordant, meaning "pleasant-sounding" and the second are "discordant", meaning "unpleasant-sounding".

Only in the Renaissance times was further progressive change searched for, and this came with Ludovico Fogliano. About him, Wittkower wrote: "It was Ludovico Fogliano of Modena who, in his *Musica theorica* of 1529, first protested against the sole authority of the Pythagorean consonances; according to him experience teaches that, apart from the five [compound consonant intervals included, too] Pythagorean consonances, minor (5:6) and major third (4:5), minor (5:8) and major sixth (3:5), and major (2:5) and minor tenth (5:12), eleventh (3:8), and minor and major sixth above the octave (5:16 and 3:10) are all consonances"(Wittkower, 1988, pp.132-133). In other words, major and minor thirds and their inversions, minor and major sixths, are consonant intervals as well, and also include all compound intervals created from consonant intervals above or below an octave. This belief was fully accepted in the theoretical field thanks to the great Renaissance music theorist Gioseffo Zarlino, who in 1558 published his *Istitutioni harmoniche*. The reason it took so long to incorporate thirds and sixths into this category might be explained by the widespread practice of the Pythagorean tuning system. As Paul Zweifel clarified that "deficiencies of the scheme [of Pythagorean tuning] included the facts that […] the major thirds were badly mistuned (the "syntonic comma" […]). In fact, in Medieval music the third was considered a dissonance" (Zweifel, 1994, p.90).

The second category of intervals, the dissonant one, includes the minor (9:10) and major (8:9) second, the very disharmonious tritone (32:45) and lastly, the minor (5:9) and major (8:15) seventh. These intervals kept their dissonant character unchanged throughout history, starting from Pythagoras and persisting to this day.

The changed Renaissance perspective on consonant intervals also influenced their interrelation with architecture.

TETRACTYS

For Pythagoras, who placed strong importance on the number as the base for the whole world as well as the universe, the geometrical figure named *tetractys* was quintessential. The *tetractys* (Greek τετρακτύς *tetraktýs* = group of four) was created by the first four whole numbers 1 2 3 4, which were organized as dots, each in a separate row, producing a triangular figure. This figure was a representation of the decade, as the sum of all the dots was ten (Cohen, 2009, p.36).

However, the interpretation of *tetractys* went beyond that. Primarily, *tetractys* symbolized an ontological development of the world, then it represented the dimensional spectrum and finally, it signified the connection between different disciplines – in the Middle Ages, it was also referred to as *Quadrivium* (arithmetic, geometry, music, astronomy) (Bass and Critchlow, 2019, pp.16-18).

As mentioned, *tetractys* had also a special importance in music, as clearly stated by Karlheinz Schüffler, amongst others, in his work *Proportionen und Ihre Musik*. He defined *tetractys* as one of three models, "welche die Verbindung der Musik mit der Lehre der Proportionen sowohl „visuell" als auch „hörbar" herstellen" ("which establish a connection between music and proportional theory which is both 'visual' and 'audible'." Informal translation.) (Schüffler, 2020, p.11). His words were reflected by the perfect consonant intervals which were created from these four numbers, specifically: prime (1:1), octave (1:2), octave plus perfect fifth (1:3), octave plus octave (1:4), perfect fifth (2:3) and lastly, perfect fourth (3:4).

However, in the musical field, the so-called *first tetractys – Harmonia perfecta maxima* – from numbers 6 8 9 12 (the *Pythagorean canon*) was better known, since the essential principles of Greek music theory were anchored in it. The very importance of *first tetractys* lay in the manifestation of the unifying nature

of the octave. The octave (6:12 = 1:2) was constructed either by a perfect fourth (6:8 = 3:4) + whole tone (8:9) + perfect fourth (9:12 = 3:4) or by perfect fourth (6:8 = 3:4) + perfect fifth (8:12 = 2:3), as well as by perfect fifth (6:9 = 2:3) + perfect fourth (9:12 = 3:4). The whole tone (8:9) was therefore understood as the interval difference between perfect fourth and perfect fifth (von Naredi-Rainer, 2001, pp.158-159). The truth that the octave was completed by layering inverse intervals was referred to as complementarity. It is also worth mentioning the unification of an arithmetical and a harmonic mean into one relation – 6:8:9:12 = *first extreme: harmonic mean: arithmetic mean: second extreme*. Although the *first tetractys* did not include the ratios of octave plus perfect fifth (1:3) and octave plus octave (1:4) as the *tetractys* 1 2 3 4, its significance for music was greater, as it expressed the complementarity of inverse intervals in the octave and its unifying character.

If we were to take a close look at the painting *The School of Athens*, by the well-known Renaissance painte Raffaello Santi (1483-1520), we would find a summarization of the previous discussion. All the great philosophers and thinkers of Antiquity are depicted in this painting, including Plato, Aristotle and Pythagoras. Pythagoras is shown here writing a book while looking at a small chalkboard on which important ancient knowledge is outlined. What is shown on the chalkboard includes, firstly, the complementarity of an octave explained by the *first tetractys* 6 8 9 12 – note that the Greek names of the intervals were used (*diapason* = octave, *diapente* = perfect fifth, *diatessaron* = perfect fourth, *epigdoon* = whole tone). And secondly, the usual *tetractys* 1 2 3 4 underneath, was drawn in a triangular figure adding up to the number ten, so the connection between mathematics and music was represented.

SENARIUS

As already mentioned, thanks to Ludovico Fogliano and Gioseffo Zarlino, the 3rd and 6th became considered consonant as well. Hence, the mystical character of the *tetractys* and its 'all-powerful' application in music was no longer sufficient and, during the Renaissance, the four-number-figure needed to be extended to the six-number-figure, the *senarius* 1 2 3 4 5 6. "Zarlino attributed almost mystical significance to the *senario* [or *senarius*] in the same way that Pythagoras apparently did to the *tetractys*—the first four numbers" (Duffin, 2006, p.3). The most significant ratios attached to *senarius* were 1:1 (prime), 1:2 (octave), 2:3 (perfect fifth), 3:4 (perfect fourth), 4:5 (major third), 5:6 (minor third). The major sixth (3:5) and minor sixth (5:8) were now also categorized as consonants. Despite the fact that the minor sixth ratio could not be fully expressed the *senarius*, because of the sixths' complementary nature to thirds, they were still bound to this figure – major third with minor sixth completed an octave, 4/5 x 5/8 = 1/2, and minor third with major sixth as well, 5/6 x 3/5 = 1/2.

In the context of *senarius*, Hammer pointed out the breakdown of larger intervals into smaller ones through the construction of means (Hammer, 2005, pp.28-30). The continuation of a simple arithmetical progression of *tetractys* 1 2 3 4 to *senarius* 1 2 3 4 5 6 could be grasped as a division of a perfect fifth interval. Because the arithmetical mean between two extremes expressing the perfect fifth interval (2:3 = 4:6) was number 5. Thus, the perfect fifth (4:6) divided by the arithmetical mean created ratios 4:5 and 5:6, analogous to major third and minor third intervals.

The characteristic role of prime numbers in *senarius* was also observable.

"Das erste Auftreten der Primzahl 2 charakterisiert (auch rein mathematisch) die Oktave, das der 3 die Quinte (und auch ihre Ergänzung zur Oktave, die Quarte). Die Terzen sind durch die Primzahl 5 charakterisiert" ("The first occurrence of the prime number 2 characterises (also in purely mathematical terms) the octave, that of [number] 3 the fifth (and also its complement to the octave, the fourth). The thirds are characterised by the prime number 5." Informal translation.) (Hammer, 2005, p.29).

An even wider grasp of *senarius* was presented in the book *Proportionen und Ihre Musik*, where the author Karlheinz Schüffler mentioned the major ("Dur") and minor ("Moll") variability of the *senarius* progression (202). The arithmetical progression 1:2:3:4:5:6 standing for its major nature, represented by the major accord composed of octave – perfect fifth – perfect fourth – major third – minor third, and its inverse counterpart, the corresponding harmonic progression 1/6 : 1/5 : 1/4 : 1/3 : 1/2 : 1/1, which can also be expressed as 10:12:15:20:30:60, the minor accord composed of minor third – major third –perfect fourth– perfect fifth – octave, demonstrates its minor nature.

TUNING SYSTEMS

So far, we have talked only about one kind of ratio for a specific interval. However, if we want to throw more light on the topic, it is true that the ratio for the specific interval changes according to the tuning system used. In the history of Western music, there were three basic types of tuning system – *Pythagorean tuning*, *just intonation* and *equal temperament*. Each system has its pros and cons.

The first and the oldest tuning system, Pythagorean tuning, was based on a sequential *layering* of perfect fifth intervals , creating all twelve tones of a chromatic scale. Because *layering* of intervals in mathematical language means multiplication, „all musical proportions of the Pythagorean scale can be expressed as ratios of powers of the prime numbers 2 and 3" (Kappraff, 2015, p.550). The complicated ratios of numerous intervals – e.g. minor third 32:27, major third 81:64, tritone 729:512 etc. – were not the only problem with this system. Theoretically, if we started *layering* perfect fifth intervals downwards from a fundamental note twelve times, we should arrive at a note, which was exactly seven octaves lower. However, this was not the case! In the Pythagorean tuning system, the result was $(3/2)^{12} = 129.74\ldots$ and not $128 = (2/1)^7$. This slight difference was given the name *Pythagorean comma* or *ditonic comma*, also explained as a "gap between two enharmonically identical notes such as B# and C" (Darling, 2019c). Although it corresponded to approximately a quarter of a half-tone, the human ear already perceived it as a dissonance. Another problem with the system was the audible dissonance of major thirds, known as a *syntonic comma*. The consequence of these realities was a construction of ever-open spiral of fifths, suitable only for a single major key. Every modulation would mean that a retuning of an instrument with a fixed tuning (e.g. a piano) was required – which of course was highly impractical (Darling, 2019b). However, the key modulations were neglected for a long time and the *Pythagorean tuning* met the needs of the most musicians until the Renaissance.

The second tuning system, the *just intonation*, addressed some problems of *Pythagorean tuning* (though not all of them), and one of its best well-known advocates was none other than Gioseffo Zarlino – sometimes he was even called "the most conspicuous champion of Just tuning" (Duffin, 2006, p.8). No wonder, since *just intonation* was a system of tuning based on small whole-number

ratios largely rooted in *senarius*, to which Zarlino attributed great importance. However, as Duffin also said, "But the intervals represented in the *senario* cannot be the only ones in the system [of Just intonation] because they do not fully account for stepwise motion" (Duffin, 2006, p.3). He meant that simple ratios of intervals in this tuning system continued even beyond the limits of the *senarius*, either in the successive form when the denominator exceeded the numerator by 1, e.g. halftone (15:16), or by incorporating the interval inversions, e.g. minor sixth (5:8) as an inversion to the major third (4:5). *Just intonation* was considered by many to be the purest, most harmonious, and pleasant-sounding tuning system (Barbour, 1938, p.48; Zweifel, 1994, p.91) because it supported the natural character of the overtone series. That is also why its intervals were referred to in terms such as *perfect* or *pure*. One of the novelties of *just intonation* was the significance of chords (multiple intervals played together) over single intervals. In spite of its much-praised acoustic purity and the consonance of major and minor thirds, it shared with *Pythagorean tuning* one major disadvantage. It was 'just' for one (major) key. Any other key meant that any instrument with fixed tuning had to be re-tuned.

Equal temperament, which is the most popular tuning system nowadays, provided a compromise between acoustic purity and unrestricted key modulation. It was based on a constant ratio between successive halftones, equal to $\sqrt[12]{2} \sim 1.059$ (Darling, 2019a). The reason for having exactly $\sqrt[12]{2}$ was rooted in the chromatic scale of one octave, which consisted of 12 halftones. If the octave ratio was exactly 1:2, we needed 12 steps of size $\sqrt[12]{2}$ to regain a fundamental tone one octave higher. *Equal temperament*, with the commencement of key modulations and polytonality was essential, even at the cost of sacrificing perfect harmony of sound. (And in any case, it must be said that this slight disadvantage of interval *impurity* in *equal temperament* was perceptible only by a very(!) small fraction of the population.

MUSICAL ANALOGY

"The rule of these proportions is best gathered from those things in which we find Nature herself to be most compleat and admirable; and indeed I am every day more and more convinced of the truth of Pythagoras's saying, that Nature is sure to act consistently and with a constant analogy in all her operations: from whence I conclude the same numbers, using which the agreement of sounds affects our ears with delight, are the very same which please our eyes and our mind. We shall therefore borrow all our rules for the finishing of our proportions from the musicians, who are the greatest masters of this sort of numbers, and from those particular things wherein Nature shows herself most excellent and compleat: not that I shall look any further into these matters than is necessary for the purpose of the architect…." (Alberti, 1955, pp.196-197)

This quote from Alberti comprehensively illustrates the ideas presented in the Renaissance, which was strongly rooted in the beliefs of Antiquity. Beauty was understood as an objective quality, which could be attained if generally accepted rules were followed. These rules were inextricably connected to proportion. Furthermore, the Renaissance drew a strong parallel between the beauty of proportion in music and architecture, in the shape of a musical analogy.

And it was precisely Leon Battista Alberti (1404-1472), the Italian Renaissance architect and writer, who laid the theoretical foundations for the musical analogy. Alberti's theory was grounded on knowledge about Pythagorean consonant intervals and applied to the dimensions of horizontal planes, or *areas*. Alberti proposed three categories, according to the scale of the rooms; three *areas*, with the following three variations for optimal ratios: the small *area*, with ratios 1:1, 2:3 and 3:4; the medium *area*, with ratios 1:2, 4:9 and 9:16; and the large *area*, with ratios 1:3, 3:8, 1:4 (Frascari and Volpi Ghirardini, 2015, pp.624-625). The fact that Alberti in practice also used a ratio of 3:5 anticipated the changes that would come in the next century.

If we looked closer at the proposed ratios for *areas*, we would notice that not all of them were true ratios of musical consonances! Two of them – 4:9 and 9:16 – were actually dissonant when played. In order to understand the logic behind Alberti's suggestions, let us look more closely at the method that Wittkower called the *generation of ratios*. Firstly, the ratio 4:9, corresponding to a ninth interval (major second above an octave) was created by *layering* two consonant perfect fifths 2:3, mathematically expressed as 2/3 x 2/3 = 4/9. Wittkower explained that the ratio 4:9 could also be understood as a result of *layering* ratios 4:6 and 6:9 (both were variations of interval 2:3, expressed as a compound fraction), 4/6 x 6/9 = 4/9 (Wittkower, 1988, pp.114-115). Secondly, ratio 9:16 was created by *layering* two consonant perfect fourths 3:4, 3/4 x 3/4 = 9/16, which again resulted in a dissonance. It could also be understood as a compilation of ratios 9/12 and 12/16 (both were variations of interval 3:4, expressed as a compound fraction) because 9/12 x 12/16 = 9/16. Wittkower argued that "nothing shows better than this that Renaissance artists did not mean to translate music into architecture, but took the consonant intervals of the musical scale as the audible proofs for the beauty of the ratios of the small whole numbers 1:2:3:4" (Wittkower, 1988, p.116). Alberti's method may be described as constructing composite ratios rooted in the tradition of Pythagorean consonant intervals. Wittkower named the outcome of this process a *polyphony of proportions*.

In order to translate 2D *areas* into three-dimensional space, Alberti proposed the medians for determining the third dimension, the height. Arithmetic or the harmonic mean were applied to extremes of short or double square areas. For longer rooms, the height defined by this method would be excessive, so a second intermediate dimension was needed (Padovan, 2002).

A century after Alberti, the Italian Renaissance architect Andrea Palladio (1508-1580) was also a significant proponent of a musical analogy. According to Scholfield, although Palladio did not write a theoretical script on musical analogy like Alberti did, from the practice, it was evident that musical consonances played an important role in his practice.

Like Alberti, Palladio had his own list of ideas for ideal shapes of rooms, he wrote: "The most beautiful and proportionable manners of rooms, and which succeed best, are seven, because they are either made round (tho' but seldom) or square, or their length will be the diagonal line of the square, or of a square and a third, or of one square and a half, or of one square and two thirds, or of two squares" (Palladio, 1965, ch.1.XXI.27). In other words, Palladio prescribed ratios for rooms: 1:1 (circle or square), 1: √2 , 3:4, 2:3, 3:5, 1:2. With the exception of 1: √2, all ratios were musical consonances. Moreover, unlike Alberti and Francesco Giorgi, Palladio offered not only Pythagorean consonances (Padovan, 2002, p.244), but the changing musical theory of the 16th century and its *just intonation* has influenced architecture by the incorporation of *just* or *pure* consonances as well.

For the heights of the rooms, Palladio built on the mathematical means like Alberti did, but, unlike Alberti, he introduced all three means – harmonic, arithmetic and geometric – as possible methods for defining only the third dimension of the room. Although Palladio pointed out that the geometric mean might be used only in certain cases, all three dimensions were expressible as whole numbers.

Of all the novelties introduced by Palladio, the *fugal system* – as Wittkower called it – was one of the largest. Wittkower stated that: "The systematic linking of one room to the other by harmonic proportions was the fundamental novelty of Palladio's architecture" (Wittkower, 1988, p.113).

Since the proportionality of a building is a relationship of parts to parts, but also of its parts to the whole, Scholfield drew attention to the fact that both Alberti and Palladio had failed in fulfilling the second part of the relationship. "Alberti limits himself to considering the three separate dimensions of individual rooms. Although Palladio often deals with a succession of rooms in plan, we have no evidence as to how he dealt with the problem of adding their dimensions together to form the overall dimensions of the house of which they were parts"(Scholfield, 1958, p.75).

A detailed description of the later evolution of musical analogy would go beyond the scope of this thesis, which is why only a brief summarization is provided here. In the 16th century, musical analogy was further supported by the works of Francesco Giorgi (1466-1540), Vignola (1538-1545) and Gerolamo Cardan (1501-1576). In the centuries that followed, the ideas of musical analogy spread further out, from Italy into France, where François Blondel (1618-1686) advocated it; into England, represented by Robert Morris (1701-1754), who addressed the issue of excessive room height as defined by Palladio's methods with a recommendation to have seven ideal three-dimensional rectangular forms appropriate for the cold climate of England; and, last but not least, musical analogy was revived in Italy when Ottavio Bertotti Scamozzi (1719-1790) rediscovered Palladio's legacy.

Wittkower wrote "With the rise of the new science the synthesis which had held microcosm and macrocosm together, that all-pervading order and harmony in which thinkers had believed from Pythagoras' days to the 16th and 17th centuries, began to disintegrate" (Wittkower, 1988, p.143). The new discoveries and scientific developments provided a strong base for the later critique of musical analogy.

The critique began in the 17th century, when Claude Perrault (1613-1688), Blondel's contemporary and rival argued that the sensations perceived through the ears, and those perceived through the eyes were of significantly different nature and a parallel between them could not be drawn (Perrault, James and Sturt, 1708, ch.IV).

Further works, such as *Sensations of Tone* (1862) by Hermann von Helmholtz, *The Physical Basis of Music* (1913) by Alexander Wood, and *Science and Music* (1937) by Sir James Jeans supported Perrault's opinions, through a scientific lens. Scholfield stated that it was in fact the structure of the ear that was responsible for the harmonious sound of the consonant intervals, and not the simple ratios. "It is thus primarily a physiological phenomenon depending on the structure of the ear, and not purely a psychological phenomenon depending on the recognition of simple ratios by the mind itself"(Scholfield, 1958, p.74).

In my opinion, the main problem of musical analogy lies in an assumption, that the ratios of musical consonances were more appropriate for delivering *well-proportioned* architecture than the others. As a consequence, a hegemony and at the same time monotony was created. The architectural musical analogy lacked the flexibility and variability which a musical theory did possess – but harmonic progressions, key modulations, polytonality and even inclusion of dissonances were all beyond the reach of the musical analogy's limited view. In the book *Architecture and Mathematics from Antiquity to the Future*, in the chapter *From Renaissance Musical Proportions to Polytonality in Twentieth Century Architecture*, Radoslav Zuk presented a contemporary extension of musical analogy when he considered tonal modulations as being a change of the rotation angle of the whole system and polytonality as the presence of multiple tonal modulations at the same time. In this connection, he said: "A work of architecture where the spaces and/or volumes intersect at distinct angles, and are therefore experienced simultaneously, may be compared to a polytonal composition" (Zuk, 2015, p.581). On the other hand, even when attempts to extend the limited musical analogy were made, unfortunately, they abounded in complexity, and could not be translated into architectural practice.

Nonetheless, if there are still doubts the profound power of musical consonances and their parallel in architecture, let us look at this topic from the opposite perspective. In architecture, the golden ratio occupies a special place for many: an extraordinary, beautiful ratio. And it is precisely the golden ratio which embodies the ambiguity between proportions in architecture and music. The golden ratio ϕ, $(1+\sqrt{5})/2 \sim 1.618\ldots$, when *translated* into music as the frequency (not string division!) ratio $\phi : 1$, "is in its effect quite discordant, as it falls (not evenly) between the Major and the Minor Sixth. It is not one of the accepted musical dissonant interval ratios, such as 9:8 or $\sqrt{2}$:1, which […] form part of distinct musical structures"(Zuk, 2015, p.573).

When looking at proportion in architecture, it is always important to ask what is significant for the eye, and what is not. What differences is it not capable of detecting? I agree with Scholfield's statement that it is not the specific ratio that strikes the eye, but rather, it is the repetition of the same figure (Scholfield, 1958, pp.5-6). And together with its additive properties – the ability to create bigger figures of the same system by combining multiple smaller figures – makes one proportional system more suitable than the other. Rational (commensurable) proportional systems, including systems of musical analogy, do indeed have fewer additive properties than the irrational (incommensurable) systems (Scholfield, 1958, pp.11, 75).

That is why I do not consider a musical analogy necessary for the design of *well-proportioned* architecture: rather, what is necessary is a flexible proportional system equipped with numerous additive properties.

PHILOSOPHY

The cross-circular presence of proportion theory in various fields is best described in the so-called *music of the spheres* (or *musica universalis*). Pythagoras is once again considered as its father. The concept represented by the *Music of the Spheres* is that both the macro- and the microcosm are ordered by the same universal rules, and the ratios which produce harmonious sounds in music – consonant intervals – are the very same in astronomy, which describes the relationships between the spheres. This theory, born in classical Antiquity,

which reached its peak in the 16th-17th century, was more or less present until the 19th century. Although it underwent numerous changes through the centuries, the core belief remained the same. Let us take a brief look at its historical development, which is exhaustively explored in *The Harmony of the Spheres*, by Joscelyn Godwin.

Although Pythagoras did not anchor this idea in a written theory (Kinkeldey, 1948, p.30), it is known that he believed in a geocentric universe, with the Earth at its centre – still, unmoving – and the known celestial bodies – Moon, Mercury, Venus, Sun, Mars, Jupiter and Saturn – revolving around it at constant speeds (Proust, 2009, p.358). Pythagoras thought the distances between planets corresponded to consonant intervals. The median of the two-octave system was the Sun, hence it was distanced an octave from Moon and in the opposite direction, an octave from Saturn. On the one side, between the Sun and the Moon were Venus and Mercury, matched to perfect fourth and perfect fifth from the Sun, respectively. On the other side, between Saturn and the Sun were Mars and Jupiter, again at perfect fourth and perfect fifth interval distance, respectively (Heinz, 2005, p.32). George L. Rogers brought the idea of the Pythagorean "spheres" closer when he wrote that they "referred to transparent, concentric crystal spheres that were thought to carry the sun, moon, planets, and stars around the Earth"(Rogers, 2016, p.43). This idea was comparable to Keppler's vision, later on, when he assumed five regular polyhedrons inscribed to the orbits of celestial bodies.

The continuity of the Pythagorean tradition is found in Plato's *Timaeus*, in which the section *world-soul* described how Demiurge created the cosmos. In *Timaeus*, the identical mixture of Same-Different-Being which gave rise to the numerical order in the world and harmonious intervals in music is used to create the universe – they are both rooted in the Pythagorean philosophy of perfect fifth interval (2:3). Plato wrote: "Next, he [Demiurge] sliced this entire compound in two along its length, joined the two halves together center to center like an X, and bent them back in a circle" (Platon and Zeyl, 2000, p.21:35b-c). Plato differentiated between the external (circle of sameness) and internal (circle of difference) circles, while the internal one was further divided so as to produce the seven unequal internal circles. The external circle, embracing the whole universe, corresponded to a movement of fixed stars and it revolved "laterally towards the right hand", while the internal circles, in contrast, related to orbits of seven "wandering" stars (Moon, Mercury, Venus, Sun, Mars, Jupiter and Saturn) revolved "diametrically towards the left". Naturally, the Earth was at the centre of this universe. Plato's vision was one of the most complex of the ancient beliefs about the creation of the world.

Aristotle, who, as we know, was Plato's disciple, had quite different notions on the subject. His criticism became crucial for the evolution of the *harmony of the spheres* up to the Middle Ages. He argued that the spheres did not produce any audible sounds, because, given their enormous mass, the effect of the sound would be exceptionally violent (Heinz, 2005, p.43).

Nicomachus of Gerasa (50-150 AD), who further developed the Pythagorean-Platonic tradition, concluded that the sounds of the planets, which "circle without respite, whistling in the ethereal vapor" (qtd. in Godwin, 1993, p.10), were differentiated according to: their size, their speed, their position, and the medium in which they revolved. Although the planets produced harmonies, they were inaudible to human ears. He drew a parallel between the names of the sounds and those of the seven celestial bodies, where the Moon - *nete*, Venus – *paranete*, Mercury – *paramese*, Sun – *mese*, Mars – *hypermese*, Jupiter – *parahypate* and Saturn – *hypate* produced from the lowest to the highest sound, respectively.

A quite unique perspective on the matter was held by Ptolemy (127-148), an Alexandrian astronomer. In the *Book III* of his *Harmonics*, Ptolemy drew a strong correlation between music and astronomy. The connecting component was the assumption that rational order could be found in everything that is regulated by nature. Ptolemy considered the stars' and the soul's movements to be the "most complete and rational" (qtd. in Godwin, 1993, p.25). He based his theory on the two-octave perfect system and its twelve whole-tones compared to the twelve houses of the Zodiac. Ptolemy illustrated this concept by a circle, proportionately divided according to the Pythagorean consonant intervals, and he associated every division point with a specific house of the Zodiac. Ptolemy's ideas, together with Aristotle's (who came later), played a major role in the Middle Ages.

Boethius (480-524), who acknowledged Nicomachus' thoughts, among others, was an important figure on the cusp between classical and medieval beliefs. He distinguished three types of music: *musica mundana* (played by the celestial bodies), *musica humana* (encountered in the human body and soul) and *musica instrumentalis* (sung music or music played on musical instruments). Boethius' theory was special, as he sought a balance between the theories of Plato and those of Aristotle. (Although he sometimes paid a price for this when he presented two contradictory notions, which led to a lack of consensus (Godwin, 1993, pp.86-88).)

As Werner Heinz wrote in his book *Musik in der Architektur*, although the Medieval Age continued in the Pythagorean-Platonic vision of the cosmos, represented by the School of Chartres in the 11th-12th century, with the full acceptance of the Aristotelian critic of the *harmony of the spheres* in the 13th century, the theory went through its eclipse. Only later were the classical ideas revived again (Heinz, 2005, pp.46-47).

The biggest peak in the *harmony of the spheres* came with Johannes Kepler (1571-1630) in the Baroque. Kepler accepted the pioneering new Copernican heliocentric theory, in which the Sun – and not the Earth – occupied the central position in the universe, and he added his thoughts summarized in three laws. Kepler presented two significant contributions to the *musica universalis*: firstly in his *Mysterium Cosmographicum* in 1596 and later in *Harmonices Mundi* in 1619. In the first book, Kepler correlated distances between the planets using a Platonic regular polyhedron "octahedron between Mercury and Venus, the icosahedron between Venus and the Earth, the dodecahedron between the Earth and Mars, the tetrahedron between Mars and Jupiter and finally the cube between Jupiter and Saturn" (Proust, 2009, p.362). In the second work, Kepler introduced his laws of planetary motion. First law: "All planets move around the Sun in elliptical orbits, with the Sun as one focus of the ellipse"; second law: "A radius vector joining any planet to the Sun sweeps out equal areas in equal lengths of time"; and third law: "The squares of the sidereal periods (*P*) of the planets are directly proportional to the cubes of their mean distances (*d*) from the Sun" (Britannica Editors, 2021). In other words, he assumed that planetary orbits were not circular but elliptical and the velocity of a specific planet changed according to its remoteness from the Sun. This angular

velocity was fastest when the planet was closest to the Sun (at Perihelion) and the slowest when furthest from it (at Aphelion). Lastly, the third law defined the interrelations between the planets. His shift in the theory of the *harmony of the Spheres* lay in the notion that it was not the distances between planets that produced harmonic relations, but the range of their velocity. To every planet he allocated a specific interval, starting with the unison of Venus and ending with the minor 10th of Mercury (Rogers, 2016, p.46). Kepler pointed out that these intervals should not be understood as an intermittent stepwise motion, but rather as a continuous glissando. Thus, Kepler's cosmic music was inaudible, even though it demonstrated the harmonic order of the universe.

Sir Isaac Newton (1642-1727), most famous for being the great physicist of the Age of the Enlightenment, built on Kepler's knowledge not only in the realm of physics, but in the subject of the *music of the spheres*, too. His "inverse square law" was true, and not only when applied to planets. Newton made an analogy between the force of gravity acting on planets and the tension acting on the strings of a musical instrument (Rogers, 2016, p.45). He stated: "But by this symbol, they indicated that the Sun by his own force acts upon the planets in that harmonic ratio of distances by which the force of tension acts upon strings of different lengths, that is reciprocally in the duplicate ratio of the distance"(qtd. in McGuire and Rattansi, 1966, p.116). In addition, Newton came up with a unique association, when he linked the seven planets of the universe, the seven notes of a scale and the seven colours of a spectrum (Proust, 2009, p.364).

Even after Newton, the theme of the *musica universalis* was addressed numerous times. However, the most fundamental milestones regarding this topic have already been discussed. Hence the exploration of the subject ends here.

SUMMARY

In this chapter, we have provided first insights on the theme of proportion, which we explored from three different perspectives, namely from the perspective of architecture, of music, and of philosophy.

In architecture, the categorization of proportional systems into two families – rational (also arithmetical, commensurable), and irrational (also geometrical, incommensurable) – was introduced. And whereas most of the proportional systems are clear advocates of one of these families, the modern principles of the 20th century built a bridge between both families, taking from each their specific advantages. Scholfield's contemplation on the subject, what aspects are significant to the eye, is also not negligible. He argues that, first, the repetition of the same shape, second, the repetition of the same shape and size, and third, the repetition of the same size but different shape, are decisive. He also states that the first aspect of these three is the most important (Scholfield, 1958, pp.5-6). We have also witnessed the historical shift in the perception of proportion from a concept of absolute beauty, rooted in the classical Pythagorean-Platonic tradition, to relative beauty, shaped by scientific progress in the Age of Enlightenment.

In order to understand the connection between proportion in architecture and music, a closer exploration of musical intervals was necessary. As defined earlier, interval is "the amount by which one note is higher or lower than another"(Cambridge Dictionary Editors, 2021). Pythagoras described the formation of intervals in relation to the division of a string – e.g. the octave interval corresponds to the 1:2 ratio (division in the middle of the string), the perfect fifth to the 2:3 ratio, and the perfect fourth to the 3:4 ratio. These intervals, together with the unison, 1:1 ratio, were labelled consonant intervals (harmonious) and for many centuries were considered more beautiful than their counterparts, the dissonant intervals (disharmonious). No wonder mathematical figures such as Tetractys and Senarius were deeply interconnected with them (although Senarius was influenced by the extended version of consonant intervals, including thirds and sixths, introduced in the Renaissance). These consonant intervals expressed by single ratios gave rise to the so-called musical analogy, the greatest supporters of which were the Renaissance architects Leon Battista Alberti and Andrea Palladio. They applied the interval's ratios to their architectural design in the belief of absolute beauty and its mighty power. At the same time, we must keep in mind the changing nature of the interval's ratio according to the tuning system (*Pythagorean tuning, just intonation, equal temperament*).

Lastly, proportion in philosophy revealed itself in the form of *music of the spheres* – a central topic of many philosophers throughout the ages. Once again, its origins can be traced back to Pythagoras, who is considered the father of this concept. And although we are now in the field of philosophy, we are in essence encountering the same idea, just "dressed up" differently. It is the idea that the micro- and macrocosm are ruled by the same universal rules. It was believed that the harmonious intervals, with their corresponding ratios in music, were the same ruling force for relationships between cosmic spheres in astronomy. This notion had undergone a number of variations throughout history, nicely described by Joscelyn Godwin in his book *The Harmony of the Spheres* –from the belief, that musical intervals embodied the distances between spheres, to the concept of their correspondence to the changing velocity of the spheres, or even their linking to the colours of a spectrum.

As we can see, the theme of proportion encompasses a vast field of study, and much more could be said – but I have tried to at least provide an exploratory outline in this chapter.

CHAPTER 1 // PROPORTION: HISTORICAL BACKGROUND

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CHAPTER 2 // PROPORTION: CONSTRUCTION

The theoretical background of the matter of proportion is already familiar to us from the previous chapter *Proportion: Historical Background*, but its practical complement has not been given proper attention – yet. Thus, this chapter *Proportion: Construction* will be all about the shift to the practical realm: we will discuss the tools which are necessary for this purpose, the techniques and methods which are used in practice, and we will finish by exploring the controversy surrounding the topic of precision. Because the assertion, "the whole course of practical architecture requires, in all its details, the most minute and indefatigable exactness of execution"(Rogers and Bartholomew, 1886, p.1), is not as unambiguous as one might think.

In fact, I must warn you against blind acceptance of historical treatises on practical architecture, since practical and *practical* are two different things. In the article *Why Didn't Historical Makers Need Drawings? Part I*, the authors stated, "attempts to develop practical geometry in a theoretical context, with propositions and proofs, were generally ignored, not the least because the users of practical geometry – the masons, surveyors, carpenters, and so on – were unlikely to be able to read Latin texts"(Birkett and Jurgenson, 2001, p.251). Hence the works as *Practica Geometriae* (de Clavasio, 1346), *Practical Geometry* (Rudd, 1650), *Architecture Pratique* (Bullet and Séguin, 1788), etc., need to be assessed with circumspection. Nonetheless, there is one rule of them which could help us here: in practice, the most commonly-used techniques are the easiest and most straightforward ones.

It is also worth noting the importance that Birkett and Jurgenson attributed to the utilization of a module. Although their focus was mainly on crafts, they stated more than once that "architectural thinking was central to all the crafts-"(Birkett and Jurgenson, 2002, p.183). The implication is that the module played a key role in architecture in the first place. In this regard, they mentioned two methods for its application, either indirect or direct: "this construction of dimensions within the object can be accomplished either indirectly, by physically marking out dimensions using dividers and (or) a modular scale, or directly, using geometrical constructions"(Birkett and Jurgenson, 2001, p.246).

Now we can begin our exploration of the topics of this chapter.

TOOLS

"Geometry, also, is of much assistance in architecture, and in particular it teaches us the use of the rule and compasses, by which especially we acquire readiness in making plans for buildings in their grounds, and rightly apply the square, the level, and the plummet" (Vitruvius, 2012, b. I.I.4). This passage, from Vitruvius' first book of *The Ten Books on Architecture*, directs the reader's attention to the connection between geometry and the essential tools for its application. He mentioned rule, compass, square, level, and plummet, although in the other parts of his voluminous treatise we come across cords and pegs, too (Vitruvius, 2012, b. VII.III.2,5).

In other written evidence, *Vita Sancti Oswaldi IV* [The Life of Saint Oswald IV], this time from medieval times, Oswald "sought most keenly for masons who would know how to set out the foundations […] with the straight line of the rule, the threefold triangle and the compasses" (qtd. in Harvey, 1972, p.107).

In order to provide a multi-layered view on the topic, let us also include the authors' perspective from the article *Why Didn't Historical Makers Need Drawings?* They declared, "compasses (also called dividers), straightedge, and set squares were the layout tools of the craftsman. […] Master masons are frequently portrayed in paintings holding these layout tools, or placed beside them in their burial imagery" (Birkett and Jurgenson, 2001, p.253).

Rule, straightedge, cord, pegs, compass, square (or triangle), level, and plummet – these are the tools mentioned in previous paragraphs. These are all instruments that architects and builders needed to realise their architectural visions. In this section, those related to proportion will be examined in more detail.

However, before we focus on these tools, we will need to classify them into two categories. The first category comprises tools used to construct proportions when drawings are being drafted, and the second comprises tools used to construct proportions directly on-site. The theme of proportion is ubiquitous in the architectural process, starting with the building plan and ending with the building itself. To mediate the architect's ideas on proportion so they could be realized, the following instruments were used in the past.

ROD, CORD AND PEGS

Nowadays, if a builder is entrusted with constructing a house, we may with confidence claim that we will find a thoroughly-marked rule among his working tools. The same is true for any other craftsmen. If, for instance, a carpenter is entrusted with the construction of a storage cabinet, he will use a marked rule, for sure. Nevertheless, the situation in the past was notably different. Percy Blandford in his book *Country Tools and How to Use Them* stated, "[…] yet in the not very distant past a craftsman would go through most of his working day without using any such measuring device"(Blandford, 2012, p.127). In this context, the following question arises: How did historical builders (and craftsmen) manage to construct without using a marked rule? Well…

Firstly, as already discussed, the workers usually could not read; and not only could they not read Latin, they could not read at all – mathematical figures included. "Counting in five was common" (Blandford, 2012, p.127). That means that even if they had possessed a *precisely marked rule*, it would have done more harm than good, and just caused more confusion. This brings us to the

second reason, which is that, until the Industrial Revolution, the accuracy of *precisely marked rule* was dubious. This was because, without any ways and means of reliable duplication, every rule could be different – not to mention the regional variations. Thirdly, the absence of a marked rule can also be explained by its lack of usefulness. If the building was erected locally – without having to align with other measurements– a builder could use a rod with a fixed measure, to be used for the current project, or measure parts against each other.

Historical literature such as *The Construction and Principal Uses of Mathematical Instruments* (Bion and Stone, 1972) first published in 1758 at the beginning of the Industrial Revolution, described several existing types of marked rules: the *carpenter's rule*, the *four-foot gauging rod*, *Everard's sliding rule* and *Cogeshal's rule,* although, for the reasons mentioned above, I doubt they were in common use, at least, not until the Industrial Revolution was more advanced.

In actual fact, the rod, also known as the "stick", was the essential tool of a historical builder. Blandford suggested that the "measurements of length were often compared with *rods*, which were straight-edged pieces of wood on which all the vital sizes were marked" (Blandford, 2012, p.129-130). They were used only as references, therefore *absolute* accuracy was not prioritized, but *relative*. A number of historical depictions of architects holding unmarked yardstick in their hands would support this claim (Hiscock, 2018).

Before the standardization of working tools, the builders used any straight hardwood stick, made a few relevant notches – usually in the form of symbols rather than figures – and their measuring tool for the specific project was ready. The rod was already commonly used in ancient times, when the units of the same system of measurement were not necessarily multiples of each other, but the sets of length units were easily calibrated on it (Tavernor, 2007). From this primary rod, additional rods were created by comparing them with the first one, so that there were enough measuring rods for the whole construction.

Furthermore, the rod was used to construct the proportions of the building effortlessly, as any rational ratio – for instance, 1:2, 3:5, 5:8 – was the multiplication of the measuring unit.

Nevertheless, by itself, the rod was not sufficient for the building process. The cord and pegs were vital as well. They were utilized on building site as a substitute for draughting tools, rule and compass: "[…] which [referring to geometrical figure] could then be subdivided into parts by 'geometrical rules and methods', using rule and compass on a drawing, or a cord and pegs on site" (Hiscock, 2018, ch.5). Regarding their uses, Hiscock continued "thus by swinging arcs with a cord from one peg after another, squares, double squares and the sides and diagonals of squares would result and possibly wall thicknesses could be determined" (Hiscock, 2018, ch.9). In other words, they were the solution when the length of the rod was insufficient and multiplication was therefore impractical; when the arcs and circles were to be traced on the ground, or when the angles needed to be checked.

Evidence that the use of cord in construction has a long tradition is provided, inter alia, by the *Sulvasutras*, a Hindu sacrificial-fire-altars-construction manual of the ancient Indus River Valley Civilization, thought to date back to the first millennium BCE, as the name of *Sulvasutras* literally means *the rules of the cords* (Richeson, 2021, p.86).

The important role of the cord can be inferred from other historical sources, too, such as the story about the dream of a Medieval monk named Gunzo. This story will be further discussed in the section *Precision*.

In *The Construction and Principal Uses of Mathematical Instruments*, the author discussed technical specifications of cord and pegs in more detail. Firstly, in the case of the cord (also string, or line), the material of which it was made was very important. Any stretchy materials were inappropriate; instead, well-twisted packthread or whipcord were suitable. Sometimes, alterations to the basic cord were made, when the chain was formed, instead. The shorter segments of the cord were connected with brass circles, where the pegs were inserted. Secondly, the pegs (also known as staffs) were manufactured from hardwood, for optimum moisture- and weather resistance. One end was cut at an angle and then the iron caps were fitted onto it. The pegs were commonly 2 to 3 feet long, but other lengths were possible as well. Their visibility from a longer distance was paramount. Analogous to the cord-chain transformation was the pegs-fathom. The fathom (or toise) consisted of one-foot-long parts, joined by little rings or brass pins. The resulting tool was a six-foot-long round staff (Bion and Stone, 1972).

The cord and pegs were highly important for proportion, as not only rational proportions were constructible – via a chain, or fathom usage – but also irrational ones – via a cord and pegs. Moreover, the various geometrical figures were no problem for these tools. Circle, arc, square roots, irrational figures, or rational ratios – they were all possible with cord and pegs.

<u>SET SQUARE</u>

Another construction tool of high significance, which was relevant as far back as Vitruvius' times, was the set-square, which usually consisted of two unequal arms set at right-angles. It was made of metal or wood, although with wooden set square one had to be careful, as inaccuracies could result due to changing moisture content.

Set squares were produced in different types and sizes used according to the purpose. They were used both for drafting and on the building site. According to Hiscock, in the Middle Ages, use on the building site prevailed "it is with this mason's square, not an architect's set square, that they [architects in 13th century portrayals] are depicted"(Hiscock, 2018, ch.5). The set squares for draughting were considerably smaller, unlike those necessary for construction on-site. The latter had two- to three-foot-long arms, sometimes even longer, usually supported by a diagonal piece between them (Roubo, 1769, p.70).

The primary function of set square was to construct and identify right-angles. However, they were also used to construct geometric means, as well as for linear division in equal parts. We will discuss set squares further in the section entitled *How to…*, as well as presenting the valuable ideas from the book *R's Method of Using Ordinary Set Squares* (Roberts, 1927). In his book, Harry W. Roberts presented the uses of the set square, e.g., in the construction of polygons, curvatures, parabolas, hyperbolas, or the ratio of the scale of music. However, given that the instructions become increasingly complex, I am quite sceptical about their usefulness in architectural practice.

As an aside, the geometric mean of two figures can be constructed in numerous ways, including the method using set squares. However, the *mesolabio* is the tool most commonly associated with the geometric mean. This tool, linked

to an ancient oracle when "the god Apollo ordered a marble altar that had to be the double of the existing one" (Rossi, Russo and Russo, 2009, p.63), has undergone multiple significant changes over time. Eratosthenes, who invented the *mesolabio*, came up with the first documented solution. His version consisted of three rectangle tablets, which shifted on two parallel rules. However, the more famous version is the one built by Albrecht Dürer in the Renaissance, consisting of a grooved L-shape to which a sliding rule with an equally long arm was connected. In the Renaissance, these *mesolabia* found application in the division of musical intervals, practicing the musical analogy.

We know that there are various types of set squares, including, for example, the *fixed set square*, which is stabilized at one position, with its arms defining a right-angle; the *try set square*, which opens and shuts, so the angle of the edge could be identified. The triangular set square is also worth mentioning. Although some architects and writers consider these to be a separate category of tools, in this thesis, I will include all these types in the term "set square". According to the length of the triangular arms, we differentiate between *45°*and *60°.30° set squares* (or occasionally, any other arbitrary angle variation). To complete the bigger picture, one could also encounter a *mitre-square*, *round-square*, or *centre-square* – however, since they are used in furniture manufacture, and not in the building construction, it is not necessary to provide a detailed description here (Blandford, 2012).

Lastly, in the context of proportion, it is important to emphasize the ability of the set square to divide lengths into equal parts. Roberts successively manifested the division of a line from one-half to one-twelfth, using only 45°and 60°.30° set squares. To sum up, I consider the most significant qualities of the set square to be its versatility and simplicity, both at the same time.

<u>COMPASS</u>

Like the size of the set squares adapt them either to draughting or construction on-site, the same is true for the compass. The compass, quite a general term, refers to a large number of different tools which share certain similarities. A compass is usually a two-pointed tool, with equally long arms, connected on one side by a joint, so they may increase or decrease the distance between the two ends, as required. Such an apparatus was already in use in Antiquity, to construct circles or ellipses, compare distances (but not only), step off equal spans, or sometimes even more.

The imposing variety of compasses is best seen in the Renaissance, when this tool came into its own. About the compass, Richeson wrote, "By the Renaissance, the term "*compass*" (or "*compasses*") referred to a variety of tools that could draw circles, ellipses, and other conic sections (*drawing compasses*), transfer distances (*dividers*), scale figures by some fixed ratio (reduction compasses), measure spherical or cylindrical objects (*calipers*), transfer distances on maps (*three-legged compasses*), and perform calculations involving ratios (*proportional compasses*)"(Richeson, 2021, p.228). To this long list we should add the *sector compass*, a highly sophisticated mechanical calculator with various scales on its two arms.

In the following paragraphs, we will focus on the three types of compasses that are most closely related to the subject of proportion, namely, the divider, proportional divider, and sector compass.

This is what Hiscock had to say about them: "The dividers shown are not to be mistaken either for the architect's small-scale draughting instrument, being instead the large dividers often held with a single or double stay that were used for describing arcs full-size on a tracing-floor and for making templates" (Hiscock, 2018, ch.5). Blandford provided a different view, one more relevant to us now. Although various compass types – e.g. callipers, or sector compasses – are not used anymore, as a rule of thumb, they could be distinguished by their ends. When their ends were both made of metal, they were considered to be a divider; but if one end was replaced by a pencil, or pen, it was called a compass. However, it is important to keep in mind that dividers are part of the bigger set of compasses, not vice versa.

As we know, dividers used to be used on building sites to mark out distances or to trace arc-like figures. With their arms easily over one metre in length, they were helpful to historical building masters in fulfilling the proportional system requirements (Dividers, n.d.). Nevertheless, for reasons of dimension, the geometric figures traced by the dividers often had to be magnified. If such a process was considered unsuitable, one could use, instead, the cord and pegs for building, or trammels (a beam compass) for furniture construction.

The other two instruments, the proportional divider and sector compass, are unlike the previously mentioned tools, and were commonly used only in draughting.

The proportional divider has two arms grooved lengthwise, and because of the adjustable screw positioned not at the ends but at the middle, are four-pointed, opening like scissors. The scales grooved on their arms vary according to their purpose, but the two most common scales are the scale of lines and the scale of circles.

Despite the fact that they have been around for at least 400-hundred years, their design has remained more or less the same, and they are still used by artists today. For what purpose were they and are they used? Well, because the proportional dividers can augment or diminish linear dimensions in a specific ratio, or divide a line in equal parts (Bion and Stone, 1972, p.79) – all conceivable due to the principle of triangle similarities – they were (and are) valued mostly for the reproduction of paintings and drawings, or possibly in architectural design focused on proportion.

Since in the next section, entitled *How to…*, the construction of π will be examined, it is worth mentioning that the proportional divider's "one interesting special ratio which is usually designated on the scale of lines is π. By using the setting, any circle can be *rectified*" (Pinette, 1955, p. 91).

Although many people believe that Galileo Galilei invented the sectorial compass in 1604, it was actually invented in 1568 by Guido Ubaldo del Monte, and even before that, a number of remarks could be found on this topic (Wood, 1954, p.535-536).

Although we will not be examining this instrument in-depth, a few key facts should be mentioned. The sectorial compass "was composed of two rulers, usually brass, hinged, with three or more scaled radiating from the pivot on each side of each ruler" (Wood, 1954, p.535). The selection of the scales depended on the tool's intended purpose. However, some were more common than the others – lines of chords, lines of solids, lines of equal parts (also lines of lines), lines of planes, and polygons. According to the available scale, it was possible to square the circle; add, or subtract in all three dimensions – in 1D

lines, in 2D surfaces, and in 3D volumes; draw polygons; scale proportionally or divide into equal parts (also in all dimensions); find the geometric mean, and many more. In short, we could say that the sectorial compasses were the mechanical calculators of the past.

HOW TO …

In the previous section, *Tools*, we discussed the variety of tools relevant for the construction of proportion, either on building site or on draughting paper. In this section, we will focus on the other part of the theme, namely, the practical construction of the most fundamental figures. We will start with the right-angle, proportional division, or division in equal parts, and end with the figure π (Ludolph's number), ϕ (golden ratio), θ (silver ratio), and basic root squares.

MAKE A RIGHT-ANGLE

In principle, there are three basic practical answers to the question: *how do we construct a right-angle?* and all of them are connected to the essential mathematical principles that children learn in elementary school.

The first one is based upon the well-known Pythagorean theorem $a^2 + b^2 = c^2$. In other words, we recognize a right-angle triangle when the sum of its square areas drawn upon its catheti is the same as the square area drawn upon its hypotenuse.

The theorem dates to the 6th century BCE – or possibly even earlier, since there are speculations that Pythagoras drew his knowledge from Ancient Egypt – and the Roman architect Vitruvius referenced it more than once in his work *The Ten Books on Architecture*. The following passage I find useful to quote in its full length:

"Then again, Pythagoras showed that a right angle can be formed without the contrivances of the artisan. Thus, the result which carpenters reach very laboriously, but scarcely to exactness, with their squares, can be demonstrated to perfection from the reasoning and methods of his teaching. If we take three rules, one three feet, the second four feet, and the third five feet in length, and join these rules together with their tips touching each other so as to make a triangular figure, they will form a right angle. Now if a square be described on the length of each one of these rules, the square on the side of three feet in length will have an area of nine feet; of four feet, sixteen; of five, twenty-five"(Vitruvius, 2012, b.IX,i,6).

The numbers 3-4-5 mentioned by Vitruvius are the first whole numbers which fit the Pythagorean equation $a^2 + b^2 = c^2$. The right triangle can be easily constructed, either with rods (rules) or even with a cord and pegs. Moreover, it is important to remember: the bigger the triangle constructed, the more accurate this method is.

The second method of constructing and verifying the 90° angle is using a set square. "Very laboriously, but scarcely to exactness" are the words that Vitruvius used of constructing right-angles with set squares. However, I beg to differ. Even with this construction method, the size of the set square is decisive. When the set square is intended for the work on a building site and its size is adequate for the purpose, this method is fairly precise. Moreover, the great advantages of this solution are its speed and simplicity. The builder can trace the edges of the set square to construct a right-angle or to place this tool to a built structure to assess its rectangularity.

The last method stands on the properties of the quadrangles. Because if the diagonals of quadrangles are of the same length, the examined figure is either a square or a rectangle. Nonetheless, both figures have all their internal angles right. This evaluation method of right-angles can be accomplished just with cords.

DIVIDE PROPORTIONALLY AND IN EQUAL PARTS

There are various techniques for the division of a line proportionally or into equal parts. For instance, the bisection of a line could be accomplished with a compass, alternatively, cord and pegs (when a perpendicular is run from the intersection of two circles with the same arbitrary radius and centre on the ends of a line), or other divisions into equal parts with the help of a sectorial compass, and the proportional division using a proportional divider. However, the methods listed are most suitable for drafting on paper, not for construction on a building site – except for the bisection with the cord and pegs. At the same time a technique that involves the utilization of set squares (either in triangular or in L-shape) for division is highly practical and very suitable for tracing work on-site. Thus, we shall focus our attention in this direction. Although the proposed techniques are inherently applicable on a building site, for ease of demonstration, I will refer to a division of a single line AB.

The proportional division is based upon the properties of similar triangles and for its construction, we will need only set squares. Let's begin with a single line AB, which we need to divide in ratio *x:y*. To do this, draw with a set square a new discretionary *unit* line starting from one end of line AB. The length of our new line is the *unit* multiplied by the number *x+y*, the angle between line AB and although the *unit* line can be freely chosen, it should be somewhere in the middle range of a 90°angle, otherwise greater inaccuracies may occur. Now, draw a connecting line between the open ends of line AB and the *unit* line. Remember, the division in ratio *x:y* of the *unit* line is already known since its length is determined by stepping off the *unit x+y* times. Let's call this point of division *D*. The sought division of line AB in the ratio *x:y*, we find by drawing a parallel line to the connecting line through point *D*. Parallels are achieved by sliding one edge of one set square onto the other.

Regarding division into equal parts, Harry W. Roberts presented in his book *R's Method of Using Ordinary Set Squares in Drawing and Design* simple solutions on this topic. He wrote: "I will select very easy ways to divide a line into two, three, four, five, six, seven, eight, nine, ten, eleven, twelve equal parts; using only the 60°.30° set square, except in dividing into eleven equal parts, in which case I will use also the 45°.45°"(Roberts, 1927, p.2). As mentioned before, he also explored other capabilities of set square, although these will not be described further here. Also, I will demonstrate the division only up four equal parts, as they are the most used in practice.

To bisect a line, Roberts proposes the use of the 60°.30° set square. In order to divide line AB into half, place the longer leg of the set square on line AB, so that line AB and the hypotenuse contain the 30° angle. Draw the 60° line from both ends of line AB by tracing the set square's hypotenuse. From the point of intersection of both 60° lines, run perpendicular to line AB. The point where this perpendicular meets line AB is the bisection.

As is well-known, the intersection of diagonals in a square, or rectangle, would

also contribute to the bisecting of their sides – when a perpendicular is led from the intersection point to the divided side. However, one still needs to first construct the square or rectangle to obtain the intersection of their diagonals. Again, this could be achieved with the set squares, but more laboriously.

Roberts' proposed method for trisecting of a line is again to use the 60°.30° set square. To trisect line AB, place the longer leg of the set square on one end. Draw the 60° line. From the other end of line AB, draw a perpendicular. Name the point of intersection of 60° line and perpendicular point *I*. Place the longer leg of the set square on the perpendicular line and draw a new 30° line through point *I*. The 30° line divides line AB at one third.

In addition to Roberts' method, I will briefly introduce another trisection principle, although the practical implementation is again far more arduous. This method is an extension of the previous bisection based on a square figure. Take a square with its diagonals and into this figure construct an inscribed isosceles triangle. The intersection of the square's diagonals and the legs of the triangle are the points of division from which we lead the perpendiculars to the divided side. In the 16th century, Italian Renaissance architect Sebastiano Serlio, in his *Regole* used this method to establish the correct proportions for a church door (von Naredi-Rainer, 2001, p.231). Other divisions can also be achieved by the further application of this technique: "Errichtet man dieses eingeschriebene Dreieck über allen vier Quadratseiten, so lassen sich aus den verschiedenen Schnittpunkten von Dreieckseiten und Quadratdiagonalen alle ganzzahligen Teilungen der Quadratseite bis zur Zehnteilung gewinnen" („If one constructs this inscribed triangle on all four sides of the square, then from the various points of intersection of the sides of the triangle and the diagonals of the square all integer divisions of the side of the square up to the division by ten can be obtained" Informal translation.) (von Naredi-Rainer, 2001, p.231).

Lastly, in order to quarter line AB, Roberts unsurprisingly suggests working with the 60°.30° set square. From one end of line AB, place the longer leg of the set square on this end to draw the 60° line; from the other end, place the shorter leg of the set square to draw the 30° line. Then run a perpendicular from the point of intersection of 60° and 30° lines to line AB. This perpendicular divides line AB at one quarter.

If for any reason, a division beyond twelve equal parts were required and Roberts' method were not available, the above-mentioned proportional division could be adapted for this purpose as well. The degree of universality and flexibility is considerable.

CONSTRUCT *π*

If we are looking at proportion, it's important to take a closer look at the constant π, given its frequent appearance in the visual world. This irrational constant π, approximately equal to 3.14159… . It expresses a relationship between the circumference and diameter of a circle: $\pi = C/d$. However, π also appears in other mathematical themes, as well as the physical, and engineering realm.

Although, this constant was only given the π symbol by British mathematician William Jones in 1706, and later popularized by Swiss mathematician Leonhard Euler, its first approximations can be dated to ancient civilizations. For instance, in Mesopotamia, the Babylonians (~2000 BCE) approximated π

to the perimeter of a regular hexagon inscribed into a circle. The value was $\pi = 25/8 = 3.125$. As well, the Egyptian π appeared in the Rhind papyrus (~1650 BCE), where its approximation was equal to $\pi = 4(8/9)^2 = 256/81 \sim 3.1640\ldots$. Egyptians assumed that the area of a circle was the same as of a square whose side is 8/9ths of the circle's diameter. However, Babylonians and Egyptians were not the only ones who performed rough calculations of π. Even Indians of the Indus Valley Civilization, the Chinese of Ancient China, and Christians searched for the solutions of π – some more accurately than others (Richeson, 2021, pp.81-94).

The first precise way to quantify π was proposed by Archimedes, the ancient Greek mathematician, physician, and philosopher. It was a work-intensive method involving inscribing and circumscribing regular polygons about a circle to calculate the upper and lower bounds (Britannica Editors, 2021). Archimedes came to an average value of 3.1418 from the following bounds: $223/71 < \pi < 22/7$.

The work of Archimedes highly fascinated the German mathematician Ludolph van Ceulen –and π is also known as "Ludolph's number", because he spent 25 whole years searching for a better approximation of this mathematical constant, attaining 35-digit accuracy (Lewis, 2018).

The ubiquity of the π constant is quite obvious at this point. On the other hand, the following question still remains open: what is the practical way of constructing π and relating dimensions using its value?

Although some theoreticians deny that π was the primary plan for the Great Pyramid of Giza (Richeson, 2021, p.93), constructed ~2600 BCE, and call its presence "an amazing coincidence"(Richeson, 2021, p.94), and the result of a completely different building strategy, yet these are the undeniable facts: "If we take the altitude of the pyramid and use it as the radius of a circle, then the circumference of the circle is very nearly the perimeter of the base of the pyramid"(Richeson, 2021, p.93) – a built demonstration of a mathematical problem referred to as squaring the circle. The embodiment of π in the Great Pyramid would be equal to 3.142. This is quite a precise approximation, which gave Richeson more motives to doubt π as the primary plan, since the Egyptian π in the Rhind papyrus was less precise.

Nevertheless, if we stay open to the possible interrelation of pyramid dimensions through the π value, let's look at a promising approach of how the ancient Egyptians could have achieved it. In this case, instruments which already existed at the time provide a clue: "The wheelwright and his smith used a *traveller* to compare the distance around the wheel rim and its iron tyre, without reference to feet and inches, by counting the revolutions [...] a more sophisticated version with a recording dial is used today for land measuring"(Blandford, 2012, p.131). So, if the ancient Egyptians used a wheel for pyramid construction, since the π is present in its intrinsic essence, by "counting the revolutions" its dimensions would be naturally interrelated by the π value. How elegant is that!

CONSTRUCT Φ

Divina proportione – also known as the golden ratio, golden section, golden mean, etc. – characterized by the Greek letter ϕ, is the denomination for "extreme and mean ratio". Nowadays, there is probably not a single person who has not heard about this much-praised proportion. Despite having its roots in

ancient times, the rebirth of the golden ratio happened only in the 19th century.

Since a proper description of the golden ratio has already been provided in the previous chapter, in *Proportion: Historical Background /Architecture / 19th Century: Rebirth of the Golden Ratio*, just a brief introduction will be provided here. The golden ratio is a special ratio where the larger quantity is to the whole, as the smaller quantity to the larger; mathematically formulated $(a+b):a = a:b$. If $b = 1$ and $a = \phi$, then the equation could be rewritten following $(\phi + 1): \phi = \phi:1$. Thus $\phi = (1+\sqrt{5})/2 \sim 1.618\ldots$. The term "logarithmic spiral" is closely linked to the golden ratio. The logarithmic spiral is believed to be the invisible organizing principle of organic growth rooted in the constant ϕ (Cook, 1914; Hambidge, 2012). An important feature of the golden ratio is its self-similarity, meaning that an infinite series of growth can be created. In other words, the reciprocal of the golden ratio is another golden ratio. This series of growth can be approximated by the Fibonacci series, composed only of whole numbers: 0, 1, 1, 2, 3, 5, 8, 13, 21, 34, 55, 89, 144, ... Now that we know the theoretical basics, let's look at the practical approaches to constructing ϕ.

First there is the linear golden ratio. In order to construct the golden ratio on a line, cord and pegs, and a set square are needed. Having line AB of length *L*, construct a perpendicular of length *L*/2 at one end of the line, using the set square. Make an auxiliary line AC connecting the open ends of line AB and the perpendicular. Now, with the cord and pegs, trace an arc with the centre at point C and the radius equal to the perpendicular's length. The intersection of the arc and the auxiliary line AC is point D. The last step is to trace another arc with the centre at point A and a radius of length AD. The intersection of this arc and line AB is point E, which divides line AB into the golden ratio.

Second comes the planar golden ratio. For the construction of a golden rectangle with its sides of ratio 1:ϕ the same tools are needed as for the linear golden ratio – cord and pegs and set square. With a help of a set square, start by constructing a square AFGD with side $a=1$ and its semi-diagonals of length $\sqrt{5}/2$ (utilizing the previously-mentioned methods for bisection). For the next step, make an arc with its centre in the middle of the square's side DG and radius equal to the square's semi-diagonal. Use the cord and pegs. The extension of side DG intersects with the arc at point C. Lastly, use the set square to complete the rectangle ABCD, which is the golden rectangle.

Third, adding to the category of the planar golden ratio is a pentagon (or, alternatively, a decagon) since the golden ratio is an intrinsic part of this regular figure. Probably its best demonstration is in the division of the pentagon's diagonals, which intersect themselves in the golden ratio. Since the construction of a regular pentagon is a rather complicated procedure, various approximation methods were developed throughout history, such as the one used by Gothic architect Matthäus Roritzer, whose method involved a single line AB and the use of three circles and their intersectios to draft a figure of a pentagon. However, if the golden ratio is the objective rather than the pentagon itself, to spare ourselves a laborious process of pentagon construction, other methods of golden ratio construction(mentioned above) should be favoured. In this connection, von Naredi-Rainer wrote: "Keine der beiden hier genannten Konstruktionen läßt das Fünfeck als besonders geeignete Grundlage eines architektonischen Entwurfes und noch weniger als praktisches Hilfsmittel bei der Vermessung auf der Baustelle mittels Meßlatte und Schnurzirkel erscheinen" ("Neither of the two constructions mentioned here makes the pentagon seem a particularly suitable basis for an architectural design, and even less a practical aid for measuring on the building site using measuring rod and compass." Informal translation.) (von Naredi-Rainer, 2001, p.198).

CONSTRUCT θ

Now we've discussed the well-known constants π and ϕ, this section will be dedicated to what is for many of us the completely unfamiliar constant θ. Although in reality, it's only unfamiliar to us in the theoretical realm. In practice, this irrational constant is very familiar to us, since it is closely related to the square root of two, which is inherent in a square as its diagonal. Beyond a doubt, we see $\sqrt{2}$ in everyday life. However, constant θ is not only $\sqrt{2}$, but it is defined as the sum $\theta = 1 + \sqrt{2}$, which is about 2.4142…. Analogous to the number ϕ and its denomination as the golden ratio, the number θ is referred to as the silver ratio (Weisstein, n.d.). This ratio mathematically described as $(2a+b)/a = a/b$, expresses a relation between two quantities, where the smaller quantity is to the larger, as the larger quantity is to the sum of the smaller and double the larger quantity. The θ progression is approximated with whole numbers by the Pell's series, 0, 1, 2, 5, 12, 29, 70, 169, …, which again creates a parallel to ϕ progression and the corresponding Fibonacci series.

Hambidge demonstrated the close link between the θ number and $\sqrt{2}$ by the "application of a square". Schofield said of him: "He goes on to show how the application of a square to the end of a ϕ rectangle, and inside it, leaves its reciprocal, a smaller ϕ rectangle. In the same way the application of a square inside the end of a $\sqrt{2}$ rectangle leaves a θ rectangle, and the application of a square inside the end of a θ rectangle leaves a $\sqrt{2}$ rectangle" (Scholfield, 1958, p.119). Later, in his *The Theory of Proportion in Architecture*, Scholfield expressed a desire for detailed exploration of the θ series, "it would be well worth exploring the possibility of using a proportional scale based not, like Corbusier's Modulor, on the ϕ series, but on the closely related θ series" (Scholfield, 1958, p.127).

The questions arising now are *why is this* θ *constant so important?* And *why should it be given special attention?* First of all, I want to emphasize the vast space for its exploration, since it is still relatively uncharted. Secondly, θ series ($1, \theta, \theta^2, \theta^3, \ldots$) possesses interesting additive properties – such as the previous series-member added to the current series-member doubled is equal to the next series-member: $1+2\theta = \theta^2$ - which are essential for the flexibility of the proportional system. Moreover, if the θ progression and $\sqrt{2}$ progression are blended into a double geometric progression (Table 2.01), the additive properties that emerge are indeed spectacular: $1+1 = 2$; $1+\sqrt{2} = \theta$; $1+\theta = \sqrt{2}\theta$; $1+2\theta = \theta^2$; as well as $1+\theta^2 = 2\sqrt{2}\theta$ (Scholfield, 1958, p.10).

However, this construction method will focus solely on the silver ratio. The

Table 2.01
Double geometric progression:
θ progression and $\sqrt{2}$ progression

1	θ	θ^2	θ^3	…
$\sqrt{2}$	$\sqrt{2}\,\theta$	$\sqrt{2}\,\theta^2$	$\sqrt{2}\,\theta^3$	…
2	$2\,\theta$	$2\,\theta^2$	$2\,\theta^3$	…
$2\sqrt{2}$	$\sqrt{2}\,\theta$	$2\sqrt{2}\,\theta^2$	$2\sqrt{2}\,\theta^3$	…
⋮	⋮	⋮	⋮	

tools required for this purpose are a set square, cord, and pegs. For the planar silver ratio, start by creating a square using the set square, then expand the square into a double square. Trace the diagonal of a single square. Now, with the assistance of the cord and pegs, rotate the diagonal with the centre of rotation in the middle of the longer side of the double square and align it with the side of the double square. Through the endpoint of the diagonal of the rotated square, complete the figure to make a rectangle. The rectangle thus formed is in the silver ratio θ:1.

Lastly, the θ series has a characteristic figure of an octagon, similar to the ϕ series and its pentagon. However, about the θ series account, Scholfield remarked, "they [θ series] have a far richer geometrical background [than the ϕ series], being related to the radial symmetry of the square, the octagon, and various star octagons, to the proportions of expanding systems of squares and circles and of star octagons, and to systems of repeat symmetry based on the square" (Scholfield, 1958, p.110). In the past, Leonardo da Vinci was particularly enchanted by the geometrical potential of the θ constant, which is observable in his various octagonal designs (Scholfield, 1958, p.52).

CONSTRUCT √n RECTANGLES

After exploring the construction methods for the π, ϕ and θ constants, we should devote a few words to the topic of the square-root rectangles, as they are the basis for the irrational proportional systems. According to Scholfield, "with few exceptions incommensurable systems can be divided again into systems based on the numbers $\sqrt{2}$ and $1 + \sqrt{2}$, or θ, systems based on the numbers $\sqrt{3}$ and $1 + \sqrt{3}$, which is not common enough to require a special name, and finally systems based on the numbers $\sqrt{5}$ and $(1+\sqrt{5})/2$, or ϕ"(Scholfield, 1958, p.13). Thus, we will be focusing on $\sqrt{2}$, $\sqrt{3}$, and $\sqrt{5}$ rectangles, which are the rectangles with a side ratio of $\sqrt{n}$:1. The square-root rectangles also play a key role in Hambidge's theory, dynamic symmetry.

Since the previously-discussed π, ϕ and θ numbers are interlinked with the square roots, only a brief introduction is sufficient. Probably the most natural root-rectangle for the human eyes is the $\sqrt{2}$-rectangle. Ratio $\sqrt{2}$:1 can be seen almost everywhere, as it is a ratio inherent to the square – it is the ratio of the square's diagonal to its side. Furthermore, $\sqrt{2}$ creates the base for the above-mentioned θ series – characteristic for octagons. A remarkable feature of $\sqrt{2}$-rectangle is its endless subdivision without residue, which is the reason the DIN system of paper formats was established upon it (Elam, 2011, p.36). On the other hand, the $\sqrt{3}$ is a natural quality of the spatial representation of a square, the cube, because its diagonal is equal to $\sqrt{3}$. Its permutations are also visible in planar geometry – in equilateral triangles and in hexagons. And finally, the mostly commonly-seen square root in reference to proportion is $\sqrt{5}$, seeing that its expanded form $(1+\sqrt{5})/2$ is the well-known ϕ, the golden ratio – which is naturally present in pentagons, or decagons.

To demonstrate the intertwined relationship between square-root rectangles, let us look at the following construction method: with the help of a set square create a square and trace its diagonal. Using a cord and pegs, rotate the diagonal so that it touches the square base line. Enclose the new rectangle – this is the $\sqrt{2}$-rectangle. Repeat the same procedure, but instead of the square's diagonal, use the diagonal of the newly-traced $\sqrt{2}$-rectangle – the result will be a $\sqrt{3}$-rectangle. If this process is repeated over and over, always using the diagonal of the newest rectangle, the formation of successive $\sqrt{n}$-rectangles is achieved.

PRECISION

Designed proportion vs. built proportion – two actualities bridged by the power of precision. The design proportion is an abstract idea that exists in the designer's mind before construction, but the built proportion, its counterpart in the tangible world deviates from it in various ways. It is precision that fills the space between intentions and results – and we can either talk about the precision of the concept or of the dimensions.

There are various views held by architects about accuracy – although many agree that conceptual inaccuracy gives rise to creativity. An example of this is David Leatherbarrow, in his foreword to Mhairi McVicar's book *Precision in Architecture* (McVicar, 2019), in which he stated: "an architect's highest skill: ingenuity", a skill of "productive responses to fateful accidents draw upon [*sic*]". He also pointed out, that Vitruvius already "described the working of the architect's mobile fantasy when explaining the adjustment of canonical proportions to make details seem appropriate in their context, according to the principle of *eurhythmy*". Further along in the book, McVicar herself stated, "that deviation, and the moments of uncertainty which accompany any deviation, may be viewed as productive in pursuing an extraordinary architectural quality" (McVicar, 2019, ch.I.2). Similarly, Robert Tavernor in his *Smoot's Ear*, talking about built-in error, stated: "I would argue that it is an essential quality of human nature, and is at the root of human creativity" (Tavernor, 2007, p. xvi) .

As we have seen, imprecision or inaccuracy do not have to be automatically considered negative, however, concerning (mostly) dimensional inaccuracies, there are certain limits that must not be exceeded. But "how precise is precise enough?" – McVicar's question now seems even more topical.

I would argue that this question does not have one single answer. Circumstances such as the time in history, material, and method of construction or even a worker's profession all exert an influence on achievable precision. It would be incorrect to assume that the same precision was aimed at before and after the Industrial Revolution, or that mason and carpenter worked according to the same standards of precision. For example, maybe you have heard the expression "*mason's hair*", an informal term for the imprecision of masonry, which is expressed in centimetres – it is considerably different to *carpenter's hair* which is measured in millimetre.

Given the changing concept of precision throughout history, Tavernor stated that "ancient measures were neither as precise nor as finely subdivided as the modern scientific measures used today because they did not need to be" (Tavernor, 2007, p. 4). Construction was even executed without exact plans – an idea quite incomprehensible to our modern minds. Although Vitruvius urged that "the plans should be worked out carefully, and with the greatest attention, before the structures are begun" (Vitruvius, 2012, b.X.i.4), he was talking in a financial context, so that expenses could be approximated –the accuracy in terms of planning at that time was far less structured than it is nowadays. It was only in the 15th century, with the advent of the Renaissance, that complete planning in advance became a habitual practice.

It is difficult to make any statement with confidence regarding planning precision in the Middle Ages, before the Renaissance, due to a paucity of documentation – most of the documentation are plans of details, however, and seldom

of entire floorplans. For this reason, there are various theories about medieval tactics, some of them suggesting almost complete avoidance of drafted plans (Birkett and Jurgenson, 2001), or usage of the same parchment throughout the construction process, so that only the most advanced phases of the project remained (Hiscock, 2018, ch.5).

The only thing that can be said with a modicum of certainty is that the vast majority of the medieval plans that were preserved are dimensionless, drawn to an arbitrary scale, adjusted to the size of parchment. It is assumed that medieval builders were able to transpose drawings onto the building site by using proportional methods and a definition of one fixed size, the module. "Geometry, a daughter of orality and a good friend of memory, works the same at every scale" (Carpo, 2003, p.465). However, as Nigel Hiscock, the author of the book *The Wise Master Builder* observed about the exactitude of such a process: "Inaccurate building will almost certainly result from laying the foundations of a large structure without modern aids" (Hiscock, 2018, ch.5). He went on, commenting on several medieval constructions: "The main axis of Cluny III was bent twice, Canterbury's is misaligned twice and bent once, Laon's nave tapers by 3%, Bourges's by nearly 6% and the entire layouts of Vèzelay and Notre Dame in Paris are little short of chaotic". Hiscock concluded that an error in a range of ±3% was quite common in medieval architecture.

In his article *On Precision in Architecture*, Constantino Caciagli warned of "useless precision and the cold mechanicalness" (Caciagli, 2001, pp.13-14) in the analysis of historical buildings. According to Caciagli, they are both aspects that do not lead to an understanding of the architect's intentions. And I can only agree with him.

Probably the most decisive feature of a building in terms of its dimensional precision is the building unit. Taking this into consideration, I enjoyed the parallel to human temperature made by Bill Schmalz in his working paper *Being Precise in the Construction World*. He pointed out the misconception in the unit conversion of degrees Celsius to degrees Fahrenheit – when the typical human temperature of *around* 37°C was mistakenly converted to *precisely* 98.6°F. While the difference of 1°C corresponds to a difference of 1.8°F – a significantly wider range of temperature – conversion in precision to one decimal is theoretically incorrect! A slight error, which resulted in "millions of parents […] panicked because their children had 'fevers' of 98.8°F'" (Schmalz, n.d., p.1).

The same is true for architecture. Let's say that a building was constructed in imperial units, but someone who was careless and ignorant would analyse the precision of construction in the metric system. Then even if the builders were *perfectly* accurate – which is actually impossible – the measured analysis would suggest imprecisions. For instance, 1 inch in mathematic conversion equals 2.54 cm or 4 inches corresponds to 10.16 cm.

However, the situation with systems of measurement is not so straightforward and limited to the 'game' of imperial vs. metric system. Throughout history, a wide variety of units have existed, such as the Egyptian cubit, the Roman foot, the French *ligne*, and many more! The characteristic of old measurement units was that they were local and body-centred – at least in Western civilizations. The human body, understood as the embodiment of universal harmony, provided the basis for establishing the first units of measurement. One of the most well-known ancient systems of measurement took the *finger*, also called the *digit*, as the smallest unit of the system. The bigger units were related to it by whole numbers – so 1 *palm* was equal to 4 *fingers*; 1 *foot* to 16 *fingers*; 1 *cubit* (length of forearm) to 24 *fingers*; and 1 *span* or *fathom* (body height) to 96 *fingers*. Tavernor further explained, "sets of linear relations of this kind were usually calibrated on rigid linear rods and defined as the official standard. Replicas were displayed in public places […], while the original standards were stored safely in the treasuries of temples" (Tavernor, 2007, p.6).

In later historical periods, as Caciagli stated as well, medieval builders used their own measuring instruments, and these varied in size. One assumption suggests that each construction hut had its own tools (Caciagli, 2001); another suggests that measuring instrument size was based on the building's module (Birkett and Jurgenson, 2001).

The plurality and ambiguity of historical systems of measurements was not an issue until the Enlightenment, but the new thirst for exactitude and precision drove the search for a universal mensuration while at the same time destroying the body-centred unit-systems. The metric system, born in the radical time of the First Industrial Revolution as well as the French Revolution, was an essential step for promoting scientific progress and international trade. At the turn of the 19th and 20th century, the Second Industrial Revolution, almost a synonym for standardization, only approved the changes of previous centuries. In spite of qualities which the universal metric system certainly possesses, in the field of architecture, I perceive one significant disadvantage, which is explained by its definition. "The metre is now thus defined as the distance travelled by light in a vacuum in 1/299.792.458 of a second" (Britannica Editors, 2014). But how is "the distance travelled by light in a vacuum" related to the measures of the most important occupant of architecture – the human being? And that is precisely the issue – the issue for well-known artists and architects such as Marcel Duchamp or Le Corbusier, too, who warned of the sterility and dehumanization of the metric system.

Nevertheless, that was only part of the process of transition to precision, as perceived through modern lenses. Francesca Hughes in her *The Architecture of Error* asked questions such as: "What has precision now become?", or "How and why did the tolerance of material error get smaller and smaller?" (Hughes, 2014, pp.1-2). She described how the concept of precision nowadays is completely different compared to what is was in the past – and not always for the better. Numerous building standards or exhaustive four-hundred-page books (such as, for example, *Building Construction – Tolerances* (International Organization for Standardization, n.d.), or *Handbook of Construction Tolerances* (Ballast, 2007) – try to contribute to improvement in construction. However, the focal point regarding this matter should be elsewhere, namely: where is the meaningful border between precision and error? Because precision should neither be achieved for its own sake, nor hang like a shadow over every move that an architect makes. Establishing a fine balance between accuracy and inaccuracy is essential. On the one hand, it is important to avoid 'purposeless accuracy', complicating and prolonging the whole architectural process; and on the other, it's equally important to prevent "a needle that was found blunt and a window that was not; a stone that hid a flaw; an airplane too heavy to take off; a stream that knew the way down; a jigsaw that could draw; a dolls' house that defied entropy; a corridor that went nowhere; and a radiator that was razor-sharp"(Hughes, 2014, p.2).

After this brief inquiry into the changing concept of precision, let us take a closer look at historical causes of inaccuracies. For example, let us look at deviations which possibly emerge throughout the whole architectural process – starting in the *tracing-house* and not ending, even when the construction has been finalized.

The author of *The Wise Master Builder* demonstrated the potential imprecisions by means of an old story about Gunzo, the medieval monk living in the 11th century, who had a dream about the necessity for a further extension of the Cluny II monastery. Hiscock wrote: "in the dream, saints Peter, Paul and Stephen appear to Gunzo, […] Stephen uncoils a rope for Peter and Paul to lay out in the form of diagonals across the building site. […] The portrayal of Gunzo's dream also shows how inaccurate the method of setting out was likely to be. Ropes can be heavy and therefore difficult to keep taut and their length varies with their moisture content. The use of the large squares already encountered might seem helpful but not even Vitruvius's four-foot square could guarantee an accurate projection of an angle over long distances"(Hiscock, 2018, ch.5).

Hiscock also generally summarized that "errors could arise from one or more of the following causes: inaccurate drawing, unstable drawings, the extrapolation of dimensions, inaccurate setting-out, or inaccurate construction" (Hiscock, 2018, ch.5). Further along in the book, Hiscock mentioned the importance of "common human error" as well. I would just like to add to his accurate reflection that post-processes after construction – such as the settlement of the foundation, etc. – contribute to dimension deviations, too. And the difference between "inaccurate" and "unstable" drawing is that in the case of the former, inaccuracies are the result of sloppy draughting and theoretical misconceptions – e.g. theoretically wrong construction of a pentagon – while in the case of the latter, inexactness is a result of "movement of the material, caused, as with ropes, by variations in moisture content". To my surprise, it turns out that these anisotropic changes are anything but negligible; for instance, "the *Plan of St Gall* has evidently shrunk 5-6% and still moves".

This reflection on precision, as described in the present section, has explored several key aspects regarding proportion in architecture. We have learned that it is important to bear in mind that architectural intentions do not fully align with architectural results – and the matter of precision lies in between. So, when analysing the historical buildings, the system of measurement used in its construction must be the same as the system used for its analysis, with *a priori* matching *a posteriori*. Furthermore, there must be room in the proportional analysis for error tolerance – the tolerance of error that occurred throughout the whole architectural process.

To sum up this section, accuracy is crucial, now more than ever; however, the right balance between accuracy and inaccuracy is even more crucial. (Architects must not become slaves to precision.)

SUMMARY

Whereas, in the previous chapter, we got acquainted with the trans-disciplinary historical background of proportion, the leitmotif in this chapter has been the practical side of the theme, the shift to the practical realm. Our quest for knowledge focused on proportional tools, as well as methods of period craftsmen or builders, and the matter of precision that and goes hand in hand with them.

Here, it is worth reminding ourselves of the distinction between practical and *practical*. Because the historical treatises that talk about practical tools and methods of construction were most likely never used or even read by typical craftsmen or builders. Why is that so? We discovered that the reason is quite simple: they could not read – neither Latin, the language in which the texts were written, nor any other language – they could not read at all (Blandford, 2012, p.127). This is also why the *rule of thumb* should not be underestimated. And as we saw, and as we will see later in the analyses, simplicity rules.

Based on the citations from several historical documents we could see that the choice of construction tools of craftsmen or builders was wide – for instance rule and compasses, set squares, level, plummet, straightedge, threefold triangle, cord and pegs, etc. However, we looked more closely at only a few of them (rod, cord and pegs; set square; compass), those most linked to the construction of proportion on-site.

In the section entitled *How to…* we explored how to construct a right angle, perform division (proportional and in equal parts), and construct prestigious ratios (Ludolph's number π, golden ratio ϕ, silver ratio θ), and $\sqrt{n}$-rectangles. The set squares, which had already enchanted us with their versatility and simplicity in the discussion of the tools, played a crucial role in these construction methods. In addition, we also explored the practical application of the basic geometrical and mathematical principles (Pythagorean Theorem, properties of quadrangles or similar triangles). Let us not forget Scholfield's desire for a closer exploration of the silver ratio θ, which possesses even more additive properties than its better-known sibling, the golden ratio ϕ (Scholfield, 1958, p.127). Further research in this direction could be indeed enriching, as we still find ourselves in relatively uncharted territory here.

Lastly, we devoted some attention to the gap between the designed proportion and the built proportion – and discovered that it is precision that fills the gap between intention and reality. According to quotations from several architects, it is crucial to have the right balance of accuracy and inaccuracy. They point out that a small margin for error opens up new ground for creativity (McVicar, 2019, ch.I.2) .

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TERMINOLOGY

"Between these [vernacular] buildings and [prestige] architecture (thought of as an art of the elite), there existed a similar relationship to the one linking tale and popular music with literature and classical music", said Andrea Bocco Guarneri in *Modern Architecture and the Mediterranean* (qtd. in Lejeune & Sabatino, 2009, p.232).

To analyse the distinct and overlapping systems of proportion within vernacular and prestige architecture, the definition of fundamental terms is an essential first step. In this subchapter, two vital terms of this thesis – *prestige* and *vernacular* – will be broken down. Furthermore, terms such as primitive, folk, or traditional architecture, which are commonly imprecisely used as their synonyms, will also be discussed.

According to Paul Oliver, "distinctions can be made between formal, architect-designed architecture and vernacular architecture, and between these and what may be termed popular architecture"(Oliver, 1997, vol.1-xxii). Nevertheless, most contemporary buildings, can be classified into the latter category, *popular* or *eclectic* architecture (Noble, 2013, p.9). The area between the poles of prestige and vernacular architecture is understood by some scholars as a spectrum – with a certain position on this range, we incline to one pole or the other. For instance, Stanley Trimble depicted how a form and material of a building relate to the position on this imaginary scale (Trimble, 1988, pp.98-100).

The study of vernacular architecture does not have a long scholarly tradition as the first notion of the term vernacular was employed only in 1839 in England and a restrained interest among a few academics emerged at the turn of the 19th and 20th centuries. Despite this, the fascination of (even a small number of) gathered momentum later in the 20th century. The field is far more popular now, and there are several detailed books and papers on the subject, including; *Traditional buildings* (2009) by Allen Noble, *Vernacular architecture* (2000) by Henry Glassie, *Vernacular Architecture and Regional Design* (2009) by Kingston Wm. Heath, a volume of essays named *Vernacular Architecture: Towards a Sustainable Future* (2015) edited by C. Mileto, F. Vegas, L. García Soriano, V. Cristini, and multiple works by Paul Oliver such as *Dwellings* (1987), *Built to Meet Needs* (2007), *Atlas of Vernacular Architecture of the*

World (2007) co-authored by Paul Oliver, Marcel Vellinga, and Alexander Bridge, and finally the three volume *Encyclopedia of Vernacular Architecture of the World* (1997) edited by Oliver, with an updated and extended version by Marcel Vellinga anticipated at the end of 2022 or shortly thereafter (Oxford Brookes University Editors, n.d.).

The term *vernacular* is variously defined and understood. The Cambridge Dictionary gives offers two definitions of vernacular: "the form of a language that a particular group of speakers use naturally, especially in informal situations"; and "a local style in which ordinary houses are built"(Cambridge Dictionary Editors, n.d.-d).

Remarkably, as the first definition suggests, the use of the word vernacular emerged from Latin *vernaculus*, translated as native (Oliver, 1997a). For many languages, there exist several vernacular dialects of regional variations of the official language. For example, Cardiff, Yorkshire, or Sussex vernacular languages, are all local forms of English.

Only in 1839 was the word vernacular used in the context of architecture, leading to the second definition, thus, the second definition. Nonetheless, the definition is incomplete and partially inaccurate, since the formulation "ordinary houses" excludes other typologies (churches, house barns, byres, sheds, storehouses) which are inherent to rural (and in some cases urban) settlements.

Although Oliver considered seeking "a single definition of vernacular architecture [to be] probably ill-advised" due to its richness and diversity, he did devise a working definition: "Vernacular architecture comprises the dwellings and all other buildings of the people. Related to their environmental contexts and available resources, they are customarily owner- or community-built, utilizing traditional technologies. All forms of vernacular architecture are built to meet specific needs, accommodating the values, economies, and ways of living of the cultures that produce them"(Oliver, 1997a, p.xxiii).

Attempts to define vernacular architecture are manifold. Beyond Oliver's working definition, the perspective of archaeologist Cary Carson is of note. Carson argued that vernacular architecture describes "buildings that are built according to local custom to meet the personal requirements of the individuals for whom they are intended" (qtd. in Noble, 2009, ch.1). Furthermore, the Irish cultural geographer Frederick H. A. Aalen argued that; "The term vernacular architecture is [...] applied to the buildings used by ordinary people, especially in pre-industrial societies [...] Within regions there is marked and voluntary adherence by most of the society to a single model or ideal pattern of house form. Even though professional builders may be operating, the basic model is not seriously questioned by builder or peasant. The model has no designer but is part of the anonymous folk tradition and tends to be persistent in time [...] Conformity, anonymity, and continuity may be seen as the hallmarks of regional vernacular architecture, reflecting the cultural coherence, simplicity, and conservatism of present communities and the deep rooted traditions within the building craft"(Aalen, 1973, p.27). Despite the comprehensiveness of Aalen's definition, the aforementioned limitation in the Cambridge Dictionary definition applies in this case as well, because Aalen refers only to housing typology and omits further relevant typologies.

Some other approaches in understanding *vernacular* were presented in the

articles "Viewpoint: 'From the Unknown to the Known'" (2011) by Mike Christenson and "Memory without Monuments: Vernacular Architecture" (1999) by Stanford Anderson. Christenson novel definition was based upon "practices of structuring information about architecture". He argued that "a vernacular organization of information is one that is highly specific to a place, one that is not directed toward a particularly academic purpose"(Christenson, 2011, p.8). His definition does appear to have been applied to the realm of architecture. Vernacular architecture based upon Christenson's idea is imprecise, as the transition from vernacular to non-vernacular occurs when the information spreads beyond the local community. Thus, the process of de-vernacularisation of vernacular architecture is possible within Christenson's formulation. In the second article, Anderson reflects on memory, which is bound in vernacular architecture. He argues for an understanding of "vernacular architecture as document," because the two types of memory, namely social and disciplinary, both intertwine within vernacular architecture, which provides "memory without monuments".

Several other designations are used synonymously with vernacular architecture; including primitive, folk, ethnic, traditional, and less often anonymous, indigenous, spontaneous, ordinary, everyday architecture. Therefore, proceeding with caution is important, as these terms do not convey precisely the same meaning.

Primitive architecture is not an adequate alternative. The word primitive has pejorative undertones, which is present even when used in an otherwise neutral sentence. Nevertheless, Gwyn Meirion-Jones argues that vernacular architecture is a more evolved form of primitive architecture, and that a clear-cut distinction between the two terms cannot be made (Noble, 2009, ch.1).

The term vernacular architecture is most prevalent in the UK, but in North America the term folk architecture is more common. The distinction between vernacular and folk is slight, thus their interchangeability occasionally possible. Some scholars have attempted to distinguish between these terms based on who the builder is. Christopher Weeks argues that if the builder is from a local community, and builds in the manner of local customs, the term vernacular architecture applies. On the other hand, if the builder is also the inhabitant, the term folk architecture applies (Weeks, 1996, p.16). I argue that this differentiation does not correctly conceptualize the issue and, if applied, might lead to more misconceptions than benefits. Noble's conceptualization of folk architecture in North America has valuable elements. He argues that; "The term vernacular architecture (in its regional sense) works well in England and some other countries, where settlement has been more or less homogeneous with differences only perceptive at the regional level. In North America concentrated settlements, derived originally from numerous immigrant peoples, are decidedly more limited geographically and are scattered across the landscape in a checkerboard fashion" (Noble, 2013, ch.1).

In the previous context, folk architecture is closely related to ethnic architecture, which according to Carolyn Torma has a broader meaning than solely "the folk architecture built by immigrant groups before World War I." It can "encompass everything built by an ethnic or cultural group"(Torma, 1991, p.136). Later in his article "Ethnicity and Architecture", Torma uses folk and ethnic architecture synonymously.

The closest term to vernacular architecture is likely traditional architecture.

The Cambridge Dictionary defines the traditional as "following or belonging to the customs or ways of behaving that have continued in a group of people or society for a long time without changing"(Cambridge Dictionary Editors, n.d.-c). Although vernacular and traditional architecture overlap precisely, Oliver argues that; "the phrase [traditional architecture] is also broadly applicable to a variety of monumental and architect-designed constructions"(Oliver, 1997a, p. xxi).

Given that the other synonyms for vernacular architecture, including anonymous, indigenous, spontaneous, ordinary, and everyday architecture, occur with lower frequency and their area of overlap is narrower, further discussion of these terms is not necessary.

Nonetheless, the existence of contemporary vernacular architecture is considered within the book *Contemporary Vernacular Design* by Clare Nash. Nash notes that "to achieve a new vernacular is to achieve a regional identity at the same time as meeting modern-day energy requirements"(Nash, 2019, ch.1.2). Beyond addressing the energy issue, the involvement of an architect does not disqualify a building in Nash's conceptualization of contemporary vernacular architecture. Sometimes the term neo-vernacular is used instead, however misconceptions can arise as, according to Oliver, owner-built squatter settlements since World War II have also been designated as neo-vernacular (Oliver, 1997a, p. xxii).

The second point of interest concerns prestige architecture which is slightly more complicated than vernacular architecture. An appropriate definition of prestige architecture does not exist. This may be because of its ubiquity, leading to the need for its proper characterization not being perceived. Therefore, an original definition will be devised within this text.

Based on the Cambridge Dictionary, prestige refers to the "respect and admiration given to someone or something, usually because of a reputation for high quality, success, or social influence"(Cambridge Dictionary Editors, n.d.-b). In various texts, nomenclatures such as formal, academic, official, elitist, power, or noble architecture are used instead. Noticeably, several texts assign prestige architecture a glorified status, conveying a slightly derisive undertone. However, these descriptions are typically made by writers who are sympathetic to vernacular architecture, and may be disheartened by the disappearance of vernacular architecture. In an unpublished lecture named "Back to Kindergarten", Bernard Rudofsky stated: "I rarely address an audience of architects, if only because I consider them a hopeless breed, and a threat to humanity. I prefer to speak to laymen instead, since it is from them that any re-orientation in the field of architecture must come"(qtd. in Lejeune & Sabatino, 2009, p.245). Within this text, neither vernacular nor prestige *architecture* is preferred and are regarded merely as different. There is much to learn about vernacular architecture. The relationship of prestige architecture to the values of vernacular architecture is undoubtfully worth consideration.

This research defines prestige architecture as follows: it is the product of formally regulated design and building processes, including housing and other typologies used by people, which is not place-specific but rather movement or style specific, designed by a well-known architect (or a group of architects) for an investor, and it is understood as an artistic manifestation of architect's idiosyncratic design principles. It is built by professionals with the utilization of available technologies and global materials, which are sometimes transported long distances to the site. The dynamics of the economic and built environment are influential upon it. This architecture gains its prestige through the professional status of the architect.

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After defining the term prestige architecture, similar terms can now be examined. The terms formal or official architecture are almost interchangeable with prestige architecture, however, they have slight distinctions. In the Cambridge Dictionary prestige is defined as "respect and admiration […]" that the architecture has a positive reputation. Similarly, in the definition asserted by this research prestige architecture acquires its prestige through the reputation of the well-known architect who designed it. Although the architect's name may be well-known, internationally, nationally, or locally, the most decisive attribute is that the architect inspires "respect and admiration". Contrastingly, formal and official architecture need not necessarily be "designed by a well-known architect".

In his book *The Icon Project: Architecture, Cities, and Capitalist Globalization*, Leslie Sklair named three groups of architects, who, according to him, fall into "The Icon Project". He argues that, "the top four designers of unique architectural icons at the beginning of the 21st century (Gehry, Foster, Koolhaas, and Hadid), a group of about 30 signature architects, and a larger group of firms producing many more successful typical icons"(Sklair, 2017, p.7). Furthermore, the same three groups of architects identified by Sklair fall into the category of power architecture. This term is not suitably synonymous with prestige architecture since it implies a hegemonic belief within society. Within Sklair's description of iconic projects, he sees architecture as "an important weapon in the struggle to create and solidify capitalist hegemony"(Sklair, 2017, p.3). Nonetheless, the fields of hegemonic influence do vary over time and place. Church hegemony played a significant role in European history.

While major differences may not exist between prestige and noble architecture, the opposite is true for elitist architecture. Elitism according to the Cambridge Dictionary means: "organized for the good of a few people who have special interests or abilities"(Cambridge Dictionary Editors, n.d.-a); and according to Dictionary.com means: "considered superior by others or by themselves, as in intellect, talent, power, wealth, or position in society"(Dictionary.com Editors, n.d.). Thus, elitism explicitly supports the segregation of society and superiority of a few which is not the explicit intention of prestige architecture.

A small excursus into the distinction between building and architecture may be necessary. Within this thesis, these terms are used interchangeably; however, some architects and scholars insist on their distinctions when considering vernacular building and prestige architecture. This semantic separation highlights a hierarchical relationship, as architecture is understood to be qualitatively superior to buildings.

Nikolaus Pevsner demonstrated this distinction when he stated: "A bicycle shed is a building; Lincoln Cathedral is a piece of architecture. Nearly everything that encloses space on a scale sufficient for a human being to move in, is a building; the term architecture applies only to buildings designed with a view to aesthetic appeal … this aesthetic superiority is, moreover, supplemented by a social superiority"(Pevsner, 1942, p. xx). John Harvey reiterated the distinction when he noted: "Two separate words do exist side by side: architect and builder, and their products architecture and building. This is fitting, since Architecture is acknowledged as the Mistress Art. Building, with all its component skills such as masonry, carpentry, glazing, is a collective technique taught by the members of one generation to those of the next. It may be greatly modified in course of time by the discovery of new materials or the invention of improved methods, but these changes come from outside. Architecture, however, is not simply the control and supervision of buildings; its primary function is the creation of solutions to fresh problems posed by patrons who wish to have not standardized but specially designed works put up in answer to their requirements" (Harvey, 1975, p.2).

In this thesis, this linguistic contrast is considered valid, if the distinction is purposeful in context. For instance, mediocre catalogue houses, the numerous copies of a socialistic block of flats, or the typical working halls do not represent architecture. A building must abound with qualities which make it worthy of the designation of architecture, such as a functional design (either conscious or unconscious), rootedness in the existing environment (natural, physical, cultural, and social), truthfulness and suitability of material, and the presence of a system of proportions. Of course, this is not an absolute list of architectural qualities that must be met exactingly – each piece of architecture is specific, having stronger and weaker points, and particular attributes. The distinction between building and architecture is even trickier, as we can look at *architecture* as a narrower term, or as a subcategory of building. In other words, all pieces of architecture are buildings, but not all buildings can be referred to as architecture. Nevertheless, prestige and vernacular buildings or architecture are equal partners in the realm of architecture and are all deserving of special attention.

IDIOSYNCRASIES CONFRONTED

In this short section, the main characteristics of both vernacular and prestige architecture will be considered to expand upon the relationship between the two.

On account of the first feature, variation over time and place, the American historian Howard W. Marshall stated: "folk things tend to vary little over time but much over space and the opposite is true for fashionable things and academic architecture" (Marshall, 1981, p.25). Vernacular architecture is a product of slow, evolutionary processes, which creates unique place identities becoming bound to its place. On the other hand, prestige architecture, designed in a short process by one architect (or a group of architects), acts as their intellectual property contributing to the formulation of the architect's personal identity – it is therefore bonded to this architect. The activities connected to vernacular architecture shape a homogenous environment, and by contrast pieces of prestige architecture compose a heterogeneous environment.

Why is this so? Given that in vernacular architecture, a community, settled at a specific place, applies their own architectural language, formulated over centuries, and deeply rooted in the surrounding natural environment, their customs, traditions, it all results in place homogeneity. Since in *prestige architecture*, one architect receives contracts in various cities or even various countries, their field of impact is very widespread. Thus, a particular place may comprise the works of several different architects, each articulating their idiomatic architectural language, which results in place heterogeneity. Furthermore, vernacular architecture houses in a specific place are more or less identical to one another, while the houses of prestige architecture tend toward uniqueness, even when designed by the same architect.

Another distinction can be made based on the organization of the architectural process. Vernacular architecture is an outcome of a tradition-rooted process, which is formally unregulated and does not require any exhausting plans created beforehand. Dissimilarly, prestige architecture is a formally regulated process, in which all steps demand precise and detailed plans.

Taking credits for the outcome of the architectural process is interesting to compare, too. Design in vernacular architecture is based on the intellectual heritage of an entire community and buildings do not have a particular architect (the architect is unknown) therefore the credit belongs to the entire community. In the case of prestige architecture, the credits for the building belong to the designing architect (the architect is known) and this building is closely associated with the architect's name.

Contrasts can also be drawn in terms of the workforce constructing the building. The builders of vernacular architecture are from the community and buildings are built either by untrained, but highly skilled community inhabitants, or by the owner themself. On the other hand, prestige architecture engages qualified professionals in the construction process.

Other distinctions can be drawn with respect to sustainability. Vernacular architecture, which is "related to their environmental contexts and available resources", is often intrinsically sustainable. These buildings draw on the local materials, cater to local climate, and are therefore highly attuned to their natural environment. By contrast, buildings that are detached from their natural environment are not uncommon within prestige architecture. Although sustainability is more often a concern of contemporary prestige architecture, this is often a nonessential bonus of the overall design, not an indispensable principle. Sustainability is related to the choice of building materials, and while vernacular buildings utilize exclusively local materials and resources, prestige buildings rely on materials transported from around the world.

Lastly, these types can be distinguished by comparing their time of influence. Vernacular architecture is currently in a precipitous decline. It is most present in underdeveloped countries, where the heritage of local communities is still valued, or in contemporary vernacular architecture, which differs from traditional vernacular architecture in multiple aspects. Given its vulnerability, the preservation of vernacular architecture for subsequent generations is of great importance. Oliver elaborated on this in his book *Built to Meet Needs*: "Vernacular architecture in countries throughout the world is threatened. […] The vernacular suffers from indifference and ignorance of its historic or social value, and from being assigned low status in housing. Mass migration from the rural areas to the cities of the developing world is driven by the push–pull factors of sophisticated urban living and fragile job opportunities. In the process, traditional homes and life-styles are abandoned, and in the villages, urban housing becomes a model" (Oliver, 2007, ch.I.2). Contrastingly, prestige architecture, began its golden age in the 20th century and continues its rise.

APPLICATION OF FILTERS

The study of proportional systems within vernacular and prestige architecture is a vast area of study. Therefore, more specific definitions are necessary to reign in the scope of this thesis. Thus, an application of wisely selected filters is necessary. As previously stated, the aim of this thesis is to present proportional systems of vernacular and prestige architecture independently and comparatively. To facilitate a reasonable comparison, it is necessary to determine the common denominators (filters) between these types of architecture. These filters include location, period, building typology, and the projection (plan, or elevation) of the building.

Factors relating to the location filter are as follows. Since its inception, the intention of this thesis has been to study European architecture. Nevertheless, through the research process the particular area of interest has become clearer and more narrowly defined. The scope was influenced by Oliver's exhaustive three-volume *Encyclopedia of Vernacular Architecture of the World*, each volume having roughly eight hundred pages. This vast work of scholarship still only represents the tip of the iceberg with respect to international vernacular architecture. Almost an uncountable number of different categories of vernacular architecture are listed, however each category only carries a few representative images. A reasonable analysis of proportional systems of this architecture requires a significantly larger sample of buildings representing a particular community.

The inclination to narrow the studied location was bolstered by the statements of Polish architect Amos Rapoport, and American historian Carl Lounsbury. Rapoport argued: "Generalizations based upon limited samples are suspect. The broader our sample in space and time, the more likely we are to see regularities in apparent chaos and to understand better those differences which are really significant"(Rapoport, 1980, ch.IV.9). Furthermore, Lounsbury argued: "The study of vernacular architecture must proceed with a systematic and careful investigation of a large sample of buildings in a given area in order to distinguish common house types, materials, and structural systems. Unlike the study of academic architecture where emphasis is placed on the analysis of individual buildings of exceptional character, the study of vernacular forms depends on the recognition of the repetitive and commonplace. Too few buildings in a survey may distort the overall picture"(Lounsbury, 1983, p.186). Therefore, *Alea iacta est* and the study location was downsized.

This decision raised subsequent questions: Which subregion of Europe should be the focus of the study? There exist several world subdivision models, for example EuroVoc, The World Factbook, or the UN geoscheme (United Nations geoscheme). The UN geoscheme, for example, initially divides Europe into large regions – Eastern, Northern, Southern, and Western – and subsequently into individual countries in the second step (United Nations Editors, n.d.).

In his *Encyclopedia of Vernacular Architecture of the World (EVAW),* Oliver argues that the classification of vernacular architecture should not be presented according to countries because "the determination of national boundaries in many parts of the world took place in the 19th and earlier 20th centuries, long after numerous vernacular traditions had been established"(Oliver, 1997a, p. xxvi). He considers culture and habitat to be a far more appropriate means of categorizing vernacular architecture, and proposed a new map representation accordingly. He noted, "it is intended that the culture areas should also be related as far as possible to geo-physical and climatic features, and that they should broadly correspond with the distribution of vernacular architecture traditions". However, for each building, he also indicated the country in which it was located in at the time of publication (the country was included simply as an additional characteristic). Oliver divided the area of Europe into two main categories Europe and Eurasia, and into Mediterranean and Southwest Asia.

Europe and Eurasia are further comprised of ten subregions, namely Alpine; Baltic and Finland; British Isles; Central Europe; Gallic; Germanic; Lowlands; Nordic; Russia; and lastly Ukraine, Belarus, and Eastern Europe.

The study area should provide enough diversity in vernacular and prestige architecture, and be well-documented, in order to facilitate a meaningful comparison. In other words, too much diversity would make the analysis complicated, but too little diversity may be uninteresting.

These factors led to a selection of two of the *EVAW* regions. These regions are connected by the German language but differ in their historical and geographical conditions: the Alpine and Germanic regions.

The focus on a certain period is also important, as proportions were perceived differently in a very distinct way across the period. This is elaborated upon in the chapter of this thesis named *Proportion: Historical Background/Architecture*. Given the presence of sufficient study material, and the anticipated contrast between types of architecture, this research will concentrate on the architecture of the 19th century. A limitation of this selection is that a clear and representative slice of vernacular architecture from the 19th century is not possible, as building and rebuilding has occurred in a very organic and natural manner.

Several factors shape the selection of a building typology. There are several different building typologies and it would therefore be illogical to compare the proportional systems of vernacular storehouses and prestige churches, or vernacular houses with prestige schools. The selected typology, should be of such quality that the application of proportional systems was possible. However, the incorporation of proportional systems has likely been a subconscious element of design, particularly in the case of vernacular architecture. This research will focus upon the typology of residential buildings (housing for people). Undoubtedly, typologies of sacral buildings would provide a fertile field of study, but the personal interest of the author was the determining factor in this decision.

Vernacular sympathizers lay emphasis on the entirety of the context in which buildings were created and urge academics to assess them in their fullness whenever possible. Noble asserted: "Above all, it must be remembered that traditional buildings rarely exist in isolation. They make up an ensemble of structures as part of a farmstead, a compound, a hamlet, or a small village, and they need to be considered in their context whenever possible. A fundamental error, which many local historical preservation entities make, is to preserve a single building, often moved and reassembled on a new site"(Noble, 2009, ch.1). Furthermore, a clear distinction between buildings for people and buildings for animals in vernacular architecture, is often unattainable as humans and animals often resided under the same roof. Thus, the typology of vernacular residential buildings will be addressed with a degree of openness in interpretation.

Lastly, the selection of projection (plan, or elevation) of the building is essential in shaping the analysis. While a plan "reveals the shape and horizontal extent of a structure, as well as the internal arrangement of its space", an elevation describes "the vertical extent of a structure. Normally the term refers to that part of the building completely above ground"(Noble, 2009, ch.1). Although the study of both would be achievable, it is important to keep in mind that the dimensions found in the plan, primarily in vernacular architecture, are substantially influenced by the structural properties of the materials used and the function of the rooms, and not by the aesthetic qualities of proportional systems. Therefore, the elevation of buildings will be the focus of this thesis. The composition of elevations is freed, although not completely, from structural constraints. Even here, the size of openings impacts the overall stability of the building. Furthermore, practicality plays a vital role. For instance, "in a large number of European and European-derived dwellings with gable or hipped roofs, the doors usually occupy a position on an eave side of the structure", however, "having the door on an eave side of a gable-roofed building could create considerable inconvenience in areas of high rainfall, and especially in areas of high snowfall" (Noble, 2009, ch.9). Even such unexpected events, such as window taxes, influenced building elevations. This manifested in Irish houses, where "prior to 1800 window taxes were levied on the number and sizes of windows" (Sharkey, 1985, p.13). Not to mention, early glassed windows were so expensive for common people, "that a house owner would often take them with him when he moved and it was not uncommon for windows to be bequeathed in wills"(Breckon & Parker, 1991, p.112).

Nevertheless, it is assumed, that elevations will provide a good basis for the recognition of peculiarities of proportional systems in vernacular and prestige architecture, as well as their divergencies when compared. On the topic of wealth-representation through dimensions and number of openings in the elevation of a building, Noble noted: "the higher the standard of living, the larger and greater the number of openings, and the more these openings can be blocked and closed easily at required times"(Noble, 2009, ch.9).

METHODS

"If, as Manning Robertson once remarked, the theory of proportion can be compared to a detective story, what we are trying to do here is to give an explanation of the crime before we start to tell the story"(Scholfield, 1958, p.3). An apt parable of Robertson, amplified by Scholfield, fits the intention of the following chapters exactly. A crime occurred, and this thesis searches for its motive.

This assignment can be approached in two ways, namely numerically, or geometrically. First, the potential and pitfalls of these approaches were clear from the outset. In his *The Theory of Proportion in Architecture*, Scholfield stated that the numerical method "has the very great advantage that the degree of approximation of ratios suggested by theory to measured ratios is immediately obvious. It can be stated in a quantitative form, as, for example, a percentage error", and it was clear that "geometry is a much less reliable instrument of analysis than arithmetic. The excitement of discovering supposed coincidences in a drawing is not restrained by unsympathetic figures, and self-deception is easy"(Scholfield, 1958, pp.96-97). Nevertheless, for the purpose of this analysis, a geometric approach was selected, for several reasons.

The reason for this choice lies not only in the ease with which one can grasp relationships visually. This is indeed vital for the study of proportions (closely related to shape repetition – see thesis chapter *Proportion: Historical Background /Architecture*). However, it is also reflected in the fact that the same type of analytical method should be applicable to both areas of concern, namely vernacular and prestige architecture. Within the numerical method,

plans, sections, or elevations with clearly indicated dimensions are inevitable, but are not as common in vernacular architecture. Deploying numerical comparisons would result in a severely limited study sample, as the plans in vernacular architecture, if any, are most often dimensionless, or were completed long after construction for academic purposes. Deduction of dimensions based on these in-scale dimensionless plans may be possible, but it would cause additional errors in precision (see *Proportion: Construction/ Precision*). Geometrical analysis thus provides a unifying working tool for this research.

The note of caution expressed by Wittkower in the following example applies to both numerical and geometric analytical approaches: "If one takes the trouble to delve into some of the proportional analyses of the "poor old Parthenon" (to quote Theodore A. Cook) published from Penrose's days on (1851), it will be seen that almost anything under the sun can be proved: that the design was based on the Golden Section (Zeising, 1854), on commensurable ratios (Pennethorne, 1878), on triangulation (Dehio, 1895), on the ratios of small whole numbers (Raymond, 1899), on root-five rectangles (Hambidge, 1924), on Greek modules (Moe, 1945), and so forth"(Wittkower, 1960, p.209). Thus, approaching the analysis without bias is essential, and all ratios and proportions should be equally plausible at the outset, and the analysis should not be primarily focused on any one of them (unless there exists any written documentation showing otherwise).

These geometric analyses of vernacular and prestige architecture can be found in the *Appendix* of this thesis. Given their variations, to make well-grounded conclusions, the studied sample had to include a large number of buildings in order to capture a robust statistical cross-section.

Managing the graphic data also presented challenges. A vast amount of information had to be organized in a comprehensive way, which would allow easy manipulation and extraction of quantities, as needed. *Microsoft Excel*'s functions proved very useful. All data were manually imported into a large table, from which pivot tables and pivot charts were derived. Data *slicers* interactively filtered the data from the table, greatly facilitating the statistical analysis of the sample.

Furthermore, in order to perform a broader analysis, the large number of individual ratios and proportions were categorized based on their decimals. Tolerance between the separate categories was 0.1 of the decimal ratio, for instance, the category of 0.8 decimal ratio, includes decimal ratios from 0.75 to 0.84 (where 3:4=0.75, 4:5=0.80, or 5:6~0.83).

EXPECTATIONS

The objectives, expectations, and aims of this thesis are formulated in this subchapter. A comprehensive discussion of aims is impossible, and the most important and intriguing aims will be discussed.

A lingering architectural question is *whether there is an apparent dominance of one particular ratio (proportion). If so, does this proportion behave like an idiosyncratic signature of a particular region?* This topic will recur as the centre point throughout the analysis. Answers will be sought from different perspectives – specifically, the proportions of building elevations and openings will be examined separately, and, in the section *Openings: Diagonal Repetition* they will be examined together. These analyses will seek to determine *whether there is any connection between the proportions of the elevation of a building* *and its openings.*

A closer look at Hambidge's "Lesson 4: The Reciprocal", as well as "Lesson 5: The Diagonal" from *The Elements of Dynamic Symmetry* may be beneficial (Hambidge, 1967), as they present a concept of shape repetition, represented by a simple diagonal.

Another question is *whether the so-called prestigious ratios – golden ratio, silver ratio, and Ludolph's number (see Proportion: Construction/ How to… within this thesis) truly play a prominent role among other ratios.* It is likely that great contrasts between vernacular and prestige architecture will be found, given the importance of prestigious ratios in the latter. However, this suspicion will remain open for further investigation.

An aforementioned intention is to study the proportions of openings. Nevertheless, this requires explanation and justification. Neufert stated: "Throughout history man has created things to be of service to him using measurements relating to his body. Until relatively recent times, the limbs of humans were the bass for all the units of measurement" (Neufert & Neufert, 2000, p.1). While the proportions of the human body are essential in door openings, in window openings this is not the case. Thus merging doors and windows into a single study category would be erroneous. Neufert continues: "One of the reasons for the failure of buildings to have cohesive relationships with one another is because the designers have based their work on different arbitrary scales and not on the only true scale, namely that of human beings"(Neufert & Neufert, 2000, p.1). The question that emerges from this is *whether a cohesive relationship will be found between the dimensions of door openings, whose dimensions are regulated by the dimensions of the human body.*

Furthermore, the existence of hierarchy between openings is commonly observable in buildings. There are openings of higher importance (major and prestigious openings) leading to rooms with greater prestige, and openings of lower importance (minor openings). The resulting question concerns *whether the hierarchy of openings affects their proportions and/or orientation.*

Another question regarding elevations concerns *whether there any proportional differences between front and side elevation.*

In the analysis of windows, as well as doors, visible boundaries (further as frames) will be independently analysed and evaluated, considering *whether the proportions of one opening are interconnected by scaling of the same shape.*

These and other questions will be addressed in the coming chapters.

SOURCES

Information regarding the sources used appears below. In vernacular architecture, an important resource was the multi-volume series: *Das Bauernhaus in Österreich-Ungarn und in seinen Grenzgebieten: Atlas* (Österr. Ingenieur- und Architeken-Verein, 1906), *Das Bauernhaus in der Schweiz* (Schweizerischer Ingenieur- und Architekten-Verein, 1903), and *Das Bauernhaus im Deutschen Reiche und in seinen Grenzgebieten: Atlas* (Verband Deutscher Architekten- und Ingenieurvereine, 1906). Additionally, *Das Bauernhaus in Tirol und Vorarlberg* (Deininger, 1979) was an additional useful resource. These sources provided clear, comprehensive drawings of building elevations, sections, and plans in the areas of interest.

Although the drawings were of sufficient scale, they were dimensionless, which potentially introduced inaccuracy.

In future research, greater precision can be by incorporating dimensioned drawings (for instance those from Austrian architect Adalbert Klaar, who made a valuable contribution to the survey of farmhouses in Austria). However, due to time constraints, these drawings were not included in this thesis.

The following sources were used in the research on proportions in prestige architecture. First, illustrations of the architecture of the Austrian monarchy from 1836 to 1918 were published in the periodical *Allgemeine Bauzeitung* (Österreichische Nationalbibliothek, n.d.). However, only the issues until 1899 were relevant for the purposes of this thesis. Second, the German periodical *Atlas zur Zeitschrift für Bauwesen* (Digital Repository of the BTU Cottbus, n.d.) provided further materials for the studied areas (typically those located in contemporary Germany). The periodical was first published in 1851. Third, the multi-volume *Das Bürgerhaus in der Schweiz* (Schweizerischer Ingenieur- und Architekten-Verein, 1921, 1924, 1925, 1928, 1935) provided images for buildings in Swiss territories. Lastly, as a greater focus was placed on the architecture of the highly prominent Wiener Ringstraßen in Vienna (the Ring Road) the materials provided by the University of Vienna's digital archive (*Wiener Ringstraßen-Archiv)* were essential for this research.

Like the vernacular architecture drawings, these prestige drawings were detailed and of adequate scale, but were ultimately dimensionless, which contributed to imprecision.

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CHAPTER 4 // VERNACULAR ARCHITECTURE: ANALYSIS OF PROPORTIONS

As mentioned earlier in this thesis, the architecture of Alpine and the Germanic regions is the focus of this research. The following subchapters (*Whole building*, *Openings*, *Prestigious ratios*, and *(Im)perfect square*) will discuss the outcomes of the geometrical analysis of vernacular architecture (see *Appendix*).

WHOLE BUILDING

A brief general overview of the proportions of a vernacular building, and a description of its basic characteristics, is necessary before entering into an exhaustive description of the proportions of openings. This will follow in three sections; *Initial Insights*, *Elevation*, and *3-Level*.

Within this subchapter, the orientation of a ratio is an important distinction and thus the original ratio (i.e., 3:4) and its reciprocal (i.e., 4:3) are treated individually.

INITIAL INSIGHTS

This section explores some of the ruling conventions of building composition–specifically, symmetry, spacing-grid, and segmented composition.

According to the *Architecture Dictionary*, symmetry is "the exact correspondence in size, form, and arrangement of parts on opposite sides of a dividing line or plane, or about a centre or axis. Also, regularity of form or arrangement in terms of like, reciprocal, or corresponding parts"(Architecture Dictionary Editors, n.d.-b). In this thesis, emphasis is placed only on the vertical symmetry of a building's façade. Given that precise symmetry on both sides of an invisible line is very rare in vernacular architecture, approximate symmetry with some minor variations will be considered symmetry.

Next, the spacing-grid should not be imagined as a grid with a single unit, in which multiples or additions compose the entirety of the grid. Instead a grid with several reference distances is the approach taken within this thesis. These distances are rooted in the widths or heights of windows, doors, or the distances between them.

Lastly, it is common practice to identify subdivisions in a façade as well as characteristic compositions of these subdivisions. Therefore, the category segmented composition features in the analysis. Segmented compositions can be horizontal, vertical, or both.

The study outcomes are listed in Fig. 4.01. The results show only small variations over the regions studied. Symmetry is quite rare in vernacular architecture; featuring in only 15.31% of architecture studied in all regions, 18.64% in the Alpine region, and just 10.26% in the Germanic region. However, a looser type of symmetry, which will be referred to as object symmetry, is more common (see *Appendix*). An example of object symmetry may be three windows on both sides of an axis, but with different types of windows or different spacing.

Secondly, a spacing-grid is evident in a majority of the buildings studied; is 81.63% of buildings in the combined regions, 84.75% in the Alpine region, and, slightly less, 76.92% in the Germanic region.

And lastly, segmented compositions were almost equally present and absent, with slightly more instances in which a segmented composition was present; with 56.12% of buildings presenting a segmented composition in the combined region, 54.24% in the Alpine region, and 58.97% in the Germanic region. Furthermore, in the *Appendix*, one can observe that a segmented composition is almost completely consistent in the side elevation, whereas in front elevation it less a frequent practice.

ELEVATION

This section concerns which ratios (of width to height) of a building elevation are the most common in vernacular architecture, and whether there is one ration which is more common. The use of specific proportions is most possible in front elevations because the side elevation has historically been freely extended based on occupant need. This thesis will therefore focus on the front elevation.

Fig. 4.03 shows the percentage occurrence of individual ratios by regions. Although the initial intention of this part of the analysis was to categorize these ratios based on their decimal value (which is shown in Table 4.01 of this section) it is valuable initially, to observe the ratio distribution without distortion. Otherwise, potential peculiarities of relationships within the ratios could go unnoticed.

A predominant ratio does exist, and it is the 1:1 ratio. This ratio stands out regardless of the region. In all regions, the occurrence of this ratio reaches almost 16%, almost 15%, in the Alpine region, and slightly over 16% in the Germanic region. The in all regions the 2:3 ratio has a frequency of around 10%, which is above average. It is the second most frequent ratio in the Alpine and Germanic regions, and in these regions it shares its frequency with other ratios. Surprisingly, in the Alpine region, the 2:3 ratio is as frequent as its reciprocal ratio of 3:2 (each ~9%). In the Germanic region, the ratio 3:5 is as frequent as the 6:5 ratio (each ~12%).

The dominance of the 1:1 ratio is not so similarly evident in the decimal ratio table (Table 4.01). In the Germanic region, the highest frequency is shared by decimal ratio categories: 0.7, 0.8, and 1.0. This is an example of how the peculiarities or relationships may be obscured in the decimal data. This is the result of the category 0.7 comprising the ratios 2:3, and 5:7; the category 0.8

CHAPTER 4 // VERNACULAR ARCHITECTURE: ANALYSIS OF PROPORTIONS

Fig. 4.01
Initial insights: Occurrence of symmetry, spacing-grid, and segmented composition by region

Decimal ratio a/b = **C**	Front elevation All regions (%)	Front elevation Alpine region (%)	Front elevation Germanic region (%)	Side elevation All regions (%)
0.5	-	-	-	7.14
0.6	5.17	-	12.50	7.14
0.7	12.07	8.82	16.67	-
0.8	12.07	8.82	16.67	-
0.9	8.62	8.82	8.33	-
1.0	15.52	14.71	16.67	7.14
1.1	6.90	11.76	-	-
1.2	10.34	8.82	12.50	7.14
1.3	5.17	5.88	4.17	-
1.4	1.72	-	4.17	-
1.5	5.17	8.82	-	-
1.6	3.45	2.94	4.17	7.14
1.7	3.45	5.88	-	21.43
1.8	6.90	8.82	4.17	28.57
2.0	3.45	5.88	-	7.14
2.3	-	-	-	7.14
%: Total	100.00	100.00	100.00	100.00
#: Elevations	58	34	24	14

Table 4.01
Elevation: Decimal ratios by region and elevation type

Orientation	Front elevation All regions (%)	Front elevation Alpine region (%)	Front elevation Germanic region (%)
Landscape	46.55	58.82	29.16
Neutral	15.52	14.71	16.67
Portrait	37.93	26.47	54.17
%: Total	100.00	100.00	100.00
#: Elevations	58	34	24

Table 4.02
Elevation: Orientation of the front elevation by region

comprising the 3:4, 4:5, and 5:6; and 1.0 category comprising only the 1:1 ratio (Fig. 4.03). The resulting percentage of the decimal ratio category is the sum of the percentages of the corresponding ratios.

Before continuing, a small excursus on the proportions of elevations is necessary. A distinction should be made between the orthogonal and appearance proportions. As the name suggests, the orthogonal proportion is derived from the orthogonal projection and includes the width and height of an elevation. In prestige architecture orthogonal proportions could also be referred to as planned proportions. However, within the scope of vernacular architecture, such terminology loses its meaning. On the contrary, appearance proportions (proportions as they appear to a pedestrian) can be variable, as this changes with the position of an observer, as demonstrated in the following example: the closer an observer stands to a building, the less of the roof he or she sees, and vice versa. Within the analysis of appearance proportions, a close distance from the building will be used.

These two kinds of elevation proportions are further compared in Fig. 4.02, where the decimal ratio categories of the front elevations are shown. The side

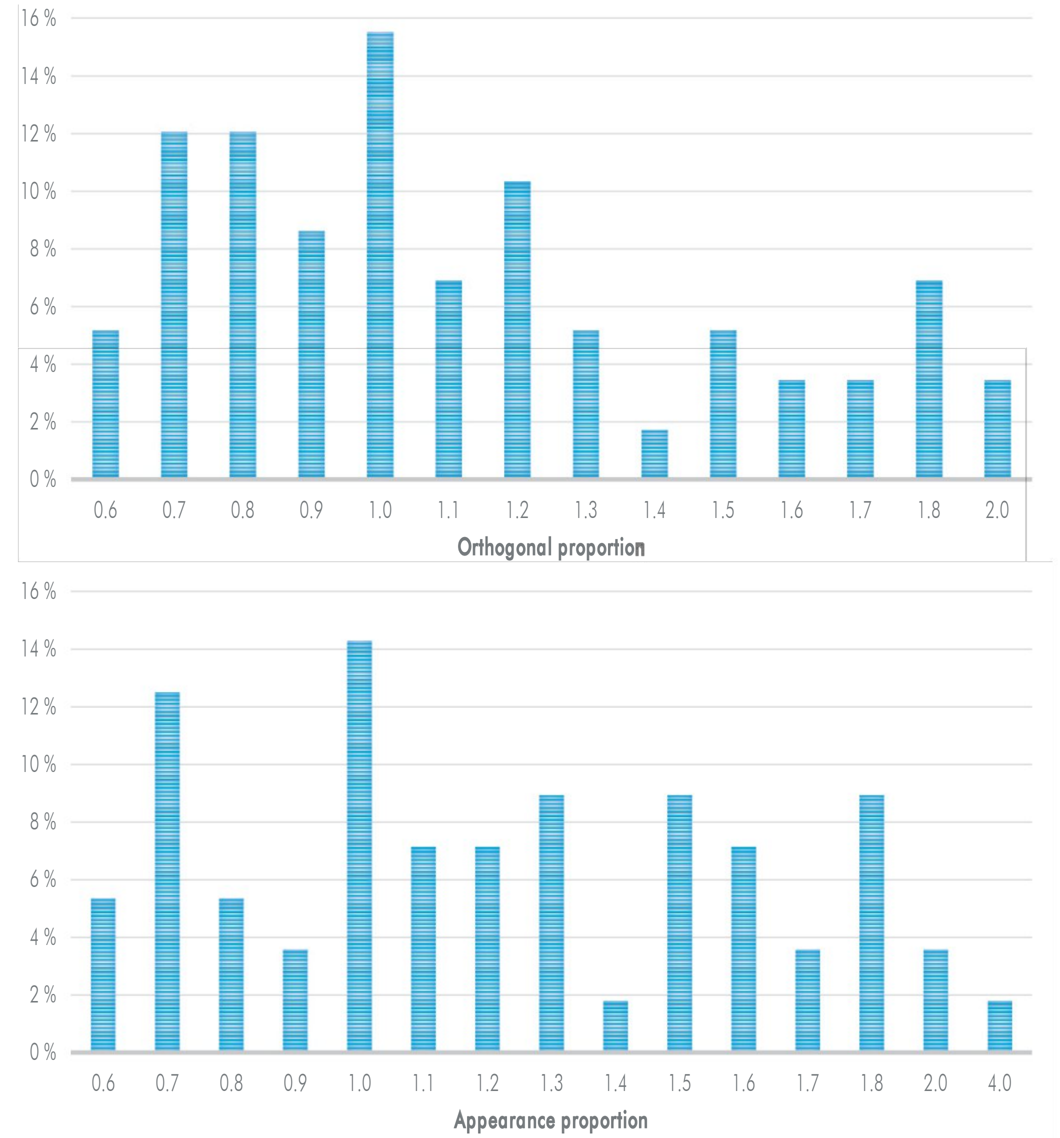

Fig. 4.02 Elevation: Decimal ratios by orthogonal proportion and appearance proportion

and rear elevations are omitted. As one can see, there is a modest peak at the 1.0 category in both orthogonal and appearance proportions, the former having almost 16% and in the latter having ~14%. Other than that, within orthogonal proportion, the 0.7 and 0.8 categories are tied for second most frequent, while 1.2 is third most frequent. In appearance proportion, 0.7 was second most frequent, however, the frequency of 0.8 noticeably decreased, rendering it one of the less significant decimal ratio categories. By contrast, the 1.3, 1.5, and 1.8 categories increased in frequency. From this we may deduce that the portrait orientation of an elevation plays a more important role in the orthogonal proportion than in the appearance proportion and vice versa. Furthermore, the landscape orientation is of greater relevance in the appearance than in orthogonal proportion.

The combined values of side elevations can be found in Table 4.01. Although the study sample of 14 cases is too small to conclude objective statements, some observations can still be made, and the decimal ratio categories of 1.8 (with 28.57%), and 1.7 (with 21.43%) prevail.

Nevertheless, if with the blurring process is continued and multiple decimal ratio categories from Table 4.01 are merged together, some interesting results are obtained. These values are listed in Table 4.02, where the decimal ratios below 1.0 form the landscape category, ratio 1:1 (equal to 1.0) forms the neutral category, and those above 1.0 form the portrait category. While the

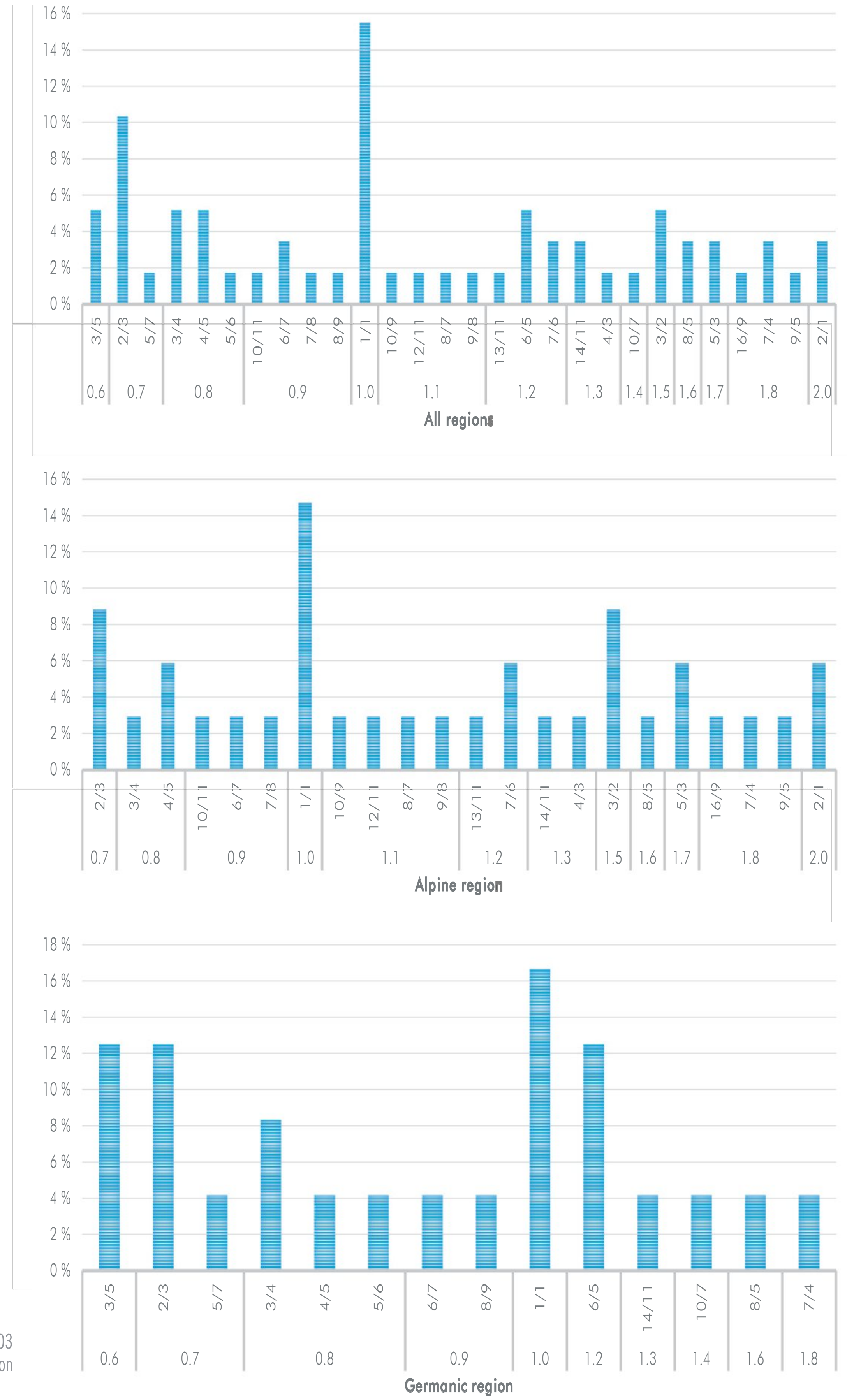

Fig. 4.03
Elevation: Ratios of front elevations by region

CHAPTER 4 // VERNACULAR ARCHITECTURE: ANALYSIS OF PROPORTIONS

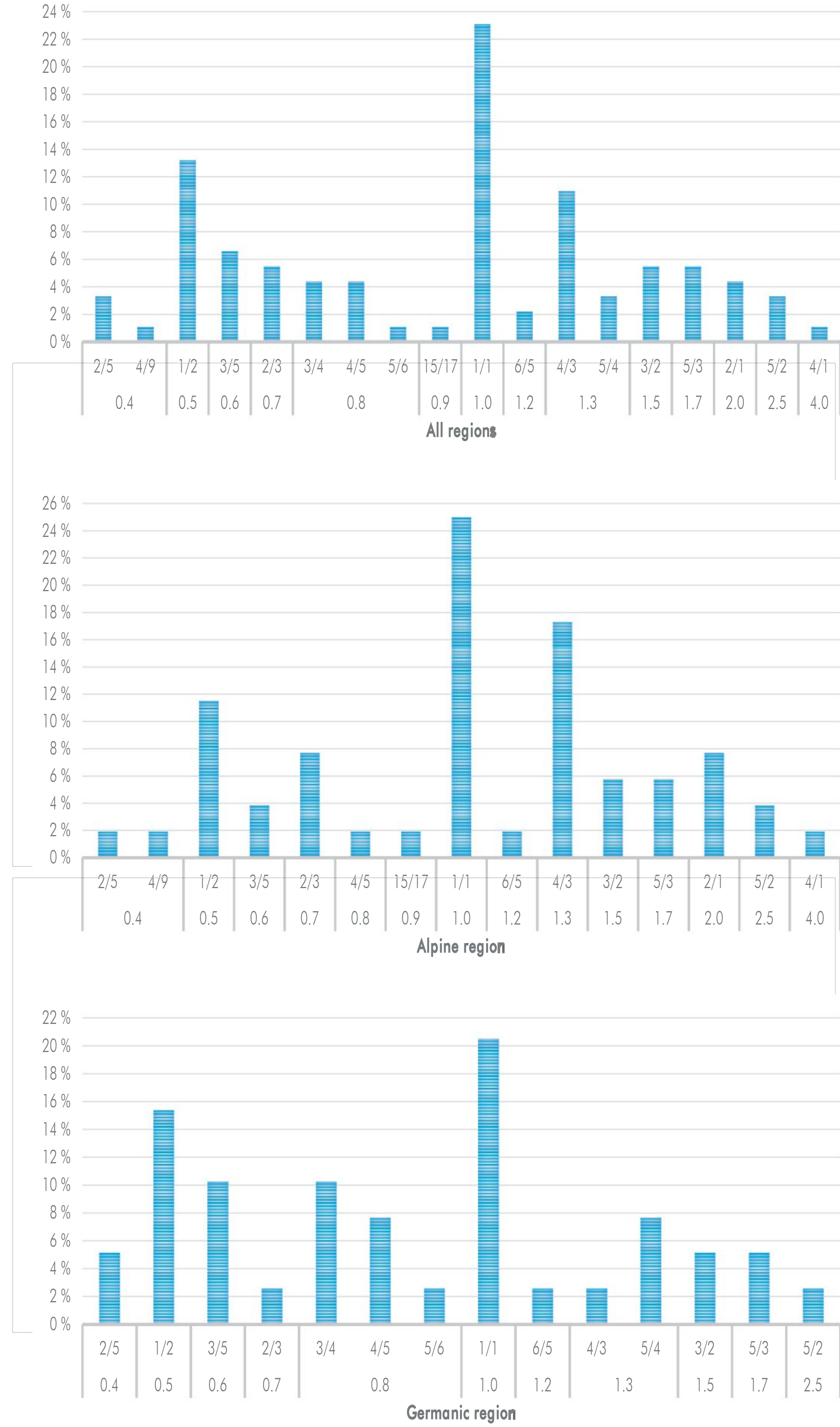

Fig. 4.04
3-Level: Ratios of front elevations by region

Decimal ratio a/b = C	All elevations: All regions (%)	Alpine region (%)	Germanic region (%)
0.4	4.40	3.85	5.13
0.5	13.19	11.54	15.38
0.6	6.59	3.85	10.26
0.7	5.49	7.69	2.56
0.8	9.89	1.92	20.51
0.9	1.10	1.92	-
1.0	23.08	25.00	20.51
1.2	2.20	1.92	2.56
1.3	14.29	17.31	10.26
1.5	5.49	5.77	5.13
1.7	5.49	5.77	5.13
2.0	4.40	7.69	-
2.5	3.30	3.85	2.56
4.0	1.10	1.92	-
%: Total	100.00	100.00	100.00
#: 3-level	91	52	39

Table 4.03
3-Level: Decimal ratios by region

majority of Alpine elevations fall into the landscape category, the opposite is true for Germanic elevations, where the portrait category is more common.

3-LEVEL

As the name of this section suggests, the relations between 3 levels of a building elevation will be examined: ground level (alternatively plinth level), eaves level (alternatively attic level), and roof ridge level. This analysis is independent of elevation type (front, side, or rear); thus, the results are listed inclusively in a category of all elevations.

Within Fig. 4.04 the individual ratio occurrence is depicted. Once again, special attention is drawn to the 1:1 ratio, which is the most common ratio in all study regions (with ~23% corresponding to all regions, ~25% to the Alpine region, and ~20% to the Germanic region). The subsequent order of ratio incidence is region-based.

In all regions, the 1:2 ratio is the second most frequent (~13%), and the 4:3 ratio is the third (~11%). Similar results are obtained from the Alpine region, but in reversed order, where 4:3 is most frequent (~17%), outstripping the 1:2 ratio with ~12%. In the Germanic region, the ratio of 1:2 has an even greater frequency (~16%), the occurrence of the 4:3 ratio, however, is much lower and is one of the least frequent ratios in this area. Instead, ratios as 3:5 or 3:4 (each ~10%) are more pronounced in the Germanic region.

In Table 4.03 individual ratios are grouped in the corresponding decimal ratio categories. The 1.0 decimal ratio is most frequent in every region (20.51% and 25.00% respectively), although in the Germanic region it is as frequent as the 0.8 decimal ratio. Categories 1.3 and 0.5 also deserve attention given that their values are above average regardless of the region.

OPENINGS

The urge to separate window and door openings into individual categories

emerged from the fact that while the proportions of window openings are not liable to major restrictions (except static ones), in case of the proportions of door openings this is not the case as the most important determinants are the measurements of the human figure. Otherwise, the joined analysis of openings proportions would lead to misguided or incorrect conclusions.

Furthermore, the hierarchy of openings (major or minor) requires some attention. Already noted in the chapter *Vernacular vs. Prestige Architecture: Introduction to Analyses/ Expectations*. Although it was difficult to make clear-cut categorizations as hierarchical relationships weren't always perfectly clear, in most cases differentiation based on the building plan was sufficient. Thus, the openings leading into premises with higher prestige were designated as major openings and those into lower prestige as minor openings. Main entrance doors and openings of salons or lounges (*Stube*), guest rooms (*Gästezimmer*), and tile stove rooms (*Kachelstube*) were included in the major category, while openings of sleeping rooms or chambers (*Kammer*), smoking-chambers (*Rauchstube*), kitchens, and all other rooms (such as farm-related ones) were included in the minor category. This differentiation was crucial in the assessment of their proportions separately and in concluding whether dissimilitude between them exists.

Furthermore, to trace contrasts among ratios of a single opening type, the inner and outer frame categories (and occasionally the extra frame category) were introduced. The inner frame indicates the wall opening itself. This is usually surrounded by the outer frame, which further emphasizes the presence of the opening. In a few cases, inner and outer frames were not satisfactory for the comprehensive opening characteristic, thus the extra frame was added. The extra frame was used to describe doubly framed windows or very large farm doors (where there is a smaller entrance (for people) and a larger entrance (for animals and other farming uses) in the same opening).

DIAGONAL REPETITION

The first characteristic of openings is diagonal repetition. Given that a simple diagonal is an unambiguous representation of a geometric ratio, in this section diagonal usage relates the proportions of the building elevation (width or length to height) to its openings. However, the diagonal orientation will not be taken into consideration, and initial and reciprocal (rotated about 90°) shapes will be treated equally.

This section will consider the absolute-opening quantity, not the relative quantity (based on an opening type). In other words, if one type of opening is used ten times and another type of opening is used three times, a sample of thirteen openings in total is used.

Fig. 4.05 shows data for both analysed regions together. According to the studied sample of 787 openings, two-thirds (69.00% = 37.74% maj + 31.26% min) revealed no connection to the proportions of the building. However, one-third, not a negligible amount, (31.00% = 17.66% maj + 13.34% min) consists of openings that were interrelated with the proportions of the building. In this case, the distinction between major and minor openings did not play a significant role, as their values were proportionate and similar. On the other hand, an observable distinction could be made according to the elevation type. Table 4.04 shows that 63.58% lacked and 36.42% contained diagonal repetition. The side (or rear) elevation had an even more pronounced

	Elevation type			
Diagonal repetition: All regions	**Front**	**Side**	**Rear**	**All**
False				
Percentage amount	63.58%	76.67%	91.67%	69.00%
Number of openings	302	230	11	543
True				
Percentage amount	36.42%	23.33%	8.33%	31.00%
Number of openings	173	70	1	244
Percentage amount	**100.00%**	**100.00%**	**100.00%**	**100.00%**
Number of openings	**475**	**300**	**12**	**787**
Diagonal repetition: Alpine region	**Front**	**Side**	**Rear**	**All**
False				
Percentage amount	67.97%	75.44%	-	70.80%
Number of openings	191	129	-	320
True				
Percentage amount	32.03%	24.56%	-	29.20%
Number of openings	90	42	-	132
Percentage amount	**100.00%**	**100.00%**	**-**	**100.00%**
Number of openings	**281**	**171**	**-**	**452**
Diagonal repetition: Germanic region	**Front**	**Side**	**Rear**	**All**
False				
Percentage amount	57.22%	78.29%	91.67%	66.57%
Number of openings	111	101	11	223
True				
Percentage amount	42.78%	21.71%	8.33%	33.43%
Number of openings	83	28	1	112
Percentage amount	**100.00%**	**100.00%**	**100.00%**	**100.00%**
Number of openings	**194**	**129**	**12**	**335**

Table 4.04
Diagonal repetition: Occurrence by region and elevation type

absence in diagonal repetition with a value of 76.67% and a rate of only 23.33% for the presence of diagonal repetition. The values representing rear elevations should be taken with a pinch of salt, as the studied sample of rear elevation openings is unrepresentatively small.

In the Alpine region, an analysis of a sample of 452 openings was conducted. If diagonal repetition was compared based solely upon opening hierarchy a similar result to the general analysis is reached. Again, approximately two-thirds (70.80% = 40.27% maj + 30.53% min) of openings do not exhibit diagonal repetition, and one-third (29.20% = 17.70% maj +11.50% min) of openings reflect the proportions of the building. The values in the major category and in the minor category are proportionately and similar (Fig. 4.05). The absolute quantity difference of major and minor openings is greater in the Alpine region than in both regions combined, and in the Germanic region alone. Table 4.04 contains the values of diagonal repetition according to the elevation type. When examined, similar results are reflected in this table as in the previous focus area.

The situation in the Germanic region does not show any significant deviations from the previous two areas of focus. Analysis of the 335 opening sample showed that 66.57% (34.33% maj + 32.24% min) of windows showed diagonal repetition, and 33.43% (17.61% maj +15.82% min) for the diagonal

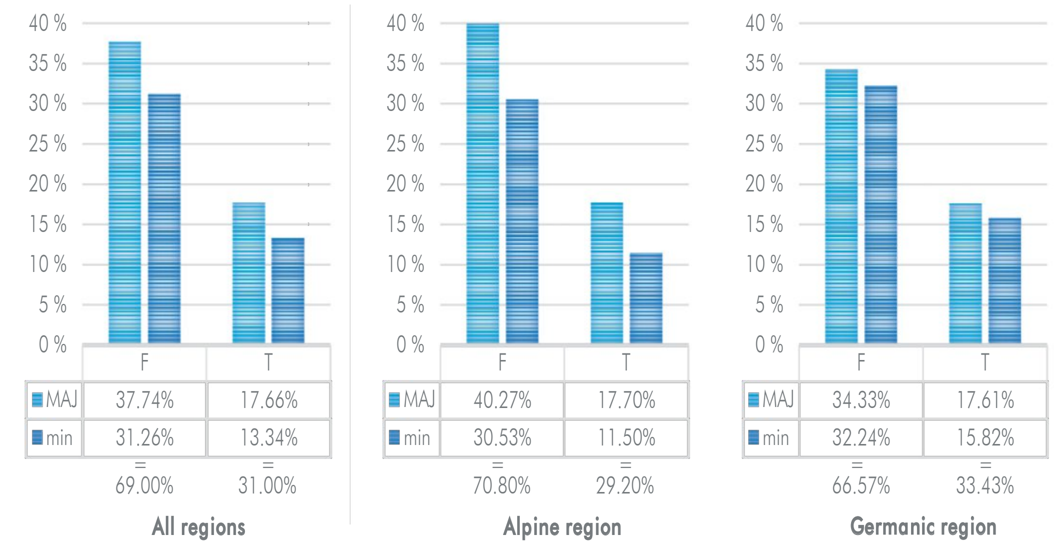

Fig. 4.05
Diagonal repetition: Occurrence by hierarchy of openings and region

repetition (Fig. 4.05). Outcomes inside the individual categories of major and minor openings depict proportional equality once again. However, the front elevation is more evened and the side elevation more polarized than in the areas studied so far (Table 4.04).

FRAME-SHAPE REPETITION

As mentioned at the beginning of the *Openings* subchapter, the study concerns not only the proportions of the actual wall openings (referred to as inner frames), but also the proportions of its framing (outer frames), and, in select cases, the proportions of extra frames. This section concerns the proportional similarities in the opening itself. The ratios of inner or outer frame (and if one exists, the extra frame), are set compared to identify their repetitions. Ratios in the initial position (e.g., 7:8 and 7:8), as well as the reciprocal position (e.g., 7:8 and 8:7), are considered repetitions. Reciprocal repetitions were very rare and for the entire analysis, could be counted on one hand.

The particularity of diagonal repetition and frame-shape repetition requires clarification: while diagonal repetition concerns the repetition of building elevation ratios (width or length to height) within the scope of its openings, the frame-shape repetition concerns repetitions among the ratios of single opening types. Furthermore, the absolute number of openings was used for the sake of diagonal repetition analysis, while for frame-shape repetition, only the number of opening types was used. For example, if there were 10 openings of type one, and 3 openings of type two, the absolute number of openings is 13, while the number of opening types is 2.

The commonness of frame-shape repetition is evident in Table 4.05. A study of 397 opening types in all regions shows that this characteristic of the openings is uncommon: merely 19.65% of openings were common, while 80.35% were distinct. Interestingly, in individual regions, differences were observed. In the Alpine region, based on a sample of 216 opening types, the frame-shape repetition was diagnosed in 26.39%, on the other hand, in the Germanic region, out of 181 opening types, only in 11.60% - deducing, the frame-shape repetition is in the Alpine region more than twice as common as in the Germanic region.

In this area of focus, the type of elevation (front, side, rear) does not contribute to any major differences, thus a more detailed analysis in this regard is unnecessary.

Frame-shape repetition	Regions All regions	Alpine region	Germanic region
False			
Percentage amount	80.35%	73.61%	88.40%
Number of opening types	319	159	160
True			
Percentage amount	19.65%	26.39%	11.60%
Number of opening types	78	57	21
Percentage amount	**100.00%**	**100.00%**	**100.00%**
Number of opening types	**397**	**216**	**181**

Table 4.05
Frame-shape repetition: Occurrence by region

Compound type	Regions All regions	Alpine region	Germanic region
2			
Percentage amount	80.00%	80.00%	80.00%
Number of compound types	48	16	32
3			
Percentage amount	10.00%	5.00%	12.50%
Number of compound types	6	1	5
4			
Percentage amount	8.33%	10.00%	7.50%
Number of compound types	5	2	3
6			
Percentage amount	1.67%	5.00%	-
Number of compound types	1	1	-
Percentage amount	**100.00%**	**100.00%**	**100.00%**
Number of compound types	**60**	**20**	**40**
Number of all opening types	**397**	**216**	**181**

Table 4.06
Compound: Occurrence by region and compound type

The role of hierarchy between openings plays in the context of frame-shape repetition is an interesting topic for exploration. From Fig. 4.06 it is clear that in a cumulative analysis of both regions, the hierarchy of openings does not influence the outcomes of frame-shape repetition. In both cases, the results are evenly distributed: one-fifth reflect frame-shape repetition, and four-fifths do not. Nonetheless, these are averaged figures of otherwise polarized outcomes in individual regions. In the Alpine region, this ratio repetition within an opening is dominant in major openings, where 32.4% of them reflect this characteristic (whereas in minor openings 21.1% do). In the Germanic region, not only are the positive values of frame-shape repetition significantly lower than in the Alpine region but this characteristic is also more common within minor openings, where 15.5% favour it (whereas in major openings 6.4% do). This surprising outcome in the Germanic region could be explained by the assumption that the decisive element is a square-shaped opening, which usually exhibits frame-shape repetition, and thus the potential that it occurs more frequently in minor openings could explain these results. This assumption requires further investigation in coming sections, namely *Inner Frame: Window*, and *Outer Frame: Window*.

COMPOUND

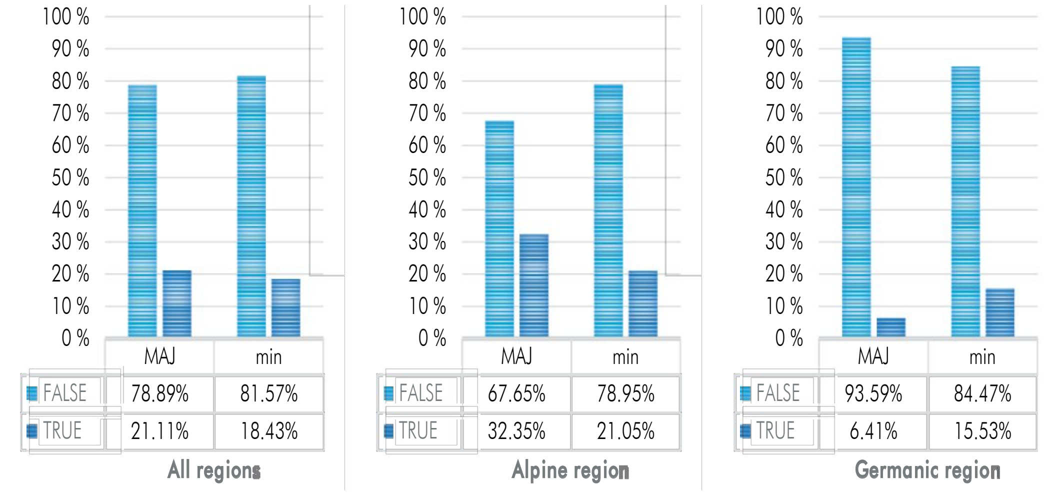

Fig. 4.06
Frame-shape repetition: Occurrence by hierarchy of openings and region

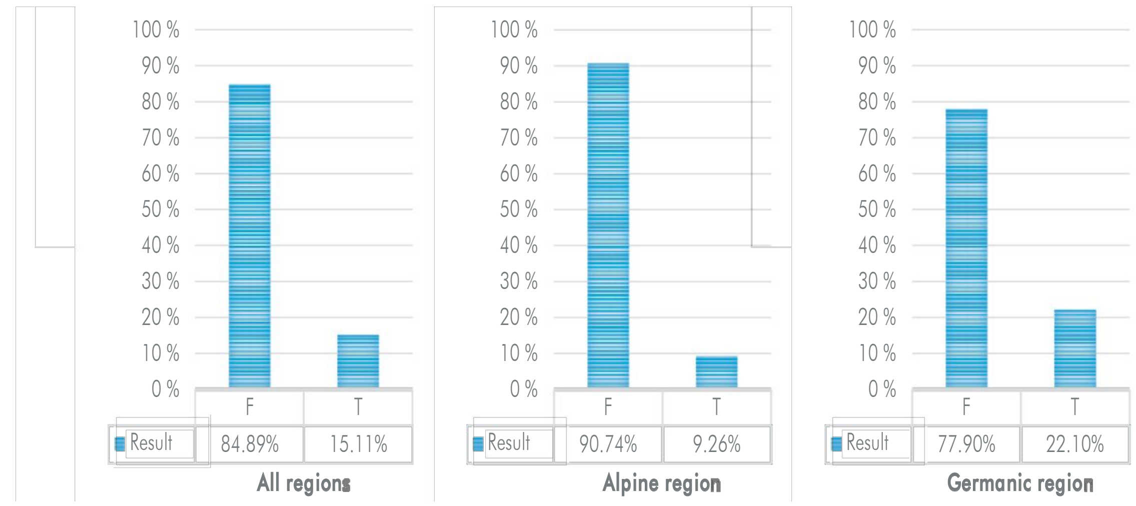

Fig. 4.07
Compound: Occurrence by region

Openings are not always placed individually, but sometimes in compounded arrangements, which is the subject of this section. The compound characteristic of an opening should be noted, because it affects the outer frame proportions in peculiar ways.

First, the frequency and geographic spread of these compounded openings will be considered within the sample of vernacular architecture (Fig. 4.07). Starting with all regions, 15.11% of all openings were categorized as compound. In absolute numbers, 60 of 397 opening types were compound. In the separate analysis of the Alpine region, compound opening types were even less common. Only 9.26% are arranged in a cluster, and the remaining 90.74% were placed individually; namely, there were 20 compound opening types in the sample of 216 windows. The Germanic region reveals greater favour for this opening characteristic. 22.10% of opening types were organized in groups; or a total of 40 compounded opening types out of 181 openings. Furthermore, the type of elevation (front, side, rear) did not play a major role and a more detailed analysis in this regard is unnecessary.

Table 4.06 shows the percentage and absolute numbers of specific compound types. The most preferred compound type in all three study areas (all regions, Alpine region, and Germanic region) is the compound of two individual openings. Within all three the frequency of this type was 80.00%. Other types of compounds included three, four, and six openings. However, these compound types were very rare by comparison to the two openings type. For instance, the largest six-opening compound was found only once in the entire study sample, specifically in the Alpine region.

INNER FRAME: WINDOW

Opening proportions are the topic of this and several subsequent sections. Within this section, focus will be directed toward the ratios of the inner measurements of openings, which coincide with the wall penetration itself.

Fig. 4.08 shows the percentage occurrence of individual ratios by regions. In all regions, the ratio 1:1 is dominant (at nearly 18%), however ratios 2:3 (at ~12%), and 3:4 (at ~11%) are also significant. The remaining ratios(3:5, 5:7, 4:5, 5:6, and 6:7) have a low incidence of about 6% to 7%. The other remaining ratios are even less frequent.

The analysis for each region (all, Alpine, and Germanic) separately is purposeful since the combined analysis does not show the idiosyncrasies within each region but averages them out. The best example of this occurs in the case of the 1:1 ratio. Its frequency within the Alpine region is about 26% which outstrips any other ratio. In the Germanic region however, the 1:1 ratio had a frequency of about 9%, which meant that it ranked sixth among other ratios. Other frequent ratios in the Alpine region include 2:3 (~12%), 3:4 (~10%), and 6:7 (~10%). By contrast, in the Germanic region, there is no clear superior ratio, although there is a slight peak at a ratio 3:5 with nearly 13%. However, ratios 2:3 (~12%), 3:4, and 4:5 (~11% each), and 5:7 (~10%) were comparably frequent.

Table 4.07 lists the frequency of the inner-frame ratio divided into decimal ratio categories. Furthermore, the table captures the incidence of these decimal ratios according to the elevation type. It is notable that the category of 0.8 (including ratios 3:4, 4:5, and 5:6 among others) is the most common decimal ratio in all regions and the Germanic region regardless of the elevation type. The percentage frequency ranges from 22% to 33%. When based upon the elevation type, the figures in the Alpine region differ, reflecting only one incident of the decimal ratio 1.0 (consisting solely of ratio 1:1), and one incident of decimal ratio 0.8. In all elevations, and in the front elevations, the most common decimal ratio is 1.0 (with 26.3% and 28.0% respectively), and in the side elevation category, the most common decimal ratio is 0.8 (with 26.8%). Decimal ratio categories 0.6, 0.7, and 0.9 are also more prevalent. Despite some deviations (for example in decimal ratio 0.6, which is more prevalent in front elevations than in side elevations, or in the variability in the most frequent decimal ratio in the Alpine region) many values do approximately overlap, regardless of the elevation type.

Thus far, analysis has focused on the general proportions of inner frames by region and elevation. However, one intriguing question remains: whether the hierarchy of openings plays any role in an aspect of frame proportions (in this case, inner frame proportions). Fig. 4.09 provides an appropriate basis this analysis. One apparent difference between proportions of major and minor openings, regardless of the study region, is the diversity of ratios, which is considerably higher within the category of minor openings. There are two possible explanations: first, the number of minor openings sizably surpasses the number of major openings; and second, the minor openings lead to rooms of lower importance (such as kitchen, sleeping room, etc.) and therefore their proportions are handled with less care. The first possible explanation does not hold up to scrutiny however, as the number of minor and major types, from which these graphics are derived, is approximately even. In the combined regions, out of 263 types of inner frame openings, there are 130 minor and

	All elevations			Front elevation			Side elevation		
Decimal ratio a/b = C	All regions (%)	Alpine region (%)	Ger. region (%)	All regions (%)	Alpine region (%)	Ger. region (%)	All regions (%)	Alpine region (%)	Ger. region (%)
0.4	1.90	-	3.97	2.42	-	4.76	-	-	-
0.5	3.80	2.19	5.56	4.24	2.47	5.95	3.26	1.79	5.56
0.6	11.79	7.30	16.67	15.15	11.11	19.05	5.43	1.79	11.11
0.7	18.25	15.33	21.43	19.39	16.05	22.62	17.39	14.29	22.22
0.8	25.10	21.17	29.37	22.42	17.28	27.38	29.35	26.79	33.33
0.9	12.55	19.71	4.76	9.09	16.05	2.38	19.57	25.00	11.11
1.0	17.87	26.28	8.73	16.97	28.04	5.95	19.57	23.21	13.89
1.1	3.42	3.65	3.17	4.24	3.70	4.76	2.17	3.57	-
1.2	0.76	0.73	0.79	0.61	1.23	-	-	-	-
1.3	1.52	1.46	1.59	1.82	2.47	1.19	1.09	-	2.78
1.5	0.38	0.73	-	-	-	-	1.09	1.79	-
1.7	1.52	1.46	1.59	1.82	1.23	2.38	1.09	1.79	-
2.3	1.14	-	2.38	1.82	-	3.57	-	-	-
%: Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
#: Types of inner frames	263	137	126	165	81	84	92	56	36

Table 4.07
Inner frame: window: Decimal ratios by region and elevation type

133 major openings; within the Alpine region there are 66 types of minor and 71 major inner frame openings; and in the Germanic region there are 64 minor and 62 major inner frame openings. The second explanation is therefore more likely.

In all regions, and in both categories, the decimal ratio of 0.8 dominates (~ 28% and ~22% respectively). However, the decimal ratio of 1.0 in minor openings strives for the first place, too - even if it fails. Both graphics are quite similar until the decimal ratio of 0.8, and after this decimal ratio, the incidence of ratios is more diverse, followed by the occurrence of the 1.0 decimal ratio. On the other hand, in the Alpine region, there are distinctions between major and minor inner frame openings visible at first sight. While the decimal ratios by the major openings increase successively, with a slight peak in the 1.0 decimal ratio (~25%), within the minor opening data, the local peak is located at the decimal ratio of 0.8 (~20%), and the global peak is located at the decimal ratio of 1.0 (~27%). In the Germanic region's major openings data, the decimal ratio occurrence rapidly increases until the 0.8 decimal ratio (~34%), which is the turning point, and thereafter the incidence of decimal ratios decline precipitously and then decrease gradually. Within the minor openings data, the situation is somewhat comparable to the minor openings in the Alpine region, but here the global and local peaks are in reversed order: 0.8 (~22%) and 1.0 (~20%).

Finally, the influence of the wall construction on the proportions of the inner-frame openings will be assessed. Although the categorization of wall construction would ideally consist of three separate categories (namely wood, brick, and stone) unfortunately, only two categories (wood, and brick/stone) are used, as a clear separation between brick and stone construction is not always possible based only on the drawing of the elevation or the plan of the building. Despite minor alterations between the two categories (Fig. 4.10) where the decimal ratio 0.6 is preferred within wooden constructions, or on the other hand, the decimal ratio of 0.9 is more frequent within brick/stone

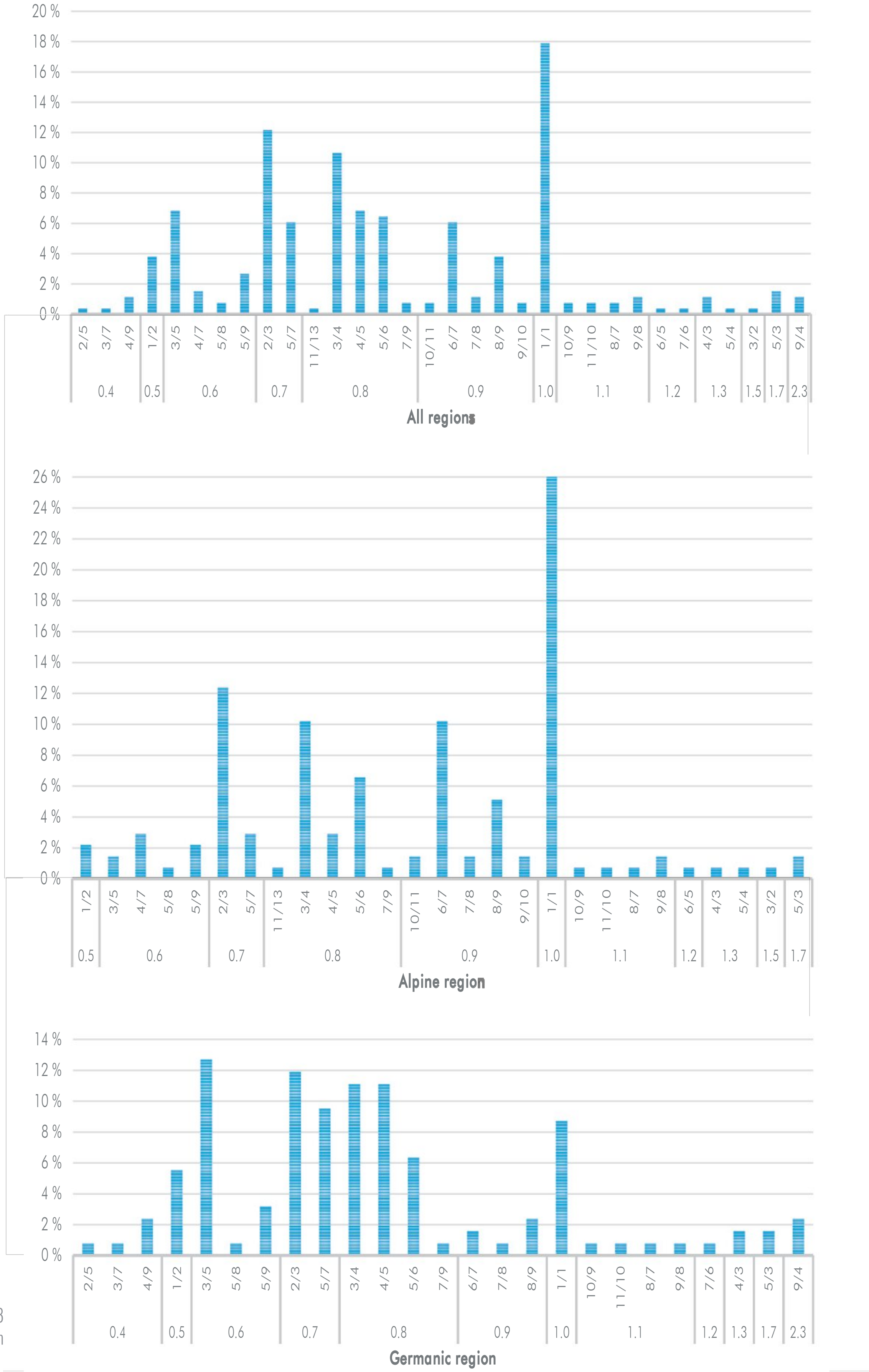

Fig. 4.08
Inner frame: window: Ratios by region

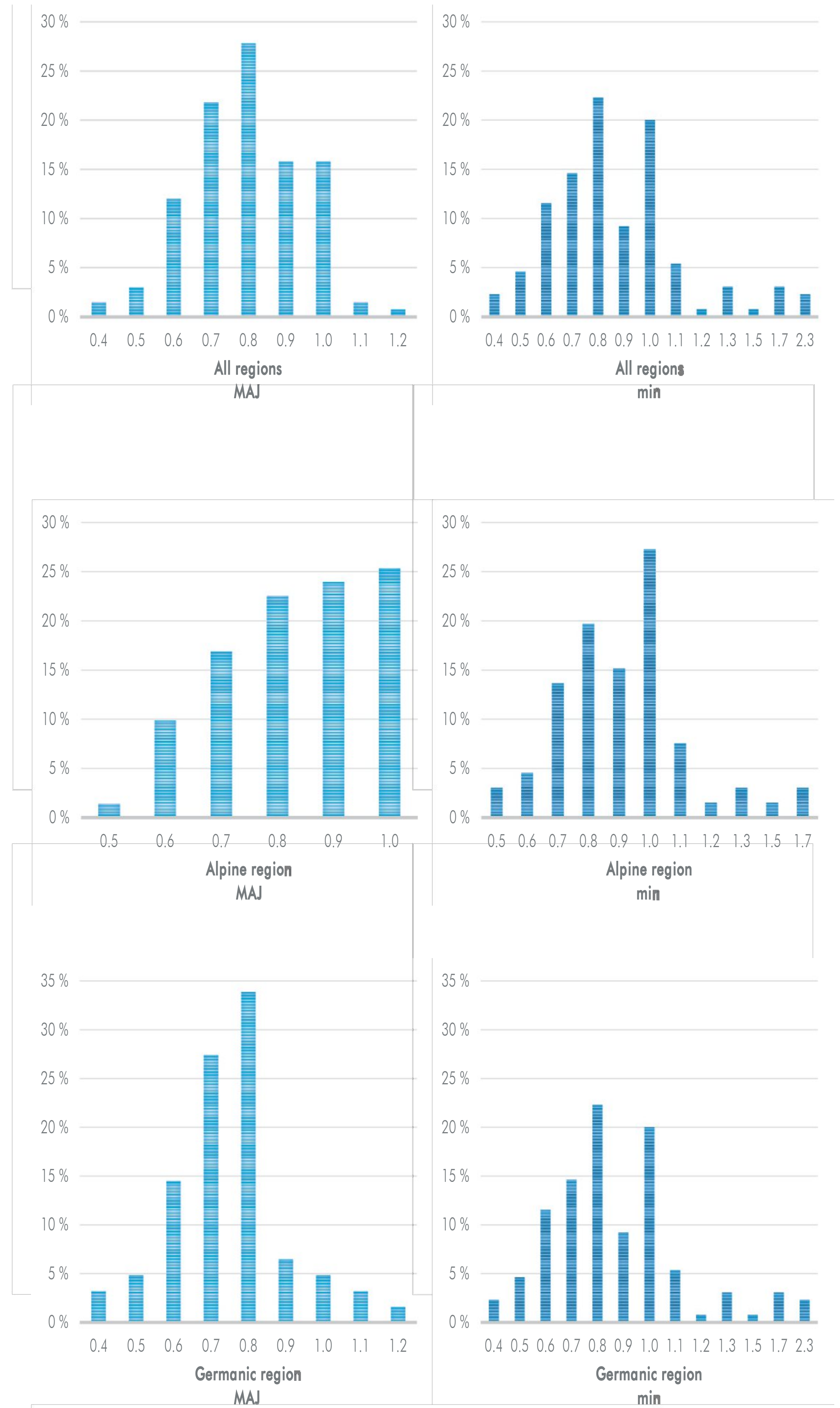

Fig. 4.09
Inner frame: window: Decimal ratios by hierarchy of openings and region

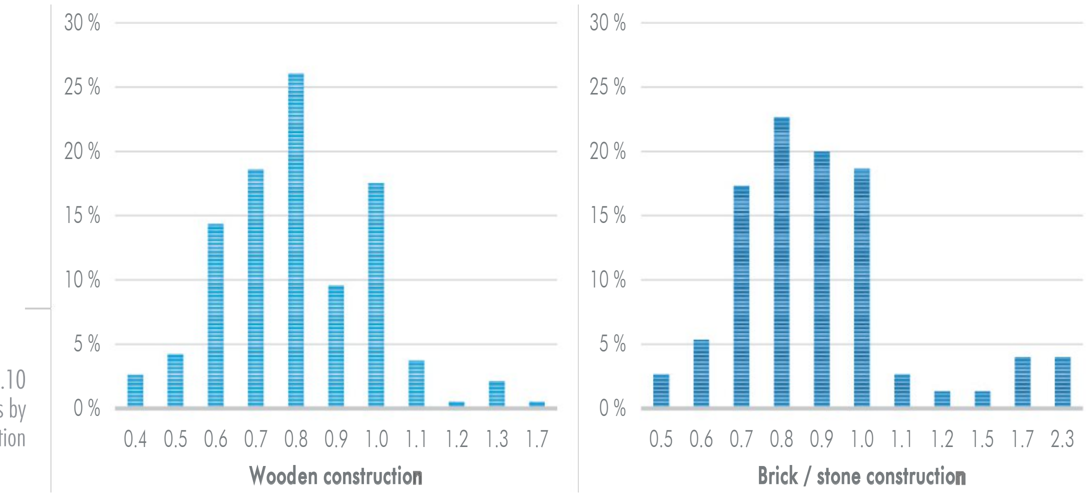

Fig. 4.10
Inner frame: window: Decimal ratios by construction

construction, both are similarly frequent, with the frequent decimal ratio being 0.8 (~26% wooden construction, and ~23% brick/stone construction).

OUTER FRAME: WINDOW

This section will entail an in-depth examination of the proportions of the outer frames of windows (in a similar manner to the section *Inner Frame: Window*). However, given that the outer frame does not affect the structure of walls in any way, because it does not penetrate the wall, and merely borders the inner frame, further investigation in this regard is not necessary. Furthermore, it is important to note the subordinate character of an outer frame to an inner frame.

As was the case with inner frames, an initial study of the general distribution of ratios by region (Fig. 4.11) is necessary. Thereafter, their adjusted categorization (Table 4.08) will occur. Interestingly, as opposed to inner frame ratios, the occurrence of the 1:1 ratio is significantly more frequent in all analysed regions, with around 23% in all regions, nearly 26% in the Alpine region and, and approximately 20% in the Germanic region. Apart from that, there are a few ratios which standing out, albeit marginally, from the otherwise consistently low frequency ratios.

These ratios vary by study region. In all regions two ratios are considerably above-the-average, namely 3:4 and 5:6. This is due to their frequency in the Alpine region. At first sight, it is harder to identify above average ratios in the Germanic region. However, upon closer inspection, the ratios of 3:4, 4:5, or 5:3 are slightly more frequent.

After unifying ratios into corresponding categories (presented in Table 4.08) the dominance of the decimal ratios 0.8 and 1.0 are once again pronounced. In the combined and side elevations the most frequent decimal ratio was 1.0 (from 23.1% to 30.0%), while in front elevation the most frequent decimal ratio was 0.8 (from 18.1% to 23.1%). The decimal ratio 0.9 was also frequent, by contrast to the Germanic region.

Fig. 4.12 shows the decimal ratio preferences according to the hierarchy of an opening. Surprisingly, in the category of major openings, beyond the typically frequent 0.8 and 1.0 decimal ratios, the most frequent decimal ratio was 0.9 (which included 10:11, 6:7, 7:8, 8:9, or 9:10). These ratios approximate a square shape. The mostly frequent decimal ratio trio 0.8, 0.9, and 1.0 depended on the study region in the following manner: the frequencies were 20:23:20 % in all regions, around 20:27:24 % in the Alpine region, and

	All elevations			Front elevation			Side elevation		
Decimal ratio a/b = **C**	All regions (%)	Alpine region (%)	Ger. region (%)	All regions (%)	Alpine region (%)	Ger. region (%)	All regions (%)	Alpine region (%)	Ger. region (%)
0.4	1.78	1.71	1.85	1.46	-	2.78	2.44	3.85	-
0.5	1.33	0.85	1.85	2.19	1.54	2.78	-	-	-
0.6	4.00	2.56	5.56	5.11	3.08	6.94	2.44	1.92	3.33
0.7	2.67	1.71	3.70	2.92	3.08	2.78	1.22	-	3.33
0.8	19.11	21.37	16.67	20.44	23.08	18.06	18.29	19.23	16.67
0.9	16.00	21.37	10.19	15.33	21.54	9.72	15.85	21.15	6.67
1.0	23.11	25.64	20.37	19.71	23.08	16.67	29.27	28.85	30.00
1.1	4.44	5.98	2.78	3.65	6.15	1.39	4.88	5.77	3.33
1.2	4.00	0.85	7.41	5.11	1.54	8.33	1.22	-	3.33
1.3	5.78	5.98	5.56	5.84	6.15	5.56	6.10	5.77	6.67
1.4	2.67	0.85	4.63	2.19	1.54	2.78	3.66	-	10.00
1.5	3.11	1.71	4.63	2.19	-	4.17	4.88	3.85	6.67
1.6	0.44	-	0.93	0.73	-	1.39	-	-	-
1.7	4.00	2.56	5.56	5.11	3.08	6.94	2.44	1.92	3.33
1.8	2.22	3.42	0.93	2.19	3.08	1.39	2.44	3.85	-
2.0	1.33	0.85	1.85	1.46	1.54	1.39	1.22	-	3.33
2.3	0.89	-	1.85	1.46	-	2.78	-	-	-
2.5	0.89	-	1.85	1.46	-	2.78	-	-	-
3.0	1.33	0.85	1.85	0.73	-	1.39	2.44	1.92	3.33
3.3	0.44	0.85	-	-	-	-	1.22	1.92	-
5.0	0.44	0.85	-	0.73	1.54	-	-	-	-
%: Total	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**
#: Types of outer frames	**225**	**117**	**108**	**137**	**65**	**72**	**82**	**52**	**30**

Table 4.08
Outer frame: window:
Decimal ratios by region and elevation type

approximately 18:18:14 % in the Germanic region, respectively. In addition, decimal ratios of 1.2 and 1.5 were somewhat more frequent in the Germanic region.

On the other hand, in the category of minor openings, the leading decimal ratio trio 0.8, 0.9, and 1.0, remained the same for all regions and within the Alpine region. Nevertheless, the most frequent decimal ratio was 1.0 and not 0.9. Therefore, they were present at frequencies of approximately 19:9:22 % in both regions combined, and around 22:15:28 % in the Alpine region. In the Germanic region, the more frequent decimal ratios included the abnormal decimal ratio of 0.6 (~10%), and the more common ratios 0.8 (~15%) and 1.0 (~26%).

The difference in diversification of decimal ratios between major and minor openings (mentioned in the section *Inner Frame: Window*), was not observed in the data, because the decimal ratio diversification is incomparable for both categories.

ALL FRAMES: WINDOW

This section concerns overall window proportions, and will not distinguish between the inner and outer frames. The analysis of window openings carried out in the previous two sections was done with great care and detail. As a result there is no need to continue in such detail in the current section, which

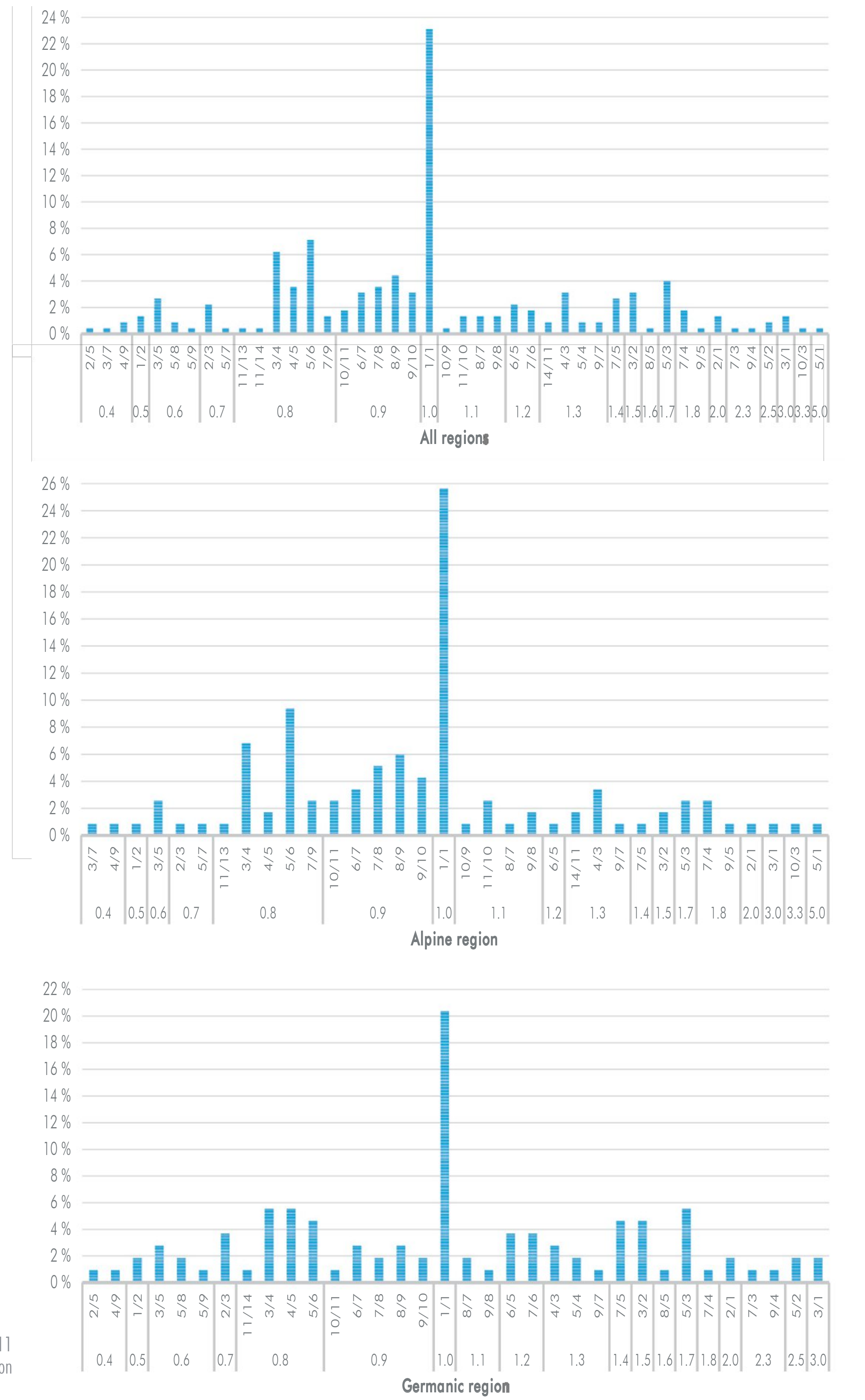

Fig. 4.11
Outer frame: window: Ratios by region

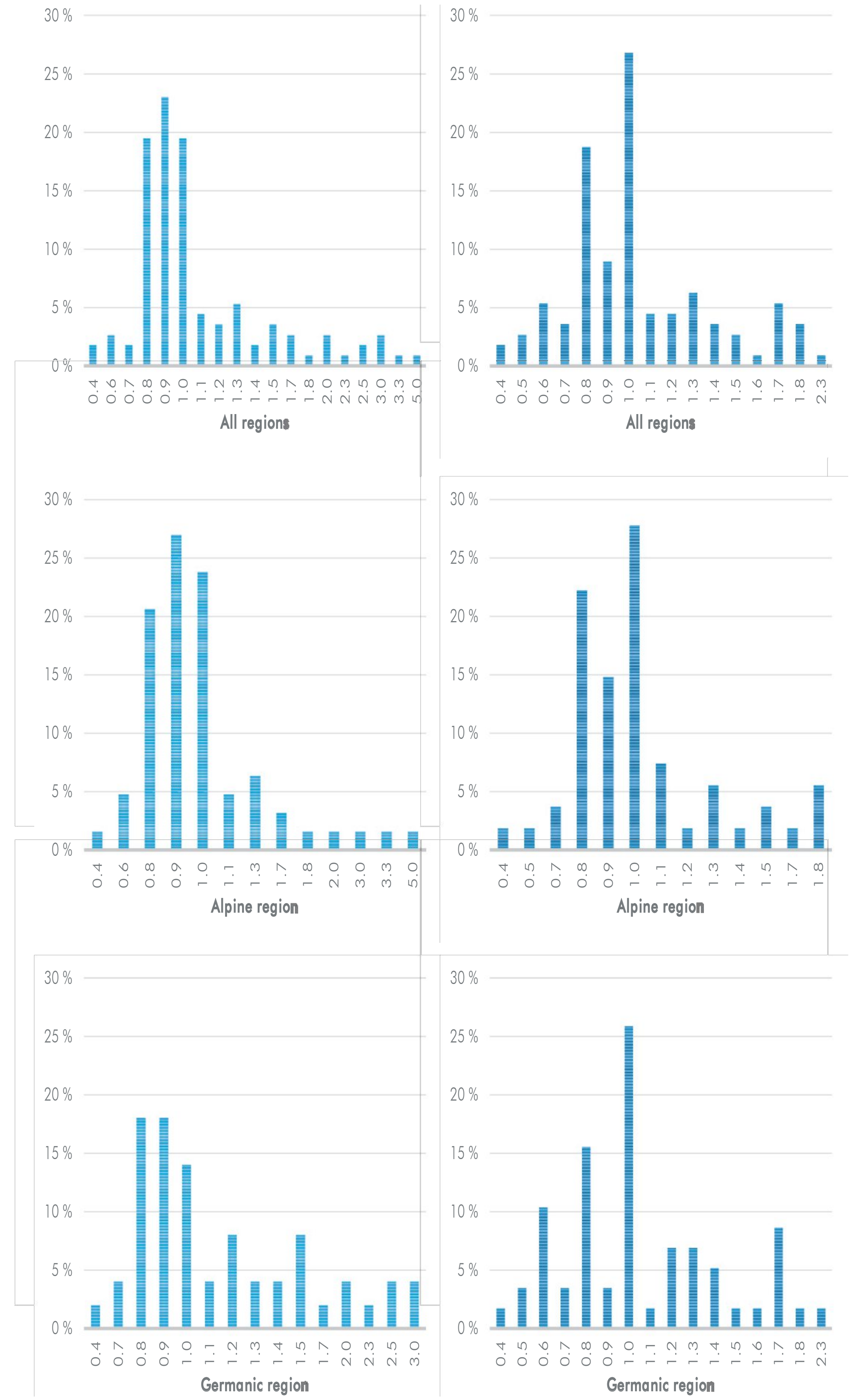

Fig. 4.12
Outer frame: window: Decimal ratios by hierarchy of openings and region

Decimal ratio a/b = **C**	Region All regions (%)	Alpine region (%)	Germanic region (%)
0.4	1.82	0.77	2.97
0.5	2.63	1.54	3.81
0.6	9.09	6.18	12.29
0.7	11.31	9.65	13.14
0.8	22.02	20.85	23.31
0.9	13.94	20.08	7.20
1.0	20.00	25.48	13.98
1.1	3.84	4.63	2.97
1.2	2.22	0.77	3.81
1.3	3.43	3.47	3.39
1.4	1.21	0.39	2.12
1.5	1.62	1.16	2.12
1.6	0.20	-	0.42
1.7	2.63	1.93	3.39
1.8	1.01	1.54	0.42
2.0	0.61	0.39	0.85
2.3	1.01	-	2.12
2.5	0.40	-	0.85
3.0	0.61	0.39	0.85
3.3	0.20	0.39	-
5.0	0.20	0.39	-
%: Total	**100.00**	**100.00**	**100.00**
#: Types of all frames	**495**	**259**	**236**

Table 4.09
All frames: window: Decimal ratios by region

will focus upon the general frequency of ratios, or their decimal ratios (Fig. 4.13, and Table 4.09).

As shown in Fig. 4.13, the 1:1 ratio is the most frequent – with a frequency of around 20% in combined regions, nearly 26% in the Alpine region, and approximately 14% in the Germanic region. The limit of 6% incidence is not exceeded by many ratios, therefore ratios will be classified according to this threshold. Apart from the 1:1 ratio, in all regions this 6% limit is only crossed by the ratios 2:3, 3:4 and 5:6; in the Alpine region by ratios 2:3, 3:4, 5:6, and 6:7; and in the Germanic region by ratios 3:5, 2:3, 3:4, and 4:5. The ratios 2:3 and 3:4 (and 1:1 as well) are the only ratios, which exceed the 6% threshold regardless of study region.

Categorized according to the decimal ratios listed in Table 4.09, the occurrence of specific decimal ratios differs by region. In the combined regions and the Germanic region there is a peak frequency in the 0.8 decimal ratio (22.0% and 23.3% respectively), whereas in the Alpine region, the peak decimal ratio is 1.0 (25.5%). Other than that, in all regions, decimal ratios of 0.7 or 0.9 are frequent, in the Alpine region, the decimal ratios as 0.8, or 0.9 are frequent, and lastly, in the Germanic region, the decimal ratios 0.6, 0.7, and 1.0 are frequent. This study was based upon a study sample of 495 types of all frames, of which 259 were Alpine and 236 were Germanic frames.

<u>ORIENTATION: WINDOW</u>

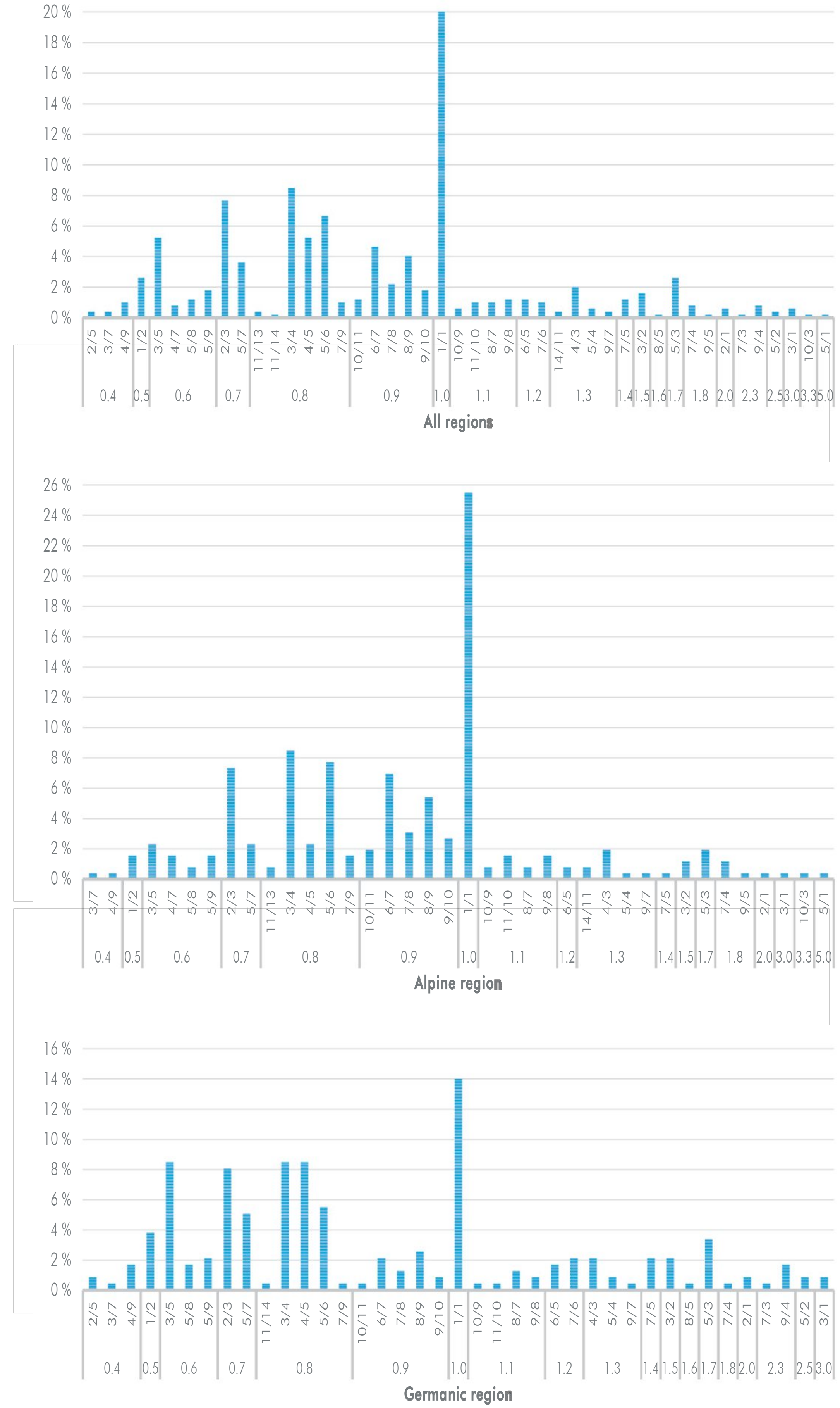

Fig. 4.13
All frames: window: Ratios by region

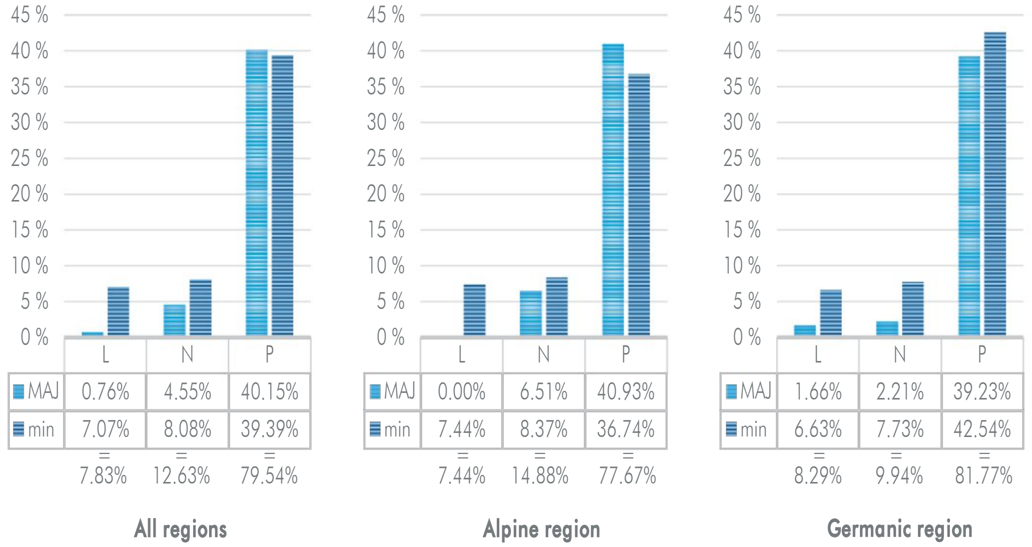

Fig. 4.14
Orientation: window: Type of orientation by hierarchy of openings and region

Thus far, the hierarchy of windows and the impact of hierarchy upon their proportions have been examined in detail for each decimal ratio category. Such a process is certainly a valuable one, however, looking at the data from a broader perspective could provide other interesting insights. Thus, if individual ratios or decimal ratios (of width to height) are grouped into only three single categories according to their orientation (namely landscape, neutral, and portrait with decimal ratios larger, equal, or smaller than 1.0, respectively) this reaps interesting results.

Fig. 4.14 depicts these three orientation categories, including divisions by opening hierarchy and region. The portrait orientation is more or less balanced between major and minor openings, regardless of the region (around 40% each). The neutral orientation (square-shaped openings) greater distinctions are evident. In all regions, minor openings are more likely to be neutral, with the largest percentage difference in the Germanic region (2.2% for major openings and 7.7% for minor openings). In combined regions, this difference is smaller (4.6% for major openings and 8.1% for minor openings), and in the Alpine region, the neutral orientation of openings is almost even (6.5% for major openings and 8.4% for minor openings). Even though the landscape orientation of openings is infrequent, it is exactly within this category that the greatest contrasts lie between major and minor categories. This orientation is almost exclusively used for minor openings. The ratios (of major to minor openings) for the landscape orientation by region are: 0.8:7.1 % in all regions, 0.0:7.4% in the Alpine region, 1.7:6.6% in the Germanic region. These ratios demonstrate a consistent preference minor openings.

The conclusion can therefore be made, that the landscape orientation of opening is usually used for rooms with lower prestige in vernacular architecture.

Furthermore, the assumptions explained in the Frame-Shape Repetition section apply in this section too, and its further examination is necessary. Given that the results indicate that the repetition of the same frame-shape (between inner, outer, or extra frames) is more common for minor than major openings in the Germanic region, it was assumed that the square-shape is more common among minor openings. Based on the results illustrated in Fig. 4.14, this assumption is confirmed. The square shape, corresponding to neutral orientation, is most frequent among minor openings in the Germanic region.

	All elevations			Front elevation			Side elevation		
Decimal ratio a/b = **C**	All regions (%)	Alpine region (%)	Ger. region (%)	All regions (%)	Alpine region (%)	Ger. region (%)	All regions (%)	Alpine region (%)	Ger. region (%)
0.4	7.83	8.57	6.67	3.77	-	14.29	11.86	19.35	3.57
0.5	21.74	24.29	17.78	20.75	25.64	7.14	23.73	22.58	25.00
0.6	43.48	35.71	55.56	39.62	41.03	35.71	44.07	29.03	60.71
0.7	18.26	21.43	13.33	26.42	28.21	21.43	11.86	12.90	10.71
0.8	6.96	10.00	2.22	5.66	5.13	7.14	8.47	16.13	-
0.9	0.87	-	2.22	1.89	-	7.14	-	-	-
1.0	0.87	-	2.22	1.89	-	7.14	-	-	-
%: Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
#: Types of inner frames	115	70	45	53	39	14	59	31	28

Table 4.10
Inner frame: door:
Decimal ratios by region and elevation type

INNER FRAME: DOOR

This section is very similar to the previous *Inner Frame: Window* section. However, the door opening will be focused upon. The inner frame, refers to the proportions of the wall penetration itself. Since the standard door opening is inseparably linked to the proportions of the human body, it can be assumed that the proportions of door openings will be more unequivocal than those of window openings. Regardless this section examines the peculiarities of proportions of inner door frames in vernacular architecture.

The extra-large door openings suitable for barn use were not included in this and other sections concerning door openings, due to the radical contrasts of their proportions compared to standard ones. Thus, a separate analysis of this door category is necessary, however given that this is a non-vital tangent to the thesis, these door opening types will be omitted.

Fig. 4.15 shows distribution of ratios by region. Remarkably, the first and second most frequent ratios are consistent regardless of region, namely the 5:9 ratio (always ~26%), and the 1:2 ratio (from ~18 to 24%). The third most frequent ratio fluctuated according to study area. The ratio 2:3 was the third most frequent ratio for inner door frames in all regions (almost 16%), as well as Alpine region (~18%). In the Germanic region, this ratio shares the fourth place with the 4:7 ratio (each ~11%), while the third place was occupied by the ratio 3:5 (nearly 16%). Other ratio types were so infrequent that they were not notable.

Table 4.10 shows more data on the proportions of inner door frames. First, the assumption formulated at the beginning of this section is confirmed, as this table lists only 7 decimal ratio categories, which is almost double the number of categories in Table 4.07 (13). It is possible that the outcomes may be influenced by the size of the study sample, as 115 types of inner door frames were analysed, compared to 263 types of inner window frames. However, this sample size difference is due to buildings possessing more windows than doors. Future research could interrogate this hypothesis with a larger study sample, as well as an assessment of so-called *Pareto principle* in decimal ratio distribution (which roughly states that 80% of the decimal ratio occurrence is ruled by 20% of the decimal ratio categories).

Table 4.10 displays other noteworthy results, specifically that the decimal ratio

Fig. 4.15
Inner frame: door: Ratios by region

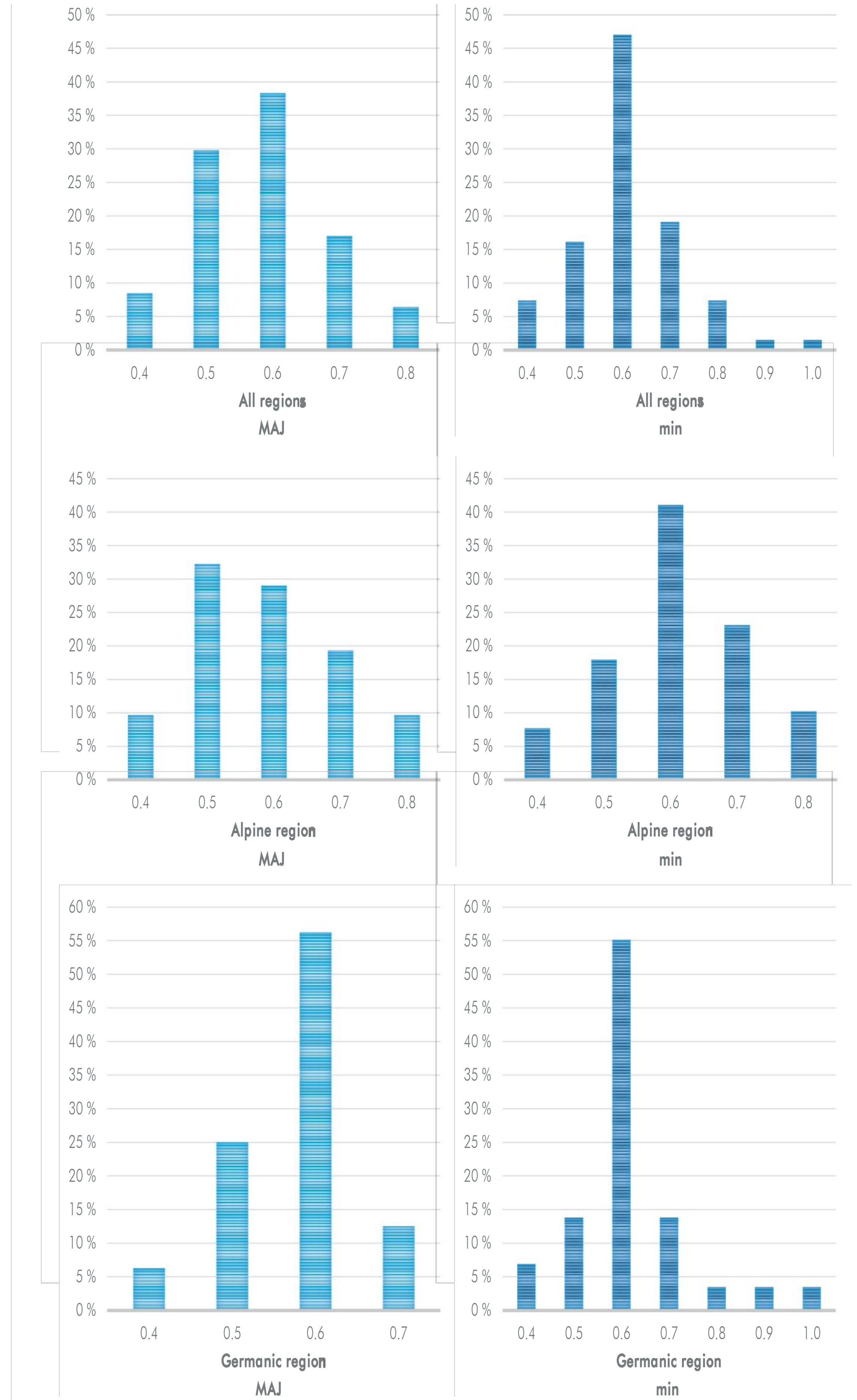

Fig. 4.16
Inner frame: door: Decimal ratios by hierarchy of openings and region

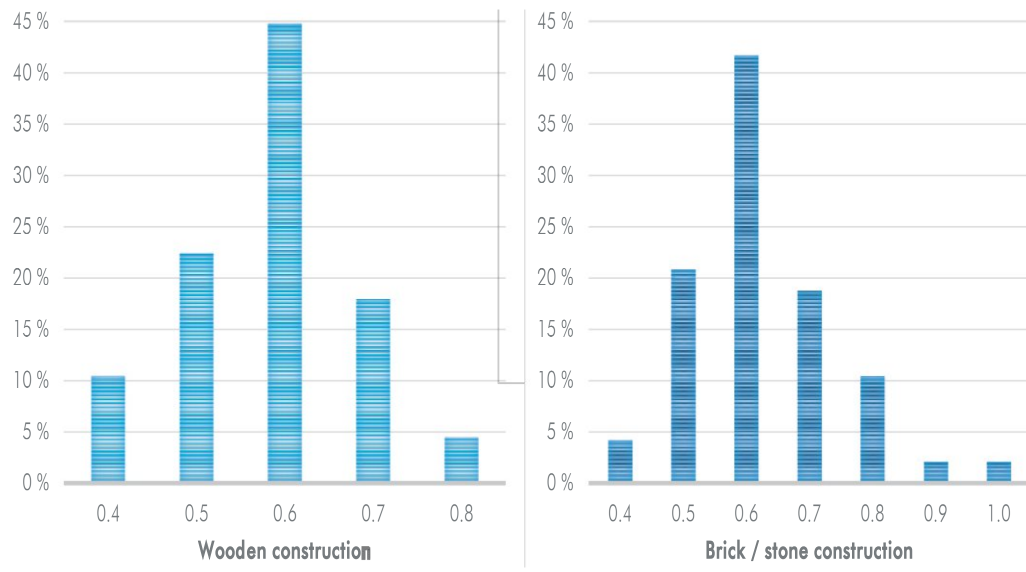

Fig. 4.17
Inner frame: door: Decimal ratios by construction

0.6 is the most frequent across all regions and elevation types (with the minimum of 29.03% for the side elevation in the Alpine region, and the maximum of 60.71% for the side elevation in the Germanic region). Although the most common decimal ratio unambiguous regardless of region, minor variations are clear among other decimal ratio categories. For instance, the category 0.5 is the second most widespread for all elevations and side elevations, but for the front elevation, the decimal ratio 0.7 is more frequent. Surprisingly, the category 0.4 reaches a high percentage occurrence in one case, specifically the side elevation in the Alpine region.

Fig. 4.16 sheds light on the hierarchy of door openings has not yet been discussed in detail. At first glance, one ratio is more frequent than the others – namely, the decimal ratio 0.6 is the most frequent for major and minor openings across the study regions, with one exception. The decimal ratio 0.5 takes is the most frequent ratio for major openings in the Alpine region.

Fig. 4.16 summarizes an overall differences in proportion between major and minor categories. It shows that the decimal ratio 0.6 is preferred by major openings with ~38%, and by minor openings even more with ~47%. Furthermore, the decimal ratio 0.5 (~28%) is the second most frequent, and 0.7 (~17%) is the third most frequent decimal ratio for major openings, while the opposite is true for minor openings (this time in favour of the 0.7 decimal ratio with ~19%, which decreases to ~16% for the ratio 0.5).

However, the most obvious differences are visible in the graphs of the Alpine region. In the first case of major openings, the frequency peak corresponds to the decimal ratio 0.5 (~32%) and from this point, frequency gradually decreases with 0.6, 0.7, and 0.8 decimal ratios. For minor openings, by contrast, the peak is at the 0.6 decimal ratio (~41%), followed by the decimal ratio 0.7 (~23%) and then 0.5 (~18%).

In the Germanic region, the leading position for both cases goes to the decimal ratio 0.6 (~56% and ~55%), and the occurrence of the 0.5, and 0.7 decimal ratios is either equal (each ~14%) for minor openings, or 0.5 is second (~25%) and 0.7 third (~13%) for major openings.

The relationship between a wall construction and a decimal ratio is depicted in Fig. 4.17. The same type of comparison was made in the Fig. 4.10 from *Inner Frame: Window* section, and while minor alterations exist, the data is overall very similar regardless of construction technique. This can be explained

by the fact that the construction type plays a minor role in the proportions of inner door frame by comparison to the decisive role which the proportions of the human body play. The most frequent decimal ratio is 0.6 (with ~45% and ~42%), the second most frequent is 0.5 d (with ~22%, or ~21%), and the third most frequent is 0.7 (with ~18, or 19%).

OUTER FRAME: DOOR

This section covers the proportions of the bounding frame of the wall penetration (also referred to as the outer frame). Two facts require attention: first, an outer frame does not affect the structure of a building in any way, thus structural analysis to this end is omitted, and second, the outer frame is of less importance (lower hierarchy) to the inner frame. Furthermore, the extra-large door openings (of barns for example) were not included in this section.

Fig. 4.18 includes the frequencies of individual ratios by region. One obvious contrast compared to Fig. 4.15 lies in the greater frequency of the ratios 5:9 and 1:2. The ratio 5:9 decreased in frequency an in this figure is a minor ratio (except in the Alpine region). For the 1:2 ratio the decrease in its frequency is even more evident where the frequency of this ratio in outer door frames is zero, in the Germanic region. Therefore, it could be argued that scaling of this same shape is uncommon in these regions.

The ratio 2:3 is the most frequent, with an occurrence of ~16% in all regions, ~14% in the Alpine region, and ~ 18% in the Germanic region, in which it shares the same frequency with 5:7 ratio. The second and third place of incidence is not as unequivocal as it was for the inner door frame. These positions are occupied by a variety of ratios – specifically, 5:7, 3:5, 3:4, 5:8, and in the Alpine region also 5:9. In all regions, it is the 5:7 ratio, which is second most frequent at around 11%. The 3:5, as well as 3:4 ratios, follow closely at 10%. In the Alpine region, the most frequent ratio is 3:4 at 11%, followed by 3:5 and 5:9 at almost 10%. In the Germanic region, the second position is held by the 3:5 ratio again at around 11%, and the third position is shared by 5:8, 3:4, and 4:5 at 9% each.

The frequency of decimal ratio categories by region and elevation are presented in Table 4.11. The results are not uniform. Not only do the above-the-average incidence categories fluctuate, but even the most frequent category changes with region and elevation type. For instance, the categories 0.6, 0.7, and 0.8 are each most frequent at different points .

This can be explained by the ratio grouping and ambiguous second or third positions in ratio frequency. Ratios 3:5, 5:8, and 5:9 are included within the 0.6 category; 2:3 and 5:7 are included in the 0.7 category, and lastly, 3:4 and 4:5 are included in the 0.8 category. The frequency of individual categories is the result of the sum of percentage values of all ratios within the given category. Therefore, a category consisting of three ratios of average percentage values can exceed a category comprising of two of the most frequent ratios.

Differences between proportions of major or minor outer door frames are clarified in Fig. 4.19. Upon first glance, within all regions, the most frequent decimal ratio is shared by the 0.6, and 0.7 categories (with ~33% occurrence), but for minor openings, the most frequent decimal ratio if 0.8 (with ~28%). Furthermore, the 0.8 and 0.9 decimal ratios show great differences between the two hierarchical categories. First, while the 0.8 decimal ratio

	All elevations			Front elevation			Side elevation		
Decimal ratio a/b = **C**	All regions (%)	Alpine region (%)	Ger. region (%)	All regions (%)	Alpine region (%)	Ger. region (%)	All regions (%)	Alpine region (%)	Ger. region (%)
0.4	0.93	-	2.27	2.00	-	7.14	-	-	-
0.5	3.74	6.35	-	-	-	-	7.41	14.81	-
0.6	28.04	30.16	25.00	16.00	16.67	14.29	40.74	48.15	33.33
0.7	27.10	20.63	36.36	28.00	25.00	35.71	22.22	14.81	29.63
0.8	23.36	20.63	27.27	28.00	30.56	21.43	20.37	7.41	33.33
0.9	9.35	14.29	2.27	16.00	19.44	7.14	3.70	7.41	-
1.0	3.74	4.76	2.27	4.00	2.78	7.14	3.70	7.41	-
1.1	0.93	-	2.27	2.00	-	7.14	-	-	-
1.3	1.87	1.59	2.27	2.00	2.78	-	1.85	-	3.70
1.4	0.93	1.59	-	2.00	2.78	-	-	-	-
%: Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
#: Types of outer frames	107	63	44	50	36	14	54	27	27

Table 4.11
Outer frame: door:
Decimal ratios by region and elevation type

is the most common decimal for minor openings, for major openings, its frequency decreased appreciably. This is similarly the case in the individual Alpine and Germanic regions, which demonstrate a higher frequency of the 0.8 decimal ratio for minor rather than major openings. Secondly, a similar situation is true for the 0.9 category, which is infrequent in the case of major openings, but, for minor openings, it increases to fourth most frequent ratio with an incidence of around 14%.

A brief description of proportions according to the hierarchy of openings in individual regions follows; in the Alpine region, the 0.6 decimal ratio is the most common for both hierarchical categories (with ~33%, and 28%). The second and third positions vary. For major openings, the second most frequent decimal category is 0.7 (~26%), and the third is 0.8 (~15%). For minor openings, the second most frequent decimal ratio is 0.8 (25%), and the third is 0.9 (~22%). In the Germanic region, the most frequent decimal ratio is 0.7 (~44%, and ~32%) in both hierarchical categories, although, it shares its first position with 0.8 for minor openings. For major openings, the second most common decimal ratio is the 0.6 (~31%), and the third is 0.8 (~19%). For minor openings, the 0.6 decimal ratio (~21%) is the third most frequent.

ALL FRAMES: DOOR

Given that a comprehensive analysis regarding door proportions has already been performed, this section will provide only a brief discussion of the proportions of various door frame types. The focus will be put on the general frequency of ratios, or their decimals (Table 4.12, Fig. 4.20).

As in the other sections concerning door proportions, extra-large door openings are omitted due to their measurement peculiarities.

Fig. 4.20 shows that there are relatively consistent results. The most common ratio of all frame types (inner, outer, and extra) is 5:9 (with ~15% to ~18%). However, this first place position in the Germanic region is shared with 2:3, which remains in proximity with the 5:9 ratio in other study regions. The threshold of a frequency of 6%, which is not surpassed by many ratios, was used to filter other ratios of note. In addition to the mentioned ratios, the

	Region		
Decimal ratio a/b = **C**	All regions (%)	Alpine region (%)	Germanic region (%)
0.4	4.48	4.48	4.49
0.5	13.00	15.67	8.99
0.6	35.87	32.84	40.45
0.7	22.42	20.90	24.72
0.8	14.80	14.93	14.61
0.9	5.38	7.46	2.25
1.0	2.24	2.24	2.25
1.1	0.45	-	1.12
1.3	0.90	0.75	1.12
1.4	0.45	0.75	-
%: Total	100.00	100.00	100.00
#: Types of all frames	223	134	89

Table 4.12
All frames: door:
Decimal ratios by region

ratio 1:2, and 3:5 exceeded this limit regardless of the region, and the 5:7 ratio exceeded it in all regions and the Germanic region.

The decimal ratios of all door frames summarized in Table 4.12 are organized in a uniform matter. The generally prevailing decimal ratio is 0.6 with 35.87% in all regions, 32.84% in the Alpine region, and 40.45% in the Germanic region. Next is the 0.7 decimal ratio, with 22.42%, 20.90%, and 24.72%, respectively. The 0.5, and 0.8 categories are also noteworthy, as they represent the third and fourth place in the incidence of decimal ratios.

PRESTIGIOUS RATIOS

The golden ratio, silver ratio, and Ludolph's number are proportional constants, which are popular within analysis and commonly identified. The golden ratio was touched upon in an earlier chapter (*Proportion: Historical background/Architecture*), and the other two ratios in two subsequent chapters (*Proportion: Construction/How to…* and *Vernacular vs. Prestige Architecture: Introduction to Analyses/Expectations*). As a result, the research question arose, whether the so-called prestigious ratios truly play a prominent role among other ratios?

The golden ratio, designated by the Greek letter ϕ, is equal to $\sim 1.618 = (1+\sqrt{5})/2$ and its reciprocal is equal to $\sim 0.618 = 1/\phi$. Thus, the decimal ratio categories of 1.6 and 0.6 correspond to it. Alternatively, the another approximation takes the ratios of 5:3, and 8:5 (or in reciprocal cases the reverse of each), according to Fibonacci series. Although ratios of 1:2(=0.50), or 2:3(~0.67) are also found in the Fibonacci series, their approximations to the golden ratio are too imprecise, and they are thus unsuitable for the purpose of this assessment. The silver ratio is expressed as $\theta = 1+\sqrt{2}$, which is about 2.414, and its reciprocal is $\sim 0.414 = 1/\theta$. These correspond to the decimal ratio categories 2.4 and 0.4. Based on Pell's series, it corresponds to the ratios 5:2, 12:5, or reversed (see *Proportion: Construction/How to…*). Lastly, Ludolph's number, or π, is equal to ~3.142 and its reciprocal is ~0.318. It expresses the ratio of a circle's circumference to its diameter. This ratio conforms to decimal categories of 3.1 and 0.3, or to ratios 3:1, and 1:3. Even though the corresponding decimal categories of prestigious ratios are listed above, the focus on the individual ratios is of greater significance, as the dec-

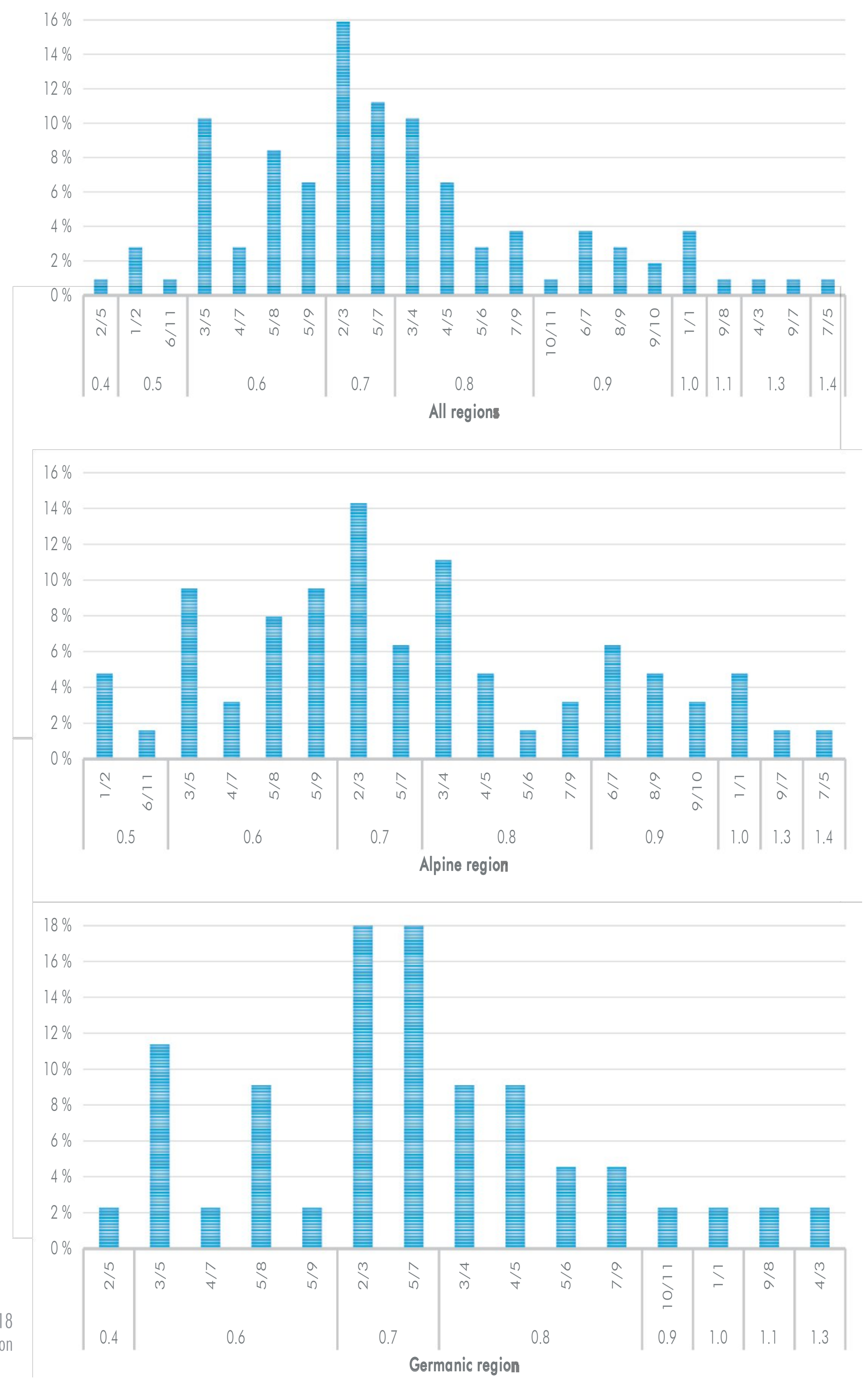

Fig. 4.18
Outer frame: door: Ratios by region

Fig. 4.19
Outer frame: door: Decimal ratios by hierarchy of openings and region

imal categories might lead to incorrect conclusions. For example, the ratios of 3:5, 4:7, and 5:9 are all included within the decimal ratio 0.6, but only 3:5 is linked to the golden ratio.

Concerning the proportions of a building, according to Fig. 4.03 in section *Elevation*, the ratios stated above did not receive any special attention. Moreover, most of these ratios were simply omitted. The only potential presence of a special ratio would be for the ratio 3:5 (the golden ratio) in the Germanic region, where it shares the second position in occurrence with two other ratios. A similar situation is true in Fig. 4.04 in 3-Levels, where the ratio of 3:5 shares the third position.

Regarding window proportions, the frequency of the 3:5 ratio increased, as it was the most frequent ratio in the Germanic region (Fig. 4.08 in section *Inner Frame: Window*). Nevertheless, in the Alpine region, its incidence was negligible. In Outer Frame: Window (Fig. 4.11), this trend continued, and none of these prestigious ratios occurred frequently enough to warrant mention. In All Frames: Window (Fig. 4.13), the ratio 3:5 was once again more frequent only in the Germanic region, where it shared the second position.

Lastly, regarding door proportions, a survey of Table 4.10 (in section *Inner Frame: Door*), one might initially think that the golden ratio was found frequently, as the 0.6 category is the most frequent. However, according to Fig. 4.15 although 3:5 ratio is not insignificant, the 5:9 ratio is the more significant portion of the 0.6 category. Given that 5:9 is not part of the Fibonacci series, it cannot be considered as the approximation of the golden ratio. In Fig. 4.18 from an earlier section (*Outer Frame: Door*), the ratio 3:5 reached its most balanced frequency across the regions, as its rank was at worst third. For the first time, the ratio of 5:8 (also an approximation of the golden ratio) increased in frequency, and for the first time (if their percent frequencies were counted together together), the golden ratio would dominate in all study regions. In Fig. 4.20 (All Frames: Door), the ratio 3:5 receives its most attention in the Germanic region, and too, when combined with the ratio of 5:8, the ratio reaches prevalence.

In conclusion, the so-called prestigious ratios are not given special importance in vernacular architecture. The silver ratio and Ludolph's number are almost completely negligible. However, the golden ratio (approximated by 3:5 and less often by 5:8) stands out from time to time, primarily within the Germanic region. Among door proportions, its frequency increased noticeably, however, whether this actuality is conditioned by the golden ratio itself or by a coincidence of the proportions of the human body, remains an open question. The author's personal tendency is toward the latter.

(IM)PERFECT SQUARE

After an extensive analysis of proportions in vernacular architecture, one outcome requires further discussion the square shape. Within the analysis, the 1:1 ratio was most prevalent. This ratio was repeatedly in the leading position across the various areas of study (unless the main proportion determinant was the human body, as with door openings). The most important results of the analysis concerning the square shape will be summarized in the coming paragraphs. Focus will also be directed to its close approximations. Therefore, not only the decimal ratio category 1.0 (1:1 ratio) will be taken into consideration, but also the 0.9 category (including ratios 6:7, 7:8, 8:9, 9:10, 10:11),

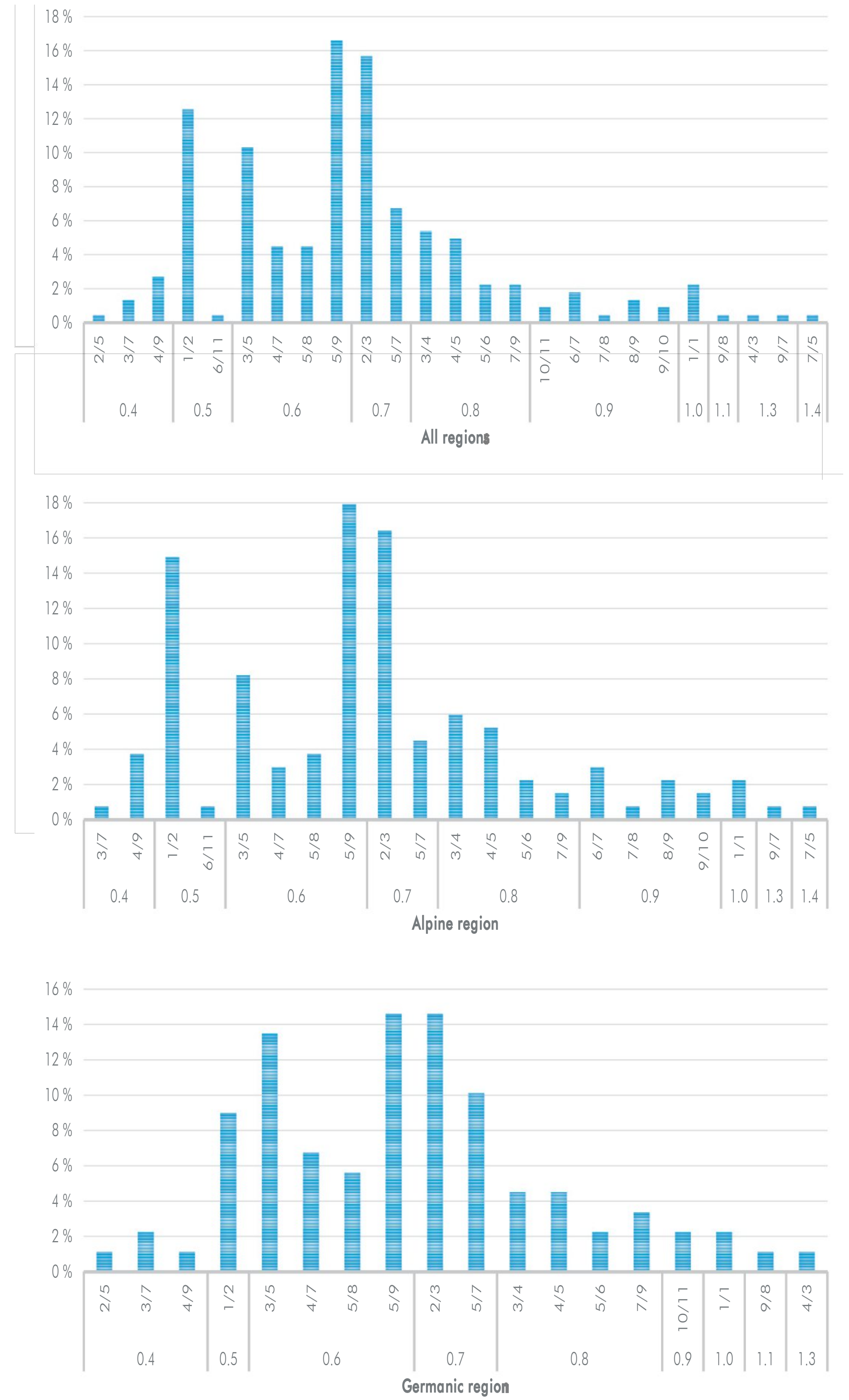

Fig. 4.20
All frames: door: Ratios by region

and the 1.1 category (including ratios 12:11, 11:10, 10:9, 9:8, 8:7).

To start with the general description of building proportions, in Fig. 4.03 (within the *Elevation* section), the ratio of 1:1 is dominant regardless of the study region, however, with less of a margin in the Germanic region. The square ratio approximations (0.9 and 1.1) are roughly equal in frequency. On the other hand, in Fig 4.04 (within the *3-Level* section) despite remaining the most frequent ratio, almost none of its approximating ratios are observable.

The biggest contrasts in this ratio and its approximations lie between window and door openings. While window openings present indubitable preference for the 1:1 ratio, within door openings this ratio becomes insignificant.

Specifically, in Fig. 4.08 (in the *Inner Frame: Window* section) the unequivocal favour of the square shape is evidenced for all regions, and the Alpine region. Dissimilarly, it is only ranked sixth in the Germanic region. Concerning its approximations, the ratios 0.9 is more frequent than the 1.1 ratio. The preference for the ratio 1:1 increases even more in Fig. 4.11 (within the *Outer Frame: Window* section). Once again, the 0.9 decimal ratio is more frequent than 1.1. In Fig. 4.13 (within the *All Frames: Window* section), the results remain in the same trend; the 1:1 ratio is the dominant ratio overall, and 0.9 decimal ratio category is more prevalent than the 1.1 category. It is notable that while the ratio 1:1 leads with around 20% in all regions, and almost 26% in the Alpine region, in the Germanic region, it is only around 14%.

The exact and approximated square shape of the inner door frame is extremely rare as seen in Fig. 4.15 (within the *Inner Frame: Door* section). The reason for this is the measurements of the human body: an average human body is approximately three times as tall as it is wide, and the square shape (which has the same height and width) is therefore unsuitable for door proportions. On the other hand, the outer door frame with an arbitrary width only encloses the inner one, thus an increase in the occurrence of the ratio 1:1 and its approximations is possible here as shown in Fig. 4.18 (within the *Outer Frame: Door* section). In this context, the square shape approximations, specifically the 0.9 decimal ratio , are more common than the exact 1:1 ratio. The same is true for the combined frames, where the (im)perfect square shape is of very low incidence and again the 0.9 approximating category is more common than the exact 1.0 as shown in Fig. 4.20 (within the *All Frames: Door* section).

The extra-large door openings suitable for barn use were not included in the door opening category due to their contrasting purpose and proportions. Furthermore, the ratio of 1:1 and its approximations are very common among these doors (see geometrical analysis in *Appendix*).

Fechner's experiment (see the earlier chapter *Proportion: Historical Background/ Architecture*) published in his *Zur Experimentalen Aesthetik* (Fechner, 1871) is interesting to relate to the outcomes of this analysis. The approximations of the 1:1 ratio are not at all uncommon in vernacular architecture. However, as mentioned before, Bosanquet summed up Fechner's experiment as follows: "the least deviation from symmetry has a far more decided unpleasantness than a proportionally much greater deviation from the golden section"(Bosanquet, 2005, p.383). Deducing, approximations of 1:1 ratio are considered unpleasant and thus avoided. However, this is not the case within vernacular architecture.

One might venture into the field of optical perception to understand this assertion further, given that the human eye does not perceive vertical and horizontal directions equally. In his *Grundlagen der Architekturwahrnehmung,* Grütter writes: "Für den Gesichtssinn ist die vertikale Ausdehnung wichtiger als die horizontale. Ein Quadrat erscheint uns erst dann als gleichseitiges Viereck, wenn die Breite in Wirklichkeit etwas grösser ist als die Höhe", he continues, "dies hängt wahrscheinlich mit der Tatsache zusammen, dass bei einer horizontalen Augenbewegung nur halb so viele Muskeln beteiligt sind als bei einem vertikalen Blickwechsel […].Die Wahrnehmung horizontaler Ausdehnung ist weniger anstrengend als die von eher vertikal betonten Elementen"(Grütter, 2019, p.35). But this is not the case from our analysis, as the 0.9 category is more frequent than 1.1; meaning, the width is generally slightly smaller than the height.

Another explanation could be found in phenomena pointed out by Scholfield in his book *The Theory of Proportion in Architecture*. He argued that custom or convention play a significant role in this regard. "In the same way when strong conventions are established in architecture, such as those controlling the proportions of the orders, any very marked departure from what the eye expects may destroy the pleasing effect of the design"(Scholfield, 1958, p.4). Although it is certainly possible that custom or convention influence the use of proportions, the precision of construction (see chapter *Proportion: Construction/ Precision*), as well as structural parameters, have an even greater influence on proportions. Moreover, the art theorist and perceptual psychologist Rudolf Arnheim argued that "the square is a rational shape [simple, clear-cut, identifiable] to every person with an undamaged brain" (Arnheim, 1972, p.128) and that "a slight deviation from a simple shape [namely square, or circle] is ambiguous, hard to identify" (Arnheim, 1972, p.103).

CHAPTER 4 // VERNACULAR ARCHITECTURE: ANALYSIS OF PROPORTIONS

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CHAPTER 5 // PRESTIGE ARCHITECTURE: ANALYSIS OF PROPORTIONS

After the careful analysis of proportions in vernacular architecture presented in the previous chapter, this chapter shifts focus to its counterpart; prestige architecture. *Prestige Architecture: Analysis of Proportions* is organized in a similar way to *Vernacular Architecture: Analysis of Proportions*, in anticipation of their comparison in the subsequent chapter, named *Vernacular vs. Prestige Architecture: Summary*. The first section, *Whole Building*, will be followed by a section on *Openings*, and the chapter will end with a section on *Prestigious Ratios* (the results of the geometrical analysis attached in the *Appendix* will be summarized in the form of graphs and tables here), and a section on *Double Square*.

Ensuring the comparability of both chapters is vital (see *Vernacular vs. Prestige Architecture: Introduction to Analyses/ Application of Filters*). Therefore the selection of a sample of buildings from the same period, of the same building typology, and the same geographical locations is logical.

Most of the vernacular buildings used for the purposes of the analysis were built or rebuilt in the 19th century (although sometimes this was difficult to define since the process of building according to current needs is very organic within vernacular architecture), meaning that buildings from the 19th century ought to be selected for prestige architecture as well.

The typology of the vernacular architecture studied was one type of residential housing typical for life in the countryside, namely the farmhouse. On the other hand, while retaining the typologies of residential housing in prestige architecture, the specific building diverges slightly. Three individual categories of residential housing considered prestige architecture, namely; palaces and castles (P+C), residential buildings (R), and villas (V) were included. Differences in the prestige among these buildings exist, with the greatest prestige attributed to palaces and castles. Whether these individual variations of residential housing do or do not play some role in the selection of proportions will be examined to an extent within this chapter.

Finally, the geographical location should be determined. Since the regions of interest were areas of the Alpine and Germanic regions (based on Oliver's definition in *EVAW* (Oliver, 1997b)) in vernacular architecture, the areas of the same regions are applicable for prestige architecture. Despite many similarities, one significant change was made in the assessment of the study sample, specifically the separation of Vienna from the remaining Germanic region. The reason for this is the special attention that has been paid the city as the throne of the Austrian monarchy, resulting in a greater number of studied buildings within this specific location, which could distort the results.

WHOLE BUILDING

This subchapter begins with a brief description of some general characteristics of buildings which will be analysed in further detail. Unlike in vernacular architecture, this subchapter only consists of the *Initial Insights* and *Elevation* sections, leaving out the *3-Level* section which appeared in the vernacular analysis. This is due to the absence of saddle roofs in prestige architecture, which renders this analysis meaningless.

INITIAL INSIGHTS

Among the features observed in this study are symmetry, spacing-grid, and segmented composition. Since the previous chapter already characterized these features, the outcomes of the analysis will be begin without elaborating on these features.

The housing typology is more diverse in prestige architecture than vernacular, therefore Fig. 5.01 presents a finer division of study sample based on the housing typology. It consists of the following categories: palaces and castles (P+C), residential buildings (R), and villas (V).

The presence or absence of symmetry in the elevation of the building is the first aspect to be broken down. While its presence dominates all of the study areas, the strength of its dominance varies widely, from 57.58% in the Germanic region to its hegemonic position of 92% in the Germanic region-Vienna. In all regions, symmetry is present in 75.68% of building elevations. The fluctuations occur primarily in the villa category, as symmetry is equally present in palaces and castles, and residential buildings. In the case of villas in the Germanic region, the absence of symmetry is most dominant.

The second feature for analysis is the spacing-grid. A similar set of frequencies is evident in for this feature, with the notable exception of within villas. Palaces and castles, and residential buildings overwhelmingly feature spacing grids, resulting in an overall minimum inclination of 78,79% in the Germanic region and a 100% frequency in the Alpine and Germanic-Vienna regions. On the other hand, in the villas category spacing-grids occur almost as frequently as they are absent in the Germanic region, but the presence of spacing-grid is still slightly more prevalent.

Finally, the overall preference for segmented compositions is significant, ranging from an overall frequency of 87,88% in the Germanic region, to a frequency of 100% in the Alpine and Germanic-Vienna regions. Once again, the villa category deviates from the other types. Slightly less than one-third of all villas lack a segmented composition in the Alpine region.

To summarize, all three features (symmetry, spacing-grid, and segmented composition) feature heavily regardless of the study region. However, their prevalence varies, mostly among villas. Villas, according to the results, have lower incidences of the features than palaces and castles, or residential buildings.

CHAPTER 5 // PRESTIGE ARCHITECTURE: ANALYSIS OF PROPORTIONS

	Front elevation				Side elevation
Decimal ratio a/b = **C**	All regions (%)	Alpine region (%)	Germanic region (%)	Germanic region - V (%)	All regions (%)
0.6	1.92	-	4.76	-	-
0.7	1.92	-	4.76	-	-
0.8	3.85	-	-	10.00	10.53
0.9	13.46	-	14.29	20.00	10.53
1.0	7.69	9.09	9.52	5.00	-
1.1	11.54	9.09	4.76	20.00	21.05
1.2	5.77	9.09	-	10.00	5.26
1.3	15.38	27.27	19.05	5.00	10.53
1.4	5.77	9.09	9.52	-	15.79
1.5	9.62	9.09	4.76	15.00	-
1.6	1.92	-	4.76	-	-
1.7	3.85	18.18	-	-	5.26
1.8	5.77	-	9.52	5.00	5.26
1.9	3.85	9.09	-	5.00	10.53
2.0	1.92	-	4.76	-	-
2.1	1.92	-	-	5.00	-
2.3	-	-	-	-	5.26
2.7	-	-	-	-	5.26
3.0	1.92	-	4.76	-	-
3.2	1.92	-	4.76	-	-
%: Total	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**
#: Elevations	**52**	**11**	**21**	**20**	**19**

Table 5.01
Elevation: Categories of ratio quotient by region and elevation type

	Front elevation			
Orientation	All regions (%)	Alpine region (%)	Germanic region (%)	Germanic region - V (%)
Landscape	71.15	90.91	66.67	65.00
Neutral	7.69	9.09	9.52	5.00
Portrait	21.15	-	23.81	30.00
%: Total	**100.00**	**100.00**	**100.00**	**100.00**
#: Elevations	**52**	**11**	**21**	**20**

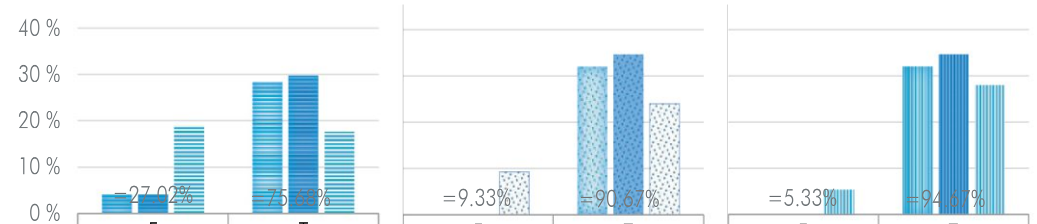
Table 5.02
Elevation: Orientation of the front elevation by region

ELEVATION

To find out whether a certain ratio (width to height) of a building elevation in prestige architecture is more frequent in a specific geographic location is the focus of this section. Fig. 5.02 and Tables 5.01 and 5.02, list data relating to proportions in the elevations of the typologies. As in vernacular architecture, the focus will be on front elevations, because the proportions of side elevations are usually altered according to need.

The investigation begins with the single ratios depicted in Fig. 5.02. At first look, no single dominant ratio stands out. There is little, if any, clear order among them.

In all regions, the most frequent ratio was 4:3 with a frequency of 9.46%, followed by the 7:5 ratio with a frequency of 6.76%. The third position is di-



Symmetry

	F	T
P+C	4.05%	28.38%
R	4.05%	29.73%
V	18.92%	17.57%

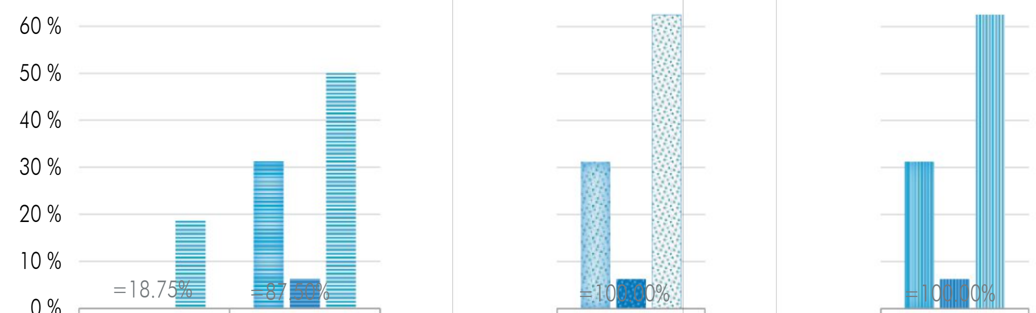
Spacing-grid

	F	T
P+C	0.00%	32.00%
R	0.00%	34.67%
V	9.33%	24.00%

Segmented composition

	F	T
P+C	0.00%	32.00%
R	0.00%	34.67%
V	5.33%	28.00%

All regions



Symmetry

	F	T
P+C	0.00%	31.25%
R	0.00%	6.25%
V	18.75%	50.00%

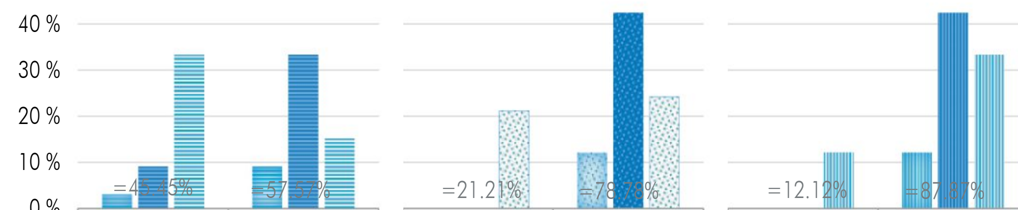
Spacing-grid

	T
P+C	31.25%
R	6.25%
V	62.50%

Segmented comp.

	T
P+C	31.25%
R	6.25%
V	62.50%

Alpine region



Symmetry

	F	T
P+C	3.03%	9.09%
R	9.09%	33.33%
V	33.33%	15.15%

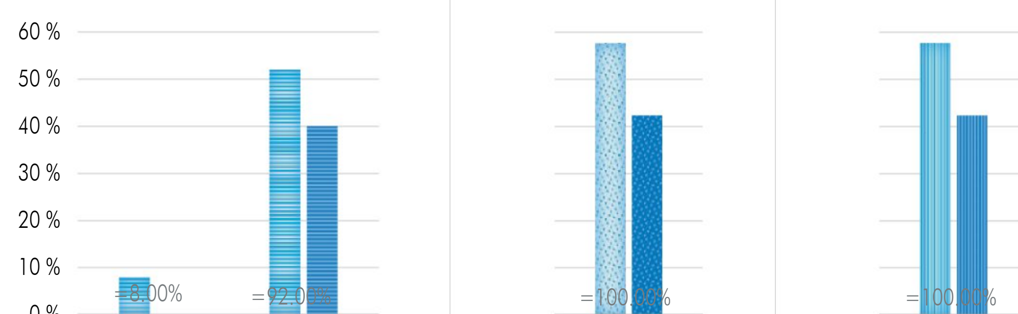
Spacing-grid

	F	T
P+C	0.00%	12.12%
R	0.00%	42.42%
V	21.21%	24.24%

Segmented composition

	F	T
P+C	0.00%	12.12%
R	0.00%	42.42%
V	12.12%	33.33%

Germanic region



Symmetry

	F	T
P+C	8.00%	52.00%
R	0.00%	40.00%

Spacing-grid

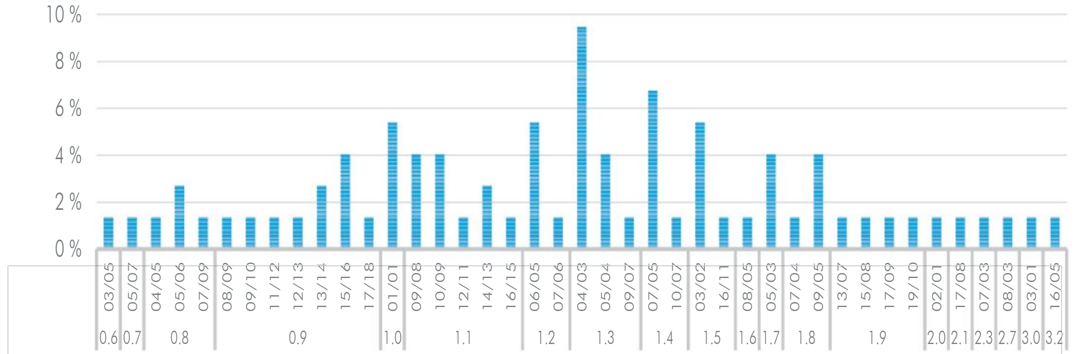
	T
P+C	57.69%
R	42.31%

Segmented comp

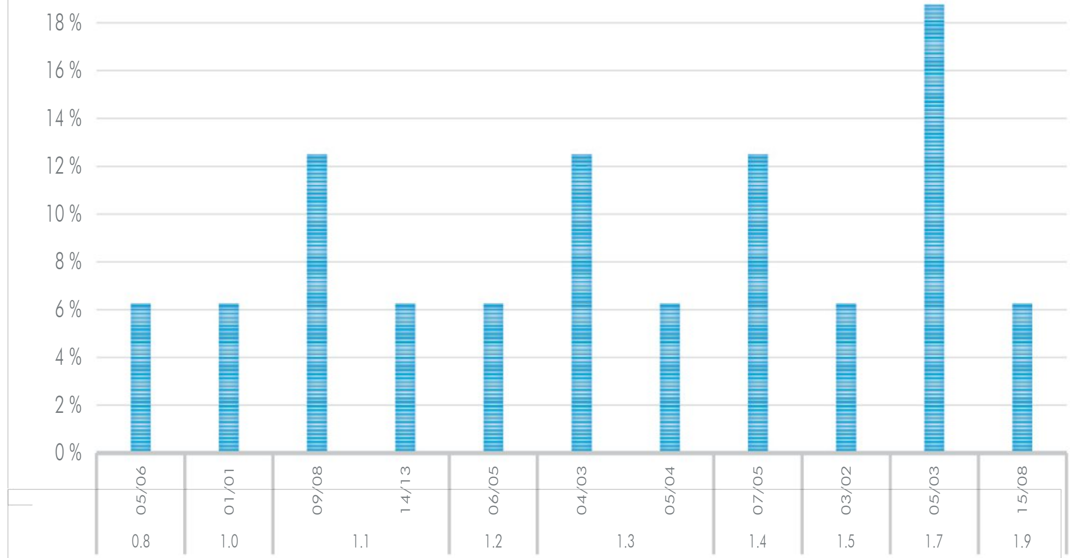
	T
P+C	57.69%
R	42.31%

Germanic region - Vienna

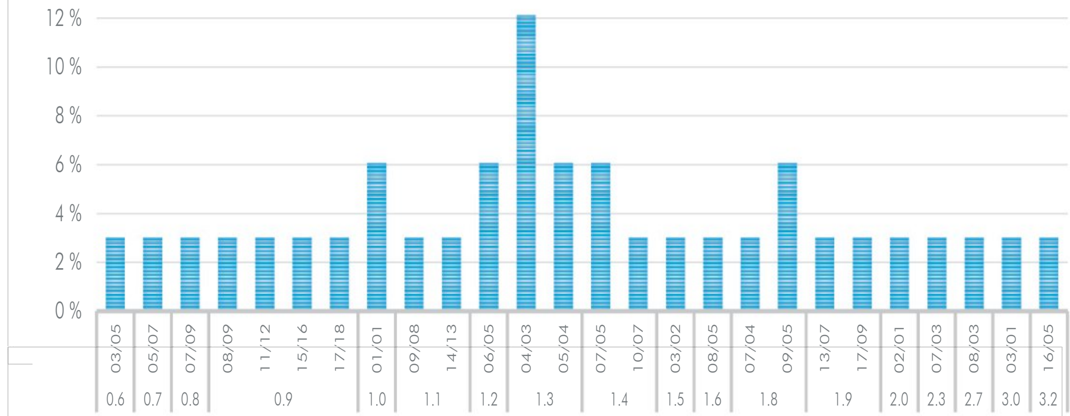
Fig. 5.01
Initial insights: Occurrence of symmetry, spacing-grid, and segmented composition by region



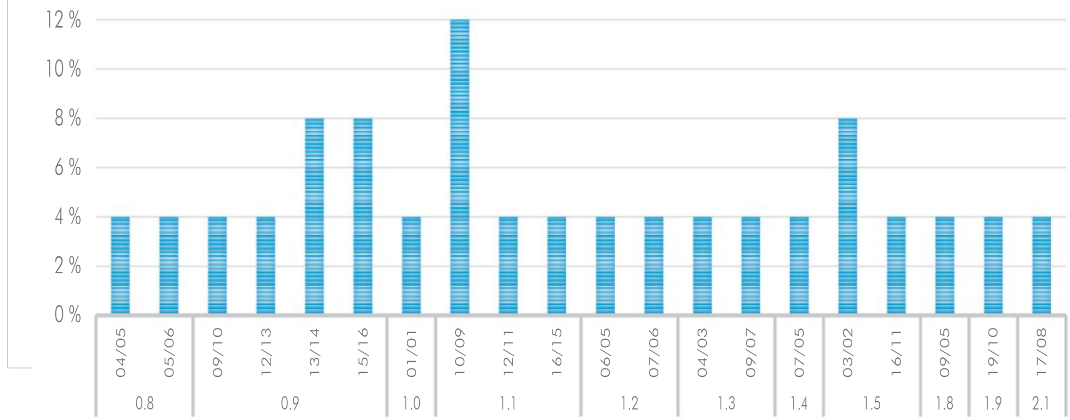
All regions



Alpine region



Germanic region



Germanic region - Vienna

Fig. 5.02
Elevation: Ratios of front elevations by region

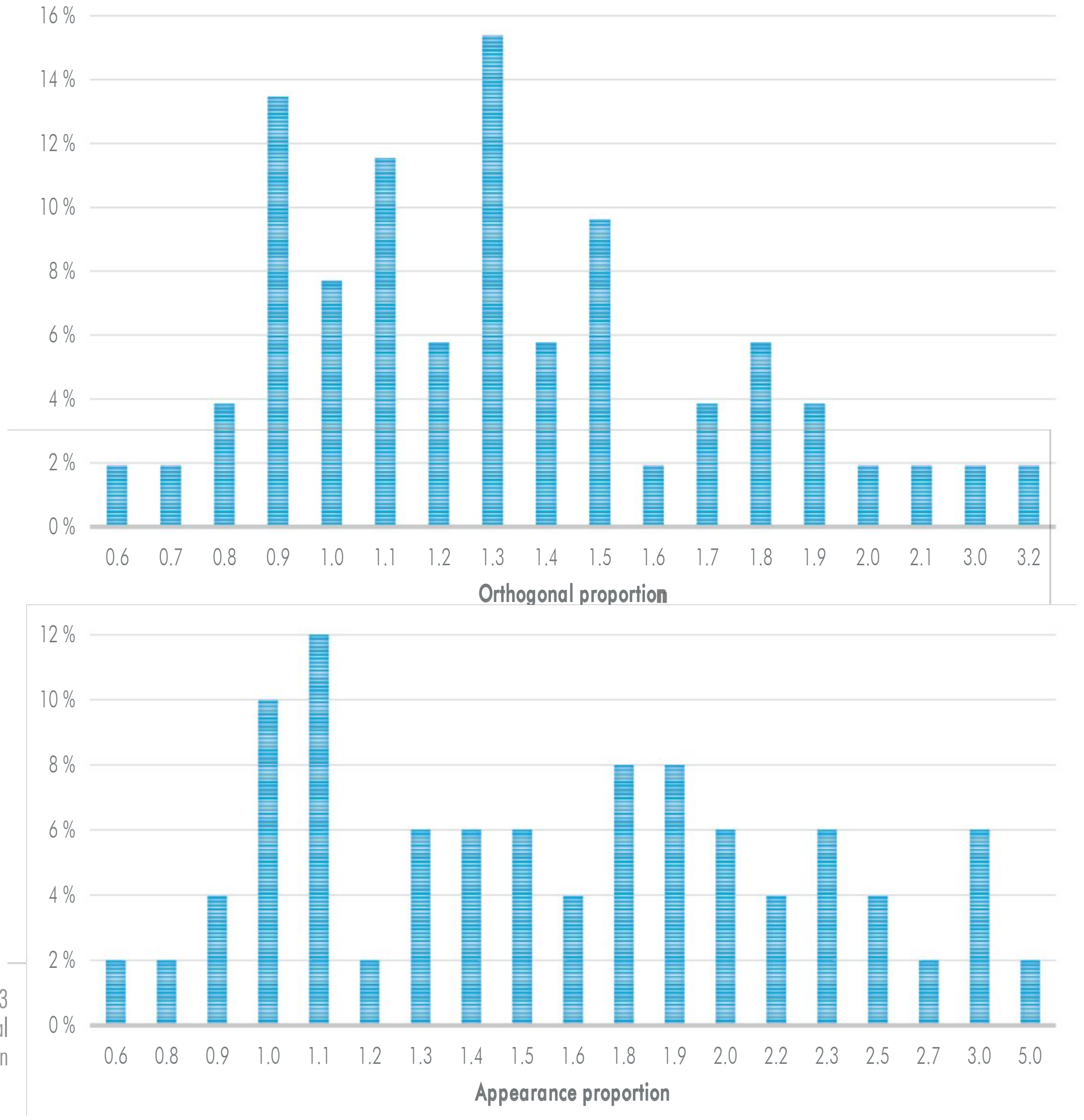


Fig. 5.03
Elevation: Decimal ratios by orthogonal proportion and appearance proportion

vided between the ratios 1:1, 6:5, and 3:2 with 5.41% per each. On the other hand, in the Alpine region, the most popular ratio is 5:3, with a frequency of 18.75%. The second position is shared between the ratios 9:8, 4:3, and 7:5 with frequencies of 12.5% each. All remaining ratios occur with the same small frequency. In the Germanic region, the highest incidence belongs to a ratio 4:3 with a frequency of 12.12%, and the second highest incidence is divided among five ratios, namely 1:1, 6:5, 5:4, 7:5, 9:5, with frequencies of 6.06% per each. The third position is undefinable. Lastly, in the Germanic region-Vienna, the most common ratio is 10:9 with 12%, the second most common ratios are 13:14, 15:16, and 3:2 with frequencies of 8%, the remaining ratios are equally uncommon.

The first ratios overlap minimally (varying between the ratios 4:3, 5:3, and 10:9) and the second ratios are equally scattered.

The ratios were grouped according to their decimal ratio and the results are presented in Table 5.01. However, even this approach does not clarify the results. The 1.3 decimal ratio is the most frequent within the front elevation in All, Alpine and Germanic regions. The diffuse second place is occupied by ratios 0.9, 1.1, 1.4, and 1.7, and for side elevations also includes 1.4. The diffuseness of these results conveys the variability of the designs. The only thing that can be concluded based on the Table 5.01 results is the range of the most frequent decimal ratio categories, starting with 0.9 and ending with

1.5. However this range is quite wide and does not contribute to the stated aims of the thesis.

The juxtaposition of both kinds of proportions of elevations mentioned in the previous chapter, namely orthogonal and appearance proportions, should be discussed in the context of prestige architecture as well. However, their identification is occasionally too indistinct in prestige architecture. The jaggedness of the façade is particularly influential among avant-corps, or towers, and the topography of the terrain. These render it difficult to identify the elevation proportions. Thus, the results presented in Fig. 5.03 should be taken with a grain of salt.

Fig. 5.03 compares the decimal ratio categories of orthogonal and appearance proportions of an elevation. The landscape orientation heavily outweighs the neutral or portrait orientations in frequency. Furthermore, the unimportance of the elevation proportions is clear, as the peak of incidence differs in both kinds of proportions, the orthogonal proportion being in the 1.3 category (~16%), and the appearance proportion in the 1.1 category (12%). Beyond these common decimal ratios, the 0.9, 1.1, and alternatively 1.5 categories are pronounced in the former proportion, while in the latter, the 1.0 category is more frequent. The overlapping of the frequent categories is scarce between orthogonal and appearance proportions. Interestingly, there is a clear increment in the decimal ratio categories corresponding to the (im) perfect square figure, namely the 1.0 and 1.1 categories, in the appearance proportion.

Another perspective on this topic is provided in Table 5.02, where the preferred decimal ratio categories are organized only into three groups based on their orientation – specifically, landscape, neutral, and portrait. There is clear dominance of the landscape category, ranging from frequencies of 65.00% to 90.91% among the studied regions. Thereafter, the portrait category is represented in all but the Alpine region. This could be the result of the small sample of front elevations in the Alpine region. Lastly, the neutral orientation, which corresponds to the ratio of 1:1, varies in frequency between 5.00% and 9.52%.

In other words, the proportions of the building elevations do not play an important role in building design and are a matter of coincidence more than intention. This assumption can be further questioned in the coming sections (*Openings* and *Diagonal Repetition*), where the proportions of building elevation are juxtaposed on the proportions of an opening itself.

OPENINGS

The openings will be assessed similarly to within the vernacular architecture chapter (*Vernacular Architecture: Analysis of Proportions/ Openings*). Here too, the window and door data analysis will be separated.

The hierarchy of the openings will be considered, although this time, the categories will also include prestigious openings (resulting in major, minor, and prestigious openings). The boundary between the categories is even more blurred than it was in vernacular architecture, where the plan played a decisive role in determining the categories of openings. Instead, building elevations and its so-called *piano nobile,* are used to determine the categories of openings. According to *Architecture Dictionary*, it is "the principal story of a large building, as a palace or villa, with formal reception and dining rooms,

	Elevation type			
Diagonal repetition: All regions	Front	Side	Rear	All
False				
Percentage amount	94.61%	96.78%	100.00%	95.25%
Number of openings	1719	481	87	2287
True				
Percentage amount	5.39%	3.22%	-	4.75%
Number of openings	98	16	-	114
Percentage amount	**100.00%**	**100.00%**	**100.00%**	**100.00%**
Number of openings	**1817**	**497**	**87**	**2401**
Diagonal repetition: Alpine region	Front	Side	Rear	All
False				
Percentage amount	96.65%	91.11%	-	95.14%
Number of openings	231	82	-	313
True				
Percentage amount	3.35%	8.89%	-	4.86%
Number of openings	8	8	-	16
Percentage amount	**100.00%**	**100.00%**	**-**	**100.00%**
Number of openings	**239**	**90**	**-**	**329**
Diagonal repetition: Germanic region - rest	Front	Side	Rear	All
False				
Percentage amount	96.56%	96.58%	100.00%	96.69%
Number of openings	505	226	28	759
True				
Percentage amount	3.44%	3.42%	-	3.31%
Number of openings	18	8	-	26
Percentage amount	**100.00%**	**100.00%**	**100.00%**	**100.00%**
Number of openings	**523**	**234**	**28**	**785**
Diagonal repetition: Germanic region - Vienna				
False				
Percentage amount	93.18%	100.00%	100.00%	94.41%
Number of openings	983	173	59	1215
True				
Percentage amount	6.82%	-	-	5.59%
Number of openings	72	-	-	72
Percentage amount	**100.00%**	**100.00%**	**100.00%**	**100.00%**
Number of openings	**1055**	**173**	**59**	**1287**

Table 5.03
Diagonal repetition: Occurrence by region and elevation type

usually one flight above the ground floor" (Architecture Dictionary Editors, n.d.-a). The original Italian term *piano nobile* was limited to the main floor of Renaissance *palazzos* (Britannica Editors, n.d.). In palaces and castles the differentiation between *piano nobile* and other floors is clear, and corresponded to prestigious openings of a larger scale, with ornate embellishments, etc. However, in residential buildings and villa typologies, the presence of this prestigious floor is not very clear, and in some cases is even missing. This leads to the overlapping of major and prestigious categories of openings. Minor openings are more easily categorized, corresponding to attic and cellar areas.

The categorization of the frames of openings happens a similar manner. In

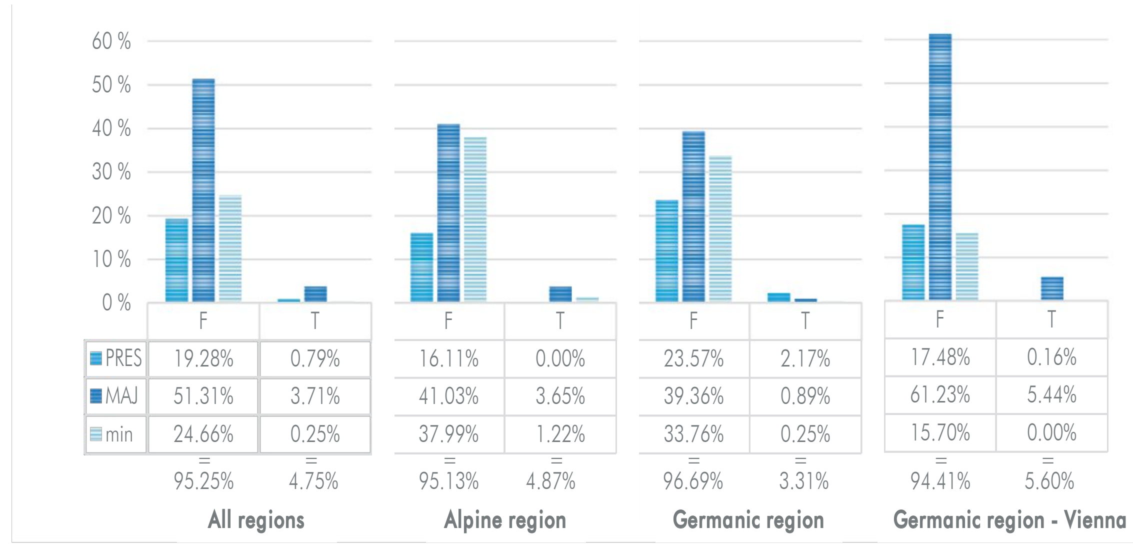


Fig. 5.04
Diagonal repetition: Occurrence by hierarchy of openings and region

keeping with the vernacular architecture analysis, the categories include; inner, outer, and exceptional extra frames (for more information see the introduction in *Vernacular Architecture: Analysis of Proportions/ Openings*).

DIAGONAL REPETITION

In this section, the diagonals (an unambiguous representation of a shape ratio) of a building elevation and its openings will be set against each other, so that possible relationships can be revealed. The rotation of a diagonal about 90° will be treated inclusively, and the initial and reciprocal (rotated) diagonal will not be differentiated. Furthermore, in the assessment of diagonal repetition, the absolute-opening quantity is used, not the quantity of opening types.

The results of the diagonal repetition analysis are presented in Fig. 5.04. Surprisingly, the graph shows an almost absent relationship between the shape of an elevation and the shape of an opening, with minor fluctuations from 94.41% (Germanic region-Vienna) to 96.69% (Germanic region) in the frequency of diagonal repetition. The Germanic region has the lowest frequency of diagonal repetition, where it was only 3.31%. On the other hand, the highest frequency (which was still relatively low) was in the Germanic region-Vienna with 5.59%. If the results relating to opening hierarchy are examined, the highest values of diagonal repetition correspond to the major openings in All, the Alpine, the Germanic–Vienna regions, and the prestigious openings in the Germanic region. Among minor openings, the diagonal repetition is rare.

Secondly, Table 5.03 shows the preferences for diagonal repetition classified by the elevation type. The non-diagonal repetition is most frequent in every elevation type and every geographical region, from a minimum frequency of 91.11% to a maximum of 100.00%. Particularly in the rear elevation, the frequency is consistently 100.00% regardless of the study region (except the Alpine region, where no study sample for rear elevation was given).

The expectation was that the diagonal repetition would be more frequent in prestige architecture. However, this was not the case and the opposite undoubtedly was true. This may be the case due to the already formulated statement in the *Elevation* section, where it was assumed that the proportions of building elevations do not play an important role in the design of prestige architecture, but other principals - for instance, symmetry – are more important.

FRAME-SHAPE REPETITION

Frame-shape repetition	Regions All regions	Alpine region	Germanic region - rest	Germanic region - Vienna
False				
Percentage amount	87.44%	92.92%	83.81%	88.51%
Number of opening types	543	105	207	231
True				
Percentage amount	12.56%	7.08%	16.19%	11.49%
Number of opening types	78	8	40	30
Percentage amount	**100.00%**	**100.00%**	**100.00%**	**100.00%**
Number of opening types	**621**	**113**	**247**	**261**

Table 5.04
Frame-shape repetition: Occurrence by region

Compound type	Regions All regions	Alpine region	Germanic region - rest	Germanic region - Vienna
Same-opening type				
2				
Percentage amount	77.03%	72.73%	63.89%	96.30%
Number of compound types	57	8	23	26
3				
Percentage amount	6.76%	-	13.89%	-
Number of compound types	5	-	5	-
Mixed-opening type				
Percentage amount	16.22%	27.27%	22.22%	3.70%
Number of compound types	12	3	8	1
Percentage amount	**100.00%**	**100.00%**	**100.00%**	**100.00%**
Number of compound types	**74**	**11**	**36**	**27**

Table 5.05
Compound: Occurrence by region and compound type

By contrast to the *Diagonal Repetition* section, the *Frame-Shape Repetition* section aims to discern the relationships between ratios in the scope of the opening itself. Their peculiarities were discussed in further detail in a prior chapter (*Vernacular Architecture: Analysis of Proportions*). For frame-shape repetition, the quantity of opening types is essential to the analysis, not the absolute quantity of openings.

Table 5.04 includes data relating the prevalence of non-frame-shape repetition in a sample of 621 types of openings. In this instance, non-frame-shape repetition is more frequent. On the other hand, frame-shape repetition was most frequent in the Germanic region with 16.19% and least frequent in the Alpine region with 7.08%.

Fig. 5.05 shows the diversification of the hierarchy of openings. Interestingly, although the frequency of non-frame-shape repetition is highest regardless of location, the differences correspond to the opening's hierarchy. Prestigious openings have the highest incidence of frame-shape repetition, in All regions with a frequency of 19.66%, in the Germanic region with a frequency of 24.07%, and in the Germanic region-Vienna with a frequency of 20.00%. It is only in the Alpine region, where the most frequent opening type is major openings with a frequency of 10.42%.

Furthermore, in All regions (the Alpine, Germanic, and Germanic -Vienna regions) the frequency of frame-shape repetition in prestigious openings

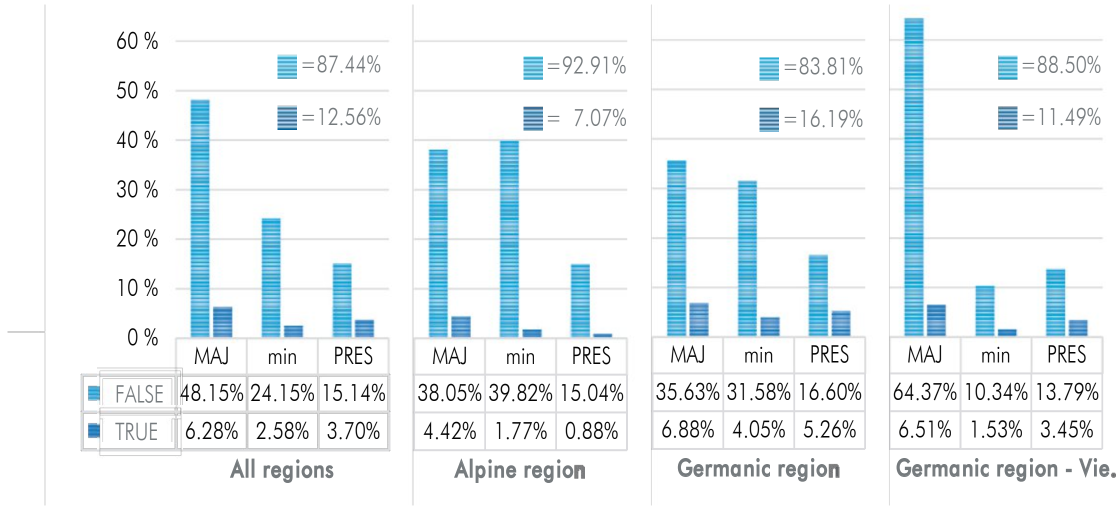


Fig. 5.05
Frame-shape repetition: Occurrence by hierarchy of openings and region

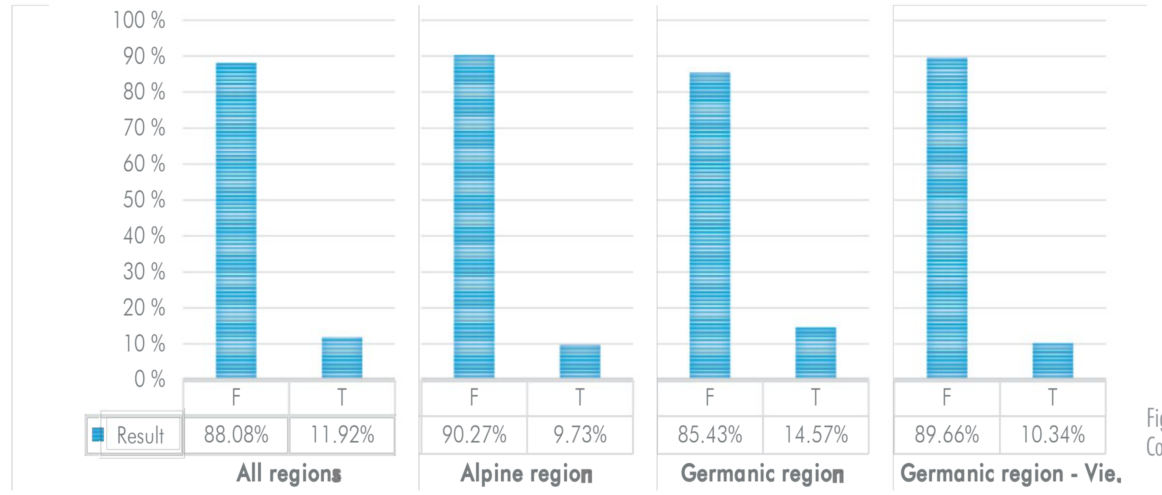


Fig. 5.06
Compound: Occurrence by region

(19.66%) is more than twice that of minor openings (9.64%), and just less than twice that of major openings (11.54%). This could be expected if one assumes the proportional design is related to a higher prestige status. Nevertheless, the unquestionable incidence of non-frame-shape repetition renders this hypothesis questionable.

COMPOUND

When individual openings are grouped together in a single arrangement, a compound opening is created. It is important to pay special attention to them, as they change the outer frame proportions of an opening. In the vernacular architecture analysis, compounds comprised of the same opening type, where one type of opening was repeated and grouped into a single unit. The same is not true in prestige architecture, as mixed-opening compounds also occur, where various types of openings are arranged in a single unit. Distinguishing between the type of elevation (front, side, rear) is not essential in this regard; thus, the analysis will summarizing all elevations together.

The results of the compound analysis are presented in Fig. 5.06. It is possible to conclude that the compound openings are rare, and, in most cases, openings are present individually. Although the outcomes are quite balanced throughout the regions, compounds are least common in the Alpine region with a frequency of 9.73%, and most in the Germanic region with a frequency of 14.57%.

Nonetheless, the types of compound openings that do occur are presented in Table 5.05. The most frequent compound opening is the double same-opening compound, ranging from frequencies of 72.73% to 96.30% in the Alpine and the Germanic - Vienna regions, respectively. Furthermore, a non-negligible percentage of mixed-opening compounds features in the All, Alpine, and Germanic regions. The least common type is the triple same-opening compound, which is completely absent from the study sample in the Alpine and Germanic - Vienna regions.

INNER FRAME: WINDOW

As the title suggests, the proportions of the inner frame of an opening (the penetration in a wall) are the central topic of this section.

Fig. 5.07 presents the individual ratios of inner frames. At first look, the ratio 1:2 (=0.500) stands out in all geographical regions. Next, 5:9 (~0.556) is consistently the second most frequent type. Nevertheless, their deviations according to specific regions are noteworthy. While in the Alpine region their deviation is at its lowest, equal to ~7%, in the Germanic region it is at its highest, at ~25%. While the first and second most common ratios are stable, the third place changes based on the location.

Depending on the region, the results are as follows. In All regions, the ratio 1:2 dominates with a frequency of ~28%, followed by the 5:9 ratio with ~11%. The third place is taken by the ratio 4:7 with ~6%. Although many other ratios are listed in the graphic, most of them are of negligible magnitude, and therefore require no more attention. In the Alpine region, the scene is a little less polarized, where the ratio of 1:2 has a frequency of ~18%, and the ratio of 5:9 has 11%, followed closely by the 5:7 ratio at 10%. In the Germanic region, the affinity to one specific ratio - namely the 1:2 ratio – is clear, as it has a frequency of 34% which has a clear margin over the second most frequent ratio –5:9 which only has a frequency of ~9%. The third most frequent ratio is 2:3 with just more than 5%. Lastly, in the Germanic region-Vienna, the circumstances are similar to all regions, where again the most common ratio is the 1:2 ratio, followed by 5:9, and 4:7, with frequencies of ~26%, ~13%, and ~11%, respectively.

After this detailed analysis of the separate ratios, multiple ratios are merged into decimal ratio categories for further analysis. From Table 5.06 it is clear that the first and second most frequent decimal ratios are of 0.5 and 0.6. For all and front elevations their frequency changes according to the region – the 0.5 category leads in All and Germanic regions, and the 0.6 category leads in the Alpine and Germanic-Vienna regions. For side elevations the distribution is even more balanced and 0.5 is consistently in the first place. Categories exceeding the 1.1 category are, due to their low incidence, insignificant.

The hierarchy of openings will be analysed next. In the Fig. 5.08 graph, the major, minor, and prestigious openings are treated individually, to enable comparison of percentage amounts. As one can deduce, based on the height of individual percentage peaks, there is clearly on unambiguously preferred prestigious opening, or two decimal ratio categories (0.5, alternatively 0.6). Thereafter, in major openings the relative preference for a certain category is a little less obvious. Regardless, the most frequent decimal ratio is 0.5, followed by the 0.6 decimal ratio. Similarly, among minor openings, the frequencies are scattered among a number of decimal ratio categories, and a clear ranking of ratios cannot be deduced.

The most pronounced differences between the studied regions will now be

	All elevations				Front elevation				Side elevation			
Decimal ratio a/b = **C**	All reg. (%)	Alp. reg. (%)	Ger. reg. (%)	Ger. reg.-Vie (%)	All reg. (%)	Alp. reg. (%)	Ger. reg. (%)	Ger. reg.-Vie (%)	All reg. (%)	Alp. reg. (%)	Ger. reg. (%)	Ger. reg.-Vie (%)
0.2	0.46	-	-	1.27	0.34	-	-	0.79	0.83	-	-	4.17
0.3	3.94	1.11	6.52	2.53	2.40	-	4.81	1.59	8.26	3.57	10.14	8.33
0.4	11.57	3.33	11.96	15.82	11.30	4.84	10.58	15.08	10.74	-	11.59	20.83
0.5	27.55	17.78	33.70	25.95	28.42	12.90	42.31	24.60	24.79	28.57	23.19	25.00
0.6	23.38	22.22	18.48	29.75	24.66	22.58	16.35	32.54	19.01	21.43	20.29	12.50
0.7	8.10	13.33	6.52	6.96	9.25	19.35	4.81	7.94	5.79	-	8.70	4.17
0.8	5.09	10.00	4.35	3.16	3.77	6.45	1.92	3.97	8.26	17.86	7.25	-
0.9	4.40	8.89	2.72	3.80	3.77	9.68	0.96	3.17	6.61	7.14	5.80	8.33
1.0	4.86	6.67	3.80	5.06	4.79	4.84	4.81	4.76	5.79	10.71	2.90	8.33
1.1	2.08	-	4.89	-	1.37	-	3.85	-	3.31	-	5.80	-
1.2	0.93	2.22	0.54	0.63	1.03	1.61	0.96	0.79	0.83	3.57	-	-
1.3	2.31	2.22	2.72	1.90	3.08	1.61	4.81	2.38	0.83	3.57	-	-
1.4	0.69	-	1.63	-	0.68	-	1.92	-	0.83	-	1.45	-
1.5	0.23	1.11	-	-	0.34	1.61	-	-	-	-	-	-
1.6	0.23	-	0.54	-	0.34	-	0.96	-	-	-	-	-
1.7	0.93	2.22	1.09	-	1.03	3.23	0.96	-	0.83	-	1.45	-
1.8	0.93	2.22	0.54	0.63	0.68	1.61	-	0.79	1.65	3.57	1.45	-
2.0	0.69	1.11	-	1.27	0.68	1.61	-	0.79	0.83	-	-	4.17
2.3	0.46	2.22	-	-	0.68	3.23	-	-	-	-	-	-
2.5	0.23	1.11	-	-	0.34	1.61	-	-	-	-	-	-
2.7	0.23	1.11	-	-	0.34	1.61	-	-	-	-	-	-
3.0	0.23	1.11	-	-	0.34	1.61	-	-	-	-	-	-
3.5	0.46	-	-	1.27	0.34	-	-	0.79	0.83	-	-	4.17
%: Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
#: Types of inner frames	432	90	184	158	292	62	104	126	121	28	69	24

Table 5.06
Inner frame: window:
Decimal ratios by region and elevation type

examined. To start with, while the decimal ratio 0.5 is most common among prestigious openings followed by the 0.4 category (in All, Germanic, and Germanic-Vienna regions) in the Alpine region where the 0.6 category is most frequent, and the 0.5 category is second most frequent. Furthermore, the deviation in preference between these categories fluctuates with the greatest magnitude in the Germanic region (~37%), and the smallest in the Germanic region-Vienna (less than 10%). In the case of major openings, the most common category is 0.5, followed by 0.6 (in All, Alpine, and Germanic regions) except in the Germanic region-Vienna, where their rankings are reversed. As mentioned, the deviations between frequencies are smaller, ranging from as little as ~4% in All regions, to as high as ~19% in the Germanic region. Lastly, the variable first place ranking of minor openings alters successively between 0.6 (All regions), 0.8 (Alpine region), 0.6 again (Germanic region), and 1.0 (Germanic region-Vienna) categories. The greatest fluctuations in the incidence of minor openings between the first three places are present in the Germanic region-Vienna, while All, and Germanic regions are evenly inconsistent; with frequencies scattered among several decimal ratio categories with small percentage differences separating them.

As in vernacular architecture, the inner frames were analysed according to the

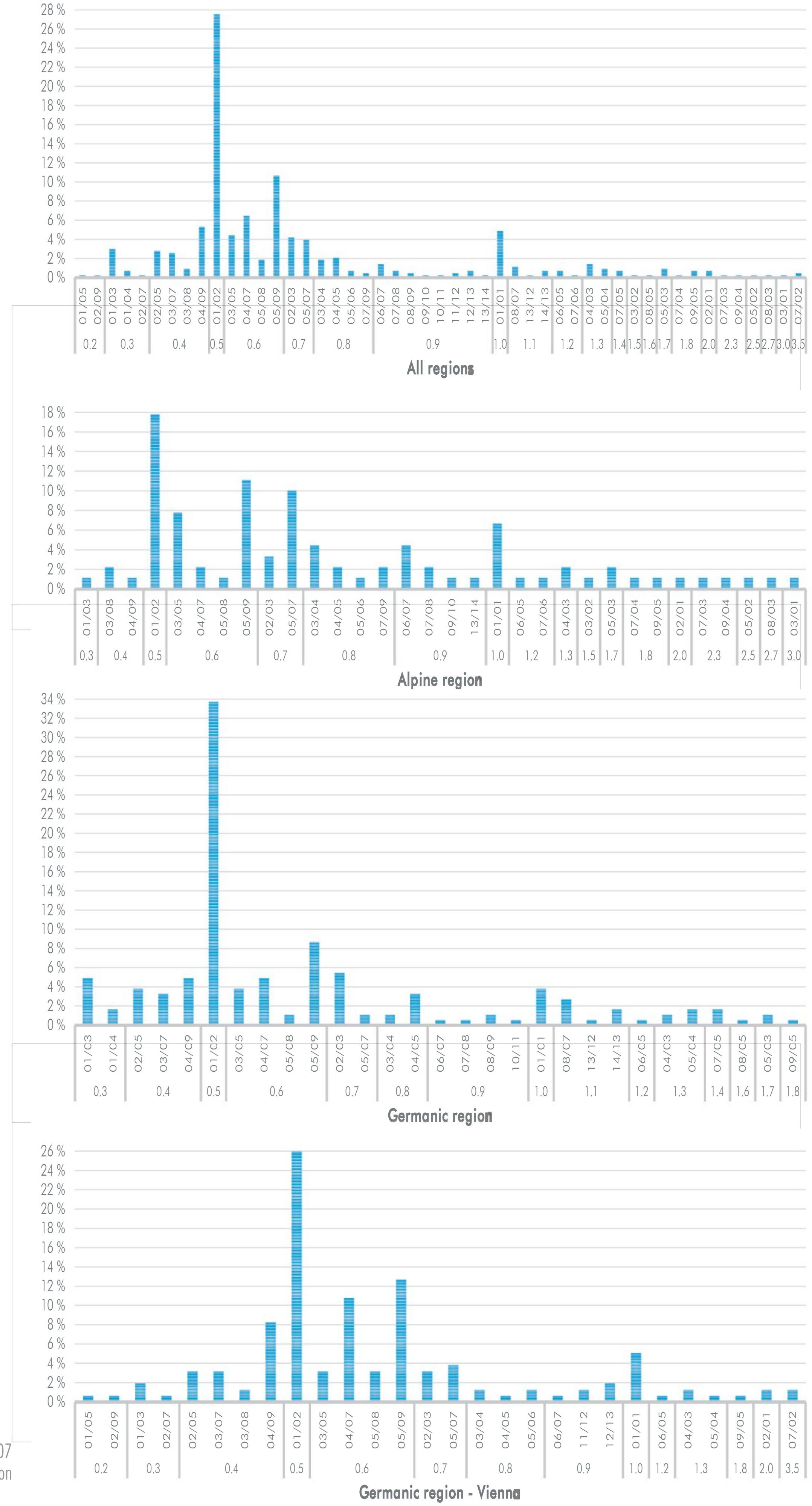


Fig. 5.07
Inner frame: window: Ratios by region

CHAPTER 5 // PRESTIGE ARCHITECTURE: ANALYSIS OF PROPORTIONS

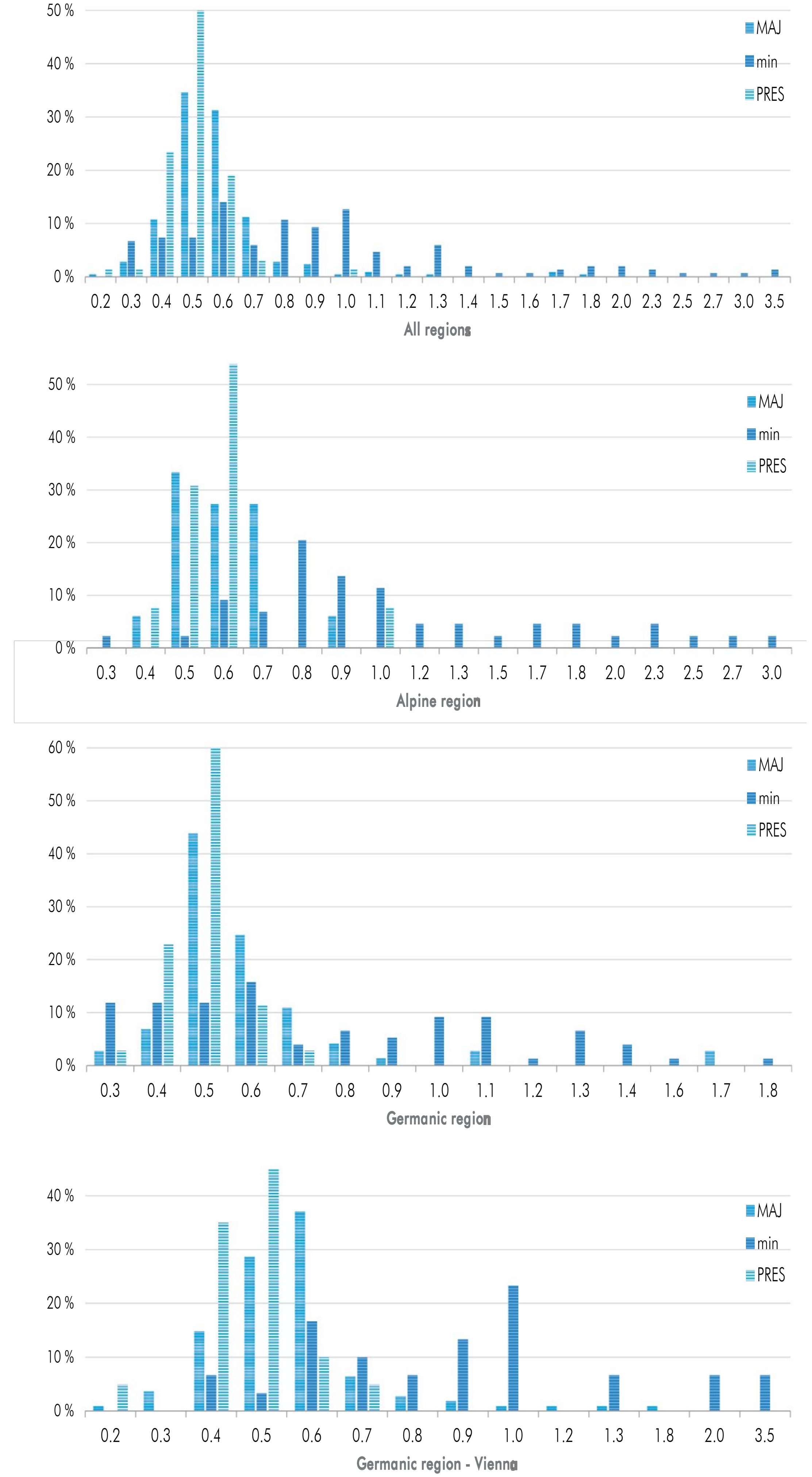


Fig. 5.08
Inner frame: window: Decimal ratios by hierarchy of openings and region

construction of the building, and the intention of the analysis was the same in prestige architecture. Unfortunately, due to little certainty in determining the type of building construction, this section of the analysis had to be omitted so as to avoid misleading conclusions.

OUTER FRAME: WINDOW

As described earlier, the outer frames creating the visual borders of inner frames, and their relationship to the inner frames is therefore subordinate.

Incidences of individual ratios are presented in Fig. 5.09. The most frequent ratio varies according to the location: 1:2 in All regions, 1:2 together with 3:5 in the Alpine region, 5:8 in the Germanic region, and 4:9 in the Germanic region-Vienna. However, the 1:2 ratio is still the most common one in the unifying analysis of all regions.

A closer look at the separate regions sheds further light on the presence of certain ratios. As already observed in All regions, the ratio of 1:2 is the most common with a frequency of ~11%, although it exceeds the next ratio(4:9) by only 1% with ~10%. Interestingly, the third and fourth positions belong to ratios which approximate the golden ratio, namely 5:8 (~9.5%), and 3:5 (~9%). If their percentage amounts would be summed up, the golden ratio would easily be most frequent in the region. In the Alpine region, the first three places were divided between two ratios; the first place between the 1:2 and 3:5 (~12% per each), the second between 2:3 and 5:7 ratios (~9% per each), and the third between 4:9 and 5:8 ratios (~7% per each). Here too, the golden ratio ratios 3:5 and 5:8 rank highest when counted together. In the Germanic region, the ratio 5:8 is most frequent with ~16%, distantly followed by the 1:2 ratio with 9%. The 3:5 and 5:9 ratios share third place (~8% per each). In the Germanic region - Vienna, the most preferred ratio is 4:9 with ~15%, followed by 1:2 with ~13%, and then unusually the 2:3 ratio with ~11%. In this region, even after summing up of 3:5 and 5:8 ratios, the golden ratio would not rank higher than third place.

In Table 5.07, the categories of decimal ratios are introduced according to the type of elevation and geographical location. The 0.6 category is most frequent for almost any region and any elevation, aside from the 0.4 category which ranks highest in the Alpine and Germanic-Vienna regions in the side elevation. The 0.4 category is generally second most frequent. Compared to all and front elevations, the side elevation demonstrates less consistency in a dominant decimal ratio category. Furthermore, the 0.3 and greater than 0.7 categories are of such low frequencies that they are negligible.

One element of the analysis of outer frame proportions has remained undiscussed. Fig. 5.10 shows the decimal ratio categories according to the hierarchy of openings – either major, minor, or prestigious openings. While the major and prestigious openings show a greater affinity to two or three specific categories, it is not the case for the minor openings, which are dispersed between several decimal ratio categories. Furthermore, the major openings persistently tend toward the 0.6 category regardless of the region, whereas among prestigious openings, the 0.4 category is more common in any region but the Alpine (where the 0.5 category is favoured). Within the minor openings data, the 1.0 category is preferred in All regions, in the Alpine region the 1.0, 1.1, and 1.4 categories are preferred, in the Germanic region the 0.6 category is preferred, and lastly, in the Germanic region-Vienna the 1.0

	All elevations				Front elevation				Side elevation			
Decimal ratio a/b = **C**	All reg. (%)	Alp. reg. (%)	Ger. reg. (%)	Ger. reg.-Vie (%)	All reg. (%)	Alp. reg. (%)	Ger. reg. (%)	Ger. reg.-Vie (%)	All reg. (%)	Alp. reg. (%)	Ger. reg. (%)	Ger. reg.-Vie (%)
0.3	0.89	-	2.04	-	0.43	-	1.22	-	2.25	-	3.70	-
0.4	16.27	12.28	12.93	21.64	15.15	2.56	15.85	19.09	17.98	33.33	9.26	29.41
0.5	11.54	12.28	9.52	13.43	12.12	12.82	8.54	14.55	10.11	11.11	9.26	11.76
0.6	30.47	22.81	40.14	23.13	31.17	23.08	45.12	23.64	30.34	22.22	35.19	23.53
0.7	12.72	17.54	6.80	17.16	14.29	23.08	3.66	19.09	10.11	5.56	11.11	11.76
0.8	5.62	5.26	4.08	7.46	5.19	7.69	2.44	6.36	4.49	-	7.41	-
0.9	4.73	7.02	4.08	4.48	4.76	5.13	4.88	4.55	5.62	11.11	3.70	5.88
1.0	4.44	3.51	3.40	5.97	4.33	2.56	3.66	5.45	5.62	5.56	3.70	11.76
1.1	2.66	3.51	2.72	2.24	2.16	2.56	1.22	2.73	2.25	5.56	1.85	-
1.2	1.78	-	4.08	-	1.73	-	4.88	-	2.25	-	3.70	-
1.3	3.85	5.26	5.44	1.49	4.33	7.69	6.10	1.82	2.25	-	3.70	-
1.4	1.48	3.51	2.04	-	0.87	2.56	1.22	-	2.25	5.56	1.85	-
1.5	1.18	1.75	0.68	1.49	0.87	2.56	-	0.91	2.25	-	1.85	5.88
1.6	0.30	-	0.68	-	-	-	-	-	1.12	-	1.85	-
1.7	1.18	1.75	1.36	0.75	1.30	2.56	1.22	0.91	1.12	-	1.85	-
1.8	0.30	1.75	-	-	0.43	2.56	-	-	-	-	-	-
2.0	0.30	1.75	-	-	0.43	2.56	-	-	-	-	-	-
2.3	0.30	-	-	0.75	0.43	-	-	0.91	-	-	-	-
%: Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
#: Types of outer frames	338	57	147	134	231	39	82	110	89	18	54	17

Table 5.07
Outer frame: window:
Decimal ratios by region and elevation type

category is preferred. Thus, the most frequent decimal ratio fluctuates based on the hierarchy of opening.

ALL FRAMES: WINDOW

This section will present a unified analysis of the inner and outer frames. Moreover, if present, the extra frames will be included in this analysis as well. In addition to typical points of interest, building typology and its effect on proportions will be explored at the end of this section.

To begin with, Fig. 5.11 presents the occurrence of individual ratios, where the 1:2 ratio is the most frequent across the studied regions. More specifically, the ratio 1:2 (~20%) is the first, followed by 5:9 (~9%), and 4:9 (~7.5%) in All regions. The deviation between first and second place, equal to ~11%, is large. In the Alpine region, the most frequent ratio is again 1:2 (~16%), the second place is shared by 3:5 and 5:7 (~9.5% per each), and 5:9 is third most frequent (~7.5%). In the Germanic region, the ratios rank in the following order: 1:2 (~22.5%), 5:9 (~8%), and 5:8 (~7.5%). Lastly, in the Germanic region-Vienna, the first place belongs to the 1:2 ratio (~20%), followed by 4:9 and 5:9 which share the second position (~11% each), and 4:7 and 2:3 share third place (~7% each).

The results shown in Table 5.08 are unequivocal, demonstrating a clear preference for the 0.6 category, and the 0.5 decimal ratio in second place in all regions. The importance of analysing each ratio individually was confirmed yet again, otherwise, the dominant ratio 1:2 corresponding to 0.5 catego-

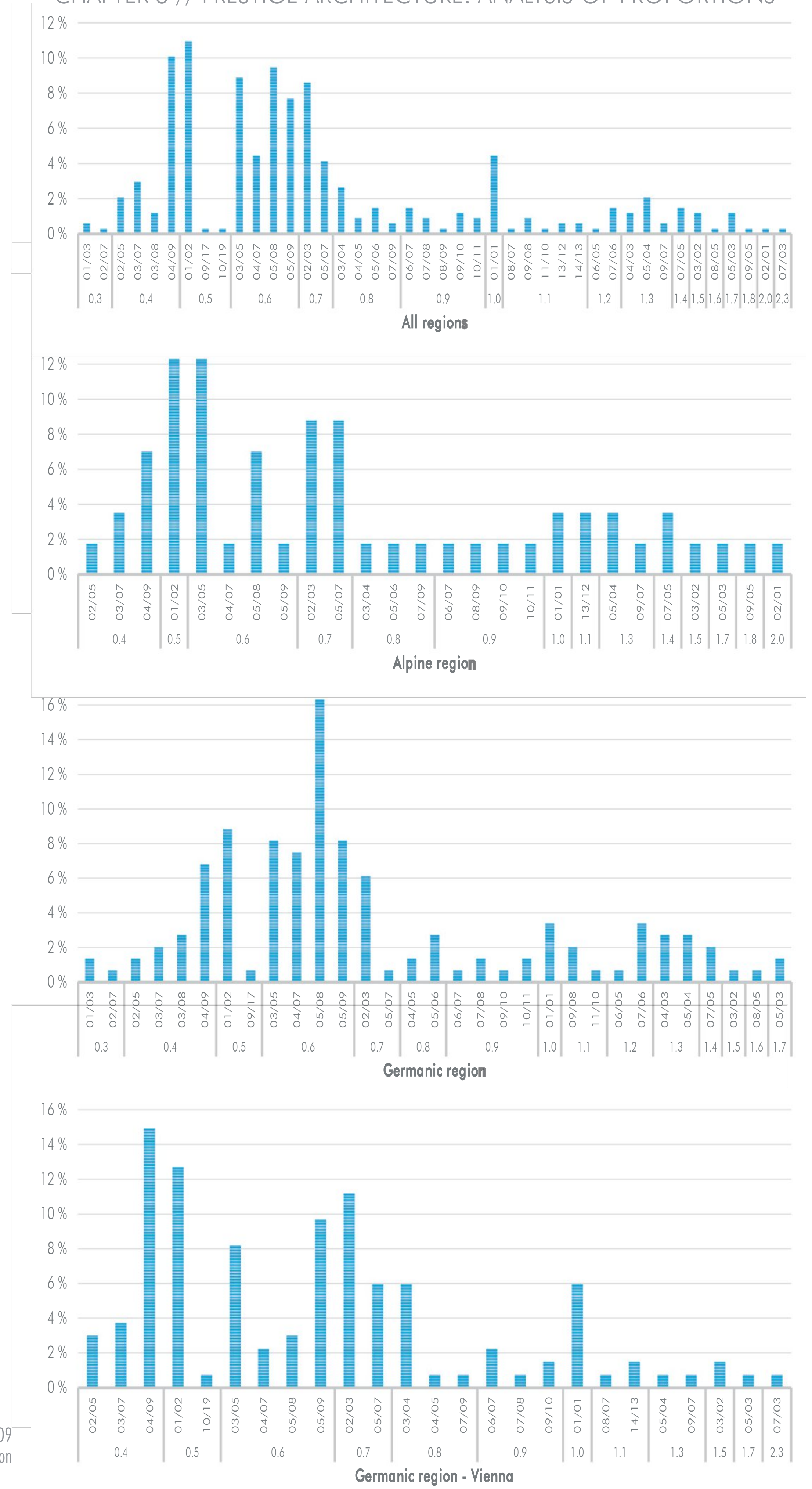


Fig. 5.09
Outer frame: window: Ratios by region

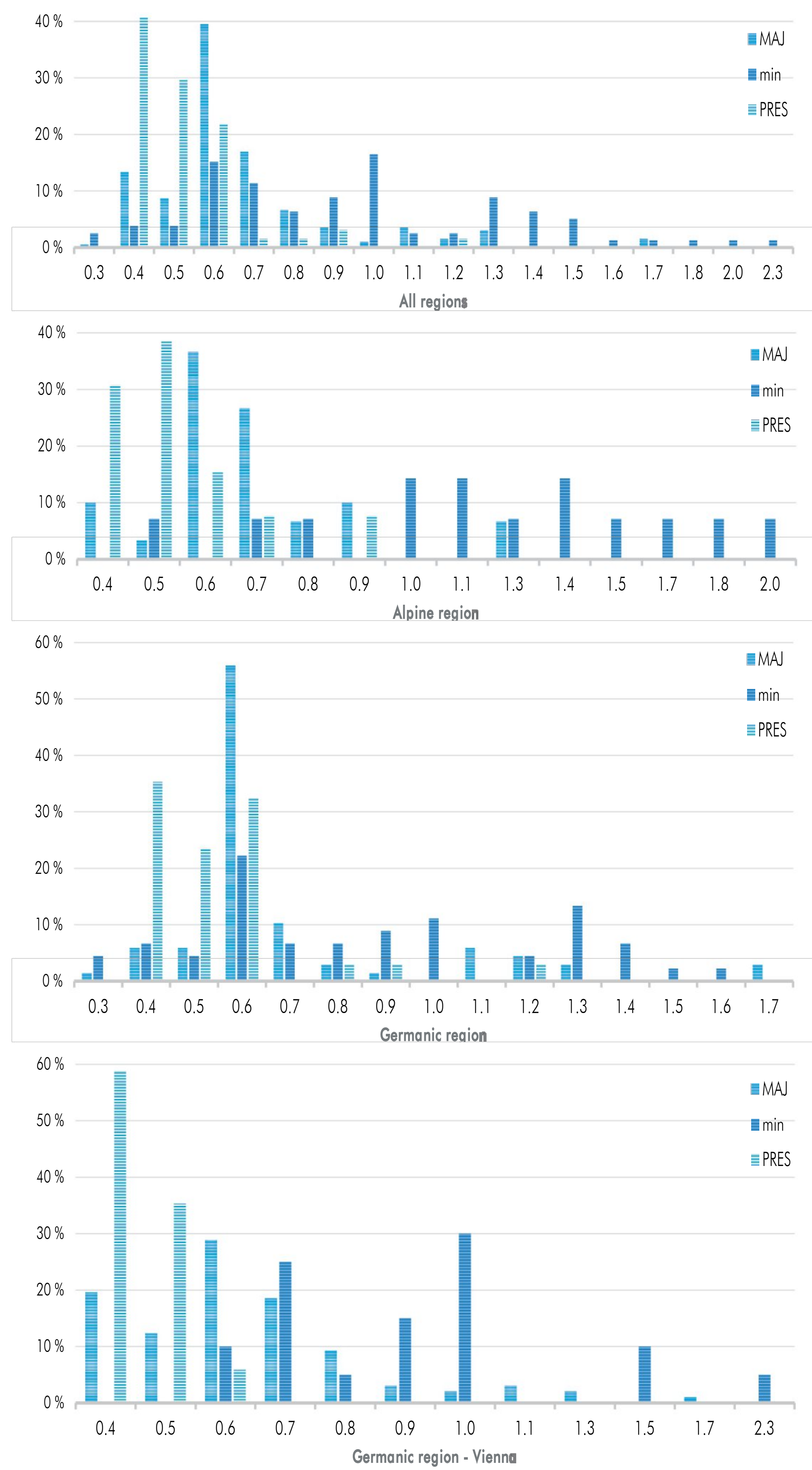


Fig. 5.10
Outer frame: window: Decimal ratios by hierarchy of openings and region

ry would have been subsumed into the broader category, and would have been outstripped by the 0.6 category which consists of multiple frequent ratios (which after summation exceeds the frequency of the 1:2 ratio).

As noted at the beginning of this section, Fig. 5.12 displays the decimal ratio categories according to the building typology – palaces or castles (P+C), residential buildings (R), and villas (V). This time as well, the results are unified in character, the most frequent category being 0.6, and the second most frequent being 0.5 . Nevertheless, the differences among building typologies can be observed in the frequency of a specific category, for example, residential buildings demonstrate a higher percentage frequency in the 0.5 category than in the other two typologies.

ORIENTATION: WINDOW

It is usually valuable to study the same topic from different scales, or in other words, to merge or split the filter criteria. Thus, the ratios will be studied through three super categories: landscape, neutral, or portrait (corresponding to a decimal ratio bigger, equal to, or smaller than 1.0, respectively).

The dominance of the portrait orientation of the windows is clear in Fig. 5.13, where it is the most common window orientation regardless of the opening's hierarchy. On the other hand, the highest value of landscape orientation is present in the Alpine region, where 17.78% of all openings (coincidently, all minor openings) are arranged in this manner. The neutral orientation is the least favoured across all hierarchies and all regions except the Germanic region-Vienna, where the neutral orientation exceeded the landscape orientation and ended in second place in minor openings. The fact that the prestigious openings are solely portrait in orientation, is a remarkable result.

The same conclusion as in vernacular architecture can be made in prestige architecture, where the landscape orientation is associated with lower prestige status.

INNER FRAME: DOOR

As mentioned in the chapter on vernacular architecture, there is a close connection between human proportions and those of door openings. Therefore a separate analysis of window and door proportions is necessary. Although, in vernacular architecture, "the category of extra-large door openings suitable for barn use" was not included in the overall assessment of door proportions, in prestigious architecture such an approach won't be necessary. All door openings will be treated inclusively. It is true that, in prestige architecture, bigger door openings occur at entrances. However, these will be included in the unified category of door openings.

Fig. 5.14 contains the frequency of individual ratios. Remarkably, the approximation of the silver ratio takes the lead in every studied region but the Germanic region-Vienna. Nevertheless, the ratio of 2:5, representing two successive numbers in Pell's series (see chapter *Proportion: Construct/How to…/Construct* θ), is the second most frequent in the region. Ratios like 3:8, 1:2, and 4:9 rank higher or lower depending on the region.

In All regions, the ratio 2:5 ranks first with a frequency of almost 18%, closely followed by the 3:8 with almost 16%. The third position belongs to the 1:2 ratio (~13.5%). The data in the Alpine region is different, where the ratios 2:5

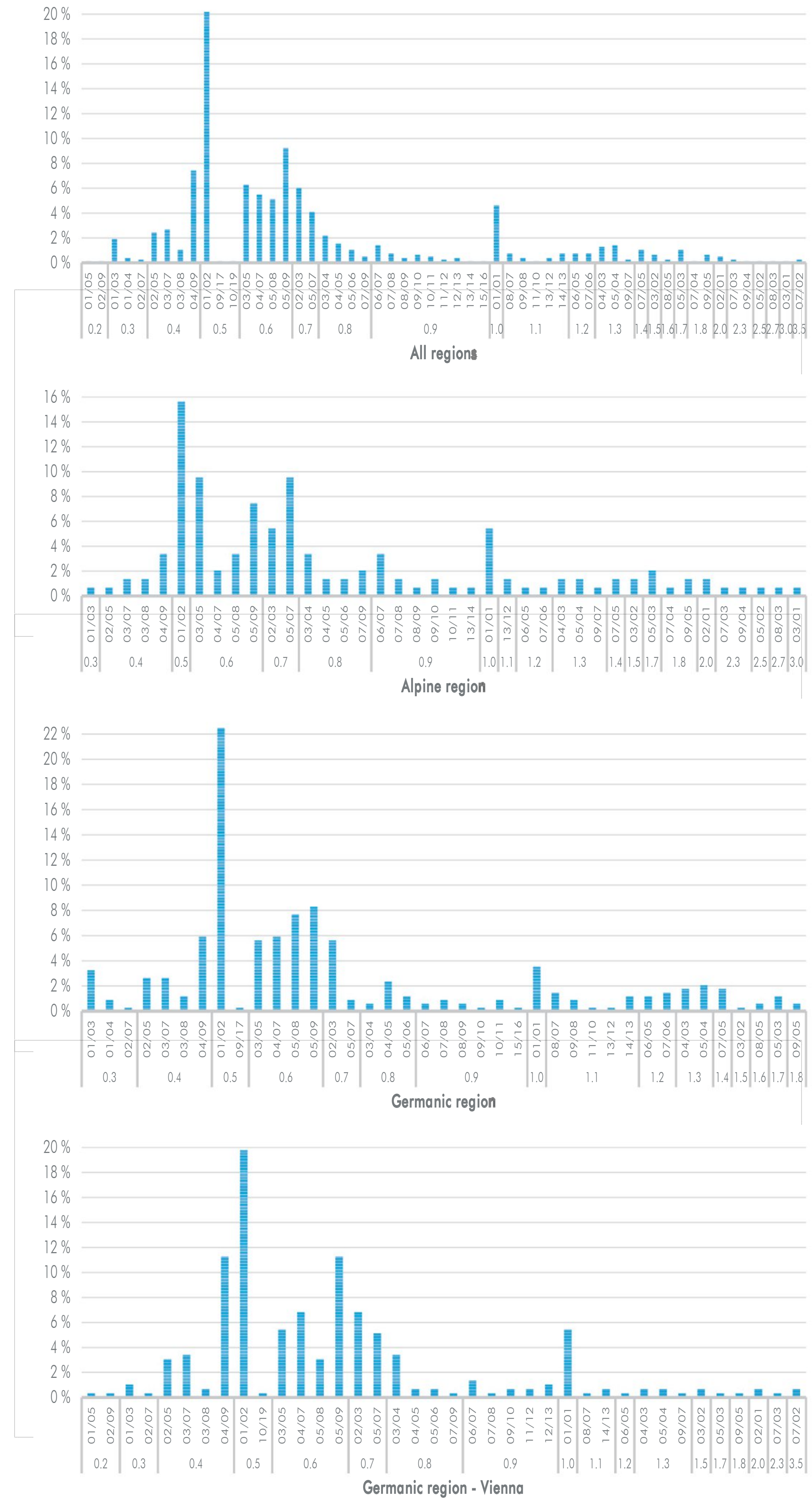


Fig. 5.11
All frames: window: Ratios by region

Decimal ratio a/b = **C**	All elevations All reg. (%)	Alp. reg. (%)	Ger. reg. (%)	Ger. reg.-Vie (%)
0.2	0.26	-	-	0.68
0.3	2.57	0.68	4.44	1.37
0.4	13.62	6.80	12.43	18.43
0.5	20.44	15.65	22.78	20.14
0.6	26.22	22.45	27.51	26.62
0.7	10.15	14.97	6.51	11.95
0.8	5.27	8.16	4.14	5.12
0.9	4.63	8.16	3.55	4.10
1.0	4.63	5.44	3.55	5.46
1.1	2.44	1.36	4.14	1.02
1.2	1.54	1.36	2.66	0.34
1.3	2.96	3.40	3.85	1.71
1.4	1.03	1.36	1.78	-
1.5	0.64	1.36	0.30	0.68
1.6	0.26	-	0.59	-
1.7	1.03	2.04	1.18	0.34
1.8	0.77	2.04	0.59	0.34
2.0	0.51	1.36	-	0.68
2.3	0.39	1.36	-	0.34
2.5	0.13	0.68	-	-
2.7	0.13	0.68	-	-
3.0	0.13	0.68	-	-
3.5	0.26	-	-	0.68
%: Total	100.0	100.0	100.0	100.0
#: Types of all frames	778	147	338	293

Table 5.08
All frames: window: Decimal ratios by region

and 4:9 share first place (~22% each). The second 1:2 ratio has a frequency of 17%. Quite atypically, the third most common ratio in the Alpine region is the 4:7 ratio (~13%) and the 3:8 ratio was much less frequent. In the Germanic region, the ratio 2:5 (~20%) once again took the leading position, followed by 1:3 and 3:8 which share second position (~15% each), and third, the 1:2 ratio with ~11.5%. As mentioned, the 3:8 ratio with ~17.5% is the most common ratio in the Germanic region-Vienna, followed by 2:5 (~15.5%), and subsequently the 4:9 ratio (~14.5%), followed very closely by the 1:2 ratio.

Table 5.09 contains the data organized by decimal ratio category. This table distinguishes between elevation types. The most frequent decimal ratio category is the same for all study regions and all elevation types, namely the 0.4 category. The second most frequent decimal ratio category differs according to the elevation type: while the 0.6 category exceeds in all and front elevations, the 0.3 category is most frequent in side elevations. The outcomes of the separate elevations are consistent across all studied regions.

Fig. 5.15 presents the decimal ratio categories depending on the hierarchy of openings. First, the 0.4 category is the most common in all regions and all hierarchies except minor openings in the Germanic region-Vienna. More

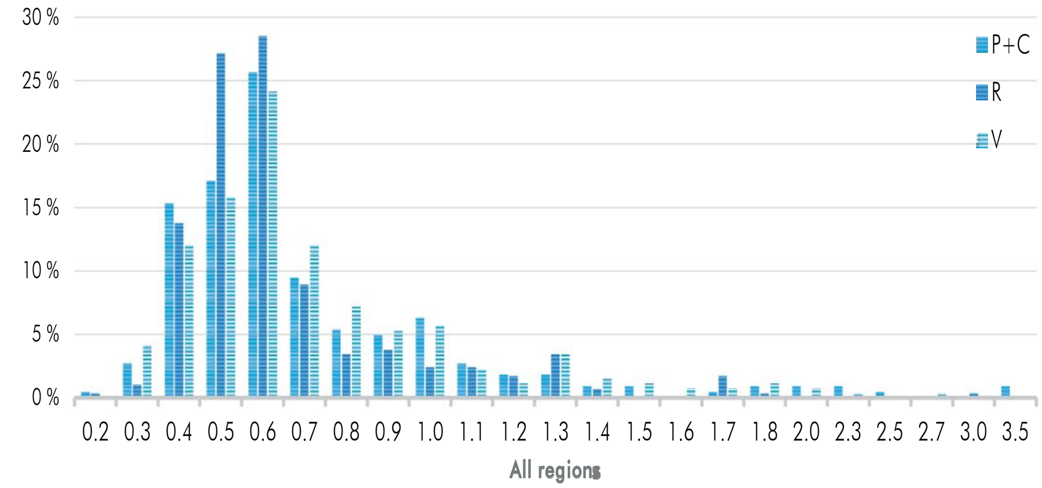


Fig. 5.12
All frames: window: Decimal ratios by building typology

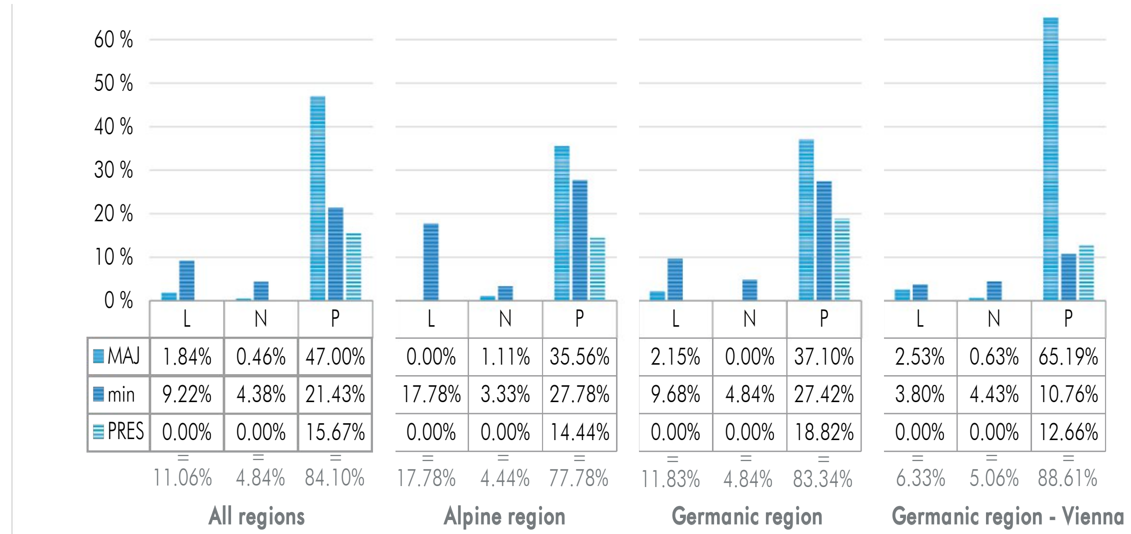


Fig. 5.13
Orientation: window: Type of orientation by hierarchy of openings and region

specific outcomes are detailed in the next paragraph.

In All regions, the most frequent decimal ratio category for major, minor, and prestigious openings is the 0.4 category, where their percentage frequencies were ~ 45%, ~50%, and ~65%, respectively. The frequencies are balanced among the remaining categories of minor openings. This cannot be said for major, nor prestigious openings, where the remaining decimal categories have a clear ranking. In the Alpine region, the 0.4 category is consistently the most frequent, however, the for minor openings frequencies are equally split between the categories 0.4, 0.5, and 0.6. In the Germanic region, once again, the most frequent category is 0.4. The balanced distribution among the other categories of minor openings is not present in the Germanic region. The same is true for the Germanic region-Vienna, the 0.6 category has a frequency of 100% among minor openings. The 0.4 category is most frequent among major, as well as prestigious openings.

The analysis on the proportions of inner frames based on the building construction will be omitted, as was the case with the inner frames of windows. The reason is the same: it was not possible to determine the construction of the building with high certainty. Thus, no guarantee could be given as to the accuracy of the results.

OUTER FRAME: DOOR

This section focuses on the proportions of the outer frames of doors. The outer

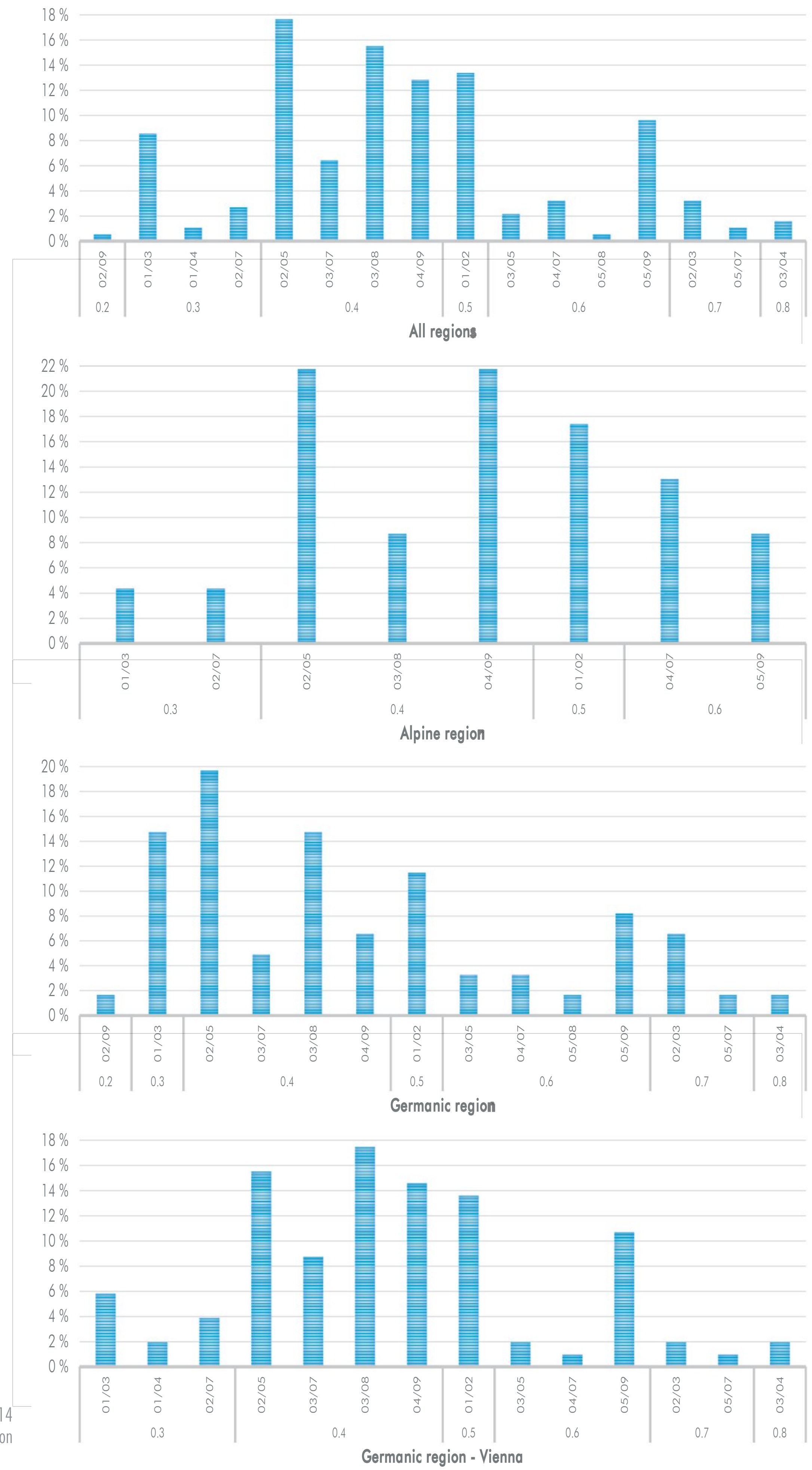


Fig. 5.14
Inner frame: door: Ratios by region

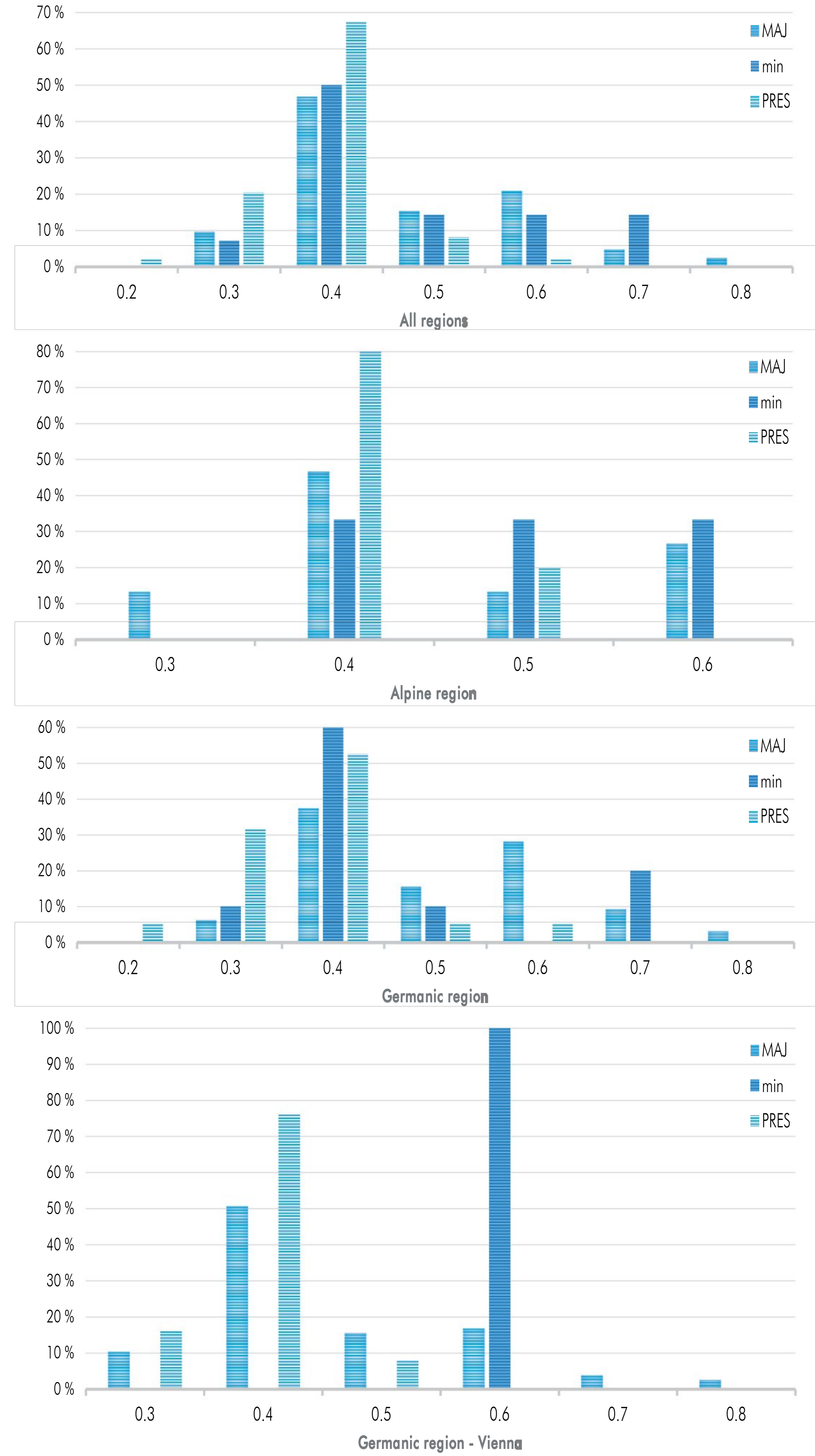


Fig. 5.15
Inner frame: door: Decimal ratios by hierarchy of openings and region

	All elevations				Front elevation				Side elevation			
Decimal ratio a/b = **C**	All reg. (%)	Alp. reg. (%)	Ger. reg. (%)	Ger. reg.-Vie (%)	All reg. (%)	Alp. reg. (%)	Ger. reg. (%)	Ger. reg.-Vie (%)	All reg. (%)	Alp. reg. (%)	Ger. reg. (%)	Ger. reg.-Vie (%)
0.2	0.53	-	1.64	-	-	-	-	-	2.56	-	4.76	-
0.3	12.30	8.70	14.75	11.65	12.06	10.00	13.51	11.90	15.38	-	19.05	13.33
0.4	52.41	52.17	45.90	56.31	51.77	45.00	45.95	55.95	58.97	100.0	42.86	73.33
0.5	13.37	17.39	11.48	13.59	14.18	20.00	13.51	13.10	10.26	-	9.52	13.33
0.6	15.51	21.74	16.39	13.59	17.02	25.00	18.92	14.29	5.13	-	9.52	-
0.7	4.28	-	8.20	2.91	2.84	-	5.41	2.38	7.69	-	14.29	-
0.8	1.60	-	1.64	1.94	2.13	-	2.70	2.38	-	-	-	-
%: Total	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**
#: Types of inner frames	**187**	**23**	**61**	**103**	**141**	**20**	**37**	**84**	**39**	**3**	**21**	**15**

Table 5.09
Inner frame: door:
Decimal ratios by region and elevation type

frame, comprises the frame which surrounds the inner frame, and which is subordinate to the inner frame.

Fig. 5.16 features a graph illustrating the incidence of individual ratios. The most frequent ratios are 1:2 (=0.500) and the 5:9 ratio (~0.556). Other ratios worth mention include 3:5, 2:3, and 4:9, which represent the second, or third positions depending on the study region.

As mentioned, the 1:2 ratio is dominant with 22% in All regions. Next, the 5:9 ratio has a frequency of more than 17%. The third position belongs to the ratio 4:9 with a frequency of almost 10%. In the Alpine region, the 1:2 ratio holds retains the leading position with more than 26%. However, the 5:9 ratio occupies the third position (~10%), and 3:5 and 2:3 share the second position (~16% each). Other ratios in this area are equally rare. The data for the Germanic region is almost the same as that of All regions, with only slight changes in percentages. The most common is the 1:2 ratio (~25%), then 5:9 (14%), followed by the 4:9 ratio (~11%). The rankings are different in the Germanic region-Vienna, where the most frequent ratio is 5:9 (~20.5%). This is closely followed by 1:2 (~19.5%). The third position is split between 4:9 and 3:5 (~10% each).

Another topic for analysis is the distribution of decimal ratios based on the type of elevation and geographical region. As evident in Table 5.10, the results are fairly consistent. The 0,6 category is most frequent and the second most frequent is 0.5. The only exceptions are in the front elevation of the Germanic region, where the number one place is split between 0.4 and 0.5, and in the side elevation of the Alpine region, where the most frequent decimal ratio category is 0.5. Thus, there are no major differences present among the studied regions or the elevation types.

Fig. 5.17 presents decimal ratio categories of the outer door frames according to hierarchy. This graph shows that the analysis of proportions made from various perspectives is meaningful as each hierarchy of openings has idiosyncrasies.

Regarding major openings, the most frequent decimal ratio category is 0.6. It is the most frequent decimal ratio with almost 50% in All regions, ~40% in the Alpine region, 40% in the Germanic region, and over 50% in the Germanic region-Vienna. By contrast, the 0.4 category is the most frequent one

CHAPTER 5 // PRESTIGE ARCHITECTURE: ANALYSIS OF PROPORTIONS

	All elevations				Front elevation				Side elevation			
Decimal ratio a/b = **C**	All reg. (%)	Alp. reg. (%)	Ger. reg. (%)	Ger. reg.-Vie (%)	All reg. (%)	Alp. reg. (%)	Ger. reg. (%)	Ger. reg.-Vie (%)	All reg. (%)	Alp. reg. (%)	Ger. reg. (%)	Ger. reg.-Vie (%)
0.3	2.99	-	8.93	-	0.80	-	3.03	-	11.43	-	20.00	-
0.4	22.16	10.53	23.21	23.91	22.40	11.11	27.27	22.97	22.86	-	15.00	35.71
0.5	24.55	26.32	25.00	23.91	24.80	22.22	27.27	24.32	25.71	100.0	20.00	28.57
0.6	34.73	36.84	26.79	39.13	34.40	38.89	24.24	37.84	34.29	-	35.00	35.71
0.7	9.58	15.79	8.93	8.70	11.20	16.67	9.09	10.81	2.86	-	5.00	-
0.8	4.19	5.26	5.36	3.26	4.00	5.56	6.06	2.70	2.86	-	5.00	-
1.0	0.60	-	-	1.09	0.80	-	-	1.35	-	-	-	-
1.2	0.60	-	1.79	-	0.80	-	3.03	-	-	-	-	-
1.3	0.60	5.26	-	-	0.80	5.56	-	-	-	-	-	-
%: Total	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**
#: Types of outer frames	**167**	**19**	**56**	**92**	**125**	**18**	**33**	**74**	**35**	**1**	**20**	**14**

Tabel 5.10
Outer frame: door:
Decimal ratios by region and elevation type

for prestigious openings, which has a frequency of ~55% in All regions, 40% in the Alpine region (sharing the first position with the 0.5 category), ~ 45% in the Germanic region, and almost 70% in the Germanic region-Vienna. While major and prestigious openings have consistent frontrunner categories, this is not the case for minor openings. The most frequent decimal ratio among minor openings is split between numerous categories. Although the 0.6 category is the most frequent in All regions, in the Alpine region first position is shared between 0.6 and 0.8. In the Germanic region, first position is shared between 0.3, 0.5, and 0.6. The minor openings are not represented in the Germanic region-Vienna. Among major and prestigious openings, the category of the most preferred decimal ratio changes with the hierarchy of the opening, not with the study region.

<u>ALL FRAMES: DOOR</u>

Since individual analyses of the inner and outer frames of door openings has already been performed in the previous sections, this section will summarize the results for all frames (inner, outer, and extra) together. Here, the analysis will focus on individual ratios, and the decimal ratio category by region – omitting the elevation type, as well as the hierarchy of opening. The analysis of decimal ratio categories according to building typology will be performed elsewhere.

Fig. 5.18 depicts the incidence of individual ratios by region. The highest frequency corresponds to the 1:2 ratio regardless of the geographical location, even though the magnitude of its frequency fluctuates. Specifically, it has ~17% in All regions, almost 22% in the Alpine region, 18% in the Germanic region, and ~15.5% in the Germanic region-Vienna. The ratio of 5:9 also has pronounced frequencies in every studied region except the Alpine region. Other noteworthy ratios are 2:5 and 4:9.

The top three ratios in All regions are as follows: the 1:2 ratio (~17%), followed by 5:9 (~13%), and lastly 2:5 (~11.5%). The rankings are similar for the Alpine region, except for second place, which belongs to the 4:9 ratio, and not 5:9. Almost 22% of cases favour the 1:2 ratio, 4:9 has a frequency of 14%, followed by 2:5 with a frequency of 12%. In the Germanic region, the

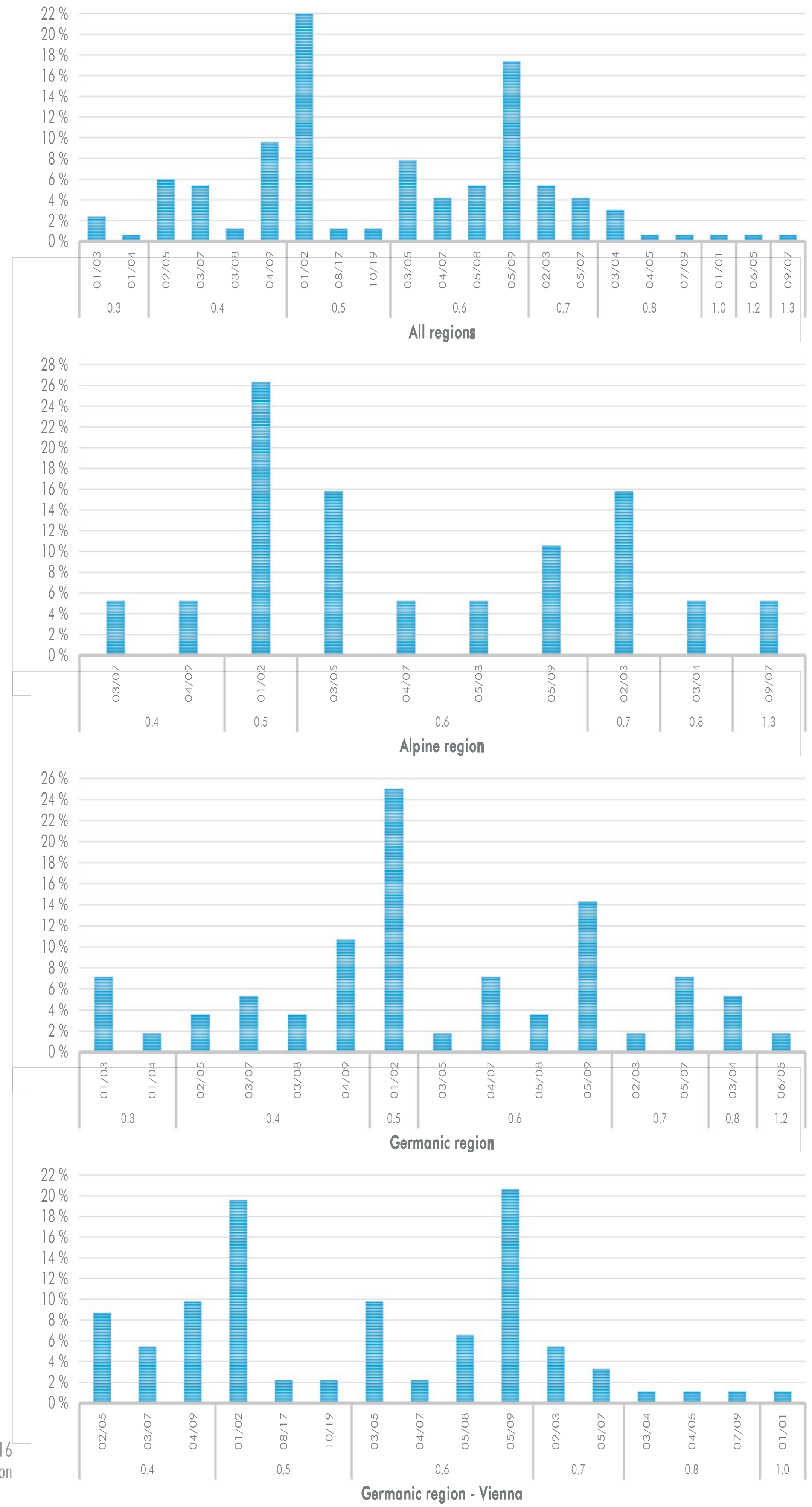


Fig. 5.16
Outer frame: door: Ratios by region

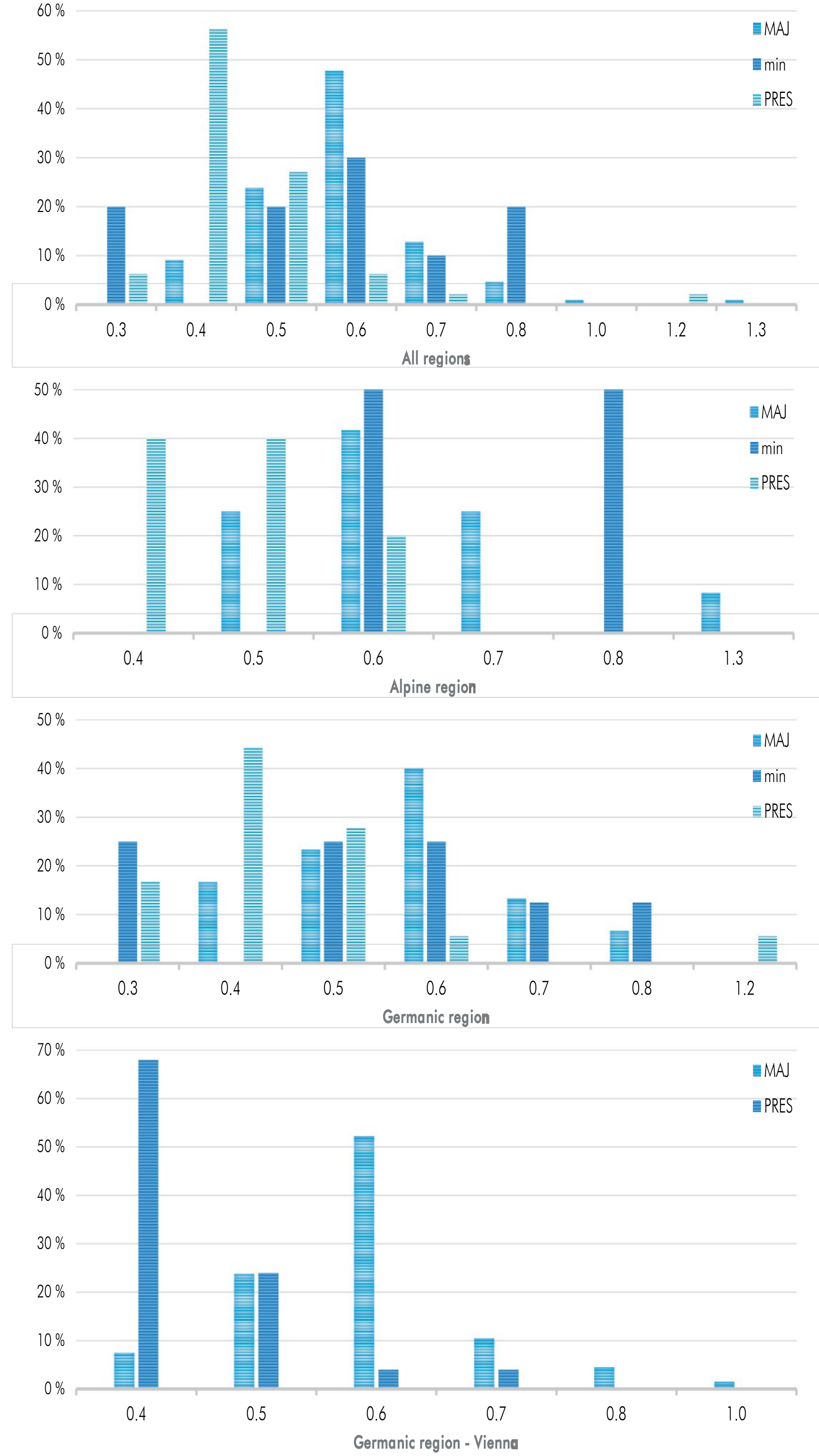


Fig. 5.17
Outer frame: door: Decimal ratios by hierarchy of openings and region

most frequent ratios are identical to those of All regions. The ratio 1:2 has a frequency of 18%, the 5:9 has ~12%, followed by 2:5 with ~11%. The same applies to the Germanic region- Vienna, although, the percentage difference between first and second place is very small, and the third place is split between two ratios: the 1:2 ratio has over 15%, very closely followed by the 5:9 ratio with under 15%, and subsequently the 2:5 and 4:9 ratios with almost 12% each. Based on these results, the trio of ratios 1:2-5:9-2:5 is almost consistently preferred over other ratios.

The decimal ratio categories presented in Table 5.11 are relatively consistent. The 0.4 decimal ratio is the most frequent in all geographical locations, and ranges in frequency from 32.03% to 38.46%. The 0.6 category is the second most frequent, ranging from 21.88% to 28.57%. The 0.5 category is the third most common decimal ratio. The frequencies of categories larger than 0.7, as well as the 0.2 category, are so small, that these decimal ratios are negligible.

The decimal ratio categories according to building typologies are shown in Fig. 5.19. While the first position of the 0.4 category is the same for palaces and castles, and residential buildings, on the contrary, villas have the highest preference for the 0.6 category. Interestingly, a frequency of almost 45% is given to just one category, which makes the typology of palaces and castles the most unambiguous in their proportions. On the other hand, the percentage deviations between the first three categories in villas are very small.

PRESTIGIOUS RATIOS

This section will focus on prestigious ratios within prestige architecture. The golden ratio, silver ratio, and Ludolph's number, have already been described in this thesis (see *Proportion: Construct/How to…*, and *Vernacular Architecture: Analysis of Proportions/ Prestigious Ratios*). These ratios are approximated as follows: the golden ratio is approximated with the ratios of 3:5, or 5:8, the silver ratio with 2:5, or 5:12, and Ludolph's number with 1:3. All of these ratios can also be inverted with ratios in reversed order. Furthermore, their corresponding decimal ratio categories are 0.6 (or 1.6), 0.4 (or 2.4), and 0.3 (or 3.1), respectively. However, the decimal ratio categories should be treated with caution, as multiple individual ratios are included in single decimal ratio categories.

The outcomes of the analysis are as follows. In elevation, it is clear that prestigious ratios do not affect proportions at all. Their frequencies range from 0.00% to a maximum of 4.76%, according to geographic location. The conclusions of the last chapter apply here too, namely the proportions of building elevations do not play an important role in building design and are more a matter of coincidence than of intention.

The proportions of building openings detailed in Table 5.06. Among window openings and the proportions of their inner frames, the 0.6 category is the most frequent. This is misleading as the reason for its popularity is the ratio of 5:9, and not the approximating ratios of the golden ratio. This is further supported in Fig. 5.07, where the golden ratio does not stand out regardless of the geographical location. Even after summing up preferences of 3:5 and 5:8 ratios, the resulting preference is at best fourth most frequent. The silver ratio, as well as Ludolph's number have such low frequencies as to be rendered negligible.

The proportions of window outer frames present different results, although

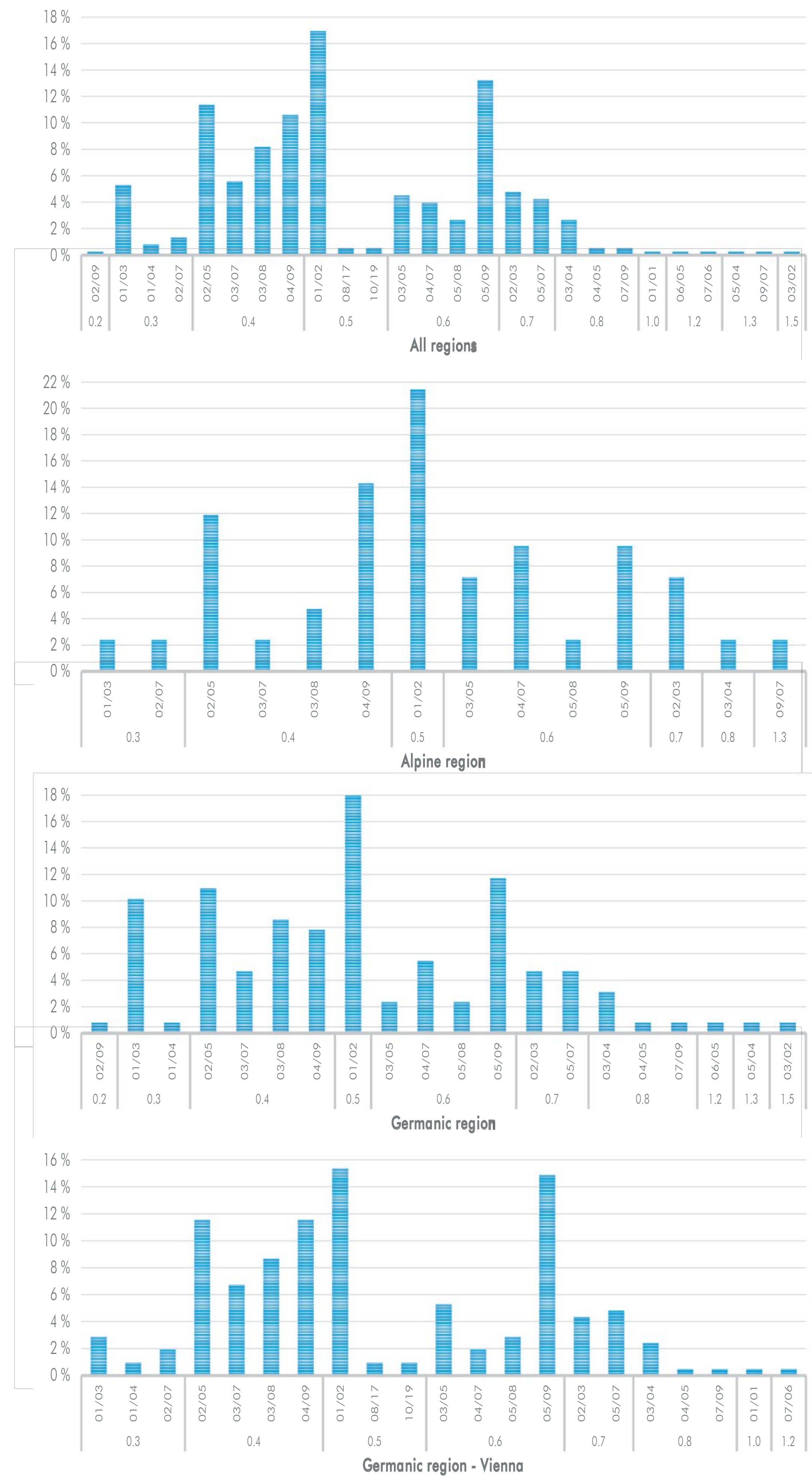


Fig. 5.18
All frames: door: Ratios by region

	All elevations			
Decimal ratio a/b = **C**	All reg. (%)	Alp. reg. (%)	Ger. reg. (%)	Ger. reg.-Vie (%)
0.2	0.26	-	0.78	-
0.3	7.41	4.76	10.94	5.77
0.4	35.71	33.33	32.03	38.46
0.5	17.99	21.43	17.97	17.31
0.6	24.34	28.57	21.88	25.00
0.7	8.99	7.14	9.38	9.13
0.8	3.70	2.38	4.69	3.37
1.0	0.26	-	-	0.48
1.2	0.53	-	0.78	0.48
1.3	0.53	2.38	0.78	-
1.5	0.26	-	0.78	-
%: Total	**100.0**	**100.0**	**100.0**	**100.0**
#: Types of all frames	**378**	**42**	**128**	**208**

Table 5.11
All frames: door: Decimal ratios by region

the silver ratio and Ludolph's number remain negligible. Table 5.07 shows that the most frequent decimal ratios are 0.6 followed by 0.4. Nevertheless, only the first category is of interest, as the frequency of the 0.4 category is the result of the 4:9 ratio, see Fig. 5.09. The golden ratio features prominently among outer frames. In the Alpine region, and the Germanic region, the ratios of 3:5, and 5:8, respectively, rank first in frequency even individually. After summing up both approximating ratios of the golden ratio, their frequency is highest in every region except the Germanic region-Vienna (where they share the third position).

Similarly, to the window category of inner frames, prestigious ratios are not frequent among all of the frames, although the golden ratio is not completely negligible. Table 5.08 shows that the most frequent decimal ratio is 0.6 (corresponding to the golden ratio), but this is the result of several ratios, namely 3:5, 4:7, 5:8, and 5:9 (Fig. 5.11). After 3:5 and 5:8 are summed, the golden ratio is ranked second in frequency in all regions except the Germanic region-Vienna, where it ranks third.

Table 5.09 shows decimal ratios according to door openings, and interesting results are perceptible among inner frames. The most frequent decimal ratio category is 0.4, followed by 0.6 in all and front elevations, and 0.3 in the side elevations. While the frequency of 0.4 is due to the approximating ratio of the silver ratio (the 2:5 ratio) along with 4:9 and 3:8, the favour for the 4:9 is not associated with the prestigious ratio, as seen in Fig. 5.14. Furthermore, the increased frequency of 0.3 in the side elevations is rooted in the 1:3 ratio, but it is dubious that this is connected to Ludolph's number. The dominance of the silver ratio occurs in every region except the Germanic region-Vienna, where it decreases to the second position.

Among the outer frames, the supremacy of the silver ratio is absent, and Ludolph's number is similarly absent. The frequency of the golden ratio is more pronounced, although even here the summation of both approximating ratios, 3:5 and 5:8, is not enough to reach beyond second position (Fig. 5.16). Thus, the frequency of the 0.6 decimal ratio category in Table 5.10 is the

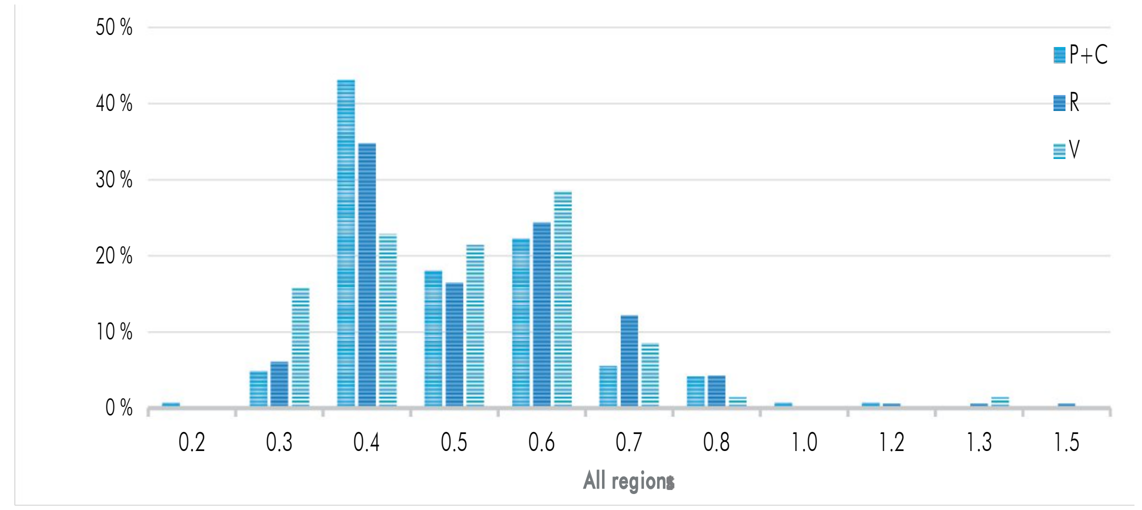


Fig. 5.19
All frames: door: Decimal ratios by building typology

result of the frequency of the 5:9 ratio.

An analysis of All frames is required, including the presence of silver and golden ratios visible in Table 5.11. While the 2:5 ratio, corresponding to the silver ratio, ranks third across the frames and regions the results for the golden ratio are less consistent (Fig. 5.18). In the All and Germanic regions, the summed incidence of 3:5 and 5:8 ratios remains insignificant, and in the Alpine and Germanic-Vienna regions, the final incidence only reaches fourth position.

A few conclusions can be made about prestigious ratios within prestigious architecture. First, the golden ratio is most common among outer frames, while the silver ratio is most frequent among the inner frames of doors. The golden ratio is evident in All frames of windows; and outer frames, and All frames of doors, and the silver ratio is evident in All frames of doors. Second, based on multiple situations, the outcomes usually differ in the Germanic region-Vienna. Third, it is possible to conclude that prestigious ratios receive less attention in prestige architecture than anticipated. As hinted in an earlier chapter (*Vernacular vs. Prestige Architecture: Introduction to Analyses/ Expectations*), a stronger inclination toward these special ratios was anticipated, not only because the architecture of higher prestige is a topic of interest within this thesis, but also because the sample of architecture was from the 19th century, which was the era when the golden ratio was most glorified (see *Proportion: Historical Background/Architecture/ 19th century: Rebirth of the Golden Ratio*). These unfulfilled expectations could be explained in several ways. First, only analysing the residential typology may skew the results, and the ratios may be more frequent in other typologies. Second, the frequency and affinity for prestigious ratios is not generalized among the majority of architects, but is only popular among a subset of architects, meaning that the sample of buildings, which is not focused on this minority, does not demonstrate their particular preference for prestigious ratios.

One ratio did receive special attention, namely the 1:2 ratio. This corresponds to a double square in plane representation which is the topic of the next subchapter.

DOUBLE SQUARE

The double square is the graphical representation of the 1:2 ratio (corresponding to the 0.5 decimal ratio category), and also its reciprocal of 2:1 (corresponding to the 2.0 category). Even though this ratio was not included among the prestigious ratios, it is indisputably significant in the theory of proportions, being one of the key figures across a few distinct proportional systems.

The ratio 1:2 is significant within music and represents a perfect consonant interval or an octave (also called diapason) (see *Proportion: Historical Background/ Music/ Intervals*). It is considered "perfect" because the length of each musical string can be changed either by halving or doubling it so that a tone is produced one octave higher, or lower, respectively. The application of an octave interval (octavation) to one tone in a repetitive way is analogous to creating a geometrical progression with a common ratio 1:2. Members of such geometrical progression may be for instance: … 8, 4, 2, 1, 1/2, 1/4, 1/8 …

The importance of this perfect consonance was later attributed to various Renaissance architects, including Leon Battista Alberti and Andrea Palladio. The former architect suggested this ratio as one of three optimal ratios for "middling platforms" (Alberti et al., 1955, b.IX. ch.VI), while the latter prescribed this ratio as one of seven of "the most beautiful and proportionable manners of rooms" (Palladio et al., 1965, 1. XXI. 27).

It may be surprising to learn that the double square found its place even in Hambidge's theory of dynamic symmetry, as he focuses on irrational figures (see *Proportion: Historical Background/ Architecture/ 20th Century: Modern Principles/ Dynamic Symmetry* and *Proportion: Construction/ How to…/ Construct √n rectangles*). Nevertheless, the ratio of 1:2, and its further representation as 1: √4, renders this incomprehensible. This duality perseveres in its behaviour and Hambidge points out, that "a root-four rectangle may be treated either dynamically or statically" (Hambidge, 1967, pp.51-52).

Moreover, the connection between the square, the double square, and the golden ratio in Le Corbusier's *Modulor* is indeed a fascinating one. He writes: "we may, therefore, say that this rule pins down the human body at the essential points of its occupation of space, and that it represents the simplest and most fundamental mathematical progression of a value, namely the unit, the double unit, and the two golden means, added or subtracted" (Le Corbusier, 2004, p.50). Although the square and the double square gave rise to the golden ratio series, beyond this they are cast in its shadow.

So far, the double square has been related only to the architects of the past, even though there are contemporary architects, who consciously, or unconsciously touch on the topic of this ratio. One example is the Swiss architect Peter Märkli, who uses the geometrical progression of decimal 1:2, analogous to the octavation, in his design. "Wenn er [Peter Märkli] feinere Schritte erstellen möchte, muss er mit Achtel (x/8), Sechzehntel (x/16), Zweiunddreißigstel (x/32), Vierundsechzigstel (x/64) arbeiten" (Kaprinayova, 2020, p.11), based on a short film *Peter Märkli;* Education Research and Practice in Architecture (Schevers & Herrenberg, 2012, 39:58).

This was only a small demonstration, of how important the double square is regarding proportional systems. If one dives deeper, many more examples can be found.

The following paragraphs present results of an analysis of the prestige architecture sample in terms of the double square ratio. The ratio 1:2 is completely omitted in the proportions of the elevations and its reciprocal, 2:1, reaches minimal rates. However, it is assumed that proportions do not play an influential role on the elevations prestige architecture (see the *Elevation* section of this thesis). However, an analysis of the building's openings provides different results.

First, the proportions of window openings will be discussed. The contrasting approach reaps striking results in the first graphics and tables for window inner frames. Table 5.06 shows the dominant position of the 0.5 decimal ratio category (corresponding to the 1:2 ratio). This is reinforced by Fig. 5.07, where the absolute supremacy of the 1:2 ratio is present in all studied regions, with frequencies ranging from 18% in the Alpine region to 34% in the Germanic region.

In the case of the outer frame of windows, the consistent first position belongs to the double square, challenged only the increasing frequency of the golden ratio. In Table 5.07, the category 0.6 takes the lead and the decimal ratio 0.5 is overshadowed. Nevertheless, Fig. 5.09, which depicts the incidences of individual ratios, shows that the 1:2 ratio is still not completely overshadowed. It is the most common ratio in All and Alpine regions (although in the Alpine region the first position is shared) and is the second most common in the Germanic and Germanic-Vienna regions.

Table 5.08 includes data for All window frames. It shows that the 0.5 decimal ratio category is the second most frequent one, and that 0.6 is the most frequent. However, the dominance of the 0.6 category lies mostly in the number of ratios which comprise it, namely 3:5, 4:7, 5:8, and 5:9 (Fig. 5.11). Since each of these four ratios are roughly equal in frequency, the greatest frequency amounts in the 0.6 category. On the other hand, the 0.5 category is comprises primarily one exceptional ratio; the 1:2 ratio (9:17 and 10:19 have insignificant frequencies). Individually, the frequency of the 1:2 ratio does not overcome the combined frequencies of the four average ratios, but when compared individually it is clearly much more prevalent. There is an evident supremacy of the 1:2 ratio in all studied regions.

Second, the proportions of door openings will be analysed. Like the outer frames of windows, the prevalence of the double square in the inner frames of doors is weakened by prevalence of the silver ratio. Although the 0.5 decimal ratio category is not the most frequent in Table 5.09, it is still not negligible. The ratio 1:2 reaches the second position in the Alpine region, third in All and the Germanic region, and fourth in the Germanic region-Vienna (Fig. 5.14).

On the other hand, the double square again demonstrates its importance in the outer frames of doors. The second and sometimes even first position belongs to the 0.5 decimal ratio category in Table 5.10. Even though the 0.6 category is most frequent, the reason is the same as in the analysis of All frames of windows; it is due to the number of ratios shaping the 0.6 category. This fact is confirmed in Fig. 5.16, where the ratio of 1:2 is ranked first in all studied regions, except the Germanic region-Vienna (where it is ranked second, with only ~1% deviation from the winning 5:9 ratio).

Lastly, the All frames of doors is analysed. Table 5.11 shows that the category 0.5 ranks as low as third, but this is altered by the results in Fig. 5.18. Here, the ratio of 1:2 comfortably takes first place in every studied region. The frequency of the 5:9 ratio is almost equal to this ratio in the Germanic region-Vienna.

To summarise, the preference for the ratio of 1:2 representing the double square is clear in almost all geographical locations. The only exceptions appear in the outer frames of windows and the inner frames of doors, where instead the golden and silver ratios are more frequent. Despite this, the ratio 1:2 is prominent. The proportions of the double square are essential for the window openings as well as for the door openings, which bear very different functions.

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CHAPTER 6 // VERNACULAR VS. PRESTIGE ARCHITECTURE: SUMMARY

The previous two chapters provided a detailed examination of proportions, first in vernacular architecture and then in prestige architecture. The approach in this chapter is different – it is about conducting a comparative analysis so as to see the larger context and to recognize similarities or dissimilarities between the two types of architecture.

First, we are going to compare the individual outcomes of the previous two chapters in the section entitled *Comparative Analysis*. Next, *Revisiting the Expectations* will provide us with the explicit answers to the research questions formulated earlier (see *Vernacular vs. Prestige Architecture: Introduction to Analyses/ Expectations*). And lastly, in the section entitled *Back to Scholfield* we come full circle and return to Scholfield's personality and his notions on the subject of proportion.

COMPARATIVE ANALYSIS

The comparison will begin with some initial observations relating to the study samples. Two samples of similar extent were required to compare vernacular and prestige architecture in the period. On one hand, this aim was achieved as the number of analysed elevations was approximately even (58 front and 14 side elevations (Table 4.01) in vernacular architecture, and 52 front and 19 side elevations (Table 5.01) in prestige architecture). On the other hand, the number of openings was even less. In vernacular architecture, there were 475 openings (Table 4.04) of which there were 397 openings of unique type (Table 4.05). In prestige architecture, there were 1817 openings (Table 5.03) of which 621 openings were unique (Table 5.04). This was the result of there being several more openings per elevation in prestige architecture than in the vernacular architecture within the sample. This was the result of the selection of the study sample. The only solution might be to multiply the number of studied elevations in vernacular architecture; however, the balanced number of elevations was prioritized over the balanced number of openings or their types.

Another point of note is the geographical location of the study sample. The intention was to choose the buildings from approximately the same areas in both analyses. Although the Alpine and Germanic regions remain the same in both cases, this is due to the slight shifts in the character of vernacular and prestige architecture in the studied areas. Vienna is a representative example of this. It was historically the capital city of the Austrian monarchy, and it is therefore not surprising that in this city, prestige architecture abounds and vernacular architecture is largely absent. To prevent distortions in the outcomes of the analysis, a separate category named Germanic region-Vienna was created in prestige architecture.

Next, the analysis results should be compared. Despite the differences between the analyses of vernacular and prestige architecture, the differences between the dominant ratios are the most pronounced. While the 1:1 (representing square) ratio is most frequent within vernacular architecture, the ratio 1:2 (representing double square) is the most common in prestige architecture. Nevertheless, a closer look at the analyses demonstrates other interesting disparities too.

The three features presented in the *Initial Insights* section (symmetry, spacing-grid, and segmented composition) are the first to be compared.

There are great differences in symmetry between vernacular and prestige architecture. In vernacular architecture, symmetry is very rarely evident (Fig. 4.01), occurring only in 10.26% - 18.64% cases according to region. On the other hand, in prestige architecture, it is one of the main organizing principles of an elevation (Fig.5.01), occurring in 57.58% - 92.00% of cases. The values would be even more pronounced in prestige architecture if the villa typology were omitted. The smallest percentages corresponded to both types of architecture in the Germanic region. As noted in the chapter on vernacular architecture, a variation on the principle of symmetry can be observed there, which was named object symmetry. In object symmetry the presence of openings corresponds to their variation in type and spacing. Two possible reasons may explain these contrasts of symmetry in vernacular and prestige architecture. One is that the elevation organization could be performed with more care in prestige architecture, the other is that there are several distinct functions grouped under one roof in vernacular architecture which can make it difficult to accommodate symmetry In the design as well.

The spacing-grid is comparably used in vernacular and prestige architecture (Fig. 4.01, Fig. 5.01), with slightly greater frequency in the latter. Specifically, 76.92% - 84.75% of vernacular cases featured a spacing grid, whereas 78.79% - 100.00% of prestige cases featured a spacing grid.

There were clear distinctions in segmented composition between vernacular and prestige architecture. While in vernacular architecture ~55% of cases exhibited a segmented composition (Fig. 4.01), in prestige architecture, it was evident in almost every case, ranging from 87.88% to even 100% (Fig. 5.01).

There were peculiarities in the proportions of elevations. Great contrasts were be observed, in vernacular architecture. Fig. 4.03 clearly shows that a predominant ratio (for front elevation) does exist: the 1:1 ratio. This stands out regardless of the region, and in prestige architecture (Fig. 5.02) the proportions of a building elevation do not play an important role in building design and are more a matter of coincidence than intention. Nevertheless, the juxtaposition of the orthogonal (rooted in the orthogonal projection) and appearance proportions (depending on the standing point of an observer) of an elevation revealed the importance of the (im)perfect square. This ratio dominates in both types of architecture (Fig. 4.02, Fig. 5.03). Furthermore, the orientation of front elevation (Table 4.02, Table 5.02) (landscape, neutral, or portrait) is

another rich area for comparison. The landscape orientation enjoys the highest favour in both types of architecture. Nevertheless, its dominance is lower in vernacular architecture, in one element of the analysis even being replaced by the portrait orientation for first place in the Germanic region. The neutral orientation is the least frequent orientation regardless of region or architecture type.

The *3-Level* section presented in vernacular architecture will not be commented on, because it could not be included in the analysis of prestige architecture.

One of the greatest surprises of this comparative approach was the frequency of diagonal repetition (including similarities in proportions of the building's elevation and its openings) based on the type of architecture (Table 4.04, Table 5.03). Initially there were relatively low frequencies of diagonal repetition in vernacular architecture (which for front elevation according to the region were: 36.42%, 32.03%, 42.78%). This was to be expected as one might assume that vernacular architecture received less careful consideration in its proportions. However, what was remarkable is that there were even lower frequencies in prestige architecture (which for front elevation according to the region were: 5.39%, 3.35%, 3.44%, 6.82%). This was explained because the proportions of building elevations are insignificant within prestige architecture, thus the absence of proportions among its openings is understandable.

Next the analyses of frame-shape repetition will be compared. One might expect a more pronounced presence of frame-shape in prestige rather than vernacular architecture. However, as seen in Table 4.05 and Table 5.04 the non-frame-shape repetition dominates in every region and in both types of architecture, with greater frequency in the prestige architecture. The percentages in favour of frame-shape repetition according to region are: 19.65%, 26.39%, and 11.60% in vernacular architecture, and 12.56%, 7.08%, 16.19%, and 11.49% in prestige architecture.

The compound characteristic of openings is a comparably uncommon practice in vernacular as well as prestige architecture (Fig. 4.07, Fig. 5.06), although the Germanic region shows a slightly higher preference for this practice in vernacular architecture. Furthermore, there were evident discrepancies between the types of compound compositions when present (Table 4.06, Table 5.05). While the same-opening types of compound compositions occurred in vernacular architecture (either double, triple, quadruple or sextuple), in prestige architecture, the same-opening types of compounds (double or triple) and mixed-opening types of compounds were common.

Next, the analyses of the proportions of openings will be compared, including windows and doors. The framing of windows and doors(inner, outer, or unified all frames) will be presented later. As already mentioned, the most eye-catching disparity between vernacular and prestige architecture is the dominant 1:1 ratio in vernacular architecture, and 1:2 in prestige architecture. This idiosyncrasy between vernacular and prestige architecture is observable in other openings though it is not completely consistent.

In terms of the inner frames of windows, the outcomes of vernacular and prestige architecture differ widely. For vernacular architecture, the data varies across the studied regions. The 1:1 ratio dominates in All and the Alpine regions, but not in the Germanic region, where several ratios are comparably frequent (Fig. 4.08). For prestige architecture, the ratio 1:2 and the ratio of

5:9 are always ranked first and second, respectively, regardless of the geographical region (Fig. 5.07). Only their the magnitudes of their frequencies vary. Interestingly, the most decisively frequent ratio occurs in the Alpine region in vernacular architecture (with 26%), which is the most undecisive region in prestige architecture (with 18%). The opposite is true of the Germanic region, with the most frequent ratio in vernacular architecture having a frequency of only ~13%, and the most prevalent ratio in prestige architecture having a frequency of ~34%.

Naturally, the preference for the decimal ratio category changes with distinct prevailing ratios (Table 4.07, Table 5.06). Despite this, it is remarkable that (within the All and front elevations) the most common category fluctuates according to region. In side elevation it is constant across the regions, which applies to both vernacular and prestige architecture. Specifically, the decimal ratio categories that fluctuate are 0.8 and 1.0 in vernacular, and 0.5 and 0.6 in prestige architecture.

Regarding the hierarchy of openings, frequencies were scattered among multiple decimal ratio categories of minor openings in prestige architecture. This was missing within vernacular architecture. Nonetheless, the greater diversity of decimal ratio categories in minor openings compared to other hierarchies is observable in both types of architecture. As assumed earlier, the reason may relate to the relative absence of care in vernacular architecture. On the contrary, the category of prestigious openings demonstrates the most unambiguous primary choice of decimal ratio category.

The analyses of frames of windows will be compared next. The ratio 1:1 is particularly pronounced across the studied regions in vernacular architecture (Fig. 4.11), ranging from ~20% to ~26% in frequency. The golden ratio (and its approximating ratios, 3:5 and 5:8) rendered the 1:2 ratio in prestige architecture less frequent (Fig. 5.09). However, when these golden ratios were summed together, they dominate in every region except the Germanic region-Vienna. The 1:2 ratio is still notably pronounced within prestige architecture.

Considering the decimal ratio categories (Table 4.08, Table 5.07), there are apparent discrepancies between both types of architecture. In vernacular architecture, the leading position of the 1.0 and 0.8 categories changes with the elevation type. In prestige architecture, the leading 0.6 category seldomly gives way to the 0.4 category (it does so in the Alpine and the Germanic-Vienna regions in the side elevation).

The hierarchy of openings also influences the decimal ratio category, as the 0.9 and 1.0 categories lead in major and minor openings respectively in vernacular architecture (Fig. 4.12). The same is true of the decimal ratio categories 0.4 and 0.6 in prestigious and major openings respectively, in prestige architecture (Fig. 5.10). The top preferences of minor openings are once again scattered between several decimal ratio categories in prestige architecture.

When examining the individual ratios of All frames of windows, the idiosyncrasies of vernacular and prestige architecture are once again pronounced (Fig. 4.13, Fig. 5.11). Furthermore, the same peculiarity, noted in inner frames, appears here as well. The most common ratio, the most decisive in vernacular architecture of the Alpine region (~26% for 1:1) is the least decisive one in prestige architecture (~16% for 1:2), and vice versa for the Germanic region

(~14% for 1:1 in vernacular architecture, and ~22.5% for 1:2 in prestige architecture).

In vernacular architecture, the decimal ratio category of the highest incidence changes with the region, while in prestige architecture, it remains the same across all locations (Table 4.09, Table 5.08). Specifically, in vernacular architecture, the 0.8 category leads in All and the Germanic regions, the 1.0 category leads in the Alpine region, and in prestige architecture, the category 0. has the highest frequency everywhere.

Lastly, the analyses of orientation (landscape, neutral, portrait) should be compared (Fig. 4.14, Fig. 5.13). Unequivocally, the most common window orientation is the portrait one in both types of architecture. In terms of the landscape orientation, which is far less common than the portrait orientation and mostly applied to minor openings, it can be deduced that it is of lower prestige status by comparison to other window orientations. Furthermore the low frequency of the neutral orientation of windows in prestige architecture is notable.

The inner frames should first be discussed in relation to door openings. In vernacular architecture, there are two most frequent ratios, namely 5:9 and 1:2, which remain the same for every studied region (Fig. 4.15). Within prestige architecture this is different, as the most common ratio is 2:5 in every location studied except the Germanic region-Vienna (Fig. 5.14). Interestingly, this is the approximating the silver ratio. Other noteworthy ratios include 3:8, 1:2, and 4:9, depending on the region. While the most common ratio of vernacular architecture, the 5:9 ratio, finds its place also in the prestige one, the opposite is not true for the ratio of 2:5, which was not identified in any single case in vernacular architecture. Furthermore, the decisiveness of the most frequent ratio is greater in vernacular architecture, where the 5:9 ratio reaches a minimum frequency of ~26% in every region. The most frequent ratio (either 2:5 or 3:8) in prestige architecture ranged from ~18% to ~22%.

When the decimal ratios were introduced, the most common decimal ratio did not vary and remained constant (across the regions and elevation types). In less prestigious architecture, the 0.6 category was preferred (Table 4.10), and in architecture of higher prestige, the 0.4 category was preferred (Table 5.09).

These preferences of decimal ratio categories remained almost unchanged upon closer inspection of their hierarchies (Fig. 4.16, Fig. 5.15). The 0.6 category is the leading one in every region and hierarchy in vernacular architecture (except the major opening in the Alpine region), and in the prestige architecture, the same position was taken by the 0.4 category, which dominated in every region and hierarchy (except the minor opening in the Germanic region-Vienna). The pattern of preference for decimal ratio in minor openings is of note. In less prestigious architecture, one clear number-one choice is followed by other decimal ratios with decreasing popularity. In more prestigious architecture, this is a less often the case. For example, the preferences are equally split among three decimal ratio categories in the Alpine region, and 100% of openings correspond to one single decimal ratio category in the Germanic region-Vienna.

Next the analyses of the outer frames of door openings will be compared. Although it is certainly a matter of coincidence, it is interesting that the two most common ratios of inner frames in vernacular architecture, 5:9 and 1:2, (Fig.

4.15) dominate the outer frames in prestige architecture, but in reversed order (Fig. 5.16). The ratio of 1:2 is usually more common than 5:9. The ratio 2:3 is the most common ratio in every studied location in vernacular architecture, though its first position is shared in the Germanic region (Fig. 4.18). The second or third position of incidence fluctuates.

In terms of the decimal ratio categories, it may be stated that a nonuniform approach is present in vernacular architecture. Furthermore, a change in decimal ratio between the categories 0.6, 0.7, and 0.8 according to the elevation type is observable (Table 4.11). On the other hand, the outcomes are uniform in prestige architecture, where the leading position is usually taken by the 0.6 category, followed by the 0.5 decimal ratio. This is true across almost every studied geographical location and elevation type.

The hierarchies of openings demonstrate differences, too. Within vernacular architecture, there is not only one category corresponding to one specific hierarchy preferred across all studied regions. In prestige architecture, however there is. Prestigious openings favour the 0.4 decimal ratio category, and the major openings tend toward the 0.6 category. Nevertheless, the decimal ratios of minor openings are more scattered and the selection of solely one dominating category is impossible.

Two distinct tendencies typical of vernacular and prestige architecture are recognizable in all frames of doors (Fig. 4.20, Fig. 5.18). Specifically, in the former the ratio of 5:9 is in close competition with the 2:3 ratio. This results in slight dominance of the first (although they share the first position in the Germanic region). In the latter, the most common ratio is the 1:2 ratio, followed by the 5:9 ratio in every studied region but the Alpine, where the second place is taken by the 4:9 ratio. Thus, a clear preference for one ratio is observable in both types of architecture, whether it is the ratio 5:9 or 1:2, respectively.

Even decimal ratios convey somewhat unified preferences across the studied regions, where the first and second highest frequencies are demonstrably categories 0.6 and 0.7 in vernacular architecture, and the 0.4 and 0.6 in prestige architecture. The 0.5 category, corresponding to the ratio of 1:2, is the third most common in prestige architecture.

To conclude, even though there are deviations from the major tendencies of the analyses when they are broken down into their constituent parts, these most important tendencies emerge repeatedly. As already mentioned, the ratio 1:1 (square) is most common within vernacular architecture and the ratio 1:2 (double square) is most common within prestige architecture.

Next, the research questions defined earlier (chapter V*ernacular vs. Prestige Architecture: Introduction to Analyses/ Expectations*) will be addressed.

REVISITING THE EXPECTATIONS

In this subchapter, we are going to recall the formulated expectations and research questions of the analyses described in *Vernacular vs. Prestige Architecture: Introduction to Analyses/ Expectations*, and we are going to provide definite answers to them.

Let's begin with the first point of interest: *whether there is an apparent dominance of one particular ratio (proportion). If so, does this proportion behave like an idiosyncratic signature of a particular region?* First, it must be clarified

CHAPTER 6 // VERNACULAR VS. PRESTIGE ARCHITECTURE: SUMMARY

that there is a short answer and a long answer to this question. The short answer is "yes". Yes, there truly is one particular ratio which takes the lead, and it is the 1:1 ratio in vernacular architecture, and the 1:2 ratio in prestige architecture. The ease and straightforwardness of their manufacturing is most likely the reason they were prioritised over any other ratio in that non-digital age. Nevertheless, how deeply this dominance is rooted can be seen by the previous subchapters, namely *Vernacular Architecture: Analysis of Proportions/ (Im)perfect square* and *Prestige Architecture: Analysis of Proportions/ Double square*.

On this subject, I have to say that I would be eager to expand the analysis, this time focusing on a different building typology/different time period. Would the dominant ratio vary? I am convinced the answer would be "yes". However, how these outcomes would look will have to remain a mystery for now.

Let us now switch our focus to the second part of the question – whether, in terms of proportions, there is space for an idiosyncratic signature of a particular geographical region. If we were expecting, for instance, some ratio number one to be typical only for the Alpine region, and then some ratio number two to be characteristic of the Germanic region, it can be stated that the results of the analyses did not reveal any idiosyncratic signature for a specific geographical area. True, there are some differences between individual geographical regions, but the prevailing ratios of 1:1 in vernacular and 1:2 in the prestige architecture emerge over and over again regardless of the geographic location.

It is important to remember that although the Alpine and the Germanic region are of distinct character, according to Oliver's view of the world, they still form a single greater unit, the continental region of Europe and Eurasia (Oliver, 1997, p. xxvi-xxvii). The question remains what would happen if we would choose even more culturally diverse regions of study, regions which do not belong to the same continental region – for instance the *Arabian Peninsula* of the *Mediterranean and Southwest Asia* and the *Alpine* region of *Europe and Eurasia*. Would those regions perhaps reveal idiosyncratic signatures?

The next question to be answered is as follows: *Is there any connection between the proportions of the elevation of a building and its openings?* Just a quick reminder: this connection is expressed by the phrase *diagonal repetition* in this thesis. Also, when reference is made to the proportion of an elevation and there is no further specification, the orthogonal proportion is meant (not the appearance one).

Before we proceed with the answer, let me say that I had high expectations… high expectations that a clear relationship between the two would be uncovered – maybe not for vernacular architecture (as that is not thoroughly planned and reacts organically and adaptively to the needs of its residents), but surely for prestige architecture (which is thoroughly planned and architects would not leave that to chance). So it was all the more surprising when the Excel graphs and tables began to reveal different results.

On the one hand, the outcomes for vernacular architecture did not tear my assumptions down, since "two-thirds [sample of openings] revealed no connection to the proportions of the building. However, one-third, not a negligible amount, consists of openings that were interrelated with the proportions of the building" (Fig. 4.05). Yes, it is not an earth-shattering amount, but it is after all acceptable for vernacular architecture. On the other hand, it was very unexpected that "the graph shows an almost absent relationship between the shape of an elevation and the shape of an opening" (Fig. 5.04) and that "the supremacy of non-diagonal repetition is evident in every elevation type and every geographical region" (Table 5.03). Somehow, this finding shocked me. Not only was *diagonal repetition* practically absent in prestige architecture, but its incidence was far more common in vernacular architecture! Quite the opposite of what I expected.

On second thoughts, I admit, it could be understandable. In my earlier expectations, I was convinced that the proportion of the building's elevation was carefully planned, and that this proportion would further influence the proportions of other parts of the building. However, it is not the case (as I have mentioned several times). It is observable mostly in prestige architecture, where the proportions of elevation are very diverse and more a matter of coincidence than intention. Nevertheless, what is a coincidence for the proportions is an intention for the function of a building, building site and other regulations. While the vernacular sample consisted mostly of detached buildings, the prestige sample of buildings was taken from an urban context (with a few exceptions) and had to deal with all restrictions that such building density entails (matching the attic height to the neighbour building, placement in a gap between other buildings, etc.).

Whether there is a proportional correspondence between other parts of the building – for instance between the frames of one opening – will be answered in one of the upcoming questions regarding *frame-shape repetition*.

I anticipated another potentially fertile field of differences between vernacular and prestige architecture when I explored the question: *Do the so-called prestigious ratios – golden ratio, silver ratio, and Ludolph's number – truly play a prominent role among other ratios?* I expected that while in vernacular architecture, the position of these prestigious ratios would not be dominant, and that the opposite would be true in prestige architecture. However, my expectations were not met. Although it's true that prestigious ratios stand out from time to time, it is impossible to speak of their dominance in either vernacular or in prestige architecture.

More specifically, in vernacular architecture, the golden ratio features more prominently with respect to the window openings in the Germanic region, and more frequently in general with regard to door openings. However, whether this increment in the incidence of the golden ratio in door openings is related to this special proportion as such or whether it is only a coincidence rooted in proportions appropriate for the human body must be left for future analysis. On the other hand, in prestige architecture, the golden ratio found its special place in the outer frames of windows, and the silver ratio in the inner frames of doors. Nonetheless, these few *bright* cases could not satisfy my huge hunger for a clear dominance of prestigious ratios in prestige architecture. The hunger was all the greater because the studied sample of architecture was from the 19^{th} century – the century of golden ratio glorification (see *Proportion: Historical Background/ Architecture/19th Century: Rebirth of the Golden Ratio*). As mentioned in the previous chapter, some potential explanations for my expectations not being met could lie in the building typology selected or in the statistical selection of the buildings studied.

Now we go on with the question: *Will a cohesive relationship be found between the dimensions of door openings, whose dimensions are regulated by the dimensions of the human body?* Since the human body is influential only on the proportions of the inner frames, the outer frames, and all frames will not be considered.

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If we study the table of decimal ratios in vernacular architecture (Table 4.10), we see that the most common category – the 0.6 category –is the same irrespective of the region or type of elevation. Similarly, in vernacular architecture, the highest occurrence of the inner-door-frame ratio is unambiguously the 5:9 ratio, irrespective of the region or type of elevation (Fig. 4.15). Such realizations could ignite hope of finding a cohesive proportional relationship for doors. However, when we examine the outcomes for prestige architecture, this small hope quickly dies. According to the table of their decimal ratios (Table 5.09), the most praised category, across regions and types of elevation, is 0.4 category, which is negligible in the context of vernacular architecture. On the other hand, if we look at the issue the other way around, we discover that the 0.6 category is not unimportant in prestige architecture – in fact, ranking second in incidence in the category all elevations and in the category front elevations. If we shift our focus to individual ratios, the 2:5 ratio stands out almost all the time (Fig. 5.14). We experience a sense of *déjà vu* when the most common ratio for prestige architecture is insignificant in the context of vernacular architecture, but the reverse scenario shows a certain significance (although not large) of the most common ratio of vernacular architecture in the prestige one.

To sum up, the proportions of inner door openings do not connect trans-architecturally – i.e. their most preferred proportions are not the same in vernacular and prestige architecture. Nevertheless, the unifying phenomenon (the dimensions of the human body) of their proportions in an isolated type of architecture is observable. We can finish this examination with a statement that the prevalent proportions for inner door frames are stretched in height in prestige architecture and pressed-down in vernacular architecture.

And now the time has come to discuss the inquiry formulated a few chapters ago: *Does the hierarchy of openings affect their proportions and/or orientation?* The short answer is "yes", the hierarchy of openings really is influential in terms of proportion. However, to what extent it is influential is open to debate. Since a greater zoom-in on individual proportions according to the hierarchy of the openings was considered unnecessarily detailed, a little less exhaustive approach was taken instead, namely the decimal ratio categorization.

The varying results are the best observable on an opening's orientation, either *portrait, neutral,* or *landscape* (with a decimal ratio smaller, equal, or greater than 1.0, respectively). It is meaningless to speak about the orientation of door openings, as the *portrait* orientation is inherent to them (as long as they are intended for a person), thus only the window openings will be considered. And here, an interesting phenomenon could be observed and that is: the *landscape* orientation was almost exclusively found in the window openings of lower prestige in both types of architecture (Fig. 4.14, Fig. 5.13). Naturally, some deviations from this occurred when the major openings were *landscape* oriented, although this happened quite rarely. So, *landscape* orientation, in general, is not very frequent and it clearly leaves the spotlight to shine on *portrait* orientation, which is the most common window orientation (across regions and architecture types). On the other hand, *neutral* orientation can be found in both (major and minor) types of openings in vernacular architecture, but by contrast, it is found almost exclusively in minor openings in prestige architecture.

In this context, let us look at architectural practice for a moment. There are practical reasons why *landscape* orientation is mostly used for minor openings and rarely for major openings (and never for prestigious openings). One of them is the clear height of the room. Since the rooms of lower prestige have lower ceilings and are frequently positioned in the basement, there is not much space left for an opening, which results in their pressed-down proportions. Contrariwise, rooms with higher prestige have higher ceilings, permitting the openings to be of larger size. In this case, the weight of the opening part – door wing or casement window – is of crucial importance, and leads to their narrower proportions.

The decimal ratios do not enable us to formulate such clear statements as was possible for orientation. Although it is true that there are dissimilarities between major and minor (or prestigious) openings, however, these peculiarities usually vary from region to region, frame to frame, and opening type to opening type. I argue that an attempt to summarize such outcomes would be chaotic, and if one possesses such eagerness for an answer, it is better to go back to previous chapters, where these outcomes are thoroughly described.

To continue, let's have a look at the subsequent question: *Are there any proportional differences between front and side elevation?* We will look at this from different perspectives, including the proportions of their elevations, as well as the proportions of their openings. Note that what was not separately analysed for these types of elevation is the symmetry attribute. In spite of that, I am certain that symmetry plays a much more important role for front elevations than for side elevations. To convert my conviction into a fact would require further analysis. But let's come back to the characteristics that were studied.

In this regard, it is only natural that there should be differences between the elevations of greater and lesser representative importance (front and side elevation, respectively). Starting with the (orthogonal) elevation, in vernacular architecture, the proportions of the side elevation stretch according to need (Table 4.01): from the 1.0 decimal ratio typical for front elevation to 1.8 for side elevation. On the other hand, no such clear statement can be made for prestige architecture, where the proportions of an elevation were found not to be decisive for further proportional design (Table 5.01).

As already summarized in one of the previous questions, a proportional connection between a building's elevation and its openings is relatively rare in practice, especially in prestige architecture. However, the type of elevation is one of the influential parameters in this regard. From Table 4.04 and Table 5.03, we can see that *diagonal repetition* is more typical for front than side elevations (except for prestige architecture in the Alpine region). This fact is quite evident in vernacular architecture and somewhat less so in prestige architecture.

Let us now turn our attention to the proportions of openings and their decimal ratios. Here, we observe dissimilarities between the front and side elevation at the peak of incidence, although the top three most common decimal ratios usually overlap. To give you an example of what is meant by the previous

statement: in vernacular architecture, the most common decimal ratio of the window outer frames is 0.8 for front elevation, but 1.0 for side elevation; however, the three most common categories are almost exclusively the 0.8, 0.9, and 1.0 decimal ratios for both types of elevation (Table 4.08). It is normal practice to apply the same types of windows for the front and the side elevation.

Are the proportions of one opening interconnected by scaling of the same shape? is the last question that is looking for an answer. In this context, the term *frame-shape repetition* is of special importance: this is the name I gave to the proportional resemblances in the opening itself.

Interestingly, *frame-shape repetition* is not a common practice in any buildings of either type of architecture. This time, similar to the connection between the proportions of the elevation of a building and its openings, the proportional resemblance in vernacular architecture exceeds that for prestige architecture. While *frame-shape repetition* occurs in nearly one-fifth of openings in vernacular architecture (see All regions of Table 4.05), it occurs in only one-eighth of openings in prestige architecture (see All regions of Table 5.04).

The explanation for this may lie in their dominant ratios – be it the 1:1 ratio in vernacular architecture, and 1:2 in prestige architecture – and offset principle. (Although further examination is necessary in this regard …) Let me clarify my observation: I have noticed that in most vernacular architecture (even though it might be the case in prestige architecture as well), the proportions of an outer frame are constructed as offset proportions of an inner frame. In other words, the outer frame is at an equal distance from the inner frame in both directions (width and height). Thus, it is only natural that the offset of the 1:1 ratio forms another 1:1 ratio. On the other hand, an offset of any other ratio, whether 1:2 or different, produces a different ratio from the original. I suppose that is the reason why *frame-shape repetition* in the vernacular exceeds that in prestige architecture.

If we are looking at interconnections of proportions of the same opening, an opening hierarchy is also an important parameter. Although the prevalence of *frame-shape repetition* in major openings compared to minor openings is only very subtle in vernacular architecture (21.11% compared to 18.43%, see All regions, Fig. 4.06), in prestige architecture, the *frame-shape repetition* of prestigious openings is approximately double compared to major and minor openings (19.66% compared to 11.54% and 9.64%, see All regions, Fig. 5.05). So, the debate about the link between the prestige status of an opening and the interconnection of its proportions may start here. At the same time, however, as noted in the previous chapter: "the unquestionable preponderance of non-*frame-shape repetition* makes this hypothesis questionable".

BACK TO SCHOLFIELD

The notions of P.H. Scholfield summarized in his book *The Theory of Proportion in Architecture* were one of the leading topics in the chapter *Proportion: Historical Background/ Architecture*. His enriching thoughts on the subject of proportion left strong impressions in my perception of the matter as a whole. After these exhaustive analyses of the proportions of vernacular and prestige architecture, it's time to go back to Scholfield and reflect on his ideas one last time.

As mentioned in the chapter, it was fundamental to him to explore the fine line between what the human eye can and cannot perceive. He concluded that three aspects are more relevant than any other: the repetition of the same shape, the repetition of the same shape and the same size, and the repetition of the same size but different shape. Of these aspects, he put the greatest emphasis on the first, and considered it the most fascinating for further investigation of proportions (Scholfield, 1958, pp.5-6).

In this connection, he stated: "The importance of similarity of shape as a source of unity in design has seldom been denied. Its simplest and most familiar use in architecture lies in the repetition of some shape taken from the structural system. […] We can therefore reasonably define the object of architectural proportion as the creation of visible order by the repetition of similar shapes"(Scholfield, 1958, p.6). His notions seemed well-founded, so I took them to heart yet I was determined to challenge them in my analyses. My main focus was directed onto the proportions of the building's elevations and its openings, thus, searching for a relation between them looked like a logical step to proceed.

The *diagonal repetition* looked to be a likely candidate for that kind of relationship, while the *frame-shape repetition* sought to achieve the proportional similarities within one opening. As we now know, the results of both approaches were disappointing, and no master discovery was made. However, it is worth mentioning that these two approaches only scratch the surface of possibilities of what proportional relations may still be explored. However, further exploration would require far more accurate materials for study would be required, as well as switching to a more accurate method of analysis – arithmetical instead of geometrical. At the same time, both the precision of the study materials and methods of analysis) were sufficient for the purposes of this thesis.

Another crucial aspect according to Scholfield was the so-called additive property of a proportional system. Although this was an aspect which, due to its complexity, did not get enough space in the scope of this thesis, I feel it is my duty to draw attention to it once more as a potentially fertile field for future study. And in that case, of course, a smaller study sample would be acceptable, since a very meticulous and in-depth analysis would be the priority. In this context, he wrote: "But while the principle [of additive property] itself is extremely simple, its application in practice can become a very complicated matter. Once we decide to use a restricted number of shapes for all the parts of a design, the choice of these shapes is no longer an arbitrary affair. The smallest parts of the design add together to form larger parts, these larger parts form still larger ones, and eventually we come to the largest parts which add together to form the whole. […] We must therefore select a group of shapes which can be added together in the most varied ways without producing any new ones" (Scholfield, 1958, p.7).

Furthermore, Scholfield found geometric progressions (single, double or in some cases even triple) to be of great help when thinking about possible additive properties of some proportional systems. He noted: "Our geometric progressions, whether single or compound, must not only possess the normal property of embodying a pattern of repeated ratios. They must also possess a wide range of additive properties, by means of which smaller terms of the progressions can be added together to form larger terms. […] As a matter of fact, only certain geometric progressions and combinations of geometric progressions have properties of this kind at all, and some have a richer variety of

useful additive properties than others" (Scholfield, 1958, p.9). In other words, not only can one single proportion (ratio) form a proportional system, but several proportions (ratios) can too, provided their additive properties can create new members of the same proportional system. A nice example of this fact was introduced in the chapter entitled *Proportion: Construction/ How to…/ Construct* θ.

Lastly, in all this murmur of quite complex double or triple geometric progressions and additive properties of proportional systems, let's not forget one very fundamental aspect of the building praxis – simplicity. No wonder that the ratio of 1:1 (square) and of 1:2 (double square) dominated in the vernacular and in the prestige architecture, respectively. They are indeed utterly simple. And as the icing on the cake, Scholfield points out the additive properties of these most common ratios of analyses: "If two squares are added together, they form a double square. If two double squares are placed together side by side, they form a square. Two double squares can also be arranged with a square between them to form another double square"(Scholfield, 1958, p.7). Fascinating, isn't it?

APPE
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IX

APPENDIX

VERN ACU LAR

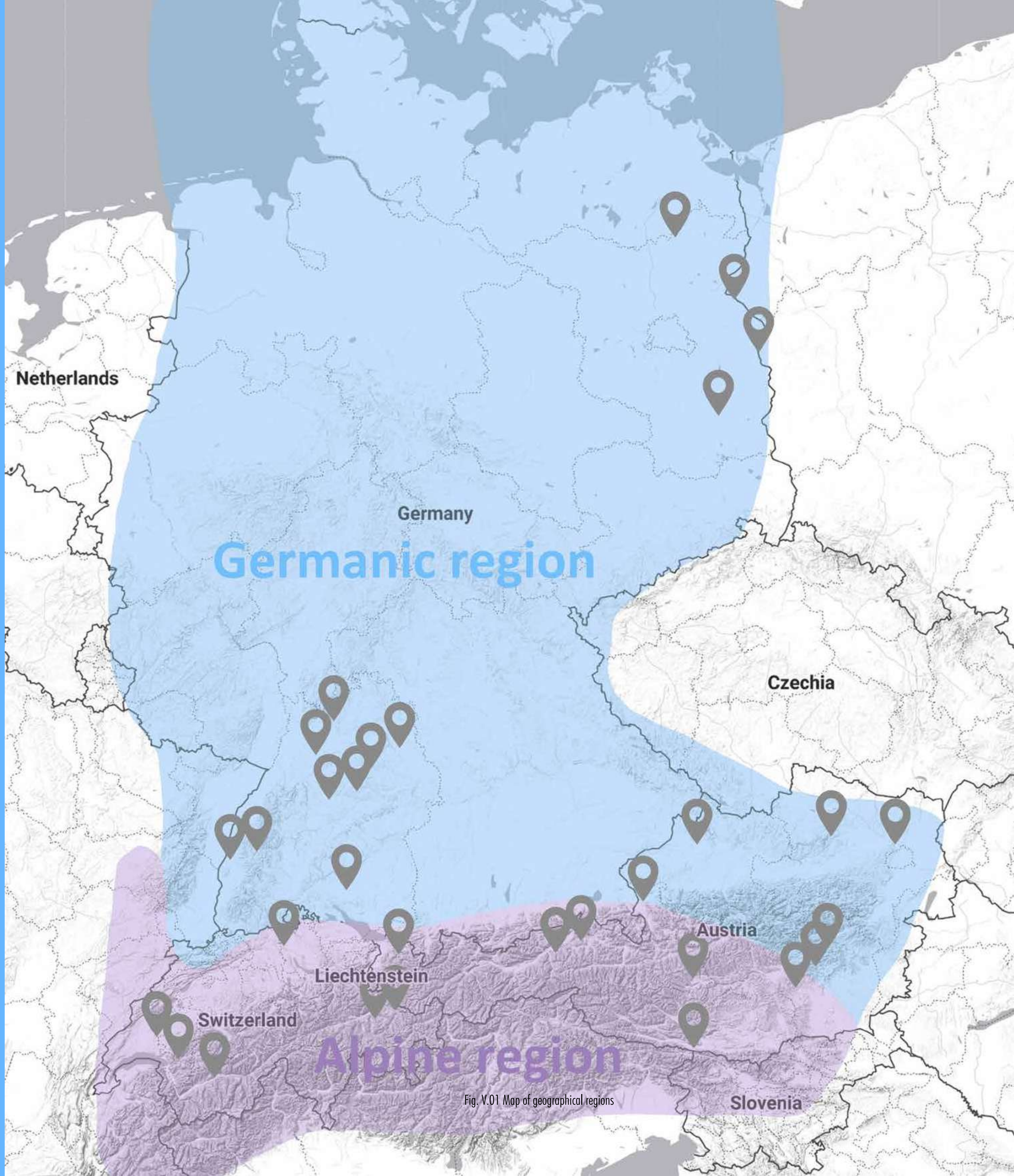


Fig. V.01 Map of geographical regions

ALPINE REGION // AREAS IN CURRENT AUSTRIA

Tyrol

T01: Alpine hut in Falzthurn
(front and side elevation, openings)

T02: Farmhouse in Alpbach
(front elevation, openings)

T03: Farmhouse in Alpbach
(front elevation, openings)

T04: Farmhouse in Alpbach
(front elevation, openings)

T05: Farmhouse in Alpbach
(front elevation, openings)

T06: Farmhouse in Söll
(front elevation, openings)

T07: House near Söll
(front elevation, openings)

T08: Farmhouse near Kirchbichl
(front elevation, openings)

Vorarlberg

V01: Farmhouse in Bizau
(front and side elevation, openings)

Styrian

S01: House vulgo Heimann
in Adriach near Frohnleiten
(front and side elevation, openings)

S02: House Valentin Schragl vulgo Obersattler
in Breitenau near Mixnitz
(front and side elevation, openings)

S03: House Johann Fellner vulgo Michelbacher
in Breitenau near Mixnitz
(front and side elevation, openings)

S04: House Jakob Schweiger vulgo Gräsinger
in Breitenau near Mixnitz
(front and side elevation, openings)

S05: “Das Hübler-Haus“
House No. 48 in Kemetberg near Köflach
(front and side elevation, openings)

S06: “Das Jud-Haus“
House No. 46 in Kemetberg near Köflach
(front and side elevation, openings)

Carinthia

C01: “Pleschinhaus“, House No. 1 in Agoritschach
near Arnoldstein in Gailthale
(front and side elevation, openings)

C02: “Unterdebernigg-Keusche”, House No. 14
in Pöckau near Arnoldstein in Gailthale
(front and side elevation, openings)

C03: “Das Winteritschhaus”, House No. 12
(front and side elevation, openings)

C04: “Das Sank-Haus“, House No. 4 in Gritschach
near Millstätter lake
(front and side elevation, openings)

C05: “Rumpler-Keusche“, House No. 7 in Kraut
near Millstätter lake
(front and side elevation, openings)

C06: “Das Winkler-Haus“, House No. 4 in Reich
near Millstätter lake
(front and side elevation, openings)

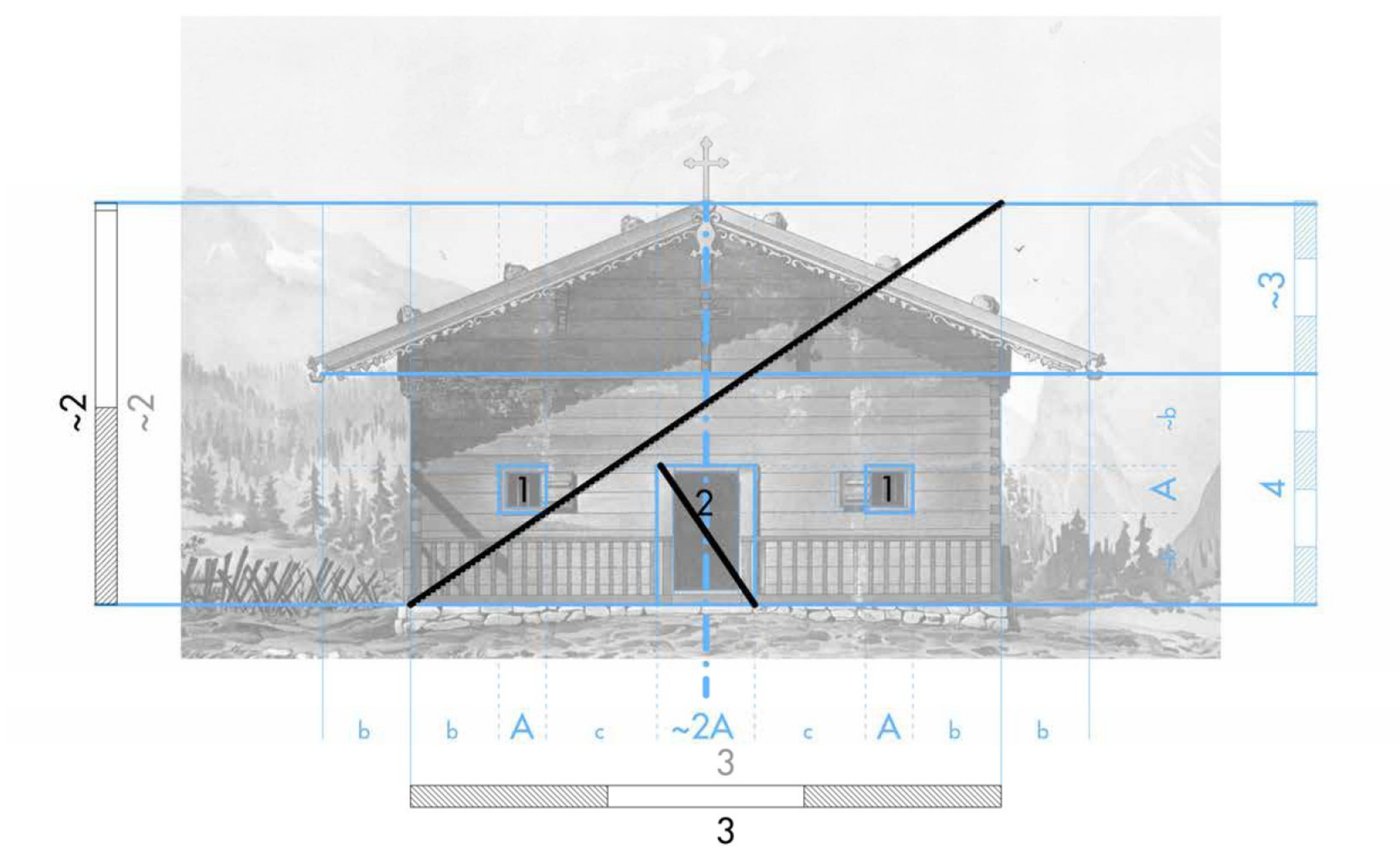
Salzburg

Sa01: “Ernstgut“ in Fanning
(front and side elevation, openings)

Sa02: "Adam-Gut" in Neuhofen near Kraiwiesen
(front elevation, openings)

Sa03: House in Seekirchen
(front elevation, openings)

Sa04: "Nieder-Traxl-Gut" in Berg near Söllheim
(front and side elevation, openings)



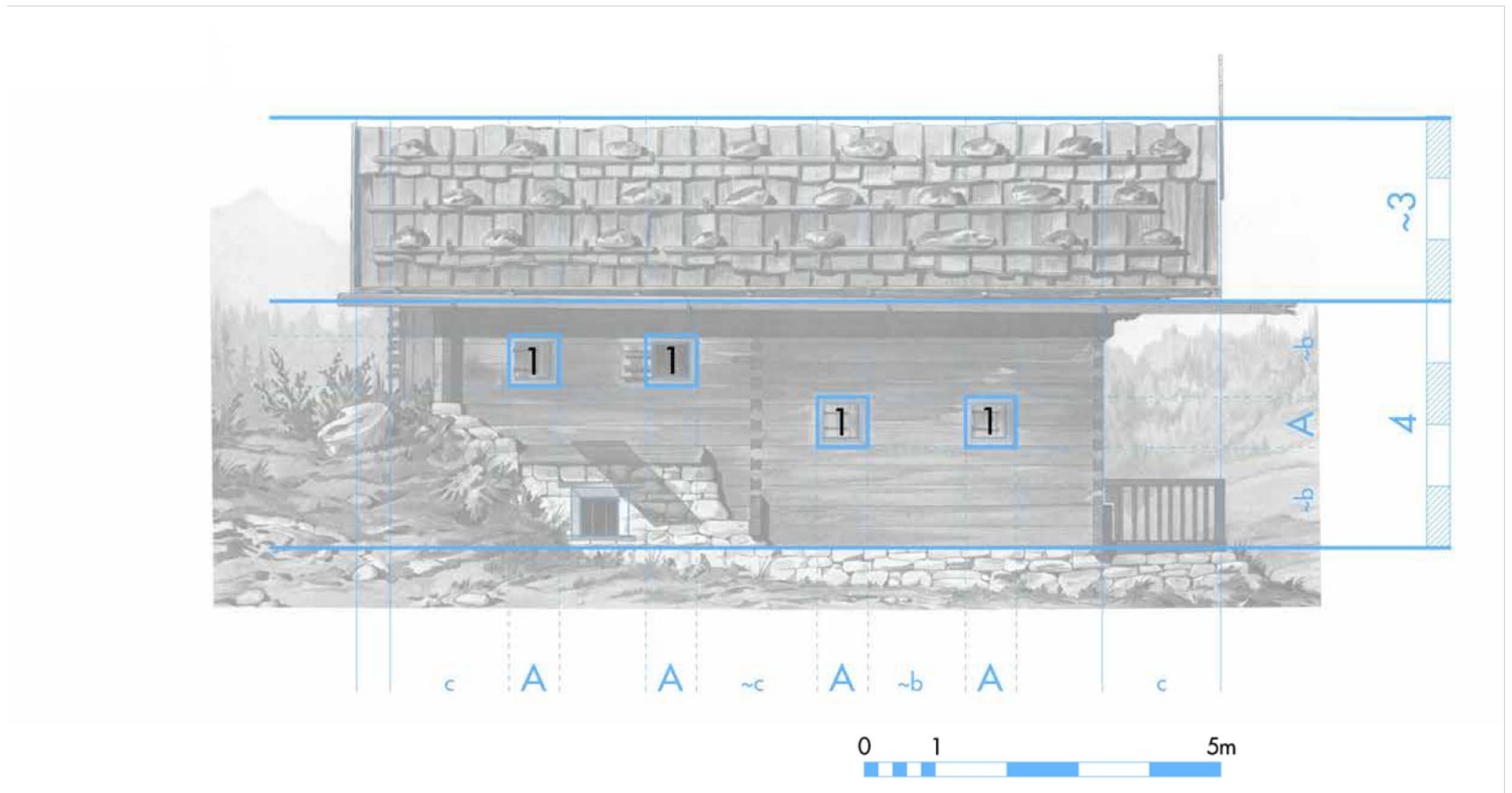


Fig. V.02 Geometrical analysis of front elevation: (T01) Alpine hut in Falzthurn
Fig. V.03 Geometrical analysis of side elevation: (T01) Alpine hut in Falzthurn

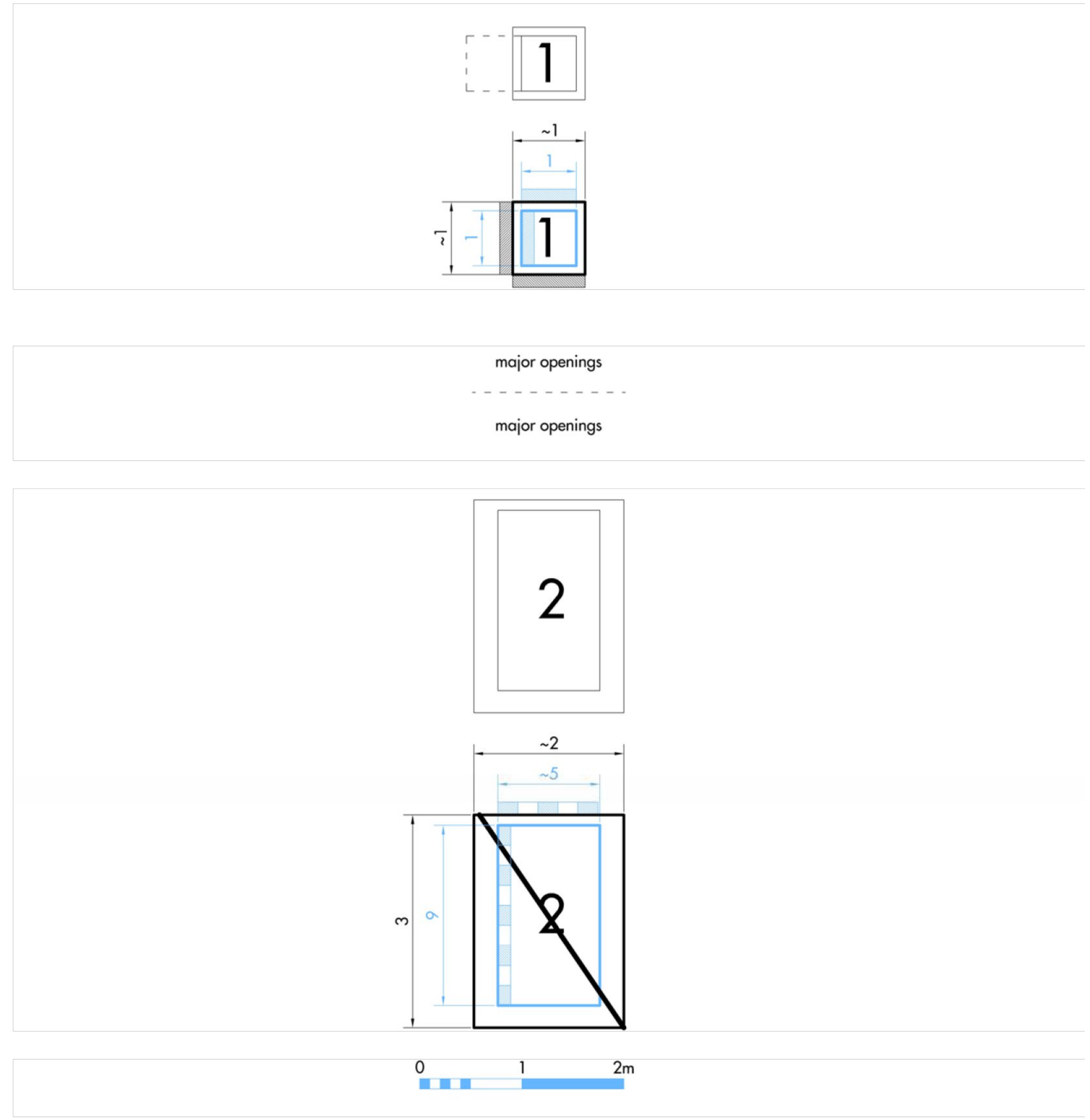
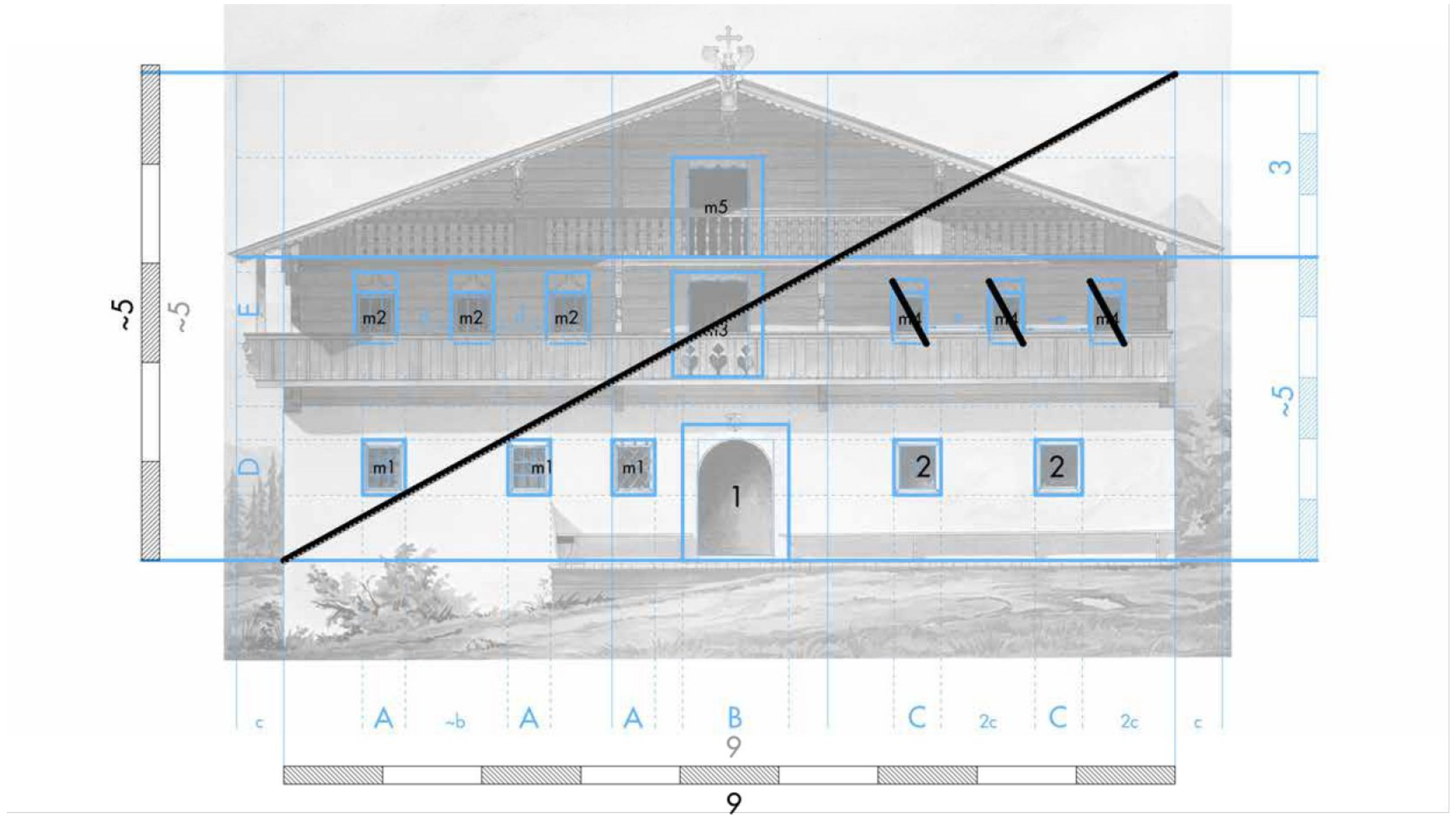


Fig. V.04 Geometrical analysis of openings: (T01) Alpine hut in Falzthurn



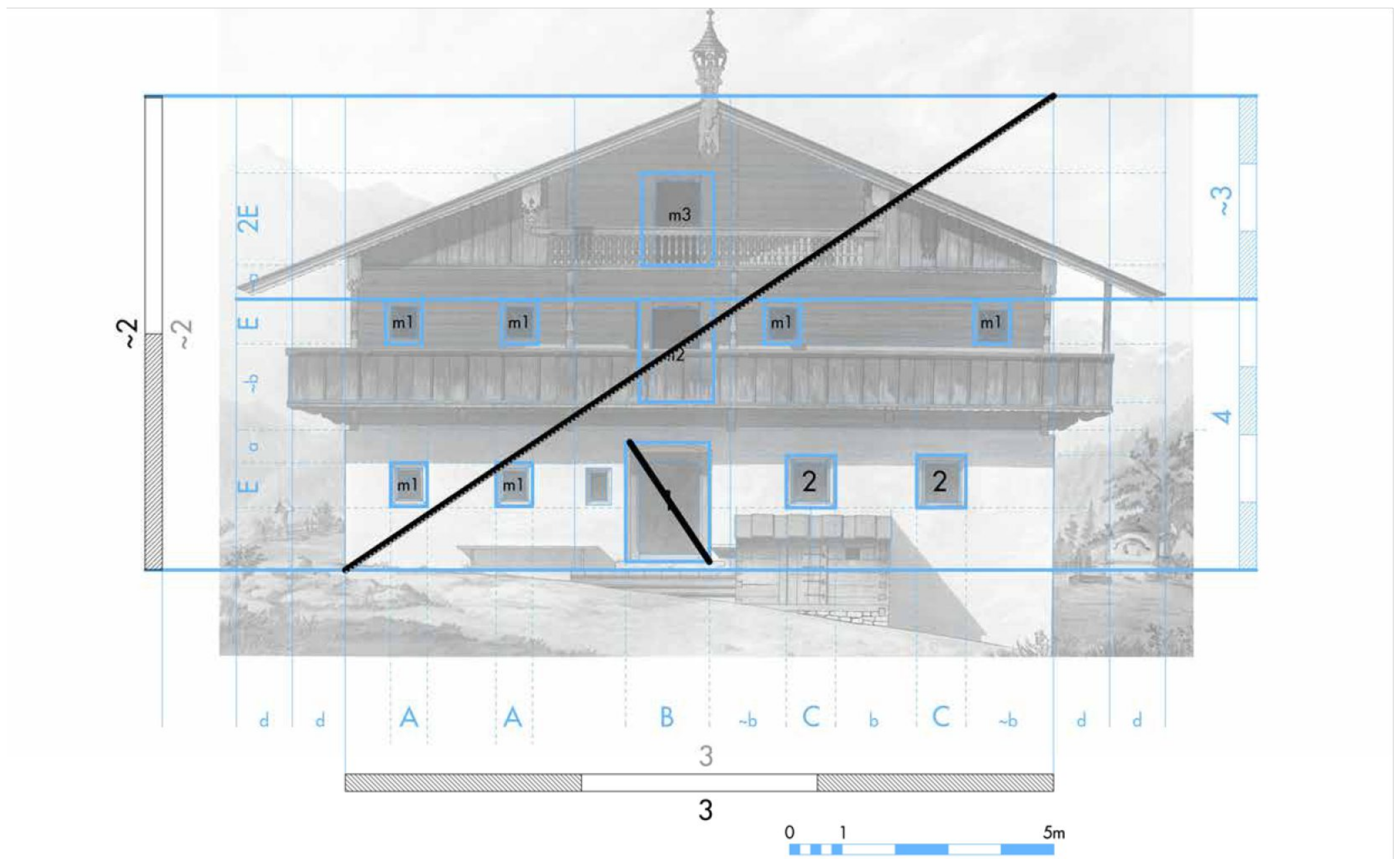


Fig. V.05 Geometrical analysis of front elevation: (T02) Farmhouse in Alpbach
Fig. V.06 Geometrical analysis of front elevation: (T03) Farmhouse in Alpbach

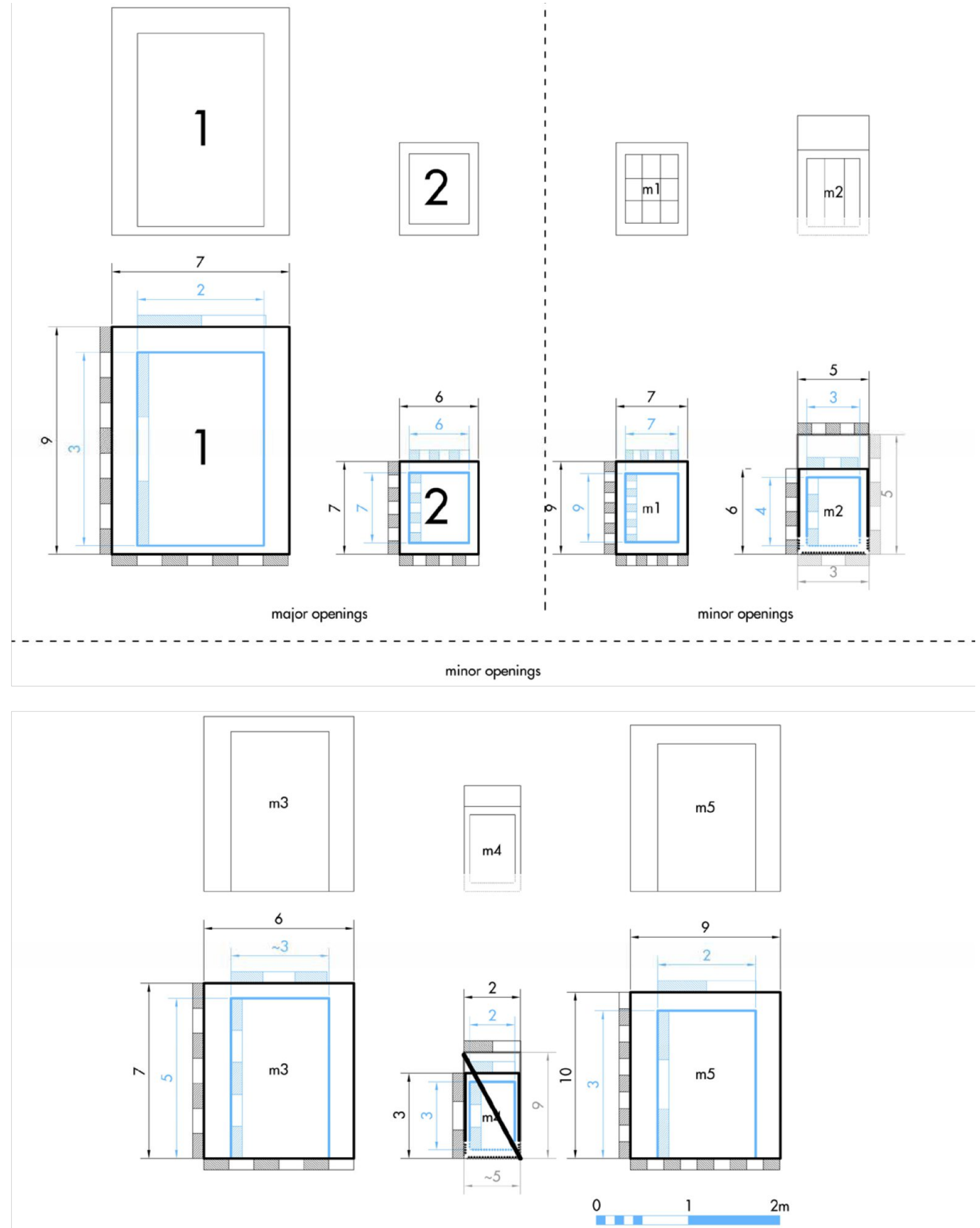


Fig. V.07 Geometrical analysis of openings: (T02) Farmhouse in Alpbach

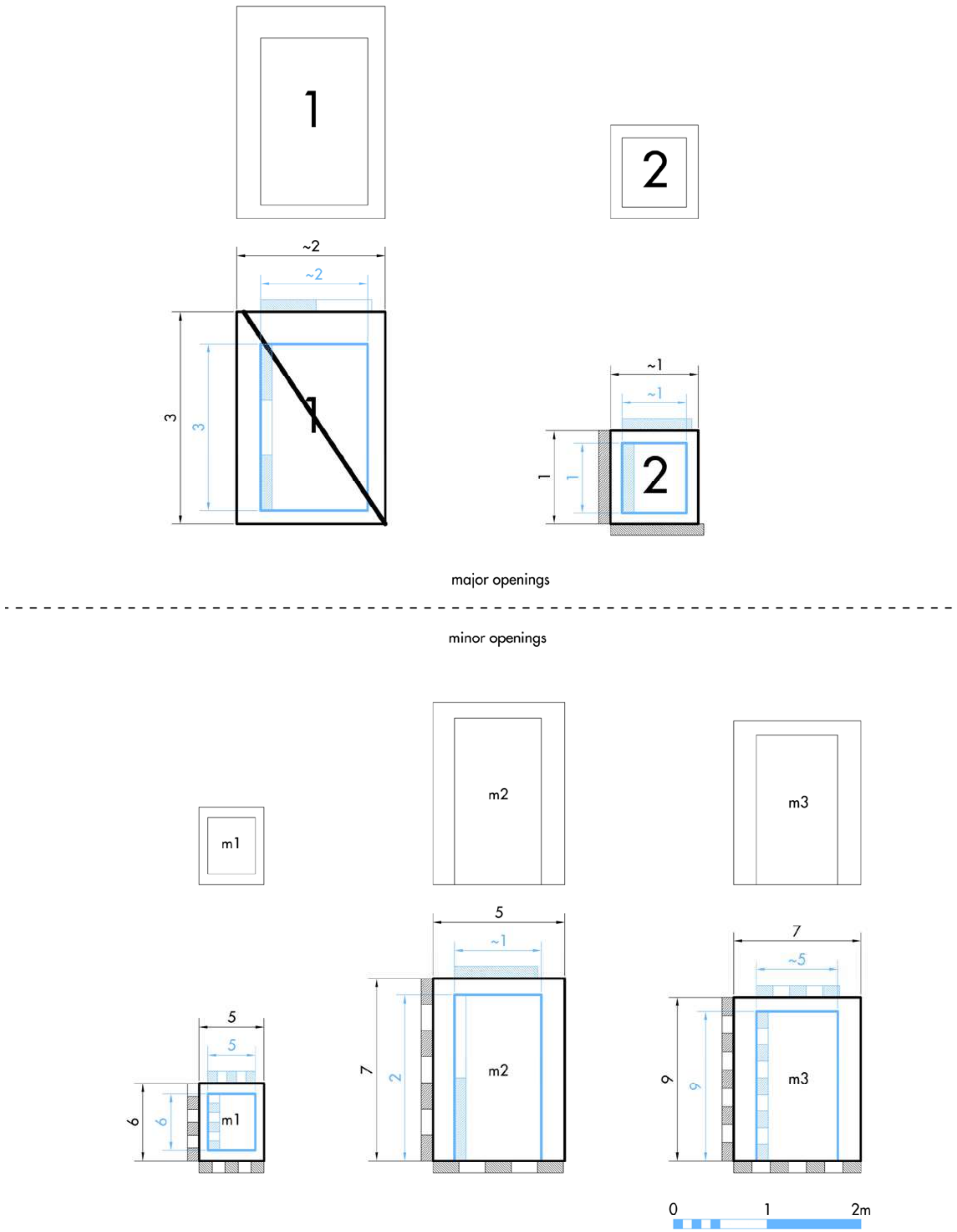
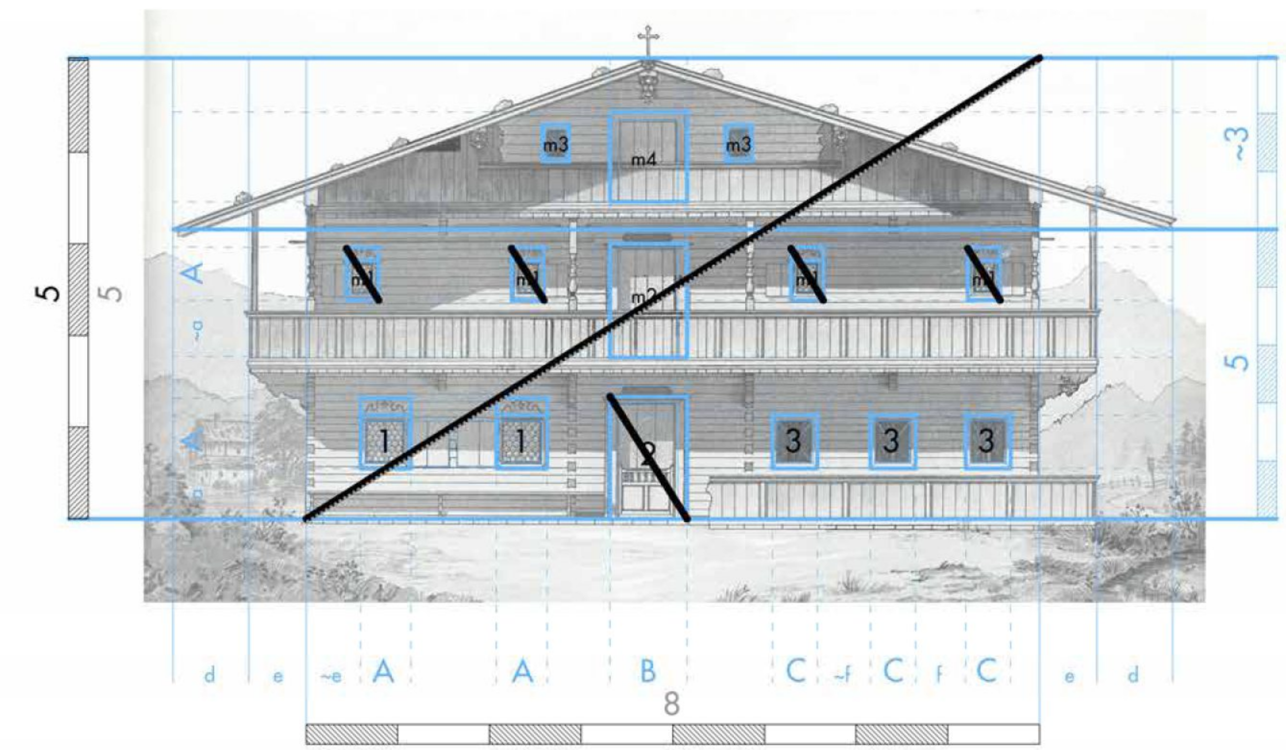


Fig. V.08 Geometrical analysis of openings: (T03) Farmhouse in Alpbach



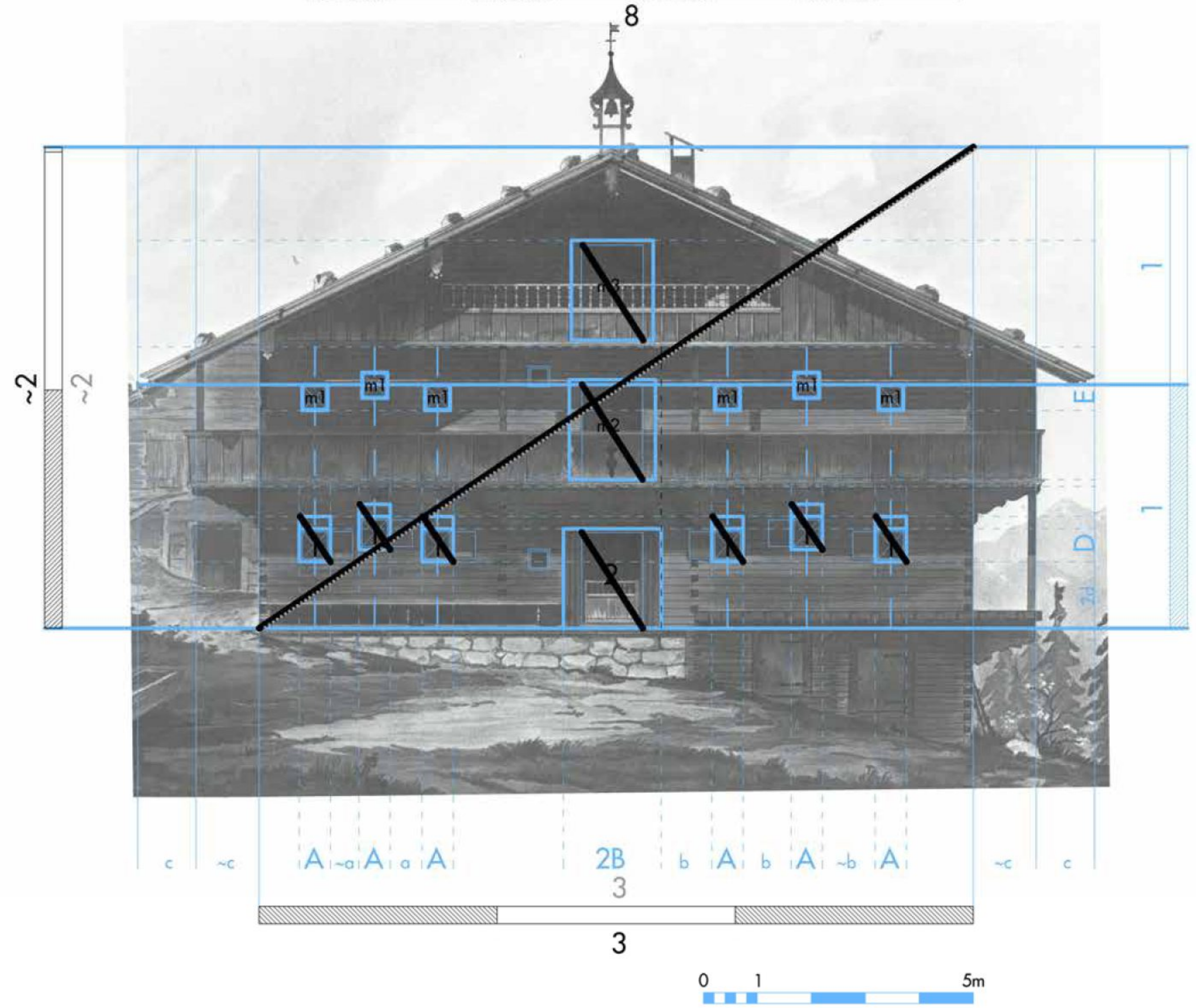


Fig. V.09 Geometrical analysis of front elevation: (T04) Farmhouse in Alpbach

Fig. V.10 Geometrical analysis of front elevation: (T05) Farmhouse in Alpbach

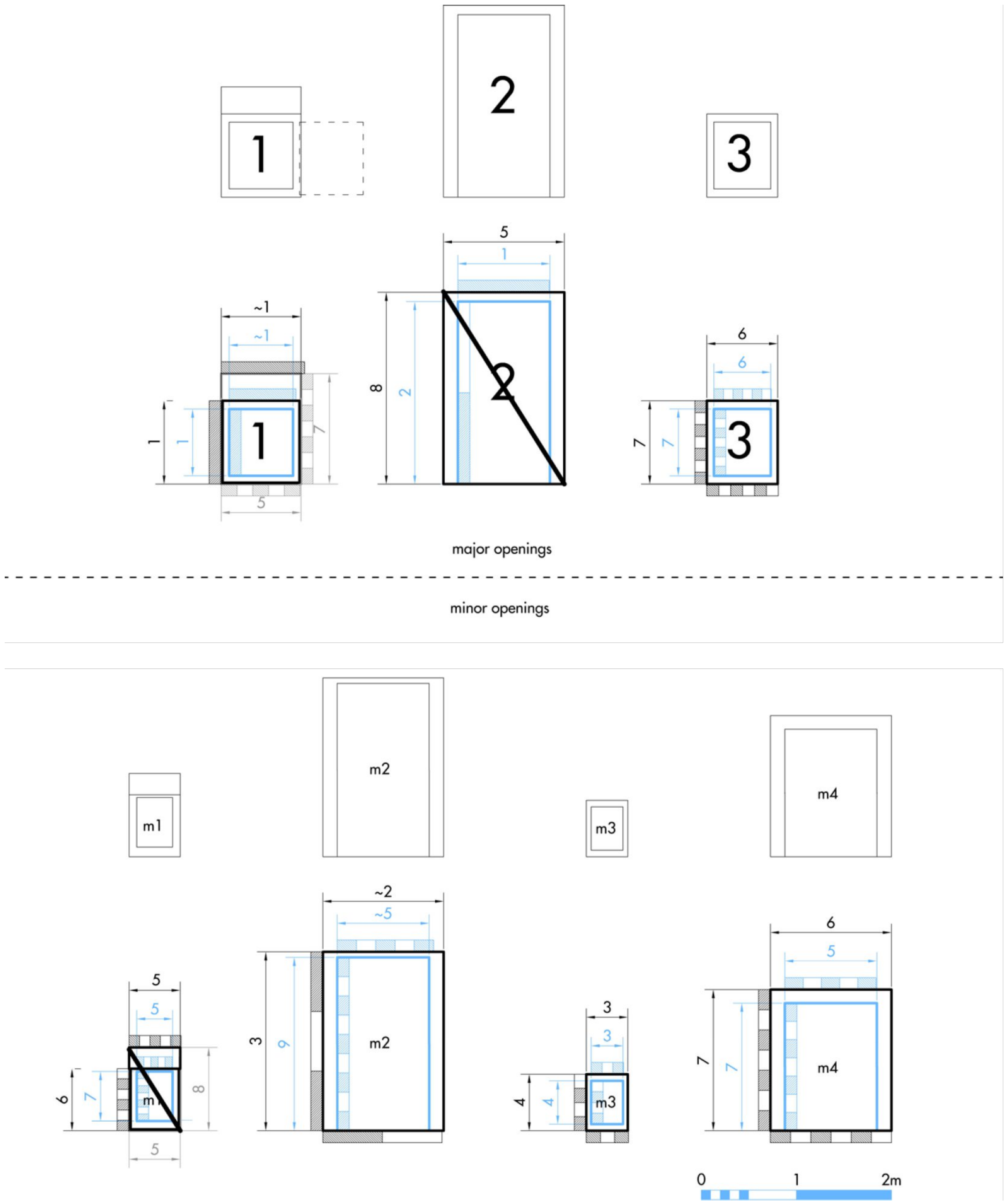


Fig. V.11 Geometrical analysis of openings: (T04) Alpine hut in Falzthurn

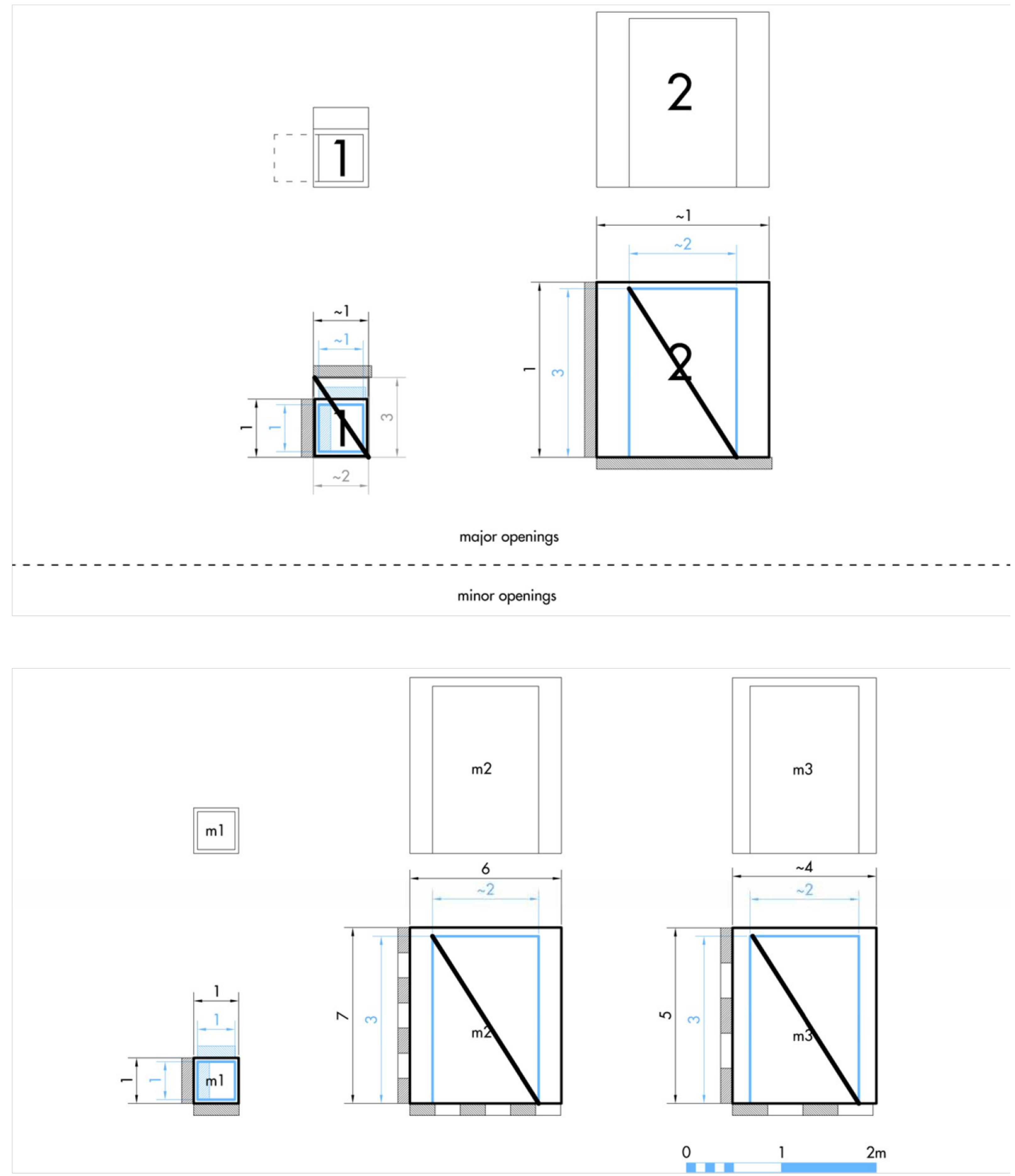
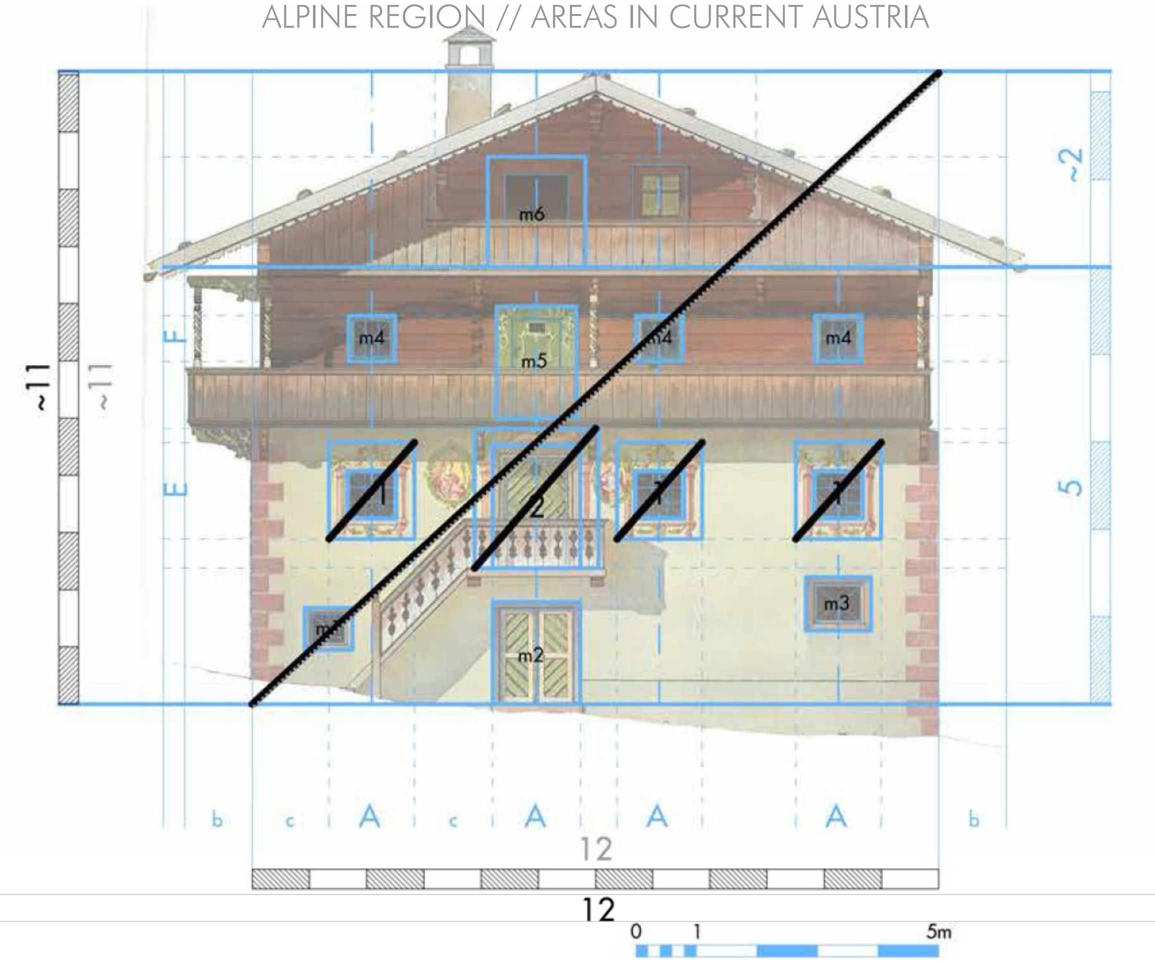


Fig. V.12 Geometrical analysis of openings: (T05) Alpine hut in Falzthurn



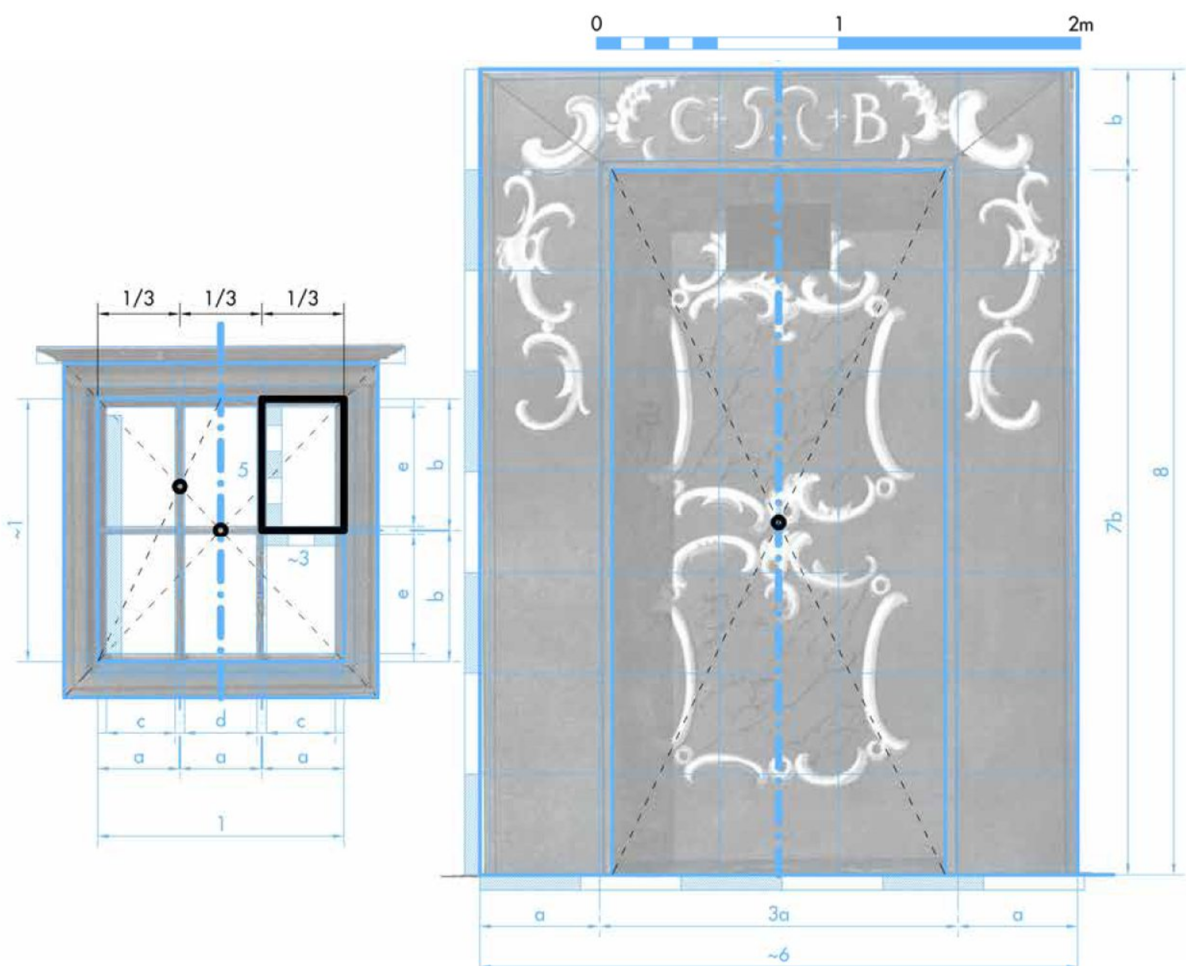


Fig. V.13 Geometrical analysis of front elevation: (T06) Farmhouse in Söll
Fig. V.14 Geometrical analysis of openings: (T06) Farmhouse in Söll

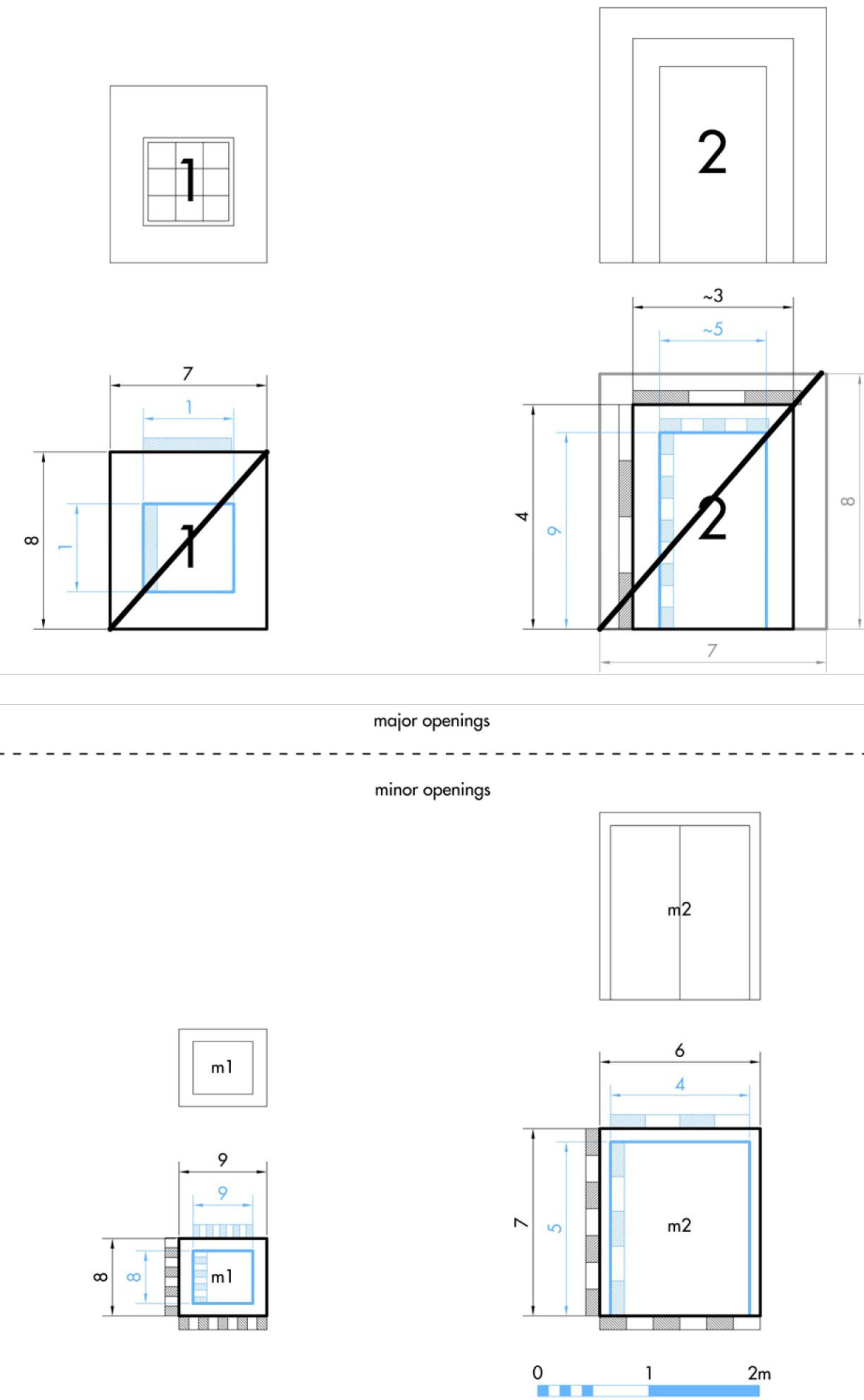


Fig. V.15 Geometrical analysis of openings: (T06) Farmhouse in Söll

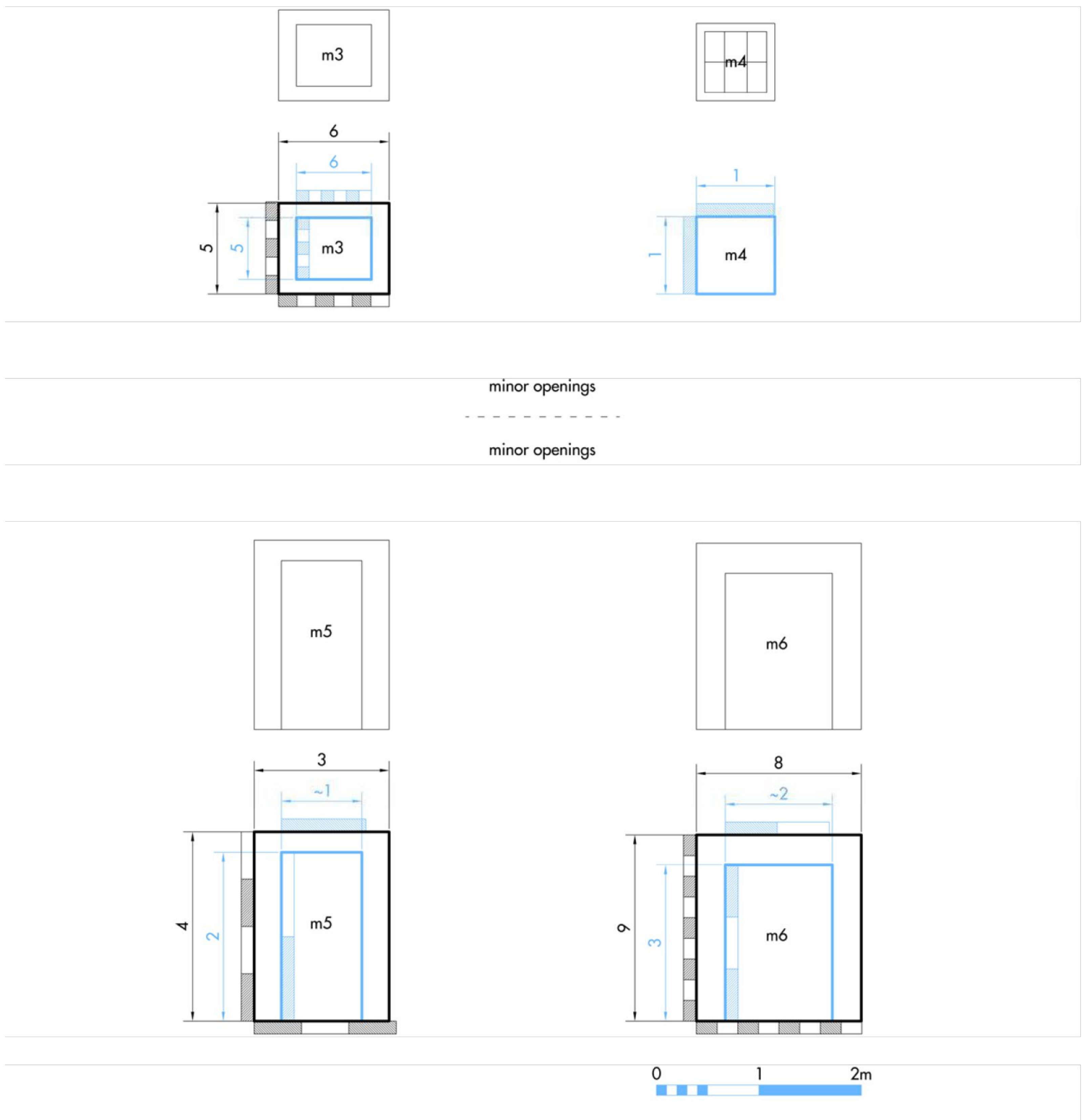
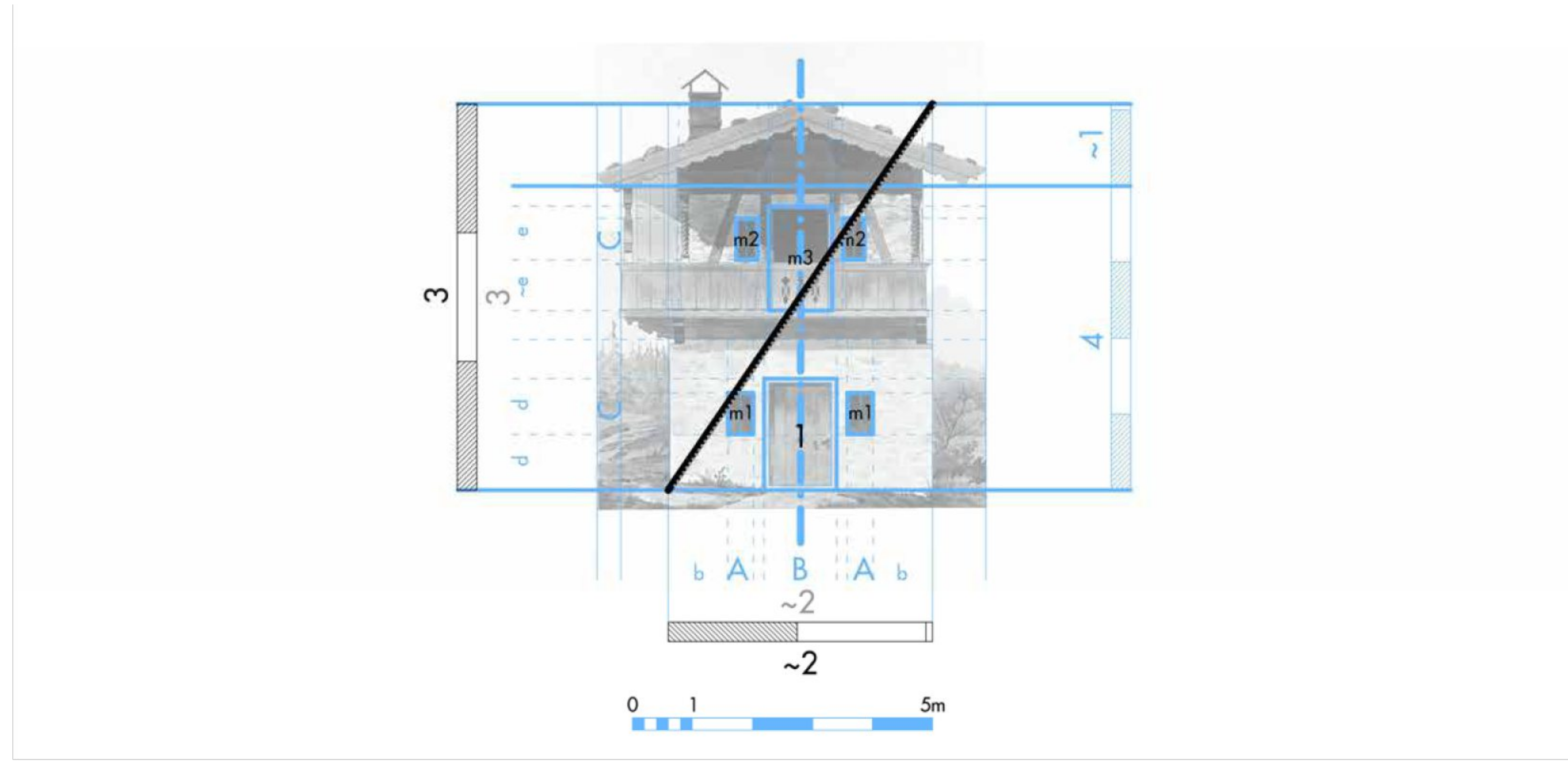


Fig. V.16 Geometrical analysis of openings: (T06) Farmhouse in Söll



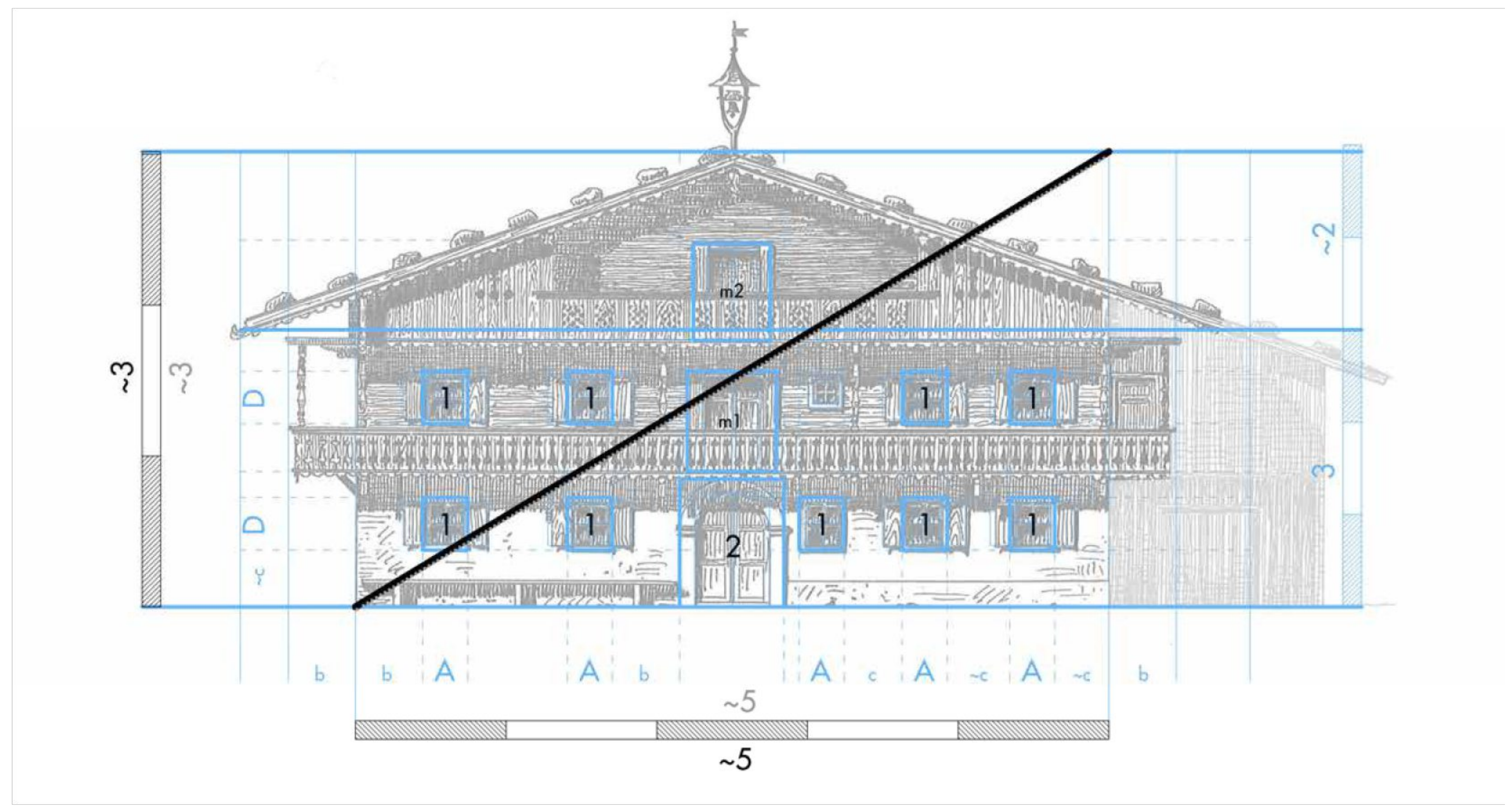


Fig. V.17 Geometrical analysis of front elevation: (T07) House near Söll
Fig. V.18 Geometrical analysis of front elevation: (T08) House near Kirchbichl

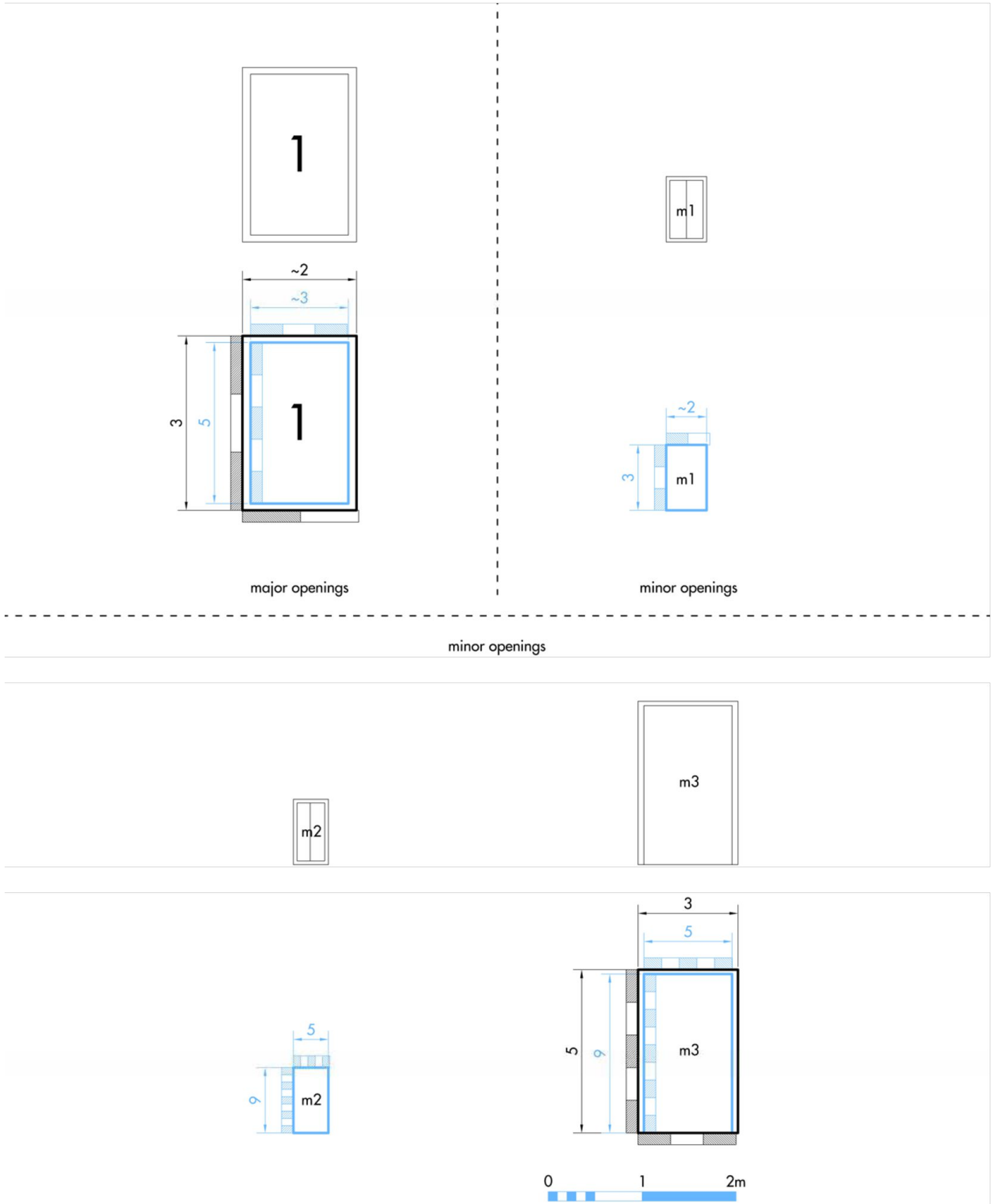


Fig. V.19 Geometrical analysis of openings: (T07) House near Söll

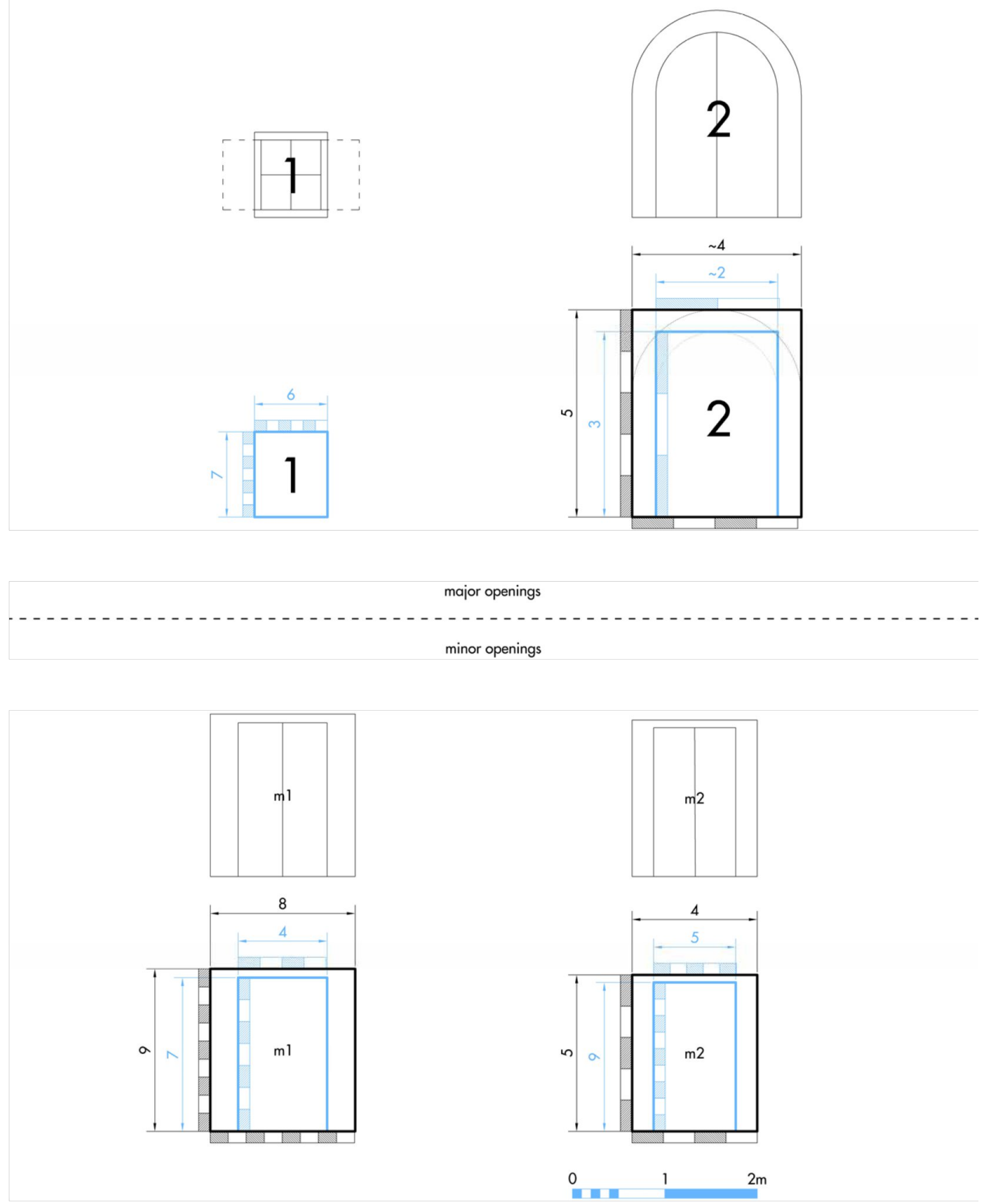
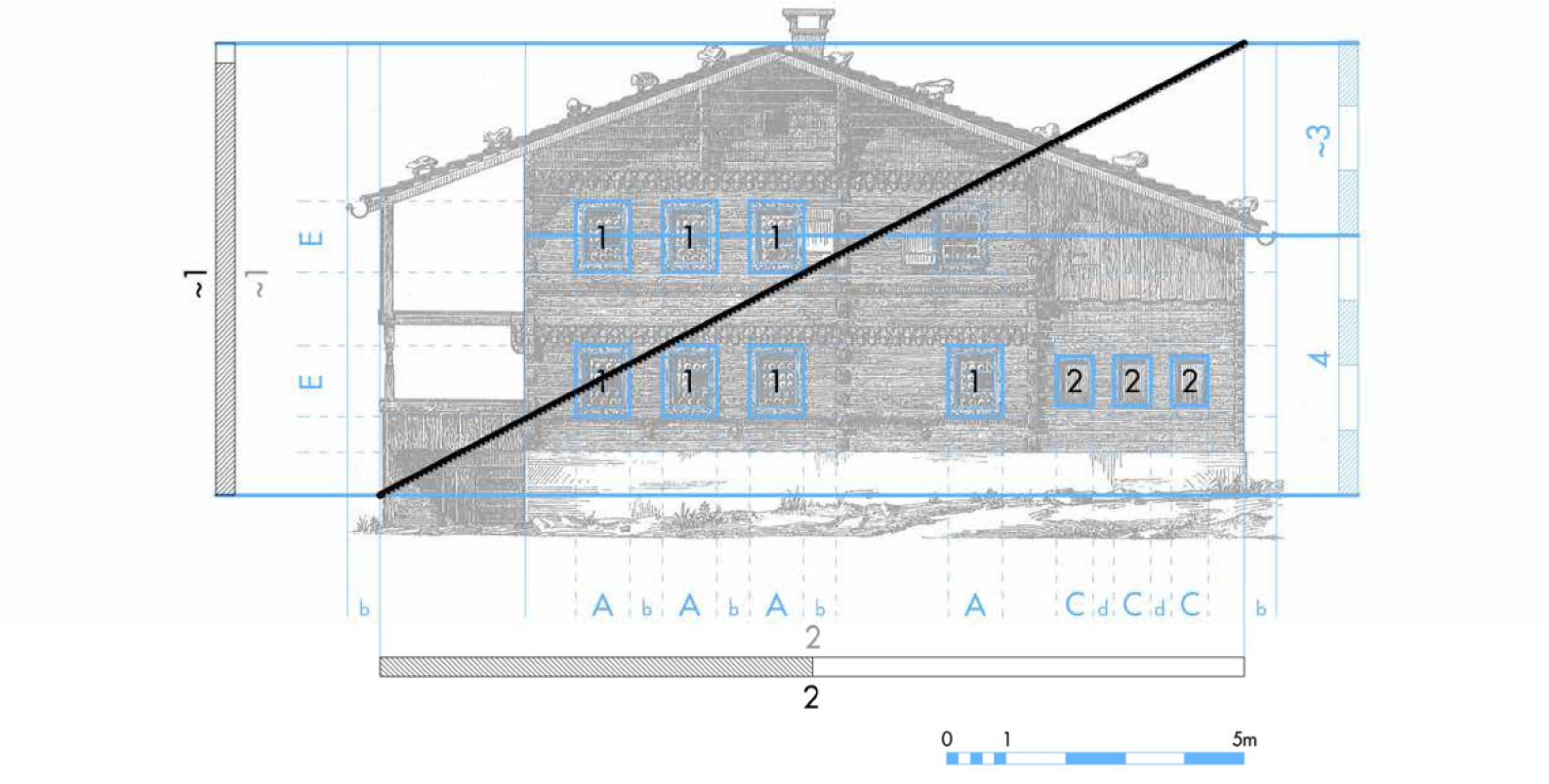


Fig. V.20 Geometrical analysis of openings: (T08) Farmhouse near Kirchbichl



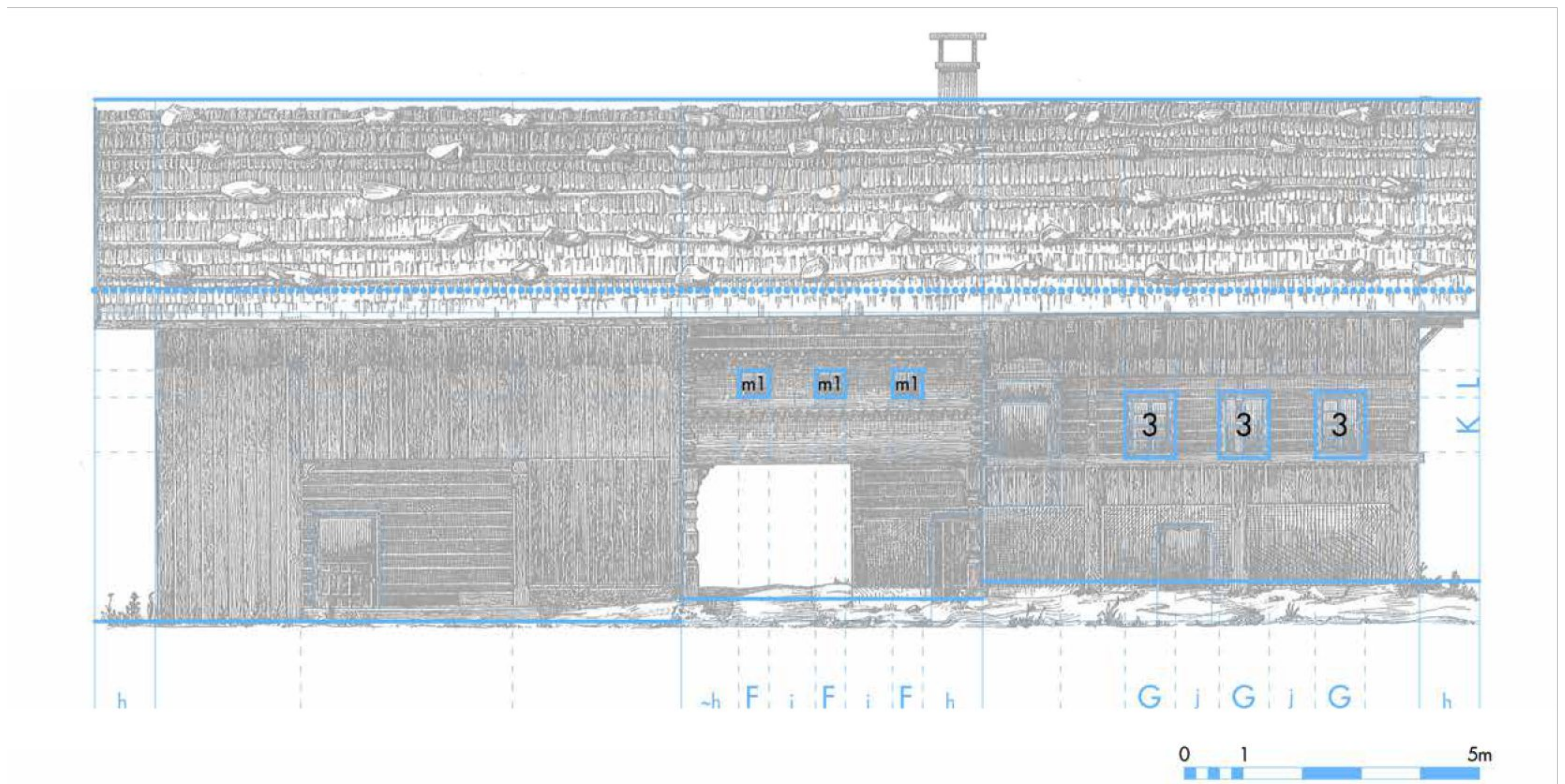


Fig. V.21 Geometrical analysis of front elevation: (V01) Farmhouse in Bizau

Fig. V.22 Geometrical analysis of side elevation: (V01) Farmhouse in Bizau

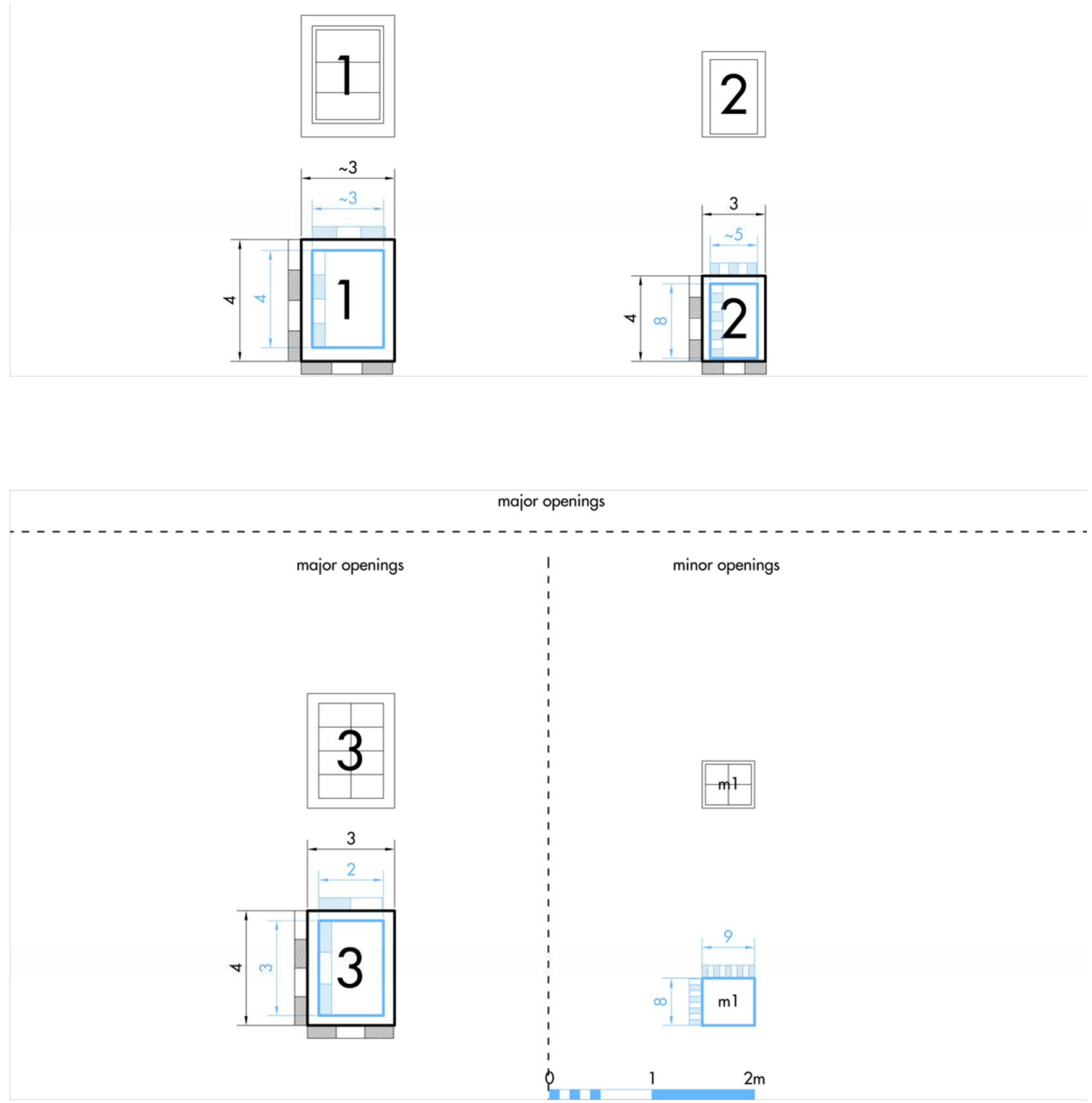
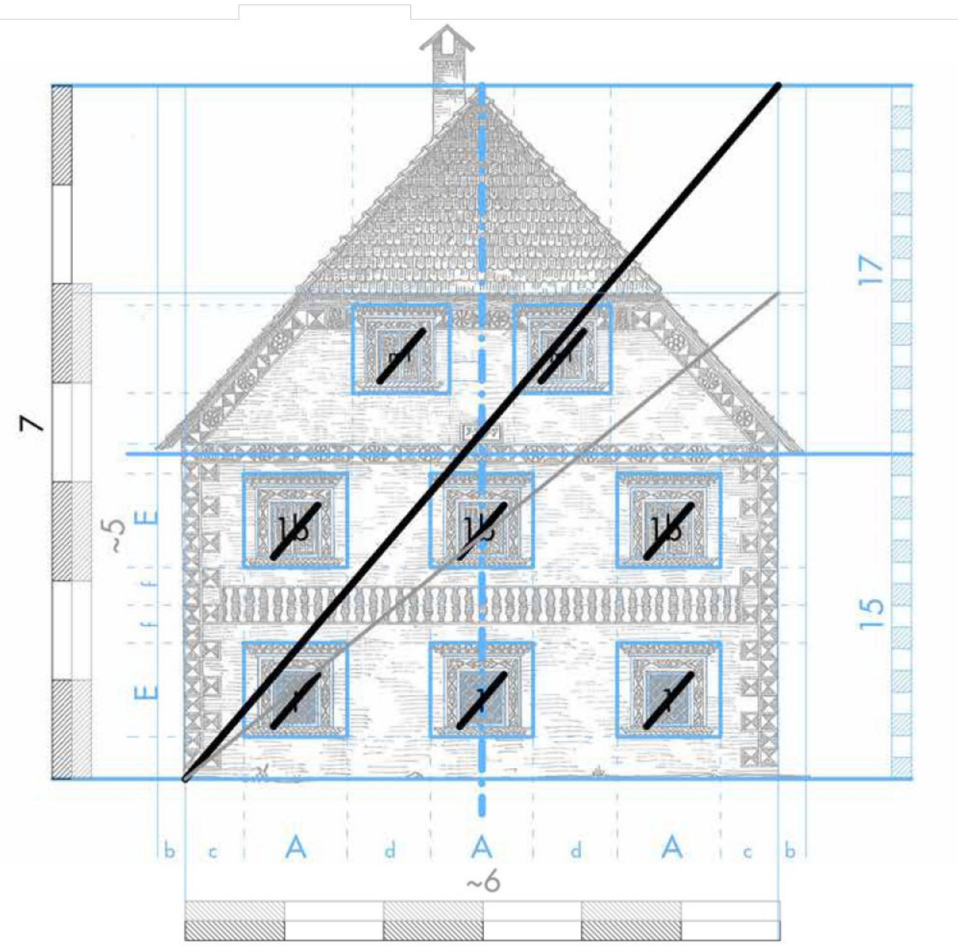


Fig. V.23 Geometrical analysis of openings: (V01) Farmhouse in Bizau



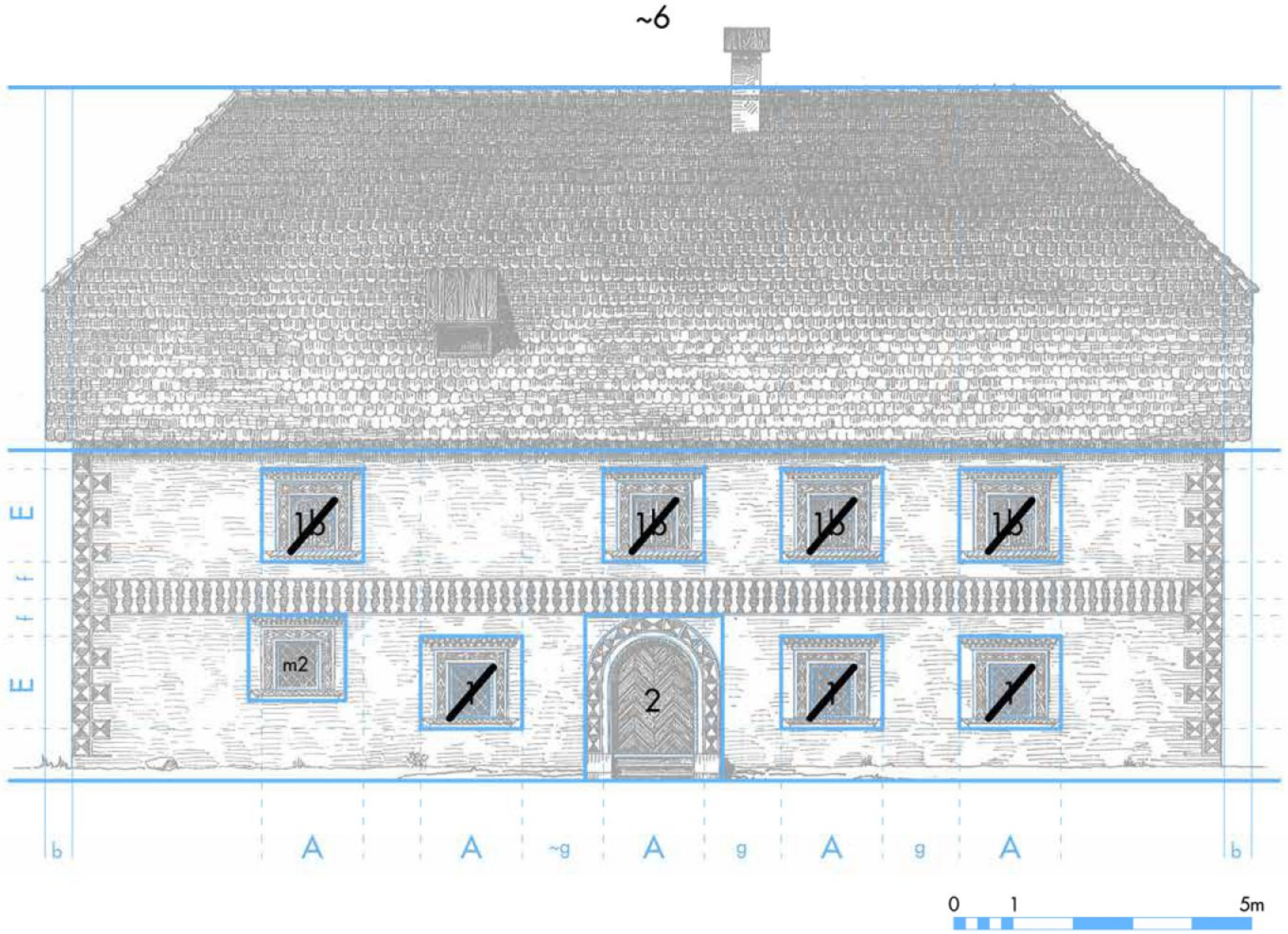


Fig. V.24 Geometrical analysis of front elevation: (S01) House vulgo Heimann in Adriach near Frohnleiten
Fig. V.25 Geometrical analysis of side elevation: (S01) House vulgo Heimann in Adriach near Frohnleiten

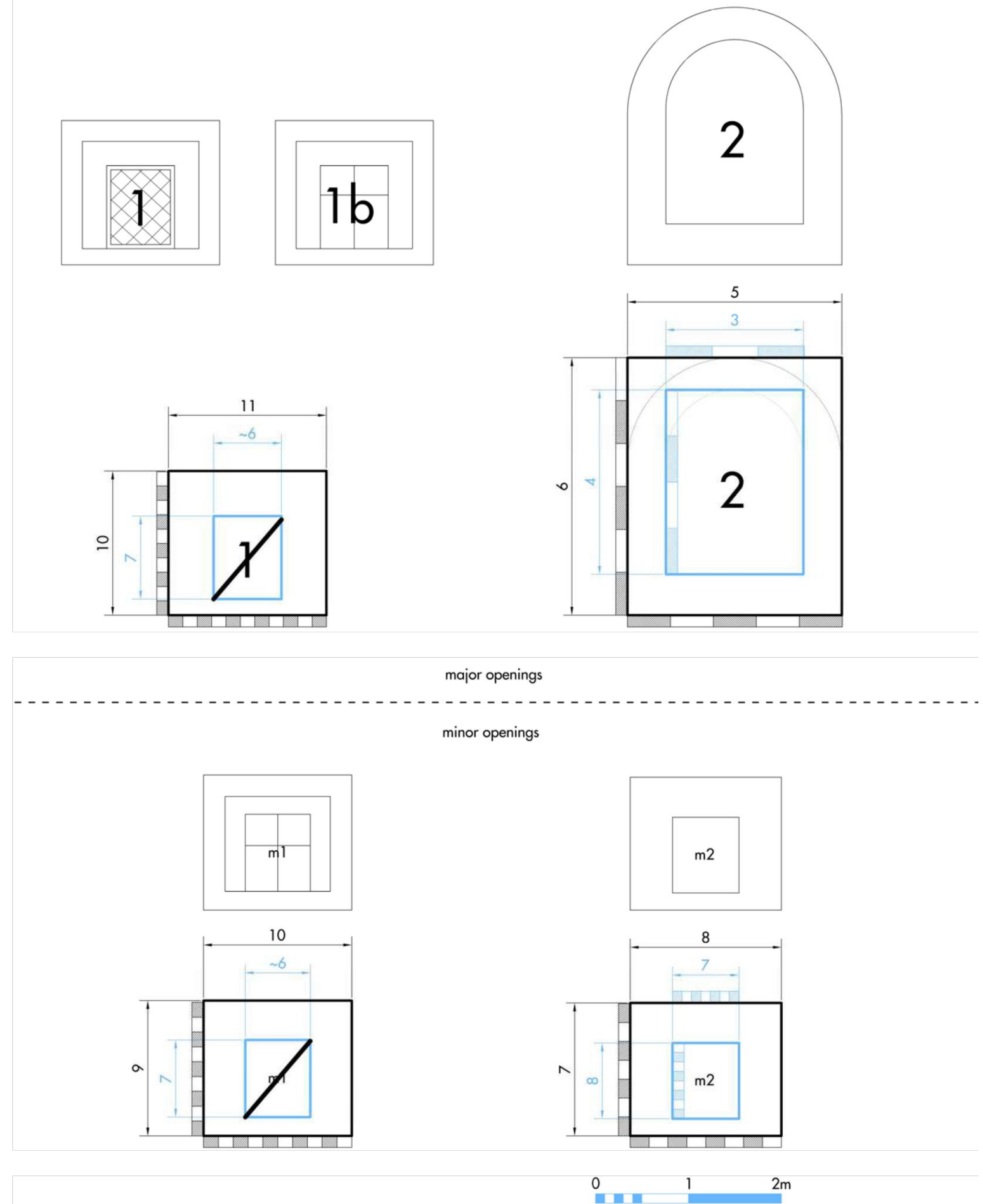
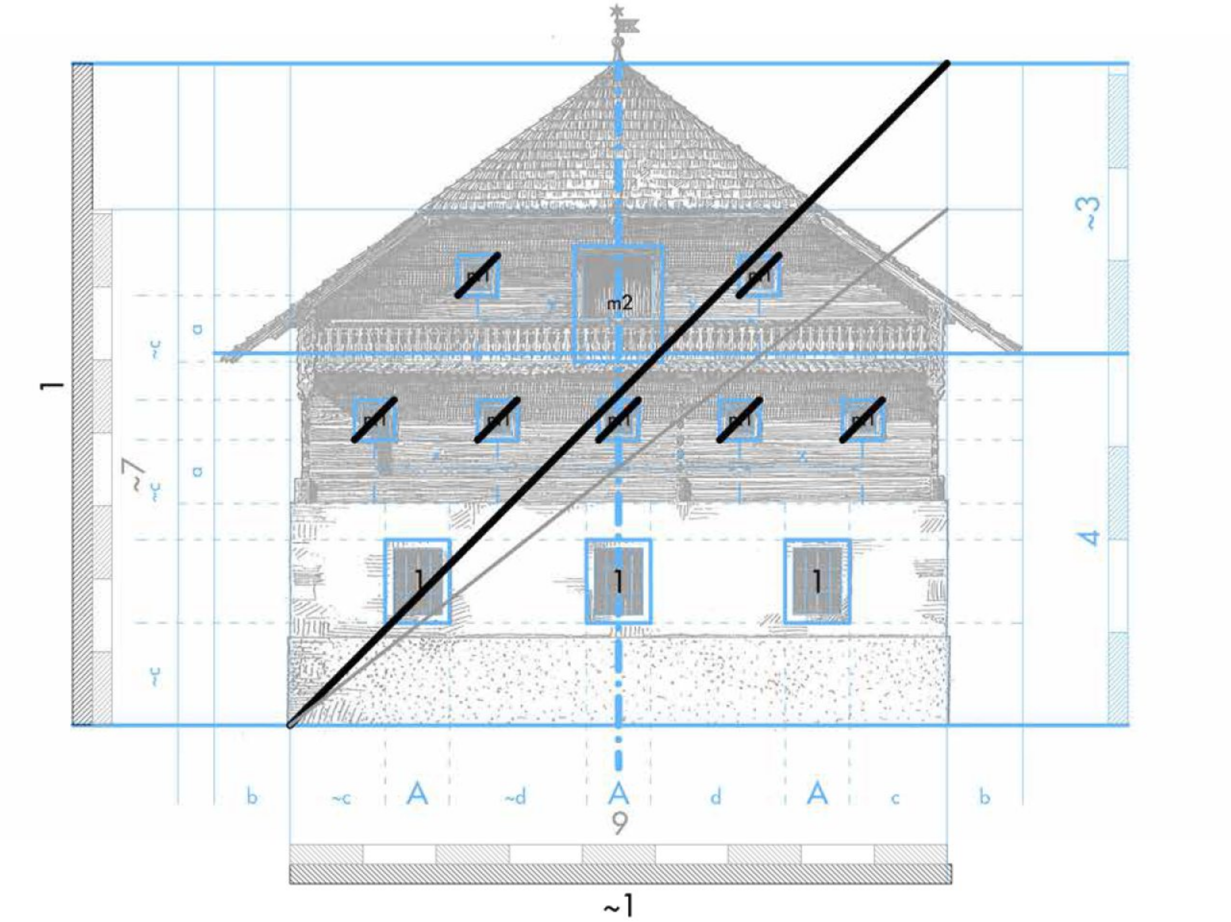


Fig. V.26 Geometrical analysis of openings: (S01) House vulgo Heimann in Adriach near Frohnleiten



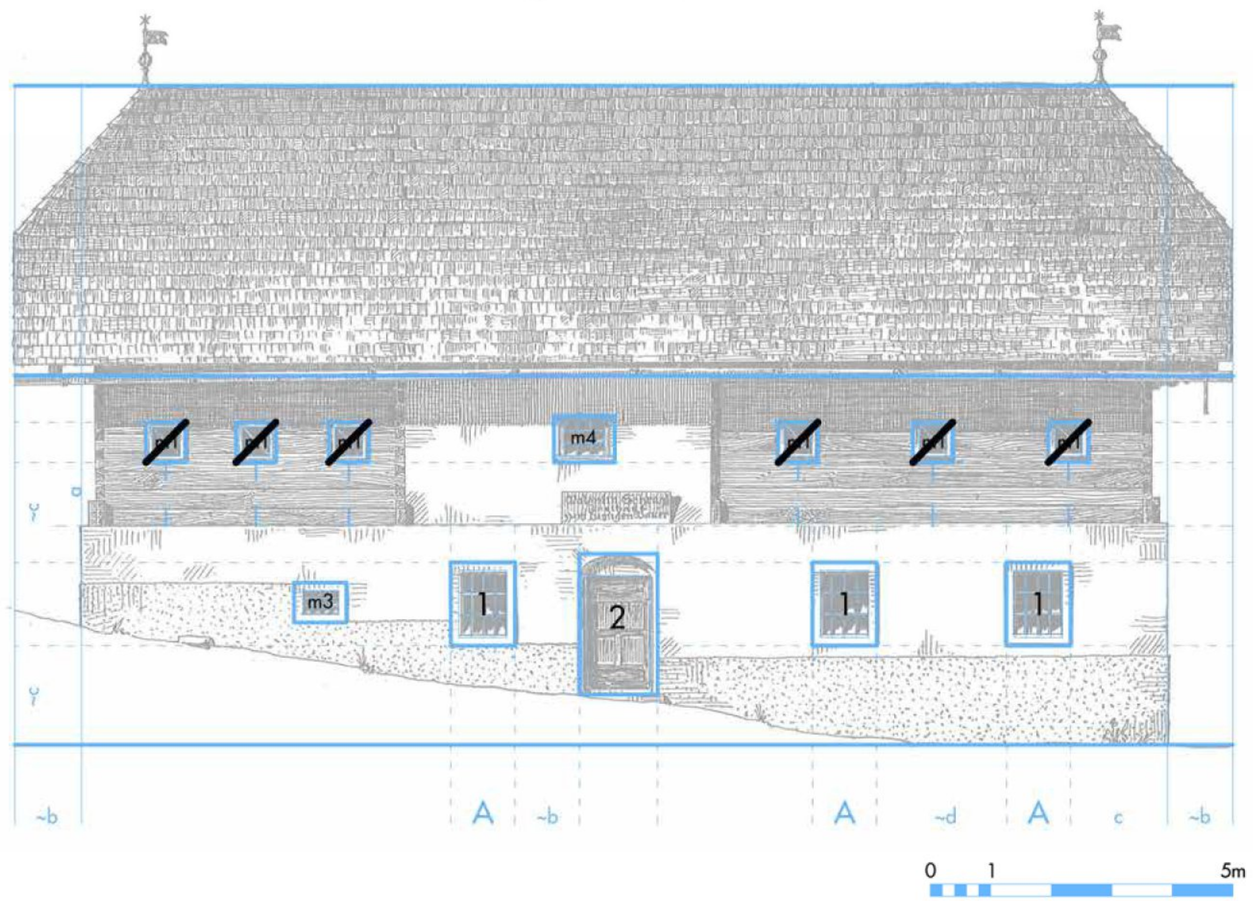


Fig. V.27 Geometrical analysis of front elevation: (S02) House Valentin Schragl vulgo Obersattler in Breitenau near Mixnitz

Fig. V.28 Geometrical analysis of side elevation: (S02) House Valentin Schragl vulgo Obersattler in Breitenau near Mixnitz

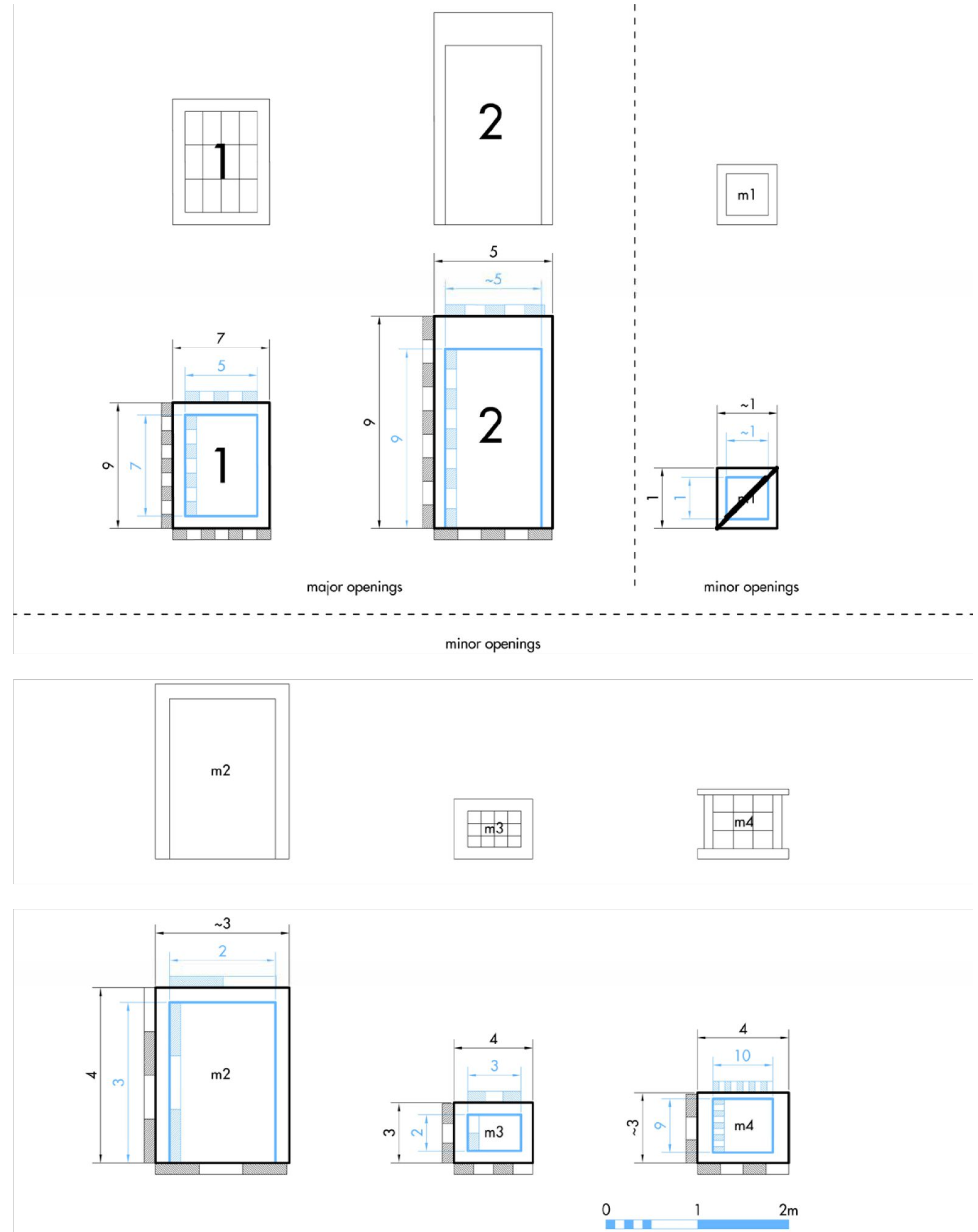
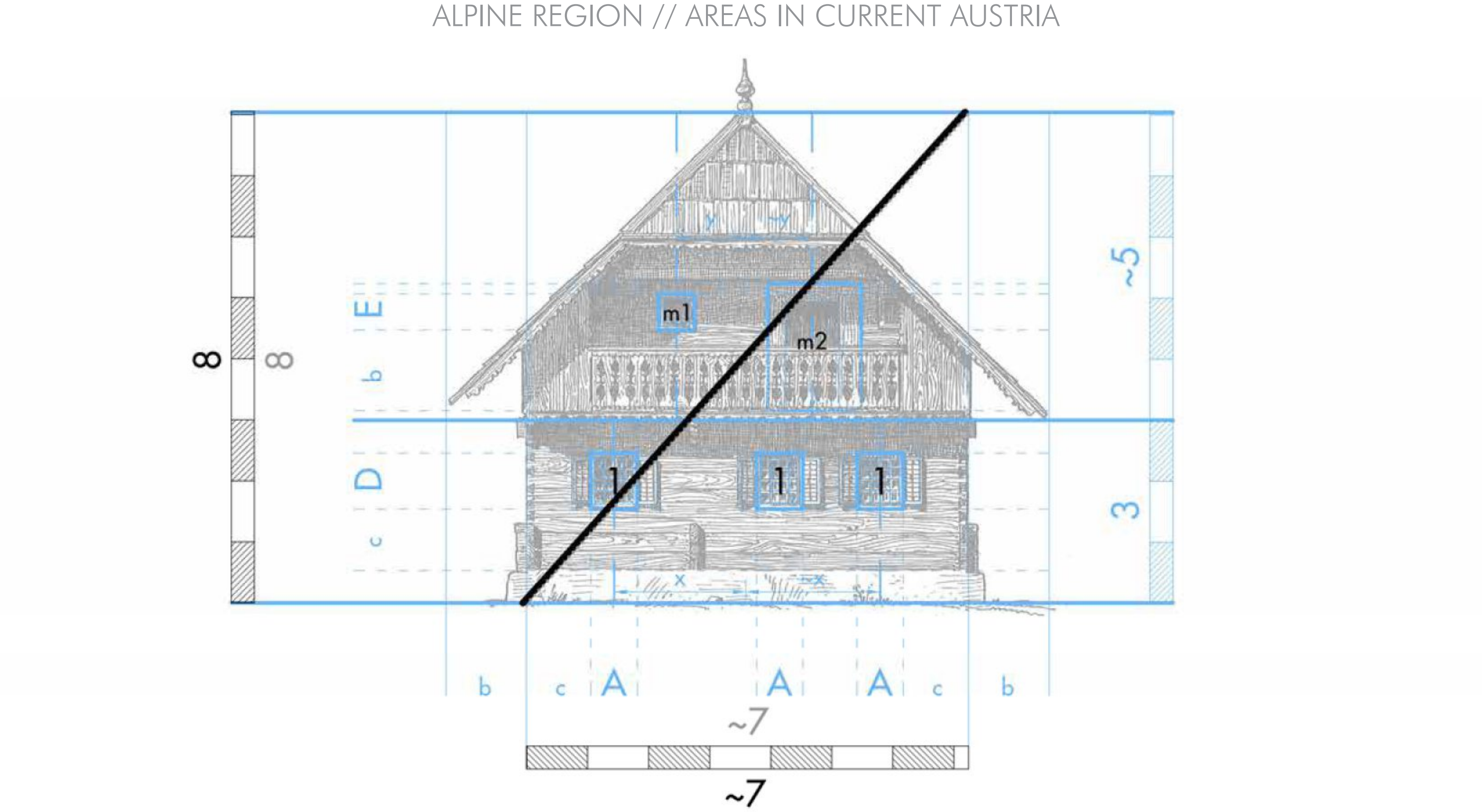


Fig. V.29 Geometrical analysis of openings: (S02) House Valentin Schragl vulgo Obersattler in Breitenau near Mixnitz



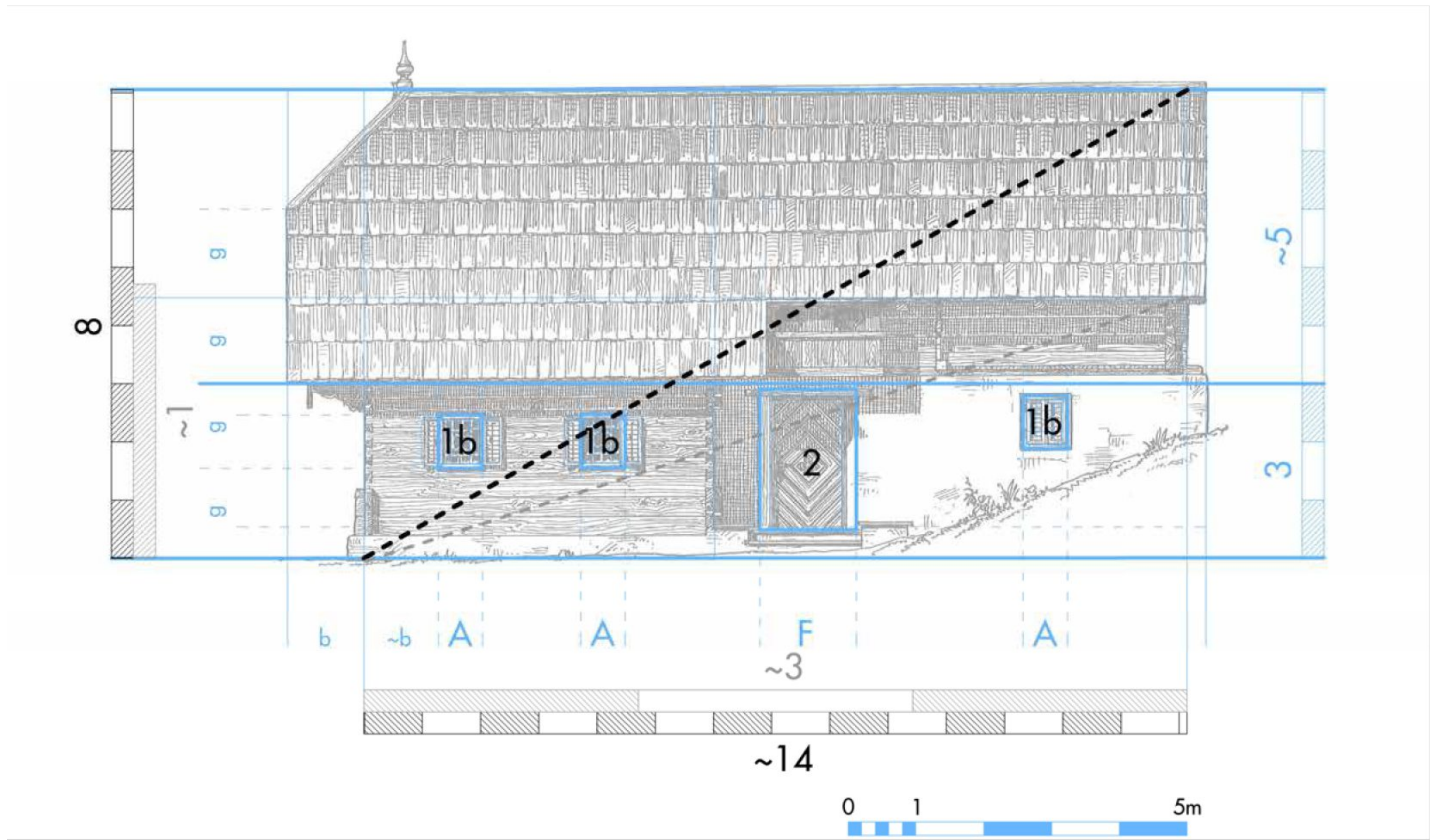


Fig. V.30 Geometrical analysis of front elevation: (S03) House Johann Fellner vulgo Michelbacher in Breitenau near Mixnitz
Fig. V.31 Geometrical analysis of side elevation: (S03) House Johann Fellner vulgo Michelbacher in Breitenau near Mixnitz

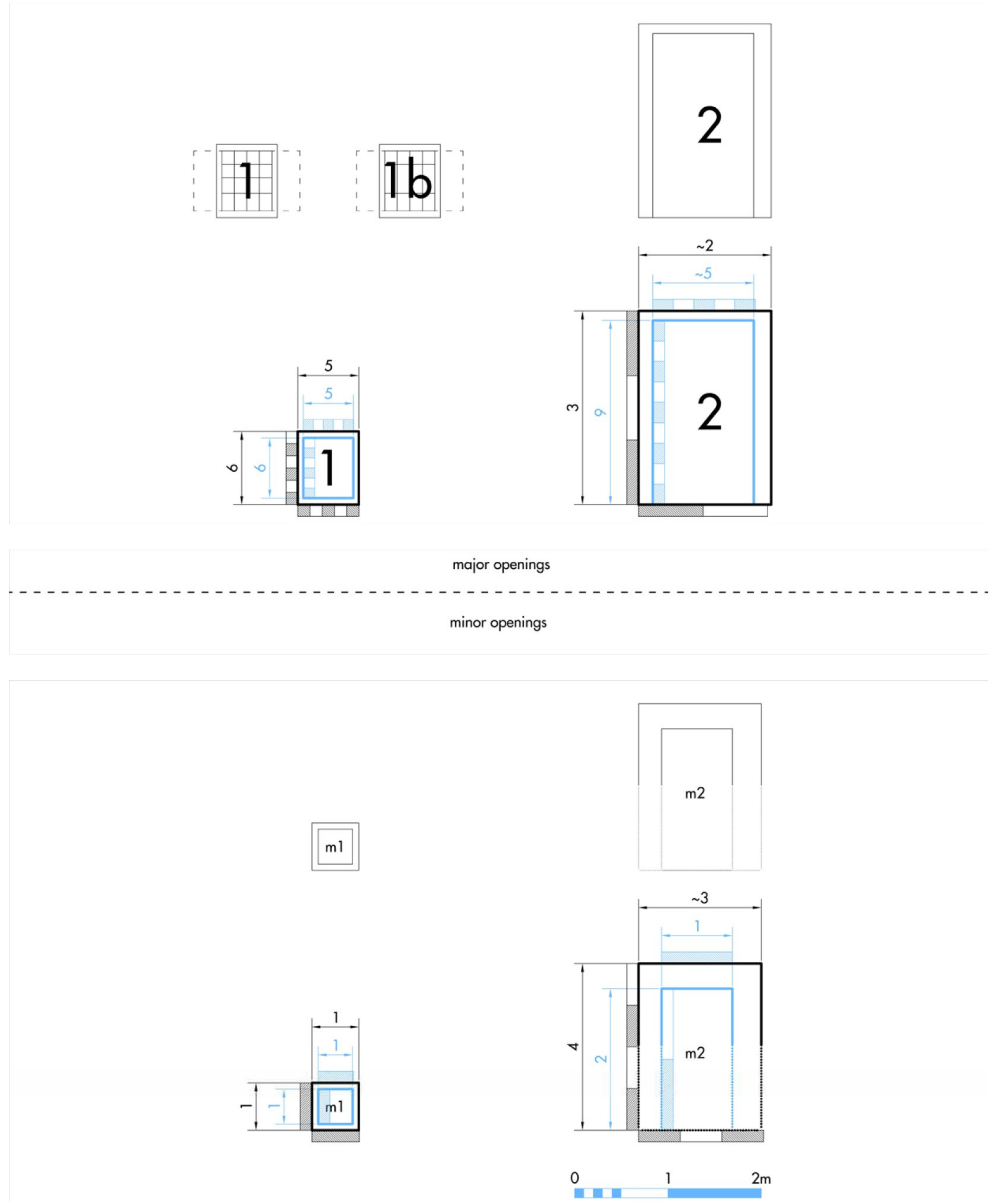
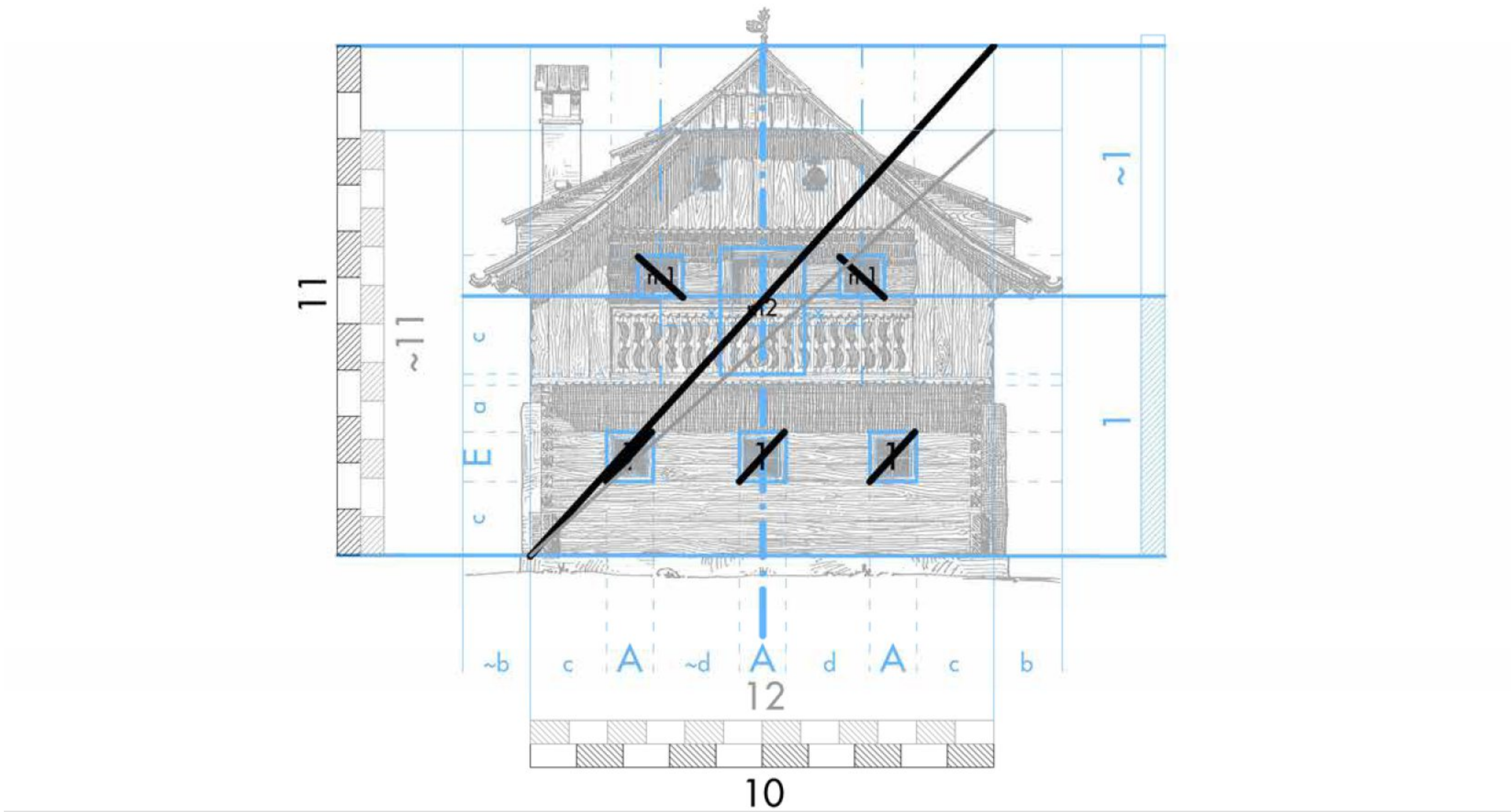


Fig. V.32 Geometrical analysis of openings: (S03) House Johann Fellner vulgo Michelbacher in Breitenau near Mixnitz



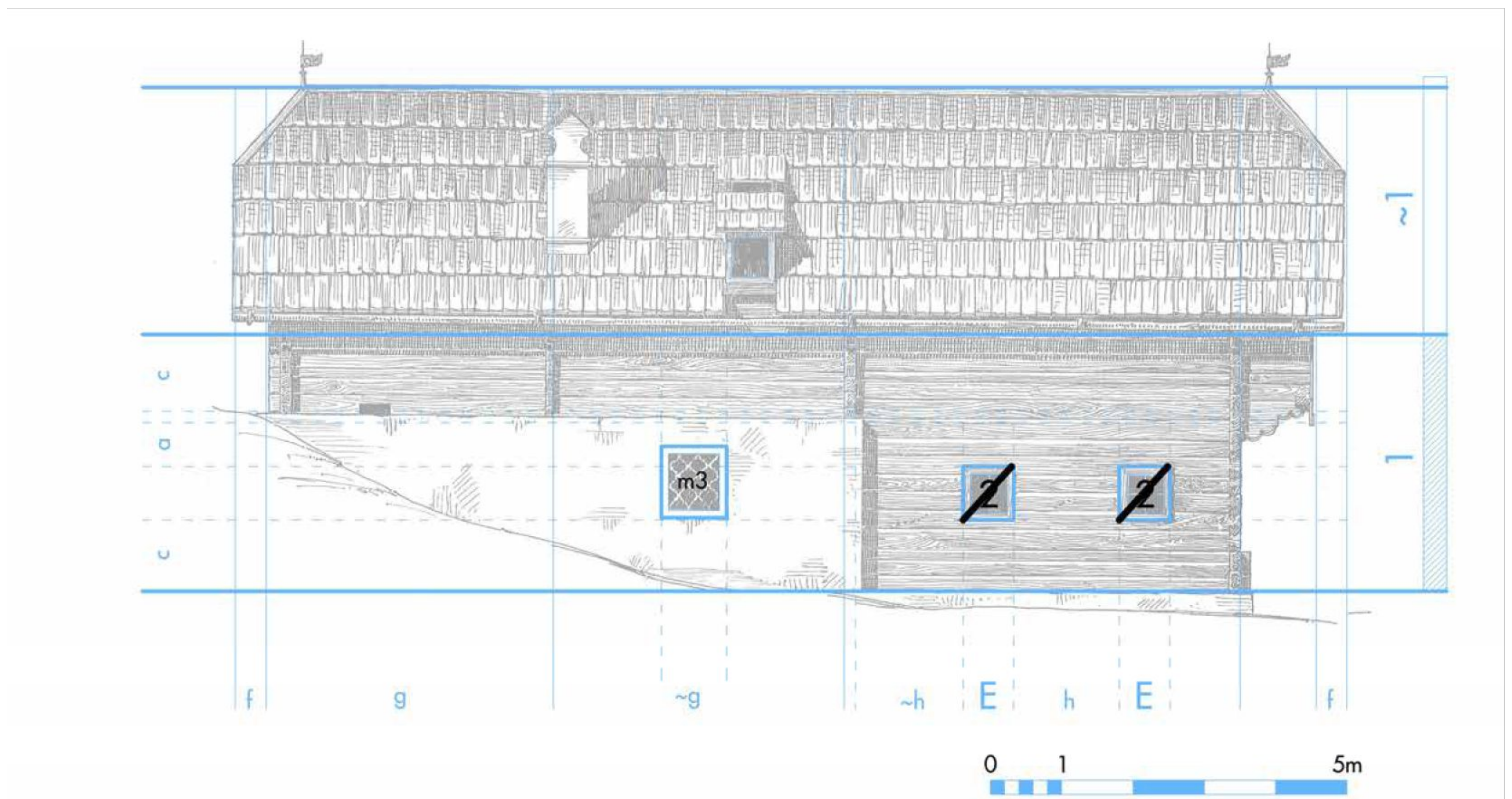


Fig. V.33 Geometrical analysis of front elevation: (S04) House Jakob Schweiger vulgo Gräsinger in Breitenau near Mixnitz
Fig. V.34 Geometrical analysis of side elevation: (S04) House Jakob Schweiger vulgo Gräsinger in Breitenau near Mixnitz

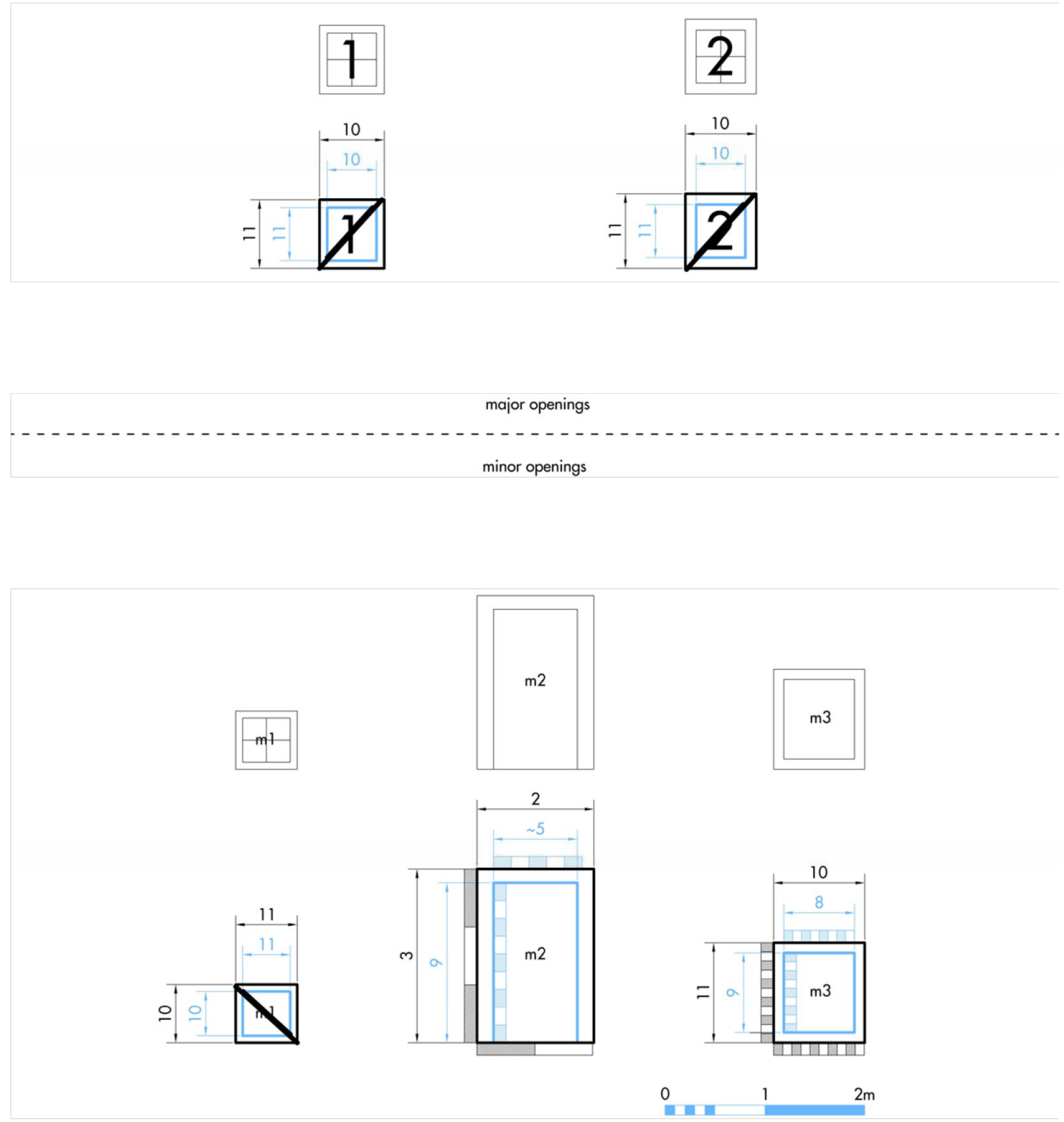
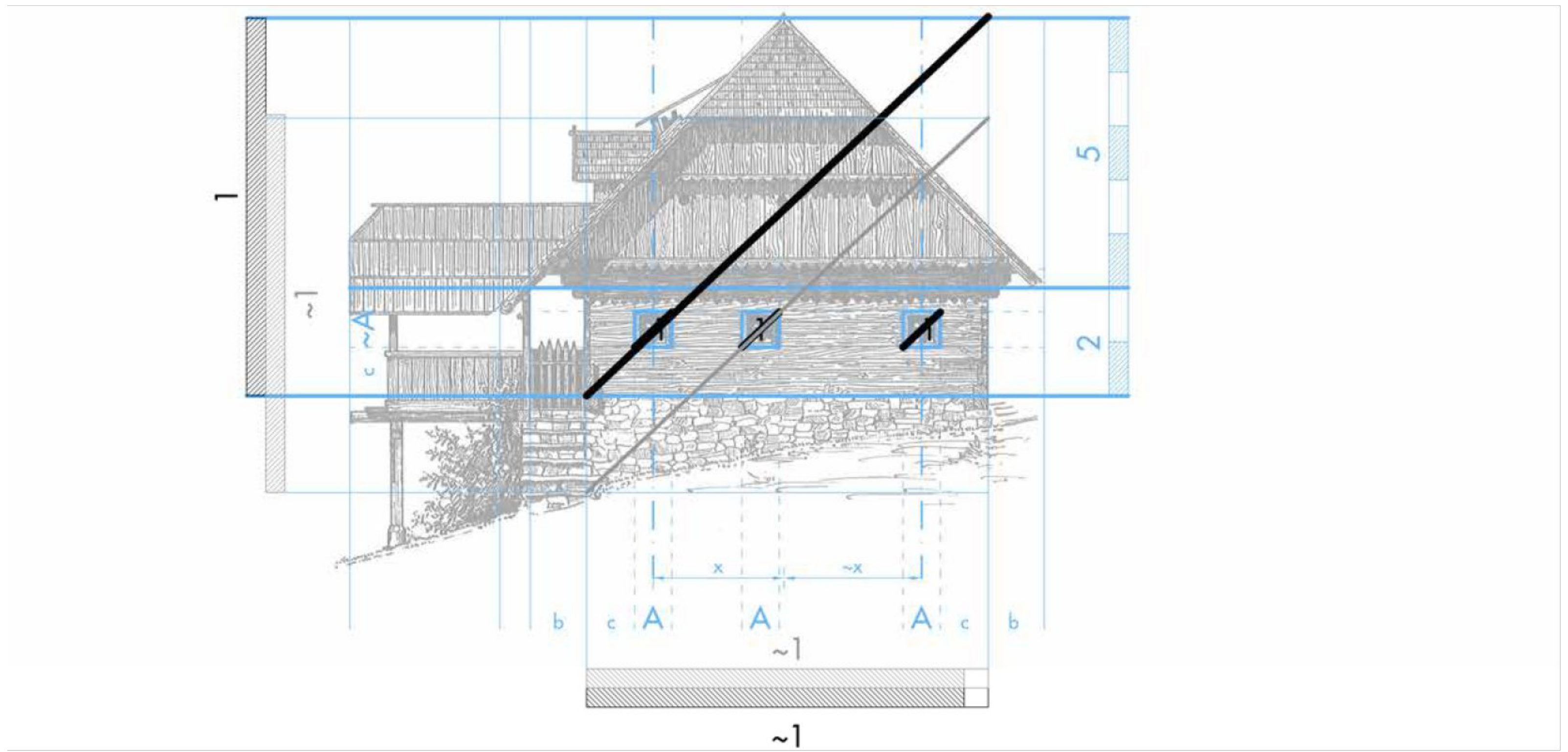


Fig. V.35 Geometrical analysis of openings: (S04) House Jakob Schweiger vulgo Gräsinger in Breitenau near Mixnitz



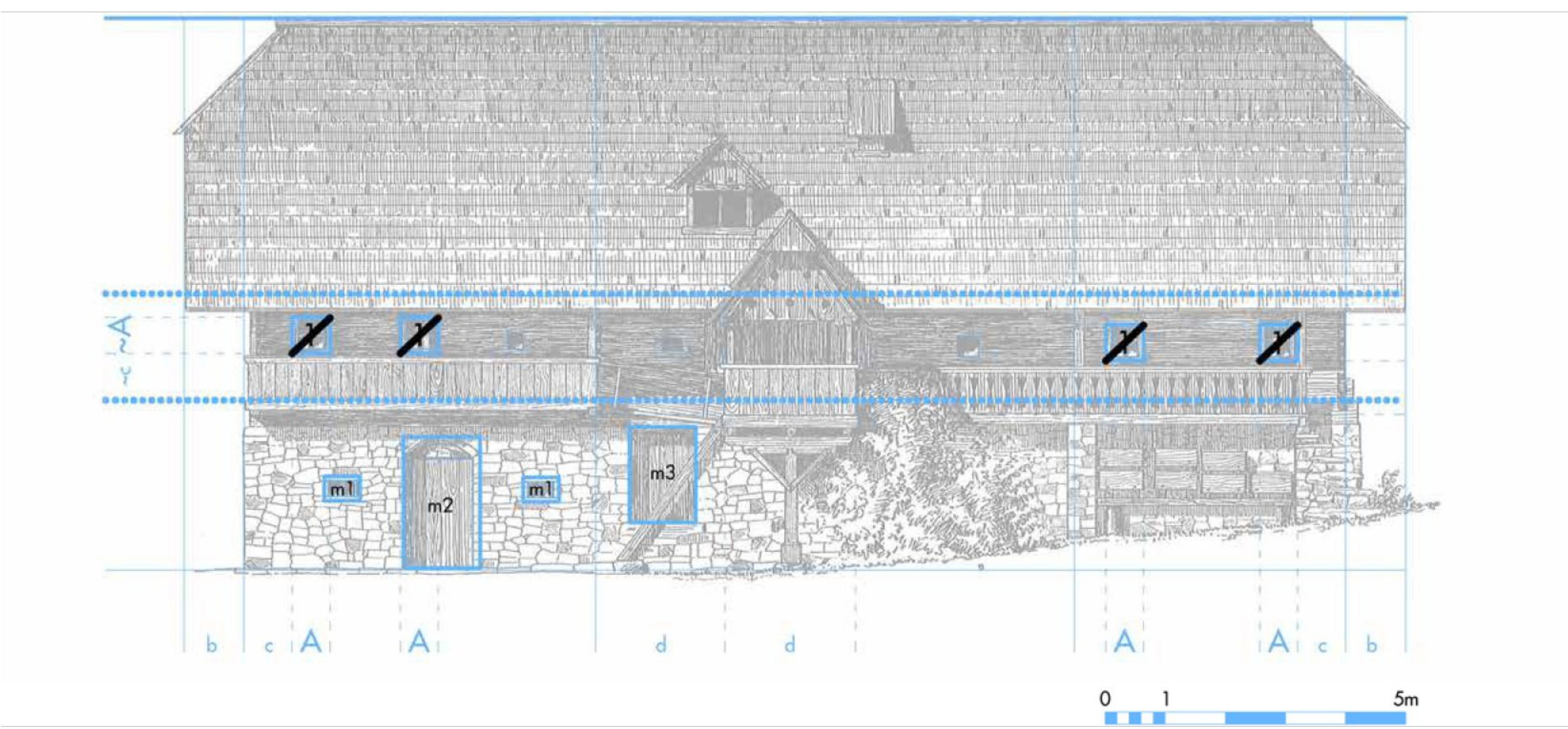


Fig. V.36 Geometrical analysis of front elevation: (S05) "Das Hübler-Haus"House No. 48 in Kemetberg near Köflach
Fig. V.37 Geometrical analysis of side elevation: (S05) "Das Hübler-Haus"House No. 48 in Kemetberg near Köflach

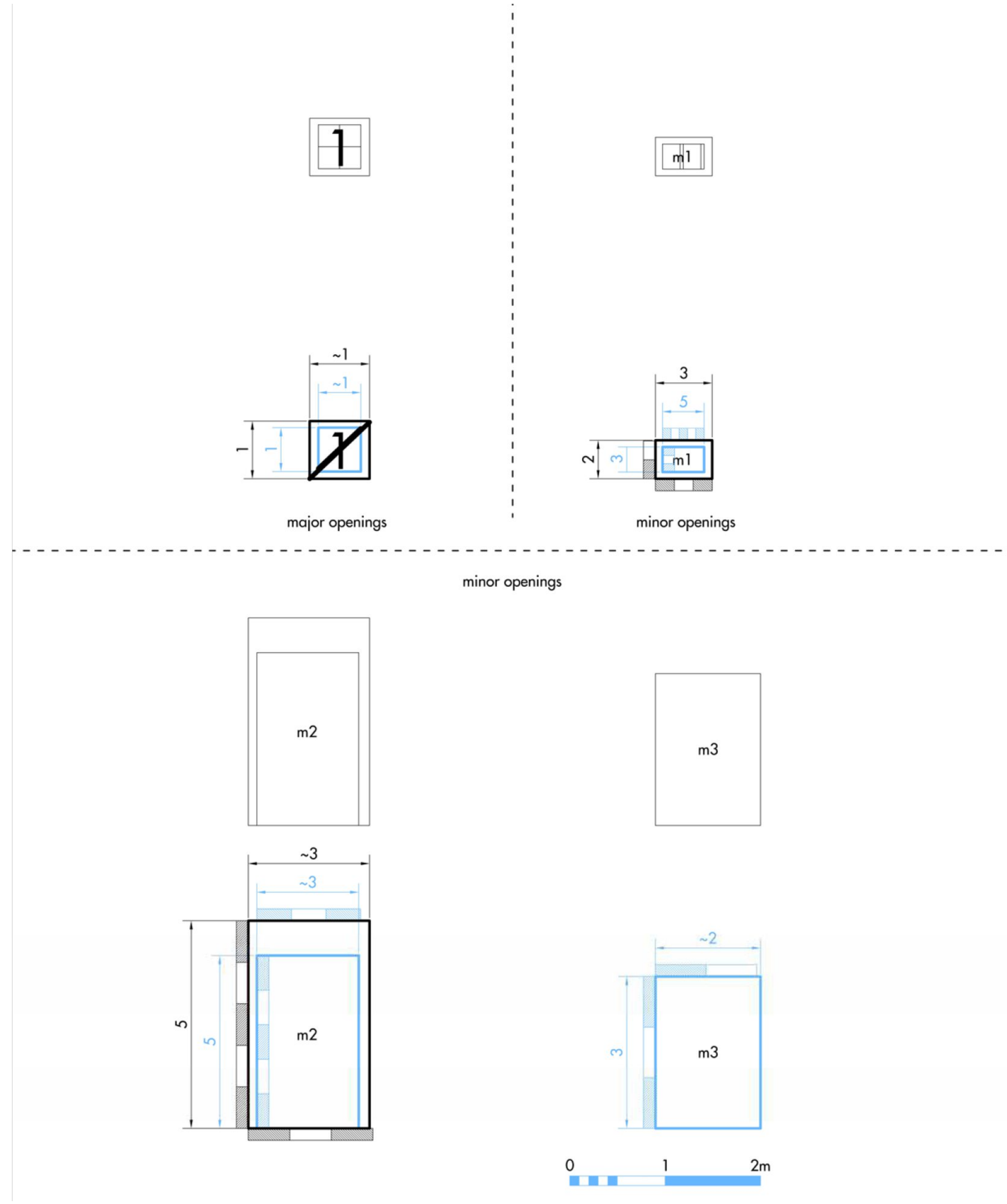
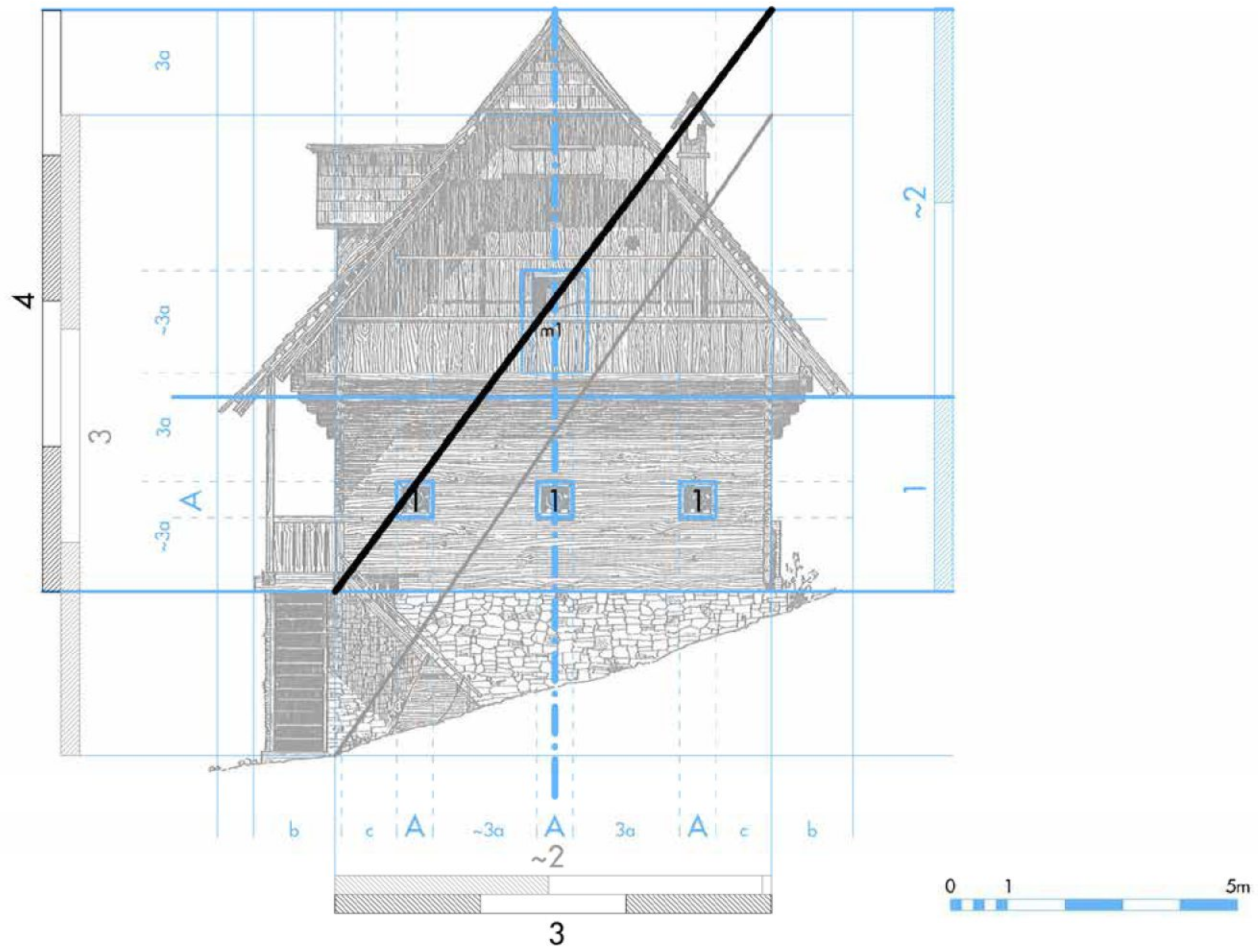


Fig. V.38 Geometrical analysis of openings: (S05) "Das Hübler-Haus"House No. 48 in Kemetberg near Köflach



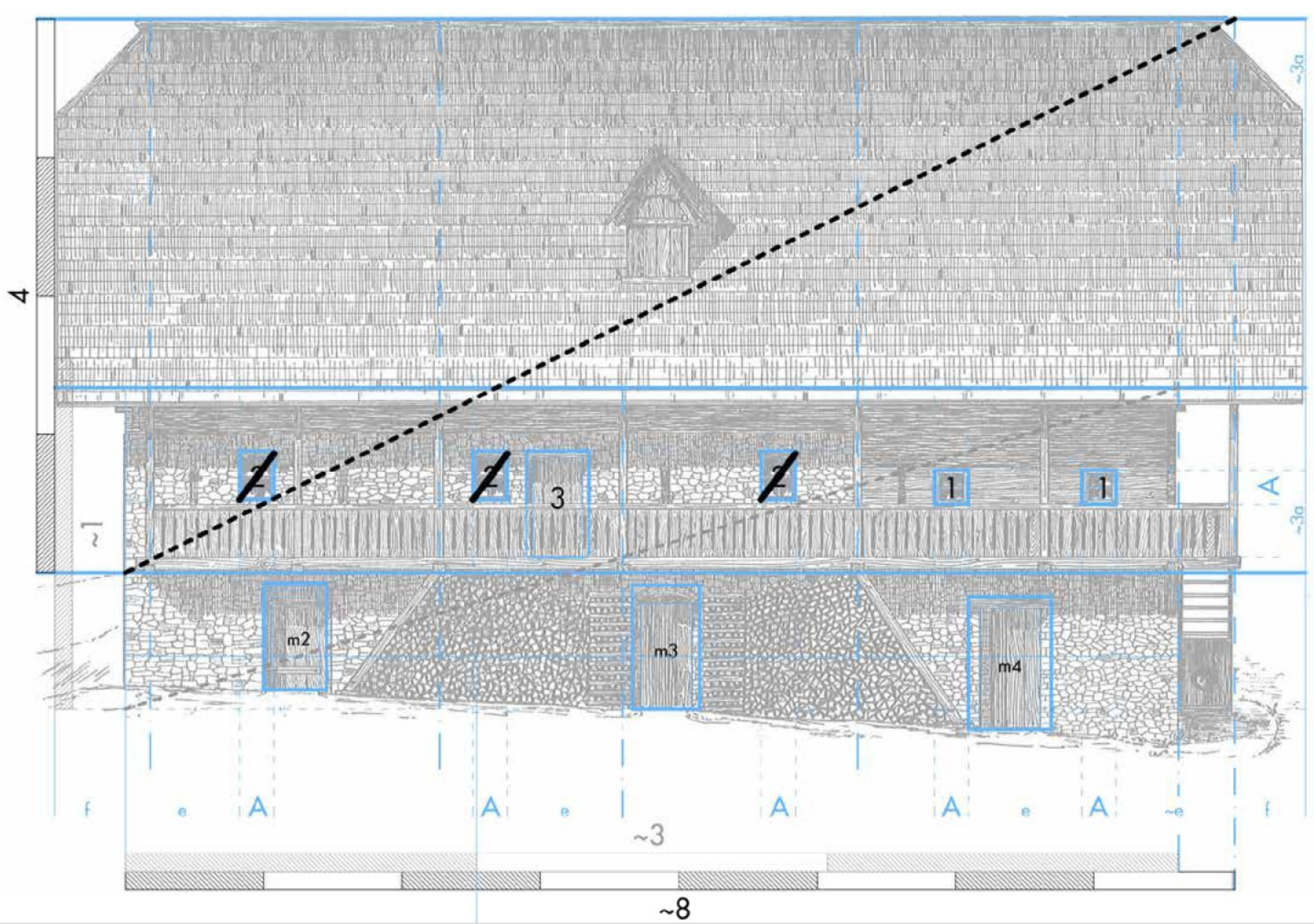


Fig. V.39 Geometrical analysis of front elevation: (S06) "Das Jud-Haus" House No. 46 in Kemetberg near Köflach
Fig. V.40 Geometrical analysis of side elevation: (S06) "Das Jud-Haus" House No. 46 in Kemetberg near Köflach

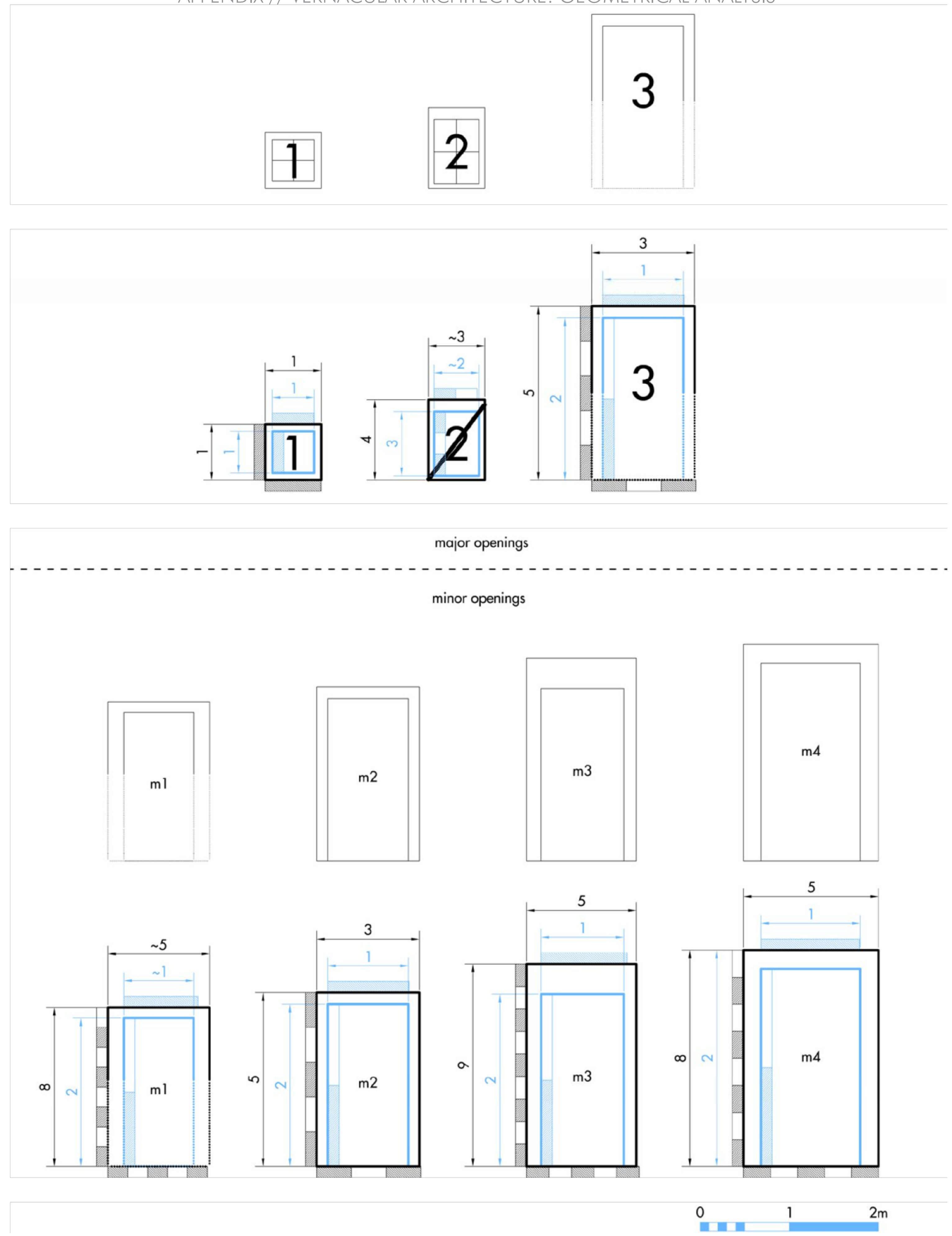
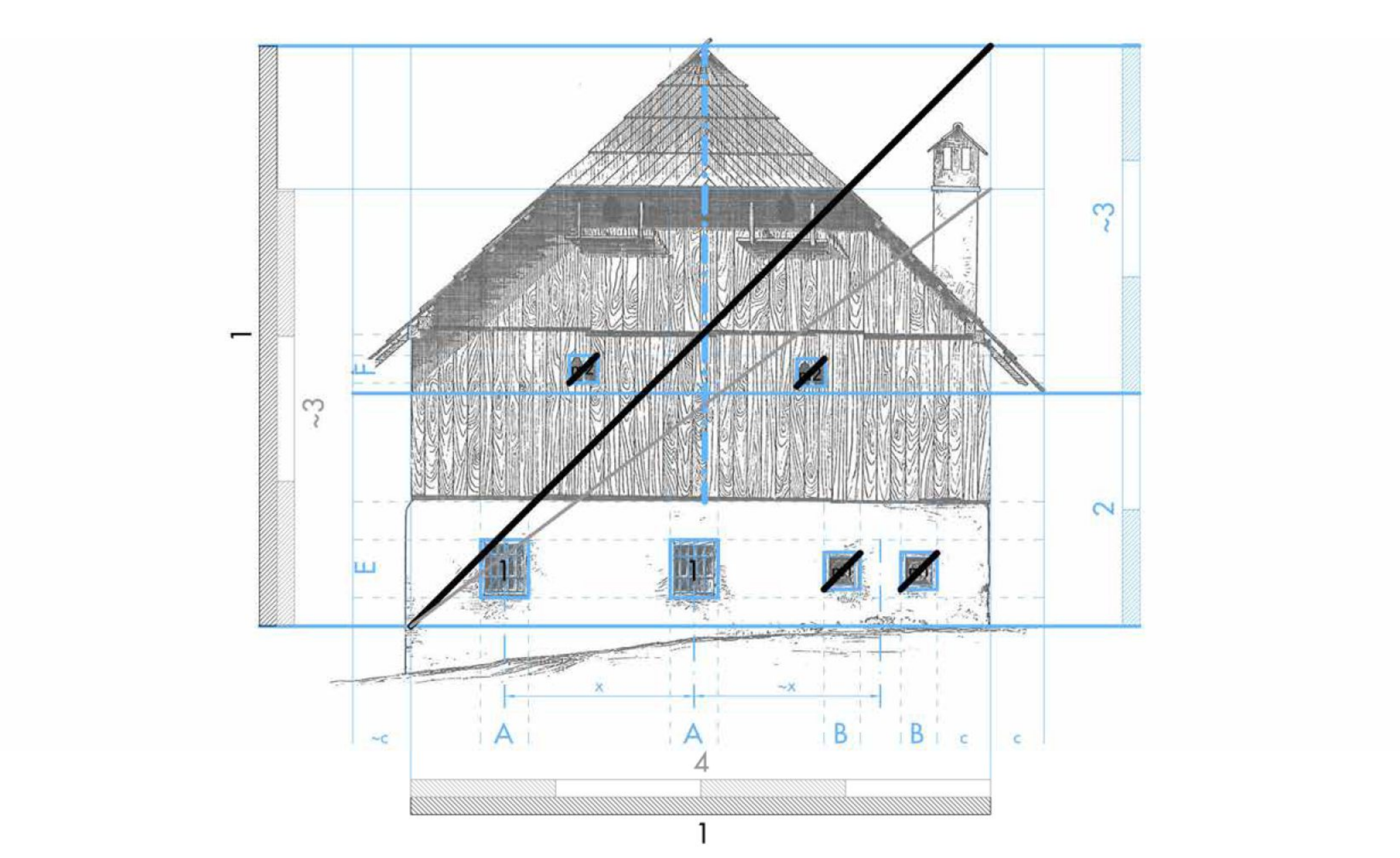


Fig. V.41 Geometrical analysis of openings: (S06) "Das Jud-Haus" House No. 46 in Kemetberg near Köflach



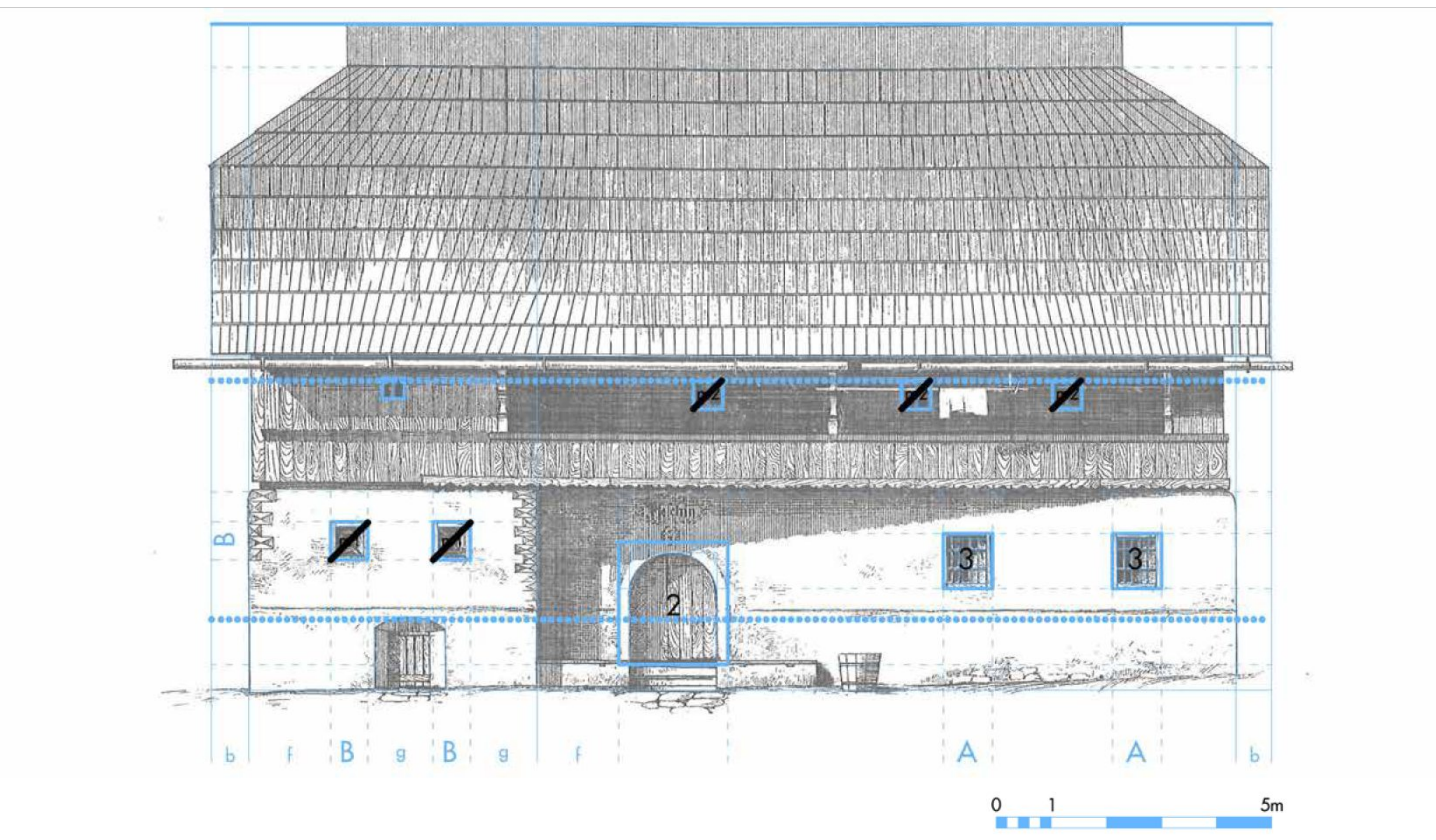


Fig. V.42 Geometrical analysis of front elevation: (C01) "Pleschinhaus", House No. 1 in Agoritschach near Arnoldstein in Gailthale

Fig. V.43 Geometrical analysis of side elevation: (C01) "Pleschinhaus", House No. 1 in Agoritschach near Arnoldstein in Gailthale

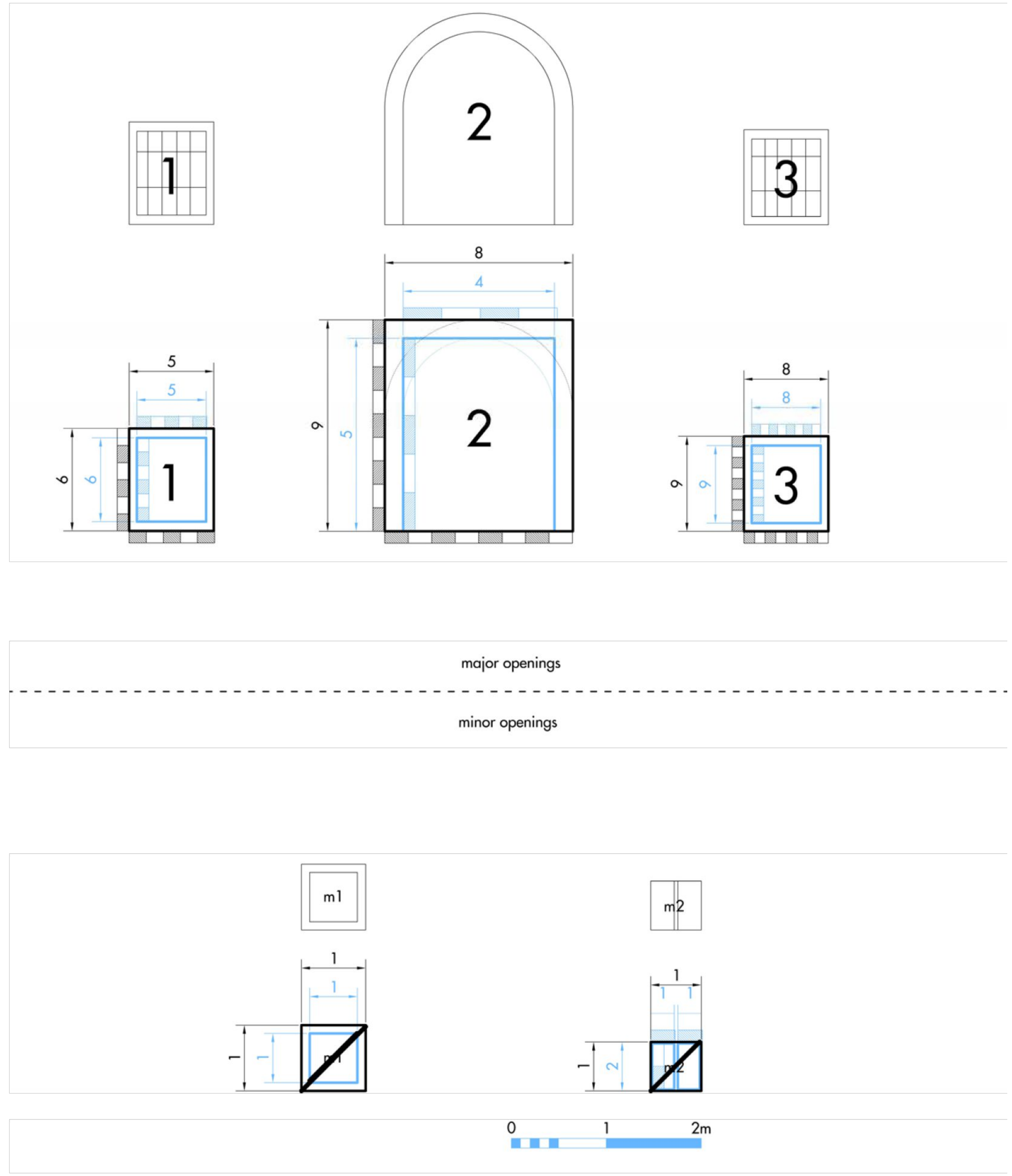
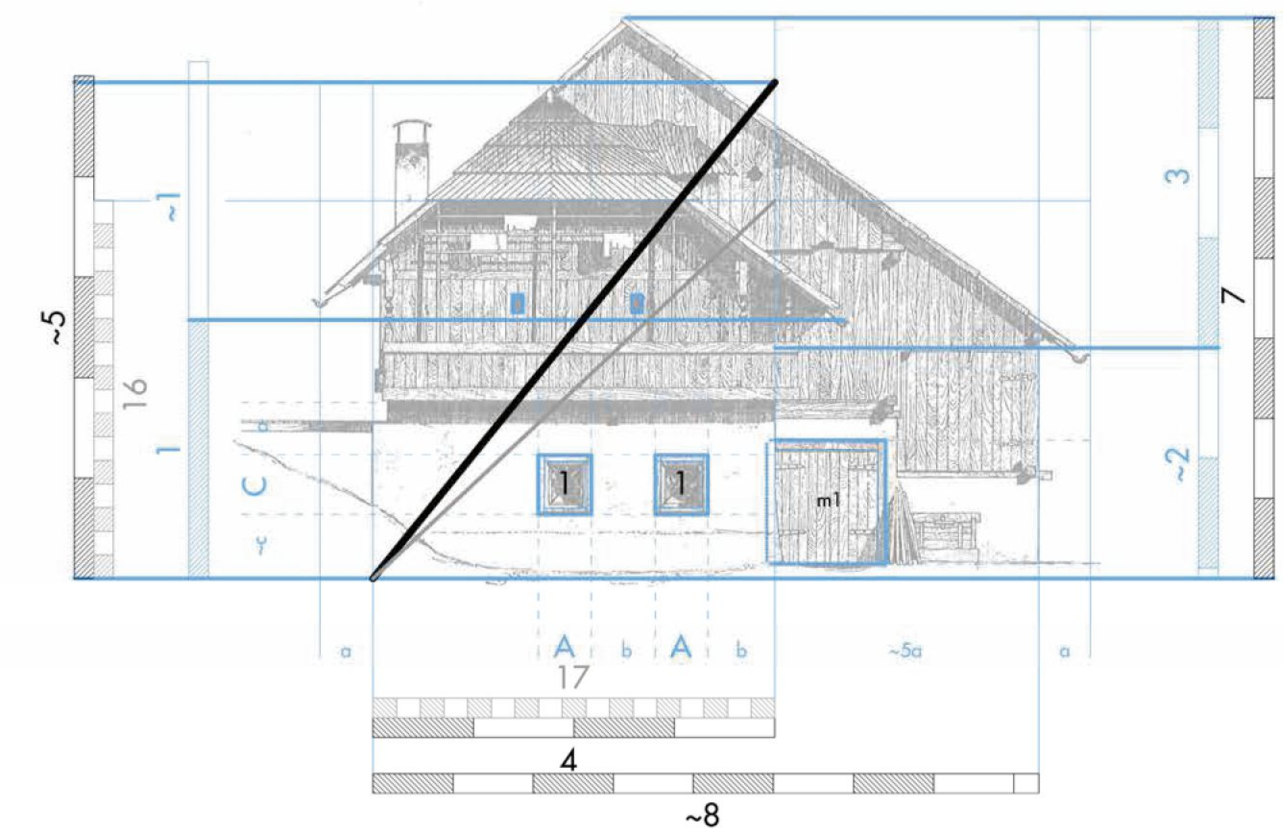


Fig. V.44 Geometrical analysis of openings: (C01) "Pleschinhaus", House No. 1 in Agoritschach near Arnoldstein in Gailthale



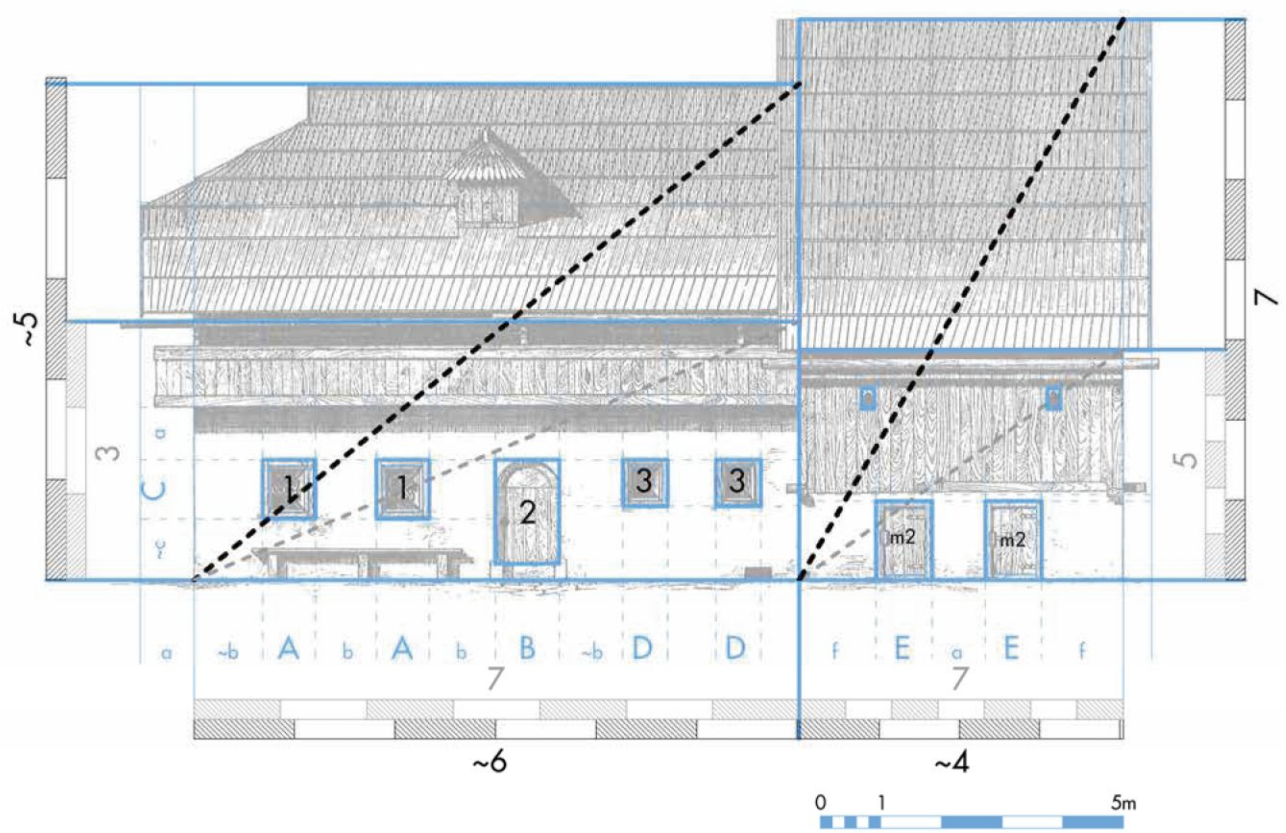


Fig. V.45 Geometrical analysis of front elevation: (C02) "Unterdebernigg-Keusche", House No. 14 in Pöckau near Arnoldstein in Gailthale
Fig. V.46 Geometrical analysis of side elevation: (C02) "Unterdebernigg-Keusche", House No. 14 in Pöckau near Arnoldstein in Gailthale

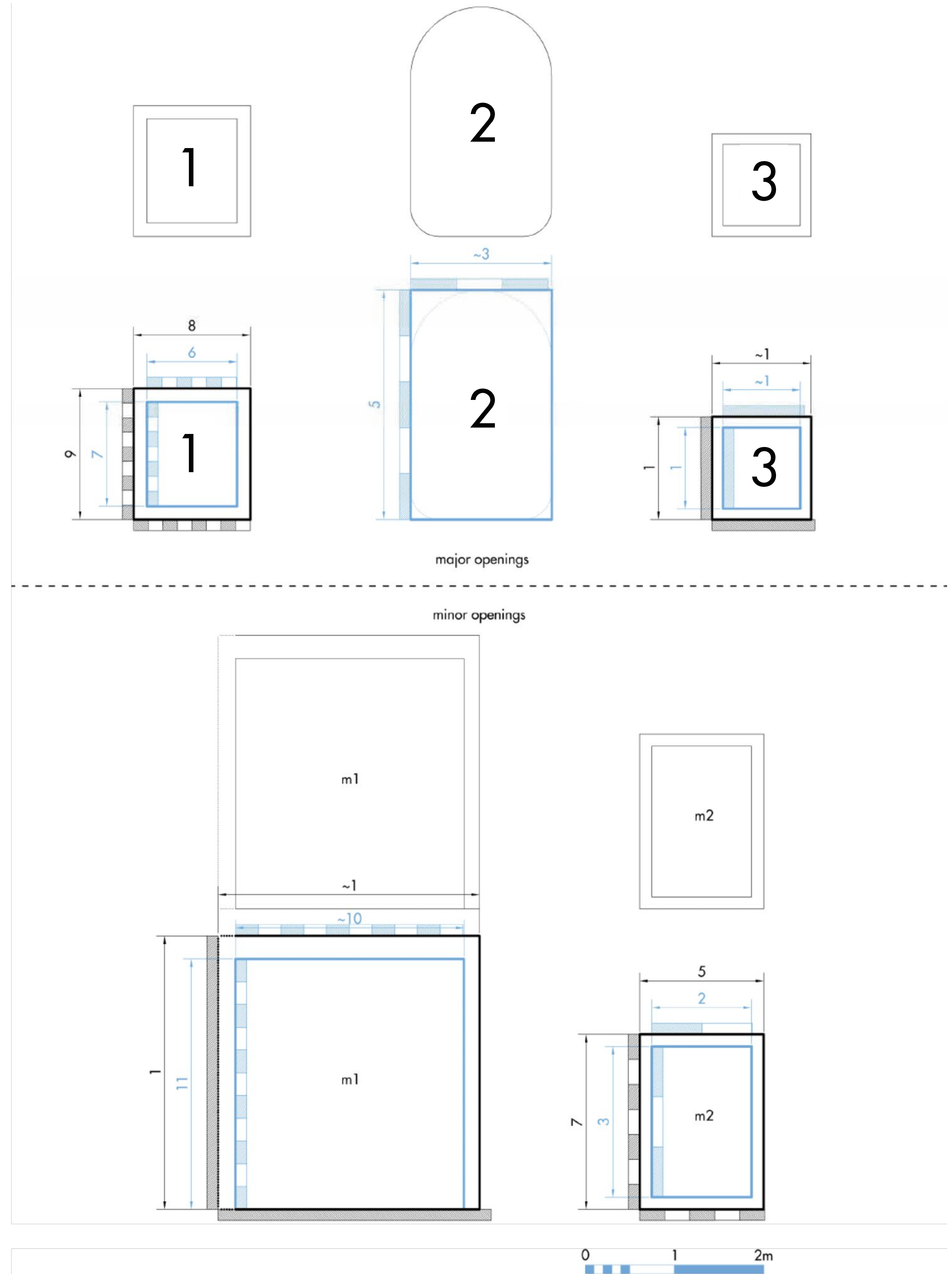
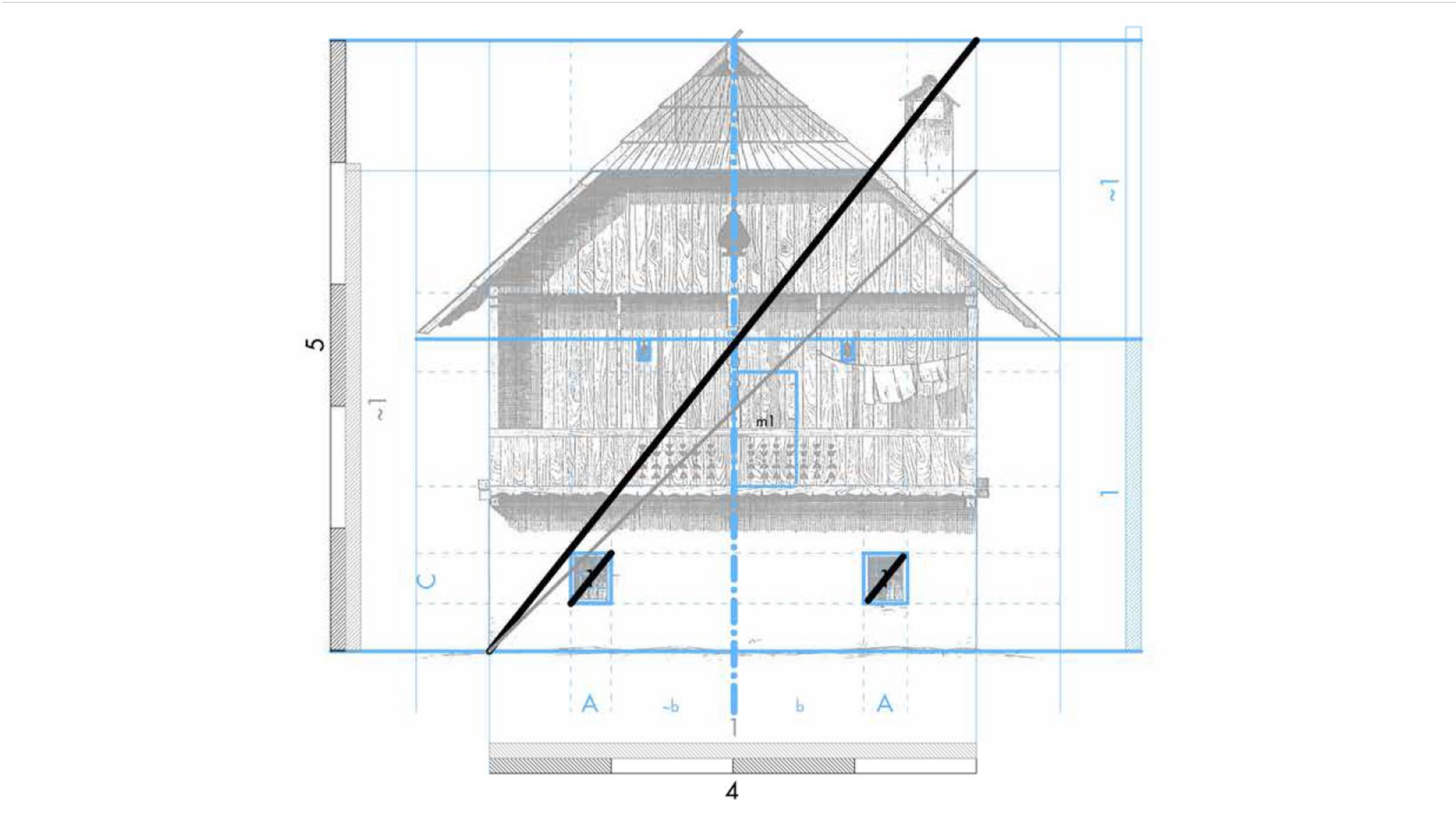


Fig. V.47 Geometrical analysis of openings: (C02) "Unterdebernigg-Keusche", House No. 14 in Pöckau near Arnoldstein in Gailthale



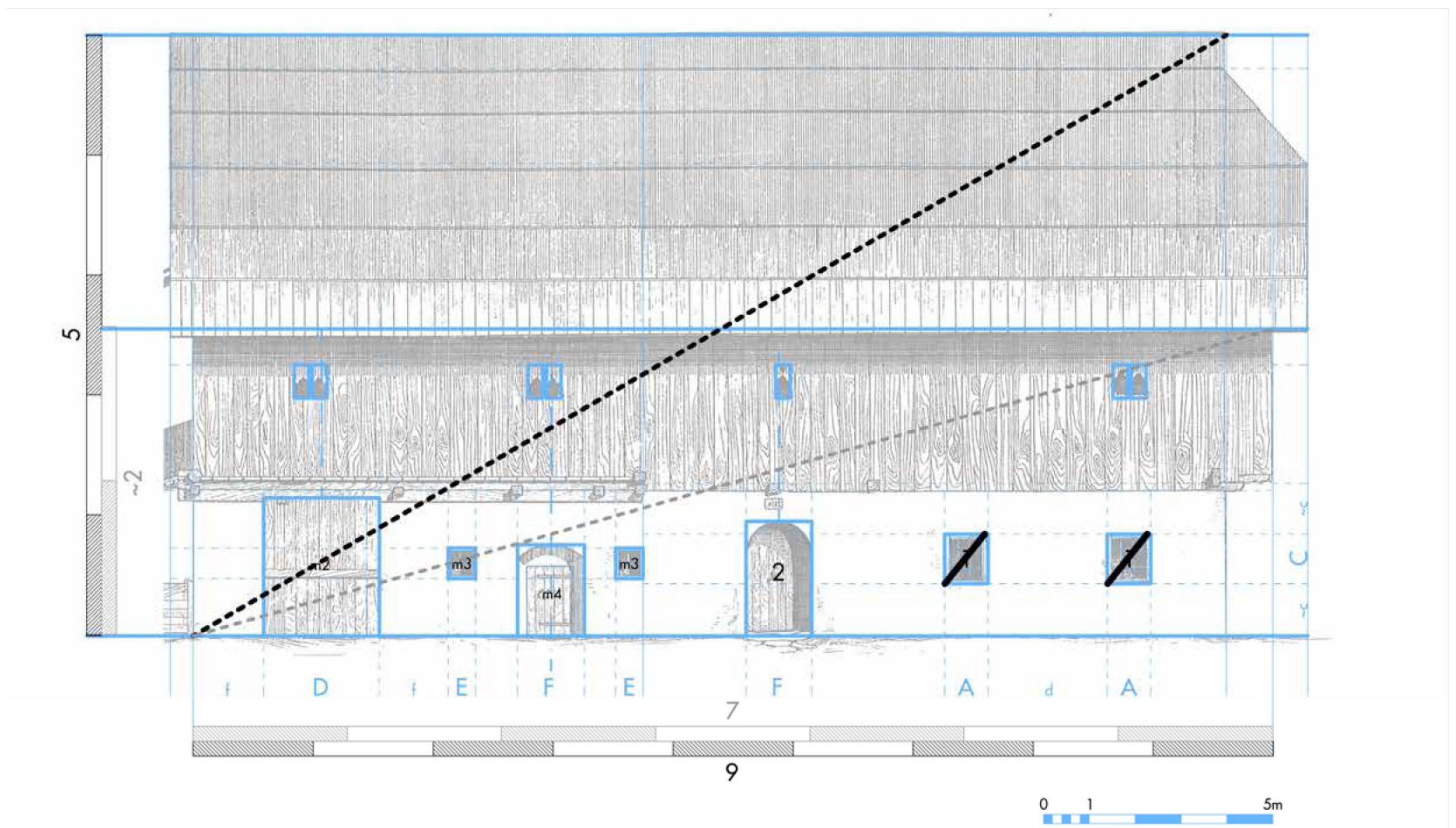


Fig. V.48 Geometrical analysis of front elevation: (C03) "Das Winteritschhaus", House No. 12
Fig. V.49 Geometrical analysis of side elevation: (C03) "Das Winteritschhaus", House No. 12

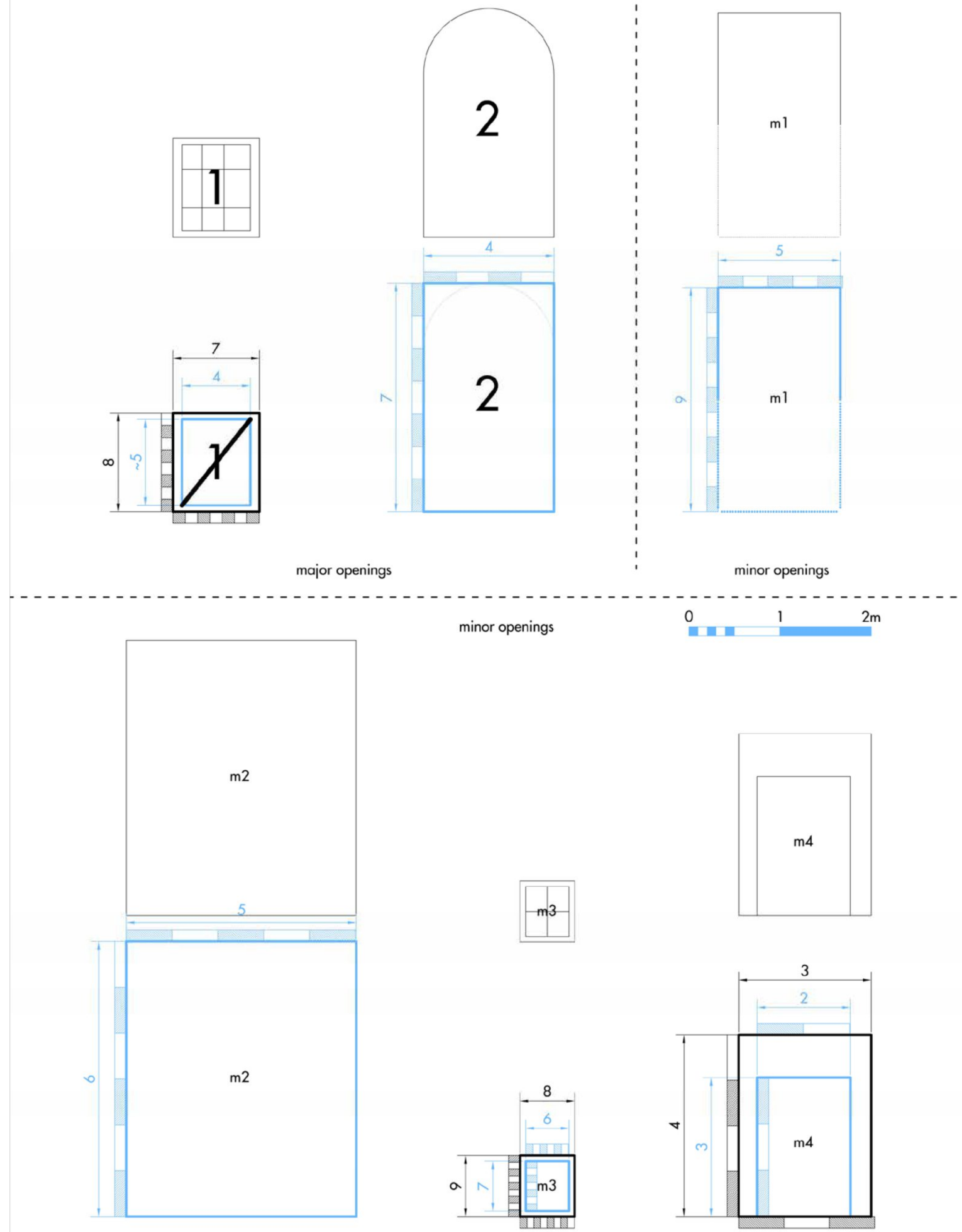
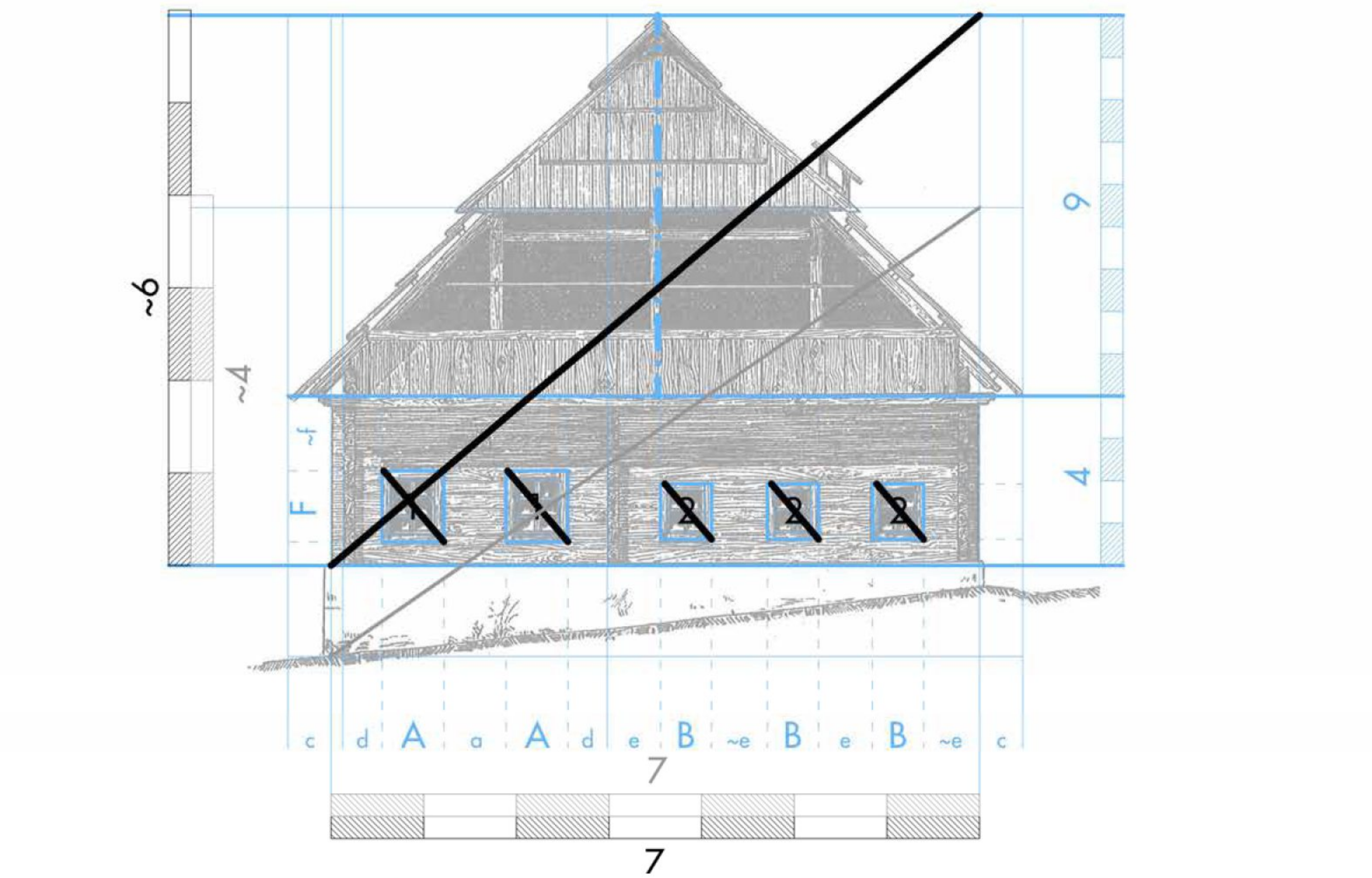


Fig. V.50 Geometrical analysis of openings: (C03) "Das Winteritschhaus", House No. 12



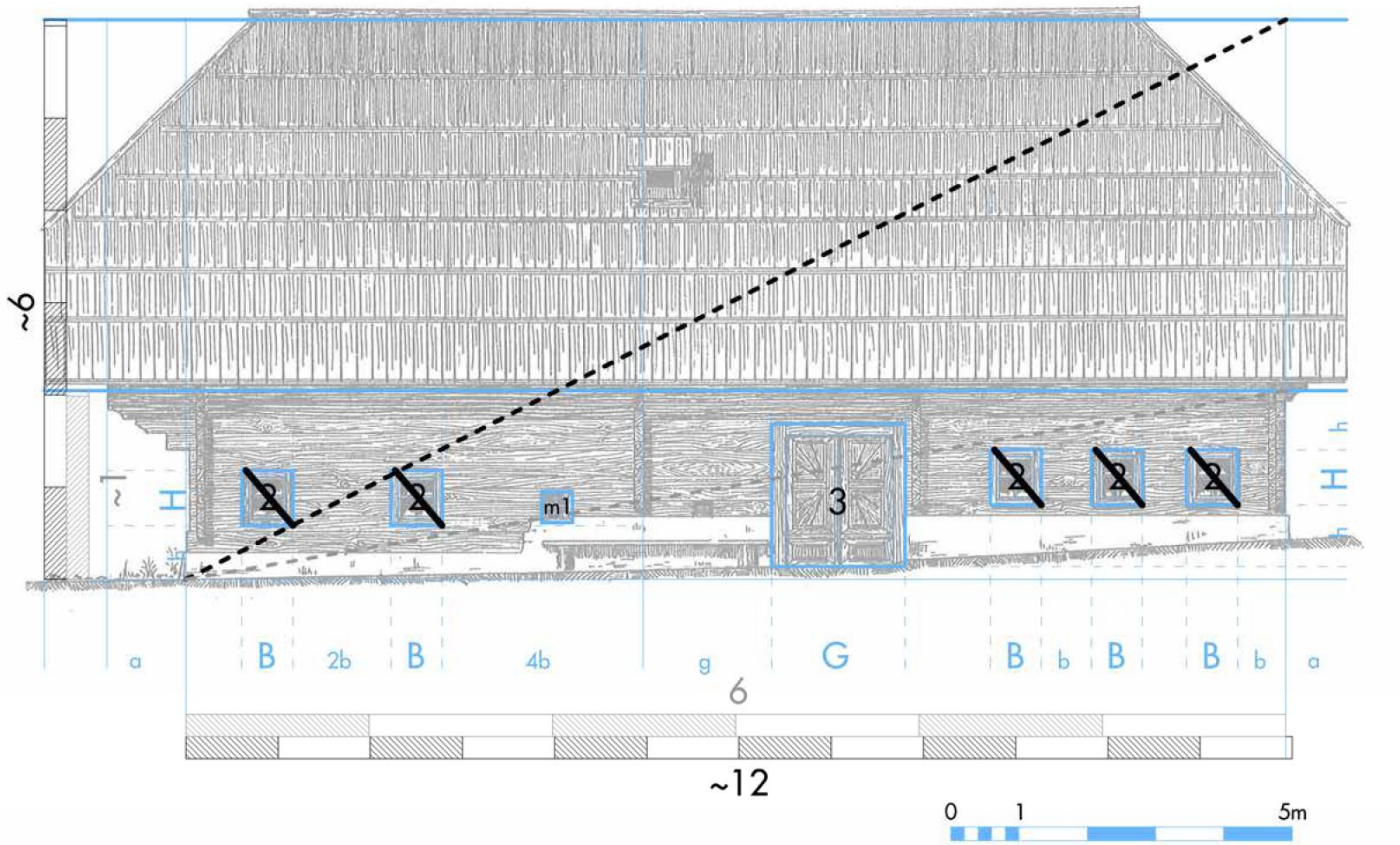


Fig. V.51 Geometrical analysis of front elevation: (C04) "Das Sank-Haus", house No. 4 in Gritschach near Millstätter lake

Fig. V.52 Geometrical analysis of side elevation: (C04) "Das Sank-Haus", house No. 4 in Gritschach near Millstätter lake

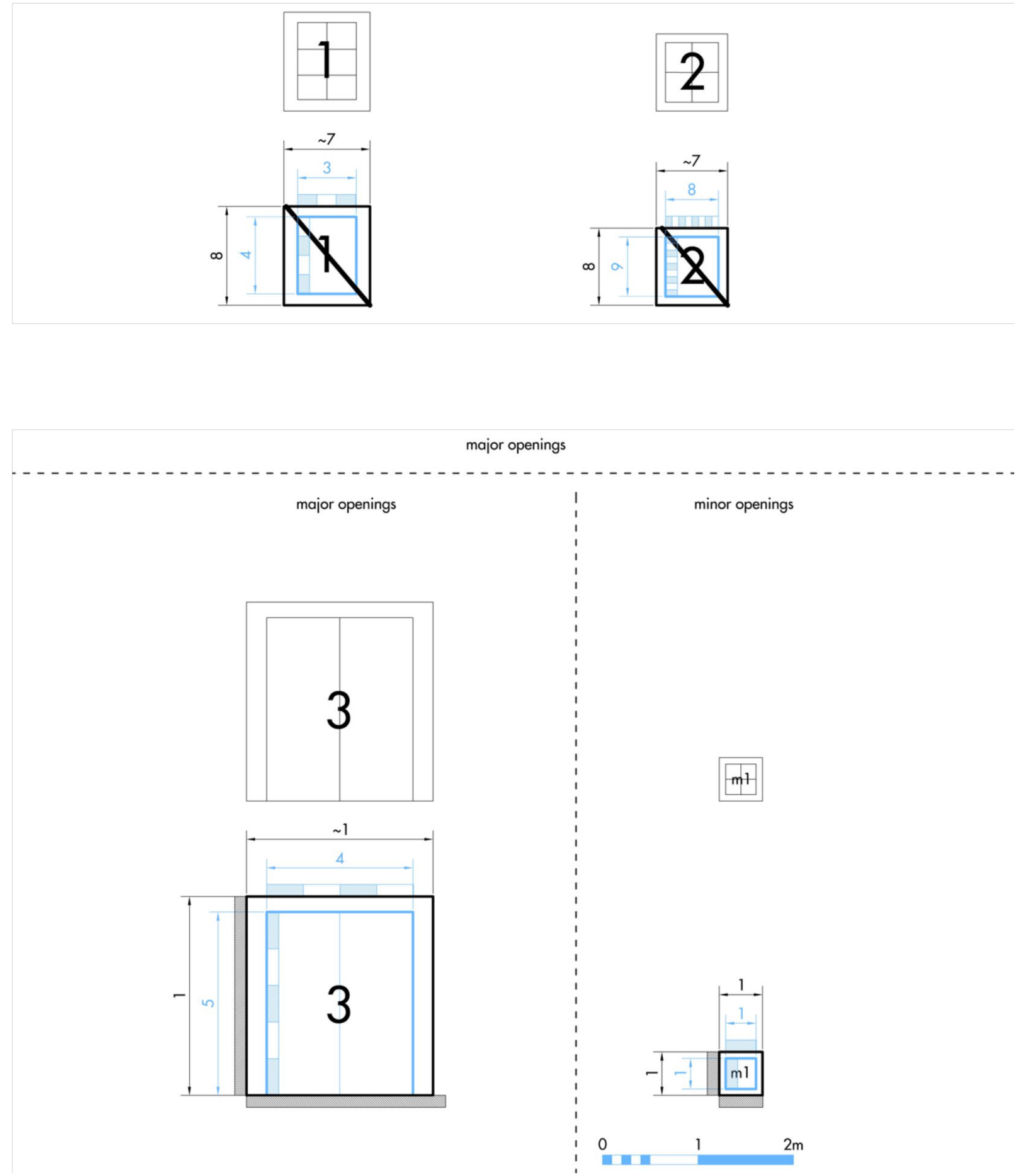
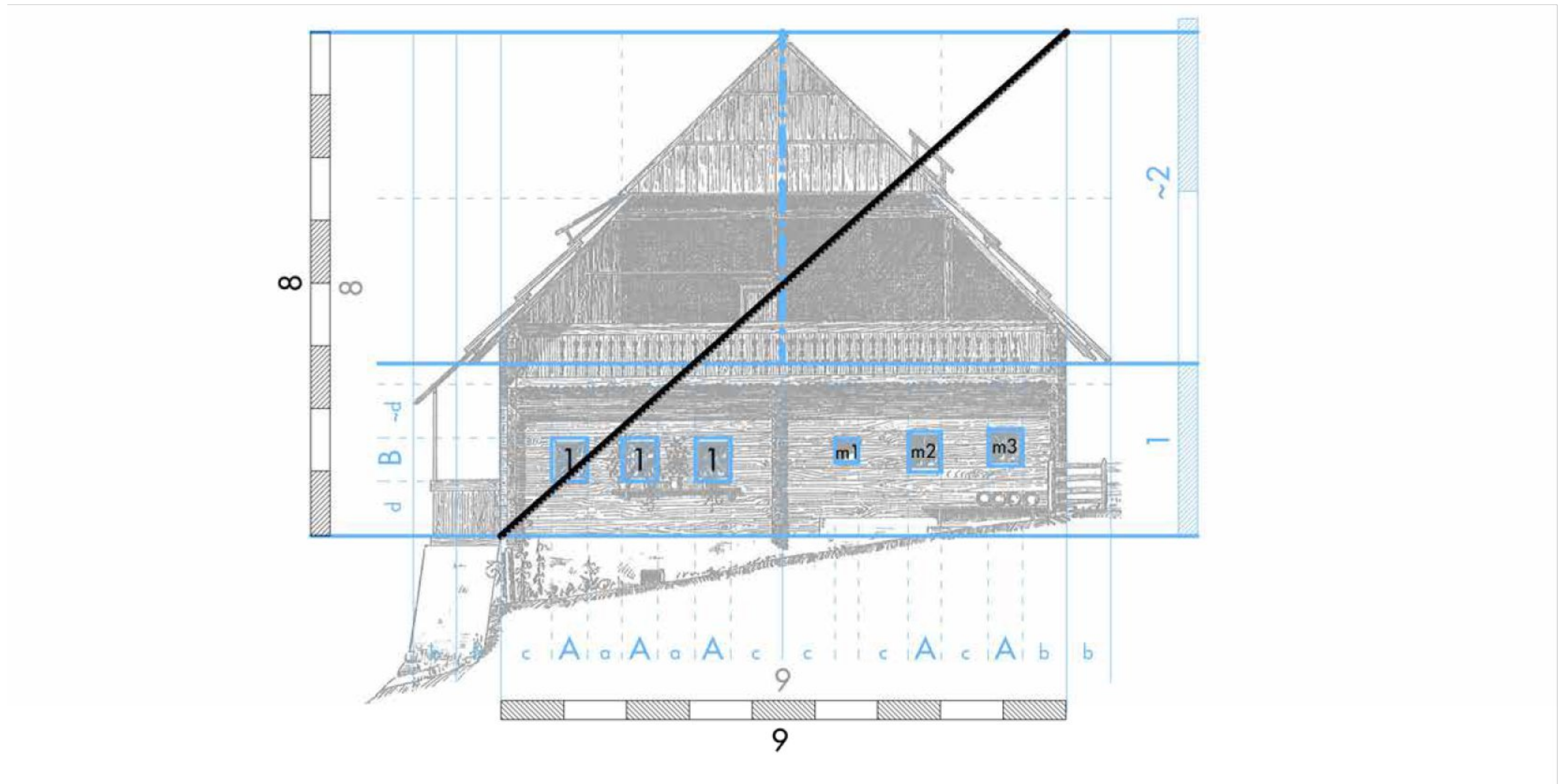


Fig. V.53 Geometrical analysis of openings: (C04) "Das Sank-Haus", house No. 4 in Gritschach near Millstätter lake



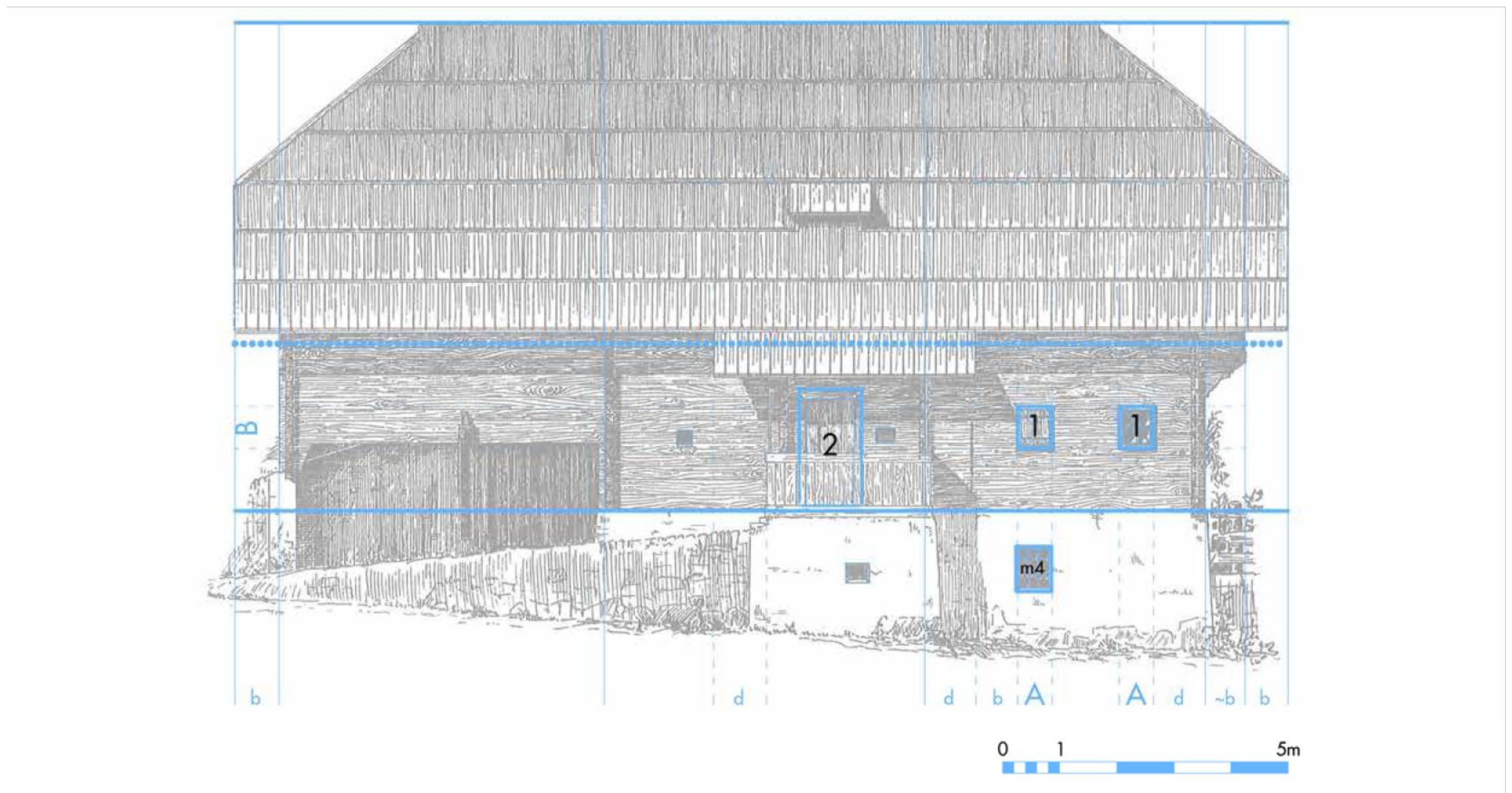


Fig. V.54 Geometrical analysis of front elevation: (C05) "Rumpler-Keusche", House No. 7 in Kraut near Millstätter lake
Fig. V.55 Geometrical analysis of side elevation: (C05) "Rumpler-Keusche", House No. 7 in Kraut near Millstätter lake

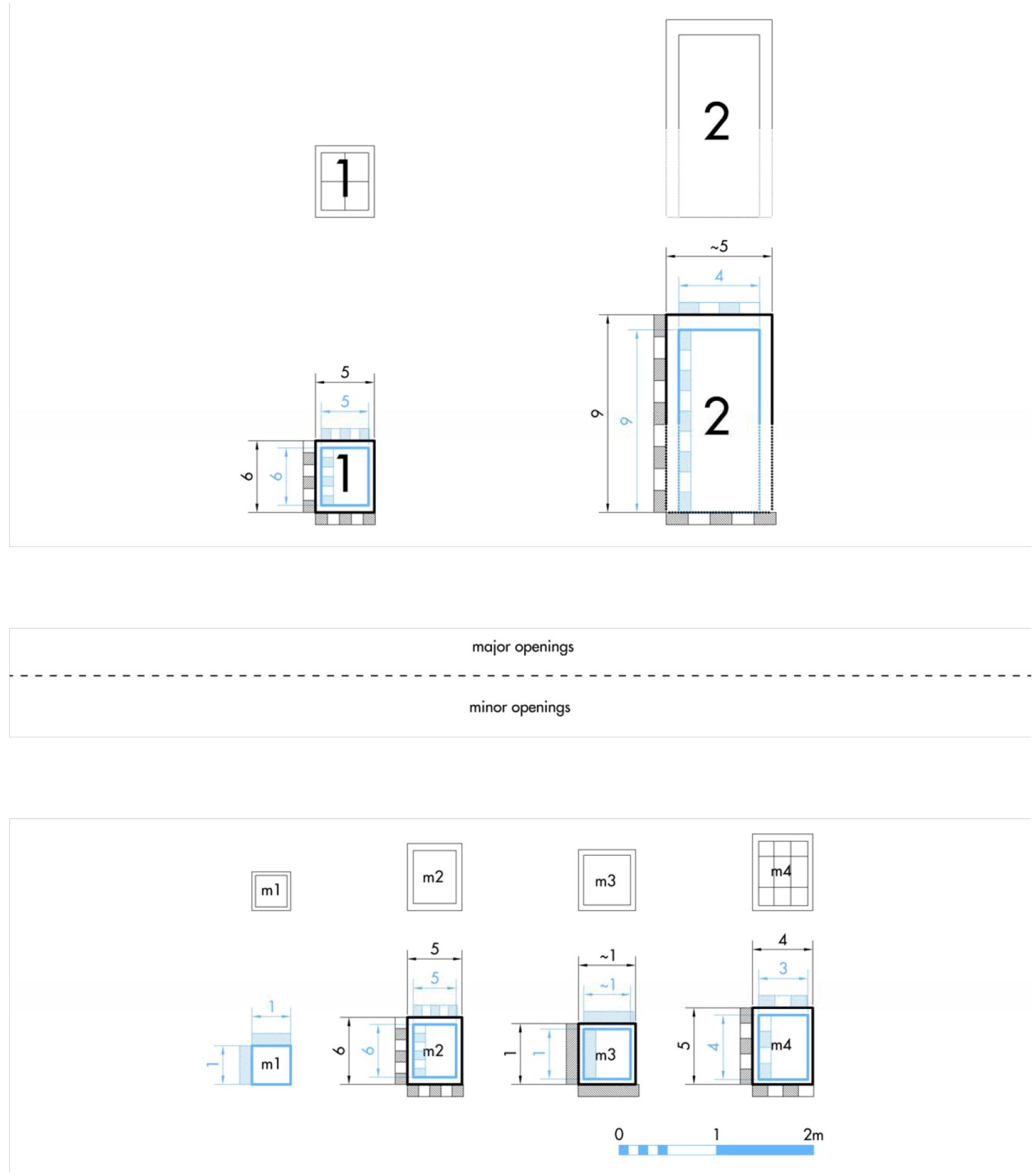
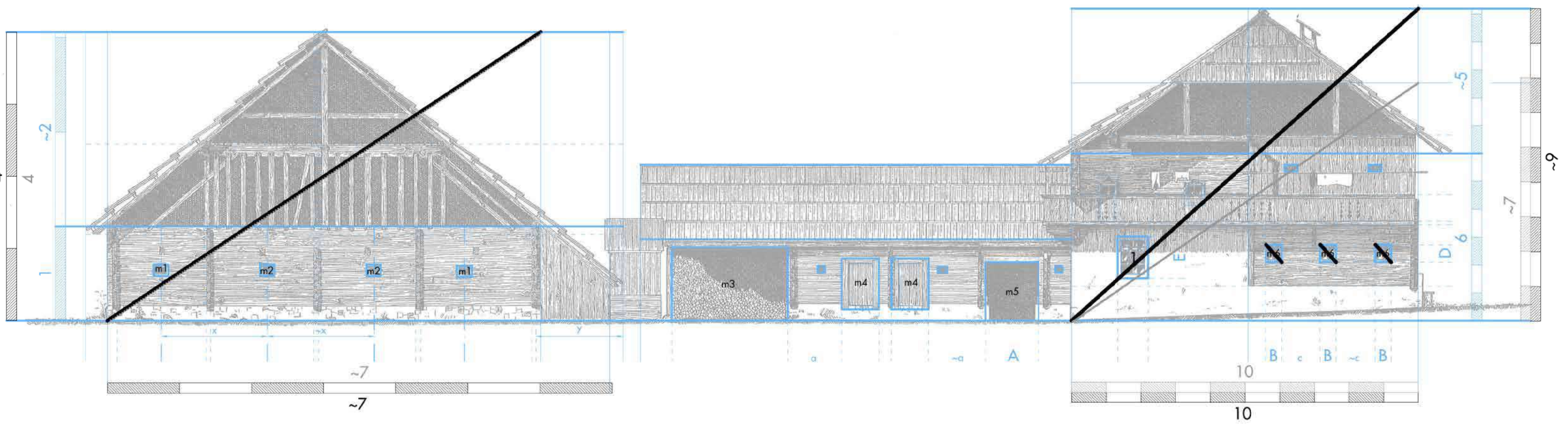
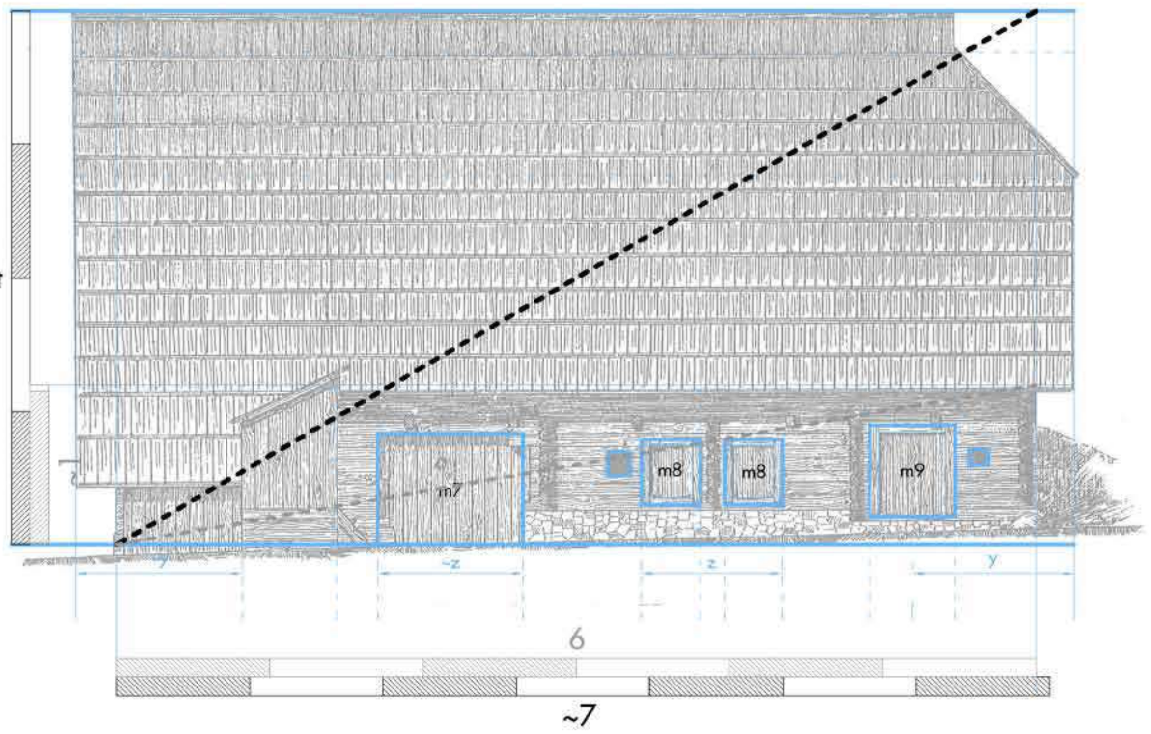


Fig. V.56 Geometrical analysis of openings: (C05) "Rumpler-Keusche", House No. 7 in Kraut near Millstätter lake





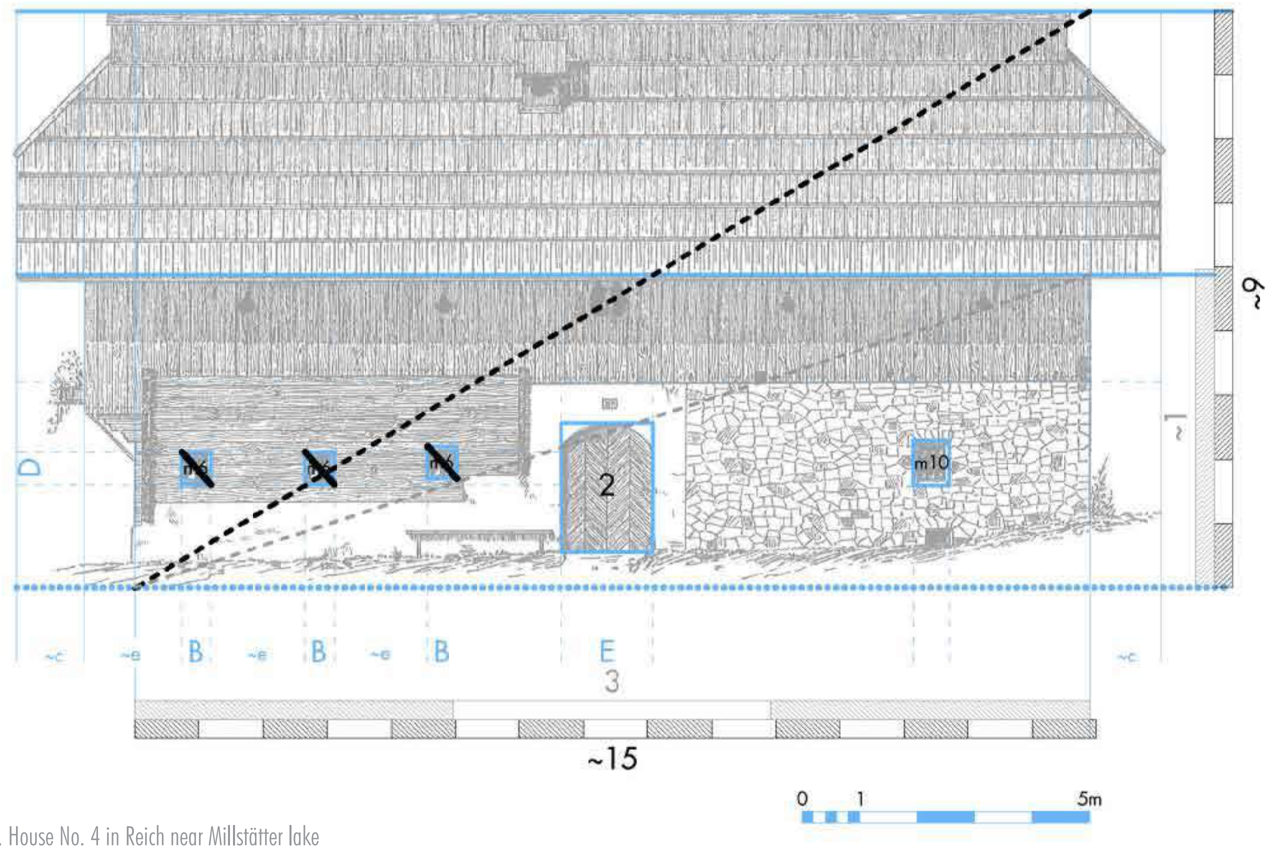


Fig. V.57 Geometrical analysis of front elevation: (C06) "Das Winkler-Haus", House No. 4 in Reich near Millstätter lake
Fig. V.58 Geometrical analysis of side elevation: (C06) "Das Winkler-Haus", House No. 4 in Reich near Millstätter lake
Fig. V.59 Geometrical analysis of side elevation: (C06) "Das Winkler-Haus", House No. 4 in Reich near Millstätter lake

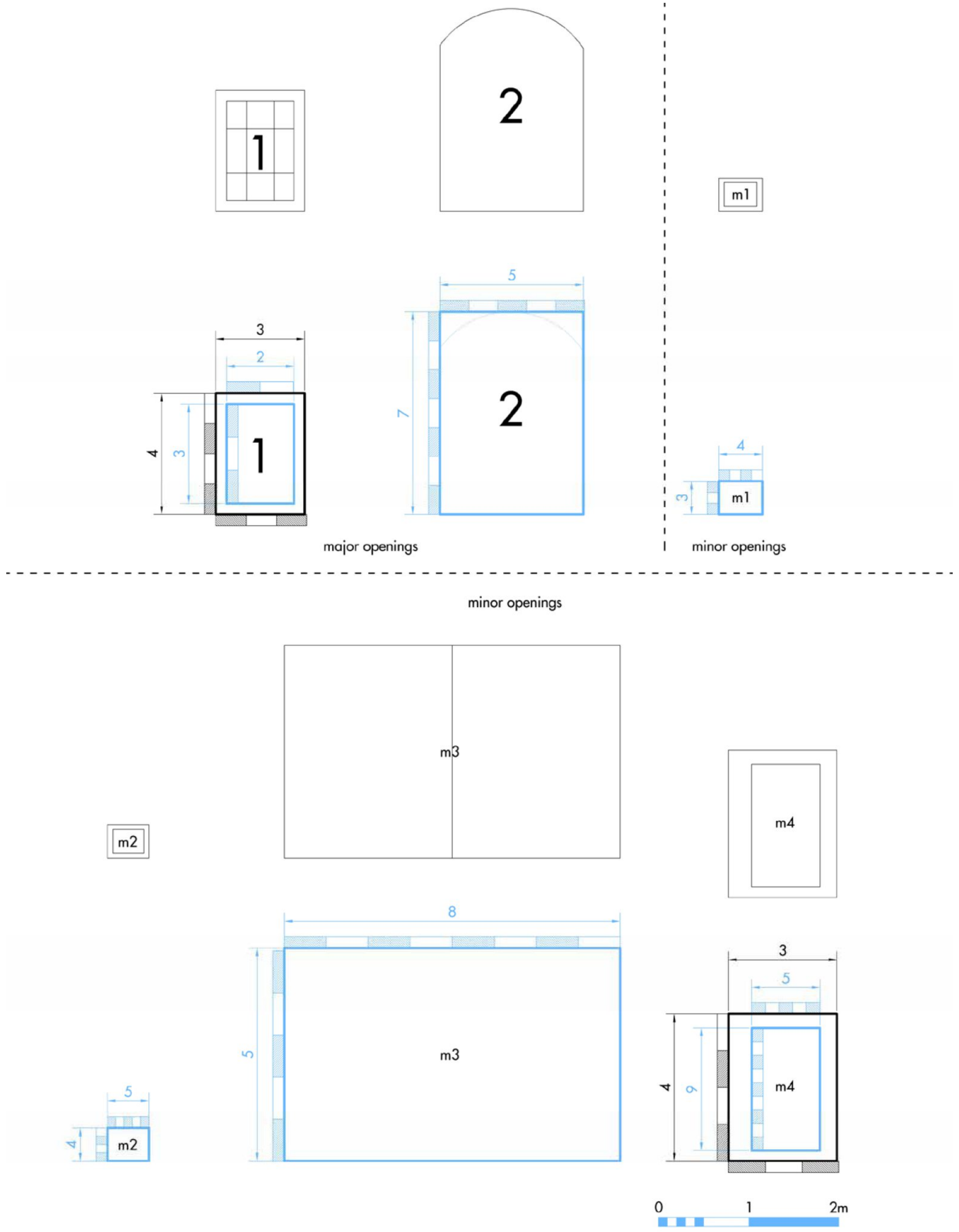


Fig. V.60 Geometrical analysis of openings: (C06) "Das Winkler-Haus", House No. 4 in Reich near Millstätter lake

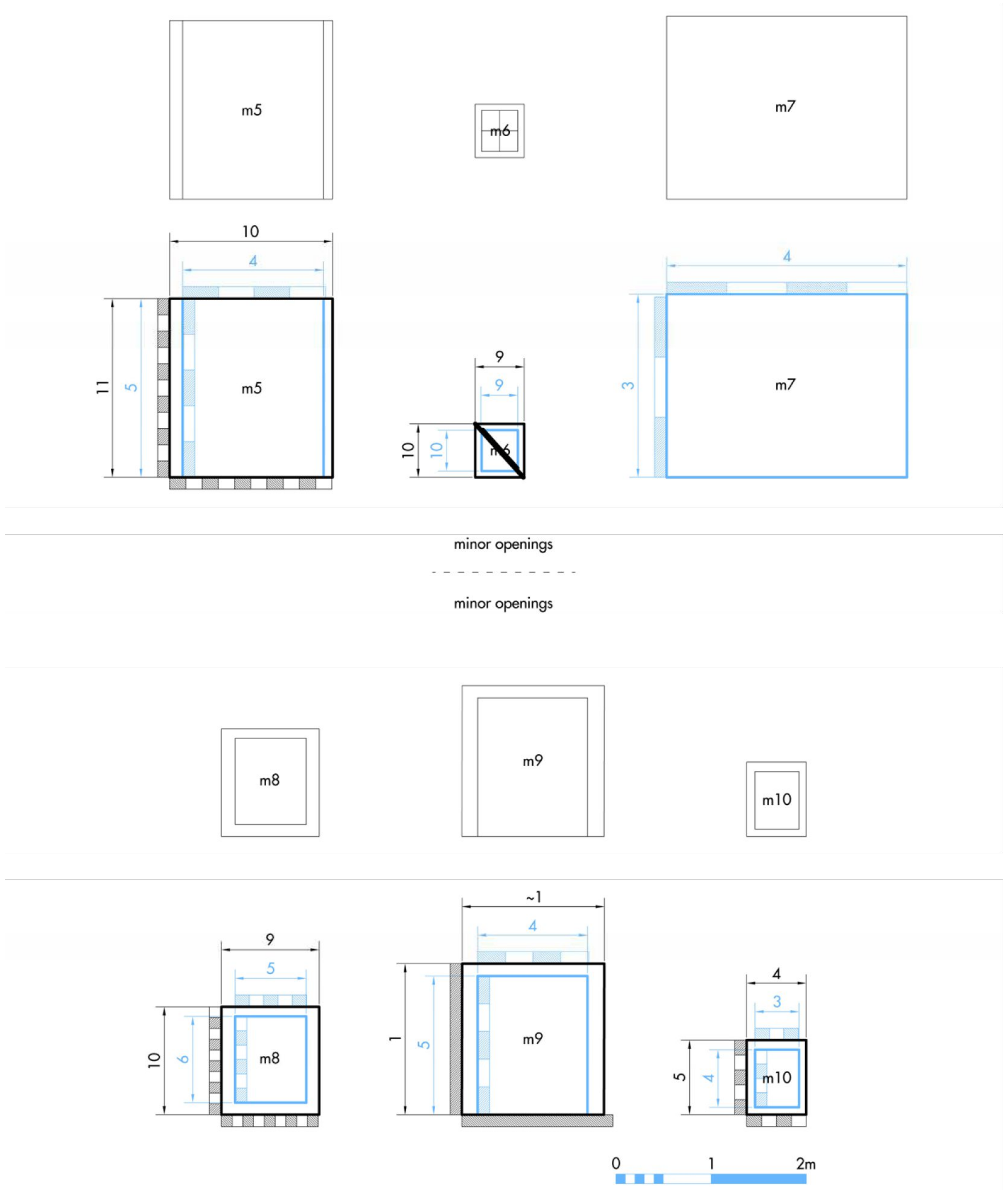


Fig. V.61 Geometrical analysis of openings: (C06) "Das Winkler-Haus", House No. 4 in Reich near Millstätter lake

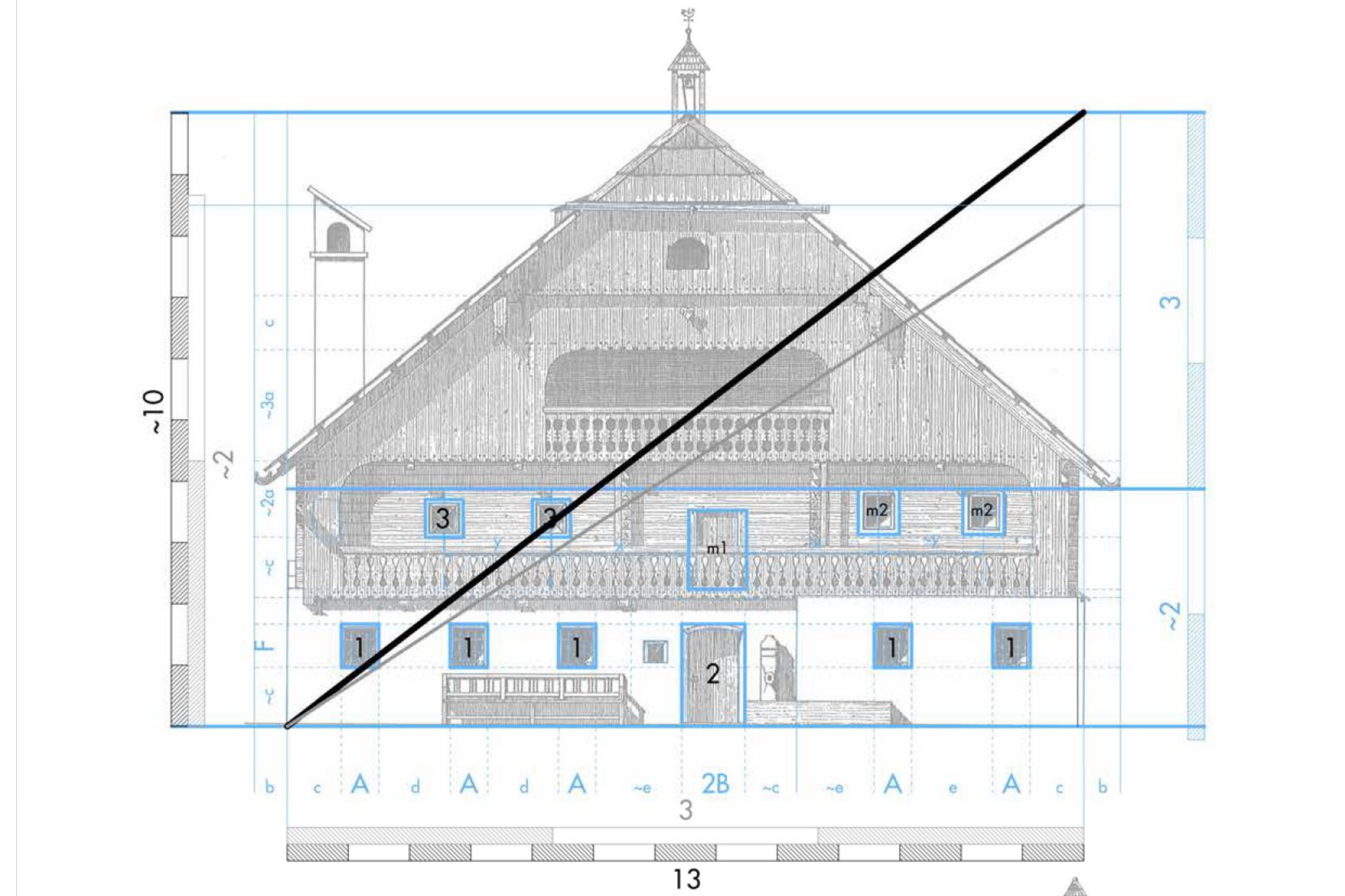


Fig. V.62 Geometrical analysis of front elevation: (Sa01) "Ernstgut" in Fanning
Fig. V.63 Geometrical analysis of side elevation: (Sa01) "Ernstgut" in Fanning

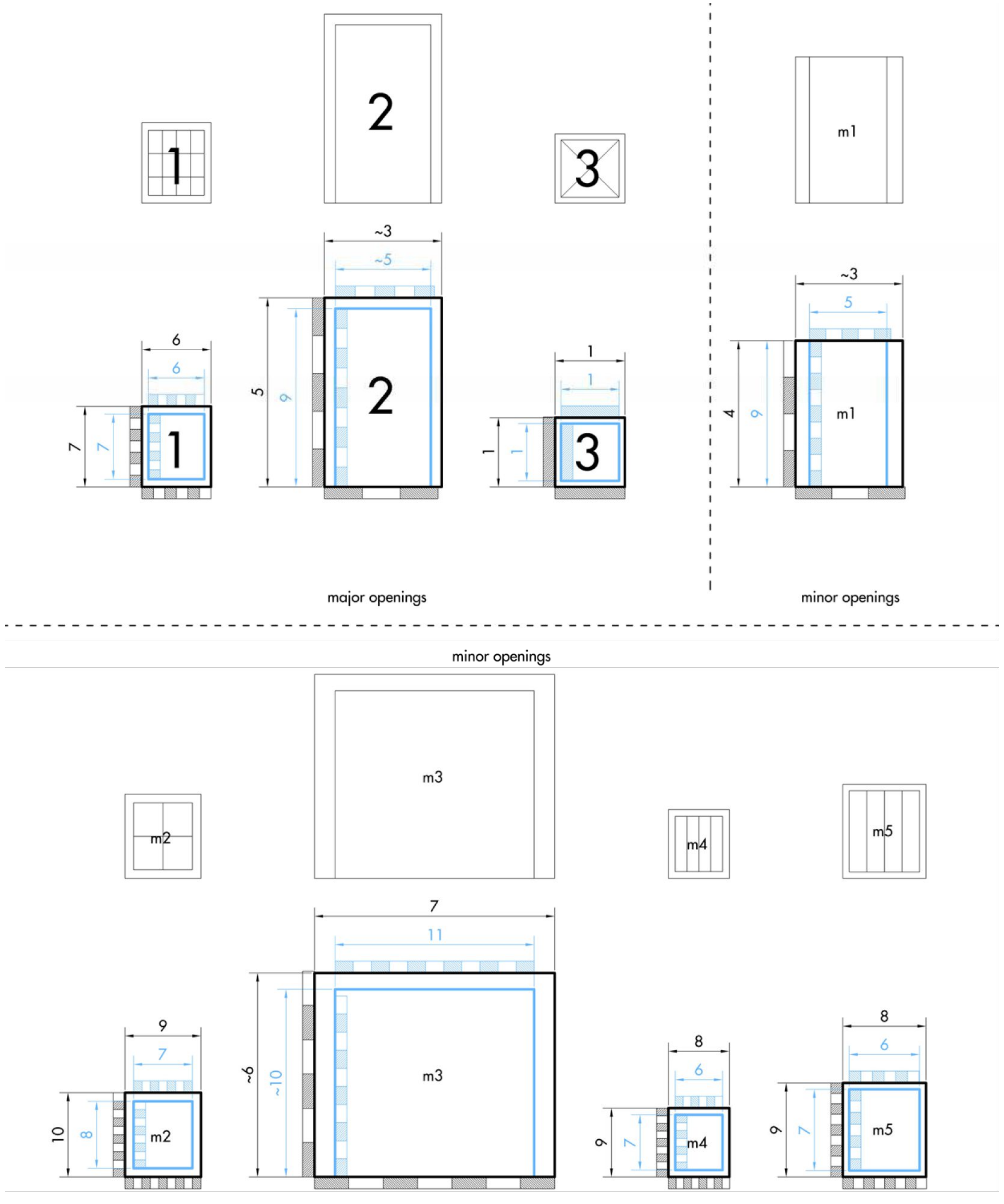
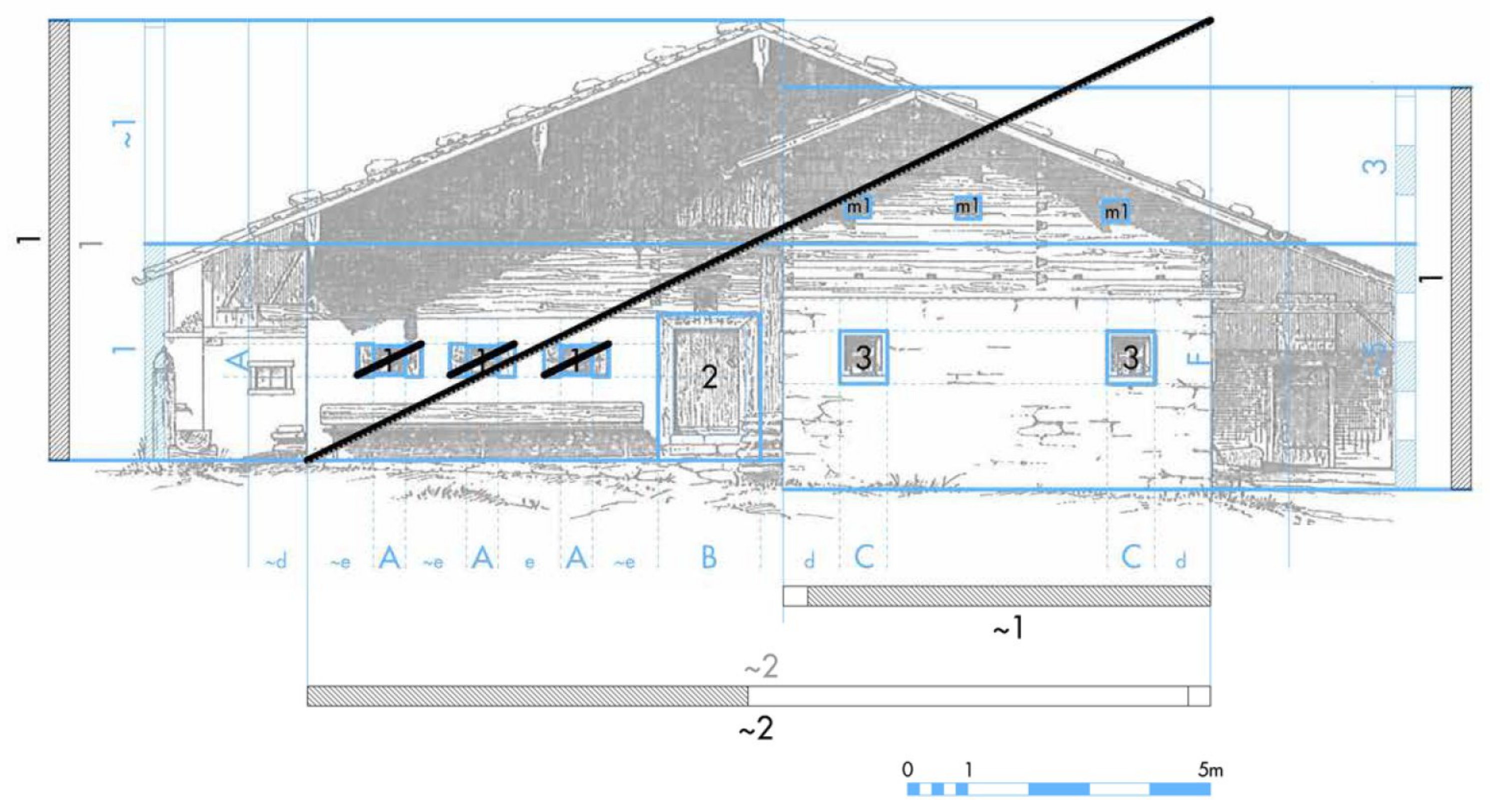


Fig. V.64 Geometrical analysis of openings: (Sa01) "Ernstgut" in Fanning



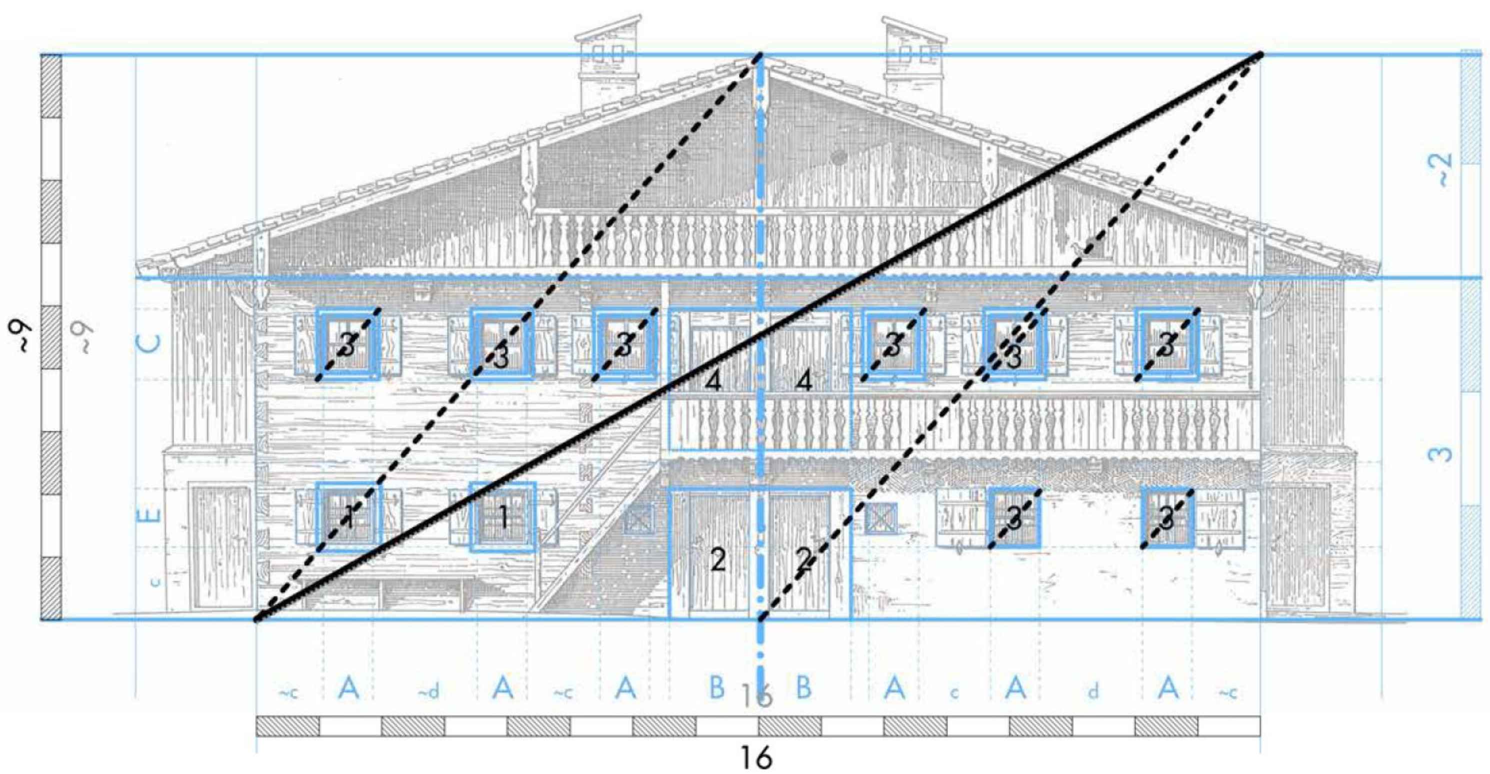


Fig. V.65 Geometrical analysis of front elevation: (Sa02) "Adam-Gut" in Neuhofen near Kraiwiesen

Fig. V.66 Geometrical analysis of front elevation: (Sa03) House in Seekirchen

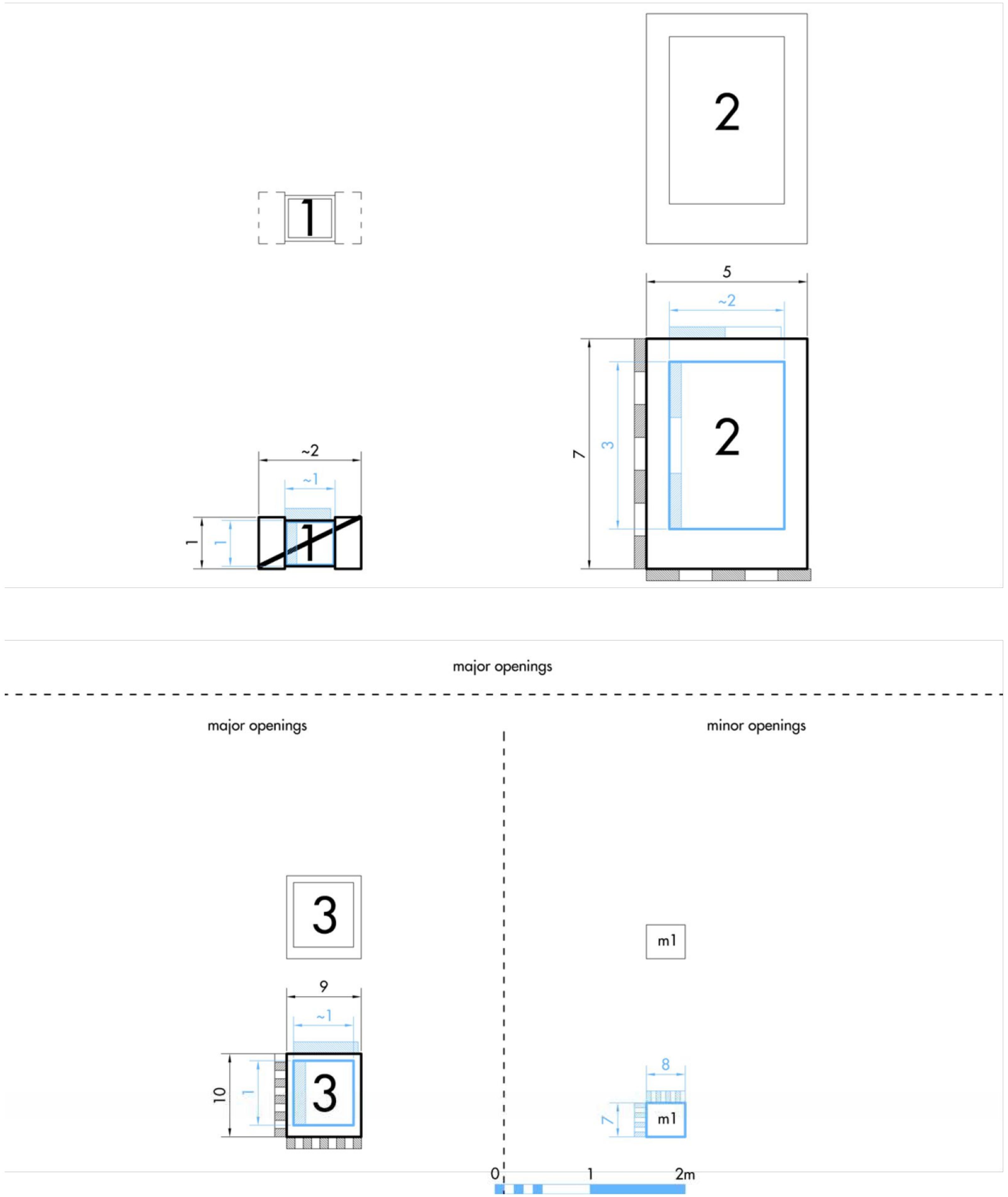


Fig. V.67 Geometrical analysis of front elevation: (Sa02) "Adam-Gut" in Neuhofen near Kraiwiesen

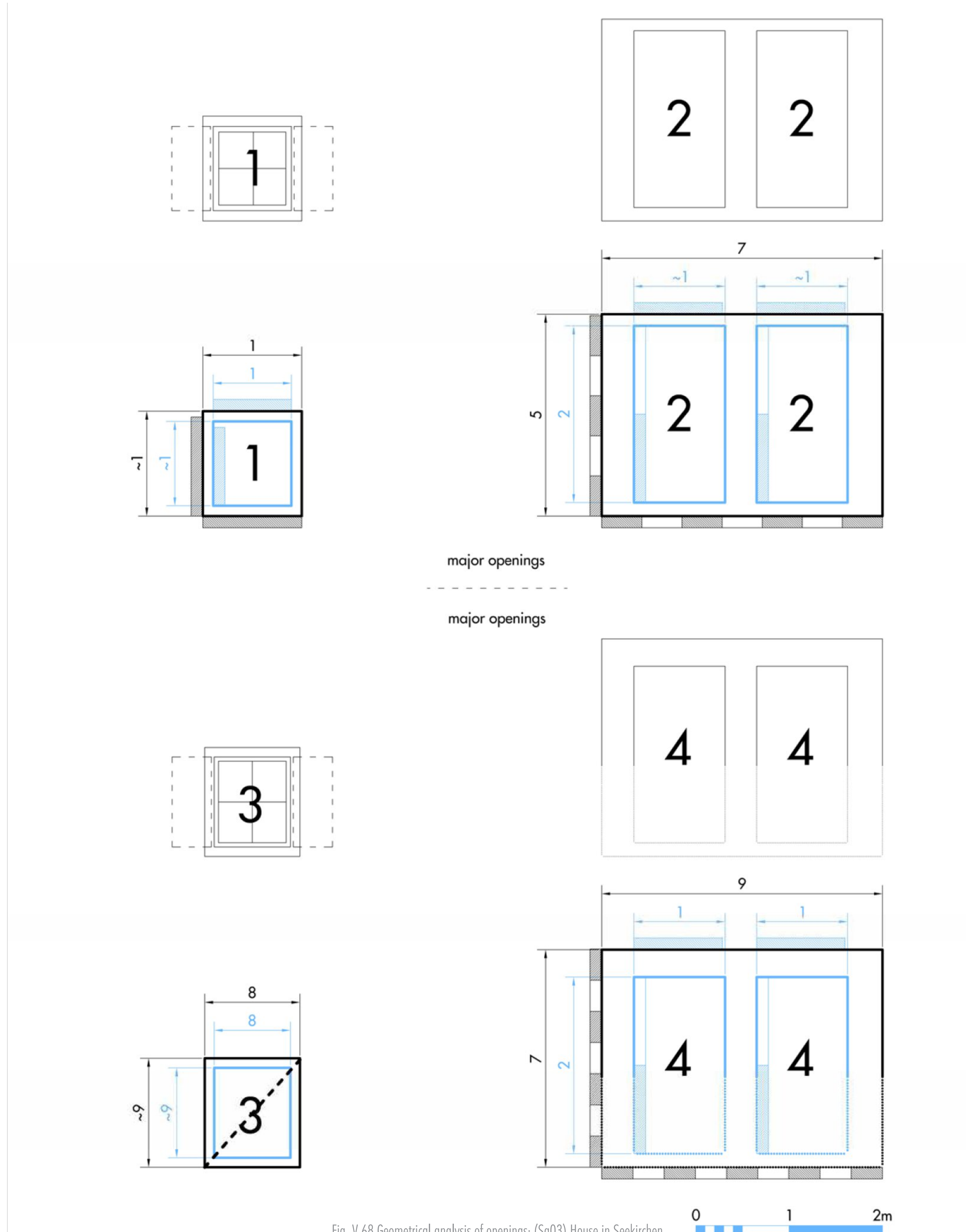
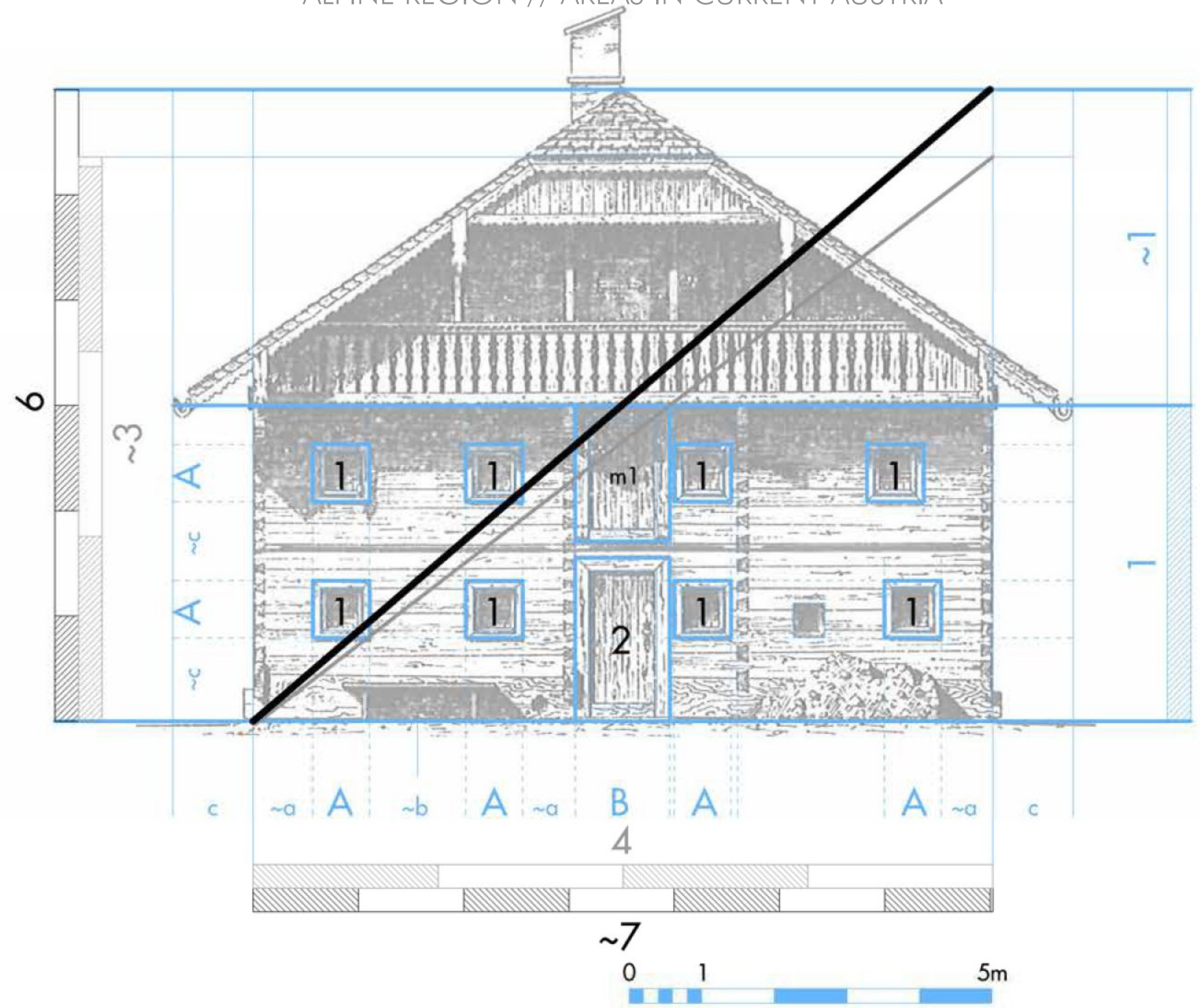


Fig. V.68 Geometrical analysis of openings: (Sa03) House in Seekirchen



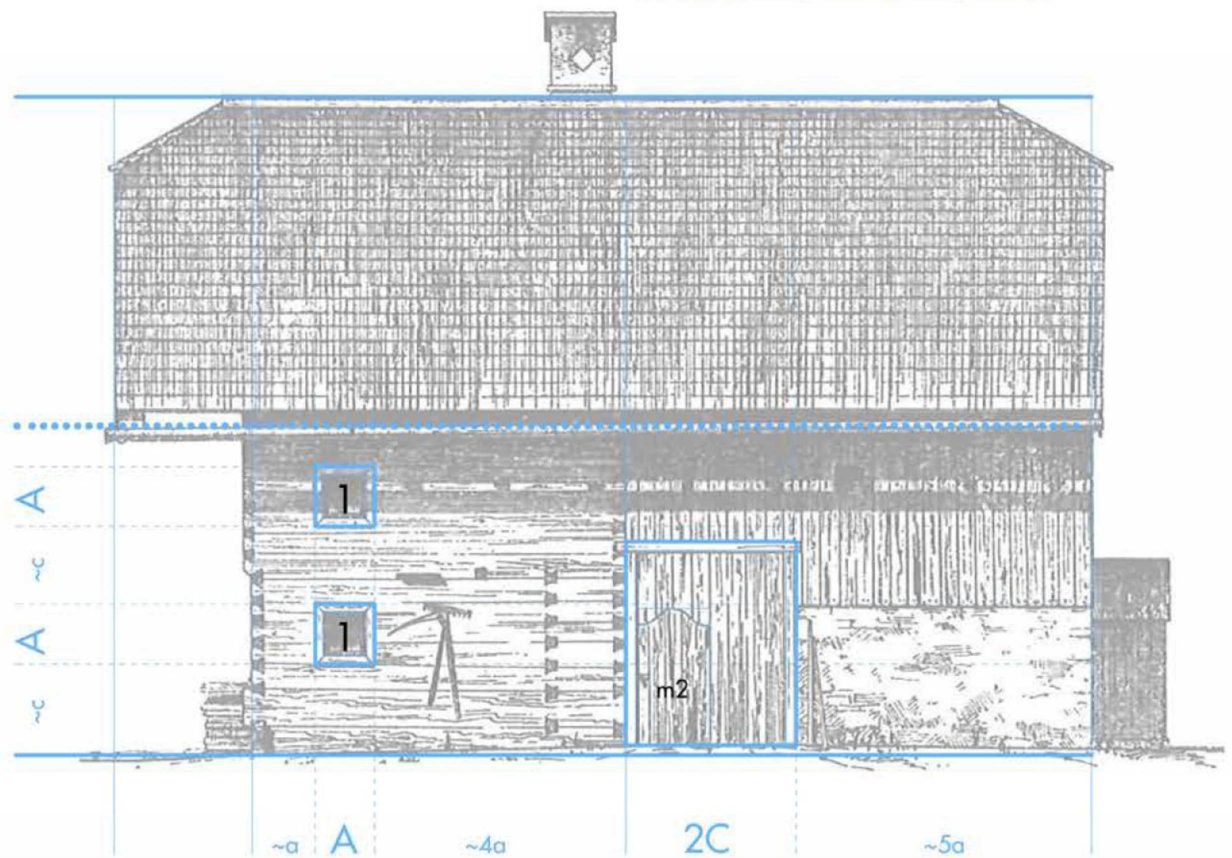


Fig. V.69 Geometrical analysis of front elevation: (Sa04) "Nieder-Traxl-Gut" in Berg near Söllheim
Fig. V.70 Geometrical analysis of side elevation: (Sa04) "Nieder-Traxl-Gut" in Berg near Söllheim

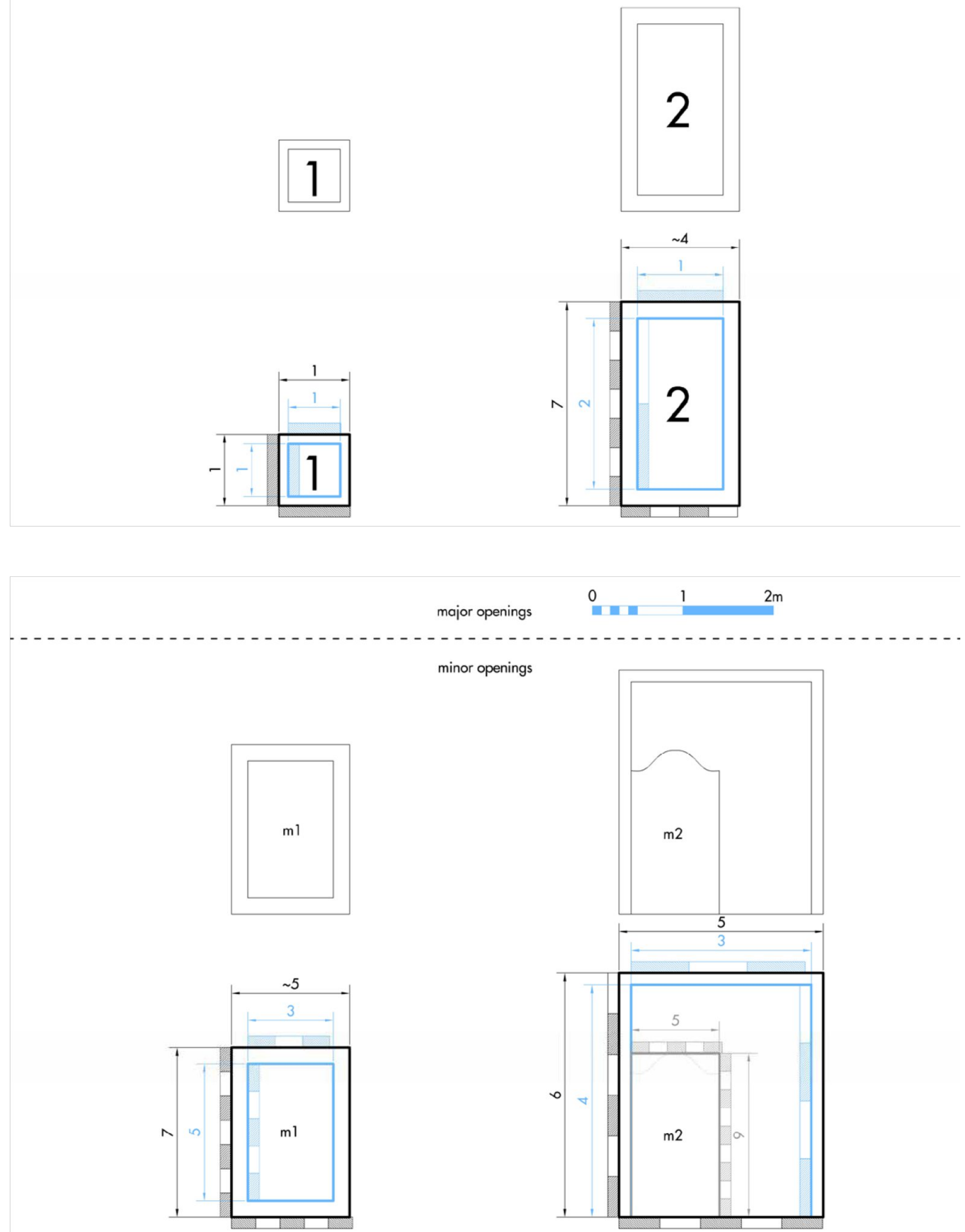


Fig. V.71 Geometrical analysis of openings: (Sa04) "Nieder-Traxl-Gut" in Berg near Söllheim

ALPINE REGION // AREAS IN CURRENT SWITZERLAND

Zürich

Z01: House in Watt in Regensdorf
(front and side elevation, openings)

Wallis

W01: House Tonosi in Sierre
(front elevation, openings)

Vaud

V01: House in Rossinières
(openings)

Fribourg

F01: Farmhouse in Montet
(side elevation, openings)

Graubünden

G01: House in Jenaz
(side elevation, openings)

G02: Farmhouse Andreas Mathies
in Buchen near Jenaz
(front elevation, openings)

G03: House in Buchen near Jenaz
(front and side elevation, openings)

G04: House in Gebr. Luck in Putz near Luzein
(front and side elevation, openings)

G05: House in Mezzaselva bei Serneus
(side elevation, openings)

G06: House in Bächli
in Tschiertschen-Schanfigg
(front elevation, openings)

intentionally omitted

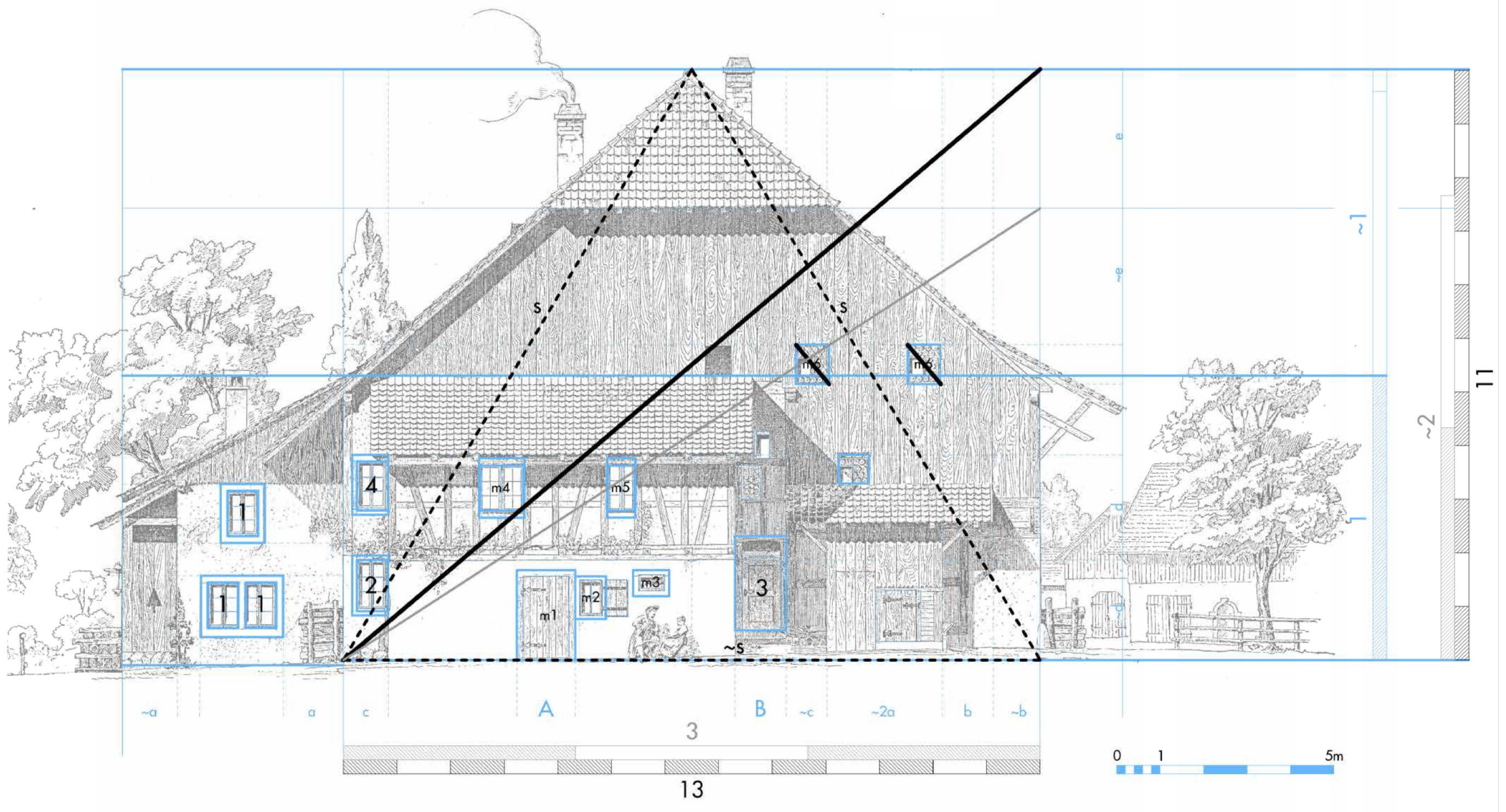


Fig. V.72 Geometrical analysis of front elevation: (Z01) House in Watt in Regensdorf

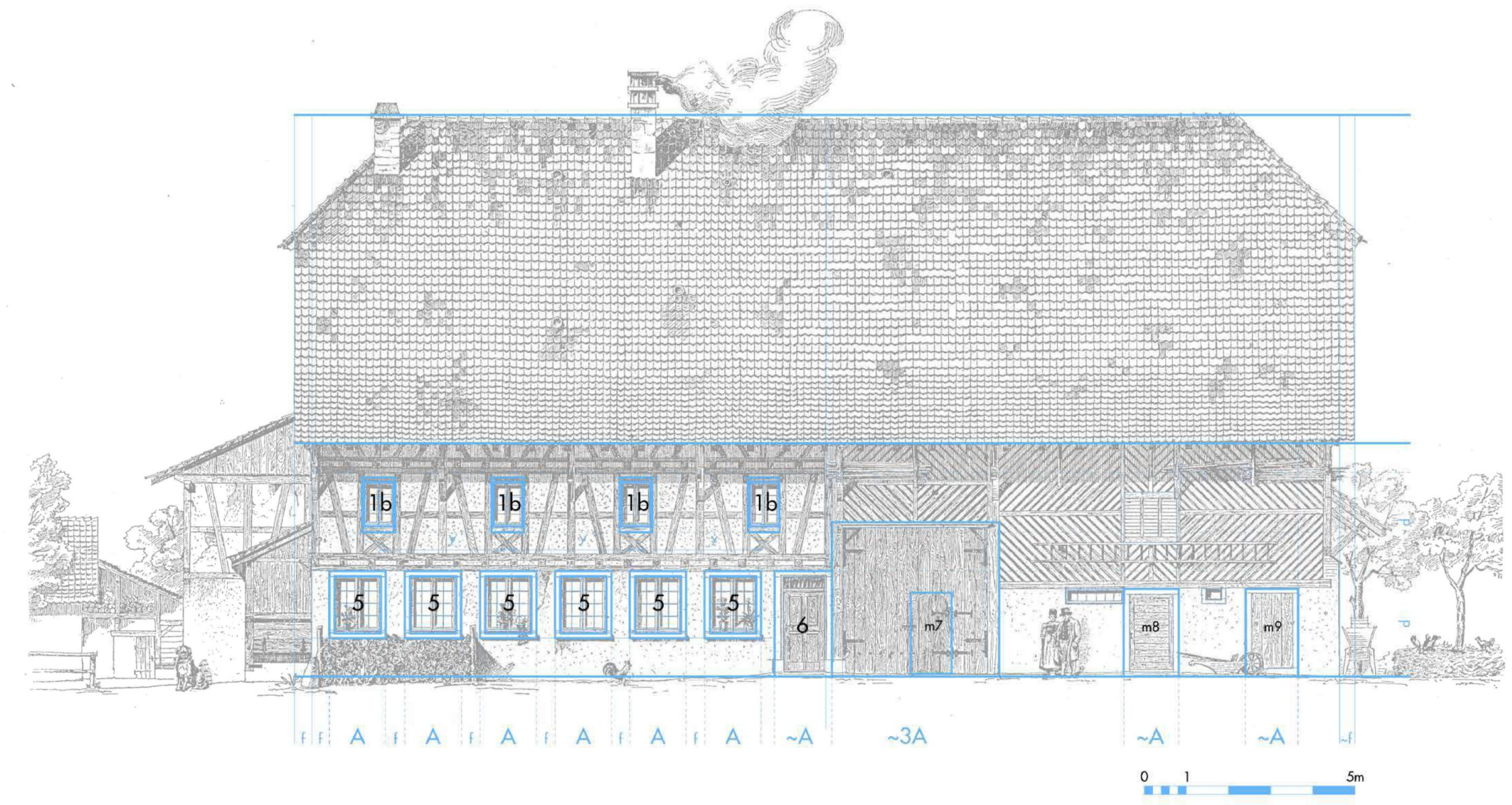


Fig. V.73 Geometrical analysis of openings: (Z01) House in Watt in Regensdorf

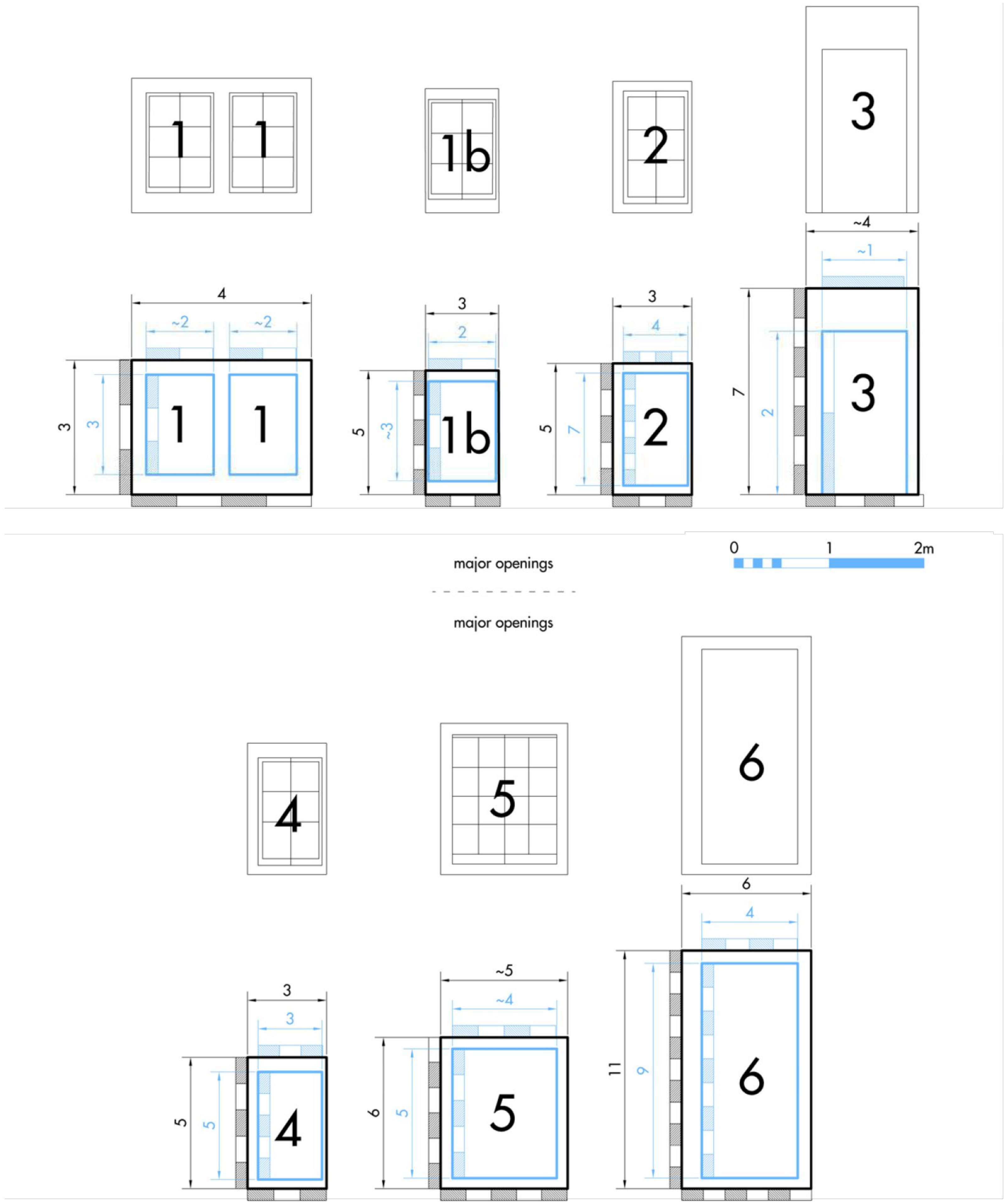


Fig. V.74 Geometrical analysis of openings: (Z01) House in Watt in Regensdorf

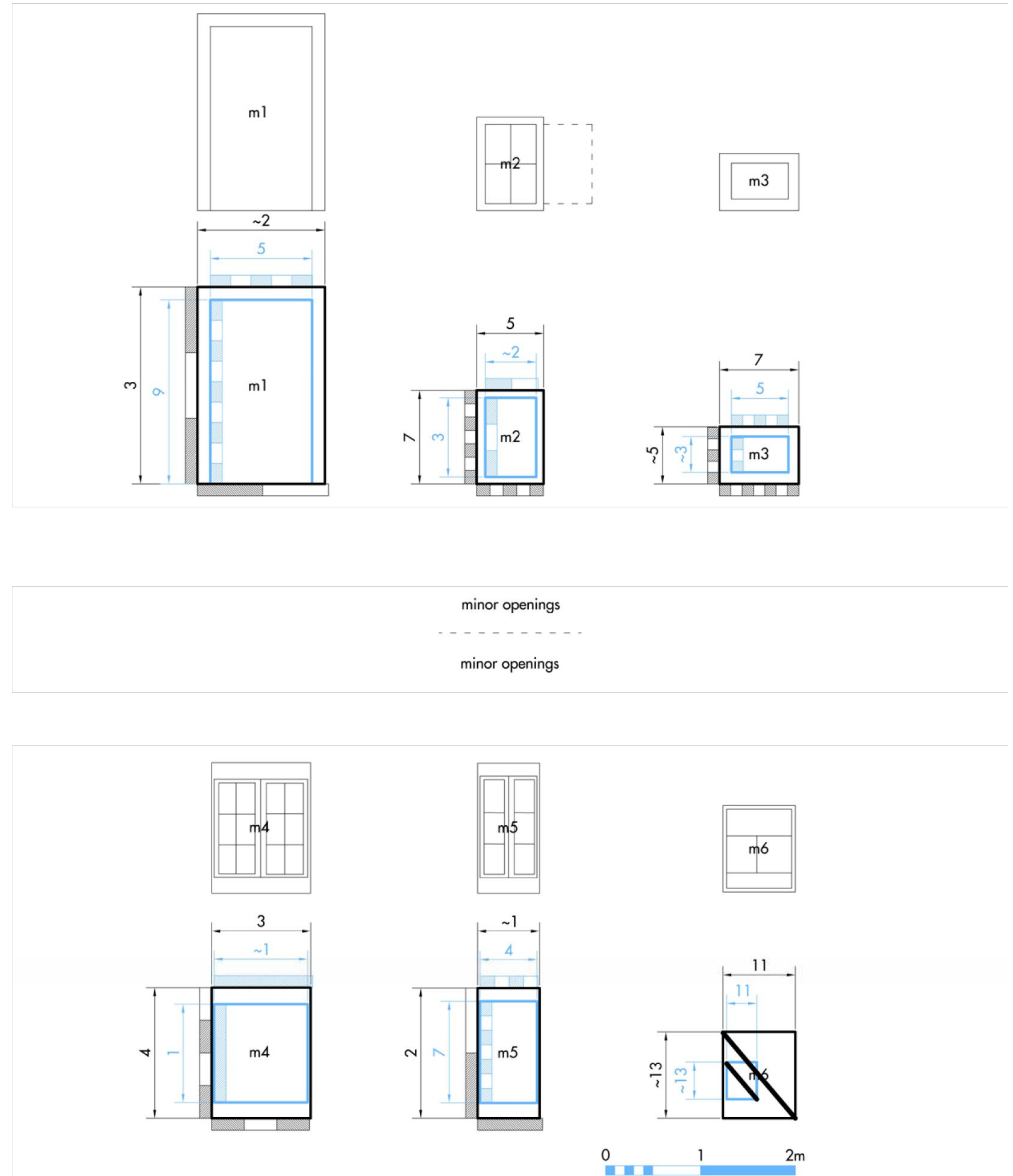


Fig. V.75 Geometrical analysis of openings: (Z01) House in Watt in Regensdorf

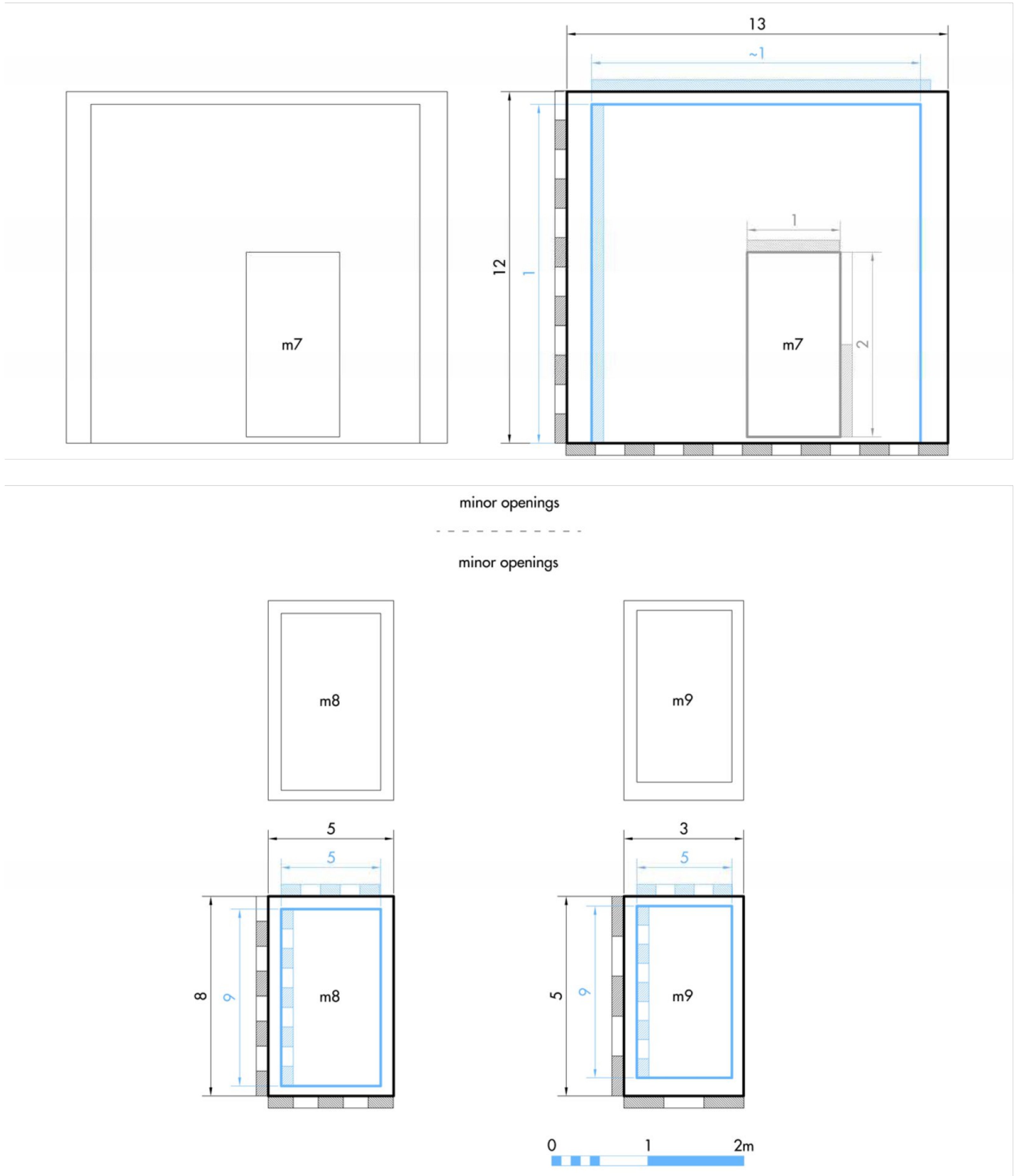
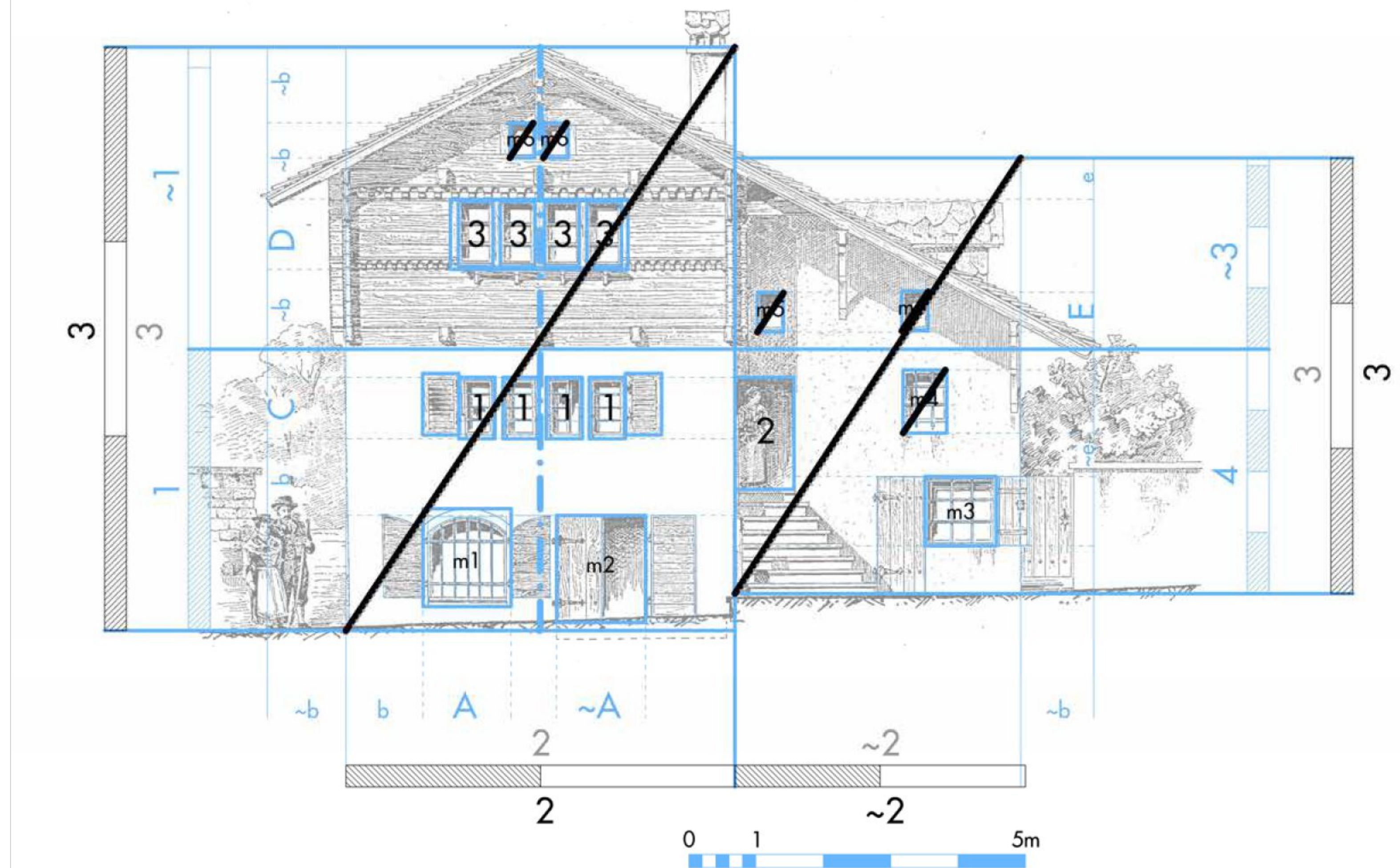


Fig. V.76 Geometrical analysis of openings: (Z01) House in Watt in Regensdorf



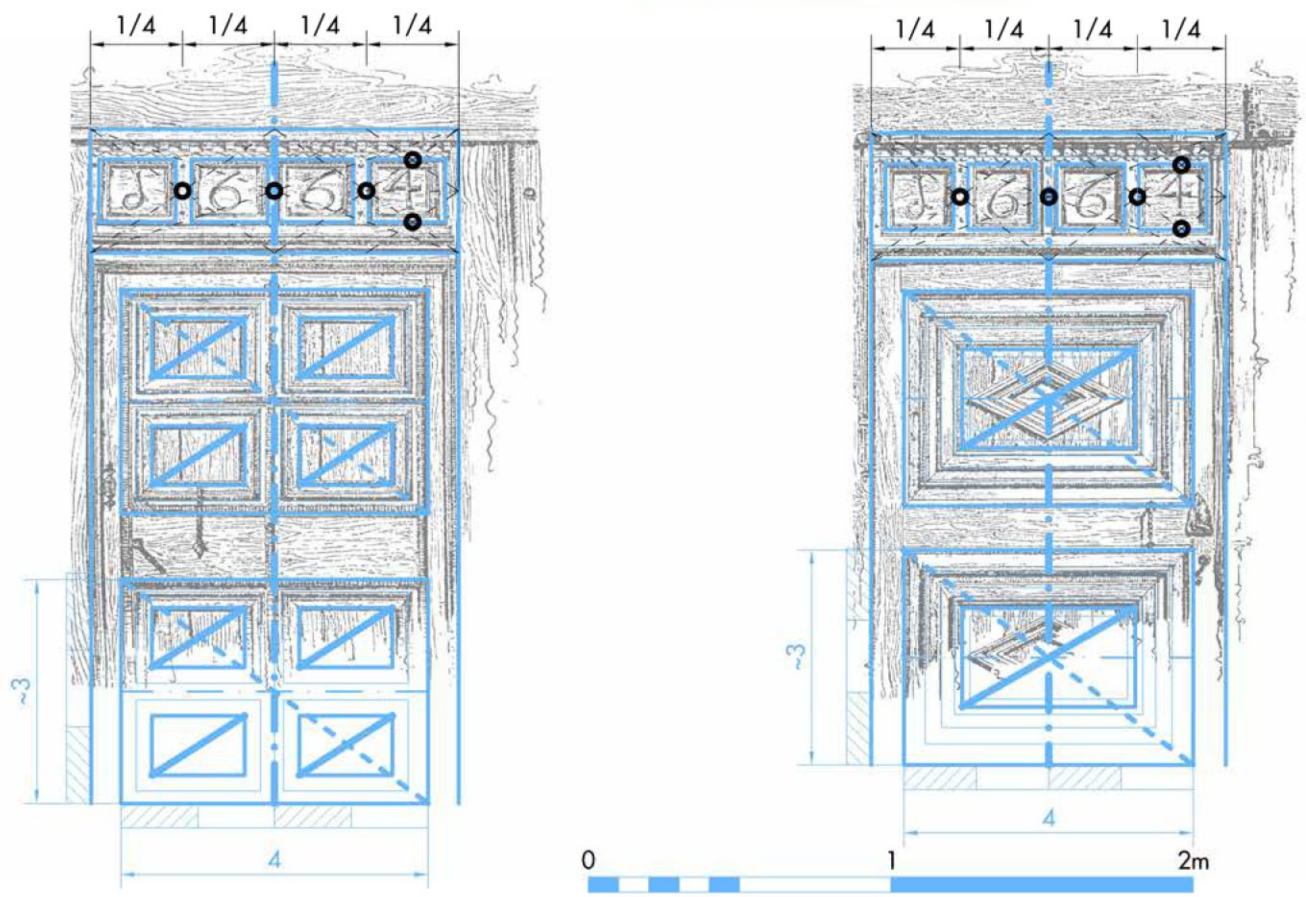


Fig. V.77 Geometrical analysis of front elevation: (W01) House Tonosi in Sierre
Fig. V.78 Geometrical analysis of openings: (V01) House in Rossinières

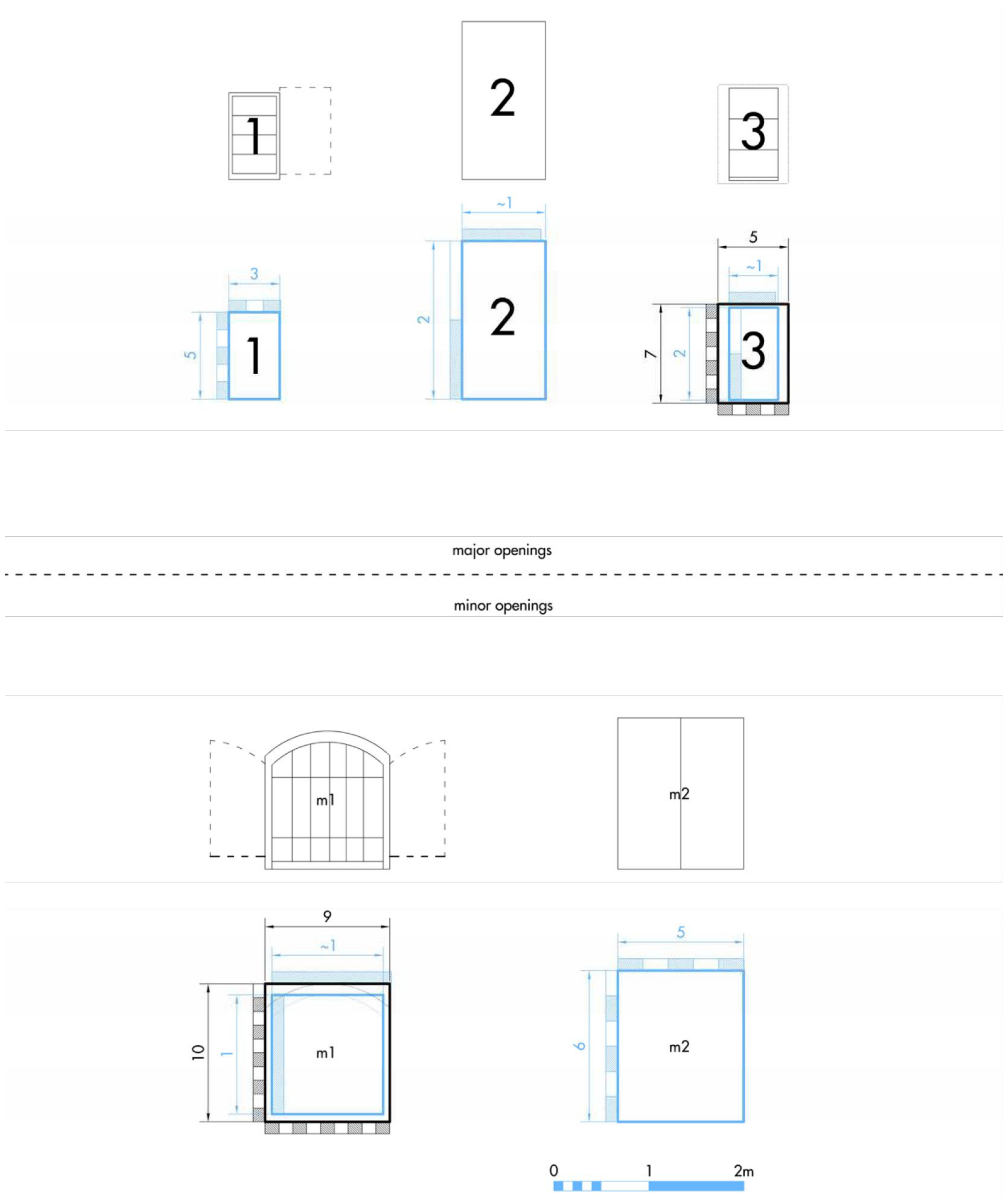


Fig. V.79 Geometrical analysis of openings: (W01) House Tonosi in Sierre

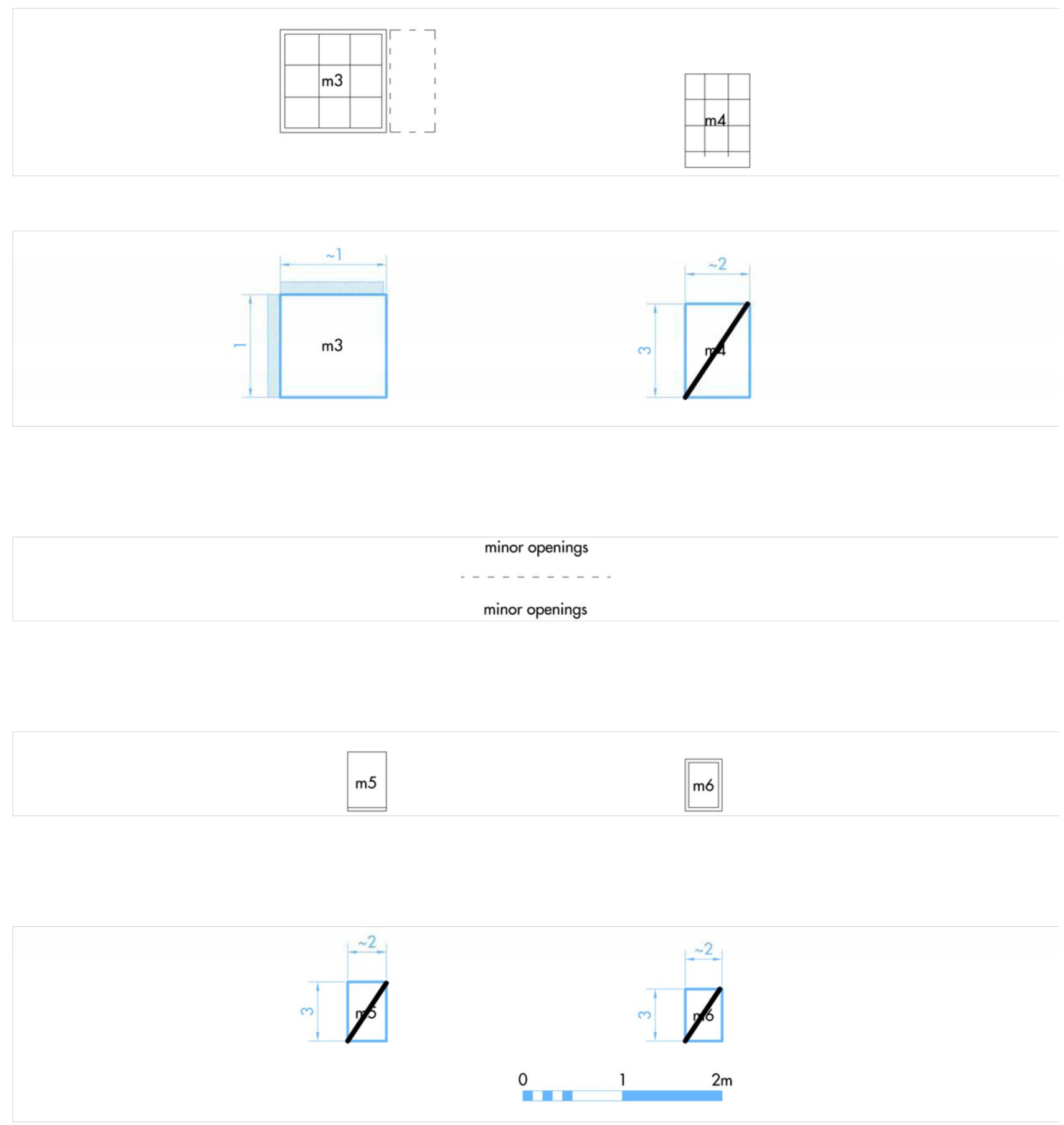


Fig. V.80 Geometrical analysis of openings: (W01) House Tonosi in Sierre

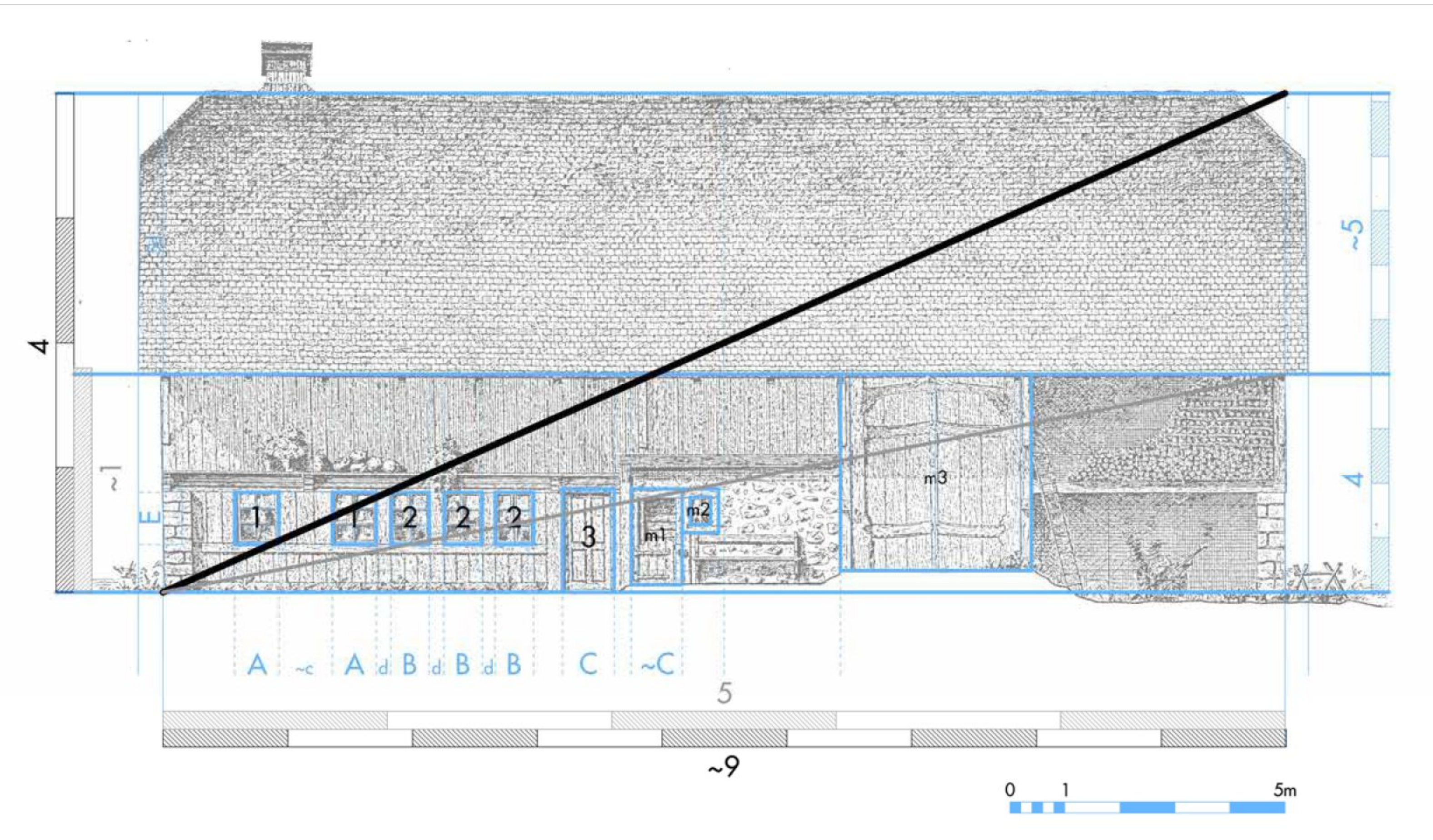


Fig. V.81 Geometrical analysis of side elevation: (F01) Farmhouse in Montet

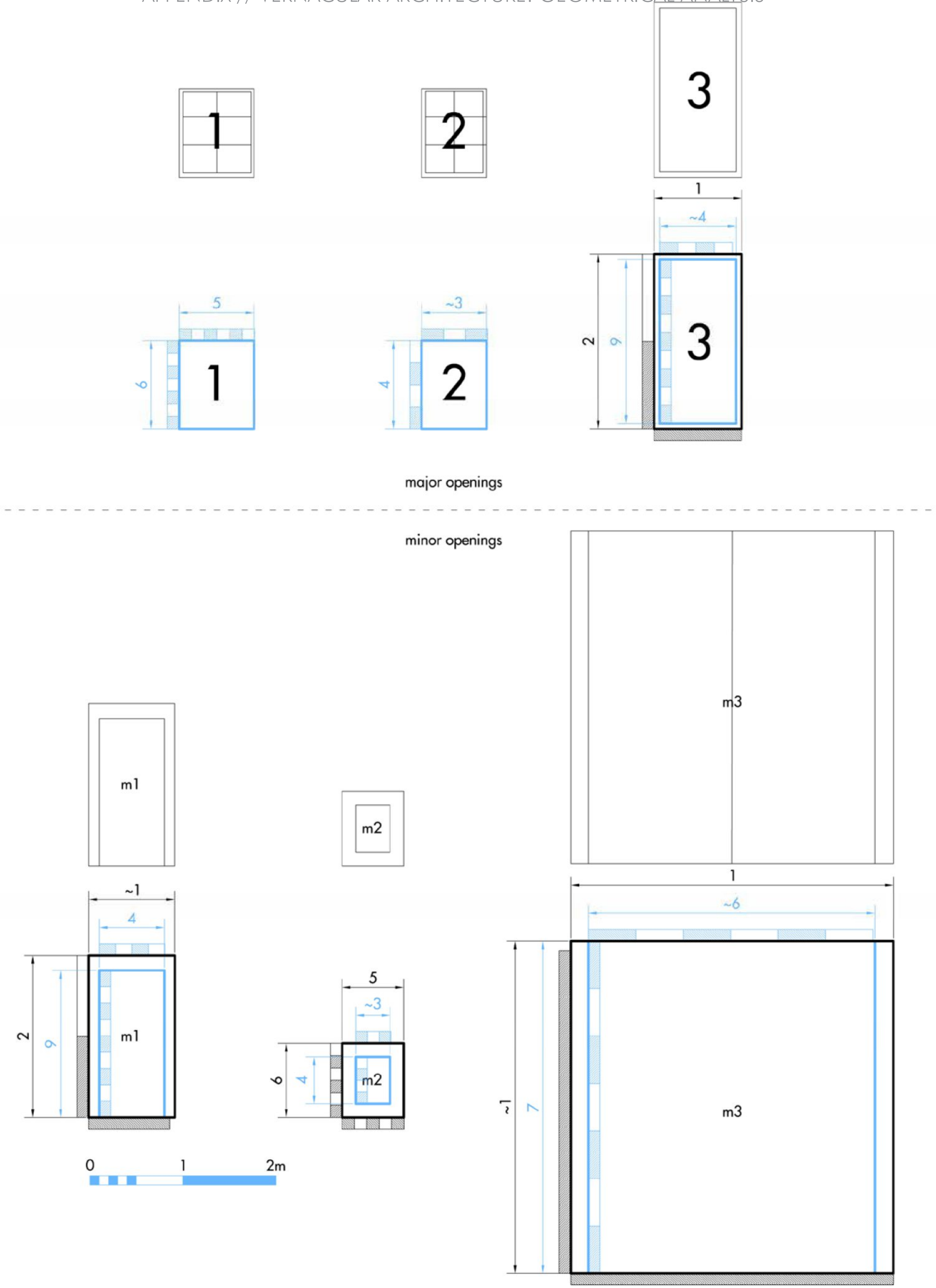
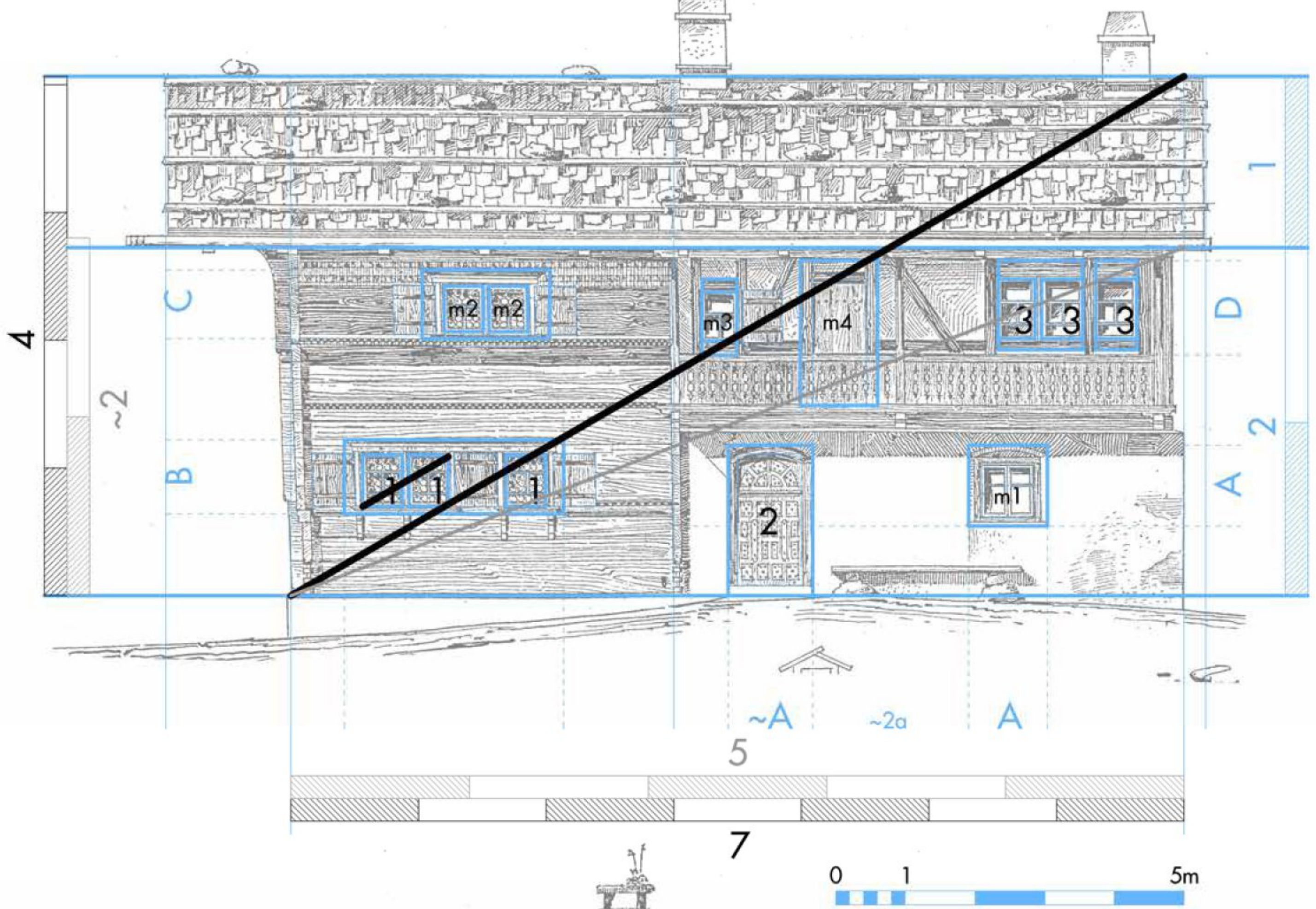


Fig. V.82 Geometrical analysis of openings: (F01) Farmhouse in Montet



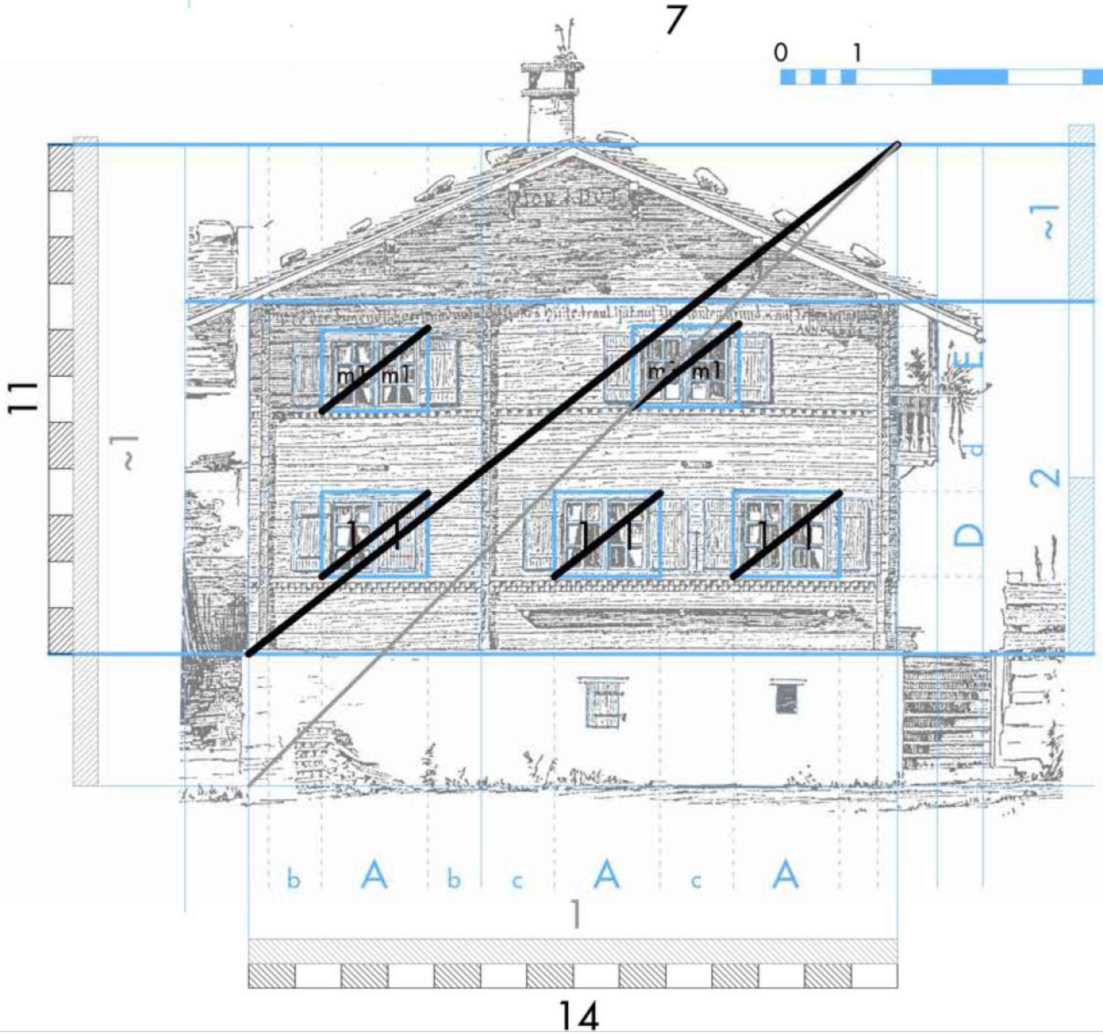


Fig. V.83 Geometrical analysis of side elevation: (G01) House in Jenaz

Fig. V.84 Geometrical analysis of front elevation: (G02) Farmhouse Andreas Mathies in Buchen near Jenaz

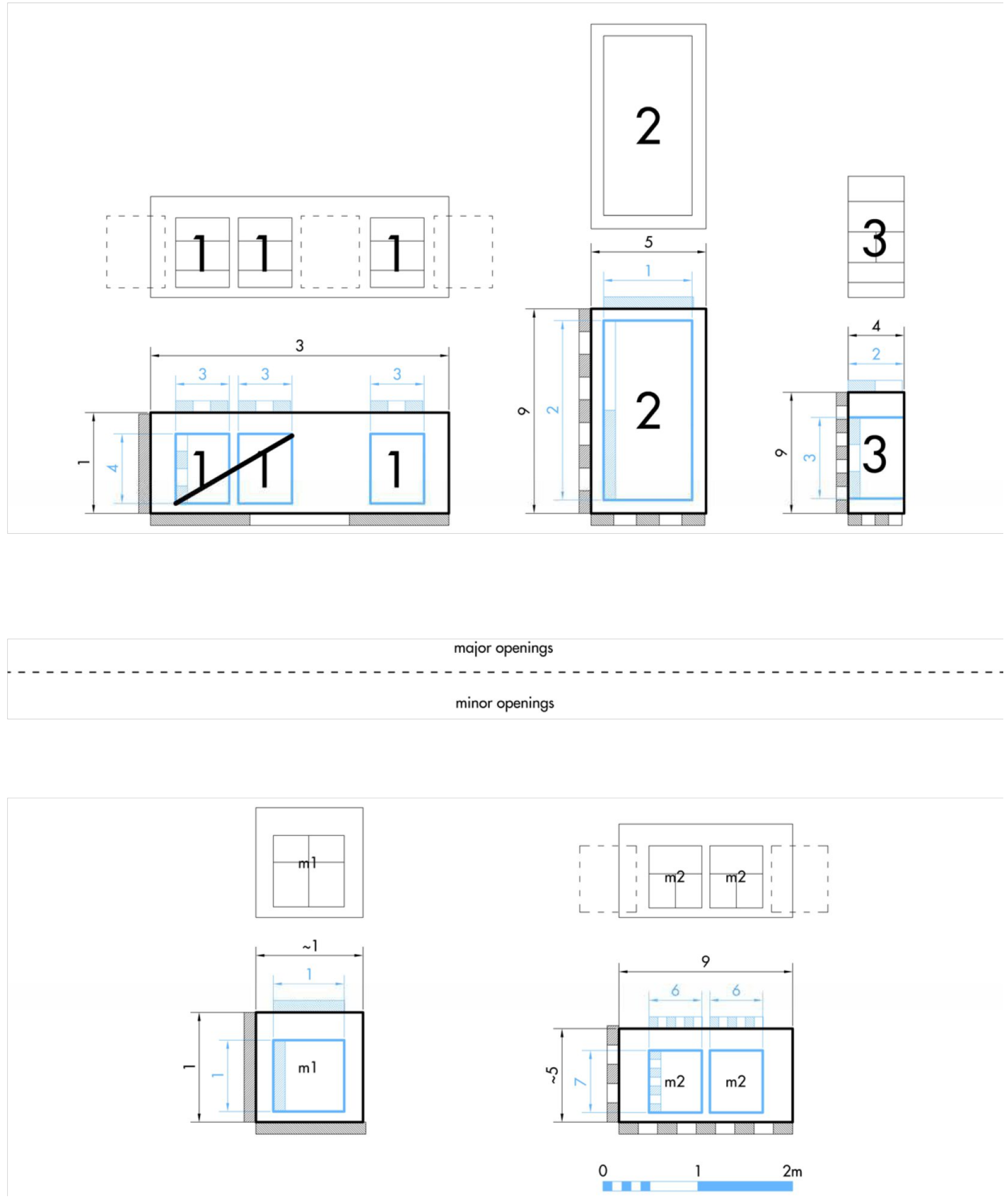


Fig. V.85 Geometrical analysis of openings: (G01) House in Jenaz

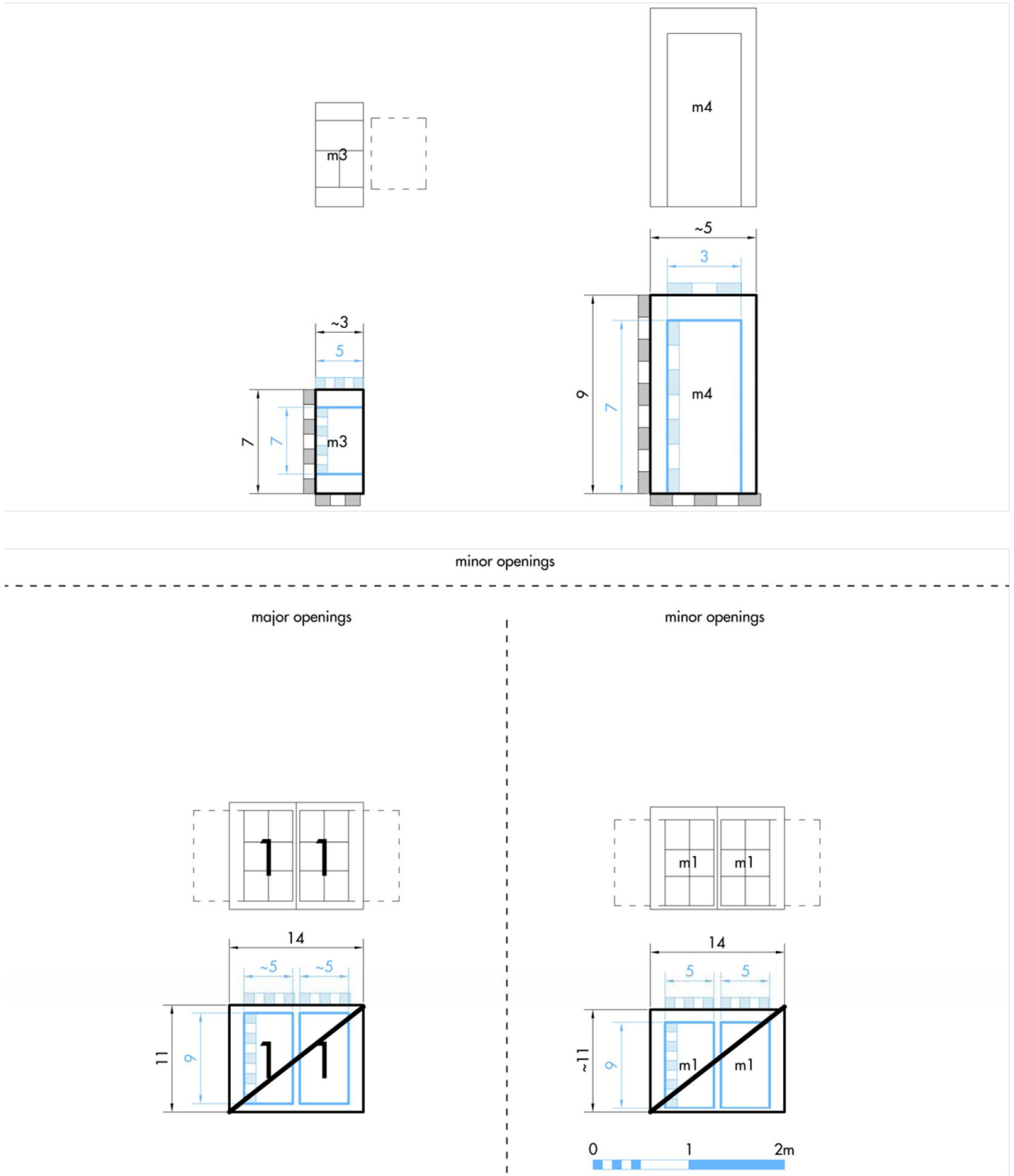
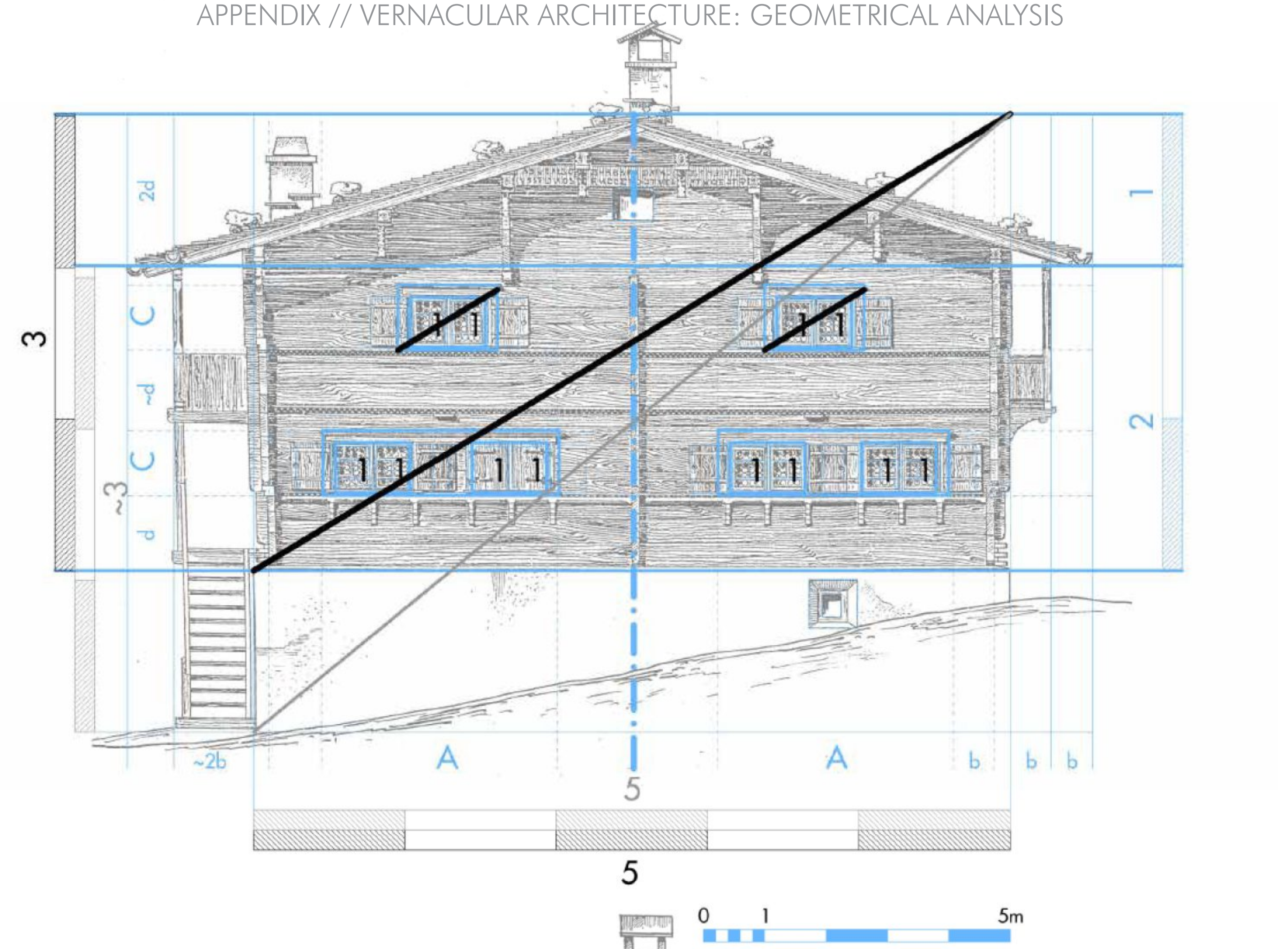


Fig. V.86 Geometrical analysis of openings: (G02) Farmhouse Andreas Mathies in Buchen near Jenaz



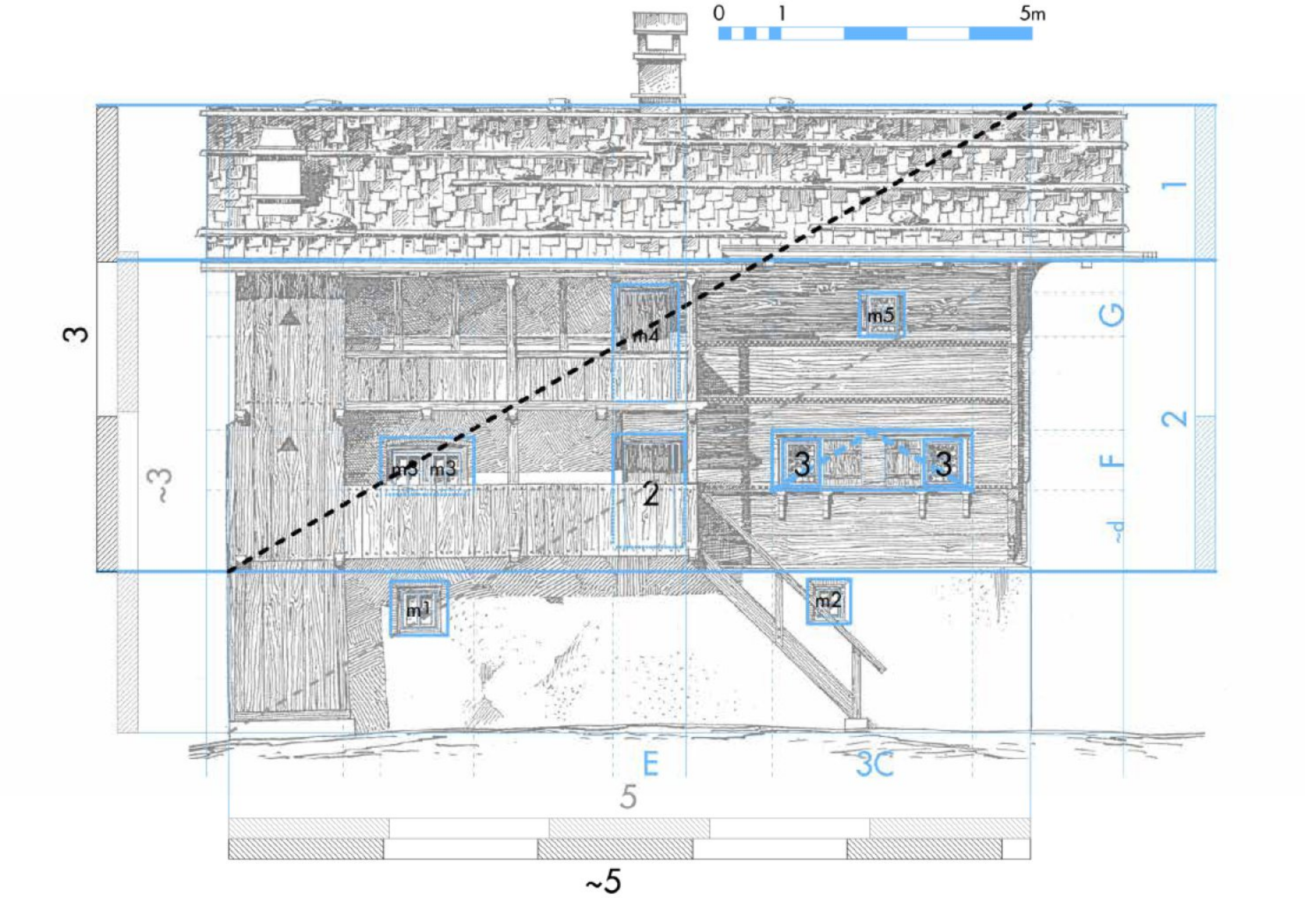


Fig. V.87 Geometrical analysis of front elevation: (G03) House in Buchen near Jenaz

Fig. V.88 Geometrical analysis of side elevation: (G03) House in Buchen near Jenaz

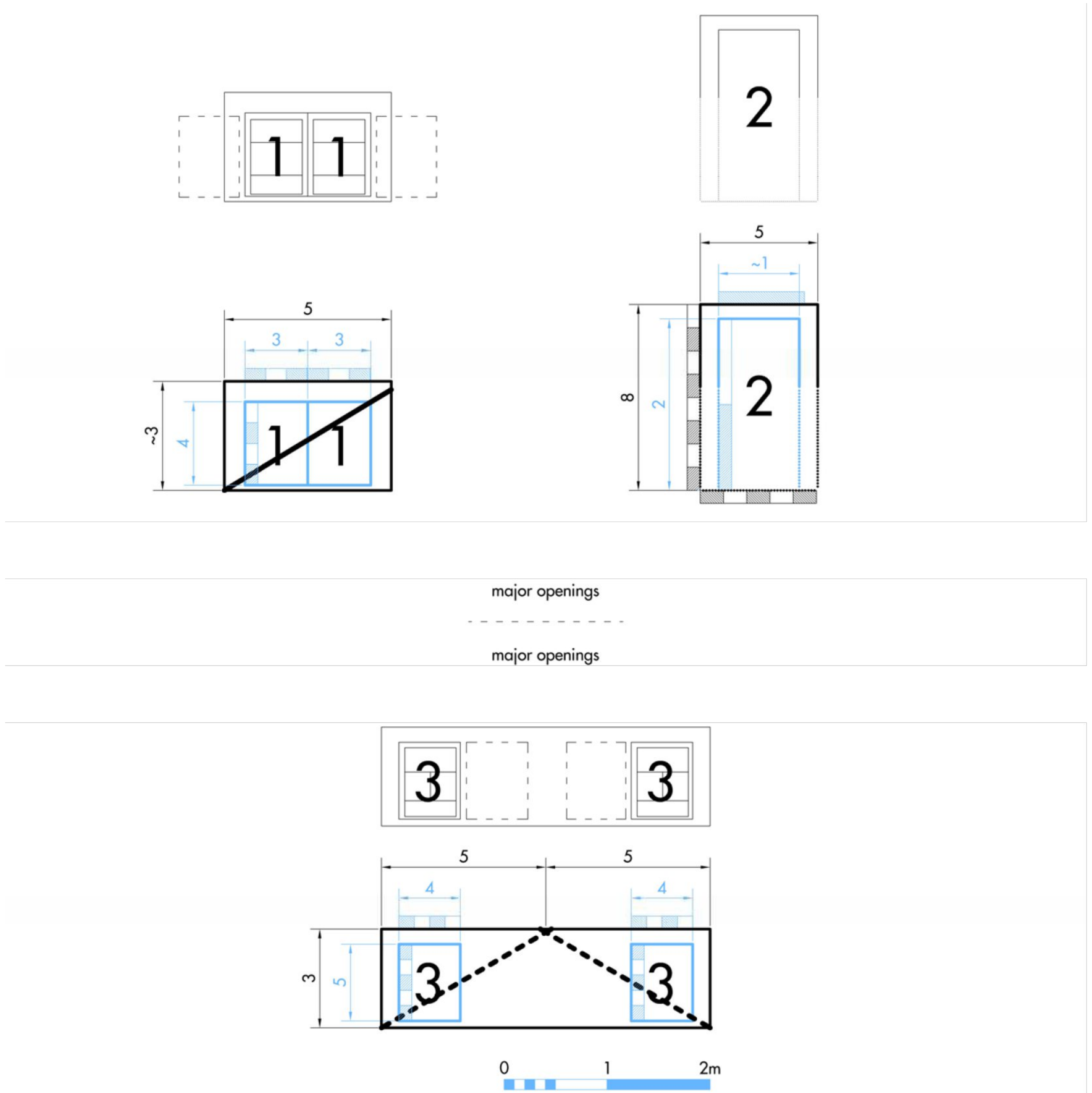


Fig. V.89 Geometrical analysis of openings: (G03) House in Buchen near Jenaz

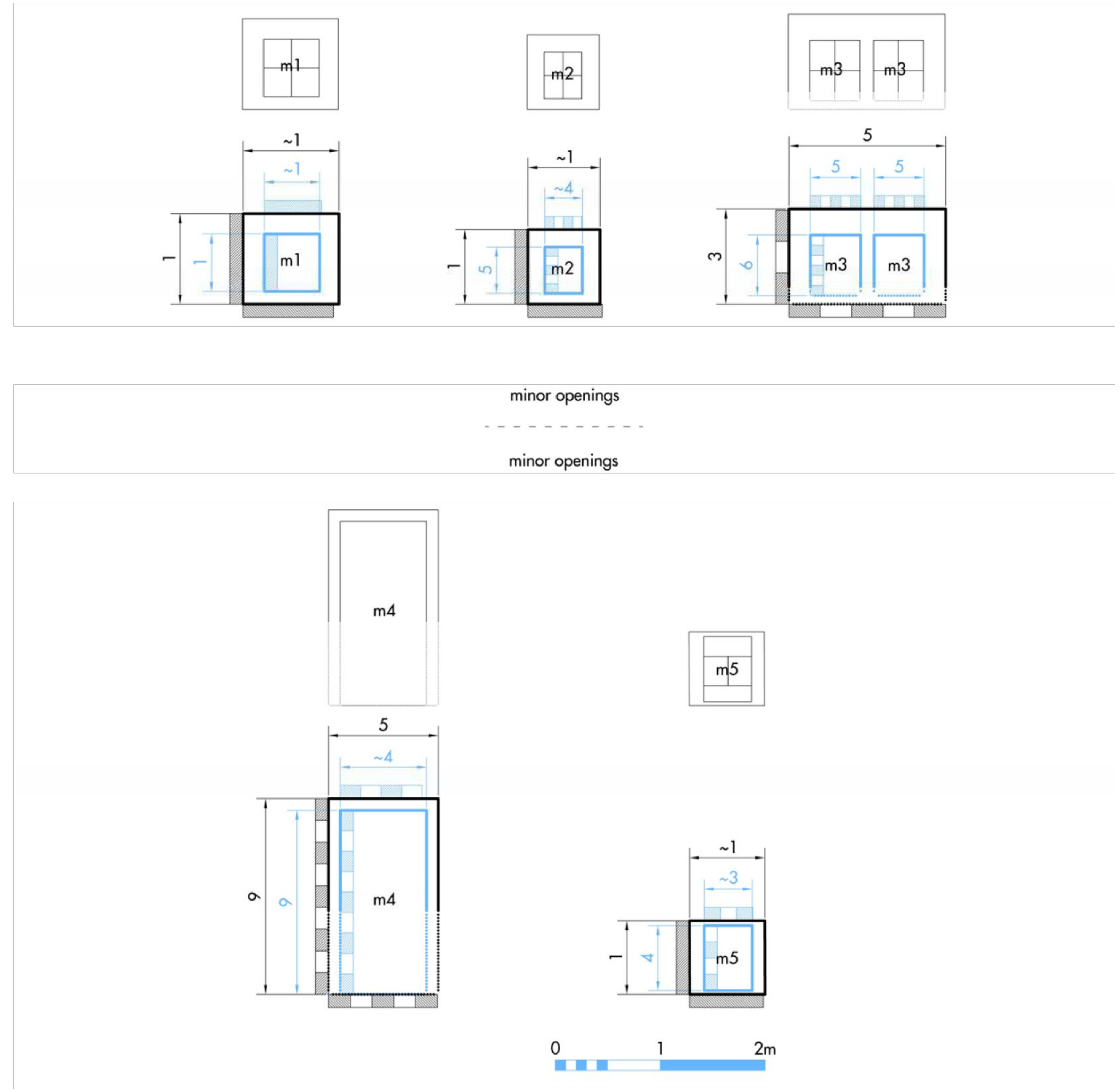


Fig. V.90 Geometrical analysis of openings: (G03) House in Buchen near Jenaz

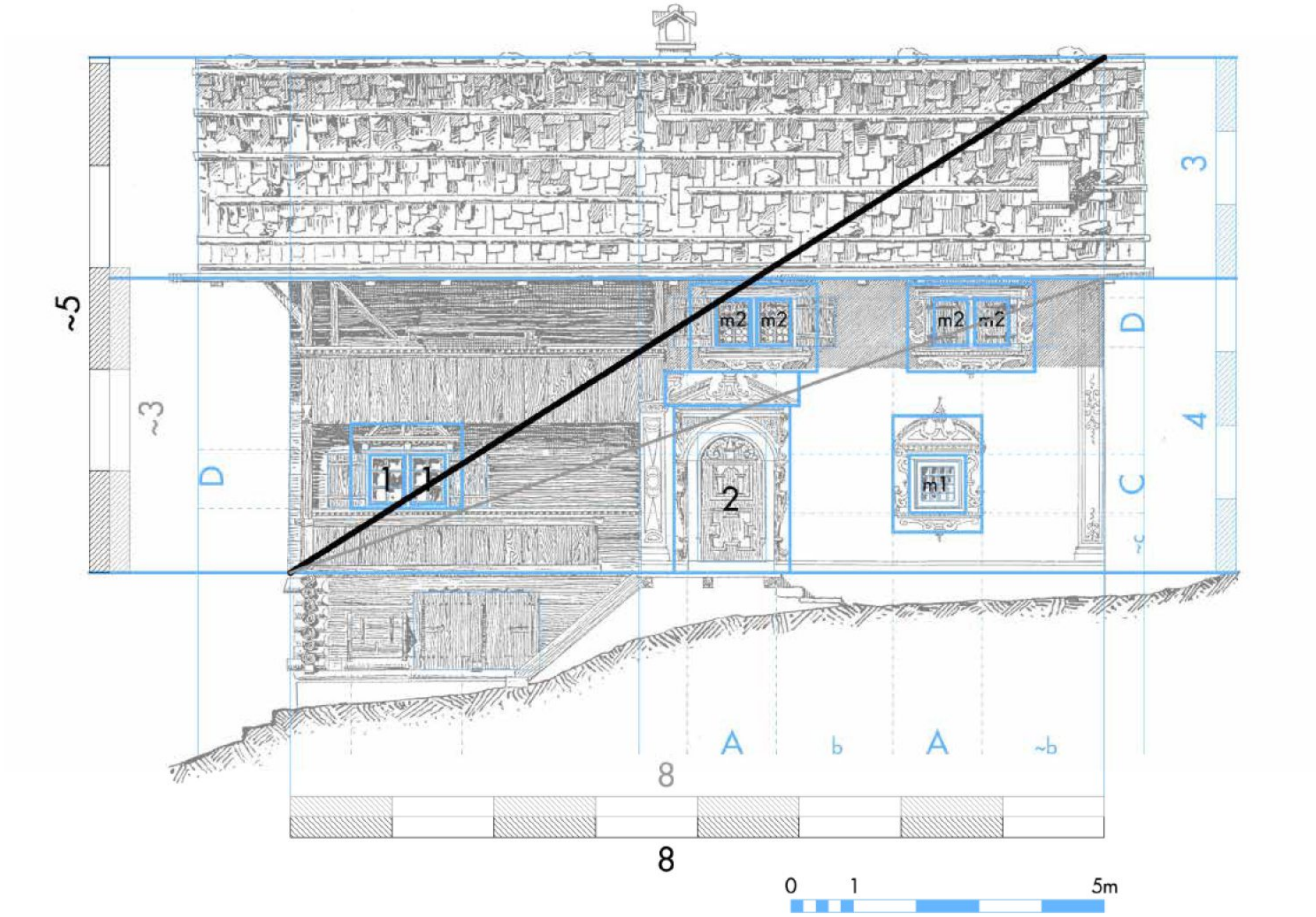


Fig. V.91 Geometrical analysis of front elevation: (G04) House in Gebr. Luck in Putz near Luzein
Fig. V.92 Geometrical analysis of side elevation: (G04) House in Gebr. Luck in Putz near Luzein

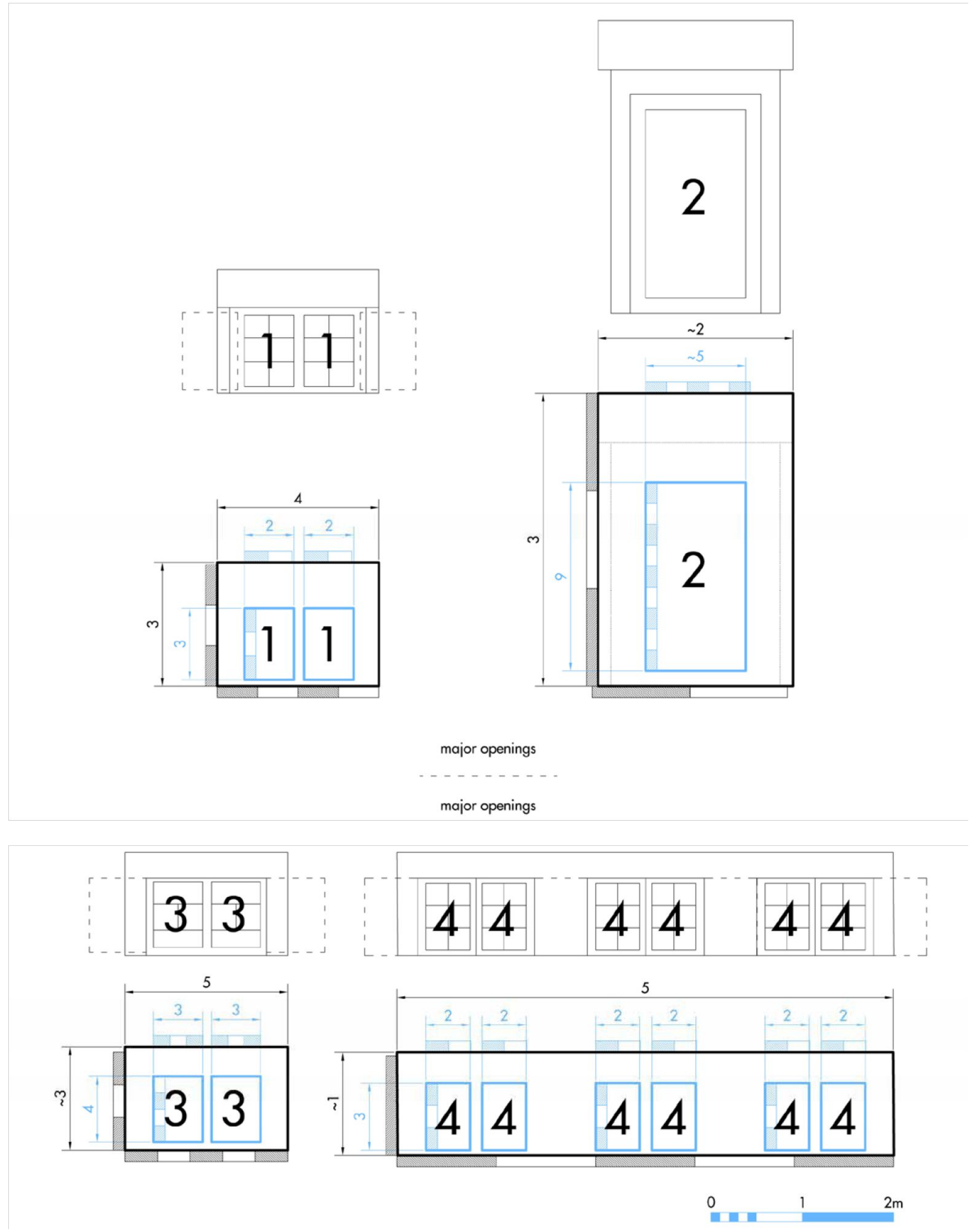
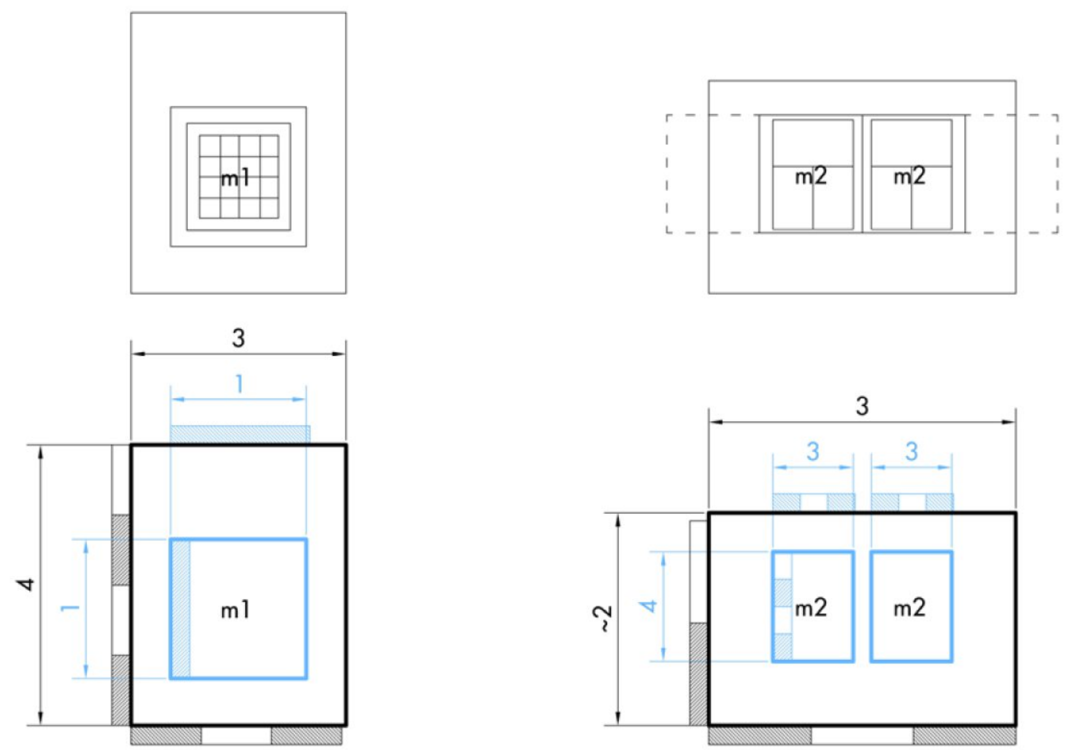


Fig. V.93 Geometrical analysis of openings: (G04) House in Gebr. Luck in Putz near Luzein



minor openings

minor openings

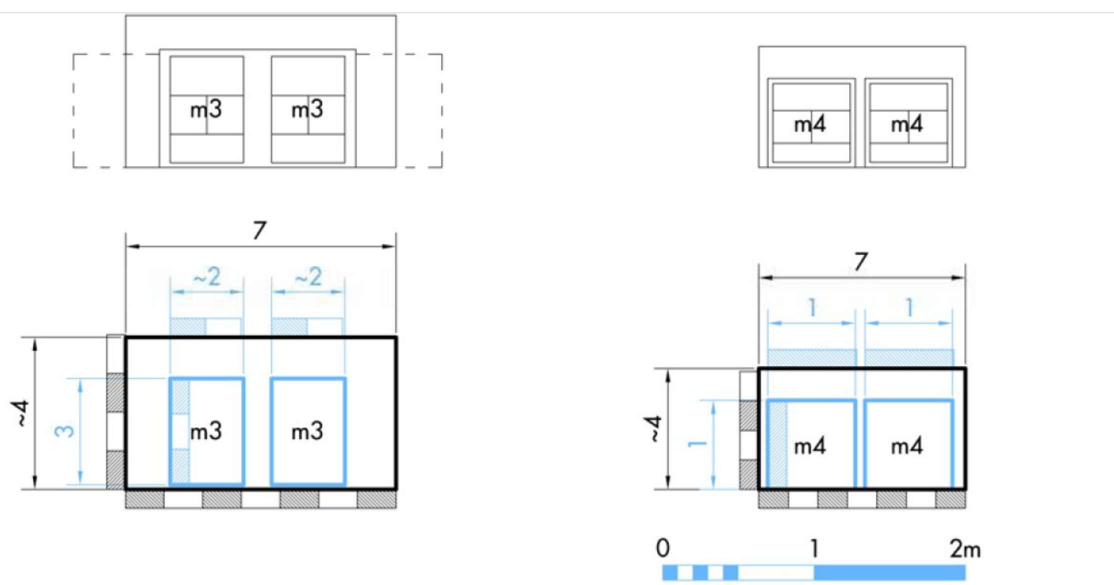
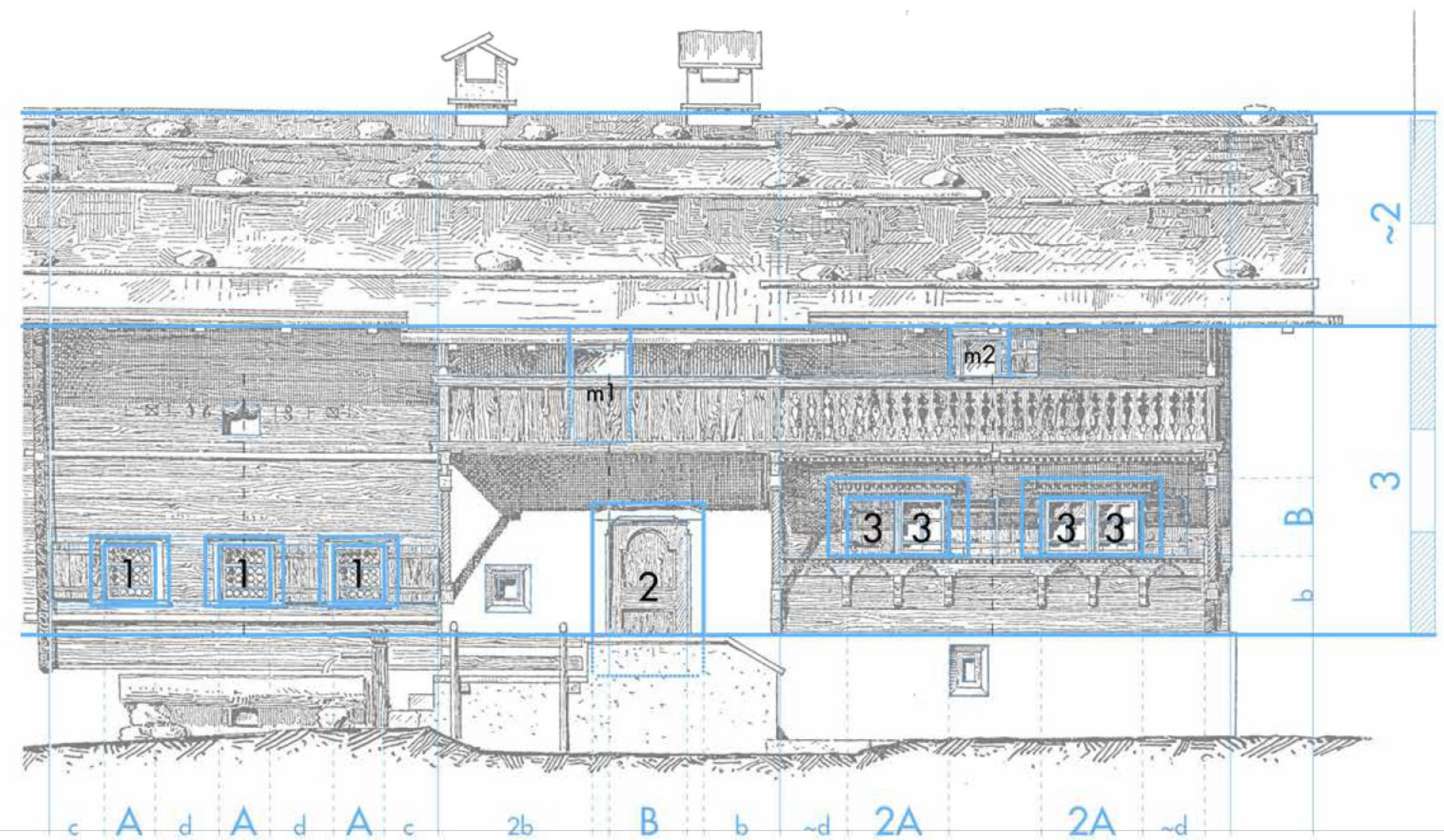


Fig. V.94 Geometrical analysis of openings: (G04) House in Gebr. Luck in Putz near Luzein



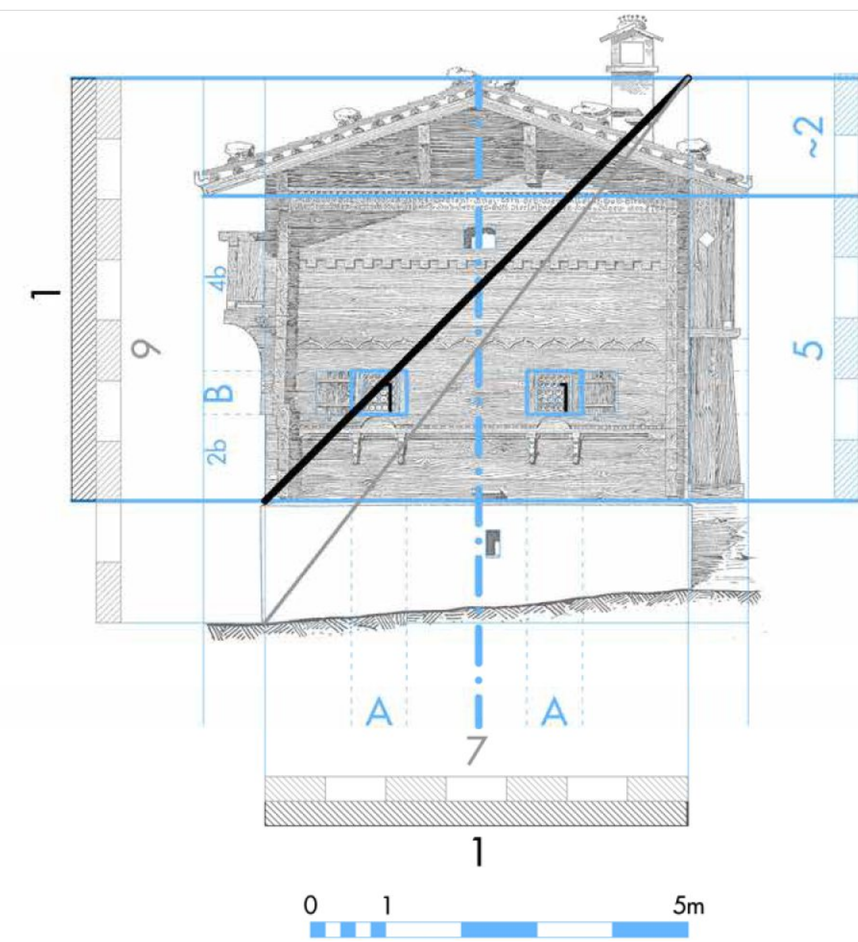


Fig. V.95 Geometrical analysis of side elevation: (G05) House in Mezzaselva bei Serneus
Fig. V.96 Geometrical analysis of front elevation: (G06) House in Bächli in Tschiertschen-Schanfigg

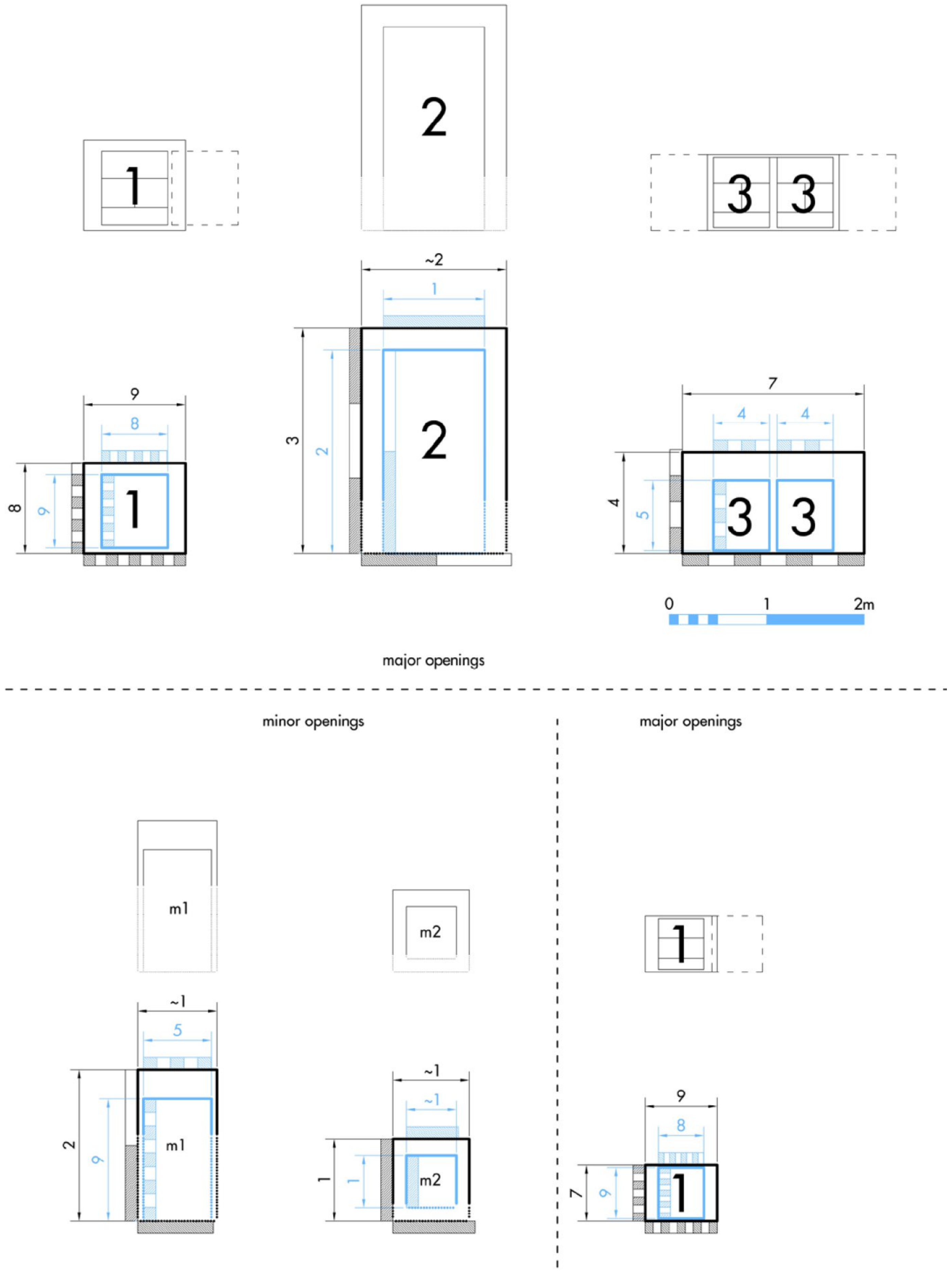


Fig. V.97 Geometrical analysis of openings:
(G05) House in Mezzaselva bei Serneus and (G06) House in Bächli in Tschiertschen-Schanfigg

intentionally omitted

GERMANIC REGION // AREAS IN CURRENT AUSTRIA

Upper Austria

U01: House in Steegen near Peuerbach
(front elevation, openings)

U02: "Greder-Haus" in Kephen-Steegen
(front elevation, openings)

U03: "Schwarzmayergut" in Siegharting in Thal
(front and side elevation, openings)

Lower Austria

L01: Vineyard house No. 50 in Kritzendorf
(front elevation, openings)

L02: Vineyard house in Weissenkirchen
(front elevation, openings)

intentionally omitted

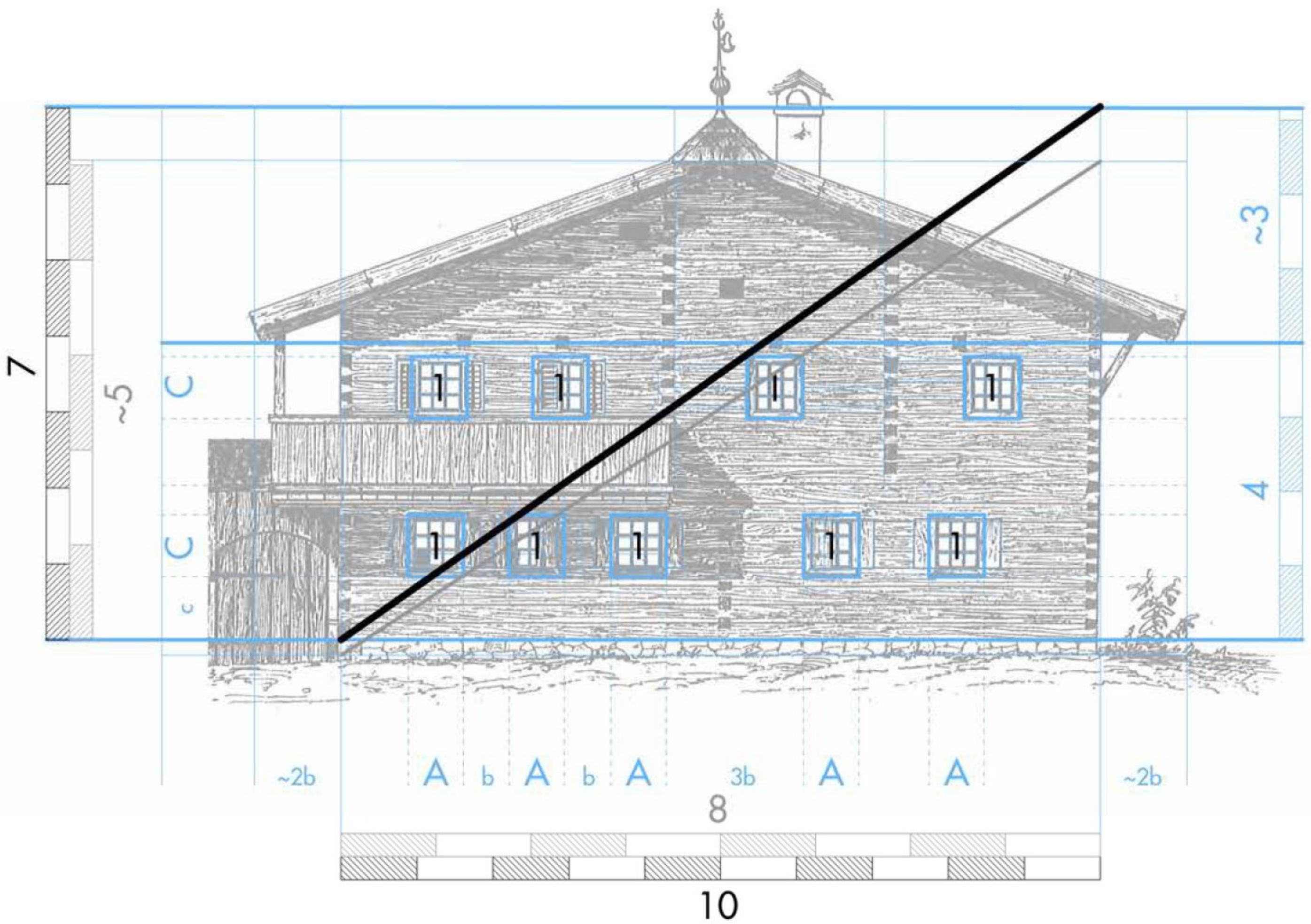


Fig. V.98 Geometrical analysis of front elevation: (U01) House in Steegen near Peuerbach
Fig. V.99 Geometrical analysis of front elevation: (U02) "Greder-Haus" in Kephen-Steegen

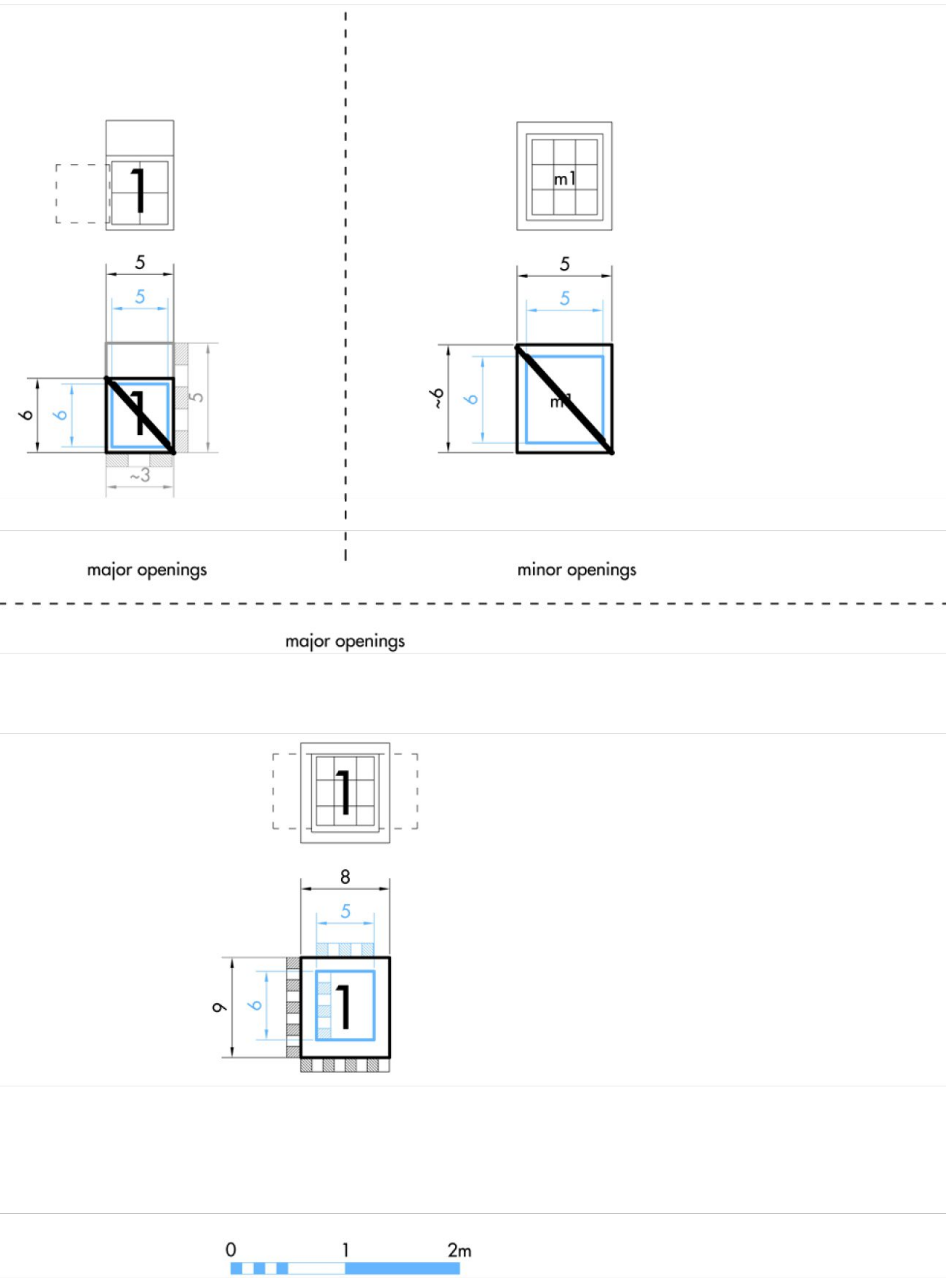
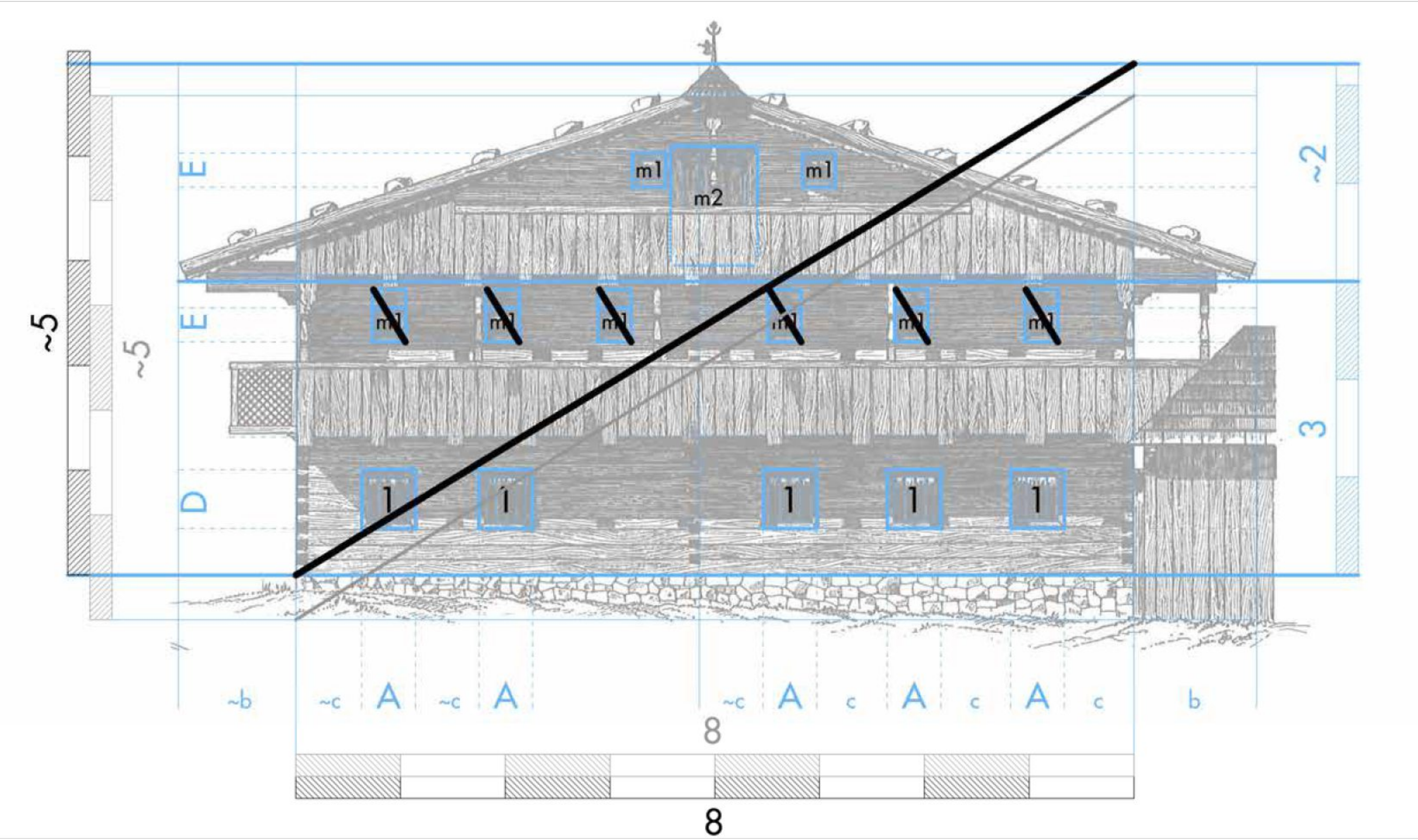


Fig. V.100 Geometrical analysis of openings:
(U01) House in Steegen near Peuerbach and (U02) "Greder-Haus" in Kephen-Steegen



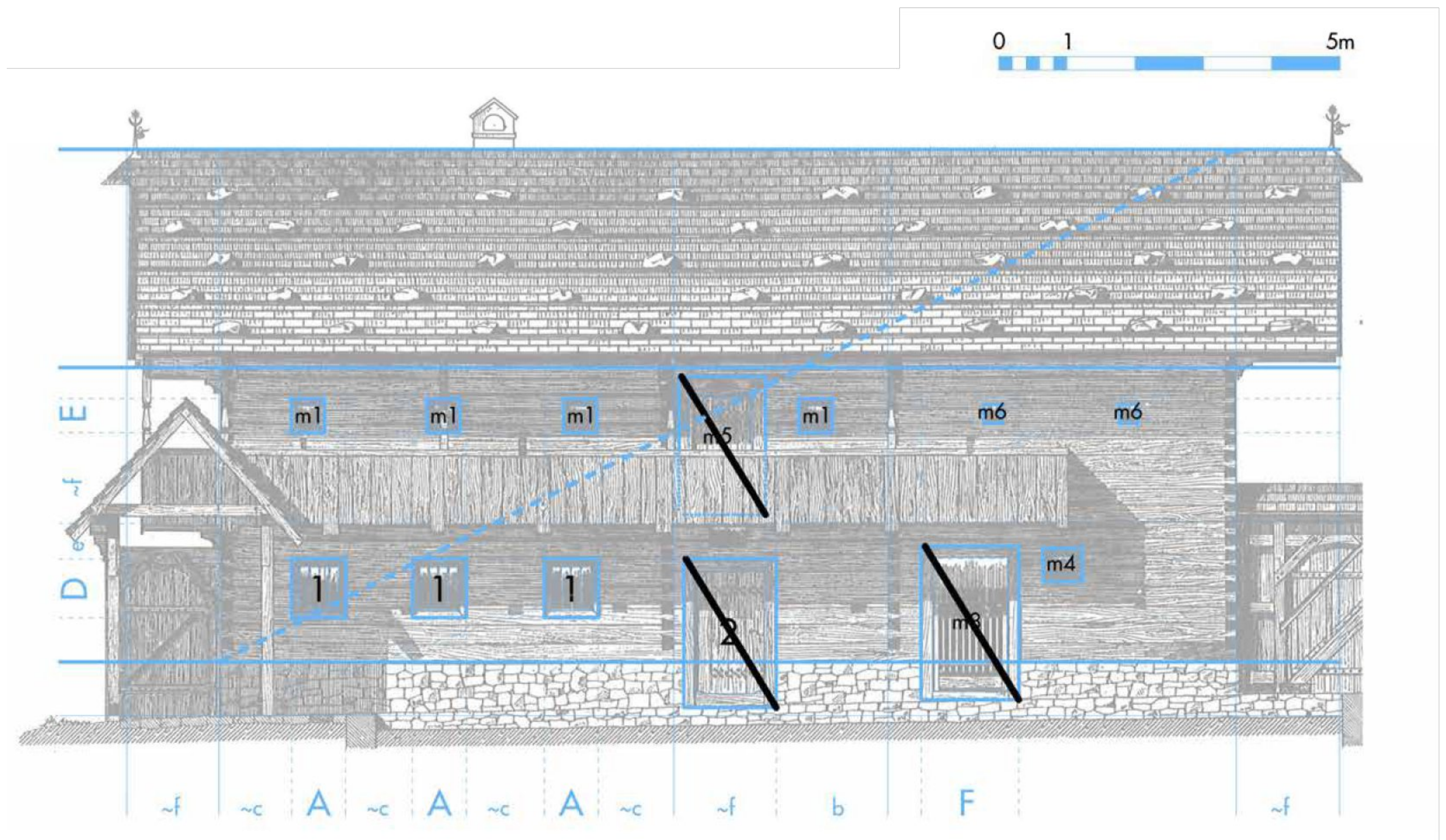


Fig. V.101 Geometrical analysis of front elevation: (U03) "Schwarzmayergut" in Siegharting in Thal

Fig. V.102 Geometrical analysis of side elevation: (U03) "Schwarzmayergut" in Siegharting in Thal

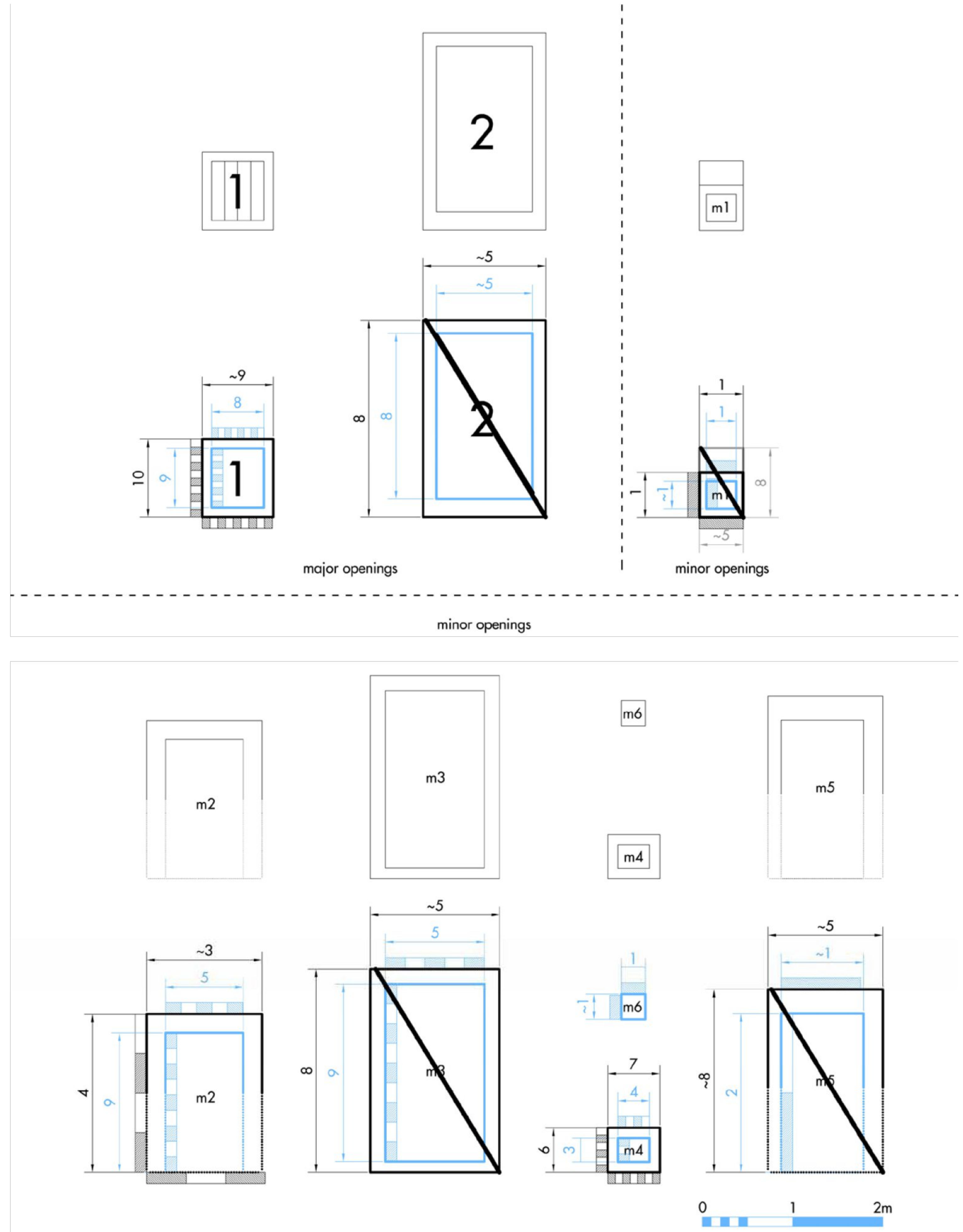


Fig. V.103 Geometrical analysis of openings: (U03) "Schwarzmayergut" in Siegharting in Thal

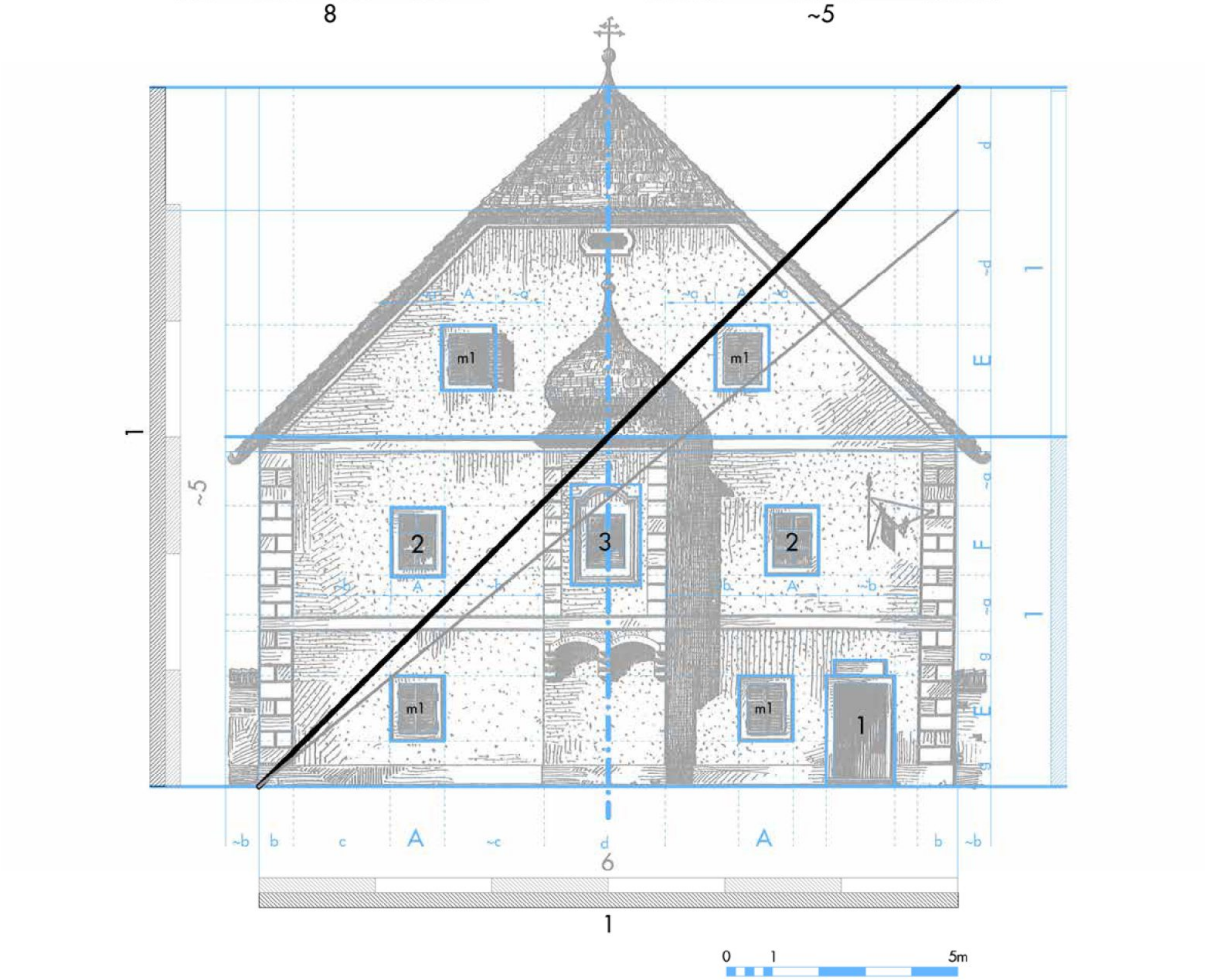


Fig. V.104 Geometrical analysis of front elevation: (L01) Vineyard house No. 50 in Kritzendorf
Fig. V.105 Geometrical analysis of front elevation: (L02) Vineyard house in Weissenkirchen

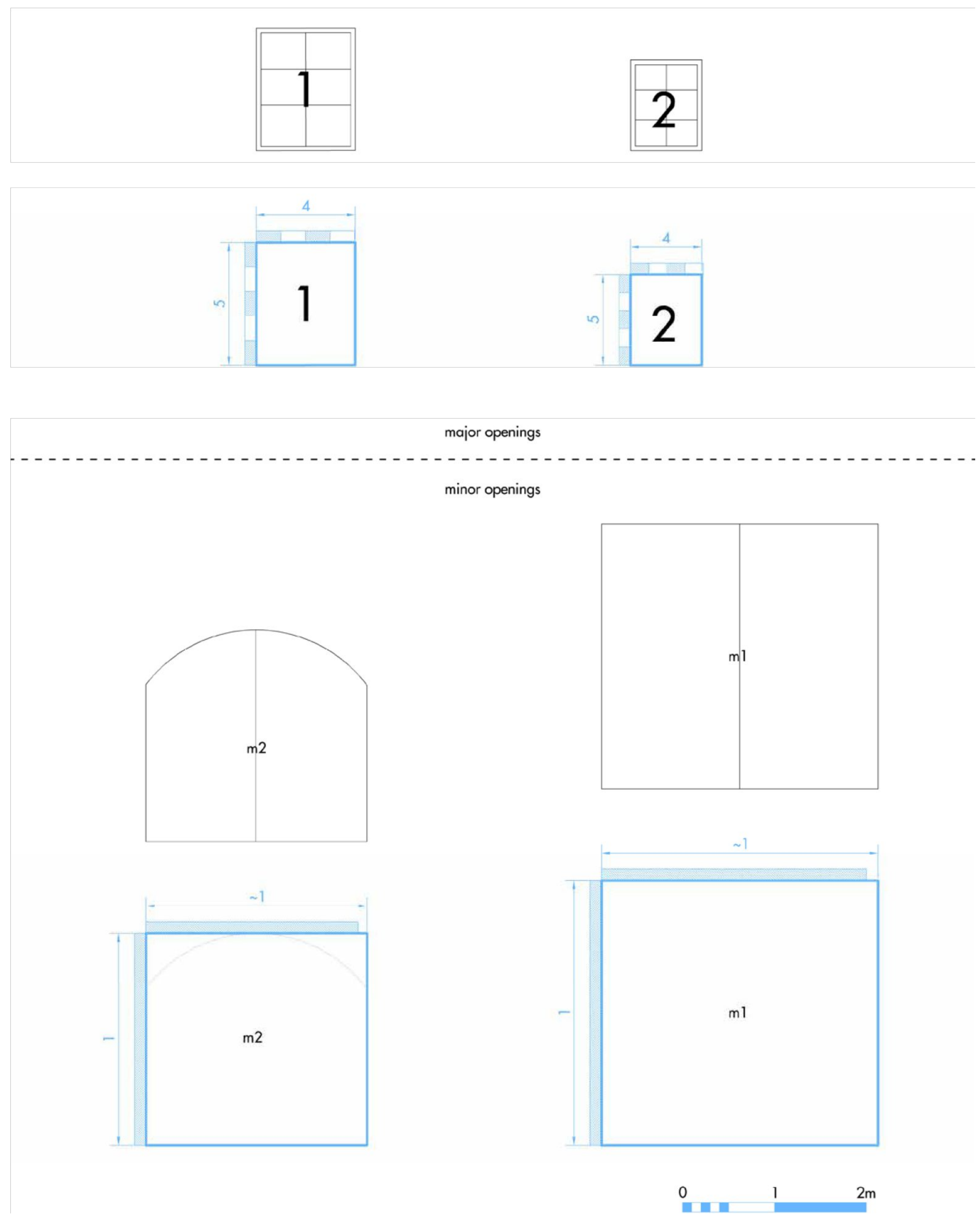


Fig. V.106 Geometrical analysis of openings: (L01) Vineyard house No. 50 in Kritzendorf

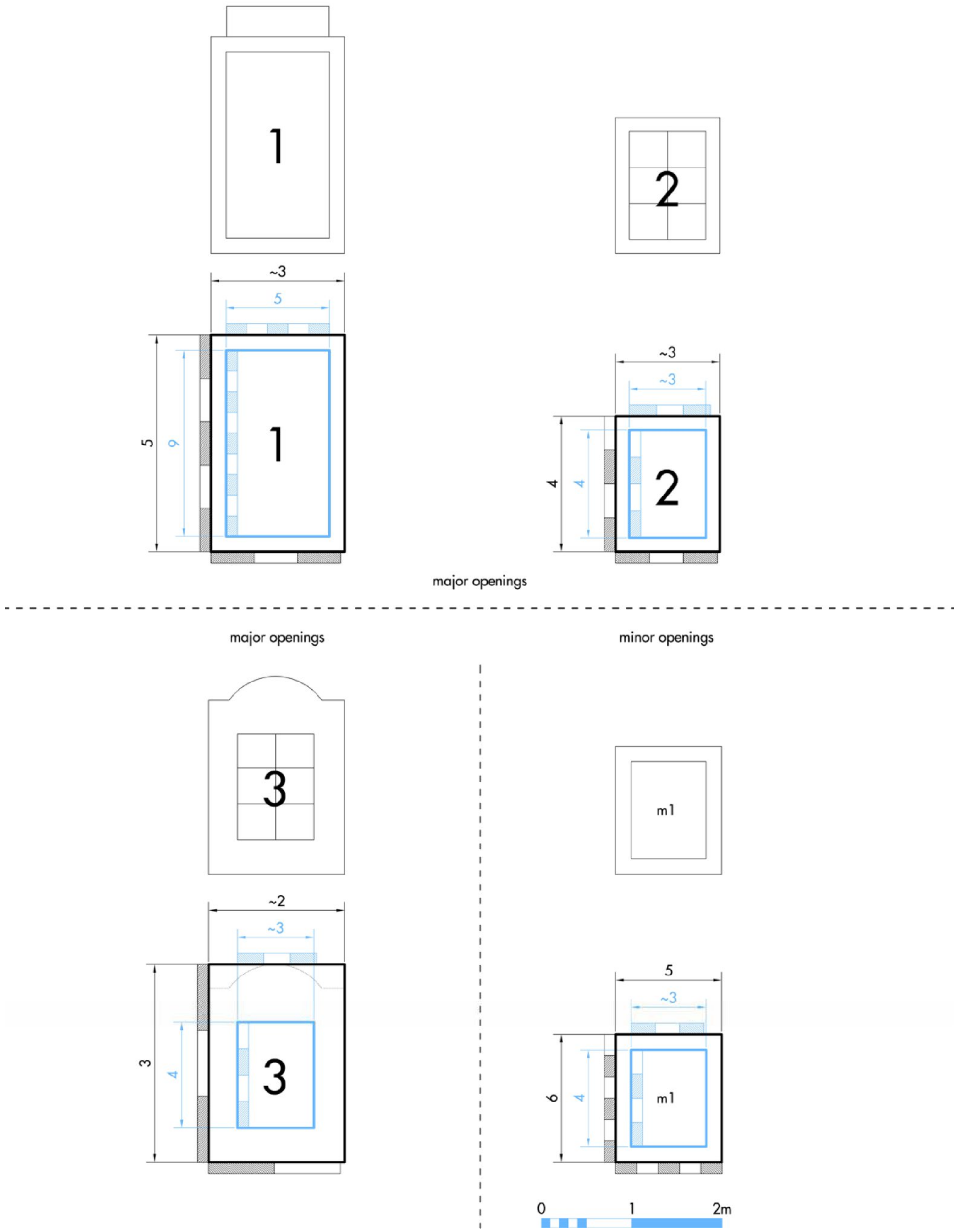


Fig. V.107 Geometrical analysis of side elevation: (L02) Vineyard house in Weissenkirchen

intentionally omitted

GERMANIC REGION // AREAS IN CURRENT GERMANY

Brandenburg

B01: Farmhouse in Dlugi, Reg.-Bez. Frankfurt
(front and side elevation, openings)

B02: Farmhouse in Alt-Blessin, Reg.-Bez. Frankfurt
(front elevation, openings)

B03: Farmhouse in Zäckerick, Reg.-Bez. Frankfurt
(front elevation, openings)

B04: Farmhouse in Leipe, Reg.-Bez. Frankfurt
(front and side elevation, openings)

B05: Farmhouse in Burg, Reg.-Bez. Frankfurt
(front and side elevation, openings)

B06: Farmhouse in Hardenbeck, Reg.-Bez. Potsdam
(rear elevation, openings)

Württemberg

Wü01: Farmhouse in Sindelfingen
(front and side elevation, openings)

Wü02: Farmhouse in Dürrmenz
(front elevation, openings)

Wü03: Farmhouse in Murrhardt
(side elevation, openings)

Wü04: Farmhouse in Haslach
(front and side elevation, openings)

Wü05: Farmhouse in Kürnbach
(side elevation, openings)

Wü06: Vineyard house in Strümpfelbach
(front elevation, openings)

Wü07: Farmhouse in Unter-Aspach
(front and side elevation, openings)

Wü08: Farmhouse in Waffenried
(front and side elevation, openings)

Baden

Ba01: Farmhouse in Simmersbachthal near Ottenhöfen
(front elevation, openings)

Ba02: House in Pfullendorf
(front elevation, openings)

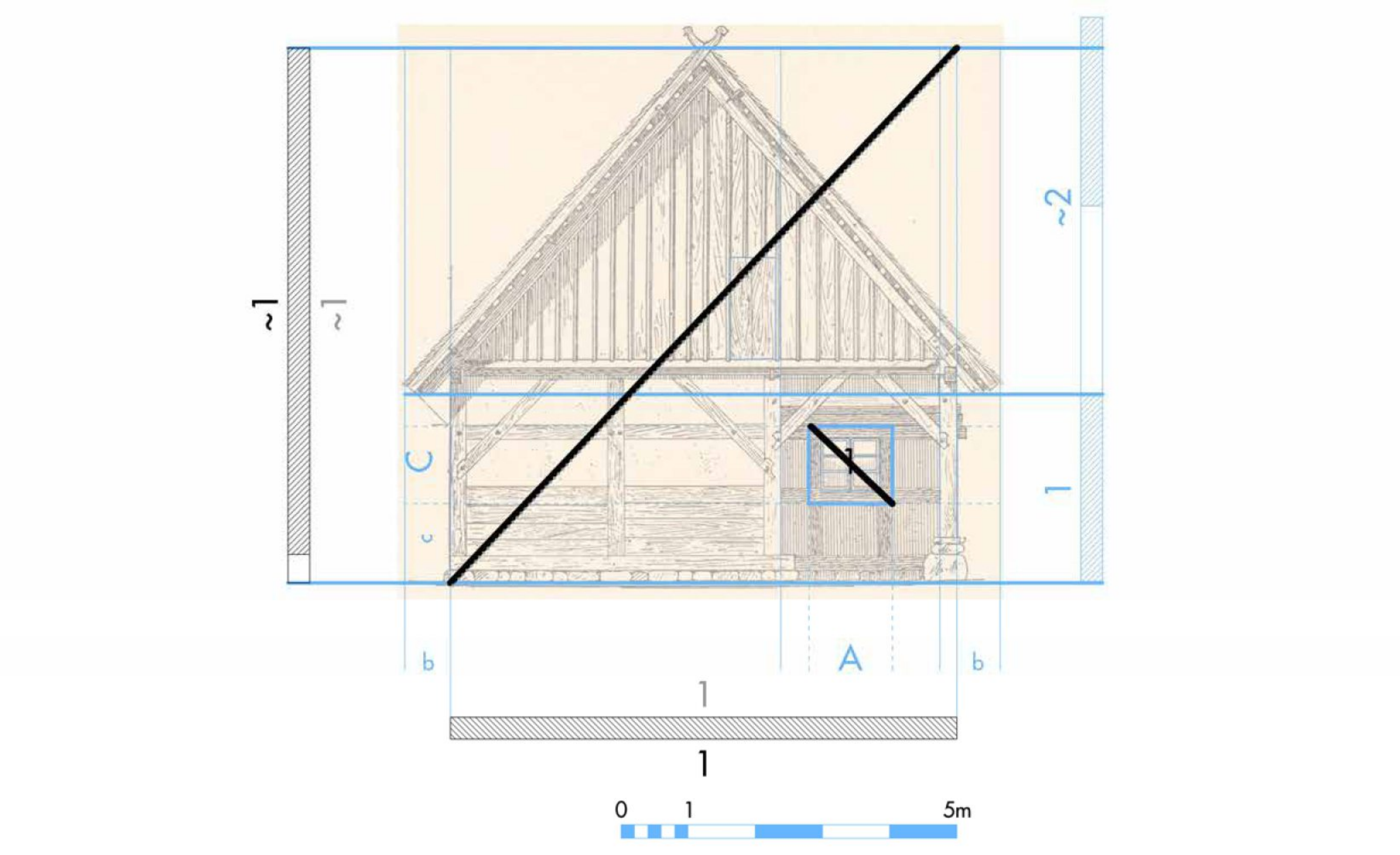
Ba03: Farmhouse No. 73 in Herbolzheim
(front and side elevation, openings)

Ba04: Farmhouse in Allmannsweier near Lahr
(front elevation, openings)

Ba05: Farmhouse No. 58 in Kippenheim near Lahr
(front elevation, openings)

Ba06: Farmhouse No. 227 in Kippenheim near Lahr
(front and rear elevation, openings)

Ba07: Farmhouse in Binau
(front and side elevation, openings)



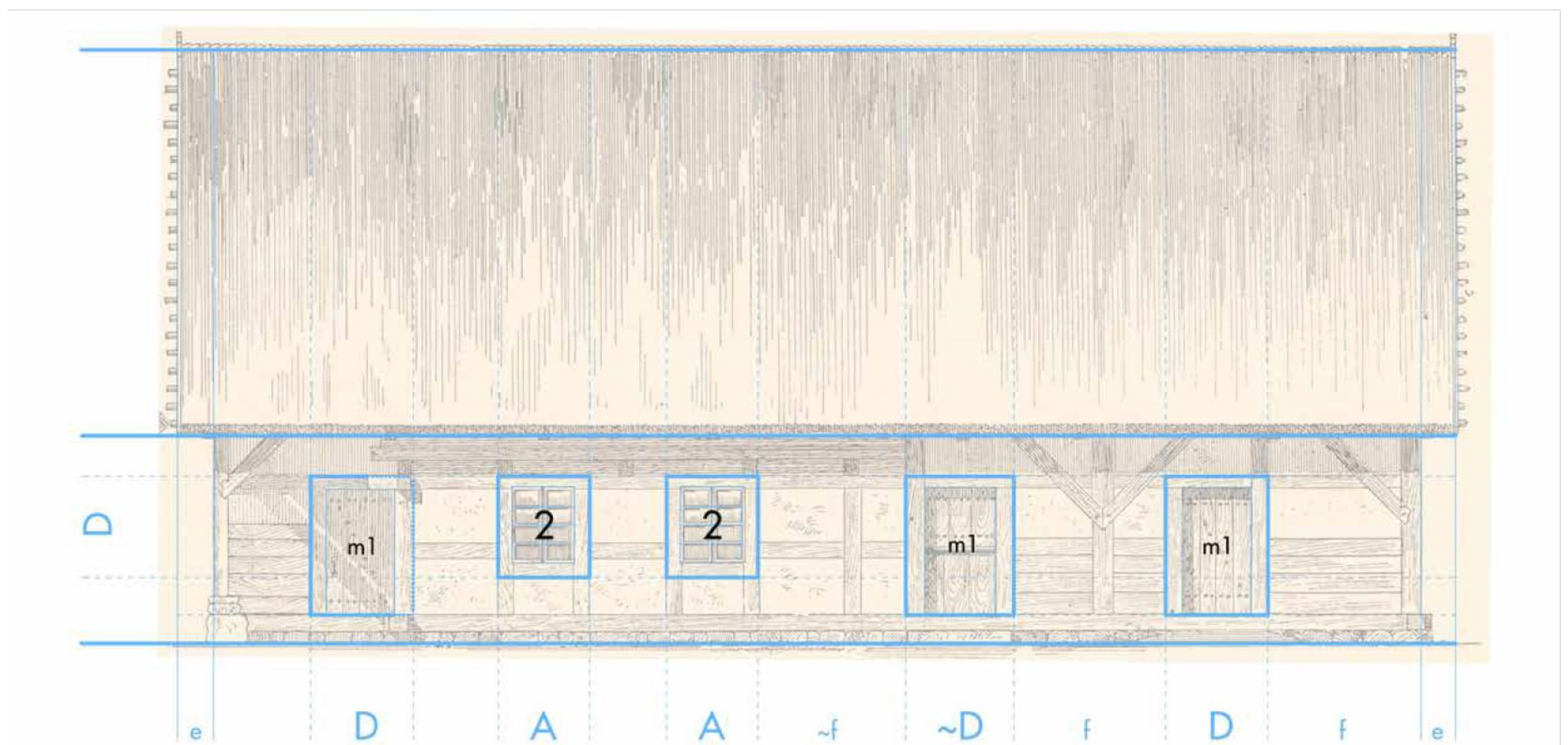


Fig. V.108 Geometrical analysis of front elevation: (B01) Farmhouse in Dlugi, Reg.-Bez. Frankfurt
Fig. V.109 Geometrical analysis of side elevation: (B01) Farmhouse in Dlugi, Reg.-Bez. Frankfurt

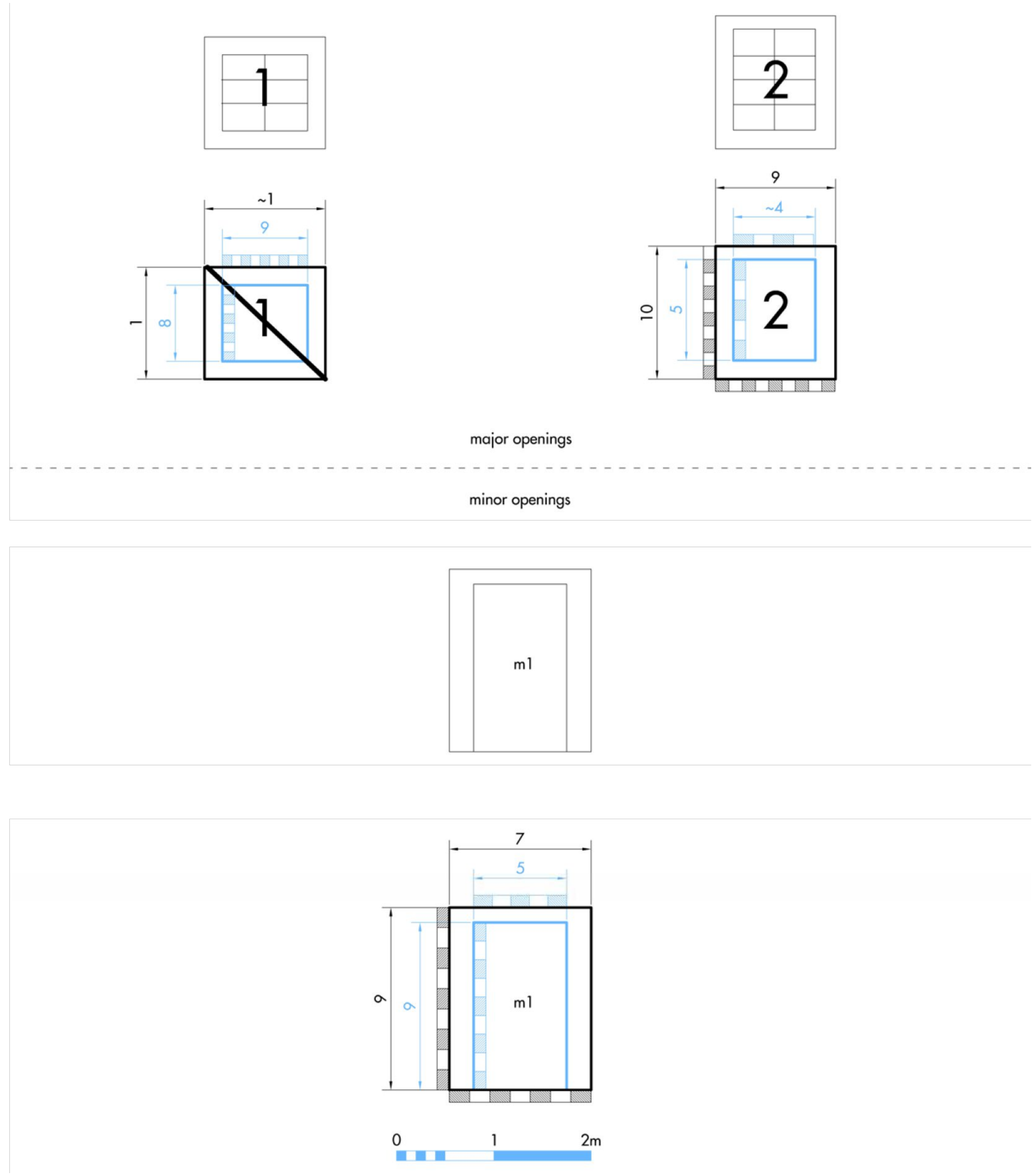
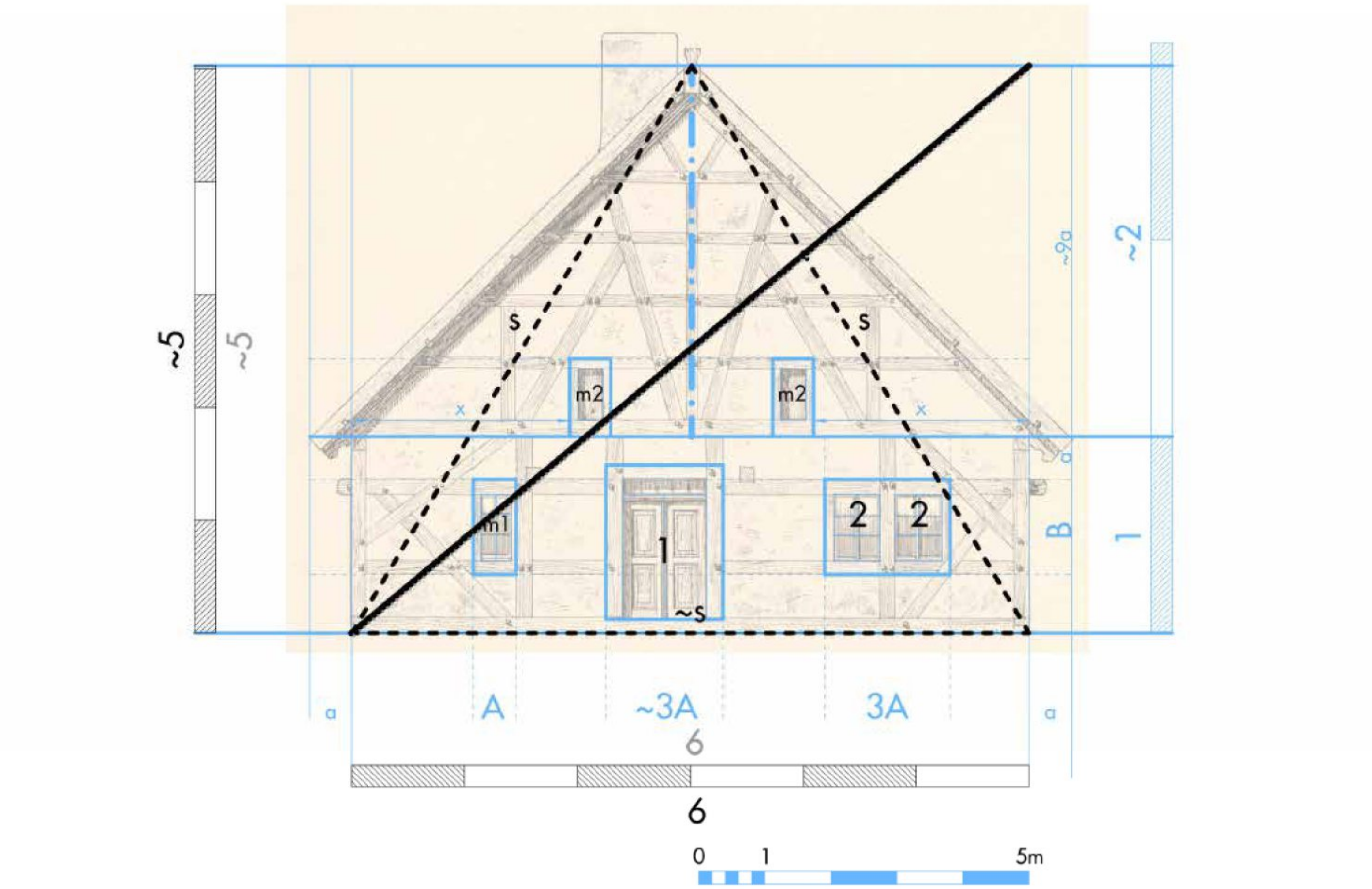


Fig. V.110 Geometrical analysis of openings: (B01) Farmhouse in Dlugi, Reg.-Bez. Frankfurt



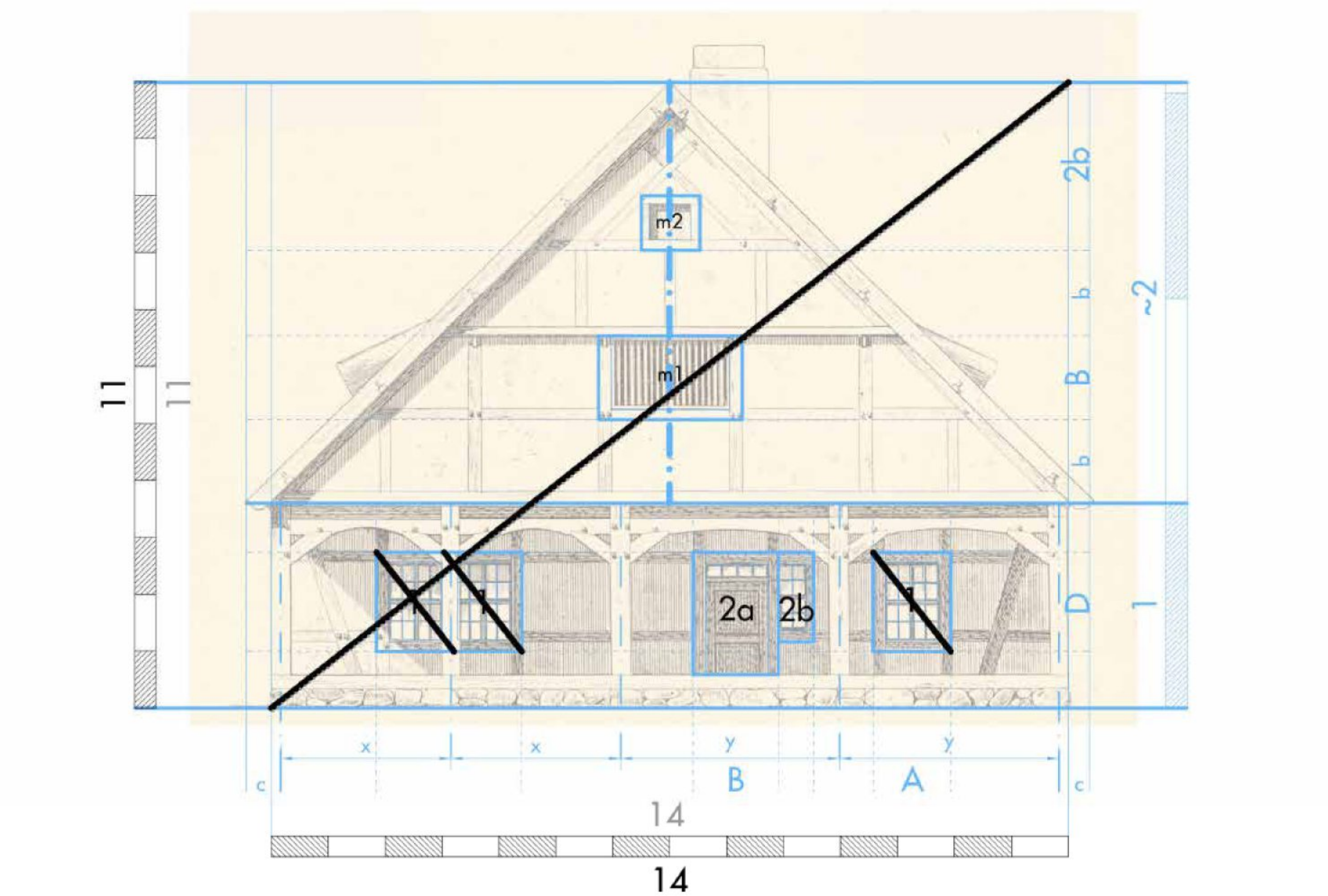


Fig. V.111 Geometrical analysis of front elevation: (B02) Farmhouse in Alt-Blessin, Reg.-Bez. Frankfurt
Fig. V.112 Geometrical analysis of front elevation: (B03) Farmhouse in Zäckerick, Reg.-Bez. Frankfurt

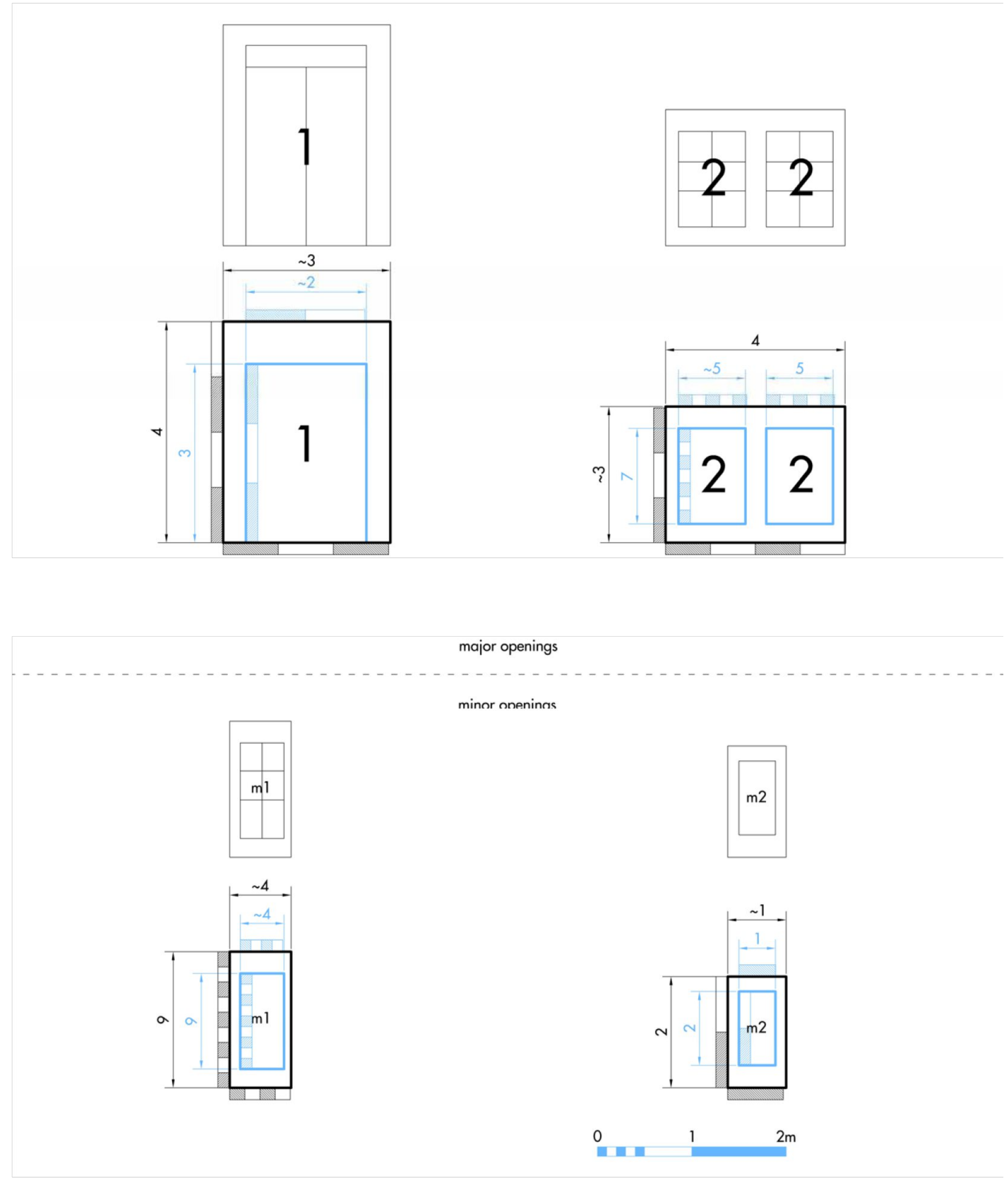


Fig. V.113 Geometrical analysis of openings: (B02) Farmhouse in Alt-Blessin, Reg.-Bez. Frankfurt

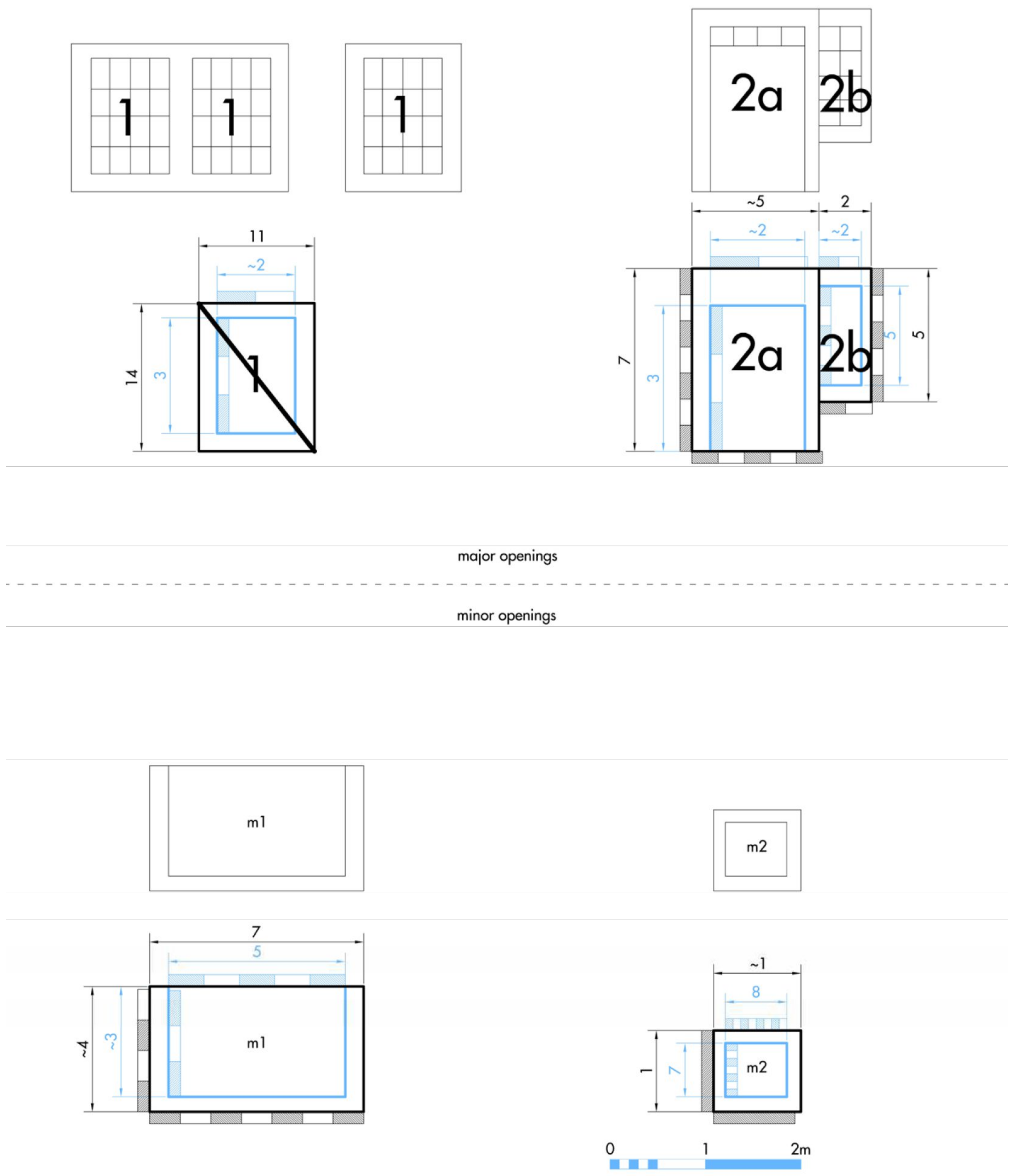
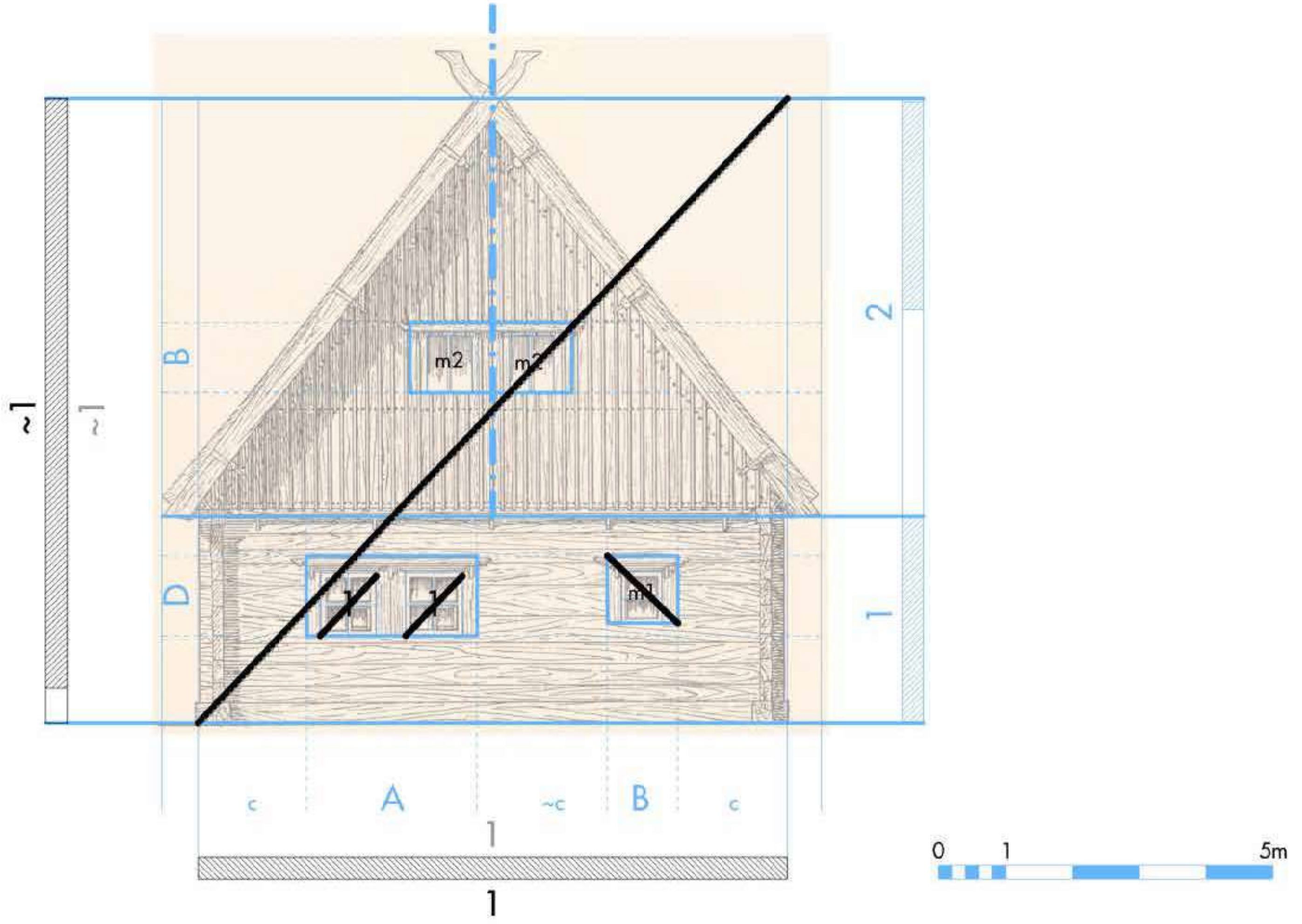


Fig. V.114 Geometrical analysis of openings: (B03) Farmhouse in Zäckerick, Reg.-Bez. Frankfurt



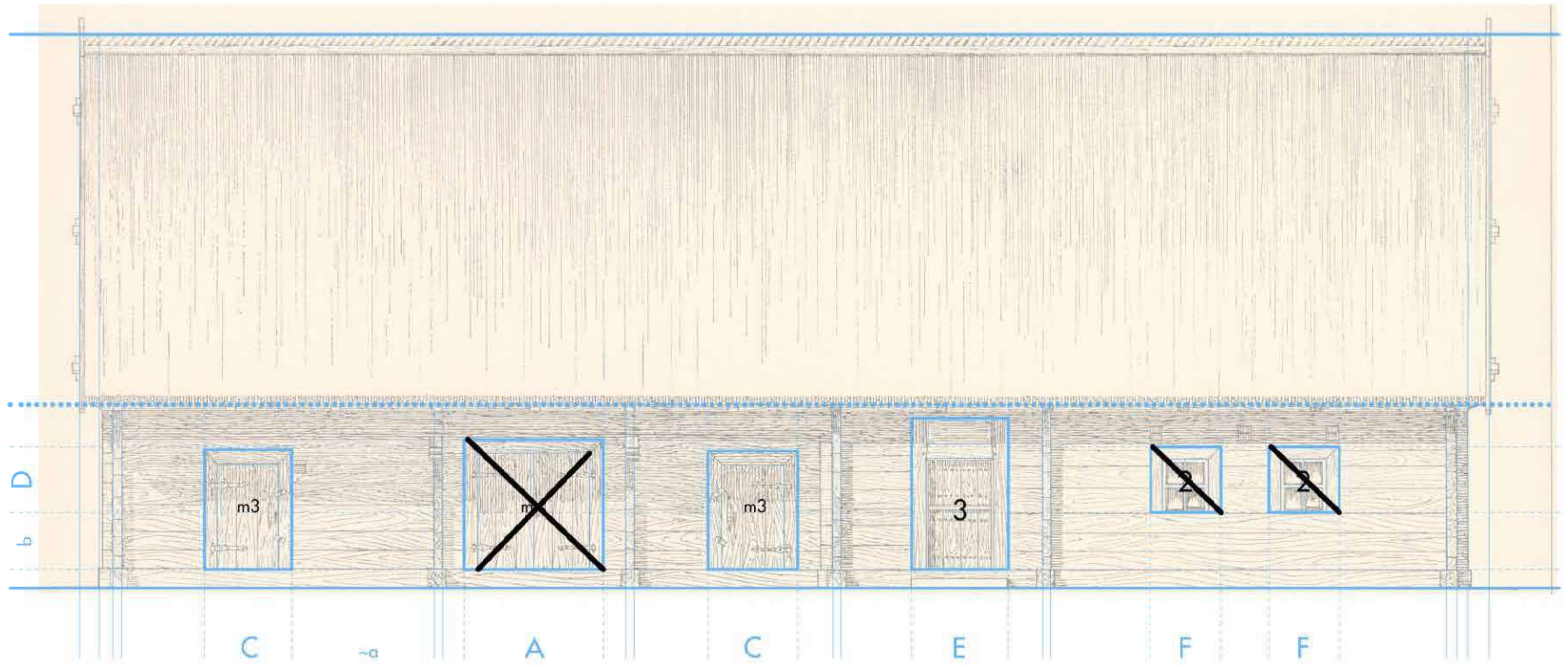


Fig. V.115 Geometrical analysis of front elevation: (B04) Farmhouse in Leipe, Reg.-Bez. Frankfurt
Fig. V.116 Geometrical analysis of side elevation: (B04) Farmhouse in Leipe, Reg.-Bez. Frankfurt

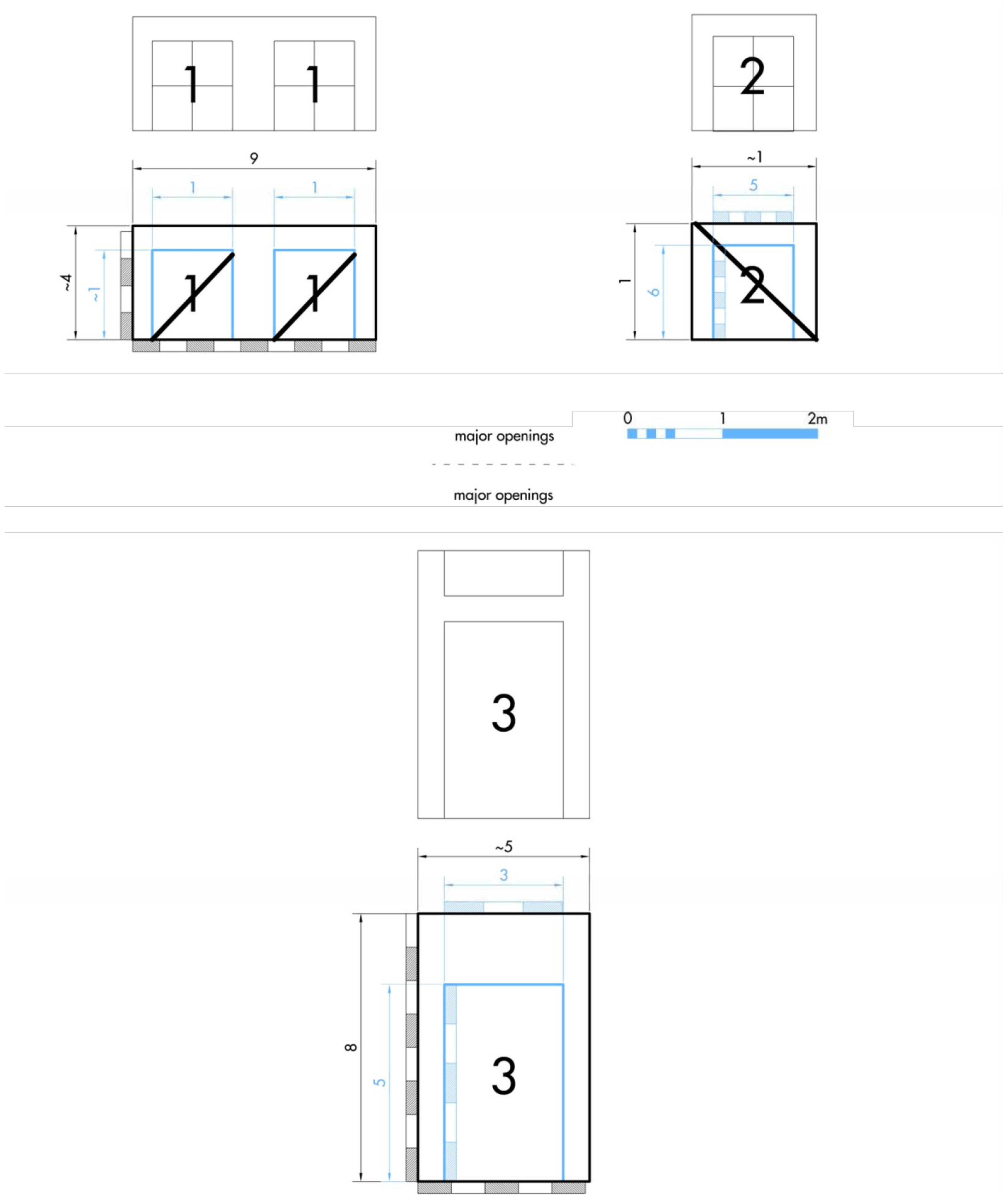


Fig. V.117 Geometrical analysis of openings: (B04) Farmhouse in Leipe, Reg.-Bez. Frankfurt

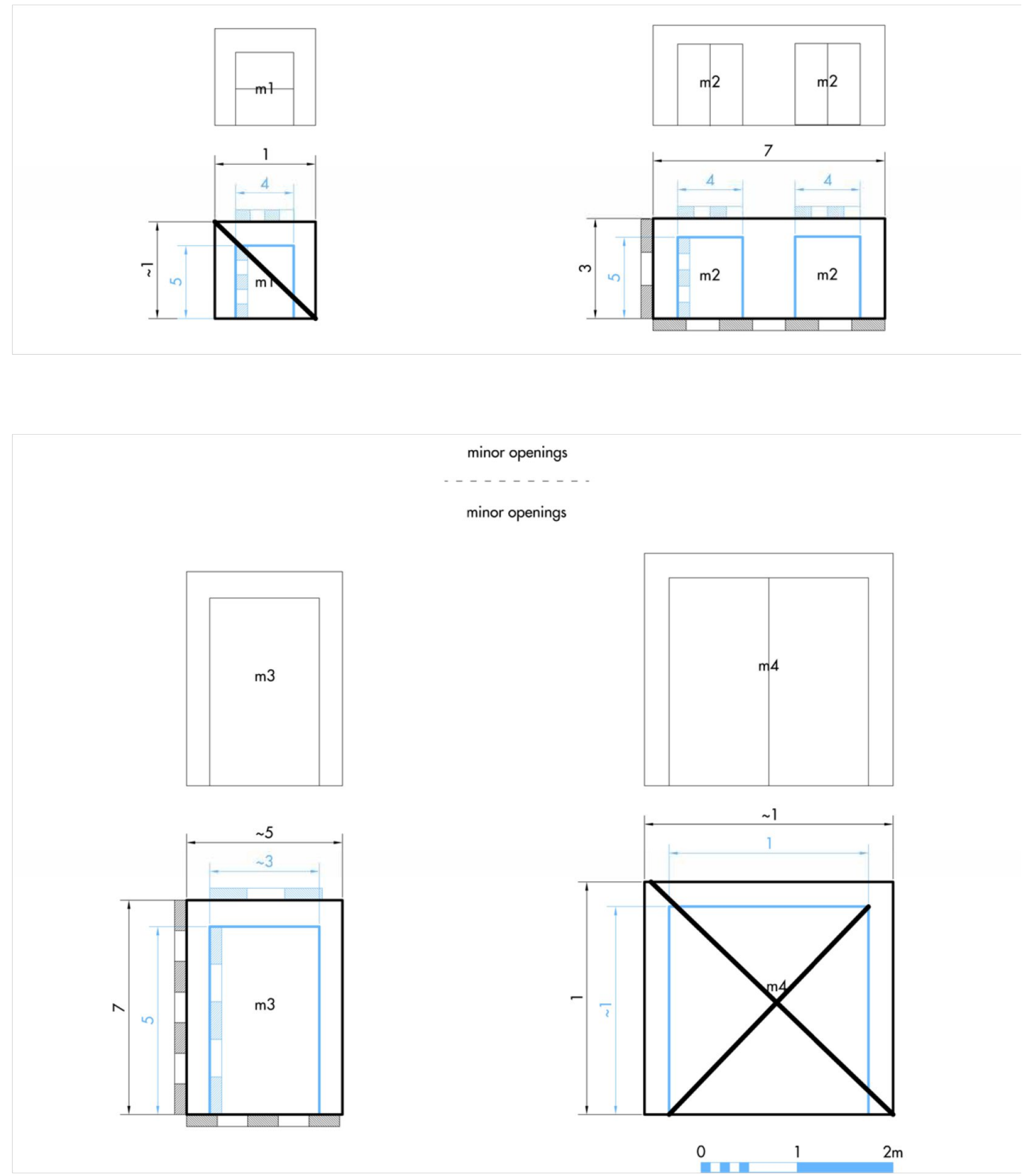
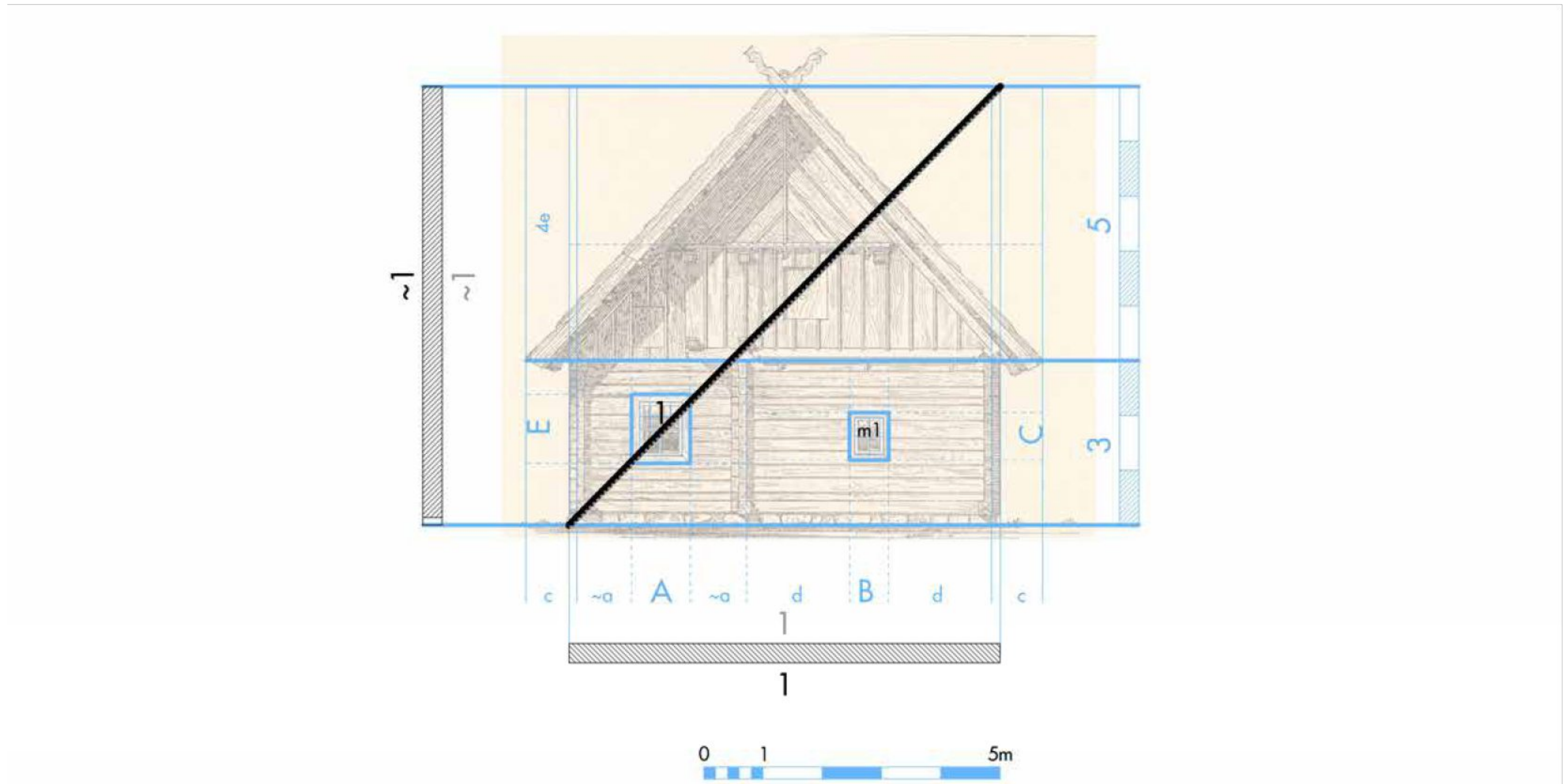


Fig. V.118 Geometrical analysis of openings: (B04) Farmhouse in Leipe, Reg.-Bez. Frankfurt



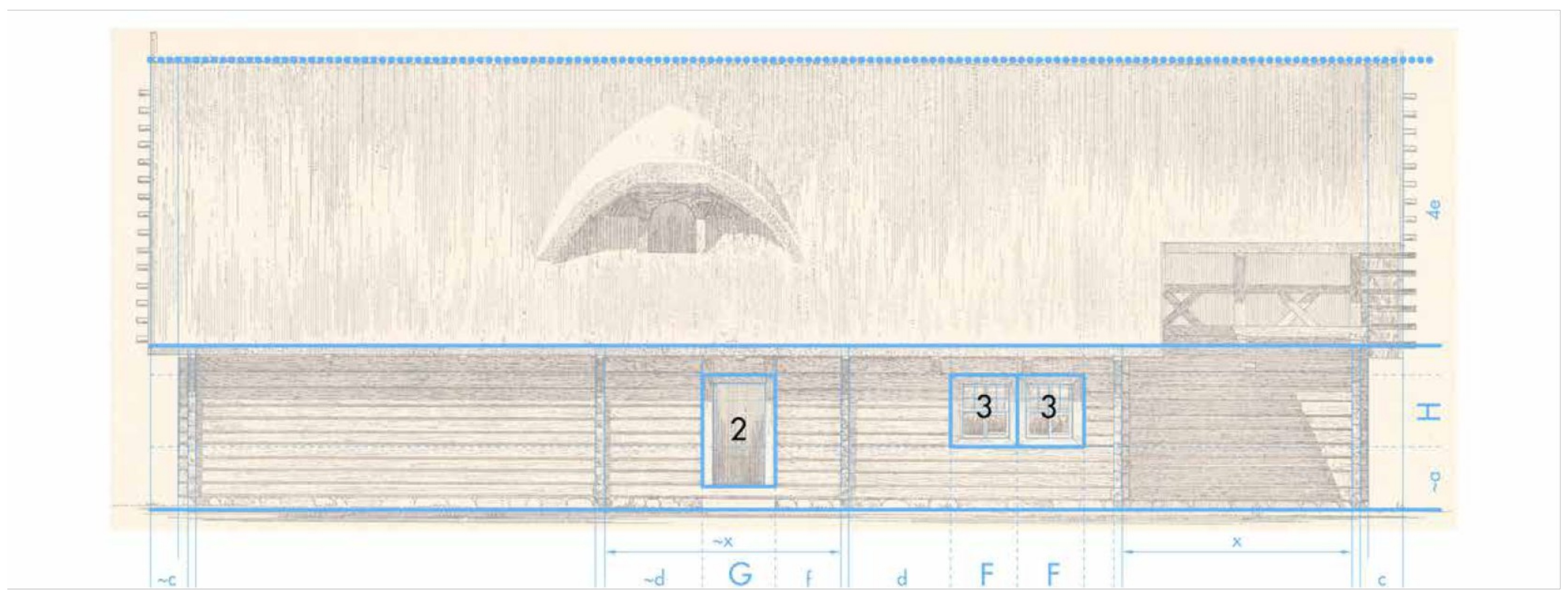


Fig. V.119 Geometrical analysis of front elevation: (B05) Farmhouse in Burg, Reg.-Bez. Frankfurt

Fig. V.120 Geometrical analysis of side elevation: (B05) Farmhouse in Burg, Reg.-Bez. Frankfurt

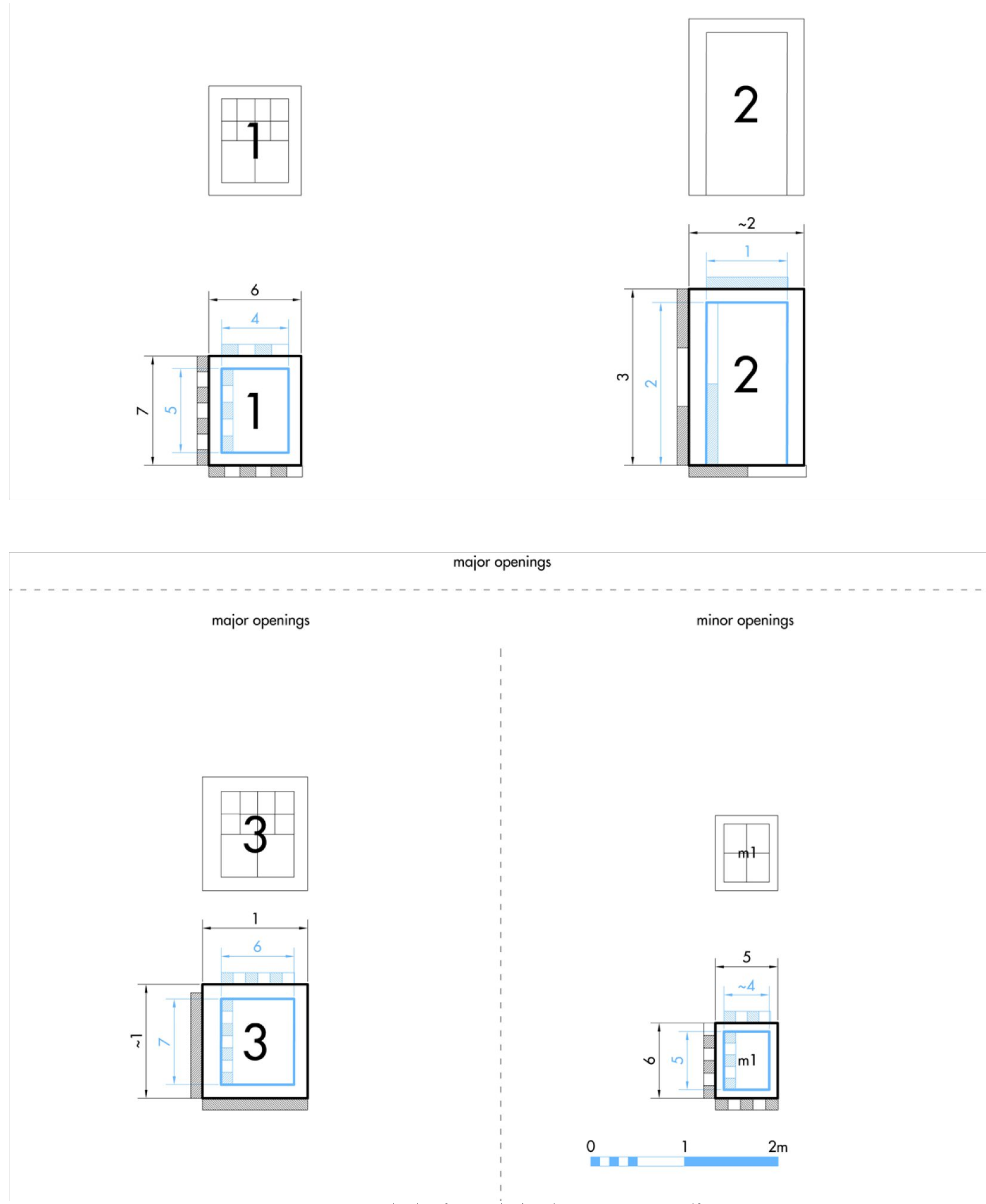


Fig. V.121 Geometrical analysis of openings: (B05) Farmhouse in Burg, Reg.-Bez. Frankfurt

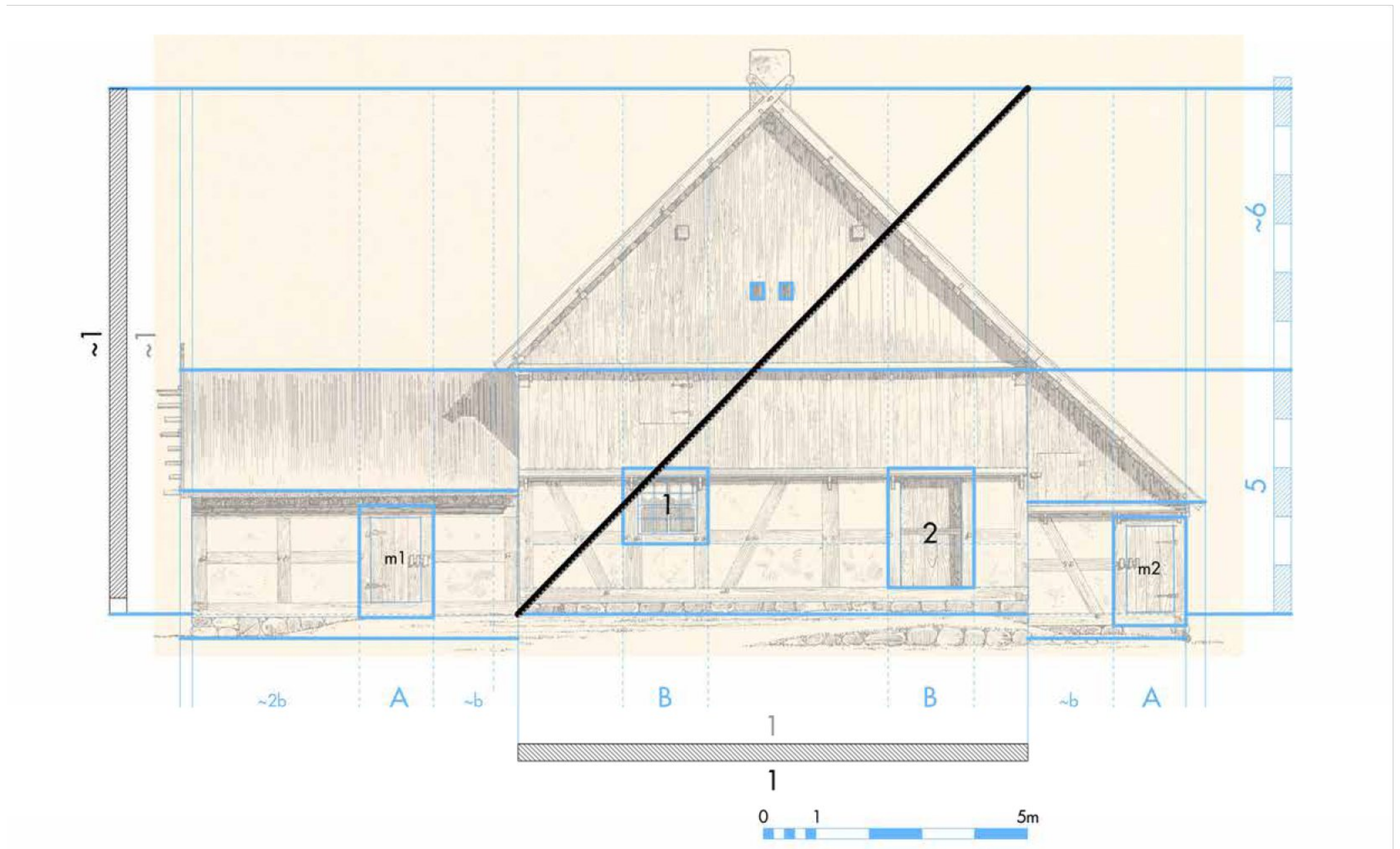


Fig. V.122 Geometrical analysis of rear elevation: (B06) Farmhouse in Hardenbeck, Reg.-Bez. Potsdam

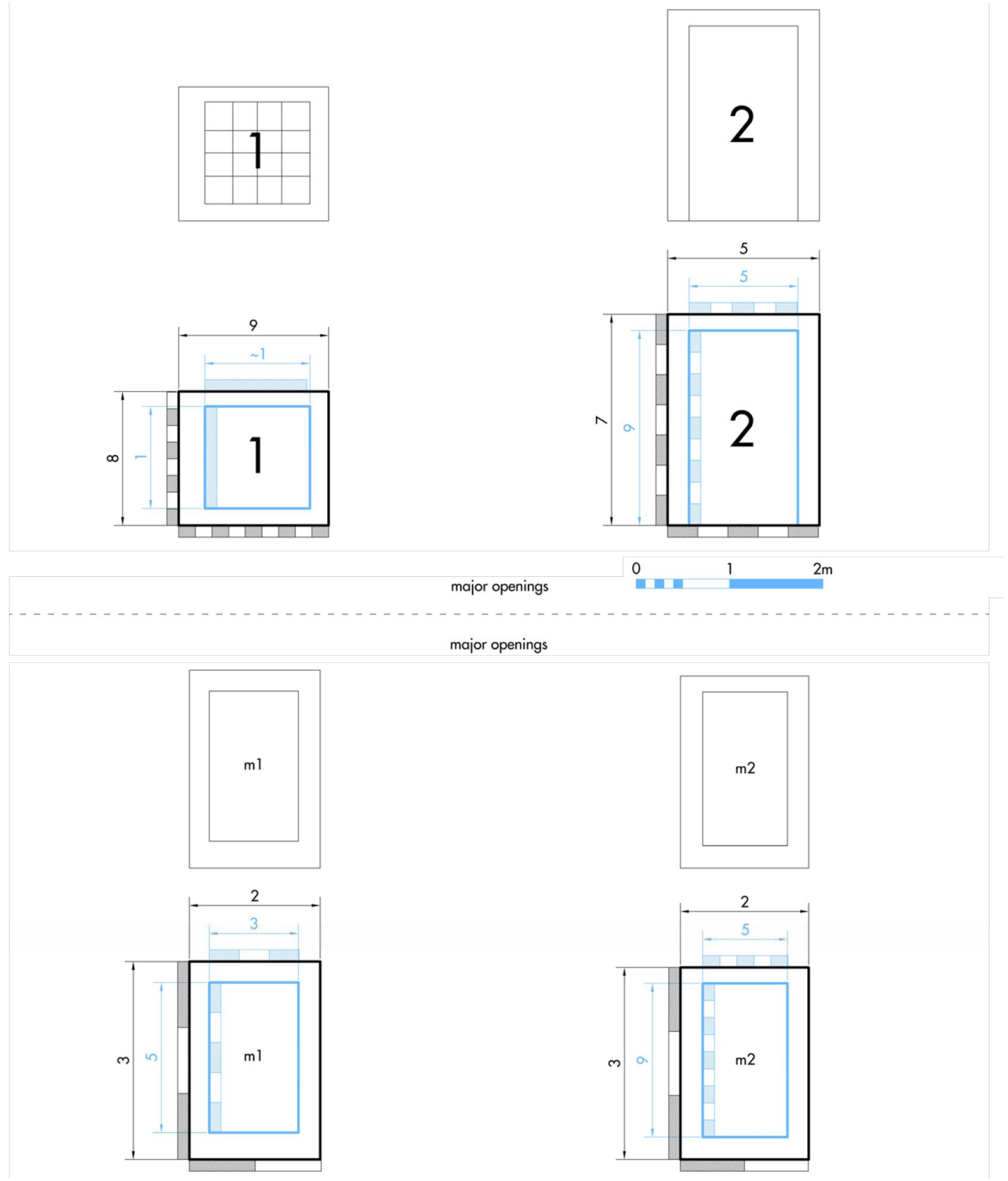
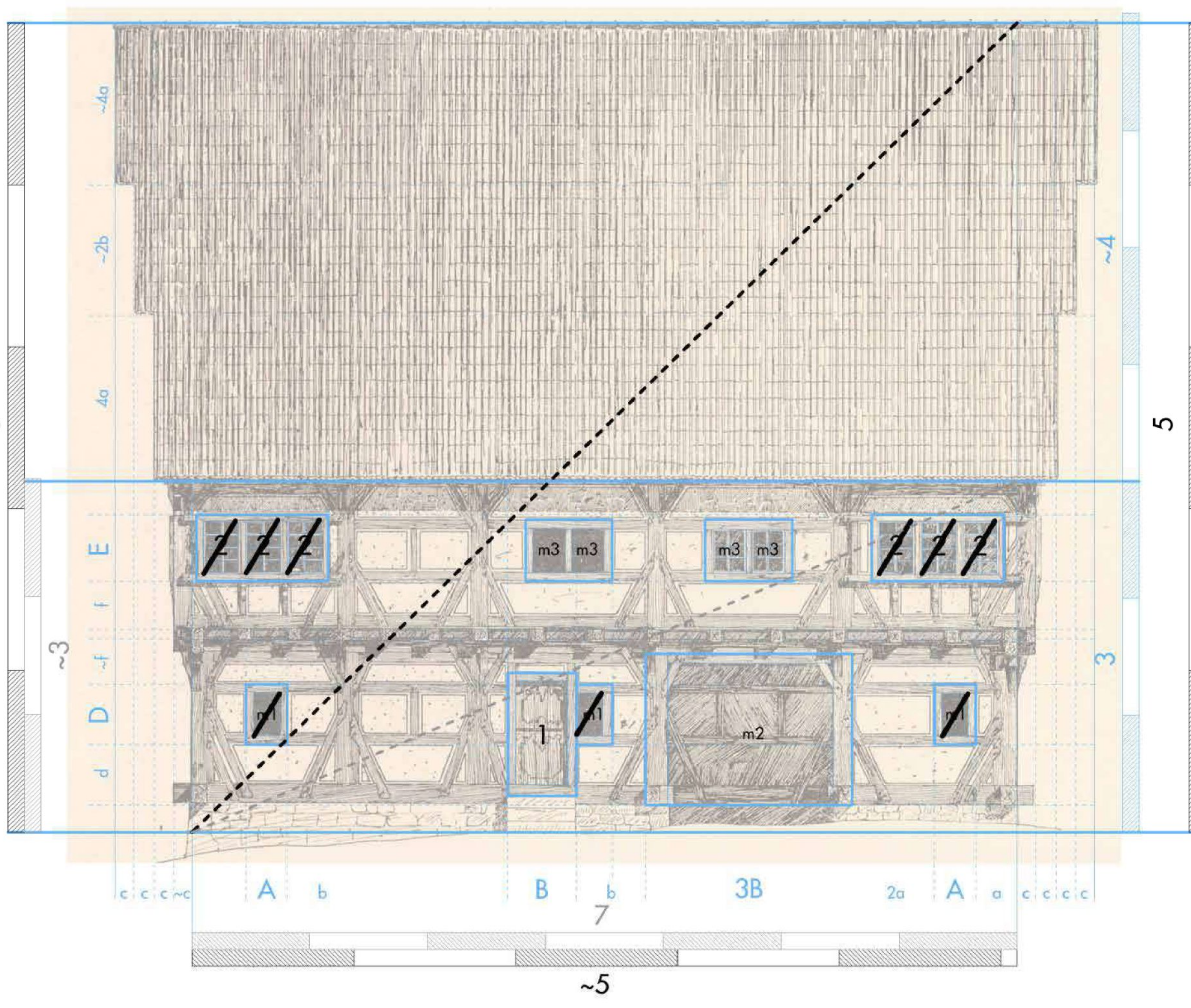


Fig. V.123 Geometrical analysis of openings: (B06) Farmhouse in Hardenbeck, Reg.-Bez. Potsdam



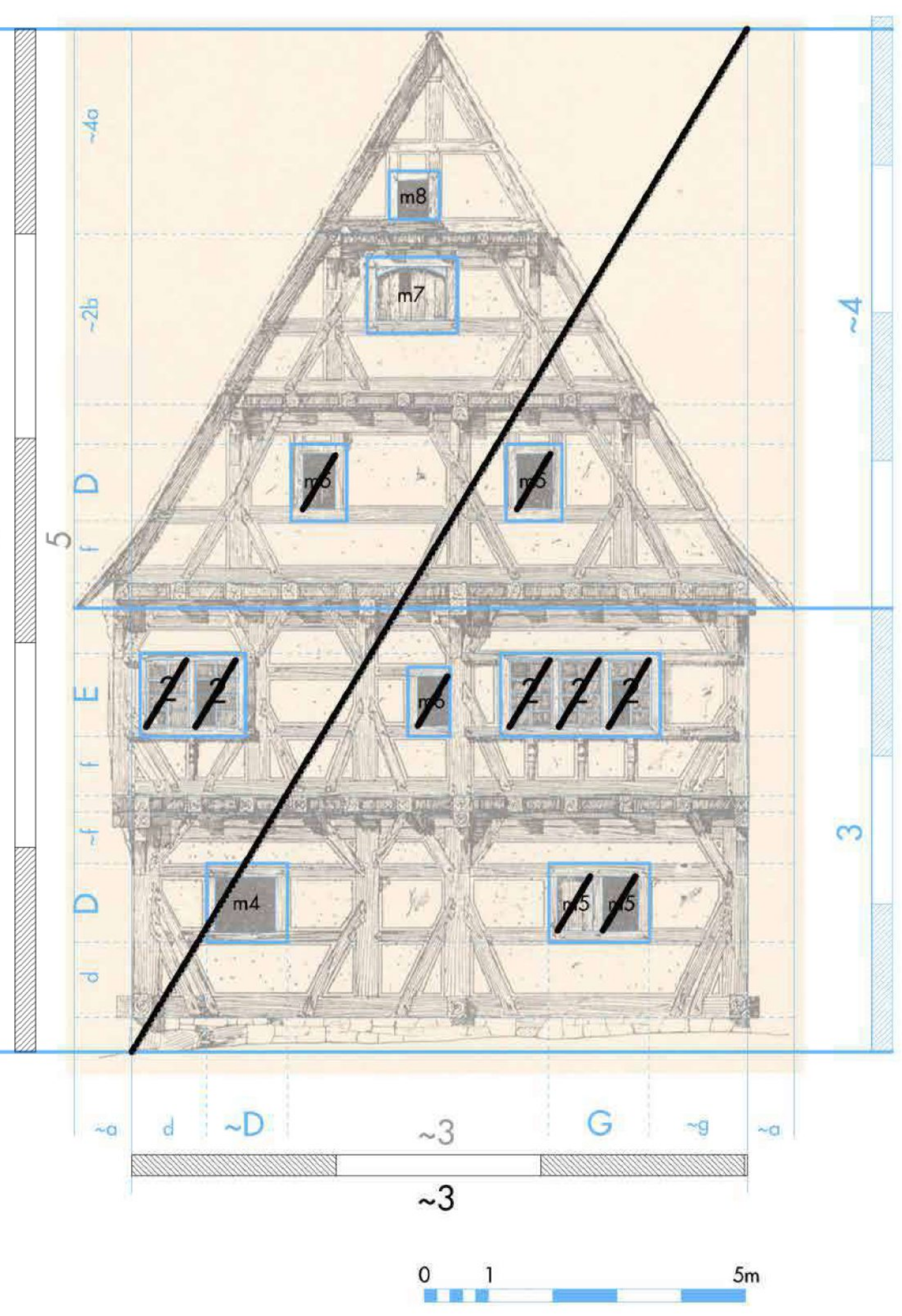


Fig. V.124 Geometrical analysis of side elevation: (W01) Farmhouse in Sindelfingen

Fig. V.125 Geometrical analysis of front elevation: (W01) Farmhouse in Sindelfingen

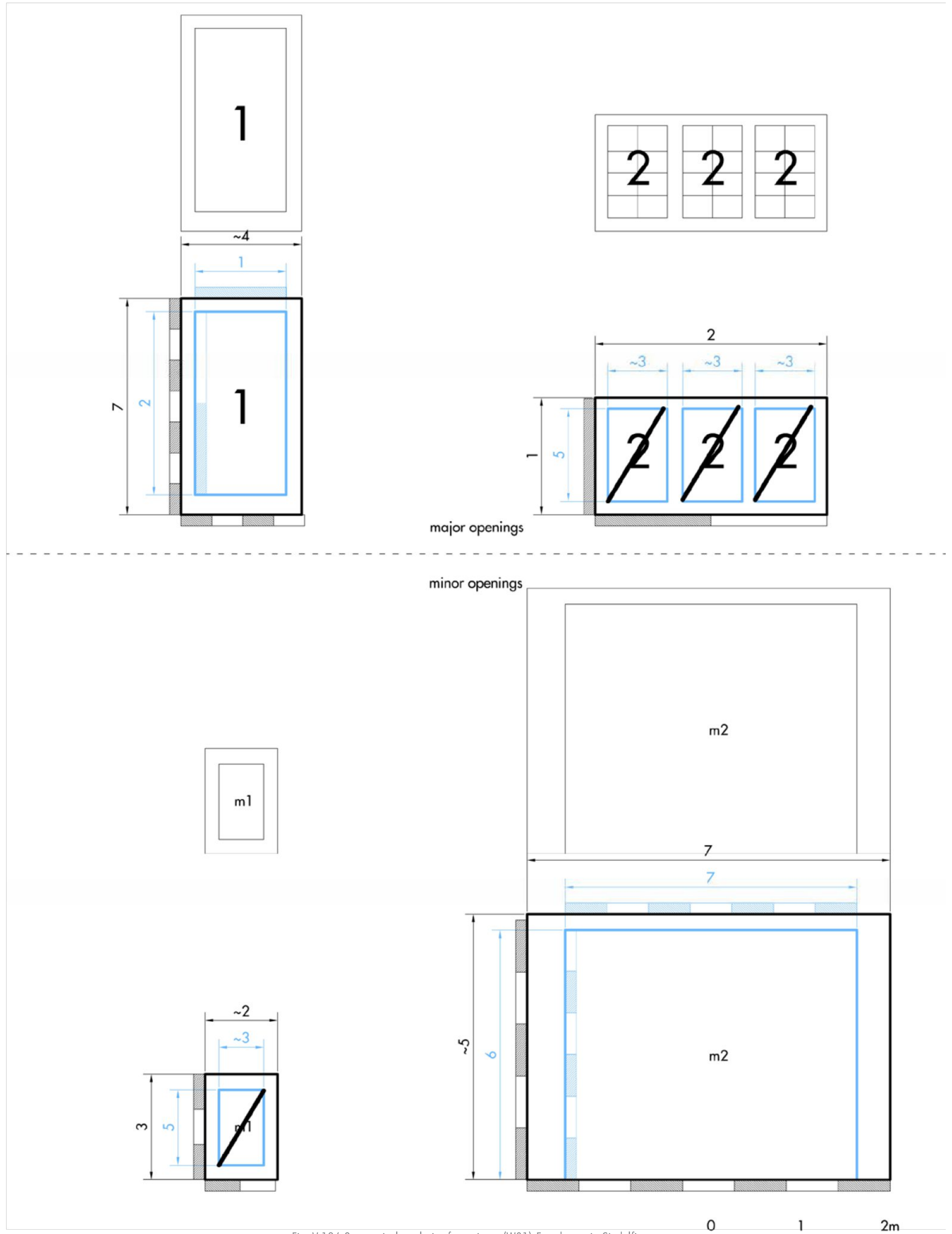


Fig. V.126 Geometrical analysis of openings: (W01) Farmhouse in Sindelfingen

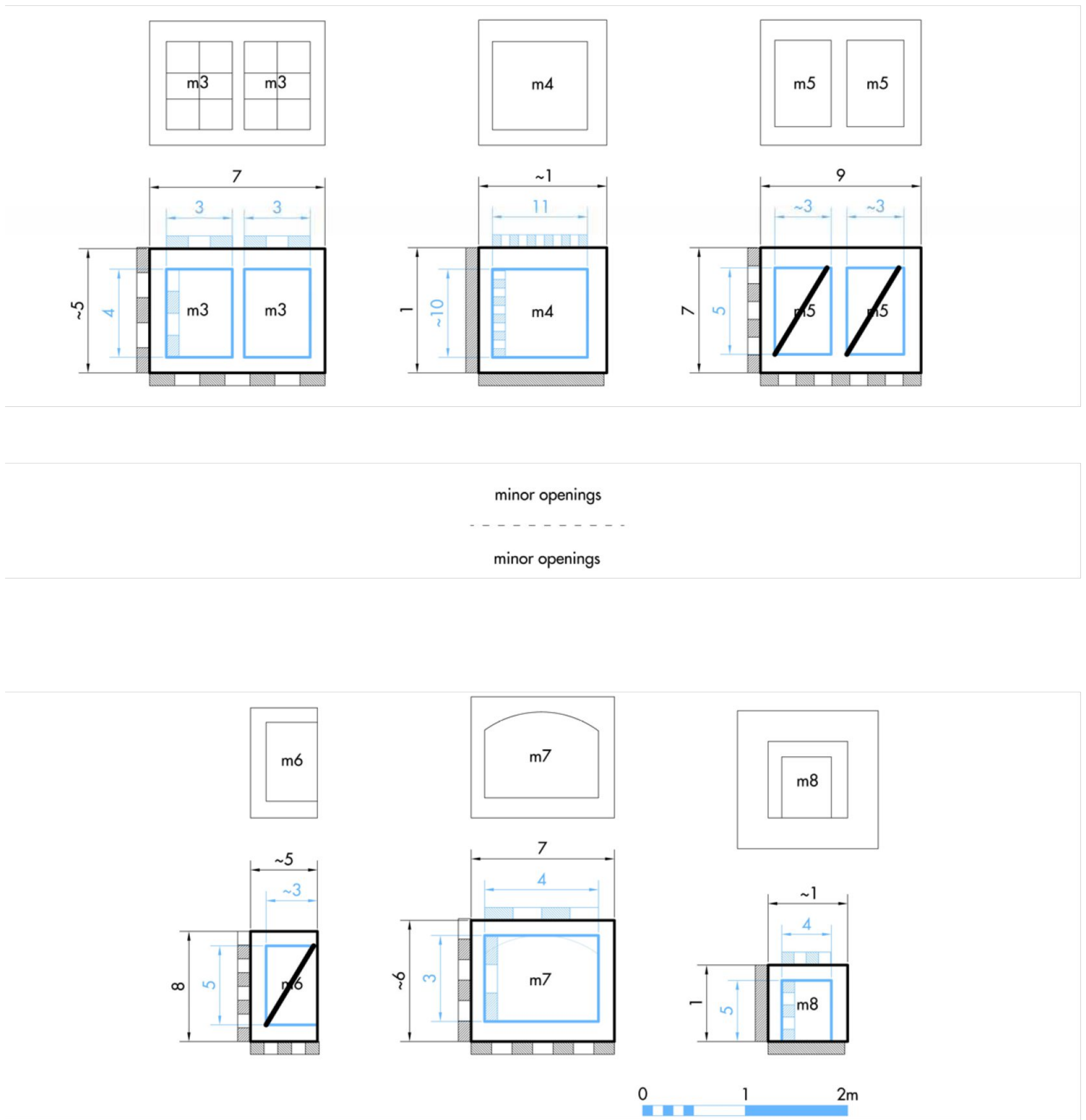
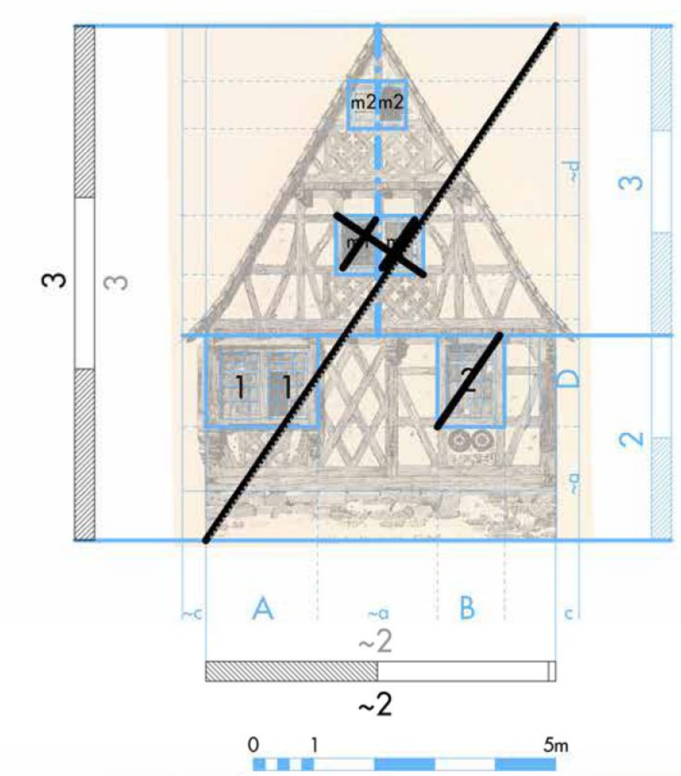


Fig. V.127 Geometrical analysis of openings: (W01) Farmhouse in Sindelfingen



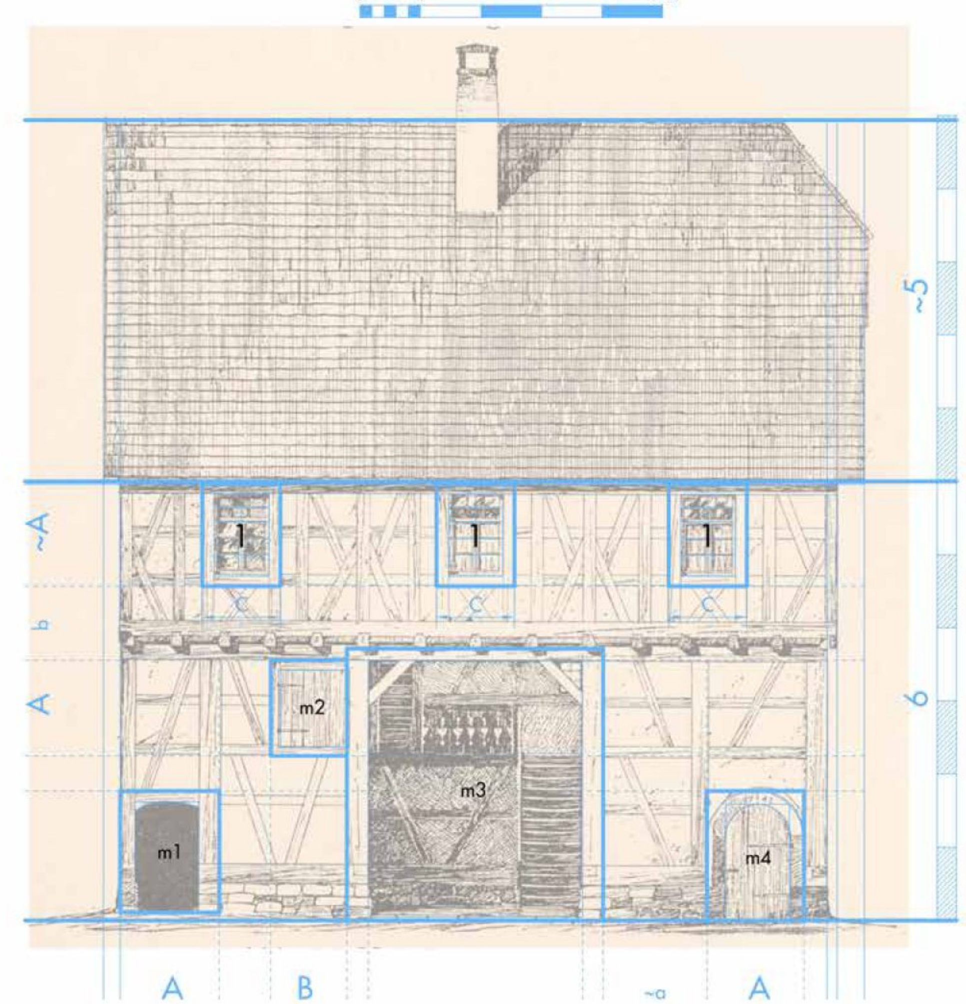


Fig. V.128 Geometrical analysis of front elevation: (W02) Farmhouse in Dürrmenz
Fig. V.129 Geometrical analysis of side elevation: (W03) Farmhouse in Murrhardt

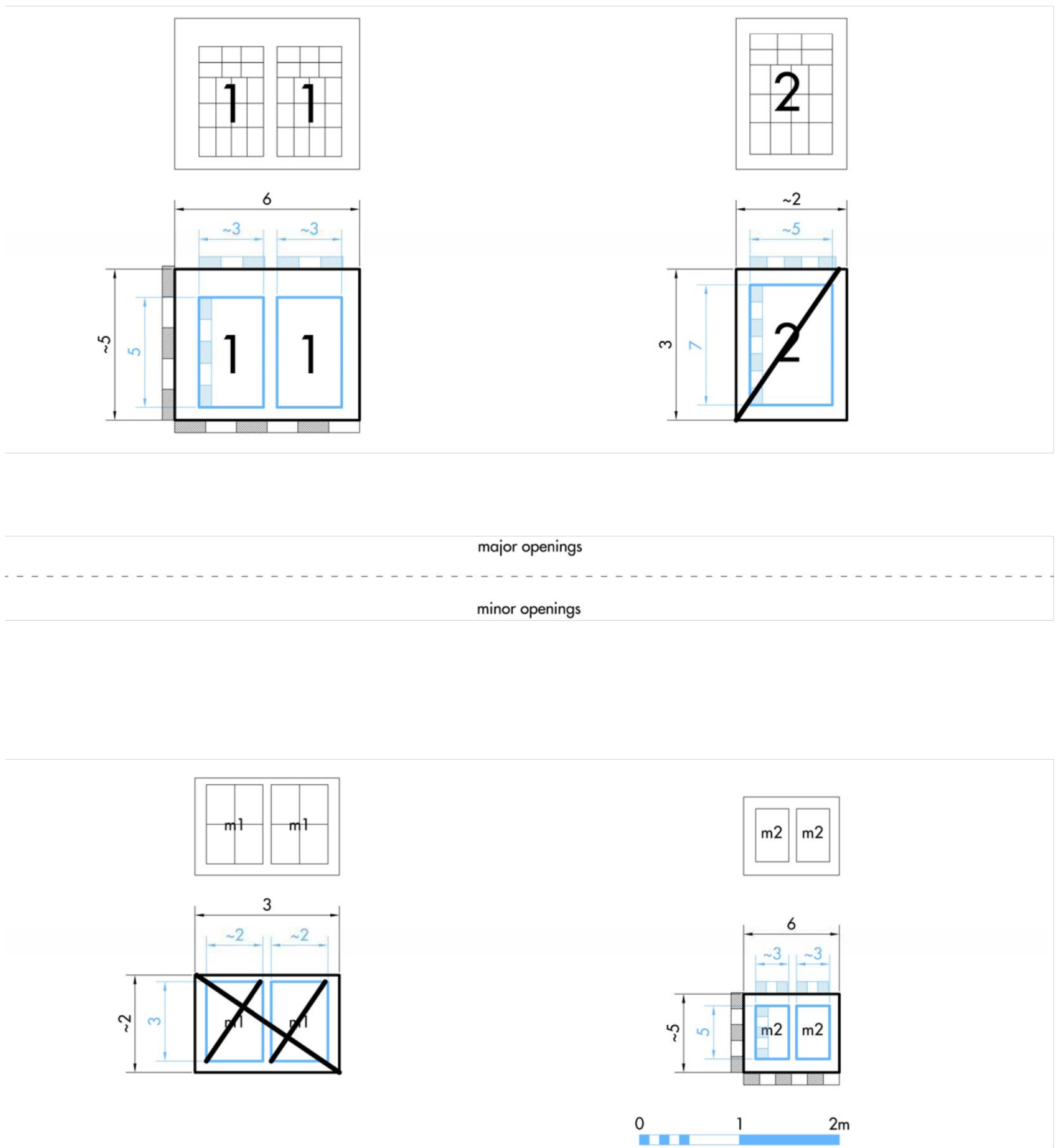


Fig. V.130 Geometrical analysis of openings: (W02) Farmhouse in Dürrmenz

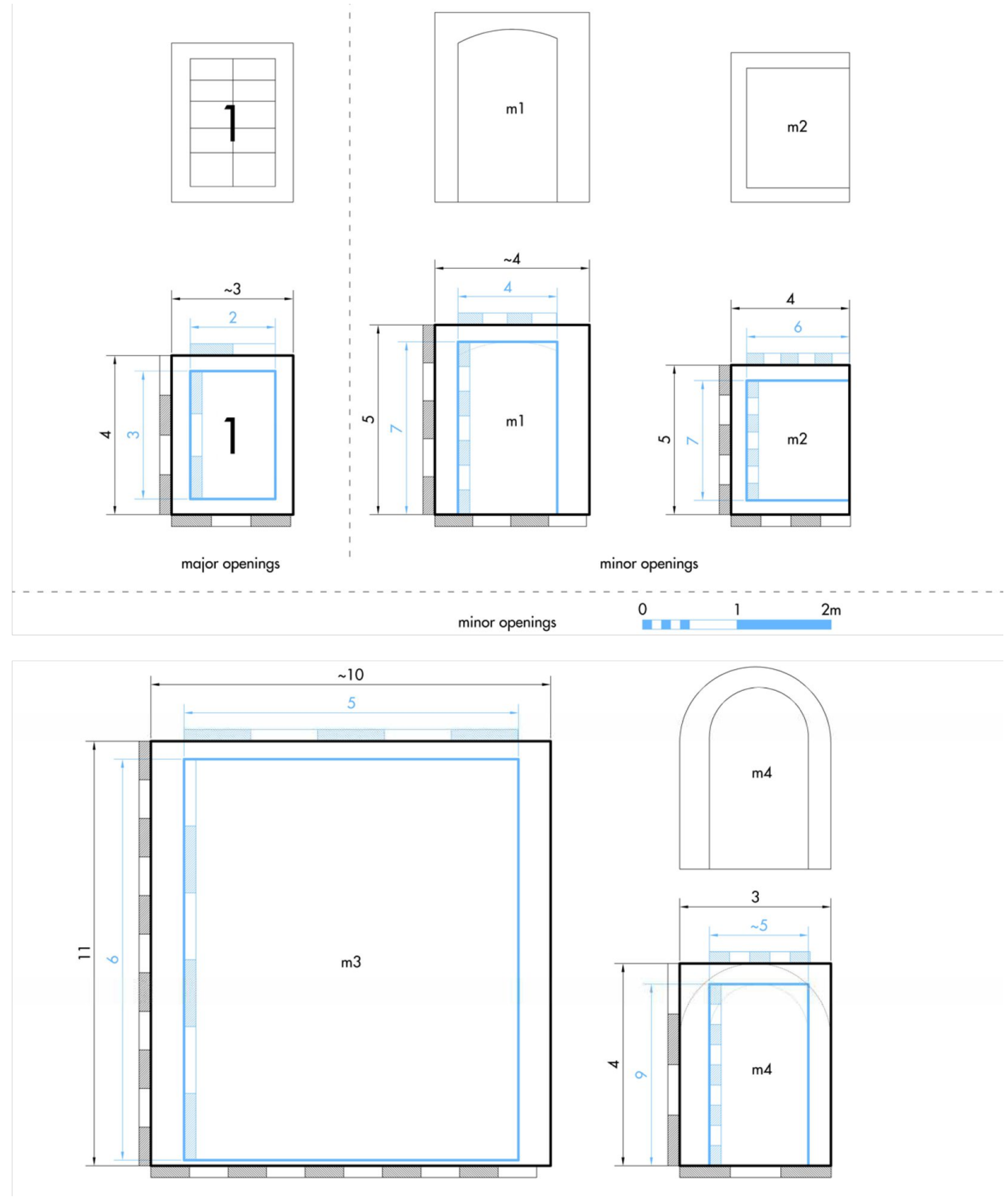


Fig. V.131 Geometrical analysis of openings: (W03) Farmhouse in Murrhardt

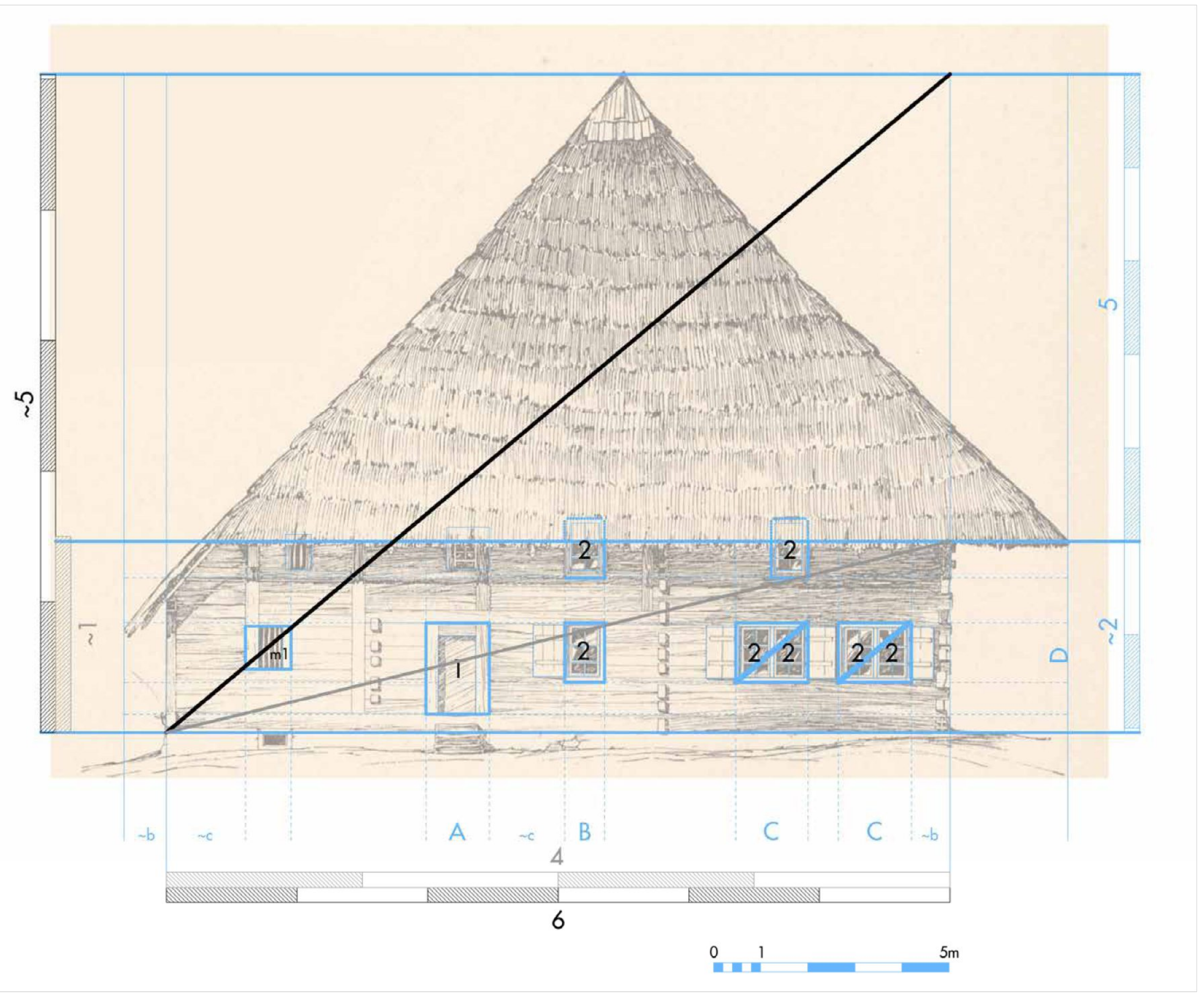


Fig. V.132 Geometrical analysis of front elevation: (W04) Farmhouse in Haslach

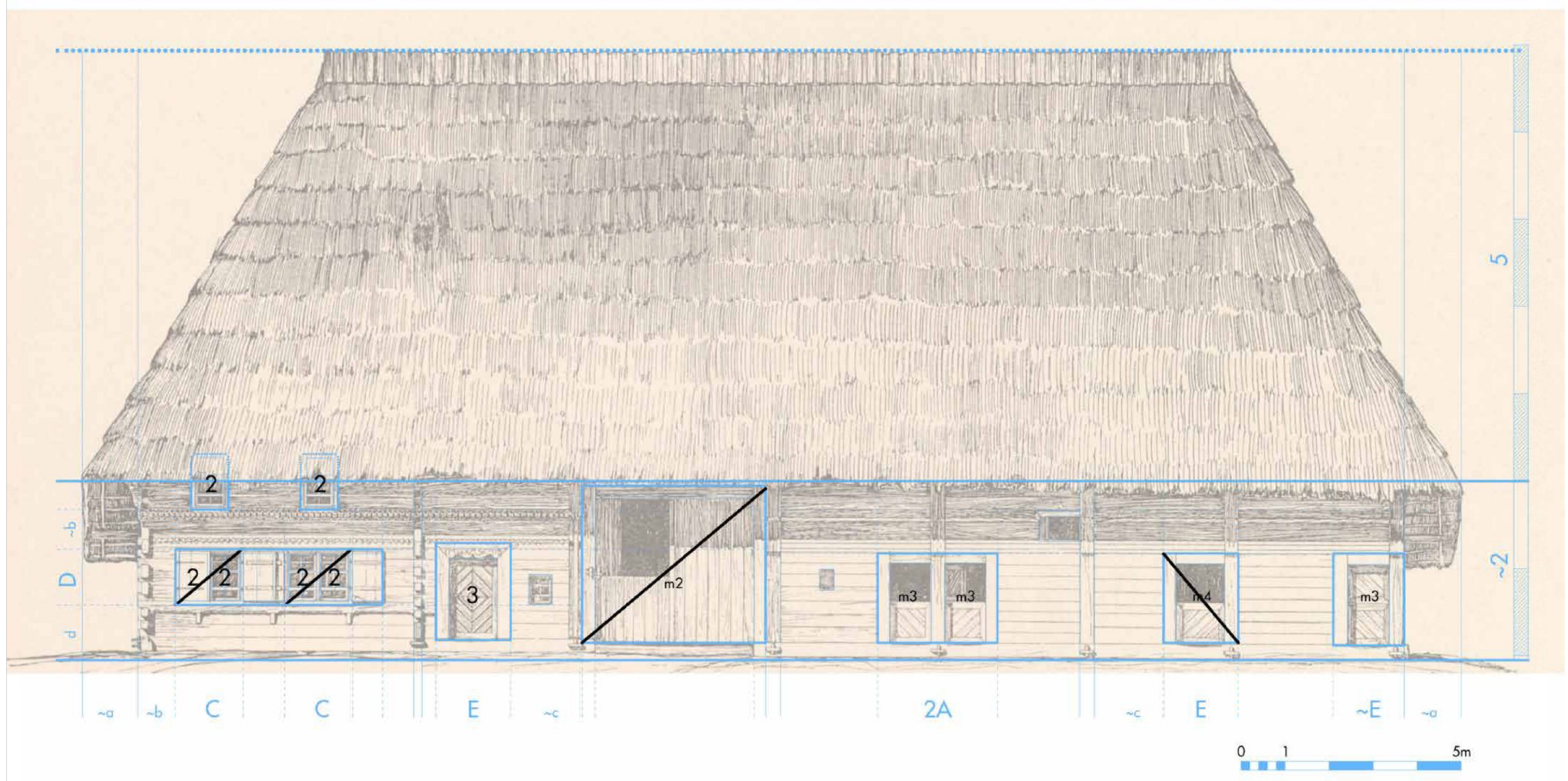


Fig. V.133 Geometrical analysis of side elevation: (W04) Farmhouse in Haslach

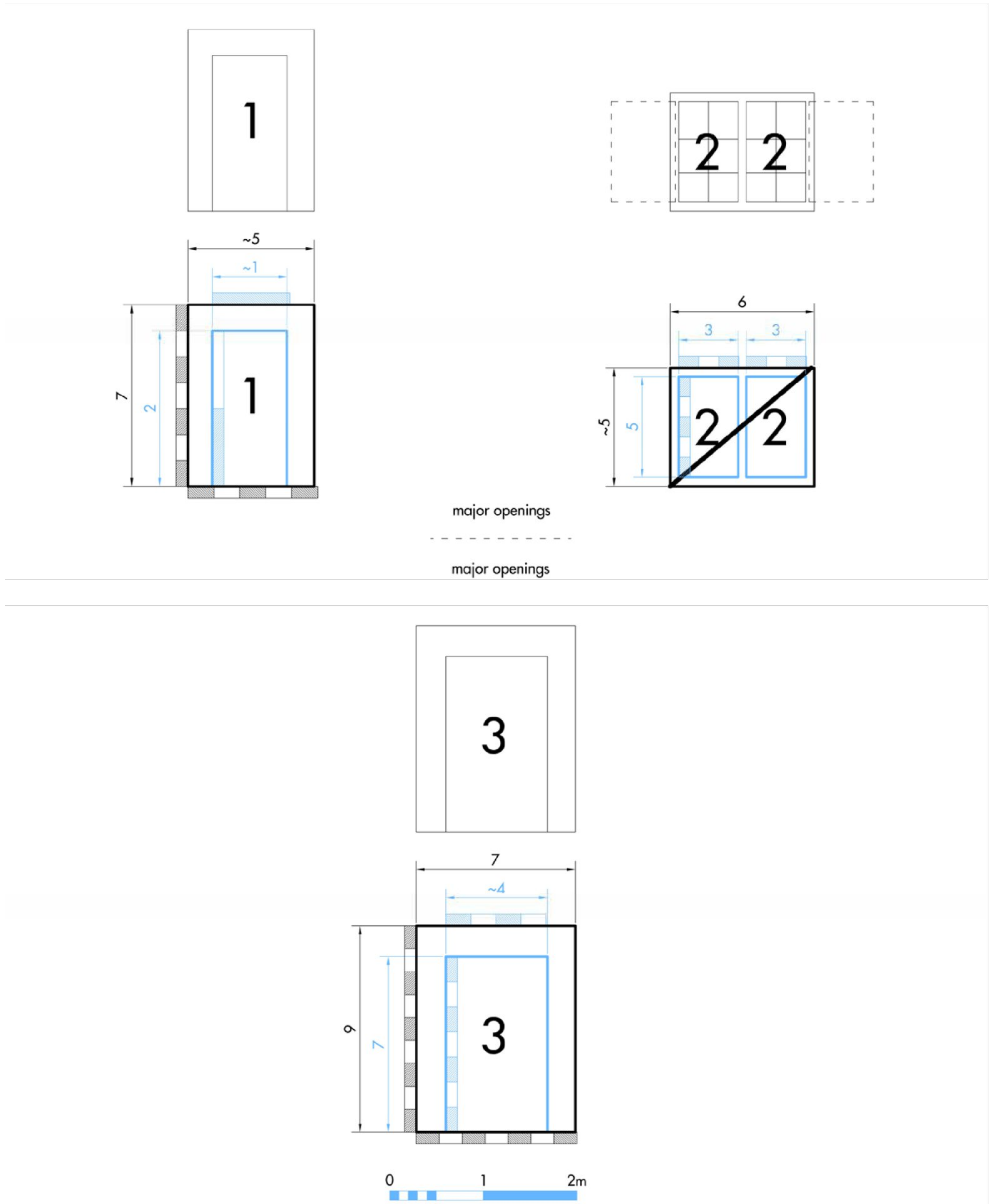


Fig. V.134 Geometrical analysis of openings: (W04) Farmhouse in Haslach

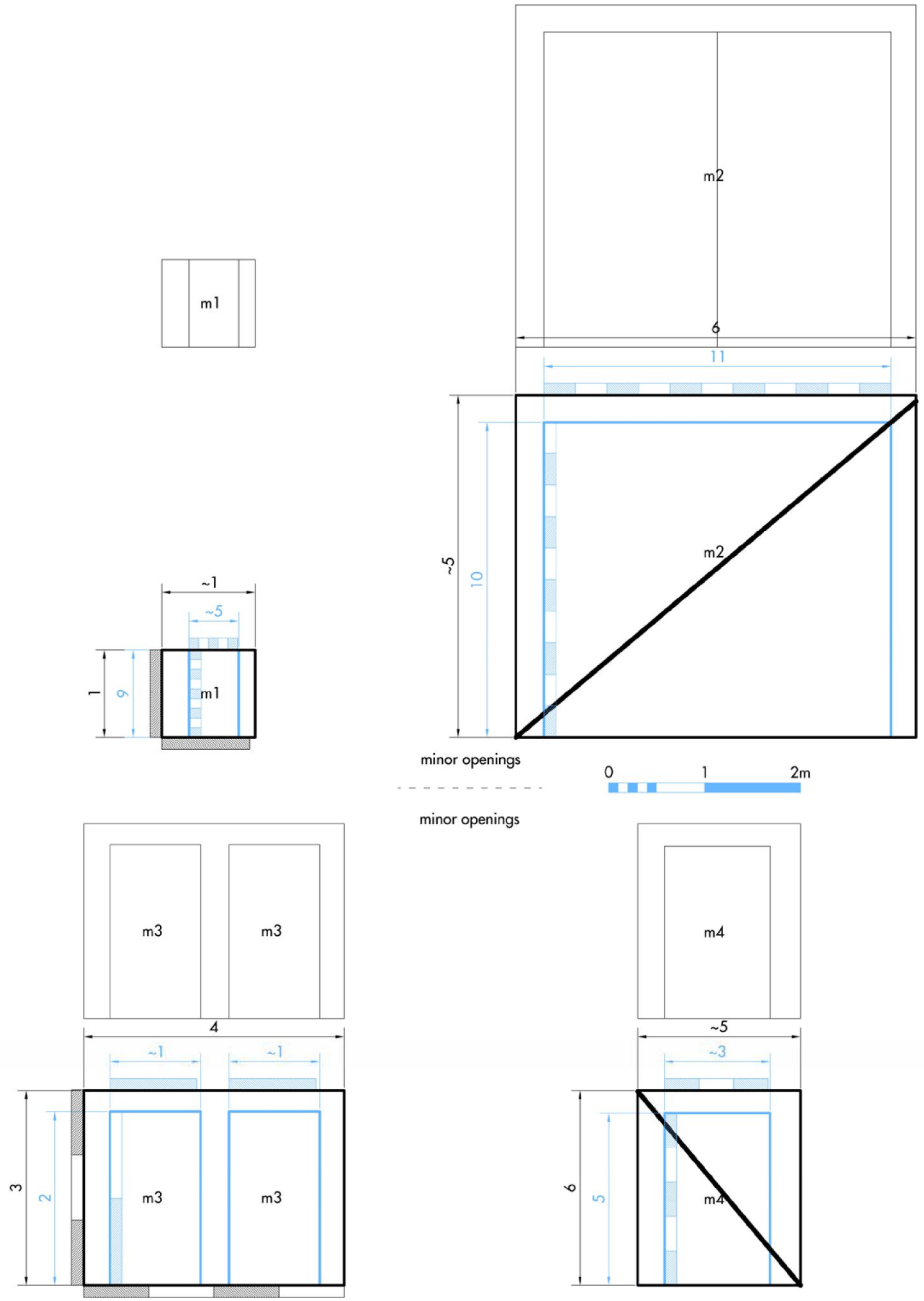
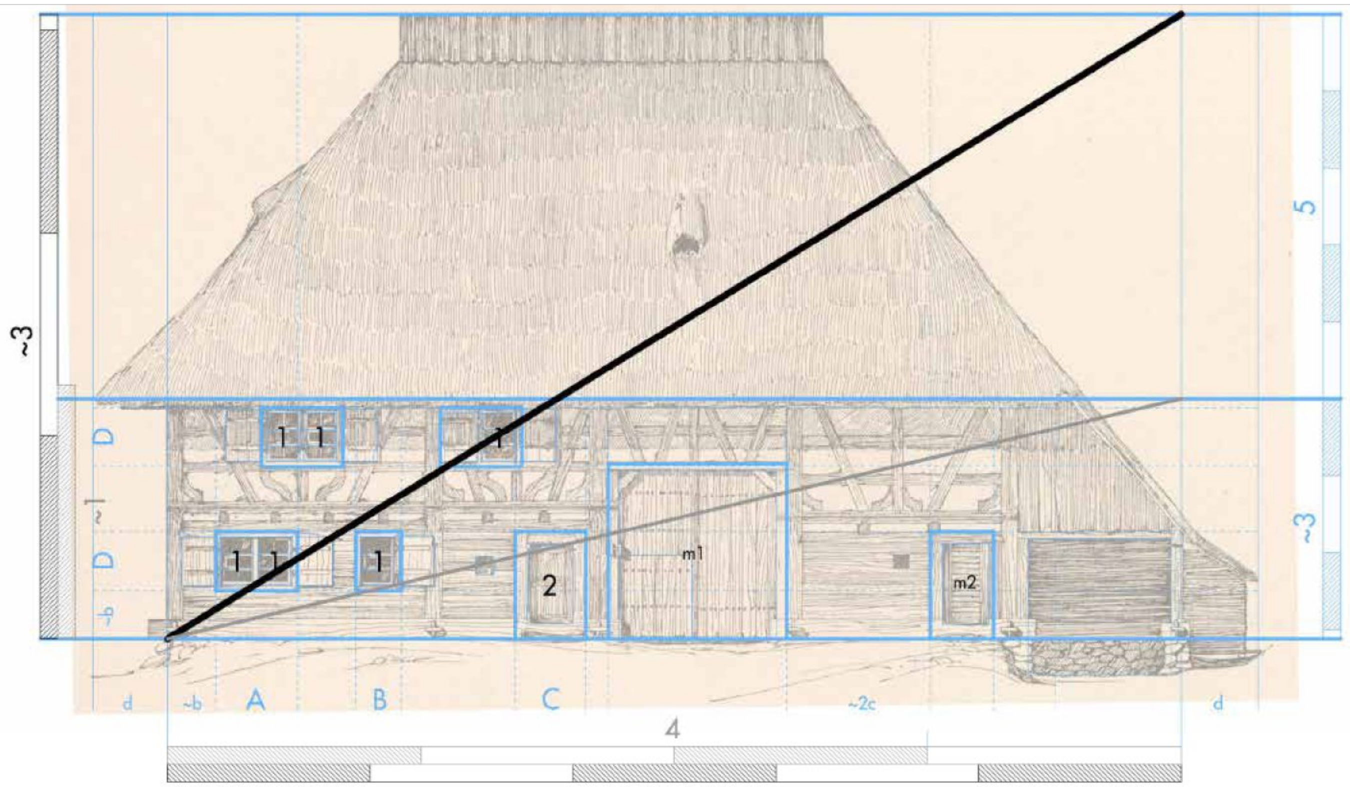


Fig. V.135 Geometrical analysis of openings: (W04) Farmhouse in Haslach



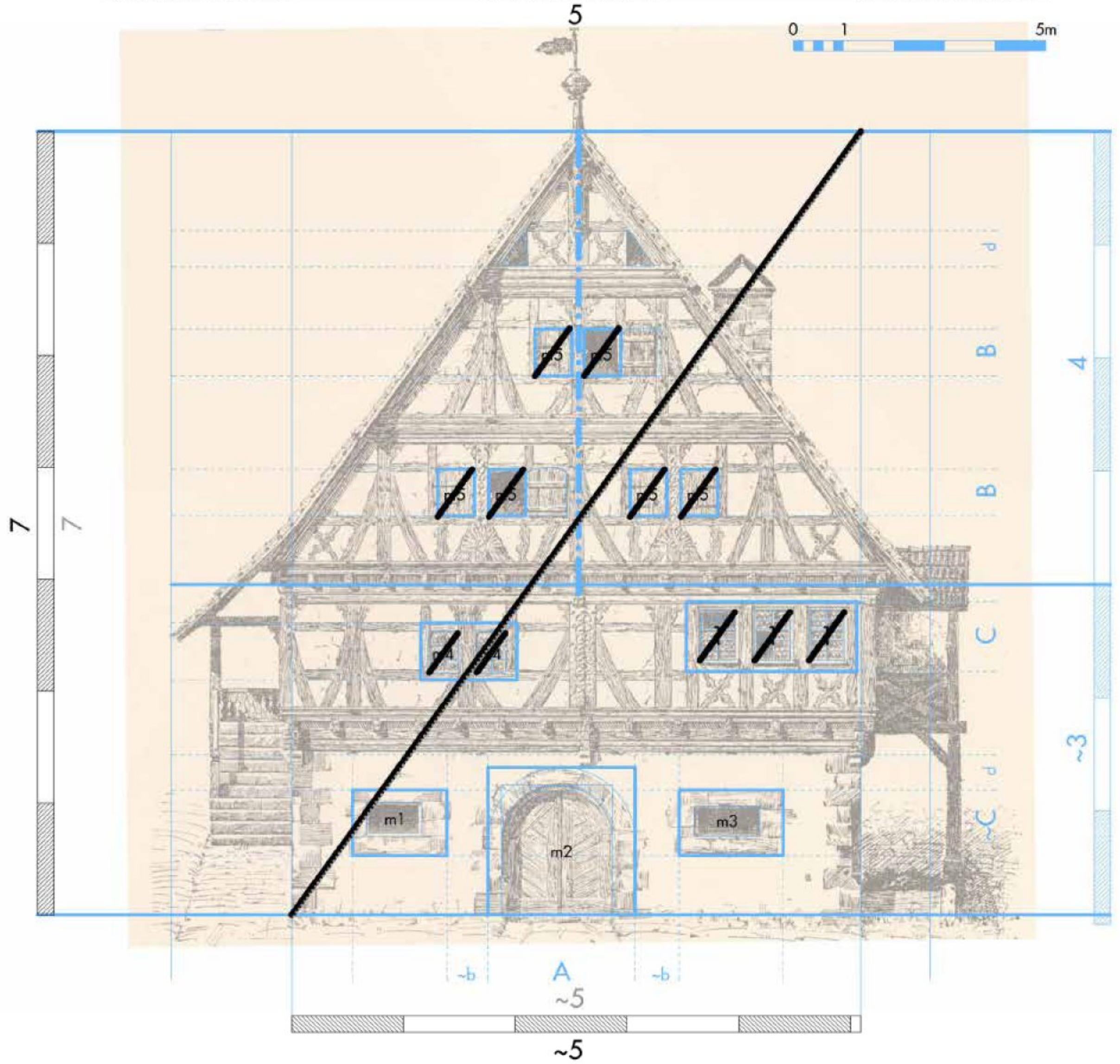


Fig. V.136 Geometrical analysis of side elevation: (W05) Farmhouse in Kürnbach
Fig. V.137 Geometrical analysis of front elevation: (W06) Vineyard house in Strümpfelbach

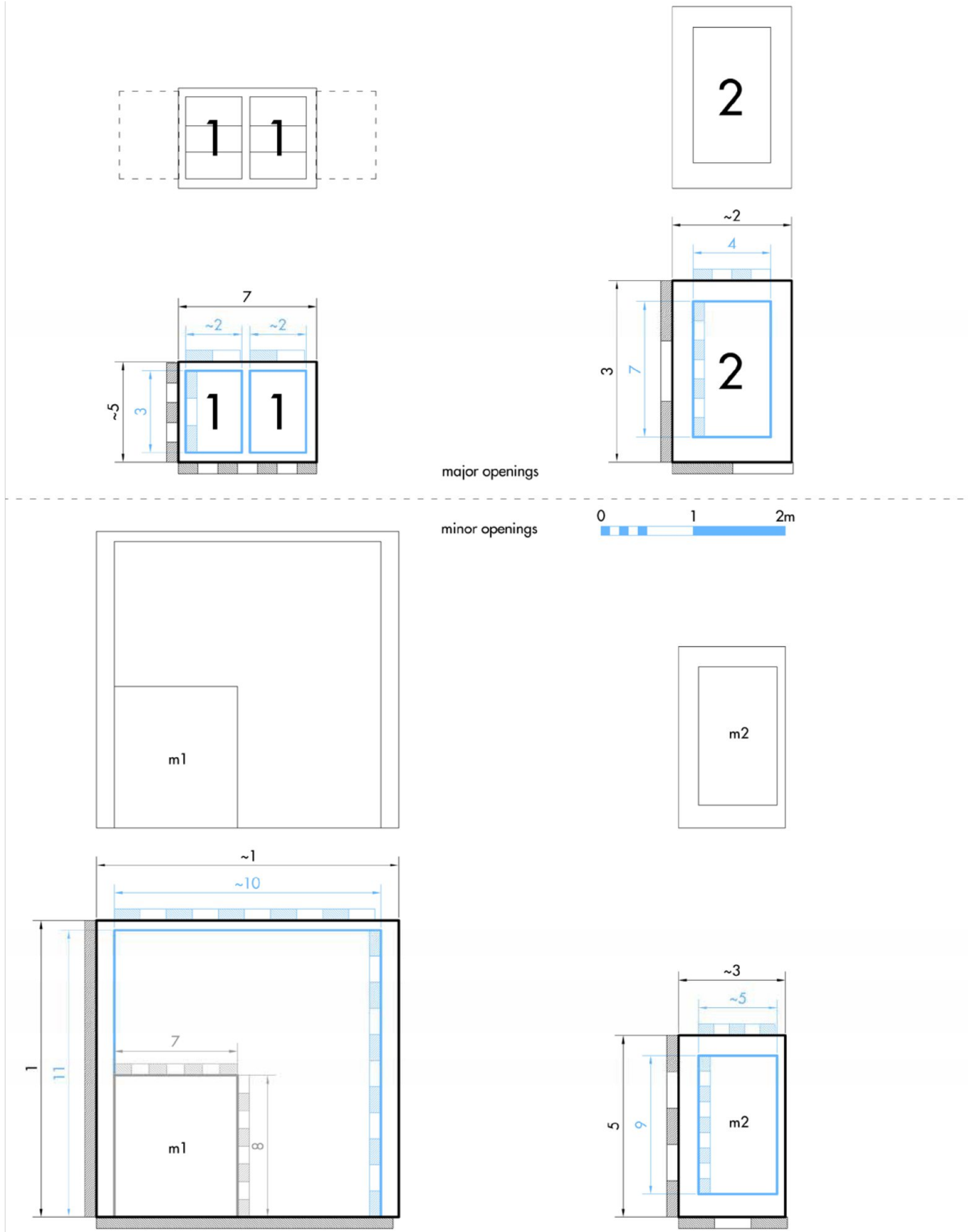


Fig. V.138 Geometrical analysis of openings: (W05) Farmhouse in Kürnbach

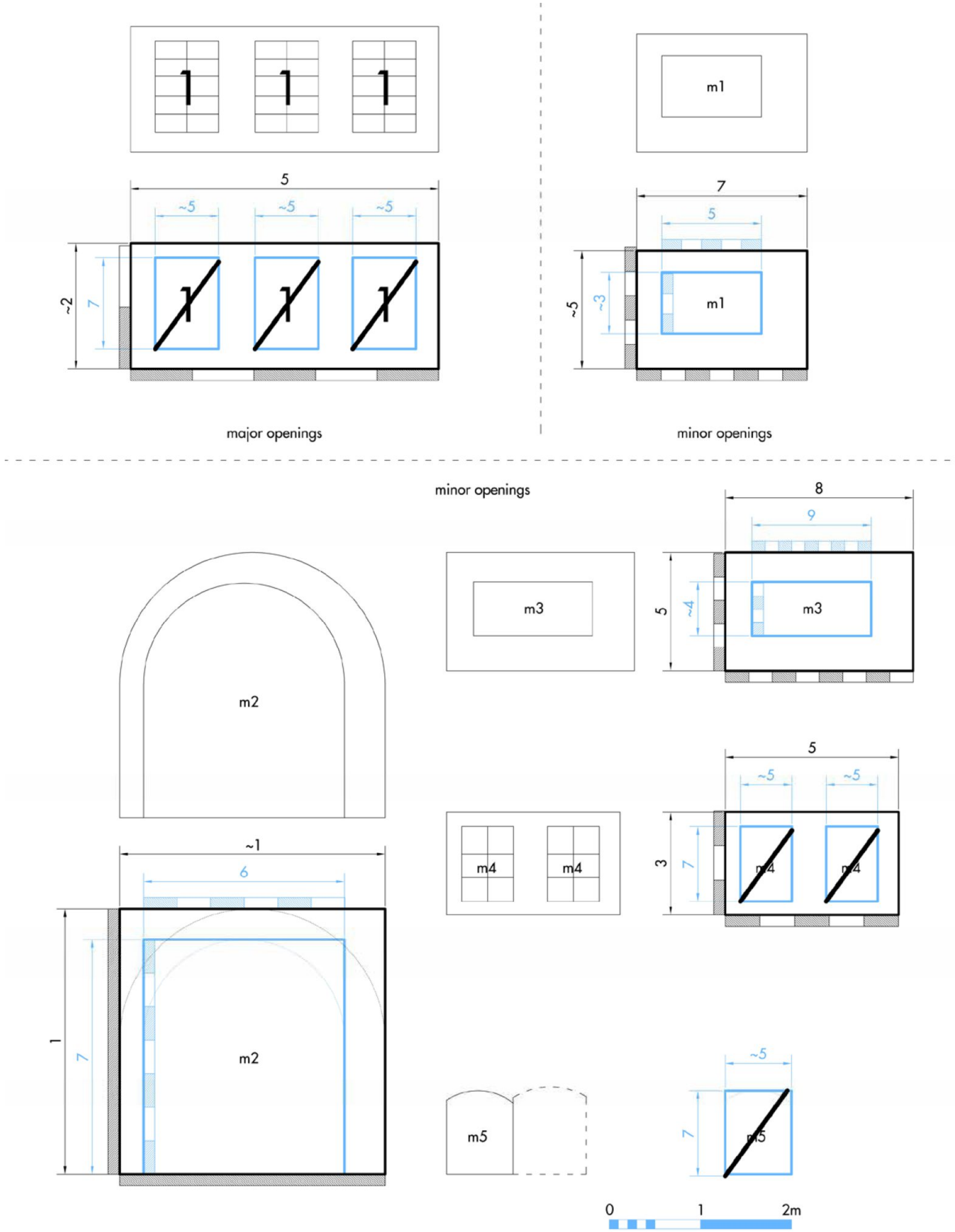
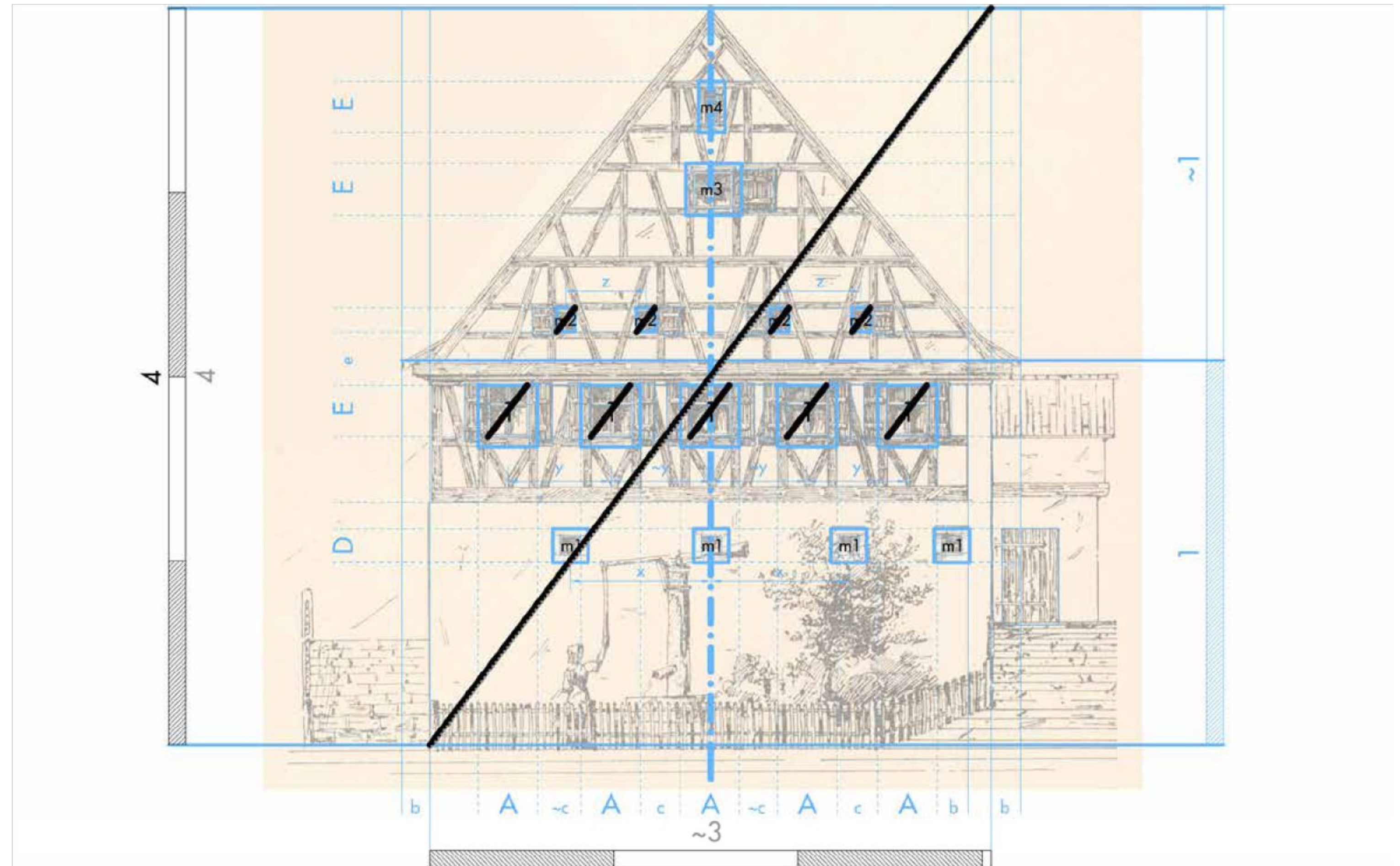


Fig. V.139 Geometrical analysis of openings: (W06) Vineyard house in Strümpfelbach



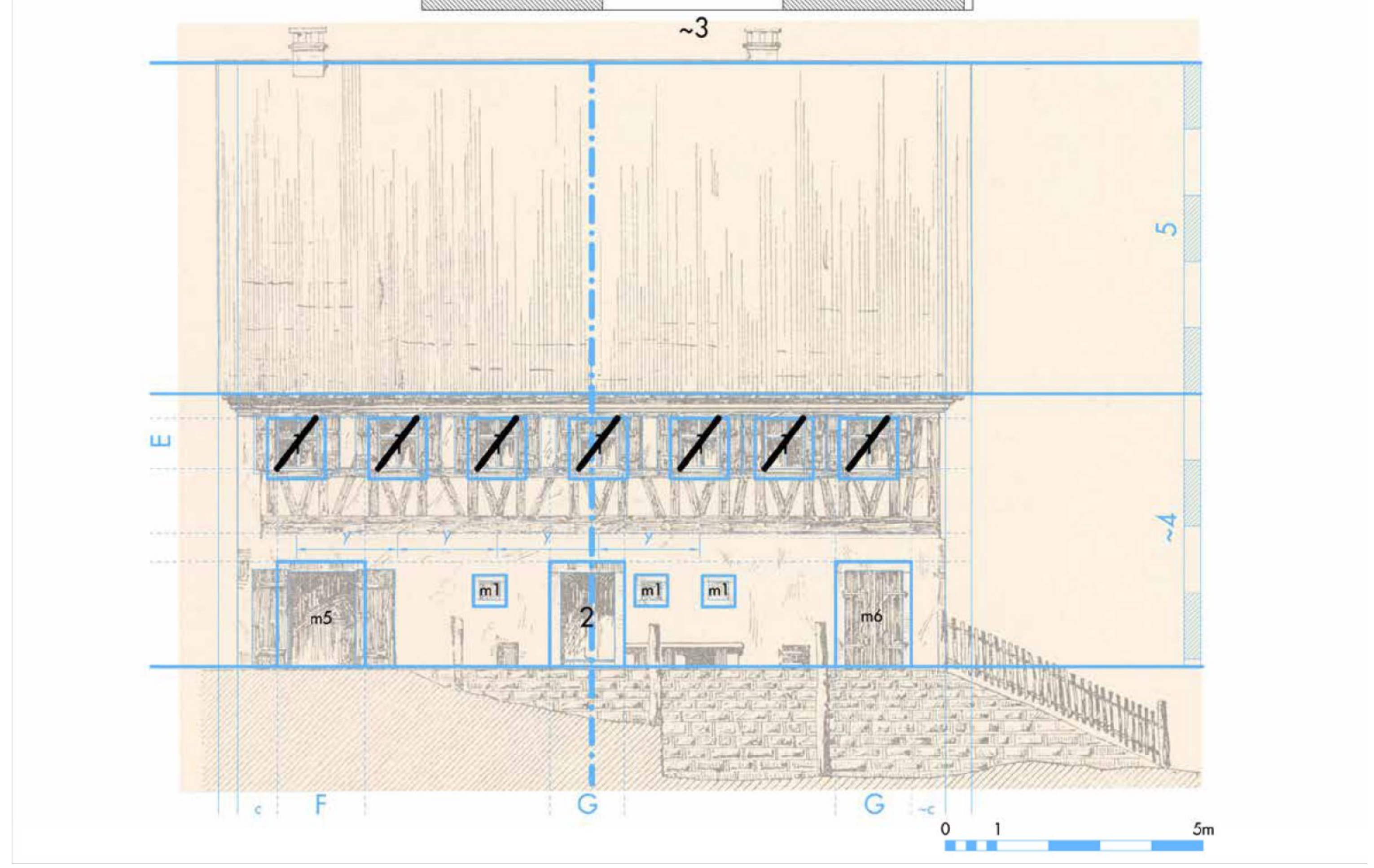


Fig. V.140 Geometrical analysis of front elevation: (W07) Farmhouse in Unter-Aspach
Fig. V.141 Geometrical analysis of side elevation: (W07) Farmhouse in Unter-Aspach

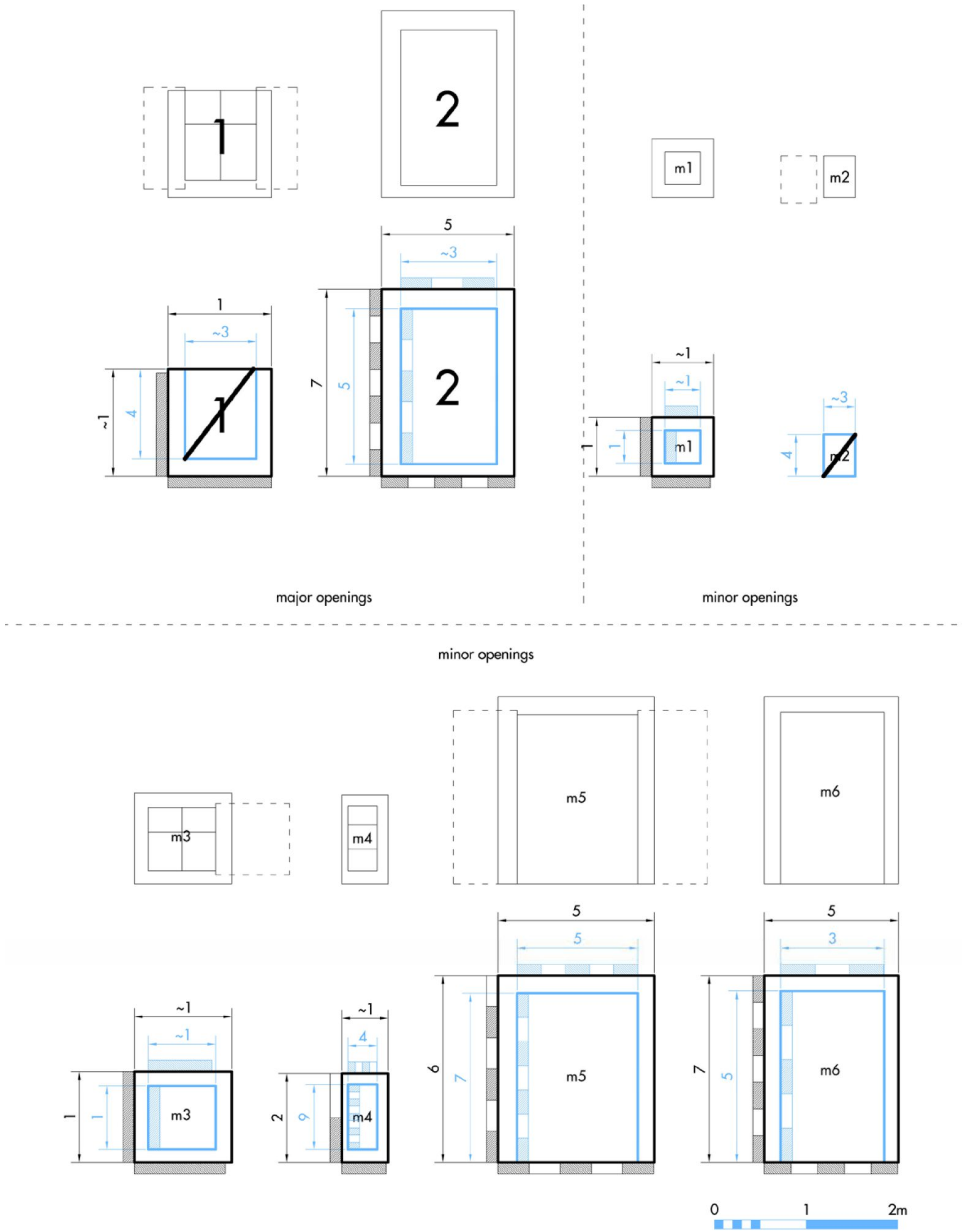
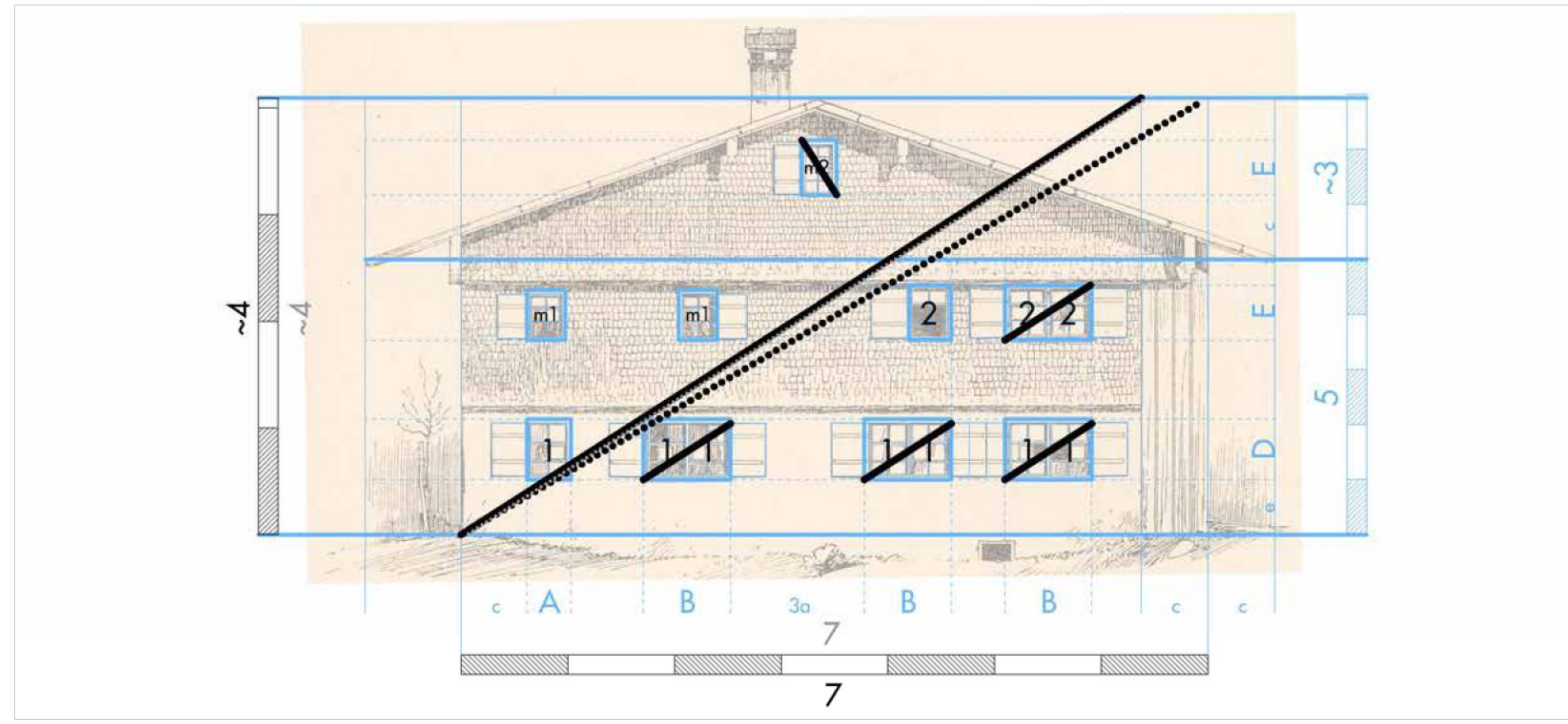


Fig. V.142 Geometrical analysis of openings: (W07) Farmhouse in Unter-Aspach



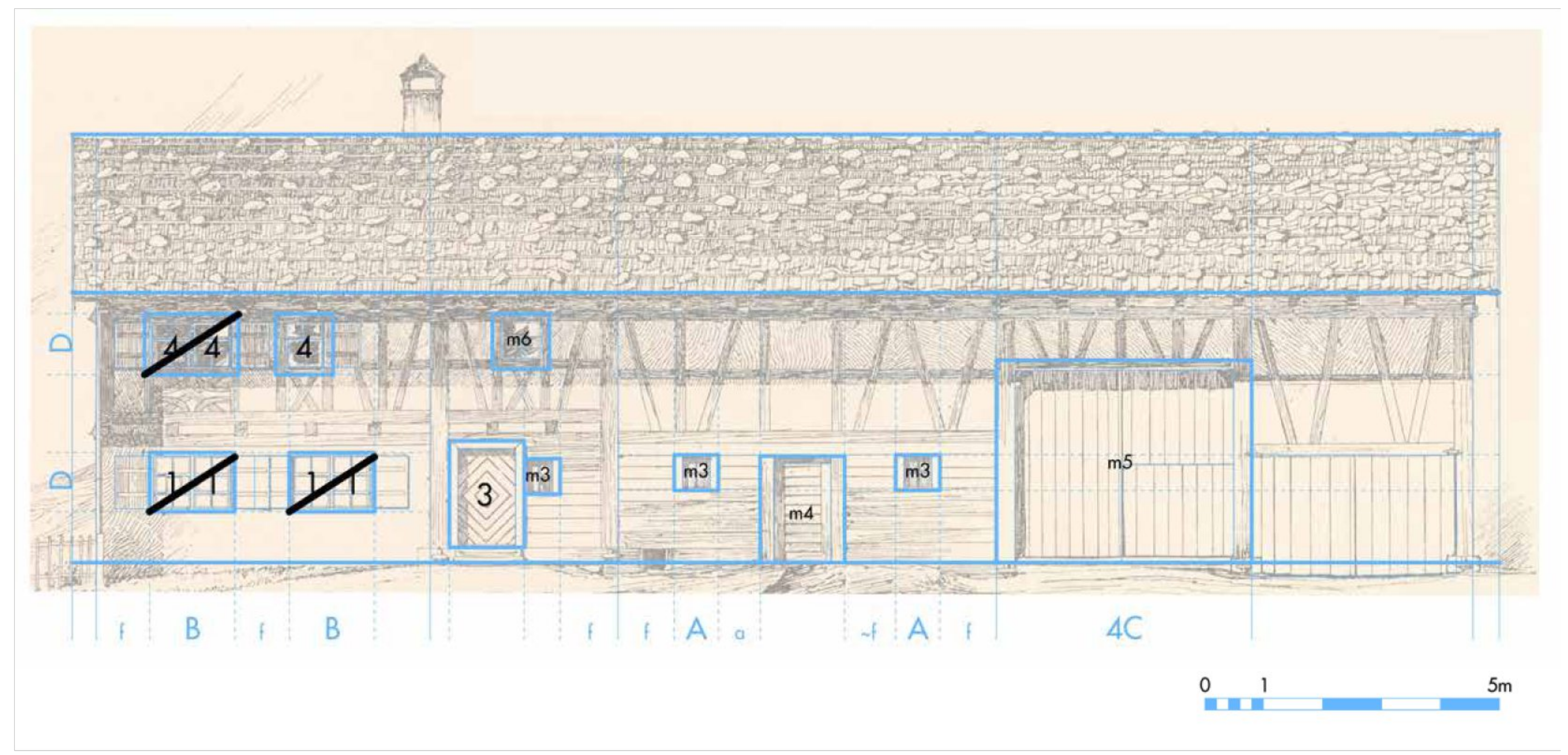


Fig. V.143 Geometrical analysis of front elevation: (W08) Farmhouse in Waffenried
Fig. V.144 Geometrical analysis of side elevation: (W08) Farmhouse in Waffenried

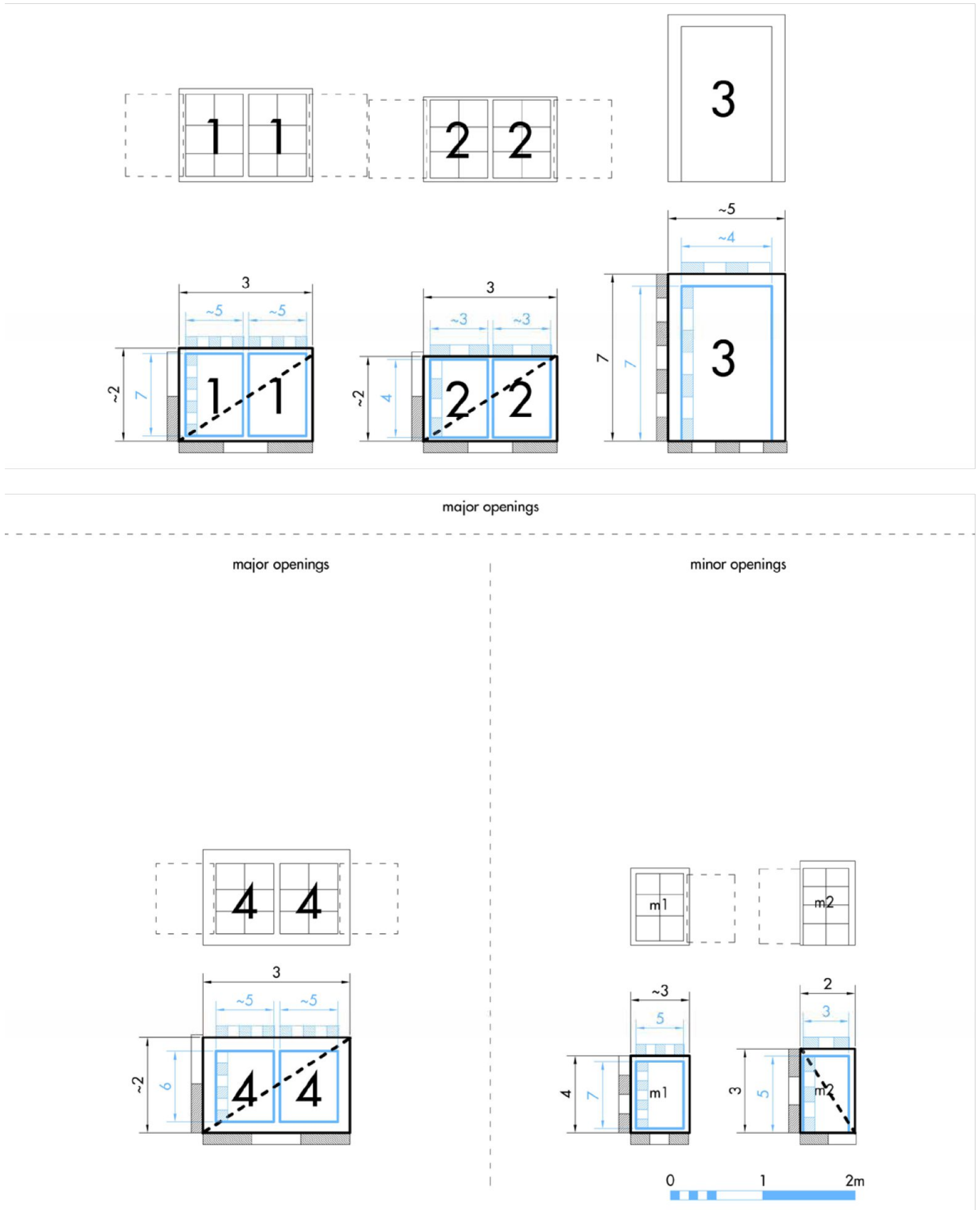


Fig. V.145 Geometrical analysis of openings: (W08) Farmhouse in Waffenried

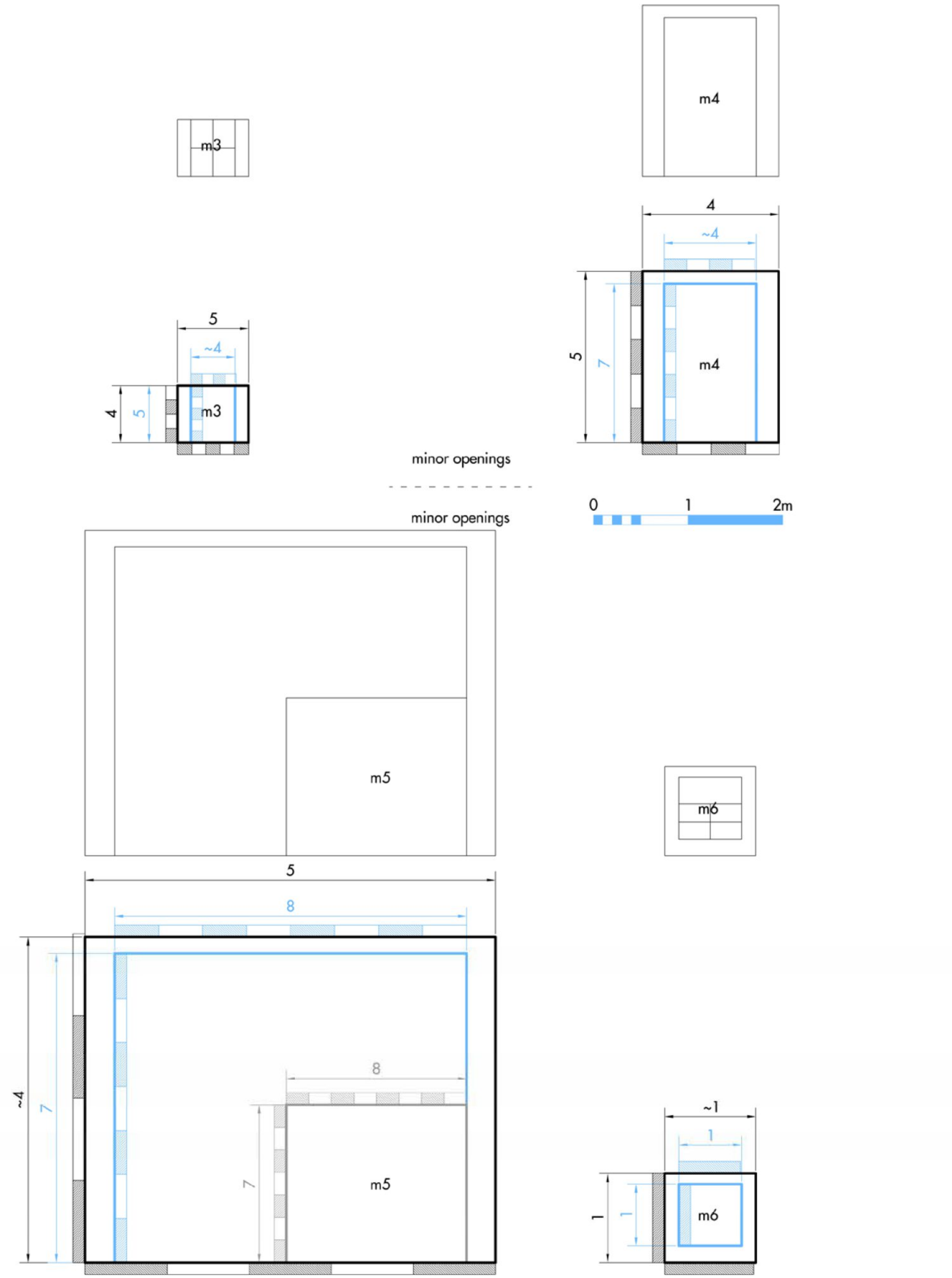


Fig. V.146 Geometrical analysis of openings: (W08) Farmhouse in Waffenried

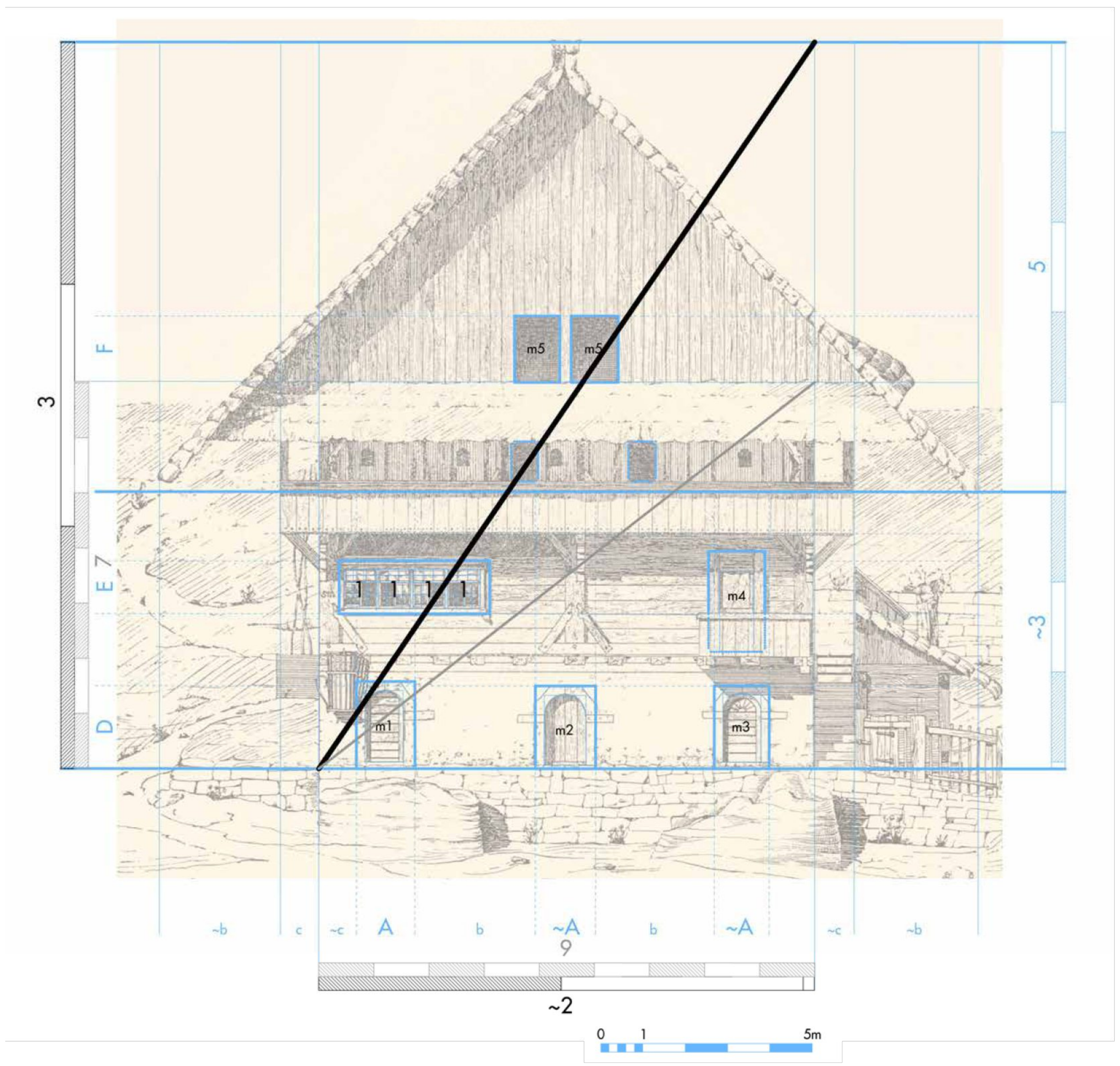


Fig. V.147 Geometrical analysis of front elevation: (Ba01) Farmhouse in Simmersbachthal near Ottenhöfen

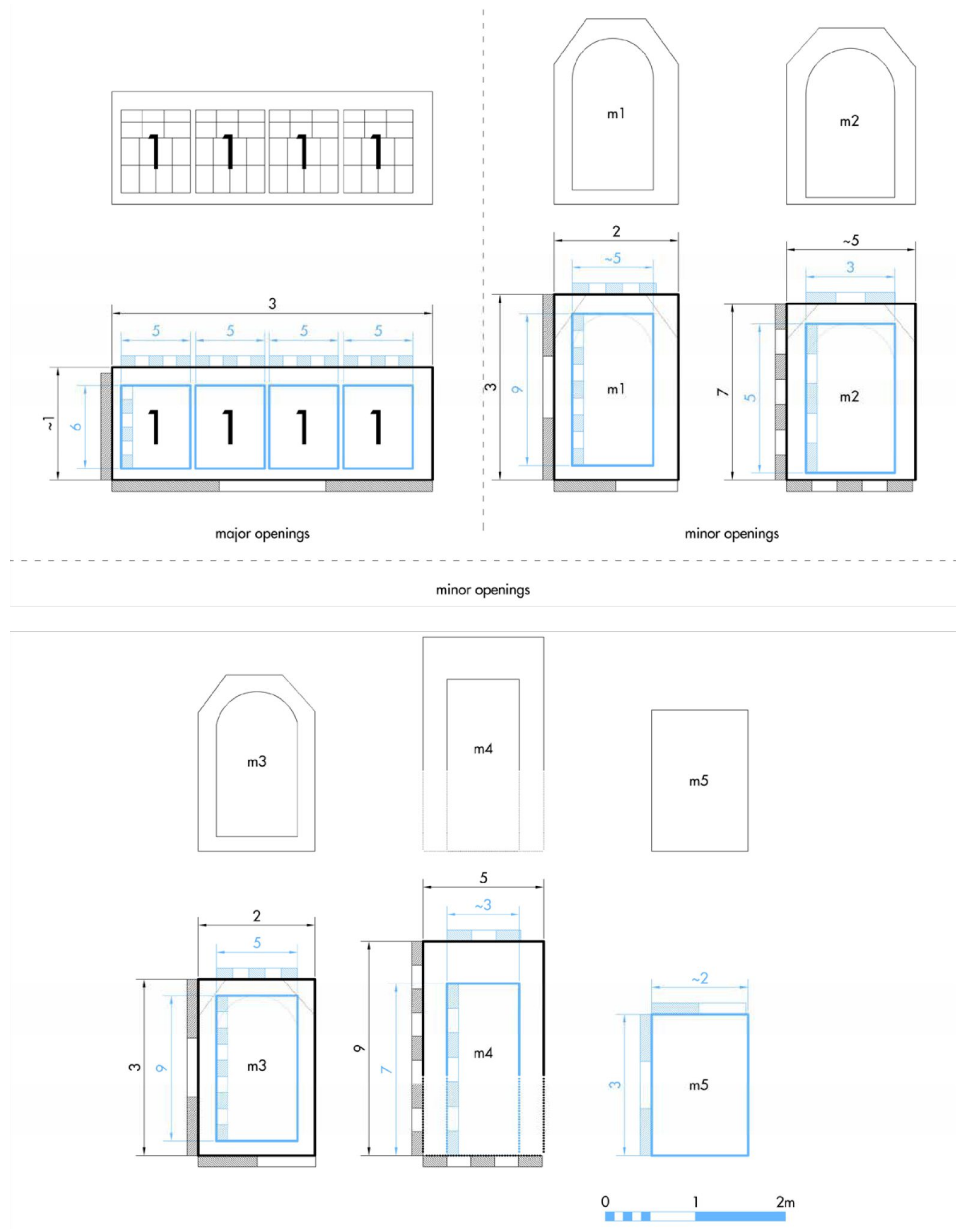
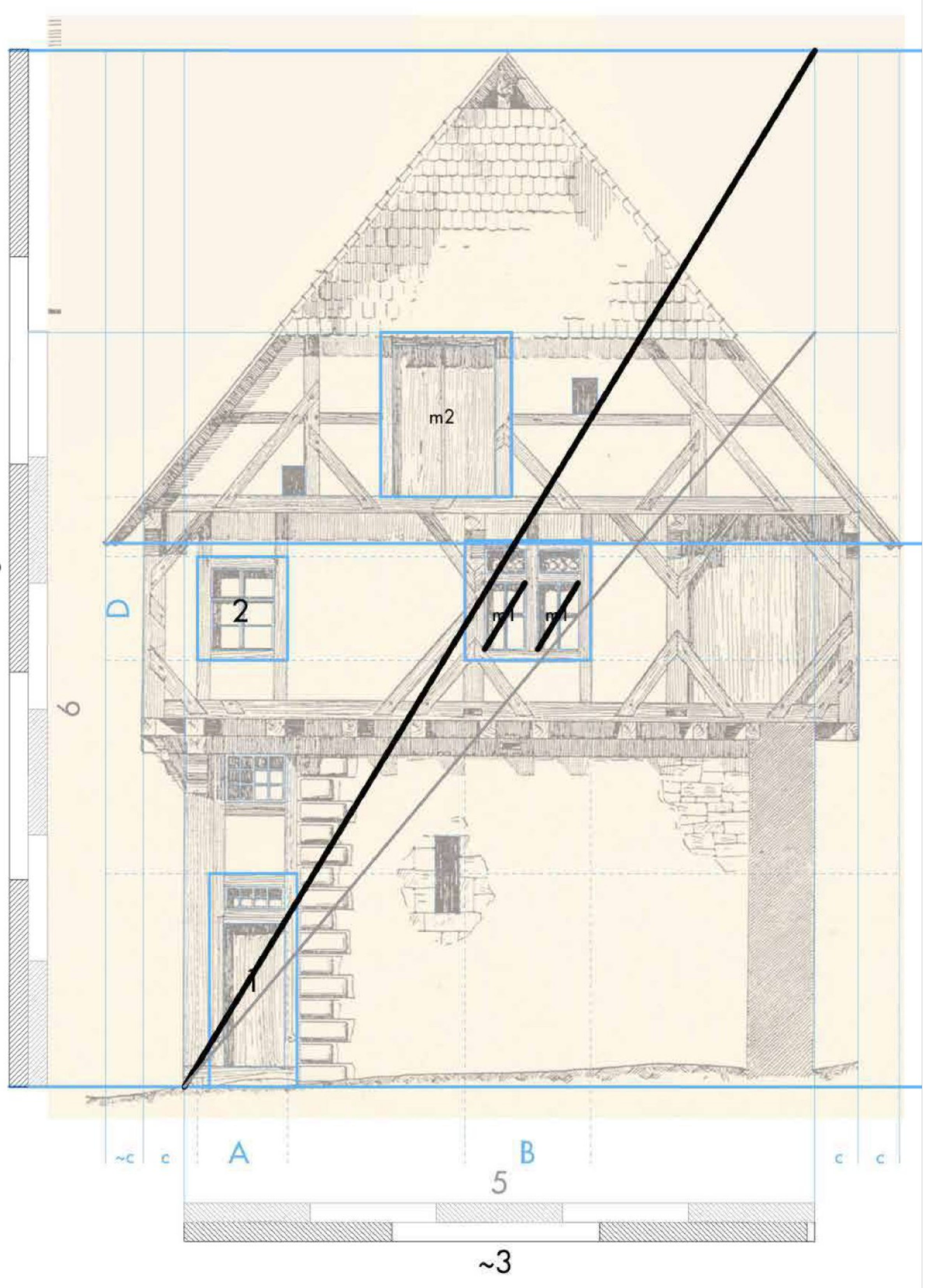


Fig. V.148 Geometrical analysis of openings: (Ba01) Farmhouse in Simmersbachthal near Ottenhöfen



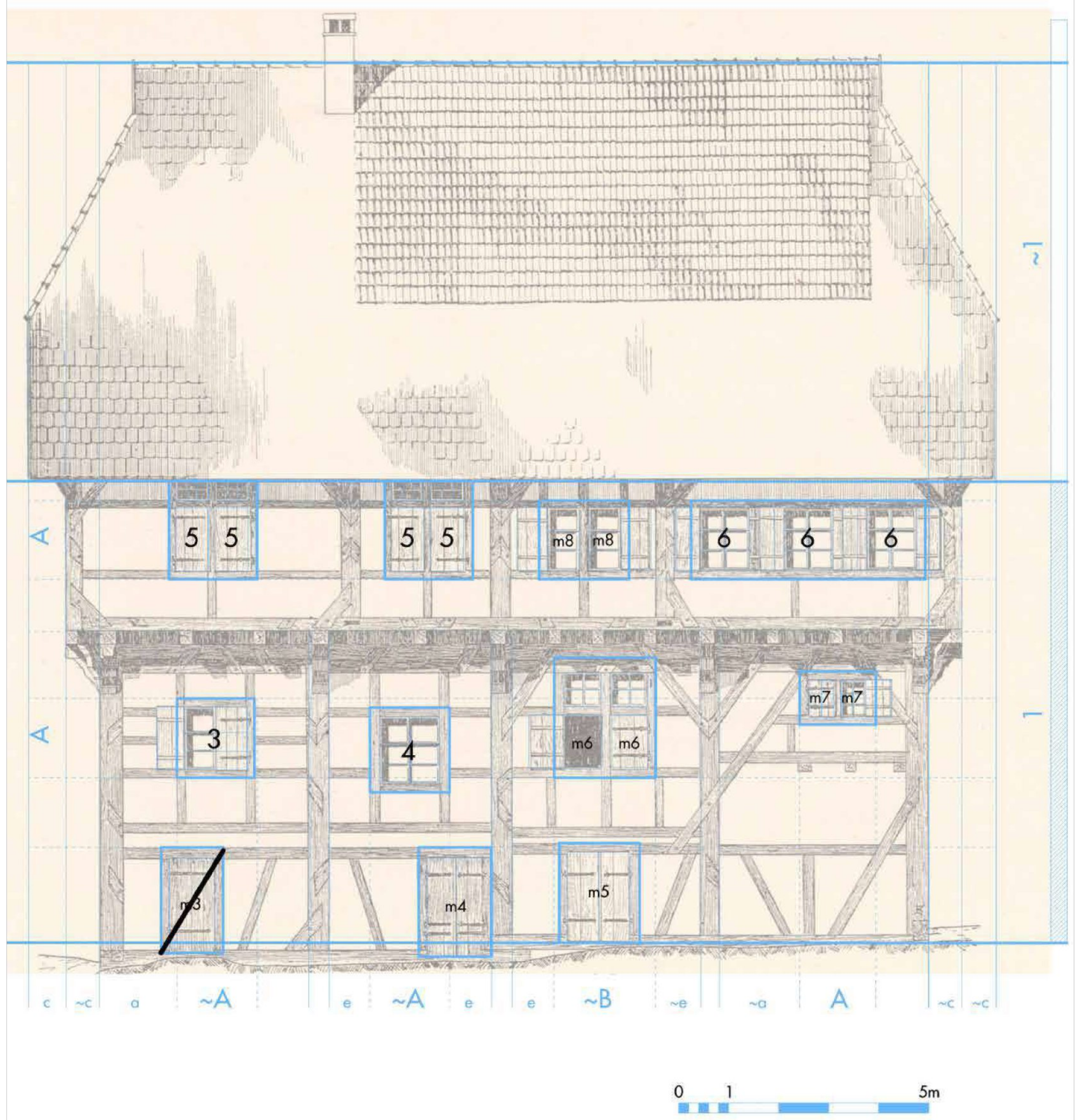


Fig. V.149 Geometrical analysis of front elevation: (Ba02) House in Pfullendorf
Fig. V.150 Geometrical analysis of side elevation: (Ba02) House in Pfullendorf

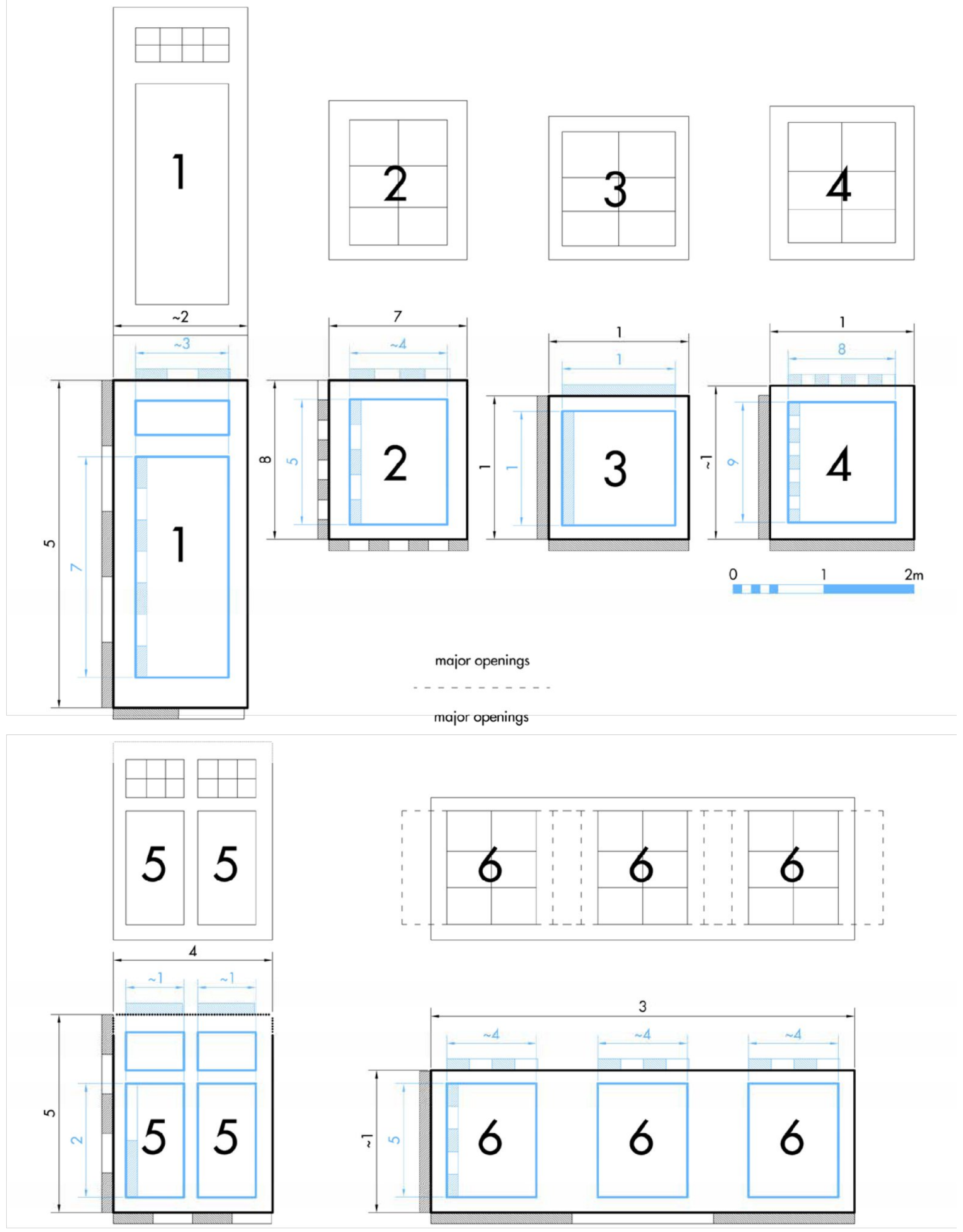


Fig. V.151 Geometrical analysis of openings: (Ba02) House in Pfullendorf

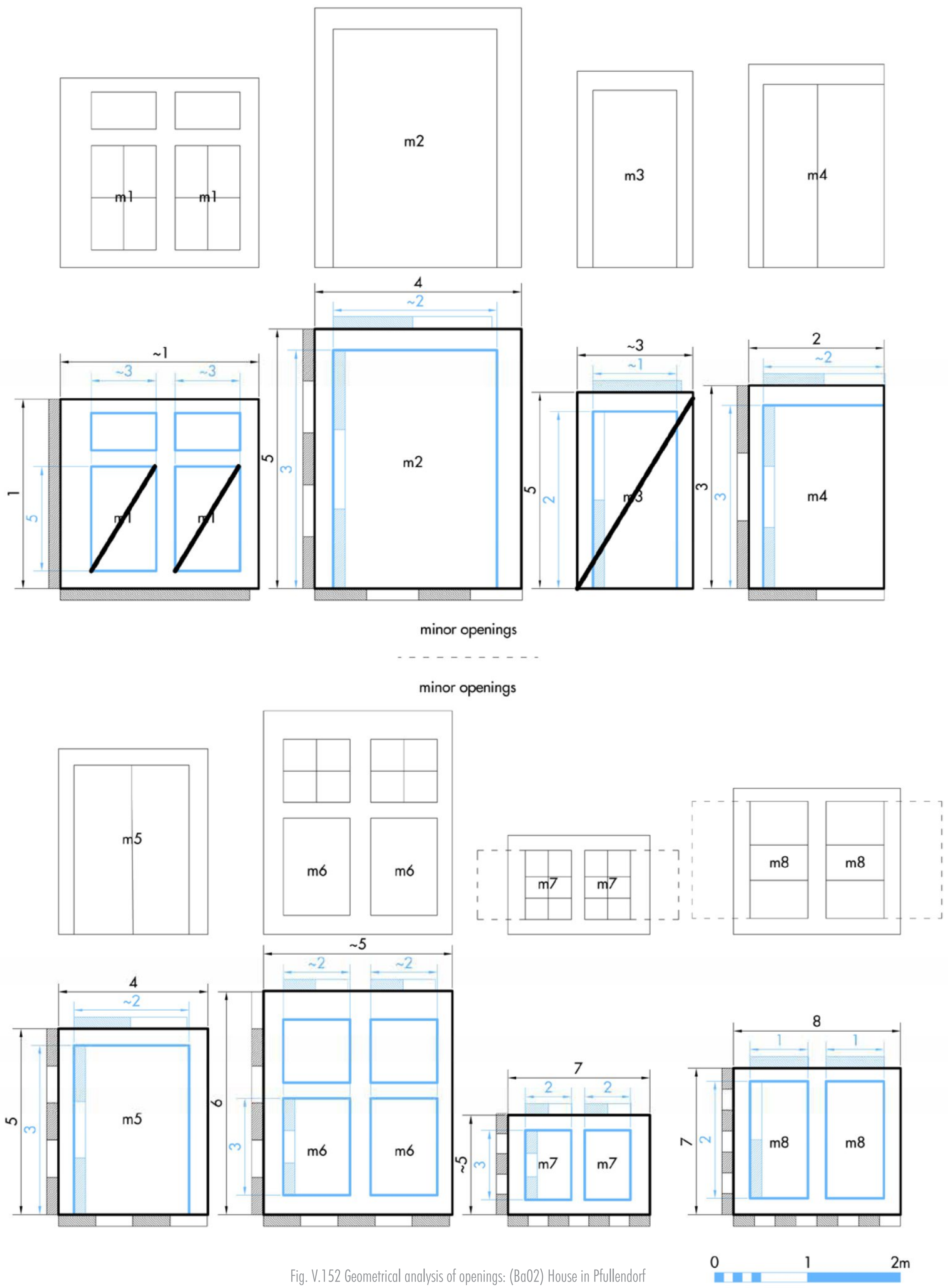
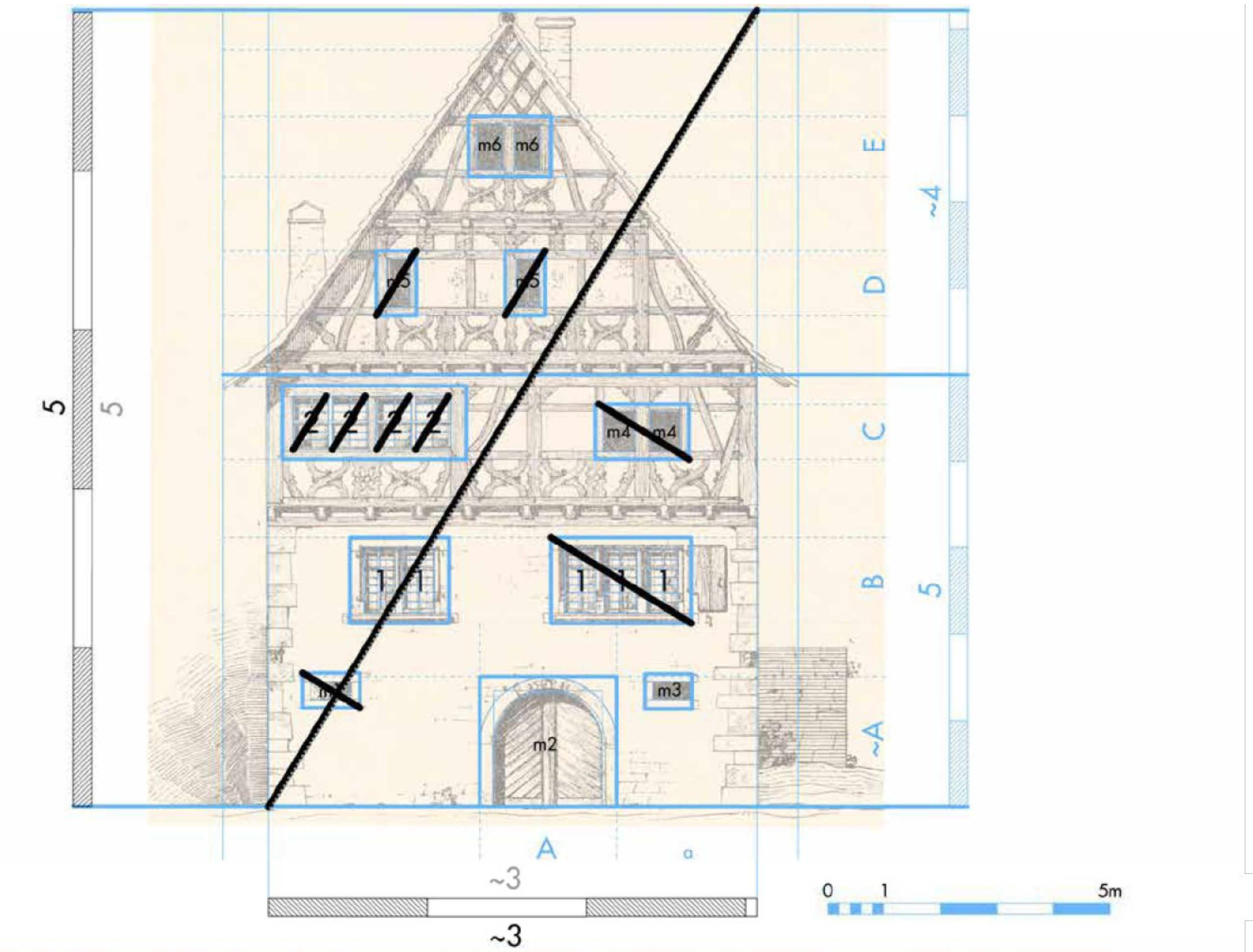


Fig. V.152 Geometrical analysis of openings: (Ba02) House in Pfullendorf



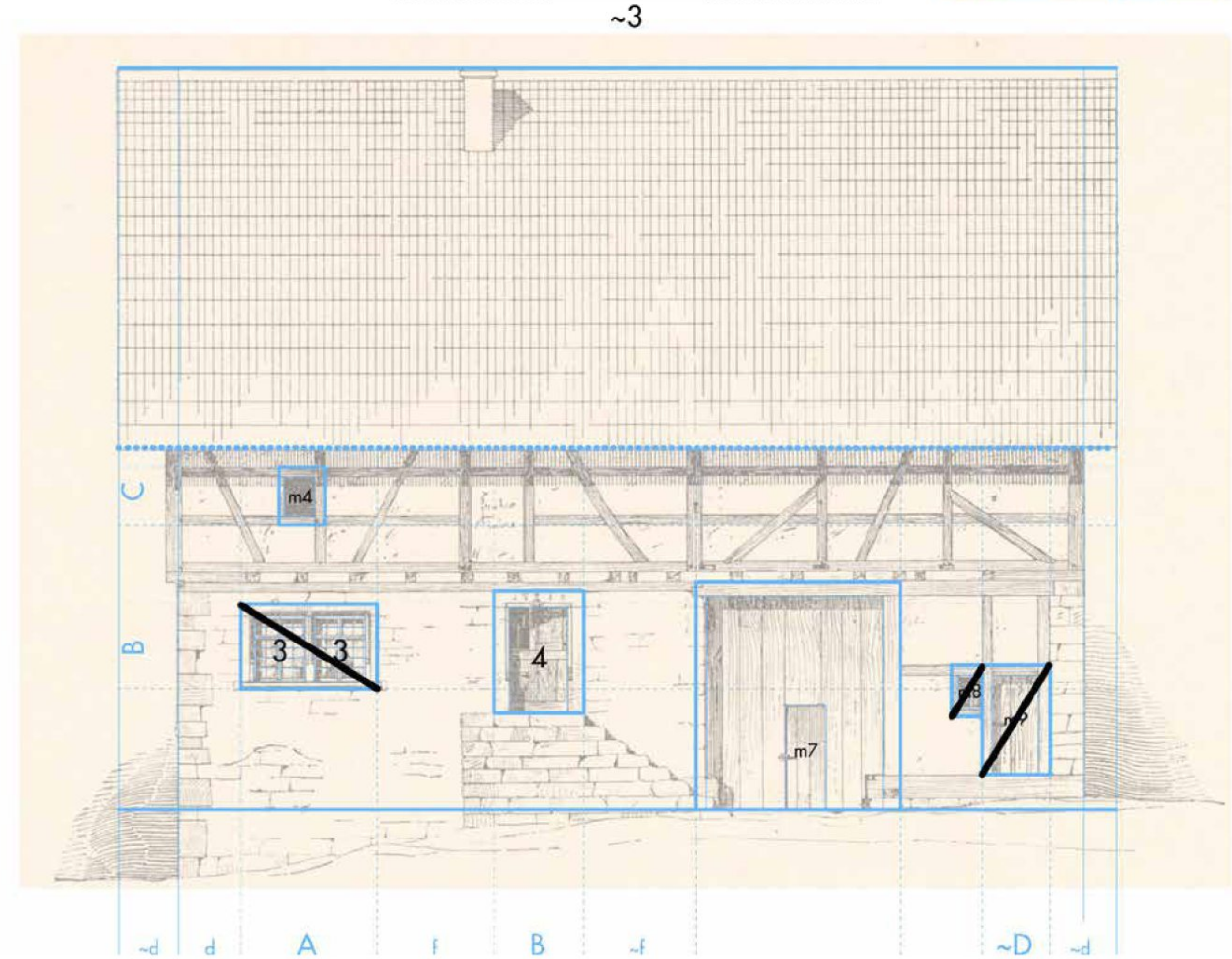


Fig. V.153 Geometrical analysis of front elevation: (Ba03) Farmhouse No. 73 in Herbolzheim

Fig. V.154 Geometrical analysis of side elevation: (Ba03) Farmhouse No. 73 in Herbolzheim

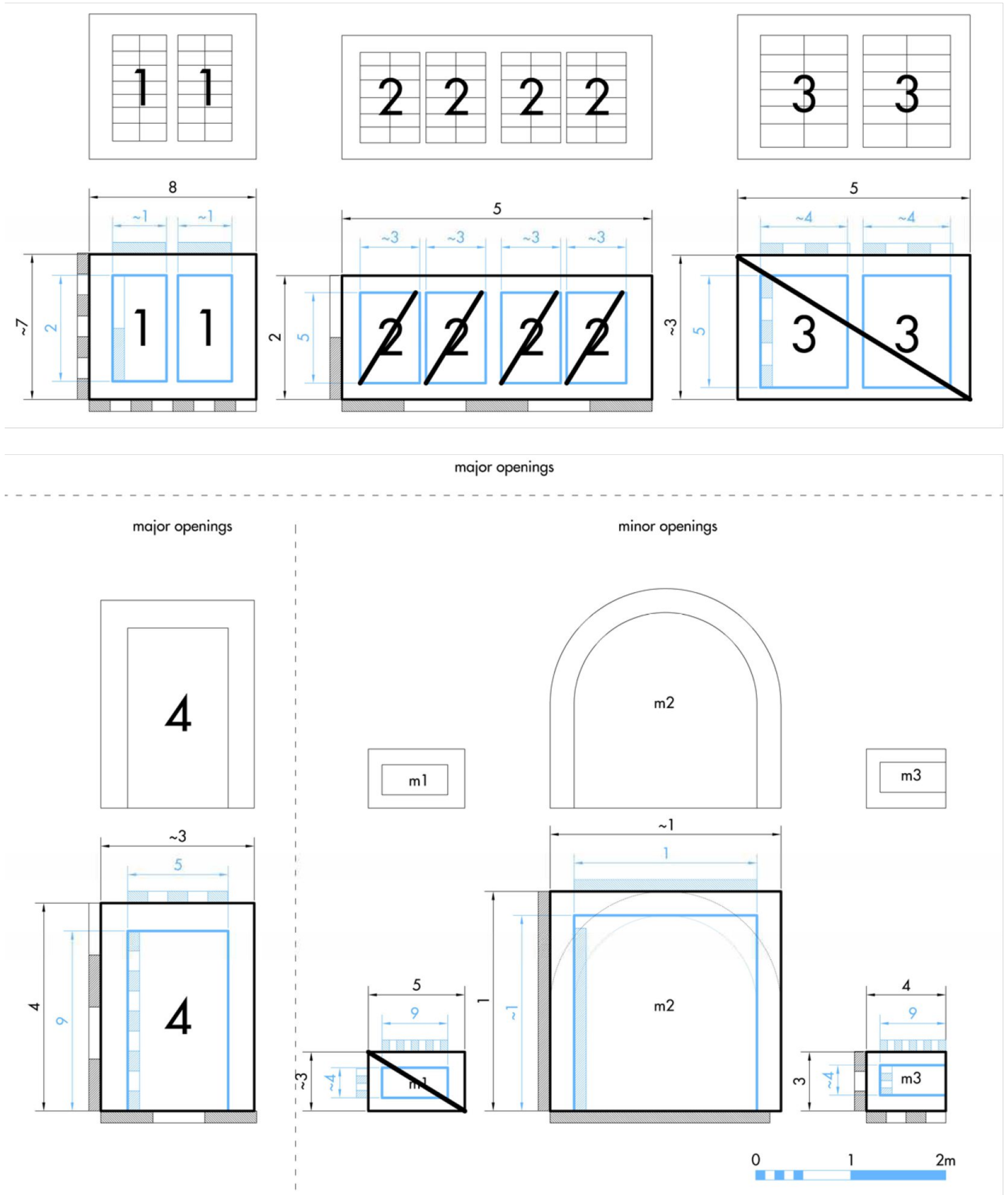


Fig. V.155 Geometrical analysis of openings: (Ba03) Farmhouse No. 73 in Herbolzheim

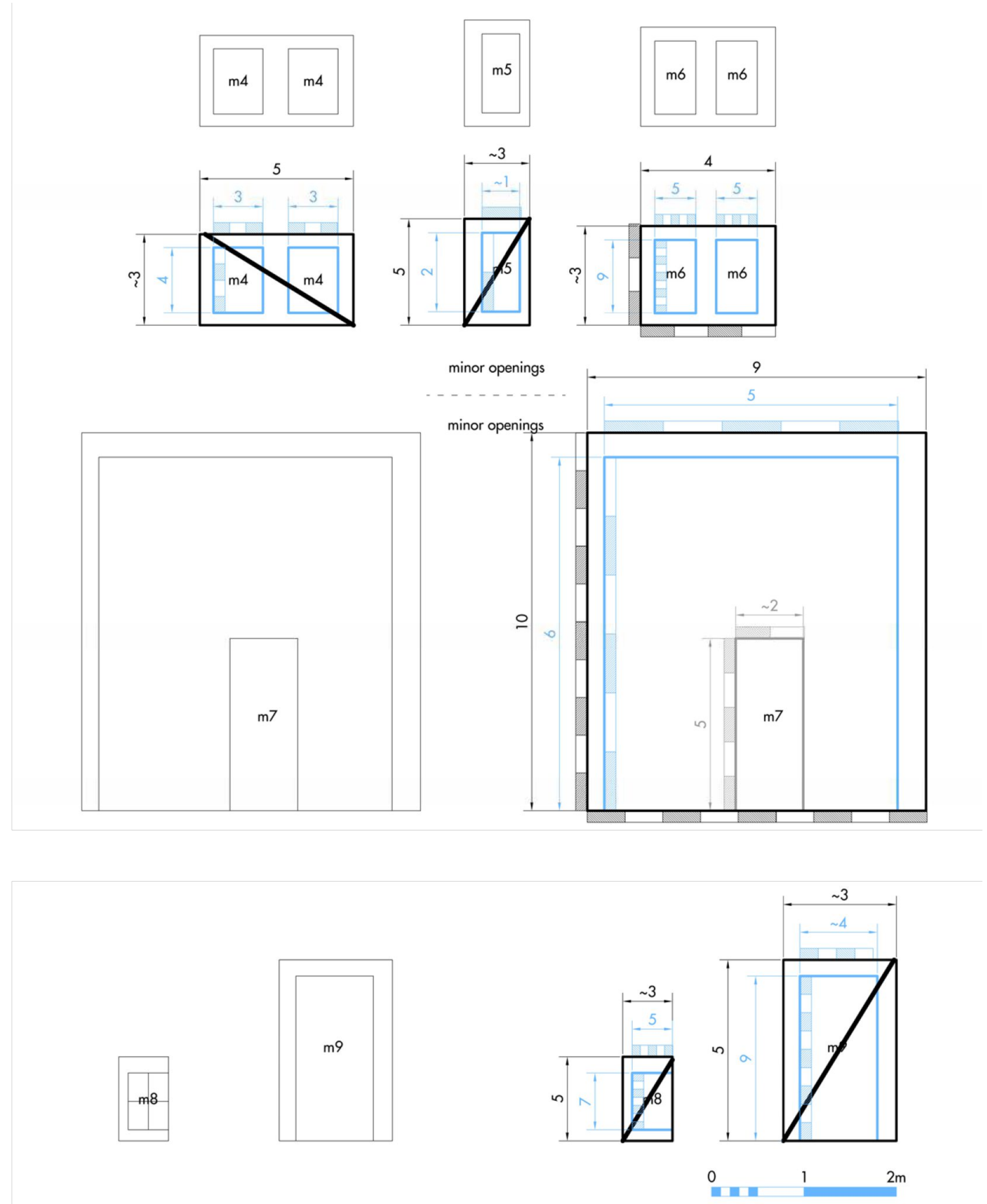
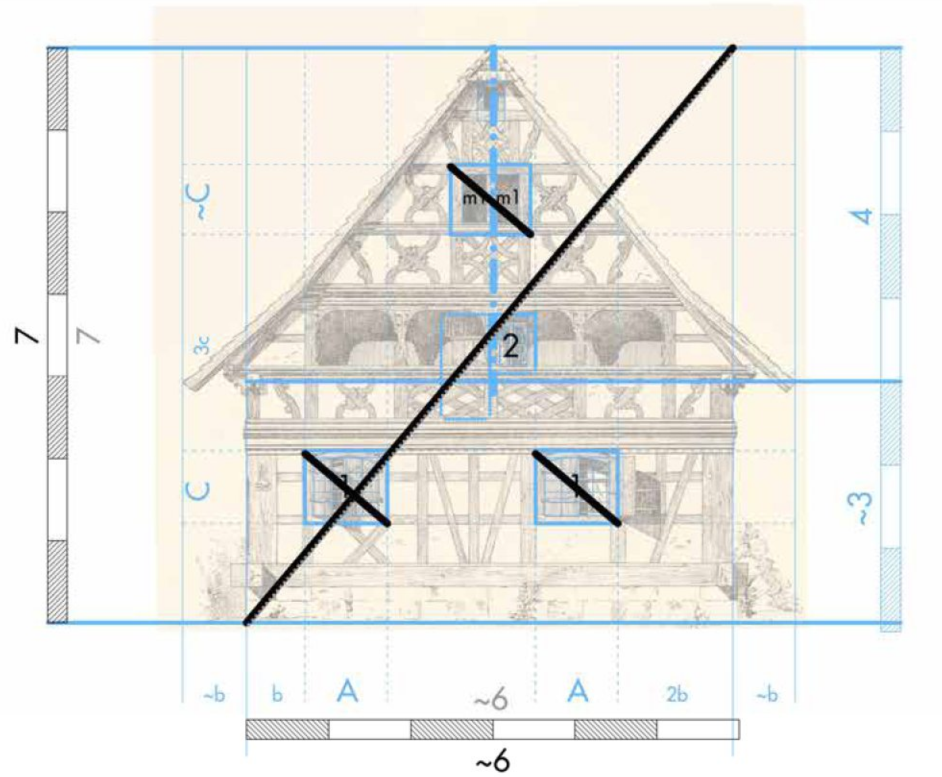


Fig. V.156 Geometrical analysis of openings: (Ba03) Farmhouse No. 73 in Herbolzheim



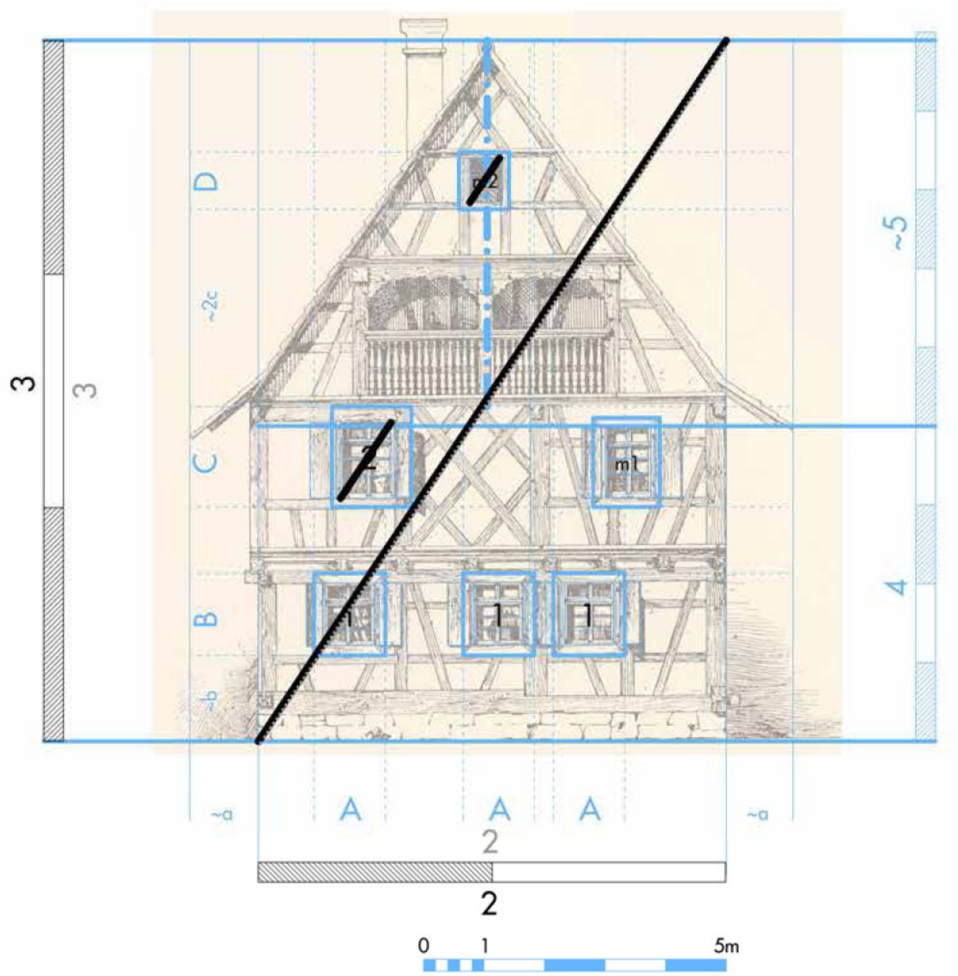


Fig. V.157 Geometrical analysis of front elevation: (Ba04) Farmhouse in Allmannsweier near Lahr
Fig. V.158 Geometrical analysis of front elevation: (Ba05) Farmhouse No. 58 in Kippenheim near Lahr

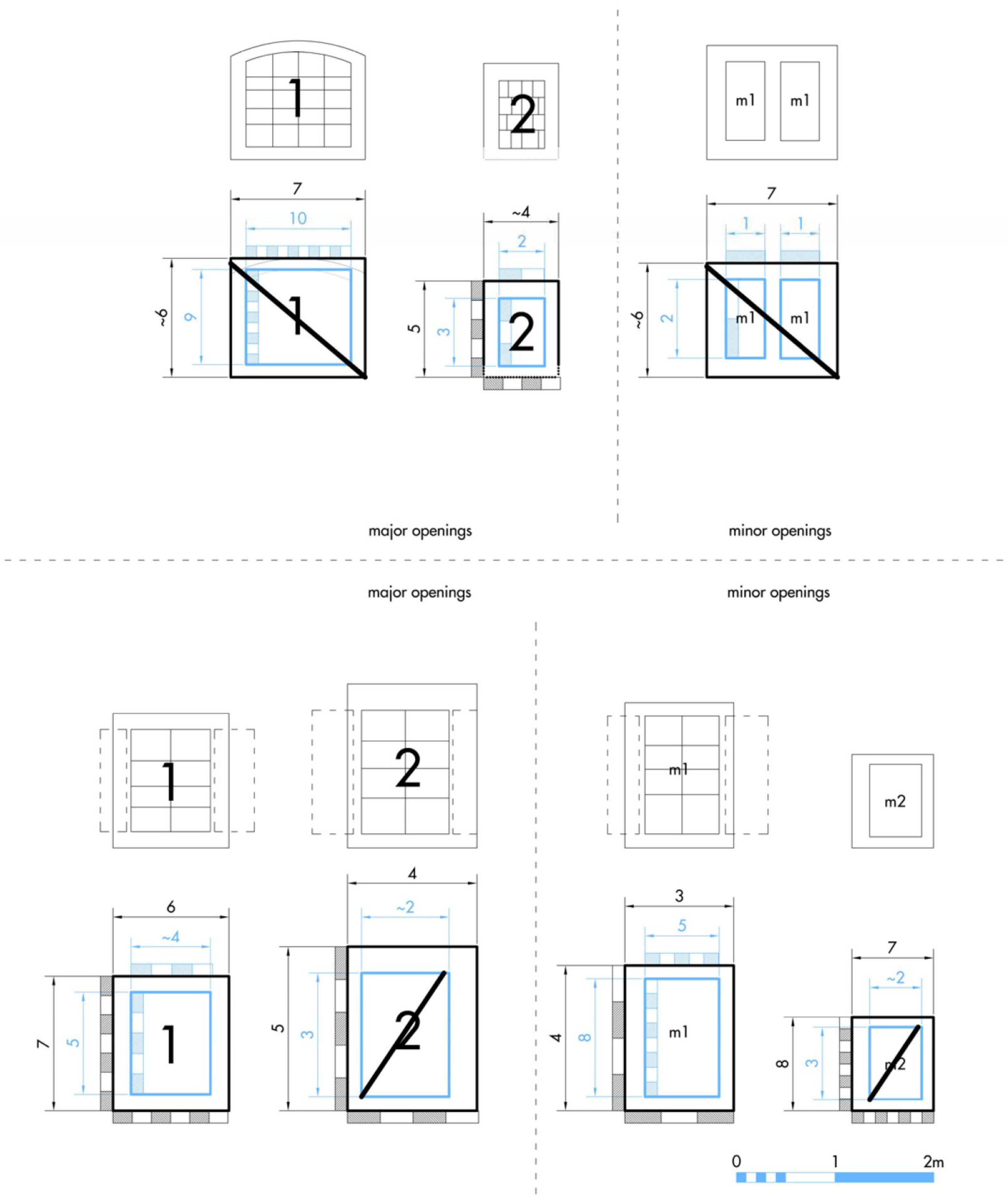
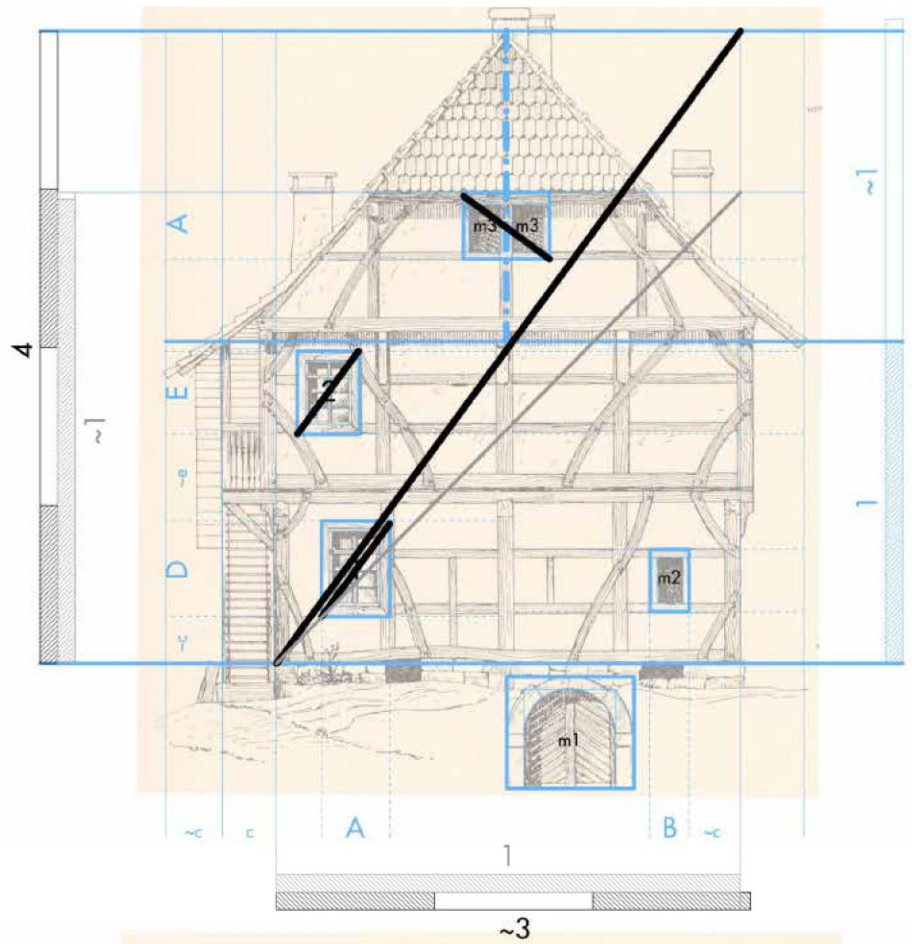


Fig. V.159 Geometrical analysis of openings:
(Ba04) Farmhouse in Allmannsweier near Lahr and (Ba05) Farmhouse No. 58 in Kippenheim near Lahr



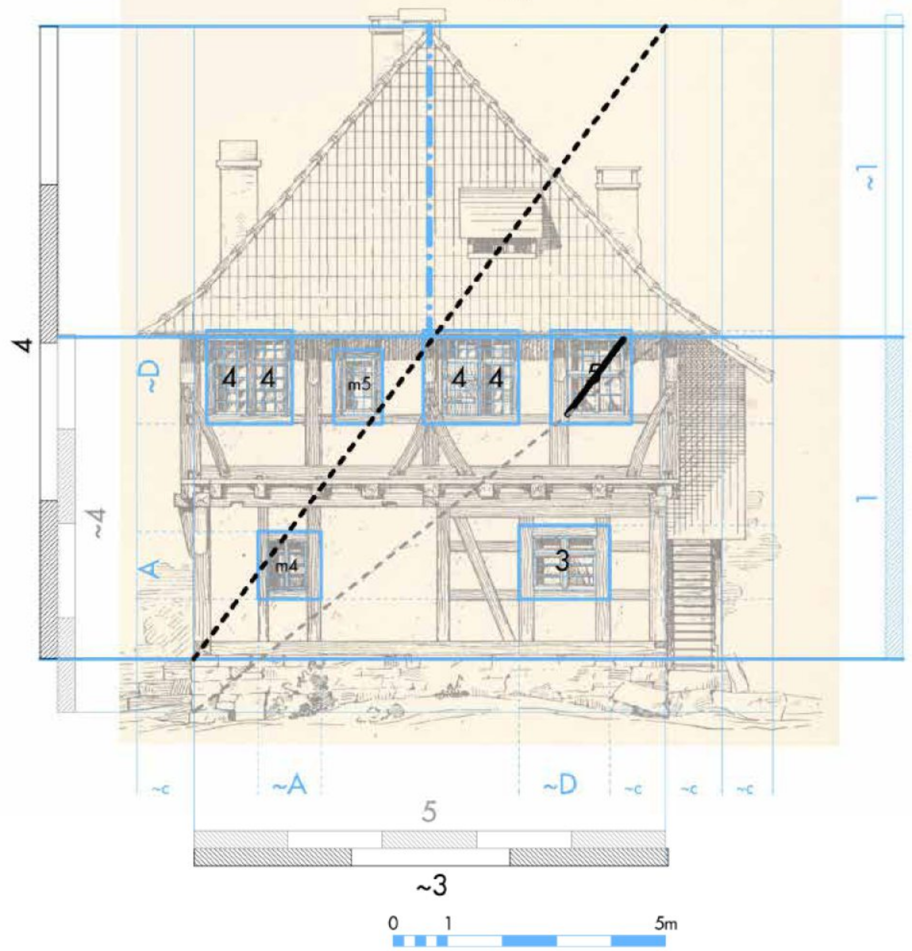


Fig. V.160 Geometrical analysis of rear elevation: (Ba06) Farmhouse No. 227 in Kippenheim near Lahr
Fig. V.161 Geometrical analysis of front elevation: (Ba06) Farmhouse No. 227 in Kippenheim near Lahr

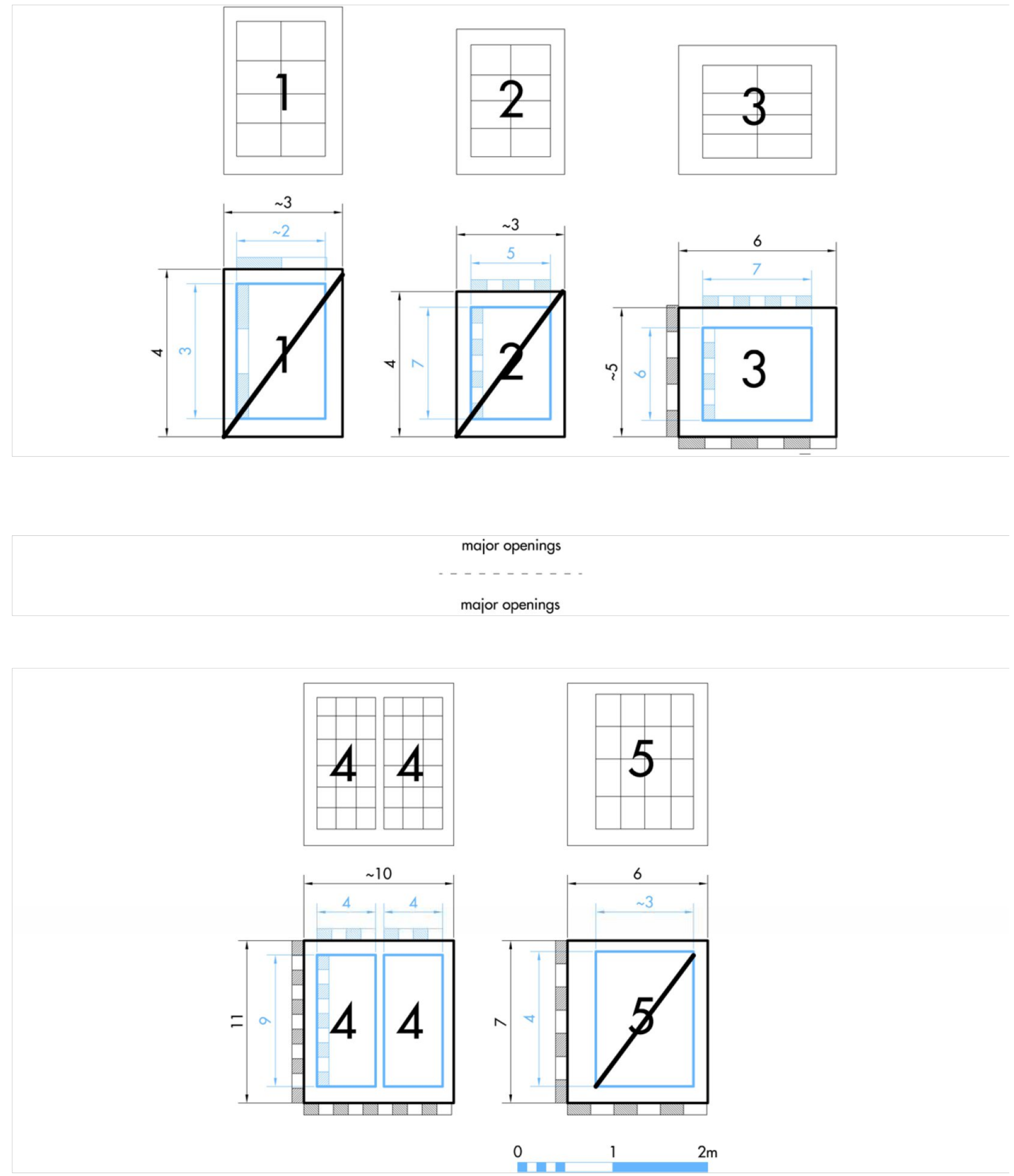
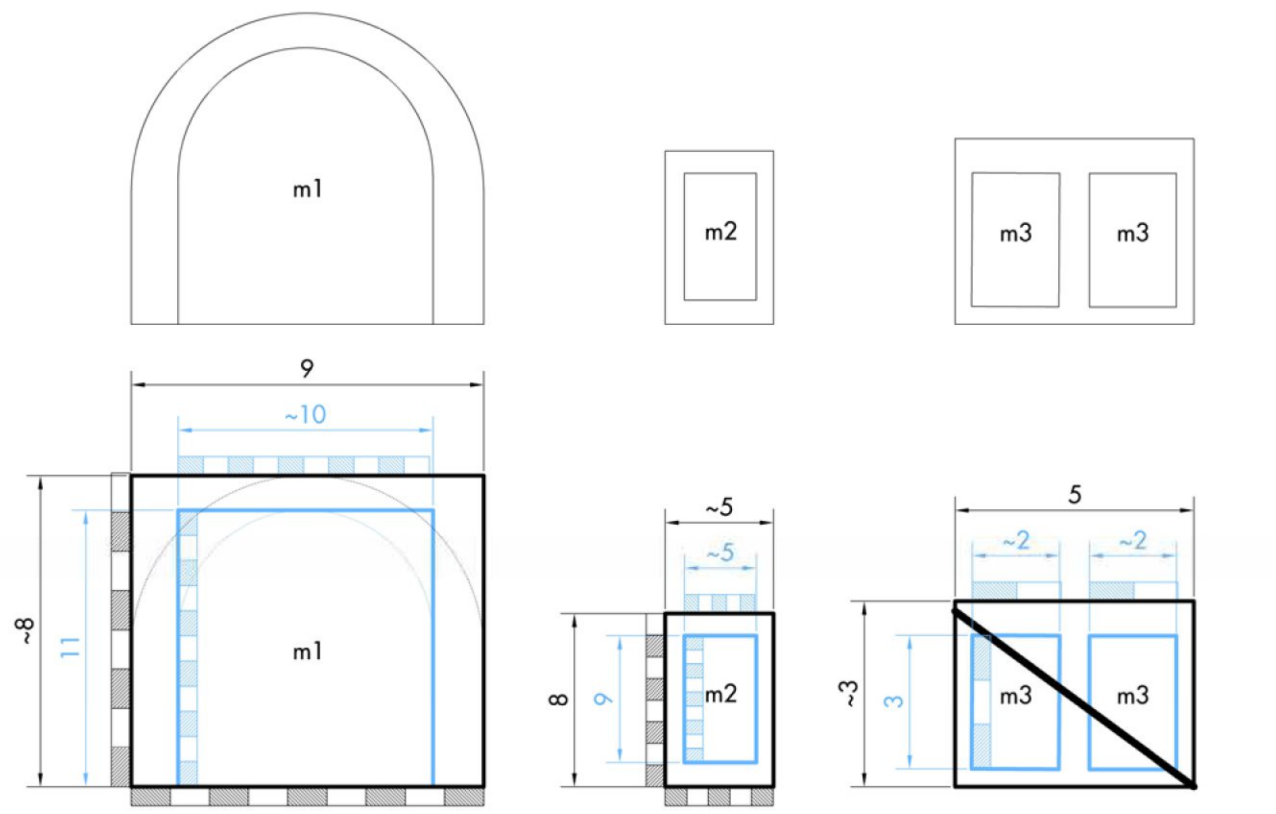


Fig. V.162 Geometrical analysis of openings: (Ba06) Farmhouse No. 227 in Kippenheim near Lahr



minor openings

minor openings

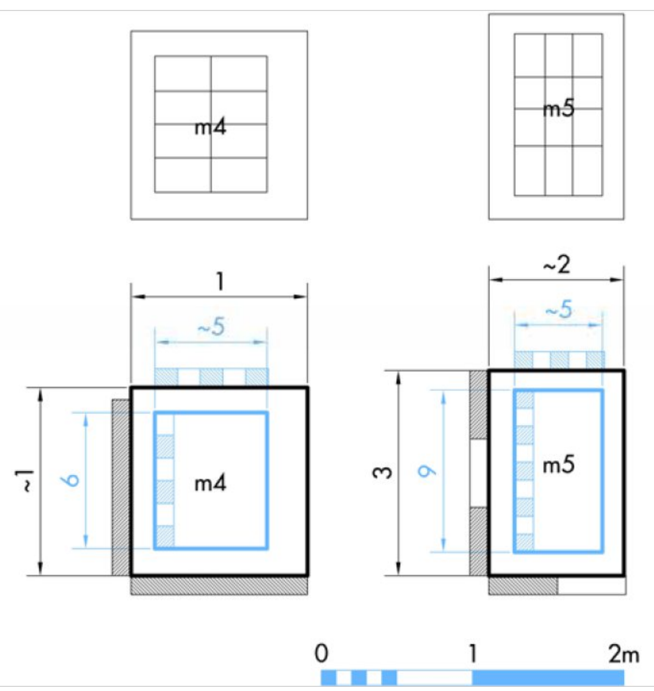


Fig. V.163 Geometrical analysis of openings: (Ba06) Farmhouse No. 227 in Kippenheim near Lahr

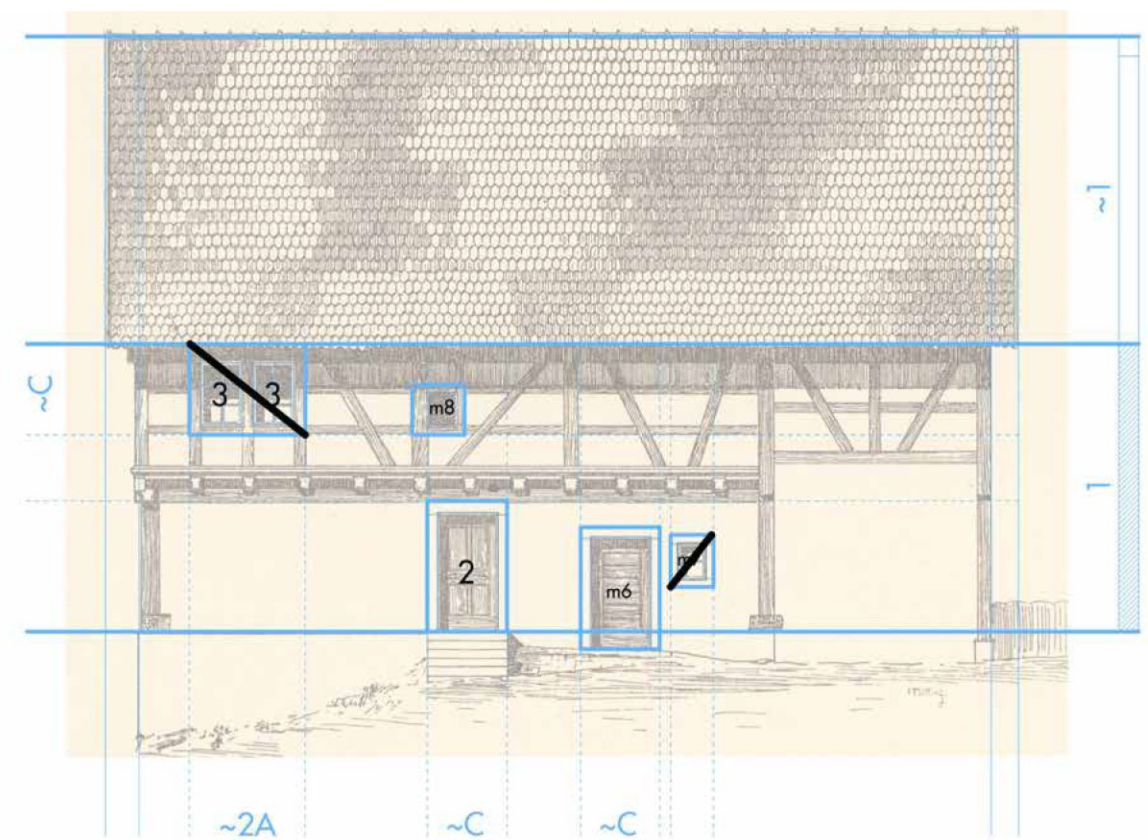


Fig. V.164 Geometrical analysis of front elevation: (Ba07) Farmhouse in Binau
Fig. V.165 Geometrical analysis of side elevation: (Ba07) Farmhouse in Binau

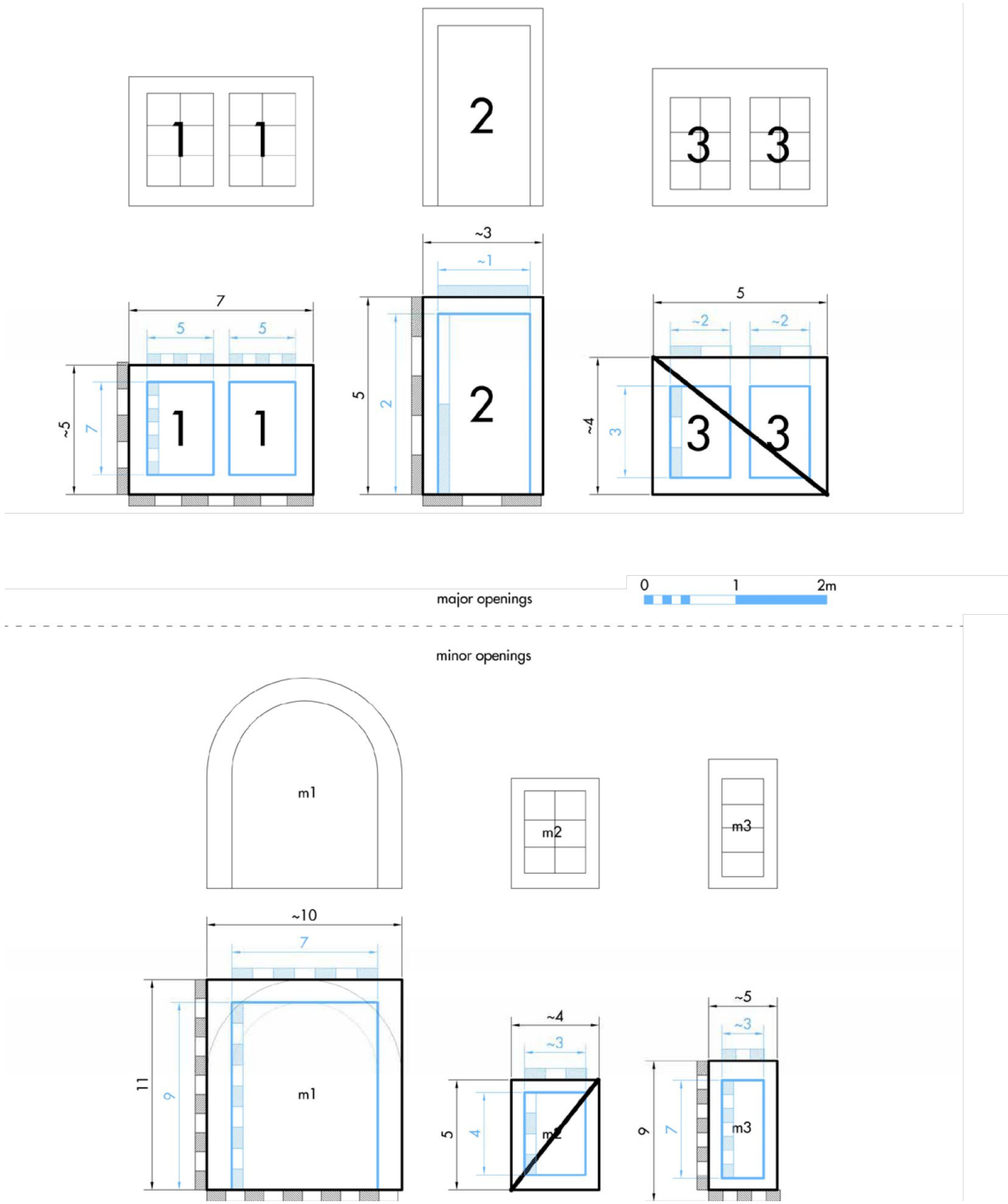


Fig. V.166 Geometrical analysis of openings: (Ba07) Farmhouse in Binau

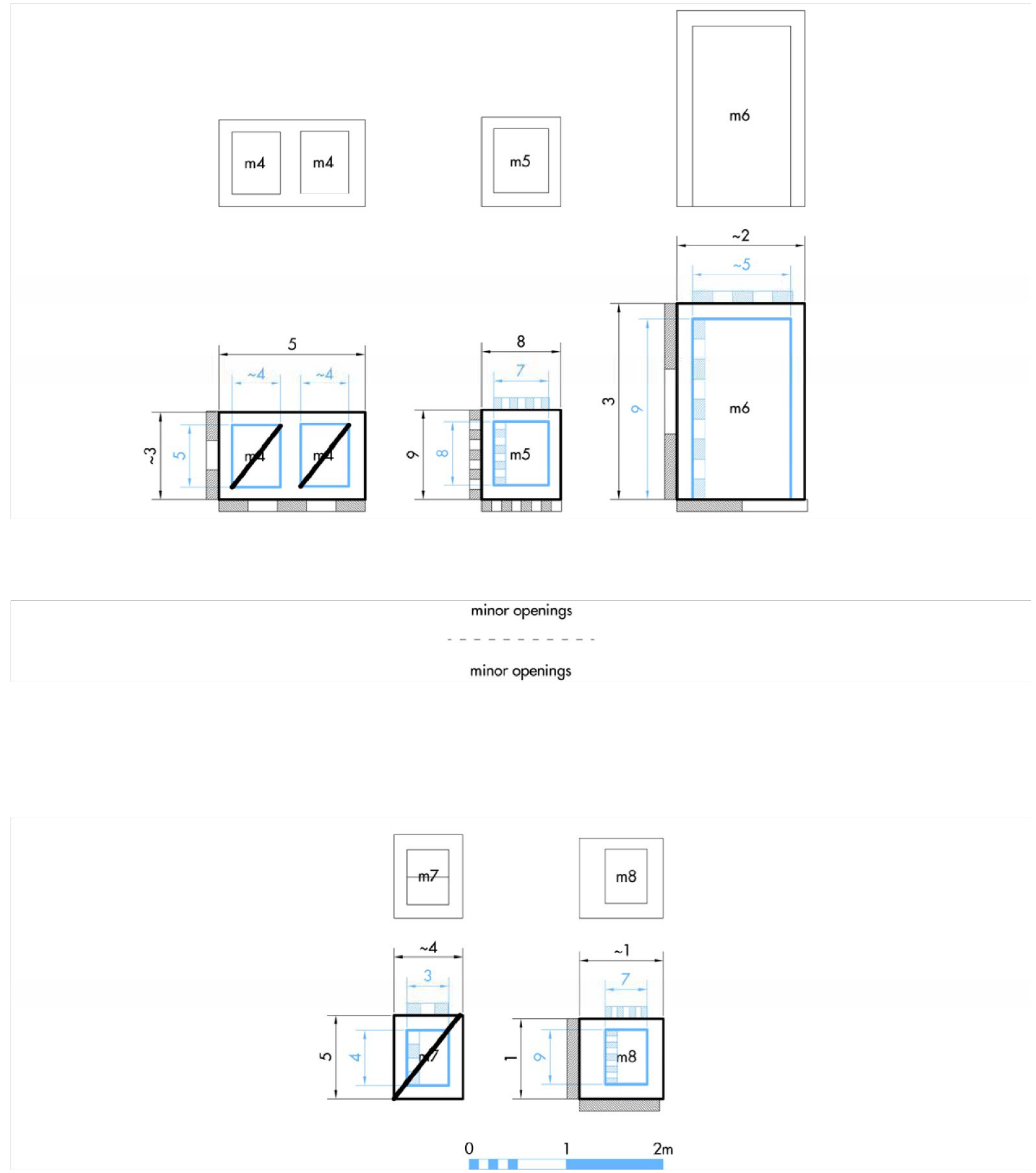


Fig. V.167 Geometrical analysis of openings: (Ba07) Farmhouse in Binau

PRES TIG E

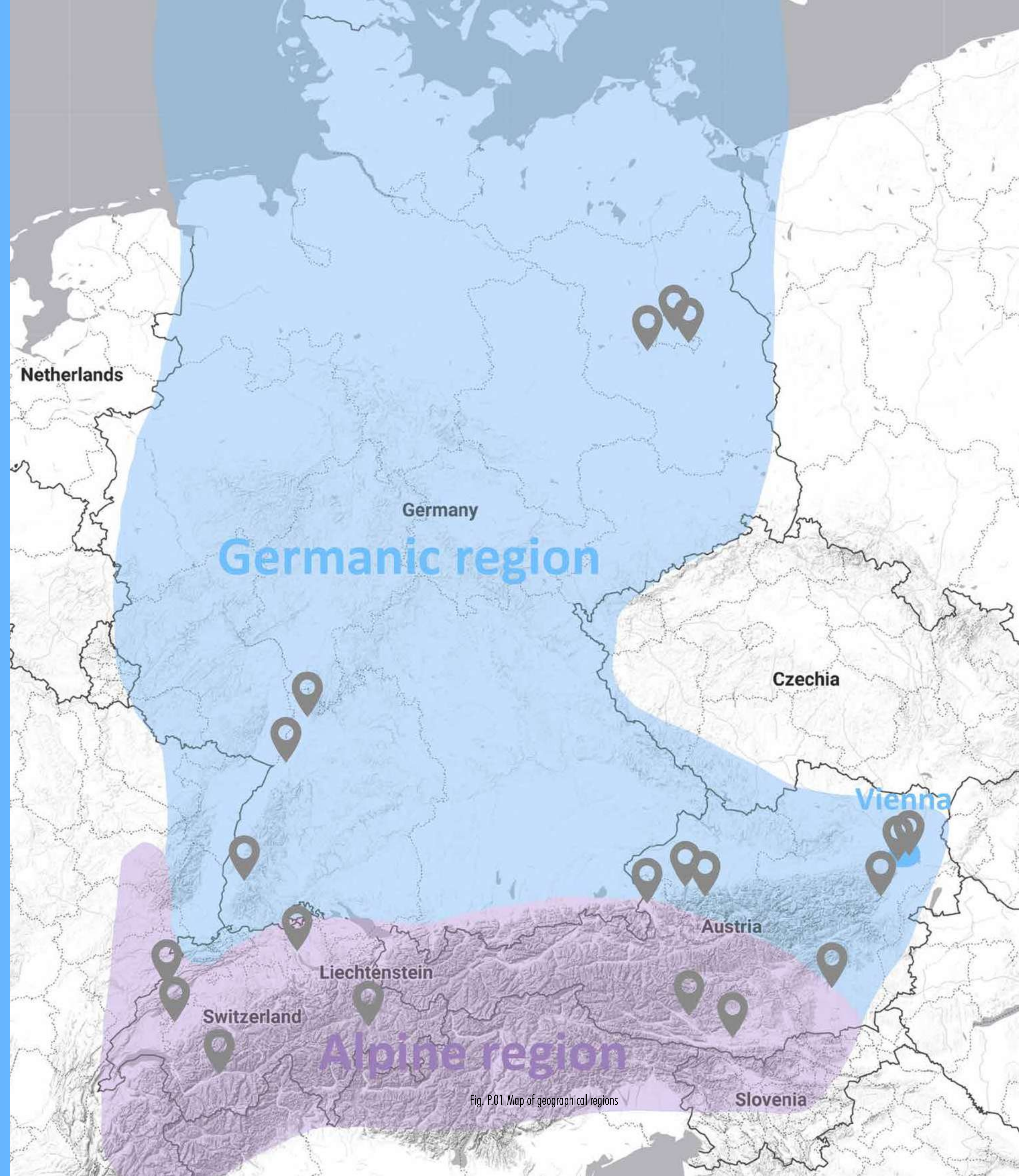


Fig. P.01 Map of geographical regions

ALPINE REGION // AREAS IN CURRENT AUSTRIA

Styrian

S01: House of baron Seßler von Herzinger, Graz,
arch.: F. Schachner
(front elevation, openings)

Carinthia

C01: Lake villa, Millstatt,
arch.: K. Mayreder, H. Köchlin
(front elevation, openings)

C02: "Deutsches Haus" German house, Millstatt,
arch.: K. Mayreder, H. Köchlin
(front elevation, openings)

C03: Villa of Mr. Bucher, at Wörther-See near Klagenfurt,
arch.: -
(front elevation, openings)

Salzburg

Sa01: Villa Dworzak, Salzburg, Schwarzstraße 27,
arch.: G. Haussmann
(front and side elevation, openings)

Sa02: Villa of Mr. F.G. Schäffer, Salzburg,
arch.: H. Krackowizer
(side and side elevation, openings)

intentionally omitted

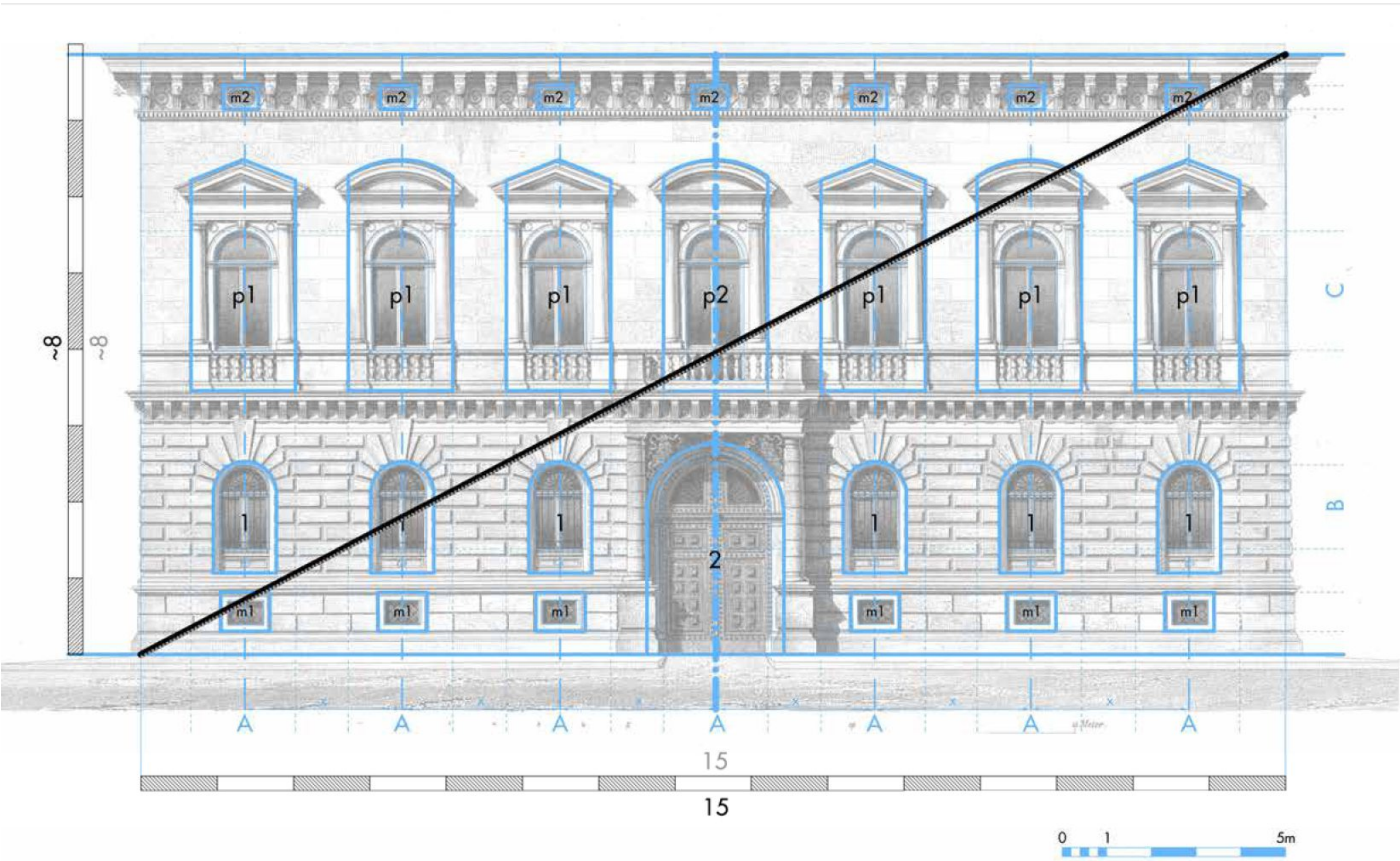


Fig. P.02 Geometrical analysis of front elevation: (S01) House of baron Seßler von Herzinger, Graz

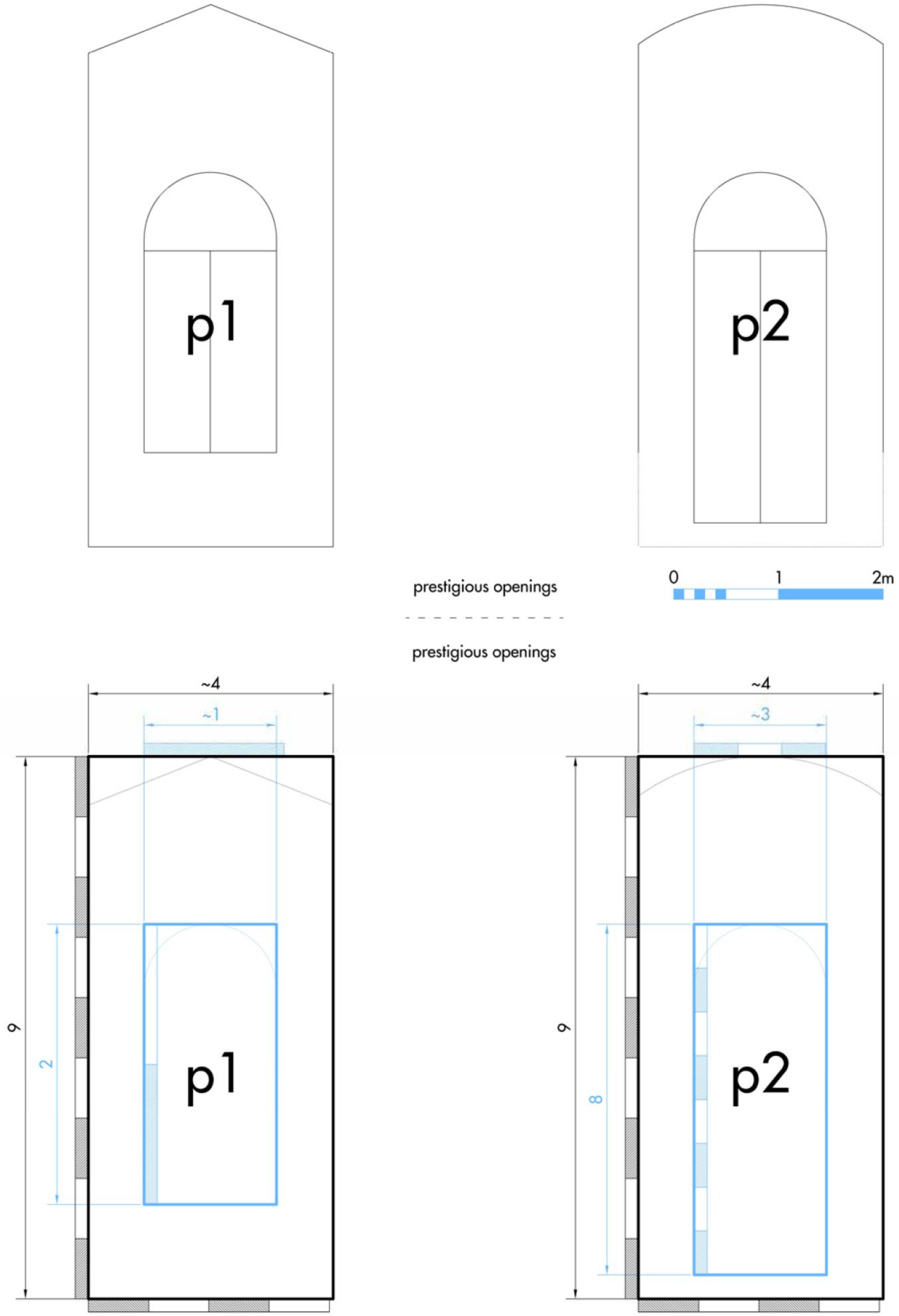


Fig. P.03 Geometrical analysis of openings: (S01) House of baron Seßler von Herzinger, Graz

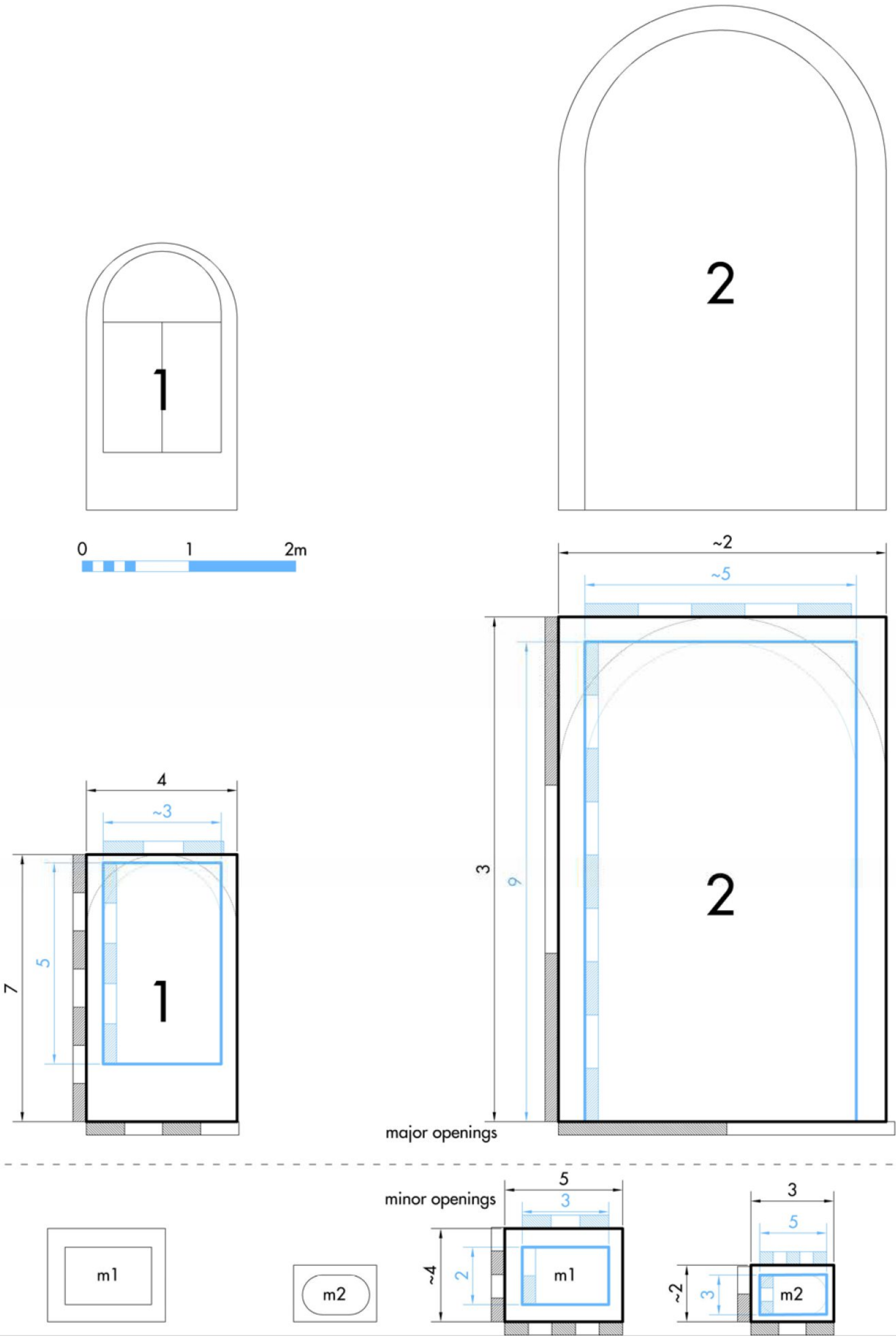
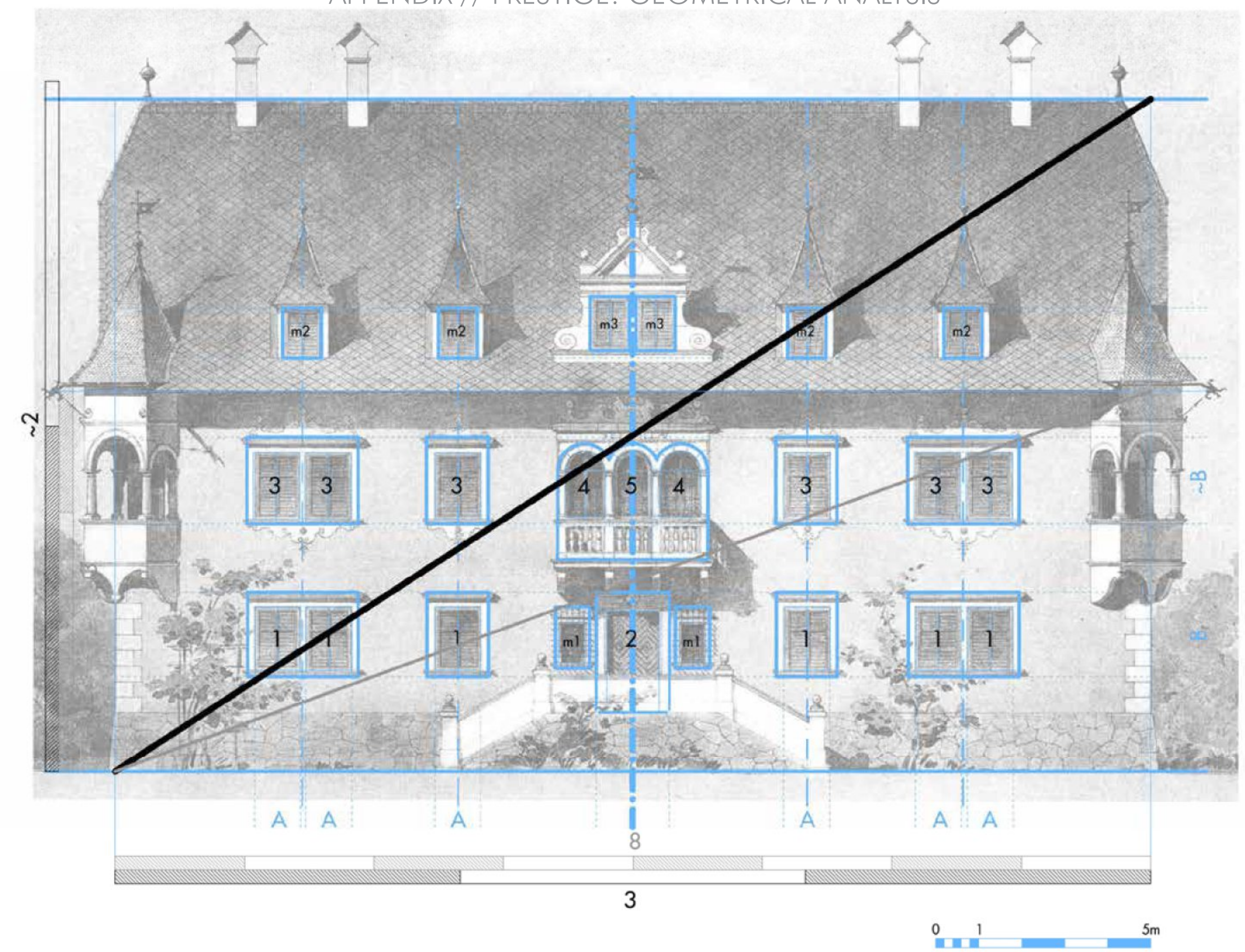


Fig. P.04 Geometrical analysis of openings: (S01) House of baron Seßler von Herzinger, Graz



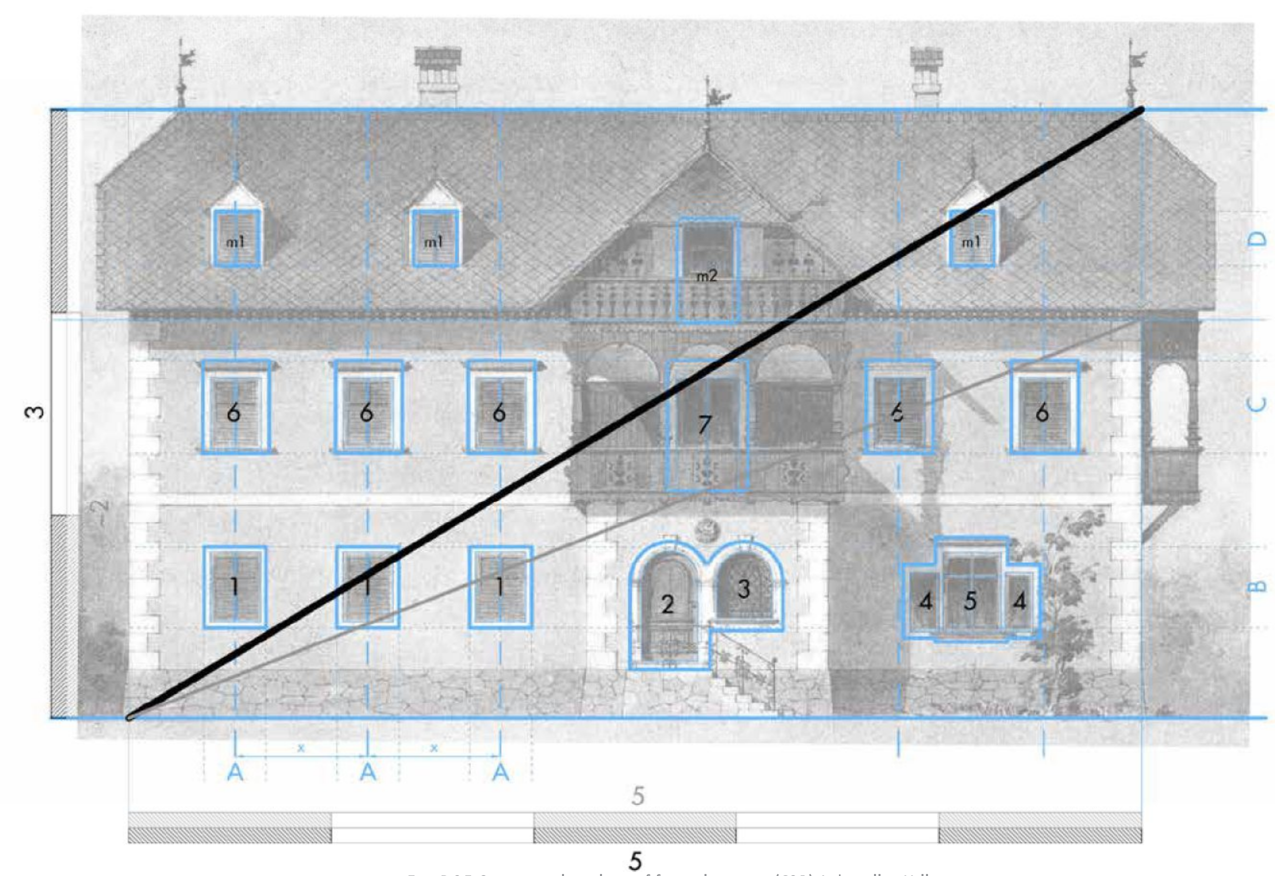


Fig. P.05 Geometrical analysis of front elevation: (C01) Lake villa, Millstatt

Fig. P.06 Geometrical analysis of front elevation: (C02) "Deutsches Haus" German house, Millstatt

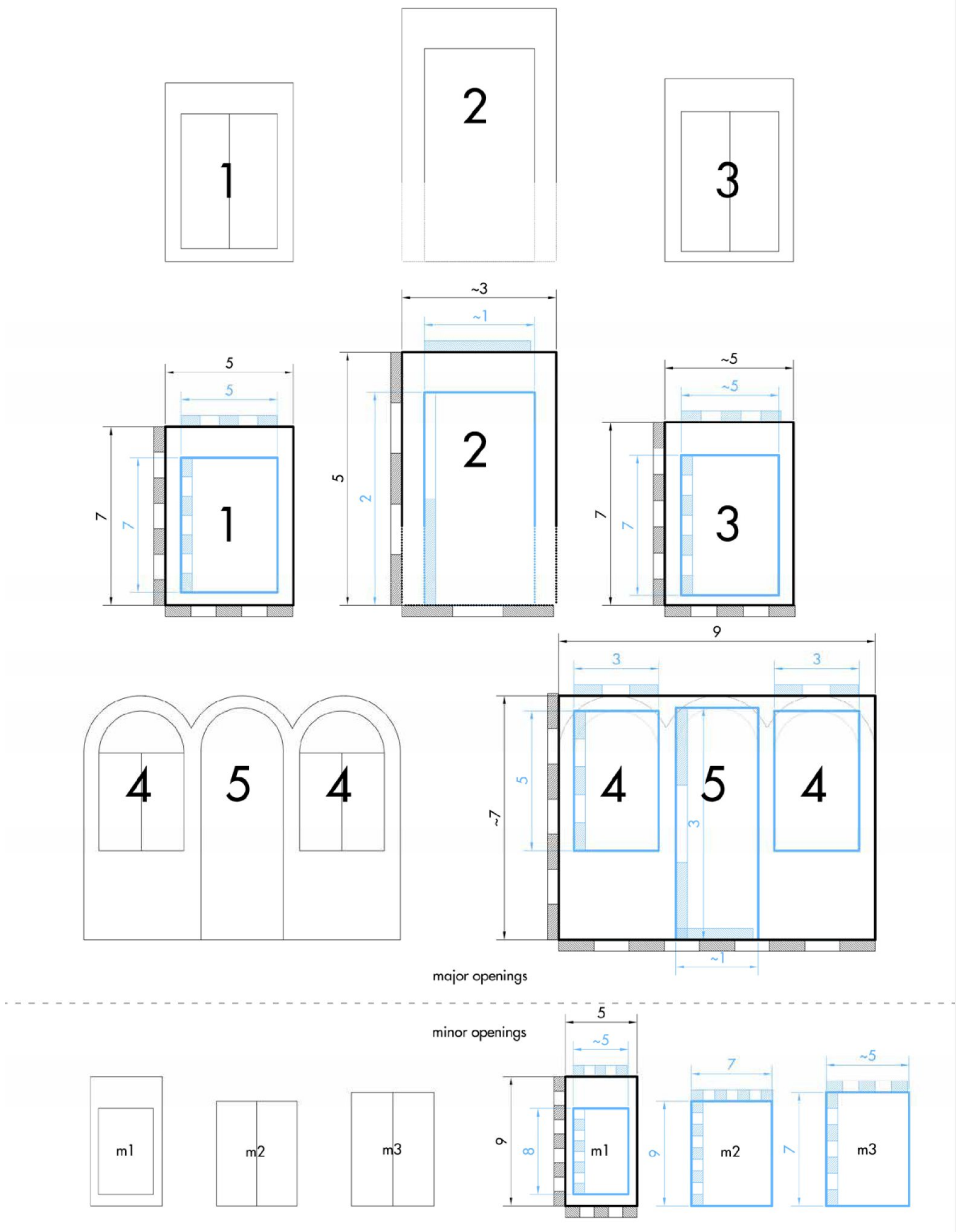


Fig. P.07 Geometrical analysis of openings: (C01) Lake villa, Millstatt

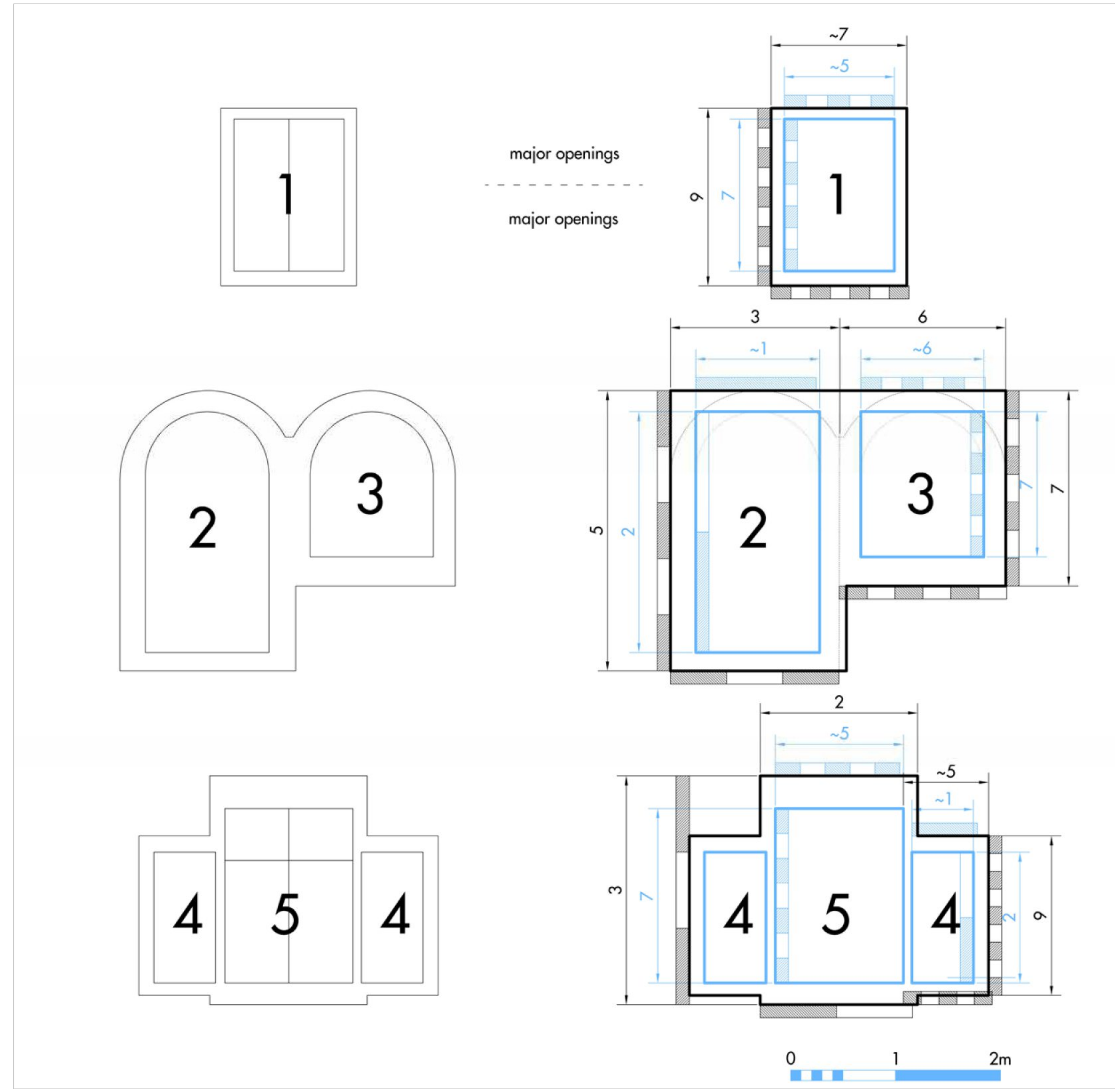


Fig. P.08 Geometrical analysis of openings: (C02) "Deutsches Haus" German house, Millstatt

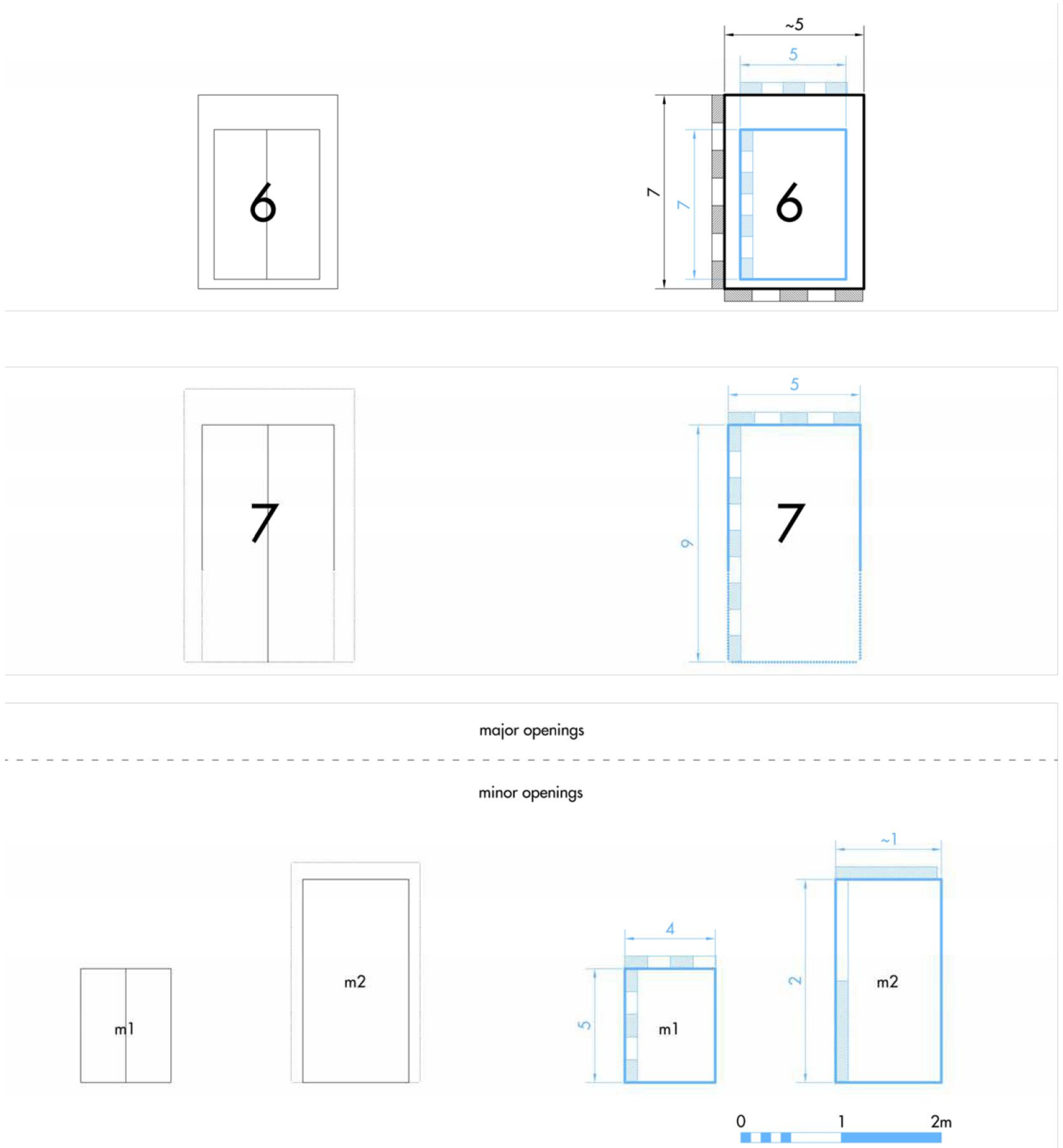


Fig. P.09 Geometrical analysis of openings: (C02) "Deutsches Haus" German house, Millstatt

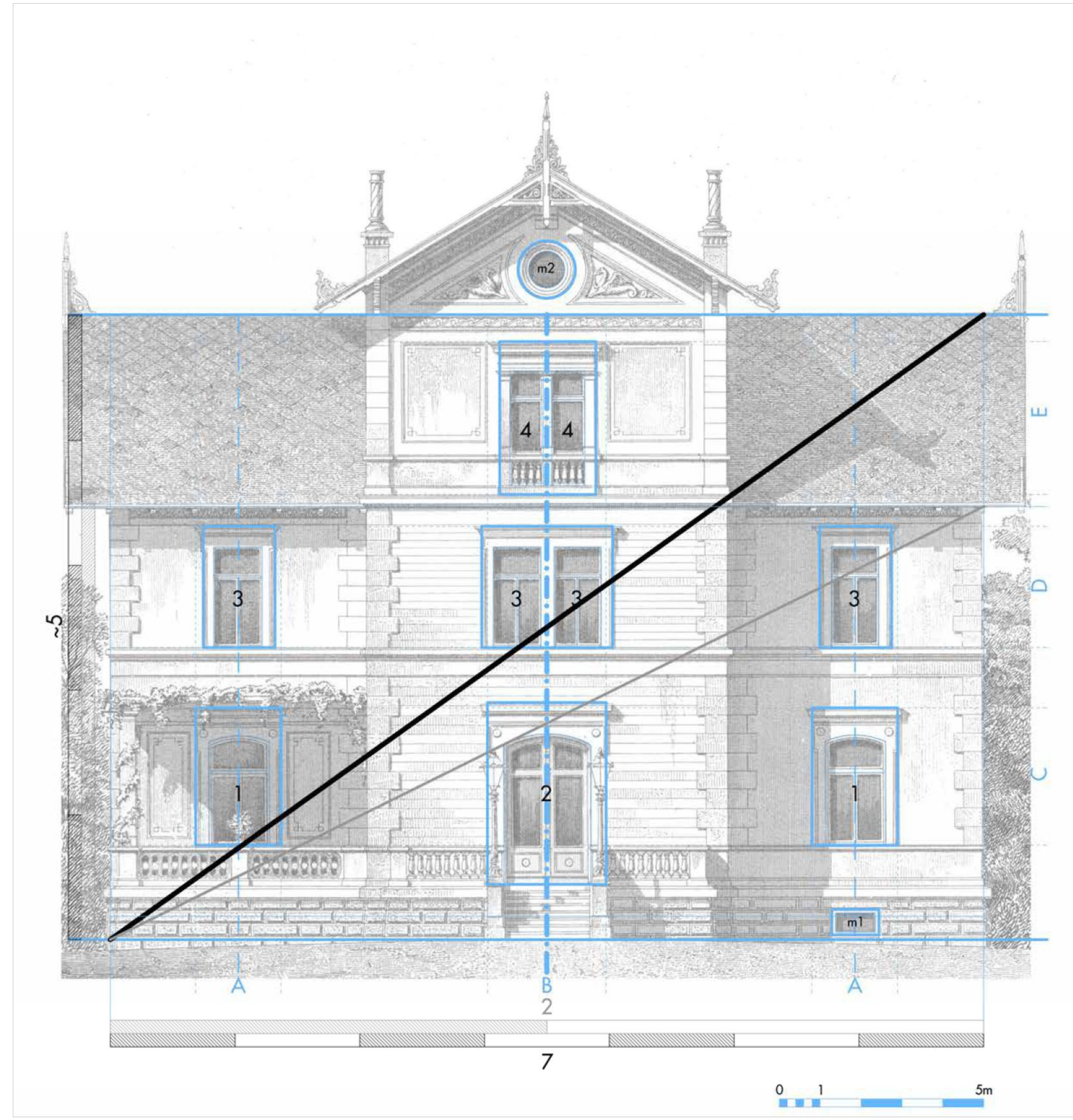


Fig. P.10 Geometrical analysis of front elevation: (C03) Villa of Mr. Bucher, at Wörther-See near Klagenfurt

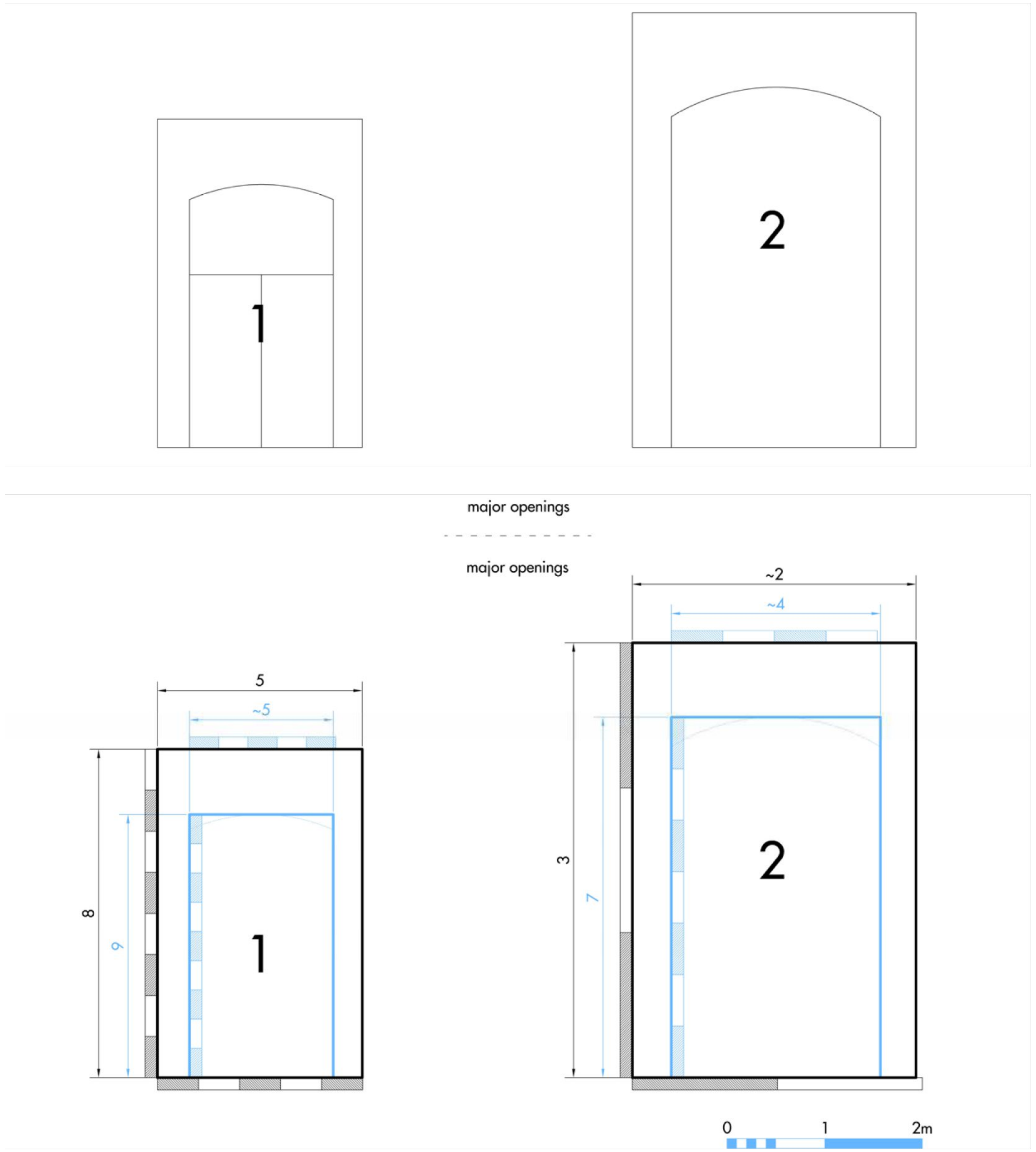


Fig. P.11 Geometrical analysis of openings: (C03) Villa of Mr. Bucher, at Wörther-See near Klagenfurt

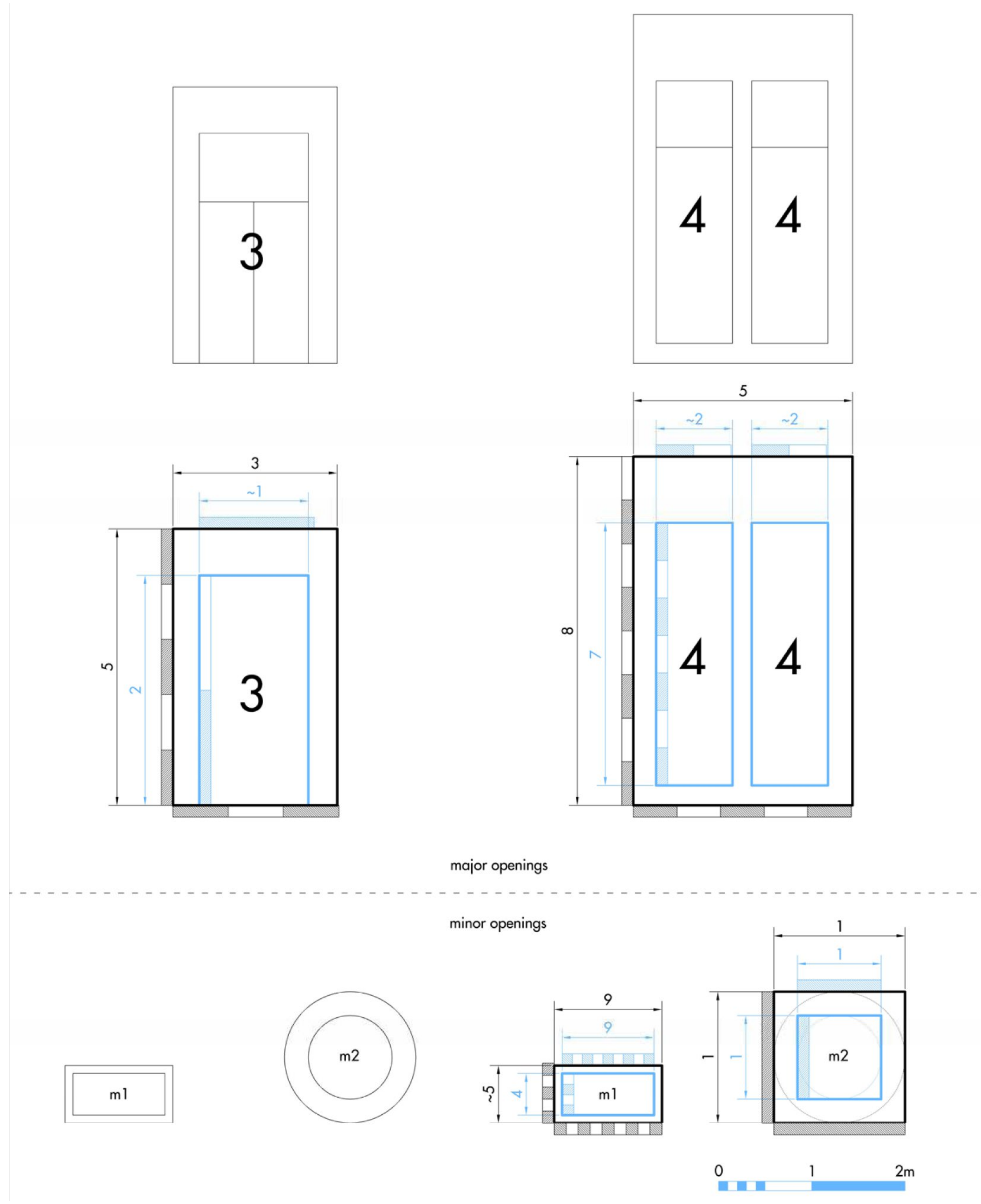


Fig. P.12 Geometrical analysis of openings: (C03) Villa of Mr. Bucher, at Wörther-See near Klagenfurt

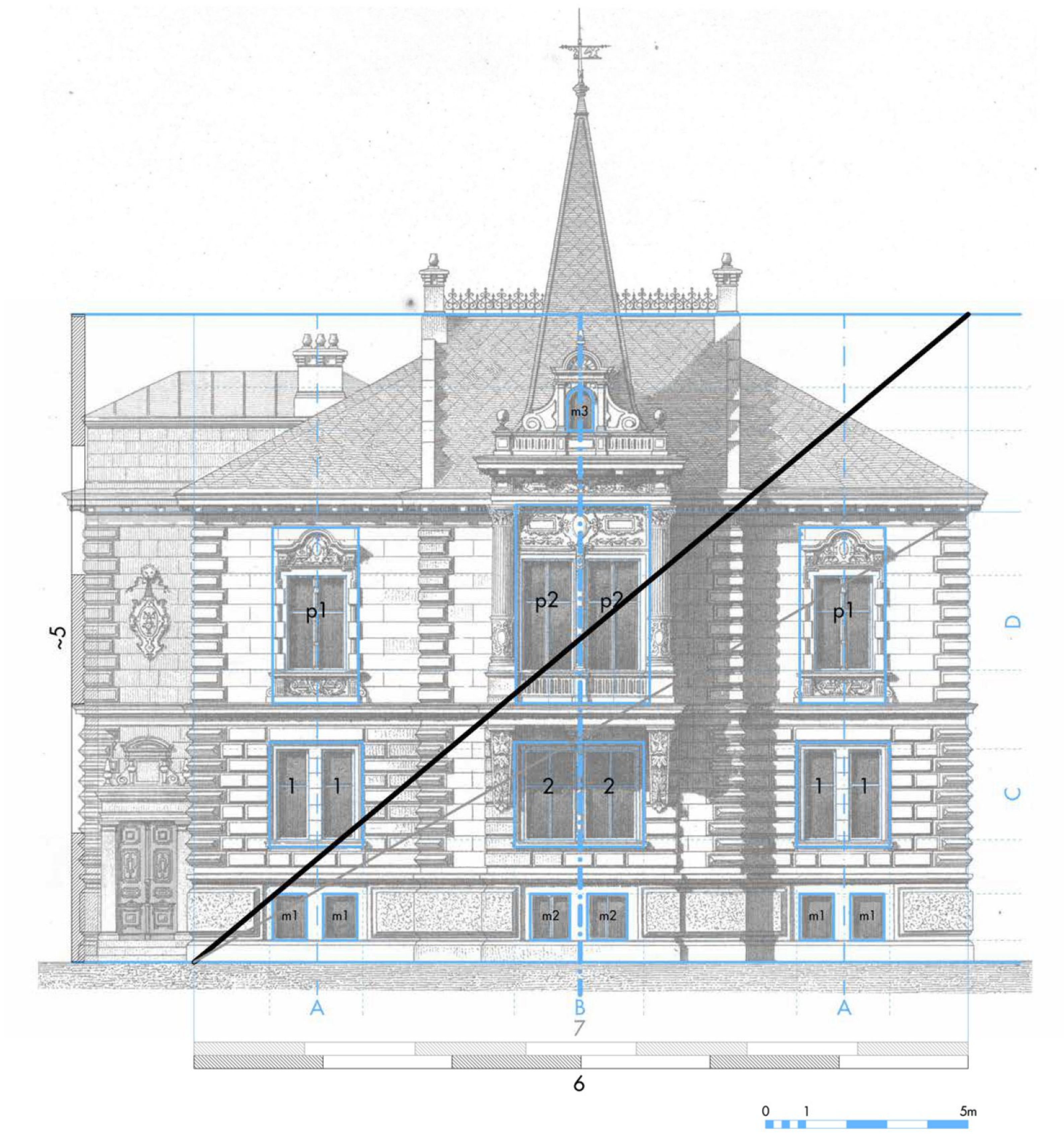


Fig. P.13 Geometrical analysis of front elevation: (Sa01) Villa Dworzak, Salzburg, Schwarzstraße 27

Fig. P.14 Geometrical analysis of side elevation: (Sa01) Villa Dworzak, Salzburg, Schwarzstraße 27

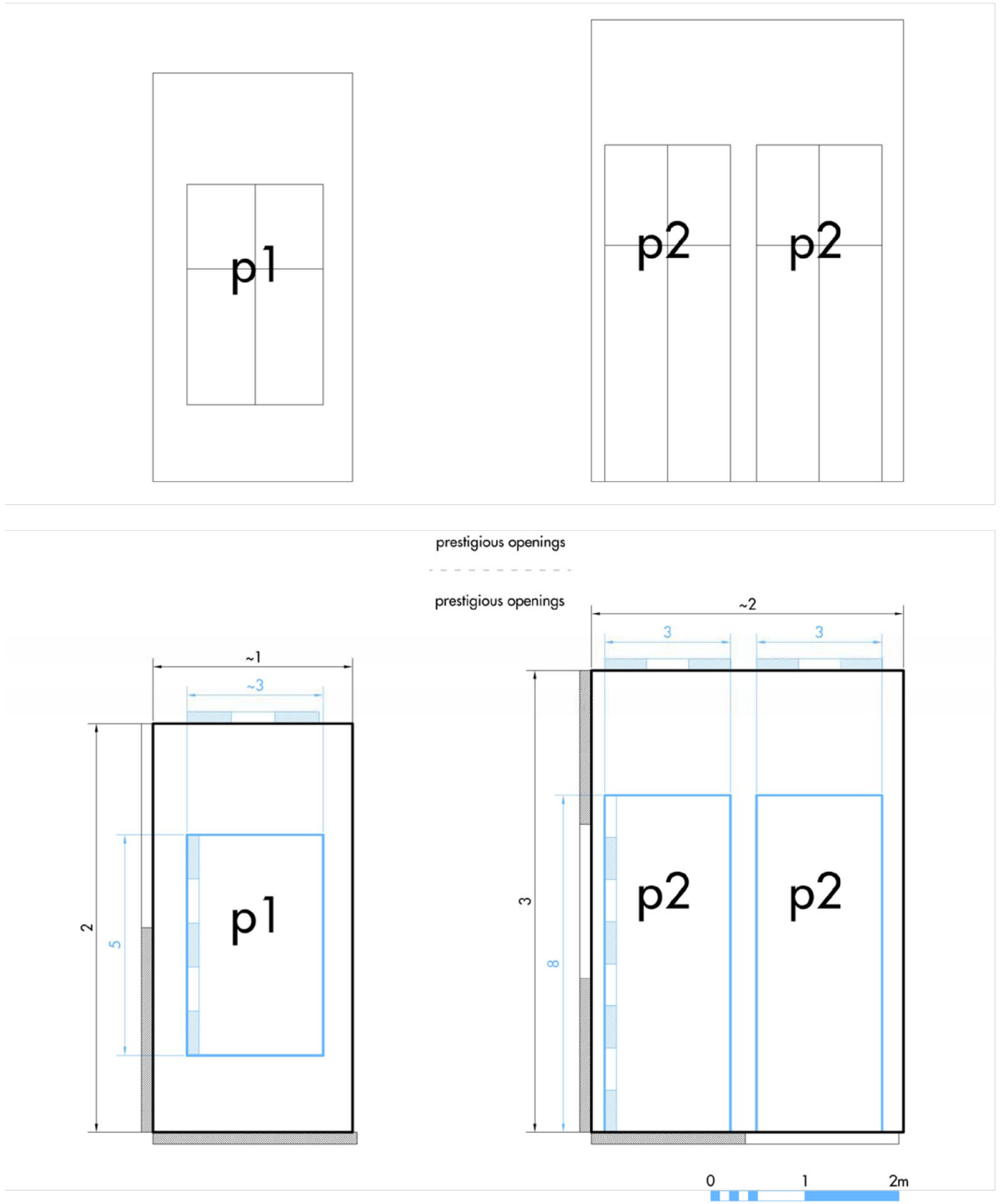


Fig. P.15 Geometrical analysis of openings: (Sa01) Villa Dworzak, Salzburg, Schwarzstraße 27

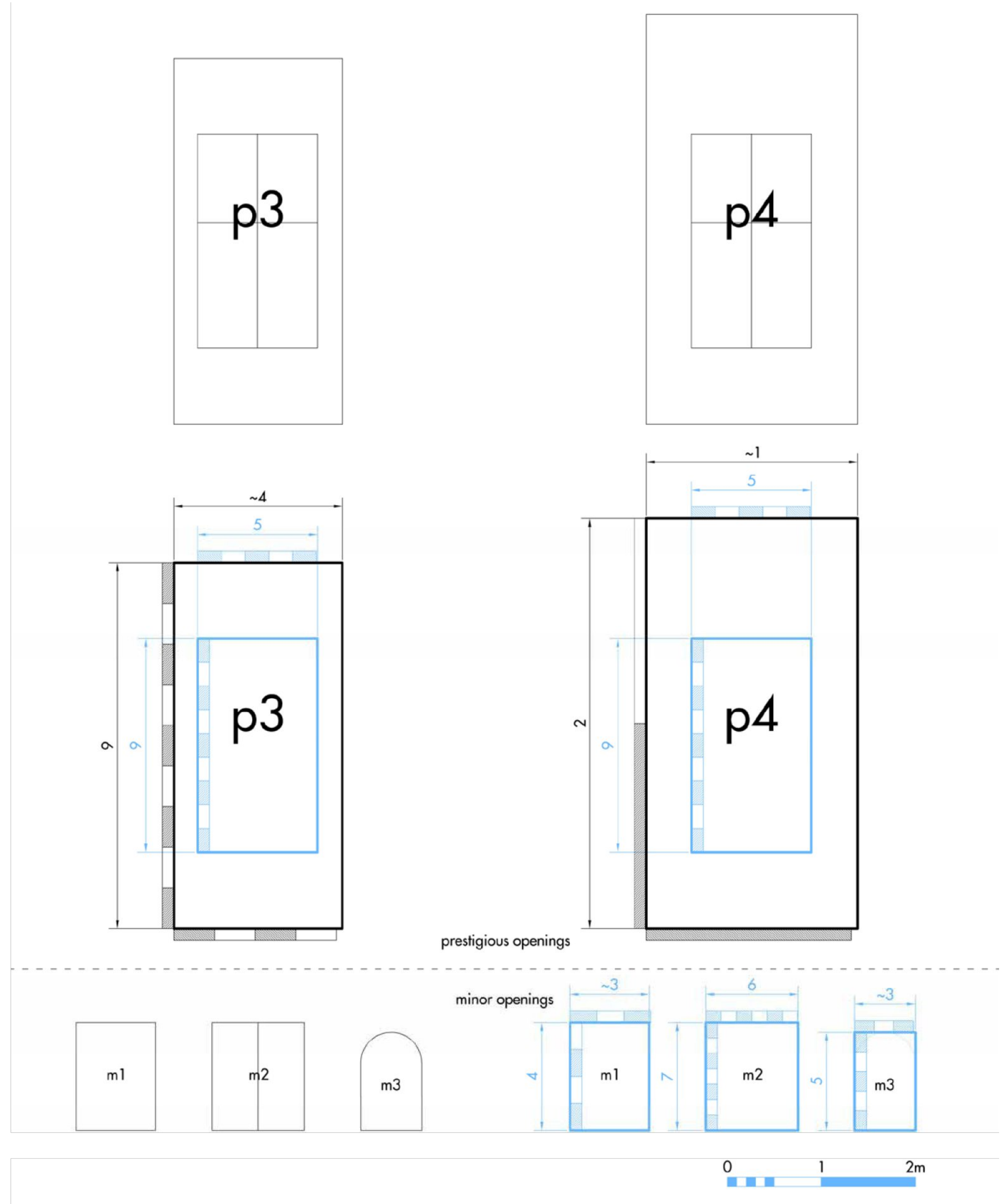


Fig. P.16 Geometrical analysis of openings: (Sa01) Villa Dworzak, Salzburg, Schwarzstraße 27

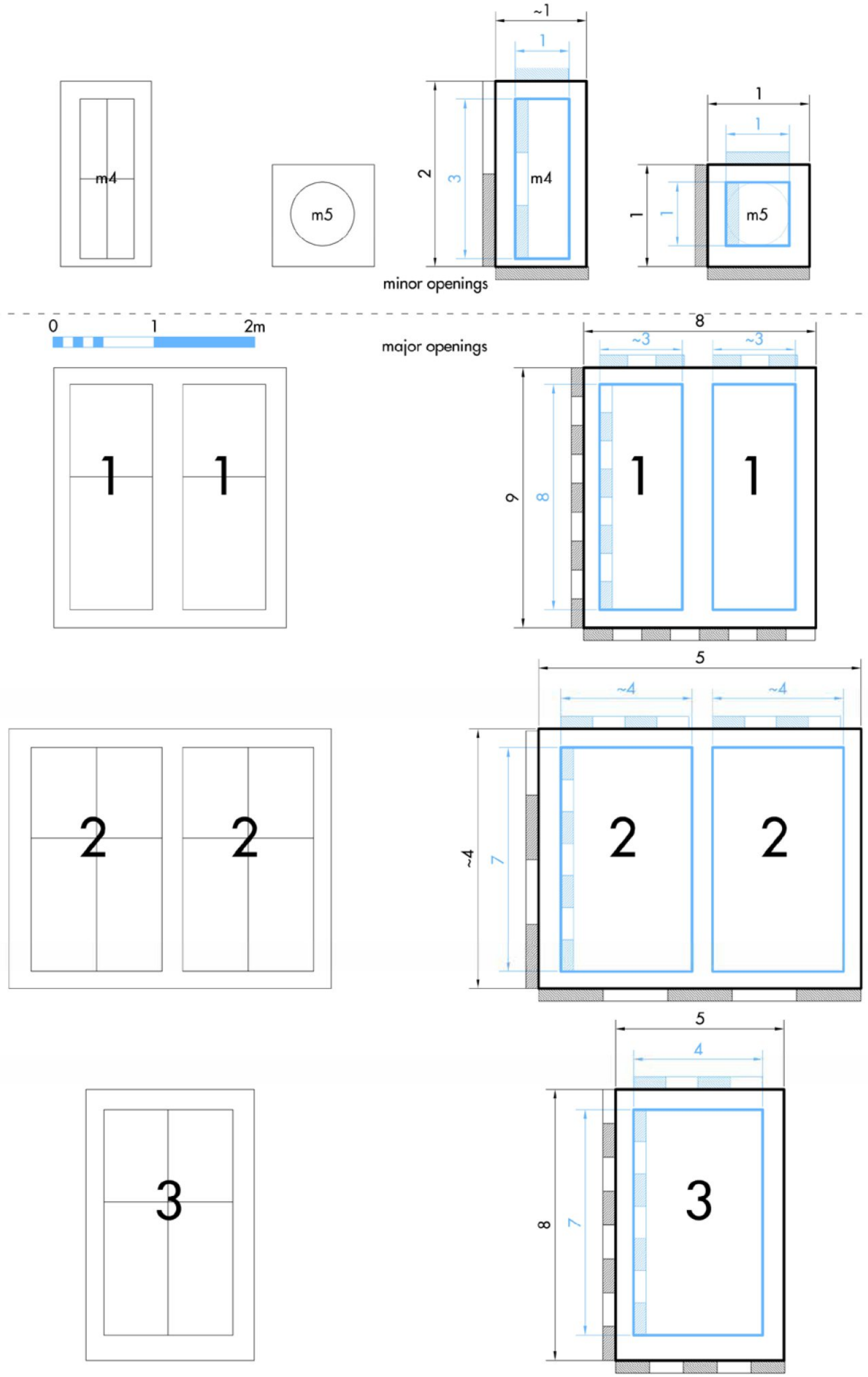


Fig. P.17 Geometrical analysis of openings: (Sa01) Villa Dworzak, Salzburg, Schwarzstraße 27

Fig. P.18 Geometrical analysis of side elevation: (Sa02) Villa of Mr. F.G. Schäffer, Salzburg

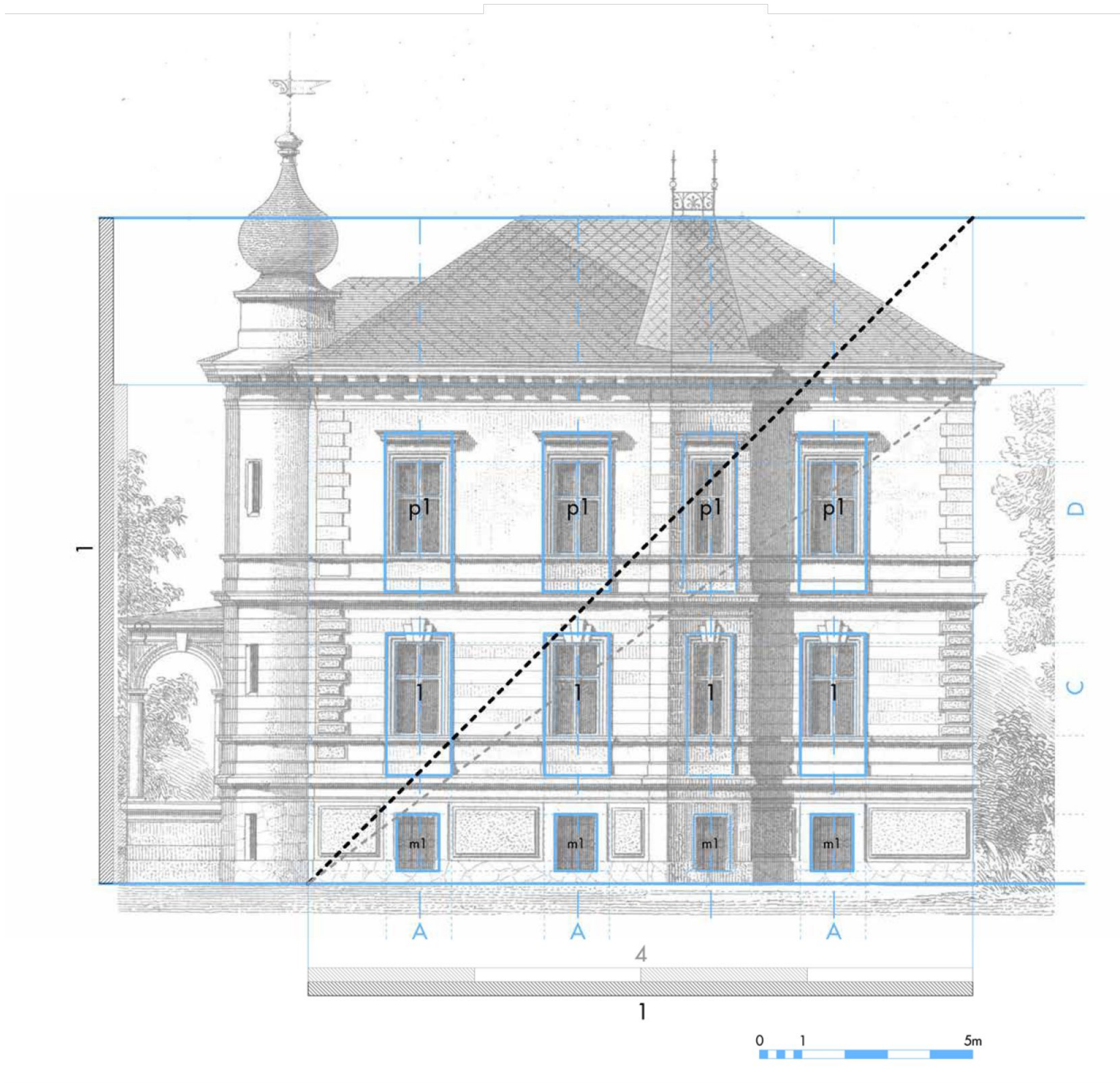


Fig. P.19 Geometrical analysis of side elevation: (Sa02) Villa of Mr. F.G. Schäffer, Salzburg

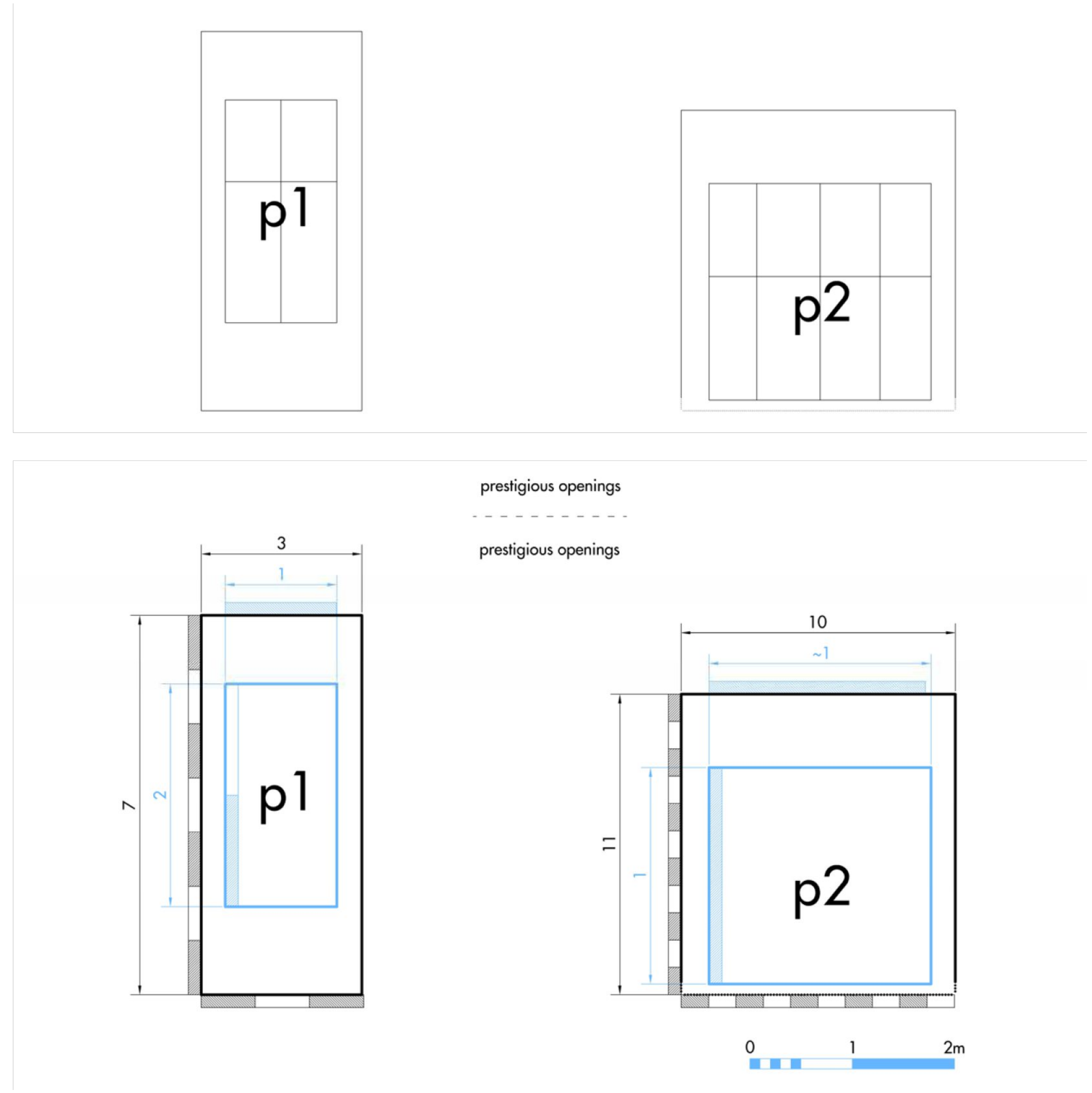


Fig. P.20 Geometrical analysis of openings: (Sa02) Villa of Mr. F.G. Schäffer, Salzburg

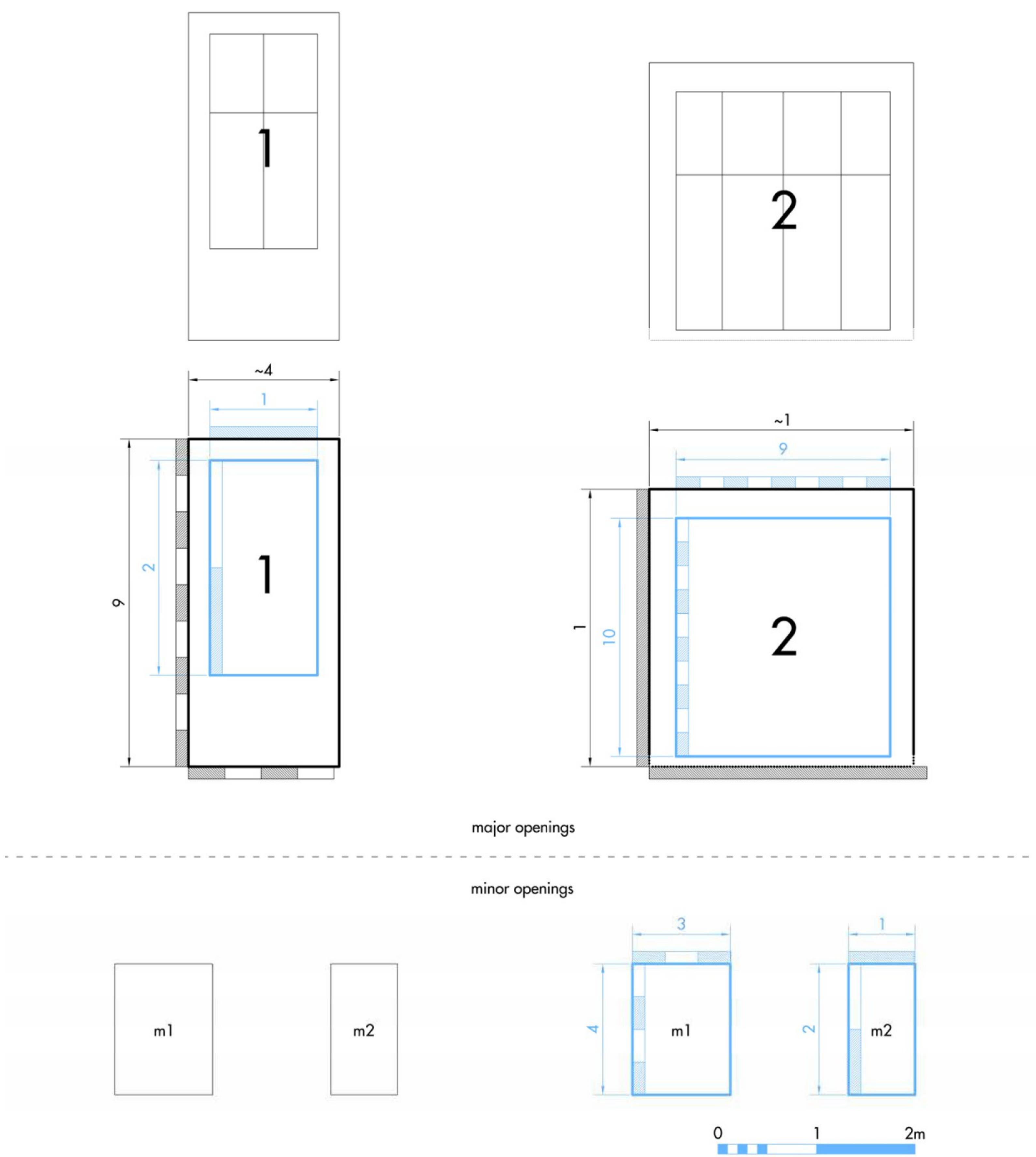


Fig. P.21 Geometrical analysis of openings: (Sa02) Villa of Mr. F.G. Schäffer, Salzburg

intentionally omitted

ALPINE REGION // AREAS IN CURRENT SWITZERLAND

Zürich

Z01: Residential house “Sihlgarten”, Zürich, Talacker 39,
arch.: H. C. Stadler
(front elevation, openings)

Z02: Summer house “Muraltengut”, Zürich, Seestraße 203,
arch.: J. Werdmüller
(front elevation, openings)

Wallis

W01: House Pancrace de Courten, Sierre, Rue du Bourg 30,
arch.: -
(front elevation, openings)

Fribourg

F01: Castle Middes (or Castel Griset de Forel), Torny,
arch.: J. P. Nader
(front and side elevation, openings)

F02: Castle “Bonnes Fontaines à M.F. de Weck”,
arch.: -
(front elevation, openings)

Graubünden

G01: Palais Donatz, Sils im Domleschg,
arch.: -
(front and side elevation, openings)

intentionally omitted

Fig. P.22 Geometrical analysis of front elevation: (Z01) Residential house "Sihlgarten", Zürich, Talacker 39

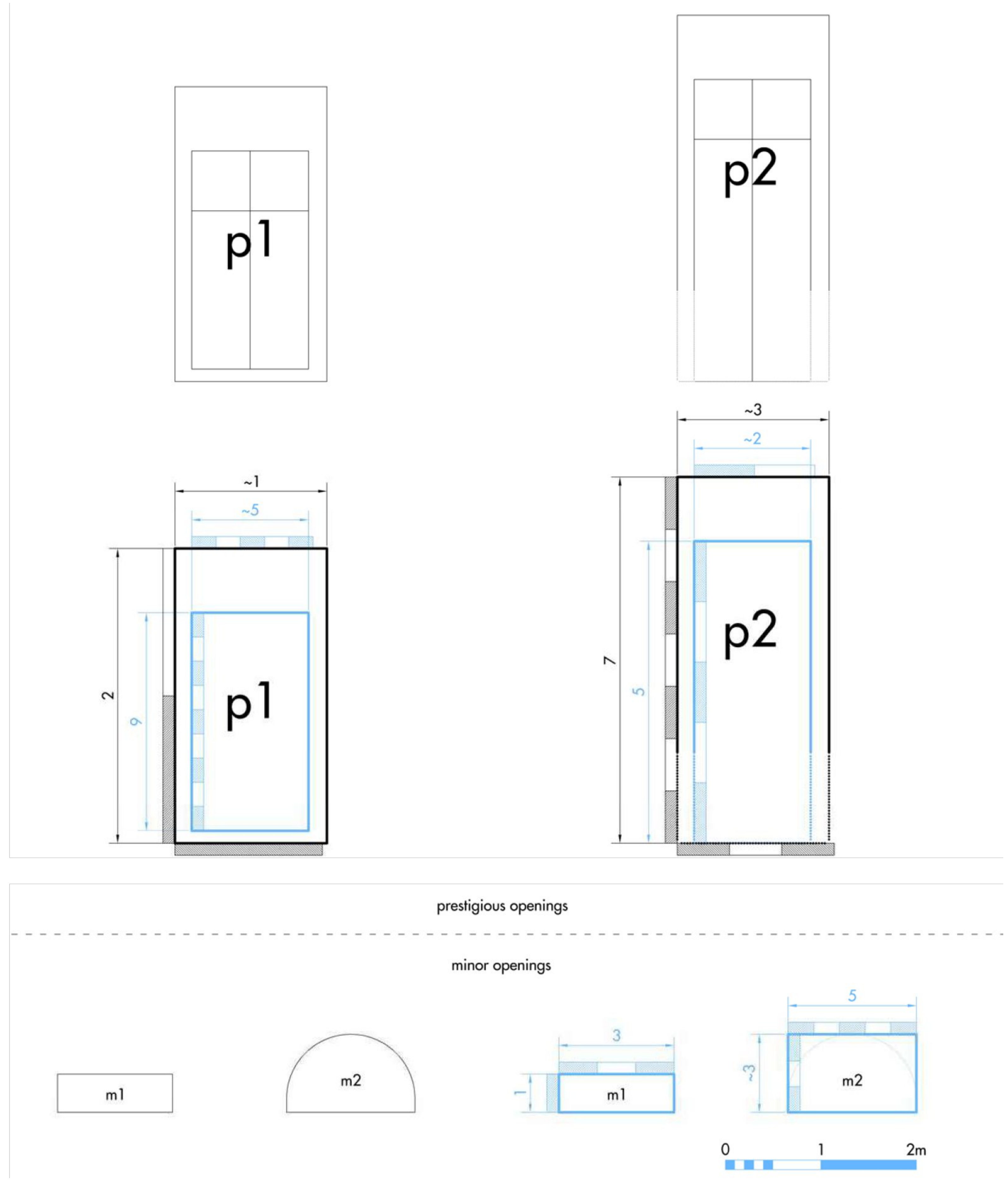


Fig. P.23 Geometrical analysis of openings: (Z01) Residential house "Sihlgarten", Zürich, Talacker 39

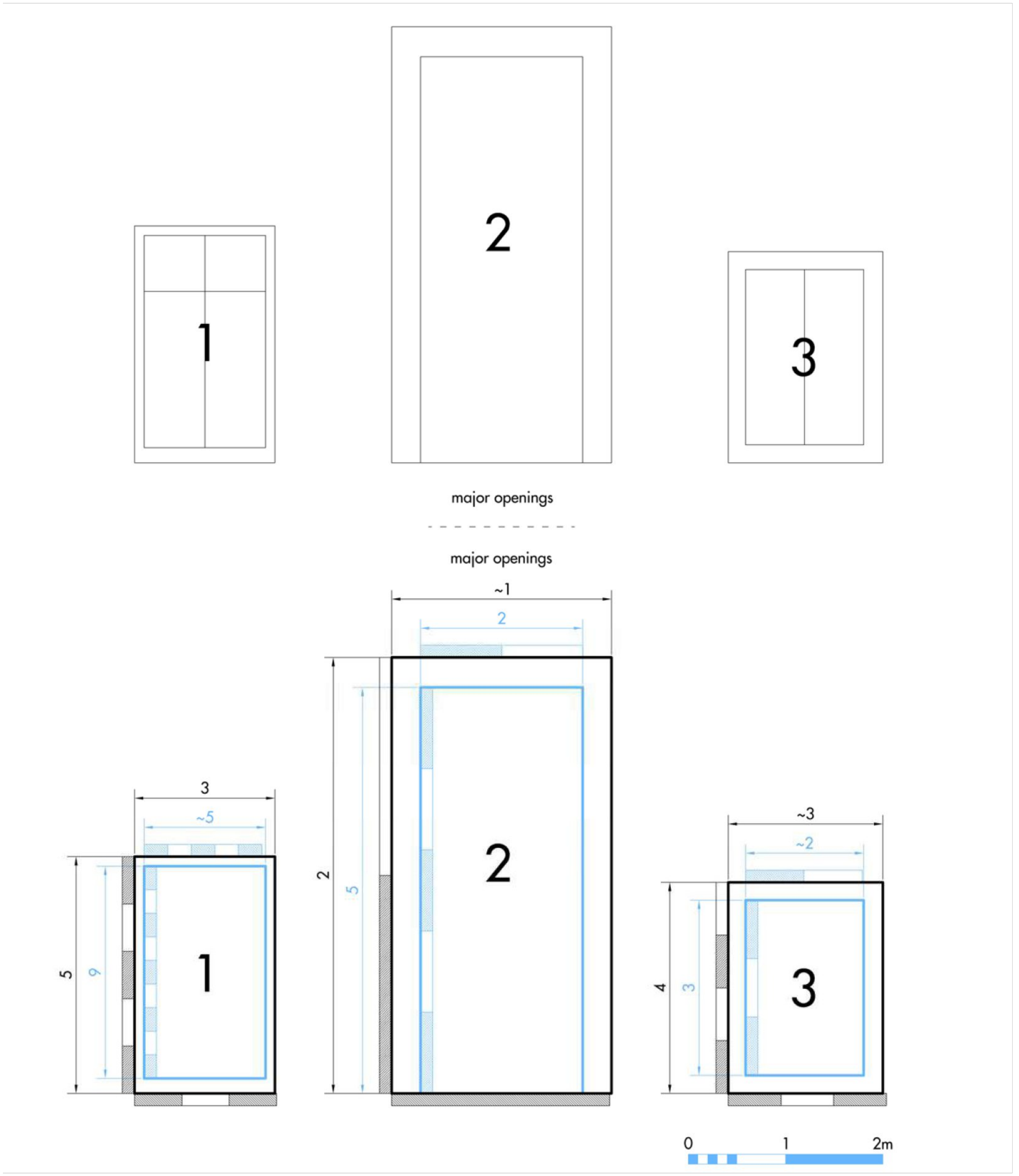


Fig. P.24 Geometrical analysis of openings: (Z01) Residential house "Sihlgarten", Zürich, Talacker 39

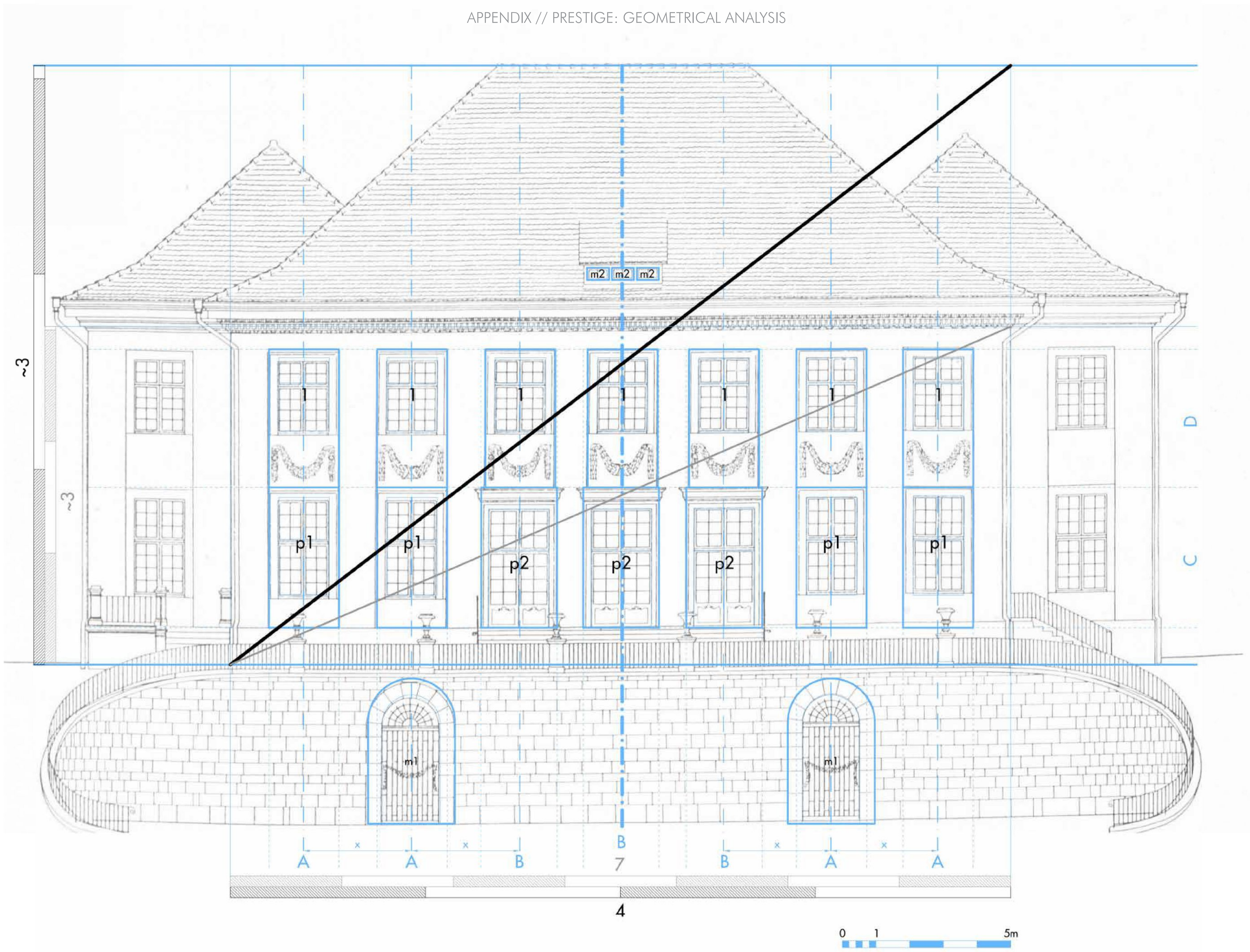


Fig. P.25 Geometrical analysis of front elevation: (Z02) Summer house "Muraltengut", Zürich, Seestraße 203

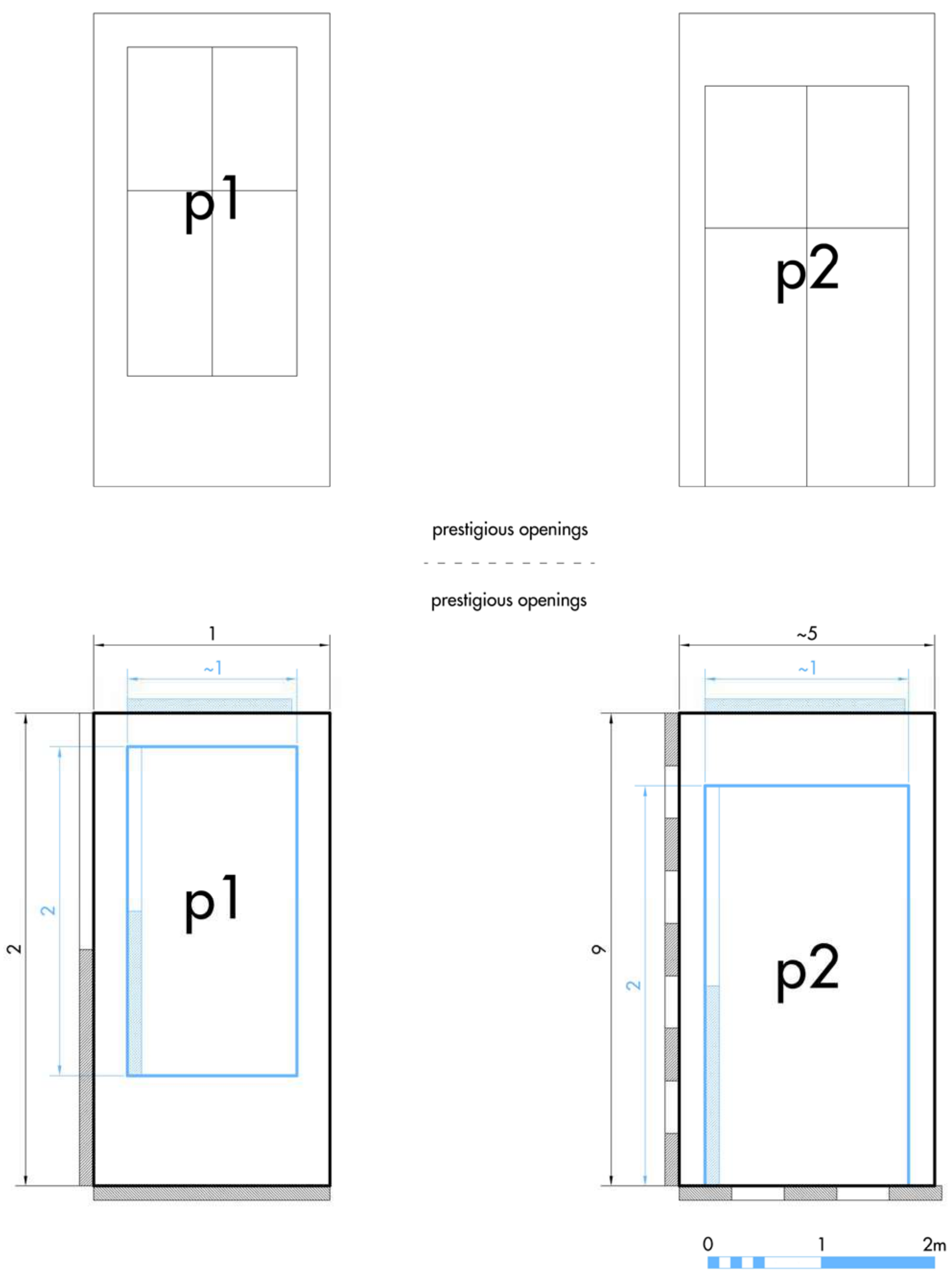


Fig. P.26 Geometrical analysis of openings: (Z02) Summer house "Muraltengut", Zürich, Seestraße 203

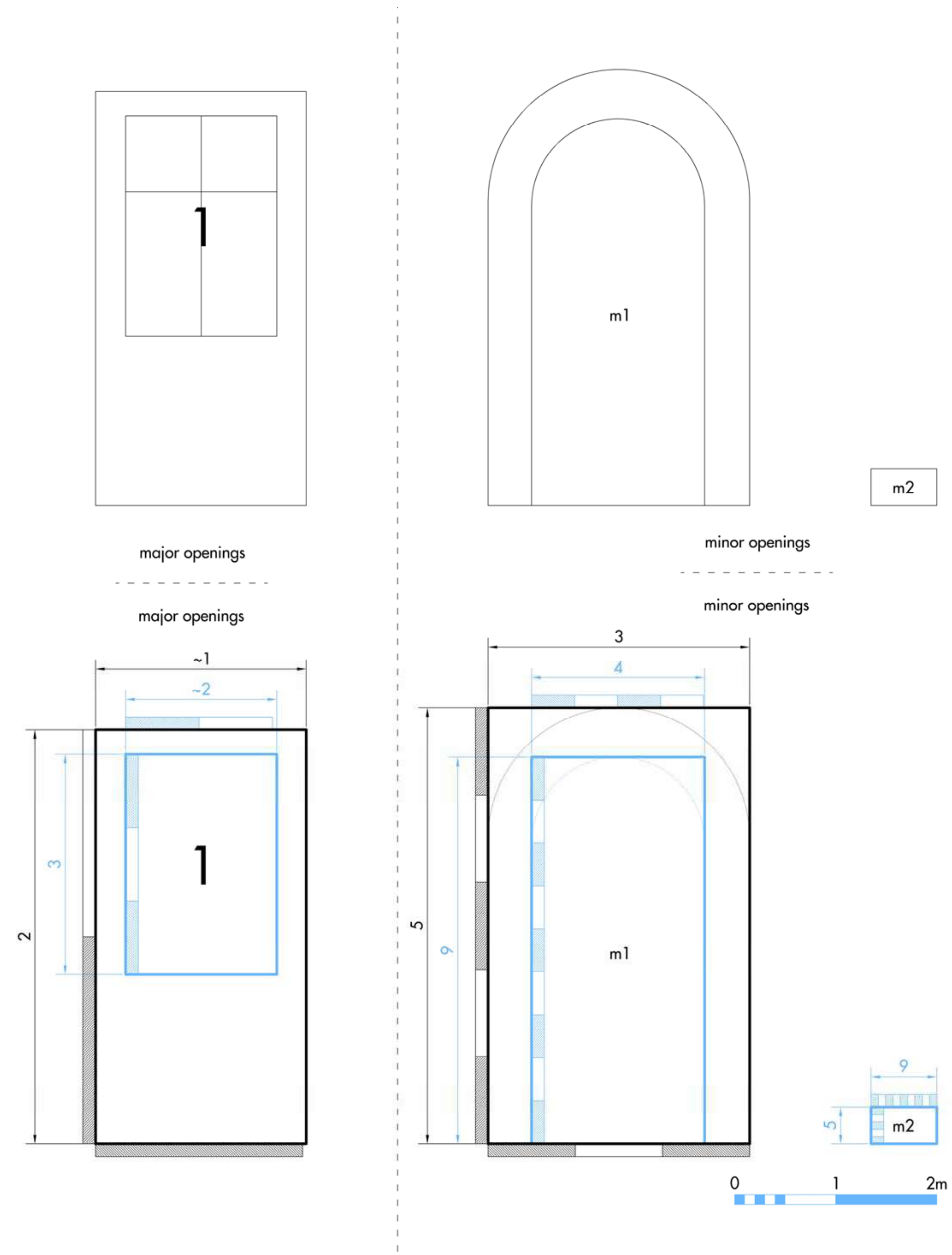


Fig. P.27 Geometrical analysis of openings: (Z02) Summer house "Muraltengut", Zürich, Seestraße 203

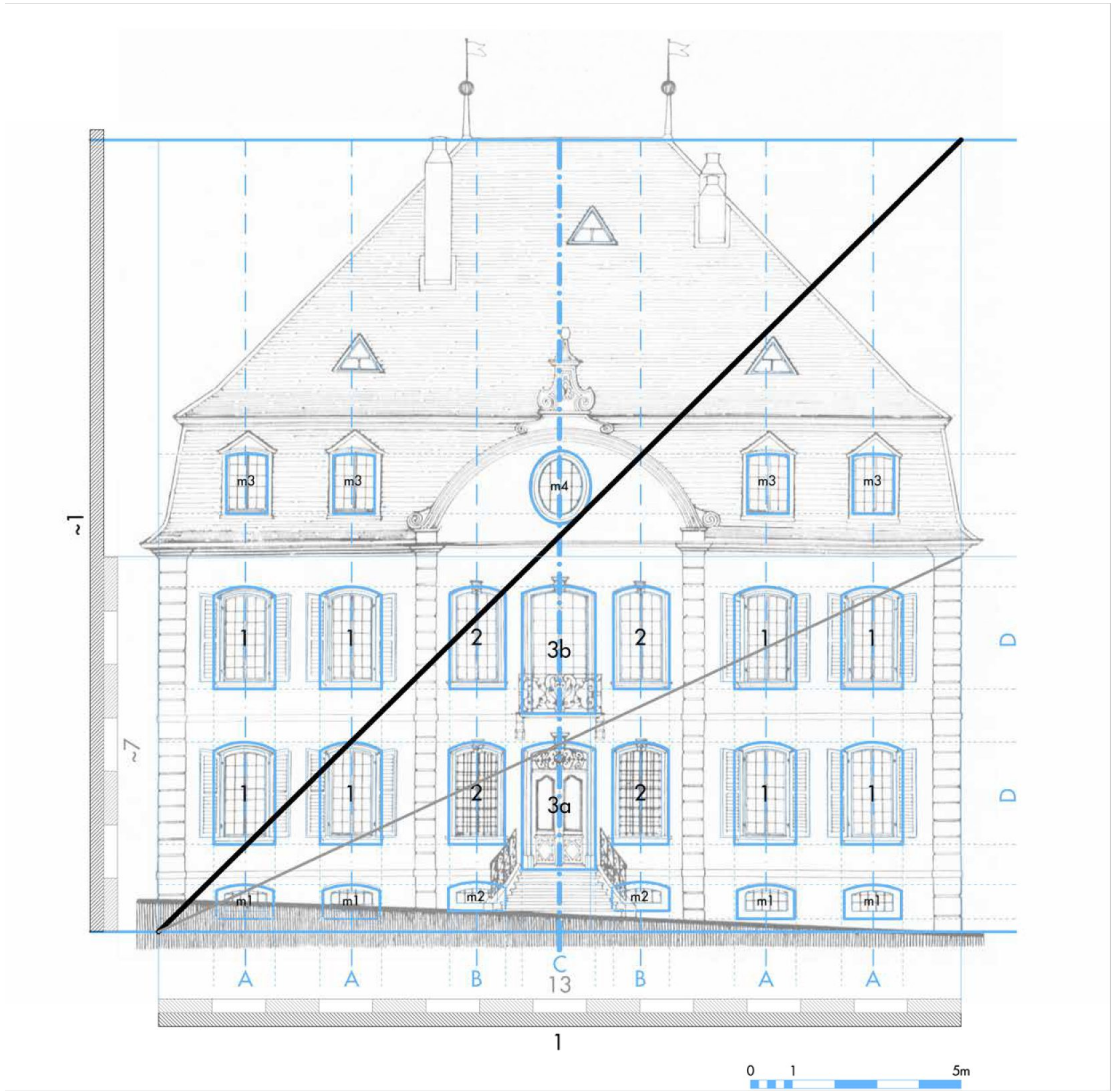


Fig. P.28 Geometrical analysis of front elevation: (W01) House Pancrace de Courten, Sierre, Rue du Bourg 30

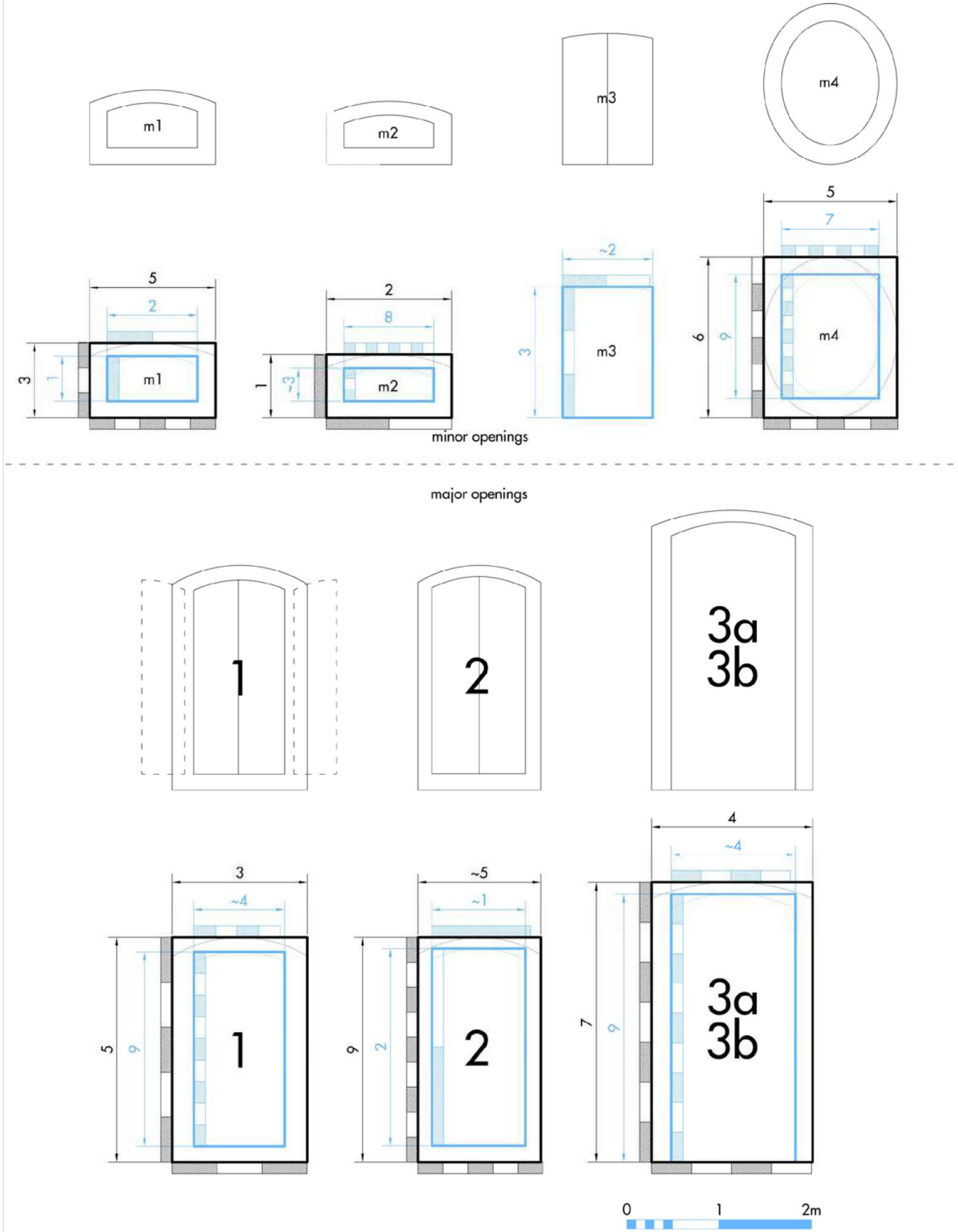


Fig. P.29 Geometrical analysis of openings: (W01) House Pancrace de Courten, Sierre, Rue du Bourg 30

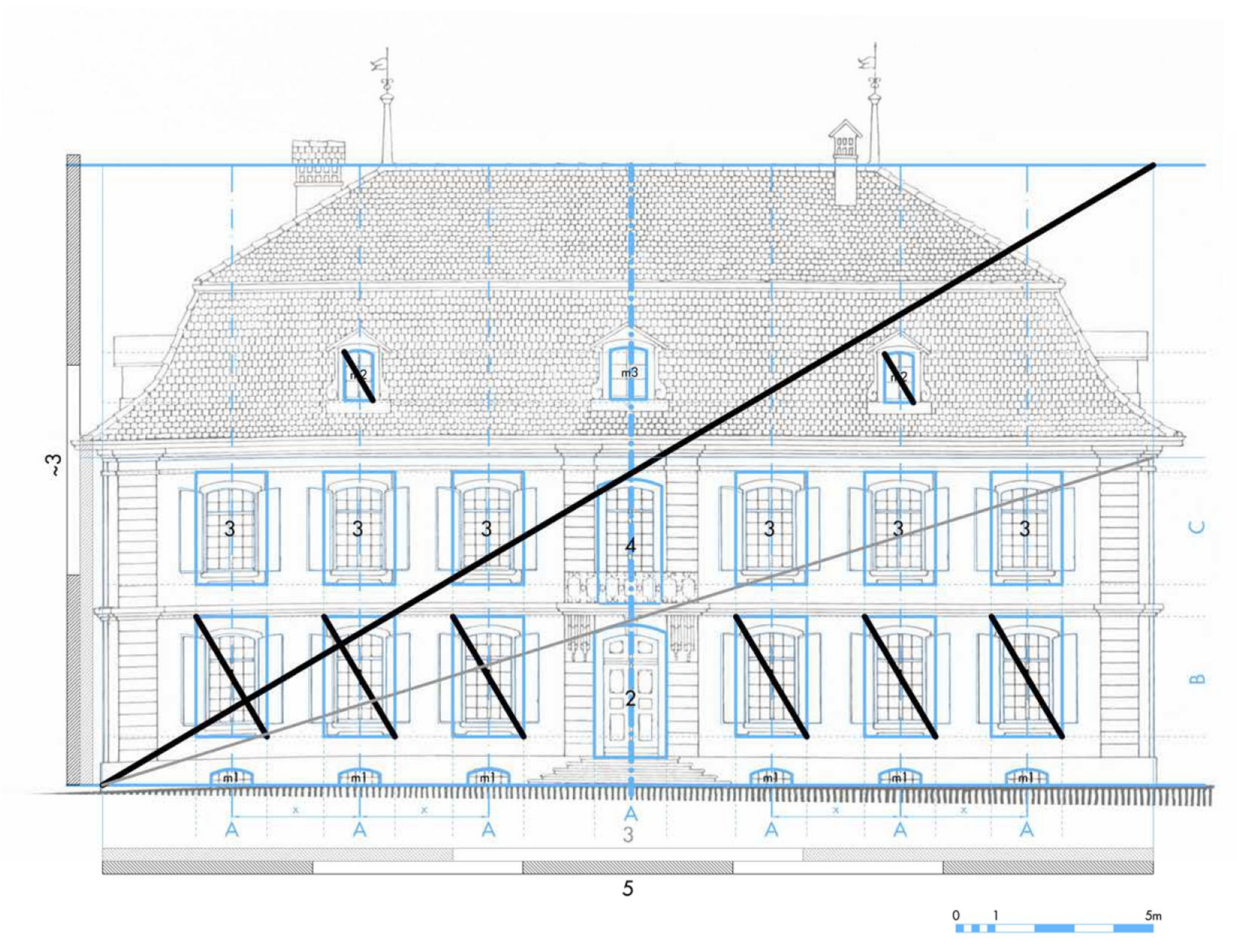


Fig. P.30 Geometrical analysis of front elevation: (F01) Castle Middes (or Castel Griset de Forel), Torny

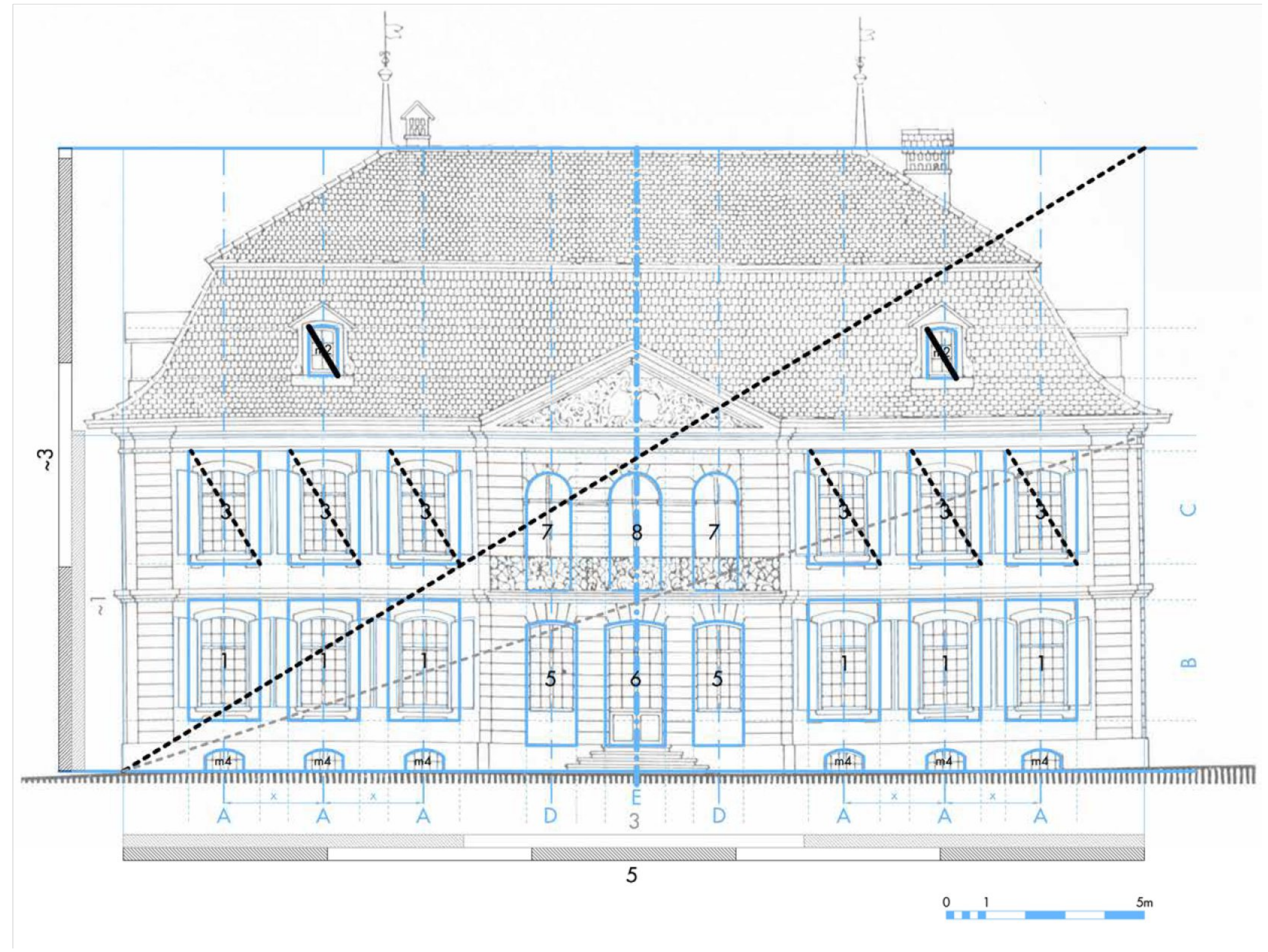


Fig. P.31 Geometrical analysis of side elevation: (F01) Castle Middes (or Castel Griset de Forel), Torny

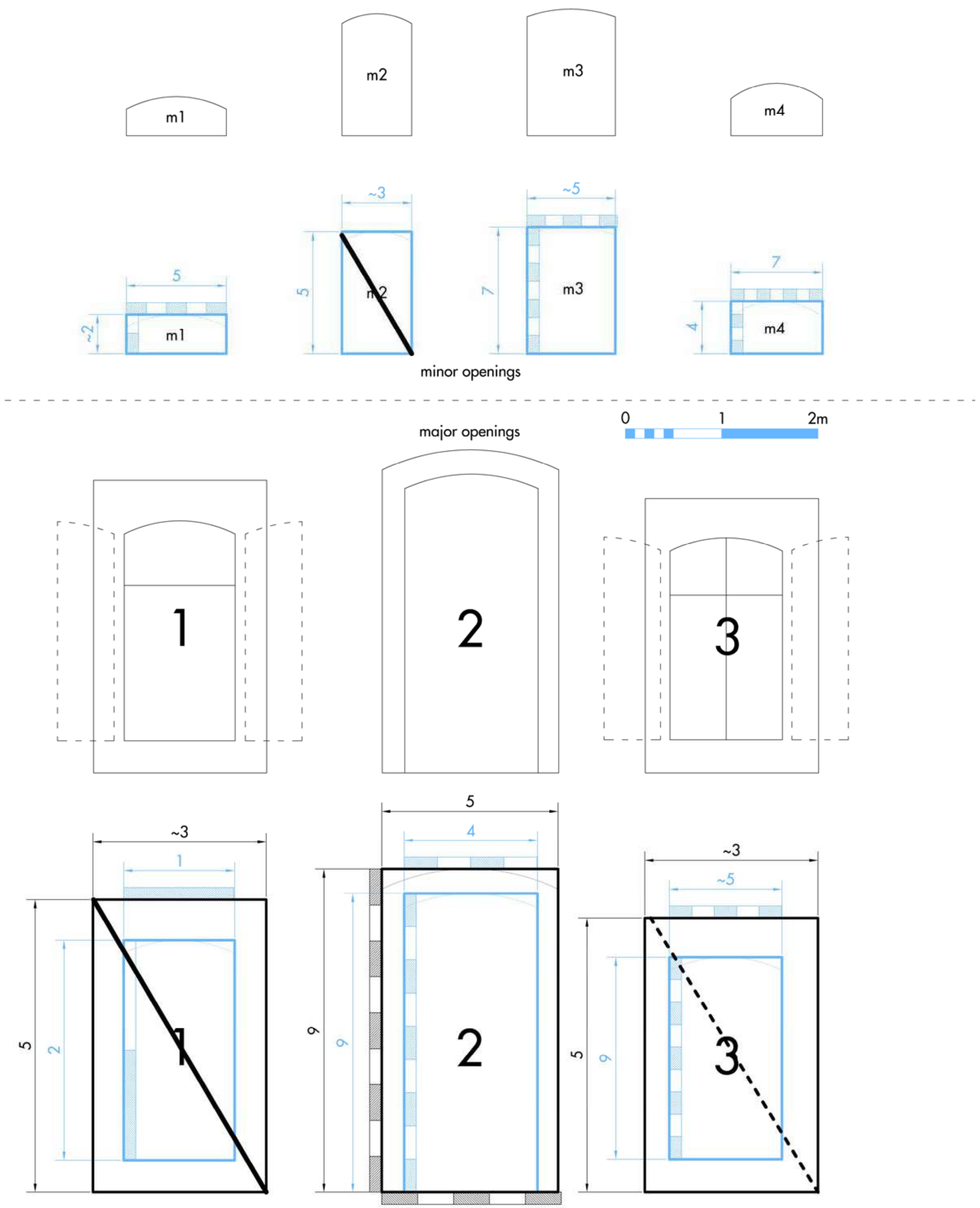


Fig. P.32 Geometrical analysis of openings: (F01) Castle Middes (or Castel Griset de Forel), Torny

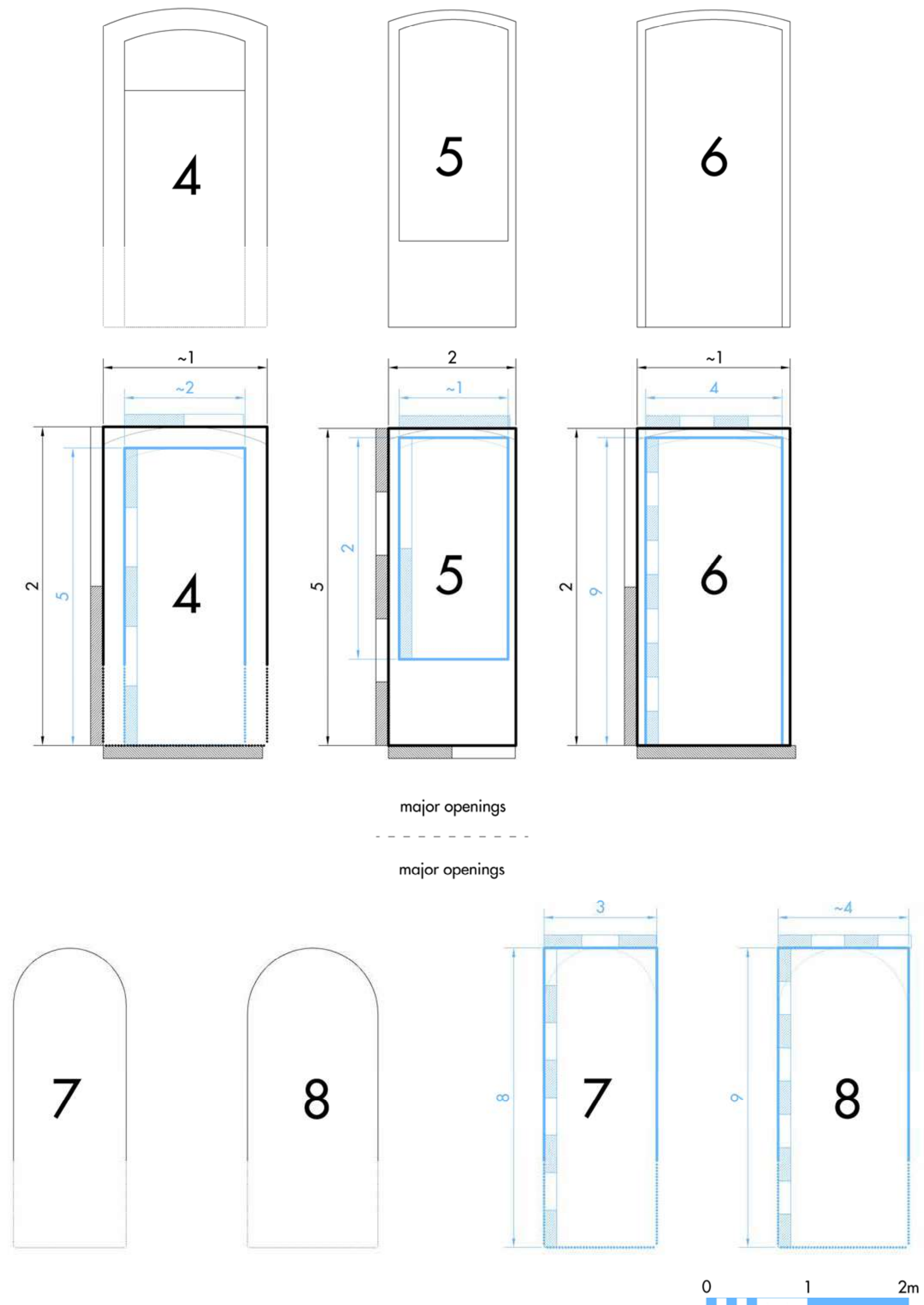


Fig. P.33 Geometrical analysis of openings: (F01) Castle Middes (or Castel Griset de Forel), Torny

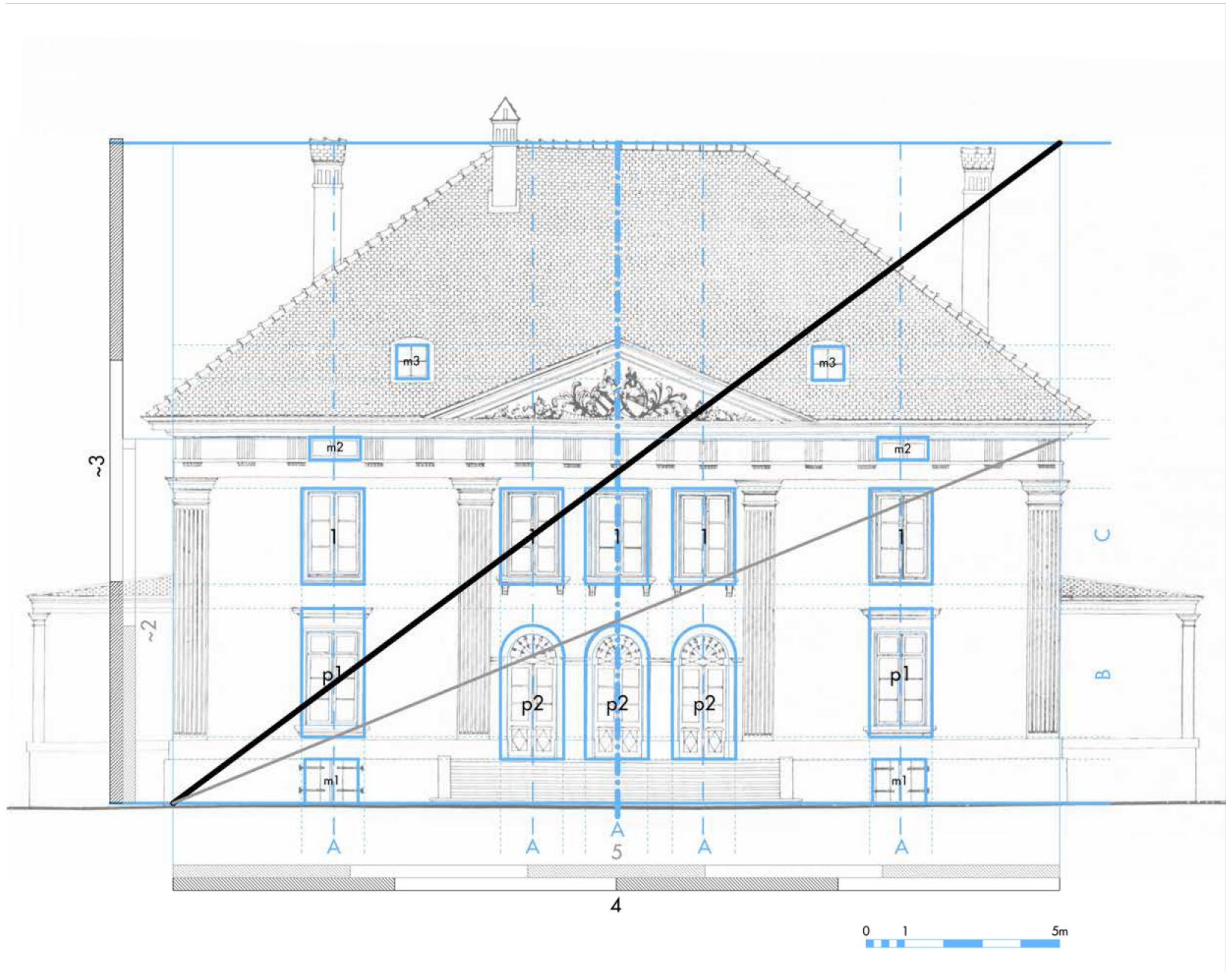


Fig. P.34 Geometrical analysis of front elevation: (F02) Castle "Bonnes Fontaines à M.F. de Weck"

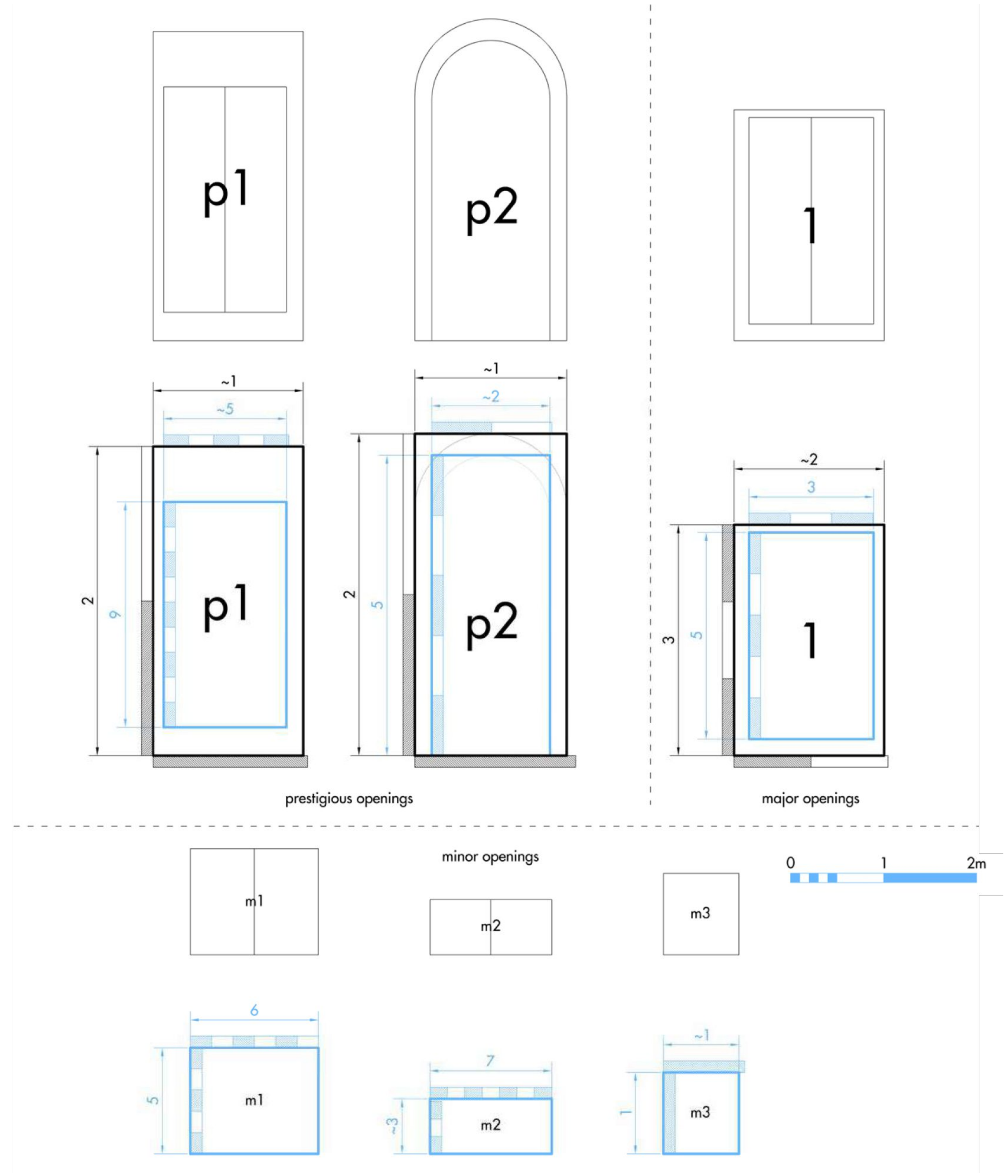


Fig. P.35 Geometrical analysis of openings: (F02) Castle "Bonnes Fontaines à M.F. de Weck"

Fig. P.36 Geometrical analysis of front elevation: (G01) Palais Donatz, Sils im Domleschg

Fig. P.37 Geometrical analysis of side elevation: (G01) Palais Donatz, Sils im Domleschg

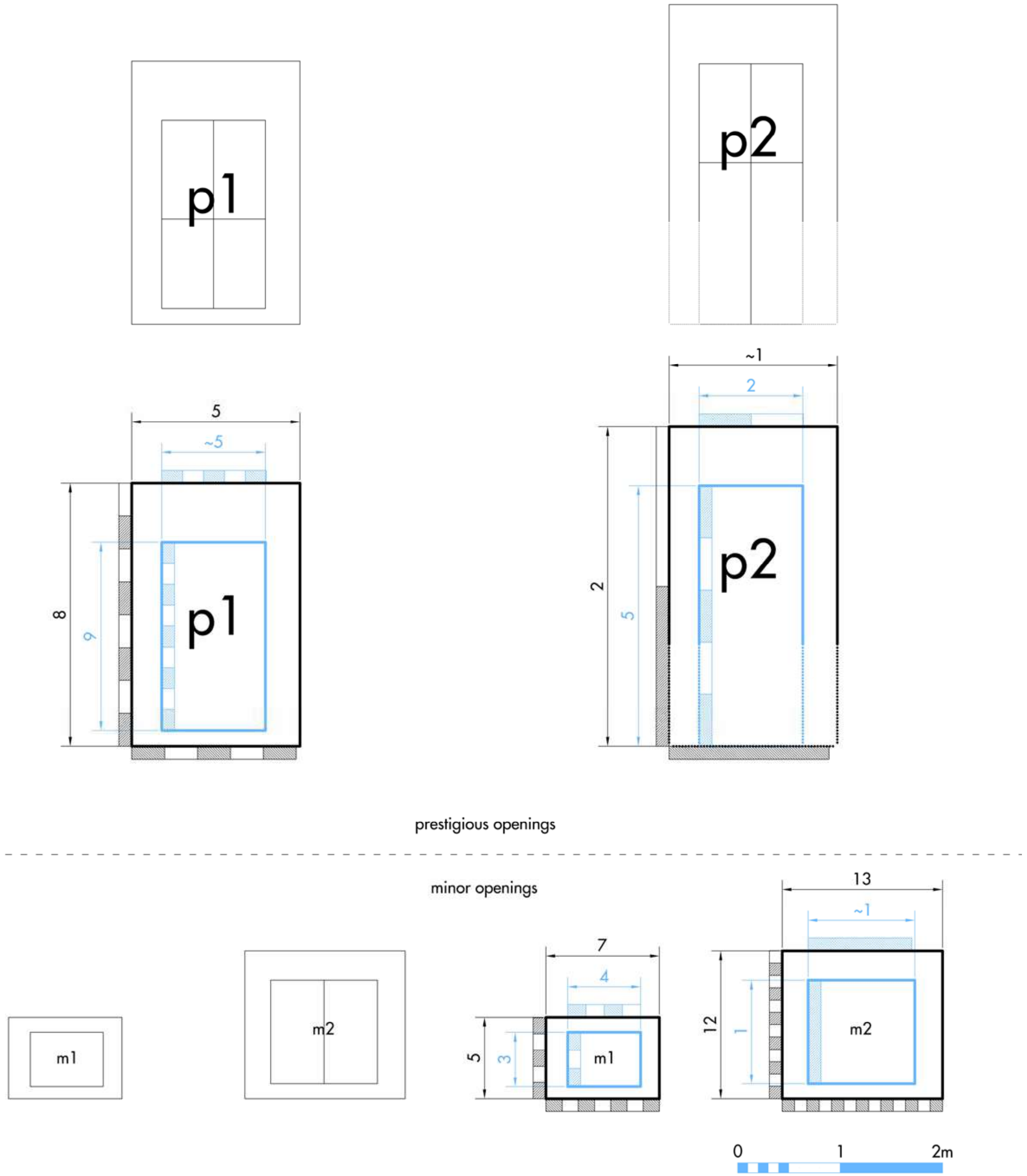


Fig. P.38 Geometrical analysis of openings: (G01) Palais Donatz, Sils im Domleschg

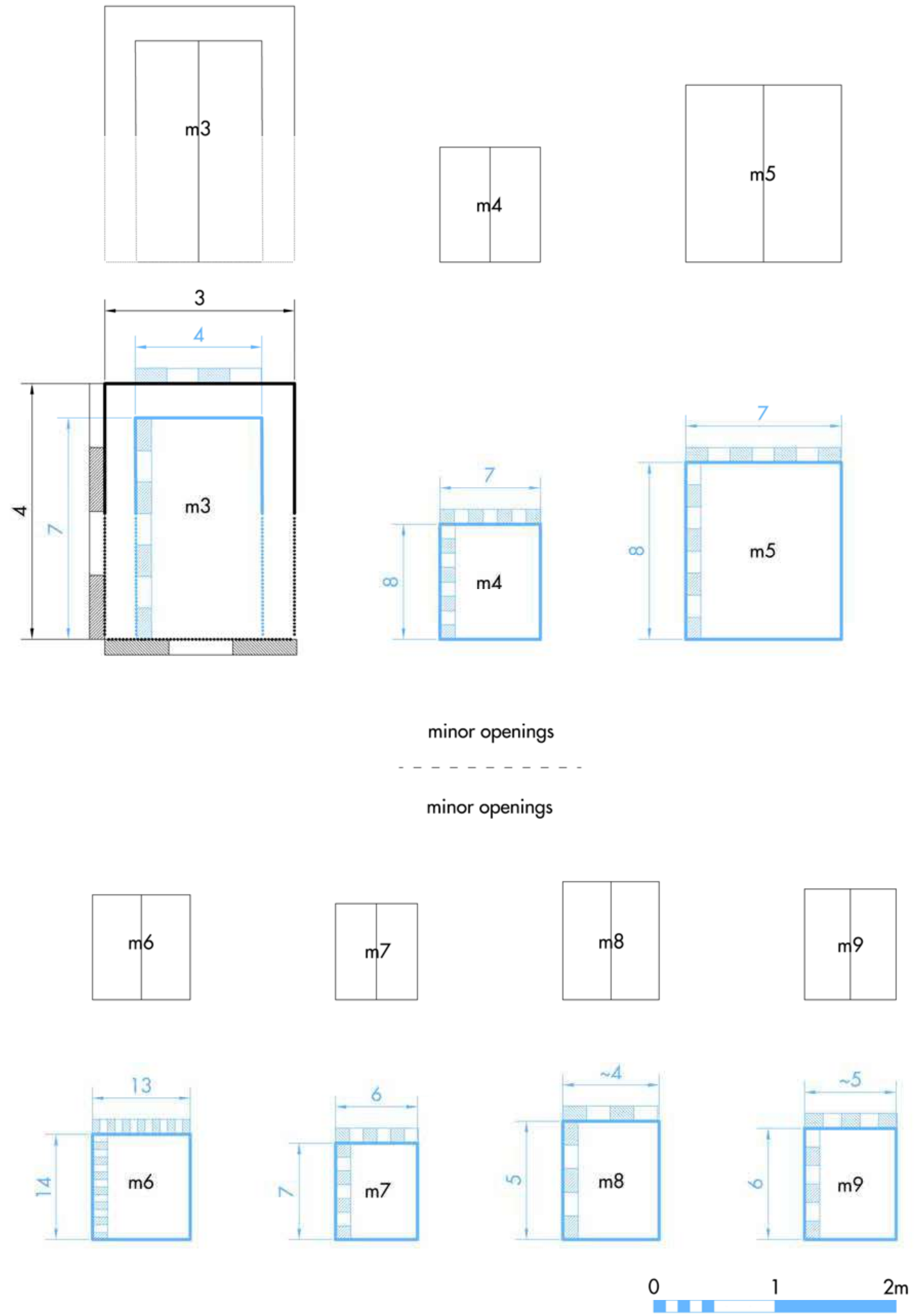


Fig. P.39 Geometrical analysis of openings: (G01) Palais Donatz, Sils im Domleschg

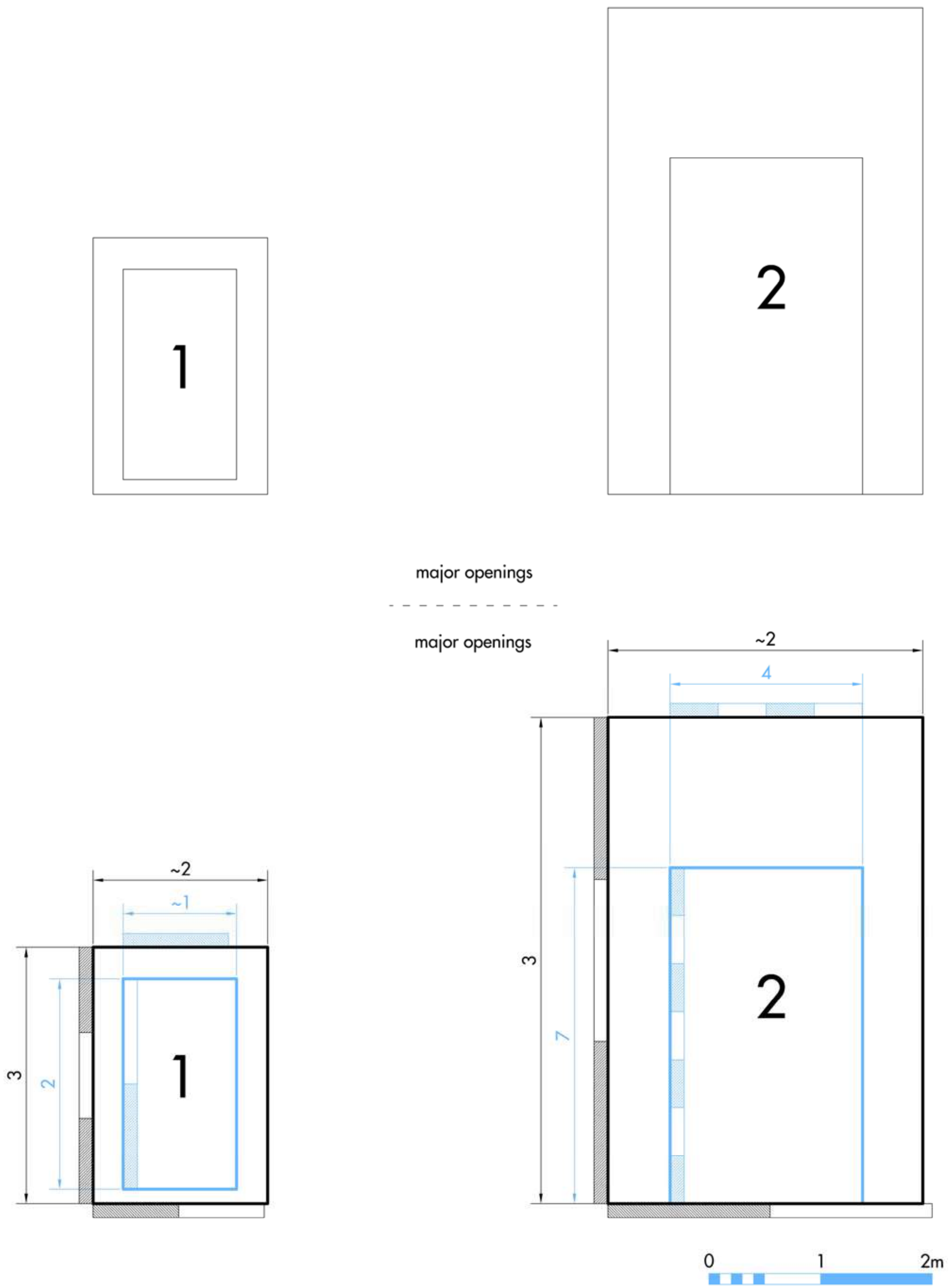


Fig. P.40 Geometrical analysis of openings: (G01) Palais Donatz, Sils im Domleschg

intentionally omitted

GERMANIC REGION // AREAS IN CURRENT AUSTRIA

Upper Austria

U01: Castle Traunsee-Württemberg
(before "Villa Maria Theresia"), Gmunden,
arch.: H. Adam
(front and side elevation, openings)

U02: Summerhouse, am Traunsee,
arch.: Th. Hansen
(front and side elevation, openings)

U03: Summerhouse, am Traunsee,
arch.: H. Ferstel
(front and side elevation, openings)

U04: Villa Paulick, Seewalchen am Attersee,
arch.: F. König, R. Feldscharek
(front and side elevation, openings)

Lower Austria

L01: Restoration of Castle Hernstein, Hernstein,
Berndorfer Straße 32,
arch.: Th. Hansen
(front and side elevation, openings)

L02: Summerhouse, Baden near Vienna,
arch.: L. Förster
(front and side elevation, openings)

intentionally omitted

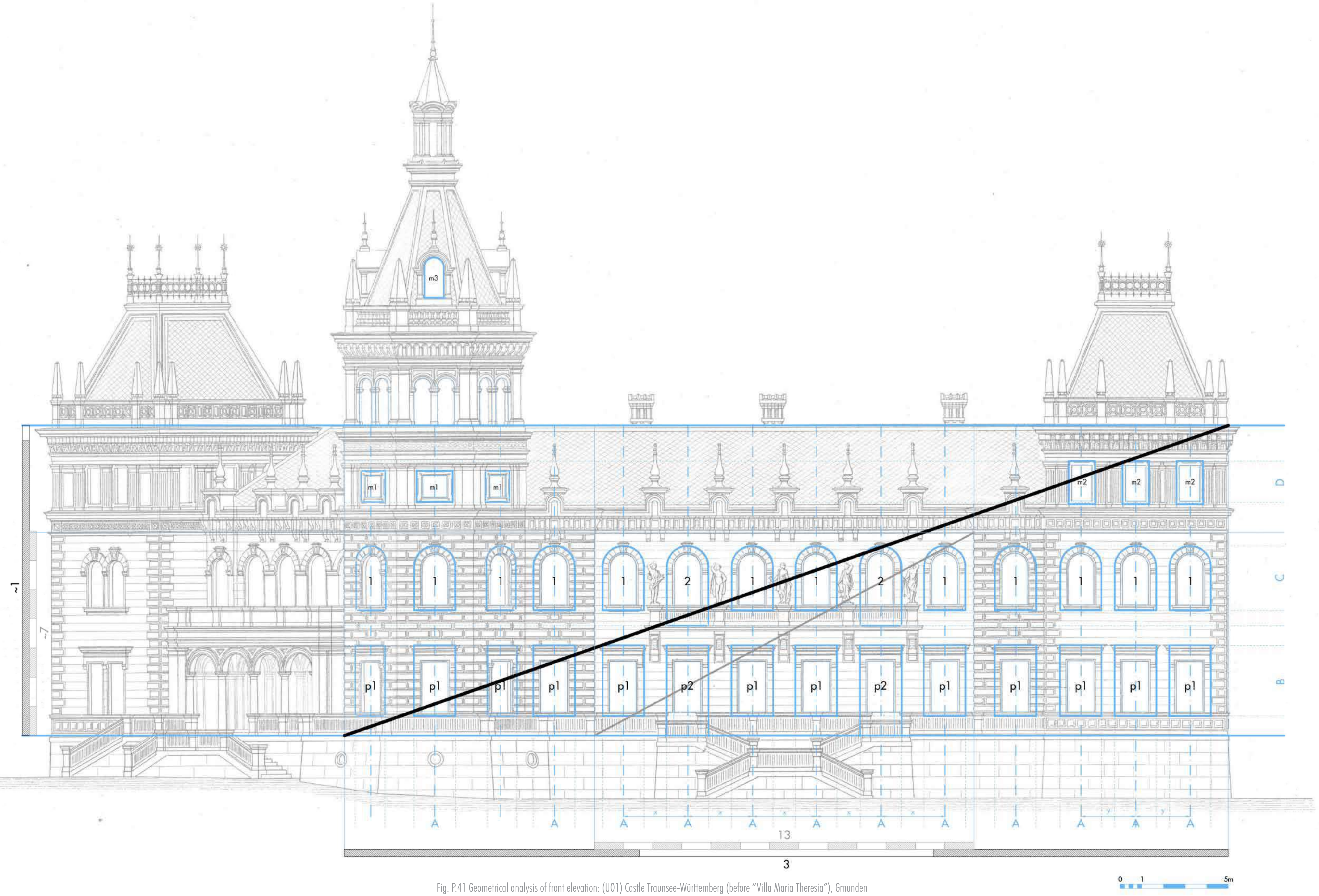


Fig. P.41 Geometrical analysis of front elevation: (U01) Castle Traunsee-Württemberg (before "Villa Maria Theresia"), Gmunden

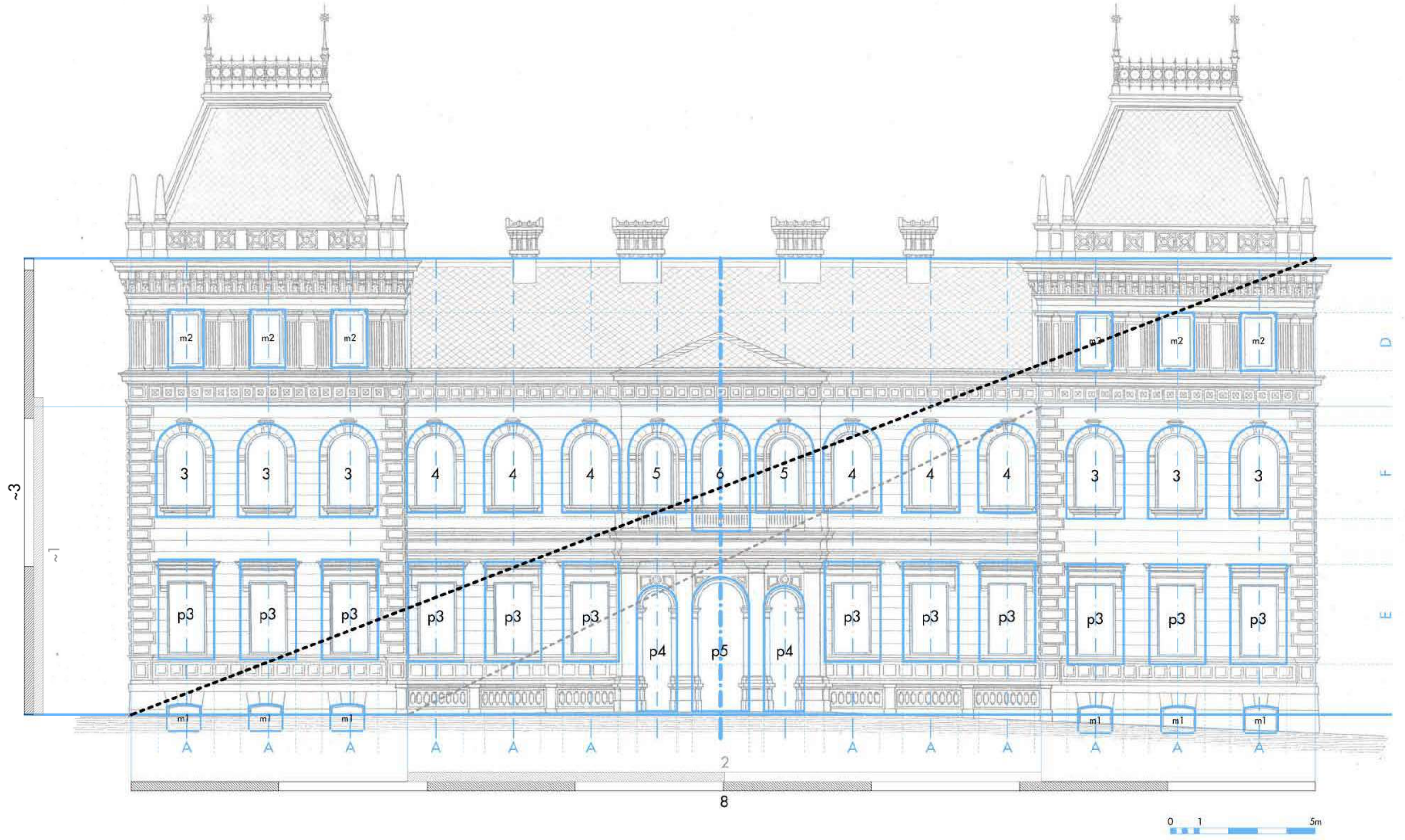


Fig. P.42 Geometrical analysis of side elevation: (U01) Castle Traunsee-Württemberg (before "Villa Maria Theresia"), Gmunden

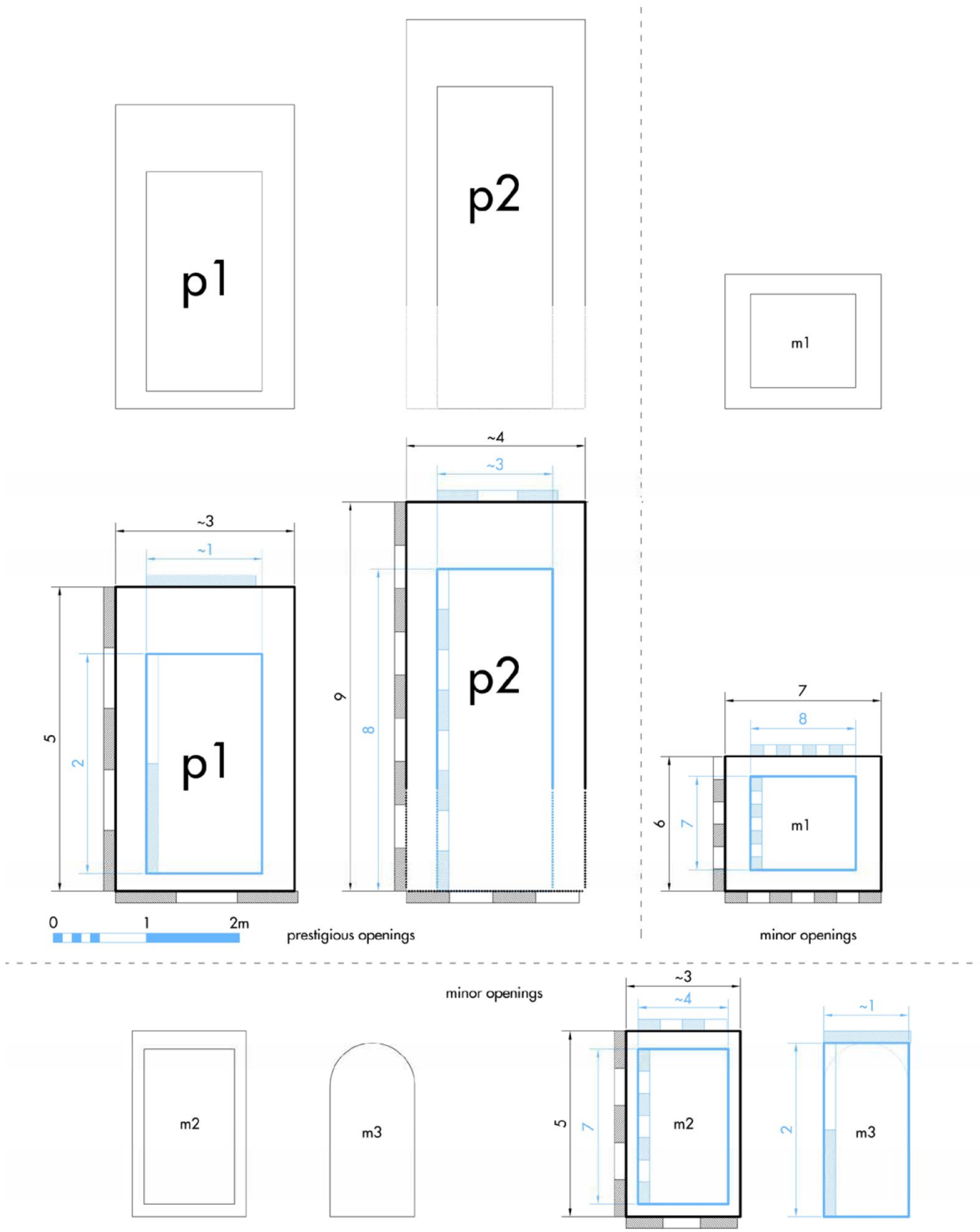


Fig. P.43 Geometrical analysis of openings: (U01) Castle Traunsee-Württemberg (before "Villa Maria Theresia"), Gmunden

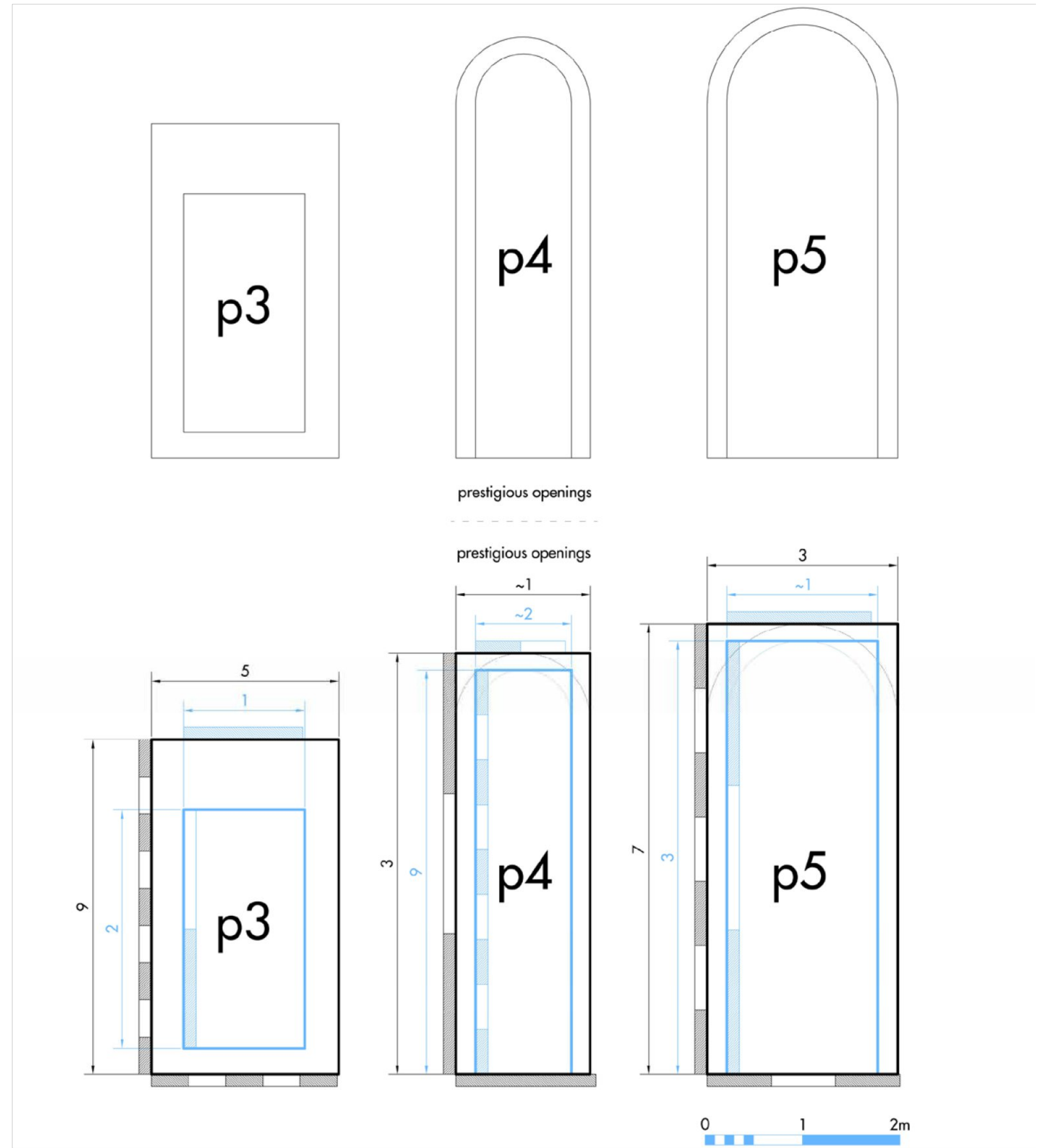


Fig. P.44 Geometrical analysis of openings: (U01) Castle Traunsee-Württemberg (before "Villa Maria Theresia"), Gmunden

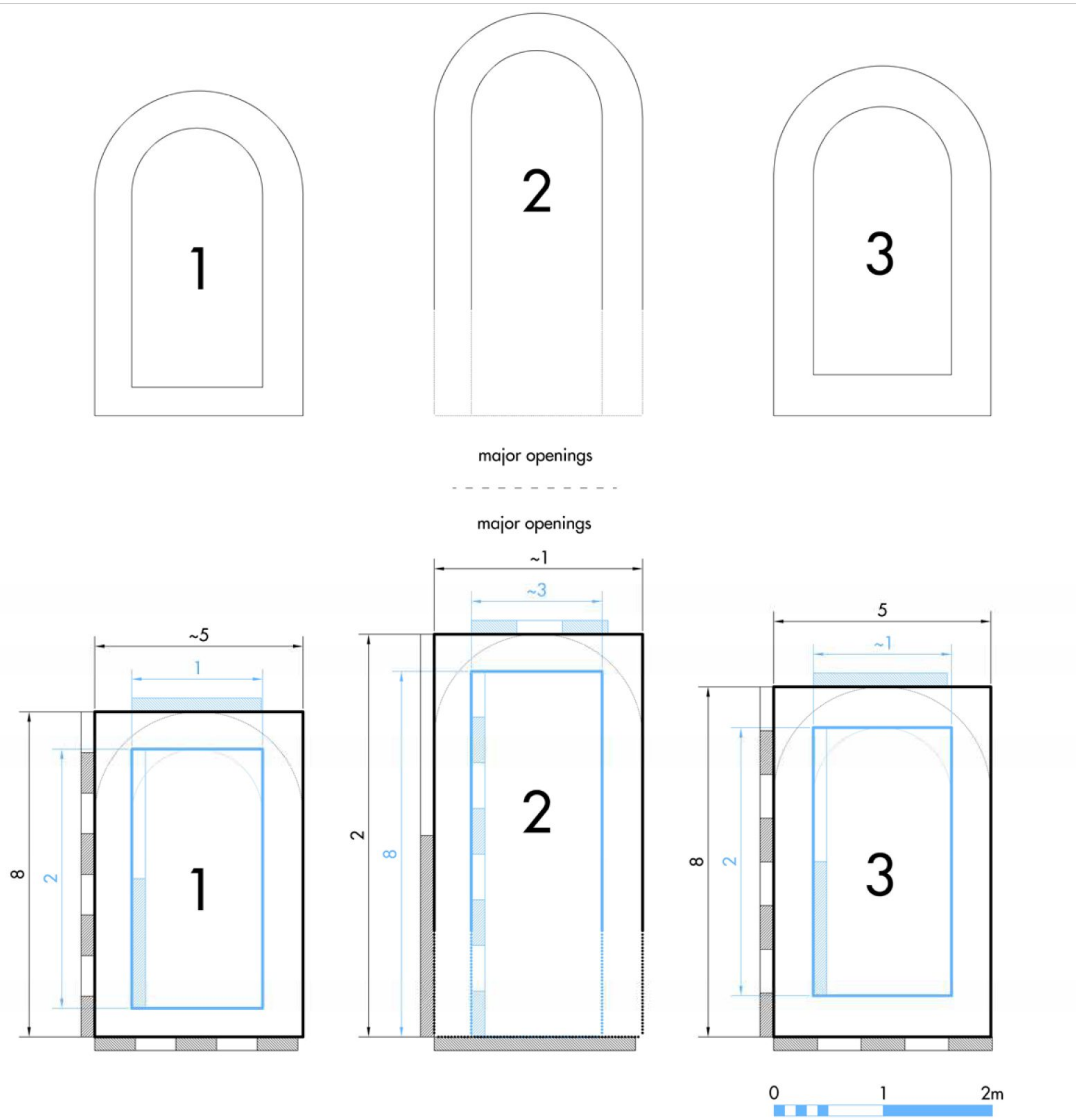


Fig. P.45 Geometrical analysis of openings: (U01) Castle Traunsee-Württemberg (before "Villa Maria Theresia"), Gmunden

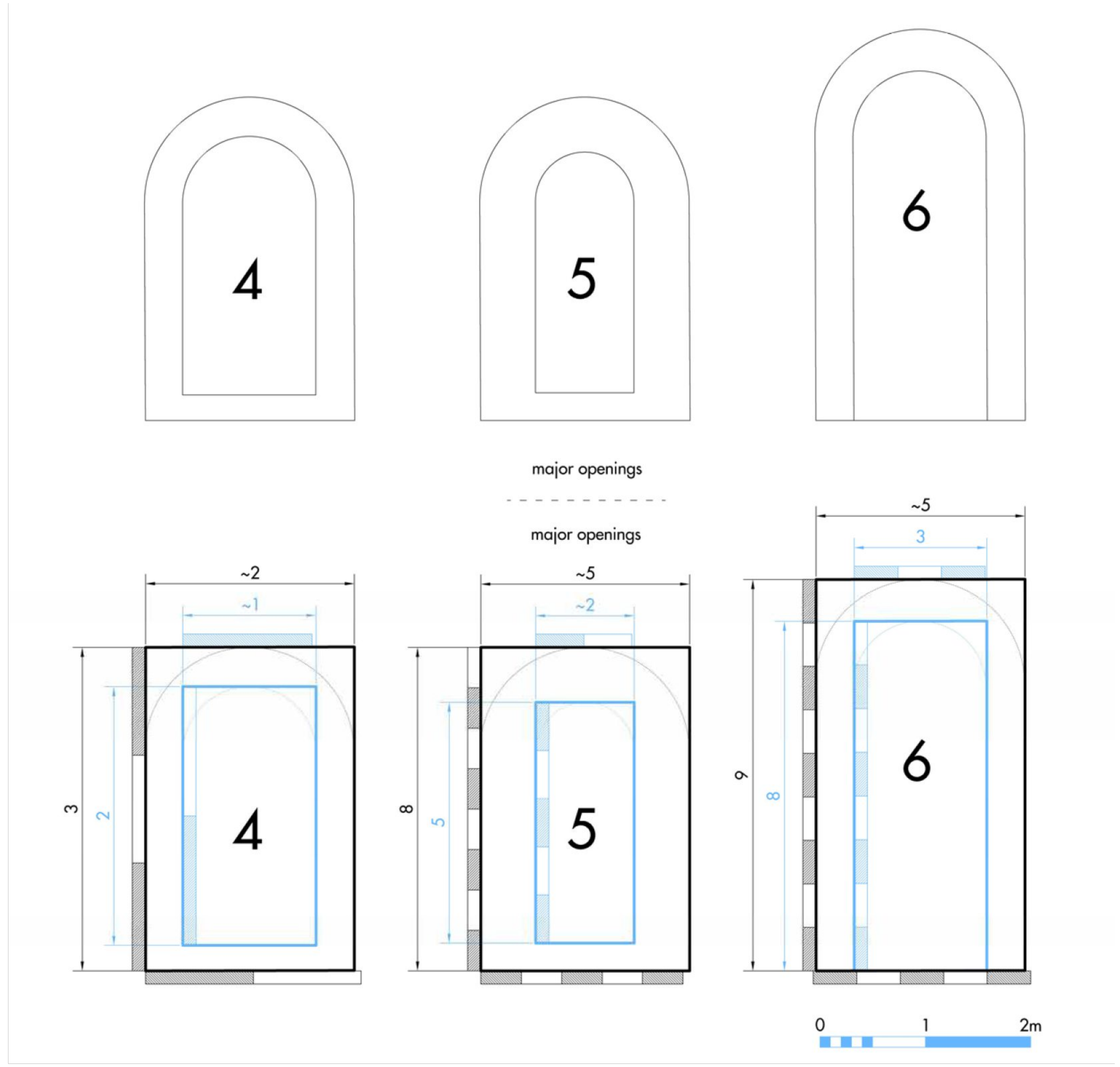


Fig. P.46 Geometrical analysis of openings: (U01) Castle Traunsee-Württemberg (before "Villa Maria Theresia"), Gmunden

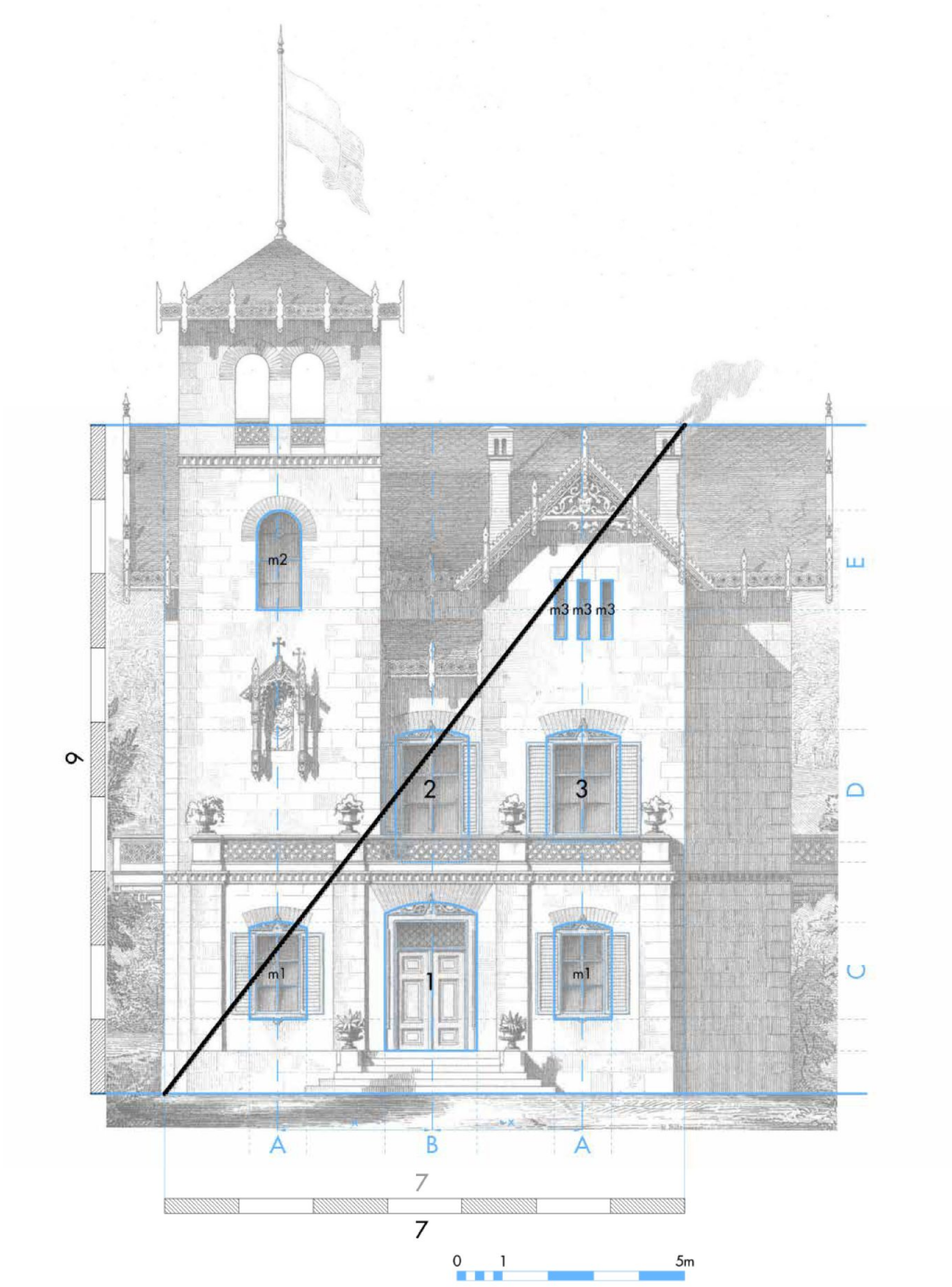


Fig. P.47 Geometrical analysis of front elevation: (U02) Summerhouse, am Traunsee

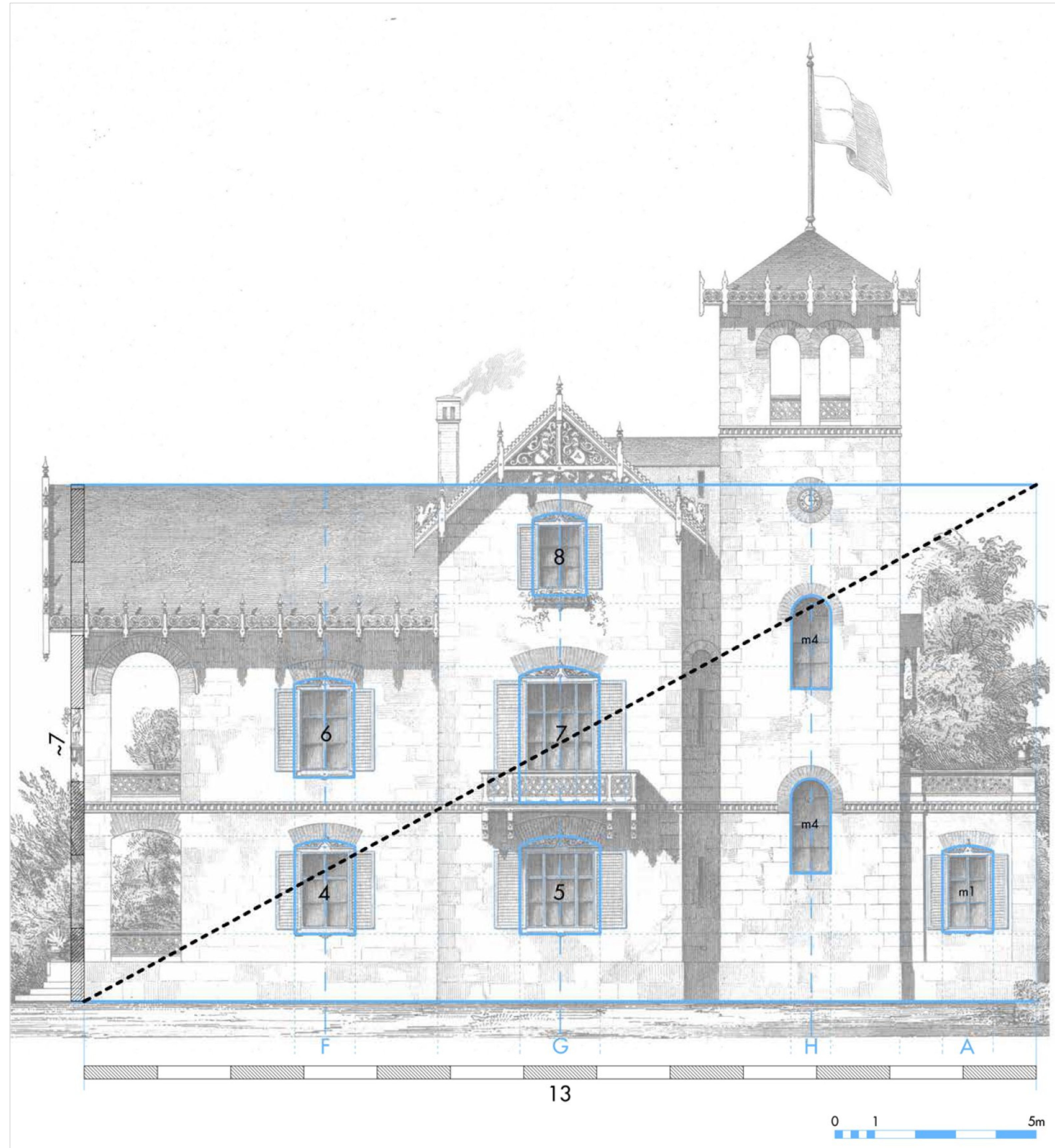


Fig. P.48 Geometrical analysis of side elevation: (U02) Summerhouse, am Traunsee

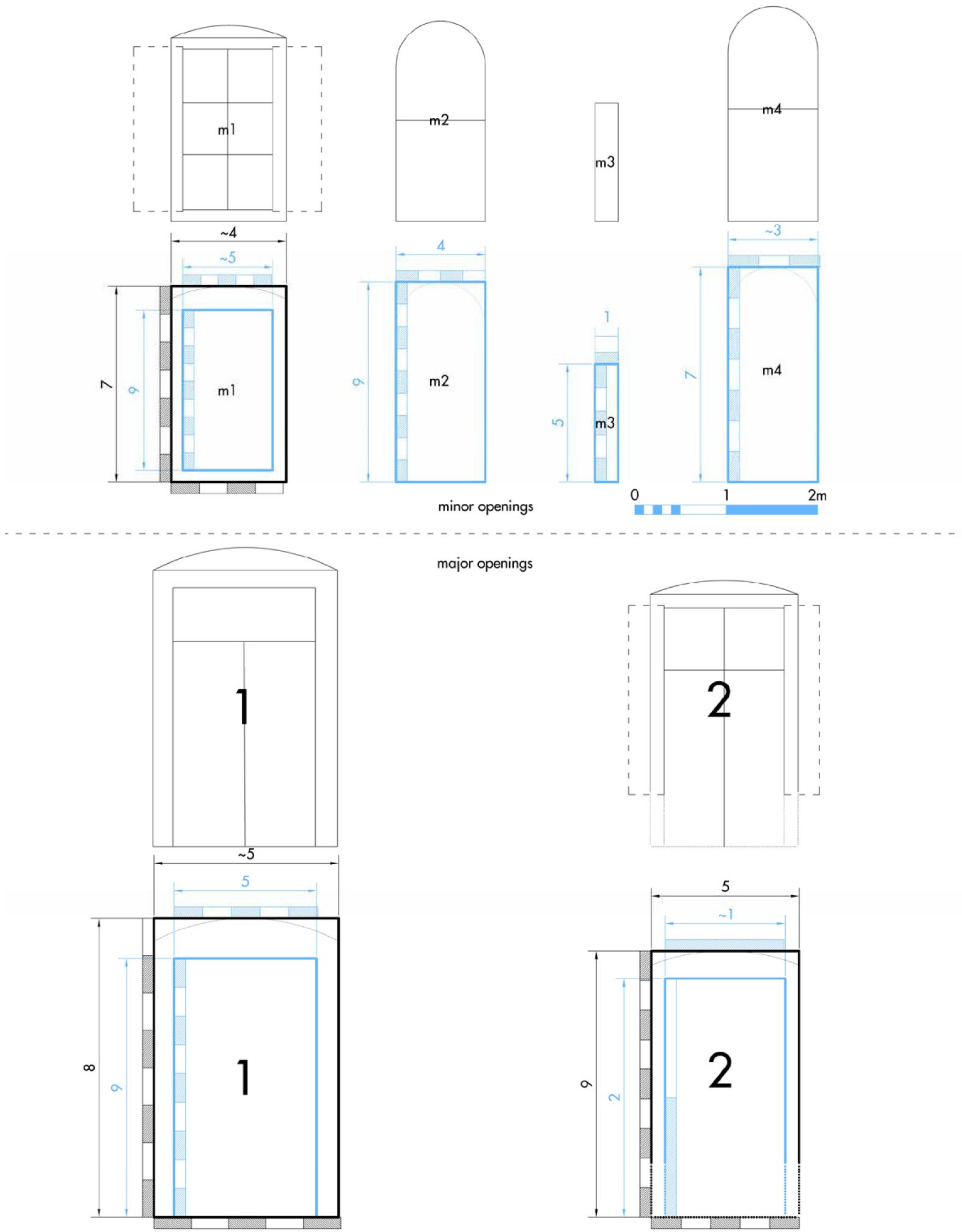


Fig. P.49 Geometrical analysis of openings: (U02) Summerhouse, am Traunsee

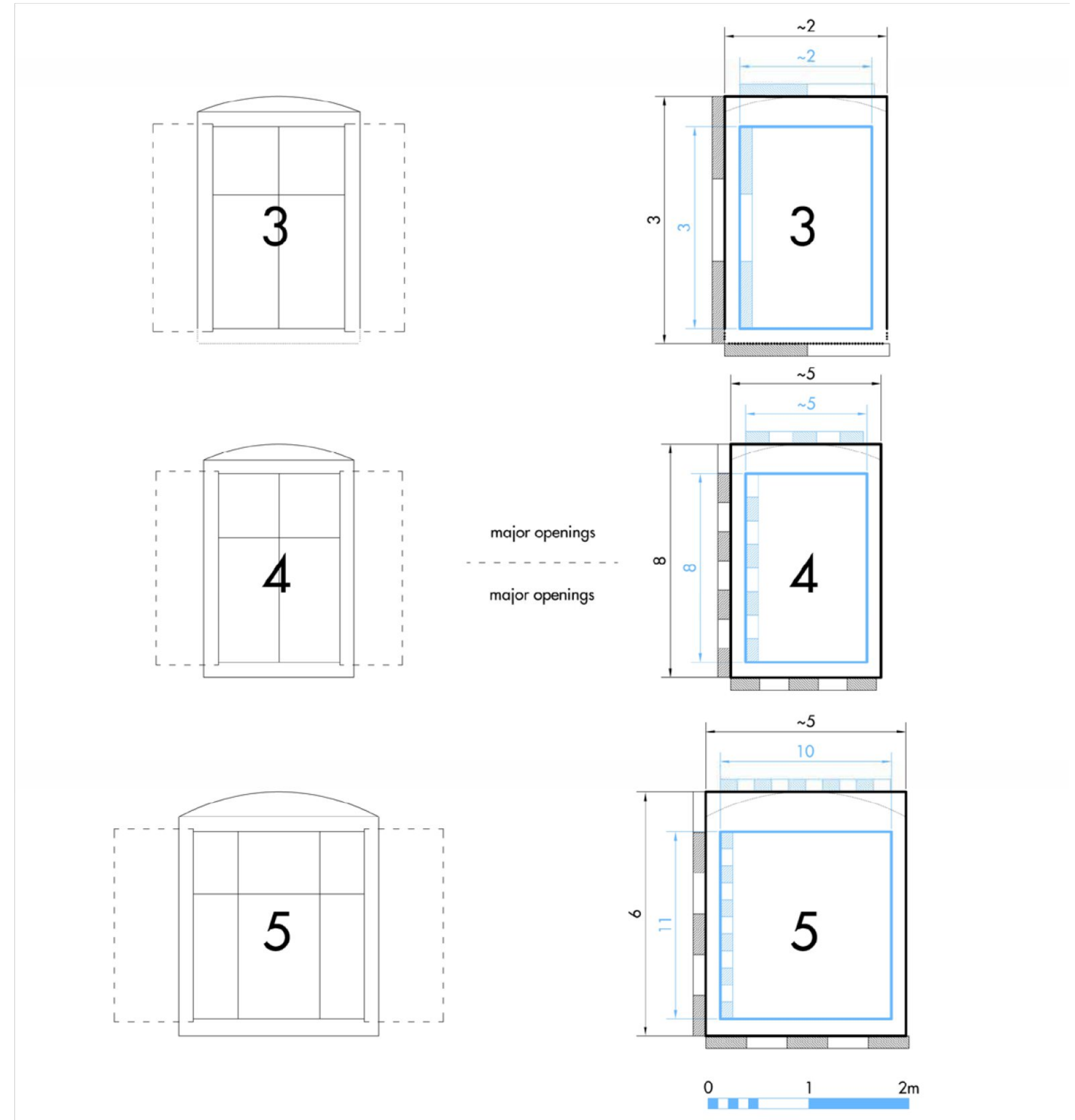


Fig. P.50 Geometrical analysis of openings: (U02) Summerhouse, am Traunsee

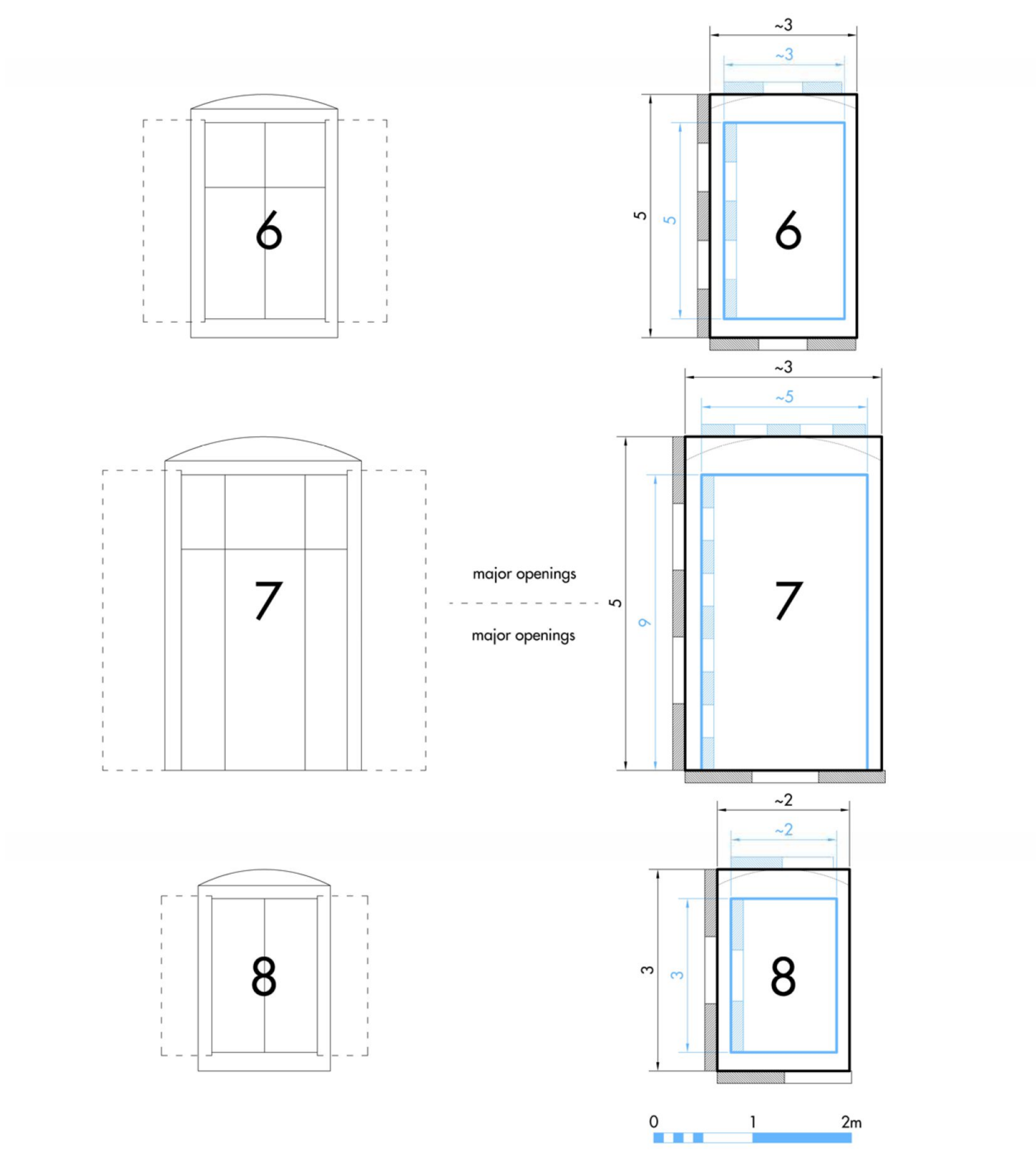


Fig. P.51 Geometrical analysis of openings: (U02) Summerhouse, am Traunsee

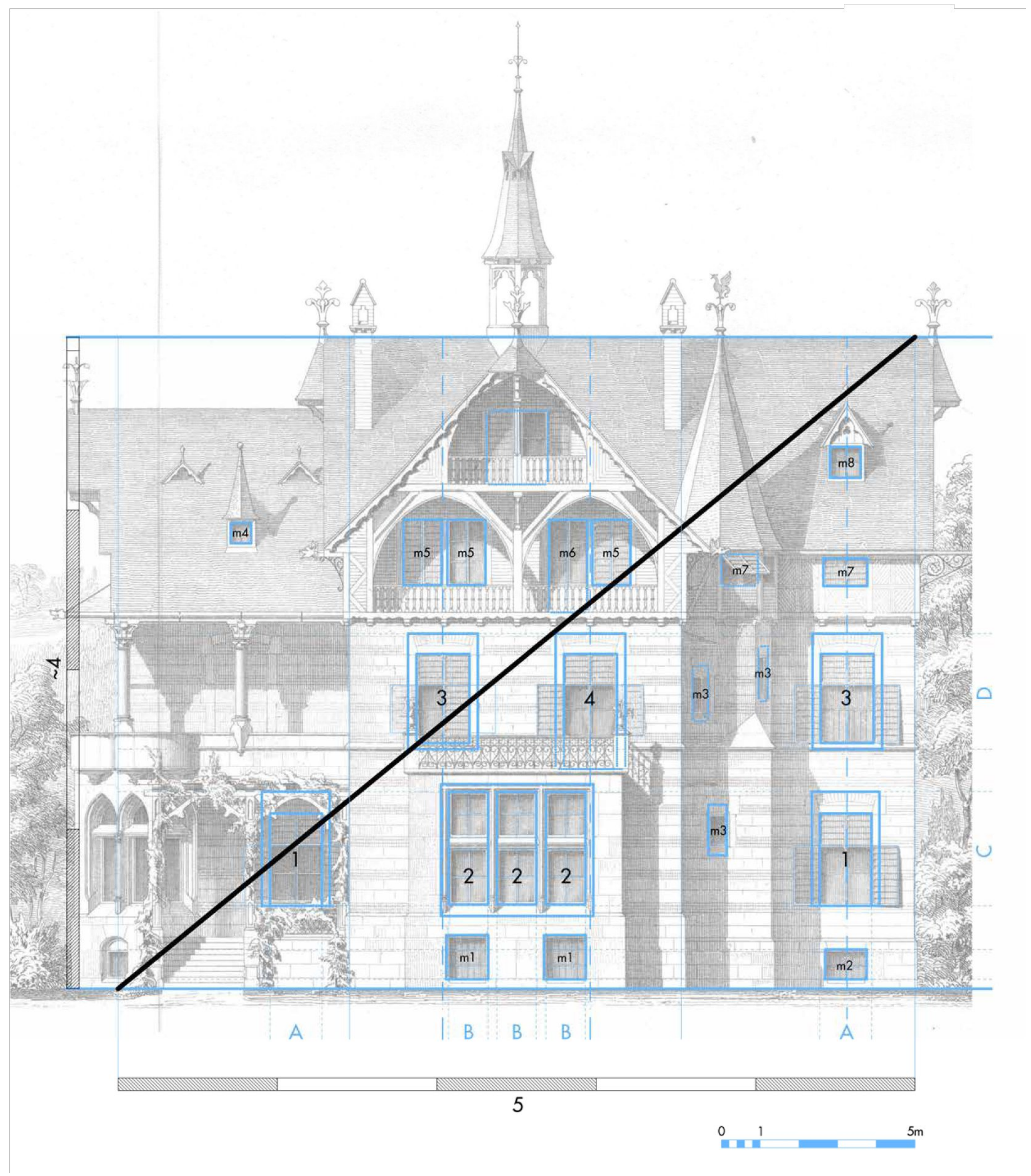


Fig. P.52 Geometrical analysis of front elevation: (U03) Summerhouse, am Traunsee

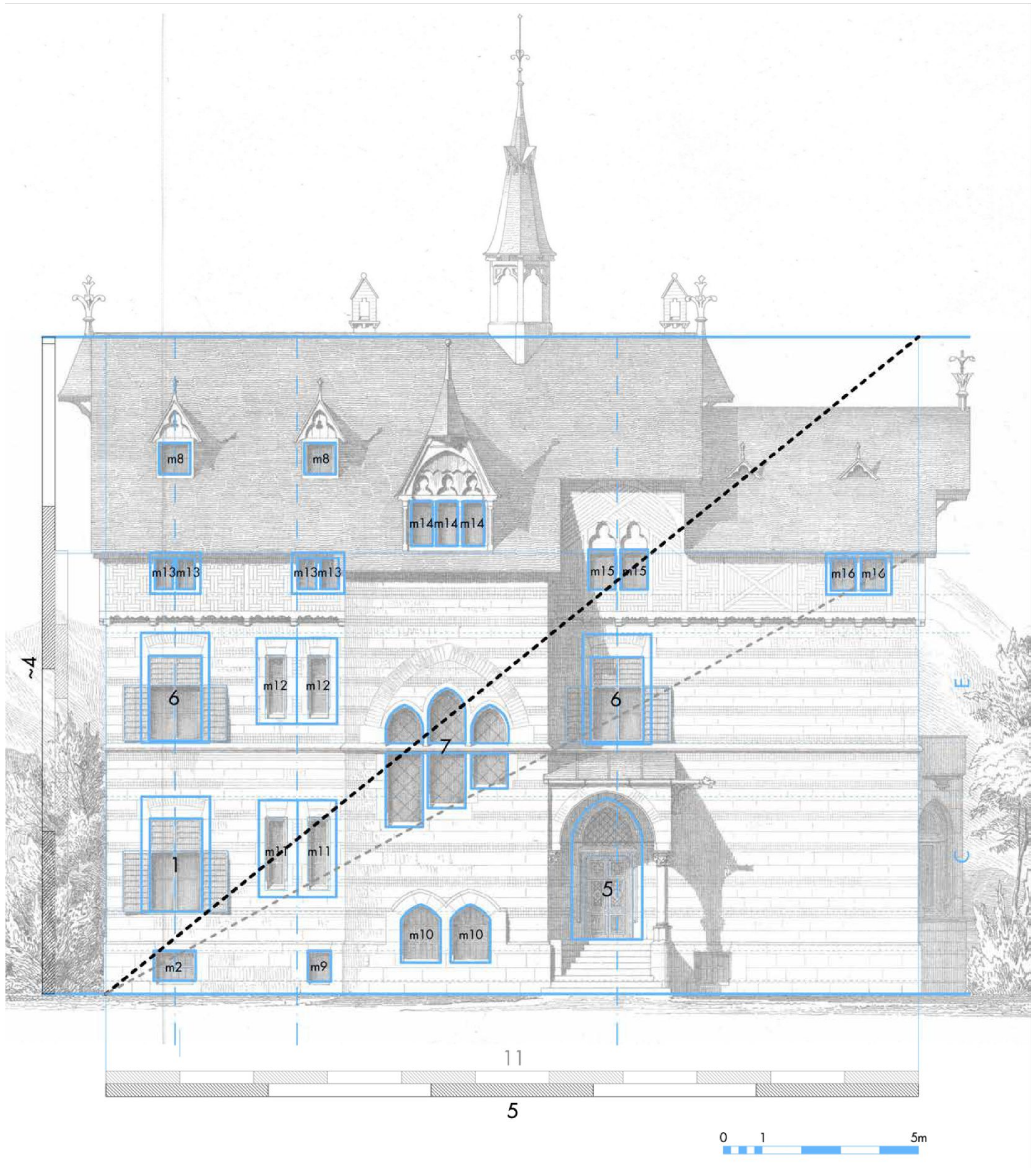


Fig. P.53 Geometrical analysis of front elevation: (U03) Summerhouse, am Traunsee

Fig. P.54 Geometrical analysis of openings: (U03) Summerhouse, am Traunsee

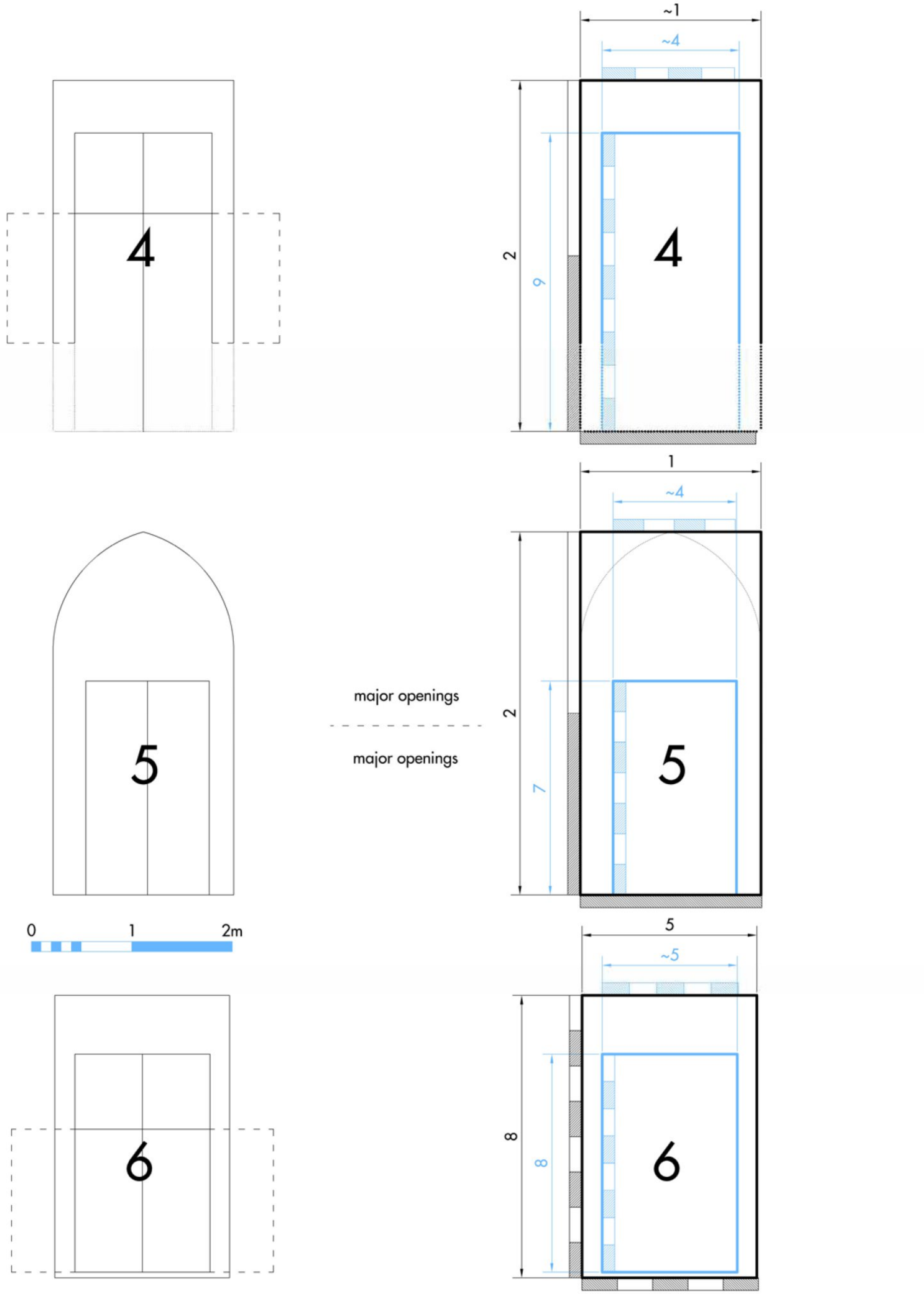


Fig. P.55 Geometrical analysis of openings: (U03) Summerhouse, am Traunsee

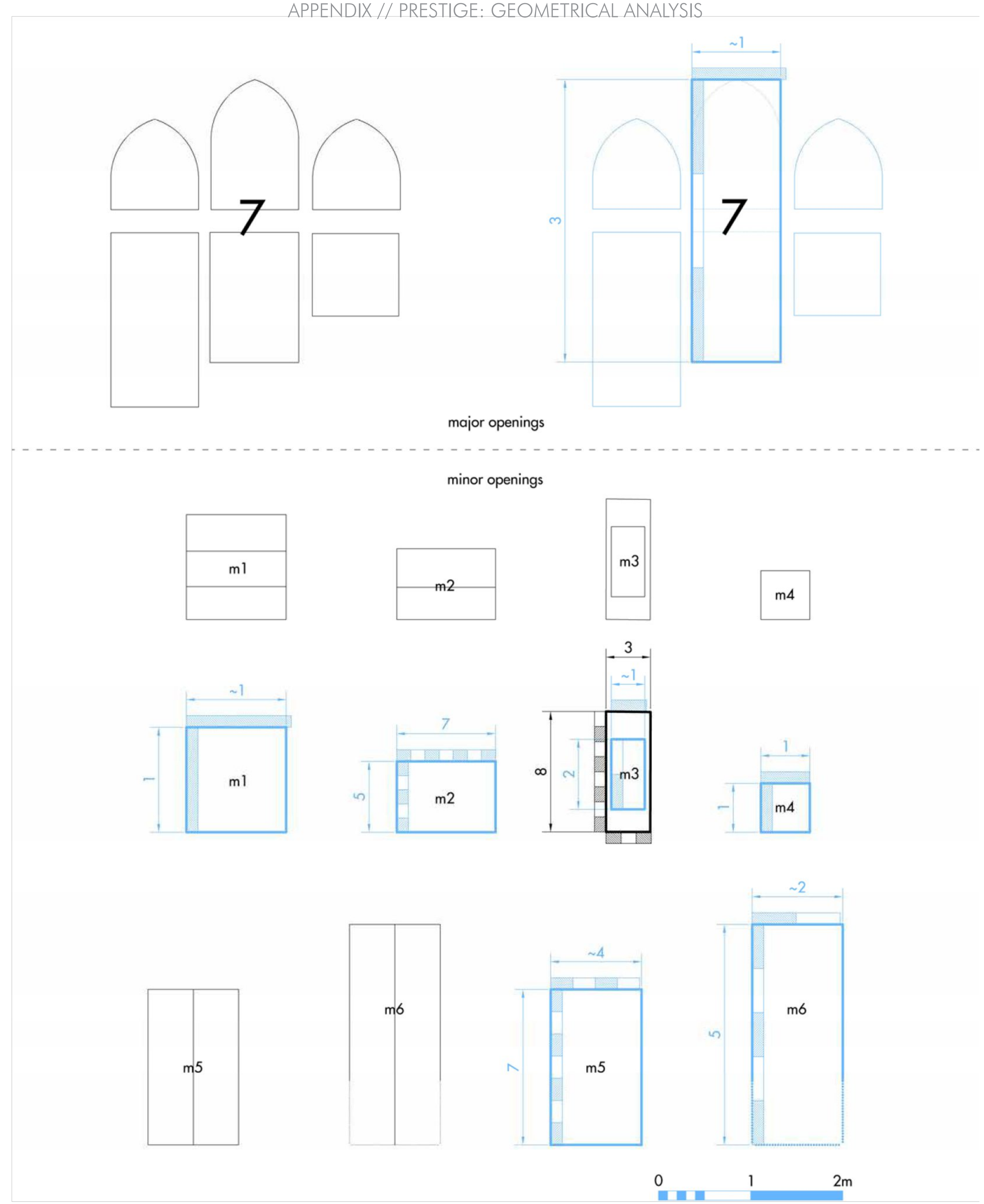


Fig. P.56 Geometrical analysis of openings: (U03) Summerhouse, am Traunsee

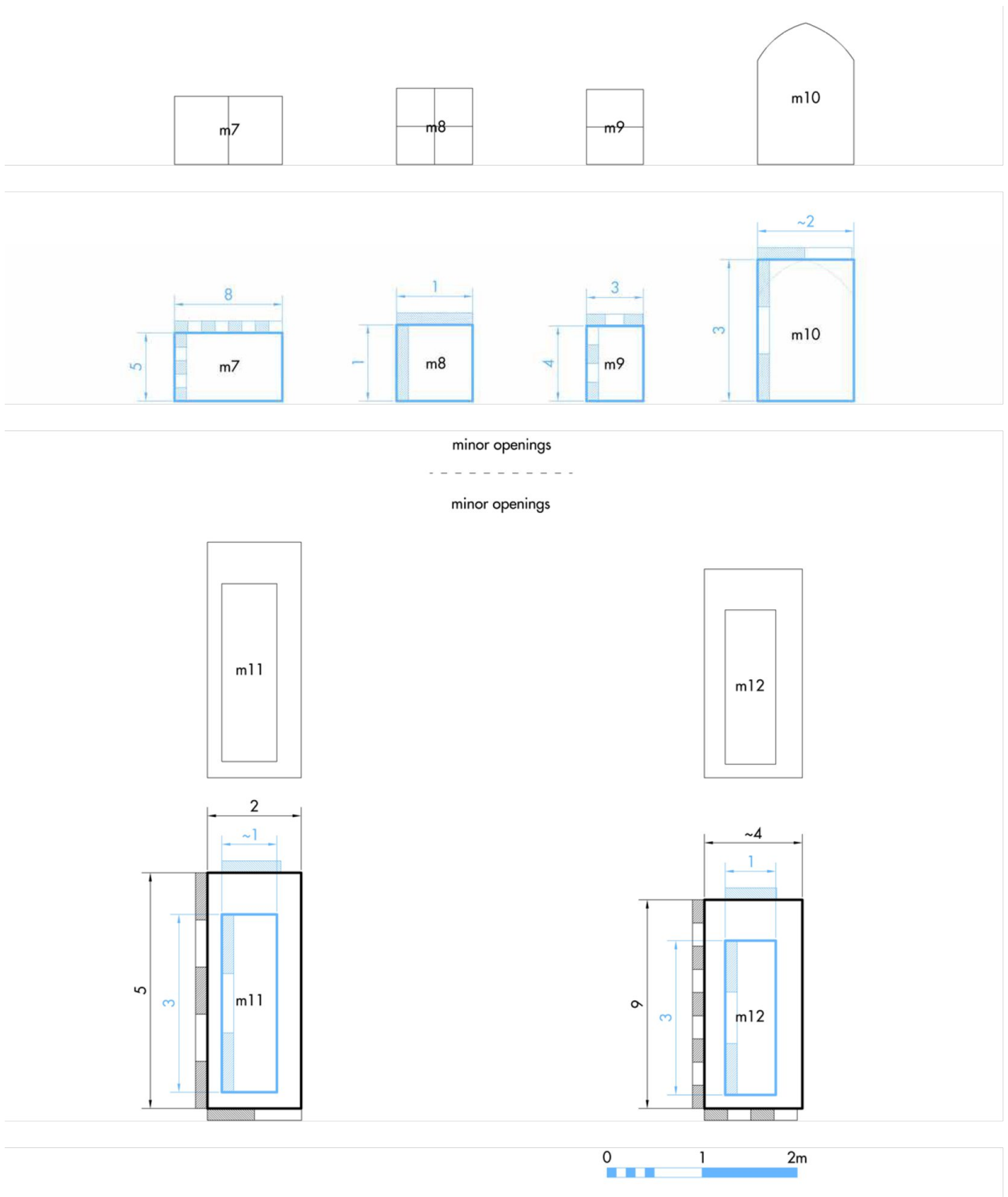


Fig. P.57 Geometrical analysis of openings: (U03) Summerhouse, am Traunsee

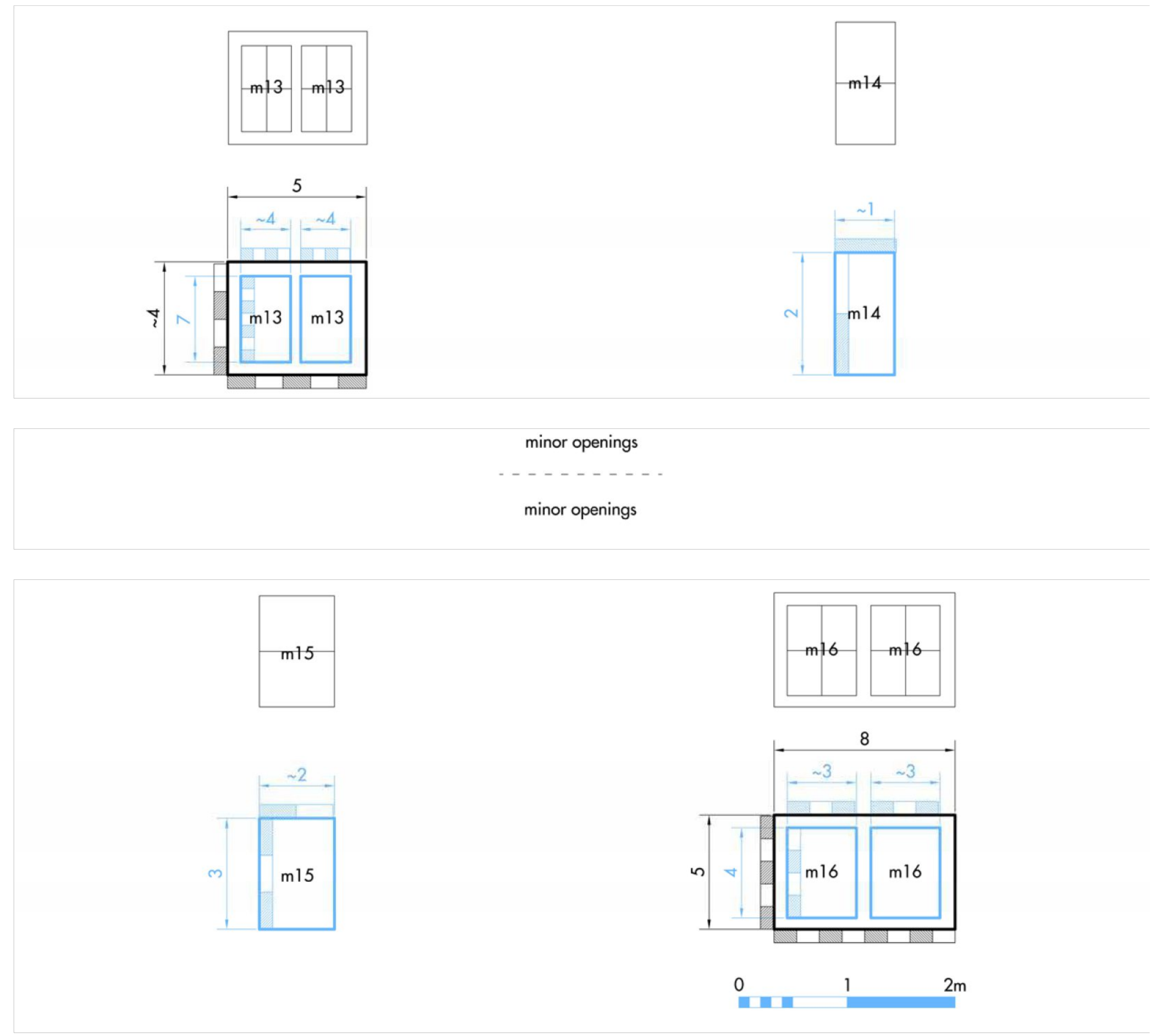


Fig. P.58 Geometrical analysis of openings: (U03) Summerhouse, am Traunsee

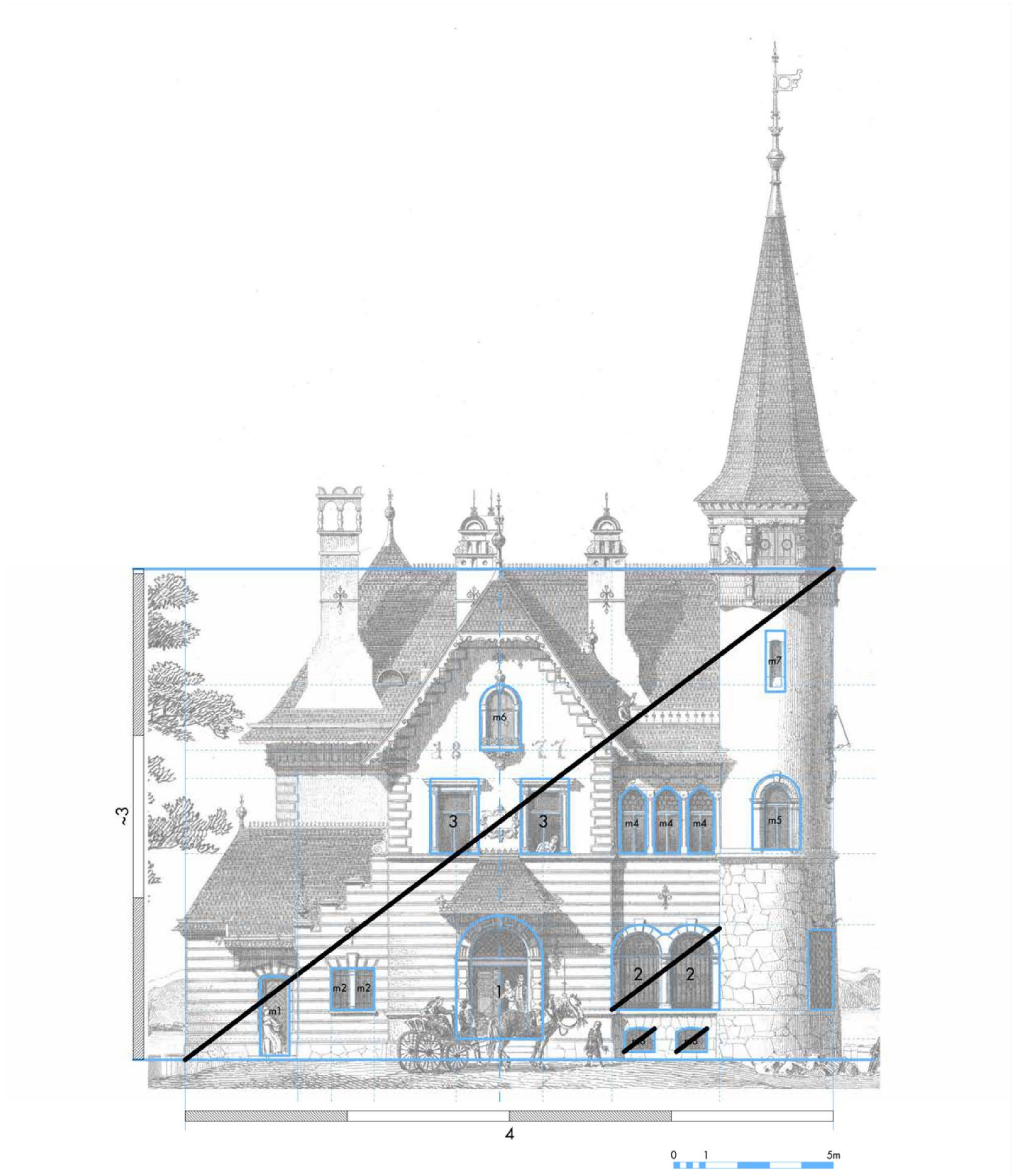


Fig. P.59 Geometrical analysis of front elevation: (U04) Villa Paulick, Seewalchen am Attersee

Fig. P.60 Geometrical analysis of side elevation: (U04) Villa Paulick, Seewalchen am Attersee

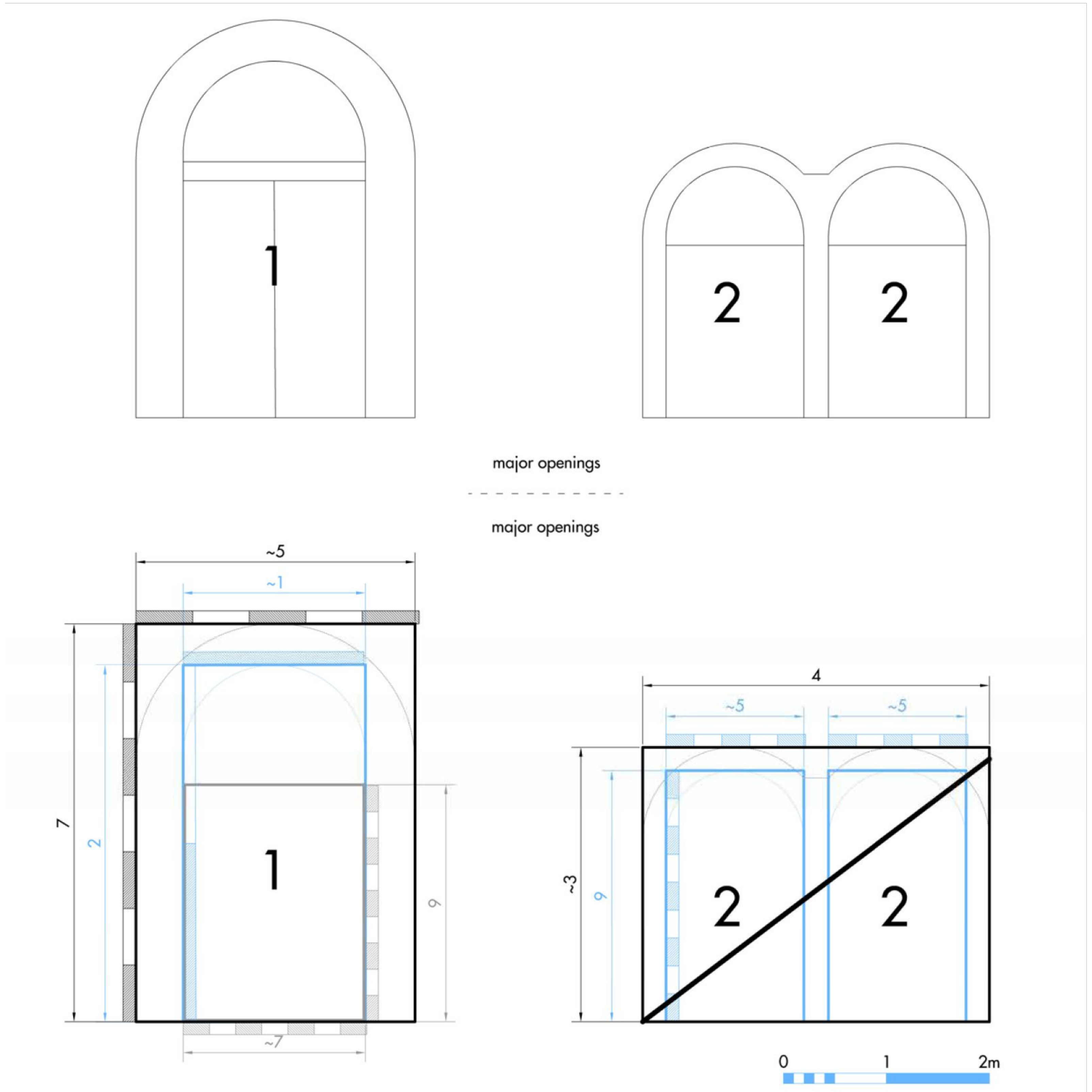


Fig. P.61 Geometrical analysis of openings: (U04) Villa Paulick, Seewalchen am Attersee

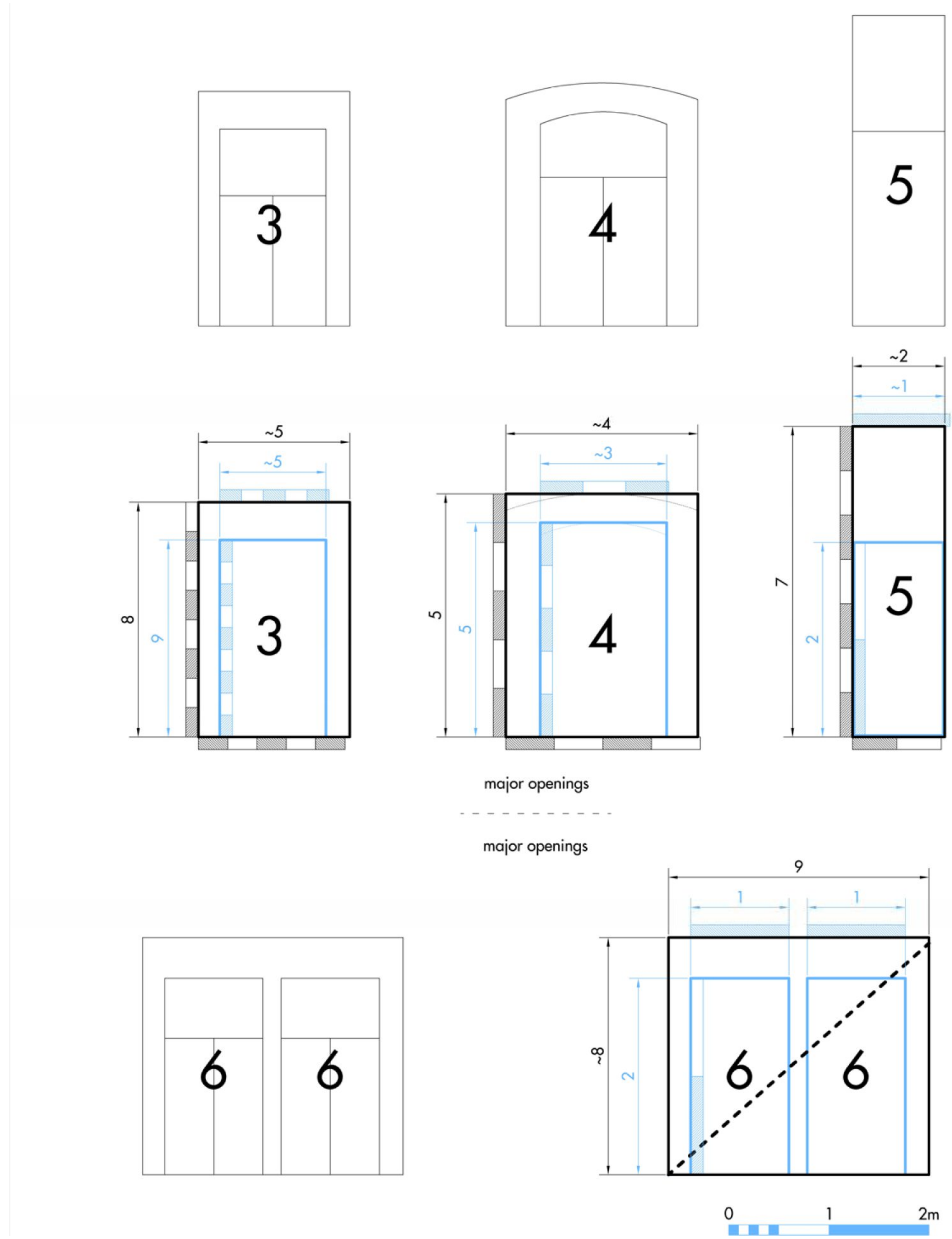


Fig. P.62 Geometrical analysis of openings: (U04) Villa Paulick, Seewalchen am Attersee

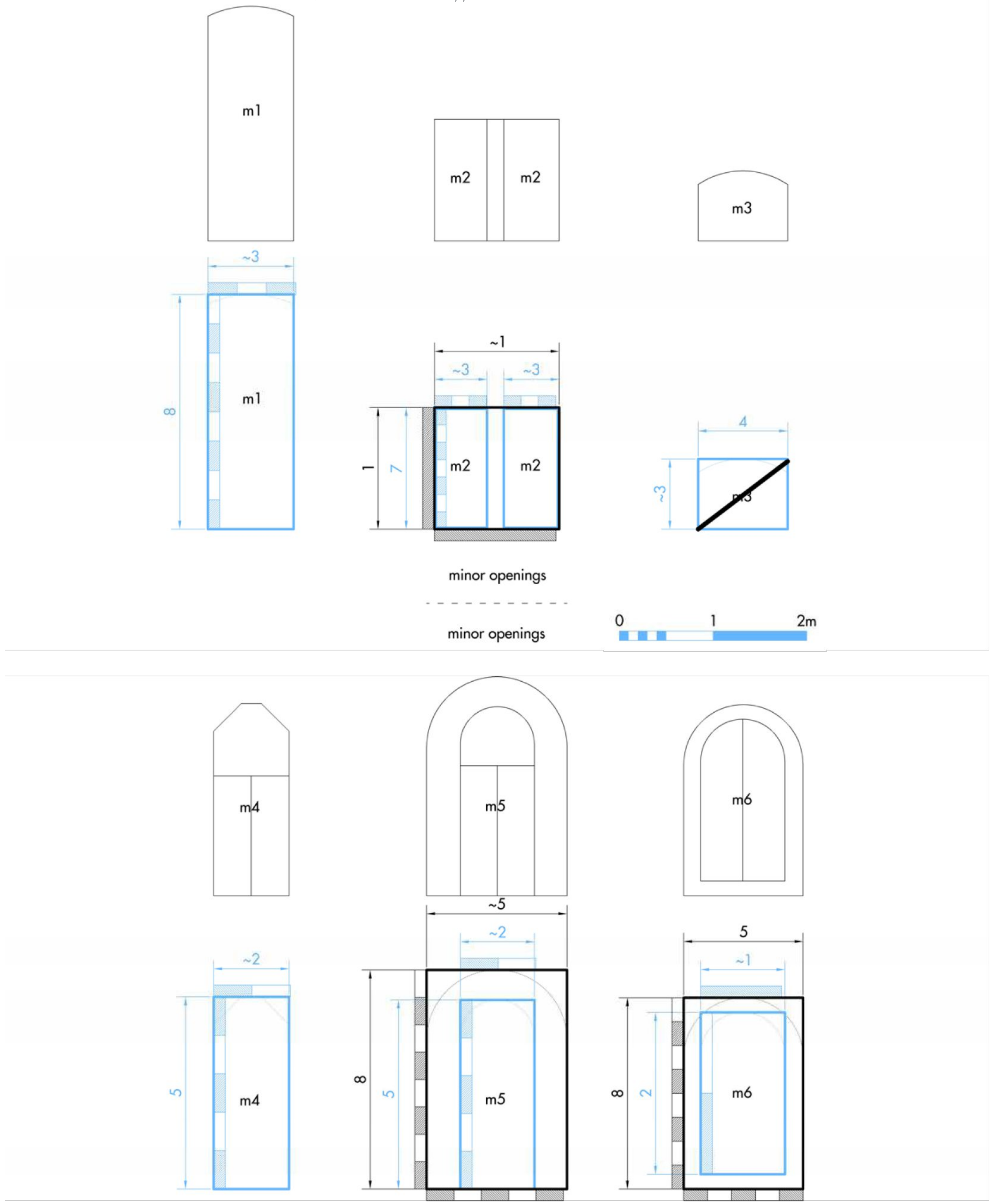


Fig. P.63 Geometrical analysis of openings: (U04) Villa Paulick, Seewalchen am Attersee

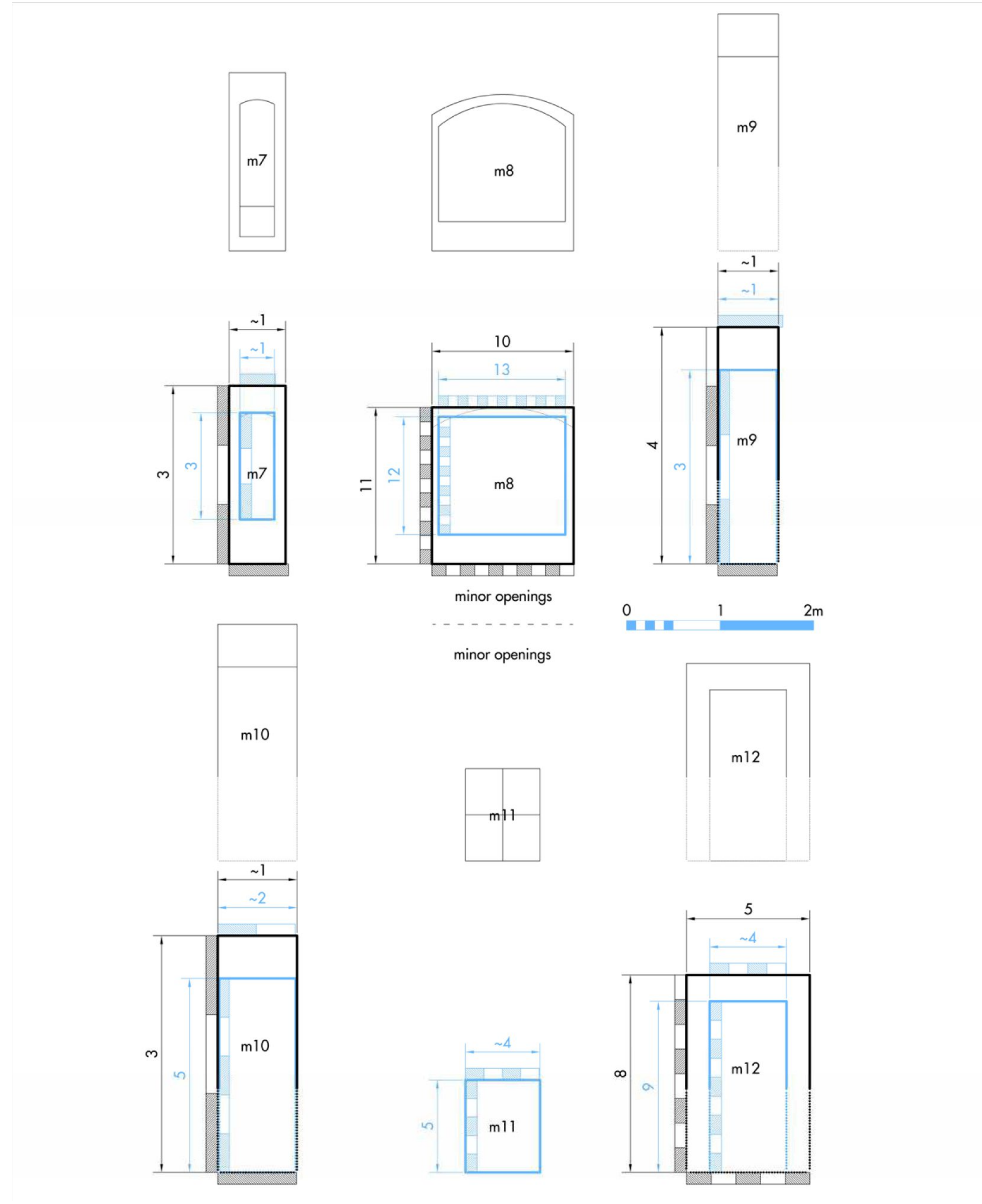


Fig. P.64 Geometrical analysis of openings: (U04) Villa Paulick, Seewalchen am Attersee

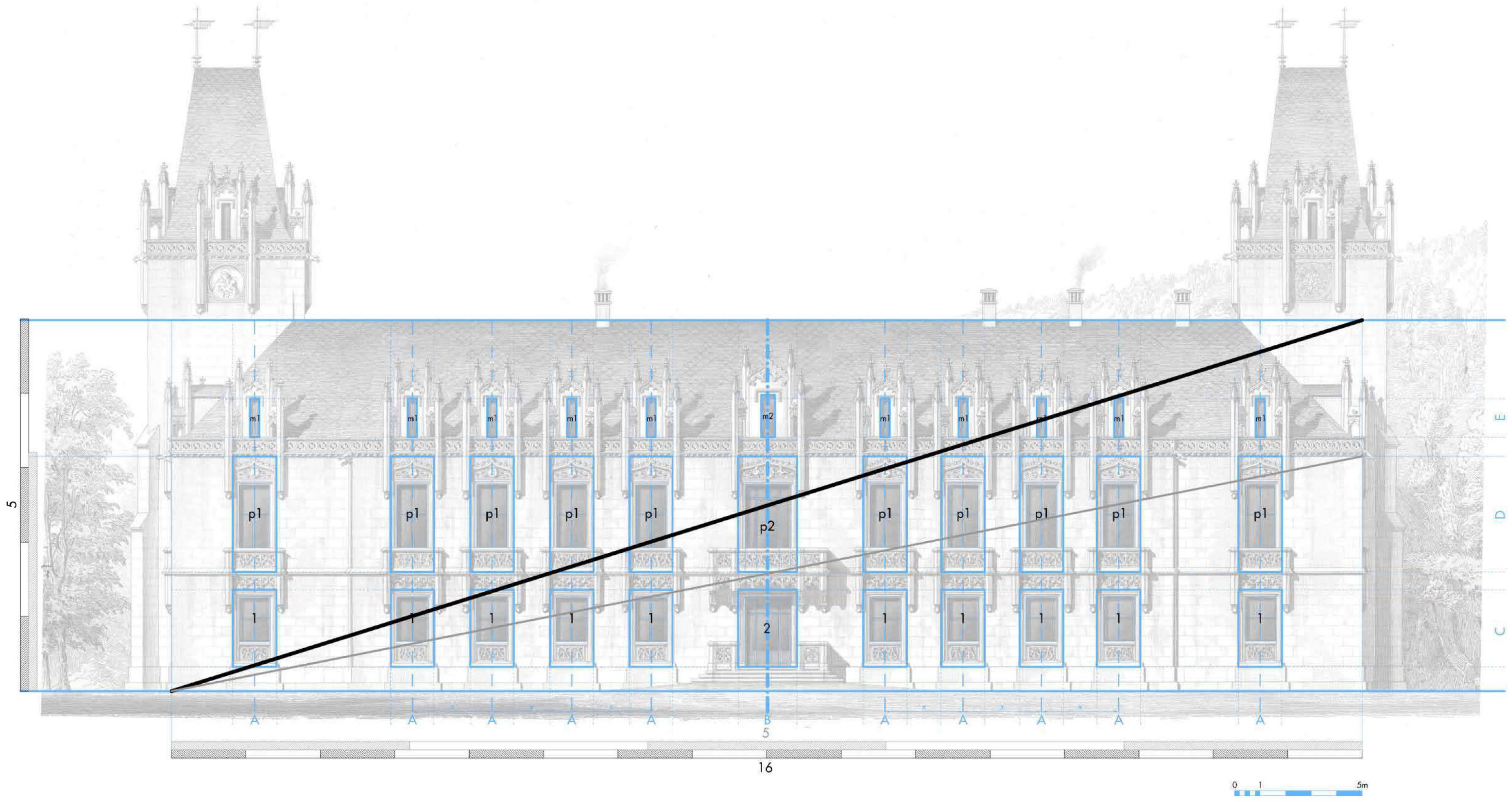


Fig. P.65 Geometrical analysis of front elevation: (L01) Restoration of Castle Hernstein, Hernstein, Berndorfer Straße 32

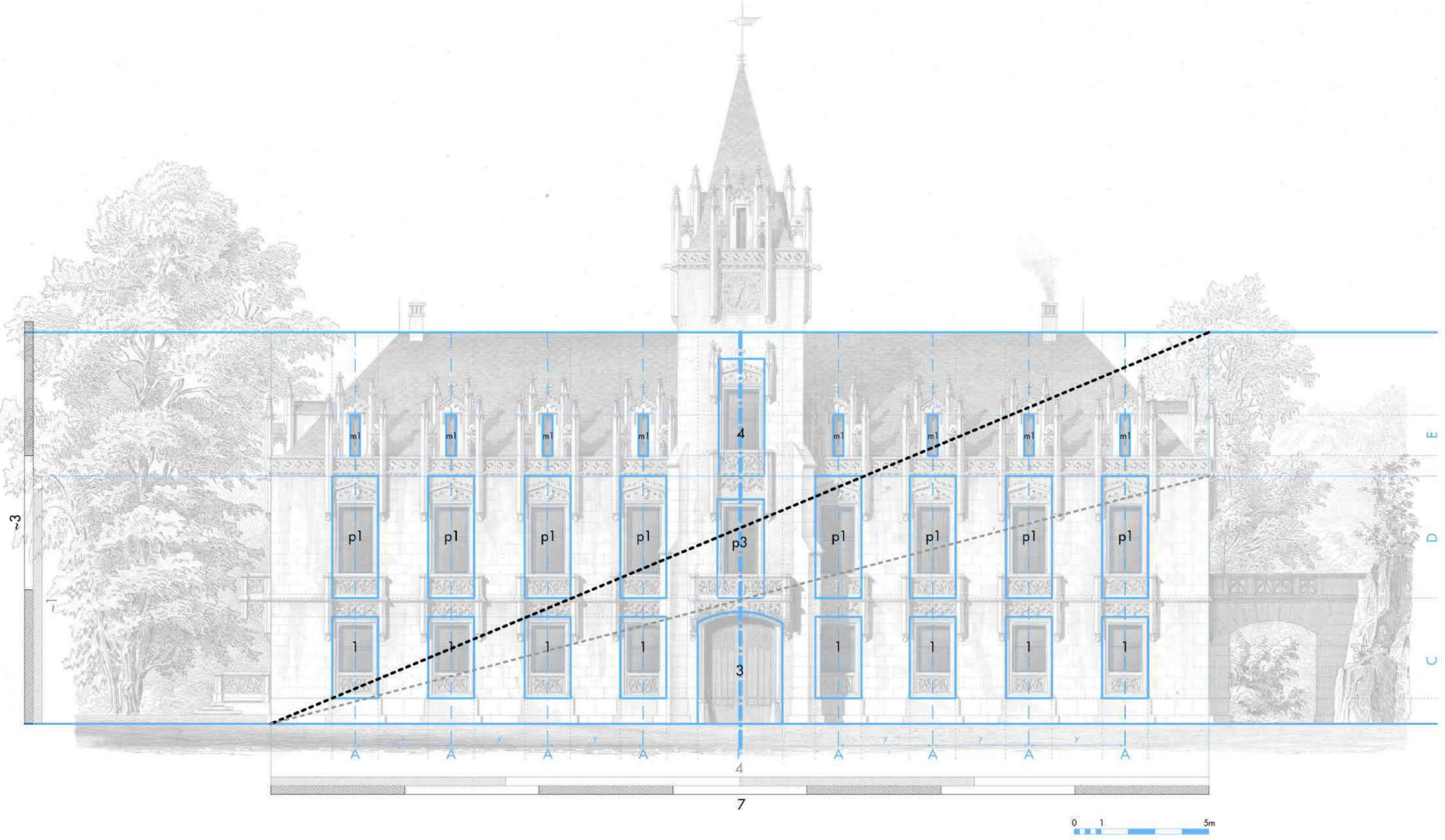


Fig. P.66 Geometrical analysis of side elevation: (L01) Restoration of Castle Hernstein, Hernstein, Berndorfer Straße 32

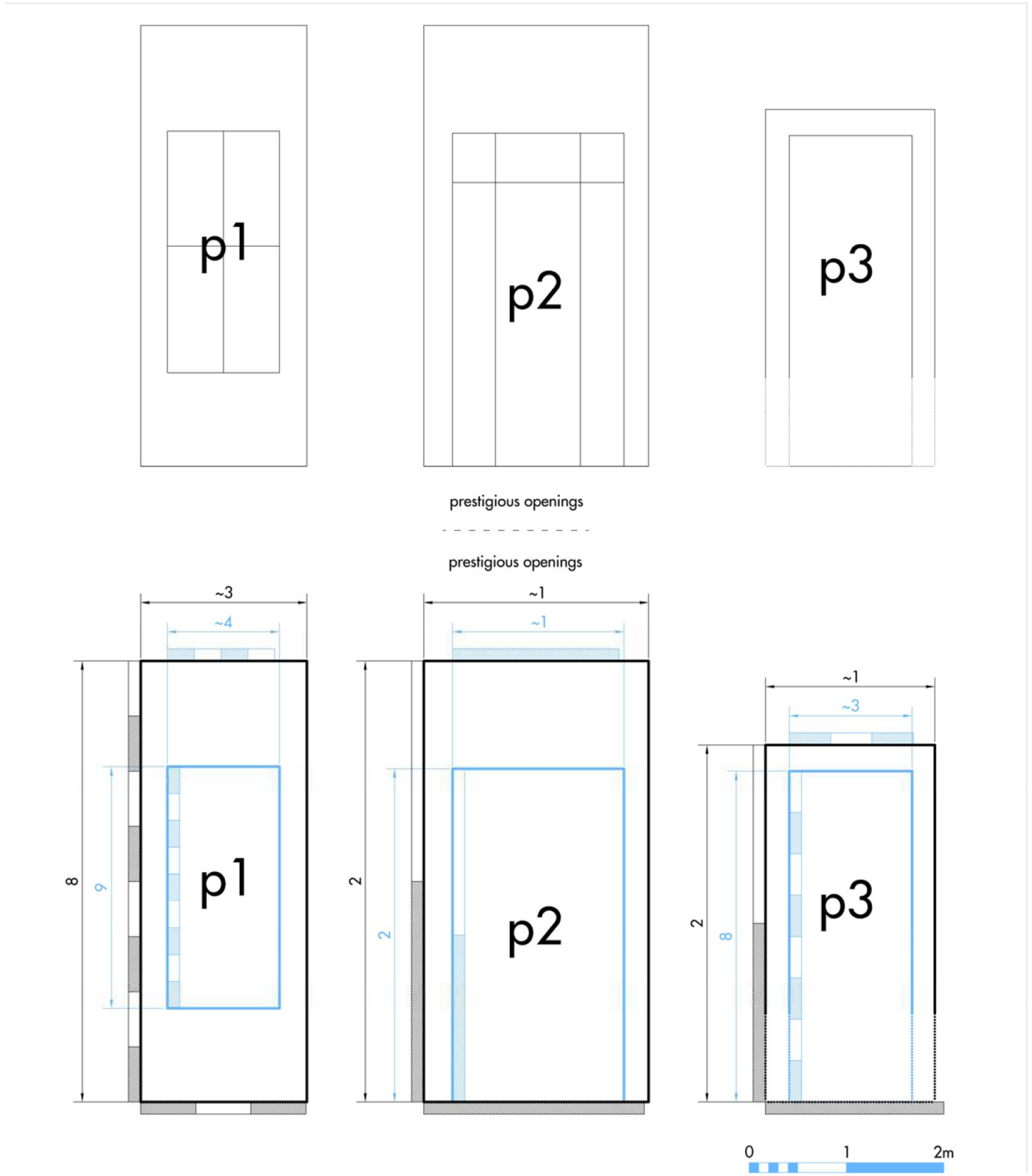


Fig. P.67 Geometrical analysis of openings: (L01) Restoration of Castle Hernstein, Hernstein, Berndorfer Straße 32

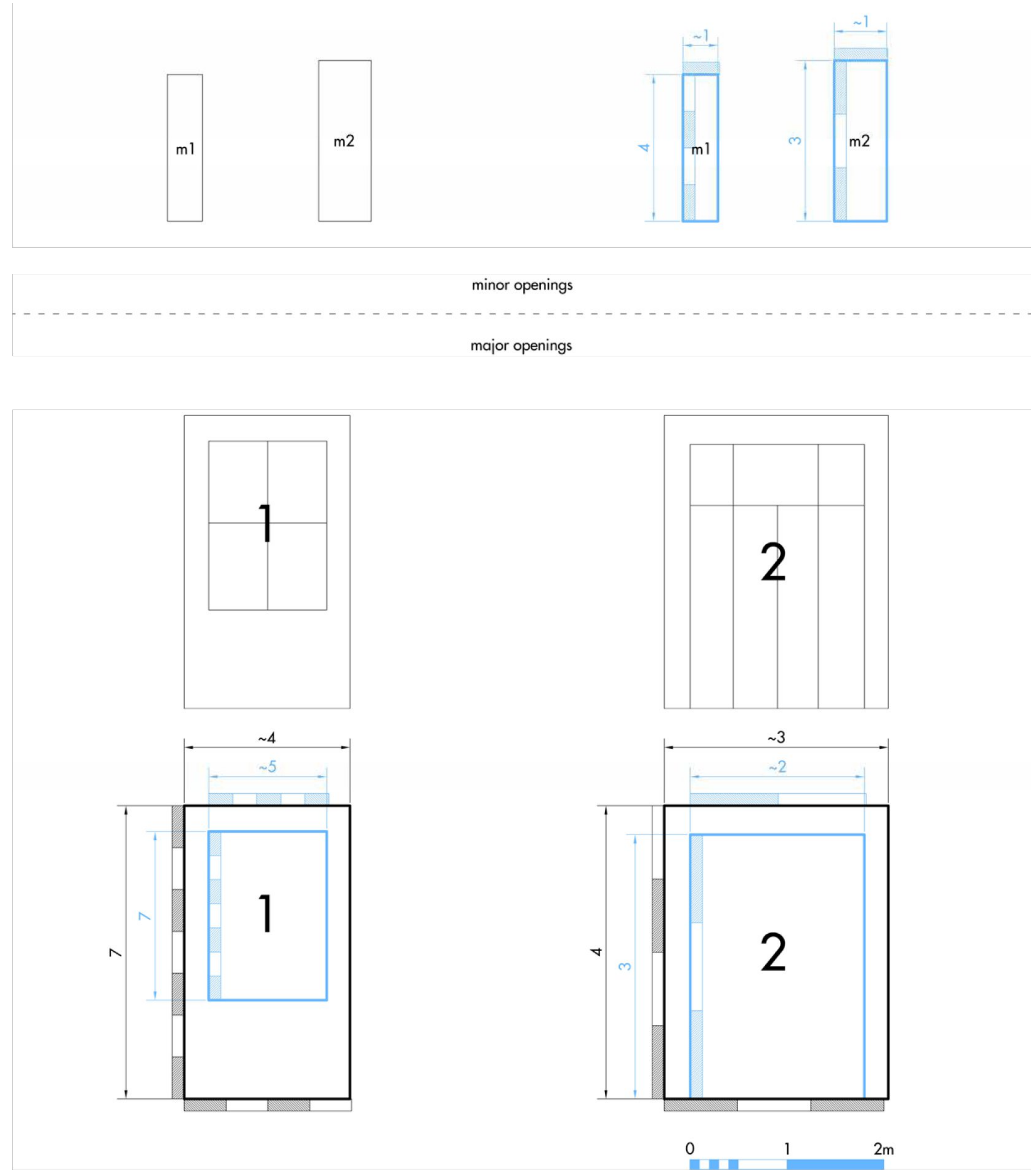


Fig. P.68 Geometrical analysis of openings: (L01) Restoration of Castle Hernstein, Hernstein, Berndorfer Straße 32

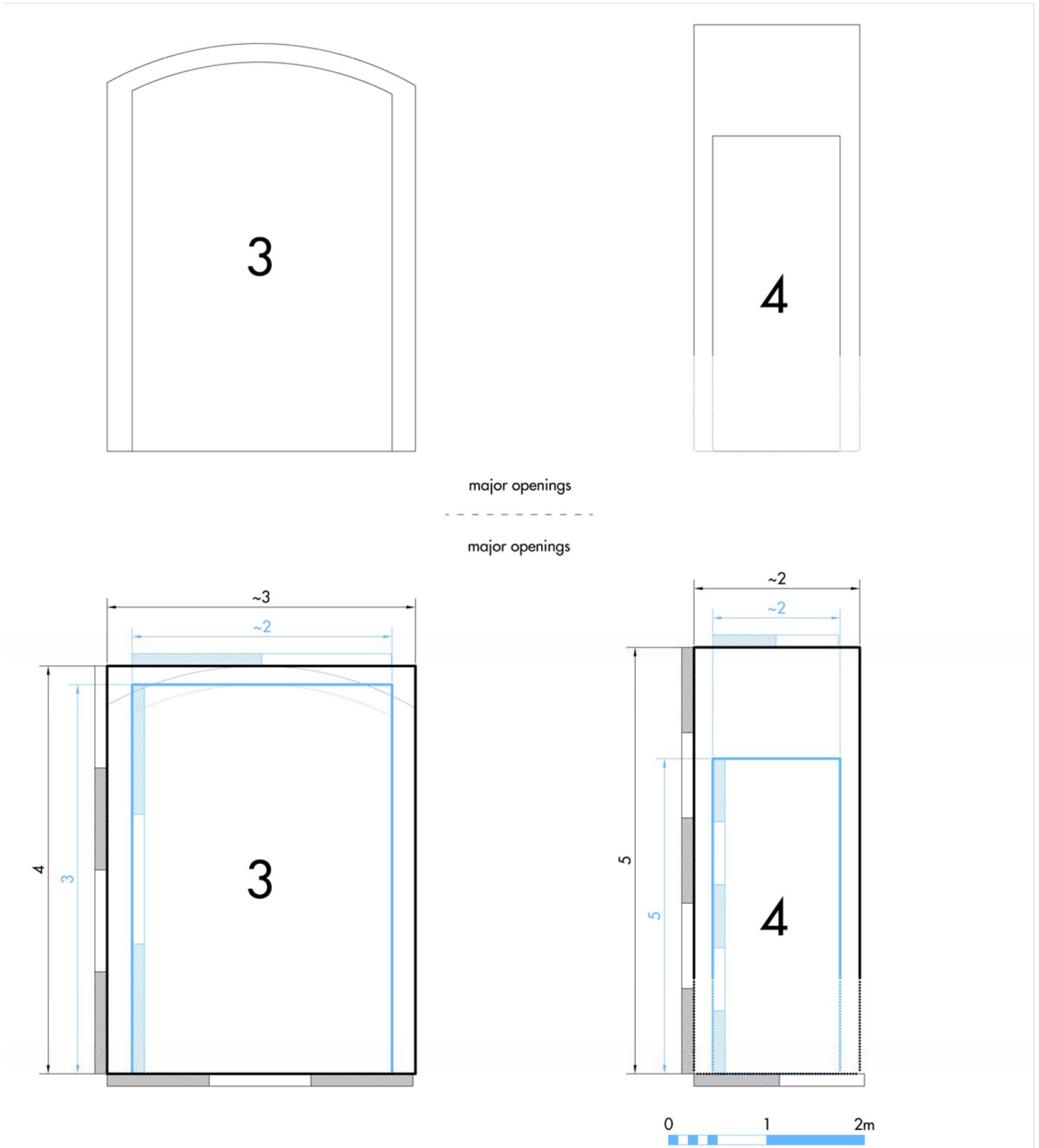


Fig. P.69 Geometrical analysis of openings: (L01) Restoration of Castle Hernstein, Hernstein, Berndorfer Straße 32

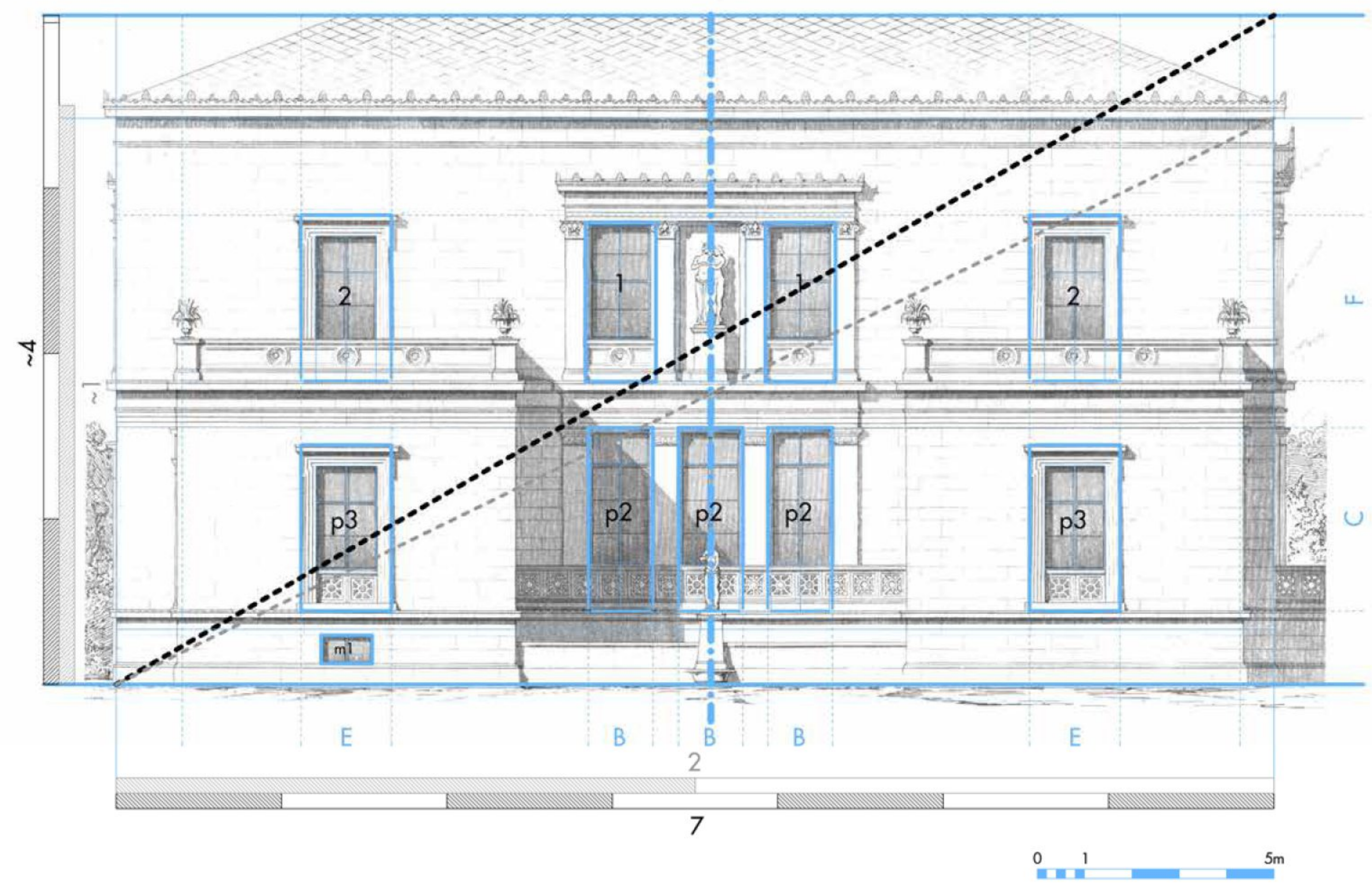


Fig. P.70 Geometrical analysis of front elevation: (U02) Summerhouse, Baden near Vienna
Fig. P.71 Geometrical analysis of side elevation: (U02) Summerhouse, Baden near Vienna

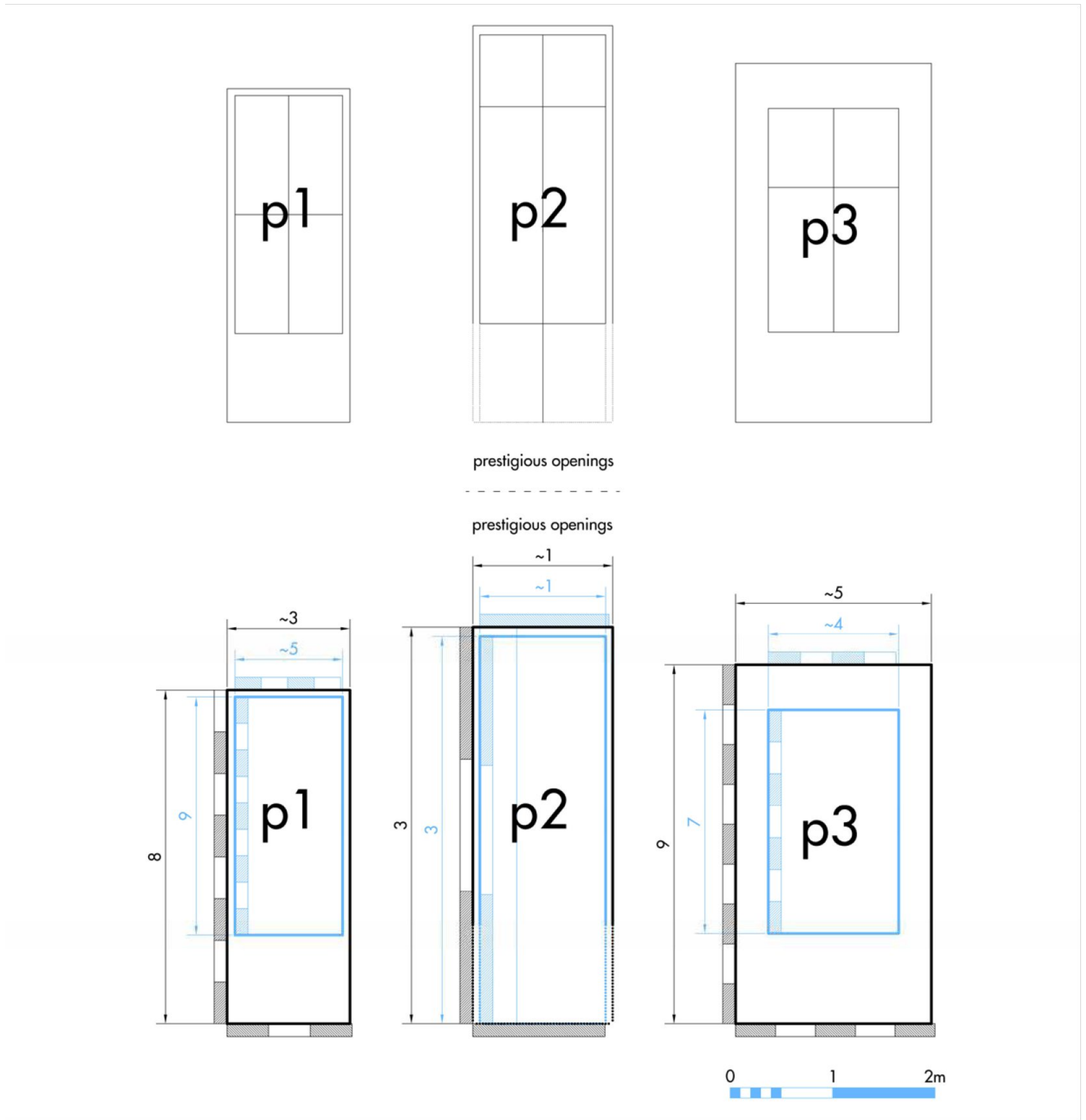


Fig. P.72 Geometrical analysis of openings: (U02) Summerhouse, Baden near Vienna

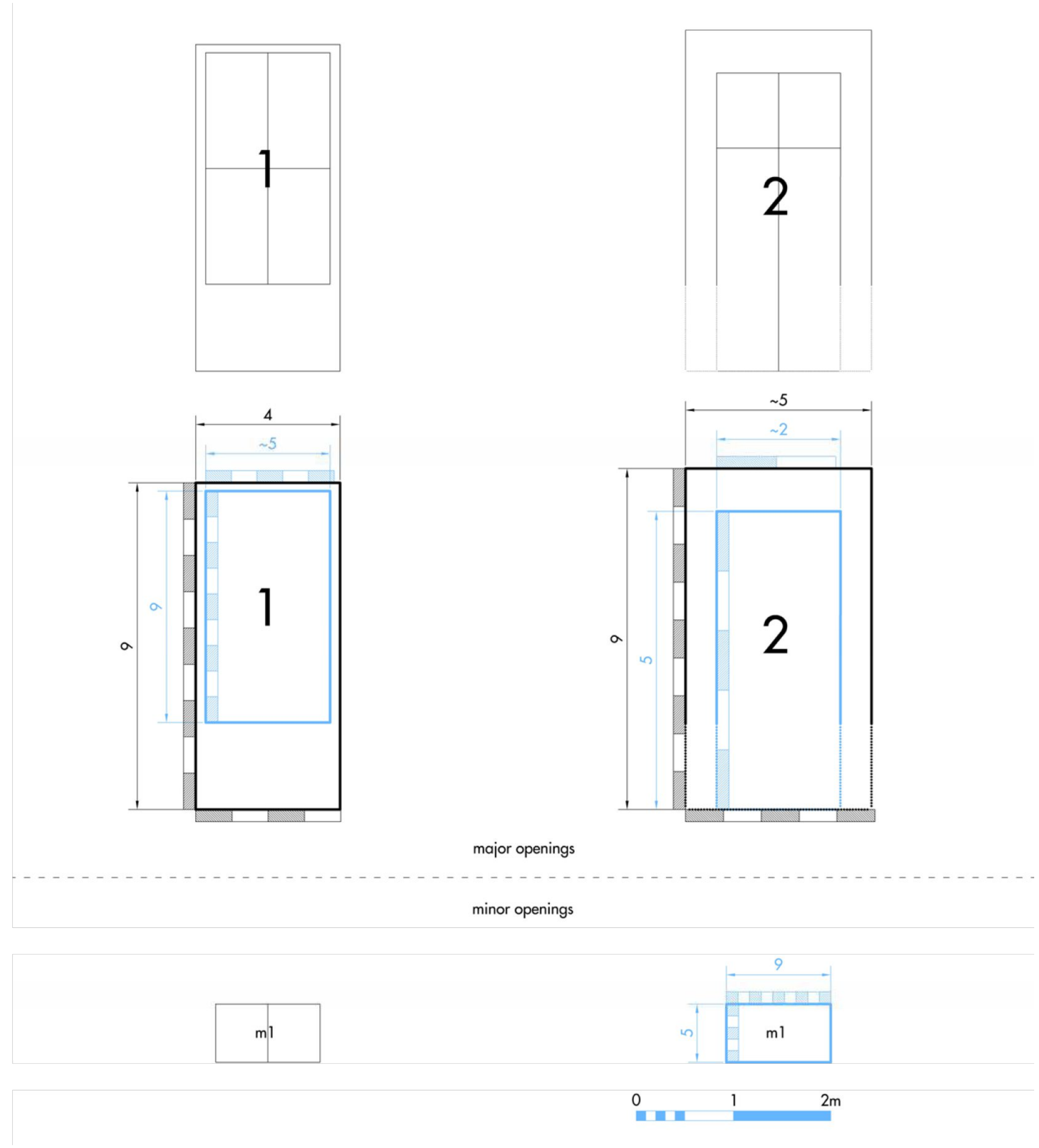


Fig. P.73 Geometrical analysis of openings: (U02) Summerhouse, Baden near Vienna

GERMANIC REGION // AREAS IN CURRENT GERMANY

Brandenburg

B01: Villa of princess von Liegnitz, Potsdam
(in the Sanssouci Park),
arch.: A. D. Schadow
(front and side elevation, openings)

Baden-Württemberg

Ba-Wü01: Residential house of Mr. K. Model, Karlsruhe in Baden,
arch.: H. Lang
(front and side elevation, openings)

Ba-Wü02: Villa Friedrich, Heidelberg,
arch.: H. Lang
(front elevation, openings)

Ba-Wü03: Summerhouse of Mr. Schwarzweber, Freiburg,
arch.: E. Rau
(side and rear elevation, openings)

Berlin

BerV01: Residential house No. 13, Victoria-Straße,
arch.: -
(front elevation, openings)

BerV02: Residential house No. 7, Victoria-Straße,
arch.: -
(front elevation, openings)

BerV03: Residential house No. 6, Victoria-Straße,
arch.: -
(front elevation, openings)

BerV04: Residential house No. 5, Victoria-Straße,
arch.: -
(front elevation, openings)

BerV05: Residential house No. 4, Victoria-Straße,
arch.: -
(front elevation, openings)

BerV06: Residential house No. 12, Victoria-Straße,
arch.: -
(front elevation, openings)

BerV07: Residential house, Victoria-Straße,
arch.: -
(front elevation, openings)

BerV08: Residential house No. 9, Victoria-Straße,
arch.: -
(front elevation, openings)

Ber01: Residential house,
arch.: F. Adler, W. Walther
(front elevation, openings)

Ber02: Residential house, Unter den Linden 42,
arch.: F. A. Stüler
(front elevation, openings)

Ber03: Residential house, Oberwall-Straße 4,
arch.: H. Nicolai
(front elevation, openings)

Ber04: Residential house, Wilhelmsplatz 5,
arch.: W. Walther
(front elevation, openings)

Ber05: Villa Kabrun, near Berlin, Rauchstraße 17-18,
arch.: H. Ende, W. Böckmann
(side and rear elevation, openings)

Ber06: Villa Kaufmann,
arch.: G. Ebe, J. Benda
(side elevation, openings)

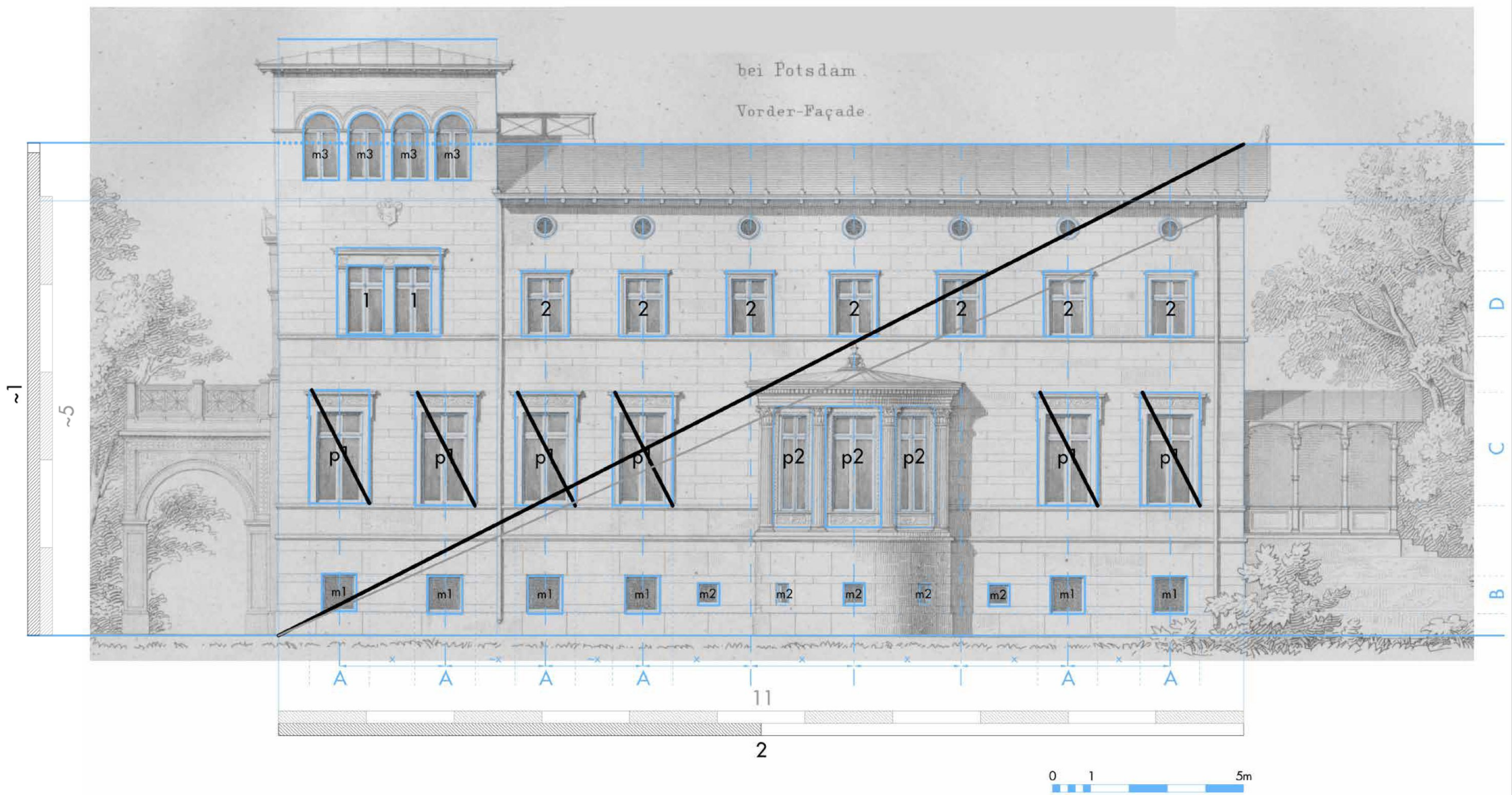


Fig. P.74 Geometrical analysis of front elevation: (Ba07) Villa of princess von Liegnitz, Potsdam (in the Sanssouci Park)

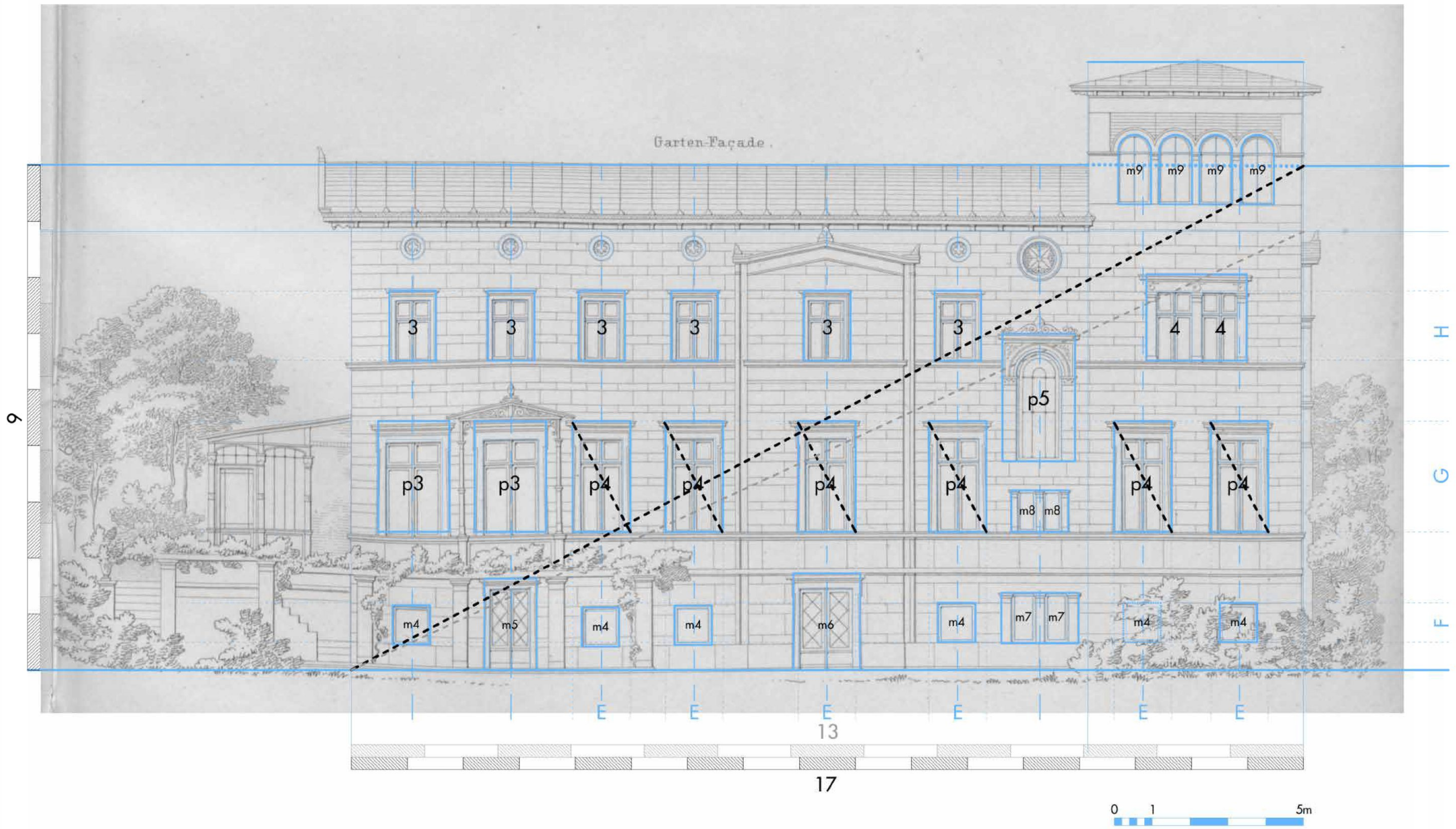


Fig. P.75 Geometrical analysis of side elevation: (Ba07) Villa of princess von Liegnitz, Potsdam (in the Sanssouci Park)

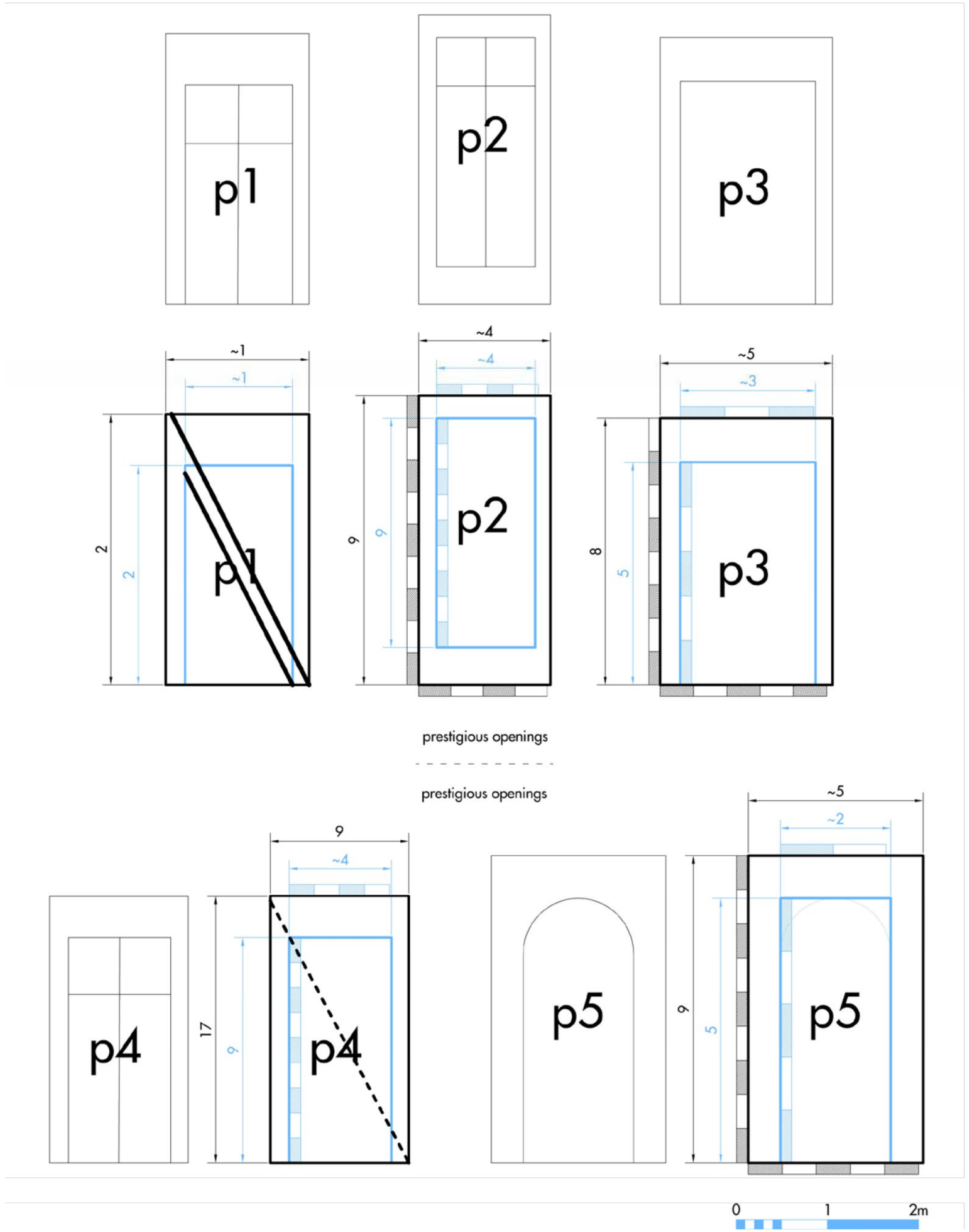


Fig. P.76 Geometrical analysis of openings: (Ba07) Villa of princess von Liegnitz, Potsdam (in the Sanssouci Park)

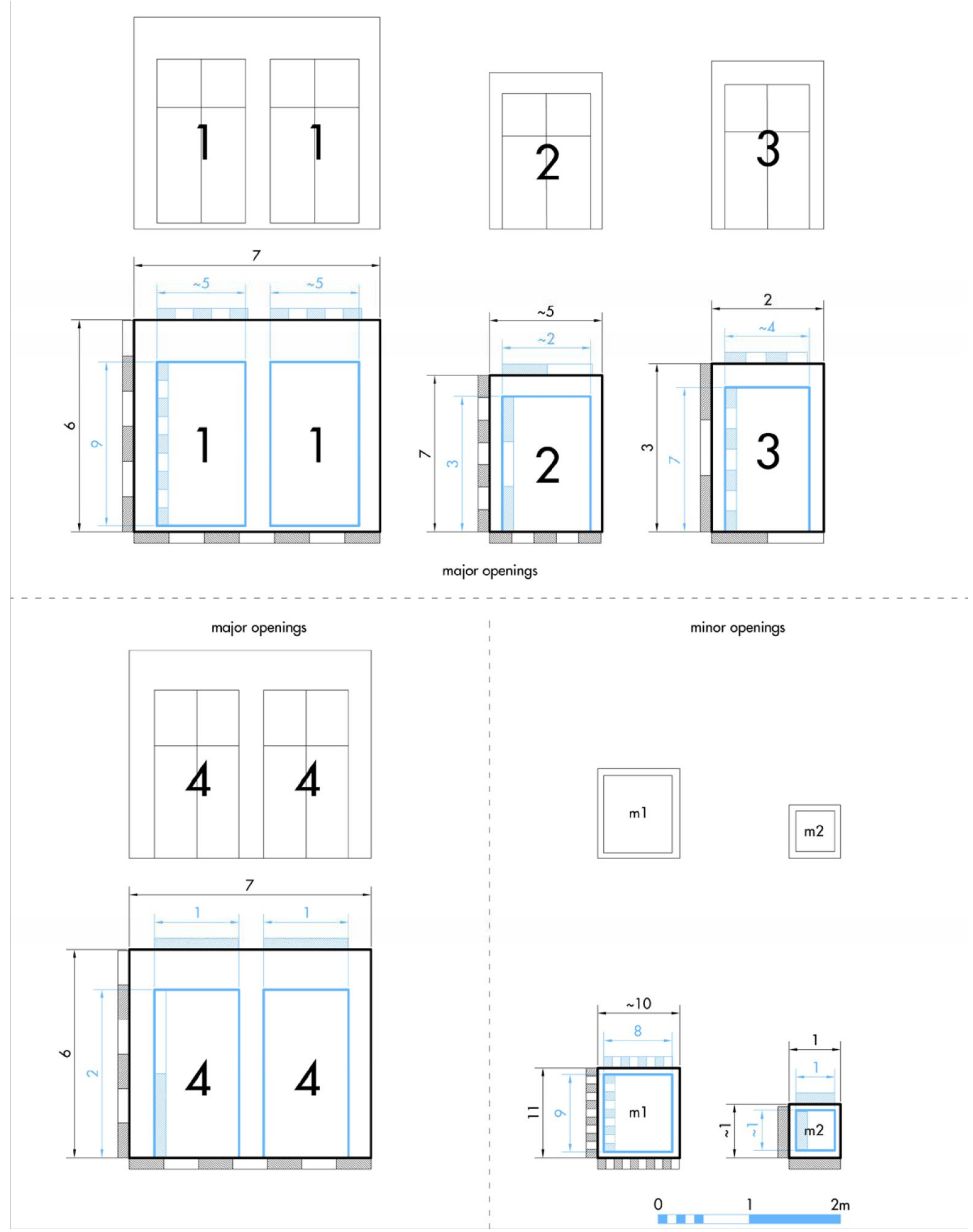


Fig. P.77 Geometrical analysis of openings: (Ba07) Villa of princess von Liegnitz, Potsdam (in the Sanssouci Park)

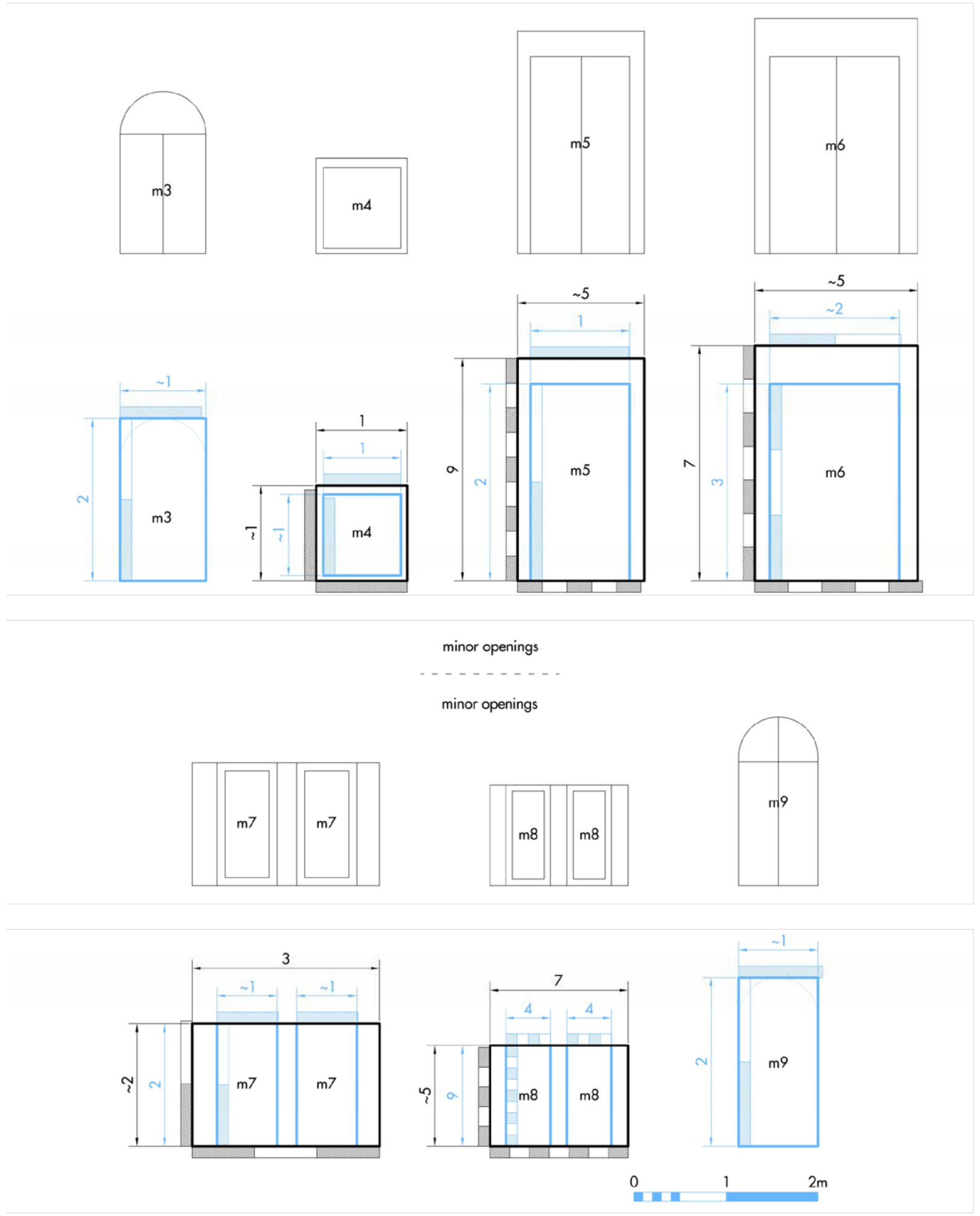


Fig. P.78 Geometrical analysis of openings: (Ba07) Villa of princess von Liegnitz, Potsdam (in the Sanssouci Park)

Fig. P.79 Geometrical analysis of front elevation: (Ba-Wü01) Residential house of Mr. K. Model, Karlsruhe in Baden

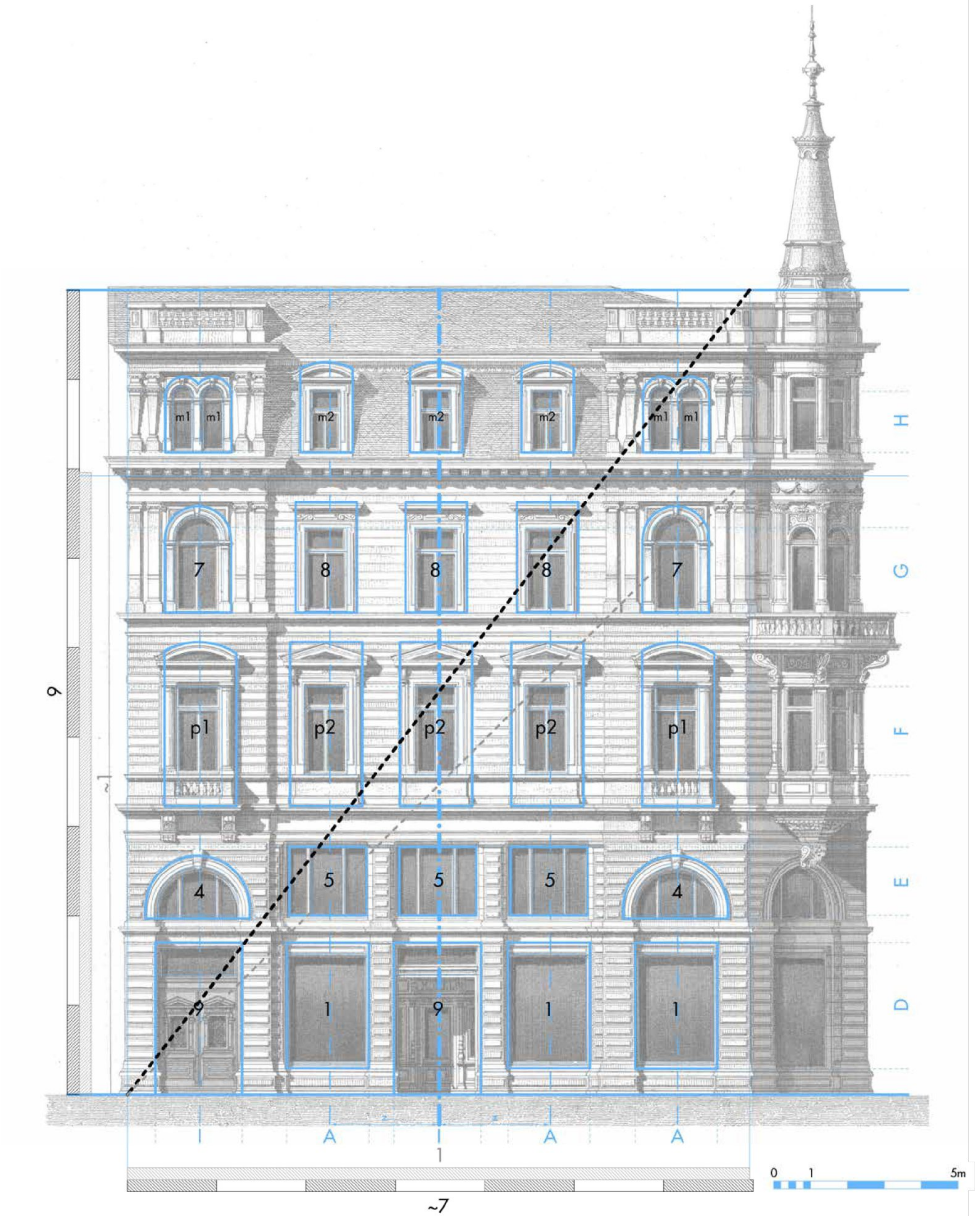


Fig. P.80 Geometrical analysis of side elevation: (Ba-Wü01) Residential house of Mr. K. Model, Karlsruhe in Baden

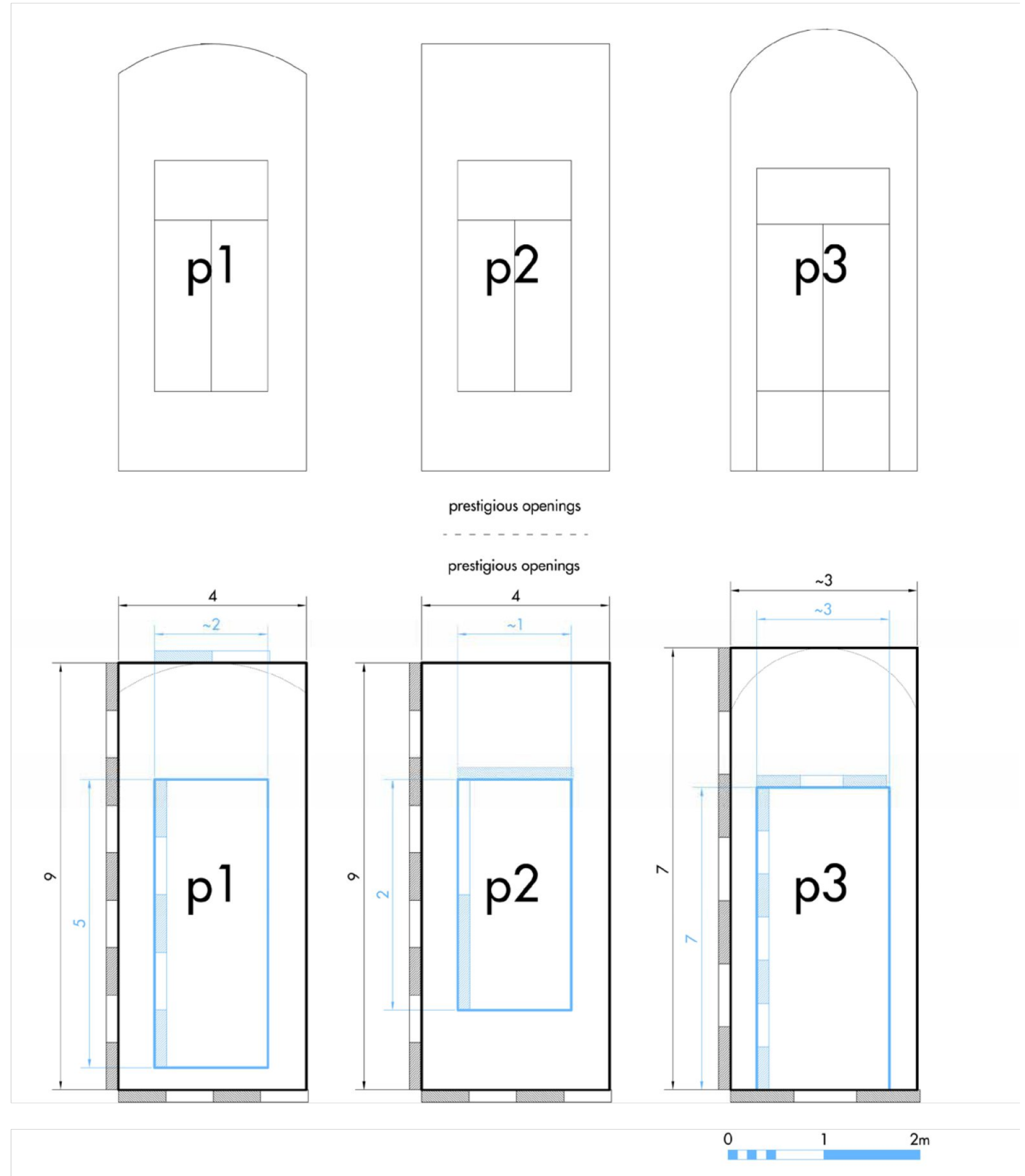


Fig. P.81 Geometrical analysis of openings: (Ba-Wü01) Residential house of Mr. K. Model, Karlsruhe in Baden

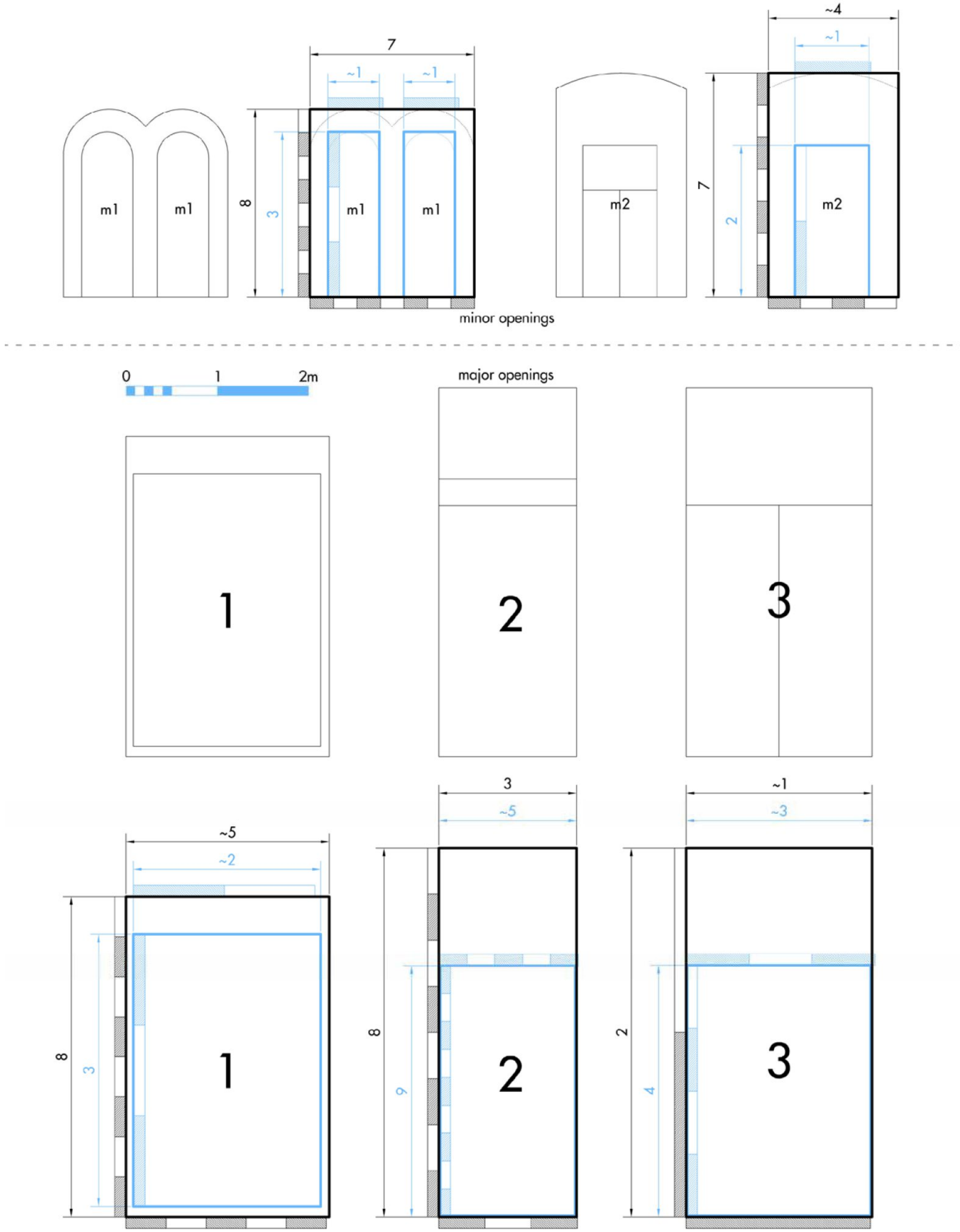


Fig. P.82 Geometrical analysis of openings: (Ba-Wü01) Residential house of Mr. K. Model, Karlsruhe in Baden

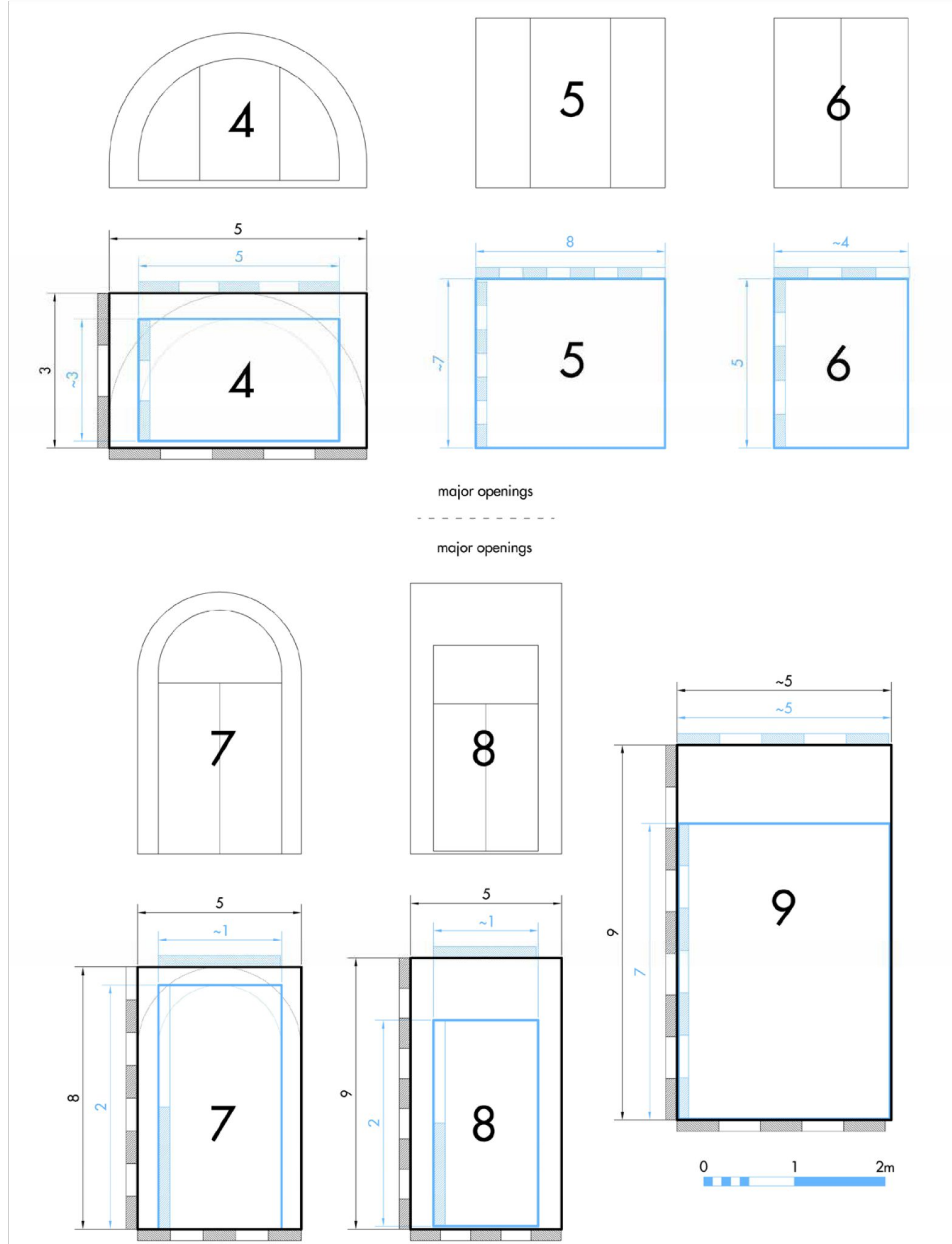


Fig. P.83 Geometrical analysis of openings: (Ba-Wü01) Residential house of Mr. K. Model, Karlsruhe in Baden

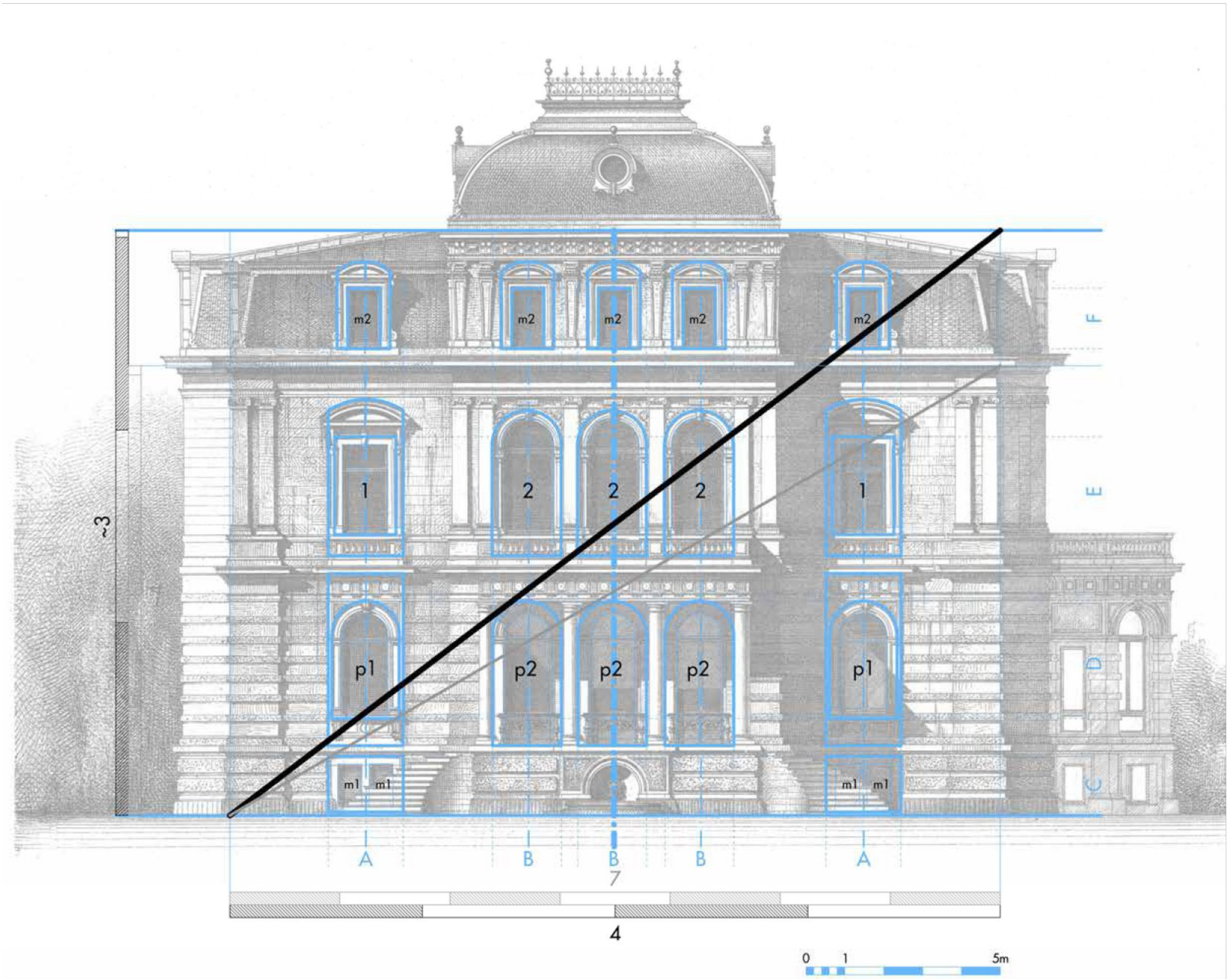


Fig. P.84 Geometrical analysis of front elevation: (Ba-Wü02) Villa Friedrich, Heidelberg

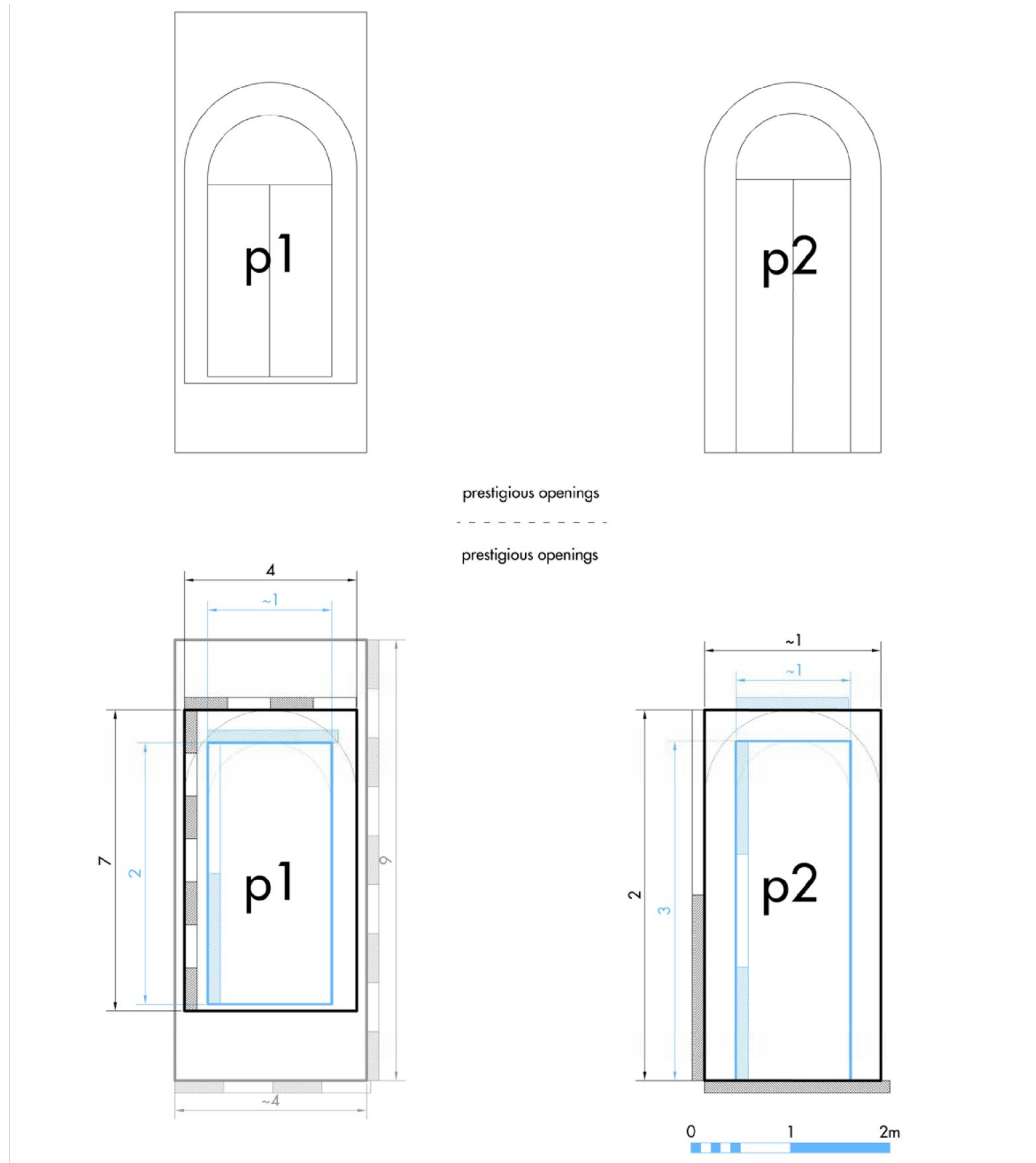


Fig. P.85 Geometrical analysis of openings: (Ba-Wü02) Villa Friedrich, Heidelberg

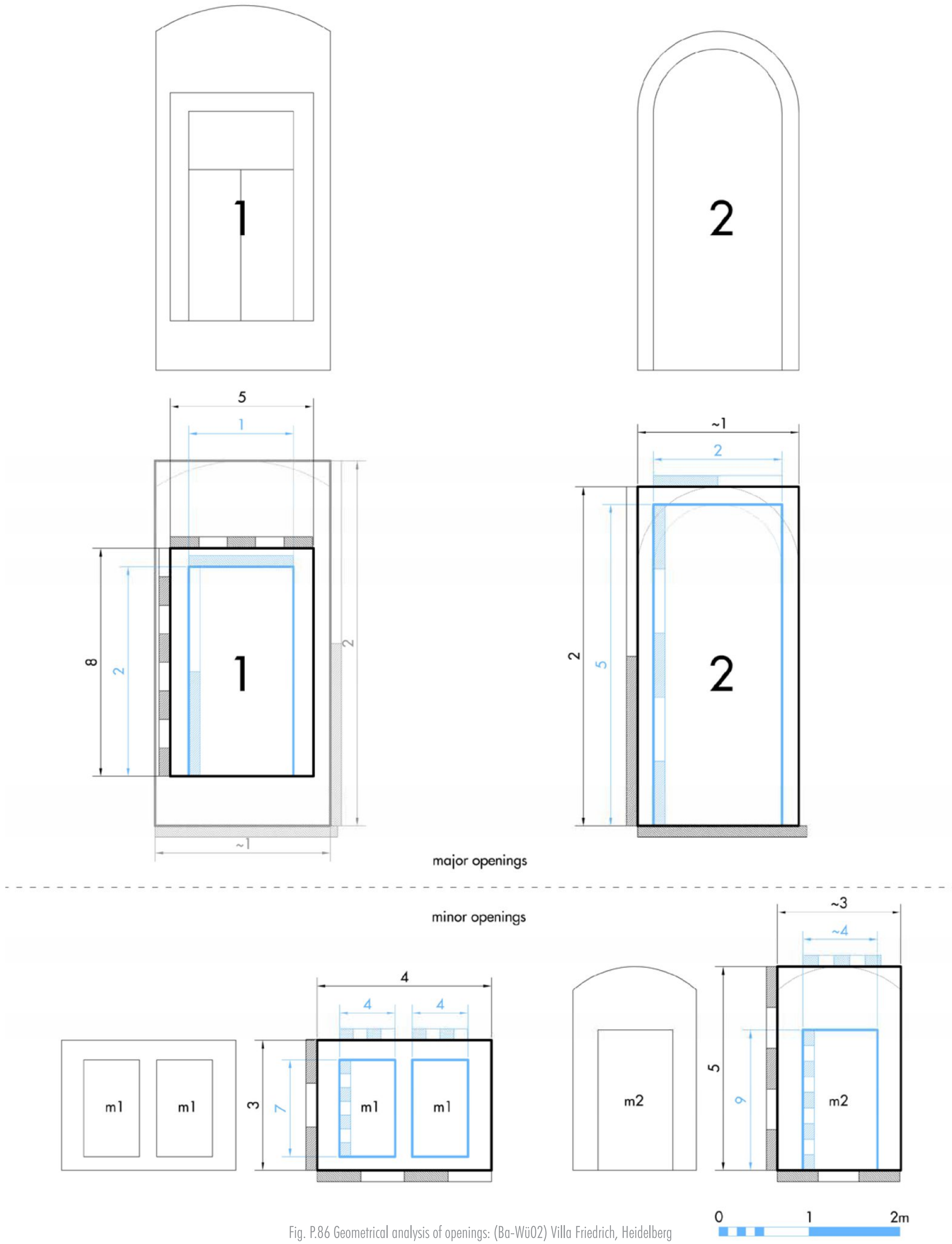


Fig. P.86 Geometrical analysis of openings: (Ba-Wü02) Villa Friedrich, Heidelberg

Fig. P.87 Geometrical analysis of front elevation: (Ba-Wü03) Summerhouse of Mr. Schwarzweber, Freiburg

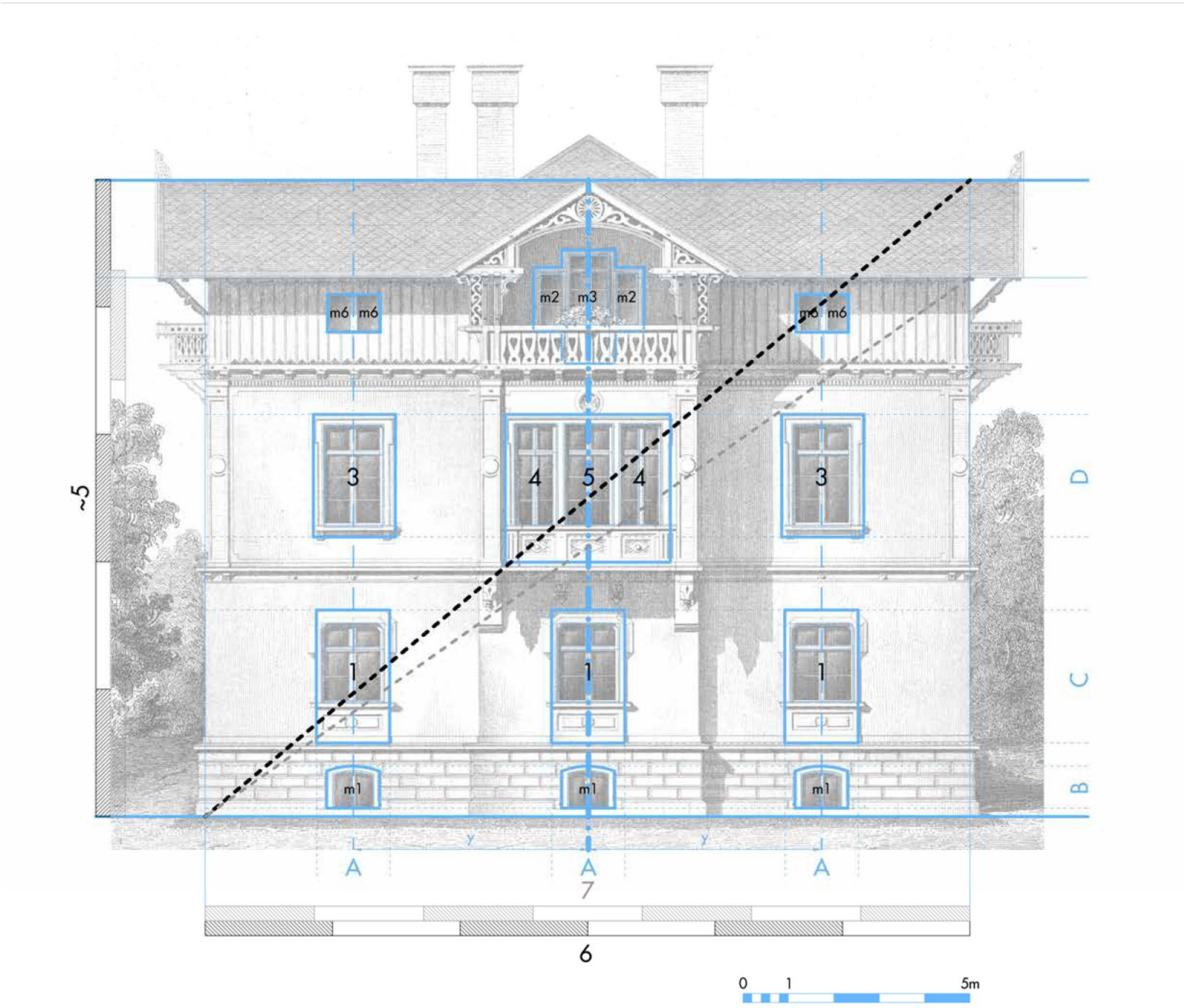


Fig. P.88 Geometrical analysis of side elevation: (Ba-Wü03) Summerhouse of Mr. Schwarzweber, Freiburg

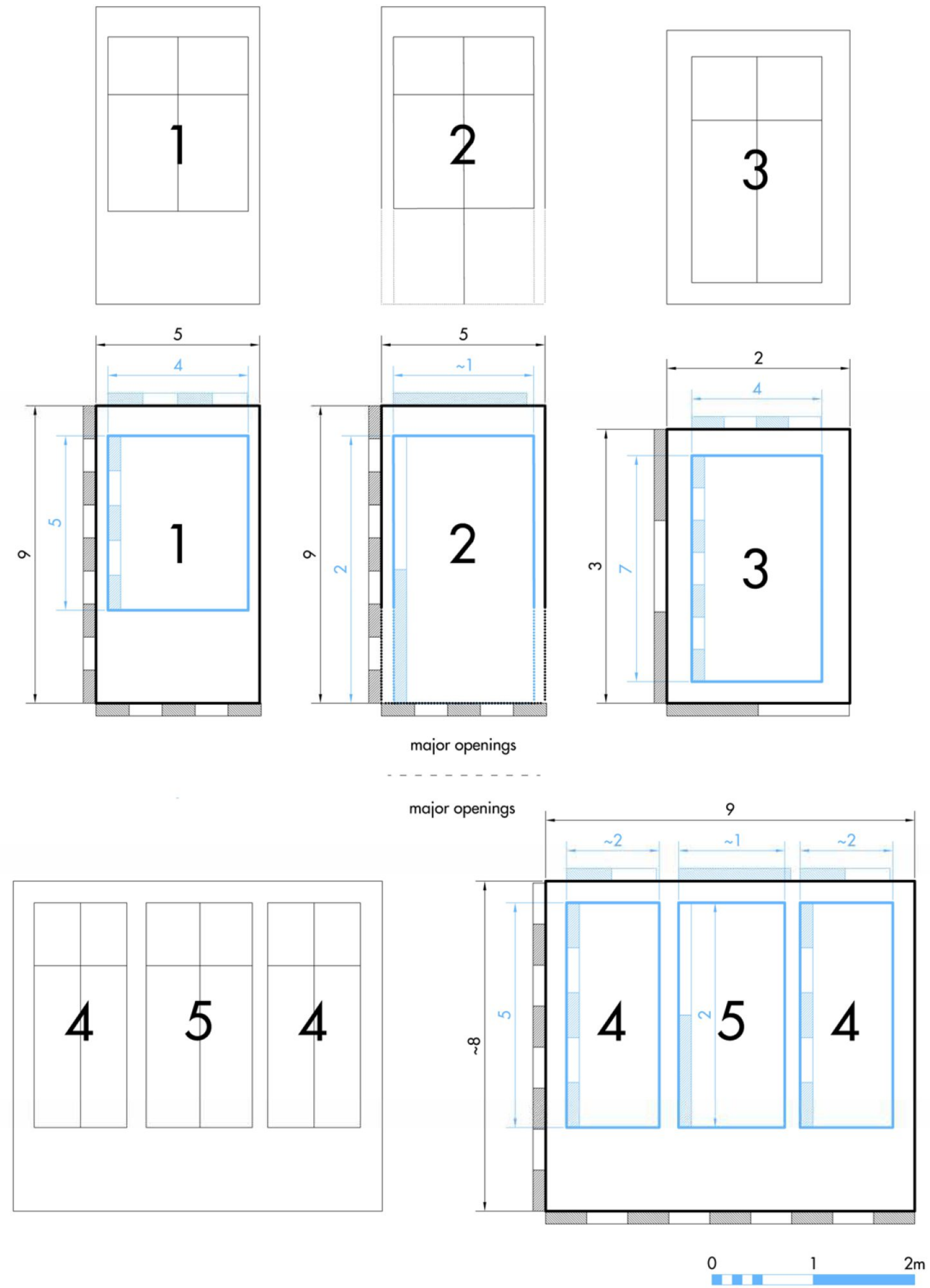


Fig. P.89 Geometrical analysis of openings: (Ba-Wü03) Summerhouse of Mr. Schwarzweber, Freiburg

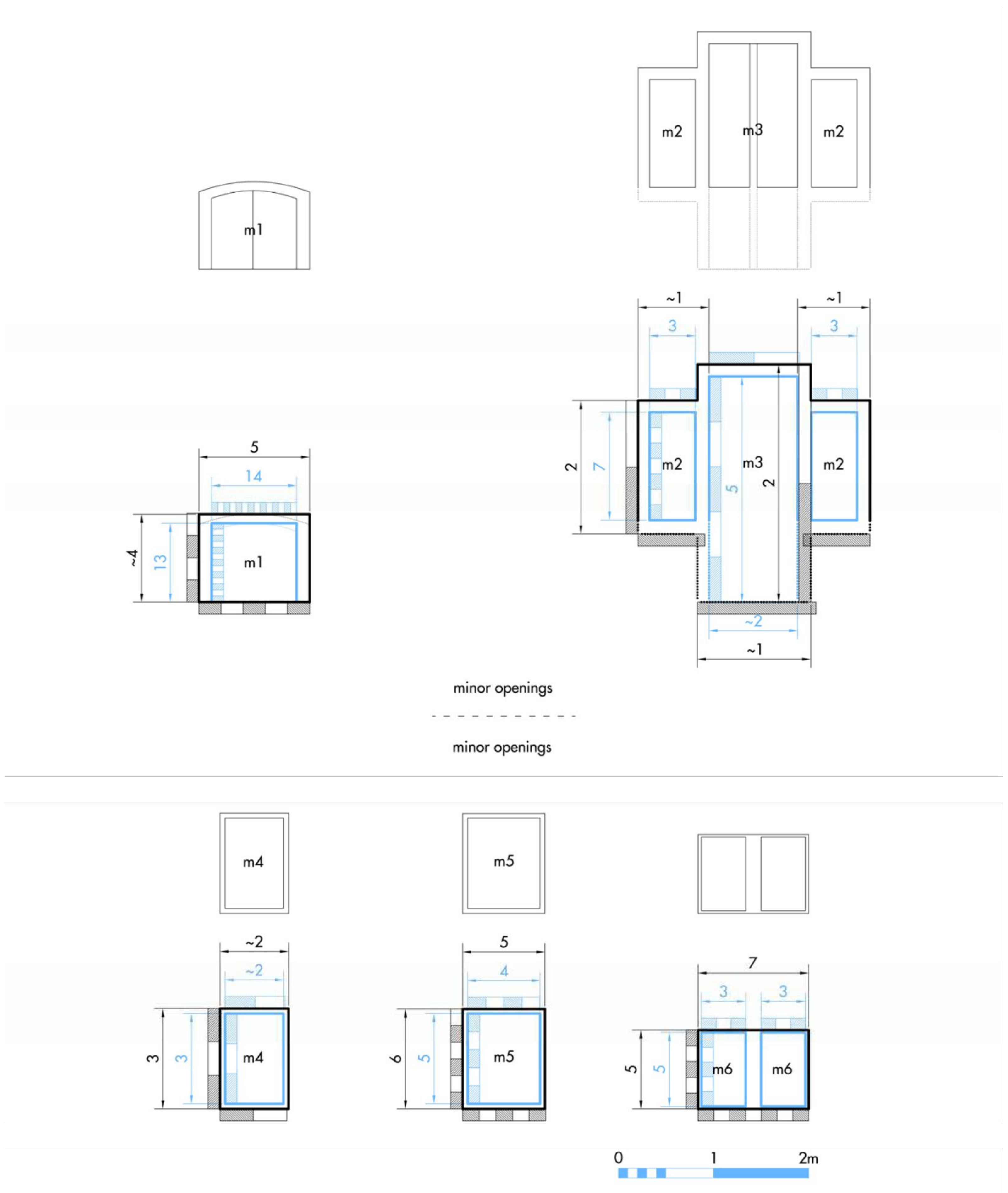


Fig. P.90 Geometrical analysis of openings: (Ba-Wü03) Summerhouse of Mr. Schwarzweber, Freiburg

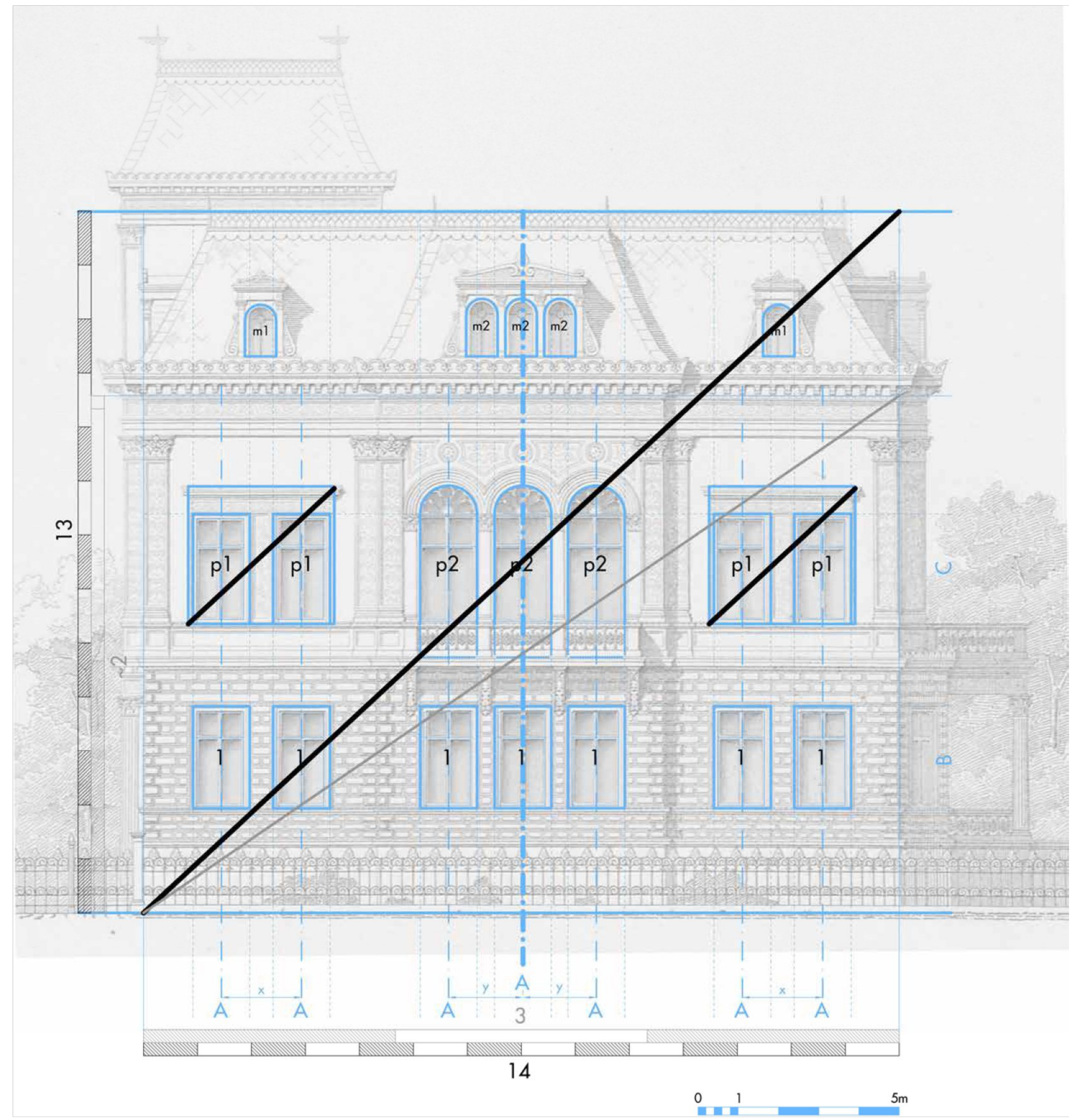


Fig. P.91 Geometrical analysis of front elevation: (BerV01) Residential house No. 13, Victoria-Straße

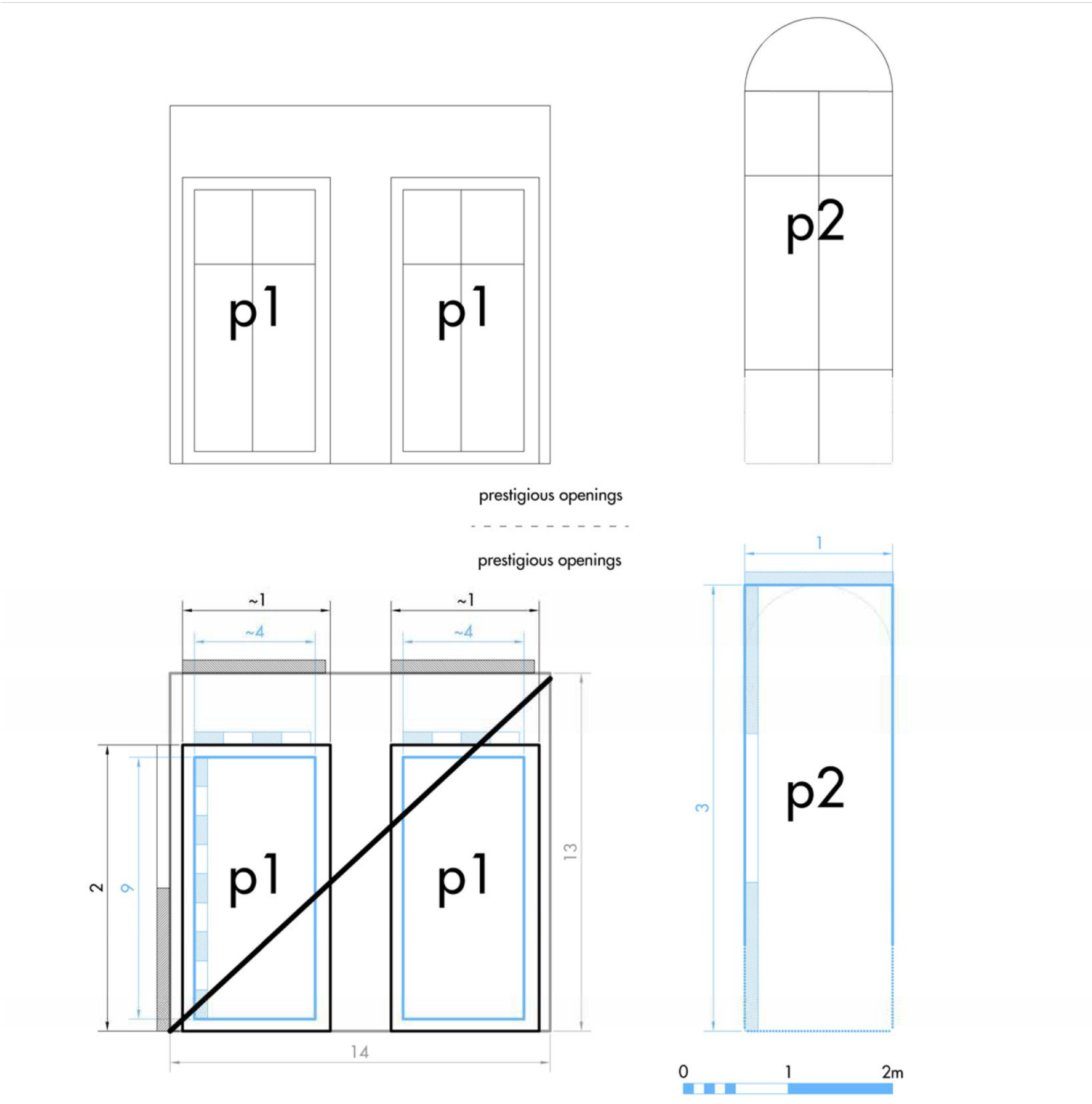


Fig. P.92 Geometrical analysis of front elevation: (BerV01) Residential house No. 13, Victoria-Straße

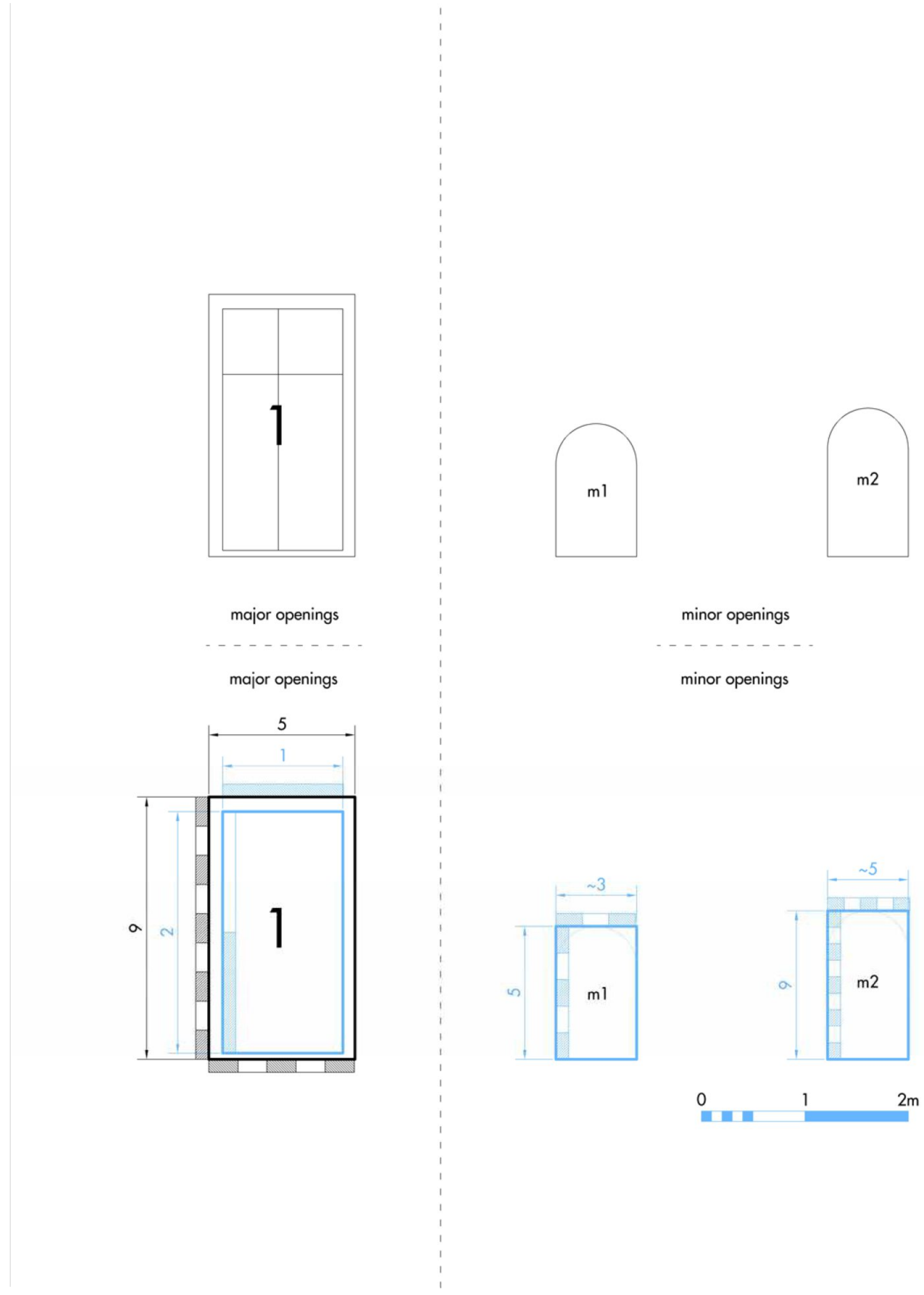


Fig. P.93 Geometrical analysis of front elevation: (BerV01) Residential house No. 13, Victoria-Straße

Fig. P.94 Geometrical analysis of front elevation: (BerV02) Residential house No. 7, Victoria-Straße

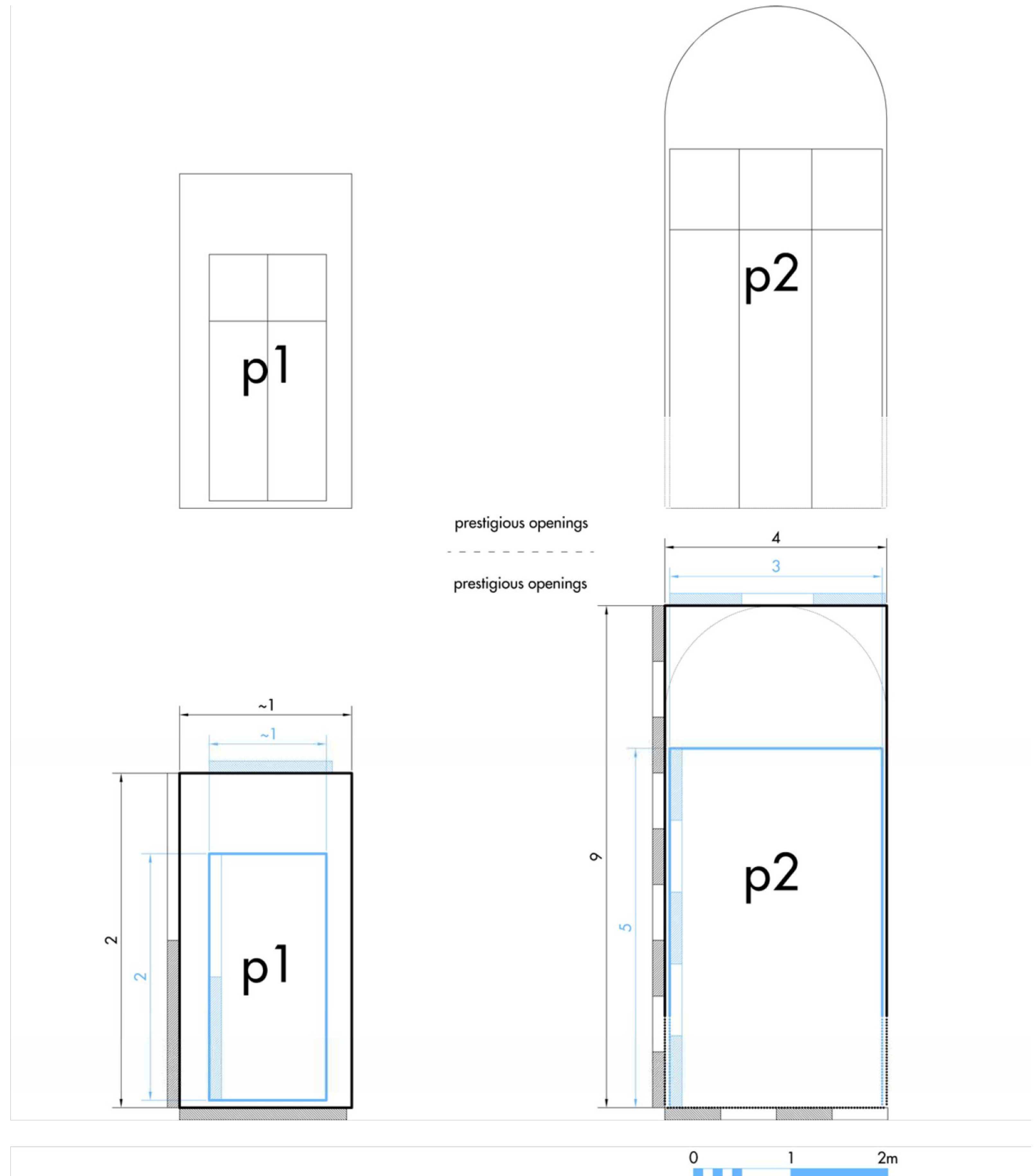


Fig. P.95 Geometrical analysis of openings: (BerV02) Residential house No. 7, Victoria-Straße

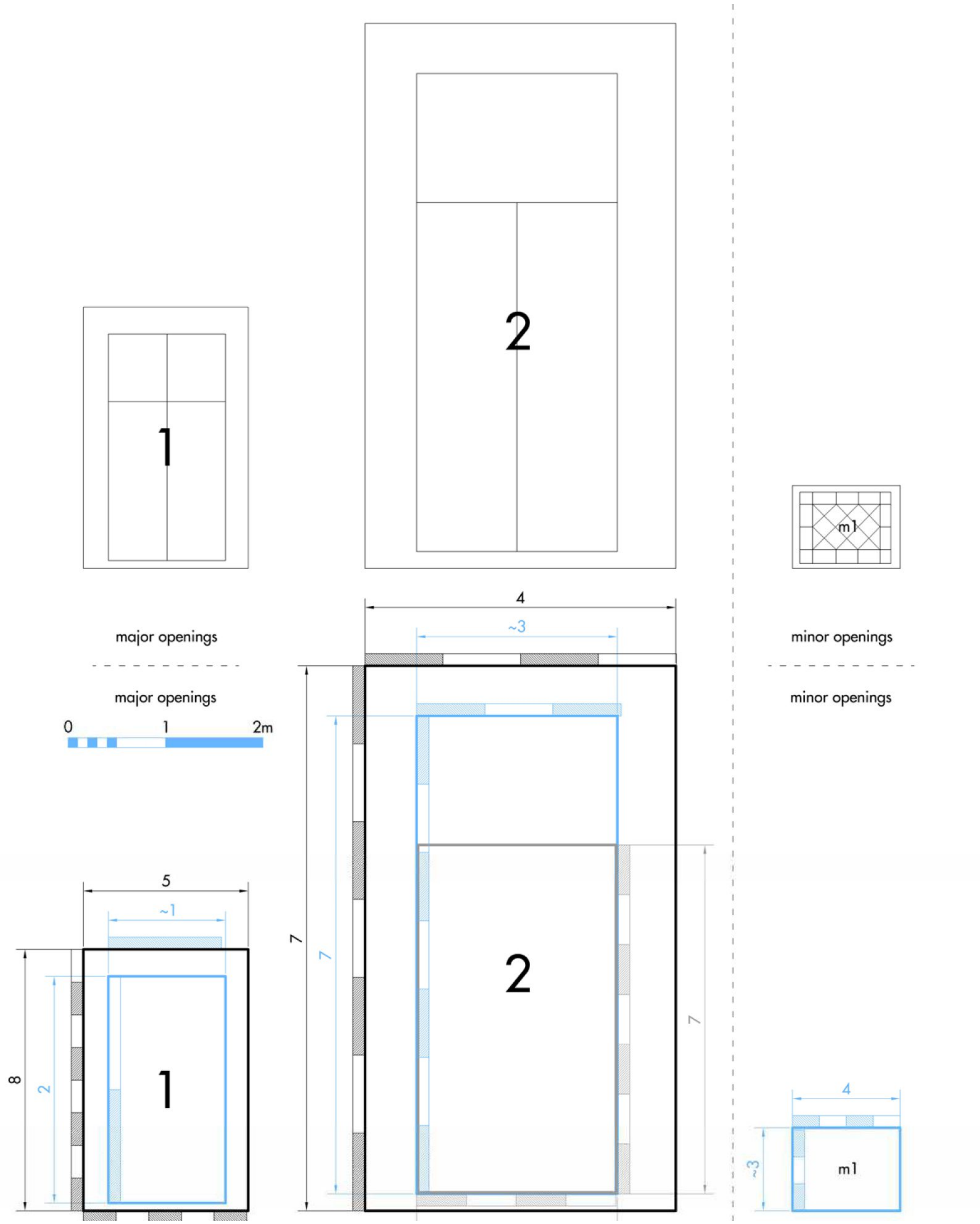


Fig. P.96 Geometrical analysis of openings: (BerV02) Residential house No. 7, Victoria-Straße

Fig. P.97 Geometrical analysis of front elevation: (BerV03) Residential house No. 6, Victoria-Straße

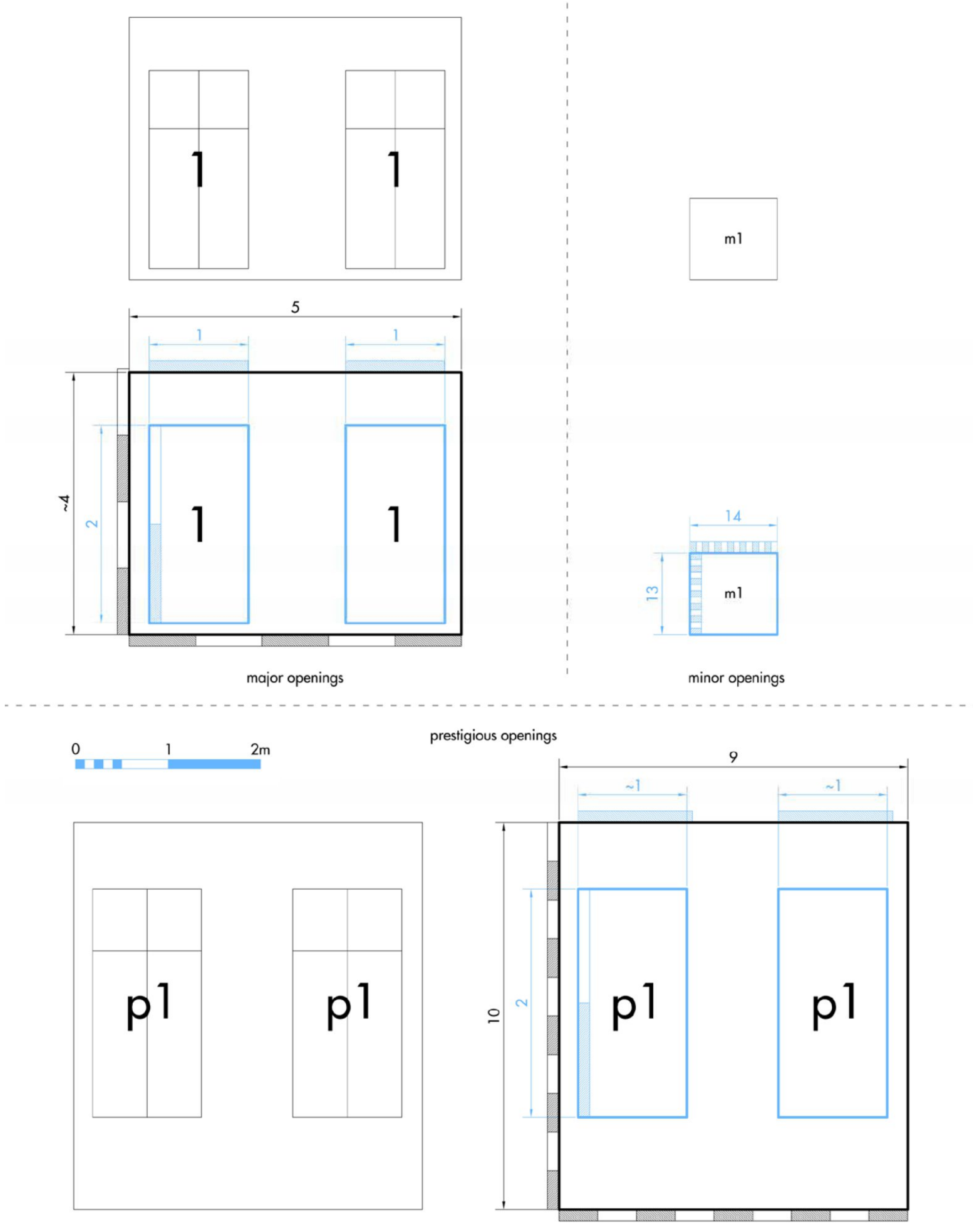


Fig. P.98 Geometrical analysis of openings: (BerV03) Residential house No. 6, Victoria-Straße

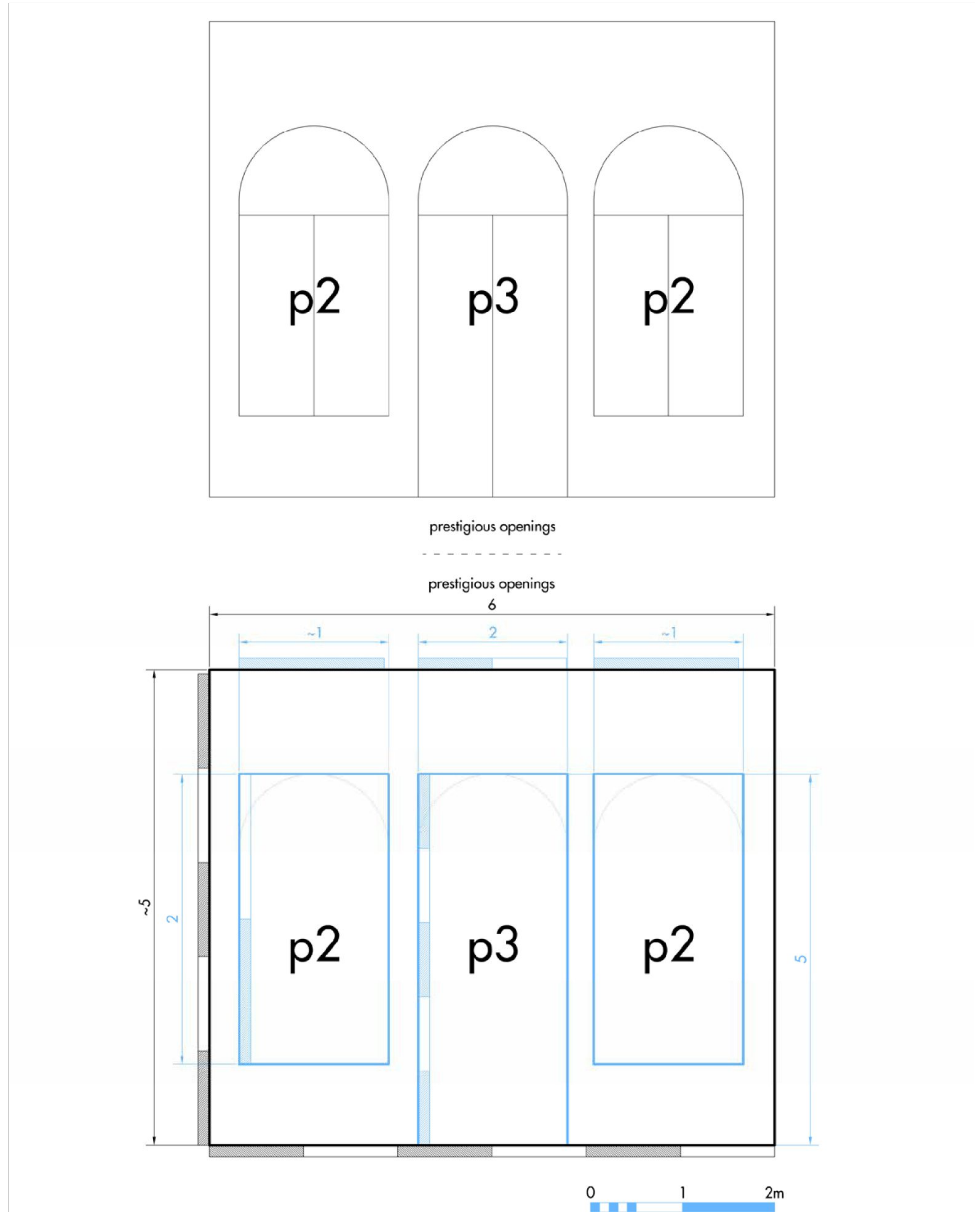


Fig. P.99 Geometrical analysis of openings: (BerV03) Residential house No. 6, Victoria-Straße

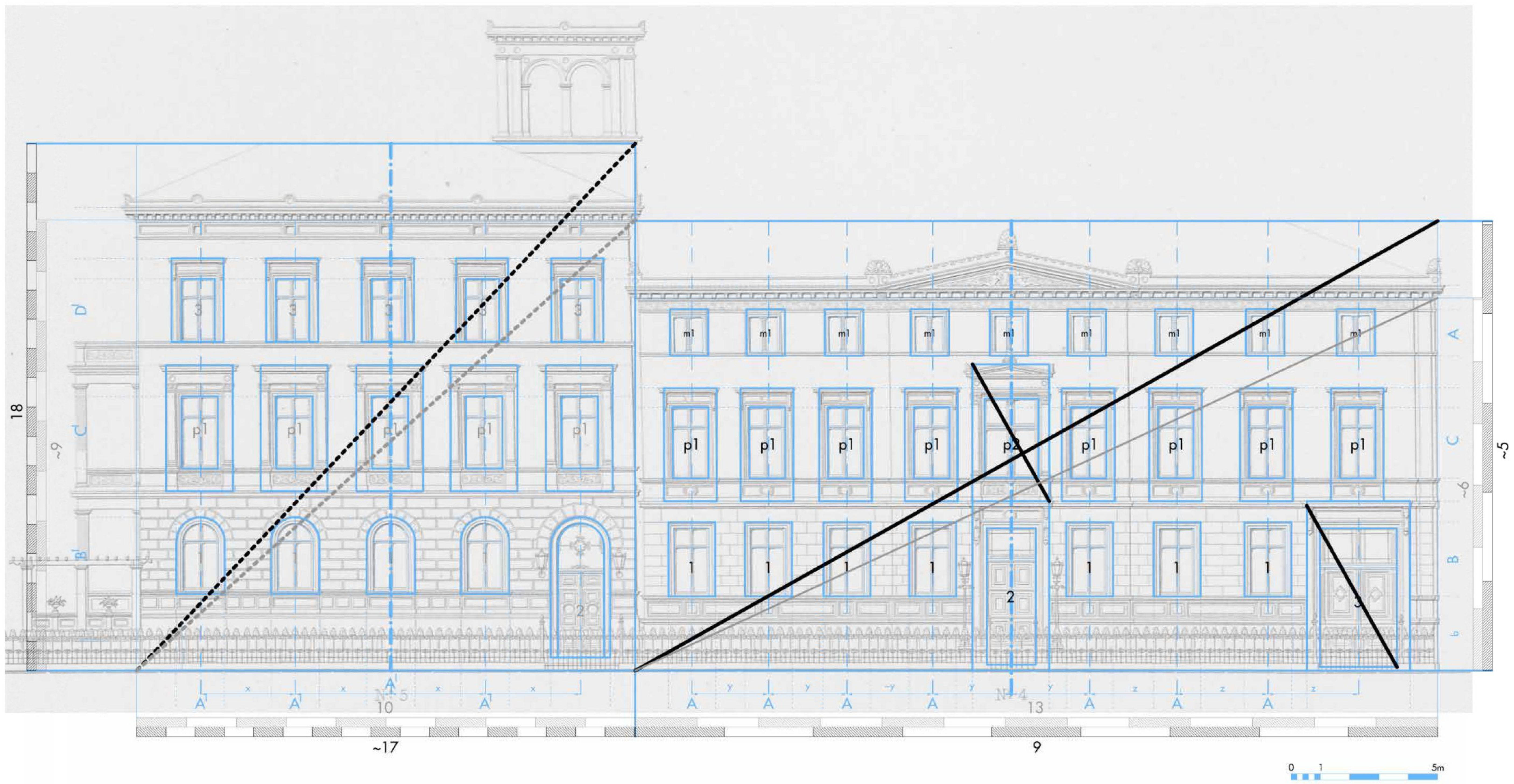


Fig. P.100 Geometrical analysis of front elevation: (BerV04) Residential house No. 5, Victoria-Straße
Fig. P.101 Geometrical analysis of front elevation: (BerV05) Residential house No. 4, Victoria-Straße

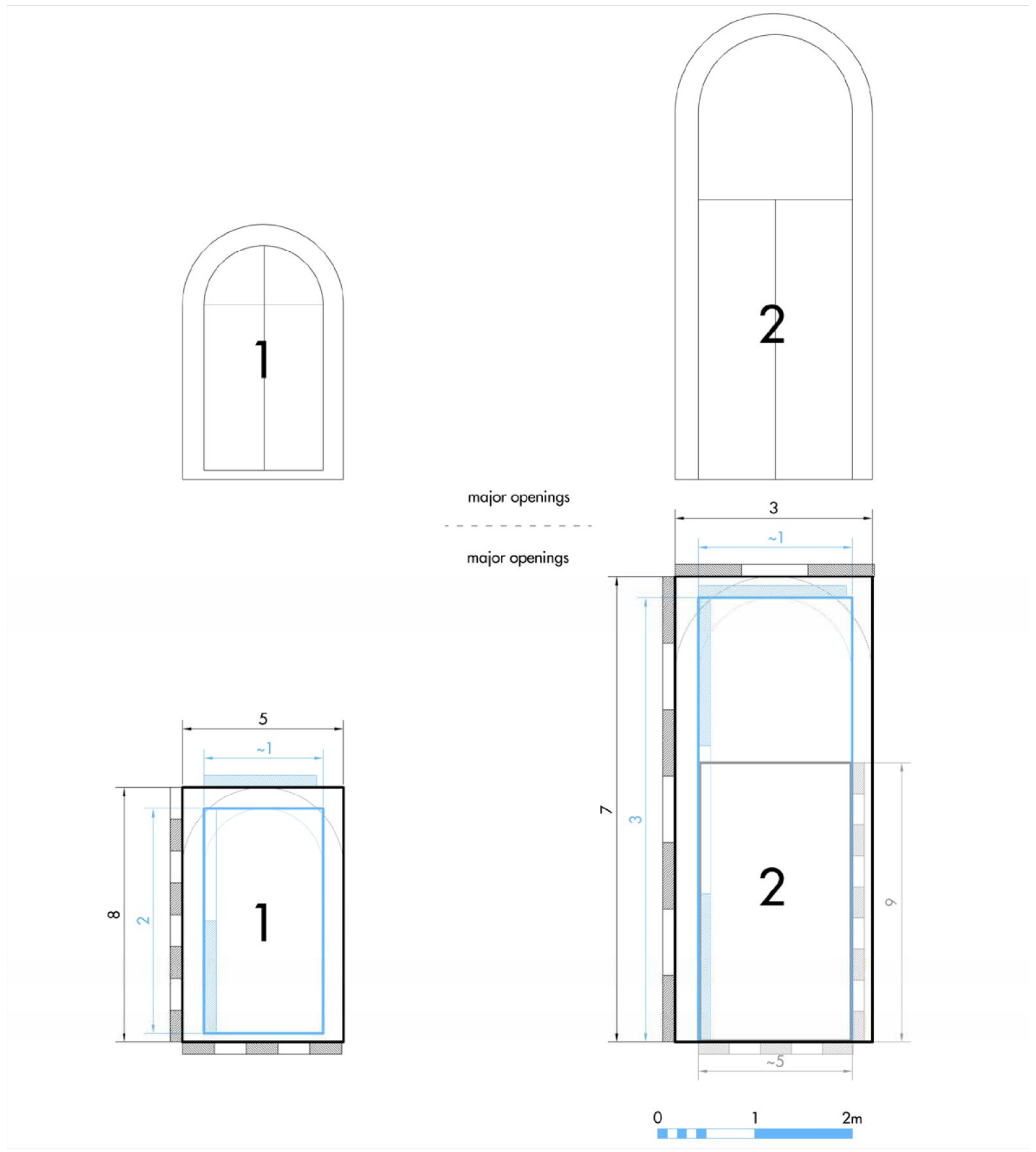


Fig. P.102 Geometrical analysis of openings: (BerV04) Residential house No. 5, Victoria-Straße

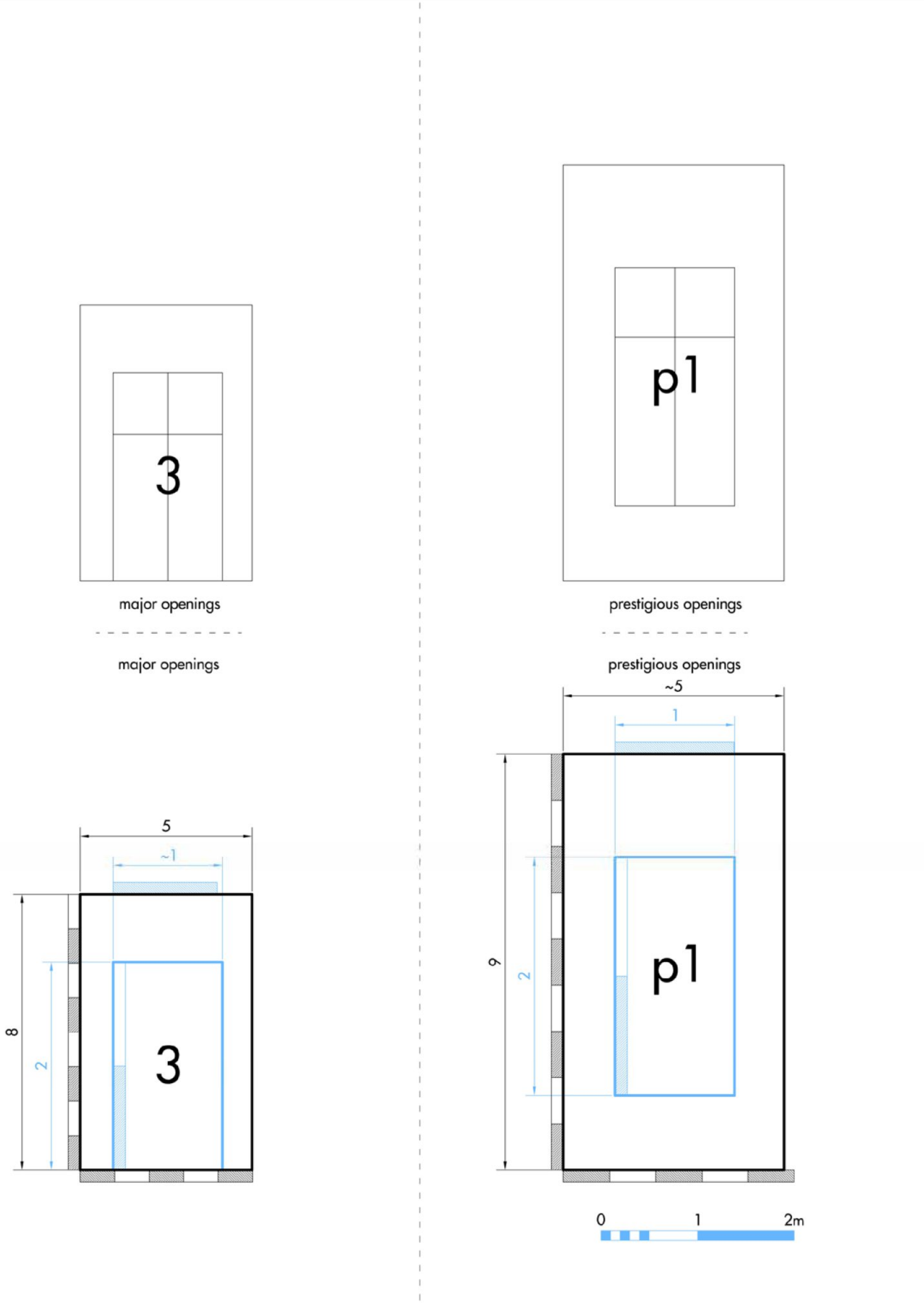


Fig. P.103 Geometrical analysis of openings: (BerV04) Residential house No. 5, Victoria-Straße

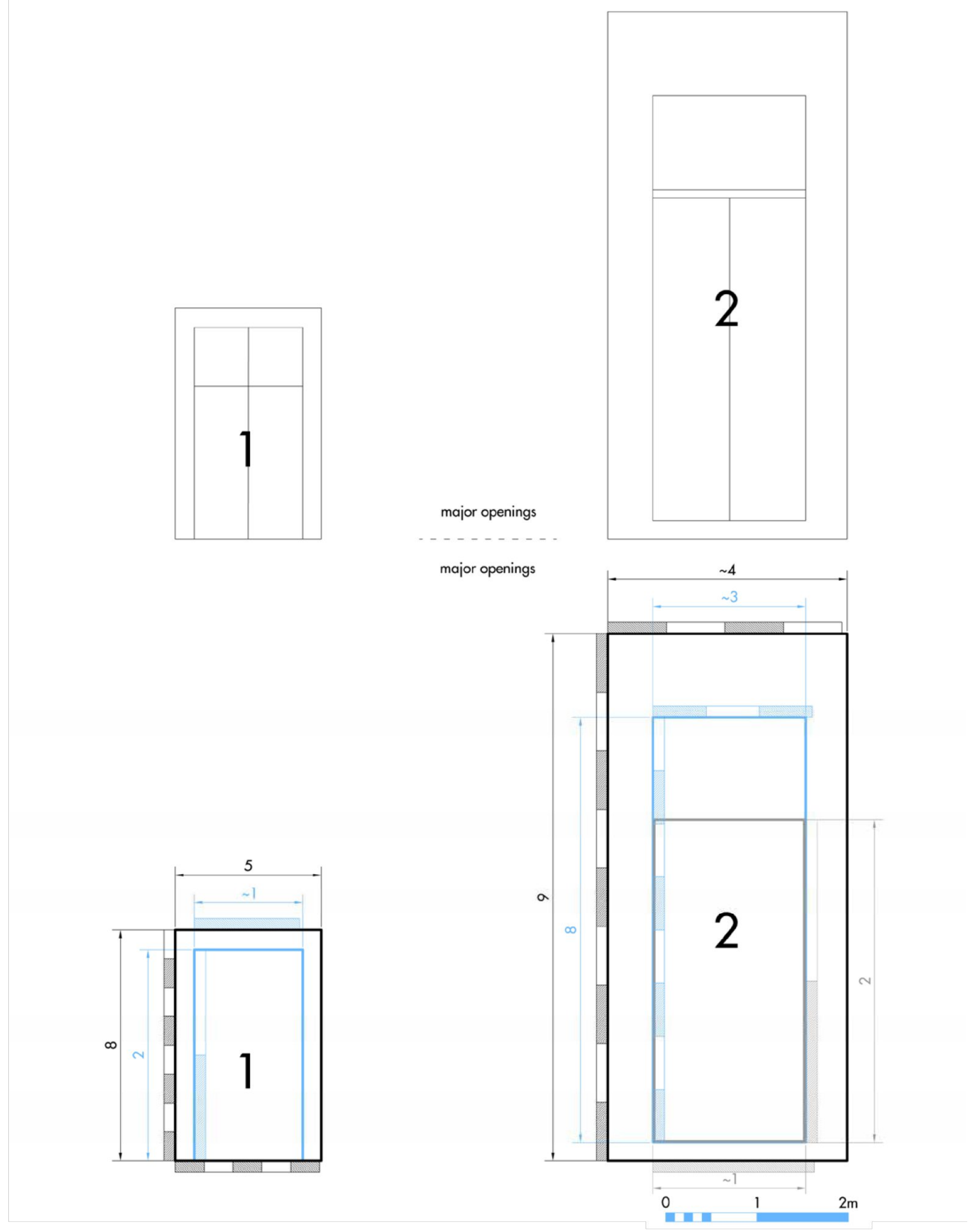


Fig. P.104 Geometrical analysis of openings: (BerV05) Residential house No. 4, Victoria-Straße

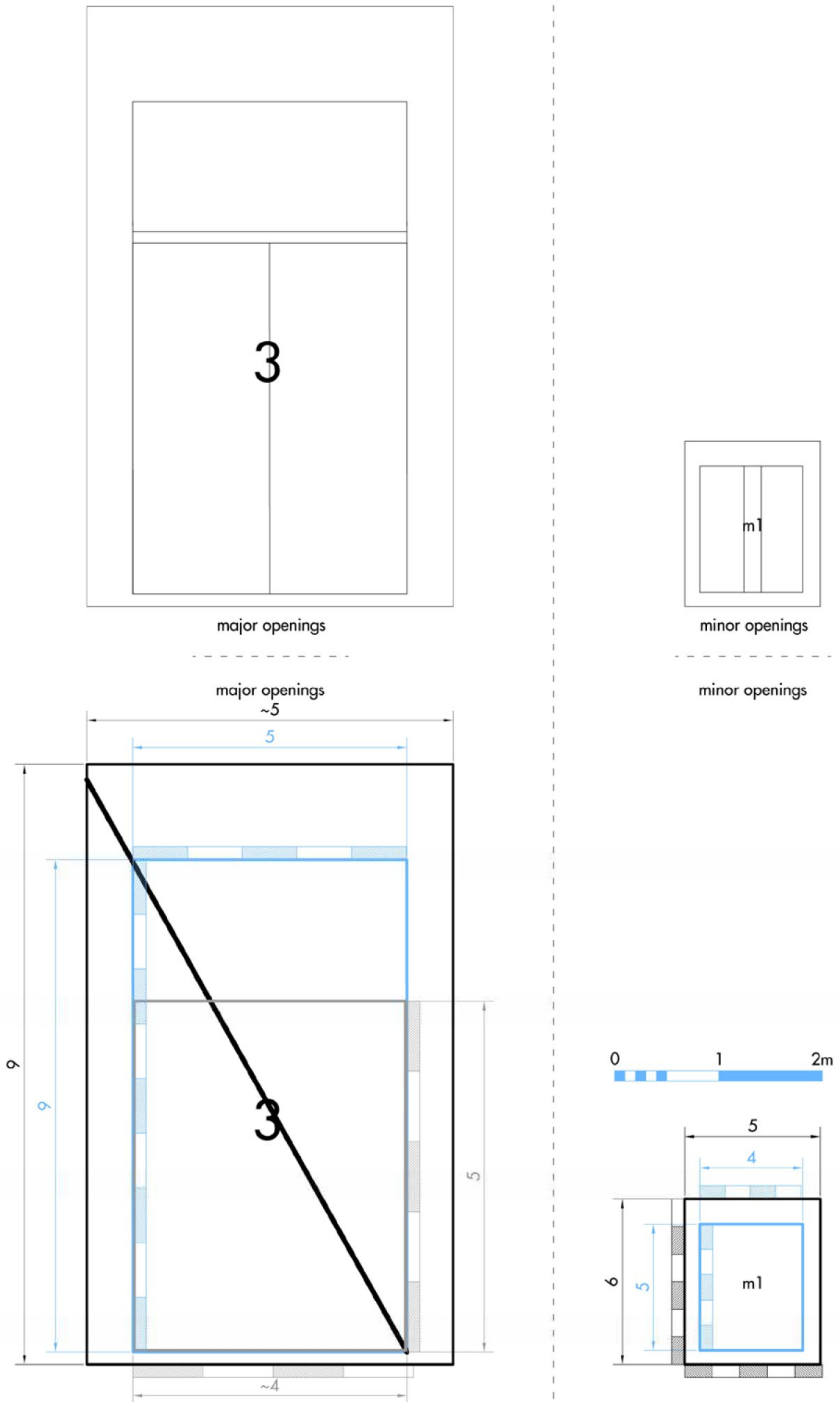


Fig. P.105 Geometrical analysis of openings: (BerV05) Residential house No. 4, Victoria-Straße

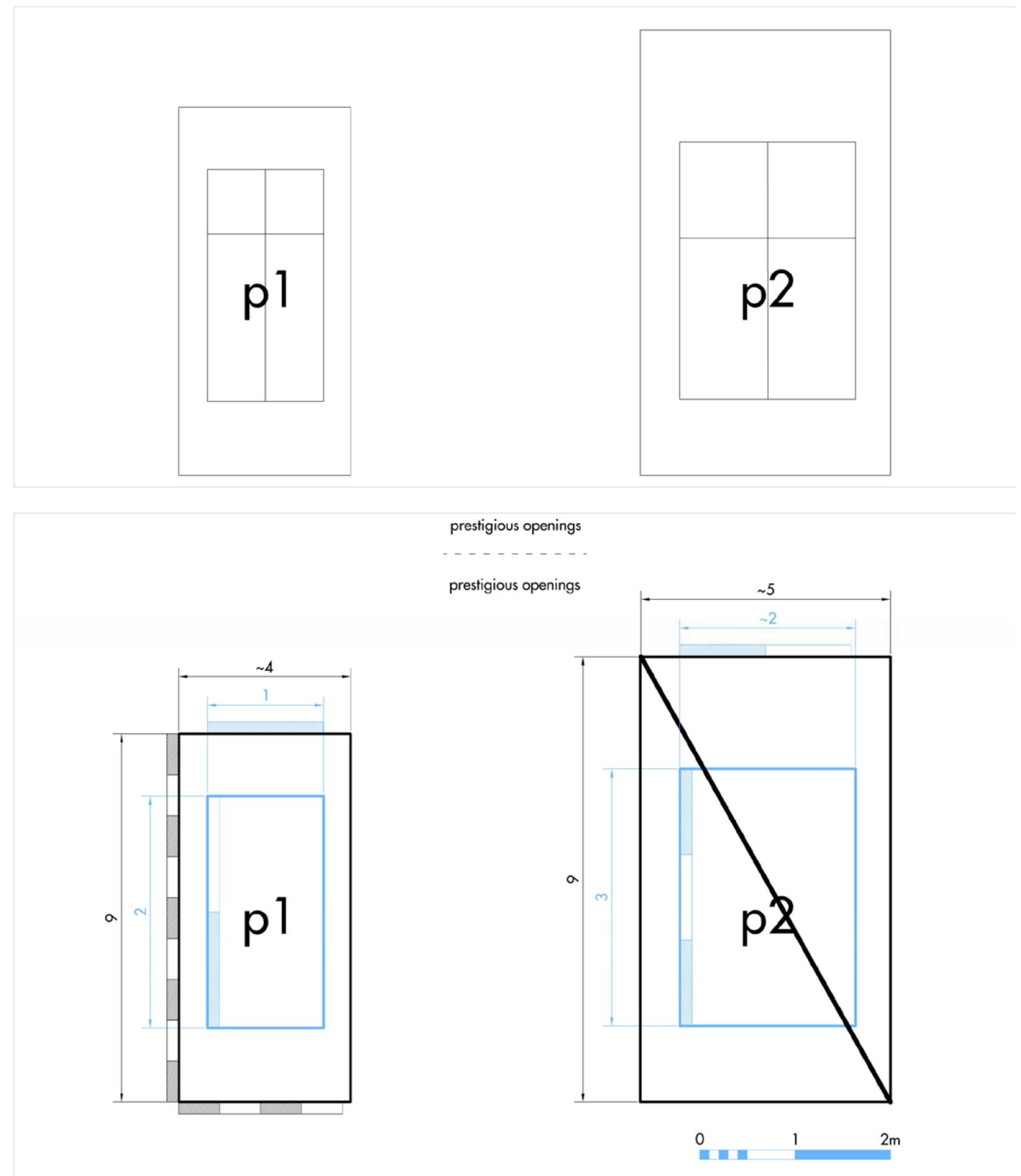


Fig. P.106 Geometrical analysis of openings: (BerV05) Residential house No. 4, Victoria-Straße

Fig. P.107 Geometrical analysis of front elevation: (BerV06) Residential house No. 12, Victoria-Straße

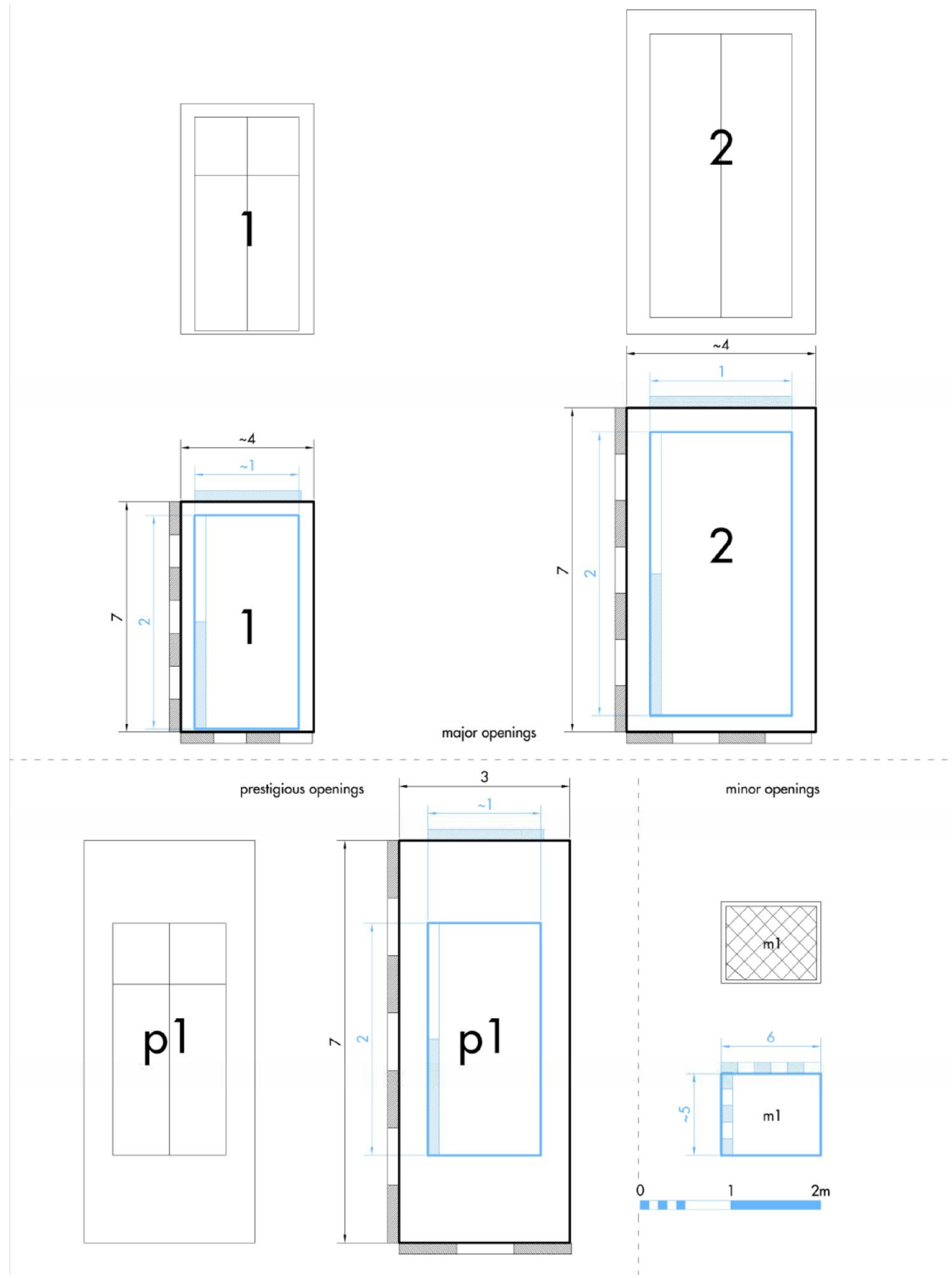


Fig. P.108 Geometrical analysis of openings: (BerV06) Residential house No. 12, Victoria-Straße

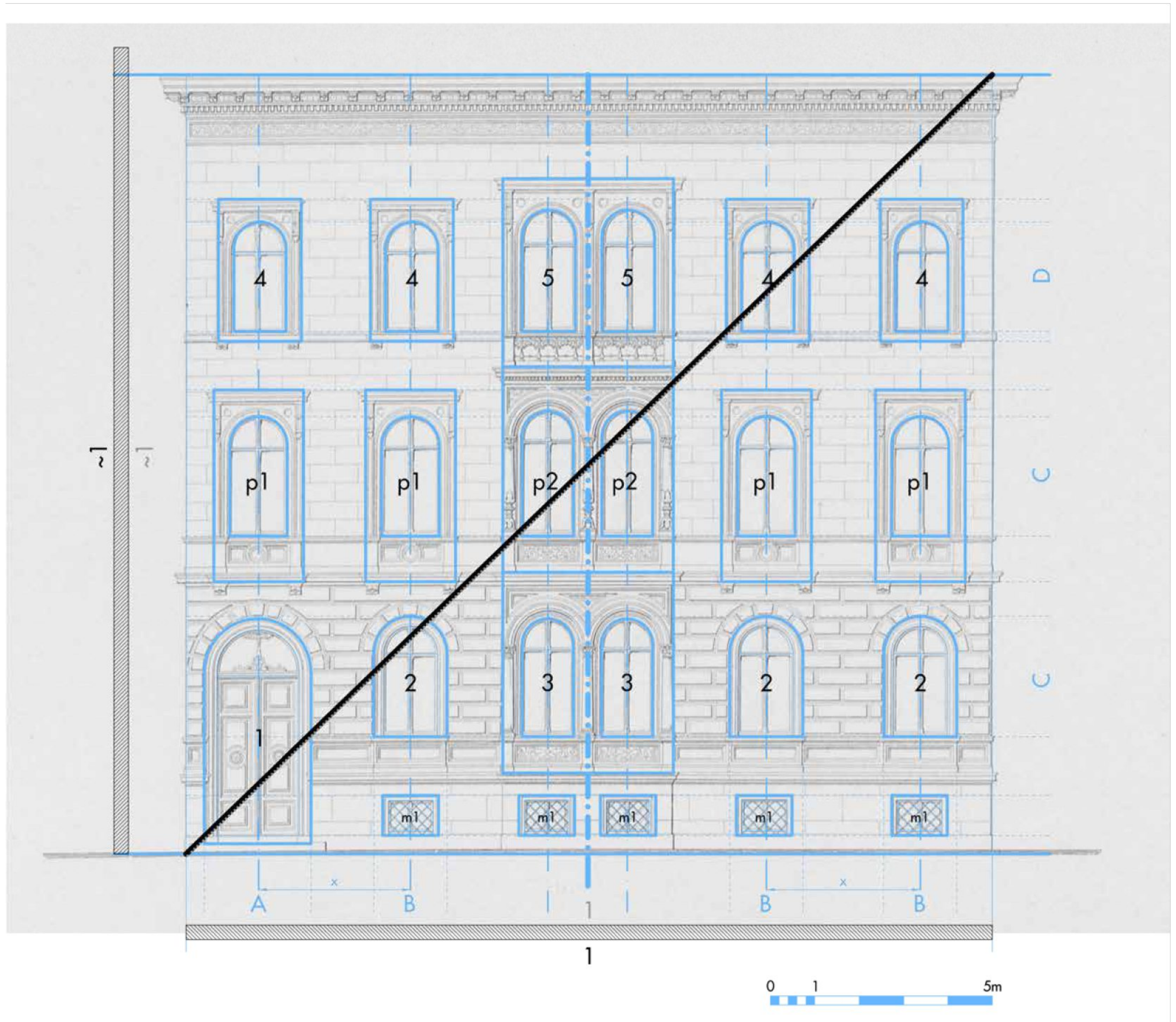


Fig. P.109 Geometrical analysis of front elevation: (BerV07) Residential house, Victoria-Straße

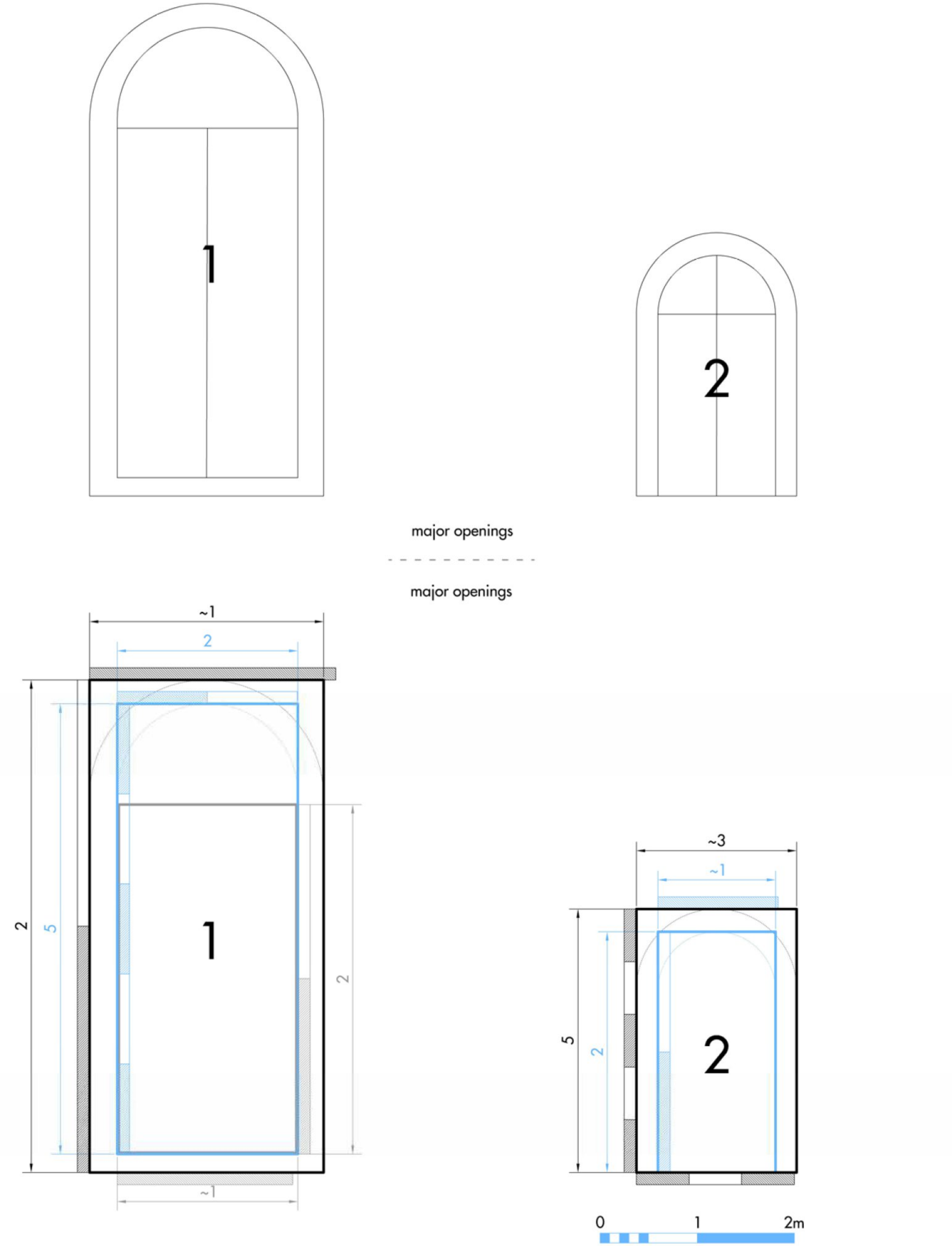


Fig. P.110 Geometrical analysis of openings: (BerV07) Residential house, Victoria-Straße

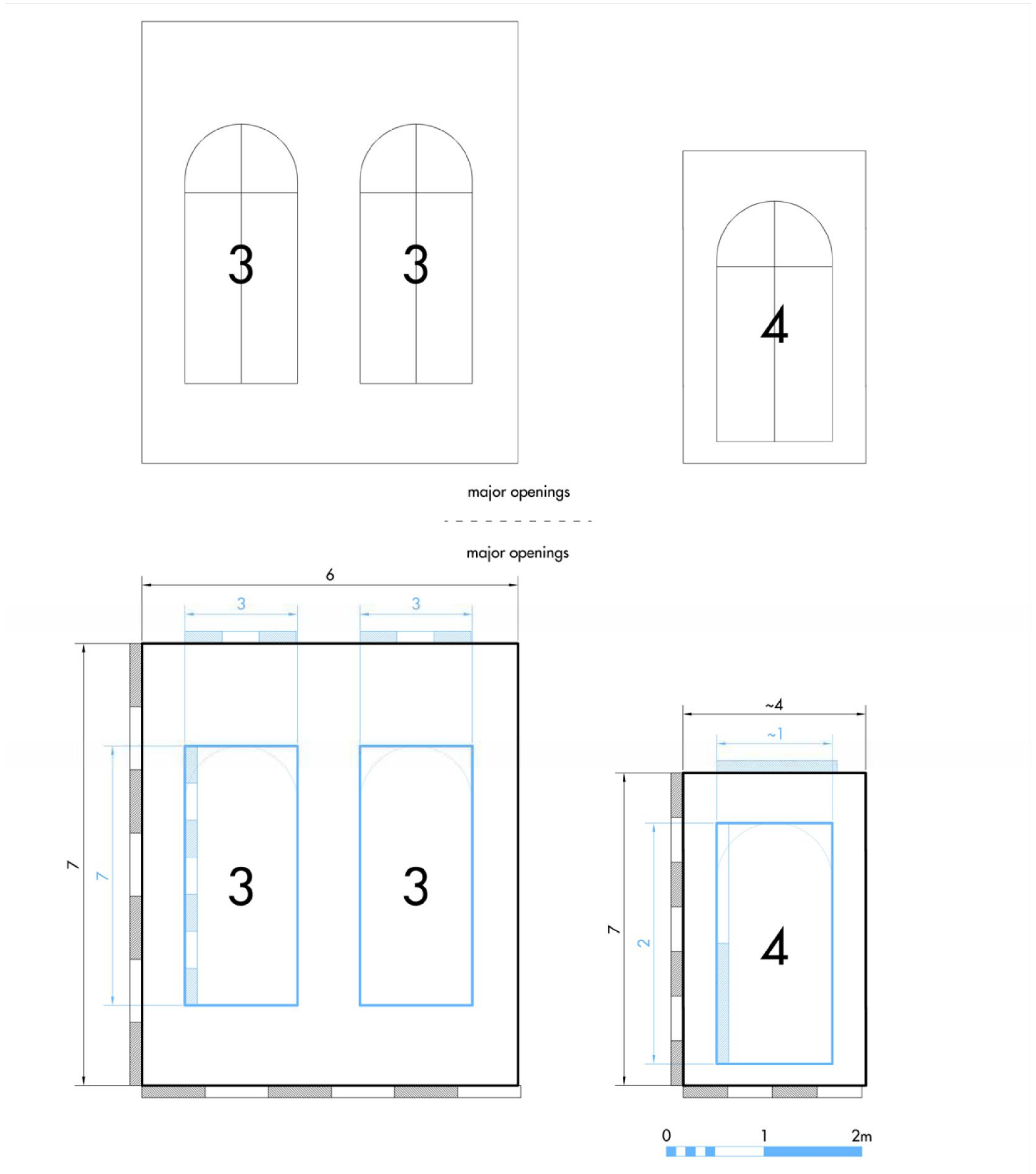


Fig. P.111 Geometrical analysis of openings: (BerV07) Residential house, Victoria-Straße

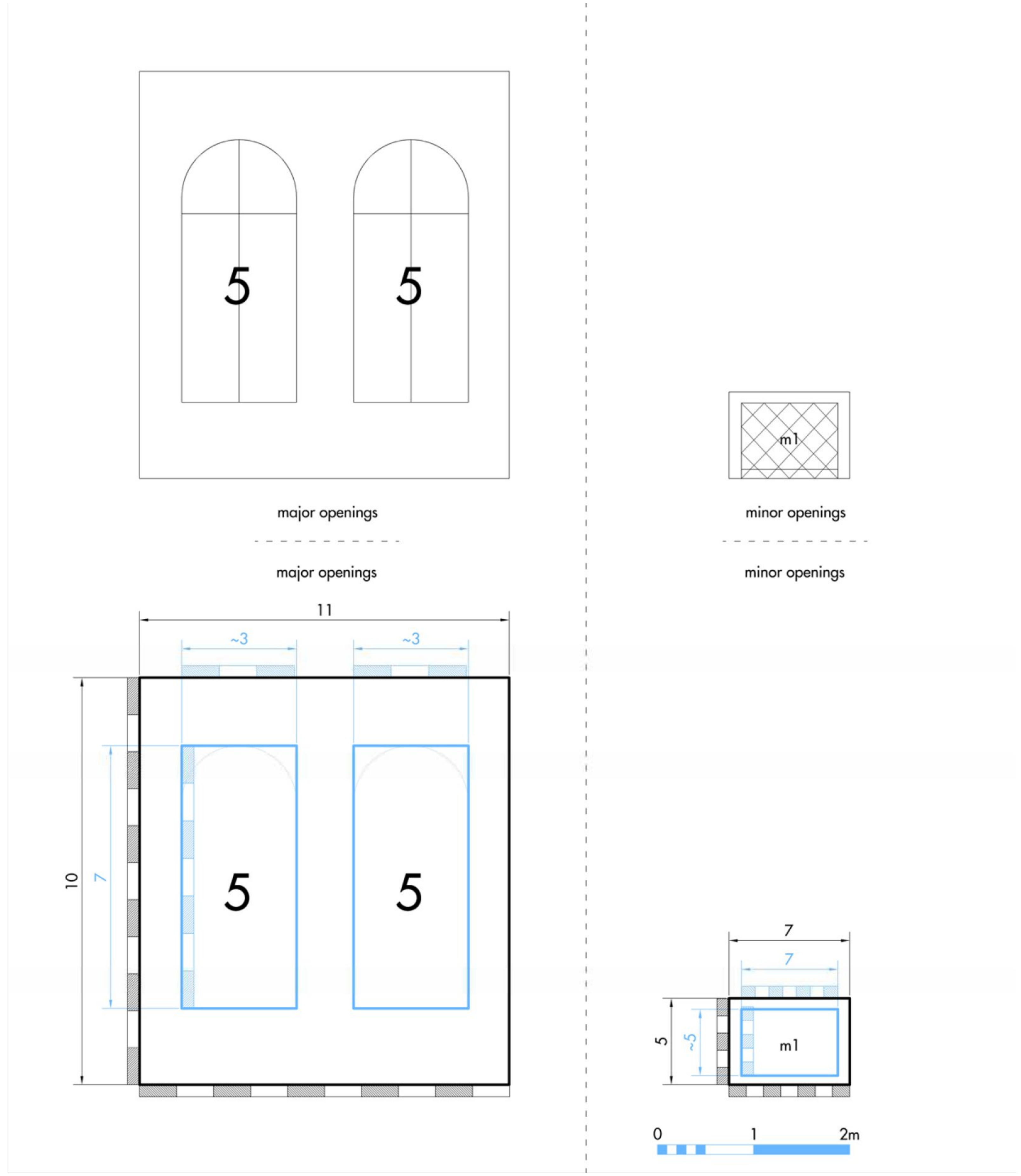


Fig. P.112 Geometrical analysis of openings: (BerV07) Residential house, Victoria-Straße

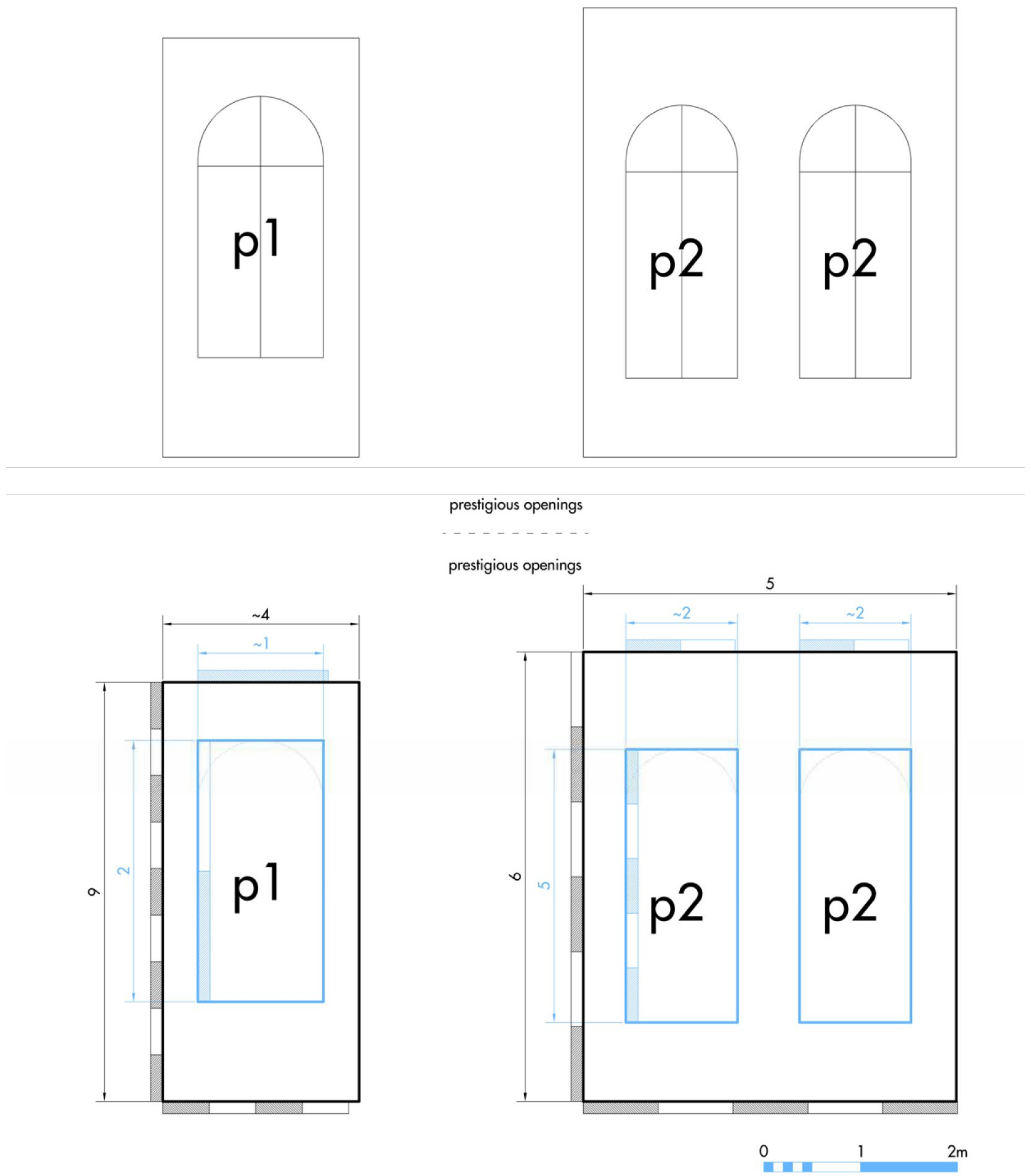


Fig. P.113 Geometrical analysis of openings: (BerV07) Residential house, Victoria-Straße

Fig. P.114 Geometrical analysis of front elevation: (BerV08) Residential house No. 9, Victoria-Straße

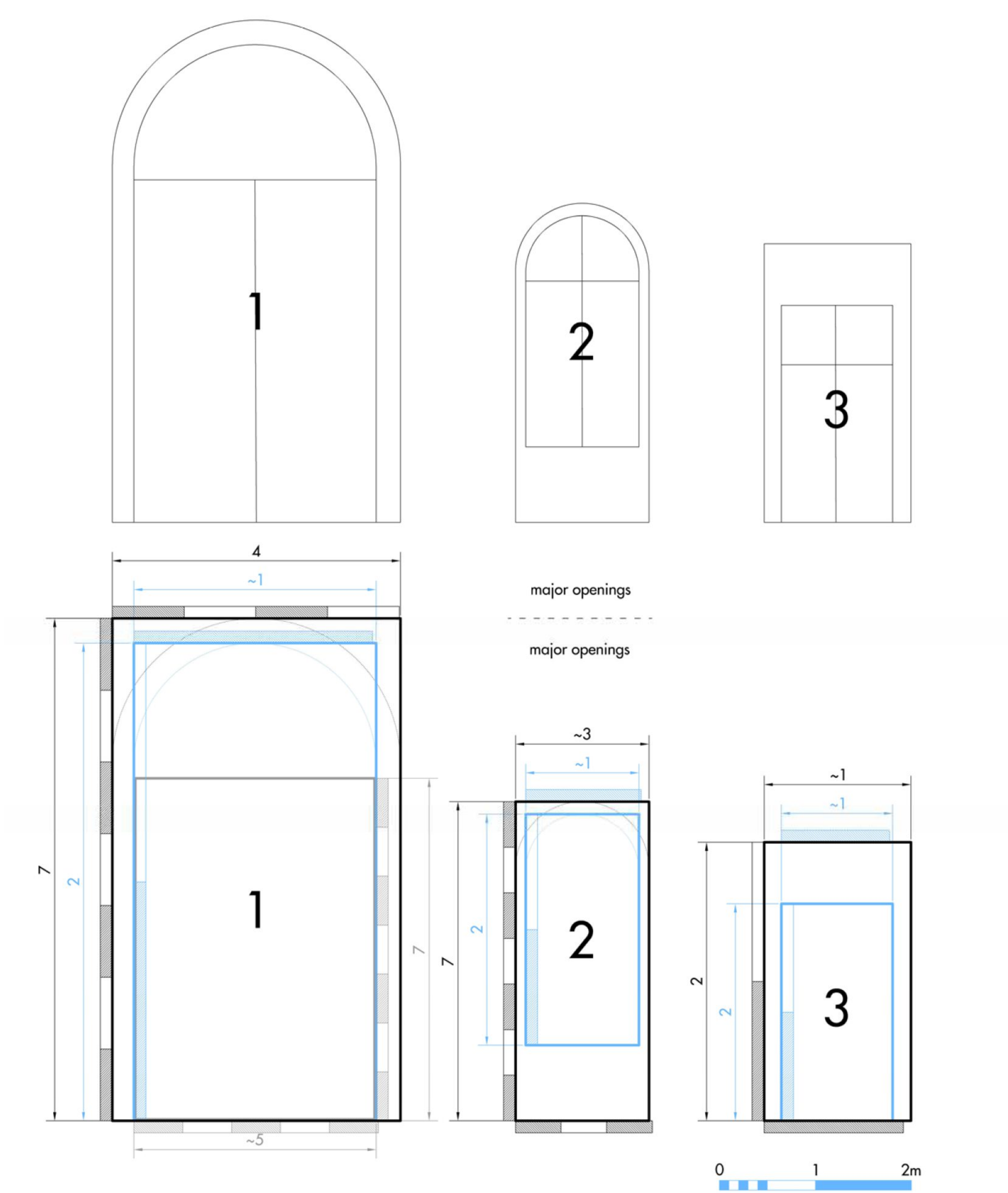


Fig. P.115 Geometrical analysis of openings: (BerV08) Residential house No. 9, Victoria-Straße

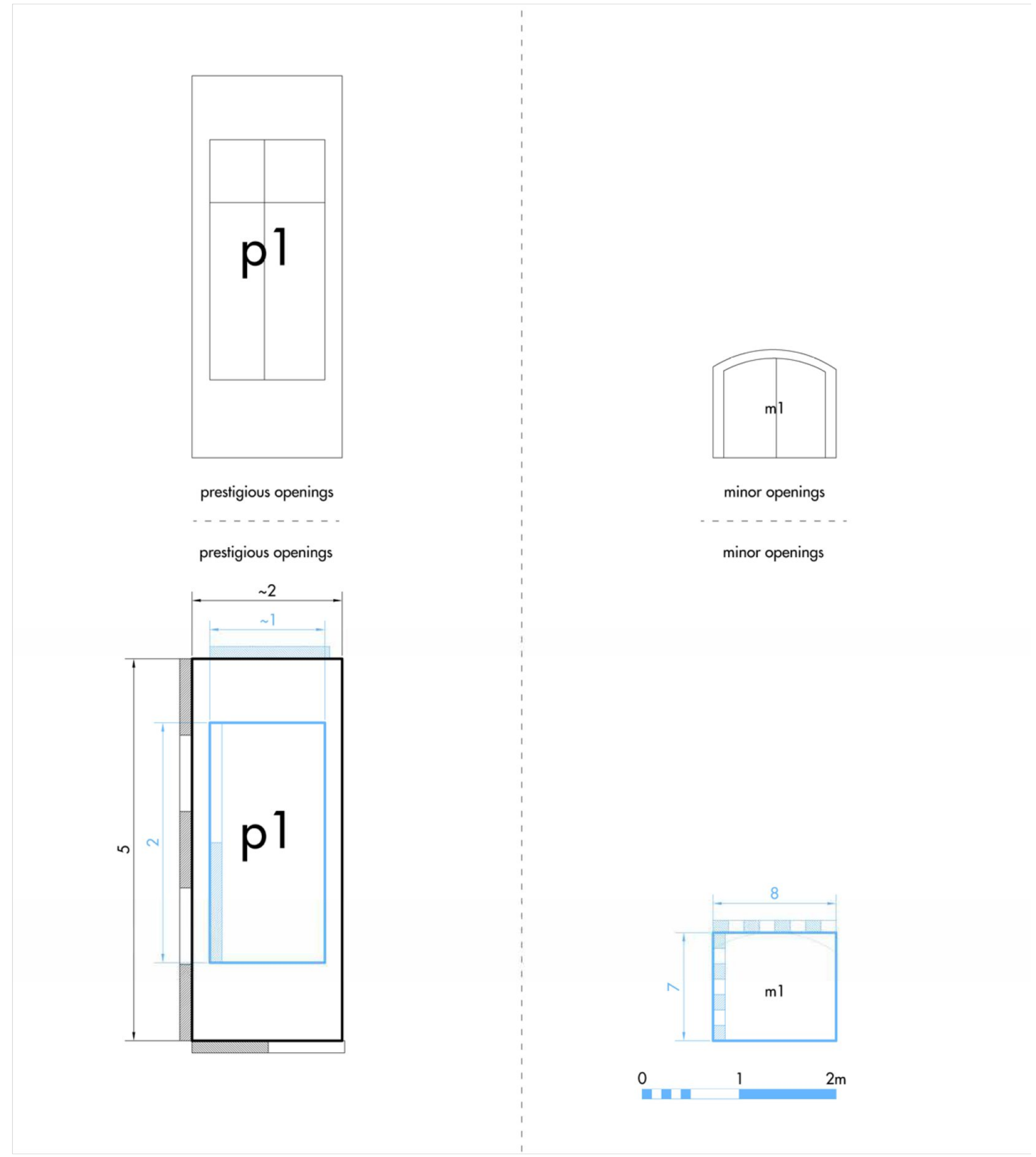


Fig. P.116 Geometrical analysis of openings: (BerV08) Residential house No. 9, Victoria-Straße

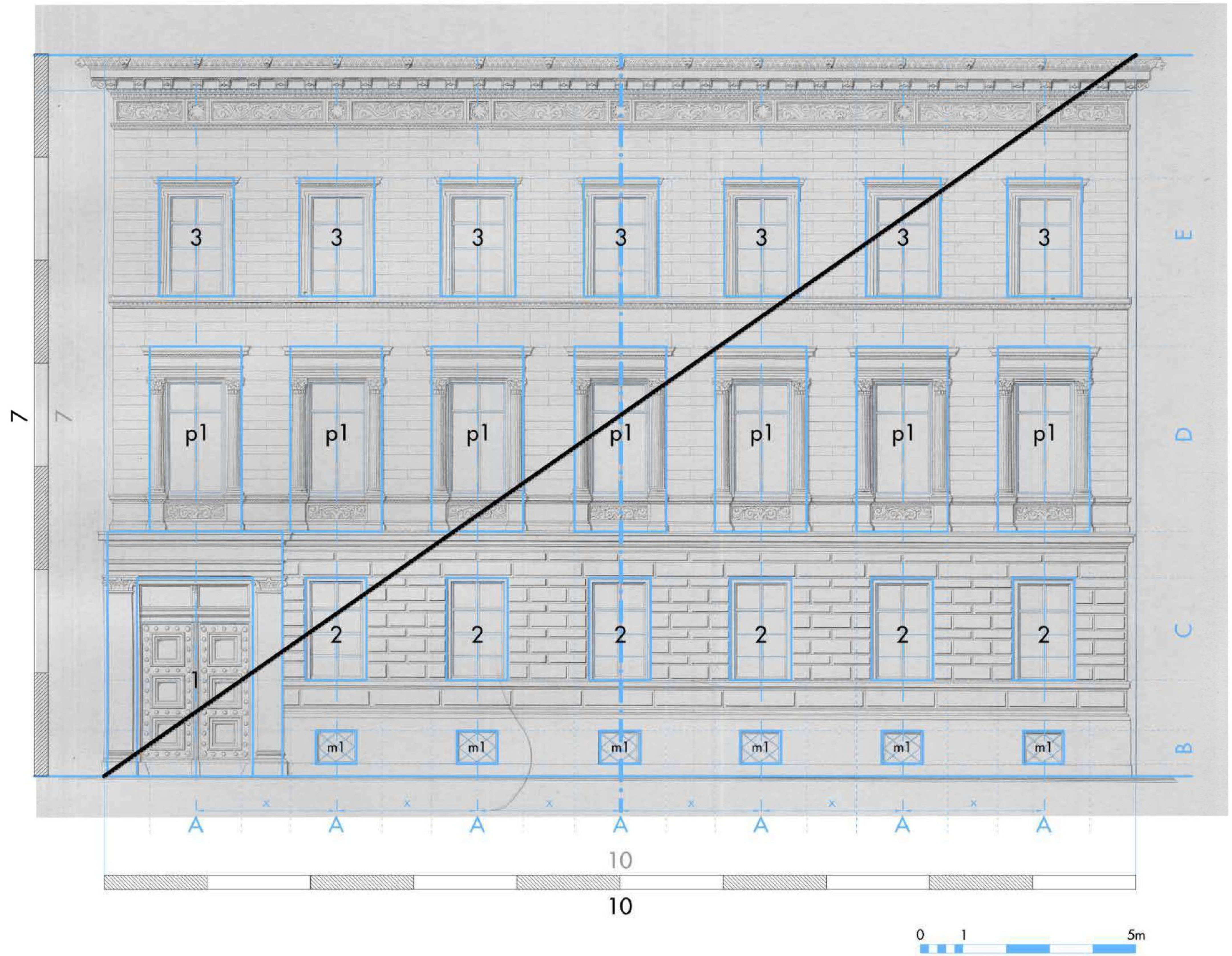


Fig. P.117 Geometrical analysis of front elevation: (Ber01) Residential house

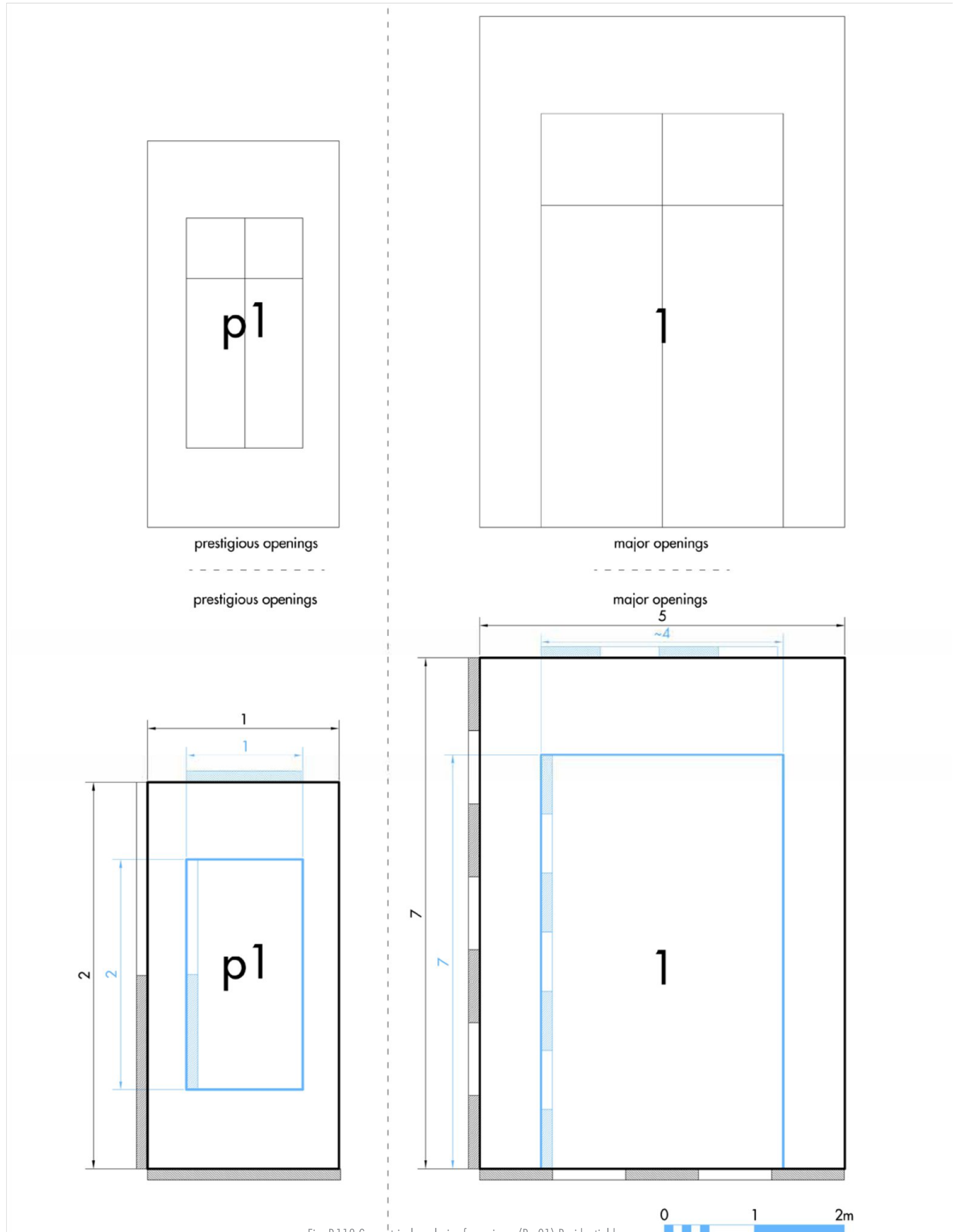


Fig. P.118 Geometrical analysis of openings: (Ber01) Residential house

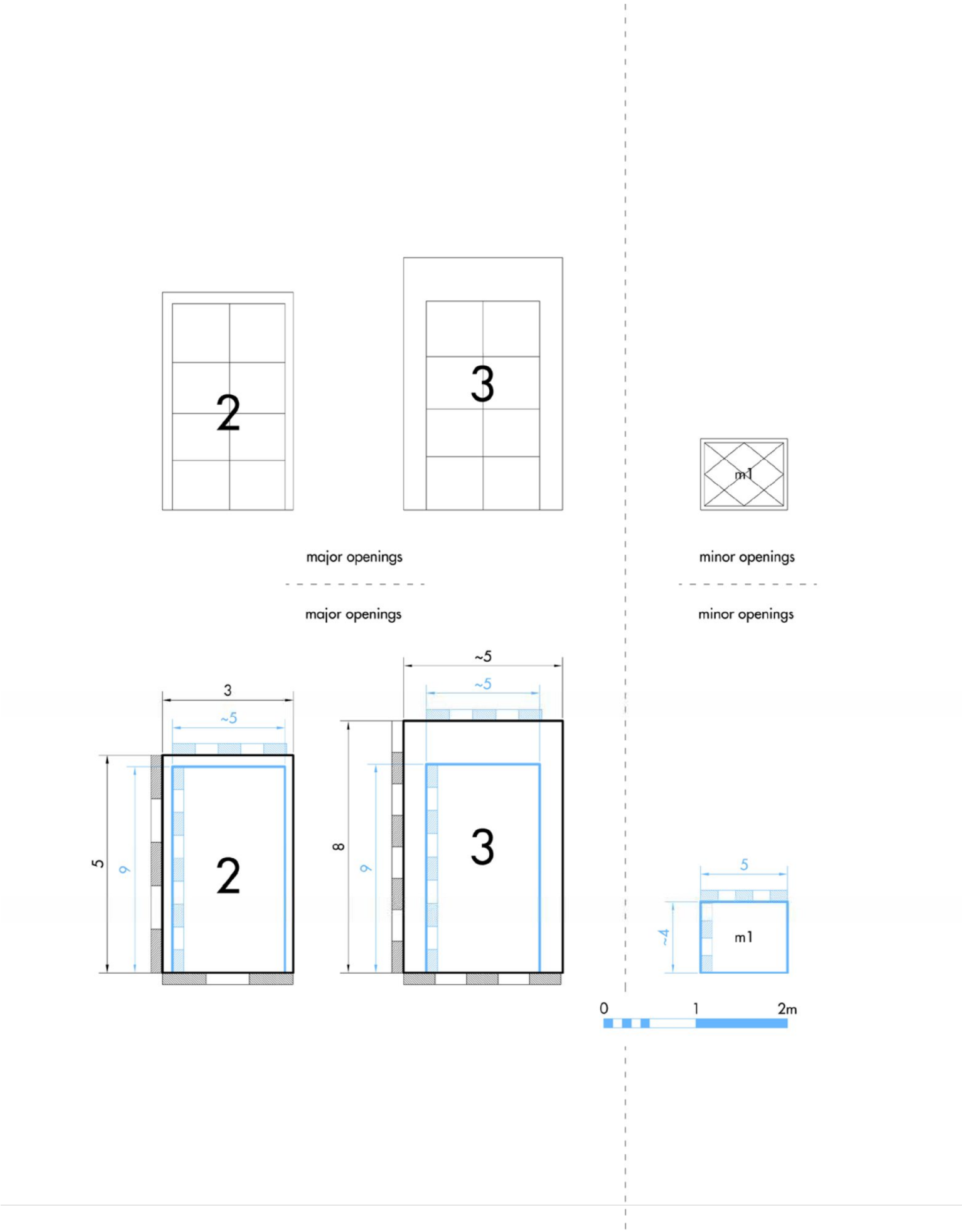


Fig. P.119 Geometrical analysis of openings: (Ber01) Residential house

Fig. P.120 Geometrical analysis of front elevation: (Ber02) Residential house, Unter den Linden 42

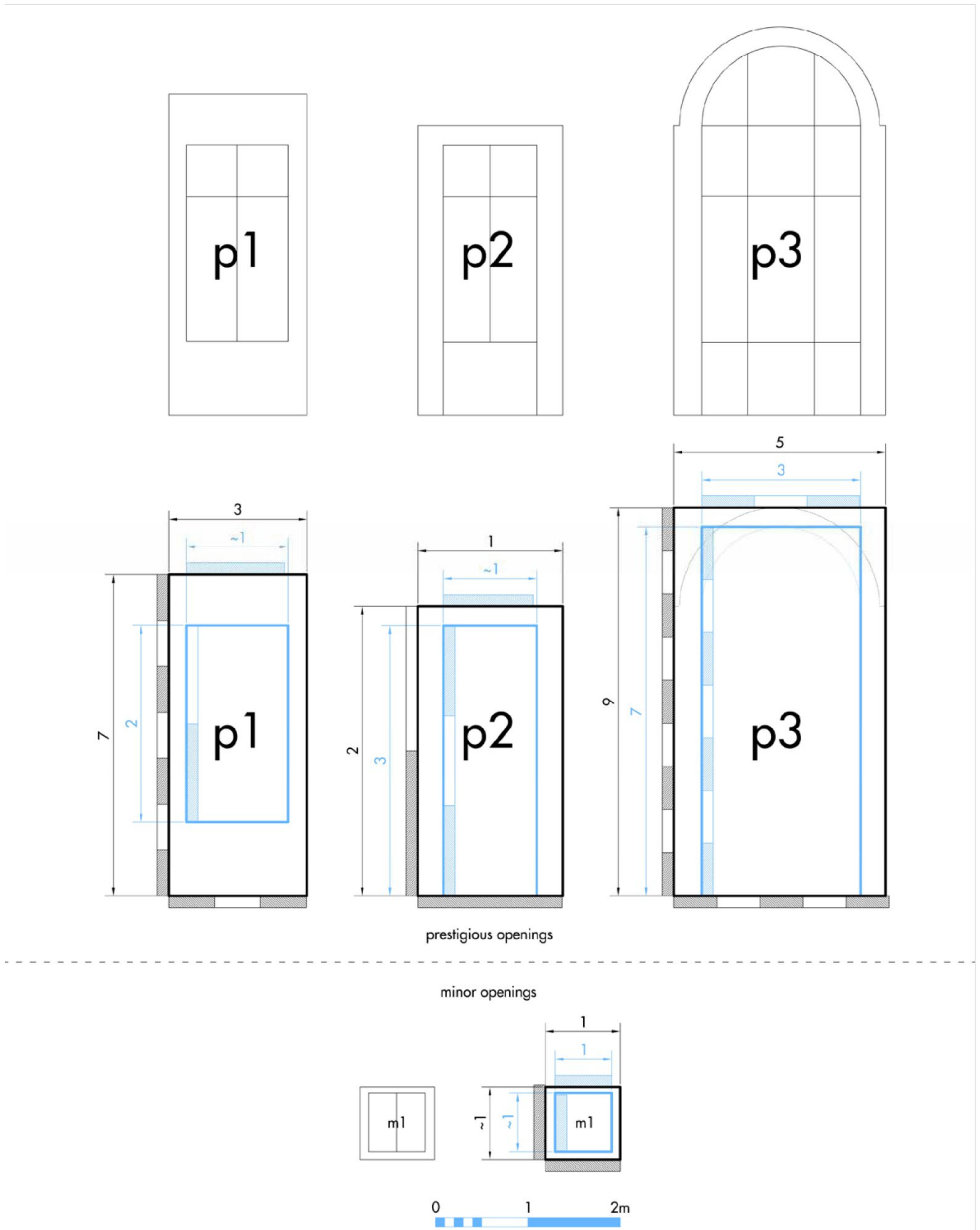


Fig. P.121 Geometrical analysis of openings: (Ber02) Residential house, Unter den Linden 42

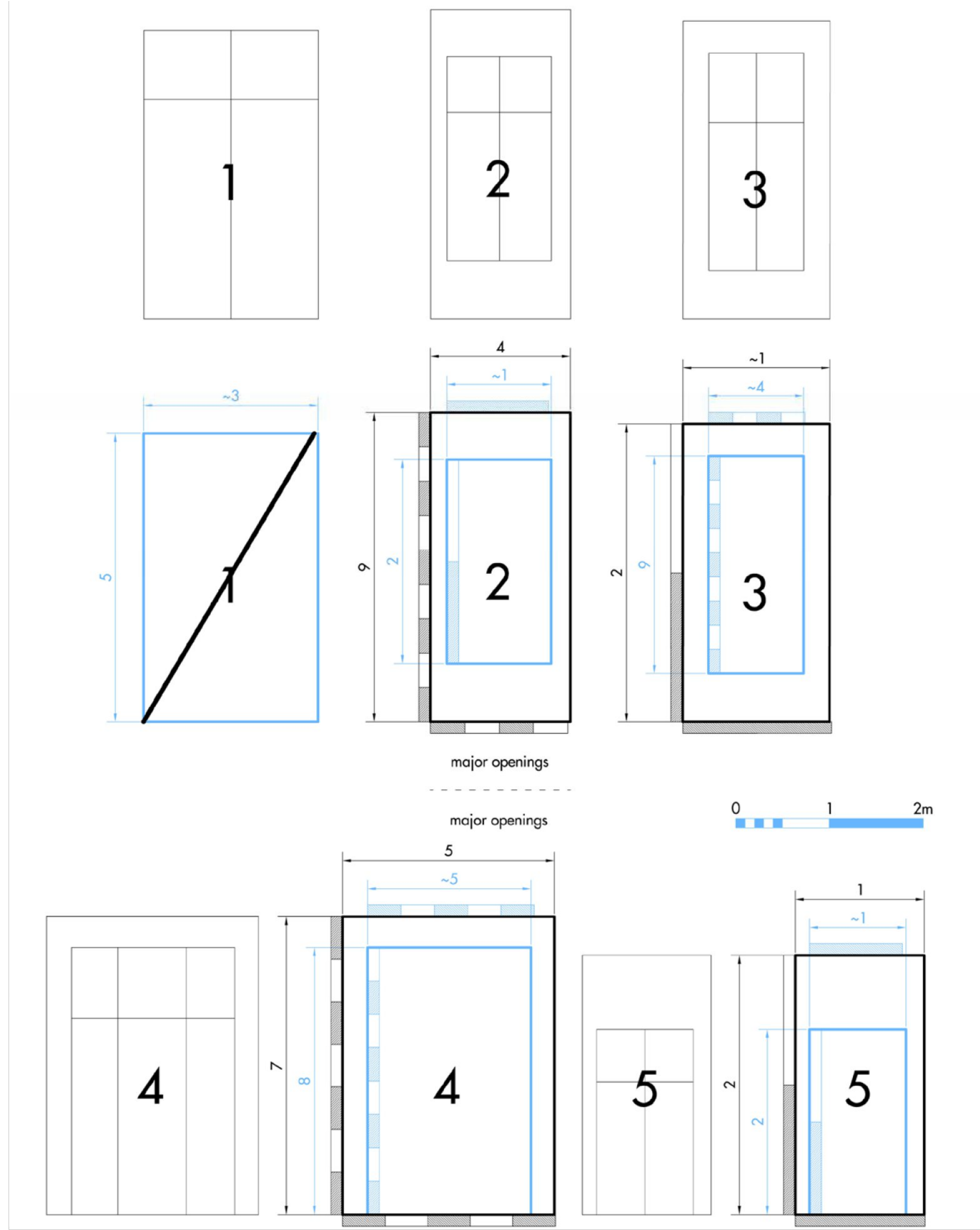


Fig. P.122 Geometrical analysis of openings: (Ber02) Residential house, Unter den Linden 42

Fig. P.123 Geometrical analysis of front elevation: (Ber03) Residential house, Oberwall-Straße 4

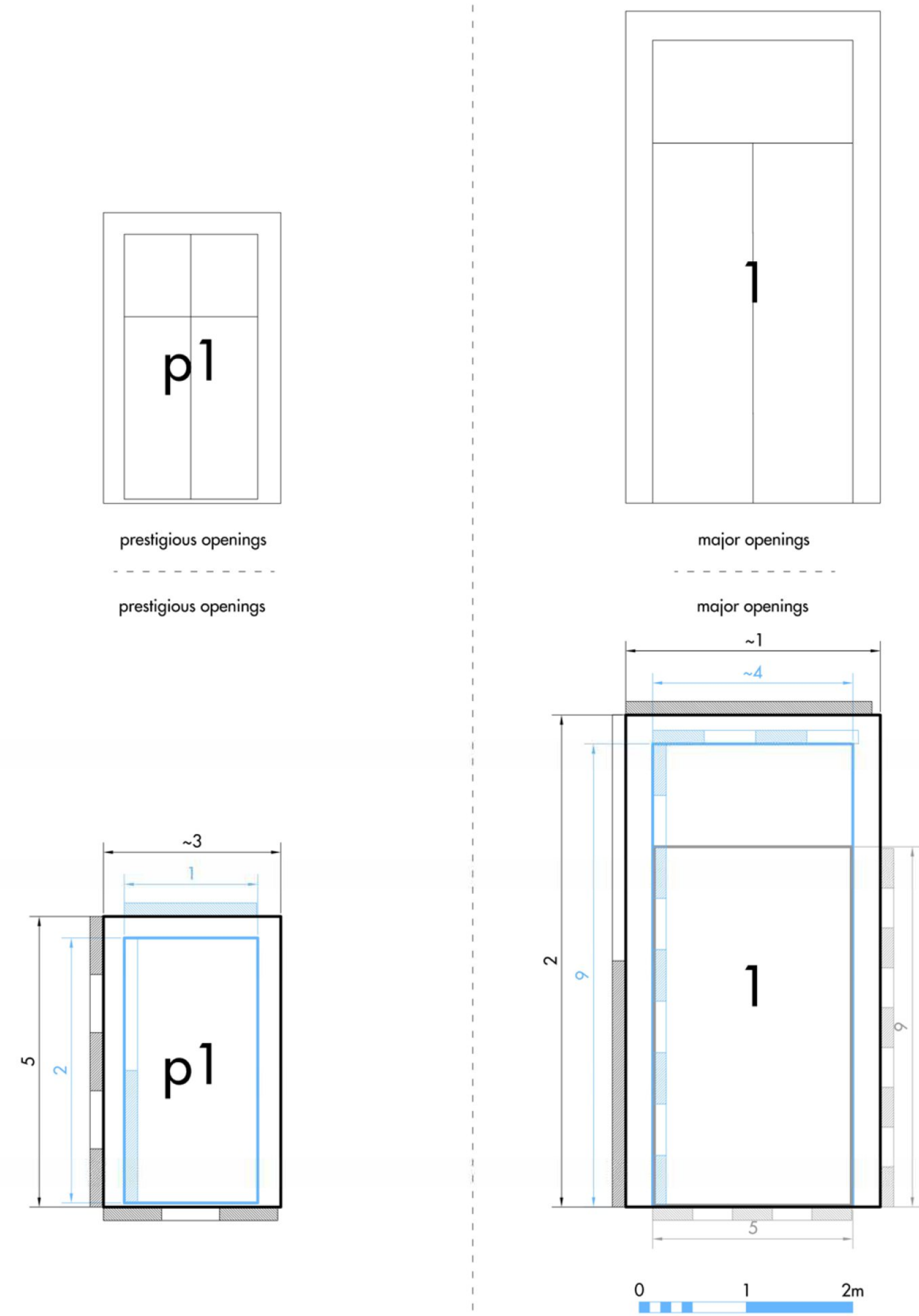


Fig. P.124 Geometrical analysis of openings: (Ber03) Residential house, Oberwall-Straße 4

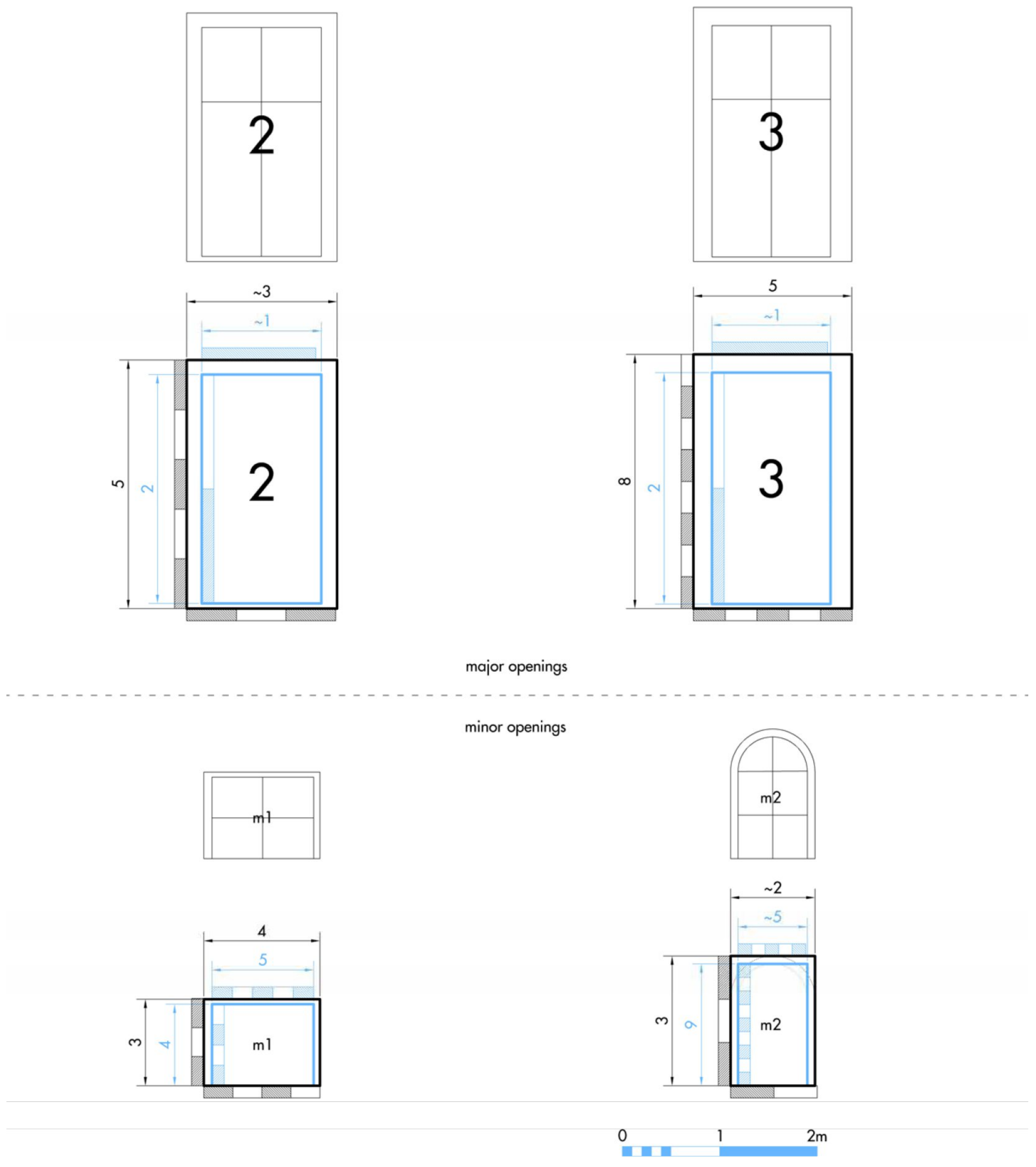


Fig. P.125 Geometrical analysis of openings: (Ber03) Residential house, Oberwall-Straße 4

Fig. P.126 Geometrical analysis of front elevation: (Ber04) Residential house, Wilhelmsplatz 5

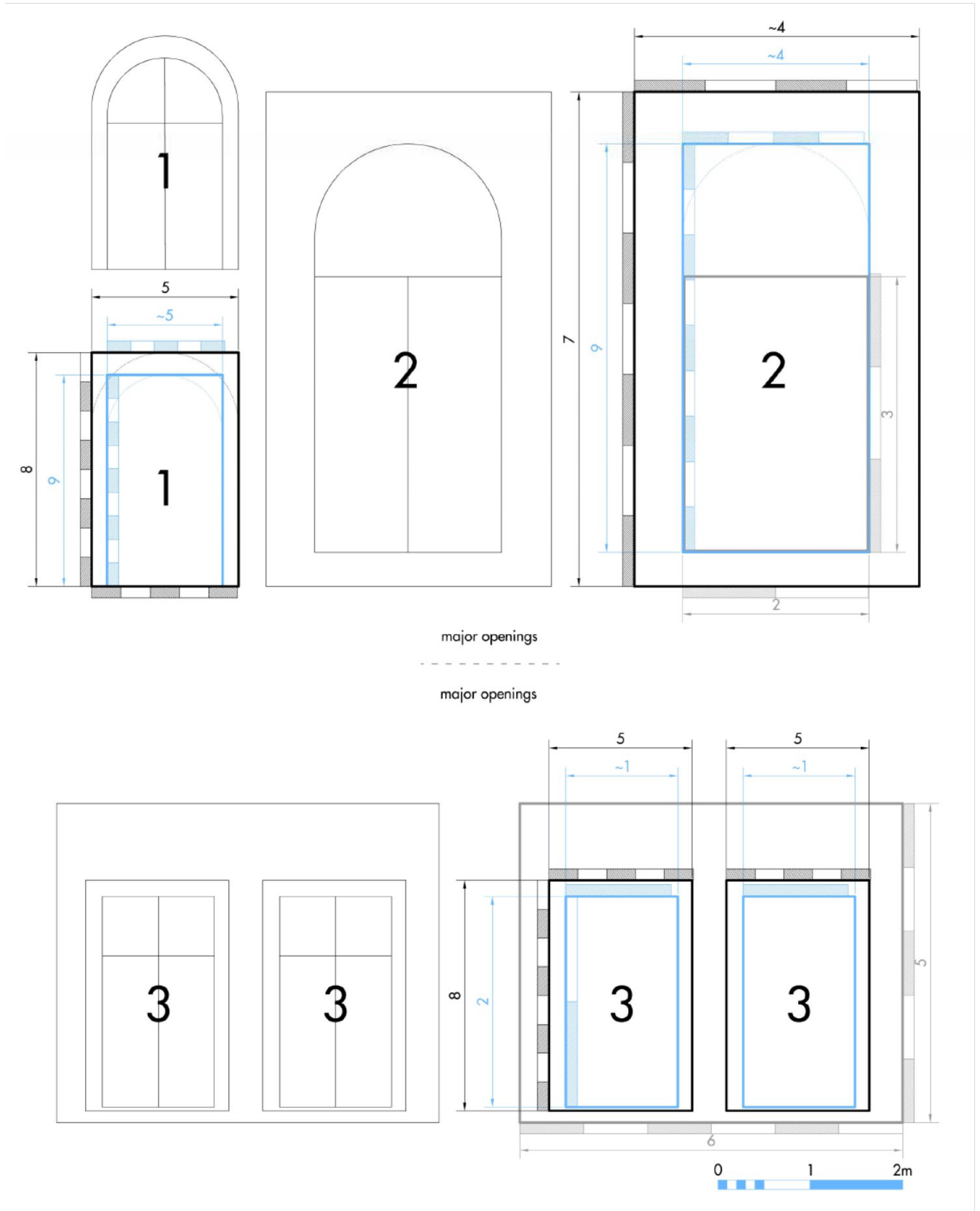


Fig. P.127 Geometrical analysis of openings: (Ber04) Residential house, Wilhelmsplatz 5

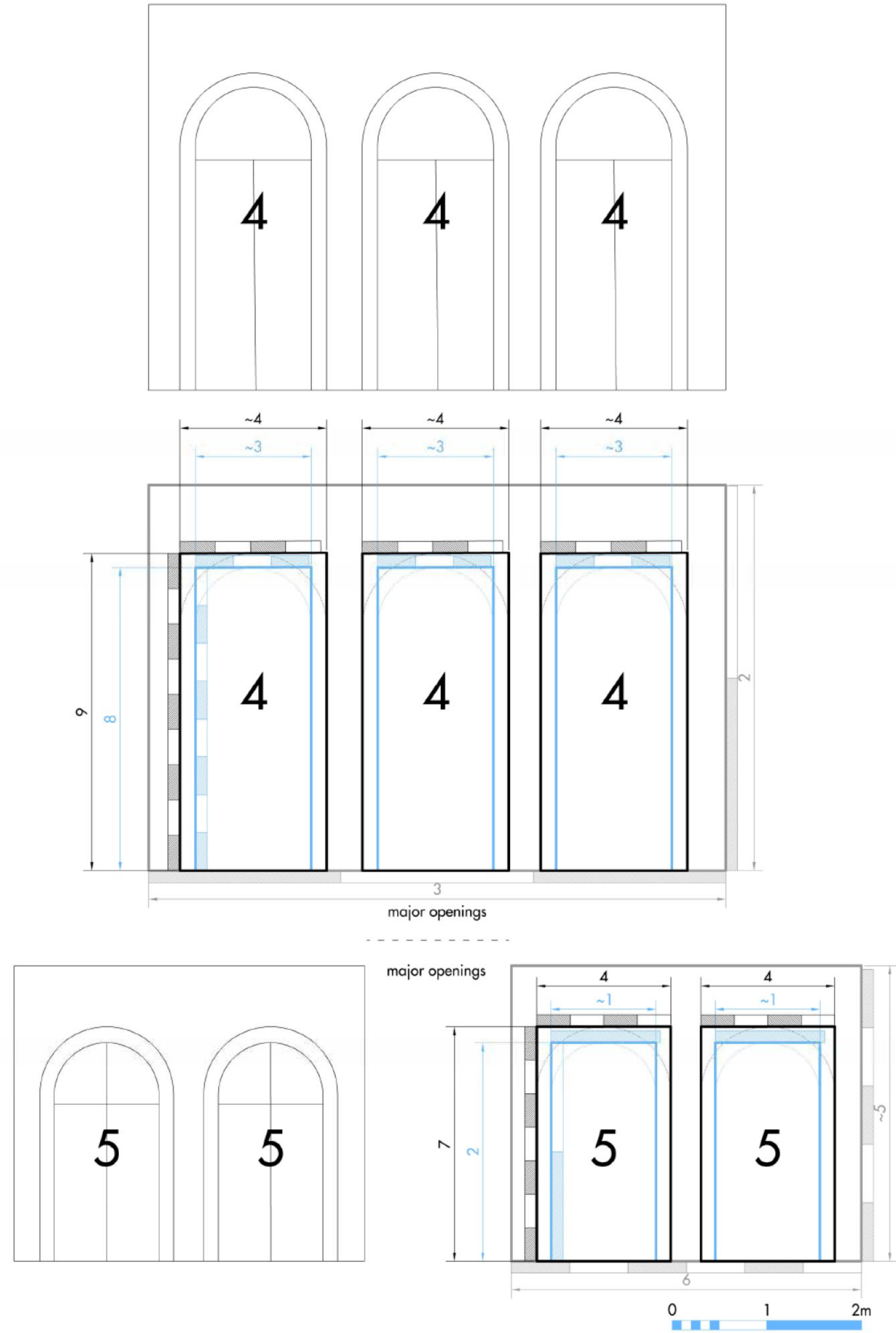


Fig. P.128 Geometrical analysis of openings: (Ber04) Residential house, Wilhelmsplatz 5

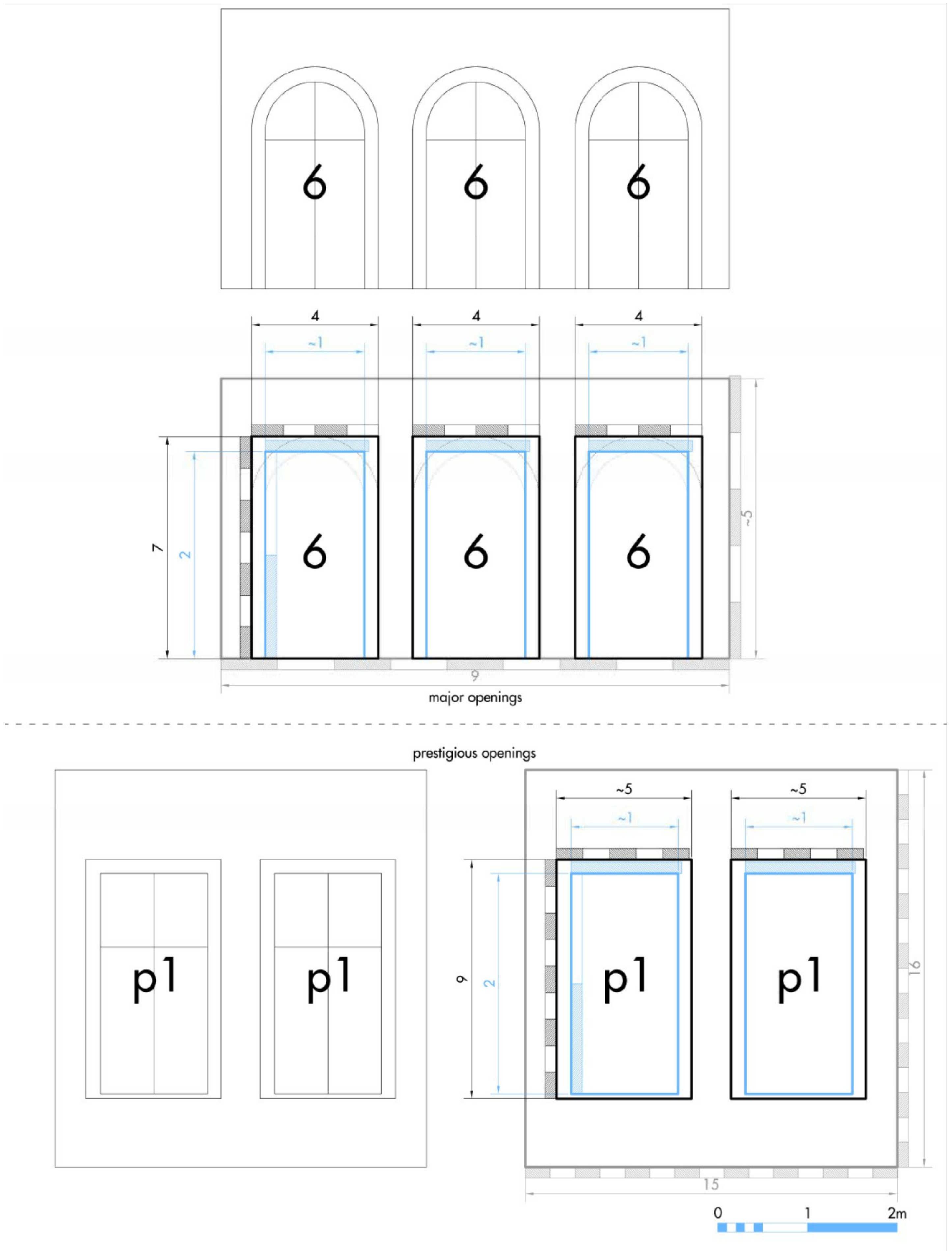


Fig. P.129 Geometrical analysis of openings: (Ber04) Residential house, Wilhelmsplatz 5

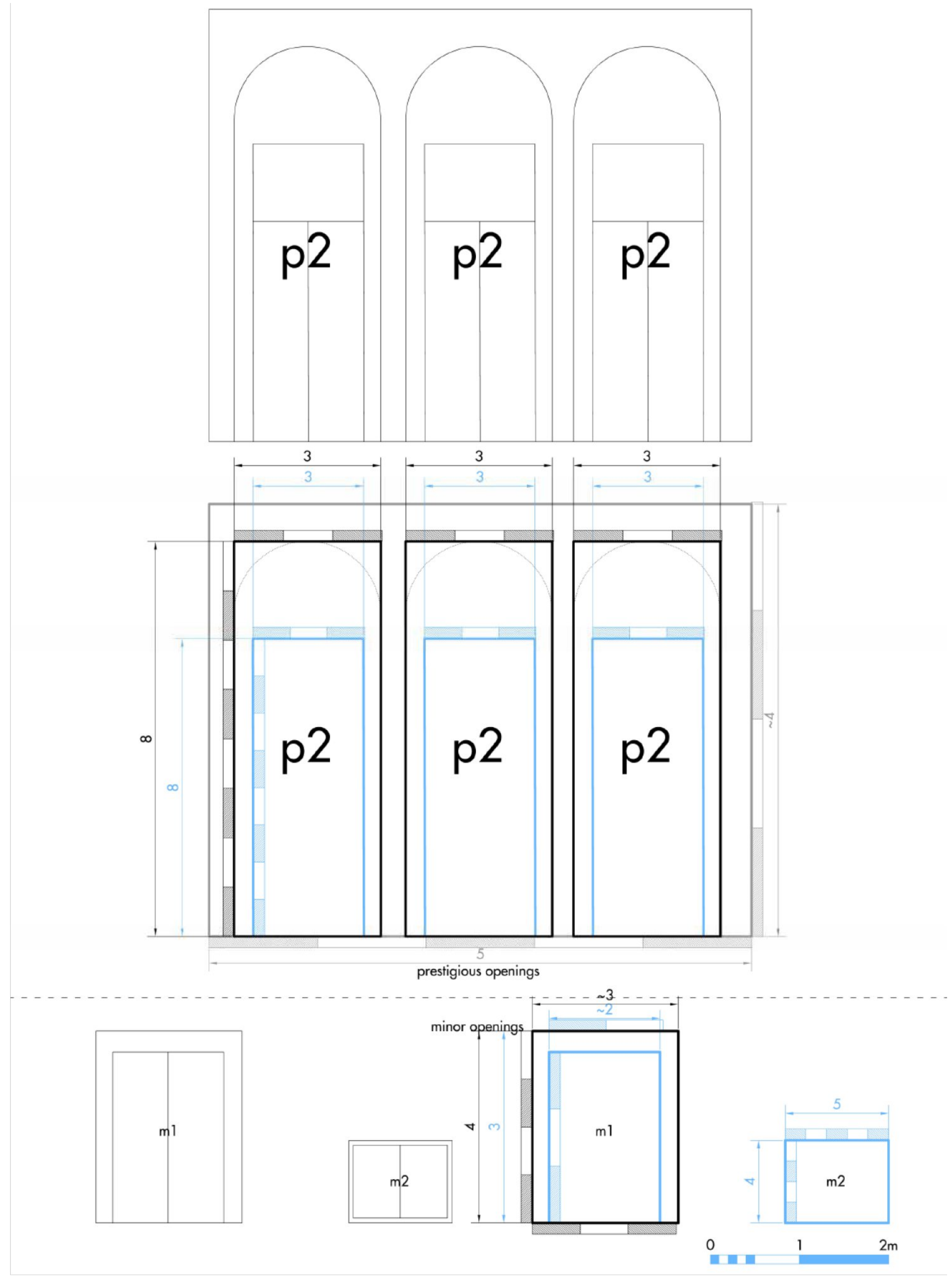


Fig. P.130 Geometrical analysis of openings: (Ber04) Residential house, Wilhelmsplatz 5

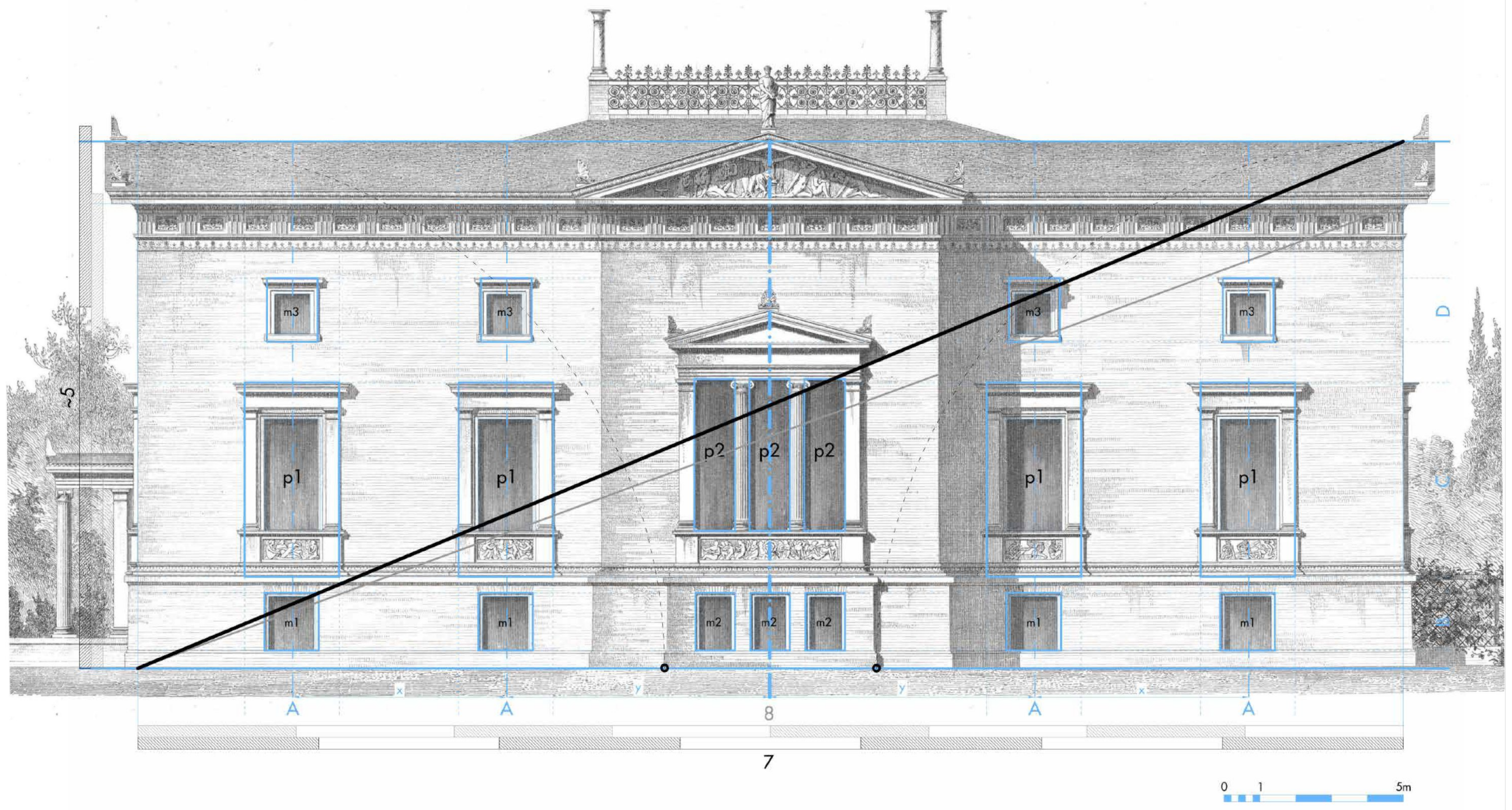


Fig. P.131 Geometrical analysis of side elevation: (Ber05) Villa Kabrun, near Berlin, Rauchstraße 17-18

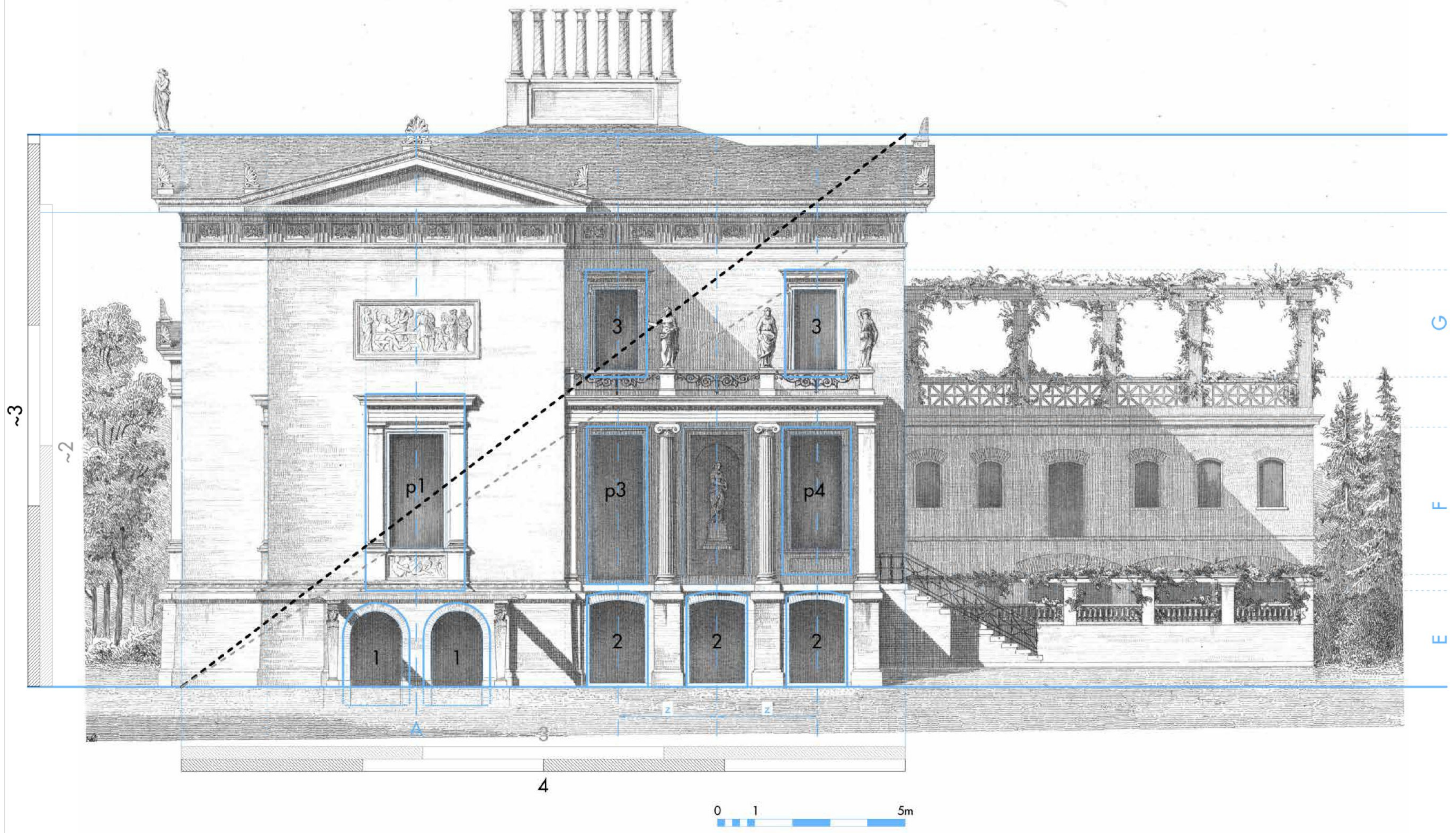


Fig. P.132 Geometrical analysis of rear elevation: (Ber05) Villa Kabrun, near Berlin, Rauchstraße 17-18

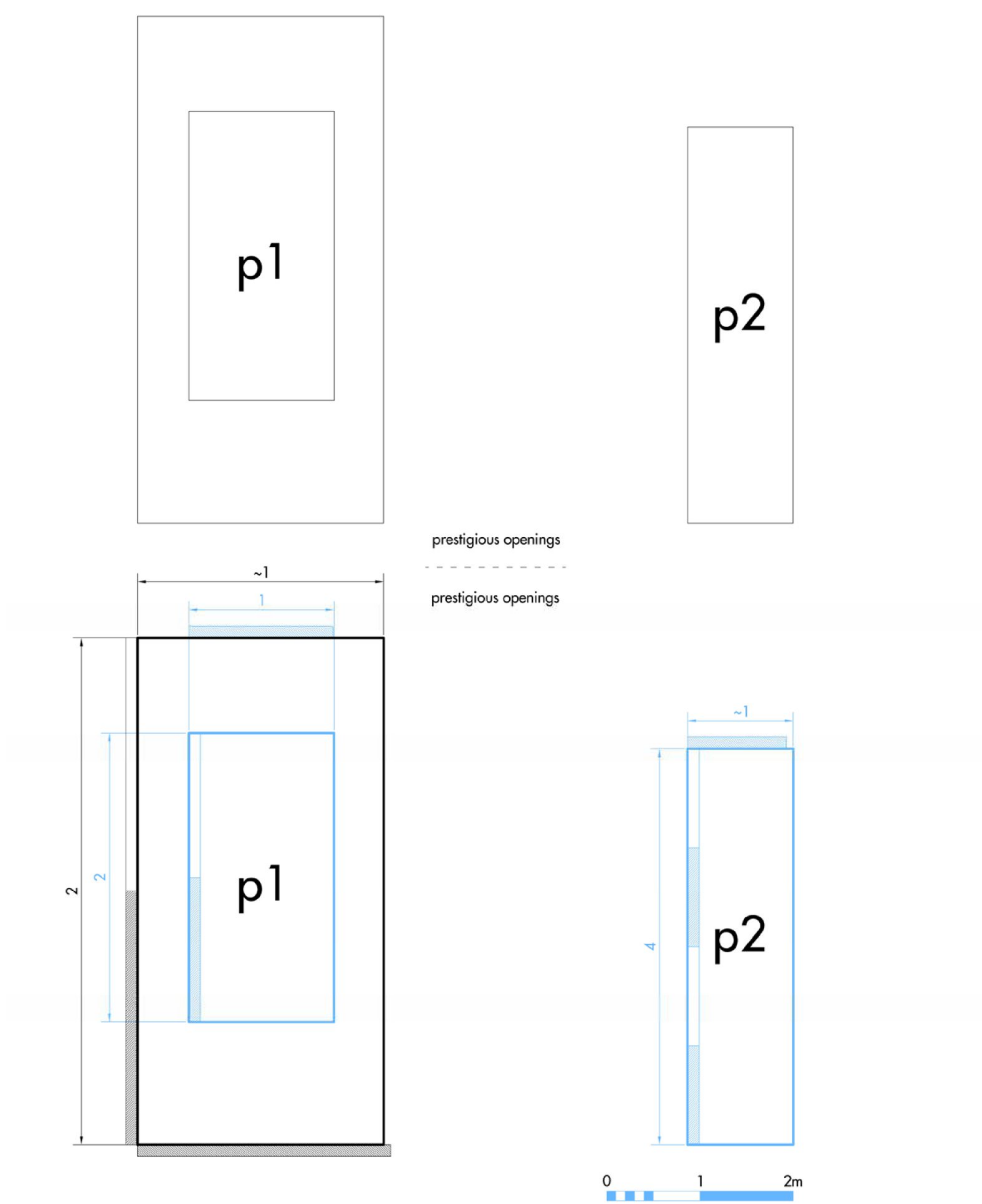


Fig. P.133 Geometrical analysis of openings: (Ber05) Villa Kabrun, near Berlin, Rauchstraße 17-18

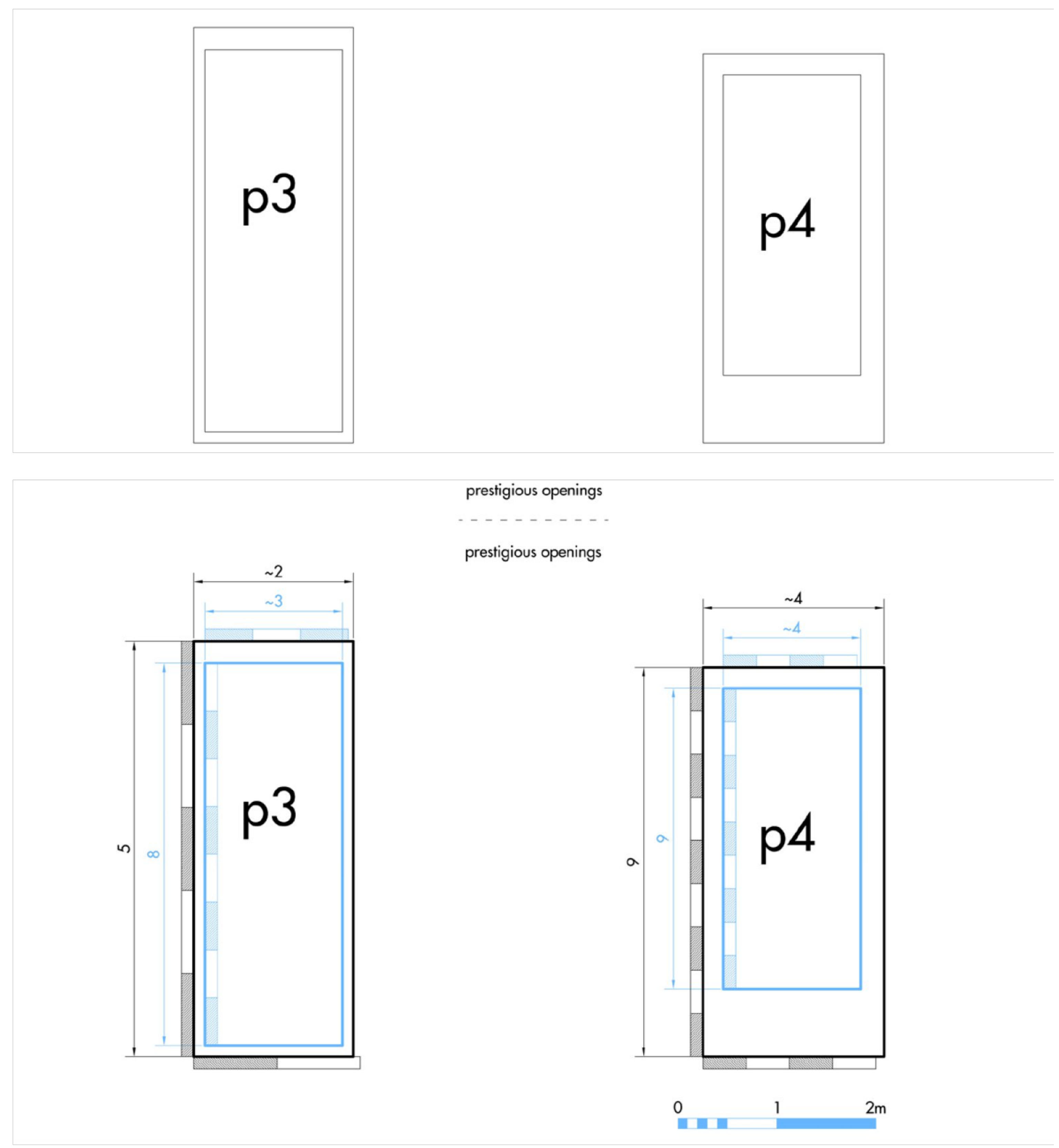


Fig. P.134 Geometrical analysis of openings: (Ber05) Villa Kabrun, near Berlin, Rauchstraße 17-18

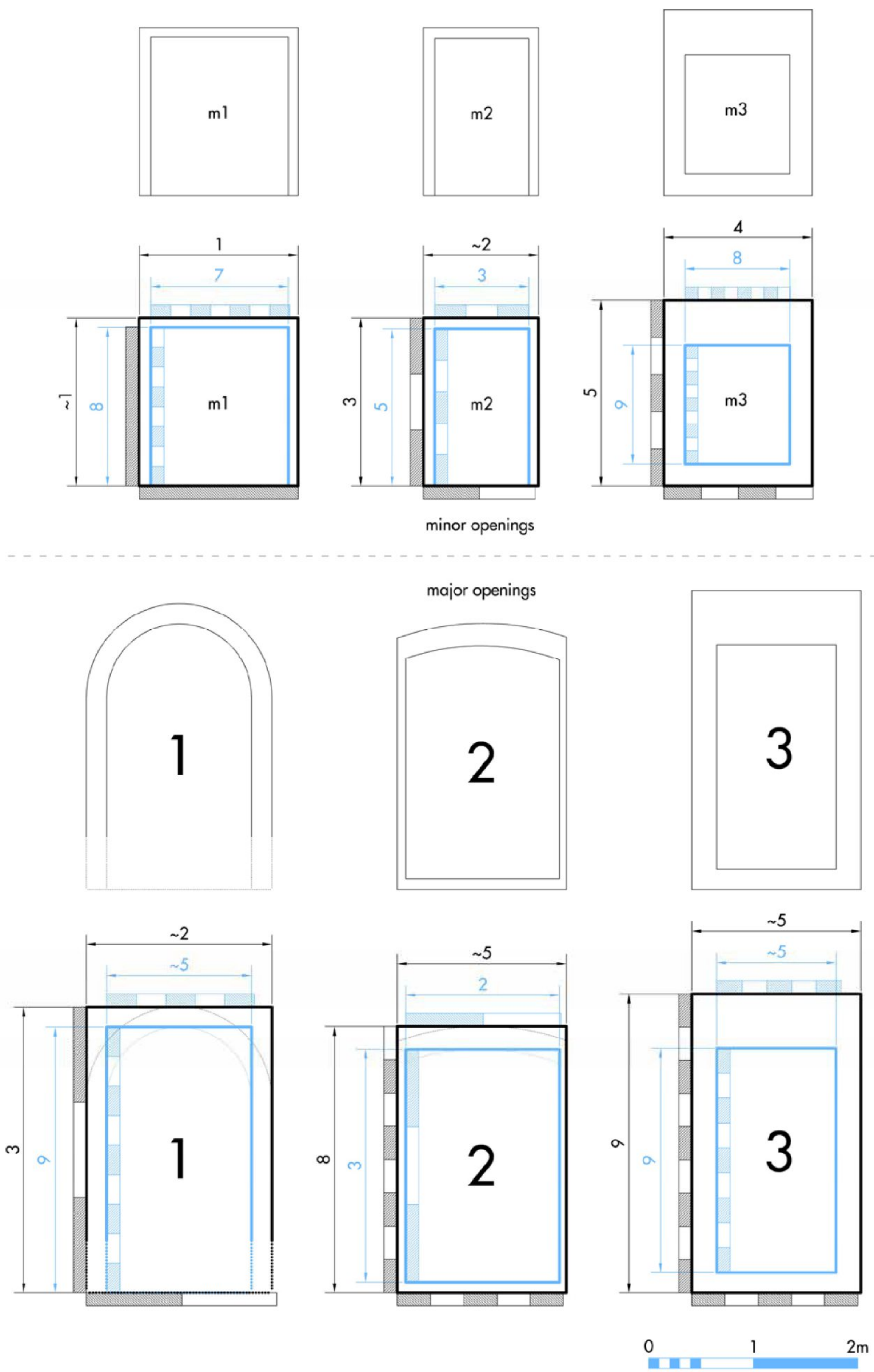


Fig. P.135 Geometrical analysis of openings: (Ber05) Villa Kabrun, near Berlin, Rauchstraße 17-18

Fig. P.136 Geometrical analysis of front elevation: (Ber06) Villa Kaufmann

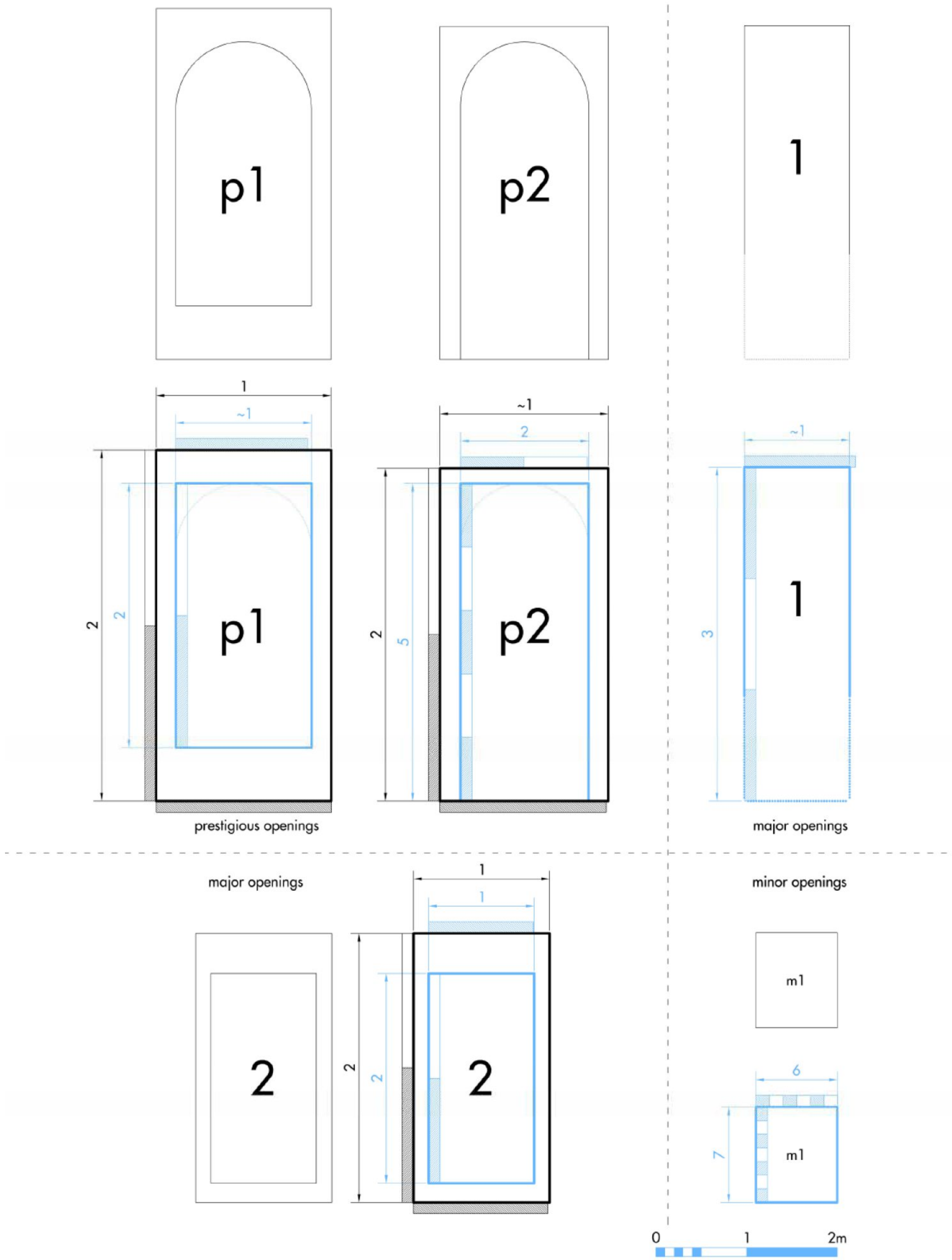


Fig. P.137 Geometrical analysis of openings: (Ber06) Villa Kaufmann

intentionally omitted

GERMANIC REGION - VIENNA // AREAS IN CURRENT AUSTRIA

Vienna

VieR01: Palais Ephrussi, Ring Road, Schottengasse,
arch.: Th. Hansen
(front and side elevation, openings)

VieR02: Palais Epstein, Ring Road, Burgring,
arch.: Th. Hansen
(front and side elevation, openings)

VieR03: Palais Schey, Ring Road, Opernring 10,
arch.: J. J. Romano, A. Schwendenwein
(front elevation, openings)

VieR04: Palais Angerer (today Hotel Regina), Ring Road, Rooseveltplatz 15-17,
arch.: E. Ritter von Förster
(front elevation, openings)

VieR05: Palais Pranter-Haas, Ring Road, Waaggasse 6,
arch.: F. Schachner
(front elevation, openings)

VieR06: Palais Lieben-Auspitz (site of Cafe Landtmann, Salon of Berta Zuckerkandl), Ring Road, Franzensring 4 (today Universitätsring),
arch.: C. Schumann, L. Tischles
(front elevation, openings)

VieR07: Palais Hoyos-Sprinzenstein, Ring Road, Kärntner Ring 5 and Maximilianstraße 6 (today Mahlerstraße 6),
arch.: L. Förster
(front and rear elevation, openings)

VieR08: Residential house on the Ring Road, Kärntner Straße corner, Ring Road,
arch.: L. Förster
(front elevation, openings)

VieR09: Residential house of Mr. Alexander Ritter von Schöller, Ring Road, Opernring 6,
arch.: J. Hlávka
(front elevation, openings)

VieR10: Residential house of Mr. Adalbert Zinner, Ring Road,

Opernring 8,
arch.: J. J. Romano, A. Schwendenwein
(front elevation, openings)

VieR11: Residential house, Ring Road, Kärntner Ring 15,
arch.: J. Wagner
(front elevation, openings)

VieR12: Residential house of Mr. Carl Förster, Ring Road, Franz-Josefs-Kai 55-57,
arch.: -
(front elevation, openings)

VieR13: Residential house, Ring Road, Opernring 21,
arch.: -
(front elevation, openings)

VieR14: Residential house, Ring Road, Berggasse 24,
arch.: -
(front elevation, openings)

VieR15: Residential and commercial building, Ring Road, Universitätsring 10,
arch.: E. Ritter von Förster
(front elevation, openings)

VieR16: Residential house, Ring Road,
arch.: -
(front elevation, openings)

VieR17: Residential house of Mr. Carl Schmidl, Ring Road,
arch.: -
(front elevation, openings)

VieR18: Residential house, Ring Road
arch.: -
(front elevation, openings)

Vie01: Restoration of Palace Sina, Hoher Markt 8,
arch.: Th. Hansen
(front elevation, openings)

Vie02: Palace Reitzes, Universitätsstraße 5,
arch.: W. Fraenkl
(front and side elevation, openings)

Vie03: Palace of count Seldern, Pettenkofen-Gasse 2,
arch.: L. Tischler
(front and side elevation, openings)

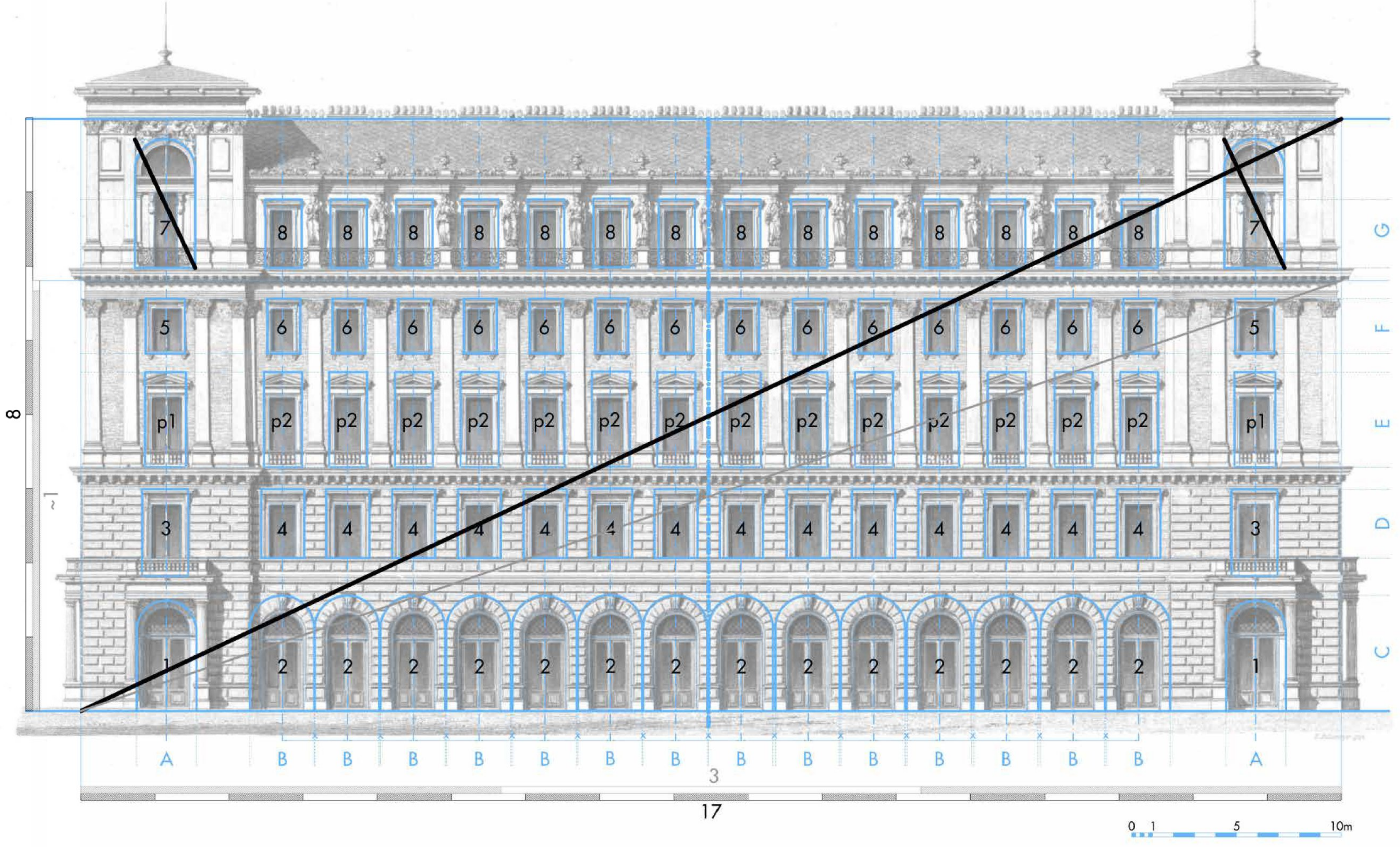


Fig. P.138 Geometrical analysis of front elevation: (VieR01) Palais Ephrussi, Ring Road, Schottengasse

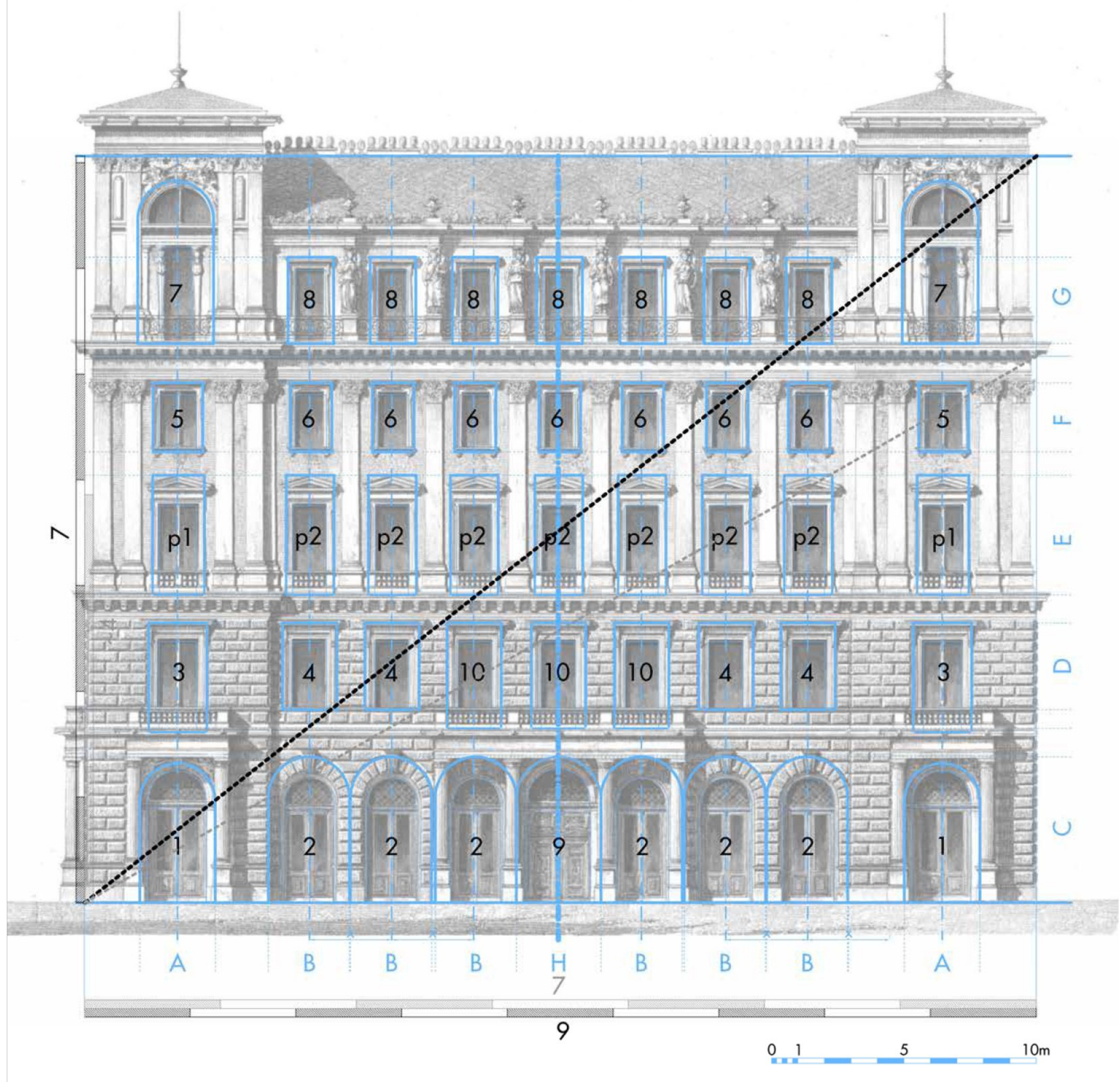


Fig. P.139 Geometrical analysis of side elevation: (VieR01) Palais Ephrussi, Ring Road, Schottengasse

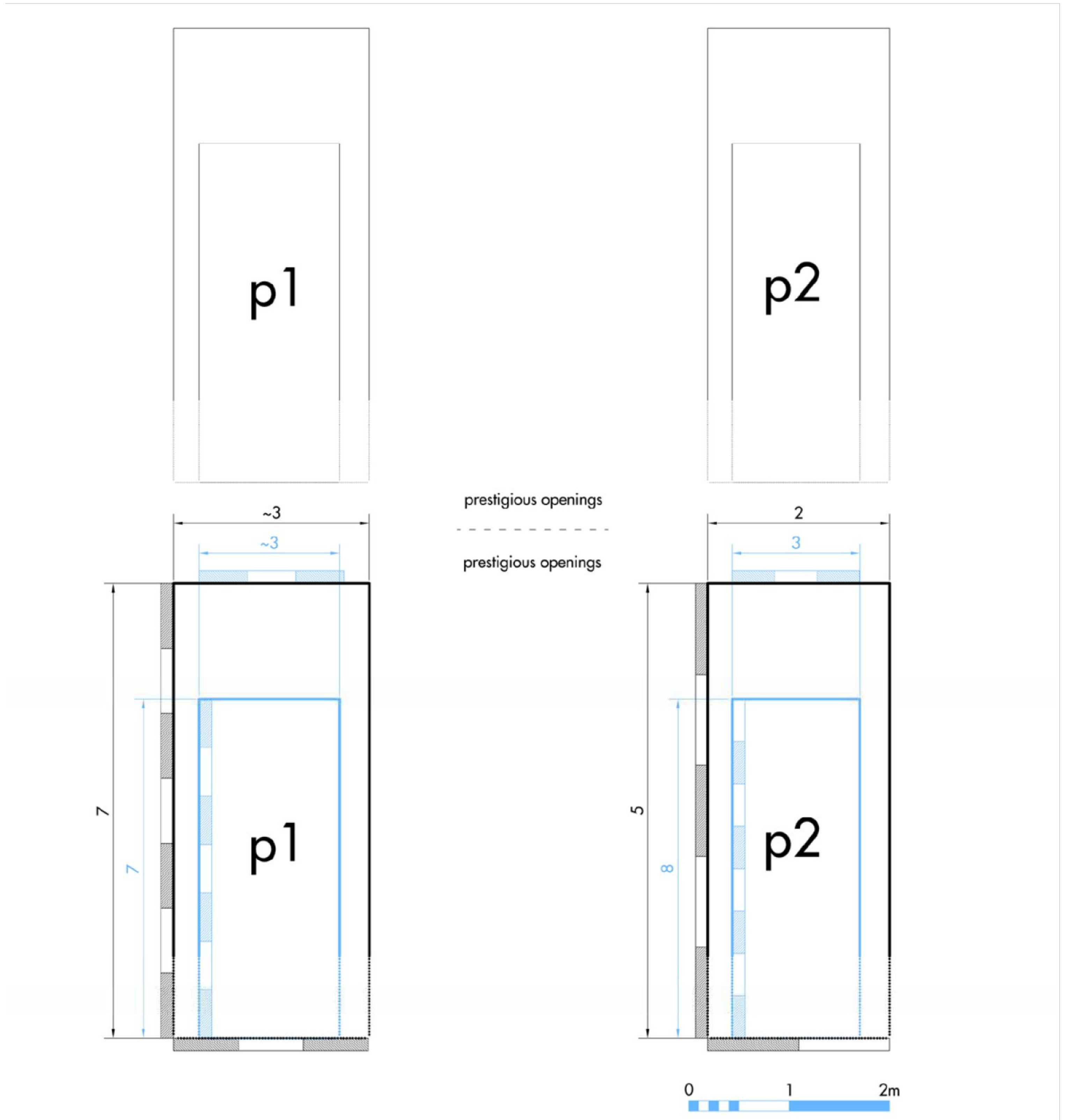


Fig. P.140 Geometrical analysis of openings: (VieR01) Palais Ephrussi, Ring Road, Schottengasse

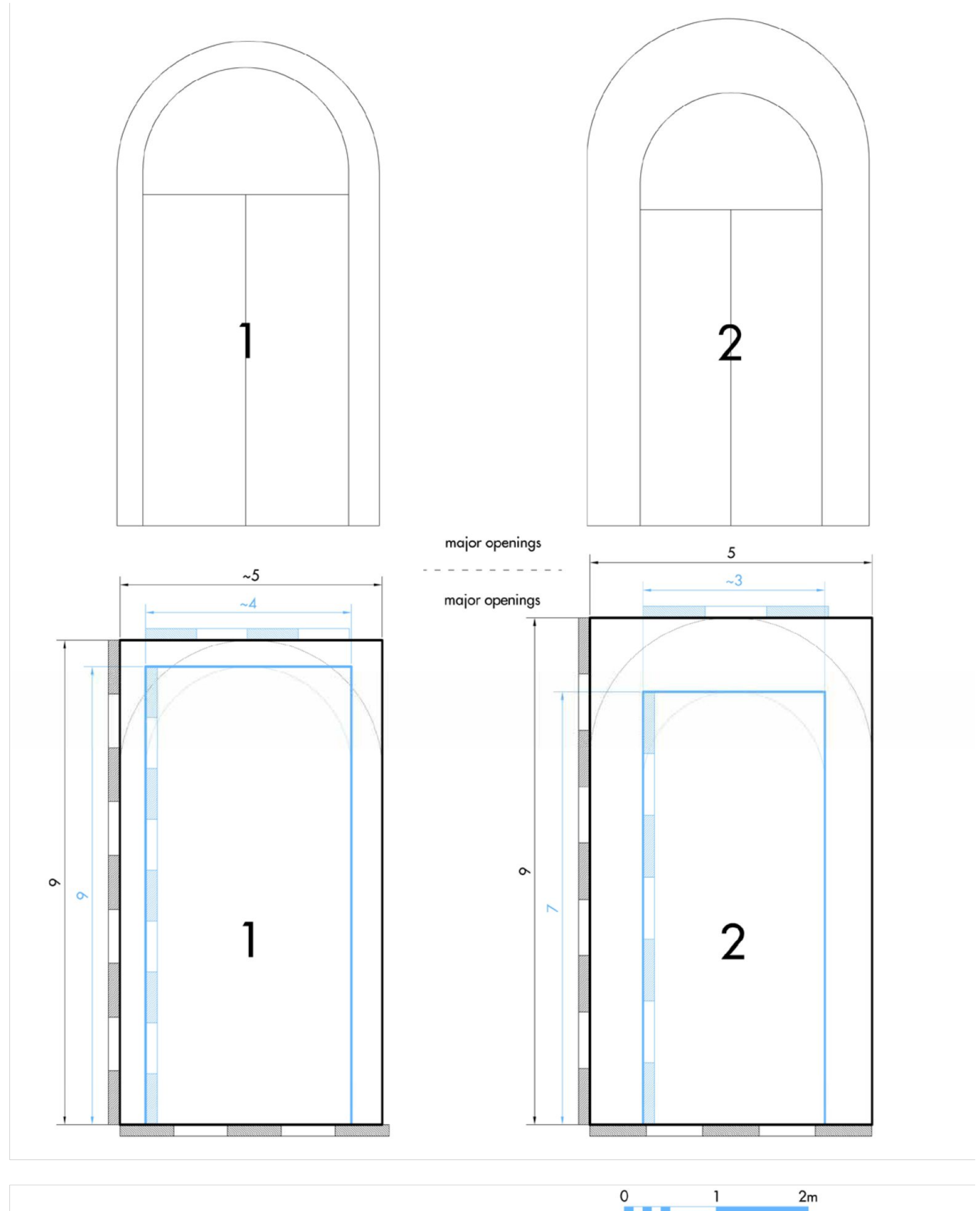


Fig. P.141 Geometrical analysis of openings: (VieR01) Palais Ephrussi, Ring Road, Schottengasse

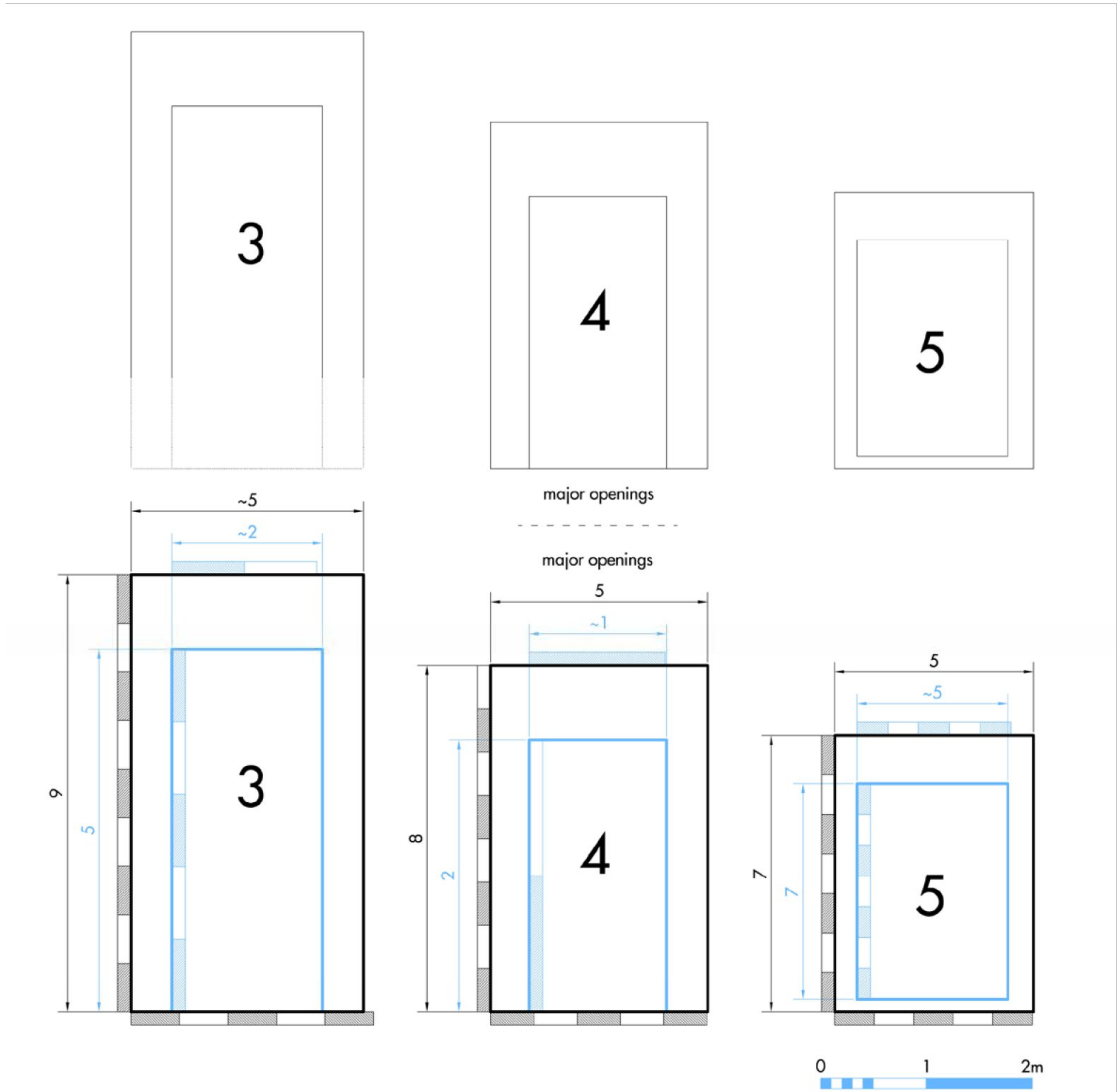


Fig. P.142 Geometrical analysis of openings: (VieR01) Palais Ephrussi, Ring Road, Schottengasse

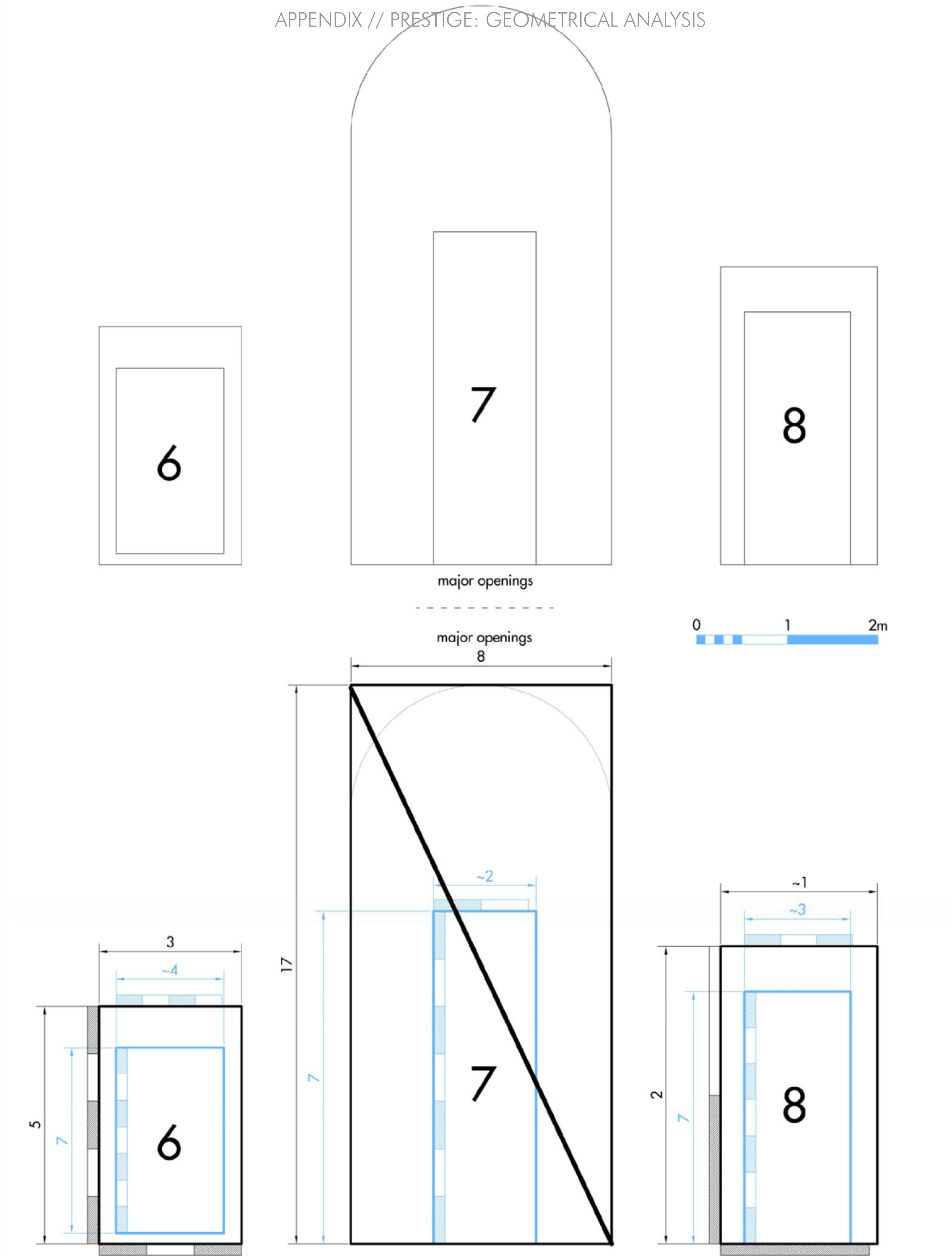


Fig. P.143 Geometrical analysis of openings: (VieR01) Palais Ephrussi, Ring Road, Schottengasse

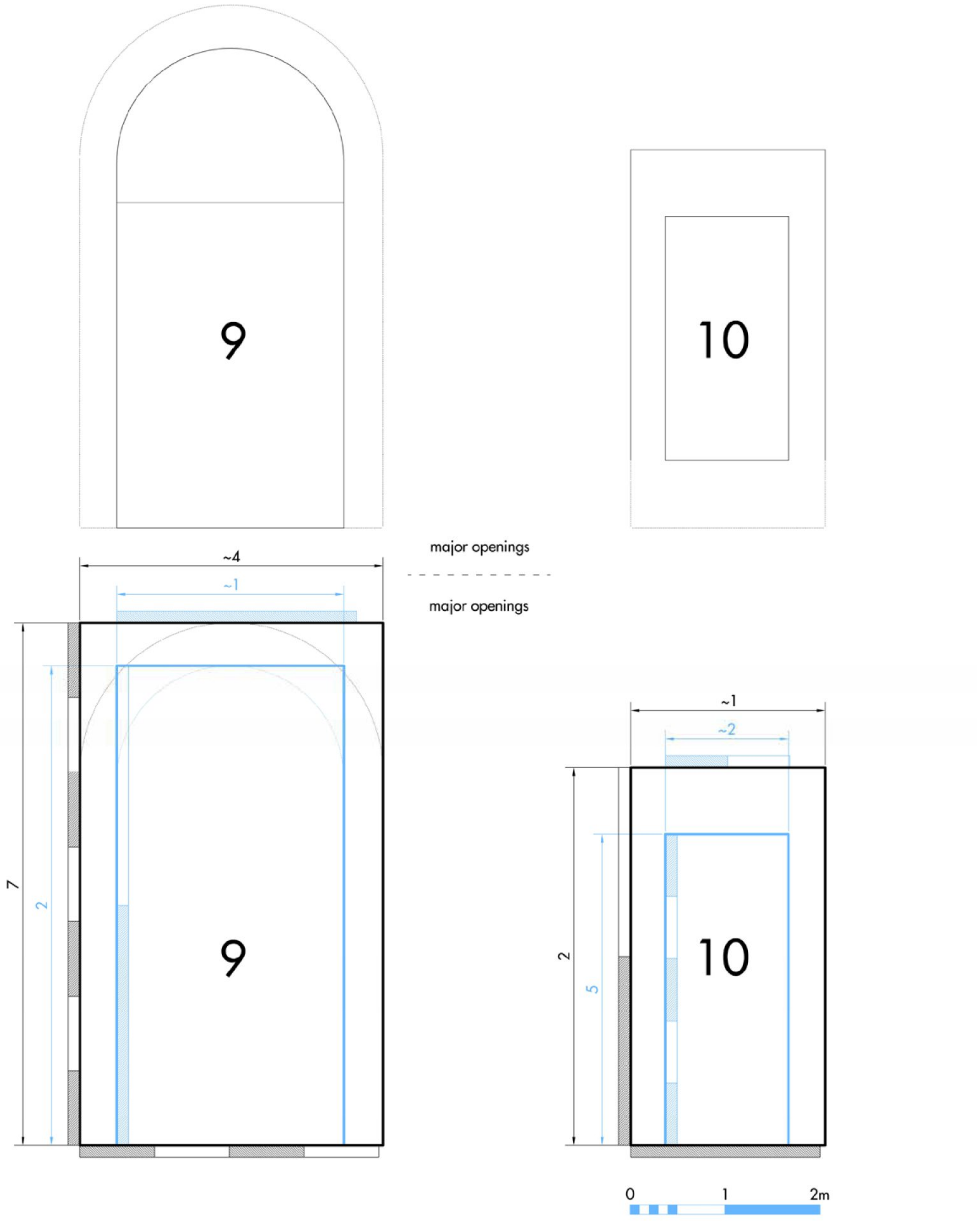


Fig. P.144 Geometrical analysis of openings: (VieR01) Palais Ephrussi, Ring Road, Schottengasse

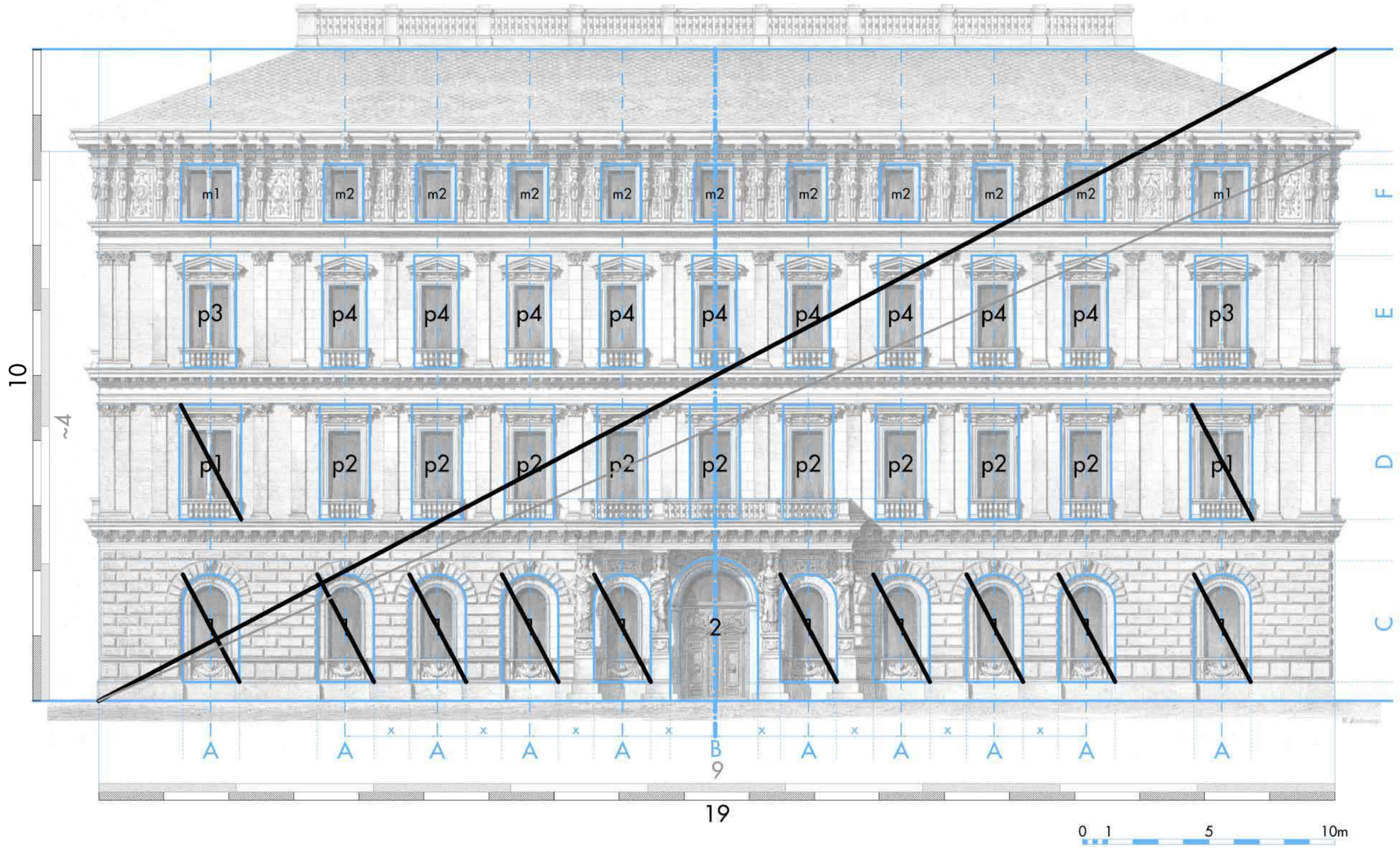


Fig. P.145 Geometrical analysis of front elevation: (VieR02) Palais Epstein, Ring Road, Burgring

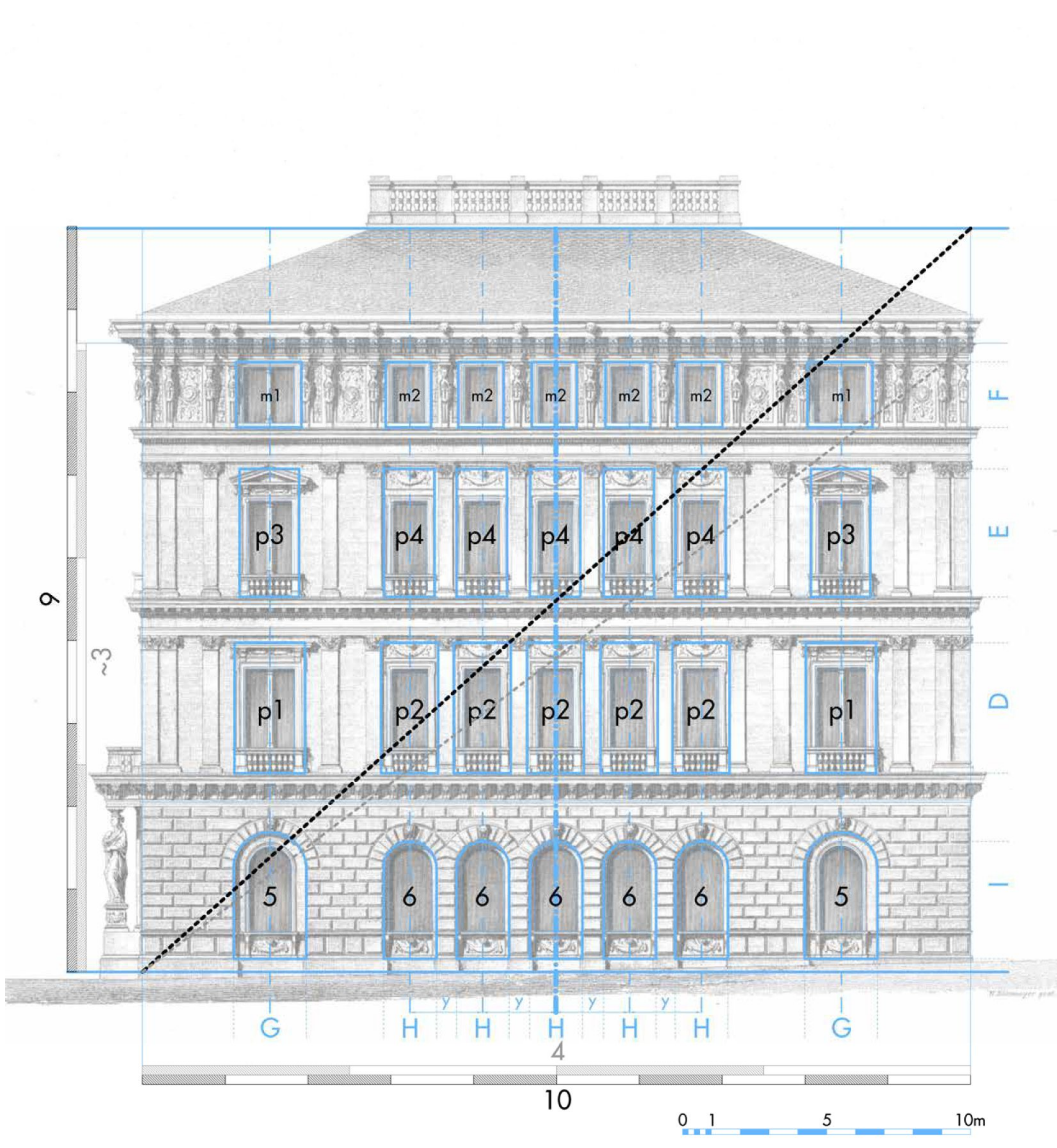


Fig. P.146 Geometrical analysis of side elevation: (VieR02) Palais Epstein, Ring Road, Burgring

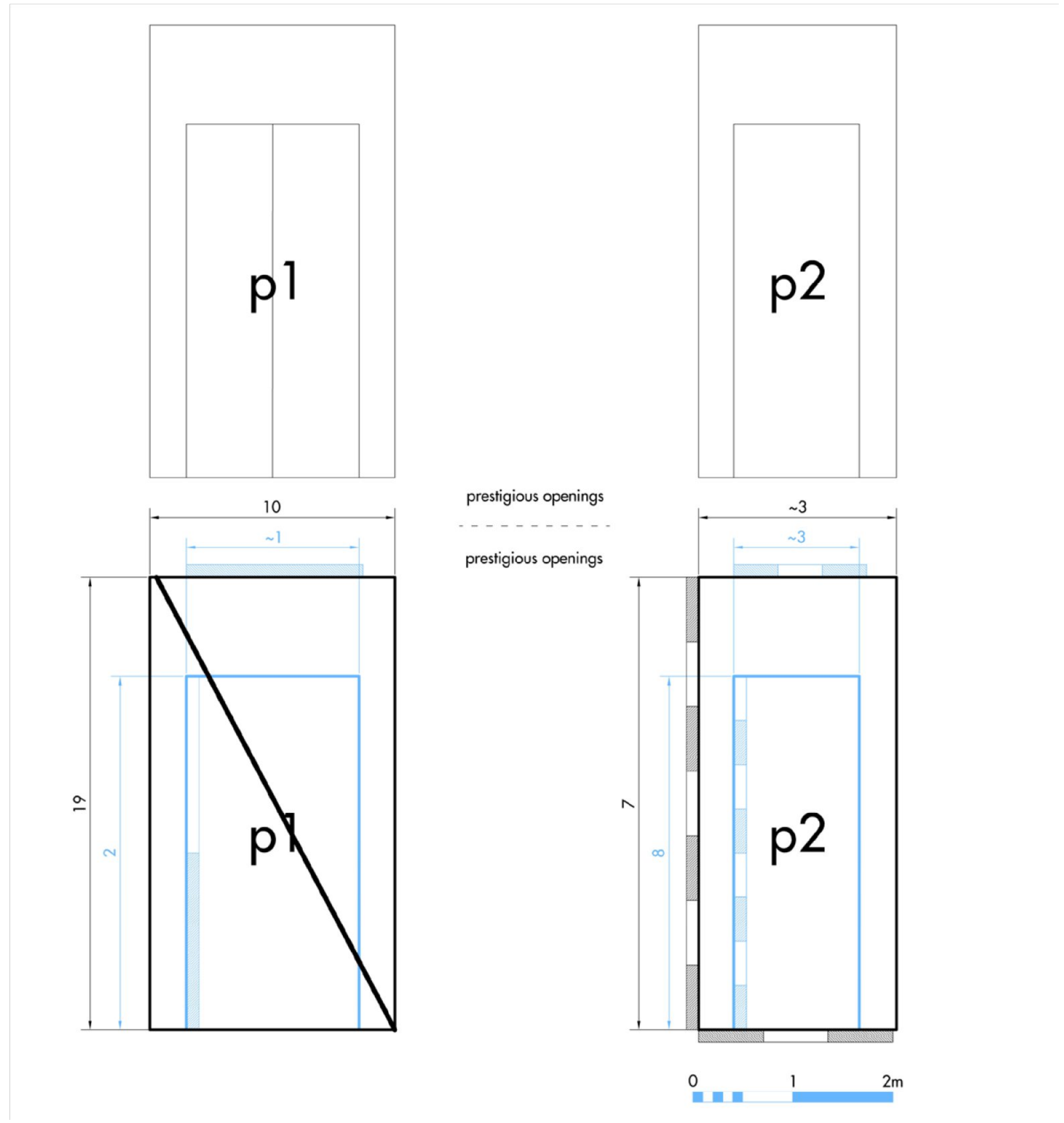


Fig. P.147 Geometrical analysis of openings: (VieR02) Palais Epstein, Ring Road, Burgring

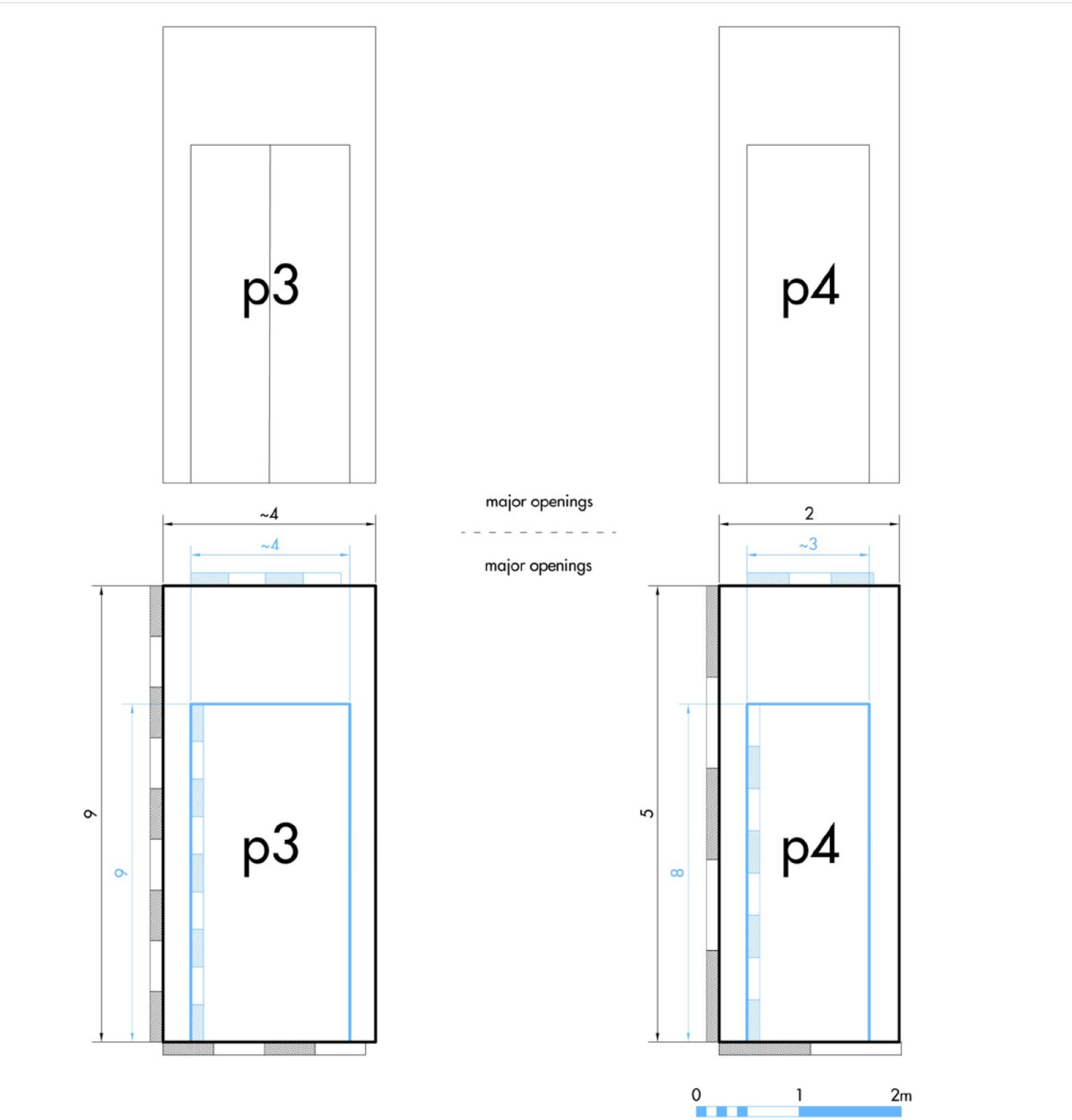


Fig. P.148 Geometrical analysis of openings: (VieR02) Palais Epstein, Ring Road, Burgring

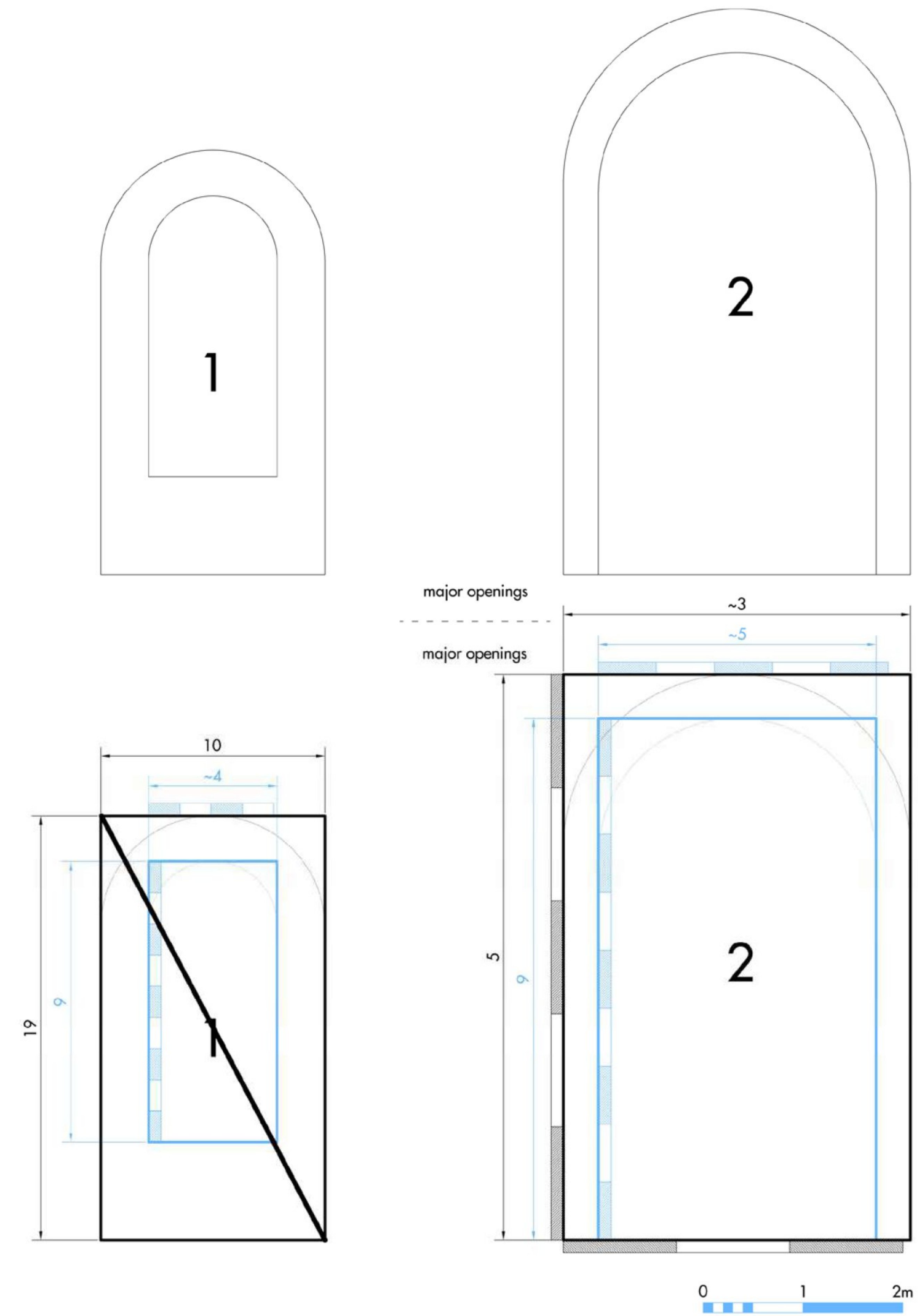


Fig. P.149 Geometrical analysis of openings: (VieR02) Palais Epstein, Ring Road, Burgring

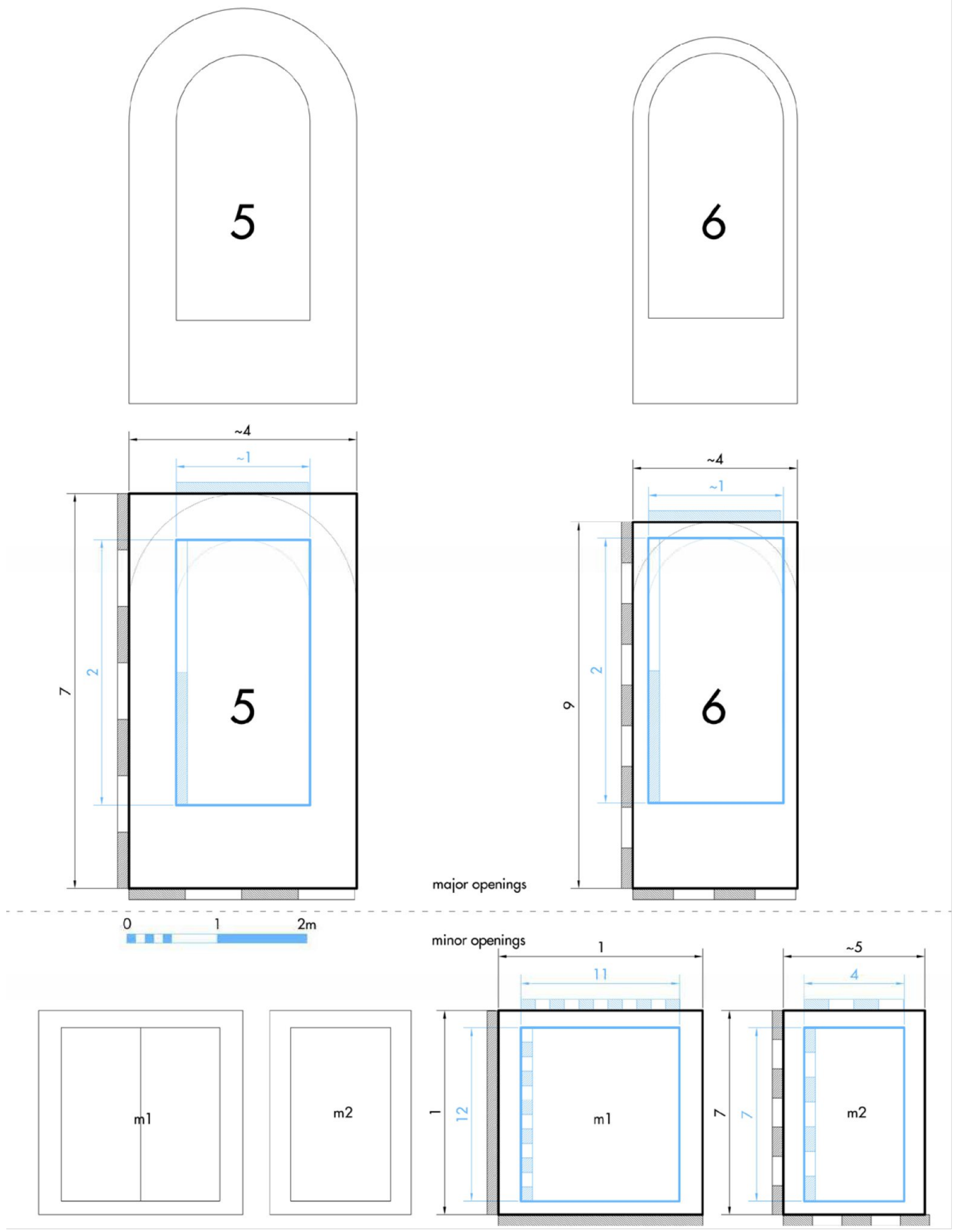


Fig. P.150 Geometrical analysis of openings: (VieR02) Palais Epstein, Ring Road, Burgring

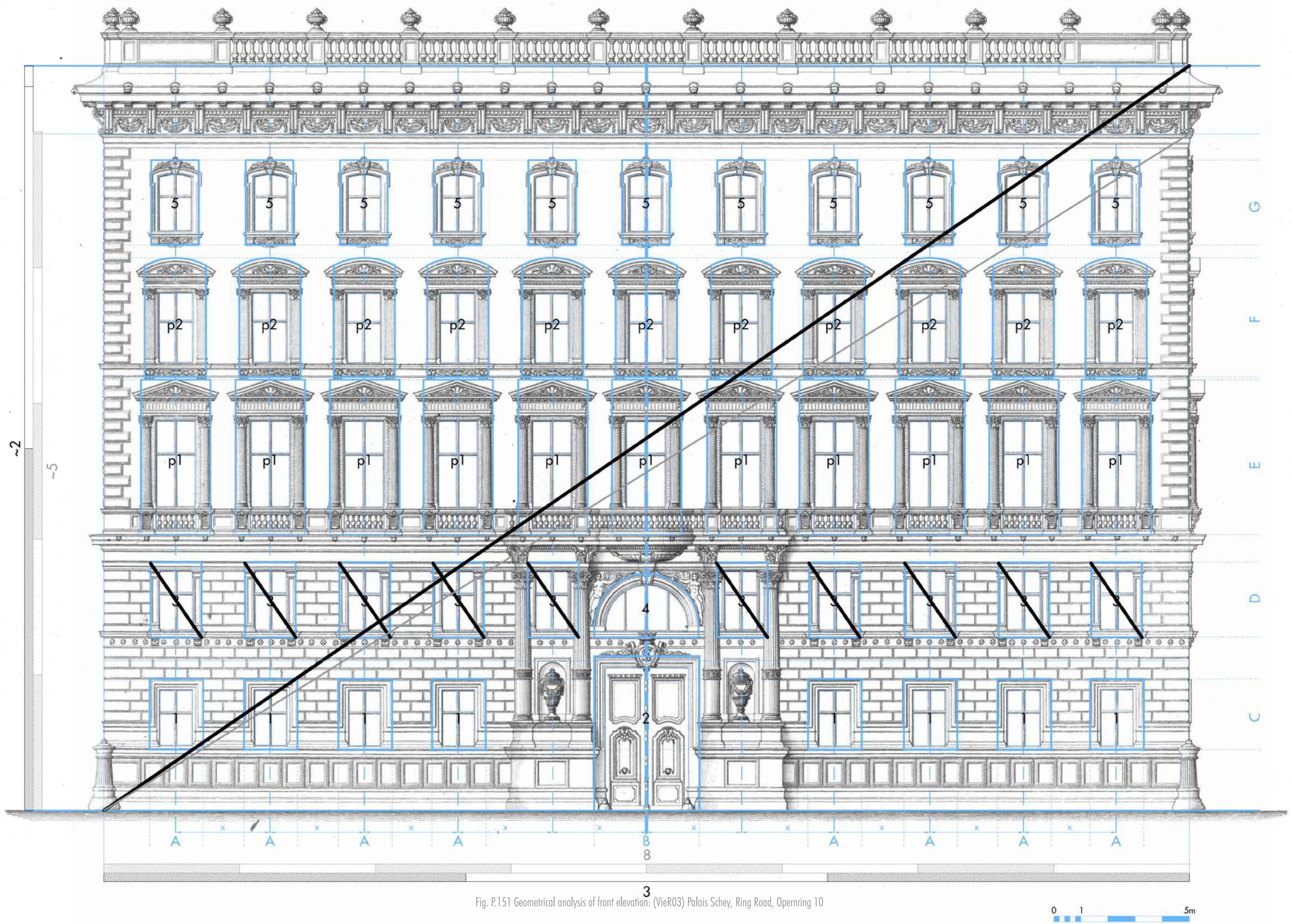


Fig. P.151 Geometrical analysis of front elevation: (VieR03) Palais Schey, Ring Road, Opernring 10

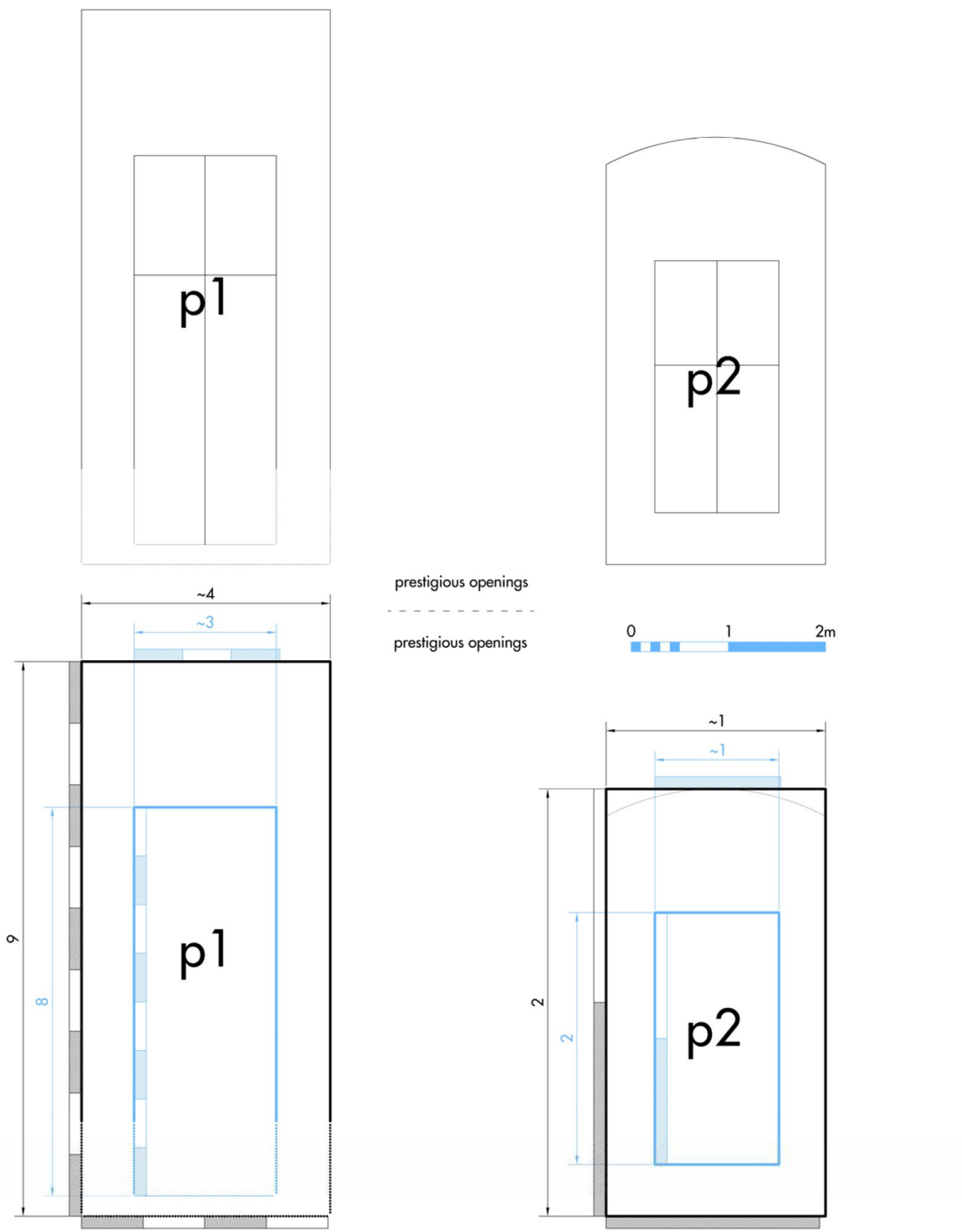


Fig. P.152 Geometrical analysis of openings: (VieR03) Palais Schey, Ring Road, Opernring 10

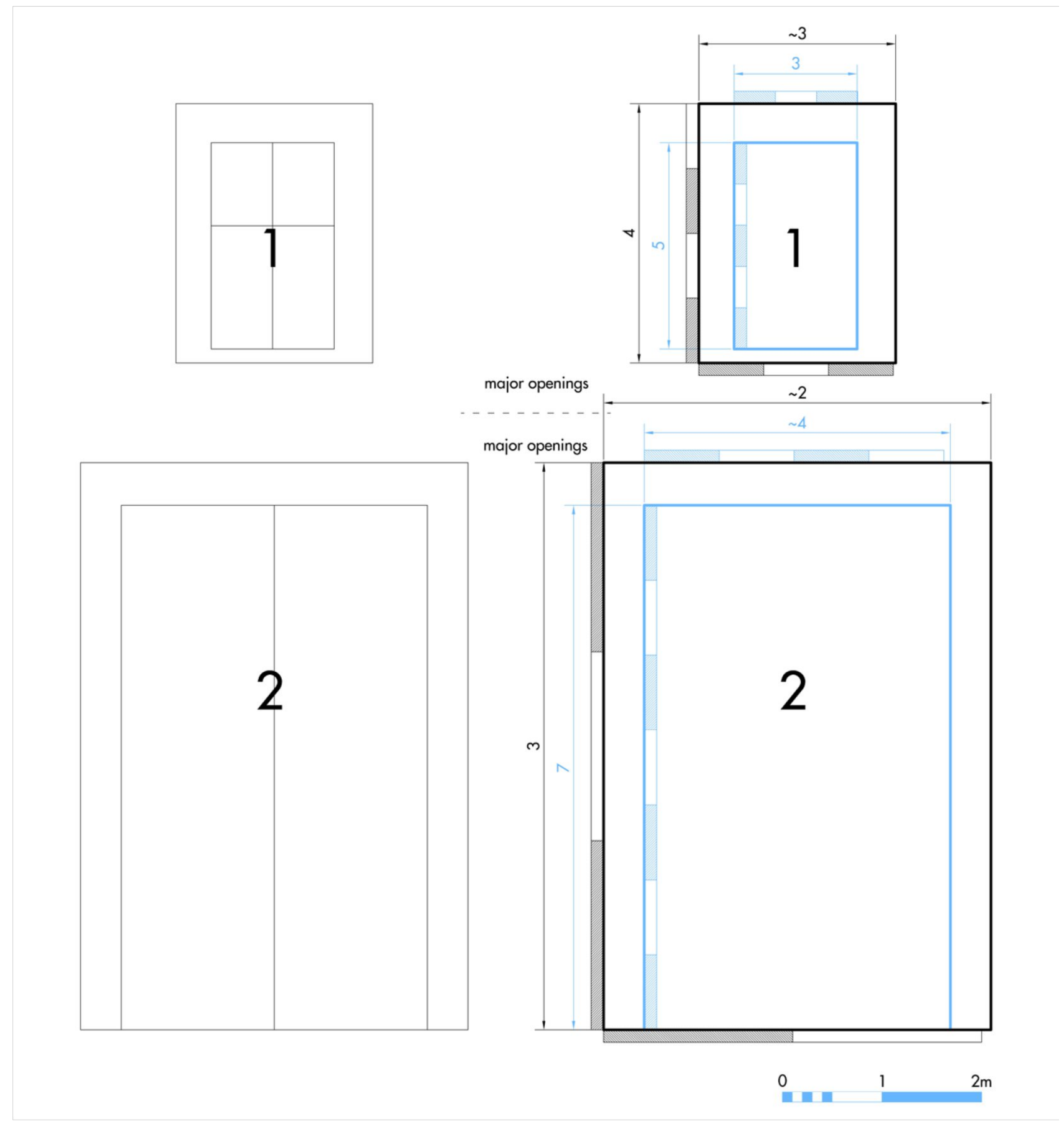


Fig. P.153 Geometrical analysis of openings: (VieR03) Palais Schey, Ring Road, Opernring 10

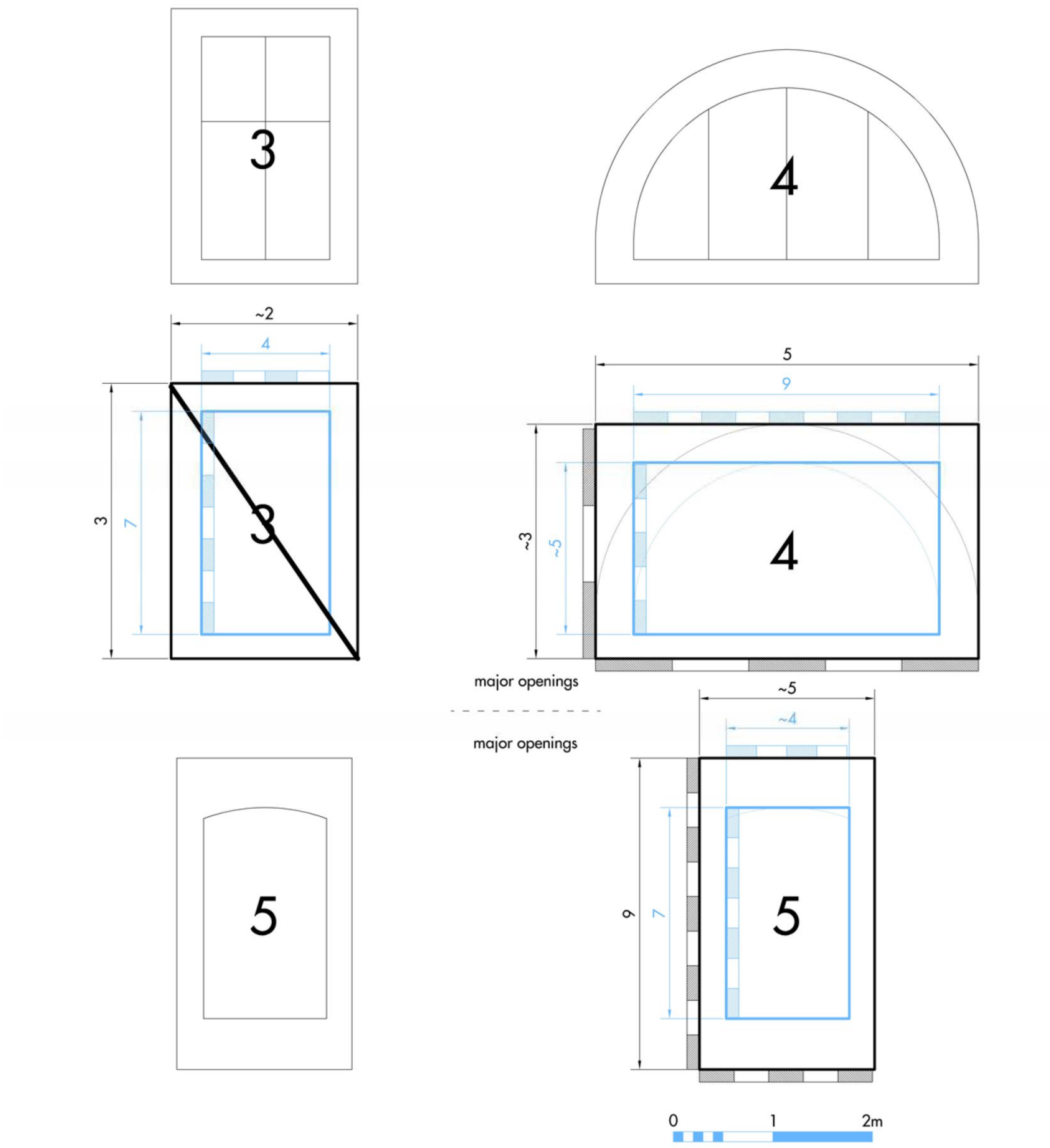


Fig. P.154 Geometrical analysis of openings: (VieR03) Palais Schey, Ring Road, Opernring 10

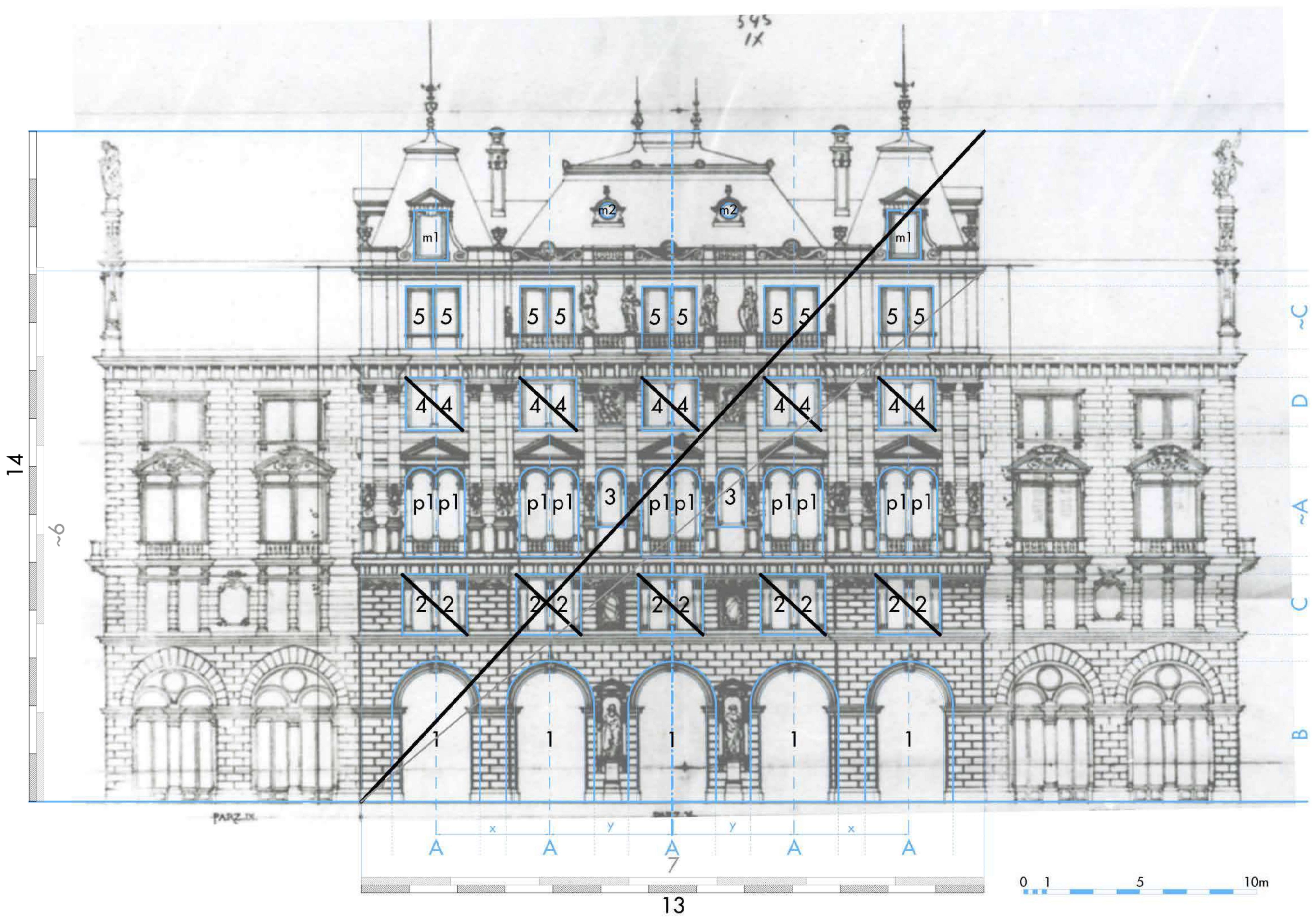


Fig. P.155 Geometrical analysis of front elevation: (VieR04) Palais Angerer (today Hotel Regina), Ring Road, Rooseveltplatz 15-17

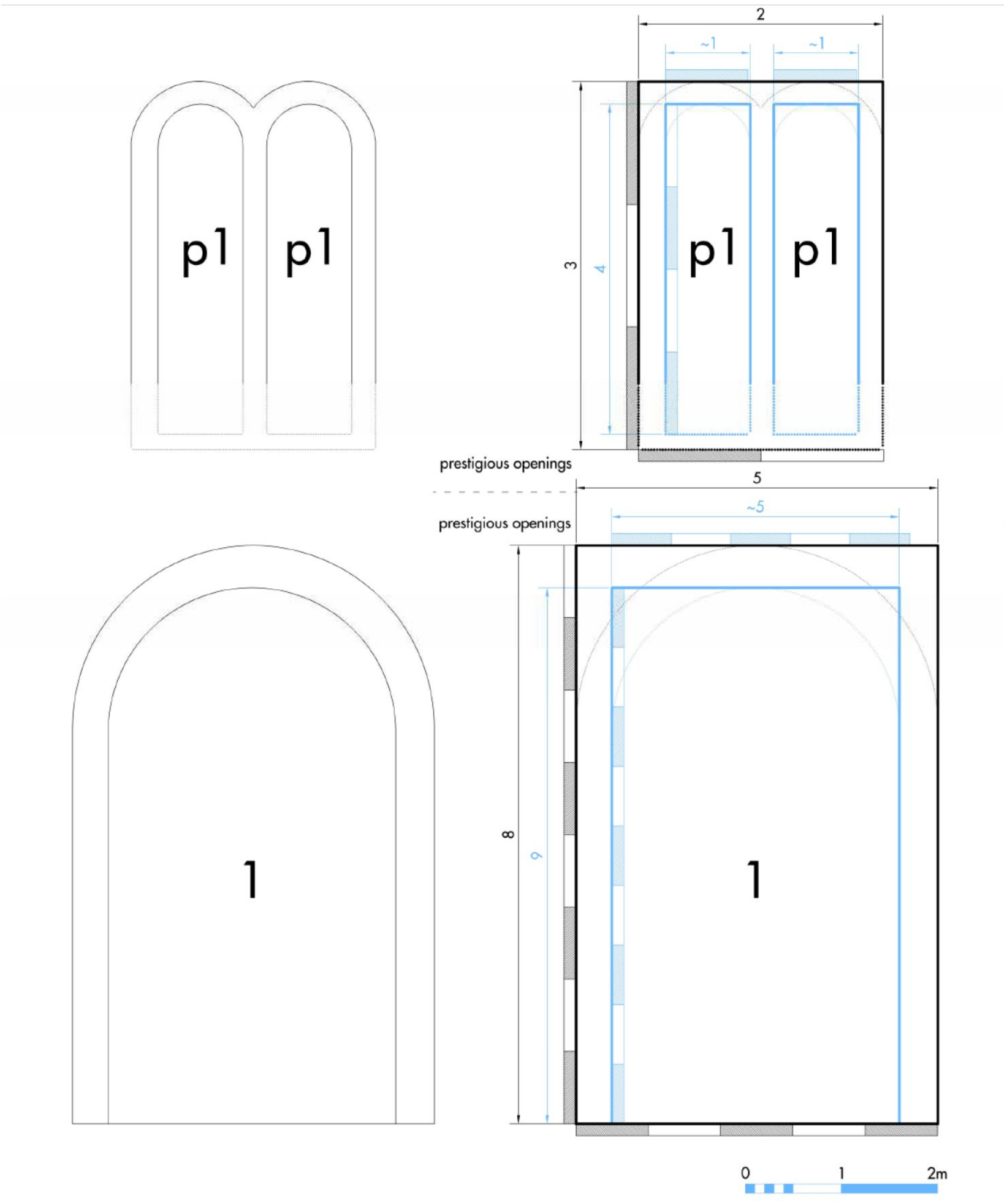


Fig. P.156 Geometrical analysis of openings: (VieR04) Palais Angerer (today Hotel Regina), Ring Road, Rooseveltplatz 15-17

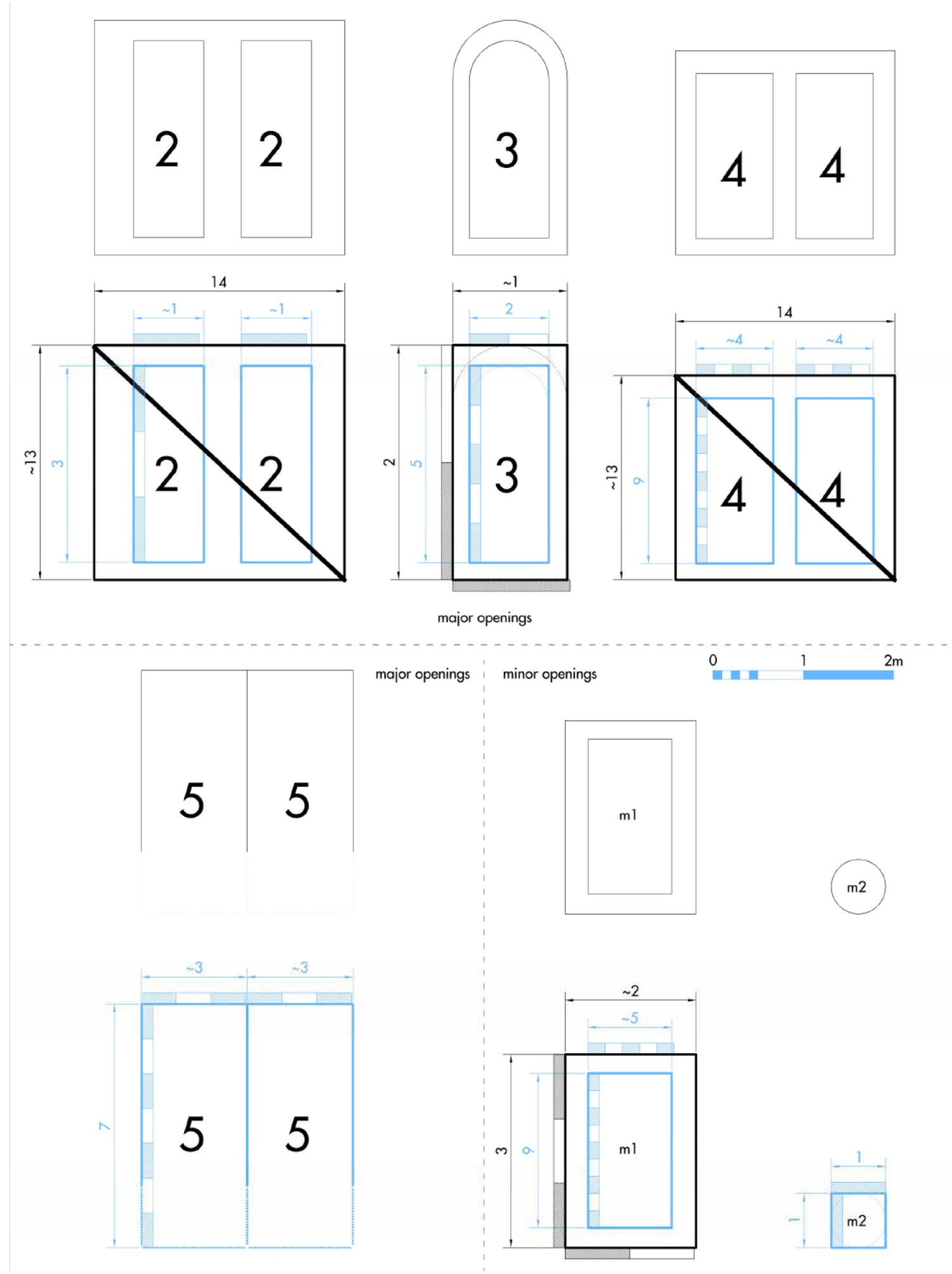


Fig. P.157 Geometrical analysis of openings: (VieR04) Palais Angerer (today Hotel Regina), Ring Road, Rooseveltplatz 15-17

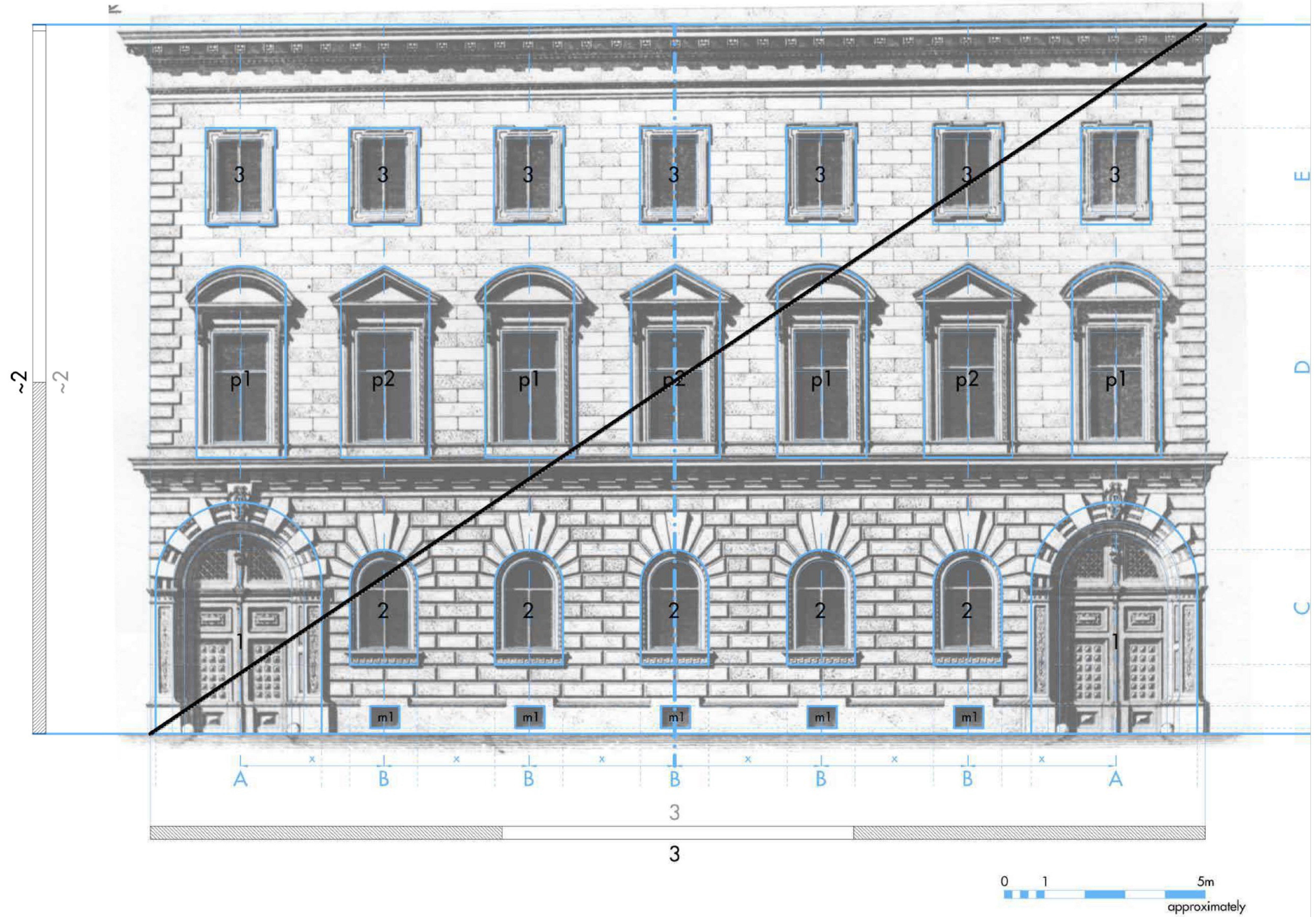


Fig. P.158 Geometrical analysis of front elevation: (VieR05) Palais Pranter-Haas, Ring Road, Waaggasse 6

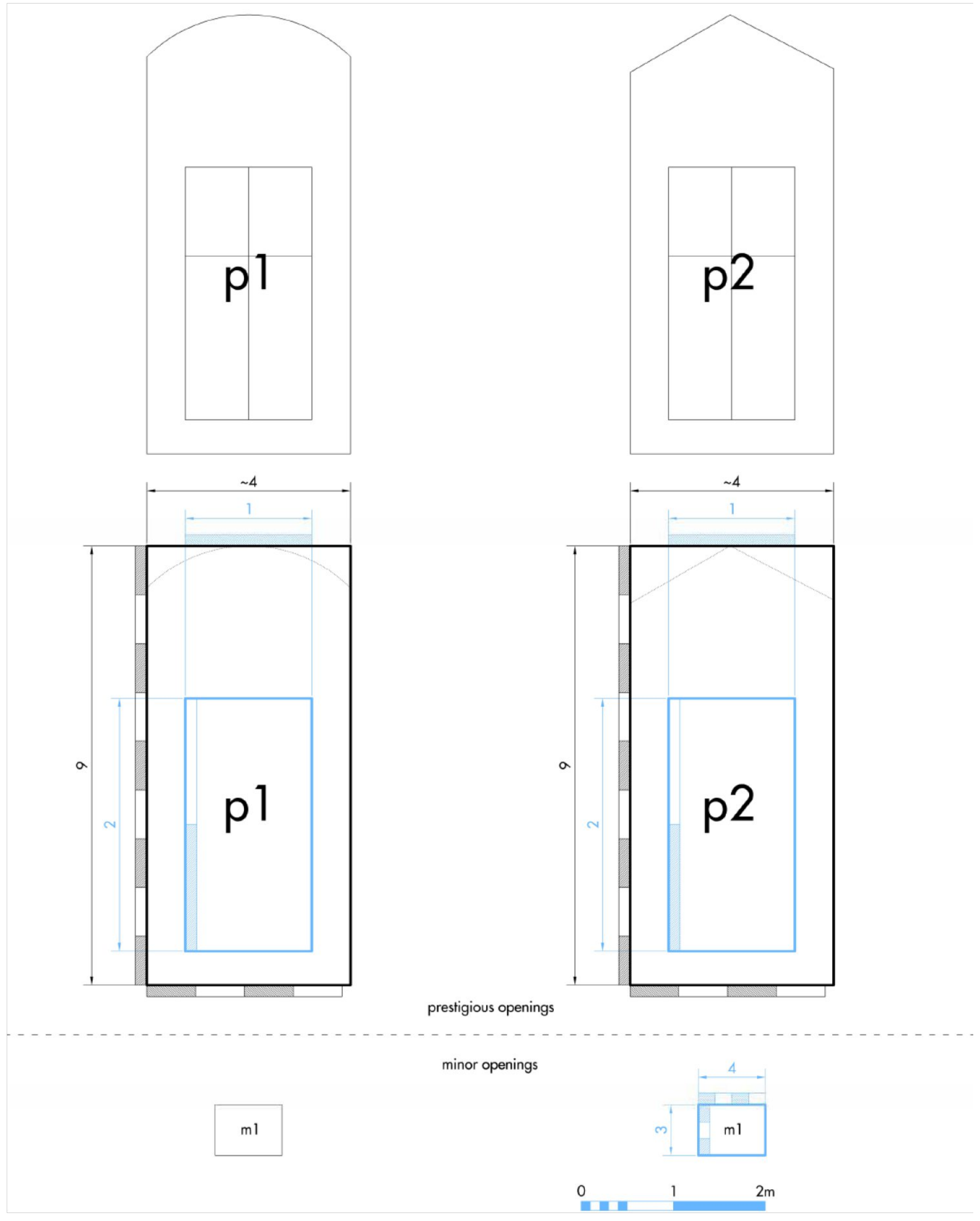


Fig. P.159 Geometrical analysis of openings: (VieR05) Palais Pranter-Haas, Ring Road, Waaggasse 6

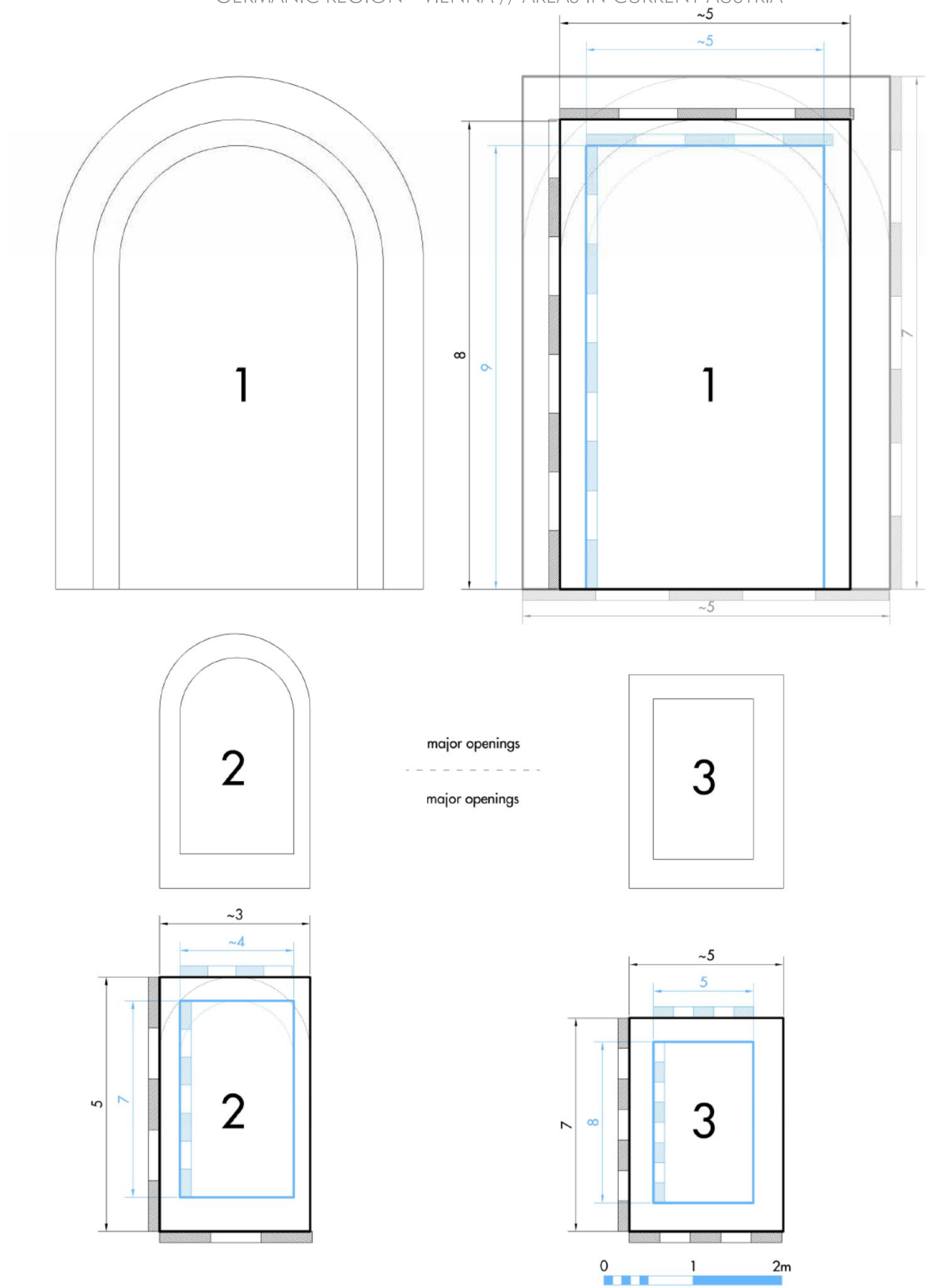


Fig. P.160 Geometrical analysis of openings: (VieR05) Palais Pranter-Haas, Ring Road, Waaggasse 6

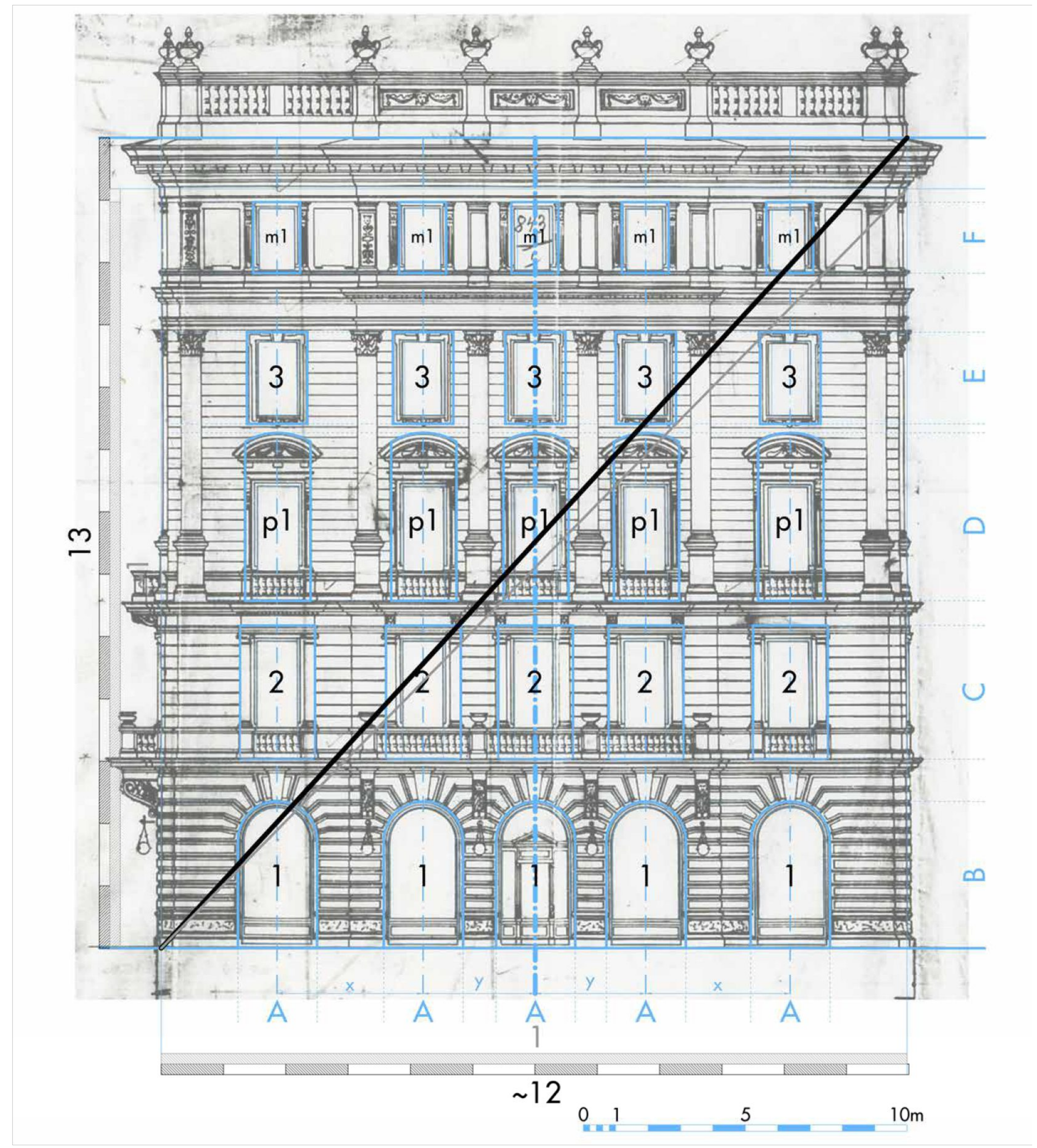


Fig. P.161 Geometrical analysis of front elevation: (VieR06) Palais Lieben-Auspitz (site of Cafe Landtmann,Salon of Berta Zuckerkandl), Ring Road, Franzensring 4 (today Universitätsring)

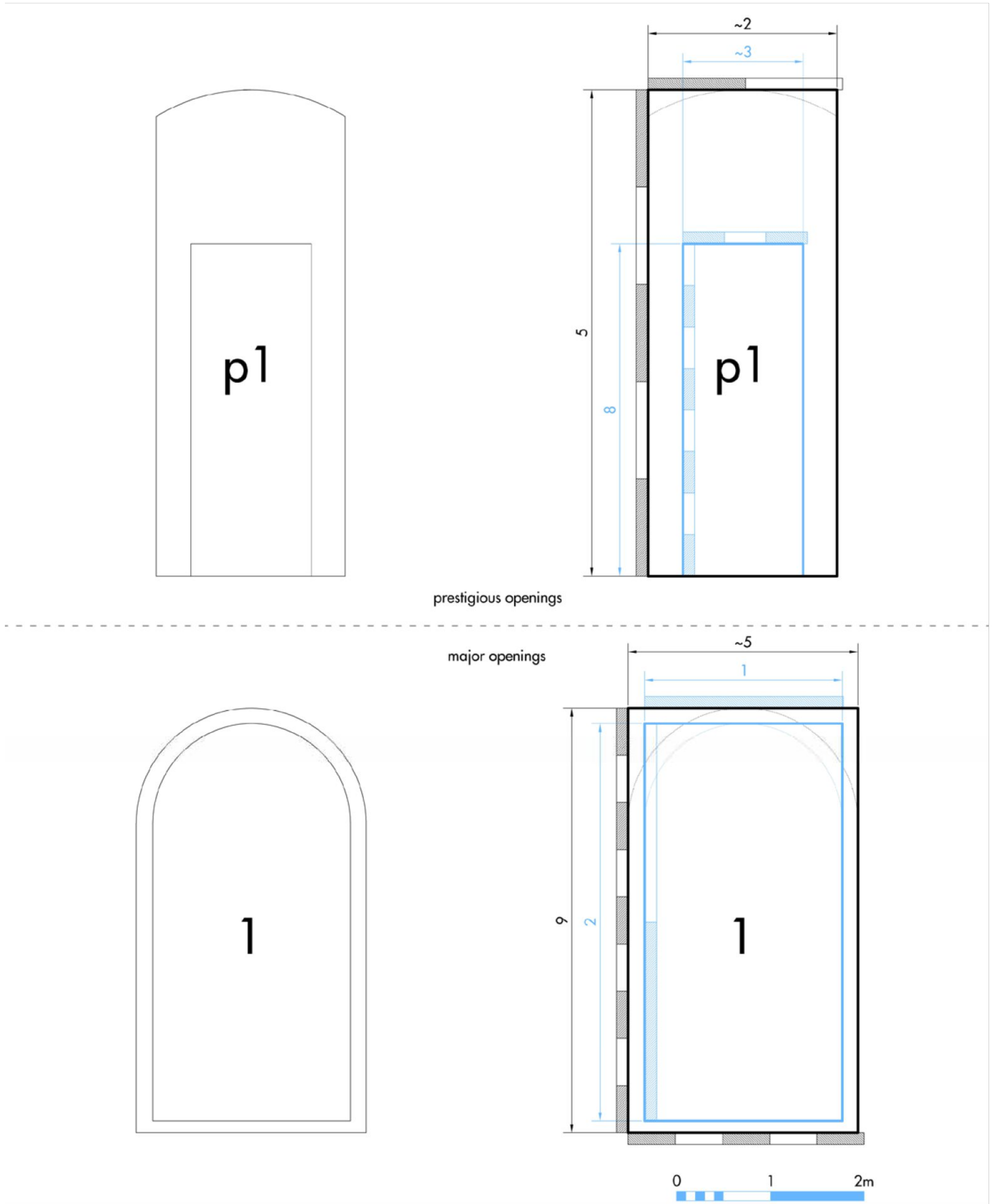


Fig. P.162 Geometrical analysis of openings: (VieR06) Palais Lieben-Auspitz (site of Cafe Landtmann,Salon of Berta Zuckerkandl), Ring Road, Franzensring 4 (today Universitätsring)

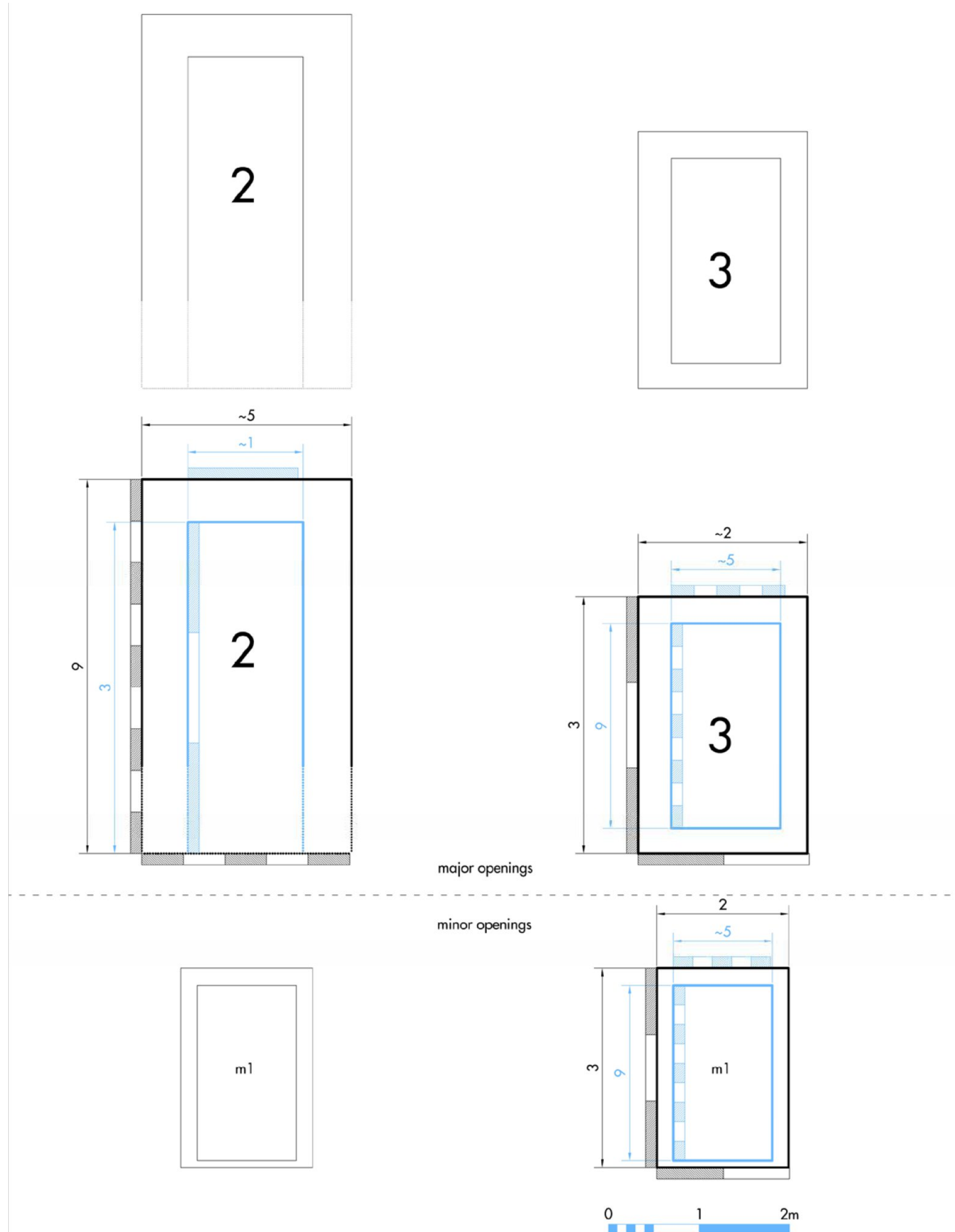


Fig. P.163 Geometrical analysis of openings: (VieR06) Palais Lieben-Auspitz (site of Cafe Landtmann,Salon of Berta Zuckerkandl), Ring Road, Franzensring 4 (today Universitätsring)

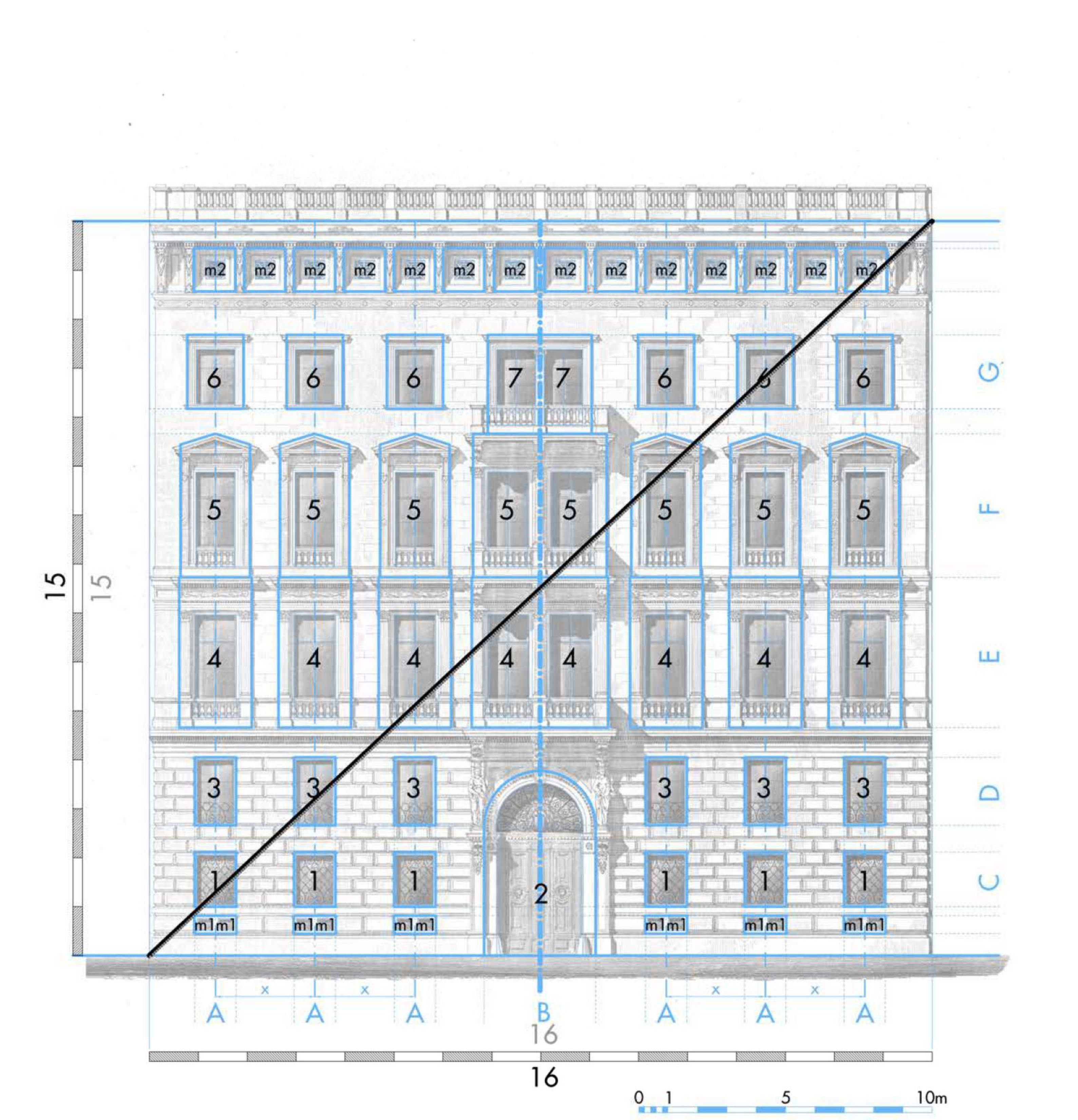


Fig. P.164 Geometrical analysis of front elevation: (VieR07) Palais Hoyos-Sprinzenstein, Ring Road, Kärntner Ring 5 and Maximilianstraße 6 (today Mahlerstraße 6)

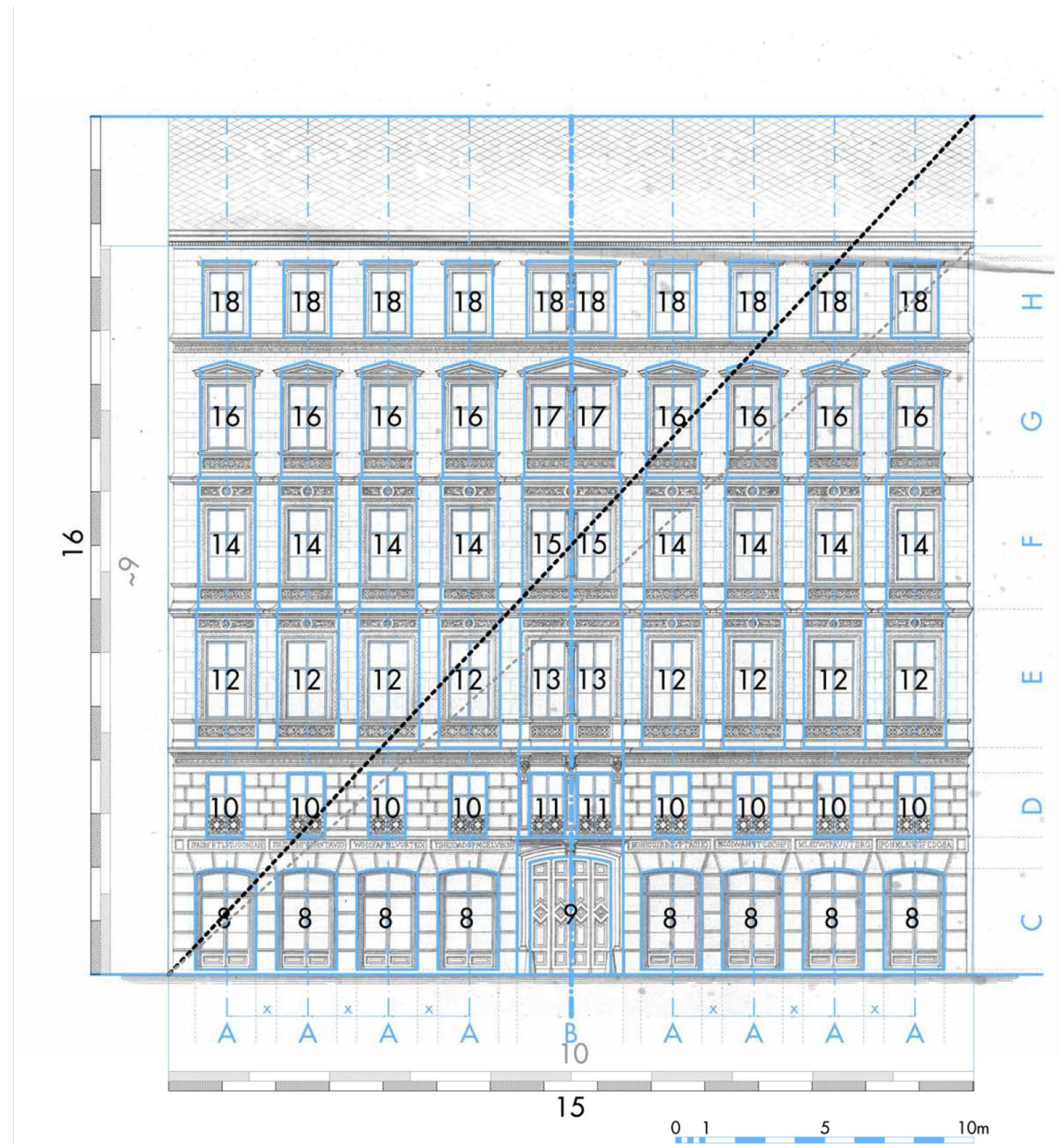


Fig. P.165 Geometrical analysis of rear elevation: (VieR07) Palais Hoyos-Sprinzenstein, Ring Road, Kärntner Ring 5 and Maximilianstraße 6 (today Mahlerstraße 6)

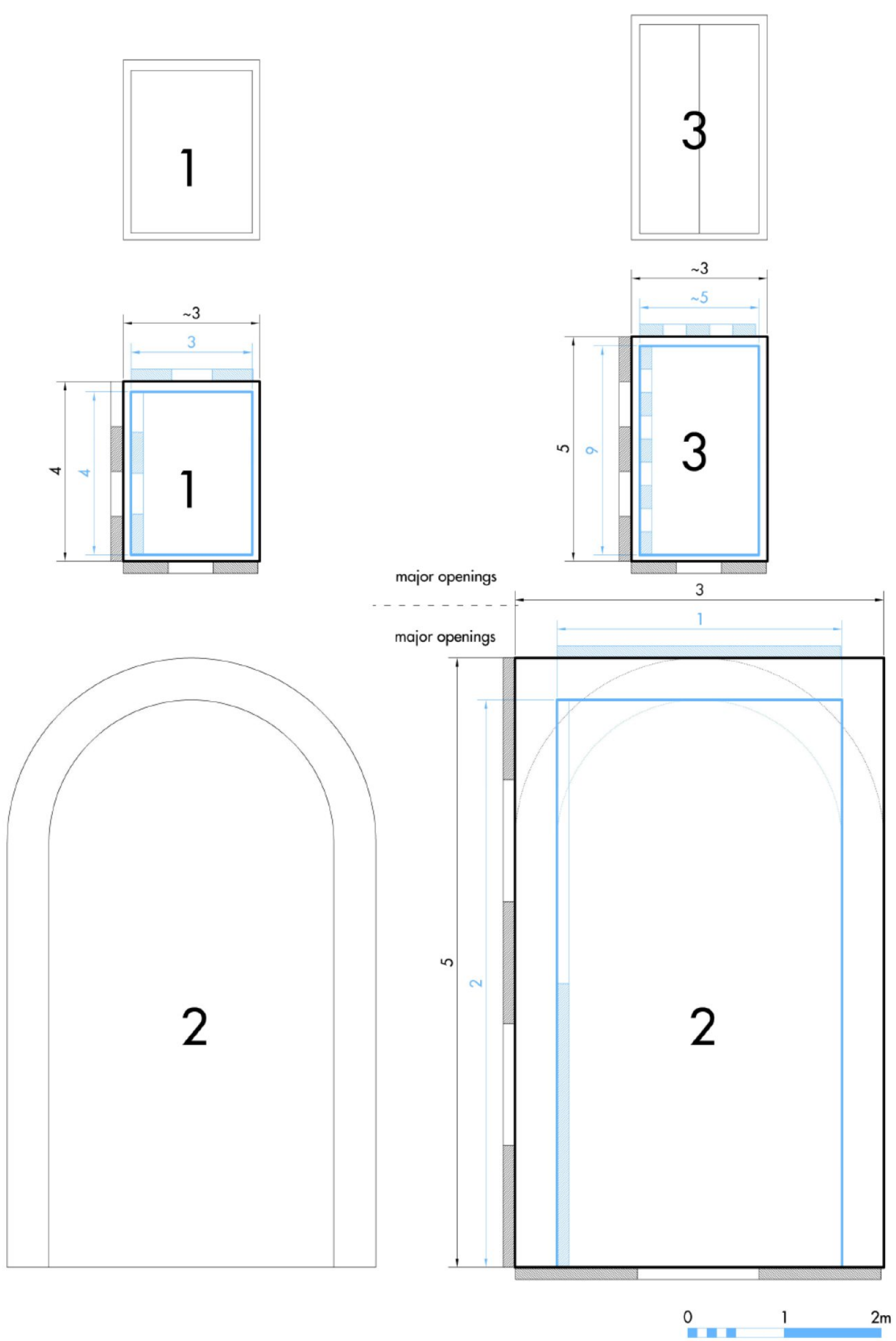


Fig. P.166 Geometrical analysis of openings: (VieR07) Palais Hoyos-Sprinzenstein, Ring Road, Kärntner Ring 5 and Maximilianstraße 6 (today Mahlerstraße 6)

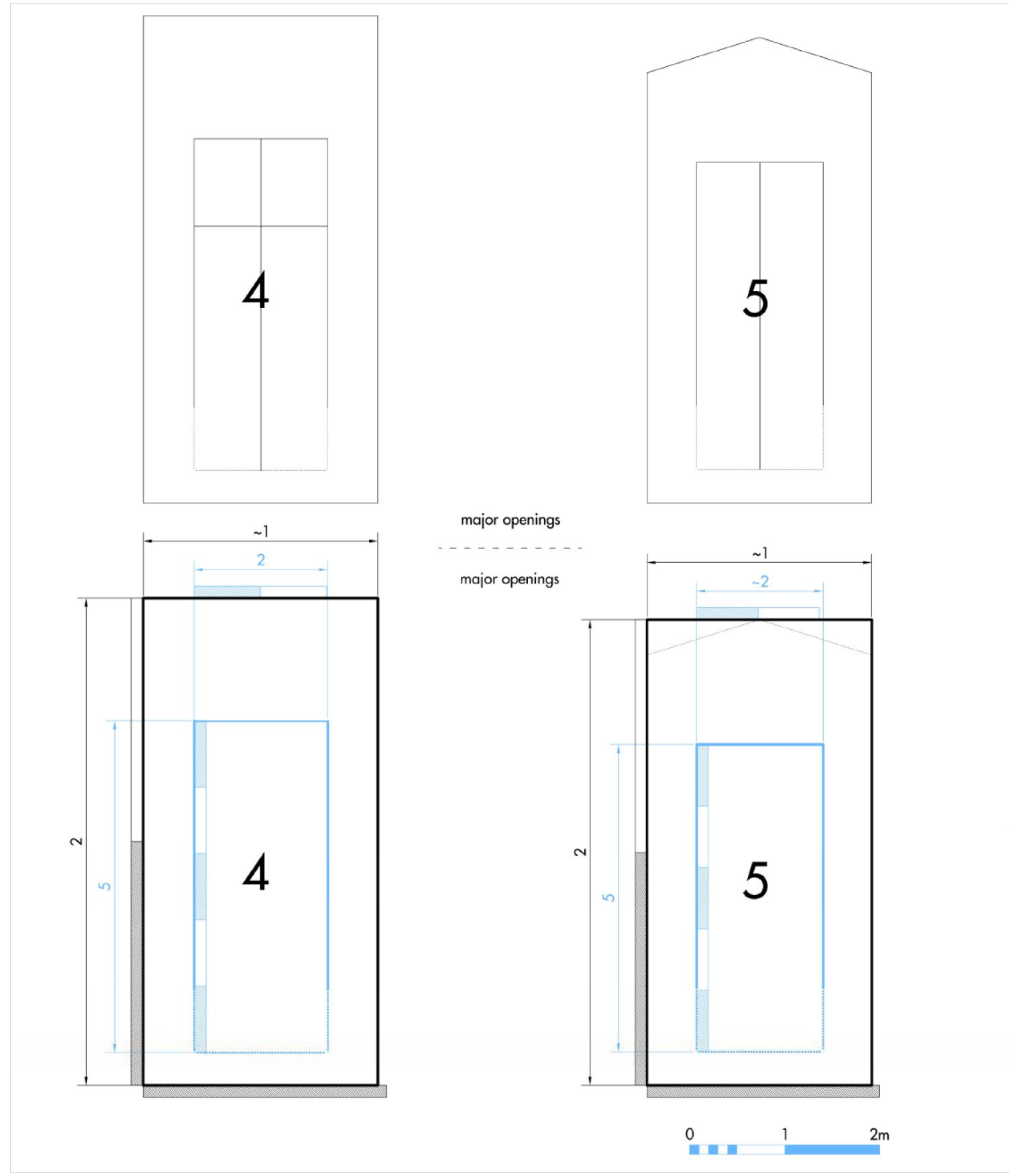


Fig. P.167 Geometrical analysis of openings: (VieR07) Palais Hoyos-Sprinzenstein, Ring Road, Kärntner Ring 5 and Maximilianstraße 6 (today Mahlerstraße 6)

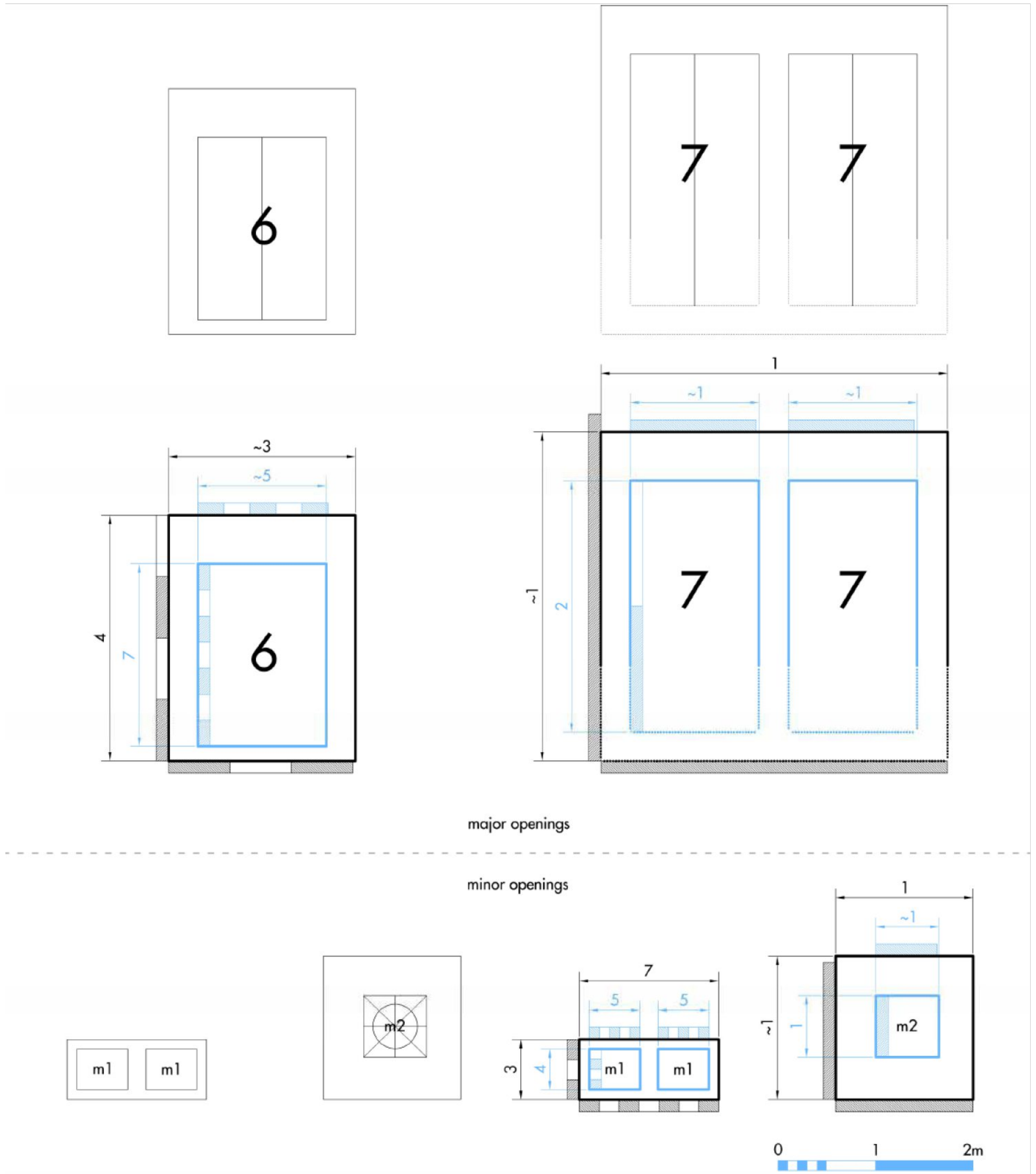


Fig. P.168 Geometrical analysis of openings: (VieR07) Palais Hoyos-Sprinzenstein, Ring Road, Kärntner Ring 5 and Maximilianstraße 6 (today Mahlerstraße 6)

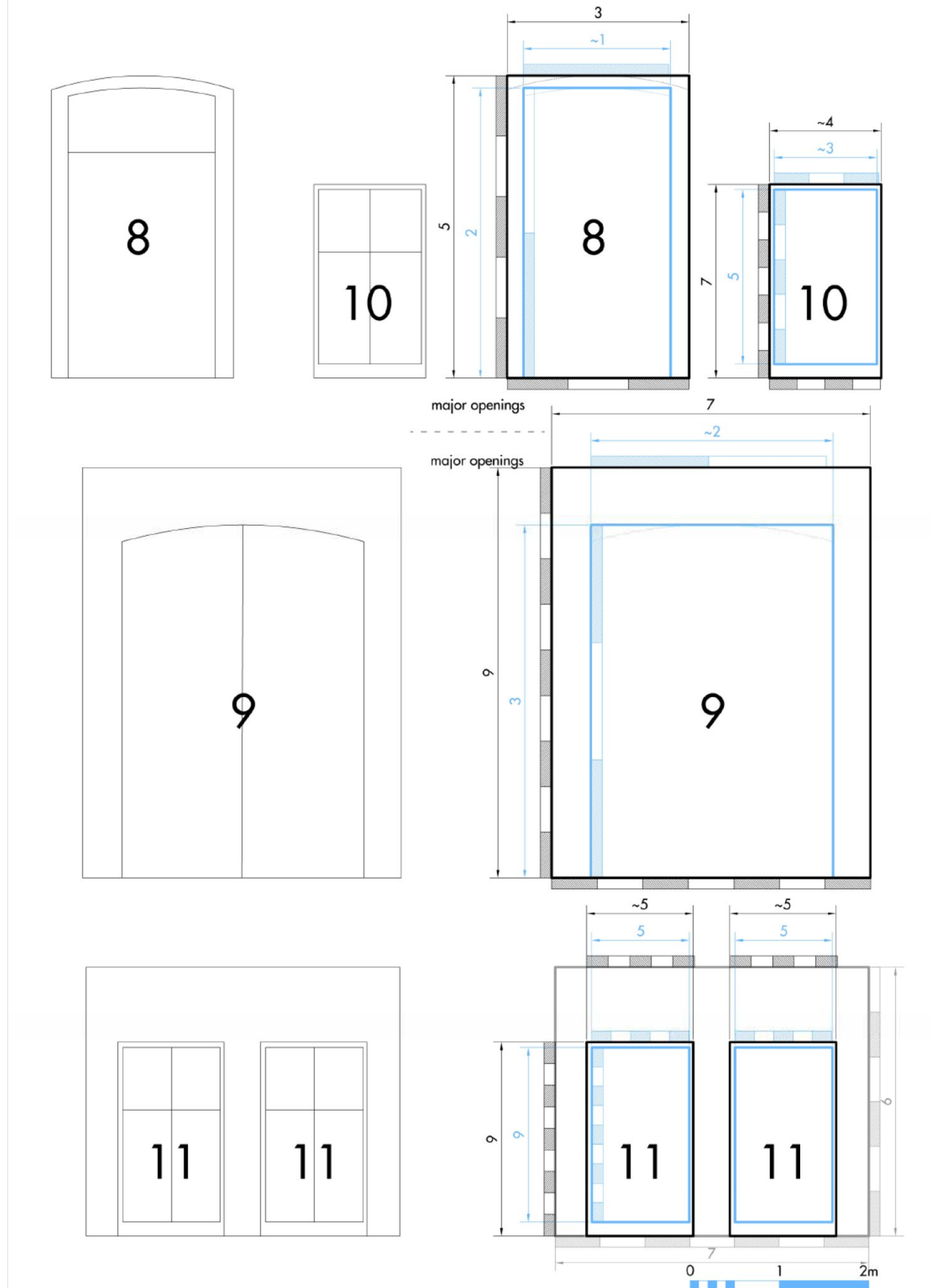


Fig. P.169 Geometrical analysis of openings: (VieR07) Palais Hoyos-Sprinzenstein, Ring Road, Kärntner Ring 5 and Maximilianstraße 6 (today Mahlerstraße 6)

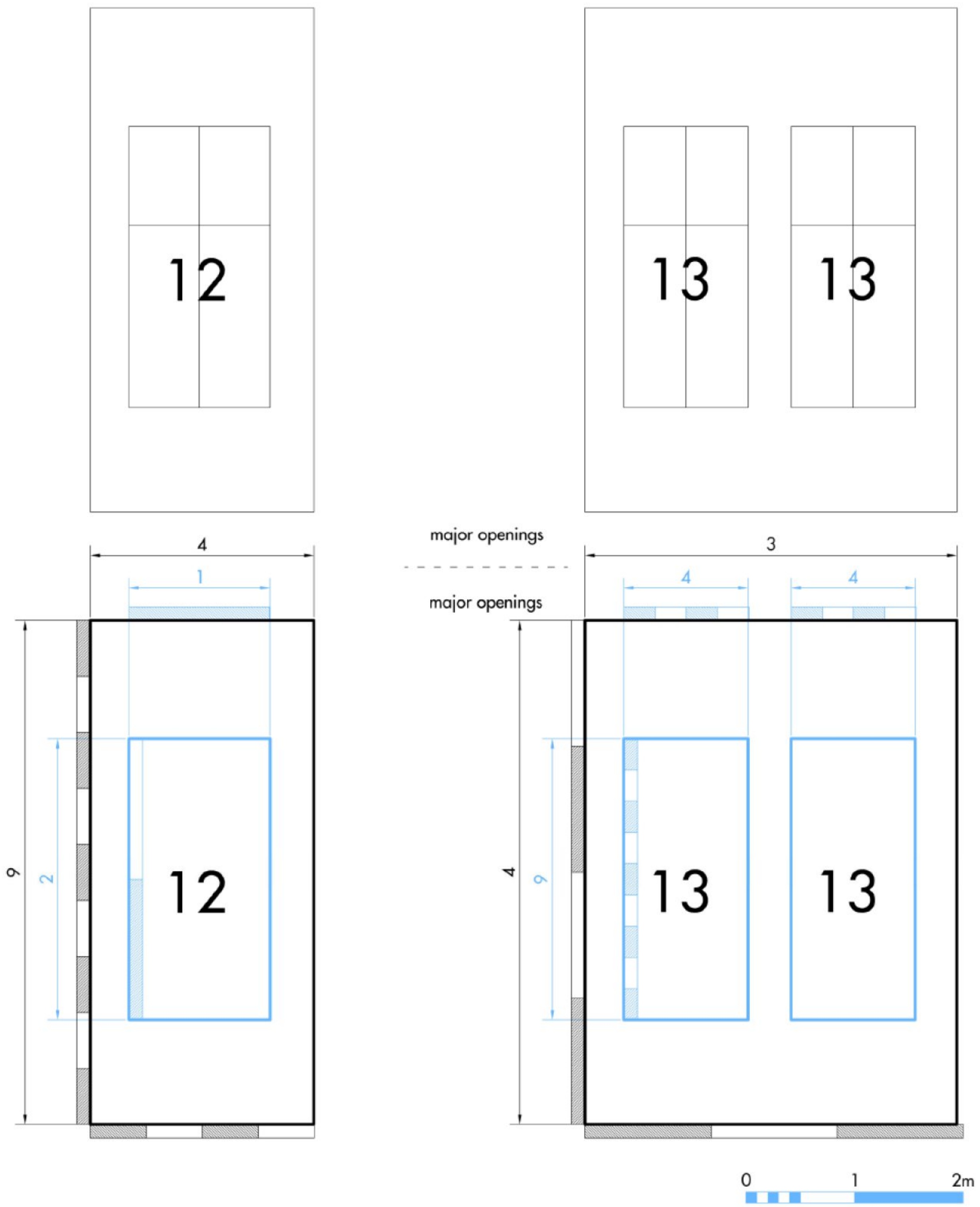


Fig. P.170 Geometrical analysis of openings: (VieR07) Palais Hoyos-Sprinzenstein, Ring Road, Kärntner Ring 5 and Maximilianstraße 6 (today Mahlerstraße 6)

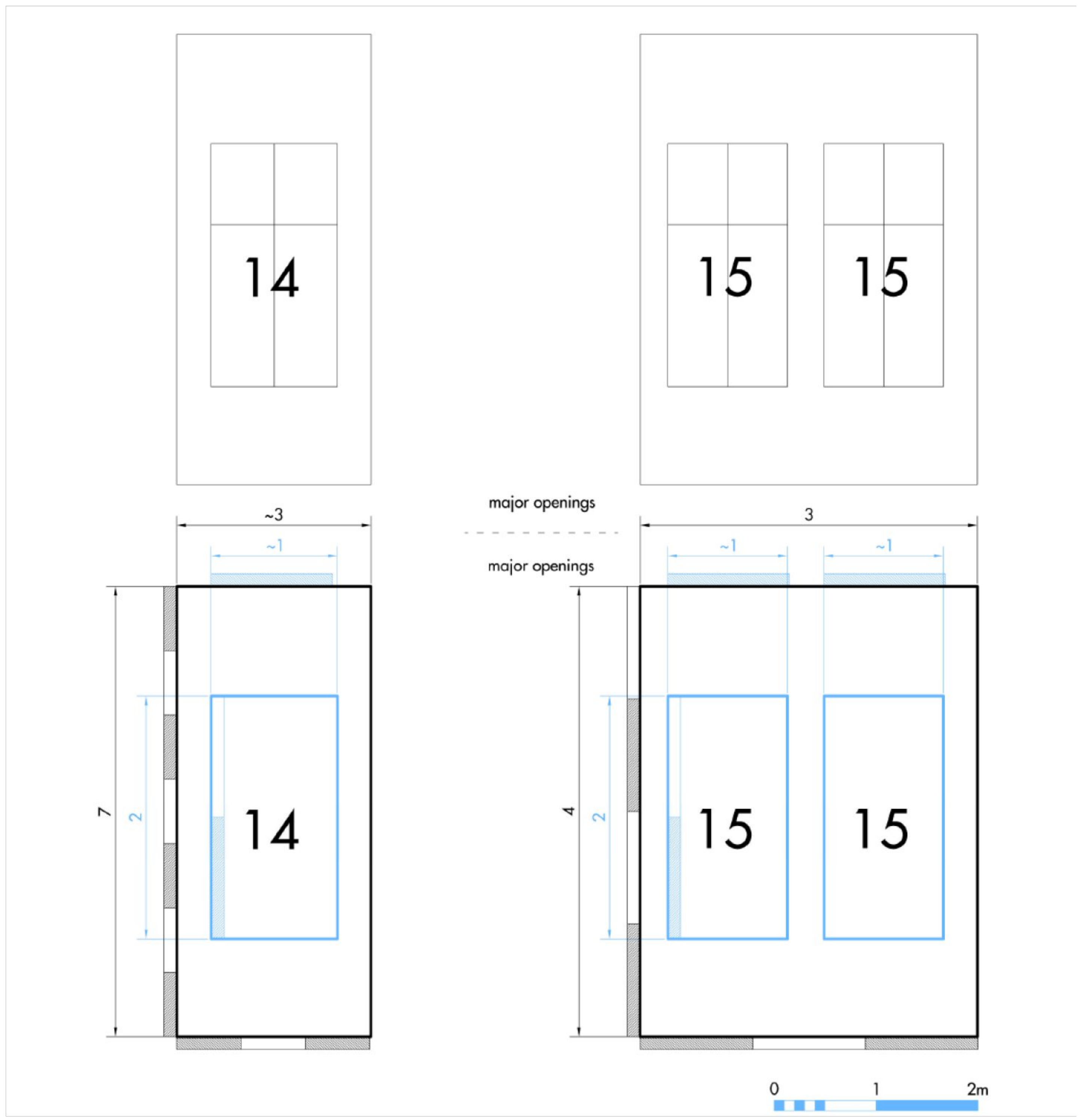


Fig. P.171 Geometrical analysis of openings: (VieR07) Palais Hoyos-Sprinzenstein, Ring Road, Kärntner Ring 5 and Maximilianstraße 6 (today Mahlerstraße 6)

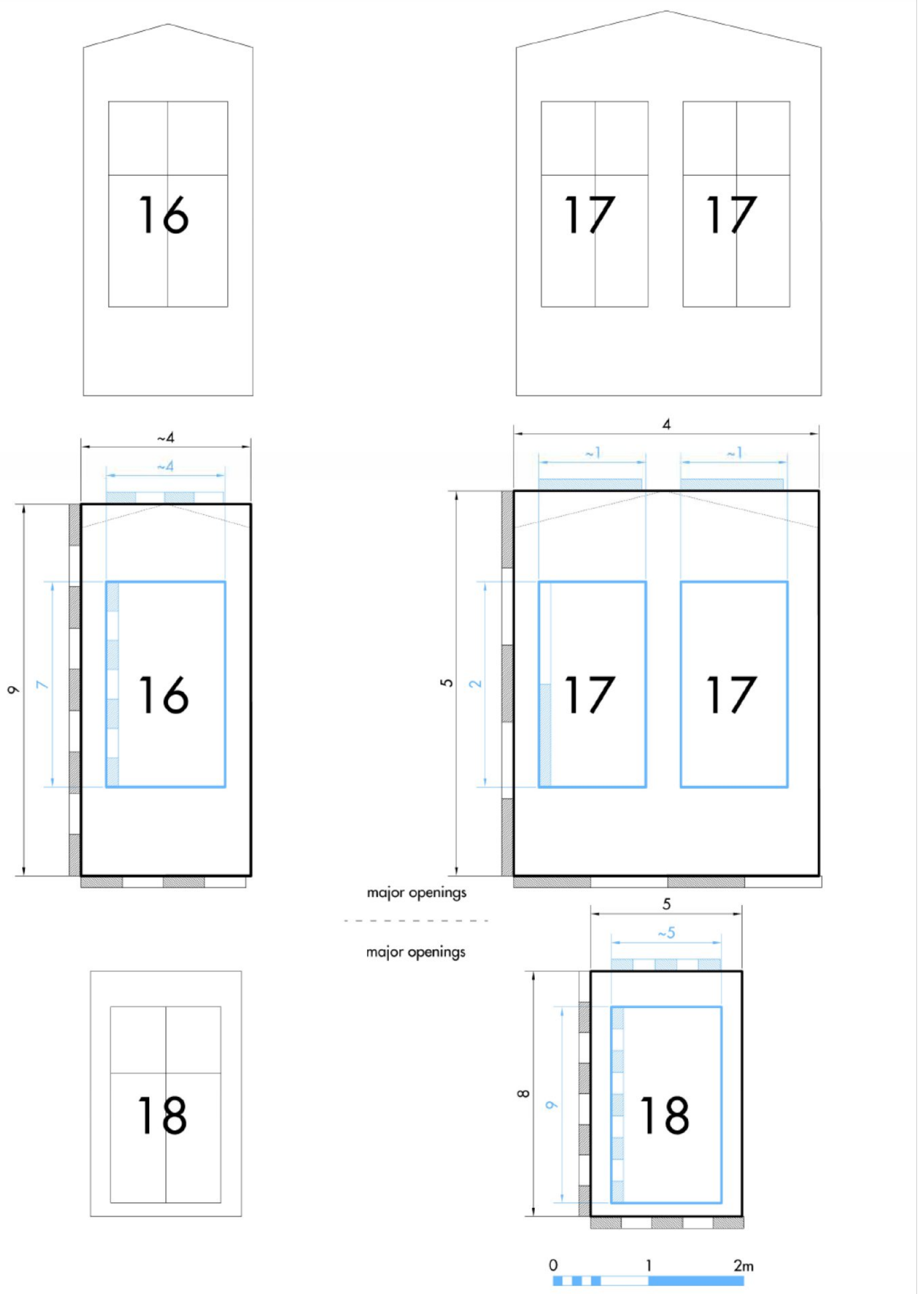


Fig. P.172 Geometrical analysis of openings: (VieR07) Palais Hoyos-Sprinzenstein, Ring Road, Kärntner Ring 5 and Maximilianstraße 6 (today Mahlerstraße 6)

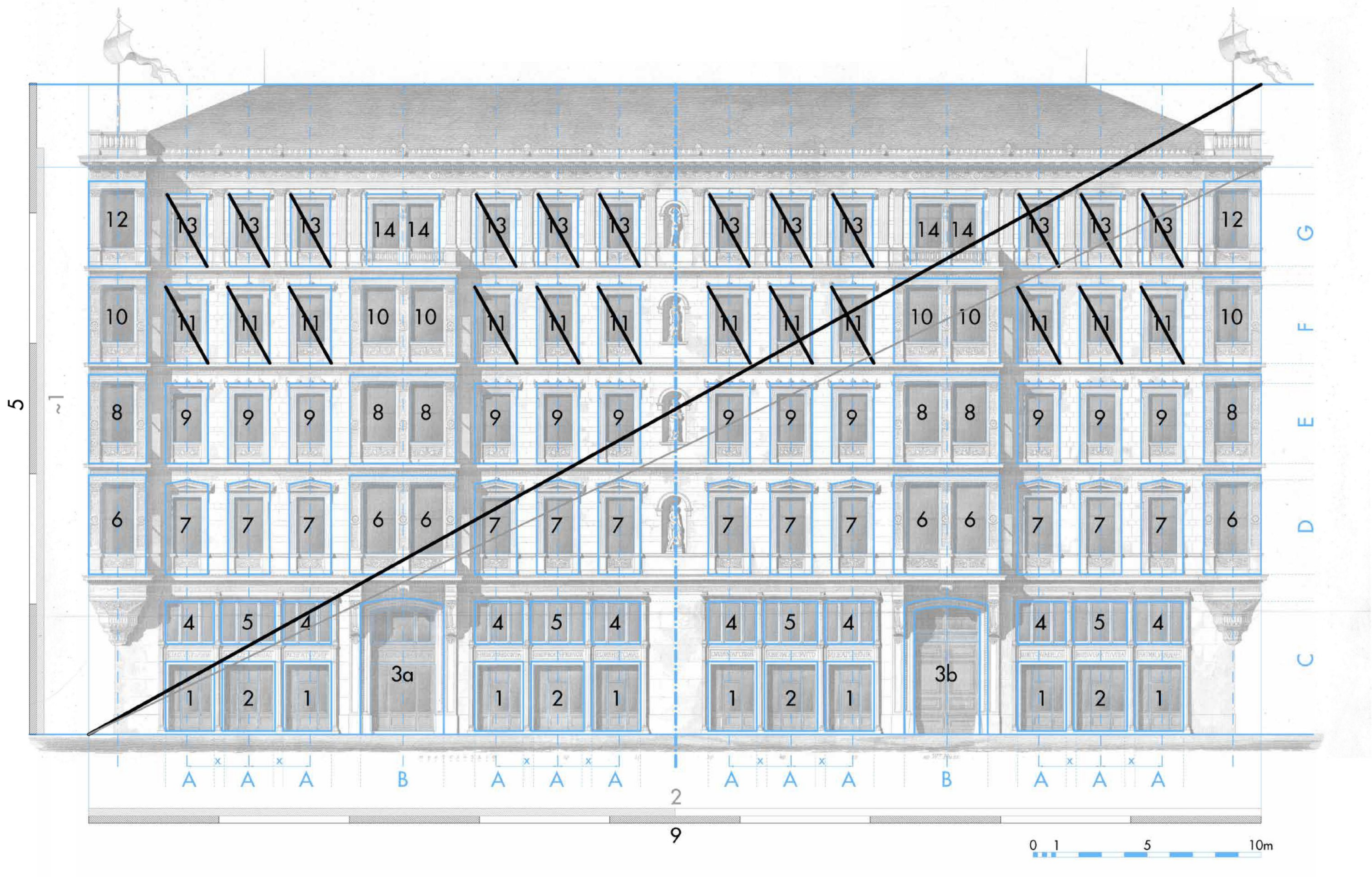


Fig. P.173 Geometrical analysis of front elevation: (VieR08) Residential house on the Ring Road, Kärntner Straße corner, Ring Road

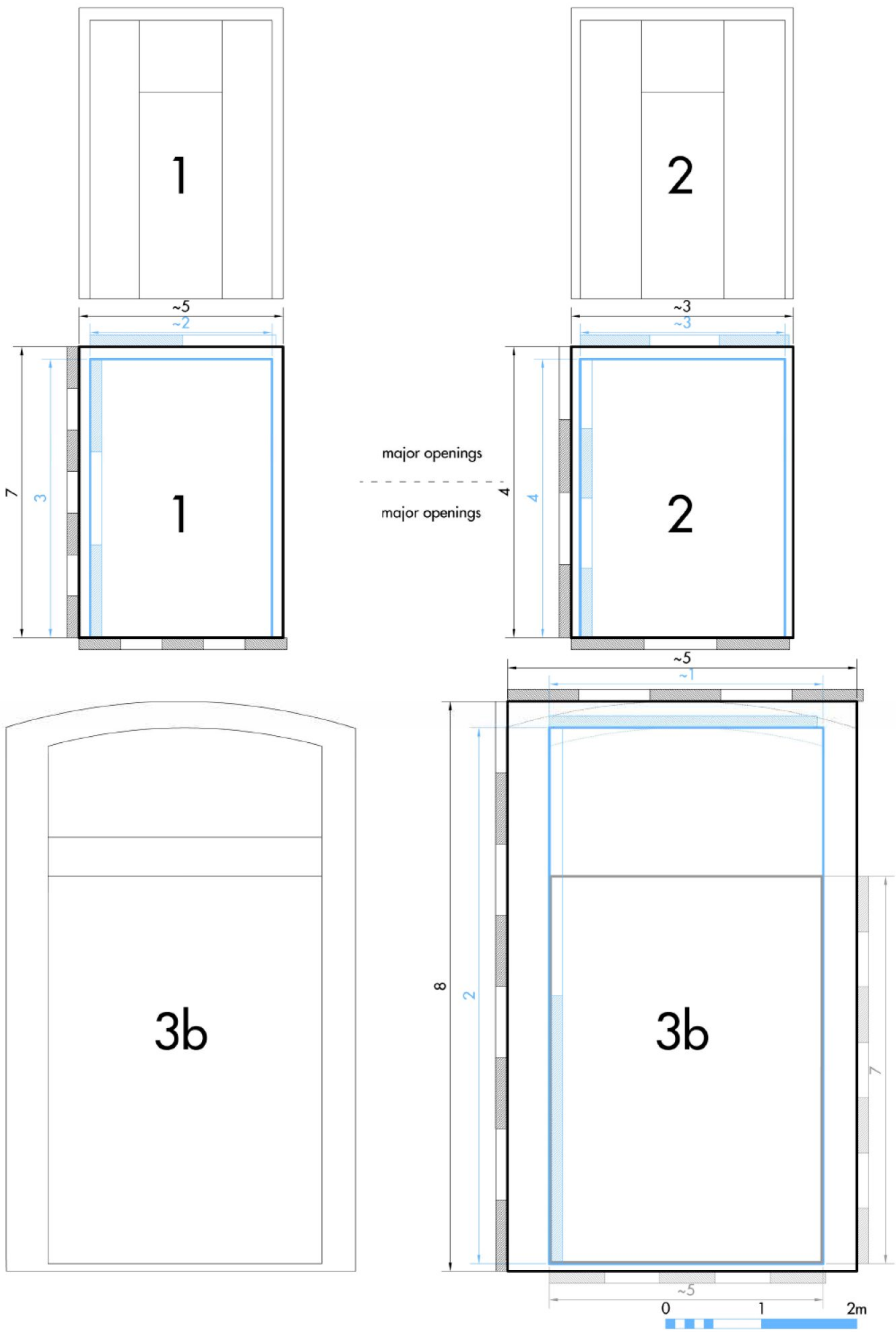


Fig. P.174 Geometrical analysis of openings: (VieR08) Residential house on the Ring Road, Kärntner Straße corner, Ring Road

Fig. P.175 Geometrical analysis of openings: (VieR08) Residential house on the Ring Road, Kärntner Straße corner, Ring Road

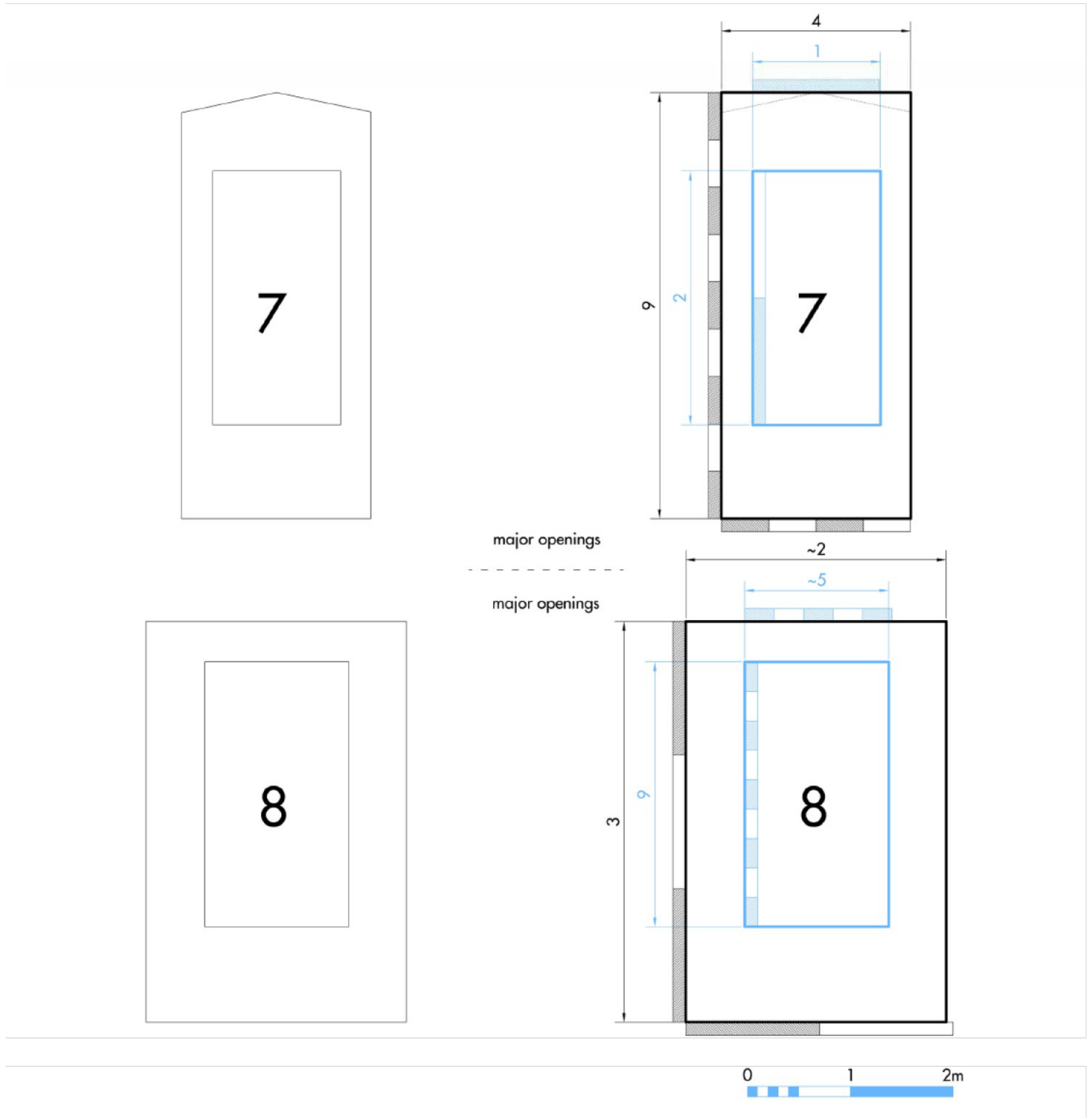


Fig. P.176 Geometrical analysis of openings: (VieR08) Residential house on the Ring Road, Kärntner Straße corner, Ring Road

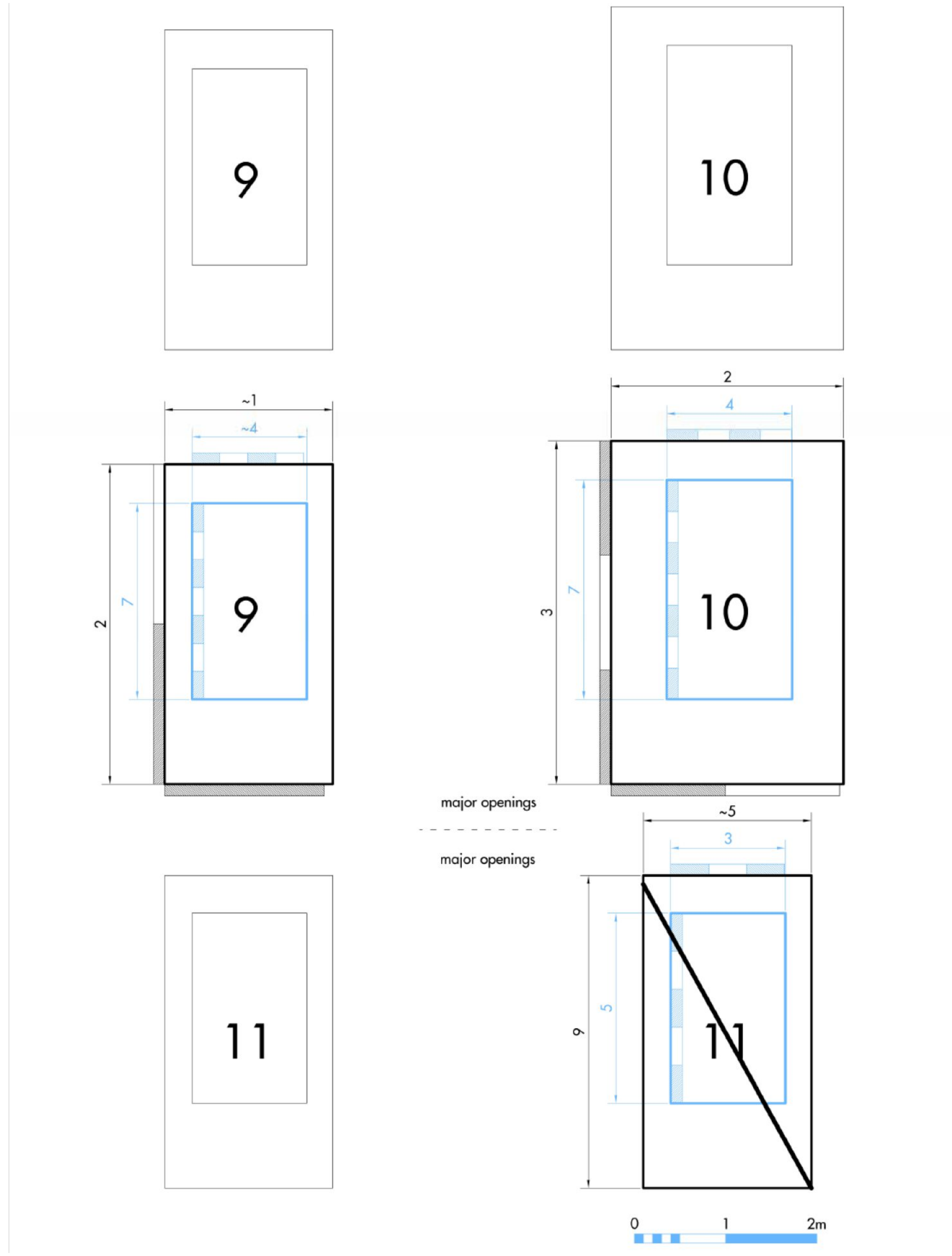


Fig. P.177 Geometrical analysis of openings: (VieR08) Residential house on the Ring Road, Kärntner Straße corner, Ring Road

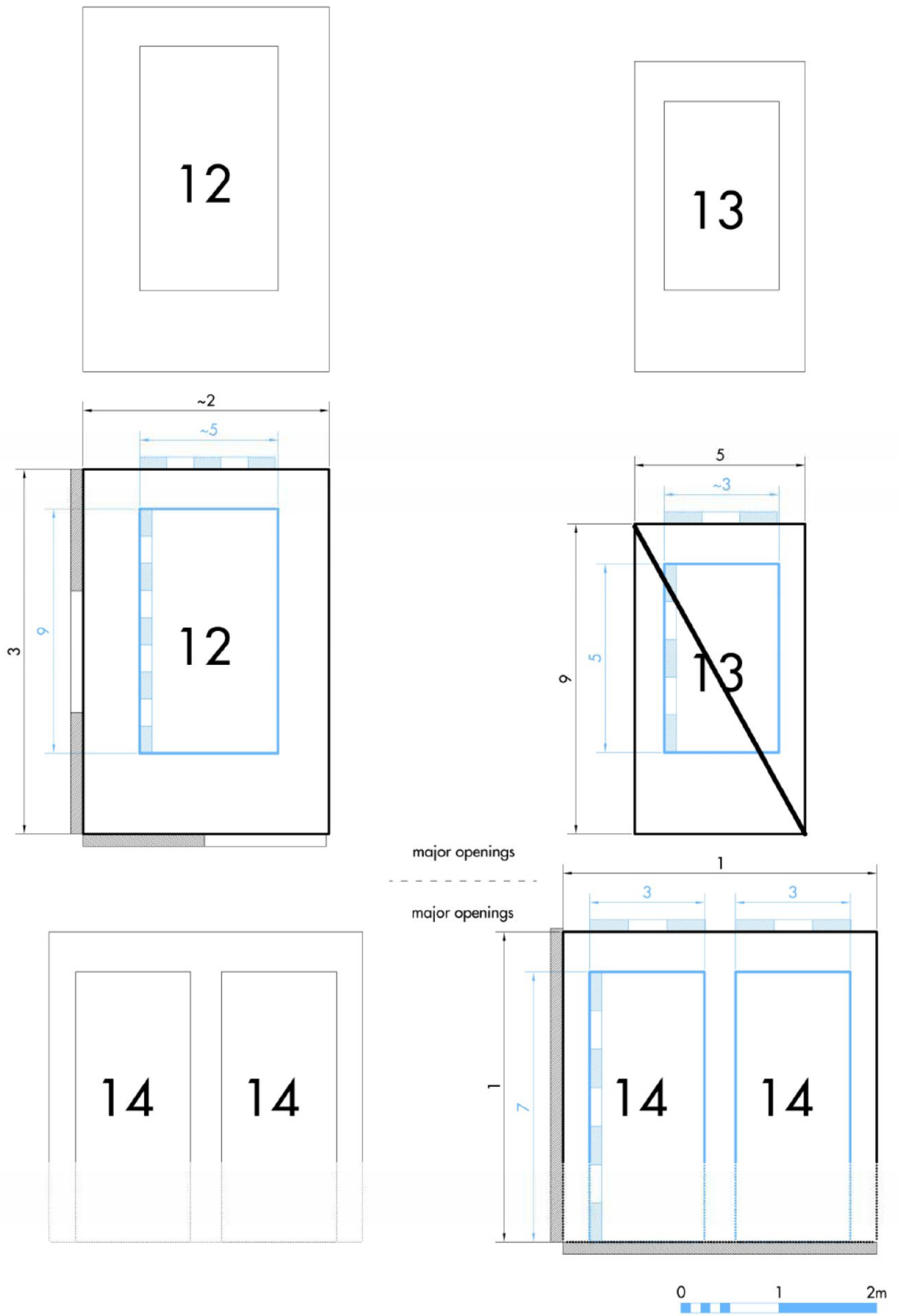


Fig. P.178 Geometrical analysis of openings: (VieR08) Residential house on the Ring Road, Kärntner Straße corner, Ring Road

Fig. P.179 Geometrical analysis of front elevation: (VieR09) Residential house of Mr. Alexander Ritter von Schöller, Ring Road, Opernring 6

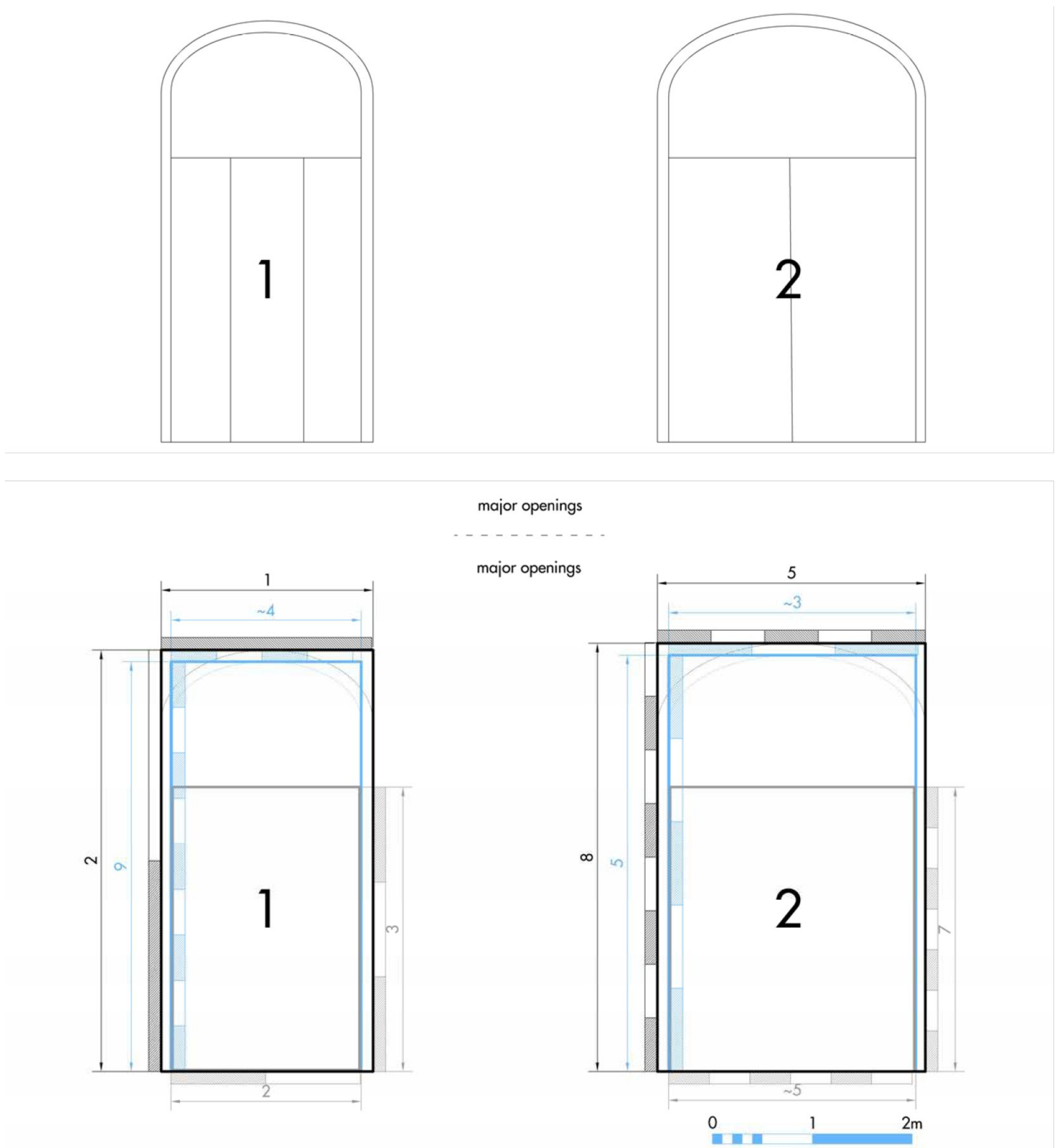


Fig. P.180 Geometrical analysis of openings: (VieR09) Residential house of Mr. Alexander Ritter von Schöller, Ring Road, Opernring 6

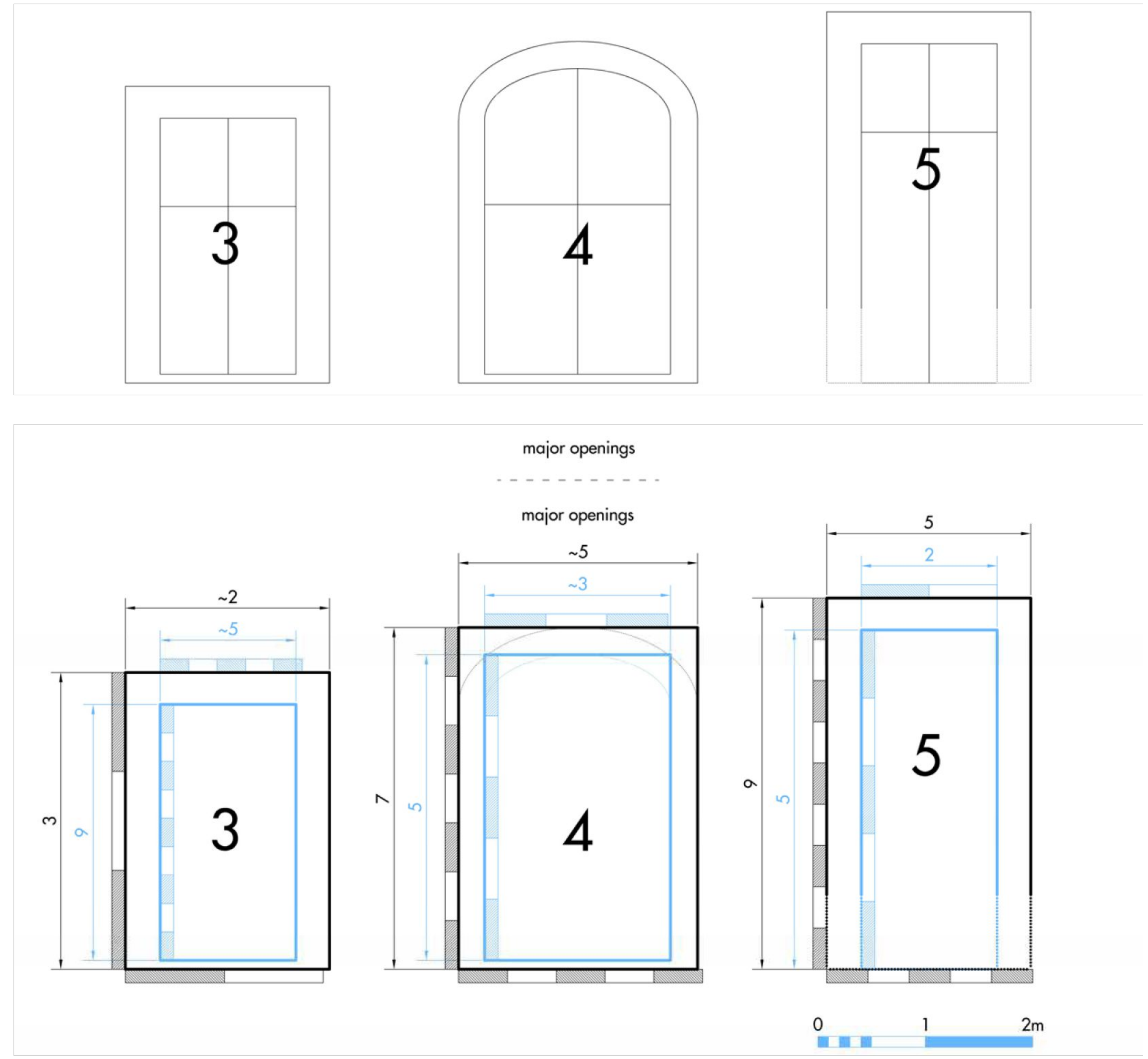


Fig. P.181 Geometrical analysis of openings: (VieR09) Residential house of Mr. Alexander Ritter von Schöller, Ring Road, Opernring 6

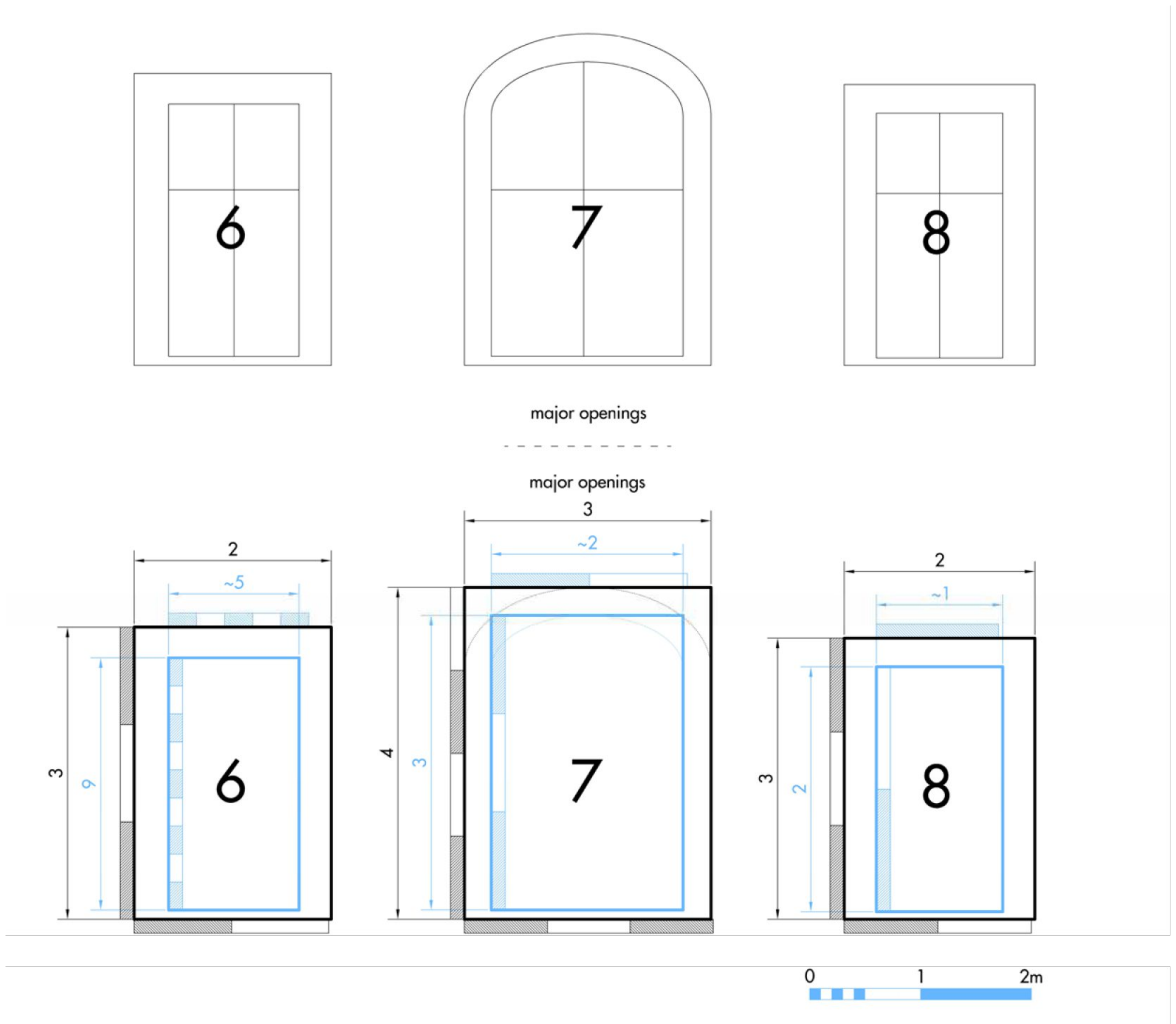


Fig. P.182 Geometrical analysis of openings: (VieR09) Residential house of Mr. Alexander Ritter von Schöller, Ring Road, Opernring 6

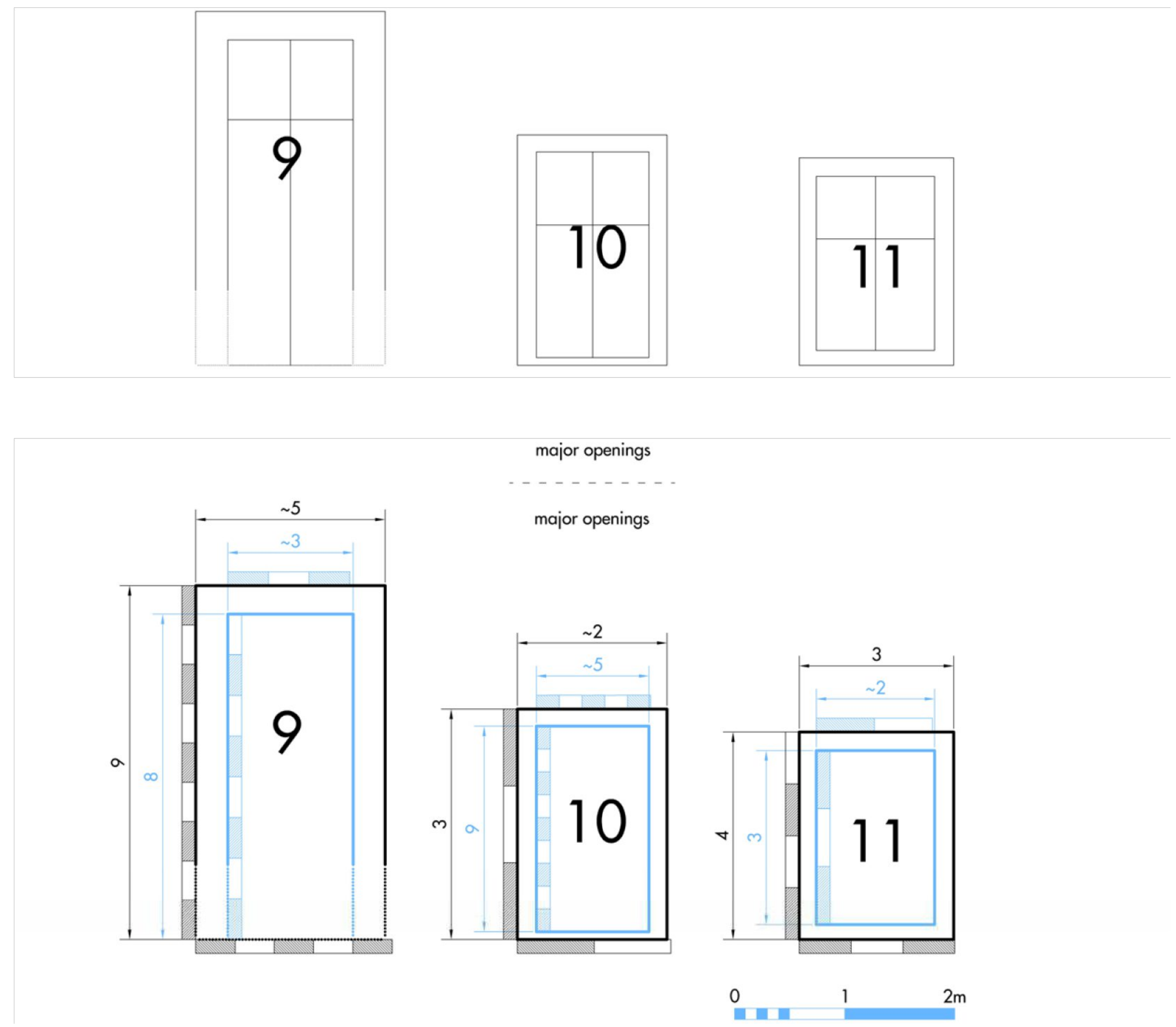


Fig. P.183 Geometrical analysis of openings: (VieR09) Residential house of Mr. Alexander Ritter von Schöller, Ring Road, Opernring 6

Fig. P.184 Geometrical analysis of front elevation: (VieR10) Residential house of Mr. Adalbert Zinner, Ring Road, Opernring 8

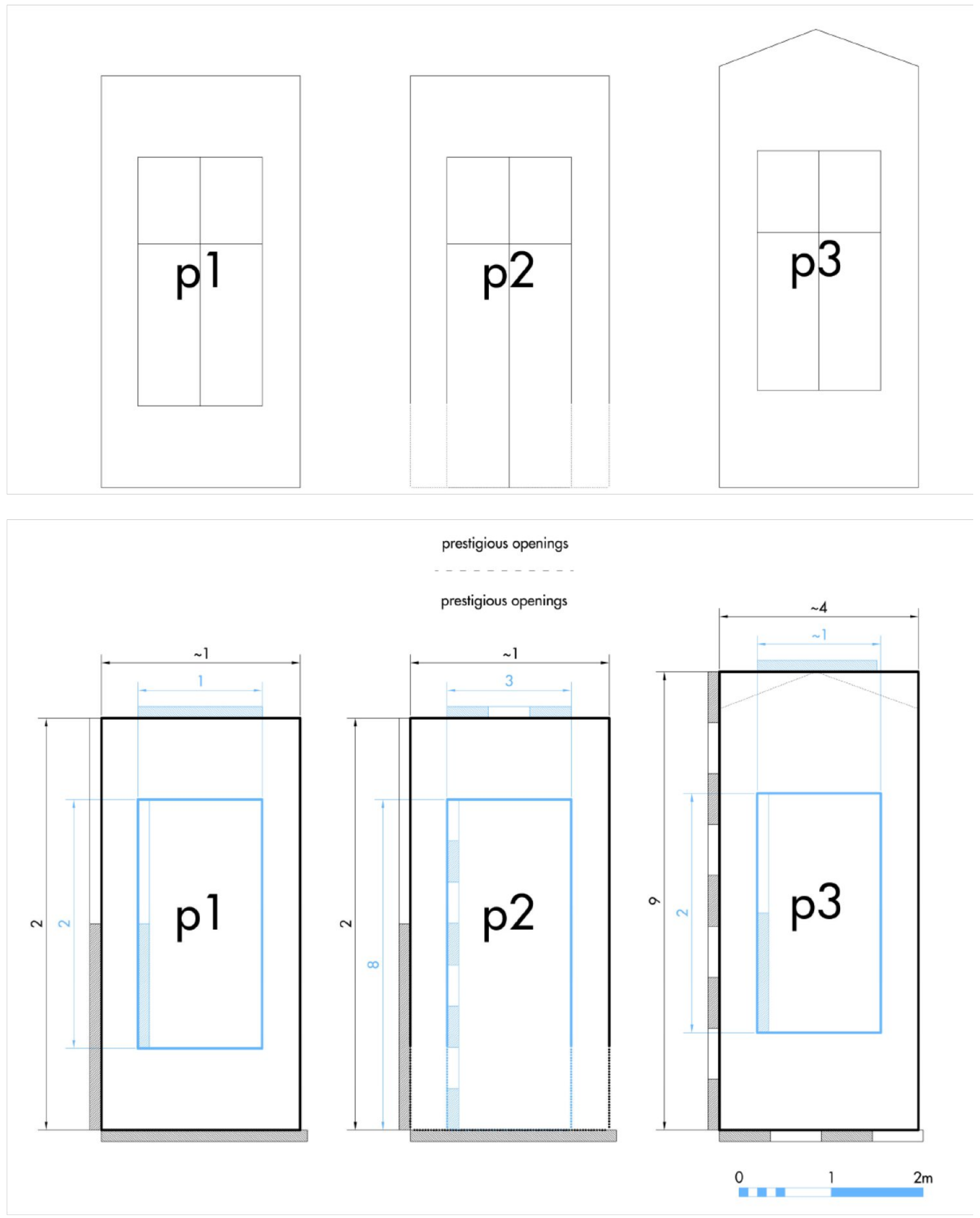


Fig. P.185 Geometrical analysis of openings: (VieR10) Residential house of Mr. Adalbert Zinner, Ring Road, Opernring 8

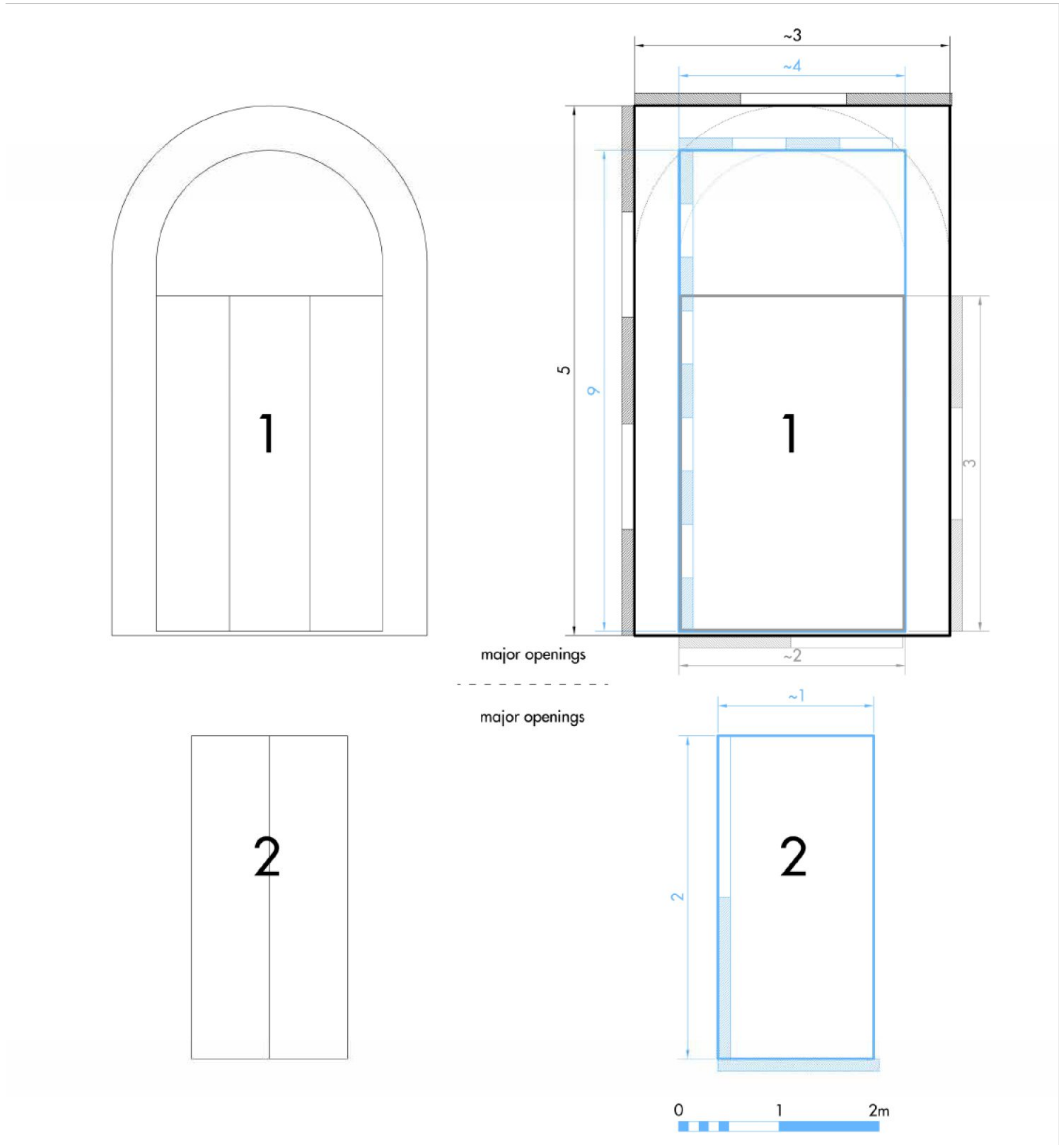


Fig. P.186 Geometrical analysis of openings: (VieR10) Residential house of Mr. Adalbert Zinner, Ring Road, Opernring 8

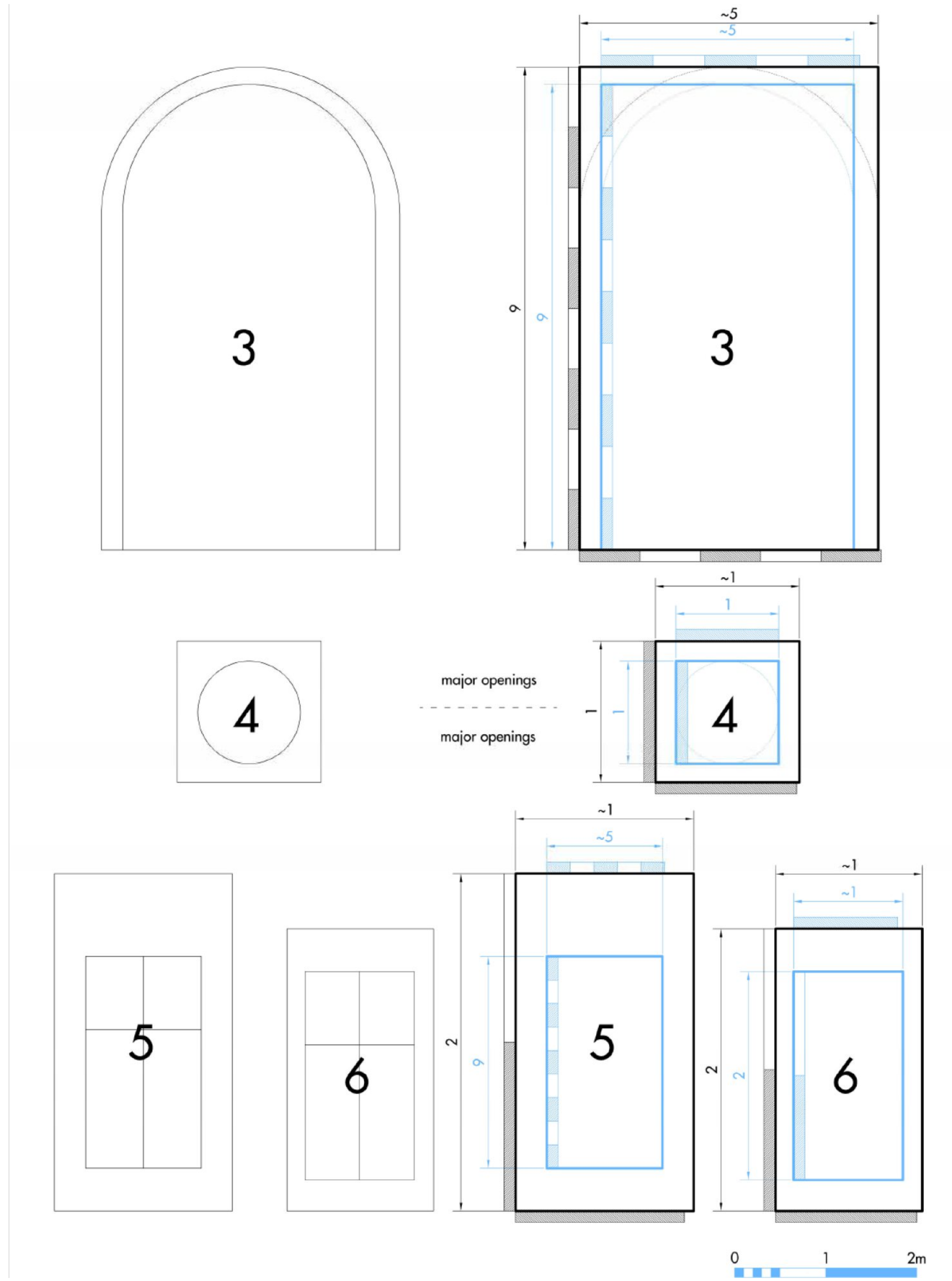


Fig. P.187 Geometrical analysis of openings: (VieR10) Residential house of Mr. Adalbert Zinner, Ring Road, Opernring 8

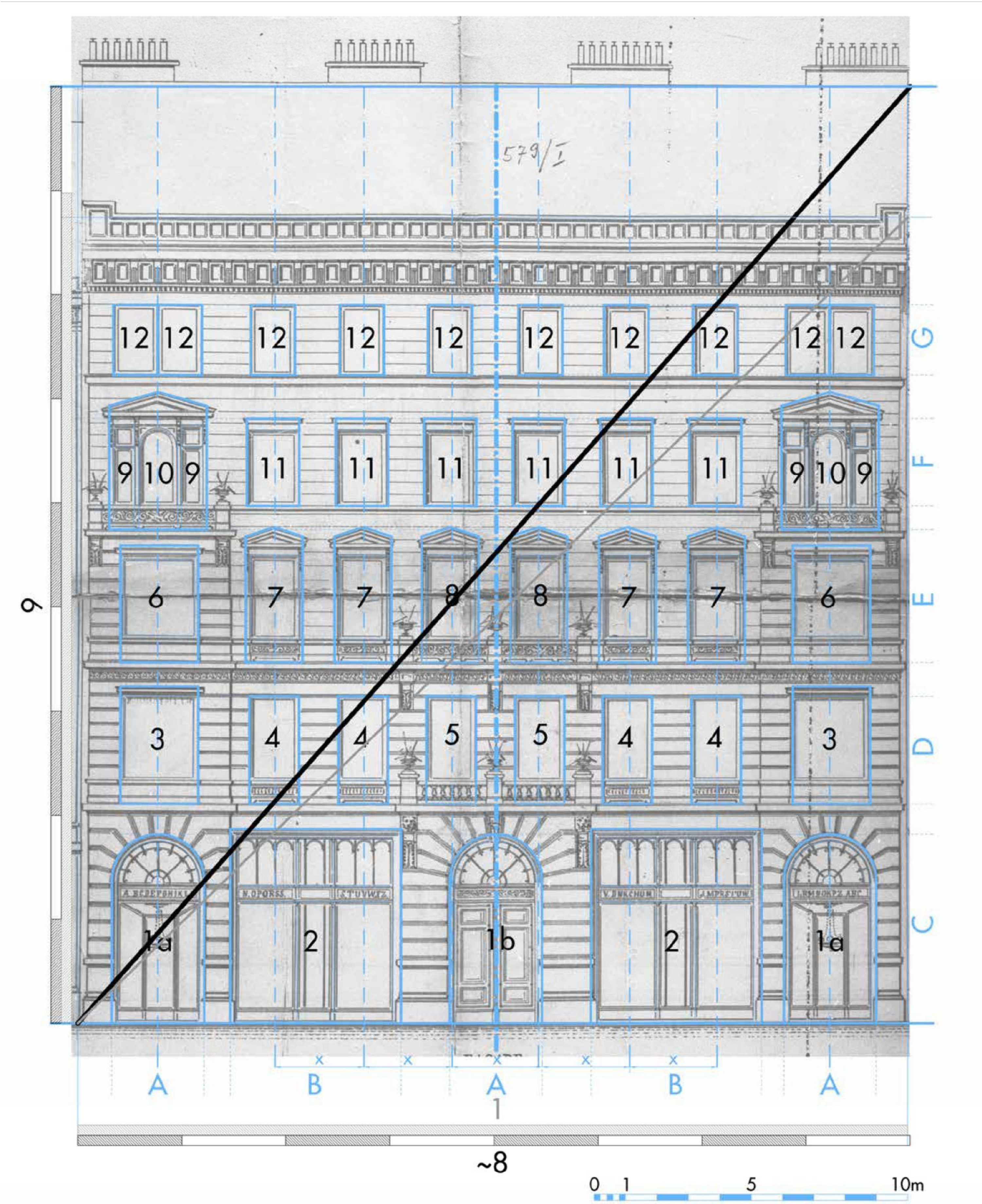


Fig. P.188 Geometrical analysis of front elevation: (VieR11) Residential house, Ring Road, Kärntner Ring 15

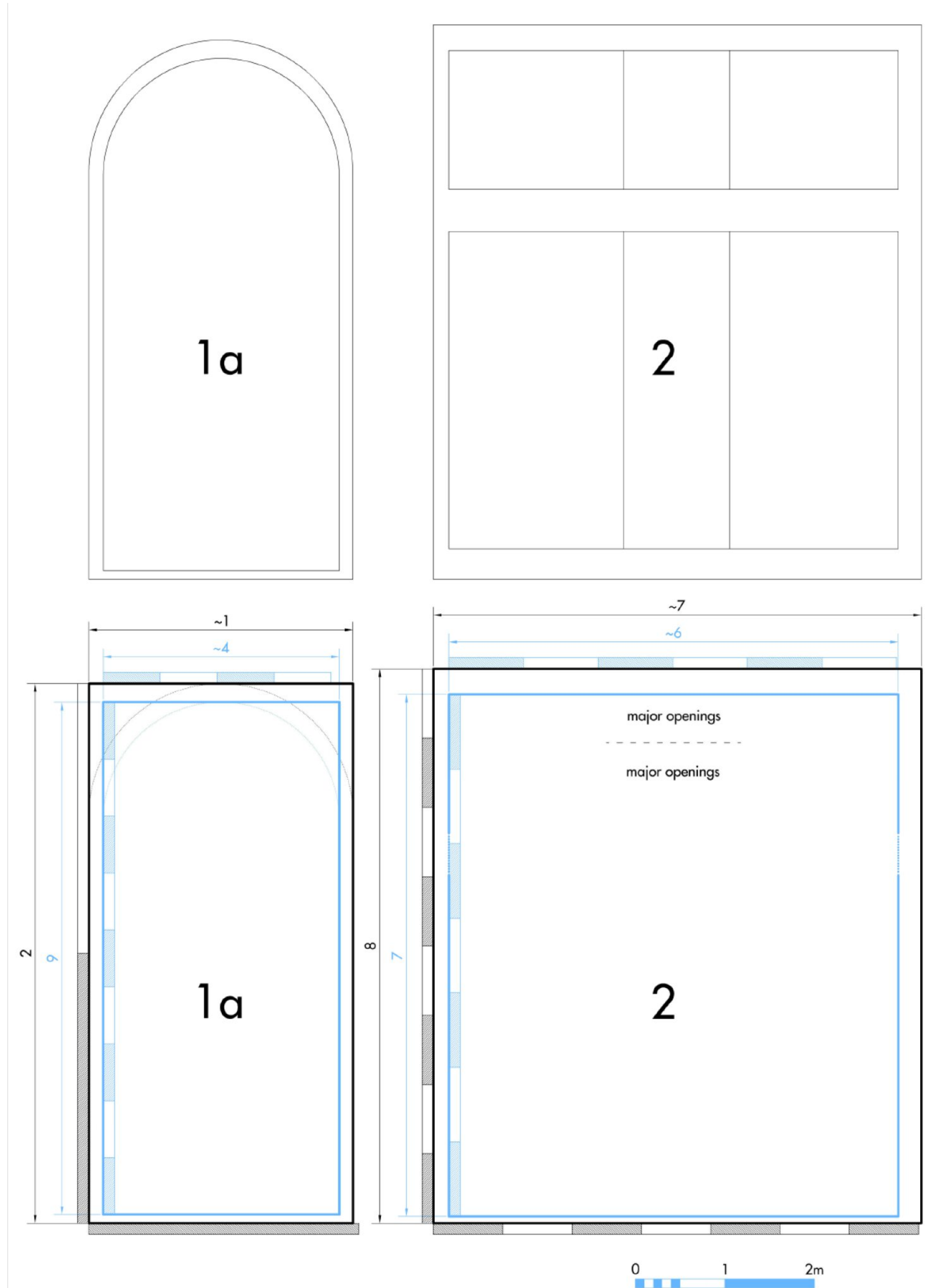


Fig. P.189 Geometrical analysis of openings: (VieR11) Residential house, Ring Road, Kärntner Ring 15

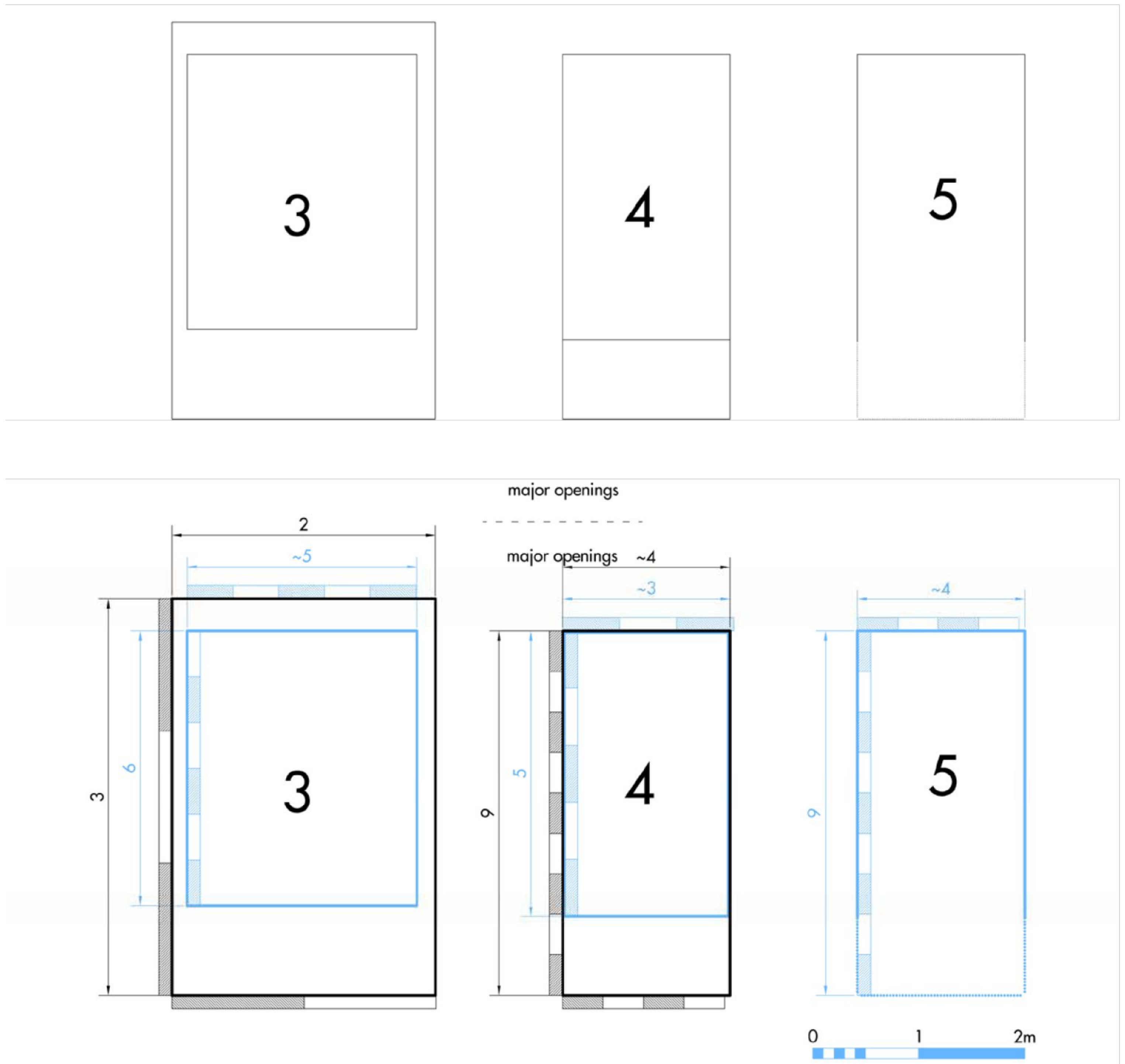


Fig. P.190 Geometrical analysis of openings: (VieR11) Residential house, Ring Road, Kärntner Ring 15

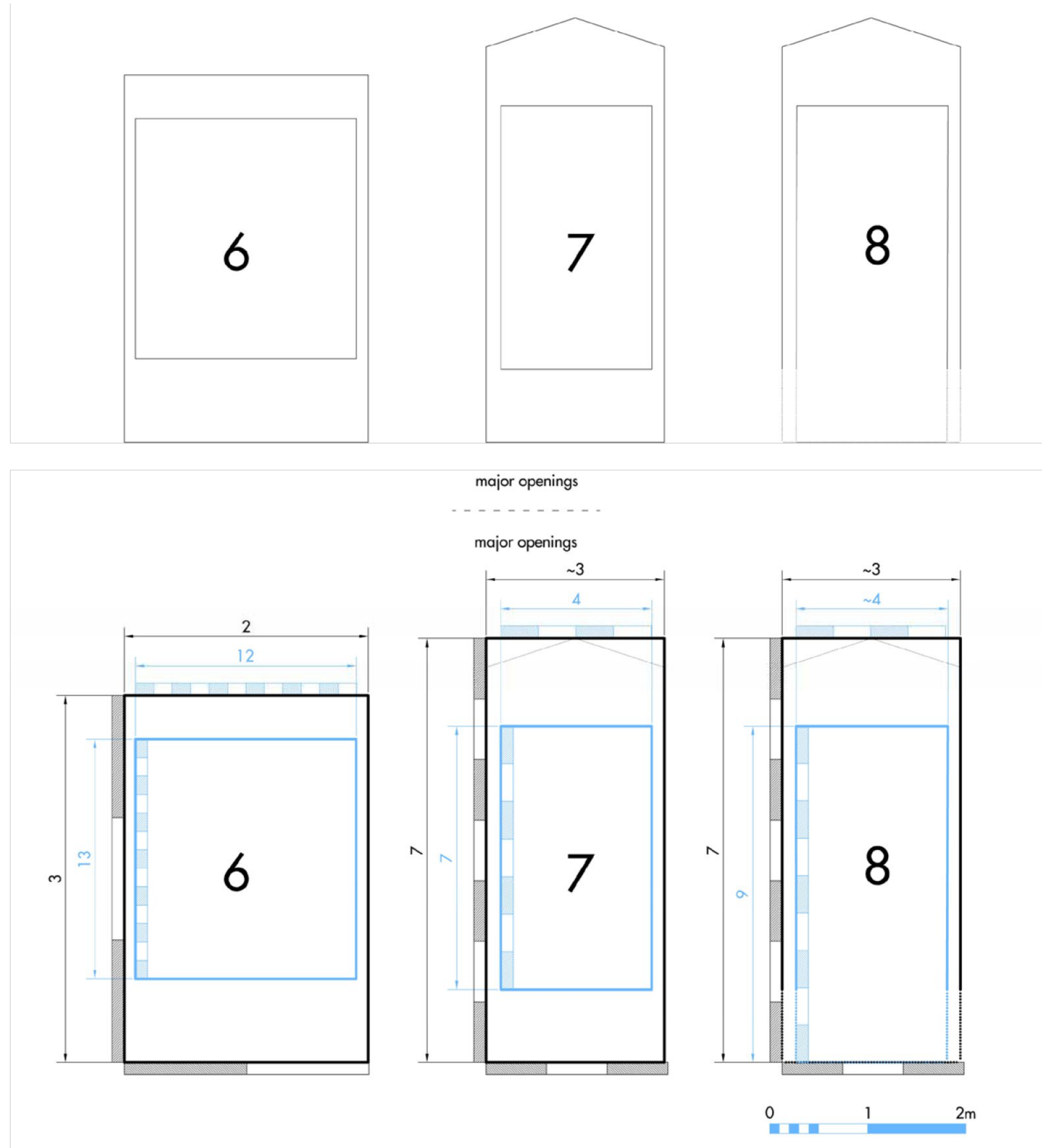


Fig. P.191 Geometrical analysis of openings: (VieR11) Residential house, Ring Road, Kärntner Ring 15

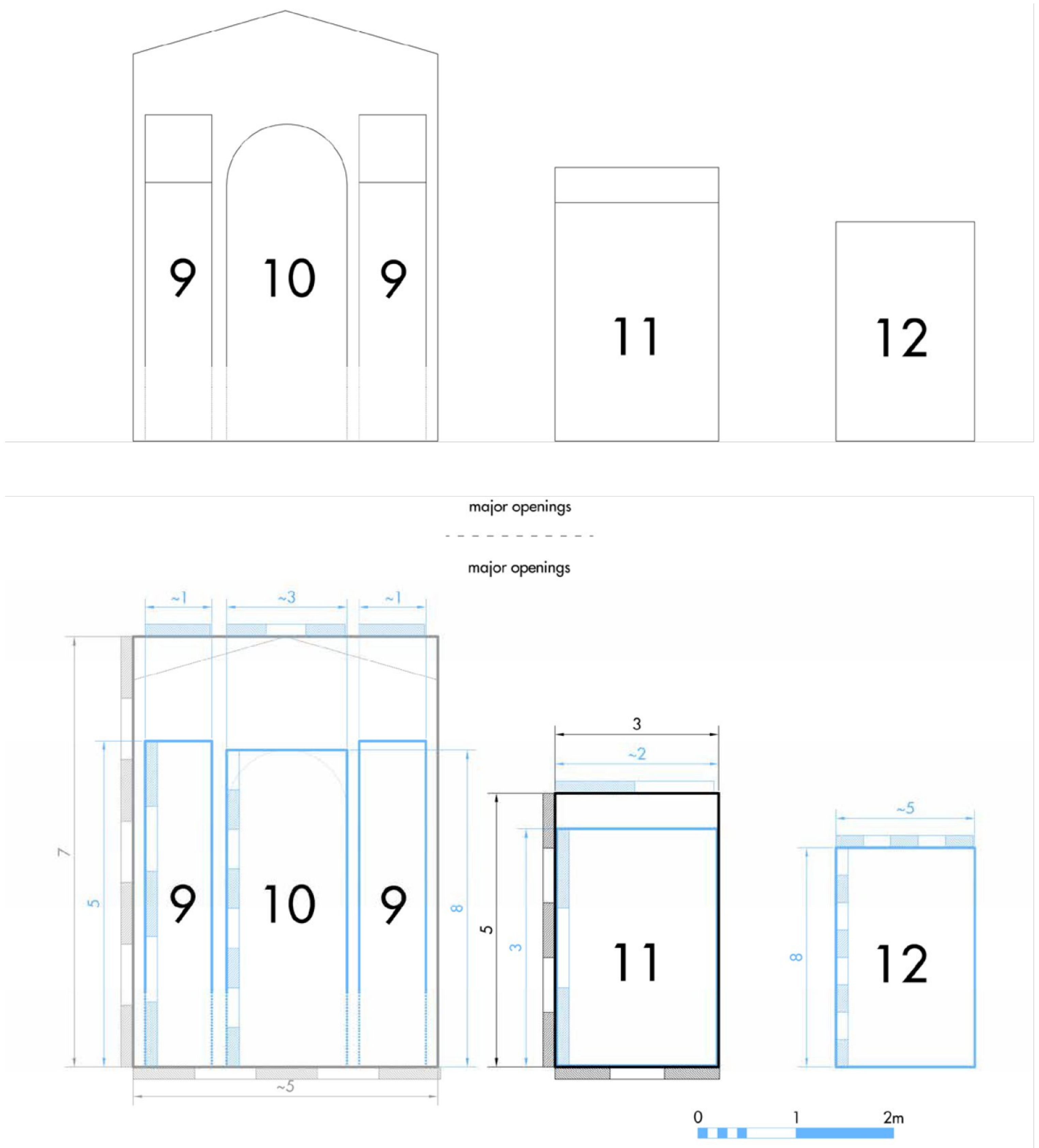


Fig. P.192 Geometrical analysis of openings: (VieR11) Residential house, Ring Road, Kärntner Ring 15

Fig. P.193 Geometrical analysis of front elevation: (VieR12) Residential house of Mr. Carl Förster, Ring Road, Franz-Josefs-Kai 55-57

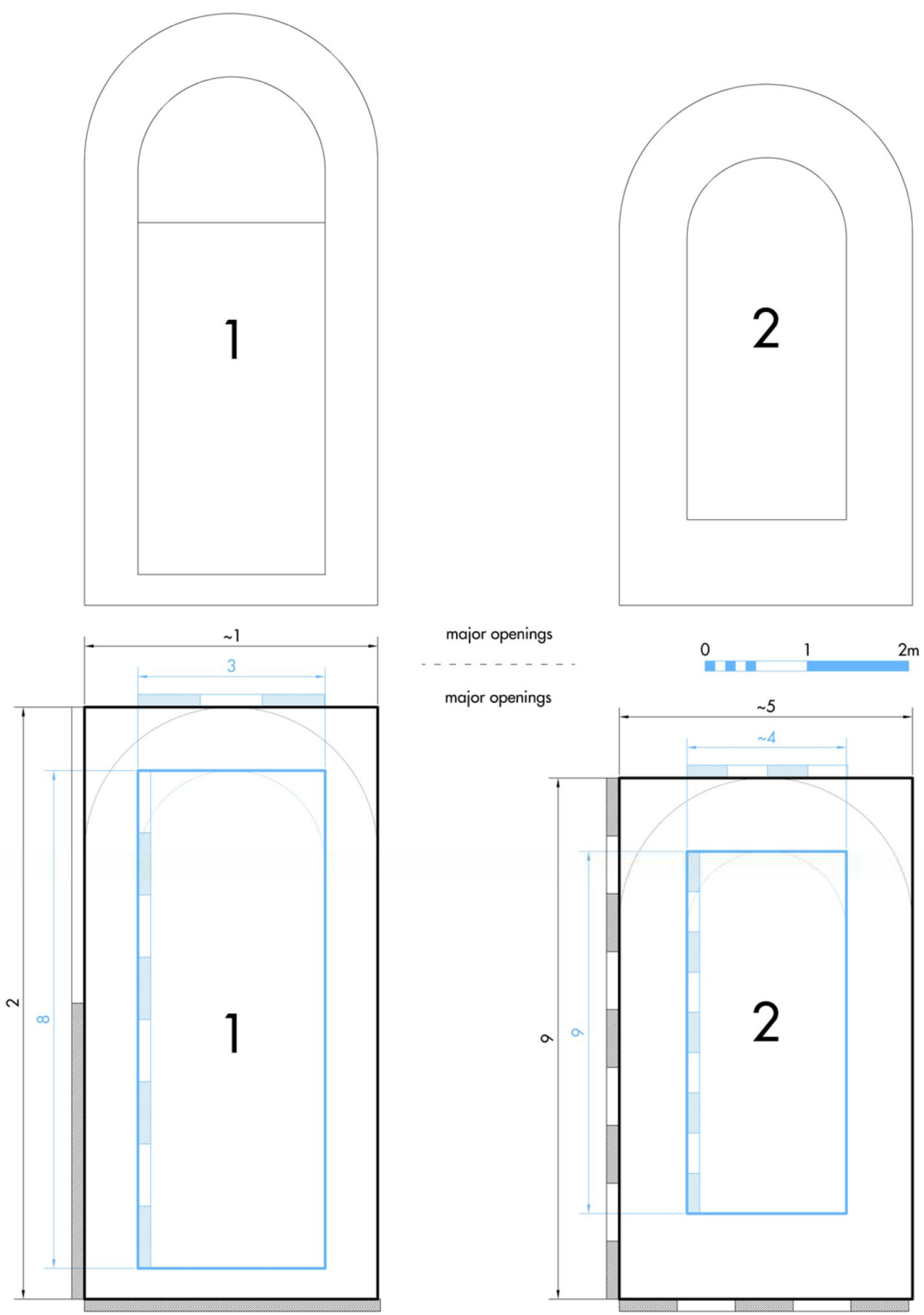


Fig. P.194 Geometrical analysis of openings: (VieR12) Residential house of Mr. Carl Förster, Ring Road, Franz-Josefs-Kai 55-57

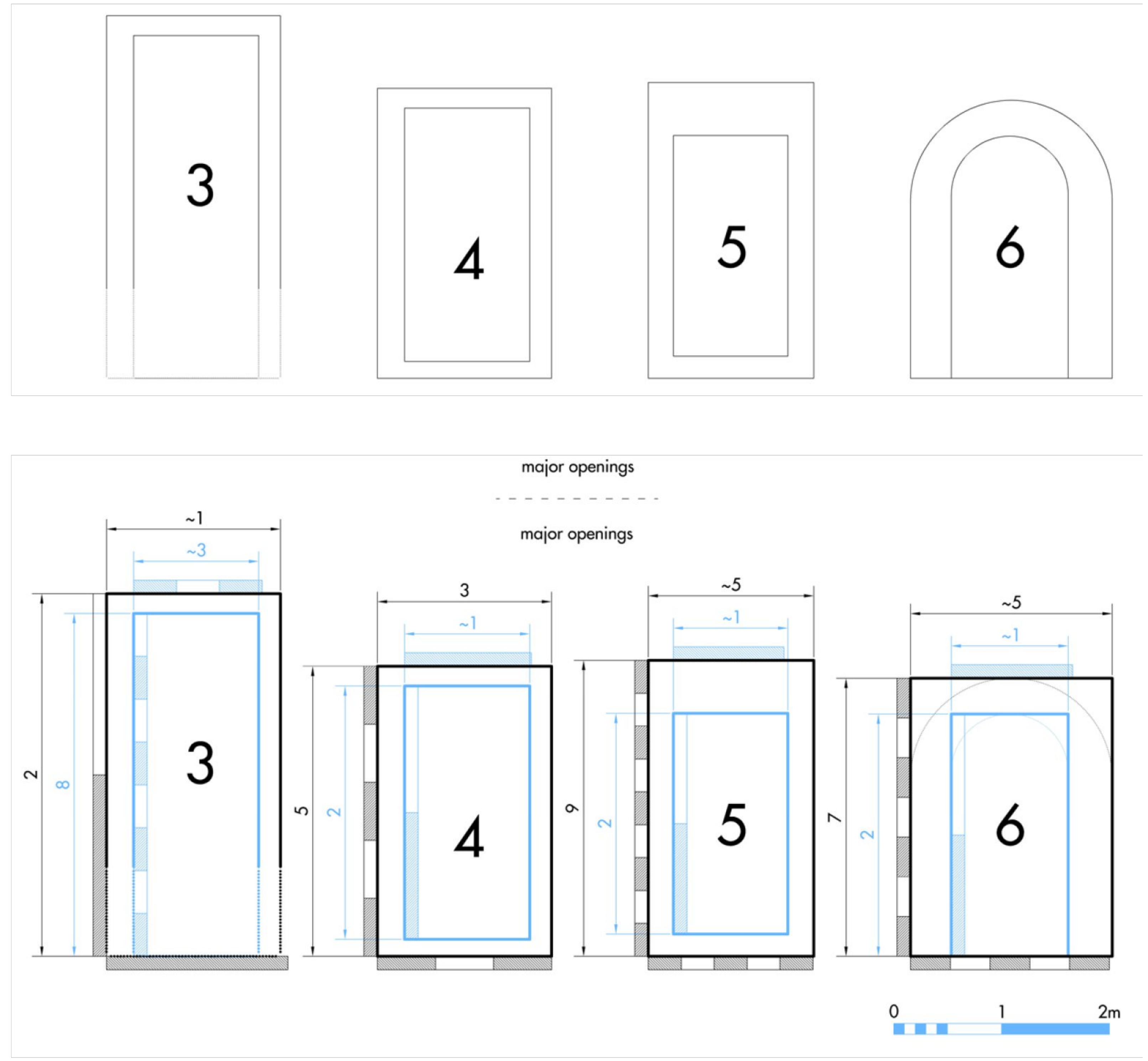


Fig. P.195 Geometrical analysis of openings: (VieR12) Residential house of Mr. Carl Förster, Ring Road, Franz-Josefs-Kai 55-57

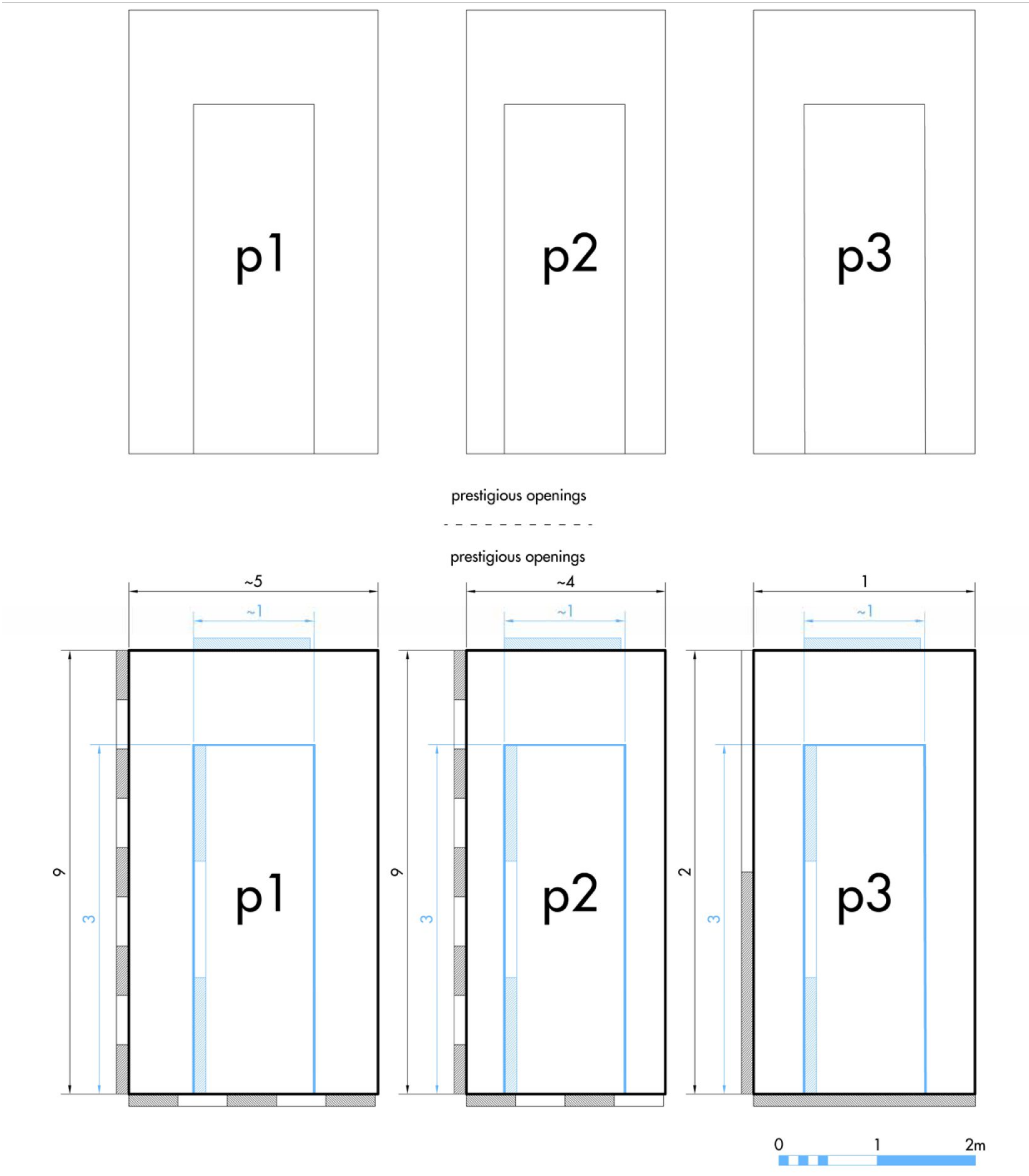


Fig. P.196 Geometrical analysis of openings: (VieR12) Residential house of Mr. Carl Förster, Ring Road, Franz-Josefs-Kai 55-57

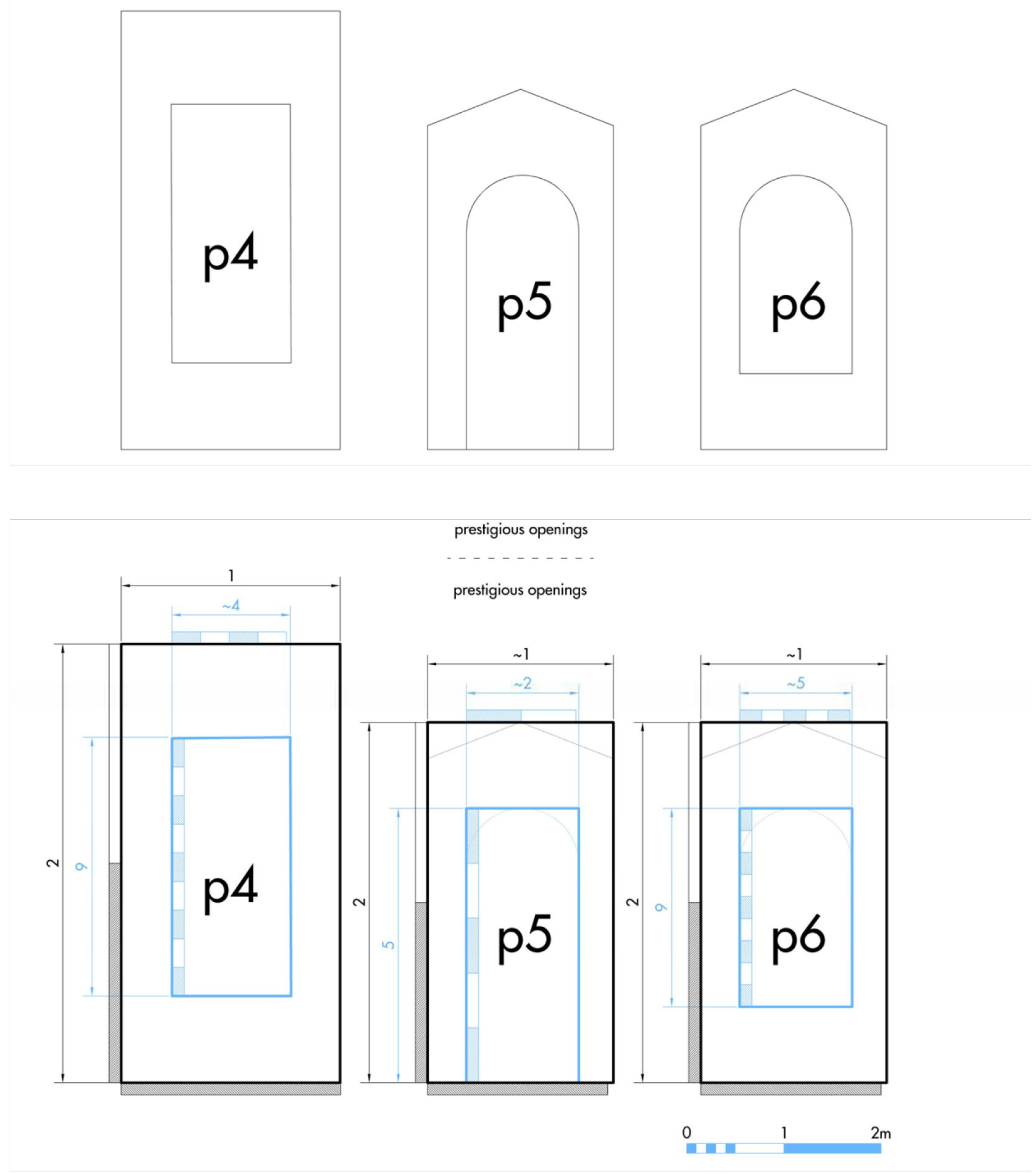


Fig. P.197 Geometrical analysis of openings: (VieR12) Residential house of Mr. Carl Förster, Ring Road, Franz-Josefs-Kai 55-57

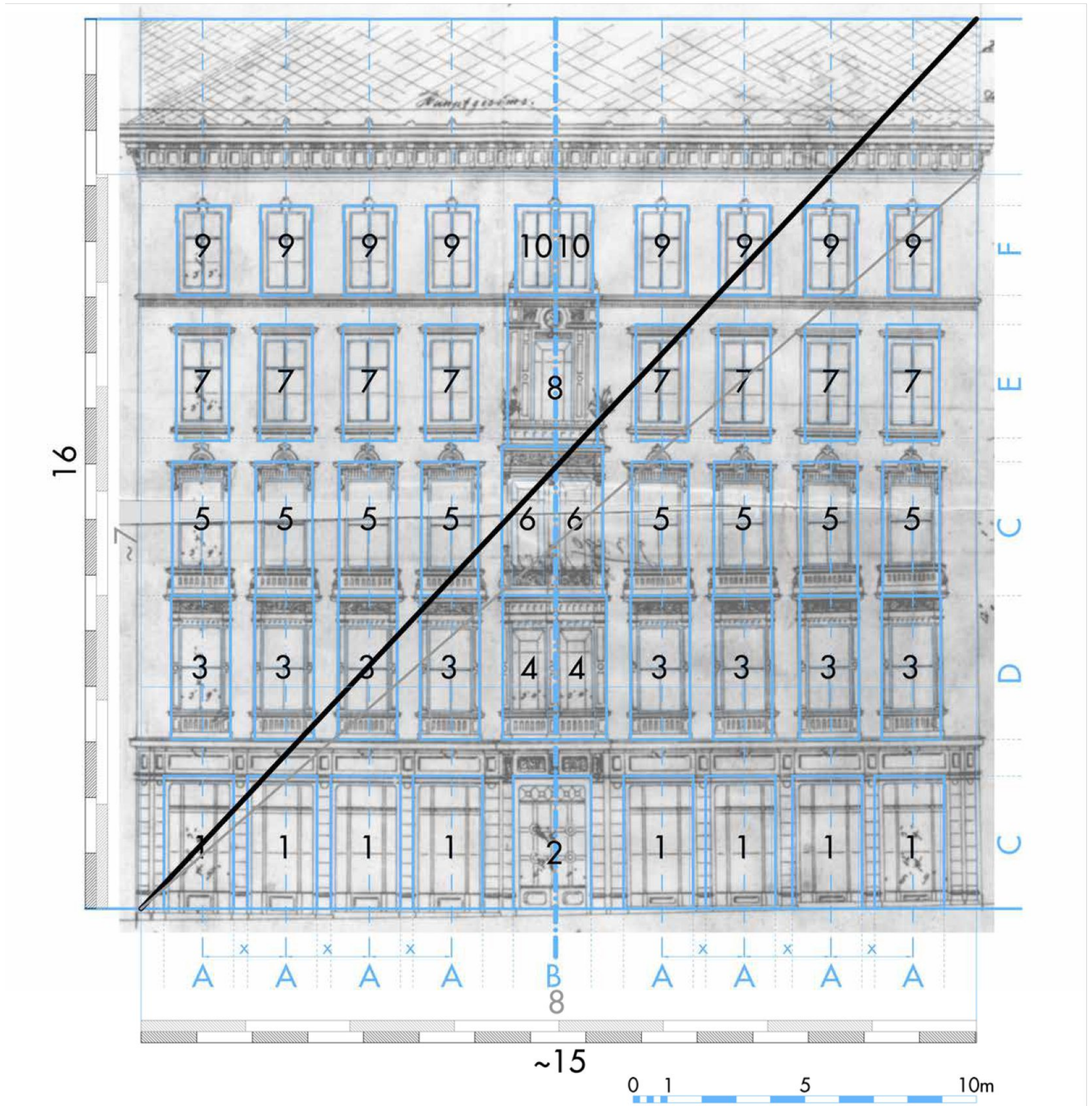


Fig. P.198 Geometrical analysis of front elevation: (VieR13) Residential house, Ring Road, Opernring 21

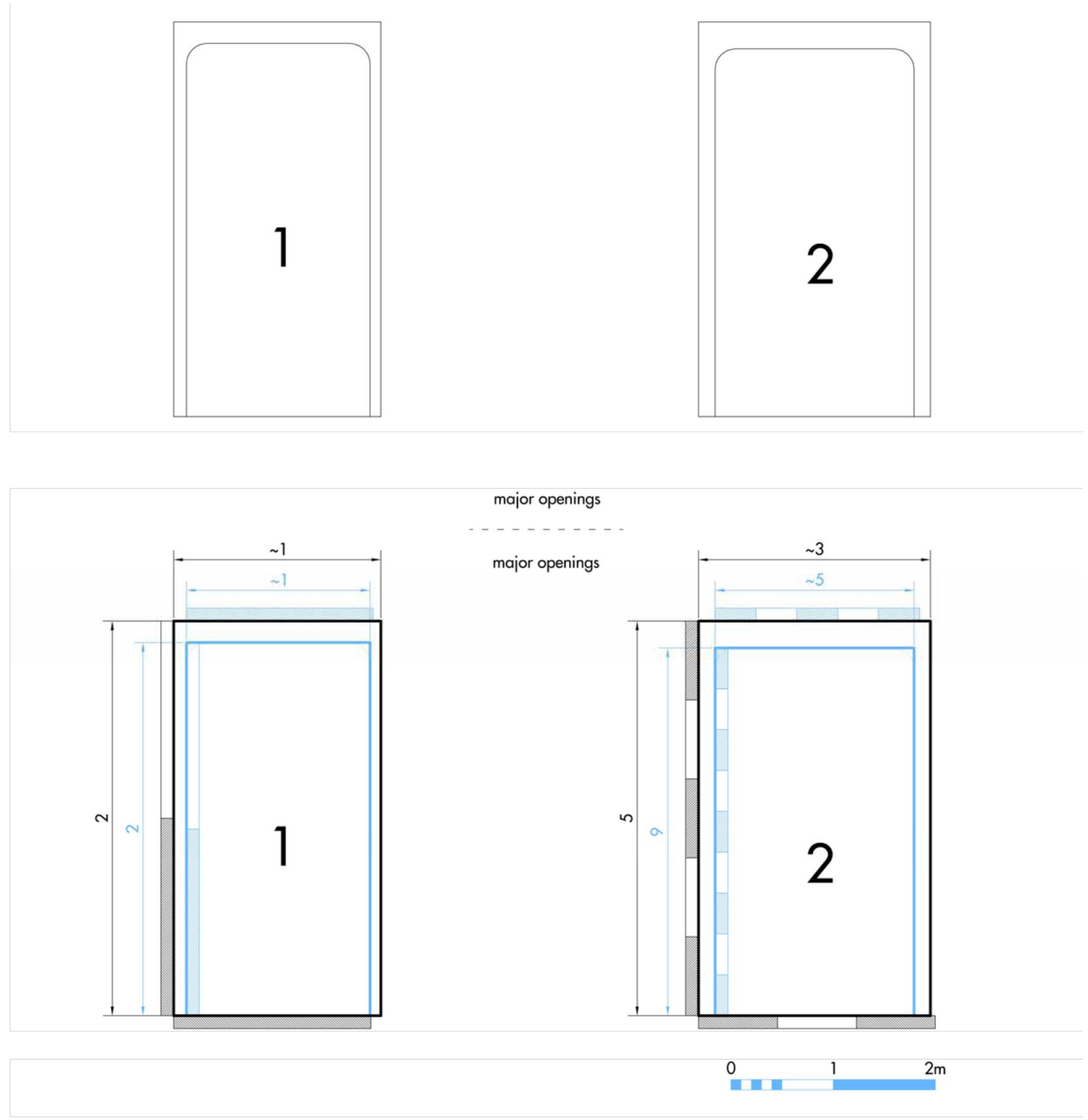


Fig. P.199 Geometrical analysis of openings: (VieR13) Residential house, Ring Road, Opernring 21

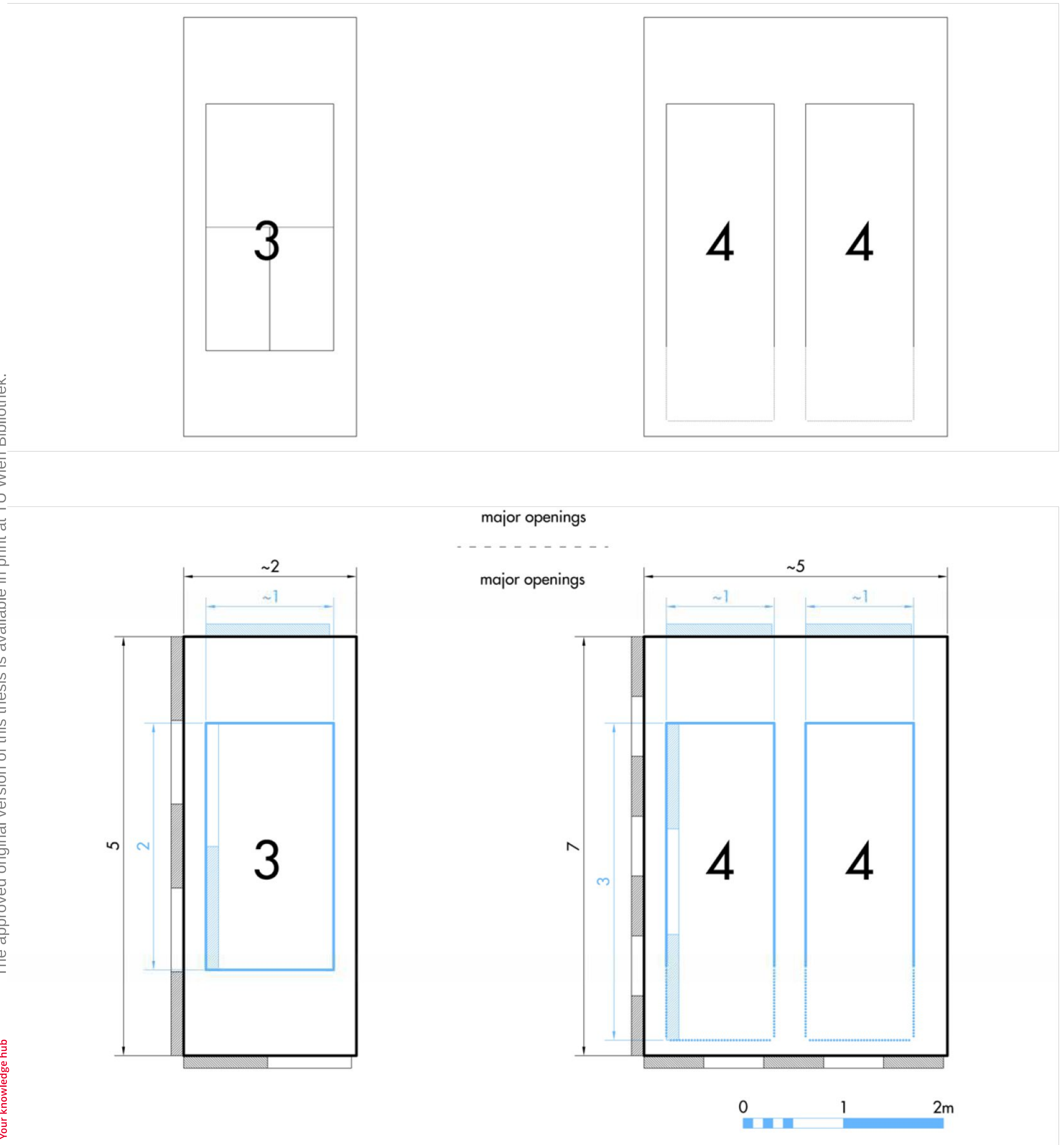


Fig. P.200 Geometrical analysis of openings: (VieR13) Residential house, Ring Road, Opernring 21

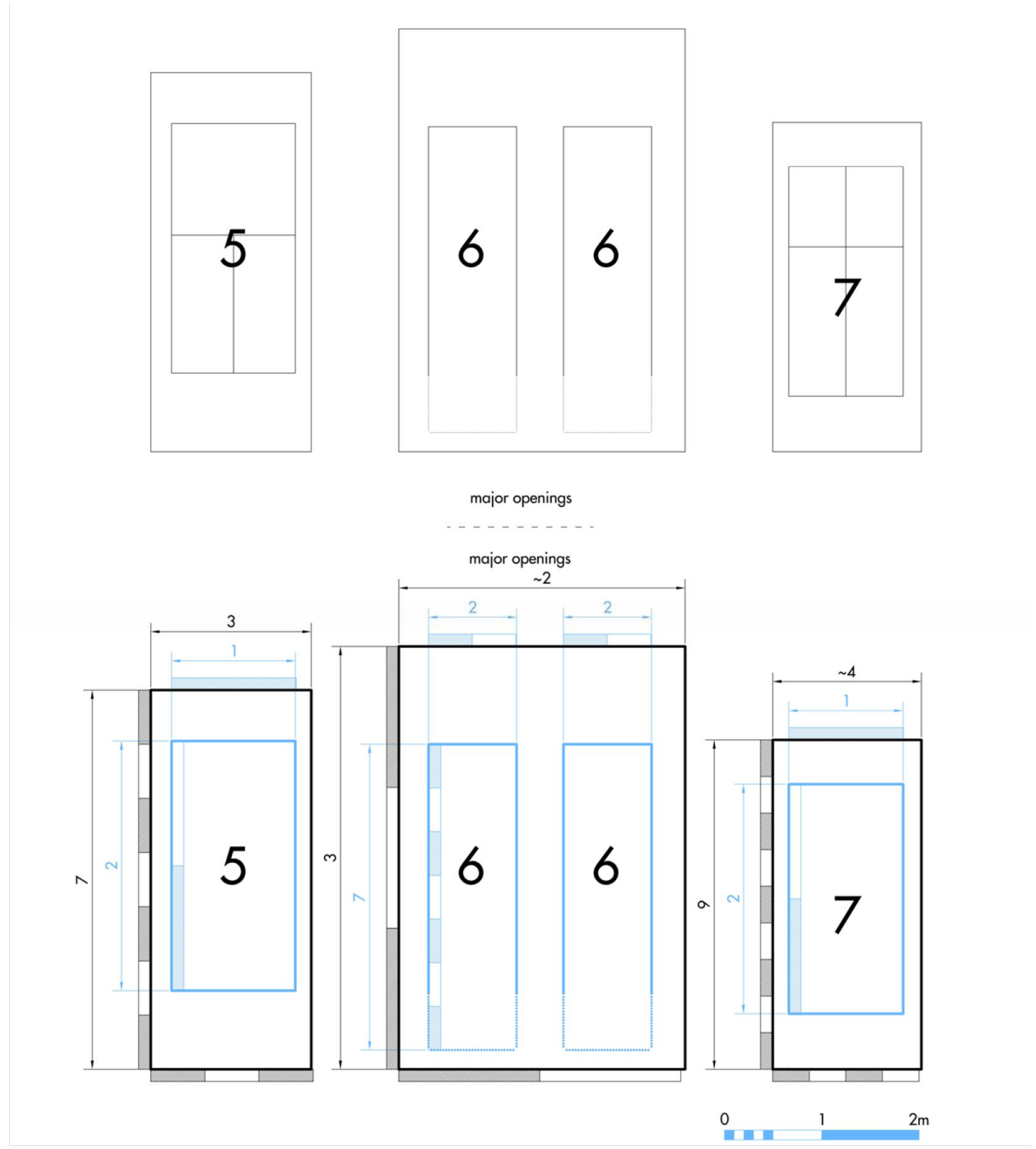


Fig. P.201 Geometrical analysis of openings: (VieR13) Residential house, Ring Road, Opernring 21

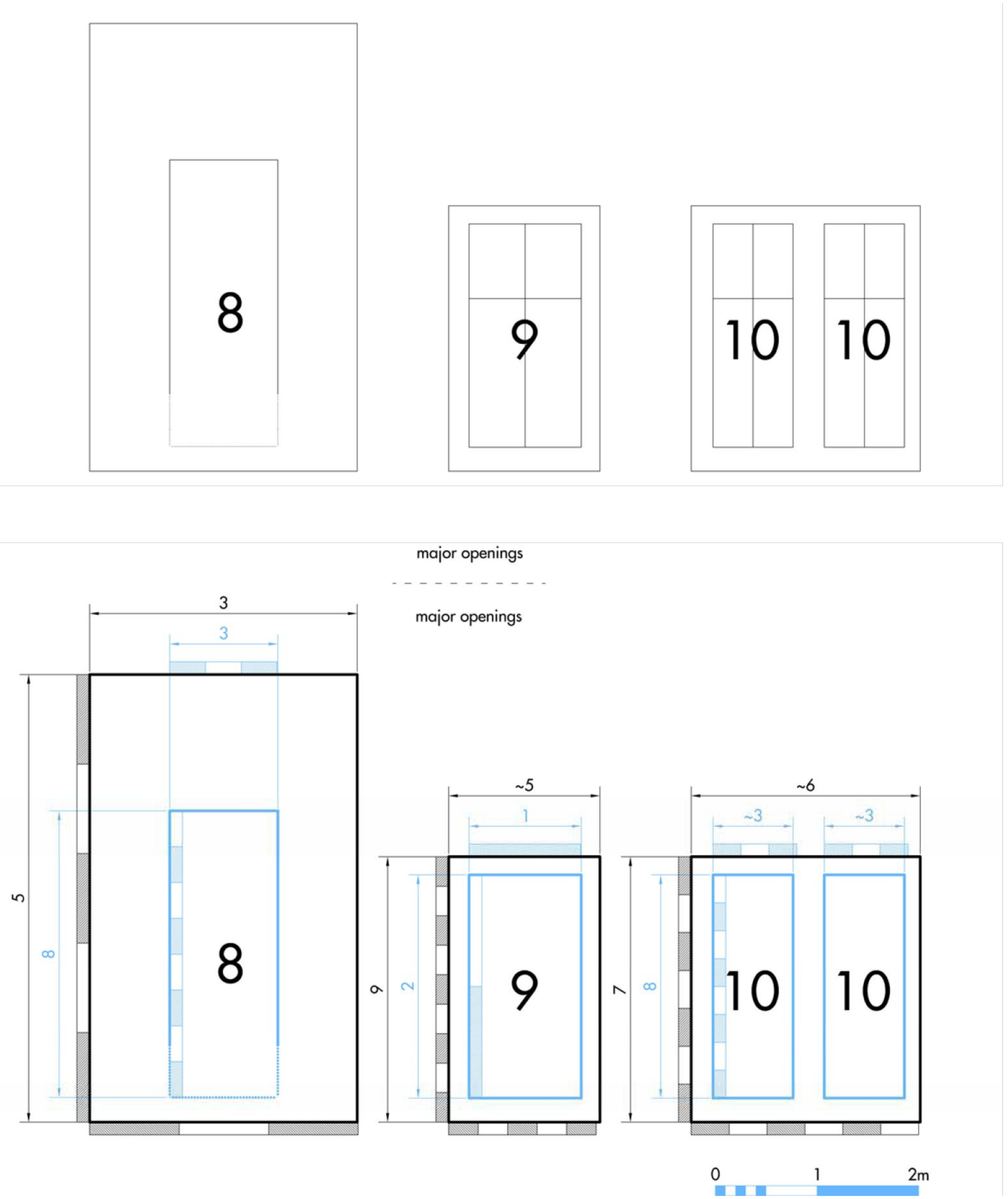


Fig. P.202 Geometrical analysis of openings: (VieR13) Residential house, Ring Road, Opernring 21

Fig. P.203 Geometrical analysis of front elevation: (VieR14) Residential house, Ring Road, Berggasse 24

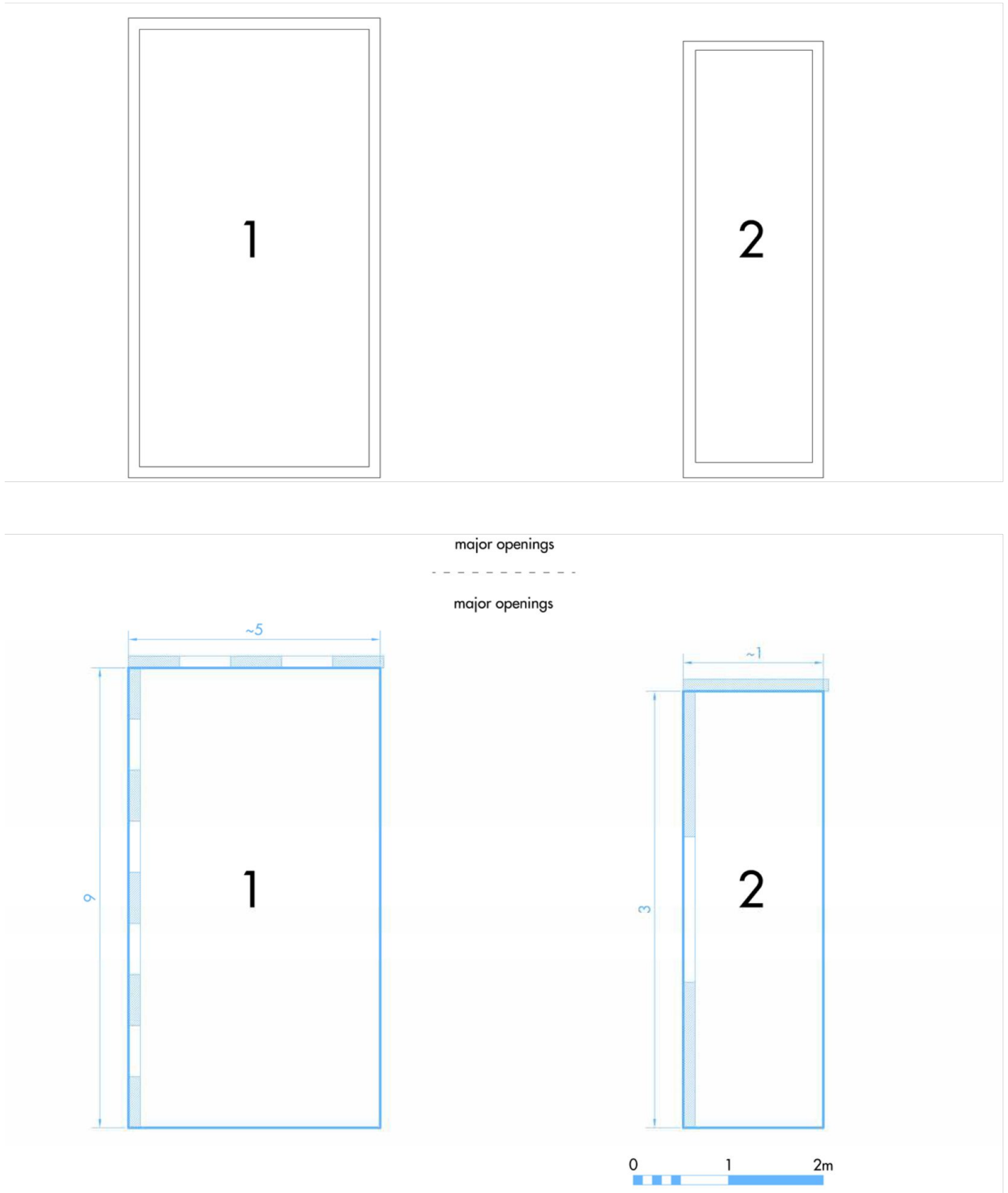


Fig. P.204 Geometrical analysis of openings: (VieR14) Residential house, Ring Road, Berggasse 24

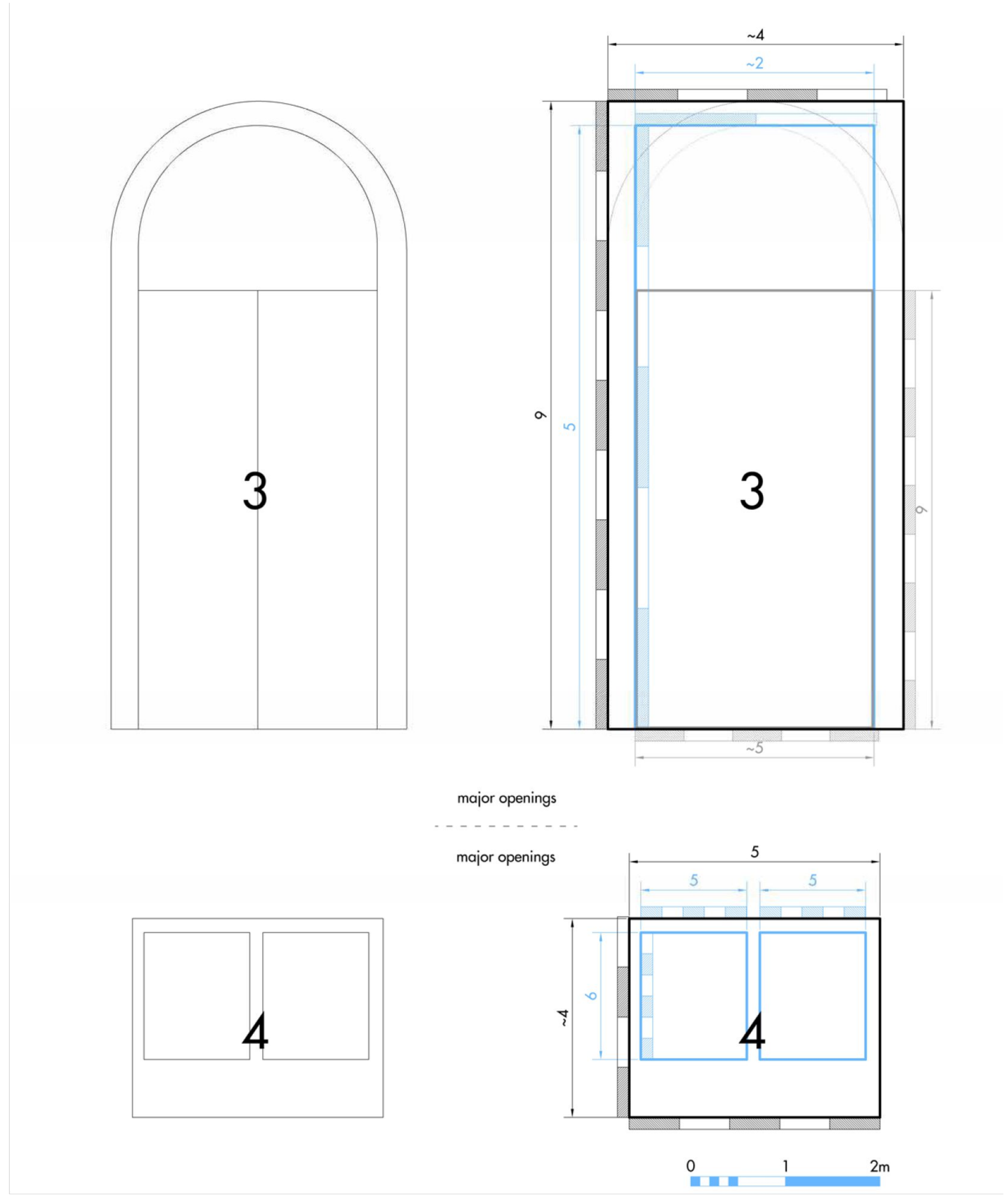


Fig. P.205 Geometrical analysis of openings: (VieR14) Residential house, Ring Road, Berggasse 24

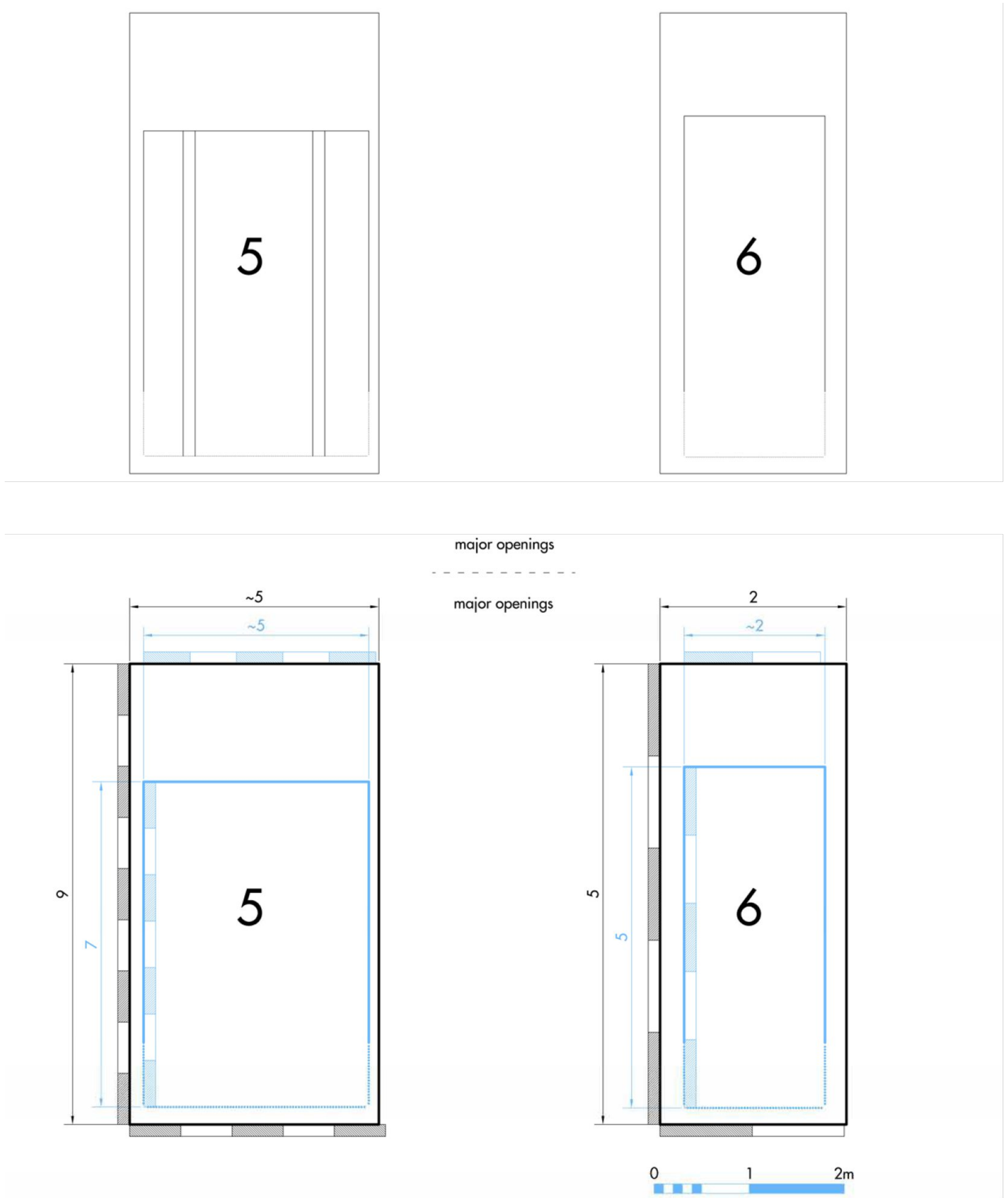


Fig. P.206 Geometrical analysis of openings: (VieR14) Residential house, Ring Road, Berggasse 24

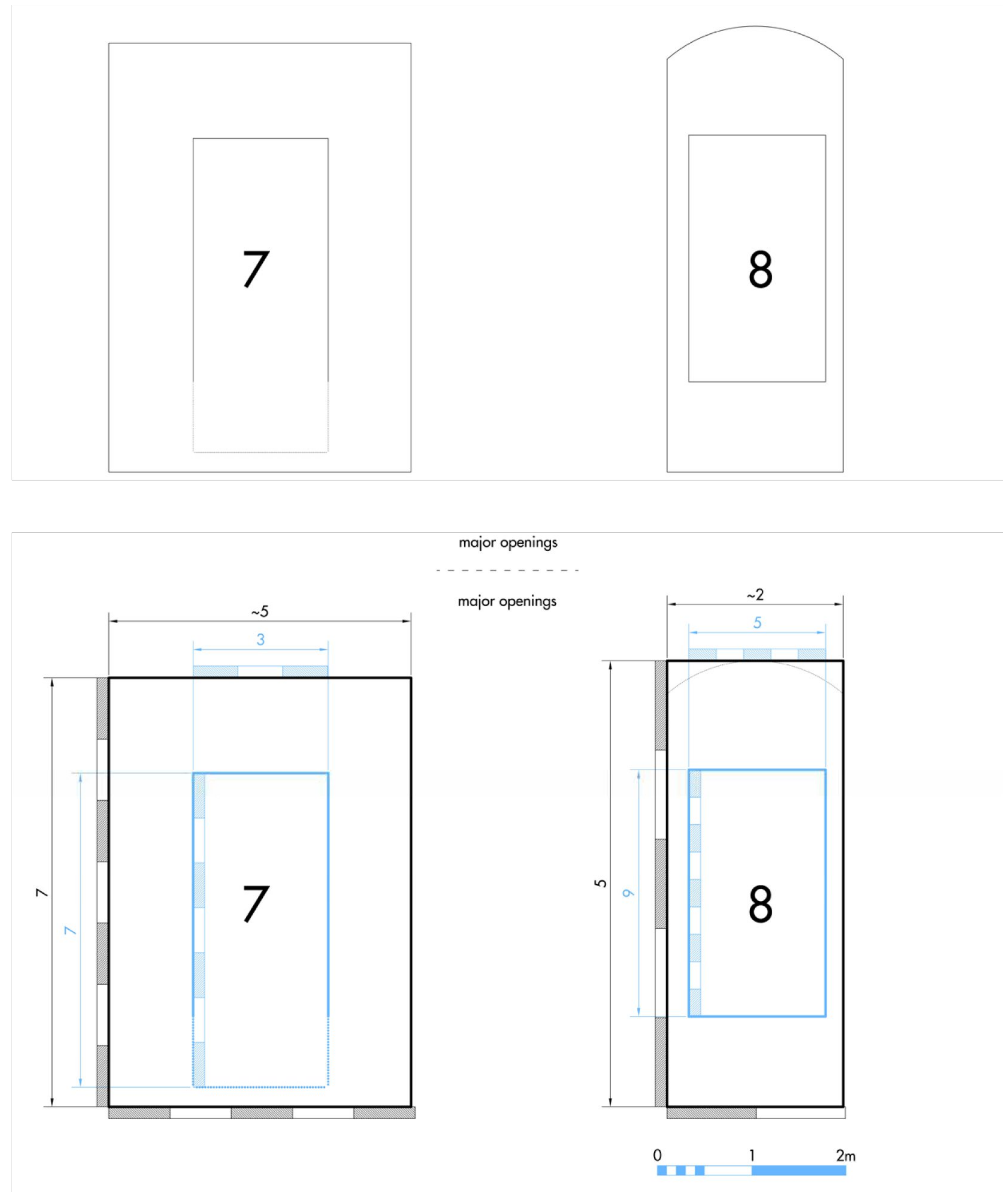


Fig. P.207 Geometrical analysis of openings: (VieR14) Residential house, Ring Road, Berggasse 24

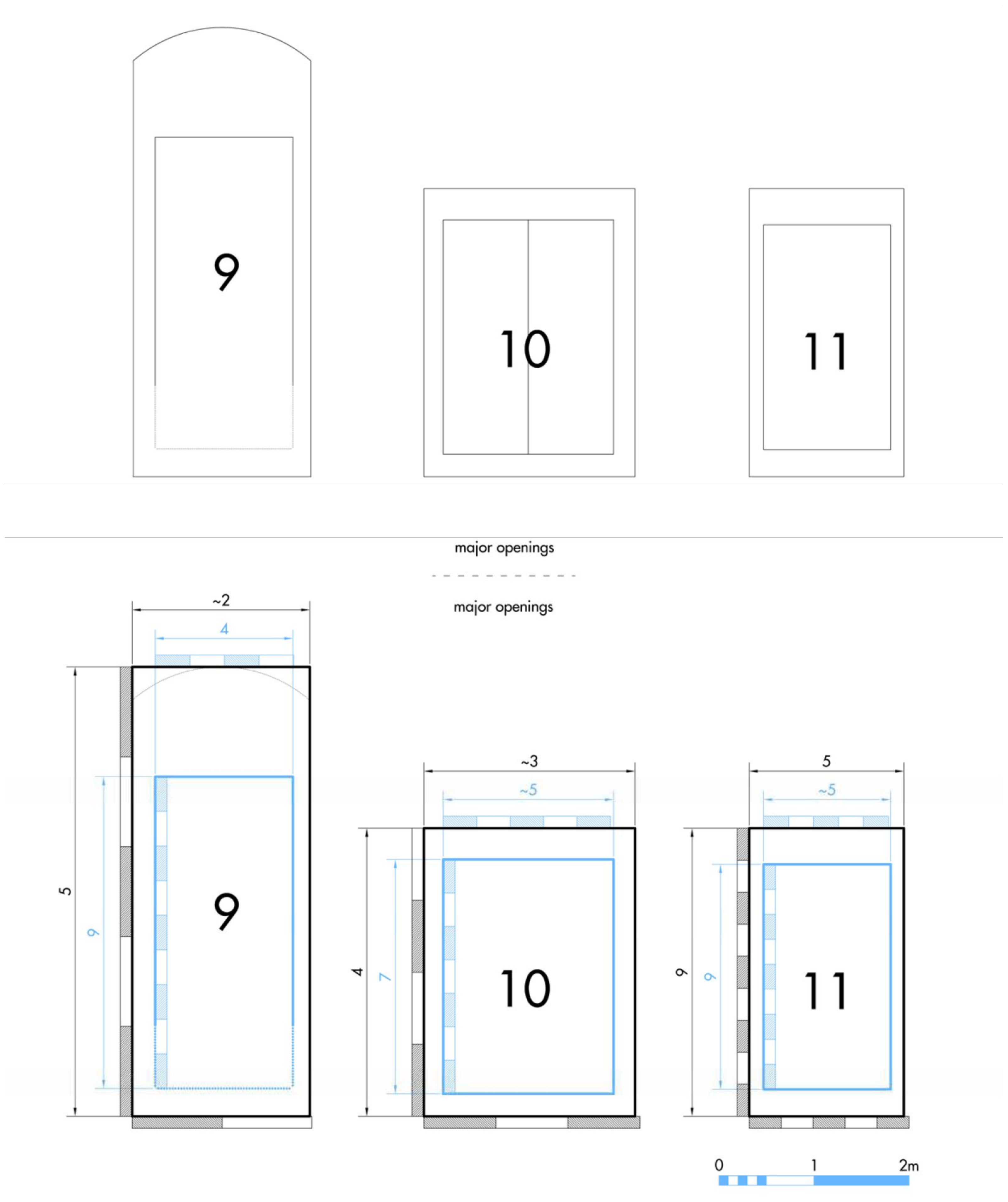


Fig. P.208 Geometrical analysis of openings: (VieR14) Residential house, Ring Road, Berggasse 24

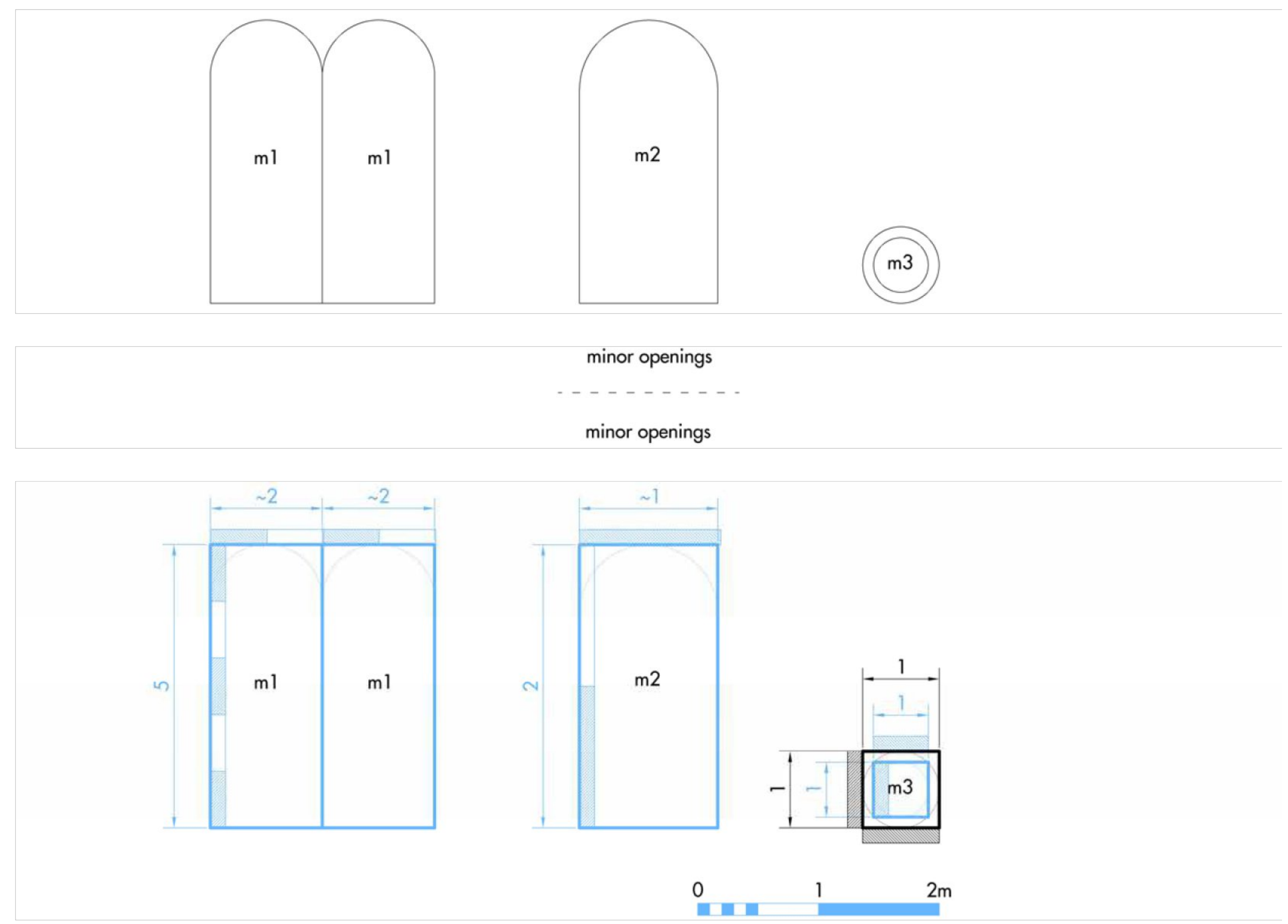


Fig. P.209 Geometrical analysis of openings: (VieR14) Residential house, Ring Road, Berggasse 24

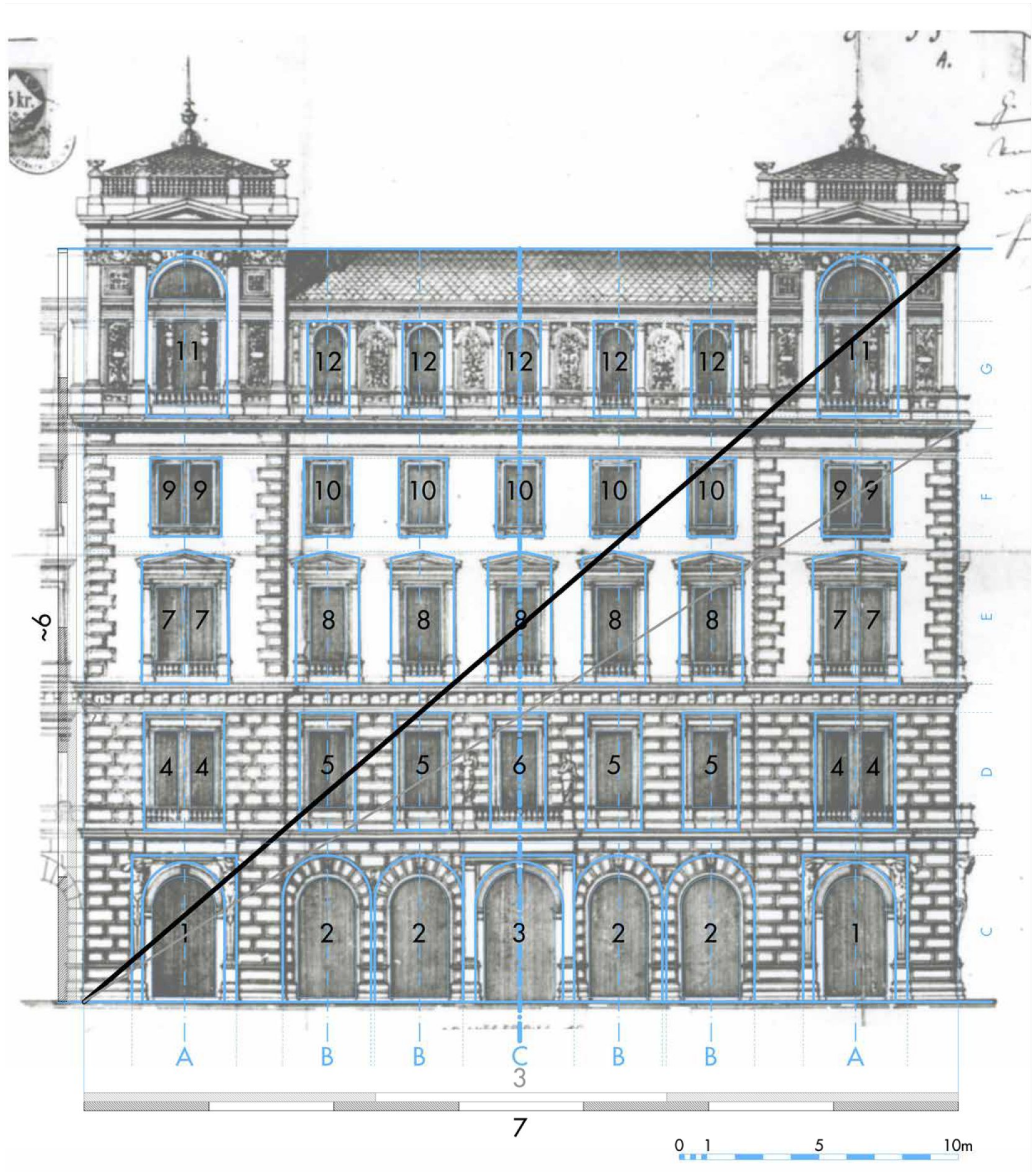


Fig. P.210 Geometrical analysis of front elevation: (VieR15) Residential and commercial building, Ring Road, Universitätsring 10

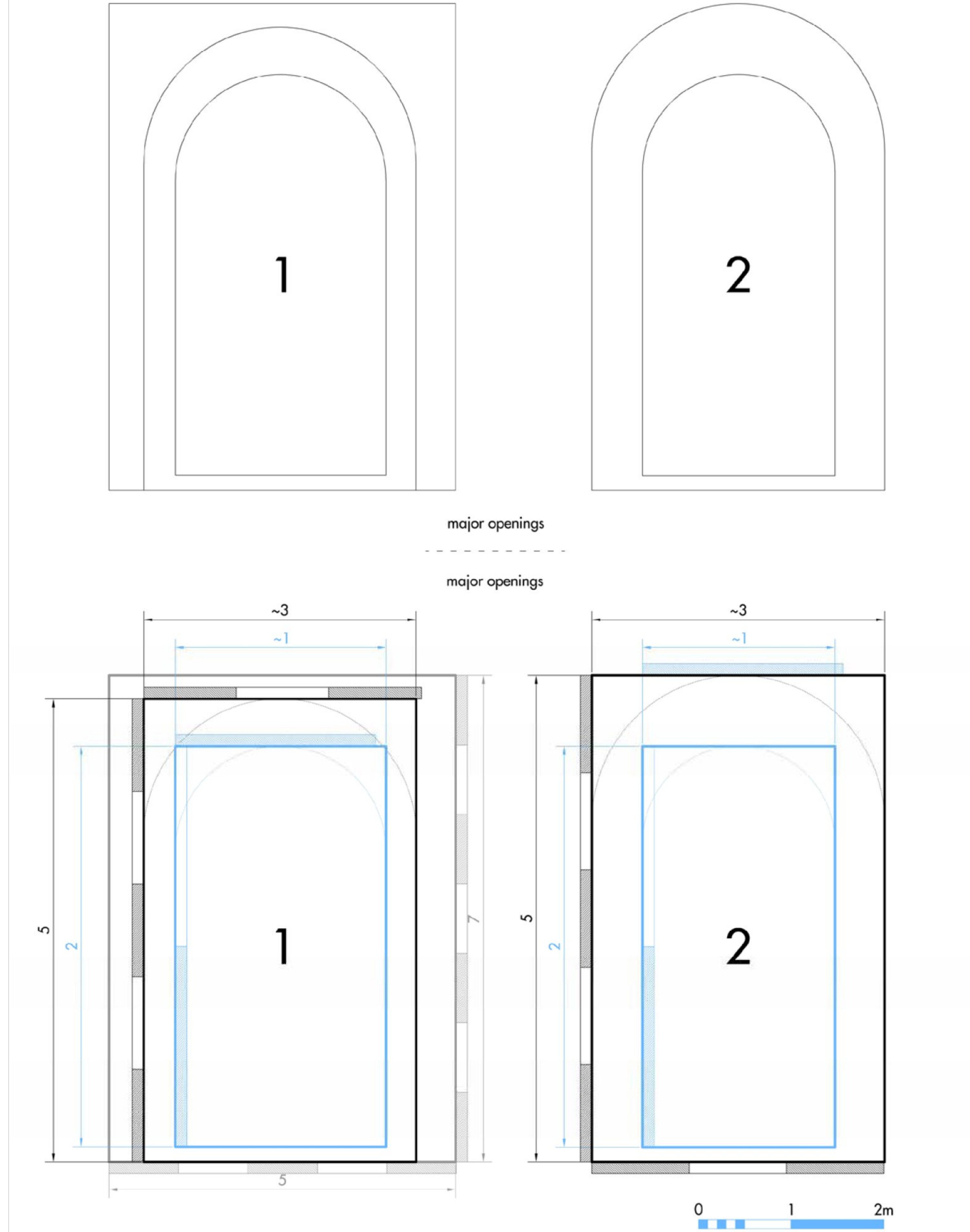


Fig. P.211 Geometrical analysis of openings: (VieR15) Residential and commercial building, Ring Road, Universitätsring 10

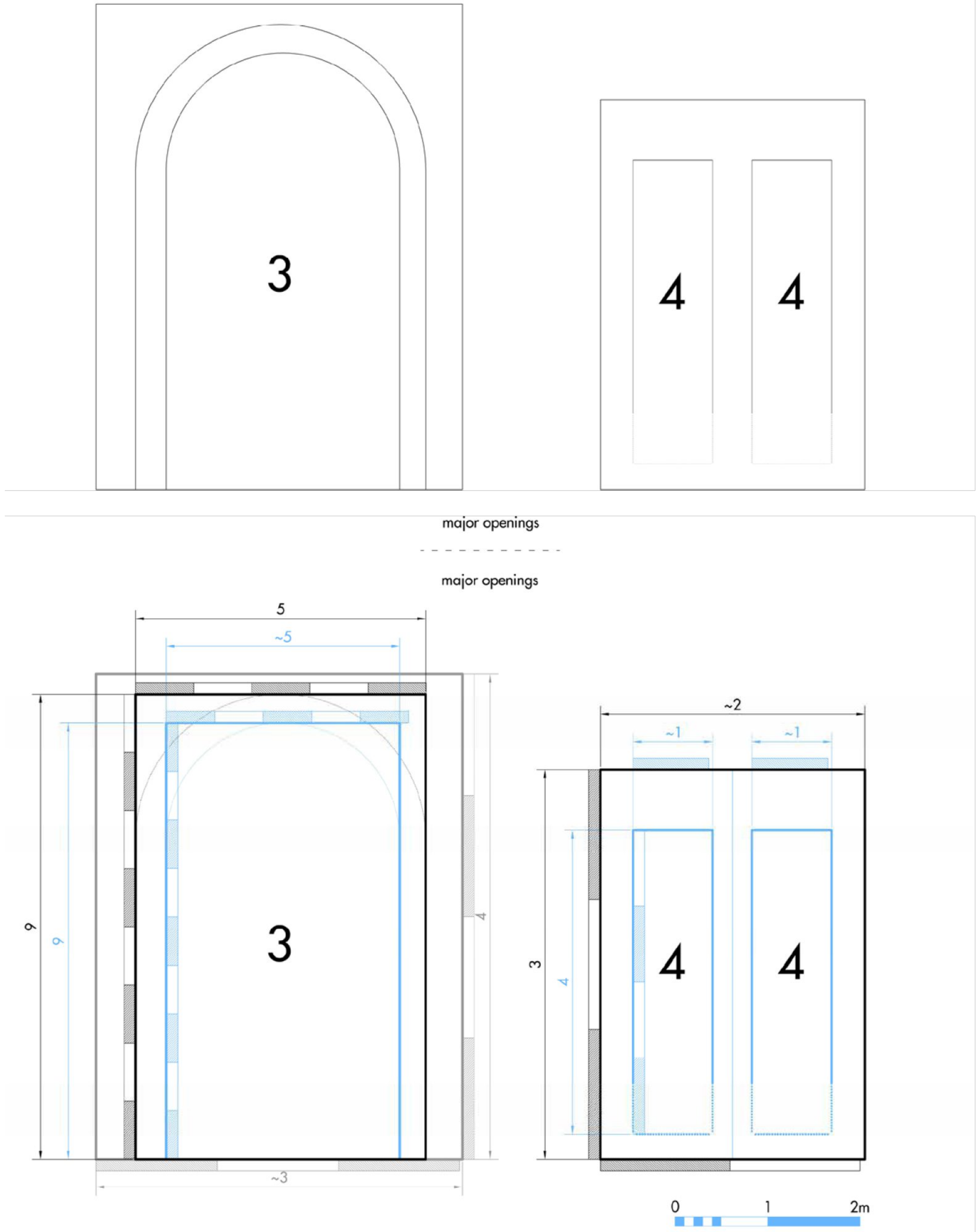


Fig. P.212 Geometrical analysis of openings: (VieR15) Residential and commercial building, Ring Road, Universitätsring 10

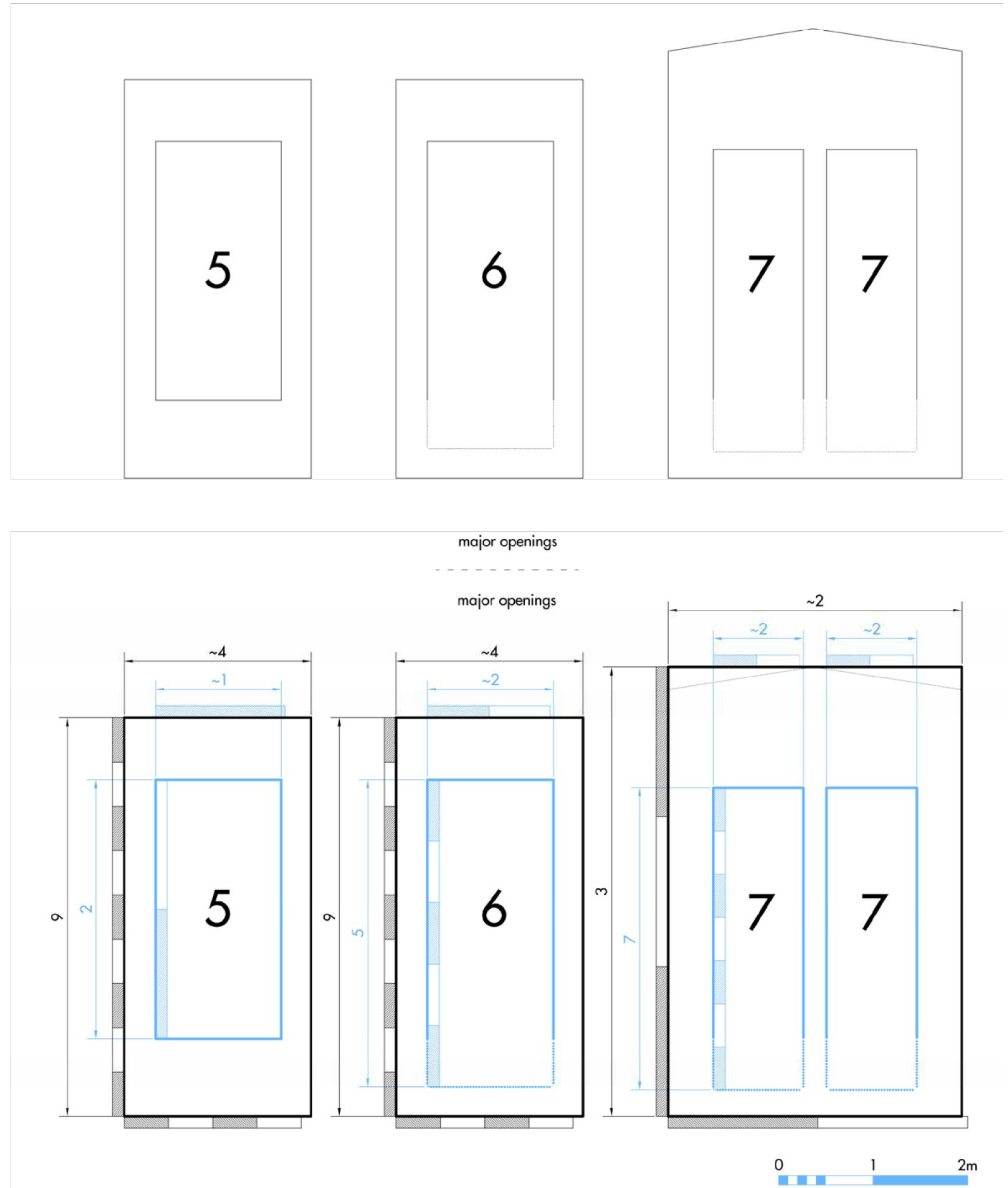


Fig. P.213 Geometrical analysis of openings: (VieR15) Residential and commercial building, Ring Road, Universitätsring 10

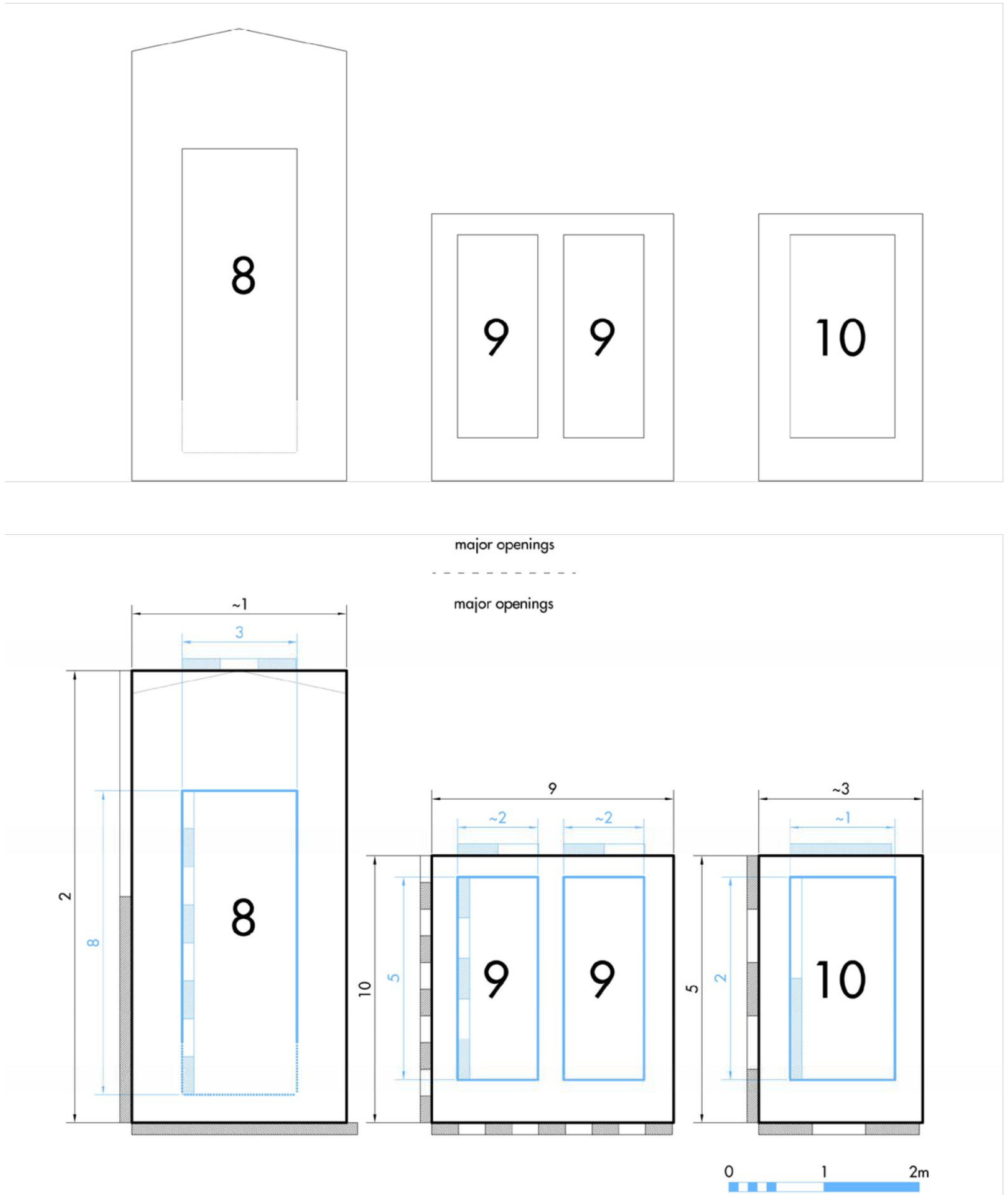


Fig. P.214 Geometrical analysis of openings: (VieR15) Residential and commercial building, Ring Road, Universitätsring 10

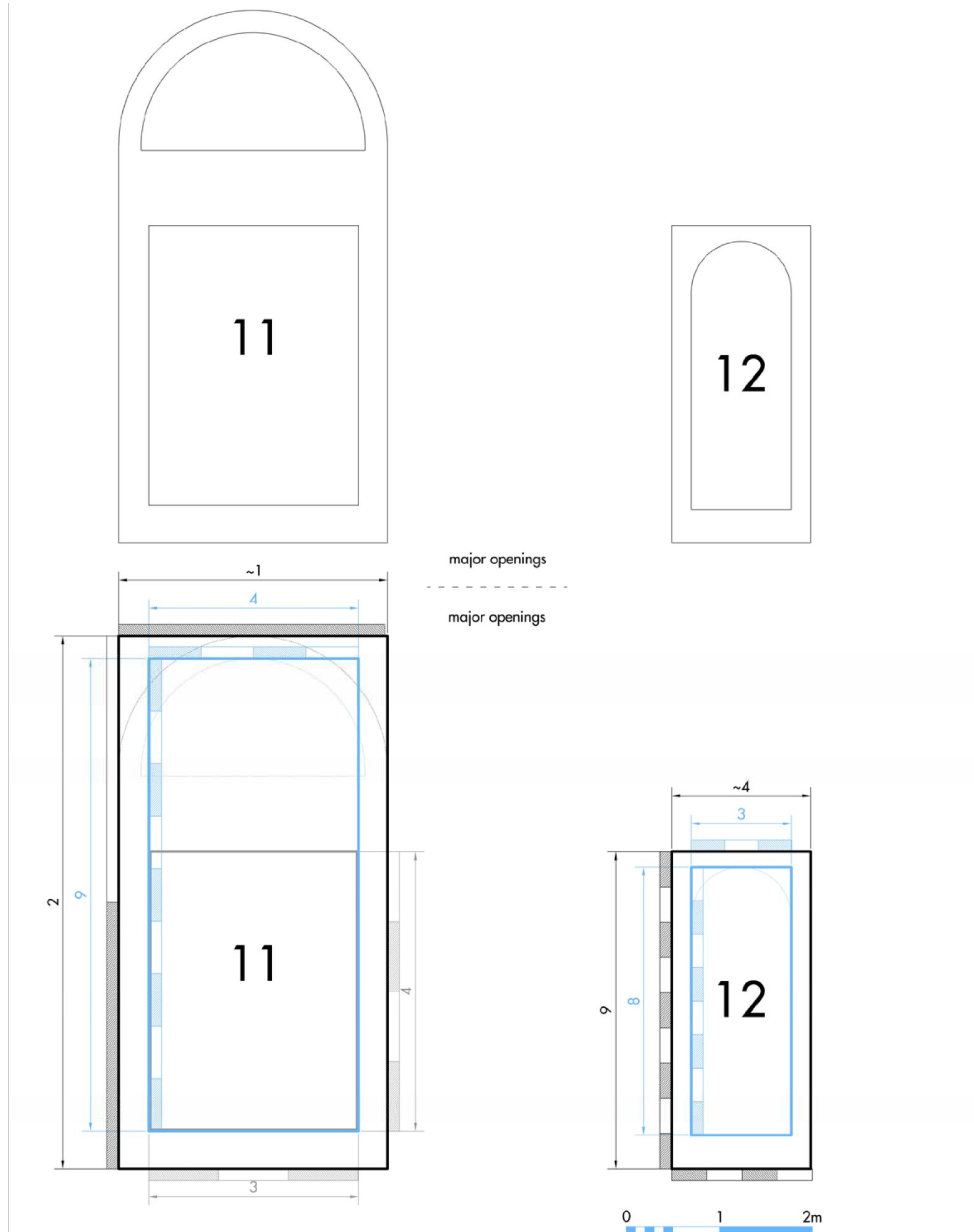


Fig. P.215 Geometrical analysis of openings: (VieR15) Residential and commercial building, Ring Road, Universitätsring 10

Fig. P.216 Geometrical analysis of front elevation: (VieR16) Residential house, Ring Road

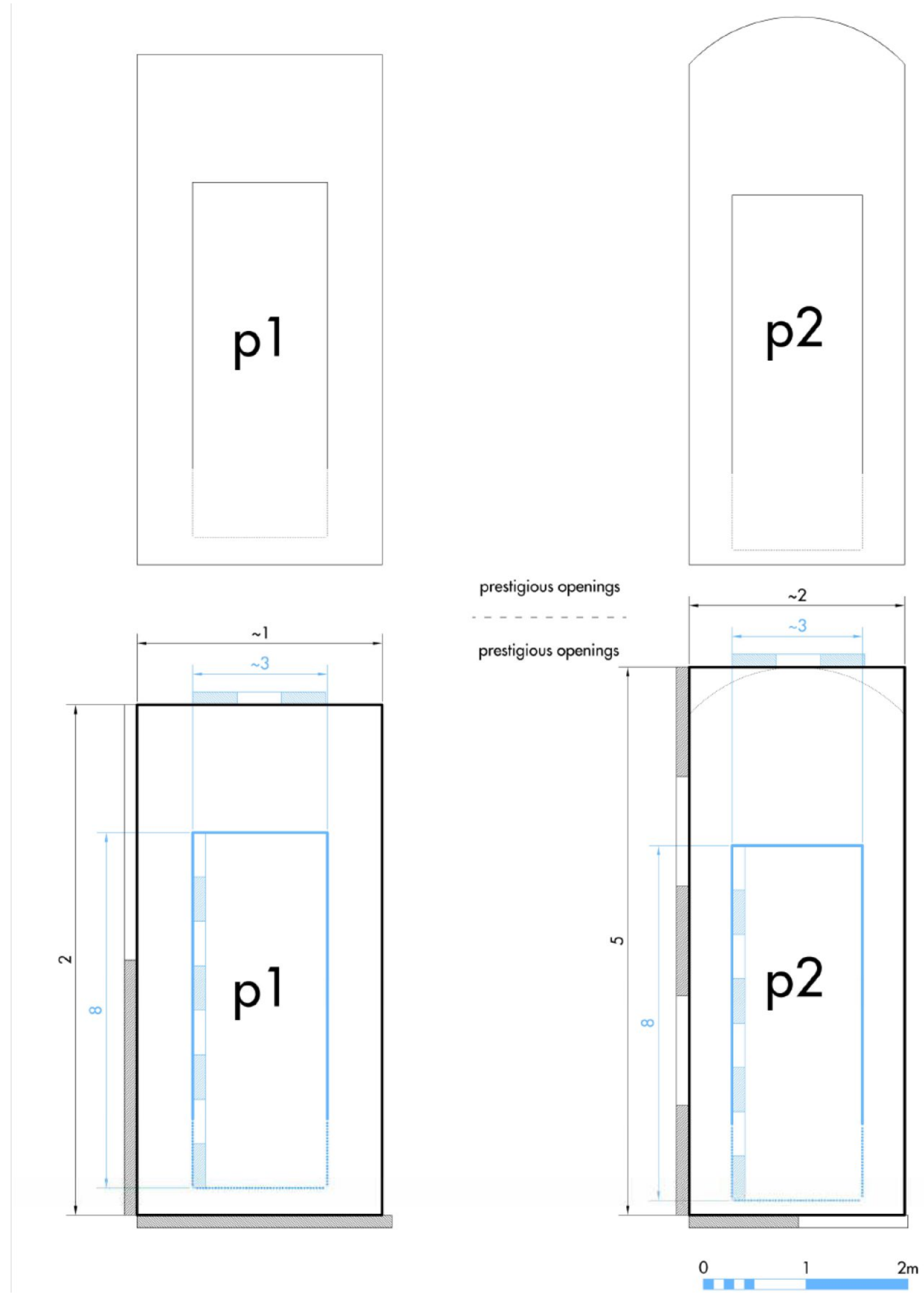


Fig. P.217 Geometrical analysis of openings: (VieR16) Residential house, Ring Road

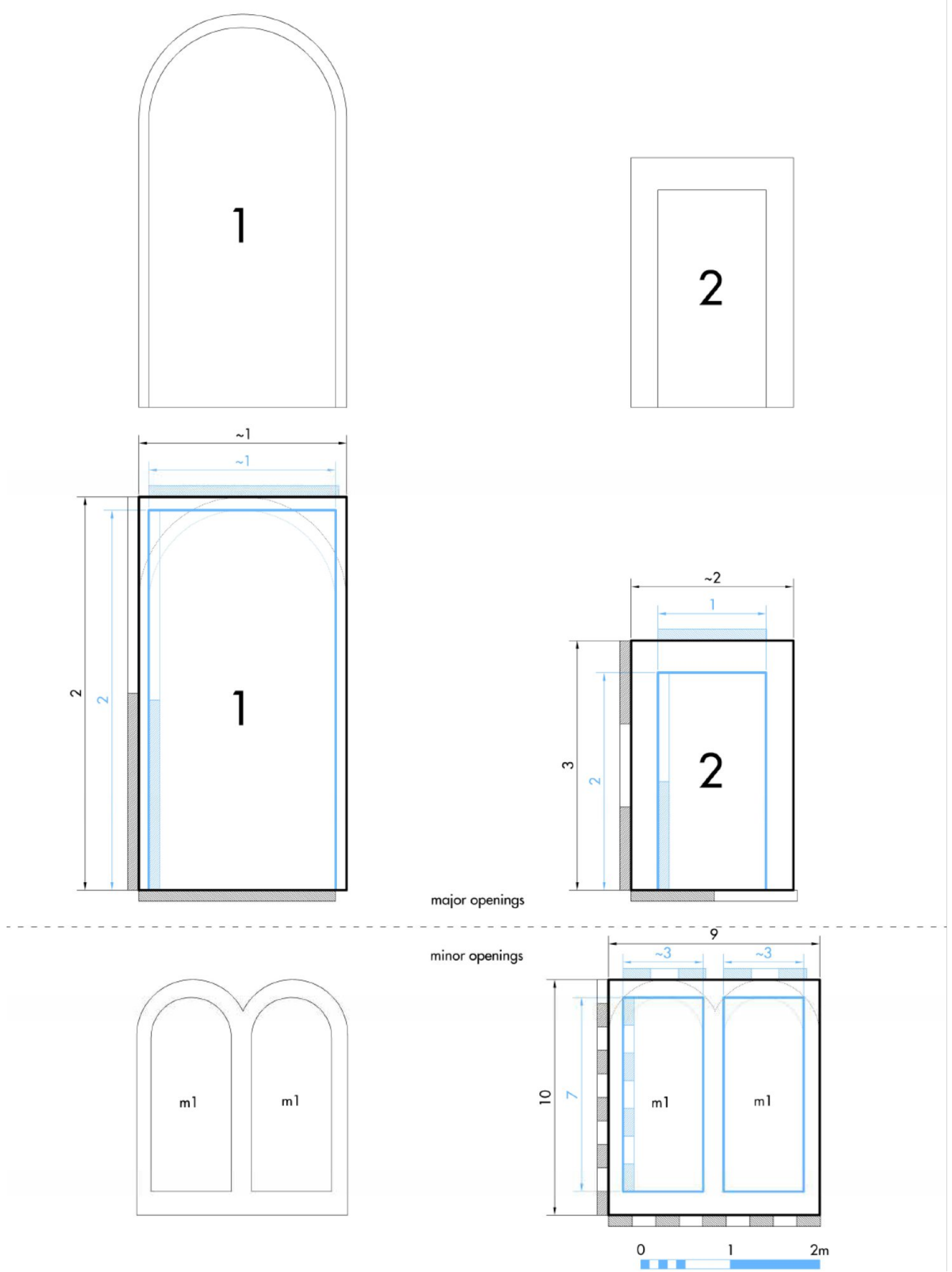


Fig. P.218 Geometrical analysis of openings: (VieR16) Residential house, Ring Road

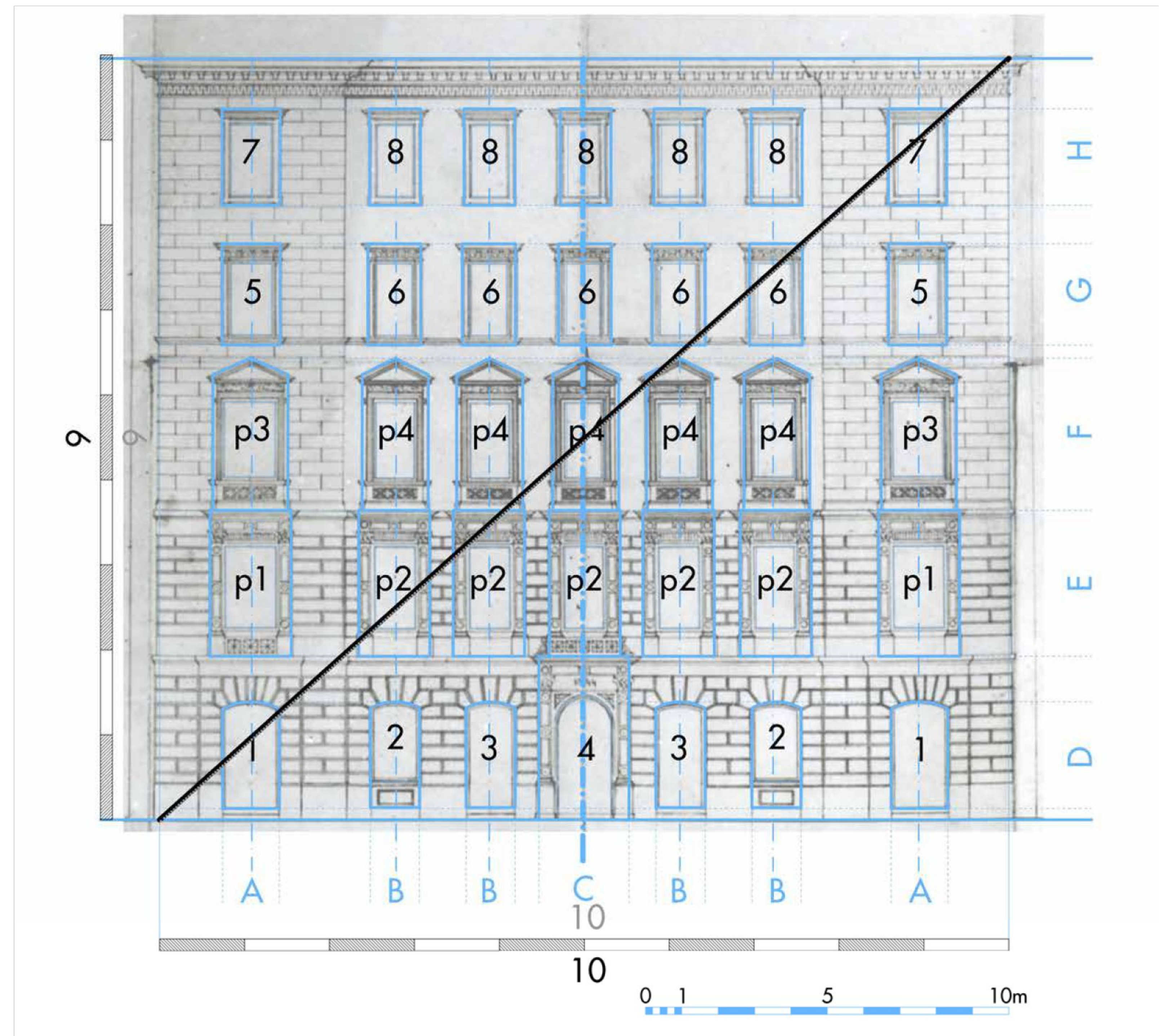


Fig. P.219 Geometrical analysis of front elevation: (VieR17) Residential house of Mr. Carl Schmidl, Ring Road

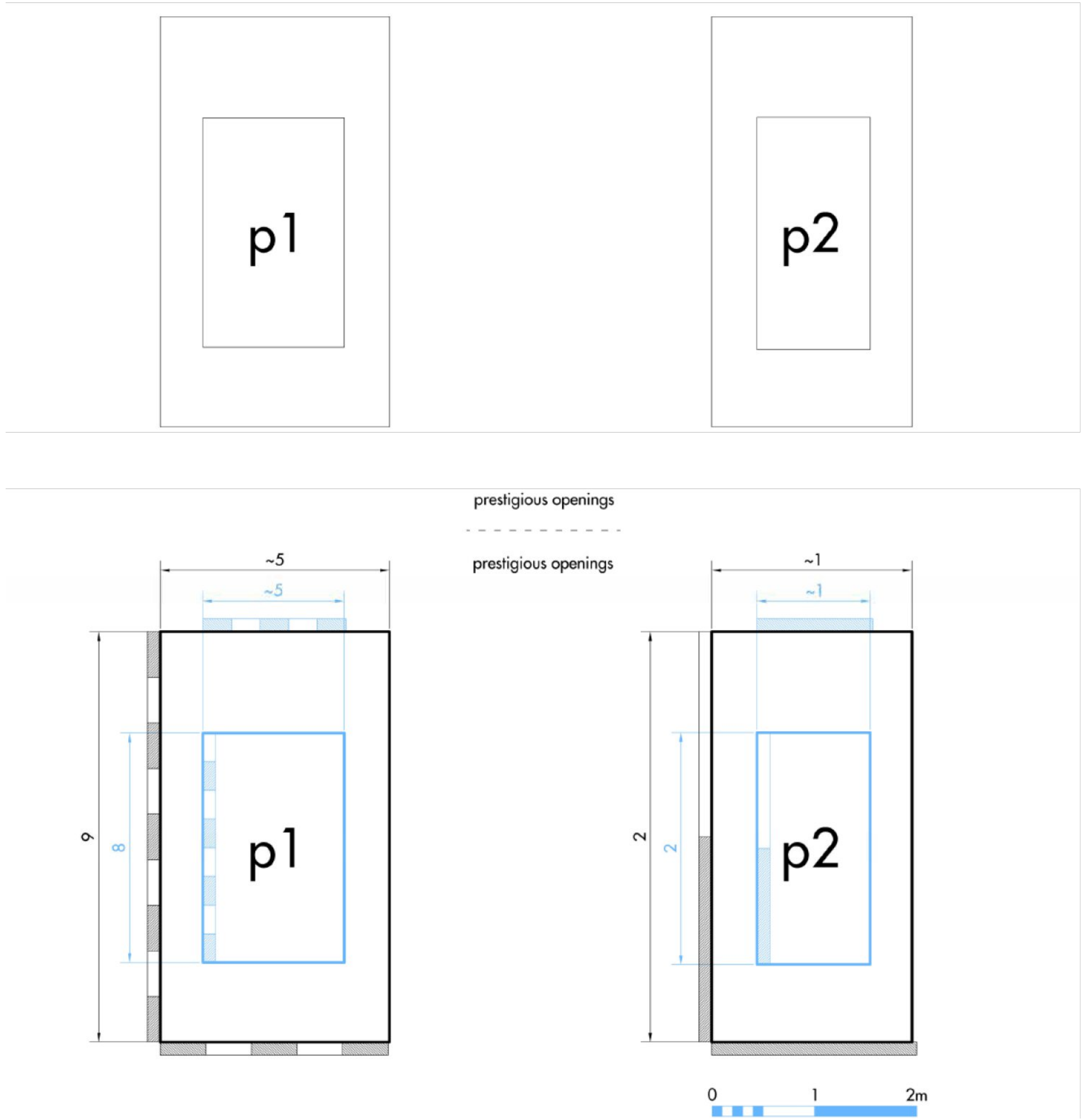


Fig. P.220 Geometrical analysis of openings: (VieR17) Residential house of Mr. Carl Schmidl, Ring Road

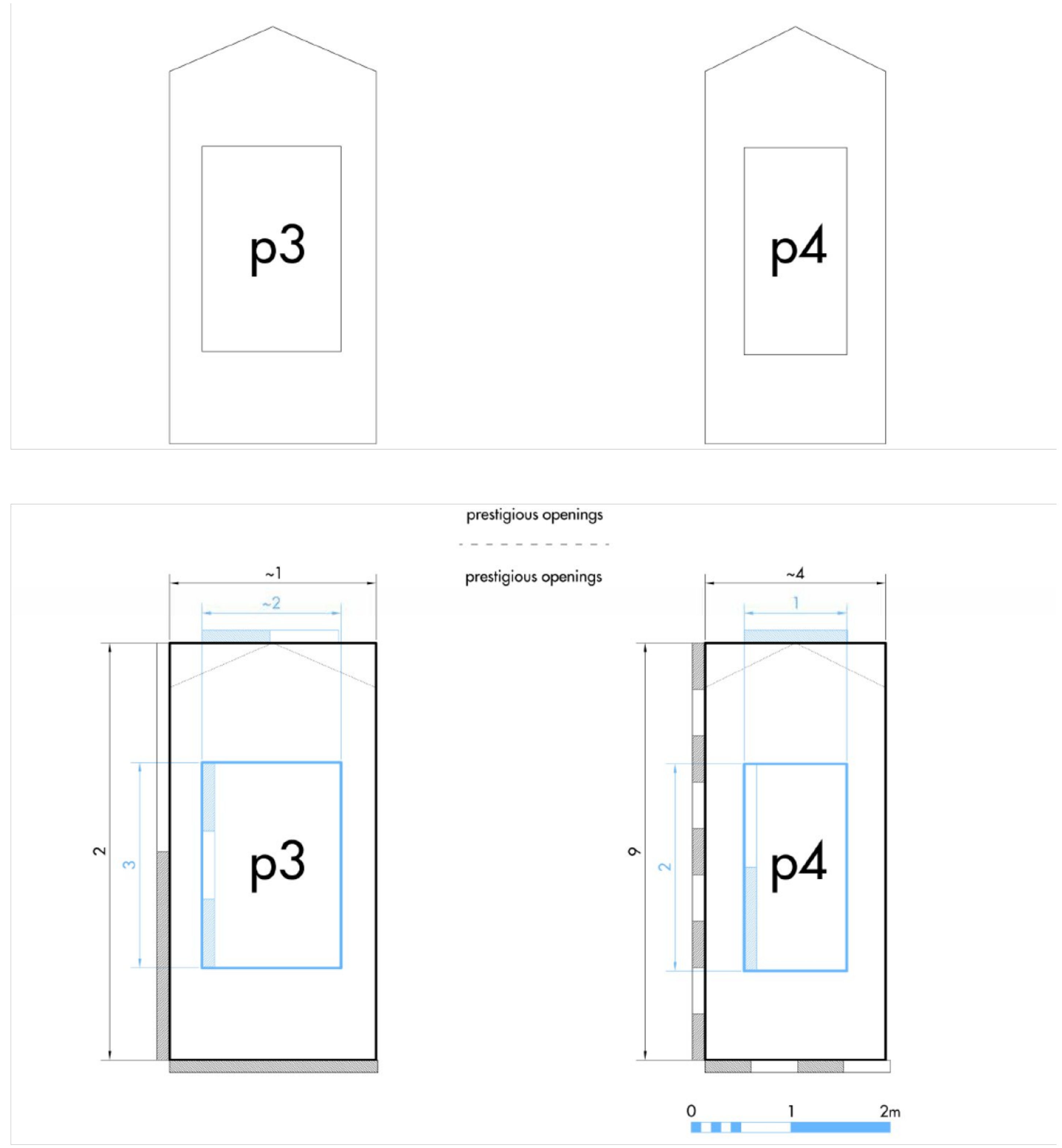


Fig. P.221 Geometrical analysis of openings: (VieR17) Residential house of Mr. Carl Schmidl, Ring Road

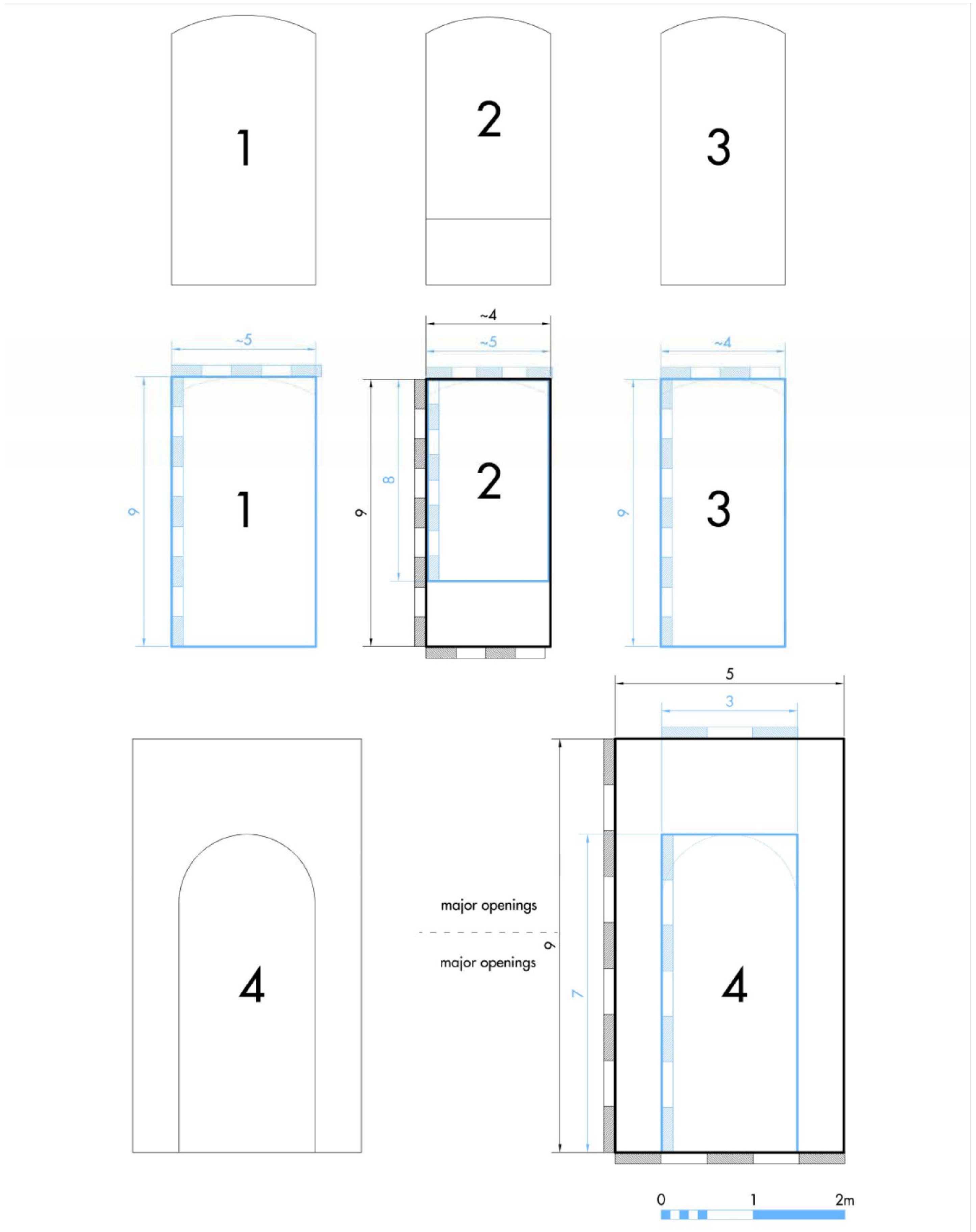


Fig. P.222 Geometrical analysis of openings: (VieR17) Residential house of Mr. Carl Schmidl, Ring Road

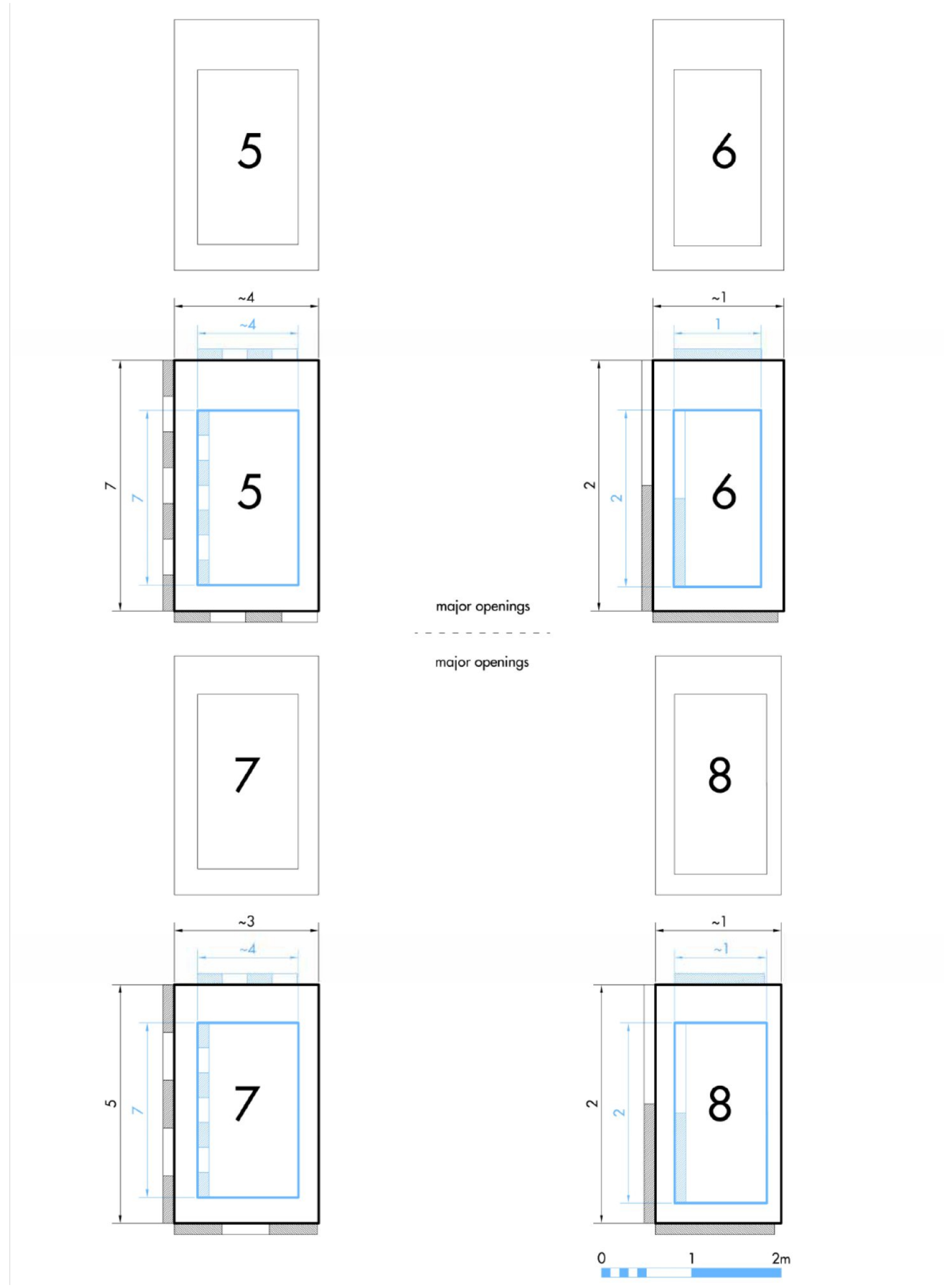


Fig. P.223 Geometrical analysis of openings: (VieR17) Residential house of Mr. Carl Schmidl, Ring Road

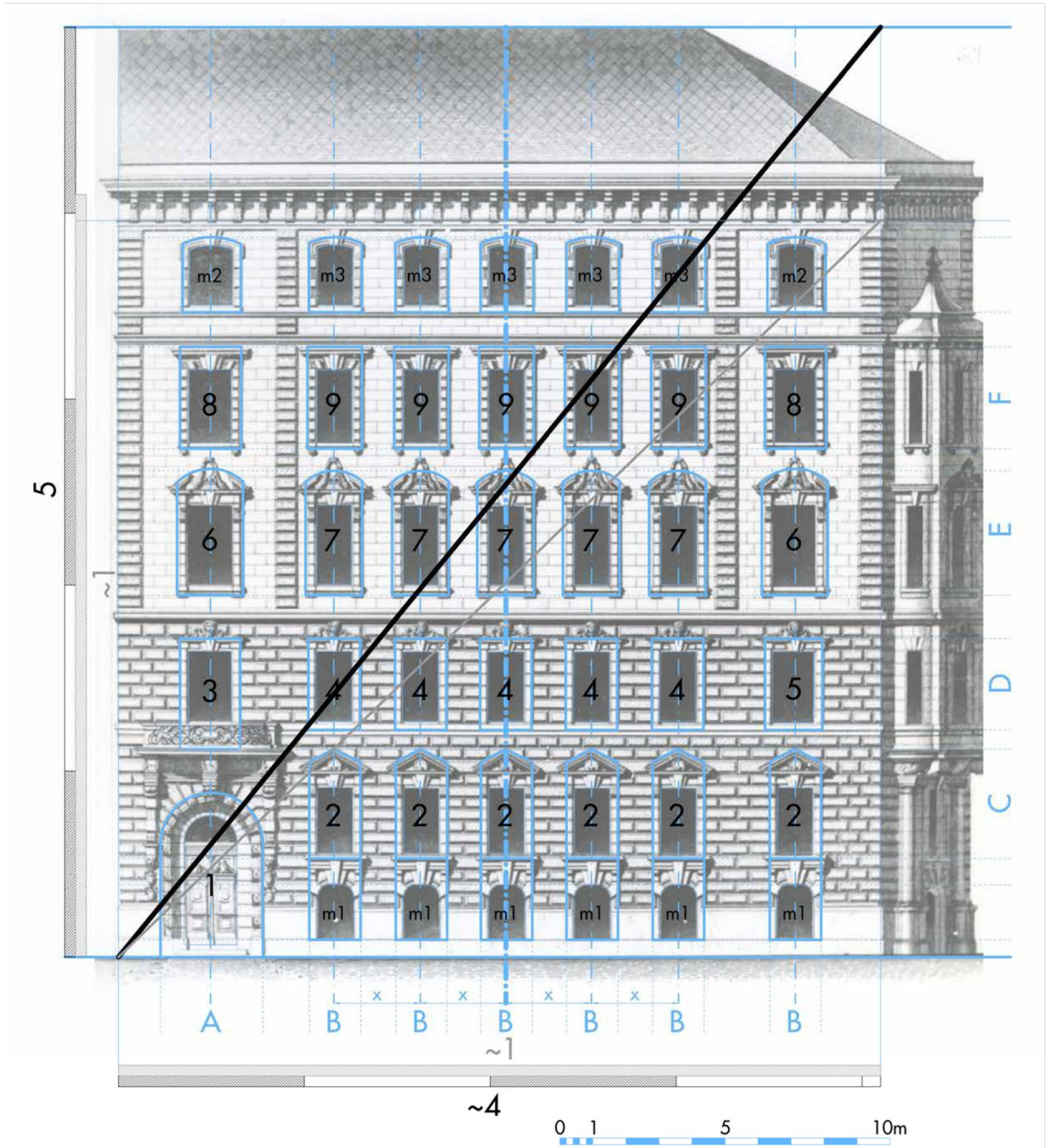


Fig. P.224 Geometrical analysis of front elevation: (VieR18) Residential house, Ring Road

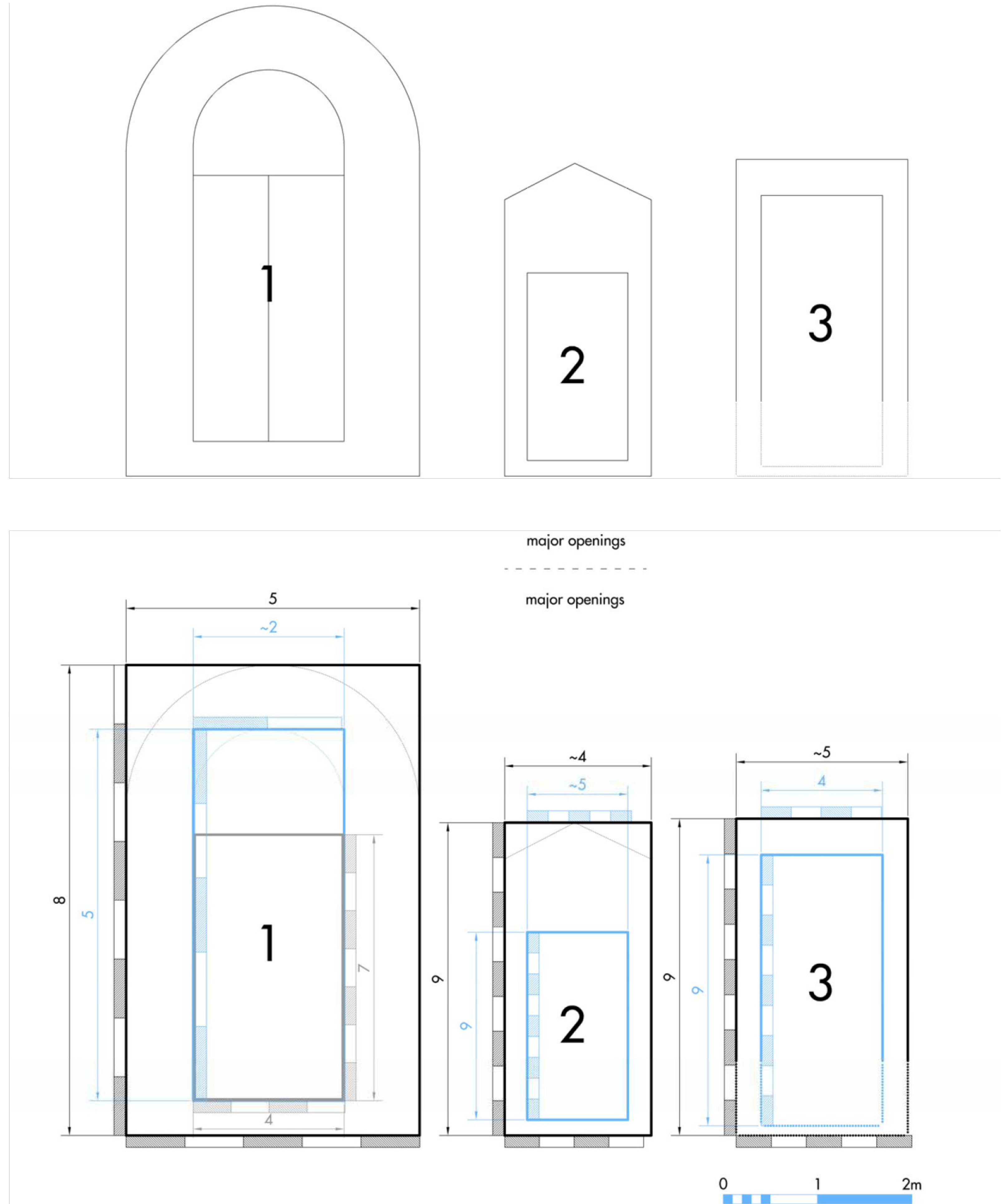


Fig. P.225 Geometrical analysis of openings: (VieR18) Residential house, Ring Road

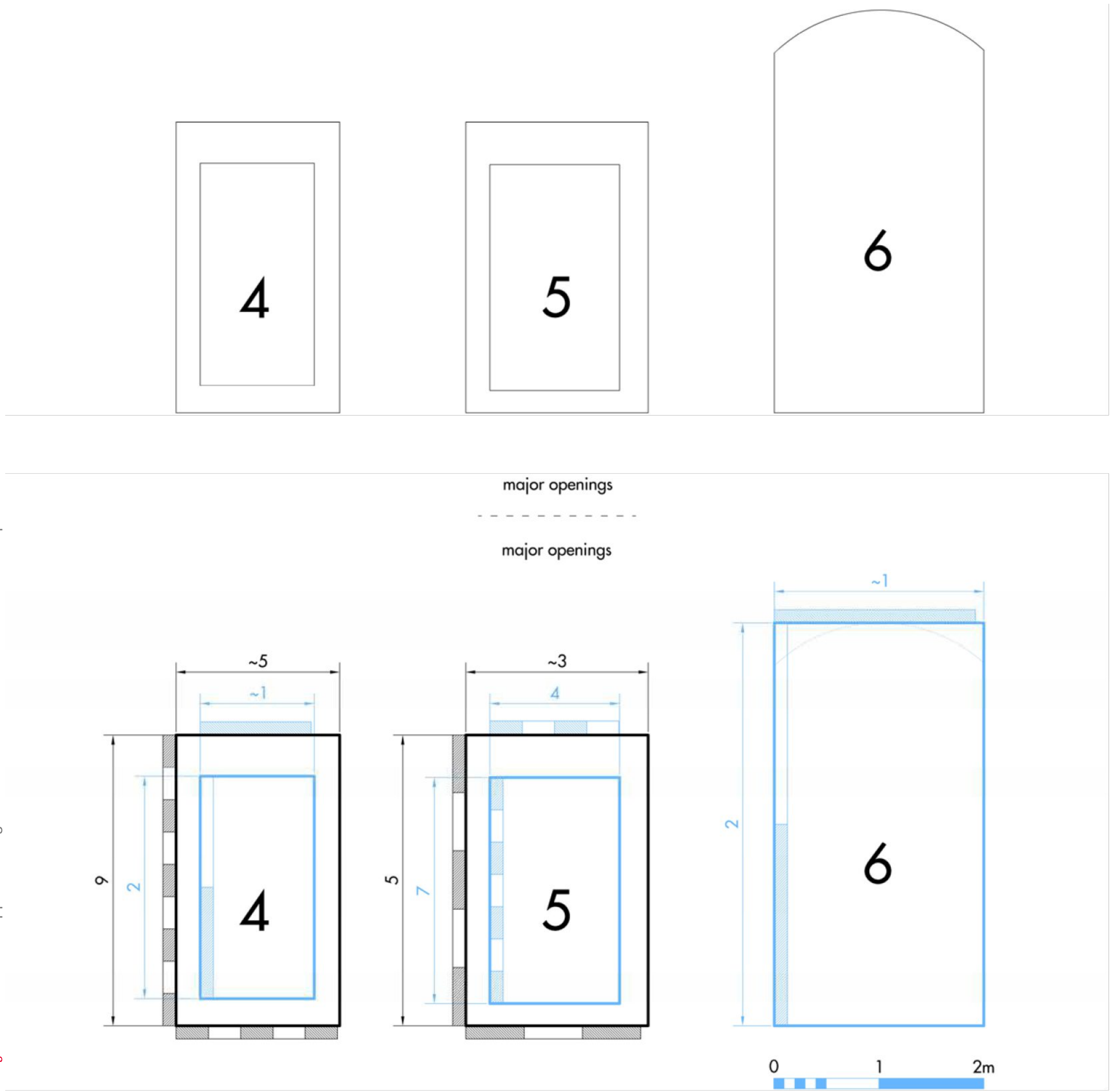


Fig. P.226 Geometrical analysis of openings: (VieR18) Residential house, Ring Road

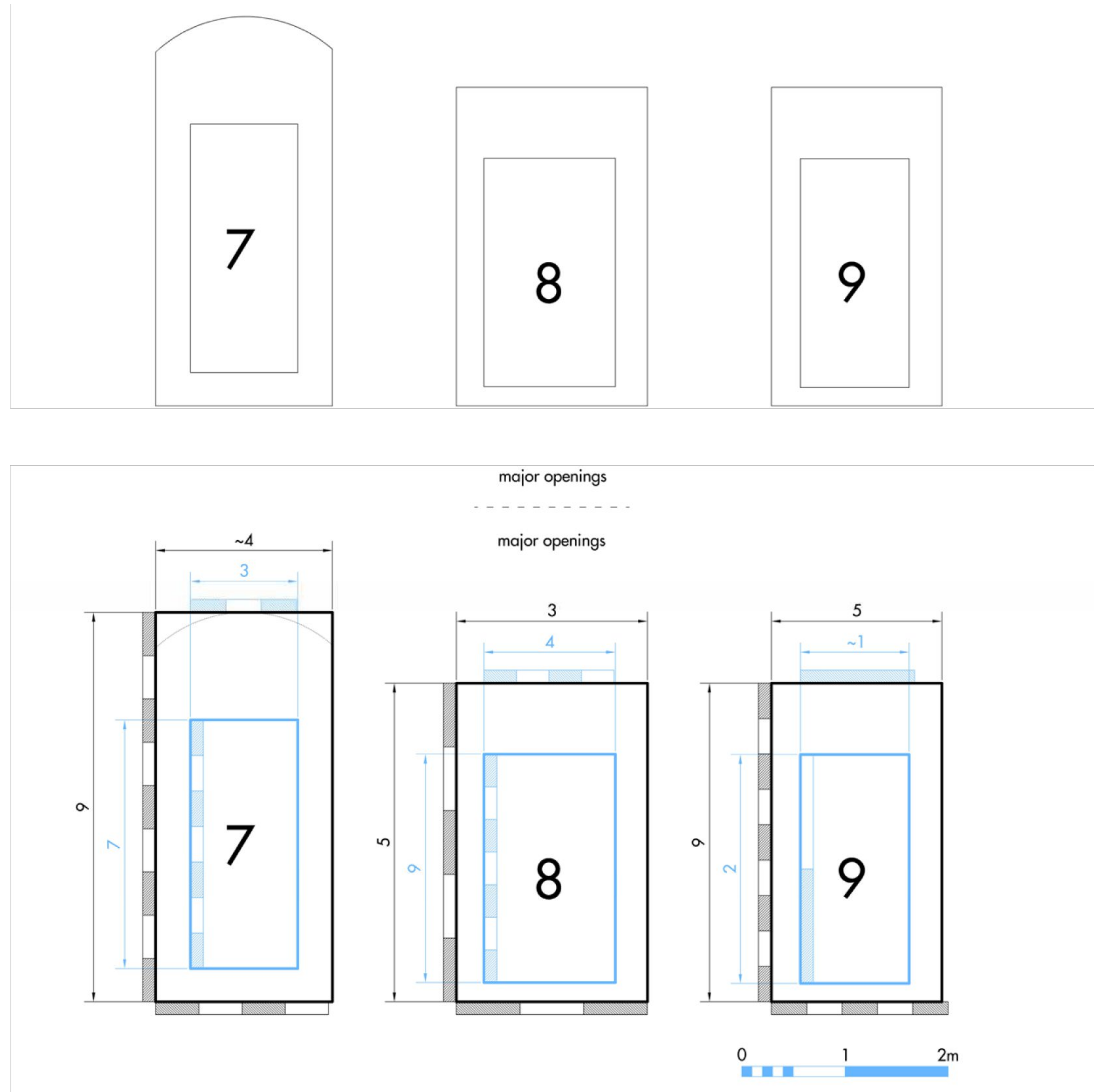


Fig. P.227 Geometrical analysis of openings: (VieR18) Residential house, Ring Road

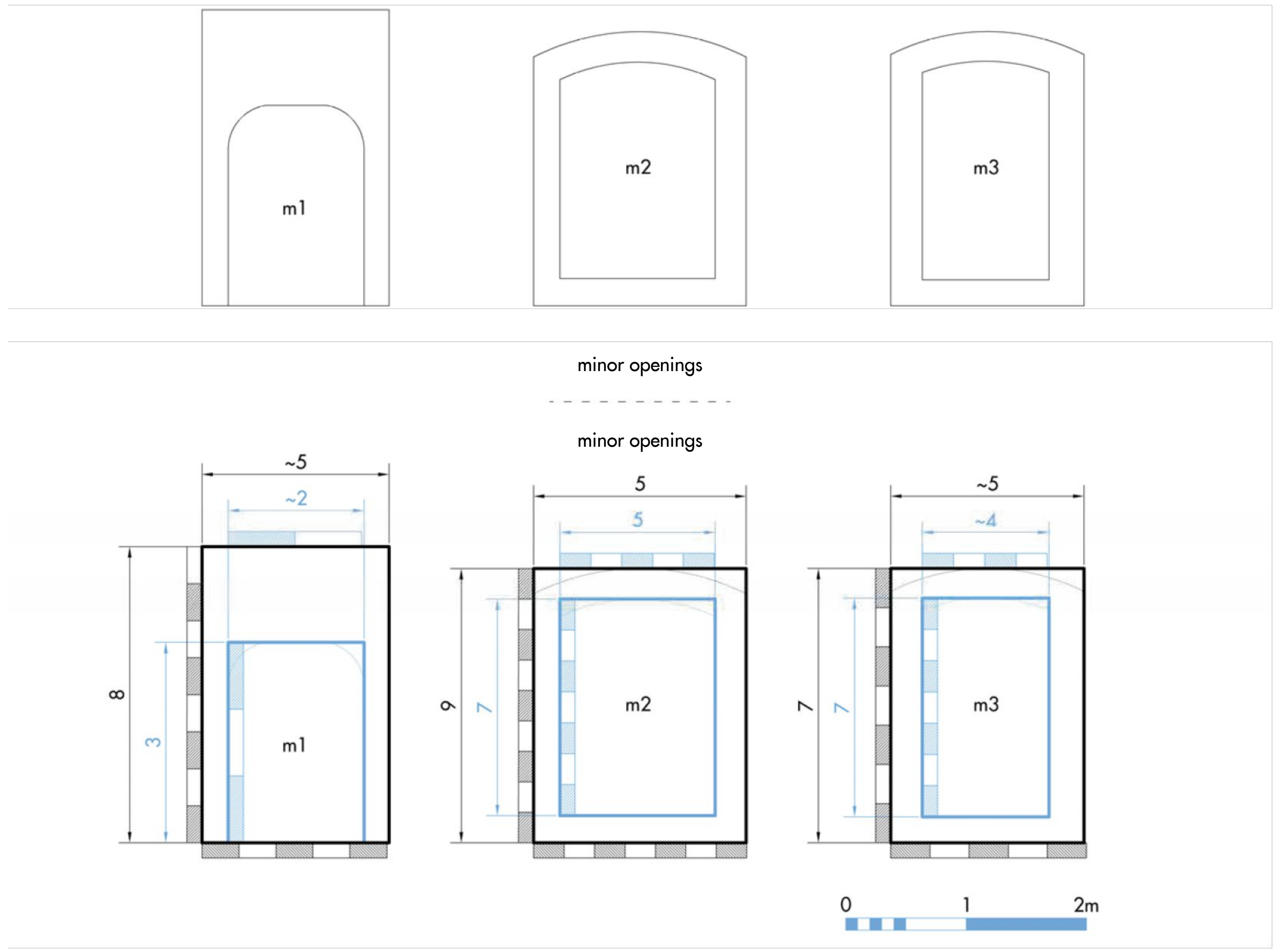


Fig. P.228 Geometrical analysis of openings: (VieR18) Residential house, Ring Road

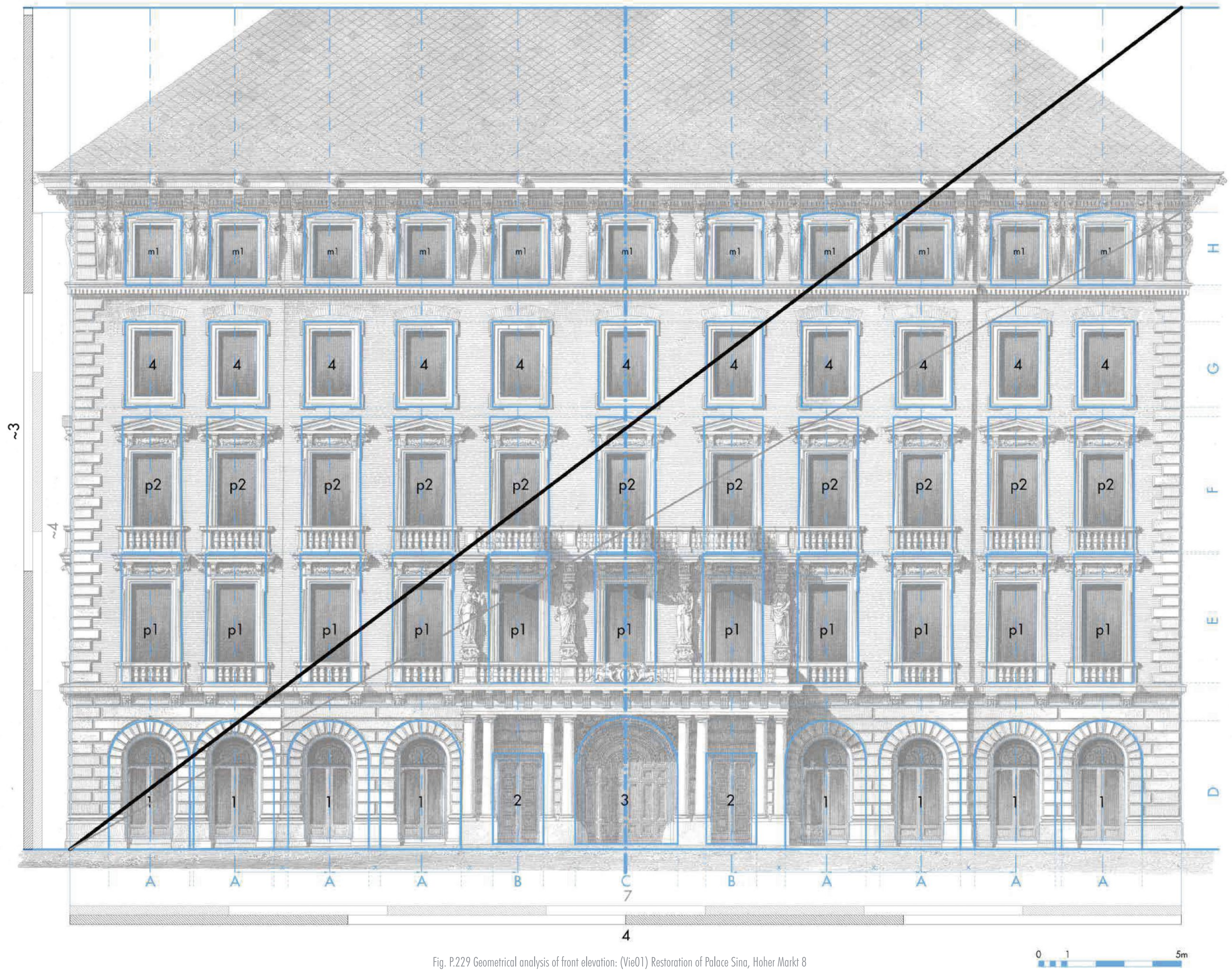


Fig. P.229 Geometrical analysis of front elevation: (Vie01) Restoration of Palace Sina, Hoher Markt 8

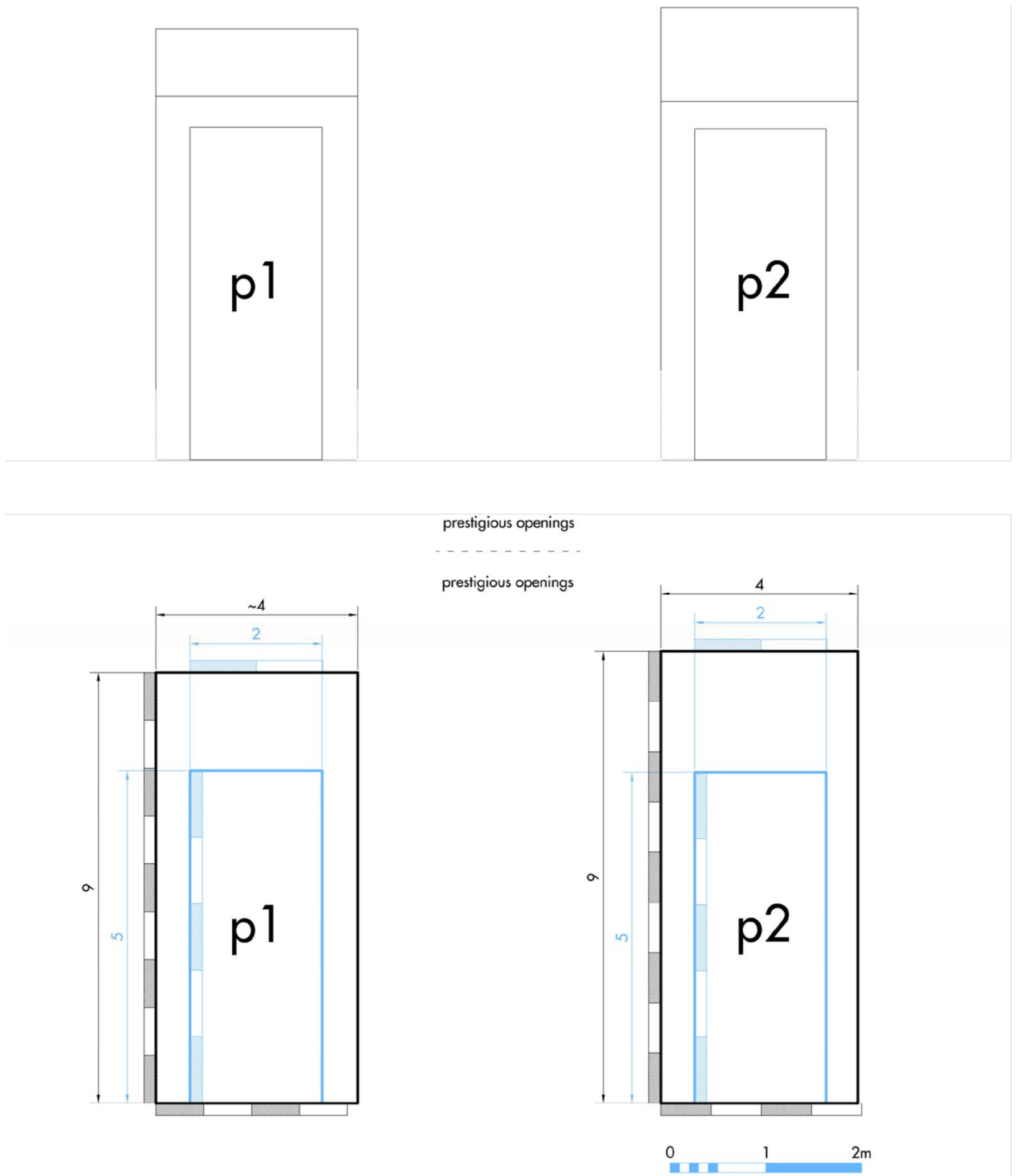


Fig. P.230 Geometrical analysis of openings: (Vie01) Restoration of Palace Sina, Hoher Markt 8

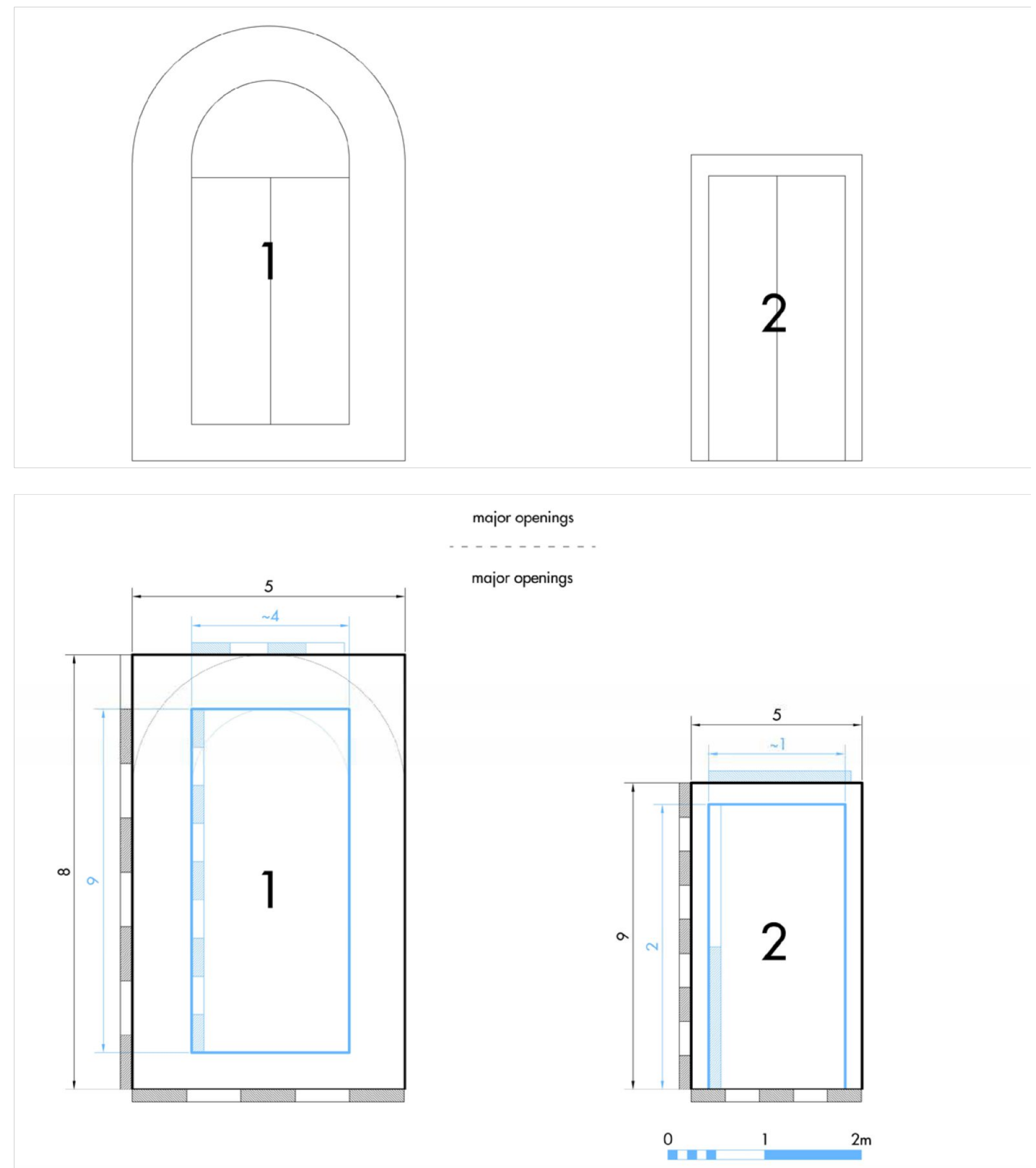


Fig. P.231 Geometrical analysis of openings: (Vie01) Restoration of Palace Sina, Hoher Markt 8

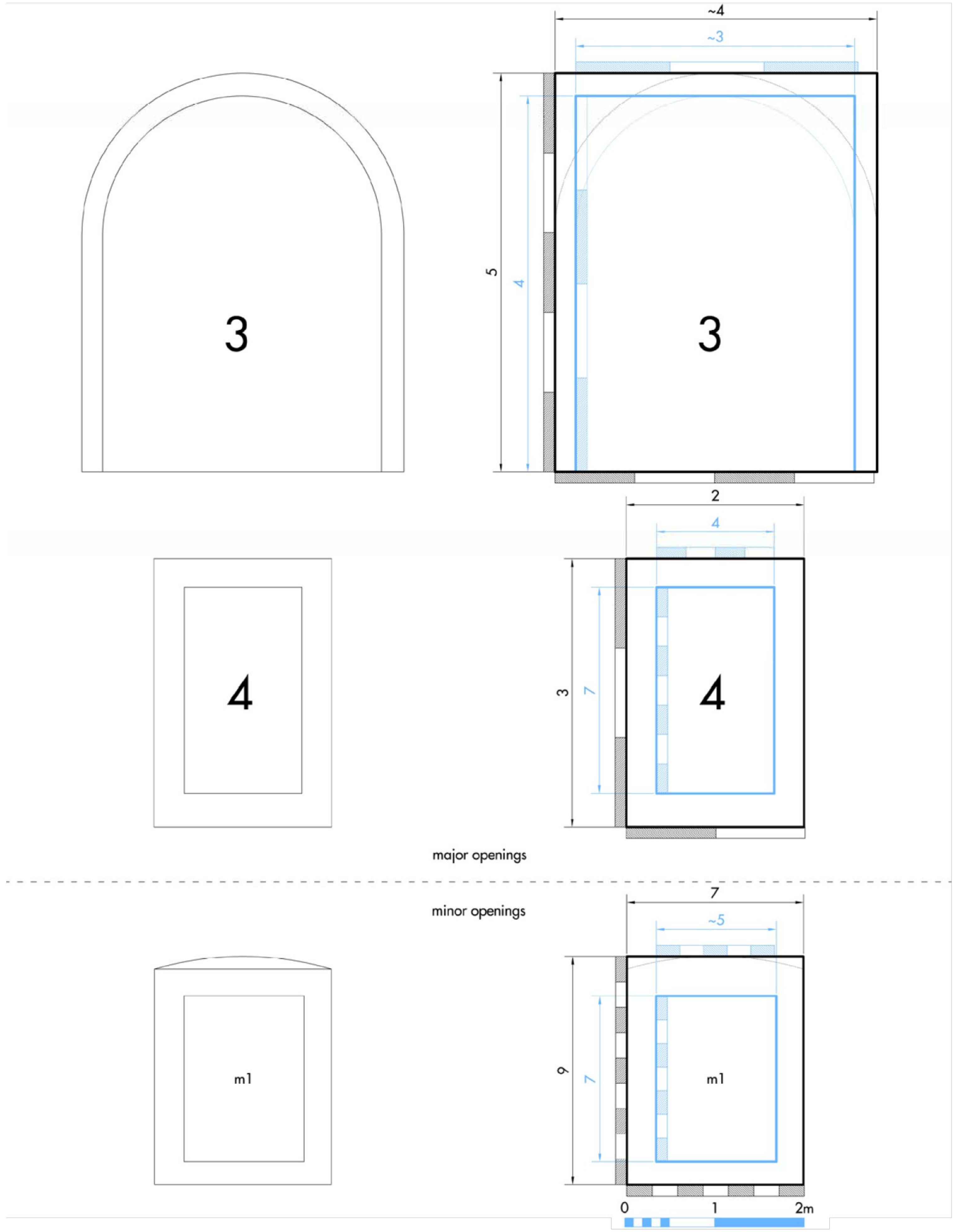


Fig. P.232 Geometrical analysis of openings: (Vie01) Restoration of Palace Sina, Hoher Markt 8

Fig. P.233 Geometrical analysis of front elevation: (Vie02) Palace Reitzes, Universitätsstraße 5

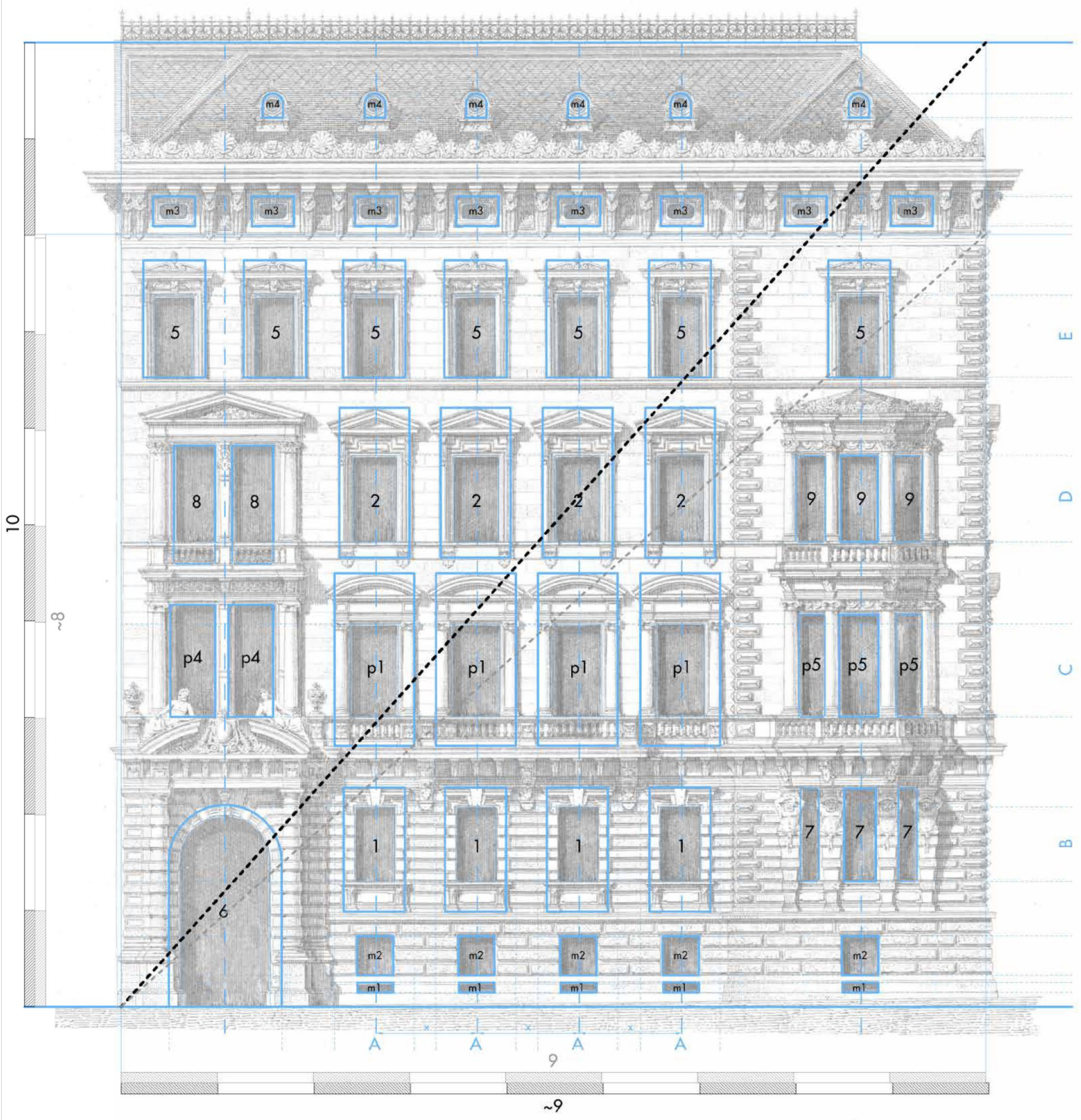


Fig. P.234 Geometrical analysis of side elevation: (Vie02) Palace Reitzes, Universitätsstraße 5

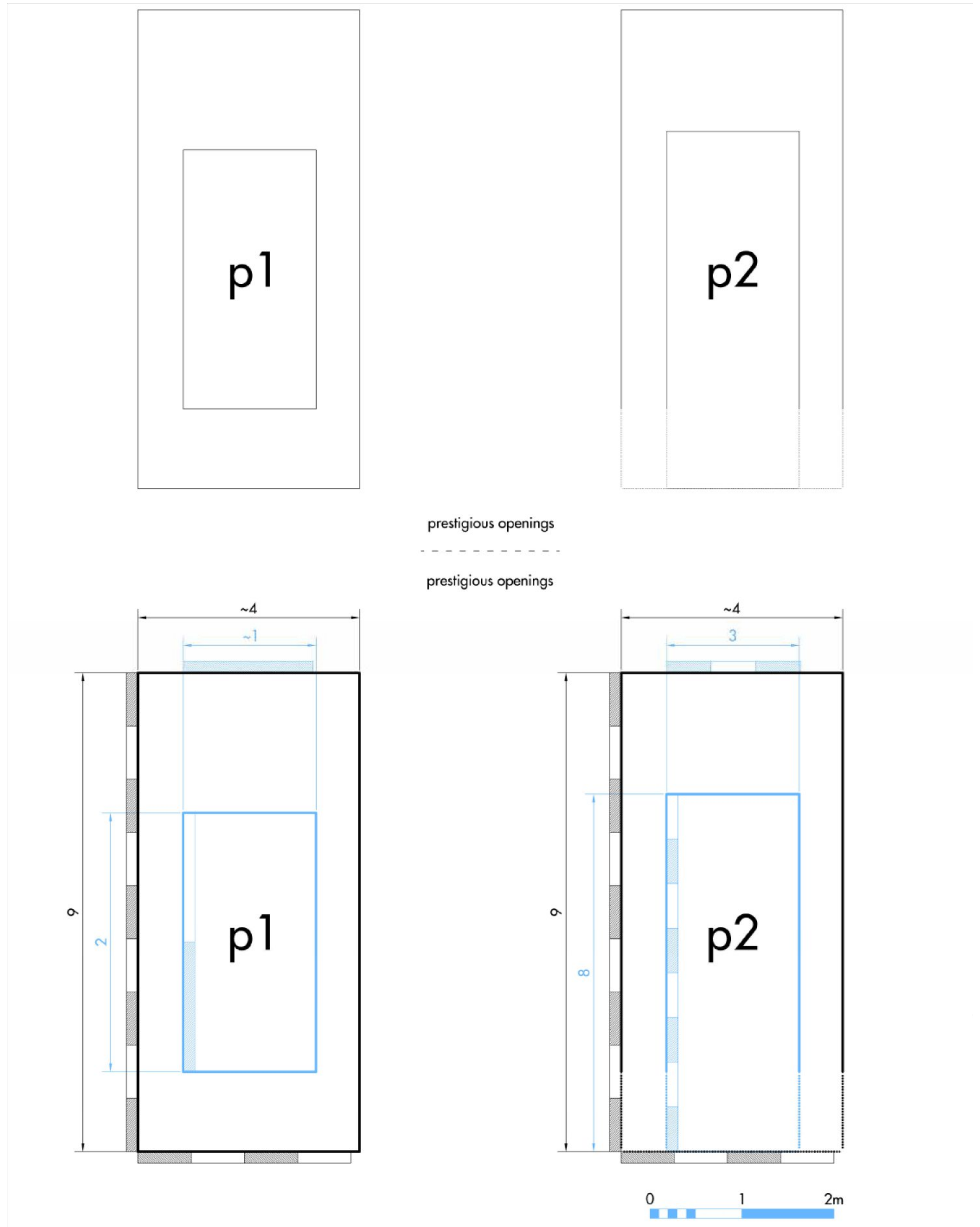


Fig. P.235 Geometrical analysis of openings: (Vie02) Palace Reitzes, Universitätsstraße 5

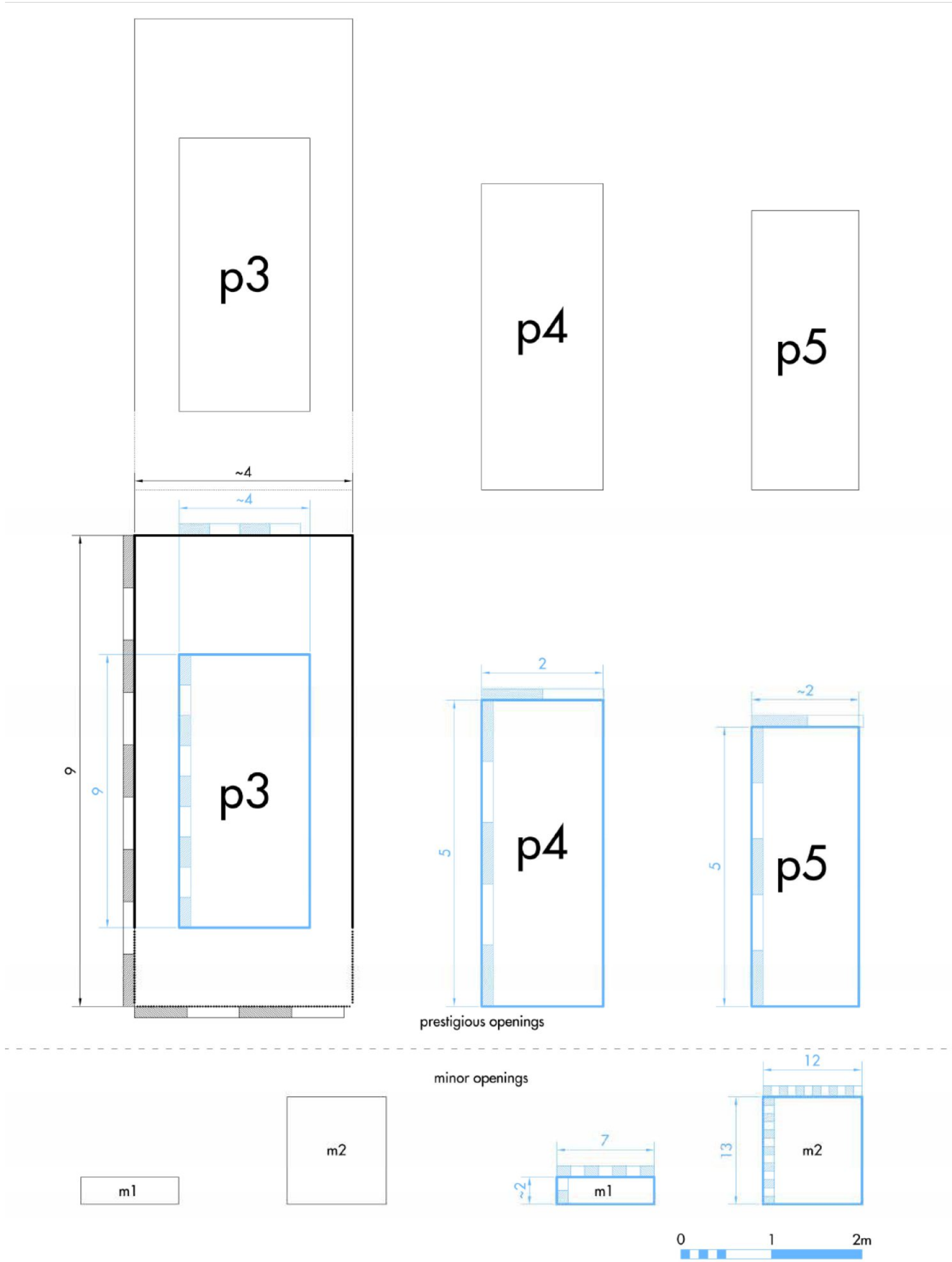


Fig. P.236 Geometrical analysis of openings: (Vie02) Palace Reitzes, Universitätsstraße 5

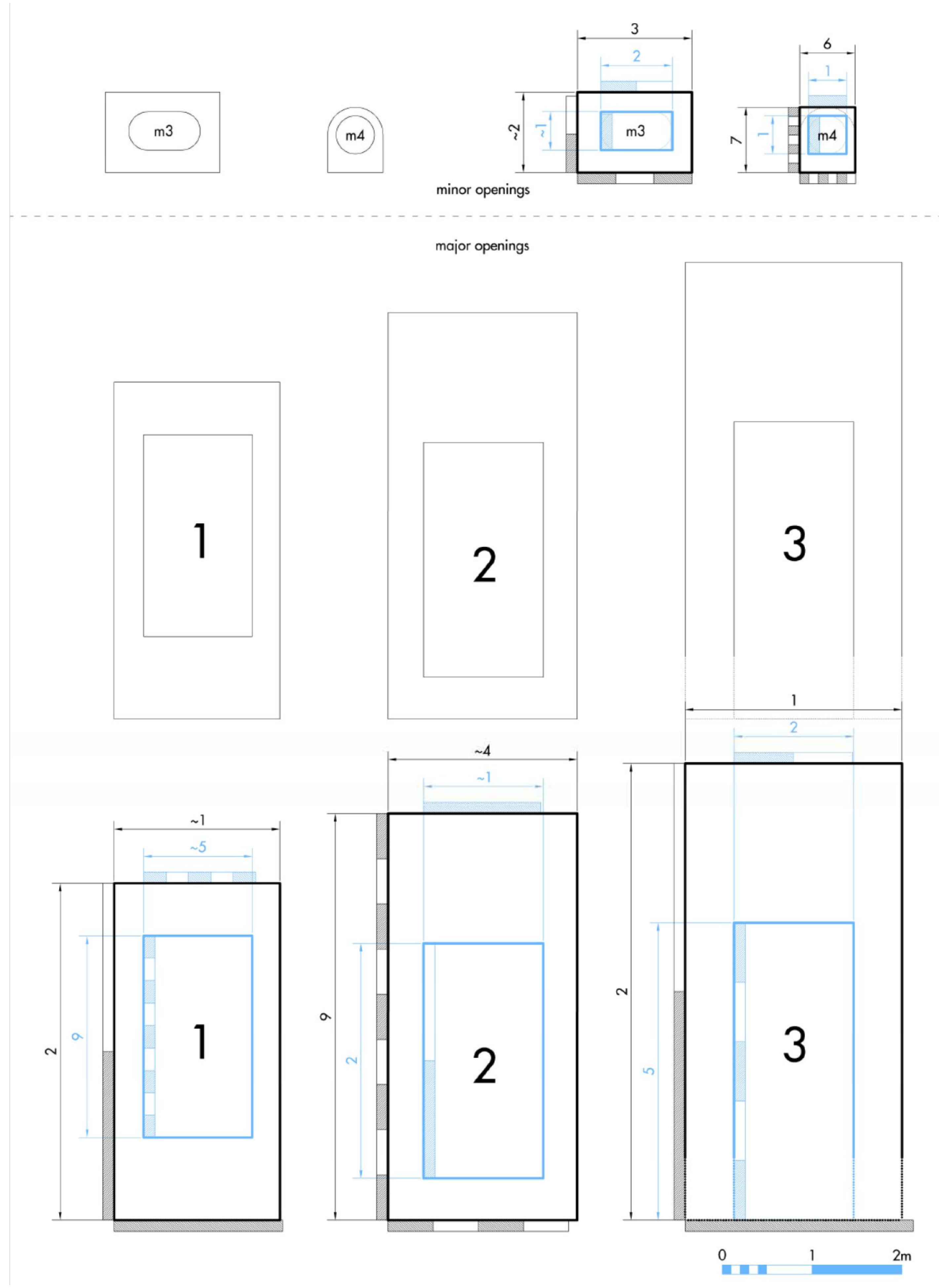


Fig. P.237 Geometrical analysis of openings: (Vie02) Palace Reitzes, Universitätsstraße 5

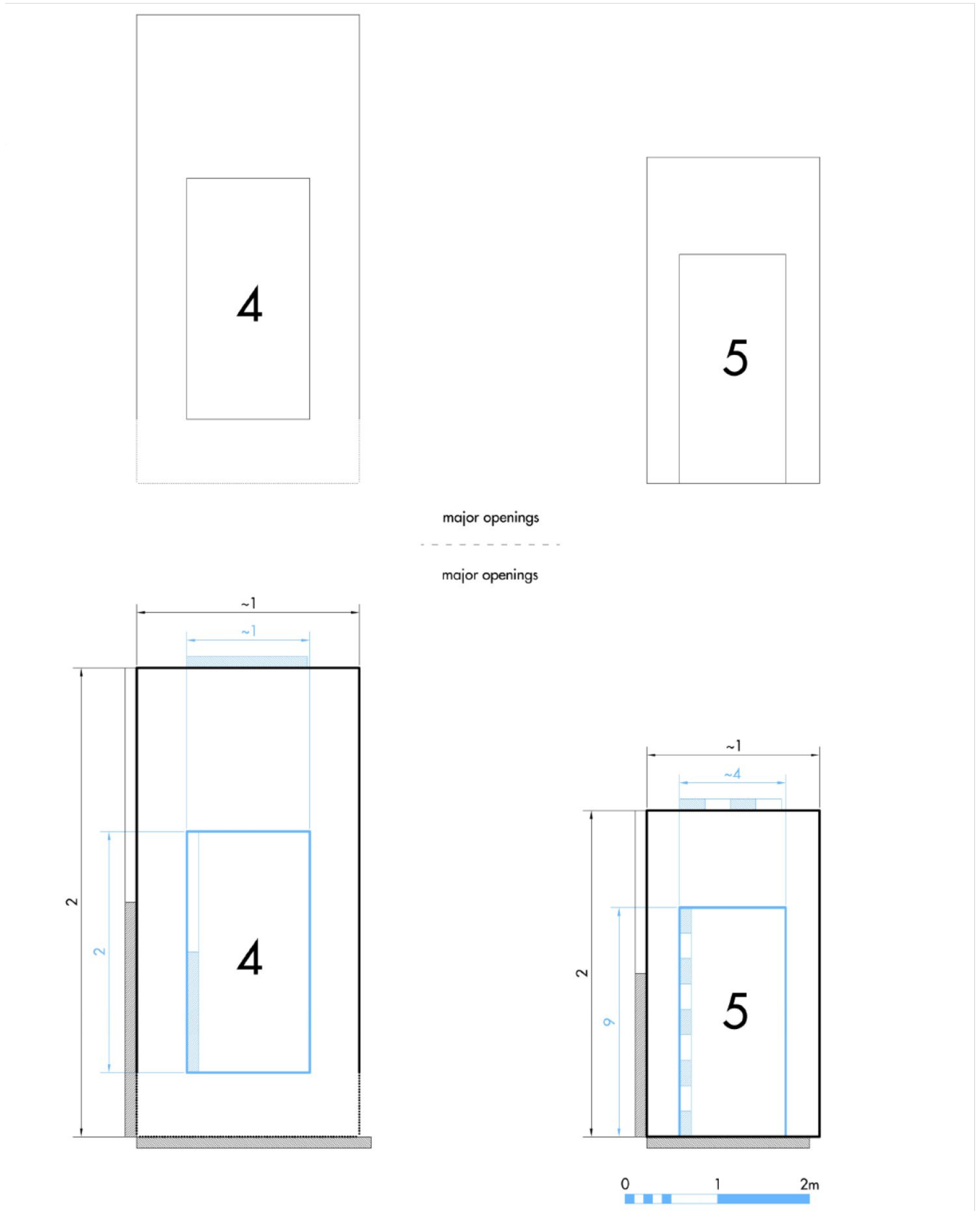


Fig. P.238 Geometrical analysis of openings: (Vie02) Palace Reitzes, Universitätsstraße 5

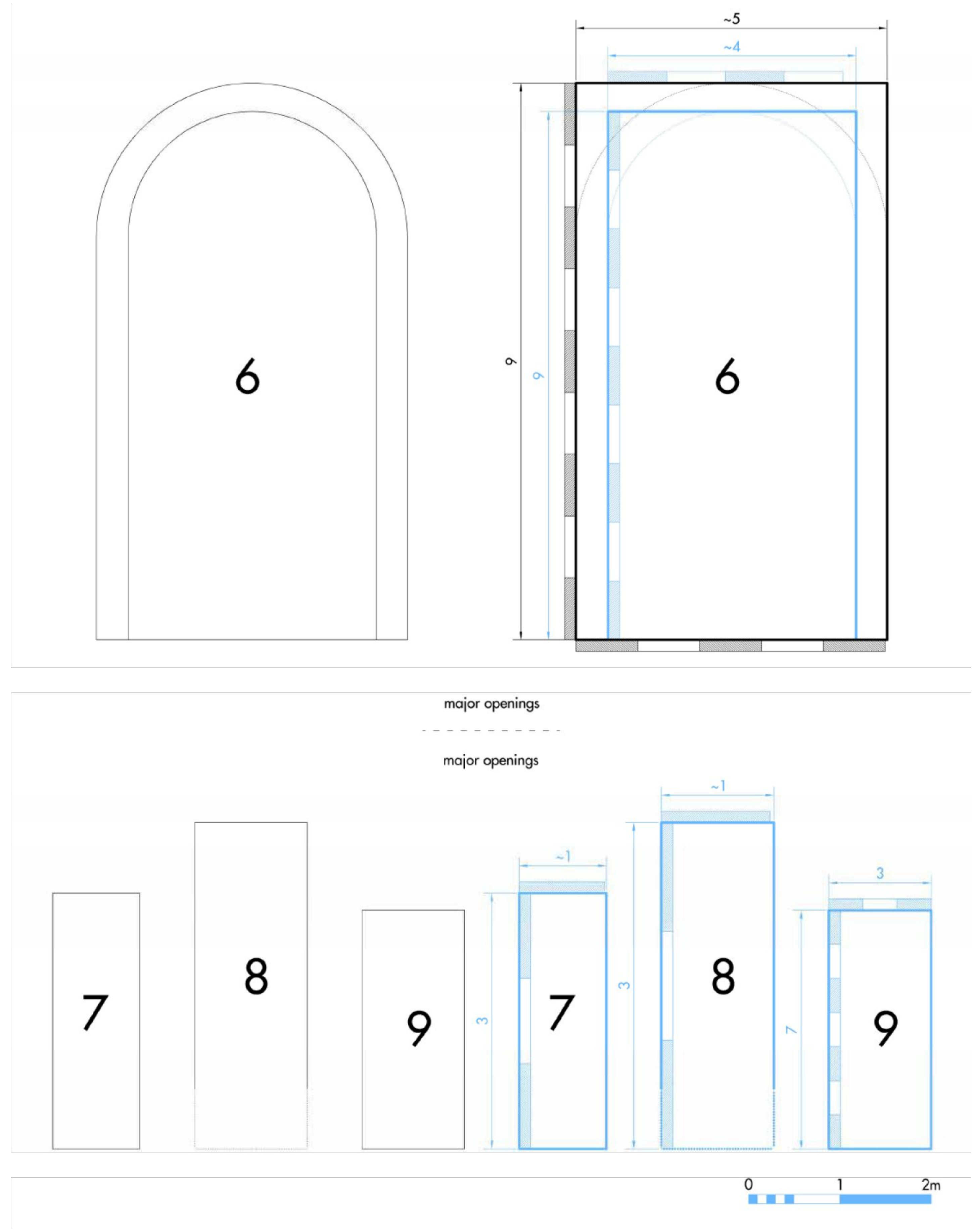


Fig. P.239 Geometrical analysis of openings: (Vie02) Palace Reitzes, Universitätsstraße 5

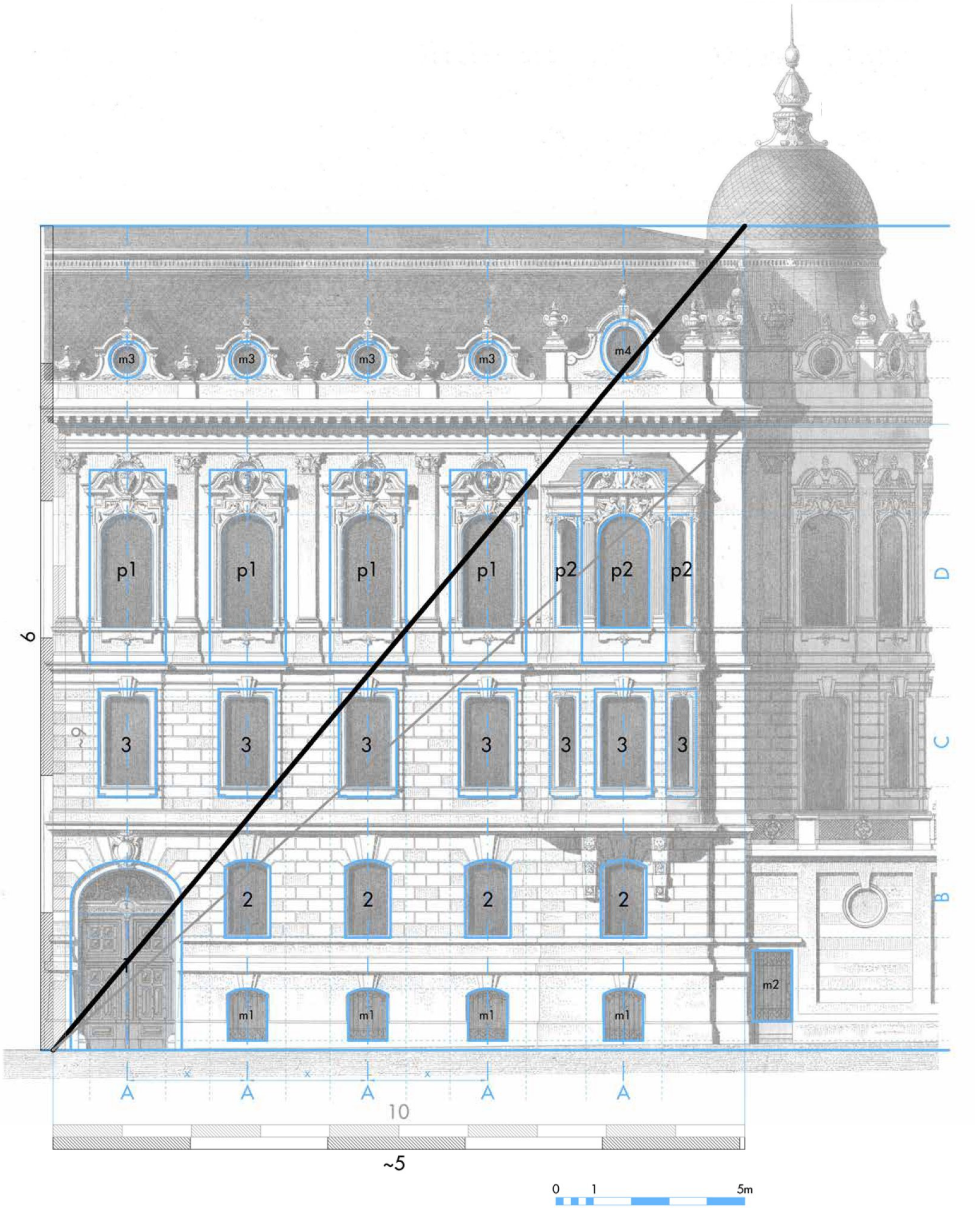


Fig. P.240 Geometrical analysis of front elevation: (Vie03) Palace of count Seldern, Pettenkofen-Gasse 2

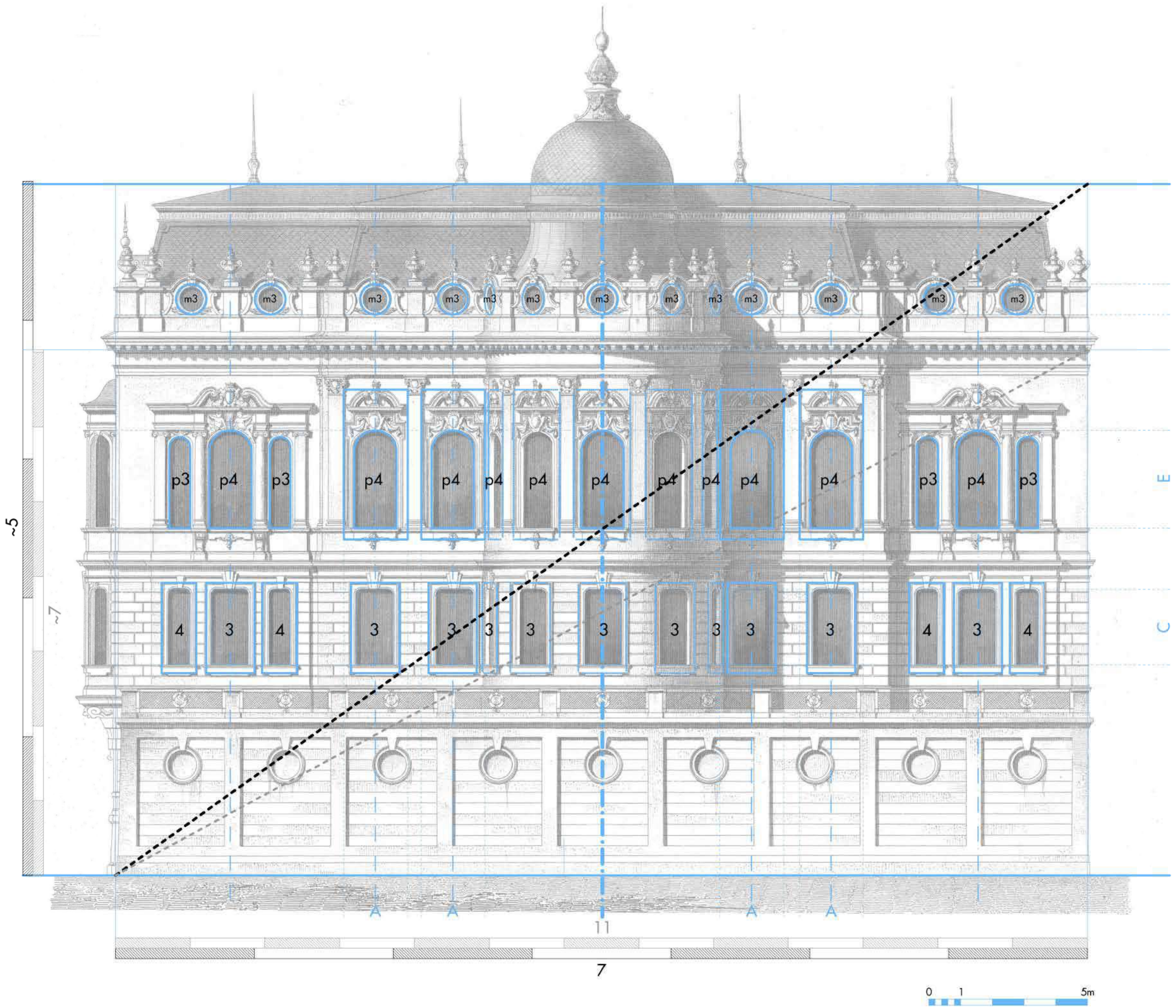


Fig. P.241 Geometrical analysis of side elevation: (Vie03) Palace of count Seldern, Pettenkofen-Gasse 2

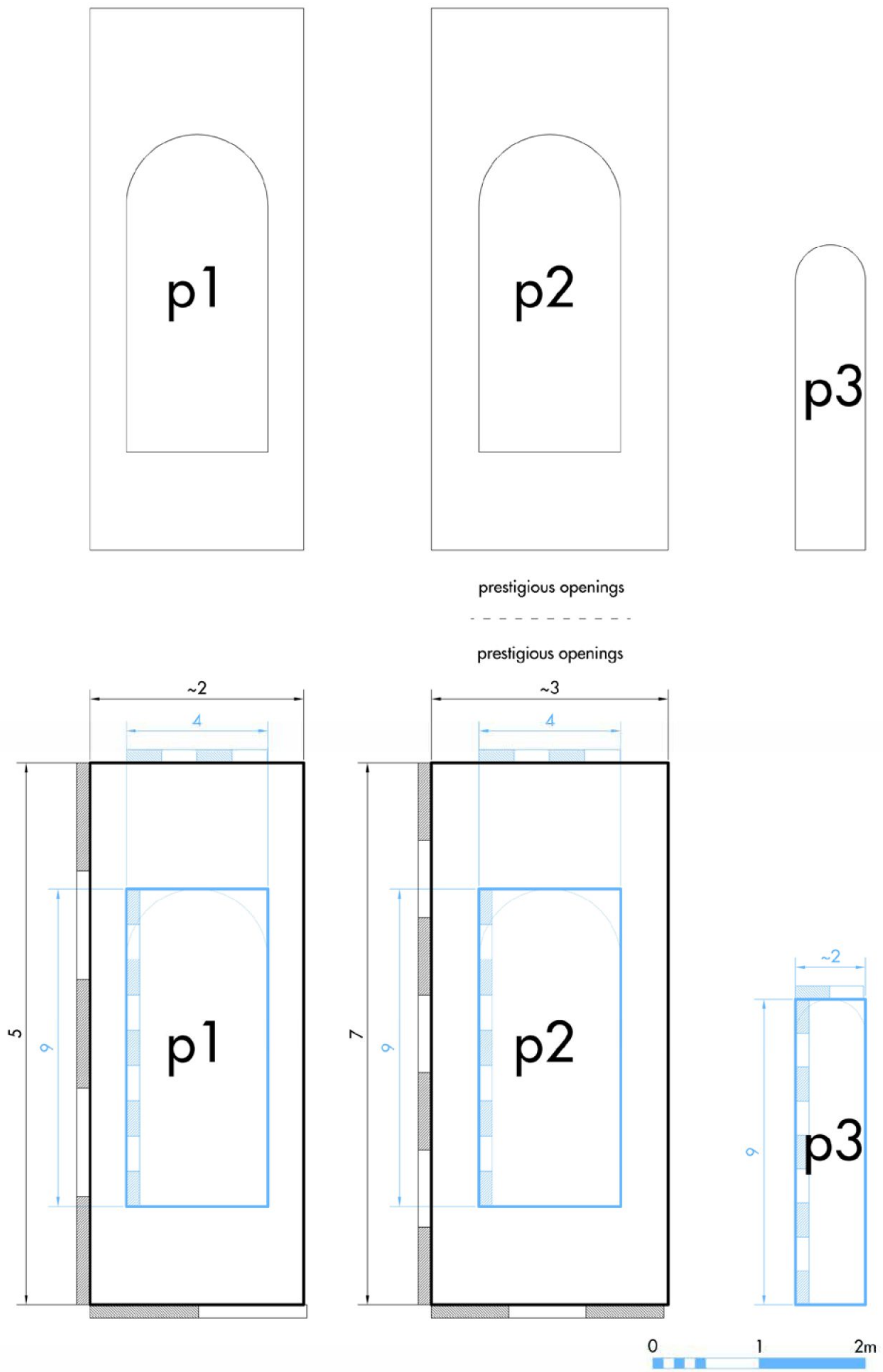


Fig. P.242 Geometrical analysis of openings: (Vie03) Palace of count Seldern, Pettenkofen-Gasse 2

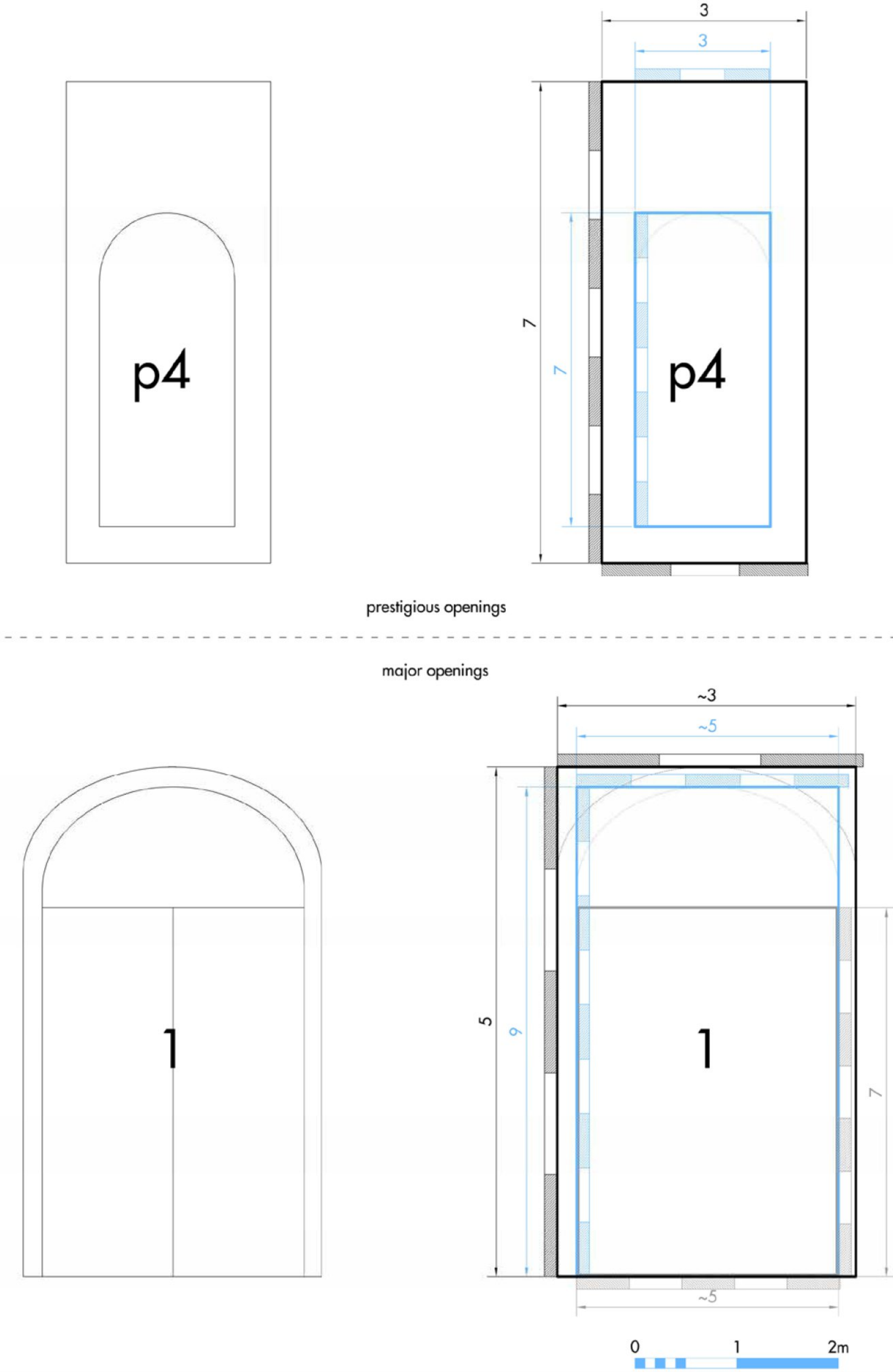


Fig. P.243 Geometrical analysis of openings: (Vie03) Palace of count Seldern, Pettenkofen-Gasse 2

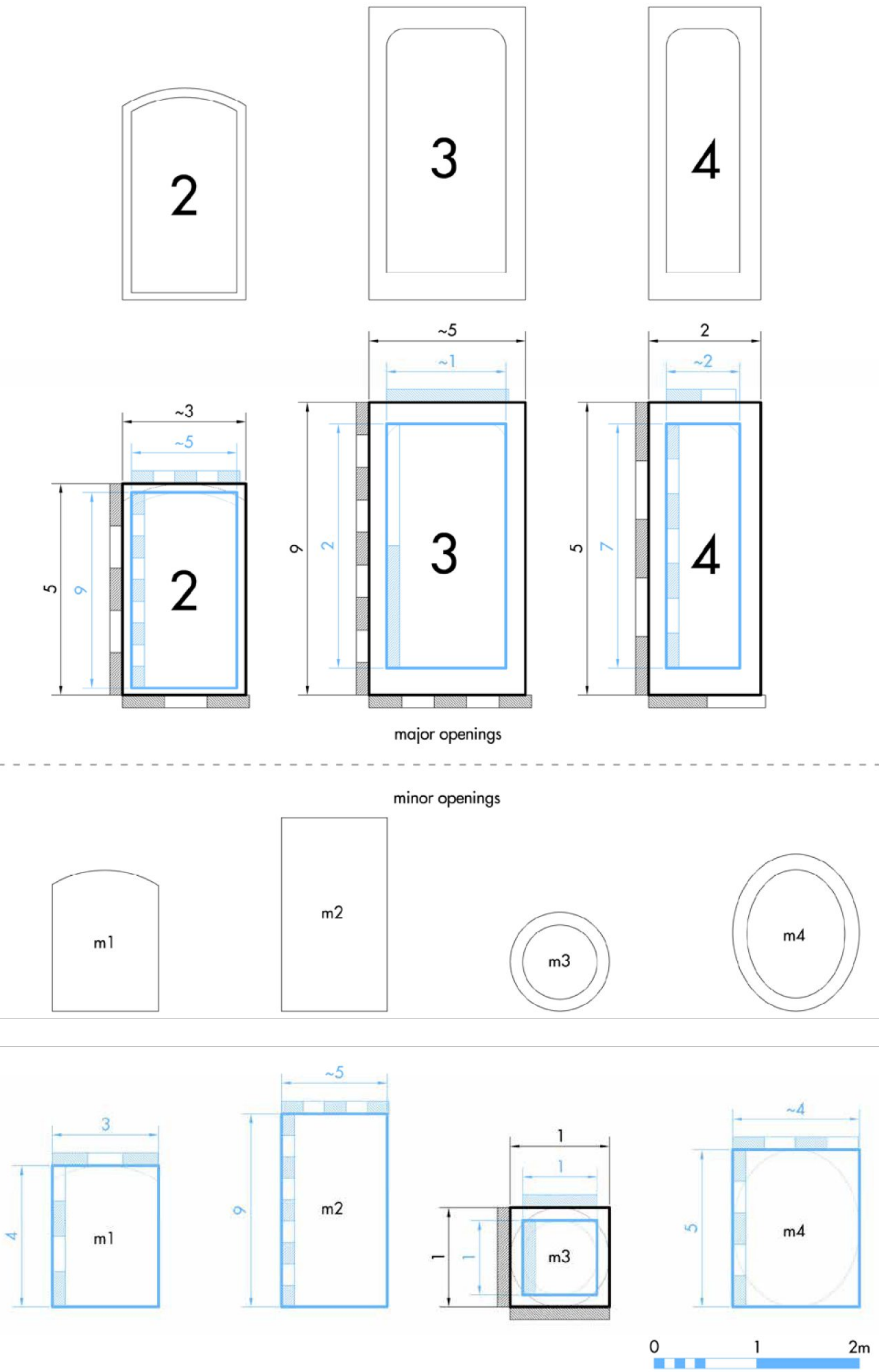


Fig. P.244 Geometrical analysis of openings: (Vie03) Palace of count Seldern, Pettenkofen-Gasse 2

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