MASTER THESIS

A Tool for the rule-based Optimization of multi-layered Building Components

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

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KURZFASSUNG

Das Ziel dieser Arbeit war es herauszufinden ob es prinzipiell möglich ist die Zusammenhänge, Regeln und Strukturen welche für die (teil)automatisierte Erstellung von validen (d.h. konstruktiv und logistisch möglichen) Bauteilkonstruktion notwendig sind, (i) zu finden und (ii) derart zu formulieren, dass dieses Wissen zur raschen, computergenerierten Erstellung solcher Konstruktionen genutzt werden kann. Eine manuelle Erstellung von Konstruktionen wird in der allgemeinen Planungspraxis ständig durchgeführt, hier werden oftmals Schritte, die gut geeignet für eine Automation erscheinen, wieder und wieder manuell durchgeführt. Diese Beobachtung, wie auch die Arbeit an dem Forschungsprojekt SEMERGY diente als Ausgangspunkt, bei welchem die Idee zu einer solchen Anwendung entstand. Eine Schwierigkeit an der Erstellung eines solchen Tools ist es, das erforderliche Fachwissen (Domain-Knowledge) über die Zusammenstellung der Bauteilaufbauten zusammenzutragen und der Zielsetzung entsprechend aufzubereiten. Um all die komplexen Zusammenhänge und Abhängigkeiten zu erfassen wurde eine große Anzahl von Aufbauten analysiert und daraus Systematiken und Regeln abgeleitet. Es wurden Templates erstellt die als Grundgerüst für eine solche Anwendung dienen können, und eine große Zahl von möglichen Varianten eines Aufbaues enthalten (Es wurde angestrebt Regeln zu definieren, welche jeweils taxativ sind, d.h. alle möglichen Kombinationen berücksichtigen). Das konzentrierte und um Regeln angereicherte Wissen aus diesem Prozess wurde in eine allgemein verständliche Form gebracht: Damit eine programmiertechnische Umsetzung weitestgehend unabhängig von proprietären Programmiersprachen oder Applikationen gemacht werden kann, wurden Abläufe für den Genese-Prozess als „Pseudocode“ ausgedrückt. Diese Ausdrucksform besitzt den Vorteil, dass (i) eine spätere Umsetzung auch von Nicht-Baufachleuten relativ einfach (ohne Domänenwissen) durchgeführt werden kann, (ii) potentielle Fehler oder Abweichungen rasch identifiziert werden können, sowie (iii) eine große Flexibilität, Erweiterbarkeit und Editierbarkeit gewährleistet ist. Es wurde auch der gesamte mögliche Arbeitsablauf innerhalb eines solchen Tools modelliert, um die möglichen Konstruktionen genauestens evaluieren zu können und entsprechend des geforderten Anwendungsfalles bestmöglich abzustimmen zu können. Dazu wurden eine Berechnung des Wärmedurchgangskoeffizienten, des etwaig anfallenden (Bauteil-)Kondensats gemäß normativer Methoden, des OI3 Koeffizienten (Environmental Footprints) und der Speichermasse als mögliche Kontrollinstanzen zu einer Qualitätssicherung bzw. Überprüfung abgebildet. Weitere Methoden können nach

Maßgabe vorhandener Eingabedaten jederzeit hinzugefügt werden. Beispiele hierfür könnten Kosten und Investition- bzw. Instandhaltung-Kostenberechnung oder bauakustische Eigenschaften und zugehörige Berechnungen sein. Die Ergebnisse dieser Arbeit sollen zur Anwendung in anderen Projekten wie zum Beispiel in einem laufenden Projekt zur Fassung von Bauteileigenschaften in zeitgemäßen Datenstrukturen (Forschungsprojekt BAU_WEB, TU Wien) vorbereitet werden. Eine generische und auf viele Anwendungsfälle übertragbare Methode ist explizites Ziel dieser Arbeit.

Keywords:

Optimierungs-Tool, Baukonstruktionen, Schicht Abhängigkeiten, einfacher Zugang, Pseudo-Code

ABSTRACT

This thesis addresses an important issue of the common building delivery and optimization process: The generation of building components. While this process is regularly considered to be of high importance for the final quality of a building, it is regarded as a tiring repetitive routine by most planners. Toward this end this contribution addresses the possibility of (semi)automation of (layer wise) building part composition. Thereby, the relationships and interdependencies between different layers are examined to identify typical structures and derive rules for the building component composition. While this task can be performed by human planners given a certain domain knowledge rather easily, the formulation of building composition rules for IT-based automation is far from trivial. A major objective is to (i) collect and to (ii) formalize the required knowledge of building component composition in a way that it can easily be transformed to programmed routines. There are a multitude of interdependencies and relations between the different layers of composition, and the properties of the different layers, as well as the overall composition strongly influence the final performance of a building component. After definition, collection, and structuring of all required information, this knowledge is formalized in a close-to computer-readable format. In the present case, the overall process of component generation is depicted as "Pseudo-Code", which offers three major advantages: (i) Pseudo-Code is a vendor and platform allowing programmers, who are regularly non-professionals in the building domain, to implement the rules independent, in process able software code; (ii) potential mistakes and issues can be easily identified; (iii) Flexibility, Extensibility and easy editing are assured. The building component generation process was fully modelled for a large number of constructions. Furthermore, certain normative performance indicators of the created constructions were calculated. These indicators, including the U-Values, a condensate evaluation, the thermal storage mass and an environmental footprint indicator, act as decision support to evaluate the appropriateness of a construction for a given, specific purpose. These methods are not taxative; Indeed, later enhancements of the environment would allow to integrate further performance indicators, such as acoustical performance parameters and cost calculation. The results of this work – a formalized modelling language for building component generation – are intended for use in applications, such as building performance simulation. There is a major need in practice for such developments, as can be seen as proven in different related efforts, such as the SEMERGY project or the BAU-

WEB project. The opportunity to integrate the developments of this thesis in these or other efforts can be seen as a large (side)benefit of this work.

Keywords

Rule-based tool, building constructions, layer dependencies, easy access, pseudo code

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I want to thank to my beloved mother and father who have supported me and made my academic career possible. Last but not least important I would like to thank my beloved wife, who always motivated me to go ahead in my thesis.

Dedicate to my beloved ones.

CONTENTS

1 INTRODUCTION

1.1 Overview

Within the design process of buildings, a key task for planners is the generation of suitable layered building components. Suitable hereby refers, on the one hand, to fulfilling functional requirements such as, structural durability and protection from climatic influences (thermal insulation, humidity dampening, etc.). On the other hand, it refers to aesthetics and architectural design. However, the assembling of materials can be considered as one of the major challenges in architectural work. In this context, this Thesis documents an approach to a semi-automated building part generation method. Developments in this thesis are based on formal modelling concepts as first described within the framework of the SEMERGY project (as described for instance by Pont 2014 or SEMERGY 2016). This approach focuses on the aspects of building performance, in the building assembly generation. The majority of building performance assessment tools includes, predefined databases for constructions, or requires users to set up the layered constructions from scratch. The described efforts are intended, to facilitate building component assembling for both, professionals and non-professionals. Moreover, the findings are expressed as pseudocode, to allow programmers more easily implement the developed rules and methods. A comprehensive set of building constructions was evaluated on the relations between their constituting layers. They were formalized and generalized. Thereby, a set of rules was distilled and formulated accordingly. The goal of this work is to provide design support in the building construction generation within an easy-to-use, flexible and extensible framework.

1.2 Motivation

In the modern planning processes, architects and building planners are often forced to work under time and cost pressure. While these obstructions, on the one hand, encourage a certain pragmatism and efficiency in the planning progress, planners, on the other hand, are forced to reduce quality-defining decisions to routine solutions and accept a loss of creative alternatives for security and economic reasons. These, mostly manual conducted decisions, cannot guarantee pareto-optimal solutions for given planning problems. Furthermore, manual attempts in reaching "good" solutions, often, lead to time-consuming dead ends in the planning process and error-prone, that are both time- and nerve-consuming.

While the AEC-industry tries to offer tools for architects and planners that allow a fast and high-precision workflow, few attempts have successfully brought out decision-support-systems for professionals, that evaluate all requirements in a satisfactory way. Scientific studies toward this end have been published by Felfernig et al. (2001) or Mahattanatawe (2002).

A common situation for architects (in advanced steps of the planning process) is the detailed definition of building part's constitutive elements: defining layers (layer-per-layer) of different functions in the different elements of the building's envelope. Figure 1 illustrates influencing factors on this process.

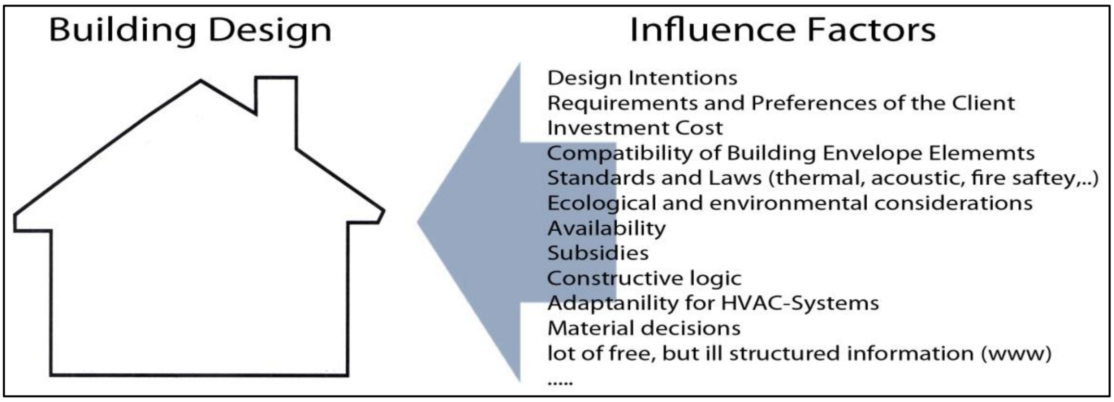


Figure 1 Sketch of influence on the building design (Source: Own)

This playing field features a confusing number of crucial design options that need to be decided upon in, a very thorough way. Thus, this challenge is seen as the key starting point of the intended work:

The work, in this master thesis should point out the layout of a computer-aided support tool for the automated generation of building elements, which meet predefined requirements (for instance U-Values stated by law, or desired lower U-Values stated by the planner). In the end, the proposed method should be capable of semi-automated design building elements, that can be used by professionals, as an enrichment of and relief for their work. This rule-based tool should evaluate, based on data available in the World Wide Web (building product property information, laws, subsidies, etc.) and provided by the information from designer/user (geometry implications, constraints toward cost and desired constructive systematic) a large number of layer combinations and define the best set of solutions that can then be exported and used in further design steps.

1.3 Background

In the mentioned direction have been made few efforts. Nowadys, there are many simulation programs, which require users to define building constructions from scratch or allow, only, to choose from the list predefined construction templates, as stated in Mahdavi et al. (2012). Therefore, an analysis of the different simulation and calculation tools work flow will be the starting point of the development process. Related automation efforts in the AEC sector will be evaluated in detail. Existing developments, that fit to the examined field will be considered for integration, if possible. One of the mayor starting points is the online web tool SEMERGY (2016), the final product of a prior research effort. This tool allows the user to choose from already defined constructions, which can be slightly modified and optimized with a real time simulation that can be seen in recent advances in SEMERGY (Pont et al. 2013).

In many working and product fields the products have to fit to a certain format so that the professional and the final consumer can better compare or find products. One of this format’s is for example the IES-Format (1998) which is used to show the photometric profile of lamps. Therefore, the consumers can better find the needed and fitting product for the actual use case. Such formats for building materials just exist as rough material categorize but the companies can give as much information, as they want. Every product is promoted as completely unique and non-comparable to other already existing products of the same kind. Kernstock (2003) and Häusler (2003) were analysing the procurement and processing of construction information by architects and developers. They figure out that the biggest amount of information is still obtained over paper catalogues or in personal meetings with the producing companies or retailors. The consumers also pay very less attention to the finding process of the correct material, as found out in an empirical study of Mahdavi et all (2004). Mostly, they are making decision based on the product or material that they have at home or in the office. The advantages of modern technologies, like internet, just start to take over the old conventional methods. With the better formatting and user supporting tools, information’s in the internet will become easier accessible and more used. Nowadays, an ongoing research project, named BAU_WEB is aiming to solve this problem. This project analyses how the product information can be easier assessable and better structured. So, the findings of this work and the current state of the BAU_WEB project, will influence on each other.

A lot of information can be derived from field-related standards (e.g. OIB, DIN 4108, ON 8110 – 4/5, ON 8115, IBO OI3 Guidelines, etc.). It can be used to extract calculation methods. Moreover, these standards act as starting point for formalization and (re)implementation of the evaluation schemes into the programming languages. It can be considered as a crucial part of the developments, described in this thesis. All these calculations can be used as upgrades, to enrich the tool in its functionality and service for the user.

Another part of the background research focuses on formal languages. The concept of formal languages will be used for generation of building constructions. The big advantage of these formal languages is that they overcome weaknesses and deficiencies of the human languages, and therefore can be easily adapted into computer programs. As different programmers do not share the same common understanding and working approaches in programming, definitions in formal languages can act as common framework for implementation. Considering that Flick (2009) adapted from Glaser (1978) wrote “In general, the outlined alternatives in applying grounded theory coding are different ways to the same aim”. The main source of these formal languages are obtained from the lectures of Salzer et all (2015) held at Vienna University of Technology in the winter term. With this knowledge a rule-based tool should be generated, which can then be adapted to different use cases and all kind of information formats.

2 METHOD

2.1 Overview

The main research work in this thesis focuses on the analysis of the different building constructions, their constituting layers and connected interdependencies. The term construction in this work is used in the way of a set of multiple layers added together as one building element, like a wall, roof, ceiling, slab, etc. The constructions were chosen out of different standard construction encyclopaedias (e.g. Cheret 2010), internet databases (e.g. dataholz or baubook), architecture and construction periodicals (e.g. DETAIL, architektur.aktuell). The most common types were selected for evaluation, classification and creation of the construction compassion foundation.

During the classification process, it turned out that the relations of the different materials and layers, to each other, surpass the importance of the construction class or the used materials alone. Not every layer is compatible to any other. Rules are required to formalize the compatibility of layers to each other. These rules depend on material properties and targeted performance criteria values.

The merge of rules and further analysis of the real construction can act as a framework to find valid construction alternatives (Constructions of different layers but with the same functionality). In the end, a “construction-kit”-based modular system is targeted that it can be easily expanded or changed in the later stages.

2.2 Hypothesis

Research questions of this work include:

- Is it – in general – possible, to develop a way of modelling building elements and their accompanying information (requirements, constraints) for automated evaluation with the help of known IT-technologies (formal modelling)?
- How can building elements, their constitutive elements, rules for generation, and necessary evaluation procedures be translated in a flexible, extendable and easy-to-use machine-readable form?
- Finally, how, and with which methods the evaluation of a very large number of design options can be performed in a feasible way? Given the fact, that the number of design alternatives for every building element reaches a nearly unlimited number of combination possibilities, how can rules be applied to

pre- or post-reduce the number of analysed options, and to generate fast optimization outputs?

A potential intermediate goal of this work is the generation of the Pseudo-Code for calculation routines, for the described decision support tool, so that a translation into any programming environment can be easily performed in a future step.

As workflow for this environment / generation tool the following steps are planned:

The general idea of this generation tool is that users select first the sort of construction that he wants to have by setting up the classification. In these process things like material, type, boundary conditions, etc. are defined to cut down the pool of all possible variants. With the defined layers and connected constraints, a tool with the programed rules than build together all the different possible variants, which have not been excluded from the process. After the creation process, the user can select and optimize one of it with the different materials, which can be applied to the different layers.

By creating all the rules and setting up a possible scenario of how to use them, a mock-up of the tool should be created so that a programmer later understands how to work with it. Just because most programmers have their own way of the algorithms integration and style of programming, the work does not directly aim toward a programming code. Instead, this work will document and explain all taken steps as good as possible, so, that it can be easier understood and programmers can directly work with this knowledge.

2.3 Classification

The process of the classification has to be done as easy as possible, to make it accessible for the users even with no or just rudimentary building knowledge. Thus in the proposed environment some graphics or short explanations of the different options should be used. This could facilitate the definition of required results by the user. Figure 2 illustrates how the user can select the type, boundary conditions and materials in the classification process.

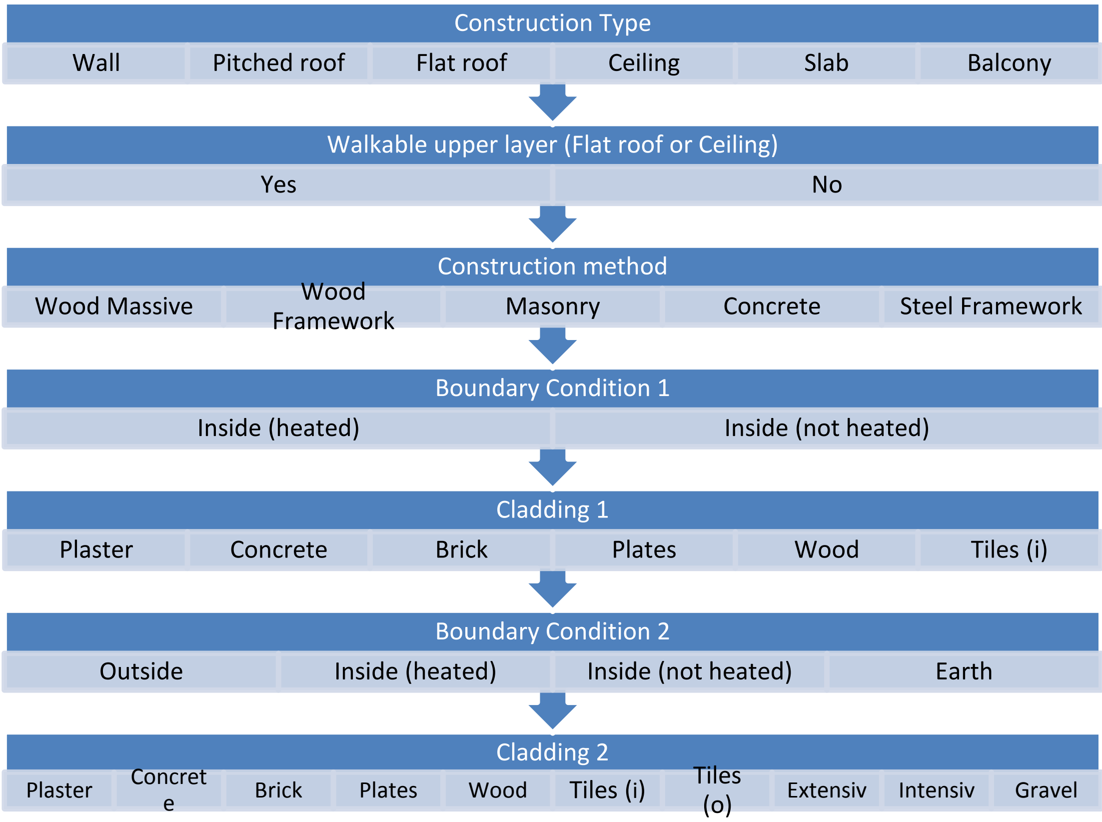


Figure 2 Classification Process (Source: Own)

With the selection of the type and the boundary conditions it can be already specified where the heat flow is directed, which boundary conditions, due to the elements position within the building envelope, are applicable and if there are any special properties needed e.g. water resistance. These classes are the major selection criteria for the later used layers and applied rules of them. The general construction method and the completion layer define the used materials, which are further specifying the rules. To shorten down the list of the possible constructions and to give more flexibility, the user can also apply the advanced settings. This function is a better search filter, for the users that know, for what they are looking for.

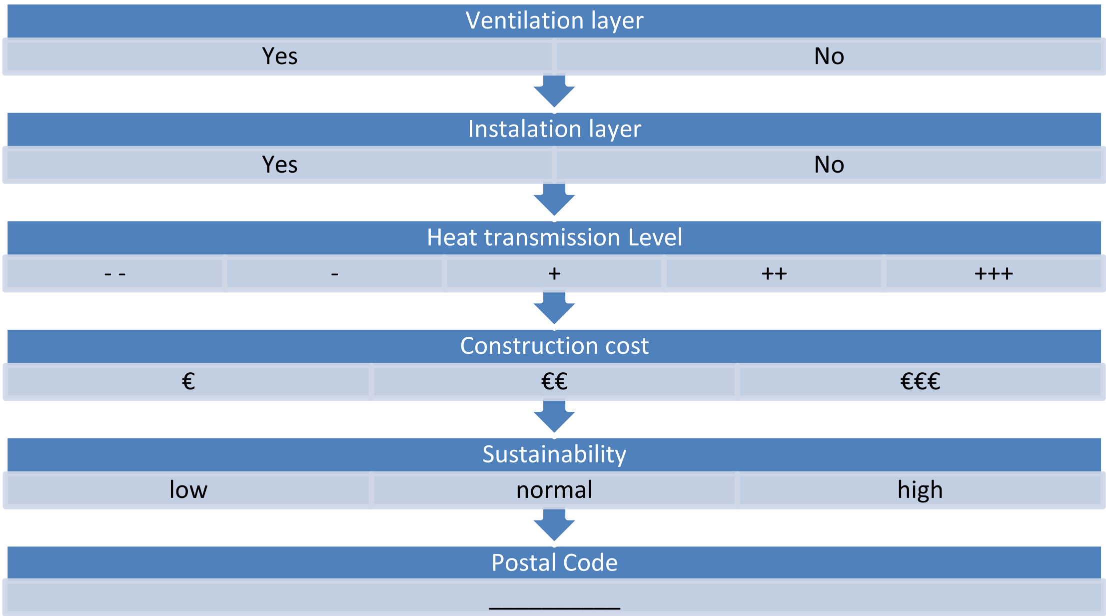


Figure 3 Advanced classification process (Source: Own)

The answer categories for heat transmission and construction cost are shown as abstract symbols to work freely for the chosen variety of constructions. When the advanced settings are not used the middle category is applied as default.

2.4 Layers

The Layers are the next important step in this approach. For its better overview was created a standard template, in which all information and rules about the different layers were filled as can be seen in Table 1.

Table 1 Standard Template for layer properties and rules

Short name	Long name
Explanation of the layer	
Max Thickness	Examples of materials which can be used for this layer

In sum, there are twenty layers, which are organized in six different groups. This separation is needed, because some layers are similar from the function but different in the used material. Every Layer has a short name, which consists of two Letters, the big one for the group and the small one for the specification. The short name is created for the later usage in the programming structure and the working process. Every layer has also a detailed explanation of its position and how it can be used. The maximum thickness of the layers, avoids that the single layers can be oversized and so, falsifies result. The last field lists possible materials, which can be used for this layer, so that it gets more real and easier to work with it in the process. The following set of all layers is already written in the style of a pseudo code and create the definition pool for the templates.

```
{(Ci),(Co),(Cl),(Fh),(Fl),(Fs),(Ga),(Gv),(If),(Ih),(Ii),(Il),(
Is), (Iw),(L),(Sb),(Sh),(So),(Sv),(Sw)}
```

Completion

Ci	Completion inside
Can be any finished surface, which is facing the heated or unheated surface of the room. The orientation of the layer is generated out of the chosen building element. The used materials are not suitable for the outside surfaces.	
0,05 m	Plaster, Wood formwork, Tiles, Parquet, Dry-wall plate

Co	Completion outside
This layer is the finished surface to the outside surface of a construction. All used materials are weather proof and water resistant.	
0,05 m	Plaster, Facade plate, Substrate

Cl	Completion loadbearing
When the loadbearing material should be used as one or both surface sides of a construction, this layer is used.	
1,00 m	Masonry wall, Exposed concrete

Load bearing

L	Load bearing layer
Layer for constructive and load bearing elements	
0,60 m	Concrete, Brick, Wood

Filling

Fh	Hard filling
This Layer is for all form stabile elements in a construction, like building plates. A hard filling can be used for reinforcement, closing or filling up layers.	
0,05 m	Building plates (wood, gypsum...)

Fl	Lose filling
The lose materials can be found in the ceilings, the slabs or the flat roofs, when the system has to be levelled or more mass, for the acoustical insulation is needed.	
0,15 m	Sand, Gravel, Soil, Substrate

Fs	Sheet filling
All the separation layers between gravel and insulation or some rigid elements, which can be done out of plastic or even paper.	
0,01 m	PE foil, separation paper

Gas

Ga	Standing air layer
This layer can be used in inhomogeneous construction. The standing air layer has no connection to the open air to ensure that it is not moving. Depending on the thickness of the layer the convection increases with higher number.	
0,20 m	Empty construction space, Window filling

Gv	Back ventilation layer
The back ventilation layer can be found in roofs and framework construction walls. It is directly connected to the outside air, which makes it a moving layer. In the heat transmission, it has not such a huge effect, as for the condensation calculation.	
0,10 m	Constructive ventilation layer

Insulation

Is	Soft insulation
This insulation layer can only be used in inhomogeneous layers because, all the insulation materials for this layer are not dimensionally stabile on their own. It can be, for example, sheep wool in between rafters. This type can also be replaced by lose insulations if the correct parameters are meet.	
0,30 m	Wool insulations (e.g. Sheep)

Ih	Hard insulation
The insulation materials, which are dimensionally stabile like insulation plates or boards without any special properties are categorised in this layer.	
0,30 m	EPS, Mineral boards, Hemp plates

Iw	Waterproof insulation
Insulation boards, which can resist water contact. Mostly used when the construction has earth as one boundary condition or in the flat roofs.	
0,30 m	XPS, Foam glass

Ii	inside insulation
Layer for inside insulation materials which can compensate the condensation water, which will appear in the construction or high performance insulation materials.	
0,20 m	Vacuum boards, Mineral foam board

Il	lose insulation
This layer is used in horizontal building elements like ceilings, slabs or flat roofs. It can also be used for constructions instead of Is layer when all adjacent layers have a stable and closed surface. The advantage of this insulation type is that it can level constructions and get in any form possible like concrete.	
0,20 m	lose insulation fillings (e.g. Cellulose)

If	Footfall sound insulation
In ceilings, the needed sound insulation is mostly achieved by some special insulation elements. Those can be slightly compressed by the weight of the upper construction, but still keep their insulating properties.	
0,10 m	Sound insulation plate or wool

Sealing

So	Diffusion open sealing
Sealing layer that is open for water vapour but closed for water drops. It is mostly used in pitched roofs or in outside walls in the rear ventilation. It ensures that the condensation from the construction can get out but no new water can get in.	
0,01 m	Breathable membrane out of plastic or paper

Sh	Half diffusion open sealing
This layer is for vapour retarder which are breaking the vapour during its movement in the construction. Usually, it is built in, on the warm side of the construction, to ensure that the condensation transport can be achieved in both directions. There are even some, of this sealing's that can adapt their sd-value accordingly to the needs in winter and summer term. In this case vapour cannot pass in winter but can get out of the construction in summer.	
0,01 m	Vapour retarder or adaptive vapour retarder out of plastic or paper

Sb	Boards airtight taped
Building boards that have a higher vapour resistance can be airtight glued to achieve a barrier against wind. These boards have the advantage that they are stable from alone without any extra layer and can be directly applied on the loadbearing framework.	
0,03 m	OSB

Sv	Vapour barrier
Vapour barriers are almost completely airtight and can seal off water vapour. Every sealing with an sd-value higher than 1500 is considered as vapour barrier. They consist out of metal or metal covered glass fibre. This sealing is used when the construction is tighter outside than inside, like in the case of a flat roof.	
0,01 m	Metal foil or metal covered glass fibre sheets

Sw	Water sealing
Sealing which is done out of glass fibre or metal sheets covered with bitumen or plastic foils. It is water tight, can withstand water pressure and is resistant to roots. It is mostly used on the outside of constructions, which are touching the earth and on the outside of the flat roofs. The stronger water pressure the more layers of this sealing have to be added up. The application can be done over gluing or vulcanization to the underground.	
0,01 m	Bitumen sealing, plastic foil

2.5 Layer rules

The rules are regulating how the general setup of the layers has to look like and also the detailed behaviour of every layer itself. They work as control mechanism for the later shown templates, so that they can be later enlarged or new templates can be written. From every rule can exist some exception, which will be directly written under the affected rule. These Exceptions are marked shortly with an E at the beginning.

R1. Each construction consists of minimum 3 Layers and maximum 17 Layers.

R2. Each construction has a maximum thickness of 1,2 m.

a.

R3. Every construction should have one `L` or `Cl` layer.

- E1 `Cl` cannot be used when the construction type is framework.
- E2 Walls can also have two `L` or `Cl` layers when there is at least one layer in-between.

R4. The heat flow direction is always from Boundary Condition 1 to Boundary Condition 2. For walls it is always horizontal, for flat and pitched roofs it is considered upwards and for slabs and ceilings downwards.

R5. Every construction should have as last layers `Ci` for Boundary Condition 1and `Co` for Boundary Condition 2.

- E1 In the case that both Boundary Conditions are the same `Ci` and `Co` are still used.
- E2 A ceiling with the boundary condition 1 as unheated and not walkable can have a Layer from the category `Is,Fh`, or `Cl` instead of `Ci`.
- E3 Flat roofs can have a layer `Sw` instead of `Ci`, when it is not walkable.

R6. Values of inhomogeneous layers are calculated over percentage parts

R7. By inhomogeneous layers the thickness is defined by the mixed layer and the axial spacing is standard by `L / Cl` with 625 mm and for `Fh` with 400 mm.

R8. Homogeneous layers of the same kind should never be adjacent to each other.

- E1 `Sw` can be two homogeneous layers adjacent to each other.
- E2 `Fh` can be two homogeneous layers adjacent to each other.
- E3 Two homogenous layers of `Fh` adjacent to each other can be maximum two times in the whole construction.

R9. Inhomogeneous layers are always assumed normal to the heat flow direction.

- E1 If multiple inhomogeneous layers, follow up on each other the layer with `L` or the thickest `Fh` is considered as normal oriented. The other layer is rotated by 90 degrees

R10. `L` and `Cl` are always homogeneous layers.

- E1 Layers with `L` are inhomogeneous when the construction type is chosen as Framework.

R11. Only `L` and `Fh` can be homogeneous and inhomogeneous Layers.

R12. Inhomogeneous layers can only be mixed with `Ga, Gv, Fl, Is, Ii`.

R13. `Is` can only be used as mixed layer in inhomogeneous layers.

- E1 `Is` can be replaced with `Il` if the adjacent layers are homogeneous and stabile.

R14. `So` should always be after `L` or `Cl`, but before `Co` or inhomogeneous layers with `Gv`.

- E1 `So` can be replaced by `Sb` if another homogeneous layer (e.g. `Fh`) is adjacent to `So`.

R15. `Sh` should be after `Ci` before `L` on the warm side of the boundary condition if the construction is out of wood, adjacent to earth, a ceiling, a pitched or a flat roof.

- E1 `Sv` should replace `Sh` in construction when the condensation calculation shows unsatisfied results.
- E2 `Sh` can also be used on the outside of constructions, when the density of the construction is denser to the insight.

E3 `Sh` can be replaced by `Sb` if another homogeneous layer (e.g. `Fh`) is adjacent to `Sh`.

R16. `Sw` should always be in the list between `L` and `Co` layer.

E1 `Sw` can be between `Ci` and `L` when tiles were chosen for the inside cladding.

R17. If boundary condition adjacent to earth is chosen than the construction can be without `Sw` if the main construction method is concrete → Water proof concrete (dew point calculation will proof if possible or not).

R18. When completion is chosen as plaster the adjacent layer should not be from the layer group `S` or `G`.

R19. `Fs` and `Sw` should always have at least one homogeneous layer next to them.

R20. If the construction method is chosen as framework the inhomogeneous layers with `L` should be closed with a homogeneous layer of `Fh, So, Sh` or `Sv`.

R21. `Id` has to be the only insulation layer in the whole construction and always on the warm side of the construction within the first 4 layers.

2.6 Template Generation

The templates are done in a way of reverse engineering. First different constructions of the same type and material are analysed and translated in the layer logic. Than these strings are checked on errors with the rules and after, combined to one formula string, which will be later used in the generation process of the tool, as a template.

The symbols and brackets, which are used in the formulas are lent from the Extended Backus Naur Form (EBNF). In the context of this work, every layer is represented as one pair of normal brackets. The whole construction is represented in the curly brackets and the squared brackets are positioned for a layer, which can be used optionally. The pointed brackets indicate alternatives in the construction, in which the frame character works, as a separator between the variants.

“{}”	curly brackets	complete construction string
“()”	normal brackets	one layer
“[]“	squared brackets	optional layer
“<>“	pointed brackets	usable layer with alternatives
“|“	frame character	divider within the alternative layer

On Outside wall constructions from dataholz will be explained how the analysis of the constructions is working. The construction criteria were already set before. In this case it is Outside wall, Wood Framework, no back ventilation, no installation level, wooden coated

Fitting Constructions:

awroho01a, awroho01b, awroho02a, awroho03a, awroho04a, awroho04b

The layers have been written down and after, converted into the internal layer designations. If one of the analysed constructions has differences in the structure, they were written down as shown in Table 2 on the next page.

Table 2 Construction with possible alternatives

Construction	**Layer**	**Alternative 1**		**Alternative 2**	
Outside					
Fire protection planks	Co	Wooden boarding	Co		
Diffusion open sealing	So	Counter battens, Wooden wool board	Fh/Is		
Chipboard	Fh	MDF	Fh		
Construction wood with Insulation	L/Is				
OSB airtight taped	Sb	Chipboard	Fh	Vapour retarder	Sh
		Vapour retarder	Sh		
Plasterboard	Ci	Gypsum fiberboard	Ci		
Inside					

From all the different layer structures, can be generated six different templates, not counting different variants appearing because of material changes inside the constructions.

{(Ci),(Sb),(L/Is),(Fh),(So),(Co)}

{(Ci),(Sb),(L/Is),(Fh),(Fh/Is),(Co)}

{(Ci),(Sh),(Fh),(L/Is),(Fh),(Fh/Is),(Co)}

{(Ci),(Sh),(Fh),(L/Is),(Fh),(So),(Co)}

{(Ci),(Sh),(L/Is),(Fh),(So),(Co)}

{(Ci),(Sh),(L/Is),(Fh),(Fh/Is),(Co)}

All these different combinations can be combined in one template.

{(Ci),<(S),[Fh]|(Sb)>,(L/Is),[Fh],<(Fh/Is)|(S)>,(Co)}

This template will be done for all different constructions, which will be later merged together according to the construction type. With this smaller set of templates, the tool can prepare different variants of the wanted construction for the user. With the analysis of different existing constructions, can be created a general template for multiple solutions, for every main construction type and method. In this template can be filled layers according to the rules, short simulations of u-value or condensation risk. In addition, according to this rules various solutions can be provided to the user. In the following for better understanding of the method, this process is shown on the outside walls.

2.7 Calculation

2.7.1 Overview

When some calculation is not passed, the tool will adjust the thickness or material setting depending on the predefined orders within the borders. The gained results will be then presented to the user. The user can now choose from the different sets. Depend on the tool implementation created constructions can be used after in the different simulation programs, like SEMERGY (2016) or just printed and saved, locally, by the users. The calculation phase can be enhanced with more possible calculations, like material costs, sound insulation, thermal mass storage and fire safety class. Some of the main calculations and possible enhancements will be shown in this section.

2.7.2 Heat transmission calculation

This calculation follows the standard calculation from the (DIN) EN ISO 6946. The different Lambda values (conductivity) will be taken from the building material producers or from the ON B 8110 – 7. The resistances caused trough heat flow and temperature results will be taken from the chosen construction type and boundary condition. The tool will show the direct calculated value within the given threshold, taken from the OIB 6 to give the user an impression about the location of the construction. The heat transmission calculation gives the user already a good understanding, of how his project will perform later on, when he will use them. Based on the building physic simulation tools, like ArchiPHYSIK the constructions are categorized after the thermal heat flow, as it can be seen in Figure 4.

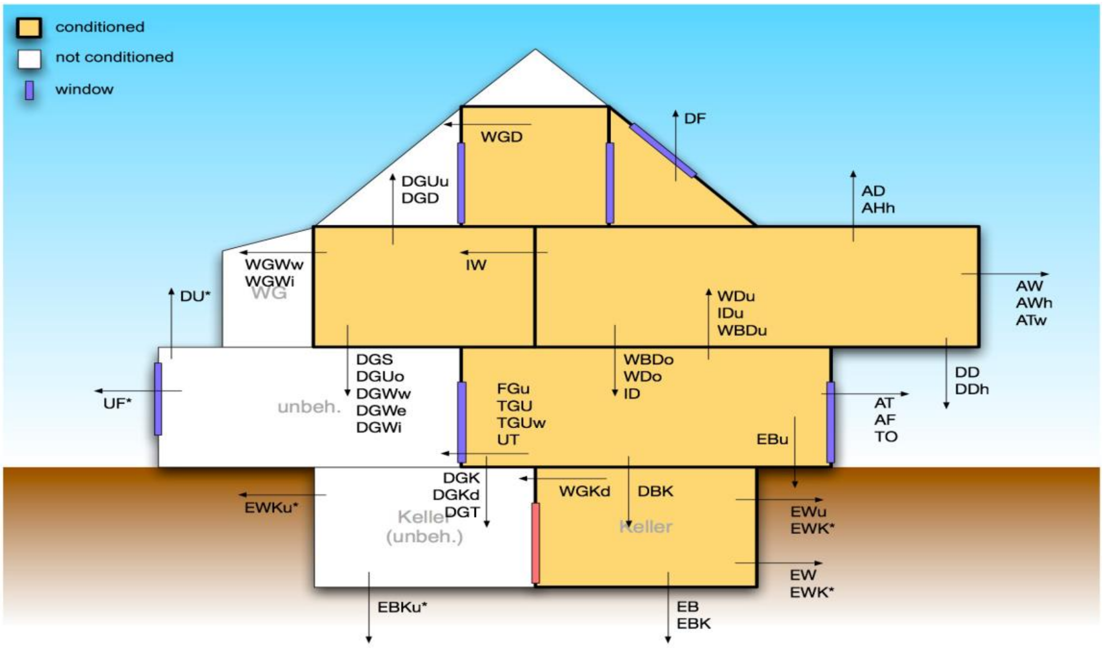


Figure 4 Categorization of constructions according to ArchiPHYSIK (Source: ArchiPHYSIK)

The different heat flow conditions are good criterion for differentiation of the constructions. This Categorization shows mostly two different groups, as there are uninsulated constructions between spaces of the same conditions and insulated constructions between spaces of different thermal conditions. Therefore, the main separation between building elements is with and without insulation, but a finer categorization is needed, which will be explained in the next section, the condensation risk calculation.

2.7.3 Condensation risk calculation

As it has been already explained in the previous section, the humidity in the constructions is another main factor for categorization. This is even more needed when insulation is applied on the construction. These materials are very likely to suffer from condensation problems, due to their thermal insulation abilities. That can lead to a worse performance of the material or even ineffectiveness of the whole construction due to mould. To protect the constructions against this problem, the correct positioning of the layers is important and also a finer categorization is needed, as it can be seen in Figure 4. The calculation of the condensation is based on the ON B 8110 - 2 and the needed values are gained in the same way as for the heat transmission. Furthermore, the advises and knowledge from the DIN 4108-3 and DIN EN ISO 13788 will be taken into account. The tool will check if the chosen values and designed construction fit to the need of the user. Most interesting in this calculation is the relation of the dew point and the temperature trend inside of the construction. If the temperature falls deeper than the dew point temperature, condensation will happen, as it can be seen on Figure 5.

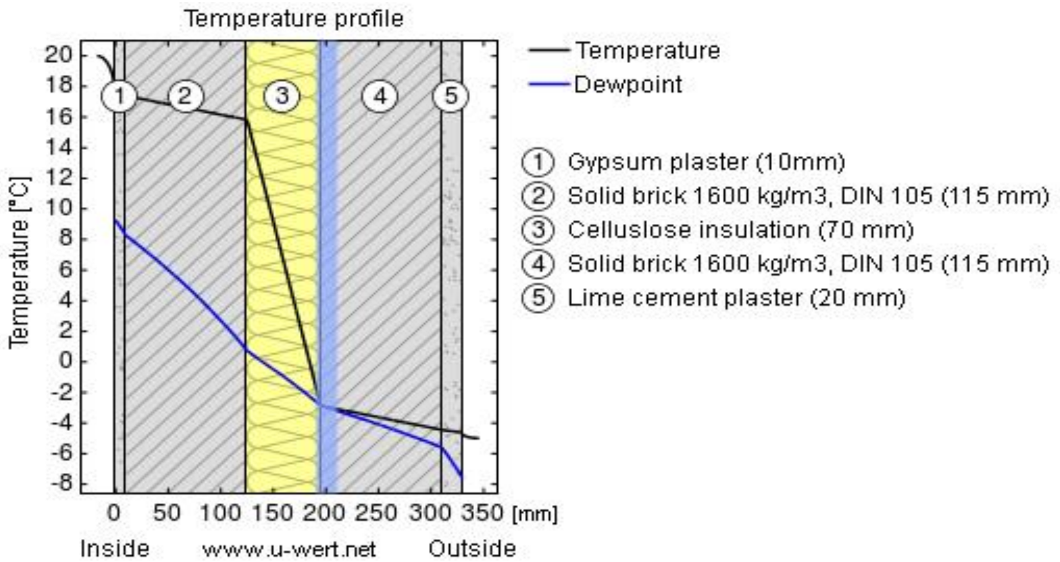


Figure 5 condensation risk calculation with the Glaser method (Source: www.u-wert.net)

If a construction shows condensation risk without a possibility to dry out, it will be excluded or optimized by the program. If the construction has no condensation, it will be shown to the user. The constructions which will show condensation risk, but have the possibility to dry out, will be marked and have explanation about the risks.

2.7.4 Specific heat capacity

The specific heat capacity is the heat energy a body can store. This information is very important when some layers should be used for thermal activation or for the summer overheating. This chapter should show a possible upgrade variant for the tool in a later stage. When layers of building constructions are used for heating or cooling this is called thermal activation. In this process a medium (hot or cold) goes through the element and its surface acts as a huge radiator. The principal is the same as by a heating screed, the difference is that there are also solutions for cooling and storing of thermal energy for later use in the deeper layers of main constructions.

The calculation of the summer overheating also depends on the thermal mass or heat capacity of the building. It can be observed by old massive buildings compared to new one in very hot summer days, how cool the old buildings are. That is because of the huge mass of the building construction, which does not warm so fast as the air and so, acts as a cooling radiator, the temperature stays more constant expressed in Figure 6.

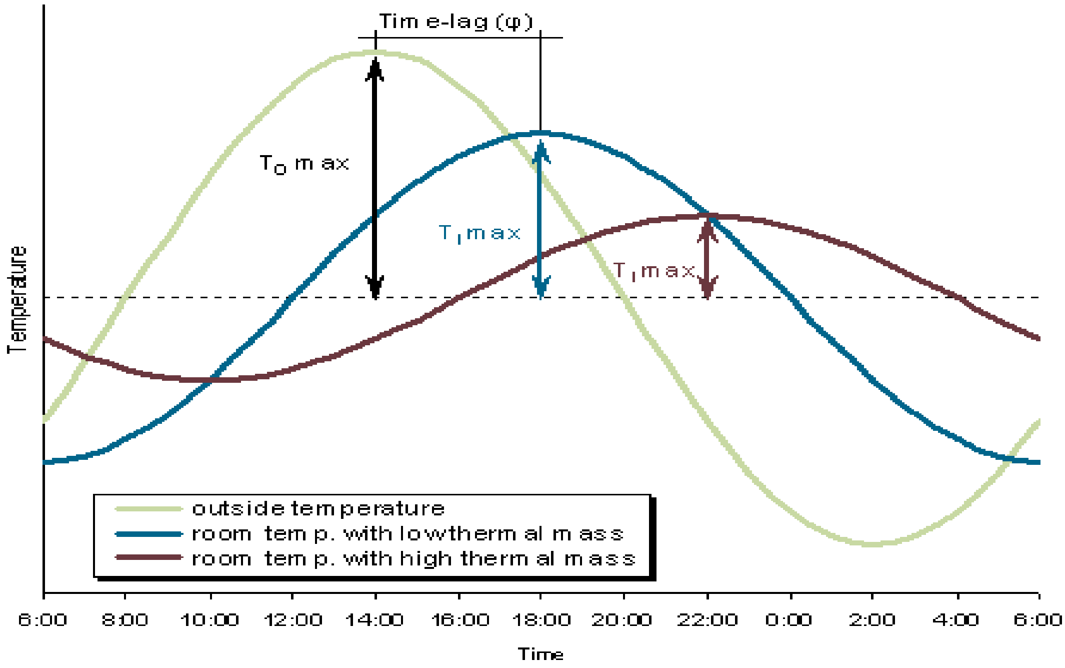


Figure 6 Influence of thermal mass on periodic heat flow (Source: http://www.new-learn.info, euleb)

By now there are different theories about summer overheating and the best way how to tackle it. The most common one is to build as massive as possible. These and other topics are by now reviewed in another master thesis from Wurm (2016).

2.7.5 OI3 calculation

The ecological index or OI3 value of a construction is calculated after the regulations of the Austrian Institute for Healthy and Ecological Building (IBO). The OI3 indicator is merged together out of three key factors as the Global warming potential (GWP), the Acidification potential (AP) and the Primary energy content of non-renewable resources (PEI n.e.). The values for these factors can be obtained from the producers or from standard values provided by IBO. When this factors than are converted, as seeable in Figure 7, in the point system of the IBO and summated the OI3 index for a material is calculated. More details about the calculation and background information can be found in the IBO (2013). The OI3 factor can be obtained for every layer separately or for the whole construction, which can together with the building mass determination show much clearer ecological performance of the building. This factor is wide spread and already used in the calculation system of the state of Salzburg, Niederösterreich, Steiermark and Kärnten for the housing subsidy as read from Lipp (2006).

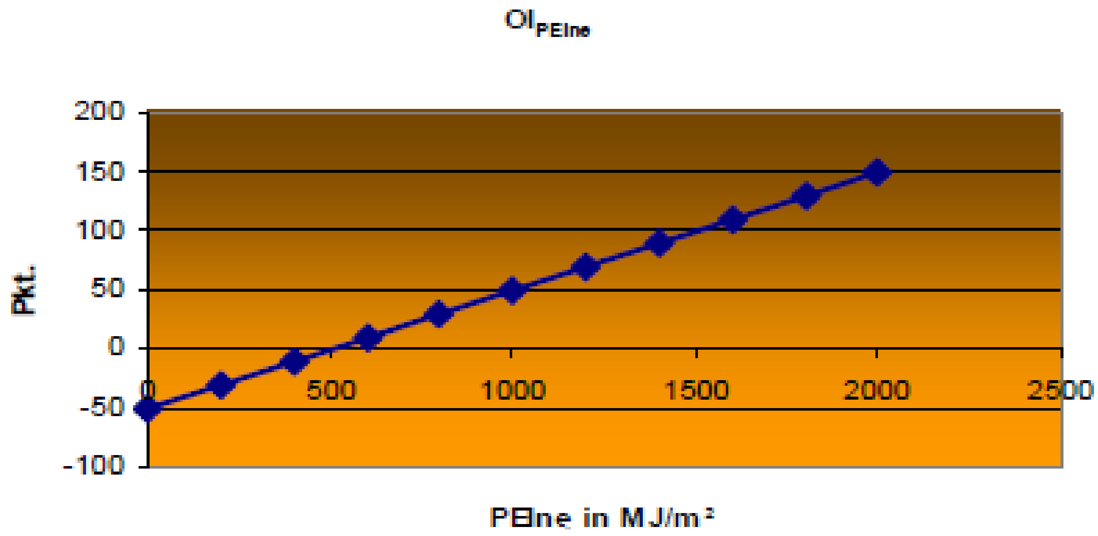


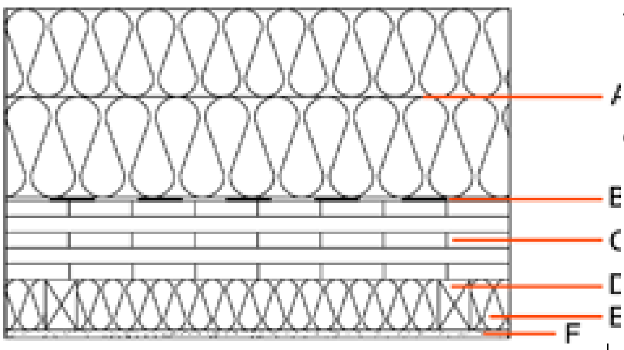
Figure 7 Conversionfunction PEIne in MJ.m^{-2} to OI$_{PEIne}$-Points (www.ibo.at)

This calculation is integrated in the tool, because it should show how the tool can be linked together with other decision-making factors. Normally these values should be already considered in the planning process, to create a later benefit for the building. The by now common workflow shows that these factors are considered far too late in the design stage.

2.8 Case study

Previously explained method will be applied on the pool of different constructions from different sources to cover a wide field of possible variants. In this section some of them will be shown as prototypes, to point out the adaption and changes in the method. All these constructions are from the same source to provide a uniform layout.

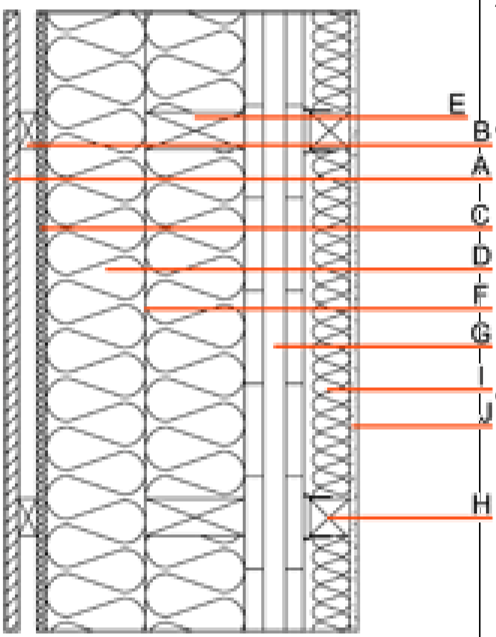
Table 3 Typical ceiling to unheated roof construction for the method analysis

Ceiling to unheated roof	ddmxxi02a-00	Source: www.dataholz.com
Categorization according to the classification in the construction type, construction method, Cladding, Boundary Conditions and advanced classes.		
		Outside
	A	Stone woll
	B	Foil (convection inhibiting)
	C	Cross laminated timber
	D	Wooden battens
	E	Mineral wool
	F	Plasterboard
		Inside
Conversion of the original layers into the layer logic mentioned in the thesis and implementation into the template for the chosen category.		

Layer	Thickness [mm]	Thermal Conductivity [W.m^{-1}K^{-1}]	Water vapour diffusion coefficient	Density [kg.m^{-3}]	Specific heat capacity [kJ.kg^{-1}K^{-1}]	Fire resistance class
A	300	0,04	1	130	1,03	A1
B						
C	125	0,13	50	500	1,60	D
D	80	0,13	50	500	1,60	D
E	80	0,04	1	20	1,03	A2
F	13	0,25	10	800	1,05	A2
The technical values will be taken in consideration for the advanced category settings and optimization of the calculated values.						

Table 4 Typical outside wall construction for themethod analysis

Outside wall	awmhhi02a-00	Source: www.dataholz.com
Categorization according to the classification in the construction type, construction method, Cladding, Boundary Conditions and advanced classes.		



		Outside
	A	Outside Cladding
	B	Rear ventilation
	C	MDF
	D	Construction wood horizontal
	E	Construction wood
	F	Cellulose insulation
	G	Cross laminated timber
	H	Wooden battens on swinging hoops
	I	Cellulose insulation
	J	Plasterboard
		Inside

Conversion of the original layers into the layer logic mentioned in the thesis and implementation into the template for the chosen category.

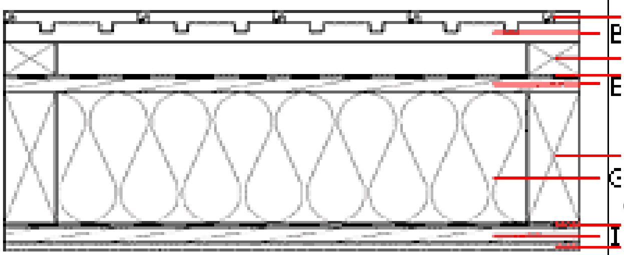
Layer	Thickness [mm]	Thermal Conductivity [W.m^{-1}K^{-1}]	Water vapour diffusion coefficient	Density [kg.m^{-3}]	Specific heat capacity [kJ.kg^{-1}K^{-1}]	Fire resistance class
A	20	0,15	50	600	1,60	D
B	30	0,13	50	500	1,60	D
C	15	0,12	11	600	1,70	D
D	160	0,13	50	500	1,60	D
E	160	0,13	50	500	1,60	D
F	320	0,04	1	50	2,00	E
G	94	0,13	50	500	1,60	D
H	80	0,13	50	500	1,60	D
I	80	0,04	1	50	2,00	E
J	13	0,25	10	800	1,05	A2

The technical values will be taken in consideration for the advanced category settings and optimization of the calculated values.

Table 5 Typical pitched roof construction for the method analysis

Pitched roof	sdrhzi02a-00	Source: www.dataholz.com

Categorization according to the classification in the construction type, construction method, Cladding, Boundary Conditions and advanced classes.



		Outisde
	A	Tiled roof
	B	Wooden battens
	C	Wooden counter battens
	D	Breathable membrane
	E	Full wood boarding
	F	Construction wood
	G	Glass wool
	H	Vapour retarder
	I	Wooden battens
	J	Plasterboard
		Inside

Conversion of the original layers into the layer logic mentioned in the thesis and implementation into the template for the chosen category.

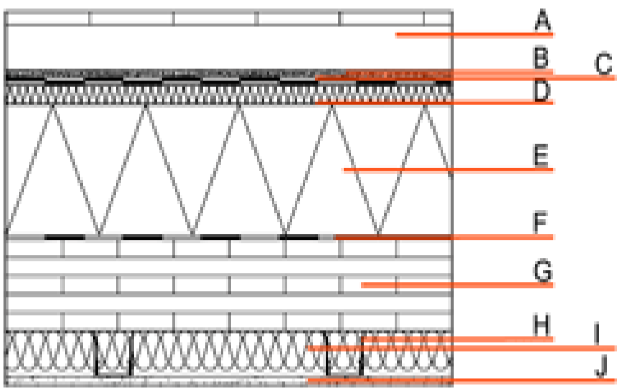
Layer	Thickness [mm]	Thermal Conductivity [W.m^{-1}K^{-1}]	Water vapour diffusion coefficient	Density [kg.m^{-3}]	Specific heat capacity [kJ.kg^{-1}K^{-1}]	Fire resistance class
A				2100		A1
B	30	0,130	50	500	1,60	D
C	50	0,130	50	500	1,60	D
D				1000		E
E	24	0,130	50	500	1,60	D
F	200	0,130	50	500	1,60	D
G	200	0,040	1	16	1,03	A1
H				1000		
I	24	0,130	50	500	1,60	D
J	13	0,250	10	800	1,05	A2

The technical values will be taken in consideration for the advanced category settings and optimization of the calculated values.

Table 6 Typical flat roof construction for the method analysis

Flat roof	fdmnti01a-00	Source: www.dataholz.com

Categorization according to the classification in the construction type, construction method, Cladding, Boundary Conditions and advanced classes.



	Outisde
A	Terrasse construction
B	Roof sealing membrane
C	Separation fleece
D	Footfall sound insulation
E	Wooden fibre insulation board
F	Sealing membrane
G	Cross laminated timber
H	Suspension
I	Mineral wool
J	Plasterboard
	Inside

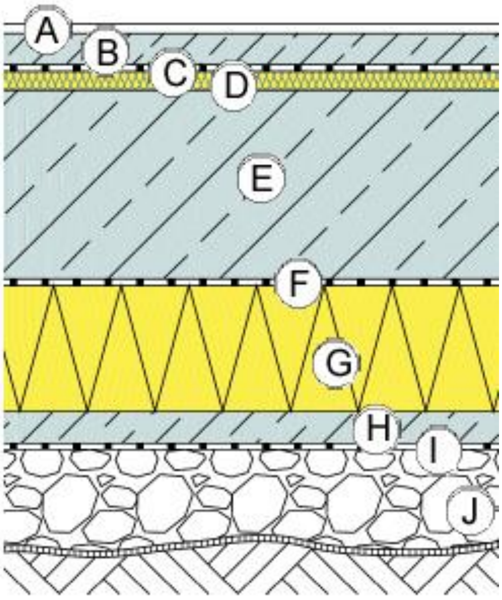
Conversion of the original layers into the layer logic mentioned in the thesis and implementation into the template for the chosen category.

Layer	Thickness [mm]	Thermal Conductivity [W.m^{-1}K^{-1}]	Water vapour diffusion coefficient	Density [kg.m^{-3}]	Specific heat capacity [kJ.kg^{-1}K^{-1}]	Fire resistance class
A	80	0,13	50	500	1,60	D
B						
C						
D	30	0,036	1	130	1,03	A1
E	200	0,045	5-7	160	2,10	E
F						
G	140	0,13	50	500	1,60	D
H	70					
I	60	0,04	1	20	1,03	A2
J	13	0,25	10	800	1,05	A2

The technical values will be taken in consideration for the advanced category settings and optimization of the calculated values.

Table 7 Typical ground slab construction for the method analysis

Ground Slab		Source: www.hermann-kaufmann.at
Categorization according to the classification in the construction type, construction method, Cladding, Boundary Conditions and advanced classes.		



	Inisde
A	Flooring
B	Cement screed
C	PE foil
D	Footfall sound insulation
E	Concrete slab
F	Sealing membrane
G	XPS
H	Granular subbase
I	Building paper
J	Gravel layer with filter fleece
	Outside

Conversion of the original layers into the layer logic mentioned in the thesis and implementation into the template for the chosen category.

Layer	Thickness [mm]	Thermal Conductivity [W.m^{-1}K^{-1}]	Water vapour diffusion coefficient	Density [kg.m^{-3}]	Specific heat capacity [kJ.kg^{-1}K^{-1}]	Fire resistance class
A	20	0,16	50	740	1,60	D
B	50	1,4	15	2000	1,08	A1
C						
D	30	0,039	1	130	1,03	A1
E	300	1,35	60	2000	1,00	A1
F						
G	200	0,042	150	43	1,45	E
H	50	1,35	60	2000	1,00	A1
I						
J	150	0,16	3	1000	1,00	A1

The technical values were not given by this data source. So, the data was obtained from the baubook standard values for the given product information.

3 RESULTS AND DISCUSSION

3.1 Overview

The Results is structured in four different sections to show and proof the correctness of the claimed statements. In Section 3.2 Case Study is explained, how the example constructions are converted into the tool logic of the layers and classification and how the rules help by this step. All the master templates for every different classification are shown in section 3.3 Templates, in a detailed table. Section 3.4 Proof of concepts, represents how the master templates can generate different constructions and that all these templates are really linked to it. In the last section 3.5 Workflow is demonstrated, how the tool in a programmed variant could work and all the different pieces are working together.

3.2 Case study

Table 8 Typical ceiling to unheated roof with explaination of template generation

<table>
<tr><td colspan="2">Ceiling to unheated roof</td><td>ddmxxi02a-00</td><td>Source:
www.dataholz.com</td></tr>
<tr><td colspan="2">Classification:
Construction Type: Ceiling
Construction Method: Wood massive</td><td colspan="2">According to classification the construction will be used for the template of the ceiling out of massive wood.</td></tr>
<tr><td></td><td colspan="2">Outside</td><td></td></tr>
<tr><td>A</td><td colspan="2">Stone woll</td><td><code>Is</code></td></tr>
<tr><td>B</td><td colspan="2">Foil (convection inhibiting)</td><td><code>So</code></td></tr>
<tr><td>C</td><td colspan="2">Cross laminated timber</td><td><code>L</code></td></tr>
<tr><td>D</td><td colspan="2">Wooden battens</td><td><code>Fh/Is</code></td></tr>
<tr><td>E</td><td colspan="2">Mineral wool</td><td></td></tr>
<tr><td>F</td><td colspan="2">Plasterboard</td><td><code>Ci</code></td></tr>
<tr><td></td><td colspan="2">Inside</td><td></td></tr>
<tr><td colspan="4"><code>{(Ci),(Fh/Is),(L),(So),(Is)}</code></td></tr>
<tr><td colspan="4">The construction consists of five layers which fulfils rule R1 and the overall thickness (0,51m) is not more than 1,2m according to R2. The layers <code>L</code> and <code>Ci</code> are present and are positioned at the correct places (R3, R5). The Layer <code>Co</code> was exchanged to Is according to R5-E2. No Layers of the same kind are adjacent to each other (R8). The layer of <code>Fh/Is</code> is taken into account in the correct way of orientation and spacing as regulated in R6, R7, and R9. The layer <code>L</code> is homogeneous according to R10 and also <code>Fh</code> is used as inhomogeneous layer with the correct mix layer (R11, R12, R13). The layer <code>So</code> is in the correct position according to R14 and R19.</td></tr>
<tr><td colspan="4">The values of the layers will be taken into account for the maximum and minimum thickness of the layers. The specific values like Thermal Conductivity, Water vapour diffusion coefficient, Density and Specific heat capacity should be stored in a database for materials and linked to the correct layers. These values also help to calculate average values for the layers in the control calculation, before the user will see them.</td></tr>
</table>

Table 9 Typical outside wall with explaination of template generation

<table>
<tr><td colspan="2">Outside wall</td><td>awmhhi02a-00</td><td>Source: www.dataholz.com</td></tr>
<tr><td colspan="2">Classification:
Construction Type: Wall
Construction Method: Wood massive</td><td colspan="2">According to classification the construction will be used for the template of the outside wall out of massive wood.</td></tr>
<tr><td></td><td>Outside</td><td colspan="2"></td></tr>
<tr><td>A</td><td>Wood Cladding</td><td colspan="2">Co</td></tr>
<tr><td>B</td><td>Rear ventilation</td><td colspan="2">Fh/Gv</td></tr>
<tr><td>C</td><td>MDF</td><td colspan="2">Fh</td></tr>
<tr><td>D</td><td>Construction wood horizontal</td><td colspan="2">Fh/Is</td></tr>
<tr><td>E</td><td>Construction wood</td><td colspan="2">Fh/Is</td></tr>
<tr><td>F</td><td>Cellulose insulation</td><td colspan="2"></td></tr>
<tr><td>G</td><td>Cross laminated timber</td><td colspan="2">L</td></tr>
<tr><td>H</td><td>Wooden battens on swinging hoops</td><td colspan="2">Fh/Is</td></tr>
<tr><td>I</td><td>Cellulose insulation</td><td colspan="2"></td></tr>
<tr><td>J</td><td>Plasterboard</td><td colspan="2">Ci</td></tr>
<tr><td></td><td>Inside</td><td colspan="2"></td></tr>
<tr><td colspan="4">{(Ci),(Fh/Gs),(L),(Fh/Is),(Fh/Is),(Fh),(Fh/Gv),(Co)}</td></tr>
<tr><td colspan="4">The construction consists of eight layers which fulfils rule R1 and the overall thickness (0,57m) is not more than 1,2m according to R2. The layers L, Ci and Co are present and are positioned at the correct places (R3, R5). The Fh/Is layer is just one time doubled directly to each other and no other layers of the same kind are adjacent to each other (R8-E2, R8-E3). The double layer of Fh/Is is taken into account in the correct way of orientation and spacing as regulated in R6, R7 and R9-E1. The layer L is homogeneous according to R10 and also Fh is used as inhomogeneous layer with the correct mixed layers (R11, R12, R13).</td></tr>
<tr><td colspan="4">The values of the layers will be taken into account for the maximum and minimum thickness of layers. The specific values like Thermal Conductivity, Water vapour diffusion coefficient, Density and Specific heat capacity should be stored in a database for materials and linked to the correct layers. These values also help to calculate average values for the layers in the control calculation, before the user will see them.</td></tr>
</table>

Table 10 Typical pitched roof construction with explaination of template generation

<table>
<tr><td colspan="2">Pitched roof</td><td>sdrhzi02a-00</td><td>Source: www.dataholz.com</td></tr>
<tr><td colspan="2">Classification:
Construction Type: Pitched roof
Construction Method: Wood skeleton</td><td colspan="2">According to classification the construction will be used for the template of the pitched roof of a skeleton wood construction.</td></tr>
<tr><td></td><td colspan="2">Outside</td><td></td></tr>
<tr><td>A</td><td colspan="2">Tiled roof</td><td>Co</td></tr>
<tr><td>B</td><td colspan="2">Wooden battens</td><td>Fh/Ga</td></tr>
<tr><td>C</td><td colspan="2">Wooden counter battens</td><td>Fh/Gv</td></tr>
<tr><td>D</td><td colspan="2">Breathable membrane</td><td>So</td></tr>
<tr><td>E</td><td colspan="2">Full wood boarding</td><td>Fh</td></tr>
<tr><td>F</td><td colspan="2">Construction wood</td><td>L/Is</td></tr>
<tr><td>G</td><td colspan="2">Glass wool</td><td></td></tr>
<tr><td>H</td><td colspan="2">Vapour retarder</td><td>Sh</td></tr>
<tr><td>I</td><td colspan="2">Wooden battens</td><td>Fh/Ga</td></tr>
<tr><td>J</td><td colspan="2">Plasterboard</td><td>Ci</td></tr>
<tr><td></td><td colspan="2">Inside</td><td></td></tr>
<tr><td colspan="4">{(Ci),(Fh/Ga),(Sv),(L/Is),(Fh),(So),(Fh/Gv),(Fh/Ga),(Co)}</td></tr>
<tr><td colspan="4">The construction consists of nine layers (R1) and has a thickness under 1,2m (R2). The layers L, Ci and Co are used and laid in the correct positions (R3, R5). The rules R6 – R13 for inhomogeneous layers are fulfilled with exceptions R8-E2, R9-E1 for the wooden batten layers and R10-E1 for the L layer. Position of Sh is within the first three inside layers (R15). The rule R20 is satisfied with the combination of (Sh),(L/Is),(Fh)</td></tr>
<tr><td colspan="4">The values of the layers will be taken into account for the maximum and minimum thickness of layers. The specific values like Thermal Conductivity, Water vapour diffusion coefficient, Density and Specific heat capacity should be stored in a database for materials and linked to the correct layers. These values also help to calculate average values for the layers in the control calculation, before the user will see them.</td></tr>
</table>

Table 11 Typical flat roof construction with explaination of template generation

Flat roof	fdmnti01a-00	Source: www.dataholz.com
Classification: Construction Type: Flat roof Construction Method: Wood massive	According to classification the construction will be used for the template of the flat roof of a massive wood construction.	
	Outside	
A	Terrasse construction	Co
		Fh/Ga
B	Roof sealing membrane	Sw
C	Separation fleece	Fs
D	Footfall sound insulation	If
E	Wooden fibre insulation board	Ih
F	Sealing membrane	Sv
G	Cross laminated timber	L
H	Suspension	Fh/Is
I	Mineral wool	
J	Plasterboard	Ci
	Inside	
{(Ci),(Fh/Is),(L),(Sv),(Ih),(If),(Fs),(Sw),(Fh/Ga),(Co)}		
The construction consists of ten layers (R1) and has a thickness under 1,2m (R2). The layers L, Ci and Co are used and in the correct positions (R3, R5). The rules R6 – R9 and also R11 – R13 for inhomogeneous layers are fulfilled by two Fh layers which can be seen in the construction. The position of Sw is fulfilled according to R16 and R19.		
The values of the layers will be taken into account for the maximum and minimum thickness of layers. The specific values like Thermal Conductivity, Water vapour diffusion coefficient, Density and Specific heat capacity should be stored in a database for materials and linked to the correct layers. These values also help to calculate average values for the layers in the control calculation, before the user will see them.		

Table 12 Typical ground slab construction for method analysis

Ground Slab		Source: www.hermann-kaufmann.at
Classification: Construction Type: Slab Construction Method: Concrete		According to classification the construction will be used for the template of slab in concrete method.

	Inside	
A	Flooring	`Ci`
B	Cement screed	`Fl`
C	PE foil	`Fs`
D	Footfall sound insulation	`If`
E	Concrete slab	`L`
F	Sealing membrane	`Sw`
G	XPS	`Iw`
H	Granular subbase	`Fl`
I	Building paper	`Fs`
J	Gravel layer with filter fleece	`Fl`
		`Co`
	Outside	

`{(Co),(Fl),(Fs),(Fl),(Iw),(Sw),(L),(If),(Fs),(Fl),(Ci)}`
The construction consists of eleven layers (R1) and has a thickness under 1,2m (R2). The layers `L`, `Ci` and `Co` are used and in the correct positions (R3, R5). The Rules for inhomogeneous layers are not in charge because none of them are in this construction. The position of Sw is fulfilled according to R16 and R19.
The values of the layers will be taken into account for the maximum and minimum thickness of layers. The specific values like Thermal Conductivity, Water vapour diffusion coefficient, Density and Specific heat capacity should be stored in a database for materials and linked to the correct layers. These values also help to calculate average values for the layers in the control calculation, before the user will see them.

3.3 Templates

In this chapter, generated templates are sorted by the boundary condition, construction type and method. All templates have been done in the same way, as previously has been discussed in the section 2.6 Template Generation. All used building constructions and corresponding references can be found in the Appendix.

Table 13 Templates according to the categorization

<table>
<tr><th>Constrution Type</th><th>walkable</th><th>Boundary condition 1</th><th>Boundary condition 2</th><th>Construction Method</th><th>Template</th></tr>
<tr><td rowspan="5">Wall</td><td rowspan="5"></td><td rowspan="5">Inside (heated) / Inside (not heated)</td><td rowspan="5">Outside</td><td>Wood Massive</td><td>{ (Ci) , [Fh/<Is|Ga>] , (L) , [Fh/Is] ,<[Fh] , (So) , [Fh/Gv] | (Ih)>, (Co) }</td></tr>
<tr><td>Wood Framework</td><td>{ (Ci) , [Fh/<Is|Ga>] ,<Sh, [Fh] |Sv|Sb>, (L/Is) ,<[Fh] , [Ih|Fh/Is] ,So] |Sb>, [Fh/<Gv|Ga>] , (Co) }</td></tr>
<tr><td>Masonry</td><td>{<(Cl) | (Ci) , [L,Il] , (L)>, [Ih[So,Ga] |Fh|Fh/Gv] , (Co) }</td></tr>
<tr><td>Concrete</td><td>{<Cl, [Fs] |Ci, [Fh/<Is/Ga>] ,L>,<Ih,Cl|<Ih|Fh/Is, [Ih]>, [Fh] , [[So]Fh/Gv] ,Co>}</td></tr>
<tr><td>Steel Framework</td><td>{ (Ci) , [Fh/<Is|Ga>] ,<Sh, [Fh] |Sv|Sb>, (L/Is) ,<[Fh] , [Ih|Fh/Is] ,So] |Sb>, [Fh/<Gv|Ga>] , (Co) }</td></tr>
<tr><td rowspan="5">Wall</td><td rowspan="5"></td><td rowspan="5">Inside (heated) / Inside (not heated)</td><td rowspan="5">Inside (heated) / Inside (not heated)</td><td>Wood Massive</td><td>{<Cl|Ci , [Fh|Fh/Is] ,L>, [Fh] , [Fh/Is] , (Co) }</td></tr>
<tr><td>Wood Framework</td><td>{ (Ci) ,<[Fh/Is] , [Fh] , [Fh] | [Fh,L/Is, [Fh] , [Fh] ,Ih,Fh, [Fh]]>, (L/Is) , [Fh] , [Fh] , [Fh/Is] , (Co) }</td></tr>
<tr><td>Masonry</td><td>{<Cl|Ci , [Fh|Fh/Is] ,L>, [Fh] , [Fh/Is] , (Co) }</td></tr>
<tr><td>Concrete</td><td>{<Cl|Ci , [Fh|Fh/Is] ,L>, [Fh] , [Fh/Is] , (Co) }</td></tr>
<tr><td>Steel Framework</td><td>{ (Ci) ,<[Fh/Is] , [Fh] , [Fh] | [Fh,L/Is, [Fh] , [Fh] ,Ih,Fh, [Fh]]>, (L/Is) , [Fh] , [Fh] , [Fh/Is] , (Co) }</td></tr>
<tr><td rowspan="2">Wall</td><td rowspan="2"></td><td rowspan="2">Inside (heated) / Inside (not heated)</td><td rowspan="2">Earth</td><td>Masonry</td><td>{<(Cl) | (Ci) , (L) ,<(Sw) | (Sw) , (Sw)>>, (Iw) , [Fh] , (Co) }</td></tr>
<tr><td>Concrete</td><td>{<(Cl) | (Ci) , (L) ,<(Sw) | (Sw) , (Sw)>>, (Iw) , [Fh] , (Co) }</td></tr>
<tr><td rowspan="4">Pitched roof</td><td rowspan="4"></td><td rowspan="4">Inside (heated)</td><td rowspan="4">Outside</td><td>Wood Massive</td><td>{<Cl|Ci , [Fh/Is] ,L>, [Sh] ,<Fh/Is|Ih>, [Fh] , (So) , (Fh/Gv) , [Fh,Fs|Fh/Ga] , (Co) }</td></tr>
<tr><td>Wood Framework</td><td>{<(Cl) , (Fh) , (Sh) | (Ci) , [Fh] , (Fh/<Is|Ga>) ,<Sb|Sh[Fh]>, (L/Is)>[Fh|Fh/Is] , [Fh/Is] ,<So|Sb>, (Fh/Gv) , [Fh,Fs|Fh/Ga] , (Co)</td></tr>
<tr><td>Concrete</td><td>{<Cl|Ci , [Fh/Is] ,L>, [Sh] ,<Fh/Is|Ih>, [Fh] , (So) , (Fh/Gv) , [Fh,Fs|Fh/Ga] , (Co) }</td></tr>
<tr><td>Steel Framework</td><td>{<(Cl) , (Fh) , (Sh) | (Ci) , [Fh] , (Fh/<Is|Ga>) ,<Sb|Sh[Fh]>, (L/Is)>[Fh|Fh/Is] , [Fh/Is] ,<So|Sb>, (Fh/Gv) , [Fh,Fs|Fh/Ga] , (Co)</td></tr>
<tr><td rowspan="4">Pitched roof</td><td rowspan="4"></td><td rowspan="4">Inside (not heated)</td><td rowspan="4">Outside</td><td>Wood Massive</td><td>{<Cl|Ci,L>, [Fh] , (So) , (Fh/Gv) , [Fh,Fs|Fh/Ga] , (Co) }</td></tr>
<tr><td>Wood Framework</td><td>{<(Cl) , (Fh) , (Sh) | (Ci) , [Fh] ,<Sb|Sh[Fh]>, (L/Ga)>,<[Fh] ,So|Sb>, (Fh/Gv) , [Fh,Fs|Fh/Ga] , (Co) }</td></tr>
<tr><td>Concrete</td><td>{<Cl|Ci,L>, [Fh] , (So) , (Fh/Gv) , [Fh,Fs|Fh/Ga] , (Co) }</td></tr>
<tr><td>Steel Framework</td><td>{<(Cl) , (Fh) , (Sh) | (Ci) , [Fh] ,<Sb|Sh[Fh]>, (L/Ga)>,<[Fh] ,So|Sb>, (Fh/Gv) , [Fh,Fs|Fh/Ga] , (Co) }</td></tr>
<tr><td rowspan="5">Flat roof</td><td rowspan="5">walkable / not walkable</td><td rowspan="5">Inside (heated)</td><td rowspan="5">Outside</td><td>Wood Massive</td><td>{<Ci,Fh/<Is|Ga>,L|Cl>[Fs] ,<Sv|Sh>, (Ih) , [Sb,Fh/Gv,Fh/Ga|Sw,<Fs|Fh>|If,Fs,Sw,Fh/Ga] , (Co) }</td></tr>
<tr><td>Wood Framework</td><td>{ (Ci) , [Fh] , [Fh/<Is|Ga>] ,<Sv, [Fh] |Sh, [Fh] |Sb>, (L/Is) , [Fh,Sw,Iw,Fs|Fh,So, [Fs] ,Fh/Gv,Fh[Fs,Sw,Fl]] , (Co) }</td></tr>
<tr><td>Masonry</td><td>{ (Ci) , (L) , [Fs] , [Sv] ,<Fh/Is|Ih>, [Fs|Fh] ,<So,Fh/Gv|Sw[Iw] |Sh>, [Fh,Fs|Fh,Fl,Fs|Fh,Fh/Ga|Fs] , (Co) }</td></tr>
<tr><td>Concrete</td><td>{ (Ci) , (L) , [Fs] , [Sv] ,<Fh/Is|Ih>, [Fs|Fh] ,<So,Fh/Gv|Sw[Iw] |Sh>, [Fh,Fs|Fh,Fl,Fs|Fh,Fh/Ga|Fs] , (Co) }</td></tr>
<tr><td>Steel Framework</td><td>{ (Ci) , [Fh] , [Fh/<Is|Ga>] ,<Sv, [Fh] |Sh, [Fh] |Sb>, (L/Is) , [Fh,Sw,Iw,Fs|Fh,So, [Fs] ,Fh/Gv,Fh[Fs,Sw,Fl]] , (Co) }</td></tr>
<tr><td rowspan="5">Flat roof</td><td rowspan="5">walkable / not walkable</td><td rowspan="5">Inside (not heated)</td><td rowspan="5">Outside</td><td>Wood Massive</td><td>{<Ci,L|Cl>[Fs] ,<Sv|Sh>, [Sb,Fh/Gv,Fh/Ga|Sw,<Fs|Fh>|If,Fs,Sw,Fh/Ga] , (Co) }</td></tr>
<tr><td>Wood Framework</td><td>{ (Ci) , [Fh] ,<Sv, [Fh] |Sh, [Fh] |Sb>, (L/Ga) , [Fh,Sw,Iw,Fs|Fh,So, [Fs] ,Fh/Gv,Fh[Fs,Sw,Fl]] , (Co) }</td></tr>
<tr><td>Masonry</td><td>{ (Ci) , (L) , [Fs] , [Sv] , [Fs|Fh] ,<So,Fh/Gv|Sw[Iw] |Sh>, [Fh,Fs|Fh,Fl,Fs|Fh,Fh/Ga|Fs] , (Co) }</td></tr>
<tr><td>Concrete</td><td>{ (Ci) , (L) , [Fs] , [Sv] , [Fs|Fh] ,<So,Fh/Gv|Sw[Iw] |Sh>, [Fh,Fs|Fh,Fl,Fs|Fh,Fh/Ga|Fs] , (Co) }</td></tr>
<tr><td>Steel Framework</td><td>{ (Ci) , [Fh] ,<Sv, [Fh] |Sh, [Fh] |Sb>, (L/Ga) , [Fh,Sw,Iw,Fs|Fh,So, [Fs] ,Fh/Gv,Fh[Fs,Sw,Fl]] , (Co) }</td></tr>
<tr><td rowspan="2">Slab</td><td rowspan="2">walkable</td><td rowspan="2">Inside (heated) / Inside (not heated)</td><td rowspan="2">Earth</td><td>Masonry</td><td>{ (Ci) , (Fl) ,<Fs,If, [Fl] |<Ih,Il|Fs,Iw,Fs>,Sw>, (L) ,<Fs,<Iw|Fl>|Sh,<Ih|Iw,Sw,Fh,Fs,Fl>>, (Co) }</td></tr>
<tr><td>Concrete</td><td>{ (Ci) , (Fl) ,<Fs,If, [Fl] |<Ih,Il|Fs,Iw,Fs>,Sw>, (L) ,<Fs,<Iw|Fl>|Sh,<Ih|Iw,Sw,Fh,Fs,Fl>>, (Co) }</td></tr>
<tr><td rowspan="5">Ceiling</td><td rowspan="5">walkable / not walkable</td><td rowspan="5">Inside (heated) / Inside (not heated)</td><td rowspan="5">Outside / Inside (heated) / Inside (not heated)</td><td>Wood Massive</td><td>{ (Ci) ,<[Fl, [Fs]] ,If,Fl, [Fs|Sh] |Fh/Is>,<Cl|L,<So|Fh/Is, [Fh|Fh/Is, [Sw]]>,Co></td></tr>
<tr><td>Wood Framework</td><td>{ (Ci) ,<<[Fl] ,Fs|Fh|Ih>,If,<Fl,Fs,Fh|Fl,Sh,Fh|Fh>|Fh/Ga,<Sb|Sh>>,<Cl|L/Is, [Fh| [Fh] ,Fh/Ga|So|Fh,Fh/Is,Fh] ,Co>}</td></tr>
<tr><td>Masonry</td><td>{ (Ci) , [Sw,Fl,Fs|Fl,Fs|Fl,Sh] ,<If, [Fl|Ih|Sh] |Il|Fh,Fh/Is>, [Fh,Fh/Is] ,<Cl|L, [Fh/Is|Ih|Ih,Ih] , (Co) }</td></tr>
<tr><td>Concrete</td><td>{ (Ci) , [Sw,Fl,Fs|Fl,Fs|Fl,Sh] ,<If, [Fl|Ih|Sh] |Il|Fh,Fh/Is>, [Fh,Fh/Is] ,<Cl|L, [Fh/Is|Ih|Ih,Ih] , (Co) }</td></tr>
<tr><td>Steel Framework</td><td>{ (Ci) ,<<[Fl] ,Fs|Fh|Ih>,If,<Fl,Fs,Fh|Fl,Sh,Fh|Fh>|Fh/Ga,<Sb|Sh>>,<Cl|L/Is, [Fh| [Fh] ,Fh/Ga|So|Fh,Fh/Is,Fh] ,Co>}</td></tr>
</table>

3.4 Proof of concept

To show the accuracy of the main templates different constructions were chosen from the data pool and were discussed in the following section. All four constructions are Outside walls in frame work method. The differences can be found in the presence of installation and /or ventilation layers. Through this it should become clearer how the template can create different variations of constructions. The first wall which we can see in Figure 8 has both before mentioned layers and acts as the base case for this example. Just those rules will be discussed, which take direct influence on the appearance of these constructions. First the rule R1 is fulfilled because the created construction has just six layers. The L/Is layer met with the requirements of R3 after which a L layer is needed and R5 is also fulfilled due to one Ci and Co. There are no similar layers which are adjacent to each other as required in R8. According to R11 only L and Fh are inhomogeneous layers and mixed with Is as stated in R12 and R13. The layer Sh is used as allowed in R14 and also the inhomogeneous layers are closed according to R20.

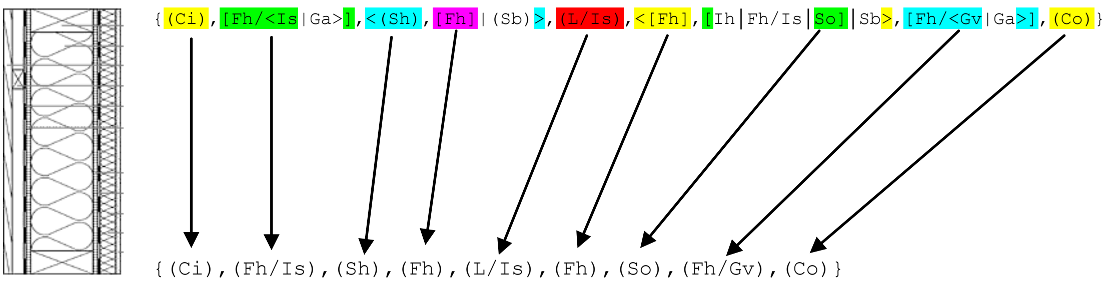


Figure 8 Outside wall construction awrhhi01a (Source: www.dataholz.com)

The biggest difference between the construction in Figure 8 and Figure 9 is that instead of the Rear ventilation an extra insulation on the outside plus a lathing are applied. The layers `Sh` and `Fh` are replaced by one `Sb` which is regulated in R15-E3. Because there is no rear ventilation the layer So is replaced by an extra `Ih` and `Fh/Ga` layer. The `Fh/Ga` layer is oriented vertically due to the fact that the `Co` layer is already horizontally applied. This is fine due to the Exception R9-E1.

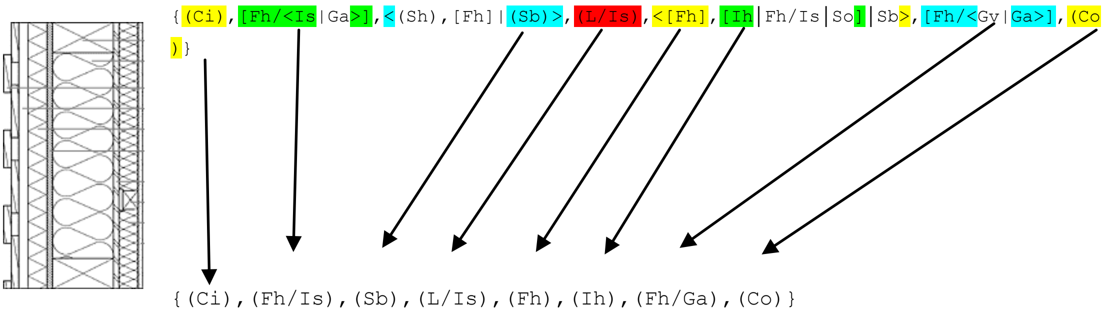


Figure 9 Outside wall construction awrohi01b (Source: www.dataholz.com)

In Figure 10 the installation layer is by now also gone. As already explained the Rules are not the only control mechanism, also the template has a huge influence on the assembly of the construction. For example, `Ci` and `Co` stand in normal brackets what means they are automatically assigned. The layer `Sb` stands in pointed brackets together with `Sh` and `Fh` as a possible alternative. That shows how one of the two options has to be taken and replaces the other one. The loadbearing layer `L/Is` acts equal to `Ci` and `Co` because it also stands just in normal brackets. The layer `Fh/Is`, near to `Ci`, stands in squared brackets what demonstrates how this layer can be used or not in the construction.

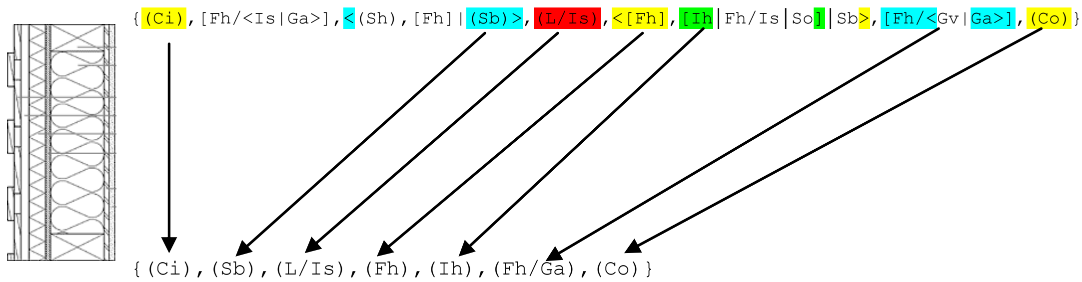


Figure 10 Outside wall construction awroho01a (Source: www.dataholz.com)

The last construction, seeable in Figure 11 has by now again a rear ventilation layer but absolutely no expression from the second green brackets like `Ih` or `So`. In the template it is also seeable how the brackets influence together on the process for example in the turquoise `Fh/Ga` layer. The layer stands in squared brackets so it is an optional choice. The second part of this term stands in pointed brackets, so when this expression is chosen one of those two layers has to be applied.

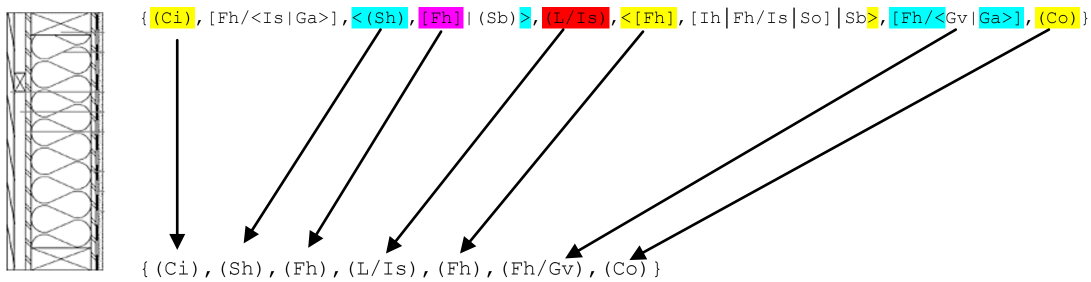


Figure 11 Outside wall construction awrhho03a (Source: www.dataholz.com)

3.5 Workflow

In this chapter the imagined workflow of the tool is shown for better understanding of the single steps described in the method section.

The user has by now to define, what sort of construction he wants and can give as much additional information as he wants, to specify the final construction.

Table 14 User input from Classification process

Construction Type:	Wall
Construction method:	Masonry
Boundary condition1:	Inside (heated)
Cladding1:	Plaster
Boundary condition2:	Outside
Cladding2:	Plaster
Advanced settings:	not used (default)

When the advanced settings are not used the tool automatically picks average (default) values for everything. After this step the tool works in the background while the user has to wait for some minutes. The correct template will be generated and different constructions according to the settings created.

Used Template

{(Ci),[Fh,Sh,Fh/<Is|Ga>],(L),<Ih|Fh/Is,So>,[Fh/Gv,Fh],(Co)}

The system can create

{(Ci),(L),(Ih),(Co)}

{(Ci),(L),(Ih),(Fh/Gv),(Fh),(Co)}

{(Ci),(Fh),(Sh),(Fh/Is),(L),(Fh/Is),(So),(Co)}

{(Ci),(Fh),(Sh),(Fh/Is),(L),(Fh/Is),(So),(Co)}

{(Ci),(L),(Fh/Is),(So),(Fh/Gv),(Fh),(Co)}

All these solutions can be already saved in a database so that the tool doesn't have to generate all variants every time again. It will save time and calculation capacity of the hardware.

Because the advanced settings are adjusted to default the tool will choose not to complex constructions to keep all parameters in equilibrium.

Now the tool selects default materials according to the user settings, which lay in an open database together with some standard thicknesses, defined for this use case. The average material for each layer will be set over the all average technical value. With these adjustments, the tool performs different calculations to check if all the variants are fine.

After calculation, the constructions with unsatisfied results like, too high heat transmission or condensation risk will be ignored and from the pool of the correct constructions, the best three will be shown to the user. After he can than decide which one fits more to his needs.

Table 15 Construction choice after generation from the tool

Construction 1	Construction 2	Construction 3
	Outside	
2 cm Gypsum plaster	2 cm Gypsum plaster	2 cm Gypsum plaster
	5 cm Vorsatzschale	
30 cm Porotherm Clay Block	30 cm Porotherm Clay Block	30 cm Porotherm Clay Block
5 cm stone wool plaster board	5 cm stone wool plaster board	5 cm stone wool
		5 cm Rear ventilation
		3 cm Plasterboard
1 cm Silicate plaster	1 cm Silicate plaster	1 cm Silicate plaster
	Inside	
Heat transmission: 0,185 $W.m^{-2}K^{-1}$	Heat transmission: 0,16 $W.m^{-2}K^{-1}$	Heat transmission: 0,17 $W.m^{-2}K^{-1}$
Condensation risk: NO	Condensation risk: NO	Condensation risk: NO
OI3 Index: 3	OI3 Index: 2,8	OI3 Index: 3,5

By now user can adjust different fitting products from the database to the layers, depend on his material product preferences. The material selection will be limited by the layer itself, so that no incorrect materials can be filled. When the construction is adjusted to the preferences, user after can apply the created construction or to change something in his settings. How the construction will be used depends on the tool integration.

4 CONCLUSION

4.1 General

The documented efforts illustrate the high degree of complexity of formulating the required knowledge about building component construction in a formalized language. The larger the repository of analysed construction is (and the more construction types are integrated), the more accurate results will become. While the initial efforts were addressing an easy to grasp and limited set of layers and rules, it became evident that the domain of building construction assemblies requires the consideration of a large number of special cases and exceptions to rules. Therefore, the original intention to work just rule-based was adjusted: For the examined cases, templates were defined that help to avoid getting lost in the large domain space. These templates foster the feasibility of the developed building component design principles. The major working steps of the developed algorithms are “categorizing”, “sorting” and “omitting”. This utilization of templates reduces the solution space, but can act as starting point for further developments.

4.2 Future Research

The next development step in this domain should be the implementation of the ideas into programmed and ready-to-use code. While the manual proof of concept was already provided, programed code could help to speed up the further integration of components. Via iterative or non-iterative (genetic) algorithms, the test of existing rules and integration of new rules can be facilitated. Especially the integration of non-iterative – evolutionary/genetic algorithms – seems promising. Thereby, one or more fitness functions need to be defined and integrated into the code. This could also be the key to avoid the intermediate step of using templates. Due to genetic algorithms structure, presumably not an pareto-optimum, but at least a rather good approximation could be reached.

For experienced users like architects or interested future developers the tool could be extended with a renovation optimiser. In this case the user would be requested to define the already existing building construction. Alternatively, templates based on existing background information such as the year of construction, main material, thickness, could be implemented. Based on this initial design, retrofit options can be explored via exchange or addition of the different layers and assessed via the rule-based optimization. The optimization can be influenced toward its main objective, which for instance could be cost optimum, highest energy saving potential, small environmental impact or similar.

In the long run, coupling with artificial intelligence (AI) approaches could be considered, so that a system is able to “learn” how to construct building assemblies. Via semantic web technologies, the AI could be constantly fed with new input data. This approach might help in updating the portfolio of possible constructions. Based on a clever design, such a system would require only very little manual maintenance.

Additional evaluation domains, such as acoustical performance of building assemblies, aspects of fire safety, or in-depth cost calculation (material and labour cost, maintenance cost) can be considered in implementation. The different standards pertaining to these domains can be examined regarding required input data and potential performance indicators.

For the building costs the standard ON B 1801 and DIN 276-2 (DIN 276-1) can provide the needed information how the building costs have to be processed. For example, in the SEMERGY project such attempts were already implemented. The critical point in this calculation is that the costs are divided in two main parts, namely, the labour costs and the material costs. The material costs can be easier obtained than the labour costs but in general it is not so easy to define them, (cannot be just taken from catalogues). The prices which building contractors can give largely depend on the market, wholesale prices and bidding processes in which the companies can give large discounts to receive the contract. Building companies are trying to keep this information confidential because it is there advantage in the tendering. The information obtained by the SEMERGY project was gathered from the “Sirados Kalkulationsatlanten 2014” by Dam et al. (2014), which evaluated the building costs of hundreds of bidding processes.

The acoustical calculation of building constructions is described in the standard ON B 8115-2 and the OIB Guideline 5. Many programs can already calculate the sound insulation level of homogeneous constructions but inhomogeneous constructions have to be tested empirically. Because of such complex calculations it is hard to optimise constructions regarding this values. One possible option for inhomogeneous construction can be that the tool knows the values of certified constructions and then compares the structure of them with the digital version and could so at least make a rough estimation.

The fire resistance class is regulated by the OIB Guideline 2, ON B 3800 and ON EN 13501 which give information about materials, constructions and testing methods. The easiest approach to this topic is to give at least the information about the fire protection class of the material surface of a building construction. This gives the user no information about the classification of the whole construction. To obtain this information the building components have to be certified in mock ups similar to the acoustic classification. Moreover, these properties can change depending on the usage and mounting situation, for example in a building corner where fire can concentrate and become more intense. As long as there are no better simulation methods, the fire resistance of a component should always be tested in a laboratory to ensure the quality.

4.3 Implementation Possibilities

This thesis contributes to a currently running research project (BAU_WEB), which analyses the building material and product information handling. The main objective of this project is to create ontologies for the automated development of web-based building product data for industry, planners and clients. Some of the main tasks in this ambitious project are the development of a coherent construction product categorization system to ensure a long term functionality, maintainability and extensibility of the ontology. The layer categories created in this master thesis can add information to this task. Another important step in BAU_WEB is the semantically meaningful connection of all different kinds of data sources. The rules and dependencies, which were found and are expressed by the rules can also be used in this process. BAU_WEB also contributes to this tool because when more and more online data bases of materials become consistent, it becomes also easier for this tool to implement them into its database.

The tool could also be adapted as a teaching tool for students to test their knowledge of building construction. A possible variant would be to show their knowledge about the single layers of building constructions and their requirements change with the use case. Another variant can be to check self-made building constructions and to see if they would work or not. It can also be used to show them the huge variety of the building materials for different layers, which can be more sustainable or less cost intensive than the standard products.

The original idea was to implement the tool in the SEMERGY project to give the user a more open choice in the construction and to lower the amount of needed work in the implementation of new building constructions. The needed database for building materials and also the needed input from the user for the classification is already available in the SEMERGY tool. If some of the described future research ideas would also be implemented, it would add a major gain for the functionality of SEMERGY by simultaneously cutting down the needed resources and maintenance. From its concept the tool is not bound to one program like SEMERGY, so it could also be implemented in more complicated simulation tools like ArchiPHYSIK or Energyplus. The tool could be used as a helper for the first programs or an assist function in the early design stage, when the constructions are not fixed.

5 INDEX

5.1 List of Figures

5.2 List of Tables

5.3 List of Abbreviations

AI	Artificial intelligence
AP	Acidification potential
Ci	Completion inside
Co	Completion Outside
Cl	Completion loadbearing
DIN	German institute of standardization
EN	European standard
EPDM	Ethylenpropylendien monomer
EPS	Expanded polystyrene
Fh	Hard filling
Fl	Lose filling
Fs	Sheet filling
Ga	Standing air layer
Gn	Standing noble gas layer
Gv	Back ventilation layer
GW	Glass wool
GWP	Global warming potential
IBO	Austrian institute for healthy and ecological building
If	Footfall sound insulation
Ih	Hard insulation
Ii	Inside insulation
Is	Soft Insulation
Iw	Waterproof insulation
L	Load bearing layer
MDF	Medium density fibreboard
MW	Mineral wool
OI	Eco-Index

OIB	Austrian institute of construction engineering
ON	Austrian standard
OSB	Oriented strand board
PE	Polyethylen
PEI n.e.	Primary energy content of non-renewable resources
PP	Polypropylen
Sb	Boards airtight taped
Sh	Half diffusion open sealing
So	Diffusion open sealing
Sv	Vapour barrier
Sw	Water sealing
SW	Stone wool
WF	Woof fibre
WW	Wood wool
XPS	Extruded polystyrene

6 LITERATURE

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7 APPENDIX

7.1 Construction Database

7.1.1 Outside wall, massive brick

Master Template:

{<(Cl)|(Ci),[L,Il],(L)>,[Ih[So,Ga]|Fh|Fh/Gv],(Co)}

Source: Handbuch & Planungshilfe Baukonstruktion, S.42 Abb 7.; S.43 Abb 10.		Brickwall, plastered
	Outside	
A	Plaster	Ci
B	Brickwall	L
C	Plaster	Co
	Inside	
{(Ci),(L),(Co)}		

Source: https://www.baubook.at/phbtk/index_BTR.php?SW=19		AWm 04 a
	Inside	
	Clay plaster	Ci
A	Clay brick	L
B	Stone wool MW(SW)-W	Ih
C	Silca plaster	Co
D	Outside	
{(Ci),(L),(Ih),(Co)}		

Source:.Handbuch & Planungshilfe Baukonstruktion, S.48, Abb.37		Bivalve brickwall
	Inside	
A	Brickwall	Cl
B	Rear ventilation	Fh/Gv
C	Brickwall	Co
	Outside	
{(Cl),(Fh/Gv),(Co)}		

Source: https://www.baubook.at/phbtk/index_BTR.php?SW=19		AWm 07 b
	Inside	
	Clay plaster	Ci
A	Vertically perforated bricks	L
B	Expanded perlite filling	Il
C	Vertically perforated bricks	L
D	Lime cement plaster	Fh
E	Silca plaster	Co
	Outside	
{(Ci),(L),(Il),(L),(Fh),(Co)}		

Source: https://www.baubook.at/phbtk/index_BTR.php?SW=19		AWm 08 a
	Inside	
A	Lime cement plaster	Ci
B	Vertically perforated bricks	L
C	Glass wool board MW(GW)-W	Ih
D	Wind barrier	So
E	Air layer	Ga
F	Clinker brick	Co
	Outside	
{(Ci),(L),(Ih),(So),(Ga),(Co)}		

7.1.2 Outside wall, massive concrete

Master Template:

{<Cl,[Fs]|Ci,[Fh/<Is/Ga>],L>,<Ih,Cl|<Ih|Fh/Is,[Ih]>,[Fh],[[So] Fh/Gv],Co>}

Source: Handbuch & Planungshilfe Baukonstruktion, S.209, Abb.84.		Concrete Wall with facing shell
	Inside	
A	Fair face concrete	Cl
B	PE foil	Fs
C	Insulation	Ih
D	Rear ventilation	Fh/Gv
E	Outside cladding	Co
	Outside	
{(Cl),(Fs),(Ih),(Fh/Gv),(Co)}		

Source: Handbuch & Planungshilfe Baukonstruktion, S.209, Abb.85.		Bivalve Concrete Wall, core insulation
	Inside	
A	Fair face concrete	Cl
B	Insulation	Ih
C	Fair face concrete	Cl
	Outside	
{(Cl),(Ih),(Cl)}		

Source: http://www.baubook.at/phbtk/index_BTR.php?SW=19		AWm 01 a
	Inside	
A	Gypsum plaster	Ci
B	Reinforced concrete	L
C	EPS-F	Ih
D	Silica plaster	Co
	Outside	
{(Ci),(L),(Ih),(Co)}		

Source: http://www.baubook.at/phbtk/index_BTR.php?SW=19		AWm 02 a
	Inside	
A	Lime cement plaster	Ci
B	Lightweight concrete with brick chippings	L
C	Stonewool within construction wood	
D	Stonewool within OSB	→ Fh/Is
E	Stonewool within construction wood	
F	Full wood boarding	Fh
G	Windbreak	So
H	Rear ventilation within aluminum profiles	Fh/Gv
I	Fiber concrete plates	Co
	Outside	
{(Ci),(L),(Fh/Is),(Fh),(So),(Fh/Gv),(Co)}		

Source: http://www.baubook.at/phbtk/index_BTR.php?SW=19		AWm 03 a
	Inside	
A	Lime cement plaster	Ci
B	Wood concrete blocks	L
C	Stonewool within construction wood	
D	Stonewool within OSB	→ Fh/Is
E	Stonewool within construction wood	
F	Wood wool board WW	Ih
G	Adhesive filler	Fh
H	Silica plaster	Co
	Outside	
{(Ci),(L),(Fh/Is),(Ih),(Fh),(Co)}		

7.1.3 Outside walls, massive wood

Master Template:

{(Ci),[Fh/<Is|Ga>],(L),[Fh/Is],<[Fh],(So),[Fh/Gv]|(Ih)>,(Co)}

Source: http://www.dataholz.at/cgi-bin/WebObjects/dataholz.woa/wa/bauteil?language=de&kz=awmhhi01a		awmhhi01a
	Outside	
A	Wood Cladding	Co
B	Rear ventilation	Fh/Gv
C	MDF	Fh
D	Wood-based beam	Fh/Is
E	Insulation	
F	Cross laminated timber	L
G	Wooden battens on swinging hoops	Fh/Is
H	Insulation	
I	Plasterboard	Ci
	Inside	
{(Ci),(Fh/Is),(L),(Fh/Is),(Fh),(Fh/Gv),(Co)}		

Source: http://www.dataholz.at/cgi-bin/WebObjects/dataholz.woa/wa/bauteil?language=de&nr=0&kz=awmhhi02a		awmhhi02a
	Outside	
A	Wood Cladding	Co
B	Rear ventilation	Fh/Gv
C	MDF	Fh
D	Construction wood horizontal	Fh/Is
E	Construction wood	Fh/Is
F	Insulation	
G	Cross laminated timber	L
H	Wooden battens on swinging hoops	Fh/Is
I	Insulation	
J	Plasterboard	Ci
	Inside	
{(Ci),(Fh/Is),(L),(Fh/Is),(Fh/Is),(Fh),(Fh/Gv),(Co)}		

Source: http://www.dataholz.at/cgi-bin/WebObjects/dataholz.woa/wa/bauteil?language=de&kz=awmhhi01a		awmohi01a
	Outside	
A	Wood Cladding	Co
B	Rear ventilation	Fh/Gv
C	Diffusion open foil	So
D	Wooden battens	Fh/Is
E	Insulation	
F	Insulation	Fh/Is
G	Cross laminated timber	L
H	Wooden battens on swinging hoops	Fh/Is
I	Insulation	
J	Plasterboard	Ci
	Inside	
{(Ci),(Fh/Is),(L),(Fh/Is),(Fh/Is),(So),(Fh/Gv),(Co)}		

Source: http://www.dataholz.at/cgi-bin/WebObjects/dataholz.woa/wa/bauteil?language=de&kz=awmohi02a		awmohi02a
	Outside	
A	Wood Cladding	Co
B	Rear ventilation	Fh/Gv
C	Diffusion open foil	So
D	Plasterboard	Fh
E	Construction wood	Fh/Is
F	Insulation	
G	Cross laminated timber	L
H	Wooden battens on swinging hoops	Fh/Is
I	Insulation	
J	Plasterboard	Ci
	Inside	
{(Ci),(Fh/Is),(L),(Fh/Is),(Fh),(So),(Fh/Gv),(Co)}		

Source: http://www.dataholz.at/cgi-bin/WebObjects/dataholz.woa/wa/bauteil?language=de&kz=awmoho01a		awmoho01a
	Outside	
	Wood Cladding	Co
A	Rear ventilation	Fh/Gv
B	Diffusion open foil	So
C	Wooden battens	Fh/Is
D	Insulation	
E	Insulation	Fh/Is
F	Cross laminated timber	L
G	Plasterboard	Ci
H	Inside	
{(Ci),(L),(Fh/Is),(Fh/Is),(So),(Fh/Gv),(Co)}		

Source: http://www.dataholz.at/cgi-bin/WebObjects/dataholz.woa/wa/bauteil?language=de&kz=awmoho02a		awmoho02a
	Outside	
A	Wood Cladding	Co
B	Rear ventilation	Fh/Gv
C	Diffusion open foil	So
D	Insulation	Is
E	Cross laminated timber	L
F	Plasterboard	Ci
	Inside	
{(Ci),(L),(Is),(So),(Fh/Gv),(Co)}		

Source: http://www.dataholz.at/cgi-bin/WebObjects/dataholz.woa/wa/bauteil?language=de&kz=awmoho03a		awmoho03a
	Outside	
A	Wood Cladding	Co
B	Rear ventilation	Fh/Gv
C	Diffusion open foil	So
D	Plasterboard	Fh
E	Construction wood	Fh/Is
F	Insulation	
G	Cross laminated timber	L
H	Plasterboard	Ci
	Inside	
{(Ci),(L),(Fh/Is),(Fh),(So),(Fh/Gv),(Co)}		

Source: http://www.dataholz.at/cgi-bin/WebObjects/dataholz.woa/wa/bauteil?language=de&kz=awmoho05a		awmoho05a
	Outside	
	Wood Cladding	Co
A	Rear ventilation	Fh/Gv
B	Diffusion open foil	So
C	Plasterboard	Fh
D	Insulation	Is
E	Cross laminated timber	L
F	Plasterboard	Ci
G	Inside	
{(Ci),(L),(Is),(Fh),(So),(Fh/Gv),(Co)}		

Source: http://www.dataholz.at/cgi-bin/WebObjects/dataholz.woa/wa/bauteil?language=de&kz=awmopi01a		awmopi01a
	Outside	
A	Plaster	Co
B	Insulation board	Ih
C	Cross laminated timber	L
D	Wooden battens on swinging hoops →	Fh/Is
E	Insulation →	
F	Plasterboard	Ci
	Inside	
{(Ci),(Fh/Is),(L),(Ih),(Co)}		

Source: http://www.dataholz.at/cgi-bin/WebObjects/dataholz.woa/wa/bauteil?language=de&kz=awmopi03a		awmopi03a
	Outside	
A	Plaster	Co
B	Insulation board	Ih
C	Wood-based beam →	Fh/Is
D	Insulation →	
E	Cross laminated timber	L
F	Wooden battens on swinging hoops →	Fh/Is
G	Insulation →	
H	Plasterboard	Ci
	Inside	
{(Ci),(Fh/Is),(L),(Fh/Is),(Ih),(Co)}		

Source: http://www.dataholz.at/cgi-bin/WebObjects/dataholz.woa/wa/bauteil?language=de&kz=awmopi04a		awmopi04a
	Outside	
	Plaster	`Co`
A	Insulation board	`Ih`
B	MDF	`Fh`
C	Wood-based beam	`Fh/Is`
D	Insulation	
E	Cross laminated timber	`L`
F	Wooden battens on swinging hoops	`Fh/Is`
G	Insulation	
H	Plasterboard	`Ci`
I	Inside	
	`{(Ci),(Fh/Is),(L),(Fh/Is),(Fh),(Ih),(Co)}`	

Source: http://www.dataholz.at/cgi-bin/WebObjects/dataholz.woa/wa/bauteil?language=de&kz=awmopo01a		awmopo01a
	Outside	
A	Plaster	`Co`
B	Insulation board	`Ih`
C	Cross laminated timber	`L`
D	Plasterboard	`Ci`
	Inside	
	`{(Ci),(L),(Ih),(Co)}`	

Source: http://www.dataholz.at/cgi-bin/WebObjects/dataholz.woa/wa/bauteil?language=de&kz=awmihi01a		awmihi01a
	Outside	
A	Wooden Cladding	`Co`
B	Rear ventilation	`Fh/Gv`
C	Insulation board	`Ih`
D	Insulation board	
E	Cross laminated timber	`L`
F	Wooden battens on swinging hoops	`Fh/Is`
G	Insulation	
H	Plasterboard	`Ci`
	Inside	
	`{(Ci),(Fh/Is),(L),(Ih),(Ih),(Fh/Gv),(Co)}`	

Source: http://www.dataholz.at/cgi-bin/WebObjects/dataholz.woa/wa/bauteil?language=de&kz=awmihi02b		awmihi02b
	Outside	
A	Wooden Cladding	Co
B	Rear ventilation	Fh/Gv
C	Diffusion open foil	So
D	Construction wood	Fh/Is
E	Insulation	
F	Cross laminated timber	L
G	Wooden battens on swinging hoops	Fh/Is
H	Insulation	
I	Plasterboard	Ci
	Inside	
{(Ci),(Fh/Is),(L),(Fh/Is),(So),(Fh/Gv),(Co)}		

Source: http://www.dataholz.at/cgi-bin/WebObjects/dataholz.woa/wa/bauteil?language=de&kz=awmopi02a		awmopi02a
	Outside	
A	Plaster	Co
B	Insulation board	Ih
C	Construction wood	Fh/Is
D	Insulation	
E	Cross laminated timber	L
F	Wooden battens on swinging hoops	Fh/Is
G	Insulation	
H	Plasterboard	Ci
	Inside	
{(Ci),(Fh/Is),(L),(Fh/Is),(Ih),(Co)}		

Source: http://www.dataholz.at/cgi-bin/WebObjects/dataholz.woa/wa/bauteil?language=de&kz=awmopo02a		awmopo02a
	Outside	
A	Plaster	Co
B	Insulation board	Ih
C	Construction wood	Fh/Is
D	Insulation	
E	Cross laminated timber	L
F	Plasterboard	Ci
	Inside	
{(Ci),(L),(Fh/Is),(Ih),(Co)}		

7.1.4 Outside walls, Framework wood

Master Template:

{(Ci),[Fh/<Is|Ga>],<Sh,[Fh]|Sv|Sb>,(L/Is),<[Fh],[Ih|Fh/Is],So]
|Sb>,[Fh/<Gv|Ga>],(Co)}

Source: http://www.dataholz.at/cgi-bin/WebObjects/dataholz.woa/wa/bauteil?language=de&kz=awrhhi02a		awrhhi02a
	Outside	
A	Wood Cladding	Co
B	Rear ventilation	Fh/Gv
C	Wind retarder	So
D	Chipboard	Fh
E	Construction wood	L/Is
F	Insulation	
G	Chipboard	Fh
H	Vapour retarder	Sh
I	Wooden battens	Fh/Is
J	Insulation	
K	Plasterboard	Ci
	Inside	
{(Ci),(Fh/Is),(Sh),(Fh),(L/Is),(Fh),(So),(Fh/Gv),(Co)}		

Source: http://www.dataholz.at/cgi-bin/WebObjects/dataholz.woa/wa/bauteil?language=de&kz=awroho03a		awroho03a
	Outside	
A	Wood Cladding	Co
B	Counter battens	Fh/Is
C	Wood wool plate	
D	Chipboard	Fh
E	Construction wood	L/Is
F	Insulation	
G	Chipboard	Fh
H	Vapour retarder	Sh
I	Wood battens	Fh/Is
J	Insulation	
K	Plasterboard	Ci
	Inside	
{(Ci),(Fh/Is),(Sh),(Fh),(L/Is),(Fh),(Fh/Is),(Co)}		

Source: http://www.dataholz.at/cgi-bin/WebObjects/dataholz.woa/wa/bauteil?language=de&kz=awrhho05a		awrhho05a
	Outside	
A	Wood Cladding	Co
B	Rear ventilation	Fh/Gv
C	MDF	Fh
D	Construction wood	L/Is
E	Insulation	
F	Vapour retarder	Sh
G	Plasterboard	Ci
	Inside	
{(Ci),(Sh),(L/Is),(Fh),(Fh/Gv),(Co)}		

Source: http://www.dataholz.at/cgi-bin/WebObjects/dataholz.woa/wa/bauteil?language=de&kz=awroho04a		awroho04a
	Outside	
A	Wood Cladding	Co
B	Wind retarder	So
C	Construction wood	L/Is
D	Insulation	
E	Vapour retarder	Sh
F	Plasterboard	Ci
	Inside	
{(Ci),(Sh),(L/Is),(So),(Co)}		

Source: http://www.dataholz.at/cgi-bin/WebObjects/dataholz.woa/wa/bauteil?language=de&kz=awrhho01a		awrhho01a
	Outside	
A	Wood Cladding	Co
B	Rear ventilation	Fh/Gv
C	MDF	Fh
D	Construction wood	L/Is
E	Insulation	
F	OSB airtight taped	Sb
G	Plasterboard	Ci
	Inside	
{(Ci),(Sb),(L/Is),(Fh),(Fh/Gv),(Co)}		

Source: http://www.dataholz.at/cgi-bin/WebObjects/dataholz.woa/wa/bauteil?language=de&kz=awrhhi05a		awrhhi05a
	Outside	
A	Wood Cladding	Co
B	Rear ventilation	Fh/Gv
C	OSB	Fh
D	Construction wood	L/Is
E	Insulation	
F	OSB	Fh
G	Vapour retarder	Sh
H	Wooden battens	Fh/Is
I	Insulation	
J	Plasterboard	Ci
	Inside	
{(Ci),(Fh/Is),(Sh),(Fh),(L/Is),(Fh),(Fh/Gv),(Co)}		

Source: http://www.dataholz.at/cgi-bin/WebObjects/dataholz.woa/wa/bauteil?language=de&kz=awrhhi08a		awrhhi08a
	Outside	
A	Wood Cladding	Co
B	Rear ventilation	Fh/Gv
C	Wind retarder	So
D	Chipboard	Fh
E	Construction wood	L/Is
F	Insulation	
G	OSB airtight taped	Sb
H	Wooden battens	Fh/Is
I	Insulation	
J	Plasterboard	Ci
	Inside	
{(Ci),(Fh/Is),(Sb),(L/Is),(Fh),(So),(Fh/Gv),(Co)}		

Source: http://www.dataholz.at/cgi-bin/WebObjects/dataholz.woa/wa/bauteil?language=de&kz=awrohi01a		awrohi01a
	Outside	
A	Wood Cladding	Co
B	Counter battens	Fh/Ga
C	Wood wool plate	Ih
D	MDF	Fh
E	Construction wood	L/Is
F	Insulation	
G	OSB airtight taped	Sb
H	Wood battens	Fh/Is
I	Insulation	
J	Plasterboard	Ci
	Inside	
{(Ci),(Fh/Is),(Sb),(L/Is),(Fh),(Ih),(Fh/Ga),(Co)}		

Source: http://www.dataholz.at/cgi-bin/WebObjects/dataholz.woa/wa/bauteil?language=de&kz=awrhho02a		awrhho02a
	Outside	
A	Wood Cladding	Co
B	Rear ventilation	Fh/Gv
C	Wind retarder	So
D	Chipboard	Fh
E	Construction wood	L/Is
F	Insulation	
G	Chipboard	Fh
H	Vapour retarder	Sh
I	Plasterboard	Ci
	Inside	
{(Ci),(Sh),(Fh),(L/Is),(Fh),(So),(Fh/Gv),(Co)}		

Source: http://www.dataholz.at/cgi-bin/WebObjects/dataholz.woa/wa/bauteil?language=de&kz=awrohi01a		awrohi01a
	Outside	
A	Wood Cladding	Co
B	Counter battens	Fh/Ga
C	Wood wool plate	Ih
D	MDF	Fh
E	Construction wood	L/Is
F	Insulation	
G	OSB airtight taped	Sb
H	Wood battens	Fh/Is
I	Insulation	
J	Plasterboard	Ci
	Inside	
{(Ci),(Fh/Is),(Sb),(L/Is),(Fh),(Ih),(Fh/Ga),(Co)}		

Source: http://www.dataholz.at/cgi-bin/WebObjects/dataholz.woa/wa/bauteil?language=de&kz=awrhho08a		awrhho08a
	Outside	
A	Wood Cladding	Co
B	Rear ventilation	Fh/Gv
C	Wind retarder	So
D	Chipboard	Fh
E	Construction wood	L/Is
F	Insulation	
G	OSB airtight taped	Sb
H	Plasterboard	Ci
	Inside	
{(Ci),(Sb),(L/Is),(Fh),(So),(Fh/Gv),(Co)}		

Source: http://www.dataholz.at/cgi-bin/WebObjects/dataholz.woa/wa/bauteil?language=de&kz=awrohi04a		awrohi04a
	Outside	
A	Wood Cladding	Co
B	Wind retarder	So
C	Construction wood	L/Is
D	Insulation	
E	Chipboard	Fh
F	Vapour retarder	Sh
G	Wood battens	Fh/Is
H	Insulation	
I	Plasterboard	Ci
	Inside	
{(Ci),(Fh/Is),(Sh),(Fh),(L/Is),(So),(Co)}		

Source: http://www.dataholz.at/cgi-bin/WebObjects/dataholz.woa/wa/bauteil?language=de&kz=awropi01a		awropi01a
	Outside	
A	Plaster	Co
B	EPS	Ih
C	Chipboard	Fh
D	Construction wood	L/Is
E	Insulation	
F	Chipboard	Fh
G	Vapour retarder	Sh
H	Wood battens	Fh/Is
I	Insulation	
J	Plasterboard	Ci
	Inside	
{(Ci),(Fh/Is),(Sh),(Fh),(L/Is),(Fh),(Ih),(Co)}		

Source: http://www.dataholz.at/cgi-bin/WebObjects/dataholz.woa/wa/bauteil?language=de&kz=awroho02a		awroho02a
	Outside	
A	Wood Cladding	Co
B	Counter battens	Fh/Is
C	Wood wool plate	
D	MDF	Fh
E	Construction wood	L/Is
F	Insulation	
G	OSB airtight taped	Sb
H	Plasterboard	Ci
	Inside	
	{(Ci),(Sb),(L/Is),(Fh),(Fh/Is),(Co)}	

Source: http://www.dataholz.at/cgi-bin/WebObjects/dataholz.woa/wa/bauteil?language=de&kz=awropi09a		awropi09a
	Outside	
A	Plaster	Co
B	Cement-bonded wood wool panel	Ih
C	Construction wood	L/Is
D	Insulation	
E	Chipboard	Fh
F	Vapour retarder	Sh
G	Wood battens	Fh/Is
H	Insulation	
I	Plasterboard	Ci
	Inside	
	{(Ci),(Fh/Is),(Sh),(Fh),(L/Is),(Ih),(Co)}	

Source: http://www.dataholz.at/cgi-bin/WebObjects/dataholz.woa/wa/bauteil?language=de&kz=awropi04a		awropi04a
	Outside	
A	Plaster	Co
B	Wood fibre board	Ih
C	Construction wood	L/Is
D	Insulation	
E	OSB airtight taped	Sb
F	Wood battens	Fh/Is
G	Insulation	
H	Plasterboard	Ci
	Inside	
{(Ci),(Fh/Is),(Sb),(L/Is),(Ih),(Co)}		

Source: http://www.dataholz.at/cgi-bin/WebObjects/dataholz.woa/wa/bauteil?language=de&kz=awropi11a		awropi11a
	Outside	
A	Plaster	Co
B	Wood fibre board	Ih
C	MDF	Fh
D	Construction wood	L/Is
E	Insulation	
F	OSB airtight taped	Sb
G	Wood battens	Fh/Is
H	Insulation	
I	Plasterboard	Ci
	Inside	
{(Ci),(Fh/Is),(Sb),(L/Is),(Fh),(Ih),(Co)}		

Source: http://www.dataholz.at/cgi-bin/WebObjects/dataholz.woa/wa/bauteil?language=de&kz=awropo04a		awropo04a
	Outside	
A	Plaster	Co
B	Wood fibre board	Ih
C	Chipboard	Fh
D	Construction wood	L/Is
E	Insulation	
F	Vapour retarder	Sh
G	Plasterboard	Ci
	Inside	
{(Ci),(Sh),(L/Is),(Fh),(Ih),(Co)}		

Source: http://www.dataholz.at/cgi-bin/WebObjects/dataholz.woa/wa/bauteil?language=de&kz=awropo03a		awropo03a
	Outside	
A	Plaster	Co
B	Wood fibre board	Ih
C	Construction wood	L/Is
D	Insulation	
E	Chipboard	Fh
F	Vapour retarder	Sh
G	Plasterboard	Ci
	Inside	
{(Ci),(Sh),(Fh),(L/Is),(Ih),(Co)}		

Source: http://www.dataholz.at/cgi-bin/WebObjects/dataholz.woa/wa/bauteil?language=de&kz=awropo03a		awropo03a
	Outside	
A	Plaster	Co
B	Wood fibre board	Ih
C	Construction wood	L/Is
D	Insulation	
E	Chipboard	Fh
F	Vapour retarder	Sh
G	Plasterboard	Ci
	Inside	
{(Ci),(Sh),(Fh),(L/Is),(Ih),(Co)}		

Source: http://www.dataholz.at/cgi-bin/WebObjects/dataholz.woa/wa/bauteil?language=de&kz=awropo08a		awropo08a
	Outside	
A	Plaster	Co
B	Wood fibre board	Ih
C	Chipboard	Fh
D	Construction wood	L/Is
E	Insulation	
F	Chipboard	Fh
G	Vapour retarder	Sh
H	Plasterboard	Ci
	Inside	
{(Ci),(Sh),(Fh),(L/Is),(Fh),(Ih),(Co)}		

Source: http://www.dataholz.at/cgi-bin/WebObjects/dataholz.woa/wa/bauteil?language=de&kz=awropo19a		awropo19a
	Outside	
A	Plaster	Co
B	Wood fibre board	Ih
C	MDF	Fh
D	Construction wood	L/Is
E	Insulation	
F	OSB airtight taped	Sb
G	Plasterboard	Ci
	Inside	
{(Ci),(Sb),(L/Is),(Fh),(Ih),(Co)}		

Source: http://www.dataholz.at/cgi-bin/WebObjects/dataholz.woa/wa/bauteil?language=de&kz=awropo09a		awropo09a
	Outside	
A	Plaster	Co
B	Wood fibre board	Ih
C	Construction wood	L/Is
D	Insulation	
E	OSB airtight taped	Sb
F	Plasterboard	Ci
	Inside	
{(Ci),(Sb),(L/Is),(Ih),(Co)}		

7.1.5 Outsidewall to earth, massiv

Master Template:

{<(Cl)|(Ci),(L),<(Sw)|(Sw),(Sw)>>,(Iw),[Fh],(Co)}

Source: http://www.baubook.at/phbtk/index_BTR.php?SW=19		EAm 01 a
	Inside	
A	Gipsumplaster	Ci
B	Waterproof reinforced concrete	L
C	Bitumencoating	Sw
D	XPS-G 50	Iw
E	Drainage panel EPS	Fh
F	PP Fleece	Co
	Outside	
{(Ci),(L),(Sw),(Iw),(Fh),(Co)}		

Source: Beinhauer Baudetails dr04.pdf		Brickwall
	Inside	
A	Plaster	Ci
B	Brickwall	L
C	Vertical humidity sealing	Sw
D	XPS insulation	Iw
E	Filter fleece	Co
	Outside	
{(Ci),(L),(Sw),(Iw),(Co)}		

Source: http://www.baubook.at/phbtk/index_BTR.php?SW=19		EAm 01 a
	Inside	
A	Waterproof reinforced concrete	Cl
B	XPS-G 50	Iw
C	Drainage panel EPS	Fh
D	PP Fleece	Co
	Outside	
{(Cl),(Iw),(Fh),(Co)}		

Source: http://www.baubook.at/phbtk/index_BTR.php?SW=19		EAm 02 b, EAm 03 a, EAm 04 a
	Inside	
A	Clayplaster	Ci
B	Reinforced Concrete	L
C	Polymerbitumen sealing	Sw
D	Bitumencoating	Sw
E	XPS-G 50	Iw
F	Concrete drainage panel	Fh
G	PP fleece	Co
	Outside	
{(Ci),(L),(Sw),(Sw),(Iw),(Fh),(Co)}		

7.1.6 Inside wall, massive wood and mineral

Master Template:

`{<Cl|Ci,[Fh|Fh/Is],L>,[Fh],[Fh/Is],(Co)}`

Source: Handbuch & Planungshilfe Baukonstruktion, S.209, Abb.84		Brickwall plastered
	Inside	
A	Plaster	Ci
B	Brickwall	L
C	Plaster	Co
	Outside	
{(Ci),(L),(Co)}		

Source: http://www.dataholz.at/cgi-bin/WebObjects/dataholz.woa/wa/bauteil?language=de&kz=iwmxxo01b		iwmxxo01b
	Inside	
A	Plasterboard	Ci
B	Plasterboard	Fh
C	Cross laminated timber	L
D	Plasterboard	Fh
E	Plasterboard	Co
	Outside	
{(Ci),(Fh),(L),(Fh),(Co)}		

Source: http://www.dataholz.at/cgi-bin/WebObjects/dataholz.woa/wa/bauteil?language=de&kz=iwmxxi01b		iwmxxi02b
	Inside	
A	Plasterboard	Ci
B	Wooden lathering	Fh/Is
C	Mineral wool	
D	Cross laminated timber	L
E	Wooden lathering	Fh/Is
F	Mineral wool	
G	Plasterboard	Co
	Outside	
{(Ci),(Fh/Is),(L),(Fh/Is),(Co)}		

Source: http://www.dataholz.at/cgi-bin/WebObjects/dataholz.woa/wa/bauteil?language=de&kz=iwmxxi01b		iwmxxi01b
	Inside	
A	Cross laminated timber	Cl
B	Wooden lathering →	Fh/Is
C	Mineral wool	
D	Plasterboard	Fh
E	Plasterboard	Co
	Outside	
{(Cl),(Fh/Is),(Fh),(Co)}		

Source: http://www.baubook.at/phbtk/index_BTR.php?SW=19		IWm 05 a
	Inside	
A	Plasterboard	Ci
B	Mineralwool between swinging hoops	Fh/Is
C	Brick filled with concrete	L
D	Lime cement plaster	Co
	Outside	
{(Ci),(Fh/Is),(L),(Co)}		

7.1.7 Inside wall, framework

Master Template:

`{(Ci),<[Fh/Is],[Fh],[Fh]|[Fh,L/Is,[Fh],[Fh],Ih,Fh,[Fh]]>,(L/Is),[Fh],[Fh],[Fh/Is],(Co)}`

Source: http://www.baubook.at/phbtk/index_BTR.php?SW=19		IWI 02 a
	Inside	
A	Plasterboard	Ci
B	Plasterboard	Fh
C	Glass wool in between metal profiles	L/Is
D	Glass wool	Ih
E	Plasterboard	Fh
F	Glass wool in between metal profiles	L/Is
G	Plasterboard	Fh
H	Plasterboard	Co
	Outside	
{(Ci),(Fh),(L/Is),(Ih),(Fh),(L/Is),(Fh),(Co)}		

Source: http://www.baubook.at/phbtk/index_BTR.php?SW=19		IWI 04 a
	Inside	
A	Plasterboard	Ci
B	Glass wool in between metal profiles	Fh/Is
C	Plasterboard	Fh
D	Plasterboard	Fh
E	Glass wool in between construction wood	L/Is
F	Plasterboard	Fh
G	Plasterboard	Fh
H	Glass wool in between metal profiles	Fh/Is
I	Plasterboard	Co
	Outside	
{(Ci),(Fh/Is),(Fh),(Fh),(L/Is),(Fh),(Fh),(Fh/Is),(Co)}		

Source: http://www.baubook.at/phbtk/index_BTR.php?SW=19		IWI 01 a
	Inside	
A	Plasterboard	Ci
B	Glass wool in between metal profiles	L/Is
C	Plasterboard	Co
	Outside	
{(Ci),(L/Is),(Co)}		

Source: http://www.dataholz.at/cgi-bin/WebObjects/dataholz.woa/wa/bauteil?language=de&kz=iwrxxo03b		iwrxxo03b
	Inside	
A	Plasterboard	Ci
B	Plasterboard	Fh
C	Glass wool in between metal profiles	L/Is
D	Plasterboard	Fh
E	Plasterboard	Co
	Outside	
{(Ci),(Fh),(L/Is),(Fh),(Co)}		

Source: http://www.dataholz.at/cgi-bin/WebObjects/dataholz.woa/wa/bauteil?language=de&kz=iwrxxo06a		iwrxxo06a
	Inside	
A	Plasterboard	Ci
B	Plasterboard	Fh
C	OSB	Fh
D	Glass wool in between metal profiles	L/Is
E	OSB	Fh
F	Plasterboard	Fh
G	Plasterboard	Co
	Outside	
{(Ci),(Fh),(Fh),(L/Is),(Fh),(Fh),(Co)}		

Source: http://www.baubook.at/phbtk/index_BTR.php?SW=19		IWI 03 a
	Inside	
A	Plasterboard	Ci
B	Plasterboard	Fh
C	Glass wool in between construction wood	L/Is
D	Plasterboard	Fh
E	Plasterboard	Fh
F	Glass wool	Ih
G	Plasterboard	Fh
H	Plasterboard	Fh
I	Glass wool in between construction wood	L/Is
J	Plasterboard	Fh
K	Plasterboard	Co
	Outside	
{(Ci),(Fh),(L/Is),(Fh),(Fh),(Ih),(Fh),(Fh),(L/Is),(Fh),(Co)}		

7.1.8 Slab massiv to earth

Master Template:

{(Ci),(Fl),<Fs,If,[Fl]|<Ih,Il|Fs,Iw,Fs>,Sw>,(L),<Fs,<Iw|Fl>|Sh,<Ih|Iw,Sw,Fh,Fs,Fl>>,(Co)}

Source: Beinhauer Baudetails md16.pdf, Isover 1.1.2.		Slab to earth
	Inside	
A	Tiles	Ci
B	Screed	Fl
C	PE foil	Fs
D	Waterproof insulation	Iw
E	PE foil	Fs
F	Sealing	Sw
G	Reinforced concrete slab	L
H	Separation layer	Fs
I	XPS insulation	Iw
J	Subbase of lean concrete	Co
	Outside	
{(Ci),(Fl),(Fs),(Iw),(Fs),(Sw),(L),(Fs),(Iw),(Co)}		

Source: http://www.baubook.at/phbtk/index_BTR.php?SW=19		Efo 01 b
	Inside	
A	Wooden floor	Ci
B	Screed	Fl
C	Woodfiber WF-T	Ih
D	Expanded perlit fill	Il
E	Aluminium-bitumen sealing	Sw
F	Reinforced concrete	L
G	Construction paper	Fs
H	Sand, chippings and gravel fill	Fl
I	PP fleece	Co
	Outside	
{(Ci),(Fl),(Ih),(Il),(Sw),(L),(Fs),(Fl),(Co)}		

Source: http://www.baubook.at/phbtk/index_BTR.php?SW=19		Efu 01 a
	Inside	
A	Wooden floor	Ci
B	Screed	Fl
C	PE Sealing	Fs
D	Glaswool MW (GW)-T	If
E	Reinforced concrete	L
F	PE Sealing	Sh
G	Foamglasinsulation	Iw
H	Polymerbitumen sealing	Sw
I	Subbase of lean concrete	Fh
J	Construction paper	Fs
K	Sand, chippings and gravel fill	Fl
L	PP fleece	Co
	Outside	
{(Ci),(Fl),(Fs),(If),(L),(Sh),(Iw),(Sw),(Fh),(Fs),(Fl),(Co)}		

Source: http://www.baubook.at/phbtk/index_BTR.php?SW=19		Efu 10 a
A	Inside	
B	Wooden floor	Ci
C	Screed	Fl
D	PE Sealing	Fs
E	Glaswool MW (GW)-T	If
F	Waterproof reinforced concrete	L
G	Construction paper	Fs
H	Sand, chippings and gravel fill	Fl
I	PP fleece	Co
	Outside	
{(Ci),(Fl),(Fs),(If),(L),(Fs),(Fl),(Co)}		

Source: http://www.baubook.at/phbtk/index_BTR.php?SW=19		Efu 11 a
	Inside	
A	Wooden floor	Ci
B	Screed	Fl
C	PE sealing	Fs
D	Glaswool MW (GW)-T	If
E	Cement-bounded EPS filling	Fl
F	Waterproof reinforced concrete	L
G	PE sealing	Sh
H	Glass foam gravel fill	Iw
I	PP fleece	Co
	Outside	
{(Ci),(Fl),(Fs),(If),(Fl),(L),(Sh),(Iw),(Co)}		

7.1.9 Pitched Roof, framework wood

Master Template:

{<(Cl),(Fh),(Sh)|(Ci),[Fh],(Fh/<Is|Ga>),<Sb|Sh[Fh]>,(L/Is)>[Fh|Fh/Is],[Fh/Is],<So|Sb>,(Fh/Gv),[Fh,Fs|Fh/Ga],(Co)}

Source: http://www.baubook.at/phbtk/index_BTR.php?SW=19		Dal 01 a
	Inside	
A	Plasterboard	Ci
B	Plasterboard	Fh
C	Glass wool within wooden battens	Fh/Is
D	Vapor retarder	Sh
E	Chipboard	Fh
F	Glass wool within construction wood	L/Is
G	Glass wool within wooden battens	Fh/Is
H	Chipboard, bitumen coated	Sb
I	Rear ventilation	Fh/Gv
J	Roof lathing	Fh/Ga
K	Clay roof tiles	Co
	Outside	
{(Ci),(Fh),(Fh/Is),(Sh),(Fh),(L/Is),(Fh/Is),(Sb),(Fh/Gv),(Fh/Ga),(Co)}		

Source: http://www.baubook.at/phbtk/index_BTR.php?SW=19		Dal 02 a
	Inside	
A	Construction wood	Cl
B	Wooden lathing	Fh
C	Vapor retarder	Sh
D	Glass wool within construction wood	Fh/Is
E	Glass wool within construction wood	Fh/Is
F	Wooden fiber board	Fh
G	PE diffusion open sealing	So
H	Rear ventilation	Fh/Gv
I	Roof lathing	Fh/Ga
J	Clay roof tiles	Co
	Outside	
{(Cl),(Fh),(Sh),(Fh/Is),(Fh/Is),(So),(Fh/Gv),(Fh/Ga),(Co)}		

Source: http://www.baubook.at/phbtk/index_BTR.php?SW=19		Dal 03 a
	Inside	
A	Plasterboard	Ci
B	Plasterboard	Fh
C	Glass wool within wooden battens	Fh/Is
D	Vapor retarder	Sh
E	Chipboard	Fh
F	Glass wool within OSB	
G	Glass wool within construction wood	→ L/Is
H	Glass wool within OSB	
I	MDF	Fh
J	PE diffusion open sealing	So
K	Rear ventilation	Fh/Gv
L	Roof lathing	Fh/Ga
M	Clay roof tiles	Co
	Outside	
{(Ci),(Fh),(Fh/Is),(Sh),(Fh),(L/Is),(Fh),(So),(Fh/Gv),(Fh/Ga),(Co)}		

Source: http://www.baubook.at/phbtk/index_BTR.php?SW=19		Dal 03 a
	Inside	
A	Plasterboard	Ci
B	Plasterboard	Fh
C	Glass wool within wooden battens	Fh/Is
D	OSB	Sb
E	Glass wool within construction wood	
F	Glass wool within OSB	→ L/Is
G	Glass wool within construction wood	
H	Wooden fiber board, bitumen coated	Sb
I	Rear ventilation	Fh/Gv
J	Wooden lathing	Fh
K	PP mat	Fs
L	Aluminum sheet	Co
	Outside	
{(Ci),(Fh),(Fh/Is),(Sb),(L/Is),(Sb),(Fh/Gv),(Fh),(Fs),(Co)}		

Source: http://www.dataholz.at/cgi-bin/WebObjects/dataholz.woa/wa/bauteil?language=de&kz=sdrhzi07a		sdrhzi07a
	Outside	
A	Concrete roofing tile	Ci
B	Wooden lathing	Fh/Ga
C	Rear ventilation	Fh/Gv
D	Vapour open sealing	So
E	OSB	Fh
F	Construction wood	→ L/Is
G	Glass wool	
H	OSB	Fh
I	Vapour retarder	Sh
J	Wooden lathing	Fh/Ga
K	Plasterboard	Co
	Inside	
{(Ci),(Fh/Ga),(Sh),(Fh),(L/Is),(Fh),(So),(Fh/Gv),(Fh/Ga),(Co)}		

Source: http://www.dataholz.at/cgi-bin/WebObjects/dataholz.woa/wa/bauteil?language=de&kz=sdrhzi06a		sdrhzi06a
	Outside	
A	Concrete roofing tile	Ci
B	Wooden lathing	Fh/Ga
C	Rear ventilation	Fh/Gv
D	Vapour open sealing	So
E	Wooden boarding	Fh
F	Construction wood	→ L/Is
G	Glass wool	
H	OSB airtight taped	Sb
I	Wooden lathing	→ Fh/Is
J	Glass wool	
K	Plasterboard	Co
	Inside	
{(Ci),(Fh/Is),(Sb),(L/Is),(Fh),(So),(Fh/Gv),(Fh/Ga),(Co)}		

Source: http://www.dataholz.at/cgi-bin/WebObjects/dataholz.woa/wa/bauteil?language=de&kz=sdrhzi02a		sdrhzi02a
	Outside	
A	Concrete roofing tile	Ci
B	Wooden lathing	Fh/Ga
C	Rear ventilation	Fh/Gv
D	Vapour open sealing	So
E	Wooden boarding	Fh
F	Construction wood	L/Is
G	Glass wool	
H	Vapour retarder	Sh
I	Wooden lathing	Fh/Ga
J	Plasterboard	Co
	Inside	
{(Ci),(Fh/Ga),(Sh),(L/Is),(Fh),(So),(Fh/Gv),(Fh/Ga),(Co)}		

7.1.10 Pitched Roof, massive wood and mineral

Master Template:

{<Cl|Ci,[Fh/Is],L>,[Sh],<Fh/Is|Ih>,[Fh],(So),(Fh/Gv),[Fh,Fs|Fh/Ga],(Co)}

Source: http://www.dataholz.at/cgi-bin/WebObjects/dataholz.woa/wa/bauteil?language=de&kz=sdmhzo01		sdmhzo01
	Outside	
A	Concrete roofing tile	Co
B	Wooden lathing	Fh/Ga
C	Rear ventilation	Fh/Gv
D	Vapour open sealing	So
E	Insulation over rafters	Ih
F	Vapour retarder	Sh
G	Cross laminated timber	Cl
	Inside	
{(Cl),(Sh),(Ih),(So),(Fh/Gv),(Fh/Ga),(Co)}		

Source: http://www.dataholz.at/cgi-bin/WebObjects/dataholz.woa/wa/bauteil?language=de&kz=sdmhzi01		sdmhzi01
	Outside	
A	Concrete roofing tile	Co
B	Wooden lathing	Fh/Ga
C	Rear ventilation	Fh/Gv
D	Vapour open sealing	So
E	Wooden battens	Fh/Is
F	Mineral wool	
G	Vapour retarder	Sh
H	Cross laminated timber	L
I	Lathing on swinging hoops	Fh/Is
J	Mineral wool	
I	Plasterboard	Ci
	Inside	
{(Ci),(Fh/Is),(L),(Sh),(Fh/Is),(So),(Fh/Gv),(Fh/Ga),(Co)}		

Source: https://www.baubook.at/BTR/PHP/Win_E_Ausdruck.php?SW=19&SBT=99108,99109&Frame=y&backTo=BauteilKategorien_BTKat4		Dam 01 a
	Outside	
A	Clay roofing tile	Co
B	Wooden lathing	Fh/Ga
C	Rear ventilation	Fh/Gv
D	Vapour open sealing	So
E	Wooden boarding	Fh
F	Glass wool within construction wood	
G	Glass wool within OSB	Fh/Is
H	Glass wool within construction wood	
I	Reinforced Concrete	L
JI	Plaster	Ci
	Inside	
{(Ci),(L),(Fh/Is),(Fh),(So),(Fh/Gv),(Fh/Ga),(Co)}		

7.1.11 Flatroof, massive concrete

Master Template:

{(Ci),(L),[Fs],[Sv],<Fh/Is|Ih>,[Fs|Fh],<So,Fh/Gv|Sw[Iw]|Sh>,[Fh,Fs|Fh,Fl,Fs|Fh,Fh/Ga|Fs],(Co)}

Source: http://www.baubook.at/phbtk/index_BTR.php?SW=19		DAm 02 a
	Inside	
A	Gypsum plaster	Ci
B	Reinforced concrete	L
C	Glass wool within construction wood	
D	Glass wool within OSB	Fh/Is
E	Glass wool within construction wood	
F	Wooden planking	Fh
G	Diffusion open sealing	So
H	Rear ventilation	Fh/Gv
I	Wooden planking	Fh
J	PP fleece	Fs
K	PE sealing	Co
	Outside	
{(Ci),(L),(Fh/Is),(Fh),(So),(Fh/Gv),(Fh),(Fs),(Co)}		

Source: http://www.baubook.at/phbtk/index_BTR.php?SW=19		DAm 03 a
	Inside	
A	Gypsum plaster	Ci
B	Reinforced concrete	L
C	Vapor pressure equalizing layer	Fs
D	Aluminum bitumen sealing	Sv
E	EPS-W	Ih
F	Vapor pressure equalizing layer	Fs
G	Polymer bitumen sealing	Sw
H	Sand, gravel and chippings layer	Co
	Outside	
{(Ci),(L),(Fs),(Sv),(Ih),(Fs),(Sw),(Co)}		

Source: http://www.baubook.at/phbtk/index_BTR.php?SW=19		DAm 04 a
	Inside	
A	Gypsum plaster	Ci
B	Reinforced concrete	L
C	Vapor pressure equalizing layer	Fs
D	Aluminum bitumen sealing	Sv
E	EPS-W	Ih
F	Vapor pressure equalizing layer	Fs
G	Polymer bitumen sealing	Sw
H	Rubber granulate mat	Fh
I	Sand, gravel and chippings layer	Fl
J	PP fleece	Fs
K	Plant substrate	Co
	Outside	
{(Ci),(L),(Fs),(Sv),(Ih),(Fs),(Sw),(Fh),(Fl),(Fs),(Co)}		

Source: http://www.baubook.at/phbtk/index_BTR.php?SW=19		DAm 05 b
	Inside	
A	Clay plaster	Ci
B	Reinforced concrete	L
C	PE vapor barrier	Sv
D	Insulating cork	Ih
E	PE sealing	Fs
F	PE vapor retarder	Sh
G	Concrete	Fh
H	Wooden battens	Fh/Ga
I	Wooden terrace floor	Co
	Outside	
{(Ci),(L),(Sv),(Ih),(Fs),(Sh),(Fh),(Fh/Ga),(Co)}		

Source: http://www.baubook.at/phbtk/index_BTR.php?SW=19		DAm 07 b
	Inside	
	Gypsum plaster	Ci
A	Reinforced concrete	L
B	EPS-W 25	Ih
C	Polymer bitumen sealing	Sw
D	XPS-G 30	Iw
E	PP fleece	Fs
F	Sand, gravel and chippings layer	Co
G	Outside	
{(Ci),(L),(Ih),(Sw),(Iw),(Fs),(Co)}		

7.1.12 Flatroof, massiv wood

Master Template:

{<Ci,Fh/<Is|Ga>,L|Cl>[Fs],<Sv|Sh>,(Ih),[Sb,Fh/Gv,Fh/Ga|Sw,<Fs|Fh>|If,Fs,Sw,Fh/Ga],(Co)}

Source: http://www.baubook.at/phbtk/index_BTR.php?SW=19		Dah 01 a
	Outside	
A	Sand, gravel and chippings layer	Co
B	Rubber granulate mat	Fh
C	Polymer bitumen sealing	Sw
D	Stone wool MW(SW)-W	Ih
E	Aluminum bitumen sealing	Sv
F	Vapor pressure equalizing layer	Fs
G H	Cross laminated timber	L
I	Plasterboard	Fh
J	Plasterboard	Ci
	Inside	
{(Ci),(Fh),(L),(Fs),(Sv),(Ih),(Sw),(Fh),(Co)}		

Source: http://www.dataholz.at/cgi-bin/WebObjects/dataholz.woa/wa/bauteil?language=de&kz=fdmnti01a		fdmnti01a
	Inside	
	Plasterboard	Ci
A	Mineral wool →	Fh/Is
B	Wooden battens with Swinging hoops ↑	
C	Cross laminated timber	L
D	Bitumen sealing	Sh
E	Insulation	Ih
F	Footfall insulation MW-T	If
G	Fleece	Fs
H	Roof insulation	Sw
I	Wooden terrace floor on battens →	Fh/Ga
J	↳	Co
	Outside	
{(Ci),(Fh/Is),(L),(Sh),(Ih),(If),(Fs),(Sw),(Fh/Ga),(Co)}		

Source: http://www.dataholz.at/cgi-bin/WebObjects/dataholz.woa/wa/bauteil?language=de&kz=fdmnko01		fdmnko01
	Inside	
A	Cross laminated timber	Cl
B	Bitumen sealing	Sh
C	Insulation	Ih
D	Roof sealing	Sw
E	Fleece	Fs
F	Chipping layer	Co
	Outside	
{(Cl),(Sh),(Ih),(Sw),(Fs),(Co)}		

Source: http://www.dataholz.at/cgi-bin/WebObjects/dataholz.woa/wa/bauteil?language=de&kz=fdmnbi01a		fdmnbi01a
	Inside	
	Plasterboard	Ci
A	Mineral wool	Fh/Is
B	Swinging hoops	
C	Cross laminated timber	L
D	Bitumen sealing	Sh
E	Insulation	Ih
F	Roof sealing EPDM	Co
	Outside	
{(Ci),(Fh/Is),(L),(Sh),(Ih),(Co)}		

Source: http://www.dataholz.at/cgi-bin/WebObjects/dataholz.woa/wa/bauteil?language=de&kz=fdmobi01a		fdmobi01a
	Inside	
A	Plasterboard	Ci
B	Mineral wool	Fh/Is
C	Wooden battens with Swinging hoops	
D	Cross laminated timber	L
E	Bitumen sealing	Sh
F	Insulation	Ih
G	Plastic cover	Co
	Outside	
{(Ci),(Fh/Is),(L),(Sh),(Ih),(Co)}		

Source: http://www.dataholz.at/cgi-bin/WebObjects/dataholz.woa/wa/bauteil?language=de&kz=fdmhbo01		fdmhbo01
	Inside	
A	Cross laminated timber	Cl
B	Bitumen sealing	Sh
C	Insulation	Ih
D	Under roof boards	Sb
E	Counter battens	Fh/Gv
F	Wood battens	Fh/Ga
G	Metal sheet elements	Co
	Outside	
{(Cl),(Sh),(Ih),(Sb),(Fh/Gv),(Fh/Ga),(Co)}		

Source: http://www.dataholz.at/cgi-bin/WebObjects/dataholz.woa/wa/bauteil?language=de&kz=fdmhbi01b		fdmhbi01b
	Inside	
A	Plasterboard	Ci
B	Mineral wool →	Fh/Is
C	Wooden battens with Swinging hoops ↑	
D	Cross laminated timber	L
E	Bitumen sealing	Sh
F	Insulation	Ih
G	Under roof boards	Sb
H	Counter battens	Fh/Gv
I	Wood battens	Fh/Ga
J	Metal sheet elements	Co
	Outside	
{(Ci),(Fh/Is),(L),(Sh),(Ih),(Sb),(Fh/Gv),(Fh/Ga),(Co)}		

7.1.13 Flatroof, framework wood

Master Template:

{(Ci),[Fh],[Fh/<Is|Ga>],<Sv,[Fh]|Sh,[Fh]|Sb>,(L/Is),[Fh,Sw,Iw,Fs|Fh,So,[Fs],Fh/Gv,Fh[Fs,Sw,Fl]],(Co)}

Source: http://www.baubook.at/phbtk/index_BTR.php?SW=19		Dal 05 a
	Inside	
A	Plasterboard	Ci
B	Plasterboard	Fh
C	Glass wool within wood poles	Fh/Is
D	Aluminum sealing	Sv
E	Chipboard	Fh
F	Glass wool within OSB	
G	Glass wool within OSB	L/Is
H	Glass wool within OSB	
I	Chipboard	Fh
J	Polymer bitumen sealing	Sw
K	XPS-G	Iw
L	PP fleece	Fs
M	Sand, gravel and chippings layer	Co
	Outside	
{(Ci),(Fh),(Fh/Is),(Sv),(Fh),(L/Is),(Fh),(Sw),(Iw),(Fs),(Co)}		

Source: http://www.baubook.at/phbtk/index_BTR.php?SW=19		Dal 05 a
	Inside	
A	OSB	Ci
B	Vapor retarder	Sh
C	Stone wool	Fh/Is
D	Construction wood	
E	OSB	Fh
F	Roof sealing EPDM	Co
	Outside	
{(Ci),(Fh),(Fh/Is),(Sv),(Fh),(L/Is),(Co)}		

Source: http://www.baubook.at/phbtk/index_BTR.php?SW=19		Dal 06 a
	Inside	
A	Plasterboard	Ci
B	Plasterboard	Fh
C	Glass wool within swinging hoops	Fh/Is
D	Vapor retarder	Sh
E	OSB	Fh
F	Glass wool within construction wood	L/Is
G	OSB	Fh
H	PE diffusion open sealing	So
I	PUR sound absorption mat	Fs
J	Rear ventilation	Fh/Gv
K	Construction wood	Fh
L	Vapor pressure equalizing layer	Fs
M	Polymer bitumen sealing	Sw
N	Sand, gravel and chippings layer	Fl
O	Concrete	Co
	Outside	
{(Ci),(Fh),(Fh/Is),(Sh),(Fh),(L/Is),(Fh),(So),(Fs),(Fh/Gv),(Fh),(Fs),(Sw),(Fl),(Co)}		

Source: http://www.dataholz.at/cgi-bin/WebObjects/dataholz.woa/wa/bauteil?language=de&kz=fdrhbi01a		fdrhbi01a
	Outside	
A	Metal sheet roof	Co
B	Wooden full lathing	Fh
C	Rear ventilation	Fh/Gv
D	Under roof sealing	So
E	Wooden fiber board	Fh
F	Construction wood	L/Is
G	Stone wool	
H	Vapor retarder	Sh
I	Counter battens	Fh/Is
J	Stone wool	
K	Plasterboard	Ci
	Inside	
{(Ci),(Fh/Is),(Sh),(L/Is),(Fh),(So),(Fh/Gv),(Fh),(Co)}		

Source: http://www.dataholz.at/cgi-bin/WebObjects/dataholz.woa/wa/bauteil?language=de&kz=fdrhbi01a		fdrhbi06a
	Outside	
A	Metal sheet roof	Co
B	Wooden full lathing	Fh
C	Rear ventilation	Fh/Gv
D	Under roof sealing	So
E	OSB	Fh
F	Construction wood	L/Is
G	Stone wool	
H	Vapor retarder	Sh
I	OSB	Fh
J	Counter battens	Fh/Is
K	Stone wool	
L	Plasterboard	Ci
	Inside	
{(Ci),(Fh/Is),(Fh),(Sh),(L/Is),(Fh),(So),(Fh/Gv),(Fh),(Co)}		

Source: http://www.dataholz.at/cgi-bin/WebObjects/dataholz.woa/wa/bauteil?language=de&kz=fdrhbi10a		fdrhbi10a
	Outside	
A	Metal sheet roof	Co
B	Wooden full lathing	Fh
C	Rear ventilation	Fh/Gv
D	Under roof sealing	So
E	MDF	Fh
F	Construction wood	L/Is
G	Stone wool	
H	OSB airtight taped	Sb
I	Counter battens	Fh/Is
J	Stone wool	
L	Plasterboard	Ci
	Inside	
{(Ci),(Fh/Is),(Sb),(L/Is),(Fh),(So),(Fh/Gv),(Fh),(Co)}		

Source: http://www.dataholz.at/cgi-bin/WebObjects/dataholz.woa/wa/bauteil?language=de&kz=fdrhbi03a		fdrhbi03a
	Outside	
A	Metal sheet roof	Co
B	Wooden full lathing	Fh
C	Rear ventilation	Fh/Gv
D	Under roof sealing	So
E	OSB	Fh
F	Construction wood	L/Is
G	Stone wool	
H	OSB	Fh
I	Vapour retarder	Sh
J	Battens	Fh/Ga
K	Plasterboard	Ci
	Inside	
{(Ci),(Fh/Ga),(Sh),(Fh),(L/Is),(Fh),(So),(Fh/Gv),(Fh),(Co)}		

Source: http://www.dataholz.at/cgi-bin/WebObjects/dataholz.woa/wa/bauteil?language=de&kz=fdrhbi04a		fdrhbi04a
	Outside	
A	Metal sheet roof	Co
B	Wooden full lathing	Fh
C	Rear ventilation	Fh/Gv
D	Under roof sealing	So
E	OSB	Fh
F	Construction wood	L/Is
G	Stone wool	
H	OSB airtight taped	Sb
I	Battens	Fh/Ga
J	Plasterboard	Ci
	Inside	
{(Ci),(Fh/Ga),(Sb),(L/Is),(Fh),(So),(Fh/Gv),(Fh),(Co)}		

7.1.14 Ceiling, massive, mineral

Master Template:

{(Ci),[Sw,Fl,Fs|Fl,Fs|Fl,Sh],<If,[Fl|Ih|Sh]|Il|Fh,Fh/Is>,[Fh,Fh/Is],<Cl|L,[Fh/Is|Ih|Ih,Ih],(Co)}

Source: http://www.baubook.at/phbtk/index_BTR.php?SW=19		GDm 01 a
	Inside	
A	Tiles	Ci
B	Liquid sealing	Sw
C	Screed	Fl
D	PE sealing	Fs
E	EPS-T 1000	If
F	Reinforced concrete	L
G	Gypsum plaster	Co
	Outside	
{(Ci),(Sw),(Fl),(Fs),(If),(L),(Co)}		

Source: http://www.baubook.at/phbtk/index_BTR.php?SW=19		GDm 02 a
	Inside	
A	Wooden floor	Ci
B	Chipboard	Fh
C	Mineral wool within metal profiles	Fh/Is
D	Reinforced concrete	L
E	Gypsum plaster	Co
	Outside	
{(Ci),(Fh),(Fh/Is),(L),(Co)}		

Source: http://www.baubook.at/phbtk/index_BTR.php?SW=19		GDm 03 a
	Inside	
A	Wooden floor	Ci
B	Screed	Fl
C	PE sealing	Fs
D	Glass wool MW(GW)-W	If
E	Chipping filling	Fl
F	Hollow brick elements	L
G	Gypsum plaster	Co
	Outside	
{(Ci),(Fl),(Fs),(If),(Fl),(L),(Co)}		

Source: http://www.baubook.at/phbtk/index_BTR.php?SW=19		ADm 01 a
	Inside	
A	Wooden floor	Ci
B	Chipboard	Fh
C	Mineral wool within metal profiles	Fh/Is
D	Reinforced Concrete	L
E	EPS-F	Ih
F	Silicate plaster	Co
	Outside	
{(Ci),(Fh),(Fh/Is),(L),(Ih),(Co)}		

Source: http://www.baubook.at/phbtk/index_BTR.php?SW=19		KDb 01 a
	Inside	
A	Wooden floor	Ci
B	Screed	Fl
C	Vapor retarder	Sh
D	Bound EPS granules	Il
E	Reinforced Concrete	L
F	Wood wool board	Ih
G	Stone wool MW(SW)-W	Ih
H	Wood wool board	Co
	Outside	
{(Ci),(Fl),(Sh),(Il),(L),(Ih),(Ih),(Co)}		

Source: http://www.baubook.at/phbtk/index_BTR.php?SW=19		KDo 01 a
	Inside	
A	Wooden floor	Ci
B	Screed	Fl
C	Vapor retarder	Sh
D	EPS-T 1000	If
E	EPS-W 20	Ih
F	Reinforced Concrete	Cl
	Outside	
{(Ci),(Fl),(Sh),(If),(Ih),(Cl)}		

Source: http://www.baubook.at/phbtk/index_BTR.php?SW=19		KDo 02 a
	Inside	
A	Wooden floor	Ci
B	PE foam	If
C	Vapor retarder	Sh
D	Chipboard	Fh
E	Mineral wool within metal profiles	Fh/Is
F	Reinforced Concrete	Cl
	Outside	
{(Ci),(If),(Sh),(Fh),(Fh/Is),(Cl)}		

Source: http://www.baubook.at/phbtk/index_BTR.php?SW=19		KDu 01 a
	Inside	
A	Wooden floor	Ci
B	Screed	Fl
C	PE sealing	Fs
D	Glass wool MW(GW)-W	If
E	Sand, chipping and gravel filling	Fl
F	Reinforced Concrete	L
G	Mineral wool within metal profiles	Fh/Is
H	Wood wool plate	Co
	Outside	
{(Ci),(Fl),(Fs),(If),(Fl),(L),(Fh/Is),(Co)}		

7.1.15 Ceiling, massive wood

Master Template:

{(Ci),<[Fl,[Fs]],If,Fl,[Fs|Sh]|Fh/Is>,<Cl|L,<So|Fh/Is,[Fh|Fh/Is,[Sw]]>,Co>

Source: http://www.baubook.at/phbtk/index_BTR.php?SW=19		GDh 01 a
	Inside	
A	Wooden floor	Ci
B	Screed	Fl
C	PE sealing	Fs
D	Glass wool MW(GW)-W	If
E	Chipping filling	Fl
F	PE sealing	Fs
G	Cross laminated timber	L
H	Mineral wool within swinging hoops	Fh/Is
I	Plasterboard	Fh
J	Plasterboard	Co
K		
L		
	Outside	
{(Ci),(Fl),(Fs),(If),(Fl),(Fs),(L),(Fh/Is),(Fh),(Co)}		

Source: http://www.baubook.at/phbtk/index_BTR.php?SW=19		ADh 01 a
	Inside	
A	Wooden floor	Ci
B	Screed	Fl
C	PE sealing	Fs
D	Glass wool MW(GW)-W	If
E	Chipping filling	Fl
F	Vapor retarder	Sh
G	Cross laminated timber	L
H	Glass wool within construction wood	Fh/Is
I	Glass wool within construction wood	Fh/Is
J	Wind breaker	So
K	Wood cladding	Co
L		
M		
	Outside	
{(Ci),(Fl),(Fs),(If),(Fl),(Sh),(L),(Fh/Is),(Fh/Is),(Sw),(Co)}		

Source: http://www.dataholz.at/cgi-bin/WebObjects/dataholz.woa/wa/bauteil?language=de&kz=gdmtxa01a		gdmtxa01a
	Inside	
A	Dry screed	Ci
B	Footfall sound insulation	If
C	Chipping filling	Fl
D	Tickle protection	Fs
E	Cross laminated timber	L
F	Suspending profiles	Fh/Is
G	Mineral wool	
H	Plasterboard	Co
	Outside	
{(Ci),(If),(Fl),(Fs),(L),(Fh/Is),(Co)}		

Source: http://www.dataholz.at/cgi-bin/WebObjects/dataholz.woa/wa/bauteil?language=de&kz=gdmnxn02		gdmnxn02
	Inside	
A	Screed	Ci
B	Plastic foil	Fl
C	Footfall sound insulation	If
D	Chipping filling	Fl
E	Tickle protection	Fs
F	Cross laminated timber	Cl
	Outside	
{(Ci),(Fl),(If),(Fl),(Fs),(Cl)}		

Source: http://www.dataholz.at/cgi-bin/WebObjects/dataholz.woa/wa/bauteil?language=de&kz=ddmxxi02a		ddmxxi01a
	Outside	
A	Wooden fibre board	Co
B	Foil convection tight	So
C	Cross laminated timber	L
D	Wooden battens	Fh/Is
E	Mineral wool	
F	Plasterboard	Ci
	Inside	
{(Ci),(Fh/Is),(L),(So),(Co)}		

7.1.16 Ceiling, framework wood

Master Template:

{(Ci),<<[Fl],Fs|Fh|Ih>,If,<Fl,Fs,Fh|Fl,Sh,Fh|Fh>|Fh/Ga,<Sb|Sh>>,<Cl|L/Is,[Fh|[Fh],Fh/Ga|So|Fh,Fh/Is,Fh],Co>}

Source: http://www.dataholz.at/cgi-bin/WebObjects/dataholz.woa/wa/bauteil?language=de&kz=gdrtxn01a		gdrtxn01a
	Inside	
A	Floor covering	Ci
B	Dry screed	Fh
C	Footfall insulation MW-T	If
D	Filling layer	Fl
E	Trickle protection	Fs
F	OSB	Fh
G	Construction wood with glass wool in-between	L/Is
H	Battens	Fh
I	Plasterboard	Co
	Outside	
{(Ci),(Fh),(If),(Fl),(Fs),(Fh),(L/Is),(Fh),(Co)}		

Source: http://www.baubook.at/phbtk/index_BTR.php?SW=19		GDl 01 a
	Inside	
A	Wooden floor	Ci
B	Screed	Fl
C	PE sealing	Fs
D	Glass wool MW(GW)-W	If
E	Chipping filling	Fl
F	PE sealing	Fs
G	OSB board	Fh
H	Glass wool within Construction beams	L/Is
I	OSB board	Fh
J	Mineral wool within swinging hoops	Fh/Is
K	Plasterboard	Fh
L	Plasterboard	Co
	Outside	
{(Ci),(Fl),(Fs),(If),(Fl),(Fs),(Fh),(L/Is),(Fh),(Fh/Is),(Fh),(Co)}		

Source: http://www.dataholz.at/cgi-bin/WebObjects/dataholz.woa/wa/bauteil?language=de&kz=gdrnxa03a		gdrnxa03a
	Inside	
A	Screed	Ci
B	Plastic foil	Fs
C	Footfall insulation MW-T	If
D	Filling layer	Fl
E	Trickle protection	Fs
F	OSB	Fh
G	Construction wood with sheep wool in-between	L/Is
H	OSB	Fh
I	Feather-rails	Fh/Ga
J	Plasterboard	Co
	Outside	
{(Ci),(Fs),(If),(Fl),(Fs),(Fh),(L/Is),(Fh),(Fh/Ga),(Co)}		

Source: http://www.baubook.at/phbtk/index_BTR.php?SW=19		KDI 01 a
	Inside	
A	Wooden floor	Ci
B	Screed	Fl
C	PE sealing	Fs
D	Glass wool MW(GW)-W	If
E	Chipping filling	Fl
F	Vapor retarder	Sh
G	OSB board	Fh
H	Glass wool within Construction beams	L/Is
I	Wooden cladding	Co
	Outside	
{(Ci),(Fl),(Fs),(If),(Fl),(Sh),(Fh),(L/Is),(Co)}		

Source: http://www.dataholz.at/cgi-bin/WebObjects/dataholz.woa/wa/bauteil?language=de&kz=gdrnxa05a		gdrnxa05a
	Inside	
A	Screed	Ci
B	Plastic foil	Fs
C	Footfall insulation MW-T	If
D	OSB	Fh
E	Construction wood with stone wool in-between	L/Is
F	OSB	Fh
G	Feather-rail	Fh/Ga
H	Plasterboard	Co
	Outside	
{(Ci),(Fs),(If),(Fh),(L/Is),(Fh),(Fh/Ga),(Co)}		

Source: http://www.baubook.at/phbtk/index_BTR.php?SW=19		KDI 01 a
	Inside	
A	Wooden floor	Ci
B	Screed	Fl
C	PE sealing	Fs
D	Glass wool MW(GW)-W	If
E	Chipping filling	Fl
F	Vapor retarder	Sh
G	OSB board	Fh
H	Glass wool within Construction beams	L/Is
I	Wooden cladding	Co
	Outside	
{(Ci),(Fl),(Fs),(If),(Fl),(Sh),(Fh),(L/Is),(Co)}		

Source: http://www.dataholz.at/cgi-bin/WebObjects/dataholz.woa/wa/bauteil?language=de&kz=gdrtxn03a		gdrtxn03a
	Inside	
A	Floor covering	Ci
B	Dry screed	Fh
C	Footfall insulation MW-T	If
D	Chipboard	Fh
E	Construction wood with glass wool in-between	L/Is
F	Battens	Fh/Ga
G	Plasterboard	Co
	Outside	
{(Ci),(Fh),(If),(Fh),(L/Is),(Fh),(Co)}		

Source: http://www.dataholz.at/cgi-bin/WebObjects/dataholz.woa/wa/bauteil?language=de&kz=gdrnxn04a		gdrnxn04a
	Inside	
A	Screed	Ci
B	Plastic foil	Fs
C	Footfall insulation MW-T	If
D	Chipboard	Fh
E	Construction wood with cellulose fibre in-between	L/Is
F	Battens	Fh/Ga
G	Plasterboard	Co
	Outside	
{(Ci),(Fs),(If),(Fh),(L/Is),(Fh/Ga),(Co)}		

Source: http://www.dataholz.at/cgi-bin/WebObjects/dataholz.woa/wa/bauteil?language=de&kz=gdsnxx04a		gdsnxx04a
	Inside	
A	Screed	Ci
B	Plastic foil	Fs
C	Footfall insulation MW-T	If
D	Filling layer	Fl
E	Tickling protection	Fs
F	Fire protection boarding	Fh
G	Construction beams	Cl
	Outside	
{(Ci),(Fs),(If),(Fl),(Fs),(Fh),(Cl)}		

Source: http://www.dataholz.at/cgi-bin/WebObjects/dataholz.woa/wa/bauteil?language=de&kz=ddrtxn03a		ddrtxn03a
	Outside	
A	Wooden boarding	Co
B	Wind retarder	So
C	Construction wood with glass wool in-between	L/Is
D	OSB airtight taped	Sb
E	Battens	Fh/Ga
F	Plasterboard	Ci
	Inside	
{(Ci),(Fh/Ga),(Sb),(L/Is),(So),(Co)}		

Source: http://www.dataholz.at/cgi-bin/WebObjects/dataholz.woa/wa/bauteil?language=de&kz=ddrtxn05a		ddrtxn05a
	Outside	
A	Plasterboard	Co
B	Wooden boarding	Fh
C	Construction wood with glass wool in-between	L/Is
D	Vapour retarder	Sh
E	Battens	Fh/Ga
F	Plasterboard	Ci
	Inside	
{(Ci),(Fh/Ga),(Sh),(L/Is),(Fh),(Co)}		

Source: http://www.dataholz.at/cgi-bin/WebObjects/dataholz.woa/wa/bauteil?language=de&kz=ddrtxn04b		ddrtxn04b
	Outside	
A	EPV plate	Co
B	Battens	Fh/Ga
C	Construction wood with glass wool in-between	L/Is
D	Vapour retarder	Sh
E	Battens	Fh/Ga
F	Plasterboard	Ci
	Inside	
{(Ci),(Fh/Ga),(Sh),(L/Is),(Fh/Ga),(Co)}		