Comparison of Brazilian and Austrian Low-Traffic Pavement Design Methods

L.J.S. Santos, F.G.R.G. Silva & L.M. Gondim
Universidade Federal do Cariri, Juazeiro do Norte, Ceará, Brazil

P.M. Souza
Universidade Regional do Cariri, Juazeiro do Norte, Ceará, Brazil

L. Eberhardsteiner & S. Roth
Vienna University of Technology, Vienna, Austria

ABSTRACT: Comparison of pavement design methods is essential for developing a universal approach adaptable to different regions of the world. Brazil and Austria have adopted Mechanistic-Empirical (M-E) methods: MeDiNa and RVS 03.08.68, respectively, for pavement design. This study compares these methods for low-traffic roads using Brazilian data. The analysis highlights key differences: MeDiNa provides customized designs, while RVS 03.08.68 simplifies low-traffic pavement design through pre-dimensioned solutions. RVS resulted in a wider pavement structure than MeDiNa, for the condition evaluated. Rutting analysis shows that the Austrian method results in lower deformation (1.57 mm after 120 months) than MeDiNa's (2.27 mm after 120 months), as a consequence of the larger structure. A life-cycle assessment (LCA) is recommended to evaluate long-term economic and environmental impacts. This study contributes to the harmonization of international pavement design methodologies, aiming to promote more efficient and sustainable road infrastructure.

1 INTRODUCTION

In the last 20 years, several Mechanistic-Empirical (M-E) methods have been developed and implemented in different countries. For asphalt pavements, Brazil developed the New National Design Method (MeDiNa), whose implementation was initiated by the National Department of Transport Infrastructure (DNIT) (Franco & Motta, 2020). Also, in Austria a new M-E method has been developed, taking advantage of greater detail on the stiffness and fatigue properties of materials, as well as more information on traffic conditions (Eberhardsteiner & Blab, 2019).

This preliminary report stems from a collaboration between Austria and Brazil to develop new pavement design methodologies. The study compares the Brazilian MeDiNa and Austrian RVS 03.08.68 methods, analyzing their similarities, differences, and interchangeability. These comparisons help the technical and scientific community better understand different national contexts, enabling more accurate characterizations of traffic variables and material properties. This, in turn, supports the ongoing improvement of pavement design methods for varied environmental and operational conditions.

This can support the adaptation of methodologies to distinct regions, promote the harmonization of design practices, and encourage future collaborative developments in pavement engineering.

To this end, a comparison was made, primarily assessing low traffic conditions, weather, and material performance properties. Next, the interchangeability of the two methods was evaluated to adapt the Brazilian data for use in the Austrian method. Finally, a comparison of the final structures for low traffic resulting from both methods was conducted.

2 COMPARISON OF THE MEDINA AND RVS 03.08.68 METHODS

To perform design based on M-E principles, three stages are considered: input data, structural analysis and performance, and output data. The procedures required by MeDiNa and RVS 03.08.68 for each step are outlined below.

2.1 *Input data*

The input data stage includes traffic, weather, and material data. In MeDiNa, traffic is converted into an equivalent standard axle using load spectra and axle configurations, with load, axle, and vehicle factors estimating axle load effects. The RVS 03.08.68 method classifies vehicles into 11 groups, using parameters to determine weight and axle load distribution. Both methods consider the design period, lane configuration, and annual traffic growth rate. Regarding weather data, MeDiNa does not currently consider temperature and humidity effects in structural analysis, while RVS 03.08.68 divides the year into six representative temperature periods, with further distinctions between day and night, accounting for the temperature dependence of asphalt properties and traffic distribution. This results in 12 temperature periods, providing realistic distributions in the pavement structure across two different geographical conditions in Austria. For materials, both methods rely on laboratory testing but differ in tests and calculations. MeDiNa includes tests for stabilized, granular, and subgrade materials, while RVS 03.08.68 classifies materials based on particle size, shape, and resistance. Additionally, both methods use performance-related approaches to assess the stiffness and fatigue behavior of bituminous materials.

2.2 *Structural analysis and performance*

An M-E method uses computational resources to assess pavement structural responses for calculating lifetime damage. In MeDiNa, failures due to rutting and fatigue are considered, as these are the most common in Brazilian pavements. Although rutting is not calculated for the asphalt layer in MeDiNa, the method considers the Flow Number as a requisite for the mix design, to help prevent asphalt mixtures prone to rutting. In RVS 03.08.68 fatigue failure of bituminous materials is considered as a factor resistant to traffic loads.

2.3 *Output data*

MeDiNa presents reports detailing the monthly progression of fatigue and rutting, a summary of permanent deformations, and deflection basins, which are obtained through the Falling Weight Deflectometer (FWD) and the Benkelman Beam. However, RVS 03.08.68 reports whether the design of the pavement was accepted or rejected according to the data provided.

3 PAVEMENT DESIGN METHODS

The data obtained for Brazilian traffic, weather, and materials are directly used in the design of the pavement with the MeDiNa method. However, to carry out pavement design using the RVS 03.08.68 method, it is necessary to establish equivalence between the two methods for these data. Below is a summary of the main steps of the procedure, as well as the data to be used in the Austrian design.

3.1 *Traffic data*

Brazilian traffic data for 2023 was obtained from the National Infrastructure Department (DNIT) website (DNIT, n.d.). The study focused on BR-020 highways in Ceará, Brazil. The data allows for identifying vehicle axles but not the vehicles themselves, needing the selection of a vehicle class based on axle count. Unlike the Austrian method, the Brazilian design typically uses standard vehicle weights. This research applied current axle weights without considering tolerances permitted by Brazilian laws.

Various Brazilian vehicle axle configurations are outlined in standards from agencies like DNIT (DNIT, 2006) and National Traffic Council (CONTRAN) (Brazil, 2021). The Brazilian vehicle classes and their similar Austrian counterparts are presented in Table 1.

Table 1. Equivalent Vehicle Classes Adopted.

Brazilian axle number	Brazilian	Austrian
2	2C	FK2-1
3	2S1	FK3-3
4	2C2	FK4-3
5	2I3	FK4-7
6	3D3	FK4-7
7	3Q4	FK3-3 + FK4-3
8	3M5	FK3-3 + FK4-7
9	3T6	FK4-3 + FK2-1 + FK2-1

Equivalence was determined by matching the total weight of Austrian vehicles to the closest Brazilian axle weight. For four Brazilian configurations with 6 to 9 axles, no direct Austrian counterparts were found. In these cases, vehicles with the nearest total weight were selected, disregarding axle weight distribution and count. Table 2 summarizes vehicle quantities and classes to use in the Austrian method, considering the low traffic data obtained in Brazil.

Table 2. Brazilian vehicle quantities and classes adapted for the Austrian method.

Austrian Vehicle Class	BR-020
FK2-1	5
FK3-3	4
FK4-3	1
FK4-7	3
AADTT	13

It is important to note that the Brazilian method calculates the average daily traffic volume by considering all vehicles, whereas the Austrian equivalent, the AADTT (Annual Average Daily Truck Traffic), considers only heavy goods vehicles (HGV) with a gross weight above 3.5 t. The AADTT found (13) confirms the low traffic volume. The Austrian method suggests that additional standards should be used for low-traffic roads, such as RVS 03.08.63 and RVS 03.03.81, which use pavements designed based on a standard axle (DESAL) (Equation 1). Table 3 presents the data used for DESAL determination for RVS, while Table 4 shows the traffic data for the MeDiNa method.

$$DESAL = ESAL_{day} \cdot V \cdot S \cdot R \cdot 365 \cdot n \cdot z \qquad (1)$$

Table 3: Traffic data for RVS 03.03.81

A_{AADTT} (Average equivalent factor of vehicle category)	1.6
R (Traffic direction)	1
V (Lanes per direction)	0,9
S (Distribution of wheel tracking in one lane)	1
n (Design life in years)	10
ESAL/day (Average daily load application)	20,8
z (Growth factor)	1.146388
DESAL	39,166

where, ESAL/day is obtained by multiplying A_{AADTT} with AADTT. Furthermore, MeDiNa uses the number N based on the USACE method, which is described in Equation 2.

$$N = 365 \cdot VMD \cdot FV \cdot S \cdot \frac{(1+p)^n - 1}{p} \qquad (2)$$

Table 4. Traffic data for MeDiNa

Vehicle factor (FV)	1
% Vehicles in the design lane (S)	100
% Traffic growth rate (n)	3
Period (Design life in years) (p)	10
Road Type	local road
N	$9.96 \cdot 10^5$

3.2 *Materials data*

Table 5 presents the material data to be used for low traffic pavements, for both methods. It is worth noting that for low-traffic conditions in Brazil, a double surface treatment is used, and, according to RVS 03.08.68, no equivalent layer is specified.

Table 5. Characterization of Brazilian materials for applications in the RVS (Elastic Modulus) and MeDiNa (Resilient Modulus)

Materials	Layer	Period	Elastic Modulus	Resilient Modulus
			MN/m²	
Silty Soil	Subgrade	(Jan -Jun)	105	189
		(Jul-Dec)	205	
Fine Sandy Soil	Base	Entire year	331	494
Double Surface Treatment	Surface	Entire year	Standard material	1000

4 DESIGNED PAVEMENT STRUCTURES

It was observed that the RVS 03.03.81 specifies a base layer with a thickness of 40 cm, complemented by an asphalt surfacing layer. In contrast, the MeDiNa method proposes a 15 cm thick base layer combined with a 2 cm double surface treatment as the surfacing. It is important to note that, according to the Austrian design model, the thickness of the surface treatment layer is not specified. This is why the layer is graphically represented in Figure 1 for MeDiNa only.

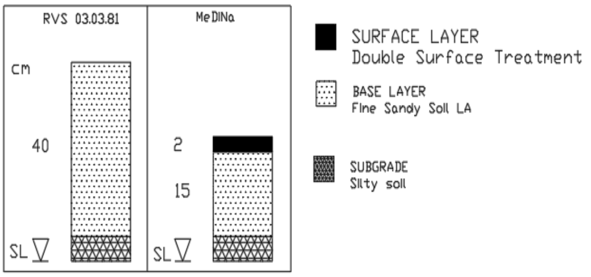

Figure 1: Structures of pavement designed

Additionally, the MeDiNa software was applied to the designed structures for rutting analysis. Table 6 presents the results, highlighting the performance of the pavement layers under expected traffic conditions. The rutting analysis was conducted based on the structural configuration, offering insights into the deformation behavior of the materials used. As anticipated, the RVS design resulted in lower rutting than MeDiNa, due to the thicker layer. However, both results are considered low compared to the failure criteria for low-volume roads in MeDiNa (20 mm for local roads) (Franco & Motta, 2020). Finally, fatigue analysis was not conducted for these pavement designs, as the low traffic volume requires the use of a double surface treatment as the wearing course, which is not prone to fatigue due to its small thickness. Consequently, the Medina software does not evaluate fatigue in surface treatment layers, whether in terms of cracked area or other fatigue-related parameters.

Table 6: Rutting Analysis Results

Pavements designed	Period (Month)	Rutting (mm)
RVS 03.03.81	30	1.36
	60	1.46
	120	1.57
MeDiNa	30	2.27
	60	2.40
	120	2.53

5 FINAL CONSIDERATIONS

The comparison between the Brazilian MeDiNa method and the Austrian RVS 03.08.68 method highlighted key differences in pavement design for low-traffic conditions: MeDiNa uses tailored solutions for all traffic levels, while the Austrian method simplifies low-traffic design with pavements designed based on a standard axle, reserving detailed analysis for higher traffic volumes; MeDiNa provides customized designs based on detailed analysis, whereas the Austrian method offers standardized, efficient solutions for low-traffic roads; the Austrian method results in a thicker base layer, which, although initially more costly, may be more durable and require less maintenance, as suggests the lower rutting observed. A life-cycle assessment (LCA) is recommended to evaluate long-term economic and environmental impacts, helping to identify the most sustainable and cost-effective approach.

These findings show the strengths of both methods: MeDiNa excels in adaptability and detailed analysis, while the Austrian method emphasizes simplicity and efficiency for low-traffic roads. The study is being expanded to include comparisons for medium and high-traffic volumes, aiming to offer more insights into the methods' effectiveness in different traffic scenarios. This will help guide better decision-making for pavement design across varying road usage levels. Initiatives like this comparison of design methods are essential for the evolution of a universal pavement design method that could be generic for all locations while allowing the necessary adaptations for each specific situation.

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