Low-Volume Roads Pavements

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Extended Abstract

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Abstract

Low-volume roads are roads that may have an additional importance to national and municipal network. It is important to ensure the accessibility of some populations and the flow of the product of their economic activities.

This work essentially concerned the linkage of certain kinds of pavement to each low volume road classification. Basically, intended to create a theoretical tool to frame the case study. In this case, a road drawn by RE1.

It described a sizing process of a pavement in order to be used for a possible dimensioning of the case study. It was used the paving catalog suggested by the literature to make a qualitatively analysis of the case study. It was analyzed the constitution of the road, more specifically the type of materials used, the number and thickness of layers in execution. Finally, the case study was framed on the previously proposed catalogues and possible improvements to implement were identified.

It is concluded that the surface used in the case study was the correct one, with only slight improvement recommendations that may lead to better performance of it and also a cost reduction. It is necessary to ensure a road maintenance and pavement to extend its duration.

Key words

Low volume roads; Classification; Pavement Materials; RE1

1 Introduction

When it comes to road infrastructures, we focus our attention on the roads where the volume of traffic is higher. However, low-volume roads are of extremely important to ensure accessibility to some of the most isolated populations, allowing them to have a proper and a professional life according to their needs. These roads guarantee their importance in terms of economic and social development. (Jorge, 2014)

A project for a low-volume road must, like any other, be technically and financially appropriate, also with the influence of various other factors, divided into 2 groups: those which are the engineer's responsibility, and those which are the project owner’s responsibility. In relation to the first ones, there is the need for an environmentally sustainable, technologically suitable and financially solid design. In relation to the second ones it is necessary to obtain social acceptance, be economically viable and framed with the institution where it will be inserted. (E.R.A., 2011)

The knowledge of road pavements, particularly in subjects such as technology and techniques are of very importance. The pavement of a road may have multiple functions. The basic functions are to work as an engineering structure and satisfy the functional requirements. It must be composed by quality materials and it should has sufficient thickness to withstand the loads imposed on it. On a functional level,

the floor should ensure a comfortable and safe journey for users and must maintain its integrity, resisting the horizontal and vertical surface tensions. (Austroads, 2009b)

The Portuguese Army, one of the entities with the capacity to build these roads, is often asked by local authorities to do it. This work is a contribution to the Army so that the concepts explained here can be applied.

The objective of this dissertation is the choice of a suitable type of pavement for each low volume road classification considered. The catalog created was used to make a qualitative comparison with a practical case study conducted by the Army. It was also used a process of sizing to obtain a paving structure for the same. After the comparison some notes will be made to increase the performance of the constructed pavement road.

2 Low volume roads general characteristics

2.1 Classification

A road is not classified in the same way in all parts of the world, so that each country develops, according to their needs, its own rating system.

The classification of a road in most countries is performed through the Annual Average Daily Traffic (AADT). The value of the TMDA is extremely important because transpires in the planning stage, the demand that a particular road will have. It is presented in vehicles per day. (Costa e Macedo, 2008)

Adopted as a model, the 2009 classification of Austroads, we get five classes of low-volume roads, U1, U2, U3, U4 and U5. The AADT values for each type of road vary, as shown in Table 1. Vehicles considered for the AADT value are different depending on the type of road. These values are also presented in Table 1. For simplicity we say that class of vehicles 1 to 3 are cars, while vehicles with less than class 4 are lorries. The value of AADT is considered for the two traffic lanes. (Austroads, 2009a)

Table 1: Road classification. (Austroads, 2009a)

Class	TMDA (vehicles/day)	Type of vehicles
U1	> 200	Class 1 - 3 com 20% Class ≥ 4
U2	100 - 200	Class 1 - 3 com 10% Class ≥ 4
U3	20 - 100	Class 1 - 3 com 10% Class ≥ 4
U4	< 20	Class 1 - 3
U5	< 10	Class 1 - 3

The consideration of pavement structures based on the "*Manual de Concepção de Pavimentos para a Rede Rodoviária Nacional"* in Portugal is done using the Heavy Annual Average Daily Traffic in the project route. This value is obtained from a traffic study and is considered in each direction for the most requested lane. After this it is possible to identify and associate to existing traffic classes. Traffic classes are presented in Table 2. (JAE, 1995)

Table 2: Traffic classes through the Heavy Annual Average Daily Traffic. (JAE, 1995)

Classe	TMDAp
T_7	<50
T_6	50 - 150
T_5	150 - 300
T_4	300 - 500
T_3	500 - 800
T_2	800 - 1200
T_1	1200 - 2000
T_0	>2000

On a comparative level with the 2009 Austroads classification, we can see that all roads considered in Table 1.1 are in T_7 class in Table 2, as the most loaded class, U1, will have 20 heavy vehicles at the requested route (either way, admitting one in each direction and a 50% traffic allocation for each).

2.2 Layout Geometry

The geometry of a road has geometric features designed to meet the needs of users. The cost of road construction and the benefits to users of it are two important factors to take into consideration. The parameters of the geometry are defined to be ensured the minimum levels of safety and comfort for users, as well as adequate visibility, friction coefficients and necessary maneuver spaces. (Jorge, 2014)

2.3 Pavements

There are many variables that influence the choice of constructive solution of a road surface. Traffic, climate, available materials, subgrade conditions and implementation costs are the main factors to consider when we have to choose a solution. (Santos, 2010)

The structures of floors, built taking into account the factors referred above are built with certain purposes of which are: (Jorge, 2014)

- Ensure the possibility of lower costs in vehicles, there by generating less costs to users;

- To ensure safety and comfort to users;

- Ensure resistance and transfer of loads transmitted by traffic will foundations, without suffering significant changes in your working life.

A pavement should ensure during the design period (number of years) the circulation of traffic under certain conditions. The load capacity can be verified considering:: (JAE, 1995)

- The heavy AADT on the opening year;
- The design period;
- The average annual growth rate of heavy vehicles in the design period;
- The distribution of traffic by existing roads in a given direction.

On a pavement for a low volume road, it is possible to reduce the cost by adapting the thickness of the layers, the materials and techniques used to request traffic. (Jorge et all, 2016)

For low volume roads several authors suggest the use of a pavement composed by three layers. Thus, above the subgrade floor we can find the sub-base layer, then the base coat and finally the wear layer. In Figure 1 we can find a type scheme for low-volume roads. (MTPW, 2013a)

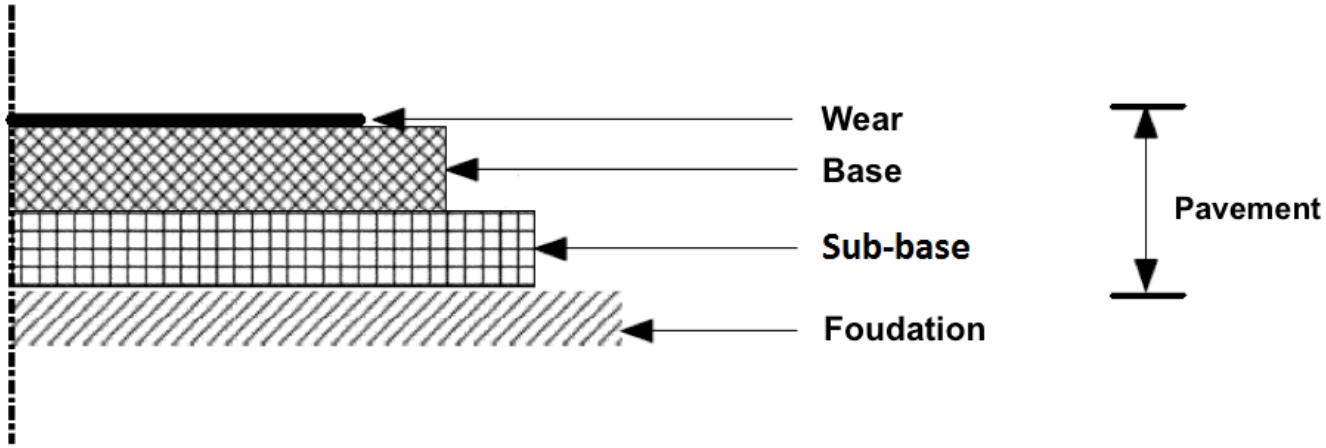

Figure 1: Constitution of a typical pavement for low volume roads. (adapted MTPW, 2013a)

2.4 Materials

The behavior of a material used for the construction of a pavement can be affected by several factors including the nature of the respective materials. Factors such as stability, permeability, workability and compaction are important factors that need to be considered in all layers, while the wear resistance has its greatest importance in the wear layer. (Austroads, 2009a)

The materials most commonly used in construction are the soils and granular materials, bituminous mixtures manufactured hot and mixes with hydraulic binders.

2.5 Pavements conservation

Conservation of pavements is considered a set of actions that are performed with the aim to preserve and extend the life of a pavement till its rehabilitation or reconstruction. (U.S.D.T. 1996)

The degradation of a pavement can occur in two ways: superficial or structural. Surface degradations are known to affect the behaviour of the pavement surface, which reduce the safety and

convenience for users. With regard to structural deterioration, these are manifested by the appearance of pathologies on the surface of the pavement, which may result from the lack of foundation soil load capacity or ruin the constituent materials of the pavement structure. (Figueiredo, 2011)

The causes which cause deterioration and degradation of a floor depends on its type. Conservation activities are classified in terms of their frequency and divided into: urgent conservation, periodic conservation, recurring conservation and routine conservation. (MAI, 2005)

3 Pavement Design

In order to achieve a better cost effective method for the construction of low volume roads, the pavement design takes into account the climate conditions, the traffic, the subgrade conditions and the materials so that they allow a less layer's thickness. (CEPSA, 2010)

Using the model of Austroads, but this time for the design, the process starts with the determination of the subgrade's resistance. To evaluate the foundation are determined the CBR, the elastic parameters and the modulus of subgrade reaction (k). This value is crucial in the pavement structure. It is also necessary to determine the value of Equivalent Standard Axle (ESA). So the pavement structure is determined by the design curves. (Austroads, 2009a)

4 Seletion of the type off pavement to use in each classification

As noted above, the criteria to choose a pavement type are volume and type of traffic which affects the thickness and quality of the pavement wear layer, the speed of traffic in relation to dust and safety issues, the importance of the floor in relation to the social and economic impacts and check the availability of materials for the wear layer which allows to avoid to raise maintenance costs.

As we are making the study of low-volume roads, we can say that granular materials are the main option to use and are also easier to obtain. Do not forget that one of the most important principles of low volume roads is to use materials available in the area. Regarding the type of flooring we can consider the flexible pavements, usually with wear layer formed by these unbound materials available in the area.

The case study presented will be analyzed and compared with the solutions and classifications considered and will also be presented measures to improve the solution used in the case study.

4.1 Type of structure to use in each classification

There is, for each type of road classification considered in Chapter 2, a deck structural solution that best suits it. This structural solution, presented by Austroads, has the number of layers used, as well as its thickness and the material used. For each classification will be then described the solution that best suits it. The catalog will be considered solutions of the 2009 Austroads taking into account that this was the classification used for the roads.

4.2 Case study – road built in Castelo de Vide by Regimento de Engenharia nº1 (RE1)

4.2.1 Location

Opened between February 2 and June 12, 2015 the RE1 constructed a road near Castelo de Vide village designated road of Marrões. The road has an extension of 1450 meter and has a height difference about 115 meters. The road was constructed mainly for two reasons. Firstly, now it serves to access some lands by motorized vehicles. Secondly, the road allows the access to forest area by fire trucks. In summer, with the increased probably of fire it was it was required to ensure access to inaccessible areas and difficult access areas. So in case of fire, the road permits an efficient passage of these vehicles to these areas. This road also connects the national road no. 2 and a forest area.

4.2.2 Building sit

Before the intervention of RE1, the building sit was just a pedestrian and narrow path. Cause it had an elevation value lower than the neighboring it was necessary to level the ground. The building sit was sandy, composed by grit and with many granite outcrops in certain areas.

4.2.3 Executed work

Globally, the aim of the work carried out by RE1 were clearing, enlargement, regulation, leveling and execution of ditches and drainage systems.

The works were divided essentially in two phases. First phase, in the first 700 m, the road was deep enough in relation to land around and contained some rocks. Only the salient rocky outcrops were removed and in order to level the ground was placed a layer of about 50 cm of backfill material. After compacted and dried, it was placed a crushed stone layer with a relatively large size and having a minimum thickness of 20 cm. As wear layer and with the objective of void filling and leveling target path has been finally placed one gravel layer with a minimum thickness of 10 to 15 cm.

The second phase of the work was carried out in the last 800 m of road built. This part of the road was considerably narrower and contained dividing walls of the existing road to the land that were necessarily removed with enlargement of it. The number of rocky outcrops was much higher in this area, so we chose to take only a few and got support from the city council to, with the help of explosives, destroy the outcrops that have not been removed from the site. After use of explosives, we had the need to fill the empty spaces with backfill material removed from zone, then the layer of gravel 20 cm and ending with the wear layer 10 to 15 cm of gravel.

It was made a proper drainage system with the respective hydraulic passages where it would be necessary as well as trenches for the direction of water.

4.2.4 Case Study Analysis

Classification

Starting from the analysis of road use, it will be inserted in the ratings previously proposed to ensure the best choice of paving solution. Knowing that the road gives access to forest areas for fire trucks, you need to ensure an adequate type of paving to heavy vehicles, although this use is only periodical. We will ensure a minimum of U3 classification. Considering also the other reason to use the road we can assume that, given its size, the number of vehicles that it would not be very high. Next we consider that the range 20-100 AADT with 10% vehicle class greater than or equal to 4 (heavy) is enough to include the use of the built road. We conclude that we can classify the road related to the case study on the U3 classification Austroads.

Structure

Starting again a qualitative comparison of the case study with the catalogue presented in chapter 4.2, U3, we find that as in the classification, the number of layers used were two. Comparing the thicknesses of the respective layers, in the wear layer in the case study was used a thickness of 10 to 15 cm as in the U3 classification was obtained a minimum thickness of 10 cm. Regarding the second layer, the theoretical classification suggests a minimum thickness of 15 cm and in the case study was used a layer of 20 cm.

As can be verified, study to obtain the values needed for the road design has not been made. Assuming by default the lowest value of CBR to a sand can stipulate a CBR range between 10 and 20. Not knowing the ESA value, but also obtaining a value conservative, i.e., 5×10^5 ESA we managed to obtain by conception curves a minimum thickness of 15 cm layer. This process should be made for each pavement layer.

As mentioned above, it is necessary to give priority to existing materials in the local area. By using local materials to fill and level rocky outcrops areas we put into practice the principles already established

Recommendations to implement

First, and referencing the number and thickness of the layers, it is possible to say that a more detailed study of road use, could lead to a better assessment of the thickness of each layer so that there is a saving of material used in its construction. As in the previous subchapter sub-base layer has a thickness of 20 cm, while theoretical analysis states that it could be a minimum of 15 cm. This study could lead to saving 5 cm height which would result in a large volume of material and consequently less cost savings. It could have also been made a study of the foundation ground, as this also influences the thickness of the layers. By the design process we obtained a size of 15 cm in one layer could also make a more detailed analysis of the thickness of the various layers.

Referring to drainage pavement, this was taken as indicating the analysed theory, a superficial form hydraulic passages through the trenches and to direct the water.

It should also be noted that we must ensure a constant maintenance to ensure a proper functioning and good performance for the road over a long lifetime.

5 Conclusions

This dissertation proposed the goal of finding a catalogue of solutions for a given classification of roads in order to use the same for a comparison and evaluation with a practical case study. It is important to emphasize this subject, not only for the need of such roads to the country's development but also for the Army since it is one of the entities that builds this type of roads.

With the completion of the dissertation is possible to conclude that is required an extensive analysis to design and construct a road. It is also important to take into account the diversity of materials, types of pavements, maintenance and conservation modes.

The lack of elements is overcome with some simple considerations to be able to use the design method. The road was classified as a U3 road due to various reasons for which it was built.

After the analysis made, theoretical and the case study, it was concluded that there would have been the possibility of savings in the thickness of layers built if there were a more detailed study of the use of the road and also the foundation of land. It is important to note the use of appropriate and available materials in the vicinity of the building so putting into practice one of the most important principles of construction of low-volume roads.

The creation of such catalogues and the realization of this type of study is very important when the goal is to find a good relationship cost efficiency of this type of roads. Wanting always to ensure maximum utilization and duration so that it can serve the most basic needs of a population.

As future developments are presented below some recommendations.

It can be done, by the army or by the entity responsible for the construction of low-volume road, a detailed study of their use in order to promote a better management of the resources used in the construction of it. In this study it can be incorporated into the class of road and to pre-establish a traffic solution.

The weather differs throughout the area of our country and the use of these roads is very important for population. It could be prepared a catalogue of pavements to which the surface used was more suited to predefined areas (in climate function and commonly available materials).

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