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PERPEETUUM PATH SOLUTION FOR INCREASED SPEED ON DIFFICULT ROADS

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Abstract: *Increased velocity on narrow and difficult road segments (serpentine or mountain roads) has always been a problem with limited solutions. The average speed of traffic between origin-destination points depends directly on the driving speed of these road segments with speed limit. The solution presented in this paper focuses on the road type, amended design requirements and technical elements of infrastructure and road safety. The pilot project discussed, the basic model, is the E81 European Road section (DN7) called Olt Valley, portion of 67.4 km between the towns Boiţa and Lunca involving many traffic accidents and difficult traffic, which will be transited in standard driving mode in approximately one hour. This study reveals the situation where this stretch of road will be transited with an average speed of 90 km / h, in a 25% shorter time, with reduced resources, while maintaining normal safety and comfort levels.*

Key words: *road, infrastructure, design, elements, speed.*

1. Introduction

Road traffic safety, the cornerstone of road transit, implies the responsible and lucid participation of all parties involved in the road traffic.

Another cornerstone of road transit is the average driving speed.

Usually, the variation of the indicators pointing at these very factors is inversely proportional: when the driving speed increases, the safety of the traffic participants decreases and the other way around.

The third important factor is the fuel consumption that will occur on the targeted road segment and which ought to be the setting out point for new investments in infrastructure.

There is a balance between these factors, which can adapt depending on the features of the road and the social and economic requirements in the region [3].

2. Goals of Road Transit

The goals of interest presented in this paper limit to identifying an elevated average driving speed in increased conditions of safety and with a minimal fuel consumption on the experimental road segment, mainly populated by people and merchandize, of European interest (E81). The term “perpetuum path” derives from the attempt to preserve the energy consumed when braking before a curve

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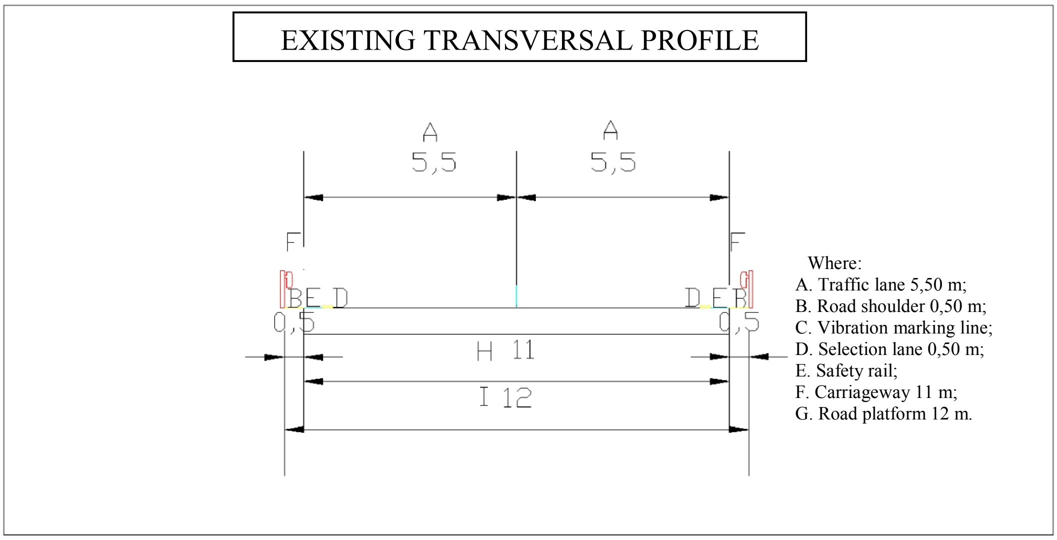


Fig. 1. *Existing transversal profile*

and when speeding after a curve, cumulated with keeping up an average driving speed ideal for the fuel consumption levels and enhancing road traffic safety by means of technical elements and optical comfort.

2.1. Road Traffic Safety

The road traffic safety on the road segment studied is difficult to achieve because the carriageway has an average width of 12 m, cannot be expanded and is sinuous, as it goes along the right side bank of River Olt through Oltului Pass, with safety rails along the river and consolidation work on the opposite side slope.

The existing technical elements are the metal safety rails, the selection lanes, the vibration marking lines, lighting only on some portions, traffic signs for sustaining traffic, gauge limits.

There are no center lines, however the marking of central line son the 2x2 roads would reduce the risk of traffic accidents with up to 60% [9].

2.2. Average Driving Speed

would reduce the risk of traffic accidents with up to 60% [9].

The average driving speed is the most important parameter of the action of transiting since it provides us data regarding the time necessary to drive the road segment.

The average speed achieved through the experiment varies from 52.40 km/h in relaxed pace to 68.33 km/h in an alert pace [4].

$$\bar{v} = \frac{\Delta d}{\Delta t} \qquad (1)$$

Thus, ensuring an average speed of 90 km/h, not only ensures to drive the segment in a very short time but it also has a direct financial result on the traffic participants as well as on the environment.

2.3. Fuel Consumption

The internal combustion engines transform the chemical energy of fuel into mechanic energy, available at the crankshaft. The process of transforming energy is not optimal, the output energy being affected by losses. In the case of thermal engines in vehicles, the losses are considerable, the output being of approximately 20% [8].

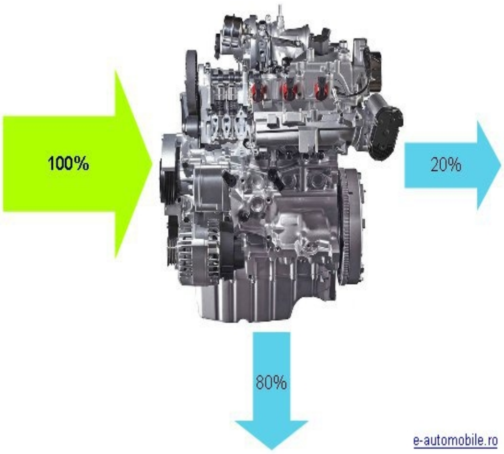


Fig. 2. *Power balance of the internal combustion engine*
Source: e-automobile.ro

The experimental studies reveal that the regular Otto and Diesel engines have a minimum consumption when operated at velocities between 80 and 100 km/h.

The ratio of the gearbox level may be utilized as a way to reduce fuel consumption, as it gradually changes the engine's levels of engagement.

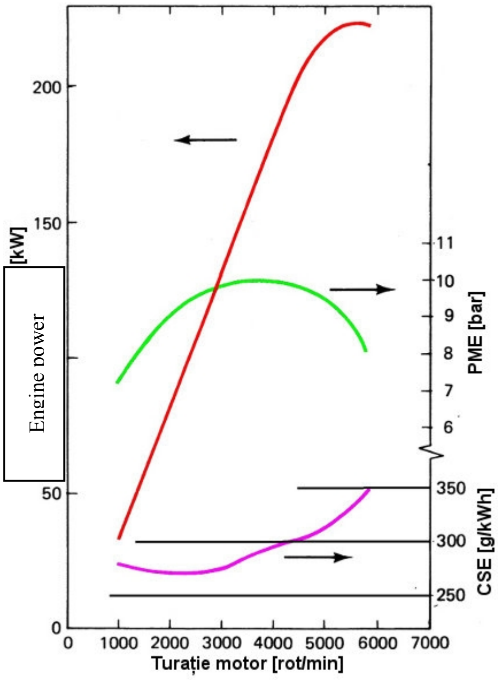


Fig. 3. *Features of the output of a thermal engine running on gasoline (PME, power, CSE), at maximum load*
Source: http://www.e-automobile.ro/categorie-motor/20-general/110-consum-combustibil.html.

For instance, in the graphic above, we can see how the same engine power (110 CP) can achieve different numbers or rotation and moments of rotation [8].

Fuel consumption depending on the operational parameters Table 1

Engine power [CP]	**Number of rotation motor [rot/min]**	**Moment of rotation [Nm]**	**Speed in gearbox [-]**	**CSE [g/CPh]**	**C [%]**
110	5700	80	2	455	refference
110	2600	140	4	410	- 9.89
110	1800	235	5	365	- 19.78

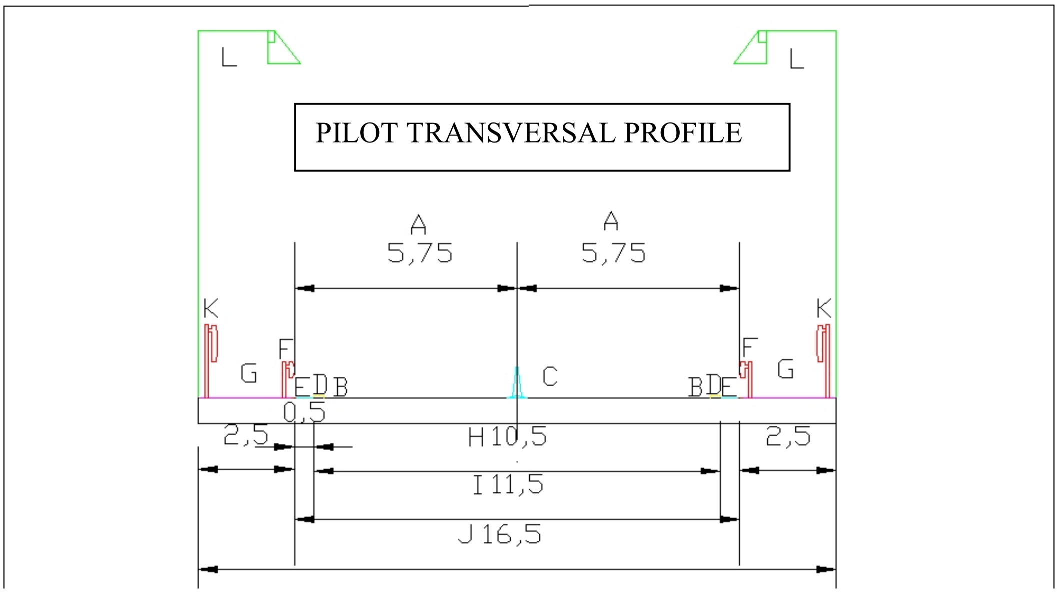
3. Pilot Project: Combining the Factors of Road Transiting

The major issue on several road segment in Romania is the same: the width of the road and the average driving speed that varies between 40 and 60 km/h. The traffic participants hold the freight transport as the main culprit in the problem of transit Taking into account the elements of the pilot transversal profile (Figure 4), which eliminates pedestrians, bicyclists, and animal-powered vehicles, and takes from the elements of a highway, this new type of road will enhance driving on the newly designed road segment.

The values of the transversal descent in curves (dever) will also be reconsidered by emphasizing them, ensuring a greater speed in curve and a more efficient draining of the surface waters from the carriageway. The hard shoulder platform will be designed with a telephone booth at mere 500 m and1000 m and will incorporate the entrance and exit lanes. The center line will separate the traffic moving in opposite directions and will provide increased safety, without allowing overtaking.

The selection lane will ensure a safety distance from the metal safety rail.

The lighting poles are LED powered and will ensure ideal traffic conditions even in nighttime. The traffic signs will also refer to the minimum and maximum speed. Increasing visibility, enhancing traffic safety, widening the carriageway by eliminating the road shoulders together with the optical comfort ensured by the elements of the transversal profile will all contribute to an increased average speed of the participants on the targeted road segment.



Where:

A.Traffic lane 5,75 m; D.Vibration marking line; G.Hard shoulder platform 2,50 m; J.Road platform16,50 m;
B.Road shoulder 0 m; E.Selection lane 0,50 m; H.2 Traffic lanes K.SOS Telephone booth; 5,50 m;
C.Center line; F.New Jersey Rigid safety rail; I.Carriageway 11,50 m; L.LED Lighting pole.

Fig. 4. *Pilot Transversal Profile*

4. Results and Discussions About the Performance on the Targeted Road Segment

Increased velocity on narrow and difficult road segments (serpentine or mountain roads) has always been a problem with limited solutions.

The practical studies and the above presented figures reveal that in Romania on a national road the average speed reaches 52.40 km/h in safe driving, 62.50 km/h in standard driving and 68.33 km/h in fast driving. The analysis will be performed on short sections of the road segment where an outstanding speed variation is noted. This is due the braking before curves and the speeding after curves, which are not appropriately set up and where the geometrical elements are underappreciated. An effective solution would start with ensuring visibility inside the curves as well as instituting a high level of optical comfort, seeing that this is a European road. Another solution is to upgrade the curves by interior or exterior addition to the width in order to broaden the positioning of the light and heavy vehicles. The most severe and important solution would be to emphasize the turn in curves by adding space to the STAS 863-85 curves, by expanding the radius comprised between the minimal and current radius available for the same turn. This will involve increasing the inclination of the road surface towards the inside of the curve, reducing the centrifugal effect deriving from entering the curve with a high speed. This way, it will no longer be necessary to brake excessively when entering curves that are not designed in direct correlation with the alignment movement possibilities. Such approach would reduce driving time by 25 % without any major effect on the comfort and safety of the traffic participants [4].

Taking into account the combination of the solutions, it can easily be demonstrated that the optimal version of movement is that of a freight transportation vehicle convoy moving with an average speed of 90 km/h, which does not use the brake before a curve and does not speed after the curve.

The cost-benefit analysis of the investment required to transform the exiting road segment according to the pilot project will be positive and redeemed in maximum 5 years, an extremely short time when compared to other infrastructure related investments.

The direct benefits regard the savings made possible to the traffic participants by the low fuel consumption needed to transit this particular road segment, reduced by 10% up to 20% (Table 1).

The direct benefits regard the traffic safety ensured, first of all, by the center lines dividing opposite traffic and by the optical comfort elements included in the pilot project.

The indirect benefits may also be measured in the transit time reduced by 25% per transited segment, by means of which the drivers, passengers and merchandize reach from one end to another in only 45 minutes as opposed to approximately 1 hour, the currently implied transit time, with an average speed of 67.40 km/h.

The performance of this type of road, considered to lack capacity due to the existence of a single traffic lane, will suddenly become comparable to an express road with 2 traffic lanes.

5. Conclusions

The average speed of traffic between origin-destination points depends directly on the speed of these road segments with speed limit. The solution presented in this paper focuses on road safety, optical comfort, amended design requirements and modern technical elements of infrastructure. The pilot project discussed, the basic model, is the E81 European Road section (DN7) called Olt Valley, portion of 67.4 km between the towns Boiţa and Lunca involving many traffic accidents and difficult traffic, and that will be transited in standard driving mode in approximately one hour. This study reveals the situation where this stretch of road will be transited with average speed of 90 km / h, in a 25% shorter time, in approximately 45 minutes, with reduced resources while maintaining normal safety and comfort levels.

This goal may be achieved by ensuring traffic flow with speed varying between 100 km/h on the linear road segments and 80 km/h in curves, rendering the average speed around approximately 90 km/h.

Traffic safety will be positively influenced, eliminating the perturbing factors and other risk elements like pedestrians and bicyclists.

The most significant contribution and the sustainment of this hypothesis is the cornerstone of the transit itself: the more emphasized the carriageway and its inclination towards the inside of the curve, the more reduced the braking and speeding to recover the initial speed.

The optical comfort is just as important for the traffic flow, as it insures a constant movement without interruptions and braking.

The specific goal of reducing fuel consumption will be reached, given that the optimal driving speed for a reduced consumption coincides with the average speed on the presented road segment, subject to the pilot project.

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