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DESIGN OF A SPEED BUMP WITH A COMPLEX OPENING SYSTEM

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Abstract: *The paper presents the design of a speed bump that has a complex sliding opening system, and for designing this system the Fusion 360 program has been used. This speed bump is opened by means of sliders when a vehicle has a speed higher than the allowed limit, and if the speed is legal the speed bump remains closed and the vehicle can pass over this obstacle without having an influence on it. The sliders are driven by a linear actuators.*
Key words: *speed bump, design, complex system, sliders, traffic calming, vehicle.*

1. INTRODUCTION

A variety of methods are used to control the speed of vehicles and to prevent accidents caused by speed, two of them are speed bumps and humps. These are vertical obstacles used in traffic management, shaking the occupants of a vehicle moving too fast over these obstacles. These two methods are the most commonly used in traffic calming, being made of asphalt, concrete, metal, plastic or rubber. Speed humps are also called undulations or road humps and are used to limit speed between 10 and 15 mph, often being observed in areas where traffic must flow smoothly, but excessive speed will endanger pedestrians. If a car travels at a higher speed and passes over this system, the car is shaken together with the occupants causing discomfort. These obstacles are usually located on the entire lane on which the car travels, and in this way the car overcomes this obstacle with both wheels. Speed humps are most often placed in a series, thus maintaining speed reduction through a corridor. Speed bumps are a more aggressive option to calm traffic than speed humps, being useful in places where pedestrians and cars share space closely, such as parking lots and alleys, with a height of 5 to 10 cm. Because speed bump generally slows down traffic at 2-10 mph, it gives both cars and pedestrians time to react safely to each other.

Speed bumps are rarely used on public roads, as they require vehicles to stop close to overcome these obstacles, being able to damage vehicles moving at regular speeds. No matter how accustomed drivers become to these obstacles, they still remain a deterrent to drivers [1].
This article is structure as follow: after introduction the next section review the current state of the art, continuing with proposed system in section 3. Section 4 presents design process of the speed bump, followed by conclusions and references.

2. BACKGROUND

Various models of speed bumps can be found in the current literature and various studies have been done on the effect of a speed bumps on traffic. Various studies have been done to design an optimal speed bump, an example of such a study was made by the authors of [2] who made a study to determine an optimal design of a speed bump that can best reduce the speed of a vehicle without cause a vertical acceleration that would endanger road safety. Article [3] provides a physical-mathematical assessment of the kinematic values of road accidents. Another paper describes how the influence of the speed of a speed bump decreases the speed of a vehicle. In this study, comparisons were made between vehicle speeds in three locations (A, B, C) in Belgrade, before and after the installation of speed bumps. The speed measurement was made by several researchers on Tuesdays and Wednesdays, they stayed hidden and measuring the speed with the help of a device called PRO LASER III. As a conclusion, it resulted that in location A speed bump with a height of 3 cm reduced the speed by approximately 13% to a speed of 40 km/h. In location B was placed a speed bump with a height of 5 cm, reducing the speed of vehicles by about 30% at a speed of 35 km/h. Placing a speed bump with a height of 7 cm in location C, it considerably reduced the speed to 35%, at a speed of 30 km/h [4]. The authors of [5] make a study on the behavior of cars of different classes by experimental and simulation methods on the loss of control of cars when cornering, causing road accidents. In 2016, a study was conducted in different areas of Lithuania on the impact of a speed bump on particulate air pollution. Speed bumps are installed in residential areas and cities to regulate speed in traffic, and during braking when vehicles pass over on the speed bumps, particulate air pollution increases due to vehicle emissions. The study was done in different residential areas analyzing different types of speed bumps and according to the results air pollution with particles increased by 55.7% near pedestrian crossings where trapezoidal speed bumps were used and by 58.6% where speed bumps were used circular plastic shape [6]. Țîțu et. al [7] makes an analysis of road accidents that have occurred in certain national road sectors. The authors of [8] conducted a study on the detection of a speed bump using a smartphone used to warn drivers about the location of a speed bumps nearby, thus avoiding accidents caused by careless drivers. Witchayangkoon et. al [9] performs an experiment on the construction of a simple and inexpensive speed bumps using rubber from car tires of different sizes. In this experiment it can be seen the increase of safety for the local community near such cheap devices. Other studies have been done on the impact of noise inside a car when the car passes over on the speed bump. The tests were performed on cars that drove at different speeds on roads with two types of speed bumps. The impact noises were recorded in the interior cabin of the car, building a noise database, and 44 samples were taken to make an analysis. The results indicated that a speed bump with a slope of 25% can induce a higher noise level that can aggravate the driver [10]. Another paper makes an experimental study on the vibrational behavior of a car that transports people and its maintenance [11]. The speed bump device presented in this paper has a unique concept and having an advantage over other devices on the market because it is easy to place. In addition, the idea of a lateral sliders speed bump is economically efficient, given that its installation is done in a few minutes, and its operation should be smooth and reliable.

3. THE PROPOSED SYSTEM

The subject of a smart speed bump is relatively small because it has a small niche market that has not reached a developed phase, but which has an opportunity to grow, increasing interest in management in a city. An intelligent speed bump can be defined as electromechanical device, containing a control element, an electronically controlled motor [12] and a rigid casing that has both a protective purpose as well as a functional one. This device has been conceived to treat differently the traffic users who are passing by it, depending on their travelling speed. The device is fitted with speed cameras with tracking function, that enable the system to work in a multi-lane situation, so that the vehicles would not be able to trick the system. The idea behind this smart and promising design is to have a cheap and easy to mount speed bump that will provide a smooth ride and a non-destructive platform for the road surface on which it is placed. This speed bump model was designed taking into account the less developed countries that have a lower financial potential, being intended to become competitive in the area of smart cities.

The solution of this speed bump is one with electronically operated sliders [13], as we can see in the sketch in figure 1. We can list some advantages of this system, as follows:

- simple and robust structure;
- fast reaction time;

- cheap to produce and maintained;
- easy and quick to assemble;
- a reduced force is required to operate the sliders.

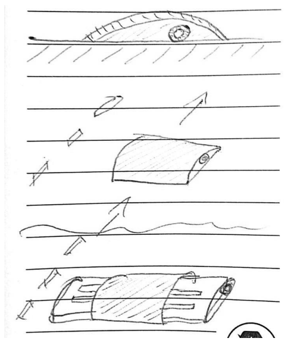

Fig. 1 Speed bump with electronically actuated sliders

4. THE DESIGN PROCESS OF THE SPEED BUMP

The speed bump system (figure 2) was designed in the Fusion 360 program.

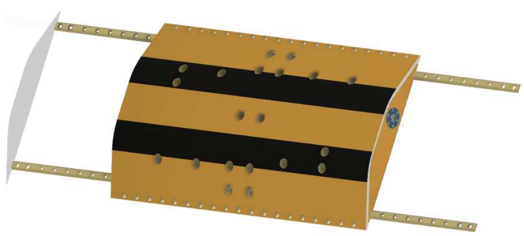

Fig. 2 Designing a speed bump system

4.1 Dimensioning the main components

The dimensioning of the components is crucial from this study, because if done wrong it can be disastrous from all points of view. The importance of this step is linked mostly to the end users, the drivers, who will have to put up with any inconvenience the speed bump may add to their daily routes. However, this may prove to be a very troubling problem, because it is most likely that it may raise concerns and reclamations. That would only lead, thanks to its status of a brand new idea, to its ultimate failure. There are many dimensions that have to be taken into account, the most important being the external ones, the maximal extended width, minimal width, the peak's height. Because of the different vehicle track widths, the minimal width the raised middle fixed component that houses the lateral sliders has to be narrower than narrowest small vehicles found in circulation. The size requirement for those are found by studying the typical smallest automobile vehicle's class sizes.

The narrow main, fixed part aside, the maximal extent that the sliders can reach are also important, or as important as the other one. This is especially an important thing to consider since the width dictates if the solution is appropriate to a multi-lane road situation or not.

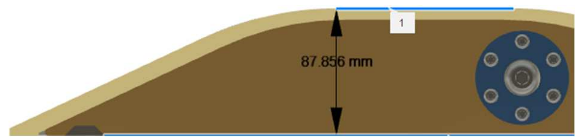

Fig. 3 Peak height of the speed bump

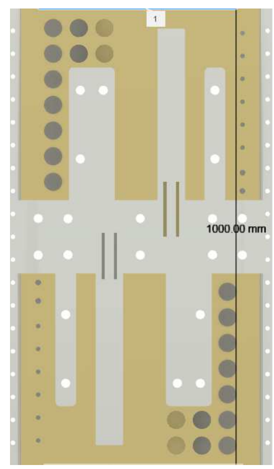

Fig. 4 Width limit of the speed bump

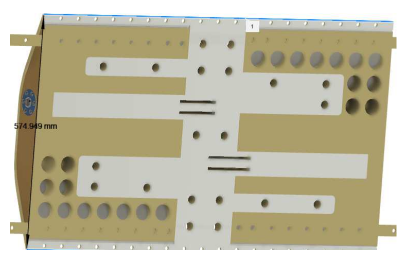

Fig. 5 Length of the speed bump

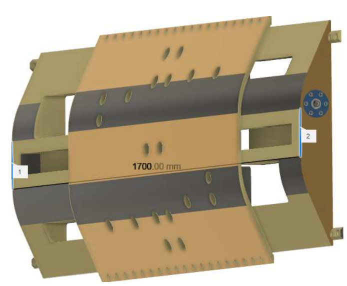

Fig. 6 The speed bump in its fully extended form

According to different sources the maximum distance in between a HGV's wheels from a front view perspective is 1104 mm. The minimum distance for it to have any impact on the truck's dynamics is 1454 mm, that being the distance from in between the inner wheels of the vehicle.

The same principle of acting on the inner side of the wheels is used to the wider sport cars or supercars, such as the Ferrari Enzo, a typical large size supercar. This particular vehicle would have the fully extended speed bump running from one middle to another of the rear wheels. This is considered to be more than enough.

The ground clearance of this vehicle is also an impediment, being lower than on almost all the other vehicles in this side of the market. The intelligent speed bump design is constrained to have a minimum of 87.86mm of ground clearance allowance before scrapping the lower side of a vehicle. This however is enough to allow one such vehicle to pass since its rated ground clearance level height of 99mm.

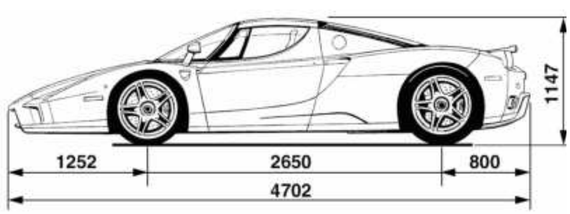

Fig. 7 Ferrari Enzo [14]

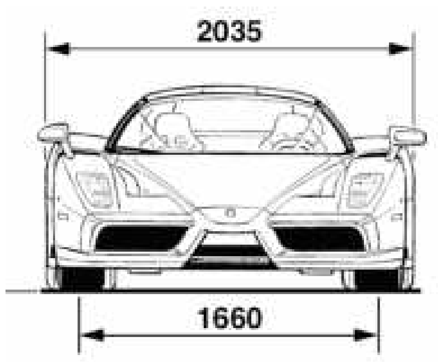

Fig. 8 Ferrari Enzo [14]

The design of this speed bump can allow any type of vehicle to pass efficiently without causing any problem, but also can effectively impede the traffic participants who are disobeying the laws, safely determining them to reduce their speed and drive more carefully around. Also, because of the mountable rails, the speed bump system can be used in extreme loads conditions, where the weight limitation is not available on the road section where heavier lorries may be required to pass or even descend steep hills while braking onto the platform, thus increasing the amount of carried inertia.

The main components are designed from scratch and have a particular purpose and a couple of design features that make them stand out.

4.1.1 The sliders

This art is the most important since this is the one that is being acted upon in order to transmit the motor power and that creates the blockage that, in turn makes the vehicles slow down.

The way in which this part works is that is slides on the low friction μ coefficient faces of the middle fixed part and on the optional rails that come with the system.

The material that has been chosen for this particular iteration of the design is a Peek plastic type that offers an excellent mix between weight and tensile strength.

There is also the imposed limit of price which, depending on the provider, may be higher. In this case, the aluminum option is a great one as well, because of its great properties and corrosion free nature.

The way in which the materials glide one over the other is through an add-on fine bronze layer added to both of the contact surfaces, one either one of the parts. In this way, a proper and reliable sliding linkage is created and can safely guide the sliding part in and out of the cover.

The two visible cuts in the body of the slider (the ones on the extremes) are the ones that make up the guiding mechanism, while the one in the middle is made in order to house the wiring, annexed to the motor. That particular part is normally closed with a sealing plastic lid. There is also a visible hole and locking mechanism on the front side of the slider that serves as a connecting spot. There is where the sealing cap fits, housing the motor that acts on the motor's slider. The motor's slider is screwed on the end cap and allows the whole slider body to move with it in a direct manner

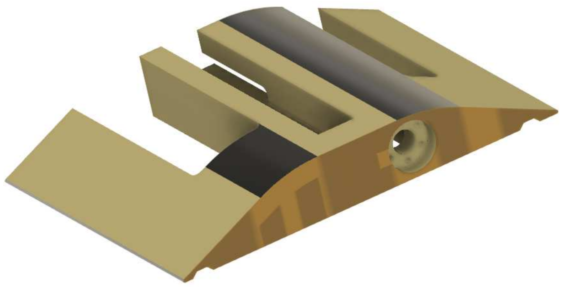

Fig. 9 Sliding part of the system

The picture below show the lower side (that is in permanent contact with the ground through the railing bars) and the back side (which is kept under the cover at all times when the system is installed). Here we can observe the weight reduction drilled holes that have the purpose of keeping the weight under control, thus requiring a slightly less powerful motor to displace it.
The structure keeps its rigidity under any load conditions despite the weight reduction features. Besides the holes that reduce the inertia of the moving sliding components, the slider has been cut-extruded to allow two guiding rails to be fitted in there. Another aspect that must be mentioned is the existence of a middle floor hole, where the motor must be placed.
Another aspect that must be mentioned is the existence of a middle floor hole, where the motor must be placed. The reason behind its existence is a clever feature with which I have foreseen the construction of the slider. Because of the very high, and sometimes even terminal, shocks that the system has to endure because of the high stopping inertia caused by the slider reaching its stroke end suddenly, in a rushed manner, the motor has to be very well anchored. Because of its light and reduced dimensions, the motor can only be screwed down in the end sides, leaving its cylindrical shape unrestrained. The solution that we came up with is to be fixed in that particular spot, ensuring that there will be no slip or torsion play and, in the same time, adding another set of gliding guide faces to increase the rigidity of the extended slider even further.

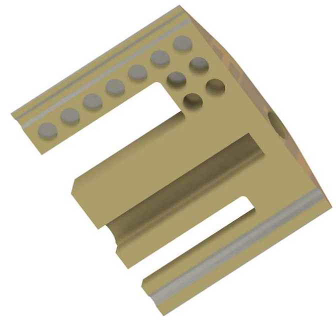

Fig. 10 Lower side of the sliding component

The figure on the below reveals the mounting bay for the motor, where the wiring connections are placed. The curved cut in the motor compartment represents the end stroke of the motor, where the connection grill of the linear motor meets a shape friendly cut.

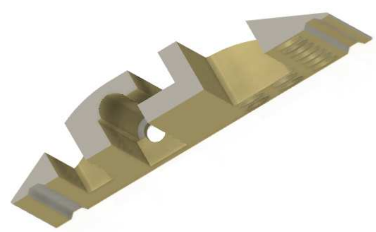

Fig. 11 Back side of the sliding component

4.1.2 The middle fixed part

All components of a moving system must have one that is fixed, either in an absolute way (but relative to Earth's revolution motion) or a relative way (holding a position), while the other moves. This one is in the case of this speed bump intelligent system [15] is the middle component, or the cover.
The middle fixed part of the speed bump houses and covers all the other components and it is screwed down in the tarmac with the numerous screws mounted in the respective positions that are specially made for sealing holes in tarmac, but also offering a good grip.

The holes drilled into the part are of 4 different sizes:

- 30mm Ø larger hole for the screw head;
- 20mm Ø threaded screw holes;
- 15mm Ø larger hole for the 20mm Ø screw head;

- 10mm Ø threaded screw holes for the slope end screws.

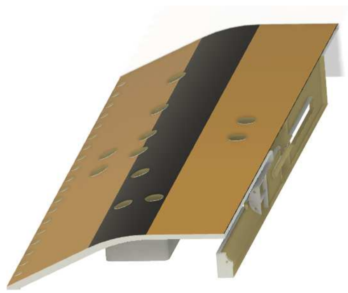

Fig. 12 Middle fixed part section view for the motor support holder

The section view allows for a more comprising look that reveals the motor holder extension. The motor fits right into the empty block that we can see in front. It is fastened in place with 6 screws, 2 in the front, facing the slider cap and 4 in the back, facing the middle of the part.
The material used for this part is AISI 1035 Steel that is recommended for its good elasticity and stainless property to not be affected by the weather elements that will act on it day by day.
Another advantage is the great tensile strength that is certainly a requirement in this field, since large vehicles weighing up to 50 tones are very likely to pass over it.
Every component is basically directly linked to the middle component and so, it is of a very high importance to have a good and solid, yet pretty elastic base in order to allow high loads to act on it, without causing any damage.
On the lower side of the component (figure..), a total of four holes have been cut in order to offer access to the installation team. The screws that link the motor to the inner base are only accessible through there.

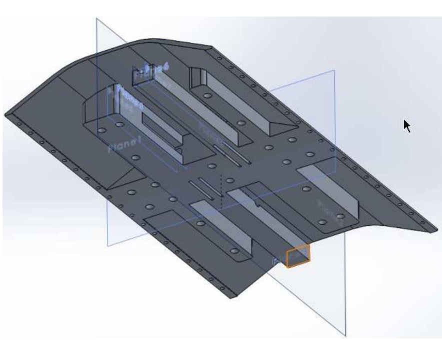

Fig. 13 The lower side of the middle part

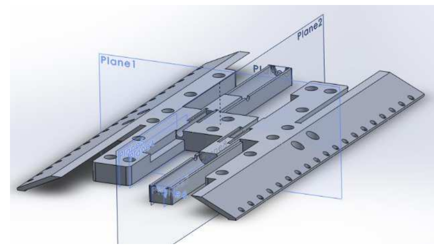

Fig. 14 Section view of the middle part from a top perspective view

4.1.3 Slider cap

Even though this component doesn't seem to have an important role in the correct working of the speed bump active intelligent system [16], the way it has been integrated in this operation does very much.
The purpose of this relatively small and apparently unimportant part is actually transmitting the motion developed by the DC electromagnetic linear motor onto the sliding part.
This linkage is done through and kept up to tolerances with a set of screws that press up against the two rigid materials. The selected materials allow it to have a bit of inertia delay/play when accelerating onward to the extended or retracted position.

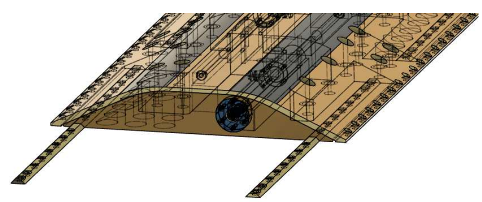

Fig. 15 Sealing cap assembly view

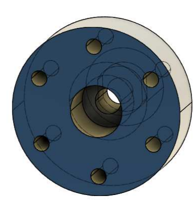

Fig. 16 Sealing cap detailed view

4.1.4 The rails

The supportive rails serve the purpose of guiding the sliding mechanism precisely to the

end of its stroke, being capable of withstanding higher loads than without them.
There are two rails on each side. This type of railing permits the slider to also slightly float above the ground and thus, be very silent in its operation.
The material out of which the rails are made must be a stainless steel type, to prevent small destructive road debris from clutter it. Also, a profile bar would not cope, as it must withstand elements that can destroy it such as loaded vehicles. This is the reason that they have a slope inclination on both of its sides, to prevent incoming cars and lorries squish. The other aspect of it is that the vehicle will not have to feel the amount of shock a rectangular profile rail on the road, so they could pass over it without any other speed constraint. Rails are not a particularly a clean solution, but depending on the road type, they may be necessary for the imposed road section payload limit.

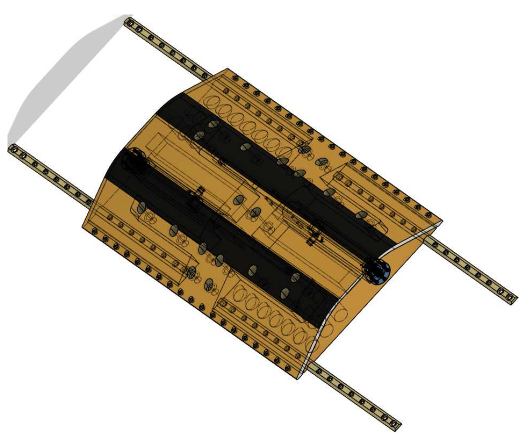

Fig. 17 The railing system top view

5. CONCLUSION

This paper presents the design of a speed bump with a complex sliding opening system. For this speed bump we created the concept, being a very easily integrable device. Also, the installation of this device does not require holes in the asphalt, apart from those necessary for fixing. This is an advantage as it ensures that the surface quality will not be affected at all. This speed bump can be used to calm traffic, being active only when a vehicle has a speed higher than the allowed limit, and if the speed is legal the speed bump remains inactive.

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PROIECTAREA UNUI DIMINUATOR DE VITEZA CU UN SISTEM COMPLEX DE DESCHIDERE

Rezumat: Lucrarea prezintă proiectarea unui diminuator de viteza care are un sistem complex de deschidere cu glisoare, iar pentru proiectarea acestui sistem s-a folosit programul Fusion 360. Acest speed bump se deschide prin intermediul unor glisoare atunci cand un autovehicol are o viteză mai mare decât limita admisă, iar dacă viteza este una legală speed bump-ul rămâne închis și autovehicolul putând trece peste acest obstacol fără să aibă o influență asupra lui. Actionarea glisoarelor se face prin intermediul unui motor liniar.

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