METABK 56(3-4) 375-378 (2017)
UDC – UDK 539.67:621-752:629.1-4:532.7=111

EFFECT ON THE VIBRATION OF THE SUSPENSION SYSTEM

Received – Prispjelo: 2016-12-15
Accepted – Prihvaćeno: 2017-04-20
Original Scientific Paper – Izvorni znanstveni rad

In order to determine the damping effect of shock absorbs in vehicles, different vehicles acceleration values were measured while they were passing over speed bumps at different speeds. The vehicles' vibration magnitudes caused by road roughness were analyzed. In this study the measurements were conducted with two different vehicles, multiple drivers and at different speeds. The vibration valves were determined with a HVM 100 device, in different field conditions and at 20 - 40 and 60 km/h by transferring the results to the system. According to the results of statistical analysis damping effect of the shock absorbers in the vehicles changed in different speed ranges and field conditions and it was seen that driver's performance was significantly affected due to the vibration.

Keywords: damping, shock absorbers, vibration, vehicles, suspension

INTRODUCTION

Suspension system of the vehicle is connected to the wheels which provides contact between the road and vehicles. The task of the suspension system is to undertake the shocks that are transferred to the vehicle due to the holes that a moving vehicle's wheels way fall into or bumps that they may come across and as a result, it both protects the vehicles mechanical parts and provides driving comfort. Wheels move up and down while they are passing over the holes and bumps on the roads. The suspension system prevents the vibration of the wheels from reaching the body of the car and from resulting in uncontrolled movements of the body.

It was concluded that when vehicles have a damping element which gives a high damping at low frequencies, does not do its duty after a certain frequency, and activates at about 9 Hz, both transportation safety and vibration comfort will be in about a 20 % better state [1]. In a study on repetitive tractors examined the isolation systems of driver's seats. For this purpose, mechanical vibration generator tests were conducted in laboratory conditions [2]. In a dissertation study, vibration sizes were measured using cushions made of three different materials during field work [3]. In another study, the impact of suspension systems elements on the vibration of the vehicles was examined by creating a mathematical model [4]. The most important element to consider in projecting the vibrant machines is the determination of damping [5]. The objective in vibration measurements is the vibration frequency and vibration amplitude [6]. Damping is an obvious event of engineering, and is an important factor in material-vibration control implementations [7]. The damping is efficient on amplitude and damages of the vibration [8]. The value at which the amplitude reaches its peak is named resonance frequency [9]. Analytic modal model was selected for measuring the FRF data, and estimation of FRF was executed by using any of modal parameters [10]. The measurement of vibration data is required in many domains in mechanic, aviation, automotive, and construction engineering. This data allows the structure and other mechanic systems to be modelled appropriately [11].

In this study, in order to examine the damping effect of the shock absorbs used in cars and to calculate the magnitude of vibration, the vehicle vibration isolation system behavior was examined by calculating vertical acceleration valves, of certain speeds, of two different types of vehicles used in test studies conducted at different speeds on bumpy road conditions.

MATERIALS AND METHODS

Passage of the vehicle over the bam and suspension systems shown in Figure 1.

Suspension systems are composed of spring and damping elements as well as mass and wheels. Road roughness was shown as sinusoidal curve shown as.

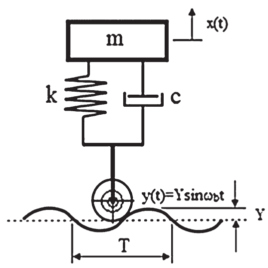

Figure 1 Passage of the vehicle over the bam and Suspension system

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Vibrational frequency is obtained from the connection between road roughness and vehicle speed. The equation for the displacement of the vehicle is as shown.

$$x(t) = A.sin(\omega t + \theta) \quad (1)$$

In this equation ; A: amplitude (m, rad)
ω: frequency (Hz)
t: time (s)
θ: phase constant

The acceleration value equation is as shown

$$\ddot{x}(t) = \omega^2.A.sin(\omega t + \theta) \quad (2)$$

The frequency generated from the ground roughness depends on the horizontal speed of the vehicle. The equation of warming frequency caused by speed and road are as shown,

$$\omega_b = \vartheta(km/h) \quad (3)$$

If ground roughness, height and period are taken into account, an equality occurs shown as

$$\omega_b = a.\vartheta(rad/s)$$

Here is a constant coefficient, and is the speed of the vehicle.

ω_b is the surface frequency. The damping ratio equation is as shown:

$$\zeta = \left(\frac{c}{2\sqrt{km}}\right) \quad (4)$$

In this equation ; c: damping coefficient

km given in the denominator depens on the characteristic of the damping system. It determines the critical damping constant. It ratio of vehicle displacement in the vertical direction to road roughness is shown as,

$$X = Y.\sqrt{\frac{1+(2\zeta r)^2}{(1-r^2)^2+(2\zeta r)^2}} \quad (5)$$

where X is the vertical displacement of the vehicle, and Y is the height of road's roughness. According to the standard toolbar using the information in the above equations, the vertical amplitude rations of vehicles at 20, 40, 60, 70, and 90 km/h speeds. Passenger car 1 and land vehicle 2 are shown in the index.

Table 1 **The amplitude ratios of vehicles**

Hız / km/h		r_1	r_2	x_1 / cm	x_2 / cm
20	5,82	1,08	1,31	7,77	3,36
40	11,67	2,16	2,62	0,78	0,51
60	17,45	3,23	3,93	0,35	0,25
70	20,36	3,77	4,59	0,26	0,17
90	26,18	4,85	5,89	0,18	0,11

In the experiments, statistical data were obtained through obtaning the valves of Passenger car 1 and land vechile vehicles on bumpy roads speeds of at 20 km/h, 40 km/h and 60 km/h. The speed bumps created for the test roads are 60 cm wide and 5 cm height.

Two types of vehicles used for the test. One of them was land, and the other was passenger car. The pick up truck was a 2012 model and has been selected owing to its use in difficult land conditions and load-carrying.

The acceleration valves, in the vertical direction, of the car and pick-up truck occuring while they are passing over bumps in different speeds are shown in Figures 2 - 7. Experiments were conducted on two different vehicles.

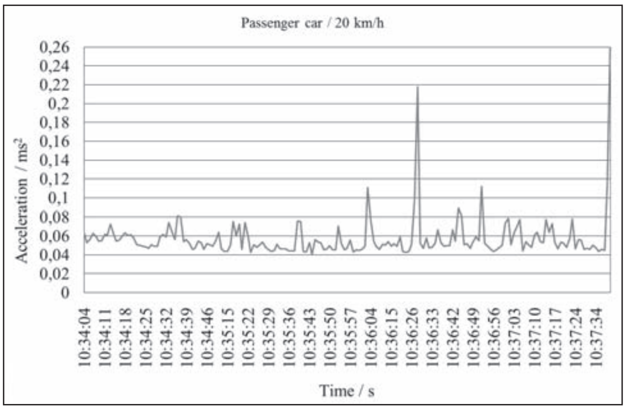

Figure 2 The car's acceleration graph at 20 km/h

In Figure 2 it is seen that the acceleration valves increase as per the next bump.

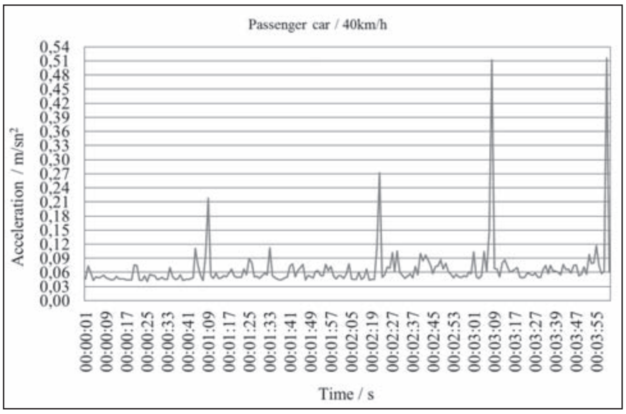

Figure 3 The car's acceleration graph at 40km/h

In Figure 3 a higher acceleration occurs at the first bump. The acceleration valve is observed as a higher degree at the first bump due to the noughness in front of it.

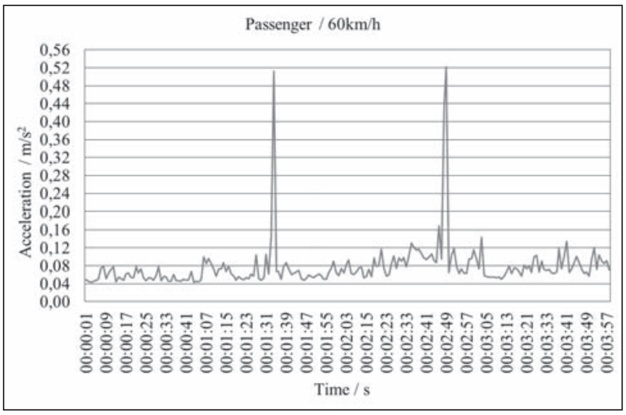

Figure 4 The car's acceleration graph at 60 km/h

In Figure 4 we observed that the acceleration valve in the second bump is higher than the others. It is related to the surface of the bump. In general, the acceleration value of all three bumps are close to each other.

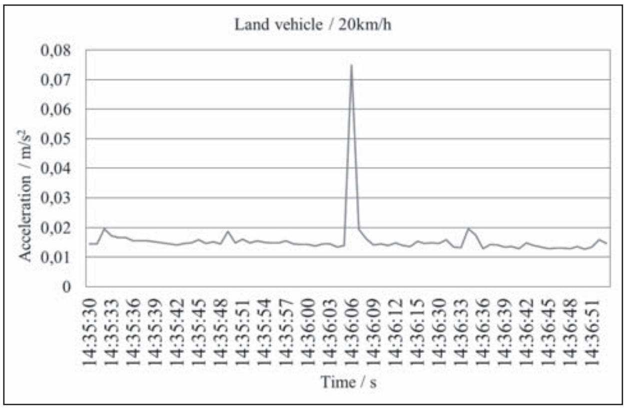

Figure 5 Land vehicle acceleration graph at 20 km/h

It can say that acceleration also increases nearly in the ratio of speed increase. In Figure 5 a land vehile passes over two bumps, and the others pass, over three bump.

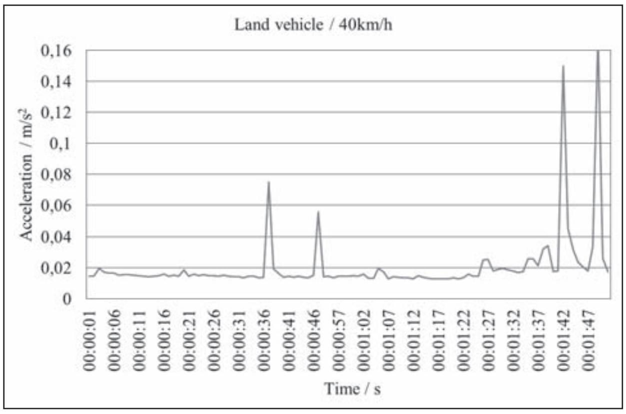

Figure 6 Land vehicle acceleration graph at 40 km/h

When Figure 6 -7 are analyzed, it is seen that acceleration valves are higher speed increase. It is observed that it is higher than the speed increase in the experiments conducted with the car.

In the light of the data obtained through the conducted tests, measumed acceleration valves of the passenger car and land vehicle during their passages over the road

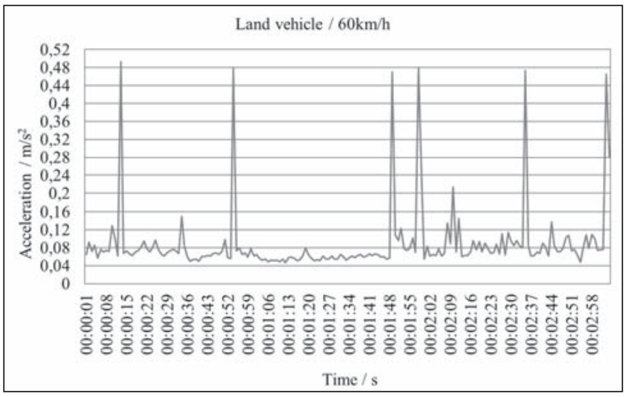

Figure 7 Land vehicle acceleration graph at 60 km/h

Table 2 **Passenger car's and land vehicle speed / acceleration values**

Vehicle	Speed / km/h	a_{max1} / m/s² acceleration1	a_{max2} / m/s² acceleration2
Passenger car	20	0,272	0,218
	40	0,553	0,516
	60	0,722	0,682
Land vehicle	20	0,0749	0,0557
	40	0,17	0,15
	60	0,493	0,478

at 20 km/h, 40 km/h and 60 km/h and over the bumps at the stated speeds are shown in Table 2.

The acceleration valve is seen to fall when the amplitude increases. It can be seen from the figures acceleration values vary depending on the speed. It is observed that acceleration valves increase in proportion to speed. It is seen that land vehicle's acceleration valve rise is higher although passenger car's acceleration valve rise is regular.

CONCLUSION

The data recorded whiile the vehicles were moving were transformed into graphs and numeric data a computer software program. The experimental and theoretical data were compared and it was seen that there was a little difference between theem. It was observed that the acceleration, valve increased with an increase in speed. At the same time, while acceleration increased, amplitude decreased. A vehicle passing at a high speed over the speed bumps created less amplitude. The graph of the passenger vehicle shows a hyperbolic curve of acceleration in proportion to speed, and the graph of land vehicle shows a parabolic curve of speed-acceleration increase. It is concluded that the sizes of acceleration and amplitude, mass, spring and damping elements have a significant effect on. It is detected that of acceleration and amplitude may increase or decrease through changes on these three vibration elements. As a result of studies conducted at different speeds, the following results are found.

As the speed increases, acceleration valves increased in proportion to the state of road vehicles passage over bumps and, so on and amplitude valves decreased. It was also detected that frequency ratios increased with an increase in speed. At the same speeds as the mass of vehicle increased, the acceleration valve decreased and as the mass decreased, the acceleration valve increased.

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Note: The responsible translator for English language: Volkan Serin, Izmir, Turkey