Brake efficiency determination of light vehicles

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Abstract. The present paper presents a study whose objective is to determine the brake deceleration of two classes light vehicles - class A is vehicles with weight up to 1350kg, class B is vehicles with weight up to 1000kg. The vehicles of both classes are equipped with ABS system. The measurements are made with commercial device BRAKESAFE. Measured parameters are vehicle speed, stopping distance and total time to stop. The vehicles were tested under varying conditions: with ABS system activated or deactivated; tires at different stage of wear. The obtained results are analyzed and conclusions are made about measured brake parameters under all conditions.

1. Introduction

The exact determination of brake deceleration at emergency stopping is important parameter, which is used for calculation of some values at preparation of vehicle crash expertise. In technical literature exists information about brake deceleration, but in some books that are used when preparing expertise this information is old or not accurate enough \cite{1, 2, 3}. Also, this data in most causes is not valid for new vehicles. To improve accuracy of results it is necessary to update this database. In this study are determined brake deceleration, stopping distance and total time to stop of some of the most common light vehicles.

The value of brake deceleration is used in many formulas for determination of speed of vehicle before impact, speed of vehicle in the moment of impact, time for moving of a vehicle from point A to point B, necessary distance to stop of vehicle and etc. The exact determination of this parameter will increase accuracy of calculation and at preparation of vehicle crash expertise \cite{4,5}.

The aim of this study is to measure and determine the brake deceleration, stopping distance at emergency stopping at different vehicle speeds, different tire tread wear and with or without ABS system. For the experiments of stopping without ABS system, the tested vehicles are the same, only this system is electrically turned off.

2. Experimental study procedures

2.1. Classes vehicles and measurement device

The study was carried out at Department of Transport Engineering and Technologies at Technical University of Varna. Two classes of light vehicles are researched.

Class A are vehicles with weight up to 1350kg, sedan or station wagon with four and five doors, produced from 2000 till 2010 year. All of the vehicles are equipped with ABS system and use brake disc...
for front and rear wheels. Class B are vehicles with weight up to 1000kg, sedan or hatchback with three and four doors, produced from 1999 till 2010 year. All of the vehicles are equipped with ABS system and use also brake disc for front and rear wheels.

The experiments are conducted at sunny days, dry asphalt with temperature around 34°C on a horizontal road section. Measured speed of vehicles is from 10 till 70 km/h to full stop.

The measurement device is shown in figure 1. The tester is BRAKESAFE [6], certified and produced in England.

![Brake tester](image)

Figure 1. Brake tester.

Parameters of the device are shown in table 1.

| №  | Parameter                                           | Value                                      |
|----|-----------------------------------------------------|--------------------------------------------|
| 1  | Range (m/s²)                                        | 0 ÷ 13                                     |
| 2  | Accuracy (m/s²)                                     | 0.2                                        |
| 3  | Display                                             | Graphical LCD                             |
| 4  | Measures force applied to brake pedal               | Yes                                        |
| 5  | Bluetooth                                           | Wireless connectivity                     |
| 6  | Case                                                | IP65                                       |
| 7  | Weight (kg)                                         | 1                                          |
| 8  | Approved from - Vehicle and Operator Services Agency | (VOSA)                                    |

2.2. Results

The shown results are averaged for class A from 10 tested vehicles, class B from 8 tested vehicles.

The graphs shown in figure 2 illustrate the variation of brake deceleration for both classes vehicles at speed from 20km/h, 30 km/h, 40 km/h, 50km/h and 70 km/h.
At speed till 50km/h the brake deceleration have slightly lower values for vehicles of class A around 8.5 m/s², for vehicles of class B around 7.8 m/s². Over 50km/h vehicles of class A have brake deceleration around 9.0 m/s², vehicles of class B around 8.0 m/s².

Figure 3 illustrate the variation of stopping distance for both classes vehicles at speed from 20km/h, 30 km/h, 40 km/h, 50km/h and 70 km/h.
At speed 20km/h – stopping distance is around 5m, at 50km/h – stopping distance is around 16m and at speed 70km/h stopping distance is around 30 meters.

Figure 4 illustrate the variation of total time to stop for both classes vehicles at speed from 20km/h, 30 km/h, 40 km/h, 50km/h and 70 km/h.

![Figure 4. Variation of total time to stop.](image1)

The total time to stop is a function again of brake deceleration. At speed 20km/h – time to stop is around 1.2s, at 50km/h - time to stop is around 2.0s and at speed 70km/h – time to stop is around 2.6s.

Also is tested on the same vehicle how braking deceleration changes when the automobile stop with and without ABS system at speed 40km/h. Results are shown on figure 5. The shown values are averaged for every tested class of vehicles.

![Figure 5. Braking deceleration with and without ABS system.](image2)
At the same conditions is conducted a test to determine what is the influence on braking deceleration at different tire tread wear at speed 40km/h. Tests are made with three type of tires with depth of protector 3mm, 6mm and 8mm. Tested vehicle is from class A, model of the tires is Continental - Conti eco contact. The results are shown in next figure.

![Figure 6. Braking deceleration depending from tire wear.](image)

3. Conclusion

The analysis of the experimental results provides the basis for drawing the following conclusions:

- At speed over 50km/h the braking deceleration of vehicles from class A is with 7% higher than at speed under 50km/h;
- At speed over 50km/h the braking deceleration at vehicles class B is around 10% higher than at speed under 50km/h;
- ABS system increases braking deceleration for vehicles class A with 25%, for vehicles class B with 26%.
- The presence of an ABS system in the vehicles increases the braking deceleration (Braking efficiency) average with around 25%.
- Tire tread wear up to minimal allowable value reduces braking deceleration with 10%.

References

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