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CHANGES OF AUTOMOBILE ACCELERATION DEPENDING ON MOVEMENT REGIME

AUTOMOBILIO GREITĖJIMO KITIMAS PRIKLAUSOMAI NUO VAŽIAVIMO REŽIMO

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Three kinds of acceleration can be distinguished – linear, cross direction and vertical. Depending on the direction of acceleration it can be either positive or negative. There is a united conception only concerning linear acceleration – in the direction of the movement, or running up it is positive but it is assumed to be negative when braking. In the research the acceleration of the automobile Renault Traffic in all three directions performing trial rides on the roads with asphalt-concrete and ground cover of Jelgava region have been determined. The data were recorded continuously but analyzed only in definite regimes in turnings as well as on ground cover roads with different movement speed.

Acceleration, direction of acceleration, driving comfort, measurement methods, device.

Introduction

Vehicles of different age and technical condition are being exploited on roads with various condition levels in Latvia. Some vehicles are operated off-road. Acceleration in different directions seriously affects the cargo compartment and the passengers. In technical literature there is little available information on the fluctuation of acceleration effects on the human organism. If it is then this data is outdated, because the car park and their design have changed.

The study aims to find out what forces are acting on the vehicles, if to drive at cover corners. The investigational item is a vehicle, acceleration values and directions. The vehicle, the nature of the motion set at different driving modes, and bottom coverage of asphalt roads, as well as the acceleration changes in the law - in the city and beyond. The nature of motor vehicle movement provides the acceleration changes in corners - the city and beyond. A simple method was developed by author during trials for accurate determination of the vehicle acceleration of an accelerometer EK3LV02DL. The method approbated tests of the car RENAULT TRAFFIC [3].

Materials and Methods

Car running smooth is its ability to move over the rough road with a sufficiently high speed, ensuring a smooth process with minimal fluctuation. Car moving along an uneven path, body movements cause of suggestive force of the road bumps. Car body fluctuations may cause discomfort to passengers, a fast driver fatigue and affect his capacity to work in a negative manner. Car body movements also affect the cargo maintain during transportation and the car's technical condition. Car body suggestive force fluctuation effects depend on speed of the car, road roughness height and placement, and these factors often have random character. Therefore, the car's body movements have random character. For these reasons, the car running smooth characterized by the car body oscillation parameters characterizing the light of how they affect the human senses of comfort levels. Car body oscillation on human is typically evaluated by subjective criteria, but the car running smooth characterized only from the qualitative side. There is no common criterion for assessing the smoothness of car running, which would link the character of these fluctuations with the effect of the fluctuations on human body. Therefore, for characterization of car running smoothness several different oscillation process parameters are used [2].

Experimental studies of acceleration. The investigational object is a car produced in 2007 Renault Traffic (gross weight of 2835 kg, 1957 kg unloaded weight, tires 195/65R16C Roadstone EURO-WIN 650, the tread depth of 8 mm, tire pressure 3.4 bar front axle, rear axle 3.7 bar, the chassis type front axle independent McPherson-type suspension, dependent rear suspension system with a monolithic bridge beams and leaf springs, 1995 cm^3 diesel engine with 66 kW power).

The studies were conducted in 2009, on the 15th and 22nd of April in Jelgava, Jelgava region, Dobele and the region. The weather conditions were good, the wind speed was 2-3 $m \cdot s^{-1}$, the air pressure 770 $mm \cdot hg^{-1}$, no precipitation was. The bottom roads were in good condition, recently graded without pits.

In total in the experiments 99 426 measurements were obtained, of which the selection for characterization of specific motion regimes was done. Only the data, obtained performing the tasks in the planned regimes – different driving modes along the bottom road out of town, were used and processed.

In the experiments two devices were used:

• ELM SCAN 5 USB which transforms the engine speed and speed signals sent from the car in a format that may be perceived to be used by a computer program.

• EK3LV02DL 3 Three axes digital output low voltage linear accelerometer or g sensor.

The *AUTO PROCESS MONITOR* can write data from the two facilities. First, calibrating accelerometer for changes to program settings. Calibration settings for each channel window installed in the appropriate parameters.

Technology research program

1. Vehicles placed in a flat position. Turn on the ignition, the added diagnostic nest ELM SCAN 5USB converter.

2. Plug the computer power unit SBS adopter Car Notebook PC A090 cable car 12 V socket. Measuring equipment connected to the signal wire to the computer.

3. Place the tripod in the car accelerometer steel plate and secure to an accelerometer attached EK3LV02DL.

4. Turn on the accelerometer program. Indicate a connection port and press the button "connect" the accelerometer illuminates the green diode. Then press the "start" button and "dir detect" – moving the accelerometer in the set operational direction. Once all parameters are entered, an accelerometer is attached to the stand in the car stand and levered.

5. The *AUTO PROCESS MONITORS* program is opened. The monitoring mode, data are shown in the graph in real time. Each channel corresponds to one specified color line. The channels are in the following order: revolutions per minute (rpm), speed, air flow (MAP), 3 axis of accelerometer (Fig. 2).

6. During the pilot runs the value of different driving modes was fixed in the computer. Depending on the time axis data the driving regime is recorded in the experiment notes. They are used for identification of the corresponding motion regime, through data processing after the experiment. [3]

In order to describe the turn it is necessary to determine the radius of it Fig.1:

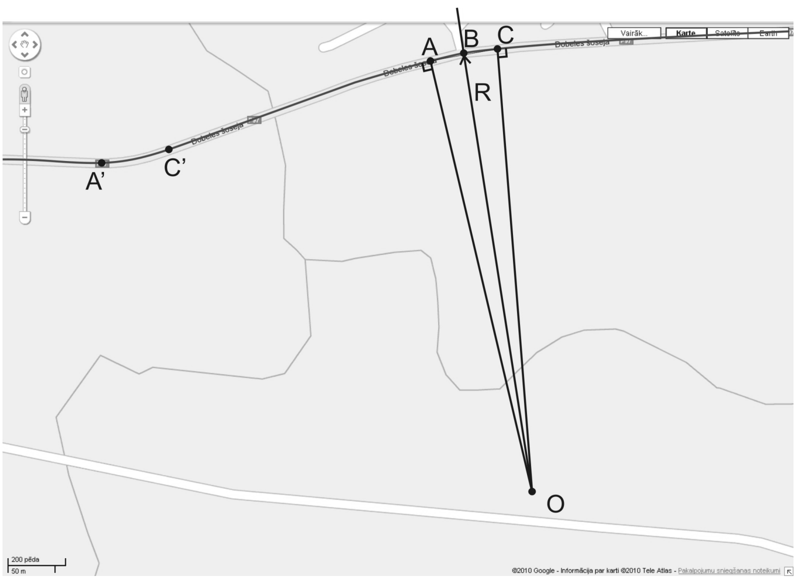

Fig. 1. Determination of the radius of turn
1 pav. Posūkio spindulio nustatymas

1st On the map, with a defined scale, start and end points A and C are set;

2nd points A and C are connected;

3rd a perpendicular to the road center line of the points A and C is drawn;

4th O is obtained, a straight through the beam mid-point of AC is pulled and point B obtained, which is the midpoint of the turn;

5th according to the map scale the length of the OB is defined.

Results and discussion

Research objects grouped:

Across acceleration turns outside the city;

Across acceleration turns in the city.

1. Investigation of across acceleration in turns outside the city. *RENAULT TRAFFIC* was used as the object for these studies. It had an acceleration reading device, which recorded acceleration in three directions. Test runs were made at maximum possible speed following the traffic regulations.

The first turn outside the city was done on highway to Dobele which is near Jelgava city at speed ≈ 80 $km \cdot h^{-1}$, although before the turn the speed was lowered up to 77 $km \cdot h^{-1}$, which can be observed in the software „Auto process monitor" (APM) longish acceleration curve Fig 2.

During trial runs on the computer were recorded acceleration values in different driving modes. Depending on the time axis data, the ride regime in the experiment protocol was noted. The protocol was used to identify the mode of movement through the processing of data from the experiment. In order to get with other data curves comparable data, the APM program acceleration values were increased 100 times. Within data processing further three columns were created, values in which were divided by and the real values of acceleration $m \cdot s^{-2}$ obtained. During the experiment geographical locations in nature were manually fixed. After recording five turns in the city and five outside were selected. Depending on the data on time axis the experimental protocol was filled in with the information about regime of motion. Protocol was used to identify the motion system, through data processing after the experiment. Exploring APM curve was specified entry and exit serial numbers, the data selected and displayed in the first table.

Geographic location is showed in the map Fig. 3. The figures indicate studied curves, the sequence of the performance. It is quite difficult and inaccurate to determine the turning radius in nature, therefore it would be appropriate to use the car's steering angle recorder. It would also facilitate the turning radius of the city turns the recording would record real turning radius of a turn.

Figure 4 reflects curves which come from APM drawn based on the information in table 1. X-axis curve is longish acceleration curve, the Y axis is across acceleration curve, but the Z axis is vertical acceleration curve. Longish acceleration and the vertical acceleration corresponds the left of the acceleration scale, but across acceleration corresponding right-hand scale of acceleration.

1 Table. Turn outside the city before bridge Svete direction to city Dobele, surface asphalt.
1 lentelė. Užmiesčio posūkis už Svete tilto Dobele miesto kryptimi, kelio danga – asfaltas.

				readed g values				real g values $m \cdot s^{-2}$		
time	Nr	rpm min^{-1}	speed $km \cdot h^{-1}$	X axle	Y axle	Z axle		X axle	Y axle	Z axle
4	9317	1623	78	2	59	1008		0,02	0,59	10,08
5	9318	1623	78	9	90	1058		0,09	0,9	10,58
6	9319	1623	78	0	113	1083		0	1,13	10,83
7	9320	1623	78	-7	133	1117		-0,07	1,33	11,17
8	9321	1623	78	5	125	1121		0,05	1,25	11,21
9	9322	1623	78	-15	125	1092		-0,15	1,25	10,92
10	9323	1623	78	9	118	1031		0,09	1,18	10,31
11	9324	1623	78	-9	108	881		-0,09	1,08	8,81
12	9325	1623	78	11	110	854		0,11	1,1	8,54
13	9326	1623	78	-2	124	890		-0,02	1,24	8,9
14	9327	1623	78	9	112	943		0,09	1,12	9,43
15	9328	1623	78	-14	118	876		-0,14	1,18	8,76
16	9329	1623	78	8	132	1087		0,08	1,32	10,87
17	9330	1623	78	11	124	1216		0,11	1,24	12,16
18	9331	1623	78	-7	110	1120		-0,07	1,1	11,2
19	9332	1623	78	-21	87	1023		-0,21	0,87	10,23

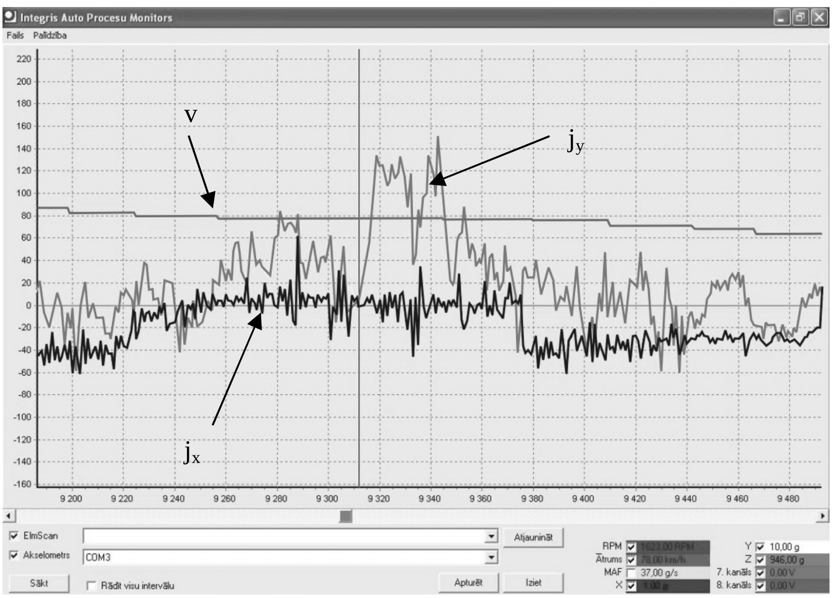

Fig. 2. APM curved during 1st turn outside the city
2 pav. APM kreivės atliekant 1-mą posūkį užmiestyje

Fig. 3. Experimental turns out of the city
3 pav. Eksperimentiniai posūkiai už miesto

Average across acceleration in the first curve was 0.919 $m \cdot s^{-2}$, the maximum across acceleration 1.49 $m \cdot s^{-2}$, the minimum across acceleration 0.18 $m \cdot s^{-2}$. Turn made at an average speed of $V_{vid.p.}$ = 78 $km \cdot h^{-1}$. Turning radius of about 800 m.

2nd Studied turn was with the about same radius, only directed to the right, so the schedules of the Y-axis has negative values. Average across acceleration in second turning was -1.427 $m \cdot s^{-2}$, the maximum across acceleration -2.24 $m \cdot s^{-2}$, the minimum across acceleration -0.74 $m \cdot s^{-2}$. Turn done at an average speed of $V_{vid.p.}$ = 68 $km \cdot h^{-1}$. In these curves, which are outside the city and carried out at a high speed, exposure of passengers may vary. For example, if the path is profiled, the passengers feel less across acceleration as opposed to unprofiled road. Both above mentioned curves are profiled.

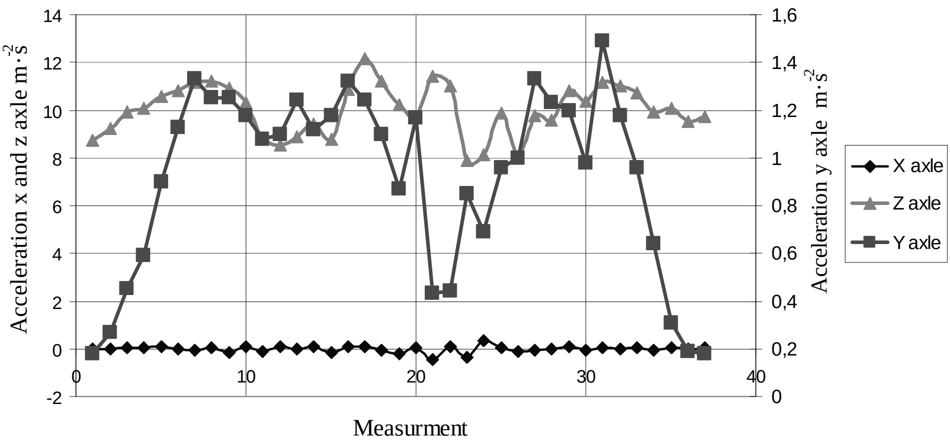

Fig. 4. Values of acceleration driven in 1st turn outside the city, surface – asphalt
4 pav. Greitėjimo rezultatai pirmame užmiesčio posūkyje, kelio danga - asfaltas

The 3rd studied turn is not far from the first and the second, directed to the right. The curves from the APM after data analysis and selection can be seen in figure 6. This is an unprofiled turn, probably that is the reason why the passengers could face the acceleration more than during 1st and 2nd turns. Turn was made at an average speed of $V_{vid.p.}$ = 62 km·h^{-1}. Average across acceleration in third curve was -1.74 m·s^{-2}, the maximum across acceleration -2.52 m·s^{-2}, the minimum across acceleration 0.34 m·s^{-2}. Turning radius is approximately 115 m.

The 4th studied turn is towards P98, directed to the right. This is an unprofiled turn. Turn made at an average speed of $V_{vid.p.}$ = 90 km·h^{-1}. Average across acceleration in 4th turn was -0.775 m·s^{-2}, the maximum across acceleration -1.91 m·s^{-2}, the minimum across acceleration 0.47 m·s^{-2}. Turning radius is approximately 700 m.

The 5th Studied turn is towards P98. This is an unprofiled turn and made at an average speed of $V_{vid.p.}$ = 87 km·h^{-1}, the average across acceleration in 5th curve was 1.195 m·s^{-2}, the maximum across acceleration 1.85 m·s^{-2}, the minimum across acceleration 0.04 m·s^{-2}. Turning radius is approximately 750 m.

2. Investigation of across acceleration in turns in the city. The first studied turn in the city was near to the Technical Faculty, leaving the courtyard of the Akademijas Street. The average speed in this turn was $V_{vid.p}$. = 10 km·h^{-1}. Geographical location shown on the map in Fig 5. This is a right turn, so a negative value is seen in the schedules on the Y axis.

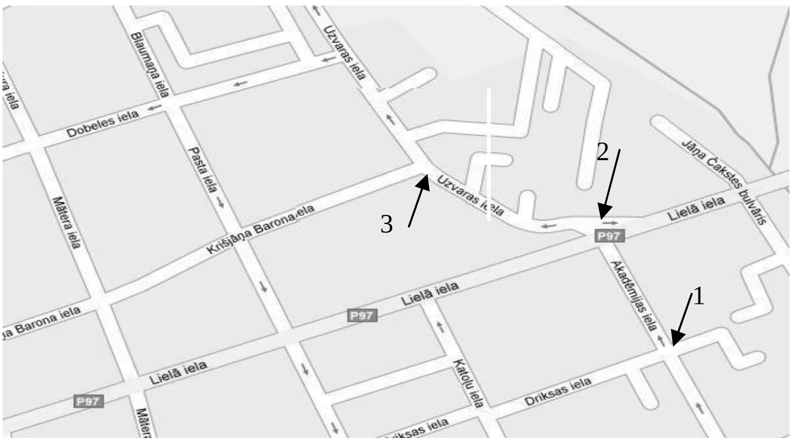

Fig. 5. Experimental turns in the city
5 pav. Eksperimentiniai posūkiai mieste

The average across acceleration in the first turn in the city was -1.03 m·s^{-2}, the maximum across acceleration -1.93 m·s^{-2}, the minimum across acceleration 0.1 m·s^{-2}.

The second studied turn of the city is located in the city center and it's a smooth turn from Akademijas street to Uzvaras street. The average speed was $V_{vid.p}$. = 25 km·h-1. On the APM curves through the data selection curves were designed as shown in Fig 6. Average across acceleration second turn the city was 1.66 $m \cdot s^{-2}$ maximum across acceleration 2.5 $m \cdot s^{-2}$, minimum across acceleration 0.28 $m \cdot s^{-2}$.

In the third studied turn of the 90° left from Uzvaras street to Dobeles street. The average speed was $V_{vid.p.}$ = 18 $km \cdot h^{-1}$. The average across acceleration in third turn of the city was 1.62 $m \cdot s^{-2}$ maximum across acceleration 3.16 $m \cdot s^{-2}$, minimum across acceleration -0.33 $m \cdot s^{-2}$.

4^{th} and 5^{th} investigated turns visibly in Fig 7. Fourth turn is a turn where the street enters the industrial rotary circle near the Gaisa bridge. This is a right turn. The average speed was $V_{vid.p}$. = 23 $km \cdot h^{-1}$. The average across acceleration was -0.74 $m \cdot s^{-2}$, the maximum across acceleration -1.65 $m \cdot s^{-2}$, the minimum across acceleration 0.13 $m \cdot s^{-2}$.

The fifth turn was the exit from the rotary circle railway station along Station Street. Directed to the right. The average speed was $V_{vid.p}$. = 33 $km \cdot h^{-1}$. The average across acceleration was -2.47 $m \cdot s^{-2}$, the maximum across acceleration -4.28 $m \cdot s^{-2}$, the minimum across acceleration -0.35 $m \cdot s^{-2}$. This is the sharpest of all the turns, in addition with toning a change from left to right, until it reached the highest across acceleration value (4.28 $m \cdot s^{-2}$).

So as to analyze the acceleration values between different modes, designed for Fig 8 and Fig 9, these summarize the average values of acceleration studied at different motion modes. Average values of across acceleration in turns driving out of town can see the Fig 8. Average across acceleration outside the city was 1.21 $m \cdot s^{-2}$. Absolute values of modules were considered, because the negative ones reflect the turn to the other side.

In curves, which are extra-urban and carried at a high speed, exposure of passengers may vary. For example, if the path is profiled, the passengers feel less across acceleration as opposed to unprofiled road.

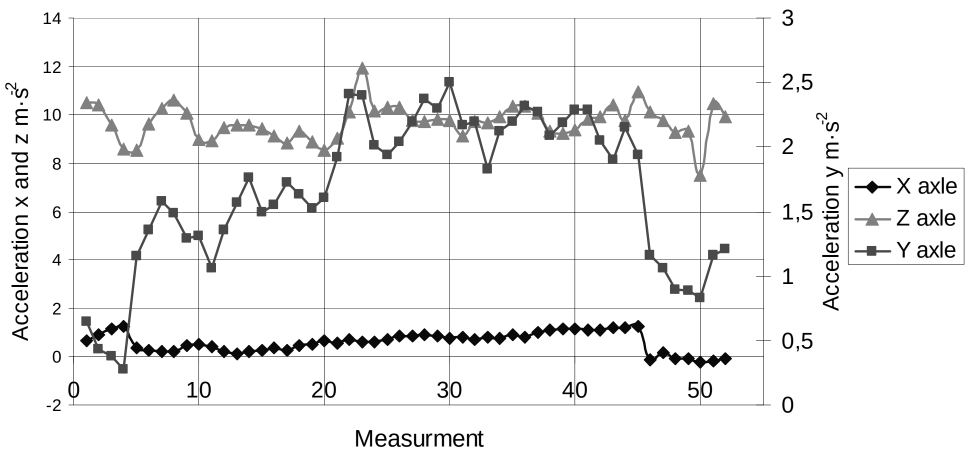

Fig. 6. Values of acceleration driven in 2nd turn in the city
6 pav. Greitėjimo rezultatai antrajame posūkyje mieste

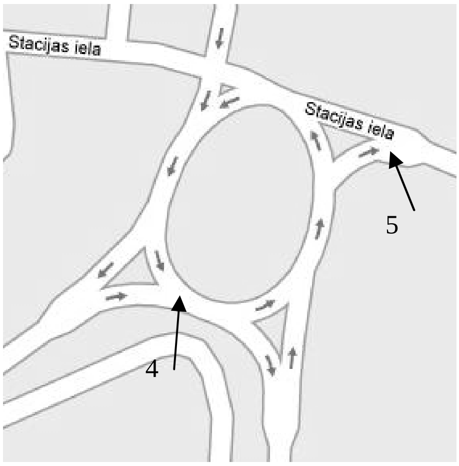

Fig. 7. Experimental turns in the city
7 pav. Eksperimentiniai posūkiai mieste

Average values across acceleration driving curves in the city can be viewed in the Fig. 9. Average across acceleration curves in was 1.56 m·s^{-2}. According to the average across acceleration values it can be observed that higher acceleration values were observed in the city, it would be explained by the fact that the city turns are sharper and often while leaving turn the vehicle accelerates.

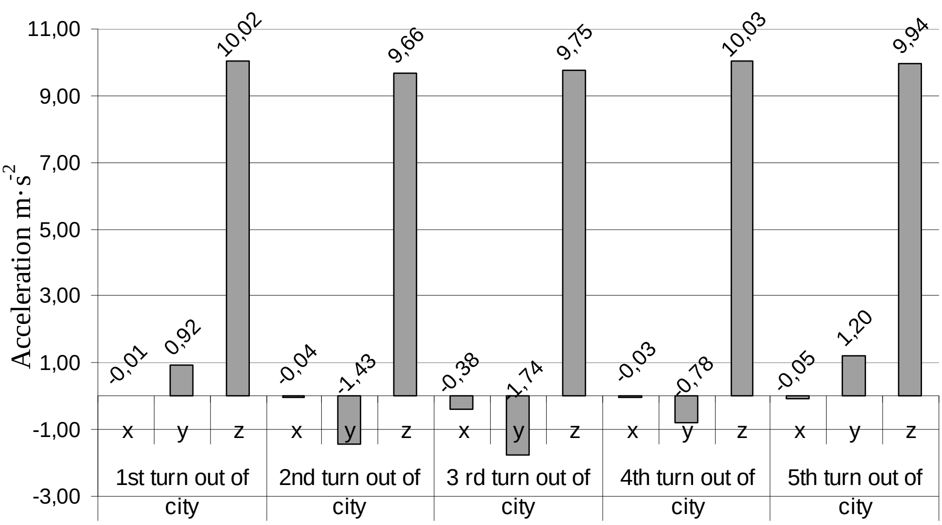

Fig. 8. Acceleration changes in out of city turns
8 pav. Greitėjimo kitimai užmiesčio posūkiuose

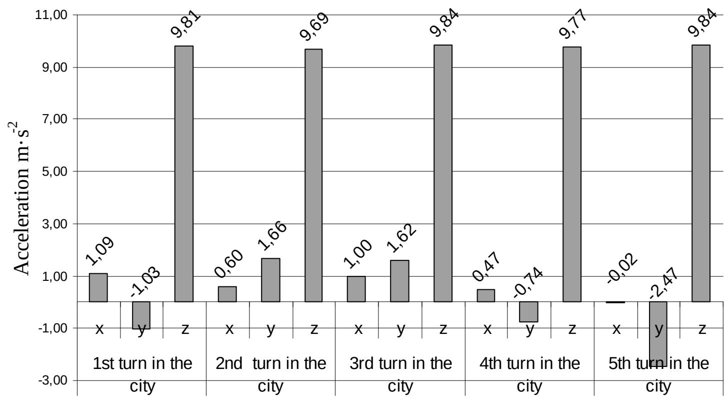

Fig. 9. Acceleration changes in city turns
9 pav. Greitėjimo kitimai miesto posūkiuose

Conclusions

1. The changes of the speed and acceleration can significantly affect cargo maintenance and passenger comfort.
2. Accelerometer and the "Automotive Process Monitor" can be used for continuous recording of parameters of different cars, and research, but requires a computer with sufficient technical resources and power connection to the car.
3. In the city the highest acceleration values in the transverse direction, in our studies is 4.28 $m \cdot s^{-2}$, but outside the city traffic mode 2.52 $m \cdot s^{-2}$.
4. In turns, which are outside the city and carried out at high speeds, the effect on passengers may be different if the road is profiled, the passengers feel less across acceleration as opposed to unprofiled road.
5. It is quite difficult to determine the turning radius, therefore it would be appropriate to use the car's steering angle recorder.

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Андрис Лининш

ИЗМЕНЕНИЕ УСКОРЕНИЕ АВТОМОБИЛЯ ЗАВИСИМОСТИ ОТ РЕЖИМА ДВИЖЕНИИ

Резюме

При движении автомобиля на пассажиров и груз действуют ускорения в трех направлениях: продольном, поперечном и вертикальном. В зависимости от направления ускорения, оно может быть положительным или отрицательным. Продольное ускорение считают положительным при разгоне, а при торможении – отрицательным. В исследованиях определены ускорения автомобиля *RENAULT TRAFIC* во всех вышеупомянутых направлениях. Исследования проводились на дорогах с асфальтным и грунтовым покрытием, на разных режимах движения. Экспериментальные данные в ходе эксперимента зарегистрированы компьютерной программой и проанализированы после эксперимента при конкретных режимах. При анализе поперечных ускорений получены наивысшие значения 1,74 м·с$^{-1}$ в загородном режиме езды и 2,47 м·с$^{-1}$ в городском режиме.

Ускорение, направления ускорения, комфорт езды, методы измерения.

Andris Lininš

AUTOMOBILIO GREITĖJIMO KITIMAS PRIKLAUSOMAI NUO VAŽIAVIMO REŽIMO

Reziumė

Automobiliui važiuojant pagreitis veikia keleivius ir krovinį trim kryptimis: išilgine, skersine ir vertikalia. Priklausomai nuo krypties pagreitis gali būti teigiamas ir neigiamas. Pagreitis išilgine kryptimi yra laikomas teigiamu kai automobilis įgreitinamas, o stabdant − neigiamu. Tyrimuose nagrinėti automobilio *RENAULT TRAFIC* pagreičiai visomis išvardintomis kryptimis. Tyrimai atlikti asfaltuotame ir gruntiniame keliuose įvairiais važiavimo režimais. Eksperimentų metu matuojami duomenys buvo registruojami kompiuteriu naudojant specialią programą ir po eksperimento buvo analizuojami konkretus važiavimo režimai. Atlikus eksperimentų analize didžiausia išilginio pagreičio reikšmė gauta 1,74 м·с$^{-1}$ užmiesčio važiavimo režime ir 2,47 м·с$^{-1}$ miesto režime.

Greitėjimas, greitėjimo kryptis, matavimo metodai, priemonės.