EXPERIMENTAL RESEARCH OF DYNAMIC STRESSES OF MOTORCYCLE'S FRAME

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INTRODUCTION

Motorcycle dynamic characteristics and the paths/roads along which they have been driven often do not have correlated characteristics, i.e. the quality of the road often is not appropriate to high dynamic performance of motorcycles.

In this paper work is considered the effect of vertical oscillations to dynamic reactions, which are in direct relation with the force transmitted by the wheel, both in lateral and in longitudinal direction. It's quite obvious that vertical vibrations have considerable effect to motorcycle safety and stability.

EXPERIMENTAL MEASUREMENT CONDUCTED ON HONDA MTX 125 R MOTORCYCLE

In figure 1. the entire HONDA MTX 125 R motorcycle is shown, while in figures 2. and 3. is shown the way how device should be installed to the motorcycle frame.

Figure 1.

Figure 2.

In figures 4, 5 and 6. is presented a driver with already installed measurement device before the experiment started.

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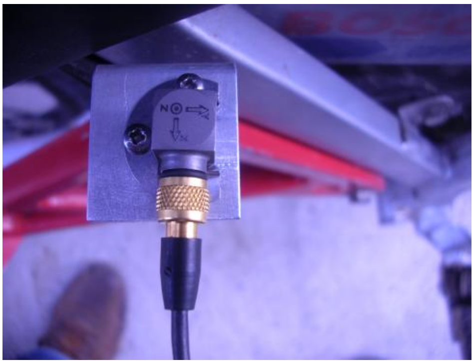


Figure 3.

Figure 4.

Figure 5.

Figure 6.

In the following figure 7. 1100m long test road where the experiment was performed is shown. The asphalt cover is made of good quality; the road is strait and even without longitudinal or lateral inclinations.

Figure 7.

Motorcycle was accelerated up to the certain speed. At the moment when desired speed was reached, that was observed directly on the instrument panel a device would be turned on and based on the marks previously set along the road, the acceleration along the road L=1100m was recorded.

The results are presented by direct transmission from device display to the paper (print screen). The marks given in the table have the following meaning:

- RMS – Root Mean Square
- MTVV – Maximum Transient Vibration Valve the highest RMS value during the measurement for the integration time 1sec.
- Peak
- CF- Peak/ RMS - crest factor
- F – factor of difficulty (is used during vibration measurement – body acceleration, in this case this factor is equal to 1)
- VTV – Vibration Total Value

DESCRIPTION OF MEASUREMENT EQUIPMENT–VIBRATION ANALYZER 4447

Human response to vibrations differs according to the frequency range of the vibration, amount of exposure and the point of contact. For power tool and vehicle operators, prolonged exposure to vibration can be harmful.

To protect workers, legislation such as EU Directive 2002/44/EC, sets forth minimum health and safety requirements for those exposed to risks arising from work-related vibration.

Figure 8: *Human Vibration Analyzer Type 4447*

Human Vibration Analyzer Type 4447 is a portable system designed for those who wish to monitor and reduce the exposure of potentially harmful vibration influences and ensure compliance to the EU directive. It is an effective and easy-to-use instrument that fulfils the international standard ISO 8041:2005, - Human response to vibration - Measuring instrumentation.

USES AND FEATURES

USES

- Hand-arm vibration measurements
- Whole-body vibration measurements
- Assessment of vibration exposure

FEATURES

- Compact, battery-powered instrument
- Four-button operation: Easy to use, ideal for field work, and can be operated using gloves
- Minimal cable connections: Only one transducer cable connection in the basic setup
- Triaxial and uniaxial measurements
- EU Directive parameters measured and displayed
- In-field assessment of vibration exposure all necessary data are displayed
- Simultaneous display of X, Y and Z axes. vibration, as well as total value
- USB connection: Transfer data to a computer for post-processing and archiving as well as battery charging
- Included PC software, 4447 Vibration Explorer
- BZ-5623, for data transfer, management and calculations on a PC

USER INTERFACE

Vibration analyzer Type 4447 can be operated easily with only four pushbuttons, as shown in Fig. 9.

Figure 9: *The four buttons on the front panel control the user interface of Type 4447*

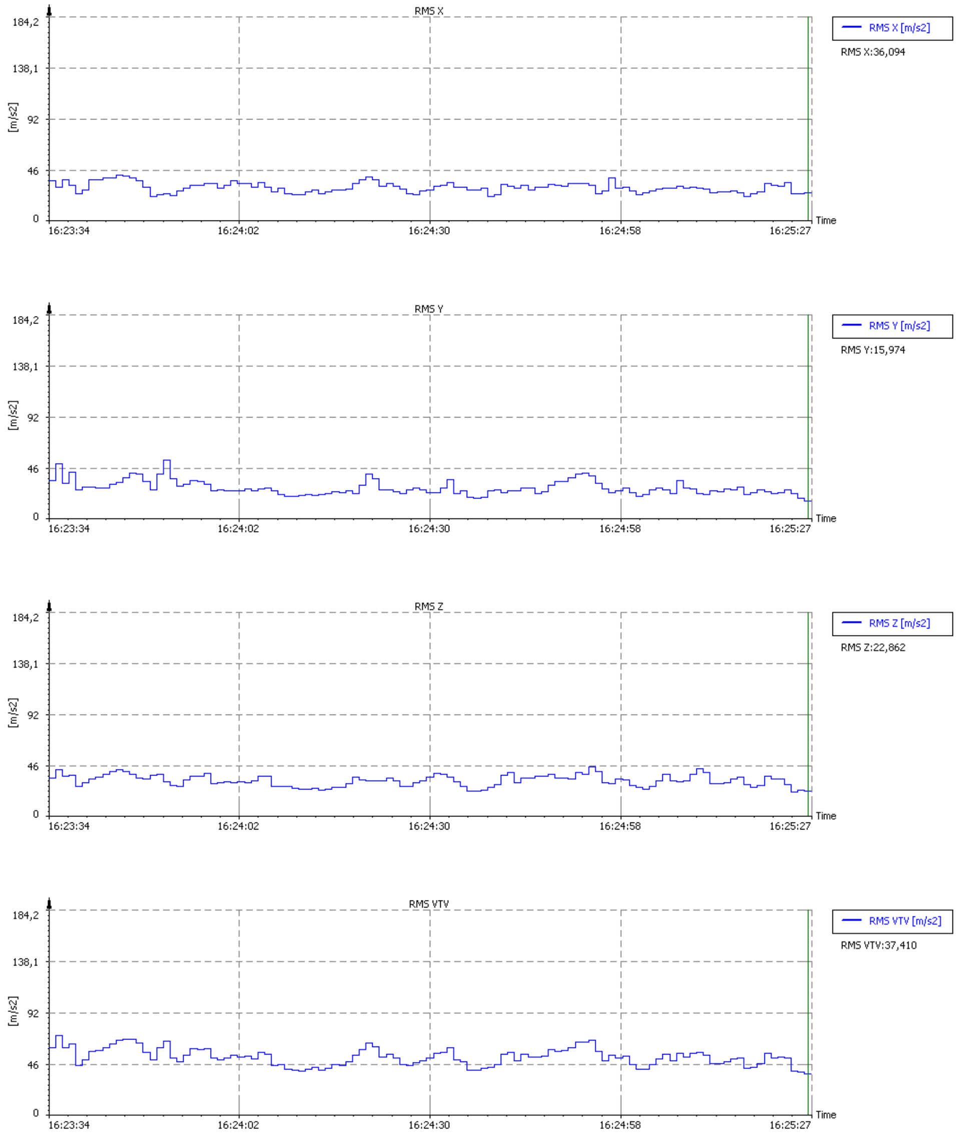
Type 4447.s graphical colour interface makes it easy to set up measurements and display results. Readings are by default in meters per second squared (m/s2), but can be displayed in g, dB re. µm/s2, m/s1.75 or g·s0.25.During a measurement, the results for the individual and combined axes are displayed. See Fig. 2 for an example of a measurement display. You can step through additional screen displays at any time during a measurement.

Results at the speed 30 km/h

Table 1.

Name	Unit	X	Y	Z	VTV
RMS	[m/s2]	30,264	28,446	32,473	52,722
MTVV	[m/s2]	40,453	47,718	44,934	
Peak	[m/s2]	126,044	148,316	175,408	
CF		4,164	5,213	5,401	
Factor		1,00	1,00	1,00	
Overload		No	No	No	
Underrange		No	No	No	

Diagram 1.

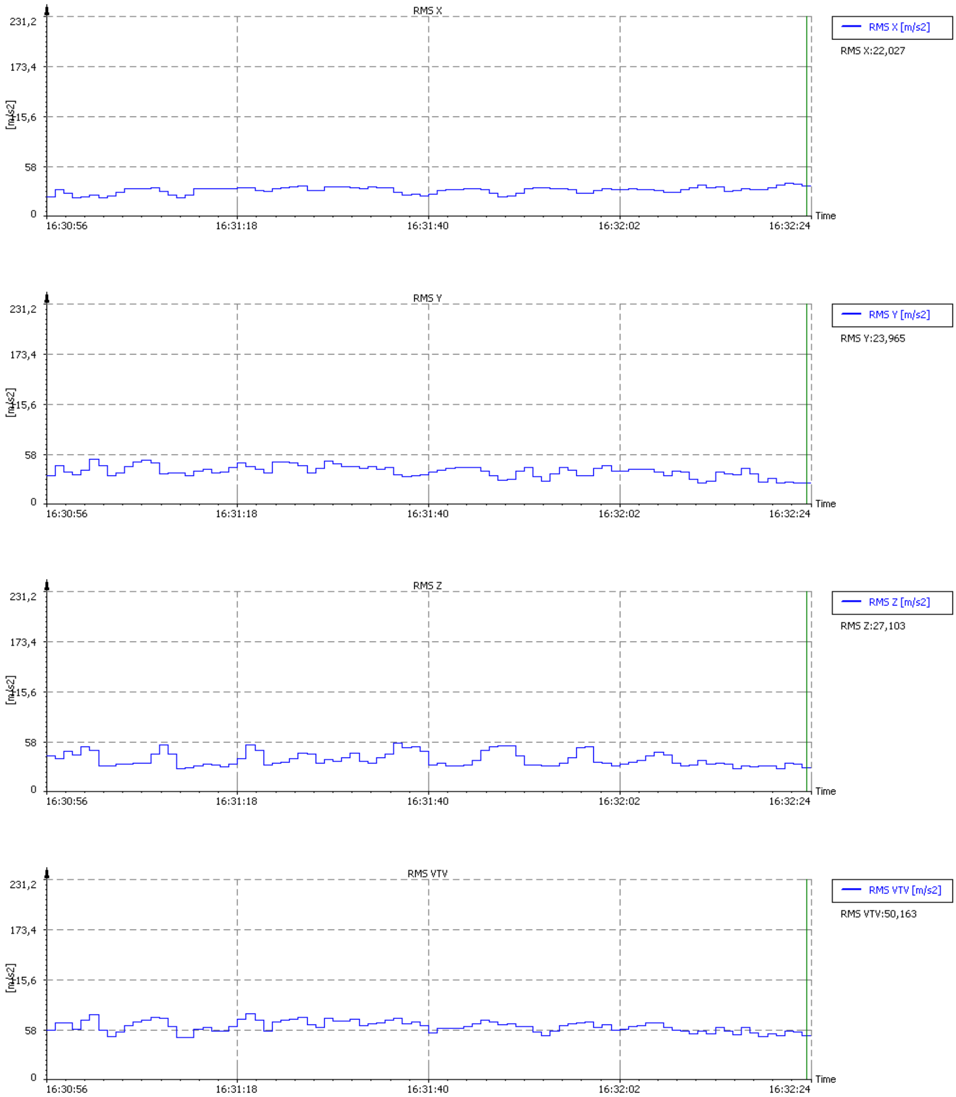


Results at the speed 50 km/h

Table 2.

Name	Unit	X	Y	Z	VTV
RMS	[m/s2]	30,119	38,264	37,819	61,657
MTVV	[m/s2]	37,658	49,212	53,824	
Peak	[m/s2]	118,179	159,552	220,146	
CF		3,923	4,169	5,820	
Factor		1,00	1,00	1,00	
Overload		No	No	No	
Underrange		No	No	No	

Diagram 2.

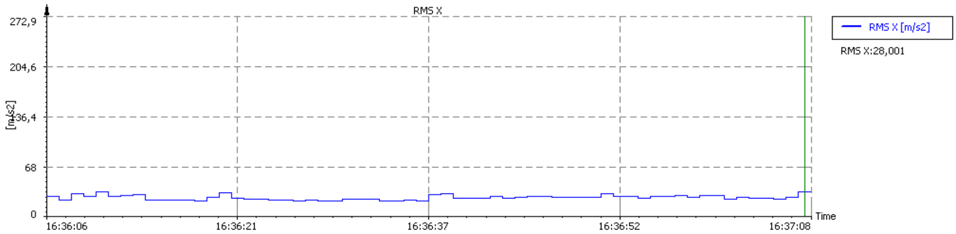


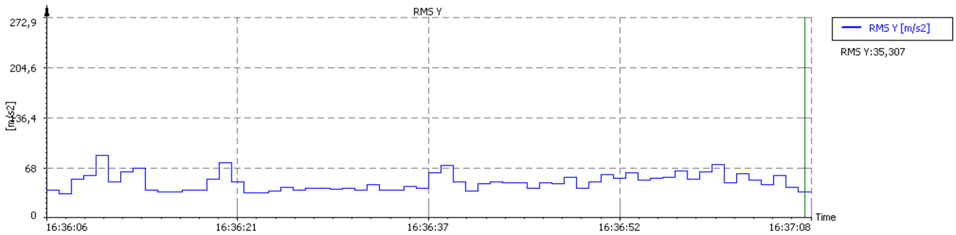
Results at the speed 70 km/h

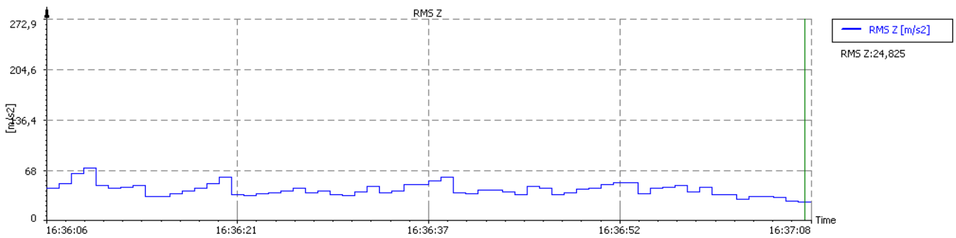
Table 3.

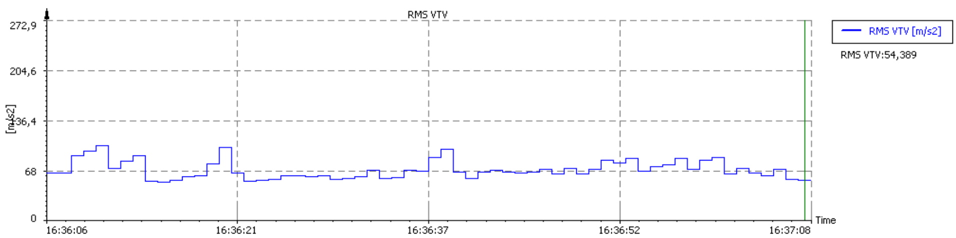
Name	Unit	X	Y	Z	VTV
RMS	[m/s2]	25,937	49,441	42,386	70,099
MTVV	[m/s2]	34,346	77,801	71,945	
Peak	[m/s2]	156,295	259,860	251,152	
CF		6,025	5,255	5,925	
Factor		1,00	1,00	1,00	
Overload		No	No	No	
Underrange		No	No	No	

Diagram 3.







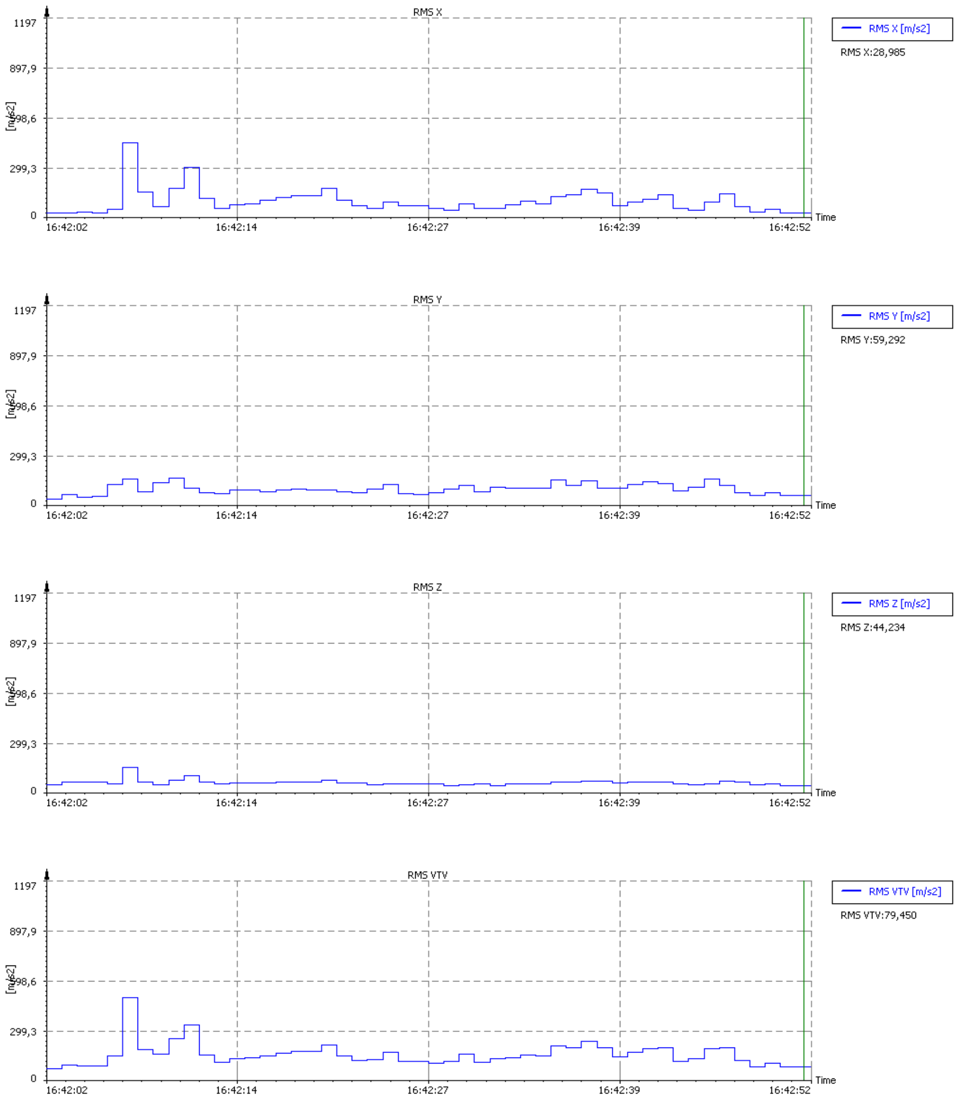


Results at the speed 90 km/h

Table 4.

Name	Unit	X	Y	Z	VTV
RMS	[m/s2]	120,503	102,891	64,164	170,953
MTVV	[m/s2]	403,961	151,002	143,772	
Peak	[m/s2]	1140,248	415,123	487,023	
CF		9,462	4,034	7,590	
Factor		1,00	1,00	1,00	
Overload		No	No	No	
Underrange		No	No	No	

Diagram 4.

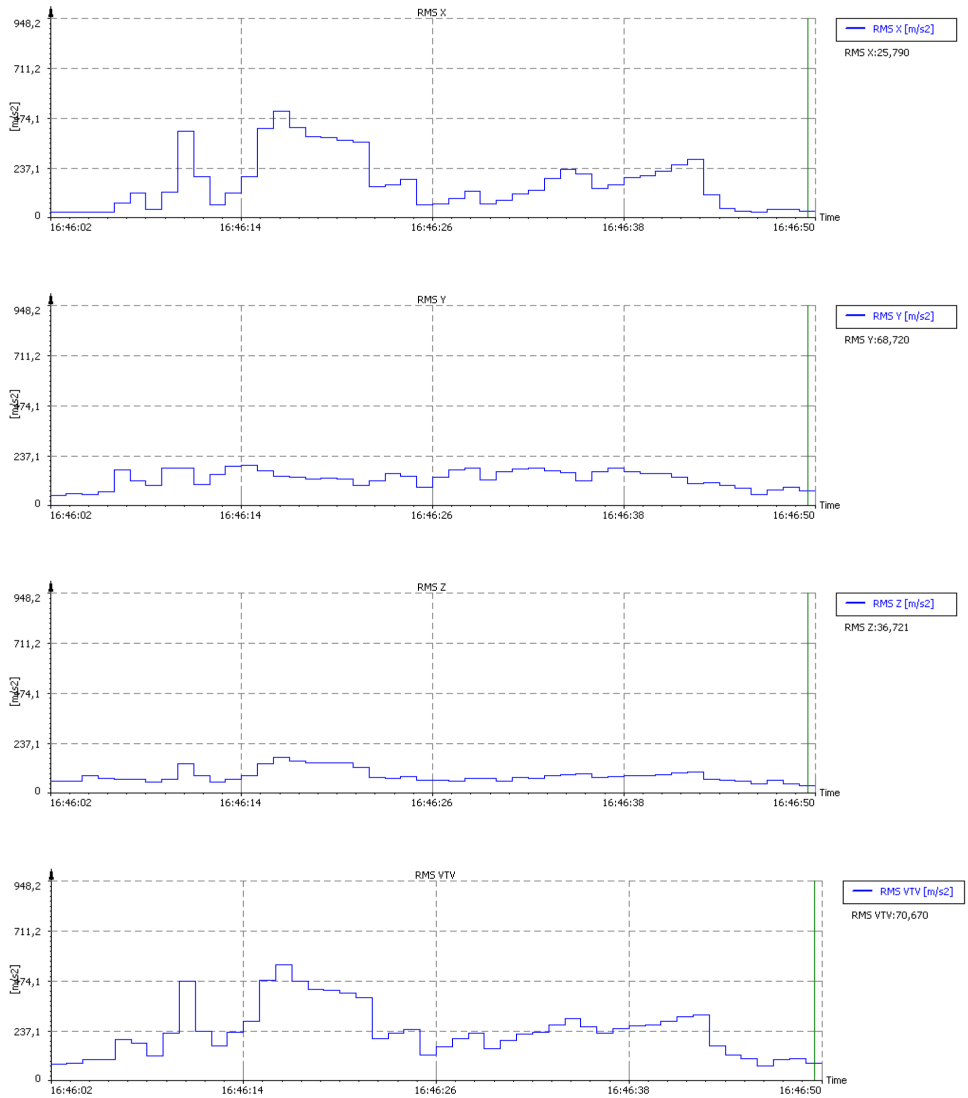


Results at the speed 110 km/h

Table 5.

Name	Unit	X	Y	Z	VTV
RMS	[m/s2]	208,751	134,426	87,027	263,099
MTVV	[m/s2]	460,810	185,903	155,154	
Peak	[m/s2]	903,082	444,949	489,238	
CF		4,326	3,309	5,621	
Factor		1,00	1,00	1,00	
Overload		No	No	No	
Underrange		No	No	No	

Diagram 5.

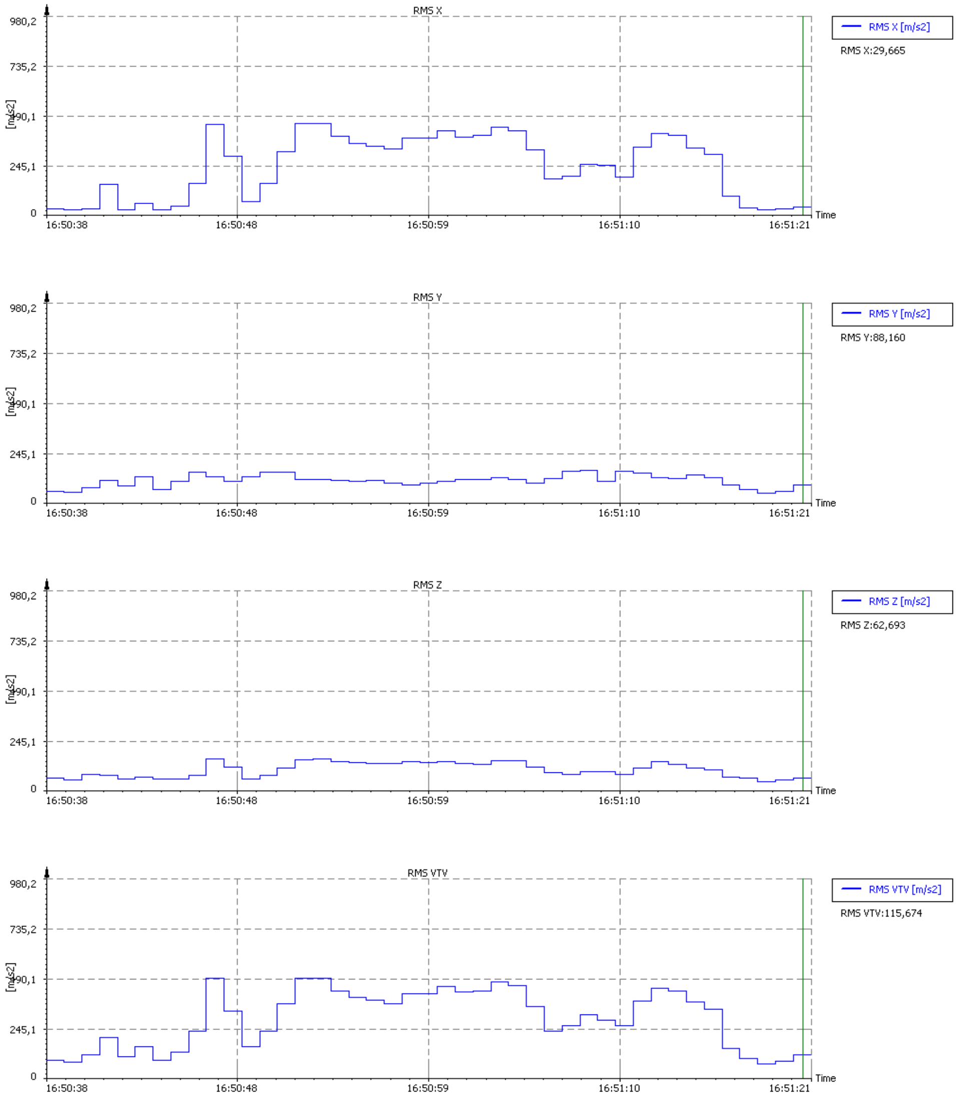


Results at the speed 130 km/h

Table 6.

Name	Unit	X	Y	Z	VTV
RMS	[m/s2]	284,232	114,140	108,265	324,865
MTVV	[m/s2]	438,575	154,949	151,731	
Peak	[m/s2]	933,535	395,511	558,559	
CF		3,284	3,465	5,159	
Factor		1,00	1,00	1,00	
Overload		No	No	No	
Underrange		No	No	No	

Diagram 6.



DYNAMIC REACTIONS

The simplified model based on which it's possible to calculate dynamic reactions is shown in the following figure.

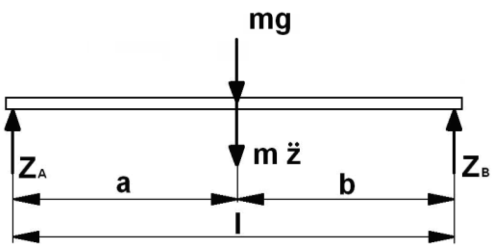


Figure 10.

Force equilibrium equation of all forces in "z" direction:

$$m \cdot (\ddot{z} + g) = Z_A + Z_B$$
$$\ddot{z}^* = \ddot{z} + g$$
$$m \cdot \ddot{z}^* = Z_A + Z_B$$

The torque equation at point "A" is:

$$m \cdot \ddot{z}^* \cdot a - Z_B \cdot l = 0 .$$

Based on these equations it's possible to calculate the values of dynamic reactions:

$$Z_A = \frac{m \cdot \ddot{z}^* \cdot b}{l} \text{ и } Z_B = \frac{m \cdot \ddot{z}^* \cdot a}{l}$$

where:

$\ddot{z}^*$ - acceleration measured along z – axis, Z_A - dynamic reaction of a front wheel and Z_B - dynamic reaction of a rear wheel.

Data necessary for calculation of forces are:

- motorcycle and driver's weight $m = 180kg$
- wheel base $l = 1{,}45m$ and
- center of gravity is defined by distances $a = 0{,}8m$ and $b = 0.65m$

Since the motorcycle was driven with the constant speeds: 30 km/h, 50 km/h, 70 km/h, 90 km/h, 110 km/h и 130 km/h, for each value will be calculated dynamic reactions at the beginning (I - turning device “on”), in the middle (II) and at the end of each measurement interval (III – turning device “off”).

Motorcycle motion, same as specified interval points in which dynamic reactions are being calculated might be presented in the following diagram.

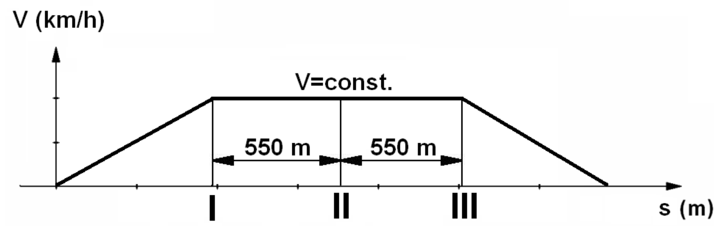


Figure 11.

Obtained results are presented in the following table:

		DYNAMIC REACTIONS (кN)					
	Speed (km/h)	30	50	70	90	110	130
	Interval duration (s)	1'53"	1'28"	1'02"	50"	48"	43"
I	Z_A	2.90	3.55	3.87	4.68	5.08	5.57
	Z_B	3.58	4.37	4.77	5.76	6.26	6.85
II	Z_A	3.15	3.95	4.19	5.00	5.24	7.67
	Z_B	3.87	4.87	5.16	6.16	6.46	9.43
III	Z_A	1.86	2.58	2.66	3.22	3.14	4.92
	Z_B	2.28	3.18	3.28	3.97	3.87	6.06

Obtained results could be presented by diagram.

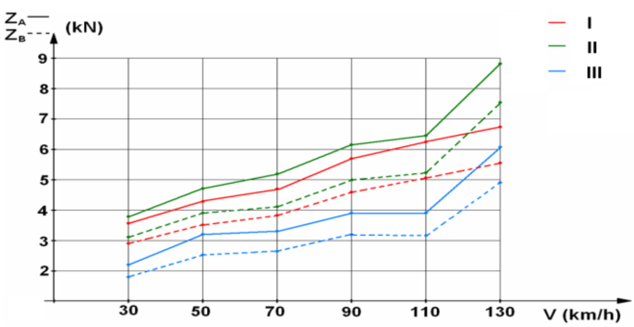


Diagram 7.

In order to make the analysis of dynamic reactions in longitudinal and lateral direction the equations of equilibrium should be settled based on figure 12.

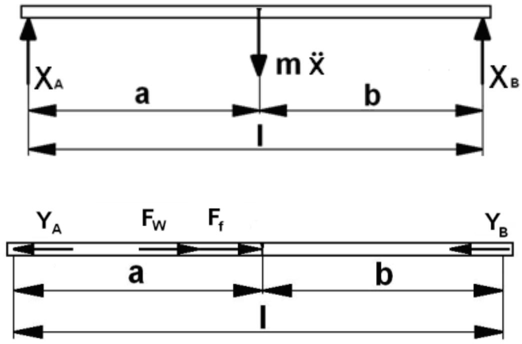


Figure 12.

This analysis, due to its complexity was not comprehended by this paper-work, but it might be the subject of some further researches.

COMMENTS ON THE RESULTS

Constant speed drive

Observing the recorded values during the constant speed drive, it can be noticed that the acceleration is present in all three directions - that means that the rolling effect is present, considering the fact that the device was placed on the motorcycle frame. These accelerations are more or less same up to the speed 90km/h when they became multiplied. This indicates the presence of resonant frequency of the frame at speeds higher than 90km/h.

In the measurement the influence of the road is also counted, i.e. the asphalt cover is not brand new, it is a bit rough and that impact to the measuring results. Also, the subjective behavior of driver has some influence to the results too. Further researches could be performed with the goal to eliminate these two effects – choosing some other, better test roads and some other drivers.

Dynamic reaction values

Based on the diagram where dynamic reaction values are shown, it might be concluded that within the interval and at the small speeds dissipation of the values is under 50%, while at higher speeds dissipation is about 70%.

The effect of a driver to the steering system and to dynamic reactions is highly expressed, because opposite to drive by car, where driver's position is much more stable, in a case of a motorcycle - driver's position has been constantly changing, because driver in this way keeps stability of a motorcycle.

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