Dynamic Tests for Fastening Rubber Plates to Determine Attenuation of Impact Loads

TIBERIU STEFAN MANESCU[1], CRISTIAN CATALIN PETRE[2], NICUSOR LAURENTIU ZAHARIA[3*], TIBERIU MANESCU JR[1], MIHAI BAYER[2]

[1] University "Eftimie Murgu",1-4 Traian Vuia Square, 320085 Reşiţa, Romania
[2] Politehnica University of Bucharest, 313 Splaiul Independenţei, 060042 Bucharest, Romania
[3] Romanian Railway Authority, 393 Calea Griviţei, 010719 Bucharest, Romania

The railways mounting must ensure by strength and stability of the components, the guiding safety and running quality of the railways vehicles at the prescribes speeds and loads. The upper structure of the railroad is made from the ballasts, ties and rails. The steel rails mounted on ties with fastening systems, indication to maintain the railway gauge, rails inclination, stability and lasting of the railroad.

Keywords: dynamic tests, rubber plates, fastening, Centipede, MGCplus

The railways are conventionally divided in *infrastructure* which is represented by the ballast, bridges, tunnels etc. and *upper structure* – which is represented by the rails, ties, devices against derailment etc.

Different types of rail-tie fastening are used in that moment at Romanian Railways [1, 4, 11].

In figure 1 is presented basically the fastening system.

The quality of a railroad depends on the geometrical characteristics, axle load and speed of the railway vehicle.

Until the year 1990, only the fastening *type K* was used at Romanian Railways.

During the years the type K fastening was replaced with other types of fastening with elastic characteristics (the K type is a rigid fastening) based on experience of other railways administrations. The main advantage of the K type fastening is the low cost maintenance during life time compared with others.

On the four pan-European passage on Romanian section which is now in upgraded are used concrete ties and fastening type PANDROL FASTCLIP or type VOSSLOH W14 which were certificated for 200 km/h speed and 25 t axle load.

Nowadays the maximum speed at Romanian Railways is 140 km/h (on some sections) and the maximum axle load is 22.5 t (most of the vehicles have 20 t axle load).

In figure 2 it is shown the elastic fastening. The rubber plate (1) and elastic safety pin (2) make the fastening to be elastic.

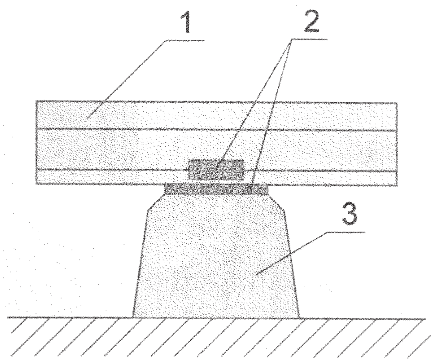
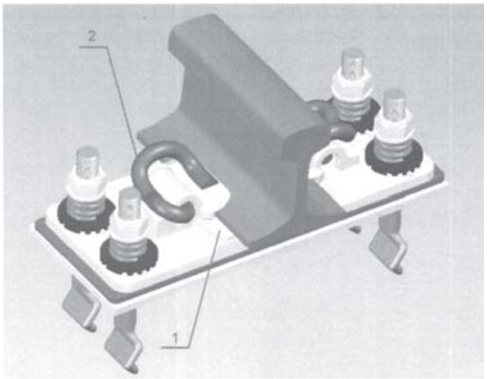
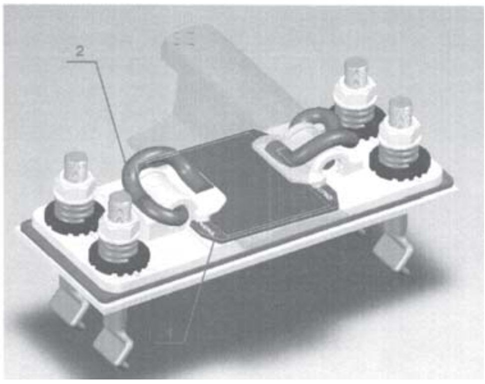


Fig. 1. Rail – tie fastening (1 – rail, 2 – fastening, 3 - tie)



a) Elastic elements of the fastening



b) Rubber plate in view

Fig. 2. Elastic fastening (1 – rubber plate, 2 – elastic safety pin)

Experimental part

Tests

Dynamic tests were performed on the fastening [2, 3, 6, 7, 10, 12]. Hottinger concrete strain gauges were glued on the tie (fig.3). The strain gauges were named TER1 and TER2.

The strain gauges were connected with cables at Hottinger MGCplus dynamic acquisition data system. MGCplus was connected at a laptop with a USB link; the acquisition data interface, was created in Catman 4.5 software (a Hottinger product) [12-14].

For the tests, the tie, must be without cracks, changing of its characteristics with support surfaces precisely

* email.: laurentiu@afer.ro; Tel.: 0723344258

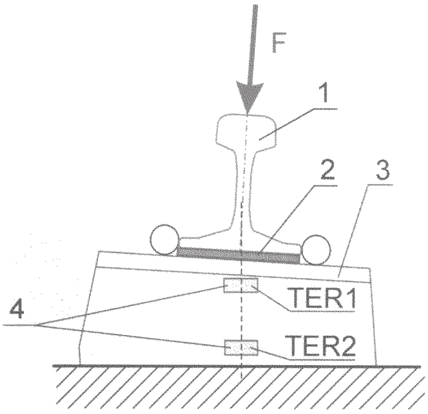


Fig. 3. The test bench (1 – rail, 2 – rubber plate, 3 – tie, 4 – strain gauges)

dimensioned for the fastening system which will be tested [5, 8, 9].

On the tie, the strain gauges are resistive transducers with 100 – 200 mm length glued on lateral tie face symmetrically due the line from the center of support surface, perpendicularly on inferior tie face.

Due to the position of the strain gauges on the tie which is basically a beam, with a bending force on it, the strain gauges will measure the strain on upper fiber and lower fiber.

The main settings of the MGCplus were:
[HBM_MGCPLUS_SETUP]
Amplifier = ML10 (IDS = 5006)
FirmwareVersion = HBM,RD003-ML10,0,P5.42
SerialNumber = 048413095131; AP1:
ConnectorPlate = AP 14 (IDS = 5503)
SensorType = SG quarter bridge 120/4-wire (IDS = 368)
ExcitationVoltage = 5 V (IDS = 14)
GaugeFactor = 2,05
BridgeFactor = 0
NativeUnit = μm/m
FilterCharacteristic = Bessel (IDS = 142)
FilterFrequency = 100 Hz (IDS = 955)
FilterHighPass = H-PASS OFF (IDS = 1200)
The tests were done according to SR EN 13146.

System calibration

Due the strain gauges gluing, the tie becomes a transducer (a force cell), which makes necessary calibrating operation of the whole system.

For calibrating, Hottinger MGCplus dynamic acquisition data system was used by applying known static loads, increasing the force and maintaining for a time bearing. The results were recorded and used later for the tests.

In figure 4 is presented the calibrating diagram for both strain gauges.

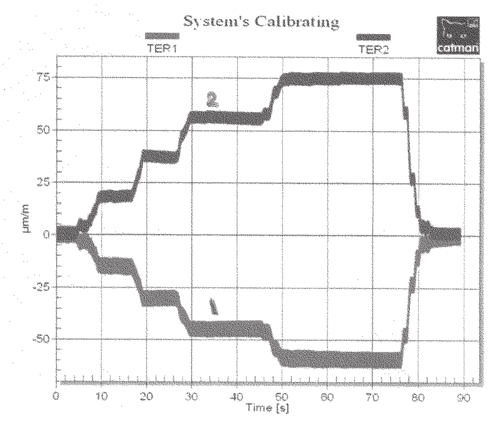


Fig. 4. System's calibrating

Results and discussions

The dynamic tests were performed by applying a dynamic force resulted from the falling down of a load on a upper face of a rail, mounted on the concrete tie. The shock effect was measured in the tie. The shock attenuation which characterize the fastening system is evaluated by comparing the stresses when it is used a reference plate with small attenuation and the tested rubber plate. For the reference plate, the stresses due the impact force, must be smaller than 80 % from the crack stress calculated from tie moment of resistance in the measuring section (M_{dr} according to EN 13230-1).

The weight of the load, the falling height and the impact elasticity are settled so that the admissible stress should not be exceeded. The test is repeated for the tested rubber plate without modifying the above parameters.

The fastening system and the rail are mounted by using the tested plate. A shock is applied on the rail by load's falling down; the data acquisition is started at least 3 ms before the impact and at least 5 ms after the impact. Five shocks are applied on tested rubber plate. The strain is recorded for three consecutive shocks.

The integrity of the tie must be checked after each shock by comparing the ratio between the signal recorded by TER1 and TER2 (ratio R1) with the ratio for a identical tie subjected to a static load (ratio R2). The static load must be identical with the load test which is according to EN 13230-2 and EN 13230-3.

If the difference between ratio R1 and ratio R2 is larger than 10 %, then the fastening system is not good, and the tests must be repeated on other tie.

Results for the reference plate

For reference plate, the weight was released from 400, 600 and 800 mm height. Strains recorded by TER1 and TER2 were saved in the data base. In figure 5 are shown the strains recorded for the reference plate.

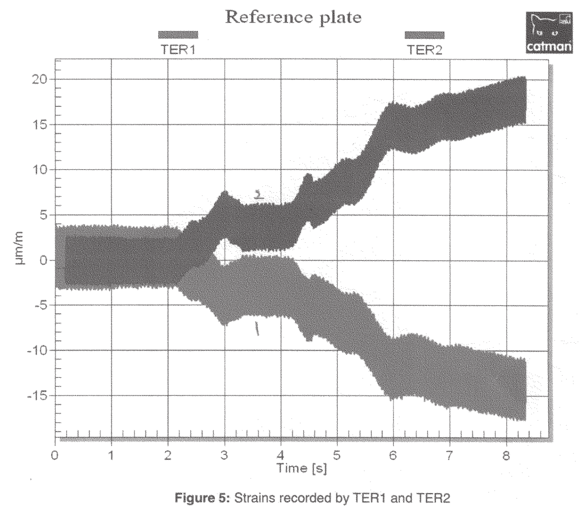


Fig. 5. Strains recorded by TER1 and TER2

For the reference plate, the strains are presented in table 1:

Table 1

Height [mm]	TER 1 [μm/m]	TER 2 [μm/m]
400	-7,027	7,464
600	-15,250	17,263
800	-17,598	19,651

Results for 400 mm falling height

For the first test, the weight was released from 400 mm height. Strains recorded by TER1 and TER2 were saved in the data base.

The diagram from the figure 6 is graphically made in Catman 4.5 based on data base acquisition.

In the table 2 are presented the values recorded during the test which is presented in figure 6. In this table , “minimum values” means minimum value from the point of view of real numbers and “maximum value” was maximum value from the point of view of real numbers.

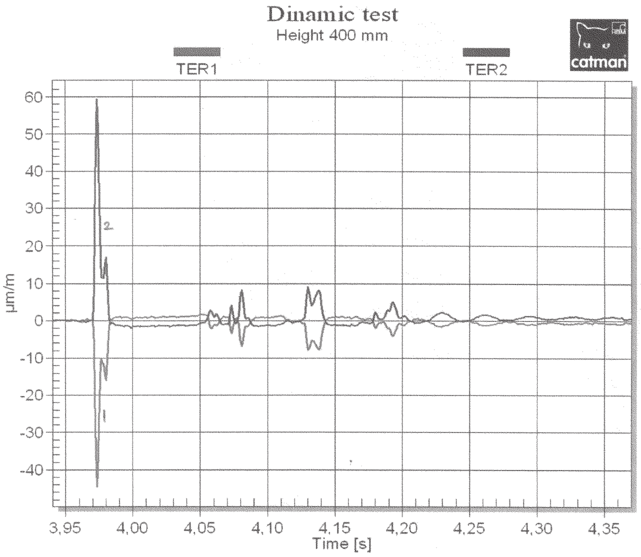


Fig. 6. Strains recorded by TER1 and TER2

Table 2

	TER 1 [µm/m]	TER 2 [µm/m]
Minimum value	-44.646	-2.007
Maximum value	1.615	59.389

Results for 600 mm falling height

For the second test, the weight was released from 600 mm height. Strains recorded by TER1 and TER2 were saved in the data base. Those strains are shown in figure 7.

In the table 3 are presented the values recorded during the test which is presented in figure 7.

The remarks from the table 2 are the same for the table 3.

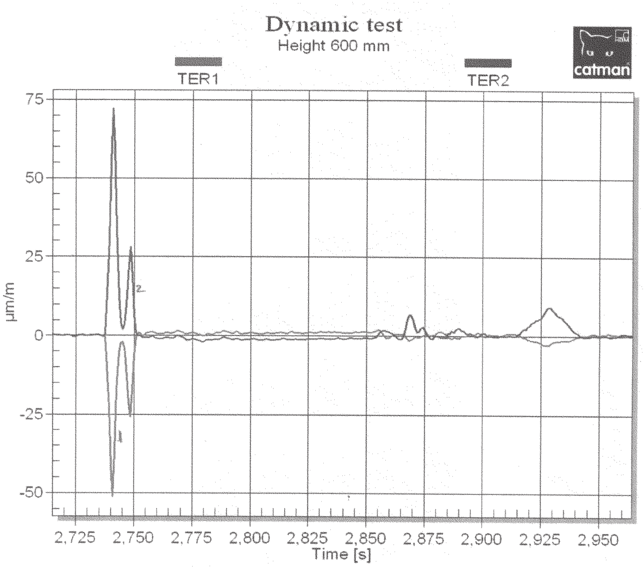


Fig. 7. Strains recorded by TER1 and TER2

Table 3

	TER 1 [µm/m]	TER 2 [µm/m]
Minimum value	-51.243	-2.134
Maximum value	1.981	72.091

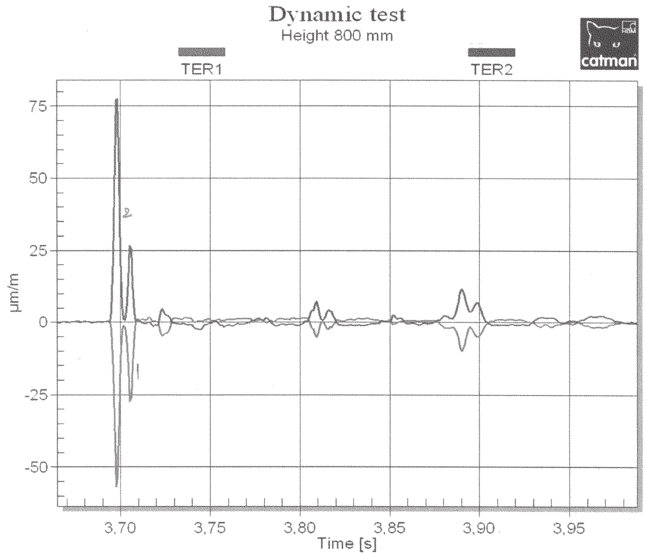


Fig. 8. Strains recorded by TER1 and TER2

Table 4

	TER 1 [µm/m]	TER 2 [µm/m]
Minimum value	-56.898	-6.456
Maximum value	1.837	77.382

Results for 800 mm falling height

For the third test, the weight was released from 800 mm height. Strains recorded by TER1 and TER2 were saved in the data base. Those strains are shown in figure 8.

In the table 4 are presented the values recorded during the test which is presented in figure 8.

The remarks from the table 4 are the same as those from table 2.

Conclusions

With the results, the manufacturer can calculate the attenuation of the impact forces on the rubber plate.

From the result, it can be observed that the results are not significantly different for different load.

The performed tests were used by the manufacturer of the rubber plate to certify the produc for sale.

References

1.MANESCU, T. S., COPACI, I., OLARU, S., CREANGA, F. Tensometria electrică în cercetarea experimentală, Editura Mirton, Timişoara, 2006

2.TABACU, S., HADAR, **A.,** MARINESCU, D., IVANESCU, M., BALASOIU, V., Mat. Plast., **46**, no. 2, 2009, p. 192

3.ILIESCU, N., HADAR, A., PASTRAMA, S.,D., Mat. Plast., **46**, no. 1, 2009, p. 91

4.COPACI, I., MANESCU, T. S., OLARU, S., CREANGA, F., Rezistenţa la solicitări variabile care apar în exploatarea vehiculelor feroviare, Editura Mirton, Timişoara, 2005

5.SPANU, A., HADAR, A., DRAGOI, G., Mat. Plast., **43**, no. 3, 2006, p. 199

6.ATANASIU, C., ILIESCU, N., HADAR, A., Distribuţia tensiunilor în compensatoare lenticulare, Rev. Chim. (Bucureşti), **56**, no. 1, 2005, p. 46

7.ILIESCU, N., ATANASIU, C., HADAR, A., S., Mat. Plast., **42** , no.1, 2005, p. 72
8.TABACU, S., HADAR, A., MARIN, D., DINU, G., IONESCU, D.S., Mat. Plast., **45**, no. 1, 2008, p. 113
9.MARIN, C., HADAR, A., GRIGORAS, S., MARIN, A., STANESCU, M. M., Step Function Used in Calculating Continuous Footing Foundation Placed of Elastic and Discrete Soil", The 19th International DAAAM Symposium "Intelligent Manufacturing & Automation: Focus on Next Generation of Intelligent Systems and Solutions", 22-25th October, 2008, Trnava, Slovakia, p. 793
10.ATANASIU, C., ILIESCU, N., HADAR, A., Rev. Chim. (Bucureşti), **56**, no. 6, 2005, p. 687
11.SR EN 13146-3 Aplicaţii feroviare cale. Metode de încercare pentru sistemele de prindere Partea 3: Determinarea atenuării forţelor de impact
12.HOFFMAN, K., An Introduction to Measurement Using Strain Gages, Hottinger Baldwin Messtechnik GmbH, Darmstadt, 2005
13.***** Amplifier system MGCplus Operating Manual, Hottinger Baldwin Messtechnik GmbH, Darmstadt, 2004
14.***** Catman 4.5 User's Guide, Hottinger Baldwin Messtechnik GmbH, Darmstadt, 2004

Manuscript received: 25.08.2009