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# STATIC TESTING OF BRAKE TRIANGLES OF RAILWAY VEHICLES

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***Abstract*** *– Brake triangles are very important parts of the braking system of railway vehicles that can significantly affect safety and security on the railway. In accordance with the international standard UIC 833, the requirements for manufacturers of brake triangles are very strict and require the supplier to provide proof of the quality of the brake triangles. Therefore, manufacturers must provide appropriate evidence of the quality of production of brake triangles in accordance with the above-mentioned international standard. The paper presents the basic requirements of the international standard UIC 833 and the development of the test stand for static testing of brake triangles of railway vehicles in the Serbian company Tehnoliv Komerc from Velika Plana. This allowed this company to start a very successful mass production of brake triangles for the international market.*

***Keywords – Static test; test stand; brake triangles; railway vehicles.***

## 1. INTRODUCTION

The quality of braking is one of the most important prerequisites for adequate safety and security of railway traffic. The concept of braking of freight wagons is usually based on the friction between the brake shoes and the running surfaces of the wheels [1, 2]. Brake triangles play a very significant role in achieving that friction, i.e. realizing the braking force (Fig. 1).

*Fig.1. Braking elements of freight wagon*

As very important and responsible elements of the braking system, the brake triangles are subject to rigorous requirements prescribed by international standards. In order to ensure quality, every manufacturer of brake triangles for the international market must meet requirements of standards of International Union of Railways (UIC) [3, 4].

## 2. BASIC REQUIREMENTS OF INTERNATIONAL STANDARD UIC 833

Brake triangles should be made of carbon steel which geometric, physical, mechanical and chemical characteristics must meet all necessary requirements of ISO and EN standards. According to the UIC 833, brake triangles are classified into two groups: brake triangles for nominal load $F_n$=60 kN and brake triangles for nominal load $F_n$=120 kN. The relative positions of the functional parts of brake triangles such as trunnions, traction head and holes for the traction pin (Fig. 2), must be within certain prescribed limits.

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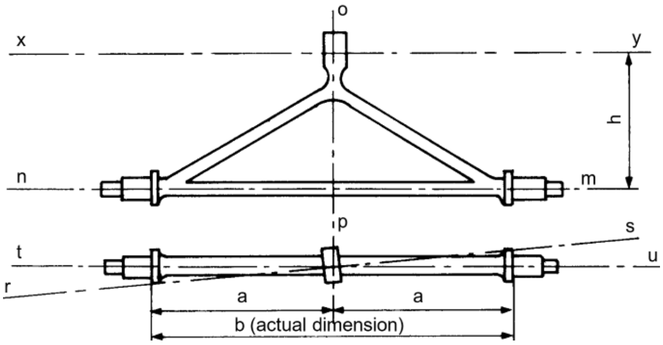


*Fig.2. Relative positions of functional parts of brake triangles [3]*

During the action of the nominal load $F_n$ applied in accordance with the diagram shown in Fig. 3, the height *h* of the brake triangle must not have an elastic deflection greater than 2 mm. The values of loads for testing of brake triangles are given in Table 1.

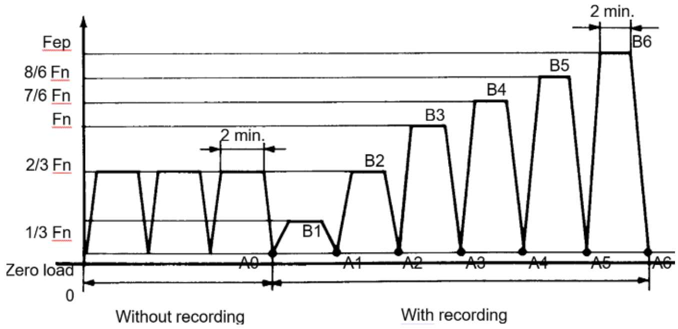


*Fig.3. Load-time diagram for testing of brake triangles [3]*

*Tab. 1. Values of loads for testing of brake triangles*

| Type | "Zero" load | Nominal load $F_n$ | Test load $F_{ep}$ | Load variations during fatigue test |
|---|---|---|---|---|
| Tr. 60 kN | 5 kN | 60 kN | 90 kN | 10 kN to 60 kN |
| Tr. 120 kN | 10 kN | 120 kN | 180 kN | 20 kN to 120 kN |

After the end of force action, the height *h* must not have a permanent deflection greater than 0.1 mm. Also, there must not be any other permanent deformations that can affect other parts of the brake triangle. During the action of the test load $F_{ep}$ (9/6 of the nominal load $F_n$), applied in accordance with the diagram shown in Fig. 3, the height *h* of the brake triangle must not have an elastic deflection greater than 3 mm. After the end of force action, the same height must not have a permanent deflection greater than 0.5 mm. After testing, no defects must be present. Furthermore, the brake triangles must withstand 106 cycles of tensile loads applied at a frequency between 2 Hz and 16 Hz, without any apparent defects. These loads must vary cyclically within the limits specified in Table 1 [3, 4].

Consequently, manufacture of brake triangles can only be entrusted to suppliers who have appropriate approvals of purchasing Railways. The purchasing Railway must approve each prototype of the brake triangle and the conditions of its production. The authorized representative of the purchasing Railway performs an appropriate inspection of the production of brake triangles. He can perform all the checks he deems necessary to prove that all production conditions are satisfied. He may be present at welding operations and individual tensile tests conducted by the manufacturer. In addition, he must be informed about any change in the production process of the brake triangles. Regarding the acceptance inspection of the authorized representative of purchasing Railway, a batch of parts intended for the acceptance procedure must be provided. It consists of a minimum of 10 brake triangles produced by normal manufacturing methods. These brake triangles must not be exposed to a load greater than 2/3 of the nominal load $F_n$ (Fig. 3, Table 1). Thus, brake triangles must be subjected to appropriate checks and tests specified in UIC 833 [3]. They are performed either at the time of receipt during delivery or during production. The tests prescribed by the acceptance program must be carried out by a laboratory approved by the purchasing Railway. The brake triangles must be submitted for acceptance in the delivery condition, before any protective treatment. Previously, they must be subjected to static deflection tests in accordance with the details specified in UIC 833.

## 3. TEST STAND FOR STATIC TESTING OF BRAKE TRIANGLES

With the aim of conquering the production of brake triangles in accordance with the requirements of the UIC 833 standard, a special test stand for static tests of brake triangles was developed in company Tehnoliv Komerc from Velika Plana, Serbia (Figs. 4 and 5). The test stand enables fast and simple mounting of the tested brake triangles and setting the load [5].

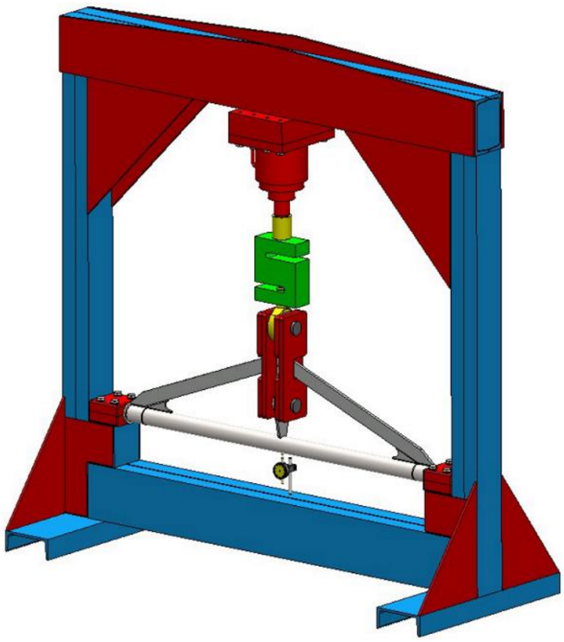

*Fig.4. Model of developed test stand*

*Fig.5. Test stand in operation (company Tehnoliv Komerc)*

The test stand is made as a robust spatial frame construction within which the load flow is "closed". The material of the supporting structure of the test stand is structural steel S355. The strength of the test stand is calculated using the finite element method (FEM) (Fig. 6). The calculation results show that the supporting structure of the test stand meets the strength criteria, while the stresses and deformations are within the permissible limits (Figs. 7 and 8).

The load setting system is based on a hydraulic cylinder with manual control (Fig. 5). The measuring system for registering and recording the value of the applied force is based on the force transducer type ZEMIC - H3-C3-30t-6B (Figs. 5 and 9).

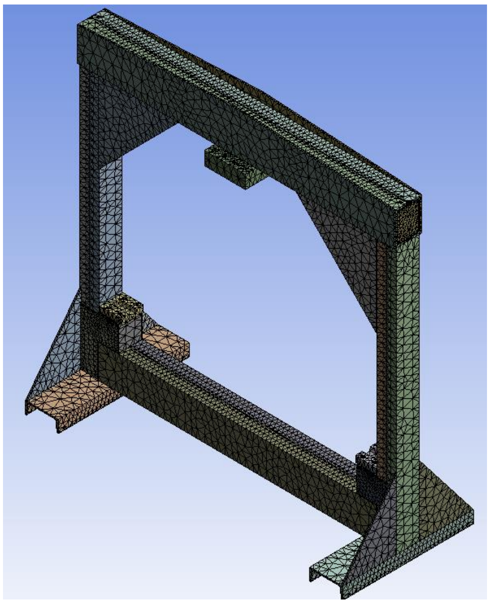

*Fig.6. Discretized model of test stand structure (122908 nodes and 54594 finite elements)*

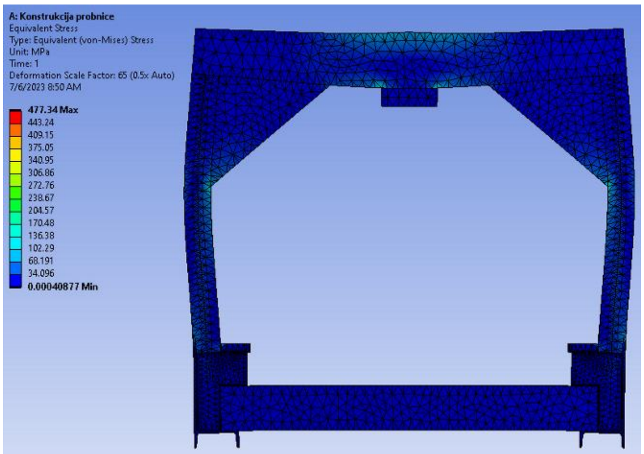


*Fig.7. Equivalent stress of test stand structure*

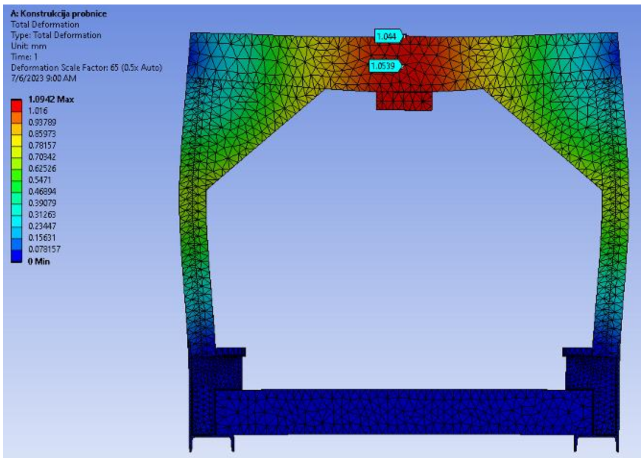


*Fig.8. Total deformation of test stand structure*


*Fig.9. Force transducer with data acquisition system*

The developed test stand has a vertical movement and allows maintaining a constant load for at least 2 minutes, while this load is measured with an error of less than 1%. The deflections are measured with rigidly fixed dial gauges with graduation of 0.01 mm.

Before conducting the static tests, three consecutive preliminary loads of 2 min duration and equivalent to 2/3 of the normal load $F_n$ specified in Table 1 are applied. After that, the force returns to the "zero" load which is also listed in Table 1. These procedures are performed without recording deflection values.

After that, loads equal to 1/3 $F_n$, 2/3 $F_n$, $F_n$, 7/6 $F_n$, 8/6 $F_n$ and 9/6 $F_n$ are then applied, in turn, for two minutes each. The application of each new load is preceded by a return to the load that must not be less than the mentioned "zero" load specified in Table 1. The deflection values reading from dial gauges is performed for each of the "zero" loads and under each of the above mentioned loads, i.e. in the points A0, B1, A1, B2, A2, B3, A3, B4, A4, B5, A5, B6 and A6 (Fig. 3).

During the described test, the following deflections are measured:

- Elastic deflection under the nominal load $F_n$ (equal to the difference in measurement results in points B3 and A3);
- Permanent deflection under the nominal load $F_n$ (equal to the difference in measurement results in points A3 and A0);
- Elastic deflection under the test load $F_{ep}$ (equal to the difference in measurement results in points B6 and A6);
- Permanent deflection under the test load $F_{ep}$ (equal to the difference in measurement results in points A6 and A0);
- Any permanent deflection, other than that obtained in the direction in which tension was applied (determined by comparing the measurements performed to the nearest 0.1 mm by reference to a surface-plate, before and after the tensile test).

Therefore, the developed test stand fully meets the requirements of the UIC 833 standard for static testing of brake triangles of railway vehicles.

## 4. RESULTS AND CONCLUSION

The paper presents the cooperation between the company Tehnoliv Komerc from Velika Plana and the Faculty of Mechanical and Civil Engineering in Kraljevo in the field of conquest the production of brake triangles of railway vehicles and the design and development of test stand for static tests of brake triangles. It provided Tehnoliv Komerc mass production of brake triangles for the international market (Fig. 10). So far, more than 3500 brake triangles have been successfully manufactured and delivered.

*Fig.10. Detail from brake triangles production (company Tehnoliv Komerc, Velika Plana, Serbia)*


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