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Modelling geometric properties in construction of special devices

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Abstract

The paper presents the collection of assumptions for the conception of construction solutions of a device for measuring and calibrating portable scales for registering loads of vehicles travelling on public roads. The analysis of rigidity of particular subsystems of the construction has been conducted. Strength properties as well as displacements of the main structural joints of the upper and lower plate of the test bench as well as the pillars connecting them have been analysed. Based on the analysis of stress and displacement values of the structural plates in the function of their thickness, their geometric dimensions have been chosen. The next step was modelling the elongation of the structural pillars in the function of load. As a result of this work, the geometry of the circular cross section pillars with the highest rigidity has been chosen. The outcome is the proposed change in construction properties with regards to geometry and the main body load. On the basis of the conducted research, the design documentation of the device has been created. A new prototypical device has been made on this basis. The work has been implemented at Okręgowy Urząd Miar (Local Office of Measures) in Poznan. These research and design efforts have resulted in achieving higher accuracy of calibrating mobile vehicle scales.

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1. Introduction

Normatively overloaded vehicles that participate in road traffic are a danger for other motorists, have a negative influence on road safety and undermine infrastructure durability. There is a higher probability of getting involved in a car accident for an overloaded tractor unit. The heavier the vehicle, the larger its kinetic energy, which translates into stronger impact force and – as a consequence – broader damage to the vehicle [1, 2].

It is difficult to keep statistics of car accidents involving overloaded vehicles as more often than not they lose their load as a result of the collision. Road vehicles exceeding load mass are a danger for road traffic safety but also for infrastructure as they contribute to an increase in surface wear [1, 2].

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Therefore a constant and immediate selection of vehicle load is extremely important in order to minimize the negative effects of overload. Vehicle scales for static weighing of axle load, among other devices, are used to achieve this [3]. Also, in order to increase the amount of active control, modern Weigh-in-Motion systems for dynamic weighing are used [1, 2, 4-10]. They make it possible to weigh the load without the need for the vehicle to stop. Weighing takes place in motion when the vehicle wheels onto the electronic scale embedded in road surface. If such weighing is to be done correctly, it is important for the device to be properly calibrated by authorized organizations using calibration instruments. This kind of instruments have to provide high accuracy and stability of measurement.

One of Poznan-based companies is authorized in this respect and has a device for calibrating mobile scales at its disposal. The company commissioned the team consisting of academics from Poznan University of Technology and State University of Applied Sciences in Kalisz to introduce design changes in the calibrating device in order to increase measurement accuracy.

2. Design analysis and principles of operation

The subject of the analysis and of the original design modernization has been a device for measuring load of portable car scales. The original state of the device to be modernized is presented in Fig. 1.

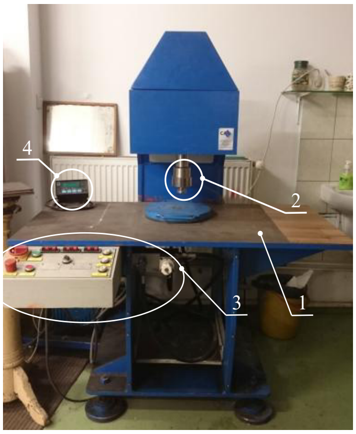

Fig. 1. Device for measuring load of portable car scales: 1 – table, 2 – force sensor, 3 – control panel, 4 – display.

The current design of the device is a single monolithic welded body made of 20 mm thick sheets.

3. Causes leading to design modernization

The idea to modernize the device had a number of important aspects:

1. Reducing geometric dimensions of the device to less than 1520 mm (height), 1300 mm (width) and 952 mm (depth),
2. Improving the strength properties of the load-bearing structure and the frame,
3. Improving functional properties of the measuring table,
4. Raising measurement accuracy.
5. Changing the structure of forces and stresses acting in the measuring head axis. During the observation stage it was noted that there are conditions for large values of displacement of the upper body under the influence of upward reaction R originating as a result of pressure force F acting on the controlled scale. Figure 2 presents the distribution of forces acting on the device body.

In order to verify the expected possibility of displacement of the upper body of the device (Fig. 2) a series of measurements of displacement have been taken in three points of the upper body for various values of pressure