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STRESS ANALYSIS OF PART OF THE WELDED STRUCTURE

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Abstract: *This paper deals with strength analysis of a part of the welded steel structure of the test device that will be used to calibrate vehicle axle scales with a loading capacity up to ten tons. The analysis is carried out in ADINA software. This analysis results will be used to check the safety of the design and structure. In the case of exceeding the permissible stress, deformation, displacement, etc., this analysis results will form a benchmark material for optimization of the structure.*

Keywords: Strength analysis, ADINA software, Welded structure.

1. Introduction

Weight measurement is one of the most widely used laboratory and technical activities. New types of scale designs have been developed and widely used in practice, increasing the accuracy and speed of measurement. In order to ensure measurement accuracy over the entire technical life of the scales, these require regular calibration with precisely defined recalibration intervals whose time step is defined in standards.

A testing device has been designed in order to enable carrying out experimental measurements to determine suitability of a scale for vehicle axles with a loading capacity up ten tons. Since, currently, great emphasis is placed on efficiency, cost reduction and economically advantageous performance; this structure will be subjected, prior to a prototype manufacture, to strength analysis with software support in order to determine whether the structure is able to withstand the given load with a certain degree of safety (Murín, 1999, Žmindák et al., 2013). Based on the above-mentioned analysis (Gerlici et al., 2014) we are able to say in advance whether a given structural design is satisfactory or, conversely, it needs further optimisation in order to prevent potential loss of life or property.

2. Analyzed welded steel structure

This steel structure will be gradually loaded with a burden weighting from 2 tons up to 10 tons, including its own weight, so as the structure will gradually lift the boxes containing weights, located inside the structure.

The boxes with weights are stockpiled, and each box contains four weights. The burden consists of 16 weights – 500 kg each, own weight, and additional lighter weights so that the total weight is 10 tons. The main part of the structure consists of two parallel angle girders – side plates, to which suspension means of thick metal sheet are welded and which will be analyzed in this paper. Here will be fitted suspension tubes of the boxes in which the load (weight) is situated. The load chronology is guaranteed by different sizes of holes for hanging tubes. On this support structure, a hydraulic cylinder is placed that will lift the whole structure and transmit the compressive force derived from the burdens onto a scale placed on a platform, through the girder, in order to calibrate the scale (Fig. 1-left).

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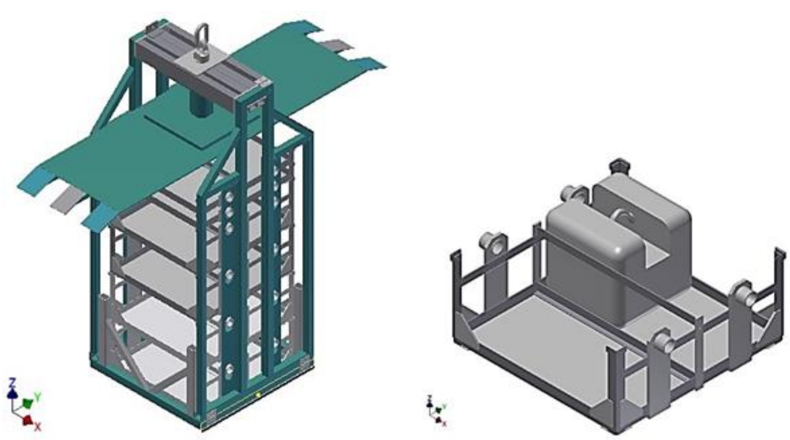

Fig. 1: Steel structure for vehicle axle scale calibration (left) and box for weights (right).

The analysis will result in comparison of the observed values of stress, displacement and strain (deformation) of the steel structure with the permissible values that depend on the type of material used (strength, stiffness, etc.) (Handrik et al., 2016, Sapieta et al., 2016, Žmindák et al., 2004). Since we are dealing with a welded structure consisting of thin-walled sections, it will be modelled as a shell body using central line planes, with a subsequent thickness assignment. The structure is made of EN S355 (STN 11 523) steel that has the yield strength $R_e = 320 \div 360\ MPa$, and the ultimate strength $R_m = 520 \div 640\ MPa$ (Bajla et al., 2014). The safety coefficient is $k = 2\ (-)$. At the weld sites we must take into account a reduced permissible stress by the recommended 30 %, through introducing the welding effect coefficient $c = 0.7\ (-)$.

The permissible stress for the material chosen, with consideration of the relevant coefficients, will be as follows:

$$\begin{aligned} \sigma_{dov} &= \frac{R_e}{k} \\ \sigma_{dov} &= \frac{320}{2} = 160\ MPa \end{aligned} \tag{1}$$

and the permissible stress at the weld site will be as follows:

$$\begin{aligned} \sigma_{dov}^{w} &= c \cdot \sigma_{dov} \\ \sigma_{dov}^{w} &= 0.7 \cdot 160 = 112\ MPa \end{aligned} \tag{2}$$

3. Side plate stress analysis

In this paper the simulation analysis of side plates is described. The computer model of side plates is shown in Fig. 2-left.

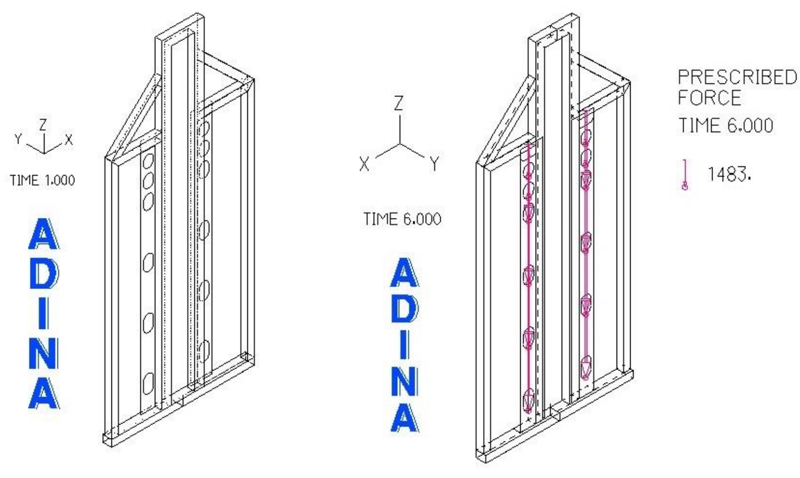

Fig. 2: Model of the side plate (left) and its load at time t = 6 s (right).

By reason that the request of the stepwise loading is demanded on the structure regarding the exact calibration of scale, the load was applied by several time functions (Tab. 1).

The load is applied in the form of single forces entered in points (Fig. 2-right). Values of these forces are listed in Tab. 2.

Tab. 1: Time functions 1 – 6 for the gradual lifting of boxes 1 – 6.

Time [s]	**Function value 1**	**Function value 2**	**Function value 3**	**Function value 4**	**Function value 5**	**Function value 6**
0	0	0	0	0	0	0
1	1	0	0	0	0	0
2	1	1	0	0	0	0
3	1	1	1	0	0	0
4	1	1	1	1	0	0
5	1	1	1	1	1	0
6	1	1	1	1	1	1

Tab. 2: Values of the forces applied at the time.

Force	**Value [N]**	**Time function**
F_1	1483	1
F_2	1483	2
F_3	5140	3
F_4	5140	4
F_5	5140	5
F_6	5140	6

It follows from Tabs. 1 and 2, that the side plate is subjected at time t = 6 s to the force F'. Its value is given (side plate has two parallel suspensions):

$$F' = 2 \cdot (F_1 + ... + F_6) = 47052N, \tag{3}$$

The values of individual forces are determined as the sum of the forces from the weight mass and the box mass, where the box mass (weight) was calculated in ADINA software. Furthermore, we prescribe to the structure also a load resulting from its own weight, namely m = *204.05 kg*:

$$F'' = m \cdot g = 204.05 \cdot 9.81 = 2001.7N. \tag{4}$$

Then, the total loading force is:

$$F = F' + F'' = 47052 + 2001.7 = 49053.7N. \tag{5}$$

The results form numerical analysis show (Fig. 3), that the largest reduced stress is at the site No 1 and it reaches the value of 184.5 MPa and exceeds the permissible stress of 112 MPa.

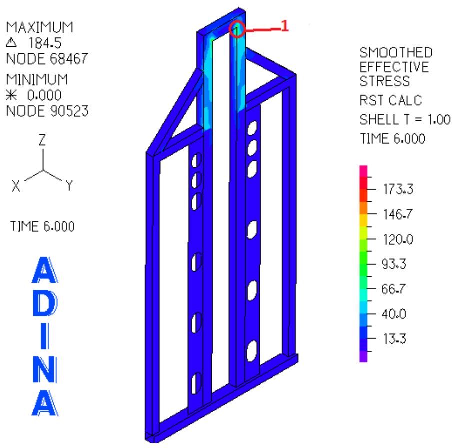

Fig. 3: Distribution of HMH reduced stress in the side plate.

For stress reduction in the site No 1 we propose the thickness modification from the original 5 mm to 10 mm.

This proposed structural modification caused a reduction of the stress at the site No. 7 on the value of 55.63 MPa (Fig. 4).

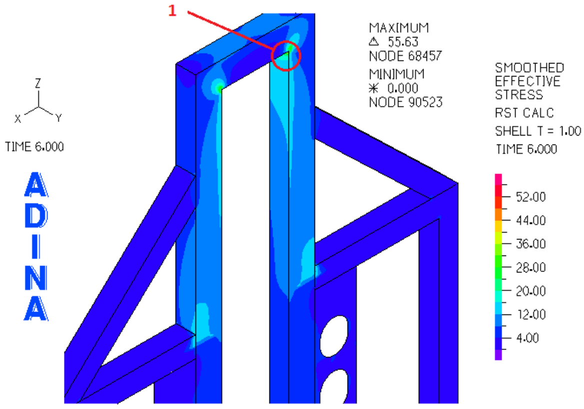

Fig. 4: Distribution of HMH reduced stress in the side plate following the structural modification.

4. Conclusion

The aim of this paper was to perform strength analysis of a part of the welded steel structure of the testing device. Using the structure's draft modelled in the CAD software, the part of the considered structure was modelled in ADINA Software (Bathe, 1996). Then the strength analysis was carried out and the stress value was compared to the permissible stress. It was found that the part of the structure does not meet the requirements of the selected safety level. The thin-walled sections´ thickness increased at the site where stress exceeded the permissible value. Subsequently, the device was reanalysed to assess the strength. This reanalysis resulted in the fact that the part analyzed complies with safety requirements, and is thus suitable for manufacture and use, when applying the conditions corresponding with the initial task – that is the maximum loading mass with a total weight of 10 tons.

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