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EXPERIMENTAL ANALYSIS OF TENSIONS FROM AN WORKING MECHANISM ATTACHED TO A MULTI-STOREY CAR PARKS

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ABSTRACT: The design of any mechanical structures requires an analysis of its resilience considering the cases of the most unfavorable load. For increased safety in design, it must be compared to the analytical method or with a numerical method. Of experimental methods set out in the framework of this work will be used the method of electro-resistive tensometry, as part of the general electrical methods for measuring non-electric routes. The experiment was focused on measuring normal voltage on the platform (on its back surface) at the middle of distance between the wheels. This area is considered to be the place where the greatest tensions occur. Experimental tension was obtained as a result of electro-resistive tensometry techniques, considering that the request appears in the area where we can apply Hooke's law for elastic surfaces. Signal amplification was achieved using software made under the programming environment Test Point. The experimental results were validated with analytical models.

Keywords: Vehicle parking, working mechanisms, burden, optimizations

1. FUNDAMENTAL CONCEPTS REGARDING THE EXPERIMENTAL ANALYSIS OF THE TENSIONS

Within the framework of this work will be used the method of electro-resistive tensometry. It is part of the general electrical methods for measuring non-electric routes. The main advantages of the use of electro-resistive tensometry are: the method is non-destructive, allows the execution of measurements during operation process, has a greater accuracy comparing with mechanical methods, optical, acoustic, pneumatic already known, etc. [7] [8]

The tensometric mark, according to Figure 1, consists of a resistance wire or metal foil, glued together in the form of a coil on a support, which can be paper, or plastic foil. In turn, the brand sticks on the piece and it will faithfully follow the deformations of it. The mark suffers through a distortion of its variation. It has been found experimentally that the variation of the electro-resistive transducer is within a certain range, proportional to the specific element deformation suffered by it with the piece is sticking out. Morphometric marks have the following common values of resistance: 120, 350, 700 or 1000 ohms. [9]-[11]

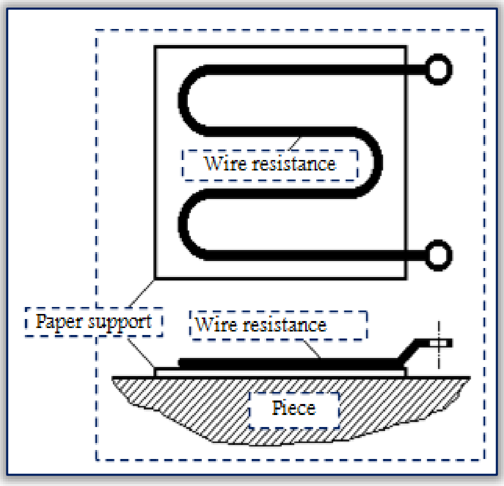

Figure1. Tensometric mark. General presentation

2. PRESENTATION OF THE EXPERIMENTAL MODEL

Figure 1 presents a layout what symbolizes a vehicle normally based on an elevating platform.[1]-[6]

A presentation of the final assembly is shown in Figure 2, where we find the following main elements:

1 - a platform (where all the vehicles are stopped during the lifting operation)
2 - intermediate element that makes the platform work.

From the point of view of the resistance, the determination of mechanical tensions comes in the interest of the Platform 1, which supports the vehicle. In Figure 2 is shown the final assembly of the platform (the force ratio is measured using transducer of 50 kN).

Screwing the bolt (the easiest way is by hand, with a key) as shown in Figure 1, a force F shall be recorded with a force transducer 2. Further, through the device 3 a creation force 4 is sent to the layout platform.

Further action is continued by the components F1 and F2 from platform 5 as required for the moment. With the help of an active mark a curving can be registered as a specific of the platform as a result of the action of force F.

Multiple values were taken into consideration, values that form an angle of inclination α corresponding to an element of the platform: α = 900, 650 and 500 (for different values, it will take account of Figure 4 and 5. Dimensions where were located the morph metric marks are given in Figure 3. Section is rectangular platform with a height of 10 mm and 20 mm.

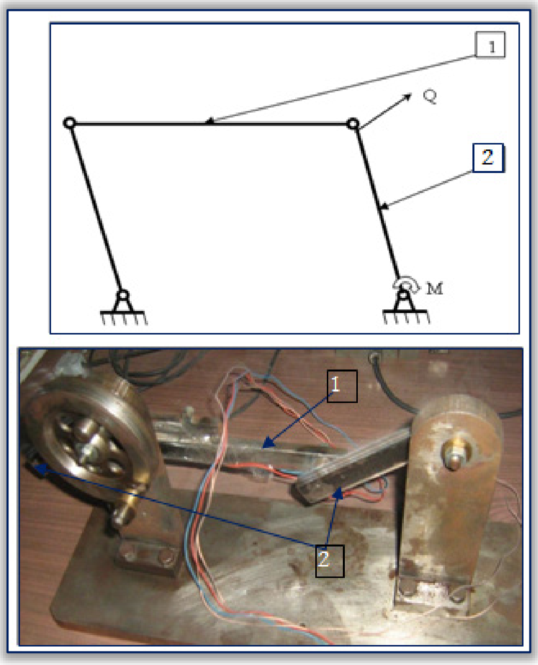

Figure 2. General view with the image symbolizing a lifting platform for a motor vehicle

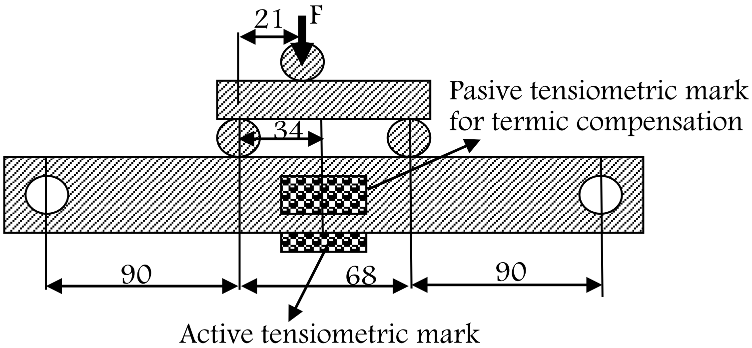

Figure 3. Distances between tensiometric marks

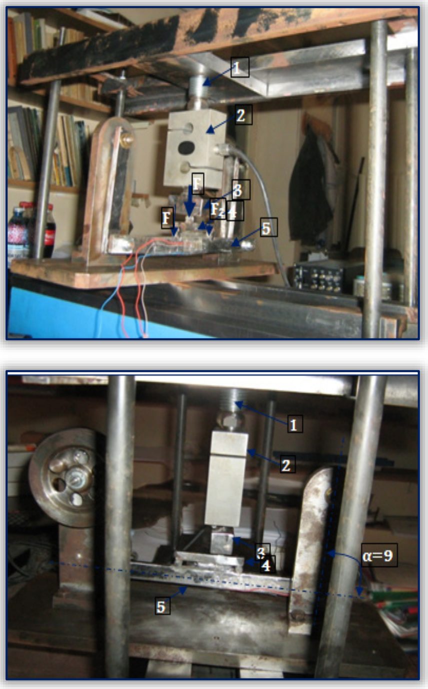

Figure 4. Charge scheme of the platform where all the vehicles are stopped

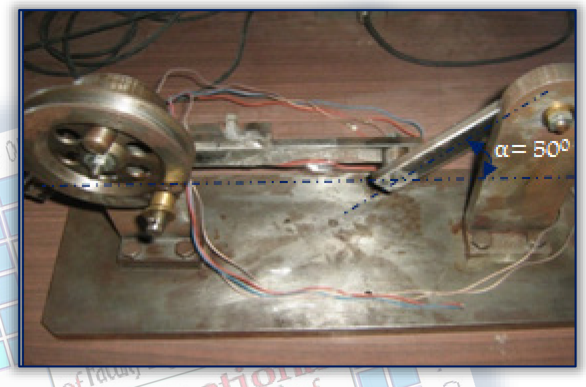

Figure 5. General view of the angle α

3. EXPERIMENTAL RECORDINGS. DATA INTERPRETATION

The experimental request was characterized by applying force F via the feed screw until the chosen value of the person uncharged. We waited for a few seconds maintaining the same value of the force and then the experiment was stopped. In Figure 6 are exposed the recordings of the experiment where α = 900. The force was applied increasing continuously.

According to experimental data, an 8.0192 MPa was obtained for a force F= 1224.6 n. The period of time while the force was maintained is shown in the left section at the bottom, between

7.4021 and 10.339 seconds. The value of the force F of 1224.6 represents, in fact, the average value measured on 10 equidistant intervals markers 1 (red) and 2 (blue). In the time between that doing so has not been operated, we can observe a slight decrease in the labor force (and hence voltage).

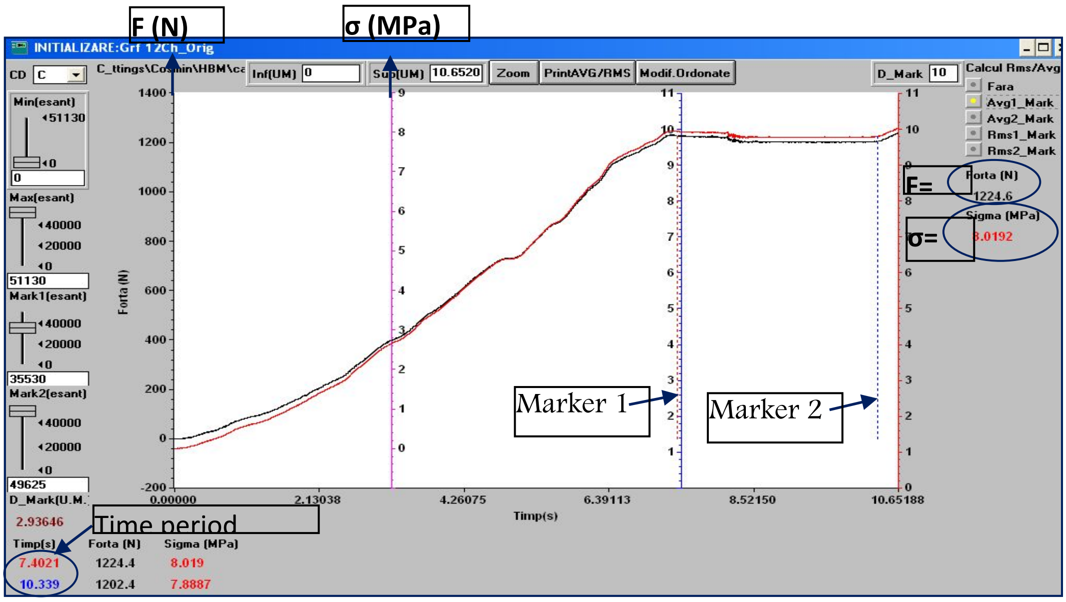

Figure 6.Impact load for the mechanism F= 1224.6 N where α= 90⁰

For α = 650 was obtained a 1.8069 MPa at a force of 254.59. Unlike the previous case, there was no continuous operation of the structure but after second 23.36, the experiment was discontinued. The results obtained for each loading case are centralized in table 1.

Table 1.Centralised results of the experiment

α [⁰]	90	65	50	20
F [N]	1224,6	254,59	402,79	461,61
σ_{exp} [MPa]	8,0192	1,8069	2,5622	3,3812

In case when α = 650 the applied force was the smallest, we will seek other graphs of force F 254 values N and determine the respective values of tensions. It will show how much influence the angle of inclination α values for the same tension force F.

Table 2.Centralised results of the experiment for F= 254 N

α [⁰]	90	65	50	20
F [N]	254,54	254,59	254,57	254,93
σ [MPa]	1,7228	1,8069	1,6853	1,8951

4. ANALYTICAL VALIDATION OF EXPERIMENTAL RESULTS

To be reminded the following formulas for the calculation of forces F1, F2, reactions V1, V2 and H1 or tensions σ65ech (what you consider both the request and the bending and axial) and σ65 (which takes into account only the bending request):

$$F_1 = F \cdot \frac{l \cdot k - a}{l - 2 \cdot a},\ F_2 = F \cdot \frac{l - k \cdot l - a}{-2 \cdot a + l} \tag{1}$$

$$V_2 = \frac{F_2 \cdot (l_0 + a) + F_1 \cdot a}{l},\ V_1 = \frac{F_1 \cdot (l_0 + a) + F_2 \cdot a}{l}, \tag{2}$$

$$H_1 = ctg\alpha \cdot \frac{F_1 \cdot a + F_2 \cdot l - F_2 \cdot a}{l}$$

$$\sigma_{56} = 12 \cdot \frac{F \cdot \frac{X - a}{l - 2 \cdot a} \cdot (l_0 + a) + F \cdot \frac{l - X - a}{l - 2 \cdot a} \cdot x - F \cdot \frac{X - a}{l - 2 \cdot a} \cdot (x - a)}{B \cdot H^3} \tag{3}$$

$$\sigma_{ech56} = \sigma_{56} + ctg\alpha \cdot \frac{F \cdot \frac{X - a}{l - 2 \cdot a} \cdot a + F \cdot \frac{l - X - a}{l - 2 \cdot a} \cdot l - F \cdot \frac{l - X - a}{l - 2 \cdot a} \cdot a}{l \cdot B \cdot H} \tag{4}$$

Notice: in formulas (3) and(4) was taken into account the rectangular section of the platform (base B and height H) but also we must notice the fact that parameter K is the result of relation k=X/l.

All the result obtained in the analytical model (formulas (1)-(4)) were centralized in table 3, as it is shown.

Table 3. Centralized analytic results and comparisons with the experimental ones

F (N)	α(°)	F_1 (N)	F_2 (N)	V_1 (N)	V_2 (N)	H_1 (N)	σ_{56} (MPa)	σ_{ech56}(MPa)	Δ(%)
1224,6	90	378,185	846,415	548,107	676,493	0	8,266	8,266	2,986
254,59	65	78,623	175,967	113,95	140,64	65,582	1,718	2,046	5,145
402,79	50	124,931	278,399	180,281	222,509	186,707	2,719	3,652	5,761
461,61	20	142,556	319,054	206,608	255,002	700,613	3,116	6,619	8,516
254,54	90	78,608	175,932	113,927	140,613	0	1,718	1,718	0,271
254,59	65	78,623	175,967	113,95	140,64	65,582	1,718	2,046	5,145
254,57	50	78,617	175,953	113,941	140,629	118,002	1,718	2,308	1,923
254,93	20	78,728	176,202	114,102	140,828	386,922	1,721	3,655	10,13

Notice: the errors between the tensions, both experimental and analytical (marked with Δ), were determined with the following formula (5):

$$\Delta = \frac{\left|\sigma_{exp} - \sigma_{56}\right|}{\sigma_{56}} \cdot 100 \qquad (5)$$

From the analysis of calculation formulas (1), (2) and (3) it appears that the forces F1, F2, the reactions V1 and V2 and σ56 voltage do not depend on the value of the angle α. Small differences arise between the values are coming from the decimals after the comma (the value of the force F), recorded with a force transducer. If the force had been constant (for example, 254), then regardless of the value of the angle α, all the values presented in table 4 would have been obtained.

Table 4. Centralized results, both analytical and experimental

F (N)	α(°C)	F_1 (N)	F_2 (N)	V_1 (N)	V_2 (N)	σ_{56} (MPa)
254	any	78,441	175,559	113,685	140,315	1,714

Figure 7 shows the reaction H1 increasing in the same time with the decreasing of angle α, which leads to multiples errors between tensions, both theoretical and normal. This can be explained through the fact that the higher the rake angle decreases, the percentage of tension H1 increases (reaction that in turn is influenced by the variation of angle α - increases in the same time with its decreasing value).

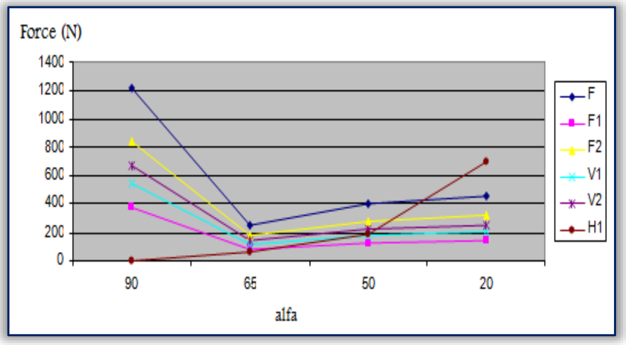

Figure 7. Force variations and reactions, considering the bedded angle α

Figure 8 shows voltage variations according to the inclination angle α. There can also be observed the increase of the equivalent tension (comparing with normal experimental and theoretical tensions) once with the decrease of α angle, which can be explained in terms of increasing the percentage of normal voltage data reaction H. Its value rises considerably with decreasing the angle of inclination of the operating platform.

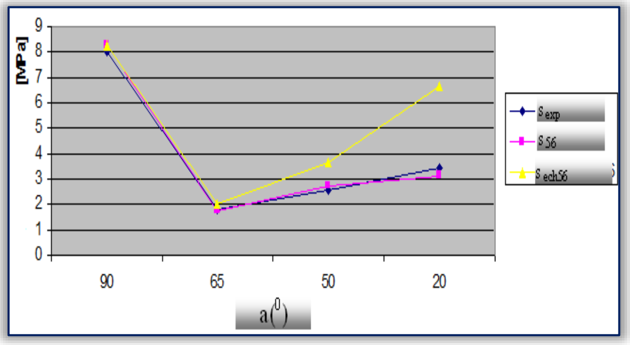

Figure 8. Tensions variations considering the bended angle α

Analyzing the change in force and motion according to the angle of inclination α≈ F 254 N it appears that for a force F ≈ 254 N, all the reactions and forces are almost equal (thing that was expected because it does not depend on the variation of angle) with the exception of motion reaction H1, which depends on the angle (which increases with its decreasing).

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5. CONCLUSIONS

For designing any mechanism attached to a parking system is required, in addition to the implementation of part of the elements, an analysis of its resistance (a checklist of elements as a result of the action of the weight of the car). Since the vehicle is positioned on the platform, from the point of view of the resistance, the study is focused on the mechanical tension developed in it. It was called F the weight of a mechanism, which was later distributed through F1 and F2 considered the main components and the contact points between the wheels and the platform.

The experiment was focused on measuring normal voltage on the platform (on its back surface) at the middle of distance between the wheels. This area is considered to be the place where the greatest tensions occur. Experimental tension was obtained as a result of electro-resistive tensometry techniques, considering that the request appears in the area where we can apply Hooke's law for elastic surfaces. This led to the amplification of the signal represented by its bended part, notated with μm/m. There can also been seen the elasticity module of the material from which it was enforced platform – S235JRG1 STAS 10027/1,2:1997, resulting in normal voltage value.

Signal amplification was achieved using software made under the programming environment Test Point. The experimental results were validated with analytical models presented in the previous chapters, which were implemented in computer programs automatically. Moreover, to facilitate the pursuit of an analytical model we should remind the most important 2(10) chapeau, calculation formulas, used for validation of experimental results.

The main conclusions drawn from the present study are:

≡ forces F1, F2, reactions V1 and V2 and σ56 voltage do not depend on the value of the angle α; the final results shows small differences arising from the decimals after the comma (the value of the force F), recorded with a force transducer; there is the recommendation that for future researches to be use maximum lower force transducer because when these happens at lower values and the values are more precisely comparing to the transducer from the present study.

≡ Reaction H1 increases while α angle decreases, which lead to the increasing tension between equivalent theoretical errors and normal voltage experimental; This phenomenon is explained through the fact that the higher the rake angle decreases, the more increases the tension from force H1 (reaction which in turn is influenced by the variation of angle α - increases in the same time with its decreasing value).

≡ equivalent voltage increases (in comparison with normal experimental and theoretical tensions) once the α angle decreases, which can be explained in terms of increasing the share of normal voltage data reaction H1, whose value rises considerably once the platform element angle inclination decreases; we can conclude that the axial effort must be taken into account (its neglect could lead to large errors in the final calculations);

≡ for a force F ≈ 254 N, all the reactions and forces are slightly equal (thing that was expected because it does not depend on the variation of angle α) with the exception of motion holds H1, which depends on the angle (who increases during its comedown);

The author’s main contributions coming from the technical book from literature concern mainly about the resistance calculations and about the actuation mechanism for multi level car-park. Herein this chapter this kind of calculation was presented mainly focused on the study of tensions, such as:

≡ establishing an experimental model with its own wide practical design mechanisms attached to multilevel car-park

≡ solution found by simulating a vehicle parked on the platform;

≡ assembly for the experimental platform used for these study and the accuracy of the experimental assembly; finding the suitable solution eliminating the small errors (marked with Δ in table 3) comparing with the complex of this experimental model introduced in a mathematical calculation program (MathCAD);

≡ choosing the place where all these tensometric marks were placed and establishing the way of sticking these marks together.

≡ thinking of an analyzing programme for all the data collected at the end of the study in a way that we can apply the Hooke law. We must into account the charge for the elastic domain where we can apply the Hooke law for the bended specific parts of the platform where the mechanical tension occurs, measured with MPa;

≡ introducing all the data in analyses programs and graphics programs, such as Microsoft Excel, leading to an easier interpretation of all the experimental results

Through the study undertaken along this chapter, the author considers that his contribution has lead to the development of research in the multilevel car-park domain. This study can constitute the base of further researches and studies for specialists and drafts-men who work in such domains.

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