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OPTIMIZATION OF THE PASSENGER LIFT CAR FRAME STRUCTURE

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ABSTRACT
This paper is the result of the need for optimization of the passenger lift in platforms by means of numerical method of the finite elements. The manner of modelling of supporting structures of the lift car frame is shown and identification of static behaviour of the car frame structure is made for the competent most critical lord case. After that, the procedure for creating the model for the leverage calculation is exposed. Strength, and the scarring capacity of construction, is proving by the structure analysis by Finite Element Method.
Keywords: design, structural analysis, elevating platform, finite element, passenger lift, car frame, optimization, structure.

1. INTRODUCTION

It is stated in the literature [2], that the manners of calculation of supporting structures of the passenger lift cars and car frames are not in compliance, with the valid calculations of steel structures as prescribed by national Yugoslav standards. That requires, besides the definition of component load cases, establishing of a new calculation methodology, which will take into account all specific aspects of the calculation of supporting car structures and car frames. The calculation methodology computerized and based upon application of the finite elements method. It is a numerical method, consisting of discretion of the structure into a number of finite elements of regular geometrical shape, the behaviour of which is described in a relatively simple way, whereby it enables modelling and calculation of complex structures and problems. The sophisticated software package [2], enabling full identification of static and dynamic behaviour of supporting structures. Computer-assisted modelling and structure calculation by means of finite elements method enables modelling and calculation of complex structures and problems, definition of an actual picture of displacements and stresses, as well as determination of actual structure behaviour. Accordingly, this method was used for the calculation of the supporting structure of the lift car frame.

2. MODELLING OF THE SUPPORTING STRUCTURE OF THE LIFT CAR FRAME

Modelling of the supporting structure of the lift car and car frame was carried out for the existing delivered technical solution of lift car and car frame, made by”HONEX, [1, 3]. Carrying capacity of the modelled lift amounts to 630 kg or 8 persons. For an easier insight into the calculation and interpretation of results, as well as a precise diagnostics of influence of the structure elements on its global static and dynamic behaviour, models of the supporting structure of the lift car and the lift car frame were separated. The advantage of the said simplification is that the calculation results are oriented to higher safety, as the actual structure has a higher stiffness than its elements. Static calculation of the car frame supporting structure comprises definition of the field of displacement and maximum displacement of the structure, definition of the stiffness of structure elements, definition of the stress area and the maximum stress, distribution of potential deformation energy on structure elements, as well as distribution of stress state on finite elements of the plate type. he model of the carrying structure of the car frame consists of 116 nodes, 150 beam-type elements, one stick-type element and 4 plate-type finite elements and is show in fig. 1 axonometric ally and in three main planes. The model of the rear side of the car, which is the most critical for the calculation, from the point of view deformation, consist of 53 nodes, 80 beam-type elements and 128 plate-type elements and is show in fig.3.

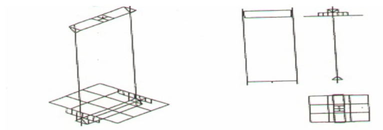


Figure 1. Model of the car frame: a-axonometric view; b-three projections.

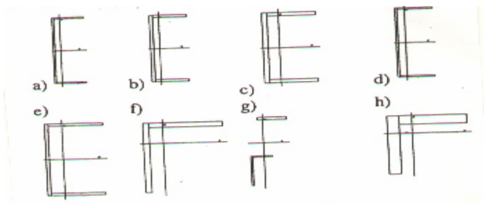
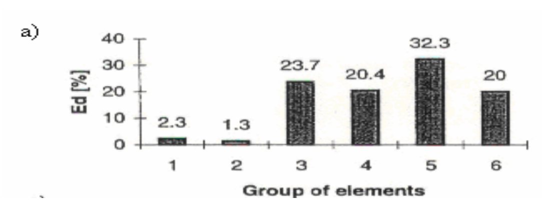


Figure 2. Cross-sectional view: a- frame column; b- upper frame girder; c- lower frame girder; d- car support; e- car floor support; f- upper and lower frame girder stiffeners; g- plate stiffener.

The characteristics of cross-sections of the supporting structure elements of the car frame are very important for the calculation and represent the subject of optimization. View of the cross-sections of the elements by which the car frame was modelled is shown in fig.2 and here below they will be marked as PP1…PP8, respectively

3. OPTIMIZATION PARAMETERS

Some of the results of the static calculation of the car frame supporting structure are show in the referenced literature. Full identification of the static behaviour of the frame supporting structure requires an analysis of distribution of the potential deformation energy on car frame structure elements for the six load cases mentioned in the literature [2]. The numbers on the fig.4 mean: 1- lower car frame girder, 2- lateral car frame girder, 3- car floor girder, 4- upper car frame girder, 5- vertical car frame columns, 6-fastening plate.



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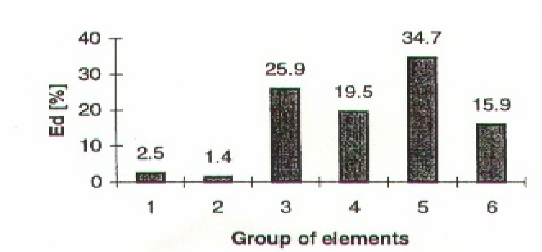

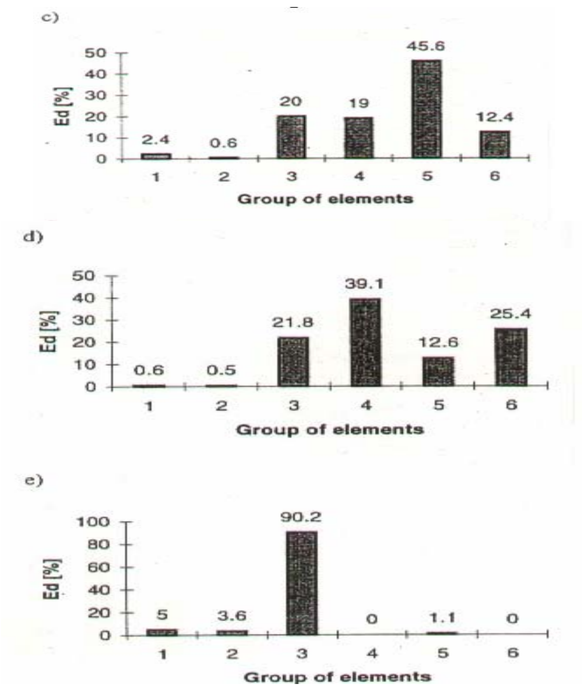

Figure 3. Distribution of deformation on groups of elements: (a... e), LIFT 1...LIFT 6 respectively.

Distribution of deformation energy on elements of the supporting structure indicates that in normal lift exploitation (cases LIFT 1 and LIFT 2) elements of vertical columns of the car frame, elements of the upper frame girder and fastening plates are the most loaded ones. Optimization of the structure should reduce deformation energy on these elements on the account of other groups of structure elements. Also on the basis of all states calculation results it is concluded that the structure optimization should be carried out for the LIFT 2 case, which represents the normal lift exploitation, while the LIFT 5 and LIFT 6 cases are damage load cases, with significantly higher allowed stresses.

4. OPTIMIZATION OF THE LIFT CAR STRUCTURE ANE THE CAR FRAMES

Optimization of the lift car structure and the car frame structure was performed for the non-stationary lift operation mode. Two optimizations were performed. The first one (LIFT 21) consists of the change of geometrical characteristics of cross-sections of the elements PP1 …PP6, where basic shapes of all cross-sections were maintained ,while profile heights, widths and thicknesses were significantly changed. Also, unification of lateral girder thicknesses was made, so that in all cross-sections of the metal sheets in LIFT 21 it now amounts to 4mm.The second optimization of the car frame supporting structure (LIFT 22) consists of reduction of.

Metal sheet thickness in all cross-sections, from 4 mm to 3 mm. Global pictures of the fields of displacement of the optimized supporting structure for the cases LIFT 21 and LIFT 22 are shown in Fig.4

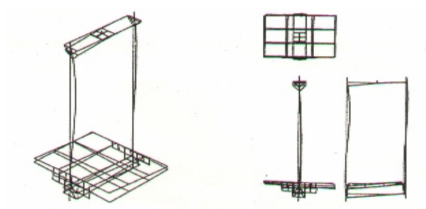

Figure 4. Field displacement of the car frame: a-LIFT 21; b-LIFT 22.

Optimization of the rear car side was made by reducing the existing meat sheet thickness of 1.5 mm to 1mm. The filed of displacement of the rear car side under the load is shown in Fig.4 while the Fig.5,a shows the distribution of stress state in the rear car side in 0.5 steps, while Fig.5,b presents the distribution of stress values in $8 \div 10\, kN/cm^2$, in steps of 1.

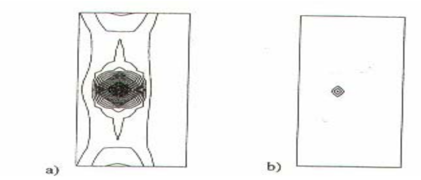

Figure 5. Stress state of the car side: a-0, 5 steps; b-1, 0; step, 8...10 kN/cm^2 .

The maximum stress in the rear car side amounts to 10,3 kN/cm2, which is significantly lower from the elastic limit. Analysis of the distribution of the potential element deformation energy of the rear car side indicates that the plate type elements ”bear “ 77,9% of the load, while the rest is ”borne” by beam type elements. In finite elements of the plate type bending stresses fully prevail with respect to the membrane stresses, with is not good but can not be avoided. Parameters required for the full identification of the static behaviour of the supporting structure of the car frame are shown in Table 1.

Table 1.

Optimization case	LIFT2	LIFT21	LIFT22
Load [Kn]	10,186	10, 186	8,42
Maximum displacement [cm]	0,257	0,098	0,117
Stiffness [kN/cm]	39,63	104	72
Maximum stress [kN/cm]	7,89	4,16	5,45

The results shown in the Table 1 indicate considerably increased car frame structure stiffness after the optimization, along with reduction of stress state and state and displacement filled. Also, the structure of the most loaded elements of the structure is changed. In the LIFT 2 case, the most loaded were the elements of vertical columns of car frame, while the most loaded ones after the optimization are the elements of the car floor girders.

5. CONCLUSION

Analysis of results of the analysis performed in this paper brings the following conclusions:
- Optimization of metal sheets in the car structure achieved reduction of car weight from the existing 224 DaN to new 148 daN, which amounts to 40%;
- Unification of thicker metal sheets in profiles used in the structure was made (all thicknesses amount to 3 min);
- Car frame structure weight was reduced from existing 222 daN, to the new 154 daN, which amounts to 31%;
- Maximum stress value in elements of the supporting structure of the car frame was reduced for 31%, and the maximum structure displacement was reduced for 55%;
- Stiffness of optimized structure was increased for 82%;
- A more even distribution of potential deformation energy in groups of structure elements was achieved.

6. REFERENCES

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