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CAD OF THE SPECIAL CAR LIFTING DEVICE

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Summary: *One way of solving the improperly parked cars problem is their towing by means of a special vehicle. Hanging the car and putting it onto that vehicle is realized by a special lifting device. This paper presents some design details of the 5 t lifting capacity device.*

Keywords: *car lifting device, design, FEA.*

1. INTRODUCTION

“Thousands of car accidents happen annually and some can even occur when there is no one actually sitting in the offending vehicle. In such instances, an automotive malfunction, like brake failure, can be the culprit. In other situations, driver error, such as an improperly parked car, can be behind the collision” [1].
“**The myth:** Council only tows away badly parked cars to make money. **The truth:** Removing the vehicles actually costs Glasgow £500,000 a year. Glasgow loses half a million pounds a year seizing badly parked cars” [2].
Generally, there are two ways of solving the problem of mproperly parked cars, Figure 1.

(a) removing a vehicle [2] (b) destroying a vehicle [3]
Figure 1: Ways of solving the improperly parked car problem

The special car lifting device (SCLD) of m_Q = 5 t lifting capacity, with hydraulic adjustment of the car's center of gravity position, is designed for mobile crane MKG HMK 242 HP Ta3 (lifting capacity 22,12 tm), but it is not the constraint for SCLD usage, Figures 2 and 3. The crane is mounted on a

special vehicle used for removing badly parked or damaged cars, Figures 4 and 5. The joining of the SCLD and crane is realised by a hydraulic slewing connection with a sliding bearing, Figure 4.
The paper gives some details of the design, Figures 2 and 3, and the calculation procedure of the SCLD structure made of steel S355J2G3 whose yield stress is σ_{YS} = 35.5 kN.

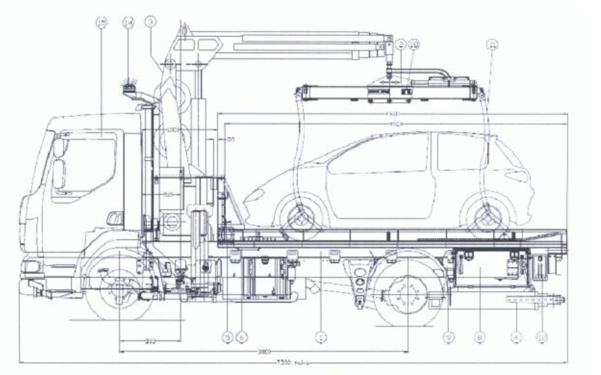

Figure 2: Structural scheme

Figure 3: Car lifting

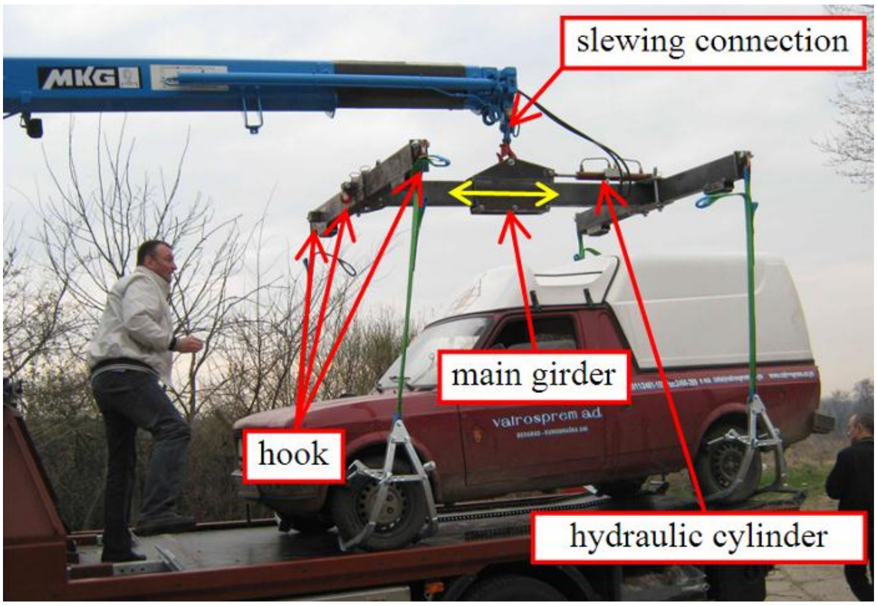

Figure 4: Detail of SCLD

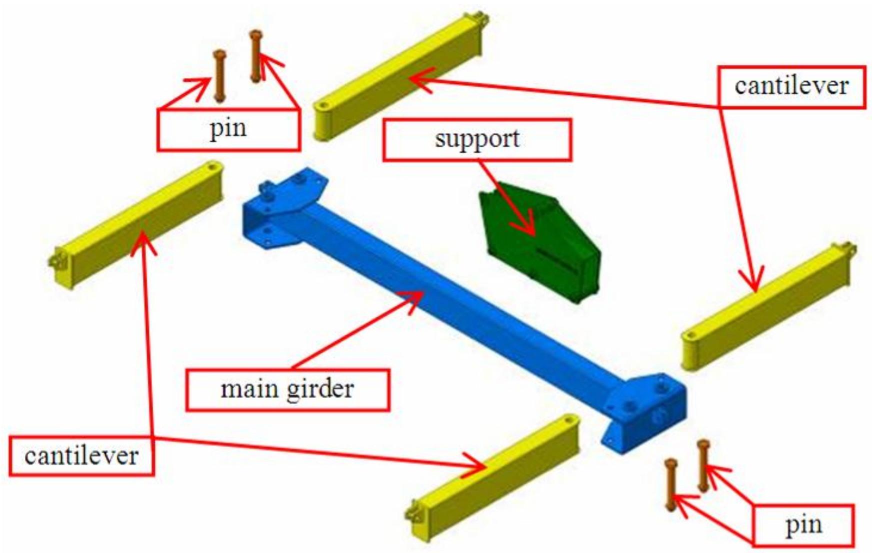

Figure 5: Exploded 3D model of SCLD structure

2. CALCULATION MODELS

Stress-strain analysis of the SCLD structure was done by applying the finite element method [4,5]. Two calculation models were developed, the first one by using beam type elements (model 1), Figure 6, and the second by using tetrahedron type elements to discretize 3D model of the SCLD structure, Figures 7 and 8 (model 2).

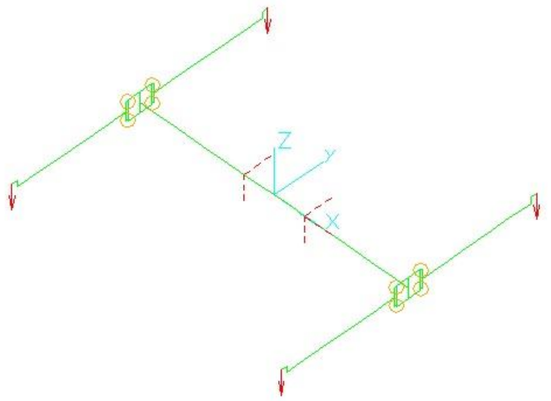

Figure 6: Beam model of SCLD structure (model 1)

Figure 7: 3D model of SCLD structure

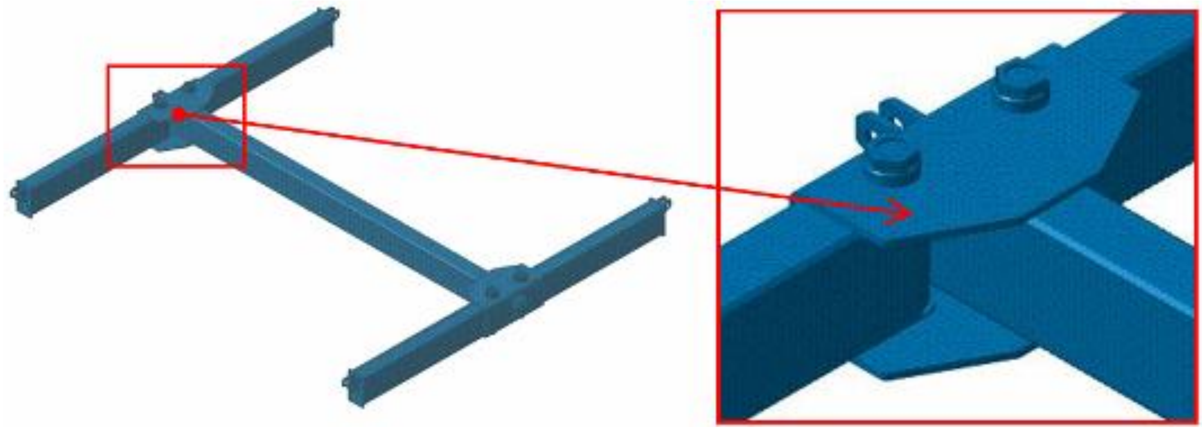

Figure 8: Detail of the FE mesh (model 2)

3. FEA RESULTS AND DISCUSSION

Responses of the SCLD structure are determined by taking into account the maximum working load which includes, among other things, extreme dynamical effects. Namely, on investor demand it was adopted that the total vertical calculation load is F_V = 64 kN, which implies that dynamic coefficient is

$$\psi = \frac{F_V}{Q} = \frac{F_V}{m_Q g} = \frac{64000}{5000 \times 9.81} = 1.3\,. \qquad \textbf{(1)}$$

Because of the very high dynamic coefficient value, verification of the SCLD structure strength and elastic stability was done with factor of safety value S = 1.33 [6].
The maximum calculated stress value using beam type elements, Figure 9, is

$$\sigma_{max} = 24.5\ \text{kN/cm}^2 < \frac{\sigma_L}{S} = \frac{35.5}{1.33} = 26.7\ \text{kN/cm}^2, \qquad \textbf{(2)}$$

while using tetrahedron type elements, Figures 10 and 11,

$$\sigma_{max} = 22.8\ \text{kN/cm}^2 < \frac{\sigma_L}{S} = \frac{35.5}{1.33} = 26.7\ \ \text{kN/cm}^2, \qquad \textbf{(3)}$$

which satisfy the condition prescribed by [6].

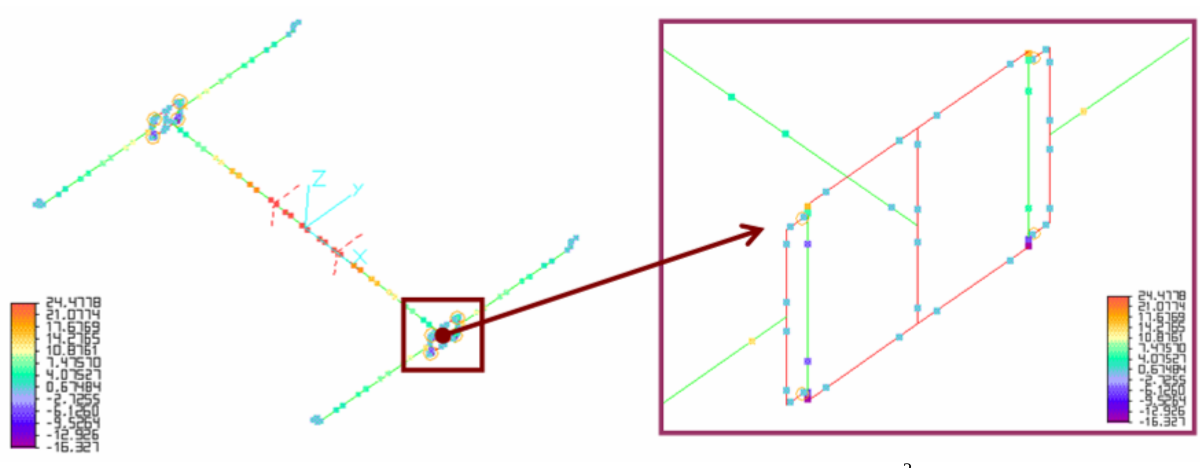

Figure 9: Model 1 - stress state, σ_{MAX} = 24.5 kN/cm^2

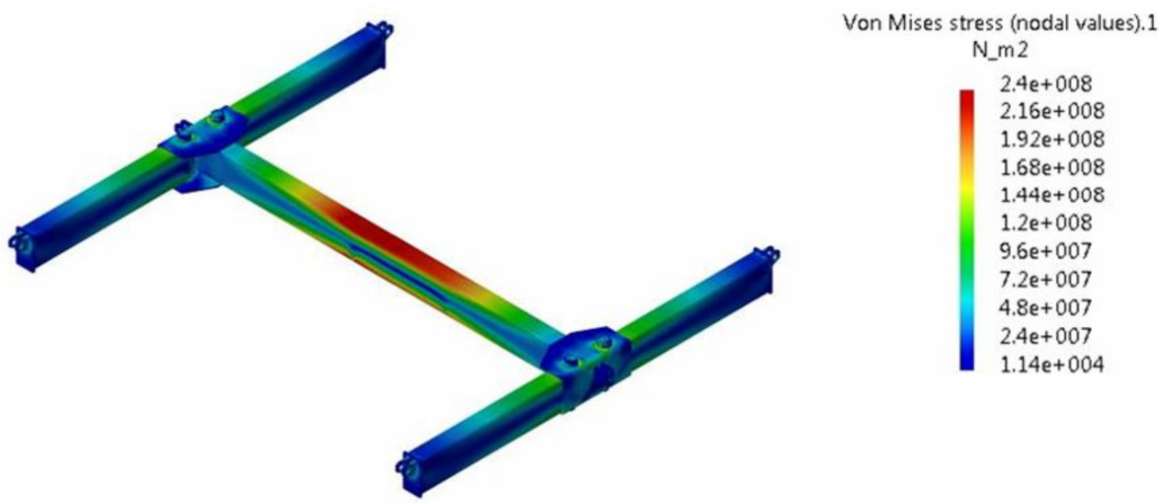

Figure 10: Model 2 - von Mises stresses, $\sigma_{vM,MAX}$ = 22.8 kN/cm^2

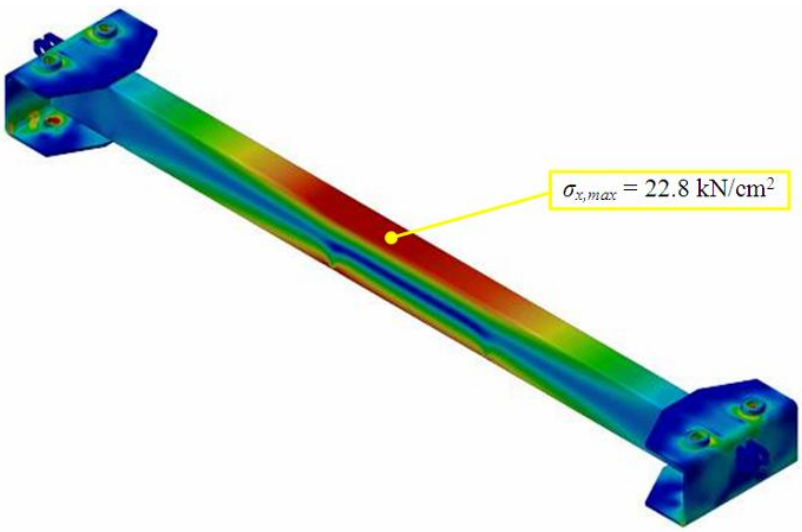

Figure 11: Model 2 - von Mises stresses of the most loaded structure element

Response of the SCLD structure on maximum dead load (50 kN), Figure 12, is the basis for verifying its deformability.

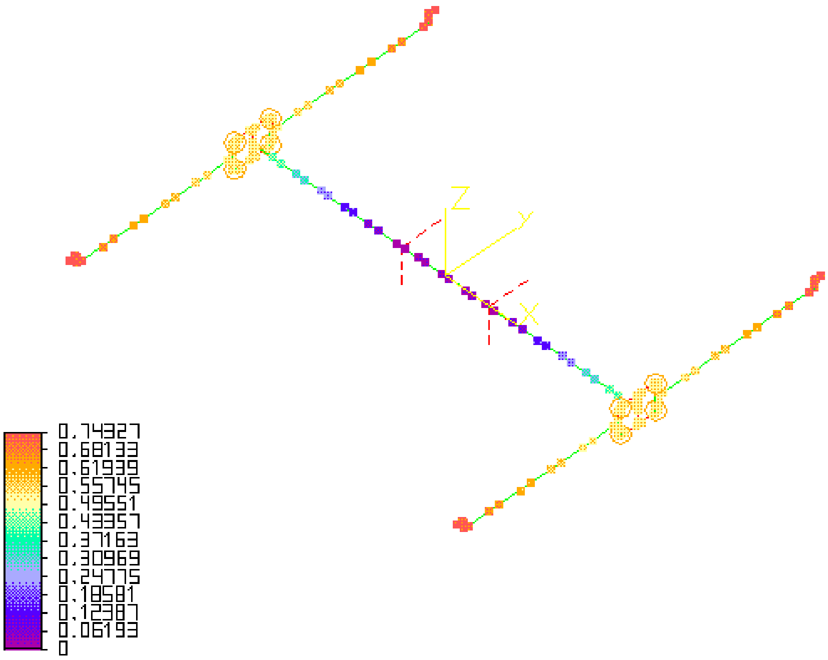

Figure 12: Model 1 - displacements field in the case of maximum dead load, t_{MAX} = 0.74 cm

Total deformation of the main girder in vertical plane, f_G in Figure 13, is

$$f_G = \left|t_Z^{39}\right| + \left|t_Z^{47}\right| = |0.04| + |-0.53| = 0.57 \text{ cm} \tag{4}$$

Having in mind that main girder length is

$$l_{MG} = 220 \text{ cm}, \tag{5}$$

the ratio between its deformation and length

$$\frac{f_G}{l_{MG}} = \frac{0.57}{220} = \frac{1}{386} \tag{6}$$

satisfies [6].

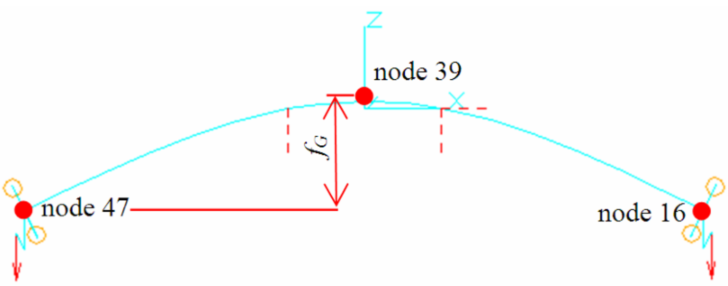

Figure 13: Main girder displacements in vertical plane

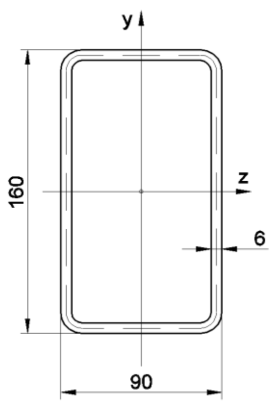

Figure 14: Main girder cross-section

Verification of the main girder safety against lateral buckling is conducted due to [6]. Since, Figure 14,

$$\frac{h}{b}=\frac{160}{90}=1.8<10, \quad \textbf{(7)}$$

and the main girder span $l_{MG}=220$ cm is less than

$$l_{MG,cr}=b\frac{1750}{\sigma_{YS}}=9\times\frac{1750}{35.5}=443.7 \text{ cm}, \quad \textbf{(8)}$$

it was adopted that the limit stress value in respect to lateral stability for the girder exposed to bending is $\sigma_L = \sigma_{YS} = 35.5$ kN/cm^2.
The maximum calculated stress value satisfies the condition prescribed by [6]

$$\sigma_{max}=24.5 \text{ kN/cm}^2 < \frac{\sigma_L}{S}=\frac{35.5}{1.33}=26.7 \text{ kN/cm}^2, \quad \textbf{(9)}$$

so it was concluded that the main girder is safe with respect to lateral buckling. Verification of the cantilever was done in the same way and it was stated that it satisfies all prescribed criterions.

4. CONCLUSION

Applying FEM enables weight minimization of the SCLD structure. Based on the FEA results and verification of the deformability and elastic stability, it can be concluded that the designed SCLD satisfies both safety and reliability criterions.

ACKNOWLEDGMENTS

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REFERENCES

[1] Proner, M.: Improperly Parked Car Accidents. Available on Web site: http://www.prolaw1.com/blog/2010/09/10/improperly-parked-car-accidents-47216.
[2] Leask, D.: THE MYTH: Council only tows away badly parked cars to make money. Available on Web site: http://www.eveningtimes.co.uk/news/editor-s-picks/the-myth-council-only-tows-away-badly-parked-cars-to-make-money-1.1047579.
[3] The mayor of Vilnius destroyed improperly parked car. Available on Web site: http://www.liveleak.com/view?i=279_1312306681.
[4] Spyrakos, C.: *Finite element modeling in engineering practice*. Morgantown: West Virginia University, 1994.
[5] Zamani, N.: *CATIA V5 FEA Tutorials release 14*. Windsor Ontario: University of Windsor, SDC Publication, 2005.
[6] Petković, Z. & Ostrić, D.: *Metal structures in mechanical engineering*. Belgrade: University of Belgrade – Faculty of mechanical engineering, 1996. (In Serbian)