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INFLUENTIA OF THE STOPPAGE - BRAKING SYSTEM OF ELEVATOR IN THE ELEVATOR'S STUDS (RAILS) FOR THE CASE OF FAILURE

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ABSTRACT
Elevators are complex machines for transportation of humans and goods. In this workshop we are going to study the stresses and loads that studs (rails) of the elevator undergo for the case of failure, which means the case when the cables cease to function and break off. Based on immediate stoppage system of elevator's cabin in the case of failure, we will analyze the influential of these systems in entire length of the stud (rail). Results have been calculated using Finite Elements Methods Application Visual Nastran 4d with preliminary determination of the loads nature and their activity, all this after creating the "virtual" model of the elevator. Gained results using FEM will be compared with results using classical methods. Parameters of the results can help in construction of the elevators and selection of the stoppage-braking system for the case of failure and can be given influential factors which determine the selection of the Stud's (rail) type and dimensions, also the distance of the reinforcement consoles of the rails.
Keywords: Elevator, rails, brake, forces, stresses, simulation, FEM.

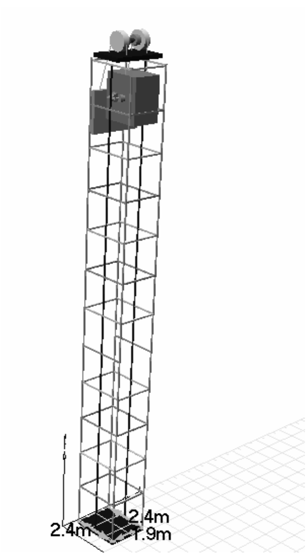


Figure 1. Virtual Model of elevator

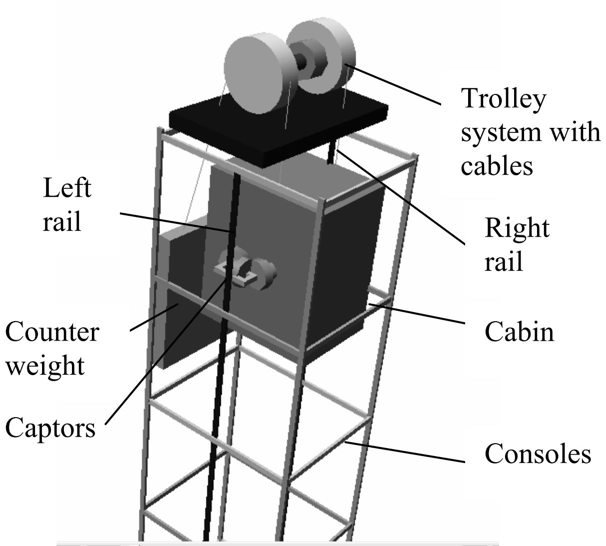


Figure 2. View of cabin and other key elements

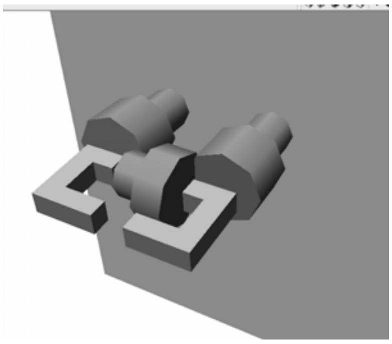


Figure 3. Captors (Hookers) of the elevator. Virtual model with pistons

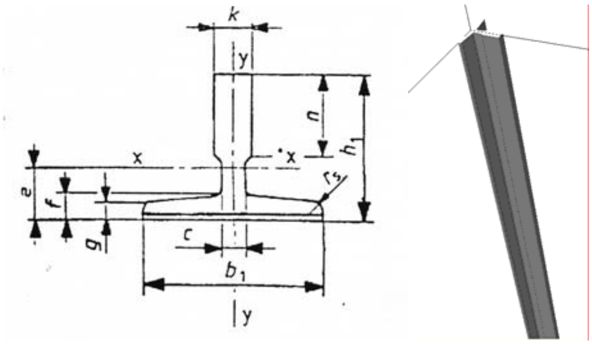


Figure 4. Cross section of rail and virtual model

1. ELEVATOR PROPERTIES

Dimensions of the cabin: Height h = 2.2 m. Length A = 1.35 m; Width B = 1.4 m:
Mass of the cabin with components: P = 550 kg. Load: Q = 600 kg
Rail: Section type 90x75x9. Height: L = 20 m. Height of the section between consoles: l_k = 2 m Material: Steel, Yield Stress R_m=$3.7 \cdot 10^8$ Pa; Modulus of elasticity: E=$2 \cdot 10^8$ Pa; Model has two rails which will be identified as left rail and right rail.

2. THEORY – VIEW AND CALCULATIONS

2.1. Calculation of rails in case of failure (case "HH")

Pressure force for buckling:

$$F_c = \frac{k_1 g_n (P + qQ)}{n} = 18246{,}6\ N$$

k_1=3 – impact factor (EN 81.1)
g_n – standard acceleration (9.81 m/s^2)
q =1,15 – balance factor indicating the amount of counterbalance of the rated load
n =2 – number of guide rails
Force of brake of the capture system act eccentrically towards the rail section center and acts in distance 25…30 mm from the head of rail.
- Normal forces acting in rails F_x and F_y:

$$F_x = \frac{k_1 g_n (Q \cdot X_Q + P \cdot X_P)}{n \cdot h} = 1258{,}46\ \text{N}; \quad F_y = \frac{k_1 g_n (Q \cdot Y_Q + P \cdot Y_P)}{n \cdot h/2} = 2458\ \text{N}$$

X_Q = 0,239 m ; Y_Q = 0,225 m ; X_P =Y_P = 0,1 m – eccentricity distances from cabin center;
h=2.2 m – height of cabin

Maximal bending moment in the center of the rail length:

$$M_y = \frac{3F_x \cdot l}{16} = 471{,}92\ \text{Nm} \quad ; \quad M_x = \frac{3F_y \cdot l}{16} = 921{,}92\ \text{Nm}$$

Normal componential stresses and normal total stress:

$$\sigma_y = \frac{M_y}{W_y} = 4036{,}95 \frac{N}{cm^2} = 4.036 \cdot 10^7\ \text{Pa}\ ; \quad \sigma_x = \frac{M_x}{W_x} = 6538{,}43 \frac{N}{cm^2} = 6.538 \cdot 10^7\ \text{Pa};$$

$$\sigma_m = \sigma_x + \sigma_y = 10575{,}389 \frac{N}{cm^2} = 1.0575 \cdot 10^8 \text{ Pa} ; \qquad W_x = 14.1 \text{ cm}^3 \ ; W_y = 11.69 \text{ cm}^3$$

Buckling stress with ω method:

$$\sigma_k = \frac{(F_c + k_3 M)\cdot \omega}{A} = 2521{,}48 \frac{N}{cm^2} \ \lambda = \frac{l_k}{r_i} = 105{,}82 \ ; \ r_i = \sqrt{\frac{I_{\min}}{A}} = 1{,}89; \ \omega{=}2{,}03 \ ; A{=}14{,}69 \text{ cm}^2$$

Permissible stress:

$$\sigma_{perm} = \frac{R_m}{S_t} = 165 \frac{N}{mm^2}$$

Total stress:

$$\sigma_{tot} = \sigma_k + 0{,}9\sigma_m = 120{,}393 \frac{N}{mm^2}$$

$\sigma_{tot} = 1.203 \cdot 10^8$ Pa $< \sigma_{perm} = 1.65 \cdot 10^8$ Pa

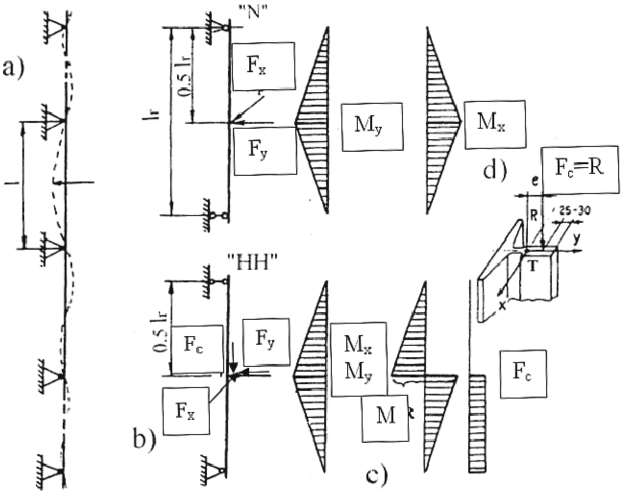
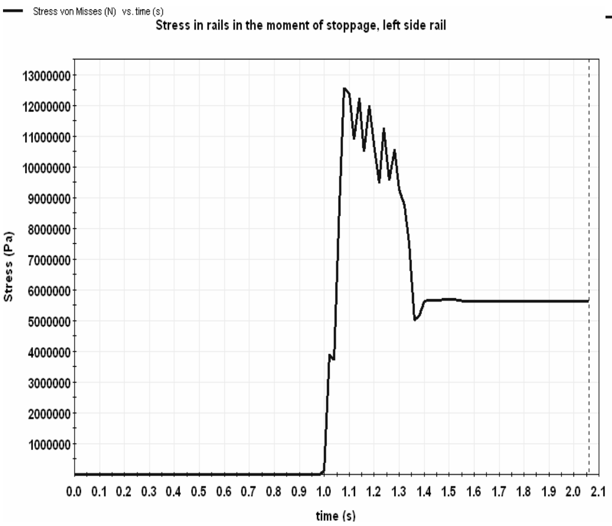


Figure 5. Diagrams of the forces in rails

3. RESULTS USING VIRTUAL MODEL AND FINITE ELEMENTS METHODS

Cabin of the elevator will go down with a speed of 1 m/s for the length of 1 m. In the moment of 1 s captors (Figure 3) will be activated using cylinders. Cabin will be stopped immediately. Stress in the rails will be shown in graphic diagram in time frame. Simulation will be stopped in time of 2 s.

3.1. Calculation of stress



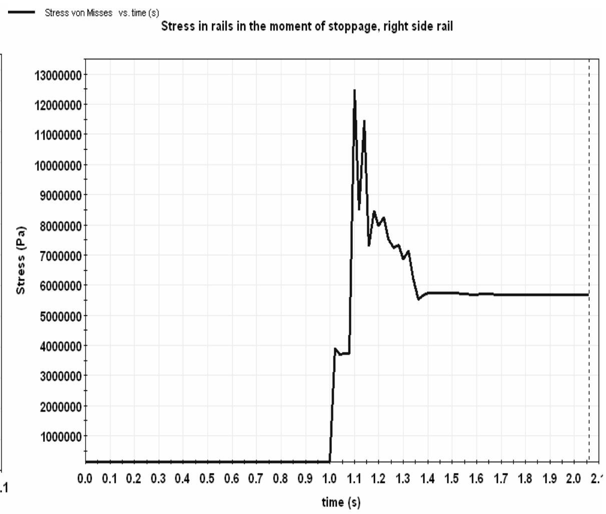


Figure 6. Total stress of the left rail *Figure 7. Total stress of the right rail*

From Figure 6 we can see that at the moment of stoppage time t = 1 s intensity of stress will rise intensively from no loading case up to max level which is σ_{max} = 12540000 = $1.254 \cdot 10^8$ Pa. After that it will fall down, but not immediately, with some oscillations, which shows the dynamic nature of

the loading in stoppage time. This time moment is short, and after Δt = 0.5 s it reaches the static loading which is σ_{st} = 5520445 = $5.52 \cdot 10^7$ Pa.
Figure 7 shows the stresses in the right rail. The graph is similar with one of left rail but not the same. This tells that both rails don't have identical graph of stresses. Graph is showing some different curves but reaches the same time Δt = 0.5 s the static loading. Maximum stress for the right rail is σ_{max} = 12480000 Pa, slightly smaller than left rail. If we compare stresses from simulation with those from classic calculations σ_{tot} (2.1) we can see that simulations give 4.2% higher stresses. But this is still below the permissible stress σ_{perm}.

3.2. Calculation of loads in rails

Total loads that act in rails are shown in Figure 8 and Figure 9:

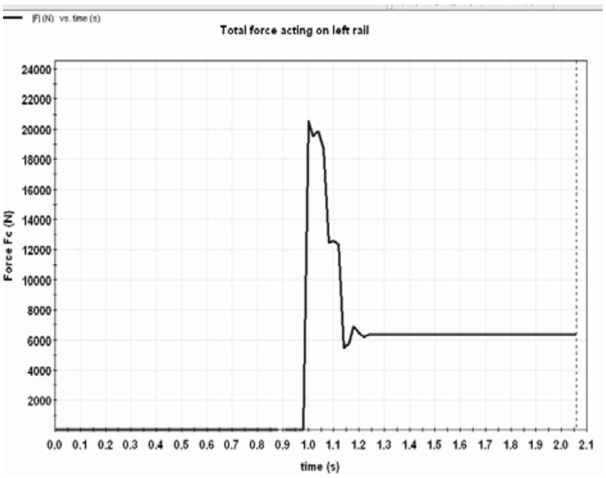


Figure 8. F_{max} load on left rail

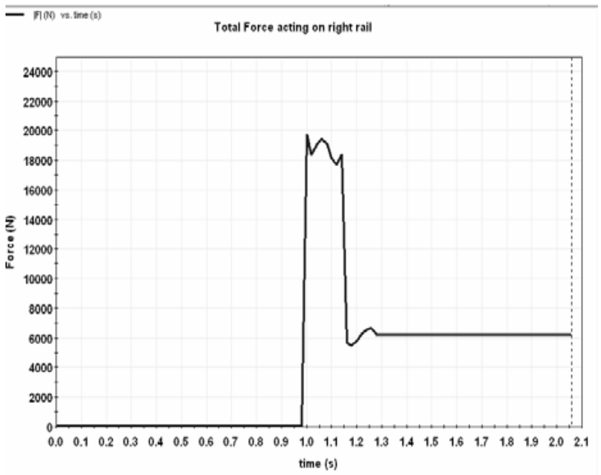


Figure 9. F_{max} load on right rail

There is similarity between the graphs of stress and graphs of force. Load graphs also tell us about the dynamic activity in the stoppage time. Max load for left rail is $F_{max\text{-}left}$ = 20055 N and static load F_{st} = 6352 N. Max load for right rail is $F_{max\text{-}right}$ = 19720 N and static load F_{st} = 6208 N. From the theory (2.1) total load is $F_{tot} = \sqrt{F_c^2 + F_x^2 + F_y^2}$ = 18454 N. This means that model in simulations using Finite Elements Methods gives higher results for 8%.

4. CONCLUSIONS

Creating computer models of elevators and applying simulations using Finite Elements Methods is a good way for studying these systems and it helps engineers for better understanding the nature of these systems. In this workshop we studied only the part connected with rails. We presented two key parameters for study and these are stresses and loads. Comparing simulations and classic calculations we have a difference for about 4.2% to 8% for simulations, and that there is a dynamic activity which should be considered.

5. REFERENCES

[1] British Standard, BS EN 81-1:1998.
[2] Slobodan Tošić, Liftovi, Beograd, 2004.
[3] MSC VisualNastran 4D User Guide, MacNeal-Shwendler Corporation, Santa Ana, 2003.
[4] Musli Bajraktari, Ilir Doçi, Praktikum nga Mjetet Transportuese, Prishtinë, 1997.