ANALYSIS OF THE MECHANICAL STRENGTH OF A DRIVING MECHANISM CALLED SHOCK

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***Abstract**. It evaluates the maximum static and dynamic stresses produced in the elements of a quadrilateral mechanism transporting a vehicle in the storage in an urban park. Determine multiplier shock hazard if the mechanism freezes and increases mechanical stress.*

Keywords. Parking the car, actuators, shock requests, optimizations.

1. Defining the problem

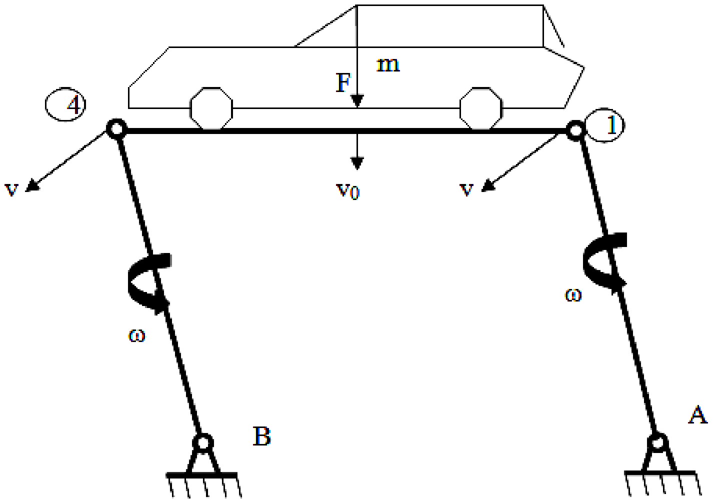

Fig. 1. Car platform

It examines platform transport a car in the modular storage in a multi-storey car park. The system is essentially a two beams oscillating platform articulated according to data in figure 1. Scheme for calculating the strength of the structure is given in Figure 2.
Kinematic parameters required are:

$$\omega = \frac{0,5 \cdot \pi}{T}, \qquad v = \omega \cdot r$$

notations: ω - speed swing angle bars;T- time lowering the car; r- oscillatory length;

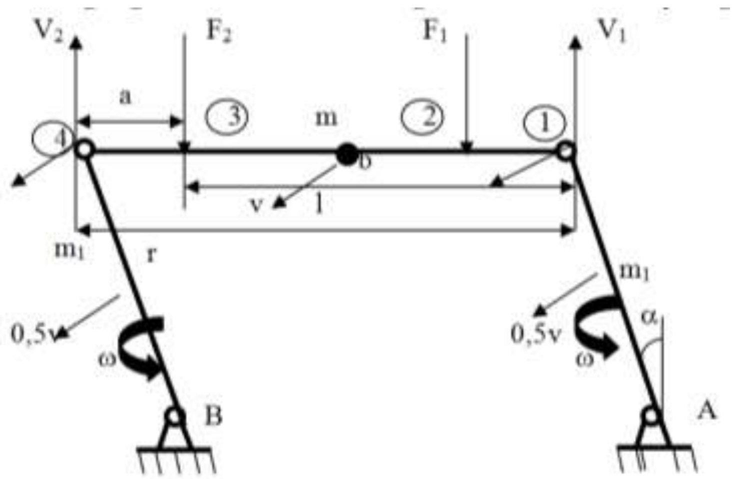

Fig.2. Calculus scheme

The masses in motion are:
car table: M=$\frac{F_1 + F_2}{g} = \frac{F}{g}$; platform table: m=$m_0$l; oscillating bar table: $m_1 = m_0 \cdot r$;
Ratings: F-weight car; g-gravitational acceleration , m_0-specific mass of the beams.
It will define only the reactions required for resistance calculation (calculation is not complete).

2. Static analysis

In terms of balancing the moments on the platform, the reactions are (neglecting the masses platform).

$$V_1 = \frac{1}{l}\left[F_1(l-a) + F_2(l-b)\right], \quad F_1 = k \cdot F, \quad F_2 = (1-k)F$$

$$V_2 = \frac{1}{l}\left[F_1 a + F_2 b\right] \qquad (1)$$

It will take into account only the request in bending. Platform moment equations are:

$$M_{12} = V_1 \cdot x; \quad M_{23} = V_1 \cdot x - F_1(x-a); \quad M_{34} = V_1 \cdot x - F_1(x-a) - F_2(x-b) \qquad (2)$$

If either of the oscillating bars are locked in lower joint, the bar will be requested blocked and bending moment was:

$M_1 = V_1 \cdot \sin\alpha \cdot x$ sau $M_2 = V_2 \cdot \sin\alpha \cdot x$ (3)

It defining the mechanism bars: the moment of inertia Ix, modulus Wx, m_0-specific mass. The masses bars are:

$m = l \cdot m_0$, $m_1 = r \cdot m_0$ (4)

Tensions are likely maximum:

$$\sigma_2 = \frac{M_2}{W_x} = \frac{V_1 \cdot a}{W_x};\ \sigma_3 = \frac{M_3}{W_x} = \frac{V_1 \cdot b - F_1(b-a)}{W_x};\ \sigma_1 = \frac{V_1 \cdot \sin\alpha \cdot r}{W_x};\ \sigma_4 = \frac{V_2 \cdot \sin\alpha \cdot r}{W_x};\ (5)$$

3. Shock calculation

It requires a locking mechanism during collaboration, causing an increase in the mechanical stresses. Impact multiplier is calculated using the equation:

$$\Psi = 1 + \sqrt{1+K}\ ,\quad K = \frac{E_c}{E_{pc}}; \qquad (6)$$

notations are: E_c-kinetic energy of the moving masses, E_p- the potential energy stored in mechanism elements.

Define 3 cases blocking the movement:

1.platform blocking horizontal direction;

2.rocker blocking A-1 in the lower joint;

3.rocker blocking B-4 in the lower joint;

It will calculate the multiplier in 3 cases.

3.1.Blocking Case 1.

The kinetic energy is:

$$E_{c1} = 0{,}5\left(\frac{F}{g} + m\right) \cdot v^2 \qquad (7)$$

Potential energy due to bending deformation is:

$$E_{p1} = \frac{1}{2 \cdot E \cdot I_x}\int M^2 \cdot dx = \frac{1}{2 \cdot E \cdot I_x}\left(\int_0^a M_{12}^2 \cdot dx + \int_a^b M_{23}^2 \cdot dx + \int_b^l M_{34}^2 \cdot dx\right) \qquad (8)$$

Replacing the timing relationship and make the integrals, parenthesis in equation (8) is calculated with equation (9).

$$I_1 = \frac{F^2}{3 \cdot l^2}\left\{(k \cdot a - l + b - k \cdot b)^2 \cdot b^3 + k(a-b)^2 l\left[(a + 2 \cdot b) \cdot (k \cdot a - l + b - k \cdot b) - (a-b) \cdot kl\right]\right\} +$$

$$+ \frac{F^2}{3 \cdot l^2}\left[(l-b)^3 \cdot (k \cdot a + b - k \cdot b)^2\right] \qquad (9)$$

Potential energy is:

$$E_{p1} = \frac{I_1}{2 \cdot E \cdot I_x} \tag{10}$$

E-modulus of elasticity of the material

$$\Psi_1 = 1 + \sqrt{1 + K_1}\,, \quad K_1 = \frac{E_{c1}}{E_{p1}} \tag{11}$$

Maximum dynamic tensions are:

$$\sigma_{2d} = \sigma_2 \cdot \Psi_1\,,\ \sigma_{3d} = \sigma_3 \cdot \Psi_1 \tag{12}$$

3.2.Blocking Case2

The kinetic energy is:

$$E_{c2} = 0,5 \cdot \left(\frac{F}{g} + m + 0,25 m_1 \right) \cdot v^2 \tag{13}$$

Potential energy stored in the elements of the mechanism is:

$$E_{p2} = \frac{I_2}{2 \cdot E \cdot I_x} = \frac{1}{2 \cdot E \cdot I_x} (E_{p1} + \int_0^v M_{A1}^2 \cdot dx) \tag{14}$$

After performing the integral bracket of equation (14) is calculated using the equation:

$$I_2 = \frac{F^2}{3 \cdot l^2} \{(ka-l+b-kb)^2(b^3+v^3\sin^2\alpha)+k(a-b)^2[l(ka-l+b-kb)(a+2b)-kl^2(a-b)]+(l-b)^3(ka+b-kb)^2 \tag{15}$$

Dynamic tensions are:

$$\Psi_2 = 1 + \sqrt{1 + K_2}\,, \quad K_2 = \frac{E_{c2}}{E_{p2}}\,;\ \sigma_{2d} = \Psi_2 \cdot \sigma_2\,;\ \sigma_{3d} = \Psi_2 \cdot \sigma_3\,;\ \sigma_{1d} = \Psi_2 \cdot \sigma_1\,; \tag{16}$$

3.3.Blocking Case 3

The kinetic energy is similar to the previous situation:

$E_{c3}=E_{c2}$

Potential energy is:

$$E_{p3} = \frac{I_3}{2 \cdot E \cdot I_x} = \frac{1}{2 \cdot E \cdot I_x} (E_{p1} + \int_0^r M_2^2 dx) \tag{17}$$

Parenthesis in equation (17) is calculated using the equation:

$$I_3 = \frac{F^2}{3 \cdot l^2} \{(ka-l+b-kb)^2 b^3+k(a-b)^2[l(ka-l+b-kb)(a+2b)-kl^2(a-b)]+(ka+b-kb)^2[(l-b)^3+r^2\sin^2\alpha] \tag{18}$$

Dynamic stresses are calculated:

$$\Psi_3 = 1 + \sqrt{1 + K_3}\,, \quad K_3 = \frac{E_{c3}}{E_{p3}} \tag{19}$$

$$\sigma_{d2} = \Psi_3 \cdot \sigma_2\,,\ \sigma_{d3} = \Psi_3 \cdot \sigma_3\,,\ \sigma_{d4} = \Psi_3 \cdot \sigma_4$$

3.4.Evaluation of a particular case

We adopt dimensions: l = 400cm, a = 80cm, 300cm b = r = 180cm (20)

Full displacement (vertical-horizontal) will be in T = 30s, resulting kinematic parameters:

$\omega = \frac{0,5\pi}{T} = 0,052 rad/s$, v=ωr=9,42cm/s (21)

Rolling mechanism is adopted to build IPE200 type that has the following characteristics:

I_x=1940cm^4, W_x=194cm^3, m_0=0,224 kg/cm (22)

The position of the center of gravity of the vehicle and its weight are:

F=2000daN, K=0,4, g=1000cm/s^2, F_1=KF=800daN, F_2(1-K)F=1200daN (23)

Maximum voltages are (it is thought that $\alpha = 0,5\pi$):

σ_1=872daN/cm^2, σ_2=387daN/cm^2, σ_3=546daN/cm^2, σ_4=983daN/cm^2 (24)

Dynamic stresses calculated with shock multipliers are given in Table 1.

Table 1

Cazul	1	2	3
Ψ	4,9	4,17	4
σ_{1d}(daN/cm^2)	-	3637	-
σ_{2d}	1895	1616	1558
σ_{3d}	2671	2278	2196
σ_{4d}	-	-	3953

4. Conclusions

Defined mathematical model for assessing static voltages and multipliers shock for threecases blocking transport mechanism. Under quasi-static stress mechanical stresses are relatively small, lower value (considerated admissible) of 100daN /cm^2 (100MPa).

If it is assumed that the mechanism is made of steel S235 (blood flow σ_c = 235Mpa = 2350daN /cm^2), static requirements are much lower blood flow.

It compares the 3 cases and found that the rod-platform is the most disadvantaged in case 1, the multiplier having the maximum value, the maximum voltage exceeds the yield, so it is necessary to increase the time of descent from T = 30s to 50 or 60 seconds (blood decreases maximum 1890 daN /cm^2).

In case 2 and 3 locking platform is less dynamic query request while remaining high (blood flow is reached).In case 2 the request is slightly larger than in case 3. Comparing requests oscillating bars are found in the worst case case 3, which recommends preferable drive lock joint articulation A. B rupture respective oscillating bar; if it doubles during descent (T = 60s) swing over the yield required, so it must necessarily bar to rotate freely. It is possible that in other specific conditions (size, strength, speed, material, etc) comparative analysis of requests and cases lead to other conclusions. The mathematical model being defined parameters, numerical determinations allow complete and easy.

Acknowledgement

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