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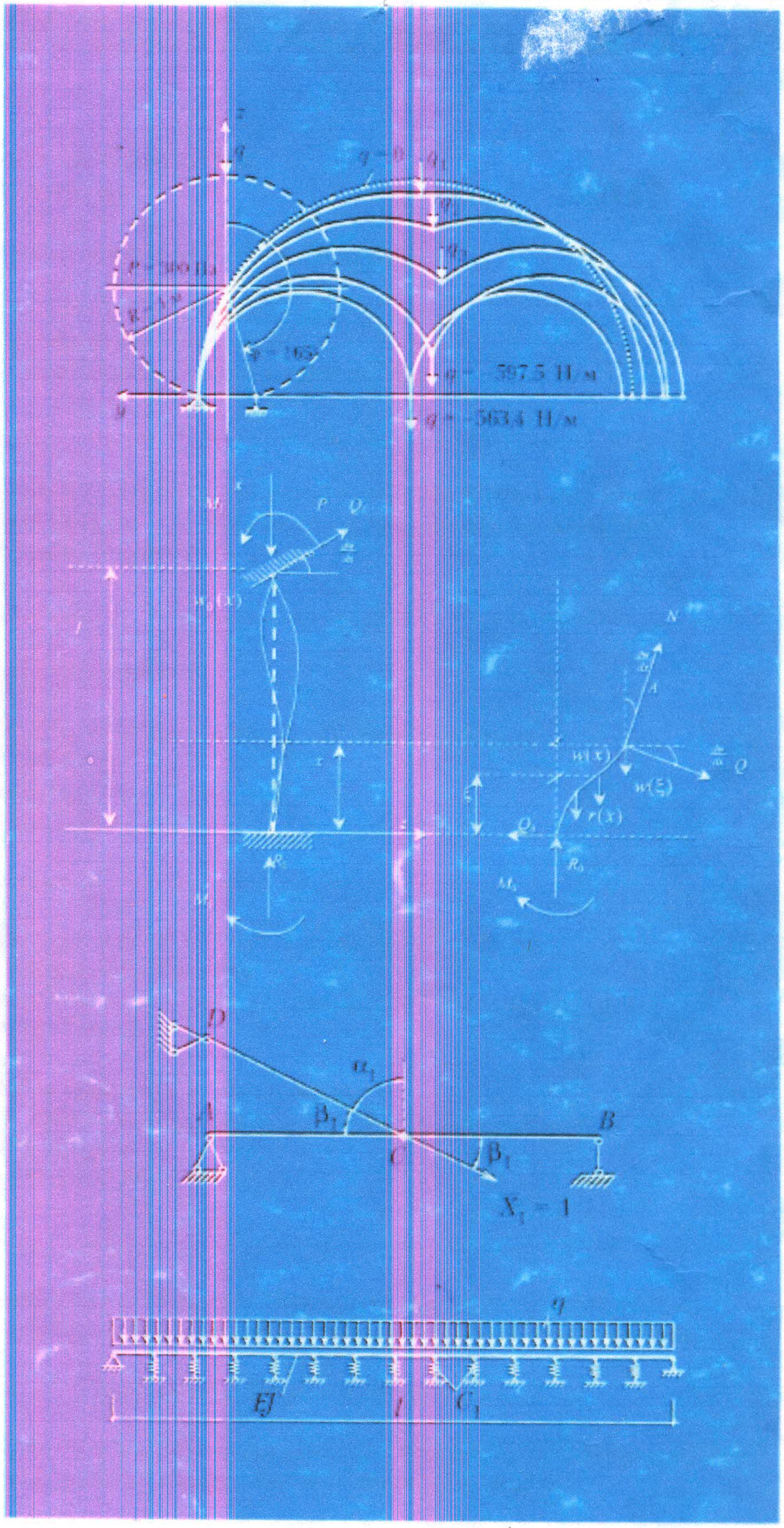

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SPSUACE

ANALYSIS OF NONLINEAR ELASTIC MATERIAL TRUSS UNDER WIND LOADS

Nonlinear problems are generally solved by iterative method. Iteration process on physical properties of a system is recommended to be performed at each time step [1]. The initial data necessary are the flexural rigidity of members, mass and damping coefficients. The equation of motion of lumped mass is written as:

$$\mathbf{M\ddot{Y}_t + C\dot{Y}_t + KY_t = R_t}, \qquad (1)$$

where **M, C, K** are mass, damping and rigidity matrices; $\mathbf{R_t}$ is a vector depicting the external force; $\mathbf{Y_t}$, $\mathbf{\dot{Y}_t}$, $\mathbf{\ddot{Y}_t}$ are the displacement, velocity and system mass acceleration vectors with finite degree of freedom. In case of variable elemental values the matrices of equation (1) for time t take the following form:

$$\mathbf{M(y_t)\ddot{Y}_t + C(y_t)\dot{Y}_t + K(y_t)Y_t = R_t}, \qquad (2)$$

and for time $t + \Delta t$ the elements of the matrices will receive an increment.

$$\mathbf{M(y_{t+\Delta t})\ddot{Y}_{t+\Delta t} + C(y_{t+\Delta t})\dot{Y}_{t+\Delta t} + K(y_{t+\Delta t})Y_{t+\Delta t} = R_{t+\Delta t}}, \qquad (3)$$

Substituting in equation (3) of expressions $\mathbf{\ddot{Y}_{t+\Delta t}}$ and $\mathbf{\dot{Y}_{t+\Delta t}}$ obtained from linear solution [1] results in the following equations:

$$\begin{aligned}&[a_0\mathbf{M(y_{t+\Delta t})} + a_1\mathbf{C(y_{t+\Delta t})} + \mathbf{K(y_{t+\Delta t})}]\mathbf{Y}_{t+\Delta t} = \mathbf{R}_{t+\Delta t} + \\ &+ [a_0\mathbf{M(y_{t+\Delta t})} + a_1\mathbf{C(y_{t+\Delta t})}]\mathbf{Y}_t + [a_2\mathbf{M(y_{t+\Delta t})} + a_4\mathbf{C(y_{t+\Delta t})}]\mathbf{\dot{Y}}_t + \\ &+ [a_5\mathbf{M(y_{t+\Delta t})} + a_3\mathbf{C(y_{t+\Delta t})}]\mathbf{\ddot{Y}_t}\end{aligned} \qquad (4)$$

Diagram $\sigma - \varepsilon$ is taken as cubic parabola [2]: $\sigma = E\varepsilon - A\varepsilon^3$. The constant A is determined from the conditions in which tangential modulus of elasticity is equal to zero for the relative ultimate strain. In order to solve this problem the secant modulus $E_c = \sigma/\varepsilon$ is used. The resultant expression for modulus of elasticity is:

$$E_c = E_k - A\varepsilon^2$$

Or after substitution of relative strain with stress: (5)

$$E_{c(n+1)} = E_k - A\sigma^2 / E^2_{c(n)}. \qquad (6)$$

In solving equation (4), the process of iteration with the help of expression (6) is performed for each time step until the differential displacement between two neighboring iterations exceeds the prescribed calculations accuracy degree. General calculations procedure is specified in books [1, 2].

The truss in Fig. 1 is taken as an example. The truss members are double equal angles with design section 200x200x30 mm [3]. Sectional area of all the members is $A_{1\text{-}86}$ = 2x111.54 cm^2. Minimum moment of inertia is 2x4019.60 cm^4. Masses are uniform $m_{1\text{-}14}$ = 20 t, m_{15} = 40 t. Initial modulus of elasticity is $E_k = 20.6\ 10^7$ kN/m^2 and $\sigma_{nn} = 215 \cdot 10^3$ kN/m^2 [4], thereafter $\varepsilon_{nn} = 0.00104447$.

The given data for truss contain vectors of length, cross sections and members initial modulus of elasticity. Besides, the following is introduced: force matrix from unit forces applied along mass displacement direction and force matrix from unit values of basic unknown variables for force method in case of statically indeterminate truss. Vectors of damping coefficients are introduced in the dynamic analysis; vector of minimum critical stresses is also introduced for checking possible loss of local stability in separate members. This analysis is implemented on the basis of Appendix 7 program from book [2].

Wind pressure variation law is calculated based on actual wind speed diagram taken from book [5]. The results obtained are presented in Fig. 2 and 3 for the most stressed members No. 1 (for tension) and No. 4 (for compression).

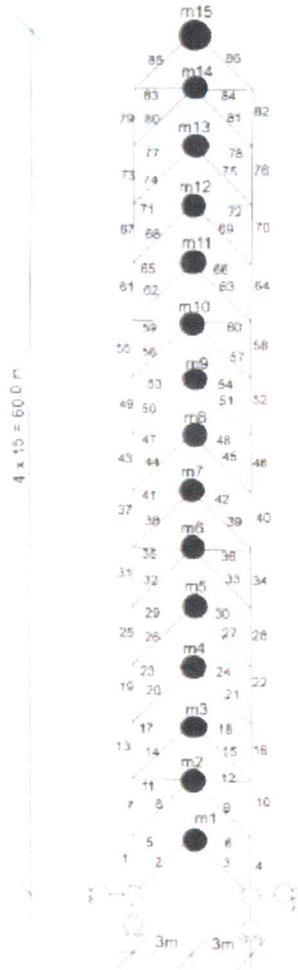

Fig. 1. Analytical model of steel truss

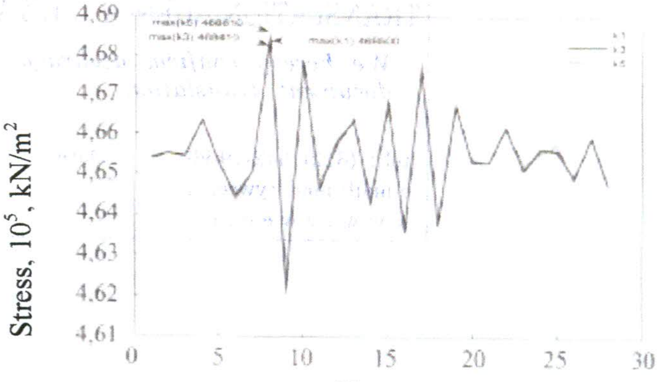

Fig.2. Stresses in the 1st member (tension)

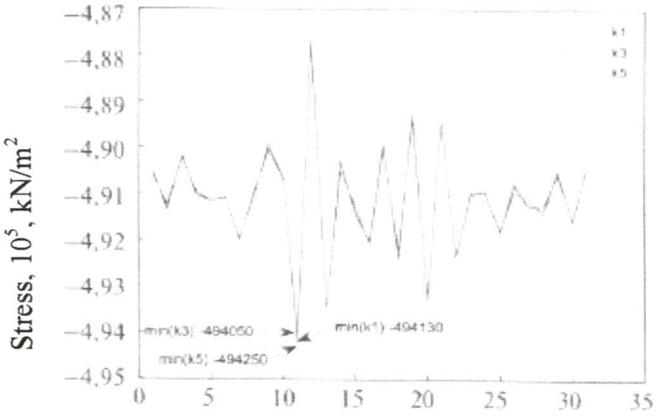

Fig.3. Stresses in the 4th member (compression)

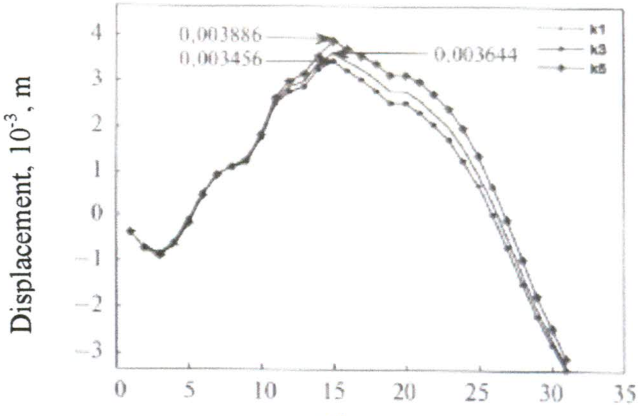

Fig.4. Displacements of the 15th mass (m_{15})

Figures show comparison of obtained stresses with stresses for linear elastic material. For every member iteration on nonlinearity is performed 3 to 5 times.

Fig. 4 shows displacements of the 15th mass at different iteration number. It should be noted that material nonlinearity was not significantly evident at prescribed force.

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