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MATHEMATICAL MODEL OF THE OPTIMIZATION PROBLEM TAKING INTO ACCOUNT A NUMBER OF FACTORS

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Abstract:

The article describes a mathematical model of optimization of statically indeterminate frame reinforced concrete structures, taking into account a number of factors; as an elastic-plastic state, conditions of reliability, geometric nonlinearity, spatiality, elasticity of the foundation, shear deformations and taking into account the failure of individual elements of the system.

Keywords: Mathematical model, elastic-plastic state, reliability conditions, geometric nonlinearity, spatiality, elasticity of the base, shear deformations.

A mathematical model of the optimization problem is formulated: find such a solution x* on the set of weighted parameters so that the optimality criterion C_i^{ϵ} reached an extreme value when the following conditions are met:

$\Omega\ (x^*(x\epsilon\Omega))$

$\Phi_i(g)=C_i(x)\rightarrow \min\limits_{x\rightarrow\Omega}\ (\max), x=\{EA, EI(x,y,z), GA\}$

$\Omega=\{\ \Omega_x\cap\ \Omega_z\cap\ \Omega_s\cap\ \Omega_\beta\}.$

$M_{r(x)}\leq M_{crk}=W_{crk*}R_{btn+}N_r$- elastoplastic state;

$R_{ss(x)}\geq[R_{sn}]$- reliability conditions;

$\overrightarrow{\{P\}}=[K\overrightarrow{(z)}]\ \overrightarrow{\{S\}}$- geometric nonlinearity;

$\sum x=0;\sum y=0;\sum z=0;$- spatiality;

$[K]=[K^M]+[K^O]$- elasticity of the base;

$[K]=[K^M]+[K^C]$- shear deformations;

$EI_{(x)_i}\rightarrow 0;\ \ 1=1,2,\ldots\ldots,n$- accounting for the failure of individual system elements.

Where, Ω the area of the system's existence, selected from the conditions and requirements for the object arising from the tasks of real design, which allows you to maximally adapt the optimal solution to real conditions. Region of feasible solutions Ω, i.e. the system of restrictions Ω_z, is determined from the conditions of the statics (kinematics) of the structure, the requirements of the limiting states, the design requirements Ω_s, and conditions ensuring the seismic resistance of the system Ω_β.

The problem of ensuring the optimality (efficiency) of reinforced concrete frame structures is investigated on the example of IIS-04, with the maximum approximation of the mathematical model to the real work of the structure by taking into account objective, significantly influencing factors and properties.

In contrast to the traditional formulation and model of the optimization problem [1, 2, 3, 4], the present research [5] introduces the following requirements and conditions that refine the design model:

1. The design scheme of the structure is considered both in a flat one and taking into account its spatial work;
2. The joint work of the structure with the base is considered;
3. The design scheme of the structure is considered taking into account the nonlinearity of the structure;

4. The elastic, elastic-plastic and plastic states of the structure are investigated;
5. The calculation is carried out taking into account bending, shear and longitudinal deformation;
6. The structure is designed for both static and seismic loads.
7. For this task, it is considered given:

Loads: p, q, s - static (permanent, long-term, short-term) and seismic.

Geometric parameters: L = {L,$H_{ЭТ}$, B, a} - span lengths, floor height, section length, concrete cover thickness;

Physical and mechanical characteristics of materials: G = (R_s, R_b, E_b, E_s, E_0,) design and standard resistances of reinforcement and concrete, moduli of elasticity of reinforcement and concrete, soil bed coefficient (base of foundations), bulk density of reinforced concrete.

Domain of definition, i.e. realm of existence Ω system is identified from a set of conditions - requirements and restrictions. The system of conditions and restrictions has the form

$\overrightarrow{\{P\}} = [K\overrightarrow{(z)}]\ \overrightarrow{\{S\}}$

- equilibrium equation taking into account geometric nonlinearity,

Where K (z) - equilibrium matrix;

$P=\begin{bmatrix} P_x \\ P_y \\ P_z \end{bmatrix}$ - vector of external forces

$S=\begin{bmatrix} N_x \\ N_y \\ N_z \end{bmatrix}$ - vector of internal forces

$(A-p^2 E)x=0$ system of secular equations of oscillations;

- requirements of limiting states, i.e.

$S_{before}=f(R_i,\ M_{kr},\ A,\ L,\ E_0)$

I group of limit states:

$(R_bA_b+R_sB_s)-N\geq 0$

$R_sA_s-N>0$

$R_bS_b+R_sS_o-M\geq 0$

I Igroup of limit states:

$M_{сов}\leq M_{ui}$; $Q_{col}\leq Q_{ui}$; $N_{col}\leq N_{ui}$; $\xi \leq \xi_R$

$Q\leq 0{,}3\varphi w_i\varphi b_i R_{bt}\ bh$.

$$\sigma_{(sp)_{min}} \leq \sigma_{(sp)} \leq \sigma_{(sp)_{max}};\ \sigma_{(bp)} \leq \sigma_{(b)_{max}};$$

Ω_p: conditions ensuring the seismic resistance of the system.

$S_{max}\leq S_{before}$ – seismic conditions.

$S_{max}=\{M_x+M_{kr}+M_n;\ Q_x,\ N_x\}$, Where M_{kr},M_n - torsional forces.

$f\leq[f]$; $\alpha_{crc}\leq[\alpha_{crc}]$ - conditions of rigidity, crack resistance

Ω_s - technological and design requirements:

$\mu_{min}\leq \mu \leq \mu_{max}$; $S_{min}\leq S\leq S_{max}$; $A\leq[A]$.

The above described mathematical model of optimization of statically indeterminate frame reinforced concrete structures of arbitrary shape, which forms the basis of our research.

The implementation of the model is carried out by developing the capabilities of the "CROSS" program, which was developed by scientists and specialists of the Tashkent Institute of Architecture and Construction, Namangan Institute of Engineering and Construction and JSC "ToshuyjoyLITTI" .

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