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I.V. Melnyk
Lviv Polytechnic National University

REVIEW THE CALCULATION METHODS OF MONOLITHIC REINFORCED CONCRETE FLAT OVERLAP WITH THE HOLLOW INSERTS

The methods that were used and can be used to general static calculation of the monolithic concrete slabs, including cavity forming with inserts.

Key words: monolithic slabs, cavity formation, static calculation

Розглянуто методи, що використовувалися і можуть бути використані для загального статичного розрахунку монолітних залізобетонних перекриттів, зокрема з порожниноутворювальними вставками.

Ключові слова: монолітні перекриття, порожниноутворення, статичний розрахунок.

Introduction

In the Lviv Polytechnic National University the complex experimental and theoretical researches of the monolithic flat reinforce-concrete ceilings with the hollow inserts are continuing. The principle technological decisions of monolithic concrete and reinforce-concrete wares with hollow inserts were protected in 2000 by the patent on an invention [1].

The principle structural decisions of the monolithic reinforce-concrete ceilings with effective insertions were given in a publication [2] after 1997. It is tubular insertions of the different crossings (round, rectangular, vaulted) with the location of tubes on one-way; separate square or rectangular in a plan insertions of considerable sizes which enable to get monolithic lighter reinforce-concrete construction with the location of ribs-beams in two directions and others like that. In subsequent publications the insertions of other forms are offered, which were realized in practice [3, 4].

The general statistical calculation of these ceilings was performed with the use the PC «Lira» is in supposition of resilient work of materials. However such experimental researches of fragments of the monolithic ceilings rotined with tubular insertions shown that inflexibility in two directions was different that should consider in the static calculations of ceilings. Together with cracks appeared and plastic properties of concrete they can influence on the substantial redistribution of efforts in ceiling that should reflect in calculation dependences.

Aims and objective of research

To analyze methods (calculation apparatus) that were used or can be used for the general static calculation of the flat monolithic reinforce-concrete ceilings with effective insertions with further subsequent perfection and development.

The main material

For the general statistical calculation of monolithic slabs which work in two directions can use the calculation method of thin elastic plates which is the same size with the thickness of plate. Basis of this method there is the differential equation that describing the curved surface of the plate and the relationship between moments and deformations using all dependencies cylindrical rigidity[5]:

$$\left.\begin{aligned} &D\left(\frac{\partial^4 w}{\partial x^4} + 2\cdot\frac{\partial^4 w}{\partial x^2 \partial y^2} + \frac{\partial^4 w}{\partial y^4}\right) = q(x,y); \\ &M_x = -D\left(\frac{\partial^2 w}{\partial x^2} + \nu\frac{\partial^2 w}{\partial y^2}\right);\ M_y = -D\left(\frac{\partial^2 w}{\partial y^2} + \nu\frac{\partial^2 w}{\partial x^2}\right); \\ &M_{xy} = -D(1-\nu)\frac{\partial^2 w}{\partial x\cdot\partial y};\ D = \frac{Eh^3}{12(1-\nu^2)}. \end{aligned}\right\} \quad (1)$$

In these dependences:

D – cylinder inflexibility of plate (slab);*w=w(x, y)* – functions of bendings (vertical moving) slab; *q(x, y)* – functions of intensity of loading up-diffused on all area of flag;M_x, M_y, M_{xy} – moments in dimensions XZ, YZ and the corresponding torque in section (point) areconsidered; E – elastic modulus of the plate (slab);h – thickness of slab; ν – Poisson's coefficient.

The decision of differential equalizations (1) can get by the selection of the special functions which satisfy maximum terms to contoured plate. In most cases it is trigonometric functions thatenable to define a moment and bendings for the plates of regular (symmetric) shape in a plan – square, rectangular, round and others like that.

However it is necessary to notice that these upshots (often given in a table form) are based on supposition of resilient work of material; the resiliency module of reinforce-concrete flag is expressed only through the initial elasticity module of concrete. An origin of cracks is in the stretched area, plasticity of concrete and presence of armature substantially influence on the redistribution of efforts that determined at the initial stage in supposition of resilient work of materials.

Classic equalizations of flat resilient plate (1) are basic (source) that use for reinforce-concrete and permanent reinforce-concrete ceilings of different type.

For description tensely deformed state between columns flags of the reinforced concrete structures ceiling [6]of decision of equalization (1) is written in double trigonometric rows (a Navie's decision) provided $L_1=L_2=L$ [6]:

$$W_{(x,y)} = \frac{16q_0(L-2a)^4}{\pi^6 D}\sum_{m=1}^{\infty}\sum_{n=1}^{\infty}\frac{sin\frac{m\pi x}{a}\,sin\frac{m\pi y}{a}}{mn(m^2+n^2)^2}, \quad (2)$$

m, n – purpose odd numbers (1, 3, 5, …);L_1, L_2 – the distance between the axis column; a – size of the cantilever slab; $q(x, y)=q_0$ – uniformly distributed load.

Semchenko A.S. is developed technical theory of semi-instantaneous structurally orthotropic flag for the calculation of ceiling disk from the combined teams of reinforce-concrete flags [7]. As a result of insignificant influence of transversal bend inflexibility in direction perpendicular to the axis of flags, in direction of Y an author accepted zero. At such condition initial bending deformational equation is simplified and has the form:

$$D_x\frac{\partial^4 w}{\partial x^4} + 2H\frac{\partial^4 w}{\partial x^2\partial y^2} = q\,, \quad (3)$$

$H = 2(D_{yx} + D_{xy}) + \nu_x D_y + \nu_y D_x$.

D_x, D_y, D_{xy}, D_{yx} – stiffness in bending and in torsion to the main directions of elasticity;

ν_x, ν_y – Poisson's coefficient in tension in the direction X andY.

For the calculation of monolithic reinforced concrete ceilings with the location of beams in both directions can be used in a simplified form of the theory developed for the calculation of the plate (plate) double bottom vessel. Such construction is accepted as a structurally orthotropic plate that plate in which the difference of inflexibilities is predefined the difference of transversal cuts on two mutually perpendicular directions. The row of suppositions are accepted: the hypothesis of flat cuts take place for the beams of two directions; an amount of beams in two directions is considerable; the quantity of beams in both directions are identical; on the thickness of floorings tensions are up-diffused evenly a thickness of floorings and general height of plate is permanent.

On such conditions differential equalization of bend and expressions for inflexibilities along main directions of resiliency in principle is similar to equalizations that hasgot Lekhnickiy S. for plates that supported ribs [8]:

$$D_1\frac{\partial^4 w}{\partial x^4} + D_3\frac{\partial^4 w}{\partial x^2\partial y^2} + D_2\frac{\partial^4 w}{\partial y^4} = q(x,y); \quad (4)$$

$$D_1 = \frac{E \cdot I_1}{b_0(1-\mu^2)};\ D_2 = \frac{E \cdot I_2}{a_0(1-\mu^2)};\ D_3 = 2D_k + D_1\mu_2 = 2D_k + D_2\mu_1 . \quad (5)$$

For determination of inflexibility there is the offered [8] dependence on twisting:

$$D_k = \frac{G \cdot t_1 \cdot t_2}{t_1 + t_2} h^2 . \quad (6)$$

E, G, μ – resilient permanent isotropic material of ceiling; I_1, I_2 – moments of inertia of longitudinal and transversal connections of ceiling with the added bars of the overhead and lower floorings breadth ways a_0 and $в_0$ accordingly; t_1, t_2, h – thickness overhead and lower layers and general height of flag.

Poisson's coefficients of orthogonal plate close on a structural chart to the reinforce-concrete ceiling accepted identical. In a large difference in moments of inertia I_x and I_y to improve the accuracy of the calculation can take:

at $I_x > I_y$, $\quad \mu_x = \mu\frac{I_y}{I_x}$, $\quad \mu_y = \mu$;

at $I_y > I_x$, $\quad \mu_x = \mu$, $\quad \mu_y = \mu\frac{I_y}{I_x}$.

One of the most suitable and closest to the actual calculation of flat monolithic reinforced concrete beams with inserts should be considered a method developed by Volga V. and Yevstafyev V. [9]. It is based on the following assumptions:

- overlap with inserts seen as a three-layer and reduced to a thin uniform thickness orthotropic plates with small deflections;
- configuration in a plan and conditions of leaning overlap can be arbitrary (the case of mutually in a plan beams however is considered only in two directions);
- direction of beams and axis of orthotropic plate are coincide;
- steel and concrete material of ceiling are heterogeneous in properties and to distributing on a thickness that reduced to relatively homo generous material through the resulted modules of resiliency of $E_{red,x}$, $E_{red,y}$ and shear modulus G_{red}.

The values of the resulted modules of resiliency in two directions determine ceiling from expression of cylinder inflexibilities:

$$D_x = \frac{E_{red,x} \cdot h^3}{12(1-\mu^2)} = \frac{1}{b_{f,x}(1-\mu^2)} E_b \cdot I_{red,x}; \quad (7)$$

$$D_y = \frac{E_{red,y} \cdot h^3}{12(1-\mu^2)} = \frac{1}{b_{f,y}(1-\mu^2)} E_b \cdot I_{red,y} , \quad (8)$$

$b_{f,x}$, $b_{f,y}$ - a width of calculation cuts is on axes X, Y; E_b – initial module of resiliency of concrete.

Moment of inertia calculation a cut in general case determine after the known dependences support of materials taking into account the relation of the modules of resiliency of armature and concrete.

$$I_{red} = \sum I_j = \sum \int_{A_j} x^2 dA ; \quad (9)$$

A calculation vehicle that developed inprocess [9] based on supposition of resilient work of ceiling and needs of iteration calculations. It does not take into account crack and plastic properties of concrete, which predetermine considerable influence on work of ceiling and redistribution of efforts.

Under the direction of author of this article experimental researches of fragments of ceilings were conducted with round and square tubular insertions that in subsequent were realized in practice [3,4]. For their static calculation it is possible to apply such approach.

As linear sizes of ceilings in a plan are on an order greater from its thickness (*h/l<1/10*), for a calculation it is possible to use the theory of bend of plates [5] in supposition hookian deformation of constructions. Design work of actual reinforce-concrete construction of ceiling an orthotropic plate with the system of co-ordinates of XoY, which main directions of resiliency coincide with (Figure. 1).

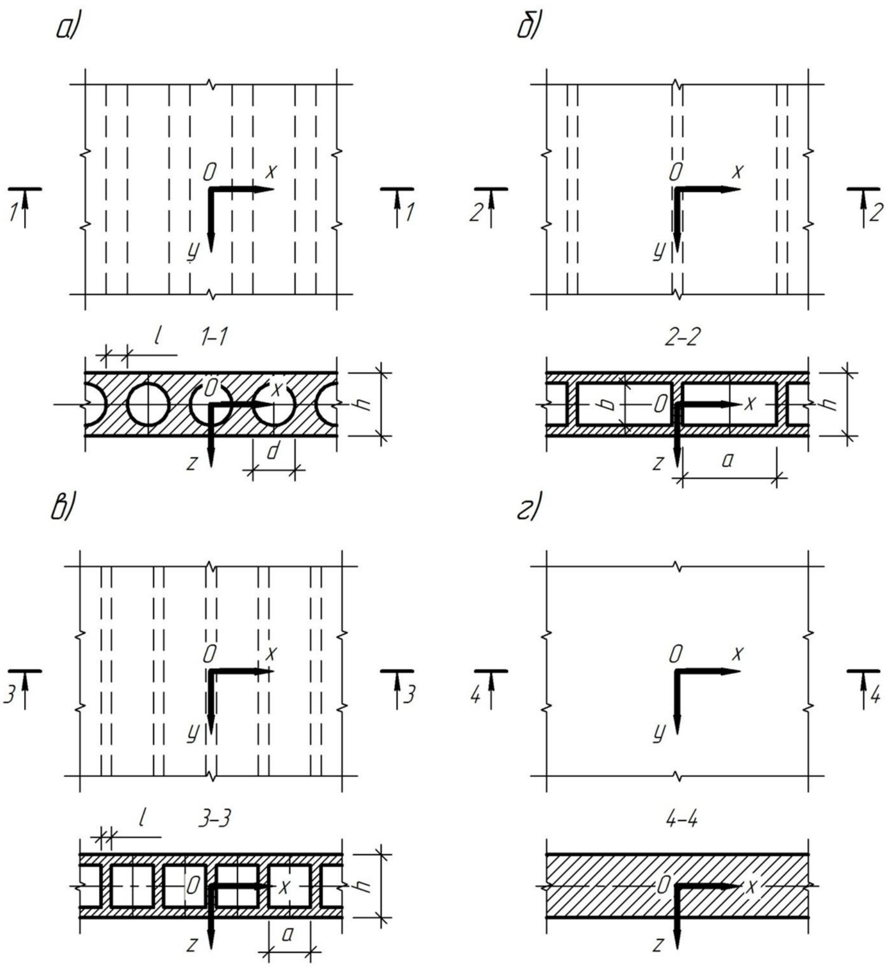

Fig.1. Actual (a, b, c) and calculated (d) Section monolithic slabs with tubular inserts

The equation of equilibrium structurally-orthotropic plate which simulate a concrete slab with tubular inserts (Figure 1, 2) are similar to the equations of the theory of solid plate, namely:

(10)

– the intensity of the external load in the direction*OZ;* – bending momentand – twisting moment; – effort that cuts.

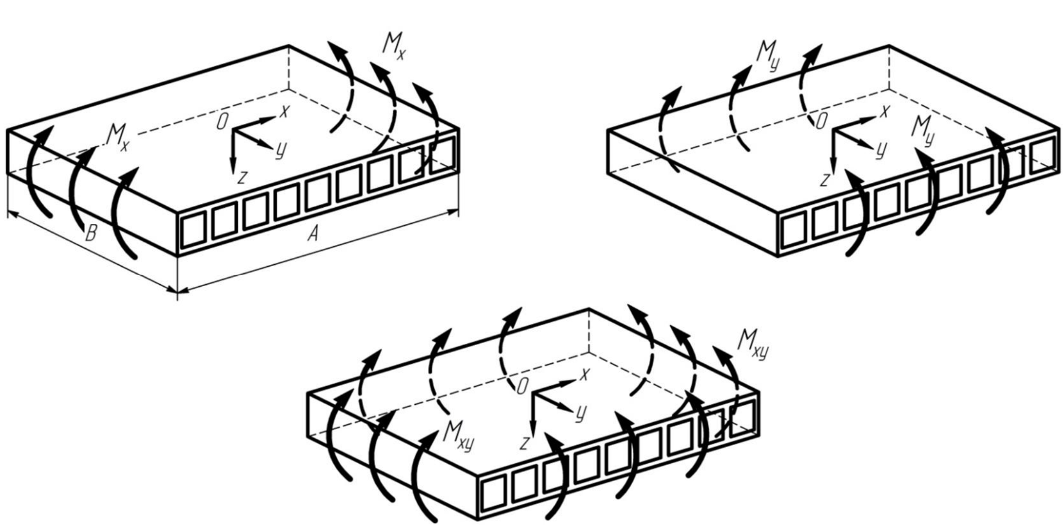

Fig. 2. Calculation of overlap with tubular inserts

Strain components of the middle surface of the plate $\chi_{11}, \chi_{22}, \tau$expressed in terms of the deflection w as follows [5]:

$$\chi_x = -\frac{\partial^2 w}{\partial x^2};\ \chi_y = -\frac{\partial^2 w}{\partial y^2};\ \chi_\tau = -\frac{\partial^2 w}{\partial x \partial y}. \qquad (11)$$

The equation of state that connecting pointsM_x, M_y, M_{xy} та M_{yx}curvature of the middle surface χ_x, χ_y, χ_τ structurally orthotropic plate record in the same form of the equations of the theory of bending of solid plates[5]:

$$\left.\begin{array}{c} M_x(x,y) = D_x^*\chi_x(x,y) + D'^*_y\chi_y(x,y);\ M_y(x,y) = D_y^*\chi_y(x,y) + D'^*_x\chi_x(x,y); \\ M_{xy}(x,y) = 2D_{xy}^*\chi_\tau(x,y); M_{yx}(x,y) = -2D_{yx}^*\chi_\tau(x,y). \end{array}\right\} \qquad (12)$$

$D_x^*, D_y^*, D'^*_x, D'^*_y, D_{xy}^*, D'^*_{yx}$ – transitional cylindrical stiffness in bending and in torsion in the appropriate directions. They can be written as:

$$\left.\begin{array}{c} D_x^* = c_x\frac{Eh^3}{12(1-\nu^2)};\ D_y^* = c_y\frac{Eh^3}{12(1-\nu^2)}; \\ D'^*_x = \nu c'_x\frac{Eh^3}{12(1-\nu^2)};\ D'^*_y = \nu c'_y\frac{Eh^3}{12(1-\nu^2)}; \\ D_{xy}^* = c_{xy}\frac{Gh^3}{12};\ D'^*_{yx} = c_{yx}\frac{Gh^3}{12}, \end{array}\right\} \qquad (13)$$

h – thickness of overlap; c_x, c_y, c'_x, c'_y, c_{xy} та c_{yx}– functions that depend on the structural features of concrete overlaps (effective geometrical sizes of tube insertion and mechanical parameters of concrete and rebar etc.). The significance of these features characterize the cylindrical stiffness reduction compared with the same values for a concrete slab with a solid wall of thickness h and can be determined by the results of theoretical and/or experimental studies.

In this case can be used approach that designed to calculate polyethylene pipes with hollow wall structure [10].

Conclusions

Almost all the calculation methods of monolithic reinforced concrete beams based on the theory of thin elastic plate calculation.

To calculate the static monolithic reinforced concrete hollow ceilings in example of ceilings with tubular inserts of different forms proposed general approach to the method using transient stiffness. It is necessary to hold further experimental and theoretical studies for their determinationin view of other influencing factors (cracking, creep of concrete etc.).

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I. M. Petrushka, A.V. Pashuk, O. D. Tarasovych
Lviv Polytechnic National University,
Department of ecological safety and nature protection activity

PURIFICATION OF SEWAGE FROM SALTS OF HEAVY METALS BY NATURAL ZEOLITE

It is investigated prospect of using of natural zeolite for purification of sewages from salts of heavy metals. It is well-proven that maintenance of heavy metals in purified sewage reply requirements of SNIP for drinking-water in Ukraine.

Key words: a zeolite, adsorption, sewage, heavy metals.

Досліджено перспективність використання природного цеоліту для очищення стічних вод від солей важких металів. Доведено, що вміст важких металів у очищеній стічній воді відповідає вимогам СНиП на питну воду в Україні.

Ключові слова: цеоліт, адсорбція, стічні води, важкі метали.

Raising of problem

Every year volumes of polluted natural water and sewage grows as a result of anthropogenic influence and need to search a new safe methods of their purification. Principal polluters of environment are heavy metals: iron, copper, molybdenum, cobalt, manganese, nickel, cadmium, lead, zinc, chrome etc. Most of them belong to the so-called oligoelements - chemical elements which are in alive creatures in low concentrations (thousandth particles of percent and below). These elements, as vitamins, are necessary for a human organism for its normal functioning. A lack of oligoelements in organism, especially of heavy metals, causes different diseases.

During process of evolutional development alive organisms produce the special mechanisms for the accumulation of heavy metals, as there were not enough of them in environment. When people began intensively pollute an environment, peculiarity to «accumulate» entailed the surplus piling up of heavy metals in human organism. The same «accumulate» peculiarity of human organism blockade taking out of surplus of heavy metals from him [1].

Heavy metals belongs to the priority polluters, looking after which is obligatory in all environments. A term “heavy metals”, that characterizes the wide group of polluters, during last time is wide used. As a criteria of belonging are used a lot of characteristics: atomic mass, density, toxicness, prevalence in natural environment, degree of involve in natural and technogenic cycles. In works, dedicated problems of natural environment pollution and ecological monitoring, nowadays to the heavy metals belongs more than 40 metals of the periodic system with atomic mass over 50 atomic units. According to N. Reymers’s classification to heavy belongs metals with density more than 8 g/sm^3. Thus, to heavy metals belongs Pb , Cu, Zn, Ni, Cd, Co, Sb, Sn, Bi, Hg.