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A.V. Mazurak, I.V. Kovalyk, V.O. Mehaylechko, M.V. Sadovyi, P. Ambroziak
Lviv National Agrarian University,
Department of building technologies and industrial engineering

BEARING CAPACITY OF STRENGTHENED REINFORCED CONCRETE BEAMS

The article is focused on the methods of calculating bearing capacity of reinforced concrete strengthened in different ways. It examines calculation data on the bearing capacity of the reinforced concrete beams.

Key words: bearing , strengthening of beams, air-placed concrete.

Розглянуто методи розрахунку несучої здатності залізобетонних конструкцій за зміцнення різними способами, результати розрахунку несучої здатності залізобетонних балок.

Ключові слова: міцність, зміцнення балок, торкрет-бетон.

Introduction

Mass application of concrete and reinforced concrete in all spheres of building business resulted in damaging structures caused by time wear and some external factors. This phenomenon is rather spread. The process of damaging often starts with the partial ruin of structures through concrete carbonation, scaling of concrete layer of the body of structure, partial or full corrosion of reinforcement which, finally, finish with the complete loss of bearing capacity.

Operations on strengthening building structures are needed not only in restoration and reconstruction, but also when the loading projects are subjected to some alterations caused by some changes in normative documentation which are not foreseen earlier. A big number of structures with different construction schemes need different ways of strengthening. Effective methods of strengthening structures is a very important problem which is actively discussed by scholars and widely used in building business technologies [1-6].

Strengthening of bearing capacities of reinforced concrete elements without any alteration in construction schemes is fulfilled by means of the cross section of the strengthening element by the additional layer of concrete, air-placed concrete with the additional reinforcement by means of reinforced rods or metal frameworks.

Last publications. The problem of strengthening reinforced concrete structures are discussed in the scientific works of Ye. M. Babych, A. Ya. Barashykov, Z. Ya. Blikharskyi, S. V. Bondarenko, O. I. Valovoy, H. V. Hetun, O. B. Holyshev, O. Yu. Yeryomenko, Ye. F. Lysenko, H. A. Molodchenko, L. A. Murashko, Yo. L. Novatorskyi, R. S. Sanzharovskyi, H. N. Haidukov, O. L. Shahin and others [1-5]. Their positions were used in developing constructive decisions on strengthening reinforced concrete structures and various methods of calculations.

Objectives of research. The research is focused on the calculation of the bearing capacities of standard sections of reinforced concrete beams and on comparing experimental values of bearing capacities of strengthened reinforced concrete beams which have been strengthened on various levels of loading with theoretical values received from the suggested later calculation methods on the example of deformation patterns.

Discussions. The suggested methods were based upon the positions of valid normatives [7;8] and the corresponding algorithm presented on Fig. 1. Theoretic calculation of a diagram of concrete and reinforcement deformation got the formula added by real values of experimental patterns and strengthened section of beam made of steel reinforcement and concrete.

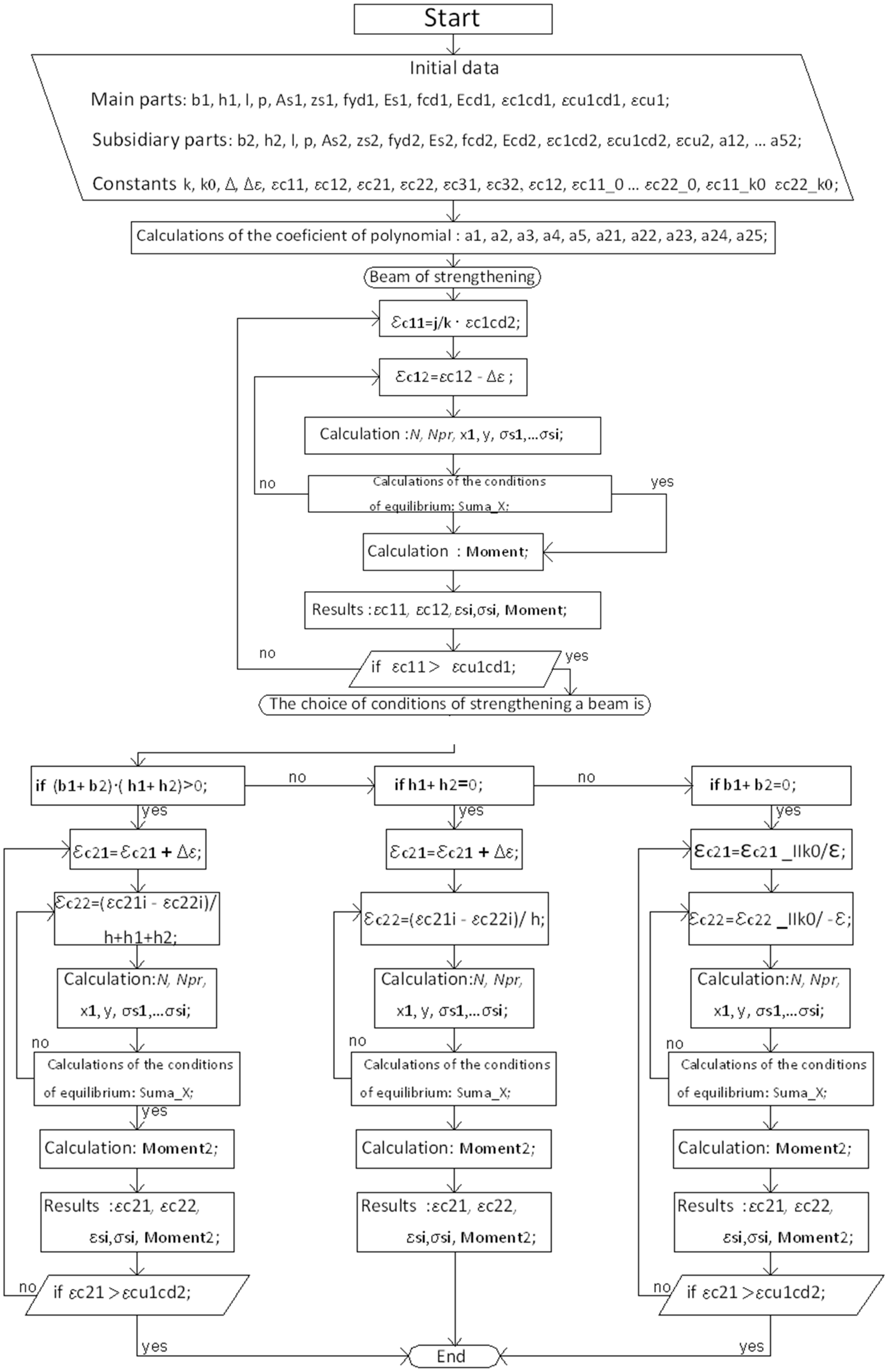


Fig.1 Block scheme of making calculations of reinforced concrete beams (See also Fig 2,3,4)

The suggested methods evaluate the stressed deformation state of strengthened reinforced concrete beams where the basic criterion is a common work of the former and the strengthened parts (without any shift) and a common curvature from the moment of strengthening. The general form of equation for determining the bearing capacity of strengthened beams presented at Fig. 1-4 is written in the following way:

- for the main part of a beam

$$\mathbf{M}_1 := \frac{b \cdot f_{cd_1}}{N_{pr}^{\,2}} \cdot \int_0^{y_1} \sum_{i=1}^{5} a_{1+i} \cdot y^{i+1} \, dy + \sum_{i=1}^{3} \sigma_{s_{1+i}} \cdot A_{s_{1+i}} \cdot \left(x_1 - z_{s_{1+i}}\right); \tag{1}$$

- for the strengthened part of a beam

$$\mathbf{M}_2 := \frac{b_1 \cdot f_{cd_2}}{N_{pr}^{\,2}} \cdot \int_0^{y_2} \sum_{i=1}^{5} a_{2+i} \cdot y^{i+1} \, dy + \frac{b_2 \cdot f_{cd_2}}{N_{pr}^{\,2}} \cdot \int_0^{y_2} \sum_{i=1}^{5} a_{2+i} \cdot y^{i+1} \, dy + \frac{b \cdot f_{cd_2}}{N_{pr}^{\,2}} \cdot \int_{y_2}^{y_2} \sum_{i=1}^{5} a_{2+i}$$

$$\cdot y^{i+1} \, dy + \sum_{i=1}^{3} \sigma_{s_{2+i}} \cdot A_{s_{2+i}} \cdot \left(x_2 - z_{s_{2+i}}\right); \tag{2}$$

We get the total value of the moment by the two values of the main and strengthened parts of a beam which we have received from the previous equations:

$$M = M_1 + M_2 \tag{3}$$

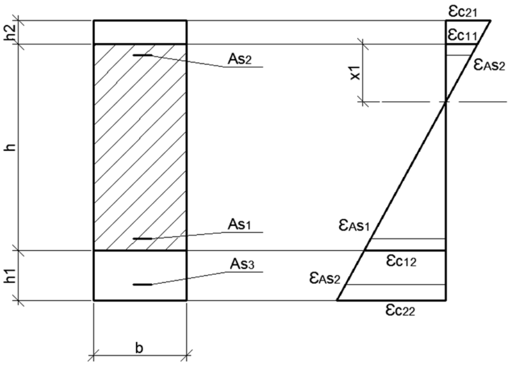


Fig. 2. Scheme of the stressed deformation state of a rectangular section at strengthening by growing horizontal faces.

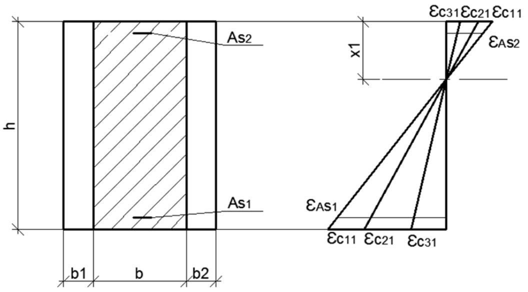


Fig. 3. Scheme of the stressed deformation state of a rectangular experimental patterns of section at strengthening by growing vertical faces.

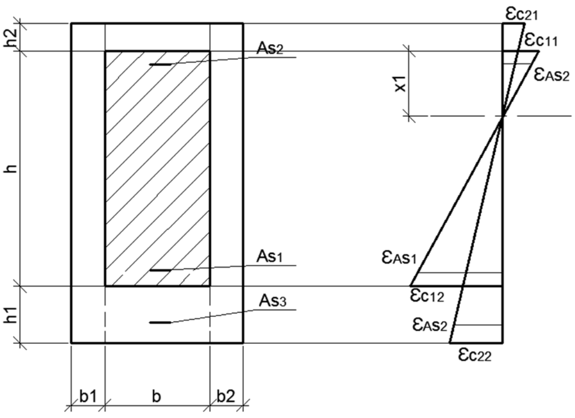


Fig. 4. Scheme of stressed deformation

Tests and results

Experimental materials comprise four experimental beams with parameters (Lxhxb) 2300x200x80(120). The experimental beams are made of the reinforced concrete (*f_{cd}*=25,5 MPa) by an ordinary technology and were subjected to the strengthened growing on the side surface by the 40 mm layer of concrete with metal frames. The beams strengthened on two levels of loading: 0; end 0,1-0,15 of the moment. All elements of the strengthening on the beam surface have start reinforcement rods (anchors) in pressed and stretched zones. The class of airplaced concrete strengthening for beams (B-1,… B-4) - f_{cd}= 31,0 MPa.

Having received the results of experimental testing and compared them with the suggest calculations (see table 1)we arrived at the conclusion that theoretic and experimental values coinside, maximal difference in the beams reaches 2-13%. The checking of the value calculations and experiments confirmed the reliable coincidence results.

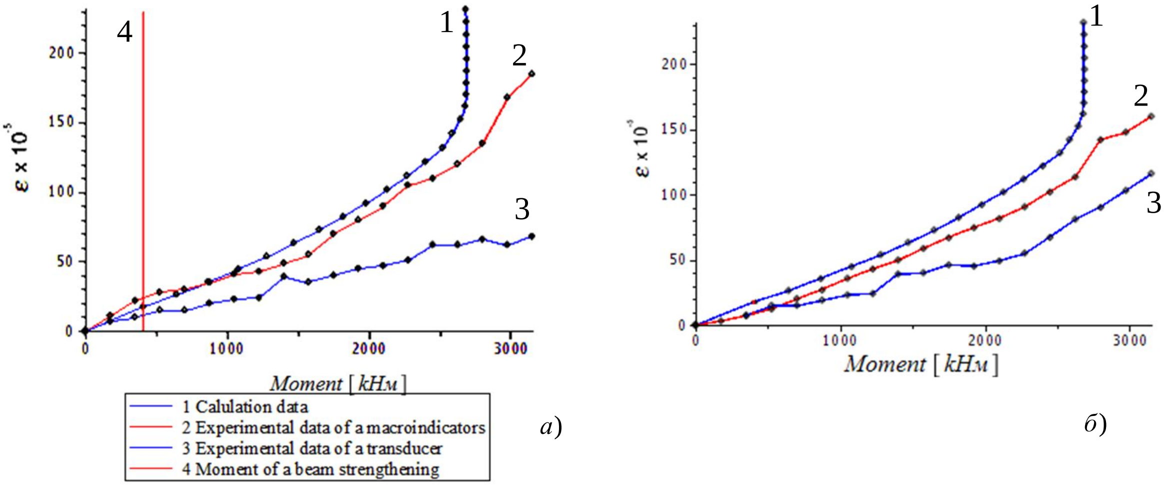
Table 1

Bearing capacity of the strengthened reinforced concrete beams

№	The beams code	Load level	Geometrical parameters (strengthening) b xh, mm	Value of the curving moments, M, *кН m*		$\frac{M_{и}^{експ}}{M_{и}^{ДБН}}$
				calculation by the *DBN*	experiments (limiting)	
1	B-1	0,1-0,15	80x205 (130x205)	26,64	30,15	1,131
2	B-2	0	85x200 (125x200)	26,02	29,155	1,120
3	B-3	0,1-0,15	97x196 (140x196)	27,28	29,92	1,096
4	B-4	0	85x199 (135x199)	26,63	27,274	1,024

Deformation dependence on the loading for beams B – 1, 2, 3, 4 on the hight of section have the form of analogous results suggestered on Fig 5, 6, 7. The given research used the results of the beam B-1.

The graphs of deformation dependence upon the loading within the beam B-1 on the hight of section are presented on the Fig 5, 6, 7 and illustrate the division of distribution deformation on the hight of a section (h=2060 for reinforcement 175 mm). The data of graphical dependence state that different section (h=20 and h=60) have different theoretic and calculation values, e.g. at exploitation level of loading of 0,7 M at section h=20 mm at the main part of a beam the difference is 10-26 % (at the strengthened part it is 10-20 %). At the section of h=60 mm approximate to the neutral axis, the difference at two part of a beam is 2-4 %. Graphs of the reinforcement deformation at h=175 mm illustrate the difference of parameters in the main part of a beam 10-15 % and the strengthened part 40-85 %. Such a difference of calculation and experimental values of the main and strengthened part of a beam, as we consume, is caused by the late including of the strengthened part of reinforcement into the operation.



а)

б)

Fig 5. Graph of deformation dependence upon the loading on the beam B-1 within the distance (h=20mm): a) the main part of the beam; b) the strengthened part of a beam.

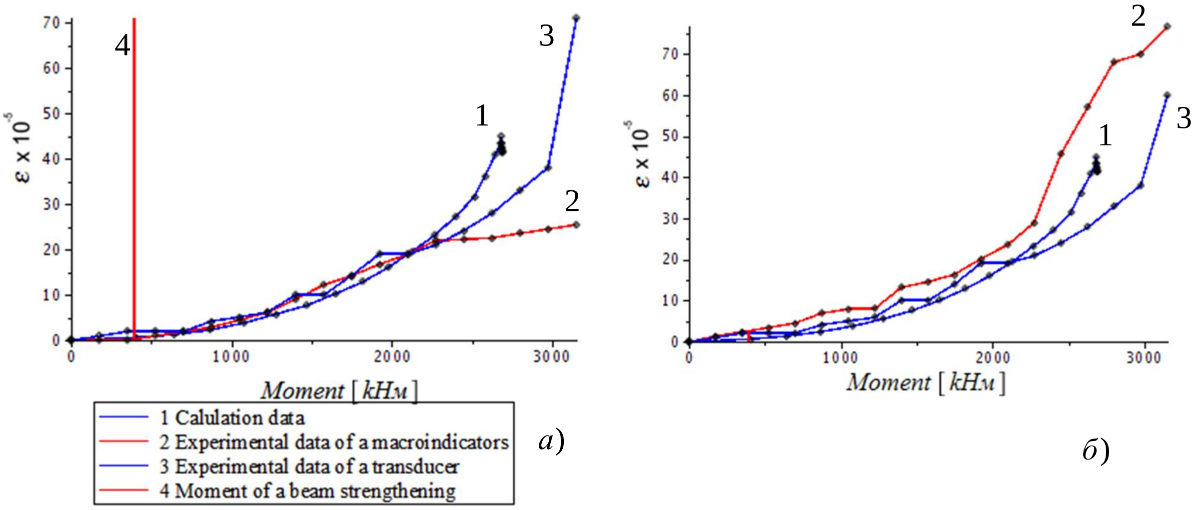


Fig 5. Graph of deformation dependence upon the loading on the beam B-1 within the distance (h=60mm): a) the main part of the beam; b) the strengthened part of a beam.

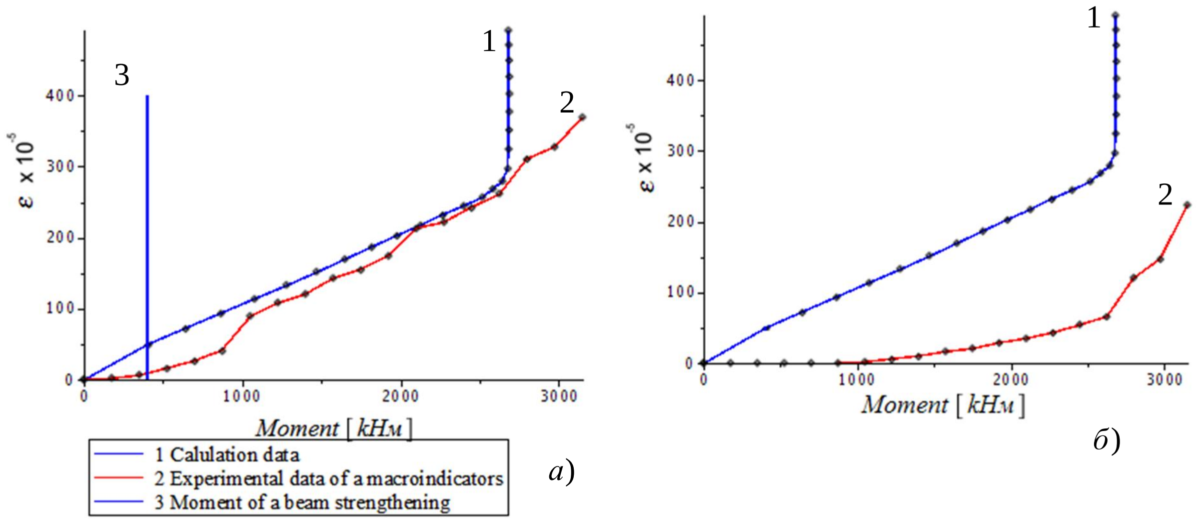


Fig 7. Graph of the reinforcement dependence upon the loading on the beam B-1 within the distance (h=175 mm): a) the main part of the beam; b) the strengthened part of a beam.

Conclusions

Analysis of experimental and theoretic research states that according to the valid normative on the bearing capacities of standard sections of strengthened reinforced concrete beams, methods of calculations are presented by the corresponding algorithms and give the satisfactory results. The deflections is 15 %. Nevertheless on the hight of section the values of experimental and calculation deformations result in more significant difference (10-26 %), in particular, the reinforcement of the strengthened part (40-80 %). Therefore, the further research needs the enlargement of the number of sections for their comparison and considering the wider diapason of the level of strengthening.

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O. Mazurak, A. Mazurak[1], U. Marushchak, O. Pozniak[2]
[1] Lviv National Agrarian University [1],
[2] Lviv Polytechnic National University[2]

USING OF SILICATE MATERIALS FOR SEWAGE SORPTION TREATMENT FROM HEAVY METALS

The article presents the research results of using different types of silicate minerals, their modified forms for sewage sorption treatment. Their physical and chemical properties, the mechanisms of action and sorption efficiency of the widespread natural minerals are characterized in this paper.

Key words: silicate minerals, sorption, zeolites, mica, vermiculite, clays, heavy metals, isotopes, sewage.

Подано результати досліджень використання різних типів силікатних мінералів, їх модифікованих форм для сорбційного очищення стоків. Охарактеризовано їх фізико-хімічні властивості, механізми дії та ефективність сорбції найпоширеніших мінералів.

Ключові слова: силікатні мінерали, сорбція, цеоліти, слюди, вермикуліт, глини, важкі метали, ізотопи, стічні води.

Introduction

Sorption method is the most promising method among the known effective and inexpensive reagentless methods of sewage treatment according to the relevant quality standards. However, it is true assumption that a prolonged adsorbent functioning as the water purifier and the possibility of its regeneration must be carried out directly in the filtering structures.

Effective base for obtaining adsorbents with high surface activity of grains and purposefully adjustable properties is the natural alumosilicate minerals as well as the artificially obtained (or modified natural) ones, becauseit is possible to incorporate into their structure any additives of the organic and mineral origin. These additives will provide the grain surface with the required properties.

Ukraine has many deposits of silicate materials. But not all the deposits virtually have minerals with relevant sorption characteristics. However, even this potential is used only for a quarter. Among the natural silicate minerals and sorbents there are clay materials (montmorillonite, saponite, natronite, sokolite and other clayssuchas bentonite, kaolin, palygorskite, palygorskite-morilonite); mica materials (hydromica,