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USING TEST LOAD FOR ASSESSMENT OF REINFORCED CONCRETE BENDING STRUCTURES STRENGTH

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Problem statement. Particular attention during diagnostics is given to assessment of structures strength. The structural strength is determined by non-destructive methods and techniques with partial or the complete destruction of the structure [2, 3].

There is generally accepted method for determining the strength of reinforced concrete structures by the static proof load test the selected structure is mounted on the testing stand and loading starts. A disadvantage of this method is that during control tests reinforced concrete structure is brought to exhaustion of bearing capacity.

Therefore, improving of methods for determining the strength of structural components without destroying them is an actual technical problem.

Purpose of the study is to improve the method of determining the strength of reinforced concrete bending structures by test load, to achieve the possibility of determining the strength without destroying them during the test.

General statements. According to the proposed method of determining the strength of reinforced concrete bending structures by test load, during the test reinforced concrete bending construction do not lead to the destruction, determination of its strength conducted by comparing the value and nature of the stress-strain state indicators at the time of the test load with the control values and further approximation.

Generally, the nature of the reinforced concrete bending constructions deformation described by the dependencies shown fig. 1:

– the dependence 1 for lightly reinforced concrete bending constructions (typical is the destruction of the reinforcement at tensioned area);

– the dependence 2 for heavily reinforced concrete bending constructions (typical is the destruction at concrete compressed zone);

– the dependence 3 for reinforced concrete bending constructions, that occupy an intermediate position, i.e. which are characterized by the destruction at the same time by the reinforcement at tensioned area and concrete compressed zone.

Indicators of the stress-strain state of the bent reinforced concrete structure are relative reinforcement deformation (ε_s) and the value of bending moment (M), that match certain indicators of deformations (fiber deformation (ε_f), curvature ($\frac{1}{r}$), deflection (f)).

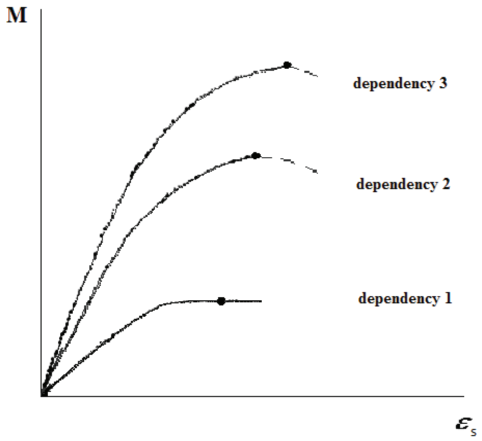

Fig. 1. Nature of the reinforced concrete bending constructions deformation

Control chart of stress-strain state indicators contains a graph, which corresponds to the mean strength of the structure (fig. 2, graph 3), and the graphs corresponding to the smallest and the largest deviation from the mean value of strength (fig. 2, graphs 2 and 4).

Strength of the structure and values of stress-strain state indicators are determined taking into account the variability of the strength characteristics of materials and geometrical parameters of the structure. Laws of distribution of the materials and the geometric parameters and the strength of the structure functions obey the normal Gauss law.

a) b) c)

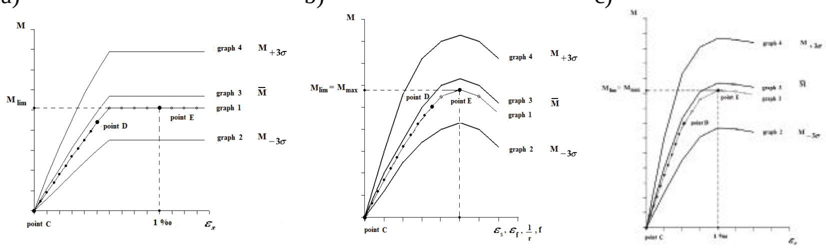

Fig. 2. Control chart of stress-strain state indicators for:
a) lightly reinforced concrete bending constructions; b) heavily reinforced concrete bending constructions; c) for reinforced concrete bending constructions that occupy an intermediate position

Values of the stress-strain state indicators corresponding the mean value (mathematical expectation) strength of the structure are determined on the basis of the deformation model in accordance with current regulations of the reinforced concrete structures calculation [1].

Values of the stress-strain states indicators corresponding the smallest and the largest deviation from the mean strength of the reinforced concrete structure are determined by the formulas:

$$M_{-3\sigma} = \overline{M}_j - 3\sigma_M ;$$

$$M_{+3\sigma} = \overline{M}_j + 3\sigma_M ,$$

where $\overline{M}_j$ – the mean value of structures strength at the point with j-th coordinate of the stress-strain state indicator;

$M_{-3\sigma}$ – functions value of the structures strength, which corresponds deviation to the smallest value from the mean at the corresponding point;

$M_{+3\sigma}$ – functions value of the structures strength, which corresponds deviation to the biggest value from the mean at the corresponding point;

σ_M – mean-square deviation of the structures strength function $M = f(x_1, x_2, ..., x_i, ... x_n)$.

The algorithm of the proposed method is presented in the flowcharts (fig. 3).

The test load is applied in stages. At each stage the load must not exceed 10 % of the calculated value of the limit load. After each stage pause is performed for at least 10 minutes before the next stage. The load on the final stage is the limit design value.

During the test load, at each stage data from detectors and deflectometer is fixed with the double-reading (at the beginning and end of the pause time). The received data is processed and in the appropriate scale is applied to the control chart.

Determination of the limit value of the strength of reinforced concrete bending structures ($\mathrm{M_{lim}}$) performed by approximation according to the following criteria (fig. 2):

– achievement in the tensioned reinforcement area limit value of the relative strain $\varepsilon_{su} = 0{,}01$ (for slightly reinforced concrete bending constructions);

– achieving maximum by the function of the equilibrium states ($\mathrm{M_{max}}$) (for heavily reinforced concrete bending constructions and reinforced concrete bending constructions, that occupy an intermediate position).

To test the proposed method, a series of laboratory experiments was conducted. Concrete class, reinforcement bars class, geometric parameters and reinforcement type for experimental samples were chosen so that the deformations nature, during samples loading satisfy the dependencies shown in fig. 1.

continuation flowcharts

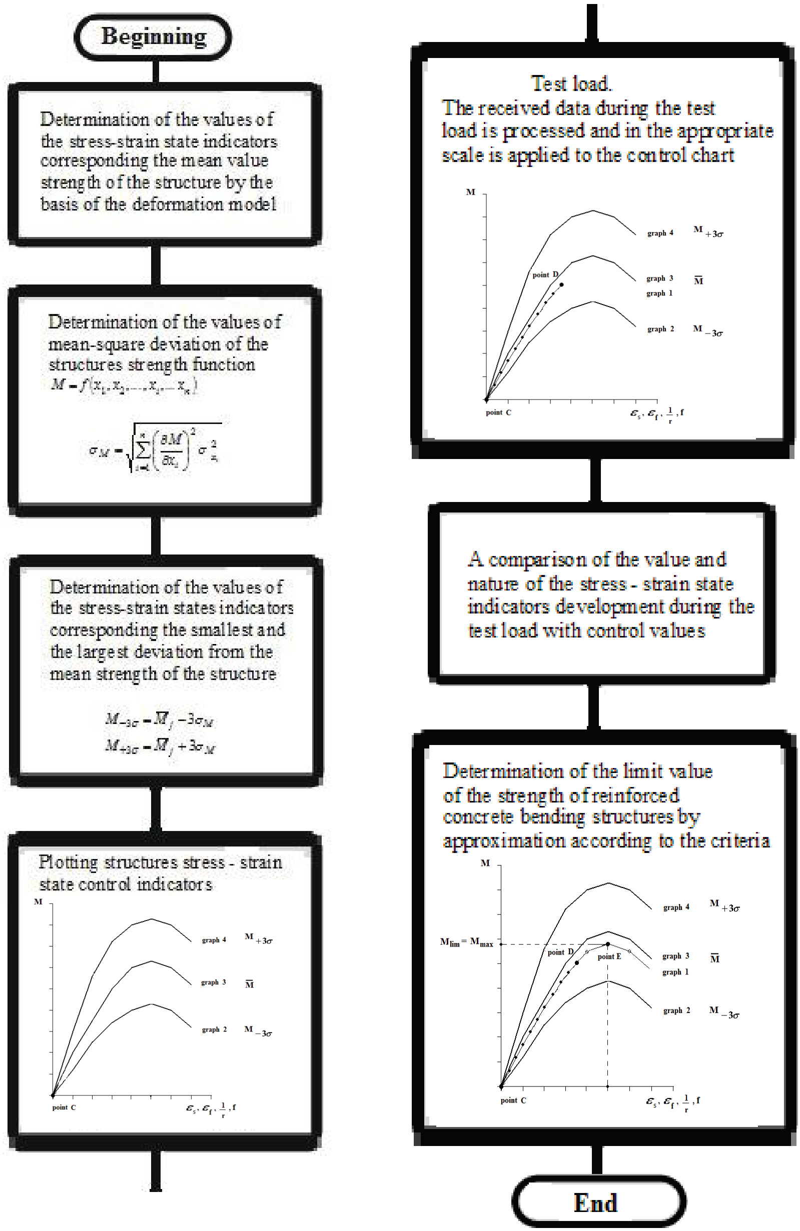

Fig. 3. The algorithm of the proposed method is implemented in the flowchart

As the experimental samples were used reinforced concrete rectangular in cross-section beams with dimensions 85 x 135 x 1400 mm made of heavy-weight concrete class C16/20. Longitudinal reinforcement was made of reinforcement bars A500C. As the transverse reinforcement were chosen reinforcement bars class Bp-I. In all 9 samples were prepared (fig. 4): 3 for each of the selected types of reinforcement (fig. 5). For the validation of the proposed method experimental samples were brought to destruction. Testing stand for experimental samples is shown in fig. 6.

Numerical modeling was implemented in a program complex "Mathcad".

Received theoretical and experimental data, indicate the possibility of using this method to determine the strength of reinforced concrete bending elements.

Fig. 4. General view of the experimental samples

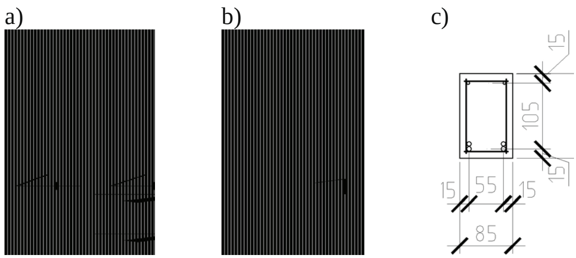

Fig. 5. Types of the experimental samples reinforcement:
a) type I – cross-section of the lightly reinforced sample; b) type II – cross-section of the sample that occupies an intermediate position; c) type III – cross-section of the heavily reinforced sample

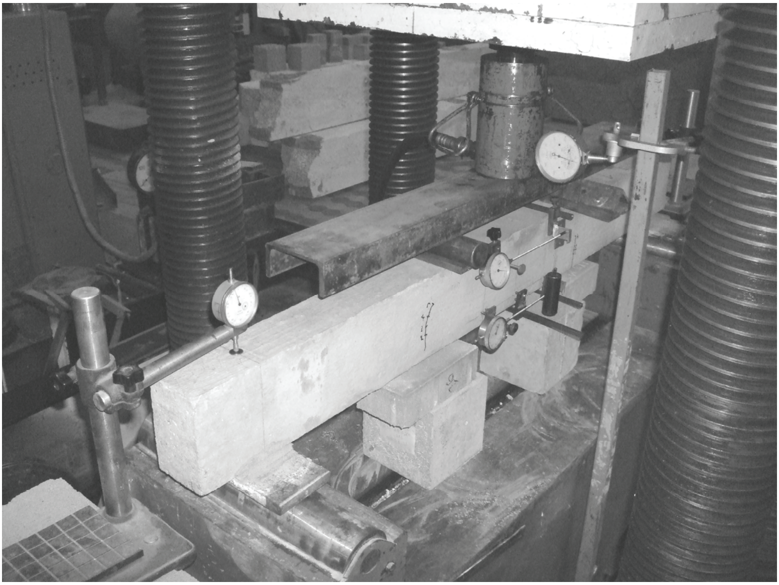

Fig. 6. Testing stand for experimental samples

Conclusions. Method for determination of reinforced concrete bending structures strength was proposed, which allows to define strength without destroying them during the test.

As a result of experimental studies sustainable relation load-deformation at all stages of the test load is confirmed.

Received theoretical and experimental data, indicate the possibility of using this method to determine the strength of reinforced concrete bending structures.

REFERENCES

1. ДБН В.2.6-98:2009. Конструкції будинків і споруд. Бетонні та залізобетонні конструкції. Основні положення проектування. – Офіц. вид. – К.: Мінрегіонбуд України, 2009. – 97 с.
2. ДСТУ Б В.2.6-7-95. Конструкції будинків і споруд. Вироби будівельні бетонні та залізобетонні збірні. Методи випробувань навантажуванням. Правила оцінки міцності, жорсткості та тріщиностійкості. – Офіц. вид. – К.: Укрархбудінформ, 1997. – 45 с.
3. Обследование и испытание сооружений / [Лужин О.В., Злочевский А.Б., Горбунов И.А., Волохов В.А.]. – М.: Стройиздат, 1987.– 263 с.