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ANALYSIS OF REINFORCED CONCRETE BEAM SECTIONS BASED ON DESIGN REINFORCED CONCRETE STRENGTH

The generalized deformation model for the calculation of reinforced concrete structures is presented, in which reinforced concrete is considered as composite material formed of reinforcement and concrete. On this basis, it is proposed to introduce new concept – the design strength of reinforced concrete – into the modern nonlinear theory of reinforced concrete. This allows us to reduce the structural analysis of reinforced concrete members to the methodology of calculations introduced in the classical 'strength of materials', which contributes to a significant simplification and acceleration of the design process of both single members and structures in general.

The main advantage of the structural analysis method with the use of the reinforced concrete strength concept is that it remains unchanged when changing the stress-strain diagrams of reinforcement and concrete, the introduction of new information about these materials properties, technological parameters, loads, etc. Only one parameter – the design strength of the reinforced concrete, which is synthesized for all of the above factors, is changed in the proposed analysis method. This approach to the structural analysis of reinforced concrete members makes it universal for all deformation types of reinforced concrete members.

The paper demonstrates and confirms the possibility of using the developed methodology not only in the bearing capacity calculations of reinforced concrete members, but also in calculations of the crack formation and in checking the crack width.

The first methods of flexural reinforced concrete members' strength determination were based on the method of structural analysis, which was proposed by Naiver in 1826. This method was used for members of elastic materials. The first mention of reinforced concrete occurs in the middle of the eighteenth century. At the same time, the method of structural analysis for reinforced concrete members began to be used only in 1887 – 1892. The main prerequisites of the method included the following: the validity of Hooke's law for materials and the hypothesis of plane sections, the cross-section was reduced to a conditional homogeneous, the ratio of elasticity modules was assumed constant [1]. The essence of the method was to determine the stresses σ_i in structures caused by the action of external loads and compare them with allowable stresses $[\sigma_i]$ for the structure material on the condition: $\sigma_i \leq [\sigma_i]$.

Problem statement. The purpose of this method is to simplify the structural analysis of reinforced concrete members by introducing the synthesized concept of the design reinforced concrete strength, taking into account the strength characteristics of concrete and reinforcement, the reinforcement ratio and the location of reinforcement in the cross-section.

Basic material and results. The following prerequisites for structural analysis are accepted [2]:

1) Concrete stress-strain diagram $\sigma_c = f(\varepsilon_c)$ is used in the form of nonlinear dependencies that conformed by generally accepted deformation criteria.

2) Reinforcing steel stress-strain diagram $\sigma_s = f(\varepsilon_s)$ is described by bi-linear Prandtl diagram with corresponding values of the limiting points.

3) Hypothesis of plane cross sections is used.

4) The tensile strength of concrete is ignored.

As destruction criteria for nonlinear stress-strain diagrams of materials, the following are accepted:

1) The extremum is achieved by the function of the load-bearing capacity $dM_{Ed}/d\varepsilon_c=0$ within ε_{c1} ... ε_{cu} with simultaneous the tensile reinforcement yield.

2) The ultimate concrete compressive strains ε_{cu} and the yield strength of the tensile reinforcement in the absence of the extremum of the load-bearing capacity are achieved in the cross-section.

3) The extremum of the load-bearing capacity function $dM_{Ed} / d\varepsilon_c = 0$ is achieved within ε_{c1} ... ε_{cu} without reaching the yield strength of the reinforcement [3].

4) The ultimate concrete compressive strains ε_{cu} are achieved without achieving the yield strength of the tensile reinforcement and in the absence of an extremum in the function of bearing capacity within ε_{c1} ... ε_{cu}.

5) The tensile reinforcement strains reach ε_{ud}.

Conclusions. The strength characteristic of reinforced concrete is synthesized, which using substantially simplifies the practical method of structural analysis of flexural reinforced concrete members based on the deformation model. The proposed method gives the opportunity to teach it in the Strength of Materials base course for the calculation of reinforced concrete members.

References

1. Design of concrete structures. Eurocode 2: Part 1. General rules and rules for buildings. – prEN 1992-1 (October 2001). – 230 p.

2. Kochkarev D.V. Nonlinear resistance of reinforced concrete elements and structures to force: Monograph – D.V. Kochkarev. – Rivne: O. Zen, 2015. - 384 p.: Ill .: 139; table 48; bibliography: 326 - ISBN 978-617-601-125-5.

3. Pavlikov A.M. Nonlinear model of stress-strain state of biaxially loaded reinforced concrete elements in the critical stage: Monograph / A.M. Pavlikov. – Poltava: PoltNTU, 2007. - 259 p.