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Specifics of Assessing the Strength and Crack Resistance of Prestressed Elements Without Transverse Reinforcement Along Inclined Sections

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Annotation: A practical method for assessing the strength and moment of crack formation of prestressed bending elements without transverse reinforcement along inclined sections is substantiated in relation to improved standard racks for power transmission line supports with a voltage of 0.4-10 kV. The racks in question are produced using bench-type formless molding technology, which provides for their reinforcement only with longitudinal prestressed wire. The consumption of reinforcing steel for improved racks is 2.3 times less than for standard racks. A special feature of the proposed racks is operation without the formation of normal and inclined cracks. The standard calculation methodology represents the concept of calculating strength and crack resistance, which assumes the formation of cracks in bending elements - for the feasibility of calculations for crack opening and taking them into account when calculating the deformability of the element. The proposed method for assessing the strength and crack resistance of prestressed elements without transverse reinforcement along inclined sections, based on a normative representation, has a safe level of strength along inclined sections and the necessary potential for concrete resistance to the formation of inclined cracks.

Key words: prestressed reinforced concrete without transverse reinforcement; shear force absorbed by concrete; calculation method.

Introduction

The technology for manufacturing reinforced concrete structures using bench-type formless molding is a modern and developing technology in the CIS countries, including Uzbekistan. This technology allows projects to be developed individually for industrial construction, and the production of reinforced concrete structures to be repurposed in a short time in accordance with emerging needs.

Structures using bench formless molding technology are manufactured without: transverse reinforcement, mesh, reinforcement outlets, sling loops - this is due to the peculiarities of the construction technology.

It is most advisable to manufacture structures using bench formless molding technology that meet the following requirements:

- long products – beams, slabs, piles, etc.;

- the cross-sectional dimensions of the product must be the same along the entire length, since the forming machine moves forward along the stand.

Considering the features of bench-type formless molding, the production of prestressed support posts for high-voltage power lines is of interest.

Specialists [2] are engaged in research on the problem of improving standard racks [1] for supports of high-voltage lines (OHV) with a voltage of 0.4-10 kV for the implementation of their production by formless molding. A utility model patent was received for the design of an improved standard rack for overhead line supports [3]. In the proposed prestressed racks without transverse reinforcement for overhead line supports, the formation of normal and inclined cracks during operation, as well as during manufacturing, transportation and installation, is not allowed, which also increases their service life.

The racks for the overhead line supports work like cantilever beams and double longitudinal reinforcement is provided for its section (with prestressing wire rods), since the racks experience alternating moments along the height of the section during operation.

The crack resistance of a beam that does not have transverse reinforcement and is operated without the formation of cracks in concrete should be ensured mainly due to the resistance to tensile stresses of only one concrete along normal and inclined sections. For the formation of cracks in a prestressed beam, it is necessary to suppress the compression stresses of concrete with prestressing reinforcement and overcome the resistance of concrete by tensile stresses. In this case, it is necessary to use the calculated tensile strength of concrete R_{bt}, which corresponds to the calculation for the first group of limit states (according to safety requirements) of SP [4], i.e. the calculation of the proposed racks for overhead line supports for the formation of cracks along normal and inclined sections becomes decisive.

SP [4] recommend the concept of calculating the strength and crack resistance of bending elements, which proposes the formation of cracks - to establish the feasibility of calculating crack opening and taking them into account when calculating deformations, which causes difficulties in the design of reinforced concrete structures.

The goal is to propose a practical methodology for assessing the moment of crack formation and load-bearing capacity along inclined sections of prestressed bending elements without transverse reinforcement, for the design of racks for power line supports produced by formless molding.

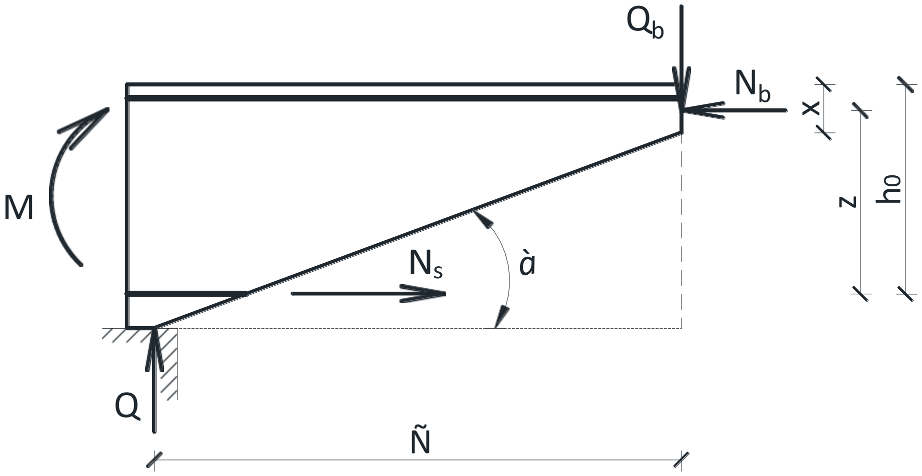
Based on the principle of the normative methodology, the strength along inclined sections of bending elements without transverse reinforcement is guaranteed due to the resistance to transverse forces of only one concrete according to the condition

$$Q \leq Q_b. \quad (1)$$

The main parameters characterizing the lateral force Q_b are:

- concrete tensile strength R_{bt};
- section width "b" and working section height "h_0".

It should be said that the transverse force in the inclined section of a bending element without transverse reinforcement passing through the inclined crack (Q_{sb}) consists of the transverse force perceived by the concrete and the transverse force perceived by the longitudinal reinforcement crossing the inclined crack (Fig.). To date, no acceptable methods have been found for determining each of these components. In practical calculation methods, two elements of transverse force are distinguished: transverse force Q_b, perceived by concrete, and transverse force Q_{sw}, perceived by transverse reinforcement (if such reinforcement is present in the element).



Drawing. *Forces acting on a block of an element without transverse reinforcement, separated by a section passing through an inclined crack: Q_b is the transverse component of the force in the concrete of the compressed zone above the inclined crack;* N_b*-longitudinal component in concrete above an inclined crack;* N_s *is the tensile force in the longitudinal reinforcement (at the intersection of the reinforcement and the inclined section); C is the length of the projection of the inclined section onto the longitudinal axis of the element;* α *— angle of inclination of the crack to the longitudinal axis of the element*

Thus, for prestressed elements without transverse reinforcement, the transverse force Q_b is determined by the formula

$$Q_b = \frac{1{,}5\varphi_n \cdot R_{bt} \cdot b \cdot {h_0}^2}{C} = \frac{M_b}{C}, \tag{2}$$

where the maximum value $Q_{(b,max)}$ and $Q_{(b,min)}$ are determined by the following formulas (depending on the length of the projection "C" of the inclined section)

$$Q_{b,max} = 2{,}5\varphi_n \cdot R_{bt} \cdot b \cdot h_0, \tag{3}$$

minimum value $Q_{b,min}$

$$Q_{b,min} = 0{,}5\varphi_n \cdot R_{bt} \cdot b \cdot h_0, \tag{4}$$

$$M_b = 1{,}5\varphi_n \cdot R_{bt} \cdot b \cdot {h_0}^2, \tag{5}$$

$$\varphi_n = 1 + 1{,}6\frac{P}{R_b \cdot A_1} - 1{,}16\left(\frac{P}{R_b \cdot A_1}\right)^2. \tag{6}$$

From an analysis of the standard methodology for calculating bending elements using inclined sections [5], it is noted that if there are normal cracks in the tensile zone of a bending element, then $Q_{b,min} = 0{,}5\varphi_n \cdot R_{bt} \cdot b \cdot h_0$ corresponds to the occurrence of inclined cracks.

The expression for determining the transverse force Q_{crc}, which corresponds to the formation of inclined cracks, is determined by the formula given in [6]

$$Q_{crc} = \frac{R_{bt} \cdot J_{red} \cdot b}{S_{red}} \sqrt{1 + \frac{P}{R_{bt} \cdot A_{red}}}. \tag{7}$$

where A_{red} is the reduced section of the element;

S_{red} is the static moment of the part of the reduced section located on one side of the axis passing through the center of gravity of the section (in the case under consideration, above this axis);

J_{red} is the moment of inertia of the reduced section.

The value of Q_{crc} is used in condition (1) only in the area where $M<M_{crc}$, then the moment of formation of normal cracks M_{crc} is determined by formula (80) SP [7], replacing the parameter $R_{(bt,ser)}$ with R_{bt}.

Testing the strength of a compressed concrete strip between inclined sections according to formula (64) SP [7] can be omitted due to the prevention of the formation of cracks in prestressed structures normal and inclined to the longitudinal axis of the element without transverse and non-prestressed longitudinal reinforcement. The considered method for assessing the strength and crack formation of prestressed elements without transverse reinforcement along inclined sections was tested using examples of calculations of the proposed racks for overhead line supports across the entire range of manufactured products.

The method under consideration can be used not only to assess the crack resistance and strength of the proposed racks for overhead line supports, but also for other prestressed structures without transverse reinforcement that work in bending.

This technique can be adapted to the use of modern calculation software systems, which makes it possible to perform analytical verification.

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