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Numerical Study of Short Reinforced Concrete Beams

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Abstract

The main objective of this study was to identify features stress-strain state of short reinforced concrete beams when changing the shear span a/h_0 from 0,5 to 1,5. Determined difference short beams from conventional beams on the nature of the stress distribution.

Keywords: short reinforced concrete beams, stress-strain state

Introduction

To obtain more information on the stress-strain state of short beams with shear span a/h0≤1,5 [1,2,3], has made numerical calculation of these constructions using finite element method by program "Lira". Objectives of the study was:
- to determine the short beams stress σ_x; σ_y; τ_{xy}; $\sigma_{гл.сж}$; $\sigma_{гл.р}$;
- to determine of stress fields and angles principal compressive and tensile stresses at the main change in shear span.

Research program was supposed to calculate short beams loaded one concentrated force, with shear span of the following values: 0,5; 1,0; 1,5.

Design scheme beams is the set of finite elements in the form of rectangular cells size 2,5×2,5 and width 25 sm. Due to the symmetry in the calculation was activated only half of the beam.

Action of the discarded part is replaced by horizontal connections. Both parts of the beam are working symmetrically about the line of action of the external force. The reference platforms simulated application of vertical links in the nodes of the support zone, and the load acting on the beam, was modeled by concentrated forces at the nodes of the upper middle of the finite element.

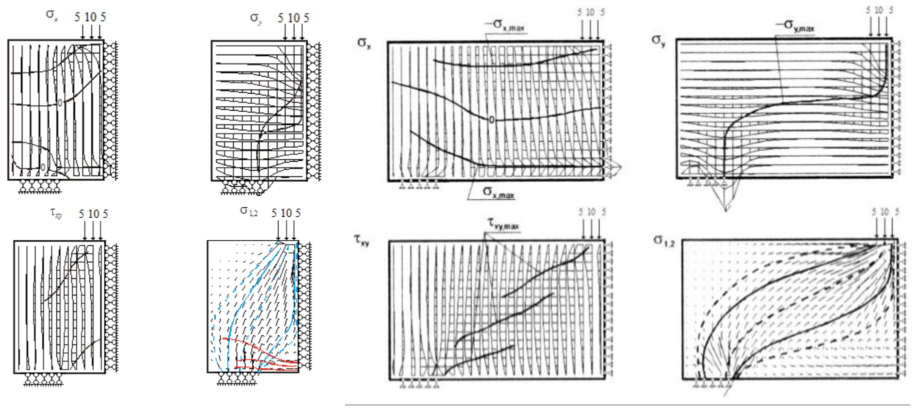
The results of calculation

Has made the calculation of short beams with shear span 0,5; 1,0; 1,5, determine the magnitude and nature of the distribution: normal stresses – σ_x; σ_y; shear stresses – τ_{xy} and principal stresses – σ_1; σ_2.

Review and analyze the results of the calculation for beams with the lowest (a/h_0=0,5) and highest (a/h_0=1,5) shear span (pic. 1).

A characteristic feature of the distribution of normal stresses σ_x (pic. 1) at change a/h_0 is that in the span share diagrams have different signs. The maximum compressive stress σ_x is located at the top of the beam, maximum tensile stress - at the bottom edge of the beam.

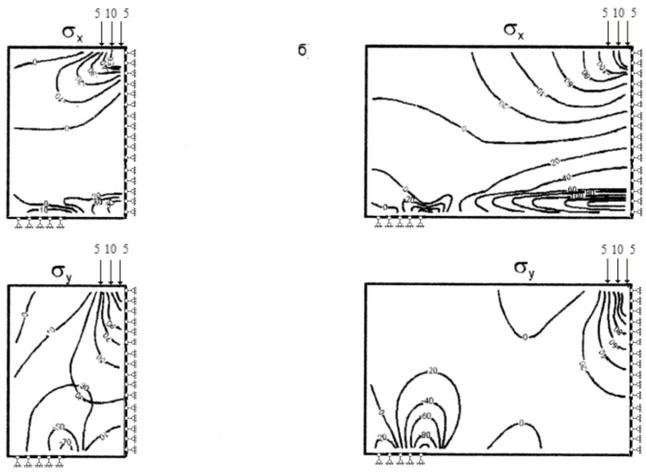
A characteristic feature of the distribution of normal stresses σ_y (pic. 1) beams is that the maximum stresses are located in a vertical section through the load. In this case with growing distance from the line of action of load the value of maximum stress is reduced, but the length of the diagrams σ_y in the direction of the axis OX increases.



Pic.1 Stress distribution in the beam with a/h_0=0,5, a/h_0=1,5

When the shear stress distribution (pic.1) characteristic is that the diagrams τ_{xy} cut in a span are maximum values in the vertical sections at the top, located near the center of the load transmission, and at the bottom in the cross sections located closer to the center of action of the reaction. Pictures 1 also show the character of the distribution of the major principal compressive and tensile stresses for beams with a/h_0=0,5 and a/h_0=1,5.

Analyzing the behavior of the distribution of normal stresses σ_x in beams with shear span of 0.5 and 1.5, special attention will be repositioning the zero line. In beams with shear span 0.5, there are three zero line, with the main line that runs approximately zero in the middle part of the beam and has parabolically increase (on X) character (pic. 1). In beams with a / h0 = 1,5, also there are several zero lines, the basic zero line is also located in the middle part of the beam, but has slight arcuate character (pic. 1). Having multiple lines of zero normal stress distribution σ_x (pic. 2) indicates a significant difference between usual beams and the short beams (with $a/h_0 \geq 3$). The distribution pattern of lines of equal stress σ_x (pic. 2) means the concentration tensile stresses at the level of tension reinforcement and indicates a uniform reduction in compressive stress σ_x in the direction of the line connecting the centers of the application loads.



Pic.2. The lines of equal stress σ_x , σ_y in the beam with:
а – a/h_0=0,5; б – a/h_0=1,5

A distinctive feature in the location of the maximum compressive stress σ_x in the beams a/h_0=0,5 and a/h_0=1,5 (pic. 1) is to change the trajectory of the line of maximum compressive stress $\sigma_{x\ max}$. In beams with a / h_0 = 0,5 line σx max is inclined and trajectory reduced σx max occurs at a distance from the line of force. In beams with a / h_0 = 0,5 line $\sigma_{x\ max}$ is inclined and reduce of the trajectory σx max occurs at a distance from the line of force. In beams with a / h_0 = 1,5 line compressive stress becomes less steep and almost parallel to the upper edge. In general, there is no fundamental differences in the distribution σx beams with a / h_0 = 0,5 and a / h_0 = 1,5.

Analysis of the distribution of normal stresses σ_y in beams with a/h_0=0,5 and с a/h_0=1,5 showed that the distribution of these stresses with increasing a/h_0 changes. Unified feature is the maximum stress concentration in the range of loads. However, beams with a/h_0=0,5 line of maximum stress are continuous and are arcuate in nature. In beams with a/h_0=1,5 line of maximum stress rupture in the middle of the beam. Along the lines of equal stress σ_y can judge the size of the zones of local action loads, as well as the mutual influence of these zones. In beams with a/h_0=0,5 zones of local action loads merge, level lines of the same stress is high. In beams with a/h_0=1,5 zones of local action efforts are removed by increasing a/h_0. This reduces the mutual influence of these zones and lines of maximum stress rupture. Analysis of the distribution of shear stresses in beams with a/h_0=0,5 and a/h_0=1,5 showed that the maximum values of these stresses are located in the shear span. With the increase of a/h_0 changing the nature of the stress distribution τ_{xy} in the middle of the span. Maximum line stresses held at the top and bottom of the beam are essentially forecasted trajectories of cracks in the concrete. A distinctive feature in the distribution $\tau_{xy\,\max}$, in beams with a/h_0 =1,5 is the appearance in the middle of beam another line $\tau_{xy\,\max}$.

Analysis of the main compressive and tensile stresses showed that the main compressive stresses are concentrated between the axes of action the external and reactive load. Concentration level of these stresses in beams with a/h_0=0,5 and a/h_0=1,5 is different. Compressive principal stresses trajectories with increasing a/h_0 have a smaller angle of inclination and different degrees of concentration. In this case, the width of the inclined portion, within which are concentrated main strains (stresses) line, decreases with increasing a/h_0. Main tensile stresses concentrated at the bottom face of the beam path with the maximum tensile stress in the beam is deflected in depth range of reactive forces.

Conclusions

Revealed the difference of short beams from conventional beams by the distribution of normal stresses σ_x. A distinctive feature of short beams is the existence of several zero lines σ_x, and the nature of their location. Revealed, also difference of short beams from conventional beams by the distribution of normal stresses σ_y. Found, that with increasing shear span from 0.5 to 1.5 decreases the mutual influence of local stresses areas by increasing spacings $\sigma_{y\,\max}$ lines.

Line of maximum shear stress $\tau_{xy\,\max}$, which, in fact, are the trajectories of inclined cracks in concrete short beams, fully in line with the classification of fractures, adopted earlier [2].

Revealed that in the short beams with a/h_0=1,5 as well as in short beams with a/h_0=0,5, major compressive stresses are concentrated in the inclined portions located between the places of application of external forces and reactive forces. Main tensile stresses are concentrated in the horizontal sections along the bottom edge of the beam.

Revealed the character of changing the position of the inclined portions within which concentrates main compressive stress with increasing shear span from 0.5 to 1.5. The distinctive feature of these bands is that an increase in shear span decreases angle principal compressive stress, as well as the width of the inclined portion, within which there is a concentration of compressive principal stresses.

Besides, increases the value of the principal compressive stress at the inner edge of the inclined portion.

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