УДК 692.231.3

STRENGTH AND CRACK RESISTANCE OF THREE-LAYER CONCRETE BEAMS

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Keywords: three-layer reinforced concrete beam, testing, durability, crack resistance.

Introduction. As the fuel resources are limited and non-reproducible and their production is complicated and expensive there is a need to save and reasonable use these resources.

Today, one of the main criteria for the quality of modern buildings is heat-ability of their external constructions. Thus the development of energy-efficient constructions which could maintain microclimate conditions with minimal energy consumption is a topical problem. One of the possible solutions is the application of lightweight concrete external structures with improved thermal insulation properties. Multi-layer reinforced concrete wall panels are related to this type of external structures. Some experimental studies of these wall panels are described in the works [1-5].

Objective. Presentation of the methodology and results of the experimental study of three-layer reinforced concrete beams with insulation layer of polystyrene concrete.

The main material. According to the technology [6] four series of beam specimens were produced (Fig. 1). The geometrical parameters of specimens are following: length of 250 cm; design span of 220 cm; height of 30 cm, width of 16 cm. The external layers of specimens are made of high-density concrete (thickness of 5 cm and 7 cm), and a middle layer is made of polystyrene concrete (thickness of 18 cm). The main and secondary reinforcements of specimens are made of wire reinforcement (class Bp-I and diameter of 4 mm).

1st and 2nd series of beam samples are designed such that destruction of specimen will occur in the middle of the span over the cross section normal to the longitudinal axis. The numbers of specimens are 2 units for first series and 3 units for second series. The difference between these series is in crossbars installation in the 1 series specimens.

The strength in the support areas and inclined to the longitudinal axis sections was studied on third and fourth series which both consist of three specimens. The samples of these series are identical. The varying parameter of this test was the shear span (the distance from the bearing to the load application point) which was: 283 mm (effective depth of section) and 425 mm (1.5 of effective depth of section).

Fig. 1. Test specimens of three-layer beams

Check samples for the determination of strength and deformation characteristics of concrete beams were made in the inventory metal forms. The results of their tests are shown in Table 1.

Table 1

Strength and deformation characteristics concrete for beam specimens

Series of specimens	High-density concrete, MPa				Polystyrene concrete, MPa			
	R_m	R_b	R_{bt}	$E_b{\cdot}10^{-3}$	R_m	R_b	R_{bt}	$E_b{\cdot}10^{-3}$
1,2	27,5	15,5	1.85	31,2	0,45	0,25	0,07	0,35
3,4	32,5	17,1	1.88	32,5	0,45	0,25	0,07	0,35

Strength and deformation characteristics of the reinforcement were determined by the tensile tests of samples which were picked out during the reinforcing cage manufacture (Table 2).

Table 2

Strength and deformation characteristics reinforcement for beam specimens

Series of specimens	Diameter (mm) and class	A_s, см^2	σ_y, МПа	σ_u, МПа	E_s,$\cdot10^3$МПа
1-4	ø4 Вр-I	0,132	473	572,5	176

The testing stand was assembled for the beam specimens test. The general view of testing stand is presented in Figure 2.

Fig. 2. General view of testing stand

Loading of beam specimens was carried out by stages equal to 1/10 of assumed failure load, with load endurance of 10 ... 15 min at every stage.

Side surfaces were whitewashed with lime before the test to facilitate visual observation of cracks initiation and distribution. The scheme of test equipment is shown in Figure 3.

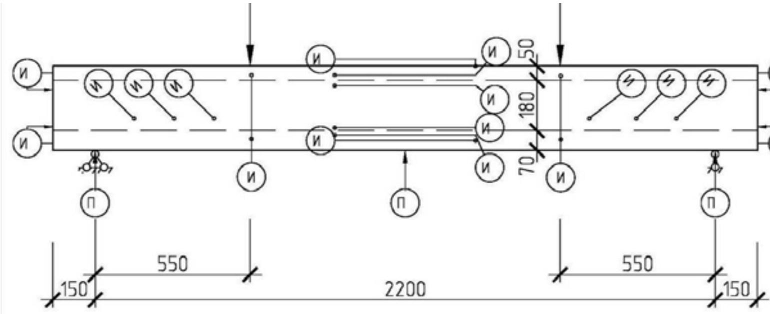

Fig. 3. The scheme of scheme of test equipment on the beam samples of the 1st and 2nd

To estimate the stress-strain state of three-layer beam specimens, deformations of the concrete were measured at each stage of loading in the middle of the span.

To determine the deformation in the direction of principal tensile and compressive stresses, the deformations of the middle concrete layer were measured in the support areas of beams by the indicators which were placed at the angle of 45 ° to the longitudinal axis of the beam.

The deflections of three-layer beams were measured by deflectometers of Maximov system. They were placed in the middle of the span and on the supports to exclude their settlement.

During the tests of beam specimens the loads of normal and inclined cracks initiation, failure loads and character of destruction were determined for specimens of all series (Fig. 4)

The bending moments of visible cracks initiation were fixed. Magnitude of the moment of cracking is the average value of moments for the cracks appearance stage and prior stage.

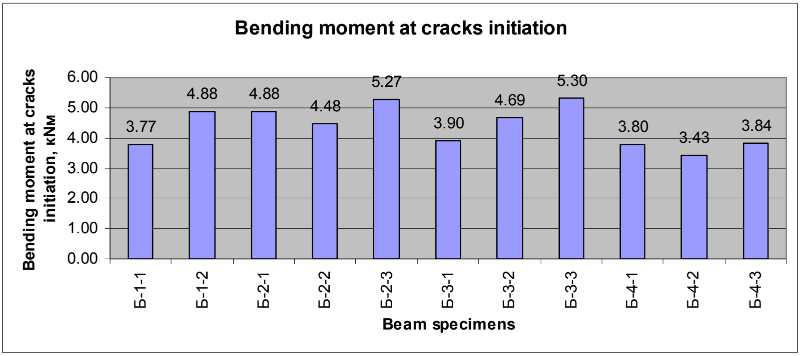

Fig. 4. Diagram of the bending moment at cracks initiation

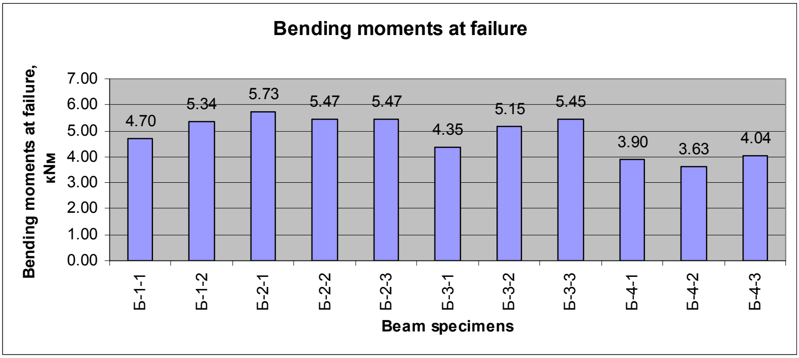

Fig. 5. Diagram of the bending moments at failure

For beam samples of 1-st and 2-nd series the differences of cracking moments does not exceed 19%, for beam samples of 3rd series - 16%. This fact may be explained mainly by concrete inhomogeneity and partly by the inaccuracy of measurements.

For beam specimens of the 4th series the values of the cracking moments differ insignificantly.

Conclusions. Test procedure for three-layer reinforced concrete beams with the middle layer of polystyrene concrete is formulated.

The values of cracking bending moments and the character of cracks distribuion and propagation were determined in the results of the experiments.

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