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DESTRUCTIVE MOMENTS STUDY OF CONCRETE BEAMS REINFORCED WITH ARMATURE CONNECTION

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Abstract. For reinforcement of prestressed concrete structures using reinforced thermo-hardened steel rebar standard length 12 m class A400, A500, A600, A800 with periodic profile. However, thermo-hardened steel rebar is essential for the production flaw – bad soldered, welded connection to that she did not meet the performance requirements for fittings in this class. Since adhesion to concrete reinforcement studied mainly experimental method because the results depend on many factors. This paper presents the design of prototypes, methods of testing and analysis of the strength of concrete beams reinforced with connected valves. Experimental research program provides four series test reinforced concrete beams crossing 120 × 220 mm length 2000 mm bend with two concentrated forces. Experimental beams were reinforced with welded frame constructions of armature 4 ∅ 8 A400 and working pre-stressed armature ∅ 12 A500C. Steel bars in reinforced concrete beams connected by crimp sleeves. To determine the characteristics of strength, deformation and crack-resisting of experimental beams they were tested for bending to destruction.

Key words: reinforced concrete beam, valves, crimp sleeves, durability, re-load

PROBLEM ANALYSIS AND PROBLEM STATEMENT

For reinforcement of pre-stressed reinforced concrete structures reinforcement bar thermo-mechanical of strengthened armature of standard length 12 m class A400C, A600, A800C with periodic profile are used. In domestic building from the fifties of the last century, for low-dimensional periodic reinforcement profile time-consuming and

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energy-welded butt or inlet joints were used. However, thermo-mechanical strengthened steel of armature Class A500, A600, A800 has a significant production fault: it is bad welded, i.e. its welded connections do not satisfy the operational requirements for armature of this class. That is why connected in such a way non-standard length rods can be used as reinforcement of class A400 with low estimated strength σ_s = 600 MPa. Taking this into consideration, engineers and scientists developed and implemented alternative ways to connect small-sized armature. The most common include connections with fine threaded and squeezing bushing [Luchko 1997, 2000, Luchko and Pentsak 2009].

Since armature adhesion to concrete is studied mainly with experimental method that is why the results depend on many factors: the properties of concrete and armature, satiation with armature, structure samples, climatic environment testing, and methods of testing. The distribution of displacements and stresses of redistribution efforts in the area between the concrete and armature, as well as influence on them deformations of the concrete shell analytically is investigated [Sprygin 1977, Holmyanskyi 1981, Vasil'ev et al. 1986]. As it is seen, the study of the connection armature in the beam elements, its influence on adhesion reinforcement with concrete remains relevant today.

Analysing the works of local and foreign scientists were defined goal of our research – experimental determination of bearing capacity of reinforced concrete beams reinforced with armature connected by squeezing bush.

PROBLEM

Analysis of the literature published in our country and abroad, showed:

- insufficiently investigated joints of reinforcing rods with squeezing bush or other mechanical connection methods, including adhesion between armature and concrete in the vicinity of squeezing bushes, depending on the diameter, length and profile of bush,
- not enough researched operation of reinforced concrete beams elements reinforcement with armature using squeezing bushes with small cyclic loadings. In particular, the influence of the reinforcement on the strength, deformation and crack-resisting of beams under repeated loads.

To solve these problems it is necessary to determine the method of testing, design of prototypes and the effect of additives on the properties of strength, crack-resisting and deformation of beam samples of connected armature.

THE CONSTRUCTION OF PROTOTYPES

The research program involves making two series of reinforced concrete beams that reinforcement with rods connected squeezed bush and without joints [Luchko et al. 2010].

In the stretched zone working unstressed and pre-stressed reinforcement rod of 12 mm diameter class A500C are used.

Before concreting beams the preloading of working armature connected by means of moulded bushings and no connection was carried.

To determine the physical and mechanical properties of reinforcement rod and armature connections with squeezing bush tests were conducted on the tensile machine TMC-50.

Experimental research program provides four series test reinforced concrete beams crossing 120 × 220 mm length 2000 mm bend with two concentrated forces. Experimental beams were reinforced with welded frame constructions of armature 4 ∅ 8 A400 and working pre-stressed armature ∅ 12 A500C.

The first series of beams 12 × 22 × 200 cm size is made of concrete class C12/15 reinforced structural frame of the armature Ø8 A400 and unstressed armature Ø12 A500C.

The second series of beams 12 × 22 × 200 cm size is made of concrete class C12/15 reinforced structural frame of the armature Ø8 A400 and pre-stressed armature Ø12 A500C.

The third series of beams 12 × 22 × 200 cm size is made of concrete class C20/25 reinforced structural frame of the armature Ø8 A400 and unstrained armature Ø12 A500C.

The fourth series of beams 12 × 22 × 200 cm size is made of concrete class C12/15 reinforced structural frame of the armature Ø8 A400 and pre-stressed armature Ø12 A500C.

Tentatively it was planned to produce beams with concrete class C12/15 and C20/25. To determine the characteristics of the concrete was made concrete cubes, prisms from the same batch of the concrete as beams.

Physical and mechanical properties of concrete on squeezing were determined by testing cubes with edge 100 mm and prisms 400 mm length with a cross section of 100 × 100 mm on the press P-100. Determination of physical and mechanical properties of concrete was performed according to State Standard B.2.7-214:2009 “Building Materials. Concrete. Methods for determination of strength for control samples”. The gained values confirmed that the concrete test specimens corresponds classes C12/15 and C20/25.

The research methodology of experimental beams

To determine the characteristics of strength, deformation and crack-resisting of experimental beams they were tested for bending to destruction.

Tests were carried out after 28 days from the date of concreting. Download of beams occurred by means of two concentrated forces applied to the upper edge in the third passage span (Fig. 1). The load was applied to the degrees $\Delta F = 0.05F_{max}$ to cracking and more $\Delta F = 0.1F_{max}$ with endurance after each stage 30 min: 10 min – before removing the instrument readings and 20 min – during removing the instrument readings. Application of concentrated forces occurred by means of a hydraulic jack of 200 kN and distribution cross-arm. Significance effort was determined by two ring dynamometers located on beams bearings. Besides the first dynamometer was a movable bearing and could move in a horizontal direction, and the second was immovable.

Beams deflections were measured by three indicators clock type with a scale division 0.01 mm. Indicators fastened on a special metal tube, which remained its axis in the deformation process of beam and served for the base line from which were counted deflections. Irremovable basis axis was provided by mounting point frame on the beam at the neutral axis of the bearings.

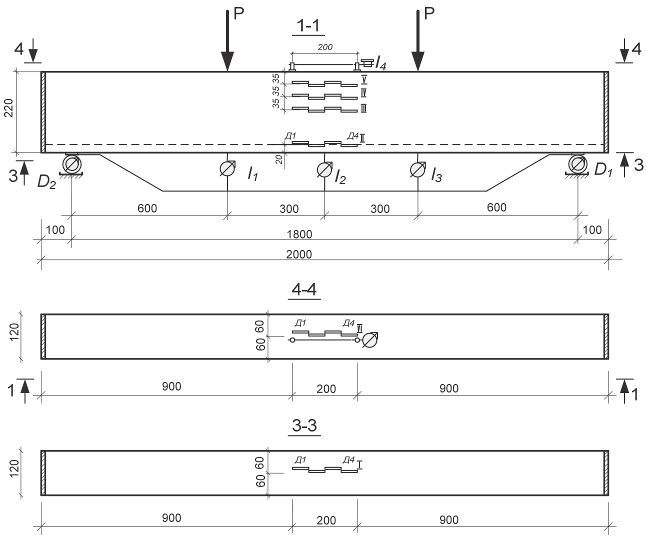


Fig. 1. Circuit tests of beams

This method of measuring deflections simplifies data processing, since the deformations of bearings do not affect indicators and as studies have shown the fault made in measuring is no more than 1%.

Stand for testing of beams on bending with static load is shown in Figure 2.

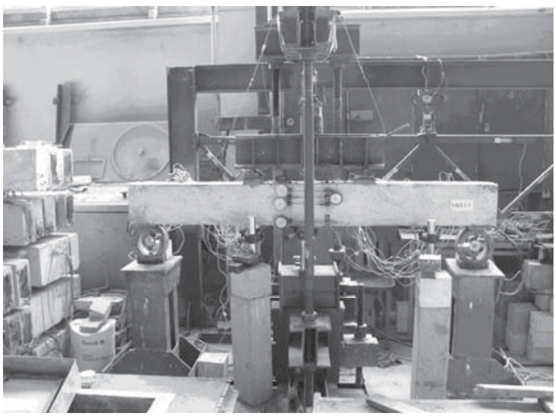


Fig. 2. General view of the stand for the test beam bending

At a height devices are located so as to cover all the key points: the upper edge of the beam (compression), side edge of the beam at a height of 20 mm from the top edge (compression) and at a height of 70 mm from the top edge (the neutral axis), at the center of gravity of internal steel armature (extension).

For measuring strains were used micro-indicators clock type with a scale division of 0.001 mm, fixed on special holders that were stuck on the prepared concrete surface.

RESULTS AND DISCUSSION

Research of reinforced concrete beams on the strength at bending

For determination of the structures deflected mode was carried out beams tests at bending to destruction. Comparison of experimental cross sections of beams of destroying moment with the theoretical, taking the actual values of the concrete and armature characteristics, obtained during the test are presented in Table 1.

Table 1. Destructive moments tested beams – experimental and defined by State Standard B.2.6 B-156: 2010 and Building regulations 2.03.01-84*

Code of beams	M_1 [KN·m]	M_2 [KN·m]	M_3 [KN·m]	M_4 [KN·m]
Concrete B15 (C12/15)				
Base beams				
1БЗ-1-1	11,52	10,94	11,05	10,59
1БЗ-1з-2	11,47	11,18	11,56	10,49
1БЗ-1-3	11,67	11,19	11,81	10,87
Pre-stressed beams				
1БН-1з-1	11,28	11,05	11,28	10,60
1БН-1з-2	11,53	11,16	11,77	10,71
1БН-1з-3	11,43	11,21	11,88	10,70
1БН-1з-4	11,37	11,12	11,72	10,71
1БН-1з-5	11,32	10,80	11,45	10,28
1БН-1з-6	11,11	10,78	11,37	10,86
Concrete B25 (C20/25)				
Base beams				
2БЗ-1-1	12,87	12,22	13,01	11,87
2БЗ-1з-2	13,01	12,48	13,06	11,84
2БЗ-1-3	12,35	12,21	12,77	11,53
Pre-stressed beams				
2БН-1з-1	12,72	12,11	12,67	11,49
2БН-1з-2	12,91	12,17	12,73	11,56
2БН-1з-3	12,73	12,49	12,97	11,83
2БН-1з-4	12,52	12,44	13,01	11,84
2БН-1з-5	12,68	12,66	13,29	12,10
2БН-1з-6	12,62	12,56	13,14	11,99

Explanations: M_1 – experimental destructive moment; M_2 – the destructive beam moment with tested characteristics of concrete and armature (working and constructive) and the actual size of the beams, calculated in accordance with State Standard B.2.6 B-156:2010; M_3 – destructive beam moment of real beam size and characteristics of the concrete, taken by DBN B.2.6-98:2009 and armature (working and constructive) taken by ISO 3760:2006 „Reinforcing steel bars for concrete structures", counted according to State Standard B.2.6 BS B-156:2010; M_4 – destructive beam moment with the real size and characteristics of concrete and armature (working or constructive) taken by Building regulations 2.03.01-84*, calculated in accordance with BR 2.03.01-84*

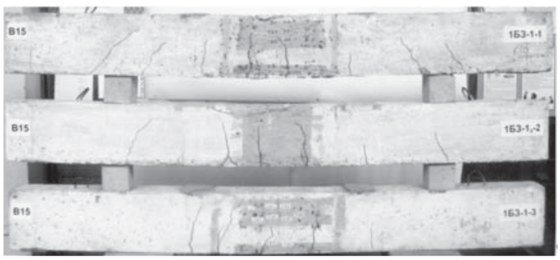
Characteristics of beams destructions reinforced with armature connections A500 using squeezing bushes, depending on the class of concrete shown in Figure 3 and Figure 4.

Analyzing the value of destructive moments of tested beams the following can be mentioned:

– strength of beams series 1 and series 3, series 2 and series 4 are different in these tests at 10% and 12% by increasing class of concrete and redistribution of stresses,
– the destructive moments of tested beams are determined experimentally and counted according to State Standard B.2.6 BS B-156:2010 in all series proved to be greater from 2 to 4% by the accuracy of measurement and variation data in determining the strength of concrete,
– the strength of the cross-section beams tested experimentally and the beams with the characteristics of the relevant classes of concrete and armature, taken from DBN B.2.6-98:2009 and State Standard 3760:2006 and State Standard B.2.6 B-156:2010 in all series were within from minus 2% to 1% due to declining real values of the characteristics of concrete and armature from values specified in the regulations.

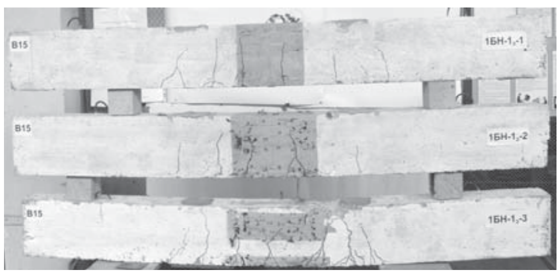
The first series of beams

a



The second series of beams

b



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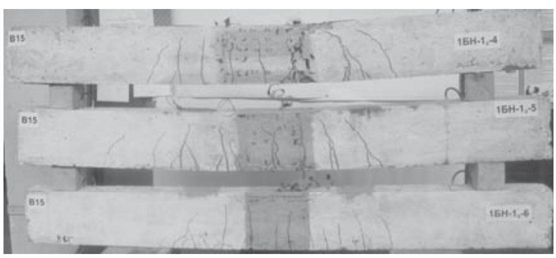
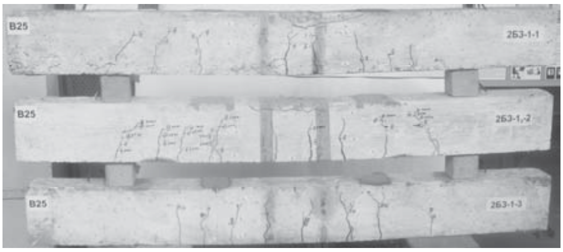


Fig. 3. The nature and location of the cracks in the tested beams: a, b, c – Concrete C12/15(B15)

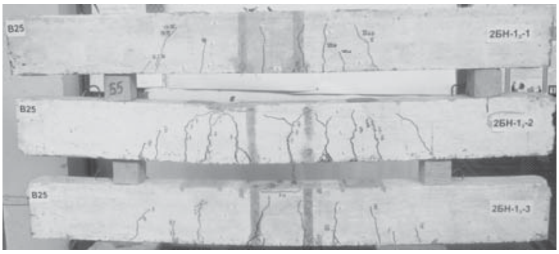
The third series of beams

d



The forth series of beams

e



f

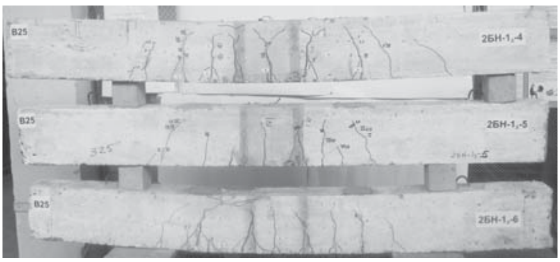


Fig. 4. The nature and location of the cracks in the tested beams: d, e, f – Concrete C20/25(B25)

Destructive moments of beams, determined experimentally and beams with the characteristics of the relevant classes of concrete and armature, taken according to BR 2.03.01-84* and calculated according to BR 2.03.01-84* in all series were greater from 7% to 8%. This deviation can be attributed not taking into account some factors of strength of materials and conditions of the cross-sections of beams in given regulations in comparison with a new DBN B.2.6-98:2009.

As shown in Figure 3 character of beams destruction reinforced with continuous armature and beams, reinforced with armature connections using squeezing bushes was similar. The distribution of normal cracks along the length of the beams with concrete class C12/15 (B15) and class C20/25 (B25) is practically identical (Fig. 4). Beam destruction from beams of concrete class C12/15 (B15) took place at a compressed area, and the class C20/25 (B25) at compressed area of concrete and armature stretched area almost simultaneously.

CONCLUSIONS

Based on the tests we can formulate the following conclusions:

1. Experimental study of beams on small-circle fatigue showed that their strength in multiple repetitive loadings does not depend, in these experiments, on continuous or connection reinforcement of armature.

2. The strength of the experimental beams in these experiments of series 1 and series 3, series 2 and series 4 differ by 10% and 12% due to the various classes of concrete.

3. Experimental values of destructive moments in cross-sections of beams with different classes of concrete prove the correctness of theoretical calculations according to State Standard B.2.6 B-156:2010. The difference is within the statistical deviation of 2% to 4%.

4. Stress concentration in the connection armature does not significantly affect the overall strength of beams with small-circle loads.

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BADANIA MOMENTÓW NISZCZĄCYCH BELEK Z MECHANICZNYMI POŁĄCZENIAMI PRĘTÓW ZBROJENIOWYCH

Streszczenie. Do zbrojenia żelbetowych konstrukcji sprężonych używane są pręty ze wzmocnionej termicznie stali o standardowej długości 12 m, klasy A400, A500, A600, A800, o periodycznie powtarzalnym profilu. Często się zdarza, że ze względu na wady występujące przy spawaniu takiej stali pręty te nie spełniają wymagań swojej klasy. Adhezja między betonem a zbrojeniem zależy od wielu czynników, jest więc najczęściej badana na drodze eksperymentalnej. Przedstawiono sposób wykonania prototypów, metodę badań i analizę wytrzymałości belek żelbetowych z łączonymi mechanicznie prętami zbrojeniowymi. Program badań doświadczalnych przewiduje badania czterech serii belek żelbetowych o przekroju 120 × 220 mm i długości 200 mm, pracujących na zginanie i obciążonych dwiema siłami skupionymi. Badane belki były wzmocnione spawaną ramą zbrojeniową z prętów 4 × ∅ 8 A400 i sprężonego zbrojenia ∅ 12 A500C. Pręty stalowe łączone były tulejami zaciskowymi. W celu określenia wytrzymałości, odkształceń i odporności na pękanie badanych belek poddano je badaniom niszczącym na zginanie.

Słowa kluczowe: belki żelbetowe, zbrojenie, wytrzymałość, tuleje zaciskowe, obciążenia powtarzalne

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