The research of load bearing capacity and fracture toughness of steel concrete beams, reinforced by cut and stretchy sheet

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Annotation: *The experimental researches of load bearing capacity and fracture toughness of steel concrete beams, armored by cut and stretchy sheet in comparison to reinforced concrete, armored by reinforcement bar.*

Key words*: load bearing capacity, fracture toughness, deflections, cut and stretchy sheet, steel concrete beams.*

Setting of the problem

Solving the problem of the reduction of steel concrete constructions metal content not only solid sheet but also cut and stretchy one can be used as work taped reinforcement [2-3]. On the one hand, it can reduce construction weight but on the other it can provide the bond of work reinforcement and reinforced concrete part of the construction without additional unifying elements.

Analysis of the latest researches and publications

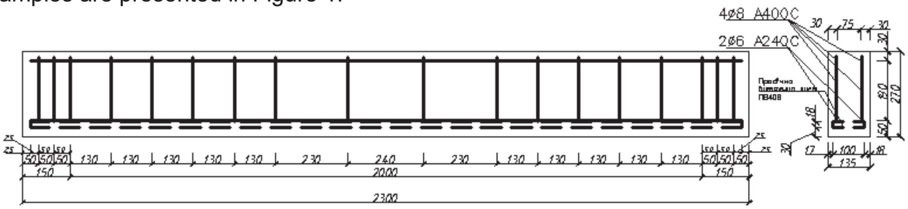
The development and research of steel concrete constructions has been done by groups led by prominent scientists and scholars of Ukraine: F.Ye. Klymenko, O.B.Holyshev, V.I.Yefymenko, L.I.Storozhenko, O.V.Semko, E.D.Chykhladze, O.L.Shahin, etc.

The research of D.V.Talantov is devoted to the use of pressed tape as work reinforcement in bended reinforced concrete elements [5]. The author describes a feature of deformation at all stages of the test samples, peculiarities of common action of carve and concrete. Later, M.M. Hubii suggested using cut and stretchy sheet as reinforcing element in the stone structures [1].

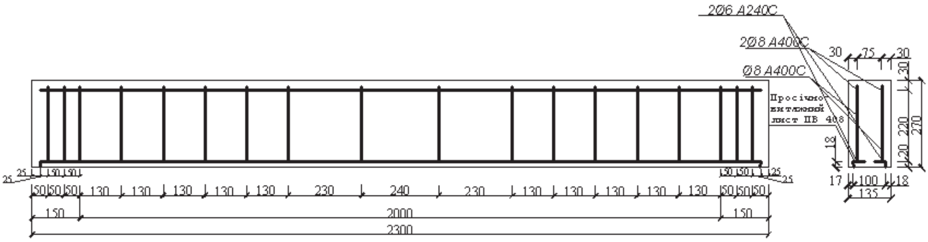
Setting of the task.

In the process of conducting experiment it is necessary: to learn the work of bending steel concrete beam elements, reinforced by cut and stretchy sheet; to evaluate the character of the deformation and possible forms of elements damage; to obtain data on fracture toughness and load bearing capacity of elements, armored by cut and stretchy sheet as compared to reinforced concrete one.

The main material. Samples of rectangular section reinforced by cut and stretchy sheet and reinforced concrete ones armored by reinforcement bar were made in order to determine the load bearing capacity and fracture toughness of steel concrete beam elements [4]. Three beam samples were tested. The test samples were made with section 135×270 mm, length of 2300 mm and the design span of all beams was - 2000 mm. Concrete used for test spaces was of class C40/50. In the test samples B-III-1- working reinforcement made of cut and stretchy sheet placed with a protective layer of concrete and reinforcement bar 2∅6 mm class A240C (Fig. 1 a); B-III-2- cut and stretchy sheet without protective layer and reinforcement 2∅6 mm class A240C (Fig. 1b); B-III-3- work reinforcement made of reinforcement bar 2∅12 mm class A400C (Fig. 1c). Designs of test samples are presented in Figure 1.



a)



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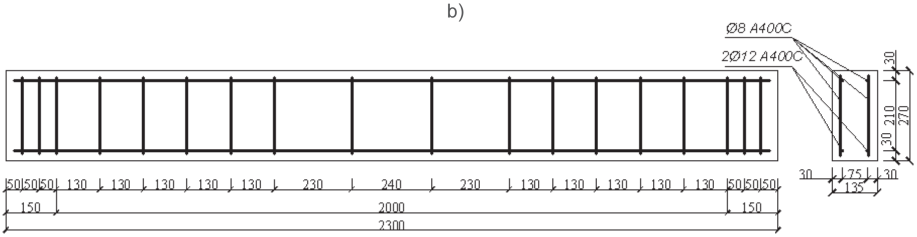


c)

Fig.1. The scheme of reinforcement of test beam samples:
a) beam B-III-1; b) beam B-III-2; c) beam B-III-3.

Before experimental researches of test bending beam samples it was measured physical and mechanical properties of concrete and steel: cube strength $f_{ck,cube}$ = 42,4 MPa, the design value of compressive strength of concrete of 28 days (prism strength) f_{ck} = 36 MPa; design value of concrete strength on the axial tensile $f_{ctk,}$= 2,82 Mpa; modulus of elasticity E_{ck} = 36499 MPa. Regarding mechanical properties of cut and stretchy sheet and reinforcement bar, they were determined by standard samples, which were made of cut parts of reinforcement of test samples and are summarized in Table.1.

Table 1.

Results of the determining steel features

Kind of reinforcement	Type of reinforcement	Size of cross section, diameter, mm	Area of cross section, A, cm^2	Design meaning of reinforcement resistance f_{yk}, MPa	Modulus of reinforcement elasticity E_sx10^5, MPa
1	2	3	4	5	6
Cut and stretchy sheet	longitudinal tensile	50x4	1,12	271	1,9
Reinforcement bar of class A400C	longitudinal tensile	∅12	1,13	553	2,1
Reinforcement bar of class A240C	longitudinal tensile	∅6	0,283	316	2,1
Reinforcement bar of class A400C	longitudinal compressed	∅8	0,503	598	2,1
Reinforcement bar of class A400C	transverse	∅8	0,503	598	2,1

The research of bending beam samples was conducted on the stand where loading was carried out with two symmetric concentrated forces, applied on the top of beam sample (Fig.2). Beams rested on two supports: movable and immovable. The load was created by hydraulic jack of 50 tf capacity and applied degrees F = (0,05…0,1)$F_{\max}$ with a break in between 25-30 minutes. Applied load was controlled by exemplary dynamometer of Tokarev system and manometer of pump station.

Beam deflections were measured by indicators of clock type with division value 0,01 mm. Indicators are set in the middle of the beam and axis of force application.

Fig.2. The general view of test sample

Concrete deformations of compressed and stretched zone and reinforcement deformation were determined by micro indicators. Meanwhile it was examined the side face of beam and recorded the appearance and development (growth and width) of cracks in concrete. The development and opening of cracks was observed by measuring microscope MPB-2M (Fig.3).

Fig.3. Observing of appearing and development of cracks.

Statement of research results. Initially during the load primary normal cracks appeared in the zone of pure bending. Due to the fact that adding support areas of test samples were deliberately reinforced again then inclined cracks did not appear in the area of transverse forces and it helped to research deformations of normal sections of test samples effectively. With further loading additional normal cracks appeared between them and there was the process of opening and growth of cracks. The appearance of cracks in beam sample B-III-1, occurred during loading $0{,}35F_{max}$; in beam sample B-III-2 − $0{,}43F_{max}$; in beam sample B-III-3 − at 0,17$F_{max.}$ In the process of the experiment the height of cracks development has been tracked and one can observe the following picture: the height of cracks reached *0,22* of the general sample height in beam sample B-III-1; *0,05* - in beam sample B-III-2; *0,22* - in beam sample B-III-3. The development of normal cracks in height virtually stopped during loading 0,75-0,8 from destructive. The destruction of all experimental beam samples was ductile in nature and occurred as a result of fragmentation of the compressed zone of concrete above the normal dominant crack (Fig.4).

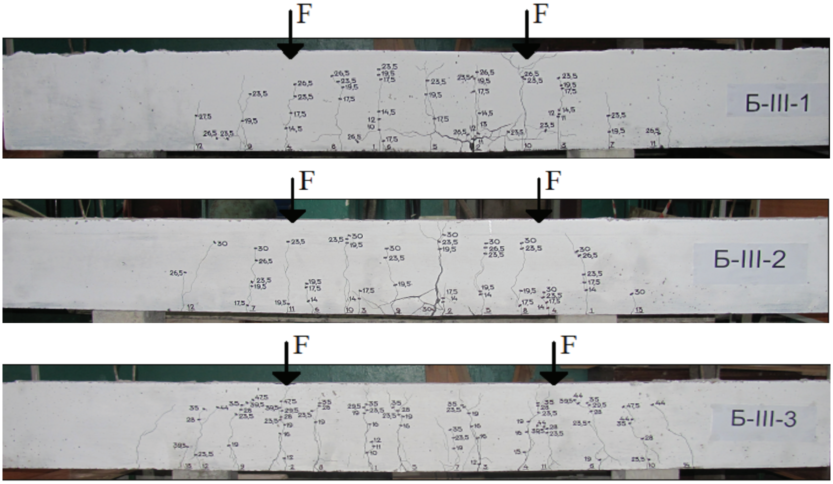


Fig.4. Character of appearing cracks and destruction of test samples: B-III-1; B-III-2; B-III-3.

The results of conducted experimental researches are presented in Table 2 and Fig.5, 6.

Table 2

The experimental meaning of deformation and load bearing capacity of test beam samples

Beam code	Coefficient of reinforcement μ, %	Deflection *f* when loading, mm		Moment of crack appearing M_{crc}^{exp}, кN*m	Maximal width of opening of normal cracks at $M = 0{,}7M_{max}$ a_{crc}, mm	Destructive moment M_{max}, кN*m
		$M = 0{,}5\ldots 0{,}6M_{max}$	$M=0{,}7M_{max}$			
B-III-1	0,8	0,74	2,09	7,43	0,18	19,17
B-III-2	0,7	0,45	2,38	7,86	0,13	20,31
B-III-3	0,7	4,16	6,61	7,95	0,39	38,35

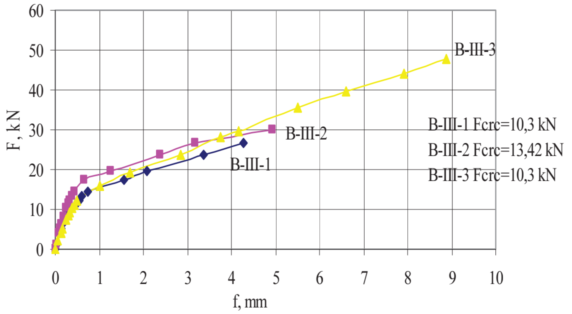
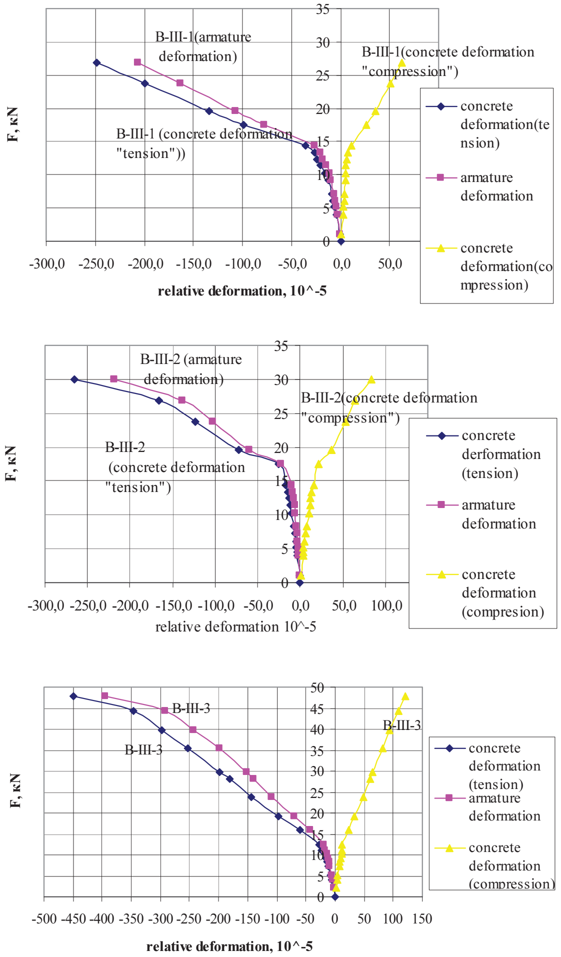


Fig.5. Diagram of dependence of deflections of test beam samples on the degree of loading.



a)

b)

c)

Fig.6. Dependance of value of experimental relative deformation in researched samples on loading level: a) beam B-III-1; b) beam B-III-2; c) beam B-III-3.

Consequences.

Due to the conducting experimental researches one can draw the following conclusions:

1. Cut and stretchy sheet can be used as work reinforcement in bending beam elements.

2. Deflections of test beam samples, armored by cut and stretchy sheet are smaller as compared to common test beam samples armored with reinforcement bar on the same levels of loading.

3. As for operational levels of loading beams, reinforced by cut and stretchy sheet have lesser maximal width of opening cracks that reinforced concrete, reinforced with reinforcement bar.

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The report is reviewed.