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TEST RESULTS OF THE DAMAGED T-SECTION BEAMS

Introduction

Reinforced concrete T-structures are used in the construction of individual structures - typical beams and slabs in stock - monolithic and prefabricated ribbed panel. Due to the location of the shelves in the upper zone, the height of the beams under the ceiling is reduced, making them more comfortable when used in the construction of public buildings, shopping and entertainment centers. Efficiency and economy of tee sections beams use in comparison with rectangular is proven.

There are two schemes of bending elements destruction:

1) the achieving of stretched armature calculated resistance at yield point;
2) the destruction of the compressed zone of concrete earlier than tension in the armature reaches the yield point.

1. Analysis of the previous studies

During operation of concrete tee beams they appear damaged, as in the ribs, so in the shelf.

The most common damage in ribs of the beams - normal and slanted cracks, spalling of the protective layer of concrete stretched zone.

The most common damage in shelves of the beams - the destruction of compressed concrete layer in the zone of pure bending and at the point of the concentrated load application.

A major contribution to the study of defects and damages of bending elements was made by: Adhikary [1], Al-Bayati [2], Chalioris and Pourzitidis [3], Hassan [4], Jayaprakash [5], Smith Roger [6], Wu Hao [7] and others.

2. The relevance of the work

Unfortunately, in current regulations of Ukraine [8] there is not considered the possibility to determine the residual bearing capacity of damaged reinforced

concrete T-beams, although it could significantly reduce the costs of strengthening. Study of the stress-strain state of such structures would analyze their future work in conjunction with the construction of strengthening. Based on this the definition of the residual bearing capacity is a very important task.

3. Experimental set-up of damaged t-beams study

To solve this problem at the Department of Building Structures of the Odessa State Academy of Building and Architecture was performed a series of experiments (15 samples of T-beams with damaged shelves and an equal number of prisms and cubes) using the mathematical theory of experiment planning.

The variation factors are the following:

– damaged part of the shelf, as expressed by the ratio ($b_1/b_1^{/}$), where b_1 - the width of the damage; $b_1^{/}$ - value overhangs the shelf;
– depth of damage a_1 in terms of the ratio of the depth of damage to the rack shelf thickness ($a_1/h_f^{/}$);
– angle of the damage β, expressed in terms of the ratio of the angle of damage to the shelf angle equal to 90°.

Level and range of variation of these factors are shown in Table 1.

TABLE 1

Factors of variation for the model experiment planning

The investigated factors of Y series		Levels of variation			The variation interval
Subsistence value	Symbol	«–1»	«0»	«+1»	
Angle of the damage β/90°	X_1	0/90° = 0	22.5°/90° = 0.25	45/90° = 0.5	0.25
Depth of the damage $a_1/h_f^{/}$ [mm]	X_2	0/60 = 0	30/60 = 0.5	60/60 = 1	0.5
The damaged part of the shelf $b_1/b_1^{/}$ [mm]	X_3	0/165 = 0	82.5/165 = 0.5	165/165 = 1	0.5

To produce prototypes-beams, cubes and prisms was used ordinary heavy concrete class to the project C30/35 prefabrication.

Reinforcement of prototypes - beams was made single Ø16A500C (operating armature) and Ø6A240C (transverse and mounting armature). Reinforcement damaged shelves missing for purity of the experiment. Tests were carried out on a hydraulic press P-125. The load on the beam handed using two traverse to distribute the load through the socket joints.

During the test values of deflections recorded using indicators such as a clock with a scale division of 0.05 mm, located on both sides of the beams at the bottom, and the transverse and longitudinal deformation of concrete and armature through strain gauges with a 5 cm base for concrete and 2 cm - for armature with resistance 200 Ω.

The first cracks appeared in the zone of pure bending at the level of loading (0.25 ... 0.3). By increasing the load in the span shear oblique cracks began to appear (that have evolved to a level shelf and often crossed it). Moreover, in samples with wide shelves (400 mm) shortly before the destruction formed the vertical longitudinal cracks at the site abutting ribs to overhang the shelf. Normal crack also to increase the load applied to the entire height of the ribs and go on the shelf (Fig. 1).

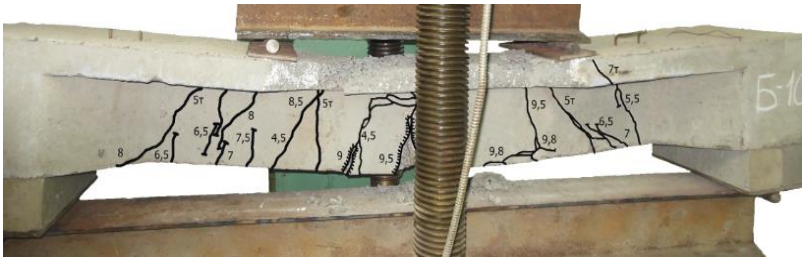

Fig. 1. The destruction of the beam B10

TABLE 2

The values of the external load corresponding to the first appearance of normal, oblique fractures and fracture of beams

Marks of beams	$F_{w,ult\perp}$ [kN]	$F_{w,ult\,/}$ [kN]	F_{ULS} [kN]	M [kNm]
B1	55	35	80	20
B2	40	35	40	10
B3	40	50	130	32.5
B4	20	40	105	26.25
B5	30	25	95	23.75
B6	30	50	130	32.5
B7	30	35	110	27.5
B8	30	25	75	18.75
B9	30	20	95	23.75
B10	25	50	98	24.5
B11	20	30	90	22.5
B12	30	50	118	29.5
B13	25	30	90	22.5
B14	30	50	105	26.25
B15	20	40	110	27.5

Fracture of beams corresponds to the case 2 when stretched armature voltage has not reached its yield strength and fracture was due to the fragmentation of concrete compressed zone of the prevailing bending moment.

In conducting of experimental studies were fixed values of the external load corresponding to the appearance of the first normal cracks in the zone of pure bending specimens, and the inclined cracks in the shear span of beams and experienced the destruction of beams (Table 2).

Pre-analysis of experimentally obtained data shows that the greatest load weathered samples, which had the least damage, and the smallest load weathered samples with the width of the damaged shelves $b_f{}' = 70$ cm. A distinctive feature of the deformation of beams was different in nature to the development of cracks operational level uploading.

Before the formation of the first crack deflection of beams was observed. The appearance of the first normal and then oblique cracks accompanied by jump-like increase in the deflection, the relationship between load and deflection is proportional. After the formation of these cracks increase the deflection was not proportional to the increase of the external load. With the exhaustion of the bearing capacity of the beam deflection increased even with a small increment of the external load (Fig. 2).

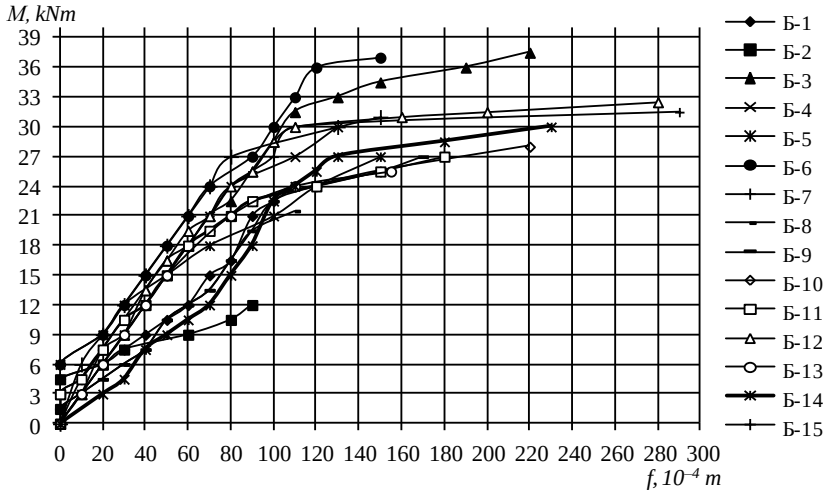

Fig. 2. The growth of deflection before the destruction of beams under load level (0.95 F_{ULS})

Table 3 shows the average value of deflections experienced beams at points of measurement on the operational (0.67 F_{ULS}) level of loading, and before the destruction (0.95 F_{ULS}).

Pre-analysis of the obtained values of deflections evident that the greatest deflection received beams B7, B12, B14, a distinctive feature of which is the angle of damage $\beta = 22.5°$. The smallest deflections were recorded in beams B1, B2, B8 with damaged shelves $b_f{}' = 70$ cm.

TABLE 3

The average values of deflection of beams on the operational (0.67 F_{ULS}) level of loading and before the destruction (0.95 F_{ULS})

Marks of beams	f under 0.67 F_{ULS} [cm]	f under 0.95 F_{ULS} [cm]	Subsistence value of the factors		
			$\beta/90°$ (β [°])	a_1/h_f' (a_1 [mm])	b_{eff1}/b_{eff2} (b_{eff} [mm])
B1	0.8	1.1	0.5 (45°)	1 (60)	1 (70)
B2	0.6	0.9	0 (0°)	1 (60)	1 (70)
B3	0.9	2.2	0.5 (45°)	1 (60)	0 (400)
B4	0.7	1.3	0.5 (45°)	1 (60)	0.5 (235)
B5	0.8	1.5	0 (0°)	0 (0)	1 (70)
B6	0.8	1.5	0 (0°)	0 (0)	0 (400)
B7	0.8	2.9	0.25 (22.5°)	0.5 (30)	0.5 (235)
B8	0.8	1.1	0.25 (22.5°)	1 (60)	1 (70)
B9	0.9	1.7	0.5 (45°)	0.5 (30)	1 (70)
B10	0.7	2.2	0.5 (45°)	0.5 (30)	0.5 (235)
B11	0.6	1.5	0 (0°)	0.5 (30)	0.5 (235)
B12	0.8	2.8	0.25 (22.5°)	0.5 (30)	0 (400)
B13	0.7	1.55	0 (0°)	0.5 (30)	0 (400)
B14	0.9	2.3	0.25 (22.5°)	1 (60)	0.5 (235)
B15	0.65	1.5	0 (0°)	0 (0)	0.5 (235)

Conclusion

The article raises the question of further operation of damaged reinforced concrete T-beams. An important task for the future is the mathematical definition of the residual load-bearing capacity of beams for the type of damage. It is proved that the type of damage affects the residual load-bearing capacity, the nature of the occurrence and the further development of cracks, the beam deflection.

References

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Abstract

The aim of the paper is the experimental determination of residual bearing capacity prototypes - beams with damaged shelf. Tests conducted to study the effect of beam damage on its residual load carrying capacity. In this paper it is proved that the type of damage affects the residual load--bearing captivity, the nature of the occurrence and the further development of cracks, the beam deflection.

Wyniki badań doświadczalnych uszkodzonych belek o przekroju teowym

Streszczenie

W artykule przedstawiono wyniki badań doświadczalnych belek teowych z uszkodzoną półką. Badania wykonano w celu przestudiowania wpływu uszkodzeń na resztkową nośność belek. Udowodniono, że rodzaj uszkodzenia wpływa na resztkową nośność, charakter występowania i dalszy rozwój rys oraz ugięcie belek.