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CONSIDERATION OF THE EFFECT OF THE CROSS-SECTION SHAPE ON THE BEARING CAPACITY OF INCLINED SECTIONS IN DESIGN STANDARDS

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УРАХУВАННЯ ВПЛИВУ ФОРМИ ПОПЕРЕЧНОГО ПЕРЕТИНУ НА НЕСУЧУ ЗДАТНІСТЬ ПОХИЛИХ ПЕРЕРІЗІВ У НОРМАХ ПРОЕКТУВАННЯ

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УЧЕТ ВЛИЯНИЯ ФОРМЫ ПОПЕРЕЧНОГО СЕЧЕНИЯ НА НЕСУЩУЮ СПОСОБНОСТЬ НАКЛОННЫХ СЕЧЕНИЙ В НОРМАХ ПРОЕКТИРОВАНИЯ

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It isn't enough concrete data on influence of a form of cross section on the bearing ability of elements. As a rule, the models of sections are already idealized previously on the basis of the available dependences established in the relevant normative documents.

Key words: *reinforced concrete members; bearing capacity; strength; building codes.*

Конкретних даних про вплив форми поперечного перерізу на несучу здатність елементів недостатньо. Як правило, моделі перетинів вже попередньо ідеалізуються на підставі наявних залежностей, які встановлені у відповідних нормативних документах.

Ключові слова: *залізобетонні елементи, несуча здатність, міцність, будівельні норми.*

Конкретных данных о влиянии формы поперечного сечения на несущую способность элементов недостаточно. Как правило, модели сечений уже предварительно идеализируются на основании имеющихся зависимостей, установленных в соответствующих нормативных документах.

Ключевые слова: *железобетонные элементы, несущая способность, прочность, строительные нормы.*

The statement of problem and the an alysis of researches. The method of balance of boundary efforts in an inclined section developed in forties of previous century by O. O. Gvozdevii and M. S. Borishanskiy became famous and was acknowledged and included in the next normative documents [1] and new norms [2] of Russia. Taking into account the complexity of harmonization of European [3] and Soviet [1] normative documents that have as general approaches as essential differences, European norms of design of reinforced concrete constructions [4] are introduced on the territory of Ukraine. The main demand of that is the deformative method of calculation of reinforced concrete elements that permits to forecast the deformability, crack resistance and power, mainly, of their normal sections in terms of the united positions. The foundation of calculation of inclined sections with the use of the deformative method is laid in works [5, 6]. At the same time, in present new norms of design [4], the existent influence on the bearing ability of inclined sections of some factors including the geometric form of section isn't really considered. Therefore, the realization of experimental and theoretical researches in a current way is an **actual task.**

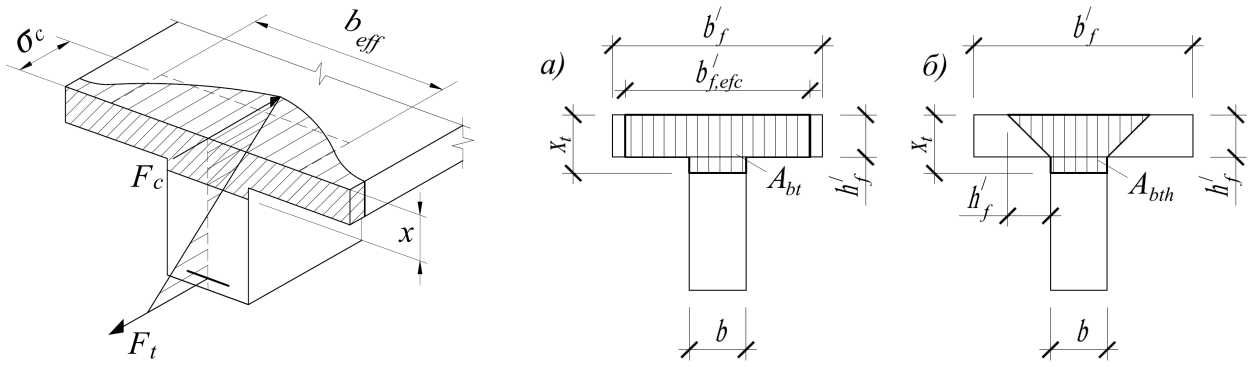
The objective of the study consists in a detailed experimental and theoretical research of VAT and the bearing ability of bearing parcels previously strained T-shaped reinforced concrete elements, the improvement of deformative model of work of present elements.

The presentation of principal material. According to the accepted plan of system researches [7] were executed the corresponding experiments [5]. In the capacity of the testing, the next factors are accepted: a relative bearer of section in view of bearing parcels a/h_0 (factor X_1), the width b'_f/b (X_2) and the thickness h'_f/h_0 (X_3) of compressed shelf of transversal cutover, the quantity of transversal ferro-concrete reinforcement μ_{sw} (X_4) and the dimension of previous tension σ_{sp} (X_5) of operating ferro-concrete reinforcement of T-shaped reinforced concrete elements. Whereas, the accepted research factors could influence and influence in a nonlinear way on emergent parameters, then research models-beams were made and tested on almost D-optimal plan of type Ha-5 [8].

The reinforced concrete elements with the transversal sections of different forms (T-shaped, double-T, box-shaped and other) compose the meaningful part of combined and monolithic constructions, where the data about their work under the loading is limited. The necessity of the evaluation of influence of the forms of section of elements on the ability that carries the deformability and crack resistance appears not only during the bend and pressure, but that is particularly important, during the complex kinds of strained state, such as a slanting, off-center pressure, a slanting bend when the form of pressured zone has a triangular or trapezium-shape outline.

In not-numerous native [5, 6, 9, 10, 11] and foreign studies is indicated the possibility of influence of a form of transversal section on the parameters that determine on the bearing ability of elements, however it isn't enough concrete data on these questions, at the same time, as a rule, the models are idealized in advance on the basis of present dependences, established in the relevant normative documents.

The most effective form of a transversal section of reinforced concrete elements that are characterized by an alternating diagram of tensions is T-shaped (double-T) (pic. 1).



Pic. 1. The idealization of distribution of tensions in truncated cornices of T-shaped section:
a – the zone of perception of normal tensions;
b – the zone of perception of tangent tensions

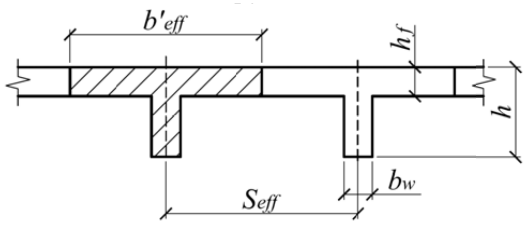
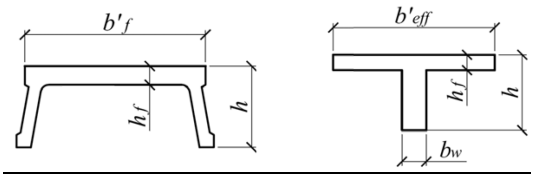
In consequence of concentration of a pressured zone of concrete in a thin full-blown shelf are efficiently used the strong characteristics of the concrete during the simultaneous reduction of a stretched zone of concrete to the narrow edge, that doesn't take part directly in the perception of the stretched efforts but that is necessary mainly for the setting a working, longitudinal and transversal reinforcement, and also the bearing of a knocked together effort [12].

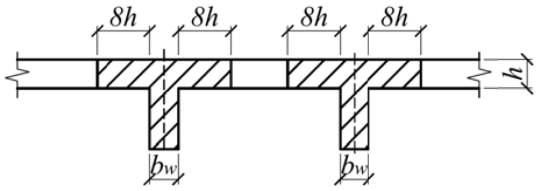
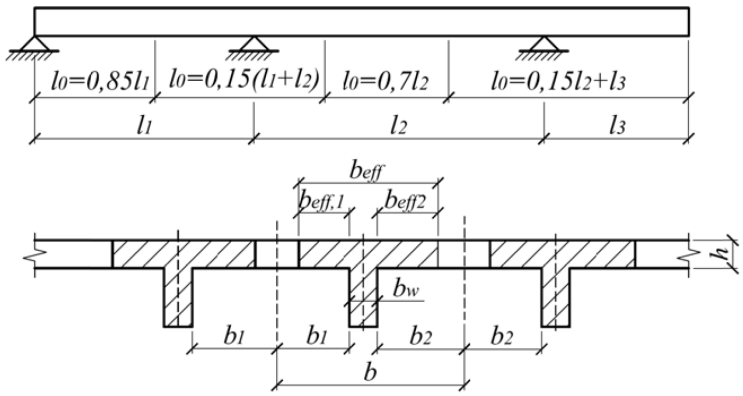
The compressed cornices of shelves of T-shaped sections on their length function irregularly that is reflected on their common work with the edge to the extensible direction that can't be in full measure provided. It's explained by various reasons, where the main one is a local loss of durability of cornices, their excessive flexion and as well a possible cutoff at the place of combination of shelf and edge. Having big meanings of width of cornices, the distant from the edge, parts of cornices are strained less than approximate to the edge, that's why the compressive tensions on the width of shelf practically are distributed irregularly, especially on the wide and thin shelves - at the ends of cornices they are considerably smaller than near the edge. It's happening because of the deplanation (contortion) of section on the length: the deformations of borders fall behind the deformations of the middle. Therefore, the model of transversal section is idealized in the calculations in the different norms, limiting the width of cornices of b'_f T-shaped (double-T) section that is counted in the calculation replacing it by the equivalent (efficient) width of cornices of the shelf $b'_{f,efc}$ and considering that the constant compressed tensions (a dotted line in the pic. 1) function by the whole square of a compressed zone of concrete.

The main not numerous dependences for the determination of an efficient width of cornices of the shelf $b'_{f,efc}$ are used in the relevant normative documents, presented in the table 1.

The table 1

The idealization of receipted into the calculation in different norms of design the width of compressed cornices of shelves in T-shaped sections

The name of a normative document	The dimension of an efficient width of cornices of the shelf
1	2
	1. In the monolithic constructions  a) in the presence $h_t' \geq 0,1h$ of the transversal edges, $b_{eff}' \leq b_w + 2\left(\frac{1}{6} l_{eff}\right)$ and $b_{eff}' \leq b_w + 2\left(\frac{1}{2} S_{eff}\right)$, where l_{eff} - the bay of the element. b) in the absence of the transversal edges or in the distance between them that is bigger than the distance between the longitudinal edges and by $h_t' < 0,1h$ $b_{eff}' = b_w + 2\left(6h_f'\right)$
ВС 2.03.01- 84* [1] ВС 52-01 - 2003 [2] ВСВ 5.03.01- 02 [13]	2. In mixed constructions an actual section an equivalent section  a) by $h_f' \geq 0,1h$, $b_{eff}' = b_w + 2\left(6h_f'\right)$; b) by $0,05h \leq h_f' < 0,1h$, $b_{eff}' = b_w + 2\left(3h_f\right)$; c) by $h_f < 0,05h$ the cornices in the work aren't taken into account - the section is accepted by the rectangle, $b_{eff} = b_w$.

1	2
ACI 318 - 05 [16]	 The dimension of an efficient width of cornices of the shelf is accepted. $b'_{eff} = b_w + 16h'_f$.
EN 1992-1-1 [3] NBC B.2.6-98:2009 [4] TKP EN 1992- 1-1 [14] DIN 1045- 1 [15]	 $b'_{eff} = \sum b_{eff,i} + b_w$, at that $b_{eff,i} = 0,2b_i + 0,1l_0 \le 0,2l_0, b_{eff,i} \le b_i$ In addition, for T-shaped beams are considered the
	conditions: $b_{eff,i} \le 6h'_{f,i}$ - in the presence of the shelf by two sides. $b_{eff,i} \le 4h'_{f,i}$ - in the presence of the shelf by one side.
Economic concrete frame elements [17]	According to the type of beam. a) for one bay beams $b_{eff} = b_w + 0,2l_{eff}$ b) for continuous beams $b_{eff} = b_w + 0,14l_{eff}$, where l_{eff} - the bay of the element.
Theory of Elasticity [18]	$b_{eff} = 0,85\frac{4l_{eff}}{\pi\left(3+2\vartheta-\vartheta^2\right)}$

The table 2

The comparison of the results of the accounts of the bearing ability of inclined sections previously strained T-shaped reinforced-concrete beams with the experimental data

№ of research	The experimental data	The calculated meanings of destructive transversal power, determined by the method					The form of destruction [5]
	the meaning of destructive transversal power [5] $\hat{Q}_u$	EN 1992-1:2001[2] ДБН В.2.6-98:2009 [4]	DIN-1045-1.12.1998[15]	ACI CODE 318-95 [16]	СНиП 52.101-2004 [2]	СНиП 2.03.01-84*[1]	
1	2	3	4	5	6	7	8
1	87,49	68,60	140,77	120,29	68,77	86,65	-from M by/tr.
2	93,29	111,71	115,26	84,24	100,93	88,24	-on the line
3	76,49	111,71	91,09	101,36	100,93	79,93	-on the line
4	64,69	27,90	106,31	65,31	40,22	44,68	-from Q by/tr.
5	94,29	111,71	89,94	100,95	100,93	88,24	-on the line
6	82,49	68,60	104,76	64,90	68,77	86,65	-from M by/tr.
7	69,69	26,70	141,77	121,43	40,22	51,84	-from Q by/tr.
8	75,49	111,71	115,93	85,38	100,93	79,93	-on the line
9	96,29	111,71	115,26	120,29	100,93	88,24	-on the line
10	84,49	50,50	140,77	84,24	67,15	98,20	-from M by/tr.
11	67,69	24,60	106,31	101,36	40,22	51,84	-from Q by/tr.
12	73,49	111,71	91,09	101,36	100,93	79,93	-on the line
13	78,49	111,71	115,93	121,43	100,93	79,93	-on the line
14	66,69	25,70	141,77	85,38	40,22	50,05	-from Q by/tr.
15	85,49	74,50	104,76	100,95	66,19	98,20	-from M by/tr.
16	91,29	111,71	89,94	64,90	66,19	88,24	-on the line

1	2	3	4	5	6	7	8
17	76,70	49,10	127,81	91,85	64,27	81,82	-from M by/tr.
18	85,50	111,71	106,43	91,85	100,93	83,60	-on the line
19	81,00	37,86	121,70	109,88	52,94	83,55	-from Q by/tr.
20	78,00	37,71	121,70	73,83	52,94	83,55	-from Q by/tr.
21	82,10	37,84	133,99	103,03	52,94	97,11	-from Q by/tr.
22	80,10	37,74	101,57	83,20	52,94	66,59	-from Q by/tr.
23	90,99	43,18	120,92	91,36	68,14	83,55	-from Q by/tr.
24	73,19	33,30	122,08	92,10	40,12	66,59	-from Q by/tr.
25	81,10	37,31	121,70	91,85	52,94	83,55	-from Q by/tr.
26	81,10	38,29	121,70	91,85	52,94	80,66	-from Q by/tr.
27	81,10	37,80	121,70	91,85	52,94	94,61	-from Q by/tr.

The conclusions:

1. The analysis of different dependences, presented in the table 1, demonstrates that the present approaches for the idealization of the models of sections of a complicated form are different and possibly will correspond to the different level of reliability of constructions.

2. The most of the norms don't connect the dimension of an efficient width of cornices of the shelf ((with the correlation h_f / h, don't divide the elements by the form of a transversal section (T or double-T shaped) and the elaboration of (mixed or monolithic) and as well, don't consider the supplementary factors in the form of shoring from transversal edges and other.

3. At the same time in the norms of design [3, 4, 14, 15, 16], nowise is considered really the existent influence of the form of section on the bearing ability of inclined sections.

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