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ДОСЛІДЖЕННЯ РОБОТИ КОНТАКТНОГО ШВА ПРИ ПІДСИЛЕННІ ЗАЛІЗОБЕТОННИХ КОНСТРУКЦІЙ МЕТОДОМ ПРИКЛЕЮВАННЯ

ИССЛЕДОВАНИЕ РАБОТЫ КОНТАКТНОГО ШВА ПРИ УСИЛЕНИИ ЖЕЛЕЗОБЕТОННЫХ КОНСТРУКЦИЙ МЕТОДОМ ПРИКЛЕИВАНИЯ

RESEARCH THE CONTACT SEAM WORKING OF THE FERROCONCRETE BEAMS WORK STRENGTHENED BY GLUENING

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Наведено і проаналізовано результати випробувань підсилених балок на якість роботи клеєного контактного шва при різних рівнях повторного навантаження.

Приведены и проанализированы результаты испытаний усиленных балок на качество работы клееного контактного шва при разных уровнях повторяющейся нагрузки.

The quality of glued contact seam work test results for strengthened beams with different level of re-loading were shown and analyzed.

Key words:
Балка, підсилення, випробування, навантаження, тріщина.
Балка, усиление, испытание, нагрузка, трещина.
Beam, strengthening, testing, loading, crack.

Problem and its connection with scientific and practical objectives. One of the modern methods of the bearing ability increasing for the ferroconcrete bending elements is the auxiliary reinforcement in the tensile zone and setting of the monolithic slabs in the compressive zone.

The plating of the bending ferroconcrete elements from below is made as usual if it is impossible to be strengthened by plating from above where low bearing ability is applicable at the structure. Nowadays in construction the urgent problem is the research of the mode of the contact seam's deformation for the strengthened structures at the high level stresses taking into account the changes while exploitating.

Research analysis. The working of the strengthened ferroconcrete structures is researched in the works of L.V.Afanas'yev, A.Ya.Barashykov, S.V.Bondarenko, B.A.Boyarchuk, O.I.Valovoy, H.V.Hetun, O.B.Holyshev, A.Yu.Eremenko, O.D.Zhuravs'kyy, P.Y.Kryvosheyev, E.F.Lysenko, H.A.Molodchenko, L.A.Murashko, Y.P.Novators'kyy, R.S.Sanzharovs'kyy, P.O.Sunak, H.N.Khaydukov, O.L.Shahyn, V.S.Shmukler, A.Kasassbekh, H.V.Chanh, L.M.Chy, M.A.Maksur and others.

Concrete and ferroconcrete elements at the low-cycle loads are studied in the works of E.M.Babych, A.Ya.Barashykov, N.M.Byt'ko, O.I.Valovoy, A.V.Voytsekhovs'kyy, A.V.Herhel', A.B.Hryhorchuk, A.S.Zalisiv, V.V.Karavan, N.Y.Karpenko, A.M.Kokarev and others.

In the same time the research of the working of the structural elements strengthened in the tensile zone with the layer of ferroconcrete by gluing at the acting of the repeated loads has not been carried.

Problem of research is to compare experimental and calculation values of the contact seams' durability. The seams are strengthened in the tensile zone of the ferroconcrete beams at the low-cycle loads the problem of research is also to understand the working efficiency of the strengthening with the help of glue.

Research results. 5 sets of the reinforced concrete beams from the iron ore dressing wastes [1] were made for experiments. All sets of beams, except of the first one were preloaded with the 0,7…0,8 force from distractive of the first set. After this the beams were reloaded and strengthened by plating in the tensile zone with the layer of concrete.

The beams of the first and second sets are pilot and they were tested with the monotonous load to destructive. The testing of the third, fourth and fifth beam sets were conducted with cycle loading. The maximum level of the repeated load has follows: for the third beams set – 0.75, the fourth – 0,85 , and fifth – 0,9 from destructive. Force was applied during 10 cycles and after this the load was brought to destructive.

The moment of the cracks originating and its further development of the opening crack width was estimated visually with microscope of twenty four fold magnification. Also, the indices of the tensoresistors were taken into account. As a destructive point of the strengthened beams was taken a moment of the exceedance of the width of the normal cracks and buckling length from the standard values and beams destruction in the upper part of the middle third of span.

The existent calculation methods for the strength of the contact seam in the strengthened cast-in-place and precast constructions foresee the strengthening contact seam by functional and technological measures. It allows to confine to test strength in the critical state in the zone of the most bending moments and by oblique section (Fig.1), by methodic shown in [2,3], with this hypothesis

$$T_{sh} \leq T_{sh,u},$$

where T_{sh} – transverse force in the contact seam from the acting of the external load;

$T_{sh,u}$ – critical transverse force supported by the contact seam,

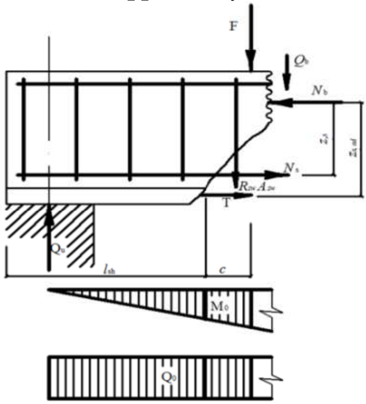

Fig.1 Calculation scheme of the contact seam.

Critical transverse force supported by the contact seam in the general case is determined by the formula.

$$T_{sh,u} = R_{sh} b_{sh} l_{sh}, \tag{2}$$

where R_{sh} –middle calculation resistant of the transversion of the contact seam by the length of the section;

b_{sh} –calculating surface width of the transversion;

l_{sh} – calculating length of the transversion.

In the general case the average calculating transversion resistance of the contact seam is taken by formula:

$$R_{sh} = R_{sh,b} + R_{sh,k} + R_{sh,s} + R_{sh,n}, \tag{3}$$

where $R_{sh,b}$ – resistance of the transversion seam by means of adhesion, mechanical engagement and concrete crimp;

$R_{sh,k}$ – resistance of the transversion seam by glue working. Implementation of this resistance is offered on the basis of experimental research described in [4] ; $R_{sh,k}$ = 0,08 MPa;

$R_{sh,s}$ – resistance of the transversion seam working on the cutting of the cross reinforcement which passes over the seam ;

$R_{sh,n}$ – resistance of the transversion seam cross connectors.

In this case the cross reinforcement which passes over the seam is absent. Cross connectors are absent between the surface of the tensile zone of the strengthened and strengthening layer. So, in this case only two members (3) are left for the calculation.

$$R_{sh} = R_{sh,b} + R_{sh,k}, \quad (4)$$

where $R_{sh,b}$ – according to [2] is determined by formula

$$R_{sh,b} = \gamma_{b1}\gamma_{b2}\gamma_{b3}R_{bt,m}\left(1 + \gamma_{b4}\frac{\sigma_{bm}}{R_{bt,m}}\right), \quad (5)$$

In the ratio (5) the following values of multiplies are used:

$R_{bt,m}$ – middle calculation resistance of concrete strengthening $R_{bt,1}$ and main concrete of the strengthened structure $R_{bt,2}$, so

$$R_{bt,m} = \frac{R_{bt,1} + R_{bt,2}}{2} \quad (6)$$

γ_{b1} – coefficient for taking into account the influence of the multiple repeated loading, (for the beams of the TSB set γ_{b1} = 1, and for SB-0.75, SB-0.85 and SB-0.9 γ_{b1} = 0.75);

γ_{b2} – coefficient for taking into account the influence of the long-term loading; in this case the calculation was made only for the short term experimental tests, on this point γ_{b2} = 1;

γ_{b3} – coefficient for taking into account the influence of the surface state of the contact seam on the concrete adhesion. It is taken according Table 1 [2];

γ_{b4} – coefficient for taking into account the influence of the surface state of by its crimp; its values can be found in Table. 1;

Table 1

Characteristics of contact seams

№	State of the contacts surface of the strengthened construction	Coefficient γ_{b3} and γ_{b4} at concrete strength Rb, MPa				
		0,5	10,0	15,0	20,0	40,0
1	2	3	4	5	6	7
1	Smooth surface, contact is provided by a few planes	$\frac{0,4}{1,6}$	$\frac{0,6}{1,1}$	$\frac{0,9}{0,7}$	$\frac{1,2}{0,5}$	$\frac{1,0}{0,65}$
2	The same, flat contact	$\frac{0,3}{2,2}$	$\frac{0,5}{1,3}$	$\frac{0,6}{1,1}$	$\frac{0,6}{1,1}$	$\frac{0,5}{1,3}$
3	Rough surface, contact is provided in a few planes	$\frac{0,5}{1,3}$	$\frac{0,8}{0,8}$	$\frac{1,2}{0,55}$	$\frac{1,6}{0,4}$	$\frac{1,3}{0,5}$
4	The same, flat contact	$\frac{0,4}{1,6}$	$\frac{0,7}{0,9}$	$\frac{0,8}{0,8}$	$\frac{0,8}{0,8}$	$\frac{0,6}{1,1}$

Notes: 1. Over the dash the values γ_{b3} are given, under the dash – γ_{b4};

2. Under smooth is understood the surface with the print of the timber beam form or troweled manually on the immature concrete; under rough is understood a surface, which has artificial or natural edges (or dimples with height) till 10 mm.

σ_{bm} – average value of the crimp tension for contact seam, which is determined bay formula:

$$\sigma_{bm} = \frac{Q_u}{b_{sh} l_{sh}}, \tag{7}$$

where Q_u – bearing reaction in the moment of destruction.

b_{sh} and l_{sh} – calculation width and length of the transversion surface.

Strength calculations of the contact seams for different beams` sets are made in the following primary data.

The width of the horizontal sector for all beams sets is taken the same and it is equal to beam`s width, i.e. b_{sh} = 120 mm.

If the oblique cracks were almost absent, then the calculating section is taken according the crack which is the farthest. The value l_{sh} is realized when this crack crosses the contact seam.

The values of the coefficients γ_{b3} i γ_{b4} are bound by formula (5) by Table 1, which is recommended in the work [2]. The worst adhesion conditions for the layers of strengthening with the best last tensile fibers were taken into consideration. It corresponds to the above mentioned coefficients by column 2 in the Table 1. For the strength of the primary concrete of the strengthened beams is taken R_{b1}=20,95 MPa, coefficient found by interpolation are equal to: γ_{b3}=0,605, γ_{b4}=1,115. Transversion force from the acting of the external load is determined from the ratio

$$T_{sh} = \frac{M - R_s A_s z}{z_{s,ad}}, \qquad (8)$$

And it is checked by formula

$$T_{sh} = \frac{c}{z_s}\left(Q_0 - q_{sw}\frac{c}{2}\right), \qquad (9)$$

where all conventional signs are shown in Fig.1.

All basic data and results of the calculations are listed in the Table 2.

Table 2

Results of the strength calculation for the contact seams of the strengthened beams

№	Name of volume	Unit of measure	Conventional signs	Calculating values for beam set			
				TSB	SB-0,75	SB-0,85	SB-0,9
1	2	3	4	5	6	7	8
1	Average experimental bending moment by destruction	кN · m	M_u^{exp}	41,1	42,3	42,9	43,2
2	Value of bending moment from the acting of external load in the normal cross-section, through the end of considered oblique cross-section	кN · m	M	35,55	35,25	34,67	35,14
3	Experimental values of destructive cross force	кN	Q_u	68,5	70,5	71,5	72
4	Average value of crimp tension of the contact seam	MPa	σ_{bm}	0,87	0,93	0,96	0,96
5	Average calculation value for strength by	MPa	$R_{bt.m}$	3,105	3,105	3,105	3,105

	transversian						
6	Length of transversion surface	mm	l_{sh}	526	635	620	623
7	Coefficient of the influence of multiple repeated load	-	γ_{b1}	1	0,75	0,75	0,75
8	Coefficient of the influence of the surface state of the contact seam	-	γ_{b3}	0,6	0,6	0,6	0,6
9	Coefficient of the influence of the surface state of the contact seam by its crimp	-	γ_{b4}	1,1	1,1	1,1	1,1
10	Calculation resistance of the transversion seam by means of mechanic engagement and concrete crimp	MPa	$R_{sh,b}$	2,44	1,86	1,87	1,87
11	Calculation resistance of the transversion seam by means of the glue working	MPa	$R_{sh,k}$	0,08	0,08	0,08	0,08
12	Critical crimp force which supports the contact seam	кН	$T_{sh,u}$	197,70	147,46	145,30	146,08
13	Crimp force in seam from external load	кН	T_{sh}	59,48	54,53	47,44	47,90
14	$T_{sh,u}/T_{sh}$	-	-	3,32	2,70	3,06	3,05

Having analyzed the data of Table 2 and having considered the character of destruction of the tested samples, we can insist on the fact, that when destructed the strength of the contact seams was not determinative. The exceedance of the calculating value over de facto ones in the plane of the “new” and “old” concretes is::

for the sample at TSB set – 3,32 times;

For the sample of SB set -0,75, BS-0,85, SB-0,9, – 2,7-3,06 times;

Conclusion and further research direction. Taking into consideration the de facto force within the bounds of the contact seam is relatively weak. The segregation was not visually observed in any of the beams. The way of the contact arrangement with the use Cerinol ZH glue is efficient. The strength calculation of the contact seam by [2] with corrective amendments in the work [4] for the seam calculation with glue reveals the sufficient qualitative and quantitate results.

Literature

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