Theoretical study of the ability of two concrete layers to interact under load

Shermukhamedov U.
Tashkent State Transport University, Department of Bridges and tunnels, professor
Malikov G.
Tashkent State Transport University, Department of Bridges and tunnels, assistant

To date, the method of increasing the load-bearing capacity of load-bearing reinforced concrete structures of buildings by laying an additional layer of concrete on top of them has also been widely used in the practice of bridge construction in our republic. This method serves not only to increase the load-bearing capacity of bridge spans in operation (repair), but also to ensure flexibility during the design period for future increases in temporary loads, as well as to ensure savings in material consumption.
Theoretically, laying a new layer of concrete creates an additional limiting moment, which leads to an increase in load-bearing capacity.
Two types of prismatic reinforced concrete samples are used for theoretical and practical research: Sample 1. The sample is 10x180x1000 cm in size, made of ordinary concrete of concrete class B35 (cast based on the composition of concretes produced at the enterprises of the Bridge Construction Trust), and used as reinforcement a periodic profile of class A-III with a diameter of 12 mm (Figure 1). The design parameters of the construction materials are selected based on the data given in SHNK 2.05.03-22 Bridges and pipelines.
Sample 2. The sample is a structure consisting of two layers of concrete with dimensions of 10x250(180+70)x1000cm, the concrete class in both layers is B35. The 1st layer is made of 180mm thick ordinary concrete (made based on the composition of concretes produced at the enterprises of the bridge construction trust), its design parameters are selected based on the data given in SHNK 2.05.03-22 “Bridges and Pipes”, the 2nd layer is made of 7cm thick fine-grained KMB (based on the composition determined through experimental testing), its design parameters are selected based on the results obtained from experimental testing (Table 1).
Table 1
Accounting indicators of the KMB

1	Accounting indicators	R_b	R_{bt}	$R_{bt,sh}$	E_b
2	Accounting values	19,6 MPa	1,2 MPa	6,1 MPa	$39{,}6\times10^3$,MPa

The reinforcement in the structure was made of A-III class periodic profile reinforcement with a diameter of 12 mm (Figure 2). The calculation parameters of ordinary concrete are based on the data provided in SHNK 2.05.03-22 "Bridges and Pipes", the 2nd layer of concrete

Based on the conclusion that two concrete layers should have the same concrete class to ensure that they work together under mutual load [5], both layers are poured from the same B35 concrete class, and the original and new concrete layers are connected using a mechanical cutting method. That is, in the cutting method, the surface of the original sample is cut, and the resulting voids are filled with a new concrete layer, forming a single structure. Due to the presence of basalt fiber in the composition of the new concrete layer, structural reinforcement is not used.

Sample 1

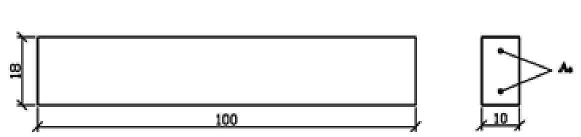

Figure 1. Sample model made of ordinary concrete

Sample 2

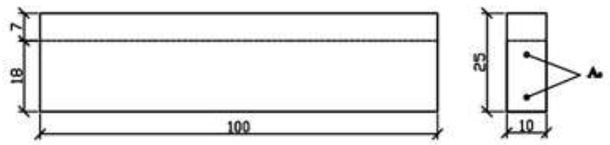

Figure 2. Sample model with additional complex modified concrete laid on top

Theoretical calculations.

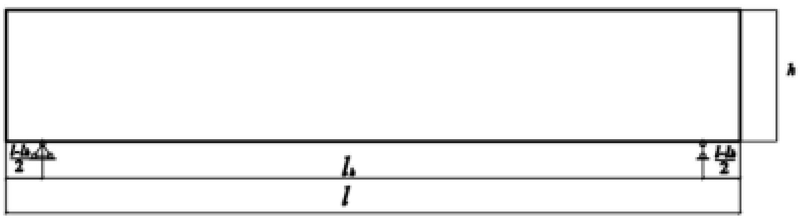

Figure 3. Sample selected as a beam.

The calculations begin by determining the working height of the structure, i.e. the distance from the center of gravity of the reinforcement to the compressed surface of the section, h0=h-a. The height of the compressed zone of the concrete is determined by x.

We determine the height of the compacted area of concrete using the following formula

$R_s \cdot A_s = R_b \cdot b \cdot x$

$x = R_s \cdot A_s / R_b \cdot b$

The formula for determining the reinforcement surface area is:

$$A_s = \pi d^2/4$$

We determine the strength of the sample in terms of the ultimate bending moment using the following formula.

$$M \le R_b \cdot b \cdot x \cdot (h_0 - 0{,}5x)$$

The ultimate bending moment when the specimen height is increased as a result of placing an additional concrete layer is determined using the following expression.

$$M \le R_{b,q} \cdot b \cdot x \cdot \left(h_0 + h_q - 0{,}5x\right)$$

Where: $R_{b,q}$- design resistance of the new concrete layer.

h_q- height of the new concrete layer

$$x = \frac{R_s \cdot A_s}{R_{b,q} \cdot b}$$

If the above formula is not valid, i.e. $x \ge h_q$[2]:

$$M \le R_b \cdot b\left(x - h_q\right)\left(h_0 + 0.5h_q - 0.5x\right) + R_{b,q} \cdot b \cdot h_q(h_0 + 0.5h_q)$$

$$R_s \cdot A_s = R_{b,q} \cdot b \cdot h_q + R_b \cdot b \cdot (\, x - h_q)$$

The deformation that occurs in a sample under load, i.e., its vertical deflection, is determined using the following formula.

$$f_v = \frac{5M_{ch}l_h}{48KE_bI_{kel}}$$

Moment of inertia:

$$I_{kel} = \frac{b \cdot h^3}{12} + n \cdot A_s$$

When two-layer concrete is used in structures, their vertical stiffness is determined by the following formula[5].

$$f_v = \frac{M_{ch}}{b_1 \cdot h_0^2\left[\frac{R_{b,ser1} \cdot A_{kel1}}{A_{kel}} + \frac{R_{b,ser2} \cdot A_{kel2} \cdot E_{b2}/E_{b1}}{A_{kel}}\right]}$$

Theoretical calculations were performed based on the above conditions and formulas and are presented in Table 2.

Table 2

Sample	**x, m**	**h, m**	**As, m^2**	**I**	**M, kNm**	**P, kN**	**f,m**
Theoretical calculations, ordinary concrete	0,0047	0,18	0,00032	5,3095E-05	13,25	58,90	0,0005
Theoretical calculations, KMB	0,0045	0,25	0,00032	0,00014027	18,48	82,16	0,0002

By laying a new layer, an additional load appears on the specimen along with an additional ultimate moment. In this case, the values of the ultimate and bending moments in specimens 1 and 2 and the differences between them are given in Table 3, respectively.

Table 3

Sample	h	b	l	p	m	M xususiy	M chegaraviy	M
Theoretical calculations, ordinary concrete	0,18	0,1	0,9	2500	40,5	4,10	13,25	9,15
Theoretical calculations, KMB	0,25	0,1	0,9	2500	56,25	5,70	18,48	12,79

The data in Table 2-3 show that by laying an additional concrete layer on the structure, the structure was strengthened.

• by theoretical studies – 30%.

The following reduction in the deformation values of the samples was achieved.

• by theoretical studies – 40%.

Based on the graphs in Table 3, it can be concluded that as the height of the structure increases, the bending moment value increases, as well as the specific gravity increases symmetrically. Considering that the thickness of the newly poured concrete layer should not be less than 60 mm[5], we can consider the thickness of 70 mm proposed by us as the optimal value for the structure.

Conclusion.Another main goal of the experimental test was to determine the sequence of simultaneous failure of both layers when cracks appear in the sample, as well as the opening of the joint boundary of the two concrete layers and the appearance of vertical cracks. During the loading process, vertical cracks first appeared in the sample and continued to the upper part. The opening of the two concrete layers appeared after the vertical cracks. Therefore, in this case, the two concrete layers have the property of working together under the influence of the load.

References

1. Ashrabov A.A., Raupov Ch.S. Qurilish konstruksiyalarining diagnostikasi va sinovi. 5A580603 – Ko’priklar va transport tonnellaridan foydalanish mutaxassisligi magistrlari uchun o’quv qo’llanma. – Toshkent, O’ROvaO’MTV. 2013.

Qism I va II. – 102 b. va – 96 b.

2. Transport inshootlarini loyihalash va qurish. Ko'priklarni loyihalash va hisoblash: O'quv qo'llanma/ S.S. Salixanov. Complex Print, 2022 -472b.

3. A.A. Ashrabov, Ch.S. Raupov. Ko'priklar va transport tonnellarini rekonstruksiya qilish va ularni tiklash. O'quv qo'llanma. I va II qismlar. ToshTYMI, 2011. ¬72 va – 89 b

4. Методические указания к курсовому и дипломному проектированию для студентов специальности 270205.65 – «Автомобильные дороги и аэродромы» по дисциплине «Искусственные сооружения на автомобильных дорогах». Н. Новгород, изд. ННГАСУ, 2009 г., 34 с.

5. Лазовский Д.Н. Усиление железобетонных конструкций эксплуатируемых строительных сооружений. -Новополоцк: Изд-. Во Полоцкого гос. ун-та, 1998.-240 с

6. Этин П. Ю. Диагностика и испытания мостов. Учебно-методическое пособие. М-во образования Респ. Беларусь, Белорус. гос. ун-т трансп. – Гомель: БелГУТ, 2010. – 65 с.

7. Картопольцев А.В. Курс «Эксплуатация и реконструкция мостовых сооружений, ч.1», 4 курс, АМиТ, бакалавры, Дорожно-строительный факультет. Томск 2015. – 102 с.

8. Bahromkulovich, M. G. (2023). BRIDGE DECK STRUCTURES: LOCAL AND FOREIGN EXPERIENCE. Scientific Impulse, 1(10), 1313-1319.

9. Raupov, C. S., Malikov, G. B., & Zokirov, J. J. (2022). FOREIGN EXPERIENCE IN THE USE OF HIGH-STRENGTH EXPANDED CLAY CONCRETE IN BRIDGE CONSTRUCTION (LITERATURE REVIEW). Евразийский журнал академических исследований, 2(10), 125-140.

10. Raupov, C. S., Malikov, G. B., & Zokirov, J. J. (2022). FOREIGN EXPERIENCE IN THE USE OF HIGH-STRENGTH EXPANDED CLAY CONCRETE IN BRIDGE CONSTRUCTION (LITERATURE REVIEW). Евразийский журнал академических исследований, 2(10), 125-140.

11. Raupov, C. S., & Malikov, G. B. (2022). CREEP OF EXPANDED CLAY CONCRETE UNDER COMPRESSION AND TENSION. Innovations in Technology and Science Education, 1(3), 4-15.

12. Zokirov, F., & Normurodov, H. (2024). EKSPLUATATSIYADAGI AVTOYO 'L KO 'PRIK INSHOOTLARI ORALIQ QURILMALARNING YUK KO 'TARISH QOBILIYATINI MIDAS CIVIL DT YORDAMIDA BAHOLASH. Наука и технология в современном мире, 3(6), 7-12.

13. Салиханов, С., & Zokirov, F. (2022). МОСТОВОЕ ПОЛОТНО С ПРИМЕНЕНИЕМ СОВРЕМЕННЫХ ГИДРОИЗОЛЯЦИОННЫХ МАТЕРИАЛОВ.“. Yosh ilmiy tadqiqotchi” xalqaro ilmiy-amaliy anjumani. Toshkent–2022 y.
14. Zokirov, F. Z., Pirnazarova, G. F., & Ozodjonov, J. T. (2023). MODERN MATERIALS IN THE WATERPROOFING SYSTEMS OF HIGHWAY REINFORCED CONCRETE BRIDGES. IJTIMOIY FANLARDA INNOVASIYA ONLAYN ILMIY JURNALI, 3(7), 1-6.