

TEMIRBETON USTUN KONSTRUKSIYALARINI TURLI MATERIALLAR BILAN KUCHAYTIRISH BO'YICHA HISOBLASH NAMUNALARI

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Kalit so'zlar: beton, temirbeton, kompozit materiallar, ugletola, xalqa, deformatsiya, siqiluvchi elementlar.

Annotatsiya

Ushbu maqolada temirbeton ustunni kompozitbeton, temirbeton, metall burchaklik va ugletolali mato xalqasi bilan kuchaytirish bo'yicha hisob-kitob namunalari va natijalari keltirilgan. Hisob-kitoblar natijalariga ko'ra, ushbu kuchaytirish usullarini texnik-iqtisodiy jihatdan taqqoslash amalga oshirildi.

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Ko'ngdalang kesim yuzasi 200x200mm, ustun uzunligi 1500mm. Beton sinfi B20 ($R_b=11,5\text{MPa}$). Bo'ylama armatura 4Ø8AIII ($A_{s,tot}=2,01\text{sm}^2$), ($R_{sc}=355\text{MPa}$), bo'lgan mavjud ustunni turli xil kuchaytirish usullari orqali 1,5 barobar yuk ko'tarish qobilyatini oshirish bo'yicha xisoblar keltirib o'tilgan.

$$N = 1,5 \cdot N_{byq}$$

1. Ustun konstruksiyasini temirbeton yordamida kuchaytirish:

Avvalambor ustun konstruksiyasining yuk ko'tarish qobilyatini aniqlaymiz

$$N_{byq} = \varphi \cdot (R_B \cdot A + R_S \cdot A_S),$$

Ustunning egiluvchanligi:

$$\frac{l_0}{h} = \frac{1500}{200} = 7,5$$

$$\varphi = 0,913$$

Yuqoridagi formulaga sonli qiymatlarini qo'yib hisoblaymiz:

$$N_{byq} = 0,913 \cdot (11,5 \cdot 40000 + 355 \cdot 201) = 485,13kN,$$

$$N = 1,5 \cdot 485,13 = 727,695kN,$$

Kuchaytiruvchi xalqa beton sinfini B25 qabul qilamiz, $R_{b,RCR}=14,5MPa$; bo'ylama armatura AIII sinfli $R_{SC,RCR}=355MPa$, ko'ndalang armatura AI sinfli berk xomut sifatida karkas hosil qilingan, $\eta_b=1$ qabul qilamiz. Ustunni kuchaytirish butun balandligi bo'yicha amalga oshiriladi.

Xalqa qalinligini 30mm qabul qilamiz, bunda kuchaytirilgan ustunning egiluvchanligi

$$b' = b + 2 \cdot d = 20 + 2 \cdot 3 = 26sm \text{ ga teng.}$$

$$\frac{l_0}{b'} = \frac{150}{26} = 5,77 \rightarrow \varphi = 0,92$$

$$A_{S,RCR} = 0,01 \cdot A_{RCR} = 0,01(26 \times 26 - 20 \times 20) = 276mm^2$$

Bo'ylama va oddiy ko'ndalang armatura xomuti bilan armaturalangan beton xalqaning kesim yuzasini quyidagi formula orqali aniqlaymiz

$$A_{RCR} = \frac{\frac{N}{\varphi} - \eta_b (R_b \cdot A + R_{SC} \cdot A_S)}{\eta_{RCR} (R_{b,RCR} + 0,01 \cdot R_{SC,RCR})} = \frac{\frac{727700}{0,92} - 1(11,5 \cdot 40000 + 355 \cdot 201)}{0,8(14,5 + 0,01 \cdot 355)} = 179,8sm^2$$

Talab qilinadigan temirbeton xalqa qalinligini quyidagi formula orqali aniqlaymiz

$$d = \frac{\sqrt{(b+h)^2 + 4 \cdot A_{RCR}} - b - h}{4} = \frac{\sqrt{(20+20)^2 + 4 \cdot 179,8} - 20 - 20}{4} = 2,04sm$$

Temirbeton xalqaning minimal qalinligini $d=3sm$ qabul qilamiz.

Xalqadagi bo'ylama ishchi armaturaning kesim yuzasini aniqlaymiz

$$A_{S,RCR} = 0,01 \cdot A_{RCR} = 0,01(260^2 - 200^2) = 276mm^2$$

Konstruktiv talablarga ko'ra 4Ø 8AIII $A_S=2,01sm^2$ qabul qilamiz.

Kuchaytirilgan ustunning mustahkamligini tekshiramiz

$$\frac{l_0}{b'} = \frac{150}{26} = 5,77 \rightarrow \varphi = 0,92$$

$$N = N \leq \varphi \cdot (\eta_b (R_b \cdot A + R_{SC} \cdot A_S) + \eta_g \cdot (R_{b,RCR} \cdot A_{RCR} + A_{S,RCR} \cdot R_{SC,RCR})) =$$

$$727,69 = 0,92(1(11,5 \cdot 200 \cdot 200 + 355 \cdot 201) + 0,8(0,9 \cdot 14,5 \cdot 27600 + 355 \cdot 201)) = 806,46kN$$

$$727,69kN \leq 806,46kN$$

Ustunning yuk ko'tarish qobiliyati ta'minlandi.

2. Ustun konstruksiyasini kompozitbeton yordamida kuchaytirish:

Kuchaytiruvchi xalqa beton sinfini B25 qabul qilamiz, $R_{b,RCR}=14,5MPa$; bo'ylama armatura ShKA $R_{SC,RCR}=1200 MPa$, ko'ndalang armatura ShKA, $\eta_b=1$ qabul qilamiz. Ustunni kuchaytirish butun balandligi bo'yicha amalga oshiriladi.

Xalqa qalinligini 30mm qabul qilamiz, bunda kuchaytirilgan ustunning egiluvchanligi

$$b' = b + 2 \cdot d = 20 + 2 \cdot 3 = 26 \text{ sm ga teng.}$$

$$\frac{l_0}{b'} = \frac{150}{26} = 5,77 \rightarrow \varphi = 0,92$$

$$A_{S,R_{CR}} = 0,01 \cdot A_{R_{CR}} = 0,01(26 \times 26 - 20 \times 20) = 276 \text{ mm}^2$$

Bo'ylama va oddiy ko'ndalang armatura xomuti bilan armaturalangan beton xalqaning kesim yuzasini quyidagi formula orqali aniqlaymiz

$$A_{R_{CR}} = \frac{\frac{N}{\varphi} - \eta_b (R_b \cdot A + R_{SC} \cdot A_S)}{\eta_{R_{CR}} (R_{b,R_{CR}} + 0,01 \cdot R_{SC,R_{CR}})} = \frac{\frac{727700}{0,92} - 1(11,5 \cdot 40000 + 1200 \cdot 113)}{0,7(14,5 + 0,01 \cdot 1200)} = 105,3 \text{ sm}^2$$

Talab qilinadigan temirbeton xalqa qalinligini quyidagi formula orqali aniqlaymiz

$$d = \frac{\sqrt{(b+h)^2 + 4 \cdot A_{R_{CR}} - b - h}}{4} = \frac{\sqrt{(20+20)^2 + 4 \cdot 105,3 - 20 - 20}}{4} = 1,24 \text{ sm}$$

Temirbeton xalqaning minimal qalinligini $d=3 \text{ sm}$ qabul qilamiz.

Xalqadagi bo'ylama ishchi armaturaning kesim yuzasini aniqlaymiz

$$A_{S,R_{CR}} = 0,01 \cdot A_{R_{CR}} = 0,01(260^2 - 200^2) = 276 \text{ mm}^2$$

Konstruktiv talablarga ko'ra 4Ø 6ShKA $A_s=1,13 \text{ sm}^2$ qabul qilamiz.

Kuchaytirilgan ustunning mustahkamligini tekshiramiz

$$\frac{l_0}{b'} = \frac{150}{26} = 5,77 \rightarrow \varphi = 0,92$$

$$N = N \leq \varphi \cdot (\eta_b (R_b \cdot A + R_{SC} \cdot A_S) + \eta_g \cdot (R_{b,R_{CR}} \cdot A_{R_{CR}} + A_{S,R_{CR}} \cdot R_{SC,R_{CR}})) =$$

$$727,69 = 0,92(1(11,5 \cdot 200 \cdot 200 + 355 \cdot 201) + 0,7(0,9 \cdot 14,5 \cdot 27600 + 1200 \cdot 113)) = 841,6 \text{ kN}$$

$$727,69 \text{ kN} \leq 841,6 \text{ kN}$$

Ustunning yuk ko'tarish qobiliyati ta'minlandi.

3. Ustun konstruksiyasini metal xalqa yordamida kuchaytirish:

Avvalambor ustun konstruksiyasining yuk ko'tarish qobiliyatini aniqlaymiz

$$N_{byq} = \varphi \cdot (R_B \cdot A + R_S \cdot A_S),$$

Ustunning egiluvchanligi:

$$\frac{l_0}{h} = \frac{1500}{200} = 7,5$$

$$\varphi = 0,913$$

yuqoridagi formulaga sonli qiymatlarini qo'yib hisoblaymiz:

$$N_{byq} = 0,913 \cdot (11,5 \cdot 40000 + 355 \cdot 201) = 485,13 \text{ kN},$$

$$N = 1,5 \cdot 485,13 = 727,695 \text{ kN},$$

$$N_0 = N - N_{byq} = 727,7 - 485,1 = 242,6kN$$

Ustun bir tomonining talab qilingan kuchaytirish yuzasi:

$$A_0 = \frac{N_0}{2 \cdot \varphi \cdot m_0 \cdot R_y} = \frac{242,6 \cdot 10^3 N}{2 \cdot 0,913 \cdot 0,9 \cdot 210 MPa} = 702,9 mm^2 = 7,03 sm^2,$$

bunda m_0 -iShKAsH sharoitini hisobga oluvchi koeffisient;

R_y - C235 sinfli po‘latning hisobiy qarshiligi.

Ustunning qarama-qarshi tomonida joylashgan har bir rasporikalarni 2ta burchakliklardan qabul qilamiz va 63x40x4;

$$A_{2bur63x40x4} = A_0 = 8,08 sm^2 > 7,03 sm^2$$

2ta 63x40x4 burchaklik uchun sortament jadvalidan quyidagi xususiyatlarni qabul qilamiz:

$$A = 4,04 sm^2; t_{qal} = 4 mm; i_x = 2,01 sm;$$

$$i_y = 1,13 sm; x_0 = 0,91 sm; y_0 = 2,03 sm;$$

Burchakliklarni bog‘lovchi plankalar hisobi

Plankalarga shartli ko‘ndalang kuchlar ta’sir etadi. A240 sinfli metal uchun:

$$Q_p = 0,2 \cdot A_0 = 0,2 \cdot 8,08 sm^2 = 16,16 kN.$$

“Metal konstruksiyalar” ga asosan ustundagi plankalarning egilishi 40 dan yuqori bo‘lmasligi talab etiladi.

$$l_n = \lambda \cdot i_u = 40 \cdot 0,87 = 33,6 sm.$$

Plankalar qadamini $l_n = 35 sm$ qabul qilamiz.

Plankalarni qirquvchi kuch $l_n = 35 sm$ da quyidagiga teng:

$$T = \frac{Q_p \cdot l_n}{c} = \frac{1,62 kN \cdot 0,35 m}{0,19} = 2,98 kN,$$

bunda c-burchaklik og‘irlik markazi orasidagi masofa:

$$c = b + 2 \cdot t_{qal} - 2 \cdot x_0 = 200 mm + 2 \cdot 4 mm - 2 \cdot 9,1 mm = 189,8 mm = 0,19 m$$

Planka tekisligidagi eguvchi moment:

$$T = \frac{Q_p \cdot l_n}{2} = \frac{1,62 kN \cdot 0,35 m}{2} = 0,28 kN \cdot m,$$

$$W_{NT} = \frac{M}{R_y} = \frac{0,28 \cdot 10^6 N \cdot m}{210} = 1333 mm^3 = 1,5 sm^3,$$

Planka qalinligini burchaklik profiliga yaqin qabul qilamiz $\delta = 6 mm$.

$$h_{pl} = \sqrt{\frac{W_{NT} \cdot 6}{\delta}} = \sqrt{\frac{1333 \cdot 6}{6}} = 36,5 mm \approx 37 mm.$$

Plankani 40x6 qabul qilamiz.

Plankalar qadamini 150mm qabul qilamiz.

Metal burchaklik bilan kuchaytirilgan ustunning yuk ko'tarish qobilyati quyidagiga teng:

$$N_{0ult} = \varphi \cdot [R_b \cdot A_b + R_{SC} \cdot A_{s,tot} + \varphi_1 \cdot R_{sc,ad} \cdot A_{sad,tot}] =$$

$$0,913 \cdot [11,5 \cdot 40000 + 355 \cdot 201 + 0,913 \cdot 210 \cdot 1616] = 768,0kN;$$

$$727,69kN \leq 768,0kN$$

Ustunning yuk ko'tarish qobilyati ta'minlandi.

4. Temirbeton ustun konstruksiyasini kompozit materiallar bilan kuchaytirish:

Murakkab kuchlanish holatida ishlovchi betonning talab qilingan mustahkamlik qiymatini aniqlaymiz:

$$R_{b3}^{talab} = \frac{\frac{N}{\varphi} - R_{SC} \cdot A_{stot}}{A_b} = \frac{\frac{729670}{0,913} - 3550 \cdot 2,01}{384} = 2062,7kg * kuch / sm^2$$

$$\text{bunda } A_b = b \cdot b - 2 \cdot r \cdot r = 20 \cdot 20 - 2 \cdot 2 \cdot 2 = 384sm^2$$

yaxlit xalqa hosil qilinganda beton mustahkamligining oshishi.

$$R_{bf} = R_{b3}^{talab} - R_b = 2062,7 - 1150 = 910,7kg * kuch / sm^2$$

ko'ngdalang kompozit armaturalash koeffisienti:

$$\mu_f = \frac{R_{bf}}{k_{ef} \cdot k_b \cdot R_f} = \frac{910,7}{0,36 \cdot 1 \cdot 30000} = 0,084;$$

$$\text{bunda; } k_{ef} = 1 - \frac{(b-2r)^2 + (h-2r)^2}{2b \cdot h} = 1 - \frac{(20-2 \cdot 2)^2 + (20-2 \cdot 2)^2}{2 \cdot 20 \cdot 20} = 0,36;$$

yaxlit xalqa uchun xalqadagi mavjud uzilishlarni hisobga oluvchi koeffisient $k_b = 1,0$

kompozit materialning cho'zilishdagi hisobiy qarshiligi $\gamma_{f2} = 1,0$ koeffisientda

$$R_f = \frac{\gamma_{f1} \cdot \gamma_{f2} \cdot R_{fn}}{\gamma_f} = \frac{0,95 \cdot 1 \cdot 3790}{1,2} = 3000kg * kuch / sm^2;$$

kompozit material kesim yuzasi maydoni:

$$A_f = \mu_f \cdot A = 0,084 \cdot 384 = 32,3sm^2$$

kuchaytirish kerak bo'ladigan ishchi kesim yuzasi perimetri:

$$U_f = 2(b+h-4r) = 2(20+20-4 \cdot 2) = 64sm$$

Armoshel KB500 li t=0,27 sm li xalqadagi qatlamlar soni

$$n_f = \frac{A_f}{U_f \cdot t_f} = \frac{32,3}{64 \cdot 0,27} = 1,87;$$

2 qatlamli xalqa qabul qilamiz.

Armoshel KB900 li t=0,48 sm li material qo'llanilganda:

$$n_f = \frac{A_f}{U_f t_f} = \frac{32,3}{64 \cdot 0,48} = 1,05;$$

1 qatlamli xalqa qabul qilamiz.

Uglekompozit material bilan kuchaytirilgan ustunning yuk ko'tarish qobilyati quyidagiga teng:

$$N_{0ult} = \varphi \cdot [R_b \cdot A_b + \varphi_1 \cdot R_f \cdot A_{sad,tot}] =$$

$$0,913 \cdot [11,5 \cdot 40000 + 0,913 \cdot 300 \cdot 1230] = 727,6kN;$$

$$727,69kN \leq 727,6kN$$

Ustunning yuk ko'tarish qobilyati ta'minlandi.

No	Kuchaytirish usullari	Kuchaytirilmagan ustun yuk ko'tarish qobilyati, kN	Kuchaytirilgan ustun yuk ko'tarish qobilyati, kN
1	Ustun konstruksiyasini temirbeton yordamida kuchaytirish	727,69	806,46
2	Ustun konstruksiyasini kompozitbeton yordamida kuchaytirish	727,69	841,6
3	Ustun konstruksiyasini metal xalqa yordamida kuchaytirish	727,69	768,0
4	Temirbeton ustun konstruksiyasini kompozit materiallar bilan kuchaytirish	727,69	727,6

Shishakompozit va po'lat armatura narxlarini taqqoslash jadvali

Kompozit armatura ishlab chiqaruvchi "UNIVERSAL FRP SYSTEMS" MChJ			Taqqoslash uchun AIII sinfli armatura narxlarini		
Nomlanishi	1m uchun kompozit armatura narxi	Iqtisodiy tejamkorlik bo'yicha koeffitsient %	Teng kesim yuzali o'rni bosuvchi armatura	1m uchun po'lat armatura narxi	1 tonna uchun metal narxi
ShKA-04mm	1064	60	BP-1 06mm	2664	12000000
ShKA-05mm	1736	52	BP-1 07mm	3624	12000000
ShKA-06mm	2352	32	AIII- 08mm	3476	8800000
ShKA-07mm	2632	52	AIII- 010mm	5430	
ShKA-08mm	3248	58	AIII- 012mm	7814	
ShKA-010mm	5208	51	AIII- 014mm	10648	
ShKA-012mm	7616	45	AIII- 016mm	13904	
ShKA-014mm	10752	39	AIII- 018mm	17600	
ShKA-016mm	14224	35	AIII- 020mm	21736	

Olingan ma'lumotlar va tahlillarga ko'ra, quyidagi xulosalarni chiqarish mumkin:

1. Ushbu tadqiqot ishida tasvirlangan barcha kuchaytirish usullari 1,5 kuchaytirish koeffitsientida ustun mustahkamligini oshirishga imkon beradi.

2. Kuchaytiruvchi materiallarining narxiga ko'ra, eng arzoni kompozitbeton xalqalar bilan kuchaytirish usuli bo'lib chiqdi, uglekompozit materiallar bilan kuchaytirish boshqa kuchaytirish yuqori narx sababli boshqa usullardan sezilarli darajada farq qiladi.
3. Kuchaytirish ishlari nafaqat materiallarni, balki ishlarni, shuningdek, materiallarni obyektga yetkazib berishni, qoliplarning ijara haqqini, kran va boshqa xarajatlarni o'z ichiga oladi.
4. Tadqiqot ishida 1,5 kuchaytirish koeffitsientida bitta ustunni hisoblash misoli ko'rib chiqildi. Ushbu usulni to'liq ko'z o'ngimizga keltirishimiz uchun kuchaytirish koeffitsient miqdorini ko'paytirishimiz va ko'p sonli konstruksiyalarni iqtisodiy jihatdan taqqoslashni amalga oshirish kerak.

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