«O’zbekiston temir yo’llari» DATK
Toshkent temir yo’l muhandislari instituti

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BIR QAVATLI SANOAT BINOSINING ASOSIY YUK KO’TARUVCHI KONSTRUKSIYALARINI HISOBLASH VA LOYIHALASH

5340200 – “Bino va inshootlar qurilishi”,
5111000 – “Kasb ta’limi” (Bino va inshootlar qurilishi) ta’lim yo’nalishlari
4 – bosqich bakalavriat talabalari uchun kurs loyihasini bajarishga doir
o’quv – uslubiy qo’llanma

Toshkent – 2013

UDK 691

Bir qavatli sanoat binosining asosiy yuk ko'taruvchi konstruksiyalarini hisoblash va loyihalash. O`quv-uslubiy qo'llanma. **Shaumarov N.B., Shaumarov S.S.** ToshTYMI, T.: 2013, 80 bet.

Ushbu o'quv-uslubiy qo'llanma 5340200 − "Bino va inshootlar qurilishi", 5111000 – kasb ta'limi "Bino va inshootlar qurilishi" ta'lim yo'nalishlari bo'yicha tahsil olayotgan talabalarga "Qurilish konstruksiyalari" fani bo'yicha "Bir qavatli sanoat binosining asosiy yuk ko'taruvchi konstruksiyalarini hisoblash va loyihalash" mavzusidagi kurs loyihasini bajarishga mo'ljallangan.

Mazkur qo'llanmada bir qavatli sanoat binosining ko'ndalang ramasi, ustuni va oldindan zo'riqtirilgan temirbeton to'sinini hisoblash usullari ko'rsatib berilgan. Bino ko'priksimon kran bilan jihozlangan bo'lib, rama statik kuchlarga hisoblangan. Bu kuchlar ta'sirida ustun va to'sinning kesim yuzasida hosil bo'ladigan kuchlanishlar aniqlangan. Bu kuchlanishlar asosida element kesim yuzasining o'lchamlari va kerakli bo'lgan armatura yuzasi topilgan.

Qo'llanma O'zbekiston Respublikasida amal qiluvchi me'yoriy hujjatlar asosida va qurilishda qo'llanuvchi ko'p qavatli ishlab chiqarish binosining tipik konstruksiyalariga mos ravishda tuzilgan.

Jadvallar −12 ta, rasmlar − 27 ta, bibliogr. nom − 12 ta.

O`quv-uslubiy qo'llanma institutning O'quv-uslubiy komissiyasi tomonidan nashrga tavsiya etilgan.

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Kirish

Hisoblash ishlarini bajarishdan asosiy maqsad tashqi yuklar ta’siridan konstruksiya elementlarida hosil bo’ladigan zo’riqishlarni hamda talab etilgan armatura miqdori va konstruksiya ishchi chizmalarini tayyorlashdagi zarur ma’lumotlarni aniqlash hisoblanadi. Konstruksiyani hisoblash qurilish me’yorlari talabi asosida amalga oshiriladi.

QMQ 2.03.01-96 [1] temirbeton nazariyasining amaliy natijasi hisoblanib, u konstruksiyalarni loyihalashda, qurishda va foydalanishda erishilgan yutuqlarni o’zida aks ettiradi.

Temirbeton konstruksiyani loyihalash deb, ularning statik kuchlarga konstruksiyalarning ayrim elementlarini kesim yuzalarini hisoblash va loyihalash tushuniladi.

Umuman qurilish konstruksiyalarni hisoblash 2 bosqichdan iborat bo’ladi:

1-bosqichda elementlardagi kuchlanishni aniqlash va bu kuchlanish asosida kesim yuzasini topish;

2-bosqichda konstruksiya egilishini me’yordan oshmasligi uchun tekshirish hisoblanadi.

Kuchlanishni aniqlash bilan “Qurilish mexanikasi” fani shug’ullanadi va uni statik hisoblash usuli bilan tekshiradi. Materialning qarshiligi va uning xususiyatlarini esa “Materiallar qarshiligi” fani o’rganadi.

“Temirbeton konstruksiyalari” fani esa, beton va armaturaning xususiyatlari va ishlash sharoitini hisobga olgan holda yuqoridagi barcha vazifalarni birgalikda hal qiladi. Ya’ni statik hisob ishlarida konstruksiyalar ishlashini aniq ko’rsatadigan hisob tarhlarini belgilash, konstruksiya ishlash vaqtida ularga ta’sir etadigan tashqi yuklarni hisoblash hamda loyihalanayotgan elementlardagi kesim yuzalarida hosil bo’ladigan ichki kuchlanishlarni (eguvchi moment-M, ko’ndalang kuch-Q va bo’ylama kuch-N) aniqlash bilan shug’ullanadi.

Elementning normal kesim yuzasini samarali shakli va o’lchamlarini, beton va armaturaning optimal sinfini, kesim yuzasini va elementini yorilishga bardoshligini va bikirligini hisobga oladigan kesim- hisobiy kesim yuzasi deyiladi. Konstruksiya deb, element qismlarini birlashtirish tushuniladi.

Binolarni konstruktiv hal etish, ularning elementlaridan ishchi va montaj armaturasini foydalanishni samarali sxemasini belgilash, armatura konstruksiya tugunlari va elementlari chizmalarini ishlab chiqish konstruksiyalash deyiladi. Konstruksiyalarni loyihalash kesim yuzasi haqidagi ma’lumotlar asosida me’yoriy talablarni hisobga olgan holda

bino va inshootni qurish va foydalanish jarayonida mustahkamligi, yoriqbardoshligi va bikirligini ta’minlaydigan hisobiy kuchni aniqlashdan iborat bo’ladi.

Loyihalangan konstruksiyalarning samaradorligi ularning texnik-iqtisodiy ko’rsatkichlari hamda ishlash jarayonida mavjud foydalanish talablariga mosligi darajasiga qarab baholanadi.

Konstruksiyalarning hisoblashni eng samarali va keng qo’llanilayotgan usuli bu chegaraviy holatlar usulidir.

Konstrutsiyalarning chegaraviy holati deganda shunday holat tushuniladiki, bu holatda konstruksiyalarga qo’yilgan talablarga hamda ishlab chiqarish talablariga javob bermay qoladi, ya’ni ulardan foydalanib bo’lmaydi. Chegaraviy holatlar bo’yicha hisoblashning asosiy maqsadi, konstruksiyani tayyorlashda yoki ulardan foydalanishda chegaraviy holatlar paydo bo’lishiga yo’l qo’ymaslikdir.

Temirbeton konstruksiyalarining chegaraviy holat bo’yicha hisoblashda:

Birinchidan, tashqi yuklar holatini elementning kesim yuzasiga ta’sirini hisobga olish ko’zda tutiladi (M, Q, N). So’ng mustahkamligi va yorilish bardoshligini ta’minlovchi ichki kuchlar aniqlanadi va ular tashqi kuchlar bilan solishtiriladi.

Ikkinchidan, tashqi kuchlar ta’sirida temirbeton elementlaridagi yoriqlarni paydo bo’lishi va kengayishi hamda deformatsiyasi aniqlanadi. Bular ruxsat etilgan me’yoriy qiymati bilan taqqoslanadi.

Kuchni hisoblash statik noaniq konstruksiyalarda, masalan ramalarda qurilish me’yoriy qoidasi bo’yicha mavjud bikirligini hisoblashda amalga oshirilishi kerak.

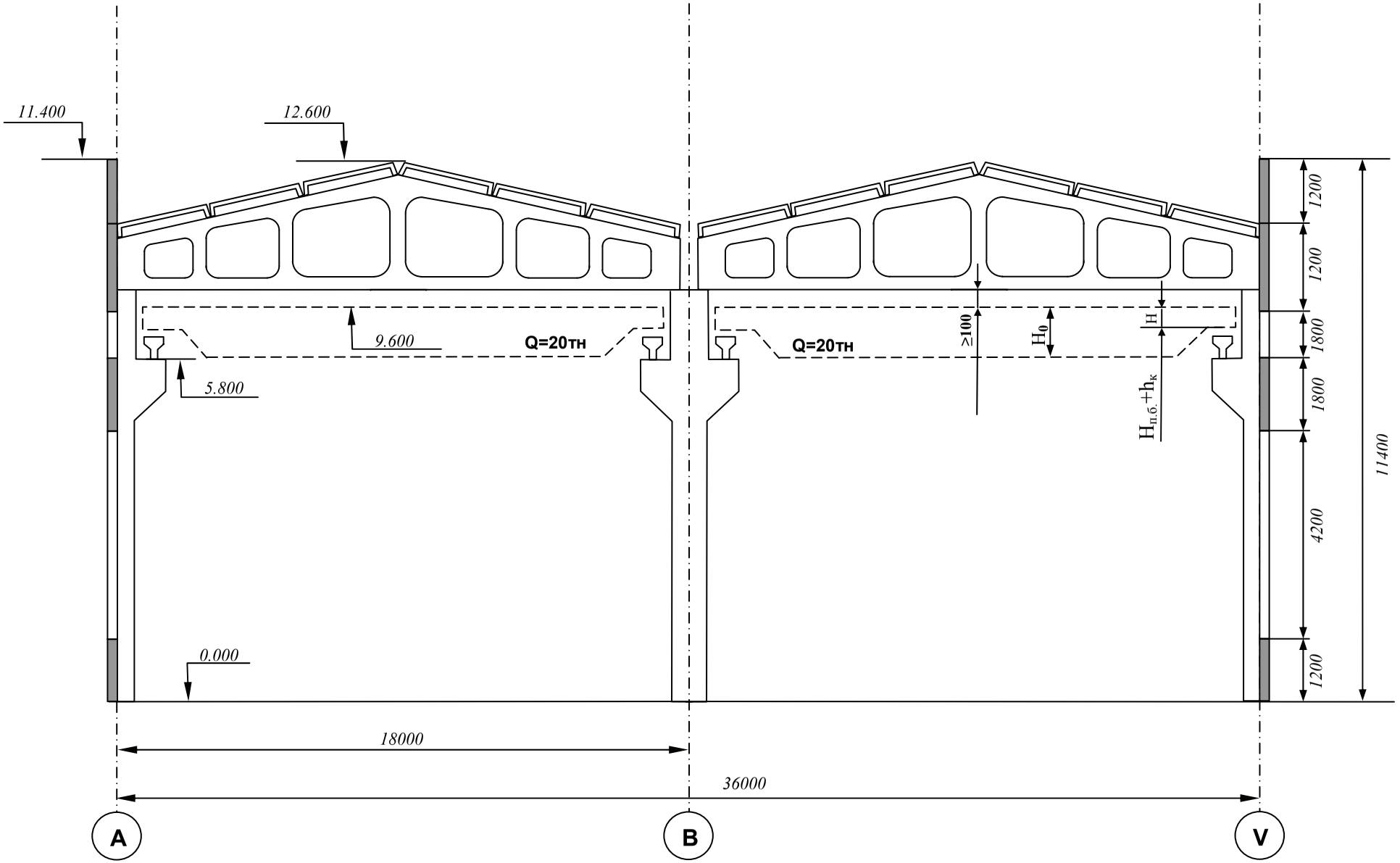
Shuning uchun mazkur o’quv qo’llanmada bir qavatli, ko’prik kranli, sanoat binosini hisoblash va loyihalash ko’rsatilgan. Bir qavatli ishlab chiqarish binolarining sinchi fazoviy tizimnini ifodalaydi, ya’ni ularni hisoblashda shartli ravishda bo’ylama va ko’ndalang tekis ramalarga ajratish mumkin. Shuning uchun ko’ndalang ramaga ta’sir qilayotgan kuchlar va ularning ta’sirida konstruksiyada hosil bo’ladigan kuchlanishlarni aniqlash hamda oldindan zo’riqtirilgan to’sinni hisoblashga doir masalalar yoritib berilgan.

1. Bir qavatli sanoat binosining asosiy yuk ko'taruvchi konstruksiyalarini hisoblash va loyihalash

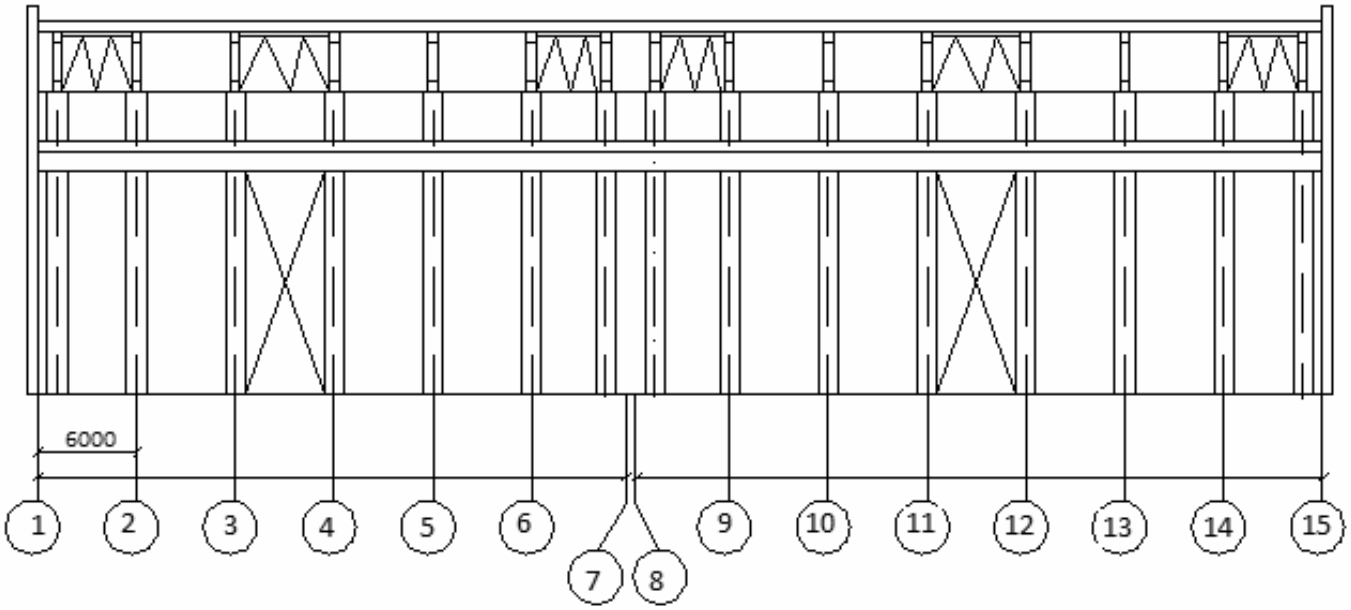
Bir qavatli sanoat binosining konstruktiv yechimi. O'lchami 36x78 m bo'lgan bir qavatli sanoat binosining konstruktiv elementlarini hisoblash talab etiladi. Ikki oraliqli bu bino o'lchami 18x6 m ustunlar qatori bilan ajratilgan. Binoning har bir oralig'iga $Q_{кр}$=20t ko'tarish quvvatiga ega ikkitadan ko'priksimon kran o'rnatish ko'zda tutilgan. Yerdan stropila konstruksiyasining pastki qismigacha bo'lgan balandlik H=9.6 m ni tashkil etadi. Bir qavvatli sanoat binosining ko'ndalang yo'nalish bo'yicha turg'unligini ko'ndalang rama va uning tarkibiga kiruvchi ustun va rigellar, bo'ylama yo'nalishi esa ustun va to'sinlardan iborat bo'ylama ramalar (1-rasm) bilan ta'minlangan. Ular tayanch nuqtalarida maxsus bog'lagichlar orqali stropila konstruksiyasining markaziy qismi va ustunlar bilan uzviy bog'langan.

3-rasmda bino tom konstruksiyalarini bog'lagichlar yordamida qanday mahkamlanishi ifodalangan. Tom yopmalari vertikal tomdan, qordan tushadigan yuklar hamda ventilyatsiya moslamalari va boshqa qurilmalari bilan birgalikda stropil konstruksiyasiga tushadi. Shuningdek, ular bino sinchining zilzila, shamol ta'siriga hamda ko'tarma kranlarning yonlama ta'siridan saqlanishi uchun bikir disk shaklidagi gorizontal bog'lag'ich vazifasini ham bajaradi.

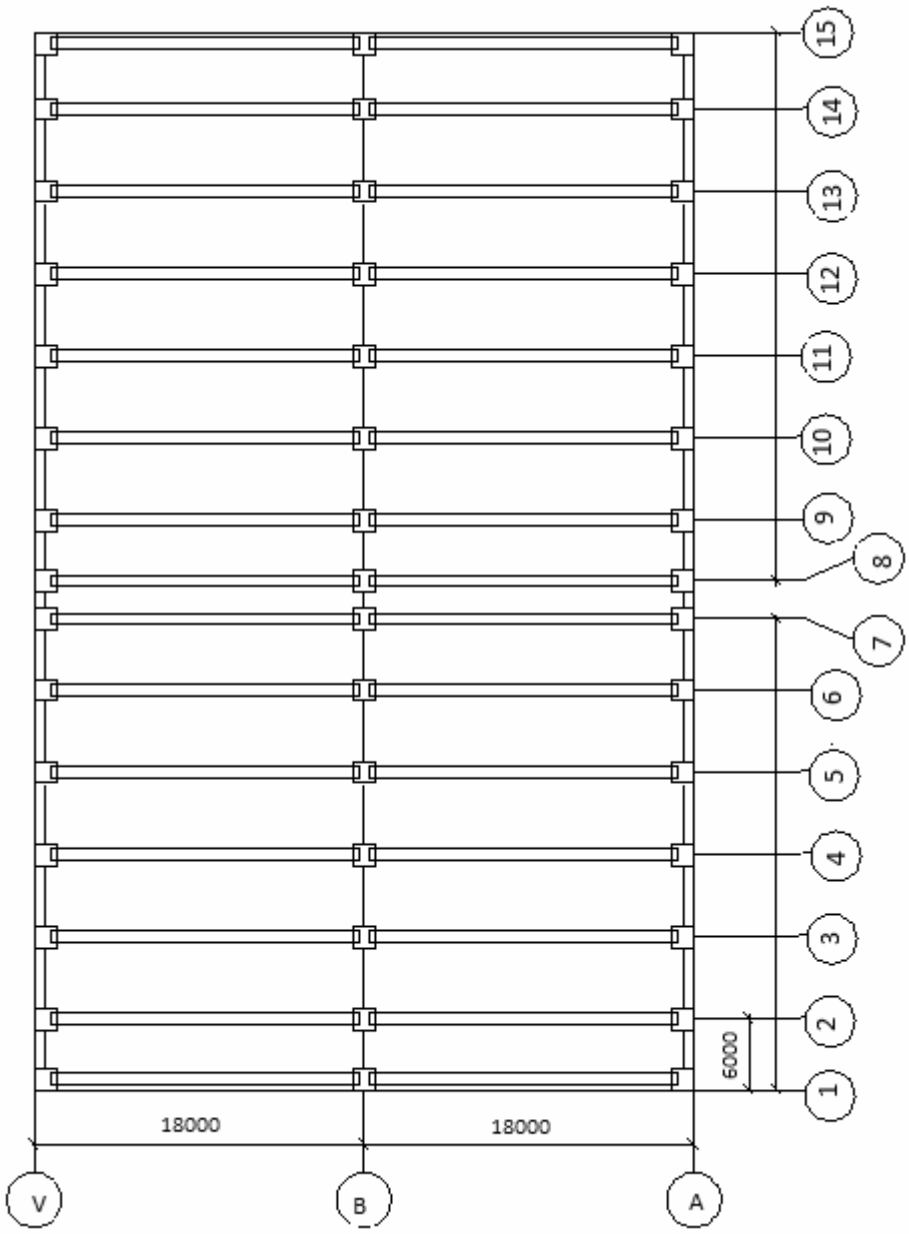
Sanoat binosining uzunligi harorat ta'sirini hisobga olgan holda antiseysmik chok bilan birlashtiriladi. Chok uzunligi aniq hisob-kitoblarga ko'ra belgilanadi.



1-rasm. Binoning ko’ndalang qirqimi



2- rasm. Binoning bo’ylama qirqimi



3-rasm. Tom yopma stropilalar tarhi

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Bo'ylama o'qlar bo'yicha bog'lanish. 30 t gacha yuk ko'taruvchi ko'priksimon kranlar bilan jihozlangan (oralig'i 6 m va balandligi 16.2 m dan kam bo'lmagan ustun) (1-rasm) binolar ustunlarining tashqi tomoni va devorlarning ichki- ustki qismi uzunasiga oraliq o'qlar bilan birlashtiriladi (nolli bog'lanish).

50 t gacha yuk ko'taruvchi ko'priksimon kranlar bilan jihozlangan oralig'i 6 m hamda balandligi 16.2 m yoki 18 m, shuningdek, oralig'i 12 m va balandligi 8.4 m dan 18 m gacha bo'lgan binolar ustunlarining tashqi tomoni va devorlarning ichki-ustki qismi bo'yicha 250 mm lik oraliq o'qlari bilan birlashtiriladi. Ma'lum asoslarga ega bo'lgan holda ustunlarning tashqi tomoni va devorlarning ichki-ustki qismini bo'yiga 500 mm lik oraliq o'qlari bilan birlashtirishga ruxsat beriladi.

O'rta qator ustunlari uzunasiga antiseysmik choklar bilan birlashtirilgan bir yo'nalish oralig'ida balandligi o'zgaradigan o'rta qator ustunlaridan tashqari ularning kran osti qismlari bo'yiga ham eniga ham oraliq o'qlari mos kelishi kerak.

Ko'ndalang o'qlarning joylashishi. Ustunlarning geometrik o'qi bino burchagida joylashgan hamda harorat choklar bilan uyg'un ustunlarni istisno qilingan holda eniga yo'naltirilgan o'qlari bilan birlashtiriladi.

Bino asosiy sinchning burchagida joylashgan ustunlarining geometrik o'qi 500 mm ga bino ichki tomoniga surilgan o'qlarga joylashtiriladi. Burchak devorlarining ichki qismi binoning yon tomoni bilan joylashgan o'qlarga mos keladi (nolli bog'lanish) (3-rasm). Balandligi 9.6 m bo'lib, 30 t gacha yuk ko'taruvchi kranlar bilan jihozlangan, oralig'i 24 m bo'lgan bino ustunlari to'g'ri burchakli qilib qabul qilinadi. Agar binoning parametrlari yuqorida keltirilgan qiymatlardan katta bo'lsa u holda ichki teshikli ustunlar qo'llaniladi.

1.1. Hisoblash uchun kerakli ma'lumotlar

Qurilish hududi:

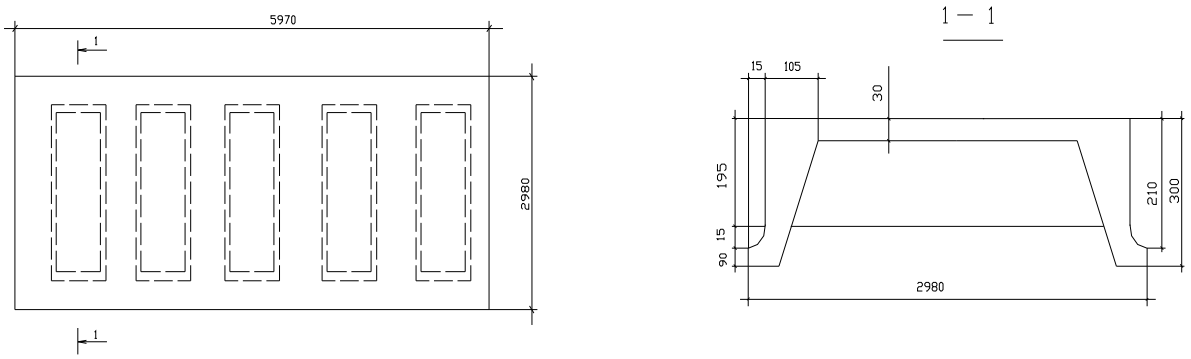
Qor qalinligi hosil bo'lgan yuk II (S_0=0.7 kN/m^2);

Shamol bosimi (tezligi) bo'yicha III (W_0 =0.38kN/m^2).

Bir qavatli sanoat binosining konstruktiv asosini yig'ma temirbeton konstruksiyadan iborat bo'lgan karkas asosidagi bo'ylama va ko'ndalang ramalar tashkil etadi.

Karkasli bino elementlarining konstruksiyalari:

1. O'lchami 3×6 m oldindan zo'riqtirilgan tom yopma plitalari (4-rasm).

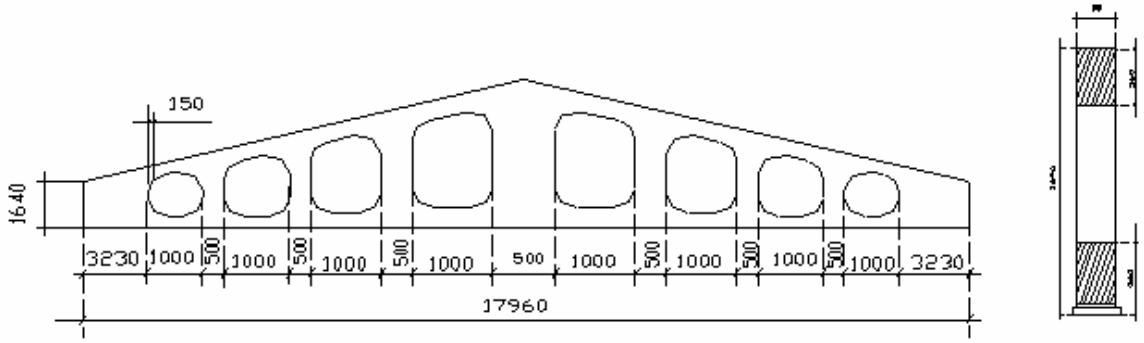


4-rasm. Oldindan zo'riqtirilgan tom yopma plitasi

1-jadval

Plitaning marka va seriyasi	Betonning sinfi	Material sarfi		Plitaning og'irligi, kN
		Beton, m^3	Po'lat.kg	
1	2	3	4	5
$\frac{AV}{3x6}-5$	B25	1.07	103	27

2. Bino tomi rulonli to'shama bilan yopilgan hamda ikki nishabli uzunligi 18m bo'lgan oldindan zo'riqtirilgan panjarasimon tuynukli to'sin bilan jihozlangan (5-rasm).



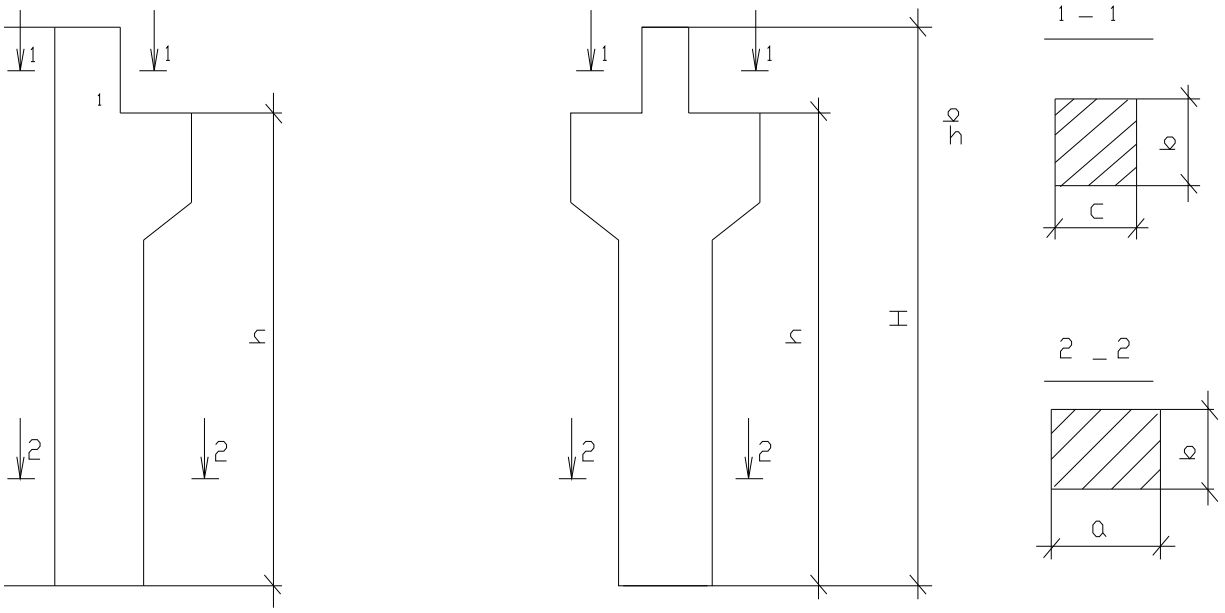
5-rasm. Ikki nishabli uzunligi 18m bo'lgan oldindan zo'riqtirilgan panjarasimon tuynukli to'sin

2-jadval

To'sinning marka va seriyasi	Kesim yuzasining o'lchamlari,mm		Betonning sinfi	Material sarfi		To'sinning og'irligi, kN
	h_1	h_2		Beton, m^3	Po'lat,kg	
1	2	3	4	5	6	7
БДР 18-2 A-V	320	360	B30	3,4	307	92

1. Chetki ustunlari oralig'i 6m., o'rtadagilari oralig'i 6 (12m). bo'lib, 10-20t lik ko'priksimon kran bilan jihozlangan, oralig'i 18-24m bo'lgan

bir qavatlik binoning ustunlari yaxlit kesimli to’g’ri burchakli qilib loyihalanadi (6-rasm).



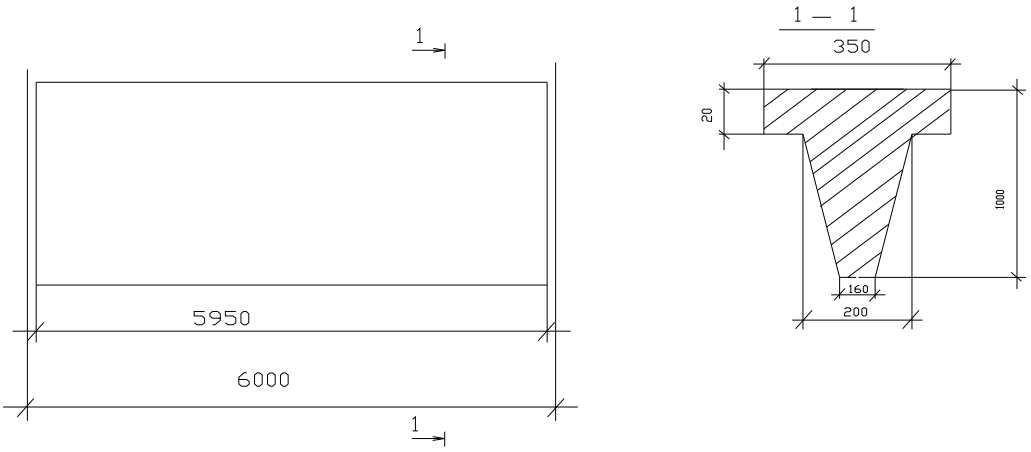
6-rasm. Chetki va o’rta qator ustunlari

3-jadval

Ustun-ning marka va seriyasi	Ustun qadami, m	Poldan balandligi, m		Kran-ni yuk ko’tarishi (tN)	Ustun o’lchamlari (mm)					Beton-ning sinfi	Material sarfi		Ustun og’irligi, kN
		Storopil konstruksiyasi-ning pastki qismigacha	Kran relsi-ning yuqori qismigacha		H	h	a	b	c		Beton m^3	Po’lat kg	
1	2	3	4	5	6	7	8	9	10	11	12	13	14
КП1-5	6	9.6	Chetki qator ustunlari										
			6.95	20	10600	6800	800	400	380	B20	2.83	271	71
КП1-8	6	9.6	O’rta qator ustunlari										
			6.95	20	10600	6800	800	400	600	B20	3.67	421	92

2. Oldindan zo’riqtirilgan kran osti yig’ma to’sinlari.

КЭ-01-40 seriyasidagi Q=5÷20t. yuk ko’taruvchi kranlar bilan jihozlangan, oralig’i 6m (7-rasm).

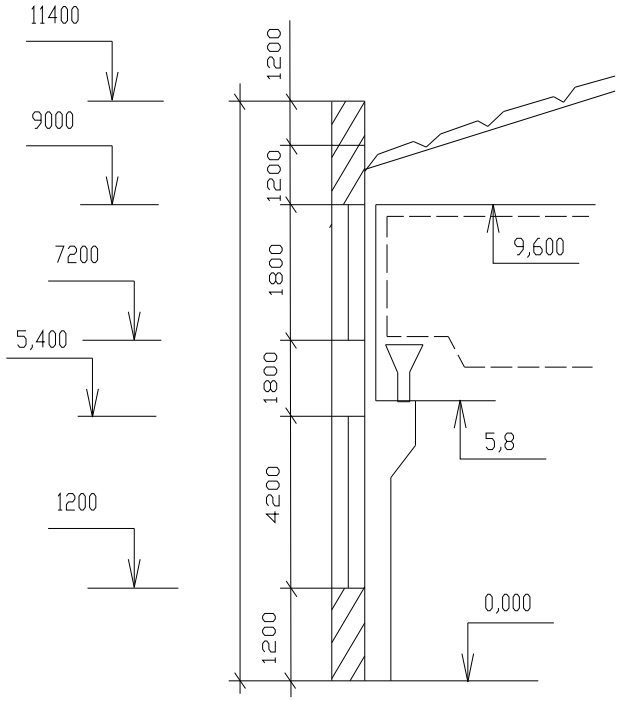


7-rasm. Oldindan zo'riqtirilgan kran osti to'sini

4-jadval

Balkaning marka va seriyasi	O'lchamlar (mm)			Betonning sinfi	Kranning yuk ko'tarishi, QTN	Material sarfi		To'sin og'irligi kN
	l	b	h			Beton, m^3	Po'lat,kg	
1	2	3	4	5	6	7	8	9
БКНЛ6-1К	5950	350	1000	B25	20	1.17	178	29.3

3. Qalinligi 240mm bo'lgan, yengil betondan tayyorlangan oralig'i 6m li ustunlarga o'rnatilgan devor paneli (isitiladigan binolar uchun) (8-rasm).



8-rasm. Ustunlarga o'rnatilgan devor panellarining joylashuvi

PPYu – parapet panelining yuqori qismi PPYu =SKT+$h_т$+$h_{пл}$+$t_{кр}$ (20...30sm) SKT=9,6m stropila konstruksiyasining tag qismigacha bo'lgan masofa.

$h_т$ =0.89m stropila to'sinining tayanch qismi balandligi

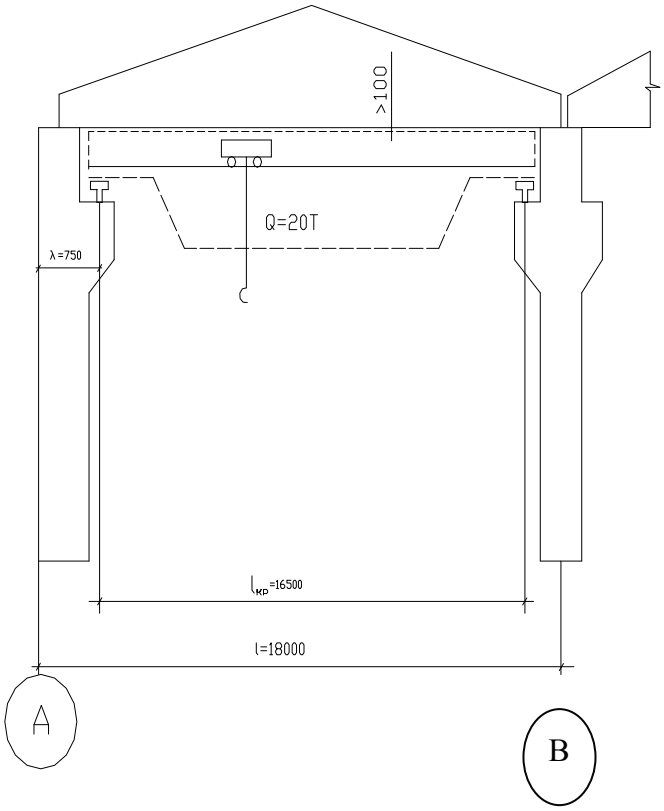
$h_{пл}$ =0.3m plita balandligi $t_{кр}$ =0,2+0,3m tom yopma to'shamasining qalinligi parapet panelining yuqori qismi PPYu =11.4 m.

5- jadval

Panel chizmasi	Panel markasi	Panelning qalinligi	Betonning hajmiy og'irligi,kg/m^3	Material sarfi		Panel og'irligi, kN
				Beton, m^3	Po'lat, kg	
1	2	3	4	5	6	7
1200 6000	$\frac{ПСЛ20}{1.2x6}$	200	900-1200	1.14	28-119	20
1800 6000	$\frac{ПСЛ20}{1.8x6}$	200	900-1200	1.70	34-151	30

1.2. Kran jihozlarining asosiy ko'rsatkichlari

Berilgan topshiriqqa ko'ra, o'rtacha ish rejimli Q=20 t yuk ko'taruvchi ko'priksimon kran qabul qilingan (9-rasm).



9-rasm. Ko'priksimon kranning ko'rinishi

$$l_{kp} = l - 2 \cdot \lambda = 18 - 2 \cdot 0{,}75 = 16{,}5м$$

6- jadval

Q (тN)	$l_{кр}$, (m)	Asosiy o'lchamlar (mm)			Kranning relsi	Kran g'ildiragining relsga ta'sir qilayotgan bosimi				Og'irligi (kN)	
		B	K	N		P^{max}	P^{min}	T	$T_{пр}$	aravacha	kranning
1	2	3	4	5	6	7	8	9	10	11	12
20	16.5	6300	4400	2400	P43, KP70	195	48	7.1	19.5	85.0	285

2. Sinchli binoning ko'ndalang ramasini statik kuchlar ta'siriga hisoblash

2.1. Ko'ndalang ramaning tuzilishi

Asosiy uyg'unlashgan kuchlar ta'siridagi bosimni hisobga olgan holda ko'ndalang ramalar qatorini ko'rib chiqamiz. Ko'ndalang ramalarning tuzilish sxemasini aniqlash uchun uni o'lchamlarini topamiz.

$N_{в=}$N-h=10600-6800=3800mm=3.8m

$N_N=N_0-N_в$+0,15=9600-3800+0,15=5950mm=5,95m

$N_в$- kran usti qismi balandligi;

N_N- kran ostki qismidan to poydevor ustki qismigacha bo'lgan balandlik;

N- ustunning uzunligi;

h- ustunning kran ustki qismi balandligi;

N_0- bino balandligi; 0,15- pol ustidan poydevorning usti qismigacha bo'lgan masofa.

Ko'ndalang rama uchun ustun kesim yuzasining inersiya momentlari formulasi quyidagicha aniqlanadi:

Chetki ustun (kran usti qismi uchun) $I_{b1} = \frac{b \cdot c^3}{12} = \frac{0.4 \cdot 0.38^3}{12} = 1.83 \cdot 10^{-3} m^4$;

Chetki ustun (kran osti qismi uchun) $I_{H1} = \frac{b \cdot a^3}{12} = \frac{0.4 \cdot 0.8^3}{12} = 17{,}07 \cdot 10^{-3} m^4$;

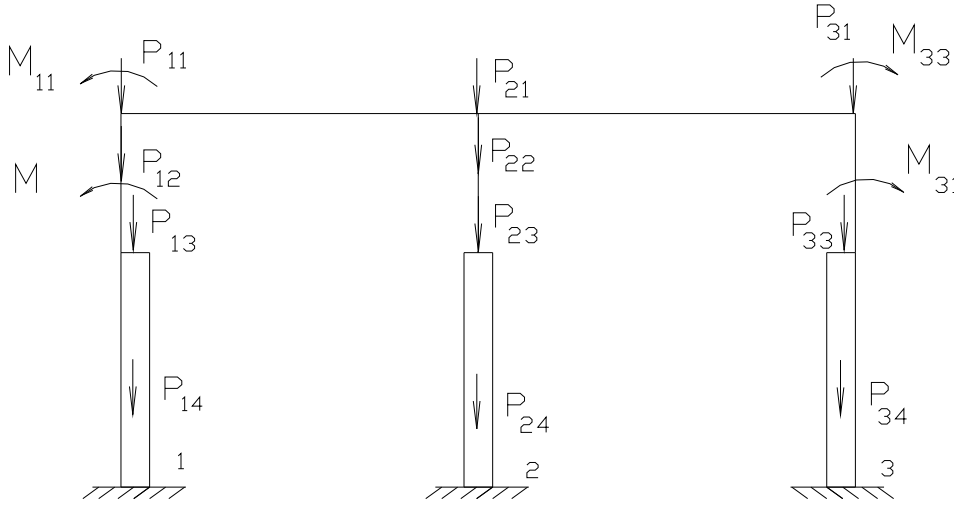
O'rta ustun (kran usti qismi uchun) $I_{b2} = \frac{b \cdot c^3}{12} = \frac{0.4 \cdot 0.6^3}{12} = 7.2 \cdot 10^{-3} m^4$;

O'rta ustun (kran osti qismi uchun) $I_{H2} = \frac{b \cdot a^3}{12} = \frac{0.4 \cdot 0.8^3}{12} = 17.07 \cdot 10^{-3} m^4$.

$J_{B3} = J_{B1} = 1{,}83 \cdot 10^{-3}$; $\quad J_{H3} = J_{H1} = 17{,}07 \cdot 10^{-3}$

2.2.Ko'ndalang rama sinchiga ta'sir qilayotgan vertikal yuklarni aniqlash

2.2.1. Ramaga tushayotgan doimiy yuklarni aniqlash



10-rasm. Doimiy yuklar ta'sirida bo'lgan ramaning hisobiy sxemasi

7-jadval

Doimiy yuk miqdorini aniqlash

Yuk turi	Me'yoriy yuk	Ishonchlilik koeffitsiyenti, γ_f	Hisobiy yuk
1. Tom, (kN/m^2)			
-rulonli yopma	0.15	1.2	0.18
-asfaltli qatlam δ=20mm	0.35	1.2	0.42
-gazobetonli issiqlik o'tkazmaydigan qatlam δ=120mm, γ=400 kg/m^3	0.48	1.3	0.624
-bug'dan himoya qiladigan qatlam	0.05	1.2	0.06
-choki to'ldirilgan t/b plitalar	1.78	1.1	1.96
Jami	$q^{н}_{кр}=2.81$		$q_{кр}=3.244$
Ikki nishabli,tuynukli to'sin (kN)	85	1.1	$G_δ$=93.5
chetki qator ustuni			
-kran usti qismi 0.38·0.4·3.8·25=14.44			
-kran osti qismi	14.44	1.1	G_{b1}=15.884
$G_{H1}=G_k-G_{b1}=71-14{,}44$			
o'rta qator ustuni	56.56	1.1	$G_{H!}$=62.216
-kran usti qismi 0.6·0.4·3.8·25=22.8			
-kran osti qismi	22.8	1.1	G_{b2}=25.08
$G_{H1}=G_k-G_{b1}=92-22.8$	69.2	1.1	G_{H2}=76.12
-kran osti to'sini, kN	29.3	1.1	$G_{nδ}$=32.23
-devor panellari, kN/m^2	2.2	1.1	$g_{ст.n}$=2.42
-deraza oynalari, kN/m^2 .	0.4	1.1	$g_{ост}$=0.44

$$e_1 = \frac{C}{2} - 150 = \frac{380}{2} - 150 = 40\ mm$$

$$e_2 = \frac{C}{2} + 20 + \frac{h_{C.T.П}}{2} = \frac{380}{2} + 20 + 100 = 310\ mm$$

$$e_3 = \lambda - \frac{a}{2} = 750 - 400 = 350\ mm$$

$$e_4 = \frac{a}{2} - \frac{C}{2} = 400 - 190 = 210\ mm$$

$$e_5 = \frac{a}{2} + 20 + \frac{h_{C.T.П}}{2} = 400 + 20 + 100 = 520\ мм$$

Sxemaga ko'ra yuklarning uyg'unlashishidan doimiy yuklarni hisoblab chiqamiz.

$$P_{11} = q_{кр} \cdot \frac{Ld}{2} + \frac{G_\delta}{2} + q_{ct.n.} \cdot d \cdot h_1 = 3.244 \cdot \frac{18 \cdot 6}{2} + \frac{93.5}{2} + 2.42 \cdot 6 \cdot 1.8 = 175.18 + 46.75 + 26.136 = 248.07$$

$$P_{12} = G_{b1} + q_{CT.П.} \cdot d(h_2 + h_4) + q_{O.C.T} \cdot d \cdot h_3 = 15.88 + 2.42 \cdot 6 \cdot (0.6 + 1.4) + 0.44 \cdot 6 \cdot 1.2 =$$

$$= 15.88 + 29.04 + 3.168 = 48.09$$

$$P_{13} = G_{n.б.} = 32.23$$

$$P_{14} = G_{H1} + q_{CT.П.} \cdot d \cdot h_5 + q_{OC.T} \cdot d \cdot h_6 = 62.22 + 2.42 \cdot 6 \cdot 0.4 + 0.44 \cdot 6 \cdot 1.8 = 62.22 + 5.8 + 4.75 = 72.77$$

$$P_{21} = q_{кр} \cdot Ld + G_\delta = 3.24 \cdot 18 \cdot 6 + 93.5 = 349.92 + 93.5 = 443.42$$

$$P_{22} = G_{b2} = 25.08$$

$$P_{23} = 2G_{n.б.} = 2 \cdot 32.23 = 64.46$$

$$P_{24} = G_{H2} = 76.12$$

Bu yerda L va d – to'sinining uzunligi va ustun qadami L=18,0 m; d=6,0m.

Doimiy yuklar ta'siridan eguvchi moment qiymati (nol bog'lanish).

$$M_{11} = -\left(q_{кр} \cdot \frac{Ld}{2} + \frac{G_\delta}{2}\right)e_1 - q_{CT.П.} \cdot d \cdot h_1 \cdot e_2 = -(3.24 \cdot \frac{18 \cdot 6}{2} + \frac{93.5}{2}) \cdot 0.04 - 2.42 \cdot 6 \cdot 1.8 \cdot 0.31 =$$

$$= -(174.96 + 46.75) \cdot 0.04 - 8.10 = -8.67 - 8.10 = -16.97$$

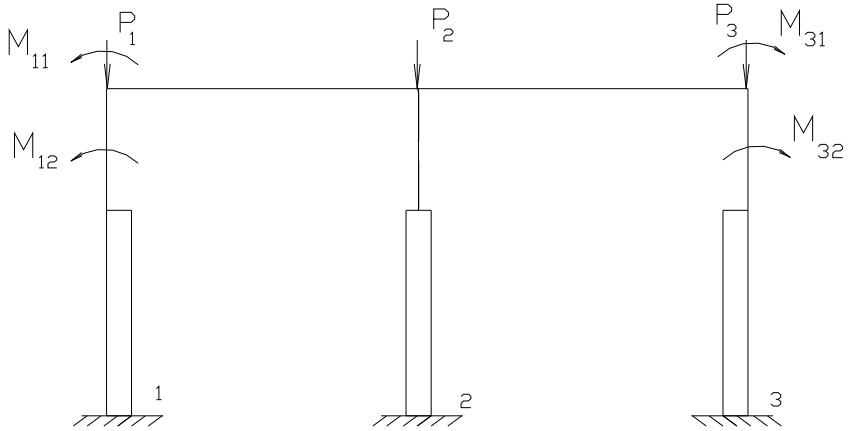
$$M_{13} = -(P_{11} + G_{b1}) \cdot e_4 + q_{CT.П.} \cdot d(h_2 + h_4 + h_5)e_5 - q_{O.C.T.} \cdot d(h_3 + h_6)e_5 + P_{13}e_3 =$$

$$= -(248.07 + 15.88) \cdot 0.21 + 2.42 \cdot 6(0.6 + 1.4 + 0.4) \cdot 0.52 +$$

$$+ 0.44 \cdot 6(1.2 + 1.8) \cdot 0.52 + 32.23 \cdot 0.35 = -55.43 + 18.12 + 4.12 + 11.28 = -21.9$$

2.2.2. Ramani qor bosimi ta'siriga hisoblash

Qor bosimi ta'sirida bo'lgan ramaning hisobiy sxemasi 11-rasmda berilgan.



11-rasm. Qor bosimi ta’sirida bo’lgan ramaning hisobiy sxemasi

Teng taqsimlangan yoyiq hisobiy qor bosimining hisobi $S = S_0 \mu \gamma_f h_c$ aniqlanadi. Bu yerda S_0 1 m^2 yuzaga tushadigan qor og’irligi (13.4-jadval)ga ko’ra, μ=1 (п5.3-5.6 [2]) binoan, yerdagi qor qalinligini tomdagi qor bosimga o’tish koeffitsiyenti; $\gamma_{f=1,4,}$ yuk bo’yicha ishonchlilik koeffitsiyenti. Yuklarning uyg’unlashishidagi asosiy yuk S=0,7·1·1,4·0,9=0,88kN/m^2. Chetki ustunga hisobiy qor bosimining ta’siri.

$\rho_1^{сн} = \rho_3^{сн} = S\frac{Ld}{2}$ =0,88$\frac{18*6}{2}$=47,5kN

O’rta ustunga ta’siri p_2^{cN}=SLd=0,88·18·6=95,04kN

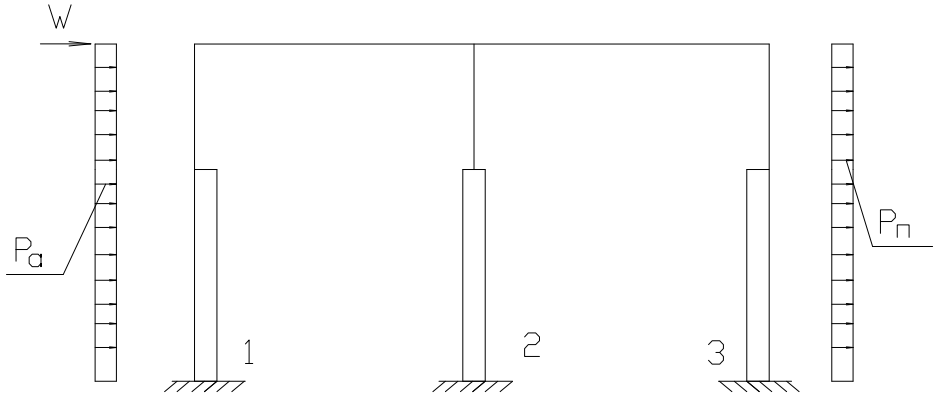
Qor bosimining ta’siridan hosil bo’ladigan eguvchi moment qiymati

$M^{сн}_{11} = -\rho^{сн}_1 e_1$ =-47,5·0,04=-1,9kN·m

$M^{сн}_{12} = -\rho^{сн}_1 (e_4 + e_1)$=-47,5(0,21+0,04)=-11,88kN·m

2.2.3. Ramani shamol bosimi ta’siriga hisoblash

Shamol bosimi ta’sirida bo’lgan ramaning hisobiy sxemasi 12-rasmda keltirilgan.



12-rasm. Shamol bosimi ta’sirida bo’lgan ramaning hisobiy sxemasi

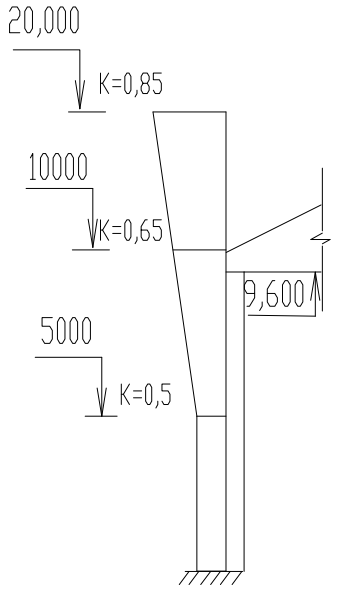
Shamol ta’siridan hosil bo’ladigan kuch quyidagi formula bo’yicha aniqlanadi.

$$W = W_0 \mathrm{K} C \gamma_f$$

Bu yerda W_0 =0.38 kN/m^2 ; koeffitsiyenti K quyidagi formula bo’yicha topiladi.

$\mathrm{K} = \mathrm{K}_{10} + \frac{(\mathrm{K}_{20} - \mathrm{K}_{10})}{10} h$. Ustunning tepa qismida

$$\mathrm{K}_{9,6}=0,5+\frac{(0,65-0,5)}{5}\cdot 4,6 = 0,638m .$$



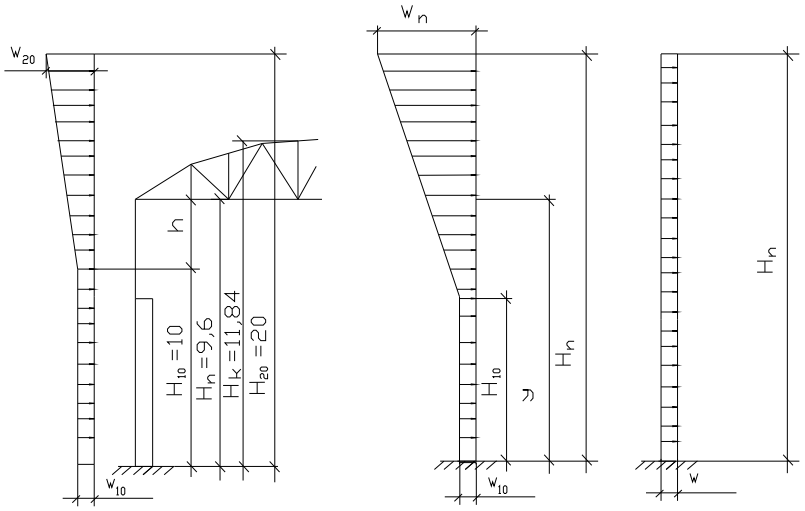
13-rasm

Ustunning tepa qismida $H_п$ dan H_k gacha bo’lgan masofaning o’rtacha qiymatiga teng. $(\mathrm{H}_{П} + \frac{\mathrm{H}_{К} - \mathrm{H}_{П}}{2} - \mathrm{H}_{10}) = 9,6 + \frac{11,84 - 9,6}{2} - 10 = 0,72m$

$$N_к=9,6+1,64+0,3=11,84m$$

$$K=K_{10,72}=0,65+\frac{(0,85-0,65).0,72}{10}=0,664$$

Parapet devor panelini hisobga olgan holda, shamolning ustun tepa qismiga bo’lgan ta’siri quyidagicha hisoblanadi. $W=Wh_cd(H_k-H_h)=$ $W_0\, k_{10.72}\ C\gamma_f h_c d(H_k - H_h) = 0,38\cdot 0,664\cdot(0,8+0,6)\cdot 1,4\cdot 0,9\cdot 6\cdot(11,84\text{-}9,6)=6,0\text{kN}$



14-rasm. Ustun bo'ylab teng ta'sir etuvchi shamol kuchi

Ustun bo'ylab teng ta'sir qiluvchi shamol kuchi $P=Wh_cd$ ga teng.

$H_п>10m$ bo'lgan holatida tayanch nuqtasidagi momentlarni tengligidan shartli mahkamlangan sterjen shamol bosimiga ekvivalent bo'lgan ta'siri quyidagicha hisoblanadi.

$$M_{on} = W_{10}\frac{H^2_n}{2} + (W_{Hn} - W_{H10})(H_n - H_{10})\frac{1}{2}[H_{10} + \frac{2}{3}(H_n + H_{10})];$$

$$M^{экв}_{on} = W_{экв}\frac{H^2_n}{2} \quad ; \quad W_{экв} = \frac{2M_{on}}{H^2_n}$$

u holatda shamol bosimi:

a) Shamolning faol ta'siri:

$$W_5 = W_0 \cdot 0{,}5 \cdot 0{,}8 \cdot 1{,}4 = 0{,}38 \cdot 0{,}5 \cdot 0{,}8 \cdot 1{,}4 = 0{,}21 kN/m^2$$

$$W_{9.6} = W_{0 \cdot \kappa_{9,6}} \cdot 0{,}8 \cdot 1{,}4 = 0{,}38 \cdot 0{,}638 \cdot 0{,}8 \cdot 1{,}4 = 0{,}27 kN/m^2$$

$$M^a_{on} = W_5\frac{H^2_n}{2} + (W_{9.6} - W_5)(H_n - H_5)\frac{1}{2}[H_5 + \frac{2}{3}(H_n - H_5)] = 0{,}21 \cdot \frac{9{,}6^2}{2} + (0{,}27 - 0{,}21)(9{,}6 - 5) \cdot \frac{1}{2} \cdot$$

$$\left[5 + \tfrac{2}{3}(9{,}6 - 5)\right] = 10{,}79 kN \cdot m$$

$$W^a_{экв} = \frac{2M^a_{on}}{H^2_n} = \frac{2 \cdot 10.79}{9.6^2} = 0.23 kN/m$$

b) Shamolning faol bo'lmagan ta'siridan:

$$W_5 = W_0 \cdot 0{,}5 \cdot 0{,}6 \cdot 1{,}4 = 0{,}38 \cdot 0{,}5 \cdot 0{,}6 \cdot 1{,}4 = 0{,}16 kN/m^2$$

$$W_{Н.П} = W_{9.6} = W_0 \cdot K_{9.6} \cdot 0.6 \cdot 1.4 = 0.38 \cdot 0.638 \cdot 0.6 \cdot 1.4 = 0.20 kN/m^2$$

$$M^n_{on} = W_5 \frac{H_n^2}{2} + (W_{9.6} - W_5)(H_n - H_5)\frac{1}{2}[H_5 + \frac{2}{3}(H_n - H_5)] = 0{,}16 \cdot \frac{9{,}6^2}{2} + (0{,}20 - 0{,}16)(9{,}6 - 5) \cdot \frac{1}{2} \cdot$$

$$\cdot \left[5 + \frac{2}{3}(9{,}6 - 5)\right] = 8{,}11 kNm$$

$$W^n_{экв} = \frac{2M^n_{on}}{H_n^2} = \frac{2 \cdot 8{,}11}{9{,}6^2} = 0.18 kN/m$$

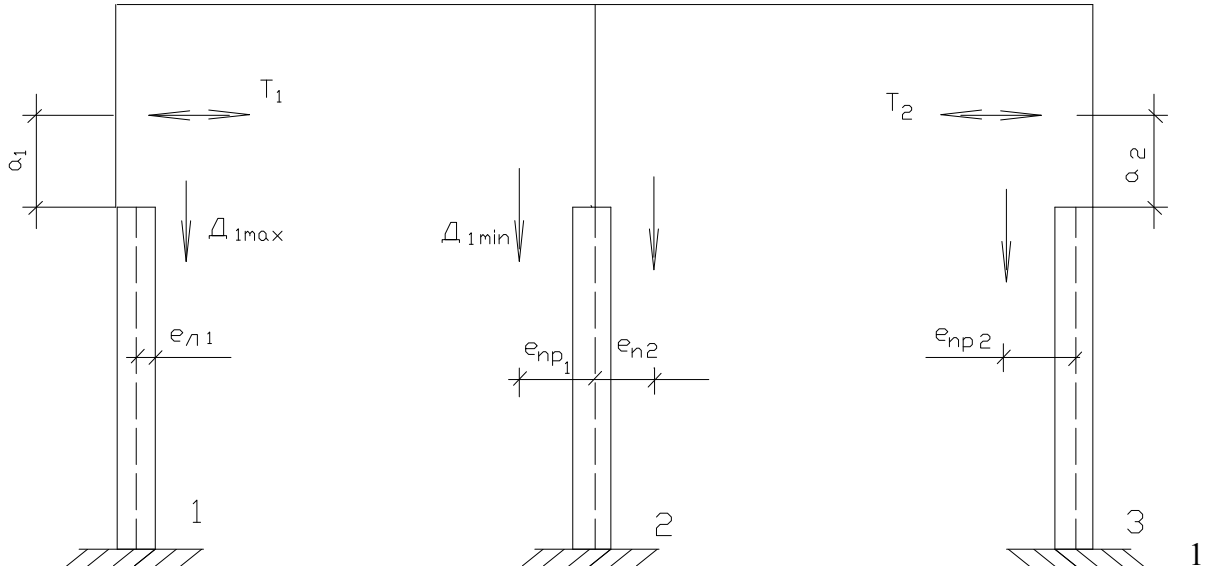
Ustun bo'ylab shamolning ta'siri $P=Wh_cd$ formulasiga ko'ra:

faol holatda $P_a = Wh_cd = 0.23 \cdot 0{,}9 \cdot 6 = 1{,}24 kN/m$

faol bo'lmagan holatda $P_п = 0{,}18 \cdot 0{,}9 \cdot 6 = 0{,}97 kH/м$ ga teng.

2.2.4. Ramani kran ta'siriga hisoblash

Ko'priksimon kranlar ta'sirida bo'lgan ramaning hisobiy sxemasi 15-rasmda ifodalangan.



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5-rasm. Ko'priksimon kranlar ta'sirida bo'lgan ramaning hisobiy sxemasi

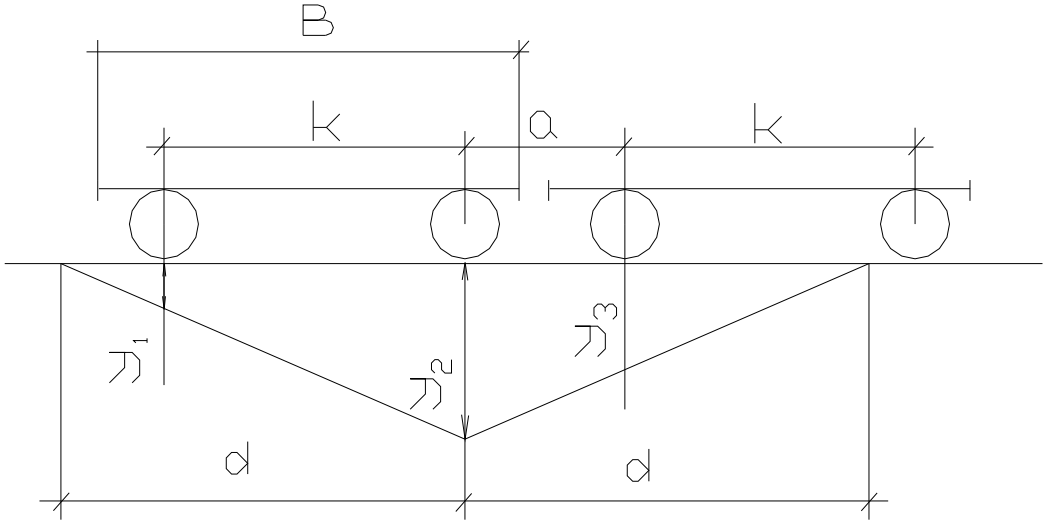
$Q_{кр}$= 20/5 t yuk ko'tarish quvvatiga ega (o'rtacha ish rejimli , ikki ilmoqli) ko'priksimon kran berilgan. Oralig'i $L_к$ =16.5m kengligi B=6300mm, g'ildiraklar orasidagi masofa K=4400mm, balandligi N= 2400mm, kranning telejkasi bilan birga og'irligi $Q_{общ}$=285 kN telejka og'irligi G = 85kN, relslarga kran g'ildiragining maksimal bosim ta'siri $\rho^n_{max} = 195kN$ minimal bosim ta'siri $\rho^n_{min} = 48kN$. Kranning tormozlanish vaqtidagi kuchi $T^n_{поп}$=7,1 kN.

Bitta g'ildirakning hisobiy bosim ta'siri.

P_{max} =195·1.2=234 kN; P_{min} =48·1.2=57.6 kN ; $T_{поп}$=7,1·1,2 =8,5 kN tashkil etadi.

Ikkita kranning ustunga vertikal yo'nalishidagi bosimi ta'siri o'rnatilgan ikki kran osti to'sinlarining tayanch reaktsiyasining yig'indisi

(ikkita bir – biriga yaqinlashtirilgan holatda) kranning ta'sir chizig'i bo'yicha quyidagicha aniqlanadi (16-rasm).



16-rasm.

Ikki kran yaqin holatda bo'lgandagi g'ildiraklari orasidagi masofa a=B-K=6300-4400=1900mm, ustun qadami d=6m.

U holda ta'sir chizig'i ordinatasi:

$$Y_1 = \frac{Y_2(d-k)}{d} = \frac{1(6-4.4)}{6} = 0.267$$

$$y_2 = 1{,}0$$

$$Y_3 = \frac{Y_2(d-a)}{d} = \frac{1(6-1.9)}{6} = 0.684$$

$$Y_4 = \frac{Y_2[d-(k+a)]}{d} = 0 \text{ ga teng.}$$

Chunki k+a =4.4+1.9=6.3>d=6m , $Y_4 = 0$

Ta'sir chizig'i ordinatasining yig'indisi:

$$\sum Y = Y_1 + Y_2 + Y_3 + Y_4 = 0{,}267 + 1 + 0{,}684 + 0 = 1{,}951$$

Ustunga ta'sir qilayotgan bosim kuchi:

a) maksimal qiymati $D_{1max}=D_{2max}=P_{max}\sum Y\cdot 0{,}9=234\cdot 1{,}951\cdot 0{,}9=411kN$

b) minimal qiymati $D_{1\min} = D_{2\min} = P_{\min}\sum Y \cdot 0.9 = 57.6 \cdot 1.951 \cdot 0.9 = 101kN$

Kranlarning vertikal yo'nalishdagi ta'siridan hosil bo'lgan qo'shimcha ekssentrisitetlar qiymati: $e_{n1} = e_{np,1} = e_3 = 350мм$; $e_{np,1} = e_{n,2} = \lambda = 750mm$

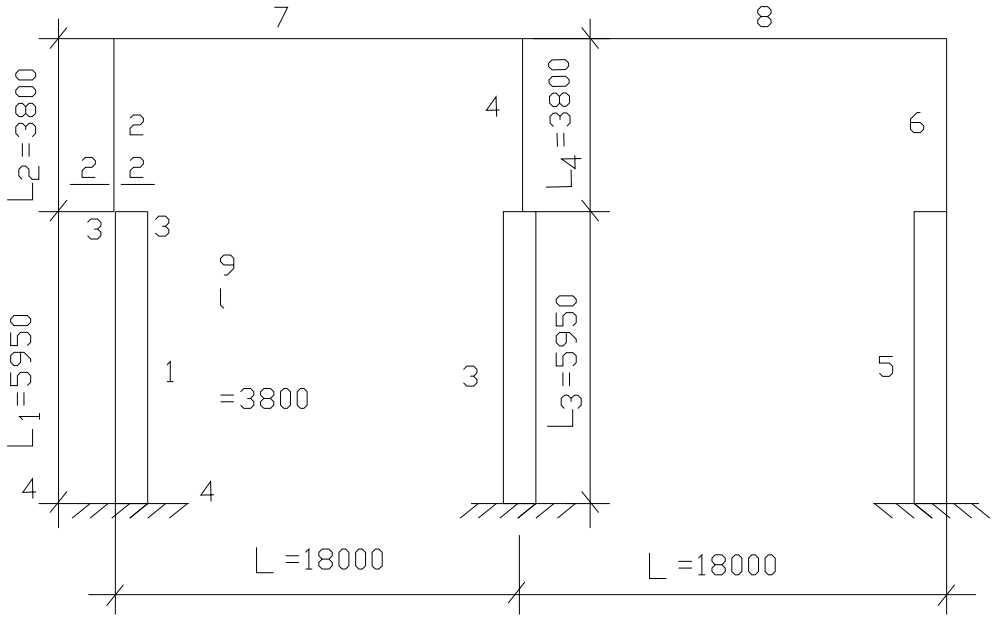
Gorizontal bosim (kuchi) ikkita bir–biriga yaqin kelgan holatdagi kranning tormozlanish paytidagi ustunga ta'sir qilayotgan gorizontal bosimi (kuchi) $T_1 = T_2 = T_{non}\cdot\sum Y\cdot 0{,}9 = 8{,}5\cdot 1{,}951\cdot 0{,}9 = 15кН$ ga teng.

Kran relsining ustki qismiga ko'ndalang tormozlanish kuchi ustun tepasiga masofasi $a_1 = h_{nб} + h_{кр} = 1000 + 120 = 1120мм = 1{,}12м$ qo'yilgan deb hisoblaymiz.

3. EHM da sinchli ko’ndalang ramaning statik hisobi

EHM da sinchli ko’ndalang ramaning statik hisobini “RAMA - 1” dasturi asosida amalga oshirish mumkin. Ushbu dastur bir qavatli sanoat binolari ko’p oraliq ramalarning statik va dinamik kuchlar ta’siriga hisoblashga mo’ljallangan.

Ramaning tuzilish sxemasi quyidagi 17-rasmda ko’rsatilgan.



17-rasm. Ramaning tuzilish sxemasi

220 DATA 3.0 (3-ustunlar soni; 0-seysmikaga hisoblash)
240 DATA 0.4, 0.8; 0.4, 0.38;0.4, 0.8; 0.4, 0.6 (ustunlarning kesim yuzasi)
260 DATA 5.95, 3.8,;5.95, 3.8, (ustunlarning ostki va ustki qismining uzunligi)
280 DATA 368.93; 47.5; 32.23; 411(tepadan pastga qarab ta’sir qilayotgan yuklar:$p_{11}+p_{12}+p_{14}$; $p_{1,cN}$; $p^{пб}_{1,3}$; $Д_{max}^{kp}$)
300 DATA 15;2.68 (kranning tormozlanish ta’siridagi kuchi; masofasi)
320 DATA 1.24;0.97, 6 (shamol ta’siri)
360 DATA (talabaning ismi,sharifi; hisoblash vaqti)

RAMA-1 dasturi bo’yicha bir qavatli sanoat bino ramasining hisobi.
Boshlang’ich ma’lumotlar:

N=3 S=0
B1=0.4 H1=0.8 B2=0.4 H2=0.38 B3=0.4 H3=0.8
B4=0.4 H4=0.6
L1=5.95 L2=3.8 L3=5.95 L4=3.8
PPH=368.93 PCH=47.5 PPB=32.23 DMAX=411
T=15 L5=2.68
P1=1.24 P2=0.97 W=6

Yig’ma temir beton konstruksiyalaridan qurilgan sanoat binosining ustunida tashqi kuchlar ta’siridan hosil bo’ladigan kuchlanishlarni EHMda hisoblash natijasida:

- bir qavatli sanoat bino ramasini“A„ o’qi bo’ylab;
- doimiy yuklar ta’sirida;
- qor bosimi ta’siridan;
- shamol ta’siridan;
- kran ta’siridan;
- kran tormizlanish ta’siridan, ustunda hosil bo’ladigan kuchlanishlar qiymatlari aniqlanadi.

Shu bilan birga ko’ndalang ramaning “B„ o’qi bo’ylab, o’rta qator ustun kesim yuzasida yuqorida keltirilgan kuchlar ta’siridan kuchlanishlar qiymati alohida-alohida holda aniqlanadi.

Natijada, ramada tashqi kuchlar ta’siridan hosil bo’ladigan „M“ „Q“ va „N“ epyuralari quriladi.

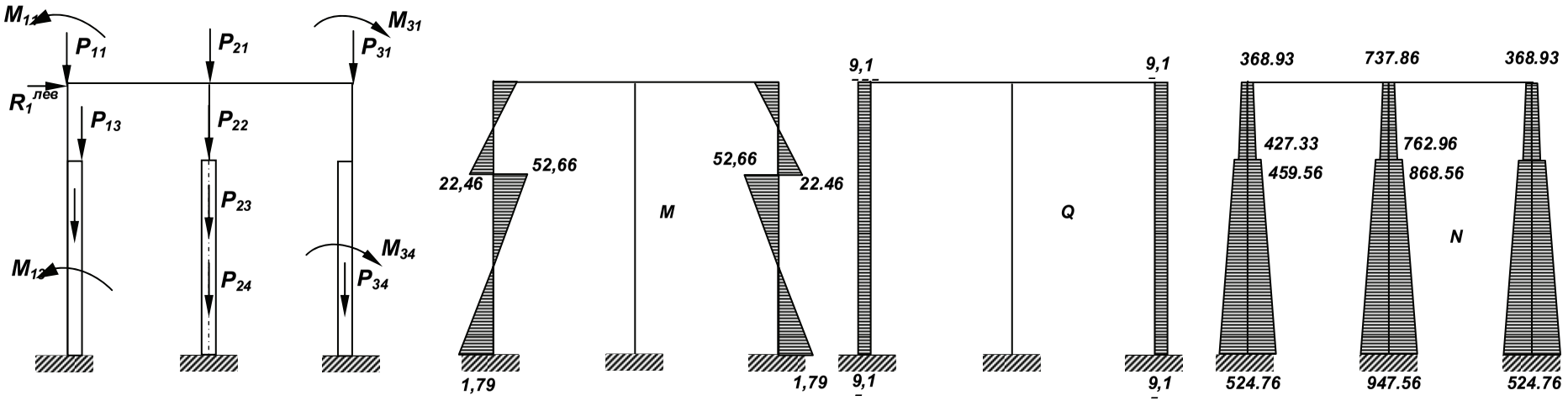
Chetki qator ustunlar uchun uchta kesim yuzasi bo’yicha yuqorida keltirilgan kuchlardan olingan natijalar 8-jadvalda keltirilgan.

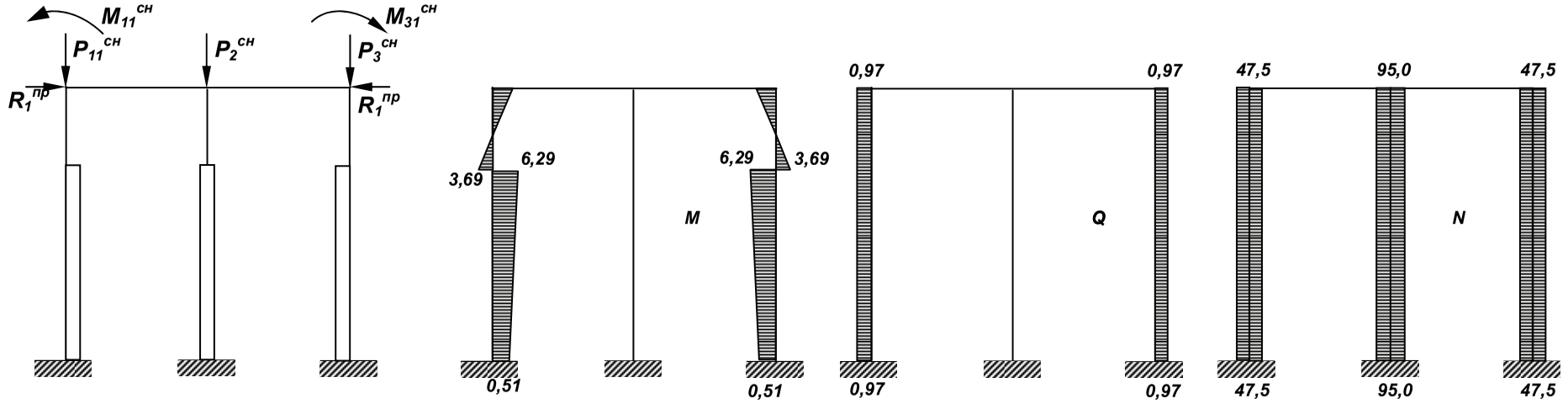
Ko’ndalang rama chetki ustunining kesim yuzasida hosil bo’ladigan kuchlanishlar

8-Jadval

Yuklar	Eguvchi moment epyuralari	Yuklanish tartibi	Uygunlanish koef.	Ustunning kesim yuzasi						
				2		3		4		
				M, kNm	N, kN	M, kNm	N, kN	M, kNm	N, kN	Q, kN
1	2	3	4	5	6	7	8	9	10	11
Doimiy yuk		1	1	22.5	427,33	-52,66	459,56	1,79	524,76	9,15
Qor bosimi ta’siridan		2	1	4.09	52,78	-6,98	52,78	-0,57	52,78	1,08
		3	0.9	3.68	47,5	-6,28	47,5	-0,51	47,5	0,97
Shamol ta’siridan		4	1	5.56	0	5,56	0	54,22	0	12,28
		5	0.9	±5.00	0	±5,00	0	±48,80	0	±11,05
Kran ta’siridan (A tayanchdagi Dmax)		6	1	-59,11	0	100,71	456,67	8,16	456,67	15,56
		7	0.9	-53,20	0	90,64	411	7,34	411	-14,00
Kranni tormozlanish ta’siridan (A tayanchdagi T)		8	1	-11,48	0	-11,48	0	40,48	0	8,73
		9	0.9	-10,33	0	-10,33	0	36,43	0	7,86
Kran va shamolni hisobga olgandagi kuchlarning asosiy uyg’unlanishi		M_{max}		1,3,5		1,5,7		1,5,7,9		
				31,13	474,83	42,98	870,56	94,36	935,76	14,06
		M_{min}		1,5,7,9		1,3,5,9		1,3,5		
				-46,08	427,33	-74,27	412,06	-47,52	527,26	-0,93
		N_{max}		1,3		1,3,7		1,3,7		
				26,13	474,83	31,7	918,06	8,62	983,26	-3,88
Shuning o’zi kran va shamolni hisobga olmaganda				1,2		1,2		1,2		
				26,54	480,11	-59,64	512,34	1,22	577,54	10,23

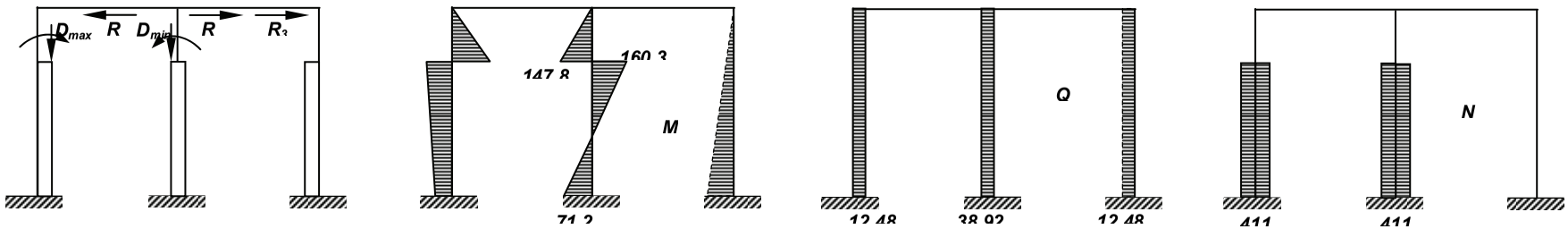
Doimiy yuklar ta’siriga hisoblash



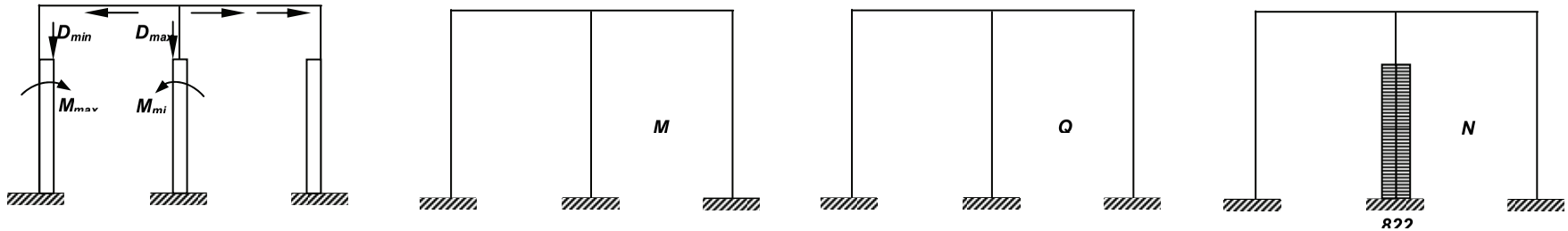


18-rasm. Ramani “A” o’qi bo’ylab yuklash

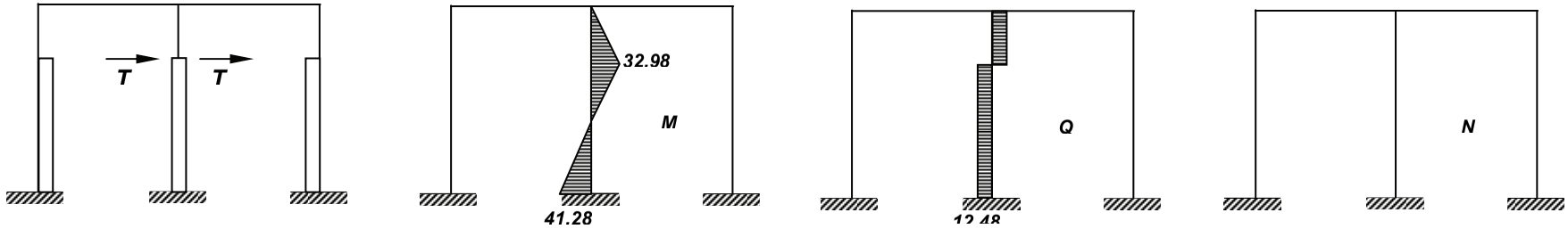
Chap chetki ustunga kran ta’siridan Dmax



O’rta ustun AB va BV tomonidagi kran ta’siridan Dmax



Kranning tormozlanishi T ta’siridan



19-rasm. Ramada hosil bo’ladigan „M“, Q“ va „N“ epyuralari

4. Bir qavatli sanoat binosining tom yopmasi uchun ishlatiladigan oldindan zo'riqtirilgan to'sinni hisoblash va loyihalash

4.1. Ikki nishabli, tuynukli to'sinlarni loyihalash

Temirbeton to'sinlar asosan 12 va 18 m ravoqli sanoat binolari tomini yopishda qo'llaniladi. To'sinlar o'rta qismining ko'ndalang kesim yuzasi to'g'ri to'rt burchakli, tavr yoki qo'shtavr, tayanch zona qismi esa, to'g'ri to'rtburchak shaklida olinada. Ko'p hollarda ikki nishabli to'sinlar devorlarining o'rta qismi siniq ko'p burchak shaklida tuynukli qilib tayyorlanadi (to'sinning vaznini yengillashtirish maqsadida). Bu teshiklarning har birining yuzasi 0,5….1,0 m^2 teng bo'ladi. Shuning uchun ularni tuynukli to'sin deyiladi. Ikki nishabli tuynukli to'sinlar gorizontal holatda tayyorlanadi. Ulardagi teshiklar to'sin vaznini yengillashtirish bilan birga betonni tejashda hamda har-xil kommunikatsiyalarni o'tkazishda xizmat qiladi.

Bu to'sinlar B20....B60 sinfli og'ir betonlardan tayyorlanadi. To'sinlarning uzunligi 12 m va undan ortiq bo'lgani uchun, ular o'ta mustahkam po'lat armaturalar bilan jihozlanadi va oldindan zo'riqtiriladi.

Zo'riqtirilgan armatura sifatida B-II, Bp-II, K-7, K-19, A-IV, A-V va A-VI va oddiy armaturalar sifatida esa A-I, A-II, A-III va Bp-I sinfli armaturalar qo'llaniladi.

Vaqtincha va doimiy ta'sir etuvchi yuklar to'singa tom yopmalarining qobirg'alari yordamida tayanch qismi orqali to'singa to'plangan (yig'iq) yuk tarzida uzatiladi. Agar to'plangan yuklarning soni 5 va undan ortiq bo'lgan hollarda, ularni teng tarqalgan (yoyiq) yuk bilan almashtirishga ruxsat etiladi.

Bunda yorug'lik va havo almashinuvi fonarlari hamda osma transport vositalaridan tushadigan yuklar to'plangan yig'iq yuklar tarzida olinadi.

Ikki nishabli tuynukli to'sinning geometrik o'lchamlari va uni armaturalanish tarhlari 19-rasmda keltirilgan. To'sin o'rta qismining balandligi $h\left(\frac{1}{10}\cdots\frac{1}{15}\right)l$ga teng qilib, ustki kamarining qiyaligi $i=\frac{1}{10}\cdots\frac{1}{15}$ oralig'ida, tayanch qismi balandligi esa h=800….900 mm oralig'ida olinadi. To'sinning ostki kamar eninig o'lchami oldindan zo'riqtiriladigan armaturalarning joylanish shartiga asosan, B=200....300 mm oralig'ida olinadi.

To'sinning siqiluvchi kamarining balandligi quyidagi shartga binoan olinadi.

$$h'_f > \mu h_0 \frac{R_s}{R_b} \quad (1)$$

bu yerda μ 0,004.....0,005 armaturalash koeffitsiyenti bo'lib, to'sin devoridagi tuynukni hisobga olgan holda belgilanadi.

Yig'ma stropil to'sinlarni hisolashda uni ikki tayanchga erkin tayangan holda deb qaraladi (4-rasm).

Bu holda to'sinning uzunligi quyidagicha aniqlanadi (20-rasm).

$$l_0 = l - 2\delta - 2c \quad (2)$$

Bu turdagi to'sinlar ko'p oraliqli statik noaniq va tugunlari bikir birlashtirilgan uzluksiz qator ramalardan iborat deb qaraladi. Bu ramalardagi zo'riqish va defomatsiyalar EHM orqali aniqlanadi. Biroq loyihalashda uni soddalashtirilgan holda tuynukli to'sin tarzida ham hisoblash mumkin (20-rasm).

Ikki nishabli to'sinlarda eng xavfli kesimi to'sinning o'rta qismida emas, balki tayanch qismidan L=(0,35…..0,40)l masofada bo'ladi. Bo'ylama ishchi armaturaning yuzasi shu kesim uchun topilgan eguvchi moment bo'yicha aniqlanadi.

To'sinning kesim yuzalari uchun eguvchi moment qiymatlari (3-rasm) quyidagi formula orqali aniqlanadi:

$$M=0,5qx(l_0-x) \quad (3)$$

To'sin kesimlarining geometrik xarakteristikalarini aniqlash jarayonida, elastik-plastik qarshilik momentlarini (w_{pl} va w'_{pl}) hisoblashda qo'llaniladigan, kesim yuzasi shaklini hisobga oluvchi koeffitsiyent γ ni bunday to'sinlar uchun jadvaliy qiymati yo'qligi tufayli w_{pl} va w'_{pl} ni hisoblash quyida keltirilgan to'sin kesimining nol chizig'ini aniqlovchi tenglama (4) orqali bajariladi. Bunda kesimning pastki cho'zilishga w_{pl} va aksincha, kesimning yuqori qismi siqilishga ishlaydi deb w'_{pl} aniqlanadi.

$$S'_{bo} + \alpha S'_{so} - \alpha S_{so} = \frac{(h-x)}{2} A_{bt} \quad (4)$$

bu yerda S_{bo} - kesim yuzasidagi beton siqilish zonasining holis o'qqa nisbatan olingan statik momenti;

$\alpha S'_{so}$ - kesim yuzasidagi siqiluvchi zonada joylashgan armaturaning holis o'qqa nisbatan olingan statik momenti;

αS_{so} - kesim yuzasidagi cho'ziluvchi zonada joylashgan armaturaning holis o'qqa nisbatan olingan statik momenti;

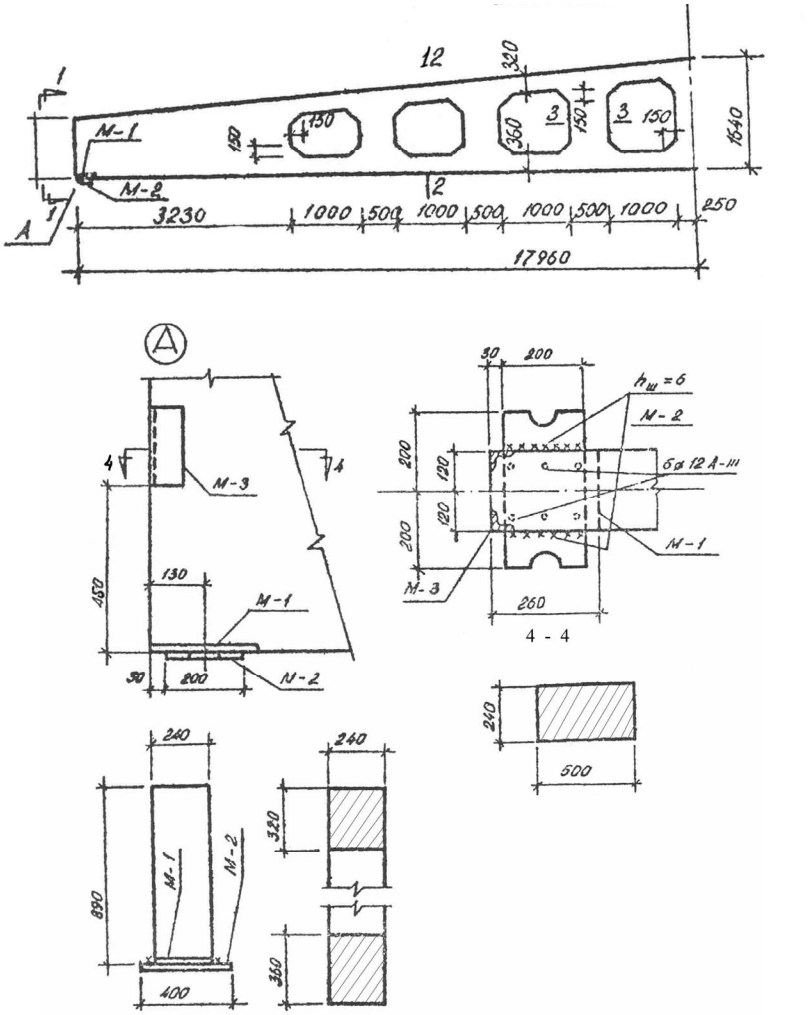
A_{bt} - cho'ziluvchi zonadagi betonning kesim yuzasi.

4.2. Ikki nishabli oldindan zo'riqtirilgan, tuynukli temirbeton to'sinning hisobi

To'sin, havo namligi $\varphi = 50...60\%$ li va agressiv bo'lmagan muhitli yopiq binoni qurishda qo'llaniladi. U oldindan zo'riqtirilgan bo'lib, ishchi armaturasi stend tirgovichlari yordamida mexanik usulda tortilib taranglanadi. Stend tirgovichlarining oralig'i 20 m ga teng.

To'sin gorizontal holatda tayyorlanadi va qotish jarayonida unga atmosfera bosimi ostida harorat orqali ishlov beriladi.

Shuning uchun taranglanayotgan armatura bilan tirgovichlar orasidagi haroratning farqi $t=65^o\ C$ ga teng bo'ladi



20-rasm. 18 m li tuynukli to'sinning geometrik o'lchamlari

4.2.1. Hisoblash uchun berilgan kerakli ma'lumotlar

To'sinning uzunligi l=18 m, qiyaligi $i = \frac{1}{12}$, tayanch zona balandligi h=900, eni b=240 mm, xususiy vazni 92kN, ustun qadami 6 m,

cho'ziluvchi kamarning balandligi h=360mm olinadi. Siqiluvchi kamarning balandligi (1) formula shartiga binoan $h'_f > 0{,}005 \cdot 1270 \cdot \frac{680}{15{,}3} = 282$ mm hamda armatura karkaslarining joylanish shartiga asosan h_f=320 mm ga teng qilib olinadi. Ishlatiladigan beton sinfi B30, zo'riqtirilgan armatura sinfi A-V.

Og'ir beton sinfi B30, [1]

R_b=17MPa; R_{bt}=1,2 MPa ($R_b = 17 \cdot 0{,}9 = 15{,}3 MPa$; R_{bt}=1,2·0,9$MPa;$)

$R_{b,ser}$=22MPa; $R_{bt,ser}$=1,8MPa; E_b=32,5·10^3MPa.

Ish sharoiti koeffitsiyenti $\gamma_{b2} = 0{,}9$;

Tortilgan armaturani bo'shatib yuborilgan holatdagi betonning mustahkamligi: R_{bp}=0,8 B=0,8·30=24MPa. Bunda quyidagi qiymatlar B20 va B25 sinflari oralig'ida interpolyatsiya yo'li bilan olinadi.[6]

$R_{bp,ser}$=16,2MPa; $R_{bt,p,ser}$=1,54 MPa; E_b=26,4 MPa.

Taranglangan armatura sinfi A-V (R_s=680 MPa; $R_{s,ser}$=785 MPa; E_s=19·10^4 MPa)

Oddiy armaturalar sinfi A-III (R_s=365 MPa diametri 10…40 mm li sterjenilar uchun; R_s=355 MPa; (R_{sw}=285 MPa diametri 6…8 mm li sterjenlar uchun; E_s=20·10^4 MPa); A-I (R_s=255MPa, R_{sw}=175MPa) ва B_p-I(R_s=360MPa; E_s=17·10^4 MPa) [1].

Taranglangan armaturada hosil bo'ladigan kuchlanish quydagicha aniqlanadi.

Kuchlanish miqdori quyidagi shartga ko'ra aniqlanadi [1].

$$\sigma_{sp} + P < R_{s,ser}$$

bundan $\sigma_{sp} = \frac{R_{s,ser}}{1{,}05} = \frac{785}{1{,}05} = 747 MPa$ $\sigma_{sp} = 740 MPa$ qilib qabul qilamiz.

4.3. To'singa tushadigan yuklarni hisoblash

To'sinning hisobiy uzunligi (2) formula bo'yicha topiladi.

$$l_0 = 18 - 2 \cdot 0{,}04 - 2 \cdot 0{,}13 = 17{,}7\, m$$

To'singa ta'sir etuvchi yuklarning hisobi 9-jadvalda keltirilgan:

9-jadval

	Yuk turlari	Me'yoriy yuk,kN/m^2	Yuk bo'yicha ishonchlilik koef.γ_f	Hisobiy yuk kN/m^2
1	2	3	4	5
1	Doimiy yuk: Atmosfera ta'siridan himoya qiladigan qatlam (bitum mastikasi bilan yopishtirilgan 3 qavatli ruberoid) Sement qorishmasi (δ=15 mm ρ=18kN/m^3) Issiqlik ta'siridan himoya qiladigan qatlam (δ=100 mm ρ=5kN/m^3) Bug' ta'siridan himoya qiladigan qatlam Tom yopmasidagi temirbeton plitadan	 0,1 0,27 0,5 0,05 1,57	 1,1 1,2 1,2 1,1 1,1	 0,11 0,32 0,60 0,06 1,73
2	tushadigan yuk (3x6 m). JAMI:	2,49		2,82
	Vaqtinchalik yuk: Qor og'irligi	0,5	1,4	0,7
	Umumiy yuk miqdori:	2,99		3,52

To'sinning 1 m uzunligiga tushadigan yuk qiymatini aniqlash:

To'liq yuklarning me'yoriy qiymati:

$$q_n=2,99\cdot6+5,12=23,06 \text{ kN/m}$$

Uzoq muddat ta'sir etuvchi yuklarning qiymati:

$$q_{nl}=2,49\cdot6+5,12=20,06 \text{ kN/m}$$

To'liq yuklarning hisobiy qiymati:

$$q=3,52\cdot6+5,63=26,75 \text{ kN/m}$$

bu yerda balkani 1 m uzunlikdagi vaznining me'yoriy qiymati.

$$q_n=92/17,96=5,12 \text{ kN/m}$$

hisobiy qiymati: $q=5,12\cdot1,1=5,63$ kN/m

To'sinning 5b-rasmda ko'rsatilgan har bir hisobiy kesimlari uchun (3) formula bo'yicha eguvchi moment qiymatlari topiladi.

Quyida misol tariqasida 1-1 kesimda (x=2,95 m) hosil bo'ladigan eguvchi momentlar qiymatini hisoblash keltirilgan.

Uzoq muddat ta'sir qiladigan me'yoriy yukning qiymatidan (γ_f=1 bo'lgan holda) hosil bo'ladigan moment.

$$M_{1-1}=0,5\cdot q_{nl}\cdot x(l_0-x)=0,5\cdot20,06\cdot2,95\cdot(17,7-2,95)=436,4 \text{ kNm}$$

To’liq yukning me’yoriy qiymatidan hosil bo’ladigan eguvchi moment

$$M_{1\text{-}1}=0,5\cdot 23,06\cdot 2,95\cdot (17,7\text{-}2,95)=501,7 \text{ kNm}$$

To’liq yukning hisobiy qiymatidan hosil bo’ladigan eguvchi moment ($\gamma_f>1$ bo’lgan holda)

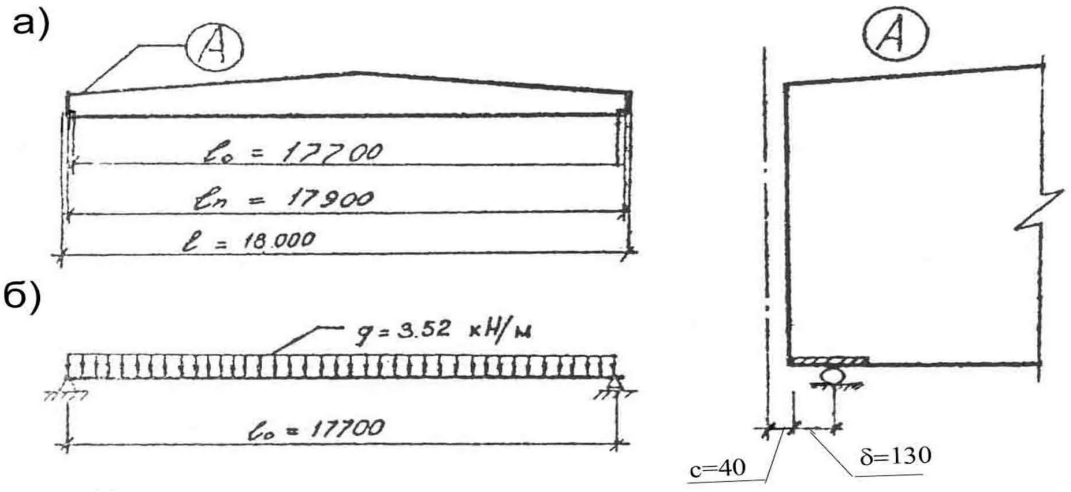
$$M_{1\text{-}1}=0,5\cdot 26,75\cdot 2,95\cdot (17,7\text{-}2,95)=582 \text{ kNm}$$

Xuddi shuningdek 2-2, 3-3 va 4-4 kesimlar uchun (x masofani o’zgartirgan holda) eguvchi moment qiymati topiladi. Ularning qiymatlari kNm birligida 10-jadvalda keltirilgan.

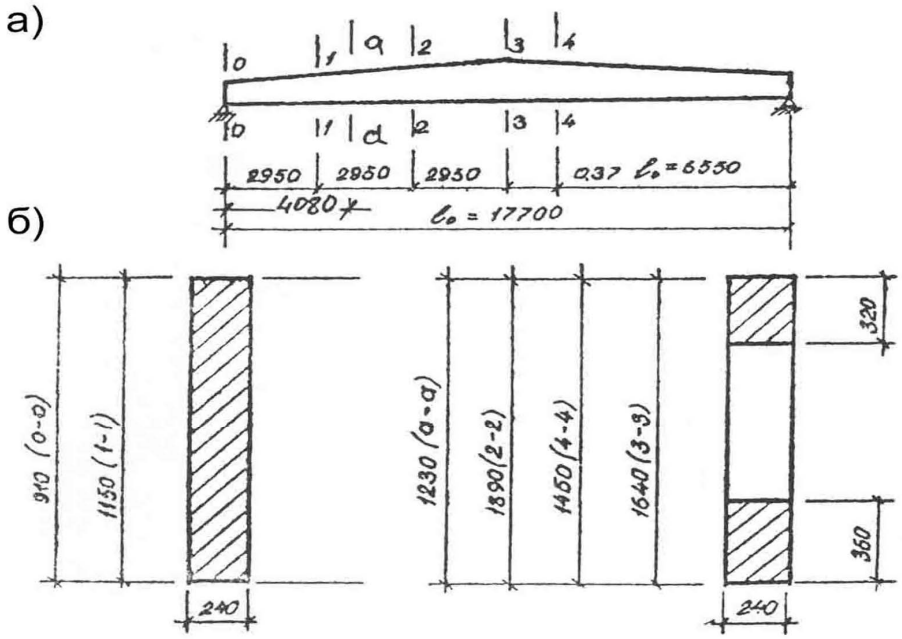
Kesim bo’yicha eguvchi momentlarning qiymati

10-jadval

Kesim	Masofa *x*, m	Uzoq muddatli yuklar, (γ_f=1)	To’liq yuklar	
			γ_f=1	γ_f>1
1-1	2,95	436,4	501,7	582,0
2-2	5,9	698,3	802,7	931,2
3-3	8,85	785,6	903,0	1047,6
4-4	6,55	732,5	842,1	976,8



21-rasm. To’singa tushadigan yuklar



22-rasm. To’sinning hisobiy uzunligi va kesimlari

4.4. To’sinni normal kesimi bo’yicha mustahkamlikka hisoblash

To’sinning normal kesimi bo’yicha mustahkamligi eng havfli kesim uchun aniqlanadi (4-4 kesim, 22-rasm).

Kesim balandligi

$$h = h_0 + (\delta + 0{,}37 \cdot l) \cdot i = 890 + \frac{(130 + 0{,}37 \cdot 17700)}{12} = 1447mm \approx 1450mm$$

bu yerda $i = \frac{1}{12}$ -to’sin ustki kamarining qiyaligi

δ=130 mm (20-rasmga qarang)

h_0=890 mm to’sin uchining balandligi

Kesimning ishchi balandligi

$$h_0 = h - a = 1450 - 180 = 1270 \text{ mm}$$

Siqilish zonasida beton kesim yuzasining ishlashini xarakterlovchi koeffitsiyent ω.

$$\omega = a - 0{,}008 \cdot R_b = 0{,}85 - 0{,}008 \cdot 15{,}3 = 0{,}728$$

bu yerda $a = 0{,}85$ koeffitsiyent, og’ir betonlar uchun. [1]

Taranglangan armaturadagi qo’shimcha kuchlanish $\Delta\sigma_{sp}$ topiladi, buning uchun:

a) ankerlarning deformatsiyalanishi natijasida oldindan uyg’otilgan kuchlanishning kamayishi aniqlanadi.

$$\sigma_3 = \frac{\Delta l}{l} \cdot E_s = \frac{3,95}{18000} \cdot 19 \cdot 10^4 = 41,7 MPa;$$

bu yerda $\Delta l = 1,25 + 0,15 \cdot d = 1,25 + 0,15 \cdot 18 = 3,95 mm$ (d=18mm mo'ljallangan ishchi armatura diametri).

b) po'lat qolipning deformatsiyalanishi natijasida kuchlanishning kamayishi.

$\sigma_5 = 30 MPa$ (agar qolip to'g'risidagi ma'lumotlar bo'lmagan taqdirda).

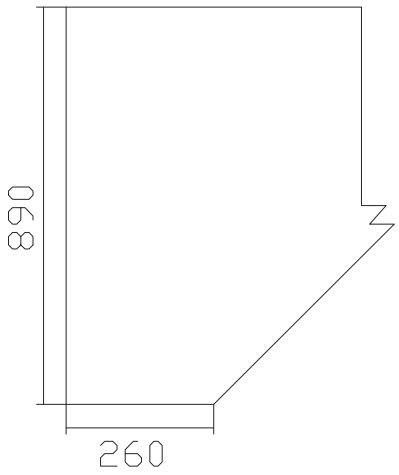
v) betonning siqilishga qadar, armaturaning to'g'ri tortilishini hisobga oluvchi koeffitsiyent $\gamma_{sp} > 1$ bo'lganda (σ_3 bilan σ_5 larni nazarga olgan holda) taranglangan armaturadagi kuchlanish qiymati quyidagicha aniqlanadi.

$$\sigma_{sp1} = \sigma \cdot (1 - \Delta\gamma_{sp}) - \sigma_3 - \sigma_5 = 740(1 - 0,1) - 41,7 - 30 = 594,3 MPa,$$

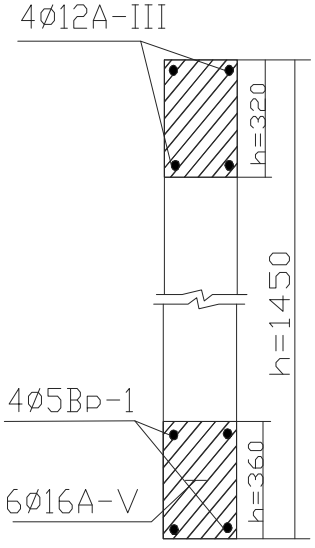
bu yerda $\Delta\gamma_{sp}$- taranglangan armaturadagi kuchlanishning chegaraviy holatidan og'ish qiymati, lekin u 0,1 dan kam bo'lmasligi lozim [1]. Shuning uchun $\Delta\gamma_{sp}$=0,1 deb olamiz.

$\Delta\sigma_{sp}$ ning qiymati quyidagi formula orqali aniqlanadi:

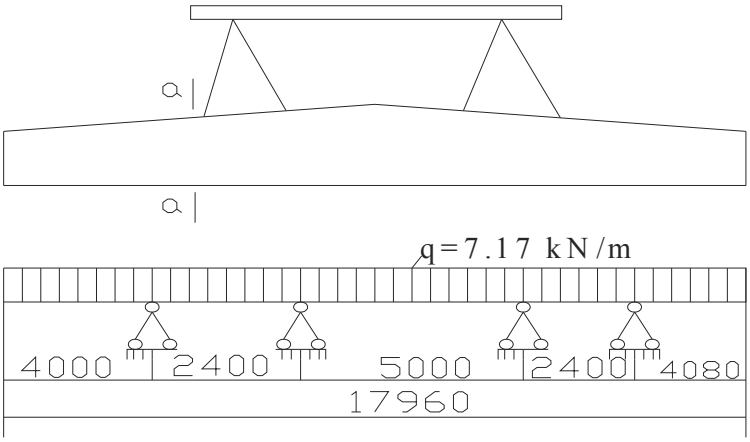
$$\Delta\sigma_{sp} = 1500 \frac{\sigma_{sp1}}{R_s} - 1200 = 1500 \cdot \frac{594,3}{680} - 1200 = 111 MPa > 0.$$



23-rasm. To'sin uchining o'lchami



24-rasm. To'sin kesimi



25-rasm. To’sin hisobiy sxemasi

Taranglangan armaturada nisbiy chegaraviy oquvchanlik chegarasidagi kuchlanish $\Delta\sigma_{sr}$ ni aniqlashda va shu armaturadagi oldindan uyg’otilgan kuchlanishlarning umumiy kamayishi noma’lum bo’lsa, u holda $\Delta\sigma_{sp}$ quyidagicha olinadi:

$$\Delta\sigma_{sp}=0,6\cdot R_s=0,6\cdot 680=408 \text{ MPa}.$$

U holda $\Delta\sigma_{sr}$ quyidagi formula orqali topiladi

$$\Delta\sigma_{sr}=R_s+400-\sigma_{sp}-\Delta\sigma_{sp}=680+400-408-111=561MPa$$

Ishlash sharoiti bo’yicha koeffitsiyenti $\gamma_{b2}=0,9$, shuning uchun $\sigma_{sc,u}=500МПа$ deb olinadi, ($\gamma_{b2}>1$ bo’lgan holda esa $\sigma_{sc,u}=400MPa$ teng).

Siqiluvchi kesim yuzasining nisbiy balandligi quyidagicha aniqlanadi:

$$\xi_R=\frac{\omega}{1+\frac{\sigma_{SR}}{\sigma_{ss,u}}\left(1-\frac{\omega}{1,1}\right)}=\frac{0,728}{1+\frac{561}{500}\left(1-\frac{0,728}{1,1}\right)}=0,568$$

Balkaning mustahkamligi bo’yicha sharti:

$$M=976,8\cdot 10^5 kNsm<R_b b'_f h'_f(h_0-0,5h'_f)=$$
$$=15,3\cdot(100)\cdot 24\cdot 32\cdot(127-0,5\cdot 32)=1304\cdot 10^5 kNsm$$

Shart bajarildi, demak holis o’q yuqori kamarning balandligi oralig’ida bo’lgan masofadan o’tadi.

U holda α_m koeffitsiyentning qiymatini aniqlaymiz:

$$\alpha=\frac{M}{R_b b_f h_0^2}=\frac{976,8\cdot 10^5}{15,3\cdot 24\cdot 127^2\cdot(100)}=0,165$$

Bu qiymatga asosan 3.1-jadval [3] dan $\xi = 0{,}18;\ \zeta = 0{,}91$ qiymati olinadi.

$\xi = 0{,}18 < \xi_R = 0{,}568 \approx 0{,}57$ shart bajarildi.

Zo'riqtirilgan armatura A-V uchun ish sharoiti bo'yicha koeffitsiyenti γ_{s6} aniqlanadi.

$$\gamma_{s6} = \eta - (\eta - 1) \cdot \left(2 \cdot \frac{\xi}{\xi_R} - 1 \right) = 1{,}15 - (1{,}15 - 1) \cdot \left(2 \cdot \frac{0{,}18}{0{,}568} - 1 \right) = 1{,}20 > 1{,}15$$

bu yerda η koeffitsiyenti armaturaning sinfiga bog'liq bo'lib, A-V armatura uchun γ_{s6}=1,15 deb qabul qilamiz [1].

Ishchi armatura yuzasi quyidagi formuladan topiladi.

$$A_{sp} = \frac{M}{\gamma_{s6} \cdot R_s \cdot \zeta \cdot h_0} = \frac{976{,}8 \cdot 10^5}{1{,}15 \cdot 680 \cdot 0{,}91 \cdot 127 \cdot (100)} = 10{,}81 sm^2$$

Qabul qilamiz 6Ø 16 A-V, A_{sp}=12,06>10,81 sm^2

4.5. Kesim yuzalarining geometrik xarakteristikalari

Geometrik xarakteristikalar 22-rasmda ko'rsatilgan kesimlar uchun aniqlanadi (masalan 4-4 kesim uchun aniqlaymiz).

Beton kesimining yuzasi:

$$A_b = \Sigma h b_i = 24 \cdot 32 + 24 \cdot 36 = 1632 см^2$$

Bo'ylama armaturalarning kesim yuzalari

6Ø 16 A-V, A_{sp}=12,06sm^2 zo'riqtiriladigan armatura;

4Ø 5 Bp-I, A_s=0,785sm^2 kesimning pastki qismidagi oddiy armatura;

4Ø 12 A-III, A_s=4,52sm^2 kesimning yuqori qismidagi oddiy armatura;

u holda $A_{sp} + A_s + A_s$=12,06+0,785+4,52=17,36 sm^2 .

Armatura yuzasini quyidagi shart bo'yicha tekshiriladi:

0,008 A_b=0,008·1632=13,06 sm^2<17,36 sm^2,

demak, to'sinning keltirilgan kesim yuzasi hisoblanganda armaturalar yuzasi hisobga olingan holda aniqlanadi.

A-V –sinfli armatura uchun

$$\alpha_1 = \frac{E_s}{E_b} = \frac{1{,}9 \cdot 10^5}{3{,}25 \cdot 10^4} = 5{,}85$$

Bp-I – sinfli armatura uchun

$$\alpha_2 = \frac{1{,}7 \cdot 10^5}{3{,}25 \cdot 10^4} = 5{,}23$$

A-III – sinfli armatura uchun

$$\alpha_3 = \frac{2{,}0 \cdot 10^5}{3{,}25 \cdot 10^4} = 6{,}15$$

Keltirilgan kesim yuzasi (4-4 kesim uchun, 21-rasm).

$$A_{red} = A_b + \alpha_1 A_{sp} + \alpha_2 A_s + \alpha_3 A_s^{'} = 1632 + 5{,}85 \cdot 12{,}06 + 5{,}23 \cdot 0{,}785 + 6{,}15 \cdot 4{,}52 = 1734{,}5 sm^2$$

Keltirigan kesim yuzasining element ostki qirrasiga nisbatan olingan statik momenti:

$$S_{red,0-0} = bh_f^{'}(h - 0.5h_f^{'}) + bh_f \cdot 0{,}5h_f + \alpha_1 A_{sp} \cdot 0{,}5h_f + \alpha_2 A_s \cdot 0{,}5h_f + \alpha_3 A_s^{'} \cdot (h - 0{,}5h_f^{'}) =$$

$$= 24 \cdot 32 \cdot (145 - 0{,}5 \cdot 32) = 24 \cdot 36 \cdot 0{,}5 \cdot 36 + 5{,}85 \cdot 12{,}06 \cdot 0{,}5 \cdot 36 + 5{,}23 \cdot 0{,}785 \cdot 0{,}5 \cdot 36 +$$

$$+ 6{,}15 \cdot 4{,}52 \cdot (145 - 0{,}5 \cdot 32) = 119554 sm^3$$

Keltirilgan kesim yuzasining og'irlik markazidan, to uning ostki qirrasiga qadar bo'lgan masofa:

$$y_0 = \frac{S_{red,0-0}}{A_{red}} = \frac{119554}{1734{,}5} = 68{,}9 sm$$

Keltirilgan kesim yuzasining og'irlik markaziga nisbatan olingan inersiya momenti:

$$I_{red} = \frac{b(h_f^{'})^3}{12} + bh_f^{'}(h - y_0 - 0{,}5h_f^{'})^2 + \frac{bh_f^3}{12} + bh_f(y_0 - 0.5h_f)^2 + \alpha_1 \cdot A_{sp} \cdot (y_0 - 0{,}5h_f)^2 +$$

$$+ \alpha_2 \cdot A_s(y_0 - 0.5h_f)^2 + \alpha_3 \cdot A_s(h - y_0 - 0{,}5h_f^{'})^2 = 24 \cdot \frac{32^3}{12} + 24 \cdot 32(145 - 68{,}9 - 0{,}5 \cdot 32)^2 +$$

$$+ \frac{36^3}{12} + 24 \cdot 36 \cdot (68{,}9 - 0{,}5 \cdot 36)^2 + 5{,}85 \cdot 12{,}06 \cdot (68{,}9 - 0{,}5 \cdot 36)^2 + 5{,}23 \cdot 0{,}785 \cdot (68{,}9 - 0{,}5 \cdot 36)^2 +$$

$$+ 6{,}15 \cdot 4{,}52 \cdot (145 - 68{,}9 - 0{,}5 \cdot 32)^2 = 5465159 sm^4$$

Keltirilgan kesim yuzasini elementning ostki qirrasiga nisbatan olingan qarshilik momenti:

$$W_{red} = \frac{I_{red}}{y_0} = \frac{5465159}{68{,}9} = 79320 sm^3$$

Kesimning pastki qismi cho'zilgan holdagi nol chizig'ining holati (4) formula asosida aniqlanadi.

$$S_{b.0}^{'} + \alpha S_{s.o}^{'} - \alpha S_{s.o} = \frac{(h - x)}{2} A_{bt}$$

Bu yerda: $S_{b.0}^{'} = bx \cdot 0.5x = 24 \cdot x \cdot 0.5 \cdot x = 12x^2$

$$\alpha S_{s.o}^{'} = \alpha_3 A_s(x - 0.5h_f^{'}) = 6{,}15 \cdot 4{,}52(x - 0{,}5 \cdot 32) = 27{,}8x - 444{,}8$$

$$\alpha S_{s.o} = \alpha_1 A_{sp}(h - 0.5h_f - x) + \alpha_2 A_s(h - 0.5h_f - x) = 5{,}85 \cdot 12{,}06 \cdot (145 - 0{,}5 \cdot 36 - x) +$$

$$+ 5{,}23 \cdot 0{,}785(145 - 0{,}5 \cdot 36 - x) = 9481 - 74{,}7x$$

$$A_{bt} = bh_f + b(h_f^{'} - x) = 24 \cdot 36 + 24(32 - x) = 1632 - 24x.$$

Topilgan qiymatlarni o'rniga qo'yib, quyidagilarni topamiz.

$$12x^2 + 27{,}8x - 444{,}8 - 9481 + 74{,}7x = \frac{(145 - x)\cdot(1632 - 24x)}{2}$$

$$x = \frac{128245{,}8}{2658{,}5} = 48{,}24см > h_f^{'} = 32sm$$

Hisob boshida, A_{bt} ni topishda X<h_f deb olingan edi. Endi A_{bt}, $S'_{b.o}$ va X qiymatlariga aniqlik kiritamiz.

$$A_{bt} = bh_f = 24\cdot 36 = 864см^2$$

$$S_{b.o}^{'} = bh_f^{'}(x - 0.5h_f^{'}) = 24\cdot 32(x - 0.5\cdot 32) = 768x - 12288$$

Topilgan qiymatlarni formula (4) ga qo'yib X qiymatini topamiz.

$$768x - 12288 + 27{,}8x - 445 - 9481 + 74{,}7x = \frac{145 - x}{2}\cdot 864$$

$$x = \frac{84854}{1302{,}5} = 65{,}15sm$$

Balkaning pastki qismidagi cho'ziluvchi tolalarning chetki qirrasi uchun keltirilgan kesim yuzasining qarshilik momenti (cho'ziluvchi betonning noelastik deformatsiyasini hisobga olgan holda)

$$W_{pl} = \frac{2(I_{b.o} + \alpha I_{s.o} + \alpha I_{s.o}^{'})}{h - x} + S_{b.o} = \frac{2(1920811 + 285593 + 67152{,}2)}{145 - 65{,}15} + 53438{,}4 = 110384sm^3$$

Bu yerda, $I_{b.o}$ -nol chizig'iga nisbatan beton kesim yuzasi siqiluvchi zonasining inersiya momenti va u quyidagicha topiladi.

$$I_{b.o} = \frac{b(h_f^{'})^3}{12} + bh_f^{'}(x - 0.5h_f^{'})^2 = 24\cdot\frac{32^3}{12} + 24\cdot 32(65{,}15 - 0{,}5\cdot 32)^2 = 1920811sm^4$$

$\alpha I_{s.o}$ - nol chizig'iga nisbatan A_{sp} va A_s armatura yuzalarining keltirilgan inersiya momenti

$$\alpha I_{s.o} = \alpha_1 A_{sp}(h - x - 0{,}5h_f)^2 + \alpha_2 A_s(h - x - 0{,}5h_f)^2 = 5{,}85\cdot 12{,}06(145 - 65{,}15 - 0{,}5\cdot 36)^2 +$$

$$+ 5{,}23\cdot 0{,}785(145 - 65{,}15 - 0{,}5\cdot 36)^2 = 285593sm^2$$

Nol chizig'iga nisbatan A_s armatura yuzasining keltirilgan inersiya momenti:

$$\alpha I_{s.o}^{'} = \alpha_3 A_s^{'}(x - 0{,}5h_f^{'})^2 = 6{,}15\cdot 4{,}52(65{,}15 - 0{,}5\cdot 32)^2 = 67152{,}2sm^4$$

Nol chizig'iga nisbatan cho'ziluvchi zonadagi beton yuzasining statik momenti $S_{b.o}$ quyidagi formula bo'yicha topiladi.

$$S_{b.o} = bh_f(h - x - 0{,}5h_f) = 24\cdot 36(145 - 65{,}15 - 0{,}5\cdot 36) = 53438{,}4sm^3,$$

Keltirilgan kesim yuzasining yuqori qirrasiga nisbatan olingan qarshilik momenti

$$W_{red}^{'} = \frac{I_{red}}{h - y_0} = \frac{5465159}{(145 - 68{,}9)} = 71815sm^3$$

Kesim yuzasining yuqori qismi cho'zilganda, nol chizig'ining holati (4) formula orqali aniqlanadi.

$$S'_{b.o} = bh_f(x-0{,}5h_f) = 24\cdot 36(x-0{,}5\cdot 36) = 864x - 15552;$$

$$\alpha S'_{b.o} = \alpha_1 A_{sp}(x-0{,}5h_f) + \alpha_2 A_s(x-0{,}5h_f) = 5{,}85\cdot 12{,}06(x-0{,}5\cdot 36) + 5{,}23\cdot 0{,}785\cdot(x-0{,}5\cdot 36) =$$

$$= 74{,}66x - 1343{,}82;$$

$$\alpha S_{b.o} = \alpha_3 A'_s(h-0{,}5h'_f - x) = 6{,}15\cdot 4{,}52(145-0{,}5\cdot 32 - x) = 3586 - 27{,}8x;$$

Bunda x>h_f deb faraz qilib A_{bt} topiladi

$$A_{bt} = bh'_f = 24\cdot 32 = 768sm^2$$

Topilgan sonlarni (4) formulaga qo'yib x qiymatini aniqlaymiz,

$$864x\text{-}15552+74{,}66x\text{-}1343{,}82\text{-}3586+27{,}8x = \frac{(145-x)768}{2} \qquad x=56{,}4sm,$$

Keltirilgan kesim yuzasining cho'zilgan zonasini yuqori qirrasiga nisbatan olingan qarshilik momenti W'_{pl}, W_{pl} kabi aniqlanadi,

$$I_{b.o} = \frac{bh_f^3}{12} + bh_f(x-0{,}5h_f)^2 = 24\cdot\frac{36^2}{12} + 24\cdot 36(56{,}4-0{,}5\cdot 36)^2 = 1367332см^4$$

$$\alpha I_{s.o} = \alpha_3 A'_s(h-x-0{,}5h'_f)^2 = 6{,}15\cdot 4{,}52(145-56{,}4-0{,}5\cdot 32)^2 = 146516{,}6см^4$$

$$\alpha I'_{s.o} = \alpha_1 A_{sp}(x-0{,}5h_f)^2 + \alpha_2 A_s(x-0{,}5h_f)^2 = 5{,}85\cdot 12{,}06(56{,}4-0{,}5\cdot 36)^2 +$$

$$+ 5{,}23\cdot 0{,}785(56{,}4-0{,}5\cdot 36)^2 = 110085{,}6$$

$$S'_{b.o} = bh'_f(h-x-0{,}5h'_f) = 24\cdot 32(145-56{,}4-0{,}5\cdot 32) = 55757см^3$$

$$W'_{pl} = 2\cdot\frac{(I_{b.o}+\alpha I_{s.o}+\alpha I'_{s.o})}{h-x} + S'_{b.o} = 2\cdot\frac{(1367332+146516{,}6+110085{,}6)}{145-56{,}4} + 55757 = 92415см^3$$

To'sinning 0-0 kesim yuzasi bo'yicha geometrik xarakteristikalari yuqorida ko'rsatilgan 4-4 kesim kabi aniqlanadi.

0-0 kesim

h=91 sm

1. $A_b = \sum hb_1 = 91\cdot 24 = 2184sm^2$

$$A_{sp} + A_s + A'_s = 12{,}06 + 0{,}785 + 4{,}52 = 17{,}36sm^2$$

2. $0{,}008A_b = 0{,}008\cdot 2184 = 17{,}472см^2 > 17{,}36sm^2$

3. $A_{red} = A_b + \alpha_1 A_{sp} + \alpha_2 A_s + \alpha_3 A'_s$; demak Ared=$A_b$=2184 sm^2

4.

$$S_{red,0-0} = bh\frac{h}{2} + \alpha_1\cdot A_{sp}\cdot 0{,}5\frac{h}{2} + \alpha_2\cdot A_s\cdot 0{,}5\frac{h}{2} + \alpha_3\cdot A'_s(h-0{,}5\frac{h}{2}) =$$

$$= 24\cdot\frac{91^2}{2} + 5{,}85\cdot 12{,}06\cdot 0{,}5\cdot\frac{91}{2} + 5{,}23\cdot 0{,}785\cdot 0{,}5\cdot\frac{91}{2} + 6{,}15\cdot 4{,}52\cdot\left(91-\frac{91}{4}\right) = 102967{,}6sm^3$$

5. $y_0 = \frac{S_{red,0-0}}{A_{red}} = \frac{102967{,}6}{2184} = 47{,}1sm$

$$I_{red} = \frac{b \cdot h^3}{12} + \alpha_1 A_{sp}(y_0 - 0{,}5 \cdot \frac{h}{2})^2 + \alpha_2 A_s (y_0 - 0{,}5 \cdot h_f)^2 + \alpha_3 A_s^{'}(h - y_0 - 0{,}5 \cdot \frac{h}{2})^2 =$$

6. $$= 24\frac{91^3}{12} + 5{,}85 \cdot 12{,}06(47{,}1 - 0{,}5 \cdot \frac{91}{2})^2 + 5{,}23 \cdot 0{,}785(47{,}1 - 0{,}5 \cdot \frac{91}{2})^2 +$$

$$+ 6{,}15 \cdot 4{,}52(91 - 47{,}1 - 0{,}5 \cdot \frac{91}{2})^2 = 1563842 sm^4$$

7. $W_{red} = \frac{I_{red}}{y_0} = \frac{1563842}{47{,}1} = 33203 sm^3$

8. $S_{b0}^{'} + \alpha S_{s0}^{'} - \alpha S_{s0} = \frac{(h-x)}{2} A_{bt}$

$S_{bl} = bx \cdot 0{,}5x = 24 \cdot x \cdot 0{,}5x = 12x^2$

$\alpha S_{s0}^{'} = \alpha_3 A_s (x - 0{,}5h) = 6{,}15 \cdot 4{,}52(x - 0{,}5 \cdot \frac{91}{2}) = 27{,}8x - 632$

$\alpha S_{s0} = 5{,}85 \cdot 12{,}06(91 - 0{,}5 \cdot \frac{91}{2} - x) + 5{,}23 \cdot 0{,}785(91 - 0{,}5 \cdot \frac{91}{2} - x) = 5095 - 75x$

9. $A_{bt} = bh + b(h - x) = 24 \cdot \frac{91}{2} + 24(\frac{91}{2} - x) = 2184 - 24x$

$12x^2 + 27{,}8x - 632 - 5095 + 75x = \frac{(91 - x)(2184 - 24x)}{2}$

$2286{,}8x = 105099$

$x = 46 см$

10. $A_{bt} = b\frac{h}{2} = 24 \cdot \frac{91}{2} = 1092 sm^2$

$S_{b0}^{'} = b\frac{h}{2}\left(x - 0{,}5\frac{h}{2}\right) = 24 \cdot \frac{91}{2}(x - 0{,}5 \cdot \frac{91}{2}) = 1029x - 24843$

11. $1092x - 24843 + 27{,}8x - 632 - 5095 + 75x = \frac{1092(91 - x)}{2}$

$1740{,}8x = 80256$

$x = 46{,}1 sm$

Balkaning pastki qismidagi cho'ziluvchi tolalarning chetki qirrasi uchun keltirilgan kesim yuzasining qarshilik momenti:

$$W_{pl} = \frac{2(I_{b0} + \alpha I_{s0} + \alpha I_{s0}^{'})}{h - x} + S_{b0}$$

U holda,

$$I_{b0} = \frac{b\left(\frac{h}{2}\right)^3}{12} + b\frac{h}{2}(x - 0{,}5\frac{h}{2})^2 = 24\frac{45{,}5^3}{12} + 24 \cdot 45{,}5(46{,}1 - 0{,}5 \cdot 45{,}5)^2 = 783776см^4$$

$$\alpha I_{s0} = \alpha_1 A_{sp}(h - x - 0{,}5\frac{h}{2})^2 + \alpha_2 A_s(h - x - 0{,}5\frac{h}{2})^2 = 5{,}85 \cdot 12{,}06(91 - 46{,}1 - 0{,}5 \cdot 45{,}5)^2 +$$

$$+ 5{,}23 \cdot 0{,}785\left(91 - 46{,}1 - 0{,}5 \cdot 45{,}5\right)^2 = 8001{,}8см^4$$

$$\alpha I'_{s0} = \alpha_3 A'_s(x - 0{,}5\frac{h}{2})^2 = 6{,}15 \cdot 4{,}52(46{,}1 - 0{,}5 \cdot 45{,}5)^2 = 15156{,}1см^4$$

$$S'_{b0} = b\frac{h}{2}(h - x - 0{,}5\frac{h}{2}) = 24 \cdot \frac{91}{2}(91 - 46{,}1 - 0{,}5 \cdot \frac{91}{2}) = 24187{,}8см^3$$

Topilgan qiymatlarni o'z o'rniga qo'yamiz:

$$W_{pl} = \frac{2(I_{b0} + \alpha I_{s0} + \alpha I'_{s0})}{h - x} + S_{b0} = \frac{2\left(783776 + 8001{,}8 + 15156{,}1\right)}{91 - 46{,}1} + 24187{,}8 = 60131sm^3$$

12. $W'_{red} = \frac{I_{red}}{h - y_0} = \frac{1563842}{91 - 47{,}1} = 35623sm^3$

13.

$$S'_{b0} = b\frac{h}{2}\left(x - 0{,}5\frac{h}{2}\right) = 24 \cdot 45{,}5(x - 0{,}5 \cdot 45{,}5) = 1092x - 24843$$

$$\alpha S'_{b0} = \alpha_1 A_{sp}(x - 0{,}5\frac{h}{2}) + \alpha_2 A_s(x - 0{,}5\frac{h}{2}) = 5{,}85 \cdot 12{,}06(x - 0{,}5 \cdot 45{,}5) + 5{,}23 \cdot 0{,}785(x - 0{,}5 \cdot 45{,}5) =$$

$$= 74{,}7x - 1698{,}4$$

$$\alpha S_{b0} = \alpha_3 A'_s(h - 0{,}5\frac{h}{2} - x) = 6{,}15 \cdot 4{,}52(91 - 0{,}5 \cdot 45{,}5 - x) = 1897{,}2 - 27{,}8x$$

14. $A_{bt} = b\frac{h}{2} = 24 \cdot 45{,}5 = 1092sm^2$

$$1092x - 24843 + 74{,}7x - 1698{,}4 - 1897{,}2 + 27{,}8x = \frac{(91 - x)1092}{2}$$

$$1740{,}5x = 78124{,}6$$

$$x = 44{,}9sm$$

15. $I_{b,0} = \frac{b\left(\frac{h}{2}\right)^3}{12} + b\frac{h}{2}(x - 0{,}5\frac{h}{2})^2 = 24\frac{45{,}5^2}{12} + 24 \cdot 45{,}5(44{,}9 - 0{,}5 \cdot 45{,}5)^2 = 724153sm^4$

16. $\alpha I_{s0} = \alpha_3 A'_s(h - x - 0{,}5\frac{h}{2})^2 = 6{,}15 \cdot 4{,}52(91 - 44{,}9 - 0{,}5 \cdot 45{,}5)^2 = 15156{,}1sm^4$

$$\alpha I'_{s0} = \alpha_1 A_{sp}(x - 0{,}5\frac{h}{2})^2 + \alpha_2 A_s(x - 0{,}5\frac{h}{2})^2 = 5{,}85 \cdot 12{,}06(44{,}9 - 0{,}5 \cdot 45{,}5)^2 +$$

$$+ 5{,}23 \cdot 0{,}785(44{,}9 - 0{,}5 \cdot 45{,}5)^2 = 36628{,}3sm^4$$

17. $S'_{b0} = b\frac{h}{2}(h - x - 0{,}5\frac{h}{2}) = 24 \cdot 45{,}5(91 - 44{,}9 - 0{,}5 \cdot 45{,}5) = 25498{,}2sm^3$

Topilgan qiymatlarni o'z o'rniga qo'yamiz.

18. $W_{pl}^{'} = 2\frac{(I_{b0} + \alpha I_{s0} + \alpha I_{s0}^{'})}{h - x} + S_{b0}^{'} = 2\frac{(724153 + 15156{,}1 + 36628{,}3)}{91 - 44{,}9} + 25498{,}2 = 59161 sm^3$

1-1 kesim

Balkaning 1-1 kesim bo'yicha balandligi h=115 sm

1. $A_b = \sum hb_1 = 115 \cdot 24 = 2760 sm^2$

2. $0{,}008 A_b = 0{,}008 \cdot 2760 = 22{,}0 sm^2 > 17{,}36 sm^2$

3. $A_{red} = A_b + \alpha_1 A_{sp} + \alpha_2 A_s + \alpha_3 A_s^{'} = 2760 + 5{,}85 \cdot 12{,}06 + 5{,}23 \cdot 0{,}785 + 6{,}15 \cdot 4{,}52 = 2862{,}45 sm^2$

$h_f = h_f^{'} = \frac{h}{2} = \frac{115}{2} = 57{,}5 sm$

4.

$S_{red,0-0} = bh(h - 0{,}5h_f) + bh_f \cdot 0{,}5h_f + \alpha_1 \cdot A_{sp} \cdot 0{,}5h_f + \alpha_2 \cdot A_s \cdot 0{,}5h_f + \alpha_3 \cdot A_s^{'}(h - 0{,}5h_f) =$

$= 24 \cdot 57{,}5 \cdot (115 - 0{,}5 \cdot 57{,}5) + 24 \cdot 57{,}5 \cdot 0{,}5 \cdot 57{,}5 + 5{,}85 \cdot 12{,}06 \cdot 0{,}5 \cdot 57{,}5 + 5{,}23 \cdot 0{,}785 \cdot 0{,}5 \cdot 57{,}5 +$

$+ 6{,}15 \cdot 4{,}52 \cdot (115 - 0{,}5 \cdot 57{,}5) = 163243{,}9 sm^3$

5. $y_0 = \frac{S_{red,0-0}}{A_{red}} = \frac{163243{,}94}{2862{,}45} = 57{,}03 sm$

6 $I_{red} = \frac{b \cdot h^3}{12} + bh^{'}(h - y_0 - 0{,}5 \cdot h\ )^2 + \frac{bh^3}{12} + bh\ (y_0 - 0{,}5 \cdot h\ )^2 + \alpha_1 A_{sp}(y_0 - 0{,}5 \cdot h\ )^2 +$

$\alpha_2 A_s(y_0 - 0{,}5 \cdot h\ )^2 + \alpha_3 A_s^{'}(h - y_0 - 0{,}5 \cdot h\ )^2 = 24\frac{57{,}5^3}{12} + 24 \cdot 57{,}5(115 - 57{,}03 - 0{,}5 \cdot 57{,}5)^2 +$

$24\frac{57{,}5^3}{12} + 24 \cdot 57{,}5(57{,}03 - 0{,}5 \cdot 57{,}5)^2 + 5{,}85 \cdot 12{,}06(57{,}03 - 0{,}5 \cdot 57{,}5)^2 +$

$+ 5{,}23 \cdot 0{,}785(57{,}03 - 0{,}5 \cdot 57{,}5)^2 + 6{,}15 \cdot 4{,}52(115 - 57{,}03 - 0{,}5 \cdot 57{,}5)^2 = 3125890{,}7 sm^4$

7. $W_{red} = \frac{I_{red}}{y_0} = \frac{3125800{,}7}{57{,}03} = 54809{,}76 sm^3$

8. $S_{b0}^{'} + \alpha S_{s0}^{'} - \alpha S_{s0} = \frac{(h - x)}{2} A_{bt}$

$S_{bl} = bx \cdot 0{,}5x = 24 \cdot x \cdot 0{,}5x = 12x^2$

$\alpha S_{s0}^{'} = \alpha_3 A_s(x - 0{,}5h^{'}) = 6{,}15 \cdot 4{,}52(x - 0{,}5 \cdot 57{,}5) = 27{,}8x - 799{,}2$

$\alpha S_{s0} = 5{,}85 \cdot 12{,}06(115 - 0{,}5 \cdot 57{,}5 - x) + 5{,}23 \cdot 0{,}785(115 - 0{,}5 \cdot 57{,}5 - x) = 6439 - 74{,}65x$

9. $A_{bt} = bh\ + b(h - x) = 24 \cdot 57{,}5 + 24(57{,}5 - x) = 2760 - 24x$

$12x^2 + 27{,}8x - 799{,}2 - 6439 + 74{,}65x = \frac{(115 - x)(2760 - 24x)}{2}$

$5724{,}9x = 331876{,}4$

$x = 57{,}97 см > h_f^{'} = 57{,}5 sm$

10. $A_{bt} = bh_f = 24 \cdot 57{,}5 = 1380 sm^2$

$$S_{b0} = 24 \cdot 57,5(x - 0,5 \cdot 57,5) = 1380x - 39675$$

11. $$1380x - 39675 + 27,8x - 799,2 - 6439 + 74,65x = \frac{1380(115 - x)}{2}$$

$$4344,9x = 252526,4$$

$$x = 58,12sm$$

12. $$W_{pl} = \frac{2(I_{b0} + \alpha I_{s0} + \alpha I'_{s0})}{h - x} + S_{b0} = \frac{2(1570602,4 + 23978,5 + 59075,5)}{115 - 58,12} + 38819,4 = 96964,84sm^3$$

$$W_{pl} = W'_{pl} = 96964,8sm^3$$

13. $$W'_{red} = \frac{I_{red}}{h - y_0} = \frac{3125800,7}{115 - 57,03} = 53948,9sm^3$$

14. $$I_{b0} = \frac{bh_f^3}{12} + bh_f(x - 0,5h'_f)^2 = 24\frac{57,5^2}{12} + 24 \cdot 57,5(57,12 - 0,5 \cdot 57,5)^2 = 1570602,4sm^4$$

15.

$$\alpha I_{s0} = \alpha_1 A_{sp}(h - x - 0,5h_f)^2 + \alpha_2 A_s(h - x - 0,5h_f)^2 = 5,85 \cdot 12,06(115 - 58,12 - 0,5 \cdot 57,5)^2 +$$

$$+ 5,23 \cdot 0,785(115 - 58,12 - 0,5 \cdot 57,5)^2 = 59075,5sm^4$$

$$\alpha I'_{s0} = \alpha_3 A'_s(x - 0,5h'_f)^2 = 6,15 \cdot 4,52(58,12 - 0,5 \cdot 57,5)^2 = 23978,5sm^4$$

16. $$S'_{b0} = b\frac{h}{2}(h - x - 0,5\frac{h}{2}) = 24 \cdot 57,5(115 - 57,12 - 0,5 \cdot 57,5) = 38819,4sm^3$$

1a-1a kesim

1a-1a kesimda balkaning balandligi: h=123 sm, $A_в$=1632 sm^2 , A_{red}=1734,5 sm^2

1.

$$S_{red,0-0} = bh'_f(h - 0,5h'_f) + bh_f \cdot 0,5h_f + \alpha_1 \cdot A_{sp} \cdot 0,5h_f + \alpha_2 \cdot A_s \cdot 0,5h_f + \alpha_3 \cdot A'_s(h - 0,5h'_f) =$$

$$= 24 \cdot 32 \cdot (123 - 0,5 \cdot 32) + 24 \cdot 36 \cdot 0,5 \cdot 36 + 5,85 \cdot 12,06 \cdot 0,5 \cdot 36 + 5,23 \cdot 0,785 \cdot 0,5 \cdot 36 +$$

$$+ 6,15 \cdot 4,52 \cdot (123 - 0,5 \cdot 32) = 102046,2sm^3$$

2. $$y_0 = \frac{S_{red,0-0}}{A_{red}} = \frac{3480493,2}{58,8} = 59192sm^3$$

3.

$$I_{red} = \frac{b \cdot (h'_f)^3}{12} + bh'_f(h - y_0 - 0,5 \cdot h'_f)^2 + \frac{bh_f^3}{12} + bh_f(y_0 - 0,5 \cdot h_f)^2 + \alpha_1 A_{sp}(y_0 - 0,5 \cdot h_f)^2 +$$

$$\alpha_2 A_s(y_0 - 0,5 \cdot h_f)^2 + \alpha_3 A'_s(h - y_0 - 0,5 \cdot h_f)^2 = 24\frac{32^3}{12} + 24 \cdot 32(123 - 58,8 - 0,5 \cdot 32)^2 + \frac{36^3}{12} +$$

$$24 \cdot 36(58,8 - 0,5 \cdot 36)^2 + 5,85 \cdot 12,06(58,8 - 0,5 \cdot 36)^2 + 5,23 \cdot 0,785(58,8 - 0,5 \cdot 36)^2 +$$

$$+ 6,15 \cdot 4,5(123 - 58,8 - 0,5 \cdot 32)^2 = 3480493,2sm^3$$

4. $$w_{red} = \frac{3480493,2}{58,8} = 59192sm^3.$$

5. $S'_{b0} + \alpha S'_{s0} - \alpha S_{s0} = \dfrac{(h-x)}{2} A_{bt}$

$S'_{b0} = bx \cdot 0{,}5x = 24 \cdot x \cdot 0{,}5x = 12x^2$

$\alpha S'_{s0} = \alpha_3 A_s (x - 0{,}5h'_f) = 6{,}15 \cdot 4{,}52(x - 0{,}5 \cdot 32) = 27{,}8x - 444{,}8$

$\alpha S_{s0} = \alpha_1 A_{sp}\left(h - 0{,}5h_f - x\right) + \alpha_2 A_s\left(h - 0{,}5h_f - x\right) = 5{,}85 \cdot 12{,}06(123 - 0{,}5 \cdot 36 - x) +$

$+ 5{,}23 \cdot 0{,}785(123 - 0{,}5 \cdot 36 - x) = 7838{,}9 - 74{,}7x$

6. $A_{bt} = bh_f + b(h'_f - x) = 24 \cdot 36 + 24(32 - x) = 1632 - 24x$

o'rniga qo'yamiz:

$12x^2 + 27{,}8x - 444{,}8 - 7838{,}9 + 74{,}7x = \dfrac{(123-x)(1632-24x)}{2}$

7. $4789x = 217303{,}4$

$x = 45{,}4см > h'^{i}_{1f} = 32см$

8. $A_{bt} = bh_f = 24 \cdot 36 = 864см^2$

$S'_{b0} = bh'_f\left(x - 0{,}5h'_f\right) = 24 \cdot 32(x - 0{,}5 \cdot 32) = 768x - 12288$

$768x - 12288 + 27{,}8x - 444{,}8 - 7838{,}9 + 74{,}7x = \dfrac{864(123-x)}{2}$

$1302{,}5x = 73707{,}7$

$x = 56{,}6см$

9. $W_{pl} = \dfrac{2(I_{b0} + \alpha I_{s0} + \alpha I'_{s0})}{h-x} + S_{b0}$

10. $I_{b0} = \dfrac{bh'^{3}_f}{12} + bh_f(x - 0{,}5h'_f)^2 = 24\dfrac{32^2}{12} + 24 \cdot 32(56{,}6 - 0{,}5 \cdot 32)^2 = 1331476{,}4sm^4$

$\alpha I_{s0} = \alpha_1 A_{sp}(h - x - 0{,}5h_f)^2 + \alpha_2 A_s(h - x - 0{,}5h_f)^2 = 5{,}85 \cdot 12{,}06(123 - 56{,}6 - 0{,}5 \cdot 36)^2 +$

$+ 5{,}23 \cdot 0{,}785(123 - 56{,}6 - 0{,}5 \cdot 36)^2 = 174887{,}4sm^2$

$\alpha I'_{s0} = \alpha_3 A'_s(x - 0{,}5h_f)^2 = 6{,}15 \cdot 4{,}52\left(56{,}6 - 0{,}5 \cdot 32\right)^2 = 45821{,}1sm^4$

$S_{b0} = bh_f\left(h - x - 0{,}5h_f\right) = 24 \cdot 36\left(123 - 56{,}6 - 0{,}5 \cdot 36\right) = 41817{,}6sm^3$

Topilgan qiymatlarni formulaga olib borib qo'yamiz:

U holda $W_{pl} = \dfrac{2(1331476{,}4) + 174887{,}4 + 45821{,}1}{123 - 56{,}6} + 41817{,}6 = 88570{,}1sm^3$

$W'_{red} = \dfrac{I_{red}}{h - y_0} = \dfrac{3480493{,}2}{123 - 28{,}8} = 54213{,}3\ \text{sm}^3$

$S'_{b0} = 24 \cdot 36(x - 0{,}5 \cdot 36) = 864x - 15552$

$\alpha S'_{b0} = \alpha_1 A_{sp}(x - 0{,}5h_f) + \alpha_2 A_s(x - 0{,}5h_f) = 5{,}85 \cdot 12{,}06(x - 0{,}5 \cdot 36) + 5{,}23 \cdot 0{,}785(x - 0{,}5 \cdot 36) =$

$= 74{,}66x - 1343{,}82$

$\alpha S_{b0} = \alpha_3 A'_s(h - 0{,}5h'_f - x) = 6{,}15 \cdot 4{,}52(123 - 0{,}5 \cdot 32 - x) = 2974{,}4 - 27{,}8x$

11. $A_{bt} = 24 \cdot 32 = 768sm^2$

Topilgan qiymatlarni o'rniga qo'yamiz:

$$864x - 15552 + 74{,}66x - 1343{,}82 - 2974{,}4 + 27{,}8x = \frac{(123-x)768}{2}$$

12. $1355{,}5x = 67717{,}2$

$x = 49{,}96sm$

13. $I_{b0} = \frac{bh_f^{'3}}{12} + bh_f(x - 0{,}5h_f^{'})^2 = 24\frac{36^2}{12} + 24 \cdot 36(49{,}96 - 0{,}5 \cdot 36)^2 = 885117{,}5\,\text{sm}^4$

14. $\alpha I_{s0} = \alpha_3 A_S^{'}(h - x - 0{,}5h_f)^2 = 6{,}15 \cdot 4{,}52(123 - 49{,}96 - 0{,}5 \cdot 32)^2 = 90442{,}5sm^4$

$\alpha I_{s0}^{'} = \alpha_1 A_{sp}(x - 0{,}5h_f)^2 + \alpha_2 A_s(x - 0{,}5h_f)^2 = 5{,}85 \cdot 12{,}06(49{,}96 - 0{,}5 \cdot 36)^2 +$

$+ 5{,}23 \cdot 0{,}785(49{,}96 - 0{,}5 \cdot 36)^2 = 76257{,}3$

15. $S_{b0}^{'} = bh^{'}{}_f(h - x - 0{,}5h^{'}{}_f) = 24 \cdot 32(123 - 49{,}96 - 0{,}5 \cdot 32) = 43809{,}7sm^3$

16.

$W_{pl}^{'} = 2\frac{(I_{b0} + \alpha I_{s0} + \alpha I_{s0}^{'})}{h - x} + S_{b0}^{'} = 2\frac{(885117{,}5 + 90442{,}5 + 76257{,}3)}{123 - 49{,}96} + 43806{,}7 = 72607{,}8sm^3$

2-2 kesim

2-2 kesimda balkaning balandligi h=139 sm, A_b=1632 sm^2, A_{red}=1734,5 sm^2

1.

$S_{red,0-0} = bh^{'}{}_f(h - 0{,}5h^{'}{}_f) + bh_f \cdot 0{,}5h_f + \alpha_1 \cdot A_{sp} \cdot 0{,}5h_f + \alpha_2 \cdot A_s \cdot 0{,}5h_f + \alpha_3 \cdot A_s^{'}(h - 0{,}5h^{'}{}_f) =$

$= 24 \cdot 32(139 - 0{,}5 \cdot 32) + 24 \cdot 36 \cdot 0{,}5 \cdot 36 + 5{,}85 \cdot 12{,}06 \cdot 0{,}5 \cdot 36 + 5{,}23 \cdot 0{,}785 \cdot 0{,}5 \cdot 36 +$

$+ 6{,}15 \cdot 4{,}52(139 - 0{,}5 \cdot 32) = 114778{,}96sm^4$

2. $y_0 = \frac{S_{red,0-0}}{A_{red}} = \frac{114778{,}96}{1734{,}5} = 66{,}2sm$

3.

$I_{red} = \frac{b \cdot h_f^3}{12} + bh_f^{'}(h - y_0 - 0{,}5 \cdot h_f^{'})^2 + \frac{bh_f^3}{12} + bh_f(y_0 - 0{,}5 \cdot h_f)^2 + \alpha_1 A_{sp}(y_0 - 0{,}5 \cdot h_f)^2 +$

$+ \alpha_2 A_s(y_0 - 0{,}5 \cdot h_f)^2 + \alpha_3 A_s^{'}(h - y_0 - 0{,}5 \cdot h_f^{'})^2 = 24\frac{32^3}{12} + 24 \cdot 32(139 - 66{,}2 - 0{,}5 \cdot 32)^2 +$

$+ \frac{24 \cdot 36^3}{12} + 24 \cdot 36(66{,}2 - 0{,}5 \cdot 36)^2 + 5{,}85 \cdot 12{,}06(66{,}2 - 0{,}5 \cdot 36)^2 + 5{,}23 \cdot 0{,}785(66{,}2 - 0{,}5 \cdot 36)^2 +$

$+ 6{,}15 \cdot 4{,}52(139 - 66{,}2 - 0{,}5 \cdot 32)^2 = 4907007{,}6sm^4$

4. $W_{red} = \frac{I_{red}}{y_0} = \frac{4907007{,}6}{66{,}2} = 74123{,}98sm^3$

5. $S_{b0}^{'} + \alpha S_{s0}^{'} - \alpha S_{s0} = \frac{(h-x)}{2} A_{bt}$

$S'_{b0} = bx \cdot 0{,}5x = 24 \cdot x \cdot 0{,}5x = 12x^2$

$\alpha S'_{s0} = \alpha_3 A_s (x - 0{,}5h'_f) = 6{,}15 \cdot 4{,}52(x - 0{,}5 \cdot 32) = 27{,}8x - 444{,}8$

$\alpha S_{s0} = 5{,}85 \cdot 12{,}06(139 - 0{,}5 \cdot 36 - x) + 5{,}23 \cdot 0{,}785(139 - 0{,}5 \cdot 36 - x) = 9033{,}44 - 74{,}65x$

6. $A_{bt} = bh_f + b(h'_f - x) = 24 \cdot 36 + 24(32 - x) = 1632 - 24x$

Topilgan qiymatlarni o'rniga qo'yamiz:

$$12x^2 + 27{,}8x - 444{,}8 - 9033{,}44 + 74{,}65x = \frac{(139 - x)(1632 - 24x)}{2}$$

7. $5172{,}9x = 245804{,}48$

$x = 47{,}52 > h'_f = 32sm$

8. $A_{bt} = bh_f = 24 \cdot 36 = 864sm^2$

$S'_{b0} = 24 \cdot 32(x - 0{,}5 \cdot 32) = 768x - 12288$

$$768x - 12288 + 27{,}8x - 444{,}8 - 9033{,}44 + 74{,}65x = \frac{864(139 - x)}{2}$$

$1302{,}5x = 81814{,}24$

$x = 62{,}8sm$

9.

$$W_{pl} = \frac{2(I_{b0} + \alpha I_{s0} + \alpha I'_{s0})}{h - x} + S_{b0} = \frac{2(1747640{,}3 + 252879{,}64 + 60884{,}29)}{139 - 62{,}8} + 50284{,}8 = 104389{,}89sm^3$$

10. $W'_{red} = \frac{I_{red}}{h - y_0} = \frac{4907007{,}6}{139 - 66{,}2} = 67403{,}95sm^3$

$S_{b0} = bh_f(h - x - 0{,}5h_f) = 24 \cdot 36(139 - 62{,}8 - 0{,}5 \cdot 36) = 50284{,}8sm^3$

$S'_{b0} = 24 \cdot 36(x - 0{,}5 \cdot 36) = 864x - 15552$

$\alpha S'_{b0} = \alpha_1 A_{sp}(x - 0{,}5h_f) + \alpha_2 A_s(x - 0{,}5h_f) = 5{,}85 \cdot 12{,}06(x - 0{,}5 \cdot 36) + 5{,}23 \cdot 0{,}785(x - 0{,}5 \cdot 36) =$

$= 74{,}65x - 1343{,}81$

$\alpha S_{b0} = \alpha_3 A'_s(h - 0{,}5h'_f - x) = 6{,}15 \cdot 4{,}52(139 - 0{,}5 \cdot 32 - x) = 3363{,}58 - 27{,}8x$

11. $A_{bt} = 24 \cdot 32 = 768sm^2$

Topilgan qiymatlarni o'rniga qo'yamiz:

$$864x - 15552 + 74{,}66x - 1343{,}81 - 3363{,}56 + 27{,}8x = \frac{(139 - x)768}{2}$$

12. $1350{,}46x = 70271{,}81$

$x = 52{,}03sm$

13. $I_{b0} = \frac{bh'^3_f}{12} + bh_f(x - 0{,}5h'_f)^2 = 24\frac{32^2}{12} + 24 \cdot 32(62{,}8 - 0{,}5 \cdot 32)^2 = 1747640{,}3sm^4$

14.

$\alpha I_{s0} = \alpha_1 A_{sp}(h - x - 0{,}5h_f)^2 + \alpha_2 A_s(h - x - 0{,}5h_f)^2 = 5{,}85 \cdot 12{,}08(139 - 62{,}8 - 0{,}5 \cdot 36)^2 +$

$+ 5{,}23 \cdot 0{,}785(139 - 62{,}8 - 0{,}5 \cdot 36)^2 = 252879{,}64$

$\alpha I'_{s0} = \alpha_3 A'_s (x - 0{,}5h'_f)^2 = 6{,}15 \cdot 4{,}52(62{,}8 - 0{,}5 \cdot 32)^2 = 60884{,}29 sm^4$

$S_{b0} = bh_f \left(h - x - 0{,}5h_f\right) = 24 \cdot 36(139 - 62 \cdot 8 - 0{,}5 \cdot 36) = 50284{,}8 sm^3$

$W'_{red} = \frac{I_{red}}{h - y_0} = \frac{4907007{,}6}{139 - 66{,}2} = 67403{,}95 sm^3$

$S'_{b0} = bh_f \left(x - 0{,}5h_f\right) = 24 \cdot 36(x - 0{,}5 \cdot 36) = 864x - 15552$

$\alpha S'_{b0} = \alpha_1 A_{sp}(x - 0{,}5h_f) + \alpha_2 A_s (x - 0{,}5h_f) = 5{,}85 \cdot 12{,}06(x - 0{,}5 \cdot 36) + 5{,}23 \cdot 0{,}785(x - 0{,}5 \cdot 36) =$

$= 74{,}65x - 1343{,}81$

$\alpha S_{b0} = \alpha_3 A'_s (h - 0{,}5h'_f - x) = 6{,}15 \cdot 4{,}52(139 - 0{,}5 \cdot 32 - x) = 3363{,}58 - 27{,}8x$

$A_{bt} = 24 \cdot 32 = 768 sm^2$

$864x - 15552 + 74{,}66x - 1343{,}81 - 3363{,}56 + 27{,}8x = \frac{(139 - x)768}{2}$

$1350{,}46x = 70271{,}81$

$x = 52{,}03 sm$

$I_{b0} = \frac{bh'^3_f}{12} + bh_f (x - 0{,}5h'_f)^2 = 24\frac{32^2}{12} + 24 \cdot 32(52{,}03 - 0{,}5 \cdot 36)^2 = 1093859{,}3 sm^4$

$\alpha I_{s0} = \alpha_3 A'_s (h - x - 0{,}5h_f)^2 + \alpha_2 A_s (h - x - 0{,}5h_f)^2 = 6{,}15 \cdot 4{,}52(139 - 52{,}03 - 0{,}5 \cdot 36)^2 =$

$= 140011{,}31 sm^4$

$\alpha I'_{s0} = \alpha_1 A_{sp}(x - 0{,}5h_f)^2 + \alpha_2 A_s (x - 0{,}5h_f)^2 = 5{,}85 \cdot 12{,}06(52{,}03 - 0{,}5 \cdot 36)^2 +$

$+ 5{,}23 \cdot 0{,}785(52{,}03 - 0{,}5 \cdot 36)^2 = 86455{,}336 sm^4$

15. $S'_{b0} = bh'_f (h - x - 0{,}5h'_f) = 24 \cdot 32(139 - 52{,}03 - 0{,}5 \cdot 32) = 54504{,}96 sm^3$

16.

$W'_{pl} = 2\frac{(I_{b0} + \alpha I_{s0} + \alpha I'_{s0})}{h - x} + S'_{b0} = 2\frac{(1093859{,}3 + 140011{,}31 + 86455{,}336)}{139 - 52{,}03} + 54504{,}96 = 84867{,}75 sm^3$

3-3 kesim

3-3 kesim bo'yicha balkaning balandligi h=164 cm, A_b=1632 sm^2, A_{red}=1734,5 sm^2

1.

$S_{red,0-0} = bh'_f (h - 0{,}5h'_f) + bh_f \cdot 0{,}5h_f + \alpha_1 \cdot A_{sp} \cdot 0{,}5h_f + \alpha_2 \cdot A_s \cdot 0{,}5h_f + \alpha_3 \cdot A'_s (h - 0{,}5h'_f) =$

$= 24 \cdot 32(154 - 0{,}5 \cdot 32) + 24 \cdot 36 \cdot 0{,}5 \cdot 36 + 5{,}85 \cdot 12{,}06 \cdot 0{,}5 \cdot 36 + 5{,}23 \cdot 0{,}785 \cdot 0{,}5 \cdot 36 +$

$+ 6{,}15 \cdot 4{,}52(164 - 0{,}5 \cdot 32) = 134673{,}9 sm^3$

2. $y_0 = \frac{S_{red,0-0}}{A_{red}} = \frac{134673{,}9}{1734{,}5} = 77{,}64 sm$

3.

$$I_{red} = \frac{b \cdot \left(h_f^{'}\right)^3}{12} + bh_f^{'}(h - y_0 - 0{,}5 \cdot h_f^{'})^2 + \frac{bh_f^3}{12} + bh_f(y_0 - 0{,}5 \cdot h_f)^2 + \alpha_1 A_{sp}(y_0 - 0{,}5 \cdot h_f)^2 +$$

$$+ \alpha_2 A_s(y_0 - 0{,}5h_f)^2 + \alpha_3 A_s^{'}(h - y_0 - 0{,}5h_f^{'})^2 = 24 \cdot \frac{32^3}{12} + 24 \cdot 32(164 - 77{,}64 - 0{,}5 \cdot 32)^2 + \frac{24 \cdot 36^3}{12} +$$

$$+ 24 \cdot 36(77{,}64 - 0{,}5 \cdot 36)^2 + 5{,}85 \cdot 12{,}06(77{,}64 - 0{,}5 \cdot 36)^2 + 5{,}23 \cdot 0{,}785(77{,}64 - 0{,}5 \cdot 36)^2 +$$

$$+ 6{,}15 \cdot 4{,}52(164 - 77{,}64 - 0{,}5 \cdot 32)^2 = 7437204{,}6sm^4$$

4. $W_{red} = \frac{I_{red}}{y_0} = \frac{7437205}{77{,}64} = 95790{,}89sm^3$

5. $S_{b0}^{'} + \alpha S_{s0}^{'} - \alpha S_{s0} = \frac{(h-x)}{2} A_{bt}$

$S_{b0}^{'} = bx \cdot 0{,}5x = 24 \cdot x \cdot 0{,}5x = 12x^2$

$\alpha S_{s0}^{'} = \alpha_3 A_s(x - 0{,}5h_f^{'}) = 6{,}15 \cdot 4{,}52(x - 0{,}5 \cdot 32) = 27{,}8x - 444{,}8$

$\alpha S_{s0} = \alpha_1 A_{sp}(h - 0{,}5h_f - x) + \alpha_2 A_s(h - 0{,}5h_f - x) = 5{,}85 \cdot 12{,}06(164 - 0{,}5 \cdot 36 - x) +$

$+ 5{,}23 \cdot 0{,}785(164 - 0{,}5 \cdot 36 - x) = 10300{,}4 - 70{,}55x + 599{,}4 - 4{,}1x = 10899{,}8 - 74{,}65x$

6. $A_{bt} = bh_f + b(h_f^{'} - x) = 24 \cdot 36 + 24(32 - x) = 1632 - 24x$

Topilgan qiymatlarni o'rniga qo'yamiz:

$$12x^2 + 27{,}8x - 444{,}8 - 10899{,}8 + 74{,}65x = \frac{(164 - x)(1632 - 24x)}{2}$$

7. $2886{,}45x = 145168{,}6$

$x = 50{,}29см > h_f^{'} = 32sm$

8. $A_{bt} = bh_f = 24 \cdot 36 = 864sm^2$

$S^{'}{}_{b0} = 24 \cdot 32(x - 0{,}5 \cdot 32) = 768x - 12288$

$$768x - 12288 + 27{,}8x - 444{,}8 - 10899{,}8 + 74{,}65x = \frac{(164 - x)}{2} \cdot 864$$

$1302{,}45x = 94480{,}6$

$x = 72{,}54см$

9.

$$W_{pl} = \frac{2(I_{b0} + \alpha I_{s0} + \alpha I_{s0}^{'})}{h - x} + S_{b0} = \frac{2(25206565 + 4028744 + 8886385)}{164 - 72{,}54} + 6346944 = 12934293sm^3$$

$$I_{b0} = \frac{b(h_f^{'})^3}{12} + bh_f^{'}(x - 0{,}5h_f^{'})^2 = \frac{24 \cdot 32^3}{12} + 24 \cdot 32(72{,}54 - 0{,}5 \cdot 32)^2 = 25206565sm^4$$

$$\alpha I_{s0} = \alpha_1 A_{sp}(h - x - 0{,}5h_f)^2 + \alpha_2 A_s(h - x - 0{,}5h_f)^2 = 5{,}85 \cdot 12{,}06(164 - 72{,}54 - 0{,}5 \cdot 36)^2 +$$

$$+ 5{,}23 \cdot 0{,}785(164 - 72{,}54 - 0{,}5 \cdot 36)^2 = 4028744$$

$$\alpha I_{s0}^{'} = \alpha_3 A_s^{'}(x - 0{,}5h_f^{'})^2 = 6{,}15 \cdot 4{,}52(72{,}54 - 0{,}5 \cdot 32)^2 = 8886385$$

$$S_{b0} = bh_f(h - x - 0{,}5h_f) = 24 \cdot 36(164 - 72{,}54 - 0{,}5 \cdot 36) = 6346944sm^3$$

10. $W'_{red} = \frac{I_{red}}{h - y_0} = \frac{7437205}{164 - 77,64} = 86118,6 sm^3$

$S'_{b0} = 24 \cdot 36(x - 0,5 \cdot 36) = 864x - 15552$

$\alpha S'_{b0} = \alpha_1 A_{sp}(x - 0,5h_f) + \alpha_2 A_s(x - 0,5h_f) = 5,85 \cdot 12,06(x - 0,5 \cdot 36) + 5,23 \cdot 0,785(x - 0,5 \cdot 36) =$

$= 74,66x - 1343,82$

$\alpha S_{b0} = \alpha_3 A'_s(h - 0,5h'_f - x) = 6,15 \cdot 4,52(164 - 0,5 \cdot 32 - x) = 4114,4 - 27,8x$

11. $A_{bt} = 24 \cdot 32 = 768 sm^2$

Topilgan qiymatlarni o'rniga qo'yamiz:

$$864x - 15552 + 74,66x - 1343,82 - 4114,4 + 27,8x = \frac{(164 - x)768}{2}$$

12. $1350,46x = 69986,22$

$x = 51,82 sm$

13. $I_{b0} = \frac{bh'^3_f}{12} + bh_f(x - 0,5h'_f)^2 = 24\frac{36^3}{12} + 24 \cdot 36(51,82 - 0,5 \cdot 36)^2 = 1081548,6 sm^4$

14.

$\alpha I_{s0} = \alpha_3 A'_s(h - x - 0,5h'_f)^2 + \alpha_2 A_s(h - x - 0,5h_f)^2 = 6,15 \cdot 4,52(164 - 51,82 - 0,5 \cdot 32)^2 = 257147,96$

$\alpha I'_{s0} = \alpha_1 A_{sp}(x - 0,5h_f)^2 + \alpha_2 A_s(x - 0,5h_f)^2 = 5,85 \cdot 12,06(51,82 - 0,5 \cdot 36)^2 +$

$+ 5,23 \cdot 0,785(51,82 - 0,5 \cdot 36)^2 = 85391,4$

15. $S'_{b0} = bh'_f(h - x - 0,5h'_f) = 24 \cdot 32(164 - 51,82 - 0,5 \cdot 32) = 73866,24 sm^3$

16.

$$W'_{pl} = 2\frac{(I_{b0} + \alpha I_{s0} + \alpha I'_{s0})}{h - x} + S'_{b0} = 2\frac{(1081548,6 + 257147,9 + 85391,4)}{164 - 51,82} + 73866,24 = 99255,57 sm^3$$

0-0; 1-1; 1_a-1_a; 2-2 va 3-3 kesimlarining (21-rasm) geometrik xarakteristikalarining qiymatlari 11-jadvalda keltirilgan.

11-jadval

Kesim yuzalarining geometrik xarakteristikalari							
Kesim yuzasining geometrik xarakteristika-lari	Birlik o'lchovlari	Kesimlar					
		0-0	1-1	1_a-1_a	2-2	3-3	4-4
h	sm	91,0	1150	123,0	139,0	164,0	145
A_{red}	sm^2	2184	2760	1734,5	1734,5	1734,5	1734,5
y_0	sm	47,1	57,5	58,1	66,2	77,64	68,9
I_{red}	sm^4	1508142	3041750	3564540	4907006	7437205	5465159
W_{red}	sm^3	33124	52900	-	74158	95791	79320
W'_{red}	sm^3	33124	52900	54923,5	67376	86118	71815
W_{pl}	sm^3	57967	92575	-	104186	129342	110384
W'_{pl}	sm^3	57967	92575	74909	87585	107764	92415

4.6. Oldindan zo'riqtirilgan armaturalarda kuchlanishlarning yo'qotishini aniqlash

Yo'qotishlar ikki xil bo'ladi: birlamchi va ikkilamchi

Birlamchi yo'qotishlar.

1. Mexanik usulda taranglangan sterjenli armaturalarni kuchlanishning relaksatsiyasi natijasida yo'qotish.

$$\sigma_1 = 0{,}1 \cdot \sigma_{sp} - 20 = 0{,}1 \cdot 740 - 20 = 54 MPa$$

2. Betonning issiqlik ishlov berilishi jarayonida taranglangan armatura bilan stend tirgaklari orasidagi harorat farqi natijasida hosil bo'ladigan yo'qotishlar.

$$\sigma_2 = 1{,}25 \cdot \Delta t = 1{,}25 \cdot 65 = 81{,}2 MPa$$

bu yerda Δt - armatura bilan stend tirgaklari orasidagi harorat farqi.

3. Ankerlarning deformatsiyalanishi natijasida hosil bo'ladigan yo'qotish. $\sigma_3 = 41{,}7 MPa$ (normal kesimning hisobiga qar.)
4. Armaturaning egri chiziqli moslamalariga ishqalanishi natijasida yo'qotish.

$\sigma_4 = 0$, chunki zo'riqtirilgan armatura to'g'ri chiziq bo'ylab joylashtirilgan.

5. Temir qolipning deformatsiyalanishi natijasida yo'qotishi. $\sigma_5 = 30$ MPa (normal kesimning hisobiga qarang).
6. Betonning tob tashlashi tufayli yo'qotish - σ_6 ni aniqlash uchun, γ_{sp} va $\sigma_1 - \sigma_5$ yo'qotishlarni nazarga olgan holda, oldindan uyg'otilgan kuchlanish hamda zo'riqish aniqlanadi.

$$\sigma_{sp1} = \sigma_{sp} - \sigma_1 - \sigma_2 - \sigma_3 - \sigma_5 = 740 - 54 - 81{,}2 - 41{,}7 - 30 = 533{,}1 MPa$$

$$P = \sigma_{sp1} A_{sp} = 533{,}1 \cdot 12{,}06 = 6429{,}2 \cdot 10^2 \, N$$

Hisoblash ishlari to'sin kesim yuzalarining geometrik xarakteristikalariga bog'liq holda bajariladi (4-4 kesim).

R kuchi qo'yilgan nuqtadan keltirilgan kesim yuzasining og'irlik markazigacha bo'lgan masofa.

$$e_{op1} = y_0 - 0{,}5h_f = 68{,}9 - 0{,}5 \cdot 36 = 50{,}9 см = 509 mm$$

Armatura A_{sp} bo'shatilganda betonda P kuchning siqishi natijasida hosil bo'ladigan siqilish kuchlanishi, ($y_{sp} = e_{op1}$ bo'lgan hol uchun)

$$\sigma_{bp} = \frac{P}{A_{red}} + \frac{\left(Pe_{op1} - Mg\right)y_{sp}}{I_{red}} = \frac{\left(6429{,}2 \cdot 10^2\right)}{1734{,}5 \cdot 100} + \frac{\left(6429{,}2 \cdot 10^2 \cdot 509 - 187 \cdot 10^6\right)509}{5465159 \cdot 10^4} = 5{,}01 MPa$$

Bu yerda M_g - to'sin vaznidan hosil bo'ladigan eguvchi moment. *(x=0,37l₀)*

$$Mg = \frac{q_n}{2} \cdot x\left(l_o - x\right) = \frac{5{,}12}{2} \cdot 0{,}37 \cdot 17{,}7\left(17{,}7 - 0{,}37 \cdot 17{,}7\right) = 187 kHM = 187 \cdot 10^6 \, Nmm$$

Beton kesim yuzasining yuqori qirrasida P kuchi ta'siri ostida hosil bo'ladigan kuchlanish.

$$\sigma'_{bp} = \frac{P}{A_{red}} - \frac{\left(P_{op}e - Mg\right)\left(h - y_0\right)}{I_{red}} = \frac{6429{,}2 \cdot 10^2}{1734{,}5 \cdot 100} - \frac{\left(6429{,}2 \cdot 10^2 \cdot 509 - 187 \cdot 10^6\right)\left(1450 - 689\right)}{5465159 \cdot 10^4} = 7{,}4 MPa$$

U holda α koeffitsiyentining qiymati quyidagicha topiladi

$$\alpha = 0{,}25 + 0{,}025R_{bp} = 0{,}25 + 0{,}025 \cdot 24 = 0{,}85 > 0{,}8$$

bo'lgani uchun, $\alpha = 0{,}8$ deb qabul qilamiz.

$\frac{\sigma_{bp}}{R_{bp}} = \frac{5{,}01}{24} = 0{,}21 < \alpha = 0{,}8$ u holda yo'qotishlar

$$\sigma_6 = 0{,}85 \cdot 40 \cdot \frac{\sigma_{bp}}{R_{bp}} = 0{,}85 \cdot 40 \cdot \frac{5{,}01}{24} = 7{,}1 MPa$$

$$\sigma'_6 = 0{,}85 \cdot 40 \cdot \frac{\sigma'_{bp}}{R_{bp}} = 0{,}85 \cdot 40 \cdot \frac{7{,}4}{24} = 10{,}48 MPa$$

Birlamchi yo'qotishlarning umumiy qiymati

$$\sigma_{los1} = \sigma_1 + \sigma_2 + \sigma_3 + \sigma_5 + \sigma_6 = 54 + 81{,}2 + 41{,}7 + 30 + 7{,}1 = 214 MPa$$

Ikkilamchi yo'qotishlar

1. Betonning kirishishi natijasida hosil bo'ladigan yo'qotishlar.

$$\sigma_8 = 35 MPa \; [1]$$

Birlamchi yo'qotishlarni hisobga olingan holda taranglangan armaturadagi kuchlanish.

$$\sigma_{sp1} = \sigma_{sp} - \sigma_{los1} = 740 - 214 = 526MPa$$

Beton kesim yuzasining yuqori va pastki qismlarida joylashgan armaturalarda hosil bo'ladigan kuchlanishlar.

$$\sigma_s = \sigma_6 = 7{,}1МПа \qquad \sigma_s^{'} = \sigma_6^{'} = 10{,}48MPa$$

Kuchlanish P_1 va uning yelkasi e_{opl}

$$P_1 = \sigma_{spl} A_{sp} - \sigma_s A_s - \sigma_s^{'} A_s^{'} = 526 \cdot 12{,}06(100) - 7{,}1 \cdot 0{,}785(100) - 10{,}48 \cdot 4{,}52(100) = 6291 \cdot 10^2$$

$$e_{opl} = \frac{\sigma_{spl} A_{sp} y_{sp} + \sigma_s^{'} A_s^{'} y_s^{'} + \sigma_s A_s y_s}{P_1} =$$

$$= \frac{526 \cdot 12{,}06(100) \cdot 50{,}9(10) + 10{,}48 \cdot 4{,}52(100) \cdot 60{,}1(10) + 7{,}1 \cdot 0{,}785(100) \cdot 50{,}9 \cdot (10)}{6291 \cdot 10^2} = 511mm$$

bu yerda $y_s = y_{sp} = y_0 - 0{,}5h_f = 689 - 0{,}5 \cdot 360 = 509mm$

$$y_s^{'} = h - y_0 - 0{,}5h_f^{'} = 1450 - 689 - 0{,}5 \cdot 320 = 601mm$$

Betonning kesim yuzasida hosil bo'ladigan siqiluvchi kuchlanishlar.

$$\sigma_{sp} = \frac{P_1}{A} + \frac{(P_1 e_{op1} - Mg) y_{sp}}{I_{red}} = \frac{6291 \cdot 10^2}{1734{,}5(100)} + \frac{(6291 \cdot 10^2 \cdot 518 - 187 \cdot 10^6) \cdot 50{,}9(10)}{5465159 \cdot 10^4} = 4{,}92MPa$$

$$\sigma_s = \frac{P_1}{A_{red}} - \frac{(P_1 e_{op1} - Mg)(h - y_0)}{I_{red}} = \frac{6291 \cdot 10^2}{1734{,}5(100)} - \frac{(6291 \cdot 10^2 \cdot 518 - 187 \cdot 10^6)(1450 - 689)}{5465159 \cdot 10^4} =$$

$$= 1{,}75МПа \approx 1{,}7MPa$$

2. Betonda P kuchining siqish ta'sirida tob tashlashi natijasida hosil bo'lgan yo'qotish.

Bu turdagi yo'qotish quyidagi formula orqali topiladi:

$$\sigma_9 = 0{,}85 \cdot 150 \frac{\sigma_{sp}}{R_{bp}} = 0{,}85 \cdot 150 \cdot \frac{4{,}92}{24} = 26MPa$$

$$\sigma_9^{'} = 0{,}85 \cdot 150 \frac{\sigma_{sp}^{'}}{R_{bp}} = 0{,}85 \cdot 150 \cdot \frac{1{,}7}{24} = 9{,}3MPa \text{ , chunki}$$

$$\frac{\sigma_{sp}}{R_{bp}} = \frac{4{,}92}{24} = 0{,}21 < 0{,}75$$

Ikkilamchi yo'qotishlarning umumiy qiymati

$$\sigma_{los2} = \sigma_8 + \sigma_9 = 35 + 26 = 61MPa$$

Jami yo'qotishlar

$$\sigma_{los} = \sigma_{los1} + \sigma_{los2} = 214 + 61 = 275MPa$$

To'sinning hisobiy kesimlari 0-0, 1-1, 2-2 va 3-3 uchun yo'qotishlar σ_6, σ_9, σ_{los1} va σ_{los} yuqorida ko'rsatilgan tarzda hisoblanadi. Balkaning 0-0 kesim yuzasi bo'yicha armaturalardagi kuchlanishlarning yo'qotishini aniqlash 4-4 kesim kabi bajariladi.

0-0 kesim

h=91sm

1. $e_{op1} = y_0 - 0{,}5\dfrac{h}{2} = 47{,}1 - 0{,}5 \cdot 45{,}5 = 24{,}4см$ **;** $e_{op1} = y_{sp}$

2.

$$\sigma_{bp} = \frac{P}{A_{red}} + \frac{(Pe_{op1} - M_g)y_{sp}}{I_{red}} = \frac{6429{,}2 \cdot 10^2}{2184 \cdot 10^2} + \frac{(6429{,}2 \cdot 10^2 \cdot 24{,}4 - 111 \cdot 10^6)24{,}4}{1563842 \cdot 10^4} = 3{,}66MPa$$

3. $M_g = \dfrac{q_n}{2} \cdot x(l_0 - x) = \dfrac{5{,}12}{2} \cdot 2{,}95 \cdot (17{,}7 - 2{,}95) = 111kNm$

4.

$$\sigma'_{bp} = \frac{P}{A_{red}} + \frac{(Pe_{op1} - M_g)(h - y_0)}{I_{red}} = \frac{6429{,}2 \cdot 10^2}{2184 \cdot 10^2} + \frac{(6429{,}2 \cdot 10^2 \cdot 244 - 111 \cdot 10^6)(910 - 471)}{1563842 \cdot 10^4} =$$

$$= 1{,}66MPa$$

5. $\alpha = 0{,}25 + 0{,}025R_{bp} = 0{,}25 + 0{,}025 \cdot 24 = 0{,}85 > 0{,}8$

6. $\dfrac{\sigma_{bp}}{R_{bp}} = \dfrac{3{,}66}{24} = 0{,}15 < \alpha = 0{,}8$

7.

$$\sigma_b = 0{,}85 \cdot 40 \cdot \frac{\sigma_{bp}}{R_{bp}} = 0{,}85 \cdot 40 \cdot 0{,}15 = 5{,}2MPa$$

$$\sigma'_b = 0{,}85 \cdot 40 \cdot \frac{\sigma'_b}{R_{bp}} = 0{,}85 \cdot 40 \cdot \frac{1{,}66}{24} = 2{,}4MPa$$

8. $\sigma_{los1} = \sigma_1 + \sigma_2 + \sigma_3 + \sigma_4 + \sigma_5 + \sigma_6 = 54 + 81{,}2 + 41{,}7 + 30 + 5{,}2 = 212{,}1MPa$

Ikkilamchi yo'qotishlar

9. $\sigma_{sp1} = \sigma_{sp} - \sigma_{los1} = 740 - 212{,}1 = 528MPa$

10. $\sigma_5 = \sigma_6 = 5{,}2MPa$

11.

$$P_1 = \sigma_{sp1} \cdot A_{sp} - \sigma_s \cdot A_s - \sigma'_s \cdot A'_s = 528 \cdot 12{,}06(100) - 5{,}2 \cdot 0{,}785(100) - 24 \cdot 4{,}52(100) = 6353 \cdot 10^2$$

12.

$$e_{op1} = \frac{\sigma_{sp1} \cdot A_{sp} \cdot y_{sp} + \sigma'_s \cdot A'_s \cdot y'_s + \sigma_s \cdot A_s y_s}{P_1} = \frac{6367{,}68 \cdot 24{,}4(10) + 4{,}082 \cdot 24{,}4(10) + 10{,}848 \cdot 21{,}2(10)}{6353 \cdot 10^2} =$$

$$= 245mm$$

13. $y_s = y_{sp} = y_0 - 0{,}5\dfrac{h}{2} = 471 - 0{,}5 \cdot 455 = 244mm$

14. $y'_s = h - y_0 - 0{,}5h'_f = 910 - 471 - 0{,}5 \cdot 455 = 212mm$

15.

$$\sigma_{sp} = \frac{P_1}{A_{red}} + \frac{(P_1 e_{op_1} - M_g) y_{sp}}{I_{red}} = \frac{6353 \cdot 10^2}{2184 \cdot 10^2} + \frac{(6353 \cdot 10^2 \cdot 245 - 111 \cdot 10^6) \cdot 244}{1563842 \cdot 10^4} = 3{,}6 MPa$$

$$\sigma'_{sp} = \frac{P_1}{A_{red}} + \frac{(P_1 e_{op_1} - M_g)(h - y_0)}{I_{red}} = \frac{6353 \cdot 10^2}{2184 \cdot 10^2} + \frac{(6353 \cdot 10^2 \cdot 245 - 111 \cdot 10^6)(910 - 471)}{1563842 \cdot 10^4} = 1{,}7 MPa$$

$$\sigma_9 = 0{,}85 \cdot 150 \frac{\sigma_{sp}}{R_{bp}} = 0{,}85 \cdot 150 \cdot \frac{3{,}6}{24} = 19 Mpa$$

16.

$$\sigma'_9 = 0{,}85 \cdot 150 \frac{\sigma'_{sp}}{R_{bp}} = 0{,}85 \cdot 150 \cdot \frac{1{,}7}{24} = 9 MPa$$

17. $\frac{\sigma_{sp}}{R_{bp}} = \frac{3{,}6}{24} = 0{,}15 < 0{,}75$

18. $\sigma_{los2} = \sigma_8 + \sigma_9 = 35 + 19 = 54 MPa$

19. $\sigma_{los} = \sigma_{los1} + \sigma_{los2} = 212{,}1 + 54 = 266{,}1 MPa$

1-1 kesim

To'sinning 1-1 kesim yuzasi bo'yicha armaturalardagi kuchlanishlarning yo'qotishi qiymati 12-jadvalda keltirilgan. (h=115 sm).

1a-1a kesim

h=123 sm

1. $e_{op1} = y_0 - 0{,}5\frac{h}{2} = 58{,}8 - 0{,}5 \cdot 36 = 40{,}8 sm$ **;** $e_{op1} = y_{sp}$

2.

$$\sigma_{bp} = \frac{P}{A_{red}} + \frac{(P e_{op1} - M_g) y_{sp}}{I_{red}} = \frac{6429{,}2 \cdot 10^2}{1734{,}5 \cdot 10^2} + \frac{(6429{,}2 \cdot 10^2 \cdot 40{,}8 - 187 \cdot 10^6) 40.8}{3480493 \cdot 10^4} = 4{,}59 MPa$$

3. $M_g = \frac{q_n}{2} \cdot x(l_0 - x) = \frac{5{,}12}{2} \cdot 0{,}37 \cdot 17{,}7(17{,}7 - 0{,}37 \cdot 17{,}7) = 187 kNm$

4. $\alpha = 0{,}25 + 0{,}025 R_{bp} = 0{,}25 + 0{,}025 \cdot 24 = 0{,}85 > 0{,}8$

$$\frac{\sigma_{bp}}{R_{bp}} = \frac{4{,}59}{24} = 0{,}19$$

5. $\sigma_b = 0{,}85 \cdot 40 \cdot \frac{\sigma_{bp}}{R_{bp}} = 0{,}85 \cdot 40 \cdot 0{,}19 = 6{,}5 MPa$

6. $\sigma_{los1} = \sigma_1 + \sigma_2 + \sigma_3 + \sigma_4 + \sigma_5 + \sigma_6 = 54 + 81{,}2 + 41{,}7 + 30 + 6{,}5 = 213{,}4 MPa$

Ikkilamchi yo'qotishlar

7. $\sigma_{sp1} = \sigma_{sp} - \sigma_{los1} = 740 - 213{,}4 = 526{,}6$

$\sigma_5 = \sigma_6 = 6{,}5 MPa$

8. $P_1 = \sigma_{sp1} \cdot A_{sp} - \sigma_s \cdot A_s - \sigma'_s A'_s = 526{,}6 \cdot 12{,}06(100) - 6{,}5 \cdot 0{,}785(100) = 6346 \cdot 10^2$

$$e_{op1} = \frac{\sigma_{sp1} \cdot A_{sp} \cdot y_{sp} + \sigma_s^{'} \cdot A_s^{'} \cdot y_s^{'} + \sigma_s \cdot A_s y_s}{P_1} = \frac{408 \cdot 526{,}6 \cdot 12{,}06(100) + 6{,}5 \cdot 0{,}785(100) \cdot 408}{6346 \cdot 10^2} =$$

$$= 408{,}6mm$$

$$y_s = y_{sp} = y_0 - 0{,}5h_f = 58{,}8 - 0{,}5 \cdot 360 = 408mm$$

$$y_s^{'} = h - y_0 - 0{,}5h_f^{'} = 1230 - 408 - 0{,}5 \cdot 320 = 662mm$$

9.

$$\sigma_{sp} = \frac{P_1}{A_{red}} + \frac{(P_1 e_{op1} - M_g) y_{sp}}{I_{red}} = \frac{6346 \cdot 10^2}{1734{,}5 \cdot 10^2} + \frac{(6346 \cdot 10^2 \cdot 408{,}6 - 187 \cdot 10^6) \cdot 408}{348040{,}3 \cdot 10^4} = 4{,}51MPa$$

10. $\sigma_9 = 0{,}85 \cdot 150 \frac{\sigma_{sp}}{R_{bp}} = 0{,}85 \cdot 150 \cdot \frac{4{,}51}{24} = 23{,}95MPa$

$$\frac{\sigma_{sp}}{R_{bp}} = \frac{4{,}51}{24} = 0{,}19 < 0{,}75$$

11. $\sigma_{los2} = \sigma_8 + \sigma_9 = 35 + 23{,}95 = 58{,}95MPa$

12. $\sigma_{los} = \sigma_{los1} + \sigma_{los2} = 213{,}4 + 58{,}95 = 272{,}35MPa$

3-3 kesim

h=164 sm

1. $e_{op1} = y_0 - 0{,}5h_f = 77{,}64 - 0{,}5 \cdot 36 = 59{,}64sm$

2.

$$\sigma_{bp} = \frac{P}{A_{red}} + \frac{(Pe_{op1} - M_g) y_{sp}}{I_{red}} = \frac{6429{,}2 \cdot 10^2}{1734{,}5 \cdot 10^2} + \frac{(6429{,}2 \cdot 10^2 \cdot 596 - 187 \cdot 10^6) 40.8}{7437205 \cdot 10^4} = 5{,}27MPa$$

3. $M_g = \frac{q_n}{2} \cdot x(l_0 - x) = \frac{5{,}12}{2} \cdot 0{,}37 \cdot 17{,}7(17{,}7 - 0{,}37 \cdot 17{,}7) = 187kNm$

4. $\sigma_{bp}^{'} = \frac{P}{A_{red}} - \frac{(Pl_{op1} - M_g)(h - y_0)}{I_{red}} = \frac{(6429{,}2 \cdot 10^2 \cdot 596 - 187 \cdot 10^6)(1640 - 776)}{7437205 \cdot 10^4} = 1{,}4MPa$

5. $\alpha = 0{,}25 + 0{,}025R_{bp} = 0{,}25 + 0{,}025 \cdot 24 = 0{,}85 > 0{,}8$

$$\frac{\sigma_{bp}}{R_{bp}} = \frac{5{,}27}{24} = 0{,}21$$

6. $\sigma_b = 0{,}85 \cdot 40 \cdot \frac{\sigma_{bp}}{R_{bp}} = 0{,}85 \cdot 40 \cdot \frac{5{,}27}{24} = 7{,}46$

$$\sigma_6^{'} = 0{,}85 \cdot 40 \frac{\sigma_{bp}^{'}}{R_{bp}} = 0{,}85 \cdot 40 \frac{1{,}4}{24} = 1{,}98$$

7. $\sigma_{los1} = \sigma_1 + \sigma_2 + \sigma_3 + \sigma_4 + \sigma_5 + \sigma_6 = 54 + 81{,}2 + 41{,}7 + 30 + 7{,}46 = 214{,}36MPa$

Ikkilamchi yo'qotishlar

8. $\sigma_{sp1} = \sigma_{sp} - \sigma_{los1} = 740 - 214{,}36 = 525{,}64$

$\sigma_s = \sigma_6 = 7{,}46MPa$

9. $P_1 = \sigma_{sp1} \cdot A_{sp} - \sigma_s \cdot A_s - \sigma_s^{'} A_s^{'} = 526{,}6 \cdot 12{,}06 \cdot 100 - 7{,}46 \cdot 0{,}785 \cdot (100) = 6327{,}9 \cdot 10^2$

10.

$$e_{op1} = \frac{\sigma_{sp1} \cdot A_{sp} \cdot y_{sp} + \sigma_s^{'} \cdot A_s^{'} \cdot y_s^{'} + \sigma_s \cdot A_s y_s}{P_1} = \frac{3780 + 6176 + 3975{,}32 + 6293{,}76}{6327{,}9 \cdot 10^2} = 597{,}4mm$$

$$y_s = y_{sp} = y_0 - 0{,}5h_f = 77{,}64 - 0{,}5 \cdot 36 = 596mm$$

$$y_s^{'} = h - y_0 - 0{,}5h_f^{'} = 1640 - 596 - 0{,}5 \cdot 320 = 704mm$$

11. $\sigma_{sp} = \frac{P_1}{A_{red}} + \frac{(P_1 e_{op_1} - M_g) y_{sp}}{I_{red}} = \frac{6327{,}9 \cdot 10^2}{1734{,}5 \cdot 10^2} + \frac{(6327{,}9 \cdot 10^2 \cdot 596 - 187 \cdot 10^6) \cdot 596}{7437205 \cdot 10^4} = 5{,}12MPa$

12. $\sigma_9 = 0{,}85 \cdot 150 \frac{\sigma_{sp}}{R_{bp}} = 0{,}85 \cdot 150 \cdot \frac{5{,}12}{24} = 27{,}19MPa$

$$\sigma_9^{'} = 0{,}85 \cdot 150 \frac{\sigma_{sp}^{'}}{R_{bp}} = 0{,}85 \cdot 150 \cdot \frac{1{,}4}{24} = 7{,}4MPa$$

$$\frac{\sigma_{sp}}{R_{bp}} = \frac{5{,}12}{24} = 0{,}2133 < 0{,}75$$

13. $\sigma_{los2} = \sigma_8 + \sigma_9 = 35 + 27{,}19 = 62{,}19MPa$

14. $\sigma_{los} = \sigma_{los1} + \sigma_{los2} = 214{,}36 + 62{,}19 = 276{,}55MPa$

Berilgan kesimlar bo'yicha aniqlangan σ_6, $\sigma_6^{'}$; $\sigma_9, \sigma_9^{'}$; σ_{los1} va σ_{los2} qiymatlari 12-jadvalda keltirilgan.

12-jadval

Kesim yuzalari bo'yicha yo'qotishlar

Kuchlanish, MPa	Kesim				
1	2	3	4	5	6
	0-0	1-1	2-2	3-3	4-4
σ_6	8,7	0,7	7,08	7,34	7,1
$\sigma_6^{'}$	0	0	2,43	2,24	10,48
σ_9	32	22	26,03	26,93	26
$\sigma_9^{'}$	0	0	9,35	11,79	9
σ_{los1}	212	208	213,98	214,24	214
σ_{los2}	279	265	275,01	216,17	275

4.7. To'sinda normal yoriqlar paydo bo'lishini aniqlash

Bu hisobni 4-4 kesim uchun bajaramiz.

To'liq yo'qotishlarni nazarga olgan holda zo'riqish P_2 va uning yelkasi e_{op2} aniqlanadi.

$$P_2=\sigma_{SP2}A_{SP}-\sigma_S A_S-\sigma'_S A'_S=418,5\cdot 12,06(100)-68,1\cdot 0,785(100)-$$
$$-46,76\cdot 4,52(100)=478229,6N;$$

$$e_{op2}=\frac{\sigma_{sp2}A_{sp}(y_o-0,5h_f)-\sigma_s A_s(y_o-0,5h_f)-\sigma'_s A'_s(h-y_o-0,5h'_f)}{P_2}=$$

$$=\frac{418,5\cdot 12,6(100)[68,9(10)-0,5\cdot 36,0(10)]-68,1\cdot 0,785(100)[68,9(10)-0,5\cdot 36,0(10)]}{478229.6}-$$

$$-\frac{46.76\cdot 4.52(100)\cdot[145(10)-68.9(10)-0.5\cdot 32.0(10)]}{478229.6}=505mm$$

$$\sigma_{sp2}=\gamma_{sp}(\sigma_{sp}-\sigma_{los})=0.9(740-275)=418,5MPa$$

Bu yerda γ_{sp} taranglashgan kuchlanishni aniqlashda foydalaniladigan koeffitsiyent $\gamma_{sp}=0,9$ deb olamiz.

Kirishish va tob tashlash deformatsiyalari natijasida pastki bo'ylama taranglanmagan armaturadagi kuchlanish:

$$\sigma_s=\sigma_6+\sigma_8+\sigma_9=7,1+35+26=68,1MPa$$

Balkaning yuqori qismidagi armaturada hosil bo'ladigan kuchlanish.

$$\sigma'_s=\sigma'_6+\sigma'_8+\sigma'_9=2,46+35+9,3=46,76MPa$$

Betonning yuqori tolalarida hosil bo'ladigan kuchlanish:

$$\sigma_b=\frac{P_2}{A_{red}}-\frac{(P_2e_{op2}-M_r)(h-y_o)}{I_{red}}=\frac{478229,6}{1734,5(100)}-\frac{(478229,6\cdot 505-8421\cdot 10^5)[145(10)-68,9(10)]}{546515910^4}=$$

11,12MPa. To'liq yuk ta'siridan 4-4 kesim yuzasida hosil bo'ladigan eguvchi moment miqdori M=842,1MPa (γ_f=1 bo'lgan hol uchun).

Keltirilgan kesim yuzasining og'irlik markazidan to yadro kesimining yuqori nuqtasiga qadar bo'lgan masofa:

$$r'=\varphi\cdot\frac{W_{red}}{A_{red}}=1\cdot\frac{7932\cdot 10^4}{1734,5(100)}=4573mm$$

Bu yerda koeffitsiyent $\varphi=1,6-\frac{\sigma_b}{R_{b,ser}}=1,6-\frac{11,72}{22}=1,10>1$.

Shuning uchun φ=1 deb qabul qilinadi.

Yoriq paydo bo'lishi oldidan kesim yuzasi qabul qila oladigan eguvchi moment:

$$M_{crc}=R_{bt,ser}W_{pl}+M_{rp}=1,8\cdot 110384\cdot 10^3+460200344=658891544\ Nmm$$

Bu yerda M_{rp} yadro kesimining yuqori nuqtasiga nisbatan P_2 kuchidan (γ_{sp}= 0,9 bo'lgan hol uchun) olingan eguvchi moment.

Endi yoriq paydo bo'lish shartini tekshiramiz.

$$M_{rp}=P_2(e_{op2}+r')=478229,6(505+457,3)=460200344Nmm.$$

Demak, cho'ziluvchi zonada yoriqlar paydo bo'lar ekan.

$$M_r=8421\cdot 10^5Nmm>M_{crc}=6588,9x10^5Nmm$$

4.8 Beton zo'riqtirilganda yoriq paydo bo'lishini aniqlash

To'sinning zo'riqtirilishi natijasida, yuqori qismida yoriqlar paydo bo'lishi havfli hisoblanadi. Shuning uchun quyidagi hisob ishlari bajarilishi lozim.

Betonda A_{sp} armatura ta'sirida hosil bo'lgan kuchlanish aniqlanadi,

bunda hisoblash $P=6429,2\cdot10^2$H hamda $\sigma_1\cdots\sigma_5$ yo'qotishlarni nazarga olgan holda bajariladi.

$$\sigma_{bp}=\frac{P}{A_{red}}+\frac{(Pe_{op}-Mg)y_{sp}}{I_{red}}=\frac{6429,2\cdot10^2}{1734,5(100)}+\frac{6429,2\cdot10^2\cdot509-187\cdot10^6)509}{3564540\cdot10^4}=571\text{MPa}$$

Kesim yuqori qirrasi uchun ham σ_{bp} aniqlanadi.

$$\sigma'_{bp}=\frac{P}{A_{red}}-\frac{(Pe_{op}+Mg()h-y_o)}{I_{red}}=\frac{6429,2\cdot10^2}{1734,5(100)}-\frac{6429,2\cdot10^2\cdot509+187\cdot10^6)(1450-689}{3564540\cdot10^4}=-7,27$$

$\frac{\sigma_{bp}}{R_{bp}}=\frac{5,71}{24}$=0,238<α=0,8 bo'lgani uchun yo'qotishlar:

$$\sigma_6=0,85\cdot40\frac{\sigma_{bp}}{R_{bp}}=0,85\cdot40\frac{5,71}{24}=8,09MPa$$

σ'_6=0, chunki σ'_{bp}=0 bo'lgani uchun

Birlamchi yo'qotishlar:

$$\sigma_{los}=\sigma_1+\sigma_2+\sigma_3+\sigma_4+\sigma_5+\sigma_6=54+81,2+41,7+30+8,09=215\ MPa$$

Birlamchi yo'qotishlarni nazarga olgan holda zo'riqish oldindan uyg'otilgan kuchlanish

$$\sigma_{sp1}=\sigma_{sp}-\sigma_{los}=740-215=525\text{ MPa}$$

Kuchlanishlar:

$$\sigma_s=\sigma_6=8,09\text{ MPa};\quad \sigma'_s=\sigma'_6=0$$

Birlamchi yo'qotishlarni nazarga olgan holda zo'riqish P_1 ni aniqlaymiz.

$P_1=\sigma_{sp1}A_{sp}-\sigma_sA_s-\sigma'_sA'_s=525\cdot12,06(100)-8,09\cdot0,785(100)=632515$N

To'sin vazni va zo'riqishlar ta'sir ostida beton kesim yuzasidagi siquvchi maksimal kuch aniqlanadi.

Quyida φ koeffitsiyentining qiymatini aniqlaymiz.

$$\varphi=1,6-\frac{\sigma_{bp}}{R_{bp,ser}}=1,6-\frac{5,58}{16,2}=1,25>1$$

φ>1 shuning uchun φ=1 deb qabul qilamiz.

Bu yerda $R_{bp,ser}$=16,2 MPa

Keltirilgan kesim yuzasining og'irlik markazidan yadroning pastki nuqtasiga qadar bo'lgan masofa.

$$r = \varphi \frac{W'_{red}}{A_{red}} = 1 \cdot \frac{71815 \cdot 10^3}{1734{,}5 \cdot 10^2} = 414mm$$

Yadro kesim yuzasining pastki nuqtasiga nisbatan olingan siqilgan eguvchi moment qiymati

$$M_{rp}=P_1(e_{op}-r)=632515(509-414)=60088925\ N\ mm$$

Yoriq hosil bo'lish shartini tekshiramiz.

$M_g=187\cdot10^6 H\cdot mm<R_{bt,ser}W'_{pl}+M_{rp}=1{,}54\cdot92415\cdot10^3+60088925=202{,}4\cdot10^6$ $N\cdot mm$

Bu yerda $R_{bt,ser}=1{,}54MPa$.

Shunday qilib, to'sinning yuqori qismida yoriqlar paydo bo'lmaydi, sababi $M_g=187\cdot10^6 \le M_{crc}=202{,}4\cdot10^6$ shart bajarildi.

4.9. To'sinda normal yoriqlarning ochilishiga hisoblash

a) To'liq yuklarning qisqa muddat ta'siridan hosil bo'ladigan yoriqlarning ochilishi (γ_f=1 bo'lgan hol uchun).

Agar zo'riqtirish bosqichida to'sinning yuqori qismida yoriqlar paydo bo'lsa, u holda hisob boshlang'ich yoriqlarni hisobga oluvchi koeffitsiyent λ ni aniqlashdan boshlanadi:

$$\lambda = 1{,}5 - \frac{0{,}9}{\sigma}(1-\varphi_m)$$

$$\sigma = \frac{y_0}{h-y_0} \cdot \frac{A_{sp}+A_s}{A_{sp}+A_s+A'_s} \le 1{,}4 \qquad 0{,}45 \le \varphi_m \le 1$$

$$\varphi_m = \frac{R_{st,ser}W'_{pl}}{P_1(e_{op1}-r)+Mg};$$

$$P_{rl} = (1-\lambda)P_2 \qquad e_{sp2} = y_0 - e_{op2} - \alpha_{sp}$$

Berilgan misolda to'sin yuqori qismida yoriqlar paydo bo'lmaydi, shuning uchun hisob ishlari quyidagi tarzda olib boriladi.

$$\delta = \frac{M_r + P_2 e_{sp2}}{R_{b,ser}bh_0^2} = \frac{8421\cdot10^5 + 478229{,}6\cdot4}{22\cdot240\cdot1270^2} = 0{,}099$$

Bu yerda $e_{sp2} = y_{sp} - e_{op2} = 509 - 505 = 4mm$.

Kesimning siqilgan zonasidagi armatura A'_s ni hisobga oluvchi koeffitsiyent.

$$\varphi_f = \frac{\frac{\alpha_3}{2v} \cdot A'_s}{bh_0} = \frac{\frac{6{,}15}{2\cdot0{,}45} \cdot 4{,}52(100)}{24{,}0(10)\cdot127{,}0(10)} = 0{,}01$$

Bu yerda $v=0{,}45$ yuklarning qisqa muddat ta'sirini hisobga oladigan koeffitsiyent.

Koeffitsiyent λ aniqlanadi.

$$\lambda = \varphi_f\left(1-\frac{h_f^{'}}{2h_0}\right) = 0{,}01\left(1-\frac{320}{2\cdot 1270}\right) = 0{,}0087$$

Yelka $e_{s,lot} = \dfrac{M_r + P_2 e_{sp2}}{P_2} = \dfrac{8421\cdot 10^5 + 478229{,}6\cdot 4}{478229{,}6} = 1765mm$

Siqiluvchi zonaning nisbiy balandligi:

$$\xi = \frac{1}{\beta + \dfrac{1+5(\delta+\lambda)}{10\mu\alpha}} + \frac{1{,}5+\varphi_f}{11{,}5\dfrac{e_{s,lot}}{h_0}-5} = \frac{1}{1{,}8 + \dfrac{1+5(0{,}099+0{,}0087)}{10\cdot 0{,}0042\cdot 5{,}85}} + \frac{1{,}5+0{,}01}{11{,}5\dfrac{1765}{1270}-5} = 0{,}262 < 1$$

Bu yerda $\mu = \dfrac{A_s + A_{sp}}{bh_0} = \dfrac{0{,}785\cdot(100)+12{,}06\cdot(100)}{240\cdot 1270} = 0{,}0042$

$$\alpha = \alpha_1 = 5{,}85 \quad (\alpha_1 = 5{,}85 > \alpha_2 = 5{,}23)$$

Siqiluvchi zonaning nisbiy balandligi:

$$\xi = 0{,}262 > \frac{h_f^{'}}{h_0} = \frac{320}{1270} = 0{,}252$$

Siqilgan zonaning balandligi to'sin yuqori qismining balandligidan katta bo'lishi mumkin emas, shuning uchun $X=h_f=320mm$, ya'ni $\xi=0{,}252$ deb olinadi.

Shu hol uchun ikki juft kuchlar yelkasi aniqlanadi:

$$Z = h_0\cdot\left[1-\frac{\dfrac{h_f^{'}}{h_0}\varphi_f + \xi^2}{2\left(\varphi_f+\xi\right)}\right] = 1270\cdot\left[1-\frac{\dfrac{320}{1270}0{,}01 + 0{,}252^2}{2(0{,}01+0{,}252)}\right] = 1110mm$$

$$e_{o,lot} = \frac{M_r - P_2 e_{op2}}{P_2} = \frac{8421\cdot 10^5 - 478229{,}6\cdot 505}{478229{,}6} = 1256mm$$

Bunda quyidagi shart tekshiriladi:

$$e_{o,lot} = 1256 > 0{,}8\cdot h_0 = 0{,}8\cdot 1270 = 1016mm$$

Shart bajarildi, endi δ_1 koeffitsiyent hisobga olinadi va quyidagi ifoda orqali topiladi:

$$\delta_1 = \frac{h-X-a_2}{h-X-a_1} = \frac{1450-320-40}{1450-320-180} = 1{,}147$$

Bu yerda $a_1 = 0{,}5h_f = 0{,}5\cdot 360 = 180mm$; A_s - pastki qatorida joylashgan armaturaning og'irlik markazidan kesimning pastki qirrasiga qadar bo'lgan masofa, $a_2=40mm$.

Cho'zilgan armaturadagi kuchlanish.

$$\sigma_s = \frac{M_r - P_2\left(Z-e_{sp2}\right)}{\left(A_s+A_{sp}\right)Z}\delta_1 = \frac{8421\cdot 10^5 - 478229{,}6(1110-4)}{\left[0{,}785(100)+12{,}06(100)\right]1110}\cdot 1{,}147 = 252MПa < R_{s,ser} = 785MPa$$

To'liq yukning qisqa muddatli ta'siridan yoriqlarning qisqa muddatli ochilishi quyidagi formula orqali topiladi.

$$a_{crc1} = 20(3{,}5 - 100\mu)\delta\varphi_1\eta\frac{\sigma_s}{E_s}\cdot\sqrt[3]{d} = 20(3{,}5 - 100\cdot 0{,}0042)\cdot 1\cdot 1\cdot 1\frac{252}{1{,}9\cdot 10^5}\cdot\sqrt[3]{16} = 0{,}2mm$$

Bu yerda *d=16* mm zo'riqtirilgan armatura diametri; *δ=1* -egiluvchi elementlar uchun.

η=1 - yuklarning qisqa muddatli ta'sir etgan hol uchun; $\varphi_l = 1$- davriy profilli sterjenlar uchun.

b) Uzoq muddatli yuklar ta'siridan yoriqlarning qisqa muddatga ochilishi, ($\gamma_f = 1$bo'lgan hol uchun). M_n=732,5MPa 4-4 kesim uchun (10-jadval)

Siqiluvchi zonaning balandligi va ichki juft kuchlar yelkasini hisoblash yuqorida qanday qilingan bo'lsa shunday olinadi, ya'ni

X=320mm; Z=1110mm

U holda, cho'zilgan armaturada hosil bo'lgan kuchlanish:

$$\sigma_s = \frac{M_r - P_2(Z - e_{sp2})}{(A_s + A_{sp})Z}\delta_1 = \frac{7325\cdot 10^5 - 478229{,}6(1110 - 4)}{[0{,}785(100) + 12{,}06(100)]1110}\cdot 1{,}147 = 164MPa$$

$$\alpha_{crc} = 20(3{,}5 - 100\cdot 0{,}0042)1\cdot 1\cdot 1\cdot\frac{164}{1{,}9\cdot 10^5}\sqrt[3]{16} = 0{,}134mm$$

v) Uzoq muddatli yuk ta'sirida yoriqlarning uzoq muddatga ochilishi, ($\gamma_f = 1$bo'lgan hol uchun)

Bunday yuklar ta'siridan tabiiy namlikka ega bo'lgan og'ir betonlar uchun φ_l koeffitsiyent quyidagi ifoda orqali topiladi:

$$\varphi_l = 1{,}6 - 15\mu = 1{,}6 - 15\cdot 0{,}0042 = 1{,}537$$

U holda uzoq muddatli yuk ta'siridan ochilgan yoriqning eni

$$a_{crc3} = \varphi_l a_{crc2} = 1{,}54\cdot 0{,}134 = 0{,}21mm < [a_{crc}] = 0{,}3mm$$

ya'ni, ruxsat etilgan qiymatdan kam.

To'liq yukning uzoq muddat ta'sir etuvchi qismi ta'sirida yoriqlarning qisqa muddatga ochilishi

$$a_{crc} = a_{crc1} - a_{crc2} + a_{crc3} = 0{,}2 - 0{,}134 + 0{,}21 = 0{,}276 < [a_{crc}] = 0{,}4mm$$

ya'ni, aniqlangan qiymat ruxsat etilgan qiymatdan kam.

Demak, balkaning ishlash jarayonida hosil bo'ladigan normal yoriqlarning kengligi ruxsat etilgan yoriqlar kengligidan oshmas ekan.

4.10. To'sin solqiligini aniqlash

To'sin solqiligini aniqlashda hisobni soddalashtirish maqsadida to'sin balandligini o'zgarmas deb qabul qilinadi. Solqilik (4-4 kesim uchun) paydo bo'lgan yoriqlarni hisobga olgan holda aniqlanadi.

Qordan hosil bo'lgan qisqa muddatli yuk, to'liq yukning oz miqdorini (15%) tashkil etgani uchun, to'liq yuklarni uzoq muddatli ta'sir etuvchi

yuklar deb qabul qilinadi. U holda, egrilik va solqilikni faqat uzoq muddatli yuklarning uzoq muddatli ta'siridan aniqlanadi holos.

Yuqorida aytib o'tilgan hisobni soddalashtirilishi evaziga solqilik, ortiqroq chiqadi, bunda hatolik 4% ni tashkil etadi.

Normal yoriqlar paydo bo'lishi va ularning ochilishini aniqlash quyidagilardan iborat.

Bunda quyidagi koeffitsiyentlarni aniqlaymiz:

$$\varphi_m = \frac{R_{bt,ser} W_{pl}}{M_r - M_{rp}} = \frac{1{,}8 \cdot 110384 \cdot 10^3}{8421 \cdot 10^5 - 60988 \cdot 10^4} = 0{,}856 < 1$$

$$e_{s,lot} = \frac{M_r + P_2 e_{sp2}}{P_2} = \frac{8421 \cdot 10^5 - 606669 \cdot 39}{606669} = 1349 mm$$

bu yerda σ_{sp}, $\gamma_{sp} = 1$ bo'lgan holat uchun olingan.

$$\sigma_{sp2} = \sigma_{sp} - \sigma_{los} = 740 - 215 = 525 MPa$$

$$P_2 = 525 \cdot 12{,}06(100) - 68{,}1 \cdot 0{,}785(100) - 46{,}76 \cdot 4{,}52(100) = 606669$$

Zo'riqish P_2 ta'sirida kesim yadrosining yuqori nuqtasiga nisbatan olingan moment (siqilgan hol uchun):

$$M_{rp} = P_2 \left(e_{op2} + r^{'}\right) = 606669(548 + 457{,}3) = 60988 \cdot 10^4 H \cdot mm$$

Yelka:

$$e_{op2} = \frac{\sigma_{sp2} A_{sp} \left(y_0 - 0{,}5 h_f\right) - \sigma_s A_s \left(y_0 - 0{,}5 h_f\right)}{P_2} + \frac{\sigma_s^{'} A_s^{'} \left(h - y_0 - 0{,}5 h_f^{'}\right)}{P_2} =$$

$$= \frac{525 \cdot 12{,}06(100)(689 - 0{,}5 \cdot 360) - 68{,}1 \cdot 0{,}785(100)(689 - 0{,}5 \cdot 360)}{606669} +$$

$$+ \frac{46{,}76 \cdot 4{,}52(100)(1450 - 689 - 0{,}5 \cdot 320)}{606669} = 548 mm$$

$$e_{sp2} = y_{sp} - e_{op2} = 509 - 548 = -39 mm$$

Koeffitsiyent ψ_s ni aniqlaymiz, bunda $\varphi_{ls} = 0{,}8$ (yuklarning uzoq muddatli ta'sirida) olinadi.

$$\psi_s = 1{,}25 - \varphi_{ls} \varphi_m - \frac{1 - \varphi_m^2}{\left(3{,}5 - 1{,}8\varphi_m\right) \frac{e_{s,lot}}{h_0}} = 1{,}25 - 0{,}8 \cdot 0{,}856 - \frac{1 - 0{,}856^2}{\left(3{,}5 - 1{,}8 \cdot 0{,}856\right) \frac{1349}{1270}} = 0{,}496 < 1{,}0$$

Uzoq muddatli to'liq yuk ta'siridan hosil bo'lgan egrilik.

$$\left(\frac{1}{r}\right)_3 = \frac{M}{h_0 Z} \left[\frac{\psi_s}{E_s A_s + E_s A_{sp}} + \frac{\psi_b}{\left(\varphi_f + \xi\right) b h_0 E_b v}\right] - \frac{P_2}{h_0} \cdot \frac{\psi_s}{E_s A_s + E_s A_{sp}} =$$

$$= \frac{81844 \cdot 10^4}{1270 \cdot 1110} \cdot \left[\frac{0{,}496}{1{,}7 \cdot 10^5 \cdot 0{,}785(100) + 1{,}9 \cdot 10^5 \cdot 12{,}06(100)} + \frac{0{,}9}{(0{,}01 + 0{,}252) 240 \cdot 1270 \cdot 2{,}9 \cdot 10^4 \cdot 0{,}15}\right] -$$

$$- \frac{606669}{1270} \cdot \frac{0{,}496}{1{,}7 \cdot 10^5 \cdot 0{,}785(100) + 1{,}9 \cdot 10^5 \cdot 12{,}06(100)} = 1720 \cdot 10^{-9} mm^{-1}$$

Bu yerda $M = M_r + P_2 e_{sp2} = 8421 \cdot 10^{-7} - 606669 \cdot 39 = 81844 \cdot 10^4$ $N \cdot mm$.

Koeffitsiyent $\psi_b=0,9;\ v=0,\ 15$ uzoq muddatli ta'sir etuvchi yuklar uchun.

Betonda cho'kish va tob tashlash deformatsiyalarini yuz berishi natijasida hosil bo'ladigan egrilik (qavariq).

$$\left(\frac{1}{r}\right)_4 = \frac{\varepsilon_b - \varepsilon_b^{'}}{h_0} = \frac{4006\cdot 10^{-7} - 2338\cdot 10^{-7}}{1270} = 131{,}3\cdot 10^{-9}\, mm^{-1}$$

Bu yerda

$$\varepsilon_u = \frac{\sigma_s}{E_s} = \frac{68{,}1}{1{,}7\cdot 10^5} = 4006\cdot 10^{-7};$$

$$\varepsilon_b^{'} = \frac{\sigma_s^{'}}{E_s} = \frac{46{,}76}{2{,}0\cdot 10^5} = 2338\cdot 10^{-7}$$

To'liq egrilik

$$\frac{1}{r} = \left(\frac{1}{r}\right)_1 - \left(\frac{1}{r}\right)_2 + \left(\frac{1}{r}\right)_3 - \left(\frac{1}{r}\right)_4 = \left(\frac{1}{r}\right)_3 - \left(\frac{1}{r}\right)_4 = 1720\cdot 10^{-9} - 131{,}3\cdot 10^{-9} = 1589 mm^{-1}$$

bu yerda $\left(\frac{1}{r}\right)_1$ ва $\left(\frac{1}{r}\right)_2$ =0, chunki kuchlar o'zaro teng.

To'liq solqilik

$$f = S\frac{1}{r}l_0^2 = \frac{5}{48}\cdot 1589\cdot 10^{-9}\cdot 17700^2 = 51{,}8mm < \frac{1}{250}l_0 = \frac{1}{250}\cdot 17700 = 70{,}8mm$$

Aniqlangan salqilik ruxsat etilgan qiymatidan kam.

4.11. To'sinni qiya kesim bo'yicha mustahkamlikka hisoblash

Qiya kesim to'sinning tayanch nuqtasidan boshlanadi. Bunda, (5-5 kesimda) ko'ndalang kuchni tayanch nuqtasidagi qarshilik kuchiga teng deb qabul qilsa bo'ladi (7-rasm).

$$Q = (g+v)\gamma_n \frac{l_0}{2}$$

Bunda ko'ndalang armatura ikki qator qo'yiladi,

n= 2Ø 6 A-III, A_{sw} =0,283 sm^2, qadami *S=15sm* deb olingan,

To'sinning qiya kesimi boshlanishidagi balandligi (5-5 kesim)

$$h = 890 + 260\frac{1}{12} = 912\, mm$$ ishchi balandligi esa,

$$h_o = h - 0{,}5h_f = 912\text{-}180 = 732\ mm.$$

Qiya kesim mustahkamligini ta'minlash sharti.

$$Q = 26{,}75\cdot 0{,}95\cdot\frac{17{,}7}{2} = 224{,}9kH = 224900N.$$

$$Q = 224900H \le 0{,}3\varphi_{w1}\varphi_{b1}R_b bh_o = 0{,}3\cdot 1{,}04\cdot 0{,}847\cdot 15{,}3\cdot(100)\cdot 24\cdot 73{,}2 = 710316N.$$

Bu yerda φ_{w1} - xomut ta'sirini hisobga oluvchi koeffitsiyent,

$$\varphi_{w1} = 1 + 5\alpha\mu_w < 1{,}3$$

$$\alpha = \frac{E_s}{E_b} = \frac{20 \cdot 10^{-4}}{32{,}5 \cdot 10^{-3}} = 6{,}154,$$

$\mu_w = \frac{A_{sw}}{bs} = \frac{0{,}283 \cdot 2}{24 \cdot 20} = 0{,}0012$ topilgan qiymatlarni o'z o'rniga qo'yamiz,

Bunda $\varphi_{w1} = 1 + 5 \cdot 6{,}154 \cdot 0{,}0012 = 1{,}04 < 1{,}3$

$$\varphi_{b1} = 1 - \beta\gamma_{b2} R_b = 1 - 0{,}01 \cdot 0{,}9 \cdot 17 = 0{,}847$$

Og'ir betonlar uchun koeffitsiyent $\beta = 0{,}01$.

Shunday qilib, to'sinning ko'ndalang kesimi o'lchamlari talablariga mos keladi. Mustahkamlik sharti bajarildi.

Mustahkamlik shartiga ko'ra, ko'ndalang armatura hisob bo'yicha aniqlanadi.

$$Q = 224900\ H > \varphi_{b3}\,(1+\varphi_n)\gamma_{b2} R_{bt,ser} b h_o = 0{,}6 \cdot (1+0{,}32) \cdot 0{,}9 \cdot 1{,}2 \cdot 240 \cdot 732 = 150269{,}6\ N.$$

bu yerda koeffitsiyent $\varphi_{b3} = 0.6$ - og'ir beton uchun

φ_n - bo'ylama kuchlarning ta'sirini hisobga oluvchi koeffitsiyent, bu yerda $N = P_2$

$$\varphi_n = 0{,}1 \frac{P_2}{\gamma_{b2} R_{bt} b h_o} = 0{,}1 \frac{606669}{0{,}9 \cdot 1{,}2 \cdot 240 \cdot 732} = 0{,}32 < 0{,}5$$

$$1 + \varphi_n = 1 + 0{,}32 = 1{,}32 < 1{,}5$$

Shart bajarilmadi., $Q = 224900N > 150269{,}6N$ ko'ndalang armatura hisob bo'yicha olinadi. Balkaning qiya kesimi bo'yicha mustahkamlik tenglamasi:

$$Q_1 \le Q_{sw} + Q_b = q_{sw} c_o + \frac{\varphi_{b2}(1+\varphi_n) R_{bt} b h_{01}^{\,2}}{c}$$

Bu yerda $h_{01} + ctg\beta$ - qiya kesim oxiridagi ishchi balandlik, β- to'sinning ustki qismi bilan gorizontal chiziq orasidagi burchak.

To'sinning uzunlik birligiga to'g'ri keladigan ko'ndalang sterjenlardagi zo'riqish qiymati aniqlanadi:

$$q_{sw} = \frac{R_{sw} A_{sw}}{S} = \frac{285 \cdot (100) \cdot 0{,}283 \cdot 2}{15} = 1075{,}4 N/sm$$

Bu yerda $n=2$ kesim yuzasidagi ko'ndalang armaturalar soni.

Bunda quyidagi shart tekshiriladi.

$$q_{sw} = 1075{,}4 \ge \varphi_{b3} \frac{(1+\varphi_n) R_{bt} \gamma_{b2} b}{2} = 0{,}6 \frac{(1+0{,}32) \cdot 1{,}2 \cdot (100) \cdot 0{,}9 \cdot 24}{2} = 1026\ N/sm$$

Shart bajarildi. Endi eng noqulay bo'lgan qiya kesim uzunligi aniqlanadi.

$$b = 24 sm, i = tg\beta = \frac{1}{12} = 0{,}083$$

$$C_o = \sqrt{\frac{\varphi_{b2}(1+\varphi_n)\gamma_{b2}R_{bt}bh_0{}^2}{q_{sw}+\varphi_{b2}(1+\varphi_n)\gamma_{b2}R_{bt}btg\beta^2}} = \sqrt{\frac{2\cdot(1+0{,}32)\cdot 0{,}9\cdot 1{,}2\cdot 24\cdot 73{,}2^2\cdot(100)}{1075{,}4+2\cdot(1+0{,}32)\cdot 0{,}9\cdot 1{,}2\cdot 24\cdot 0{,}083^2\cdot(100)}} =$$

$$= 181 > 2h_o = 2\cdot 73{,}2 = 147 sm$$

C_o ning qiymati C_o=150 sm qilib olinadi.

Qiya kesimni mustahkamlikka hisoblash.

$$Q_1 = q_{sw}(c-s) + \frac{\varphi_{b2}(1+\varphi_n)\gamma_{b2}R_{bt}bh_{o1}{}^2}{c_o} = 1026(150-15) +$$

$$+ \frac{2\cdot(1+0{,}32)\cdot 0{,}9\cdot 1{,}2\cdot(100)\cdot 24\cdot 73{,}2^2}{150} = 382949N.$$

Shunday qilib *Q=224900N<Q_1=382949 N* . Shart bajarildi, demak qiya kesim mustahkamligi yetarli darajada.

4.12. To'sinda qiya yoriqlarni paydo bo'lishiga hisoblash

Hisobni to'sin tayanch yuzasining og'irlik markazi uchun bajaramiz (bunda, *γ_f=1 γ_n =0,95* qilib olinadi, 5-5 kesimga qarang).

Maksimal qirquvchi kuchning me'yoriy qiymati,

$$Q = 23060\cdot 0{,}95\cdot\frac{17{,}7}{2} = 193877N.$$

Bu kesim, 0-0 kesimga juda yaqin bo'lganligi tufayli uning 11-jadvalda keltirilgan qiymatlaridan foydalanamiz.

Urinma kuchlanish $\tau = \frac{QS_{red}}{bI_{red}} = \frac{193877\cdot 3283{,}2}{24\cdot 1508142} = 17{,}59N/sm^2$

bu yerda *S_{red}=bh(y_o-0,5h)=24·91,2(47,1-0,5·91,2)= 3283,2 sm^3*

P_2 kuchi ta'siri ostida betonda hosil bo'lgan siqilish kuchlanishi

$$\sigma_x = \sigma_b = \frac{P_2}{A_{red}} = \frac{606669}{2184} = 278N/sm^2$$

Endi asosiy bosh cho'ziluvchi kuchlanishlarni topamiz.

$$\sigma_{mt} = \frac{-\sigma_x}{2} + \sqrt{\left(\frac{\sigma_x}{2}\right)^2 + \tau_{xy}{}^2} = \frac{-278}{2} + \sqrt{\left(\frac{278}{2}\right)^2 + 17{,}59^2} = -139 + 197{,}4 = 58{,}4N/sm^2 =$$

$$= 0{,}584 < R_{bt,ser} = 1{,}8MPa$$

Shart bajarildi, demak balkada qiya yoriqlar paydo bo'lmaydi.

4.13. To'sinni o'rnatish (montaj) bosqichida hisoblash

a) yoriqlar paydo bo'lishiga hisoblashni $\alpha-\alpha$ hisobiy kesim uchun olamiz.

Zo'riqtiruvchi kuch R bilan birga to'sinning xususiy og'irligi ta'siri ostida, to'sinni o'rnatish jarayonida, uning yuqori qismida (a-a kesim

bo'ylab) eguvchi manfiy moment hosil bo'ladi. Bu eguvchi moment dinamik koeffitsiyent $K_d=1,4$ hisobga olgan holda aniqlanadi.

$$q_1 = K_d q_n = 1,4 \cdot 5,12 = 7,17 \text{ kN/ m}$$

To'sinning a-a kesim bo'yicha balandligi $h = 89 + 408 \cdot \frac{1}{12} = 123$ sm

Ishchi balandligi esa $h_o=h-0,5h_f = 123-0,5 \cdot 32 = 107$ sm

Geometrik xarakteristikalarga oid ma'lumotlarni 11-jadvaldan olinadi.

Armaturalash sxemasi 9 va 10-rasmlarda keltirilgan *(4∅ 12 A-III, A'_s= 4,52sm^2)*

Zo'riqish $P=[(\sigma_{sp}-\sigma_{los1})\gamma_{sp}-330]A_{sp} =[(740-208)1,1-330] \cdot 12,06 \cdot (100) = 307771,2$ N,

bu yerda $\sigma_{los1}=208$ MPa–1-1 kesim uchun olingan, lekin u a-a kesimga eng yaqin bo'lgani uchun shu qiymatni olishimiz mumkin (12- jadval).

Oldindan zo'riqtiriladigan armatura A_{sp} ta'siridan betondagi siqilish kuchlanishini aniqlaymiz, buning uchun (11- jadval):

$$y_{sp}=e_{op}=y_o-0,5h_f = 581-0,5 \cdot 360 = 401 \text{ mm},$$

$$\sigma_{bp} = \frac{P}{A_{red}} + \frac{\left(Pe_{op} - Mg\right)y_{sp}}{I_{red}} = \frac{307771,2}{1734,5 \cdot (10^2)} + \frac{\left(307771,2 \cdot 401 - 5968 \cdot 10^3\right)401}{3564540 \cdot 10^4} = 3,23 \text{ MPa}$$

Bu yerda $M_{a-a} = \frac{q_1 l_1^{\,2}}{2} = \frac{7,17 \cdot 4,08^2}{2} = 59,68 kNm = 5968 \cdot 10^3 N \cdot mm$

Kesimning yuqori qismidagi betonda hosil bo'ladigan cho'zilish kuchlanishi:

$$\sigma'_{bp} = \frac{P}{A_{red}} + \frac{\left(Pe_{op} + Mg\right)\left(h - y_o\right)}{I_{red}} = \frac{307771,2}{1734,5 \cdot 10^2} + \frac{\left(307771,2 \cdot 401 - 5968 \cdot 10^3\right)(1230 - 581)}{3564540 \cdot 10^4} =$$

$= 4,13$ МПа

$$\frac{\sigma_{bp}}{R_{bp}} = \frac{3,23}{24} = 0,135 < \alpha = 0,8 \text{ , shuning uchun}$$

$$\sigma_6 = 0,85 \cdot 40 \frac{\sigma_{bp}}{R_{bp}} = 0,85 \cdot 40 \cdot 0,135 = 4,57 \text{ MPa;}$$

$$\sigma'_6 = 0,85 \cdot 40 \cdot \frac{4,13}{24} = 5,85 \text{ MPa;}$$

Birlamchi yo'qotishlar

$\sigma_{los1} = \sigma_1 + \sigma_2 + \sigma_3 + \sigma_4 + \sigma_5 + \sigma_6 = 54+81,2+41,7+30+4,6= 211,5$ MPa

Birlamchi yo'qotishlarni nazarga olgan holda oldindan zo'riqtirilgan kuchlanish $\sigma_{sp1} = \sigma_{sp} - \sigma_{los1} = 740-211,5 = 528,5$ MPa

Armaturadagi kuchlanishlar

$$\sigma_s = \sigma_6 = 4,57 \text{ MPa;} \quad \sigma'_s = \sigma'_6 = 5,85 \text{ MPa.}$$

Birlamchi yo'qotishlarni nazarga olgan holda zo'riqish P_1 aniqlaymiz:

$$P_1=\sigma_{sp1}\cdot A_{sp}-\sigma_s A_s-\sigma'_s A'_s=528,5\cdot 12,06(100)-4,57\cdot 0,785(100)-$$
$$5,85\cdot 4,52(100)= =635386,7\ N.$$

Siqilgan betonda to'sin vazni va zo'riqish P_1 ta'sirlari natijasida hosil bo'ladigan kuchlanish.

$$\sigma_{bp}=\frac{P_1}{A_{red}}+\frac{\left(P_1 e_{op}+Mg\right)y_{sp}}{I_{red}}=\frac{635386,7}{1734,5\cdot 10^2}+\frac{\left(635386,7\cdot 401+5968\cdot 10^3\right)401}{3464540\cdot 10^4}=6,6\,\text{MPa}$$

Keltirilgan kesim yuzasining og'irlik markazidan yadro ostki nuqtasigacha bo'lgan masofa

$$r=\frac{\varphi W_{red}}{A_{red}}=1\cdot\frac{54923,5\cdot 10^3}{1734,5\cdot 10^2}=316,6\,\text{mm}$$

bu yerda $\varphi=1,6-\frac{\sigma_{bp}}{R_{bp,ser}}=1,6-\frac{6,6}{16,2}=1,19>1$;

$$R_{bp,ser}=16,2MPa,\quad (R_{bp}=24MPa\ bo'lganda)$$

Hisob bo'yicha $\varphi>1$, shuning uchun $\varphi=1$ deb qabul qilamiz.

Yoriqlar paydo bo'lishiga tekshirish.

$$M_{a-a}=5968\cdot 10^4 Hmm<M_{crc}=R_{bt,p,ser}W_{p\,l}-M_{rp}=1,54\cdot 7491\cdot 10^4-$$
$$5363\cdot 10^4=6173\cdot 10^4\ Nmm,$$

bu yerda $R_{bt,p,ser}=1,54MPa$

$$M_{rp}=P_1(e_{op}-r)=635386,7(401-316,6)=5362,7\ N\cdot mm$$

Shart bajarildi, demak kesim yuzasining yuqori qismida yoriqlar paydo bo'lmaydi, ya'ni kesimning mustahkamligi ta'minlangan.

Agar yoriq paydo bo'lsa hisob quyidagi tartibda amalga oshiriladi.

b) Zo'riqish P_1 va to'sin vazni ta'siridan hosil bo'ladigan momentlarning qisqa muddatli yuklar ta'siri uchun hisoblanadi.

Zo'riqish P_1 qo'yilgan nuqtasidan kesim yuzasining yuqori qismida joylashgan armatura og'irlik markaziga qadar bo'lgan masofa aniqlanadi.

$$e_{sp2}=e_{op}+(h_o-y_o);$$

Bunda quyidagi miqdorlar aniqlanadi:

$$\delta=M_{a-a}+\frac{P_1 e_{sp1}}{R_{bp,ser}bh_o^{\,2}};$$

Kesim yuzasining ostki siqiluvchi zonasi uchun

$\varphi_f=\dfrac{\dfrac{\alpha_1}{2\nu A_{sp}}+\dfrac{\alpha_2}{2\nu A_s}}{bh_o}$ aniqlanadi

Bu yerda $\alpha_1=\frac{E_s}{E_{bp}}$ (A-V sinfi uchun); $\alpha_2=\frac{E_s}{E_b}$ (Bp -I sinfi uchun).

E_{bp}; R_{bp} qiymatlari interpolyatsiya yo'li bilan olinadi.

Quyida foydalaniladigan koeffitsiyentlarning qiymatlari aniqlanadi:

$$\lambda = \varphi_f\left(1 - \frac{h'_f}{2h_o}\right); \qquad e_{s,tot} = \frac{M_{a-a} + P_1 e_{sp2}}{P_1}$$

$$\xi = \frac{1}{\beta + \dfrac{1 + 5(\delta + \lambda)}{10\mu\alpha}} + \frac{1{,}5 + \varphi_f}{11{,}5\dfrac{e_{s,tot}}{h_o} - 5} < 1$$

bu yerda $\mu = \dfrac{A'_s}{bh_o}$; $\alpha = \dfrac{E_s}{E_{bp}}$ (A-III sinfi uchun)

Quyidagi shartlar bo'yicha tekshiriladi:

$\xi \le \dfrac{h_f}{h_o}$ shart bajarilmagan holda $\xi = \dfrac{h_f}{h_o}$ deb olinadi.

Ichki juft kuchlar yelkasi quyidagicha topiladi

$$Z = h_o\left[1 - \frac{\dfrac{h_f}{h_o}\varphi_f + \xi^2}{2\left(\varphi_f + \xi\right)}\right];$$

So'ngra $e_{s,tot}$ yelka topiladi va quyidagi shart bo'yicha tekshiriladi $e_{s,tot} > 0{,}8h_o$ shart bajarilmagan holda $\delta=1$ deb olinadi.

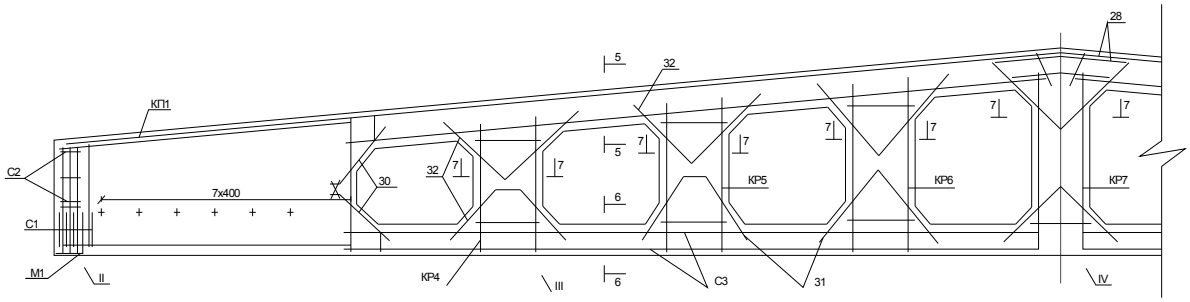
So'ngra cho'ziluvchi armaturada hosil bo'ladigan kuchlanish aniqlanadi:

$$\sigma_s = \frac{P_1\left(e_{sp2} - Z\right) + M_{a-a}}{A'_s Z}\delta;$$

Qisqa muddatli yuklar ta'sirida hosil bo'ladigan yoriqlarning eni topiladi:

$$\alpha_{crc} = 20(3{,}5 - 100\mu)\delta\varphi_l\eta\frac{\sigma_s}{E_s}\sqrt[3]{d} < [\alpha_{crc}] = 0{,}4mm$$

Bu yerda $\delta=1$ eguvchi momentlar uchun; $\varphi_l = 1$- qisqa muddatli yuklar uchun; $\eta=1$- davriy profilli sterjenlar uchun; d-A'_s armatura sterjeni diametri, mm.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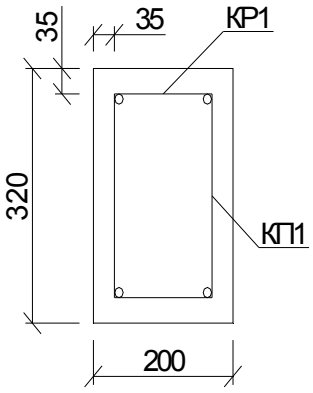
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КП1
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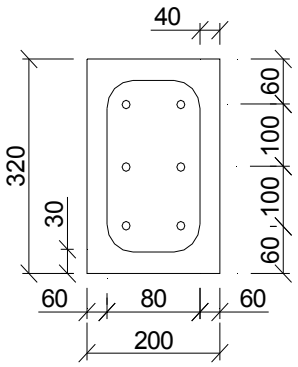
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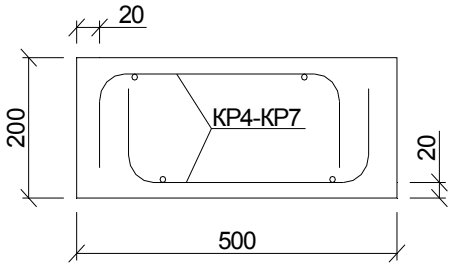
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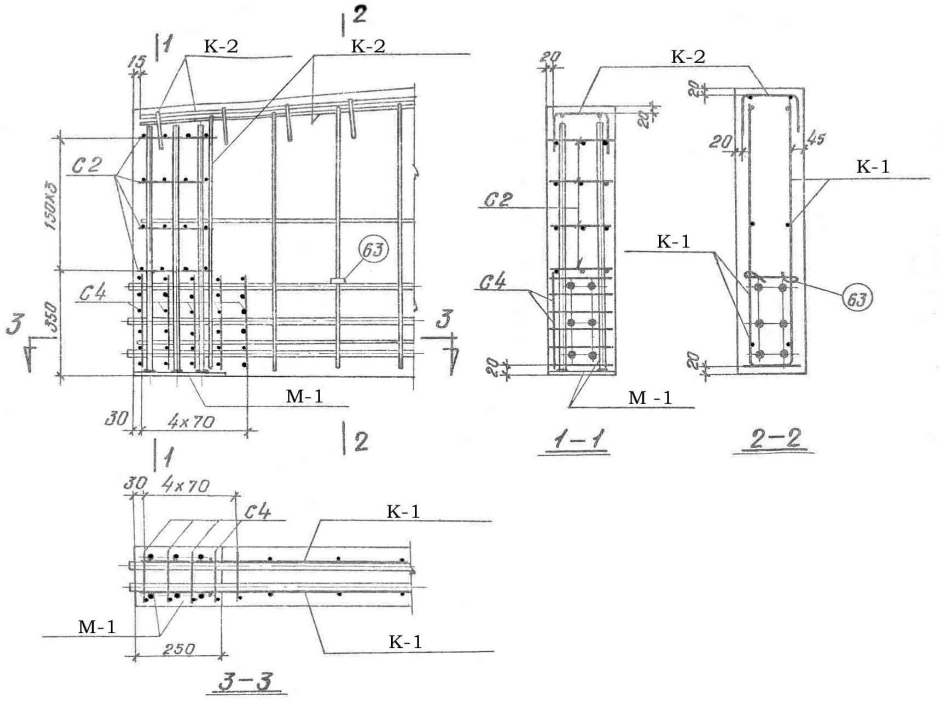
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3-3
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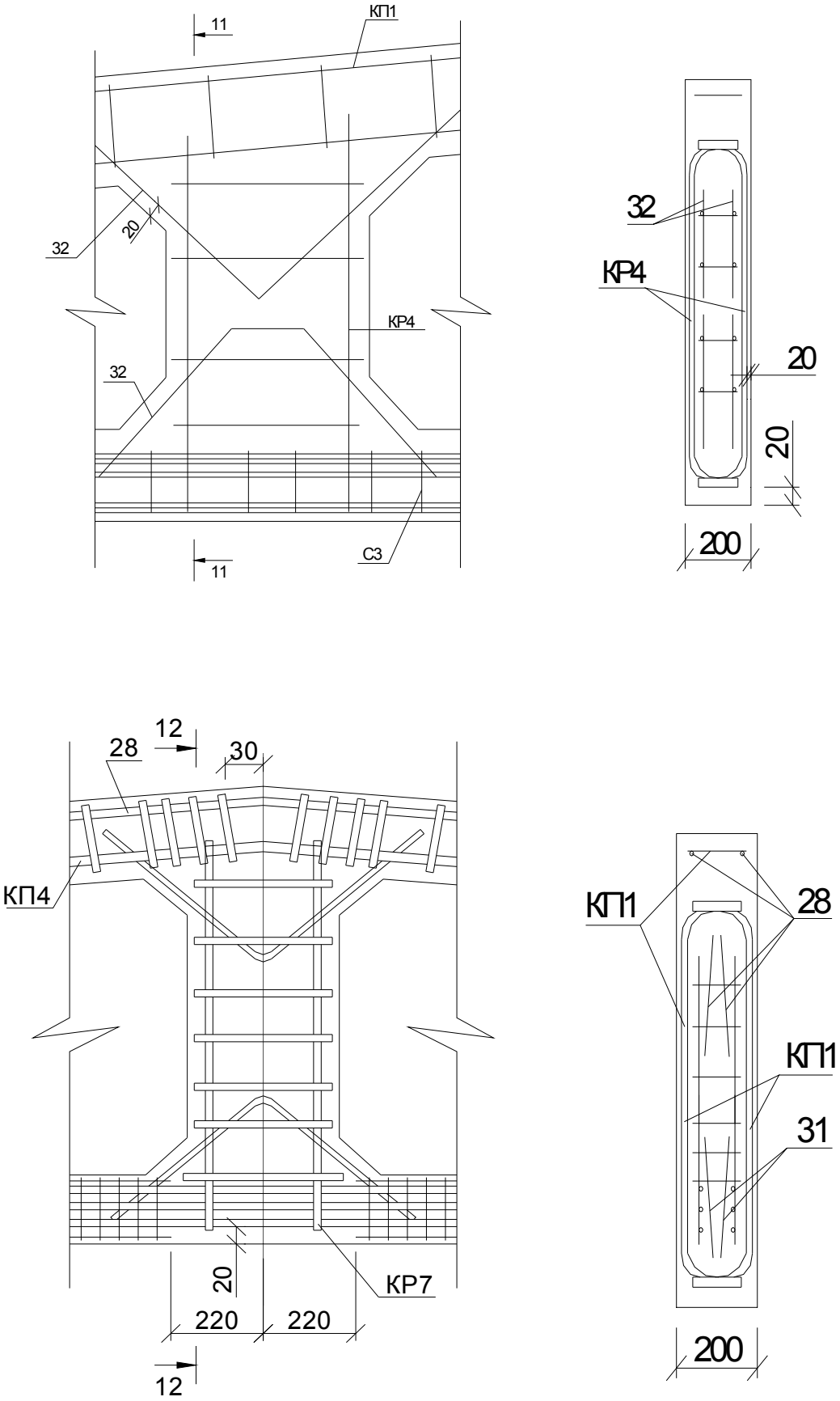


26-rasm. To’sinning armaturalash sxemasi

5. Ustunni hisoblash va loyihalash

Chetki qator ustunlar uchun.

Boshlang'ich ma'lumotlar:

1.Ustunning kesim yuzasi:

a) kran usti qismida 400x380mm;

b) kran osti qismida 400x800mm;

1.B20 sinfli og'ir beton.

2.Ustunni armaturalashda fazoviy karkas hosil qilinib, bo'ylama yo'nalishda A-II sinfi, ko'ndalangiga A-I sinfidagi po'lat armatura tanlanadi.

1.Ustunning kesim yuzasi simmetrik ($A_S=A_S^I$) ravishda armaturalanadi.

Ustun 1 – 0 va 2 – 1 kesimlari bo'yicha hisoblanadi. Ustunning hisob sxemasi –nomarkaziy siqiluvchi element sifatida qabul qilinadi.

1 – 0 kesim yuzasini hisoblashda ustunning konsol qismi, ya'ni tepa qismi kesim yuzasiga kelganda, jadvalga binoan, kuchlanishning ikki kombinatsiyasini (M;N) hisobga olish kerak:

birinchi:M=-26.54; N=-480.11kN

ikkinchi: M=-46.08; N=-427.33kN

Ustunni hisoblashda kuchlanishning ikki xil kombinatsiyasining barcha ta'siri hisobga olinadi. Lekin, $A_S=A_S^{'}$ armaturaning eng katta kesim yuzasining qiymati qabul qilinadi.

Hisobni yuklarni maxsus birikmasi ta'sirini e'tiborga olib bajaramiz.

Uzoq muddatli yuklar ta'siridan hosil bo'ladigan kuchlanish N_e=427.33kN; M_e=22.45kNm.

Kesimning hisobiy balandligi h_0=h-a=38-5=33sm

Kuchninng ekssentrisiteti $e_0 = \frac{M}{N} = \frac{26.54}{480.11} = 0.055m = 5.5sm.$

Ustunning hisobiy uzunligi $l_0=2N_2=2\cdot 3.8=7.6$m.

Kesim yuzasining inersiya radiusi $i = 0.29h = 0.29 \cdot 38 = 11.02sm$.

$$\lambda = \frac{l_0}{i} = \frac{760}{11,2} = 68,9 > 14$$

Shuni ta'kidlash joizki, ustun egilishining mustahkamlika ta'sirini ham unutmaslik kerak. Ustun kesim yuzasining uning og'irlik markaziga nisbatan inersiya momenti (armatura hisobga olinmagan holda) $I=i^2A$ $I=11.02^2\cdot 40\cdot 38=184589sm^4$

Birinchi yaqinlashishda μ=1%, ya'ni μ=0.01 ni qabul qilamiz.

Formula bo'yicha:

$$I_s = \mu A(\frac{h}{2} - a)^2 = 0.01 \cdot 40 \cdot 38(\frac{38}{2} - 5)^2 = 2979 sm^4.$$

bu yerda I_s- kesim yuzasining ustun og'irlik markaziga nisbatan inersiya momenti.

$$\varphi_l = 1 + \beta \frac{M_l}{M} = 1 + 1\frac{22.45}{26.54} = 1.85$$

$$\delta_l = \frac{e_0}{h} = \frac{5.5}{38} = 0.14$$

Formula bo'yicha topamiz:

$$\delta_{l\min} = 0.5 - 0.01\frac{l_0}{h} - 0.01R_b = 0.5 - 0.01\frac{760}{38} - 0.01 \cdot 11.5 = 0.185 > \delta_e = 0.14.$$

Hisoblash uchun δ_e=0,185; φ_p=1(zo'riqtirilgan armatura bo'lmasa) deb qabul qilamiz.

Formulaga binoan kiritik kuchni miqdorini aniqlaymiz:

$$N_{cr} = \frac{6.4E_b}{l_0^2}\left[\frac{\mathrm{I}}{\varphi_l}\left(\frac{0.11}{0.1 + \frac{\delta_l}{\varphi_p}} + 0.1\right) + \alpha \mathrm{I}_S\right] = \frac{6.4 \cdot 24 \cdot 10^3}{760^2}\left[\frac{184589}{1.85}\left(\frac{0.11}{0.1 + \frac{0.185}{1}} + 0.1\right) + 7.41 \cdot 2979\right] =$$

$$= 19052 MПa \cdot sm^2 = 1905 kN$$

Formula bo'yicha:

$$\eta = \frac{1}{1 - \frac{N}{N_{cr}}} = \frac{1}{1 - \frac{480.11}{1905}} = \frac{1}{0.75} = 1.33 \text{ topamiz}$$

U holda

$$e = e_0\eta + \frac{h}{2} - a = 5.5 \cdot 1.33 + \frac{38}{2} - 5 = 21.32 sm$$

$$\xi_R = 0.56$$

$$x = \frac{N}{R_b \cdot b} = \frac{480.11 \cdot 10^3}{11.5 \cdot 40 \cdot (10^2)} = 10.44 sm$$

$$\xi = \frac{x}{h_0} = \frac{10.44}{33} = 0.32 < \xi_R = 0.56$$

Demak, birinchi (katta ekssentrisitet) holatga ko'ra, hisobni $\xi < \xi_R$ bo'yicha bajaramiz.

Bo'ylama armaturaning kesim yuzasini aniqlaymiz:

$$A_S = A_S^{'} = \frac{N(e - h_0 + \frac{N}{2R_b b})}{R_{SC}(h_0 - a')} = \frac{480.11 \cdot 10^3 (21.32 - 33 + \frac{480.11 \cdot 10^3}{2 \cdot 11.5 \cdot 40 \cdot 10^2})}{280 \cdot (33 - 5) \cdot 10^2} = \frac{-3102189.02}{784000} = -3.9 < 0$$

Hisobni yuklarni maxsus birikmasi ta'sirini e'tiborga olib bajaramiz.

Uzoq muddatli yuklar ta'siridan hosil bo'ladigan kuchlanish:

N_l=427.33kN

M_l=22.45kNm

Kesimning hisobiy balandligi: h_0=h-a=38-5=33sm

Kuchning estsentrisiteti: $e=\frac{M}{N}=\frac{-46.08}{427.33}=0.11м=11sm$.

Ustunning hisobiy uzunligi $l_0=2N_2=2\cdot3.8=7.6$m.

Kesim yuzasining inersiya radiusi: i=0.29h=0.29·38=11.02sm.

$$\lambda=\frac{l_0}{i}=\frac{760}{11.02}=68,9>14$$

Shunday qilib, ustun egilishining mustahkamlikka bo'lgan ta'sirini ham hisobga olish kerak.

Formula bo'yicha:$I=i^2A$ topamiz $I=11.02^2\cdot40\cdot38=184589sm^4$.

Birinchi yaqinlashishda μ=1%, ya'ni μ=0.01 ni qabul qilamiz.

Formulaga binoan:

$$I_S=\mu A(\frac{h}{2}-a)^2=0.01\cdot40\cdot38(\frac{38}{2}-5)^2=2979sm^4.$$

$$\varphi_l=1+\beta\frac{M_l}{M}=1+1\cdot\frac{22.45}{46.08}=1.49$$

$$\delta_l=\frac{e_0}{h}=\frac{11}{38}=0.3$$

$$\delta_{l\min}=0.5-0.01\frac{l_0}{h}-0.01R_b=0.5-0.01\frac{760}{38}-0.01\cdot11.5=0.185>0.14$$

Hisob uchun δ_e=0,3; φ_p=1 deb qabul qilamiz.

Formula bo'yicha:

$$N_{cr}=\frac{6.4E_b}{l_0^2}\left[\frac{\mathrm{I}}{\varphi_l}\left(\frac{0.11}{0.1+\frac{\delta_l}{\varphi_p}}+0.1\right)+\alpha\mathrm{I}_S\right]=\frac{6.4\cdot24\cdot10^3}{760^2}\left[\frac{184589}{1.49}\left(\frac{0.11}{0.1+\frac{0.3}{1}}+0.1\right)+7.41\cdot2979\right]=$$

$$=18503MPa\cdot sm^2=1850.3kN$$

$$\eta=\frac{1}{1-\frac{N}{N_{cr}}}=\frac{1}{1-\frac{427.33}{1850.3}}=1.3$$

$$e=e_0\eta+\frac{h}{2}-a=11\cdot1.3+\frac{38}{2}-5=28.3sm$$

$$\xi_R=0.56$$

$$x=\frac{N}{R_b\cdot b}=\frac{427.33\cdot(10^3)}{11.5\cdot40\cdot(10^2)}=9.29sm$$

$$\xi=\frac{x}{h_0}=\frac{9.29}{33}=0.28<\xi_R=0.56$$

Demak, birinchi (katta ekssentrisitet) holat, shuning uchun hisobni $\xi < \xi_R$ ga ko'ra bajaramiz.

$$A_S = A_S^{'} = \frac{N(e - h_0 + \frac{N}{2R_b b})}{R_{SC}(h_0 - a')} = \frac{427.33 \cdot 10^3 (28.3 - 33 + \frac{427.33 \cdot (10^3)}{2 \cdot 11.5 \cdot 40 \cdot (10^2)})}{280 \cdot (33 - 5) \cdot (10^2)} = \frac{-23549,6}{940800} = -0,03 < 0$$

konstruktiv talabga ko'ra: 2Ø16 A-II. A_S=4.02sm^2 qabul qilamiz.

2 – 1 kesimni hisoblashda ikki kombinatsiyasini (Q;N;M) hisobga olish shart:

birinchi: M=8.26kNm N=983.26kN Q=-3.88kN

ikkinchi:M=94.36kNm N=935.76kN Q=14.06kN

Hisobni yuklarni maxsus birikmasi ta'sirini ikki kombinatsiyasini e'tiborga olib bajaramiz.

Uzoq davom etgan kuchdan hosil bo'lgan kuchlanish:

N_l=524.76kN

M_l=1.79kNm.

Kesimning hisobiy balandligi: h_0=h-a=80-5=75sm

Kuchning ekssentrisiteti: $e = \frac{M}{N} = \frac{94.36}{935.76} = 0.101m = 10.1sm$

Ustunning hisobiy uzunligi: l_0=1.5N_l=1.5·5.95=8.925m.

Kesim yuzasining inersiya radiusi: i=0.29h=0.29·80=23.2sm.

$$\lambda = \frac{l_0}{i} = 892,5 / 23,2 = 38,4 > 14$$

Shunday qilib, ustun egilishining mustahkamlikka ta'sirini hisobga olish kerak.

Formula bo'yicha I=i^{2}A =23,2^2·80·40=1722368 sm^4

Birinchi yaqinlashishda μ=1%, ya'ni μ=0.01 ni qabul qilamiz.

Formula bo'yicha:

$$I_S = \mu A(\frac{h}{2} - a)^2 = 0.01 \cdot 40 \cdot 80(\frac{80}{2} - 5)^2 = 39200 см^4.$$

$$\varphi_l = 1 + \beta \frac{M_l}{M} = 1 + 1 \cdot \frac{1.79}{94.36} = 1.02$$

$$\delta_l = \frac{l_0}{h} = \frac{10.1}{80} = 0.13$$

$$\delta_{l\min} = 0.5 - 0.01\frac{l_0}{h} - 0.01R_b = 0.5 - 0.01\frac{892.5}{80} - 0.01 \cdot 11.5 = 0.273 > \delta_e = 0.13$$

Hisob uchun δ_l=0.273; φ_p=1 ni qabul qilamiz.

Formula bo'yicha kritik kuchning qiymati:

$$N_{cr} = \frac{6.4E_b}{l_0^2}\left[\frac{\mathrm{I}}{\varphi_l}\left(\frac{0.11}{0.1+\frac{\delta_l}{\varphi_p}}+0.1\right)+\alpha \mathrm{I}_S\right] =$$

$$= \frac{6.4\cdot 24\cdot 10^3}{892.5^2}\left[\frac{1722368}{1.02}\left(\frac{0.11}{0.1+\frac{0.273}{1}}+0.1\right)+7.41\cdot 39200\right] == 181919 MPa\cdot sm^2 = 18192 kN$$

$$\eta = \frac{1}{1-\frac{N}{N_{cr}}} = \frac{1}{1-\frac{935.76}{18192}} = 1.05$$

Demak, birinchi (katta ekssentrisitet) holat, shuning uchun hisobni $\xi < \xi_R$ binoan bajaramiz.

$$A_S = A_S^{'} = \frac{N(e-h_0+\frac{N}{2R_b b})}{R_{SC}(h_0-a')} = \frac{935.76\cdot 10^3(45.61-75+\frac{935.76\cdot 10^3}{2\cdot 11.5\cdot 40\cdot 10^2})}{1.2\cdot 280\cdot(75-5)\cdot 10^2} = -7.65 < 0$$

Konstruktiv shartlarga ko'ra 3Ø16 A-II, A_s=6,03sm^2 armatura qabul qilamiz. U holda $\mu=A_s/bh=\frac{6,03}{40\bullet 80}\bullet 100\,\%=0,19\%>\mu_{min}=0,1\%$

Hisobni yuklarni maxsus qo'shilmalari ta'sirini (1-kombinatsiya) e'tiborga olib bajaramiz.

N_l=524.76kN

M_l=1.79kNm.

Kesimning hisobiy balandligi: h_0=80-5=75sm

Kuchning ekssentrisiteti: $e = \frac{M}{N} = \frac{8.62}{983.26} = 0.009м = 0.9sm$

Ustunning hisobiy uzunligi: $l_0=1.5N_l=1.5\cdot 5.95=8.925$m.

Kesim yuzasining inersiya radiusi: i=0.29h=0.29·80=23.2sm; λ=38,4

Shunday qilib, ustun egilishining mustahkamlikka ta'sirini hisobga olish kerak.

Formula bo'yicha: I=i^{2}A topamiz u holda I=23.2^2·40·38=1722368sm^4.

Birinchi yaqinlashishda μ=1%, ya'ni μ=0.01 ni qabul qilamiz.

Formula bo'yicha:

$$I_S = \mu A(\frac{h}{2}-a)^2 = 0.01\cdot 40\cdot 80(\frac{80}{2}-5)^2 = 39200 sm^4.$$

$$\varphi_l = 1+\beta\frac{M_l}{M} = 1+1\cdot\frac{1.79}{8.62} = 1.2$$

$$\delta_l = \frac{e_0}{h} = \frac{0.9}{80} = 0.01$$

$$\delta_{l\min} = 0.5 - 0.01\frac{e_0}{h} - 0.01R_b = 0.5 - 0.01\cdot\frac{892.5}{80} - 0.01\cdot 11.5 = 0.273 > 0.01$$

Hisob uchun δ_l=0.273 φ_p=1 ni qabul qilamiz.

Formula bo'yicha: N_{cr} quyidagicha topiladi.

$$N_{cr} = \frac{6.4E_b}{l_0^2}\left[\frac{\mathrm{I}}{\varphi_l}\left(\frac{0.11}{0.1+\frac{\delta_l}{\varphi_p}}+0.1\right)+\alpha \mathrm{I}_S\right] =$$

$$= \frac{6.4\cdot 24\cdot 10^3}{892.5^2}\left[\frac{1722368}{1.2}\left(\frac{0.11}{0.1+\frac{0.273}{1}}+0.1\right)+7.41\cdot 39200\right] = 165310 МПа\cdot см^2 = 16531 kN$$

$$\eta = \frac{1}{1-\frac{N}{N_{cr}}} = \frac{1}{1-\frac{983.26}{16531}} = 1.06$$

$$e = e_0\eta + \frac{h}{2} - a = 0{,}9\cdot 1.06 + \frac{80}{2} - 5 = 35.96 sm$$

$$\xi_R = 0.56$$

$$x = \frac{N}{R_b\cdot b} = \frac{983.26\cdot(10^3)}{11.5\cdot 40\cdot(10^2)} = 21.38 sm$$

$$\xi = \frac{x}{h_0} = \frac{21.38}{75} = 0.29 < \xi_R = 0.56$$

Demak, birinchi (katta ekssentrisitet) holat bo'yicha ya'ni $\xi < \xi_R$ hisob amalga oshiriladi.

$$A_S = A_S^{'} = \frac{N(e-h_0+\frac{N}{2R_b b})}{R_{SC}(h_0-a')} = \frac{983.26\cdot 10^3(35.96-75+\frac{983.26\cdot 10^3}{2\cdot 11.5\cdot 40\cdot(10^2)})}{280\cdot(75-5)\cdot 10^2} = -14.22 см^2 < 0$$

konstruktiv talabga ko'ra: 3Ø18 A-II. A_S=7.63sm^2 qabul qilamiz.

$$\mu = \frac{A_S}{bh} = \frac{7.63}{40\cdot 80} = 0.00238 = 0.24\% > \mu_{\min} = 0.2\%$$

5.1. Ustun konsolini hisoblash

Ustunning konsol qismiga kran osti to'sin tayanadi.

Konsolga ta'sir qilayotgan hisobiy kuchni

$Q_k = D_{\max}\cdot h_C + G_{n\delta} = 411\cdot 0.85 + 32.23 = 381.58 kNm$ formula bo'yicha aniqlanadi .

Konsol qulochi:

$$l_k \geq \lambda_{кр} + \frac{\delta_{n\delta}}{2} - h_н + 50 = 750 + \frac{160}{2} - 800 + 50 = 80 м$$

mm

Tayanch kesimi yuzasining zaruriy balandligini aniqlaymiz:

a) mustahkamlik shartiga ko'ra:

$$h_0 = \sqrt{\frac{Q_k \cdot a}{1.2 K_\varphi R_{bt} \cdot b}} = \sqrt{\frac{381.58 \cdot 0.2}{1.2 \cdot 1 \cdot 0.9 \cdot 0.4}} = \sqrt{176.657} = 13.29 sm$$

$$\frac{Q_k}{2.5 R_{bt} b} = \frac{381.58}{2.5 \cdot 0.9 \cdot 0.4} = 423.98$$

b) konstruktiv shartga ko'ra:

$$h - l_k \cdot tg45^\circ \geq \frac{h}{3}$$

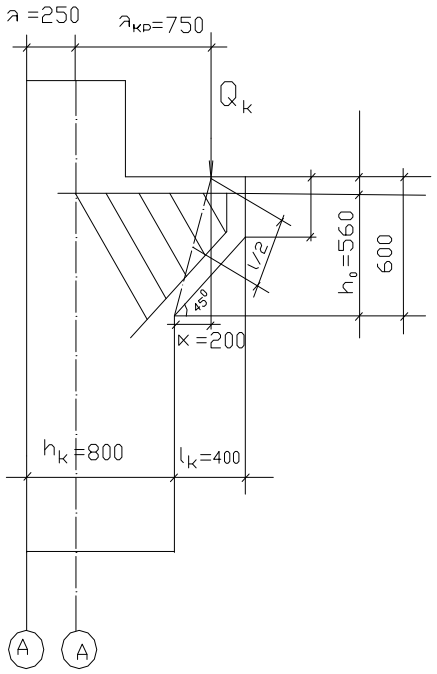
$$h = \frac{3}{2} l_k \cdot tg45^\circ = \frac{3}{2} \cdot 40 \cdot 1 = 60 sm$$

$$h_k = h - l_k \cdot tg45^\circ = 60 - 40 \cdot 1 = 20 sm$$

$$h_0 = 60 - 4 = 56 sm.$$

Konsol uchun kerakli bo'lgan bo'ylama armaturasining kesim yuzasi:

$$A_S = \frac{1.25 \cdot Q_k \cdot a}{R_S (h_0 - a')} = \frac{1.25 \cdot 381.58 \cdot 0.2}{280 \cdot 10^2 (0.56 - 0.04)} = 9.42 sm^2$$



27-rasm. Ustunning konsoli

3 yassi karkas shaklida 3Ø20 A-II (A_S=9.42sm^2>9sm^2) ni kabul qilamiz.

2.5α=2.5·20=50sm<h=60sm konsol qiya holda joylashgan xomutlar bilan armaturalanadi.

Yuqori chiziqning yarmida kesishuvchi va Q_k nuqtasini konsol asosi bilan birlashtiruvchi qiya xomutlar kesim yuzasi:

$f_K = 0.002 b h_0 = 0.002 \cdot 40 \cdot 56 = 4.48 sm^2$ bo'lishi talab qilinadi.

Ø10 A-II, unda $f_K = 6 \cdot 0.785 = 4.71 см^2 > 448 sm^2$ xomutni qabul qilamiz.

Foydalanilgan adabiyotlar ro’yxati

1. QMQ 2.03.01-96 Beton va temirbeton konstruksiyalar, O’z.RDAQQ 1998.
2. QMQ 2.01.07-96 Yuklar va ta’sirlar , O’z.RDAQQ 1996.
3. Байков В.Н., Сигалов Э.С. Железобетонные конструкции, М., Стройиздат, 1991.
4. Курс ва диплом лойиҳалари учун. Темирбетон конструкциялар. Барашиков. А.Я. таҳрири остида, Киев, “Вища школа”, 1987.
5. Asqarov B.A., Nizomov Sh.R. Temirbeton va tosh-g’isht konstruksiyalari T., “O’zbekiston” 2003.
6. Николаев И.И. Проектирование железобетонных конструкций зданий для строительства в сейсмических районах. Т., “Ўқитувчи” 1991.
7. Николаев И.И., Палкина Л.В. Оформление чертеные железобетных конструкций в курсовых и дипломных проектах.Т. “Ўқитувчи” 1985.
8. Nizomov Sh.R., Xobilob B.A., Usmonov F.T. Temirbeton konstruksiyalari .T. “Mehnat”. 1992.
9. Селимов М.М., Низомов Ш.Р. Примеры расчета и конструирования железобетонных и каменных конструкций. Учебное пособие. Т., 1989.
10. Каталог индустрально-железобетонных конструкцый в Р.Уз. сб.к-1 одноэтажные здания.

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O`quv-uslubiy qo'llanma

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