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**ferdoebis da kaTebis mdgradobis
uzrunvelyofis sainJinro gadawyvetebi**

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individualuri pirovnebebis an institutebis mier
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avtoris xelmowera

avtori inarCunebs danarCen sagamomcemlo uflebebs da arc mTliani
naSromis da arc misi calkeuli komponentebis gadabeWdva an sxva raime
meTodiT reproduqcia dauSvebelia avtoris werilobiTi nebarTvis gareSe.

avtori irwmuneba, rom naSromSi gamoyenebuli saavtoro uflebebiT dacul
masalebze miRebulia Sesabamisi nebarTva (garda im mcire zomis citatebisa,
romlebic moiTxoven mxolod specifiur mimarTebas literaturis citirebaSi, rogorc
es miRebulia samecniero naSromebis Sesrulebisas) da yvela maTganze iRebs
pasuxismgeblobas

reziume

ganasxvaveben kalTebis da ferdoebis mdgradobis darRvevis or jgufs: saerTo da
adgilobrivs. saerTo mdgradobis darRvevebisas mewyeruli procesi moicavs miwis
nagebobebis mTlian kalTas an ferdos an masivebis udides nawils. gadaadgilebis siRme
moicavs aTeulobiT metrs.

adgilobrivi mdgradobis darRvevebisas, rogorc wesi, xdeba ara mTlianad masivebis,
aramed kalTebis an ferdoebis mxolod nawilis rRvevebi. maT aqvT sxvadasxva xasiaTi da
SeiZleba warmoiqmnan kalTis an ferdos nebismier nawilSi. aseT mewyerebi mcire

moculobiisa, magram gamoirCevian didi sixSiriT da odenobiT. adgilobrivi mdgradobis rRvevis gansakuTrebuloa mdgomareobs imaSi, rom maTi ganviTareba SesaZlebelia saerTo mdgradobis uzrunvelyofis SemTxvevaSic, rasac momavalSi SeiZleba moyves mZlavri mewyerebis ganviTareba da aqtivizacia.mewyeruli procesebis formebis mravalsaxeoba gansazRvravs sxvadasxva mewyersawinaaRmdego konstruqciebis da RonisZiebebis gamoyenebis saWiroebas.mewyersawinaaRmdego konstruqciebis kompleqsi realizebuli unda iqnas misi sruli SemadgenlobiT. mewyeruli ferdos mdgradobis ganmeorebiTi darRvevbis Tavidan acilebis mizniar unda moxdes kompleqsis nawilobrivi mowyoba,

kompleqsi Semavali TiToeuli mewyersawinaaRmdego konstruqciis daniSnulebaa mewyerebis warmoqmnis erTi an ramdenime mizezis aRmofxvra.miwis nagebobebis ferdoebSi mewyerebis ganviTarebis erT-erTi ZiriTadi mizezia maTze zedapiruli da miwisqveSa wylebis zemoqmedeba. is iwvevs gruntebis fizikur-meqanikuri Tvisebebis cvlilebas maTi gawylovanebis gamo _ maTi simtkicis Semcirebas, gruntis wylis donis amaRlebis gamo _ hidrodinamikuri da filtraciuli Zalebis gazrdas, sufoziis warmoqmnas, ZiriTad qanebTan nafari gruntebis sakontaqto zedapirebis gawylovanebas. amgvarad, miwis nagebobebis ferdoebis deformaciebTan brZolis pirveli rigis RonisZiebas warmoadgens zedapiruli da miwisqveSa Canadenebis regulireba.

Semdeg RonisZiebas warmoadgens gruntebis damagreba sxvadasxva teqniki saSualebebiT, maT Soris _ gruntis daZvris Semakavebeli calkeuli konstruqciuli sistemebis mowyobiT, magaliTad, gruntuli ankerebiT an gruntis Semakavebeli nagebobebiT.

Tavisi socialur-ekonomikuri ganviTarebis Tanamedrove etapze saqarTvelo, romelic warmoadgens rTuli geografiuli reliefis qveyanas, udides Zalisxmevas iCens ganviTarebuli turistuli da sakurorto kompleqsebis da, Sesabamisad, ganviTarebuli infrastruqturis mqone qveynebis doneze gasasvlelad. ideba mniSvnelovani investiciebi axali miwebis aTvisebis, magistraluri satransporto gzebis da komunikaciebis gayvanis, samrewvelo da saxovrebeli kompleqsebis mSeneblobis da rekonstruqciis, qveynis uamrav regionSi mewyerebis zemoqmedebis Sedegad ubinaod darCenili mosaxleobis saxovrebeli farTiT uzrunvelyofis mizniT.

yovelive zemoaRniSnuli aucilebels xdis arastabiluri bunebriv _ geologiuri pirobebis mqone, kerZod, iseTi gavrcelbuli da saSiSi movlenebiT, rogorsac warmoadgenen mewyerebi _ gruntebze ukve agebuli da asaTvisebel teritoriebze asagebi nagebobebis saeqspluatacio saimedobisa da usafrTxoebis uzrunvelyofis teqniki da teqnologiuri gadawyvetebis gamosavlenad kvlevebisa da Sesabamisi samuSaoebis Catarebas. swored zemoT dasmuli problemebi aris ganxiluli da gadawyvetili disertaciaSi, rac mis aqtualurobas udavos xdis.

disertaciis mizania miwis nagebobebis ferdoebis stabilizaciis uzrunvelsayofad erTiani konstruqciuli sistemebis teqniki da teqnologiuri gadawyvetebis damuSaveba, romelic erTdroulad Seasrulebs Camongrevisagan (CamoSlisagan) gruntis masebis Sekavebis da wylis daCqarebulad moSorebis, gruntis gamoSrobis (gawylovanebis) funqciebs.

samecniero siaxle mdgomareobs SemdegSi -Kkonkretuli adgilobrivi pirobebis mixedviT SemoTavazebulia konstruqciuli sistemebi Semdegi kombinaciebiT:

1. gruntuli ankeri – sadrenaJo sistema;
2. gruntuli ankeri – sadrenaJo sistema – masivis damamagrebeli torkret garsi (membrane);
3. gruntuli ankeri – sadrenaJo sistema - msubuqi sayrdeni kedeli;
4. gruntuli ankeri – amosaRebi gruntuli ankeris sistema.

gruntis wyalgadacemis daCqarebis mizniT dasabuTebulia sadrenaJo sistemaSi eleqtroosmosis gamoyenebis efeqturoba.foladis saankero mWimebis da gruntSi Casobili foladis Reros gamoyenebiT,.

damuSavebulia kombinirebuli sistemebis mowyobis teqnologiuri procesi, rodesac TiToeuli konstruqciuli elementi uzrunvelyofs ori an meti SeTavsebuli, paraleluri funqciebis Sesrulebas da erTad axdenen miwis nagebobis ferdoebis stabilizacias.

SemoTavazebulia axali tipis, amosaRebi gruntuli ankerebis variantebi. isini saSualebas iZlevian gamoyenebuli ankeruli mWimebi dauzianeblad iqnen amoRebuli, rodesac aRar iqneba maTi eqspluataciis saWiroeba.

Summary

There are two groups that violate the stability of the slopes and hillsides- general and local. During the violations of the general stability, the landslide process includes the whole slope or the hillside, or the larger part of the massifs. The displacement depth is tens of meters.

During the violations of the local sustainability, as a rule, not the whole massifs, but the slopes or hillsides collapse, they have different nature and may result in any part of the slope or hillside. Only such landslides have much smaller volume, but they occur with greater frequency and a significant amount. The uniqueness of the local stability violation lies in the fact that their development is possible even if the overall stability is provided, which in the future may lead to the development of powerful landslides and activation.

The variety of landslide processes determines the necessity of use of different forms of anti-landslide constructions and taking special measures. The landslide complex structures must be realized in their full composition. The partial realization of the complexes shall not be allowed in order to prevent a repetition of landslide of the slope sustainability. The complex structure of each anti-landslide system has been designed to

eliminate one or more reasons of landslide production. One of the main reasons for landslide development to the building in the land is the impact of the surface water and groundwater. It causes the physical - mechanical changes of the soil due to its saturation, reduction of strength due to the rise in groundwater level, increase of filtration and hydrodynamic forces, formation of suffusion, saturation of soil contact surfaces with rocks. Thus, the first-order measure to fight the land and structure slope deformation is to regulate the surface and underground water flows. The further action is the soil fortification with various technical means, including the arrangement of the ground slide deterrent separate structural systems, such as soil anchors and ground deterrent structures. At the socio - economic development of the modern stage, Georgia, which is situated in the difficult geographical terrain, demonstrates the greatest efforts to achieve the level of developed countries through developing tourism and resort complexes. The significant investments have been carried out to explore new lands, to lay the main transport routes and communications, construct and reconstruct the industrial and residential complexes, and in many regions of the country to provide housing for numerous homeless households due to the impact of landslides.

The foregoing makes it necessary to carry out necessary research and relevant work to identify the technical and technological solutions to provide reliability and operational safety of the constructions in the soils or the buildings which are to be constructed on the soils that are characterized by unstable natural - geological conditions, particularly the grassroots and dangerous event, such as a landslide. The problems raised above are discussed and solved in the dissertation, which gives it the undeniable urgency.

The purpose of the dissertation is to provide and process the technical and technological solutions for common ground constructions in order to stabilize the slope structural systems, which simultaneously will function to prevent the collapse (topple) of soils, deter the ground water, remove the water hastily, and dry (dehydrate) the soil.

The **scientific innovation** is as follows: According to the specific local conditions, the following structural system combinations have been proposed:

1. Soil anchors - the drainage system;
2. Soil anchors - Drainage system – the massif fortification (torkret shell) membranes;
3. Soil anchors - Drainage system - light support wall;
4. Soil anchors - - anchors recoverable system.

In order to accelerate the underground water discharge, use of electrical osmoses within the drainage system proved to be effective, using the steel anchors in the form of

electrodes and the axis driven into the soil, which will be removed out of the soil after the dehydration process of the soil is complete.

The technological process for arrangement of combined systems has been developed, where each of the structural elements ensures provision of two or more compatible, parallel functions, which guarantee the land construction slope stabilization. Proposed a new type of recoverable soil anchors, which are reusable and allow removal without damaging them.

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Sesavali

saqarTvelo warmoadgens rTuli geografiuli reliefis mqone qveyanas, sadac axali miwebis aTvisebis, magistraluri satransporto gzebis da komunikaciebis gayvanas, samrewelo da sacxovrebeli kompleqsebis mSeneblobis da eqspluataciis dros, xSirad ferdoebze da kalTebze adgili aqvs gruntis cocvadobiT gamowveul bunebriv gadaadgilebbs da mewyerul movlenebs. Asmitom maTi mdgradobis uzrunvelsayofad saWiro xdeba sxvadasxva tipis Semkavebeli, wyalamridi, sadrenaJo da damcavi konstruqciuli sistemebis mowyoba. upirvels yovlisa es Seexeba zvasaSiS raionebs, rac moiTxovs mewyerebisagan gzebis, nagebobebis da garemos dacvis saimedo gadawyvetebis, Sesabamisi RonisZiebebis swor da droul ganxorcielebas.

saqarTvelos bevr raionSi gvxdება mniSvnelovani mewyersaSiSi adgilebi. mewyeruli movlenebis masStabi, gansakuTrebiT bolo wlebSi, didia. saqarTvelos qalaqeba da dasaxlebul punqtebSi, rTuli reliefiT, ferdoebze ganTavsebuli nagebobebiT _ gruntis cocvadobiT gamowveuli bunebrivi gadaadgilebebis garda, warmoiqmneba damatebiTi gadaadgilebebi da mewyerebi moZvelebuli, dazianebuli katastrofuli movlenebi xdeba saqarTvelos sxvadasxva raionebSi yovelwliurad (aWaris maRal mTiani soflebi, raWa, yazbegi, svaneTi da sxva). bunebrivi gamovlenis aseTi suraTi, gansakuTrebiT saqarTvelos teritoriis seismurobasTan erTad, roca miwisZvris dros warmoebs gruntis gaTxevadebis movlenebi, moiTxovs droul teqnukur da teqnologiur gadawyvetebis.

amacilebeli RonisZiebebis efeqturoba unda emyarebodes kompleqsur gadawyvetebis, romlebic Seicaven sxvadasxva daniSnulebis mewyersawinaaRmdego konstruqciebis erTobliv gamoyenebas: Semkavebeli, wyalamridi, sadrenaJo da damcavi, romlebic uzrunvelyofen ferdoebis zedapirul gamagrebas, agreTve maT adgilobriv mdgradobas. axali teqnikuri da teqnologiuri gadawyvetebis SemuSaveba aqtualuria ara mxolod qveynis teritoriis calkeuli nawilebis srulfasovani aTvisebisaTvis, aramed maTi gamoyenebis farTo sferos warmoadgens calkeuli obieqtebis mSenebloba. mSeneblobis masStabebisa da

SesaZleblobebis mazard tendenciebTan erTad sul ufro mniSvnelovani xdeba miwis samuSaoebis warmoebis dros Senoba-nagebobebis qvabulis kedlebis gruntis CamoSlisagan dacva. Qqvabulis kedlebis gamagrebis problemebi. gansakuTrebiT mwvaved dgas mWidrod ganaSenianebul, SezRudul adgilebSi mSeneblobis dros.

qvabulis kedlebis sxvadasxva konstruqciuli sistemebiT gamagrebis SemTxvevaSi Zalze rTuldeba TviT qvabulis SigniT samuSaoebis warmoeba. damontaJebuli konstruqciebi xSirad xels uSlian ara marto miwis samuSaoebis warmoebas, aramed Senobebis saZirkvlisa da miwiszeda nawilis agebas. aRniSnuli sirTuleebis Tavidan acilebis mizniT aqtiurad daiwyo gruntuli ankerebis gamoyenaba. maTi saSualebiT damontaJebuli gamagrebis konstruqciebi marTalia xels aRar uSlian mSeneblobis warmoebas, magram SeuZlebeli xdeba samuSaoebis dasrulebis Semdeg maTi gruntidanamoReba. gacilebiT progresulia amosaRebi gruntuli ankerebi. maTiuaryofiT mxared unda CaiTvalos is rom saWiroa sxvadasxva Casamagrebeli detalebis qarxnuli wesiT damzadeba, romelTa amoReba da mravaljeradi gamoyeneba Semdeg ver xerxdeba. arsebuli sistemebis gamokvlevis da Sedarebis procesSi gamoikveTa SemoTavazebuligogirdbetoniT Camagrebuli amosaRebi gruntuli ankerebis upiratesoba. maTi mowyoba martivad xdeba samSeneblo moedanze. amasTaneqsperimentalurad dadasturda, rom gogirdbetonis 130-140⁰C-mde gaxurebis Sedegad yovelgvari garTulebis gareSe SeiZleba ankerebis dauzianeblad amoReba da maTi xelmeored gamoyeneba.

Tavi 1.

problemis gadawyvetis meTodebi da arsebuli meTodebis analizi.

1.1. problemebis gadawyvetis meTodebi

kalTebis da ferdoebis samagri konstruqciebi, gare Zalovani da klimaturi zemoqmedebisagan gruntis damcavi funqciebis mixedviT SesaZlebelia dayofili iqnen Semdeg jgufebad:

_ zedapiruli da miwisqveSa Canadenebis maregulirebeli konstruqciebi (maT, kerZod, miekuTvneba drenejis yvela tipi);

_ mewyersawinaaRmdego damWeri konstruqciebi (ximinjovani konstruqciebi, sayrdeni kedlebis da ankeruli damagrebis yvela saxeoba);

_ miwis nagebobebis kalTebis da ferdoebis zedapirebis samagri konstruqciebi (maT miekuTvneba ferdoebis zedapirebis biologiuri da aglosamelioracio samagrebi, geoteqstili);

_ napirsamagri konstrukciebi (bunibrivi da xelovnuri masalebi).

naSromSi Cven vixilavT mewyersawinaaRmdego konstrukciebis pirvel or tips _ sadrenaJo sistemebs da ankeruli Camagrebebs sayrdeni kedlebiT.

sadrenaJo konstrukciebs, rogorc wesi, iyeneben mewyeruli masivebis an misi calkeuli wyalgamtari Sreebis gamoSrobs, gruntis wylebis donis dawewis da maTi dawnevis Semcirebis mizniT. aRniSnuli amaRlebs mewyeruli ferdos mdgradobas, qmnis maTze mewyersawinaaRmdego konstrukciis agebis saTanado pirobebs, uzrunvelyofs miwis nagebobis stabilurobas. calkeuli Sreebis da plastebis gamoSroba (gauwylovneba) amaRlebs gruntebis simtkices sakontaqto zonaSi an aRmofxvris sufozur movlenebs qviSovan SreebSi.

mewyersawinaaRmdego drenaJebis sruli nomenklaturidan farTo gamoyeneba hpoves tranSeulma horizontalurma milovanma drenaJebma, romlebic ara mxolod adableben gruntis wylebis dones, aramed maT warmatebiT iWeren da gayavT miwis nagebobis an ferdos zonebidan. tranSeul horizontalur milovan drenaJebis iyeneben 2-5 metris siRmeSi arsebul gruntis wylebisaTvis.

mSeneblobis praqtikaSi horizontaluri drenirebis meTodebs calkeul SemTxvevaSi iyeneben Rrma mTxreblis ferdoebSi. amasTan gamoiyeneba horizontaluri sadrenaJo naburRebi, romlebic atareben milfiltrebs mTxreblis ferdos ZirSi.

yofil sabWoTa kavSirSi, horizontaluri an daxrili burRvisaTvis gamosayenebeli mowyobilobis defeciti mniSvnelovanwilad aferxebda am efeqturi meTodis farTod gamoyenebis SesaZleblobas, riTac amcirebda mewyeruli monakveTebis stabilizaciisaTvis saWiro kompleksuri RonisZiebebis efeqturobas. amave dros wyalamcilebeli da sadrenaJo nagebobebi ar aris ZviradRirebuli, ar saWiroeben mniSvnelovan samSeneblo danaxarjebis, xolo masalebis xarjva umniSvneloa.

sazRvargareT drenireba _ mewyerebis stabilizaciis xSirad gamoyenebuli meTodia. rogorc wesi, sazRvargareTul praqtikaSi gamoiyeneba zedapiruli da miwisqveSa wylebis gadayvanis, maTi donis dawewis da Cadinebis regulirebis kompleksuri gadawyvetebi. horizontalurma naburRma drenaJebma bevr qveyanaSi, mewyersawinaarmdego brZolis praqtikidan gamodevnes sadrenaJo Stolnebi da galereebi. mniSvnelovanwilad horizontaluri drenirebis meTodebis farTod gavrcelbas xeli Seuwyo horizontaluri da daxrili burRvis manqanebis da mowyobilobebis daCqarebulma ganviTarebam, agreTve sxvadasxva ganivkveTis, formis da daniSnulebis plastebis drekadi drenebis Seqmnam. praqtikulad sazRvargareT mewyersawinaaRmdego

RonisZiebebis nebismieri kompleksi iwyeba mewyeruli ferdos horizontaluri drenaJis mowyobis samuSaoebiT.

saankero konstruqciebi warmoadgenen Semkavebeli mewyersawinaaRmdego nagebobebis erT-erT tips, romelTa gamoyeneba SesaZlebelia damoukidebeli konstruqciuli gadawyvetis saxiT, an drekad sayrden kedlebTan, Spuntur samagr elementebTan kombinaciaSi, agreTve iseT konstruqiebTan erTad, rogoricaa burRtenili ximinjebi da sxvdasxva daniSnulebis sayrdeni kedlebi.

ganasxvaveben gruntis ankerebs, romelTa gamoyeneba mizanSewonilia auTvisebel teritoriebze potenciuri mewyeruli kalTebis an ganaSenianebuli ferdoebis (Senoba-nagebobebi, gzebi) stabilizaciisaTvis da anker-mWimebs, romlebic gamoiyeneba kombinirebuli tipis mewyersawinaaRmdego konstruqciebSi. am SemTxvevaSi anker-mWimebi SeiZleba iyos droebiTi da mudmivi. droebiTi ankerebis samsaxuris vadaa 1-2 weli. mudmiv ankerebs awyoben 50 wlian samsaxuris vadaze gaangariSebiT.

anker-mWimebs, rogorc wesi, iyeneben iseT konstruqciul gadawyvetebSi, rodesac saWiroa mewyersawinaaRmdego konstruqciebis mowyoba SezRudul pirobebSi. aseTi pirobebi SeiZleba dakavSirebuli iyos saerTo mewyerul garemoebasTan an gzis ganaSenianebasTan, roca gamoyofili miwebis farTobi SezRudulia. aseT SemTxvevaSi masiuri sayrdeni kedlebis gamoyeneba armoCndeba xolme SeuZlebeli. amasTan dakavSirebiT mizanSewonilia anker-mWimebiani drekadi rkinabetonis anakrebi an monoliTuri elementebis varianti. aseTi konstruqcia Rebulobs dawnevas mis ukan ganTavsebuli Camongrevis mTeli prizmidan da SesaZlebelia mowyobil iqnes erT an ramdenime iarusad, nagebobis an gzis dasacavi monakveTis muSa niSnulis mxedvelobaSi miRebiT.gruntuli ankerebis muSaobis principi dakavSirebulia maT gamoyenebasTan, rogorc wesi, damoukidebeli konstruqciebis saxiT, damatebiTi elementebis gareSe.

gruntuli saankero konstruqciis muSaoba, sxva tipebisagan gansxvavebiT (sayrdeni kedlebi, burRtenili ximinjebi da sxv.), damyarebulia mewyeruli an potenciurad mewyeruli gruntis masis miwolaze (mikumSvaze) mdgrad gruntebze da amiT sayrdeni Semkavebeli prizmis Seqmnaze, romelmac unda miiRos saangariSo mewyeruli dawneva. ankeruli konstruqciis elementebi anker-mWimebis gamoyenebiT SesaZlebelia gamoyenebul iqnen ukve eqspluataciaSi myofi aseTi konstruqciebis gasamagreblad.

mewyersawinaaRmdego sayrdeni kedlebi gamoiyeneba maT ukan arsebuli srialis da gamownexvis mcire mewyerebis stabilizaciisaTvis (roca mewyeruli dawneva mcired aRemateba aqtiur dawnevas Camongrevis prizmisagan).

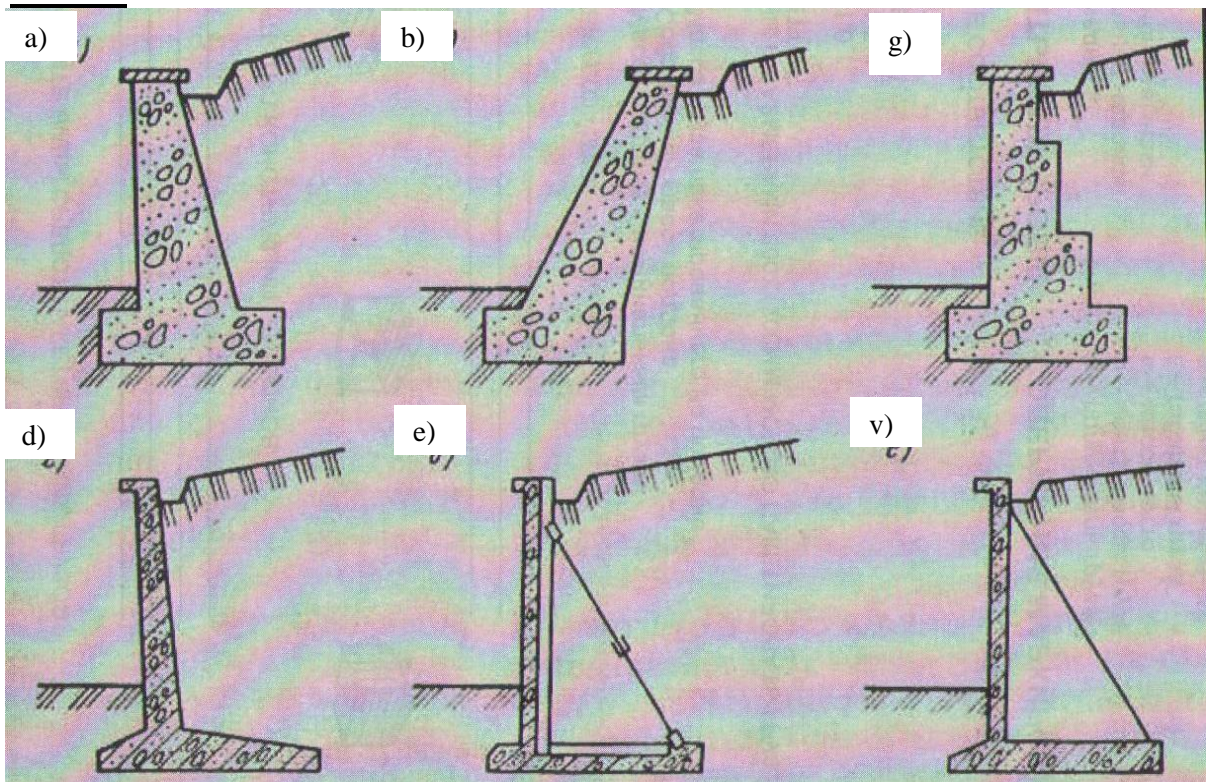
mewyeruli dawnevis didi mniSvnelobebis dros erTi mZime kedlis nacvlad ganaTavseben msubuqi mewyersawinaaRmdego kedlebis ramdenime iaruss, romlebic gaangariSebulia mewyeruli dawnevis Sesabamis nawilze, an sayrden kedlebs cvlian ximinjovani konstruqciebiT.

rogorc wesi, mewyeruli masebis Sesakaveblad, sayrdeni kedlebi ganTavsebuli unda iyvnen mtkice bunebrivi qanebis safuZvelze. kedlebis ganivkveTebma unda uzrunvelyon mewyeruli an aqtiuri dawnevis sakmarisi winaaRmdegoba, xolo maT ukan mowyobilma sadrenaJo konstruqciebma warmatebiT unda moaSoron kedlis ukana waxnagTan dagrovebuli wyali.

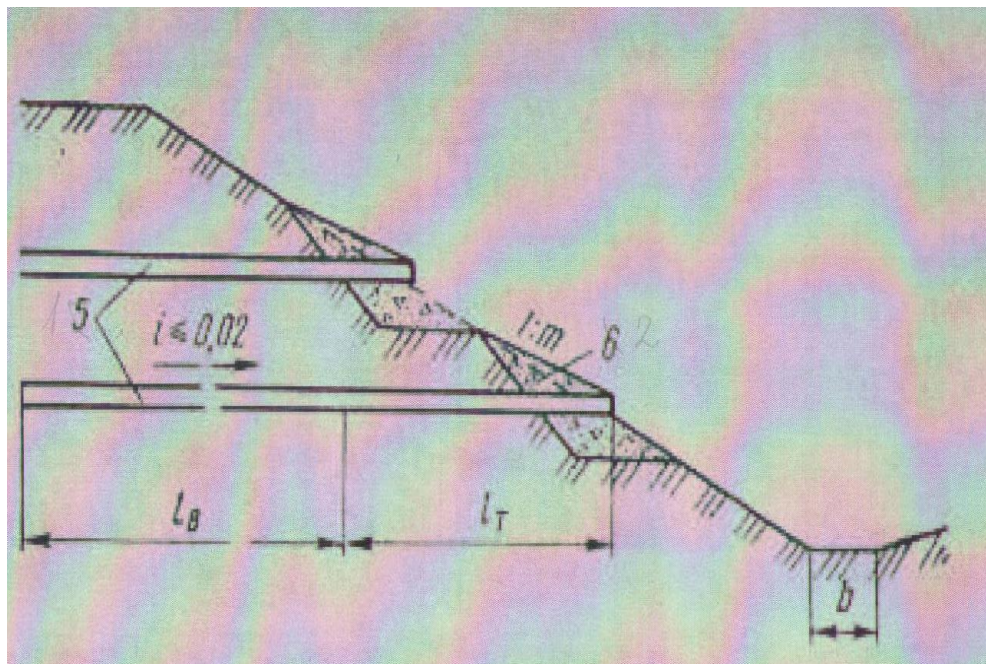
sayrdeni kedlebis ageba SesaZlebelia agreTve ximinjovan fuZeebze. mewyersawinaaRmdego brZolis mizniT Cveulebriv gamoiyeneba gravitaciuli da Spunturi sayrdeni kedlebi. umetesad farTo gamoyeneba hpova gravitaciulma sayrdenma kedlebma, romlebsac ganekuTvneba masiuri, kuTxovanisebri, kontrfarsebiani, ujedovani da sxv. konstruqciebi. sayrdeni kedlebis aRniSnuli konstruqciebi gansxvavdebian erTmaneTisgan mxolod muSaobis principiT mewyeruli an aqtiuri dawnevis zemoqmedebisas. rogorc wesi, iyeneben tipobrivi sayrden kedlebs monoliTuri an anakrebi rkinabetonisagan an betonis blokebisagan, romlebic iZlevian samSeneblo samuSaoebis industrializaciis da meqanizaciis saSualebas. gansazRvrul SemTxvevaSi iyeneben monoliTur rkinabetonis sayrden kerdlebs individualuri daproeqtebiT. masiuri mewyersawinaaRmdego sayrdeni kedlebis mdgradoba gruntis mewyeruli dawnevis zemoqmedebisas uzrunvelyofilia ZiriTadad kedlis sakuTari woniT. mizanSewonilia masiuri kedlebis daproeqteba Semcirebadi sisqiT. wylis miRebisa da mocilebisaTvis sayrden kedlebSi iTvaliswineben kedlis ukan ganTavsebul drenaJs da sadrenaJo sarkmelebs.

mSeneblobis praqtikaSi gamoiyeneba sayrdeni kedlebis sxva saxeobebic, romelTa ageba xdeba konkretuli adgilobrivi pirobebis da maT asagebad saWiro masalebis saxeobebis mxedvelobaSi miRebiT.

friad efeqturia kombinirebuli konstruqciebis gamoyeneba sayrdeni kedlebis saxiT ankeruli mWimebiT, romlebic uzrunvelyofen maT mdgradobas da racionalur ganivkveTebis.zemoaRniSnuli mewyersawinaaRmdego RonisZiebebis asaxva mocemulia naxazebe: $1.1 \div 1.6$

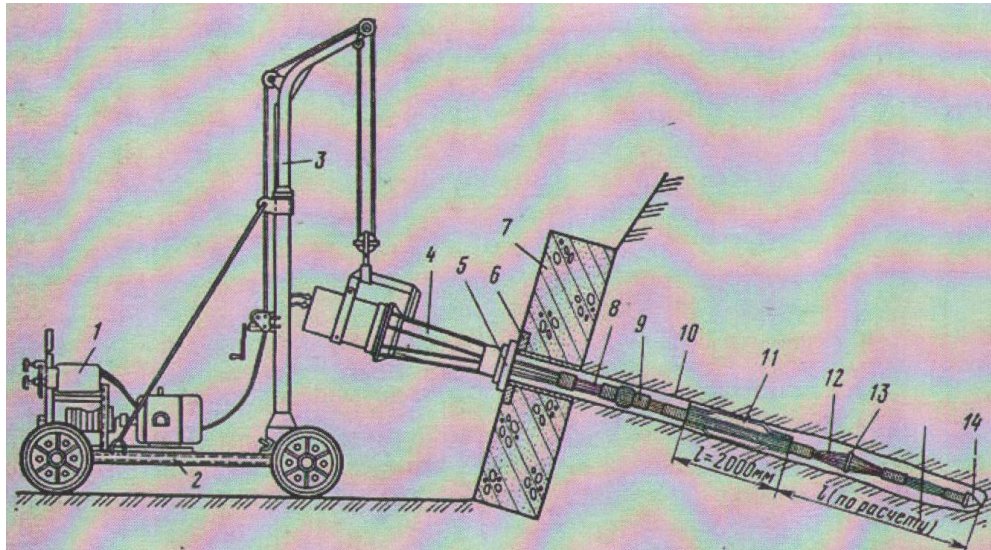


nax. 1.1. mewyersawinaaRmdego masiuri sayrdeni kedlebis konstruqciebis sqemebi
 a)-daxrili ukana waxnagi; b)-orive daxrili waxnagi; g)-safexurovani ukana waxnagi;d)-
 kuTxovaniseburi konsoluri sayrdeni kedeli; e)-kuTxovaniseburi sayrdeni kedeli ankeruli mWimebiT; v)-
 kuTxovaniseburi sayrdeni kedeli kontrfursebiT.



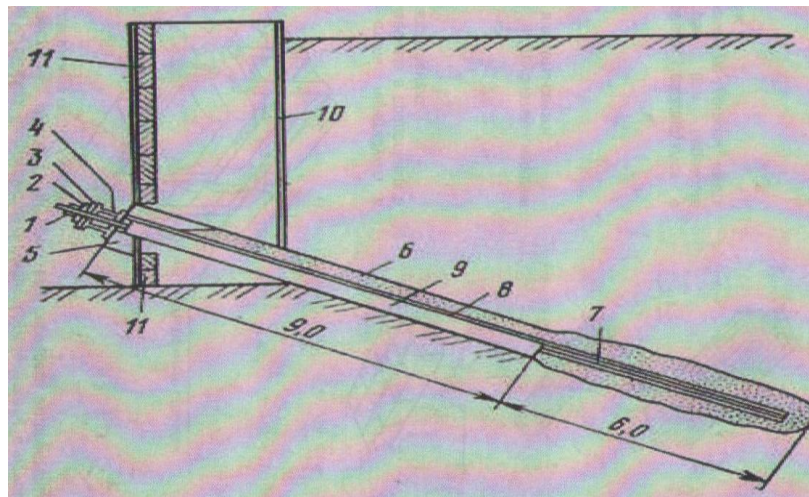
nax. 1.2. horizontaluri sadrenaJe WaburRilebi.

1-mili-filtrebi; 2-RorRi



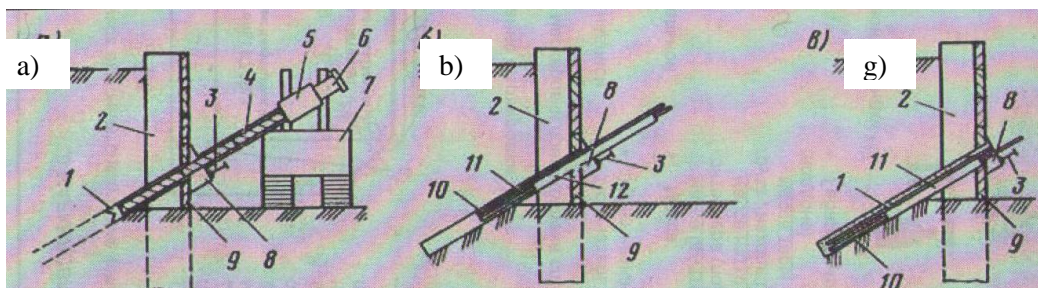
nax. 1.3. saankero mWimis daWimva

1-satumbi sadguri; 2-urika; 3-isari; 4-hidrodomkrati; 5-zeda ankeri; 6-liTonis gamanawilebeli fila; 7-rkinabetonis saankero fila; 8-rezinis an poliqlorviniluri garsi; 9-mavTulovani wnuli; 10-mimmarTveli; 11-pakeri; 12-maRali simtkicis armatura; 13-qveda ankeris diafragma; 14-mimmarTveli konusi.



nax. 1.4. WaburRili saankero kompleqti

1-ankeris saTavisis damafiqsirebeli qanCi; 2-ankeris saTavisis sferuli Canadebi; 3-ankeris saTavisis sferuli sayelo; 4-grZivi sartylis ortesebri koWi; 5-kronSteini furclovani rkinisagan; 6-ankeris tani (ankeris fesvi); 7-saankero Rero perioduli foladisagan; 8-liTonis sainieqcio mili; 9-polieTilenis mili; 10-liTonis ximinji; 11-xe-masalis Semofargvla.



d)

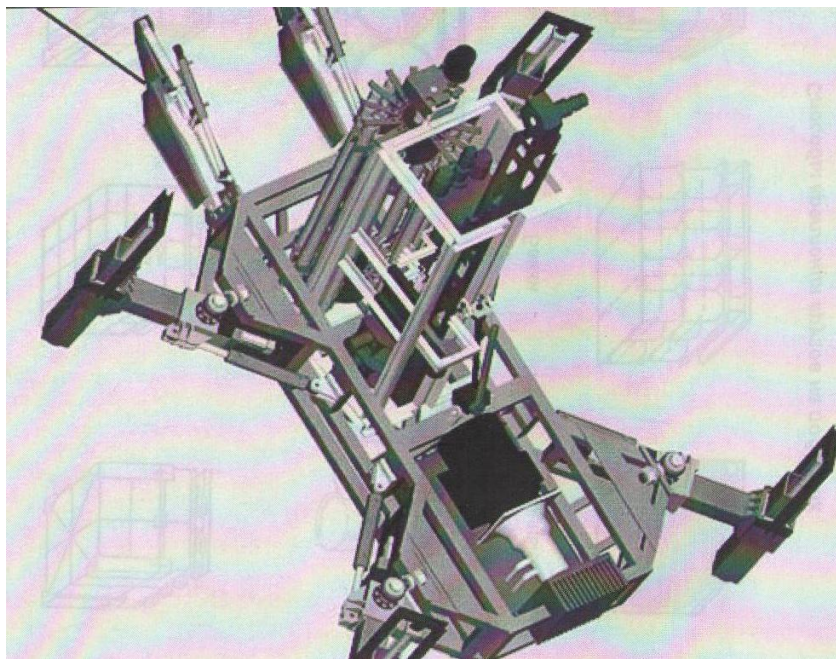
e)

nax. 1.5. qvabulis vertikaluri ferdoebis droebiTi damagrebis mowyobis teqnologiuri operaciebis sqema

a)-WaburRilis gaburRva; b)-ankeris kompleqtis dayeneba; g)-cementis duRabis pirveladi CaWirxvna; d)-cementis duRabis meoradi CaWirxvna; e)-ankerebis daWimva.

1-saburRi wveri; 2-liTonis ximinji; 3-grZivi sartylis ortisebri koWi; 4-saSneko rgolebi; 5-urika; 6-mimmarTveli CarCo; 7-saburRi manqana; 8-kronSteini; 9-xis Semofargvla; 10-sainieqcio mili; 11-saankero Rero; 12-polieTilenis mili; 13-ankeris tani; 14-ankeris saTavisis sferuli sayelo.; 15-ankeris saTavisis sferuli Canadebi; 16-damafiqsirebeli qanCi; 17-hidrodomkrati; 18-saaTis tipis indikatori; 19-Wiqa ankeris gamocdisaTvis.

a)



b)

aRniSnuli saSualebebi SeiZleba gamoyenebul iqnes, pirobebisa da situaciebis mixedviT, erTdroulad, kompleqsurad, an damoukideblad, calkcalke. amasTan, Sesabamisi gaangariSebiT da naturuli azomvebiT SesaZlebelia maTi saimedoo bis xarixis gansazRvra.

saWiroa aRiniSnos, rom CamoTvllili teqniki saSualebebis gaangariSeba, damuSaveba da teqnologiurad ageba an dayeneba xdeba erTmaneTisgan damoukideblad, rogorc calkeuli konstruqciuli erTeulebisa.aucileblobis SemTxvevaSi mxedvelobaSi miiReba maTi kompleqsurad gamoyenebis SesaZleblobac, Tumca maTi gaangariSeba, ageba da mowyoba warmoebs individualurad, ZiriTadad _ mimdevrobiT.es garkveulwilad aZvirebs mSeneblobas da adidebs kompleqsuri sistemebis mSeneblobis vadebs.

amave dros eqstremalur situaciebSi, mewyeruli procesebis moulodnelad warmoqmnis potenciuri saSiSroebisas, mkveTri klimaturi cvalebado bebis pirobebSi, mewyersawinaaRmdego konstruqciebis agebis miRebuli teqnologiuri vadebi SeiZleba aRmoCndes arasakmarisi mewyeris Tavidan acilebisaTvis.aqedan cxadia, rom saWiroa ufro moqnili, teqnikiurad da teqnologiurad ufro Tanamedrove damcavi gadawyvetilebebis miReba.

1.3. gamokvlevis miznebi da problemis SemoTavazebuli gadawyveta

damcavi da mewyersawinaaRmdego RonisZiebebis arsebuli teqniki da teqnologiuri gadawyvetebis zemoT motanili mimoxilvidan Cans, rom yvelaze ufro efeqturia mewyersawinaaRmdego konstruqciebis kompleqsuri gamoyeneba, Tumca maTi mimdevrobiTi ganxorcieleba dakavSirebulia ekonomikuri danaxarjebis gazrdasTan da mSeneblobis ufro did vadebTan.miwis nagebobebis ferdoebis mewyersawinaaRmdego stabilizaciis vadebis daCqarebis problemis gadasawyvetad Cvens mier SemoTavazebulia erTiani konstruqciuli sistemis Sesaqmnelad teqniki da teqnologiuri gadawyvetebis damuSaveba, romelic erTdroulad Seasrulebs Camongrevisagan (CamoSlisagan) gruntis masebis Sekavebis da wylis daCqarebulad moSorebis, gruntis gaSroebis (gauwyloebis) funqciebs. aRniSnuli agvacilebs mewyeris warmoqmnasa da ganviTarebas, daastabilizirebs miwis nagebobebis ferdoebis gruntul masebs, aamaRlebs maT saimedoo bas, agreTve moiTxovs samSeneblo ciklis nakleb vadebs da nakleb finansur danaxarjebis.konkretuli adgilobrivi pirobebis mixedviT Cvens mier SemoTavazebulia konstruqciuli sistemebi Semdegi kombinaciebiT:

1. gruntuli ankeri _ sadrenaJo sistema;

2. gruntuli ankeri _ sadrenaJo sistema _ masivis damangrebeli torkret-garsi (membrana);
3. gruntuli ankeri _ sadrenaJo sistema _ msubuqo sayrdeni kedeli;
4. gruntuli ankeri _ amosaRebi gruntuli ankeris sistema.

gruntis wyalgacemis daCqarebis mizniT SemoTavazebulia sadrenaJo sistemaSi eleqtroosmosis gamoyeneba, eleqtrodebis saxiT foladis saankero mWimebis da gruntSi Casobili foladis Reros gamoyenebiT, romlis amoReba gruntidan moxdeba gamoSrobis procesis damTavrebis Semdeg.kombinirebuli sistemebis mowyobis samuSaoTa kompleqsis warmoebis teqnologia iTvaliswinebs sistemaSi Semavali yvela calkeuli konstruqciuli elementebisaTvis erTdroulad Sesasrulkebel teqnologiur procesebs.

am mizniT kombinirebuli sistemis TiToeuli konstruqciuli elementi SeiZleba daproeqtebuli iyos ori da meti SeTavsebuli, paraleluri funqciebis Sesasruleblad, romlebic uzrunvelyofen miwis nagebobebis ferdoebis stabilizacias.

magaliTad, ZiriTadi funqciis garda kompleqsi „gruntuli ankeri _ sadrenaJo sistema“: gruntuli ankerisaTvis gaburRuli WaburRili daproeqtebuli iqneba rogorc elementi, milovani drenejis tani;

kompleqsi „gruntuli ankeri _ sadrenaJo sistema _ sayrdeni kedeli“: zemoaRweril pirvel SemTxvevaze damatebiTi _ sayrdeni kedeli Seasrulebs gruntuli ankeris sayrdeni filis funqciasac, xolo sadrenJo sistema Seasrulebs agreTve kedlis ukana drenejis funqcias.

arsebuli problemis _ ferdoebis mewyersawinaaRmdego stabilizaciis vadebis Semicireba _ dagegmilia Semdegi amocanebis gadawyvetiT:

_ mewyersawinaaRmdego sistemebis kompleqsis variantebis konstruqciuli damuSaveba saqarTvelos pirobebSi yvelaze ufro damaxasiaTebeli mewyeruli procesebis gamovlenisas;

_ kompleqsis konstruqciuli elementebis teqnikuri gaangariSeba saqarTveloSi mewyerebis gamovlenis yvelaze ufro damaxasiaTebeli situaciuri Sexamebis dros gamosayeneblad;

_ mewyersawinaaRmdego kompleqsebis dasamzadeblad da asagebad samuSaoTa warmoebis teqnologiuri sqemebis damuSaveba da teqnologiuri gaangariSeba;

_ gruntis masisagan wylis gamoyofis dasaCqareblad eleqtroosmosis sistemis gamoyenebis teqnikuri da teqnologiuri gangariSebebi;

_ asagebi mewyersawinaaRmdego kompleqsebis teqnukur-ekonomikuri Sefaseba variantuli daproeqtebis, saimedobis da ekonomiuobis safuZvelze.

SemoTavazebuli sistemebi mocemulia naxazebze 1.7÷1.10.

mocemuli elementebis ganmartebibi:

1-saankero WaburRilis kedeli.

2-ankeris fesvi CakeTebuli saankero mWimiT.

3-saankero mWimi.

4-sadrenaJe masala.

5-ankeris ZiriTadi fila.

6-saankero mWimis damafiqsirebeli mowyobiloba.

7-gruntis Camongrevis sibrtye.

8-gruntidan filtrirebuli wyali.

9-wylis gamosadeni wyali.

10-wyalamcilebeli Strabi.

11-seqciebisagan Sedgenili sadrenaJe mili.

12-milaki (Slangi) gruntis wylebis mosaSoreblad an gamosaqaCad (magaliTad, eleqtroosmosis dros).

13-perforirebuli sadrenaJe mili.

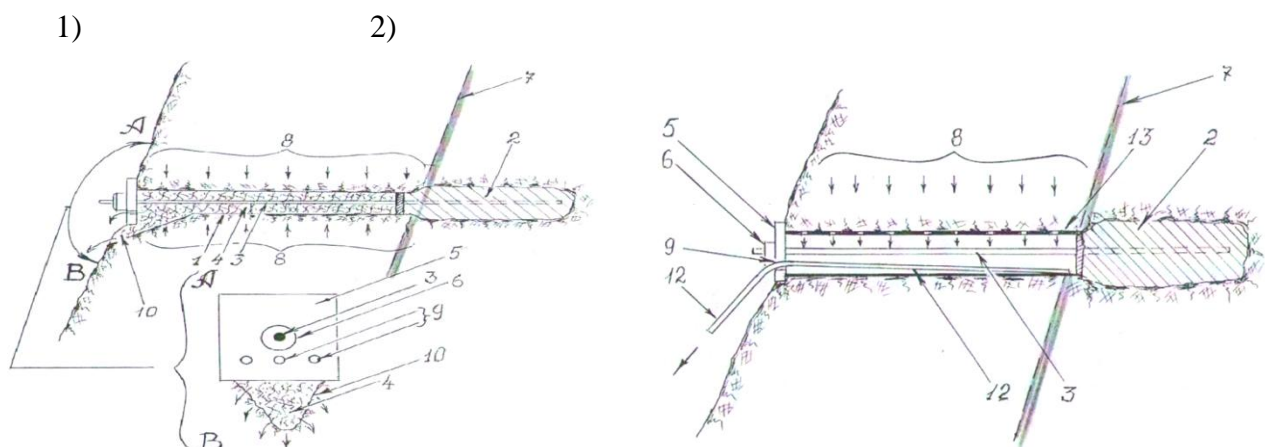
14-Sedgenili sadrenaJe mili.

15-sayrdeni kedeli.

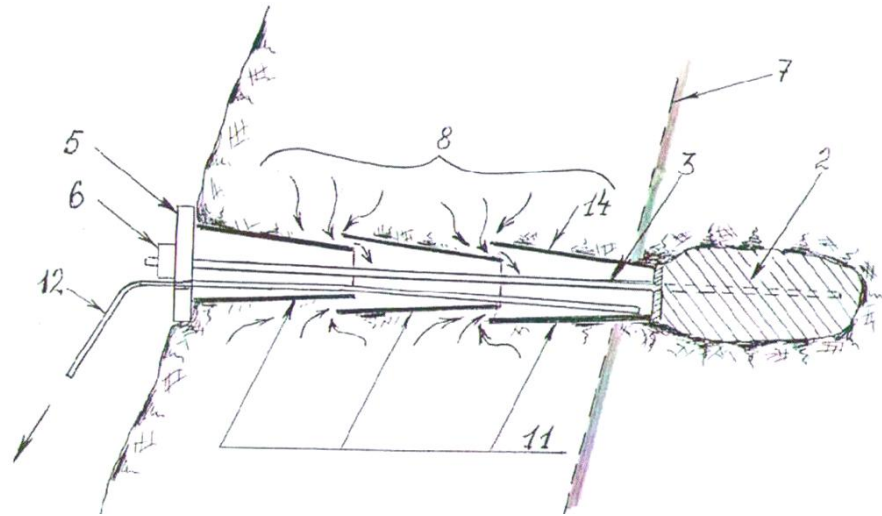
16-liTonis Rero _ mierTebuli mudmivi denis mimwodebeli sistemis dadebiT polusTan.

17-saankero mWimi _ mierTebuli mudmivi denis mimwodebeli sistemis uaryofiT polusTan.

18-ferdos membranuli damagreba, Sesrulebuli torkretirebiT, foladis badeze.

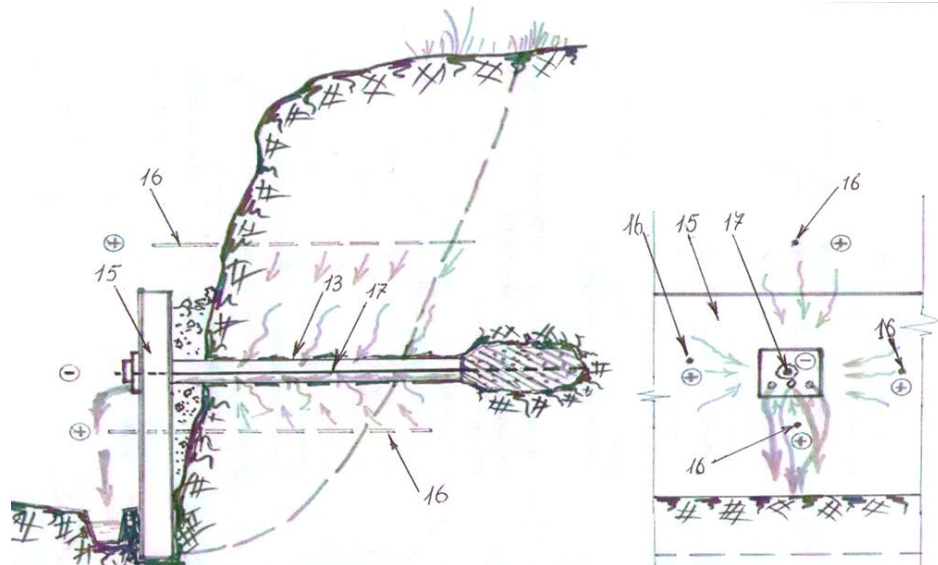


3)

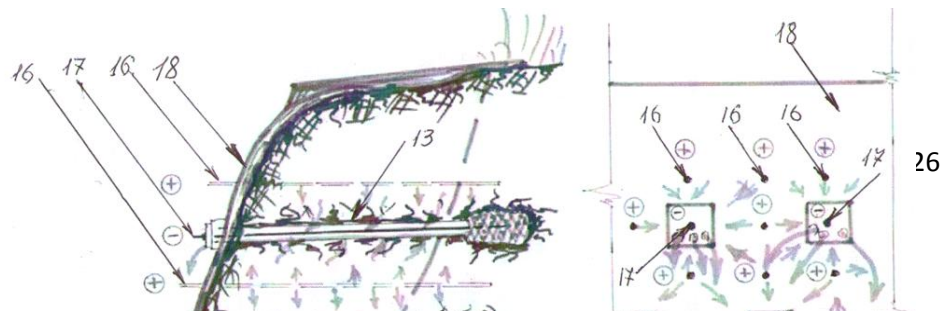


ნაქ. 1.7. კომპლესური სადრენაჟე ანკერების ვარიანტები
1-სადრენაჟე მასალი; 2-სადრენაჟე მილი; 3-ანკერი, რეკოეზისნი პირაპირები.

1)

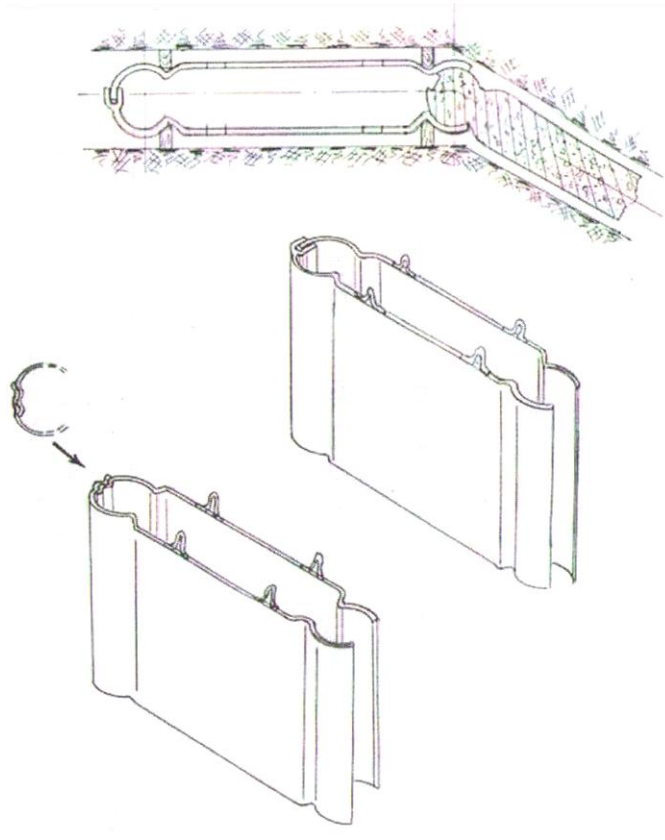


2)

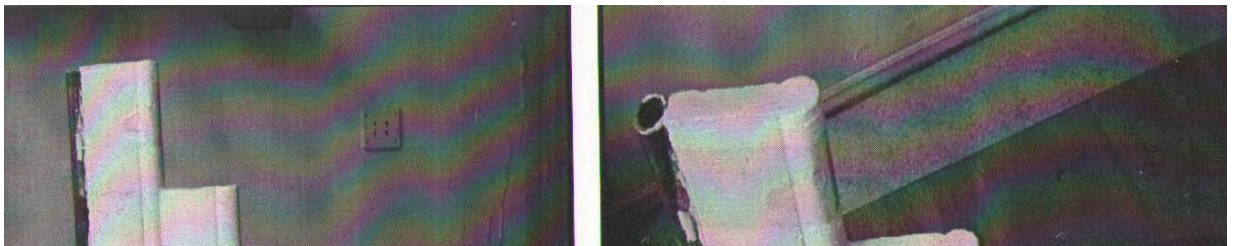


max. 1.8. kompleksuri sistemebis muSaobis principis variantebi
1-sistema sayrdeni kedliT; 2-sistema zedapiris membranuli gamagrebiT.

a)

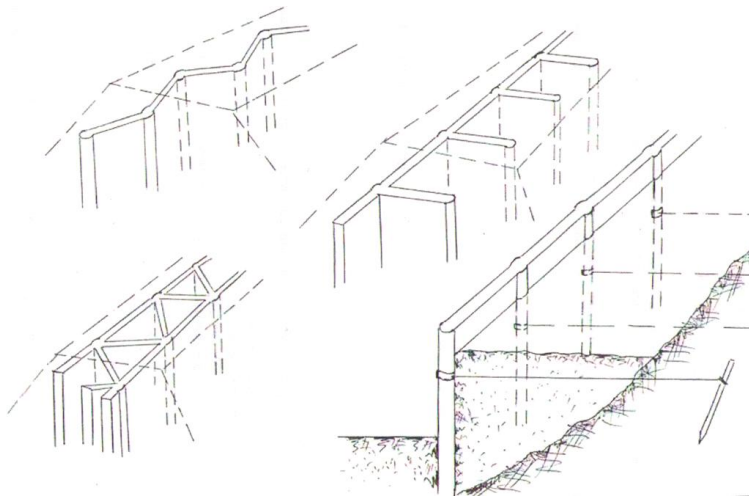


b)

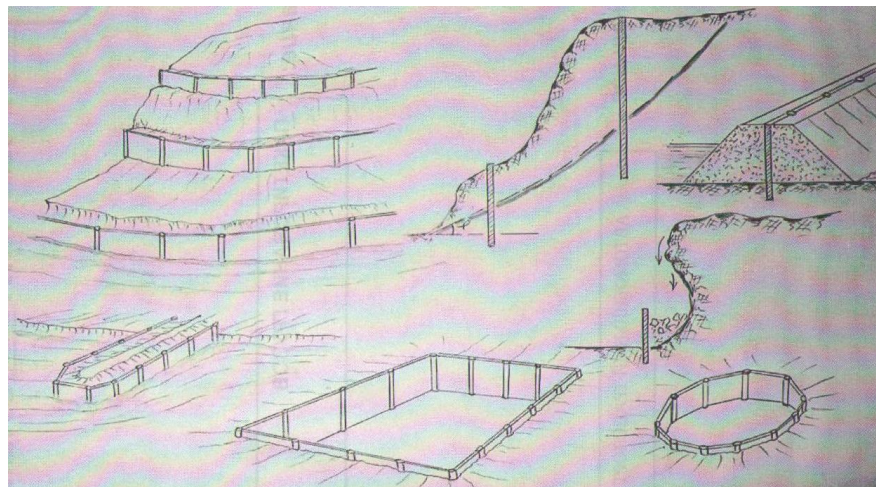


nax. 1.9. yalibi saydeni kedlis dabetonebisaTvis
a-sayrdeni kedlis saerTo xedi; b-sayrdeni kedlis modeli.

a)



b)



nax. 1.10. sayrdeni kedlis gamoyenebis variantebi da magaliTebi
a-sayrdeni kedlis gamoyenebis variantebi; b-sayrdeni kedlis magaliTebi.

1.4. problemis gadawyvetis Sedegad miRebuli rezultatebis winaswari analizi

winaswari gaangariSebebis Sedegad SeiZleba aRiniSnosSemdegi:

1. Seiqmneba ufro saimedo mewyersawinaaRmdego sistemebi;
2. SemoTavazebuli mewyersawinaaRmdego sistemis mSenebloba ganxorcieldeba SedarebiT mokle vadebSi;
3. ueWvelia ekonomikuri efeqtis miReba _ mewyersawinaaRmdego mravalfunqciuri konstruqciuli sistemis Seqmnis gziT. saerTo ekonomia miiRweva materialuri resursebis ekonomiiis, nagebobebis agebis Sromatevadobisa da teqnologiuri vadebis Semcirebis gziT;
4. saimedo mewyersawinaaRmdego sistemis mowyoba uzrunvelyofs ekologiur stabilurobas rogorc arsebul, aTvisebul, aseve asaTvisebel teritoriebze. uzrunvelyofs rogorc arsebuli, aseve perspeqtuili, turizmisaTvis asaTvisebeli da sakurorto zonebis stabilurobas;
5. uzrunvelyofili iqneba usafrTxoeba mewyeruli procesebisgan rogorc arsebul satransporto magistralebze, aseve axlad Sesaqmneli infrastruqturisaTvis;
6. amosaRebi droebiTi gruntuli ankerebis gamoyenebiT saWiro aRar iqneba qvabulis kedlebis gamagrebis mizniT sxvadasxva tipis konstruqciuli sistemebis gamoyeneba, romelebic rogorc wesi xels uSlian samSeneblo procesebis warmoebas. amiT SesaZlebeli gaxdeba SemoTavazebuli ankerebis mravljeradi gamoyeneba, rac saerTo jamSi mniSvnelovan ekonomikur efeqts iZleva;
7. aranaklebia socialuri efeqtic _ mewyersaSiSi zonebis sacxovrebeli fondis da sameurneo savargulebisSenarCuneba;
8. gansakuTrebulad mniSvnelovania saqarTvelos istoriuli

Zeglebis SenarCuneba, radganac Zveli Tbilisis da sxva qalaqebis Senobebi da nagebobebi da saqarTvelos teritoriebi xSirad ganTavsebuli arian mewyerul zonebSi da im adgilebze, romlebzec mosalodnelia gruntis jdena,gruntis wylis Cadinebis gamo.

SemoTavazebuli gaangariSebebis Sedegebis gamoyeneba SesaZlebelia: mSeneblobis sferoSi; satransporto sferoSi; regionaluri ganviTarebis da infrastruqturis saministros daqvemdebarebaSi myof obieqtebze; garemos dacvis da bunebrivi resursebis saministros ekologiisa da bunebadamcav obieqtebze; ekonomikis mdgradi ganviTarebis saministros obieqtebze.

Tavi 2

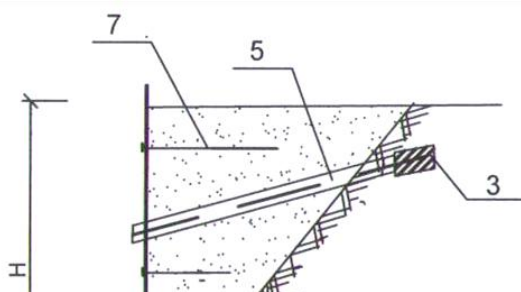
mewyersawinaaRmdago RonisZiebebis SemoTavazebuli kompleqsuri sistemebi da gruntis dawenvis gaangariSeba sxvadasxva gruntuli pirobebisaTvis

2.1. SemoTavazebuli kompleqsuri sistemebi

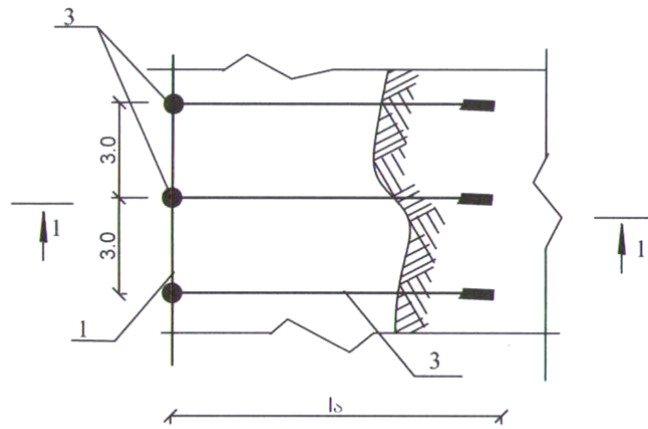
SemoTavazebul kompleqsur mewyersawinaaRmdago sistemebis ZiriTad konstruqciul elements warmoadgens sayrdeni kedeli.ganxilulia monoliTuri rkinabetonis sayrdeni kedlis ori varianti: lenturi (svetebis gareSe) da svetebiani (svetebi bijiT 3m). orive SemTxvevaSi gaTvaliswinebulia saZirkvelSi maTi saxsrovani Camagreba. saZirkvlebi daproeqtebulia mxolod sayrdeni kedlis masaze. kedlis mdgradobas gadabrunebaze da Zvraze (mocurebaze) uzrunvelyofen gruntuli ankerebi, romlebic Camagrebulia (CakeTebulia) gruntSi Siga xaxunis kuTxis gare sivrceSi.sayrdeni kedlis wonasworobaSi yofna (mdgradoba) uzrunvelyofilia 2 iarusad ganTavsebuli gruntuli ankerebiT, romlebic erTnairi manZiliT arian daSorebuli gruntis dawnevis tolqmedis (E) modebis wertilidan.

ankerebis aseTnairi ganlageba uzrunvelyofs maTSi erTnairi gamWimavi Zalvebis aRZvras ($N = \frac{E}{2}$) da, aqedan gamomdinare, sayrdeni kedlis wonaswarobaSi yofnas (nax. 2.1.)

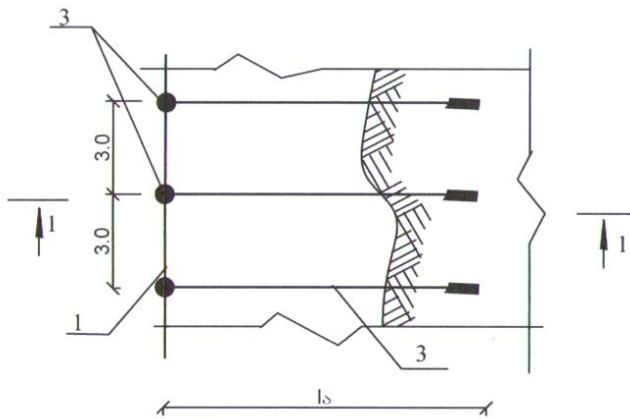
a)



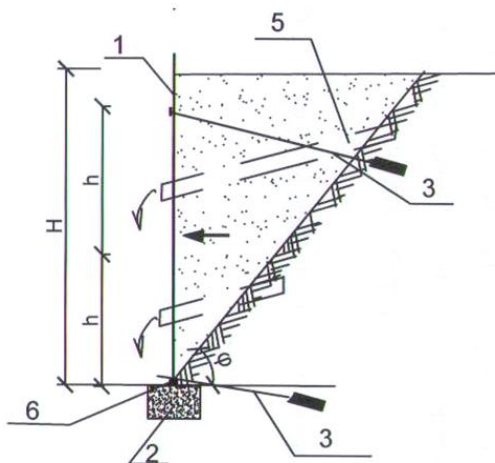
b)



g)



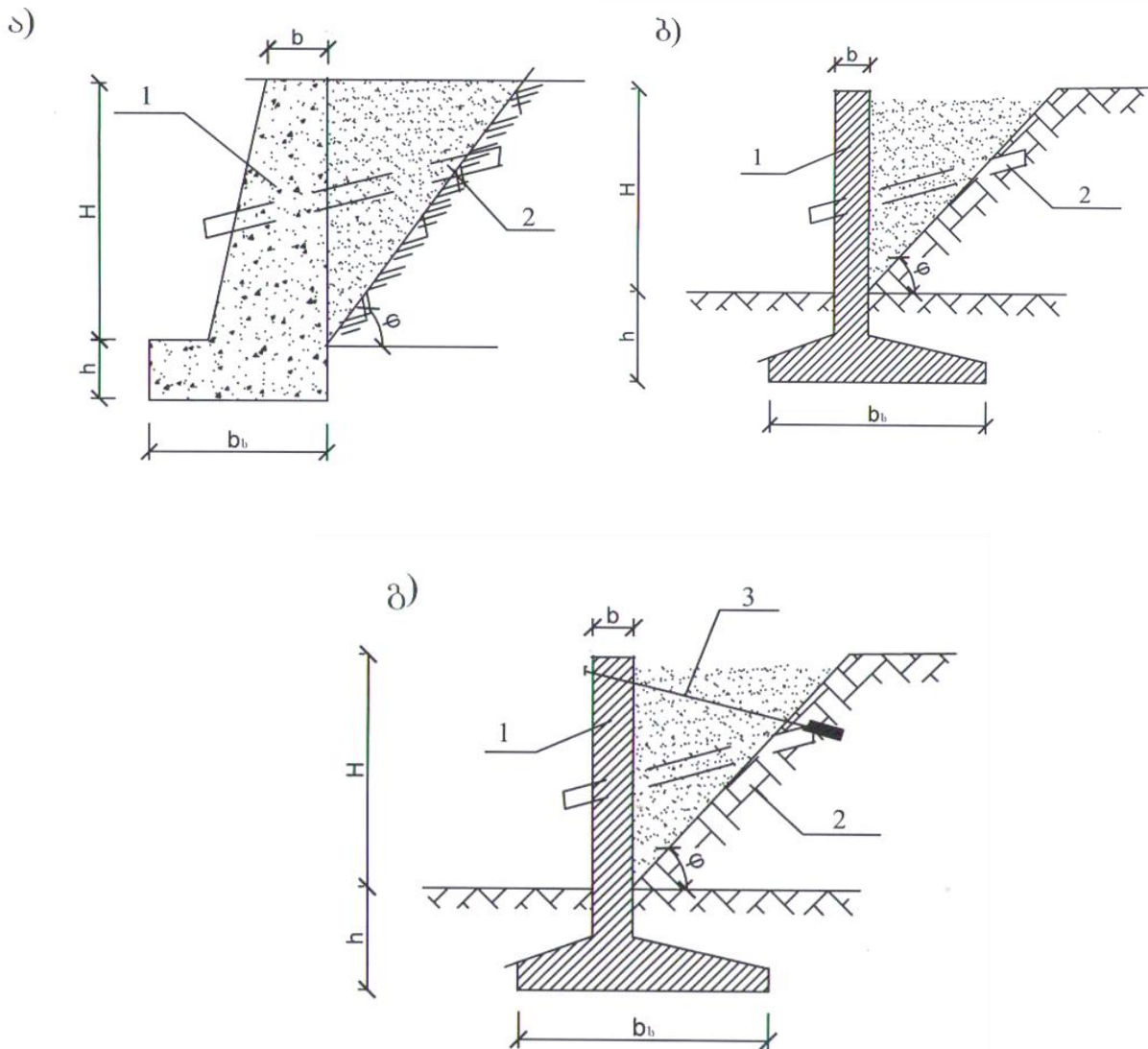
d)



nax. 2.1. SemoTavazebuli kompleksuri mewyersawinaaRmdego sistema sayrdeni kedliT

a-sistemis konstruqciuli sqema; b,g,d- SemoTavazebuli sayrdeni kedlis konstruqciuli sqemebi.
 1-lenturi sayrdeni kedeli; 2-saZirkveli; 3-gruntuli ankeri; 4-sayrdeni kedlis svetebi; 5-sayrdeni mili;
 6-idealuzirebuli saxsari; 7-foladis Reroebi (anodi)

teqnikur-ekonomikuri Sedarebis mizniT, ganxiluli gvaqvs arsebuli (tradiciuli) sayrdeni kedlebi: masiuri, monoliTuri rkinabetonis (uankero) da monoliTuri rkinabetonis (erT iarusze ganTavsebuli ankerebiT kedlis zemo nawilSi) _ nax. 2.2.



nax. 2.2 arsebuli (tradiciuli) sayrdeni kedlebi:

a) masiuri; b) monoliTuri rkinabetonis, uankero; g) monoliTuri rkinabetonis, ankeriT; 1-sayrdeni kedeli; 2-sadrenaJe mili; 3-ankeri.

Cvens mier SemoTavazebulia gruntis drenirebis daCqarebis teqnologia eleqtroosmosis movlenis gamoyenebiT, romlis arsi, rogorc cnobilia, mdgomareobs mudmivi denis wyaroze anodisa da kaTodis mierTebiT, ris Sedegadac SesaZlebeli gaxdeba anodis zonidan kaTodis zonisaken wylis gadaadgileba.

kaTodis rols Seasruleben foladis sadrenaJe perforirebuli milebi, xolo anodis rols _ aseve foladis (armaturis an bagirovani) gruntuli ankerebi, rac saSualebas iZleva anodis funqciis Sesaruleblad sistemaSi ar SeviyvanoT damatebiT foladis Reroebi.

radganac sayrden kedelze gruntis dawnevis sidide damokidebulia gruntis saxeobaze, Cvens mier ganxilulia misi yvelaze ufro gavrclebuli oTxi tipi: mSrali qviSa (qviSnari), wyalnajeri qviSa (qviSnari); mSrali Tixnari (Tixa) da wyalnajeri Tixnari (Tixa).

rogorc tradiciuli, aseve SemoTavazebuli sayrdeni kedlebis gaangariSebisas misi simaRle miRebulia $H=6m$. gaangariSebebi Sesrulebulia zemoaRniSnuli oTxive saxis gruntuli pirobebisaTvis.

radganac gruntis drenirebis milebiT aRWurvilia rogorc tradiciuli, aseve SemoTavazebuli sayrdeni kedlebi, amitom, kedlebis teqnur-ekonomikuri Sedarebisas, isini gaTvaliswinebuli ar aris.

gaangariSebebSi miRebulia:

_ sayrdeni kedlis ukan Canayari gruntis zedapiris daxris kuTxe horizontaluri sibrtyis mimarT - $\alpha = 15^0$;

- sasargeblo (droebiTi) datvirTva masze – 500 kg/m^2 ;

2.2. gruntis dawnevis gaangariSeba sxvadasxva gruntuli pirobebisaTvis.

2.2.1. winaswari monacemebi:

cnobilia, rom vertikalur an gruntisaken daxril sibrtyiani, agreTve Canayari gruntis horizontaluri an daxril sibrtyian sayrdeni kedlis 1 grZiv metrze gruntis aqtiuri dawneva, zogad SemTxvevaSi, ganisazRvrebba formuliT

$$EE=0,5 \cdot \gamma \cdot H^2 \mu \quad (1)$$

sadac:

γ – gruntis normatiuli moculobiT masaa kg/m^3 ;

H – sayrdeni kedlis simaRle, m;

μ – koeficienti, romelic damokidebulia gansaxilveli gruntis Siga xaxunis kuTxeze (φ),

Canayari gruntis zedapiris daxris kuTxeze $-\alpha$ da vertikalidan sayrdeni kedlis ukana sibrtyisgadaxris kuTxeze- β .

kedelze gruntis dawnevis epiuras aqvs samkuTxedis forma.

gruntis Camongrevis prizmaze Tanabarganawilebuli datvirTvis arsebobisas, intensivobiT q, gruntis dawneva kedelze, misi ukana sibrtyis vertikalidan mciredi gadaxrisas ($\beta \leq 10^\circ$), ganisazRvreba formuliT

$$E = 0,5 \cdot \gamma \cdot H (H + 2h_0) \mu \quad (2)$$

sadac: $h_0 = \frac{q}{\gamma}$ – gruntis fenis dayvanili simaRlea.

aseT SemTxvevaSi kedlis simaRleze gruntis dawnevis epiuras aqvs trapeciis forma, ordinatebiT, romlebic ganisazRvreba formulebiT:

trapeciis qveda doneze $q_1 = \frac{2E}{H + h_0}$ da zeda doneze $q_2 = q_1 \frac{h_0}{H + h_0}$.

trapeciis simZimis centri mdebareobs e manZilze kedlis Ziridan:

$$e = \frac{H}{3} \cdot \frac{q_1 + 2q_2}{q_1 + q_2} \quad (3)$$

wyalnajeri gruntebis SemTxvevaSi, kedelze gruntis dawnevis sidide mcirdeba, wyalSi gruntis ConCxis wonis Semcirebis gamo. magram aseT SemTxvevaSi kedeli ganicdis agreTve wylis hidrostatur dawnevasac. gruntis da wylis jamuri dawneva ganisazRvreba gruntis donis mimarT wylis donis mdgomareobiT. Tu wylis done emTxveva gruntis dones an masze maRalia, grunti mTel simaRleze imyofeba Setivtivebul mdgomareobaSi da gruntis da wylis jamuri dawneva kedelze ganisazRvreba formuliT

$$E = E_g + E_w = 0,5(\gamma - a\gamma_0) \cdot h_2^2 \mu + 0,5\gamma_0 H^2 \quad (4)$$

gruntis dawnevis epiuras aqvs ori samkuTxedis saxe.

Tu wylis done gruntis doneze dabaliala, jamuri dawneva tolia

$$E = E_g + E_w = 0,5 \cdot \gamma \cdot H^2 \cdot \mu + 0,5\gamma_0(1 - a\mu)h_2^2 \quad (5)$$

sadac:

γ – mSrali gruntis moculobiTi masaa

γ_0 – wylis moculobiTi masa;

α – nawilakebi s moculobiTi nawili gruntis moculobis

erTeulSi ($\alpha = 0,55 \div 0,7$)

2.2.2. gruntis dawnevis gaangariSeba mSrali qviSisaTvis (qviSnarisaTvis) nax. 2.3

$$H=6\text{m}; \quad \varphi = 32^\circ; \quad \gamma = 1,62 \text{ t/m}^3$$

$$\alpha = 15^\circ;$$

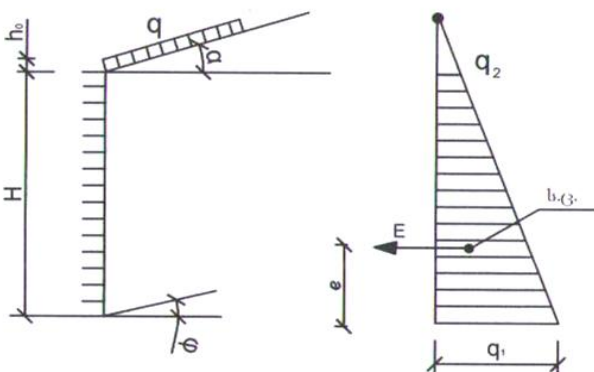
gruntis dawneva:

$$E = 0,5\gamma H(H + 2h_0)\mu_a;$$

$$h_0 = \frac{g}{\gamma} = \frac{0,5}{1,62} = 0,3 \text{ m}$$

nax. 2.3.

$$E = 0,5 \cdot 1,62 \cdot 6(6 + 2 \cdot 0,3) \cdot 0,369 = 11,839$$



$$\mu_a = 0,369$$

$$E = 11,84 \text{ t}$$

$$q_1 = \frac{2E}{H + h_0} = \frac{2 \cdot 11,84}{6 + 0,3} = 3,76 \text{ t/m}; \quad q_2 = q_1 \frac{h_0}{H + h_0} = 3,76 \cdot \frac{0,3}{6 + 0,3} = 0,18 \text{ t/m};$$

$$e = \frac{H}{3} \cdot \frac{q_1 + 2q_2}{q_1 + q_2} = \frac{6}{3} \cdot \frac{3,76 + 2 \cdot 0,18}{3,76 + 0,18} = 2 \cdot 1,051 = 2,1 \text{ m} \quad e = 2,1 \text{ m}$$

2.2.3. gruntis dawnevis gaangariSeba mSrali TixnarisaTvis (TixisaTvis):

$$H=6 \text{ m}; \quad \varphi=43^\circ; \quad \gamma=1,55 \text{ t/m}^3; \quad \alpha=15^\circ; \quad g=0,5 \text{ t/m}^2 \quad h_0 = \frac{0,5}{1,55} = 0,32 \text{ m}; \quad \mu_a = 0,22;$$

$$EE=0.5 \cdot 1.55 \cdot 6(6+2 \cdot 0.32) \cdot 0.22=6.79 \approx 6.86 \text{ t}$$

$$q_1 = \frac{2 \cdot 6,8}{6 + 0,32} = 2,15 \text{ t/m}; \quad q_2 = 2,15 \cdot \frac{0,32}{6 + 0,32} = 0,11 \text{ t/m};$$

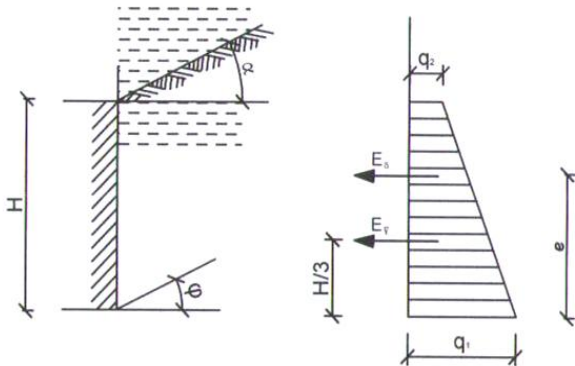
$$e = \frac{6}{3} \cdot \frac{2,15 + 2 \cdot 0,11}{2,15 + 0,11} = 2,29 \text{ m}$$

2.2.4. gruntis dawnevis gaangariSeba wyalnajeri qviSisaTvis:

$$\gamma = 2,0 \text{ t/m}^3 \quad \varphi = 25^0; \quad \alpha = 15^0;$$

$$g = 0,5 \text{ t/m}^2; \quad h_o = \frac{0,5}{2} = 0,25 \text{ m};$$

gaangariSebisaTvis miviRoT SemTxveva, roca grunti mTel simaRleze imyofeba Setivtivebul mdgomareobaSi (nax. 2.4).



kedelzeE wylis dawnevis sidide toli iqneba:

$$E_w = 0,5 \cdot \gamma_0 H^2 = 0,5 \cdot 1 \cdot 6^2 = 18 \text{ t.}$$

misi epiura warmoadgens samkuTxeds xolo gruntis sawnevis sidide:

$$E_g = 0,5(\gamma - a\gamma_0) \cdot H(H + 2h_0) \cdot \mu_a;$$

nax. 2.4.

$$h_o = \frac{g}{\gamma} = \frac{0,5}{2} = 0,25 \text{ m}$$

$$\mu_a = 0,51$$

$$E_g = 0,5(1,62 - 0,62 \cdot 1) \cdot 6(6 + 2 \cdot 0,25) \cdot 0,51 = 9,945 \approx 9,94 \text{ t};$$

misi epiura warmoadgens trapecias, romlisTvisac:

$$q_1 = \frac{2E}{H + h_0} = \frac{2 \cdot 9,94}{6 + 0,25} = 3,18 \text{ t/m};$$

$$q_2 = q_1 \frac{h_0}{H + h_0} = 3,18 \cdot \frac{0,25}{6 + 0,25} = 0,127 \approx 0,13 \text{ t/m};$$

$$e = \frac{6}{3} \cdot \frac{3,18 + 2 \cdot 0,13}{3,18 + 0,13} = 2,078 \approx 2,1 \text{ m}$$

kedelze gruntis da wylis jamuri dawneva toli iqneba:

$$E = E_g + E_w = 9,94 + 18,0 = 27,94 \approx 27,9 \text{ t}$$

$$E = 27,9 \text{ t}$$

$$\text{radgan } e_w = \frac{H}{3} = \frac{6}{3} = 2 \text{ m da } e_{gr} = 2,1 \text{ m}$$

$$\text{pirobiTad SeiZleba miviRoT: } e = 2,05 \text{ m}$$

2.2.5. gruntis dawnevis gaangariSeba wyalnajeri TixnarisaTvis:

$$\gamma = 1,9 \text{ t/m}^3 \quad \varphi = 23^0; \quad \alpha = 15^0;$$

$$g = 0,5 \text{ t/m}^2; \quad h_o = \frac{0,5}{1,9} = 0,26 \text{ m};$$

$$E_w = 0,5 \cdot \gamma \cdot H^2 = 0,5 \cdot 1 \cdot 6^2 = 18 \text{ t. } \mu_a = 0,55$$

$$E_g = 0,5(1,55 - 0,62 \cdot 1) \cdot 6(6 + 2 \cdot 0,26) \cdot 0,55 = 10,0 \text{ t};$$

$$E = E_g + E_w = 10,0 + 18,0 = 28,0 \text{ t } E = 28,0 \text{ t}$$

Zabvebis epiurisaTvis:

$$q_1 = \frac{2 \cdot 10,0}{6 + 0,26} = 3,19 \text{ t/m};$$

$$q_2 = 3,19 \cdot \frac{0,26}{6 + 0,26} = 0,13 \text{ t/m};$$

$$e_w = \frac{6}{3} \cdot \frac{3,19 + 2 \cdot 0,13}{3,19 + 0,13} = 2 \cdot 1,039 = 2,078 \text{ m}$$

pirobiTad: $e = 2,05 \text{ m}$

miRebuli Sedegebi Setanilia cxrilSi 2.1

cxrili 2.1

miRebuli Sedegebi (1 grZ. m)							
variantebi	gruntis dasaxeleba	R	φ	E	e	xaxunis koeficienti	γ
I	mSrali qviSa (qviSnari)	3	32	11,84	2,1	0,6	1,62
II	mSrali Tixnari (Tixa)	2,5	43	6,8	2,3	0,55	1,55
III	wyalnajeri qviSa (qviSnari)	2,0	25	27,9	2,1	0,5	2,0
IV	wyalnajeri Tixa (Tixnari)	1,8	23	28,0	2,05	0,4	1,9

gaangariSebuli variantebidan gruntis maqsimaluri dawneva Seesabameba wyalnajer Tixnars:

$$E = 28,0 \text{ t} \quad \text{da} \quad e = 2,05 \text{ m}$$

Tavi 3 **tradiciuli sayrdeni kedlebis gaangariSebis variantebi**

3.1. sawyisi monacemebi

rogorc ukve iyo aRniSnuli, SemoTavazebul mewyersawinaaRmdego kompleqsur sistemebSi ZiriTad elements warmoadgens sayrdeni kedeli. amitom tradiciulebTan (arsebulebTan) SemoTavazebuli sistemebis teqnikur-ekonomikuri Sedarebis mizniT motanili gvaqvs Semdegi tipis tradiciuli sayrdeni kedlebis gaangariSebebi:

_ masiuri sayrdeni kedlebi (mSrali da wyalnajeri gruntuli pirobebisaTvis);

_ monolituri rkinabetonis sayrdeni kedlebi gruntuli ankerebis gareSe (igive gruntuli pirobebisaTvis);

_ monolituri rkinabetonis sayrdeni kedlebi zeda doneze ganTavsebuli gruntuli ankerebiT (igive gruntuli pirobebisaTvis).

masiuri sayrdeni kedlebis SemTxvevaSi, maT Soris optimaluri variantis gamovlenis mizniT, Sesrulebuli maTi 3 tipis gaangariSeba.

_ kedlis wina da ukana vertikaluri sibrtyeebiT;

_ kedlis wina-daxrili da ukana-vertikaluri sibrtyeebiT;

_ daxrili sayrdeni kedlisaTvis.

gaangariSebebi Sesrulebulia B20 klasis betonisa da A-III klasis armaturisaTvis.

gaangariSebebi Sesrulebulia sayrdeni kedlis 1 grZ. metrisaTvis.

3.2. masiuri sayrdeni kedlebis gaangariSeba.

3.2.1. sayrdeni kedlis optimaluri moxazulobis da geometriuli zomebis winaswari dadgena.

masiuri sayrdeni kedlis optimaluri variantis dadgenas vawarmoebT mSrali gruntuli pirobebisaTvis (mSrali qviSa).

monacemebi gaangariSebisaTvis:

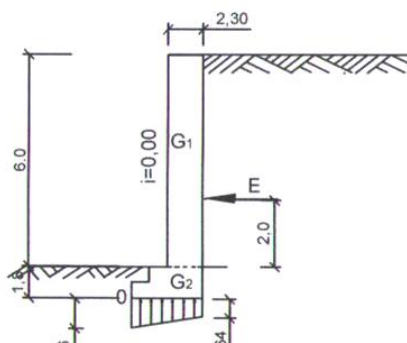
$$H_0 = 6,0 \text{ m } h = 1,8 \text{ m } H = 7,8 \text{ m};$$

$$\varphi = 32^\circ; \gamma_{gr} = 1,62 \text{ t/m}^3; \gamma_k = 1,62 \text{ t/m}^3; R = 3,0 \text{ kg/sm}^2;$$

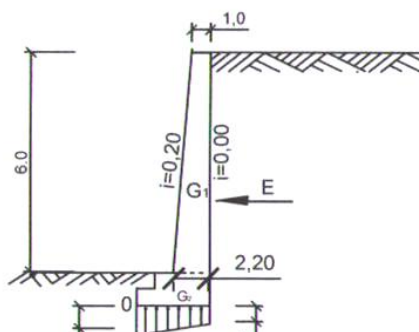
$$E = 11,84 \text{ t}; f = 0,6$$

radgan kedlis sisqe b bevradaa damokidebuli mis profilze, amitom gaangariSeba SevasruloT kedlis waxnagebis sam sxvadasxva qanobisaTvis (nax. 3.1.)

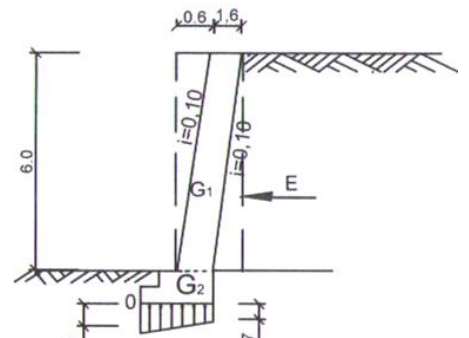
ა) ვარიანტი 1



ბ) ვარიანტი 2



გ) ვარიანტი 3



max. 3.1. sayrdeni kedlis profilis variantebi

masiuri sayrdeni kedlis sisqeebis (b_i) winaswari gaangariSeba miwis donidan nebismier (H_i) doneze, agreTve misi sisqe saZirkvlis CanaWris doneze b_0 da saZirkvlis sigane b_{II} warmoebs formulit:

$$b_i = H_i \left(-C_1 + \sqrt{0,75 + \frac{\gamma_{\Gamma}}{\gamma_k} \mu + C_2} \right)$$

sadac: C_1 da C_2 – ricxviTi koeficientebia, romlebic damokidebulia kedlis wina da ukana waxnagebis daxris kuTxeze ($\text{tg}\beta$ da $\text{tg}\beta^1$);

$\gamma_{\Gamma}, \gamma_k$ – gruntis da kedlis masalis moculobiTi wonebi;

μ – koeficientia, romelic damokidebulia gruntis Sinagani xaxunis kuTxeze – φ , gruntis zedapiris daxris kuTxeze – α da kedlis ukana waxnagis daxris kuTxeze – β .

varianti 1:

kedlis wina da ukana waxnagebi vertikaluria (max.3.1, a) $\beta^1 = \beta = 0$; saTanado cxrilidan: $C_1 = C_2 = 0$; $\mu = 0,305$

kedlis sisqe saZirkvlis CanaWris doneze:

$$b_0 = 6,0 \left(-0 + \sqrt{0,75 \cdot \frac{1,62}{2,4} \cdot 0,305 + 0} \right) = 6 \cdot 0,39 = 2,36 \text{ m}$$

viRebT $b_0 = 2,3 \text{ m}$

saZirkvlis fuZis sigane

$$b_{II} = 1,2 \cdot 7,8 \left(-0 + \sqrt{0,75 \cdot \frac{1,62}{2,4} \cdot 0,305 + 0} \right) = 6 \cdot 0,39 = 3,65 \text{ m}$$

$$v_{iRebT} b_{II} = 3,6 \text{ m}$$

varianti 2: (max.3.1, b)

kedlis wina waxnagis qanobi $i = \text{tg}\beta^1 = 0,2$; ($\beta^1 \approx 11^\circ 20'$). ukana waxnagi vertikaluria ($\text{tg}\beta = 0,00$).

$$C_1 = 0,062; \quad C_2 = 0,034; \quad \mu = 0,305$$

kedlis sisqe saZirkvliis CanaWris doneze:

$$b_0 = 6,0(-0,062 + \sqrt{0,75 \cdot \frac{1,62}{2,4} \cdot 0,305 + 0,034}) = 6 \cdot 0,3721 = 2,232 \text{ m}$$

$$v_{iRebT} b_0 = 2,2 \text{ m}$$

saZirkvliis fuZis sigane

$$b_{II} = 1,2 \cdot 7,8(-0,062 + \sqrt{0,75 \cdot \frac{1,62}{2,4} \cdot 0,305 + 0,034}) = 3,48 \text{ m}$$

v_{iRebT}

$$b_{II} = 3,4 \text{ m}$$

varianti 3: (max.3.1, g)

wina da ukana waxnagebis qanobia $i = \text{tg}\beta^1 = \text{tg}\beta = 0,1$; ($\beta^1 = \beta \approx 6^\circ$).

$$C_1 = 0,112; \quad C_2 = 0,0125; \quad \mu = 0,27$$

kedlis sisqe saZirkvliis CanaWris doneze:

$$b_0 = 6,0(-0,112 + \sqrt{0,75 \cdot \frac{1,62}{2,4} \cdot 0,27 + 0,0125}) = 6 \cdot 0,27425 = 1,6455 \approx 1,65 \text{ m}$$

$$v_{iRebT} b_0 = 1,6 \text{ m}$$

saZirkvliis fuZis sigane

$$b_{II} = 1,2 \cdot 7,8(-0,112 + \sqrt{0,75 \cdot \frac{1,62}{2,4} \cdot 0,27 + 0,0125}) = 9,36 \cdot 0,27425 = 2,567 \approx 2,57 \text{ m}$$

$$v_{iRebT} b_{II} = 2,5 \text{ m}$$

dasaxuli variantebidan optimaluri variantis SerCeva.

saWiroa miRebuli variantebi Semowmebul iqnes Semdeg pirobebze:

1. sayrdeni kedlis gadabrunebaze pirobidan $M_d > M_g$;

2. sayrdeni kedlis Zvraxe pirobidan $E \leq T = f \sum P_i$;

3. gruntze gadacemul wnevaze pirobidan $\sigma = \frac{P}{F} \pm \frac{M}{W} \leq R_n$

varianti 1:

kedlis masa: $G = G_1 + G_2$;

$$G_1 = 6,0 \cdot 2,3 \cdot 1,0 \cdot 2,4 = 33,12 \text{ t}; G_2 = 3,6 \cdot 1,8 \cdot 1,0 \cdot 2,4 = 15,55 \text{ t}. G = 48,67 \text{ t}.$$

gadabrunebeli momenti:

$$M_g = n \cdot E \cdot \frac{H_0}{3} = 1,2 \cdot 11,84 \cdot \frac{7,8}{3} = 36,94 \text{ tm}$$

damWeri momenti:

$$M_d = 0,8(33,12 \cdot 2,45 + 15,55 \cdot 1,8) = 0,8 \cdot 109,1 = 87,27 \text{ tm}$$

$$M_d > M_g$$

Zvris Zala:

$$T = 0,8 \cdot 0,6 \cdot 48,67 = 23,36 \text{ t} > E = 11,84 \text{ t}.$$

gruntze gadacemuli wneva: $\sum M = -36,94 + 33,12 \cdot 0,65 = -15,4 \text{ tm}.$

$$\sigma = \frac{P}{F} \pm \frac{M}{W} = \frac{48,67}{1 \cdot 3,6} \pm \frac{15,4 \cdot 6}{1 \cdot 3,6^2} = 13,52 \pm 7,1$$

$$\sigma_{\max} = 13,52 + 7,1 = 20,62 \text{ t/m}^2 = 2,06 \text{ kg/sm}^2 < R_n$$

$$\sigma_{\min} = 13,52 - 7,1 = 6,42 \text{ t/m}^2 \approx 0,64 \text{ kg/sm}^2$$

varianti 2:

$$\text{kedlis masa: } G = G_1 + G_2; G_1 = \frac{2,2 + 1,0}{2} \cdot 6 \cdot 2,4 = 23,0 \text{ t}$$

$$G_2 = 3,4 \cdot 1,8 \cdot 2,4 = 14,7 \text{ t}.$$

$$G = 37,7 \text{ t}.$$

gadabrunebeli momenti:

$$M_g = n \cdot E \cdot \frac{H_0}{3} = 1,2 \cdot 11,84 \cdot \frac{7,8}{3} = 36,94 \text{ tm}$$

damWeri momenti:

$$M_d = 0,8(23,0 \cdot 2,6 + 14,7 \cdot 1,7) = 67,8 \text{ tm} \quad M_d > MM_g$$

Zvris Zala:

$$T = 0,8 \cdot 0,6 \cdot 37,7 = 18,09 \approx 18,1 > E = 11,84 \text{ t.}$$

gruntze gadacemuli wneva: $\sum M = -36,94 + 23,0 \cdot 0,9 = -16,24 \text{ tm.}$

$$\sigma = \frac{P}{F} \pm \frac{M}{W} = \frac{37,7}{3,4} \pm \frac{16,24}{3,4^2} = 11,09 \pm 8,43$$

$$\sigma_{\max} = 19,52 \text{ t/m}^2 = 1,95 \text{ kg/sm}^2 < R^\sigma = 3,0 \text{ kg/sm}^2$$

$$\sigma_{\min} = 2,66 \text{ t/m}^2 \approx 0,27 \text{ kg/sm}^2$$

varianti 3:

kedlis masa: $G = G_1 + G_2$;

$$G_1 = 1,6 \cdot 6 \cdot 2,4 = 23,04 \text{ t. } G_2 = 2,5 \cdot 1,8 \cdot 2,4 = 10,8 \text{ t. } G = 33,84 \text{ t.}$$

gadambunebeli momenti:

$$M_g = 36,94 \text{ tm}$$

damWeri momenti:

$$M_d = 0,8(23,04 \cdot 2,0 + 10,8 \cdot 1,25) = 47,66 \text{ tm} \quad M_d > MM_g$$

Zvris Zala:

$$T = 0,8 \cdot 0,6 \cdot 33,84 = 16,24 > E = 11,84 \text{ t.}$$

gruntze gadacemuli wneva: $\sum M = -36,94 + 23,04 \cdot 0,75 = -19,66 \text{ tm.}$

$$\sigma = \frac{33,84}{2,5} \pm \frac{19,66}{2,5^2} = 13,54 \pm 18,87$$

$$\sigma_{\max} = 32,4 \text{ t/m}^2 = 3,24 \text{ kg/sm}^2 > R^\sigma = 3,0 \text{ kg/sm}^2$$

$$\sigma_{\min} = -5,33 \text{ t/m}^2 = -0,53 \text{ kg/sm}^2 < 0$$

amitom vzrdiT saZirkvlis siganes

$$b_{II} = 3,0 \text{ m} \quad \text{maSin:}$$

$$G_2 = 3 \cdot 1,8 \cdot 2,4 = 12,96 \text{ t} \quad \text{da } G = 36,0 \text{ t; } \sum = -36,94 + 23,04 \cdot 1,0 = -13,94 \text{ t.m;}$$

$$\sigma = \frac{36,0}{3,0} \pm \frac{13,94 \cdot 6}{3,0^2} = 12,0 \pm 9,29$$

$$\sigma_{\max} = 21,29 \text{ t/m}^2 = 2,13 \text{ kg/sm}^2 < R^\sigma = 3,0 \text{ kg/sm}^2$$

$$\sigma_{\min} = 2,71 \text{ t/m}^2 = 0,27 \text{ kg/sm}^2$$

daskvna: masalis xarjis mixedviT ufro ekonomiuiria me-3 varianti, magram Cven SemoTavazebul sayrden kedels vaproeqtetT vertikaluri wina da ukana waxnagebiT, amitom vasrulebT rogorcdaxrili, aseve vertikaluri masiuri sayrdeni kedlis gaangariSebas.

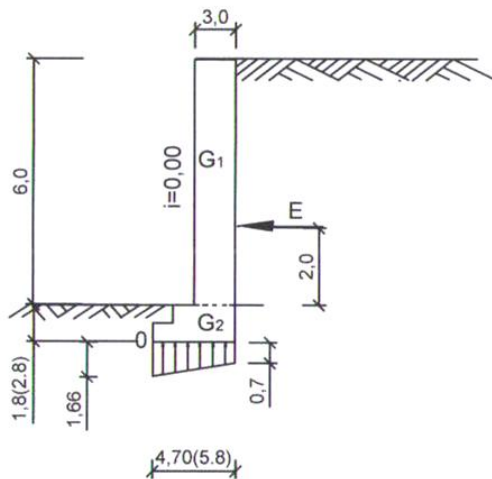
3.2.2. vertikaluri masiuri sayrdeni kedlis gaangariSeba. (grunti _ wyalnajeri Tixnari)

monacemebi gaangariSebisaTvis:

$$H_0 = 6,0 \text{ m } h = 1,8 \text{ m } H = 7,8 \text{ m};$$

$$\varphi = 23^\circ; \gamma_{gr} = 1,9 \text{ t/m}^3; \gamma_k = 2,4 \text{ t/m}^3; R^\sigma = 1,8 \text{ kg/sm}^2;$$

$$E = 28,0 \text{ t}; f = 0,5 \text{ (max. 3.2)}$$



**max. 3.2. masiuri vertikaluri
sayrdeni kedeli**

gaangariSeba:

$$\beta^1 = \beta = 0^\circ;$$

$$\text{saTanado cxrilidan: } C_1 = C_2 = 0; \mu = 0,41.$$

kedlis sisqe saZirkvlis CasaWris doneze:

$$b_0 = 6,0(-0 + \sqrt{0,75 \cdot \frac{1,9}{2,4} \cdot 0,55 + 0}) = 6 \cdot 0,51 =$$

$$\text{viRebT } b_0 = 3,0 \text{ m}$$

saZirkvlis sigane

$$b_{II} = 1,2 \cdot 7,8(-0 + \sqrt{0,75 \cdot \frac{1,9}{2,4} \cdot 0,55 + 0}) = 9,36 \cdot 0,51$$

$$b_{II} = 4,7 \text{ m.}$$

sayrdeni kedlis masa:

$$G_1 = 3 \cdot 6 \cdot 2,4 = 43,2 \text{ t}; G_2 = 4,7 \cdot 1,8 \cdot 2,4 = 20,3 \text{ t.} \quad G = 63,5 \text{ t.}$$

$$M_g = nE \cdot \frac{H_0}{3} = 1,2 \cdot 28 \cdot \frac{7,8}{3} = 87,36 \text{ tm}; M_d = 0,8(43,2 \cdot 3,2 + 20,3 \cdot 2,35) = 185,9 \text{ tm}$$

$$M_d > M_g$$

$$T = 0,8 \cdot 0,45 \cdot 63,5 = 22,86 \text{ t} < E = 28,0 \text{ t.}$$

saWiroa kedlis masis gazrda. vzrdiT kedlis sisqes $b = 3,7 \text{ m}$ da saZirkvliis zomebs: siRrme $h = 2,8$ siganes:

$$b_{II} = 5,8 \text{ m} \quad \text{maSin:}$$

$$G_1 = 3,7 \cdot 6 \cdot 2,4 = 53,3 \text{ t}; \quad G_2 = 5,8 \cdot 1,8 \cdot 2,4 = 25,06 \text{ t} \quad \text{da} \quad G = 78,4 \text{ t};$$

$$T = 0,8 \cdot 0,45 \cdot 78,4 = 28,2 \text{ t} \approx E = 28,0 \text{ t.}$$

gruntze Zabvebis Semowmeba:

$$\sum M = -87,36 + 43,2 \cdot 1,4 = -26,88 \text{ tm.}$$

$$\sigma = \frac{68,25}{5,8} \pm \frac{26,88 \cdot 6}{5,8^2} = 11,77 \pm 4,79$$

$$\sigma_{\max} = 16,56 \text{ t/m}^2 = 1,66 \text{ kg/sm}^2 < R^\sigma = 1,8 \text{ kg/sm}^2$$

$$\sigma_{\min} = 6,98 \text{ t/m}^2 = 0,7 \text{ kg/sm}^2$$

analogiurad gvaqvs Sesrulebuli masiuri vertikaluri sayrdeni kedlis gaangariSeba (naSromSi ar mogvaqvs, Tumca variantebis teqnukur-ekonomikuri Sedarebisas miRebuli gvaqvs mxedvelobaSi).

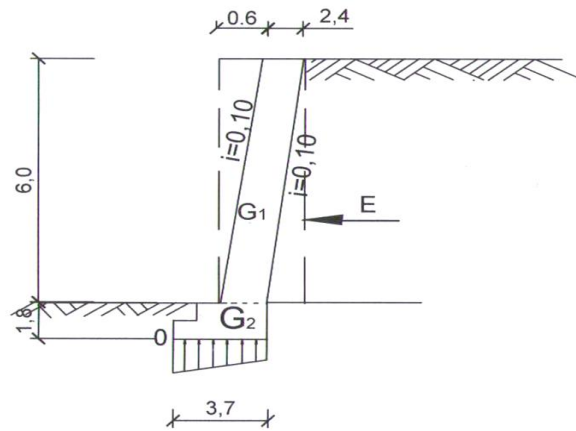
2.2.3. daxrili masiuri sayrdeni kedlis gaangariSeba. (grunti _ wyalnajeri Tixnari)

monacemebi gaangariSebisaTvis: (max. 3.3.)

$$H_0 = 6,0 \text{ m} \quad h = 1,8 \text{ m}; H = 7,8 \text{ m};$$

$$\varphi = 23^\circ; \gamma_{gr} = 1,9 \text{ t/m}^3; \gamma_k = 2,4 \text{ t/m}^3; R^\sigma = 1,8 \text{ kg/sm}^2;$$

$$E = 28,0t ; f = 0,45$$



nax. 3.3. daxrili masiuri sayrdeni kedeli

gaangariSeba: wina da ukana waxnagebis qanobia

$$i = \operatorname{tg} \beta^1 = \operatorname{tg} \beta = 0,1 \quad (\beta^1 = \beta \approx 6^0);$$

saTanado cxrilidan: $C_1 = 0,112$; $C_2 = 0,0125$; $\mu = 0,41$.

kedlis sisqe saZirkvlis SenaWris doneze:

$$b_0 = 6,0(-0,112 + \sqrt{0,75 \cdot \frac{1,9}{2,4} \cdot 0,41 + 0,125}) = 6 \cdot 0,394 = 2,36 \text{ m}$$

$$\text{viRebT} \quad b_0 = 2,4 \text{ m}$$

saZirkvlis sigane

$$b_{II} = 1,2 \cdot 7,8(-0,112 + \sqrt{0,75 \cdot \frac{1,9}{2,4} \cdot 0,41 + 0,0125}) = 9,36 \cdot 0,394 = 3,68 \text{ m}$$

$$\text{viRebT} \quad b_{II} = 3,7 \text{ m}$$

sayrdeni kedlis masa:

$$G_1 = 2,4 \cdot 6 \cdot 2,4 = 34,56 \text{ t}; G_2 = 3,7 \cdot 1,8 \cdot 2,4 = 15,98 \text{ t} \quad G = 50,54 \text{ t}$$

gadambrunebeli momenti:

$$M_g = nE \cdot \frac{H_0}{3} = 1,2 \cdot 28 \cdot \frac{7,8}{3} = 87,36 \text{ tm}$$

damWeri moment:

$$M_d = 0,8(34,56 \cdot 2,8 + 15,98 \cdot 1,85) = 0,8 \cdot 126,33 = 101,1 \text{ tm}$$

$M_d > M_g$

Semowmeba mosrialebaze (Zvraze):

$$T = 0,8 \cdot 0,45 \cdot 50,54 = 18,19 \text{ t} < E = 28,0 \text{ t}$$

amitom unda gavzardoT kedlis masa; miviRoT (nax. 3.4):

$$b_0 = 3,0 \text{ m}, b_{II} = 5,7 \text{ m da}$$

$h = 2,6 \text{ m}$, maSin:

$$G_1 = 3,0 \cdot 6 \cdot 2,4 = 43,2 \text{ t}$$

$$G_2 = 5,7 \cdot 2,6 \cdot 2,4 = 35,57 \text{ t da } G = 78,77 \text{ t};$$

damWer moments ar vamowmebT, radgan

pirvel SemTxvevaSic igi aRemateboda M_g -s.

$$T = 0,8 \cdot 0,45 \cdot 78,8 = 28,4 \text{ t} > E = 28,0 \text{ t}$$

gruntze Zabvebis Semowmeba:

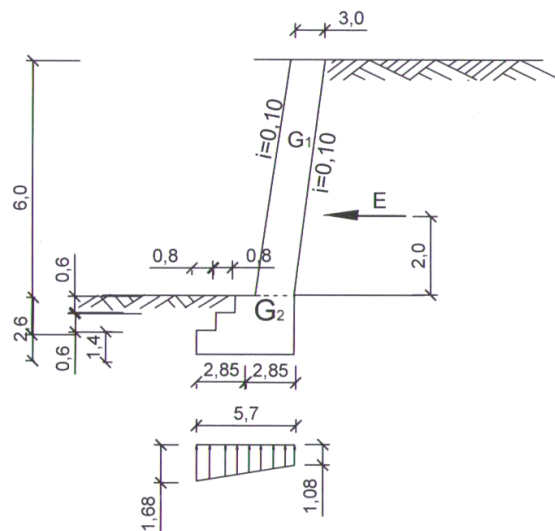
$$\sum M = -87,36 + 43,2 \cdot 1,65 = -16,08 \text{ tm}$$

$$\sigma = \frac{78,77}{5,7} \pm \frac{16,08 \cdot 6}{5,7^2} = 13,8 \pm 2,97$$

$$\sigma_{\max} = 16,77 \text{ t/m}^2 = 1,68$$

$$\sigma_{\min} = 10,83 \text{ t/m}^2 = 1,08 \text{ kg/sm}^2 \quad \text{nax.3.4}$$

analogiurad gvaqvs gaangariSebuli daxrili masiuri sayrdeni kedeli mSrali qviSnaris SemTxvevaSi. (naSromSi ar mogvaqvs, xolo teqnukur-ekonomikuri Sedarebisas mxedvelobaSi gvaqvs miRebuli).



3.3. tradiciuli monoliTuri rkinabetonis uankero sayrdeni kedlebis gaangariSeba.

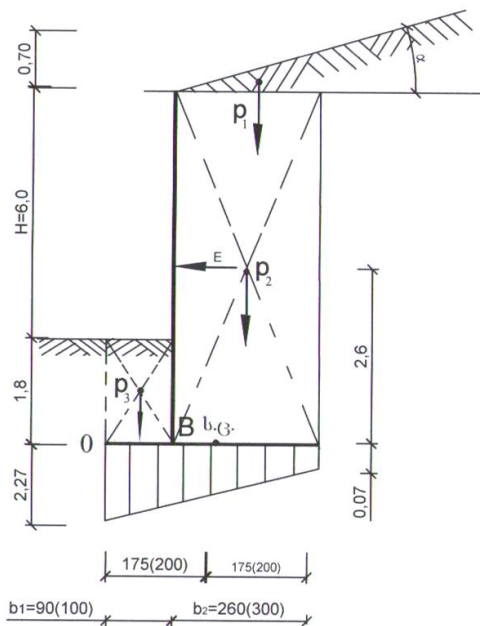
3.2.1. grunti _ mSrali qviSnari

monacemebi gaangariSebisaTvis:

$$H = 6,0 \text{ m } h = 1,8 \text{ m } \varphi = 32^\circ; \gamma_{gr} = 1,62 \text{ t/m}^3; R^\sigma = 3,0 \text{ kg/sm}^2;$$

$$\gamma_{saS} = C^1 \gamma = 1,1 \cdot 1,62 = 1,78 \text{ t/m}^3;$$

$$\alpha = 15^\circ; tg\alpha = 0,26795; \mu_a = 0,369; f = 0,6 \quad (\text{nax.3.5.})$$



gaangariSeba: saZirkvliis filis

siganis winaswari gansazRvra

$$b = (H + h) \sqrt{C \frac{\gamma}{\gamma_{saS}} \mu_a} = (6 + 1,8) \sqrt{0,6 \cdot \frac{1620}{1780} \cdot 0,369} = 7,8 \cdot 0,449 = 3,5 \text{ m}$$

saZirkvliis filis konsolebis sigrZeebi:

$$b_1 = 0,25 \cdot b = 0,25 \cdot 3,5 = 0,875 \text{ m}$$

$$\text{viRebT} \quad b_1 = 90 \text{ sm};$$

$$b_2 = 350 - 90 = 260 \text{ sm.}$$

sayrden kedels vamowmebT mdgradobaze:

sidideebi E, P_i da $\sum P_i$ tolia:

nax.3.5

$$1. \quad E = 0,5 \gamma (H + h)^2 \cdot \mu_a = 0,5 \cdot 1,62 (6,0 + 1,8)^2 \cdot 0,369 \approx 18,2 \text{ t}$$

$$2. \quad P_1 = 2,6 \cdot 0,7 \cdot 0,5 \cdot 1,78 = 1,62 \text{ t}$$

$$P_2 = 2,6 \cdot 7,8 \cdot 1,78 = 36,1 \text{ t}$$

$$P_g = 1,8 \cdot 0,9 \cdot 1,78 = 2,9 \text{ t}$$

$$\sum P_i = 40,6 \text{ t}$$

3. gadabrunebeli momenti (n=1,2):

$$M_g = -n E e = -1,2 \cdot 18,2 \cdot \frac{6 + 1,8}{3} = -56,78 \text{ t.m.}$$

4. damWeri momenti (n=0,8):

$$M_d = n \sum P_i a_i = 0,8(1,62 \cdot 2,63 + 36,1 \cdot 2,2 + 2,9 \cdot 0,45) = 0,8 \cdot 84,99 = 67,99 \text{ t.m.}$$

$$M_d > M M_g$$

5. Semowmeba Zvraze (mosrialebaze):

$$T = f n \sum P_i = 0,6 \cdot 0,8 \cdot 40,6 = 19,5 \text{ t}$$

$$T = 19,5 \text{ t} < n E = 1,2 \cdot 18,2 = 21,84 \text{ t}$$

amitom unda gavzardoT saZirkvlis filis sigane da miviRoT:

$$b = 4,0 \text{ m } b_1 = 0,25 \cdot b = 1 \text{ m}; b_2 = 4 - 1 = 3 \text{ m}$$

(nax. 3.5. filis dazustebuli zomebi mocemulia frCxilebSi).

vsazRvravT gruntis axial masebs:

$$P_1 = 3,0 \cdot 0,7 \cdot 0,5 \cdot 1,78 = 1,87 \text{ t}$$

$$P_2 = 3,0 \cdot 7,8 \cdot 1,78 = 41,65 \text{ t}$$

$$P_3 = 1,8 \cdot 1,0 \cdot 1,78 = 3,2 \text{ t}$$

$$\sum P_i = 46,72 \text{ t.}$$

sayrden kedels xelmeored aRar vamowmebT gadabrunebaze, radgan pirvel SemTxvevaSi gvqonda Semowmebuli. kedels xelmeored vamowmebT mxolod Zvraze:

$$T = 0,6 \cdot 0,8 \cdot 46,72 = 22,43 \text{ t} > n E = 1,2 \cdot 18,2 = 21,84 \text{ t}$$

vamowmebT fuZis gruntis simtkices:

EE da $\sum P_i$ Zalebis momenti fuZis filis simZimis centris mimarT; gadatvirTvis koeficientebis mxedvelobaSi miuReblad:

$$M = -M_0 + \sum P_i a_i = -\frac{56,78}{1,2} + 1,87 \cdot 1 + 41,65 \cdot 0,5 - 3,2 \cdot 1,5 = -52,12 + 22,7 = -29,42 \text{ t.m.}$$

wneva gruntze:

$$\sigma = \frac{\sum P_i}{F} \pm \frac{6M}{W} = \frac{46,72}{1,0 \cdot 4,0} \pm \frac{6 \cdot 29,42}{1 \cdot 4^2} = 11,68 \pm 11,03;$$

$$\sigma_{\max} = 22,7 \text{ t/m}^2 = 2,27 \text{ kg/sm}^2 < R^\sigma = 3,0 \text{ kg/sm}^2$$

$$\sigma_{\min} = 0,65 \text{ t/m}^2 = 0,07 \text{ kg/sm}^2$$

kedlis filebis gaangariSeba simtkiceze:

isini, rogorc cnobilia, iangariSeba saangariSo datvirTvaze. Tu Zabvebis epiurebis Sesabamis farTebis aRvniSnavT F_i asoTi, gveqneba:

$$M_1 = F_1 \cdot 0,58 - nP_3 \cdot 0,5 = \frac{22,7 + 17,2}{2} \cdot 0,58 \cdot 1,0 - 1,2 \cdot 3,2 \cdot 0,5 = 9,65 \text{ t.m.}$$

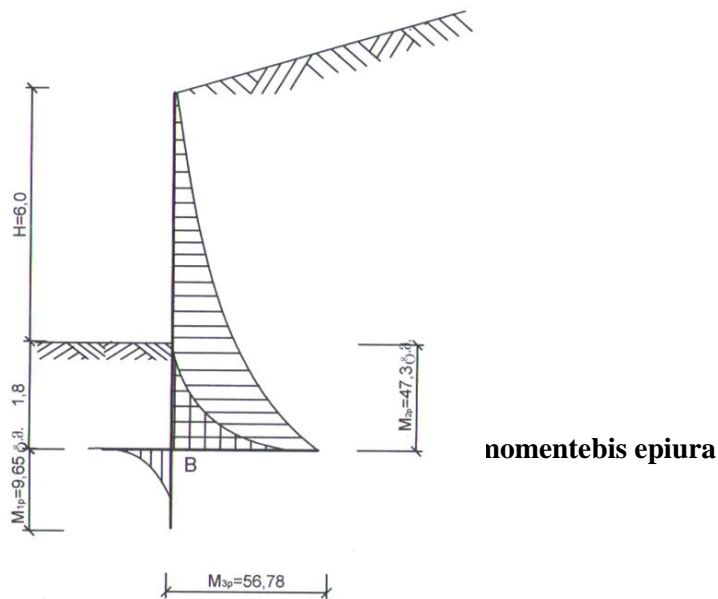
$$M_2 = nP_i \cdot 2 + nP_2 \cdot 1,5 - F_2 \cdot 1,1 = 1,2 \cdot 1,87 \cdot 2 + 1,2 \cdot 41,65 \cdot 1,5 - \frac{17,2 + 0,7}{2} \cdot 3 \cdot 1,1 = 47,3 \text{ t.m.}$$

$$M_3 = -nE \cdot 2,6 = -1,2 \cdot 18,2 \cdot 2,6 = -56,78 \text{ t.m.}$$

$$\Sigma M = 9,65 + 47,3 - 56,78 \approx 0$$

mRunavi momentebis epiura ix. nax. 3.6

miRebuli saangariSo momentebis da ganivi Zalebis mixedviT vsazRvravT **B** wertilSi filebis sisqes da armaturis farTobs.



sayrdem keunis medis daarmatureba

monacemebi gaangariSebisaTvis:

1. vertikaluri filisaTvis: $M_3=56,78 \text{ t.m.}$; $Q_3=1,2 \cdot E=1,2 \cdot 18,2=21,84 \text{ t}$
2. saZirkvli filebisaTvis: $M_1=9,65 \text{ t.m}$ da $M_2=47,38 \text{ t.m}$

vertikaluri filis daarmatureba:

kveTis geometriuli parametrebi: $b=1,0$ m; $h=0,55$ m; $a=0,05$ m; $h_0=0,50$ m; betoni mZime B 20 klasis (m 250); $R_b=11,5$ mpa; armatura S, A_T-III klasis ($R_s=365$ mpa).

saangariSo mRunavi momenti $M=567,8$ kn.m.

saWiroa grZivi armaturis ganivkveTis farTobis gansazRvra.

gaangariSeba:

vamowmebT kedlis sisqes:

$$b \cdot h_0 \cdot R_g = 100 \cdot 50 \cdot 9 = 45000 \text{ kg} = 45 \text{ t} > 1,2E = 21,84 \text{ t}$$

e.i. ganivi armaturis angariSi saWiro ar aris.

B 20 klasis betonisaTvis $\gamma_{b2} = 0,9$

koeficientis gaTvaliswinebiT

$$R_b \gamma_{b2} = 11,5 \cdot 0,9 = 10,35 \text{ mpa}$$

$$B_0 = \frac{56780}{10,35 \cdot 10^6 \cdot 1 \cdot 0,5^2} = 0,22 \quad V = 0,875$$

$$A_s = \frac{567800}{365 \cdot 10^6 \cdot 0,875 \cdot 0,50} = 0,0035557 \text{ m}^2 = 35,6 \text{ sm}^2$$

viRebT: 10Φ22A-III ($A_s=38,01 \text{ sm}^2$)

Camagrebis kvanZSi (wertili B) saZirkvlis filis sisqes viRebT igives - $h=55$ sm.

saZirkvlis filis marxena mxarisaTvis:

$$M_1=9,65 \text{ t.m}$$

$$B_0 = \frac{96500}{10,35 \cdot 10^6 \cdot 1 \cdot 0,5^2} = 0,037 \quad V = 0,98$$

$$A_s = \frac{96500}{365 \cdot 10^6 \cdot 0,98 \cdot 0,5} = 0,0005396 \text{ m}^2 = 5,4 \text{ sm}^2$$

viRebT 6Φ12A-III ($A_s=6,79 \text{ sm}^2$)

saZirkvlis filis marjvena mxarisaTvis:

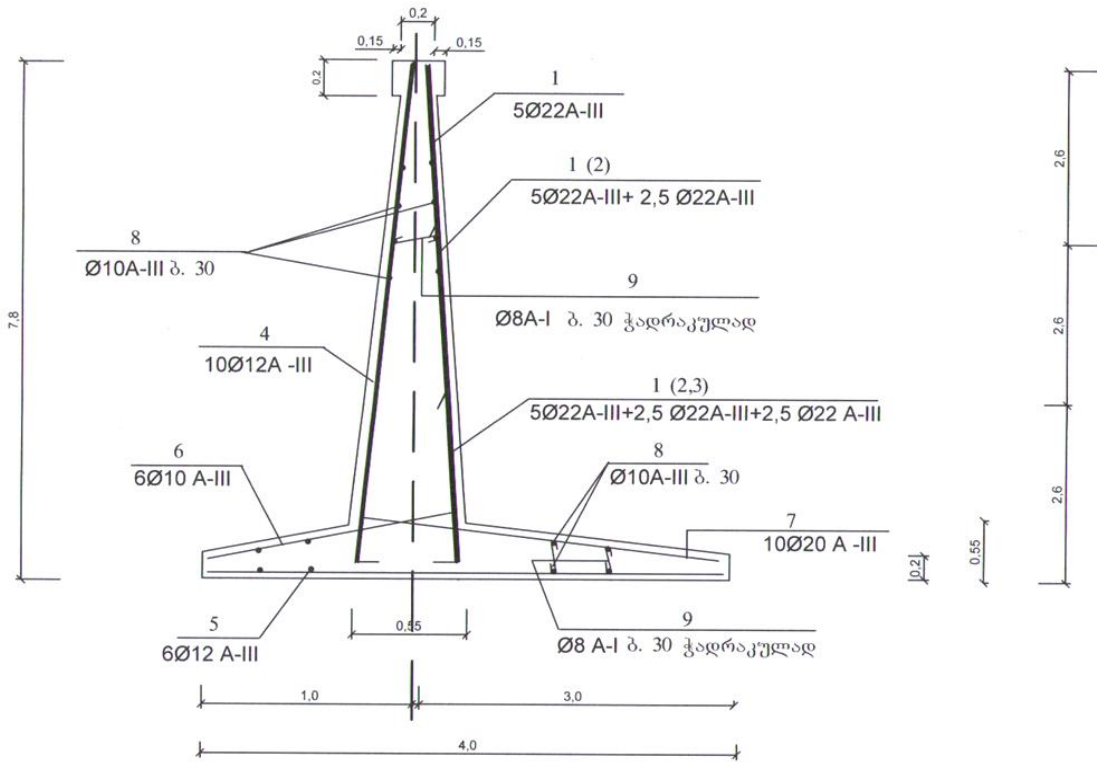
$$M_2=47,3 \text{ t.m}$$

$$B_0 = \frac{473000}{10,35 \cdot 10^6 \cdot 1 \cdot 0,5^2} = 0,183; \quad V = 0,899;$$

$$A_s = \frac{473000}{365 \cdot 10^6 \cdot 0,899 \cdot 0,5} = 0,002883 \text{ m}^2 = 28,83 \text{ sm}^2$$

viRebT 10Φ20A-III ($A_s=31,42 \text{ sm}^2$)

sayrdeni kedlis daarmatureba ix. nax. 3.7.



nax. 3.7. sayrdeni kedlis daarmatureba.

3.3.2. grunti _ wyalnajeri Tixnari

monacemebi gaangariSebisaTvis:

$$H = 6,0 \text{ m } h = 1,8 \text{ m}$$

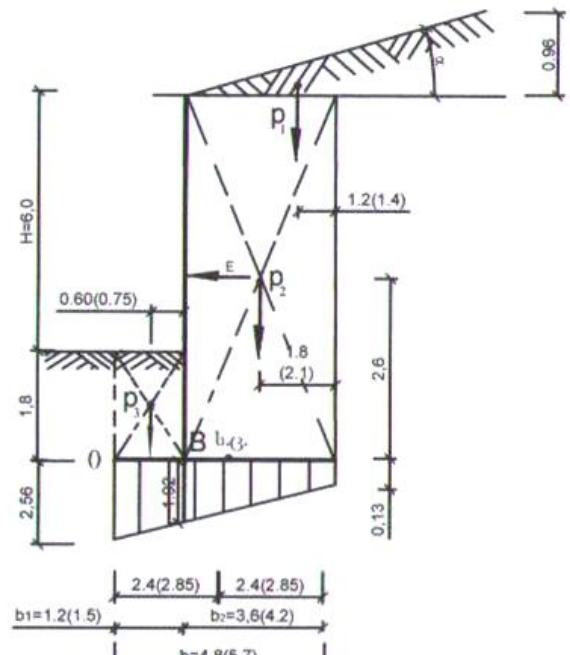
$$\varphi = 23^0; \gamma = 1,9 \text{ t/m}^3;$$

$$R^\sigma = 1,8 \text{ kg/sm}^2;$$

$$\gamma_{\text{saS}} = C^1 \gamma = 1,7 \cdot 1,9 = 2,03 \text{ t/m}^3;$$

$$\alpha = 15^0; \text{tg} \alpha = 0,26795;$$

$$\mu_\alpha = 0,54;$$



$$f = 0,6$$

nax. 3.8

gaangariSeba:

saZirkvliis filis siganis winaswari gansazRvra

$$b = (H + h) \sqrt{C \frac{\gamma}{\gamma_{saS}} \mu_a} = (6 + 1,8) \sqrt{0,7 \cdot \frac{1,9}{2,03} \cdot 0,54} = 7,8 \cdot 0,5948 = 4,64 \approx 4,8 \text{ m}$$

saZirkvliis filis konsolebis sigrZeebi:

$$b_1 = 0,25 \cdot b = 0,25 \cdot 4,8 = 1,2 \text{ m}$$

$$b_2 = 4,8 - 1,2 = 3,6 \text{ m}$$

kedlis Semowmeba mdgradobaze: sidideebi E, P_i da $\sum P_i$ tolia:

$$1. E = 0,5 \gamma (H + h)^2 \cdot \mu_a = 0,5 \cdot 1,9 (6,0 + 1,8)^2 \cdot 0,54 = 31,21 \text{ t}$$

$$2. P_1 = 3,6 \cdot 0,96 \cdot 0,5 \cdot 2,03 = 3,51 \text{ t};$$

$$P_2 = 7,8 \cdot 3,6 \cdot 2,03 = 57,0 \text{ t}$$

$$P_3 = 1,2 \cdot 1,8 \cdot 2,03 = 4,38 \text{ t}$$

$$\sum P_i = 64,9 \text{ t}$$

3. gadambrunebeli momenti (n=1,2):

$$M_g = -n E e = -1,2 \cdot 31,21 \cdot \frac{7,8}{3} = -97,38 \text{ t.m.}$$

4. damWeri momenti (n=0,8):

$$M_d = n \sum P_i a_i = 0,8 (3,51 \cdot 3,6 + 57,0 \cdot 3,0 + 4,38 \cdot 0,6) = 0,8 \cdot 186,3 = 149,0 \text{ t.m. } M_d > M M_g$$

5. Semowmeba Zvraze (mosrialebaze):

$$T = f n \sum P_i = 0,6 \cdot 0,8 \cdot 64,9 = 31,2 \text{ t}$$

$$T = 31,2 < n E = 1,2 \cdot 31,21 = 37,45 \text{ t}$$

amitom unda gavzardoT saZirkvliis filis sigane da miviRoT:

$$b = 5,7 \text{ m}; b_1 = 1,5 \text{ m } b_2 = 4,2 \text{ m}$$

(nax. 3.8. filis dazustebuli zomebi mocemulia frCxilebSi).

gruntis axali masebi:

$$P_1 = 4,2 \cdot 1,13 \cdot 0,5 \cdot 2,03 = 4,82 \text{ t};$$

$$P_2 = 4,2 \cdot 7,8 \cdot 2,03 = 66,5 \text{ t};$$

$$P_3 = 1,5 \cdot 1,8 \cdot 2,03 = 5,48 \text{ t}; \quad \sum P_i = 76,8 \text{ t},$$

$$T = fn \sum P_i = 0,6 \cdot 0,8 \cdot 76,8 = 36,86 \text{ t} \approx nE$$

fuZis gruntis Semowmeba simtkiceze:

$$M = -M_0 + \sum P_i a_i = -\frac{97,38}{1,2} + 4,82 \cdot 1,45 + 66,5 \cdot 0,3 - 5,48 \cdot 2,1 = 26,94 - 92,66 = -65,72 \text{ t.m.}$$

wneva gruntze:

$$\sigma = \frac{\sum P_i}{F} \pm \frac{6M}{W} = \frac{76,8}{1 \cdot 5,7} \pm \frac{6 \cdot 65,72}{1 \cdot 5,7^2} = 13,47 \pm 12,14;$$

$$\sigma_{\text{maqs}} = 25,61 \text{ t/m}^2 = 2,56 \text{ kg/sm}^2; < 1,2 \cdot R^\sigma = 1,2 \cdot 1,8 = 2,16 \text{ kg/sm}^2$$

$$\sigma_{\text{min}} = 1,33 \text{ t/m}^2 = 0,13 \text{ kg/sm}^2$$

marTalia, $\sigma_{\text{maqs}} > 1,2 \cdot R^\sigma$ magram saZirkvlis filis miRebul zomebs vtovetT uc vlelad da fuZis saangariSo winaRobas gavzrdiT masSi xreSis (an RorRis) CatkepniT.

sayrdeni kedlis filebis gaangariSeba simtkiceze

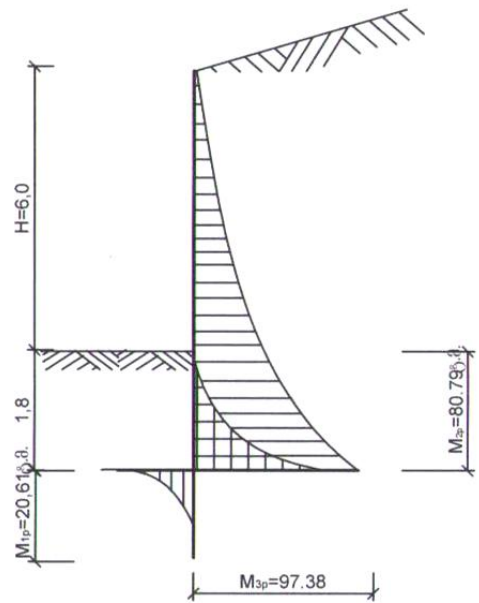
mRunavi momentebi filebis urTierTmierTebis wertilis (B) mimarT:

$$M_1 = F_1 \cdot 0,76 - nP_3 \cdot 0,75 = \frac{25,6 + 19,2}{2} \cdot 1,5 \cdot 0,76 - 1,2 \cdot 5,48 \cdot 0,75 = 20,61 \text{ t.m.}$$

$$M_2 = nP_1 \cdot 2,8 + nP_2 \cdot 2,1 - F_2 \cdot 2,09 = 1,2 \cdot 4,82 \cdot 2,8 + 1,2 \cdot 66,5 \cdot 2,1 - \frac{19,2 + 1,3}{2} \cdot 4,2 \cdot 2,09 = 80,79 \text{ t.m.}$$

$$M_3 = -nE \cdot 2,6 = -1,2 \cdot 31,21 \cdot 2,6 = -97,375 \text{ t.m.} \quad \sum M \approx 0$$

mRunavi momentebis epiura ix. nax.3.9.



nax. 3.9. mrunavi momentebis epiura

sayrdeni kedlis filebis daarmatureba

monacemebi gaangariSebisaTvis:

1. vertikaluri filisaTvis;

$$M_3 = 97,38 \text{ t.m.} \quad Q_3 = 1,2 \cdot E = 1,2 \cdot 31,21 = 37,45 \text{ t}$$

2. saZirkvlis filebisaTvis;

$$M_1 = 20,61 \text{ t.m. da} \quad M_2 = 80,79 \text{ t.m.}$$

kedlis filis daarmatureba:

kveTis geometriuli parametrebi: $b=1,0 \text{ m}$; $h=0,6 \text{ m}$; $a=0,05 \text{ m}$;

$h_0=0,55 \text{ m}$; betoni mZime _ B 20 klasis ($m=250$);

$R_b=11,5 \text{ mpa}$; armatura A_T -III_C klasis ($R_s=265 \text{ mpa}$).

saangariSo mRunavi momenti $M=973,8 \text{ kn.m}$

saWiroa grZivi armaturis ganivkveTis farTobis gansazRvra.

gaangariSeba:

vamowmebT kedlis miRebul sisqes ($h=0,6 \text{ m}$).

$$bh_0R=100 \cdot 55 \cdot 9=49 \text{ 500 kg}=45 \text{ t} > 1,2 E=37,45 \text{ t.}$$

e.i. ganivi armaturis angariSi saWiro ar aris.

$$R_b \cdot \gamma_{b2} = 11,5 \cdot 0,9 = 10,35 \text{ mpa}$$

$$B_0 = \frac{973000}{10,35 \cdot 10^6 \cdot 1 \cdot 0,55^2} = 0,31 < B_R; \quad V = 0,81$$

$$A_s = \frac{973000}{365 \cdot 10^6 \cdot 0,81 \cdot 0,55} = 0,005984 \text{ m}^2 = 59,84 \text{ sm}^2$$

viRebT 10Φ28A-III ($A_s=61,58 \text{ sm}^2$).

Camagrebis kvanZSi (wertili B) saZirkvlis filis sisqes viRebT igives
- 60 sm.

saZirkvlis filis marcxena konsolisatvis:

$$B_0 = \frac{206100}{10,35 \cdot 10^6 \cdot 1 \cdot 0,55^2} = 0,066; \quad V = 0,965$$

$$A_s = \frac{206100}{365 \cdot 10^6 \cdot 0,965 \cdot 0,55} = 0,000639 \text{ m}^2 = 6,39 \text{ sm}^2$$

viRebT 10Φ12A-III ($A_s=11,31 \text{ sm}^2$).

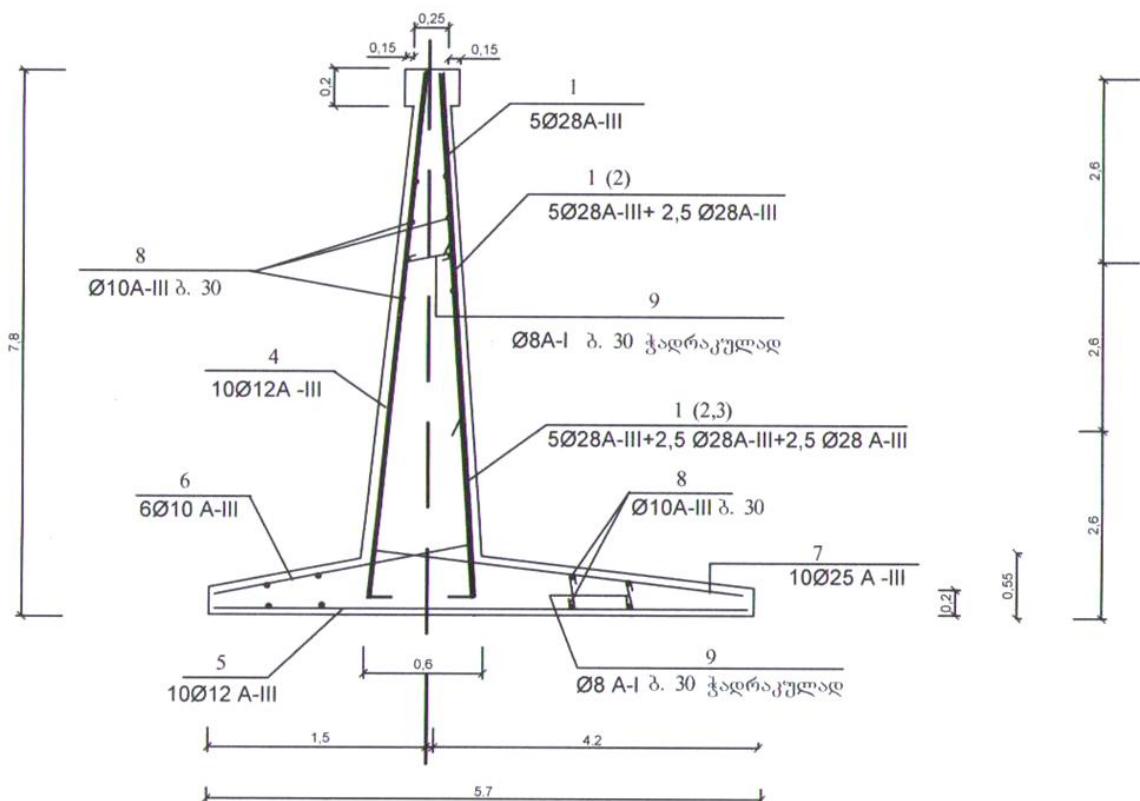
saZirkvlis filis marjvena konsolisatvis:

$$B_0 = \frac{807900}{10,35 \cdot 10^6 \cdot 1 \cdot 0,55^2} = 0,258; \quad V = 0,848$$

$$A_s = \frac{807900}{365 \cdot 10^6 \cdot 0,848 \cdot 0,55} = 0,004746 \text{ m}^2 = 47,46 \text{ sm}^2$$

viRebT 10Φ25A-III ($A_s=49,09 \text{ sm}^2$).

sayrdeni kedlis armireba ix. nax. 3.10.



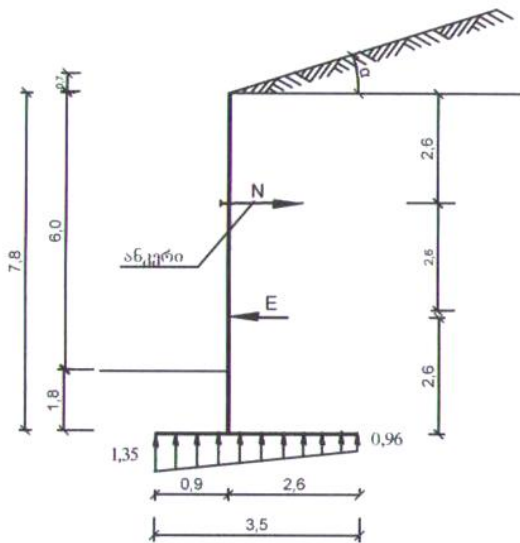
nax. 3.10. sayrdeni kedlis daarmatureba

3.4. tradiciuli monoliTuri rkinabetonis ankerebiani sayrdeni kedlis gaangariSeba

3.4.1. grunti-mSrali qviSnari

monacemebi gaangariSebisaTvis, saZirkvlis filis zomebis dadgena da saZirkvlis filaze gruntis dawnevis masebi ix. otradiciuli monoliTuri rkinabetonis uankero sayrdeni kedlebis gaangariSeba (§3.3 nax.3.5).

kedlis konstruqciul sqemas eqneba Semdegi saxe (nax. 3.11.).



$$E = 18.2 \text{ t}$$

$$N = \frac{E}{2} = 9,1 \text{ t}$$

nax. 3.11

gansaxilvel variantSi ankeris arsebobis gamo kedlis Semowmebas gadabrunebase ar vasrulebT.

kedlis Semowmeba Zvraze (mosrialebaze).

$$T = fn \sum P_i = 19.5 > t > nN = 1,2 \cdot 9,1 = 10,9 \text{ t}$$

e.i. gvakmayofilebs saZirkvlis filis naangariSevi.

zomebi: $b_1=0,9 \text{ m}$; $b_2=2,6 \text{ m}$; $b_3=3,5 \text{ m}$.

sayrdeni kedlis statikuri gaangariSeba.

konstrukcia warmoadgens statikurad erTxel urkvev sistemas.

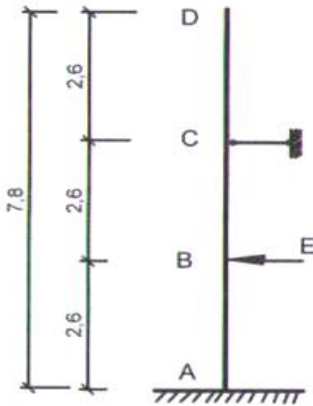
$$E = 18.2 \text{ t} \quad N = \frac{E}{2} = ? \text{ t}$$

kedlis saangariSo sqema, ZiriTadi sistema da mRunavi momentebis epiura ix. nax.3.12.

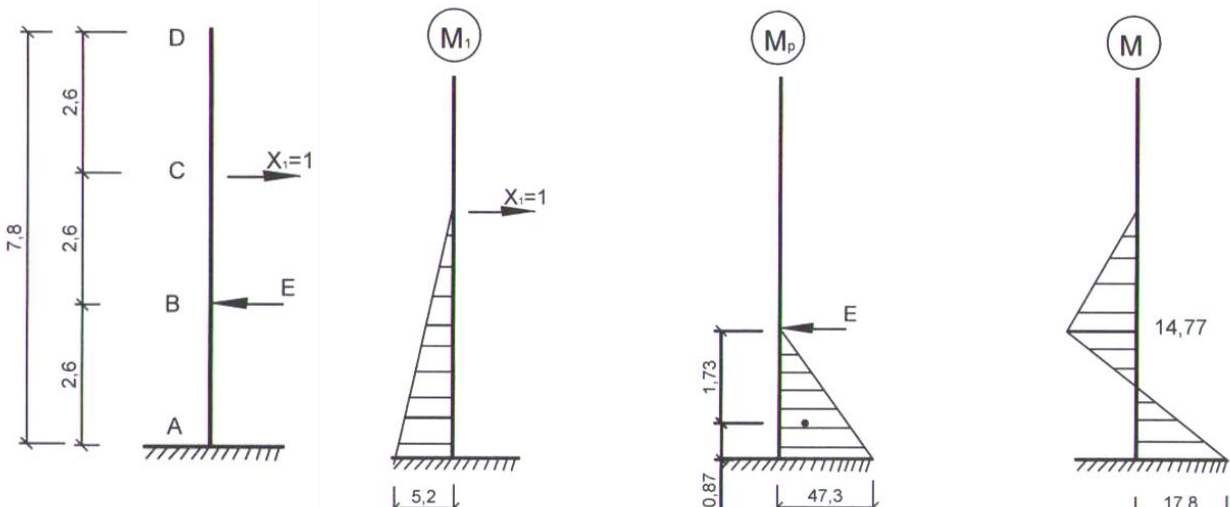
saangariSo sqema

$$\sigma_{11} x_1 + \Delta_{1p} = 0$$

$$x_1 = -\frac{\Delta_{1p}}{\sigma_{11}}$$



ZiriTadi sistema



max.3.12.

$$M_1 = 5,2 \cdot 1 = 5,2 \quad M_p = 2,6 \cdot E = 2,6 \cdot 18,2 = 47,3 \text{ t.m.}$$

$$\sigma_{11} = \frac{5,2 \cdot 5,2}{2} \cdot 5,2 \cdot \frac{2}{3} = 46,87$$

$$\Delta_{1p} = \frac{47,3 \cdot 2,6}{2} \cdot 4,33 = 266,3$$

$$x_1 = N = -\frac{266,3}{46,87} = 5,6 \text{ t}$$

jamuri momentebi:

$$M_D = 0; \quad M_c = 0; \quad M_B = \frac{5,2}{2} \cdot 5,68 = 14,77 \text{ t.m.}$$
$$M_A = 5,2 \cdot 5,68 - 47,3 = -17,80 \text{ t.m.}$$

fuZis gruntis simtkicis Semowmeba

$$M = -M_0 + \sum P_i a_i = -17,82 + 1,62 \cdot 0,88 + 36,1 \cdot 0,45 - 2,9 \cdot 1,3 = -3,96 \text{ t.m.}$$

wneva gruntze:

$$\sigma = \frac{40,6}{1,0 \cdot 3,5} \pm \frac{6 \cdot 3,96}{1 \cdot 3,5^2} = 11,6 \pm 1,94$$

$$\sigma_{\max} = 13,54 \text{ t/m}^2 = 1,35 \text{ kg/sm}^2 < R^\sigma = 3,0 \text{ kg/sm}^2$$

$$\sigma_{\min} = 9,66 \text{ t/m}^2 = 0,96 \text{ kg/sm}^2$$

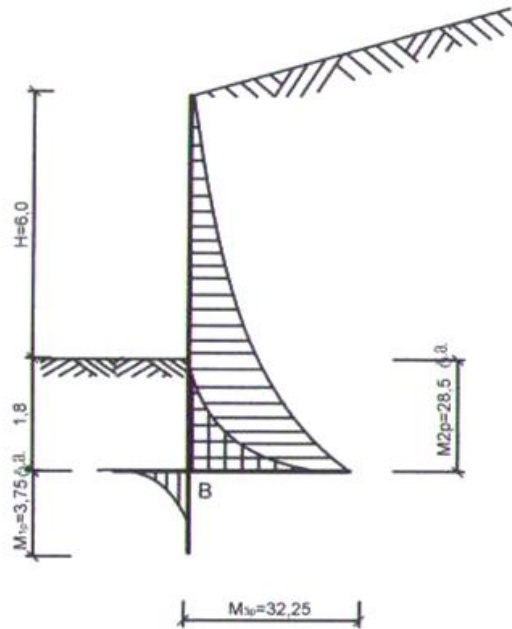
sayrdeni kedlis filebis gaangariSeba simtkiceze

$$M_1 = F_1 \cdot 0,46 - 1,2 \cdot 2,9 \cdot 0,45 = \frac{1,35 + 1,22}{2} \cdot 0,9 \cdot 0,46 - 1,57 = 3,75 \text{ t.m.}$$

$$M_2 = nP_1 \cdot 1,73 + nP_2 \cdot 1,3 - F_2 \cdot 1,25 = 1,2 \cdot 1,62 \cdot 1,73 + 1,2 \cdot 36,1 \cdot 1,3 - \frac{12,2 + 9,6}{2} \cdot 1,1 \cdot 2,6 = 28,5 \text{ t.m.}$$

$$M_3 = (M_1 + M_2) = -32,25 \text{ t.m.}$$

mRunavi momentis epiura ix. nax. 3.13.



nax. 3.13. mRunavi momentebis epiura

sayrdeni kedlis filebis daarmatureba

monacemebi gaangariSebisaTvis:

1. kedlis filisaTvis:

$$M_3 = 32,25 \text{ t.m}; \quad Q_3 = 1,2 \cdot N = 1,2 \cdot 18,2 = 21,84 \text{ t}$$

2. saZirkvlis filebisaTvis:

$$M_1 = 3,75 \text{ t.m.} \quad \text{da} \quad M_2 = 28,5 \text{ t.m.}$$

kedlis filis daarmatureba

kveTis geometriuli parametrebi: $b=1,0 \text{ m}$; $h=0,4 \text{ m}$; $a=0,05 \text{ m}$; $h_0=0,35 \text{ m}$; betoni mZime B20 klasis; ($R_b=11,5 \text{ mpa}$); armatura A-T-III C klasis ($R_s=365 \text{ mpa}$).

$$bh_0R_g=100 \cdot 35 \cdot 9=31500 \text{ kg}=31.5 \text{ t} > Q=21,84 \text{ t};$$

$$R_b \gamma_{b2} = 11,5 \cdot 0,9 = 10,35 \text{ mpa}$$

$$B_0 = \frac{322500}{10,35 \cdot 10^6 \cdot 1 \cdot 0,35^2} = 0,254; \quad V = 0,85$$

$$A_s = \frac{322500}{365 \cdot 10^6 \cdot 0,85 \cdot 0,35} = 29,7 \text{ sm}^2$$

$$\text{viRebT: } 10 \Phi 20 \text{ A-III} \quad (A_s=31,42 \text{ sm}^2).$$

saZirkvlis filis marcxena mxarisaTvis: $M_1=3,75 \text{ t.m.}$

$$B_0 = \frac{37500}{10,35 \cdot 10^6 \cdot 1 \cdot 0,35^2} = 0,03; \quad V = 0,985$$

$$A_s = \frac{37500}{365 \cdot 10^6 \cdot 0,985 \cdot 0,35} = 2,3 \text{ sm}^2$$

$$\text{viRebT: } 5 \Phi 12 \text{ A-III} \quad (A_s=5,65 \text{ sm}^2).$$

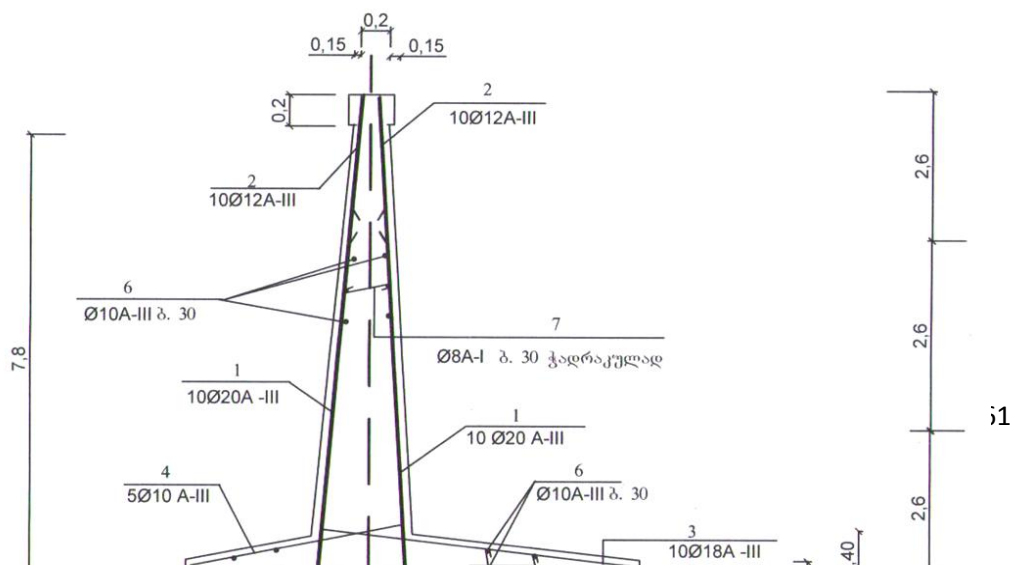
saZirkvlis filis marjvena mxarisaTvis: $M_2=28,5 \text{ t.m.}$

$$B_0 = \frac{285000}{10,35 \cdot 10^6 \cdot 1 \cdot 0,35^2} = 0,225; \quad V = 0,87$$

$$A_s = \frac{185000}{365 \cdot 10^6 \cdot 0,87 \cdot 0,35} = 25,6 \text{ sm}^2$$

$$\text{viRebT: } 10 \Phi 18 \text{ A-III} \quad (A_s=25,45 \text{ sm}^2).$$

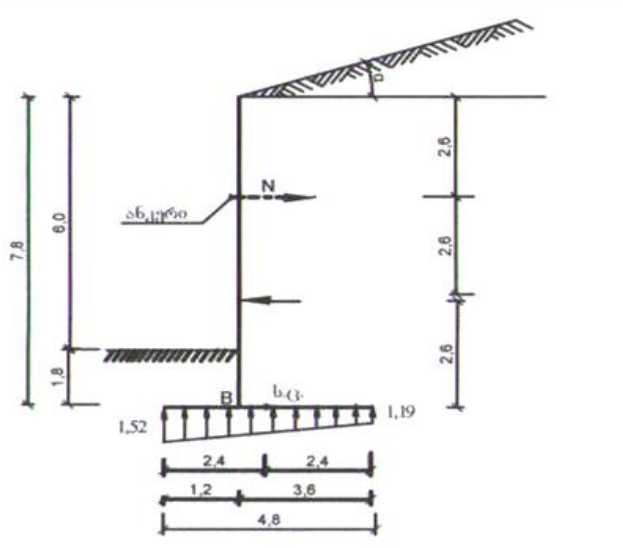
sayrdeni kedlis daarmatureba ix. nax. 3.14.



nax. 3.14. sayrdeni kedlis daarmatureba.

3.4.2. grunti-wyalnajeri Tixnari

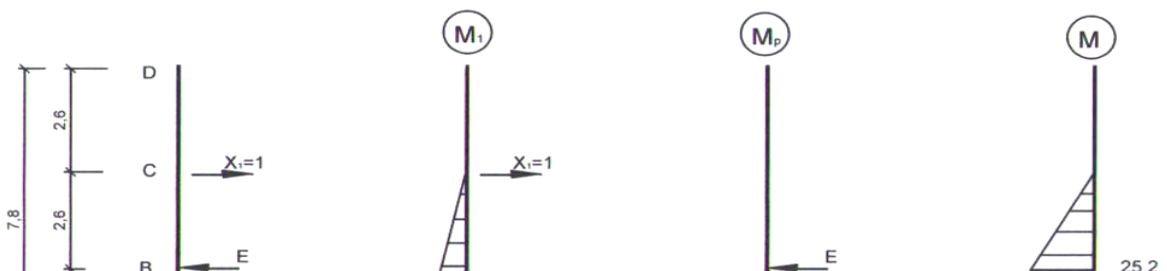
monacemebi gaangariSebisaTvis filis zomebis dadgena da filaze gruntis dawneva masebi ix. uankero sayrdeni kedlebis gaangariSeba (§3.3. nax.3.5.).kedlis konstruqciul sqema ix. nax. 3.15.



nax. 3.15. sayrdeni kedlis konstruqciul sqema

kedlis statikuri gaangariSeba.

konstruqcia warmoadgens erTxel statikurad urkvev sistemas. misi ZiriTadi sistema da mRunavi momentebis epiurebi ix. nax. 3.16.



max. 3.16

$$\sigma_{11} = \frac{5,2 \cdot 5,2}{2} \cdot 5,2 \cdot \frac{2}{3} = 46,87 \quad \Delta_{ip} = \frac{81,15 \cdot 2,6}{2} \cdot 4,33 = 456,8 \quad x_1 = 9,7 \text{ t}$$

jamuri momentebi:

$$M_0=0; \quad M_c=0; \quad M_B=2,6 \cdot 9,7=25,2 \text{ t.m.} \quad M_A = 5,2 \cdot 9,7 - 81,15 = -30,7 \text{ t.m.}$$

SevamowmoT piroba: $M_d > MM_g$

$$M_g=1,2 (N \cdot 5,2 - E \cdot 2,6)=1,2(9,7 \cdot 5,2 - 31,21 \cdot 2,6)=-1,2 \cdot 30,6 \text{ t.m.}=-36,84 \text{ t.m.}$$

kedlis Semowmeba Zvradobaze

$$T = fn \sum P_i = 0,4 \cdot 0,8 \cdot 64,9 = 20,8 \text{ t} \quad > nN = 1,2 \cdot 9,7 = 11,6 \text{ t}$$

gruntSi Zabvebis gansazRvra:

$$M = -36,84 + 3,51 \cdot 1,2 + 57,0 \cdot 0,6 - 4,38 \cdot 1,8 = -6,34 \text{ t.m.}$$

$$\sigma = \frac{64,9}{1 \cdot 4,8} \pm \frac{6 \cdot 6,34}{1 \cdot 4,8^2} = 13,52 \pm 1,65$$

$$\sigma_{\max} = 1,52 \text{ kg/sm}^2 < R^6 = 1,8 \text{ kg/sm}^2;$$

$$\sigma_{\min} = 1,19 \text{ kg/sm}^2$$

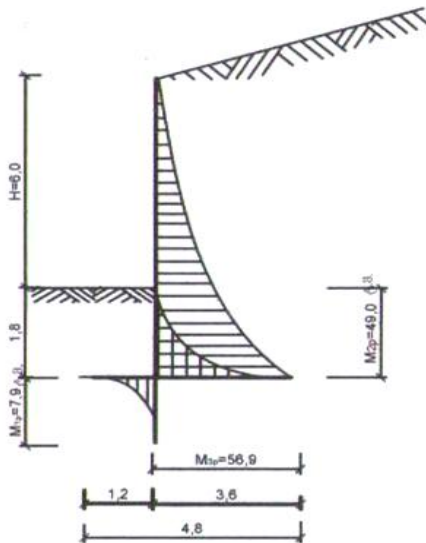
mRunavi momentebi B wertilis mimarT

$$M_1 = F_1 \cdot 0,6 - nP_3 \cdot 0,6 = \frac{15,2 + 14,4}{2} \cdot 1,2 \cdot 0,62 - 4,38 \cdot 1,2 \cdot 0,6 = 7,85 \text{ t.m.} \approx 7,9 \text{ t.m.}$$

$$M_2 = 3,51 \cdot 2,4 \cdot 1,2 + 57,0 \cdot 1,2 \cdot 1,8 - \frac{14,4 + 11,9}{2} \cdot 3,6 \cdot 1,78 = 48,96 \text{ t.m.} \approx 49,0 \text{ t.m.}$$

$$M_3 = 56,85 \text{ t.m.} \approx 56,9 \text{ t.m.}$$

mRunavi momentebi



nax. 3.17.

sayrdeni kedlis daarmatureba

monacemebi gaangariSebisaTvis:

1. kedlis filisaTvis:

$$M_3 = 56,9 \text{ t.m}; \quad Q_3 = 1,2 \cdot N = 1,2 \cdot 9,7 = 11,64 \text{ t}$$

2. saZirkvlis filisaTvis:

$$M_1 = 7,9 \text{ t.m.} \quad \text{da} \quad M_2 = 49,0 \text{ t.m.}$$

kedlis filis daarmatureba:

kveTis geometriuli parametrebi: $b=1,0 \text{ m}$; $h=0,45 \text{ m}$; $a=0,05 \text{ m}$; $h_0=0,4 \text{ m}$; betoni mZime B20 klasis; ($R_b=11,5 \text{ mpa}$); armatura A_T-III C klasis ($R_s=265 \text{ mpa}$).

nax. 3.18. sayrdeni kedlis daarmatureba

Tavi 4

SemoTavazebuli mewyersawinaaRmdago gruntulankerebiani kombinirebuli sistemebis variantebis gaangariSeba

4.1. gruntulankerebiani kombinirebuli sistemis optimaluri konstruqciuli gadawyvetis dadgena

SemoTavazebuli kombinirebuli sistemis optimaluri konstruqciuli gadawyvetis dadgenis mizniT ganxiluli gvaqvs misi Semdegi gadawyvetebi:

1. rkinabetonis monoliTuri Spunturi sayrdeni kedeli mis zeda nawilSi ganTavsebuli gruntuli ankeriT;
2. saZirkvelSi xistad Camagrebuli kedeli mis zemo nawilSi ganTavsebuli gruntuli ankeriT;
3. saZirkvelSi xistad Camagrebuli kedeli 2 iarusad ganTavsebuli gruntuli ankerebiT, kedelze dawnevis tolqmedis (E) modebis wertilidan sxvadasxva manZilze;
4. saZirkvelSi saxsrovnad Camagrebuli kedeli erT iarusad ganTavsebuli gruntuli ankerebiT mis zemo nawilSi;
5. saZirkvelSi saxsrovnad Camagrebuli kedeli 2 iarusad ganTavsebuli, E Zalis modebis wertilidan sxvadasxva manZilze mowyobili gruntuli ankerebiT;
6. saZirkvelSi saxsrovnad Camagrebuli, 2 iarusad ganTavsebuli, E Zalis modebis wertilidan erTnair manZilze mowyobili gruntuli ankerebiT.

mogvaqvs sayrdeni kedlebis zemoaRniSnuli SesaZlo konstruqciuli gadawyvetebiT gaangariSebebis Sedegebi:

_ Spunturi sayrdeni kedeli:

kedlis simaRle davuSvaT $H=6,0$ m; grunti wyalnajeri Tixnari ($\gamma=1,9t/m^3$); kedelze gruntis dawnevis tolqmedi $E=28,0$ t (ix. Tavi 2); kedlis zeda wertilSi ganTavsebulia gruntuli ankeri.

imis gaTvaliswinebiT, rom E Zala modebulia kedlis Ziridan $H/3$ manZilze (anu Cvens magaliTSi – 2 m-ze), kedlis Zvris (mocurebis) Zala toli iqneba $T = 28 \cdot \frac{2}{3} = 18,7$ t, romelic unda gaawonasworos gruntma, anu daculi unda iqnes piroba $0,5 \cdot \gamma h^2 \geq 18,7$ t, saidanac sayrdeni kedlis gruntuli nawilis simaRle iqneba:

$$h^2 = \frac{18,7}{0,5 \cdot 1,9} = 19,68 \quad \text{da} \quad h = 4,4 \text{ m.} \quad \text{rac Zalian didia.}$$

_ saZirkvelSi xistad Camagrebuli kedeli mis zemo nawilSi ganTavsebuli gruntuli ankeriT: masiuri saZirkvlis mowyobis aucilebloba sayrdeni kedlis Zvris (mocurebis) sawinaaRmdegod.

_ saZirkvelSi xistad Camagrebuli kedeli 2 iarusad ganTavsebuli gruntuli ankerebiT, kedelze dawnevis tolqmedis (E) modebis wertilidan sxvadasxva manZilze:

aseT SemTxvevaSi, marTalia, ar iqneba masiuri saZirkvlis mowyobis aucilebloba, magram E Zalis modebis wertilidan gruntuli ankerebis sxvadasxva manZilze ganTavsebis gamo, kedlis wonasworobisaTvis saWiro iqneba gruntul ankerebSi aRZruli gamWimavi Zalvebis gakontroliba, rac dakavSirebulia garkveul sirTuleebTan.

_ saZirkvelSi saxsrovnad Camagrebuli kedeli erT iarusad ganTavsebuli gruntuli ankerebiT mis zemo nawilSi:

aseTi gadawyveta gamoiwvevs masiuri saZirkvlis mowyobis aucileblobas Zvris Zalebis gamo;

_ saZirkvelSi saxsrovnad Camagrebuli kedeli 2 iarusad ganTavsebuli, E Zalis modebis wertilidan sxvadasxva manZilze mowyobili gruntuli ankerebiT.

uaryofiTi mxare igive, rac iyo me-3 variantSi.

_ saZirkvelSi saxsrovnad Camagrebuli, 2 iarusad ganTavsebuli, E Zalis modebis wertilidan erTnair manZilze mowyobili gruntuli ankerebiT. aseT SemTxvevaSi: ar iqneba saWiro masiuri saZirkveli; Semcirdeba mRunavi momentis mniSvnelobebi kedlis ganivkveTebSi; dafiqsirebuli

iqneba gamWimavi Zalvebis mniSvnelobebi gruntul ankerebSi $\left(N = \frac{E}{2} \right)$.

gamomdinare zemoaRniSnulidan, ganxilul konstruqciul gadawyvetebis Soris optimaluria es ukanaskneli gadawyveta, romelic safuZvlad daedo SemoTavazebuli mewyersawinaaRmdego

sistemebis konstruqciul gaangariSebas.sayrdeni kedlebis konstruqciul gadawyvetas eqneba nax. 4.1-ze mocemuli saxe.

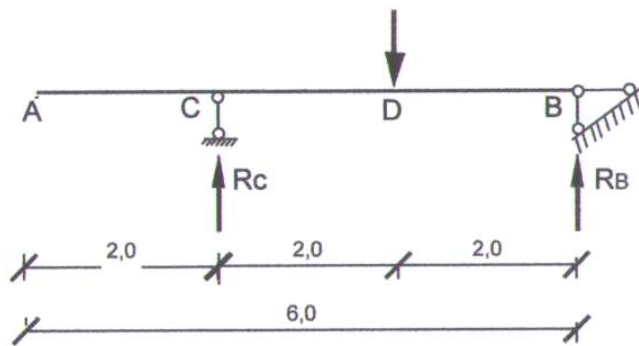
nax. 4.1. sayrdeni kedlis konstruqciuli sqema.

xolo nax. 4.2-ze mocemulia sayrdeni kedlis saangariSo sqema. gamWimavi Zalvebi gruntuli ankerebis mWimebSi

$$N = R_C = R_B = \frac{E}{2}$$

xolo maqsimaluri mRunavi momentis mniSvneloba D wertilSi $M_{\text{maqs}} = 2N$

(maqsimaluri mRunavi momentis gansazRvrisas sayrdeni kedlis konsolur nawilSi gruntis dawnevas vugulvelyof



nax.4.2. sayrdeni kedlis saangariSo sqema.

svvadasxva gruntuli pirobebisaTvis gveqneba:

_ mSrali qviSnarisaTvis:

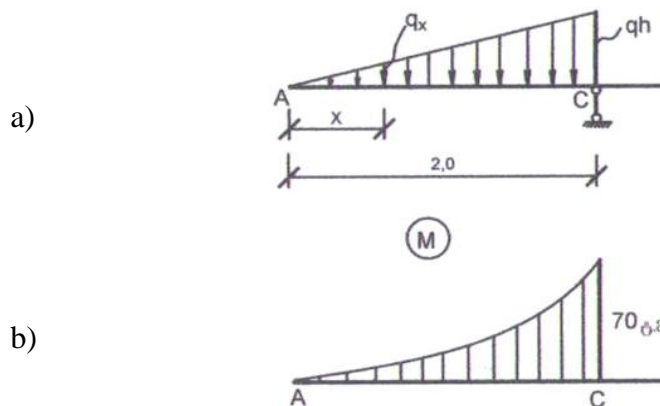
$$N = \frac{11 \cdot 84}{2} = 5,9 \text{ t}; \quad \text{da} \quad M_{\text{maqs}} = 11,8 \text{ m.}$$

_ wyalnajeri TixnarisaTvis:

$$N = \frac{28}{2} = 14 \text{ t} \quad \text{da} \quad M_{\text{maqs}} = 14 \cdot 2 = 28 \text{ t.m.}$$

sayrdeni kedlis zeda mesamedze (nax. 4.2. ubani AC), rogorc konsolze, maqşimaluri mRunavi momentis mniSvneloba tolia (nax. 4.3.).

$$M_x = \frac{\gamma^2 h^2 X^3}{12} \quad \text{da} \quad M_{\text{maqs}} = M_C = \frac{1,62 \cdot 2^2 \cdot 2^3}{12} = 7 \text{ t.m.}$$



nax. 4.3. sayrdeni kedlis konsoluri nawili.

a) _ saangariSo sqema; b) _ mRunavi momentebis epiura

4.2. monoliTuri rkinabetonis lenturi sayrdeni kedlebis gaangariSeba (kedlis erTi grZivi metrisaTvis)

4.2.1. wyalnajeri Tixnaris SemTxvevisaTvis

monacemebi gaangariSebisaTvis

kveTis geometriuli parametrebi: $b=1,0 \text{ m}$; $h=0,2 \text{ m}$; $a=0,05 \text{ m}$; $h_0=0,15 \text{ m}$; betoni mZime B 20 klasis ($m = 250$); $R_b=11,5 \text{ mpa}$; armatura SA_T-IIIC klasis ($R_s=365 \text{ mpa}$). saangariSo mRunavi momenti $M=280 \text{ kn.m}$.

saWiroa grZivi armaturis ganivkveTis farTobis gansazRvra.

gaangariSeba

B 20 klasis betonisaTvis $\gamma_{b2} = 0,9$ koeficientis gaTvaliswinebiT

$$R_b \gamma_{b2} = 11,5 \cdot 0,9 = 10,35 \text{ mpe}$$

vsazRvravT B₀-is mniSvnelobas formuliT:

$$B_0 = \frac{M}{R_b b h_0^2} = \frac{280000}{10,35 \cdot 10^6 \cdot 1 \cdot 0,15^2} = 1,2 > B_R = 0,413$$

amitom vzrdiT kedlis sisqes da vRebulobT h=0,35 m

maSin:

$$B_0 = \frac{280000}{10,35 \cdot 10^6 \cdot 1 \cdot 0,3^2} = 0,32 < B_R$$

radgan B₀=0,3<B_R, SekumSuli armatura angariSiT saWiro ar aris.

$$\text{roca } B B_0 = 0,3 \quad V = 0,815$$

armaturis saWiro farTobi:

$$A_s = \frac{M}{R_s \cdot V \cdot h_0} = \frac{280000}{365 \cdot 10^6 \cdot 0,815 \cdot 0,3} = 0,0031375 \text{ m}^2 = 31,38 \text{ sm}^2$$

viRebT: 10 Φ 20 A-III (A_s=31,42 sm²).

biji _ 100:6≈17 sm.

A-C ubnis daarmatureba.

M=7 t.m. kedlis sisqes vtovebT igives.

$$B_0 = \frac{70000}{10,35 \cdot 10^6 \cdot 1 \cdot 0,3^2} = 0,075 \quad V = 0,96$$

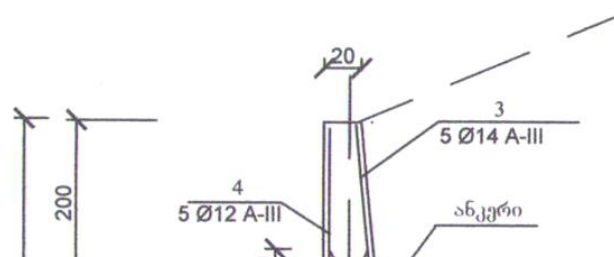
$$A_s = \frac{7}{365 \cdot 10^6 \cdot 0,96 \cdot 0,3} = 0,06659 \text{ m}^2 = 6,66 \text{ sm}^2$$

viRebT: 5 Φ 14 A-III (A_s=7,7 sm²).

biji _ 100:6≈17 sm.

kedlis daarmatureba ix. nax. 4.4.

(kedels vuwyobT saZirkvels konstruqiulad)



max.4.4. lenturi sayrdeni kedlis daarmatureba wyalnajeri Tixnaris SemTxvevisaTvis.

4.2.2. mSrali qviSnaris (qviSis) SemTxvevisaTvis

monacemebi gaangariSebisaTvis:

gruntis dawneva $E=11,84$ t 1 grZ. metrze.

$$N = \frac{E}{2} = \frac{11,84}{2} = 5,92 \approx 5,9 \text{ t}$$

maqsimumi mRunavi momenti $M_D=-2N=-2 \cdot 5,9=11,8$ t.m.

kedlis sisqe $b=25$ sm. betoni mZime B20 klasis (m 250); $R_b=11,5$ mpa; armatura SA_T-IIIC klasis ($R_s=365$ mpa).

saWiroa grZivi armaturis ganivkveTis farTobis gansazRvra.

gaangariSeba

B 20 klasis betonisaTvis $\gamma_{b2} = 0,9$ koeficientis gaTvaliswinebiT

$$R_b \gamma_{b2} = 11,5 \cdot 0,9 = 10,35 \text{ mp}\epsilon$$

vsazRvravT B_0 -is mniSvnelobas formuliT:

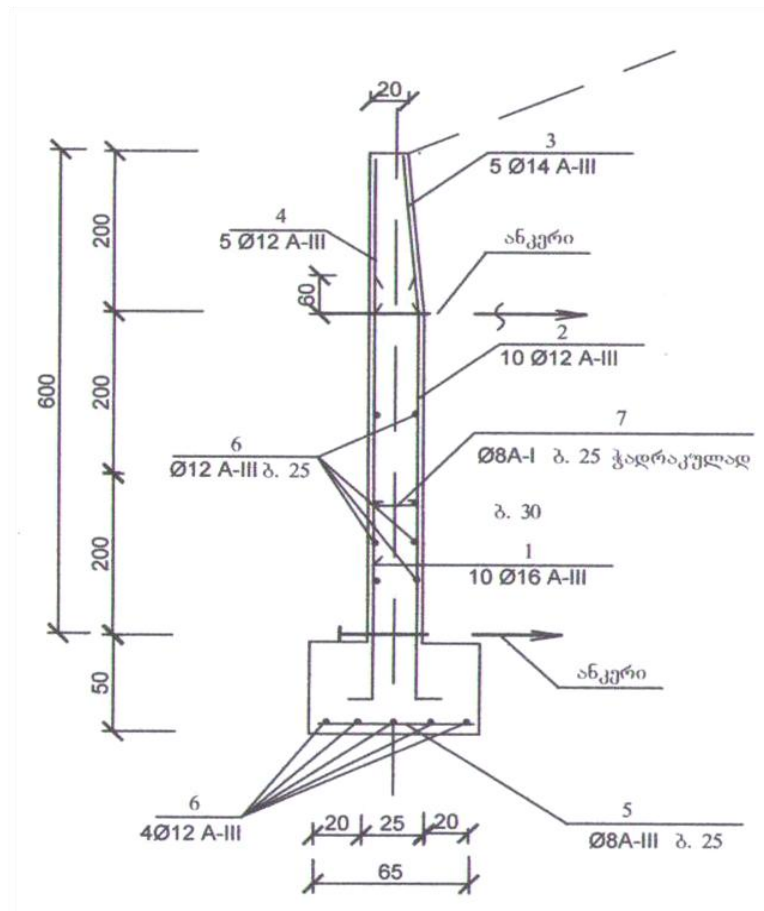
$$B_0 = \frac{M}{R_b b h_0^2} = \frac{118000}{10,35 \cdot 10^6 \cdot 1 \cdot 0,2^2} = 0,285 < B_R$$

e.i. SekumSuli armaturis angariSi saWiro ar aris $V=0,825$

$$A_s = \frac{118000}{365 \cdot 10^6 \cdot 0,825 \cdot 0,2} = 0,00195932 \text{ m}^2 = 19,59 \text{ sm}^2$$

viRebT: 10 $\Phi 16$ A-III (As=20,11 sm²).

A-Cubnis daarmaturebas viRebT, rogorc wina SemTxvevaSi. saZirkvels vawyobT konstruqciulad kedlis daarmatureba ix. nax. 4.5.



nax. 4.5. lenturi sayrdeni kedlis daarmatureba mSrali qviSnaris SemTxvevisaTvis.

4.3. svetebiani sayrdeni kedlebis gaangariSeba

4.3.1. wyalnajeri Tixnaris SemTxvevisaTvis

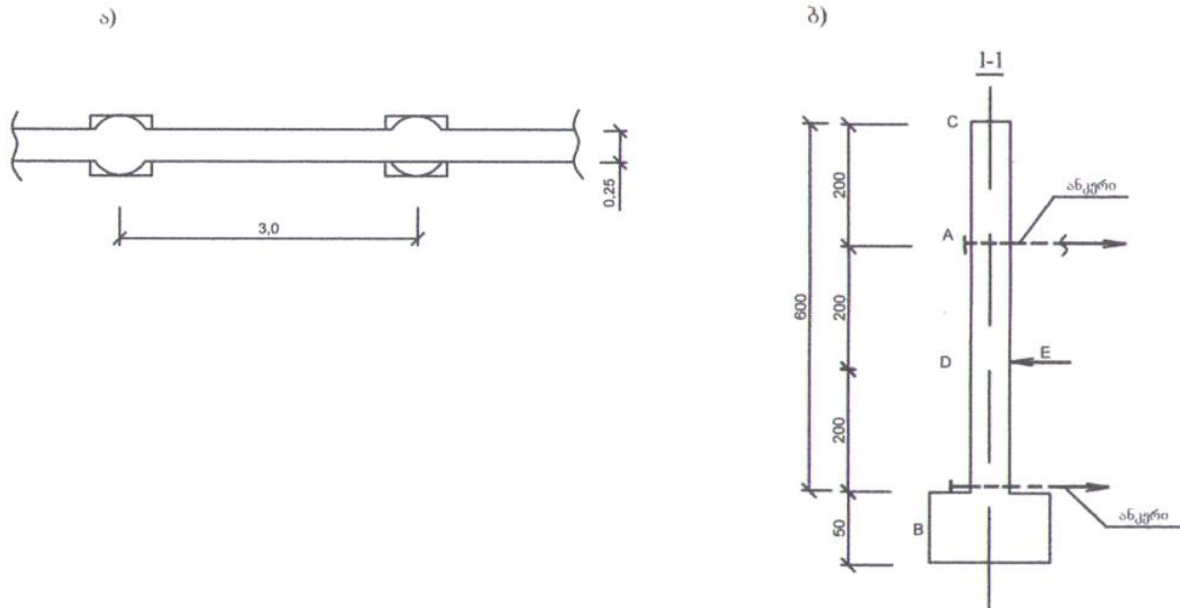
monacemebi gaangariSebisaTvis:

svetebis biji davuSvaT 3 m;

maSin 1 svetze

$$M_{\text{maqS}} = 28 \cdot 3 = 84 \text{ t.m.}$$

sveti miviRoT wriuli kveTis $d=50$ sm. kedlebi miviRoT sisqiT 25 sm davamuSaoT rogorc koWovani fila _ svetebzeE xisti mimagrebiT. sayrdeni kedlis konstruqciuli gadawyveta ix. nax. 4.6.



nax.4.6. svetebiani sayrdeni kedeli
a) gegmis fragmenti; b) Wriuli 1-1.

mRunavi momentebi tolia:

$$M_D = -2N = -3 \cdot 28 = 84 \text{ t.m.}$$

$$M_A = 21 \text{ t.m}$$

1. svetis gaangariSeba.

monacemebi gaangariSebisaTvis

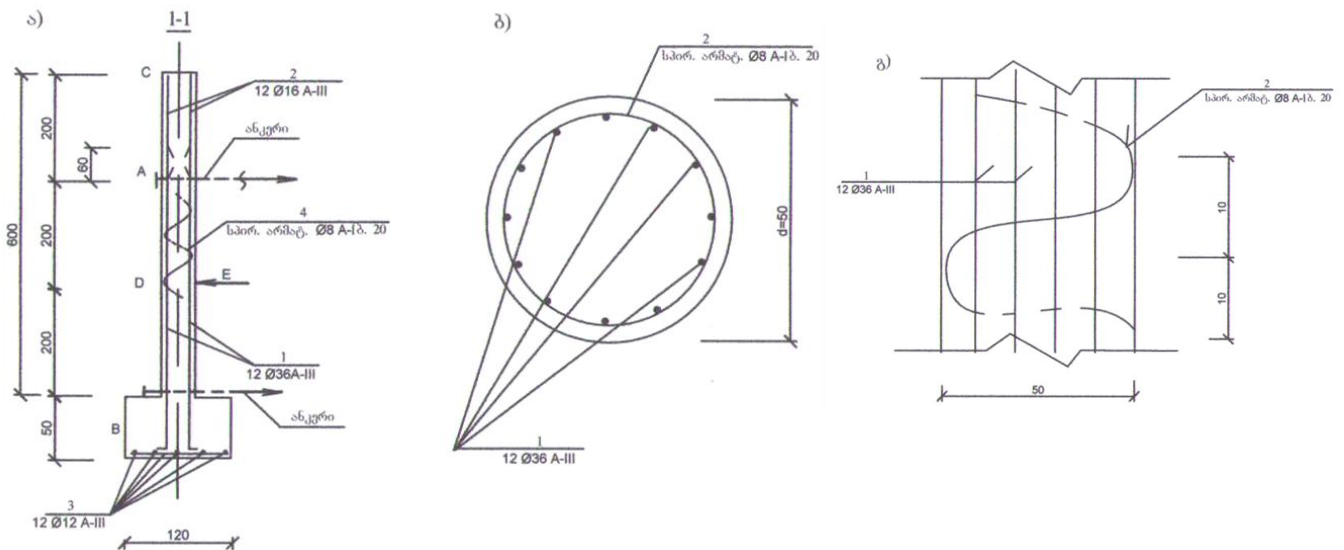
kveTis geometriuli parametrebi: $d=50\text{sm}$; $a=0,05 \text{ m}$; $h_0=0,45 \text{ m}$; betoni mZime B20 klasis ($m 250$); $R_b=11,5 \text{ mpa}$; armatura SA_T-III klasis ($R_s=365 \text{ mpa}$). saangariSo mRunavi momenti $M=840 \text{ kn.m}$.

kompiuteruli gaangariSebis (dananTi 1) muSa armaturis ganivkveTis farTobi miRebulia 121 sm^2 DwertilisaTvis, xolo maqsimumi gadaadgilebebi: C wertilSi _ $13,9 \text{ mm}$ da D wertilSi _ $10,5 \text{ mm}$, rac norme bis farglebSia:

$$f \approx [f] = \frac{H}{500} = \frac{600}{500} = 1,2 \text{ sm} = 12 \text{ mm}$$

muSa armatura miviRoT $12 \Phi 36 \text{ A-III}$ ($A_s=122,14 \text{ sm}^2$).

svetis daarmatureba ix. nax. 4.7.



nax. 4.7. svetis daarmatureba

- a) grZivi Wrili; b) ganivi Wrili
g) grZivi Wrilis fragmenti.

2. kedlis gaangariSeba

kedlis gegmis fragmenti ix. nax.

kedlis qveda boloze gruntis dawnevis epiuris ordinata tolia (nax.)

$$\gamma h = 1,9 \cdot 6 = 11,4 \text{ t}$$

kedels vangariSobT rogorc svetebSi xistad Camagrebul koWovan filas.

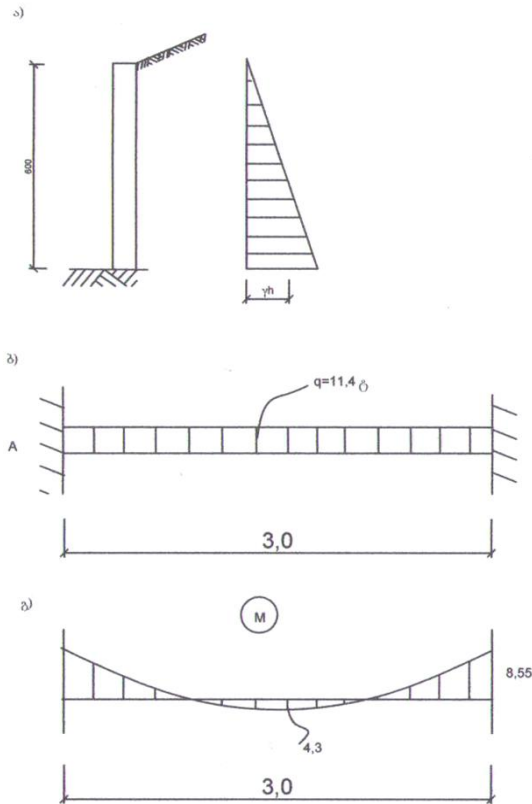
mis saangariSo sqemas eqneba aseTi saxe (nax.4.8)

momenti sayrdenze:

$$M_s = \frac{ql^2}{12} = \frac{11,4 \cdot 9}{12} = 8,55 \text{ t.m.}$$

momenti malSi

$$M_m = \frac{ql^2}{24} = 4,3 \text{ t.m.}$$



nax. 4.8. kedlis gaangariSebisaTvis

a) kedelze gruntis dawnevis epiura; b) kedlis saangariSo sqema; g) mRunavi momentebis epiura.

monacemebi gaangariSebisaTvis:

kveTis geometriuli parametrebi: $b \times h = 100 \times 25 \text{ cm}$; $a = 0,05 \text{ m}$; $h_0 = 0,45 \text{ m}$; betoni mZime B20 klasis (m 250); $R_b = 11,5 \text{ mpa}$; armatura SA_T-IIIC klasis ($R_s = 365 \text{ mpa}$). saangariSo mRunavi momenti sayrdenze $M = 85,5 \text{ kn.m}$.

gaangariSeba:

$$R_b \gamma_{b2} = 11,5 \cdot 0,9 = 10,35 \text{ mpa}$$

$$B_0 = \frac{85500}{10,35 \cdot 10^6 \cdot 100 \cdot 20^2} = 0,21 \quad V = 0,88$$

$$A_s = \frac{85500}{365 \cdot 10^6 \cdot 0,88 \cdot 0,2} = 13,3 \text{ sm}^2$$

viRebT: 10 $\Phi 14$ A-III ($A_s = 15,39 \text{ sm}^2$).

saangariSo mRunavi momenti malSi $M = 4,3 \text{ t.m.} = 43 \text{ kn.m}$.

$$A_0 = \frac{43000}{10,35 \cdot 10^6 \cdot 100 \cdot 20^2} = 0,104; \quad V = 0,945$$

$$A_s = \frac{43000}{365 \cdot 10^6 \cdot 0,945 \cdot 0,2} = 6,23 \text{ sm}^2$$

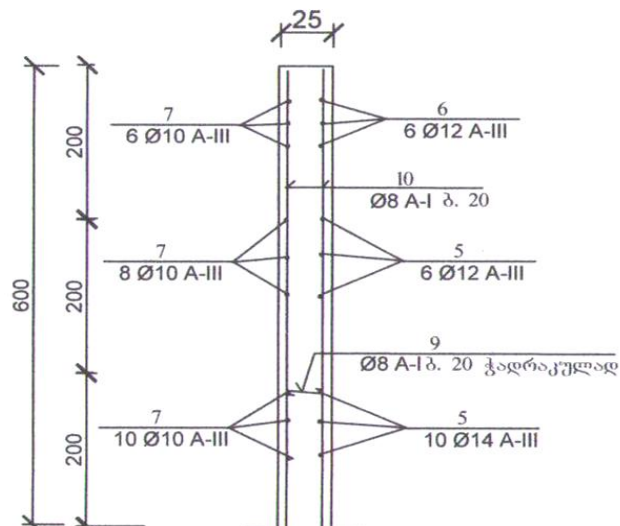
viRebT: 10 $\Phi 10$ A-III ($A_s = 7,85 \text{ sm}^2$).

aseTi armireba miRebulia kedlis fuZidan 2 m simaRleze, xolo momdevno 2 m-ze miRebulia: sayrdenze 8 $\Phi 14$ A-III

kedlis simaRlis bolo or metrze miRebulia:

sayrdenze: 6 $\Phi 12$ A-III; malSi: 6 $\Phi 10$ A-III

kedlis daarmatureba ix. nax. 4.9.



Nmax.4.9.kedlis daarmatureba

4.3.2. mSrali qviSnaris SemTxvevisaTvis

1. svetebis gaangariSeba.

svetebis biji _ 3 m; kedlis sisqe _ 20 sm; svetze moqmedi

$$M_{\text{maqs}} = 11,8 \cdot 3 = 35,4 \text{ t.m.}$$

sveti miviRoT wriuli ganivkveTis $d=40$ sm. kedlebi miviRoT sisqiT 20 sm da vamuSaoT rogorc svetebze xistad mimagrebuli koWuri fila.

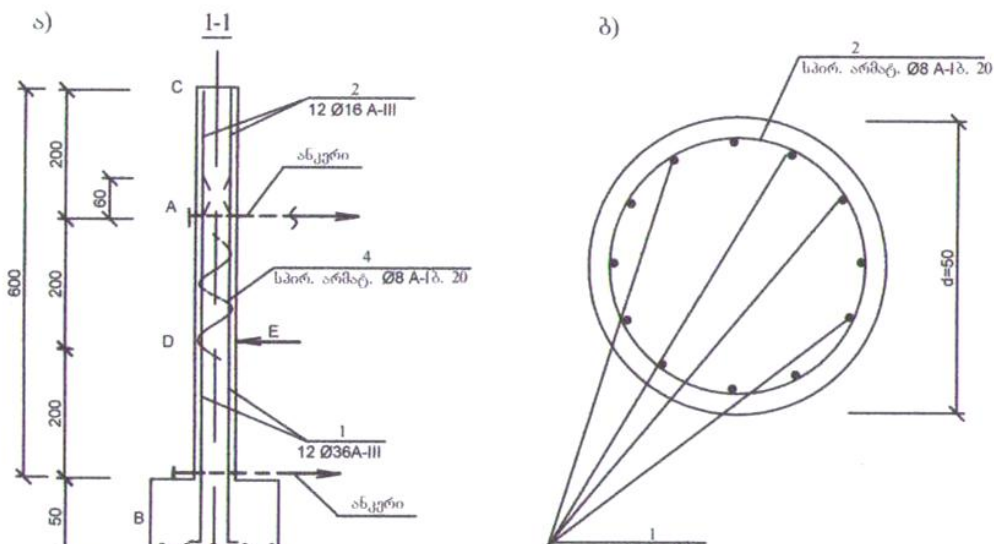
$a=0,05$ m; $h_0=0,35$ m; betoni mZime B20 klasis (m 250); $R_b=11,5$ mpa; armatura AT-III klasis ($R_s=365$ mpa). saangariSo mRunavi momenti $M=354$ kn.m.

$$R_b \gamma_{b2} = 11,5 \cdot 0,9 = 10,35 \text{ mpa}$$

kompiuteruli gaangariSebis safuZvelze (danarTi) muSa armaturis saWiro farTobi miRebulia $A_s=49,3 \text{ sm}^2$ xolo maqsimaluri gadaadgilebebi:C wertilSi _ 8 mm da DwertilSi _ 6,5 mm rac norme bis farglebSia.

muSa-armatura miRebulia 12 $\Phi 25$ A-III ($A_s=58,88 \text{ sm}^2$).

svetis daarmatureba ix. nax. 4.10.



nax. 4.10. sveltis daarmatureba

a) _ grZivi Wrili; b) _ ganivi Wrili

2. kedlis gaangariSeba

kedlis qveda boloze gruntis wnevis epiuris ordinata tolia

$$\gamma h = 1,62 \cdot 6 = 9,72 \text{ t}$$

mRunavi momenti sayrdenze (CamagrebebSi)

$$M_s = \frac{9,72 \cdot 9}{12} = 7,29 \text{ t.m.}$$

mRunavi momenti malSi

$$M_m = 3,65 \text{ t.m.} \quad \text{kedlis sisqe } _{20 \text{ sm.}}$$

sayrdenisaTvis:

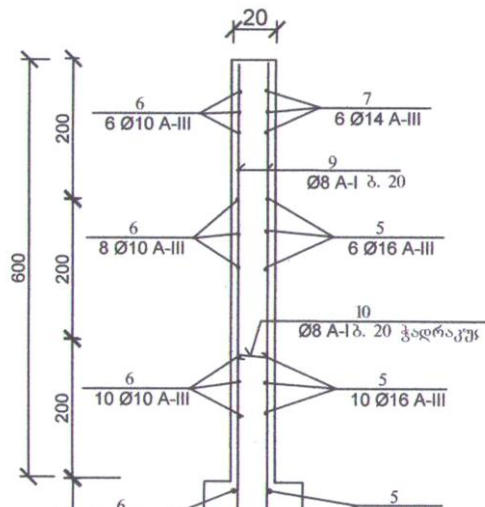
$$A_0 = \frac{72900}{10,35 \cdot 10^6 \cdot 100 \cdot 15^2} = 0,31 \quad V = 0,81$$

$$A_s = \frac{72900}{365 \cdot 10^6 \cdot 0,81 \cdot 15} = 16,44 \text{ sm}^2$$

miRebulia: 10 $\Phi 16$ A-III $A_s = 20,11 \text{ sm}^2$

malSi miRebulia: 10 $\Phi 10$ A-III

kedlis armireba ix. nax. 4.11.



max. 4.11. kedlis daarmatureba

4.4. svetebiani sayrdeni kedlis gaangariSeba B30 klasis

betonis SemTxvevaSi

4.4.1. mSrali qviSnaris SemTxvevisaTvis

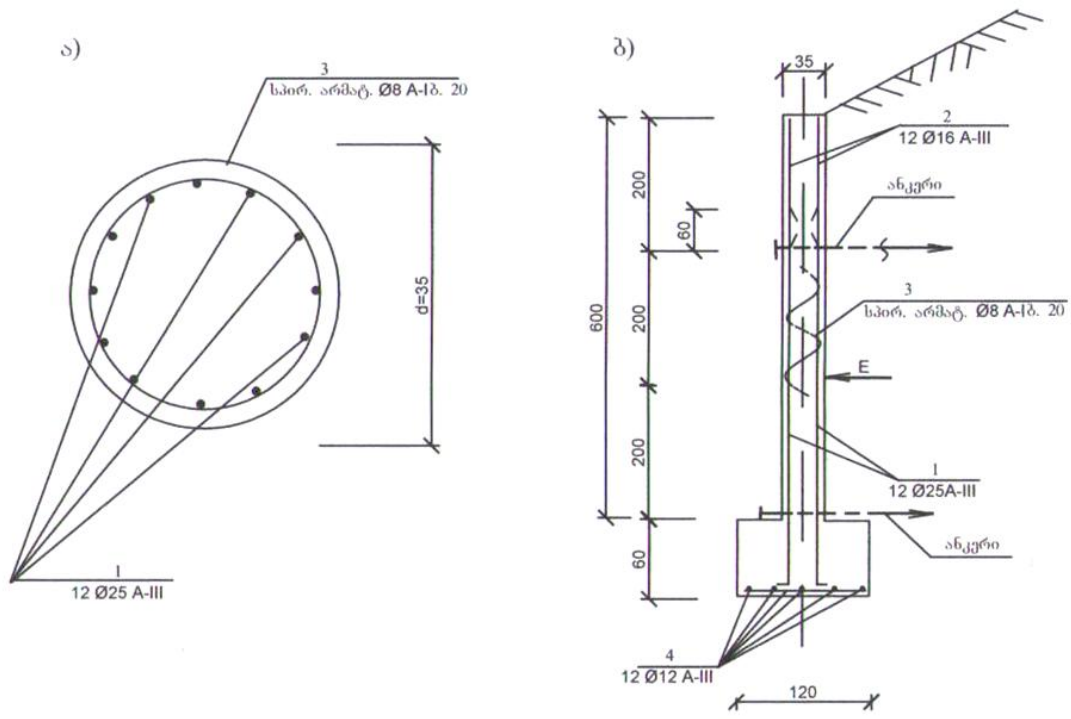
1. svetis gaangariSeba.

betoni mZime B30 klasis (m 400);

$$R_b \cdot \gamma_{b2} = 17,0 \cdot 0,9 = 15,3 \text{ mpa}$$

armatura A_T-IIIC klasis (R_S=365 mpa). saangariSo mRunavi momenti svetezbeM=11,8·3=35,4t.m. miviRoT sveti wriuli ganivkveTis d=35 sm; kedeli sisqiT 20 sm.

kompiuteruli gaangariSebis safuZvelze (dantarTi 1) miRebulia muSa- armaturis saWiro farTobi A_S=49,3 sm² da gadaadgilebebi: C wertilSi _ 11,5 mm da D wertilSi _ 9,28 mm, rac normebis farglebSia:



nax. 4.12. svetis daarmatureba

a) ganivi Wrili; b) grZivi Wrili

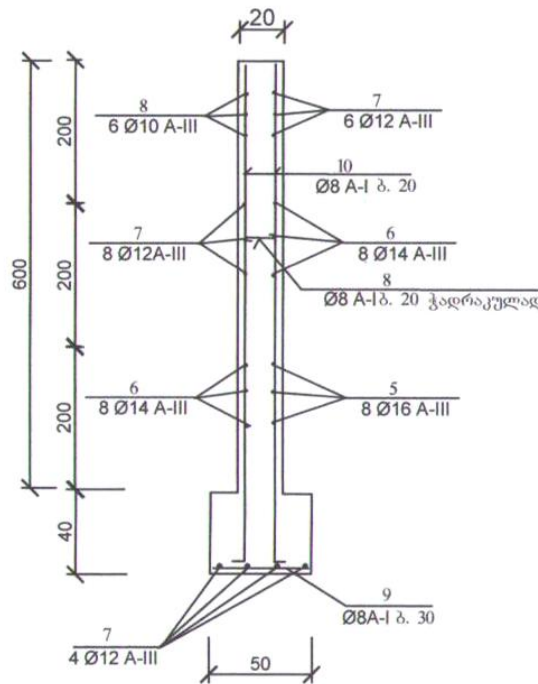
2. kedlis gaangariSeba

$$A_0 = \frac{72900}{15,3 \cdot 10^6 \cdot 100 \cdot 15^2} = 0,212$$

$$A_s = \frac{72900}{365 \cdot 10^6 \cdot 0,88 \cdot 15} = 15,1 \text{ sm}^2$$

miRebulia

$$A_s = 16,08 \text{ sm}^2$$



nax. 4.13. sayrdeni kedlis daarmatureba

matura miviRoT 12 Ø25 A-III ($A_s=58,88 \text{ sm}^2$).

svetis daarmatureba ix. nax. 4.12.

4.4.2. wyalnajeri Tixnaris SemTxvevisaTvis

1. svetis gaangariSeba.

betoni mZime B30 klasis (m 400);

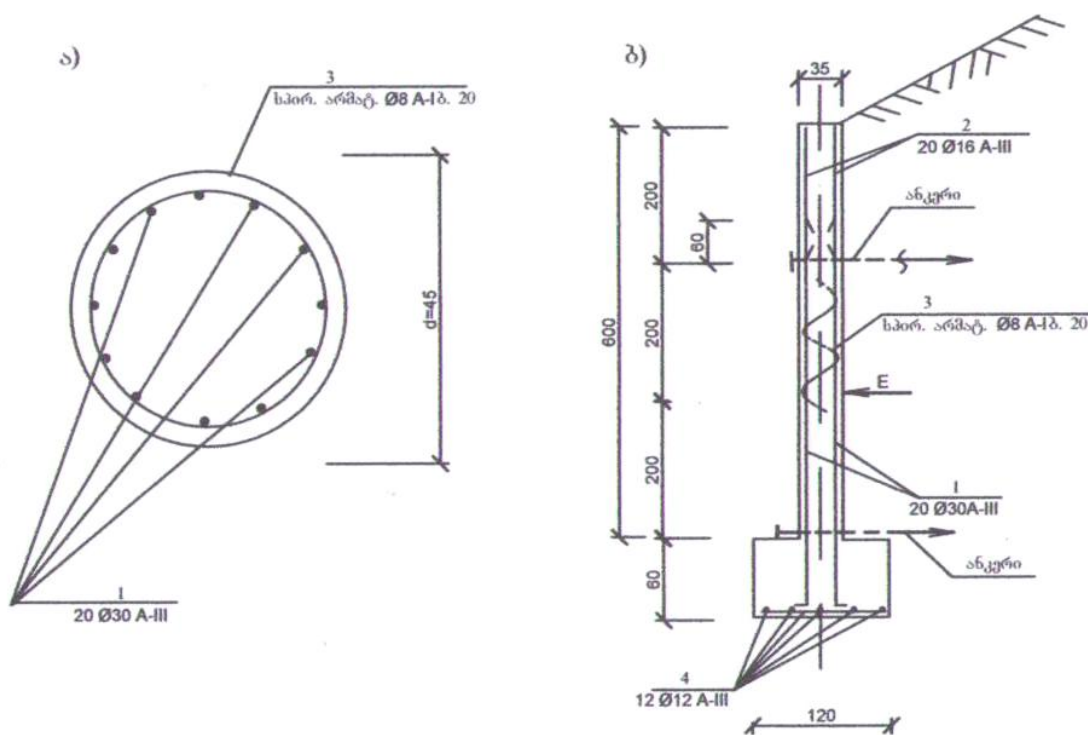
$$R_b \cdot \gamma_{b2} = 17,0 \cdot 0,9 = 15,3 \text{ mpa}$$

miRebulia svetis ganivkveTi d=45 sm.

kompiuteruli gaangariSebis safuZvelze (dantarTi 1) miRebulia muSa- armaturis saWiro farTobi $A_S=137 \text{ sm}^2$ da gadaadgilebebi: C wertilSi _ 17,6 mm da D wertilSi _ 13,4 mm, rac norme bis farglebSia:

muSa armatura miviRoT 20 Φ 30 A-III (As=141,36 sm^2).

svetis daarmatureba ix. nax. 4.14.



nax. 4.14. svetis daarmatureba

a) ganivi WriLi; b) grZivi WriLi

2. kedlis gaangariSeba

პირობები იგივე: Seicvleba mxolod betonis klasi

mRunavi momenti sayrdenze (CamagrebebSi)

$$M_s = 8,55 \text{ t.m.}$$

mRunavi momenti malSi

$$M_m = 4,3 \text{ t.m.}$$

kedlis sisqe _ b=20 sm.

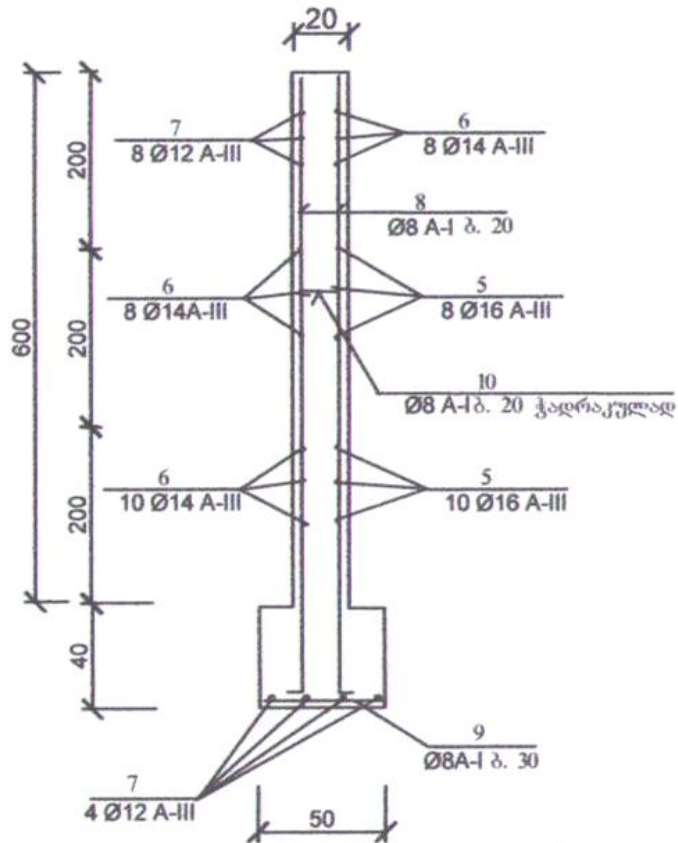
$$B_0 = \frac{85500}{15,3 \cdot 10^6 \cdot 100 \cdot 15^2} = 0,248$$

$$V = 0,855$$

$$A_s = \frac{85500}{365 \cdot 10^6 \cdot 0,855 \cdot 15} = 18,26 \text{ sm}^2$$

მიRebulia: 10 Φ 16 A-III (A_s=20,11 sm²)

kedlis daarmatureba ix. nax. 4.15



nax. 4.15 kedlis daarmatureba

**4.5. armaturis specifikaciebi monoliTuri rkinabetonis
sayrdeni kedlebis 10 grZivi metrisaTvis
cxrili 4.1.**

kedlis marka	kedliskonstr gadawyveta	armaturis specifikacia						armaturis amokreba				
		poz. ##	Eskizi	Φ ოფ	L სმ	N ცალ	nxl მ	Φ ოფ	Σ nxl მ	q 38		
										A-I	A-III	
1	2	3	4	5	6	7	8	9	10	11	12	
sk-5	tradiciul i r/bet. B-20, uanke- ro, mSr. qviSa	1		22AIII	795	50	397,5	12AIII	600,1	—	1788	
		2		22AIII	535	25	133,8	20AIII	320,0	—	790	
		3		22AIII	275	25	68,8	12AIII	1029,0	—	916	
		4		12AIII	795	100	795,0	10AIII	2312,0	—	1433	
		5		12AIII	390	60	234,0	8AI	357,5	141	—	
		6		10AIII	120	60	72,0	jami		141	4927	
		7		20AIII	320	100	320,0	Sul		5068		
		8	daiWras adgilze 	10AIII	—	—	2240	V _b = 42,2 m ³				
		9	cvalebadi 	8 AI	60	650	357,5	BB-20				
sk-6	tradiciul i r/bet. B-20, uanke- ro, wyal-	1		28AIII	795	50	397,5	28AIII	600,1	—	2898	
		2		28AIII	535	25	133,8	25AIII	445,0	—	1713	
		3		28AIII	275	25	68,8	12AIII	1355,0	—	1206	
		4		12AIII	795	100	795,0	10AIII	2755,0	—	1708	

	najerTixn.	5		12AIII	560	100	560,0	8AI	450,0	178	—	
		6		10AIII	175	100	175,0	jami		178	7525	
		7		25AIII	445	100	445,0	sul 7703				
		8	daiWras adgilze 	10AIII	—	—	2580	$V_b = 54,8 \text{ m}^3$				
		9	cvalebadi 	8AI	60	750	450,0	BB-20				
sk-7	tradiciul i r/bet. B-20, ankeriani mSr. qviSa	1		20AIII	575	200	1150,0	20AIII	1150,0	—	2841	
		2		12AIII	260	200	520,0	18AIII	270,0	—	540	
		3		18AIII	270	100	270,0	12AIII	690,0	—	614	
		4		10AIII	100	50	50	10AIII	2230,0	—	1383	
		5		12AIII	340	50	170,0	8AI	294,0	116	—	
		6	daiWras adgilze 	10AIII	—	—	2180	jami		116	5378	
		7	cvalebadi 	8AI	50	588	294,0	sul 5494 $V_b = 31,8 \text{ m}^3$ B B-20				
sk-8	tradiciul i r/bet. B-20, ankeriani wyalnajerTixn.	1		25AIII	575	200	1150,0	25AIII	1530,0	—	5891	
		2		12AIII	260	200	520,0	12AIII	802,0	—	714	
		3		25AIII	380	100	380,0	10AIII	2510,0	—	1556	
		4		10AIII	140	50	70	8AI	340,0	134	—	
		5		12AIII	470	60	282,0	jami		134	8161	
		6	daiWras adgilze 	10AIII	—	—	2440	sul 8295				
		7	cvalebadi 	8AI	50	680	340,0	$V_b = 39,5 \text{ m}^3$ B-20				
sk-9	SemoT. usve-	1		16AIII	505	100	505	16AIII	505,0	—	798	
		2		12AIII	505	100	505	14AIII	100,0	—	121	

	tebo B-20 mSr. qviSa	3		14AIII	200	50	100,0	12AIII	1125,0	—	1001
		4		12AIII	200	50	100,0	8AI	192,0	76	—
		5		8AI	60	40	24,0	jami		76	1920
		6		12AIII	—	—	520,0	sul 1996			
		7		8AI	35	480	168,0	$V_b = 17,3 \text{ m}^3$ B-20			
sk-10	SemoT. lent-uri usve- tebo B-20 wyaln. Tixn	1		20AIII	525	100	525	20AIII	525,0	—	1297
		2		12AIII	525	100	525	14AIII	100,0	—	121
		3		14AIII	200	50	100,0	12AIII	1175,0	—	1046
		4		12AIII	200	50	100,0	8AI	187,0	166	—
		5		8AI	70	35	24,5	jami		166	2464
		6		12AIII	—	—	550,0	sul 2630			
		7		8AI	45	350	162,0	$V_b = 23,3 \text{ m}^3$ B-20B			
sk-11	SemoT. svete- biani B-20 mSr. qviSa	1		25AIII	545	40	218,0	25AIII	218,0	—	839
		2		16AIII	200	40	80,0	16AIII	480,0	—	758
		3		12AIII	115	40	46,0	14AIII	170,0	—	206
		4		8AI	—	—	145,0	12AIII	46,0	—	41
		5		16AIII	—	—	400,0	8AI	813,0	321	—
		6		10AIII	—	—	500,0	jami		321	1844
		7		14AIII	—	—	170,0	sul 2165			
		8		8AI	45	35	15,8	$V_b = 17,2 \text{ m}^3$ B-20			
		9		8AI	—	—	540,0				
		10		8AI	25	450	112,5				
sk-12	SemoT. svete- biani B-20	1		36AIII	545	40	218,0	36AIII	218,0	—	1742
		2		16AIII	200	40	80,0	16AIII	80,0	—	126
		3		12AIII	115	40	46,0	14AIII	400,0	—	484

sk-13	wyaln. Tixn.	4	daiWras adgilze	8AI	—	—	160,0	12AIII	206,0	—	183
		5	daiWras adgilze	14AIII	—	—	400,0	8AI	919,0	363	—
		6	daiWras adgilze	12AIII	—	—	160,0	jami		363	2535
		7	daiWras adgilze	10AIII	—	—	510,0	sul		2898	
		8	450	8AI	45	28	12,6	V _b =20,4 m ³ B-20			
		9	daiWras adgilze	8AI	30	440	132,0				
		10	200	8AI	—	—	614,0				
sk-13	SemoT. svete- biani B-20 mSr. qviSn.	1	5150 300	25AIII	545	40	218,0	25AIII	218,0	—	839
		2	2000	16AIII	200	40	80,0	16AIII	260,0	—	411
		3	daiWras adgilze	8AI	—	—	110,0	14AIII	360,0	—	436
		4	1150	12AIII	115	40	46,0	12AIII	406,0	—	361
		5	daiWras adgilze	16AIII	—	—	180,0	8AI	899,0	355	—
		6	daiWras adgilze	14AIII	—	—	360,0	jami		355	2047
		7	daiWras adgilze	12AIII	—	—	360,0	sul		2402	
		8	200	8AI	30	710	213,0	V _b =16,8 m ³ B-30			
		9	450	8AI	45	35	15,8				
		10	daiWras adgilze	8AI	—	—	560,0				
sk-14	SemoT. svete- biani B-20 wyaln. Tixn.	1	5100 300	30AIII	540	66	356,4	30AIII	356,4	—	1978
		2	2000	16AIII	200	66	132,0	16AIII	442,0	—	698
		3	daiWras adgilze	8AI	—	—	140,0	14AIII	520,0	—	629
		4	1150	12AIII	115	40	46,0	12AIII	246,0	—	219
		5	daiWras adgilze	16AIII	—	—	310,0	8AI	1166,0	1038	—
		6	daiWras adgilze	14AIII	—	—	520,0	jami		1038	3524
		7	daiWras adgilze	12AIII	—	—	200,0	sul		4562	
		8	6300	8AI	650	104	676,0	V _b =18,0 m ³			

		200					B-30
9	450	8AI	45	30	13,5		
10	300	8AI	40	840	336,0		

4.6. kombinirebuli sistemebis gruntuli ankerebis gaangariSeba

4.6.1. sawyisi monacemebi gaangariSebisaTvis

tradiciul monoliTur rkinabetonis sayrden kedlebSi ankerebi gaTvaliswinebuli gvaqvs erT (zed) iarusad, bijiT 1 m; SemoTavazebul monoliTur lentur sayrden kedlebSi _ 2 iarusad, bijiT 1,0 m;

cxrili 4.2. ankerebis mWimebSi aRZruli gamWimavi Zalvebi, t

sayrdeni kedlis tipi	gruntuli pirobebi	ankerebis marka	ankerebis mWimebSi aRZruli Zalvis horizontaluri proeqcia (N), t	mWimebSi aRZruli Zala $N_i = \frac{N}{\cos\omega}, t$
tradiciuli monoliTuri rkinabetonis	mSrali qviSnari	a_1	5,68	5,9
	wyalnajeri Tixnari	a_2	9,7	10,0
SemoTavazebuli monoliTuri rkinabetonis lenturi	mSrali qviSnari	a_3	5,9	6,1
	wyalnajeri Tixnari	a_4	14,0	14,5
SemoTavazebuli monoliTuri rkinabetonis, svetebiani	mSrali qviSnari	a_5	17,7	18,3
	wyalnajeri Tixnari	a_6	42,0	43,5

SemoTavazebul monoliTur svetebian sayrden kedlebSi _ aseve or iarusad, bijiT 3 m (Caankerebuli iqnebian mxolod svetebi). yvela ankeri ganTavsebulia horizontis mimarT $\omega=15^0$ -iani kuTxiT. cxriliSi 4.2. mocemulia ankeris mWimebSi aRZruli gamWimavi Zalvebis horizontaluri proeqciebis mniSvnelobebi (Tavi 2- SimiRebuli gaangariSebebiT) da maTi realuri mniSvnelobebi $\omega=15^0$ -iT daxrisas.

marka	ganivkveTis farTobi, A_s, sm^2	diametri, 1,5- iani maragiT (mm)	mWimis sigrZe, m	mWimis masa, kg	Caankerebase, m^3
a_1 (a_1')	1,62	$\Phi 18 \text{ AIII}$	6,5 (3,7)	13,0 (7,4)	0,21
a_2 (a_2')	2,74	$\Phi 25 \text{ AIII}$	8,4 (4,0)	32,3 (15,4)	0,47
a_3 (a_3')	1,67	$\Phi 18 \text{ AIII}$	6,5 (3,7)	13,0 (7,4)	0,27
a_4 (a_4')	3,97	$\Phi 28 \text{ AIII}$	8,9 (4,5)	43,0 (21,7)	0,7
a_5 (a_5')	5,0	$\Phi 32 \text{ AIII}$	7,0 (4,2)	44,2 (26,5)	0,4
a_6 (a_6')	11,92	$\Phi 40 \text{ AIII}$	10,4 (6,0)	102,6 (59,2)	1,45

SeniSvna: frCxilebSi mocemulia I (qveda) iarusis ankerebis mWimebis markebi, sigrZeebi da masebi.

4.6.3. gruntSi ankerebis Camagrebis (CakeTebis) gaangariSeba.

1. sawyisi monacemebi gasaangariSeblad gaangariSeba warmoebs Semdegi pirobis dacviT:

$$F_b \geq 2 \cdot N_i \quad (4.1.)$$

sadac:

F_i _ aris gruntSi ankeris Camagrebis (CakeTebis) zonis mZidunarianoba, t;

N_i _ ankeris mWimSi aRZruli gamWimavi Zalva, t;

$$F_b = Km_p \pi d_b P_b t g \varphi \quad (4.2.)$$

sadac:

K – gruntis erTgvarovnebis koeficientia ($K = 0,6$)

m_p _ koeficienti, romelic iTvaliswin ebs garemo gruntis

daZabul mdgomareobas incirebis as wnevaze damokidebulebis mixedviT

(qviSebisaTvis - 0,5; sxvadasxva konsistenc iis TixebisaTvis is 0,4-0,2;

d - WaburRilis diametri, m;

l_b – ankeris gruntSi CamagrebissigrZe, m;

p_b – CamagrebiszonaSi inecirebis as namati wnevis sidide, t/m²;

φ – gruntis Siga xaxunis kuTxe (mSrali qviSnarisa Tvis $\varphi = 32^\circ$ da $tg\varphi = 0,62487$ wyalnajeri TixnarisaT vis $\varphi = 23^\circ$ da $tg\varphi = 0,42447$).

2. gruntSi ankerebis Camagrebis zonis mzdunarianobis gaangariSeba.

ankeri a _ 1 (a _ 1'):

$$F_b = 0,6 \cdot 0,5 \cdot 3,14 \cdot 0,4 \cdot 1,7 \cdot 30 \cdot 0,62487 = 12,0 \text{ t} \succ 2N_1 = 2 \cdot 5,9 = 11,8 \text{ t};$$

ankeri a _ 2 (a _ 2'):

$$F_b = 0,6 \cdot 0,4 \cdot 3,14 \cdot 0,55 \cdot 2,0 \cdot 60 \cdot 0,42447 = 21,1 \text{ t} \succ 2N_2 = 2 \cdot 10 = 20,0 \text{ t};$$

ankeri a _ 3 (a _ 3'):

$$F_b = 0,6 \cdot 0,5 \cdot 3,14 \cdot 0,45 \cdot 1,7 \cdot 30 \cdot 0,62487 = 13,50 \text{ t} \succ 2N_3 = 2 \cdot 6,1 = 12,2 \text{ t};$$

ankeri a _ 4 (a _ 4'):

$$F_b = 0,6 \cdot 0,4 \cdot 3,14 \cdot 0,6 \cdot 2,5 \cdot 60 \cdot 0,42447 = 28,8 \text{ t} \succ 2N_4 = 14,5 \cdot 2 = 29,0 \text{ t};$$

ankeri a _ 5 (a _ 5'):

$$F_b = 0,6 \cdot 0,5 \cdot 3,14 \cdot 0,48 \cdot 2,2 \cdot 60 \cdot 0,62487 = 37,3 \text{ t} \succ 2N_5 = 2 \cdot 18,3 = 36,6 \text{ t};$$

ankeri a _ 6 (a _ 6'):

$$F_b = 0,6 \cdot 0,4 \cdot 3,14 \cdot 0,68 \cdot 4,0 \cdot 100 \cdot 0,42447 = 87,04 \text{ t} \succ 2N_6 = 2 \cdot 43,5 = 87,0 \text{ t}.$$

Tavi 5

gamosaSrob gruntSi horizontaluri sadrenaJe WaburRilidan filtrirebuli wylis gamodinebis eleqtroosmosiT amaRlebis SesaZleblobis gamokvleva

5.1. eleqtroosmosiT gruntebis gamoSrobis ZiriTadi debulebebi

kalTebisa da ferdoebis dacvis SemoTavazebul kompleqsur sistemaSi, wyalnajeri gruntebis SemTxvevaSi, gaTvaliswinebulia, gruntSemakavebeli sistemebis saxiT, “drenaJuli ankerebi” [patenti]. ankerebis am tipis funqciebSi, gruntebis Camozvavebisagan Sekavebis garda, Sedis gruntis gamoSrobac, horizontalurad (an horizontalurobasTan axlos) ganTavsebul sadrenaJe

milSi saankero mWimis gatarebis gziT (nax. 5.1.).gruntis gamoSrobis procesis intensifikaciisaTvis damuSavebul kompleksur sistemaSi navaraudevia eleqtroosmosis gamoyeneba.eleqtroosmosi gamoiyeneba lamovani da Tixovani gruntebis gamosaSrobad, gruntis wylebis donis efeqturi wyaldawevis da qvabulebisa da tranSeebis gamosaSrobad.gruntebis gamoSrobis da gruntis wylebis eleqtroosmosiT dawewis yvela SemTxvevaSi gamoiyeneba gruntSi vertikalurad ganTavsebuli nemsafiltruli danadgarebi _ specialuri perforirebuli foladis milebi, romlebiTac xdeba wylis amoqaCva.

eleqtroosmosis meTodi efuZneba wylis moZraobas anodidan kaTodisaken gruntis forebSi mudmivi denis zemoqmedebisas. amasTan, nemsafiltribTan erTad, gruntSi, maTgan 0,5_1,0 metr manZilze gamosaSrobi zonis mxridan, yursaven foladis eleqtrodebs. nemsafiltribs aerTeben uaryofiT polusTan (kaTodTan), xolo eleqtrodebs _ dadebiT polusTan (anodTan). eleqtrodebs ganaTavseben erTmaneTis mimarT Wadrakuli TanmimdevrobiT, bijiT 0,75_1,5 metri. eleqtrodenis zemoqmedebiT, gruntis forebSi arsebuli wyali gadaadgildeba nemsafiltribisaken, amasTan filtraciis koeficienti izrdena 5....25-jer.eleqtrodenis saWiro jamuri simZlavre ganisazRvreba eleqtrodis erT grZiv metrze 1....2 amperidan gaangariSebiT; denis Zala 50-60 volti Zabvisas Seadgens 1 ampers 1 m² farTobze.eleqtroosmosis daxmarebiT wylis gamowoviT, SesaZlebelia gruntis gamoSroba filtraciis koeficientiT 0,01 m/dRe-Ramemde.mudmivi denis wyarodan iyeneben eleqtroSemduRebel aggregatebs an gardamqmqnelebs.

qvabulebisa da tranSeebis damuSavebisas, Cveulebriv, sakmarisia eleqtroosmosis zemoqmedeba drois mcire periodis ganmavlobaSi, radgan gruntebis Tvissebebi mniSvnelovnad icvleba da Cndeba miwis samuSaoebis normalurad warmoebis SesaZlebloba. magram ar asruleben gamomSrobi danadgaris demontaJs samuSaoTa damTavrebamde, raTa saWiroebis SemTxvevaSi isargeblon misi gamoyenebis SesaZlelobiT. eleqtroosmosis zemoqmedeba zrdis filtraciis koeficients TixnarebisaTvis 10-20-jer, TixebisaTvis _ kidev ufro mniSvnelovnad. 1 m³ gruntis gamoSrobaze ixarjeba daaxloebiT 40kvt.sT eleqtroenergia. usafrTxoebis teqnikis gaTvaliswinebiT eleqtrogamoSrobisaTvis iyeneben eleqtrodanadgarebis Zabvas 30-60 volts.

Tixovan gruntebSi, eleqtrodenis xangrZlivi zemoqmedebisas, viTardeba rTuli qimiuri procesebi, romlebic iwveven gruntis SemWidrovebas da gamtkicebas. Tixovani gruntis eleqtroosmosis procesSi forebSi arsebul wyalSi viTardeba mniSvnelovani uaryofiTi forovani wneva, romelic iwvevs gruntis SemWidrovebas. gruntSi am wnevis sididem, eleqtroosmosis

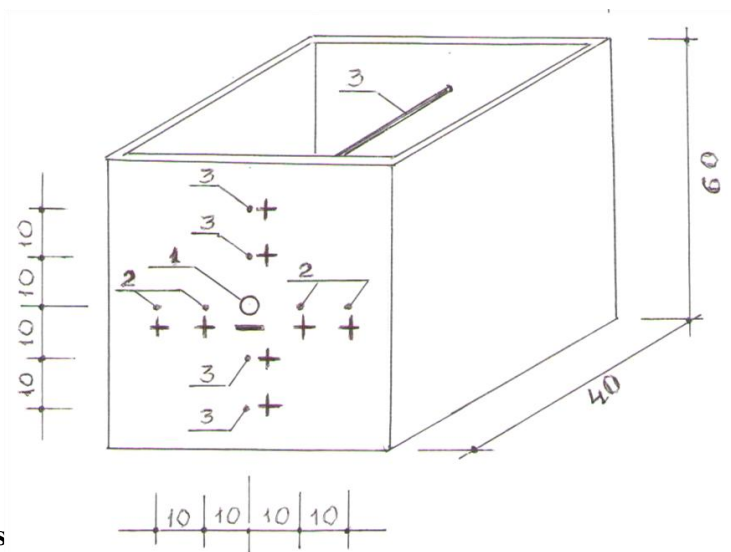
procesSi, SeiZleba miaRwios ramdenime atmosferos (3 kg/sm^2).amasTan erTad, Tixovani gruntebis wyaldawevis da SemWidrovebisaTvis eleqtroosmosis gamoyeneba fexdeba gruntSi eleqtroqimiuri procesebis warmoSobis gamo: eleqtrolizi, kationebis gacvla, eleqtrodebTan gazebis gamoyofa, gruntis fizikur-qimiuri Tvisebebis Secvla bolos iwvevs eleqtroosmosis Sewyvetas. dRemde teqnukur literaturaSi ar aris monacemebi eleqtroosmosis gamoyenebis Taobaze horizontalur sadrenaJe gamomSrob sistemebSi, ucilobels xdis eleqtroosmosis gamoyenebis principuli SesaZleblobis Seswawlis aucileblobas horizontalur drenejebSi, qvabulebisa da tranSeebis ferdoebis kedlebis gamagrebis sistemebis mowyobis procesSi, gruntis gamoSrobis aucileblobisas.

5.2. ferdoebis da kalTebis gruntis gamoSrobis procesis daCqarebis SesaZleblobis gamokvleva eleqtroosmosis gamoyenebiT

5.2.1. eqsperimentuli modeli da gamokvlevis Catarebis meTodika.

horizontalur sadrenaJe sistemebSi eleqtroosmosis gamoyenebis efeqturobis gansazRvris mizniT damzadebul iqna modeli horizontaluri sadrenaJe miliT da mis paralelurad ganTavsebuli eleqtrodebiT. modelis sqema naCvenebia naxazze 5.1. modeli warmoadgenda eleqtroizolirebeli plastikatis kedlebian Ria kubs, romlis Sua nawilSi ganTavsebuli iyo liTonis perforirebuli mili, misi gamomSvebi Riobisaken odnavi daxriT. masze ganTavsebuli iyo Camketi ventili.mudmivi deni miwodeboda: perforirebul mils _ “minusi” da “plusi” _ milis paralelurad, simetriulad ganlagebul eleqtrodebs.

kubi ivseboda sakvlevi jiSis gruntiT da miwodeboda wyali mis gasaJRenTad.



nax. 5.1. modelis

gamoyenebis

1 _ sadrenaJe mili; 2 _ horizontaluri eleqtrodebi; 3 _ vertikaluri eleqtrodebi.



nax. 5.2 eqsperimentis msvlelobis amsaxveli fotosuraTebi

el. deni miwodeboda Cveulebrivi el. qselidan _ 220 volti, gammarTvelisa da reostatis saSualebiT. Eeqsperimentis Catarebis procesi asaxulia qvemoT moyvanil fotosuraTebze (nax.5.2).. eqsperimentis msvlelobis dros xdeboda el. denis maxasiaTeblebis varireba Semdeg farglebSi: denis Zala _ 0 1,5 amperi, Zabva _ 0 50 volti.

gamokvlevebi Catarda gruntebis Semdegi saxeobebisaTvis: qviSovani, qviSnarovani da qviSnarovani-qviSovani gruntis 20%-is damatebiT.arCevani zemoarNiSnul gruntebze gakeTda imis gamo, rom qviSovani gruntebi damaxasiaTebelia dasavleT saqarTvelos zRvispiza zonisaTvis, sadac amJamad mimdinareobs intensiuri mSenebloba, xolo qviSnarovani gruntebi _ erT-erTi yvelaze ufro gavrclebuli saxea mTeli saqarTvelosTvis.eqsperimentis Catarebis meTodika iTvaliswinebda gruntis sadrenaJo Tvisebebis gamokvlevas eleqtroosmosis gamoyenebis gareSe da el. osmosis gamoyenebiT _ el. denis maxasiaTeblebis sxvadasxva mniSvnelobebisa da sadrenaJo milis mimarT eleqtrodebis sxvadasxva SeTanwyobiTa da sxvadasxva manZilebze ganTavsebiT.

5.2.2. qviSovan gruntebze eqsperimentebis Sedegebi

modelis sivrce ivseboda qviSovani gruntiT. zedapiridan grunti jirjvldeboda wylit, mis zedapirze wylis afskis gaCenamde.

eqsperimentis Sesruleba xdeboda 2 periodad. pirveli periodi iTvaliswinebda denis mierTebas sadrenaJo milTan uaxloes horizontalur eleqtrodebze, xolo meore periodi _ uSores horizontalur eleqtrodebze.orive periodi Seicavda eqsperimentebis seriebs miwodebuli el. denis sxvadasxva maxasiaTeblebiT. TiToeuli seria Sedgeboda 3 etapisagan, 15 wT-is xangrZlivobiT, sadrenaJe milidan gamosuli wylis odenobis aRricxviT.I periodis eqsperimentebis Sedegad miRebuli monacemebi Setanilia cxrilebSi 5.1 da 5.2.. Sedegebis grafikuli interpretacia motanilia naxazebze 5.2 5.8.

qviSovan gruntSi sadrenaJe milidan gamosuli wylis (litrebSi) cvlilebis gansazRvra wylis gamodinebis xangrZlivobaze (t_{wT}), denis Zalaze (I_{amp}) da Zabvaze (V_{volti}) damokidebulebiT, el. denTan uaxloesi horizontaluri eleqtrodebis mierTebisas (I periodi) cxrili 5.1

mierTebuli el. denis maxasiaTeblebi	<i>TiToeul etapze gamonadeni wylis raodenoba (litri),seriebis mixedviT, eqsperimentis Catarebis xangrZlivobisas _ 195 wT.</i>		
	<i>I etapi, 15 wT</i>	<i>II etapi, 15 wT</i>	<i>III etapi, 15 wT</i>
pirveli seria <i>I=0 amp, V=0volti (0-45 wT)</i>	4,989	4,621	3,329
meore seria <i>I=0,9 amp, V=50 volti (gagrZeleba pirvelis Semdeg 46-90 wT)</i>	4,508	3,547	2,848
mesame seria <i>I=0,65 amp, V=30volti (gagrZeleba meores Semdeg 91-135 wT)</i>	4,400	3,026	2,842
meoTxe seria <i>I=0,43 amp, V=15volti (gagrZeleba mesames Semdeg 136-180 wT)</i>	3,090	3,128	2,470
mexuTe seria <i>I=1,04 amp, V=50volti (gagrZeleba meoTxes Semdeg 181-195 wT)</i>	2,567	-	-

SeniSvnebi:

1. TiToeuli etapas sadrenaJe milidan gamonadeni wyali modelSi ar brundeboda;
2. eqsperimenti grZeldeboda uwyvetad, seriebs Soris pazzis gareSe;
3. el. denis maxasiaTeblebi fiqsrdeboda TiToeuli seriis dawyebisas da mTeli seriis ganmavlobaSi, etapebis mixedviT, ar koreqtirdeboda.

cxrili 5.2.

cxrili №	seriebi	seriaSi etapebs Soris wylis xarjis (wx) Tanafardoba 1/2, 1/3	Sefardeba wina seriis III etapTan	SeniSvna
				95

1	2	3		4	5
cxrili. 5.1-is monacemebis mixedviT	I	(seriis zRvrebSi)		-	
		1,08	1,50		
	II	1.27	1.58	II.1 : I.3 =1.35	
	III	1.45	1.55	III.1 : II.3 =1.55	
	IV	0.99	1.25	IV.1 : III.3 =1,09	
	V	-	-	V.1 : IV.3 =1.04	

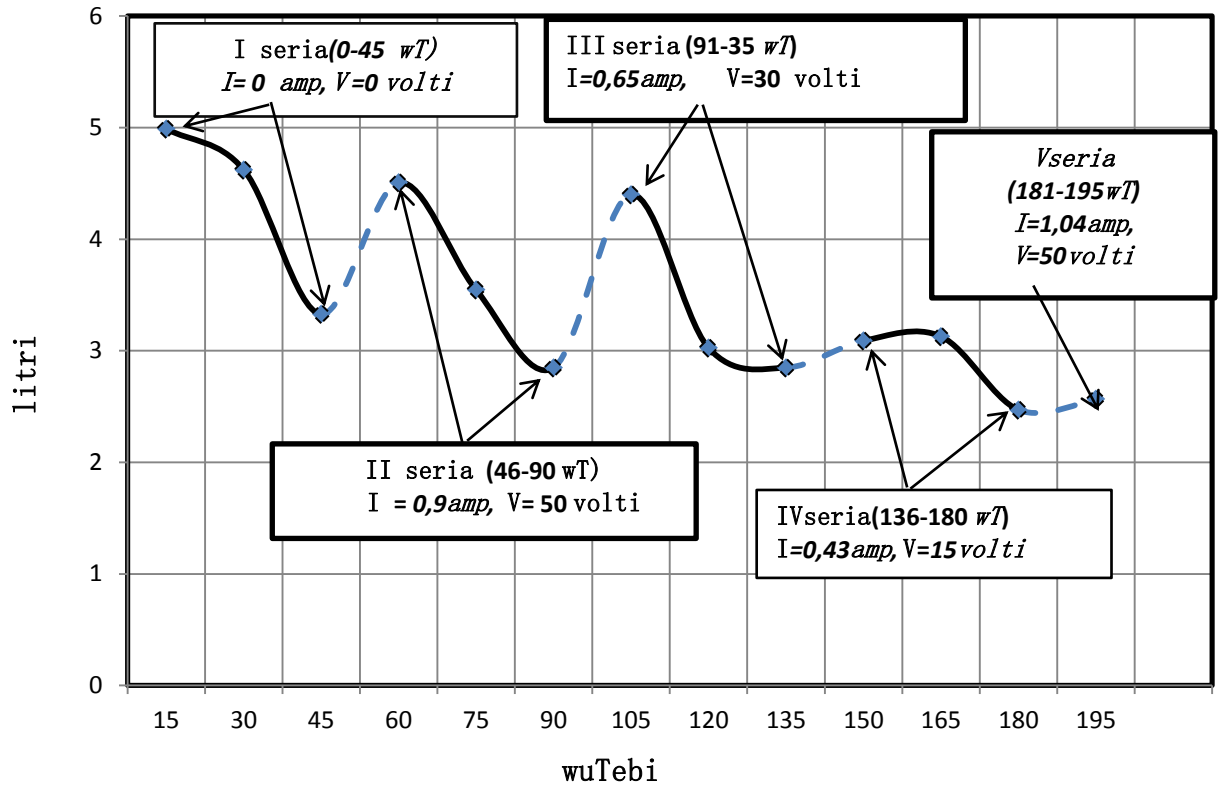
eqsperimentis etapebis da seriebis mixedviT wylis gamodinebis wylis xarjis (wx)

Tanafardoba

eqsperimentis etapebisa da seriebis mixedviT wylis gamodinebis da wylis (wx)

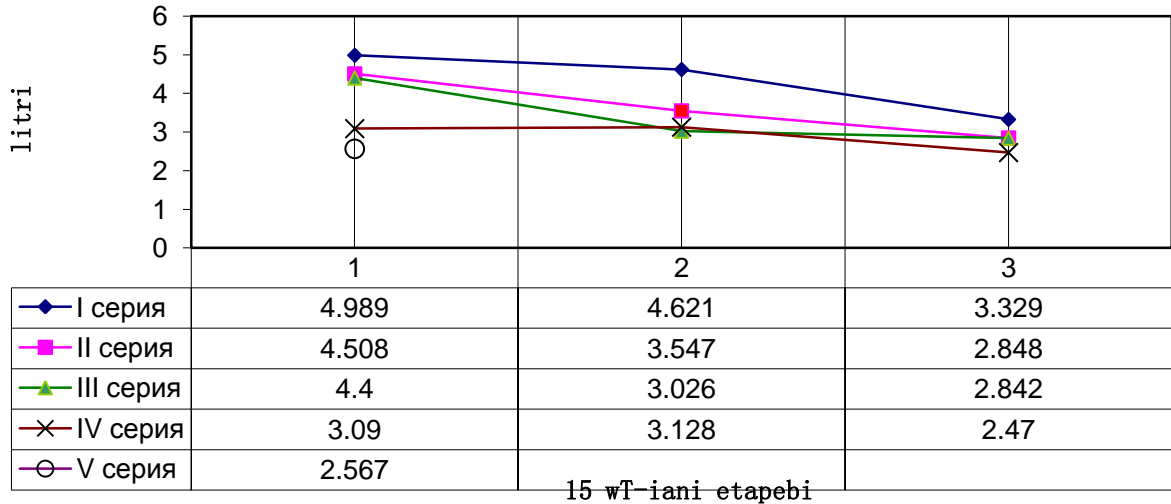
Tanafardoba

qviSovan gruntze eqsperimentisas (t=195 wT) wylis gamodineba
(litri) _ I periodi



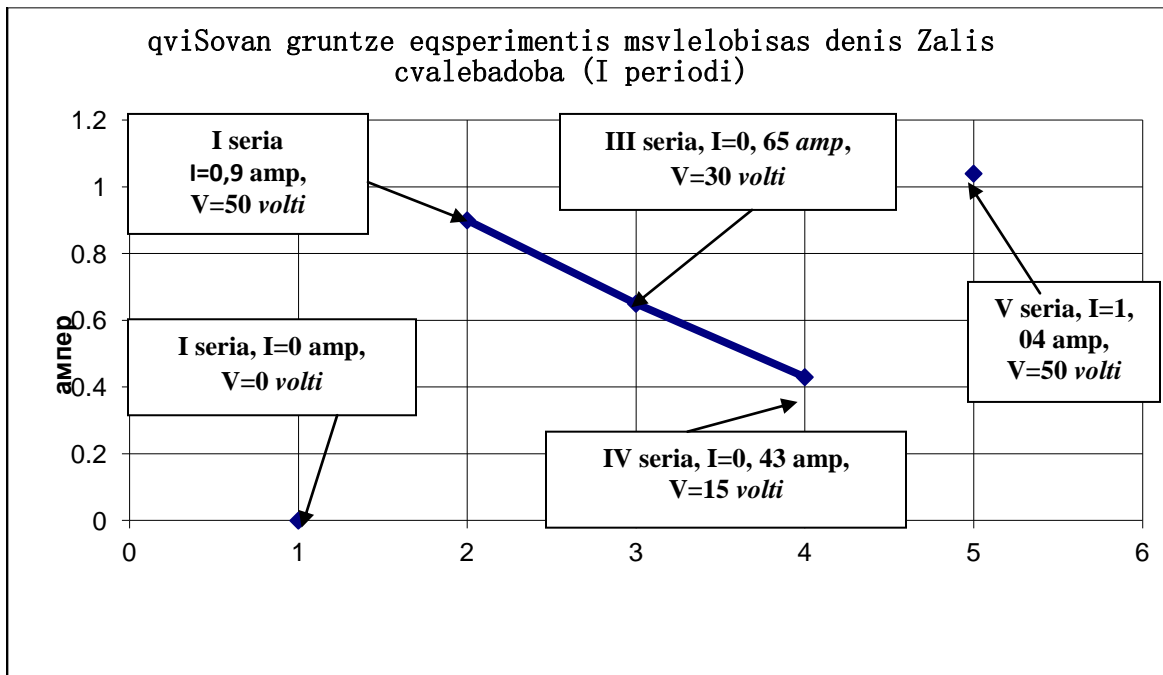
ნახ. 5.3, 5.1. ცხრილის მონაცემები

qviSovan gruntze eqsperimentisas wylis gamodineba etapebis da seriebis mixedviT _ I periodi

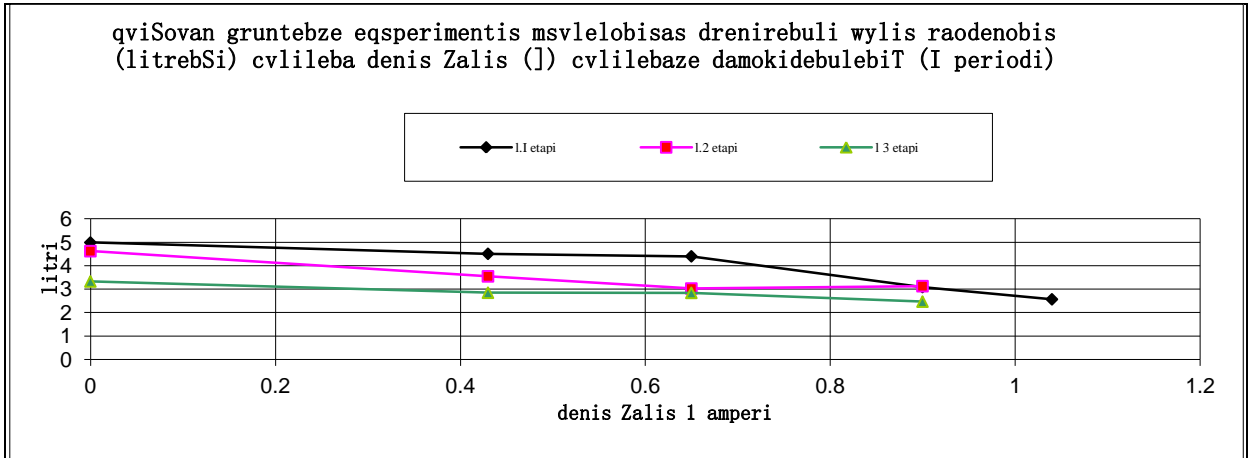


ნახ. 5.4, 5.1. ცხრილის მონაცემები

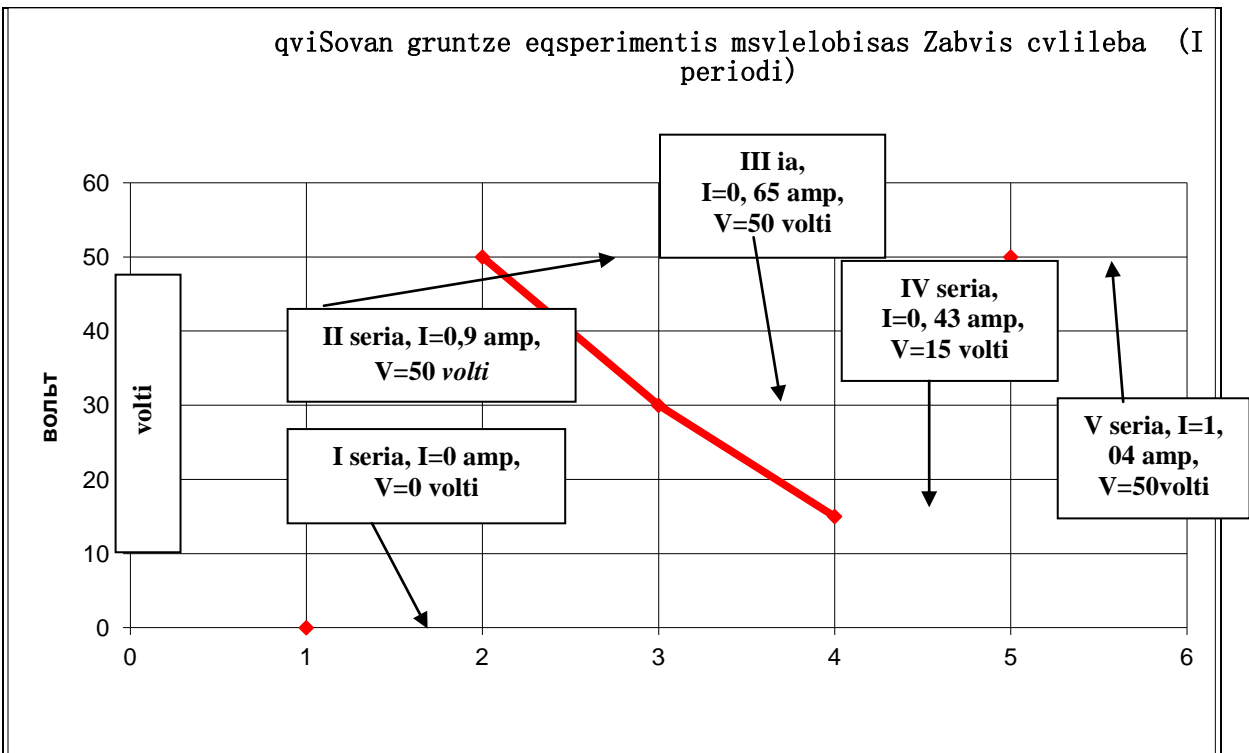
qviSovan gruntze eqsperimentis msvlelobisas denis Zalis cvalebado (I periodi)



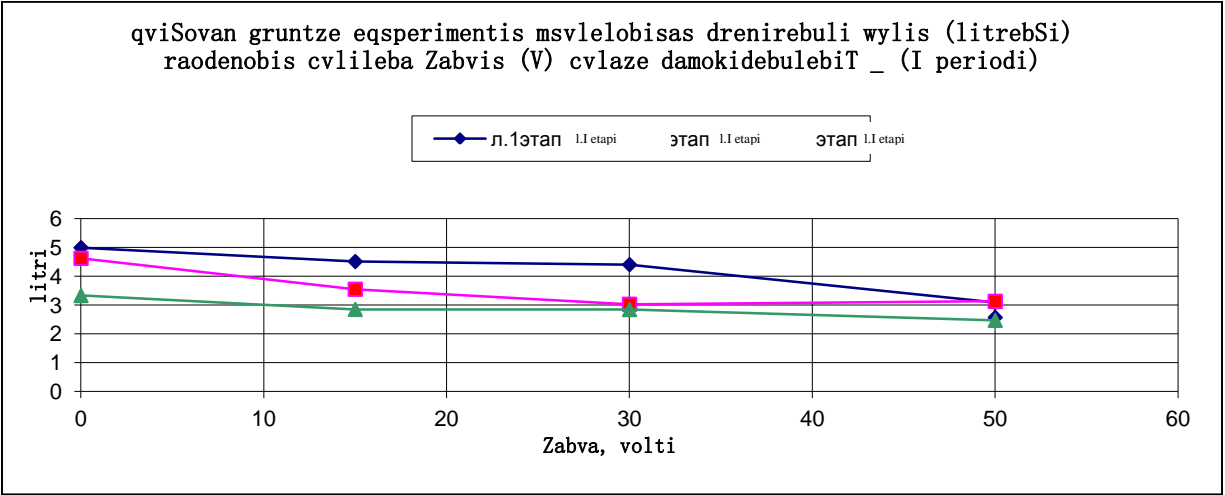
ნახ. 5.5., 5.1. ცხრილის მონაცემები



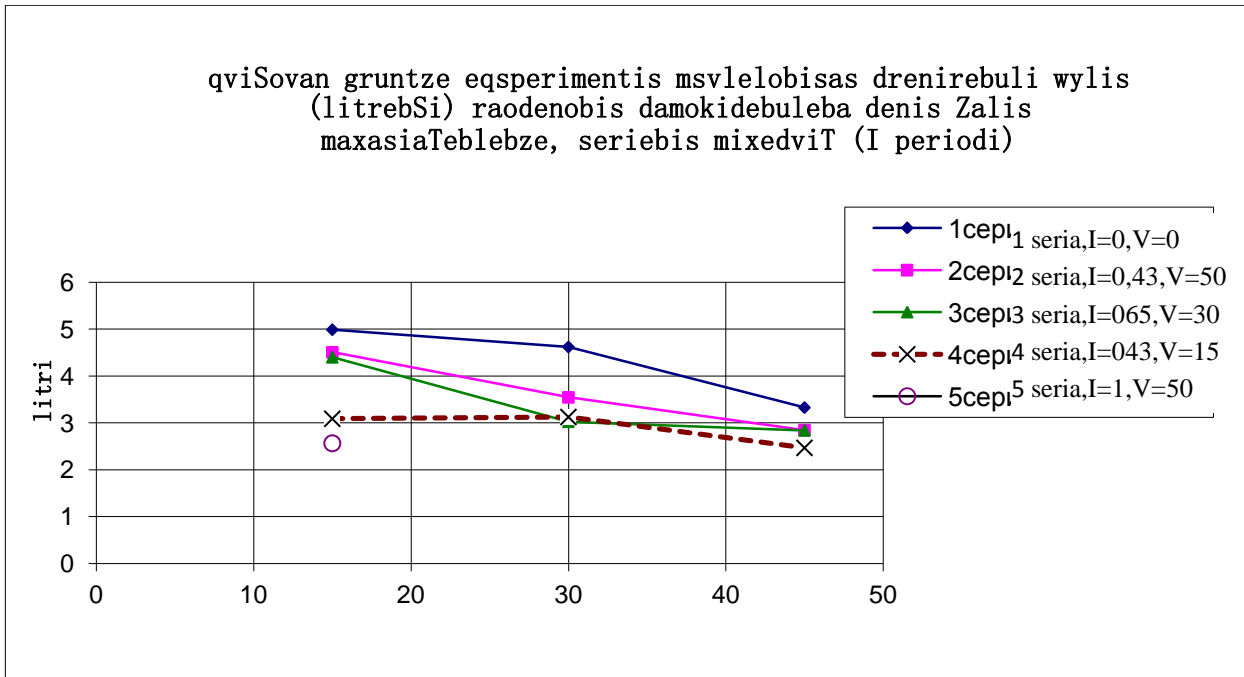
max. 5.6. 5.1.cxrilis monacemebiT



max. 5.7. 5.1. cxrilis monacemebiT



ნახ. 5.8. 5.1. ცხრილის მონაცემები



ნახ. 5.9. 5.1. ცხრილის მონაცემები

პირველი პერიოდის ექსპერიმენტების შედეგად მიღებული შედეგების ანალიზის საფუძველზე შესაძლებელია შემდეგი დასკვნების გაკეთება:

1. I seriaSi, etapebis mixedviT wylis raodenobis Secvla, Semcireba, el. denis ararsebobisas, SesaZlebelia aixsnas modelSi ganTavsebuli wyalnajeri gruntis sawyisi SemWidrovebiT, forovani sivrcis gansazRvruli kolmataciiT da gruntis nawilobrivi gamoSrobiT drenirebis procesSi.
2. I seriis III etapze da II seriis I etapze wylis xarjebis (wx) fardoba gviCvenebs, rom el. denis modeba amaRlebs wylis gamodinebis intensivobas 35%-iT.
3. intesiurobis maqsimaluri amaRleba _ 55 % dafiqsirebulia III seriaSi, Semdeg intensivoba mkveTrad ecema, 9-4%-mde aq saWiroa mxedvelobaSi miviRoT, rom modelidan (tevadobidan), eqsperimentis msvlelobisas, drenirebulia saerTo jamSi 45,437 l wyali. garda amisa, TvalsaCinoa, rom el. osmosis zemoqmedebis specifikuri Taviseburebis gamo, warmoebs gruntis Semkvriveba da forovani sivrcis kolmatacia mtvrisebri nawilakebiT, romlebic waritaca moZravma wyalma el. denis zemoqmedebisas.
ar SeiZleba agreTve modelis tevadobaSi wylis hidrostatikuri wnevis Semcirebis gauTvaliswinebloba, misi raodenobis Semcirebis gamo, drenirebisas gamodinebis procesSi.
4. el. denis maxasiaTeblebis Semcireba iwvevs drenirebisas gamonadeni wylis raodenobis Semcirebas.

gamokvlevis meore periodi Catarda I periodis damTavrebisTanave.

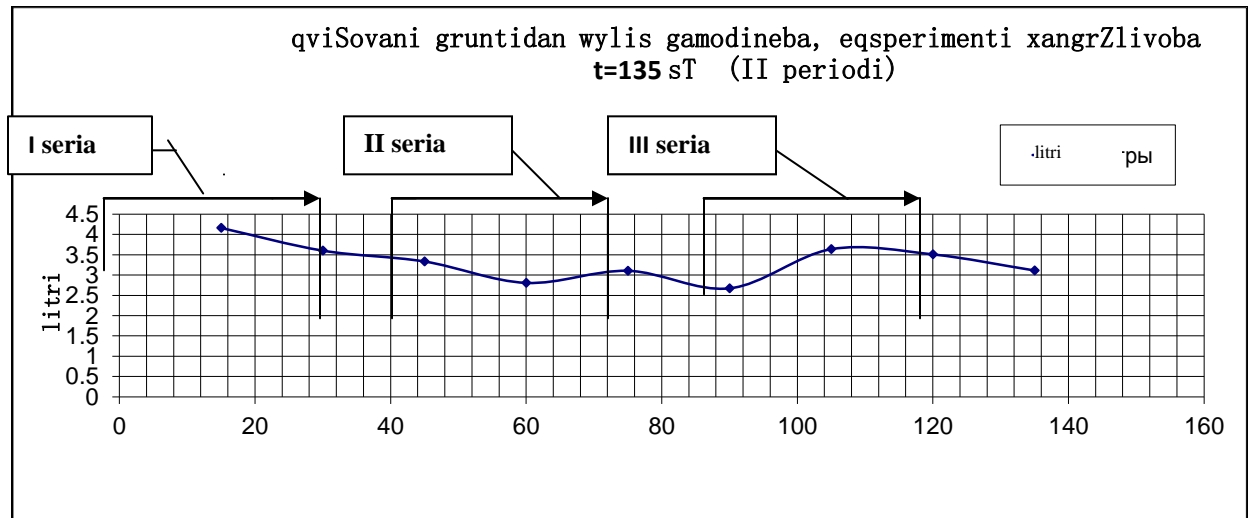
meore periodis gamokvlevis Sedegebi, CarTuli horizontaluri uSoresi eleqtrodebiT, motanilia cxrilebSi 5.2.1. da 5.2.2. Sedegebis grafikuli interpretacia naCvenebia naxazebze 5.10 _ 5.13.

meore periodis eqsperimentebis Sedegebis gaanalizebis Sedegad SeiZleba mivideT Semdeg daskvnebamde:

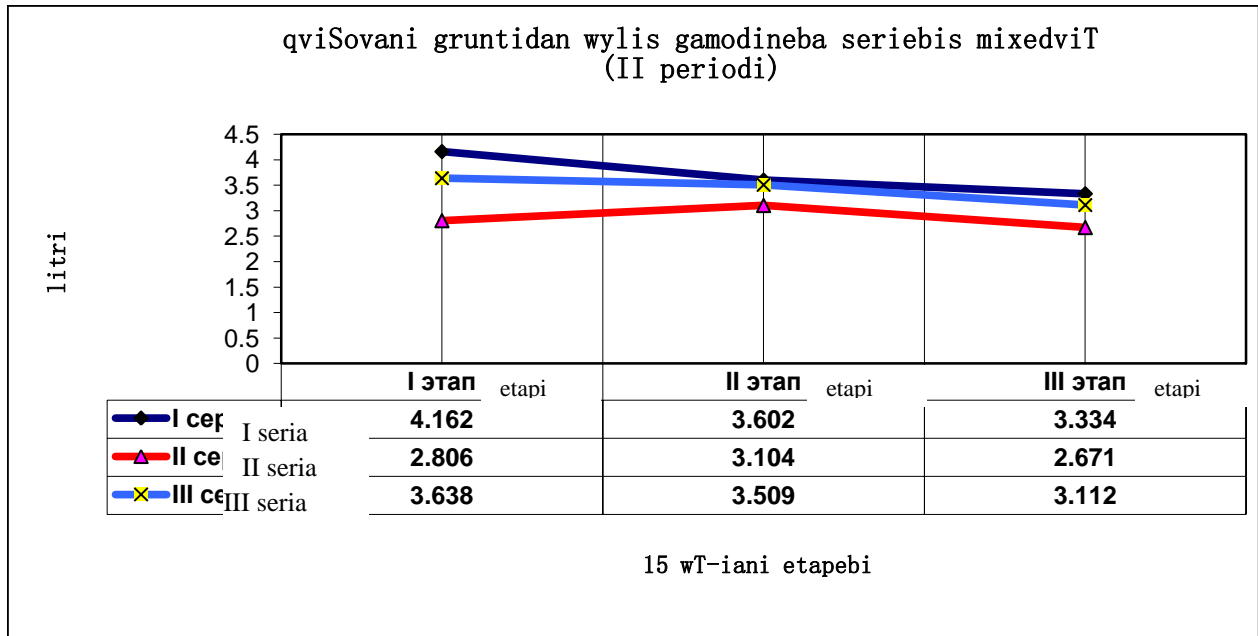
1. sadrenaJe milidan wylis gamodinebis raodenobis cvlilebis damokidebuleba droze eqsperimentis msvlelobisas seriebisa da etapebis mixedviT eqvemdebareba igive kanonzomierebas, romelic gvqonda pirvel periodSi.
2. gamonadeni wylis raodenobis gazrda II periodis I seriaSi unda aixsnas imiT, rom sadrenaJe milidan uSoresi eleqtrodebi, el. denis mierTebis Semdeg, gadaadgilen

sadrenaJe milisaken jer kidev ara SekumSuli, aragamomSrali zonidan (ix. cxrilebi 5.1. da 5.2.).

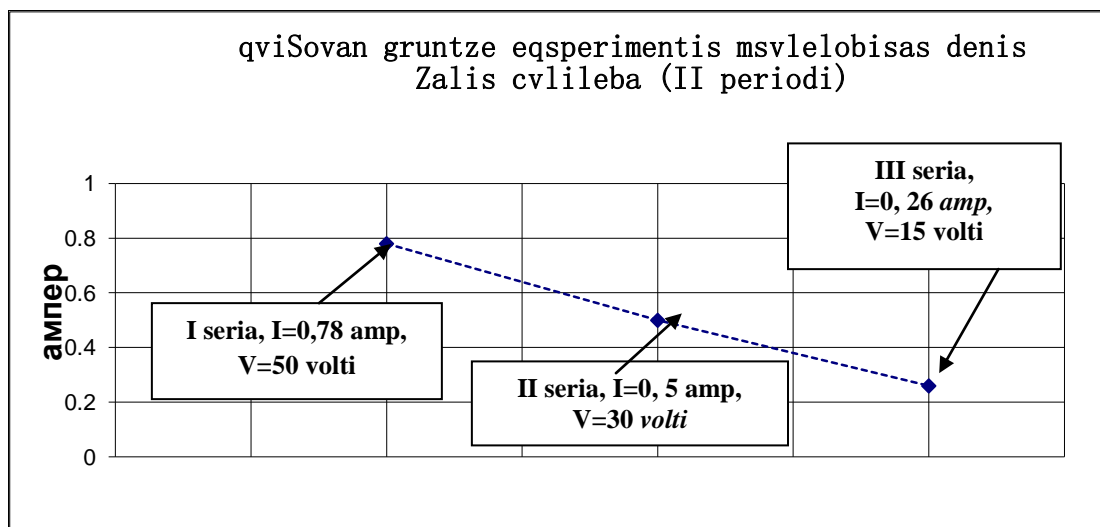
qviSovan gruntSi sadrenaJe milidan gamonadeni wylis raodenobis cvlilebis gansazRvra wylis gamodinebis xangrZlivobaze (t_{min}), midebuli denis Zalaze (I_{amp}) da Zabvaze (V_{volti}) damokidebulebiT, el. denTan sadrenaJe milidan uSoresi horizontaluri eleqtrodebis mierTebisas (II periodi).



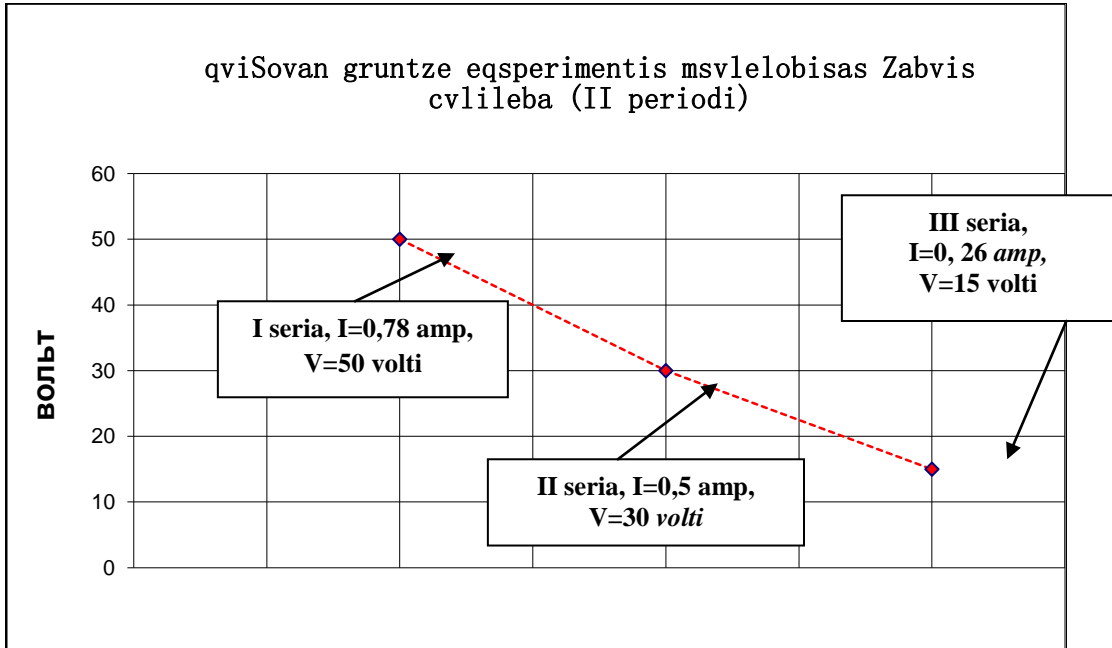
nax. 5.10, 5.2. cxrilis monacemebiT



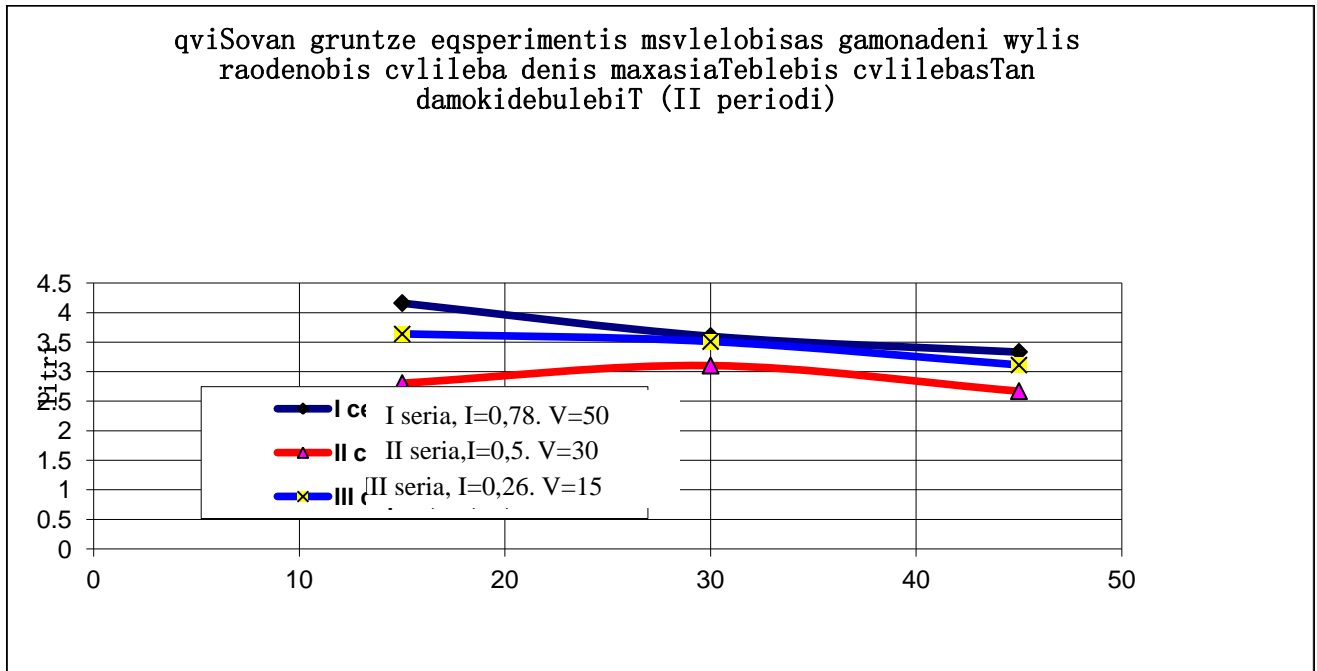
ნახ. 5.11. 5.2. ცხრილის მონაცემებიT



ნახ. 5.12, 5.2. ცხრილის მონაცემებიT



max. 5.13. 5.2. cxrilis monacemebiT



max. 5.14. 5.2. cxrilis monacemebiT

5.2.3. qviSnarovan gruntebTan eqsperimentebis Sedegebi

tevadobis Sevseba qviSnarovani grunTiT xdeboda iseve, rogorc qviSovani grunTis SemTxvevaSi _ fenebad. amasTan, mas emateboda wyalic. Sevsebuli tevadobis dayovnebisas, el denis mieraTebamde, grunTis jdenis kvaldakval, zedapirze warmoiqmneboda wylis fena sisqiT 1 sm.

eqsperimentebis procesSi, sadrenaJe milidan nadeni wyalis, awonvis Semdeg, isev brundeboda tevadobaSi.

eqsperimentebis meTodologia iyo qviSovani grunTis analogiuri erti etapis xangrZlivoba _ 10 wT.

qvemoT, cxrilSi da grafikebSi, motanilia qviSnarovan grunTze Catarebuli eqsperimentebis Sedegebi. monacemebi motanilia cxrilebSi, xolo grafikuli interpretacia _ naxazebze 5.14.....5.26. miRebuli Sedegebis analizis Sedegad SeiZleba davaskvnaT:

1. sadrenaJemilidan gamonadeni wylis raodenobaze eleqtroosmosis gavlenis saerTo kanonzomierebebi igivea, rogorc qviSovani grunTis SemTxvevaSi, magram wyalgacema SedarebiT naklebia (ix. cxrilebi 5.1. da 5.4.);
2. qviSnarovan grunTebSi gamonadeni wylis intensiurobis dadableba etapebis mixedviT xdeba ufro nela, vidre qviSebis SemTxvevaSi amasTan pirvel etapze, el. osmosis dawyebis Semdeg SeiniSneba wylis gamodinebis maRali intensiuroba, Semdeg igi mkveTrad dabldeba da stabilizirdeba daaxloebiT erT doneze (ix. nax. 5.4, 5.9, 5.17 da 5.22).

SesaZloa amis mizezia Tixovani grunTebisaTvis damaxasiaTebeli uaryofiTi forovani wnevis warmoqmna, romelic iwvevs grunTis SemWidrovebas. aRniSnuli movlena SevamowmeT praqtikulad.

pirvel etapze wylis modinebis intensiurobis mkveTri Secvla el. osmosis dawyebis momentSi aRniSnulia cxr. 5.3.. da nax. 5.15- moyvanili monacemebiTac.

cxrili 5.3.1.

gamonadeni wylis raodenobis (gramebSi) cvlilebis gansazRvra gamodinebis xangrZlivobaze (t_{wT}), modebuli denis $Zაღაზე$ (I_{amp}) da Zabvaze (V_{volti}) damokidebulebiT. uaxloesi horizontaluri eleqtrodebis mierTebisas.

	TiToeul etapze, seriebis mixedviT, gamonadeni wylis raodenoba (grami),
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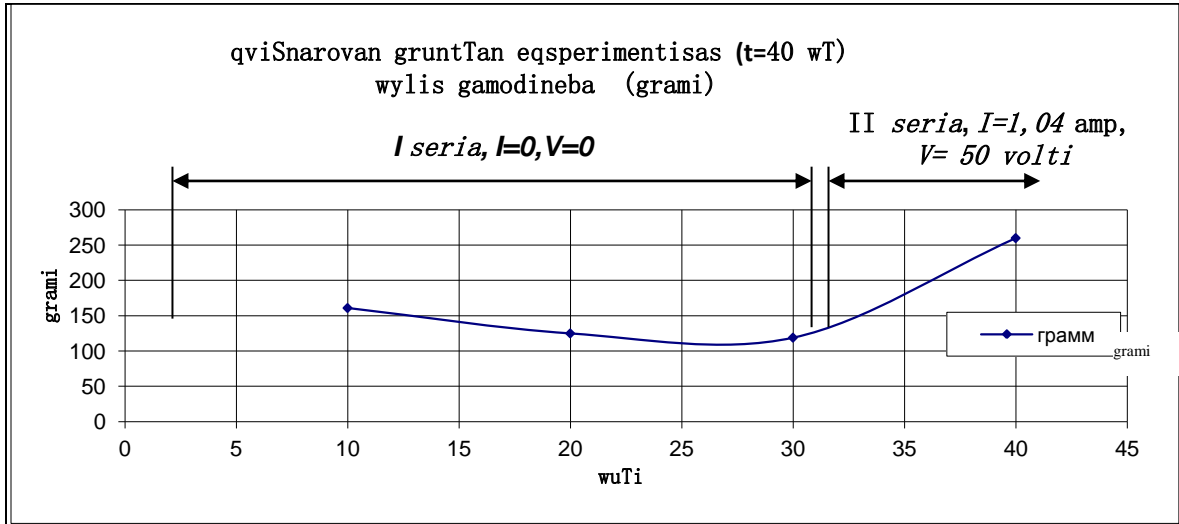
mierTebuli el. denis maxasiaTeblebi	eqsperimentis msvlelobisas - $t = 40 \text{ wT}$		
	<i>I etapi, 10 wT</i>	<i>II etapi, 10 wT</i>	<i>III etapi, 10 wT</i>
pirveli seria $I=0 \text{ amp}, V=0 \text{ volti}$ (0-30 wT)	161	125	119
meore seria $I=1,04 \text{ amp}, V=50 \text{ volti}$ (gagrZeleba pirveli seriis Semdeg 30-40 wT-is)	260	-	-

SeniSvna: yvela etapze sadrenaJe milidan gamonadeni wyali brundeboda sakvlev modelSi. magram eqsperimenti Sewyda aparaturaSi gaumarTaobis warmoqmnis gamo.

cxrili 5.3.2.

etapebis da seriebis mixedviT wylis xarjebis (wx) Tanafardoba.

cxrilis №	seria	wylis xarjis Tanafardoba (1/2, 1/3), etapebs Soris seriaSi		momdevno seriis I etapis wx-is fardoba wina seriis III etapTan	SeniSvna
1	2	3		4	5
cxr. 5.3.1.	I	1,29	1,35	-	
	II	-	-	II.1 : I.3 = 2.18	



ნახ. 5.15., 5.3.1 ცხრილის მონაცემები

გამონადენი wylis raodenobis cvlilebis gansazRvra (grami) gamodinebis droze denis Zalasa da Zabvaze damokidebuleბიT, uaxlesi horizontaluri electrodების SemTxvevaSi.cხრილი 5.4.1.

მიდებუი el. denis maxasiaTebleბი	გამონადენი wylis raodenoba (grami) yvela etapze, serieბis mixedviT, eqsperimenti _ 110 wT.		
	<i>I etapi, 10 wT</i>	<i>II etapi, 10 wT</i>	<i>III etapi, 10 wT</i>
პირველი seria <i>I=0 amp, V=0 volტი</i> (0-10 wT)	140	-	-
მეორე seria <i>I=1,5 amp, V=22 volტი</i> (გაგრZeleba პირველის Semdeg 11-40 wT-ის)	187	93	85
მესამე seria <i>I=1,0 amp, V=16 volტი</i> (გაგრZeleba მეორეს Semdeg 41-70 wT-ის)	82	120	77
მეოთხე seria <i>I=0,5 amp, V=6 volტი</i> (გაგრZelebamesames Semdeg 71-100 wT-ის)	63	83	75
მეხუთე seria <i>I=1,5 amp, V=22 volტი</i> (გაგრZeleba მეოთხეს Semdeg 101-110 wT-ის)	65	-	-

SeniSvna:

1. yvela etapze gamonadeni wyali brundeboda sakvlev modelSi.

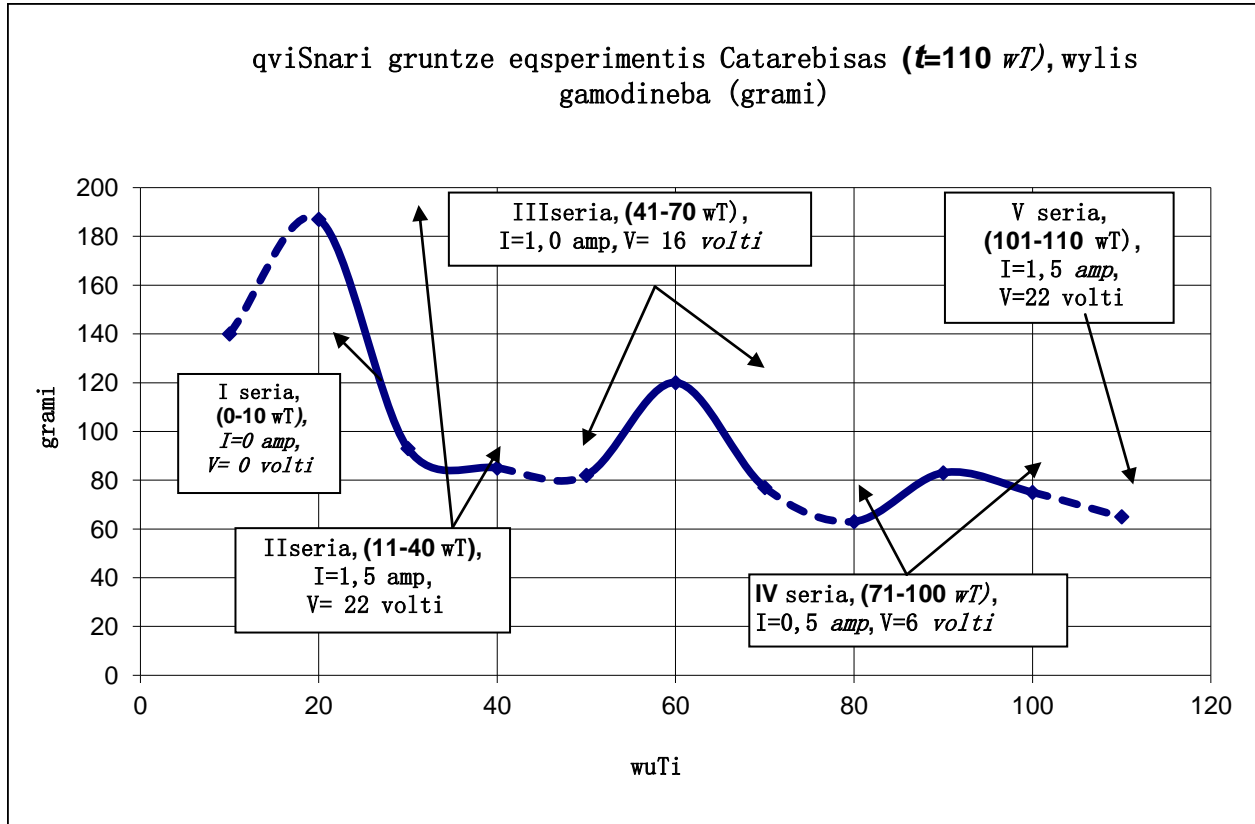
2. eqsperimenti grZeldeboda seriebs Soris pauzis gareSe.

1. el. denis maxasiaTebledi dgindeboda TviToeuli seriis dasawyisSi da ar koreqtirdeboda etapebis mixedviT mTeli seriis ganmavlobaSi.

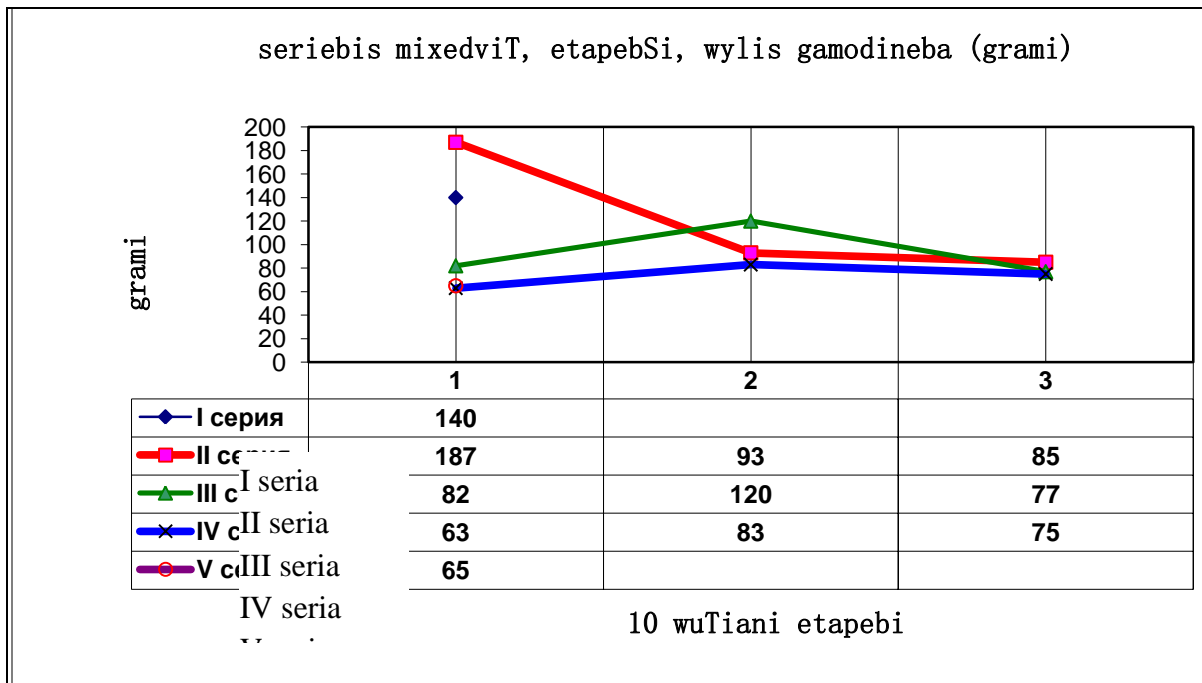
cxrili 5.4.2.

eqsperimentisas etapebisa da seriebis mixedviT wylis xarjebis Tanafardoba

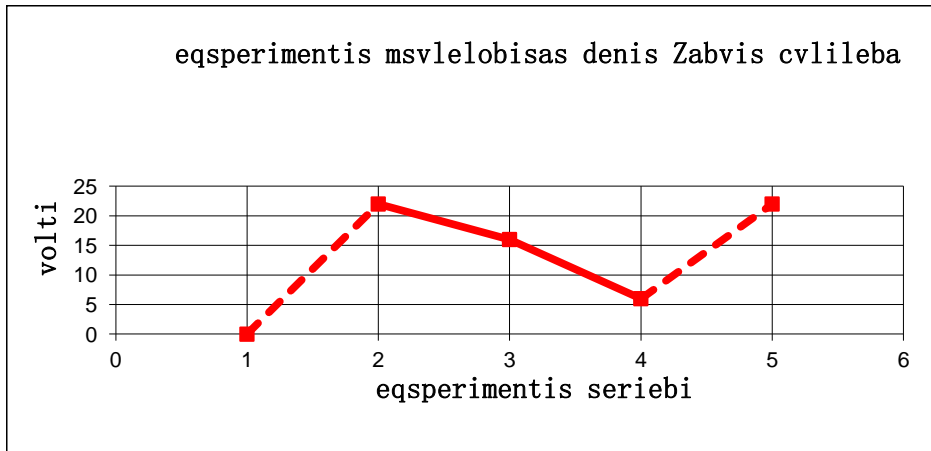
cxrilis №	seria	wylisxarjis Tanafardoba (1/2, 1/3)seriaSi etapebis mixedviT		momdevno seriis I etapi wx-is fardoba wina seriis III etapTan	SeniSyna
1	2	3		4	5
5.4.1. cxrilis mixedviT	I	-	-	-	viRebT wx I.1 = I.3
	II	2,01	2,2	II.1 : I.1 = 1.34	
	III	0,2	0,11	III.1 : II.3 = 0,96	
	IV	0,76	0,84	IV.1 : III.3 = 0,82	
	V	-	-	V.1 : IV.3 = 0,87	



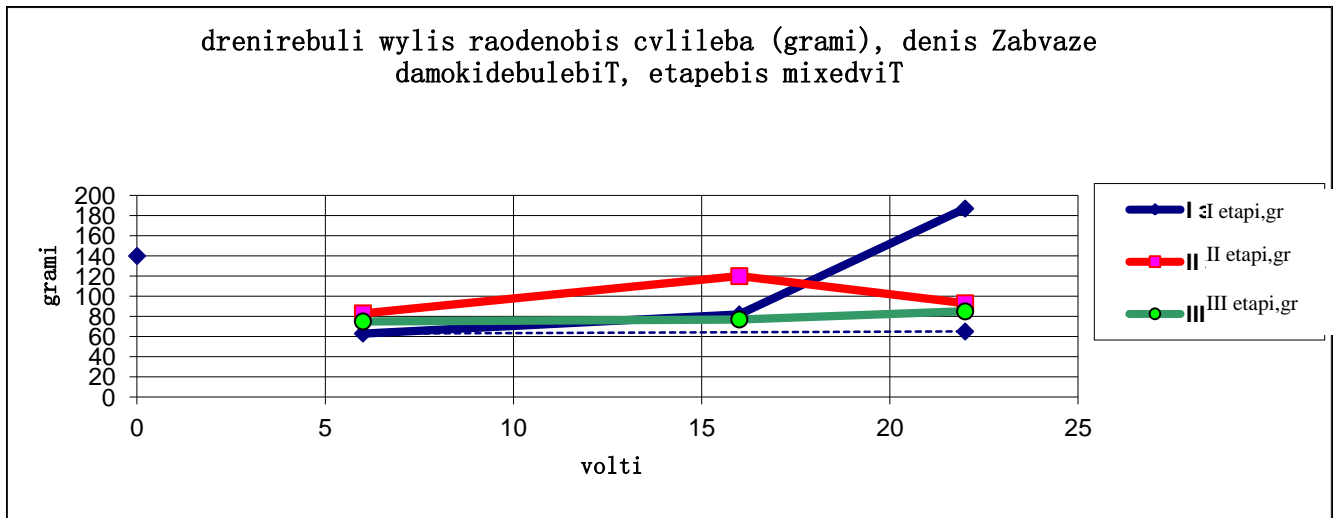
max. 5.16. 5.4.1 cxrilis monacemebiT



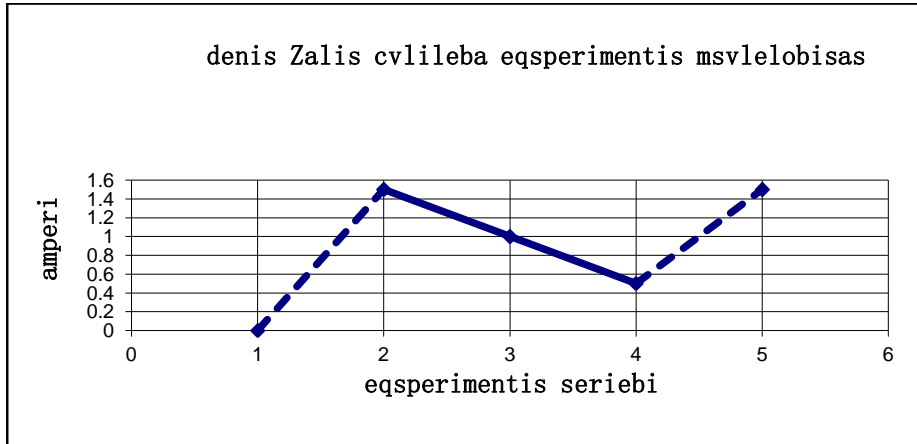
max. 5.17. 5.4.1 cxrilis monacemebiT



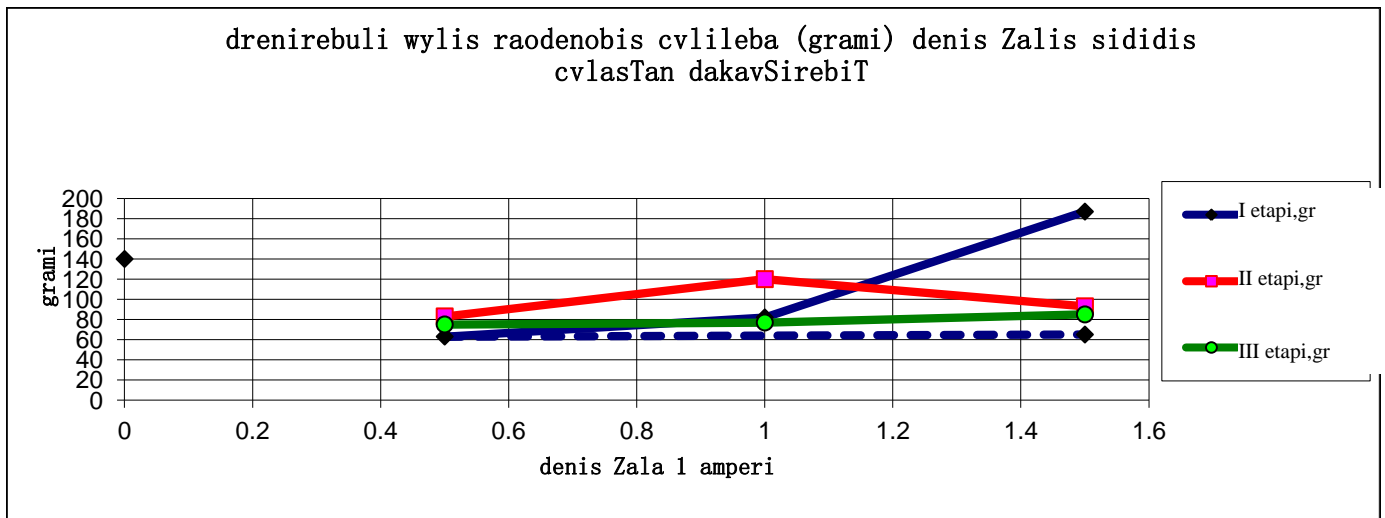
nax. 5.18, 5.4.1 cxrilis monacemebiT



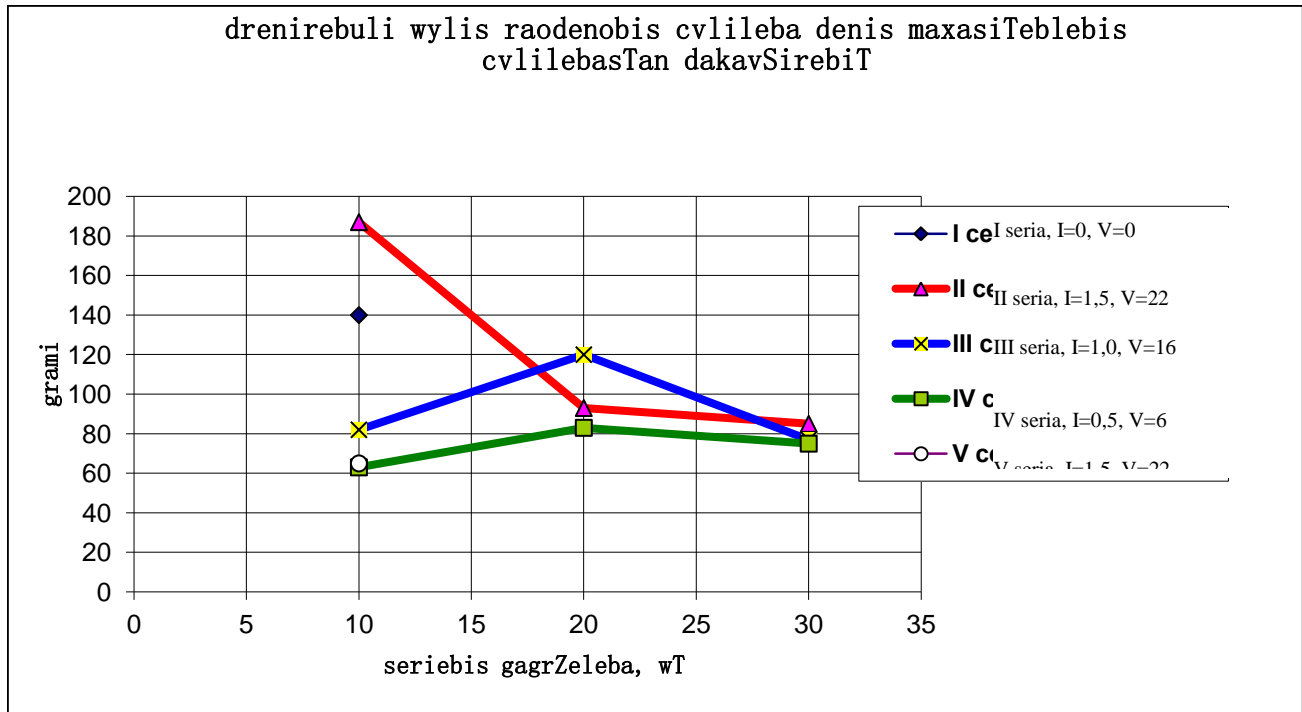
nax. 5.19, 5.4.1 cxrilis monacemebiT



nax. 5.20. 5.4.1 cxrilis monacemebiT



nax. 5.21, 5.4.1 cxrilis monacemebiT



ნახ. 5.22, 5.4.1 ცხრილის მონაცემები

ცხრილი 5.5.1.

გამონადენი წყლის რაოდენობის ცვლილების გასაზრვრა (გრამი) წყლის გამოდინების ხანგრძლივობაზე, მოდელი დენის ზალაზე და ზაბვაზე დამოკიდებულებით, უსოფისი ჰორიზონტალური ელექტროდებისთვის

მოდელი ელ. დენის მაქასიატებლები	გამონადენი წყლის რაოდენობა (გრამი) ტიტოული ეტაპზე, სერიების მიქედვით		
	<i>I</i> ეტაპი, 10 wT	<i>II</i> ეტაპი, 10 wT	<i>III</i> ეტაპი, 10 wT
პირველი სერია <i>I=1,5 amp, V=28ვოლტი</i> (0-30 wT)	93	78	93
მეორე სერია <i>I=1,0 amp, V=16ვოლტი</i> (გაგრძელება პირველის შემდეგ 31-60 wT)	100	85	93

სენიშვნა: 1. ტიტოული ეტაპზე გამონადენი წყლის ბრუნდობა მოდელი

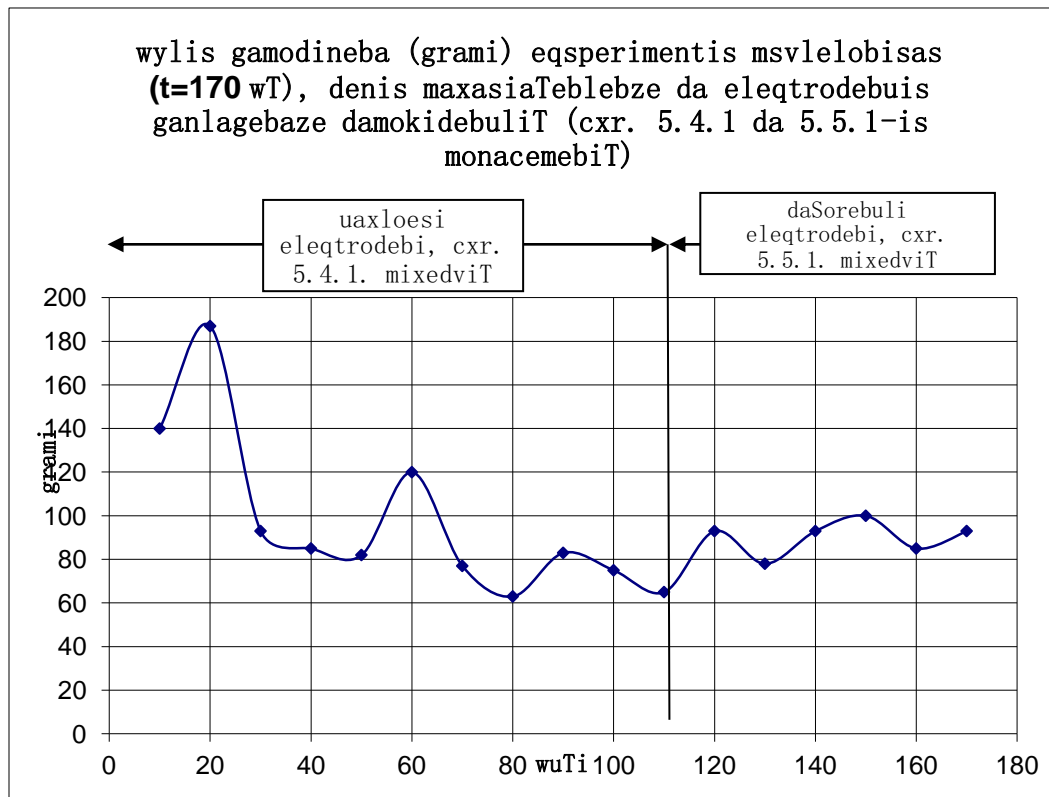
2. ექსპერიმენტი გრძელდობა სერიების შორის პაუზების გარეშე.

3. ელ. დენის მაქასიატებლები დგინდობა ტიტოული სერიის დაწყებისას კორექტირდობა მტელი სერიის ეტაპების მიქედვით.

ექსპერიმენტის მსვლელობისას წყლის ხარჯების თანაზრდობა სერიებით

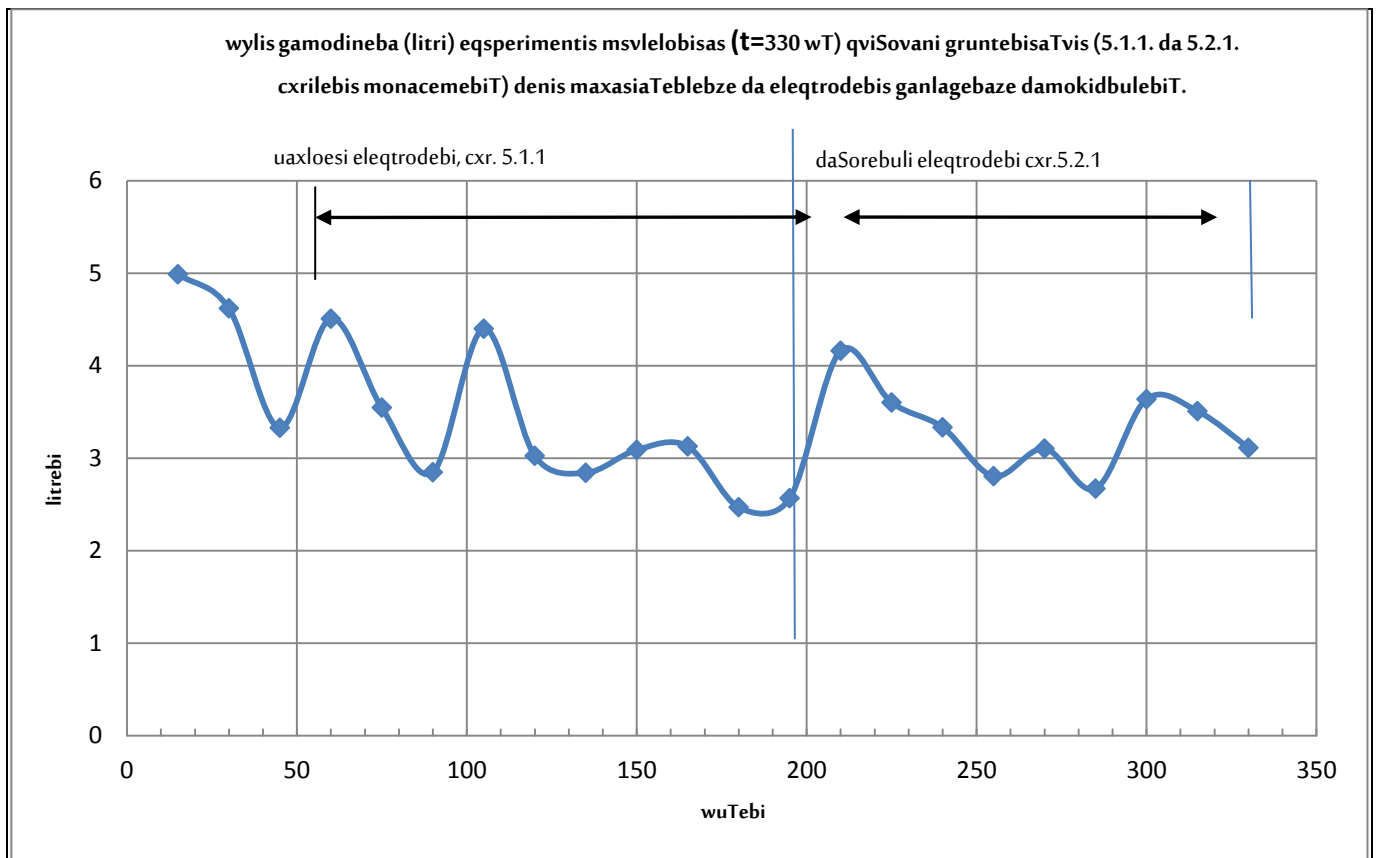
cxrili 5.5.2.

cxrili #	seria	wylis xarjebis Tanafardoba,seriaSi etapebs Soris (1/2 da 1/3)		momdevno seriis I etapi wx fardoba wina seriis III etapTan	SeniSvna
1	2	3		4	5
5.5.1. cxr-is mixedviT	(seria V. 5.4.1 cxr-is mixedviT)			I.cxr-is mixedviT.5.5.1: V.I cxr-is mixedviT 5.4.1 =1,43	V.1etapTan Sedareba cxrili 5.4.1
	I	1,19	1,0		
	II	1,18	1,08	II.1 : I.3 = 1,08	

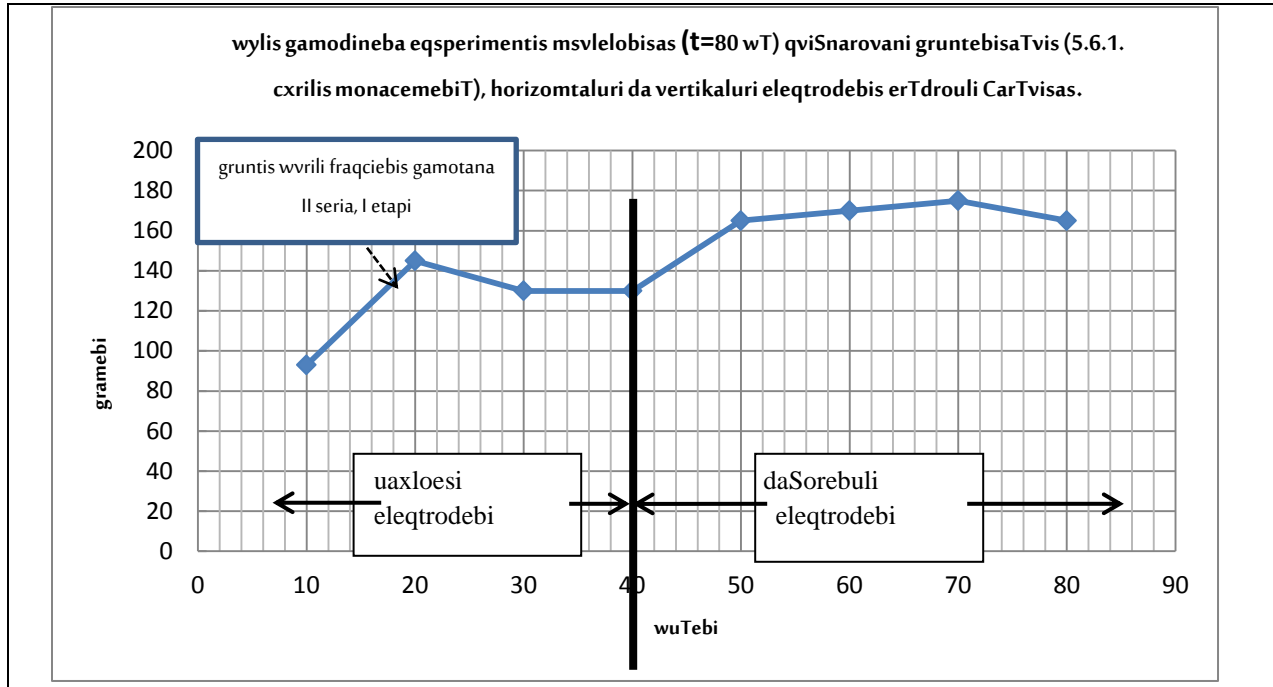


max. 5.23, 5.4.1, 5.5.1. cxrili monacemebiT

naxazebze 5.23 da 5.24 asaxulia wylis gamodinebis grafikebi etapebis mixedviT qviSovani da qviSnarovani gruntebisaTvis 5.1. da 5.2 cxrilebis (urTierTSedarebisaTvis) da 5.4.1. da 5.5.1. cxrilebis grafikebidan, Cans, rom denis gadarTvisas uaxloesi eleqtrodebidan uSoresze, adgili aqvs erTnair suraTs _ wylis gamodinebis intensiurobis amaRlebas, Semdeg _ mis vardnas da garkveul stabilizacias. SeiZleba rekomendacia, rom gruntebis gamoSrobis mizniT el. osmosis gamoyenebisas horizontaluri sadrenaJe WaburRilebis daxmarebiT dainiSnos eleqtrodebidan sadrenaJe WaburRilamde optimaluri manZili TiToeuli konkretuli gruntisaTvis. 5.6.1. da 5.6.2. cxrilebSi aris eqsperimentebis monacemebi gamonadeni wylis gansasazRvrad el. denTan rogorc horizontaluri, aseve vertikaluri eleqtrodebis mierTebisas. amasTan meore seriaSi mierTebuli iyo uaxloesi eleqtrodebi, xolo mesame seriaSi _ moSorebuli.



nax. 5.24. 5.1., 5.2.. cxrilis monacemebiT



nax. 5.25., 5.6.1 cxrilis monacemebiT

sadrenaJe milidan gamonadeni wylis raodenobis cvlileba qviSnarovani gruntebisaTvis, wylis gamodinebis xangrZlivobaze, modebuli denis Zalaze da Zabvaze damokidebulebiT, horizontalmuri da vertikaluri eleqtrodebis SemTxvevaSi.
cxrili 5.6.1

mierTebuli el. denis maxasiaTeblebi	eqsperimentis msvlelobisas (80 wT) TiToeul etapze, seriebis mixedviT, gamonadeni wylis raodenoba (gramebSi)		
	<i>I etapi, 10 wT</i>	<i>II etapi, 10 wT</i>	<i>III etapi, 10 wT</i>
pirveli seria $I=0 \text{ amp}, V=0 \text{ volti}$ (0-10 wT)	93	-	-
meore seria $I=2,2 \text{ amp}, V=25 \text{ volti}$ (gagrZeLeba pirvelis Semdeg 11-40 wT)	145 (iyo wvrili nawilakebis gamotanis Tanxleba)	130 ($I=2,5 \text{ amp}$)	130
mesame seria $I=2,0 \text{ amp}, V=26 \text{ volti}$ (gagrZeLeba meores Semdeg 41-70 wT)	165	170	175
meoTxe seria $I=2,0 \text{ amp}, V=26 \text{ colti}$ (gagrZeLeba mesames Semdeg 71-80 wT)	165	-	-

SeniSvna:

1. sadrenaJe milidan TiToeul etapze gamonadeni wyali brundeboda ukan, sakvlev modelSi.
2. eqsperimenti Catarda seriebs Soris pauzebis gareSe.
3. el. denis maxasiaTeblebi dgindeboda TiToeuli seriis dawyebisas da ar koreqtirdeboda etapebis mixedviT mTeli seriis ganmavlobaSi.
 2. meore seriaSi el. denTan mierTebuli iyo sadrenaJe milTan ganTavsebuli uaxloesi horizontaluri da vertikaluri eleqtrodebi, xolo III seriaSi _ uSoresi horizontaluri da vertikaluri eleqtrodebi.

eqsperimentis mimdinareobisas, II seriis I etapze, dafiqsirda, wylis nakadTan erTad, gruntuli masis wvrili fraqciebis gamotana, rac mowmobs sadrenaJe milTan wylis nakadis mniSvnelovan intensifikacias Siga nakadSi, el. denTan sadrenaJe milis garSemo arsebuli yvela eleqtrodis mierTebisas, agreTve sadrenaJe milis garSemo zonaSi gruntis masis SemWidrovebas.miRebuli Sedegebis grafikuli interpretacia warmodgenilia 5.24 naxazze.

sadrenaJe milidan gamonadeni wylis intensiurobis amaRleba moSorebuli eleqtrodebis mierTebisas, xolo Semdeg misi stabilizacia da Caqroba (dadableba) rogorc Cans, dakavSirebulia qviSnarovan gruntebSi sadrenaJe milidan daSorebul zonebSic gruntis gamoSrobasa da Semdgom SemWidrovebasTan. rogorc Cans, aseTive suraTi iqneba dadebiTi polusis mierTebisas gamoSrobis zonis farglebSi dayenebul nebismier eleqtrodze, rac gamoiwvevs sadrenaJe milidan wylis nakadis mniSvnelovan intensifikacias da gruntis electroosmosiT “dasamuSavebeli” zonis gamoSrobis daCqarebas.

cxrili 5.6.2.

eqsperimentis wylis xarji (wx) etapebisa da seriebis mixedviT

cxrilis Ng	seria	seriaSi wylis xarjis Tanafardoba etapebis mixedviT (1:2 da 1:3)	momdevno seriis I etapis wylis xarjis Sefardeba wina seriis III etapTan	SeniSvna
1	2	3	4	5
cxr. 5.6.1. monace	I	(seriis farglebSi)	-	viRebT wx I.1 = I.3
		-		

	II	1,12	1,12	II.1 : I.1 = 1.56	
	III	0,97	0,94	III.1 : II.3 = 1.27	
	IV	-	-	IV.1 : III.3 = 0.94	

qviSnarovan gruntSi sadrenaJe milidan gamonadeni wylis raodenobis cvlilebis gansazRvra wylis gamodinebis droze, denis Zalaze da zabvaze damokidebulebiT, el. denTan uaxloesi horizontaluri da vertikaluri eleqtrodebis mierTebisas.

cxrili 5.7.1.

mierTebuli el. denis maxasiaTeblebi	gamonadeni wylis raodenoba (gramebSi)TiToeul etapze, seriebis mixedviT, eqsperimentis dro – 70 wT.		
	<i>I etapi, 10 wT</i>	<i>II etapi, 10 wT</i>	<i>III etapi, 10 wT</i>
pirveli seria <i>I=0 amp, V=0 volti</i> (0-30 wT)	110	90	92
meore seria <i>I=1,5 amp, V=22 volti</i> (gagrZeleba pirvelis Semdeg31-60 wT)	160	130 (gruntis wvrili fraqciebis gamotaniT)	72
mesame seria <i>I=1,7 amp, V=25 volti</i> (gagrZeleba meores Semdeg61-70 wT)	80	-	-

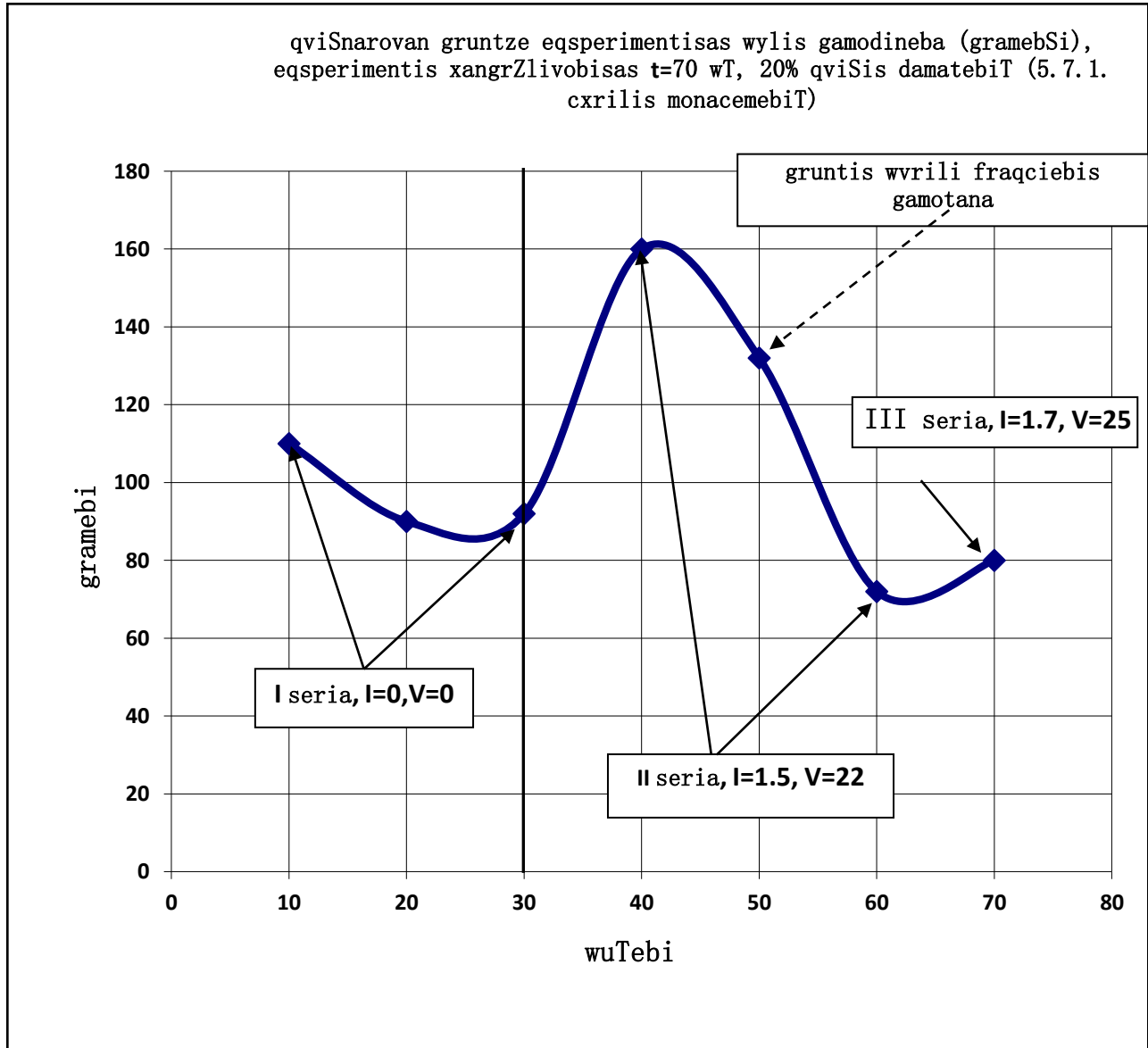
SeniSvna:

1. gruntSi damatebulia qviSa -20%.
2. sadrenaJe milidan yvela etapze gamonadeni wyali brundeboda ukan, sakvlev modelSi.
3. eqsperimenti Catarda uwyvetad, seriebs Soris pauzebis gareSe.
4. el. denis maxasiaTeblebi dgindeboda TiToeuli seriis dawyebisas da ar koreqtirdeboda etapebis mixedviT mTeli seriis ganmavlobaSi.

eqsperimentSi wylis xarjis Tanafardoba etapebisa da seriebis mixedviT

cxrili 5.7.2.

cxrili №	seria	seriaSi wylis xarjis Tanafardoba etapebis mixedviT (1:2 da 1:3)		momdevno seriis I etapis wylis xarjis Sefardeba wina seriis III etapTan	SeniSyna
1	2	3		4	5
cxr. 5.7.1. monacemebiT		(seriis farglebSi)		-	
	I	1.22	1.20		
	II	1.23	2.22	II.1 : I.3 = 1.74	
	III	-	-	III.1 : II.3 = 1.11	



nax. 5.26, 5.7.1 cxrilis monacemebiT

5.7.1. cxrilSi motanilia monacemebi qviSnarovani gruntebis gamokvlevis Taobaze 20% qviSis danamatiT. el. denTan mierTebuli iyo sadrenaJe mili (“minusi”) da masTan uaxloesi vertikaluri da horizontaluri eleqtrodebi (“plusi”).

5.7.1. da 5.7.2. cxrilebSi motanili monacemebis, agreTve 5.26 naxazze naCvenebi grafikiT (romelic agebulia 5.7.2 cxrilis monacemebiT) Cans, rom am SemTxvevaSic eleqtroosmosiT gruntis Srobis daCqarebis procesis xarisxobrivi suraTi ar icvleba.

qviSnari grunti, qviSis didi SemcvlelobiT, ufro intensiurad Sreba el. osmosis zemoqmedebisas pirvel or etapze (20 wT), Semdeg _ intensiuropa ecema.

amasTan, meore etapze, el. osmosis zemoqmedebisas, SeiniSneba gruntis wvrili fraqciebis gamotana, rac, rogorc Cans, aris gruntis intensiuri SekumSvis da amis Sedegad, agreTve el. osmosis zemoqmedebis Sedegad, wylis Siga nakadis amaRlebis Sedegi.

5.8.1 cxrilSi motanilia qviSnarovani (20% qviSis danamatiT) gruntebis gamokvlevis monacemebi. el. denTan uaxloesi horizontaluri da qveda vertikaluri eleqtrodis mierTebisas.

eqsperimenti Catarda zemoT aRwerili eqsperimentis Catarebidan ori kviris Semdeg (5.7.1 cxrilis monacemebiT) im mdgomareobaSi myof gruntze, romelic mas hqonda adre Catarebuli eqsperimentis Semdeg.

el. osmosis CarTvisTanave (ix. cxr. 5.8.1, meore seria, I da II etapebi) wylis intensiur gamodinebas (I seriis I etapis mimarT) moyva gruntis wvrili fraqciebis gamotana. mesame seriaSi “plusi” mierTebuli iyo sadrenaJe milze, xolo “minusi” _ eleqtrodebze. gruntis nawilakebis gamotana Sewyda, xolo wylis gamodineba Semcirda TiTqmis orjer, rogorc Cans, sadrenaJe milidan eleqtrodebisaken wylis “ukunakadis” gamo sadrenaJe milis qveda da gverdiT zonebSi. ZiriTadi, sadrenaJe, milidan gamomavali wylis nakadi, rogorc Cans, warmoiqmneboda zemodan, gravitaciuli hidrostatikuri wnevis gamo Camomavali wylisagan.

cxrili 5.8.1.

qviSovan gruntze, sadrenaJe milidan gamonadeni wylis raodenobis (grami) cvlilebis gansazRvra wylis gamodinebis droze, denis Zalasa da Zabvebze damokidebulebiT, el. denTan sadrenaJe milTan uaxloesi horizontaluri da qveda vertikaluri eleqtrodebis mierTebisas.

mierTebuli el. denis maxasiaTeblebi	gamonadeni wylis raodenoba (gr) TiToeul etapze, seriebis mixedviT. eqsperimentis xangrZlivoba –t=130 wT	
	<i>I etapi, 10 wT</i>	<i>II etapi, 10 wT</i>
pirveli seria		

<i>I=0 amp, V=0 volti</i> (0-10 wT)	43	–
meore seria: "minusi"sadrenaJo milze <i>I=1,45 amp, V=24 volti</i> (gagrZeLeba pirvelis Semdeg11- 30 wT)	103 (aRiniSneboda gruntis wvrili fraqciebis Tanxleba)	45 (aRiniSneboda gruntis wvrili fraqciebis Tanxleba)
mesame seria: "plusi"sadrenaJe milze <i>I=1,45 amp, V=24 volti</i> (gagrZeLeba meores Semdeg31- 40 wT)	26	–
meoTxe seria: "minusi"sadrenaJe milze <i>I=1,45 amp, V=24 volti</i> (gagrZeLeba pirvelis Semdeg41- 130 wT)	40	370 (II etabi grZeldeboda 90 wT)

SeniSvna: 1. gruntSi damatebuli iyo 20% qviSa (ix. cxr. 5.7, igive grunti).

2. TiToeul etapze sadrenaJe milidan gamonadeni wyali brundeboda ukan, sakvlev modelSi.

3. eqsperimenti Catarda uwyvetad, seriebs Soris pauzebis gareSe.

4. meore seriis dasawyisSi dadgenili el. denis maxasiaTeblebi eqsperimentis bolomde ar koreqtirdeba, mxolod III da IV seriebSi gadaadgilebul iqnen polusebi sadrenaJe milze da eleqtrodebze.

**eqsperimentSi wylis xarjis (wx) Tanafardoba etapebis da seriebis
mixedviTcxrili 5.8.2**

cxrili	seria	wylis xarjis Tanafardoba I:II seriis etapebs Soris	momdevno seriis I etapis wylis xarjis Sefardeba wina seriis III etapTan	
1	2	3	4	5
5.8.1 cxrili monacemebiT	I	(II etapis seriebis farglebSi)		1. viRebT wx etapebSi: I seria I.2 = I.1 da III seria III.1 = III.2; 2. viRebT II etaps

	II	2,29	$II.1 : I.1 = 2.4$	wx saSualod: $370/9 = 41$ grami; 3. III etapze " plusi " sadrenaJe milze; 4. IV etapze " minusi " sadrenaJe milze.
	III	-	$III.1 : II.2 = 0.58$	
	IV	1,0	$IV.1 : III.1 = 1.54$	

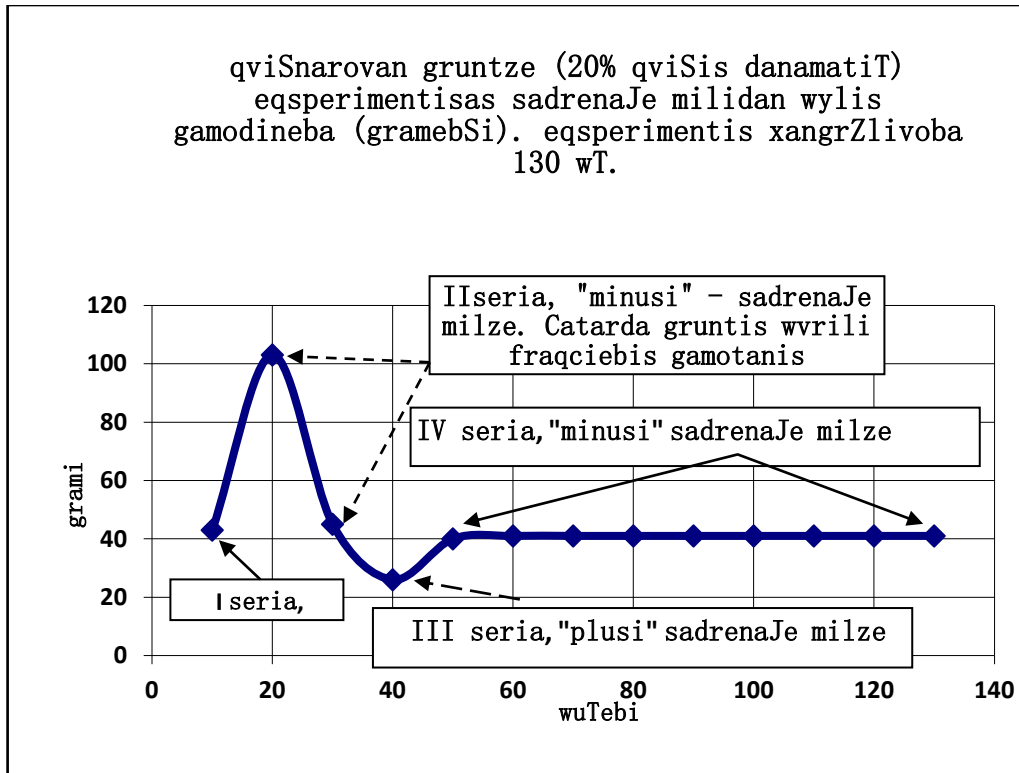
dengamtari sadenebis klemebis gadaadgilebis Semdeg kvlav: "minusi" _ sadrenaJe milze, "plusi" _ eleqtrodebeze, wylis gamodinebis intensiuroba aRdga I seriis I etapamde _ el. osmosis CarTvis gareSe, II seriis II etapze da meoTxe seriis yvela etapze. warmoqmnili procesis suraTi warmodgenilia nax. 5.26-ze grafikiT.eqsperimentis Sedegi metyvelebs imaze, rom Tixovan gruntebSi aucilebelia sadrenaJe milis mimarT eleqtrodebis daSorebis manZilebis da ganTavsebis swori SerCeva el. osmosis gamoyenebisas, winaaRmdeg SemTxvevaSi sadrenaJe milis zonaSi gruntis swrafi SemWidroveba nolamde daiyvans el. osmosis mTels efeqts (ix. 5.8.1 cxrili). QsaerTo Sedegebidan gamomdinare SeiZleba V Tavis daskvnebis gamotana:

1. dadgenilia qvabulebisa da tranSeebis bunebrivi kalTebis da ferdoebis gruntebis gamoSrobis, horizontalur sadrenaJe sistemebSi eleqtroosmosis gamoyenebis principuli SesaZlebloba;

2. eleqtroosmosis zemoqmedebiT gruntis SemWidroveba xels Seuwyobs kalTebisa da ferdoebis kedlebis gamagrebis, maTi mdgradobis amaRlebas;

3. gamosaSrob gruntebze el. osmosis zemoqmedebiT sadrenaJe milidan wylis gamodinebis amaRlebam, eqsperimentis monacemebis mixedviT Seadgina 50-60% _ qviSovan gruntebisaTvis da 70_140%-mde _ qviSnarovani gruntebisaTvis;

4. ferdoebisa da kalTebis gruntebis gamoSrobisa da SemkvrivebisaTvis eleqtroosmosis horizontaluri sadrenaJe WaburRilebisgamoyenebisas saWiroa, cdebis gziT, konkretuli gruntebisaTvis, sadrenaJe milis mimarT eleqtrodebis yvelaze ufro misaRebi manZilebisa da ganTavsebis dadgena.



nax. 5.27. 5.8.1 cxrilis monacemebiT

Tavi 6

amosaRebi gruntuli ankerebis arsebuli tipebis gaumjobesebis SesaZleblobebi gogirdbetonis gamoyenebiT

6.1. amosaRebi gruntuli ankerebi

amosaRebi gruntuli ankerebis gamoyenebis aucileblobma warmoiSva maTi mowyobis Semdeg didi raodenobiT liTonis masalebis, ZiriTadad liTonis mWimebis da sxva ankeruli mowyobilobebis erTjeradi gamoyenebis gamo. rogorc wesi gruntuli ankerebis gamoyenebiT, qvabulebis kedlebis an mewyersawinaaRmdago gamagrebis konstruqciebis mowyobis Semdeg gruntebSi umoqmedod da yovelgvari daniSnulebis gareSe rCeboda gruntuli ankerebis mTliani sistemebi. Gisini Semdeg Zalze xSirad xels uSlian maTi mowyobis teritoriaze miwis samuSaoebis warmoebas. magaliTad moyvanilia TbilisSi, nucubiZis quCis mimdebare teritoriaze, axali mSeneblobis warmoebis mizniT, quCis uSualo siaxloveSi rkinabetonis sayrdeni kedlis amosayvanad gruntuli ankerebis mowyobis samuSaoebi (nax. 6.1-6.3).



Nnax.6.1



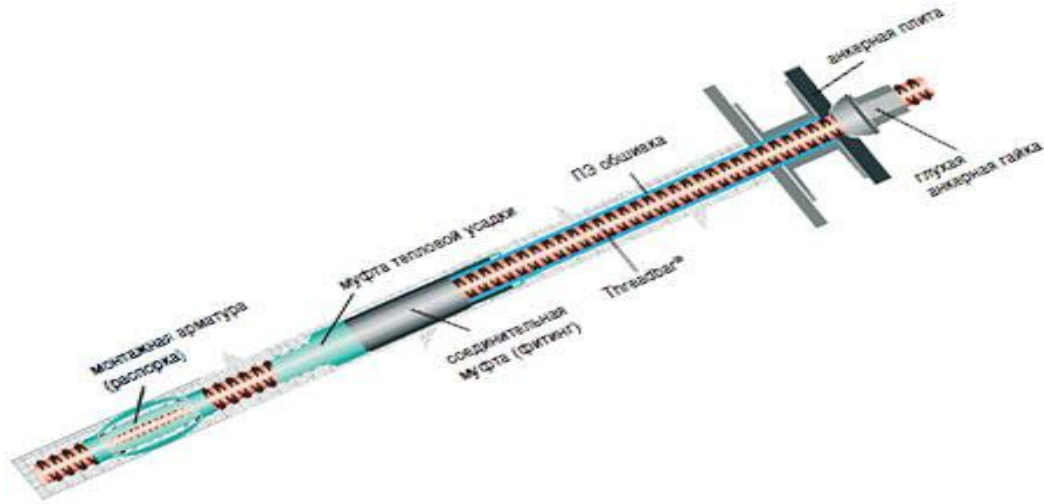
Nnax.6.2



Nnax.6.3

aRniSnuli ankerebi ewyoboda 32mm diametris mqone A-III klasis armaturisagan. amisaTvis 1,5m dacilebiT, saWiro daxris kuTxiT iburReboda 10sm diametris mqone WaburRilebi15,5-16,0 m siRrmeze. Aamis Semdeg xdeboda gakeTebul naburRebSi armaturis Reroebis Mcementizaciis meTodiT Camagreba. aRniSnuli magaliTidan kargad Cans, rom sayrdeni kedlis mowyobis samuSaoebis dasrulebis Semdeg nucubiZis quCis qveS didi raodenobiT darCeba ankerebis mWimebad gamoyenebuli armatura, xolocementaciis Sedegad iq arsebuli gruntic sakmaod iqneba gamkvrivebuli. momavalSi, quCaze komunikaciebis gasyvanis saWiroebis SemTxvevaSi an sxva tipis samuSaoebis Sesarulebis dros, yovelive es SeiZleba dauZlevel winaaRmdogbad iqces.

msgavsi garTulebebis Tavidan asacilebis mizniT, msolfio praqtikaSi, sul ufro farTod inergeba amosaRebi gruntuli ankerebi. nax.6.4-6.5 moyvanilia amJamad gavrclebuli amosaRebi ankerebis sxvadasxva tipebi, miuxedavad didi progresisa, aRniSnuli meTodis erT-erT mniSvnelovan naklad unda CaiTvalos is, rom maT mosawyobad saWiroamravali saxis, sakmaod ZviradRirebuli Casamagrebeli mowyobilobebis qarxnuli wesiT damzadeba, xolo samuSaoebis dasrulebis Semdeg SeuZlebelia gruntSi Camagrebuli nawilebis amoReba da maTi xelmeored gamoyeneba.



Nnax.6.4. gruntuli ankeri “titani”

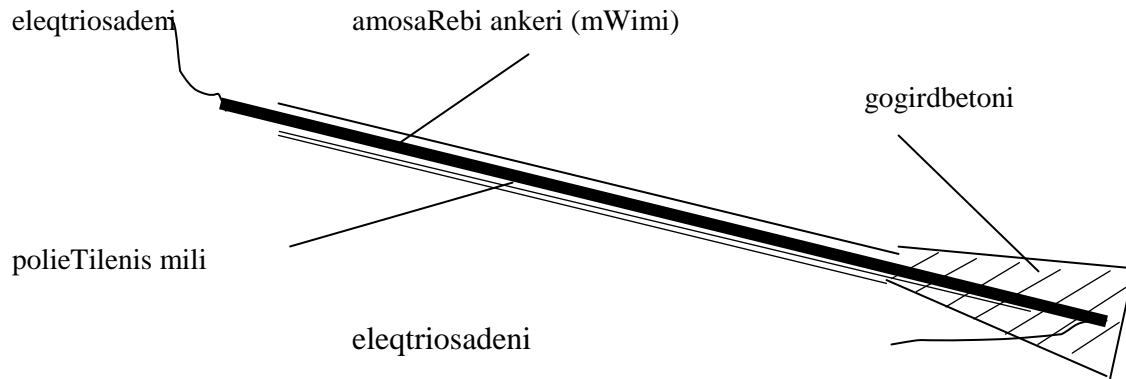


► SW-RCD anchor' s detailed part photograph

N

nax.6.5koreuli warmoebis amosaRebi gruntuli ankeri

arsebuli sistemebis gamartivebisa da gaumjobesebis mizniT, saqarTvelos teqnikuri universitetis samSeneblo fakultetze, prof. v.lolaZis mier damuSavebuli iqna axali tipis amosaRebi gruntuli ankeri, romelzec gacemulia patenti. AaseTi ankerebis mowyoba xdeba uSualod samSeneblo moedanze, saankere mWimebis boloebis gruntSi gogirdbetoniT CamagrebiT. gogirdbetoni saSualebas iZleva misi eleqtrogaxurebis Semdeg damdnari masidan advilad iqnas amoRebuli saankere mWimi. sainteresoa, rom eleqtrogaxurebisaTvis TviT saankere mWimebi gamoiyeneba. ankeris sqematuri gamosaxuleba moyvanilia nax.6.6-ze.



ნახ. 6.6 გოგირდბეტონით გამაგრებული ანკერული სისტემის სკემა

6.2. გოგირდბეტონის გამოყენება გრუნტული ანკერების გამაგრებაში

გოგირდის გამოყენება მსხვილბაზის მასტიკისა და ხსნარის სახით მრავალ საკუთარ გამოყენებაში. შემდგომში მან გოგირდბეტონის სახელწოდება მიიღო და როგორც უფრო გამოყენებული სახით

გოგირდიანი და ცემენტიანი ბეტონების მასების მასობრივი შემადგენლობა

გამოყენებაში. გოგირდბეტონის დასამზადებლად სარგებლობენ სხვადასხვა მინერალური მასებით: კვარცის კვარცის, კვარცის მთლიანი და სხვა. ამოსარები ანკერების გამაგრების განხორციელების მიზნით პირველ რიგში გამოიყენება იქნა ცველებრივი ბეტონისა და კვარცის მთლიან გამოყენებით დასამზადებელი გოგირდბეტონის ზირითადი ფიზიკურ-მექანიკური მასობრივი შემადგენლობა. მიწის მასების მასობრივი შემადგენლობა მოყვანილია ცხრილ 6.1.

მაჩვენებელი	გოგირდბეტონი	ცემენტბეტონი
სიმტკიცე კუმშვისას, მპა	58	36
სიმტკიცე ღუნვისას, მპა	8,9	4,2
დრეკადობის მოდული, მპა	$4,0 \times 10^4$	$3,0 \times 10^4$
ხაზოვანი ტემპერატურული გაფართოების კოეფიციენტი ^{0C}	$8,5 \times 10^{-6}$	$8,5 \times 10^{-6}$
სიმკვრივე, კგ/მ ³	2380	2370
მჭიდა მასალის ხარჯი, კგ/მ ³	280	360

ცხრილი 6.1.

ცხრილის მონაცემების ანალიზიდან ირკვევა რომ გოგირდბეტონს უკეთესი ფიზიკურ-მექანიკური მაქსიმალური მაჩვენებლები აქვს ცემენტბეტონთან შედარებით. გარდა ამისა განსაკუთრებით ადვილია 130-140^{0C} ტემპურამდე გაცხელებული ტევად მდგომარეობაში მიიყვანოს გოგირდბეტონის ადვილად მოთავსება სასურველ ფორმაში და რაც კიდევ უფრო მნიშვნელოვანია გაციების შემდეგ სპროექტო სიმტკიცის დანაკარგის მინიმალურად მიწვევა. მცენარის მიერ შემოთავაზებული ახალი ტიპის ამოსარები ანკერის გამოყენების უზრუნველყოფად გოგირდბეტონის სიმტკიცის მაქსიმალური დანაკარგის გარდა აუცილებელი იყო საანკეროდ გამოყენებული არმატურის გოგირდბეტონთან შედარებით საკითხის შესწავლა. ამ მიზნით გოგირდბეტონში და ცემენტბეტონში გამოყენებული იქნა 20mm დიამეტრის მკვრივი არმატურის რგოლები. ცემენტბეტონში მათი გამოყენება ხორციელდებოდა დამატებითი პროცესში, ხოლო გოგირდბეტონში გამოყენებისათვის გამოყენებული იქნა იგივე სახის ბეტონის ნიმუშები და რგოლები, რომლებიც შესაბამის ტემპურამდე გაცხელებული გოგირდბეტონის მასთან ერთად ხორციელდებოდა. ნიმუშების დამზადების პროცესი ასახულია ნახ. 6.7-ზე



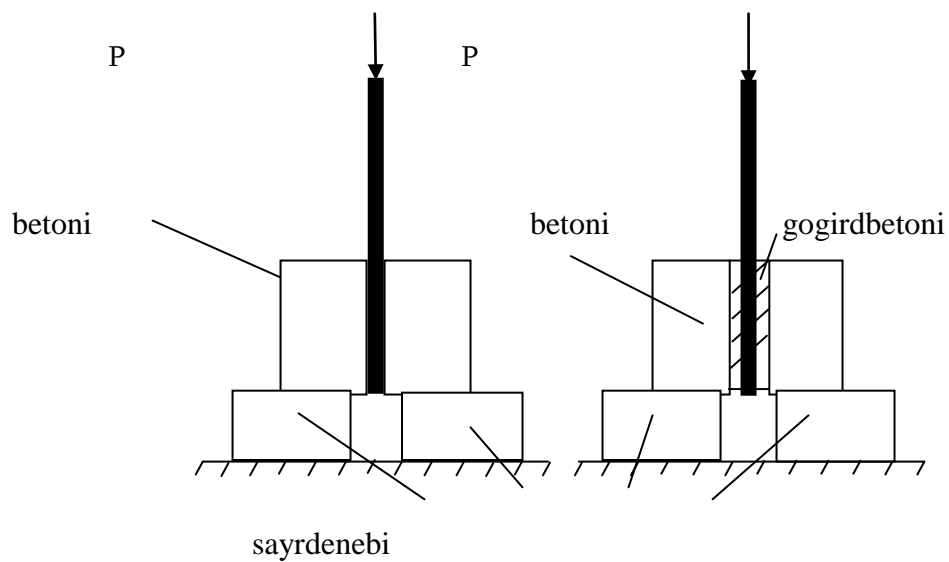
Nnax.6.7. gogirdbetoniani nimuSebis damzadeba

gogirdbetonis da Cveulebrivi betonis armaturasTan SeWidulobis SedarebiTi maxasiaTeblebis dadgenisaTvis gamoyenebuli iqna, presis zewolis dros armaturis CaWyletis meTodi. G



nax. 6.8 gamosacdeli nimuSebi

armaturis da betonis SeWidulebis gamocdis sqematuri gamosaxuleba moyvanilia nax.6.9-ze



nax. 6.9armaturis betonTan SeWidulobis CaWyletiT gamocdis sqema



nax. 6.10 armaturis betonTan SeWidulebis gamocda



nax. 6.11 gmocdili nimuSi



Nnax..6.12 gamocdili gogirdbetoniani nimuSebi

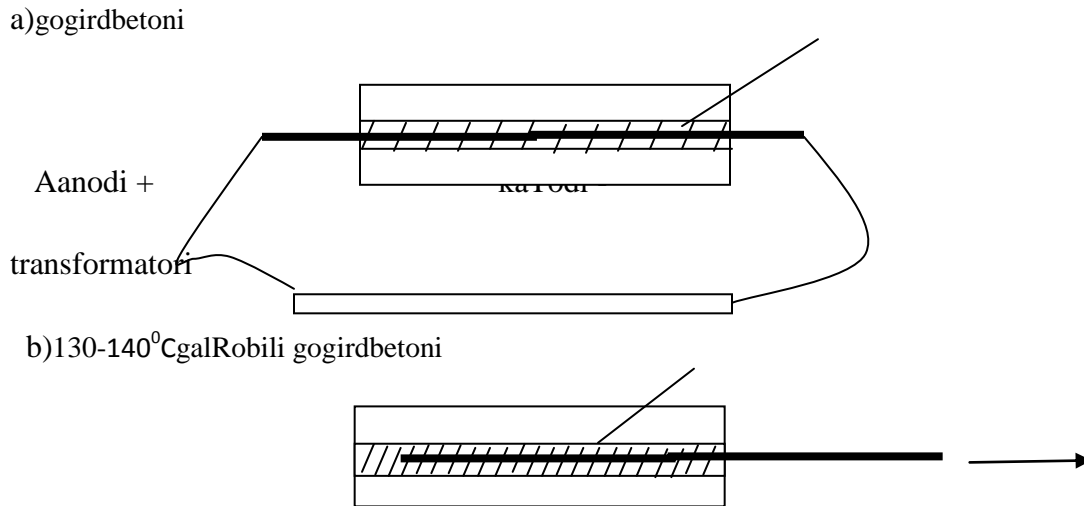
Catarebuli eqsperimentebis Sedegad gairkva, rom armaturis SeWiduleba gogirdbetonis da Cveulebrivi betonis nimuSebSi TiTqmis erTnairia da es maSin, rodesac betonis nimuSebisagan gansxvavebiT gogirdbetonis SeWiduleba faqtiurad ganisazRvreboda, rogorc Cveulebriv betonTan aseve armaturasTan. cxril 6.2-Si moyvanilia gamocdis Sedegebi.

cxrili 6.2

Ggogirdbetonis da Cveulebrivi betonis armaturasTan SeWidulobis mrRvevi Zalebis gansazRvra						
nimuSis #	#1 betoni	#2 betoni	#3 betoni	#4 Ggogird- betoni	#5 Ggogird- betoni	#6 Ggogird- betoni
mrRvevi Zala kgn	43	46	44	42	47	45

Eesperimentalurad gansazRvra aseve armaturis eleqtrogaxurebis Sedegad gogirdbetonis Sris dadnobiT armaturis amoRebis SesaZlebloba.. amisaTvis prizmulnimuSebSi zemoTaRwerili

wesiT moxda gogirdbetonis saSualebiT armaturis Reroebis Camagreba, im gansxvavebiT, rom Reros orive mxares iyo SesaZlebeli eleqtrosadenebis miyvana da eleqtrowredis Sekvra denis damadablebeli transformatoris gamoyenebiT. SerCeuli sqemiT (nax.13) Zalze martivad ganxorcielda armaturis Reros gaxureba, romelmac ukve 130-140°C temperaturaze daiwyo gogirdbetonis galRoba.



nax.6.13. gogirdbetoniT Camagrebuli armaturis Reros eleqtrogaxureba (a) da misi amoReba (b)

gogirdbetoniT Camagrebuli armaturis Reros gacxelebiT, sul mcire droSi moxda gogirdbetonis Sris Txevad mdgomareobaSi gadasvla da Camagrebis zonidan armaturis Reros amoReba. miRebuli Sedegebis gaanalizebis Sedegad SeiZleba danamdvilebiT iTqvas, rom amosaRebi gruntuli ankerebis mowyobisasefeqturia gogirdbetonis gamoyeneba, romelic simtkiciTi maxasiaTeblebiT ar Camouvardeba betons, xolo gacxelebisas advilad dneba gogirdis dnobis kargi unaris gamo.

Tavi 7

mewyerdamcavi sistemebisarsebuli (tradiciuli) da SemoTavazebuli konstruqciuli da teqnologiuri gadawyvetebis teqnukur-ekonomikuri Sedareba.

7.1. teqnukur-ekonomikuri Sedarebis meTodika.

mewyerdamcavi sistemebis arsebuli (tradiciuli) da SemoTavazebuli konstruqciuli da teqnologiuri gadawvetebi erTmaneTTan Sedarebulia teqnologiurobis Semdeg ZiriTadi kriteriumebis mixedviT: 1.masalatevadoba; 2.Sromatevadoba; 3.masalebis Rirebuleba; 4.xelfasi da 5.saeTo Rirebuleba.

erTmaneTTan Sedarebulia Semdegi variantebi:

I. arsebuli (tradiciuli sistemebi):

1. betonis masiuri vertikaluri sayrdeni kedeli;
2. betonis masiuri daxrili sayrdeni kedeli;
3. monoliTuri rkinabetonis uankero sayrdeni kedeli;
4. monoliTuri rkinabetonis gruntulankerebiani sayrdeni kedeli.

II. SemoTavazebuli sistemebi:

1. monoliTuri rkinabetonis lenturi gruntulankerebiani sayrdeni kedeli;
2. monoliTuri rkinabetonis svetebiani gruntulankerebiani sayrdeni kedeli.

Sesadarebel variantebSi gaangariSebebi Sesrulebulia B 20 klasis betonisa da A–III klasis armaturisaTvis.

sayrden kedelze gruntis dawnevis gansazRvrisas ganxilulia misi yvelaze ufro farTed gavrclebuli 4 tipi: mSrali qviSnari (qviSa); wyalnajeri qviSnari (qviSa); mSrali Tixnari (Tixa) da wyalnajeri Tixnari (Tixa). kedlebze gruntis dawnevis (E) Sesabamisi mniSvnelobebis gansazRvris Sedegad, kedlebis konstruqciuli gaangariSebebi Sesrulebulia maTgan SedarebiT ufro martivi (mSrali qviSnari) da daZabuli (wyalnajeri Tixnari) SemTxvevebisatvis.

radganac erT-erT Sesadarebel variantSi ganxiluli gvaqvs SemoTavazebuli svetebiani sayrdeni kedeli svetebis bijiT 3 m, amitom variantebis Sedareba Sesrulebulia ara sayrdeni kedlebis 1 grZivi metrisTvis (rogorc miRebulia tradiciulad), aramed 10 grZivi metrisatvis. amitom gaangariSebisas masalebis xarji 1 svetze gamravlebulia 3,3-ze.

SemoTavazebuli svetebiani sayrdeni kadlis gaangariSebisas, rogorc varianti, miRebulia B 30 klasis betonic.

radgan wylis sadrenaJe milebs iTvaliswineben rogorc tradiciuli, aseve SemoTavazebuli mewyerdamcavi sistemebi, amitom variantebis teqnukur-ekonomikuri Sedarebisas maTi mowyoba gaTvaliswinebuli ar aris.

variantebis teqnukur-ekonomikuri Sedarebisas, sayrdeni kedlebis konstruqciuli gadawyvetis da gruntuli pirobebis gaTvaliswinebiT, miRebuli gvaqvs maTi Semdegnairi markireba (cxr. 7.1).

masalebis xarji sayrdeni kedlebis 10 grZ. metrze gruntuli ankerebis mowyobaze mocemulia cxrilSi 7.2.

masalebis saerTo xarji sayrdeni kedlebis 10 grZ. metrze Sesadarebeli variantebisaTvis mocemulia cxrilSi 6.3.

variantebis teqnukur-ekonomikuri maCveneblebis urTierTSedareba mocemulia cxrilSi 7.4.

cxrili 7.1. sayrdeni kedlebis markireba

Sesadarebeli konstruqciebi	sayrdeni kedelis saxe	sayrdeni kedlis konstruqciuli gadawyveta		gruntis saxeoba	sayrdeni kedlis marka
tradiciuli, betonis klasi B 20	masiuri, betonis	Lenturi	vert.	mSrali qviSnari	sk - 1
				wyalnajeri Tixnari	sk - 2
		daxr.	mSrali qviSnari	sk - 3	
			wyalnajeri Tixnari	sk - 4	
	monoliTuri rkinabetonis	Lenturi	Uankero	mSrali qviSnari	sk - 5
				wyalnajeri Tixnari	sk - 6

SemoTavazebuli	betonis klasi B 20	mon. rkinabetonis, 2-iarusiani ankerebiT	Lenturi	ankerebiT 1 iarusad	mSrali qviSnari	sk - 7
					wyalnajeri Tixnari	sk - 8
				Svetebis gareSe	mSrali qviSnari	sk - 9
					wyalnajeri Tixnari	sk - 10
				Svetebiani	mSrali qviSnari	sk - 11
					wyalnajeri Tixnari	sk - 12
	betonis klasi B 30	mon. rkinabetonis, 2-iarusiani ankerebiT	lenturi	Svetebiani	mSrali qviSnari	sk - 13
					wyalnajeri Tixnari	sk - 14

cxrili 7.2 masalis xarji ankerebis mowyobaze kedlebis 10 grZivi m-Tvis

sayrdeni kedlis marka	ankeris marka	ankerebis raodenoba kedlis 10 gr.m	masalebis xarji 1 ankerze		masalebis saerTo xarji	
			armatura A_III,kg	cement duRabi	armatura A_III, kg	cement duRabi
sk _ 1 sk _ 2 sk _ 3 sk _ 4 sk _ 5 sk _ 6	ankerebi ar ewyoba					
sk _ 7	a _ 1	10	13,0	0,21	130	2,1
	a _ 1'	10	7,4	0,21	74,0	2,1
	jami				204,0	4,2
sk _ 8	a _ 2	10	32,3	0,47	323,0	4,7
	a _ 2'	10	15,4	0,47	154,0	4,7
	jami				477,0	9,4
	a _ 3	10	13,0	0,27	130,0	2,7

sk_9	a_3'	10	7,4	0,27	74,0	2,7
	jami				204,0	5,4
sk_10	a_4	10	43,0	0,7	430,0	7,0
	a_4'	10	21,7	0,7	217,0	7,0
	jami				647,0	14,0
sk_11	a_5	3,3	44,2	0,4	145,9	1,3
	a_5'	3,3	26,5	0,4	87,5	1,3
	jami				233,4	2,6
sk_12	a_6	3,3	102,6	1,45	338,6	4,8
	a_6'	3,3	59,2	1,45	195,4	4,8
	jami				534,0	9,6
sk_13	a_5	3,3	44,2	0,4	145,9	1,3
	a_5'	3,3	26,5	0,4	87,5	1,3
	jami				233,4	2,6
sk_14	a_6	3,3	102,6	1,45	338,6	4,8
	a_6'	3,3	59,2	1,45	195,4	4,8
	jami				534,0	9,6

cxrili 7.3.

masalebis saerTo xarji 10 grZivi metrisaTvis Sesadarebel sayrdeni kedlebis variantebisaTvis.

Sesadarebeli konstrukciebi	sayrdeni kedlis saxe	sayrdeni kedlis	grunti	sayrdeni kedlis marka	betonis klasi	masalebis xarji kedlis 10 grZ.m					masalebis saerTo xarji				
						armatura, kg			betoni m ³	ankerebi AIII, kg	ankerebisaTvis (m ²)	betoni (m ³)	duRabi (m ³)	armatura (kg)	
						A-I	A-III	sul						A-I	A-III
							foladis		duRabi grunt. grrrrr						

tradiciuli, betonis klasi, B 20	masiuri, betonis	lent.uri, vertikaluri	mSr. qviSa	sk-1	20	-	-	-	229	-	-	229,0	-	-	-
			wyal. naj. Tixn	sk-2	20	-	-	-	326,7	-	-	326,7	-	-	-
		lenturi daxrili	mSr. qviSa	sk-3	20	-	-	-	219,8	-	-	219,8	-	-	-
			wyal. naj. Tixn	sk-4	20	-	-	-	314,0	-	-	314,0	-	-	-
	Txeli, rkimabetonis	lenturi	mSr. qviSa	sk-5	20	141	4927	5068	42,2	-	-	42,2	-	141	4927
			wyal. naj. Tixn.	sk-6	20	178	7525	7703	54,8	-	-	54,8	-	178	7525
			mSr. qviSa	sk-7	20	116	5378	5494	31,8	204,0	4,2	31,8	4,2	116	5582
			wyal. naj. Tixn	sk-8	20	134	8161	8295	39,5	477,0	9,4	39,5	9,4	134	8638
SemoTavazebuli, betonis klasi B20	Txeli, rkimabetonis, 2-iarusiani ankerebiT	lenturi	mSr. qviSn.	sk-9	20	76	1920	1996	17.3	204.0	5.4	17.3	5.4	76	2124
			wyal. naj. Tixn	sk-10	20	166	2464	2630	23.3	647.0	14.0	23.3	14.0	166	3111
			mSr. qviSn.	sk-11	20	321	1844	2165	17.2	233.4	2.6	17.2	2.6	321	2077
			wyal. naj. Tixn	sk-12	20	363	2535	2898	20.4	534.0	9.6	20.4	9.6	363.	3069

SemoT. bet-is klasi B30	Txeli, rkinabetonis 2-iarusiani anker.ebiT	lenturi	mSr. qviSn.	sk- 13	30	355	2047	2402	16,8	233.4	2.6	16.8	2.6	355.	2280
			wyal. naj. Tixn	sk-14	30	1038	3524	4562	18	534.0	9,6	18,0	9.6	1038	4058

ZiriTadi daskvnebi

1. damuSavebulia kalTebisa da miwis nagebobebis ferdoebis mdgradobis uzrunvelyofis kompleqsuri teqnikiuri da teqnologiuri gadawyvetebi, romelic xasiaTdeba gruntuli ankerebis saSualebiT wylis drenirebisa da gruntis Semakavebeli dsyrdeni kedlebis erToblivi muSaobiT;
2. kalTebisa da miwis nagebobebis ferdoebis gruntebis gamoSrobis daCqarebis mizniT, laboratoriul pirobebSi dadgenilia horizontaluri sadrenaJe sistemebSi eleqtroosmosis gamoyenebis principuli SesaZlebloba da misi zemoqmedebiT gruntis SemWidroeba xels Seuwyobs kalTebisa da ferdoebis gamagrebas, maTi mdgradobis amaRlebas;

3. გამოსაშობ გრუნტებზე ელექტროსმოსის ზემოქმედებით სადრენაჟე მილიდან წყლის გამოდინების ამარტყების ექსპერიმენტის მონაცემების მიხედვით შეადგინა 50-60% - ღვიწვანი გრუნტებისათვის და 70-140%-მდე ღვიწვანოვანი გრუნტებისათვის;
4. ზედაპირული და კალტების გრუნტების გამოშობისა და შემკვრისებისათვის ელექტროსმოსის გამოყენების დროს ჰორიზონტალური სადრენაჟე უბურტყების, საწვირობა საცდელი გამოცდების გზით კონკრეტული გრუნტებისათვის სადრენაჟე მილის მიმართ ელექტროდების ყველაზე უფრო მისაღები მანტყებისა და განტყვების დადგენა;
5. ექსპერიმენტალური გზით დადგენილია გრუნტის დროებითი ამოსაღები ანკერების გამოყენებისათვის გოგირდბეტონის გამოყენების შესაშლებლობა. იგი სასუალებას იშვავა გოგირდბეტონის გაღობის შედეგად შალზე მართვად განხორციელდეს ანკერების გამოტყვისუფლება, რაც მეტად მნიშვნელოვანია, როგორც ეკონომიკური, ასევე ეკოლოგიური ტყვასაშრისით. ასეთი ტყვის ანკერების დაშლადება არ საწვირობებს მატი კარხნული წესით წარმოებას, არამედ შესაშლებელია უსალოდ სამსენებლობა მოედანზე მატი დაშლადება;
6. შემოტყვებულია რკინაბეტონის 1 და 2-იარუსად განტყვებული ანკერებისაი საყრდენი კედელი, რომლის ეკონომიკური ეფექტი სხვადასხვა გრუნტული ტყობების გატყვისწინებით ტრადიციული მონოლიტური უანკერო რკინაბეტონის საყრდენ კედელთან შედარებით დაახლოებით 40% შეადგენს. არნიშნული ეკონომიკური ეფექტი გამოვლინდა ტეკნოლოგიუობის ყველა ტყრითად მაწვენებელსი: მასალატყვადობა, შრომატყვადობა, ტყვითრეობება.

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danarTi

**sayrdeni kedlis wriuli ganivkveTis svetebis kompiuteruli
gaangariSebebis Sedegebi.**

gaangariSebulia sayrdeni kedlis wriuli ganivkveTis svetebi gruntuli pirobebis ori variantisaTvis (ori saxis datvirTvisaTvis).

1. mSrali qviSa (qviSnari)

2. wyalnajeri Tixa (Tixnari)

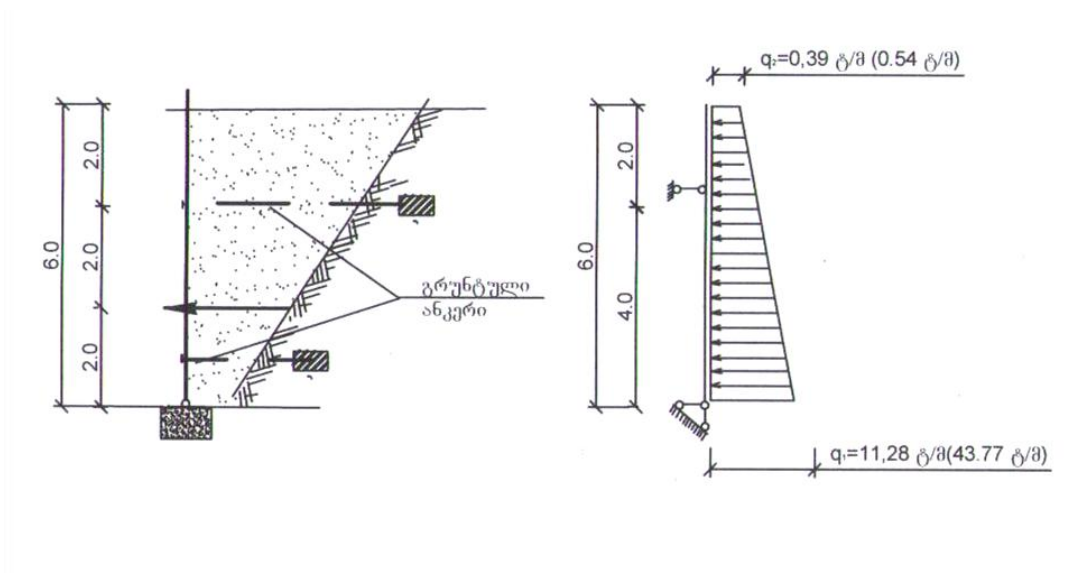
svetebis biji orive saxis datvirTvisaTvis miRebulia 3.0 m.

gaangariSebebi Sesrulebulia B 20 da B 30 klasis betonebisa daAA_III klasis armaturis gamoyenebis SemTxvevebisaTvis.

mSrali qviSis (qviSnaris) SemTxvevaSi svetis ganivkveTis diametrebi miRebulia: BB 20 klasis betonisaTvis – 40 sm, xolo B 30 klasis betonisaTvis – 35 sm.

wyalnajeri Tixis (Tixnaris) SemTxvevaSi _ Sesabamisad _ 50 da 45 sm.

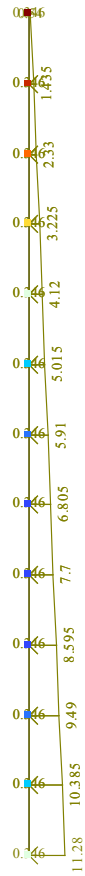
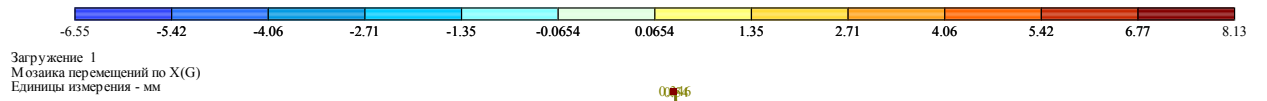
svetebis geometriuli sqema



SeniSvna:

saangariSosqemazetatvirTvisordinatebismniSvnelobebifrcxilebisgareSeSeesabamebadatvirTvebisIsaxes, (anumSralqviSas) xolofrcxilebSi _ datvirTvisIIsaxes (anuwyalnajerTixas).

I varianti B 20

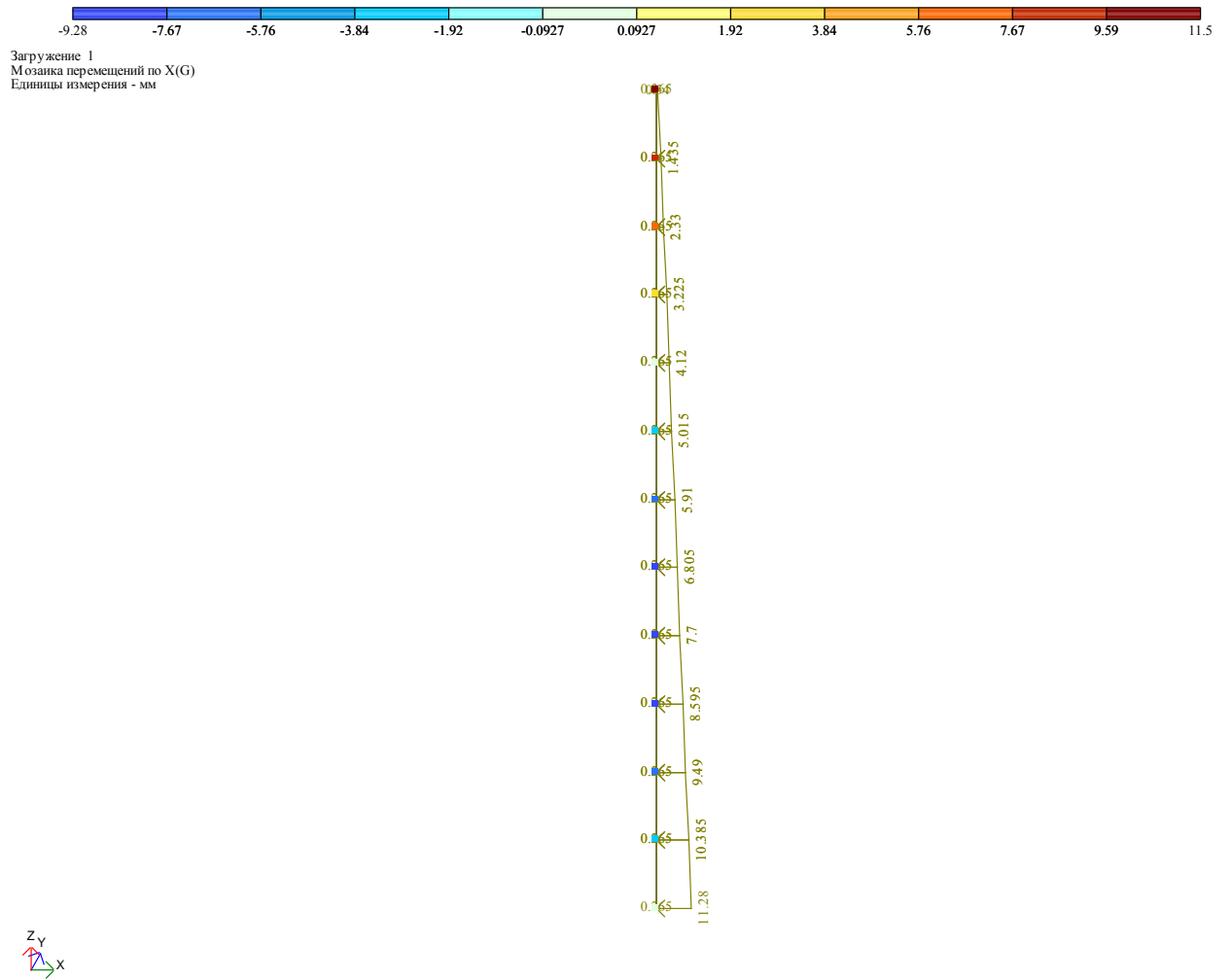


I varianti B 30

Загружение 1



I varianti B 30

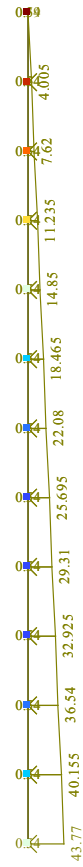
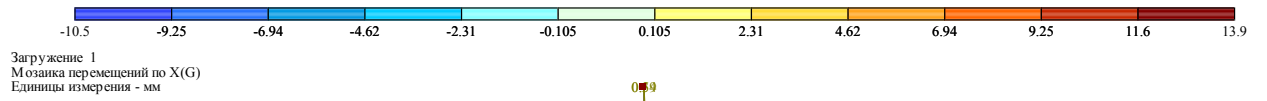


II varianti B 20

Загружение 1



II varianti B 20



II varianti B 30

Загружение 1



II varianti B 30

