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TOSHKENT DAVLAT TRANSPORT UNIVERSITETI
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# TASHKENT STATE TRANSPORT UNIVERSITY

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The “Journal of Transport” publishes the most significant results of scientific and applied research carried out in universities of transport profile, as well as other higher educational institutions, research institutes, and centers of the Republic of Uzbekistan and foreign countries.

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- Information Technology and Information Security;
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CONTEXT / MUNDARIJA

# Determining the effectiveness of seismic barriers by varying their distance from buildings

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Abstract: In the article, the impact of seismic surface waves on the building was determined using the finite element method (FEM) with the help of the Plaxis 3D software package. The amplitude of stress, displacement, velocity, and acceleration at each point was identified, and seismic barriers were employed to mitigate these effects. The effectiveness was assessed by varying the distance between the building and the seismic barrier. Seismic barriers, with a thickness of 1 meter and a height of 3 meters, were placed at distances of 24, 26, 28, and 30 meters from the center of the building. The results were compared with those in the absence of barriers, and the effectiveness was analyzed.

Keywords: the building, seismic surface waves, seismic barrier, finite element method, elasticity theory, and soil model

# Binolarni seysmik to‘lqinlardan himoya qilishda seysmik to‘siqning masofaviy joylashuvi samaradorligini aniqlash

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Annotatsiya: Maqolada binoga seysmik sirt to‘lqinlarining ta’siri Plaxis 3D dasturiy majmuasi yordamida chekli elementlar usulini qo‘llagan holda aniqlangan. Har bir nuqtadagi kuchlanish, ko‘chish, tezlik va tezlanishning amplitudalari aniqlangan va kamaytirish maqsadida seysmik to‘siq qo‘llanilgan hamda seysmik to‘siq bilan bino oraliq masofasini o‘zgartirish orqali samaradorligi aniqlangan. Seysmik to‘siqlar bino markazidan radiusi 24, 26, 28 va 30 metr uzoqlikda qalinligi 1 metr va balandligi 3 metrli qilib joylashtirilgan va to‘siqsiz hol natijalari bilan taqqoslangan va samaradorligi tahlil qilingan.

Kalit so‘zlar: Bino, seysmik sirt to‘lqinlari, seysmik to‘siq, chekli elementlar usuli, elastiklik nazariyasi va grunt modeli

## 1. Kirish

So‘nggi yillarda dunyoda talafotli zilzilalar soni ortib, ular aholi hayoti va mamlakatlarning ijtimoiy-iqtisodiy infratuzilmalariga jiddiy ta’sir ko‘rsatayotganligi sababli seysmik xavfsizlikni ta’minlash va qurilayotgan bino-inshootlarning seysmik mustahkamligini ta’minlash hamda zilzilabardoshligini yanada oshirish bo‘yicha bir qator ilmiy tadqiqotlar olib borilmoqda. Jumladan binolarga vibratsiya va seysmik sirt to‘lqinlarining ta’sirini aniqlash hamda seysmik to‘siqlar yordamida so‘ndirish katta ilmiy-amaliy ahamiyat kasb etmoqda.

## 2. Tadqiqot metodikasi

Palas Mandal va Surendra Nadh Somala [1] seysmik to‘siqlar bilan oraliq masofani o‘zgartirish orqali ularning samaradorligini aniqlash bo‘yicha ko‘plab tadqiqotlar o‘tkazgan. Seysmik to‘siqlarni tuproqning turli xususiyatlariga mos ravishda o‘rnatish bo‘yicha tavsiyalar bergan. Gruntning zichligi va namligining seysmik to‘siqlarga ta’sirini o‘rgangan.

Anastasios Sextos [2] seysmik to‘siqlarni dizayn qilish va ularni binolar atrofida optimal joylashtirish bo‘yicha ko‘rsatmalar ishlab chiqqan. Tadqiqotlar shuni ko‘rsatdiki, yumshoq va nam tuproqli hududlarda seysmik to‘siqlarni binodan uzoqroqda joylashtirish, uning samaradorligini oshiradi.

Nakashima [3] tadqiqotlari seysmik to‘siqlarni qanday qilib samarali joylashtirish orqali binolarni himoya qilish mumkinligini o‘rganishga qaratilgan bo‘lib, u yuqori seysmik faollik bo‘lgan hududlarda seysmik to‘siqlarni qayerda joylashtirish kerakligini aniqlagan. U bo‘sh gruntlarda seysmik to‘siqlarni binolardan 20-30 metr masofada joylashtirish kerakligi to‘g‘risida xulosaga kelgan.

Ko‘rib chiqilayotgan masalada Reyle sirt to‘lqinining binoga ta’sirini kamaytirish choralari aniqlanadi va qiyosiy tahlil qilinadi. Sirt to‘lqinlarining elastik gruntda joylashgan ko‘p qavatli binoga ta’siri masalasi ko‘rib chiqiladi. Masala elastiklik nazariyasining uch o‘lchamli masalasiga keltiriladi va uni yechish uchun chekli elementlar usuli qo‘llaniladi. Ma’lumki sonli usullar chekli sohaga qo‘llaniladi.

Masalada cheksiz yarim fazoni chekli soha bilan almashtiramiz. Bunda chegaralarda to‘lqinlarning cheksizlikka intilishini ta’minlovchi quyidagi shartlar

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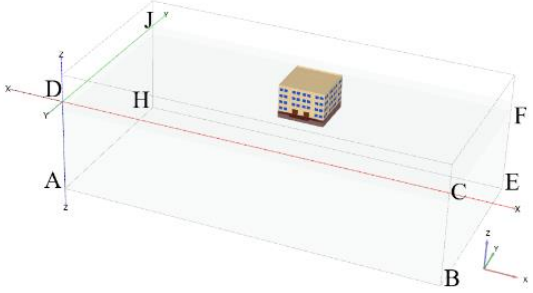
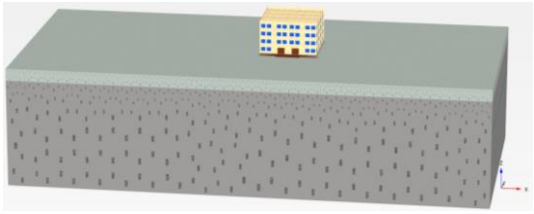
qo‘yilgan. Ajratilgan parallelepipedning AHJD va BEFC yog‘larida (a), ABCD va HEFJ yog‘larida (b) hamda ABEH yog‘ida (c) shartlar qo‘yilgan (1-rasm).




**1-rasm. Chegaraviy shartlar qo‘yilishi**

$$\left.\begin{matrix}\sigma_x = a\rho V_p\dot{u}\\ \tau_{yz} = b\rho V_s\dot{u}\\ \tau_{zy} = b\rho V_s\dot{w}\end{matrix}\right\}\text{a)}\quad \left.\begin{matrix}\sigma_y = a\rho V_p\dot{v}\\ \tau_{xz} = b\rho V_s\dot{w}\\ \tau_{zx} = b\rho V_s\dot{u}\end{matrix}\right\}\text{b)}\quad \left.\begin{matrix}\sigma_z = a\rho V_p\dot{w}\\ \tau_{xy} = b\rho V_s\dot{u}\\ \tau_{yx} = b\rho V_s\dot{v}\end{matrix}\right\}\text{c)} \quad (1)$$

Tanlab olingan model uzunligi 200 *m* eni 100 *m* va chuqurligi 50 *m* o‘lchamlarga ega. Masalada yer osti suvlari borligi ham hisobga olinadi, yer osti suvlarining sathi 20 *m* chuqurlikda deb olingan. Bino 24 *m* uzunlikda, eni 24 *m* va balandligi 14.75 *m*, qavat balandligi 3,3 *m*, binoning yer to‘la qismi esa 3 *m* chuqurlikda joylashgan. birinchi qatlami 5 metr qumloq (suglinka), ikkinchi qatlami 45 metr shag‘alli (galichniy) grunt modellashtirildi (2-rasm).



**2-rasm. Grunt modeli va turar joy binosini chekli elementlarga bo‘lish**

Tadqiqot sohasi 46739 ta chekli elementga va 85663 ta tugunlarga ajratilgan. Cheki elementlarning shakllari noto‘g‘ri tetraedr shaklida tanlanadi (1-rasm).

Harakat differensial tenglamalar sistemasining tartibi $85633 \times 3 = 256\,899$ ga teng.

Bu yerda $x$ o‘qi bo‘ylab Reyle to‘lqini harakatlanadi deb tasavvur qilamiz. Materialning fizik-mexanik xususiyatlarini hisobga olgan holda gruntdagi tugunlardagi ko‘chish, tezlik va tezlanishlarini aniqlaymiz.

Dinamik yuk ta’siridagi diskret mexanik sistema harakatining differensial tenglamalar sistemasi quyidagicha ifodalanadi:

$$\boldsymbol{M\ddot{u} + C\dot{u} + Ku = F} \quad (2)$$

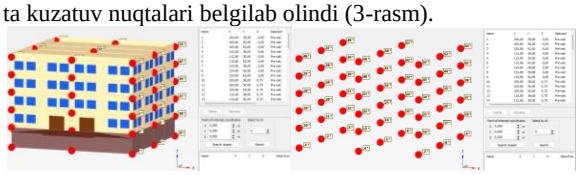
Bu yerda $\boldsymbol{M}$ – massalar matrisasi, $\boldsymbol{C}$ – so‘ndirish matrisasi, $\boldsymbol{K}$ – bikrlik matrisasi va $\boldsymbol{F}$ – dinamik yuk vektori. $\boldsymbol{u}$ – ko‘chish, $\boldsymbol{\dot{u}}$ – tezlik va $\boldsymbol{\ddot{u}}$ – tezlanishlar vektorlari vaqtning uzuluksiz funksiyalari deb olindi.

(2) tenglamalar sistemasini yechish uchun Nyumark usulidan foydalanamiz.

Dinamika masalasini raqamli ifodalashda vaqt iteratsiyasini shakllantirish hisoblash jarayonining barqarorligi va aniqligi uchun muhim omil hisoblanadi.

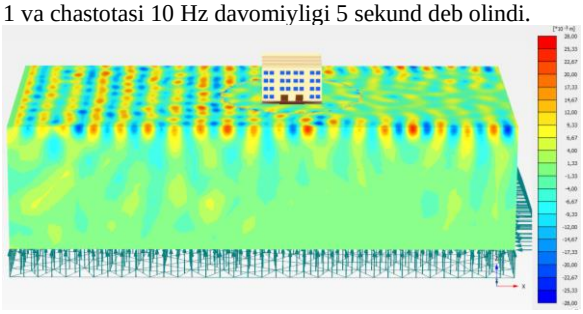
Nyumark usulining vaqt iteratsiyasi koeffitsentlarini $\alpha = 0.25$ va $\beta = 0.5$ deb qabul qilamiz. Grunt va bino materialining xususiyatlari 1 jadvalda keltirilgan.

Binoga ta’sir etayotgan seysmik sirt to‘lqinlarni aniqlash va taqqoslash uchun binoning har qavatidan 9 ta jami esa 54 ta kuzatuv nuqtalari belgilab olindi (3-rasm).



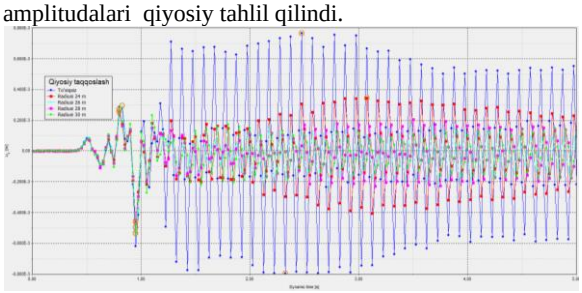
**3-rasm. Kuzatuv nuqtalari**

Seysmik sirt to‘lqinlarni tarqalishini Garmonik kuch orqali hosil qilindi. Garmonik kuchning fazasi 0, amplitudasi 1 va chastotasi 10 Hz davomiyligi 5 sekund deb olindi.



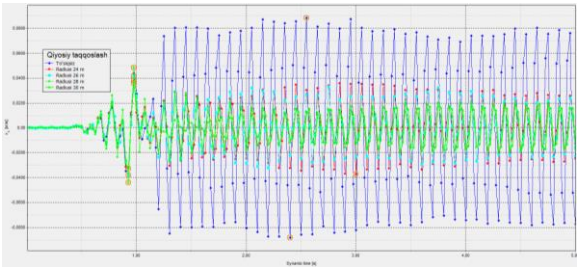
**4-rasm. Seysmik sirt to‘lqinlarni binoga ta’sir etish jarayoni**

Binoga ta’sir etayotgan seysmik sirt to‘lqinlarni kamaytirish va seysmik to‘siqlarni afzalligni aniqlash uchun bino markazidan radiusi 24, 26, 28 va 30 metr uzoqlikda seysmik to‘siqlar loyihalashtirilganda, binoning $\boldsymbol{z}$ o‘qi bo‘yicha ko‘chishning belgilangan nuqtalaridagi eng yuqori amplitudalari qiyosiy tahlil qilindi.



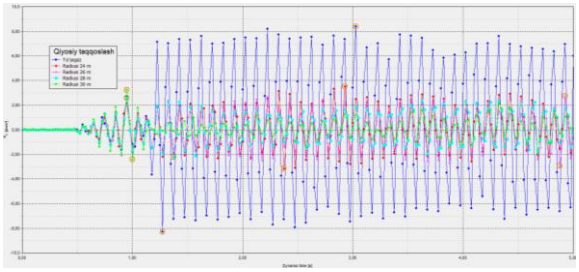

**5-rasm. 23-kuzatuv nuqtasidagi ko‘chishni taqqoslash grafiki**

5-rasmda, atrofida xech qanday to‘siq joylashmagan modeldagi binoning 23-kuzatuv nuqtasida seysmik sirt to‘lqinning $\boldsymbol{z}$ o‘qi bo‘yicha ko‘chishning maksimal qiymati $u_{zmax}$ =0,797 *mm*, radiusi 24 metrli seysmik to‘siq joylashgan binoda $u_{zmax}$ =0,496 *mm*, radiusi 26 metrli seysmik to‘siq joylashgan binoda $u_{zmax}$ =0,534 *mm*, radiusi 28 metrli seysmik to‘siq joylashgan binoda $u_{zmax}$ =0,458 *mm*, radiusi 30 metrli seysmik to‘siq joylashgan binoda 0,461 *mm* ni tashkil etdi. Qiyosiy taqqoslanganda, atrofida xech qanday to‘siq joylashmagan holga nisbatan radiusi 24 metrli seysmik to‘siq joylashganda binoning 23-kuzatuv nuqtasidagi ko‘chish 37.7%, radiusi 26 metrli seysmik to‘siq joylashgan binoda 32.97%, radiusi 28 metrli seysmik to‘siq joylashgan binoda 42.48%, radiusi 30 metrli seysmik to‘siq joylashgan binoda 42.14% ga teng bo‘lgan seysmik to‘siqlar samaradorligi qayd etildi.




**6-rasm. 23-kuzatuv nuqtasidagi tezlikni taqqoslash grafiki**

6-rasmda, atrofida xech qanday to‘siq joylashmagan modeldagi binoning 23-kuzatuv nuqtasida seysmik sirt to‘lqinning $v_z$ o‘qi bo‘yicha tezlikning maksimal qiymati $v_{zmax}$ =8,83 *sm/s*, radiusi 24 metrli seysmik to‘siq joylashgan binoda $v_{zmax}$ =4,82 *sm/s*, radiusi 26 metrli seysmik to‘siq joylashgan binoda $v_{zmax}$ =4,15 *sm/s*, radiusi 28 metrli seysmik to‘siq joylashgan binoda $v_{zmax}$ =3,79 *sm/s*, radiusi 30 metrli seysmik to‘siq joylashgan binoda $v_{zmax}$ =3,58 *sm/s* tashkil etdi. Qiyosiy taqqoslanganda, atrofida xech qanday to‘siq joylashmagan holga nisbatan radiusi 24 metrli seysmik to‘siq joylashganda binoning 23-kuzatuv nuqtasidagi tezlik 45,41%, radiusi 26 metrli seysmik to‘siq joylashgan binoda 53.00%, radiusi 28 metrli seysmik to‘siq joylashgan binoda 57.08%, radiusi 30 metrli seysmik to‘siq joylashgan binoda 59.45% ga teng bo‘lgan seysmik to‘siqlar samaradorligi qayd etildi.




**7-rasm. 23-kuzatuv nuqtasidagi tezlanishni taqqoslash grafiki**

7-rasmda, atrofida xech qanday to‘siq joylashmagan modeldagi binoning 23-kuzatuv nuqtasida seysmik sirt to‘lqinning $a_z$ o‘qi bo‘yicha tezlanishning maksimal qiymati $a_{zmax}$ =83,94 *sm/s*$^2$, radiusi 24 metrli seysmik to‘siq joylashgan binoda $a_{zmax}$ =35,28 *sm/s*$^2$, radiusi 26 metrli seysmik to‘siq joylashgan binoda $a_{zmax}$ =32,50 *sm/s*$^2$, radiusi 28 metrli seysmik to‘siq joylashgan binoda $a_{zmax}$ =29,20 *sm/s*$^2$, radiusi 30 metrli seysmik to‘siq joylashgan binoda $a_{zmax}$ =25,93 *sm/s*$^2$ tashkil etdi. Qiyosiy taqqoslanganda, atrofida xech qanday to‘siq joylashmagan holga nisbatan radiusi 24 metrli seysmik to‘siq joylashganda binoning 23-kuzatuv nuqtasidagi tezlanish 57,97%, radiusi 26 metrli seysmik to‘siq joylashgan binoda 61,28%, radiusi 28 metrli seysmik to‘siq joylashgan binoda 65.21%, radiusi 30 metrli seysmik to‘siq joylashgan binoda 69,10% ga teng bo‘lgan seysmik to‘siqlar samaradorligi qayd etildi.

## 3. Xulosa

Binoga ta’sir etayotgan seysmik sirt to‘lqinlarni kamaytirish uchun va bino markazidan radiusi 24, 26, 28 va 30 metr bo‘lgan aylana shaklida seysmik to‘siq modellashtirib seysmik sirt to‘lqinlarni kamaytirish jarayoni ko‘rib chiqildi.

Olingan natijalarga asoslanib, 5-7 rasmdagi grafiklardan ko‘rinib turibdiki, atrofida xech qanday to‘siq joylashmagan holga nisbatan bir xil koordinatada joylashgan bino markazidan radiusi 24 metr uzoqlikda joylashgan seysmik to‘siqli binoda ko‘chish o‘rtacha 11.76%, tezlik 54.39% va tezlanish 46.34%, radiusi 26 metr uzoqlikda joylashgan seysmik to‘siqli binoda ko‘chish o‘rtacha 18.90%, tezlik 55.25% va tezlanish 48.39%, radiusi 28 metr uzoqlikda joylashgan seysmik to‘siqli binoda ko‘chish o‘rtacha 24.05%, tezlik 56.53% va tezlanish 50.13%, radiusi 30 metr uzoqlikda joylashgan seysmik to‘siqli binoda ko‘chish o‘rtacha 26.13%, tezlik 57.57% va tezlanish 50.78%, ga teng bo‘lgan seysmik to‘siqlar samaradorligi qayd etildi.

Olingan natijalar, seysmik to‘siqlarni joylashtirishning muhimligini tasdiqlaydi va binolarni zilzila xavfidan himoya qilishda samarali choralar ko‘rish zarurligini ko‘rsatadi.

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