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ҚАЙЫРЫМДЫЛЫҚ ҚОРЫ HALYK CHARITY FOUNDATION

«ҚАЗАҚСТАН РЕСПУБЛИКАСЫ
ҰЛТТЫҚ ҒЫЛЫМ АКАДЕМИЯСЫ» РҚБ
«ХАЛЫҚ» ЖҚ

Х А Б А Р Л А Р Ы

ИЗВЕСТИЯ

РОО «НАЦИОНАЛЬНОЙ
АКАДЕМИИ НАУК РЕСПУБЛИКИ
КАЗАХСТАН»
ЧФ «Халық»

N E W S

OF THE ACADEMY OF SCIENCES
OF THE REPUBLIC OF
KAZAKHSTAN
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NAS RK is pleased to announce that News of NAS RK. Series of geology and technical sciences scientific journal has been accepted for indexing in the Emerging Sources Citation Index, a new edition of Web of Science. Content in this index is under consideration by Clarivate Analytics to be accepted in the Science Citation Index Expanded, the Social Sciences Citation Index, and the Arts & Humanities Citation Index. The quality and depth of content Web of Science offers to researchers, authors, publishers, and institutions sets it apart from other research databases. The inclusion of News of NAS RK. Series of geology and technical sciences in the Emerging Sources Citation Index demonstrates our dedication to providing the most relevant and influential content of geology and engineering sciences to our community.

Қазақстан Республикасы Ұлттық ғылым академиясы «ҚР ҰҒА Хабарлары. Геология және техникалық ғылымдар сериясы» ғылыми журналының Web of Science-тің жаңаланған нұсқасы Emerging Sources Citation Index-те индекстелуге қабылданғанын хабарлайды. Бұл индекстелу барысында Clarivate Analytics компаниясы журналды одан әрі the Science Citation Index Expanded, the Social Sciences Citation Index және the Arts & Humanities Citation Index-ке қабылдау мәселесін қарастыруда. Webof Science зерттеушілер, авторлар, баспашылар мен мекемелерге контент тереңдігі мен сапасын ұсынады. ҚР ҰҒА Хабарлары. Геология және техникалық ғылымдар сериясы Emerging Sources Citation Index-ке енуі біздің қоғамдастық үшін ең өзекті және беделді геология және техникалық ғылымдар бойынша контентке адалдығымызды білдіреді.

НАН РК сообщает, что научный журнал «Известия НАН РК. Серия геологии и технических наук» был принят для индексирования в Emerging Sources Citation Index, обновленной версии Web of Science. Содержание в этом индексировании находится в стадии рассмотрения компанией Clarivate Analytics для дальнейшего принятия журнала в the Science Citation Index Expanded, the Social Sciences Citation Index и the Arts & Humanities Citation Index. Web of Science предлагает качество и глубину контента для исследователей, авторов, издателей и учреждений. Включение Известия НАН РК. Серия геологии и технических наук в Emerging Sources Citation Index демонстрирует нашу приверженность к наиболее актуальному и влиятельному контенту по геологии и техническим наукам для нашего сообщества.

ЧФ «ХАЛЫҚ»

В 2016 году для развития и улучшения качества жизни казахстанцев был создан частный Благотворительный фонд «Халык». За годы своей деятельности на реализацию благотворительных проектов в областях образования и науки, социальной защиты, культуры, здравоохранения и спорта, Фонд выделил более 45 миллиардов тенге.

Особое внимание Благотворительный фонд «Халык» уделяет образовательным программам, считая это направление одним из ключевых в своей деятельности. Оказывая поддержку отечественному образованию, Фонд вносит свой посильный вклад в развитие качественного образования в Казахстане. Тем самым способствуя росту числа людей, способных менять жизнь в стране к лучшему – профессионалов в различных сферах, потенциальных лидеров и «великих умов». Одной из значимых инициатив фонда «Халык» в образовательной сфере стал проект Ozgeris powered by Halyk Fund – первый в стране бизнес-инкубатор для учащихся 9-11 классов, который помогает развивать необходимые в современном мире предпринимательские навыки. Так, на содействие малому бизнесу школьников было выделено более 200 грантов. Для поддержки талантливых и мотивированных детей Фонд неоднократно выделял гранты на обучение в Международной школе «Мирас» и в Astana IT University, а также помог казахстанским школьникам принять участие в престижном конкурсе «USTEM Robotics» в США. Авторские работы в рамках проекта «Тәлімгер», которому Фонд оказал поддержку, легли в основу учебной программы, учебников и учебно-методических книг по предмету «Основы предпринимательства и бизнеса», преподаваемого в 10-11 классах казахстанских школ и колледжей.

Помимо помощи школьникам, учащимся колледжей и студентам Фонд считает важным внести свой вклад в повышение квалификации педагогов, совершенствование их знаний и навыков, поскольку именно они являются проводниками знаний будущих поколений казахстанцев. При поддержке Фонда «Халык» в южной столице был организован ежегодный городской конкурс педагогов «Almaty Digital Ustaz.

Важной инициативой стал реализуемый проект по обучению основам финансовой грамотности преподавателей из восьми областей Казахстана, что должно оказать существенное влияние на воспитание финансовой грамотности и предпринимательского мышления у нового поколения граждан страны.

Необходимую помощь Фонд «Халык» оказывает и тем, кто особенно остро в ней нуждается. В рамках социальной защиты населения активно проводится работа по поддержке детей, оставшихся без родителей, детей и взрослых из социально уязвимых слоев населения, людей с ограниченными возможностями, а также обеспечению нуждающихся социальным жильем, строительству социально важных объектов, таких как детские сады, детские площадки и физкультурно-оздоровительные комплексы.

В копилку добрых дел Фонда «Халык» можно добавить оказание помощи детскому спорту, куда относится поддержка в развитии детского футбола и карате в нашей стране. Жизненно важную помощь Благотворительный фонд «Халык» оказал нашим соотечественникам во время недавней пандемии COVID-19. Тогда, в разгар тяжелой борьбы с коронавирусной инфекцией Фонд выделил свыше 11 миллиардов тенге на приобретение необходимого медицинского оборудования и дорогостоящих медицинских препаратов, автомобилей скорой медицинской помощи и средств защиты, адресную материальную помощь социально уязвимым слоям населения и денежные выплаты медицинским работникам.

В 2023 году наряду с другими проектами, нацеленными на повышение благосостояния казахстанских граждан Фонд решил уделить особое внимание науке, поскольку она является частью общественной культуры, а уровень ее развития определяет уровень развития государства.

Поддержка Фондом выпуска журналов Национальной Академии наук Республики Казахстан, которые входят в международные фонды Scopus и Wos и в которых публикуются статьи отечественных ученых, докторантов и магистрантов, а также научных сотрудников высших учебных заведений и научно-исследовательских институтов нашей страны является не менее значимым вкладом Фонда в развитие казахстанского общества.

С уважением,
Благотворительный Фонд «Халык»!

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© V.A. Ismailov[1,2], A.S. Khusomiddinov[1,5,*], Sh.I. Yodgorov[1,3], E.M. Yadigarov[1,3], B.U. Aktamov[1,4], 2024
[1]Institute of Seismology of the Academy of Sciences Republic of Uzbekistan, Tashkent, Uzbekistan;
[2]Tashkent State Technical University named after Islam Karimov, Tashkent, Uzbekistan;
[3]National University of Uzbekistan, Tashkent, Uzbekistan;
[4]Tashkent University of Architecture and Construction Tashkent, Uzbekistan;
[5]Tashkent State Transport University Tashkent, Uzbekistan.
E-mail: ahrorhs1980@gmail.com

SEISMIC MICROZONATION MAP OF THE TERRITORY OF YANGI–ANDIJAN: METHODOLOGY AND RESULTS

Ismailov Vakhithan — Doctor of geological mineralogical Sciences of the Institute of Seismology of the AS RUz, Tashkent, Uzbekistan
E-mail: vakhit.mbm@gmail.com, https://orcid.org/0000–0002–7893–1556;
Khusomiddinov Akhror — Doctor of Philosophy in Geological and Mineralogical Sciences (PhD); Seismology Institute of Sciences, AS RUz, Tashkent, Uzbekistan
E-mail: ahrorhs1980@gmail.com, https://orcid.org/0000–0001–6970–3482;
Yodgorov Sharofiddin — Doctor of Philosophy in Geological and Mineralogical Sciences (PhD); Seismology Institute of Sciences, AS RUz, Tashkent, Uzbekistan
E-mail: sh.i.yodgorov@gmail.com, https://orcid.org/0000–0002–8295–0194;
Yadigarov Eldor — Doctor of Philosophy in Geological and Mineralogical Sciences (PhD); Seismology Institute of Sciences, AS RUz, Tashkent, Uzbekistan
E-mail: eldoradigarov@gmail.com, https://orcid.org/0000–0002–2305–279X;
Aktamov Bekzod — Doctor of Philosophy in Technical sciences (PhD); Seismology Institute of Sciences, AS RUz, Tashkent, Uzbekistan
E-mail: b.u.aktamov@gmail.com, https://orcid.org/0000–0001–5511–1240.

Annotation. In order to improve the living conditions of the population of the Andijan city by accelerating the construction of multi-storey residential buildings, social facilities and infrastructure, engineering and communication networks and urban areas on the basis of modern urban planning requirements, the President of the Republic of Uzbekistan adopted Resolution No. PP-5180 dated 12.07.2021 "On measures for the effective organization of work on the construction of the city "Yangi Andijon". According to the decree, 4 thousand hectares of undeveloped land area are allocated for the construction of a new city on the hilly territory of the Andijan district, which is located in the north-eastern part of the city of Andijan.

For the phased complex construction of the city "Yangi Andijon" for 440 thousand inhabitants, consisting of residential buildings, social and service facilities, small industrial and green zones, projects of detailed planning of urban areas are being developed. In order to ensure the seismic safety of the population and the territory, the decree specifies the implementation of research works on seismic micro-zoning of the territory of the Yangi Andijon massif.

Keywords: seismic microdistricting, seismicity, tectonics, seismic impact, peak acceleration of soil, seismogeological models, soil density

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© **В.А. Исмаилов[1,2], А.С. Хусомиддинов[1,5,*], Ш.И. Ёдгоров[1,3], Э.М. Ядигаров[1,3], Б.У. Актамов[1,4], 2024**

[1]Өзбекстан Республикасы Ғылым Академиясының Сейсмология институты, Ташкент, Өзбекстан;

[2]Ислам Каримов атындағы Ташкент мемлекеттік техникалық университеті, Ташкент, Өзбекстан;

[3]Өзбекстан ұлттық университеті, Ташкент, Өзбекстан;

[4]Ташкент сәулет–құрылыс университеті Ташкент, Өзбекстан;

[5]Ташкент мемлекеттік көлік университеті Ташкент, Өзбекстан.

E-mail: ahrorhs1980@gmail.com

ЯНГИ–АНДИЖАН АУМАҒЫНЫҢ СЕЙСМИКАЛЫҚ МИКРОБ КАРТАСЫ: ӘДІСТЕМЕСІ МЕН НӘТИЖЕЛЕРІ

Исмаилов Вахитхан — ҚР ҒА Сейсмология институтының геология–минералогия ғылымдарының докторы, Ташкент, Өзбекстан
E-mail: vakhit.mbm@gmail.com, https://orcid.org/0000–0002–7893–1556;
Хусомиддинов Ахрор — геология–минералогия ғылымдарының философия докторы (PhD); Сейсмология ғылымдары институты, ҒА, Ташкент, Өзбекстан
E-mail: ahrorhs1980@gmail.com, https://orcid.org/0000–0001–6970–3482;
Йодгоров Шарофиддин — геология–минералогия ғылымдарының философия докторы (PhD); Сейсмология ғылымдары институты, ҒА, Ташкент, Өзбекстан
E-mail: sh.i.yodgorov@gmail.com, https://orcid.org/0000–0002–8295–0194;
Ядигаров Эльдор — геология–минералогия ғылымдарының философия докторы (PhD); Сейсмология ғылымдары институты, ҒА, Ташкент, Өзбекстан
E-mail: eldoradigarov@gmail.com, https://orcid.org/0000–0002–2305–279X;
Актамов Бекзод — техника ғылымдарының философия докторы (PhD); Сейсмология ғылымдары институты, ҒА, Ташкент, Өзбекстан
E-mail: b.u.aktamov@gmail.com, https://orcid.org/0000–0001–5511–1240.

Аннотация. Көпқабатты тұрғын үйлердің, әлеуметтік сала және инфрақұрылым объектілерінің, инженерлік-коммуникациялық желілер мен қалалық аумақтардың құрылысын жеделдету жолымен Андижан қаласы халқының өмір сүру жағдайларын жақсарту мақсатында қала құрылысының қазіргі заманғы талаптары негізінде Өзбекстан Республикасының Президенті "Янги Андижан "қаласын салу жөніндегі жұмыстарды тиімді ұйымдастыру жөніндегі шаралар туралы"12.07.2021 жылғы №ПП-5180 Қаулысын қабылдады. Жарлыққа сәйкес, Андижан қаласының солтүстік-шығыс бөлігінде орналасқан Андижан ауданының таулы аумағында жаңа қала салу үшін 4 мың гектар игерілмеген аумақ бөлінген. Тұрғын үйлерден, Әлеуметтік сала және қызмет көрсету саласы объектілерінен, шағын өнеркәсіптік және жасыл аймақтардан тұратын 440 мың тұрғынға арналған "Янги Андижан" қаласының кезең-кезеңімен кешенді құрылысы үшін қалалық аумақтарды егжей-тегжейлі жоспарлау жобалары әзірленуде. Халық пен аумақтың сейсмикалық қауіпсіздігін қамтамасыз ету мақсатында қаулымен Янги Андижан массивінің аумағын сейсмикалық шағын аудандастыру бойынша ғылыми-зерттеу жұмыстарын жүргізу көзделген.

Түйін сөздер: сейсмикалық шағын аудан, сейсмикалық, тектоникалық, сейсмикалық әсер, топырақтың ең жоғары үдеуі, сейсмогеологиялық модельдер, топырақтың тығыздығы

© **В.А. Исмаилов[1,2], А.С. Хусомиддинов[1,5*], Ш.И. Ёдгоров[1,3], Э.М. Ядигаров[1,3], Б.У. Актамов[1,4], 2024**

[1]Институт сейсмологии Академии наук Республики Узбекистан, Ташкент, Узбекистан;
[2]Ташкентский государственный технический университет имени Ислама Каримова, Ташкент, Узбекистан;
[3]Национальный университет Узбекистана, Ташкент, Узбекистан;
[4]Ташкентский архитектурно–строительный университет Ташкент, Узбекистан;
[5]Ташкентский государственный университет транспорта Ташкент, Узбекистан.
E-mail: ahrorhs1980@gmail.com

КАРТА СЕЙСМИЧЕСКОГО МИКРОЗОНИРОВАНИЯ ТЕРРИТОРИИ ЯНГИ–АНДИЖАНА: МЕТОДОЛОГИЯ И РЕЗУЛЬТАТЫ

Исмаилов Вахитан — доктор геолого–минералогических наук; Институт сейсмологии АН РУз, Ташкент, Узбекистан
E-mail: vakhit.mbm@gmail.com, https://orcid.org/0000–0002–7893–1556;
Хусомиддинов Ахрор — доктор философии геолого–минералогических наук (PhD); Институт сейсмологии АН РУз, Ташкент, Узбекистан
E-mail: ahrorhs1980@gmail.com, https://orcid.org/0000–0001–6970–3482;
Ёдгоров Шарофиддин — доктор философии геолого–минералогических наук (PhD); Институт сейсмологии АН РУз, Ташкент, Узбекистан
E-mail: sh.i.yodgorov@gmail.com, https://orcid.org/0000–0002–8295–0194;
Ядигаров Элдор — доктор философии геолого–минералогических наук (PhD); Институт сейсмологии АН РУз, Ташкент, Узбекистан
E-mail: eldoradigarov@gmail.com, https://orcid.org/0000–0002–2305–279X;

Актамов Бекзод — доктор философии по техническим наукам (PhD); Институт сейсмологии АН РУз, Ташкент, Узбекистан
E-mail: b.u.aktamov@gmail.com, https://orcid.org/0000–0001–5511–1240.

Аннотация. В целях улучшения условий жизни населения города Андижан путем ускорения строительства многоэтажных жилых зданий, объектов социальной сферы и инфраструктуры, инженерно-коммуникационных сетей и городских территорий на основе современных требований градостроительства Президентом Республики Узбекистан принято Постановление №ПП-5180 от 12.07.2021 "О мерах по эффективной организации работ по строительству города "Янги Андижан". Согласно указу, для строительства нового города на холмистой территории Андижанского района, который расположен в северо-восточной части города Андижан, выделено 4 тысячи гектаров неосвоенной территории. Для поэтапного комплексного строительства города "Янги Андижан" на 440 тысяч жителей, состоящего из жилых зданий, объектов социальной сферы и сферы обслуживания, небольших промышленных и зеленых зон, разрабатываются проекты детальной планировки городских территорий. В целях обеспечения сейсмической безопасности населения и территории постановлением предусмотрено проведение научно-исследовательских работ по сейсмическому микрорайонированию территории массива Янги Андижан.

Ключевые слова: сейсмический микрорайон, сейсмичность, тектоника, сейсмическое воздействие, пиковое ускорение грунта, сейсмогеологические модели, плотность грунта

Introduction

Seismic microzoning is a form of seismic zoning that characterizes the seismic impact parameters of a construction site based on local conditions. These conditions encompass diverse aspects, including geomorphological features (such as dissected terrain, steep slopes, and the structure of river terraces), the composition and structure of the soil, engineering-geological and hydrogeological characteristics of the site (such as the composition, physical and mechanical properties of the soil, the thickness of soil layers, moisture content, and the depth of groundwater), as well as the proximity of seismic faults. All of these factors influence the seismic impact parameters.

Normative documents for designing earthquake-resistant buildings and structures, drafting and revising city plans, and zoning territories by number of stories and location of landscaping zones with respect to seismic hazards are based on approved construction and installation projects ranging from 1:5000 to 1:25000 scales. These projects contain crucial information presented in maps of construction and installation works that can be used to evaluate the actual seismic resistance of previously constructed buildings by taking into account the specified values at selected points.

Seismic microzonation of the territory of the Yangi Andijon massif was completed as part of this work and is the focus of this article. The developed maps of seismic microzonation are being prepared for further inclusion in the regulatory documents of the Republic of Uzbekistan.

The microzoning project consisted of six distinct tasks: 1) The seismotectonic situation of the territory of Andijan and adjacent territories. 2) Assessment of seismic hazard of the territory. 3) Investigation of geotechnical features of the territory. 4) Assessment of seismic intensity increments at the territory using geophysical methods. 5) Evaluation of seismic effects on the free. 6) Development of seismic microzonation maps based on the results of geotechnical and instrumental geophysical investigations. This collaborative research and abovementioned tasks were accomplished by Laboratory of "Seismic Risk", Laboratory of "Regional Seismic and Seismic Zoning", Laboratory of "Experimental Seismology" and "Seismogeodynamics laboratory" of the Institute of Seismology in Uzbekistan.

Relevance. The scientific literature includes numerous publications on seismic microzonation methodology, such as collections of materials from various conferences, monographs, articles, manuals and recommendations. These studies include research works by (Medvedev, 1962: 284; Shebalin, 1975: 87–109; Krieger et al., 1980: 102; Kasimov et al., 1982: 187; Dzhuraev, 1985: 84; Zaalishvili, 2000: 367; Aleshin, 2017: 302; Khusomiddinov et al., 2022: 1–5; Suleyev et al., 2022: 99–104). However, it should be noted that the methods and calculations proposed by these authors were based on the results of macroseismic surveys conducted after strong earthquakes. As a result, the seismic intensity scale was used as an integral index when evaluating the intensity of the seismic effect.

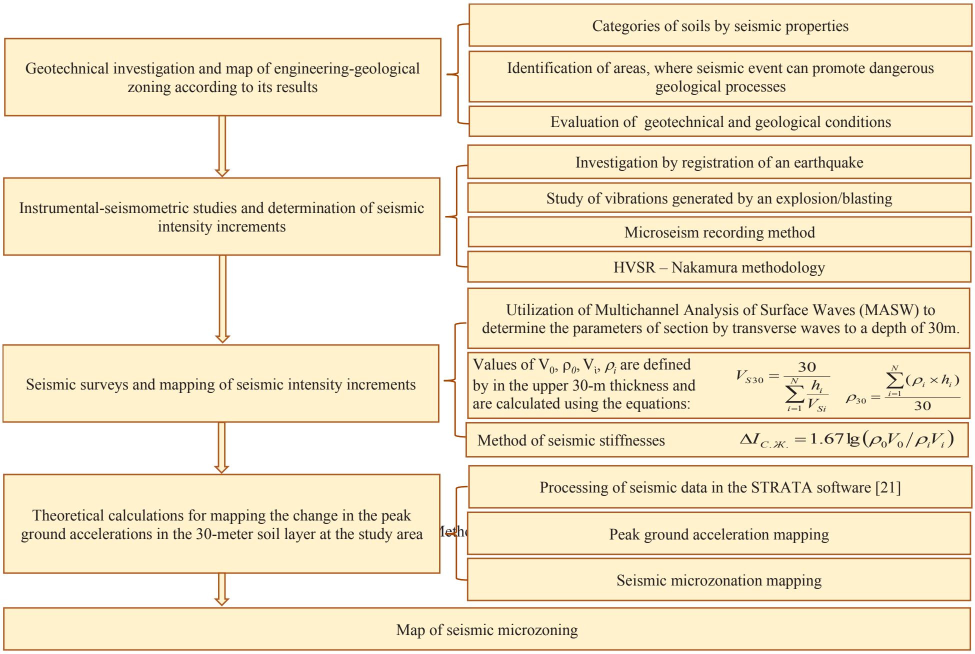
Seismic zoning in the USA and other developed countries has traditionally been based on instrumental parameters such as PGA (peak ground acceleration) and spectral accelerations, and has been carried out under the guidance of civil engineers. Numerous journal papers have been published on seismic microzoning in various countries, including works by (Sitharam et al., 2010: 54–56; Anbazhagan, 2013: 66–86; Gupta et al., 2016: 09–14; Kılıç et al., 2006: 238–255; Pilz et al., 2015: 01–14; Aleshin, 2015: 338, 2018: 326–340).

In post-Soviet countries, seismic effects were initially characterized by macroseismic intensity, which was the main output parameter. The conversion of macroseismic intensity to quantitative parameters, such as PGAs, spectral accelerations, etc., was done in building codes. The building code of Uzbekistan also uses macroseismic intensity concept.

The aforementioned approach using macroseismic intensity based construction maps is utilized for two primary reasons. First, normative coefficients established for each magnitude are utilized to calculate the earthquake resistance of a building. Second, the seismic intensity is affected by various factors, and including all of these factors into analysis can be complex. Fortunately, macroseismic intensity evaluation eliminates the need for an accurate account of each factor. With the development of computer modelling for the design of buildings and structures, new approaches have been introduced that describe seismic vibrations in terms of engineering parameters such as peak ground acceleration (PGA), acceleration response spectrum, as well as real or synthesized accelerograms. Consequently, computational methods based on modeling of behavior of real ground conditions under a given seismic load make it possible to obtain spectral characteristics of ground layers and accelerograms on the free surface.

Materials and methods

Seismic microzonation aims to provide a quantitative assessment of the influence of local engineering-geological conditions, including soil composition and properties, groundwater levels, topographical features, and the presence of seismic faults, on seismic activity. This assessment is based on the determination of changes in intensity at specific points, as defined by (Russian Federation State Standard, 2019: 27) as well as various engineering parameters, such as peak acceleration, amplitude and response spectrum and duration of vibrations.



Based on the abovementioned methodology, the following investigation and field works were carried out at the territory of Yangi Andijon:

• Engineering-geological reconnaissance (without excavation of ground) on an area of 4,000 hectares.

• Field seismic exploration consisting of 221 points using the MASW and MPV methods.

• Field electrical exploration consisting of 60 points (AB500) and 20 points (AB1000) using the Vertical Electrical Sounding (VES) method.

• Microseismic registration was conducted using the H/V method at 150 points.

• Instrumental-seismometric observations of weak earthquakes, explosions, and microseisms were carried out in 8 points, resulting in the registration of 80 surface vibrations, of which 60 were simultaneously recorded.

• Theoretical calculations of seismic impact parameters using the STRATA program were performed at 221 locations.

Seismotectonic setting of the territory. According to its location, the territory of Andijan city belongs to the mountainous part of the Fergana intermountain basin. The main tectonic disturbances associated with seismic vibrations in the territory of Andijan city are the South Fergana faults and the north-eastern strike-slip fracture zone, the system of Kurshab and Taldysuisk faults of sublatitudinal direction located east of Andijan, the North Fergana faults of north-eastern strike-slip located west of the city. To the northeast of Andijan is the Talas-Fergana northwestern strike-slip faults. Within these fault zones strong and destructive earthquakes have repeatedly occurred, which had a significant macroseismic effect on the territory of the city. A detailed description of active faults in the Earth's crust and seismogenic zones identified on their basis can be found in (Abdullabekov et al., 2002: 132; Sadikov et al., 2021: 61–72).

The seismic activity in the area of Andijan city is a result of the ongoing geodynamic activity within the South Fergana flexural-fracture zone, which has a significant dynamic influence on the Andijan seismogenic zone (Abdullabekov et al., 2002: 132; Sadikov et al., 2021: 61–72). Based on seismotectonic analysis, this zone has a high seismic potential, estimated to have an M_{max} magnitude of 7.5.

Thus, the city of Andijan, including the Yangi Andijon district, is situated directly within the Andijan seismogenic zone, which has a very high seismic potential. The seismogenic zone is formed by the South Fergana flexural-fracture zone and its current seismotectonic activity.

The seismic potential of this zone, according to seismological data, is estimated at a value of M_{LHmax}=7.5 (M_{Wmax}=7.0). During the instrumental period of time, the territory of the city has already experienced earthquakes with an intensity of 9 according to the MSK-64 scale (Fig. 2).

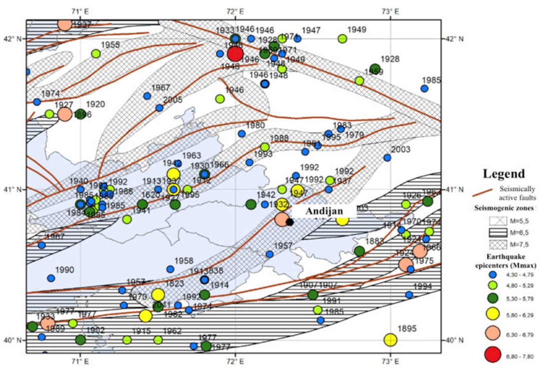


Figure. 2. The map presented in (Abdullabekov et al., 2002: 132; Sadikov et al., 2021: 61–72) shows the epicenters of strong earthquakes that have occurred in the vicinity of Andijan city for the past historical times. The map also indicates the active crustal faults and seismogenic zones in the region.

Seismic hazard of the territory of the Yangi Andijon district. Based on the RSZ-2017 (Regional Seismic Zoning) seismic zoning maps of Uzbekistan (Artikov et al., 2020: 273–294), the soil in Andijan is categorized as soil of second category by seismic properties. For the probabilities P=0.9 and P=0.95, the expected maximum macroseismic intensity in the next 50 years is estimated to be I=8. For probabilities P=0.98 and P=0.99, the expected maximum macroseismic intensity within 50 years is estimated to be I=9 according to the MSK-64 scale. Through a detailed seismic hazard analysis, probabilistic characteristics for different ground conditions in Andijan were obtained and are presented in Tables 1 and 2.

We have generated response spectra for soils of various categories (according to seismic properties) at different probabilities (P) of not exceeding the seismic loads over a span of 50 years.

Table 1. The values of seismic intensity (according to the masroseismic scale MSK-64) for various ground conditions in Andijan at given probabilities of not exceeding the seismic loads for a 50-year period.

Soil category (by seismic properties)	Macroseismic intensity (according to MSK-64)			
	P=0,9	P=0,95	P=0,98	P=0,99
Category I	8 (7,66)	8 (8,05)	8 (8,47)	9 (8,77)
Category II	8 (8,06)	8 (8,32)	9 (8,75)	9 (9,05)
Category III	8 (8,31)	9 (8,66)	9 (9,09)	9 (9,39)

Table 2. Peak ground accelerations (PGA, g) at a given probabilities of not exceeding the seismic loads for 50 years on soils categorized as I, II, and III in terms of seismic properties.

Soil category (by seismic properties)	Peak ground acceleration (a_{max}, g)			
	P=0,9	P=0,95	P=0,98	P=0,99
Category I	0,224	0,292	0,392	0,482
Category II	0,294	0,354	0,477	0,586
Category III	0,350	0,448	0,603	0,743

Geological conditions of the territory of "Yangi Andijon" district. From a geomorphological perspective, the "Yangi-Andijon" district is situated in the western part of the Northern Alamyshyk adyr zone, which is situated on the southeastern edge of the valley portion of the Fergana depression and forms a large intermountain depression. The terrain of the region is intricate and fragmented, comprising numerous ridges and hills of varying sizes, shapes, and elevations, with the lowest point at an absolute altitude of 526.0 m rising up to 720.0 m.

The geological and lithological composition of the region consists of Quaternary deposits belonging to the Tashkent complex (Q_{II}^{ts}).

The Tashkent complex (Q_{II}^{ts}) consists of alluvial-pluvial clays and coarse grained sediments, mostly loams (sometimes sandy loams), with occasional thin interlayers of sand and gravel layers. Tashkent deposits have a total thickness of over 100 m.

The loams (including sandy loams) have a loess-like texture and usually have light brown or reddish-brown color, large pores and hard consistency.

The pebble soils are heterogeneous, medium dense and have low water saturation, and usually underlay under the layer of loess-like loams.

The entire territory of the city is covered by a Quaternary deposits, mainly of Tashkent (pQ_{II}^{ts}) complex. The wings of anticlinal folds are composed of dislocated Lower Quaternary sediments of the Sokh (Q_1^{sh}) complex.

The anticlines were irregularly eroded. First, the southward-facing vaults of the brachiatic clines were eroded, so the southern slopes have some outcrops of Upper Neogene rocks. (N_2).

1. Paleozoic and Mesozoic formations are widely distributed beyond the city boundaries and are accessible through deep wells. The oldest deposits consist of continental Neogene sediments and are present throughout the study area. However, only the upper parts of the anticlinal folds, known as Andijan adyrs, are exposed on the surface. Neogene deposits in the remaining parts of the territory are accessible through wells at varying depths. Therefore, from an engineering-geological perspective, they are not the focus of our research.

2. Quaternary deposits are widespread in the geological structure of Andijan territory. The Andijan "adyrs" are mostly composed of deposits from the Sokh complex Q_I^{sh}, which are also partially found on high terraces of rivers. These deposits are characterized by considerable dislocations and layers of pebbles with clays. Outcrops of Sokh sediments above the bedrock can be observed in the area. The Sokh deposits, consisting of conglomerates, pebbles, and clays, have been penetrated by boreholes at depths of 230–280 m, with a total thickness of 100–110 m.

The Tashkent Complex Q_{II}^{ts} deposits are present on the northern slopes of the Andijan adyrs, where they coexist with Sokh deposits. These deposits are composed of conglomerates, pebbles, dense sandy clays, and loams, and exhibit consistent thickness of pebble beds in the vertical section. Although the Tashkent complex deposits are weakly displaced, they are accessed by wells at depths of 32–100 m, with a total thickness of 60-90 m.

Seismic microzonation method based on instrumental-seismometric registration of weak earthquakes. The method of registering low-energy earthquakes is one of the seismological methods which is used in seismic microzonation. This method enables the quantitative assessment of relative changes in seismic intensity in areas with distinct engineering-geological conditions.

The incremental seismic intensity at sites can be estimated using the following equation:

$$\Delta J = 3{,}3 \lg \frac{\overline{A_i}}{A_0} \qquad (1)$$

where $\overline{A_i}$ - average ground acceleration at the given location; A_0 – average ground acceleration at the reference site.

The instrumental method of inter-station amplitude and spectral relations, involves conducting comprehensive engineering-seismological observations across the investigation area and measuring the parameters of seismic vibrations during seismic events, such as strong or destructive earthquakes or powerful explosions.

To register earthquakes, three-component broadband velocimeters with built-in recorder CMG-6TD, manufactured by Guralp company in Great Britain, were used. A total of eight seismic stations were located in the territory of the Yangi Andijan district, as listed in Table 3.

Table 3. Calculation of seismic intensity increments using the recordings of weak earthquakes

№	Station	Location	Latitude	Longitude	Seismic intensity increments
1	6Y92	Farm-1	40,79	72,42	+0,49
2	6Y97	Pumping station	40,79	72,46	+0,65
3	6Y9	Fish Farm	40,78	72,47	+0,31
4	6Y93	School	40,79	72,43	+0,33
5	6Y97	Brick factory	40,84	72,47	+0,07
6	6Y92	Farm-2	40,83	72,47	-0,62
7	6Y96	Cementery-2	40,84	72,43	-0,24
8	6Y93	Garden	40,83	72,45	+0,09

Seismic survey using the seismic stiffness method. Seismic exploration works were carried out at the site using the MASW and Refraction (MPV) methods. Seismic exploration, due to its high depth and detail, is a leading method in geophysical studies of the Earth's crust. Currently, the MASW and Refraction (MPV) methods have been developed for engineering-geological and hydrogeological surveys, which allow the reliable tracing of seismic horizons during data processing.

The primary method for shallow seismic surveys is the refraction method (RM) in the first arrival modification. This is due to the relative simplicity of conducting fieldwork, processing, and interpreting data. Refracted waves are used in the method to construct depth-velocity models of the medium. Refraction method is a relatively fast and effective method, and therefore can be used for rapid reconnaissance.

The main method of shallow seismic surveying is the First Arrival Refraction Method (FARM). This is due to the relative simplicity of conducting field work, processing and interpreting data. The method uses refracted waves to construct depth-velocity models of the medium. First Arrival Refraction Method is quite fast and efficient, and therefore can be used for rapid reconnaissance of the territory. The classic type of layout is used during field work, with a step size of 2, 5 or 10 meters between receiver and source points. The depth of the method is determined by the power of the source and the length of the layout, and in the vast majority of cases does not exceed 30–50 meters. In the case of a complex section structure, a large number of observations are required to increase the detail and quality.

Seismic surveys were carried out at 222 points in the study area, with 222 points observed according to the Z-Z scheme, and 111 points according to the Y-Y scheme. The spacing between points was 500 meters. The seismic exploration was conducted using the "MAE X820-S" station (produced in Italy) with vertical and horizontal seismic receivers with a frequency of 4.5 Hz.

According to the obtained results, the V_{s30} velocities for the entire study area range from 350 to 500 m/s. The investigated area can be conditionally divided into two sections: the southern and southeastern parts of the area have relatively low velocity values (340-400 m/s), while the northern and northeastern parts have relatively high V_{s30} values (420–520 m/s). For the central part of the area, the transverse wave propagation velocities lie within the range of 380–420 m/s (Fig. 5).

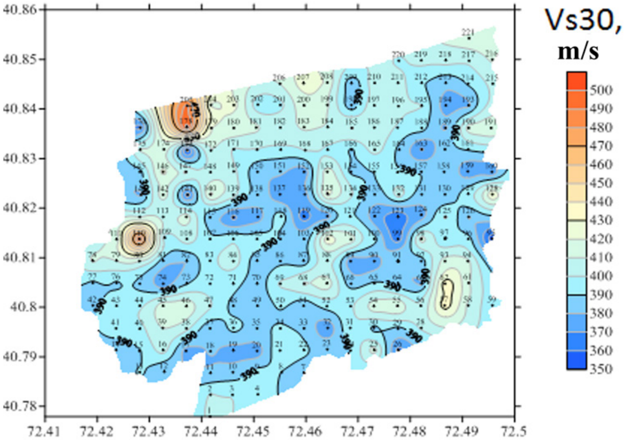


Figure.5. Map of distribution of shear wave velocities.

Research results

Selection of reference soils. The concept of reference soils will be used only for conducting seismic microzonation in terms of increments of seismic intensity.

It is recommended to select "average soils" as reference soils, which are conditionally considered as having the same value of initial seismic intensity. When selecting the reference soil for the analysis, it is important to choose the most characteristic soil in the upper 30 m layer of the ground, which is not fully saturated, sands and clays with inclusion of gravel or pebbles, or medium- to coarse-grained sandy soils of medium density, or soils of similar composition that belong to category II in terms of seismic properties.

Based on the analysis of engineering-geological data, borehole logging and the seismic exploration data on the velocity parameters of the soil layer, the value of V_{s30}=390 m/s and density ρ_{30}=1.81 g/cm^3 was taken as the reference soil parameter.

Calculation of seismic intensity increments using the seismic stiffness method. In the seismic stiffness method (SSM), the seismic intensity increments relative to the reference soil are determined by the change in the physical and mechanical characteristics of the soil, namely the product of the soil density and the shear wave velocity (seismic stiffness) in the corresponding layer. Seismic stiffness method allows the determination of the seismic intensity increments based on the seismic properties of the soil layer (at the investigated and reference sites), regardless of the physical characteristics of the initial seismic vibrations.

Currently, in the practice of seismic microzoning, shear wave velocities are used because the shear wave propagation velocity does not depend on the degree of saturation. When calculating seismic intensity increments using SSM method, only upper 30 meters of the ground are considered.

The calculation of seismic intensity increments using SSM method is carried out by comparing the seismic stiffness values of the investigated and reference soils using Equation 3.

$$\Delta J_{s.stiff} = 1.671 \times \lg\left(\frac{V_{s30,rep.} \times \rho_{30,rep.}}{V_{s30,i.} \times \rho_{30,i.}}\right) \quad (3)$$

where $J_{s.stiff.}$ – increment of seismic intensity relative to the initial (background) intensity, taken for the conditions of reference soils, to which the value of the initial intensity refers (for such soils the increment of intensity is zero); $V_{s30,\ rep.}$, $\rho_{rep.}$ – shear wave velocity and density of the upper 30 m of the ground of the reference ground; V_{s30i}, ρ_i – shear wave velocity and density of the upper 30 m of the ground of the investigated ground.

The increments of seismic intensity were determined based on the values of V_{s30} velocities obtained from seismic exploration using the MASW method, taking into account the parameters of the selected reference soil. The computed values of seismic intensity increments are shown in Fig. 6. For the entire site, the range of maximum changes in intensity increments is within -0.35 to +0.3. The site can be divided into two sections: southern/northern and western/eastern. The southern and northern sections are characterized by stable negative values of intensity increments (closer to the center - zero), while the western and eastern sections are characterized by the highest positive values (Fig. 6). The decreased increments of intensity increments are associated with areas where higher values of Vs30 shear velocities were observed.

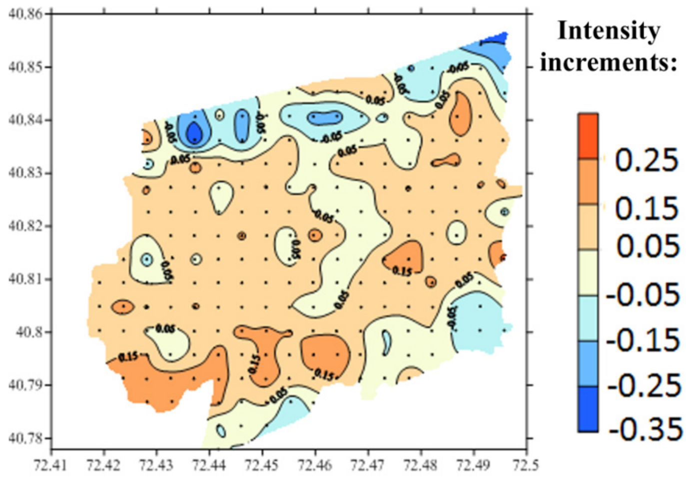


Figure. 6. Map of seismic intensity increments obtained by utilizing the seismic stiffness method.

Assessment of seismic impacts on the free surface. To calculate the ground motion at the free surface, an initial vibration is needed that is compatible with the target response spectrum to the bedrock. The next step is to construct seismic-geological models of the soil strata on the site.

These models are based on the following assumptions:

• The soil strata is assumed to be viscoelastic media, lying on a viscoelastic half-space.

• The boundaries between soil layers are horizontal.

• Volumetric seismic waves propagate vertically.

• Energy dissipation is determined by the damping ratio of the soils.

A generalized seismic-geological model was constructed based on engineering-geological and seismic exploration data (MASW profiles) for the calculations. A total of 218 models of the soil strata were built.

To account the uncertainties in soil models and input accelerograms, a Monte Carlo method implemented in the STRATA software (Ismailov et al., 2022: 15–19; Strata, 2022: 132) was used. A set of six accelerograms, described in the chapter, was used as input, and each accelerogram was passed through the soil layers. Multiplying by the number of soil model parameters, a total of 180 branches were calculated.

The calculation methods allow determining the amplitude-frequency characteristics of the layered soil strata and consequently, the modified characteristics of vibrations on the free surface of the site or at internal points of the soil. To perform calculations using this method, it is necessary to determine the initial seismic impact specified by the accelerogram and/or the response spectrum and to construct seismic-geological models of the soil strata. Real accelerograms from three earthquakes were taken, which, by their mechanism (strike-slip and thrust) and by the nature of the propagation of seismic waves, correspond to the seismological conditions of the territory of the Republic of Uzbekistan.

The following set of accelerograms were used as input: Mayli-Suu earthquake (Kyrgyzstan) 2018/08/07 17:17:28, PGA - 0.246g, M5.0, H=15 km, Latitude 41.29, Longitude 72.473, seismic station “AND”, Tash-Dobo earthquake (Kyrgyzstan) 2020/11/06 07:38:56, M5.2, H=9 km, PGA - 0.247g, Latitude 40.16, Longitude 71.72, seismic station “SOX”, Namangan earthquake (Uzbekistan) 2020/04/17 04:34:23, M4.0, H=10 km, PGA - 0.143g, Latitude 40.16, Longitude 71.72, seismic station “SOX”.

The accelerograms were normalized and adjusted to correspond to the acceleration of the soils of category 1 (by seismic properties), which are prevalent in the Yangi Andijan district at depths of 200 meters and are represented by dense aleurolites of the Neogene age (Table 4).

Table 4. Seismic-geological model used in the STRATA software calculations

Layer	Depth	Thickness, m	Specific weight, kN/m³	Vs, m/s	Lithological composition
1	0.00	0.95	16.09	223.25	Sandy loam
2	0.95	1.18	15.94	211.32	Sandy loam

3	2.13	1.48	14.68	131.67	Sandy loam
4	3.61	1.85	16.31	240.88	Sandy loam
5	5.45	2.31	17.54	366.29	Sandy loam
6	7.76	2.88	17.97	421.44	Sandy loam
7	10.64	3.61	17.12	318.36	Sandy loam
8	14.25	4.51	18.37	478.79	Gravel
9	18.76	5.64	19.40	656.25	Gravel
10	24.40	6.10	20.75	965.76	Gravel
11	30.50	169.50	22.00	1100.00	Gravel
12	200.00	-	-	1200.00	Dense siltstone

For each study point, an important indicator of engineering seismology, the ground response spectrum to seismic vibrations, has been constructed. Ground response spectra allow analyzing the change in the ground reaction to actions in different spectral ranges. The smallest change is observed for point 218, while the largest amplification of the ground reaction is observed in the frequency range of 0.11–0.50 seconds, corresponding to 1-2 Hz.

Isolines of various peak ground accelerations were depicted using the triangle method. By modeling three earthquakes for all 218 points, a seismic zoning map of the “Yangi Andijon” district was constructed using the peak ground acceleration values with initial seismicity of 0.143g, 0.247g, and 0.246g, respectively.

Initially, the maps were constructed using the triangle method with 218 points. Then, uncertain areas were corrected using ArcGIS software and other graphic editors (Ismailov et al., 2022: 15–19)

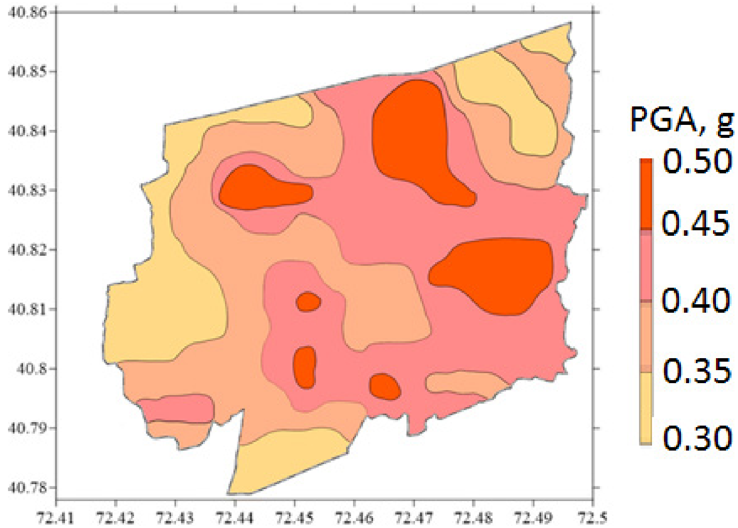


Figure. 7. Map of seismic microzonation of the territory of Yangi-Andijon district with values of peak ground acceleration (PGA)

The map of seismic microzoning of the "Yangi Andijon" district shows the summary of the seismic intensity increments (dI) obtained by different methods. For the generalization of each observation points the maximum increment values obtained by various methods were taken. However, in cases where the value obtained by one method significantly exceeds (by more than 50 %) the values of others (at least two methods), they were excluded from the set. Based on a conservative approach, the highest values obtained by different methods were taken for the final map (Fig. 8).

The intensity increments range from -0.2 to +0.9 points. The western part of the area is characterized by low values of intensity increments, while the eastern part has the maximum intensity increments.

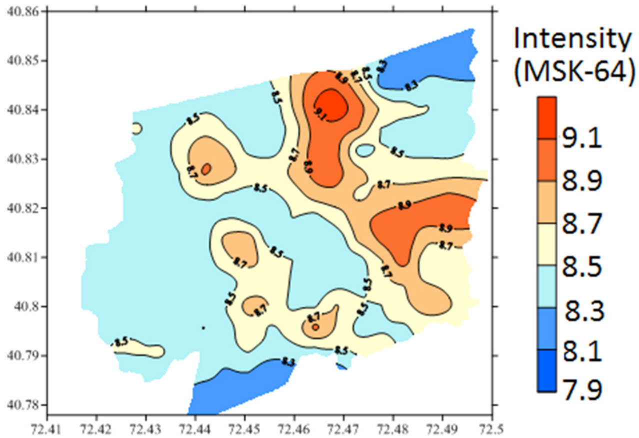


Figure. 8. Seismic intensity map (according to the MSK-64 macroseismic scale)

Based on comprehensive seismotectonic, seismological, and engineering-seismological studies, the following conclusions can be drawn regarding the seismicity of the "Yangi Andijon" district:

The city of Andijan and its surrounding territories, including the "Yangi Andijon" district, are located directly in the Andijan seismogenic zone, which is associated with the modern seismotectonic activity of the Southern Fergana flexural-fault zone. The seismic potential of this zone, both from seismotectonic and seismological data, is estimated at an M_{LHmax}=7.5 (M_{Wmax}=7.0). During the instrumental observation period, the city area has already experienced earthquakes with an intensity of I=9 according to the MSK-64 macroseismic scale.

According to the maps of the general seismic zoning of the territory of Uzbekistan (RSZ-2017), which classify seismic effects on soils of the second category (by their seismic properties), the initial macroseismicity of the territory of Andijan city is estimated as I=8 according to the MSK-64 scale for probabilities of P=0.9 and P=0.95 of not exceeding the seismic loads over a period of 50 years. For probabilities of P=0.98 and P=0.99 of not exceeding the level of seismic loads over a period of 50 years, the value is estimated as I=9.

Results and discussion

To solve urban planning tasks, design and construction of multi-story typical residential, public and social buildings in the territory of the "Yangi Andijon" district, and taking into account the international practices of seismic microzoning, we have adopted the initial seismicity value for a probability of P=0.95 for the II category of soils (by their seismic properties). Thus, the initial seismicity (design seismic intensity) is I=8.32 for average soils.

An assessment of the increase in seismic intensity under various soil conditions was carried out based on the registration of weak earthquakes and explosions at 8 observation points, determination of seismic stiffness of soil layers at a depth of 30 meters (in some cases even deeper) at 218 observation points, and establishing the ratio of spectra of horizontal oscillations to vertical ones during the registration of microseisms at 177 observation points. The summarized assessment results show a change in the increase of seismic intensity within -0.2 to +0.8. According to the methodological guidelines for seismic microzoning, the obtained increment values are within two boundary values ranging from -0.5 to +0.5 and from +0.5 to +1. Within the "Yangi Andijon" district, two zones are distinguished with an increment of 0 and an increment of +1.

In the compiled map of seismic microzoning of the territory of "Yangi Andijon" district in a scale of 1:10,000, 8- and 9-intensity zones are highlighted, which are divided depending on the characteristics of soil conditions. Thus, the zone with an intensity of I=8 covers the central, western and north-eastern parts of the territory, where the soils are denser and the observed propagation velocity of transverse waves in a 30-meter thickness was comparatively higher. The zone with an intensity of I=9 is located in the central part of the territory, where there are large deposits of low-strength loess-like clays where low shear wave velocities were observed. It should be noted that in the delimitation of zones, the values of the initial seismicity at a probability of P=0.95 of not exceeding the seismic loads for average soils were used, i.e. I=8.32, with the addition of the generalized value of the increments at a given point.

For the design of high-rise buildings using dynamic methods, a map of seismic microzoning of the territory of Yangi-Andijan district has also been developed based on peak ground acceleration (PGA) values. On the studied territory, PGA values were ranging from 0.3g to 0.5g.

The type of foundation, its structural features and depth of foundation, as well as changes in soil characteristics resulting from its reinforcement or replacement at construction site, cannot be the basis for changing the seismic microzoning zones. When carrying out special engineering measures to strengthen the foundation soils at a local site, changes in the calculated seismicity of the site and seismic microzoning zones on the seismic microzoning map should be made based on the results of additional engineering and seismological research and with the decision of Institute of Seismology of Academy of Sciences of Republic of Uzbekistan.

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