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«ҚАЗАҚСТАН РЕСПУБЛИКАСЫ
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Х А Б А Р Л А Р Ы

ИЗВЕСТИЯ

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

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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»!

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.

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RESEARCH DEVICES FROM MOVABLE, FLEXIBLE ELEMENTS AND BLOCKS IN GEOLOGICAL CONDITIONS

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Abstract.The scientific work presents the main elements of free two-dimensional waves, the determination of the design parameters of wind waves, the assessment of the impact of waves on the natural edges of the coast, recommendations for mechanical damping of wave energy by introducing environmentally friendly wave damping devices from movable, flexible elements and blocks in former use. Some features of the northeastern zone of the Caspian Sea.. The Northern Caspian, occupying 24.3 % of the area, has only 0.5 % of the volume of the Caspian Sea. The total area is 91942 km2, the volume of water is 397 km3. The depth of the sea here does not exceed 4–10 m. The bottom relief is a slightly undulating accumulative plain with a number of coasts and islands. Bottom sediments are mainly represented by siltstones, sands, silt and large banks, consisting of accumulations of broken and whole shells. The sediments of the Volga and Ural rivers, which flow into the sea here, form many shoals and shoals, which, given the general shallowness of this region, are dangerous for navigation. The shores of

the Northern Caspian are low and gentle, winding, accumulative, easily flooded, being part of the Caspian lowland, have very small (0.001 ... 0.0001) slopes and extend for considerable distances inland. When the wind from the sea is formed surge waves, and from the land - surge waves.

Keywords:waves, wave effect on the shore, main wave elements, calculated wave parameters, breakwaters and wave damping devices made of movable and flexible elements

© Б.Е. Жігітбаева[1], С.М. Қойбақов[1*], С.Т. Әбілдаев[1], М.И. Қасабеков[2], Ж.Е. Ескермесов[1], 2023

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ГЕОЛОГИЯЛЫҚ ЖАҒДАЙЛАРДА ТОЛҚЫНДАРДЫ ЖОЮ ЖӘНЕ ТОЛҚЫНДАРДЫ БӘСЕҢДЕТУ ҮШІН ЖЫЛЖЫМАЛЫ, ИКЕМДІ ЭЛЕМЕНТТЕР МЕН БЛОКТАРДАН ЖАСАЛҒАН ҚҰРЫЛҒЫЛАРДЫ ЗЕРТТЕУ

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Аннотация. Ғылыми жұмыста еркін екі өлшемді толқындардың негізгі элементтері, жел толқындарының конструктивті параметрлерін анықтау, толқындардың жағалаудың табиғи жиектеріне әсерін бағалау, қоршаған ортаға зиянсыз толқындарды енгізу арқылы толқын энергиясын механикалық демпфациялау жылжымалы, икемді элементтерден және бұрын қолданылған блоктардан толқынды демпферлік құрылғылар бойынша ұсыныстар берілген. Каспий теңізінің солтүстік-шығыс аймағының кейбір ерекшеліктері. Ауданның 24,3 %-ын алып жатқан Солтүстік Каспийде Каспий теңізі көлемінің 0,5 %-ы ғана

бар. Жалпы ауданы 91942 км^2, су көлемі 397 км^3. Мұндағы теңіздің тереңдігі 4–10 м-ден аспайды.Төменгі рельеф – бірқатар жағалаулары мен аралдары бар аздап толқынды аккумуляторлы жазық. Төменгі шөгінділер негізінен алевролиттермен, құмдармен, шөгінділермен және сынған және тұтас қабықшалардың жинақтауларынан тұратын ірі жағалармен ұсынылған. Мұнда теңізге құятын Еділ мен Жайық өзендерінің шөгінділері көптеген шоқылар мен шөгінділерді құрайды, бұл аймақтың жалпы таяздығын ескерсек, кеме қатынасы үшін қауіпті. Солтүстік Каспийдің жағалаулары аласа және жұмсақ, бұралмалы, аккумуляторлы, оңай су басқан, Каспий маңы ойпатының бір бөлігі болып табылады, өте аз (0,001 ... 0,0001) беткейлері бар және ішкі жағынан айтарлықтай қашықтыққа созылады. Теңізден жел соққанда толқындар, ал құрлықтан - толқындар пайда болады. Мұнда орта есеппен айына 3–4 көтерілу және 4–5 көтерілу байқалады, сондықтан жыл мезгілінің 80–85 % жағалық аймақтың жоғарыда аталған ерекшеліктеріне байланысты су желісі тұрақсыз және үнемі жылжиды. Теңіз деңгейінің көтерілуі нәтижесінде белсенділік, толқындардың тереңдігі мен ағыстардың қарқындылығы артады; өзендердің және таяз сулардың учаскелерінің гидрохимиялық режимі өзгеруде, сондай-ақ ауыр металдармен, мұнай өнімдерімен, пестицидтермен, басқа да зиянды және қауіпті заттармен және олардың қосындыларымен теңізге өзен ағынымен түсетін, сондай-ақ топырақтан шайылған ластану су басқан аумақтар өсіп келеді; ғимараттары бар жағалаулар шайылып кетеді, су басқан және су басқан ауыл шаруашылығы алқаптары жойылады, бұл іргелес аумақтардың табиғи және әлеуметтік-экономикалық жағдайларының нашарлауына, экологиялық жағдайдың нашарлауына және басқа да төтенше жағдайларға әкеп соғады.

Түйін сөздер: толқындар, толқынның жағалауға әсері, толқынның негізгі элементтері, толқындардың конструктивтік параметрлері, толқынды толқындар және жылжымалы және иілгіш элементтерден толқынды басатын құрылғылар

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ИССЛЕДОВАНИЕ ВОЛНОЛОМОВ И ВОЛНОГАСЯЩИХ УСТРОИСТВ ИЗ ПОДВИЖНЫХ, ГИБКИХ ЭЛЕМЕНТОВ И БЛОКОВ В ГЕОЛОГИЧЕСКИХ УСЛОВЯХ

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Аннотация. В научной работе приводятся основные элементы свободных двумерных волн, определение расчетных параметров ветровых волн, оценка воздействия волн на естественные грани берега, рекомендации для механического гашения энергии волн, путем внедрения экологически чистых волногасящих устройств из подвижных, гибких элементов и блоков в бывшем употреблении. Некоторые особенности Северо-восточной зоны Каспийского моря. Северный Каспий, занимая 24,3 % площади, имеет лишь 0,5 % объема Каспийского моря. Общая площадь 91942 км^2, объем воды 397 км^3. Глубина моря здесь не превышает 4–10 м. Рельеф дна — слабоволнистая аккумулятивная равнина с рядом берегов и островов. Донные отложения представлены в основном алевролитами, песками, илом и крупными банками, состоящими из скоплений битых и целых раковин. Наносы рек Волги и Урала, впадающих здесь в море, образуют множество отмелей и отмелей, которые при общем мелководье этого района опасны для плавания судов. Берега Северного Каспия низкие и пологие, извилистые, аккумулятивные, легко затапливаемые, входя в состав Прикаспийской низменности, имеют очень малые (0,001...0,0001) уклоны и простираются на значительные расстояния вглубь суши. При ветре с моря образуются нагонные волны, а с суши — нагонные волны. Здесь в среднем наблюдается 3–4 нагона и 4–5 нагонов в месяц, поэтому 80–85 % времени года из-за вышеперечисленных особенностей прибрежной зоны урез воды неустойчив и постоянно мигрирует. В результате повышения уровня моря увеличивается активность, глубина нагонов и интенсивность течений; изменяется гидрохимический режим участков рек и мелководий, а также загрязнение тяжелыми металлами, нефтепродуктами, пестицидами, другими вредными и опасными веществами и их соединениями, поступающими в море с речным стоком, а также вымываемыми из почвы затопляемых территорий, растет; размываются берега с расположенными на них строениями, теряются подтопленные и обводненные сельскохозяйственные угодья, что приводит к ухудшению природных и социально-экономических условий прилегающих территорий, ухудшению медико-экологической обстановки и другим чрезвычайным ситуациям.

Ключевые слова: волны, влияние волны на берег, основные элементы волны, расчетные параметры волн, волноломы и волногасящие устройства из подвижных и гибких элементов

Introduction

Frequent and strong winds in Western Kazakhstan cause surge waves on the Caspian coast. The shores of the northern Caspian, being part of the Caspian lowland, are gentle, easily flooded, have very small slopes (0.001 ... 0.0001), and extend for considerable distances. When wind occurs from the seaside, surge waves are formed, and from the land side, surge waves are formed. Here, on average, 3–4 surges and 4–5 surges are observed per month, therefore, 80–85 % of the time of the year, due to the above features of the coastal zone, the water line is unstable and constantly migrates. Under average wind conditions, the range of this migration is 3–5 km, in extreme conditions, when the wind is blowing, the amount of drying can reach 8–12 km, and the amount of land flooding can reach 20–25 km.

As a result of increasing the sea level, the duration and depth of the bunks, the intensity of the currents occurs, the hydrochemical regime of river sections and fine leads changes, the pollution of heavy metals, petroleum products, pesticides, and other harmful substances and their compounds entering the sea with river drainage, as well as lead from the soil of the flooded areas, are distinguished. Turned out and flooded agricultural lands are hiding. All this leads to a deterioration in the medical and environmental situation, another state of emergency.

The purpose of this work is to give recommendations for the mechanical damping of wave energy, through the introduction of environmentally friendly wave damping devices from movable, flexible elements and blocks in former use.

Materials and methods

Coastal hydraulic structures can be divided into two groups:

1. Shore protection structures used to protect coasts and adjacent territories from the destructive effects of waves and currents, as well as built to expand urban port areas and protective structures, the main purpose of which is to protect the water area from waves, currents, drifts, and moving ice.

2. Protective structures that protect the port water area mainly from waves are called breakwaters if the structure is not connected to the shore, and breakwaters if the structure is adjacent to the shore. Structures adjacent to another structure are called a spur, sometimes short piers are also called that (Ammaniyazov, 1999).

Coastal protection structures. Methods for protecting coasts and structures are divided into two groups: passive protection methods, when the coast is strengthened by wave protection structures that dampen wave energy directly by their design, and protection methods, when the coast is strengthened by structures that control sediments, as a result of which a protective strip of the beach is formed in front of this section of the coast, on which the waves approaching the coast are destroyed.

Wave protection structures include coastal walls, slope structures, and slope reinforcements, as well as coastal dams. Longitudinal wave-protective (wave-breaking) walls are called gravitational structures with a relatively steep, close to vertical, or steeply curvilinear outline of the face. Sloping structures are called longitudinal structures with an inclined position (up to 450 to the water level) of the face.

Sloping structures and fortifications are used both to protect the natural coastal ledge and to protect the slopes of artificially filled dams or other earthworks (Zhigitbaeva et al., 2021).

Active jet-guiding, nano-retaining structures include transverse structures — booms and longitudinal-shore-protecting breakwaters.

Booms are arranged for the formation and expansion of the beach due to the accumulation and retention of sediment (ordinary booms) or are intended to prevent erosion of existing beaches (conservation booms).

In the technique of strengthening the coast, mainly breakwater structures are used, designed to form a protective strip of the beach and which are combinations of actually made barters with booms.

The most reliable protection of the shore is provided in the presence of a sufficiently wide strip of the beach, on which the wave energy is extinguished. Therefore, when designing measures to strengthen the coast, wherever possible and appropriate, active protection methods should be used that provide for the expansion and consolidation of the strip of coastal beaches.

Wave protection passive structures. Wave protection structures are divided into coastal, directly adjacent to the coastal slopes, and wave damping barriers.

Longitudinal coastal structures are exposed to waves and wave flows of run-up and therefore must be sufficiently strong and stable, as well as withstand the effects of abrasion, which is most intense in the near-shore zone with deep banks with pebble-gravel sediments (Altunin, 1962).

When constructing longitudinal coastal structures, it is necessary to take into account not only the effects of waves on these structures but also the effects of the structures themselves on the natural environment in the zone of their construction. This impact primarily lies in the fact that by deflecting and discarding the run-up flows of developed waves, such longitudinal coastal structures as wave-protective walls themselves contribute to the erosion of the beach and the coastal slope in front of them.In conditions of open coasts formed by easily moving sandy and sandy-silty sediments and exposed to waves with a height of 1.5 m or more, the longitudinal walls of the wave-breaking type should not be located within the lower two-thirds of the width of the run-up zone. The use of wave-protective walls extended towards the reservoir beyond the shoreline is not recommended in such conditions (Dyunin, 1963).

On the shores with sandy and sandy-silty sediments, instead of walls, it is recommended to use slope structures and fortifications that do not cause consequences that are so dangerous for the stability of the beaches in the run-up zone. If it is impossible to do without such fencing, special measures are taken to protect the beach and the bottom surface from erosion, as well as to ensure the stability of the walls themselves from being washed away.

On shores with pebble sediments, sloping ones are located under the cover of a fairly wide stable beach for sloping concrete and reinforced concrete structures with a width of at least 3h, and for other types — at least 5h (here h is the wave height).

Wave-protective (wave-breaking) walls are usually arranged in the form of gravitational structures on rocky bedrock or on special artificial foundations, sufficiently reliably secured against under washing.

To reduce the intensity of the impact of abrasion, the edges of the wave walls located in the waterfront strip are given a smooth gently curvilinear outline with a horizontal laying >(0.4–0.6)Zk, where Zk is the height of the curvilinear outline of the wall. The upper part of the curvilinear outline of the wall is given the form of a wave reflector, which throws the main masses of water toward the reservoir (Kalikov, 1986).

On shores with pebble sediments and a wave height along the surf line of more than 2 m, the walls located near the shoreline are covered with a solid lining. In the case when there is a stable beach 5h wide in front of the wall (counting from the shear level), no special lining is required, as well as on sandy banks.

The elevation of the upper edge of the walls of the wave-breaking type above the calculated water level is usually taken not less than the value:

$$Z_0=0,75h+0,75,$$

Where h is the estimated wave height along the surf line in m.

At the same time, in the conditions of open deep banks of tide less reservoirs, the elevation Z0 is taken to be at least 3 m.

It should be noted that in conditions of open shores of a deep type if there is a surface beach in front of the wall with a width of more than 10 ... 15 m. The elevation of the walls above the water level to a height of Z0=3m is quite enough.

If there is no beach, then the wave splashes become so powerful that the territories and slopes protected by the walls are flooded with large masses of water and washed away.

The dimensions of the cross-section of wave-protective walls are usually determined by calculating the stability, which must be ensured by both underground pressures from the coast and under the action of wave loads along the coastal face of the structure. In the latter case, the calculation is carried out on the assumption that there is no soil backfill behind the wall (Kireev, 1986).

Results and discussions

Slope structures and slope reinforcements. Longitudinal structures of the sloping type are usually shaped so that they do not create a ledge in the profile of the coastal slope and therefore are not subjected to any significant earth pressure from the coast.

Slope structures differ from slope fortifications in that their lower (rear) face, located relative to the horizon at an angle somewhat greater than the angle of the natura slope of the soil, perceives some small load from the coastal side.

Slope structures are built of concrete or masonry and differ from slope fortifications in a somewhat more massive structure. Sloping fortifications are usually surface coverings from stone blind areas; concrete and reinforced concrete slabs and asphalt.

From the point of view of the wave-protective action and hydrodynamic conditions of interaction with waves, all structures and fortifications of the slope type, in principle, work in the same way and can be considered structures of the same type.

The height of the sloping structure or fortification is determined in such a way that its upper edge is located above the upper limit of the storm wave run-up on the sloping structure.

To reduce the height of the run-up, it is recommended to give the structures a stepped shape. For the same purpose, slope reinforcements are sometimes supplemented with special anti-roll strips made of large stones or blocks embedded in the fortification structure.

Sloping structures can be made of concrete or reinforced concrete with inclined, inclined-step or other outlines of the water face. The load from such longitudinal structures is transferred either directly to the ground or through a pile foundation.

The elements of a slope structure of any type must be sufficiently strong and stable when exposed to wave loads. They must also be secured from their “turning out” towards the side of the reservoir when the waves roll back under the action of the counterpressure of the water that has fallen under the structure, as well as from damage to them by ice.

Sloping fortifications made of various types of drafts contribute most to dampening wave energy and therefore it is advisable to use them in the zone of breaking waves with slopes steeper than 1:1.5.

Fortifications with impenetrable surfaces can be formed from concrete, reinforced concrete, asphalt, monolithic riprap and pavement of various types, covering slope surfaces with slopes corresponding to the material used and the method of forming the bank slope profile.

All types of slope fortifications must be reliably protected from erosion. This is achieved by the installation of sheet piling, impervious to soil, protective coatings of soil surfaces.

To protect shallow sandy shores, fortifications are widely used in the form of pavement coverings of various types of slabs laid directly on the coastal slopes of rock fill, as well as from asphalt and asphalt concrete structures.

Wave barriers. Wave-damping barriers, or breakwaters, designed to dampen the energy of waves with an elevation of the crest above the water level, are used relatively rarely, since to carry out sufficiently effective damping of waves, heavy and expensive structures are needed, taken to considerable depths.

More effective in this case are breakwaters made from sketches of large stone blocks or shaped massifs (in particular, from tetrapods and tribars).

Active jet guides. Conditions determining the choice of active protection structures. With an oblique approach of the wavefront to the shore, alongshore currents are formed, which cause erosion of the bottom, washing out of beach materials, and other undesirable erosion along the longitudinal protective structures. The choice of the type of structures for protecting the coast is determined primarily by the natural conditions in the fortification zone and technical and economic indicators (Imanaliyev, et al., 2022).

In most cases, it is possible to reliably protect the shore by creating a stable beach accumulation, both with the help of booms and with the help of breakwaters with traverses. Usually, the cost of strengthening with booms is less than the cost of strengthening with breakwaters, however, under certain conditions, the use of breakwaters may be more appropriate. For example, breakwaters should in most cases be preferred in areas with underwater landslide development. Breakwaters with traverses are in most cases more effective than booms in areas with steep underwater slopes.

Some features of the northeastern zone of the Caspian Sea. The Northern Caspian, occupying 24.3 % of the area, has only 0.5 % of the volume of the Caspian Sea. The total area is 91942 km^2, and the volume of water is 397 km^3. The depth of the sea here does not exceed 4–10 m. The bottom relief is a slightly undulating, accumulative plain, with a series of banks and islands. Bottom sediments are mainly siltstones, sands, silt, and large banks, consisting of accumulations of broken and whole shells. The sediments of the Volga and Ural rivers flowing into the sea here form many shoals and banks, which, given the general shallow water of this region, are dangerous for the navigation of ships. Between the delta of the Ural River and the Buzachinsky Peninsula, there is a shallow (8 m) vast depression called the Ural furrow. The shores of the Northern Caspian are low and gentle, winding, accumulative, and easily flooded, being part of the Caspian lowland, they have very small (0.001 ... 0.0001) slopes and extend for considerable distances inland (Ivkina, 1998). When wind occurs from the seaside, surge waves are formed, and from the land side, surge waves are formed. Here, on average, 3–4 surges and 4–5 surges are observed per month, therefore, 80–85 % of the time of the year, due to the above features of the coastal zone, the water line is unstable and constantly migrates. Under average wind conditions, the range of this migration is 3–5 km, in extreme conditions — during the down surge, the drying value can reach 8–12 km and the land flooding value - is up to 25–50 km. As a result of sea level rise, there is an increase in activity, the depth of surges, and the intensity of currents; the hydrochemical regime of sections of rivers and shallow waters is changing, and pollution by heavy metals, oil products, pesticides, other harmful and hazardous substances and their compounds entering the sea with river runoff, as well as washed out from the soil of flooded areas, is growing; banks with buildings located on them are washed away, flooded and flooded agricultural lands are lost, which leads to the deterioration of the natural and socio-economic conditions of the adjacent territories, the deterioration of the medical and environmental situation, and other emergency situations (Imanaliyev et al., 2022).

The rise in the water level during surges for coastal areas, the height marks of which slightly exceed the mark of the mean sea level, is sometimes a catastrophic disaster. This is especially true of the northeastern shallow, bay-like part of the Caspian Sea with the very gently sloping shores of the Caspian Lowland, off the coast of which the largest surges in this sea are noted (Utegaliev et al., 2002).

Over the past 10 years, the most catastrophic surges have been observed on the Kazakhstan coast (1990, 1991, 1993, 1996, 1999, 2003, 2007, 2009). Losses from flooding of the coast by surge waters amount to tens of millions of dollars.

The main elements of regular, two-dimensional free waves include wave height, wavelength, wave steepness, wave period, wave propagation velocity, orbital velocity, acceleration of wind waves, etc (Ivkina, 2001).

Wave height, h, m – the vertical distance between the top and bottom of the wave.

Wavelength, λ,m – horizontal distance between two adjacent wave tops.

The steepness of the waves h/λ is the ratio of the height of the wave to its length.

The period τ of a wave is the amount of time it takes for the crest of a wave to travel a distance of a wavelength.

$$\tau = \sqrt{\frac{2\pi\lambda}{g} cth \frac{2\pi H}{\lambda}}, \text{ c.} \qquad (1)$$

where, H – is the depth of the reservoir, m.

Wave propagation speed - the speed of movement of the wave crest in the horizontal direction, equal to λ / τ .

The orbital velocity of a fluid particle at the considered point of the wave at depth (from the resting level) is determined by the formula (under the wave crest)

$$\upsilon_z = \frac{\pi h}{\tau} \frac{ch \frac{2\pi}{\lambda}(H - z)}{sh \frac{2\pi H}{\lambda}}, \text{ m/s.} \qquad (2)$$

Dispersal of wind waves D km - the length of the water surface covered by the action of the wind, causing the formation of waves.

Determination of design parameters of wind waves. In the presence of a reliable long-term series of direct observations of wave parameters in existing reservoirs, these data are statically processed and curves for the availability of wave elements in different directions are constructed (Baidosova et al., 2007).

In the absence of such data, in particular, when designing structures on newly created reservoirs, these parameters are calculated based on the analysis of wave-forming factors: wind speed, duration of its action, wave acceleration, and depths of the reservoir.

The wind speed and its duration for different directions are determined by statistical processing of observational data from the nearest hydrometeorological stations. Data from stations located on low coasts or islands are preferable (Sennikov et al., 2008).

When calculating the wave elements of small reservoirs, the duration of the wind action may not be taken into account.

The acceleration of the wave is determined by the directions of the eight main points and by the direction of the greatest extent of the reservoir.

For the conditions of deep reservoirs and deep water zones, the following ratios can be taken for approximate calculations h / λ: for seas 1/10-1/20; for large reservoirs 1/10–1/15.

To switch to the parameters of waves of other coverage, you should use the data in Table 1, where h_i — is the height of the calculated coverage wave; $\overline{h}$ - average wave height.

Table 1 - To the calculation of the availability of a wave

Wave height assurance, %	1	2	3	10	20	30	40	50	60
$h_i / \overline{h}$	2,52	2,28	1,91	1,69	1,38	1,21	1,05	0,93	0,81

Approximate values of maximum observed heights and wavelengths for oceans, seas, and inland waters are given in Table 2.

Table 2 - Wave parameters

Name of the water area	Height, h, m	Length, λ, m
Atlantic, Pacific and Indian Oceans	20,0	500
Bering Sea		
Barencevo sea	14,0	250
Caspian Sea	13,0	200
Black Sea	11,0	130
Baltic Sea	9,5	140
Large lakes and reservoirs	8,5	120
	5-5,5	60-70

The determination of the wind surge ΔH (increase in the average level of the reservoir due to the action of the wind) can be carried out according to the formula

$$\Delta H = k\frac{W^2 D}{2gH}\cos\alpha, \tag{3}$$

Where, $k \approx 9\cdot 10^{-3}$; α - the angle between the axis of the reservoir and the direction of the wind; W - wind speed, m/s; D – wave overclocking, km.

Impact of wind waves on natural coastal slopes. The simplified method for calculating bank reformations given below makes it possible to determine approximately the amount of bank erosion during a given period of erosion (in years) using the formula below (Zhigitbaeva et al., 2021):

$$Q = k_p k_{\acute{a}} t^{\acute{a}} \mathring{A}\text{, m}^3\text{/m length,} \tag{4}$$

$\mathring{A}$ - calculated average long-term wave energy, ts*m in year, calculated from wind observations at nearby hydrometeorological stations. For this, the weighted average wave power is determined $\overline{N}_i$ -for waves of a given height, taking into account the distribution of these waves in time along the points, j facing the reservoir according to the formula:

$$\overline{N}_i = 795 h_i^{2,5}\frac{\Sigma p_j \cos\varphi_i}{\Sigma p_j}\text{, ts*m,} \tag{5}$$

Where, p_j – frequency of rhumb waves lying in the height interval $h_i + \Delta h$ и $h_i - \Delta h$; Δh - arbitrary, sufficiently small value; φ – the angle formed by the direction of wave acceleration and normal to the coastline (in plan) (Kireev, 1986).

Then it is defined as E

$$E = \Sigma T_i \overline{N}_i\text{, ts*m/year,} \tag{6}$$

where, T_i – the duration of the wave height h_i, h/year;

k_p – shore soil erosion index, m[3]/ts*m, wave work. Guide values k_p :

for very easily eroded rocks (fine-grained sands, light sandy loams, loesses) – from 0.0065 to 0.003;

for rocks of medium erosion (heavy loam, clay, sands with gravel and pebbles) – 0.001-0.0005;

for rocks that are difficult to erode (pebbles, clayey sandstones, moraine clays) – less than 0.0005.

Empirical coefficient $k_б = aH_б$, where $H_б$ - the average height of the coast within the area under consideration; $\grave{a}$ – for easily eroded rocks is taken equal to 0,03, with difficult to blur 0,05.

The abrasion part of the shoal is located between the upper and lower limits of erosion, determined for this part of the reservoir as follows: the upper and lower levels of the mirror are found with a probability of 6 and 96 %, respectively. One-third of the average wave height is added to the upper level and the upper limit of erosion is obtained, and from the lower level the average wave height is laid down and the lower limit of erosion is obtained (Joldassov S., and et all 2023).

Wave effects on slope-type structures. The following instructions apply to slopes with a steepness $1{,}5 \le m < 5$.

Depth H_1 after which there is a sharp increase in velocities on the slope, which is determined by the formula

$$H_1 = \frac{1{,}2}{m^{0{,}8}}\sqrt{h\lambda}\text{, m} \qquad (7)$$

Critical depth at which the wave breaks down,

$$H_{кр} = h\left(0{,}47 + 0{,}023\frac{\lambda}{h}\right)\frac{1+m^2}{m^2}\text{, m} \qquad (8)$$

The impact of the jet discharged from the crest of the wave during its collapse on the slope is determined for the point B of the slope at a depth $H_{кр} - y_B$. At this point, the maximum velocity and the greatest intensity of pressure are observed upon the impact of the collapse jet (Kalikov, 1986).

Point coordinates B

$$y_B = \frac{x_B}{m}; \qquad (9)$$

$$x_B = \frac{\dfrac{-\upsilon^2{}_A}{m} \pm \upsilon_A\sqrt{\dfrac{\upsilon^2{}_A}{m^2} + 2gy_0}}{g}, \qquad (10)$$

where, y_0 – point ordinate A, characterizing the position of the wave crest at the moment of the beginning of the collapse;

$$y_0 = H_{кр} + h_{гр}; \tag{11}$$

$h_{гр}$ – elevation of point A above the level of rest

$$h_{гр} = \left[0{,}95 - (0{,}84m - 0{,}25)\frac{h}{\lambda}\right]; \tag{12}$$

υ_A – the horizontal projection of the initial velocity of the jet discharged from the wave crest;

$$\upsilon_A = n\sqrt{\frac{g\lambda}{2\pi}th\frac{2\pi H}{\lambda}} + h\sqrt{\frac{\pi g}{2\lambda}cth\frac{2\pi H}{\lambda}}, \tag{13}$$

The maximum speed of the jet when the wave hits the slope at point B

$$\upsilon_B = \sqrt{\eta\left[\upsilon_A + \left(\frac{gx_B}{\upsilon_A}\right)^2\right]}, \tag{14}$$

where, $\eta = 1 - (0{,}017m - 0{,}02)h$.

The maximum jet speed at rest

$$\upsilon_0 = \frac{10k_m\sqrt{g}}{2\pi + m}\sqrt[6]{h^2\lambda}, \tag{15}$$

where, k_m – roughness coefficient, taken according to the table 3.

Table 3 - Roughness coefficient values

Coating type	k_m
Continuous impervious smooth coating	1
Concrete plates	0,9
Pavement (stonework)	0,8
Broken stone sketch	0,55
Sketch from concrete masses	0,5

Jet velocities below rest level, starting from depth $z = H_1$ calculated by the formula

$$\upsilon_z = \frac{n\pi h}{\sqrt{\frac{\pi\lambda}{g}sh\frac{4\pi H}{\lambda}}}, \text{ m/s.} \tag{16}$$

Maximum wave run-up height h_H on slopes is measured from the level of rest and is determined by the formula

$$h_H = \frac{2k_m h}{m}\sqrt[3]{\frac{\lambda}{h}}, \text{ м}, \quad (17)$$

where, k_m - roughness factor.

The maximum local pressure at point B from the impact of the jet at the moment of wave breaking is determined by the formula

$$p_{Вмак} = 1{,}7\gamma \frac{\upsilon^2_B}{2} \cos^2 \varphi, \quad (18)$$

where, φ – the angle between the tangent to the direction of the jet at point B and normal to the slope, equal to

$$\varphi = 90^0 - (\alpha + \beta). \quad (19)$$

The angle is calculated from the dependence β

$$tg\beta = -\frac{gx_B}{\upsilon^2_A}. \quad (20)$$

The upper limit of the capital fixing of the slopes is set to the height of the roll-out of the wave h_H, determined by formula (19), into which the value of the wave height corresponding to a 50 % probability is substituted, and determined using Table 1. To establish the boundary of facilitated fastening in the same formula, the wave height is taken with a 10% probability. When designing sloping structures on reservoirs, taking into account wave effects, the wave height assurance indicators are taken according to Table 4 (Zhigitbaeva et al., 2021).

Table 4 - Accounting for wave actions

Design characteristic	Provision, %
The height of the wave run-up on the slope when determining the elevation of the crest of the structure	1
Stability and strength of capital fixing plates	1
Stability of rock placement of the capital fastening	2
Stability and strength of lightweight fasteners	5

New standard elements and blocks are used for coastal and wave protection structures. When designing and building hydraulic structures on uninhabited areas of sea coasts with a very gentle shelf zone and long coastal areas, the use of existing coastal fortifications, breakwaters, and wave dampers described above due to their very high material consumption, complexity of structures and bulkiness from a technical and economic point of view is not profitable. Therefore, in such areas, it is necessary to use as much as possible typical elements and blocks made from local materials (Kiselev et al., 1984).

Coastal wave absorbers from standard elements. In some cases, it may be sufficient to use the simplest wave absorbers located on the sea near the coastline. The figures show the description and design of such wave absorbers from standard elements and decommissioned tires.

Coastal surge absorber made of standard elements (Figure 1,2), which is a system of many elastic steel vertical bars in a plastic shell, embedded in a reinforced concrete base, which are assembled in rows and installed along the coast. Quenching excess wave energy into many small jets and intensively mixing it.

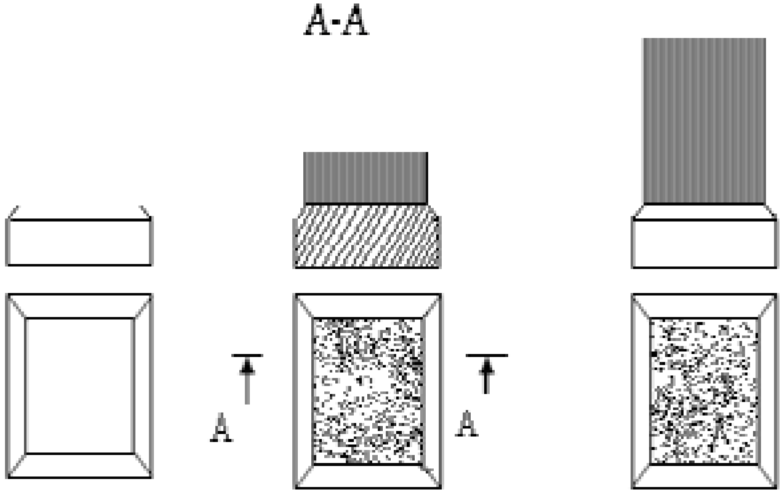


Fig. 1 - typical elements of coastal surge absorbers

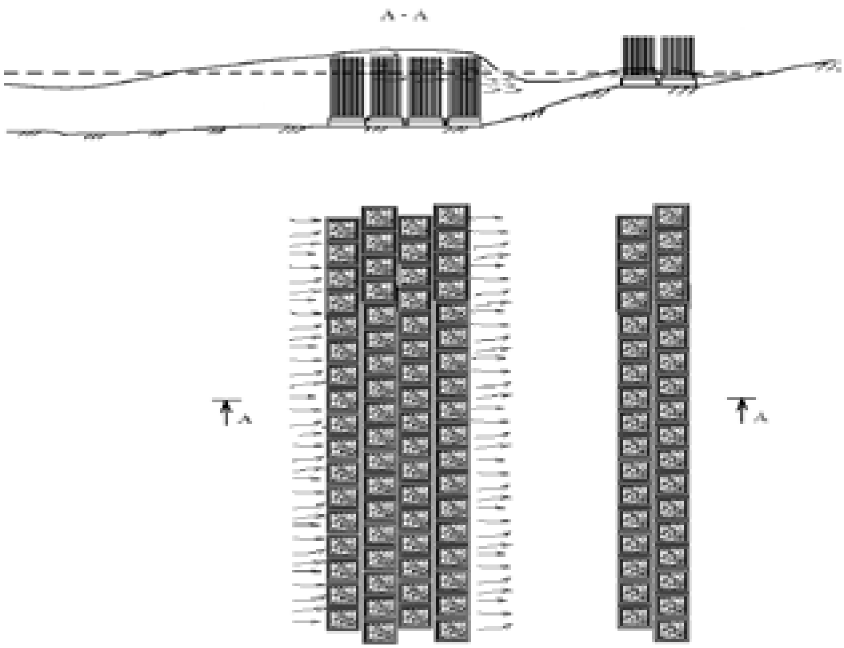
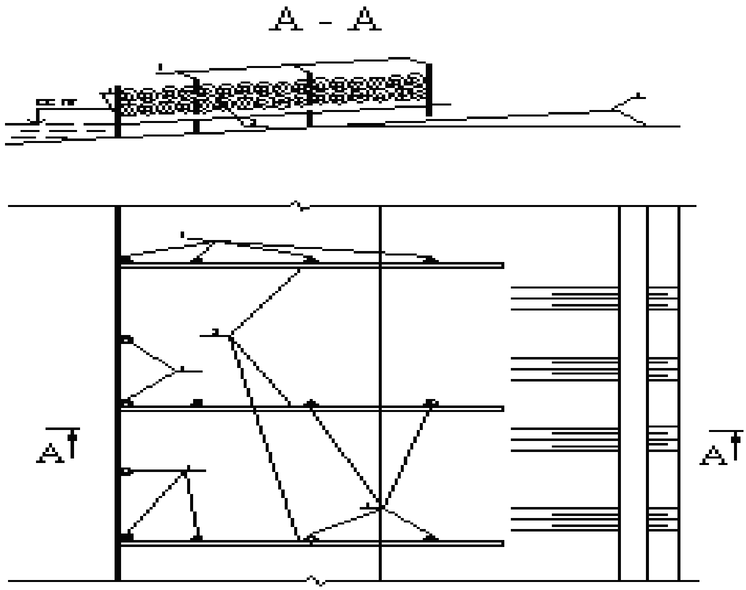


Fig. 2 - Coastal surge absorber made of typical elements (steel rods embedded in a reinforced concrete base)

All structures of the breakwater and wave dampers are designed for shallow water areas and due to the simplicity of their construction, the possibility of manufacturing them at the installation site, including from local materials, they can be widely used in engineering practice in the development of new oil fields on the northeast coast of the Caspian Sea (Ivkina, 1998).

At the same time, the most complete effect is obtained with the combined use of wave suppression and coastal surge structures in the complex. An example of this is the complex of structures shown in Figure 3, where a breakwater in the form of a longitudinal through wall of tires was erected parallel to the anti-surge dam on the sea, and traverses were installed across them, serving as a damper of longitudinal currents.



1 - wave damper; 2 - traverses; 3 - piles; 4 - anti-surge dam made of local materials.
Fig. 3 - Scheme of combined protection from coastal wave absorbers from used tires and anti-surge coastal dams

Breakwaters and wave suppression devices made of movable, flexible elements and blocks

When ecologically damping wave energy and developing uninhabited coasts of great length and shallow shelf areas of the seas inherent in the northeastern part of the Caspian Sea, the use of wave-damping structures made of standard through elements and blocks is of great importance, which significantly reduces the cost of their total cost and reduces the construction and commissioning time operation of such facilities (Koibakov, 2003).

Figure 4 shows two types of gabions G-1 and G-2, adapted to marine conditions, which are rectangular lattice boxes with side dimensions of 2000x1000x500 and 1000x1000x500 mm. The box consists of ribs along the edges, made of steel corners with profile number № 7 or more, to which metal rods with a diameter of at least 20 mm and a clearance of 100 ... 150 mm are welded. Depending on the specific purpose, the boxes can be filled with balls made of extra strong rubber and plastic with a diameter of at least 1.5 times the width of the grate opening with a bulk density close to 1, i.e. close to the volumetric weight of water or other material (Dunkovsky et al., 1967).

In the first case, they are used as components of a sloping surge absorber to dampen the excess energy of surge waves, in which, when a wave runs onto a slope, it flows around gabion lattice boxes and a lot of balls inside it breaks into thousands of small streams and calms down within the slope from the seaside (Schmidt, 1970).

In the second case, gabions are used as components of a breakwater installed in the open sea. It is a vertical two-row lattice wall, with gabions arranged in a checkerboard pattern. Individual drawers are vertically welded together with shaped sheets. Horizontally, gabion boxes are fastened with the help of a channel or brand to piles located at an equal distance from each other parallel to the shore (Ivkina, 1998).

When a wave runs on vertical columns arranged in a checkerboard pattern, it breaks up into large jets, and when flowing around the lattice part and balls inside the box, it breaks into many small jets, while the wave flow is intensively altered and the jets collide with each other. As a result, an intense and abrupt damping of the excess energy of the wave occurs (Imaaliev et al., 2022).

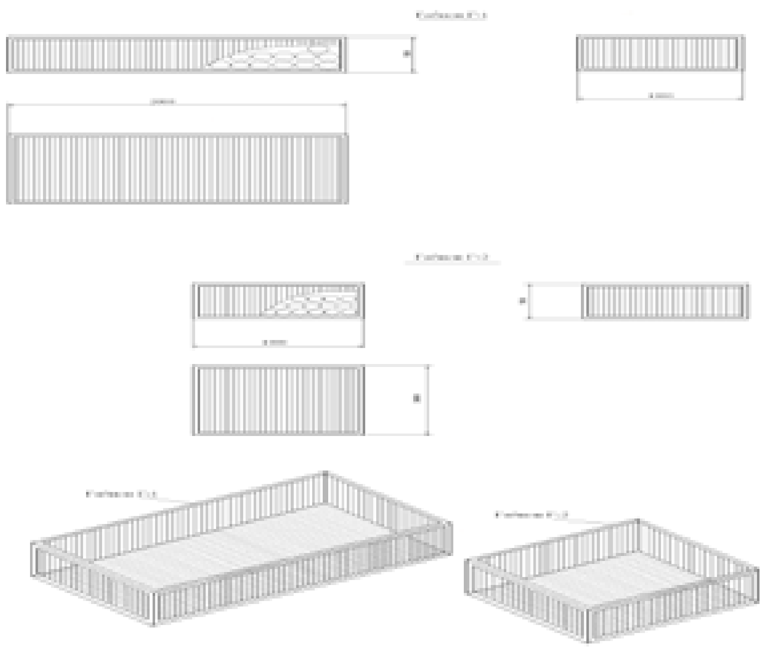


Fig.4 - Designs of wave-damping typical gabion blocks

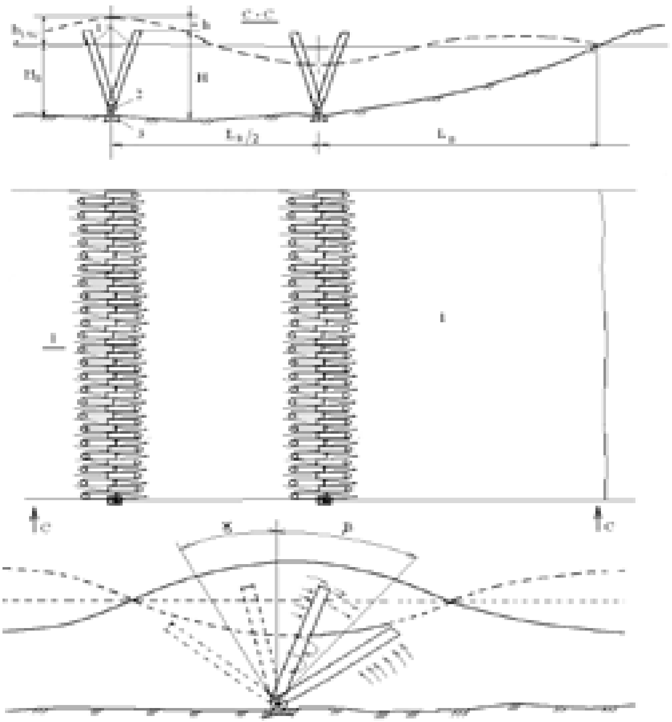


Fig. 5 - The design of the breakwater from the “V” shaped elements and the kinematic scheme of its operation

The breakwater (Fig. 5) is made of links, which is a cable 3 attached at both ends to anchor-bollards 2. The main typical “V” shaped elements 1 are strung on the cable butt to each other. A feature of the “V” shaped element is its execution in such a way that two airtight horns are welded to the base, a pipe segment with a length equal to two element diameters, spaced apart from the vertical by an angle of /2, while 30 ... 40 degrees (Rador, 1968) . Then in the link, one-half of the horns is located to the right of the vertical, and the other to the left. The kinematic scheme of the breakwater operation is shown in Fig. 5. In calm weather, the breakwater is, due to the design features, in a vertical position. Under the influence of a wind wave, the wave flow, flowing through the left-handed horns, breaks up into many small jets, which, in turn, encountering right-handed horns on the way, pile on them and turn the breakwater to the right. At the same time, the flow again breaks up into small streams, i.e. there is an intensive mixing of the wave flow, and a significant part of the excess energy of the wave is affected. The turn to the right occurs until the active pressure of the wave equalizes with the passive hydrostatic pressure, the repulse of the system of elements, and this moment occurs when the bottom of the wave approaches the axis of the breakwater when the repulse force becomes greater than the active pressure force. From this moment until the approach of the next wave, the entire breakwater turns in the opposite direction. Then another cycle is repeated. Influencing the flow in this way, the breakwater works with a double effect: a) the division of the wave flow into many small jets, their intensive mixing, and b) the swing of the breakwater around the center of the base to the right and left, i.e. reverse pendulum effect (Koibakov et al., 2007).

A wave damper with artificial movable roughness consists of a longitudinal barrier (Fig. 6) located approximately perpendicular to the prevailing wind direction, containing typical elements of mesh boxes 1, filled with balls 2 half of their volume, which are attached to piles 3, is a rigid structure in the form of a rectangular parallelepiped with channel ribs; meshes are made in the form of lattices of vertical rods welded to the ribs of the box, while the clearance of the lattice should not exceed 0.6 of the diameter of the balls, with a density close to 1, filling the box by half its volume; the height of the wave absorber H is taken equal to the water depth at the installation site plus 0.5 ... manufacturing of steel structures not less than 6 m and a multiple of 3 m (Zhigitbaeva et al., 2021).

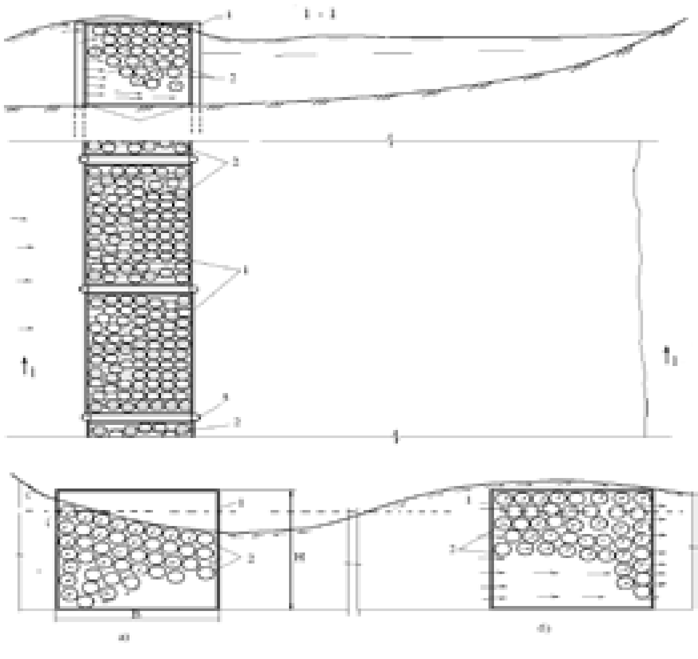


Fig. 6 - Wave damper with artificial movable roughness. Kinematic diagram of the wave absorber operation

The wave damper works as follows (Fig. 6). When a wind wave runs onto mesh boxes, the flow is forced to flow around them, and due to the thoroughness of the structure, it passes through the lattice and flows around a lot of balls freely floating in the closed volume of the box with a density close to that of water, which consumes a significant part of the excess wave energy; at the same time, the bulk of the balls under pressure is pressed against the right wall and the roof of the box and intensive mixing takes place, taking the rest of the wave energy, and when the wave rolls back, the balls are pressed against the left wall, intensively mixed under the action of a reverse current. Thus, there is an effective damping and calming of the wind wave (Ivkina, 1998).

Conclusion

For the use of new environmentally friendly types of wave protection structures, the northeastern zone of the Caspian Sea is recommended. The Northern Caspian, occupying 24.3 % of the area, has only 0.5 % of the volume of the Caspian Sea. The total area is 91942 km2, and the volume of water is 397 km3. The depth of the sea here does not exceed 4–10 m. The bottom relief is a slightly undulating, accumulative plain, with a series of banks and islands. Bottom sediments are mainly siltstones, sands, silt, and large banks, consisting of accumulations of broken and whole shells. When wind occurs from the seaside, surge waves are formed, and from the land side, surge waves are formed. Here, on average, 3–4 surges and 4–5 surges are observed per month, therefore, 80–85 % of the time of the year, due to the above features of the coastal zone, the water line is unstable and constantly migrates. Under average wind conditions, the range of this migration is 3–5 km, in extreme conditions - during the down surge, the drying value can reach 8–12 km, and the land flooding value - is up to 25–50 km (Koybakov et al., 2023).

As a result of sea level rise, there is an increase in activity, the depth of surges, and the intensity of currents; the hydrochemical regime of sections of rivers and shallow waters is changing, pollution by heavy metals, oil products, pesticides, other harmful and hazardous substances and their compounds entering the sea with river runoff, as well as washed out from the soil of flooded areas, is growing; banks with buildings located on them are washed away, flooded and flooded agricultural lands are lost, which leads to the deterioration of the natural and socio-economic conditions of the adjacent territories, the deterioration of the medical and environmental situation, and other emergency situations (Mellor, 1965).

The rise in the water level during surges for coastal areas, the height marks of which slightly exceed the mark of the mean sea level, is sometimes a catastrophic disaster. This is especially true of the northeastern shallow, bay-like part of the Caspian Sea with the very gently sloping shores of the Caspian Lowland, off the coast of which the largest surges in this sea are noted (Ivkina, 1998).

Over the past 10 years, the most catastrophic surges have been observed on the Kazakhstan coast (1990, 1991, 1993, 1996, 1999, 2003, 2007, 2019). Losses from flooding of the coast by surge waters amount to tens of millions of dollars. Therefore, we recommend new standard elements and blocks used for coastal and wave protection structures. When designing and building hydraulic structures on uninhabited areas of sea coasts with a very gentle shelf zone and long coastal areas, the use of existing coastal fortifications, breakwaters, and wave dampers described above due to their very high material consumption, complexity of structures and bulkiness from a technical and economic point of view is not profitable. Therefore, in such areas, it is necessary to use as much as possible typical elements and blocks made from local materials.

Some typical elements and blocks are given at work. In particular, as a typical element, you can use old car tires, from which you can make blocks of three types, which are called tripod, tetrapod, and pentapok. They, as indicated in the main part of the scientific work, are not environmentally harmful, the cost is low and installation does not require large funds.

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