N E W S
OF THE NATIONAL ACADEMY OF SCIENCES OF THE REPUBLIC OF KAZAKHSTAN
SERIES OF GEOLOGY AND TECHNICAL SCIENCES
ISSN 2224-5278
Volume 6, Number 444 (2020), 41 – 49 **https://doi.org/10.32014/2020.2518-170X.129**

UDC 624.152.86.31

I. S. Brovko[1], Y. B. Kunanbayeva[1], E. I. Brovko[2], K. S. Baibolov[1]

[1]M. Auezov South Kazakhstan University, Shymkent, Kazakhstan;
[2]Institute of management and information modeling
of the University of Minstroi NIISF RAASN, Moscow, Russia.
E-mail: brovkoi56@mail.ru, aira.kunaeva@mail.ru,
int-gasis@yandex.ru, kanat-bai@mail.ru

EXPERIMENTAL SUBSTANTIATION OF SOIL SELECTION IN RECONSTRUCTION OF A MAIN GAS PIPELINE

Abstract. The results of complex geotechnical studies aimed at creating a temporary soil dam for the reconstruction of the main gas pipeline are conducted. Based on the study of the properties of the three types of soils that are in the vicinity, the technical-economical efficiency and prediction of the compaction of the recommended soil are substantiated. The choice of soil laid in the dam should be carried out on the basis of the study of the properties of soils and feasibility study. Technical-economical assessment is impossible without knowledge of the characteristics of the soil, which were obtained in laboratory conditions. Three series of experiments were performed for this: determination of soil density; determination of the angle of repose; determination of soil filtration coefficient. The parameters were investigated in the course of the experiments, on which the quality of the soil dam depends to the greatest extent: density; angle of repose during dumping; filtration properties (filtration coefficient). Based on an analysis of the current situation, proceeding on environmental requirements and considerations of economic feasibility, it was proposed to fill in a temporary embankment to allow the piles to be loaded by driving, and to make it out of medium-sized sand composing the surface thickness in a given area. On the assumption of the technological requirements of the reconstruction, the dam should be 5 m high and 36 m high on the top and 51 m high on the bottom. Based on experimental-analytical researches, a motivated choice of soil is substantiated, which made it possible to obtain an economic effect confirmed by the act.

Key words: dam, embankment, soil density, angle of slope, filtration coefficient, artificial sandy foundations, laying of sandy foundations, compacted bulk soils, quality control, monitoring of the formed foundation, geotechnical indicators driven pile.

Introduction. The need to reconstruct the passage of the main gas pipeline through the Syr-Darya river is associated with the destruction of the support of the metal trestle No. 19 and the roll of six more supports No. 13, 16, 17, 18, 20 and 21, caused by the movement of ice in 2008**.**

The impossibility of exploitation the gas pipeline after its damage is confirmed by a technical examination of the condition of the supports of LLP «Constructor Sapa» and an act of inspection of the gas pipe itself by specialists of the exploitation organization.

Each support, according to the initial project, is made of 4 metal driven piles from a pipe with a diameter of 426 x 10 mm, loaded to the depth of 17 m, with support in a paleogene-neogene layer.

The grillage of pile supports is 3.5 x 1.5m in size of design and 0.95m in height, made of welded metal structures, is located above the water level in height of 5 m. Each pile is a sheath, reinforced and concreted after driving. Piles are interconnected by metal bonds.

The overpass has been in trouble-free exploitation for about 25 years, right up to the above damage caused by ice drift. Only those supports located in the deep water of the river bed were destroyed.

According to the justifications of the construction organization carrying out the reconstruction of the overpass, the structure of the restored supports (the amount of piles, the dimensions of the foundations, the material, the type of piles and the grillage) and the local experience in the construction of piles are proposed to leave the former, adopted in accordance with the original version and confirmed its operational suitability for a number of years [1]. To make an additionally protective structures (icebreakers) in the most dangerous places to prevent repeated damage to the pier supports during the flood and ice drift.

However, it seemed problematic to choose a method of piling, because there is no necessary surfacing means, and, in addition, creation of a structure is required with a 5 m exit of piles above the water level (with a high grillage).

Based on an analysis of the situation, proceeding on environmental requirements and considerations of economic feasibility [2-12], it was proposed to fill in a temporary embankment to allow the piles to be immersed by driving, and to make it out of local soil. On the assumption of the technological requirements of the reconstruction, the dam should be 5 m high and 36 m high on the top. The size of the base of the embankment will depend on the type of soil being poured. The required dimensions of the embankment mainly depend on the angle of repose and the strength characteristics of the soil to be filled [13-18]. Based on local conditions, the following can be used: sand of medium size (SMS), medium density (EGE-3), which forms the channel of the Syr-Darya river; fine sand (FS), loose (EGE-2; 2a), located in the immediate vicinity of the river; loams lying 30 km away from the dam.

Methods. In the first series of experiments, the determination of soil density was carried out according to the standard method. All experiments in this series tests were repeated five times and were carried out on medium sand and fine sand initially in a dry state. . In this case, four states of each of the sands were artificially created: minimal compaction (by simply pouring soil into the cutting ring); weak compaction; strong compaction; possible maximum compaction. Moreover, knowing the mass of soil to create the minimum and maximum compaction, a weak and strong compaction with equidistant intermediate values was modeled.

In the second series of tests, the angle of repose of SMS and FS was also determined by the standard method. For dry and water-saturated loose sands, the value of the angle of repose practically coincides with the angle of internal friction. In the air-dry state $\varphi = 30 ... 40$, under water $\varphi = 24 ... 33$.

The third series of experiments was devoted to the determination of the coefficient of soil filtration. At this point, due to the information obtained in experiments on determining the density and angle of repose of SMS and FS, is already set a definite opinion about the preference for using SMS for dumping the dam. However, the question of the filtration coefficient, its dependence on the density of soil laying, the possibility of water penetrating through the body of the dam, etc., remained unclarified. Therefore, in this series of experiments, the main attention is paid to the study of the filtration coefficient of SMS. At the same time the value was determined depending on the density of SMS laying, which was created similarly to the experiments in the first series, that is, with: minimal, weak, strong and maximum compaction. Laboratory tests to determine the filtration coefficient for SMS and FS were carried out according to standard methods. The experiments were carried out with triplicate determination at various values of the hydraulic gradient J and the average value was found. In each test the measurements were carried out at 7-8 different positions of the water level in ballon and the obtained data were averaged.

Results. In accordance with the report on engineering-geological conditions in this area, fine and medium-sized sandy soils dominate from the surface without distinct facial borders (EGE No. 1,2,3), which are lined with clays from a depth of 16 m. On the left bank sandy soils are covered by a layer of up to 1.5 m macroporous loam of solid consistency.

According to the nomenclature and physical-mechanical properties of soils, four engineering-geological elements (EGE) were identified within the transition area: EGE-1 – macroporous loam, subsiding (the subsidence of the loam from its own weight when soaking is 0.0 cm, the type of soil conditions of the site within the left bank by subsidence is the first); EGE-2 - fine sand, loose; EGE-2^a - fine sand, medium density; EGE-3- sand of medium fineness, medium density; EGE-4 –not swelling clay.

According to the results of the first series of tests was obtained the dependence of soil density on the degree of created compaction (figure 1).

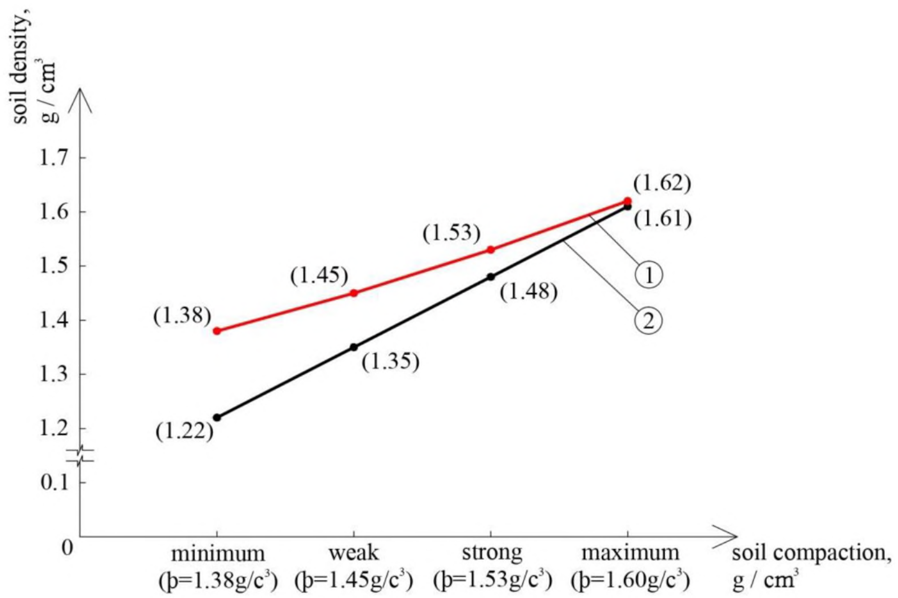

Figure 1 – The dependence of soil density (ρ) on the degree of compaction being created:
1 - for sand of medium size; 2 - for fine sand

Comparing the density values of SMS and FS simulated in laboratory conditions with the corresponding data obtained by LLP «Inzhenernyye izyskaniya» from samples of a natural undisturbed structure, can mention the natural state for SMS the density is 1.58 g/cm^3, and for FS- 1.52-1.54 g/cm^3, which corresponds to the state under laboratory conditions between strong and maximum compaction.

Therefore, we can make an intermediate conclusion that when laying in a dry state SMS is preferable for laying it in a dam in comparison with FS, in that this soil surpasses FS in almost all stages of its compaction. From the data it is also seen that the addition of the same soil masses to the same volume gives an uneven increment (in %) of the density. So, for SMS, the maximum increment ρ was for strong compaction, and for FS, for weak compaction it continued to fall from 10.7% to 9.5% (figure 2).

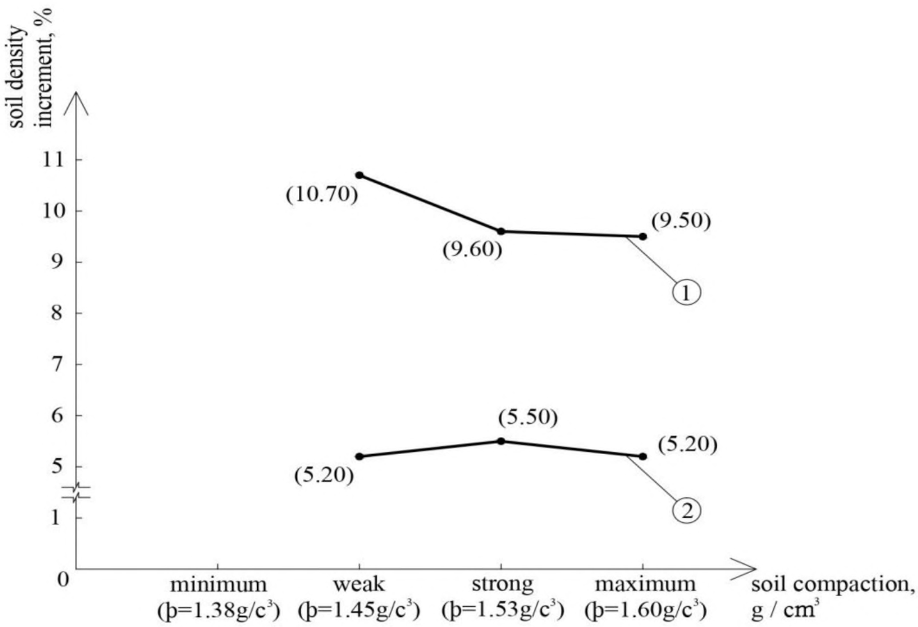

Figure 2 – The dependence of the increment of soil density on the degree of compaction:
1 - for sand of medium density; 2 - for fine sand

Interesting data were obtained when working with soils (SMS and FS), in conditions of their full saturation with water. By preliminary experiments, when soil samples of a disturbed structure were saturated with water so that it protruded to the surface and completely covered the soil, and then merged.

The density was reached so high that it is not possible to immerse the cutting ring with the efforts of a person's hands (without hammering). Experimentally obtained: ρ_1 = 1.53 g/cm^3; ρ_2 = 1.89 g/cm^3.

As a result of the second series of experiments, it was found that the angle of repose of the FS was greater than that of SMS α_{av}^{SMS} = 27,99° < α_{av}^{FS}=31,34 ° (Δ = 12,6 %).

This ratio is observed for the averaged values of SMS and FS in the dry state $\alpha_{av.dry}^{SMS}$ = 31,50 ° < $\alpha_{av.dry}^{FS}$ = 31,34 (Δ = 11,3 %).

And in a water-saturated state $\alpha_{av.wat.}^{SMS}$= 24,48° < $\alpha_{av.wat.}^{FS}$= 27,61° (Δ = 12,8 %).

The obtained average value of the angle of repose α SMS turned out to be less than the angle of internal friction of the soil φ determined by LLP «Inzhenernyye izyskaniya» α_{av}^{SMS} = 27,99° < φ^{SMS} = 32-35° (Δ = 20%).

And the average value of the angle of repose α FS is greater than the angle of internal friction φ determined by LLP «Inzhenernyye izyskaniya» φ_{av}^{FS} = 31,34° > φ^{FS} = 26 - 29° (Δ = 14 %).

Although it is noted in the technical literature that α and φ can be fairly close to each other, these experiments have established the above-mentioned difference.

Based on the analysis of the experiments, the following results were obtained.

Determination of the angle of repose in the instrument "Box of Coulomb" can be determined quite unambiguously for dry loose soils and for clean sands in a soaked state .In the case of soaking loose soils, which along with the friction forces have some proportion of the adhesion forces between the particles, it is not possible to accurately determine the angle of repose due to the curvature of the inclined plane of the caving prism.

Comparison of the slope angles of medium-sized sand and fine sand showed that medium-sized sand is more preferable for dumping dams with the given sizes of top, bottom and height from the point of view of technical-economic feasibility.

Conclusion. The data obtained during the study indicate that SMS has a more predictable behavior when laying it in a dam, compared with FS. It was expressed in the fact that the FS unevenly mixes in water (spreading out over fractions), flows worse into the form, having viscosity, holds water for a longer time, it is necessary to exert more efforts when mixing it with water, etc. These experiments allowed us to make an important conclusion - about the possibility of creating a dam by washing the soil with a dredger. Moreover, the decisive argument in favor of SMS is that it can be taken directly from the bottom of the river, while deepening the channel, which contributes to a greater flow of water. That is, the probability of preserving the dumped body of the dam is more likely. While FS should be transported from the shore, a dam should be created, which due to the above reasons, will have less stable construction properties than with soaked SSM. With the obvious economic advantages of the first method, the factor of the time of the production of work, which is advantageous in the case of using the SMS plays an important role.

A comparative analysis of the behavior of the two types of soil allows us to conclude that in the case of medium density sand, the forces that keep the slope are friction forces, and in the case of fine sand, the friction and adhesion forces. Due to the presence of adhesion forces the prism from fine sand does not immediately settle in the water, but remains for some time until the bonds that cause the adhesion forces between the particles are destroyed by the water penetrating into the ground. The presence of adhesion forces should also explain the curvilinear character of the collapse prism, which was observed in all five-fold repeated experiments.

This once again raises the question of the number and places of sampling the required number of samples in the case of testing heterogeneous soils, the presence of which is explained by the absence of clear facies boundaries between individual layers of the base as a result of annual changes in the regimes of the water sources of the Syr-Darya river.

The results of studies of the filtration properties of soils were obtained in laboratory conditions on samples of broken structure at a previously selected packing density. The results are presented in figure 3, from which it is seen that with an increase in the compaction of SMS, the value of the filtration coefficient became smaller, especially this strongly affected the first stage of compaction during the transition from minimal compaction to weak.

The obtained curve (figure 4) indicates that, as the SMS is condensed filter coefficient decreases. This is most pronounced in the first interval (þ = 1.3772 to þ = 1.454), $\Delta_1 = 42\%$.

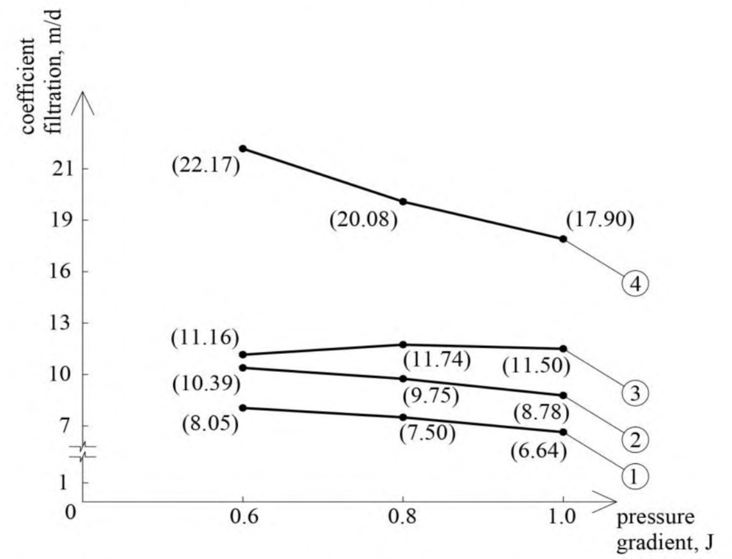

Figure 3 – The dependence of the filtration coefficient on the hydraulic gradient at:
1 - maximum SMS compaction; 2 - strong compaction of SMS; 3- weak compaction of SMS;
4 - minimal compaction of SMS.

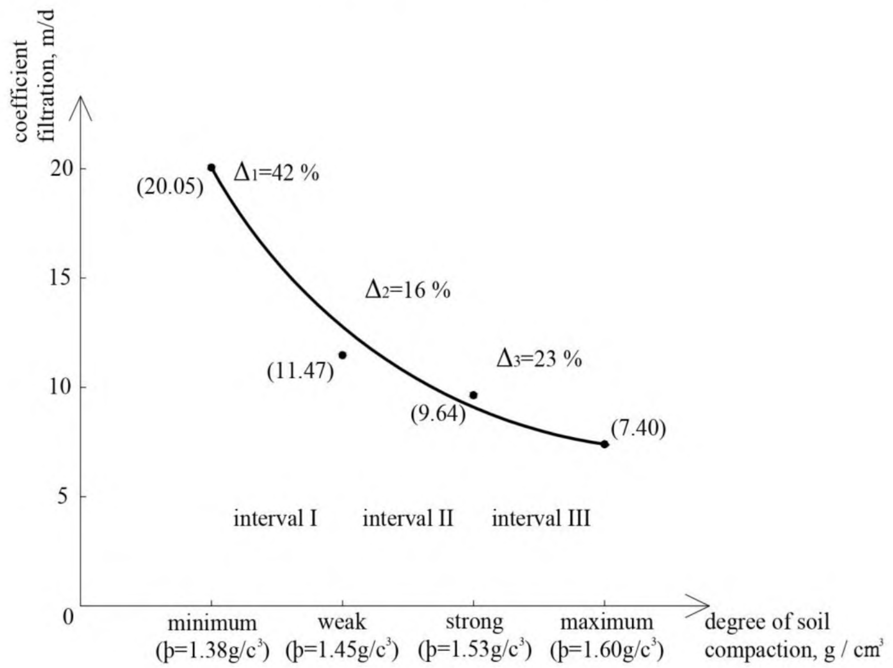

Figure 4 – The dependence of the filtration coefficient on the density of SMS

In the second interval (þ = 1.454 to þ = 1.53), K_f decreases slows down, $\Delta_2 = 16\%$, and in the third interval (þ = 1.53 to þ = 1.60) it increases, $\Delta_3 = 23\%$.

The value of the filtration coefficient obtained by LLP «Inzhenernyye izyskaniya» is $K_f = 10_{m / day}$ for SMS in its natural state. Referring this value to the conditions of the tests performed, it can be seen that this value will be between weak and strong soil compaction. Based on this, it can be stated that the data of LLP «Inzhenernyye izyskaniya» are in good agreement with laboratory determination of the filtration coefficient made in the third series of experiments.

The data obtained from three series of experiments made it possible to carry out a comparative analysis and make a conclusion about the construction properties of SSM and FS.

When laying in a dry state, SMS is preferable for laying it in a dam as compared with FS, since this soil in almost all stages of its compaction surpasses FS.

SMS has a more predictable behavior when laying it in a dam, in comparison with FS, which makes it possible to create a dam by washing the soil with a dredger. Moreover, the decisive argument in favor of SMS is that it can be taken directly from the bottom of the river, while deepening the channel, which contributes to a greater flow of water. That is, the probability of preservation of the dump body of the dam is more likely. At the same time, FS should be transported from the shore by dump trucks and with additional compaction, either by rolling or tamping, which, when water gets from the river bed, makes this operation practically impossible and leads to large material costs.

Comparison of the slope angles of SMS and FS showed that sand of medium size is more preferable for dumping the dam with the given sizes of top, bottom and height from the point of view of technical-economic feasibility.

Sand of medium size, composing the riverbed, has a more homogeneous structure, and the fine sand located in the floodplain of the river is heterogeneous. It requires the processing of more samples in laboratory conditions and its construction properties are more difficult to predict.

Comparison in experiments on determining the filtration coefficient showed that SMS, regardless of the degree of compaction, will pass water, which when forming a dam, on the one hand, will have a negative effect - the removal of small particles (the phenomenon of suffusion), and on the other hand - positive: for due to the passage of water through the body of the dam, the pressure of the water mass on the embankment structure will be slightly reduced as a whole (the probability of its destruction is reduced).

The FS has a lower filtration coefficient, and therefore, when a dam is formed from it, the water consumption in the remaining part of the river, which is not blocked by the dam, will significantly increase. In view of this, should expect an increase in the water level to the dam and, accordingly, erosion of the edge of the dam with the supposed destruction of the edge of the dam.

Considering the above, it should be counted possible to use local soil for filling temporary embankments for the purpose of production of piling, subject to the following conditions:

- must be laid with a density of at least 1.65 g / cm^3 the soil of the embankment;
- must be confirmed by preliminary laboratory tests the possibility of compacting the UCS to the required density;
- a layer-by-layer check of the actual density of its laying is required during the filling of the embankment;
- to use preferably a copra with minimal dynamic effects to reduce its impact on the artificial base for the production of piling works;
- should be carried out pile driving by installing the coper on a wooden platform to reduce the specific pressure on the ground and distribute the effort over a larger area;
- should be carried out work at the lowest water level in the river;
- comply strictly with the requirements of current regulations for the production of construction and installation works and safety regulations.

The recommendations were transmitted to the construction organization that carried out the reconstruction of the gas pipeline. Taking them into account, work on the construction of a temporary dam was optimized: the choice of the type of soil for the body of the dam; the method of laying it; the achieved density and the angle of the natural slope. As a result of the introduction of scientific research into the practice of construction, an economic effect was obtained, which was confirmed by the implementation act. The gas pipeline is currently in exploitation.

И. С. Бровко[1], Я. Б. Кунанбаева[1], Е. И. Бровко[2], К. С. Байболов[1]

[1]М. Әуезов атындағы Оңтүстік Қазақстан университеті, Шымкент, Қазақстан;
[2]Құрылыс министрлігі университетінің Басқару және ақпараттық модельдеу институты
ҚФҒЗИ РАҚҒА, Мәскеу, Ресей

МАГИСТРАЛЬДЫ ГАЗ ҚҰБЫРЫН ҚАЙТА ЖАҢАРТУ БАРЫСЫНДА ТОПЫРАҚ СҰРЫПТАУДЫҢ ЭКПЕРИМЕНТАЛЬДЫ НЕГІЗДЕМЕСІ

Аннотация. Мақалада магистральды газ құбырын қайта құру үшін уақытша топырақ бөгетін құруға бағытталған эксперименттік-талдамалық зерттеу нәтижелері келтіріледі.

Газ құбырының тірегі Сырдария өзеніндегі мұздың сөгілу барысында зақымдалған. Қада тіректерін қалпына келтіру үшін уақытша үйінді төсеу ұсынылды. Қолжетімді жақын орналасқан топырақтың үш түрінің қасиетін зерттеу негізінде ұсынылған топырақтың техникалық-экономикалық тиімділігі мен тығыздығының болжамы негізделеді.

Бөгетке салынатын топырақты таңдау топырақ қасиеттерін зертханалық зерттеу және техникалық-экономикалық негіздеме негізінде жүзеге асырылады. Бөгетті қайта жаңарту жөніндегі жұмыстарды жүргізудің технологиялық талаптарына сүйене отырып, биіктігі 5 м және биіктігі 36 м болуы тиіс. Үйіндінің қажетті габариттері ең алдымен табиғи еңіс бұрышынан және төгілетін топырақтың беріктік сипаттамаларынан қабылдануы тиіс. Жергілікті жағдайға байланысты орташа ірілігі, тығыздығы бар, Сырдария өзенінің арнасын шектейтін құм; өзенге тікелей жақын орналасқан ұсақ, борпылдақ құм; бөгеттен 30 км қашықтықта жатқан саздақ пайдаланылуы мүмкін.

Тәжірибенің бірінші сериясында тығыздықты анықтау жұмыстары жүргізілді. Бұл ретте құмның төрт жағдайы жасанды түрде пайда болды: аз нығыздау; әлсіз нығыздау; күшті нығыздау; ең жоғары мүмкін нығыздау. Тәжірибенің екінші сериясында құрғақ және суға қаныққан топыраққа арналған табиғи еңіс бұрышы анықталды. Эксперименттің үшінші сериясы бөгет арқылы суды ағызу мәселесін зерттеу үшін топырақты сүзу коэффициентін анықтауға арналды.

Эксперименталды-аналитикалық зерттеу нәтижелері негізінде экологиялық сипаттағы талаптарға және экономикалық мақсаттылық ұғымдарына сүйене отырып, қада қағу жұмыстарын жүргізу мақсатында өзен құмынан уақытша үйінді себу ұсынылды. Үйінді биіктігі 5 м, төменгі жағы бойынша 51 м, үстіңгі жағы бойынша 14 м болуы қажет.

Сүзу коэффициентін анықтау бойынша тәжірибені салыстыру орташа іріліктегі құм тығыздау дәрежесіне қарамастан суды өткізетінін көрсетті. Бұл бөгетті формирациялау кезінде бір жағынан теріс әсерге – ұсақ бөлшектерді шығаруға (суффозия құбылысы), ал екінші жағынан оң әсерге – бөгет денесі арқылы су өткізу есебінен жалпы үйінді конструкциясына су массасының қысымы және оның бұзылу ықтималдығы біршама төмендейді. Ұсақ құмда сүзу коэффициенті аз, сондықтан бөгетті қалыптастыру кезінде одан бөгетсіз өзеннің қалған бөлігіндегі судың шығыны едәуір артады. Осыған орай, су деңгейінің бөгетке дейін көтерілуін және тиісінше бөгеттің шетін алдын ала қирата отырып, шетін шайып кеткенін күту керек.

Жоғарыда айтылғанды ескере отырып, жергілікті топырақты қада қағу жұмыстарын жүргізу мақсатында уақытша үйінді бөртпесі үшін пайдаланған жөн. Ол үшін уақытша бөгет орнату бойынша жұмыстар оңтайландырылды, яғни бөгет денесіне арналған топырақ түрін таңдау, оны төсеу әдістемесі, қол жеткізілетін тығыздық және табиғи еңіс бұрышы.

Ғылыми зерттеулерді құрылыс тәжірибесіне енгізу нәтижесінде экономикалық нәтиже алынды. Қазіргі уақытта газ құбыры табысты пайдаланылуда.

Түйін сөздер: бөгет, үйінді, топырақ тығыздығы, табиғи еңіс бұрышы, сүзу коэффициенті, құмды жасанды негіздер, құмды негізді төсеу, тығыздалатын үйінді топырақтар, сапаны бақылау, қалыптасатын негізді бақылау, қадалы іргетастың геотехникалық көрсеткіштері.

И. С. Бровко[1], Я. Б. Кунанбаева[1], Е. И. Бровко[2], К. С. Байболов[1]

[1]Южно-Казахстанский университет им. М. Ауэзова, Шымкент, Казахстан;
[2]Институт управления и информационного моделирования Университета Минстроя НИИСФ РААСН, Москва, Россия

ЭКСПЕРИМЕНТАЛЬНОЕ ОБОСНОВАНИЕ ПОДБОРА ГРУНТА ПРИ РЕКОНСТРУКЦИИ МАГИСТРАЛЬНОГО ГАЗОПРОВОДА

Аннотация. Приводятся результаты экспериментально-аналитических исследований, направленных на создание временной грунтовой дамбы для реконструкции магистрального газопровода.

Опоры газопровода были повреждены при ледоходе реки Сыр-Дарья. Для восстановления свайных опор было предложено произвести отсыпку временной насыпи. На основе изучения свойств трех видов грунтов, находящихся в доступной близости, обосновывается технико-экономическая эффективность и прогноз уплотняемости рекомендуемого грунта.

Выбор грунта, укладываемого в дамбу, осуществляется на основании лабораторных исследований свойств грунтов и технико-экономического обоснования. Исходя из технологических требований производства работ по реконструкции, дамба должна быть высотой 5 м и размером по верху 36 м. Размер основания насыпи зависит от вида отсыпаемого грунта. Необходимые габариты насыпи должны быть приняты главным образом от угла естественного откоса и прочностных характеристик отсыпаемого грунта. Исходя из местных условий могут быть использованы: песок средней крупности, средней плотности, слагающий русло реки Сыр-Дарьи; песок мелкий, рыхлый, находящийся в непосредственной близости от реки; суглинки, залегающие на удалении 30 км от дамбы.

В первой серии опытов проводилось определение плотности. При этом искусственно создавалось четыре состояния каждого из песков: минимальное уплотнение; слабое уплотнение; сильное уплотнение; максимально возможное уплотнение. Во второй серии опытов определялся угол естественного откоса для сухих и водонасыщенных грунтов. Третья серия экспериментов была посвящена определению коэффициента фильтрации грунтов для изучения вопроса просачивания воды через дамбу.

На основании результатов экспериментально-аналитических исследований, исходя из требований экологического характера и соображений экономической целесообразности, было предложено произвести отсыпку временной насыпи из речного песка путем его намыва с целью производства сваебойных работ. Насыпь рекомендовано выполнить высотой 5 м, размером по низу – 51 м, по верху – 14 м.

Сопоставление опытов по определению коэффициента фильтрации показало, что песок средней крупности независимо от степени уплотнения будет пропускать воду. Это может привести при формировании дамбы, с одной стороны, к отрицательному воздействию – выносу мелких частиц (явление суффозии), а с другой стороны – к положительному воздействию: за счет пропуска воды через тело дамбы будет несколько снижено в целом давление массы воды на конструкцию насыпи и снизится вероятность ее разрушения. У песка мелкого меньше коэффициент фильтрации и поэтому при формировании дамбы из него значительно увеличится расход воды в оставшейся части реки, не перегороженной дамбой. Ввиду этого, следует ожидать повышения уровня воды до дамбы и соответственно размыванию края дамбы с предположительным разрушением края дамбы.

Учитывая вышеизложенное, следует считать возможным использование местного грунта для отсыпки временной насыпи с целью производства сваебойных работ. Для чего были оптимизированы работы по устройству временной дамбы – выбор типа грунта для тела дамбы, методика его укладки, достигаемая плотность и угол естественного откоса.

В результате внедрения научных исследований в практику строительства был получен экономический эффект. В настоящее время газопровод успешно эксплуатируется.

Ключевые слова: дамба, насыпь, плотность грунта, угол естественного откоса, коэффициент фильтрации, песчаные искусственные основания, укладка песчаного основания, уплотняемые насыпные грунты, контроль качества, контроль формируемого основания, геотехнические показатели, забивная свая.

Information about the authors:

Brovko I., Doctor of engineering, Professor, M.Auezov South Kazakhstan University, Shymkent, Kazakhstan; brovkoi56@mail.ru; https://orcid.org/0000-0003-3597-5804

Kunanbayeva Y., PhD, M. Auezov South Kazakhstan University, Shymkent, Kazakhstan; aira.kunaeva@mail.ru; https://orcid.org/0000-0002-7246-6251

Brovko E., Deputy head, Institute of management and information modeling of the University of Minstroi NIISF RAASN, Moscow, Russia; int-gasis@yandex.ru; https://orcid.org/0000-0001-6984-3733
Baibolov K., Candidate of technical Sciences, Pro-rector, M. Auezov South Kazakhstan University, Shymkent, Kazakhstan; kanat-bai@mail.ru; https://orcid.org/0000-0003-4434-3964

REFERENCES

[1] Brovko I. S., Baibolov K.S, Ibragimov K.I., Kunanbayeva Y.B. (2017) The results of modeling and field studies of the interaction of large piles with ground subsidence, News of the National Academy of Sciences of the Republic of Kazakhstan, Series of Geology and Technical Sciences. 426: 246-254 (in Eng.).

[2] Bui Chyong Shon (2006) Long-term stability of water-saturated embankment bases [Vestnik MGSU] 1: 61-68 (in Russ.).

[3] Vinogradov VV, Florovsky IK, Zaitsev AA, Ivanchenko IV (2007) Modeling of embankment reinforcement [Put i putevoe khoziaistvo] 3: 26-27 (in Russ.).

[4] Halperin AM, Panfilov AI, Punevsky SA, Zhilin SN (2007) Engineering-geological and geomechanical support of formation of dump embankments on alluvial bases [Geoekologya. Inzhenernaya geologya, gidrogeologya, geokriologya] 5: 396-403 (in Russ.).

[5] Degtyarev VV, Shlychkov VA, Shumkova MN (2018) Numerical modeling of hydrodynamic processes in the areas where riverbed dams are located [Izvestya vysshikh uchebnykh zavedenii. Stroitel'stvo] 12: 109-120 (in Russ.).

[6] Kasharin DV, Tkhai TKT (2015) System of mobile dams and method for its erection [Sistema mobilnykh damb i sposob ee vozvedenia]. Patent of the Russian Federation [Patent rossiiskoi federatsii] (in Russian).

[7] Lolaev AB, Akopov AP, Oganesyan AKh, Sumin MN (2011) Method of erecting of washed up protective dam [Sposob vozvedenia namyvnoi ograzhdaiushchei damby] Patent of the Russian Federation [Patent rossiiskoi federatsii] (in Russian).

[8] Lolaev AB, Akopov AP, Oganesyan AKh, Sumin MN (2012) Erection method of alluvial dam [Sposob vozvedenia namyvnoi ograzhdaiushchei damby] Patent of the Russian Federation [Patent rossiiskoi federatsii] (in Russian).

[9] Rafikov SK (2003) Development of technology for strengthening embankments during ground laying of Northern gas pipelines [Izv. vuzov. Neft i gaz.] 5: 77-79 (in Russ.).

[10] Fomenko NG (2015) Justification of parameters of dump embankments placed on hydraulic dumps [Gornyi informatsionno-analiticheskii biulleten] 5: 401- 405 (in Russ.).

[11] Bekbasarov II (2018) Clay-sand mixtures as a material for the device of ground pillows [Novosti nauki Kazakhstana] 135: 85-98 (in Russ.).

[12] Karaseva NS, Miroshkin AK (2018) On the procedure for calculating sand volumes and applying the relative compaction coefficient [Transportnoe stroitelstvo] 3: 26-29 (in Russ.).

[13] Lyashchenko PA, Denisenko VV (2016) Model of deformation of the microstructure of sandy soil [Politematicheskii setevoi elektronnyi nauchnyi zhurnal Kubanskogo gosudarstvennogo agrarnogo universiteta] 118: 853-877 (in Russ.).

[14] Maiorova IuN, Maltsev AV (2019) Development of a method for additional control of compaction parameters of sand soil samples when studying various compaction methods on physical models in a laboratory tray. 3-ia vserossiiskaya nauchnaya konferentsiya perspektivnykh razrabotok molodykh uchenykh, M., Russia. P. 75.

[15] Maltsev A.V., Karimov E.A., Maiorova IuN (2018) Modeling of sand compaction processes in the laboratory. Traditsii i innovatsii v stroitelstve i arkhitekture, Samara, Russia. P. 279.

[16] Novoseltsev A.V. (2018) Physical and mechanical properties of alluvial sands, on the example of the rostov-arena stadium under construction in Rostov-on-Don. Inzhenerno-geologicheskoe i ekologo-geologicheskoe izuchenie peskov i peschanykh massivov. M., Russia. P. 173.

[17] Prenglaev G.V., Ignatev A.A. (2018) Advantages of the fine sand compaction method based on regulation of interfacial interaction of mineral particles. Semdesyat pervaya vserossiiskaya nauchno-tekhnicheskaya konferentsiya studentov, magistrantov i aspirantov vysshikh uchebnykh zavedenii s mezhdunarodnym uchastiem, Yaroslavl, Russia. P. 718.

[18] Julin A.N. (2010) Engineering and geological aspects of geotechnical control when creating artificial sand bases [Inzhenernye izyskaniya] 10: 28-32 (in Russ.).

[13] Liashenko P.A., Denisenko V.V. (2016) Model' deformatsii mikrostruktury peschanogo grun-ta [Politematicheskii setevoi elektronnyi nauchnyi zhurnal Kubanskogo gosudarstven-nogo agrarnogo universiteta]. 118: 853-877 (in Russ.).

[14] Maiorova Iu.N., Mal'tsev A.V. (2019) Razrabotka metodiki dopolnitel'nogo kontrolia para-metrov uplotneniia obraztsov peschanogo grunta pri issledovanii razlichnykh sposobov uplotneniia na fizicheskikh modeliakh v laboratornom lotke. 3-ia vserossiiskaia nauchnaia konferentsiia perspektivnykh razrabotok molodykh uchenykh, M., Rossiia. P. 75-78.

[15] Mal'tsev A.V., Karimov E.A., Maiorova Iu.N. (2018) Modelirovanie protsessov uplotneniia peschanogo grunta v laboratornykh usloviiakh, Traditsii i innovatsii v stroitel'stve i arkhitekture. Samara, Rossiia. P. 279-284.

[16] Novosel'tsev A.V. (2018) Fiziko-mekhanicheskie svoistva namyvnykh peskov, na primere stroiashchegosia stadiona "Rostov-arena" v g. Rostove-na-donu. Inzhenerno-geologicheskoe i ekologo-geologicheskoe izuchenie peskov i peschanykh massivov. M., Rossiia. P. 173-176.

[17] Prenglaev G.V., Ignat'ev A.A. (2018) Peimushchestva metoda uplotneniia melkogo peska na os-nove regulirovaniia mezhfaznogo vzaimodeistviia mineral'nykh chastits. Sem'desiat pervaia vserossiiskaia nauchno-tekhnicheskaia konferentsiia studentov, magistrantov i aspirantov vysshikh uchebnykh zavedenii s mezhdunarodnym uchastiem, Iaroslavl', Rossiia. P. 718-721.

[18] Iulin A.N. (2010) Inzhenerno-geologicheskie aspekty geotekhnicheskogo kontrolia pri sozda-nii iskusstvennykh peschanykh osnovanii [Inzhenernye izyskaniia] 10: 28-32 (in Russ.).