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ИЗВЕСТИЯ
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R.E. Lukpanov*, A.S. Yenkebayeva, D.V. Tsygulyov, Y.Y. Sabitov, D.S. Dyussembinov

L.N. Gumilyov Eurasian National University, Nur-Sultan, Kazakhstan.
E-mail: rauan_82@mail.ru

ASSESSMENT OF ASH-STORAGE COOLECTOR STABILITY USING GEOSYNTHETIC REINFORCEMENT ELEMENTS BY TRAY TESTING AND NUMERICAL MODELING

Abstract. The paper presents the results of the assessment of the stability of the embankment represented by ash storage collector (ASC) located on the territory of the thermal power plant of TPP1, metallurgical plant in Temirtau (Kazakhstan). The purpose of the study was to assess the effect of reinforcement elements on the overall stability of the embankment, based on comparisons of the stress-strain state of reinforced and unreinforced embankments. The technological solution for embankment reinforcement was the use of synthetic polypropylene geogrid. Model tray tests as well as numerical simulations by the finite element method were used in the studies. The tray tests were performed at a scale of 1:30, using equivalent materials selected on the basis of the law of dynamic similarity. Based on the results of the tray tests, functional dependencies characterizing the change in the deformation state of the embankment from the increment of a given displacement were obtained. The obtained dependencies show the deformations (vertical, horizontal and resultant) of different locations from the soil base near the source of the given displacement, through the slope to the embankment crest. Similar dependencies were obtained from numerical reinforcement results. Both studies present comparisons of the deformed states of the unreinforced and reinforced models, from which the effect of the reinforcement elements on the overall stability of the embankment is evaluated. Comparisons of the results of tray tests and numerical simulations are presented. The comparisons are represented by corrective actions, which are expressed by dependencies between the values of ratio coefficients and the distance from the source of a given displacement. The ratio coefficients, in turn, reflect the quantitative difference in the deformed state of the unreinforced from the reinforced embankment. The obtained results make it possible to evaluate the overall stability of the ASC embankment by express numerical simulation, the quality of which will be improved by the introduction of corrective actions obtained on the basis of model, but still in-situ tests.

Key words: geosynthetics materials, geogrid, overall stability, embankment, tray tests, numerical modeling.

Р.Е. Лукпанов*, А.С. Енкебаева, Д.В. Цыгулев, Е.Е. Сабитов, Д.С. Дюсембинов

Л.Н. Гумилев атындағы Еуразия ұлттық университеті,
Нұр-Сұлтан, Қазақстан.
E-mail: rauan_82@mail.ru

НАУАЛЫҚ СЫНАҚТАР ЖӘНЕ САНДЫҚ МОДЕЛЬДЕУ ӘДІСІМЕН АРМАТУРАЛАУДЫҢ ГЕОСИНТЕТИКАЛЫҚ ЭЛЕМЕНТТЕРІН ҚОЛДАНА ОТЫРЫП, КҮЛ-ҚОҚЫС ЖИНАҒЫШТЫҢ ТҰРАҚТЫЛЫҒЫН БАҒАЛАУ

Аннотация. Мақалада ТЭЦ1 жылу электр орталығы, Теміртау металлургиялық комбинат аумағында орналасқан күл-қож жинағышпен (ЗШН) ұсынылған үйіндінің тұрақтылығын бағалау нәтижелері ұсынылған. Зерттеудің мақсаты арматураланған және арматураланбаған үйінділердің кернеулі-деформацияланған күйін салыстыру негізінде арматуралау элементтерінің үйіндінің жалпы орнықтылығына әсерін бағалау болды. Үйіндіні күшейту бойынша технологиялық шешім полипропиленнен жасалған синтетикалық георешетканы қолдану болды. Зерттеулерде модельдік науа сынақтары, сонымен қатар ақырлы элементтерді сандық модельдеу қолданылды. Науалық сынақтар динамикалық ұқсастық Заңы негізінде іріктелген баламалы материалдарды пайдалана отырып, 1:30 масштабында орындалды. Науалық сынақтардың нәтижелері бойынша үйіндінің деформациялық жай-күйінің берілген ығысудың өсуінен өзгеруін сипаттайтын функционалдық тәуелділіктер алынды. Алынған тәуелділіктер топырақ негізінен берілген ығысу көзіне жақын, көлбеу арқылы жағалаудың жотасына дейін әр түрлі жерлердегі деформацияларды (тік, көлденең және нәтиже беретін) көрсетеді. Осындай тәуелділіктер сандық күшейту нәтижелері бойынша алынды.

Екі зерттеуде де арматураланбаған және арматураланған модельдердің деформацияланған күйлерін салыстыру ұсынылған, олардың негізінде арматуралау элементтерінің үйіндінің жалпы тұрақтылығына әсерін бағалау берілген. Науалық сынақтар мен сандық модельдеу нәтижелерін салыстыру ұсынылған. Салыстырулар арақатынас коэффициенттерінің мәндері мен берілген орын ауыстыру көзінен қашықтық арасындағы тәуелділіктермен көрсетілген түзету әрекеттерімен берілді. Арақатынас коэффициенттері өз кезегінде арматураланбаған деформацияланған күйдің арматураланған үйіндіден сандық айырмашылығын көрсетеді. Алынған нәтижелер сандық модельдеудің экспресс әдісімен ZSHN үйіндісінің жалпы тұрақтылығын бағалауға мүмкіндік береді, оның сапасы модельдік, бірақ әлі де табиғи сынақтар негізінде алынған Түзету әрекеттерін енгізу арқылы жақсарады.

Түйін сөздер: геосинтетикалық материалдар, геогрид, жалпы тұрақтылық, жағалау, науа сынақтары, сандық модельдеу.

Р.Е. Лукпанов*, А.С. Енкебаева, Д.В. Цыгулев, Е.Е. Сабитов, Д.С. Дюсембинов

Евразийский национальный университет им. Л.Н. Гумилева,
Нур-Султан, Казахстан
E-mail: rauan_82@mail.ru

ОЦЕНКА УСТОЙЧИВОСТИ ЗОЛОШЛАКОНАКОПИТЕЛЯ С ПРИМЕНЕНИЕМ ГЕОСИНТЕТИЧЕСКИХ ЭЛЕМЕНТОВ АРМИРОВАНИЯ МЕТОДОМ ЛОТКОВЫХ ИСПЫТАНИЙ И ЧИСЛЕННОГО МОДЕЛИРОВАНИЯ

Аннотация. В статье представлены результаты оценки устойчивости насыпи, представленной золошлаконакопителем (ЗШН), расположенным на территории тепловой электрической централи ТЭЦ1, металлургического комбината в г. Темиртау (Казахстан). Целью исследования была оценка влияния элементов армирования на общую устойчивость насыпи на основании сравнений напряженно-деформированного состояния армированной и неармированной насыпей. Технологическим решением по усилению насыпи было применение синтетической георешетки из полипропилена. В исследованиях были использованы модельные лотковые испытания, а также численное моделирование методом конечных элементов. Лотковые испытания выполнены в масштабе 1:30, с использованием эквивалентных материалов, подобранных на основании закона динамического подобия. По результатам лотковых испытаний были получены функциональные зависимости, характеризующие изменение деформационного состояния насыпи от приращения заданного смещения. Полученные зависимости отображают деформации (вертикальные, горизонтальные и результирующие) разных локаций от грунтового основания вблизи источника заданного смещения, через откос до гребня насыпи. Аналогичные зависимости были получены по результатам численного армирования. В обоих исследованиях представлены сравнения деформированных состояний неармированной и армированный моделей, на основании которых дана оценка влияния элементов армирования на общую устойчивость насыпи. Представлены сравнения результатов лотковых испытаний и численного моделирования. Сравнения представлены корректирующими действиями, которые выражены зависимостями между значениями коэффициентов соотношений и расстоянием от источника заданного смещения. Коэффициенты соотношений в свою очередь отражают количественное различие деформированного состояния неармированной от армированной насыпи. Полученные результаты позволяют производить оценку общей устойчивости насыпи ЗШН экспресс-методом численного моделирования, качество которой будет улучшено введением корректирующих действий, полученных на основании модельных, но все же натурных испытаний.

Ключевые слова: геосинтетические материалы, георешетка, общая устойчивость, насыпь, лотковые испытания, численное моделирование.

Introduction. The history of soil reinforcement dates back to ancient times. The modern use of geosynthetics to improve the properties of soils dates back to the mid-sixties of the XX century in the United States (Kim, 2019: 10). It was then that geosynthetics materials made of various polymers, usually having high tensile strength, were proposed (Tang, 2020: 18). The history of the development of domestic production of geosynthetic material began in the 70-80s of the last century, when the Ministry of Transport Construction of the USSR issued a directive to expand the rational scope of their use in the construction of railways and highways (https://www.td-geo.ru/articles/istorya_razvitya_geo).

As for the Kazakhstan producers of geosynthetic material, the first to assume this function was the company «Kaz Geo Synthetics», which has been engaged in the production of a wide range of geosynthetic materials since 2009 (https://k-g-s.kz). Also, with the intention of Kazakhstan's transition to the Eurocode in 2019, the normative documents of the Republic of Kazakhstan that define the requirements for the calculation, design and technology of geosynthetic reinforcement materials in construction, geotechnics were issued (Zhaksybekova, 2018: 6), (Zhussupbekov, 2016: 5).

As defined by ASTM D4439, a geosynthetic is a product made of polymeric material used with soil, rock, earth, or other geotechnical materials, representing part of a man-made project, structure, or system (ASTM D4439, 2018: 25).

Modern application of geosynthetic material in construction is very wide, as well as the range of its functional use (Ngo, 2019: 16). Thus, geosynthetic material can be used in retaining walls, foundations bases (soil cushions), in road pavement and of course in the structures of soil embankments (e.g., highways) (Lukpanov, 2016 a: 7), (Lukpanov, 2016 b, 4). The latter is a mechanically stable earth (MSE) (Özçelik, 2018: 8). Exactly this geotechnical structure will be considered in this article together with the functional feature of geosynthetics application as a reinforcement element.

The article considers the issue of assessing the stability of the soil dam (hereinafter embankment) ash storage collector (ASC) of the thermal power plant of TPP1, metallurgical plant in Temirtau (Kazakhstan) (Nguyen, 2018: 6). Accumulators require proper control, being the objects of increased danger (Guerra-Escobar, 2018: 6). However, these geotechnical structures periodically exhaust their operational resource, being subjected to irreversible deformations as a result of loss of stability. The latter leads to severe consequences, disruption of normal operation of the power plant, as well as significant pollution of the environment (Lu, 2021: 9), (Zhang, 2022: 18).

The purpose of the study is to assess the effect of reinforcement elements on the overall stability of the soil embankment.

In order to realize the goal, the following tasks were implemented:

- conducting model tests (or tray test) of the soil embankment;
- conducting numerical analysis (or finite element method – FEM) of the soil embankment.

In both cases, two comparable variants were considered: a soil embankment with reinforcement elements and a soil embankment without reinforcement.

Research materials and methods. The main research methods are follow:

- model (tray tests, Figure 1);
- numerical analysis in the software complex Plaxis 2D (see Results).

The tray tests were performed on a scale of 1:30, under laboratory conditions, using a metal tray. The metal tray is a container with shifting elements, emulating the movement of soil masses, as a result of their leaching. Thus, not the process of leaching itself is simulated, but its consequence - the movement of soil masses, resulting in the loss of stability of the embankment (Figure 1).

Numerical modeling was performed in the software package Plaxis 2D. The simulation of the computational situation of a real soil embankment was carried out. This paper presents preliminary studies that aim to assess the validity of the numerical simulation results and, therefore, to evaluate its reliability as a research method. Validation of the method is performed in comparison with the results of flume tests.

a. Steel tray and reference system

b. Reinforced elements (geogrid)

c. Bench marks

d. Transducer

Figure 1. Conducting tray tests

In large or small-scale tests, which include tray tests, Newton's method of dynamic similarity is often used to simulate the soil, where the adjustment of physical and mechanical characteristics is carried out in proportion to the scale of the model.

The materials used in tray tests (embankment and foundational soil) are selected on the basis of the general law of dynamic similarity, taking into account gravitational effects and internal stresses.

$$\frac{N_m}{\gamma_m I} = \frac{N_r}{\gamma_r J} = K = inv\ ; \qquad (1)$$

where K - similarity criterion;

m; r – unit weight of model and full-scale soil;

I, J – linear dimensions of model and full-scale embankment;

Nm; Nr - value corresponding to different characteristics.

The geogrid is modeled in the Plaxis software using the «Geotextile» command, which specifies a single parameter - the normal stiffness. Thus, the plane-strain object of the numerical simulation only accepts axial stiffness and cannot accept compressive forces.

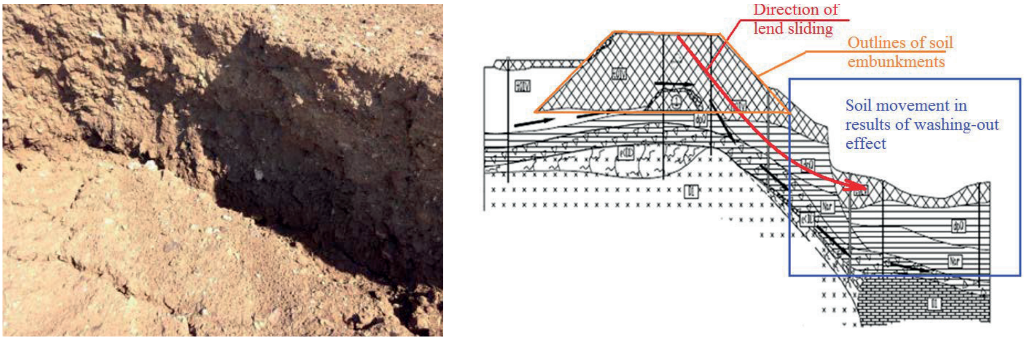


Figure 1. Calculation model of loss of overall dam stability

Table 1 shows the results of the equivalent material calculations used in the flume tests and numerical simulations.

Table 1. Parameters of full-scale and equivalent material

№	Parameters	Natural material	Equivalent material
1	Unit weight of soil, kN/m^3	16	17
2	Unit weight of wet soil, kN/m^3	18	20
3	Soil deformation modulus, MPa	18	0,64
4	Specific soil cohesion, kPa	7	0,25
5	Angle of internal friction of soil, degree	23	20
6	Dilatancy angle of soil, degree	0,0	0,0
7	Poisson's ratio of soil	0,35	0,35
8	Permeability in the horizontal direction of soil, m^3/day	0,001	0,1
9	Permeability in the vertical direction of soil, m^3/day	0,001	0,1
10	Geogrid axial stiffness	139,96 MN/m^2	360 кN/m

The stability analysis of the models was performed on the basis of the deformation assessment of certain locations: Location A - in the immediate vicinity of the base fracture, at a distance of 6 m from the bottom of the embankment, Location B - the bottom of the embankment, Location C - in the middle part of the slope, Location D - the top of the embankment.

Results and discussions. Figure 2 shows the results of the model tray tests. The results are represented by the relationships between the prescribed displacement (caused by the displacement of the tray side walls) and the embankment deformations (resulting deformations). Figure 2a shows the foundation soil deformations, and Figure 2b shows the deformations of the ASC embankment. Figure 3 shows a comparison of the deformation values of a reinforced embankment and an unreinforced embankment. Figure 3a shows comparisons of vertical deformations, Figure 3b shows horizontal deformations, and Figure 3c shows total deformations.

According to the results of model tray tests, values of the deformability of the soil embankment during displacement of the underlying soil base were obtained. The maximum deformability values were obviously observed at Locations A, i.e., at locations located in maximum proximity to the source of displacement (or prescribed displacement), and the minimum ones at Locations D or at locations as far away from the source as possible. The resulting maximum deformation at Locations A of the unreinforced model averaged 14.08 mm, while for the reinforced model, the same values were 13.50 mm.

Smaller than in point A, but still high strain values were observed in points B, locations at a horizontal distance of 20 cm from the source of the displacement. For the unreinforced model, the average resultant deformations are 3.13 mm, for the reinforced model 2.12 mm.

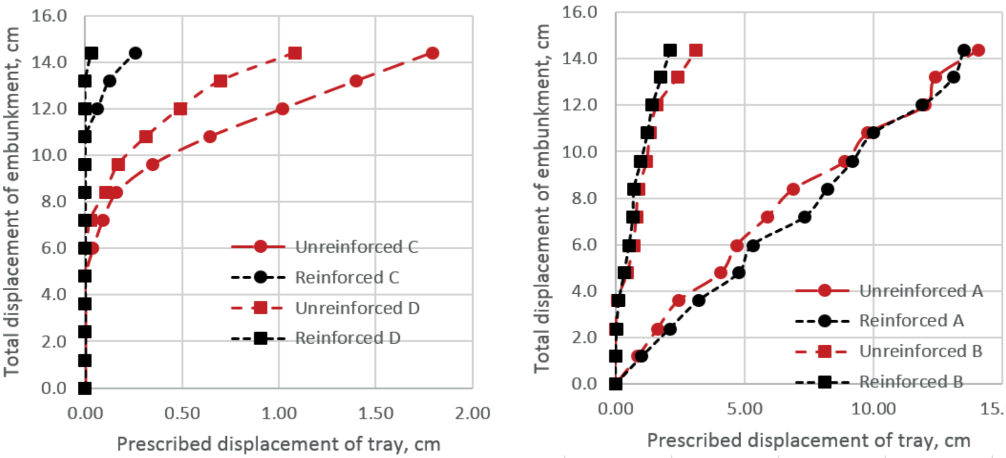


Figure 2. Dependence between the prescribed displacement and deformations

Minor soil displacement was observed at points C, locations located on the embankment slope. The average vertical deformation of the unreinforced model is 1.79 mm, while the same values for the reinforced model are only 0.26 mm. The effect of reinforcement is a 7-fold reduction in deformation, and the deformation of the embankment footing is 8 times greater than that of the reinforced slope, despite the relative proximity of the locations (3.5 m).

Minimal deformation values were observed at the location of the embankment's edge, at points D. The average resultant deformations of the unreinforced model are 1.08 mm, while the same deformation values for the reinforced model are 0.03 mm. In this case there is a maximum effect of reinforcement, compared to the unreinforced model there is a 36-fold reduction in deformation. Compared to the deformation of the reinforced slope, there is an 8.5-fold reduction in the deformation of the slope.

The effect of reinforcement elements on the reduction of embankment deformation can be observed in the comparative graphs of Figure 3. The characteristic effect of reinforcement is observed in location C, where the vertical deformation variable is 0.0168, the horizontal one is 0, and the total deformation is 0.0163. A relatively smaller but also significant influence is found in location C: the variable vertical strain is 0.1026, the horizontal strain is 0.0896, and the total strain is 0.1036. Obviously, the minimum influence was found at locations A and C, where no reinforcement was provided: the vertical deformation variable is 1.0048 and 0.9211 (respectively), the horizontal is 1.0464 and 1.1365, and the resultant is 1.0375 and 0.7517.

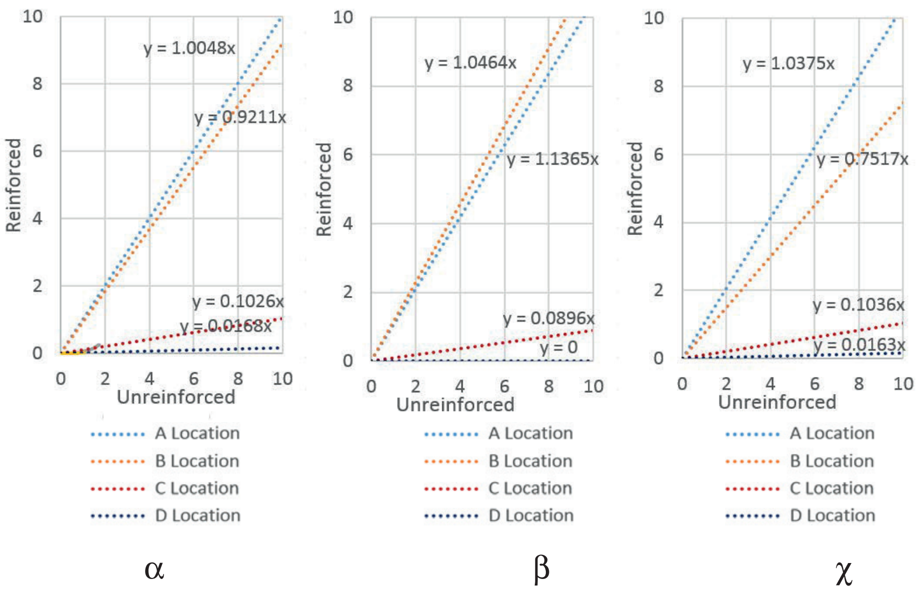
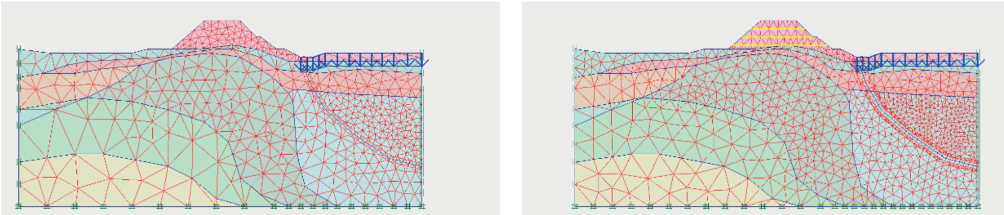


Figure 3. Comparisons of deformations of reinforced and unreinforced embankments

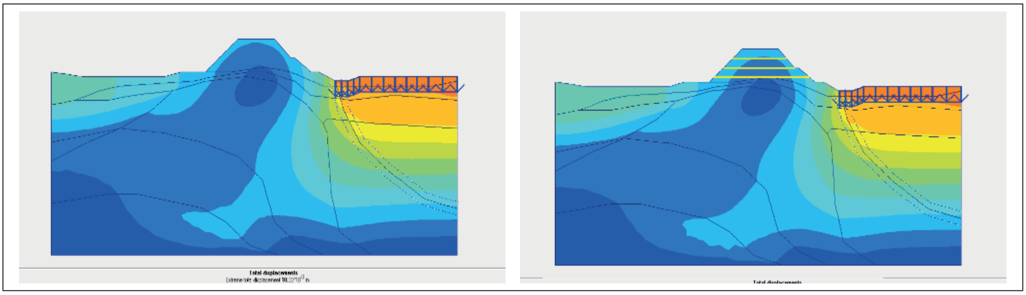
Figure 4 shows the computational schemes of the FEM models. The displacement of ground masses is done by analogy with the results of the technical survey along the collapse line. The specified displacement was applied to the underlying soil basement. In order to simulate soil failure, the collapse line was given an interface with a significantly underestimated coefficient equal to 0.1.



a – unreinforced model b – reinforced model

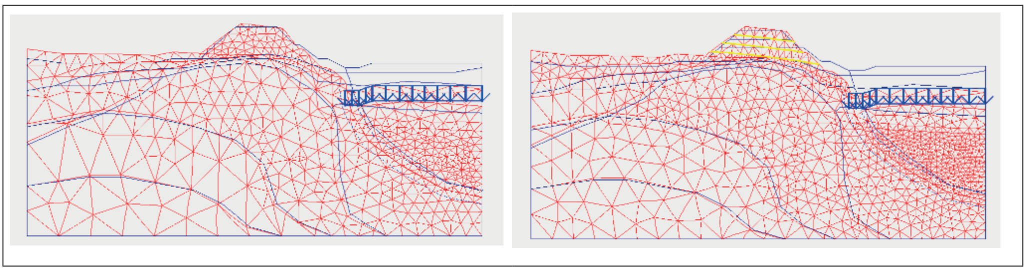
Figure 4. Calculation model of ash collector base collapse

Figure 5 shows the results of total displacement in the form of color isolines, and Figure 6 shows scaled deformations meshes of the models (a - unreinforced model, b - reinforced model). In general, the character of the stress-strain propagation in both cases is similar, but the quantitative values of displacements and stresses have differences.



a – unreinforced model b – reinforced model

Figure 5. Color isolines of total deformations



a – unreinforced model b – reinforced model

Figure 6. Scaled deformation meshes

According to the comparison results, the average values of the resulting locational displacements A of the unreinforced tray test model were 14.08 mm, whereas the same values in Plaxis were 15.63 mm. The percentage difference was 11%. The location B values of the same indicators were 3.13 mm and 3.81 mm, a percentage difference of 22%. For location C, the values were 1.79 mm and 2.81 mm, a difference of 57%. For location D, the values were 1.58 mm and 2.54 mm, a difference of 135%. A similar trend was observed for the reinforced embankment: location A was 13.50 mm and 14.71 mm (tray test and FEM models), a difference of 9%; location B was 2.12 mm and 2.50 mm, 18%; location C was 0.26 mm and 0.56 mm, 117%; location D was 0.03 mm and 0.11 mm, 289%. In both cases, there is a tendency for the percentage divergence of the data to increase with distance from the excitation source.

The corrective actions can be expressed by the curves shown in Figure 7, where Figure 7a shows the correction ratios for vertical deformations, Figure 7b for horizontal deformations, and Figure 7c for total deformations. The obtained ratios can be taken as the correction indices of vertical, horizontal and resultant deformations depending on the distance to the source of a given displacement or in reality on the displacement of the underlying subgrade soils.

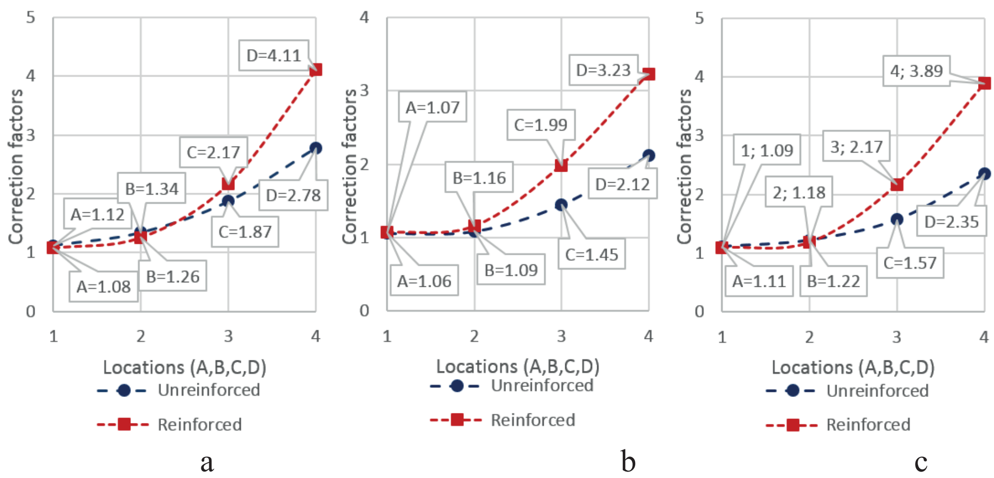


Figure 7. Corrective actions of FEM according to the results of tray tests

Conclusions. The following conclusions can be drawn from the research:

1. Model (or tray) tests at a scale of 1:30 and numerical analysis by finite element method were performed to assess the effect of geosynthetic reinforcement elements on the overall stability of the existing soil embankment.

2. The parameters of the soil and reinforcing materials of the model tests were selected on the basis of the law of dynamic similarity. To assess

the deformability, we selected locations (relative to which displacement measurements were made) located at different distances from the source of a given displacement.

3. The results of the tray tests of the embankment model are represented by the relationships between the prescribed soil displacement and the embankment deformations of the selected locations. In both cases (unreinforced and reinforced models), the maximum deformations were logically observed in the immediate vicinity of the source of the prescribed displacement and the minimum deformations at the maximum distance from it. The maximum influence of reinforcement was observed at locations D, where the vertical deformation variable was 0.0168, the horizontal deformation was 0, and the total deformation was 0.0163. The minimum influence, however, was found at locations A and C, where no reinforcement was involved: the vertical deformation variable is 1.0464 and 1.1365, and the resultant deformation is 1.0375 and 0.7517.

4. The results of numerical modeling, on the other hand, are represented by the dependencies between the specified soil displacement and the embankment deformations of the selected locations. In general, a similar trend in the deformed behavior of the embankment was revealed: the maximum vertical displacements in both cases (at the reinforced and reinforced embankments) were observed at points A, the minimum ones at points D. According to comparisons of tray tests and numerical simulation results, correction factors were obtained, which tend to increase (deviations) with distance from the source of the prescribed displacement.

5. In general, a methodology has been derived for assessing the deformed state of the embankment (for evaluating the overall stability) using finite element methods, the results of which are corrected based on model scale, but still in-situ testing.

Information about the authors:

Lukpanov Rauan Ermagambetovich – PhD, Associate Professor, Director of Scientific and Production Center «ENU-Lab», L.N. Gumilyov ENU, Munaytpasova 13, Nur-Sultan, Kazakhstan, Contact: +7 7011884444, e-mail: rauan_82@mail.ru, ORCID: 0000-0003-0085-9934;

Yenkebayeva Aigerim Seksembaykyzy – PhD student, L.N. Gumilev Eurasian National University, 13 Munaytpasova St., Nur-Sultan, Kazakhstan, Contacts: +7 777 9518321, e-mail: aikowa_21@mail.ru, ORCID: 0000-0003-1036-9621;

Dyussembinov Duman Serikovich – Candidate of Technical Sciences, Associate Professor, Department of Industrial and Civil Technology, L.N.

Gumilev ENU, Munaytpasova 13, Nur-Sultan, Kazakhstan, Contacts: +7 7054283858, e-mail: dusembinov@mail.ru, ORCID: 0000-0001-6118-5238;

Sabitov Yerlan Yenzhilovich – Candidate of Technical Sciences, Associate Professor, Head of the Department «Technology of Industrial and Civil», L.N. Gumilev ENU, Munaytpasova 13, Nur-Sultan, Kazakhstan, Contact: +7 7017735163, e-mail: e_sabitov@mail.ru, ORCID: 0000-0003-3784-8657;

Tsygulyov Denis Vladimirovich – Candidate of Technical Sciences, Associate Professor, Department «Design of Buildings and Structures», L.N. Gumilev ENU, Munaytpasova 13, Nur-Sultan, Kazakhstan,Contact: +7 7771512872, e-mail: denis_riza_72@mail.ru, ORCID: 0000-0002-7061-6992.

REFERENCES

https://www.td-geo.ru/articles/istorya_razvitya_geo.

https://k-g-s.kz/ .

ASTM D4439-18 «Standard terminology for geosynthetics».

Guerra-Escobar P. (2018). Reinforced embankments for the causeway for pont briwet project, penrhyndeaudreath, north wales, UK. Paper presented at the 11th International Conference on Geosynthetics 2018, ICG 2018, , 4 2630-2636.

Kim Y., Kotwal A.R., Cho B., Wilde J. & You B.H. (2019). Geosynthetic reinforced steep slopes: Current technology in the united states. Applied Sciences (Switzerland), 9(10) doi:10.3390/app9102008.

Lukpanov R.E. (2016). Laboratory modelling of soil testing embankment reinforced by geosynthetic elements. Paper presented at the GA 2016 - 6th Asian Regional Conference on Geosynthetics: Geosynthetics for Infrastructure Development, Proceedings, 392-398.

Lukpanov R.E. (2016). Laboratory modeling of soil dam reinforced by geosynthetic material. Paper presented at the Challenges and Innovations in Geotechnics - Proceedings of the 8th Asian Young Geotechnical Engineers Conference, 8AYGEC 2016, 159-162.

Lu L., Lin H., Wang Z., Xiao L., Ma S. & Arai K. (2021). Experimental and numerical investigations of reinforced soil wall subjected to impact loading. Rock Mechanics and Rock Engineering, 54(11), 5651-5666. doi:10.1007/s00603-021-02579-9.

Ngo T.P., Likitlersuang S. & Takahashi A. (2019). Performance of a geosynthetic cementitious composite mat for stabilising sandy slopes. Geosynthetics International, 26(3), 309-319. doi:10.1680/jgein.19.00020.

Nguyen T. & Yang K. (2018). Geosynthetic-reinforced soil slopes with different backfills and reinforcements subjected to rainfall infiltration. Paper presented at the 11th International Conference on Geosynthetics 2018, ICG 2018, , 4 3339-3353.

Özçelik H., Sadler J., Kiel R., Leaf C., Geier D., Kapita T.M., Vaciago G. (2018). Case study on the use of high hybrid MSE walls in mine industry. Paper presented at the 11th International Conference on Geosynthetics 2018, ICG 2018, 4 2958-2966.

Tang H. (2020). Application of geosynthetics in highway engineering doi: 10.1007/978-981-15-2349-6_59.

Zhaksybekova Z., Lukpanov R., Shakhmov Z. & Yenkebayev S. (2018). Test of ground embankment model with the use of geosynthetic elements of reinforcement to static external load. Paper presented at the 11th International Conference on Geosynthetics 2018, ICG 2018, , 1 544-549.

Zhang J., Li X., Ding L. & Xiao Y. (2022). Reinforcement effect investigation of geogrids in the junction between new and existing subgrades in highway widening. Journal of Testing and Evaluation, 50(5) doi: 10.1520/JTE20210223.

Zhussupbekov A.Z., Tulebekova A.S., Lukpanov R. & Zhumadilov I.T. (2016). Comparison analysis of features in eurocode and kazakhstan norms requirements. Paper presented at the Challenges and Innovations in Geotechnics - Proceedings of the 8th Asian Young Geotechnical Engineers Conference, 8AYGEC 2016, 251-255.

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