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ТРАНСПОРТНЕ БУДІВНИЦТВО

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THE BASING OF STABILIZATION PARAMETERS OF A FORTIFIED RAILWAY BED

Purpose. The article is devoted to stabilization parameters determination of reinforced railway bed. At the present time, the railway plays the leading role in transport system to ensure the needs of freight and passenger traffic. In modern conditions railway operation concentrates on ensuring the necessary level of track reliability, including the roadbed, this is one of the main elements of road structures. The purpose of this article is the determination of basic parameters of stress-strain state to stabilize the soil subgrade embankment by reinforced materials. **Methodology.** To achieve this goal the following tasks of researches were solved: the effect of reinforcing layer of geomaterial on deformation properties of soil subgrade in various design of strengthening was investigated, the distributions of stresses in the subgrade were determined, reinforced of geomaterials under state load. Experimental studies to explore the nature of the deformation model subgrade at various degrees of stress were carried out. **Findings.** The analysis of the results of performed experimental and theoretical studies permitted to do the following conclusions. In conducting researches determined the distribution of stresses in the subgrade reinforced geomaterials under static load. The complex of experimental studies allows exploring the nature of the deformation model subgrade at various degrees of stress. **Originality.** On the basis of the theoretical studies have been regarded the problem of determining the stress-strain state of subgrade reinforced geomaterials by measuring stresses in its application for step loads. **Practical value.** The practical value was presented by the results of evaluating the effect of reinforcing way for changing the stress-strain state of subgrade.

Keywords: railway bed; subgrade; traffic; roadbed; parameters; stress-strain state

Introduction

At the present time the railway transport in the unit transport system of Ukraine plays the leading role by guarantee the requirements of freight and passenger traffic. In modern conditions the railway operations concentrates on ensuring the necessary level of the track reliability, including the roadbed as the basis of the road embankment to a large extent determines the normal operation of the railway as the whole under the influence of the rolling stock. As it is known, the main cause of the traffic accident on the railways is the state of the track (50%), the state of the rolling stock (43%) and a human factor.

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Thus, it is necessary to develop new investigations with the using of subgrade reinforcement elements with different materials and determine the parameters of their efficiency, especially at higher train speeds. To achieve this goal of determining the basic parameters of the stress-strain state to stabilize the soil subgrade embankment reinforced with special materials it is required to solve next research tasks: 1) carry out the analysis of previous studies in the field of strengthening of subgrade by reinforcing materials; 2) investigate the effect of influence by reinforcing layer by geomaterials on deformation properties of subgrade strengthening in various designs; 3) determine the distribution of stresses in the subgrade, reinforced geomatherials under static load; 4) carry out the complex of experimental researches to explore the nature of the model subgrade deformation at different voltage level [2–4].

Purpose

Analyzing every works about the reinforcing of subgrade embankment, it should be noted that results of previous studies indicate to the using of traditional methods of strengthening subgrade railways are not always effective and it is necessary to develop new methods [1, 5–8, 12].

Methodology

For research inclusions of the reinforcing geomatherials on the soil subgrade method were outlined and as a result of the study its materials loaded up to the level of adequate modern rolling stock.

The results of previous studies [5–7, 11–16] indicate that the using of traditional methods of strengthening subgrade railways are not always effective and leads to the higher costs and time to conduct it. The modern ways of strengthening of railway subgrade have the several disadvantages, technological or economic nature, and therefore do not solve the issue in many causes reducing the deformability of the roadbed. Theoretical and experimental studies carried out in different countries, as well as monitoring of the test sites revealed that geotextile placed on main subgrade surface, comes into work with a ballast layer of soil and is the main site, with the stress-strain state of subgrade changing.

Thus, currently there is the problem of assessment the quality reinforcement, especially geosynthetic materials, railway roadbed [6, 7, 10, 12]. In this case, it is complicated by the fact that there is no single concept of subgrade strengthening the body over its depth, especially in combined versions [6]. Therefore in the task of developing the method need to strengthen and evaluate of its stress-strain state.

The tests were conducted in a closed system i.e. at constant soil moisture. According to test result were constructed plots of the "stress – the relative strain". Base on the results of sample tests on the compression was verify the effectiveness of placing a geotextile to reduce the deformation of the sample at the laboratory studies were performed stabilization reinforced roadbed. Dimensions of the model in plane were accepted 680×120 mm. Front wall of the tray was made of a transparent Plexiglas for observations the development of deformities. Loading of models were carried out on the linkage system with shoulder leverage of 1:10. The load transmitted to the stamp area 155.3 cm^2. In the process of model loading controlled the level of absolute displacements vertical load on the stamp was from 10 to 50 N with the stresses under the stamp changed from 0.0644 MPa to 0.332 MPa (as we know the normative power of the railways in the strengthening of 0.16 MPa). The settlement of stamp measured three dial gangs with a scale of 0.01 mm. Indicators on the stamp mounted symmetrically. Move the stamp recorded after each stage of the application load after and removed on indicators of the deformed samples and photography model. Moving of subgrade recorded of rules set on the side faces of the tray and strain model with a grid printed on its face. To substantiate methods prevent of substantially reduce the strains of subgrade for different types of reinforcement were conducted experimental researches in the tray with the geometric scale of modelling 1:20. There have been conducted several series of model tests with the specification of their deformation characteristics in depending on the nature of reinforcement (Fig. 1).

At the analysis of the parameters of the experimental studies reinforced by geotextile of subgrade found that the nature of the manifestation of deformation unreinforced model – variant 0 (Fig. 1, a) is manifested by the appearance of the stamp core compression, which was clear from the distortion mesh 2×2 cm. towards the front of the model. Option 1 (Fig. 1, *b*) during the compression of the

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soil matrix with geotextile fabric has significantly changed its shape, detached from the main site and out of shape as a result of the critical strain, indicating that non-rationality of the option for placing reinforcing element. At the analysis of the option 2 (Fig. 1, *c*) states that the considerable effort in the geotextile separation zone formed matrix and reinforcement. In options 3 and 4 (Fig. 1, *d*, *e*) there is a homogeneous deformation, since the critical strain as bundle and pulling the valve were found.

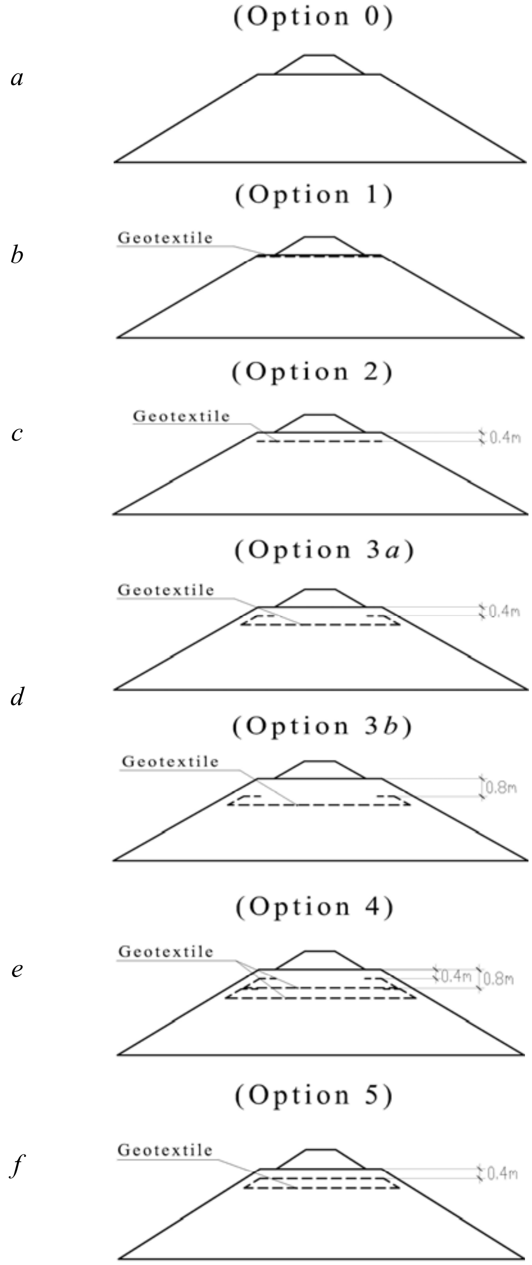

Fig 1. Special reinforced models by geotextile materials:
a) Option 0 – unreinforced model; *b*) Option 1 – the model reinforced geotextile cloth located directly under the ballast; *c*) Option 2 - the model reinforced geotextile cloth and located at a depth of 2 cm (0.4 m. in nature) from the main site; *d*) Option 3 – the model reinforced geotextile cloth with bends at depth: 3a – 2 cm (0.4 m. in nature), 3b – 4 cm (0.8 m in nature); *e*) Option 4 – the model reinforced by two contacted of geotextile clothes with bend at a depth of 2 cm (0,4 m in nature) and 4 cm (0,8 m in nature); *f*) Option 5 – the model reinforced geotextile membrane at a depth 2 cm (0,4 m in nature)

Therefore the reinforcement models of subgrade with the inline options are optimal to stabilize the railway subgrade. Having considered the option 5 (Fig. 1, *f*) at significant stresses detected deformation of soil matrix at the edges of stamp and the ballast layer consequently, the presence of cracks in surge – on the edge of stamp and the ballast layer, consequently, presence of cracks in surge – on the edge of the ballast and under the edge of the stamp is a negative effect.

Stabilization parameters that are accepted in the work for gutter tests also showed that the combined version 5 is the most effective measure of stabilization parameters. The additional geometric constructions, which simplify comparison, are shown in Fig. 2 and 3. So at the regulatory maximum stresses on the main site subgrade, which is equal to 0.08 MPa, the relative deformation of options to strengthen from the geotextiles are equal respectively: Option 0 – 0.0078, Option 1 – 0.0066, Option 2 – 0.0065, Option 3a – 0.0053, option 3b – 0.0067, Option 4 – 0.0046, Option 5 – 0.0044, that is, the introduction of the geotextile reduces deformations at 1.2…1.8 times (maximum decrease of strains in option 5). Modulus of elasticity, as one of the stabilization parameters, varied in the followed ranges; Option 0 – 2.78 MPa, option 1 – 12.5 MPa, option 2 – 5 MPa, option 3a – 25 MPa, option 3b – 3.57 MPa, option 4 – 12.5 MPa, option 5 – 25 MPa, that is, in options 3a and 5, with the introduction of geotextile modulus of elasticity increase in 9 times, respectively, the deformation characteristics of subgrade, in the conducted tests, were improved.

In the series of experimental and conducted research were carried out tests on the strengthening models by small-deformable layer of Rubble-Soils Mixe, which is located at a different depth from the main site of subgrade (Fig. 2).

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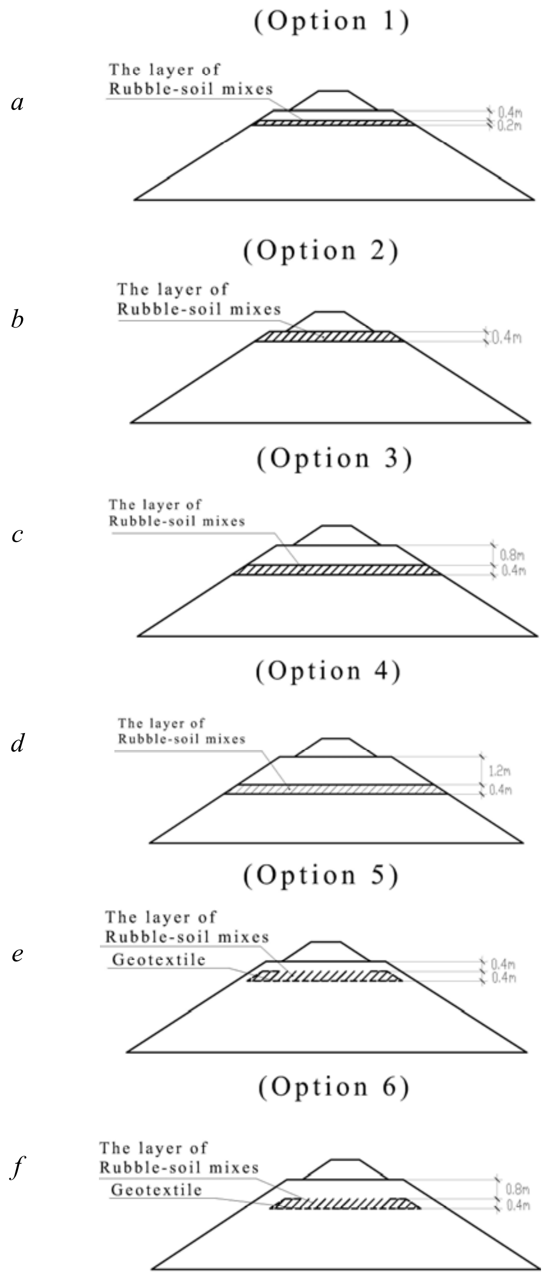

Fig. 2. Options for strengthening the model little deformable layer made of Rubble-Soil Mixes (RSM): *a*) Option 1 – RSM layer thickness of 1 cm (0.2 m in nature) at a depth of 2 cm (0.4 m in nature) from the main site, *b*) Option 2 –RSM layer of thickness 2 cm (0,4 m in nature) which is placed directly under ballast, *c*) Option 3 – RSM layer of thickness 2 cm (0.4 m in nature), which is placed at a depth of 4 cm (0.8 m in nature) from the main site, *d*) Option 4 – RSM layer of thickness 2 cm (0.4 m in nature) at a depth of 6 cm (1.2 m in nature) from the main site, *e*) option 5 – option combined RSM layer of thickness 2 cm (0.4 m in nature) at a depth of 2 cm (0.4 m in nature) from the main site, wrapped in geotextile cloth with bends, *f*) Option 6 – option combined – a layer from RSM sm. of thickness 2 cm (0.4 m in nature) at the depth of 4 cm (0.8 m in nature) from the main site, wrapped in geotextile cloth with bends

Findings

When analyzing the results of experimental studies of the stress-strain state of subgrade reinforced, the small deformable layer of crushed stone-ground mixture, established the following. In option 1 (Fig. 2, *a*) slightly improved picture of deformation, however, is not essential. But still-compared to unreinforced option 0 (Fig. 1, *a*), the damping stress is significant. By increasing the thickness of small deformed layer to 2 cm (0.4 m in nature) revealed its positive impact on the reduction of vertical deformations, and the impact of its location on these values. So in options 2, 3, 4 (Fig. 2, *b*, *c*, *d*) the influence of the position of the layer to change vertical displacements were recorded. In the version 5 (Fig. 2, *e*) was recognized sheared strain as a bundle and pulling out of the matrix and reinforcement (small deformed layer at a depth of 2 cm (0.4 m in nature) from the main site. When analyzing 6 options (Fig. 2, *f*) small deformed layer located at a depth 4 cm (0.8 m in nature) from the main site. It is established that uncritical deformation in the form deformation and loosening of fitting is not detected, so this option is effective to stabilize subgrade. As a result, were accepted parameters stabilization in the case of roadbed strengthening by small deformable layer and combined strengthening with relative deformation at the normative maximum stress to strengthen for variants equal respectively: Option 0 - 0.0078, Option 1 – 0.0062, Option 2 – 0.0034, Option 3 – 0.0034, Option 4 – 0.034, Option 5 – 0.0015, Option 6 – 0.0034. We can say that: using of combination options, as the most effective, reduces strain in 5.2 times (The rest variants amplification – only at 1.3…2.3 times). The modulus of elasticity as one of the parameters stabilization changes in the following within: Option 0 – 33.3 MPa, Option 1 – 32.1 MPa, Option 2 – 62.5 MPa, Option 3 – 55.6 MPa, Option 4 – 74.3 MPa, Option 5 – 133 MPa, Option 6 – 104 MPa, that is option 5 (combined) increase the modulus of elasticity in the 4 times. Respectively deformation characteristics of subgrade activities improved, also improves and strength characteristics, as one of the parameters of stability improves (tensile strength – a stress correspond to the relative deformation of 0.01): Option

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0 – 0.078 MPa, Option 1 – 0.09 MPa, Option 2 – 0.108 MPa, Option 3 – 0.11 MPa, Option 4 – 0.114 MPa, Option 5 – 0.142 MPa, Option 6 – 0.109 MPa. In the case of amplification at combined option 5, the tensile strength increases in 1.8 times (other options for amplification only in 1.15…1.46 times). Thus, the parameters stabilization obtained for several options amplification by geotextile and small deformable layer including combined indicate the high efficiency of combined option.

Originality and Practical value

On the base of analysis of the results of performed experiments were done the following conclusions.

The analysis of the carried out studies in the field of strengthening subgrade reinforcing materials allowed establishing a lack of development and ways to strengthen of subgrade railways.

In conducting experimental studies determined the distribution of stresses in the subgrade, reinforced geomaterial under static load as a model in the tray. On the base of the experimental studies results established the parameters of the stress-strain state to reinforce the roadbed small deformable layer is made of Rubble-Soil Mixes when the relative deformations equal from 0.008 to 0.017.

As established experimentally, the reinforcing roadbed as separate horizontal panels and strength by geotextile matrixes 1.5…1.6, the emergency of separation zones at the ends of the cloth show irrationally of these options, regardless of their location in height of the matrix.

In addition, it was found that the reinforcement of a closed shell also can not be a rational choice, even with the increasing the strength in 1.6 times, since the deformation of subgrade at this version of the reinforcement due to significant cracking.

Conclusions

The complex of experimental studies was conducted to explore the nature of the deformation model subgrade of various degrees of stress. Based on experimental studies, a way strengthen roadbed reinforcement Ruble-Soil Mixes wrapped in geotextile with bends and justified its position at a distance of 0.4 m from the main site, which will increase the strength of the roadbed in 1.8–2.0 times and stability to improve the speed of the trains.

LIST OF REFERENCE LINKS

1. Блажко, Л. С. Геоматериалы при высоких осевых нагрузках / Л. С. Блажко // Путь и путевое хоз–во. – 2002. – № 10. – С. 36–37.
2. Блажко, Л. С. Эффективность укладки геотекстиля / Л. С. Блажко, М. В. Бушуев, В. М. Ермаков // Путь и путевое хоз–во. – 2008. – № 3. – С. 5–8.
3. Даніленко, Е. І. Правила розрахунків залізничної колії на міцність і стійкість / Е. І. Даніленко, В. В. Рибкін. – Київ : Укрзалізниця, 2006. – 168 с.
4. Новые способы оздоровления земляного полотна // Путь и путевое хоз–во. – 1999. – № 6. – С. 39–40.
5. Петренко, В. Д. Дослідження впливу деформаційних характеристик шару посилення на НДС залізничного насипу при під'їзді до мостового переходу / В. Д. Петренко, В. Т. Гузченко, А. М. М. Алхдур // Вісн. Дніпропетр. нац. ун-ту залізн. трансп. ім. акад. В. Лазаряна. – Дніпропетровськ, 2010. – Вип. 32. – С. 101–105.
6. Результати аналізу параметрів експериментальних досліджень армування геотекстилем земляного полотна / В. Д. Петренко, В. Т. Гузченко, А. Л. Тютькін, А. М. М. Алхдур // Вісн. Дніпропетр. нац. ун-ту залізн. трансп. ім. акад. В. Лазаряна. – Дніпропетровськ, 2010. – Вип. 34. – С. 131–135.
7. Сравнительный анализ результатов экспериментальных исследований усиления земляного полотна малодеформируемым слоем / В. Д. Петренко, В. Т. Гузченко, А. Л. Тютькін, А. М. М. Алхдур // Вісн. Дніпропетр. нац. ун-ту залізн. трансп. ім. акад. В. Лазаряна. – Дніпропетровськ, 2010. – Вип. 35. – С. 139–144.
8. Стоянович, Г. М. Нагрузку на земляное полотно можно уменьшить / Г. М. Стоянович, В. Ф. Цветков // Путь и путевое хоз–во. – 1993. – № 8. – С. 19–20.
9. Яковлева, Е. В. Влияние армирования на деформации основной площадки / Е. В. Яковлева // Ж.-д. транспорт. – 1998. – № 11. – С. 24–26.
10. Яковлева, Т. Г. Способы усиления насыпей армогрунтовыми конструкциями / Т. Г. Яковлева, В. В. Виноградов, Ю. К. Фроловский // Путь и путевое хоз–во. – 1997. – № 1. – С. 7–10.
11. Al Shaer, A. Analyse des déformations permanentes des voies ferrées ballastées – Approche dynamique : Ph.D. thesis of Ecole Nationale des Ponts et Chaussées / A. Al Shaer // Ecole National des Ponts et Chaussées. – Paris, 2005. – 147 p.
12. Bourgeois, E. Subgrade reinforcement with columns / E. Bourgeois, A. Le Kouby, A. Smekal // INNOTRACK project. Report D2.2.5. – 2009. – P. 7–121.

doi 10.15802/STP2015/38269

13. Davis, D. Foundation Measurement Design for SpecialTrackwork / D. Davis, S. P. Singh, D. Guillen // Railway Track & Structures. – 2001. – № 12. – P. 17–19.
14. Leykauf, G. Trends bei Oberbausystemen für die Zukunft / G. Leykauf // Glassers Annalen. – 2000. – № 8. – P. 445–454.
15. Moseley, M. P. Ground Improvement. / M. P. Moseley, K Kirsch // London; New-York : Spon Press: Taylor & Francis Group, 2004. – 440 p. doi: 10.4324/9780203305201.
16. Olsson, M. Some experiences from full scale test embankments on floating lime-cement columns / M. Olsson, T. Edstamand, C. Alén // Geotechnics of Soft Soils: Focus on Ground Improvememnt : Proc. of the Second Intern. Workshop held in Glasgow, Scotland (3.09-5.09.2008). – London : Taylor & Francis Group, 2008. – P. 77–85. doi: 10.1201/9780203883334.ch8.

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ОБГРУНТУВАННЯ СТАБІЛІЗАЦІЇ ПАРАМЕТРІВ УКРІПЛЕНОГО ЗАЛІЗНИЧНОГО НАСИПУ

Мета. Стаття присвячена визначенню параметрів стабілізації підсиленого залізничного полотна. В даний час залізниця відіграє ключову роль у забезпеченні потреби пасажирських та вантажних перевезень. У сучасних умовах експлуатація залізниць сконцентрована на забезпеченні необхідного рівня надійності колії, в тому числі земляного полотна, яке є одним із ключових елементів дорожніх конструкцій. Мета цієї статті полягає у визначенні параметрів напружено-деформованого стану для стабілізації грунта земляного полотна насипу підсилюючими матеріалами. **Методика**. Для досягнення цієї мети було вирішено такі завдання досліджень: вивчено вплив армуючого шару геоматеріалу на деформаційні властивості грунтового земляного полотна при різних конструкціях укріплення; визначено розподіл напружень в земляному полотні, які посилені геоматеріалами при статичному навантаженні; виконано експериментальні дослідження для вивчення природи деформацій моделі земляного полотна на різних стадіях навантаження. **Результати**. Виконаний аналіз результатів проведених експериментальних та теоретичних досліджень дозволив зробити ряд висновків. При проведенні досліджень визначено розподіл напружень в земляному полотні, посиленому геоматеріалами при статичному навантаженні. Виконаний комплекс експериментальних досліджень дозволив вивчити природу деформацій моделі земляного полотна при різних ступенях навантажень. **Наукова новизна**. На основі теоретичних досліджень розглянуто проблему визначення напружено-деформованого стану земляного полотна, посиленого геоматеріалами, шляхом вимірювання напружень при їх застосуванні під час поетапного навантаження. **Практична значимість**. Практична значимість обумовлена підсумками оцінки впливу підсилення земляного полотна для зміни його напружено-деформованого стану.

Ключові слова: залізнична колія; насип; рух; земляне полотно; параметри; напружено-деформований стан

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ОБОСНОВАНИЕ СТАБИЛИЗАЦИИ ПАРАМЕТРОВ УКРЕПЛЕННОЙ ЖЕЛЕЗНОДОРОЖНОЙ НАСЫПИ

Цель. Статья посвящена определению параметров стабилизации усиленного железнодорожного земляного полотна. В настоящее время железная дорога играет ключевую роль в обеспечении потребности пассажирских и грузовых перевозок. В современных условиях эксплуатация железных дорог сконцентрирована на обеспечении необходимого уровня надежности пути, в том числе земляного полотна, которое является одним из ключевых элементов дорожных конструкций. Цель этой статьи заключается в определении параметров напряженно-деформированного состояния для стабилизации основания и самого земляного полотна насыпи с помощью армирующих материалов. **Методика.** Для достижения этой цели были решены следующие задачи исследований: изучено влияние армирующего слоя геоматериалов и деформационных свойств основания земляного полотна при различных конструкциях укрепления; определены распределения напряжений в земляном полотне, которые усилены геоматериалами под статической нагрузкой. Выполнены экспериментальные исследования для изучения природы деформации модели земляного полотна на разных стадиях нагружения. **Результаты.** Анализ результатов проведенных экспериментальных и теоретических исследований позволил сделать ряд выводов. При проведении исследования определено распределение напряжений в земляном полотне, усиленном геоматериалами при статической нагрузке. Выполненный комплекс экспериментальных исследований позволил изучить природу деформации модели земляного полотна при различных степенях нагружения. **Научная новизна.** На основе теоретических исследований рассмотрена проблема определения напряженно-деформированного состояния земляного полотна, усиленного геоматериалами путем измерения напряжений при их применении во время поэтапного нагружения. **Практическая значимость.** Практическая значимость обусловлена итогами оценки влияния усиления земляного полотна для изменения его напряженно-деформированного состояния.

Ключевые слова: железнодорожный путь; насыпь; движение; земляное полотно; параметры; напряженно-деформированное состояние

REFERENCES

1. Blazhko L.S. Geomaterialy pri vysokikh osevykh nagruzkakh [Geomaterials under high axial loads]. *Put i putevoye khozyaystvo –Track and track facilities*, 2002, no. 10, pp. 36-37.
2. Blazhko L.S., Bushuev M.V., Yermakov V.M. Effektivnost ukladki geotekstilya [The effectiveness of the geotextile laying]. *Put i putevoye khozyaystvo –Track and track facilities*, 2008. no. 3, pp. 5-8.
3. Danilenko E.I., Rybkin V. V. *Pravyla rozrakhunkiv zaliznychnoi kolii na mitsnist i stiikist* [The rules of railway track calculation for strength and stability]. Kyiv, Ukrsalisnytsia Publ., 2006. 168 p.
4. Novyye sposoby ozdorovleniya zemlyanogo polotna [New ways of the railroad bed improvement]. *Put i putevoe khozyaystvo – Track and track facilities*, 1999. no. 6, pp. 39-40.
5. Petrenko V.D., Huzchenko V.T., Alkhdur A.M.M. Doslidzhennia vplyvu deformatsiinykh kharakterystyk sharu posylennia na NDS zaliznychnoho nasypu pry pidizdi do mostovoho perekhodu [The influence study of the deformation characteristics of the layer of reinforcement on VAT of railway embankment at the entrance to the bridge crossing]. *Visnyk Dnipropetrovskoho natsionalnoho universitetu zaliznychnoho transportu imeni akademika V. Lazariana* [Bulletin of Dnipropetrovsk National University of Railway Transport named after Academician V. Lazaryan], 2010, issue 32, pp. 101-105.

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6. Petrenko V.D., Huzchenko V.T., Tiutkin A.L., Alkhdur A.M.M. Rezultaty analizu parametriv eksperymentalnykh doslidzhen armuvannia heotekstylem zemlianoho polotna [The analysis results of the experimental studies of railroad bed geotextile reinforcement]. *Visnyk Dnipropetrovskoho natsionalnoho universitetu zaliznychnoho transportu imeni akademika V. Lazariana* [Bulletin of Dnipropetrovsk National University of Railway Transport named after Academician V. Lazaryan], 2010, issue 34, pp. 131-135.
7. Petrenko V.D., Huzchenko V.T., Tiutkin A.L., Alkhdur A.M.M. Sravnitelnyy analiz rezultatov eksperimentalnykh issledovaniy usileniya zemlyanogo polotna malodeformiruemym sloem [Comparative analysis of the experimental results for railroad bed intensification with layer reinforcement]. *Visnyk Dnipropetrovskoho natsionalnoho universitetu zaliznychnoho transportu imeni akademika V. Lazariana* [Bulletin of Dnipropetrovsk National University of Railway Transport named after Academician V. Lazaryan], 2010, issue 35, pp. 139-144.
8. Stoyanovich G.M., Tsvetkov V.F. Nagruzku na zemlyanoye polotno mozhno umenshit [The load on the railroad bed can be reduced]. *Put i putevoye khozyaystvo –Track and track facilities*, 1993, no. 8, pp. 19-20.
9. Yakovleva Ye.V. Vliyaniye armirovaniya na deformatsii osnovnoy ploshchadki [The influence of reinforcement on the deformation of the main surface]. *Zheleznodorozhnyy transport – Railway transport*, 1998, no. 11, pp. 24-26.
10. Yakovleva T.G., Vinogradov V.V., Frolovskiy Yu.K. Sposoby usileniya nasypey armogruntovymi konstruktsiyami [Ways of reinforcement of the embankments by reinforced ground designs]. *Put i putevoye khozyaystvo – Track and track facilities,* 1997, no. 1, pp. 7-10.
11. Al Shaer A. Analyse des déformations permanentes des voies ferrées ballastées. Approche dynamique. Ph.D. thesis of Ecole Nationale des Ponts et Chaussées, Paris, France. 2005. 147p.
12. Bourgeois E., Le Kouby A., Smekal A. Subgrade reinforcement with columns. INNOTRACK project. Report D2.2.5. 2009, pp. 7-121.
13. Davis D., Singh S.P., Guillen D. Foundation Measurement Design for SpecialTrackwork. *Railway Track & Structures,* 2001. no. 12, pp. 17-19.
14. Leykauf G. Trends bei Oberbausystemen für die Zukunft*. Glassers Annalen,* 2000, no. 8, pp. 445-454.
15. Moseley M.P., Kirsch K. Ground Improvement. London; New-York, Spon Press. Taylor & Francis Group Publ., 2004. 440 p. doi: 10.4324/9780203305201
16. Olsson M., Edstamand T., Alén C. Some experiences from full scale test embankments on floating lime-cement columns. Proc. of the Second Intern. Workshop held in Glasgow, Scotland. Taylor & Francis Group Publ., 2008, pp. 77-85. doi: 10.1201/9780203883334.ch8

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