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Satbayev University

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COMPLEX STABILIZATION OF SOILS AND BASE COURSE MATERIALS DURING CONSTRUCTION AND REPAIR OF THE HIGHWAYS

Abstract. The article represents the results for investigation of a new technology of complex soil consolidation and stabilization and reuse of the material from stripping of the existing roads (cold recycling technology) with portlandcement and enzyme agent Roadzyme (USA), which allows reducing the energy costs significantly and improving ecological situation.

Cold recycling has a number of significant advantages before other means of reconstruction.

The absence of environmental pollution is due to the complete use of the material of the old pavement. There is no need in disposal sites, and the volume of the new delivered materials is the minimum one and reduces the area of contamination, which is certain during opening of new borrow-pits and rock quarries. Transportation is very small, therefore the consumption of the energy is considerably reduced, as well as devastating impact of vehicles on the road network.

Effect of the use of the agent "Roadzyme" is based on the activation of physics and chemical processes, which increase the strength, water resistance and frost resistance of the consolidated soils and materials, reducing material consumption at provision of the required elasticity modulus for pavement structure due to reduction of the thickness for pavement layers, the use of local materials and saving of binders and inert materials.

The decrease is noted for the stiffness of the materials, strengthened by complex method (binder with the agent "Roadzyme"), compared to the treatment only with the binder, which allows forecasting the increase of the crack resistance.

Key words: soil, stabilization, consolidation, cold recycling, granular asphalt.

Introduction. One of the most urgent tasks for the development of a road transport complex of the Republic of Kazakhstan is the accelerated development of the highway network, including connection of rural settlements with public roads.

Implementation of this program requires the non-standard approach from the road organizations. The overview of modern technologies for the construction of the highways all over the world shows the growing tendency of the maximum use for the local materials aiming at the reduction in cost and reducing the period for the construction.

The technology of complex soil stabilization is used for the construction of layers of base course and subgrade in recent years in Kazakhstan.

Complex soil stabilization with the use of inorganic binder and soil stabilizers provides basic change of properties for the stabilized soil and gives the required durability to them, as well as water resistance and frost resistance. The use of soil stabilizers at the same time allows receiving of the required strength characteristics and necessary rates for frost resistance in case of small amount of inorganic binder [1-3].

One of the main causes for the deformations on the roads resulting in the step-by-step failure is the soil loosening of working layer of subgrade and unstabilized lower layers of pavements. The use of complex stabilized soil in upper part of the subgrade or stabilized lower layers of the base course of pavements allows solving of this problem. During construction of layers for base course and anti-frost

heavy course of carriageway and shoulders from stabilized soils the income of moisture to the material of the subgrade from the top through pavement and shoulders is practically excluded.

The results of our investigations have shown the possibility for the essential increase of the operational characteristics for road bitumens and asphalt concretes by their modification with carbon nanopowder [4-10] and polymers [11-14]. An asphalt concrete pavement with the improved operational characteristics will function efficiently only in case when layers of base and soil of subgrade are sufficiently strong. Therefore, the possibility for the increase of a strength and other characteristics of a soil and a material are experimentally studied in this work for a pavement base by two methods of stabilization.

MATERIALS.

2.1. Soil stabilizers. Nowadays the wide range of materials for soil modification is used, which allows improving of properties for soil and materials of base course. Ionic stabilizers relate to them (Perma-Zym, LBS, Roadzym, SoilGrip - the USA, ANT - Russia, etc.) which after entering of their water solution into soil actively interact with its fine dusty and clay fraction and allows excluding the ability of clay soil to interact with water due to neutralization of forces of the superficial attraction of water.

For complex consolidation of soils during applying in road construction it is possible to use practically any soils, including clays and loams with plasticity number not more than 12.

In case of bigger plasticity value, the upgrading of soil with nonplastic local materials (sand, natural gravel sand mix, sifting and others) is carried out to achieve the required aggregative state.

Very good results are achieved when asphalt concrete granulars and complex stabilized soil during middle repair of the existing highways with asphalt concrete pavements (technology of cold recycling). The existing pavement and underlayers of the base course are milled for the desired depth, with addition of the binder and, if required, a water solution of the soil stabilizer. Further the obtained mix is profiled by a grader, and then the compaction is carried out by a smooth drum or a pneumatic-tired roller. Subsequently, if it is provided by the project documentation, it is possible construction of an asphalt concrete layer or construction of a wearing course in the form of double surface treatment. The need for stripping of the existing pavement and delivery of a large volume of sand and crushed stone is eliminated. Strength characteristics of the layer constructed under such technology allow using it as the top layer of the base course for the roads of IV and V categories or as the lower layers of the base course for the roads of the highest categories.

2.2. Roadzyme soil stabilizer. In Kazakhstan over the last 5 years the wide experience is gained for the middle repair of highways under the technology of cold recycling using the organic soil stabilizer - the enzyme agent Roadzyme. Operation of road sections repaired with the use of this method for 1-4 years showed cost and technical efficiency of such approach.

The organic soil stabilizer Roadzyme, the enzyme agent obtained on the basis of the wastes processing of the food production represents by itself the liquid of dark-brown color and it is used for road mixes in water solution. The effect of the use of the agent Roadzyme is based on activation of the physical and chemical processes increasing durability, water resistance and frost resistance of the stabilized soil and materials. At the same time the material consumption is decreased for the construction when providing the required elasticity modulus for pavement design due to reduction of the thickness for pavement layers, the use of the local materials and industrial wastes, and saving of binders and inert materials.

METHODS.

3.1. Complex stabilization. During the research of the materials strengthened by complex method, the mixes were prepared in the following ways: pre-dried mineral materials in the amount, prescribed for the mix design, were placed into vessel, then the required amount of cement and, if necessary, ash was added. The compound was carefully mixed up dry in the mixer. Then water solution of Roadzyme was added to it in the amount required for bringing the compound to optimum compaction moisture. The stabilizer Roadzyme in the form of a concentrate was included into water in the amount of 0.002% of the mass of the mix.

Cylindrical samples are formed after mixing from a compound. Load is selected according to the index of the maximum density for the optimum moisture. The samples are kept for 28 days in standard curing (95% of moisture).

Test regime of the samples for frost resistance is the following: 15 and 25 cycles of freezing and defrosting in the freezer (at a freezing temperature minus (18 ± 2) ° C) is assigned under [16-17] according to standard techniques.

For the comparative analysis the mixes (No. 1 and No. 2) were prepared using the stabilized soil with 4% of Roadzyme and 6% of cement without stabilizer, as well as soil mixes with the skeletal component of GSM in the amount of 24%.

3.2. Cold recycling. When using the technology of the cold recycling for reuse of materials from the stripping of the existing pavement it is necessary to reveal optimum amount of the included additives irrespective of the layer thickness of the existing design. The need for the research of the mixes of various compositions is explained by the fact that the old asphalt roads have different and often unpredictable pavements (asphalt concretes thickness, thickness of the base course, etc.) and it is even more complicated by the fact that for the small length of the road the pavement can change. Such conditions result in impossibility of selection for the required percent of binder in the mix for each specified road section.

The purpose of the research was the selection of the unique minimum amount of the binder, ensuring the obtaining of the required strength characteristics, including frost resistance, for any mix.

Mix designs of the recycled layer were selected based on the thickness of the asphalt concrete pavement layers and total thickness of the recycled layer.

Determination of the maximum density and optimum moisture of structures of the recycled layer with adding of the stabilizer Roadzyme and cement was carried out according to ST PK 1285 (Table 4) [15] under the modified Proctor's method.

According to GOST 23558 (Table A) [16] grade for compression strength of the treated materials and the stabilized soil for the base courses of pavements of the capital and facilitated type not below than M40. At the same time frost resistance of such mixes shall be not below than F15 or F25 depending on pavement type and average temperature of the coldest month in the area of the specific highway.

RESULTS AND DISCUSSION.

4.1. Complex stabilization. According to the test results (table 1) inclusion of Roadzyme into composition of soil with 4% of cement allows increasing tension in bending in 3 times. At the same time the composition with 6% of cement without Roadzyme with compression strength of 2.5 MPa has frost resistance of (F15), similar to the investigated composition.

Table 1 – Characteristics of soil stabilized samples

No. of the mix	Mix design, %				Strength, MPa		Grade	
	Soil	GSM	Cement	Roadzyme	At compression	Tension in bending	As per strength	As per frost resistance
1	97	0	4	0.002	2.0	0.6	M10	F15
2	97	0	4	0	1.2	0.2	M10	–
2	97	0	6	0	2.5	0.3	M10	F15
3	73	24	4	0.002	3.0	0.93	M20	F25
4	73	24	4	0	2.6	0.35	M10	–
5	70	24	6	0	3.5	0.6	M20	F25

Inclusion of skeletal additives allows raising the strength rates of the samples.

The increase in a ratio of R_u/R_{sj} should be noted with the use of the organic stabilizer Roadzyme which characterizes the material strengthened by the complex method with the use of the stabilizer Roadzyme as the most crack resistant one. Test results of the samples of the stabilized soil for alternate "freezing-thawing" also characterize the material treated by the complex method as the most frost-resistant one.

4.2. Cold recycling. The analysis of test results (table 2) shows that the strength characteristics are also increased with the use of the stabilizer Roadzyme under the cold recycling technology. The grade on samples strength with the use of Roadzyme in the mix No. 6 with 4% of Portlandcement was M40, and without Roadzyme – M20, at the same time the stiffness (ratio of compression strength to tension in bending) in the samples with Roadzyme is 10% lower.

Table 2 – Characteristics of samples from stabilized recycled material

No. of the mix	Mix design, %					Strength, MPa		Grade	
	Material from stripping of the existing road (100%)			Cement	Roadzyme	At compression	Tension in bending	As per strength	As per frost resistance
	Granular asphalt	GSM	Soil						
1	50	35	15	4	0.002	4.2	0.8	M40	F15
	50	35	15	4	–	3.5	0.6	M20	F15
	50	35	15	5	0.002	5.6	1.1	M40	F25
	50	35	15	5	–	3.9	0.7	M20	F15
2	20	55	25	4	0.002	4.1	1.0	M40	F15
	20	55	25	5	0.002	5.4	1.2	M40	F25
3	70	20	10	4	0.002	4.4	1.0	M40	F25
	70	20	10	5	0.002	5.2	1.1	M40	F25

For the samples of the mix No. 6 with 5% of Portlandcement the grade for the samples strength with Roadzyme was M 40, for frost resistance - F25, without Roadzyme – M 20 and F15. Thus, with complex strengthening of the recycled material with Portlandcement and the stabilizer Roadzyme the density increases, the water consumption decreases, strength characteristics and resistance to the crack formation increase.

The standard industry document was developed on the basis of the performed laboratory research and experimental-industrial implementation [17].

Conclusion.

1. Complex soil stabilization (Portland cement+organic stabilizer Roadzyme) increase essentially the compression strength (nearly 2 times) and bending strength (nearly 3 times), as well as crack resistance.

2. Density, strength and crack resistance are increased, and water consumption is decreased at complex stabilization of the recycled material with Portland cement and stabilizer Roadzyme.

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АВТОМОБИЛЬ ЖОЛДАРЫН САЛУ ЖӘНЕ ЖӨНДЕУ КЕЗІНДЕ ТОПЫРАҚТАР МЕН НЕГІЗ МАТЕРИАЛДАРЫН КЕШЕНДІ ТҰРАҚТАНДЫРУ

Аннотация. Мақалада топырақты кешенді нығайту мен тұрақтандырудың жаңа технологиясын және қолданыстағы жолдарды бөлшектеудің қайта пайдаланылатын материалын (суық ресайклинг технологиясы) портландцементпен және Roadzyme (АҚШ) ферменттік тұрақтандырғышымен энергетикалық шығындарды айтарлықтай қысқартуға және экологиялық жағдайды жақсартуға мүмкіндік беретін Зерттеу нәтижелері ұсынылған.

Суық қайта өңдеуді қалпына келтірудің басқа әдістеріне қарағанда бірқатар маңызды артықшылықтары бар.

Ескі жол төсемінің материалын толық пайдаланудың арқасында қоршаған ортаның ластанбауы. Үйінділерге арналған алаңдарға қажеттілік жоқ, ал жаңа жеткізілетін материалдардың көлемі аз, бұл жаңа карьерлер мен тас қашалған орындарды ашу кезінде орын алатын жергілікті жердің ластануын азайтады. Тасымалдау өте аз, сәйкесінше энергия шығыны да, көлік құралдарының жол желісіне бұзу әсері де айтарлықтай төмен.

«Roadzyme» препаратын қолданудың әсері нығайтылған топырақтар мен материалдардың беріктігін, ылғалға және аязға төзімділігін арттыратын, жол төсемесі қабаттарының қалыңдығын азайту, жергілікті материалдарды пайдалану және тұтқыр, инертті материалдарды үнемдеу арқылы жол төсемесі құрылымының қажетті серпімді модулін қамтамасыз ету кезінде құрылыстың материал шығынын төмендететін физика-химиялық үдерістерді белсендіруге негізделген.

Кешенді әдіспен өңделген материалдардың қаттылығы («Roadzyme» препараты бар тұтқырғыш) тек тұтқырғышпен салыстырғанда төмендегені байқалады, бұл олардың жарыққа төзімділігінің артқанын болжауға мүмкіндік береді.

Түйін сөздер: топырақ, тұрақтандыру, нығайту, суық ресайклинг, асфальт түйіршіктері.

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КОМПЛЕКСНАЯ СТАБИЛИЗАЦИЯ ГРУНТОВ И МАТЕРИАЛОВ ОСНОВАНИЯ ПРИ СТРОИТЕЛЬСТВЕ И РЕМОНТЕ АВТОМОБИЛЬНЫХ ДОРОГ

Аннотация. В статье представлены результаты по исследованию новой технологии комплексного укрепления и стабилизации грунтов и повторно используемого материала разборки существующих дорог (технология холодного ресайклинга) портландцементом, и ферментным стабилизатором Roadzyme (США), позволяющей существенно сократить энергетические затраты и улучшить экологическую обстановку.

Холодный ресайклинг имеет ряд значительных преимуществ перед другими способами реконструкции.

Отсутствие загрязнения окружающей среды благодаря полному использованию материала старой дорожной одежды. Нет необходимости в площадках для отвалов, а объем новых привозных материалов минимален, что снижает загрязнение местности, неизбежное при открытии новых карьеров и каменоломен. Перевозки очень невелики, соответственно, расход энергии значительно снижается, как и разрушительное воздействие транспортных средств на дорожную сеть.

Эффект от применения препарата «Roadzyme» основан на активизации физико-химических процессов, повышающих прочность, влагостойкость и морозостойкость укрепленных грунтов и материалов, снижающих материалоемкость строительства при обеспечении требуемого модуля упругости конструкции дорожной одежды за счет уменьшения толщины слоев дорожной одежды, использования местных материалов и экономии вяжущих и инертных материалов.

Отмечается снижение жесткости материалов, обработанных комплексным методом (вяжущим с препаратом «Roadzyme»), по сравнению с обработкой только вяжущим, что позволяет прогнозировать повышение их трещиностойкости.

Ключевые слова: грунт, стабилизация, укрепление, холодный ресайклинг, асфальтогранулят.

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