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THE POSSIBILITY OF USING MATERIALS FROM DEMOLISHED BUILDINGS IN COLD RECYCLING TECHNOLOGY FOR ROAD BASE LAYERS

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The work investigated the possibility of using such construction waste as asbestos-cement slate, glass, brick and concrete as aggregates in mixtures for the base layers of road pavement made using cold recycling technology. For this purpose, 17 mixture compositions were designed and studied - the control composition and 4 series of compositions, in which the milled fine-grained asphalt concrete was partially replaced by crushed asbestos-cement slate , glass , brick and concrete in an amount of 5-20 wt.%. All studied compositions contained 3% Portland cement and 3% water. The physical and mechanical indicators of mixtures and materials made using cold recycling technology with different construction waste contents were determined. The influence of the type and amount of the studied construction waste on the average density, water saturation and compressive strength after 7 days and 28 days of hardening at temperatures of 20 °C and 50 °C of road materials made using cold recycling technology was established.

Keywords: cold recycling, Portland cement, brick, glass, asbestos-cement slate, crushed concrete.

Introduction

The problem of landfill overflow with construction and demolition waste is very relevant in many countries (Shyshkin, 2023, Nasier, 2021, Gyawali, 2022, Arulrajah, 2020). This problem has become particularly acute in Ukraine, where the number of demolished buildings is increasing. A large share of construction waste is made up of fragments of asphalt concrete, roofing materials, bricks, concrete and reinforced concrete. Most of these materials are potentially suitable for reuse. One way to recycle construction waste is to use it in the layers of the road pavement structure.

The practical implementation of such an approach is aimed both at solving environmental problems arising from the accumulation of construction waste and at preserving exhaustible natural resources. Thus, the possibility of using demolition waste as alternative fillers in the construction of the subgrade (Tavakoli Mehrjardi, 2020, Zhang, 2020, Beja, 2020, Giwangkara, 2019), the arrangement of road base layers made of crushed concrete(Ding, 2020, Xiao, 2018, Buczyński, 2024, Almusawi, 2024, Kopić, 2022, Wang, 2017, Bidos, 2024, Gómez-Meijide, 2017), and as a partial replacement of stone material in asphalt concrete mixtures(Zou, 2020, Gedik, 2020, Arulrajah, 2011, Gómez-Meijide, 2016). But it should be noted that due to the increase in traffic, there is a need not only to build new roads, but also to reconstruct and overhaul existing ones. One of the technologies used to construct the base layers of road pavement and allows for the reuse of materials is the cold recycling technology. Therefore, the purpose of this work was to investigate the possibility of using waste obtained because of the destruction of buildings, such as asbestos-cement slate, glass, brick and concrete for partial replacement of aggregate when arranging road pavement layers using the cold recycling technology.

Materials and Methods

For the production of road materials using cold recycling technology, milled fine-grained asphalt concrete, Portland cement CEM II/A-S 32.5 and water were used as aggregate. Asbestos slate, window glass, brick and concrete were used to partially replace the milled material. All starting materials were pre-crushed to a grain size of 0-5 mm. The granulometric composition of the mixtures meets the requirements of the standard.

The physical and mechanical properties of the obtained road materials manufactured using cold recycling technology were determined according to DSTU 8976:2000 and included determination of average density, water saturation, and ultimate compressive strength at curing temperatures of 20 °C and 50 °C.

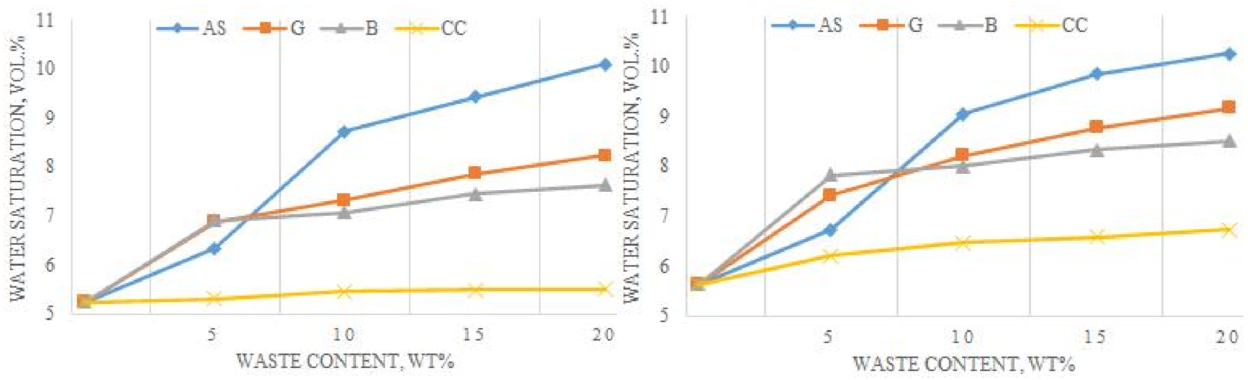
Results and discussion

For the study, 17 mixture compositions were designed, which excluded the control composition, as it did not contain waste, and 4 series of compositions in which the milled fine-grained asphalt concrete was replaced with crushed asbestos-cement slate (composition AS), glass (composition G), brick (composition B) and concrete (composition CC) in the amount of 5,10,15,20 wt.% (Table). The cement and water content in all compositions was the same: 3% cement and 3% water by weight of the mixture.

Properties of road materials using construction waste

Designation of composition	Average density, t/m^3	Compressive strength, MPa			
		For 7 days at a temperature		For 28 days at a temperature	
		20°C	50°C	20°C	50°C
Control	2,27	2,18	0,80	3,04	1,20
AS5	2,24	2,13	0,75	3,15	1,25
AS10	2,20	2,03	0,68	3,40	1,33
AS15	2,18	2,07	0,67	3,43	1,35
AS20	2,15	2,10	0,73	3,50	1,40
G5	2,26	2,10	0,73	2,75	1,00
G10	2,25	2,10	0,70	2,40	0,95
G15	2,25	2,00	0,65	2,30	0,92
G20	2,24	1,90	0,60	2,22	0,90
B5	2,26	2,14	0,77	278	1,08
B10	2,26	2,08	0,72	2,43	0,99
B15	2,24	2,02	0,66	2,31	0,94
B20	2,24	1,95	0,63	2,27	0,92
CC5	2,28	2,20	0,82	3,02	1,12
CC10	2,28	2,25	0,85	3,08	1,22
CC15	2,27	2,23	0,81	3,05	1,17
CC20	2,28	2,17	0,80	2,98	1,10
Requirements of DSTU 8976-2020 for grade M20	-	-	-	From 2.00 to 3.90	Not less than 1.00

It is advisable to begin the study of the properties of road materials of the specified compositions, produced using cold recycling technology, by determining the average density, since this indicator is directly related to their water saturation. It was found that the average density of road materials, which include construction waste of various types, mostly changed slightly (Table 1). The exception is all compositions with asbestos-cement slate - from AS5 to AS20, the average density of which decreased by 2-6% compared to the control composition, which indicates their greater porosity and susceptibility to water saturation. Water in road materials due to many cycles of freezing and thawing can lead to an increase and spread of cracks, which will affect their strength and durability. When determining the water saturation of road materials with construction waste of various compositions, it was found that their water saturation depends not only on porosity, an indicator of which is the average density, but also on the structural and textural features of the waste used (Fig.).



a *b*

The influence of construction waste of different composition on the water saturation of road material samples after 7 days (a) and 28 days (b) of hardening

Thus, the water saturation of road material samples with the replacement of 20% by weight of milled material with asbestos-cement slate, which had the lowest average density, is twice as high as that of the control composition. The water saturation of road materials containing glass and brick waste and having similar average density values was approximately at the same level. Among the studied road materials using construction waste, the samples containing concrete waste were characterized by the lowest water saturation. At the same time, their average density was on a par with the control composition and even slightly exceeded it (Table 1). This is explained by the peculiarities of the concrete composition, which contains cement hydrate phases capable of compacting its structure, reducing porosity and water saturation. After 28 days of hardening, the water saturation of road materials of all studied compositions naturally increases, but the established effect of various types of construction waste on water saturation is preserved. According to the requirements of the standard, this indicator should not exceed 9.5%. Therefore, among the studied road material compositions, one's containing 15% by weight and 20% by weight of asbestos-cement slate waste cannot be used to produce road materials using cold recycling technology.

The strength of the obtained road materials from dry land of different compositions, which differed in both the type and content of waste, was determined according to the requirements of the standard at the age of 28 days at a hardening temperature of 20 °C and 50 °C, as well as at the age of 7 days. This allowed us to trace the influence of the composition on the kinetics of the increase in the strength of the studied road materials (Table 1).

When analyzing the strength of road materials in which part of the aggregate was replaced by construction waste and comparing them with the strength of the control composition and the requirements of the standard, the influence of the type and amount of waste used should be taken into account. Thus, the strength of samples with asbestos-cement slate of compositions AS5-AS20 at the age of 28 days is the highest among all tested wastes and exceeds the strength of the control composition. But given the high water saturation of compositions AS15 and AS20, they cannot be used to produce road materials using cold recycling technology. The use of glass and brick waste in mixtures for producing road materials is limited to compositions G5 and B5, which is due to their low strength at a temperature of 50℃. Only the road material samples containing crushed concrete in compositions CC5 - CC20 fully meet all the specified strength requirements.

Conclusions

Based on a systematic approach to assessing the potential use of construction waste generated from the demolition of buildings and structures, it has been established that cold recycling technology allows for the partial replacement of traditional milled road materials with alternative components such as waste asbestos-cement slate, glass, brick, and crushed concrete. It has been established that mixtures using 5-10% by weight of asbestos-cement waste, 5% by weight of glass, 5% by weight of brick or 5-20% by weight of crushed concrete allow obtaining road materials that correspond to M20 in terms of physical and mechanical properties. Mixtures of the specified compositions can be used in the arrangement of road surface layers using the cold recycling method. This not only provides a sustainable solution for managing demolition waste but also contributes to resource conservation and environmental protection in road construction practices.

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МОЖЛИВІСТЬ ВИКОРИСТАННЯ МАТЕРІАЛІВ ІЗ ЗРУЙНОВАНИХ БУДІВЕЛЬ У ТЕХНОЛОГІЇ ХОЛОДНОГО РЕСАЙКЛІНГУ ДЛЯ ШАРІВ ОСНОВИ ДОРОЖНЬОГО ОДЯГУ

Основним напрямком сталого розвитку є раціональне використання природних ресурсів, попит на які при будівництві дорогі зростає. Важливим при цьому є також зменшення негативного впливу на довкілля, адже як в результаті активності розбудови, так і внаслідок війни в Україні кількість відходів будівництва та знесення будівель зростає. Тому вирішення проблеми утилізації цих відходів є дуже важливим.

В роботі була досліджена можливість використання таких будівельних відходів як азбестоцементний шифер, скло, цегла та бетон в якості заповнювачів у сумішах для шарів основи дорожнього одягу виготовлених за технологією холодного ресайклінгу. З цією метою було запроектовано та досліджено 17 складів суміші – контрольний склад та 4 серій складів, у яких фрезерований дрібнозернистий асфальтобетон було частково замінено подрібненими азбестоцементним шифером (склад AS), склом (склад G), цеглою (склад B) та бетоном (склад CC) у кількості 5-20 мас.%. Усі досліджені склади містили 3% портландцементу і 3% води. Визначено фізико-механічні показники сумішей та матеріалів виготовлених за технологією холодного ресайклінгу із різним вмістом будівельних відходів. Встановлено вплив виду та кількості досліджуваних будівельних відходів на середню густину, водонасичення та границю міцності на стиск через 7 діб та 28 діб тверднення за температури 20 °С та 50 °С дорожніх матеріалів виготовлених за технологією холодного ресайклінгу.

Як показали проведені дослідження, вимоги до дорожніх матеріалів марки М20 з використанням портландцементу згідно ДСТУ 8976:2020 задовольняють склади із заміною 5 мас.% та 10 мас.% фрезерованого матеріалу азбестоцементним шифером, склади із заміною 5 мас.% склом та цеглою, а також усі склади, які містили 5-20мас.% подрібненого бетону. Таким чином, ці склади можуть бути використані при влаштуванні шарів основи дорожнього одягу за технологією холодного ресайклінгу.

Ключові слова: холодний ресайклінг, портландцемент, цегла, скло, азбестовий шифер, подрібнений бетон.