6th WMCAUS 2021
World Multidisciplinary Civil Engineering - Architecture - Urban Planning Symposium
30 August-3 September, 2021 - Prague (Czech Republic)

APPLICATION OF WASTE ROCK DUST IN CEMENT BINDING MIXTURES USED IN ROADWAY

Szymon Topoliński [1], Aleksandra Gorączko [1], Ahmet Beycioğlu [2], Baki Bağrıaçık [3]

[1] Faculty of Civil, Architecture and Environmental Engineering, Department of Road Engineering, Transport and Geotechnics, University of Science and Technology in

[2]Engineering Faculty, Civil Engineering Department, Construction & Building Materials Division, M1 Engineering Building, Office Z20, Adana, Turkey

[3] Faculty of Engineering and Architecture, Civil Engineering Department, Çukurova University, Balcalı, Sarıçam, Adana 01330, Turkey

Introduction

Rock dust is a waste generated in aggregate mines during rock crushing and sorting of mineral aggregates used, among others, for the production of concrete. Similar dusty waste is produced in the technological process of producing the MMA asphalt mix. The disposal of this waste is a considerable problem. The interest in the use of waste materials is growing due to the increasing demand for aggregate in the construction industry.

During the grant implementation, research was carried out, which indicates that waste rock dust in the production of mortars and concrete can be used as a partial replacement for sand and even cement. Waste dust seals the concrete structure, increasing its durability and positively affecting its strength. This type of waste can also be successfully used for soil stabilization. It has been proven that waste rock dust has a positive effect on the properties of cohesive soils. Their addition increases their compressive strength and in the case of limestone waste, it reduces their swelling and deformability.

In the case of soil stabilization with cement according to PN-EN 14227-1: 2013-10 and WT 5, it is allowed to use additives such as lime, fly ash, or calcium chloride. However, there is no information on the possibility of using waste material of rock origin.

Research material and research program

Dust waste produced in the technological process for producing the MMA mineral-asphalt mixture obtained from PBDiM KOBYLARNIA S.A. was used for the tests. These dusts were produced by grinding limestone and gabbro rocks. The particle size distribution curve of the dusts used is shown in Figure 1. The popular and commonly used CEM II / B-V 32.5R cement was used for stabilization.

The aggregate used was fine sand from the Sikorowo mine, obtained thanks to the courtesy of GDDKiA in Bydgoszcz. Its grounding and the marked compaction parameters are presented in tables 1 and 2, respectively.

The test program is based on PN-EN 14227-1: 2013-10 , WT 5 and PN-S-96012. Mixtures with variable amounts of cement and waste dust were designed. The unconfined compressive strength R28 [MPa] was determined after 28 days of curing. Cylindrical samples with a diameter of Φ = 100 mm and H / D = 1.2 were used. The samples were formed with a Proctor mechanical compactor according to PN-EN 13286-50:2007. Figure 2 shows the particle size distribution curve of the sand used, placed between the grain size limit curves for CBGM 0/8 mixtures. The content of the finest fractions is exceeded in relation to the requirements for this type of mixtures according to WT5. possibility of using waste material of rock origin.

Laboratory tests of the mixtures were carried out in the road laboratory of the GDDKiA in Bydgoszcz. Table 3 presents a simplified scope of the mixture strength tests with a different proportion of waste rock dust and cement.

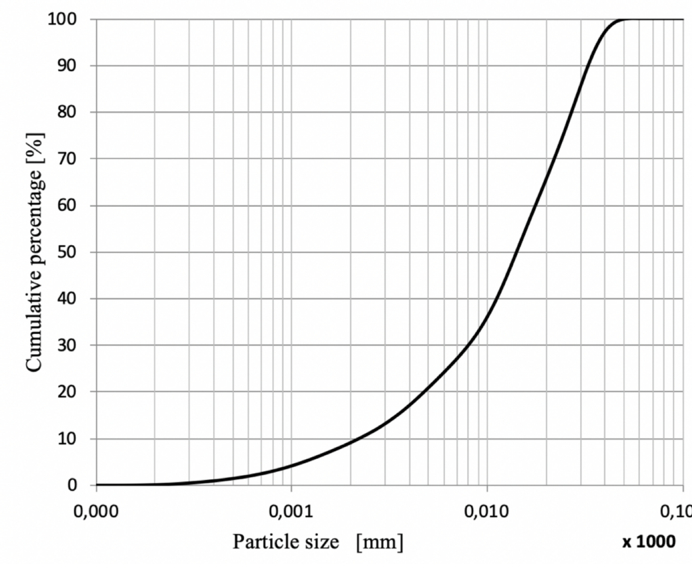

Figure 1. The particle size distribution curve of the used dust

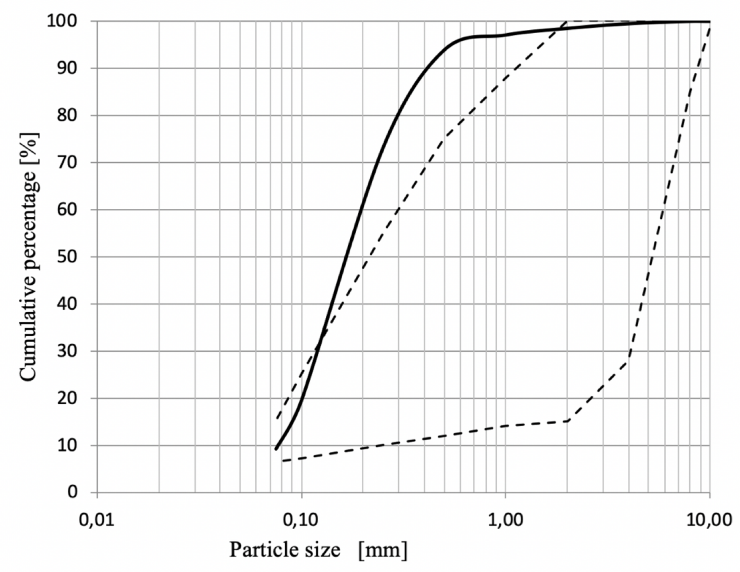

Figure 2. The particle size distribution curve of the tested sand together with the limit particle size distribution curves for CBGM 0/8 mixtures according to WT5

Table 1. The grain size distribution of the used sand

	SYMBOL	UOM	RESULTS
The Uniformity Coefficient	Cu	-	2,8
Gravel fraction content	$f_ż$	%	1,5
Sand fraction content	f_p	%	89,3
Dust fraction content	$f_{\pi+i}$	%	9,3

Table 2. Determined compactability parameters of the used sand

	SYMBOL	UOM	RESULTS
Moisture content	W_{opt}	%	15,1
Maximum dry mass density	ρ_{ds}	g/cm³	1,694

Table 3. A simplified scope of sand mixtures strength tests

		CEMENT CONTENT		
		3%	5%	7%
DUST CONTENT	0%	Mixture 1	Mixture 2	Mixture 3
	10%	Mixture 4	Mixture 5	Mixture 6
	20%	Mixture 7	Mixture 8	Mixture 9

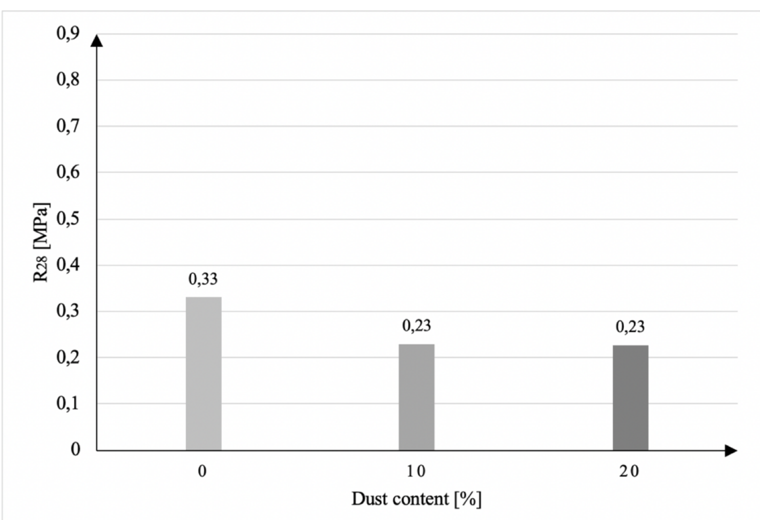

Figure 3. Average unconfined compressive strength results after 28 days of maturation R_{28} at 3% cement content

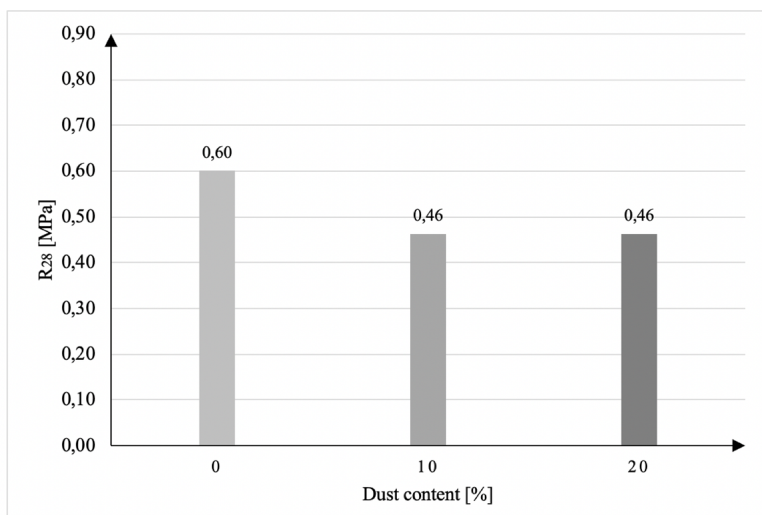

Figure 4. Average unconfined compressive strength after 28 days of maturation R_{28} at 5% cement content

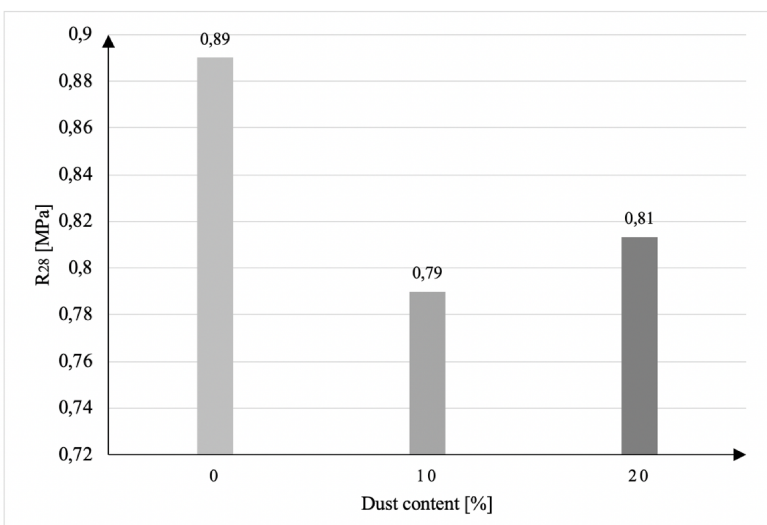

Figure 5. Average unconfined compressive strength after 28 days of maturation R_{28} at 7% cement content

Results and discussions

The obtained values of unconfined compressive strength R28 after 28 days are shown in figures 3-5. Determination method made in accordance with PN-EN 13286-41:2005.

In mixtures with the lowest cement content, the obtained compressive strengths, regardless of the share of waste dust, are low (figure 3). Without the addition of dust, the compressive strength was 0,33 MPa, and for the dust content of 10 and 20%, it reached the strength of 0,23 MPa.

Compressive strength values for mixtures with a cement share of 5% are almost twice as high (figure 4). For dust contents of 10 and 20%, the strength was 0,46 MPa and was about 23% lower than the mixture without waste dust.

For the cement content of 7%, the differences in the strength values were much smaller and did not exceed 11%, but also in this case the samples without the addition of waste dust turned out to be the strongest – 0,89 MPa (figure 5). Noteworthy is the higher compressive strength value of 0,81 MPa for mixtures with a dust share of 20% compared to 10%.

Conclusions

The tested fine grained sand is difficult to stabilize with cement, even without waste rock dust. None of the mixtures achieved a satisfactory compressive strength and are not suitable for use in road construction. It should be noted that in the case of mixtures with a low cement content (3% and 5%), the addition of waste rock dust did not significantly reduce the compressive strength. In the case of mixtures with 7% cement content, increasing the content of waste rock dust to 20% had a positive effect on the strength of the mixtures in relation to their 10% content.

Acknowledgements

This article/material has been supported by the Polish National Agency for Academic Exchange under Grant No. PPI/APM/2019/1/00003.