APPRAISAL OF DESERT SAND AS A SOURCE OF SUSTAINABLE DEVELOPMENT

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Abstract- Sustainable development demands exploring innovative construction materials and waste recycling techniques. However, the desert sand present in huge volumes remains unexplored for its suitability as construction material for decades. The stone processing industry produces large volumes of marble dust (WMD) waste, and its uncontrolled disposal poses a serious environmental hazard. The current study aimed to evaluate the physical and engineering properties of dune sand collected from Thal, a famous desert in Pakistan. After the initial exploration, the research work further evaluated the effectiveness of WMD as an additive for improving this sand. WMD was mixed with sand in proportions varying from 5-30 %. The experiments yielded promising improvements in dry density and unconfined compressive strength (UCS). Fifteen Percent (15%) by volume was identified as the optimum dosage of the WMD. The research work paves the path for utilizing desert sand in civil engineering projects and proposes fruitful recycling of WMD, reducing environmental pollution. Further studies are recommended to expand the scope of the investigation to evaluate its suitability as a mortar for masonry works and a potential concrete ingredient.

Keywords- Desert, WMD, Soil Improvement, Pollution, Dune sand.

1 Introduction

The Thal desert is situated in the southwestern part of the Punjab province in Pakistan. The geographic coordinates taken at the sample collection points are 31^0 10' N and 71^0 30' E. It has an approximate length of 190 miles (306 km) with a maximum breadth of 70 miles (113 km). The total area of the Thal desert is about 10,000 km^2 (3,900 sq mi). The Thal desert soil is alluvial with sandy textured dunes covering 50 to 60 per cent of the area. The maximum and minimum temperatures of the Thal desert are recorded at about 44 ºC and less than 0 ºC, respectively. The average annual precipitation varies from 385 mm in the north-east to 170 mm in the south. Approximately three-fourths of annual rainfall is received during monsoon. [Source: Thal Development Authority]

A large quantity of waste marble dust is produced while cutting and processing different stones. Almost twenty-five (25%) of the raw marble stone is lost in the form of dust. During the fiscal year 2016-2017, 4.9 million tons of wastage were generated in Pakistan. More than 2.15 million tons were generated in Khyber Pakhtunkhwa province (KPK), 1.92 million tons in Baluchistan, and 0.82 million tons in the previous FATA region. [1] Waste marble dust is hazardous if it is not controlled or recycled. If mixed with soil in some proportions, the results may favour geotechnical properties and effective waste management. [2]. Various industries regularly produce ceramic and marble waste everywhere in Algeria and worldwide. It is a big problem for the waste management authorities of every country. This type of waste poses serious health hazards and environmental pollution. We can recycle these types of waste to improve different soil types and waste management policies [3]. Huge volumes of waste marble dust, especially colloid, deteriorate the air quality index. It is the utmost requirement of the time to reduce the production of WMD by introducing modern processing and recycling techniques. Sustainable development requires the utilization of waste materials in the construction industry. The utilization of WMD as a slurry has been evaluated and reported to produce encouraging results [4]. Sand dunes have very low resilience; if disturbed, it becomes very difficult to stabilize again to their original position. [5]. The waste marble dust was mixed with desert sand in Oman in different proportions. Its effect on the physical properties of soil was studied and reported to produce considerable improvement in the studied properties [6]. The utilization of WMD as a fine aggregate has also been studied, and a mixture of sand and WMD in 80:20 proportion was found to produce better consistency and flexure strength [7]. Waste marble dust is not only mixed with sand, but it can also be used in black cotton soil, and it gave good results in the index properties of black cotton soil. [8]. The effectiveness of recycled waste marble dust as a grout for in situ soil improvement and deep mixing has been evaluated and reported to improve considerably. Its utilization as grouting material can be environment-friendly recycling of the WMD [9]. In geotechnical engineering, the practice of improving the strength of loose soil with waste marble materials has been increasing [10]. Expansive soil requires treatment to provide a stable foundation for roads and buildings. The studies concluded that the waste marble dust and plastic strips increase unconfined compressive strength and decrease the free swell of soil.[11, 12].

It is evident from the presented literature that researchers have been trying and testing the effectiveness of WMD for various purposes in civil engineering applications. The current study aimed to explore locally produced waste marble dust and desert sand and evaluate their raw physical and mechanical properties. Further to initial exploration, this research also evaluates WMD's potential for improving the target geotechnical properties. The purpose of this research is the maidan appraisal of geotechnical properties of dune sand of Thal desert in Pakistan.

2 Experimental Procedures

The desk study and literature review exercise was followed by a reconnaissance survey of the sample collection site, i.e. Thal desert of Pakistan (Noor Pur Thal). Visual Inspection of the soil characteristics and acquisition of geographic coordinates, followed by collecting samples for the detailed investigation in a laboratory. All the tests enlisted in Table 1 were performed according to the relevant ASTM standards. The standards and procedures followed for each test were carried out on natural and modified soil. Table 2 presents the proportion of sand: WMD and their assigned matrix IDs. The tests enlisted in Table 1 were repeated on all the mixes presented in Table 2.

Table 1 Test Description and Standard Reference

Test	Specification
Atterberg limits	ASTM D4318
Specific gravity	ASTM D854
Compaction Test (OMC and MDD)	ASTM D1577
USC-Unconfined compressive strength	ASTM D2166

Table 2 Mix Proportions and Matrix IDs

S.no	Soil (%)	WMD (%)	Notation
1	100	0	NAT
2	95	5	WMD 1
3	90	10	WMD 2
4	85	15	WMD 3
5	80	20	WMD 4
6	75	25	WMD 5
7	70	30	WMD 6

3 Research Methodology

A comprehensive work plan was devised to streamline the research execution, which is presented below. The Desk study included exploration of the existing data related to the study area, dune sand and the potential additive to improve the studied properties of the geomaterials. The flow chart is shown in figure 1.

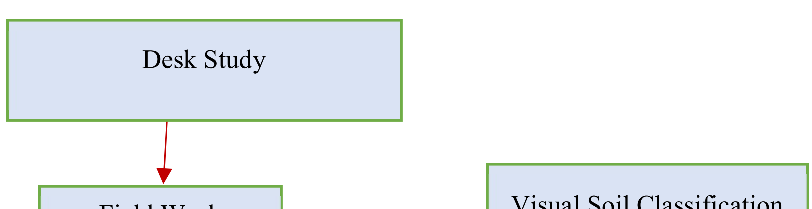

Figure 1: Flowchart

3.1 Material

The dune sand collection point is located near Noor Pur Thal of district Khushab Punjab. The geographic coordinates taken at the site are 31^0 10' N and 71^0 30'. The basic tests were performed to evaluate the physical and chemical properties of sand and are presented in Table 3 below

Table 3. Physical and chemical composition of soil

Test Description	Property Determined	Unit	Value
AASHTO Classification			A-2-4
Physical properties	Natural Moisture content	%	9.3
	Specific gravity		2.71
Atterberg limits	Liquid limit	%	NP
	Plastic limit	%	NP
	Plasticity index	%	N.P
Modified proctor Test	OMC	%	9.3
	MDD	lb/cft	109.
Strength test	UCS	kg/cm^2	0

3.2 Additives

The additive used for this research is Waste Marble Dust (WMD), collected from the marble industry located near Taxila, Pakistan. Waste marble dust is high in calcium oxide content which is cementing property, but it produces many environmental hazards. That's why we select WMD as an additive for desert sand. The Chemical composition of Waste marble dust is shown in Table 4.

Table 4 Chemical composition of WMD.

Oxide Concentrations %	CaO	Al_2O_3	SiO_2	Fe_2O_3	MgO
WMD	42.45	0.52	26.35	9.40	1.52

4 Results

4.1 Index properties

Basic index properties (LL, PL & PI) and gradation were determined to classify further collected soil samples. The Atterberg's limits tests were attempted on all the mixes, but all the mixes remain non-plastic even at the maximum dosage of WMD, i.e. 30 %. The gradation presented in figure 2 led to the classification of raw soil as A-2-4. It means our soil is silty or clayey gravel sand. The gradation curve of WMD is shown in figure 3.

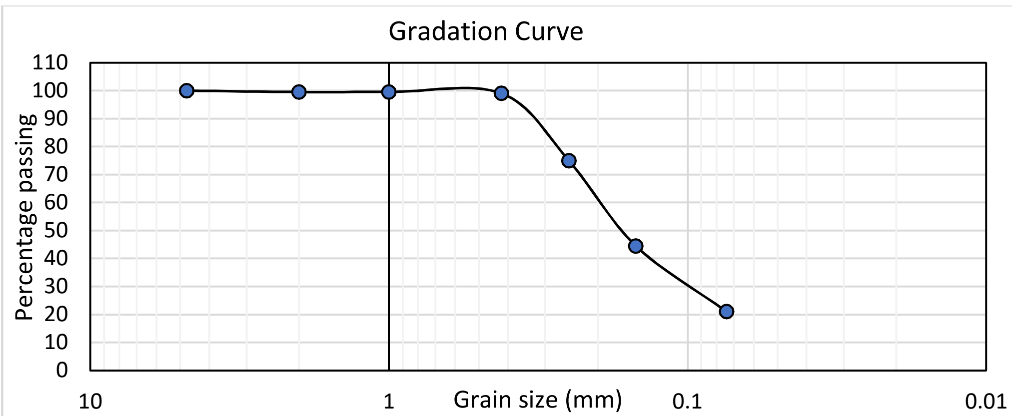

Figure 2: Gradation Curve of Dune Sand

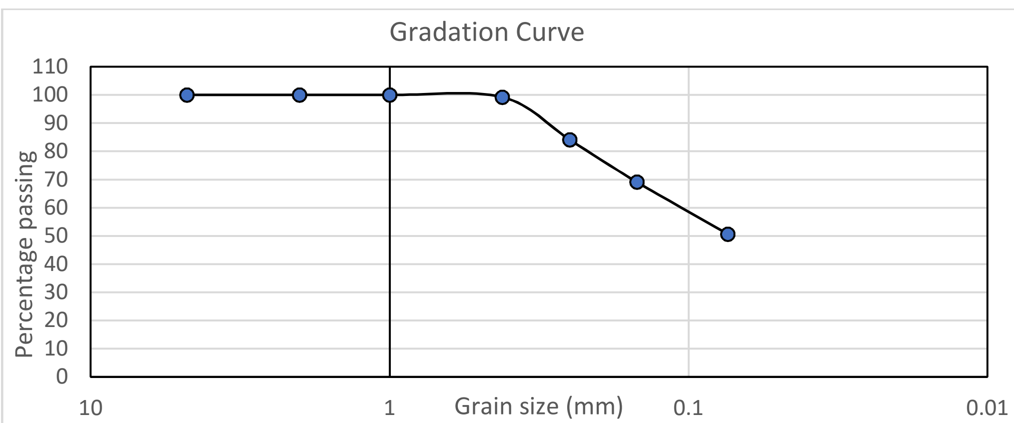

Figure 3: Gradation Curve of WMD

4.2 MDD

We performed a modified proctor compaction test according to ASTM D1557. Each test was performed twice to determine the effect of waste marble dust on MDD and OMC of soil. The results show that the waste marble dust increases the MDD of the soil, as shown in figure 4. The MDD of raw sand (pure sand without additive) was 109.3 lb/ft^3. The MDD increased to 115.9 lb/ft^3 with the addition of WMD, showing a 6 % increase with 30% WMD. The MDD increased due to the cementitious effect of CaO present in waste marble dust and the replacement of waste marble dust particles having a high specific gravity of mixes.

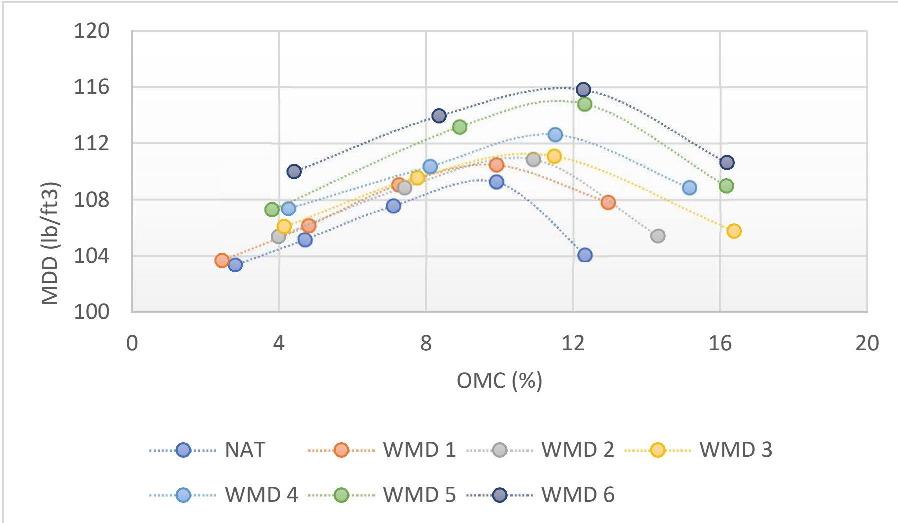

Figure 4: Effect of WMD on compaction tests

4.3 OMC

An increase in OMC was observed with the addition of waste marble dust. The OMC increased from 9.3% to 11.8% by adding 30% WMD, as shown in figure 4. OMC increase shows that an increase in a dry unit weight of soil sample improves the soil properties and reduces the permeability in soil. Hence, mixing waste marble dust in desert sand improves the geotechnical behaviour of that sand.

4.4 Unconfined Compressive Strength Test

Unconfined compressive strength test was performed on raw soil and soil: WMD mixes twice on all the mixes. The pure sand's unconfined compressive strength was zero while increasing to 0.15 (kg/cm2). The improvement in UCS for all the mixes is shown in figure 5. Adding waste marble dust to soil produces a cohesive effect in the soil and achieved 0.15(kg/cm2) unconfined compressive strength by adding 30% of waste marble dust. Hence, by adding waste marble dust to desert sand, the compressive strength of that sand increased.

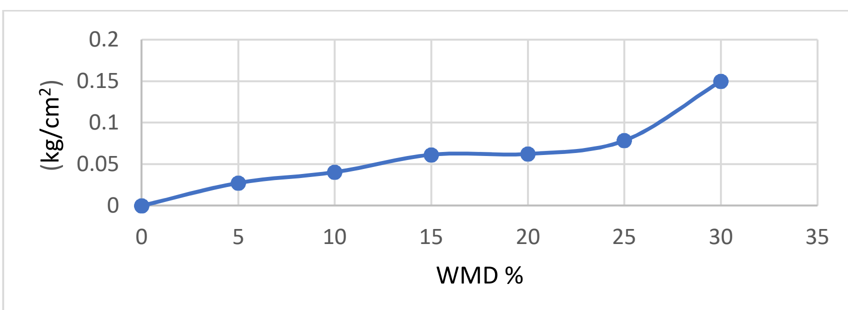

Figure 5: Combine result of UCS with varying percentages of WMD

5 Conclusion

This paper presented a maiden appraisal of the geotechnical characteristics of dune sand in the Thal desert. The initial appraisal also includes an evaluation of WMD as an additive for the dune sand. The experimental study proves WMD's effectiveness for stabilizing dune sand. The following conclusions have been drawn from this study:

1. The current study evaluated the physical and engineering properties of dune sand collected from Thal, a famous dessert in Pakistan, and waste marble dust's effectiveness in improving dune sand's physical and mechanical properties.
2. The Desert/dune sand is an abundant material, and the current study paves the way for its effective utilization in the construction industry.
3. The physical and engineering properties of desert sand can be improved by adding waste marble dust; hence WMD has been identified as an effective additive soil improvement.
4. Using waste marble dust as an additive can reduce environmental hazards posed by its uncontrolled disposal.

This research recommends expanding the investigation's scope to evaluate its suitability as a mortar for masonry works and a potential concrete ingredient.

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