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Influence on Permeability of Dune Sand Blended With Kotastone Slurry Waste

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ABSTRACT

Soil is the loose weathered material over the earth crust, available in abundance naturally. Stabilisation of soil is the technique to improve the various engineering and mechanical properties of the soil to meet the required engineering purpose. In the southern Rajasthan stone mines at Aravalli range generating lacs of MT of waste causing threat to the environment, on the other hand highly permeable desert sand in western Rajasthan is challenging to store the rainwater in water scarce underdeveloped rural areas. In this study, we used the waste of Kota stone to decrease the permeability of dune sand for increasing its water holding capacity and reducing irrigation requirements for crops. As per the data collected from the laboratory test results it is observed that by adding the Kota limestone waste dry powder in the locally available dune sand of western Rajasthan the permeability of the mix decreases significantly with increasing the proportion of the limestone powder. The testing were terminated for further study as the permeability of pure sand reduced to one third of its original value at 10% admixture and no constant pattern is observed in decrement. This study analysis only shows that the permeability of pure sand can be reduced significantly by using small amount of limestone powder. Further research is required for determining the factors by which the variation of reduction in coefficient of permeability gets affected.

Key words: *Dune sand, Kota limestone, Slurry, Waste, Permeability*

Introduction

The geographical feature of Western Rajasthan comprises of Thar Desert part in India which consists of mainly sand dunes scattered over the landmass. These sand dunes covers almost four fifth of the area of the Rajasthan. It has windblown silty sand, i.e. Aeolian soil. The soil mass in desert area is gathered due to wind transportation of rock deterioration and it does not possess any cohesion between the particles.

Introduction to the problems associated

1. Faster seepage of rain water in artificial and natural storages due to high permeable soil-

Thar Desert comes under the highly population density having Desert areas. Due to lack of natural and synthetic water sources the habitats living majorly rely on the precipitation. It also has lower

Fig. 1. Dune sand of Thar Desert

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recordings of precipitation and a very short span of monsoon thus the significance of storage of rainfall is high. The fluctuation of rainfall data are also very high in Thar region. In most parts of the Desert region synthetic and natural temporary ponds such as "johads", and "tobas" on surface depressions are the only medium to store the precipitation for community uses (Singh *et al*., 2014).

2. Generation of large amount of waste causing threat to environment-

Rajasthan has very diverse geographic features, it has Thar Desert in the western part and Aravalli mountain range in the southern part has natural storages of mineral ores and building stones.

The Kota and Jhalawar districts has natural storages of more than hundred millions of tonnes of flaggy limestone of sedimentary rock composites of siliceous calcium carbonate in finer grains spreading to more than 15000 hectares known as Kota stone.

It consists highly compressed, water tight, hard, homogeneous sedimentary stone deposits available in green, blue, light brown, and combined shades. The waste generated is more than 4 million tonnes in form of slurry (Rajni and Rajesh, 2017).

Fig. 2. (a) Kota stone (b) dressing of stone

Literature review

The studies on the dune sand has been done for their stabilisation with different materials and different methods as special stabilisers, chemical stabilisation of soils, thermal Stabilisation, electrical stabilisation, stabilisation with geotextiles and geomembranes (Ameta and Abhay, 2008), (Prasad and Purohit, 2017). Stabilisation of soil will be more economical if the admixture used is a waste and if the waste is in such amounts as Kota Lime stone waste the stabilisation will resolve two different issues with a common solution. Hence we selected Kota stone dry powder for this study.

Materials and Methodology used for study

Dune sand

Clear and pure soil used for testing is taken from dunes nearby sand dunes of local sites in Bikaner. Soil is coarse grained loose, chohesionless silty sand having particle size from 75 µ to 300µ range i.e. fine sand as per IS classification of soils.

Kota stone slurry waste

Waste Slurry of Kota limestone generated during cutting and polishing of stone is taken from Kota building stone supplier. After drying the slurry it shows minor flocking properties. The flocks are converted into powder form by wooden ramming and dry Powder is used for investigation.

Table 1. Chemical composition of limestone powder (Rajni and Rajesh, 2017)

Constituent	Composition
Lime	35-40%
Silica	20-30%
Alumina	3-4%
Iron Ores	1-2%

Fig. 3. Kota stone powder used for analysis

Sieve analysis

The sieve analysis is conducted to plot the grain size Distribution curve and classify the soil (IS-2720 Part 4:1985).

Specimen preparation

After performing sieve analysis quantity of Kota limestone powder is added into pure soil mass (0%) and different samples were prepared with proportion in 1%, 2%, 3%, 4%.....10% naming S_0, S_1, S_2,…...S_{10}

respectively. Three alike sample are tested for each mixing proportion and average of the same is used for the results to check and account the errors.

Permeability test (IS 2720-17:1986)

The permeability of each sample is determined using constant head permeability test for coarse grained soils. Darcy's law is assumed to be applicable and is used for the investigation (IS 2720 PART 17, 1986)

As per Darcy's law of permeability-

q = k * i * A or k = q/iA

q = discharge per unit time

k = darcy's coefficient of permeability

i = hygraulic gradient = hydraulic head per unit length of bed

A = area of cross section of soil specimen

Experimental outcomes and Discussion

Sieve analysis outcomes

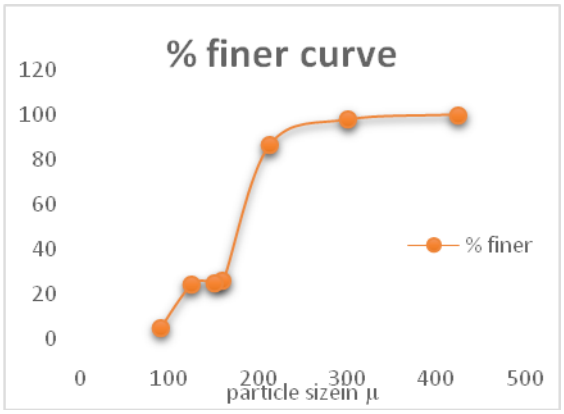

Fig. 4. Particle size distribution curve for soil specimen

Particle size distribution curve

The permeability coefficient with different proportions of limestone powder mixed with dune sand is continuously decreasing as –

Table 3. Coefficient of permeability observed at different proportion

Sample	% Kota limestone powder by weight in soil specimen	coefficient of Permeability (K) (cm/hr)
S_0	0%	61.60340
S_1	1%	52.75030
S_2	2%	44.85643
S_3	3%	40.83481
S_4	4%	39.21407
S_5	5%	39.03516
S_6	6%	36.09418
S_7	7%	35.22539
S_8	8%	31.36246
S_9	9%	26.53939
S_{10}	10%	24.60027

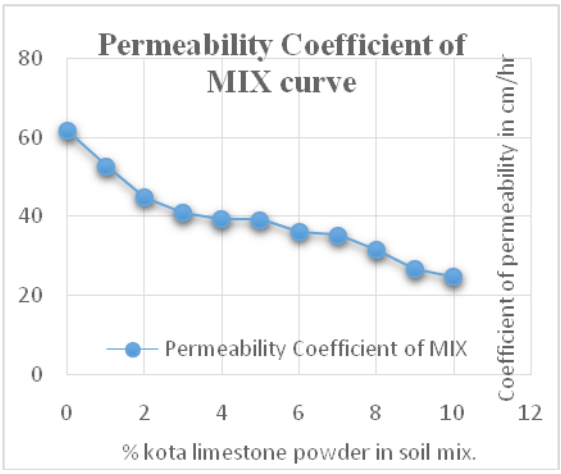

Fig. 5. Permeability Coeff. Curve

Table 2. Sieve analysis recordings of soil specimen

Is Sieve Size(µ)	Weight Retained (Kg)	%Weight Retained	Cumulative % Weight Retained (% Finer)	Cumulative % Weight Passing
425	0	0	0	100
300	0.011	2.2	2.2	97.8
212	0.057	11.4	13.6	86.4
160	0.303	60.6	74.2	25.8
150	0.005	1	75.2	24.8
125	0.003	0.6	75.8	24.2
90	0.097	19.4	95.2	4.8
L.P.	0.024	4.8	-	-
Fineness Modulus	3.362			

The permeability coefficient variation plot is as-

Conclusion

Pure desert sand has permeability coefficient

$$k = 61.6 \frac{cm}{hr} (pure\ sand)$$

Coefficient of permeability of sand (K) is reduced up to one third of its initial value at 10% limestone powder and desert sand mix.

$$k = 24.6 \frac{cm}{hr}$$ (At 10% limestone powder)

As per the data collected from the laboratory test results it is observed that by adding the Kota stone waste dry powder in the dune sand taken from Bikaner, Rajasthan the permeability of the mix decreases significantly with increasing the proportion of the limestone powder. The testing were terminated for further study as the permeability of pure sand reduced to one third of its original value at 10% admixture and no clear pattern is observed in decrement. Further study is required for determining the factors by which the reduction in permeability gets affected.

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