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Stabilization of Waste Sand Obtained from Stone Industries and Marble Slurry Waste With White Cement as Foregoing Alternatives for Bricks Industries

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Abstract —*The wastage of marble industry are responsible for many environmental problems because 70% wastes and only 30% recovery of main product contribute to the maximum wastes which are indestructible. Dumping sites give dirty look. Contaminate top fertile soil cover, along with rivers/water bodies affecting irrigation and drinking water resources and air as well as loss to flora and fauna. The most efficient Solution of marble slurry and stone slurry pollution is utilization in Bulk. The only industry which can consume marble slurry and stone slurry at so large level is only the construction industry. This paper analysis discusses the potential of stone waste and marble slurry sand stabilization with white cement as admixture. Present work has been taken up by addition of white cement as admixture. The varying percentage 5%, 7%, 9%, 11%, 13% and 15% of white cement were mixed with stone waste and marble waste sand of different densities and moisture content. All the Compressive Strength Tests were conducted at different mix compositions of normal cement and waste sand of different dry densities as arrived from Standard Proctor Test. On the basis of the experiments performed, it is determined that the stabilization of stone waste and marble waste sand with white cement as admixture improves the strength characteristics of the waste sand so that it becomes usable as construction of embankment and manufacturing of bricks. And also we manufacture a brick that is of mixture of stone sand waste and marble sand waste and white cement and the strength of this brick is as similar as II class brick.*

Keywords- *Compressive Strength Tests, C.B.R. Test, Marble Waste Sand, Standard Proctor Test, Stone Waste Sand, White Cement.*

I. INTRODUCTION

If weak soils exist, stabilization and improvement of their properties is necessary. The stabilization process aim to increasing the soil strength and reducing its permeability and compressibility. The stabilization process may include mechanical, chemical, electrical or thermal processes. The processes used depend on the type of soil at site, the time available to execute the project and the stabilization cost compared to the overall cost of the project. Expansive soil possesses great threat for the construction of buildings due to its less characteristic shear strength and high swelling and shrinkage characteristics. Problematic soils, especially expansive soil deposits are considered to be a potential natural hazard, which can cause extensive damage to structures if not adequately treated. During the last few decades, damage due to swelling action has been observed clearly in the semi-arid regions in the form of cracking and breakup of pavements, roadways, building foundations, slab-on-grade members, and channel and reservoir linings, irrigation systems, water lines, and sewer lines. In order to control this behavior, the expansive soils have to be suitably treated with industrial solid waste (stone slurry waste) or any other available materials which can alter its engineering behavior.

Rajasthan is the richest state in the country with regards to marble deposits (1100 Million Tons) both in quality & quantity. Around 4000 marble mines and 1100 marble processing units, spread over 16 Districts out of 33 Districts of Rajasthan. The important regions of marble deposits are Udaipur - Rajsamand - Chittorgarh region, Makrana - Kishangarh region, Banswara - Dungarpur region, Andhi (Jaipur) - Jhiri (Alwar) region and Jaisalmer region.

Marble occur abundant in nature. It is used and mined many places in the world since early time. Around 90% of the world's production of marble comes from India and approx 85% of India's production is received from Rajasthan and almost all mining and processing activities are concentrated around Makrana, where the proposed study is planned to undertake. Rajasthan has more than 4000 marble mines and about 1100 marble gang saws (processing units). At the same time it leads to growth of many processing units in respective areas. These two activities in Rajasthan have been extended in 20-25 years and have played important role in the economy of the state providing direct and indirect employment to majority of people and therefore also raising their living standard.

Over the last few years, utilization of byproduct of industrial solid waste has been focus of many researchers. Quarrying and stone cutting is the main extractive industry which produce huge amount of stone slurry waste during extraction, cutting and processing of rocks. The stone slurry waste is usually disposed indiscriminately in open areas and sewage network causing several health and environmental problems. The study aims to investigate using of the stone slurry waste and using specific amount of Portland cement to stabilizing the cohesive soil. The stone slurry waste taken from stone cutting plant was dried, grinded to fine particle and then mixed with specific amount of Portland cement and cohesive soil. Stone slurry wastes contain heavy metals and suspension solids and mainly consist of calcium carbonate ($CaCO3$). The stone slurry waste is usually disposed indiscriminately in open areas and sewage network causing several health and environmental problems. The amount of waste accumulating from quarries, stone cutting plants and in open areas pressing problem facing the stone industry. In addition to depleting mineral resources, it causes serious environmental

impact to water, air, soil, the landscape biodiversity and human communities. In general, the main issues associated with quarrying and stone production are:
1.) Slurry waste disposal reduces the area of fertile land.
2.) Increase in pH value and impact of flora, fauna and soil.
3.) High impact on air quality, ground water and surface water.
4.) Fine suspended solids cause respiration problems.
5.) Heavy metals in stone slurry are not soluble in water.
6.) Consumption of large amount of fresh water.

II. LITERATURE REVIEW

Soil stabilization is the process of improving the engineering properties of the soil and thus making it more stable. It is required when soil available for construction is not suitable for the intended purpose. In the broad sense, stabilization includes compaction, pre-consolidation, drainage and many other such processes. Stabilization is the process of blending and mixing materials with a soil to improve certain properties of the soil. The process may include the blending of soils to achieve a desired gradation by the mixing of commercially available additives that may alter the gradation, texture or plasticity, or act as a binder for cementation of the soil. Soil stabilization is used to reduce the permeability and compressibility of the soil mass in earth structures, to reduce the swell in case of expansive soils and to increase its shear strength. Soil stabilization is required to increase the bearing capacity of foundation soils.
Stone slurry waste is a one of the newest additives and many studies about using stone dust in soil improvement have been done. The use of stone slurry in some talented fields such as soil improvement, seepage and grouting will offer great advantages in geotechnics. Stone slurry is the by-product material generated by cutting and shaping of building stones in cutting plants the water used for cooling up the cutting saw flows out carrying very fine suspended particles as high viscous liquid known as stone slurry. For stabilization we use stone slurry with cement because cement increases its cementaneous properties of soil.
The industry involves mining and processing units for the production of tiles for walls and floors, articles, waste production and other ancillary works. The marble mining and the industry as a whole are different from other industries to the very fact that, the marble is a "Dimensional Stone", which means the stone is sold by size not by weight (In other words in sqm not by tonnes). Since the selling price increases manifolds with size, all the operations involving mining and processing are aimed to get slabs as big as possible.
Many studies have been carried out in regard to stabilizing the soil, so as to enhance its properties. Some of the notable works are mentioned here. Sridharan and soosan et.al (2005) identified that quarry dust manifest high shear strength and is beneficial for its use as a geotechnical material. Sabat et.al (2012) conducted compaction, tri-axial and durability tests on lime stabilized expansive soil-quarry dust mixes. Satyanarayana, et al (2013) has studied that the strength characteristics of compacted crusher dust and Crushed Stone mixes through a series of CBR tests by varying the crusher dust. Ramadas and Kumar et.al (2010) reported that the combination of fly ash and stone dust found to be suitable to reduce swelling and increase the strength of expansive soil.

III. MATERIALS USED FOR PRESENT STUDY

3.1 Stone Waste

The principle waste coming into the stone industry is the stone itself, specifically in the forms of overburden, screening residual, stone fragments. Stone wastes are generated as a waste during the process of cutting and polishing. It is estimated that175 million tons of quarrying waste is produced each year, and although a portion of this waste maybe utilized on-site, such as for excavation pit refill or berm construction, the disposals of these waste materials acquire large land areas and remains cattered all around, spoiling the aesthetic of the entire region. It is very difficult to find a use for all scrap stone and fines produced. This soil remains after cutting of sandstone is collected from the Stone Park, 9 Mile, Nagour Road, NH-65 Jodhpur, and Rajasthan. The Sandstone Block is transported to the stone factories from stone mines which are located at Soorsager, Keru, Balsamand, Balesar region. The geology of the zone is obscured by the high temperature 40°-50°C. Table 1 show the properties of stone waste and figure 1 show the source of sand stone and figure 2 show Waste Sand Obtained from Stone Industries as below.

Table 1: Properties of Stone Waste

Sr. No.	Constituent	Value (%)
1	SiO2	36.96
2	Al2O3	0.49
3	Fe2O3	3.40
4	CaO	28.60
5	MgO	6.08
6	SO3	0.15
7	LOI	22.16

Fig.1. Source of Sand stone

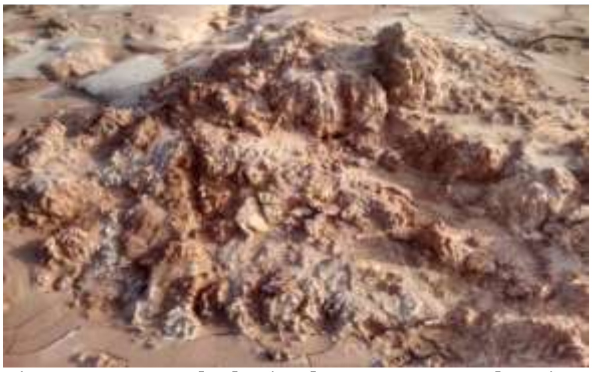

Fig.2. Waste Sand Obtained From Stone Industries

3.2 Marble Waste

Marble is a metamorphic rock composed of recrystallized carbonate minerals, most commonly calcite or dolomite. Marble may be foliated. Geologists use the term "marble" to refer to metamorphosed limestone; however, stonemasons use the term more broadly to encompass unmetamorphosed limestone. Marble is commonly used for sculpture and as a building material. Marble is a non-foliated metamorphic rock which is composed of recrystallized carbonate which is formed when limestone is exposed to high temperatures and pressures over a long time. Marble is a rock resulting from metamorphism of sedimentary carbonate rocks, most commonly limestone or dolomite rock. Metamorphism causes variable recrystallization of the original carbonate mineral grains. The resulting marble rock is typically composed of an interlocking mosaic of carbonate crystals. Primary sedimentary textures and structures of the original carbonate rock have typically been modified or destroyed. Pure white marble is the result of metamorphism of a very pure (silicate-poor) limestone or dolomite protolith. The characteristic swirls and veins of many colored marble varieties are usually due to various mineral impurities such as clay, silt, and sand, iron oxides which were originally present as grains or layers in the limestone. Green coloration is often due to serpentine resulting from originally magnesium-rich limestone or dolostone with silica impurities. These various impurities have been mobilized and recrystallized by the intense pressure and heat of the metamorphism. Table 2 show the properties of marble waste and figure 3 shows the source of marble stone and figure 4 show that Waste marble sand Obtained from marble Industries as below.

Table 2: Properties of Marble Slurry Waste

Sr. No.	Constituent	Value (%)
1	SiO2	96.60
2	Al2O3	1.0
3	Fe2O3	1.20
4	CaO	0.28
5	MgO	0.20
6	LOI	Less than 0.5

Fig.3. Source of Marble stone

Fig.4. Waste Sand Obtained From Marble Industries

3.3 Current Status of Marble slurry And Stone Slurry Disposal

Marble Slurry is a suspension of marble fines in water, generated during processing and polishing, etc. Environmental Hazards due to waste It is shaping to major threat of the Environment in the state by mining and processing activities. Nearly one thousand Gang saws and thousands of cutters are producing 15-20 lack tons of marble slurry waste which is indestructible waste and harm to general Public. Some of effects of the marble slurry may be listed as under: -

1. The waste is indestructible.
2. The sites which can be used as dumping ground are limited and give repulsive dirty look.
3. Contamination of top fertile soil cover.

4. Contamination of the rivers and other water bodies there by adversely affecting irrigation and drinking water resources.

5 Accidents due to unscientific dumping:

A) Due to dumping of mine waste and marble slurry on road side causing dust in air (polluting air) and creating less visibility, due to less visibility number of accidents occurs.

B) Accidents due to slippery roads. In rainy season marble slurry flows over roads. Due to marble slurry road becomes slippery and many accidents take place.

C) Loss to flora & fauna already grown trees and bushes die out and new ones do not grow due to deposition of marble slurry. Animals also suffer for their food and shelter

Earlier, the marble slurry and sand slurry generated through processing units was collected improperly & dumped at any abandoned land and near the roadsides. This kind of practice is still going on near to Chittorgarh, Nimbahera, Neemuch & Shahpura (Alwar) areas. However, due to Government orders on control of environmental pollution & public awareness, these kinds of activities have reduced & now the local Marble Associations have identified the disposal sites and the generated slurry is being disposed through tankers at identified sites without spilling out on roads. The current statuses of slurry disposal practices are as under:

Kishangarh district is having 523 marble gang saws and 28 granite cutters in operation. Approximately slurry generation is 5500-6000MT per day. The generated slurry is being transported through tankers (capacity 4000 litres) to the Rajasthan State Industrial Development & Investment Corporation Ltd. (RIICO) notified disposal site. Daily 2000-2200 tankers are engaged in slurry disposal. Kishangarh Marble Udyog Vikas Samiti has developed a dumping yard (Phase-I) in year 2005-06 of about 322 bigha area of 30-35 feet depth. The decanting wells are also provided and decanted water is recycled to gang saw units. This yard was designed to fulfill the 05 years of dumping requirement. Another site near to this yard has already been developed dumping yard phase-II in 532 bigha area to switch the dumping at this site. The Kishangarh Marble Udyog Vikas Samiti and Kishangarh Marble Association have taken up very effective steps towards the dumping/disposal of marble slurry and sand slurry. Penalties are being posed on units who are dumping waste marble slabs & slurry anywhere in the town. However, the broken marble slabs (Krazzy) at dumping site are freely collected by the marble chip & tiling units.

Makrana More than 421 marble processor, granite cutter, modern slab & tile processing units are in operation in this town. Many stone crafting units have also developed. About 939 querries & mines on lease/license are active in marble mining. The processed waste (slurry) is being dumped/disposed at unauthorized land near to the railway crossing, Manglana, before entering in Makrana. The proper authorization is yet to be awarded by RIICO to Sangmarmar Vyapar Mandal & Industrial area Entrepreneur Association, Makrana to develop the dumping yard.

Rajsamand district of largest marble deposits has more than 250 modern gangsaws, 125 mineral grinders & 20-25 tiling units. Marble Gangsaw Association, Rajsamand has identified & developed dumping yard is 250 bigha area near to the Nandora village. To avoid air pollution, huge plantation was done by the association; however the survival of the plants was found very poor. Other than slurry dumping at yard, it is being used as landfill in the lowlying areas. Minerals Grinding Plant Association, Rajsamand asked for 3,00,000 MT/year marble waste to replace the raw material requirement in grinding by 15-20% as a filler material.

Udaipur has over 100 Million Tons of marble deposits at around Babarmal, Rikhabdev, Masaron Ki Obri, Darauli, Tidi, Jaspura, Paduna, Manpur and Lohagarh etc. 600-700 queries/mines are in mining operation. About 135-150 Gangsaws in 100 marble processing units & 20-25 marble tiling plants are in operation. Udaipur Marble Processors Association has identified a dumping yard at Chitrakoot Nagar near to Khelgaon & regular slurry dumping/disposal is being done through tankers. This 30ft deep dumping yard needs to be raised upto 100fts high parapet walls to overcome the problem of slurry overflow during rainy season. Earlier the slurry was used to landfill the Khelgaon low-lying area.

3.3 White Cement

In this experimental work the admixture is used as Portland White Cement with their Universal properties. White cement is used as admixture because of is good bonding property and for colour of bricks is come whitish or pink. Below figure 5 show the newly manufactured bricks show the light pink colour because of white cement.

Fig.5. Brick of waste soil remains from stone industries

IV. TEST PROGRAM AND PROCEDURE

The laboratory investigation on stone waste sand stabilization with Portland white cementas admixture was performed. This work is done for beneficial utilization of stone waste sand and a mix proportion that can be mixed with white cement as a best stabilizer with limited detrimental effects.
The objective of the present study is to evaluate the use of stone waste sand as a construction material after stabilizing it with white cement as admixture and manufacturing value added products like bricks. The present study has been undertaken with the following objectives:
1. To study the effect of moisture content on dry density of stone waste sand.
2. To study the changes in compressive strength of stone waste sand of different percentage mixed with white cementin different proportions.

4.1 Test Program

The test program included the preliminary tests for stone waste sand and mix compositions of stone waste sand with white cement. Following tests were carried out:
1. Determination of particle size distribution of fine sand.
2. Standard Proctor Test (Proctor Compaction Test) for determining different dry densities for fine sand.
3. CBR Test to determine CBR value for stone waste sand and mix compositions with white cement.
4. Unconfined Compressive Strength Test to determine compressive strength of Stone waste sand and mix compositions with white cement. Table 3 shows the variables which are investigated in present study.

Table 3: Variables Investigated

S. No.	Effect of	Variables	Range Investigated
1	Moisture content in sand	Dry density	Various Ranges
2	Stone Waste Sand	Amount in Kg	As per Test Required
3	Marble Waste Sand	Amount in Kg	As per Test Required
4	Mix White Cement	Proportion Percentage	5%, 7%, 9%, 11%, 13% and 15%

4.1.1 Particle Size Distribution or Gradation Test of Fine sand

The particle size distribution test or gradation test was carried out with Indian Standard Sieve size 4.75 mm, 2.36 mm, 1.18 mm, 600 µ, 425 µ, 300 µ, 150µ, 75µ, pan and weigh balance in the laboratory. A typical sieve analysis involves a nested column of sieve with wire mesh cloth (screen). A representative sample of 1000 gm is poured into the top sieve which has the largest screen opening of 4.75 mm. Each lower sieve in the column has smaller opening than the one above. The base is a round pan, called the receiver. The sample was shaken vigorously for 10 minutes on sieve shaker. After the shaking, the weight of material retained on each sieve was weighed. Percentage passing through each sieve was calculated and plotted against particle size. Since percentage passing 75 µ is within 1% only, hydrometer analysis was not done.

$$\text{Percentage (\%) Retained} = \frac{W_{sieve}}{W_{total}} \times 100\%$$

Where Wsieve is the weight of aggregate in the sieve in gm
Wtotal is the total weight of the aggregate in gm
The cumulative percentage passing of the aggregate is found by subtracting the percent retained from 100%.
Percentage (%) Cumulative Passing = 100% - Percentage (%) Cumulative Retained
The results of particle size distribution have been shown in table 4, table 5 and figure 6.

Table 4: Particle Size Distribution of Fine Sand

S.No.	Sieve Size	Weight Retained (gm)	% Weight Retained	Cumulative % Weight Retained	Cumulative % Weight Passing	% Finer
1.	4.75 mm	0	0.0	0.0	100	100
2.	2.0 mm	0	0.0	0.0	100	100
3.	1.18 mm	0	0.0	0.0	100	100
4.	600 µ	0	0.0	0.0	100	100
5.	300	8	0.80	0.80	99.2	99.2
6.	150	962	96.2	97.00	3.00	3.00
7.	75	30	3.0	100.00	0.0	0.0
8.	PAN	0	0.0	100.00	0.0	0.0

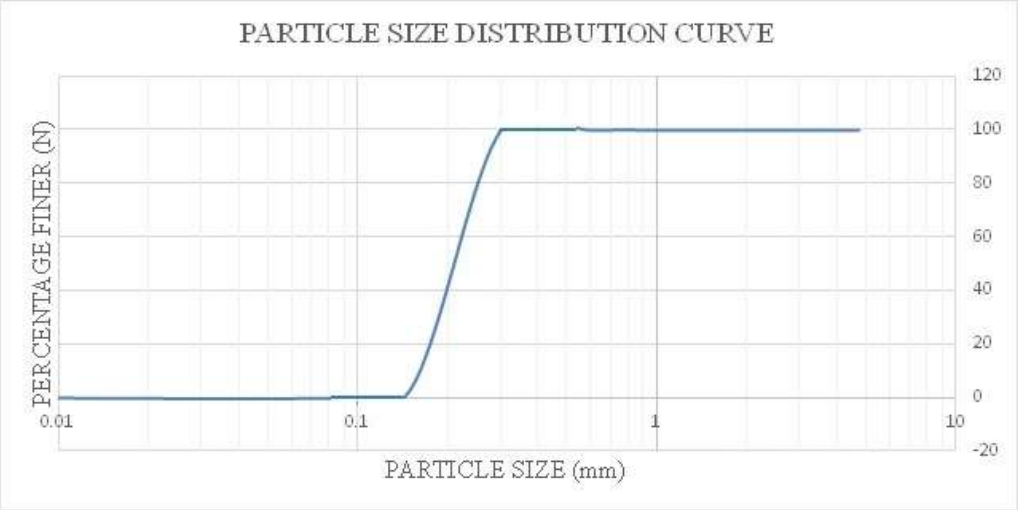

Figure 6: Particle Size Distribution Curve

Table 5: Results of Particle Size Distribution

S.No.	Property	Test Media Waste Sand
1	Coefficient of uniformity(C_u)	1.23
2	Coefficient of curvature(C_c)	0.78
3	Particle size D_{60}	0.21 mm
4	Mean Diameter (D_{50})	0.20 mm
5	Particle size D_{30}	0.16 mm
6	Effective size (D10)	0.14 mm
7	Fine soil fraction (75µ)	0%

4.1.2 Standard Proctor Test

Standard proctor covers the determination of the relationship between the moisture content and density of soils. The standard proctor test was performed in accordance with IS 2720 (Part VII) on fine sand. In this test, a standard mould of 100 mm internal diameter and an effective height of 127.3 mm, with a capacity of 1000 ml are used. The mould had a detachable base plate and a removable collar of 50 mm height at its top. The soil was compacted in the mould in 3 equal layers; each layer was given 25 blows of 2.6 kg rammer falling through a height of 310 mm.

The result tabulated in table 6 and figure 7 shows that on increment of moisture content, dry density first decrease and then increase. In the curve dry density first decrease due to bulking of sand. After reaching maximum dry density on optimum moisture content, dry density decreases.

Table 6: Dry Density Variation with Water Content for Soil Remains after Cutting of Sand Stone and Marble Stone Mixed with White Cement

S. No.	% WATER ADDED (BY WEIGHT)	DRY DENSITY (gm/cc)
1	9	1.48
2	11	1.49
3	13	1.53
4	15	1.57
5	17	1.59
6	19	1.54
7	21	1.53
8	23	1.51
9	25	1.50
10	27	1.52

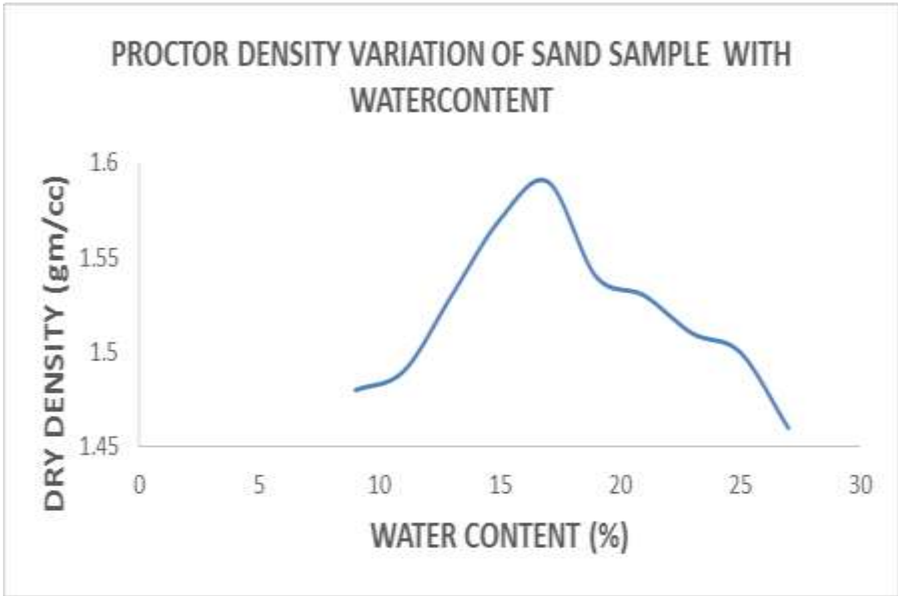

Figure 7: Proctor Density Variation of soil remains after cutting of sand stone and marble stone mixed with white cement with water content

4.1.3 California Bearing Ratio (C.B.R.) Test

In CBR test, 5 kg of soil was taken and mixed with water corresponding to required dry density and proportion of cement. The mix was compacted in 2250 ml CBR (150 mm diameter and 127.3 mm height) using light compaction. The mix was compacted in three equal layers; each layer being given 56 uniformly distributed blows of 2.6 kg hammer. Top surface of the specimen was finished properly to make it for even loading test. For the soaked condition, the samples were tested for the determination of CBR values on the next day.

For obtaining the CBR values of unsoaked samples, penetration tests were done. The mould, containing the specimen was mounted on the testing machine and a surcharge weight equal to 5 kg (two spacer discs) was placed on the top of specimen before starting the penetration test. After setting the plunger on the surface of specimen, setting the load and penetration measuring dial gauge to read zero, the load was applied. Load readings at every 0.5 mm penetration were noted and a graph was drawn between the actual load (ordinate) and penetration (abscissa). In most of the tests the curve was either straight or convex upwards in the initial portion. In such cases the test load corresponding to 2.5 mm and 5.0 mm were read from the curve. In the case of the initial upward concavity, the corrected zero is obtained by drawing a tangent to the curve at the point of the greatest curvature. The corresponding to 2.5 mm and 5.0 mm penetration are measured from the corrected zero.

Test results obtained show that CBR value increases with increase in dry density of sand. The CBR value also increases with increase in percentage of white cement for same dry density sand. The test results are shown in tables and graph.

4.1.3.1 Comparative Study

The variation in CBR values have been tabulated and graphically represented in table 7, figure 8, for unsoaked condition. On the graph, at abscissa (X-axis) dry density of stone waste sand varying 1.53 gm/cc, 1.57 gm/cc and 1.59 gm/cc has been marked and on ordinate (Y-axis) CBR values in % have been plotted for mix compositions of white cement of different percentage 5%, 7%, 9%, 11%, 13% and 15%.

It can be seen that on increment of dry density, the CBR value of the mix composition increases. The CBR value of the mix composition also increases as the percentage of admixture increases for unsoaked conditions. Hence it can be concluded that to use the mix compositions in base and sub base construction and manufacturing of bricks, the CBR values can be increased or decreased as needed.

Figure 7: CBR Value Variation in Mix Compositions in Unsoaked Conditions

Dry Density (gm/cc)	CBR (%)					
	Mix Composition					
	5% Admixture	7% Admixture	9% Admixture	11% Admixture	13% Admixture	15% Admixture
1.53	5.001	5.186	6.204	4.986	3.852	3.112
1.57	5.002	5.057	6.466	4.850	3.522	3.376
1.59	5.007	5.245	6.676	5.007	4.053	3.815

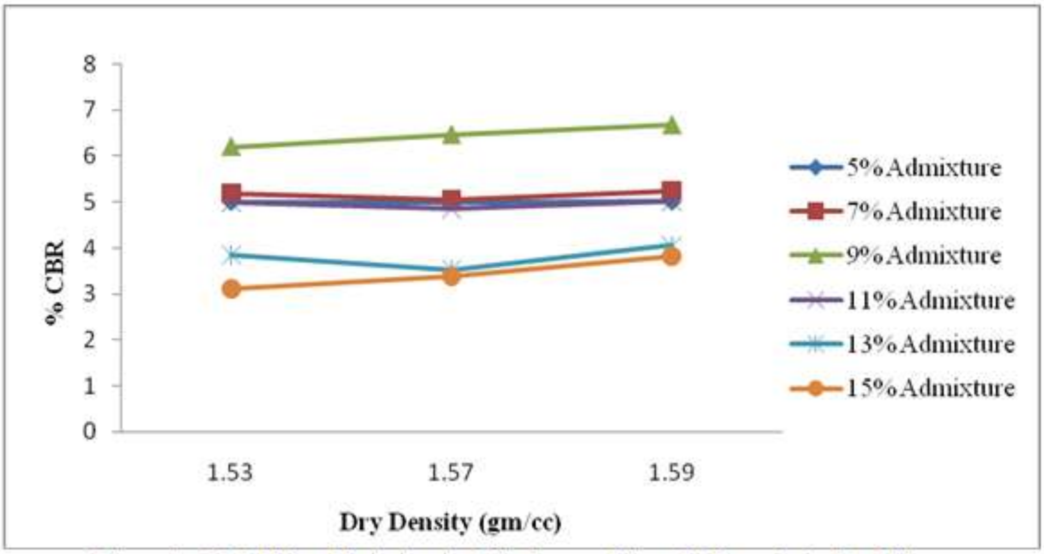

Figure 8: CBR Value Variation in Mix Compositions in Unsoaked Conditions

4.1.4 Compressive Strength Test of Specimen Cubes (Bricks)

For cube test has mould 10cm X 10cm x 10cm is used. This cube (sand mixed with cement) is poured in the mould and tempered properly so as not to have any voids. After 24 hours these moulds are removed and test specimens are put in water for curing. The top surface of these specimens should be made even and smooth. This is done by putting Cement paste and spreading smoothly on whole area of specimen.

These specimens are tested by compression testing machine after 1day, 3day, 7 days curing or 28 days curing. Load should be applied gradually at the rate of 140 kg/cm^2 per minute till the Specimens fails. Load at the failure divided by area of specimen gives the compressive strength of concrete. Below figure 9 show the setup of Compression Testing Machine and table 8 show the Mix Compositions and Symbols for C.S.T Soil Remains after Cutting of Sand Stone.

Figure 9: Compression Testing Machine

Table 8: Mix Compositions and Symbols for C.S.T Soil Remains after Cutting of Sand Stone

CEMENT % → STRENGTH	5%	7%	9%	11%	13%	15%
1st DAY	2.1	2.3	4.5	4.7	5.2	5.86
3rd DAY	4.65	5.10	5.25	6.60	7.10	7.38
7th DAY	5.0	5.25	5.35	6.80	7.25	7.43
14th DAY	5.25	5.35	5.45	7.00	7.40	7.59
28th DAY	5.40	5.50	5.85	7.25	7.55	7.67

Above results shows that the waste soil remaining of sandstone industries is used in building materials mixed with cement as partition wall, decorative wall etc. The strength of this type of bricks is at 13% cement on 28days is 7.55 N/mm^2 which is equal strength of second class bricks is 7.00 N/mm^2 so it can be used at palace of second class bricks. Further the cost of second class fly ash brick is 5 Rs. per unit as compared to high as sand waste bricks (3.50Rs.per unit).

V. CONCLUSIONS

In this investigation we have used stone waste sand, marble stone waste and white cement as admixture in different proportions to study its effect on various geotechnical properties of Stone waste sand obtained from stone industries. The results of the testing program clearly show that the engineering properties of the stone waste sand improved considerably due to stabilizing with white cement. In the present investigation, as we are increasing the quantity of admixture of white cement, the compressive strength increases. So we have stopped the further increment of admixture. Further study can be done by addition of more amount of admixture.
After analysis of the test results presented in the tables and figures of plotted graphs,

The following conclusions are drawn regarding the performed experimental study:

1. The compressive strength of specimen increases with increases in amount of Cement due to binding property of Cementations material.
2. As the results indicates that the soil characteristics such as gradation, particle size, shape are affects the strength behavior of the Cement - soil.
3. The sand waste usage in the investigation has the potential to reduce the environmental menace of sand waste.
4. The results of CBR test indicates that the proper mixing of Cement in soil with appropriate amount improved strength and deformation behavior of sub grade soil. It is appropriate to say that the reason behind the above conclusion is, the interaction between soil and Cement which causes the resistance to penetration of the plunger resulting into higher % CBR Values.
5. As percentage of Cement increases the strength of specimen also increase so it can be use in building work as a decorative work.

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