

## Laboratory Performance Assessment of Rendering made with different Sharp Sand and Silty Soil Blends

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**Abstract:** This study was undertaken to evaluate the engineering properties and behaviour of different type of soils used for rendering. Two soil types namely: sharp sand (SS) and silty soil (PS) were used for the study. The soil types were blended to produce six different mix combinations which include: 100%SS/0%PS, 80%SS/20%PS, 60%SS/40%PS, 20%SS/80%PS and 0%SS/100%PS by weight. The engineering properties of the two different soil types and a blend of the two different soil types were investigated. The two different soil types were mixed with Portland cement to produce plaster using a mix design of 1:3. (cement: aggregate). The structural properties of the plaster were also investigated. Findings obtained from sieve analysis test classified sharp sand and silty soil as A-2-4 and A-2-6 according to AASHTO Soil Classification System, SC (sand mixed with clay) and SM (sand mixed with clay) according to Unified Soil Classification System. The specific gravity of sharp sand and rendering soil were 2.65 and 2.55 respectively, liquid limit, plastic limit, shrinkage limit and plasticity index ranged from 24.74% - 34.8%, 16.1% - 28.51%, 6.02% - 8.64% and 2.22% - 8.64% respectively. The maximum dry unit weight and optimum moisture content ranged from 14.91kN/m<sup>3</sup> - 18.80kN/m<sup>3</sup> and 14.86% - 21.77%. Findings obtained from slump test revealed that the slump of the fresh plaster increased with increase in amount of sharp sand with the slump value ranging between 15mm - 40mm, the hardened density and compressive strength of the plaster increased with increase in the amount of sharp sand. The study therefore discourage the use of only silty soils for rendering as such rendered surfaces would be susceptible to occurrence of shrinkage cracks and spalling.

**Keywords :** Mortar, rendering, sustainability, compressive strength

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### 1. INTRODUCTION

Rendering entails the process of covering block walls, brick walls, concrete or reinforced concrete surfaces with cement mortar for decorative or protection purposes. According to Wayer et al. (2015), rendering is the process of covering rough surface or masonry walls with mortar which is the mixture of cement, sharp sand water and sometimes admixtures such as hydrated lime or silty soils. Usually during rendering, mortar are spread over the block or brick wall and then

trowel is used to make the surface smooth to the required level (Yusuf, 2019). The primary aim of rendering is to provide smooth and water resistant surface which guarantees further surface treatment works such as painting, tiling and screening (Yusuf, 2019). According to Corinaldesi et al. (2015), rendering also enhances thermal and sound protection in structures. Some of the structural components of buildings and other structures protected from the

adverse effect of harsh environmental conditions are: beams, columns, walls and slab. The major components of mortar used for rendering are the binder (cement) and filler also known as aggregate. The filler material conventionally used for production of rendering mortars in Eastern Nigeria is sharp sand which is often mixed with silty soil. The sharp sand silty soil blend is intended to achieve both strength and workability at any given amount of cement content. The use of sharp sand in the production of plaster is to prevent the occurrence of shrinkage cracks in rendered surfaces (Abah and Ndububa, 2020).

Built structures can be deemed or viewed as aesthetically pleasing when painted with selected paint colour but painting takes place after rendering (Yusuf, 2019). Rendering, plastering, screeding and painting are termed finishes (Yusuf, 2019). The aesthetic appearance, sound, thermal and water resistance of a structure is largely dependent on the quality of rendering, therefore, the importance of rendering on a structure cannot be overemphasized.

The quality and performance of mortars largely depends on the quality of workmanship and properties of mortar material used (Abah and Ndububa, 2020). This situation has resulted to commitment of huge amount of financial resources in the maintenance of cracks and other imperfections resulting from poor quality control as it regards rendering. Therefore there is need to investigate the different soil types used for production of mortars for rendering as this will serve as a tool for making informed decision regarding material selection and overall performance of mortars used for rendering. Abah and Ndububa, (2020) carried out a comparative assessment of the qualities of top and bottom clay soils as an alternative to river sand mortar in construction. The study was inspired by the scarcity and increasing cost of river mortar sand in Nigeria. In the study, clay soil excavated at the top and bottom level of a natural clay deposit was used as an alternative to river mortar sand in the production of mortar. The natural properties of the clay soil was investigated likewise the river fine sand. Two mortars were produced using the excavated clay and river fine sand with the structural properties of the mortars determined and compared. The structural properties of the mortars that were determined were the compressive strength, water absorption and weight due to dehydration. Results obtained from the determination of compressive strength, water absorption and weight loss due to dehydration after 7, 21 and 28 days of curing for both the cement-clay mortar and cement-river sand mortar were relatively within close range which therefore suggest that clay soils can be used as

an alternative to river mortar sand in the production of mortars for rendering.

Yusuf, (2019) conducted a research on evaluation of comparative performance of mortar sand in Yola Metropolis. The study was motivated by the speculation made by professionals within the construction industry in Yola that cement requirement for rendering sand differ considerably. In the study, two rendering sands were used, the two rendering sands were used to produce mortar cubes using nominal mix ratio of 1:3 and water to cement ratio of 0.7. Findings obtained from the study revealed that the compressive strength, flexural strength and durability of hardened mortar cubes produced using the two river fine sands were not the same as fine sand requiring high amount of cement yielded relatively higher compressive strength, flexural strength and durability than mortar sand requiring low amount of cement. Hence the need for high mortar strength and lesser cement consumption makes the study into the blending of the soils expedient (Zahedi et al., 2015). There are cases where fresh mortars spalls from rendered surface after rendering leaving visible cracks. These conditions have been attributed to poor mix design occasioned by knowledge gap on the properties of the different soil types used in the production of mortar and also the use of non-conventional materials (excavated silty soils) in the production of mortars used for rendering therefore it is pertinent to evaluate the inherent engineering properties and behaviour of the different soil types used for rendering which will serve as a basis for making informed decisions regarding the material selection, quality control during batching and production of quality mortars used for rendering. For these reasons, this study attempts to find an optimum proportion for the blending of sharp sand and silty soil in the making of mortars for rendering purposes.

## II MATERIALS AND METHODS

### 2.1 Materials

The materials used in this study includes, cement, sharp sand, silty sand, and water. Ordinary Portland cement used for the experiment was Dangote 3x cement of grade 42.5. Sharp sand used in producing the mortar is river sand from Omanbala river. The silty soil used in the research was collected from excavated top soils from construction areas within Nnamdi Azikiwe University Awka. The water sample used for the production of mortar was provided by laboratory attendant present at Civil Engineering Laboratory of the same University.

**2.2 Batching**

Considering the case of general external application for the mortar, a mix ratio of one part of cement to three parts of both sharp sand and silty soil was used. A predetermined water to cement ratio of 0.6 was used to carefully mix the cement and all other samples in the research. Sharp sand (SS) and silty soil (PS) were blended to yield six different mix combinations which are: 100%SS/0%PS, 80%SS/20%PS, 60%SS/40%PS, 40%SS/60%, 20%SS/80%SS and 0%SS/100%PS by weight.

**2.3 The Tests**

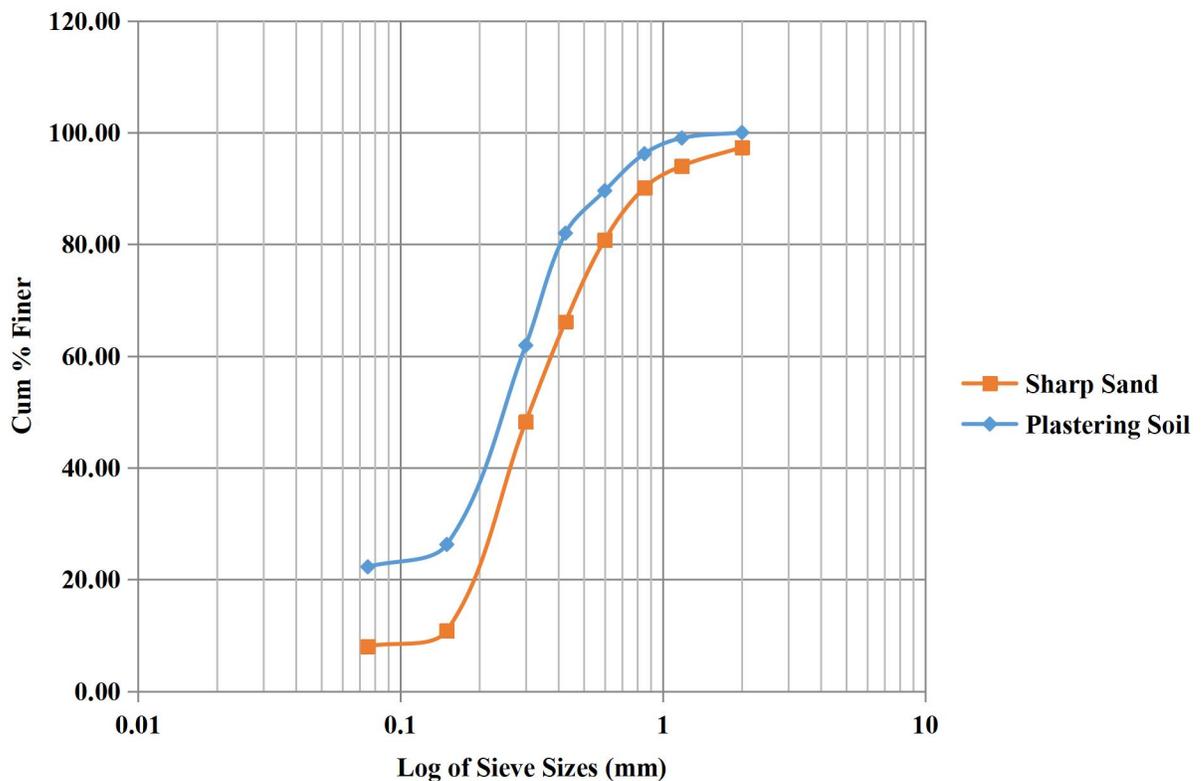
The following are the list of laboratory tests, apparatus employed and procedures for carrying out some of the above mentioned tests; sieve analysis, specific gravity, Atterberg limit, and compaction were performed on the sharp sand and silty soil whereas workability and compressive strength tests were performed on the fresh and hardened mortar respectively.

**III. RESULTS AND DISCUSSION**

This chapter presents key findings obtained from laboratory investigation of geotechnical and structural properties of sharp sand, silty soil and blend of sharp sand and silty soil. Analysis of the geotechnical properties of the individual and combined samples and how it affects the structural properties of both the wet and hardened mortar was also presented. Below is a presentation and description of the above mentioned information.

**3.1 Sieve Analysis Test**

Fig. 1 depicts the particle size distribution curve for sharp sand and silty soil (also referred to as plastering sand). The particle size distribution test was conducted so as to determine the percentages of the different soil fractions present within a given sample which is valuable in categorizing the sample.



**Fig. 1 Particle Size Distribution Curve for Sharp Sand and Silty Soil**

The percentage passing through sieve no 200 (0.075mm) sieve for sharp sand and silty soil were 8.03% and 22.26% respectively which corresponds to the amount of fines present within the respective samples. On the basis of the percentages of fractions passing through sieve no 200 (0.075mm), sharp sand

and rendering soil are classified as A-2-4 and A-2-6 according to AASHTO Soil Classification System, SC (sand mixed with clay) and SM (sand mixed with silt) according to Unified Soil Classification System. The relatively high amount of fines present in the rendering soil suggest that rendering soil will produce mortars with better degree of surface texture and will require

high water to cement ratio than sharp sand particularly when used individually. Table 1 shows the summary of

gradation parameters and classification of the soils tested.

**Table 1 Summary of Findings Obtained from Sieve Analysis Test for Sharp Sand and Silty Soil**

Parameters/Samples	Sharp Sand	Silty Soil
Coefficient of Uniformity (Cu)	4	0
Coefficient of Curvature	1.44	0
AASHTO Soil Classification System	A-2-4	A-2-6
Unified Soil Classification System	SC	SM

### 3.2 Specific gravity and Atterberg Limit Test

The specific gravity and Atterberg Limits of sharp sand and silty soil blends are shown in Table 2.

**Table 2 Specific gravity and Atterberg Limit Test Results for Different Mix Combinations**

Mixture	Specific Gravity	Liquid Limit (%)	Plastic Limit (%)	Shrinkage Limit (%)	Plasticity Index (%)
100%SS/0%PS	2.65	-	-	2.22	-
80%SS/20%PS	-	-	-	8.87	-
60%SS/40%PS	-	-	-	12.59	-
40%SS/60%PS	-	24.74	16.1	17.04	8.64
20%SS/80%PS	-	29.6	23.58	22.22	6.02
0%SS/100%PS	2.55	34.8	28.51	27.41	6.29

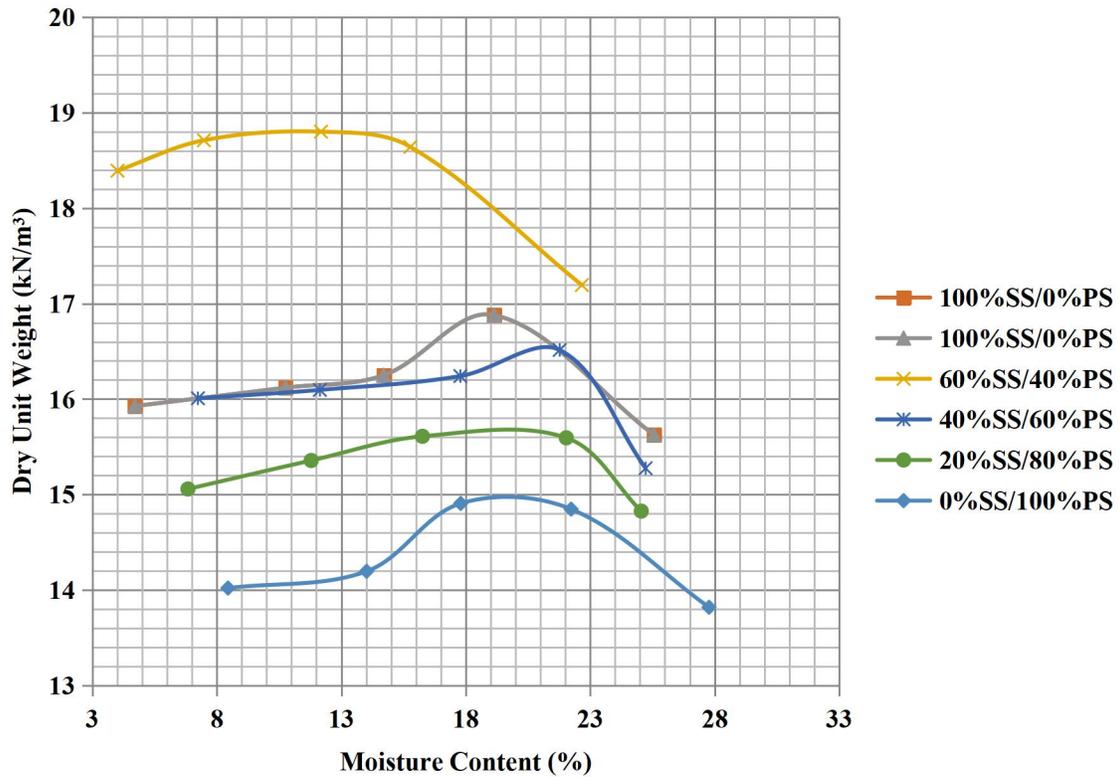
Results obtained indicate that sharp sand has relatively higher specific gravity values than silty soil. The specific gravity values obtained for sharp sand and silty soil suggest that sharp sand will produce a relatively denser mortar than silty soil. The range of specific gravity values obtained for both sharp sand and silty soil suggest the presence of fine grained soils (clay, silt) within the samples which will be of advantage when used for the production of mortar. The liquid limit and plasticity index is an index of the amount of fines present within a given sample as soil sample containing significant amount of fines (clay, silt) tend to exhibit high liquid limit and plasticity index. These soils when used for the production of mortars will require high water to cement ratio due to large surface area provided for hydration of cement necessitated by its degree of fineness. From the findings obtained, increase in the amount of sharp sand reduced the liquid limit, plastic limit and plasticity index of silty soil. The peak liquid and plastic limit was attained only for silty soil; introduction of sharp sand to the silty soil decreased the liquid limit, plastic limit and plasticity index of silty soil up to 60% of rendering. Beyond 60% of silty soil, the mixture was observed to be nonplastic. Findings obtained from shrinkage limit test revealed that the shrinkage limit increased with increase in percentages of silty soil and decreased with increase in percentages of sharp sand. The increase in shrinkage limit could be

attributed to degree of fineness of the silty soil as fine grained soils exhibit high swelling and shrinkage than coarse grained soils. This result therefore suggests that mortars produced by mixing cement and rendering soils are highly vulnerable to shrinkage cracks than mortars produced by mixing cement with a blend of sharp sand and rendering soils.

The consequent decrease in liquid limit, plastic limit and plasticity index of silty soil on partial addition of sharp sand up to 40% could be attributed to the coarse nature of sharp sand which decreased the fineness of silty soil and consequently its liquid limit, plastic limit and plasticity index. It can therefore be deduced that mortar produced with significant amount of sharp sand will have less degree of surface fineness, stickiness, require less water to cement ratio and may be less susceptible to shrinkage cracks than mortar containing insignificant amount of sharp sand. It can therefore be inferred that for production of quality mortars, the proportion of silty soil should be more significant than that of sharp sand as silty soil contributes significantly to service performance of mortars than sharp sand.

### 3.3 Compaction Test Results

Fig. 2 depicts the compaction characteristics of sharp sand, silty soil and sharp sand blended with silty soil at varying percentages.



**Fig. 2 Compaction Curves for Different Mix Proportions of Sharp Sand and Silty Soil**

The peak maximum dry unit weight was attained at a mix combination of 60% sharp sand and 40% silty soil while the highest optimum moisture content was attained at a mix combination of 40% sharp sand and 60% silty soil. It was observed that the maximum dry unit weight of sharp sand was comparatively higher than that of silty soil which suggests that mortar produced with rendering soil will have lesser density

and invariably lesser strength than mortars produced with sharp sand. It was also observed that increase in silty soil initially increased the maximum dry unit weight of sharp sand up to a point where sharp sand still predominate (60%SS/40%PS) beyond this point, the maximum dry unit weight of sharp sand was found to decrease. These values are reported in Table 3.

**Table 3 Compaction Characteristics of Blend of Sharp Sand and Silty Soil at Varying Percentages**

Mix Combination	MDUW (kN/m <sup>3</sup> )	OMC (%)
100%SS/0%PS	16.88	19.14
80%SS/20%PS	17.90	14.86
60%SS/40%PS	18.80	12.18
40%SS/60%PS	16.51	21.77
20%SS/80%PS	15.61	16.26
0%SS/100%PS	14.91	17.80

Comparison of the relationship between the maximum dry unit weight and optimum moisture content revealed that increase in maximum dry unit weight of sharp sand blended with silty soil at varying amount decreased the optimum moisture content values although slight

deviation from the usual trend was recorded at a mix combination of 40% sharp sand and 60% silty soil and 100% silty soil. The decrease in optimum moisture

content on increase in maximum dry unit weight is in agreement with the works of Nwakaire et al. (2015),

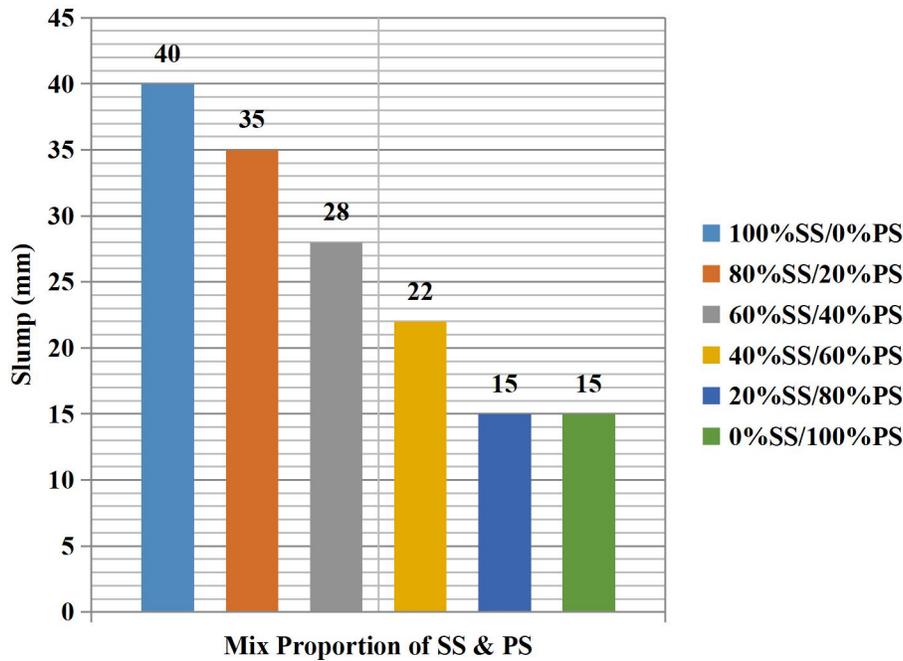
Aginam et al. (2014), Venkatramaiah (2006), Rowe (2000) and other concluded research works.

**3.4 Slump Test Results**

Table 4 and Fig. 3 depicts the slump of the fresh mortar produced with sharp sand, rendering soil and a blend of sharp sand and rendering soil at varying percentages.

**Table 4 Slump Test Result for the Fresh Mortar Produced with Varying Percentages of Sharp Sand and Silty Soil.**

Mix Proportion of Sharp Sand to Rendering Soil	Height of Slump Cone (mm)	Height of Collapse (mm)	Slump (mm)	Slump Type
100%/0%	300	260	40	True Slump
80%/20%	300	265	35	True Slump
60%/40%	300	272	28	True Slump
40%/60%	300	278	22	True Slump
20%/80%	300	285	15	True Slump
0%/100%	300	285	15	True Slump



**Fig. 3 Slump of Fresh Mortar Produced with Varying Proportion of Sharp Sand and Silty Soil**

The peak slump value was obtained for mortar produced with sharp sand while the lowest slump value was recorded for mortar produced with silty soil. It was observed that the workability of the mortar decreased as the amount of silty soil increased. A constant value in workability was attained between a mix combination of 20% sharp sand – 80% silty soil and 100% of silty soil. The decrease in workability on increase amount of silty soil could be ascribed to the high degree of fineness associated with silty soils as they provides larger surface area for hydration and has high water and cement requirement than sharp sand. It can therefore be inferred that mortars produced with

significant amount of silty soils will require more water to cement ratio to achieve workability than mortar produced with insignificant amount of silty soil as the workability of mortar is dictated by the presence of sharp sand than silty soils.

3.5 Compressive Strength Test Result

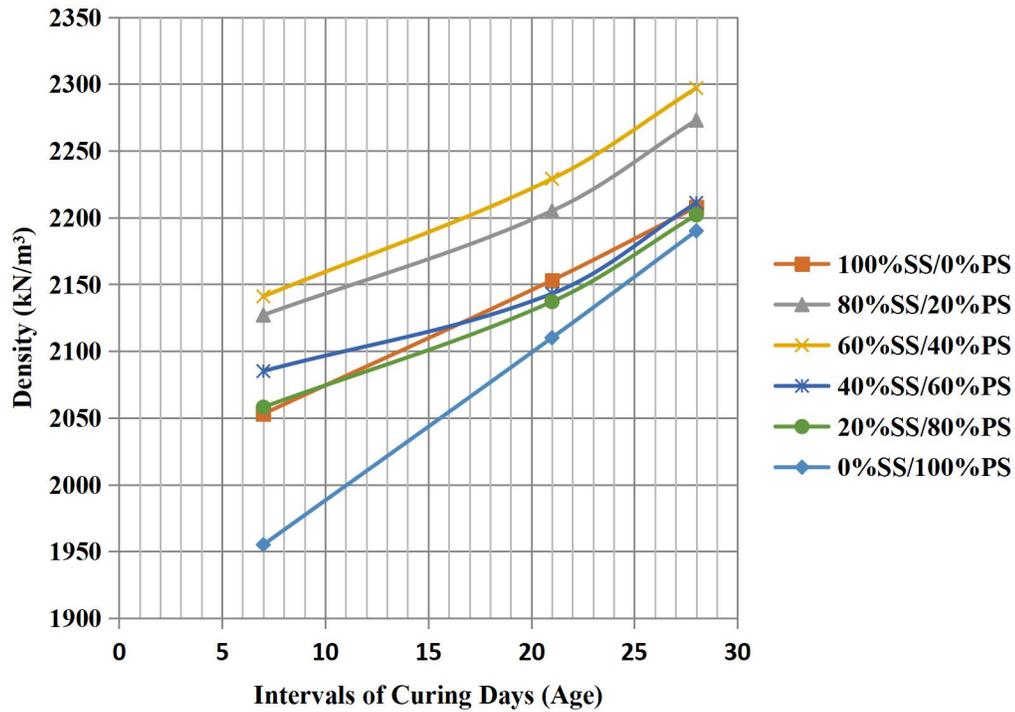


Fig. 4 Graph of Density Vs Curing Days for Mortar Produced with Different Mix Proportion of Sharp Sand and Silty Soil

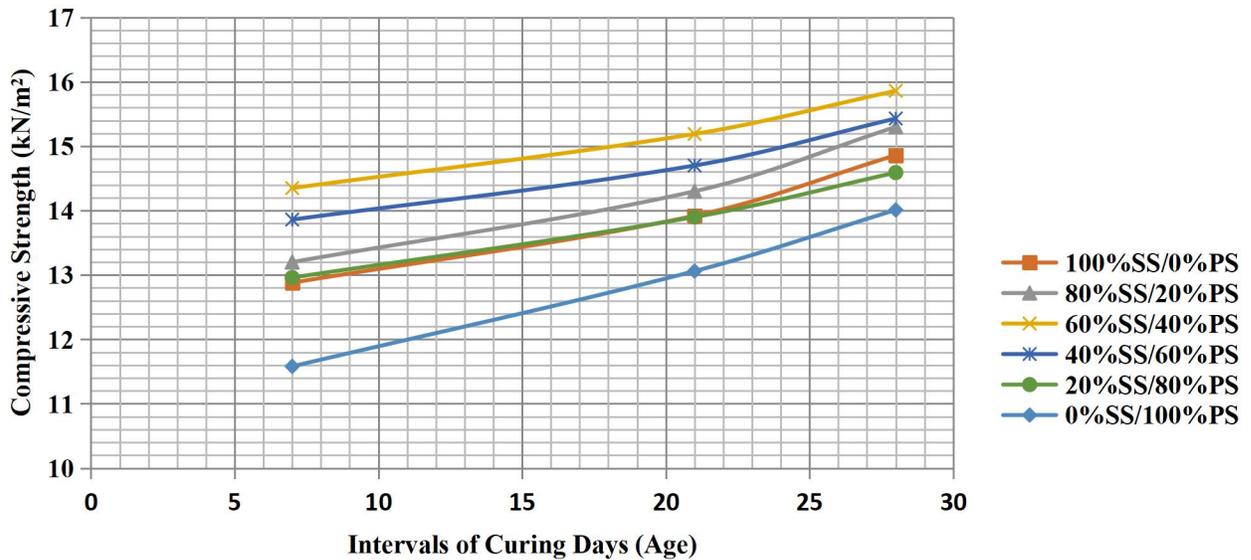


Fig. 5 Graph of Compressive Strength Vs Curing Days for Mortar Produced with Different Mix Proportion of Sharp Sand and Silty Soil

Figs 4 and 5 show the findings obtained from compressive strength test of hardened mortar produced with varying amount of sharp sand, rendering soil and

a blend of sharp sand and silty soil at intervals of curing days ranging from 7- 21-28 days. The findings obtained for the hardened density was relatively

consistent with that of the compressive strength. The peak hardened density and compressive strength was obtained for mortar produced with a mix combination of 60% sharp sand and 40% silty soils while the lowest amount of hardened density and compressive strength was obtained for mortar produced with silty soil only. It was observed that the hardened density and compressive strength increased with curing days. This finding is in agreement with the works of Yusuf, (2019) and (Abah and Ndububa, 2020) where the density and compressive strength was found to increase with increase in curing days.

It was observed that the hardened density and compressive strength of the hardened mortar increased

up to the point where sharp sand predominate the silty soil in amount beyond this point, the hardened density and compressive strength of the mortar was observed to decrease. The latter decrease in density and compressive strength of the mortar could be attributed to the increasing amount of silty soil which decreased the density and compressive strength of the mortar. Comparative assessment of the effect of mortar produced with sharp sand, silty soil and a blend of sharp sand and silty soil revealed that mortar produced with sharp sand proportioned to be fairly higher than silty soil yield the optimum density and compressive strength.

#### IV. CONCLUSION

The following conclusion in the light of the findings obtained on evaluation of engineering properties and behaviour of the different sharp sand and silty soil blends

1. Findings obtained from grain size analysis test classified sharp sand and rendering soil as A-2-4 and A-2-6 according to AASHTO Soil Classification System, SC (sand mixed with clay) and SM (sand mixed with silt) according to Unified Soil Classification System.
2. The specific gravity of sharp sand and silty soil were 2.65 and 2.55 respectively.
3. The shrinkage limit of the mixture increased with increase in percentages of silty soil and decreased with increase in percentages of sharp sand.
4. The liquid limit, plastic limit and plasticity index of rendering soil were observed to decrease on addition of sharp sand up to 40% beyond 40% sharp sand content, the mixture were found to become non plastic.
5. The unconfined compressive strength was observed to increase up to the point where sharp sand predominate beyond that point, the unconfined compressive strength was found to decrease.
6. The maximum dry unit weight was observed to increase up to the point where sharp sand predominate beyond that point, the maximum dry unit weight was found to decrease. It was also observed that increase in maximum dry unit weight generally decreases the optimum moisture content of the mixture.
7. The workability of the fresh mortar was observed to increase up to the point where sharp sand was found to predominate beyond that point, the workability of the fresh mortar was found to decrease.
8. The density and compressive strength of the hardened mortar was observed to increase up to the point where sharp sand predominate beyond that point, the density and compressive strength was found to decrease. It was also observed that hardened density of the mortar shares a direct relationship with its compressive strength.
9. The study discourages the use of only silty soils for production of mortars as mortars produced by mixing cement with rendering soil are susceptible to shrinkage cracks than mortars produced by mixing cement with a blend of sharp sand and silty soil.

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