A Study on High Strength Concrete by Partial Replacement of Sand with Laterite Sand In Concrete

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Abstract

Concrete is the most widely used composite material today. The constituents of concrete are coarse aggregate, fine aggregate, binding material, and water. A rapid increase in construction activities leads to an acute shortage of conventional construction materials. Conventionally, sand is being used as fine aggregate in concrete. The function of the fine aggregate is to assist in producing workability ad uniformity in the mixture. The river deposits are the most common source of fine aggregate. So there are great demands within the construction industries for river sand as fine aggregate used in the production of concrete. This has created a very difficult situation, also there is great fear from environmentalist and the ecology will be distorted. Hence, the need to find the materials which are affordable and available partially or totally replaced river sand in the production of concrete. Hence, we are forced to think the alternative materials. This report aims to present the study done to establish scientific data regarding the compressive strength and tensile strength of concrete on partial replacement of fine aggregate with laterite soil in concrete mix of High-Performance Concrete M100 grade. The sand shall be replaced gradually in the mentioned grade of concrete by 0%, 10%, 20%, 30%, 40% and 50% with laterite soil and the specimen shall be tested at curing intervals of 3days, 7days, and 28days. For compressive strength and at curing interval of 3days, 7days, and 28days for tensile strength for 28 days

Keywords: Laterite soil, High Performance Concrete, super plasticizer (conplast Sp-430).

1. Introduction

In developing countries, the locally available building materials can be overemphasized because there is a huge imbalance between the demand for construction activities and the shortage of conventional building materials which in turn increases the cost of construction. The demand for concrete is very high due to the rapid growth of infrastructure development in India. Fine aggregate is a primary constituent of concrete. Hence the availability and cost of fine aggregate determine the viability and economy of concrete. Natural sand from the river bed is the traditional sources of fine aggregate. But due to the enormous demand, the river sand source gets depleted and excessive explorations to create serious environmental problems. Some alternative materials have already been used as partial or full replacement of conventional natural sand as fine aggregate. The slag limestone, fly ash, manufactured sand etc. were used in concrete mixtures as a full or partial replacement of natural sand (Mohamed Saifuddin et al. 2007). However, the scarcity in essential quality is the major limitation in some of the above materials.

2. Literature survey

Prasad and Parthasarath, (2018), studied the formation of laterite. The origin of laterite was connected with the physical and climatic of a particular region. Tzu hsing Ko (2014) studied the nature and properties of laterite soil derived from different sources in Taiwan. The study revealed that parent material plays an important role during soil weathering. The physical, chemical and mineralogy compositions affect the soil formation. The most difference among all laterite soil is their content of iron oxide and the soil age of formation.

Aginam et al. (2014) investigated the geotechnical properties of laterite from Nigeria. The higher the fines, the permeability increases for different samples from different locations and based on the physical properties suitable for sub grade and sub base but should not be used as base material in road construction. Chandran P et al. (2005), investigated the mineralogy, genesis of laterite soils in Kerala. The classification of soils depends upon the variability of organic matter, the clay content and particle size.

Nieuwenhuyse et al. (2000) in their study on the origin of laterite in Costa Rica observed that the degree of weathering and difference in clay mineralogy depends upon time. Umarany Mahalinga Iyer and David Williams (1991) studied engineering properties of laterite soil in Australia and found that properties depend on the local climate, vegetation and topography of the area.

Okagbue (1986) investigated the properties of laterite in Nigeria reveals that effects of parent rock are of secondary importance on the physical and mechanical nature of laterite gravels.

Deepa Joshi and Jain (2015) investigated the compressive behavior of unreinforced clay brick masonry. The experimental results of bricks, mortar and brick masonry prisms presented with a brief description of the testing procedure. The basic compressive stress of unreinforced masonry prisms determined experimentally has been compared with the basic compressive stress of the same obtained by using IS 1905-1987. The failure mechanism of prisms under uniaxial compressive load has been discussed. Tasnia Hoque et al. (2013), studied the replacement of stone dust and found that mortar contain 25% of replacement by stone dust showed the higher strength. Tamara Kaaki (2013) studied the strength and behavior of masonry prisms with minimum height to thickness ratio requirement under compressive loading. Shyam Prakash and Haanumantha Rao (2016) studied the compressive strength of quarry dust in concrete showed up to 40% replacement of sand by quarry dust showed higher strength compared to normal M30 grade concrete.

Omotola Alawode and Idowu (2011) studied the compressive strength and workability of concrete and laterite mix concluded that the laterite concrete was not workable compared to normal concrete and not recommended for concrete. Felix Udoeyo et al. (2010) studied the effect of the specimen geometry of concrete with the laterite on compressive and spilt tensile strength showed significant influence in the geometry of concrete. Osadebe and Nwakonobi (2007) studied the structural characteristics of concrete with laterite at optimum mix proportion. Based on the result, the Modulus of elasticity, Modulus of rigidity, flexural strength, Poisson's ratio are higher at optimum mix proportion. Osunade and Babaloa (1991), in their study, established that the size of reinforcement and mix ratio have a significant effect on the anchorage bond stress of concrete with laterite. The cement content is richer in the mix ratio and the anchorage bond stress is higher of concrete with laterite.

3. OBJECTIVE AND METHODOLOGY

3.1 Objective

- Comparative study on the properties of conventional concrete and concrete containing laterite as sand partial replacement.
- Study on the workability of conventional concrete and laterite-based concrete

- Determine its mechanical properties such as compressive strength, tensile strength with and without laterite as sand.

3.2 Methodology

- Collect the laterite and sieve with IS Sieve 4.75mm, passed material used as sand replacement in the concrete.
- Physical properties tests on basic materials laterite, coarse aggregate, fine aggregate, cement.
- Mix design for M100 and its proportions. Find out the individual proportions for partial replacement of sand with laterite.
- Find out the fresh properties of concrete by slump cone test.
- Prepare the Cubes (150 x 150 x 150 mm) and Cylinders (150mm dia & 300mm height).
- Find out the Harden properties of concrete by Cube Compressive strength and Cylinder tensile strength.

4. Experimental work

4.1 Materials used

The materials used for this study are Fine aggregate, Coarse aggregate, Cement, Water, Fly ash, GGBS and laterite. The physical properties of concrete mentioned in below:

Cement

Chemical bond is vital primarily in light of the fact that its impacts the rate of advancement of compressive quality of cement. The decision of the sort of bond relies on the necessities of execution. There are different types of cement, but ordinary Portland cement is the most widely used binders. The concrete compressive strength depends upon the variation of the cement quality more than any other single material. An Ordinary Portland Cement of various evaluations OPC-33, OPC-43 and OPC-53 are accessible in the market and are for the most part utilized for delivering fly ash blended cement. The bond utilized as a part of this trial examination is Ordinary Portland Cement Grade 43. All properties of concrete are being tested by utilizing IS 12269 - 1987 for 43 grades Ordinary Portland Cement.

Physical properties	Test result	Requirement as per IS 12269 (1987)
Specific gravity	3.14	-
Fineness (%)	3	Max 10%
Normal consistency	31%	-
Initial setting time (min)	92	Min. 30 min
Final setting time (min)	325	Max. 600 min

Fig. 1: Physical Properties of Cement

Aggregates

The aggregates suitable for plain concrete can be suitably used in fly ash fiber reinforced concrete. The totals reasonable for plain cement can be appropriately utilized as a part of fly fiery debris fiber strengthened cement. In the concrete, to give great nature of solid total is utilized as a part of two size gatherings i.e. fine and coarse aggregates. Fine aggregate (sand) includes minimal exact or balanced grains of silica. Sand is generally utilized as the fine aggregate in concrete. Fine total ordinarily comprises of normal, squashed, or produced sand. Common fine aggregates have been customarily utilized as a part of cement. It is the typical segment for ordinary weight concrete. Be that as it may, made FA (MFA) then show up as an appealing other option to characteristic FA for bond mortars and cement. most extreme grain size and size conveyance relies on upon the kind of matrix being made. By differing the extent of FA, cement can be arranged financially for any required quality. It helps in solidifying of cement by permitting the water through its voids. In this trial work the sand going through 4.75mm IS sifter is utilized. The physical properties of Fine Aggregates are mentioned in table 2.2 respectively.

S. No	PARTICULARS	RESULTS	BIS SPECIFICATIONS (IS 2386-2013
1	Specific gravity	2.83	2.4 – 2.6
2	Fineness modulus	2.95	5 – 8
3	Water absorption	0.5%	<2%

Fig. 2: **Properties of Granite Fine Aggregate**

Coarse aggregates (CA) make strong and hard mass of concrete with cement and sand. CA can be regular weight, light weight, or substantial weight in nature. Typical weight totals are gotten by pulverized stone, rock and broken blocks. Lightweight coarse totals are for the most part made by extended mud, (as pumice, shale).The physical characteristics of coarse aggregate is shown in table 4.3.

S. No	PARTICULARS	RESULTS	BIS SPECIFICATIONS (IS 2386-2013
1	Specific gravity	2.83	2.4 – 2.6
2	Fineness modulus	3.28	5 – 8
3	Flakiness index	13%	<40%
4	Elongation index	10%	<40%
5	Crushing value	12%	<45%
6	Impact value	14%	<45%
7	Water absorption	0.4%	<2%

Fig. 3: **Properties of coarse Aggregate**

4.2 Fly ash & GGBS

In the present study, one of the source materials used in making geopolymer concrete was Class F fly ash. It was collected from locally available source NTPC Ramagundam, Telangana, India. The GGBS collected from Indian mart.

Water

The water utilized as a part of cement has an imperative impact in the blending, laying compaction setting and solidifying of cement. It is required for hydration of bond. Water works as a binder for the ingredients and makes the mix workable. The quality of cement specifically relies on the amount and nature of water that is utilized as a part of the blend. An increase in water cement proportion prompts a decrease in compressive strength. Water utilized for blending and curing should be spotless and free from damaging sum if oils, acids, soluble bases, salts, sugar and natural materials. Versatile water is for the most part viewed as acceptable for blending concrete. Here the potable water used for the experiment work.

4.3 Preparation of laterite-based concrete

All the required quantities of cement, fly ash, GGBS, fine aggregate and coarse aggregates weighed separately and mixed in dry condition. The obtained proportion of water is added to the composite mixture and mix thoroughly until a uniform mixture is formed. The same procedure is repeated for different mixes which includes the replacement of fine aggregate with laterite. The complete mixing is done by hand mixing.

Fig. 4: **Mixing of Concrete**

After the concrete is mixed, the fresh concrete tests are to be carried out to measure the workability. The detailed explanation of the slump test is reported below.

Slump test

Slump cone test is most simple and common test conducted to determine the workability of concrete mix. According to the IS 1199-1959, Slump test is carried out for every batch of mix.

A sample of prepared concrete mix is taken for the test. The internal surface of the frustum of cone is cleaned and greased to avoid the adhesion of concrete. A non-porous base plate is placed on a uniform surface and the slump cone mould is fixed on it. Concrete mix is filled in three equal layers in the mould. The excess concrete is removed and levelled. Now, the cone is lifted in upward direction and the concrete slumps down. The slump (Vertical settlement) is measured in mm.

Casting and Curing

In the present work cubes and disc specimens were cast to conduct various tests.

Casting of cubes

Totally 90 cubes were cast for conducting various tests. For the preparation of cube specimens, the mixed concrete is poured into the cube moulds made of steel of dimensions of 150 X 150 X 150 mm. The moulds are cleaned and greased to avoid sticking of concrete to the moulds and tighten the bolts to prevent leakage of concrete. The concrete is put in 3 layers (each layer more than 35 blows) into the moulds till the surface and levelled. The specimens are allowed to dry up for 24hrs.

Casting of cylinders

Totally 90 cylinders were cast for conducting various tests. For the preparation of cube specimens, the mixed concrete is poured into the cylinder moulds made of steel of dimensions of 150mm diameter and 300mm height. The moulds are cleaned and greased to avoid sticking of concrete to the moulds and tighten the bolts to prevent leakage of concrete. The concrete is put in 3 layers (each layer 35 blows) into the moulds till the surface and levelled. The specimens are allowed to dry up for 24hrs.

Curing

The next stage is curing of the specimens. It is an important phase as the water for hydration is to be maintained in the specimens. Proper curing gives good strength to the concrete. So, after removing from the moulds the specimens are transferred to the curing tank containing water free from impurities and cured for 28 days.

4.4 Experimental Procedure

In this section, the test setup and experimental procedure for conducting various tests are discussed.

Compressive strength test (IS 516-1989)

Compressive strength of concrete is the most important characteristic and it is an indexing property as concrete is designed to carry compressive loads. For this experimental study, 54 no. of cube specimens were cast in which 9 specimens. The number of specimens cast for each mix is shown in the table 4..

S. No	Laterite (%)	Curing		
		7 days	14 days	28 days
1	0	3	3	3
2	10	3	3	3
3	20	3	3	3
4	30	3	3	3
5	40	3	3	3
6	50	3	3	3

Fig. 5: No. of specimens for different mixes for Compressive strength test.

This test is conducted to determine the variation of strength of the specimens with varying ratios of coarse aggregate and reduction in fine aggregate content. Compressive strength test machine (CTM) with 2000KN capacity is used to conduct the test on cubes. After placing the cube between the plates in the CTM, load is applied until the crack is observed on the specimen. The load at the point of cracking is considered as failure load and it is noted. The compressive strength is calculated by

Fig. 5: Testing of cube.

Compressive Strength ( ) = Failure load / Cross sectional area of specimen

Tensile strength of concrete is the most important characteristic and it is an indexing property as concrete is designed to carry compressive loads. For this experimental study, 30 no. of cube specimens were cast in which 3 specimens.

S.No	Laterite (%)	Curing
		28 days
1	0	3
2	10	3
3	20	3
4	30	3
5	40	3
6	50	3

Fig. 6: No. of specimens for different mixes for Tensile strength test.

The cylinder specimens were tested on compression testing machine to create a tensile cracking. Align the specimen so that the lines marked on the ends are vertical and centered over the bottom plate. Apply the load continuously without shock at a rate of approximately 14-21 kg/cm2/minute (Which corresponds to a total load of 9.9 ton/minute to 14.85 ton/minute). The Tensile strength was computed by using:

Tensile strength = 2P / π L D

Here; P = peak load

L = length of cylinder = 300mm

D = diameter of cylinder = 150mm

Fig. 7: Tensile strength test on cylinder.

5. Results and Discussion

As per experimental programme results for different experiments were obtained. They are shown in table format and graph format.

5.1 Fresh properties of concrete (Workability Test)

5.1.1 Slump Test

The Slump test was performed on the laterite based concrete to check the workability of it at different replacements viz. 0 %, 10%, 20%, 30%, 40%, 50%, the following results were obtained, according to which it can be concluded that with the increase in % laterite from M1 to M6, workability increases. The results obtained for Slump test are shown below in Table 5.1.

Table 5.1: Results of Slump test

Mix No	Laterite (%)	Slump (mm)
M1	0	100
M2	10	103
M3	20	104
M4	30	107
M5	40	110
M6	50	115

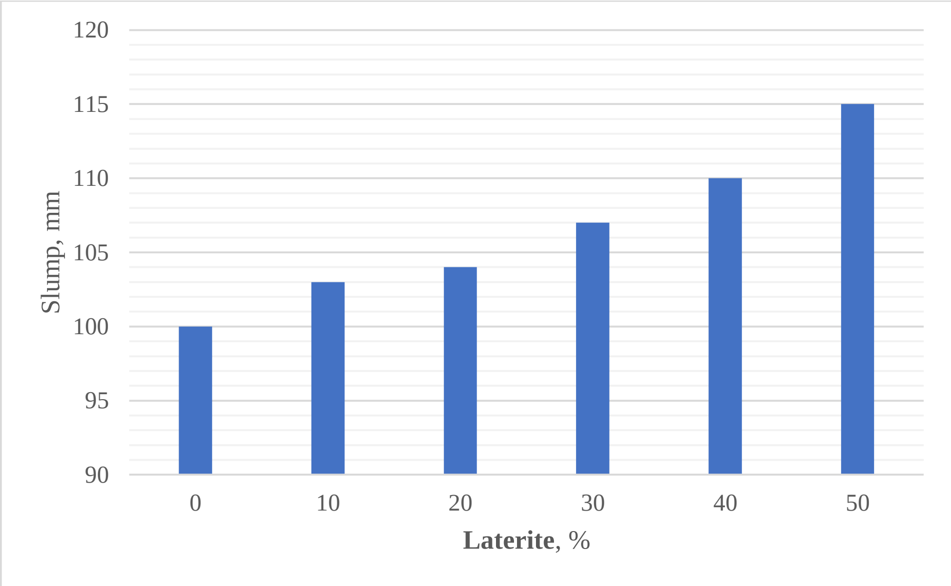

Fig 5.1: Slump test results

The above figure 5.1 shows the slump results. It was observed that, the slumps increased from M1 to M6 mix with increased Laterite in the mix. It was varied from Medium Workability to High workability.

5.2 Harden properties of concrete

5.2.1 Compressive Strength Test

The compressive strength test was performed on the cubes of size 15 cm x 15 cm x 15 cm to check the compressive strength of Laterite based concrete and the results obtained are given in Table 5.2.

Table 5.2: Results of compressive strength test

Mix No	Laterite (%)	Compressive strength of cubes (N/mm2)		
		7 days	14 days	28 days
M1	0	59	90	99
M2	10	64	97	107
M3	20	67	101	112
M4	30	65	98	108
M5	40	62	94	104
M6	50	61	92	102

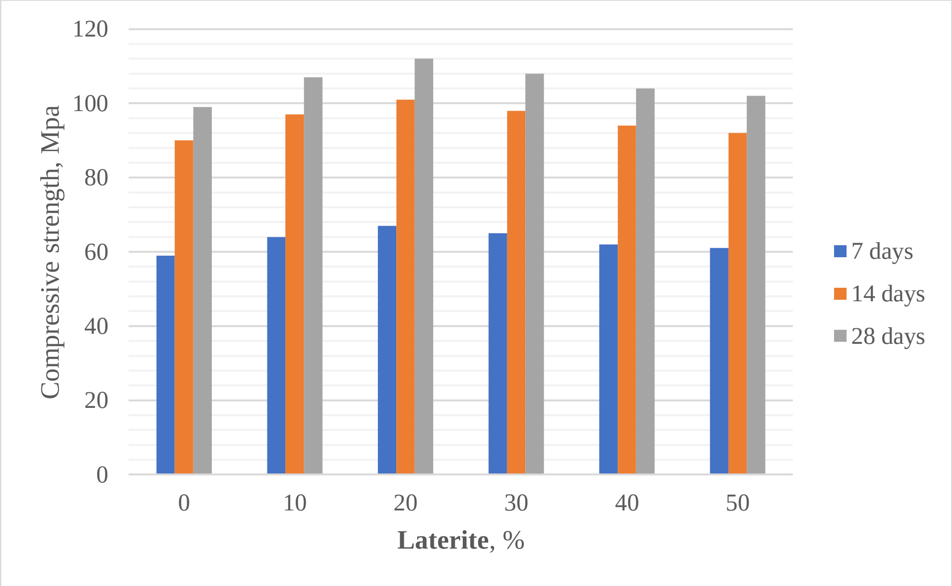

Fig 5.2: 7days Compressive strength test result graph

From the above results it was observed that with the increase in percentage of Laterite from M2 to M6 in concrete the compressive strength more than control mix M1. The highest compressive strength gained for 20% Laterite replacing with fine aggregate in the preparation of concrete. The optimum dosage suggested from this study was 20% Laterite as sand replacement.

5.2.2 Tensile Strength Test

The Tensile test was performed on the beams of size 300mm height x 150 diameter mm to check the Tensile strength of the concrete and the results obtained while performing the Tensile test on CTM are given in Table 5.3.

Table 5.3: Result of Tensile strength

Mix No	Laterite (%)	Tensile Strength for 28 days (N/mm2)
M1	0	9.3
M2	10	9.72
M3	20	10
M4	30	9.8
M5	40	9.5
M6	50	9.43

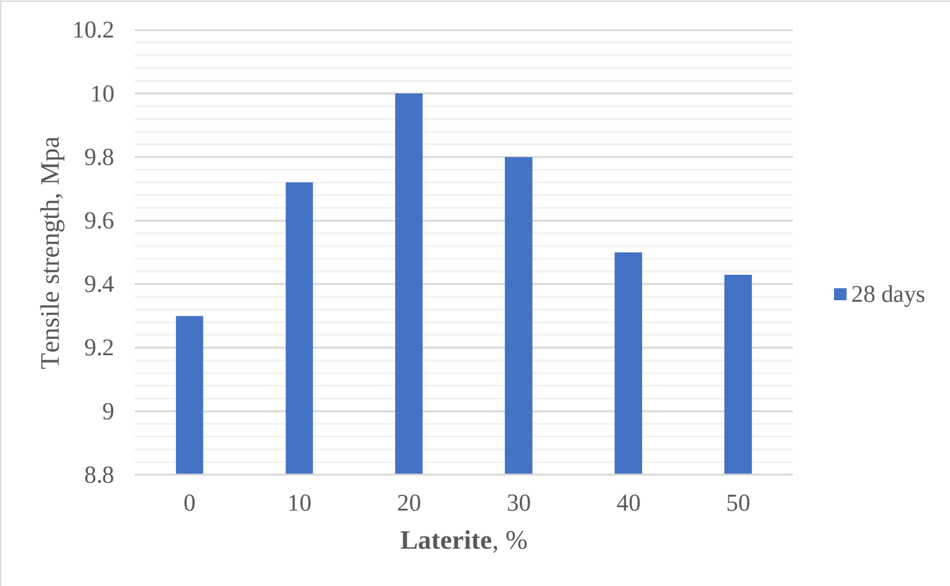

Fig 5.5: Tensile strength graph

From the above results it was observed that with the increase in percentage of Laterite from M2 to M6 in concrete the tensile strength more than the control mix M1. The highest tensile strength gained for 20% Laterite replacing with sand in the preparation of concrete. The optimum dosage suggested from this study was 20% Laterite as fine aggregate replacement.

5.3 Discussions

The workability was increasing with increasing Laterite replacement in the sand. The compressive and tensile strengths for Laterite replacement in the sand, was more than control mix. The maximum or highest strength was gained for 20% Laterite replacing with sand.

6. CONCLUSIONS

In this experimental investigation, the effect of Laterite blended in control concrete with respect to tensile behaviour of the concrete cylinders and compressive behaviour of the concrete cubes have been investigated. The experimental results have been compared with the control mix concrete. The following conclusions are drawn from the present experimental investigation.

- The absence of deleterious and the mineral compositions of laterite reveal the possibility of using the laterite as partial replacement of natural sand.
- Workability increases with increasing in the Laterite replacement in the concrete.
- The compressive and tensile strength highest gains for 20% Laterite as sand replacement in the preparation of concrete.
- The maximum strength gained for 20% Laterite replacing with sand in the preparation of concrete. The compressive and tensile strength increased by 13.13% and 7.52% as compare to the conventional concrete.

REFERENCES

[1] Tzu-Hsing Ko (2014) “Nature and Properties of Lateritic Soils Derived from Different Parent Materials in Taiwan”, Scientific World Journal, 1-4

[2] Aginam C. H, Chidolue C. A. and Nwakaire C. (2014) “Geotechnical Properties of Lateritic Soils from Northern Zone of Anambra State Nigeria”, International Journal of Engineering Research and Development 10, 23-29

[3] Chandran P, Ray S.K., Bhattacharyya T, Srivastava P., Krishnan P. and Pal D.K. (2005) "Laterite soils of Kerala, India: their mineralogy, genesis and taxonomy" Australian Journal of soil Research 43, 839–852.

[4] Nieuwenhuyse A., Verburg, P.S.J and Jongmans A.G.(2000) "Mineralogy of a soil chronosequence on andesitic lava in humid tropical Costa Rica". Geoderma98, 61–82.

[5] Umarany Mahalinga-Iyer and David Williams J (1991) "Engineering properties of a lateritic soil profile", Engineering Geology 31, 45-58

[6] Okagbue C.O (1986) "The physical and mechanical properties of laterite gravels from southeastern Nigeria relative to their engineering performance", Journal of African Earth Sciences 5, 659-664

[7] Deepa A. Joshi and Jain R.K (2015) "Evaluation of Compressive Strength and Basic Compressive Stress of Clay Brick Unreinforced Masonry by Prism Test", International Journal of Science and Research 4, 913-916

[8] Praveen Kumar K and Radhakrishna (2015) "Strength and workability of cement mortar with manufactured sand", International Journal of Research in Engineering and Technology, 186-189

[9] Asiedu Emmanuel and Agbenyega Allan (2014) "Suitability of Laterite Fines as a Partial Replacement for Sand in the Production of Sandcrete Bricks", International Journal of Emerging Technology and Advanced Engineering 4, 9-15

[10] Harish Kizhakkumodom and Venkatanarayanan (2014) "Evaluation of Sulfate Resistance of Portland Cement Mortars Containing Low-Carbon Rice Husk Ash", Journal of Materials in Civil Engineering, 582-592.

[11] Tasnia Hoque, Muhammad Harunur Rashid, Rokon Hasan and Ebna Forhad Mondol (2013) "Influence of Stone Dust as Partially Replacing Material of Cement and Sand on some Mechanical Properties of Mortar", International Journal of Advanced Structures and Geotechnical Engineering 02, 54-57

[12] Tamara kaaki (2013) "Behavior and strength of masonry prisms loaded in Compression" M.S. thesis, Dalhousie University.

[13] Venkatarama Reddy (2012) "Suitability of manufactured sand as fine aggregate in mortar and concrete", CSIC project, 11-330

[14] Shyam Prakash and Hanumatha Rao (2016) "Study on Compressive Strength of Quarry Dust as Fine Aggregate in Concrete", Advances in Civil Engineering, 1-5

[15] Khairunisa Muthusamy,. Kamaruzaman N. W, Mohamed A. Ismail and Budiea (2015) "Durability performance of concrete containing laterite aggregate." KSCE Journal of Civil Engineering, 1-8