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EXPERIMENTAL INVESTIGATION ON THE COMPRESSIVE STRENGTH OF CONCRETE BY USING QUARRIED RIVER SAND AND SUPPLIED SAND

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KeyWords
Quarried sand, Supplied sand, Irregularity, Impurities, Compressive strength, Durability

ABSTRACT

The construction industry in Ethiopia is booming sector because of increased public investment on development projects and private investments. So in this wide industry, Failure of concrete structures leading to collapse of buildings has initiated various researches on the quality of construction materials. Sand, as one of the most accessible natural resources, has been used mostly as a construction material since the earliest days of civilization. It is defined as continuously graded unconsolidated material (sediment) present on the earth's surface as a result of the natural disintegration of rock. The sand is an inert element essential in the composition of concrete; its use ensures granular continuity between the cement and gravel for better cohesion of concrete. In Ethiopia, rivers sands are transported kilometers away from Addis Ababa. So Supplying of natural sand from the quarry site is exposed for so many irregularities which affect the Compressive property of concrete. Natural sand should be free from impurities which are intentionally added. Visit to the two different sites has been made by means of high way transportation to collect the sand sample. To achieve the research objective, Quarried &Supplied sand samples for laboratory investigation were collected from Ziway and Gorro (Addis Ababa).This experimental study has been under taken to investigate the compressive Strength of concrete using the quarried and supplied sand from the same source by conducting Tests. The Experimental Test results have displayed that there is compressive test result difference between the quarried and the supplied sand with the same mix proportion.

1. INTRODUCTION

Concrete is a mixture of cement, fine aggregate, coarse aggregate and water. Concrete has a high compressive strength and a very low tensile strength. Quality of constituent materials used in the preparation of concrete plays a paramount role in the development of both physical and strength properties of the resultant concrete. Water, cement, fine aggregates, coarse aggregates and any admixtures used should be free from harmful impurities that negatively impact on the properties of hardened concrete. Sand is one of the normal natural fine aggregates used in concrete production [1]. Sand is the most common and loosely packed construction material on the earth's surface smaller than gravel and larger than silt and clay. Sand particles mostly range from 0.02 mm to 2.00 mm in diameter.

The quality of transported sand is highly exposed to some other irregularities since the transportation requires high distance from the construction site. So quality assurance, by using laboratory techniques, of the supplied sand is very essential in order to attain the desire of the customers as well as to maintain the desired mechanical property of concrete. Even if the quality of sand at the quarry site is well enough good but the supplied sand, which is assumed to be come from the same place, usually has different properties due to some other irregular action of suppliers.

This investigation has been focusing on the quality of building sand in terms of having the silt and clay content within the allowable limit as set out in British Standard (BS) 882 as well as in Ethiopian standard. This research has been also seeking to determine the level of silt and clay content present in building sand being supplied in around Addis Ababa and also the effect of these impurities to the quality of concrete. It further seeks to establish the minimum allowable limits of silt and clay for concrete production based on the tested samples.

Quality of material ingredients (i.e. cement, fine aggregates, coarse aggregates, admixtures and water) plays key roles in the development of the physical and strength properties of concrete. Concrete ingredients should be free from harmful impurities that negatively impact on the properties of concrete structures. Sand is the normal natural fine aggregates used for concrete production [1].Past researches identify the major causes of buildings failure as workmanship, quality of building materials, quality of sand, quality of coarse aggregates, quality of steel reinforcement, concrete mix proportioning, faulty construction methodology, defective designs and non-compliance with specifications or standards . Use of good quality building sands improve both operational and lifecycle performance of buildings by preventing frequent repairs and ensuring building's long
Lifespan thus reducing overall investment cost [2].

2. MATERIAL AND METHODS

2.1 Materials

This research employed laboratory experimental methods. Sand samples were collected from the river quarry, from Ziway around adami tulu which is 5km away from ziway, and market sand places, in Addis Ababa, Sand samples has been labeled based on the place where they are collected i.e. ZRS & uses to represent samples sourced from Ziway River sand and Supplied sand, respectively. From each study area, a 50 kg sand sample is procured for grading and testing. With regard to the mix proportion, volume and weight of other concrete constituent material i.e. Portland cement, coarse aggregate and water, is just to be computed.

2.1.1. Material properties

i. Sieve Analysis and Grading

Quarried River Sand

River sand is used and sieve analysis was carried out to whether it meets the AASHTO or BS standards and the result is given in table 2.1 below. Sand samples were graded by using IS sieves starting from 12.5mm sieve size up to 0.075mm sieve size. AASHTO M 6-93 Or ASTM C standard has been used for the particle size distribution of the sand samples. The gradation test result of the river sand sample clearly shows the particle size as shown Table 2.1 and 2 kg sand sample was taken for the gradation test before washing.

Table 2.1. Gradation Test result using the river sand sample AASHTO M 6-93 Or ASTM C 136

		2000 gm						
AASHTO Sieve Size mm	Weight Retained	%. Retained		% pass	AASHTO M-6		BS 882	
			Cumulative		Lower	Upper	Lower	Upper
12.5	0	0		**100**	100	100.0	100	100.0
9.5	30	1.2	1.20	**99**	95	100.0	89.0	100.0
4.75	65	2.6	3.8	**96**	80	100.0	60.0	100.0
2.36	150	6.00	15.20	**90**	50	85.0	30.0	100.0
1.18	285	11.40	26.60	**79**	25	60.0	15.0	100.0
0.6	780	31.20	57.80	**48**	10	30.0	5.0	70.0
0.3	575	23.00	80.80	**25**	2	10.0	0.0	15.0
0.15	420	16.8	97.6	**8**				
0.075	150	6.0	103.6	**2**				

From the above Table the gradation of sample of supplied sand used is within the upper and lower limit of the standards. It is therefore satisfactory to be used for the concrete preparation.

Supplied Sand

Supplied sand is used and sieve analysis was carried out to whether it meets the AASHTO or BS standards and the result is given in table 3.2 below. Sand samples were graded by using IS sieves starting from 12.5mm sieve size up to 0.075mm sieve size.

AASHTO M 6-93 Or ASTM C standard has been used for the particle size distribution of the sand samples. The gradation test result of the supplied sand sample clearly shows the particle size as shown Table 2.2

Table 2.2. Gradation Test result using the supplied sand from the suppliers AASHTO M 6-93 Or ASTM C 136

Weight Before washing		2000gm						
		2000 g						
AASHTO Sieve Size mm	Weight Retained	%. Retained		% pass	AASHTO M-6		BS 882	
			Cumulative		Lower	Upper	Lower	Upper
12.5	0	0		**100**	100	100.0	100	100.0
9.5	20	1.00	1.00	**99**	95	100.0	89.0	100.0
4.75	195	9.75	10.75	**89**	80	100.0	60.0	100.0
2.36	235	11.75	22.5	**78**	50	85.0	30.0	100.0
1.18	405	20.25	42.75	**57**	25	60.0	15.0	100.0
0.6	370	18.5	61.25	**39**	10	30.0	5.0	70.0
0.3	310	15.5	76.75	**23**	2	10.0	0.0	15.0
0.15	180	9.00	85.75	**14**				
0.075	230	11.50	97.25	**3**				

From the above Table the gradation of sample of supplied sand used is within the upper and lower limit of the standards. It is therefore satisfactory to be used for the concrete preparation.

Coarse Aggregates

A crushed aggregate of maximum size 25 mm is used. Sieve analysis was carried out and proportioned to meet the Ethiopian standards and the result is given in table 3.2 below.

Table 2.3. Grading requirements for coarse aggregates (ESC.D3.201)

weight before washing	6015gm					
Sieve size(mm)	Weight Retained(gm)	% Retained	Cumulative coarser (%)	Cumulative passing (%)	ES C.D3.201	
					lower	upper
37.5	-	-	-	-	95	100
25	2390	39.73	39.73	60.27	-	-
19	1018	16.92	56.66	43.34	30	70
12.5	950	15.79	72.45	27.55	-	-

9.5	1002.1	16.66	89.11	10.89	10	35
4.75	407	6.77	95.88	4.12	0	5
2.36	227	3.77	99.65	0.35	-	-
passing 1.18(pan)	20.9	0.35	100.00	0		
Total sum	6015					

From the above Table the gradation of sample of crushed aggregate used is within the upper and lower limit of the standards. It is therefore satisfactory to be used for the concrete preparation

ii.Specific gravity & Water Absorption

The specific gravity of a substance is the ratio between the weight of the substance and that of the same volume of water. This definition assumes that the substance is solid throughout. Aggregates, however, have pores that are both permeable and impermeable; whose structure (Size, number, and continuity pattern) affects water absorption, permeability, and specific gravity of the aggregates [17]. The specific gravity of river sand and supplied sand was determined using pycnometers by shaking the sample sand with water for about 10 minutes. The parameters needed for computing the Specific Gravity of both sand Samples are shown in the table below.

Table 2.4. Specific gravity of Quarried River sand sample

		Quarried River Sand Sample
1	Mass of dry sand sample in gm (A)	50gm
2	Mass of pycnometer+Water in gm=B	340gm
	Mass of Sand At SSD(A+B)=(C)	390gm
3	Mass of A+B after shaking 10 min.=(D)	369gm
4	Specific Gravity=A/(A+B-D)	2.63

Table 2.5. Specific gravity of supplied sand sample

		Supplied Sand Sample
1	Mass of dry sand sample in gm (A)	50gm
2	Mass of pycnometer+Water in gm=B	375gm
3	Mass of Sand At SSD(A+B)=(C)	425gm
4	Mass of A+B after shaking 10 min.=(D)	403.26
5	Specific Gravity=A/(A+B-D)	2.3

Table 2.6.Water absorption capacity of River sand sample

		River Sand Sample
1	Mass of dry sand sample with can gm (A)	500gm
2	Mass of dry sand with can +water gm(B)	1610gm
	Mass of Sand +water after being soaked for 24 hours (C)	525.2gm
3	Water absorption capacity(%)=(C-A)/A	5.04
4	Specific Gravity=A/(A+B-D)	2.63

Table 2.7. Water absorption capacity of supplied sand sample

		Supplied Sand Sample
1	Mass of dry sand sample with can gm (A)	793.67gm
2	Mass of dry sand with can +water gm(B)	1571.8
	Mass of Sand +water after being soaked for 24 hours (C)	841.91gm
3	Water absorption capacity(%)=(C-A)/A	6.03
4	Specific Gravity=A/(A+B-D)	2.3

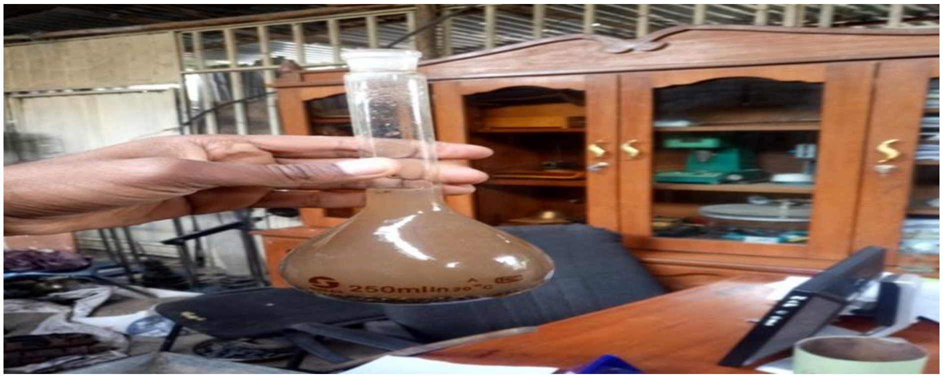

Figure 2.1. Testing of specific gravity of a sample sand using pycnometer

iii. Unit weight

Unit weight can be defined as the weight of a given Volume of graded fine aggregate. It is thus a density measurement and is also known as bulk density. The unit weight effectively measures that the graded fine aggregate will occupy in concrete and includes both the solid aggregate particles and the void between them. The unit weight simply measured by filling container of known volume and weighing it.Clearly, however, the degree of compaction will change the amount of void space. And hence the value of unit weight. Since the weight of aggregate is dependent on the moisture content of the aggregate, constant moisture content is required [17].

Table 2.8.Loose Unit Weight of River sand sample

		River Sand Sample
1	Cone 1(A)	2655gm
2	Cone 2(B)	2660gm
3	Cone 3(C)	2690gm
4	Average weight from the 3 trials=(A+B+C)/3	2668gm
5	Weight of the cylinder	935gm
6	Volume of the cylinder	0.0019m3
7	Unit weight=Avg.Weght/0.0019m3	1368

Table 2.9.Loose Unit Weight of supplied sand sample

		Supplied Sand Sample
1	Cone 1(A)	3374gm
2	Cone 2(B)	3316gm
3	Cone 3(C)	3317gm
4	Average weight from the 3 trials=(A+B+C)/3	3331gm
5	Weight of the cylinder	935gm
6	Volume of the cylinder	0.0019m3
7	Unit weight=Avg.Weght/0.0019m3	1261

Table 2.10. Compacted Unit Weight of River sand sample

		River Sand Sample
1	Cone 1(A)	2900gm
2	Cone 2(B)	2905gm
3	Cone 3(C)	2895gm
4	Average weight from the 3 trials=(A+B+C)/3	2900gm
5	Weight of the cylinder	935gm
6	Volume of the cylinder	0.0019m3
7	Unit weight=Avg.Weght/0.0019m3	1526

Table 2.11.Compacted Unit Weight of supplied sand sample

		Supplied Sand Sample
1	Cone 1(A)	3517gm
2	Cone 2(B)	3569gm
3	Cone 3(C)	3588gm
4	Average weight from the 3 trials=(A+B+C)/3	3558gm
5	Weight of the cylinder	935gm
6	Volume of the cylinder	0.0019m3
7	Unit weight=Avg.Weght/0.0019m3	1381

Figure 2.2. Testing of compacted unit weight of sample sand using a cylinder

iv. Moisture Content

A design water cement ration is usually specified based on the assumption that aggregates are inert (Neither absorb nor give water to the mixture).but in most cases fine aggregates from different sources do not comply with this i.e. wet aggregates give water to the mix and drier aggregates (those with below saturation level moisture content) take water from the mix affecting in both cases, the design water cement ratio and therefore workability and strength of workability.

In order to correct these discrepancies the moisture content of the fine aggregate has to be determined [17]. Therefore, the moisture content of the sand samples is shown in the table below.

Table 2.12.Moisture content of River sand sample

		Quarried River Sand Sample
1	Weight of bulk sand before oven(A)	542.97gm
2	Wight of dry sand after oven(B)	525.74gm
3	Weight of pan(C)	85.50gm
4	Moisture content=A-B/(B-C)	3.9%

Table 2.13.Moisture content supplied sand sample

		Supplied Sand Sample
1	Weight of bulk sand before oven(A)	542.97gm
2	Wight of dry sand after oven(B)	524.95gm
3	Weight of pan(C)	85.50gm
4	Moisture content=A-B/(B-C)	4.1%

According to the Ethiopian Standard it is recommended to wash the sand or reject if the silt content exceeds a value of 6% (Abebe dinku, 2002). Therefore, according to the experiment it satisfies the criteria as specified. According to ASTM C 33 (AASTHO M 6), the fineness modulus must be not less than 2.3 nor more than 3.1.So the above sand samples satisfies this criteria. But by comparing the physical properties of each sample, the quarried river sand has more quality and preferable than the supplied sand.

2.2 Methods

This study has tried to use both qualitative & quantitative research method to get reach data of to promote in depth about the Experimental investigation on the compressive strength of concrete using the river sand from the quarry and the supplied sand from the supplying place. To find out the compressive strength of the concrete made, mix design apparatus have been used.

2.2.1 Mix Design

This section describes the method of determining the compressive strength of concrete cubes by using both river sand sample and supplied sand sample. This is the process of selecting the correct proportions of cement, fine and coarse aggregate and water to produce concrete having the properties specified and desired in accordance to the ACI design procedures. The entire work carried out for design mix proportions of concrete is for C-25 grade concrete.

The approach to be adopted for specifying mix parameters will be with reference to the weights of materials in a unit volume of fully compacted concrete. This method will result in the mix being specified in terms of the weights in kilograms of different materials required to produce 1m3 of finished concrete. The cement and coarse aggregates proportions of the concrete making materials are mixing with each defined proportion of sand samples particles to determine if there is a difference on the compressive strength of the concrete made by using both sand samples.

To clearly find the compressive strength between the river sand sample and supplied sample two mix design is prepared with equal proportion of concrete making materials (water, sand, Coarse aggregate) in each mix design.

Stages in Mix –Design

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1. Choice of slump
2. Aggregate size
3. Mixing water and air content
4. Water/cement ratio
5. Calculation of pozzolanic materials (cement content)
6. Estimation of coarse and fine aggregates content
7. Adjustment for moistures in Aggregates
8. Mix proportion /Trial batch

Table 2.14. Adjusted mass of materials per 1m3 of concrete for mix design using quarried river sand

Material	**Mass per 1m^3**	**mass for 0.03 m^3**
coarse aggregates	1122k.g/m3	5.85
River sand	691.44k.g/m3	9.45
Cement	315k.g/m3	33.66
Water	186.g/m3	20.74
Air	1.5	

Table 2.15. Adjusted mass of materials per 1m3 of concrete for mix design using supplied sand

Material	**Mass per 1m^3**	**mass for 0.03 m^3**
coarse aggregates	1122k.g/m3	5.85
Supplied Sand	691.44k.g/m3	9.45
Cement (Derba OPC)	315k.g/m3	33.66
Water	186.g/m3	20.74
Water cement ratio	0.59	

2.2.2 Method of Data Analysis

Analysis is an interactive process by which answers to be examined to see whether these results support the hypothesis underlying each question. This study has tried to use quantitative research method to get reach data of to promote in depth about the Experimental investigation on the compressive strength of concrete using the river sand from the quarry and the supplied sand from the supplying place. The method used to analyse the experimental data is a quantitative method involving numerical data. This method assists to analyse the results which can easily be tabulated in actual numbers. Finally, numerical result analysis and discussions were carried out for this study.

3. EXPERIMENTAL RESULTS AND DISCUSSION

3.1. Introduction

This study has been aimed aims on Experimental study's to establish the quality of sand collected directly from the source (river or pit) in comparison to the quality of sand source at the supply points (market places) in order to establish the extent of adulteration within the supply chain and its effect on the compressive strength property and durability of the concrete through selective sampling and testing. According to the Experimental result the quality of river sand as well as the compressive strength of the concrete has been just decreasing as the sand is transported to the suppliers which will be distribute to customers because of that the sand in the hand of suppliers is being exposed to many irregularity which declines the quality of the sand and the strength of the concrete made.

3.2 Experimental Results

3.2.1 Compressive strength of concrete result after 7 &28 days of curing

The Compressive strength test was performed on cube specimens of size 150mmx150mmx150mm. All the specimens were cast and tested at the age of 7 and 28 days. The compressive test result for both mix design is as follow in the table below.

Table 3.1.Compressive strength result for mix design 1 (using river sand) at 7

	Date		Age in Days	Dimensions of cube(m)			Unit weight (Kg/m3)	Force (KN)	Compressive Strength	
Marking	Poured	Tested		L	W	H			Kg/cm2	Mpa
1	21/09/2011	28/09/2011	7	0.15	0.15	0.15	2413	450	204	20.4
2	21/09/2011	28/09/2011	7	0.15	0.15	0.15	2434	450	204	20.4
3	21/09/2011	28/09/2011	7	0.15	0.15	0.15	2471	470	213	21.3

Table 3.2.Compressive strength result for mix design 2 (using Supplied sand) at day 7

	Date		Age in Days	Dimensions of cube(m)			Unit weight(Kg/m3)	Force (KN)	Compressive Strength	
Marking	Poured	Tested		L	W	H				
1	21/09/2011	28/09/2011	7	0.15	0.15	0.15	2473	368	167	16.7
2	21/09/2011	28/09/2011	7	0.15	0.15	0.15	2416	382	173	17.3
3	21/09/2011	28/09/2011	7	0.15	0.15	0.15	2382	415	188	18.8

Table 3.4. Compressive strength result for mix design 1 (using river sand) at day 28

	Date		Age in	Dimensions of cube(m)			Unit	Force	Compressive Strength	
Marking	Poured	Tested	Days	L	W	H	weight(Kg/m3)	(KN)	Kg/cm2	Mpa
1	21/09/2011	19/10/2011	28	0.15	0.15	0.15	2459	555	252	25.2
2	21/09/2011	19/10/2011	28	0.15	0.15	0.15	2434	580	263	26.3
3	21/09/2011	19/10/2011	28	0.15	0.15	0.15	2481	600	272	27.2

Table 3.5. Compressive strength result for mix design 2 (using Supplied sand) at day 28

	Date		Age in	Dimensions of cube(m)			Unit	Force	Compressive Strength	
Marking	Poured	Tested	Days	L	W	H	weight(Kg/m3)	(KN)	Kg/cm2	Mpa
1	21/09/2011	19/10/2011	28	0.15	0.15	0.15	2491	440	199	19.9
2	21/09/2011	19/10/2011	28	0.15	0.15	0.15	2373	450	204	20.4
3	21/09/2011	19/10/2011	28	0.15	0.15	0.15	2407	432	196	19.6

Figure 3.1. Preparing concrete cube molds for compressive strength test

3.3 Discussion

From the study, it is clearly observed that there is a different result in the compressive strength of concrete made between the river sand sample from the quarry site and the supplied sand from the market place. The following table clearly shows that the compressive strength of the concrete made using supplied sand declines when it is compared with the concrete cube made using the quarried river sand.

Table 3.6.Loos and Result in the percentage of 7 days concrete compressive strength

Cube marking	compressive strength using quarried river sand (A) Mpa	compressive strength using supplied sand (B) Mpa	Loos in compressive strength(C)=A-B Mpa	Percentage loos in compressive strength=(C/A)*100%
1	20.4	16.7	3.7	18.14%
2	20.4	17.3	3.1	15.2%
3	21.3	18.8	2.5	11.74%

Table 3.7.Loos and Result in the percentage of 28 days concrete compressive strength

Cube marking	compressive strength using quarried river sand (A)Mpa	compressive strength using supplied sand (B)Mpa	Loos in compressive strength(C)=A-B Mpa	Percentage loos in compressive strength=(C/A)*100%
1	25.2	19.9	5.3	21.03%
2	26.3	20.4	5.9	22.43%
3	27.2	19.6	7.6	27.94%

According to the experimental test result the compressive strength of mix design trial 2(concrete made by using supplied sand) at 7 &28 day is decreased averagely by 15 % & 23.8% respectively compared to the mix design trial1(concrete made by using supplied sand). The study has observed that the quality of the river sand is reduced due to some unlawful informal practices on the supplying system of sand .so these informal practices are usually done by the sand deliberately for extra economic benefit. These practices have a negative effect on the quality strength of the concrete made in the city. Informal practices observed in the study which negetively affects the the quality of sands as well as the compressive strength of concrete made are shown below.

Figure 3.2. Suppliers are selling sand by mixing different types sands and mixing the river sand with pumice at different supply chain of Addis Ababa city.

5. CONCLUSIONS AND RECOMMENDATION

5.1. Conclusions

This study has concluded that suppliers of sand, in which their stock is in Addis Ababa, are supplying sand with improper practice, which are explained in the previous chapter, that affects the quality of the sand as well as the compressive strength of the concrete made. This study has generally concluded that:

✓ The study has observed that the quality of the river sand is reduced due to some Unlawful informal practices on the supplying system of sand.

✓ According to the experime ntal test result the compressive strength of mix design trial 2(concrete made by using supplied sand) at 7 &28 day is decreased averagely by 15 % & 23.8% respectively compared to the mix design trial1(concrete made using supplied sand).

5.2 Recommendation

5.2.1 from this study

Since there is a different result in the compressive strength of concrete made between the river sand sample and supplied sample, this study clearly recommends the following points:

- ✓ Since Suppliers do informal adulteration of sand, Suppliers should have a conformation paper about the source and the type of the sand they have in their stock from delegated Government office.
- ✓ Customers should be aware of the type and property of the sand that they are from suppliers to protect the unjustified economy bankruptcy.

✓ Before customers purchase the supplied sand professionals (Material engineers) should have scientific experimental quality test.

✓ Sudden frequent quality checking mechanism is necessary from the suppliers stock.

✓ Even if the sand is needed to blended with pumice and with other types sands, with different sources and property, there must be reasonable professional

✓ Blending mechanism to keep strength and durability of the concrete made.

5.2.2 For future this study

This study has also clearly recommends the following points for future study:

✓ This study did not show the overall supplying system of all sand suppliers in Addis Ababa. So additional investigation is required to check the sand supplying mechanism of each supplier.

✓ Durability of concrete has not been checked in this study .So further study should be conducted to check the effect of informal supplying practice of sand on the durability of concrete after a time.

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