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"Effect of Types of Fine Aggregate on Mechanical Properties of Cement Concrete"

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ABSTRACT: *This paper presents the effect of the use of artificial sand as fine aggregate in concrete as substitutes to natural sand. The experimental work is mainly concerned with the study of mechanical properties like compressive strength, split tensile strength and flexural strength of concrete by full replacement of natural sand by artificial sand as fine aggregate. Tests were carried out on cubes, cylinders and unreinforced beams to study the mechanical properties of concrete sing artificial sand and compared with conventional concrete.*

Keywords: *Artificial sand, compressive strength, flexural strength, split tensile strength.*

I. INTRODUCTION

Currently India has taken a major initiative on developing the infrastructures such as express highways, power projects and industrial structures etc. to meet the requirements of globalization, in the construction of buildings and other structures concrete plays the rightful role and a large quantum of concrete is being utilized. River sand, which is one of the constituents used in the production of conventional concrete, has become highly expensive and also scarce. In the backdrop of such a bleak atmosphere, there is large demand for alternative materials from industrial waste. Natural sand is excavated from river bed impacts on environment in many ways. Due to digging of the sand from river bed reduces the water head, so less percolation of rain water in ground, which result in lower ground water level. There is erosion of nearby land due to excess sand lifting as well as it destroys the flora & fauna in surrounding areas.

Due to limited supply of natural sand, cost is very high and its consistent supply cannot be guaranteed. Under these circumstances use of crushed fine aggregates becomes unavoidable. However, many people in India have doubts about quality of concrete and mortar with crushed sand as fine aggregates. As the supplies of suitable natural sand near the point consumption are becoming exhausted, the cost of this sand is increasing. In addition to this, the turbulence created by dredging sand near the estuaries could damage the fragile ecosystem along the coast. Thus a replacement material to the natural sand was sought, and the fines from crushing operations were identified as a possible substitute material by this research.

II. OBJECTIVES

The objective of this study is to investigate the mechanical properties of hardened concrete having artificial sand as fine aggregate

1. To assess conventional concrete.
2. To study the influence of artificial sand on the mechanical properties of concrete and compare the result with that of concrete produced using selected river sand.
3. To clear doubts about quality and properties of concrete when artificial sand used as fine aggregates.

III. EXPERIMENTAL INVESTIGATION

3.1 Test materials and mix proportions

Portland pozzolana cement with ISI mark was used for tests on fresh and hardened concrete. The compressive strength was 40.75 MPa and 55.1 MPa at 7 and 28 days respectively. Local river sand and artificial sand with fineness modulus of 3.98 and 4.05 respectively were used. The maximum size in both the types of sand was 4.75 mm. The coarse aggregates with basaltic origin, maximum size 20 mm were from local stone crusher. Potable water, with pH of 7.1, was used. The designed mix M30 with proportion 1:1.37:2.75 (Cement: Fine aggregate: Coarse aggregate) for concrete with artificial sand and 1:1.30:2.81 for that with river sand on weight basis. The mix design was done as per IS 10262:2009. Water cement ratio of 0.435 kept constant for both the types of concrete and for all specimens.

3.2 Specimen Details

There were two series. Concrete with fine aggregate as river sand and concrete with fine aggregate as artificial sand and each series comprised of three beams. For each series six beams (150mm x 150mm x 1000mm), three cubes (150 mm x 150 mm x 150 mm) and three cylinders (150 mm diameter and 300 mm height) were cast as control specimens. Specimens were cured for 28 days.

3.3 Testing

Testing was carried out on 6 beams of both series for flexure. For flexural strength beams were simply supported on constant effective span of 900 mm under two point concentrated symmetrical loads for both series. All the beams were having constant overall span and width of 1000 mm and 150 mm respectively.

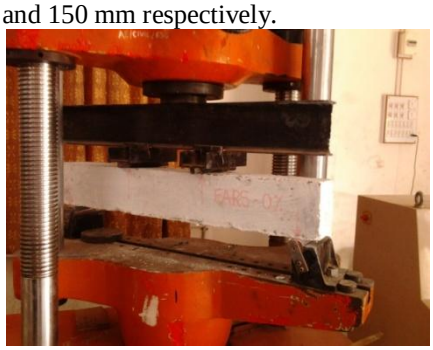


Figure 1: Flexural test setup

The beams were kept on universal testing machine. The beams were tested under gradually applied two point loading on Universal Testing machine (UTM) as shown in Fig. 1 for flexural strength. Ultimate load and modes of

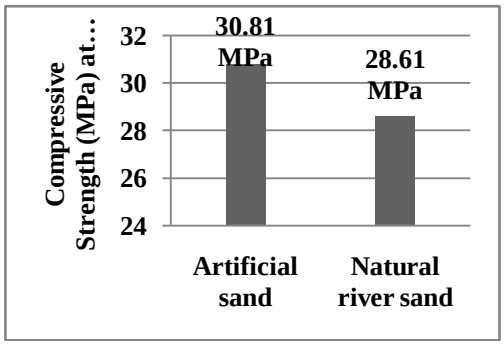
failure of beam were noted. Compressive strength and Split tensile strength are carried out on cubes and cylinders respectively, tested under compression testing machine.

IV. DISSCUSION AND RESULT

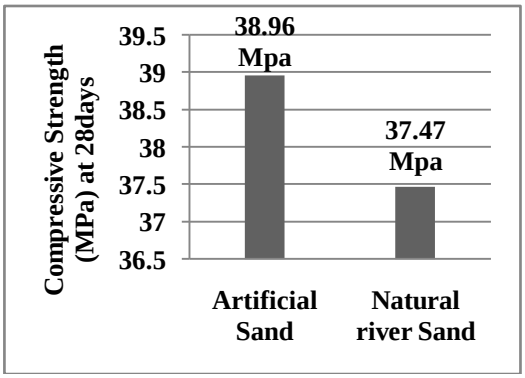
1.1 Compressive Strength

The calcium-silicate-hydrate (C-S-H) gel is the most important cementing component of concrete. It is responsible for the engineering properties of concrete including setting, hardening and strength development. The C-S-H gel micro-fibers penetrate in micro-pores of aggregate, it penetrates easily in crushed sand due to rough surface than river sand particles which results more strength.

From the result table, it is observed that, a compressive strength of cement concrete increases after replacing a fine aggregate by artificial / crushed sand at 7 and 28 days. During the crushing process the manufactured sand have irregular shapes and more fine particles which are filling gap between coarse particle and makes concrete solid also contributing to improved strength compared to river sand control mix.



Graph No.1: Compressive Strength (MPa) at 7 days

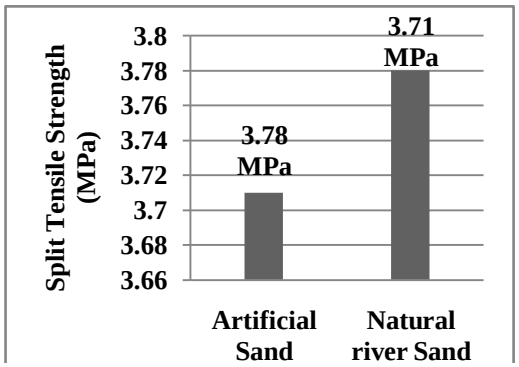


Graph No.2: Compreesive Strength (MPa) at 28 days

1.2 Split tensile Strength

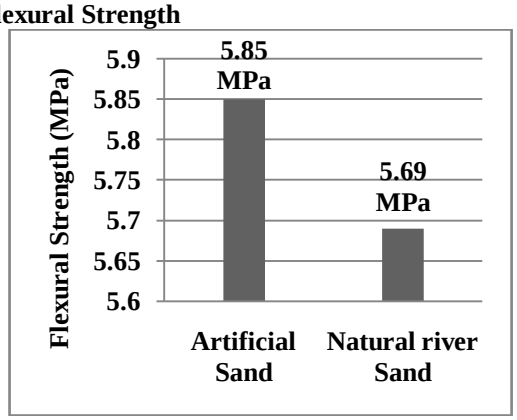
Plain concrete possesses a very low tensile strength, limited ductility and little resistance to cracking. Internal micro cracks are inherently present in the concrete and its poor tensile strength is due to propagation of such microcracks, eventually leading to brittle fracture of concrete.

From the experimental results it is seen that, the indirect split tensile strength of plain cement concrete with natural sand as fine aggregate is marginally higher than cement concrete with artificial sand as fine aggregate.



Graph No.3: Split Tensile Strength (MPa)

4.3 Flexural Strength



Graph No.4: Flexural Strength (MPa)

A good bond is essential for improving strength of concrete composite. The interfacial bond increased by larger area of contact, improving the frictional properties. The artificial sand contains more micro fines as compared to river sand which provides larger area of contact also particle shape of artificial sand is cubical, angular which helps to improve frictional properties that increases flexural strength of concrete.

Results have demonstrated that, the flexural strength of plain cement concrete with artificial / crushed sand as fine aggregate increased than cement concrete with natural river sand as fine aggregate. There was no crushing failure. All specimens are failed in pure bending zone, no shear cracks were seen.

V. CONCLUSIONS

1. A compressive strength of concrete with natural sand increased by 7.72% after fully replacing by artificial sand at 7 days and 3.98% at 28 days.
2. The effect on compressive strength of concrete by replacement of natural sand with artificial sand as fine aggregate is more prominent at seven days than that on 28 days.
3. The indirect split tensile strength of concrete with river sand as fine aggregate found marginally higher than concrete with artificial sand as fine aggregate, it is 3.78MPa and 3.71MPa respectively. Split tensile strength for all specimens was more than 10% of compressive strength.
4. The flexural strength of concrete with artificial sand as fine aggregate was recorded 2.81% more than concrete

with natural river sand as fine aggregate. All specimens are failed in pure bending zone of span, no shear failure were recorded.

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Table No.1: Compression test on at 7 days

Sr. No.	Type of Fine Aggregate	Compressive Load (N)	Compressive Strength (MPa)	Avg. Compressive Strength (MPa)
1.	Artificial sand	655×10^3	29.11	30.81
		749×10^3	33.29	
		676×10^3	30.04	
2.	Natural river sand	639×10^3	28.40	28.61
		575×10^3	30.00	
		617×10^3	27.42	

Table No.2: Compression test on cubes with river sand as fine aggregate at 28 days

Sr. No.	Type of Fine Aggregate	Compressive Load (N)	Compressive Strength (MPa)	Avg. Compressive Strength (MPa)
1.	Natural river sand	801×10^3	35.61	37.47
		897×10^3	39.87	
		831×10^3	36.93	
2.	Artificial sand	830×10^3	36.89	38.96
		895×10^3	39.78	
		905×10^3	40.22	

Table No.3: Split tensile test on cylinders at 28 Days

Sr. No.	Type of Fine Aggregate	Load (N)	Split Tensile Strength (MPa)	Avg. Split Tensile Strength (MPa)
1.	Artificial sand	228×10^3	3.23	3.71
		275×10^3	3.89	
		284×10^3	4.02	
2.	Natural river sand	247×10^3	3.50	3.78
		272×10^3	3.85	
		282×10^3	3.99	

Table No.4: Flexural strength test on beams at 28 days

Sr. No.	Type of Fine Aggregate	Load (N)	Flexural strength (MPa)	Avg. Flexural strength (MPa)
1.	Artificial sand	26.01×10^3	6.94	5.85
		20.05×10^3	5.35	
		19.80×10^3	5.28	
2.	Natural river sand	21.15×10^3	5.64	5.69
		20.90×10^3	5.58	
		21.95×10^3	5.85	