

### ABSTRACT

Concrete is the most widely used composite construction material. Fine aggregate plays a very important role for imparting better properties to concrete in its fresh and hardened state. Generally, river sand was used as fine aggregate for construction. Due to the continuous mining of sand from riverbed led to the depletion of river sand and it became a scarce material. Also, saming from river bed caused a lot of environmental issues. As a substitute to river sand, Robo sand has been used. In this present experimental study a comparative study has been carried out to check the usability of Robo sand in place of natural sand. This study involves determination of some major properties of concrete like compressive strength, split tensile strength, flexural tensile strength. Based on proposed studies, quality of Robo sand is equivalent to natural sand in many respects concrete is taken into account by taking its compressive strength, Split tensile strength and flexural strength values. The compressive strength, Split tensile strength and flexural strength value of the concrete made of Robo sand is observed to be very nearer to the strength of the concrete made of natural sand in the present investigation, there by 100% replacement is reasonable. As a substitute to river sand, Robo sand has been used.

**Keywords:** Concrete, Fine aggregate, Robo sand, compressive strength, Split tensile strength and flexural strength..

## I. INTRODUCTION

This chapter contains the general information about Robo sand ,its origin, need of Robo in construction. It also includes the exact meaning of Robo sand ,crushed dust, process of manufacturing by various machinery. Sand is the one of main constituents of concrete making which is about 35%of volume of concrete used in construction industry. Natural sand is mainly excavated from river beds and always contain high percentage of in organic materials, chlorides, sulphates, silt and clay that adversely affect the strength, durability of concrete. Generally known as Zone I, Zone II, Zone III and Zone IV. There is sieve Designation for each grade. Gradation is made as per the use of the sand .V.S.I can produce any zone of sand. But in case of natural sand quality varies from location to location without any control.

### 1.1 Robo sand

Robo sand is defined as a purpose made crushed fine aggregate produced from a suitable source material. Production generally involves Crushing, Screening and possibly Washing, separation into discrete fractions, recombining and blending. at the beginning Robo sand produced (by Jaw crusher, cone crusher, roll crusher, hammer mill) contains flaky and elongated particles. But now Robo sand produced from V.S.I (vertical shaft impactor).

### 1.2 Need for robo sand

The Civil engineers, Architects , Builders, Contractors agrees that the natural sand, which is available today, is deficient in many respect. It does not contains the fine particles, in proper proportion as required. Presence of other impurities such as coal, bones, shells, mica and silt etc makes it inferior for the use in cement concrete. The decay of these materials, due to weathering effect, shortens the life of the work. Now a days, Government have put ban on dragging sand from river bed.Due to dragging 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. In some places it may be up to 600 ft deep.

### 1.3 Market name for robo sand.

It is being called in the market with different names like Artificial sand(as it is artificially produced ), Robo sand(as it produced first by the company named Robo silicon ,pvt, limited) ,crushed sand (as it is produced from crushing),Rock sand ( as the origin is rock).

### 1.4 Difference between natural sand, robo sand

There is an ambiguity between the natural sand is river sand, the two Robo sand and Crushed dust. The actual meaning is given below which illustrates that the two are entirely different. Crushed dust is the waste product produced from the stone quarries. The main aim of the stone quarry is to produce coarse aggregate(80mm-4.75mm according to IS 383:1997) .The waste from these plants contain lot of fines( passing through 75 $\mu$ ) along with flaky and elongated particles of size ranging from 4.75mm to 75 $\mu$ . If properly treated this can be used for producing Robo sand . But treating this waste is an expensive work. Nutshell, it is a by product. Robo sand is purposefully made from parent rock but it doesn't contain fines(silt ,clay),instead it contains uniformly graded cubical particles of size ranging from 4.75mm-150 $\mu$ .

### 1.5 Manufacturing process of robo sand

Vertical Shaft Impactor principle is used for crushing bigger particles, for shaping the crushed metal (giving better shape of the particle) and for crushing fines aggregates below 4.75 mm. It is best machine Impactor is of cubical shape. Such sand can be used for all types of construction work, Concreting, Plastering etc and is better substitute to river sand. The sand manufacturing process is dry. The process requires very less water that too only to settle down the residual dust particles in colloidal state, emitted from the outlet. This machine can allow, slightly wet grit for crushing. Other machines, Cone crusher.

Manufacturing process involves the following three steps:

1. Crushing by VSI crusher.
2. Screening.
3. Washing.

Crushing of stones in to aggregates by VSI, then fed to Rotopactor to crush aggregates into sand to required grain sizes (as fines).

Screening is done to eliminate dust particles and Washing of sand eliminates very fine particles present within. The end product will satisfy all the requirements of IS:383 and can be use din Concrete & construction

The Jaw crushers are generally used for crushing stones in to metal/aggregates. Robo sand from jaw crusher, cone crusher, roll crusher often contain higher percentage of dust and have flaky particle

## II. LITERAURE REVIEW

Misra(1984) studied the effect of complete replacement of sand with crushed sand (fine sand passing through 75 $\mu$ ). The percentage of water required to produce mortar of same consistency is high for Robo sand as compared to river sand of same grading and same mix proportions. Hudson (1999) reported that Concrete Robo with a high percentage of minus 75 micron material will yield a more cohesive mix than concrete made with typical natural sand. Giridhar (2000) have observed that the concrete prepared using crusher stone dust was found to be relatively less workable than those compared with river sand and for the concrete made with crusher dust, there is an increase of 6% strength split tension and an increase of 20% strength in flexural tensile tension at 28 days for M20 grade design mix. Ratioet.al (2002) has found that as percentage of stone dust increases the workability decreases in each grade of concrete, to compensate the decrease in workability, some quantity of water and cement were added to get normal workability. The percentage of increase in water is in the range of 5% to7%.

**Bhanuprabha,(2003)** observed that the percentage of weight for M20,M25 and M30 grade Robo sand concrete increased in 5% H<sub>2</sub>SO<sub>4</sub> and 5% Na<sub>2</sub>SO<sub>3</sub> acid compared to plain concrete and found to be as-30.3%,-24.4%, -22.9%; and -5.3%, -2.2%,-1.25% respectively.

**Bhikshma et.al(2009)** conducted tests on 30 concrete cubes and 10 reinforced beams. They observed increase in compressive strengths by 6.89%, 10.76%, 17.24% and 20.24% for replacements of 25%, 50%, 75% and 100% of Robo sand.

### Literature survey on concrete

Concrete is the most widely used human-made product in the World. In contrast to its internal complexity, versatility, durability, and economy, it has been the most extensively used construction material with a production over six billion tons every year. Concrete is used to make pavements, building structures, foundations, roads, overpasses, parking structures, brick/block walls and bases for gates, fences and poles. Concrete is primarily a proportionate mixture of aggregate, cement, and water.

In India, Conventional concrete is often produced with four basic components namely Cement, Water (binder), the Crushed or uncrushed Stone and Natural Sand or Stone Dust. In addition to the above ingredients, one or two additional chemicals are also added to the recipe of concrete in order to enhance some properties, So modern concrete can have more four ingredients mentioned earlier and like many other composites, property of concrete can be suitably tailored for specific construction related performance

## III. MATERIALS AND METHODS

### 3.1 Materials of concrete

#### 3.1.1 Cement

Cements may be defined as adhesive substances capable of uniting fragments or masses of solid mater to a compact whole. Portland cement was invented in 1824 by an English mason, Joseph Aspin, who named his product Portland cement because it produced a concrete that was of the same colour as natural stone on the Isle of Portland in the English Channel.

Raw materials for manufacturing cement consist of basically calcareous and siliceous (generally argillaceous) material. The mixture is heated to a high temperature within a rotating kiln to produce a complex group of chemicals, collectively called cement clinker. Cement is distinct from the ancient cement. It is termed hydraulic cement for its ability to set and harden under water. Briefly, the chemicals present in clinker are nominally the four major potential compounds and several minor compounds. The four major potential compounds are normally termed as Tricalcium silicate ( $3\text{CaO}\cdot\text{SiO}_2$ ), declaim silicate ( $2\text{CaO}\cdot\text{SiO}_2$ ), tricalcium aluminates ( $3\text{CaO}\cdot\text{Al}_2\text{O}_3$ ) and tetra calcium aluminoferrite ( $4\text{CaO}\cdot\text{Al}_2\text{O}_3\cdot\text{Fe}_2\text{O}_3$ ).

#### 3.1.2 Coarse and fine aggregates

- All aggregates shall comply with the requirements of IS: 383-1970
- The nominal maximum size of coarse aggregate shall be as large as possible subject to the following
  - In no case greater than one-fourth the minimum thickness of the member, provided that
  - The concrete can be placed without difficulty so as to surround all prestressing tendons and reinforcements and fill the corners of the for m.
  - It shall be 5 mm less than the spacing between the cables, strands or sheathings where provided
  - Not more than 40 mm; aggregates having a maximum nominal size of 20 mm or smaller are generally considered satisfactory
  - Coarse and fine aggregates shall be batched separately
  - Specification for coarse and fine aggregates from natural sources for concrete second revision

#### 3.1.3 Robo sand

It is being called in the market with different names like Artificial sand(as it is artificially produced ), Robo sand(as it produced first by the company named Robo silicon ,pvt, limited) ,crushed sand (as it is produced from crushing),Rock sand ( as the origin is rock)

#### 3.1.4 Water

The requirements of water used for mixing and curing shall conform to the requirements given in IS: 456-2000. However use of sea water is prohibited

### 3.2 Methods

Methodology and experimental work involves the tests required to ascertain the quality of materials for making concrete, designing the concrete mix, preparation of specimens and different standard methods for testing the concrete. An experimental study is conducted to find 7 and 28 day Compressive, Split tensile and Flexural tests in M 40 grade concrete made of both Natural sand and Robo sand and the results were compared for drawing a conclusion.

The materials used in this study were cement, fine aggregates (both natural sand and Robo sand) ,Coarse aggregates and water.

#### 3.2.1 Tests on materials

##### 3.2.1.1 Cement

###### 3.2.1.1 a) Initial and final setting time

We need to calculate the initial and final setting time as per IS: 4031 (Part 5) – 1988. To do so we need Vicar apparatus conforming to IS: 5513 – 1976, Balance, Gauging trowel conforming to IS: 10086 – 1982.

###### 3.2.1.1 b) Consistency test

The basic aim is to find out the water content required to produce a cement paste of standard consistency as specified by the IS: 4031 (Part 4) – 1988. The principle is that standard consistency of cement is that consistency at which the Vicar plunger penetrates to a point 5-7mm from the bottom of Vicar mould.

###### 3.2.1.1 c) Specific gravity test

**Specific gravity:** It is the ratio between the weight of a given volume of material and weight of an equal volume of water. To determine the specific gravity of Cement, kerosene which does not react with cement is used



*Fig 3.2.1.1A) - Vicat apparatus*



*Fig 3.2.1.1C) – Pycnometer*

*Table No- 3.2.1.1 TEST RESULTS OF CEMENT*

S.NO	Characteristics	Test results	IS:12269-1897 specifications
01	Initial setting time (minutes)	35min	>30 minutes
02	Final setting time (minutes)	230min	<600 minutes
03	Consistency	30%	-
04	Specific gravity	3.0473	3.15
05	Fineness (IS sieve no 9)	3.5%	<10%

### 3.2.1.2 Fine aggregates (natural and robo sand)

The locally available natural sand and machine made Robo sand are used as fine aggregate. It should be free from clay, silt, organic impurities etc., The sand is tested for various properties such as specific gravity, bulk density etc. in accordance with IS:2386-1963. The grading or particle size distribution of fine aggregate shows that it is close to grading Zone – II or IS:383-1970

#### 3.2.1.2 a) Sieve analysis

Sieve analysis helps to determine the particle size distribution of the coarse and fine aggregates. This is done by sieving the aggregates as per IS: 2386 (Part I) – 1963. In this we use different sieves as standardized by the IS code and then pass aggregates through them and thus collect different sized particles left over different sieves.

#### Sieve analysis for fine aggregate (natural sand)

S.NO	Sieve no:	Wt retained on each sieve	% of wt retained	Cumulative % of wt retained	Cumulative % of passing
01	10 mm	00	00	00	100
02	4.75 mm	10	01	01	99
03	2.36 mm	10	01	02	98
04	1.18 mm	140	14	16	84
05	600 $\mu$	215	21.5	37.5	62.5
06	300 $\mu$	535	53.5	91	09
07	150 $\mu$	70	07	98	02
08	75 $\mu$	20	02	100	00

This fine aggregate is confirming to **Zone-II** according to **IS:383**

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Sieve analysis for fine aggregate (robo sand)

S.NO	Sieve no:	Wt retained on each sieve	% of wt retained	Cumulative % of wt retained	Cumulative % of passing
01	10 mm	00	00	00	100
02	4.75 mm	05	0.5	0.5	99.5
03	2.36 mm	95	9.5	10	90
04	1.18 mm	250	25	35	65
05	600 μ	116	11.6	46.6	54.4
06	300 μ	270	27.5	73.6	26.4
07	150 μ	135	13.5	87.1	12.9
08	75 μ	129	12.9	100	00

This fine aggregate is confirming to **Zone-II** according to **IS:383**

3.2.1.2 b) Specific gravity

$$\text{Specific Gravity} = \frac{(W_2 - W_1)}{(W_2 - W_1) - (W_3 - W_4)}$$

The specific gravity of fine aggregate (Natural sand) = **2.68**

The specific gravity of fine aggregate (Robo sand) = **2.55**

3.2.1.2 c) Bulk density test

$$\text{Bulk Density} = \frac{(W_2 - W_1) \text{ in kg}}{\text{Capacity of container in lit}}$$

Table No – 3.2.1.2 test results of fine aggregate

S.NO	PROPERTIES	TEST RESULTS		IS:2386-1963 SPECIFICATIONS
		NATURAL SAND	ROBO SAND	
01	Fineness modulus	3.4	3.16	-
02	Specific gravity	2.66	2.55	2.6-2.8
03	Bulk density	1475kg/m <sup>3</sup> (untraded)	1475kg/m <sup>3</sup> (untraded)	-
		1624kg/m <sup>3</sup> (ridded)	1768kg/m <sup>3</sup> (ridded)	

3.2.1.3 Coarse aggregates

The machine crushed annular granite metal of average size of 40mm is used as a coarse aggregate. It should be free from impurities such as dust, clay particles, organic matter etc. The fine and coarse aggregate are tested for various properties as shown in table. The grading or particle size distribution of coarse aggregate shown close to average size of 40mm as per IS:383-1970.

3.2.1.3 a) Sieve analysis of coarse aggregate

Sieve analysis helps to determine the particle size distribution of the coarse and fine aggregates. This is done by sieving the aggregates as per IS: 2386 (Part I) – 1963. In this we use different sieves as standardized by the IS code and then pass aggregates through them and thus collect different sized particles left over different sieves.

S.NO	Sieve size	Wt retained on each sieve	% of wt retained	Cumulative % of wt retained	Cumulative % of passing
01	80	00	00	00	100
02	40	00	00	00	100
03	20	2400	24	24	76
04	10	640	64.6	88.6	11.4

**3.2.1.3 b) Specific gravity of coarse aggregate**

$$\text{Specific Gravity} = \frac{(W_2 - W_1)}{(W_2 - W_1) - (W_3 - W_4)}$$

The specific gravity of coarse aggregate = 2.72

**3.2.1.3 c) Bulk density test of coarse aggregate**

$$\text{Bulk Density} = \frac{(W_2 - W_1) \text{ in kg}}{\text{Capacity of container in lit}}$$

**3.2.1.3 d) Aggregate crushing value test**

This test helps to determine the aggregate crushing value of coarse aggregates as per IS: 2386(Part IV)–1963. The apparatus used is cylindrical measure and plunger, Compression testing machine, IS Sieves of sizes – 12.5mm, 10mm and 2.36mm

Table No- 3.2.1.3 test results of coarse aggregate

Property	Test results	IS:2386-1963 Specifications
Fineness modulus	7	-
Specific gravity	2.7	2.6-2.8
Crushing value	22%	<30%
Bulk density	1483kg/m <sup>3</sup> (untraded)	-
	1563kg/m <sup>3</sup> (ridded)	-
Abrasion test	34%	40%

**3.2.1.4 Water**

Water is needed for the hydration of cement and to provide workability during mixing and for placing. There is not much limitation for water except that the water must not severely contaminated. In this study, normal tap water was used. Water used for mixing and curing shall be clean and free from injurious amount of oils, acids, alkalies, salts, organic materials or other substances. They may be deleterious to concrete. Portable water is used for mixing as well as curing of concrete as prescribed in IS:456:2000

**3.3 Mix design****Mix design for M40**

In order that not more than the specified portions of test results are likely to fall below the characteristic strength ( $F_{act}$ ), the concrete mix has to be designed for somewhat higher target average compressive strength ( $F_{act}$ ).

**$F_{ck} = f_{ck} + t_s$  (s)**

Where,  $F_{ck}$  = target average compressive strength at 28 days,  $F_{ck}$  = characteristic compressive strength at 28 days = 40 MPa,  $S$  = Standard deviation = 5 (from Table No. 1 of IS: 10262:2009),  $t = 1.65$  (from Table No. 2 of IS: 10262:2009), Therefore,  $F_{ck} = 40 + 1.65(5) = 48.25 \text{ N/mm}^2$ .

Therefore mix design is (M40) = **1:1.13:2.29**, Cement content (c) = **492.5 kg/m<sup>3</sup>**, Fine aggregate (fa) = **558 kg/m<sup>3</sup>**, Coarse aggregate (Ca) = **1132 kg/m<sup>3</sup>**, Water = **197.16 liters**

**3.4 Mixing procedure**

Pan-mixing is adopted throughout the experimental work. First the materials cement, Fine aggregate, coarse aggregate, weighed accurately. Pan mixer is used as a capacity of 1 cu. ft. The drum is made of steel plates with a number of blades put in inclined position in the drum. As the drum rotates, the materials encountered resistance from the blades and these disturbing effects help in good mixing of ingredients.

**3.5 Preparing test specimens**

For casting the cubes, cylinder and beam specimens a standard cast iron metal moulds of size 150x150x150 mm cubes, 150 mm diameter and 300 mm height cylinders and beams of size 150x150x700 mm are used. The mould has been cleaned of dust particles and applied with mineral oil on all sides, before concrete is poured into the mould. Thoroughly mixed concrete is filled in the mould in three layers of equal height followed by vibration with needle vibrator. Excess concrete is removed with trowel and top surface is finished to smooth level. Compaction of concrete: Compaction of concrete is a process adopted for expelling the entrapped air from the concrete.

**3.7 Curing**

In this study, the specimens were cured by placing in water for about 7 and 28 days. The specimens were cured until they were ready to be tested at the designated ages. The test specimens shall be stored on the site at a place free from vibration, under damp matting, sacks or other similar material for 24 hours  $\pm$  ½ hour from the time of adding the water to the other ingredients. The temperature of the place of storage shall be within the range of 22° to 32°C. After the period of 24 hours,

**3.8 Experimental study**

In this chapter, we focus on the procedures utilized for creating and testing concrete. To draw reasonable conclusions in regards to choosing appropriate mixture ratios for concrete, testing and experimentation must be conducted. Different strengths are determined by creating specimens of concrete and subjecting it to loadings until failure.

**3.8.1 Lab tests on fresh concrete**

Each batch of concrete shall be tested for consistency immediately after mixing, by one of the methods described in IS: 1199-1959. The Methods are

1. Slump Test- Workability
2. Compaction Factor

**3.8.1.1 Slump test- workability**

Slump test is used to determine the workability of fresh concrete. Slump test as per IS: 1199 – 1959 is followed. The apparatus used for doing slump test are Slump cone and tamping rod. The slump measured should be recorded in mm of subsidence of the specimen during the test. Any slump specimen, which collapses or shears off laterally, gives incorrect result and if this occurs, the test should be repeated with another sample. If in the repeat test also, the specimen shears, the slump should be measured and the fact that the specimen sheared, should be recorded.



Slump cone test values				
S.NO	W/C ratio	Natural Sand	Robo sand	Degree Of workability
01	0.4	10	10	Very low



Slump Test

### 3.8.1.2 Compaction factor

Compacting factor of fresh concrete is done to determine the workability of fresh concrete by compacting factor test as per IS: 1199 – 1959. The apparatus used is Compacting factor apparatus. When maximum size of aggregate is large as compare with mean particle size the drop into bottom container will produce segregation and give unreliable comparison with other mixes of smaller maximum aggregate sizes.

Compacting factor = (Weight of partially compacted concrete)/(Weight of fully compacted concrete)

Compaction Factor test values				
S.NO	W/C ratio	Natural Sand	Robo sand	Degree Of workability
01	0.4	0.74	0.75	Very low

Table No- 3.8.1 tests result of fresh concrete

S.NO	Degree of workability	Slump Test value		Compacting Factor	Use for which concrete is suitable
		mm	In		
01	Very low	0-25	0-1	0.78	Very dry mixes; used in road making. Roads vibrated by power operated machines.

### 3.8.2 Lab tests on hardened concrete

There are two kinds of tests which are done on hardened concrete. These are:

- i). Non-destructive tests
- ii). Destructive tests.

#### 3.8.2.1 Non-destructive tests

In Non-destructive test, the sample is not destroyed and this test is very useful in determining the strength of existing buildings or structures. The Non-destructive tests conducted on concrete are as follows:

##### 1. Rebound Hammer test

Rebound hammer for in situ evaluation of compressive strength of grade of concrete

##### 2. Ultrasonic pulse velocity test

Ultra sonic pulse velocity apparatus for the detection of cracks in the concrete

#### 3.8.2.2 Destructive tests

In destructive test a sample is made and then destroyed to find out the strength of concrete. The destructive tests conducted on concrete are as follows:

- a. Compressive strength test
- b. Tensile strength test
- c. Flexural strength test

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The tests adopted in this study are only the destructive tests. These tests are done by using Universal Testing Machine (UTM).

### 3.8.2.2 a) Compressive strength test( according to is:516-1959)

Out of many tests applied to the concrete, this is the utmost important which gives an idea about all the characteristics of concrete. By this single test one judge that whether Concreting has been done properly or not. For cube test two types of specimens either cubes of 15 cm X 15 cm X 15 cm or 10cm X 10 cm x 10 cm depending upon the size of aggregate are used. For most of the works cubical moulds of size 15 cm x 15cm x 15 cm are commonly used.



Mould



placing of concrete



De-Moulding



Curing

#### Procedure:

1. Remove the specimen from water after specified curing time and wipe out excess water from the surface.
2. Weigh the specimen on weighing machine.
3. Clean the bearing surface of the testing machine
4. Place the specimen in the machine in such a manner that the load shall be applied to the opposite sides of the cube cast.
5. Align the specimen centrally on the base plate of the machine.
6. Rotate the movable portion gently by hand so that it touches the top surface of the specimen.
7. Apply the load gradually without shock and continuously till the specimen fails
8. Record the maximum load and note any unusual features in the type of failure.

$$\text{Compression Strength} = \frac{\text{Load in N}}{\text{Area in mm}^2}$$

Minimum three specimens should be tested at each selected age. If the strength of any Specimen varies by more than 15 per cent of average strength, results of such specimen should be rejected. Average of three specimens gives the crushing strength of concrete



Specimen after Testing in Compression testing machine

Table No- 3.8.2.A) compressive strength test results ( m40 grade of concrete at 7 and 28 days)

S.no	Concrete Type	Days	Cube-1	Cube-2	Cube-3	Average	
						Load (KN)	Stress (Mpa)
01	Natural sand	7	930	1200	820	983.33	43.7
02		28	960	1200	1000		
03	Robo sand	7	850	900	920	890	39.56
04		28	900	1050	1300		

### 3.8.2.2 b) Split tensile strength test (according to is :516-1959)

It is measured by testing cylinders under diametrical compression.

#### Procedure:

- Take the wet specimen from water after 7 and 28days of curing.
- Wipe out water from the surface of specimen.
- Draw diametrical lines on the two ends of the specimen to ensure that they are on the same axial place.
- Note the weight and dimension of the specimen.
- Set the compression testing machine for the required range.
- Keep are plywood strip on the lower plate and place the specimen.
- Align the specimen so that the lines marked on the ends are vertical and cantered over the bottom plate.
- Place the other plywood strip above the specimen.
- Bring down the upper plate to touch the plywood strip.
- Apply the load continuously without shock until the specimen fails.
- Note down the breaking load (P).

#### Calculation:

The splitting tensile strength is calculated using the formula

$$\text{Split Tensile Test, } T_{sp} = \frac{2P}{\pi DL}$$

Where P = applied load, D = diameter of the specimen, L = length of the specimen



Placing of concrete in mould



Specimen under testing

Table No - 3.8.2.2 B) split tensile strength test results ( m40 grade of concrete at 7 and 28 days)

S.no	Concrete Type	Days	Cylinder 1	Cylinder 2	Cylinder 3	Average	
						Load (KN)	Stress (Mpa)
01	Natural sand	7	200	210	210	206.67	11.69
02		28	230	230	230	230	13.10
03	Robo sand	7	164	188	200	184	10.41
04		28	210	250	280	246.667	14.0

**3.8.2.2 c) Flexural strength test (according to is :516-1959)**

It is the ability of a beam or slab to resist failure in bending. It is measured by loading un-reinforced 6x6 inch (150 x 150mm) concrete beams with a span three times the depth (usually 18 in.). The flexural strength is expressed as “Modulus of Rupture” (MR). Flexural MR is about 12 to 20 percent of compressive strength depending on the type, size and volume of coarse aggregate used. However, the best correlation for specific materials is obtained by laboratory tests for given materials and mix design.

**Calculation:**

The flexural strength of the specimen shall be expressed as the modulus of rupture  $f_s$ , which, if ‘a’ equals the distance between the line of fracture and the nearer support, measured on the centre line of the tensile side of the specimen, in cm, shall be calculated to the nearest 0.5 kg/sq cm as follows:

$$f_s = \frac{P \times l}{b \times d^2}$$



Specimen



Specimen under testing

Table No - 3.8.2.2 C) flexural strength test results ( m40 grade of concrete at 7 and 28 days)

S.no	Concrete Type	Days	Beam 1	Beam 2	Beam 3	Average	
						Load (KN)	Stress (Mpa)
01	Natural sand	7	30	33	34	32.33	1.435
02		28	37	37	37	37	1.644
03	Robo sand	7	25	30	32	29.00	1.280
04		28	37	42	48	42.33	1.88

#### IV. RESULTS AND DISCUSSION

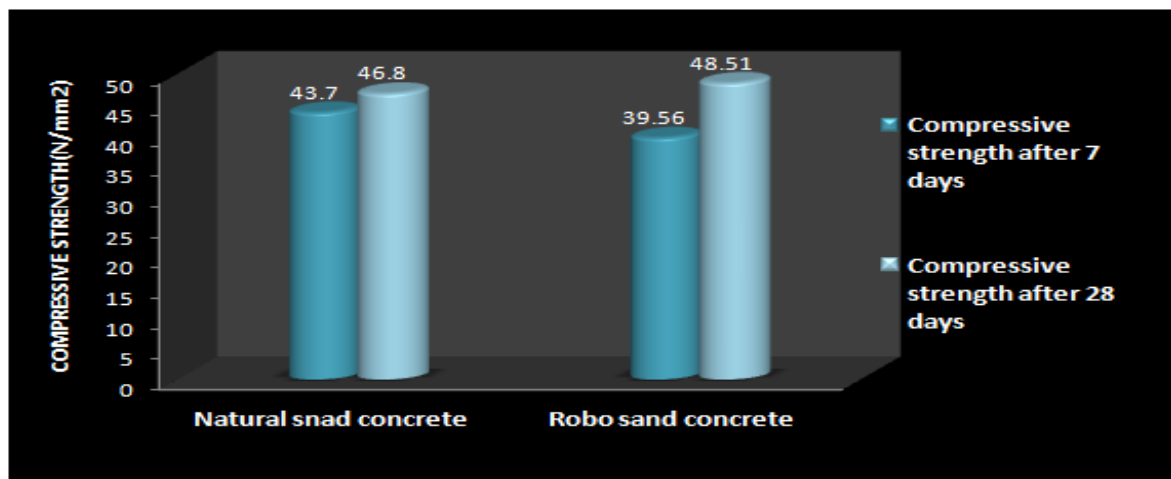
In this chapter, all the strength performance of various mixes containing two different types of fine aggregate (natural sand and robo sand ) will be discussed. All the tests conducted were in accordance with the methods described in this chapter. The discussion will be divided into three sections according to objectives stated in the earlier parts. The results are to be discussed and analyzed accordingly to draw out the conclusion later. The three sections mentioned are:

- i) Effect of robo sand concrete to Compression Strength, Tensile strength and Flexural strength.
- ii) The optimum replacement level of natural sand with robo sand
- iii) Comparison between Ordinary Concrete and robo sand concrete

##### 4.1 Compressive strength

In this section, the main concern is to study the compressive strength of concrete containing two different types of fine aggregate (**natural sand and robo sand** ) Control specimens are concrete with 100% replacement of fine aggregate (natural sand with robo sand) Cubes with the size of **150 x 150 x 150 mm** were tested at the ages of **7 and 28 days**. The results of the compressive strength test are shown in Table No.- **3.8.2.A)**

From the graph shown in the Fig.5.1., 100 % replacement of fine aggregate (natural sand with robo sand) has been observed as an optimal strength than other proportions at 7 and 28 days



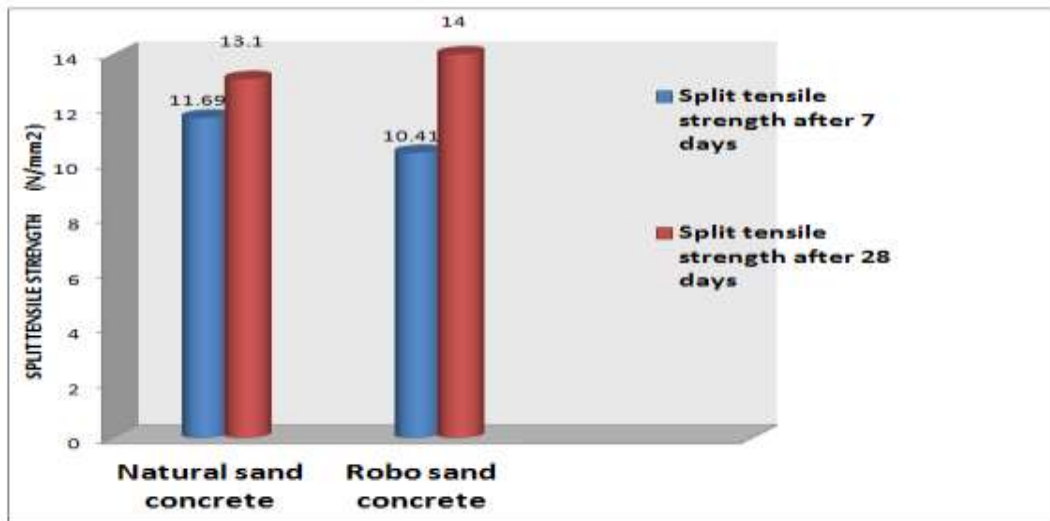
Graph 4.1 showing Compressive Strength of two types of concrete

##### 4.2 Split tensile strength test

In this section, the main concern is to study the compressive strength of concrete containing two different types of fine aggregate (**natural sand and robo sand** ).

The Cylinder consist of **150 mm diameter and 300mm Long** were tested at the ages of **7, and 28 days**. The results of the **Split tensile strength test** are shown in Table No.- **3.8.2.B)**

From the graph shown in the Fig.5.2.2. 100 % replacement of fine aggregate (natural sand with robo sand) has been observed as an optimal strength than other proportions at 7 and 28 days.



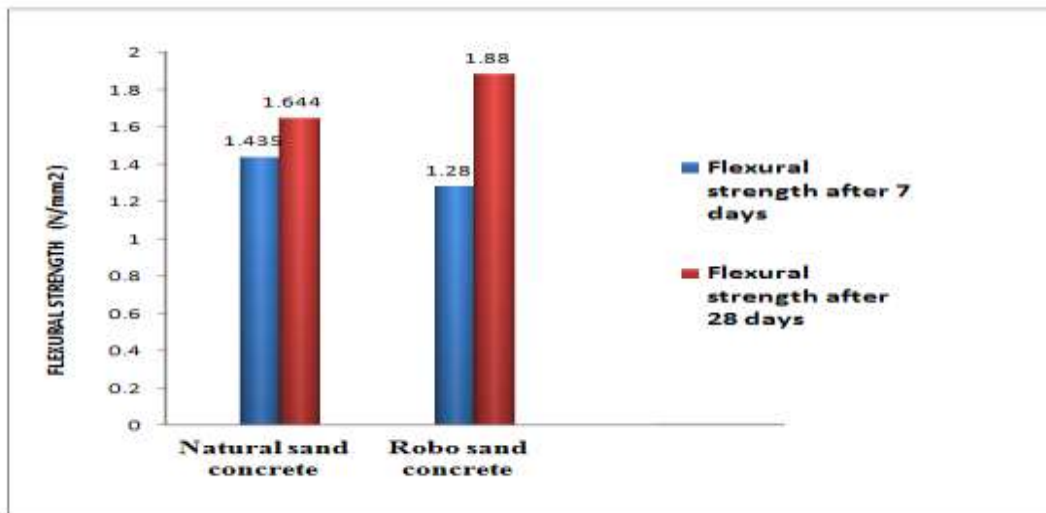
Graph 4.2 Graph showing Tensile Strength of two types of concrete

#### 4.3 Flexural strength test

The size of specimen shall be  $10 \times 10 \times 50$  cm. were tested at the ages of 7 and 28 days. The results of the

flexural strength test are shown in Table No.- 4.4.3 Where each value is averaged from the results of three cubes.

From the graph shown in the Fig.5.3., 100 % replacement of fine aggregate (natural sand with robo sand) has been observed as an optimal strength than other proportions at 7 and 28 days.



Graph 4.3 showing Flexural Strength of two types of concrete

## V. CONCLUSION

- 100% replacement is reasonable where there is low workability requirement. And where there is high workability requirement, partial replacement can be made keeping in view the strength and economy.
- Strength criteria can be fully ascertained with 100% replacement of natural sand with Robo sand.
- **MAY 2016** The Andhra Pradesh Government is seeking to encourage use of Robo sand, a natural sand substitute for use in the construction sector.
- For big projects like highways, establishing a plant leads to economy as they require large amount of fine aggregate.
- River beds can be safeguarded by reducing the excavations for at natural sand

## VI. FUTURE SCOPE

- Replacing natural sand with different % of Robo sand so that clear variation of strength can be plotted as well as optimum amount can also be determined.
- Conducting investigation for M40, M50 and also for high strength concrete.
- Conducting chloride penetration test and water absorption tests on concrete to ensure adequate durability.

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