

**EFFECTS ON PROPERTIES OF CONCRETE BY PARTIAL  
REPLACEMENT OF CEMENT WITH CARBON BLACK AND  
NATURAL FINE AGGREGATE WITH ROBO SAND**

**Submitted in partial fulfillment of the requirements  
of the degree of**

**MASTER OF TECHNOLOGY  
in  
STRUCTURAL ENGINEERING**

**by  
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**School of Civil Engineering  
LOVELY PROFESSIONAL UNIVERSITY, PHAGWARA  
2017**

## DECLARATION

I, **Danish Fayaz (11617746)**, hereby declare that this thesis report entitled “**Effects on the Properties of Concrete by Partial Replacement of Cement with Carbon Black and Natural Fine Aggregate with Robo Sand**” submitted in the partial fulfillment of the requirements for the award of degree of Master of Civil Engineering, in the School of Civil Engineering, Lovely Professional University, Phagwara, is my own work. This matter embodied in this report has not been submitted in part or full to any other university or institute for the award of any degree.

**Date:**

**Danish Fayaz  
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**Place:**

## **CERTIFICATE**

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Certified that this project report entitled “ **Effects on the Properties of Concrete by Partial Replacement of Cement with Carbon Black and Natural Fine Aggregate with Robo Sand**” submitted individually by student of School of Civil Engineering, Lovely Professional University, Phagwara , carried out the work under my supervision for the Award of Degree. This report has not been submitted to any other university or institution for the award of any degree.

### **Signature of Supervisor**

Mr. Ashfaq Malik

Assistant Professor

## **ACKNOWLEDGEMENTS**

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## ABSTRACT

From early 1990s, the demand of the mineral admixtures has been increased tremendously for the manufacturing of cement and concrete. Then after 1990s, the future demand for the mineral admixtures was expected to increase even more. Hence, in the building construction, the concrete which is manufactured with the help of constituent materials like cement, fine aggregate and coarse aggregate should be sustainable, and even stronger to withstand the loads and the weathering conditions during its age. The sustainability, strength and durability of any of the constituent material of concrete play an important role in studying and determining the effects on the properties of concrete with the advent of age.

In this present experimental study, various properties of concrete will be studied using quarry dust (robo sand, artificial sand, stone dust) as a partial replacement of natural fine aggregate and carbon black as a partial replacement of cement in concrete by using different percentages of both the materials. Based on the proposed studies it was reviewed that the enhancement in the strength of concrete was due the cement hydration acceleration at the early ages due to the effect of the stone dust. It was also found that the concrete porosity was lower than that of the corresponding concrete without robo sand at the same water/cement ratio. It was also found that at the percentage replacement of cement by carbon black (5%) and robo sand by natural sand (50%), the concrete becomes denser as both carbon black and stone dust act as micro fillers in the concrete due to their sizes with respect to cement and natural sand. Hence a study will be carried out of using both the materials carbon black and robo sand simultaneously in the concrete. Moreover, the permeability of the concrete will be decreased which reduces the corrosion rate and in turn increases the durability and sustainability properties of the concrete. Replacing a portion of cement with non-reactive waste material carbon black and natural sand with waste quarry dust and getting the same strength and durability at same w/c ratio 0.5 is of utmost importance regarding the economy (sustainability).

# TABLE OF CONTENTS

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<b>CHAPTER</b>	<b>Page No.</b>
<b>DECLARATION</b>	<b>ii</b>
<b>CERTIFICATE</b>	<b>iii</b>
<b>ACKNOWLEDGEMENTS</b>	<b>iv</b>
<b>ABSTRACT</b>	<b>1</b>
<b>CHAPTER 1 - INTRODUCTION</b>	<b>6</b>
1.1 General	6
1.2 Robo Sand	6
1.3 Carbon Black	6
<b>Chapter 2 - SCOPE OF STUDY</b>	<b>8</b>
<b>CHAPTER 3 - OBJECTIVE</b>	<b>9</b>
<b>CHAPTER 4 - LITERATURE REVIEW</b>	<b>10</b>
4.1 Discussion on the various properties of concrete	12
<b>CHAPTER 5 - EQUIPMENT, MATERIALS AND EXPERIMENTAL SETUP</b>	<b>14</b>
5.1 Equipment	14
5.2 Materials	14
<b>CHAPTER 6 - RESEARCH METHODOLOGY</b>	<b>15</b>
6.1 Design Mix	15
<b>CHAPTER 7 - EXPECTED OUTCOME</b>	<b>17</b>
<b>CHAPTER 8 - PROPOSED WORK PLAN</b>	<b>18</b>
<b>CHAPTER 9 - RESULTS AND DISCUSSION; EXPERIMENTAL WORK</b>	<b>19</b>
<b>9.1 Material Testing</b>	<b>19</b>
9.1.1 Testing of Cement.....	19
9.1.2 Testing of Fine Aggregate .....	19
9.1.2.1 Sieve Analysis of Natural Sand .....	19
9.1.2.2 Sieve Analysis of Robo Sand.....	20
9.1.2.3 Specific gravity of Natural Sand and Robo Sand.....	21
9.1.2.4 Water Absorption of Natural sand and Robo Sand .....	21
9.1.3 Testing of Coarse Aggregate .....	22

9.1.3.1 Sieve Analysis of Coarse Aggregate.....	22
<b>CHAPTER 10 - CONCLUSION</b>	<b>23</b>
<b>REFERENCES</b>	<b>24</b>

## LIST OF FIGURES

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<b>Figure No.</b>	<b>Description</b>	<b>Page No.</b>
Figure 1	Robo Sand	6
Figure 2	Carbon Black	7
Figure 3	Impact resistance in terms of dust % and number of blows	13



## LIST OF TABLES

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<b>Table No.</b>	<b>Description</b>	<b>Page No.</b>
Table 6	Strength of Concrete with Robo sand in M25 Grades	12
Table 1	Percentage Replacement and Number of Specimens	16
Table 2	Properties of Ordinary Portland Cement	19
Table 3	Sieve Analysis of Natural Sand	20
Table 4	Sieve Analysis of Robo Sand	21
Table 5	Sieve Analysis of Coarse Aggregate	22

**1.1 General**

Nowadays the building construction industry of India is facing a major problem that is natural fine aggregate. Due to restriction/ban executed on sand quarrying by government, result scarcity of natural river sand. The cost of river sand automatically increased due to huge material demand and substructure development in India. The shortage of natural sand will disturb the building industry. Maximum construction industries use natural river sand as fine aggregate. Researches are going on due to shoot up in the claim of robo sand and reduction of natural sand, besides constraints levied on the exploitation of the natural river sand. Hence there is a necessity to find a new alternative material to replace the natural fine aggregate, such that surplus river erosion and damage to surroundings is avoided. Investigators are finding alternate material to substitute the natural river sand, and one of the main material is quarry stone dust (Artificial Sand/Robo Sand).

**1.2 Robo Sand**

Robo Sand is obtained from crushing stones in a quarry. The sand used in concrete must have a proper gradation of 150 microns to 4.75 mm. The fineness modulus of robo sand is 2.52. The uniformity coefficient is less than 6 and its specific gravity is 2.66.



**Figure 1 Robo Sand**

**1.3 Carbon Black**

Carbon black is effectively pure carbon which is formed by incomplete burning/thermolysis the compounds made up of hydrogen and carbon. The appearance of carbon black is black, fine powder. It is an unwanted material obtained from the rubber manufacturing industries

and hence it is difficult to dispose. Normally these wastes from rubber manufacturing industries are decomposed in the soil thereby causing soil contamination and pollution in water. By utilizing carbon black as filler, this problem can be reduced to a high degree. The specific gravity of carbon black is 1.33. The pH of carbon black is 6, hence is an inert material.



**Figure 2 Carbon Black**

The future scopes of the current study are summarized below:

- Concrete with carbon black and robo sand can be used at the places where the effect of vibrations are more like in the cities where railway act as a major mode of transportation.
- Since both the materials carbon black as well as robo sand are the waste materials from rubber industry and quarries respectively, these wastes can be managed effectively by intruding into the concrete, thereby causing less harm to environment.
- Concrete containing carbon black and robo sand have very less permeability than a conventional concrete, in turn causing less corrosion to the reinforcement embedded in it. Hence, this type of concrete can be used where a concrete is more exposed to rain water.

The objective of the current research study is as follows:

- To make an economical concrete mix that effectively utilizes waste products and yet gives appreciable strength.

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**M.H.Kharita et al. (2009) [1]** “The effect of carbon powder addition on the properties of hematite radiation Shielding Concrete” concluded by their experimental investigation that when carbon black is used as an additive in the hematite concrete (15% of weight of the cement), there is no significant effect on the shielding properties, but it enhances the mechanical properties of hematite concrete. It has been investigated that of 6% of carbon black powder in hematite concrete enhances the workability of fresh mix, and compressive strength of the concrete. Precautions should be taken when the carbon black powder is used as an additive at high temperatures, because it gets affected easily by heat.

**M. Shahul Hameed et al (2009) [2]** “Properties of Green Concrete containing Quarry Rock Dust and Marble Sludge Powder as Fine Aggregate” investigated the feasibility of using quarry dust and marble dust in the concrete as a replacement of natural sand. The results indicated that the compressive strength, split tensile strength and flexural strength were 14% more than that of conventional concrete at 50% replacement.

**Dr. G. Chitra et al. (2014) [3]** “Carbon Black as an Additive in Conventional Concrete” investigated the different tests regarding strength and durability. Carbon black was used as a filler to minimize the presence of pores. 18 cubes, 12 cylinders were cast at the percentage replacement of cement at 0%, 2%, 5%, 8%, 12% and 15%. Different tests like compressive strength test, water absorption and split tensile test were conducted during the research work. It was later found that at 5% replacement of cement with carbon black, there is 20.7% increase in compressive strength ( for M25 grade, the compressive strength was found out to be 29.33 N/mm<sup>2</sup>). Moreover, the split tensile strength at 5% was found out to be effective.

**Sami Masadeh (2015) [4]** “The Effect of Added Carbon Black to Concrete Mix on Corrosion of Steel in Concrete” examined the impact of carbon black as an additive in the concrete on deterioration of steel reinforcement. This was accomplished by embedding of steel bars in various cement concrete blends which contained 0.1, 0.2, 0.3, 0.4, and 0.5 carbon-black/concrete ratio. The test samples were cured and then drenched in chloride solution of 3.5% for a half year. After that the penetration of chloride ions and accordingly the rate of corrosions were measured. It was found that with the increase in carbon black powder content, the corrosion rate and chloride ion infiltration diminished. It was because of filling property of fines of carbon black (in the order less than 250 nm). At 7% substitution, increment in curing from 1 month to a half year prompted around 5.7% lessening in permeability than that of no

carbon blend. It was likewise reasoned that as the chloride ion penetration decreases, rate of deterioration of steel reinforcement also decreases.

**B.Padma Priya et al. (2016) [5]** “Experimental Investigation on the Properties of Concrete with Carbon Black and PET” studied the effect of PET (Polyethylene Terephthalate) and Carbon Black in concrete. PET was kept constant and carbon black content was replaced at different percentages 0%, 10%, 20% and 30%. Then the strength properties were compared to the conventional concrete. They concluded that at 30% replacement of cement by carbon black, compressive strength is increased.

**S.Rukmangadhara Rao et al. (2015) [6]** “Study on Strength of Concrete Using Robo Sand as a Partial Replacement of Fine Aggregate” studied two grades of concrete M25 and M35 at different replacements of natural sand by robo sand. The results were quite satisfying indicating when the 50% of natural river sand was replaced by robo sand, the compressive strength was found out to be maximum rather than 0%, 75% and 100% replacement. It was concluded that the compressive strength at 50% replacement was 36.15 N/mm<sup>2</sup> for grade M25 and 49.33 N/mm<sup>2</sup> grade M35.

**K. Srinivas Reddy et al. (2016) [7]** “Replacement of Natural Sand with Robo/Artificial Sand in Specified Concrete Mix” compared the results of the concrete containing different percentages of robo sand with a reference mix. Compressive strength of concrete (grade M25) was investigated at percentage replacement of 0%, 20%, 40%, and 60% of natural sand with robo sand or quarry dust at a water-cement ratio of 0.44. Results were matched with reference mix of 0% replacement. The compressive strength of cement concrete with 20%, 40%, 60% replacements were much more than that of reference mixes. According to price – service ratio the use of robo sand gives effective results; the cost of robo sand is 30-50% less in market which is good for production of economical concrete. The service of robo sand is also as good enough for as natural sand concrete.

**Mr Shaik Mohammed Siraj et al. (2017) [8]** “Cembinder Concrete using Robo Sand” studied use of cembinder as an admixture in varying proportion of 0%, 1%, 5%, 8%, 10% by weight of cement. The grade M25 was designed as per BIS 10262:2009-2009. It was found out that the compressive strength of the conventional M20 grade concrete was 28.36 N/mm<sup>2</sup> and the highest strength attained using cembinder increased significantly to about 37.61 N/mm<sup>2</sup>. The usage of cembinder as an admixture in concrete only enhances the overall performance of concrete, but if it is used in excessive percentage it has adverse effects.

## 4.1 Discussion on the various properties of concrete

Carbon black and robo sand/quarry dust plays an important role in enhancing the mechanical and durability properties of concrete. It has been also found out that it helps in making the concrete denser than conventional concrete. Based on the literature review, some of the properties associated are discussed below;

1. **Compressive Strength and Split Tensile Strength:** - From the literature review, we can conclude that with the increase in percentage of robo sand, compressive strength increases. It is because the particles of the robo sand are much lesser in size than the natural sand. Hence there is a sort of pore refinement which increases the compressive strength of concrete. Same is the case of carbon black. Hence blending the two materials will give appropriate results with accordance with compressive strength. The optimum percentage replacement of robo sand is 50% and as of carbon black is 5-6%. Beyond this replacement the trend gets reversed.

**Table 1 Strength of Concrete with Robo sand in M25 Grades**

% age Replacement of Natural Sand with Robo Sand	Average Compressive Strength of Concrete at different ages (N/mm <sup>2</sup> )	
	7 days	28 days
0	21.81	30.99
50	24.36	35.98
75	23.20	34.10
100	22.36	32.36

2. **Workability:** - An attempt was made using carbon black ( a waste of rubber industry) as an additive filler in concrete and which imparts the enhanced properties of concrete Since the size of robo sand is very less than that of natural sand, hence during the mixing, the workability gets reduced. On the other hand, carbon black is inert i.e. it has very less positive and negative charges and carbon black has less absorption rate with water creating a sort of repulsive force, which has a great advantage in workability. Hence blending of the two materials, on one hand the workability gets reduced, but on the other hand, carbon black nullifies the reduced workability. This can lessen the water/cement ratio and has a role to act as a superplasticizer.
3. **Durability Properties:** - As mentioned above, there is pore refinement of concrete when carbon black robo sand is added to concrete due to which permeability is reduced. On



decreasing the permeability, the water entering the concrete will be less than that of the water entering in conventional concrete. Hence there will be less corrosion of reinforcement when CB and RS are added to the concrete. Hence both the materials play an important role in sustaining the concrete for a long time.

4. **Impact Resistance:** - The graph below shows the comparative dust content and impact resistance of concrete. According to Fig. 2, at 5% of the dust content in the concrete mix, the number of blows reached the maximum (81 blows). However, as the quarry dust percentage is increased, the number of blows was found out to be minimum of 33 blows at 30% of the quarry dust content, which in turn indicated that the impact resistance decreases. Hence, 5% of dust content increases the impact resistance in the concrete while the compressive strength is found out to be maximum at 10% dust content, but it was also observed that beyond the 5% replacement, impact strength may decrease due to the increase in the number of fines in the concrete.

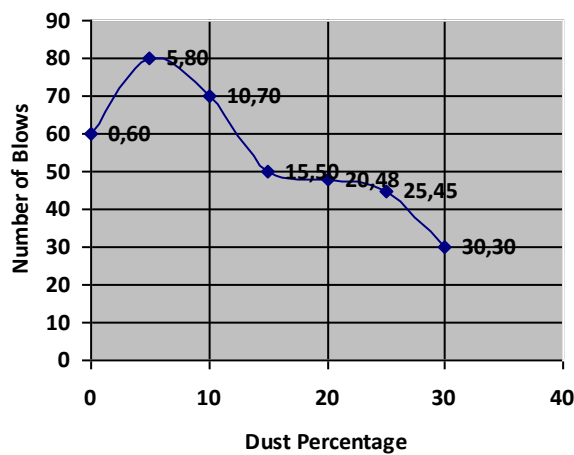


Figure 3 Impact resistance in terms of dust % and number of blows

**5.1 Equipment**

The equipment that has been used till now for the testing of materials are as follows: -

- a) IS Sieves: - To perform the gradation, sieve analysis according to IS 383 of coarse and fine aggregate.
- b) Pycnometer: - To determine the specific gravity of aggregates as per IS 2386.
- c) Impact Testing Machine: - To determine the impact value of coarse aggregates against impact loading.
- d) LOS Angeles Abrasion Testing Machine: - To determine the LOS Angeles Abrasion value of coarse aggregate against wear and tear.

The equipment that will be used for further testing of the specimens are as follows: -

- a) Compression Testing Machine: - To determine the compressive strength of concrete cubes.
- b) Universal Testing Machine: - To determine the split tensile strength and flexural strength of concrete.

**5.2 Materials**

The materials that will be used to perform the testing materials are: -

- a) Cement and Carbon Black
- b) Robo Sand and Natural Sand
- c) Coarse Aggregates

Methodology and investigational work includes the tests required to determine the quality of materials for concrete making, concrete mix design, specimen preparation and different methods for the concrete testing.

Research methodology includes: -

- A. After thorough and intense reviewing of literature, a null hypothesis “use of carbon black and robo sand to enhance the mechanical or durability properties of concrete” has been formulated.
- B. More literature regarding the hypothesis was studied. Constituent materials to be used were tested to obtain the different properties.
- C. A design mix has been prepared in accordance with IS 10262:2009 and IS 456:2000.

### 6.1 Design Mix

Based on the properties of aggregates, the design mix for M25 concrete mix as per IS 10262:2009 is calculated as: -

#### 1. Target Mean Strength

$$f_{ck}' = f_{ck} + 1.65s$$

Where standard deviation  $s = 4$  [IS 10262:2009]

Therefore,

$$f_{ck}' = 31.6 \text{ N/mm}^2$$

#### 2. Water Cement Ratio

As per IS 456:2000, the minimum w/c ratio required for the complete hydration of cement is 0.34. However, for concrete to be workable, we prefer w/c ratio of 0.45 to 0.5.

Hence we assume w/c ratio as 0.5

#### 3. Water Content

As per IS 456:2000, for aggregate size of 20mm, the water content is  $186 \text{ kg/m}^3$

#### 4. Cement Content

Water cement ratio = 0.5

Water content per  $\text{m}^3$  of concrete = 186 kg

Cement content =  $186/0.5 = 372 \text{ kg / m}^3$

Calculation of Sand & Coarse Aggregate

Volume of concrete =  $1 \text{ m}^3$

$$\text{Volume of Aggregate} = \frac{\text{Aggregate Content}}{\text{Specific Gravity of the aggregate} \times 1000}$$

$$\text{Volume of cement} = 372 / (3.0975 \times 1000) = 0.120 \text{ m}^3$$

$$\text{Volume of water} = 186 / (1 \times 1000) = 0.1440 \text{ m}^3$$

### 5. Fine and Coarse Aggregate Content

*Total Volume of other materials except coarse agg.*

$$= \text{Volume of Cement} + \text{Volume of Water}$$

$$\text{Total volume of other materials except coarse aggregate} = 0.120 + 0.1440 = 0.264 \text{ m}^3$$

$$\text{Volume of coarse and fine aggregate} = 1 - 0.264 = 0.736 \text{ m}^3$$

$$\text{Volume of Fine Aggregate} = 0.736 \times 0.33 = 0.2429 \text{ m}^3 \text{ (Assuming 33\% by volume of total aggregate)}$$

$$\text{Volume of Coarse Aggregate} = 0.736 - 0.2429 = 0.4931 \text{ m}^3$$

$$\text{Therefore, Weight of Fine Aggregate} = 0.2429 \times 2.65 \times 1000 = 643.68 \text{ kg/ m}^3$$

$$\text{Therefore, Weight of Coarse Aggregate} = 0.4931 \times 2.57 \times 1000 = 1267.26 \text{ kg/ m}^3$$

Therefore

$$\text{Cement : Fine Aggregate : Coarse Aggregate} = 372 : 643.68 : 1267.26$$

$$\text{Cement : Fine Aggregate : Coarse Aggregate} = 1 : 1.73 : 3.41$$

D. Required number of Indian Standard size cubes, cylinders and beams were fixed (as per IS codes to calculate the mean of the properties of concrete).

**Table 2 Percentage Replacement and Number of Specimens**

% age replacement	No of cubes for compressive strength		Number of beams for flexural strength		Number of cylinders for split tensile strength	
	7 Days	28 Days	7 Days	28 Days	7 Days	28 Days
0 %	3	3	3	3	3	3
5% CB + 10% RS	3	3	3	3	3	3
5% CB + 20% RS	3	3	3	3	3	3
5% CB + 40% RS	3	3	3	3	3	3
5% CB + 50% RS	3	3	3	3	3	3
5% CB + 60% RS	3	3	3	3	3	3
Total	36 cubes		36 beams		36 cylinders	

E. After that casting is to be done with adequate quality control.

F. Finally testing of the specimens and results are to be summarized.

Based on the literature review of researchers, the following points as an expected outcome are pointed out as: -

- By using carbon black as a replacement of cement and robo sand as a replacement of natural sand, it is expected that the concrete will have high strength than the conventional concrete at the same water cement ratio and same quantity of ingredients used.
- A concrete with less permeability is expected to form which may be due to the property of robo sand and carbon black to act as micro fillers, thereby reducing the number of pores in the set concrete mix.
- Concrete is expected to be more homogenous than that of conventional concrete; this may be due to the uniform filling of gaps/pores in concrete by carbon black and robo sand.
- Using carbon black (a waste of rubber industry), concrete is expected to be high shock absorbing than a conventional concrete.

The research work will be done in four phases.

**Phase 1:** - Reviewing the literature

**Phase 2:** - Testing of concrete ingredients and setting up the concrete mix design as per grade of concrete.

**Phase 3:** - Casting of the specimens.

**Phase 4:** - Final Testing of the specimens and final report writing.

The phases along with the timelines are listed below:



## CHAPTER 9 RESULTS AND DISCUSSION; EXPERIMENTAL WORK

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### 9.1 Material Testing

Several tests has been conducted to find out the different properties of fine and coarse aggregates like sieve analysis, specific gravity, water absorption, impact value, LOS Angeles Abrasion value etc. The test results are discussed below

#### 9.1.1 Testing of Cement

The cement grades available in the market are 33, 43 and 53. The cement grade that has been used for material testing is grade 43. The various tests on cement has been done confirming IS 4031-1988 and IS 12269-1987. The test results on Ordinary Portland Cement are tabulated below:

**Table 3 Properties of Ordinary Portland Cement**

S. No.	Property	Test Results
1.	Consistency	29%
2.	Specific Gravity	3.097
3.	Initial Setting Time	34 minutes
4.	Final Setting Time	280 minutes
5.	Fineness of Cement	3.5%

#### 9.1.2 Testing of Fine Aggregate

A mixture of natural sand and robo sand will be used as a fine aggregate. Several tests has been conducted according to IS 2386 and IS 383 in order to find out the different properties of fine aggregates. The test results are tabulated as:-

##### 9.1.2.1 Sieve Analysis of Natural Sand

A total of 1000gm of natural sand has been taken to carry out the sieve analysis through a set of IS Sieves and accordingly zone of sand and fineness modulus has been obtained.

**Table 4 Sieve Analysis of Natural Sand**

IS Sieve No.	Weight Retained (gm)	% age of weight retained	Cumulative % age retained
4.75 mm	5	0.5	0.5
2.36 mm	10	1.0	1.5
1.18 mm	130	13.0	14.5
600 μ	215	21.5	36
425 μ	15	1.5	37.5
300 μ	515	51.5	89
150 μ	75	7.5	96.5
75 μ	20	2.0	98.5
Pan	15	1.5	100
Total	1000 gm	100%	Cumulative % age Retained = 474%

**Test Results: -**

The fine aggregate (natural sand) is confirming Zone-II according to IS 383.

$$Fines Modulus = \frac{\text{Commulative \% age retained}}{100} = \frac{474}{100} = 4.74$$

Therefore, the fineness modulus of natural sand is 4.74

**9.1.2.2 Sieve Analysis of Robo Sand**

The robo sand is a waste product obtained from the quarries. A total of 2000gm of robo sand has been taken to carry out the sieve analysis through a set of IS Sieves and accordingly zone of sand and fineness modulus has been obtained.



**Table 5 Sieve Analysis of Robo Sand**

IS Sieve No.	Weight Retained (gm)	% age of weight retained	Cumulative % age retained
4.75 mm	0	0.0	0.0
2.36 mm	110	5.5	5.5
1.18 mm	310	15.5	21.0
600 μ	410	20.5	41.5
425 μ	150	7.5	49.0
300 μ	710	35.5	84.5
150 μ	10	0.5	85.0
75 μ	275	13.75	98.75
Pan	25	1.25	100
Total	2000 gm	100%	Cumulative %age Retained = 485.25%

**Test Results: -**

The fine aggregate (natural sand) is confirming Zone-II according to IS 383.

$$Finess Modulus = \frac{\text{Commulative \% age retained}}{100} = \frac{485.25}{100} = 4.82$$

Therefore, the fineness modulus of natural sand is 4.82

**9.1.2.3 Specific gravity of Natural Sand and Robo Sand**

The specific gravity of the natural sand has been determined by the pycnometer method. The results are showed that the specific gravity of natural sand is 2.65, whereas the specific gravity of robo sand is 2.68.

**9.1.2.4 Water Absorption of Natural sand and Robo Sand**

By the experiments, the water absorption of natural sand is 2.26%, whereas the water absorption of robo sand is 2.31%.

### 9.1.3 Testing of Coarse Aggregate

Locally available coarse aggregate has been taken and different properties like sieve analysis, specific gravity etc. has been investigated.

#### 9.1.3.1 Sieve Analysis of Coarse Aggregate

Coarse aggregate of 10 kg has been taken to carry out the sieve analysis. The grading or particle size distribution of coarse aggregate shown close to average size of 40mm as per IS383-1970 and details of sieve analysis are shown in table 4.

**Table 6 Sieve Analysis of Coarse Aggregate**

IS Sieve No.	Weight Retained (kg)	% age retained	Cumulative % retained
80 mm	0	0	0
40 mm	0	0	0
20 mm	2.7	27	27
10 mm	6.2	62	89
Pan	1.1	11	100
Total	10 kg	100%	210%

The review of literature of concrete using robo sand and carbon black and the preliminary tests have shown that using of carbon black and robo sand in concrete plays a significant role in increasing the strength and decreasing/ minimizing the corrosion of steel reinforcement which in turn increase the age of the concrete. It can be concluded that the strength of concrete increases and penetration of water in the concrete (permeability) decreases as the robo sand/quarry dust and carbon black content percentage rises. This is because when the carbon black at 5% replacement is added and natural river sand is replaced by quarry sand by 50%, the pores in the concrete gets blocked thereby increases the compressive -strength and in turn decreases the permeability. Thus in turn increases the durability and sustainability properties of the concrete.

Moreover, replacing carbon black and robo sand in concrete will not only provide strength to concrete but also it will help in the waste management, thereby decreasing the environmental pollutions and ground water contaminations. Hence both the wastes will be managed effectively/properly.

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