# Experimental Study on Sea Sand by using Partial Replacement of Fine Aggregate Incorporating Steel Fibres

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## Abstract

In this project Sea sand was collected from kalpakkam beach and it was added to the concrete as a partial replacement of Fine Aggregate in the proportion 0%, 20%, 40%, 60% to find out the behaviour of sea sand in concrete under compressive strength test and split tensile test after 28 days of curing. Mix design ($M_{40}$) was done as per IS 10262:2009 and then the proportion of concrete from the mix design was arrived and in this project coarse aggregate proportion of mix design consist of 75% of 20mm Coarse aggregate and 25% of 12mm Coarse aggregate. Steel fibres (1% by total volume of concrete) were added to the concrete cubes and concrete cylinders (excluding control cube and control cylinders). The test result shows that, compressive strength and split tensile strength was decreased for the sea sand proportions 20%, 40% and 60% when compared with control cube and control cylinder. The control cube has highest compressive strength 51.37 N/mm$^2$ when compared to sea sand proportions 20%, 40% and 60%. The sea sand proportion 20% has high compressive strength 47.55 N/mm$^2$ when compared to sea sand proportion 40% and 60%. The sea sand proportion 40% has compressive strength 45.24 N/mm$^2$ and sea sand proportion 60% has lowest compressive strength 40.80 N/mm$^2$. The control cylinder has highest split tensile strength 3.87N/mm$^2$ when compared to sea sand proportions 20%, 40% and 60%. The sea sand proportion 20% has split tensile strength 3.58N/mm$^2$ when compared to sea sand proportion 40% and 60%. The sea sand proportion 40% has split tensile strength 3.53 N/mm$^2$ and sea sand proportion 60% has lowest split tensile strength 3.38N/mm$^2$.

**Keywords: Sea sand, river sand, compressive strength, split tensile strength, steel fibres**

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## I. INTRODUCTION

Sand is a unique raw material for the construction industry at present, but contractors have to spend more allocations for obtaining bulk loads of sand for their construction work. Especially during monsoons the sources of river sand are unpredictable due to the rise in river water table. Also governments have imposed norms on the mining and utilization of river sand for construction purposes According to the industry sources, the price level of the river sand has become skyrocketed.

Due to this scarcity of river sand, many of the contractors are mixing sea sand with river sand and this leads to major problem in construction. Because sea sand has large amount of chloride content when compared to river sand.

This large amount of chloride content of sea sand has the ability to reduce compressive strength, tensile strength and flexural strength etc. The chloride content of sea sand also has the ability to corrode reinforcement quickly. Hence, most care should be taken to limit the use of sea sand.

According to the experts in the global construction grade, sea sand is being used in the construction industry in the Asian region and some leading European countries. Civil engineering department of university of moratuwa and national building organization [NBRO] (srilanka) have confirmed that the sea sand pumped from the distance of about ten kilometers is very suitable for building construction industry.

## II. EXPERIMENTAL STUDY

Sea sand also consists of temporary hardness and permanent hardness due to presence of large amount of chloride. In this project, before introducing sea sand into the concrete mix, Collected sea sand was washed with hot water to remove temporary hardness (since permanent hardness of sea water is very difficult to remove)

### A. Materials Used:

Cement - OPC 53 grade
Fine aggregate - Sand (River sand)
Coarse aggregate - Angular size (75% of 20mm and 25% of 12mm)
Replacement material - Sea sand
(Collected at kalpakkam beach)
Water - Campus water having pH 7.3
Steel fibres - 1% of total volume of concrete.

### B. Testing of Materials:

Various tests were conducted on the collected materials to determine their properties and suitability for this project. The testing of materials was done according to IS specifications. The test value of various materials is shown in the table 1.

Table - 1
Test value of various materials

| S.NO | Name of the test | Value of the test |
|---|---|---|
| 1 | Specific gravity of cement as per IS 2386 (Part II) | 3.10 |
| 2 | Consistency test on cement (By vicat's apparatus) | 12% (for 300 grams of cement taken for the test) |
| 3 | Sieve analysis of river sand (Fineness modulus in %) | 4.66% |
| 4 | Specific gravity of river sand as per IS 2386 (Part II) | 2.57 |
| 5 | Specific gravity of sea sand | 2.10 |
| 6 | Sieve analysis of coarse aggregate (Fineness modulus in %) | 7.51% |
| 7 | Specific gravity of coarse aggregate as per IS 2386 (Part II) | 2.67 |
| 8 | Aggregate (Coarse Aggregate) Impact Test as per IS 2386 part IV | 12.90% |
| 9 | Water Absorption test on Coarse aggregate | 16.5% |

### C. Mix Design:

In this project, the mix design used was M40 and the concrete proportions of M40 were calculated as per IS 10262:2009. To achieve, the concrete grade proportions of M40, all the material testing values are to be used in calculation. Hence, concrete proportions arrived for M40 grade is given in table 2.

Table - 2
Concrete proportions of M40 grade

| Cement ($kg/m^3$) | Fine Aggregate ($kg/m^3$) | Coarse Aggregate ($kg/m^3$) | Water ($litres/m^3$) |
|---|---|---|---|
| 492.5 | 731.63 | 967.40 | 197 |

Hence, Final mix ratio obtained for M40 grade as per IS 10262:2009 is 1:1.48:1.96

### D. Details of Specimens:

#### 1) Naming of Cubes:

CC - Control cube 0% of sea sand
CC1 - Concrete cube Replaced by 20% sea sand
CC2 - Concrete cube Replaced by 40% sea sand
CC3 - Concrete cube Replaced by 60% sea sand

Table - 3
Details of concrete cubes casted

| S.NO | TYPE OF CONCRETE | SAMPLE ID | NO. OF CUBES |
|---|---|---|---|
| 1 | Control cube 0% of sea sand | CC | 3 |
| 2 | Concrete cube Replaced by 20% sea sand | CC1 | 3 |
| 3 | Concrete cube Replaced by 40% sea sand | CC2 | 3 |
| 4 | Concrete cube Replaced by 60% sea sand | CC3 | 3 |
| | | TOTAL | 12 |

Steel fibres (1% by volume of concrete was added to CC1, CC2, CC3 specimens)

#### 2) Quantity of Materials Needed for Concrete Cube Mould (150mm × 150mm × 150mm):

The quantity of concrete materials needed for finding out the compressive strength of concrete cube mould is shown in the table 4, 5, 6 & 7.

Table – 4
Quantity of materials for CC

| *Materials* | *Quantity* |
|---|---|
| *Cement* | *1.743 kg* |
| *Fine aggregate* | *2.60 kg* |
| *Coarse aggregate* | *3.423 kg* |
| *Sea sand* | *NIL* |
| *Steel fibres* | *NIL* |
| *W/C Ratio* | *0.40* |

Table - 5
Quantity of materials for CC1

| *Materials* | *Quantity* |
|---|---|
| *Cement* | *1.743 kg* |
| *Fine aggregate* | *2.08 kg* |
| *Coarse aggregate* | *20mm – 2.56 kg*<br>*12mm – 0.85 kg* |
| *Sea sand* | *0.52 kg* |
| *Steel fibres* | *0.07 kg* |
| *W/C Ratio* | *0.40* |

Table - 6
Quantity of materials for CC2

| *Materials* | *Quantity* |
|---|---|
| *Cement* | *1.743 kg* |
| *Fine aggregate* | *1.56 kg* |
| *Coarse aggregate* | *20mm – 2.56 kg*<br>*12mm – 0.85 kg* |
| *Sea sand* | *1.04 kg* |
| *Steel fibres* | *0.07 kg* |
| *W/C Ratio* | *0.40* |

Table - 7
Quantity of materials for CC3

| *Materials* | *Quantity* |
|---|---|
| *Cement* | *1.743 kg* |
| *Fine aggregate* | *1.04 kg* |
| *Coarse aggregate* | *20mm – 2.56 kg*<br>*12mm – 0.85 kg* |
| *Sea sand* | *1.56 kg* |
| *Steel fibres* | *0.07 kg* |
| *W/C Ratio* | *0.40* |

*3) Naming of Cylinders:*

Cy - Control cylinder 0% of sea sand
Cy1 - Concrete cylinder replaced by 20% sea sand
Cy2 - Concrete cylinder replaced by 40% sea sand
Cy3 - Concrete cylinder replaced by 60% sea sand

Table - 8
Details of Cylinder Casted

| *S.NO* | *TYPE OF CONCRETE* | *SAMPLE ID* | *NO. OF CYLINDER* |
|---|---|---|---|
| *1* | *Control cylinder 0% of sea sand* | *Cy* | *3* |
| *2* | *Concrete cylinder replaced by 20% sea sand* | *Cy1* | *3* |
| *3* | *Concrete cylinder replaced by 40% sea sand* | *Cy2* | *3* |
| *4* | *Concrete cylinder replaced by 60% sea sand* | *Cy3* | *3* |
| | | *TOTAL* | *12* |

Steel fibres (1% by volume of concrete is added to Cy1, Cy2, Cy3 specimens)

*4) Quantity of Materials Needed for Concrete Cylinder Mould:*

The quantity of concrete materials needed for finding out the Split tensile strength of concrete cylinder mould is shown in the table 9, 10, 11 & 12.

Table - 9
Quantity of materials for Cy

| *Materials* | *Quantity* |
|---|---|
| *Cement* | *2.74 kg* |

| | |
|---|---|
| *Fine aggregate* | *4.074 kg* |
| *Coarse aggregate* | *5.39 kg* |
| *Sea sand* | *NIL* |
| *Steel fibres* | *NIL* |

Table - 10
Quantity of materials for Cy1

| *Materials* | *Quantity* |
|---|---|
| *Cement* | *2.74 kg* |
| *Fine aggregate* | *3.25 kg* |
| *Coarse aggregate* | *20mm - 4.04kg*<br>*12mm - 1.34kg* |
| *Sea sand* | *0.814 kg* |
| *Steel fibres* | *0.12 kg* |

Table - 11
Quantity of materials for Cy2

| *Materials* | *Quantity* |
|---|---|
| *Cement* | *2.74 kg* |
| *Fine aggregate* | *2.44 kg* |
| *Coarse aggregate* | *20mm - 4.04kg*<br>*12mm - 1.34kg* |
| *Sea sand* | *1.628kg* |
| *Steel fibres* | *0.12 kg* |

Table - 12
Quantity of materials for Cy3

| *Materials* | *Quantity* |
|---|---|
| *Cement* | *2.74 kg* |
| *Fine aggregate* | *1.628 kg* |
| *Coarse aggregate* | *20mm - 4.04kg*<br>*12mm - 1.34kg* |
| *Sea sand* | *2.44 kg* |
| *Steel fibres* | *0.12 kg* |

### *E. Compressive Strength Test:*

This is the important test that must be done for all types of concrete and it is a most common test for all types of concrete. The test is conducted on cubical specimens. The size of cubical specimen is 15cm× 15cm ×15 cm. The cubical specimens preferably made of steel or cast iron. Totally 3 concrete cubes of 15cm× 15cm ×15 cm was casted for each trial mix and it is cured and tested after 28 days. Tamping steel bar was used for compacting.

The concrete specimens are remolded after 24 hours and submerged in fresh clean water. The water should be maintained approximately at 27˚C ± 2˚C and on no account the specimens are allowed to become dry.

The specimens are tested in a compression testing machine at the completion of 28 days of curing. Tests were conducted using 2000KN compression testing machine as shown in Figure 1.

The compressive strength of the specimen is expressed as,

Compressive strength ($N/mm^2$) = (Load at failure in Newton) / (Area of cube in $mm^2$).

The compressive strength ($N/mm^2$) for all concrete cubical specimens is shown in table 13.

Table - 13
Results of Compressive Strength Test after 28 Days Curing

| *S.NO* | *SAMPLE ID* | *GRADE OF CONCRETE* | *AVERAGE COMPRESSIVE STRENGTH FOR 3 CUBES ($N/mm^2$)* |
|---|---|---|---|
| *1* | *CC* | *M40* | *51.37* |
| *2* | *CC1* | *M40* | *47.55* |
| *3* | *CC2* | *M40* | *45.24* |
| *4* | *CC3* | *M40* | *40.80* |


Fig. 1: Test setup for testing of cubical specimen

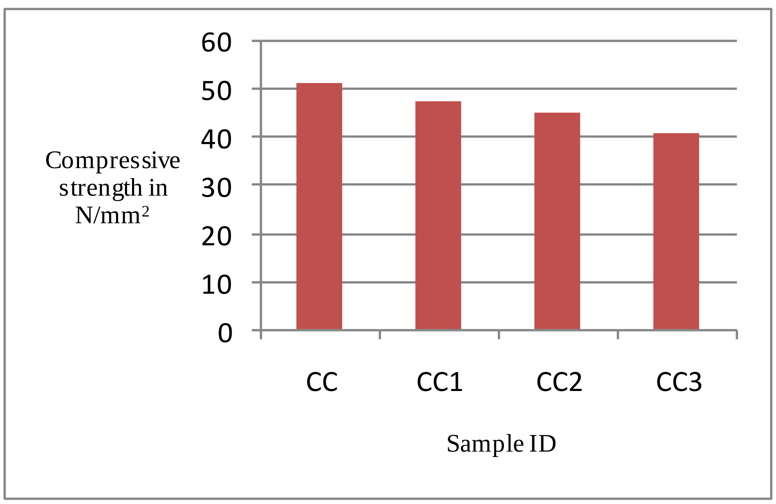


Fig. 2: Chart for Compressive Strength after 28 Days curing

### *F. Split Tensile Strength:*

The split tensile strength is one of the basic and important properties of the concrete. The test is conducted on cylindrical specimens. This cylinder specimen consists of 15cm diameter and 30cm in height. The cylindrical moulds are made in such a way that the specimen are taken out without damage. The cylindrical specimens preferably made of steel or cast iron. Totally 3 cylinders of 15cm diameter and 30cm in height are casted for each trial mix and it is cured and tested after 28 days. Tamping steel bar was used for compacting. The concrete specimens are remolded after 24 hours and submerged in fresh clean water. The determination of the tensile strength of concrete is necessary to determine the load at which the concrete members may crack. The cracking is a form of tension failure as shown in figure 3.

The split strength of cylinder can be calculated by the formula

Split tensile strength ($N/mm^2$) = $2P/\pi LD$

Where,

P = Load at failure (N)

D = Diameter of cylinder in mm

L = Length of cylinder in mm

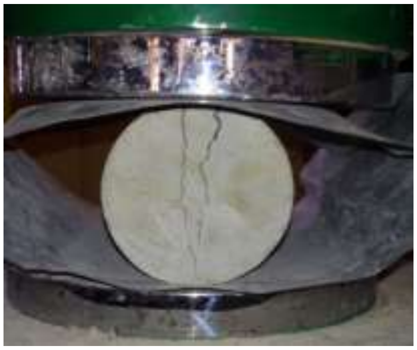

Fig. 3: Split tensile strength test

Table – 14
Results of Split tensile Strength Test after 28 Days Curing

| S.NO | SAMPLE ID | GRADE OF CONCRETE | AVERAGE TENSILE STRENGTH FOR 3 CYLINDERS (N/mm²) |
|---|---|---|---|
| 1 | Cy | M40 | 3.87 |
| 2 | Cy1 | M40 | 3.58 |
| 3 | Cy2 | M40 | 3.53 |
| 4 | Cy3 | M40 | 3.38 |

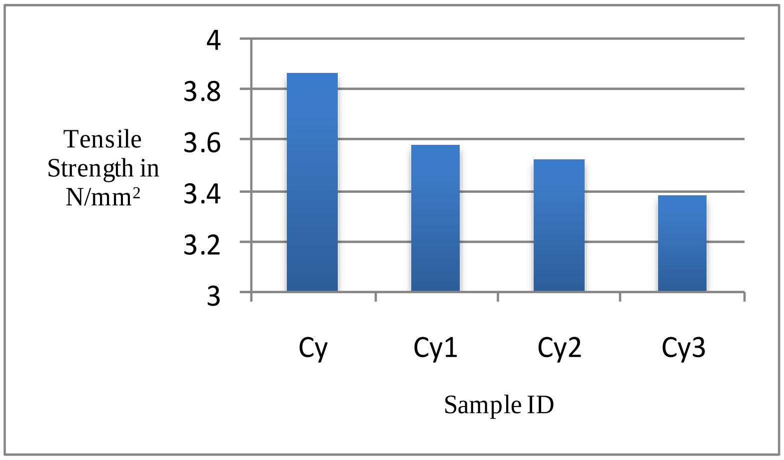


Fig. 4: Chart for Split tensile Strength after 28 Days

## III. Conclusion

Based on the experimental test, following conclusions were drawn:

1) Control cube (CC) specimen has the highest compressive strength of 51.37 N/mm² when compared with CC1, CC2 and CC3.
2) In case of 20% partial replacement of sea sand with river sand (CC1), the characteristics compressive strength of concrete was reduced 7.43% when compared with control cube (CC) specimen
3) In case of 40% partial replacement of sea sand with river sand (CC2), the characteristics compressive strength was reduced by 11.93% when compared with control cube (CC) specimen
4) In case of 60% partial replacement of sea sand with river sand (CC3), the characteristics compressive strength was reduced by 20.57% when compared with control cube (CC) specimen
5) Control cylinder (Cy) has the highest tensile strength of 3.87 N/mm² when compared with Cy1, Cy2 and Cy3
6) In case of 20% partial replacement of sea sand with river sand (Cy1), the tensile strength of concrete was reduced by 7.49% when compared with control cylinder (Cy) specimen
7) In case of 40% partial replacement of sea sand with river sand (Cy2), the tensile strength was reduced by 8.78% when compared with control cylinder (Cy) specimen
8) In case of 60% partial replacement of sea sand with river sand (Cy3), the tensile strength was reduced by 12.66% when compared with control cylinder (Cy) specimen
9) Hence, use of sea sand in concrete reduces the compressive strength and tensile strength significantly even also the addition of steel fibres
10) Further research on sea sand should be made in-order to use sea sand as a partial replacement in concrete

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