INTRODUCTION

The consumption of natural aggregate has increased remarkably in the recent years by construction industry and at the same time producing waste is also increased by the industry. Under these circumstances the construction industry requires different materials in terms of environmental and economic crisis. It can be proposed to use recycled aggregates to produce a new concrete which can be treated as one of the high potential solution. The problems like consumption of natural aggregate, transportation and dumping of construction wastage problems can be reduced by using any new materials or alternative materials. So in this research it is proposed to use demolished waste as recycled aggregate and manufactured sand in producing self compacting concrete (SCC) which can be treated as a different kind of concrete having the properties like segregation resistance and good deformability which will flow under its own weight and has to fill the form work even in congested reinforcement. Besides these properties the concrete also must have properties like proper segregation resistance and good fluidity. A concrete can be termed as Self Compacting Concrete if it satisfied the flow properties like slump flow, T50 Slump, V-funnel and L-box, U-box etc as per the guidelines provided in EFNARC[1] and IS 10292[2] 

Myle Nguyen James et al [3] used recycled aggregate and fly ash in concrete pavement. They observed that the flexural strength decreases for all the mixes containing recycled coarse aggregate and fly ash but they concluded that recycled aggregates can be used in concrete pavements.

K.C.Panda and P.K.Bal [4] has replaced natural coarse aggregate with recycled coarse aggregate by an amount of 40% and observed that flexural strength of SCC decreases with an increase in recycled aggregate replacement ratios and this may be due to water absorption more in recycle aggregates than natural aggregate.

R.Vasumit and P.SrinivasaRao,[5] designed M80 grade SCC with crushed basalt, Quartz sand, Quartz powder and micro silica and observed that there is increase in flexural strength as the curing age of concrete is increasing from 28 days to 180 days.

M.Seethapathi et.al [6] have studied by replacing the recycled coarse aggregate upto 30% in natural coarse aggregate and observed a reverse trend i.e the flexural strength increased with the 30% replacement of recycled aggregates.

Sherif AKhafaga [7] produced high strength SCC by replacing coarse and fine aggregate by recycled aggregates. He replaced both the aggregates by recycled aggregate upto 75% replacement. He observed as the percentage of recycled
aggregate is increasing the flexural strength is decreasing and concluded that SCC can be produced successfully by replacement of coarse and fine recycled aggregate up to 75%. Gdíc et al. [8] used recycled aggregate as replacement in natural aggregate by 50% and 100%. They observed as the replacement ratio increases the flexural tensile strength decreases and they reported that this may be due to bond between old mortar in recycled aggregate and natural aggregate. They also reported that flexural tensile strength decreases as the W/C ratio increases. S.Santos et al [9] has presented a literature review on SCC produced with coarse and fine recycled aggregates and explained in detail about the advantages of using both recycled aggregates in concrete. They concluded that use of recycled aggregate in SCC is justifies and technically valid but it is necessary to take some necessary precautions in regard of the performance characteristics of this type of concrete. From the literature review it is observed that not much research is done in producing SCC with both recycled aggregates. So in this research it is proposed to study the flexural strength of SCC with recycled coarse aggregate and Msand after satisfying the flow properties as per EFNARC and IS guidelines.

**Experimental Study**

**MATERIALS**

The cementitious materials used in the mixes are OPC with 53 grade corresponding to IS code12269: 1987and class F fly ash according to ASTM: C 618. The fineness of cement and flyash are 310 (m²/kg) and chemical properties of cement and fly ash are shown in Table I.

<table>
<thead>
<tr>
<th>Constituent (%)</th>
<th>Value CementFlyash</th>
</tr>
</thead>
<tbody>
<tr>
<td>SiO₂</td>
<td>19.79</td>
</tr>
<tr>
<td>Al₂O₃</td>
<td>5.67</td>
</tr>
<tr>
<td>Fe₂O₃</td>
<td>4.68</td>
</tr>
<tr>
<td>CaO</td>
<td>61.81</td>
</tr>
<tr>
<td>MgO</td>
<td>0.84</td>
</tr>
<tr>
<td>SO₃</td>
<td>2.48</td>
</tr>
<tr>
<td>Chloride</td>
<td>0.003</td>
</tr>
<tr>
<td>Lime Saturation Factor (LSF)</td>
<td>0.92</td>
</tr>
<tr>
<td>Alumina / Iron Oxide</td>
<td>1.21</td>
</tr>
</tbody>
</table>

Natural Coarse aggregate was obtained from the local sources and recycled coarse aggregates was obtained demolished building. River sand is used as fine aggregate and manufactured sand (Msand) was also used in this research. The properties of the aggregates were shown in Table II. Chemical based super plasticizer Polycarbolic ether was used as an admixture to achieve good flow properties in this research. Locally available potable water was used for mixing and curing of concrete.

<table>
<thead>
<tr>
<th>Sl.no</th>
<th>Property</th>
<th>Coarse aggregate</th>
<th>Fine aggregate</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>NCA</td>
<td>RCA</td>
</tr>
<tr>
<td>1</td>
<td>Specific gravity</td>
<td>2.66</td>
<td>2.52</td>
</tr>
<tr>
<td></td>
<td>Bulk density</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(kg/m³)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>i) Loose</td>
<td>1360</td>
<td>1200</td>
</tr>
<tr>
<td></td>
<td>ii) Compacted</td>
<td>1500</td>
<td>1350</td>
</tr>
<tr>
<td>3</td>
<td>Water absorption</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(%)</td>
<td>0.53</td>
<td>5.06</td>
</tr>
</tbody>
</table>

**DISCUSSION OF TEST RESULTS**

SCC was produced with three different combinations, First combination was replacing natural coarse aggregate by different percentages of recycled coarse aggregate without using Msand second combination was replacing fine aggregate with different percentages of Msand without using recycled coarse aggregate third combination was by using recycled coarse aggregate and Msand together with fixed water to binder ratio. In all the SCC mixes tested, the cementitious material, cement and flyash were kept constant at 351 kg/m³ and 150 kg/m³ respectively. The recycled coarse aggregate (RCA) and M-Sand were replaced in natural coarse aggregate (NCA) and fine aggregate by 0.25, 50, 75 and 100% in all the combinations.

**Test Method**

The flow property of SCC produced with recycled coarse aggregate and Msand are confirmed with EFNARC and IS guidelines and found satisfactory and presented in the paper Nirmala et al. [10].

**Flexural Strength**

The flexural strength test was done on beams 150mm x 150mm x 600mm and the beam is reinforced by two HYSD rods of 10mm diameter at top and bottom with 8mm stirrups and loading after 28 days curing is done in two point loading in a loading frame as shown in Fig 1.
Fig 2 % RAC V/S Flexural Strength

The test results of flexural strength results are presented in Table III and Fig 2.

From the table III and Fig 2, it is noticed that the flexural strength decreases as the recycled coarse aggregate content increases. In combination I recycled coarse aggregate was replaced in natural coarse aggregate by 25, 50, 75 and 100% without Msand. The decrease in flexural strength for these mixes is found to be 5.60, 9.45, 11.69 and 13.62% when compared to basic mix. In combination II Msand is replaced in fine aggregate by 25, 50, 75 and 100% without recycled coarse aggregate. The decrease in the flexural strength is found to be 4.96, 8.33, 9.61 and 12.33% compared to basic mix. In both the cases the percentage decrease in flexural strength is less than 15% when compared to the SCC mix without any replacement of recycled coarse aggregate or Msand. In combination III, recycled coarse aggregate and Msand are replaced together in natural coarse aggregate and fine aggregate and the various SCC mixes tested are shown in table No III. It is observed from the table III and Fig 2 the decrease in flexural strength more when recycled coarse aggregate and Msand replaced together when compared with the strengths obtained individually. The decrease in flexural strength ranges from 5.60 to 30.54%. The maximum decrease in flexural strength is observed for the mixes with 100% recycled coarse aggregate and 25, 50, 75 and 100% Msand and the values are 16.66, 17.30, 20.51 and 30.54%. The decrease in flexural strength may be due to difference in properties of recycled coarse aggregate and Msand when compared with natural coarse aggregate and fine aggregate. The water absorption property is more in recycled coarse aggregate and this may be also one of the reason for decrease in flexural strength.

Regression Equation of Flexural Strength of SCC with RCA and Msand

A regression model was developed by taking compressive strength into consideration along with recycled coarse aggregate and Msand.

The proposed regression equation is

\[ f = 0.88 \sqrt{f_{ck}} + 1.06 \]

Where

- \( f \) = flexural strength in MPa
- \( f_{ck} \) = 28 days cube compressive strength in N/mm²

The \( f_{ck} \) value derived from regression equation of compressive strength is given below

\[ f_{ck} = -0.098 \% \text{RCA} - 0.238 \% \text{MS} + 0.985 (f_{ck})_{28 \text{ days}} \]

From the regression equation, the flexural strength values are observed as 6.80, 6.54, 6.36, 6.17 and 6.07 MPa respectively for the mixes 0, 25, 50, 75 and 100% replacement of recycled coarse aggregate without Msand and the ratio between the experimental value and regression value ranges from 1.08 to 1.12. Even for the mixes with Msand replacement without recycled coarse aggregate the ratio between experimental value and regression value ranges between 1.08 to 1.20 and for the mixes with recycled coarse aggregate and Msand together ranges between 1.08 to 1.14. The regression values are almost coinciding with the experimental values which indicates the proposed model well suited to estimate the results.
CONCLUSIONS

Based on the above research work carried out, the following conclusions can be drawn:

1. SCC can be produced by using recycled coarse aggregate and Msand.
2. The flexural strength of SCC is decreasing with the increase in percentage replacement of recycled coarse aggregate in natural coarse aggregate and Msand in fine aggregate.
3. The percentage decrease in flexural strength is 15% more for the mixes with combinations of 100% recycled coarse aggregate and 25, 50, 75 and 100% Msand and for the mix with 75% recycled coarse aggregate and 100% Msand.
4. For all the mixes tested the ratio between the experimental values and regression model values ranges in between 1.08 to 1.20.
5. A model was developed to estimate the results and it was shown satisfied with the experimental results.

By all above observations, it can be recommended to produce SCC with replacement of recycled coarse aggregate and M-Sand.

References

1. IS 10262:2019 “Concrete Mix Proportioning” – Guidelines.

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