Study on Self Compacting Concrete Using Recycled Aggregate as Partial Replacement for Fine Aggregate and Coarse Aggregate with Addition of Steel Fibres

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***Abstract*: Self compacting concrete is a new type of concrete which can be placed in every corner of framework under its weight without any segregation. Self compacting concrete gives a fast rate of concrete placement with rapid construction times and ease of flow around congested reinforcement. The use of the waste materials has been increased for making concrete due to various environmental and economical considerations. Recycled concrete is one of the waste materials that have been used in concrete. Due to increasing air pollution the important issue of repelling the pollutants in which construction industry plays a key role so that recycled concrete has been suggested to decrease the construction pollutants and which not only allows for a more efficient life cycle of natural resources but also contributes to environmental protection leading to sustainable environment.**

In this study recycled aggregate has been used as a partial replacement for cement in self compacting concrete of grade M30. This research is an attempt to provide very useful information for the practical use of recycled aggregate in advance concrete production. The recycled aggregate has replaced the coarse aggregate in percentages of 25%, 35%, 45% and 55 %and fine aggregate by 10% with addition of steel fibres. The percentage of steel fibre used was 0.75% by weight of cementitious material .The range of the flow properties were determined by performing different tests as slump flow test, v-funnel test and l-box test. The hardened properties of self compacting concrete were determined by compressive strength test, split tensile strength test and flexural strength test at the end of 7 days and 28 days. From the study it was concluded that the optimum replacement of aggregates by recycled aggregate with addition of steel fibre was 10% for fine aggregate and 35% for coarse aggregate for self compacting concrete.

***Keywords*: Self Compacting Concrete, Glass Powder, Steel Fibres, Compressive Strength, Split Tensile Strength, Flexural Strength.**

1. INTRODUCTION

Self compacting concrete is a highly flowable type of concrete that spreads into the form without the need for mechanical vibration. Self compacting concrete is a non segregating concrete that is placed by means of its own weight. The importance of self compacting concrete is that it maintains all concrete's durability and characteristics, meeting expected performance requirements. In certain instances the addition of superplasticizers and viscosity modifier are addedc to the mix, reducing bleeding and segregation.Concrete that saggregates produces resistance to segregation by using mineral fillers or fines and using special admixtures.Self compacting concrete is required to flow and fill special forms under its own weight, it shall be flowable enough to pass through highly reinforced areas, and must meet special project requirements in terms of placement and flow. Self compacting concrete with a similar water cement or cement binder ratio will usually have a slightly higher strength compared with traditional vibrated concrete, due to the lack of vibration giving an improved interface between the aggregate and hardened paste. The concrete mix of SCC must be placed at a relatively higher velocity than that of regular concrete. Self compacting concrete has been placed from heights taller than 5m without aggregate saggregation. It can also be used in areas with normal and congested reinforcement, with aggregates as large as 2 inches.

Recycled aggregates are comprised of crushed ,graded inorganic particles processed from the materials that have been used in the constructions and devastation debris. These resources are usually from buildings,road and rail network,bridges and sometimes even from catastrophes such as earthquakes and wars. Recycled aggregate concrete(RAC) is a concrete that use partly or fully recycled aggregate as coarse or fine aggregate. Recycld concrete aggregate is generally produced by two stage crushing of demolished concrete and screening and removal of contaminents such as reinforcement ,paper,wood,plastic and gypsum. Concrete made with such recycled concrete aggregate is called recycled aggregate concrete. Due to critical shortage of natural aggregate ,the availability of demolished concrete for use as recycled concrete aggregate is increasing using the waste concrete as recycled concrete aggregate conserves natural aggregate, reduces the impact on landfills,decreases energy consumption and can provide cost savings.

Fibre is a small piece of reinforcing material. They can be circular or flat. The fibre is described by a parameter known as the 'aspect ratio'. The aspect ratio of the fibre is the ratio of its length to its diameter. The typical values of aspect ratio ranges from 30 to 150.Steel fibre is the most commonly used fibre. The diameter varies from 0.25 mm to 0.75 mm. The steel fibre is likely to get rusted and lose some of its strengths but investigations have shown that rusting of fibres takes place only at the surface. The use of steel fibre makes significant improvements in the strength of the concrete. It has been reported that upto aspect ratio of 75, increase in the aspect ratio increases the ultimate strength of the concrete linearly. Beyond 75, relative strength and toughness is reduced.

2. MIX PROPORTIONING

The mix proportioning was done as per EFNARC guidelines for self compacting concrete mix design. The grade of self compacting concrete mix was M30. The first mix was the control mix prepared in accordance to the mix design and in other four mixes partial replacement of cement by glass powder was carried out in percentages of 20%, 25%, 30% and 35% respectively. The ingredients were first mixed in dry condition. Then, 70% of the total water was added to the dry mix and mixed thoroughly. Then, 20% of water was mixed with super plasticizer and 10% with viscosity modifying agent and added to the mix. The mix was checked for flow properties by slump flow test, V-funnel test and L-box test. The concrete was tested for hardened properties at 7 days and 28 days by compressive strength test, split tensile strength test and flexural strength test.

Table 2.1 Concrete mix proportioning for M30 design mix per m^3

Mix	Cement (kg)	Recycled Fine Aggregate (%)	Recycled Fine Aggregate (kg)	Recycled Coarse Aggregate (%)	Recycled Coarse Aggregate (kg)	FA (kg)	CA (kg)	Water (litre)	SP (litre)	VMA (litre)	SF (kg)
M1	450	0	0	0	0	1024.89	870.4	149	4.5	1.8	0
M2	450	10	102.49	25	217.6	922.4	652.8	149	4.5	1.8	3.37
M3	450	10	102.49	35	304.64	922.4	565.76	149	4.5	1.8	3.37
M4	450	10	102.49	45	391.68	922.4	478.72	149	4.5	1.8	3.37
M5	450	10	102.49	55	478.72	922.4	391.68	149	4.5	1.8	3.37

3. EXPERIMENTAL PROGRAMME AND RESULTS

3.1 TESTS ON FRESH CONCRETE

Various tests were conducted on the different mixes to determine the self compacting properties of the fresh concrete. The tests included slump flow test, V-funnel test and L-box test.

Table 3.1 Tests on Fresh Concrete

Mix	Slump flow (mm)	V-funnel time (sec)	L-Box (H_2/H_1)
M1	706	8.1	0.96
M2	688	9.3	0.94
M3	680	9.8	0.91
M4	669	10.4	0.88
M5	654	11.5	0.84

3.2 TESTS ON HARDENED CONCRETE

Various tests were conducted on the hardened concrete to determine the strength of various mixes of self compacting concrete. The compressive strength test, split tensile strength and flexural strength were conducted at 7 days and 28 days.

Table 3.2 Compressive Strength

Mix	7 Day Compressive Strength (N/mm^2)	28 Day Compressive Strength (N/mm^2)
M1	25.85	41.34
M2	28.42	42.69
M3	25.99	39.43
M4	22.55	37.81
M5	18.32	30.29

Table 3.3 Split Tensile Strength

Mix	7 Day Split Tensile Strength (N/mm^2)	28 Day Split Tensile Strength (N/mm^2)
M1	3.56	5.67
M2	4.0	6.49
M3	3.5	5.24
M4	3.10	5.08
M5	2.84	4.08

Table 3.4 Flexural Strength

Mix	7 Day Flexural Strength (N/mm^2)	28 Day Flexural Strength (N/mm^2)
M1	3.97	6.24
M2	4.04	6.73
M3	3.59	6.04
M4	3.17	4.97
M5	2.62	3.72

4. DISCUSSION

4.1 SLUMP FLOW TEST: - The slump flow value was observed to decrease by 3.34 %, 4.04 %, 5.12 % and 6.13 % for partial replacement of cement by 20 %, 25 %, 30% and 35% glass powder respectively.

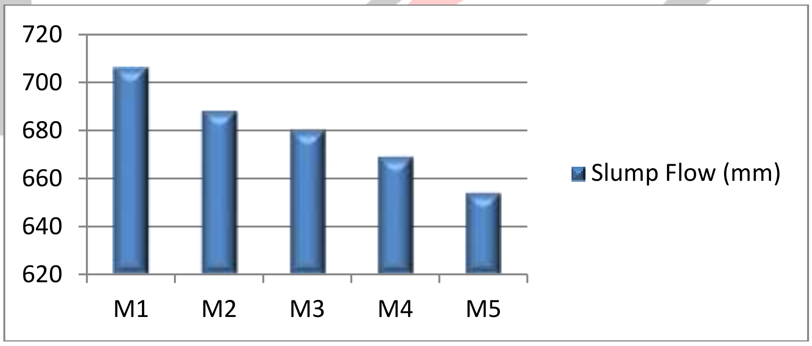

Figure 4.1 Slump Flow Test

4.2 V-FUNNEL TEST: - The V-funnel time which is a representative of the filling ability of the mix, was observed to increase by 13.95 %, 17.44 %, 23.26 % and 37.21 % for partial replacement of cement by 20 %, 25 %, 30% and 35% glass powder respectively.

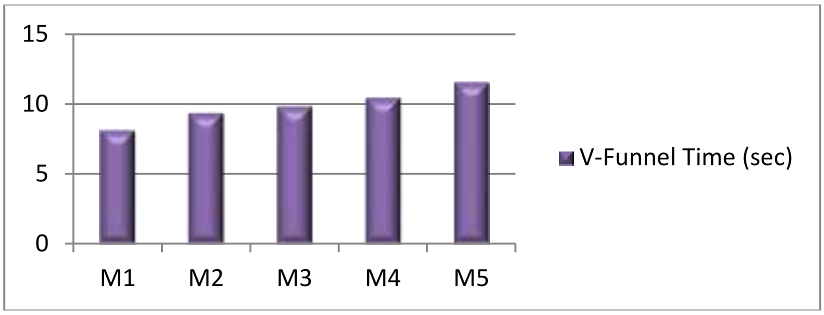

Figure 4.2 V-Funnel Test

4.3 L-BOX TEST: - The L-Box value was also observed to follow a decreasing trend by 4.21 %, 5.26 %, 7.37 % and 9.47 % for partial replacement of cement by 20 %, 25 %, 30% and 35% glass powder respectively.

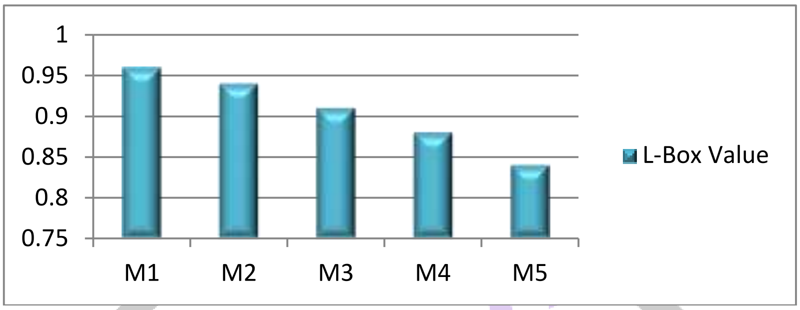

Figure 4.3 L-Box Test

4.4 COMPRESSIVE STRENGTH TEST: - The experimental investigations show that for 7 day compressive strength, the partial replacement of fine aggregate by 10 % recycled aggregate and 25 % of coarse aggregate by recycled aggregate, increases the compressive strength by 9.94 %, the partial replacement of fine aggregate by 10 % recycled aggregate and 25 % of coarse aggregate by recycled aggregate, increases the compressive strength by 0.54 % the partial replacement of fine aggregate by 10 % recycled aggregate and 25 % of coarse aggregate by recycled aggregate, decreases the compressive strength by 12.76 % the partial replacement of fine aggregate by 10 % recycled aggregate and 25 % of coarse aggregate by recycled aggregate, decreases the compressive strength by 29.13 %. For 28 day compressive strength, the partial replacement of fine aggregate by 10 % recycled aggregate and 25 % of coarse aggregate by recycled aggregate, increases the compressive strength by 3.26 % ,the partial replacement of fine aggregate by 10 % recycled aggregate and 25 % of coarse aggregate by recycled aggregate, decreases the compressive strength by 4.62 %, the partial replacement of fine aggregate by 10 % recycled aggregate and 25 % of coarse aggregate by recycled aggregate, decreases the compressive strength by 8.54 % the partial replacement of fine aggregate by 10 % recycled aggregate and 25 % of coarse aggregate by recycled aggregate, decreases the compressive strength by 26.73 %.

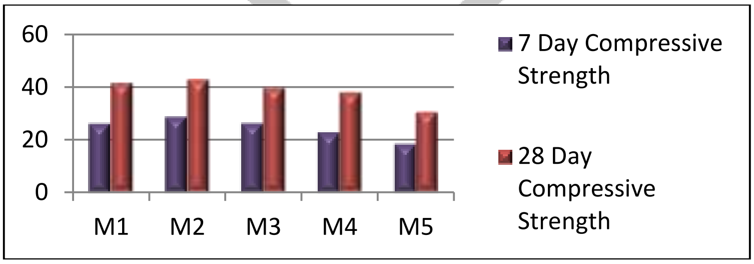

Figure 4.4 Compressive Strength

4.5 SPLIT TENSILE STRENGTH TEST: - The experimental investigations show that for 7 day split tensile strength, the partial replacement of fine aggregate by 10 % recycled aggregate and 25 % of coarse aggregate by recycled aggregate, increases the split tensile strength by 12.35 %, the partial replacement of fine aggregate by 10 % recycled aggregate and 25 % of coarse aggregate by recycled aggregate, decreases the split tensile strength by 1.65 % the partial replacement of fine aggregate by 10 % recycled aggregate and 25 % of coarse aggregate by recycled aggregate, decreases the split tensile strength by 12.90 % the partial replacement of fine aggregate by 10 % recycled aggregate and 25 % of coarse aggregate by recycled aggregate, decreases the split tensile strength by 20.20 %. For 28 day split tensile strength, the partial replacement of fine aggregate by 10 % recycled aggregate and 25 % of coarse aggregate by recycled aggregate, increases the split tensile strength by 14.45 % the partial replacement of fine aggregate by 10 % recycled aggregate and 25 % of coarse aggregate by recycled aggregate, decreases the split tensile strength by 7.60%, the partial replacement of fine aggregate by 10 % recycled aggregate and 25 % of coarse aggregate by recycled aggregate, decreases the split tensile strength by 10.40 %, the partial replacement of fine aggregate by 10 % recycled aggregate and 25 % of coarse aggregate by recycled aggregate, decreases the split tensile strength by 28.05 %.

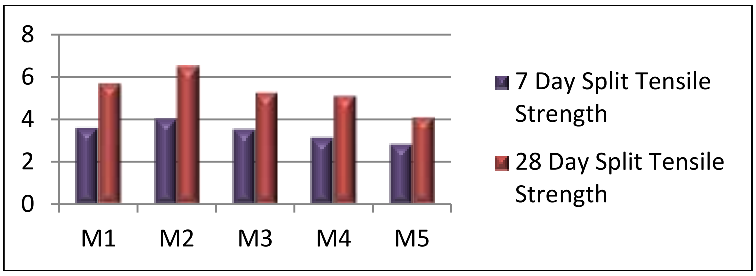

Figure 4.5 Split Tensile Strength

4.6 FLEXURAL STRENGTH TEST: - The experimental investigations show that for 7 day flexural strength, the partial replacement of fine aggregate by 10 % recycled aggregate and 25 % of coarse aggregate by recycled aggregate, increases the flexural strength by 1.75%, the partial replacement of fine aggregate by 10 % recycled aggregate and 25 % of coarse aggregate by recycled aggregate, decreases the flexural strength by 9.55 % the partial replacement of fine aggregate by 10 % recycled aggregate and 25 % of coarse aggregate by recycled aggregate, decreases the flexural strength by 20.15 %, the partial replacement of fine aggregate by 10 % recycled aggregate and 25 % of coarse aggregate by recycled aggregate, decreases the flexural strength by 34 %. For 28 day flexural strength, the partial replacement of fine aggregate by 10 % recycled aggregate and 25 % of coarse aggregate by recycled aggregate, increases the flexural strength by 7.85%, the partial replacement of fine aggregate by 10 % recycled aggregate and 25 % of coarse aggregate by recycled aggregate, decreases the flexural strength by 3.20 % the partial replacement of fine aggregate by 10 % recycled aggregate and 25 % of coarse aggregate by recycled aggregate, decreases the flexural strength by 20.35 % the partial replacement of fine aggregate by 10 % recycled aggregate and 25 % of coarse aggregate by recycled aggregate, decreases the flexural strength by 40.35 %.

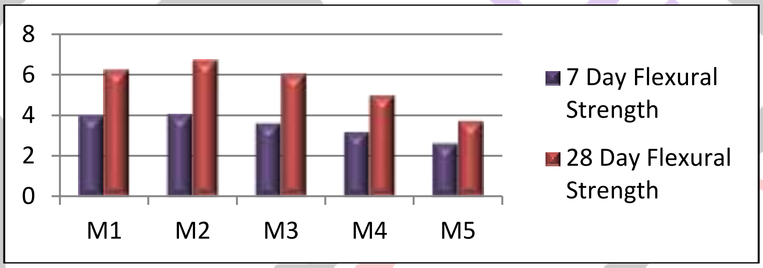

Figure 4.6 Flexural Strength

5. CONCLUSIONS

- The decrease in flow area of slump flow test indicates a decrease in the deformation of the mix.
- The increase in the V-funnel time indicates a decrease in the relative flow time and thereby higher viscosity.
- The decrease in the L-box value indicates a decrease in the relative flow of the mix.
- The research has shown that partial replacement of fine aggregate by 10% recycled aggregate and coarse aggregate by 25% recycled aggregate with addition of steel fibres increases the 7 day and 28 day compressive strength, split tensile strength and flexural strength of the concrete.
- Further increase in recycled aggregate content increases the 7 day compressive strength and reduces 28 day compressive strength. It also reduces 7 day and 28 day split tensile strength and flexural strength. However, for 35% replacement of coarse aggregate by recycled aggregate compressive strength is above the target mean strength for M 35 concrete.
- For 30% replacement of coarse aggregate by recycled aggregate the compressive strength drops below the target mean strength.
- For 35% replacement of coarse aggregate by recycled aggregate the compressive strength is almost equal to characteristic strength.
- Hence, it can be recommended that the optimum replacement of aggregates by recycled aggregate with addition of steel fibre was 10% for fine aggregate and 35% for coarse aggregate for self compacting concrete.

REFERENCES

[1] Sherif A. Khafaga (2014) 'Production of High strength self compacting concrete using recycled concrete as fine and /or coarse aggregates. "World applied sciences journal 29 940: 465-474.
[2] M.Seethapathi, Dr.S.R.R. S and Dr. K.Senthilkumar and Dr. Chinnaraju (2015) ' High performance Self compacting concrete using recycled coarse aggregate. "International journal of applied engineering research, ISSN 0973-4562 vol.10 No.47

[3] Ajith V and Praveen Mathew(2015) ‘A study on the self compacting properties of recycled concrete incorporating a new mix proportioning method. “ International journal of science technology and engineering vol 2 issue 5.
[4] Moslem Mohammadi Jatani, Ali delnavaz(2017).” Astudy on strength and durability of self compacting concretes mde of recycled aggregates. “Journal of structural engineering and Geotechnics.
[5] Prof. Y.V. akbari, Prof.Dr. K.B. parikh, Tejas H. raviya(2016).” A critical review of self compacting concrete using recycled coarse aggregate.” IOSR journal of mechanical and civil engineering (IOSR-JMCE) vol 13, issue 1.
[6] Kamal M.M, Safan M.A.,Etman Z.A and Eldaboly E.A(2013).”Evaluating the prolonged properties of fresh self compacting concrete incorporating recycled aggregates.”International journal of current engineering and technology ISSN 2277-4106. Vol :3 issue :2
[7] Revathi Purushothaman , Kavithi. P , Senthamilselvi .R(2016).” Experimental studies on scc with recycled aggregate .” International journal of research in engineering and technology(IJRET) vol:05, issue :20.
[8] Srinivas Vasam, K.Jagannadha Rao, M.V.Seshagiri rao(2015).”Self compacting concrete as green concrete with recycled concrete aggregates .”International journal of research and technology.vol 04, issue :13
[9] Prashant O.modani , Vinod M Mohitkar(2014).”Self compacting concrete with recycled aggregate” International journal of civil and structural engineering. Vol:4 ,No. 3
[10] C.Sumanth reddy, K.v. ratna sai (2014)” Recycled aggregate based self compacting concrete(RASCC) for structural applications.”International conference on advances in science and technology of concrete
[11] Kc panda , Pk bal(2012).”the properties of self compacting concrete using recycled aggregate.”Chemical , civil and mechanical tracks of 3rd Nirma unv. International conference on engineering (NUICONE)
[12] Poon Cs and kou (2007) “The use of recycled aggregate in concrete .”Department of civil and structural engineering vol. 50, issue 3
[13] Jitender Sharma and sandeep single (2014).” Study of recycled concrete aggregate .” International journal of engineering trends and technology.vol 13
[14] Jiong hu(2009)“ Self compacting concrete using recycled concrete aggregates.” Self compacting concrete using recycled concrete aggregate to be submitted to journal of solid waste technology and management
[15] Md. Safiuddin (2013) .” use of recycled concrete aggregate in concrete .” Journal of civil engineering and management . Vol. 19-issue 6
[16] European Federation of Natural Associations Representing producers and applicators of specialist building products for Concrete (EFNARC), “Specifications and Guidelines for Self Compacting Concrete”, 2002.