

# Utilization of used Foundry Sand and Waste Tyre Rubber in Self Compacting Concrete

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## Abstract

In this paper an attempt has been made to study the use of used foundry sand and waste tyre rubber on properties of Self-Compacting-Concrete (SCC) is carried out. Replacement of sand with used foundry sand as 10%, and 15% and replacement of coarse aggregate with waste tyre rubber as 5% and 10% is investigated. The results show that that utilization of used foundry sand and waste rubber tyre will increase the strength of the self-compacting concrete when compared with conventional concrete. But it should not exceed 15% of used foundry sand and 10% of waste tyre rubber.

**Keywords:** Self Compacting Concrete, used Foundry Sand, Waste Tyre Rubber, Rubberized Concrete

## I. INTRODUCTION

Concrete is normally used in the frame structure. But there is some limitation like self-compaction, surface finishes, maintains strength at congested area. Due to this limitation we are trying to make self-compacting concrete with the use of mineral admixture. SCC is concrete that can be placed and compacted under its own weight without any vibration effort, assuring complete filling of formwork even when access is hindered by narrow gaps between reinforcement bars. Originally developed in Japan, SCC technology was made possible by the much earlier development of superplasticisers for concrete. The first generation SCC is used mainly for repair application and for casting concrete in restricted areas, including sections that limited access to vibrate.

Recycling waste solid materials is one of the most challenging problems worldwide with the unprecedented growth of the world population and In order to combat the scarcity of cement and the increase in cost of concrete under these circumstances the use of recycled solid wastes, agricultural wastes, and industrial by-products like used foundry sand, waste tyre rubber, fly ash, blast furnace slag, silica, rice husk, phosphogypsum, came into use.

### A. Foundry Sand:

Foundry sand is high quality silica sand that is a by-product from the production of both ferrous and nonferrous metal castings. The physical and chemical characteristics of foundry sand will depend in great part on the type of casting process and the industry sector from which it originates. It can be reused several times in foundries but, after a certain period, cannot be used further and becomes waste material, referred to as used or spent foundry sand.

Foundry sand is basically fine aggregate. It can be used in many of the same ways as natural or manufactured sands. This includes many civil engineering applications such as embankments, flow able fill, hot mix asphalt (HMA) and Portland cement concrete (PCC). At present, although a great attention to environmental issues, the general trend is still to dispose UFSs in landfills, sometimes utilized as landfill daily cover.

The American Foundry Society estimates that 6.8 million tons of foundry sand (2007 data) was disposed in landfills, approximately the 2/3 of the total production. Several evident drawbacks could be listed due to this trend:

- Early closure of the material life cycle with consequently more consumption of virgin raw materials;
- Saturation of existing landfills and soil pollution in unmanaged landfill cases
- Release of leachable contaminants, absorbed by the sand during the moulding process and casting
- Operations, like heavy metals (cadmium, lead, copper, nickel, and zinc) and phenols;
- Economic impact, referring in particular to logistic costs in UFS transportation (sometimes landfill is not so close to the foundry)

### B. Waste Tyre Rubber:

- 1) Tyre rubber constitutes a large portion of that solid waste which has turned into a worldwide environmental concern. In several countries, tire rubber is being burned and used as fuel, which can result in serious hazards unless health considerations are carefully considered. Scrap tires dumped in sanitary landfills are a significant environmental hazard and result in possible contamination. Only small quantities of scrap tires are being used or recycled as construction

materials. The concrete mixed with waste tyre rubber added in different volume or weight proportions by replacing coarse aggregate of the concrete is called rubberized concrete.

Partially replacing the coarse aggregate of the concrete with some quantity of waste tyre rubber cubes could give qualities such as low unit weight, high resistance to abrasion, absorption to shocks and vibrations, high ductility and brittleness to the concrete (Bignozzi, 2006). Recently some research has been conducted on mixing rubber in chips and fiber form with the concrete replacing the coarse aggregate. Research has shown that the composite with waste tyres in the form of fibers outperformed tyres in the form of chips (Nizal et., 2006).

## II. EXPERIMENTAL INVESTIGATIONS

### A. Materials used:

The following materials were used in the investigation.

- 1) Cement: Ordinary Portland cement (43 Grade) with specific gravity of 3.12 confirms to IS 269-1976.
- 2) Fine Aggregate: River sand with specific gravity 2.53 confirms to Zone IV as per IS 2386 (Part V).
- 3) Coarse Aggregate: Crushed coarse aggregate of 20 mm size with specific gravity of 2.70 confirms to IS 2386 (Part I).
- 4) Water: Potable water for mixing and curing of the specimens.
- 5) Foundry sand: Used foundry sand with specific gravity of 2.80 is used in concrete as a replacement of fine aggregate. The properties of foundry sand are listed in Table 1.

Table - 1  
Properties of foundry sand

Constituent	SiO <sub>2</sub>	Al <sub>2</sub> O <sub>3</sub>	TiO <sub>2</sub>	Ca O	Mg O	Mn <sub>3</sub> O <sub>4</sub>	Fe <sub>2</sub> O <sub>3</sub>	Na <sub>2</sub> O	K <sub>2</sub> O	SO <sub>3</sub>	Sr O
Value%	83.8	0.81	0.22	1.42	0.86	0.047	5.39	0.87	1.14	0.21	-

- 6) Tyre rubber: Waste tyre rubber with specific gravity of 1.25 is used in concrete as a replacement of coarse aggregate.
- 7) Chemical Admixture: Poly carboxylic ether based super-plasticiser is used.
- 8) Viscosity modifying admixture: A polysaccharide based VMA, to enhance segregation resistance, to improve the viscosity and to modify cohesiveness of the mix

## III. CONCRETE MIXTURES

In this investigation totally six mixtures were made. Four self-compacting concretes were made with replacing sand with used foundry sand and replacing coarse aggregate with waste tyre rubber. The mixture proportions of the concretes are given in Table 1. The water to cement ratio, water were kept constant for all mixtures. Normal concrete had cement content of 421.1 kg/m<sup>3</sup> and water to cement ratio of 0.38. The mixtures were made in a laboratory mixer machine.

Table - 2  
Cement, fine aggregate, coarse aggregate, UFS & WTR content in mix

MIX	Cement (Kg/m <sup>3</sup> )	Water (Kg/m <sup>3</sup> )	Fine aggregate (Kg/m <sup>3</sup> )	Coarse aggregate (Kg/m <sup>3</sup> )	UFS (Kg/m <sup>3</sup> )	WTR (Kg/m <sup>3</sup> )
M1	421.1	160	696.54	1180.17	-	-
M2	421.1	160	1050.95	825.76	-	-
M3	421.1	160	958.92	789.61	92.03	36.15
M4	421.1	160	958.92	753.46	92.03	72.3
M5	421.1	160	912.91	789.61	138.04	36.15
M6	421.1	160	912.91	753.46	138.04	72.3

## IV. FRESH AND HARDENED CONCRETE PROPERTIES

Different ingredients were batched by weight as per mix proportion given in Table 3 and mixed well in a pan mixer of capacity 60 kg and the workability tests such as slump flow test, V-funnel test and L-box test as per specifications were carried out to test the flowability, filling ability, passing ability and segregation resistance as per specifications. The workability test results are tabulated in Table – 3 and found to be within the prescribed limits as per specifications and guideline and satisfy all the required rheological characteristics and self-compactability.

Table – 3  
Fresh concrete results

Sl.No	Method	Unit	Min	Max	M2	M3	M4	M5	M6
1	Slump flow	mm	650	800	690	665	658	662	652
2	V-Funnel	sec	6	12	8	9	11	11	12
3	T5 minutes V-Funnel	sec	0	3	2	2	3	2	3
4	L - Box	h2/h1	0.8	1	0.95	0.88	0.84	0.86	0.82

The total mixes that need to be prepared in this studies is about 6 mixing and this included a preparation of 36 cube samples (150 × 150 × 150) mm for compressive strength test, 18 samples of beam (100 × 100 × 500) mm for flexural test, 36 samples of cylinder (150 diameter × 300 height) mm for split tensile strength test and 18 samples of disc (150 diameter × 100 height) mm. All the samples have been prepared for conventional concrete and replacement of fine aggregate with used foundry sand for 10% and 15% and replacement of coarse aggregate with waste tyre rubber for 5% and 10%. The samples were categorized by age of the concrete at the day of testing, used foundry sand and waste tyre rubber content. For each mix, 3 cubes were tested for compressive strength at 7 days and 28 days of curing, 3 samples of cylinder were tested for split tensile strength for 7 days and 28 days of curing, 3 samples of disc were tested for impact strength at 28 days of curing and , 3 samples of beam were tested for flexural strength at 28 days. . The test results are given in Table – 4.

Table – 4  
Hardened concrete results

Concrete Type	7 days compressive strength (N/mm <sup>2</sup> )	28 days compressive strength (N/mm <sup>2</sup> )	7 days split tensile strength (N/mm <sup>2</sup> )	28 days split tensile strength (N/mm <sup>2</sup> )	28 days flexural strength (N/mm <sup>2</sup> )	28 days impact strength	
						1 <sup>st</sup> Crack	Final Crack
M1	23.85	36.79	2.55	3.03	3.98	85	87
M2	24.58	37.92	2.68	3.19	4.13	91	94
M3	26.24	40.42	2.75	3.46	4.28	119	122
M4	24.92	38.05	2.70	3.32	4.19	131	136
M5	25.89	39.84	2.72	3.35	4.21	115	119
M6	24.27	37.38	2.59	3.16	4.06	129	135

## V. RESULTS AND DISCUSSION

The fresh properties of SCC were found out using Slump flow test, V-Funnel Test, T5 minutes V-Funnel test and L- box test. While using the used foundry sand the water requirement for concrete is increased and it decreases the fresh concrete property of concrete. Using waste tyre rubber affects the flowability and fillability of SCC. So SCC requires more amount of superplasticiser.

The result of compression tests on the cubes with the 7<sup>th</sup> days and 28<sup>th</sup> days of curing are shown in Fig. 1. By comparing all the mixes, mix M3 shows the considerable increase in compressive strength when compared to conventional concrete.

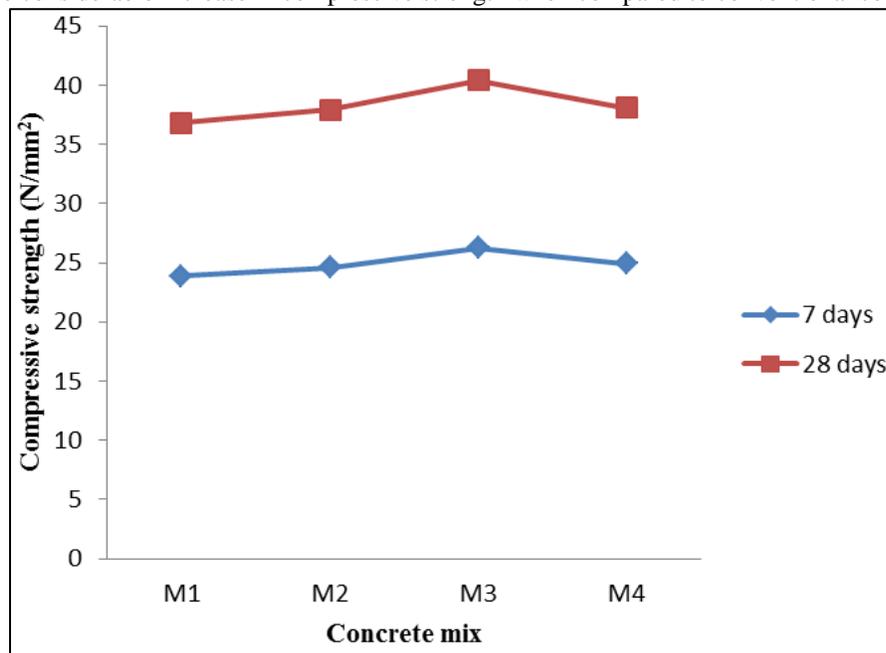


Fig. 1: Comparison of Compressive strength

The result of split tensile tests on the cylinders with the 7<sup>th</sup> days and 28<sup>th</sup> days of curing are shown in Fig. 2. By comparing all the mixes, mix M3 shows the considerable increase in split tensile strength when compared to conventional concrete.

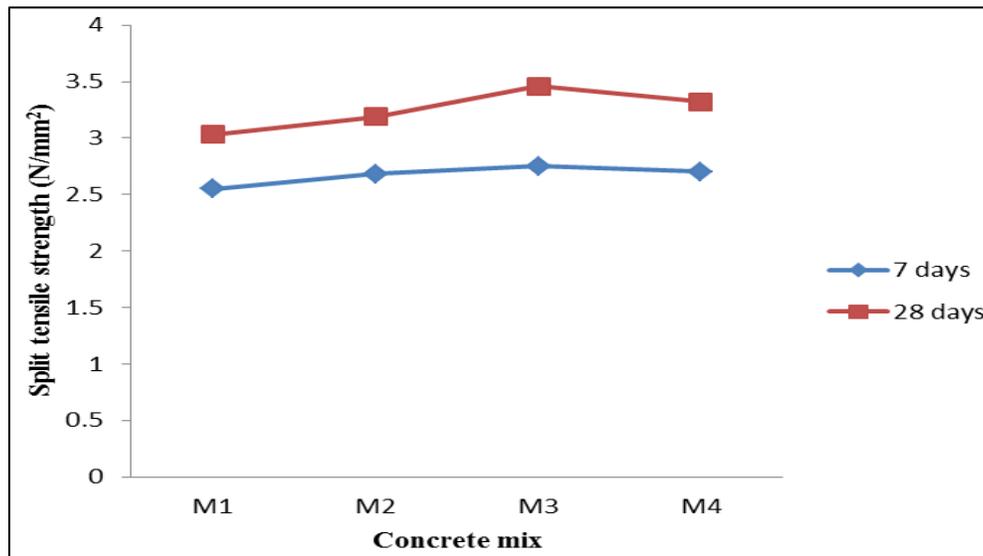


Fig. 2: Comparison of Split tensile strength

The results of flexural tests on the beam with the 28th days of curing are shown in Fig. 3. By comparing all the mixes, mix M3 shows the considerable increase in split tensile strength when compared to conventional concrete.

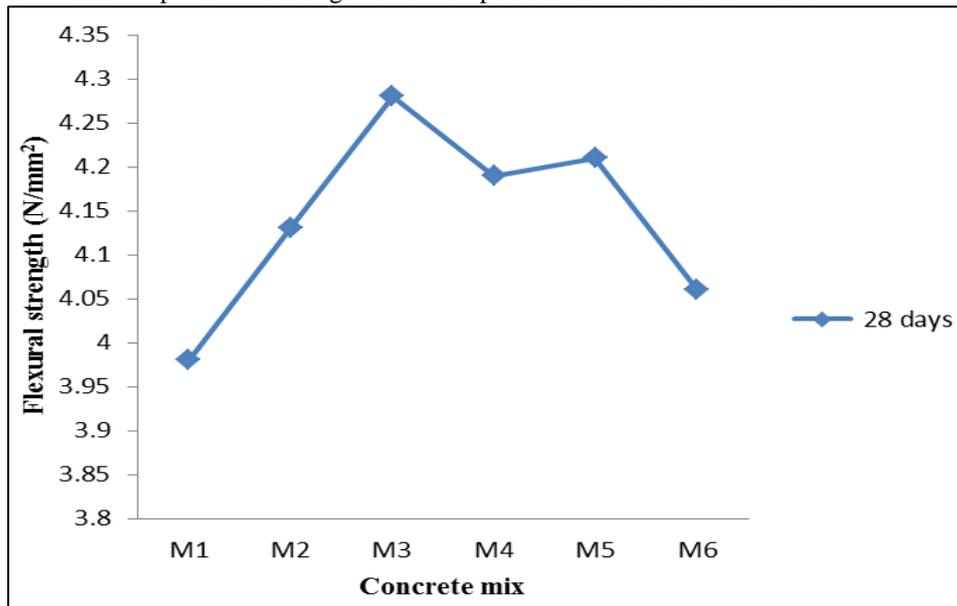


Fig. 3: Comparison of Flexural strength

By comparing all the mixes, mix M4 shows the considerable increase in impact strength when compared to conventional concrete. Because it have optimum amount of waste tyre rubber and used foundry sand.

## VI. CONCLUSION

- 1) Self-compacting concrete mix have high strength than normal concrete mix.
- 2) Used foundry sand will reduce the fresh concrete properties.
- 3) Tyre waste in SCC leads to lowering of mechanical properties. Decrease in strength and stiffness is connected with presence of rubber phase. The addition of chipped or crumb rubber aggregate is the increased tendency towards segregation and bleeding.
- 4) SCRC requires slightly higher amount of superplasticiser than SCC to reach self compacting properties.
- 5) In this experiment maximum compressive strength, split tensile strength and flexural strength achieved at M3 (F10T5) 10% of used foundry sand and 5% waste tyre rubber. The compressive strength increased by 9.86%, split tensile strength increased by 14.19% and flexural strength increased by 7.54% of the mix and the mean time other properties such as impact resistance, toughness have enhanced.

- 6) The concrete made using chipped rubber has given the lowest density as the amount of rubber in the mix decreases the density increase. This is because the density of rubber is much less than that of coarse aggregate and sand.
- 7) The results of the present research highlights positive effects on the compressive, tensile, flexural and impact properties of concrete containing used foundry sand and surface modified waste tyre rubber when compared to concrete mixes containing waste tyre rubber only.
- 8) It has been clearly found that utilization of used foundry sand and waste rubber tyre will increase the strength of the self compacting concrete. But it should not exceed 15% of used foundry sand and 10% of waste tyre rubber.
- 9) From the present experimental study and literature review, it can be concluded even if used foundry sand and waste tyre rubber used at relatively low percentages in concrete, due to the very large market for concrete products worldwide the use of used foundry sand and waste tyre rubber in concrete shows promise for developing additional route for used foundry sand and waste tyre rubber.

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