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Experimental Study of Self Compacted Concrete by Partial Replacement of Sand Using Foundry Sand

Prachi Tiwari[1], Vijay Baradiya[2], Nitya Patel[3]

[1]*M. Tech Student, Dept. of Civil Engineering, IPS Academy, Indore*
[2]*Associate Professor, Dept. of Civil Engineering, IPS Academy, Indore*
[3]*Assistant Professor, Dept. of Civil Engineering, IPS Academy, Indore*

Abstract— India is a developing country and in various developing countries like India economical construction along with economical construction material plays a vital role in the development of country. Waste material in construction can play tremendous role to make it economical and durable due to some of its specific properties relevant to construction materials. This dissertation shows comparative and experimental study on utilization of Foundry Sand by replacement of fine aggregates in concrete. Foundry sand is high quality silica sand that is used as a moulding material by ferrous and non-ferrous metal casting industries.. In this project foundry sand is added in concrete by weight of fine aggregates in the proportion of 5%, 10%, 15% and 20%. Workability and compressive strength and flexural test are performed on concrete and their result is being evaluated and compared.

Keywords— Foundry Sand, Natural coarse Aggregates, Concrete, Workability, Flexural strength and Compressive Strength.

I. INTRODUCTION

Self-compacting concrete as the name denotes is a type of concrete that does not require external or internal vibration for placing and compaction but it gets compacted under its self-weight. It is easily able to flow under its own weight and completely filling formwork and achieving full compaction even though congested reinforcement is present. Simultaneously it is cohesive enough to fill spaces of almost any size and shape without segregation or bleeding. This makes SCC specifically useful at situations where placing is cumbersome such as in heavily reinforced concrete members or in complicated formwork.

II. MATERIALS AND METHODS

A. Selection of Material

1) Cement: Portland cement is the most well-known kind of concrete when all is said in done use. It is an essential element of concrete, mortar and numerous mortars. English stone work specialist Joseph Aspdin licensed Portland concrete in 1824. It was named due to the similitude of its shading to Portland limestone, quarried from the English Isle of Portland and utilized broadly as a part of London design. It comprises of a blend of calcium silicates (alite, belite), aluminates and ferrites - mixes which consolidate calcium, silicon, aluminum and iron in structures which will respond with water. Portland bond and comparative materials are made by warming limestone (a wellspring of calcium) with earth and/or shale (a wellspring of silicon, aluminum and iron) and granulating this item (called clinker) with a wellspring of sulfate (most normally gypsum). In cutting edge concrete furnaces numerous propelled elements are utilized to bring down the fuel utilization per ton of clinker delivered. Concrete furnaces are to a great degree expansive, complex, and characteristically dusty mechanical establishments, and have discharges which should be controlled. Of the different fixings used to create a given amount of cement, the concrete is the most enthusiastically costly. Indeed, even mind boggling and proficient furnaces require 3.3 to 3.6 gigajoules of vitality to deliver a huge amount of clinker and afterward pound it into concrete. Numerous ovens can be powered with hard to-discard squanders, the most well-known being utilized tires. The to a great degree high temperatures and drawn out stretches of time at those temperatures permits bond ovens to effectively and totally blaze even hard to-use energizes. In this project, for production of concrete, Portland pozzolana cement (fly ash based) is used, conforming to specification given under IS 1489: 1991 (Part –I). Cement which is used in this project is tested in laboratory and their result is given in table 1.

Table 1 - Properties of Cement

S. NO	Property	Value
1	Fineness	3.80%
2	Initial Setting Time	42 min
3	Final Setting Time	196 min
4	Specific Gravity	3.14
5	Soundness	2 mm
6	Compressive Strength	7 Days – 24.55 MPa
		28 Days – 37.86 MPa

2) Water: Consolidating water with a cementitious material a structural bond is developed by the procedure of hydration. The concrete glue ties the total together, fills voids inside of it, and makes it workable. A lower water-to-bond

proportion yields more grounded, tougher cement, while more water gives workable cement with a higher droop. Tainted water used to make cement can bring about issues when setting or in creating untimely disappointment of the structure. Hydration includes various responses, frequently happening in the meantime. As the responses continue, the results of the concrete hydration handle slowly bond together the individual sand and rock particles and different segments of the solid to shape a strong mass. Water used for concrete should be free from injurious amount of oils, acids, alkalis, salts, sugar, organic materials or other substances. Water which is used in this project is confirming to the specification of IS 456: 2000.

3) Aggregates: Fine and coarse aggregates make up the bulk of a concrete mixture. Sand, natural gravel and crushed stone are used mainly for this purpose. The presence of aggregate greatly increases the durability of concrete above that of cement, which is a brittle material in its pure state, also reduces cost and controls cracking caused by temperature changes. Thus concrete is a true composite material. Redistribution of aggregates after compaction often creates inhomogenity due to the influence of vibration. This leads to strength gradients.

i) Coarse Aggregates: Natural aggregates used in the manufacture of concrete should meet the requirements for aggregates for concrete given in IS 383. Aggregates from natural sources are used in this project. In this project crushed stone which passes from 20 mm IS sieve and retained on 4.75 mm IS sieve is used. Coarse aggregate which is used in this project is tested in laboratory for their properties and their results are given in table 2.

Table 2 – Properties of Coarse Aggregates

S. No.	Property	Value	
1	Crushing Value	14.91%	
2	Impact Value	11.20%	
3	Abrasion Value	12.52%	
4	Specific Gravity	2.63	
5	Water Absorption	0.63%	
6	Bulk Density	1680 Kg/m3	
7	Flakiness and Elongation Index	11.85%	
8	Gradation	**Sieve No.**	**Percentage Passing**
		40 mm	100
		20 mm	92.25
		10 mm	9.64
		4.75 mm	1.23

ii) Fine Aggregates: Aggregates which passes from 4.75 mm IS sieve are termed as fine aggregate, natural river sand is used in the project which passes from 4.75 mm IS sieve and retained on 70 microns IS sieve. Fine aggregate which is used in this project is tested in laboratory for their properties and their results are given in table 3.

Table 3- Properties of fine aggregates

S. No.	Property	Value	
1	Specific Gravity	2.61	
2	Bulking	30.21%	
3	Water Absorption	0.92%	
4	Bulk Density	1590 Kg/m3	
5	Gradation	**Sieve No.**	**Percentage Passing**
		10 mm	100.00
		4.75 mm	100.00
		2.36 mm	97.32
		1.18 mm	78.57
		600 microns	69.88
		300 microns.	16.40
		150 microns	0.32
		Conforming to grading zone II of IS 383-1997	

4) Waste Foundry Sand: A foundry creates metal castings by pouring molten metal into a preformed mould to yield the resulting hardened cast. The metal casts contain iron and steel from the ferrous family and aluminum, copper, brass and

bronze from the non-ferrous family. Waste foundry sand is collected from industrial area in Indore. Nominal size of waste foundry sand which passes from 4.75 mm IS sieve is used and it was mixed in concrete with replacement of fine aggregates by 5%, 10%, 15% and 20%.it was tested in the laboratory for their properties and their results are given in table 4.

Table 4 – Properties of Waste foundry sand

S. No.	Property	Value	
1	Specific Gravity	2.42	
2	Fineness Modulus	1.22	
3	Water Absorption	1.20%	
4	Bulk Density	1485 Kg/m^3	
5	Gradation	**Sieve No.**	**Percentage Passing**
		10 mm	100.00
		4.75 mm	100.00
		2.36 mm	98.89
		1.18 mm	98.21
		600 microns	97.08
		300 microns.	74.86
		150 microns	7.35
		Conforming to grading zone II of IS 383-1997	

B. Mix Proportions

For this project M 30 & M 40 concrete is designed, as per specification given under IS 10262: 2009. The concrete mix configuration is a procedure of selecting the suitable elements of concrete and deciding their most ideal extents which would create, at this very moment conceivable, concrete that fulfills the employment necessities, i.e. the concrete having a certain base compressive quality, the craved workability and strength. Notwithstanding these prerequisites, the concrete substance in the mix ought to be right now conceivable to accomplish greatest economy. The proportioning of the elements of concrete is an essential piece of concrete innovation at this very moment the quality and economy. Mix designation is given in table 5 along with mix proportion table 6 below:

Table 5 – Mix Designation

Material	Content	Mix Name
--	--	SCC
Waste Foundry sand	5%	FSC1
	10%	FSC2
	15%	FSC3
	20%	FSC4

Table 6 –Mix proportion

Content		M40	M30
Cement		415 kg/m^3	390 kg/m^3
Water		166 kg/m^3	175 kg/m^3
Fine Aggregate		675 kg/m^3	658 kg/m^3
Coarse Aggregate		1209 kg/m^3	1180 kg/m^3
Admixture (Auramix 400)		4.15 kg/m^3	4.00 kg/m^3
--	SCC	0 kg/m^3	0 kg/m^3
Waste Foundry Sand	FSC1	33.75 kg/m^3	32.90 kg/m^3
	FSC2	67.5 kg/m^3	65.80 kg/m^3
	FSC3	101.25 kg/m^3	98.70 kg/m^3
	FSC4	135 kg/m^3	131.60 kg/m^3

III. RESULTS AND DISCUSSIONS

A) Compressive Strength

Table 7 and graph 1 shows, compressive strength of waste foundry sand concrete and it has been observed that adding waste foundry sand in concrete increases its compressive strength, control mix concrete gives 37.12 and 49.61 MPa for M30 & M40 grade respectively and its FSC4 mix which contains 20% of foundry sand gives 39.61 and 51.31 MPa for M30 and M40 grade respectively. Table 8 and graph 2 shows percentage variation in compressive strength for each mix.

Table 7 - Compressive Strength of Waste Foundry Sand Concrete

S. No	% Foundry Sand	7 Days		14 Days		28 Days	
--	--	M 30	M 40	M 30	M 40	M 30	M 40
1	0	28.20	35.43	32.12	43.83	37.12	49.61
2	5	29.64	37.05	33.25	45.21	38.45	50.59
3	10	31.25	38.79	36.14	46.85	42.12	52.13
4	15	37.41	40.37	39.81	48.48	43.56	53.45
5	20	31.15	37.45	36.59	45.72	39.69	51.31

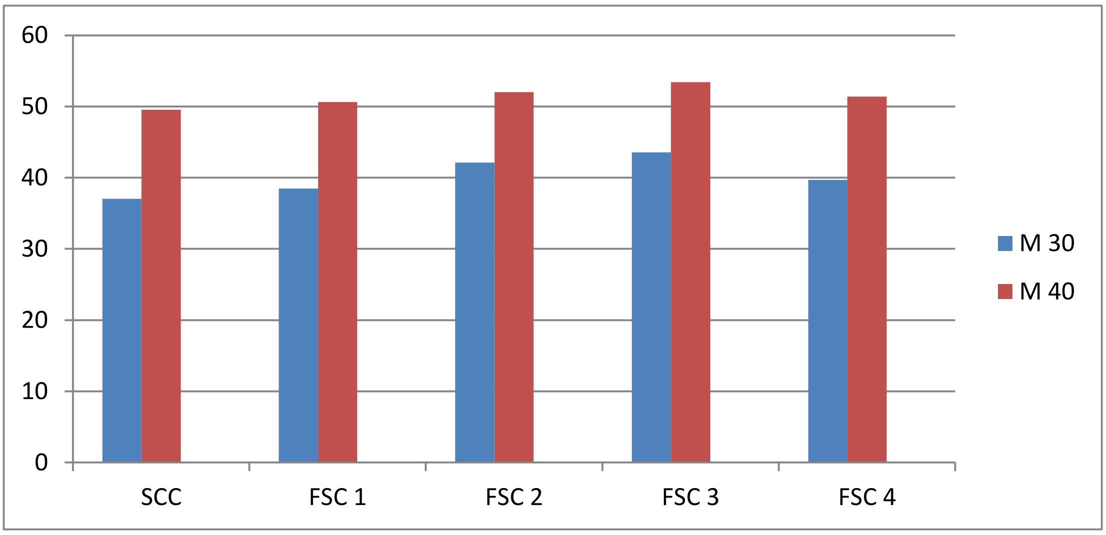

Fig 1: 28 Days Compressive strength of Self Compacted Concrete

Table 8: Variation in compressive strength of self-Compacted concrete

S. No	Percentage Waste Foundry Sand	Mix name	% CS Variation in 28 Days	
--	--	--	M 30	M 40
1	0 %	SCC	0	0
2	5 %	FSC 1	3.92	2.24
3	10 %	FSC 2	13.83	5.05
4	15 %	FSC 3	17.61	7.83
5	20%	FSC 4	7.27	3.71

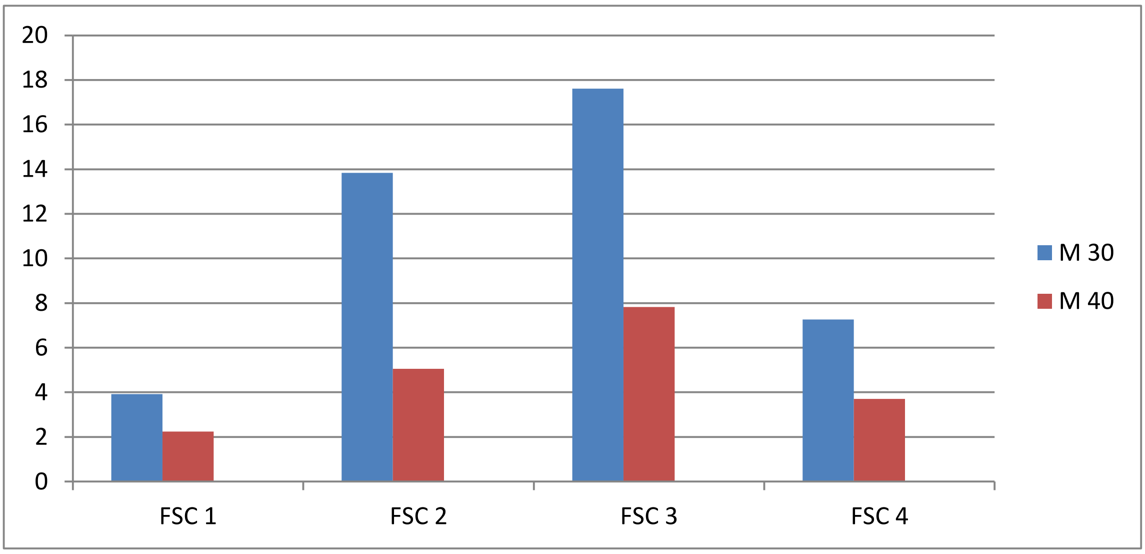

Fig 2: Variation in Compressive strength of Self Compacted Concrete

B) SPLITTING TENSILE STRENGTH

Table 9 and graph 3 shows, splitting tensile strength of waste foundry sand concrete and it has been observed that adding waste foundry sand in concrete increases its splitting tensile strength, control mix concrete gives 3.14 and 4.32 MPa for M30 & M40 grade respectively and its FSC4 mix which contains 20% of foundry sand gives 3.86 and 5.06 MPa for M30 and M40 grade respectively. Table 10 and graph 4 shows percentage variation in splitting tensile strength for each mix.

Table 9: Splitting Tensile Strength of Waste Foundry sand Concrete

S. No	**% Foundry Sand**	**7 Days**		**28 Days**	
--	--	M 30	M 40	M 30	M 40
1	0	2.34	3.22	3.14	4.32
2	5	2.56	3.49	3.55	4.69
3	10	2.65	3.81	4.01	5.05
4	15	2.81	4.16	4.25	5.41
5	20	2.74	3.93	3.86	5.06

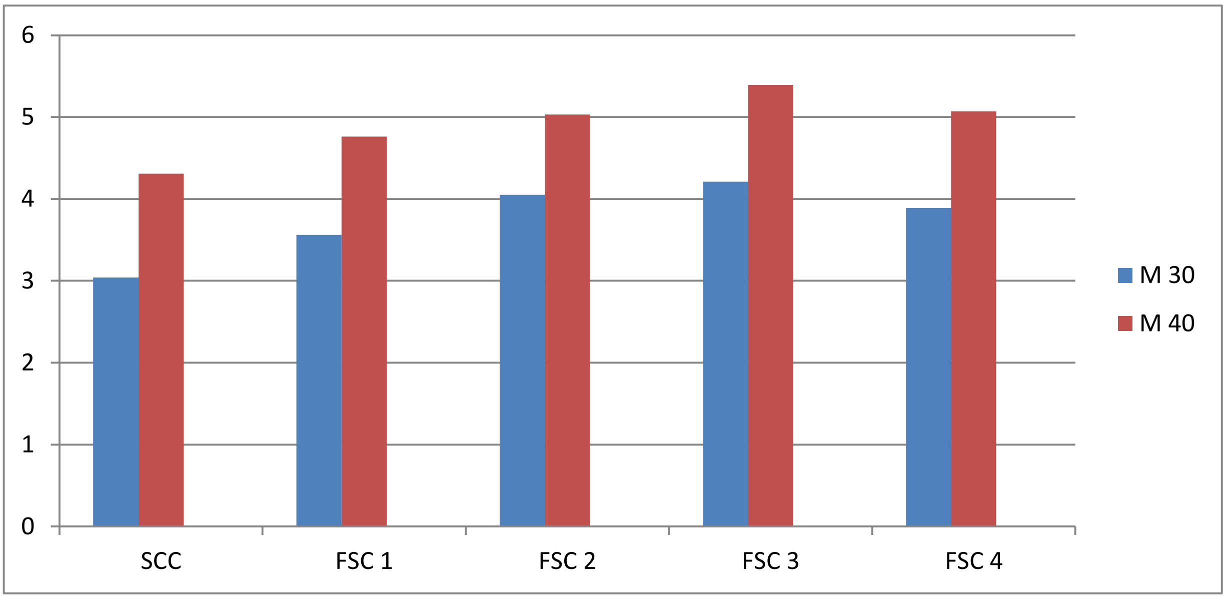

Fig 3: Splitting Tensile strength of Waste foundry sand Concrete (Bar Graph)

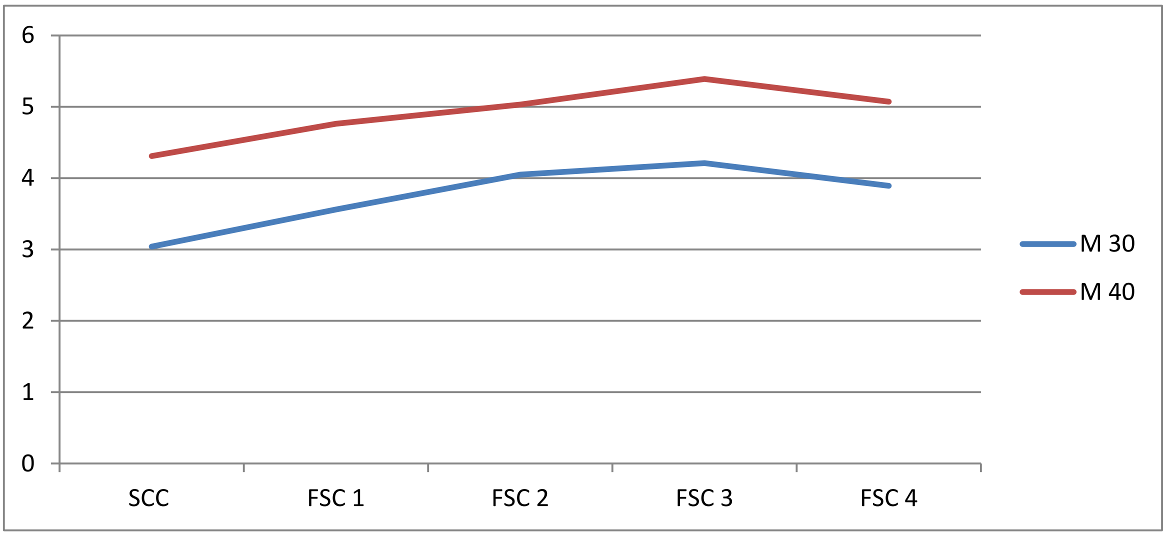

Fig 4: Splitting Tensile strength of Waste foundry sand Concrete (Line Graph)

Table 10: Variation in Splitting Tensile strength of Waste foundry sand Concrete

S. No	Percentage Foundry Sand	Mix name	% STS Variation in 28 Days	
			M 30	M 40
1	5 %	FSC1	17.10	10.44
2	10 %	FSC2	33.22	16.70
3	15 %	FSC3	38.49	25.05
4	20%	FSC4	27.96	17.63

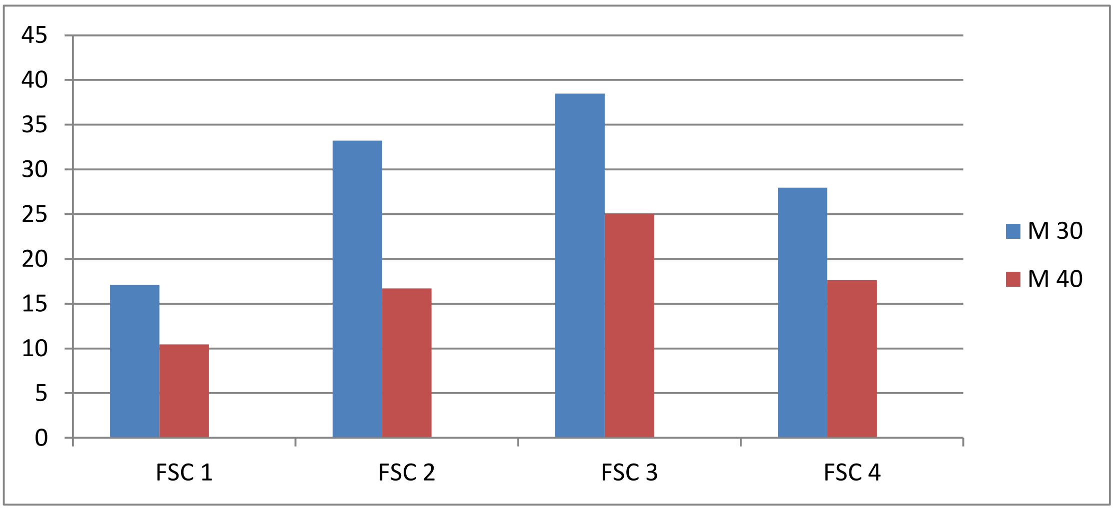

Fig 7: Variation in Splitting Tensile strength of Waste foundry sand Concrete (Bar Graph)

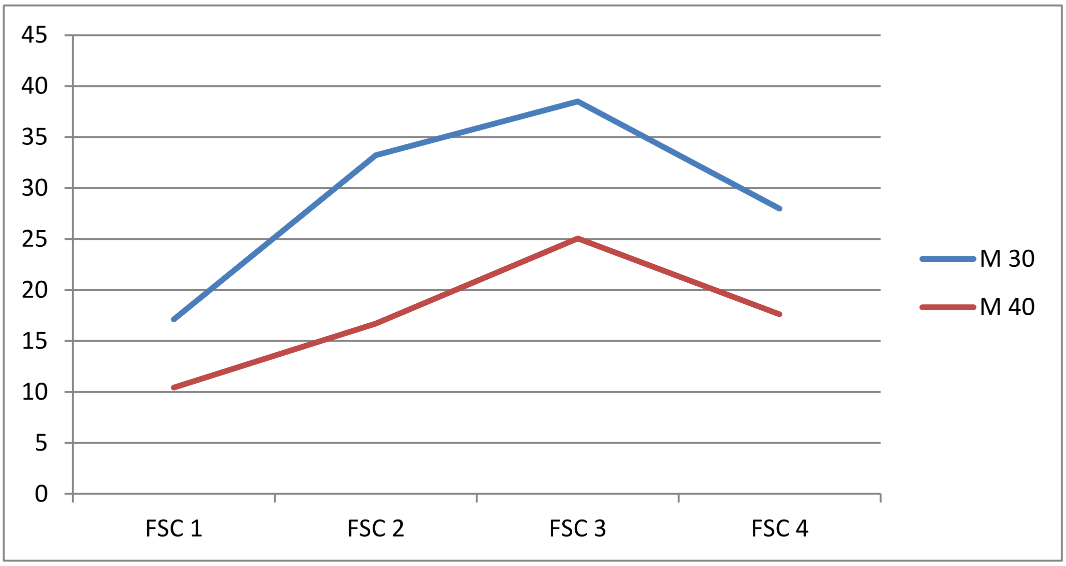

Fig 8: Variation in Splitting Tensile strength of Waste foundry sand Concrete (Line Graph)

IV. CONCLUSIONS

It is identified that foundry sand can be disposed by using them as construction materials and can be used as natural sand in self-compacted concrete. Compressive strength and flexural strength of foundry sand self-compacted concrete first increases then starts decreasing after 15 % mixing of waste foundry sand. By this study it is concluded that all foundry sand mix are useable, but its initially 3 mixes i.e. up to 15% gives better compressive & Flexural strength. It is also concluded that 15% is the optimum value for foundry sand mix. Workability of the self-compacted concrete increases when percentage of the foundry sand increases. Current study concluded that foundry sand can replace coarse aggregate in self-compacted concrete up to 15%. So this study concludes that we can use foundry sand as a replacement of natural coarse aggregates in lintels up to 20%.

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