NATURALISTA CAMPANO
ISSN: 1827-7160
Volume 28 Issue 1, 2024

An Experimental Evaluation of Robo Sand and Silica Fume Influence on Mechanical Properties of High-Performance Concrete

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Abstract: One of the key elements used in the manufacture of concrete is river sand. HPC is a concrete with a unique combination of overall performance and homogeneity requirements that can't be consistently achieved robotically with standard parts and mixing. Natural sand is growing more expensive as a result of its widespread use in building. As a result, instead of river sand, synthetic sand known as ROBOSAND is used to meet the concrete specifications. Many studies have shown that fly ash can substitute cement up to 35 percent, according to the American Concrete Institute. In this study, the evaluation of M80 and M90 grades is used to determine the overall performance characteristics of concrete.

Keywords: HPC; Robosand; Manufactured sand; Fly-ash; Silica fume.

1. INTRODUCTION:

OPC is the most widely used constructing fabric on the planet, and it will continue to grow in popularity in the near future as a result of its call for a global growth of the construction sector. Furthermore, the most difficult task confronting the concrete construction industry is to fulfil two fundamental human desires: environmental conservation and meeting the infrastructural needs of our rapidly growing population. Structures built in a competitive context are more likely to be vulnerable to corrosive attack. One of the most serious threats is sulphate attack on concrete systems, which causes the concrete to lose weight and lose energy. Some of the assets of sulfate's assault on concrete are contaminated groundwater and seawater from industrial effluents. The usage of mixed cement types has produced excellent results in terms of sulphate resistance in concrete. Because fly-ash has a higher pozzolanic content, it can be utilized as a cement substitute in concrete. It's made from a by-product of the coal and thermal industries, with the same fineness of cement and good bonding between the cement and the fly-ash.

Fine aggregates are essential in the production of concrete and mortar. The cleanness of the sand from the industry has a major impact on the longevity of concrete constructions. The use of natural (River sand) is increasing in recent years, resulting in rapid depletion of river sand. Robosand is an alternative to river sand that can be used in buildings to reduce the amount of river sand consumed. Robosand has been employed in large projects all around the world in place of natural sand. Robosand contains no impurities.

The main purpose of the thesis was to look at the workability, electricity of concrete with Robosand, and percentage replacement of Robosand by river sand using 0 percent, 25 percent, 50 percent, 75 percent, and 100 percent of river sand, respectively. The test is carried out on M80 and M90 grade concrete with 0.32 and 030 W/C cement mortar. Robosand is a suitable combination, but it must meet technical requirements like as workability and strength. Because research on concrete, cement mortar, and Robosand is limited in these areas, this paper examines the concrete made with Robosand.

2. OBJECTIVES:

1. The tests are to be conducted on cubes, cylinders, and beams to examine the strength of Robosand, fly-ash and the silica fume by taking preliminary blends in a curing period of 7 and 28 days.
2. The investigation has to be done for the proportions of 0%, 25%, 50%, 75%, and 100% of the river sand is replaced with Robosand along with the replacement of cement with 20 % of fly-ash and 5% of silica fume.

3. METHODOLOGY AND MATERIALS:

3.1 Methodology:

Mix Design: Mix proportions for M80 & M90 is represented in below table.

Grade	Mix Ratio	W/C ratio
M80	1: 0.87: 1.75	0.32
M90	1: 0.78: 1.67	0.30

Table 1. Mix Proportions

Concrete examples were cast for the blend extents of M80 and M90 utilizing the substitution of fine aggregate (River Sand) with Robosand and concrete is supplanted with 20%& 5% of fly-ash, and silica fume. 6 Cubes, 6 cylinders, and 6 beams were cast and cured for 7 and 28 days.

3.2 Materials which are required for this research is,

- ✓ Ordinary Portland Cement
- ✓ Fine Aggregates, Coarse Aggregates& Robosand
- ✓ Fly-ash
- ✓ Silica fume
- ✓ Superplasticizers

3.2.1 OPC:

OPC of 53 grades was embraced for this work and it affirming to IS: 12269-1987[16]. The physical properties of concrete were checked before the work for the fitting outcomes.

S. No	Test		Value
1	Fineness		97%
2	Sp. Gravity		3.15
3	Normal Consistency		31.22
4	Setting time	Initial	98min
		Final	260min

Table 2. Properties of Cement

3.2.2 Fine and Coarse Aggregates:

The fine aggregates (River Sand) are generally considering the sizes from 0.075mm-4.75mm. In this work, two kinds of fine aggregates are considered. Those are River sand and Robosand and the fineness is affirming to IS:383.

Robosand:

Robosand is a fine aggregate that is created by smashing stone, rock, or slag. Utilized for material less than 4.75 mm that is prepared from smashed stone or rock and expected for development use. Robosand is a material of high caliber, in logical inconsistency to non-refined excess from coarse total creation.

S. No	Test	Natural sand	Robosand
1	Sieve analysis	Zone II	Zone II
2	Fineness modulus	2.6	2.78
3	Sp. Gravity	2.66	2.79
4	Water Absorption	0.90%	1%
5	Bulk density	1602.6 Kg/m^3	1698.5 Kg/m^3

Table 3. Analysis of River Sand & Robosand

The coarse particles that are passed through 20mm and retained on 12.5mm are considered. Table 3 shows the outcomes of the tests.

S. No	Test		Result
1	Specific gravity		2.84
2	Water absorption		0.1%
3	Impact value		19.50%
4	Bulk density	Loosely packed	1524.02 Kg/m^3
5		Compacted	1700 Kg/m^3
6	Flakiness index		12.49
7	Elongation index		64.50

Table 4. Properties of Coarse aggregates

3.2.3 Fly-ash:

As a substitute for cement, a different cementitious substance called fly-ash was used. Fly ash is obtained from VTPS and is classified as Class - C. 2.15 is the specific gravity. Table 4 categorises the qualities.

S. No	Property	Result
1	Specific gravity	2.15
2	Normal consistency	34%
3	Fineness	$380m^2/Kg$

Table 5. Fly-ash Properties

Chemical composition of fly-ash:

Chemical Constituent	Sio_2	Al_2O_3	FeO	CaO	MgO	P_2O	Na_2O
Cement (%)	45.31	28.73	3.89	20	1.26	0.73	0.97

Table 6. Chemical composition of Fly-ash

3.2.4 Silica fume:

Silica fume is a by-product of silicon or ferrosilicon manufacturing. Smaller scale silica is another name for silica. Its use in concrete has grown significantly in recent years. The research on silica has been completed, and the results are ready to be used. Because of its fineness and exceptional keeping capabilities, silica is used to produce high-quality products. Between the mass hydrated concrete and the total particles in concrete, the progress zone is a delicate layer. This is the most fragile region of the cement, as well as the most penetrable area. Silica has a high SiO2 percentage and a low carbon content. This will work nicely with concrete and framing silicates to add more strength to concrete. The features of silica rage are listed in Table 5.

Sp. Gravity	**2.20**
Specific Surface area	16000 –29000 m^2/kg
Color	Greyish Black
Appearance	Fine Powder
Particle size	90 µ m

Table 7. Silica fume test Results

Chemical composition of silica fume:

SiO_2	**Al_2O_3**	**FeO**	**CaO**	**MgO**	**K_2O**	**Loss of Ignition**
92.2	0.5	1.4	0.5	0.3	0.7	2.8

Table 8. Chemical composition of Silica Fume

3.2.5 Superplasticizers:

As an additive, BASF glenium B233 superplasticizer is utilised. The item was designed primarily for use in premium solids where the highest levels of strength and execution are required. Glenium B233 is a chloride-free, low-soluble base that works well in a variety of concretes.

4. Results & Discussions:

The Compression, split, and tensile strength tests were conducted by the replacement of cement with 20 % fly-ash, 5 % of silica fume, and 25% differential percentage of river and with Robosand.

4.1. Slump Test:

Mix	**Slump (mm)**	
	M80	**M90**
Control	85	82
Trail 1(0% RS)	84	80
Trail 2(25% RS)	80	75
Trail 3(50% RS)	76	72
Trail 4(75% RS)	72	68
Trail 5(100% RS)	65	60

Table 9. Slump test results for M80 & M90

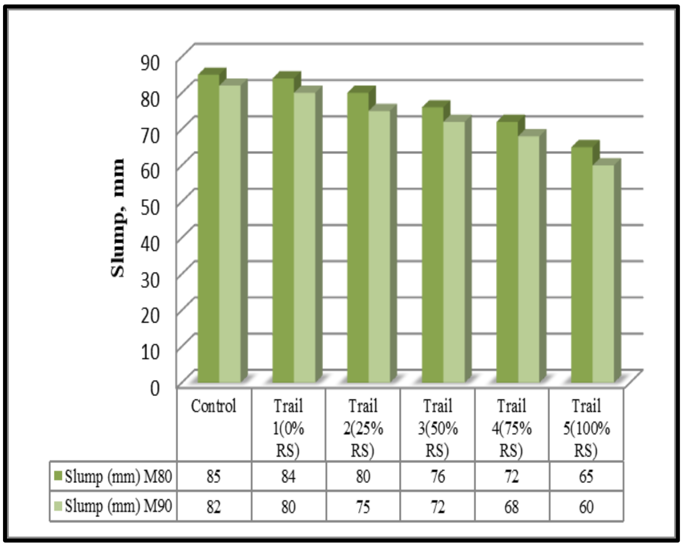

Figure 1. Graph for Slump test

4.2. **Compressive Strength:** The cubes are to be cured for 7 & 28 days and dry the surface for the compressive strength test by using of CTM. Table 7 describes the results of compressive strength of M80 & M90.

Mix	Compressive strength M80 (N/mm²) for curing period		Compressive strength M90 (N/mm²) for curing period	
	7	**28**	**7**	**28**
Control	56.1	85.5	68.8	95.5
Trail 1	57.5	89.6	70.5	96.2
Trail 2	58.1	90.5	71.8	98.2
Trail 3	**60.2**	**91.1**	**72.0**	**105.5**
Trail 4	58.5	89.2	71.2	99.5
Trail 5	56.4	88.9	69.9	98.6

Table 10. Compressive Strength Values for M80 & M90 for 7 & 28 days of curing

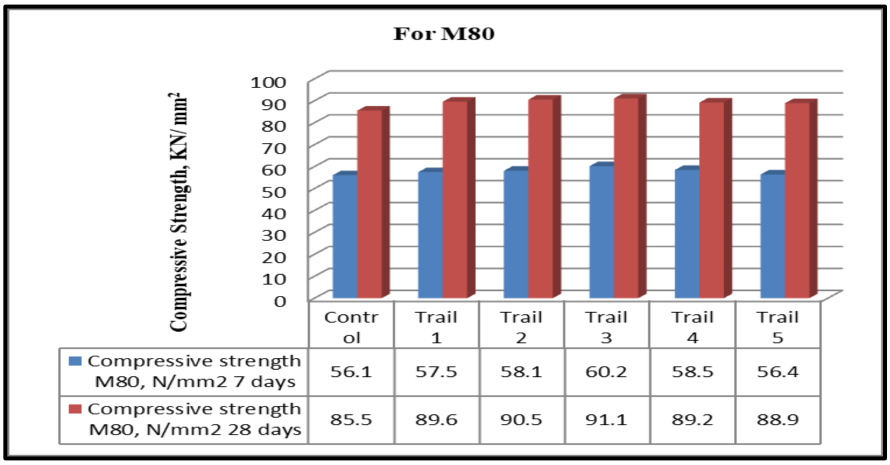

Figure 2. Graph represents the CS of M80

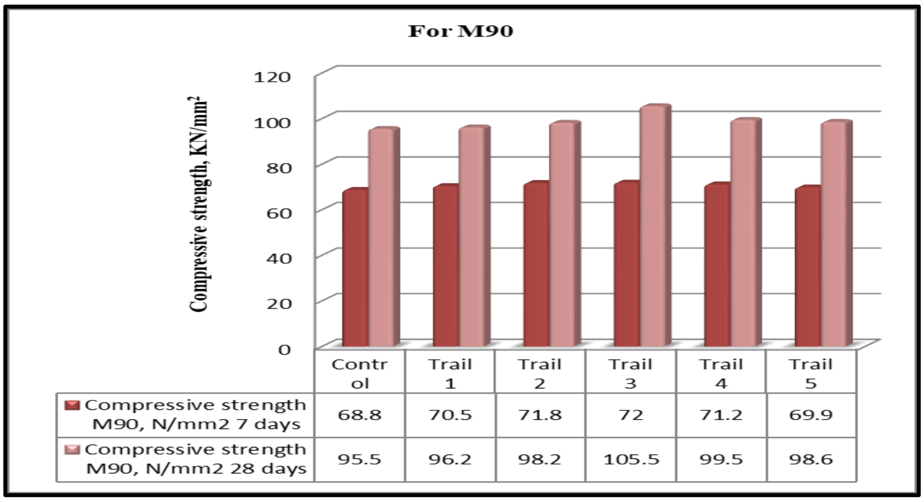

Figure 3. Graph represents the CS of M90

4.3. **Split Tensile Strength:** The Tensile Strength is most important property with all. The strength test is conducted on the cylinders of 300mm*150mm and the test is done for a curing period of 7 & 28 days. Table 8 represents the strength values for M80 & M90 grades.

Mix	**STS M80, N/mm² for curing period**		**STS M80, N/mm² for curing period**	
	7	**28**	**7**	**28**
Control	4.28	5.55	5.65	6.25
Trail 1	4.24	5.58	5.62	6.26
Trail 2	4.30	5.60	5.75	6.30
Trail 3	**4.38**	**5.65**	**5.80**	**6.65**
Trail 4	4.32	5.62	5.65	6.50
Trail 5	4.22	5.56	5.60	6.45

Table 11.STS of M80 & M90

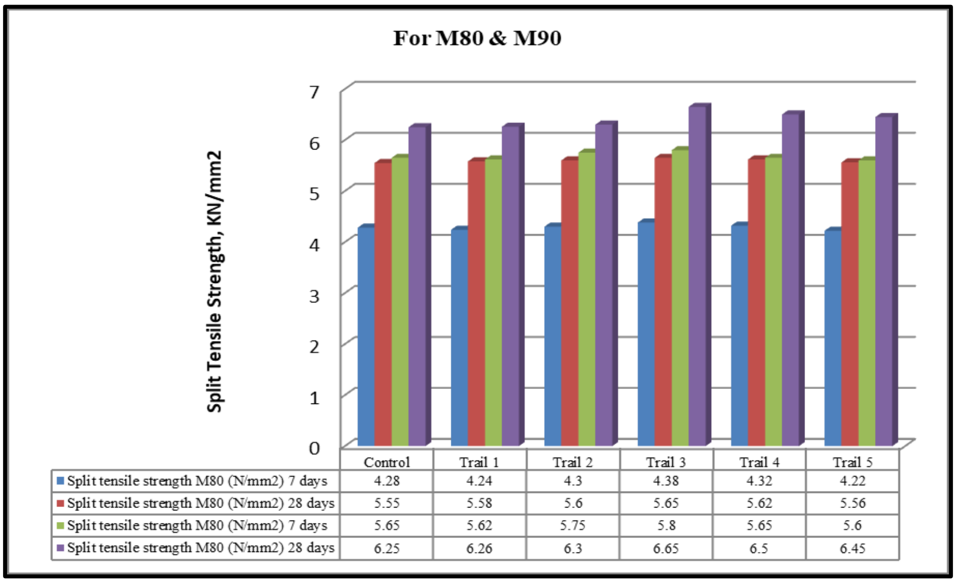

Figure 4.Graph of STS of M80 & M90

4.4. **Flexural Strength Test:** the flexural strength of the concrete is determined from the flexural strength test for the beams of sizes 500mm*100mm*100mm. The modulus rupture of the beams is tabulated in table 9. From the table 9, the maximum flexural values are obtained for trial 3.

Mix	Flexural strength M80, N/mm^2 for curing period		Flexural strength M90, N/mm^2 for curing period	
	7	28	7	28
Control	6.20	8.66	6.20	8.66
Trail 1	6.45	8.65	6.45	8.65
Trail 2	6.50	9.25	6.50	9.25
Trail 3	**6.65**	**10.50**	**6.65**	**10.50**
Trail 4	6.53	8.86	6.53	8.86
Trail 5	6.30	8.72	6.30	8.72

Table 12. Flexural Strength of M80 & M90

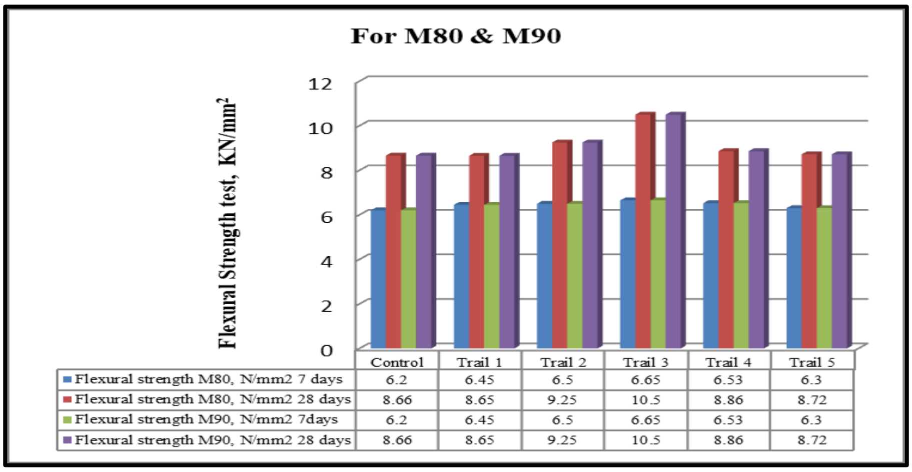

Figure 5. Graph of Flexural Strength of M80 & M90 for 7 & 28 days of Curing

4.5. Integrated analysis of the test results:

Mix	M80 GRADE (N/mm^2) for curing periods							M90 GRADE (N/mm^2) for curing periods						
	Compressive		Split tensile		Flexural		Slump (mm)	Compressive		Split tensile		Flexural		Slump (mm)
	7	28	7	28	7	28		7	28	7	28	7	28	
Control	56.1	85.5	4.28	5.55	6.20	8.66	85	68.8	95.5	5.65	6.25	6.65	8.95	82
Trail 1	57.5	89.6	4.24	5.58	6.45	8.65	84	70.5	96.2	5.62	6.26	6.68	9.05	80
Trail 2	58.9	90.5	4.30	5.60	6.50	9.25	80	71.8	98.2	5.75	6.30	6.70	10.45	75
Trail 3	**60.2**	**91.1**	**4.38**	**5.65**	**6.65**	**10.5**	**76**	**72.0**	**105.5**	**5.80**	**6.65**	**6.82**	**11.12**	**72**
Trail 4	58.5	89.2	4.32	5.62	6.53	8.86	72	71.2	99.5	5.65	6.50	6.75	10.26	68
Trail 5	56.4	88.9	4.22	5.56	6.30	8.72	65	69.9	98.6	5.60	6.45	6.62	9.12	60

Table 13. Integrated Analysis of Test Results

In the current examination probability of high qualities is watched for M80 and M90 grades that are effectively accomplished.

- The content Robosand is a fantastic solution to replace River sand because it met all of the requirements just like regular sand and could be used for all building operations instead of regular sand for cost savings.
- The 12.5mm C.A. was used to reduce the amount of territory covered by 20mm aggregates, resulting in fewer voids and improved holding.
- Using Glenium B233 as a superplasticizer at a concentration of 0.3 percent improves the functionality and consistency of cement blending. It's an effective water-saving device.
- For M80, greatest compressive strength of 91.1 Mpa, Split elasticity of 5.65 Mpa and Flexural of 10.5 Mpa had happened in Trail 3 i.e., 50% RS, 20% FA and 5% SF.
- For M90 grade, greatest compression of 105.5 Mpa, Split elasticity of 6.65 Mpa, flexural of 11.12 Mpa had happened for Trail 3.
- When 50 percent Robosand is substituted for M80grade in Trail 3, the rate of compression increase from 7 to 28 days is 34.3 percent, flexural quality is 3.5 percent, and part elasticity is 3%. The rate of increase in compressive quality for M90 grade is 35%, while flexural and part elastic qualities are 4% and 2% respectively.

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