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EXPERIMENTAL STUDY ON MECHANICAL PROPERTIES OF CONCRETE INCORPORATING WASTE FOUNDRY SAND WITH DESTRUCTIVE AND NON-DESTRUCTIVE TEST

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Abstract:

Demand for river sand which is used as fine aggregate in concrete for construction works is increasing day by day. On the other hand, the metal casting industries in India produces nearly 1.71 million tons of foundry sand yearly. These waste foundries are dumped in land as landfill which is causing environmental hazards. Its properties are similar to the properties of natural or manufactured sand. This study relate these two facts by partial replacement of river sand with waste foundry sand in concrete by 0%,10%,20%,30% and 40% for M40 grade concrete to provide economic and eco-friendly buildings. After 7 days and 28 days, the specimens are checked for the compressive strength and split tensile strength of concrete by destructive and non-destructive test. The destructive test is conducted by the compression testing machine and the non-destructive test is conducted by Ultrasonic Pulse Velocity (UPV) testing machine. This UPV technique, uses the waves to pass through the specimen and there will be no damage for the concrete elements to assess the quality of concrete. This study is mainly for determining the relationship between the UPV to that of the compressive strength of concrete. The final results show that there is increase in compressive strength and split tensile strength of concrete at replacement of 20% of foundry sand.

Key Words: Industrial Waste, Foundry Sand, Mechanical Properties, Compressive Strength & Conventional Concrete

1. Introduction:

Concrete is the most widely used material in the world next to the water. Concrete can be made into any shape by pouring it in the moulds. Concrete is a composite material composed of coarse aggregate bonded together with fluid cement that hardens over time. When aggregate is mixed together with dry Portland cement and water, the mixture forms fluid slurry that is easily poured and molded into shape. Cement is a water based material to bind over the building material together. Most concrete is poured with reinforcing materials embedded to provide tensile strength, yielding reinforced concrete. Coarse aggregate is a material used in concrete which may include gravel, crushed stone, and recycled concrete and geo-synthetic aggregate. Coarse aggregate contributes of large mass in a concrete mix. Fine aggregate is a material in which the particle passing through sieve size of 4.75mm. They are obtaining from the natural sand and also from the river basins. They may also contribute the important role in concrete. Water added for the concrete should be in a range of 6 to 8. And there should not have salt content present in the water. The concrete solidifies and hardens through a chemical process called hydration.

2. Materials Used:

Cement: Cement in concrete acts as a binding material that harden after the addition of water. It plays an important role in construction sector. In this study, the Portland Pozzolana Cement (PPC) of grade 43 is used.

Fine Aggregate: Aggregate that pass through a 4.75 mm IS sieve and having not more than 5 percent coarser material are known as fine aggregate. Main function of fine aggregate is to fill the voids in between coarser particles and also helps in producing workability and uniformity in concrete.

Coarse Aggregate: The aggregate having size more than 4.75 mm is termed as coarse aggregate. The graded coarse aggregate is described by its nominal size i.e. 40mm, 20mm, 16mm, 12.5mm etc.

Water: Water plays an important role as it contributes in chemical reaction with cement. Water is used for mixing as well as for curing purpose also it should be clean and free from salts, acids, alkalis and other harmful materials.

Foundry Sand: Foundry sand is clean, uniformly sized, high-quality silica sand that is bounded to form moulds for ferrous (iron and steel) and non-ferrous (copper, aluminum, brass) metals.. Foundry sand is generally of two types: Green sand, chemically bounded sand. Use of waste foundry sand as full or partial replacement by fine aggregate helps its compressive strength.

3. Methodology:

The collection of literature is the first step of the methodology. After the collection of literature, the study is made on it. Then, the selection of material is done. The materials are to done the corresponding tests to find its properties. determine the proper mix design. The concrete may prepared as per the mix design and fresh property of concrete is done i.e., slump cone test and compaction test.. And the casting work is done in cubes and cylinders. After demoulding, the cubes and cylinders are taken to the curing pit. After the proper curing of specimen, it is taken to the compressive testing machine to determine the compressive strength and split tensile strength of concrete. The result may obtain and it may compare between the conventional concrete to the concrete with various level of replacement of foundry sand. The flow chart of methodology is given in fig 1.

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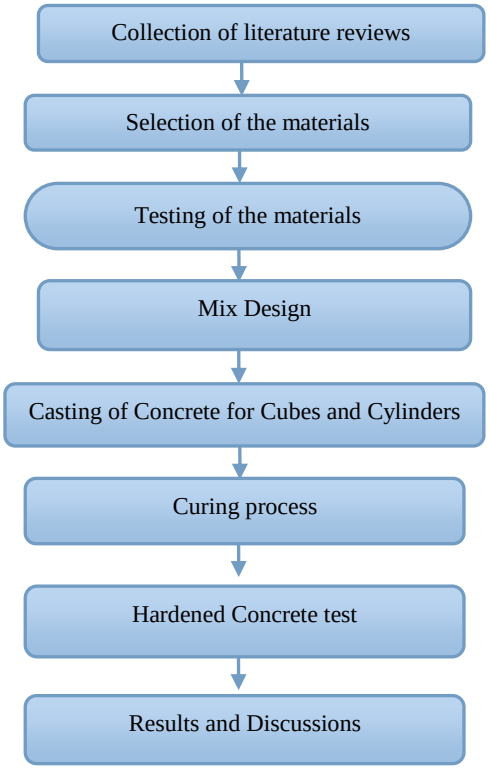

4. Mix Design:

Mix design is a process of selecting suitable ingredients for concrete and determining their proportions which would produce, as economically as possible, a concrete that satisfies the job requirements. In pursuit of the goal of obtaining concrete with desired performance characteristics, the selection of component materials is the first step, the next step is a process called mix design by which one arrives at the right combination of the ingredients. The mix proportion was modified by replacing fine aggregate by waste foundry sand (WFS) in the range of 0%, 10%, 20%, 30% and 40% . Mix design was carried out manually conforming to IS10262:2009.Mix ratio is 1:1.92:2.43 and the mix design for M40 grade concrete is given in table I and proportion of replacement in fine aggregate is shown in table2.

Table 1: Mix Proportions

Water (lit)	Cement (kg/m3)	Fine Aggregate (kg/m3)	Coarse Aggregate (kg/m3)
191.6	425.78	818	1036

Table 2: Proportion for Replacement

Mix No	Fine Aggregate	Foundry Sand
M-1	100%	0%
M-2	90%	10%
M-3	80%	20%
M-4	70%	30%
M-5	60%	40%

5. Experiment and Result Analysis:

Concrete contains waste foundry sand as a partial replacement for fine aggregate is tested. Concrete is composed of cement, coarse aggregate, fine aggregate, waste foundry sand and water. The waste foundry sand is replaced in the range of 0%, 10%, 20%, 30% and 40% by weight of fine aggregate. The mixture was prepared and three standard cubes of 150*150*150 mm were casted. After initial setting time, the mould is removed and kept in soak pit for curing and then they are subjected to compressive strength test and split tensile strength test after 7 and 28 days.

Compressive Strength Test: Compressive strength tests were performed on compression testing machine. Three cubes of 150*150*150 mm from each batch were subjected to this test. The comparative study was made on properties of concrete after partial percentage replacement of fine aggregate by waste foundry sand in the range of 0%, 10%, 20%, 30% and 40%. It is given in table 3 and a graphical representation is given in fig.1 and fig. 2 respectively.

Table 3: Compressive Strength Test Results

Mix No	Avg. Compressive Strength (N/mm2)	
	7 days	28 days
M-1	29.02	48.62
M-2	30.8	50.98

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M-3	31.24	52.29
M-4	27.84	46.14
M-5	24.18	42.34

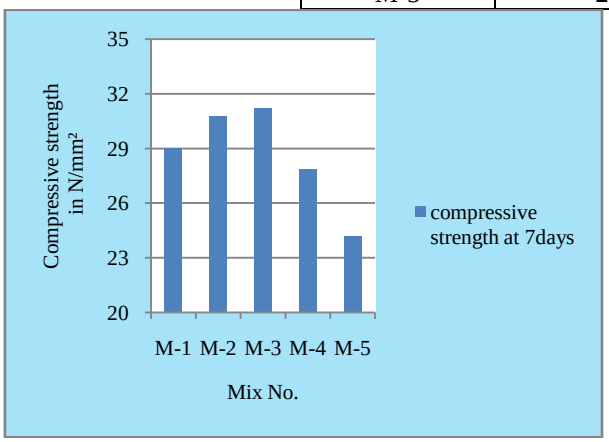

Figure 2: Compressive Strength at 7 days

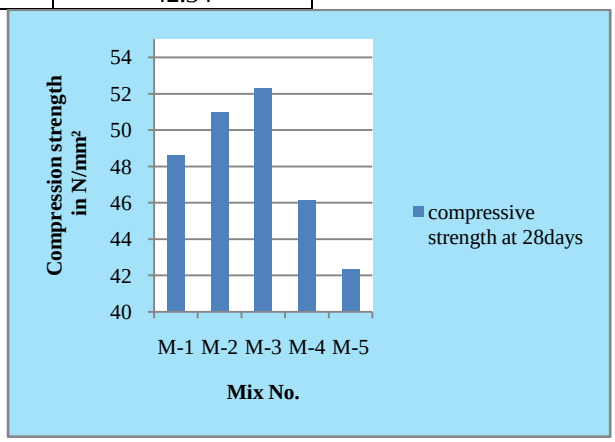

Figure 3: Compressive Strength at 28 days

Split Tensile Strength Test: The tensile strength of concrete is approximately 10% of its compressive strength. Split tensile strength tests for concrete block specimens were determined after curing for 28 days. Spilt tensile strength values at 7days and 28days is given table IV and graph denoted in fig 3 and fig 4.

Table 4: Split Tensile Strength Results

Mix No	Avg. Split tensile strength (N/mm2)	
	7 days	28 days
M-1	3.21	4.53
M-2	3.35	4.67
M-3	3.48	5.04
M-4	3.11	4.39
M-5	2.83	3.82

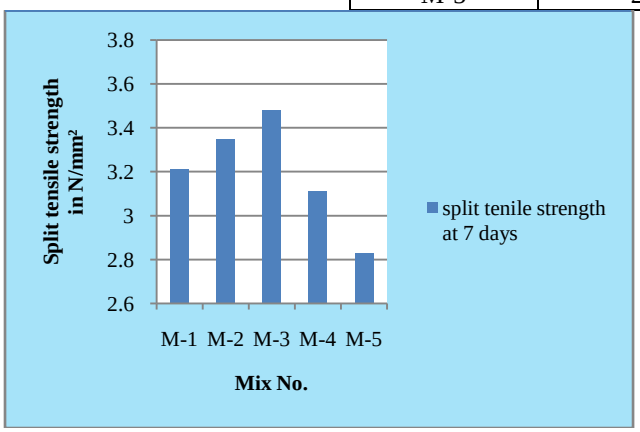

Figure 4: Split Tensile Strength at 28 days

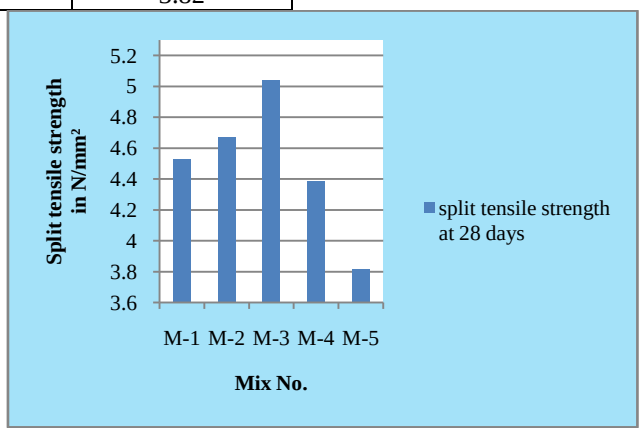

Figure 5: Split Tensile Strength at 28 days

Non Destructive Test: Among the available methods of NDT, the UPV methods can be considered as one of most promising methods for evaluating the concrete structures, material homogeneity. It is possible to obtain a total control structure, using the properties variations within the time. Using the analysis of ultrasonic velocity wave, it is possible to verify the capacity or detect heterogeneous regions in the concrete. Obtained value is shown in table 5.

Table 5: Ultrasonic Pulse Velocity Test Results

Mix No	Average ultrasonic pulse velocity (km/s)
M-1	4.8
M-2	4.93
M-3	4.9
M-4	4.73
M-5	4.71

Equations of regression and coefficients of determination for compressive strength is

$f_c = (37.25 \times UPV) - 131.25$

$R^2 = 0.85691623$

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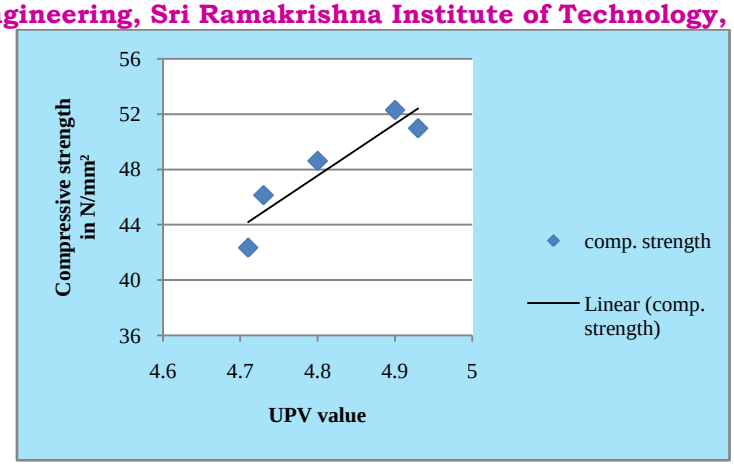

Figure 6: Correlations between compressive strength and UPV

From the equations of regression, the compressive strength of concrete may predicted and shown in table 6

Table 6: Ccomparison of UPV with Compressive Strength of Concrete

Percentage of replacement	UPV values	Compressive strength in N/mm²	
		Actual	Predicted
0%	4.8	48.62	47.55
10%	4.93	50.98	52.40
20%	4.9	52.29	51.28
30%	4.73	46.14	44.95
40%	4.71	42.35	44.20

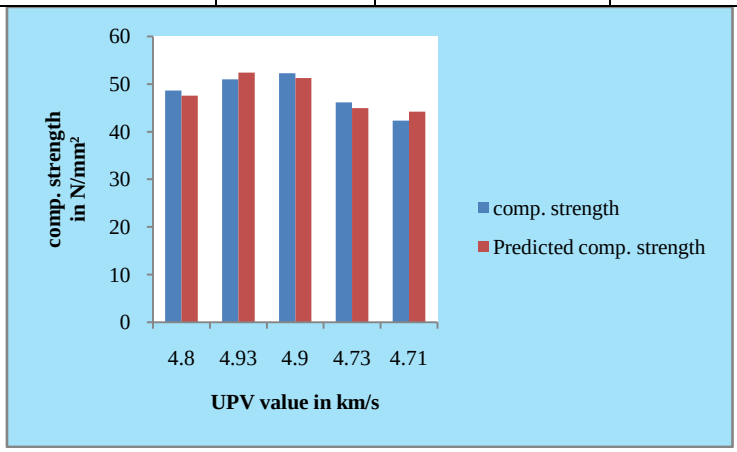

Figure 7: Comparison between Compressive Testing Value and NDT

6. Conclusion:

Based on experimental results, the following conclusions were made regarding the properties and behaviour of concrete on partial replacement of fine aggregate by waste foundry sand:

- ✓ Compressive strength increases with increase in percentage of waste foundry sand as compared to conventional concrete.
- ✓ In this study, maximum compressive strength is obtained at 20% replacement of fine aggregate by waste foundry sand.
- ✓ Split tensile strength also increases with increase in percentage of waste foundry sand.
- ✓ Use of waste foundry sand in concrete reduces the construction cost and it also provides eco-friendly building.
- ✓ The problems of disposal and maintenance of land filling is reduced and it also reduces environmental hazards.
- ✓ A simplified expression had been formed by using UPV value to estimate the compressive strength of concrete.
- ✓ Application of this study leads to development in construction sector and innovative building material.

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