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Experimental Investigation on Steel Fibre Reinforced Concrete with Partial Replacement of Marble Dust Powder as Fine Aggregate

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Abstract- *In general concrete is most commonly used in the construction activities throughout the world, with the river sand as fine aggregate. However, the excessive use of river sand in construction works results in the lack of availability of sand. By making the river sand available for future generation for future construction works, it is necessary to find either an partial or full replacement to the river sand. Instead of Finding new material, Using an waste product similar to sand as a replacement, results in less consumption of sand and also reduce the impact of waste product in our environment. Marble Dust Powder is the industrial waste obtained from marble industries. By using Marble Dust Powder as a partial replacement of sand, the environmental impact will be reduced, and also the consumption of sand also get reduced. But using Marble dust powder in concrete will leads to lack of strength characteristics of concrete. To avoid that the Steel fibre was added in specific percentage on concrete to improve the mechanical properties, and durability of the structure. In this work the investigation was carried out for the replacement of Marble dust powder of 25% to the sand with varying proportions of Steel fibre at proportion of 0.5%,0.75% and 1.0%in concrete. The Strength characteristics like Compression Strength, Split Tensile Strength and Flexural Strength result values are discussed in this investigation.*

Keywords- Steel Fibre, Concrete, Cement, Marble Dust Powder, Sand.

1.INTRODUCTION:

Concrete is most commonly used component for construction composed of cement, fine aggregates (sand) and coarse aggregates mixed with water. Portland cement is the commonly used type of cement for production of concrete. In a building construction, concrete is used for the construction of foundations, columns, beams, slabs and other load bearing elements. The use of sand in construction results in excessive sand mining which is objectionable. Due to rapid growth in construction activity, the available sources of natural sand are getting exhausted. Also, good quality sand may have to be transported from long distance, which adds to the cost of construction. Therefore, it is necessary to replace natural sand in concrete by an alternate material either partially or completely without compromising the quality of concrete. Waste marble dust is one such material which can be used to replace sand as fine aggregate. The present study is aimed at utilizing Waste marble powder as fine aggregate in concrete, replacing natural sand. Marble powder is produced from processing plants as a result of the sawing and polishing of marble blocks and about 25% of the processed marble is turn into powder form. The Disposal of the marble dust powder from the marble industry is one of the factors affecting environment worldwide today. For reduction of the waste, it is utilized in building industry itself. There is a possibility of reduction of strength values by using Marble Dust powder in concrete to avoid that Steel Fibres was added to the Concrete in various proportions to provide the characteristic strength. The present study investigates the effects of using waste marble dust (WMD) as a fine material with addition of Steel Fibres on the mechanical properties of the concrete. For this

work four different concrete-mixtures will be prepared by replacing the fine sand with WMD at constant of 25% with varying proportions of Steel fibres of 0.5%,0.75%, and 1.0%. In order to obtain the strength characteristics, the specimens are casted, cured and tested at the curing ages of 7, 14, and 28 days, to obtain the strength characters i.e., Compression Strength, Split Tensile Strength and Flexural Strength respectively.

2. SCOPE AND OBJECTIVE:

1)To study the effect of waste marble dust associated with steel fibres on the mechanical properties of concrete.

2)To compare the compressive, flexural and tensile strength of WMD with various fibre proportion to the Conventional mix.

3)To establish alternative for sand with partial use of WMD in concrete.

4)To obtain the nominal percentage of steel fibre for designed mix.

3.METHODOLOGY:

A total of four mixes of concrete samples including the control sample were prepared in order to investigate the effect of substituting marble dust25% by weight in place of fine aggregate with various proportions of Steel fibres of 0.50%,0.75% and 1.0% to investigate the strength properties of the concrete. Ordinary Portland cement (OPC)of grade 53 was used throughout the investigation. The marble dust obtained from industrial by-product is used as a sand/fine aggregate replacement material. The coarse aggregate used was 20 mm aggregate with grading confirming to IS-383-1970. The sand passing through 4.75mm sieves is used throughout the work. The design of concrete mix is done as per IS 10262: 2009 with M25 grade of concrete. The mixing of concrete is done by help of mechanical mixer. Compaction of concrete specimen was done by using tamping rod and by vibrating table. The top surface of the concrete specimens is levelled and smoothly finished. The details of the specimen and date of concreting will be mentioned on the top surface for identification. The Compression test and the Flexural strength test was performed as per IS 516: 1959 and split tensile test was performed as per IS 5816: 1970.

Various tests conducted on the concrete ingredients that were required, given by –

Initial Test Results on cement:

1) Specific gravity of cement	3.12
2) Consistency	33%
3) Initial setting time	30min
4) Final setting time	530 min

3.1 FINE AGGREGATE:

The fine aggregate used for the experimental programme was locally available M-sand and conformed to grading zone II as per IS:383-2016.The M-sand was first sieved through 4.75mm sieve to remove any particles greater than 4.75mm and then washed to remove the dust.

Property	Value Obtained Experimentally
Specific gravity	2.7
Bulk density loose (kg/m^3) Fully compacted	1550.2998kg/m^3 1750.499kg/m^3
Fineness modulus	2.9
Water absorption	1.8 %
Grading zone (based on percentage passing0.6 mm)	Zone II

Table 3.1: Properties of Fine Aggregate

3.2 MARBLE DUST POWDER:

Marble powder is produced from the marble processing plants during the sawing, shaping and polishing. During this process, almost 20-25% of processed marble is turned into powder form. In India million tons of marble wastes are released form processing plants every year. The disposal of this waste on soil cause reduction in the permeability and also it contaminates the ground water when deposited along the catchment areas. Thus, utilizing these marble dust powder in the construction industry helps to protect the environment and also limit the excessive mining of sand.

Physical properties

- Colour - White
- Form - Powder
- Odour - Odourless
- Specific gravity - 2.68 gm/cm3

3.3 STEEL FIBRE:

Steel fibres are filaments of wire, deformed and cut to lengths, for reinforcement of concrete, mortar and other composite materials. It is a cold drawn wire fibre with corrugated and flatted shape. The addition of steel fibres helps in converting the brittle characteristics to ductile ones. To faster the compressive strength without sacrificing the ductility, a strategy adopted is to add discrete steel fibres as reinforcement in concrete. Steel fibres are available in lengths between 6 and 80mm and with a cross sectional area between 0.1 and 1.5,2mm. The tensile strength is normally in the range between 300 and 2400Mpa. The fibres are usually crimped or deformed with either a hook at each fibre end or a small head in order to improve the anchorage in the concrete matrix. It is obvious that the behaviour of FRC depends on the orientations, distributions, aspect ratios, geometrical shapes and mechanical properties of fibres in concrete mixtures.

Properties of Crimped steel fibre:

- Diameter = 0.75mm
- length=50mm
- Aspect ratio=66
- Density = 7850 Kg/m^3

4. CONCRETE MIX DESIGN:

A mix M25 grade was designed as per Indian Standard method (IS 10262-2009) was used to prepare the test samples.

Material	M25 Grade
Cement	427 Kg/m^3
Sand Marble dust powder	565 Kg/m^3 192 Kg/m^3
Coarse Aggregate	1027 Kg/m^3
Water	202 Kg/m^3
Water-Cement ratio	0.47

Table 4.1: Quantity of Materials

MIX RATIO (M25): C: FA: MP: CA: WATER

1: 1.32: 0.45: 2.40: 0.47

5.EXPERIMENTAL PROCEDURE

5.1 Slump Test:

The slump is the measure to indicate the consistency or workability of the concrete. It is the measure of the water content needed for concrete for different works. Concrete is said to be workable only if it is easily mixed and compacted.

FIBRE PROPORTIONS	Slump (In mm)
0.50% of SteelFibre	110
0.75% of Steel Fibre	90
1.0% of Steel Fibre	**65**

Table 5.1: Slump values

5.2 COMPRESSION STRENGTH TEST:

The test is carried out to study the compression strength point of concrete specimens at interval of 7, 14 and 28 days. Compressive strength tests were performed on compression testing machine using cube samples of 150*150*150mm.

MIX PROPORTIONS	7 DAYS N/mm2	14DAYS N/mm2	28 DAYS N/mm2
CONVENTIONAL MIX	15.0	18.3	26.0
MIX 1 - 25%MDP & 0.5%SF	14.8	21.6	25.0
MIX 2 - 25%MDP & 0.75%SF	16.8	20.1	28.1
MIX 3 - 25%MDP & 1.0%SF	**19.5**	**24.1**	**31.7**

Table 5.2: Compression strength values

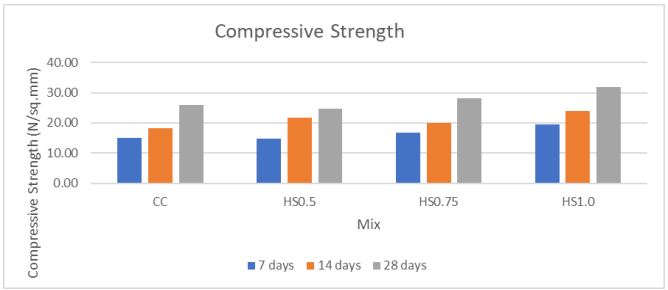

Chart -1: Compressive strength chart

From the Compression strength test the maximum Compression strength attained was 31.7 N/mm2.

5.3 SPLIT TENSILE STRENGTH TEST:

The splitting tensile strength test on concrete cylinder is a method used to determine the tensile strength of concrete. The cylinder moulds of size 150mm diameter and 300mm height, is casted and tested at period of 7,14 and 28 days.

MIX PROPORTIONS	7 DAYS N/mm2	14 DAYS N/mm2	28 DAYS N/mm2
CONVENTIONAL MIX	1.11	1.65	2.21
MIX 1 - 25%MDP & 0.5%SF	1.25	2.12	2.54
MIX 2 - 25%MDP & 0.75%SF	1.43	2.21	2.87
MIX 3 - 25%MDP & 1.0%SF	**2.43**	**3.06**	**3.71**

Table 5.3: Split-Tensile strength values

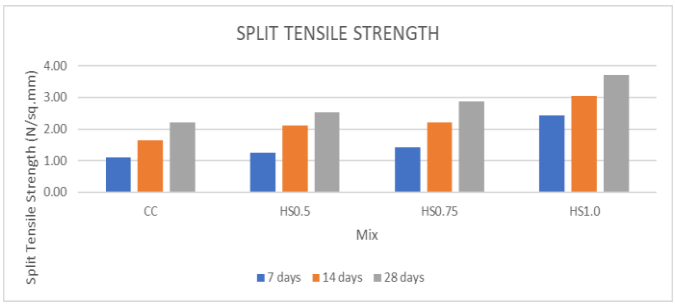

Chart -2: Split Tensile strength chart

From the Split Tensile strength test the maximum Split Tensile strength attained was 3.71 N/mm2.

5.4 FLEXURAL STRENGTH TEST:

Flexural test is used to evaluate the tensile strength of concrete indirectly. It test the ability of unreinforced concrete prism, beam or slab to withstand failure in bending while applying load on the specimen.

MIXPROPORTIONS	7 DAYS N/mm2	14 DAYS N/mm2	28 DAYS N/mm2
CONVENTIONAL MIX	2.67	3.88	4.33
MIX 1 - 25%MDP & 0.5%SF	2.40	3.52	3.92
MIX 2 - 25%MDP & 0.75%SF	2.70	3.89	.32
MIX 3 - 25%MDP & 1.0%SF	3.04	4.52	5.05

Table 5.4: Flexural strength values

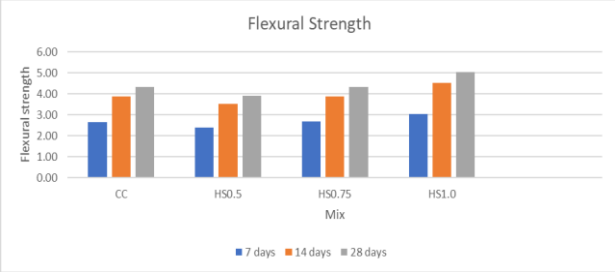

Chart -3: Flexure strength chart

From the Flexural strength test the maximum Flexural strength attained was 5.05 N/mm2.

6. RESULTS & DISCUSSION:

1) From the Slump cone test the workability of concrete for 0.75% of steel fibre comes as 90mm which is within the design range.
2) For 1% of Steel Fibre the workability comes as 65mm.
3) From the Compression strength test the maximum Compression strength attained was 31.7 N/mm2.
4) From the Split Tensile strength test the maximum Split Tensile strength test attained was 3.71 N/mm2.
5) From the Flexural strength test the maximum Flexural strength test attained was 5.05 N/mm2.
6)From the observation, mix of 0.75% of steel fibre provides Good strength with good workability.

1. 7) Incase of Strength, Mix containing 1.0% of Steel fibre have High strength Properties with Partial Workability.

2.

7. CONCLUSION:

- 1. Compressive strength, Split Tensile Strength and Flexural strength of concrete increases on increasing the steel fibre content upto1%.
- 2. Adding 1% of steel fibre in concrete possess good strength characteristics with partial workability.
- 3. Further increasing of Steel fibre to the mix affects the workability of the concrete.
- 4. If the steel fibre proportion was increased to further proportions, addition of superplasticizers into the concrete was recommended for workability conditions.

8. IDEAS OF FUTURE WORK:

From the result of this investigation, it provides way for the future works as follows,

1. It provides possibilities of using various types of steel fibres like Hooked-End fibre, Twisted fibre, and Stranded fibre into the concrete, the strength values and workability of the concrete can be obtained for MDP of 25%.

2. Also the effect of the natural fibres with MDP on concrete could also be investigated.

3. Similarly the strength values are compared with conventional concrete for various types of steel fibres.

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