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EXPERIMENTAL INVESTIGATION ON CONCRETE USING MARBLE WASTE POWDER AND STEEL SLAG

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Abstract - *Leaving the waste materials to the environment directly can cause problems.. Aggregates are the important constituents in concrete. The increase in demand for the ingredients of concrete is met by partial replacement of materials by the waste materials which is obtained by means of various industries. Slag is a byproduct of metal smelting and hundreds of tons of it are produced every year all over the world in the process of refining metals and making alloys. Steel slag can be use in the construction industry as aggregate in concrete by replacing natural aggregates.This experimental study is based on the performance of concrete by replacement (5%,10%,15%,20%) of cement with waste marble powder and replacement (10%,20%,30%,40%,50%) of fine aggregate by steel slag. This project describes the feasibility of using the waste marble powder in concrete production as replacement of cement and effective percentage of steel slag would be determined for obtaining maximum strength by conducting workability compressive strength and tensile strength tests.*

Key Words*: *Concrete, Steel Slag, Coarse Aggregate, Fine Aggregate, Marble Powder

1.INTRODUCTION

Global warming and environmental destruction have become the major issue in recent years. Emission of green house gases from industrial processes and its adverse impact on climate has changed the mind set of people from the mass-production, mass-consumption and mass-waste society of the past to a zero emission society with emphasis on utilization of industrial wastes and conservation of natural resources. Use of more and more environment friendly materials and industrial wastes in any industry in general and construction industry in particular of paramount importance's..Over a period of time waste management has become one of the most complex and challenging problems in India affecting the environment. The rapid growth of industrialization gave birth to numerous kinds of waste byproducts which are environmentally hazard and create problems of storage. The construction industry has always been at forefront in consuming these waste products. All along in India, we have been using natural sand and gravel in concrete manufacturing. Availability of natural aggregates is getting depleted and also it becoming costly. Hence, there has to be an emphasis on the use of wastes and by-products in all areas including construction industry.

1.1 Scope :

- The research will cover studying physical and chemical properties of marble waste powder blended Portland cement and studying Compressive Strength, flexural strength and water permeability of concrete produced by marble waste powder blended cement, and steel slag sand.
- The purpose of this project is to study the mechanical property of **M20** concrete by replacing Fine Aggregate By Means Of Steel Slag and Cement Replaced by Marble Waste.

1.2 Steel Slag and Its Production:

Fig(a) The consumption of Slag which is waste generated by steel industry, in con- Crete not only helps in reducing green house gases but also helps in making environmentally friendly material. Slag is a nonmetallic inert byproduct primarily consists of silicates, Alumina silicates, and Calcium-Alumina-Silicates. The mol-ten Slag which absorbs much of the sulfur from the charge comprises about 20 percent by mass of iron production. The main constituents of iron and steel slag are Silica, Alumina. Calcium and Magnesia .which to gather make about 95% of the total composition. Minor elements included are Manganese, Iron, Sulfur compounds and traces of several other elements. Physical characteristics such as Porosity, Density and particle gradation are affected by the cooling rate of the slag and its chemical composition.

Fig (a) Steel Slag's and Its Production

Types of Steel Slag

Blast Furnace Slag

Blast furnace slag is recovered by melting separation from blast furnaces that produce molten pig iron. It consists of components contained in the iron ore together with limestone. Approximately 290 kg of slag is generated for each ton of pig iron.

When it is ejected from a blast furnace, the slag is molten at a temperature of approximately **1500℃.** Depending on the cooling method used, it is classified either as air-cooled slag or granulated slag.

Applications of Granulated Steel Slag

- Ground improvement material (Backfill material, earth cover material, embankment material, road sub grade improvement material sand compaction material, ground drainage layers, etc.
- Fine aggregate for concrete.
- Calcium silicate fertilizer.
- Soil improvement.
- Raw material for Portland blast furnace slag cement.

Marble Wastes

Fig(b) Marble is one of the most important materials used in buildings. However its powder has bad effects on the environment, soil, water and health problems. Marble powder is produced from processing plants sawing and polishing of marble blocks. About 25% of the processed marble is turn into dust or powder form.

In India marble processing industry generates around 7million ton of wastes mainly in the form of powder during sawing and polishing processes. These are dumped in the open which pollute and damage the environment. The pollution issue is serious cause of concern in the state of Rajasthan .since there are around 4000 marble mines and about 1100 marble cutter in medium sector spread over 16 districts of then .out of the total waste generated in India, contribution from Rajasthan state itself 95% of the total accounting to 6millions tons annually.

2. Basic Material Requirements

- Portland cement
- Coarse aggregate
- Fine Aggregate
- Water
- Steel slag
- Marble powder waste

2.1 Portland cement (is: 8112:1989)

The Portland cement referred as (**OPC**) is the most important type of cement and is a fine powder produced by grinding Portland cement. The physical properties of the cement as determined from various test conforming to Indian standard.

Coarse Aggregate :Coarse aggregate having the maximum size of **20mm** was used in the work. The aggregate were tested as per **IS: 383-1970**. Proportioning of coarse aggregate was done and fineness modulus was obtained.

Fine Aggregate : The aggregate most of which pass through 4.75 mm IS Sieve are termed as fine aggregates. Depending upon the particle size distribution IS: 383-1970 has divided the fine aggregate into four grading zones (Grade 1 to1v). In this experimental program, fine aggregate was locally procured and conformed to Indian standard specification IS: 383-1970.it was sand light brown in colour .

Water: Water that is suitable for drinking is satisfactory for use in concrete.. This was free from any detrimental contaminants and was good potable quality.Portable tap water available in the laboratory with **PH** value of **7.0 +/- 1** and confirming to the requirements of **IS: 456-2000** was used for mixing concrete and also for curing the specimens.

Steel Slag: Steel slag obtained certified organization an **ISO 3297:2007**.Its specific gravity in fine form was found to be **2.95**.steel slag elemental analysis determined by **x-ray fluorescence**.

Marble powder: Marble powder was collected from the dressing . Finally Sieve by **IS-90** micron sieve before mixing in concrete.

Table -1: Chemical Properties of Cement, Steel Slag & Marble Powder

Chemical Compounds	Cement %	Steel Slag%	Marble Waste%
Sio_2	22.60	30.20	13.8
Al_2o_3	4.30	19.60	2.50
Fe_2o_3	2.40	0.60	1.9
Cao	64.40	32.40	43.2
Mgo	2.10	9.26	2.70
SO_3	2.30	0.27	0.07
Na_2O	0.60	-	0.90
R_2O_3	-	20.20	-
K_2O	0.60	-	0.60

Table 2Properties Of Steel Slag

Specific Gravity	Water Absorption %	Dry Loose Bulk Density Kg/cum	Soundness %	Fineness Modulus
2.38	0.90	1058	1.38	3.14

Table 3 Properties Of Marble Waste

Table 3 Properties Of Marble Waste

Specific Gravity (Gm/Cum)	Fineness (Kg/M2)	Colour	Water Absorption
2.63	350	Light gray	0.97%

3.Mix Design :

Based on the Indian Standard **(IS: 10262-2009)**, design mix for **M20** grade of concrete was prepared by partially replacing fine aggregate with five different percentages by weight of steel slag (10%, 20%,30%,40%,50%). The mix proportion for M20 Grades of concrete with varying

Mix Proportion:

The concrete mix design was proposed to achieve the compressive strength of 20MPa after 28 days curing in case of cubes. The split tensile strength of the specimens were also tested. The concrete mix proportions used, have been determined as per IS method of mix design. The mix proportion for concrete mixtures are tabulated and presented in

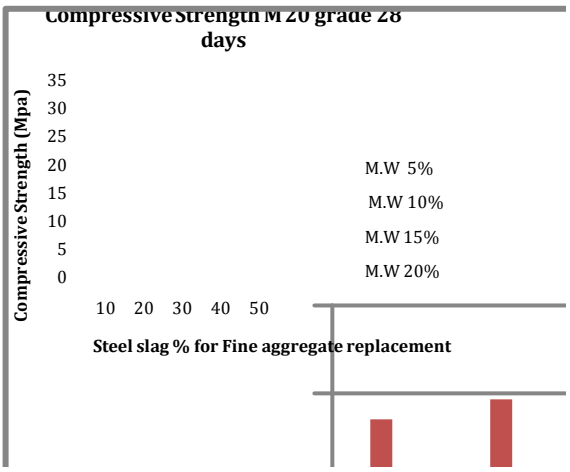
Mix Ratio in conventional concrete

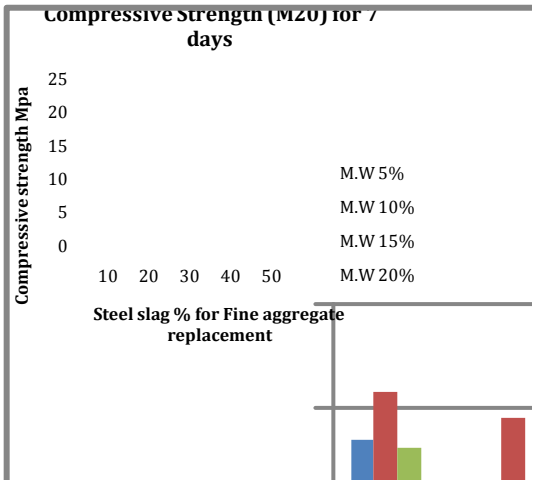
Table 4 Mix Ratio

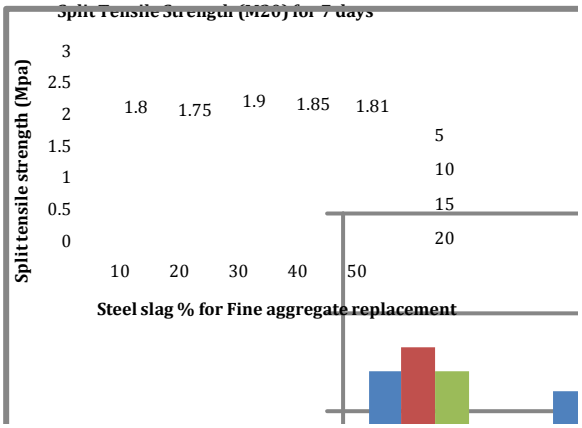
Water	Cement	Coarse Aggregate	Fine Aggregate
206.08	412.2	664.62	1100.75
0.5	1	1.61	2.67

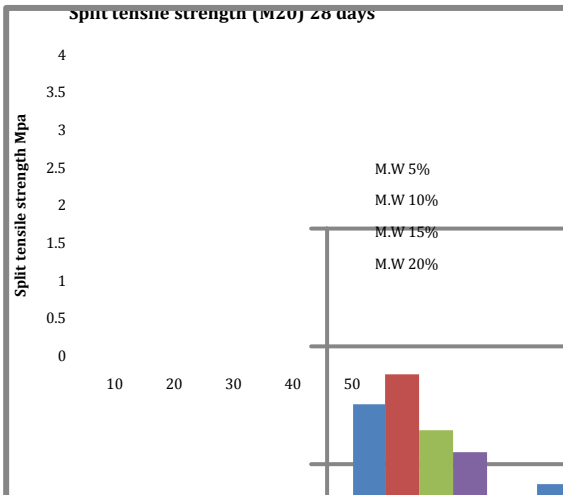
Casting details : The 20 cubes and 20cylinders were cast for compressive (7 and 28 days), split strength (7 and 28 days) . After the cast, all the test specimens were de-mould after 24 hours time and put into the water tank for curing maintaining temperature of 27±2 oC as per IS requirements.

Fresh Concrete test : The concrete was tested for slump cone test, as per the IS-1199 –Methods of sampling and analysis of concrete, Slump value of conventional concrete is 100 and it lies between 85 to 105 for different mixes. Addition of steel slag both in the form of fine aggregate giving impact on workability slightly.









Cubes:

Compressive strength of concrete is tested on cube at different percentage of marble powder and steel slag content in concrete. The strength of concrete has been tested on cube at 7 days curing and 28 days.7 days test has-been conducted to check the gain in initial strength concrete. 28 days test gives the data of final strength of concrete at 28 days curing. Compression testing machine is used for testing the compressive strength test on concrete. At the time of testing the cube is taken out of water and dried and then tested keeping the smooth faces in upper and lower part

Discussion

- With the inclusion of Marble powder and steel slag attain strength of concrete gradually increases.
- With the inclusion of Marble powder and steel slag upto10% the initial strength gain in concrete is high.
- At 10% there is 12% times increase in initial compressive strength for 7 days compare to conversion.
- At 10% there is 17.7% increase in initial compressive strength for 28 days.

Cylinder

Split Tensile strength of concrete is tested on cylinders at different percentage of marble powder and steel slag content in concrete. The strength of concrete has been tested on cylinder at 7 days curing and 28 days. 7days test has been conducted to check the gain in initial strength of concrete. 28 days test gives the data of final strength of concrete at 28 days curing. Compression testing machine is used for testing the Split Tensile strength test on concrete along with two wooden boards. At the time of testing the cylinder taken out of water and dried and then tested

Table 4 compressive strength in cubes

Marble waste(%)	Steel slag(%)	Compressive strength at 7days (N/mm²)	Compressive strength at 28days (N/mm²)
0	0	17	23.7
5	10	18.5	24.5
	20	16.5	25.8
	30	15.2	26.5
	40	16.8	25
	50	16.5	23
10	10	20.8	28.5
	20	19.5	29.6
	30	18.6	30.2
	40	19.4	29.5
	50	19.2	27.8
15	10	18.08	20.3
	20	15.8	21.5
	30	15.01	23.8
	40	16.5	22.1
	50	16.2	21.8
20	10	15.1	19.28
	20	13.2	20.5
	30	14.5	21.9
	40	15.3	20.2
	50	15.01	19.5

Discussion

- With the inclusion of Marble powder and steel slag the strength of concrete gradually increases up to a certain limit.
- With the inclusion of Marble powder and steel slag upto10% the initial strength gain in concrete is high.
- At 10% there is 27.4% increase in initial Split Tensile strength for 7 day
- **Table 5 Tensile strength of cylinders**

Marble waste(%)	Steel slag(%)	Compressive strength at 7days (N/mm²)	Compressive strength at 28days (N/mm²)
0	0	17	23.7
5	10	18.5	24.5
	20	16.5	25.8
	30	15.2	26.5
	40	16.8	25
	50	16.5	23
10	10	20.8	28.5

	20	19.5	29.6
	30	18.6	30.2
	40	19.4	29.5
	50	19.2	27.8
15	10	18.08	20.3
	20	15.8	21.5
	30	15.01	23.8
	40	16.5	22.1
	50	16.2	21.8
20	10	15.1	19.28
	20	13.2	20.5
	30	14.5	21.9
	40	15.3	20.2
	50	15.01	19.5

4.CONCLUSION

It could be said that full substitution of marble powder and slag aggregate with improved the compressive strength and split tensile strength at all replacements by 0 to 50% and in case of replacing fine aggregate with slag, and cement with replacing of marble powder 0% to 20% .Compressive strength of Cubes are increased with addition of waste marble powder and steel slag up to 10% replacement of waste marble powder and steel slag the compressive strength is increase. The Split Tensile strength of Cylinders are increased with addition of waste marble powder and steel slag up to 10% replace by weight of cement and further any addition of waste marble powder and steel slag . Thus we found out the optimum percentage for replacement of marble powder and steel slag with cement and it is almost 10%cement for both cubes and cylinders. We have put forth a simple step to minimize the costs for construction with usage of marble powder and steel slag which is freely or cheaply available; more importantly. We have also stepped into a realm of the environmental pollution by cement production

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