EXPERIMENTAL STUDY ON CEMENT CONCRETE FLOORING TILES USING INDUSTRIAL BYPRODUCTS

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***Abstract*—** The aim of this project is to utilize the solid waste materials in the best way in the constructing field without any hazardous effects on strength. In the growing environment, as well as stricter regulations on managing industrial waste, the world is increasingly turning to researching properties of the industrial waste and finding solutions on using its valuable component parts so that those might be used as secondary raw material in other industrial branches. This study presents the experimental behavior of the cement concrete flooring tiles with partial and fully replacement of fine aggregate by plastic waste, steel slag and copper slag in two phases. The Plastic waste is constantly replaced sand at 10% in both the phases, Steel slag is replaced for sand in the range of 30%, 60% and 90% in one phase and the copper slag is replaced for sand in the range of 30%, 60% and 90% in the other phase. Compressive strength is carried out for the cement mortar cubes with and without steel slag and copper slag. The compressive strength of the cement mortars are increasing up to 18% at 30% replacement of sand by steel slag and copper slag than the control specimen. The flexural strength, surface hardness testes are carried out for cement concrete flooring tiles and these results are comparing with controlled cement concrete flooring tiles which does not have any adverse effect on the strength by using plastic waste has shown an increase in flexural strength up to 20%. These tests has to be done on cement concrete flooring tiles for various replacements, this replacements would prove to have some environment benefits and would be an economical or a cost effective technique in cement concrete flooring tile manufacturing for the future.

Keywords—*Industrial waste, Fine aggregate, Steel Slag, Copper Slag, Plastic waste, Cement concrete flooring tiles, Compressive strength and Flexural strength.*

I. INTRODUCTION

General

The utilization of industrial waste or secondary materials has encouraged the production of the fine aggregate and cement concrete flooring tiles in construction filed. New by-product and waste materials are being generated by various industries. Dumping or disposals of waste materials are leads to the environment and health problems. Therefore, recycling of waste materials is a great potential in cement concrete flooring tiles industry.

a. Plastic Waste

Utilization of waste and by products is a partial solution to environment and ecological problems. Use of these materials not only helps in getting hem utilized in cement concrete and other construction materials , it helps in reducing the cost of cement and concrete manufacturing, but also has numerous indirect benefits such as reduction in landfill coast, saving in energy, and protecting the environment from possible pollution effects.

b. Steel Slag

Global warming and environment destruction have become manifest problems in recent years, heightening concern about global environment issues, and a change over from the mass-production, mass consumption , mass-waste society of the past to a zero-emission society now viewed as important. The iron and steel industry produces extremely large amounts of slag as by-product of the iron making and steel making processes, and is therefore continuing to develop slag reduction and recycling technologies and intermediate treatment technologies.

c. Copper Slag

Copper slag has been procured from two different places in India. One sample has been taken from Sholapur, Maharashtra and the second sample was procured from Kolkata, West Bengal. Copper slag is widely used in the sand blasting industry and it has been used in the manufacture of abrasive tools. The copper slag was brought from Sterlite Industries Ltd., Tuticorin , Tamil Nadu, India. Since copper slag is glassy and granular in nature and has a similar particle size range to sand, indicating that it could be used as a replacement from the sand present in the cementations mixes. Some studies were carried out using grained copper slag as fine aggregate.

d. Flooring Tiles

The paving stones are made by using fly ash and cement aggregates a very high pressure to give hard faced, strong and durable stone like product with or without beveled edges. These stones are doing not requires sole concrete and needs just a consolidated sand bed for the support. No bonding or pointing is necessary and does not require any cement. Paving stones offer the advantages of removing from position and replacing whenever needed for laying any pipelines etc. and hence eliminates any maintenance expenditure on the flooring. These stones can withstand the weight of a loaded truck and will last for a long time. They are comparatively cheaper compared to concrete and other tiles.

e. Objectives

Main objectives are listed in below:

- To study the effect of plastic waste, steel slag and copper slag in cement flooring tiles.
- To increase the compressive strength of cement mortar using steel slag and copper slag.
- To increasing tensile strength using plastic waste.
- To reduce the self weight of the current concrete flooring tiles by industrial wastes.

f. Scope Of Work

Some scopes of works are listed in below:

- To utilize the industrial waste in useful manner.
- To reduce the environment pollution.
- To introduce alternative material fro natural fine aggregate.
- To introduce cost effective cement concrete flooring tiles.

II. LITERATURE REVIEW

- ***P. Suganthy Et.al, 2010:*** To preparing 45 nos of cement concrete cubes of 1:1:2 (M25) mix were cast for 0%, 25%, 50%, 75%, 100% sand being replaced with pulverized plastic material. Volumetric proportioning was adopted instead of design mix since the density of the plastic material was too low. The Test results revealed that the yield as well as the ultimate strength of concrete at seventh day decreased by about 3 to 3.2 N/mm^2 for 25% replacement & 4 to 6.5 N/mm^2 for higher replacement of the plastic when compared to conventional concrete the ultimate as well as the yield strength of concrete at 14^{th} day and 28^{th} day decreased by about 0.2 to 1 for 25% replacement and 9.1 to 14.6 N/mm^2 for higher replacement of plastic wastes.
- ***Ankit arora et.al, 2013:*** Grinded E- Waste and plastic waste were replaced in M20 concrete by 0%, 2% and 4% of the fine aggregate. Compressive strength and flexural strength were tested and compared with the control concrete. Experiments done shows increase in compressive strength by 5% and reduce the cost of the concrete by 7% at optimum percentage of grinded waste. This will ensure better packing density and hence good strength.
- ***B.V. Kiran Kumar et.al, 2013:*** M20 concrete is taken and waste plastics are used as modifier. Modifier was added in percentage such 2%, 4%, 6%...In order to replace the same amount of cement and sand. Test was conducted on coarse aggregates, fine aggregates, cement and modifier (Waste plastics) to determine the physical properties. Cubes were casted and tested for 1,3.,7,14 and 28 days strength. The studies revealed that the optimum modifier content was 5% and the strength was found to be two times greater than the plain cement concrete
- ***Raghatate et.al, 2012:*** Control Mix of M20 concrete is prepared and modifier concrete with carrying percentages of pipes of plastic bags were presents in the rage of 0.2%,0.4%,06%,08% and 1%. Based on the experiment results compressive strength of the concrete is affected by the addition of the plastics pieces and it goes on decreasing as the percentage of plastic increase addition of 1% of plastic in concrete causes about 20% reduction in strength after 28n days curing. The splitting tensile strength observation shows the improvement of tensile strength of concrete. Up to 0.78% of plastic improvement of strength recorded after that addition of strength of concrete decreases with addition of plastic wastes. It is possible to increase the tensile strength of concrete.
- ***Mohammed Nadeem et. al, 2012:*** The study comprises of the experimental results obtained show that the partial substitution of ordinary sand by slag gives better results in both the applications i.e., masonry & plastering. The sand replacement from 50 to 75% improved mortar flow properties by 7 %, the compressive strength improved by 11 to 15 % for the replacement by 10 %to 13 % at 50 to 75% replacement levels.
- ***Praveen Mathew et.al, 2013:*** In this study, the natural coarse aggregates (NCA) were replaced with steel slag aggregate (SSA) at various proportions of 20%, 40%, 60%, 80% and 100%. Experiments were conducted to determine the compressive strength, flexural strength and split tensile strength of concrete

with various percentages of steel slag aggregate. The results were compared with conventional concrete. Incorporating slag in coarse aggregate reduces compressive strength by 2% in 20% replacement, 16% for 40% replacement, 17 % for 60% replacement, 18% for 80% replacement and 19% for 100% replacement. The flexural strength of concrete decreases with increases in percentage of steel slag aggregate (SSA), but all the mixes satisfies the minimum required flexural strength of concrete (4MPa as per IRC 58-2002) for rigid pavement. The split tensile strength decreases with increases in percentages of SSA by 3.8% in 20% replacement, 8% for 40% replacement, 12.6 % for 60% replacement, 18% for 80% replacement and 30% for 100% replacement.

- ***Sultan A el.at, 2014:*** As a result, utilization of steel slag will save natural resources and clean environment. Furthermore results have shown that the slag aggregate has better abrasion factor and impact value than conventional aggregate. Thorough investigation of the results has indicated that the amount of increases in compressive strength at age of 7 days is much more than that o f28n days for all types of aggregates replacement. This indicates that the added slag could world as accelerator at early age while 28 days age, the effect is reduced. The fine slag replacement scores the highest effect. Thorough investigation of results have indicated that the amount of increases in compressive strength at age 7 days re much more than that of 28 days for all types of aggregate replacements. This indicates that the added slag could work as accelerator at early age while at 28 days, the effect is reduced. Furthermore, the fine slag replacement scores the highest effect.

III. TERMINOLOGY

For the purpose of this standard, the following definitions shall apply.

- ***Plain Cement Tiles*** — Tiles having a plain wearing surface, in the manufacture of which pigments and stone chips are not used in the wearing surface.
- ***Plain Coloured Tiles*** — Tiles having a plain wearing surface wherein pigments are used but not stone chips.
- ***Terrazo Tiles*** — Tiles at least 25 percent of whose wearing surface is composed of stone chips in a matrix of plain or coloured Portland cement, mixed with or without pigments and mechanically ground and filled, if required.
- ***Single Layer/Monolayer Tiles*** — Tiles, plain or terrazo, in which there is only one layer that is wearing layer, and which do not contain a backing layer.
- ***Double Layer Tile*** — Tiles which contain wearing layer as well as a backing layer.

IV. CLASSIFICATION

Cement concrete flooring tiles shall be of two classes as given below depending on the duty they perform:

a) ***General Purpose Tiles*** — Used in such places where normally light loads are taken up by the floors; such as office buildings, schools, colleges, hospitals and residential buildings (usually indoor floors).

b) ***Heavy Duty Floor Tiles*** — Used for heavy traffic conditions; such as foot paths, ramps, entrances and staircases of public buildings, passages of auditoriums and storage godowns (public path or industrial floors).

V. MATERIALS

- ***Cement***

Cement used in the manufacture of tiles shall be 33 grade ordinary Portland cement conforming to IS 269 or 43 grade ordinary Portland cement conforming to IS 8112 or 53 grade ordinary Portland cement conforming to IS 12269 or Portland pozzolana cement (flyash based) conforming to IS 1489 (Part 1) or Portland pozzolana cement (calcined clay based) conforming to IS 1489 (Part 2) or Portland slag cement conforming to IS 455 or rapid hardening Portland cement conforming to IS 8041 or white Portland cement conforming to IS 8042.

- ***Aggregates***

Aggregates used in the backing layer of tiles shall conform to the requirements of IS 383. For the wearinglayer, unless otherwise specified, aggregates shall consist of marble chips or any other natural stone chips of similar characteristics and hardness, marble powder or dolomite powder, or a mixture of the two.

- ***Pigments***

Pigments, synthetic or otherwise, used for colouring tiles shall have durable colour. It shall not contain matters detrimental to concrete and shall according to the colour required be one of the following or their combination:

Pigments	*Ref to IS No.*
Black or red or brown pigment	IS 44
Green pigments	IS 54
Blue pigments	IS 55 or IS 56 or IS 3574 (Part 2)
White pigments	IS 411
Yellow pigments	IS 50 or IS 3574 (Part 1)

1. Colours other than mentioned above may also be used.

2. The pigments shall not contain zinc compounds or organic dyes.
3. Lead pigments shall not be used unless otherwise specified by the purchaser.

VI. MANUFACTURE

1.Cement concrete flooring tiles shall be manufactured from a mixture of cement, natural aggregates and colouring material where required, by pressure process (with or without vacuum dewatering) or vibration (with or without vacuum dewatering) or a combination of both, so that the tiles meet the requirements specified in the standard.
2. The tiles shall be manufactured in single layer/monolayer or in double layer.
3. The proportion of cement to aggregate in the backing of the double layer tiles shall be not leaner than 1:3 by mass. Single layer/monolayer tiles shall have only the wearing layer.
4. Where colouring material is used in the wearing layer, it shall not exceed 10 percent by mass of cement used in the mix.
5. On removal from the mould, the tiles shall be kept in moist condition continuously for such a period that would ensure their conformity to the requirements of this standard. Tiles shall be stored under cover.

VII. DIMENSIONS

The size of cement concrete flooring tiles shall be as given in Table 1.
Half tiles rectangular in shape shall also be available. Half tiles for use with full tiles in the floor shall have dimensions which shall be such as to make

Table 1. Size of Cement Concrete Flooring Tiles

Sl. No.	Length	Breadth	Single layer	Multi layer
1	200	200	10	15
2.	250	250	12	16
3.	300	300	14	20
4.	400	400	16	25

Half tiles rectangular in shape shall also be available dimensions which shall be such as to make two half tiles when joined together match with the dimensions of the one full tile.

VIII. PHYSICAL REQUIREMENTS

The tests on tile shall not be carried out earlier than 28 days from the date of manufacture.

- **Flatness of the Tile Surface**

When tested in accordance with the procedure laid down in Annex B, the concavity and convexity in the tiles shall not exceed 1 mm.

- **Perpendicularity**

The maximum gap between the arm of the square and the edge of the tile shall not exceed 2 percent of the length of the edge of the tile.

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- **Straightness**

The gap between the thread and the plane of the tile shall not exceed 1 percent of the length of the edge of the tile.

- **Water Absorption**

When tested in accordance with the procedure laid down in Annex E, the average percentage of water absorption shall not exceed 10.

- **Wet Transverse Strength**

When tested in accordance with the procedure laid down in Annex F, the average wet transverse strength shall not be less than 3 N/mm2.

- **Resistance to Wear**

When tested in the manner specified in Annex G, the wear shall not exceed the following values:
a) For general purpose floor tiles:
1) Average wear : 3.5 mm
2) Wear on individual specimen : 4 mm
b) For heavy duty floor tiles:
1) Average wear : 2 mm
2) Wear on individual specimen : 2.5 mm

IX. TESTS FOR CEMENT CONCRETE FLOORING TILES

Table 2. Flexural strength on copper slag of Cement Concrete Flooring Tiles

Specimen No	Wet Condition		Dry Condition	
	Breaking load in kg	Flexural strength in N/mm^2	Breaking load in kg	Flexural strength in N/mm^2
Control	14.08	3.32	15.21	3.66
CS 30% +PW10%	14.86	4.12	16.43	3.84
CS 60%+ PW10%	14.45	3.42	15.48	3.74
CS 90%+ PW10%	13.45	3.13	14.78	3.26

Hence the different percentages of Copper slag with 10% of Plastic wastes in Cement Concrete Flooring Tiles is tested and the flexural strength is effective in 30% of Copper slag with plastic waste 10%.

Graph 1: Flexural strength of various replacements of Copper slag with plastic waste

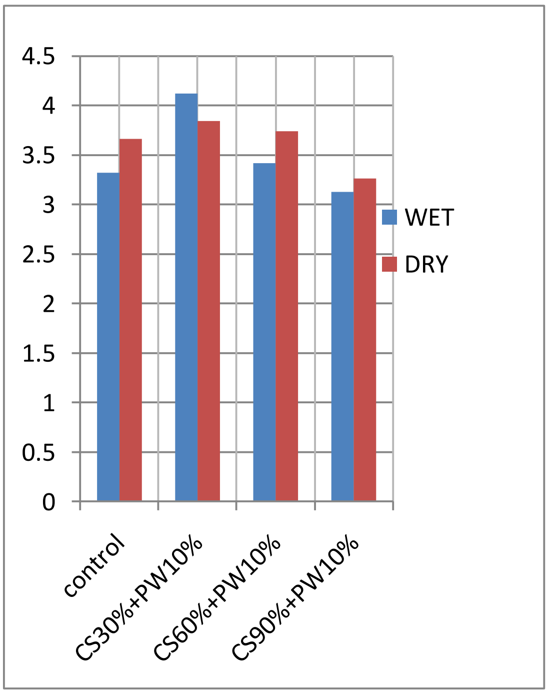
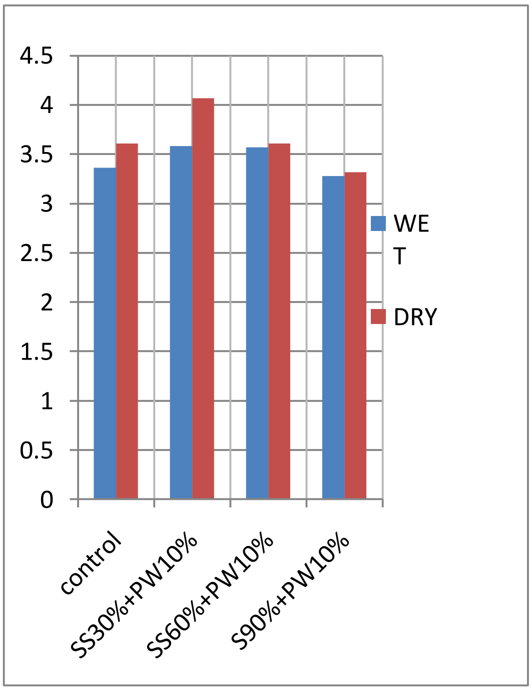


Table 3. Flexural strength on steel slag of Cement Concrete Flooring Tiles

Specimen No	Wet Condition		Dry Condition	
	Breaking load in kg	Flexural strength in N/mm^2	Breaking load in kg	Flexural strength in N/mm^2
Control	14.00	3.36	15.18	3.61
SS 30% +PW 10%	14.93	3.58	16.98	4.07
SS 60% +PW 10%	14.87	3.57	15.05	3.61
SS 90% +PW 10%	13.67	3.28	13.86	3.32

Hence the different percentages of Steel slag with 10% of Plastic wastes in Cement Concrete Flooring Tiles is tested and the flexural strength is effective in 30% of Copper slag with plastic waste 10%.

Graph 2: Flexural strength of various replacements of Steel slag with plastic waste



CONCLUSIONS

1. The usage of plastic waste, steel slag and copper slag are alternative fine aggregates in cement concrete flooring tiles.
2. This besides being a solution for reducing environment pollution and helps in developing characteristics properties of cement concrete flooring tiles.
3. Performance increase and cost reduction.
4. Thus, it can be conclude that the replacement of sand with 10% of plastics waste plus 30% of steel and copper slag is possible and attaining the compressive strength and also the flexural strength.
5. Use plastic waste, steel slag and copper slag in cement concrete flooring tile is possible to manufacture and it was very cheap and gives good results.
6. This study points out the beneficial aspects of using industrial waste as a best replacement material of fine aggregate in tile manufacture.

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