Comparative Analysis of Conventional Concrete with Concrete Using Phosphogypsum & Thermosetting Plastics

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Abstract— Concrete is a composite material composed mainly of water, aggregate, and cement. Usually there are additives and reinforcements included to achieve the desired physical properties of the finished material. For solving the disposal of large amount of recycled plastic material, reuse of plastic in concrete industry is considered as the most feasible application. The reuse of material can reduce the normal usage of ingredients in concrete and thereby reduce the cost of construction. This study is focused on the use of thermo setting plastics as a partial replacement of aggregates in concrete. The aim was to investigate the characteristics of concrete with the addition of plastic and comparing it with the control mix, thereby determining the advantages and disadvantages of doing so. One of the methods for manufacturing of such concrete involves reduction of amount of cement in the mix, which added to the reduction the total cement consumption. The use of waste materials also solves the problem of disposing the excessive amount of industrial wastes. Such Concrete is a concrete in which one or more of its constituents are replaced by a resource saving material, which ultimately has reduced environmental impacts in terms of both, resource utilization and pollution impacts together. This paper discusses the importance of such Concrete in the present day context and highlights its merits over conventional concrete which otherwise posing a serious threat to the environment through global warming. . In this phosphor-gypsum is added to a 5%, 10% & 15% by partial replacement of cement. It is proposed to replace the aggregates partially with thermosetting plastics on the basis of percentage by weight such as 5%, 10%, and 15%. The fresh concrete is tested for slump test and the compaction factor test, while the hardened concrete for compressive, tensile, flexural strength and durability.

Keywords: Conventional Concrete, Phosphogypsum, Thermosetting Plastics, Compressive Strength, Flexural Strength, Tensile Strength, Workability

I. INTRODUCTION

Concrete is the most widely used man made construction material in the world. Seeking aggregates for concrete and to dispose of the waste from various commodities is the present concern. Today sustainability has got top priority in construction industry. In this study the recycled plastics were used to prepare the fine aggregates thereby providing a sustainable option to deal with the plastic waste. There are many recycling plants across the world, but as plastics are recycled they lose their strength with the number of recycling. So these plastics will end up as earth fill. In this circumstance instead of recycling it repeatedly, if it is utilized to prepare aggregates for concrete, it will be a boon to the construction industry. The productive use of waste material represents a means of alleviating some of the problems of solid waste management .The recycle of wastes is important from different points of view. It helps to save and sustain natural resources that are not replenished, it decreases the pollution of the. Wastes and industrial by-products should be considered as potentially valuable resources merely awaiting appropriate treatment and application.

Plastic wastes are among these wastes; their disposal has harmful effects on the environment due to their long biodegradation period, and therefore one of the logical methods for reduction of their negative effects is the application of these materials in other industries. Concrete plays an important role in the beneficial use of these materials in construction. Although some of these materials can be beneficially incorporated in concrete, both as part of the cementations binder phase or as aggregates, it is important to realize that not all waste materials are suitable for such use. The strength properties and modulus of elasticity of concrete containing various types of plastic aggregate are always lower than those of a reference concrete containing normal density natural aggregate only, and they further decrease with increasing plastic aggregate content in concrete. Concrete containing plastic aggregate can stop or divert the propagation of micro cracks and improve concrete toughness, which is of great practical significance. The use of plastic waste as a natural aggregate substitute in concrete is a relatively recent concept. One of the first significant reviews on the use of waste plastic in concrete focused on the advantages and financial benefits of such use, besides their physical and mechanical properties. And more over use of plastic as aggregate gives a solution to the problems encountered with the quarrying of natural aggregate.

Phospho-gypsum is a by-product of phosphate fertilizer plants and chemical industries. As it is contaminated with the impurities that impair the strength development of calcined products, it can be used as partial replacement of cement. above 10% replacement of phosphor-gypsum in concrete lead to drastic reduction not only in the compressive strength but in the split-tensile strength also; the flexural strength decreases as width and number of cracks increases significantly at replacement above 10% of cement with phosphor-gypsum at different water binder ratios. In India, about 6 million tons of waste gypsum such as phosphor-gypsum, flouro-gypsum etc., are being generated annually. Phospho-gypsum is a by-product in the wet process for manufacture of phosphoric acid (ammonium phosphate fertilizer) by the action of sulphuric acid on the rock phosphate. It is produced by various processes such as di-hydrate, semi hydrate or anhydrite processes. In India the majority of phosphor-gypsum is produced by the dehydrate process due to its simplicity in operation and lower maintenance as compared to other processes. The other sources of phosphor-gypsum are by-products of hydrofluoric acid and boric acid industries

II. OBJECTIVES OF THE STUDY

The aim of the experimental investigation is to ascertain and compare the improvement in the performance of concrete by the partial replacement of fine aggregate with thermosetting plastics and cement with phosphor gypsum thereby to arrive at the optimum replacement percentage of thermosetting plastic and phosphor gypsum to study the durability of concrete mix. This study provides a comprehensive overview of engineering and construction properties of thermosetting plastics and phosphor gypsum for use in concrete as partial replacement materials.

III. EXPERIMENTAL INVESTIGATION

A. Test on Constituent Materials

Cement: Ordinary Portland cement of 43 grade conforming to IS 12269:1987 was used for the study. For the cement the standard consistency test, initial setting time test, final setting time test, specific gravity test and mortar cube compressive strength were conducted. Laboratory tests are conducted on cement to determine its standard consistency, initial setting time, final setting time and compressive strength. The standard consistency of the cement used is 40%

1) Phosphor gypsum:

Phosphor gypsum is a by-product in the wet process for manufacture of phosphoric acid (ammonium phosphate fertilizer) by the action of sulphuric acid on the rock phosphate. The other sources of phosphor gypsum are by-products of hydrofluoric acid and boric acid industries. Current worldwide production of phosphoric acid yields over 100 million tons of phosphor gypsum per year. While most of the rest of the world looked at phosphor gypsum as a valuable raw material and developed process to utilize it in chemical manufacture and building products, India blessed with abundant low-cost natural gypsum piled the phosphor gypsum up rather than bear the additional expense of utilizing it as a raw material. It should be noted that during most of this time period the primary reason phosphor gypsum was not used for construction products in India was because it contained small quantities of silica, fluorine and phosphate as impurities and fuel was required to dry it before it could be processed for some applications as a substitute for natural gypsum, which is a material of higher purity. However, these impurities impair the strength development of calcined products. It has only been in recent years that the question of radioactivity has been raised and this question now influences every decision relative to potential use in building products in this country. Phosphorgypsum used in the work is shown in Fig.1.

Specific gravity of phosphogypsum is 3.2
Fig. 1: Phosphogypsum

2) Fine aggregate:

Commercially available M sand with 4.75 mm maximum size was used as fine aggregate. All physical properties were tested as per IS 383:1970. Specific gravity and fineness modulus of M-Sand used were 2.36 and 2.67 respectively.

Thermosetting plastic cannot be melted by heating because the molecular chains are bonded firmly with meshed crosslink. These plastic types are known as phenolic, melamine, unsaturated polyester, epoxy resin, silicone, and polyurethane. At present, these plastic wastes are disposed by either burning or burying. However, these processes are costly. If the thermosetting plastic waste can be reused, the pollution that is caused by the burning process as well as the cost of these waste management processes can be reduced. To achieve this purpose, a study of these thermosetting plastics for application into construction materials has been conducted, particularly for the concrete wall in buildings. Thermosetting plastics are collected in the form of recycled plastics (RP). The plastic is green in colour and it poses a size of 2.36 mm. Thermosetting plastics used in this work is shown in Fig.2. Physical properties such as specific gravity and fineness modulus of steel slag used were 2and 2.7 respectively.

Fig. 2: Thermosetting Plastics

3) Coarse aggregate:

Coarse aggregate used in this study were 20mm nominal size. The properties of coarse aggregate conforming to the IS 383:1970. The coarse aggregate used was found to belong to standard zone. Specific gravity and fineness modulus of coarse aggregate used were 2.6 and 7.04 respectively.

4) Water:

Potable water is generally considered as being acceptable. Hence water available in the college water supply system was used for casting as well as curing of the test specimens.

B. Mix Design

M20, M25, & M30 mix was designed as per IS10262:2009 and the mix proportion was obtained as 1:1.54: 2.77, 1:1.39:2.61, 1: 1.29: 2.42 respectively. Four different mixes were made namely M1, M2, M3 & M4 for each grade of concrete to determine mechanical properties. M1 with 0% thermosetting plastic & 0% phosphor gypsum is considered as control mix. Other mixes are obtained by partial replacement of fine aggregate & cement by 5%, 10%, & 15%. Mix designation used for mix proportions are given in Table 1.

Mix	Fine Aggregates		Cementious Materials	
	M Sand	Thermosetting Plastic	Cement PPC (43 Grade)	Phosphor Gypsum
M1	100%	-	100%	-

M2	95%	5%	95%	5%
M3	90%	10%	90%	10%
M4	85%	15%	85%	15%

Table 1: Mix designation for different mixes

C. Specimen Details

The specimens are standard cubes of 150mm side and 100mm side, cylinders of diameter 150mm and 300mm height, beams of size 500x100x100mm. Details of number of specimens are given in Table 3.

S.No.	Specimen	Property	Size	Numbers
1	Cube	Compressive Strength	150mm X 150 Mm X 150mm	36
2	Cylinder	Split Tensile Strength	300 Mm Height And 150 Mm Dia.	24
3	Beam	Flexural Strength	500 Mm X 100 Mm X 100 Mm	24
Total No. Of Specimens				84

D. Tests on Specimens

Testing of concrete specimens plays an important role in controlling and confirming the quality of concrete. All the specimens cast were subjected to testing in order to study the effect of partial replacement of cement with phosphor gypsum and fine aggregate with thermosetting plastics on workability and strength. Thus the experimental investigation carried out was divided in to three main headings. They are as follows:

1) Study on workability
   - Slump test
2) Study on strength
   - Compressive strength test
   - Splitting tensile strength test
   - Flexural strength test

IV. Results & Discussions

A. Tests on Fresh Concrete:

Workability Test

MIX	VALUE OF SLUMP in mm.		
	M30	M 25	M20
M1	96	100	106
M2	98	103	111
M3	100	105	114
M4	102	110	120

B. Tests on Hardened Concrete

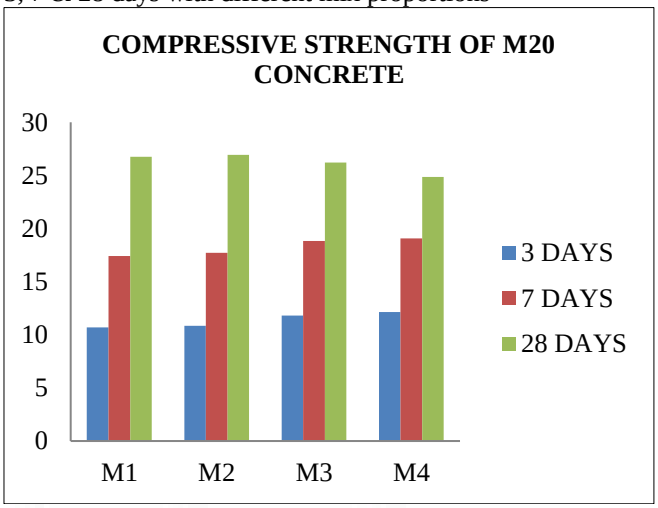
Compressive Strength Test Results

Compressive Strength of the cubes were tested by using CTM (Compressive Testing Machine) in which compressive load is applied on the specimen till the specimen fails in compression that load at which the specimen fails is termed as compressive strength. For this study, cubes of 150 mm nominal concrete cubes were casted.

For M 20 Grade of Concrete

MIX	M 20		
	3 DAYS	7 DAYS	28 DAYS
M1	10.7	17.4	26.75
M2	10.85	17.7	26.92
M3	11.8	18.82	26.22
M4	12.15	19.06	24.86

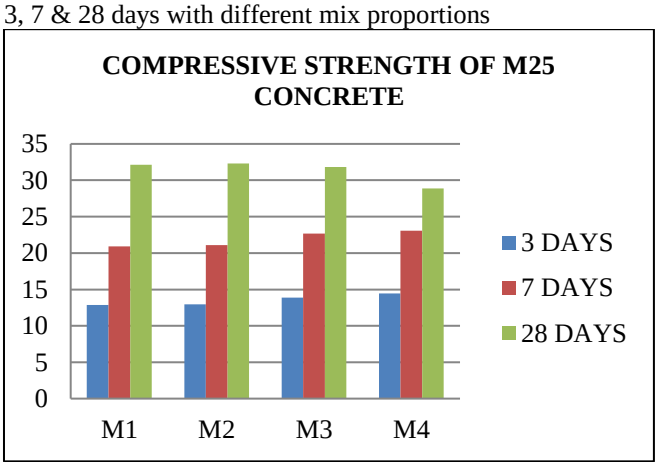
Compressive Strength of M20 Grade of Concrete at 3, 7 & 28 days with different mix proportions



For M 25 Grade of Concrete

MIX	M 25		
	3 DAYS	7 DAYS	28 DAYS
M1	12.86	20.9	32.15
M2	12.95	21.1	32.3
M3	13.86	22.68	31.82
M4	14.43	23.08	28.86

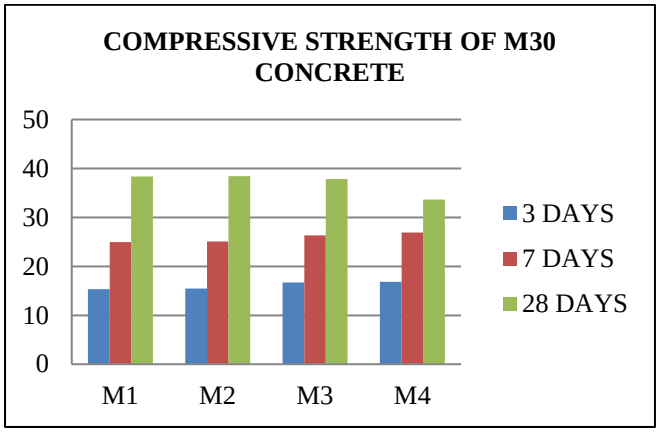
Compressive Strength of M25 Grade of Concrete at 3, 7 & 28 days with different mix proportions



For M 30 Grade of Concrete

MIX	M 30		
	3 DAYS	7 DAYS	28 DAYS
M1	15.34	24.9275	38.35
M2	15.45	25.06	38.42
M3	16.68	26.31	37.86
M4	16.83	26.93	33.67

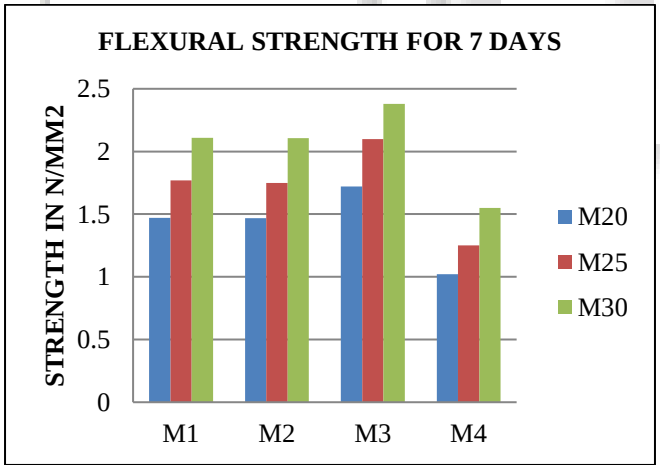
Compressive Strength of M30 Grade of Concrete at 3, 7 & 28 days with different mix proportions

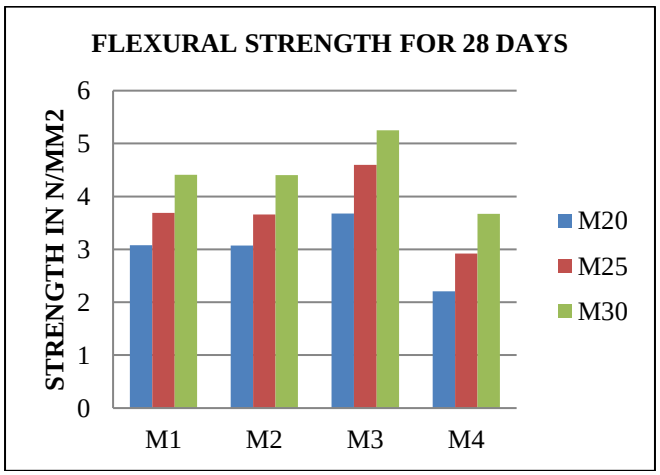


C. Flexural Strength Test Results

Beams of size 10cm*10cm*50cm are casted for determining flexural strength. Test on beams are performed at the age of 7 days & 28 days of the specimen. Placement of specimen in machine is done as per IS: 516-1959 in the clause no 8.3.1 page no 17. Load is applied at increasing rate of 108KN/min.

Mix	M 20		M 25		M30	
	7 Days	28 Days	7 Days	28 Days	7 Days	28 Days
M1	1.471	3.076	1.76	3.69	2.10	4.41
M2	1.468	3.070	1.749	3.657	2.107	4.406
M3	1.72	3.68	2.1	4.6	2.38	5.25
M4	1.02	2.21	1.25	2.92	1.55	3.67

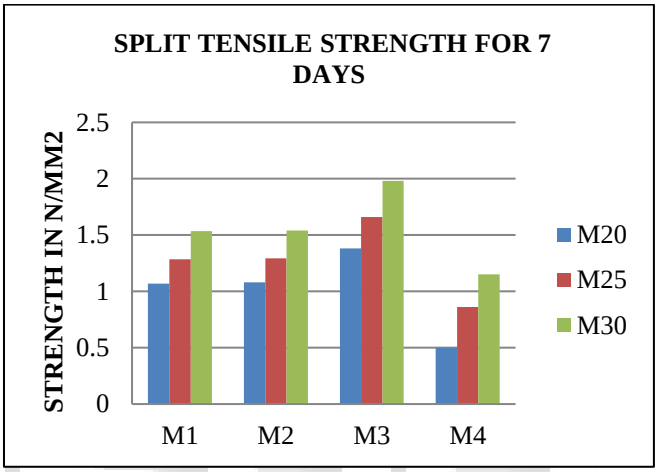


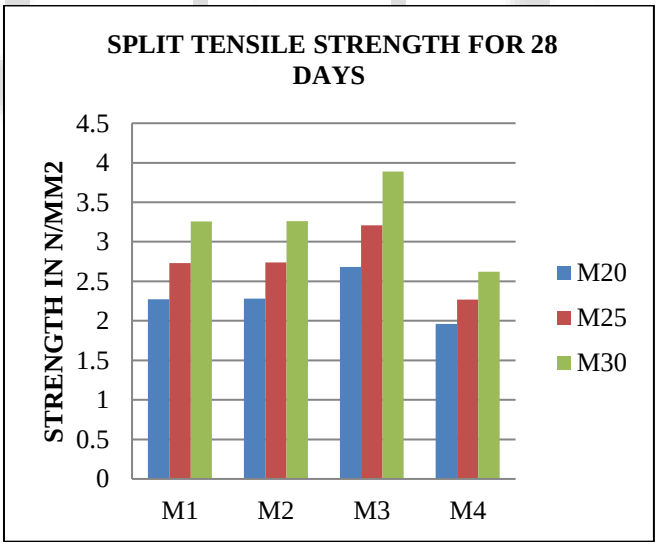


D. Tensile Strength Test Results –

Cylinders of size 15 cm diameter and 30 cm height are casted for determining Split Tensile Strength. Test on cylinders are performed at the age of 7days & 28 days of the specimen. Placement of specimen in machine is done as per IS: 516-1959.

Mix	M 20		M 25		M30	
	7 Days	28 Days	7 Days	28 Days	7 Days	28 Days
M1	1.07	2.273	1.28	2.732	1.534	3.259
M2	1.08	2.28	1.294	2.738	1.54	3.261
M3	1.38	2.68	1.66	3.21	1.98	3.89
M4	0.5	1.96	0.86	2.27	1.15	2.62





E. Cost Analysis Results

COST ANALYSIS FOR PER CUBIC METER OF CONCRETE OF GRADE M25

Cost Comparison Of M25 Grade Concrete For 1 M^3 Concrete									
S. No.	Materials	M1		M2		M3		M4	
		Qty (Kg)	Amt (Rs.)	Qty (Kg)	Amt (Rs.)	Qty (Kg)	Amt (Rs.)	Qty (Kg)	Amt (Rs.)
1	Cement	420	2900	400	2750	375	2600	355	2450
2	Phosphogypsum	-		20	40	45	90	65	130
4	M Sand	585	600	555	570	525	535	495	505
4	Thermosetting Plastics	-		30	1200	60	2400	90	3600
5	Coarse Aggregates	1095	900	1095	900	1095	900	1095	900
Total			4400		5460		6525		7585
% Cost Increment			0		24%		48%		72%

V. CONCLUSION

The concrete mix using phosphor gypsum and thermosetting plastics planned for this study with replacement of E-Waste found possible and economical based on previous studies. In this study the cement is partially replaced by phosphor gypsum and M sand is partially replaced by thermosetting plastics. The following points are arrived from the present study.

1) Workability increased with increase in thermosetting plastic content and provision of phosphor gypsum by partial replacement of cement. Maximum workability was obtained at 15% of replacement of fine aggregate with thermosetting plastics & cement with phosphor gypsum respectively.
2) Compressive strength increased up to 5% replacement of cement and fine aggregate with phosphor gypsum and thermosetting respectively. The strength value decreased at M3. The increase in compressive strength at 28th day of M2 was about 2% than control mix (M1).
3) The splitting tensile strength of cylinder was higher for conventional mix. The percentage of decrease in splitting tensile strength of M4 was about 19.77% than M1.
4) The flexural strength of beam was higher for M1. The decrease in strength of M4 shows a considerable decrement than conventional mix.

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