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Comparative Analysis of Conventional Concrete with Concrete using Marble Dust Powder and Glass Powder by the Partial Replacement of Cement

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ABSTRACT—

Concrete is mainly formed from the mixture 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 material, reuse of such materials 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 marble dust powder and glass powder as a partial replacement of cement in concrete. The aim was to investigate the characteristics of concrete with the addition of such materials and comparing it with the control mixes, thereby determining the advantages and disadvantages of doing so. In this marble dust powder and glass powder is added to a 5%, 10% & 15% respectively by partial replacement of cement. The fresh concrete is tested for slump 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,.*

1. Introduction -

Concrete is the most widely used construction material. Use of marble dust and waste glass powder in construction industry not only solve the problem of disposal of waste marble dust and glass powder but it also gives an alternative for cement in concrete. Having properties like high strength, durability, high reactivity efficiency, good cohesiveness of mortar and concrete, it is used as high-performance concrete.

Marble is a metamorphic rock resulting from the transformation of pure lime stone. Turkey has the 40% of total marble reserve in the world. 7,000,000 tons of marble have been produced in Turkey annually and 75% of these productions have been processed in nearly 5000 processing plants. It can be seen that the waste materials of these kinds of plants reach millions of tons. Stocking of these waste materials is impossible. These types of solid waste materials should be inactivated properly without polluting the environment. The most well suited inactivating method nowadays is found to be recycling. Recycling provides us with some advantages such as protecting the natural resources, contributing to economy, energy saving, decreasing the waste materials and investing in the future.

Glass is an amorphous (non-crystalline), its not a solid but a super cooled liquid. Glass can be made with excellent homogeneity in a variety of forms and sizes from small fibres to meter-sizes pieces. Primarily glass is made up of sand, soda ash, limestone and other additives.

2. OBJECTIVES OF THE STUDY

The main objective of this study are :

- To determine the behaviour of concrete with partial replacement of cement by marble dust powder and glass powder.
- To conduct workability test on fresh concrete and review its properties
- To conduct the various strength tests like compressive strength, flexural strength, split tensile strength for hardened concrete with marble and glass powder at varying percentages.
- To conduct the durability tests on each specimen of concrete.
- To compare the result with control specimen and individual concrete based on the strength and durability of the concrete.
- To compare the cost of individual concrete with conventional concrete.

3. EXPERIMENTAL ANALYSIS

A. Materials used -

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 35%.

Waste marble dust powder: waste marble dust powder used in this research is obtained from locally available marble quarrying factory. It is used as replacement material for cement.

Fig. 1 – Marble Dust powder

Glass powder: used in this research is obtained from locally available glass cutting factory. It is also used as a partial; replacement for cement with waste marble dust powder.

Fig, 2 – Glass Powder

Fine aggregate: The fine aggregate used in manufacturing of concrete should be free from debris, fungi and chemical attack. It plays a vital role in concrete, so it should durable, angular and sharp edges then only it and gives a rich mix concrete and workability. . Specific gravity and fineness modulus of coarse aggregate used were 2.67 and 2.36 respectively.

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.

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. Eight different mixes were made namely M1, M2, M3, M4, M5, M6, M7 & M8 for each grade of concrete to determine mechanical properties. M1 is considered as control mix. Other mixes are obtained by partial replacement of cement by 5%,10%, & 15%. Mix designation used for mix proportions are given in Table 1.

MIX	CEMENTIOUS MATERIALS		
	CEMENT PPC (43 GRADE)	Marble dust powder	Glass powder
M1	100%		-
M2	95%	5%	
M3	90%	10%	

M4	85%	15%	
M5	95%		5%
M6	90%		10%
M7	85%		15%
M8	80%	10%	10%

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	24 sample for each grade
2	CYLINDER	SPLIT TENSILE STRENGTH	300 mm height and 150 mm dia.	8 sample for each grade
3	BEAM	FLEXURAL STRENGTH	500 mm x 100 mm x 100 mm	8 sample for each grade
TOTAL NO. OF SPECIMENS				120

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 marble dust powder and glass powder for varying ratios 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
3. Study on Durability

4. Results & Discussions –

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
M5	105	115	130
M6	100	105	115
M7	95	100	110
M8	95	98	105

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	26.8
M2	10.85	17.7	23.95
M3	11.8	18.82	25.3
M4	12.15	19.06	25.4
M5	8.6	14.7	20.1
M6	8.1	13.5	19.95
M7	7.35	12.8	19.15
M8	10.3	15.5	22.65

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

For M 25 Grade of Concrete

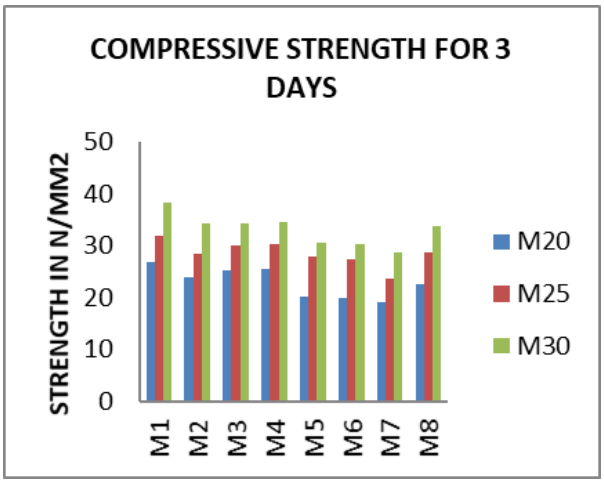
MIX	M 25		
	3 DAYS	7 DAYS	28 DAYS
M1	12.86	20.9	31.8
M2	12.95	21.1	28.5
M3	13.86	22.68	30
M4	14.43	23.08	30.21
M5	11	19.7	27.8
M6	10.5	18.9	27.5
M7	9.6	18	23.7
M8	13.6	20.25	28.8

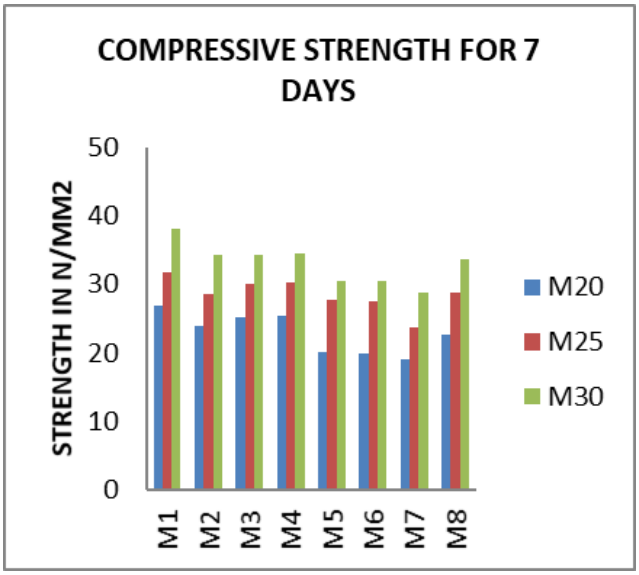
Compressive Strength of M25 Grade of Concrete at 3,7 & 28 days with different mix proportions

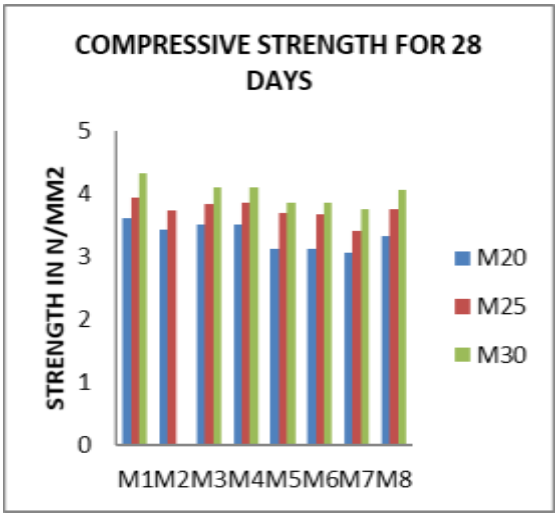
For M 30 Grade of Concrete

MIX	M 30		
	3 DAYS	7 DAYS	28 DAYS
M1	15.34	24.9275	38.2
M2	15.45	25.06	34.25
M3	16.68	26.31	34.4
M4	16.83	26.93	34.5
M5	13.5	23.1	30.52
M6	12.7	22.3	30.4
M7	11.6	21.2	28.75
M8	14.65	24.5	33.75

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





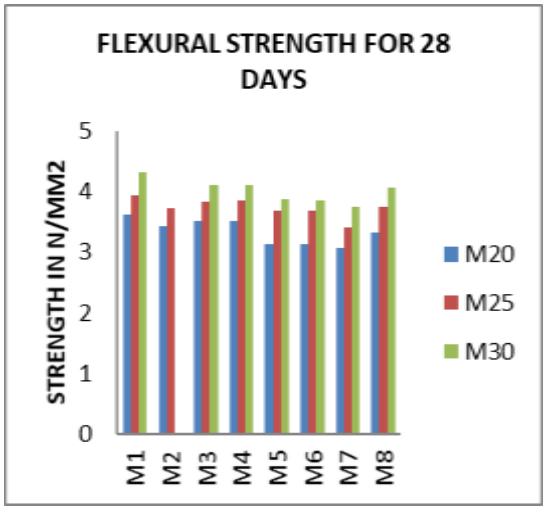


Flexural Strength Test Results –

Beams of size 10cm*10cm*50cm are casted for determining flexural strength. Test on beams are performed at the age of 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	M20	M25	M30
	28 DAYS	28 DAYS	28 DAYS

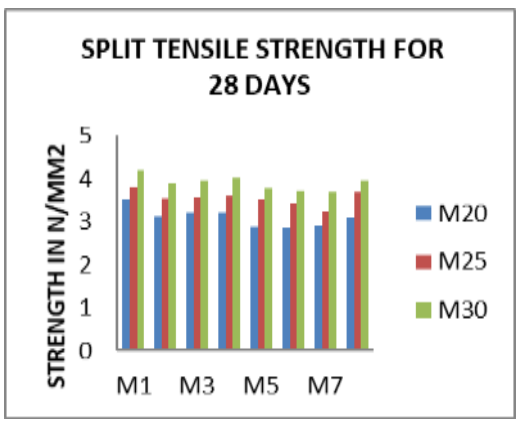
M1	3.62	3.94	4.32
M2	3.42	3.73	4..096
M3	3.52	3.83	4.10
M4	3.52	3.85	4.112
M5	3.13	3.69	3.86
M6	3.12	3.67	3.85
M7	3.06	3.4	3.75
M8	3.33	3.75	4.066



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 28 days of the specimen. Placement of specimen in machine is done as per IS: 516-1959.

MIX	M20	M25	M30
	28 DAYS	28 DAYS	28 DAYS
M1	3.5	3.8	4.18
M2	3.12	3.55	3.89
M3	3.2	3.58	3.96
M4	3.21	3.6	4.02
M5	2.88	3.51	3.78
M6	2.86	3.42	3.72
M7	2.9	3.25	3.70
M8	3.1	3.68	3.95

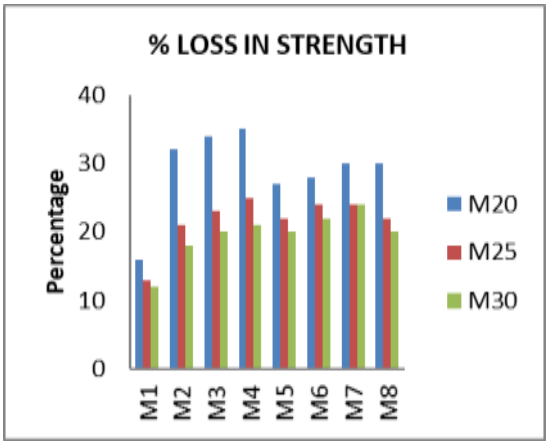


Durability Tests

Sulphuric Acid Attack Test

The compressive strength of specimens immersed in H_2SO_4 solution at 56 days were determined and compared with normal cured specimen at 28 days. Below table shows the percentage strength loss.

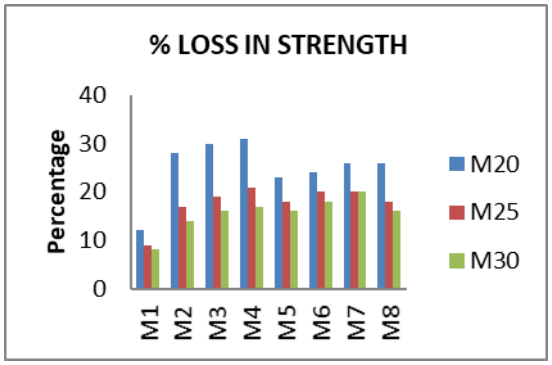
MIX	M20	M25	M30
	56 DAYS	56 DAYS	56 DAYS
M1	16	13	12
M2	32	21	18
M3	34	23	20
M4	35	25	21
M5	27	22	20
M6	28	24	22
M7	30	24	24
M8	30	22	20



Sodium Hydroxide Test

The compressive strength of specimens after NaoH exposure at 56 days were determined and compared with normal cured specimen at 28 days. Below table shows the percentage strength loss in alkaline solution.

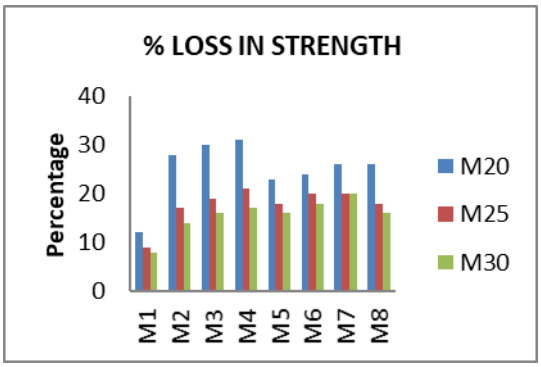
MIX	M20	M25	M30
	56 DAYS	56 DAYS	56 DAYS
M1	12	9	8
M2	28	17	14
M3	30	19	16
M4	31	21	17
M5	23	18	16
M6	24	20	18
M7	26	20	20
M8	26	18	16



Sea Water Attack Test in NaCl solution

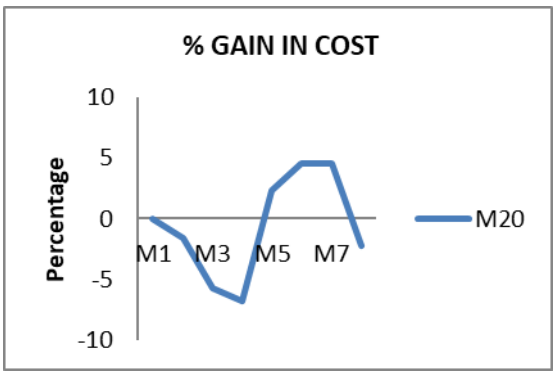
The compressive strength of specimens after sea water exposure at 56 days were determined and compared with normal cured specimen at 28 days. Below table shows the percentage strength loss in NaCl solution.

MIX	M20	M25	M30
	56 DAYS	56 DAYS	56 DAYS
M1	12	11	11
M2	30	19	16
M3	32	20	18
M4	26	23	20
M5	20	18	17
M6	18	16	15
M7	16	15	15
M8	20	13	11



Cost Analysis Results

COST ANALYSIS FOR PER CUBIC METER OF CONCRETE OF GRADE M25



5. CONCLUSIONS

The concrete mix using marble dust powder and glass powder planned for this study with partial replacement of cement found possible and economical. In this study the cement is partially replaced by marble dust and glass powder respectively by different percentage and the following points are arrived from the present study.

- Workability increased with increase in glass powder and marble dust ratio by partial replacement of cement. Maximum workability was obtained at 15% of replacement of cement by glass powder and marble dust powder each respectively.
- Compressive strength decreases while the ratio of partial replacement increases but it the value of compressive is on higher side of the desirable value which can be considered.
- The splitting tensile strength of cylinder was higher for conventional mix. The percentage of decrease in splitting tensile strength is under the limit of 15% from the conventional mix.
- The flexural strength of beam was higher for M1. The decrease in strength of all the mixes shows a considerable decrement than conventional mix.
- Such concrete with the partial mix of marble dust and glass powder had less durability property in acid test. After 56 days exposure in sulphuric acid solution the compressive strength of all the mixes was reduced considerably.
- For sodium hydroxide test, the study indicates that after 56 days exposure in NaOH solution the compressive strength of all the mixes was reduced considerably.
- With the increment in ratio of marble dust as well as of glass powder, the durability in sea water also decreases, but it seems considerable decrement than conventional concrete.
- From all the above study, it can be recommended that by the partial use of marble dust and glass powder both in a single mix up to 10% can found to be economical also and its strength and other properties can also be considerable for the specified grade of concrete.

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