PARTIAL REPLACEMENT OF WASTE GLASS POWDER WITH CEMENT FOR PREPARING CONCRETE

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ABSTRACT.

Environmental protection can be achieved by implementing various techniques in waste management. Reducing the waste generation is a matured concept in dealing with waste management. In this study, experiments were conducted to investigate the feasibility of using waste glass powder as partial cement replacement in concrete. Waste glass powder was used to partially replace cement at 10%, 20% and 30% by mass in concrete. A constant w/c ratio of 0.53 was used for all the mixes. The particle size distribution for glass powder was almost the same as that of cement and both materials showed similar shapes and sizes in terms of morphology. The slump test results increased with increasing percentage of glass powder and the unit weight decreased after adding waste glass powder to concrete. Mechanical strengths were evaluated via compressive strength and Flexural strength tests. The strength test results showed that strength decreased as the replacement level increased, however, all the mixes exceeded the target 28 days' strength. This study was conducted to investigate the effect of using waste glass powder in concrete. Laboratory work was conducted to determine the performance of control sample and concrete with used waste glass powder. The workability of concrete is determined using slump test and compacting factor test. Meanwhile, compressive strength test is done to determine the strength of concrete. For each type of concrete, a total of six 150mm x 150mm x 150mm cubes were cast. The cubes were tested at the ages of 7, 14 and 28 days to study the development of compressive strength. The results indicate that the concrete with using waste glass powder were able to increase the workability of concrete and also the compressive strength. However, the density is reduced compare to standard mixture of concrete.

INTRODUCTION

Environmental Protection is one the most important aspect that will promote the economic condition of each and every nation. Now days many research investigations are focused in the area of Reuse, Recycle and Recovery of waste material. Reducing the waste generation is a matured concept in dealing with waste management such as collection, storage and treatment. Plastic and Glass waste are non biodegradable and poses major threat to the environment. Thus Solid waste management system is being warranted to manage all types of waste. Glass is one of the most widely used man-made versatile substances in the world. The amount of waste glass has gradually increased over the recent years due to the rapid improvement in the living standards. However, due to high cost of cleaning, color sorting and transportation to recycling plants, a greater portion of waste glass is sent to landfills. As we know that now day, most of developing country facing shortage of post consumers disposal waste site and it's become very serious problems. For this reason, regenerating and using waste product as resources and prevent environmental pollutions. Therefore in research, considering the post consumer waste glass, there is effort to recover and use waste glass or otherwise its end up at disposal landfill. Currently most of

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recovered waste glass is used by glass manufactured company in the production of new glasses such as bottle and etc. But only a limited amount from the waste glass collected is that can be used towards the production of new glass.

Hence, a research study is mostly needed for better utilization of waste glass in construction practice. Concrete is one of the most commonly used construction material that can accommodate any kind of waste material as replacement against its constituent material, such as cement, sand, gravel and steel. While considering the partial replacement of cement with waste glass powder, the particle size distribution for glass powder need to be thoroughly studied and understood. The slump test must be conducted with various proportion of cement and waste glass powder by appropriate mixture of concrete. The unit weights of the concrete with respect to different proportion of mixture are needed in designing and analyzing structures. Similarly, mechanical strengths of various properties such as compressive strength and Flexural strength tests are needed to understand the stability of the structure. Curing is one of the important process after laying the concrete in order to achieve the desired strength. Normally the strength of the concrete will vary for different time duration of curing. Hence, the results of curing will certainly decides the utilization waste material for replacement of any constituent material in concrete.

The objectives of the research are:

a) The main purpose of this research is to check the compressive strength of the concrete using the waste glass powder.

b) To check the workability of the concrete using the waste glass powder.

c) To check the density of the concrete using waste glass powder.

d) To check the curing strength of concrete in different days by making cubes.

LITERATURE REVIEW

Basically waste glass powders are made from the waste glass material that cannot be reused due to the high cost of manufacturing. Therefore the manufacture will disposed in the waste landfill. Due to environmental problem, researcher tries to use the waste glass in to concrete, to create a new material to use in construction field. Researcher found that, the main material composition of glass is silica that also contain in cement production and other compound that also similarly contain in cement production.

The chemical composition of these products is similar for a given type of glass, and typical chemical compositions of the various color glass have been presented in Table 1.

TABLE-1 Composition of Materials

Composition	Clear Glass	Brown Glass	Green Glass
SiO2	72.42	72.21	72.38
Al2O3	1.44	1.37	1.49
TiO2	0.035	0.041	0.04
Cr2O3	0.002	0.026	0.130
Fe2O3	0.07	0.26	0.29
CaO	11.50	11.57	11.26
MgO	0.32	0.46	0.54
Na2O	13.64	13.75	13.52
K2O	0.35	0.20	0.27
SO3	0.21	0.10	0.07

Professor Narayanan Neithalath, of Clarkson's Department of Civil and Environmental Engineering, has been awarded a $200,000 for 2 year by the New York State Department of Economic Development Environmental Investment Program (EIP). Professor used to investigate the potential of using waste glass powder generated by Potters Industries of Potsdam in the manufacture of

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high performance concretes. Potters Industries, which is one of the largest glass bead manufacturers in the country, generates about 8000 tons of waste glass powder from their Potsdam facility alone. Most of this waste material is being land filled at a significant cost to the producer. Since the glass powder is a rich source of silica, Professor Neithalath expects that the silica compound will react with the calcium hydroxide in the cementitious system to form secondary binding compounds that can increase the strength and reduce the overall porosity of concretes. This will have a considerable impact on the long term durability of concretes. Understanding the physical and chemical effects of glass powder in cementitious matrices is an important step for Dr. Narayan Neithalath, towards the designing of high performance concrete mixtures in future.

Dr. Neithalath has teamed up with two local concrete manufacturers – Woodruff Block Company, and Graymont concrete to develop mixture proportions for concrete incorporating waste glass powder. Based on a series of tests conducted, he believes that the secondary reaction capability of glass powder can help in reducing the cement content in concretes by at least 10%, without compromising the long term performance of the material. This will be of significant economical importance, since cement is the costliest component of concrete (accounting for more than 75% of the total cost). The cementitious compositions of the present invention preferably include about 30% to about 80% of a Portland cement and 20% to 70% (averagely) of glass powder as a pozzolanic; and about 0.1% to about 10% of alkali metal aluminates.

MATERIALS AND METHODS

Concrete Mix Design

The concrete mix design is done by systematic analysis and knowledge to choose and proportion the ingredient used in a concrete mix produce economical concrete which will have the desired properties both when fresh and when hardened. The variables which can be controlled are water cement ratio, maximum aggregate size, aggregate grading, and use of admixtures. Interactions between the effects of variables complicate mix design and successive adjustments following trial mixes are usually necessary. Experiences built up by ready mix concrete producers should enable them to produce suitable mix design more quickly than this

EXPERIMENTAL PROCESS

In this research is to determine the performance of the concrete that contain the waste glass powder (WGP) by preparing concrete cube sample and tested to obtain some of the basic engineering properties. The concrete mix design is done by systematic analysis and chooses the proportion of the ingredient to use the concrete mix to produce an economical concrete and also with strength that desired when the cube is hardened. The variables which can be controlled are water cement ratio, maximum aggregate size, aggregate grading and use of admixture.

MIXING OF CONCRTE

After proportioning all concrete ingredients their mixing is done. The mixing process should ensure homogeneous mass uniform color. Segregation should not take place during the mixing operation.

METHODS OF MIXING

Mixing is done by two following methods:

1. Hand Mixing
2. Machine Mixing

TYPES OF MIXING

1. Normal mixing
2. Batching mixing

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Calculation of Volume of Sand (Fine Aggregate) in 1m3 of Concrete:

$$\text{Volume of Sand} = \frac{\text{Sand}}{\text{Cement+Sand+Aggregate}} \times 1.57$$

$$= \frac{1.5}{1+1.5+3} \times 1.57$$

$$= 0.42\ m^3$$

1m3 of Sand = 1600kg
(The value may varies upon the amount moisture content in sand)

0.42m3 of sand = 0.42 x 1600

= 672Kgs

For 1m3 of M20 grade Concrete Requires 672Kgs of Sand

Calculation of Volume of Cement in 1m3 of Concrete:

$$\text{Volume of Cement} = \frac{\text{Cement}}{\text{Cement+Sand+Aggregate}} \times 1.57$$

$$= \frac{1}{1+1.5+3} \times 1.57$$

$$= 0.28m^3$$

1m3 of cement = 1440Kg
0.28m3 of Cement = 0.28x1440 = 403.2Kgs

For 1m3 of M20 grade Concrete Requires 403Kgs of cement

Each bag of cement = 50kgs

No. of Cement bags = $\frac{403.2}{50}$ = 8.06 ~ 8bags

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Calculation of Volume of Aggregate for 1m3 of Concrete:

$$\text{Volume of Aggregate} = \frac{\text{Aggregate}}{\text{Cement+Sand+Aggregate}} \times 1.57$$

$$= \frac{3}{1+1.5+3} \times 1.57$$

$$= \mathbf{0.85m^3}$$

Bulk Density for 1m3 of aggregate (20mm) = 1560Kg

0.85m3 of Aggregate = 0.85x1560

= 1326Kgs

For 1m3 of M20 grade Concrete Requires 1326Kgs of Aggregate

Cement required for 1m3 of Concrete = 400Kgs

Assume W/c ratio = 0.50 (50% of Cement)

Water required for 1m3 of concrete = 400 x 0.50

= 200Kgs or 200litres

RESULT AND DISCUSSION

The average strength of concrete was tested after 7days,14days and 28days of curing. The compressive strength was found to decrease with increase in percentage of replacement but the workability was found to be good. The average compressive strength was shown in the following Tables.

TABLE-2 Compressive strength for normal concrete

Specimen	Age of specimen	Breaking load (KN)	Average Strength (KN)
1	7days	626.9	706.8
2		786.7	
3	14days	810	890
4		970	
5	28days	1040	1067

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6		1095	

TABLE-3 Compressive strength for 10% replacement of brick powder

Specimen	Age of Specimen	Breaking load (KN)	Average strength (KN)
1	7days	742.9	726.55
2		710.2	
3	14days	810	770
4		730	
5	28days	890	880
6		870	

TABLE-3 Compressive strength for 20% replacement of brick powder

Specimen	Age of Specimen	Breaking load (KN)	Average strength (KN)
1	7days	515.3	574.95
2		634.6	
3	14days	820	810
4		800	
5	28days	860	852.5
6		845	

TABLE-4 Compressive strength for 30% replacement of brick powder

Specimen	Age of Specimen	Breaking load (KN)	Average strength (KN)
1	7days	621.1	648.9
2		676.7	
3	14days	760	710
4		660	

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5	28days	650	735
6		820	

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CONCLUSION

As a conclusion, all the objectives of this study are achieved Concrete with using waste glass powder has a very high workability from control sample. This result achieved from the slump test that use of waste glass powder were will increase the workability of concrete. In term of strength, concrete with using waste glass powder averagely have higher strength at 14 days but once the concrete reached at 28 days the control mix give more higher value compare to mix that contained waste glass powder but still give high value of the grade 30. From this research, using waste glass powder is giving positive value even though the value compare to standard mix it just less about 1N/mm.^{2} Concrete become lighter when mix with waste glass powder. The average cube density of concrete with using more percentages of waste glass powder averagely gives lowest value compared to control sample. Therefore, concrete mix that using glass powder is giving lightweight concrete .I have chosen this topic because of most developing country facing shortage of post consumer's disposal waste site and it's become very serious problems. For this reason, regenerating and using waste product as resources and prevent environmental pollutions..

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