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Performance of Using Waste Glass Powder In Concrete As Replacement Of Cement

Gunalaan Vasudevan[1], Seri Ganis Kanapathy pillay[2]
[1]*Faculty of Engineering and Built Environment, Lecturer,Tunku Abdul Rahman University College* ,Malaysia
[2] *Department Structural & Infra*, Engineer JPTM Sdn.Bhd, Malaysia

Abstract: - 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 performance of these types of concrete was determined by the workability test, density test and compressive strength test. 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.

Keywords: - *Waste glass powder in concrete, workability of concrete and standard mixture of concrete*

I. INTRODUCTION

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 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. These is because, manufactures only can use waste glass that's has been pre-sorted by color and type and this is exclude waste glass that mixed with color were it is very expensive to produce new glass and even all the black and green glass bottles, car windshield, glass for cathode-ray tubes, glass for liquid crystal panels, glass building materials such as windowpane, and the like other than the colorless and brown bottles have come to be increasingly recycled, but are mostly discarded now and this wastes color mixed glass still it end up at landfill site.Since waste glass still gave us a problem, maybe we try to use it in the concrete mix and find the result whether because if the results gives us a good value, then it will benefit to our earth because we can reduce 1 portion of our waste that cannot dissolved by natural or normal recycling ways.

The main reason of this study is to create a better environment that free from polluted space and also to find a better solution for concrete mixture that can give higher strength to concrete from the waste glass product .Even it may gives less cost of using this kind of admixture rather than buying expensive admixture to get great and higher strength in concrete as now days it's the admixture that in market are very expensive and often increase the cost of the construction.

II. LITERATURE REVIEW

2.1 Using Waste Glass Powder in Concrete Mix

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 2.

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

Table 2.0: Chemical composition of various coloured glass

2.2 Investigate the potential of using waste glass powder generated

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 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 pozzolan; and about 0.1% to about 10% of alkali metal aluminates.

In actual use, the present cementations compositions are mixed with water to form a cementations binder composition, which can be solidified or used as the basis for a solidifiable cementations composition. The weight ratio of water to cement in the binder is from 0.1:1 to about 1:1, preferably about 0.3:1 to about 0.5:1. These cementations binder compositions may be mixed with mineral aggregate particles to form a solidifiable cementations composition, such as a concrete or mortar. This binder forms a mix in concrete or mortar products to hold together the aggregate particles. Aggregate particles are inert solid bodies that form most of the volume of a concrete article. When mixed with aggregate, the cementations binder composition forms a binder mix that holds the aggregate together. Additionally, mineral fillers such as silica flour, kaolin, shales, bentonites, feldspar and the like can be added in various amounts as extenders and to enhance physical properties. It is preferable that, after curing, a solidified and cured solidifiable cementations composition prepared according to the present invention has a compressive strength of at least about 45 Mpa. Therefore Dr.Professor Narayan find that using the glass product can give us at least 45Mpa after a series of test that been conducted.

2.3 Value added Utilization of Waste Glass in Concrete

From the chief scientist Ahmad Shayan research, using waste glass powder in concrete also gives a good result and has a high potential to increase the concrete strength with reducing the usage of 100% Portland cement. From his lab test, he found that it is better to grind the waste glass into a fine glass powder (GLP) for incorporation into concrete as a pozzolonic/ cementations material. From the laboratory experiments, it shows

that it can suppress the alkali-reactivity of coarser glass particles, as well as that of natural reactive aggregates. It undergoes beneficial pozzolonic reactions in the concrete and could replace up to 30% of cement in some concrete mixes with satisfactory strength development.

So far as utilization as fine and coarse aggregate is concerned, trial mixes were undertaken to know that value of fine and coarse glass could be used in concrete mixtures that would be suitable for some structural applications and for concrete pavements. The trials aimed at producing concrete appropriate as VicRoads 32 MPa strength grade. This mix contained a binder of255 kg/m3 cement and 85 kg/m3 fly ash. The coarse aggregate and sand contents were 1080 and780 kg/m3, respectively. After a number of trials, adjusting the properties of fresh and hardened concrete, the following concrete mix formulations were found to be satisfactory, as detailed in Table 2.3.

MixNo	.Binder (%)		glass content(%)		w/b*	slump(mm)	air(%)	Strength (MPa)		superplasticiser
	Cement	fly ash	coarse	fine				7-day	28-day	
1	75	25	50	50	0.465	60	1	28.6	39.9	yes
2	75	25	50	50	0.52	80	2	25.3	35.0	no

Table 2.2: Properties of two concrete mixes containing 50% each of coarse and fine glass

III. METHODOLOGY

3.1 Introduction

This chapter explains the methods going to be use in this research. Then, the waste glass are will collected from disposal area and grind it to powder or into cementitous form as it will use as certain proportion of cement replacement . After that, all the related laboratory experiments conducted to achieve the research objectives. All the conducted experiments and the flow chart of research work explained in this chapter clearly.

3.2 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

3.3 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.

3.4 DETAIL OF SAMPLES

In this research, the concrete will mixed using concrete mixer and for each mixes, total of six of 150x150x150mm cubes will cast. The sample will be cured until the day of testing. The cubes will be tested at ages of 7 day, 14 day and 28 day to study the development of the compressive strength. The detail of samples that to be tested are shown in table 3.0 below.

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Concrete Mix	Tested Ages(Days)		
	7	14	28
Control Mix Samples	3 Cubes	3 Cubes	3 Cubes
Concrete + 10% of WGP	3 Cubes	3 Cubes	3 Cubes
Concrete + 15% of WGP	3 Cubes	3 Cubes	3 Cubes
Concrete + 20% of WGP	3 Cubes	3 Cubes	3 Cubes

Table 3.0: Detail sample to be tested

Note WGP = Waste Glass Powder

IV. RESULTS

4.1 ANALYSIS AND DISCUSSION OF COMPRESSIVE STRENGTH

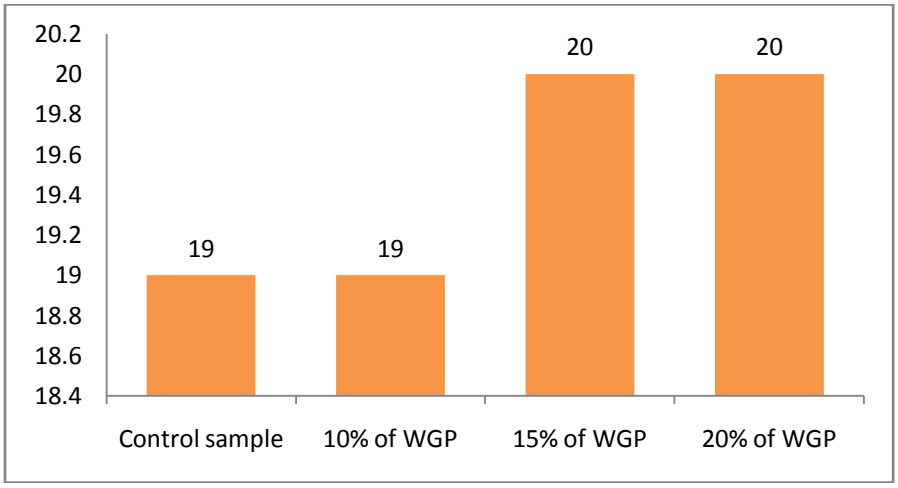

FIGURE 4.1: AVERAGE OF COMPRESSIVE STRENGTH AT 7 DAYS

Referring from the column chart above Figure 4.1, its show that the overall average compressive strength value at 7 days , which by using 20% of waste glass powder in my specimen is giving very high value were about 20N/mm2 compared to standard mixture that only give 19N/mm2. Even for the concrete mixture that contain 15% of glass powder as well giving the about the same value of 20% mixture concrete comparison to standard mixture concrete. This increment of the positive value shows that with the mixture of glass powder into the concrete will achieve the early strength ratio's for the 14 days. Therefore my experiment using glass powder to replace with cement ratio of 15 to 20% will give 14 days' strength compare to the standard mix of concrete.

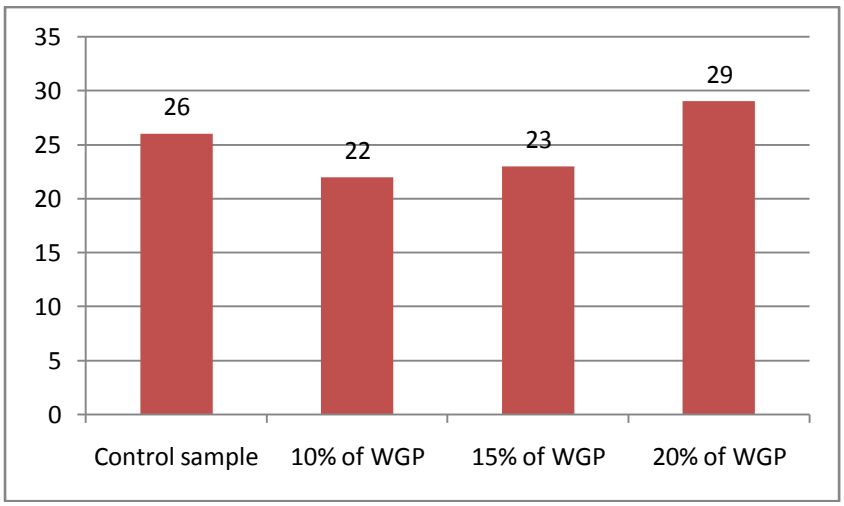

FIGURE 4.2: AVERAGE OF COMPRESSIVE STRENGTH AT 14 DAYS

With reference to Figure 4.2, its show that average compressive strength at 14 days, which show that by using 20% of waste glass powder into my concrete specimen its shows that positive increment of high value were about 29 N/mm2 compared to standard mixture that only give 26 N/mm2. Even for the concrete mixture

that contain 10% and 15% of glass powder also give a positive value of concrete strength .Therefore from the overall view of column chart, it shows a positive value of compressive strength at 14 days by using the waste glass powder product.

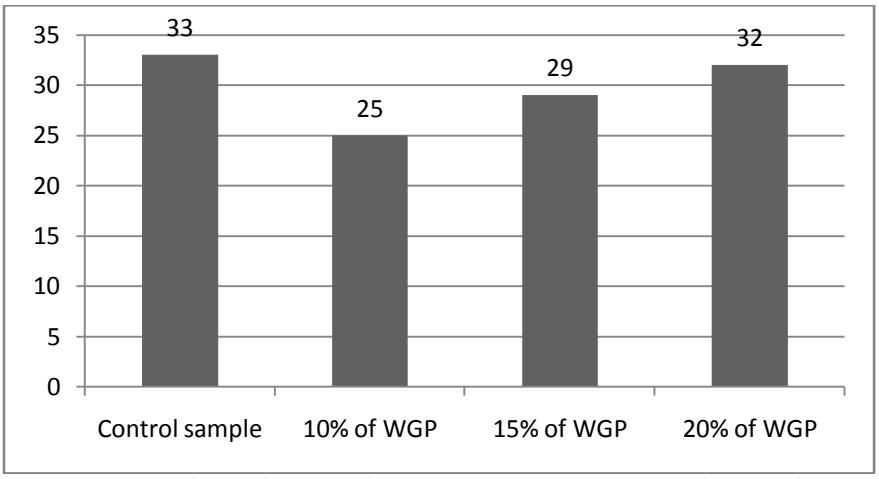

FIGURE 4.3: AVERAGE OF COMPRESSIVE STRENGTH AT 28 DAYS

As stated in Figure 4.3, its show that average compressive strength at 28 days, the 20% of waste glass powder is giving positive value more than target concrete value which is Grade 30 N/mm2 but its still low value about 32 N/mm2 compare to standard mixture which gives 33 N/mm2.For the 10% and 15% glass powder mixture which shows not much increment compare to 14 days value as well not achieving the required concrete strength. As of my understanding from the above figure, 20% amount used in concrete has caused some reaction which give concrete strength value near to standard mix and the other mix ratio does not so effective in 28 days compared to 7 days value. Therefore of the view of column chart, the 20% glass powder mix amount shows a positive value of compressive strength at 28 days compare to other ratio which 10% and 20% is not achievable even though have slight increment from 14 days results.

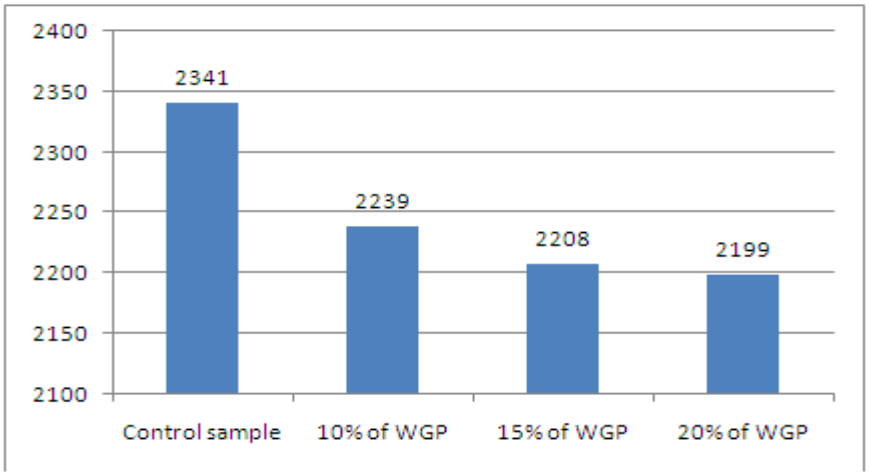

FIGURE 4.4: AVERAGE OF CUBE DENSITY AT 7 DAYS

Figure 4.4 illustrates the above 7 days average concrete cube density graph, it shows that control mix is showing very high density value compare concrete mix of 20% of waste glass powder where it shows very low value of density. The control mix shows value 2341N/mm2 and the lowest value is about 20% of waste glass powder concrete mix and the value is 2199 N/mm2.The other mix of waste glass powder also gives lower value compare to control mix. This reduction happens due to the amount water which is used in my specimen is much lesser compare to normal mix or the amount cement weight which has been replaced with glass powder where it's more lighter compare to cement. This may prove from the above graph where the 10% of glass powder used shows that the concrete density value higher than 20% mix. Even compare to 15% mix content concrete getting lighter than the 10% ratio. Therefore by using more percentage, the density of concrete will get lighter than comparable to standard concrete mix.

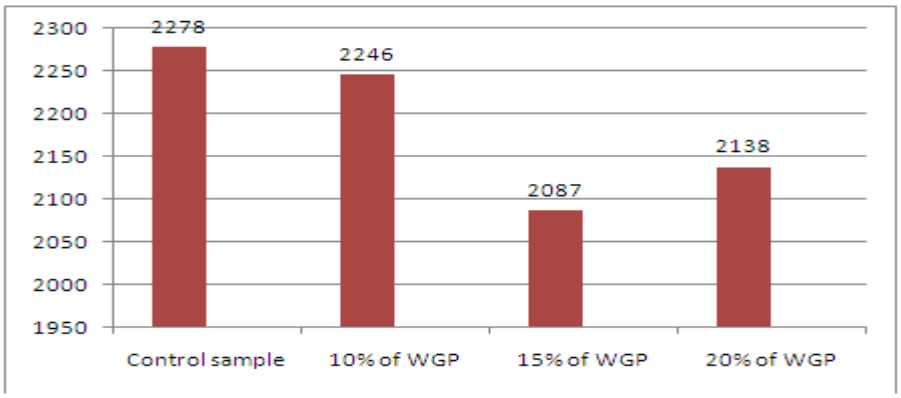

FIGURE 4.5: AVERAGE OF CUBE DENSITY AT 14 DAYS

Observed from Figure 4.5 the average concrete cube density of 14 days result graph, its show that the density of concrete is gradually decreased by using glass powder even the control mix concrete also gradually decreasing in their density. This may happen due to the contraction of concrete while in the process of gaining its strength under the curing process. I refer to control mix with 10% glass powder concrete mix, the drop in value is not much in 14 days curing process where the 15% shows have much low value compared to 20% mix ratio.

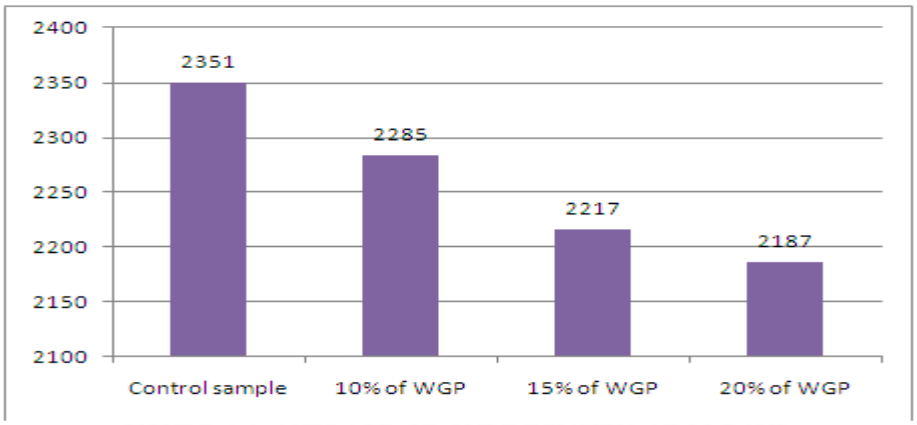

FIGURE 4.6: AVERAGE OF CUBE DENSITY AT 28 DAYS

As highlighted in Figure 4.6 it shows averagely the concrete density of control mix gives values of 2351 N/mm2 and the lowest value of concrete mix with waste glass powder is 20% on the value of density is 2187 N/mm. If we refer to the 14 days graph chart compare to 28 days graph chart, it shows the slightest increment of the density value from 2138 to 2187. Even for the 15% of waste glass powder used mix as well giving slight increment in density which is from 2087 to 2217.

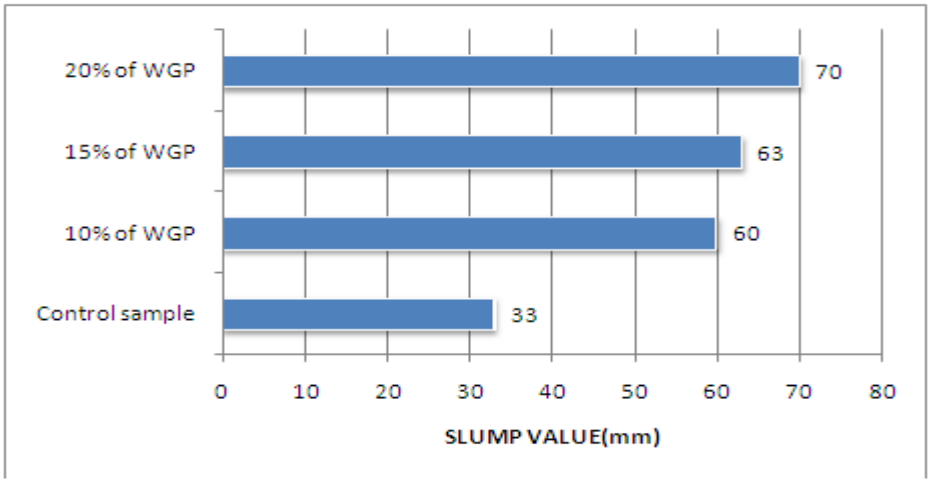

FIGURE 4.7: AVERAGE OF SLUMP VALUE

As stated in Figure 4.7 its show that averagely the slum the value of control mix give value of 33mm compare to concrete mix with waste glass powder of 10% is 60mm ,15% are 63 and 20% are 70mm.Therefore the value of slum its increase if the percentage of waste glass powder increased. Therefore it is shown that compared to control mix, by using waste glass powder will give another benefit which is the workability of concrete which is much higher.

V. 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.. From the analysis and discussion, we are clearly understood that the objectives of this study are achieved. 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.

Recommendations for Future Research

From this research, there are few recommendations to improve, to extend and to explore the usage of waste glass powder in concrete:

i. Make few samples of concrete with different percentage of using waste glass powder and determine the most suitable percentage of usage to achieve the optimum compressive strength.
ii. Determine the durability of concrete with using waste glass powder
iii. Add chemical activator into waste glass powder concrete mix for determine the compatibility by observing the compressive strength of the concrete.

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