STUDY OF WASTE GLASS POWDER AS AN PARTIAL REPLACEMENT OF CEMENT IN CONCRETE

DISSERTATION

Submitted in Partial Fulfillment of the

Requirement for Award of the Degree of

MASTER OF TECHNOLOGY

In

STRUCTURAL ENGINEERING

By

AMBATI SAI CHARAN REDDY

(Reg. No. 11309726)

Under the Guidance of

Mr. ANSHUL GARG
(Assistant Professor)

DEPARTMENT OF CIVIL ENGINEERING

LOVELY PROFESSIONAL UNIVERSITY

PHAGWARA, PUNJAB (INDIA) -144402

(MAY – 2015)

CERTIFICATE

This is to certify that the project work entitled **"STUDY OF WASTE GLASS POWDER AS PARTIAL REPLACEMENT OF CEMENT IN CONCRETE"** being submitted by **Mr. AMBATI SAI CHARAN REDDY** (Reg.no:11309726), has been carried out under my supervision and has not been submitted to any other institute or university for award of any degree.

Signature of guide
(Mr. ANSHUL GARG)
Department of Structural engineering,

Lovely Professional University.

Head of Department
(MANDEEP KAUR)
Department of Structural engineering,

Lovely Professional University.

Internal examiner

External examiner

ABSTRACT

In construction field, concrete is a material which consists of mixing of cement, aggregates, water and admixtures. Now a days a lot of researches are going around the world, by the usage of many waste materials. In this report, waste glass powder is used as partial replacement of cement in concrete. The effect of particle size of glass powder was also checked by taking the glass powder and it is retained and passed. The cement is replaced at five, fifteen and twenty five percentages. In this report size effect of glass powder is divided in to two grades one is glass powder having size less than seventy five micron and another is glass powder having particle size ranges from seventy five micron to three hundred micron. It is resulted that the initial strength which is obtained from the addition of glass powder is very less on seventh day. But, it increases on the twenty eighth day**.**It is obtained that fifteen percentage addition of glass powder gives higher strength. The glass powder size less than seventy five microns is very effective in resulting of high strength.

ACKNOWLEDGEMENT

I would like to thank **Mr. ANSHUL GARG** sir for giving us an opportunity to extend our knowledge and push is towards the excellence. Being an inspiration and motivating all the way to this stage. I would also like to thank my friends for their timely and extensive support. Last but not the least I would like to thank my friends and juniors in Lovely Professional universities for providing me the required reading materials.

AMBATI SAI CHARAN REDDY

(Reg. Id- 11309726)

DECLARATION

I here declare that the dissertation entitled "**STUDY OF WASTE GLASS AS PARTIAL REPLACEMENT OF CEMENT IN CONCRETE"** Submitted for the M.Tech Degree in structural engineering is entirely my original work and all ideas and references have been duly acknowledged. It does not contain any work for the award of any other degree or diploma.

AMBATI SAI CHARAN REDDY

REG NO: 11309726.

CONTENTS

LIST OF TABLES

LIST OF GRAPH

LIST OF PLATES

CHAPTER 1

INTRODUCTION

1.1 GENERAL:-

In construction field concrete is a material which consists of mixing of cement,aggregates,water and admixtures.Now-a-days a lot of researches are going around the world,by the usage of many waste materials like fly ash,silica fume,rice husk ash,rubber tires,etc.These waste materials are also called as filler materials in concrete.Glass is used many ways in our day to day life and it has limited span and after use it been sent to landfills. Irrespective of the nature of their products, almost all industries produce waste. In that only 5% of waste materials are recycled every year around globe.

1.2 OBJECTIVE:-

Accessibility of cement is plummeting day by day and becomes more expensive.Waste glass can be option for concrete industry.Glass is used many ways in our day to day life and it has limited span and after use it been sent to landfills. Since the glass is non-biodegradable, landfills do not provide eco-friendly, so there is a strong reason to utilize waste glass as partial replacement of cement or fine aggregates or coarse aggregates. Waste glass powder provide high strength when replaced with cement rather replacing it with fine or coarse aggregates.Glass is an amorphous solid that has been around in various forms for thousands of years and has been manufactured for human needs. In olden days solid wastes were used as landfills in low-lying areas.Waste disposal in landfill sites however are unsustainable in the long run. Industrial wastes like fly ash,silica fume,blast furnace slag,etc and other wastes of plastics,glass,tiles and agriculture are causing environmental pollution.Recycling of wastes is therefore emerging as an important component of technology for making contribution towards sustainability.

1.3 SCOPE OF STUDY:-

Glass is one the most versatile substances on Earth,used in many applications and in a wide variety of forms,from plain clears glass to tempered and tinted varieties, and so forth.Irrespective of the nature of their products,almost all industries produce waste.Effective disposal of wastes therefore is a challenging task.In olden days solid wastes were used as landfills in low-lying areas.Waste disposal in landfill sites however are unsustainable in the long run.Industrial wastes like fly ash, silica fume,blast furnace slag etc. and other wastes of plastics,glass,tiles and agriculture are causing environmental pollution.Recycling of wastes is therefore emerging as an important component of technology for making contribution towards sustainability.Glass is used many ways in our day to day life and it has limited span and after use it been sent to landfills.Since the glass is non-biodegradable,landfills don't provide eco-friendly,So there is a strong reason to utilize waste glass as partial replacement of cement or fine aggregates or coarse aggregates.

1.4 FUTURE SCOPE OF STUDY:-

As waste materials are most versatile substances on Earth, as it produced in wide variety of forms. The waste materials are easily recycled and used as many purposes by the humans.As the waste materials are recycled as produced,then it is eco-friendly to use it.The glass powder resist the chemical attack.It is usually replaced upto 30% for obtaining good strength.Irrespective of the nature of their products,almost all industries produce waste.Effective disposal of wastes therefore is a challenging task.In olden days solid wastes were used as landfills in low-lying areas.As in future wastage of industries can be easily utilized or recycled with these type of replacements.

1.5 MECHANISM OF CEMENT AND GLASS POWDER:-

Glass wastes as a cullet are used in the production of building materials mainly as an inert aggregate.However, finely grained glass powder with its well developed surface cannot be

regarded as passive toward cement solutions which has actually been proven in practice. Literary sources provide no information about chemical influence of finely grained glass on the process of hardening, especially in its early pre-induction hydration period the period which considerably conditions the cement stone structure formation and its properties. It is wellknown that glass is a material with an amorphous structure, characterized by a large supply of free energy. The glass that has been used in our investigations contains approximately 14% of Na2O and K2O. In the glass structure the ions of these metals have considerably less binding energy as compared to covalent bond of Si-O in the structural fragment of Si-O-+Na or Si-O-+K. In water solution Na+ and K+ ions are easily diffused from glass to the solution and form sodium and potassium hydroxides in the solution, correspondingly. They are displaced by H+ ions from water and thus hydrate the surfaces of glass grains. This is a so called ion-exchange mechanism of interaction between glass and water.Since the area of glass grain surface is very large, comparable to the area of cement grain surface, ionic exchange is very active. Titration analyses show that alkalinity of cement solution without glass additives is near 6 ml of 0.1N HCl. Separate glass powder in water under normal conditions has alkalinity in the range from0.15 (colourless glass) to 0.55 ml of 0.1N HCl (green glass). Thus, the total alkalinity has to increase, however alkalinity of cement mixture with glass additives is 35-40 % less. In our opinion, it is connected with high content of SiO2 in the glass (near 70 %), which results in the formation of calcium hydro silicate (CSH), as shown in chemical reaction:2(3CaO.SiO2)+6H2O=3 CaO.2SiO2.3H2O+3Ca (OH)2(Tricalcium Silicate) (Calcium Silicate Hydrate) (Calcium Hydroxide) ….(1) 3Ca(OH)2 + SiO2 + (n-1) H2O = aO.SiO2.nH2O (Calcium hydroxide) (Glass)(Calcium Silicate Hydrate) ….(2)As a result of reaction (1) the amount of calcium hydroxide in the cement solution decreases.Consequently, the alkalinity of solution with glass powder additives decreases as well and additional amount of CSH crystal phase in a cement stone is formed. It has been established that addition of finely grained glass to Portland cement or to Portland cement based concrete accelerates the binding process during preinduction period of hydration (2–4 min.) but retards it during after-induction period.However, this does not affect the mechanical strength of the concrete samples after the first day ofhardening. The strength of samples with glass is higher as compared to the control samples, because, as has been stated above,glass additives modify cement stone structure.

CHAPTER 2

LITERRATURE REVIEW

2.1 GENERAL:- Now-a-days a lot of researches are going around the world, by the usage of many waste materials like fly ash, silica fume, rice husk ash, rubber tires, etc. These waste materials are also called as filler materials in concrete.Glass is used many ways in our day to day life and it has limited span and after use it been sent to landfills. Irrespective of the nature of their products, almost all industries produce waste. In that only 5% of waste materials are recycled every year around globe.Following are the research studies as follows:

2.2 REVIEW OF PREVIOUS STUDIES:-

M.N.Bajad,C.D.Modhera**,Experimental Investigations In Developing Concrete Containing Waste Glass Powder As Pozzolana:**When waste glass is made very fine powder it shows some properties of pozzolanic properties as it contains high value of sio2.So some amount is replaced with some extent with cement and obtain strength of concrete.In this paper waste glass is replaced with the percentages from 0% to 40%.As increment of 5%.By this paper replacement of 20% has resulted high strength.

Based on the experimental investigations from this paper,high strength is obtained as cement is replaced with the waste glass by 20%.As in this paper author's concluded that,for 30 days or 90 days the high strength is obtained with 20%.

Dr.G.Vijayakumar,Ms.H.Vishaliny,Dr.D.Govindarajulu,**Studies on Glass Powder as Partial Replacement of Cement in Concrete Production:**By the deforestation and burning of fossil type of fuels,cement industries which are manufacturing cement are the most emitting corbondioxide into the air.The global warming is actually caused by the emission of carbondioxide to the earth atmosphere which contributes about the sixty five percentage of global warming to the earth atmosphere.The cement industries gives seven percent of air pollution to the earth atmosphere.They should address alternate binder's to make the concrete for addressing of environmental effects to the earth atmosphere.By the partial replacement of cement

which has the finely powder of the cement has the replacing of the good material of the accesed of the of the age of the efforts due to the accidental policy of the coarse aggregates of the examine of the concrete industry of the cement are good conveying of the material for the access of the compared of the concrete of it is good powdered of their percentages of the some extent of the fine and coarse of the extent of the particle size remains some what different.

Concrete exactly show compressive strength on 28th day is 31.1N/mm2,the split tensile strength is 2.27N/mm^2 and flexural strength is 3.25N/mm^2.By the replacement 20% with glass powder as cement increases the compressive strength as19.6%,25.3%and33.7%as respectively.By the replacement 40% with glass powder as cement increases the tensile strength as 4.4% respectively in the concrete.By the replacement 20% with glass powder as cement increases the fluxeral strength as 83.07%, 99.07% and 100% respectively.

Dhanaraj Mohan Patil,Dr.Keshav K.Sangle,**experimental investigation of waste glass powder as partial replacement of cement in concrete:**In construction field,concrete is a material which consists of mixing of cement,aggregates,water and admixtures.Now a days a lot of researches are going around the world,by the usage of many waste materials.In this report, waste glass powder is used as partial replacement of cement in concrete.The cement is replaced at ten,twenty and thirty percentages.In this report size effect of glass powder is divided in to two grades one is glass powder having size less than ninety micron and another is glass powder having particle size ranges from ninety microns to one hundred and fifty microns.It is resulted that the initial strength which is obtained from the addition of glass powder is very less on seventh day.But,it increases on the twenty eighth day**.**It is obtained that twenty percentage addition of glass powder gives higher strength. The glass powder size less than ninety microns is very effective in resulting of high strength.

The initial gain of strength is low on starting but it meet's desired strength on 28th day on addition of waste glass powder as replacement of cement.At the replacement of 20% the glass powder meets the maximum strength as compared to that of with normal concrete and percentages like 10%,30%.The particle size impact will be there in concrete.It is concluded that if the particle size of the glass powder decreases in concrete then the concrete strength increases.It is also concluded that particle size which is less than 90 microns has resulted high strength than the particle size ranged from 90 to 150 microns.

CHAPTER 3

MATERIALS AND METHODOLOGY

Concrete is a mixture of materials like cement,water,fine and coarse aggregate.These are the materials used as follows:

3.1) CEMENT:-

Cement is a material is used as binder in concrete. Cement is the most important and useful material in concrete.Cement is a material used in making concrete.Cement is a substance which is used for hardening purpose and binding of other materials.Cement is used in construction can be divided into two types.one is hydraulic and another one is non hydraulic,which is used depending upon the ability of water. Cement used was manufactured by ACC.Pozzolona Portland cement which has fourty three grade is used.Cement has the specific gravity of 3.15.

3.1.1 CHEMICAL PROPERTIES OF CEMENT:-

As per the manufacturer chemical composition certificate the composition of cement used is listed in table 3.1

Table 3.1:- Chemical properties of cement

Chemical properties	
Silicon di oxide (SiO2)	20.3(%)
Aluminum oxide (Al2O3)	6.3
Iron Oxide (Fe2O3)	3.12
Calcium Oxide (CAO)	63.6
Magnesium Oxide (MGO)	1.6
Sodium Oxide (Na2O)	0.4
Potassium Oxide (K2O)	0.51
Loss of ignition	1.13

3.2 FINE AGGREGATES AND COARSE AGGREGATES:-

As to make concrete mould,fine and coarse aggregate are used.Sand is used as fine aggregates with maximum sieve size of 4.75mm and coarse aggregates sizes of 4.75mm to 20mm is used.The reason for using of fine and coarse aggregates in concrete is that the voids in coase aggregate is filled with fine aggregates and the bonding will give good strength.

3.2.1 PHYSICAL PROPERTIES OF,FINE AGGREGATES AND COARSE AGGREGATES:-

The properties mentioned below were taken as per IS 10262:2009.

Table 3.2:-Physical properties of fine and coarse aggregates

Properties	Fine aggregate	Coarse aggregate
Specific gravity	2.645	2.56

3.2.2 SIEVE ANALYSIS OF SAND:

For thiesis,ACC plant sand is used as fine aggregates with maximum sieve size of 4.75mm.

Table 3.3:-Sieve analysis of Sand

Sieve Sizes (mm)	Retained on sieve (gm)	Cumulative weight retained	Cumulative % weight retained
4.75	0	0	100
2.36	0	0	100
1.18	0	0	100
0.6	10	10	94
0.3	25	35	80
0.15	405	440	70
0.075	45	485	15
Pan	15	500	0

3.2.3 SIEVE ANALYSIS OF COARSE AGGREGATES:

For thiesis, ACC plant coarse aggregates sizes of 4.75mm to 20mm is used.

Table 3.4:-Sieve analysis of Coarse aggregates

Sieve sizes (mm)	Retained on sieve (gm)	Cumulative weight retained	Cumulative % weight retained
50	0	0	0
40	0	0	0
31.65	130	130	100
20	1455	1755	72
10	1159	2914	44
4.75	1595	4509	32
Pan	335	5000	0

3.3 WASTE GLASS POWDER:-

Glass is a material which is produced by melting of materials like caco3,silica and soda ash by high temperatures and cooling process is followed after melting of materials.By cooling process,solidification will occur without crystallization.In our daily life glass is mostly manufactured and used as products like sheet glass,bottles and glass ware,etc.The usage of glass products in our day to day life gradually increased over the last decade. Glass is used many ways in our day to day life and it has limited span and after use it has to sent to landfills.Since the glass is non-biodegradable, landfills do not provide eco-friendly, so there is a strong reason to utilize waste glass as replacement in concrete as replacement of cement or sand.Glass powder is divided into two groups.They are,first group the particle size less than 75 microns(fig.3.1) and second group is glass powder particle size from 75 microns to 300 microns (fig.3.2).

Figure 3.1. Glass powder particle size less than 75 microns

Figure 3.2. Glass powder particle size From 75 micron to 300 micron.

Table 3.5:-Chemical properties of glass powder and cement

S r .No	**Properties (%)**	**Waste Glass Powder(GLP)**	**Cement**
1	SiO2	70.22	23.71
2	Cao	11.13	57.27
3	MGO	-	3.85
4	Al2O3	1.64	4.51
5	Fe2O3	0.52	4.83
6	So3	-	2.73
7	Na2O	15.29	-
8	K2O	-	0.37
9	Cl	-	0.0068
10	Loss on ignition	0.80	7.24

3.4 METHODOLOGY:

Based upon the literature reviewed in above papers,Waste glass powder affects the mechanical properties of concrete according to the percentage of replacement of cement in concrete.Mix design of M25 is used.

- After finding of Physical properties, the **mix design** can be done for grade **M25** by using Indian Standard method IS10262(2009)
- The cement, water and aggregates weights can be derived by mix design.
- The cement will be replaced by Waste glass powder by **5%, 15% and 25%** respectively.

3.4.1 MIX DESIGN:-

Concrete mix design in this investigation was designed as per the guidelines specified in IS10262(2009) "Guide lines for selecting proportions for high strength concrete with Portland cement and other cementations materials". Three concrete mixtures with different proportions of Glass powder ranging from 5% to 25%.The mix proportions were calculated and presented in table below.

Maximum size of aggregates = 20mm

Specific gravity of coarse aggregate = 2.56

Specific gravity of fine aggregate = 2.64

Specific gravity of cement = 3.15

As per the guidelines given in the code IS10262 (2009), mix design for M70 grade concrete had done and the proportions are given as follows:

Cement = 437 kg per cubic meter

Water = 197 kg per cubic meter

Fine aggregate = 673.29 kg per cubic meter

Coarse aggregate = 1053.26 kg per cubic meter

Chemical admixture = 7 kg per cubic meter

W/C ratio = 0.45

Mix proportions for various replacements of cement with rice GLP are given in table below:

Table 3.6:-Mix Design

Mixes	**Normal Mix**	**Cement : GLP (by weight) 95%:05%**	**Cement : GLP (by weight) 85:15**	**Cement : GLP (by weight) 75: 25%**
W/C ratio	**0.45**	**0.45**	**0.45**	**0.45**
Cement(kg/m3)	**437**	**415.15**	**371.45**	**327.75**
Water(litre)	**197**	**197**	**197**	**197**
Coarse aggregate(kg/m3)	**1053.26**	**1053.26**	**1053.26**	**1053,26**
Fine aggregates(Kg/m3)	**673.29**	**673.29**	**673.29**	**673.29**
Waste Glass Powder	**-**	**21.85**	**65.55**	**109.25**

3.4.2 CASTING AND CURING OF TEST SPECIMENS:-The specimen of standard cubes were used to determine the compressive strength of concrete. Three specimens were tested for 7, 14 & 28 days with each proportion of Waste glass powder replacement.For each measured quantities of coarse aggregate and fine aggregate was spread in a pan, the Pozzolana Portland cement (43Grade) and Waste glass powder were spread out over it,water was measured by considering the water binder ratio as 0.45.The concrete was thoroughly mixed until it achieved homogeneous sand uniform consistency.The fresh concrete was cast in cubes and was compacted by tamping rod.All freshly cast specimens were left in 24 hours before being demolded.The remolded specimens were cured in water for 7, 14 and 28 days, were air dried and then tested for its compressive strength as per Indian standards.The Casting of members as follows:

Cubes – **150 mm X 150 mm X 150 mm.**

(3 cubes for each age of curing and then average value would be taken)

3.4.3 TESTING OF CASTED SPECIMENS:-The cubes would be tested in Compressive Testing Machine (CTM)to obtain compressive strength values.The cube specimen was placed in the machine,of 2000kN capacity.The load was applied at a rate of approximately 140 kg/sq.cm/min until the resistance of the n to the increasing load can be sustained.

Figure 3.3:-Compressive strength machine

CHAPTER 4

EXPERIMENTAL WORK AND LABORATORY INVESTIGATION

The specimen of standard cubes were used to determine the compressive strength of concrete. Three specimens were tested for 7, 14 & 28 days with each proportion of Waste glass powder replacement.For each measured quantities of coarse aggregate and fine aggregate was spread in a pan, the Pozzolana Portland cement (43 Grade) and Waste glass powder were spread out over it, water was measured by considering the water binder ratio as 0.45.The concrete was thoroughly mixed until it achieved homogeneous sand uniform consistency.The fresh concrete was cast in cubes and was compacted by tamping rod.All freshly cast specimens were left in 24 hours before being remolded. The remolded specimens were cured in water for 7, 14 and 28 days, were air dried and then tested for its compressive strength as per Indian standards.

Figure 4.1:-Casting of Cubes

Figure 4.2:-Moulding Of Cubes

Figure 4.3:-Curing Of cubes

4.1 EXPERIMENTAL INVESTIGATION:-

4..1 RESULTS FOR GLP SIZE BELOW 75 MICRONS:-

The cubes are removed from curing tank and place aside upto thirty minutes for drying of moisture.Then the cubes are tested with compressive testing machine.The values obtained are as follows:

Table 4.1:- Results for glass powder particle size below 75 microns

S.No	M25 Concrete Mix(% of cement: % of glass powder) for 75 Microns	Cube Compressive Strength (150*150*150)mm		
		7 Days	14 Days	28 Days
1	M25 Normal	17.27	21.74	30.56
2	M25 (95:5)	17.67	23.52	32.25
3	M25 (85:15)	18.98	25.81	36.57
4	M25 (75:25)	17.73	24.62	34.63

4.1.2 RESULTS FOR GLP SIZE FROM 75 TO 300 MICRONS:-

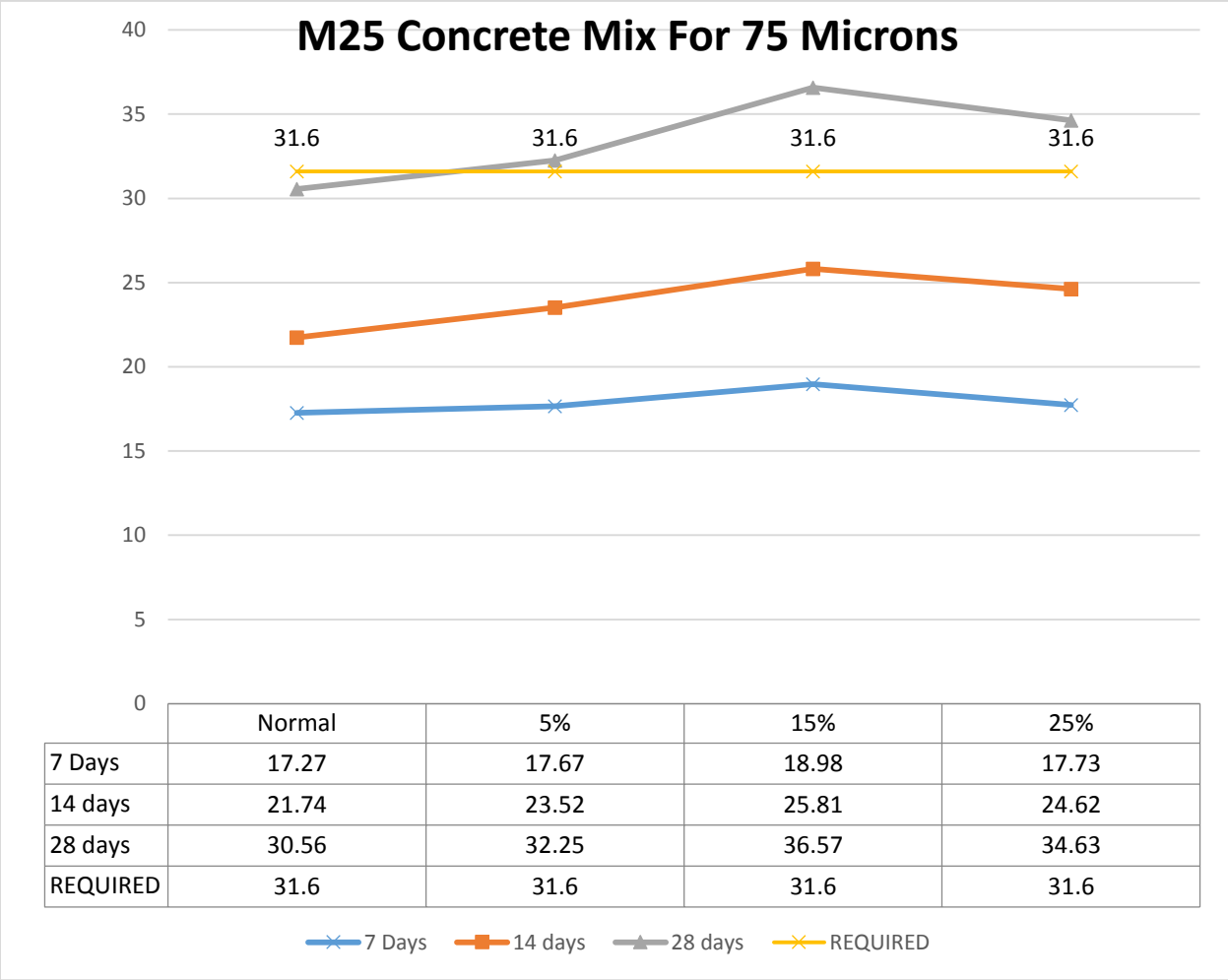
The cubes are removed from curing tank and place aside upto thirty minutes for drying of moisture.Then the cubes are tested with compressive testing machine.The values obtained are as follows:

Table 4.2:- Results for glass powder particle size from 75 to 300 microns

S.No	**M25 Concrete Mix(% of cement:% of glass powder) for 75 to 300 Microns**	**Cube Compressive Strength (0.15*0.15*0.15)m**		
		7 Days	14 Days	28 Days
1	M25 Normal	**17.27**	**21.74**	**30.56**
2	M25 (95:5)	**19.26**	**23.86**	**31.25**
3	M25 (85:15)	**20.48**	**24.92**	**32.46**
4	M25 (75:25)	**18.62**	**22.57**	**31.49**

4.2 LABORATARY INVESTIGATION IN GRAPH:-

4.2.1RESULTS FOR GLP SIZE BELOW 75 MICRONS:-

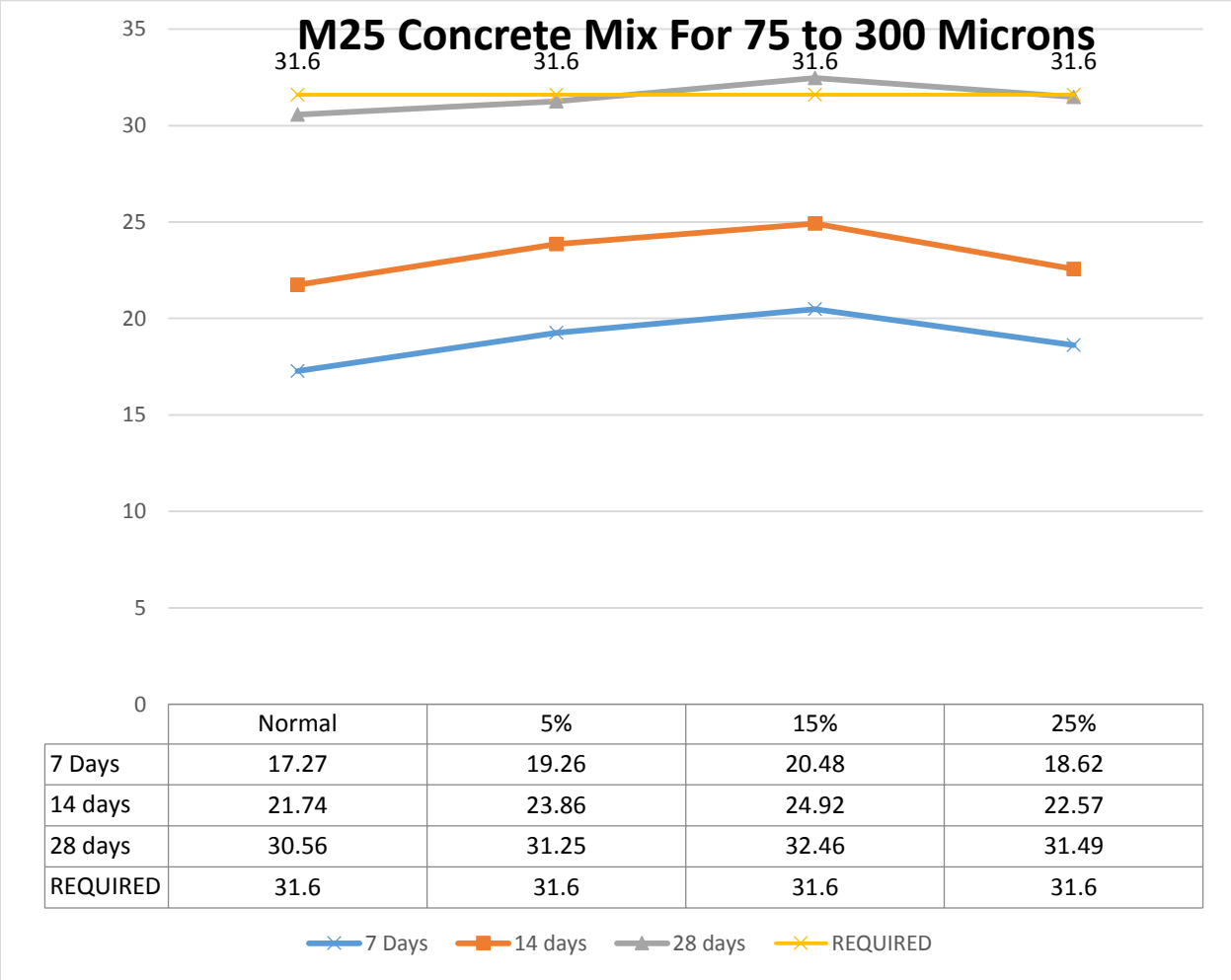


	Normal	5%	15%	25%
7 Days	17.27	17.67	18.98	17.73
14 days	21.74	23.52	25.81	24.62
28 days	30.56	32.25	36.57	34.63
REQUIRED	31.6	31.6	31.6	31.6

Figure 4.1:-Graph for M25 concrete mix for 75 microns

For M25 concrete mix which is replaced with waste glass powder as cement gets the values mentioned above.For waste glass below 75 microns,the percentages of compressive strength for 7 days of 5%,15%,25% replacement of glass powder with cement are 2.32%,7.42%,2.67%.For 14 days,the percentages are 8.19%,18.73%,13.25% and for 28 days,the percentages are 5.54%,19.67%,13.32%.The maximum value of compressive strength observed for 28 days aged concrete at replacement of 15% of cement with that of glass powder and the value is 36.57 Mpa. The normal concrete has shown the value 30.56 Mpa and is increased by 19.67%.

4.2.2 RESULTS FOR GLP SIZE FROM 75 TO 300 MICRONS:-



	Normal	5%	15%	25%
7 Days	17.27	19.26	20.48	18.62
14 days	21.74	23.86	24.92	22.57
28 days	30.56	31.25	32.46	31.49
REQUIRED	31.6	31.6	31.6	31.6

Figure 4.2:-M25 concrete mix for GLP size from 75 to 300 microns

For M25 concrete mix which is replaced with waste glass powder as cement gets the values mentioned above.For waste glass from 75 to 300 microns,the percentages of compressive strength for 7 days of 5%,15%,25% replacement of glass powder with cement are 11.53%,18.58%,7.82%.For 14 days,the percentages are 9.76%,14.63%,3.81% and for 28 days,the percentages are 2.26%,6.22%,3.05%.The maximum value of compressive strength observed for 28 days aged concrete at replacement of 15% of cement with that of glass powder and the value is 32.46 Mpa. The normal concrete has shown the value 30.56 Mpa and is increased by 6.22%.

CHAPTER 5

CONCLUSION AND FUTURE SCOPE

5.1 CONCLUSION:-

The initial gain of strength is low on starting but it meet's desired strength on 28th day on addition of waste glass powder as replacement of cement.At the replacement of 15% the glass powder meets the maximum strength as compared to that of with normal concrete and percentages like 5%,25%.The particle size impact will be there in concrete.It is concluded that if the particle size of the glass powder decreases in concrete then the concrete strength increases.It is also concluded that particle size which is less than 75 microns has resulted high strength than the particle size ranged from 75 to 300 microns.

5.2 FUTURE SCOPE OF STUDY:-

As waste materials are most versatile substances on Earth,as it produced in wide variety of forms.The waste materials are easily recycled and used as many purposes by the humans.As the waste materials are recycled as produced, then it is eco-friendly to use it.Glass is one the most versatile substances on Earth,used in many applications and in a wide variety of forms, from plain clears glass to tempered and tinted varieties, and so forth.Irrespective of the nature of their products, almost all industries produce waste.Effective disposal of wastes therefore is a challenging task.In olden days solid wastes were used as landfills in low-lying areas.Waste disposal in landfill sites however are unsustainable in the long run. Industrial wastes like fly ash,silica fume,blast furnace slag etc. and other wastes of plastics,glass,tiles and agriculture are causing environmental pollution.Recycling of wastes is therefore emerging as an important component of technology for making contribution towards sustainability.

CHAPTER 6

REFERENCES

a. Experimental Investigations in Developing Concrete Containing Waste Glass Powder as Pozzolana by M.N.Bajad and C.D.Modhera (ISSN: 0975-6754,Nov 10 to Oct11,Volume1,Issue.

b. Studies on Glass Powder as Partial Replacement of Cement in Concrete by Dr.G.Vijayakumar,Ms.H.Vishalina,Dr.D.Govindarajulu,(ISSN:2250-2459,Volume.3,Issue2. February 2013).

c. Experimental Investigation Of Waste Glass Powder As Partial Replacement Of Cement In Concrete by Dhanaraja Mohan Patil,Dr.Keshav K.Sangle**y(**ISSN:0964-6733,Oct 08 to Nov 11,Volume 2,Issue.1).Ahmad Shayan "Value Added Utilization of Waste Glass in Concrete" IABSE Symposium Melbourne,2002,p.p.1-12.

Craig Polley Steven M.Cramera and rodolfos vde lay cruzz "Potential For Using Waste Glass In Portland Cement Concrete"Cement and Concrete Research,2008 Vol.36,p.p.489–532.

Narayanan Neithalath "An Overview Of The Benefits Of theUsing Glass Powder As Partial Cement Replacement Material In Concrete" Indian Concrete Journal,2011.

Nathan Schwarzz,Hieuu Cam,Naraayanana neiithalath "Influence of a fine glass powder on the durability characteristics of concrete and its comparison to fly ash"Cement & Concrete Composites 2008,Vol.29,p.p.486–495.

R.Idir, M.Cyr,A.Tagnit-Hamou "Use Of Waste Glass As Powder as And Aggregate In Cement-Based Materials" 1st International Conference on Sustainable Built Environment Infrastructures in Developing Countries ENSET Orana fromAlgeria,2009,p.p.109-115.

Victor Shevchenko and Wojciech Swierad "A Mechanism of Portland Cement Hardening In The Presence Of Finely Grained Glass Powder" Journal of Chemistry and Chemical Technology 2007,Vol.2, No.4,p.p.179-194.

31: