EXPRIMENTAL INVESTIGATION ON STRENGTH AND DURABILITY PARAMETERS OF CONCRETE REPLACING CEMENT BY GLASS POWDER IN CONCRETE WITH DIFFERENT DOSAGES FOR M25 AND M30 CONCRETE

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ABSTRACT

Concrete is commonly used as the main component in a building. Concrete is obtained by mixing Portland cement, water, aggregates, and sometimes added ingredients at certain comparisons in the form of chemicals, fibrous materials, and non-chemical materials. Utilization of glass powder waste for concrete mixtures is now being developed. This research is conducted to determine the optimum composition of glass powder as a partial replacement of sand against the compressive strength of concrete. The content of the glass powder mixture used is 10%, 20%, 30% & 40% of the weight of sand in the concrete mixture.

This research focuses on studying the effect of waste glass on the properties of concrete mixture as a partial replacement of cement large studies undertaken to resolved the alkali silica reaction problems. Replacing cement by material like waste glass powder in concrete is increase the strength and introduces economy but also enhances the durability,

Keywords – Glass powder, Ordinary Portland Cement, Coarse aggregate & Fine aggregates.

INTRODUCTION

Concrete is one of the world's most used construction material due to its versatility, durability and economy. India uses about 7.3 million cubic meters of ready-mixed concrete each year.

It finds application in highways, streets, bridges, high-rise buildings, dams etc. Green house gas like CO2 leads to global warming and it contributes to about 65% of global warming. The global cement industry emits about 7% of green house gas to the atmosphere. To reduce this environmental impact alternative binders are introduced to make concrete.

Concrete is a blend of cement, sand, coarse aggregate and water. The key factor that adds value to concrete is that it can be designed to withstand harshest environments significant role.

Today global warming and environmental devastation have become manifest harms in recent years, concern about environmental issues, and a changeover from the mass-waste, mass consumption, mass-production society of the past to a zero-emanation society is now viewed as significant. Normally glass does not harm the environment in any way because it does not give off pollutants, but it can harm humans as well as animals, if not dealt carefully and it is less friendly to environment because it is non-biodegradable. Thus, the development of new technologies has been required.

Glass Powder

- Glass is an amorphous (non-crystalline) that in essence, a super cooled liquid and not a solid. Glass can be made with excellent homogeneity in a variety of forms and sizes from small fibers to meter-sizes pieces
- Primarily glass is made up of sand, soda ash, limestone and other additives (Iron, Chromium, Alumina, Lead and Cobalt).
- Glass has been used as aggregates in construction of road, building and masonry materials

Source of Glass

- Sand is filtered through three different size screens having three different size.
- The finest sand makes the finest glass the
- largest sand makes the strongest glass.
- Sand is melted in crucible to make glass.

Source of Waste Glass

- Glass food and beverages container.
- Window repair shops
- Glass decorative items
- Old tube lights, electric bulbs
- Glass polishing and glass window and door manufacturing shop

LITERATURE REVIEW

A. Recycled Glass as a Partial Replacement For Fine Aggregate In Self Compacting Concrete:

1. Esraa Emam Ali, Sherif H. Al-Tersawy 2012 Glass has been indispensable to man's life due to its properties, including pliability to take any shape with ease, bright surface, resistance to abrasion, reasonable safety and durability. Waste glass creates serious environmental problems, mainly due to the inconsistency of waste glass streams. With increasing environmental pressure to reduce solid waste and to recycle as much as possible, the concrete industry has adopted a number of methods to achieve this goal. Self-Compacting Concrete (SCC) may lead to evolution of a more quality controlled concrete, assuring a better workability and avoiding human errors with regard to mixing and workability issues. On the other hand, it resolves the problem of noise and vibration during installation.
2. High-volume natural volcanic pozzolan and limestone powder as partial replacements for portland cement in self-compacting and sustainable concrete.K. Celik , , M.D. Jackson, 2014 A laboratory study demonstrates that high volume, 45% by mass replacement of portland cement (OPC) with 30% finely-ground basaltic ash from Saudi Arabia (NP) and 15% limestone powder (LS) produces concrete with good workability, high 28-day compressive strength (39 MPa), excellent one year strength (57 MPa), and very high resistance to chloride penetration. Conventional OPC is produced by intergrading 95% portland clinker and 5% gypsum, and its clinker factor (CF) thus equals 0.95. With 30% NP and 15% LS portland clinker replacement, the CF of the blended ternary PC equals 0.52 so that 48% CO2 emissions could be avoided, while enhancing strength development and durability in the resulting self-compacting concrete (SCC).
3. Performance of dry cast concrete blocks containing waste glass powder or polyethylene aggregates S.E. Chidiac, , S.N. Mihaljevic 2011

   Dry-cast concrete blocks are a popular building material; however, to improve the economic and environmental sustainability of this industry, its dependence on natural aggregate and Portland cement needs to be reduced. To further this goal, blocks with up to 25% of the cement replaced with waste glass powder (WGP) or up to 15% of the sand replaced with high density polyethylene (HDPE) or low density polyethylene (LDPE) polymer pellets were produced in an industrial plant. The physical, mechanical and durability properties of the individual blocks and the mechanical properties of the block assemblages were tested. Based on statistical analyses, the blocks with 10% WGP as cement replacement performed similarly to the control blocks.

B. Recycled Glass Concrete K. Zheng 2013:

1. The chapter begins by introducing sources of waste glass and ways of recycling waste glass in concrete. It then summarizes fresh properties and mechanical properties of recycled glass concrete and discusses how recycled waste glass affects these properties. The chapter elaborates on durability of recycled glass concrete, especially on alkali-silica reactivity since this is the main concern for recycled glass concrete. Finally, the chapter presents suggestions for further studies on recycled glass concrete, and proposes future trends of using recycled glass in concrete in more economic and eco-efficient

C. **Durability of Mortar Using Waste Glass Powder As Cement Replacement**: Ana Mafalda Matos, , Joana Sousa-Coutinho2012 . It is well known that Portland cement production is an energy-intensive industry, being responsible for about 5% of the global anthropogenic carbon dioxide emissions worldwide. An important contribution to sustainability of concrete and cement industries consists of using pozzolanic additions, especially if obtained from waste such as waste glass.Crushed waste glass was ground (WGP) and used in mortar as a partial cement replacement (0%, 10% and 20%) material to ascertain applicability in concrete.An extensive experimental program was carried out including pozzolanic activity, setting time, soundness, specific gravity, chemical analyses, laser particle size distribution, X-ray diffraction and scanning electron microscopy (SEM) on WGP and resistance to alkali silica reaction (ASR), chloride ion penetration resistance, absorption by capillarity, accelerated carbonation and external sulphate resistance on mortar containing WGP.Glass particles well encapsulated into dense and mature gel observed by SEM, may help explaining enhanced durability results and thus confirming that waste glass powder can further contribute to sustainability in construction

D. **Shilpa Raju, Dr. P. R. Kumar** presented the global warming is caused by the emission of green house gases, such as CO_2, to the atmosphere. Among the greenhouse gases, CO_2contributes about 65% of global warming. The global cement industry contributes about 7% of greenhouse gas emission to the earth’s atmosphere. Consequently efforts have \been made in the concrete industry to use waste materials as partial replacement of coarse or fine aggregates and cement. Waste glass is one materials when ground to a very fine powder shows pozzolanic properties which can be used as a partial replacement for cement in concrete. In this paper, an attempt has been made to find out the strength of concrete containing waste glass powder as a partial replacement of cement for concrete. Cement Replacement by glass powder in the range 5% to 40% increment of 5% has been studied. It was tested for compressive strength and flexural strength at the age of 7, 28 and 90 days and compared with those of conventional concrete. Results showed that replacement of 20% cement by glass powder was found to have higher strength. Also alkalinity test was done to find out resistance to corrosion.

E. J.M. Khatib, E.M. Negim, H.S. Sohl and N. Chileshe were presented in this paper investigates the performance of concrete containing glass powderas partial substitution of cement. Portland cement (PC) was partially replaced with 0-40% glass powder. Testing included ultrasonic pulse velocity,compressive strength and absorption. Specimens were cured in water at 20°C. The results indicate that the maximum strength of concrete occurs at around 10% glass powder. Beyond 10% glass powder the strength of concrete reduces and is lower than that of the control Using ground glass powder can reduce the use of cement and the associated energy demend and impact on air pollution and CO2 emission. The slump of concrete seems to increase with the increase in glass powder in the concrete mix. At 10% glass powder content the compressive strength of concrete is higher than that of substantially decreases

F. Gunalaan Vasudevan, Seri Ganis Kanapathy pillay were presented in 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.

G. Dhanaraj mohan patil , Dr. Keshav , K.Sangle were explained the concrete is a construction material composed of cement, aggregates (fine and coarse aggregates) water and admixtures. Today many researches are ongoing into the use of Portland cement replacements, using many waste materials like pulverized fly ash (PFA) and ground granulated blast furnace slag (GGBS). Like PFA and GGBS a waste glass powder (GLP) is also used as a binder with partial replacement of cement which take some part of reaction at the time of hydration, also it is act as a filler material. In this study, waste glass powders have been used as replacements to the concrete ingredient i.e. cement and the mechanical properties like compressive strength are measured. Also we were studied the size effect of glass powder on strength of concrete. For checking strength effect of replacement of cement by glass powder, the cement is replaced at 10%, 20% and 30%. For study of size effect of glass powder the powder is divided in to two grades one is glass powder having size less than 90 micron and another is glass powder having particle size ranges from 90 micron to 150 micron. It is found from study, Initial strength gain is very less due to addition of GLP on 7th day but it increases on the 28th day. It is found that 20% addition of GLP gives higher strength. And also GLP size less than 90 micron is very effective in enhancement of strength.

AIM & OBJECTIVE

AIM :- Partial replacement of fine aggregate by glass powder to enhance the strength of the concrete.

OBJECTIVE :-

1. To evaluate the utility of glass powder as a partial replacement of fine aggregate in concrete.
2. To study and compare the performance of the conventional concrete and glass powder concrete.
3. To understand the effectiveness of glass powder in strength enhancement**.**
4. To determine the percentage of glass powder which gives maximum strength when compared to control concrete.

METHODOLOGY

1. MATERIALS AND PROPERTIES

Basically concrete is a versatile engineering material which can be mould in to wide verities of shapes when in wet condition. Concrete is a mixture of cement, fine aggregates, coarse aggregates, water, and admixture (if any). The red mud concrete is a mixture of cement, fine aggregates, coarse aggregates, water.

I. **Cement**

Cement is one of the binding materials in this project. Cement is the important building material in today's construction world 53 grade Ordinary Portland Cement (OPC) conforming to ([17] IS: 8112-1989). Table 3.1 gives the properties of cement used. Cement is a binder, a substance used in construction that sets and hardens and can bind other materials together. The most important types of cement are used as a component in the production of mortar in masonry, and of concrete, which is a combination of cement and an aggregate to form a strong building material. Cements used in construction can be characterized as being either hydraulic or non-hydraulic, depending upon the ability of the cement to set in the presence of water (see hydraulic and non-hydraulic lime plaster). Non-hydraulic cement will not set in wet conditions or underwater; rather, it sets as it dries and reacts with carbon dioxide in the air. It can be attacked by some aggressive chemicals after setting. The chemical reaction results in mineral hydrates that are not very water-soluble and so are quite durable in water and safe from chemical attack. This allows setting in wet condition or underwater and further protects the hardened material from chemical attack

Cement

II. Fine aggregate

It is the aggregate most of which passes 4.75 mm IS sieve and contains only so much coarser as is permitted by specification. According to source fine aggregate may be described as:

1. Natural Sand– it is the aggregate resulting from the natural disintegration of rock and which as been deposited by streams or glacial agencies
2. Crushed Stone Sand– it is the fine aggregate produced by crushing hard stone.
3. Crushed Gravel Sand– it is the fine aggregate produced by crushing natural gravel.

According to size the fine aggregate may be described as coarse sand, medium sand and fine sand. IS specifications classify the fine aggregate into four types according to its grading as fine aggregate of grading Zone-1 to grading Zone-4. The four grading zones Crushed aggregate is a maximum size of 20 mm and normal grading. The specific gravity of the coarse aggregates of 2.73 was used. The sieve analysis of coarse and fine aggregates is confirmed to IS10262

Fine aggregate

Become progressively finer from grading Zone-1 to grading Zone-4. 90% to 100% of the fine aggregate passes 4.75 mm IS sieve and 0 to 15% passes 150 micron IS sieve depending upon its grading zone

III. Coarse aggregate:

It is the aggregate most of which is retained on 4.75 mm IS sieve and contains only so much finer material as is permitted by specification. According to source, coarse aggregate may be described as:

1. **Uncrushed Gravel or Stone**– it results from natural disintegration of rock
2. **Crushed Gravel or Stone–** it results from crushing of gravel or hard stone**.**
3. **Partially Crushed Gravel or Stone**– it is a product of the blending of the above two aggregate. According to size coarse aggregate is described as graded aggregate of its nominal size i.e. 40 mm, 20 mm, 16 mm and 12.5 mm etc. for example a graded aggregate of nominal size 20mm means an aggregate most of which passes 20 mm IS sieve. A coarse aggregate which has the sizes of particles mainly belonging to a single sieve size is known as single size aggregate. For example 20 mm single size aggregate mean an aggregate most of which passes 20 mm IS sieve and its major portion is retained on 10 mm IS sieve.

Coarse aggregates

IV. GLASS POWDER: - Glass is an amorphous & transparent material, which is super-cooled liquid and not a solid. Glass can be made verity of forms and sizes from small fiber to meter-sizes pieces. Primarily glass is produced by melting a mixture of materials such as silica, $CaCO_3$, and soda ash at high temperature followed by cooling during which solidification occurs without crystallization. Glass has been used as aggregates in road construction, masonry and building materials. Before adding glass powder in the concrete it has to be powdered to wanted size. Glass powder is obtained from Crushing of glass Pieces. A Glass powder can be used as cement replacement material up to particle size less than 90μm**.**

Glass Powder

2. CONCRETE SPECIMENS

Mixing Process

The mixing process was done using an electrically operated concrete mixer of 0.04 m3 capacity. The concrete making and mixing in the laboratory was done with accordance to ASTMC-192. The batching procedure was as follows:

1) Add coarse, fine aggregate mixing for about 2-3 minutes.

2) Add cement than mixing for about 1-2 minutes.

3) Add approximately two-thirds of water slowly and mix for 2-3minutes.

4) Add fiber with water than mixing for 2-3 minutes.

Fig 2.1. Concrete Specimen

Workability of Concrete by Slump Test

The concrete slump is a empirical slump test that measures the workability of fresh concrete. More specifically, it measures the consistency of the concrete is that specific batch. This test is performed to check the consistency of freshly made concrete.

Apparatus

- Metallic mould in the shape of a frustum of cone having bottom diameter 20 cm (8 in.), top diameter 10 cm (4 in.) and height 30 cm (12in.).

- Steel tamping rod having 16 mm (5/8 in.) diameter, 0.6 m (2 ft.) long with bullet end.

Fig. 2.1.2 Slump Cone

3. Curing of Concrete Specimens

- The concrete specimens in the moulds were removed after the fresh concrete in the moulds had been allowed to set during the previous night.
- For the test of concrete's hardened qualities, all the concrete specimens were put into a curing tank after 24 hours at a regulated temperature of 25 ºC for further 7 & 28 days.
- Due to time constraints, some of the cubes were cured in the accelerated curing tank.
- Curing is a crucial step in ensuring that concrete specimens don't lose moisture while they develop the necessary strength. Lack of healing will result in inappropriate strength gain.
- The concrete samples were taken from the curing tank after 28 days in order to examine the hardened properties of Conventional and Bacterial Concrete.

Fig: 3. Curing of Concrete Specimen

3.1.1 Compressive Strength Test

The compressive strength of concrete is given in terms of the characteristic compressive strength of 150×150×150 mm size cubes tested at 28 days as per Indian Standards. The characteristic strength is defined as the strength of the concrete below which not more than 5% of the test results are expected to fall.

A characteristic strength of concrete is the strength of concrete specimens casted and tested as per given code of practice and cured for a period of 28 days; 95% of tested cubes should not have a value less than the specified value.

3.1.1Compressive Strength Test

3.1.2. Split Tensile Strength Test

One of the important properties of concrete is "tensile strength" as structural loads make concrete vulnerable to tensile cracking. Tensile strength of concrete is much lower than its compressive strength (that's why steel is used to carry the tension forces). It has been estimated that tensile strength of concrete equals roughly about 10% of compressive strength. To determine the tensile strength, indirect methods are applied due to the difficulty of the direct method. Note that the values obtained of these methods are higher than those got from the uniaxial tensile test.

3.1.2 Split Tensile Strength Test

6.2.1 Flexural Strength Test

7 Flexural tests evaluate the tensile strength of concrete indirectly. It tests the ability of unreinforced concrete beam or slab to withstand failure in bending. The results of flexural test on concrete expressed as a modulus of rupture which denotes as (*MR*) in MPa or psi. The flexural test on concrete can be conducted using either three-point load test (ASTM C78) or center point load test (ASTM C293). It should be noticed that the modulus of rupture value obtained by center point load test arrangement is smaller than three-point load test configuration by around 15 percent.

Fig: 6.2.3 Flexural Strength Test

4. MIX DESIGN

FOR M25

Summary

1. Cement - 350 kg/m3
2. Water - 157.6 kg/m3
3. Fine Aggregate - 775 kg/m3
4. Coarse Aggregate - 1127 kg/m3 (20mm -60%& 10mm – 40 %)
5. Admixture - 3.85 kg/m3 (1.1% of cement)
6. Water Cement Ratio - 0.45

The Mix Proportions Then Becomes

Cement	Fine Aggregate	Coarse Aggregate	Water
350	775	1127	157.6
1	2.2	3.22	0.45

RATIO - 1: 2.2:3.22

FOR M30

Summary

1. Cement - 394 kg/m3
2. Water - 157.6 kg/m3
3. Fine Aggregate - 791 kg/m3
4. Coarse Aggregate - 1068 kg/m3 (20mm -60%& 10mm – 40 %)
5. Admixture - 4.334 kg/m3 (1.1% of cement)
6. Water Cement Ratio - 0.4

Cement	Fine Aggregate	Coarse Aggregate	Water
394	**791**	**1068**	**157.6**
1	**2.00**	**2.71**	**0.4**

5. RECOMMENDED MIX DESIGN
IS Code – 10262 – 2019 by field work

Following mixes are recommended for concreting

Sr. No	Properties	M25	M30
1	Mix proportion (by weight)	1 : 2.2 : 3.22	1 : 2 : 2.71
2	Water cement ratio	0.45	0.4
3	Cement	350 kg / cum	394 kg/cum
4	Fine Aggregate	775 kg / cu.m	791 kg/cum
5	Coarse Aggregate	1127 kg / cu.m	1068 kg/cum
7	Water Absorption of CA @ 0.9 %	10.14 lit /cum	96.1 lit /cum
8	Water Absorption of FA @ 1.1 %	8.52 lit /cu.m	8.70 lit /cum
	TOTAL WATER CONTENT	157.6 Lit/ cu.m	157.6

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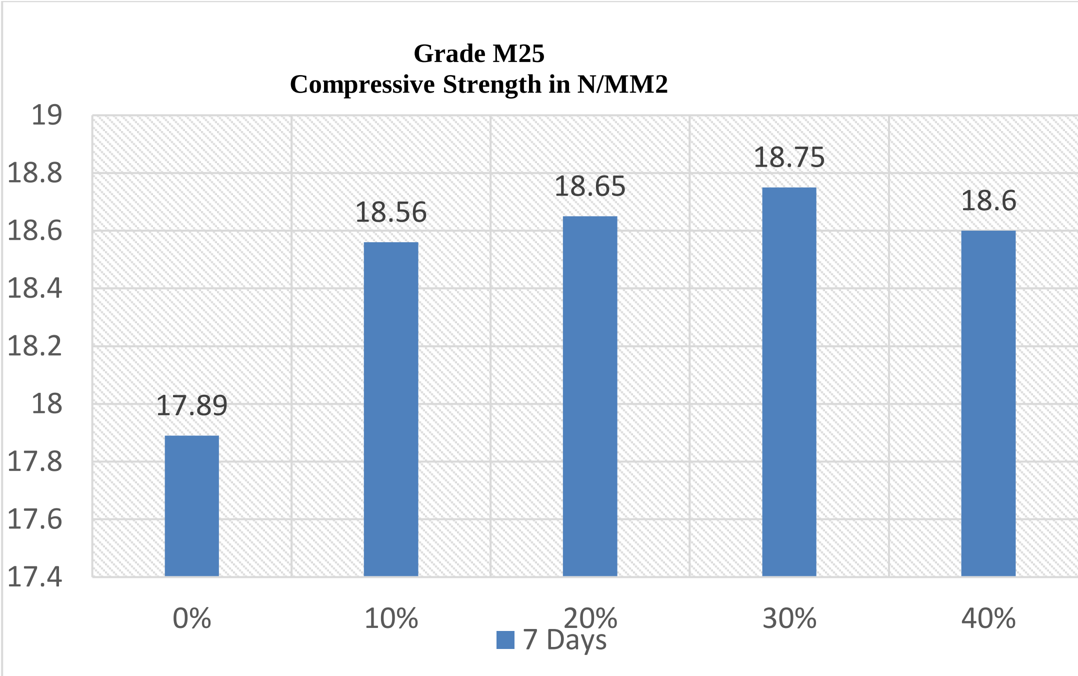
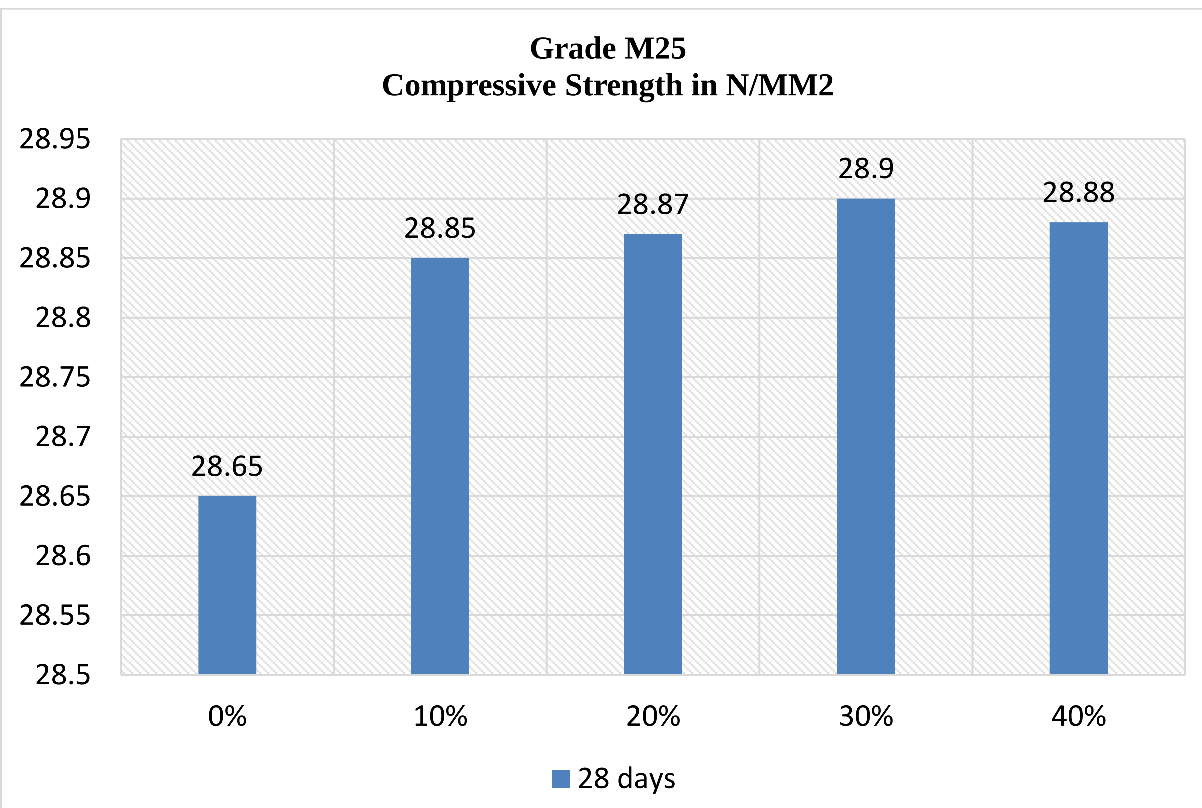
RESULT

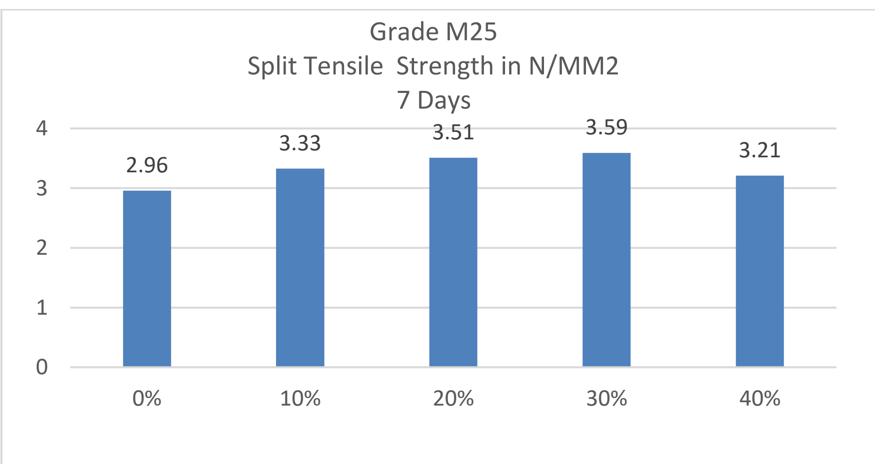
Test result on the specimen shows there is improvement in compressive strength because of continuous increase of waste glass powder. The strength increases with addition of waste glass powder at 10% 20%,30% and after that declines at 40% gradually because of more alkali silica reaction freed during hydration of cement.

GRADE 25 COMPRESSIVE STRENGTH IN N/MM2					
Sr. No.	**% of Glass Powder Replacing in Cement**	**Compressive Strength in N/mm2**		**Average Compressive Strength in N/mm3**	
		7 Days	28 Days	7 Days	28 Days
1	0%	17.85	28.28	17.77	28.65
		17.9	28.68		
		17.56	28.99		
2	10%	18.3	28.66		
		18.6	28.96	18.38	28.85
		18.25	28.92		
3	20%	18.44	28.88		
		18.6	28.75	18.61	28.87
		18.8	28.98		
4	30%	18.65	28.88		
		18.89	28.87	18.80	28.90
		18.87	28.96		
5	40%	18.05	28.86		
		18.32	28.89	18.19	28.88
		18.2	28.9		


Grade M25
Compressive Strength in N/MM2
19
18.8
18.6
18.4
18.2
18
17.8
17.6
17.4
17.89
18.56
18.65
18.75
18.6
0%
10%
20%
30%
40%
7 Days


Grade M25
Compressive Strength in N/MM2
28.95
28.9
28.85
28.8
28.75
28.7
28.65
28.6
28.55
28.5
28.65
28.85
28.87
28.9
28.88
0%
10%
20%
30%
40%
28 days

Grade M-25 Split Tensile Strength Test 7 Days				
Sr. No.	**% of Glass Powder replacing in Cement**	**Load**	**Split Tensile Strength (N/mm2)**	**Avg. Split Tensile Strength (N/mm2)**
1	0%	210	2.97	2.96
		205	2.9	
		212	3	
2	10%	235	3.33	3.33
		230	3.26	
		240	3.4	
3	20%	250	3.54	3.51
		245	3.47	
		250	3.54	
4	30%	245	3.47	3.59
		255	3.61	
		260	3.68	
5	40%	210	2.97	3.21
		220	3.11	
		250	3.54	



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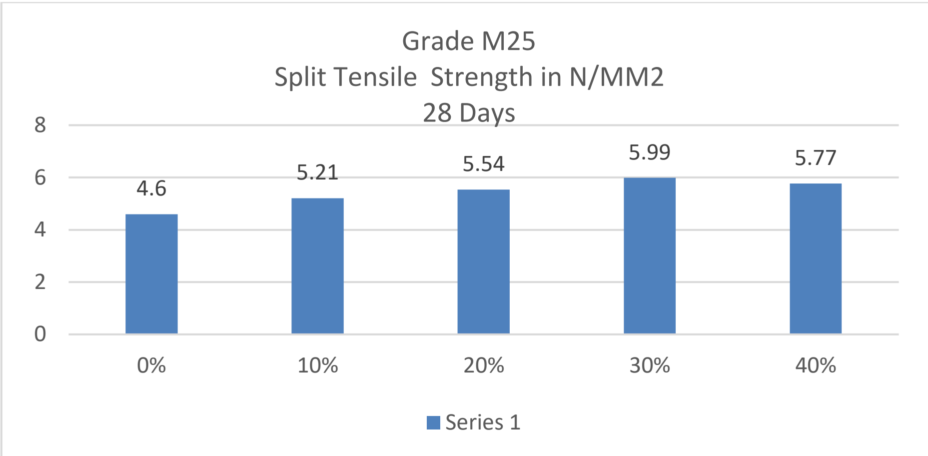
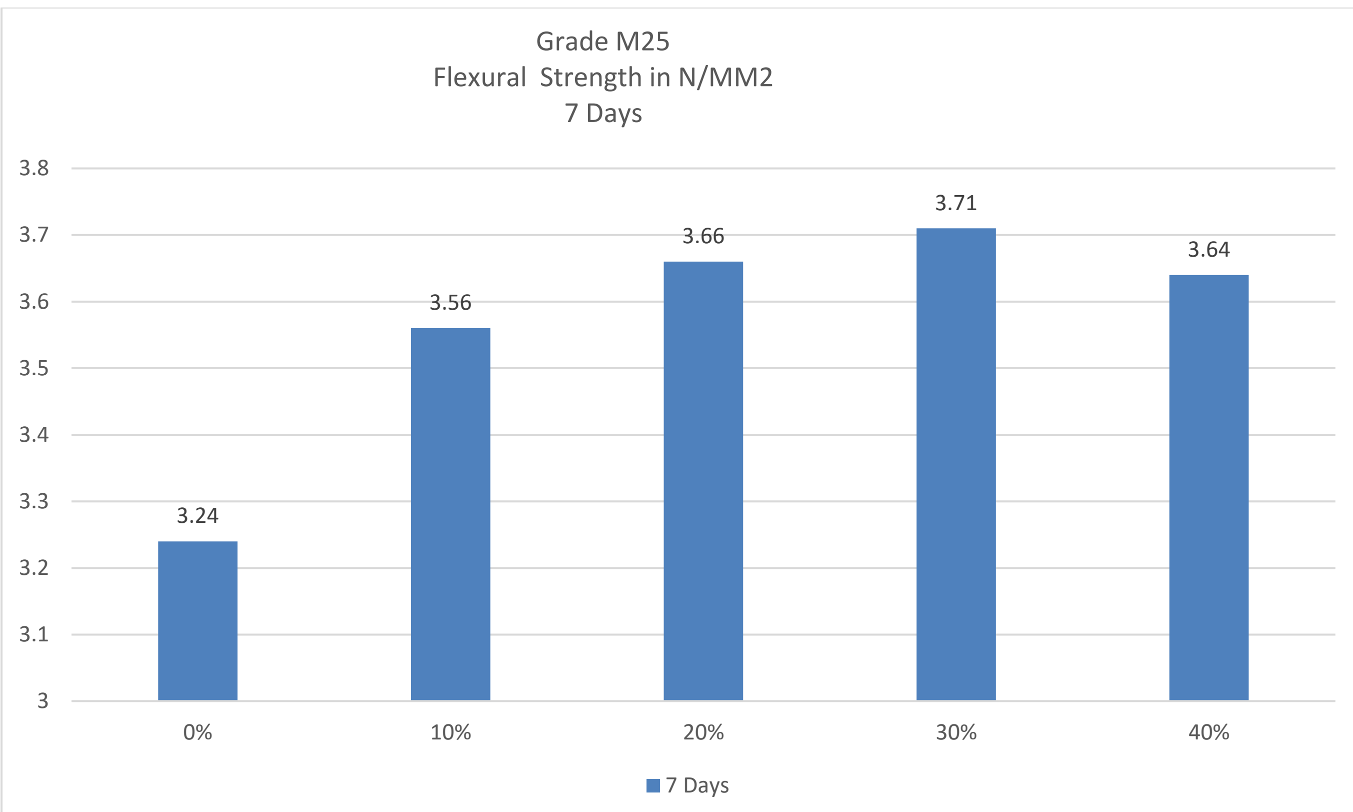


Grade M-25 Split Tensile Strength Test 28 Days				
Sr.No.	**% of Glass Powder replacing in Cement**	**Load**	**Split Tensile Strength (N/mm2)**	**Avg.Split Tensile Strength (N/mm2)**
1	0%	330	4.67	4.6
		300	4.25	
		345	4.88	
2	10%	370	5.24	5.21
		365	5.17	
		370	5.24	
3	20%	380	5.38	5.54
		395	5.59	
		400	5.66	
4	30%	415	5.87	5.99
		425	6.02	
		430	6.09	
5	40%	407	5.76	5.77
		410	5.8	
		405	5.73	

Grade M-25 Flexural Strength Test 7 Days				
Sr. No.	**% of Glass Powder replacing in Cement**	**Load**	**Split Tensile Strength (N/mm2)**	**Avg. Split Tensile Strength (N/mm2)**
1	0%	5.12	3.19	3.24
		5.2	3.24	
		5.32	3.31	
2	10%	5.73	3.57	3.56
		5.66	3.52	

		5.78	3.6	
3	20%	5.78	3.6	3.66
		5.88	3.66	
		5.98	3.72	
4	30%	5.98	3.72	3.71
		5.96	3.71	
		5.93	3.69	
5	40%	5.78	3.6	3.64
		5.88	3.66	
		5.91	3.68	



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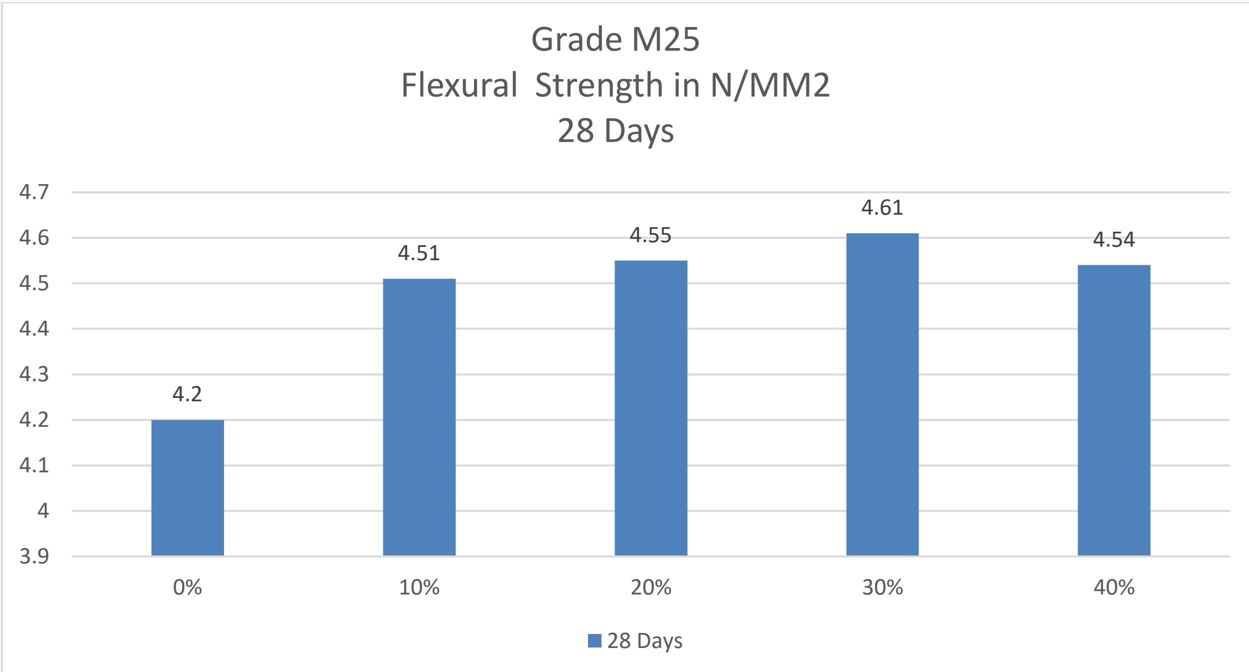
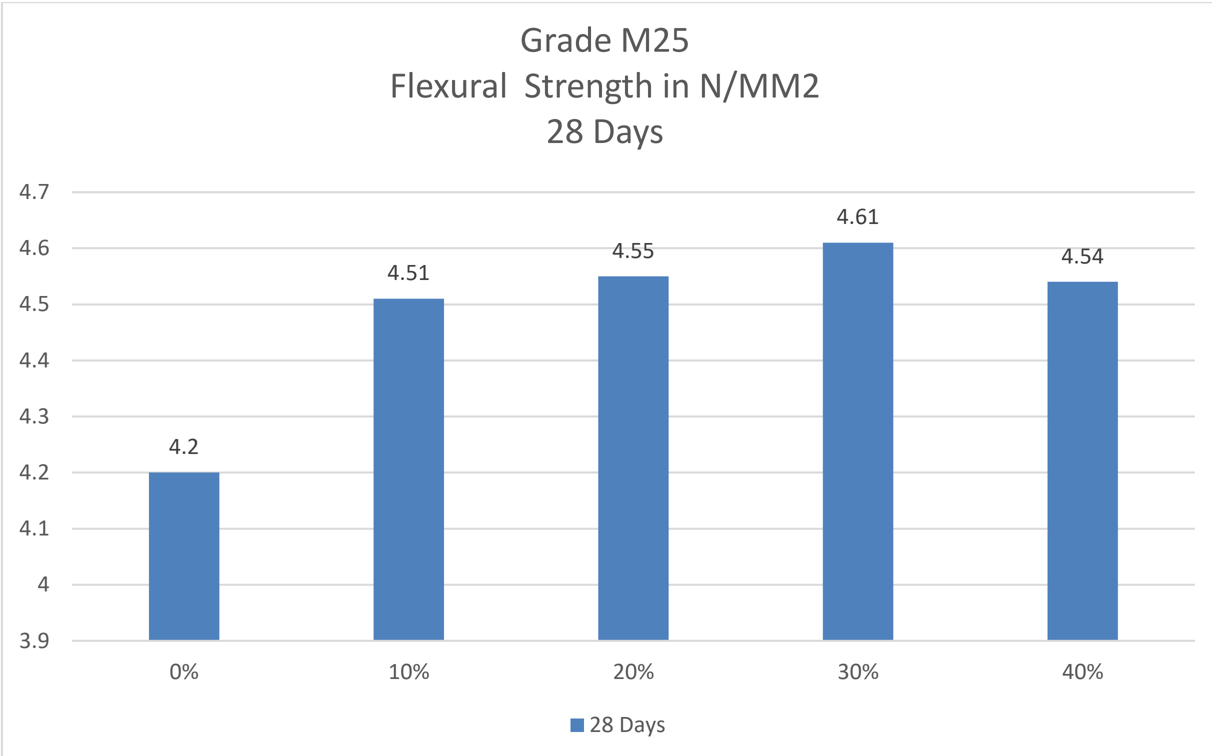
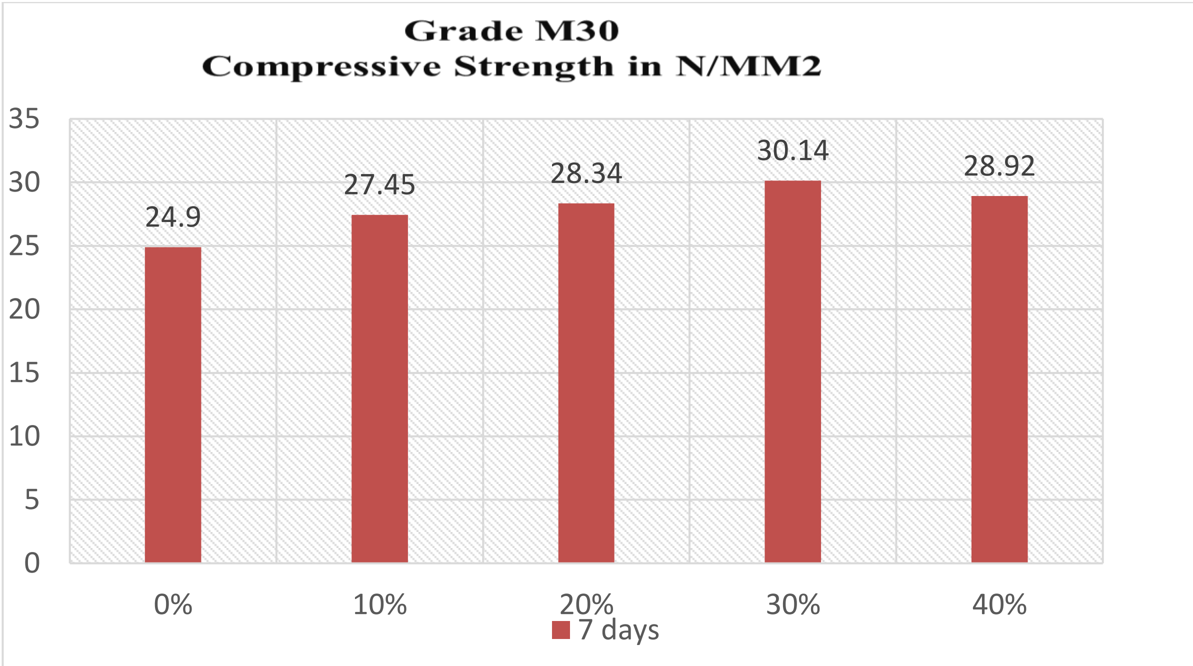
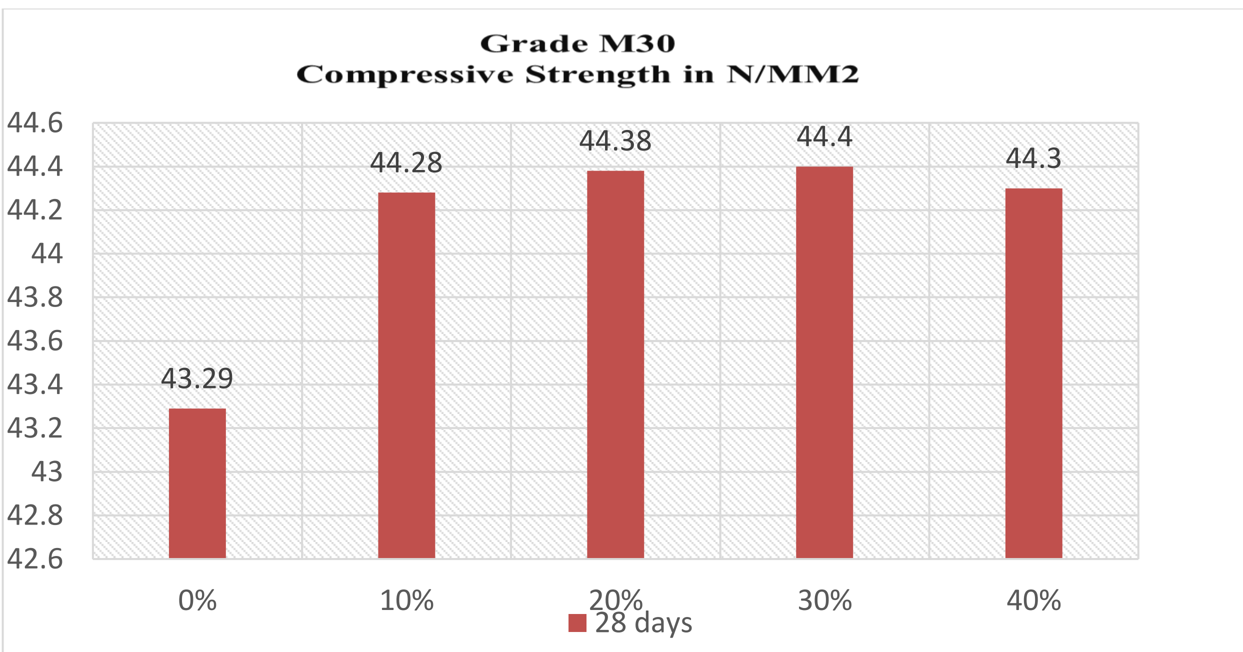


Grade M25 Flexural Strength Test 28 Days				
Sr. No.	**% of Glass Powder replacing in Cement**	**Load**	**Split Tensile Strength (N/mm2)**	**Avg. Split Tensile Strength (N/mm2)**
1	0%	6.85	4.26	4.2
		6.45	4.01	
		6.94	3.32	
2	10%	7.23	4.5	4.51
		7.31	4.55	
		7.22	4.49	
3	20%	7.5	4.67	4.55
		7.31	4.55	
		7.12	4.43	
4	30%	7.55	4.7	4.61
		7.45	4.64	
		7.25	4.51	
5	40%	7.3	4.54	4.54
		7.22	4.49	
		7.38	4.59	

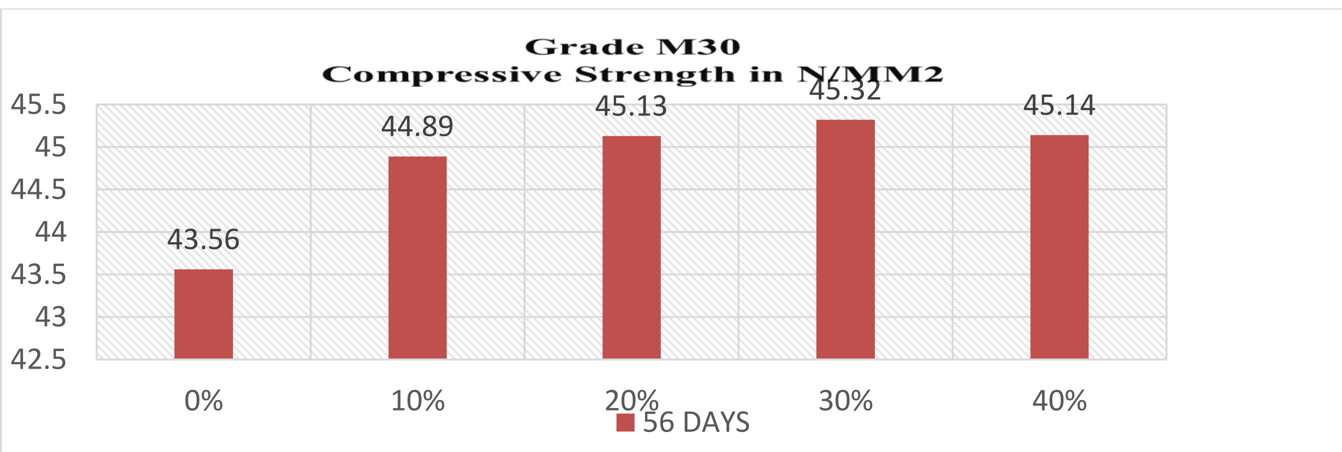


GRADE 30 COMPRESSIVE STRENGTH IN N/MM2					
Sr. No.	% of Glass Powder Replacing in Cement	Compressive Strength in N/mm2		Average Compressive Strength in N/mm3	
		7 Days	28 Days	7 Days	28 Days
1	0%	24.84	43.12	24.90	43.29
		24.89	43.2		
		24.98	43.55		
2	10%	24.42	44.3	24.45	44.28
		24.44	44.35		
		24.5	44.2		
3	20%	28.5	44.55	28.34	44.38
		28.12	44.28		
		28.4	44.32		
4	30%	30.23	44.56	30.14	44.40
		30.2	44.35		
		30	44.28		
5	40%	28.99	44.35	28.92	44.30
		28.98	44.4		
		28.79	44.15		

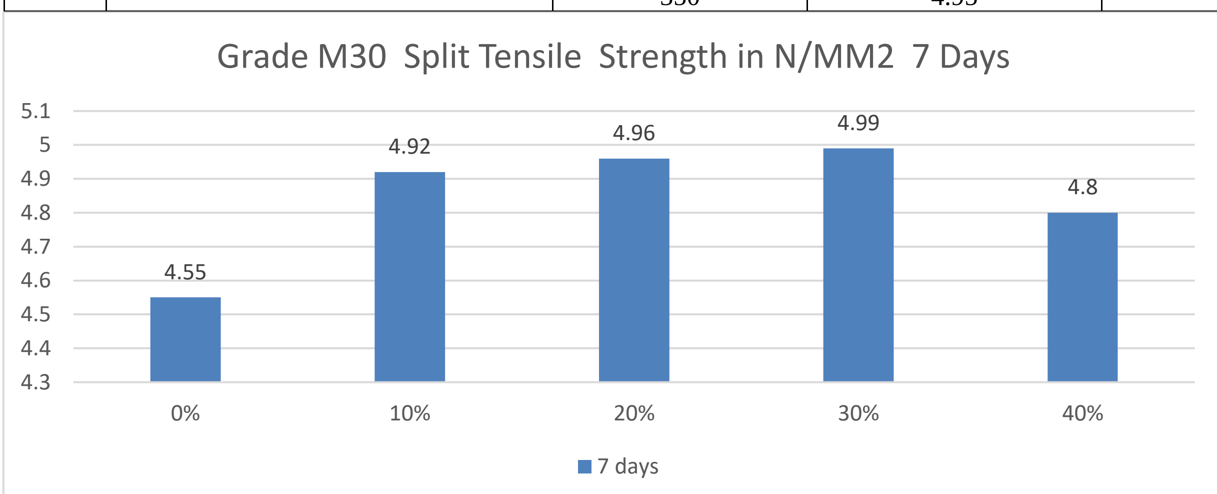

Grade M30
Compressive Strength in N/MM2
35
30
25
20
15
10
5
0
24.9
27.45
28.34
30.14
28.92
0%
10%
20%
30%
40%
7 days


Grade M30
Compressive Strength in N/MM2
44.6
44.4
44.2
44
43.8
43.6
43.4
43.2
43
42.8
42.6
43.29
44.28
44.38
44.4
44.3
0%
10%
20%
30%
40%
28 days

GRADE M30 COMPRESSIVE STRENGTH IN N/MM2			
Sr.\No.	**% of Glass Powder Replacing in Cement**	**Compressive Strength in N/mm2**	**Average Compressive Strength in N/mm3**
		56 days	**56 days**
1	0%	43.65	43.56
		43.45	
		43.58	
2	10%	44.87	44.89
		44.9	
		44.89	
3	20%	45.1	45.13
		45.2	
		45.1	
4	30%	45.33	45.32
		45.22	
		45.4	
5	40%	45.2	45.14
		45.1	
		45.12	



Grade M30 Split Tensile Strength Test 7 Days				
Sr. No.	**% of Glass Powder replacing in Cement**	**Load**	**Split Tensile Strength (N/mm2)**	**Avg. Split Tensile Strength (N/mm2)**
1	0%	330	4.67	4.55
		320	4.53	
		315	4.46	
2	10%	332	4.7	4.92
		335	4.74	
		375	5.31	
3	20%	376	4.7	4.96
		342	4.74	
		333	4.71	
4	30%	328	4.64	4.99
		360	5.1	
		370	5.24	
5	40%	345	4.88	4.8
		360	4.56	
		350	4.95	



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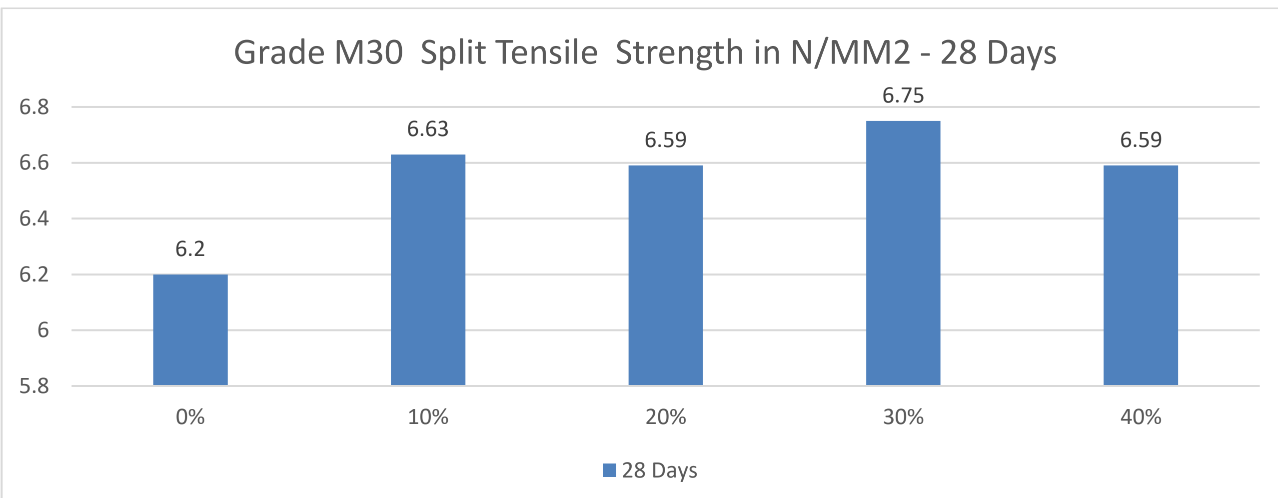
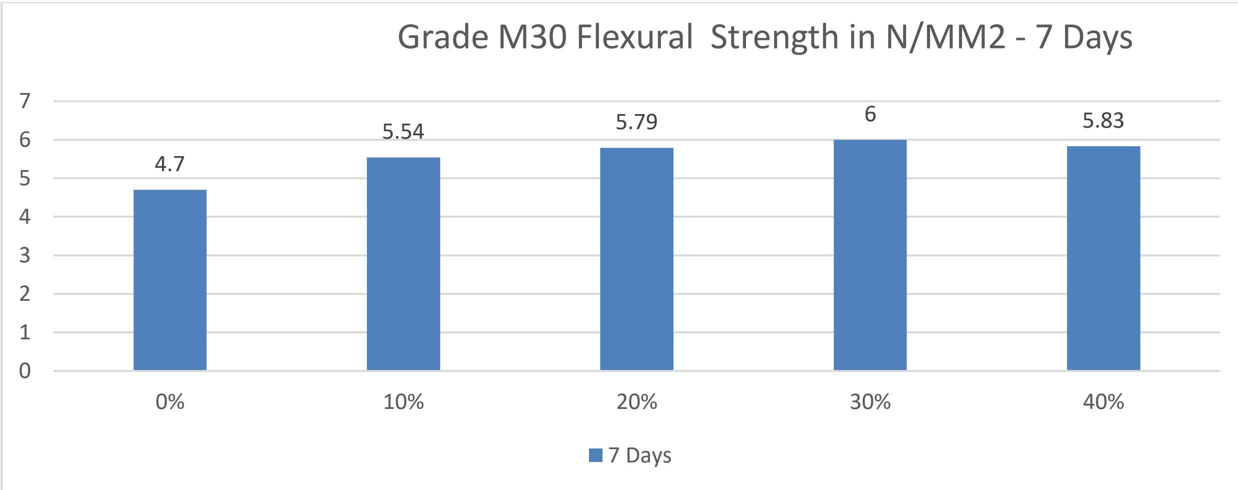
Grade M30 Split Tensile Strength Test 28 Days				
Sr. No.	**% of Glass Powder replacing in Cement**	**Load**	**Split Tensile Strength (N/mm2)**	**Avg. Split Tensile Strength (N/mm2)**
1	0%	425	6.02	6.02
		420	5.94	
		430	6.09	
2	10%	465	6.58	6.63
		470	6.65	
		470	6.65	
3	20%	475	6.72	6.59
		472	6.68	
		450	6.37	
4	30%	470	6.65	6.75
		475	6.72	
		485	6.86	
5	40%	436	6.17	6.59





Grade M30 Flexural Strength Test - 7 Days				
Sr. No.	**% of Glass Powder replacing in Cement**	**Load**	**Split Tensile Strength (N/mm2)**	**Avg. Split Tensile Strength (N/mm2)**
1	0%	20	4.15	4.7
		23	4.77	
		25	5.19	
2	10%	26.3	5.45	5.54
		26.8	5.56	
		26.98	5.6	
3	20%	27.8	5.77	5.79
		27.98	5.8	
		27.99	5.81	
4	30%	28.98	6.01	6
		28.96	6.01	
		28.8	5.97	
5	40%	28.1	5.83	5.83
		28.12	5.83	
		28.15	5.84	

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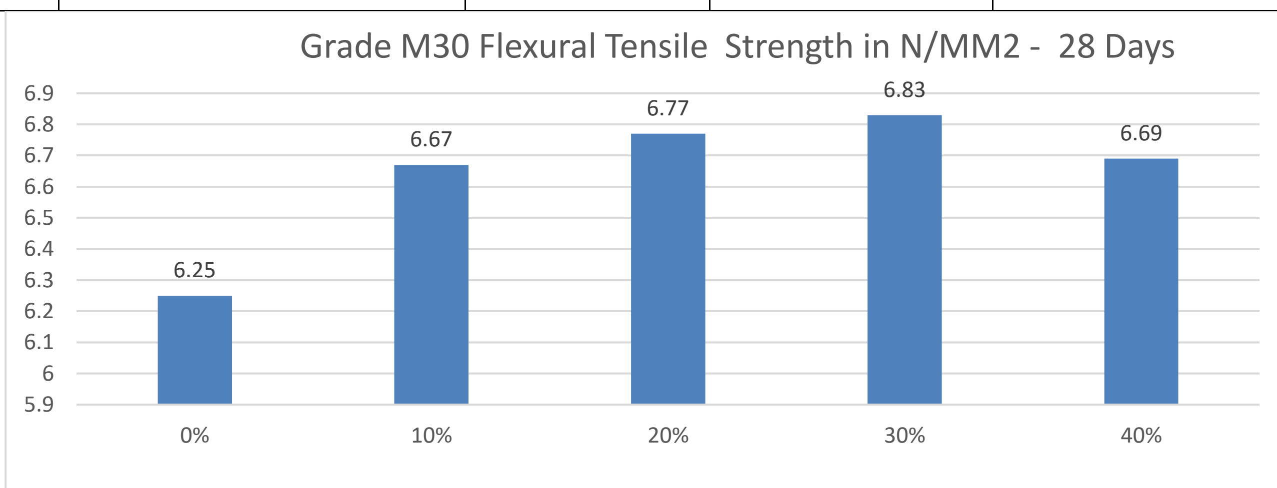
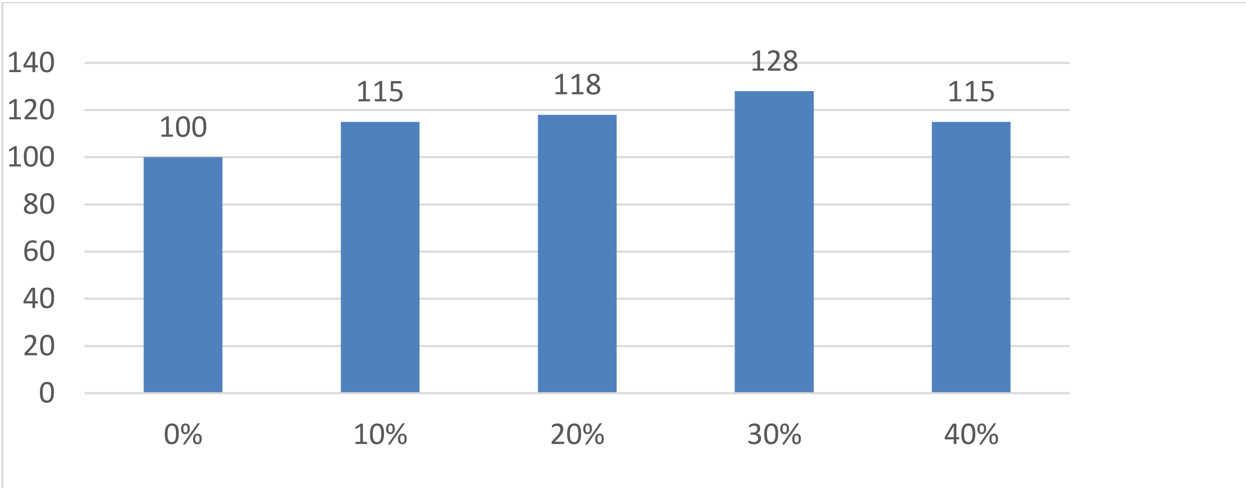
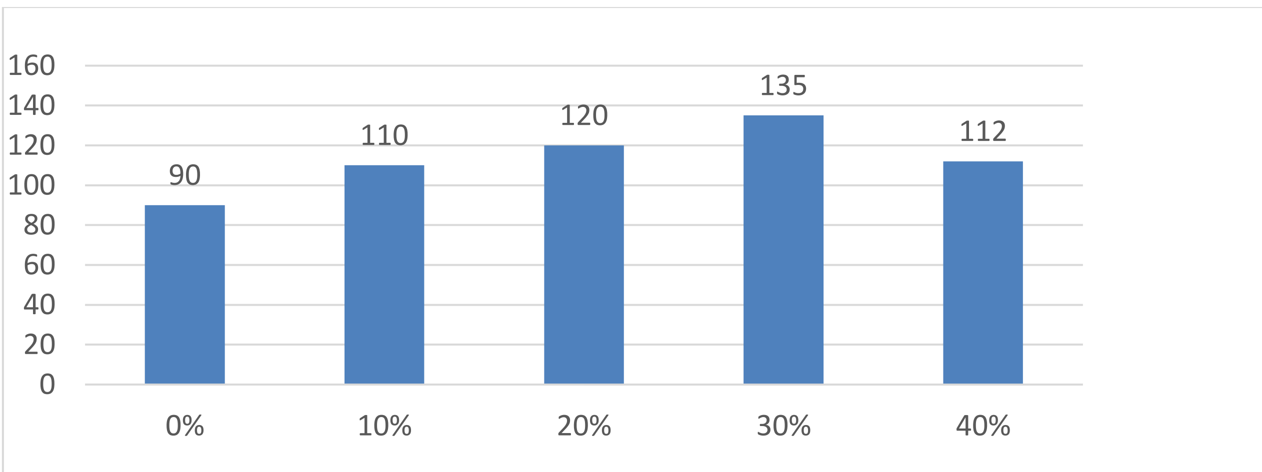
Grade M30 Flexural Strength Test - 28 Days				
Sr. No.	**% of Glass Powder replacing in Cement**	**Load**	**Split Tensile Strength (N/mm2)**	**Avg. Split Tensile Strength (N/mm2)**
1	0%	30.12	6.25	6.25
		30.1	6.24	
		30.14	6.25	
2	10%	32.11	6.66	6.67
		32.16	6.67	
		32.21	6.68	
3	20%	32.45	6.73	6.77
		32.65	6.77	
		32.78	6.8	
4	30%	32.45	6.73	6.77
		32.65	6.77	
		32.78	6.8	
5	40%	32.89	6.82	6.83
		32.99	6.84	
		32.84	6.81	



Grade M25 % of Workability



Grade M30 % of Workability



CONCLUSION

The following conclusions are made based on the above study:

1. The 7days, 28 days and 56 days compressive strengths of concrete increase initially as the replacement percentage of cement with glass powder increases and become maximum at about 30% and later decreases.
2. The flexural strength of concrete increases initially as the replacement percentage of cement with glass powder increases and becomes maximum at about 30% and later decrease.
3. The split tensile strength of concrete increases initially as the replacement percentage of cement with glass powder increases and becomes maximum at about 30% and later decrease.
4. The slump of concrete decrease monotonically as the replacement Percentage of cement with glass powder

increases. The workability decreases when cement is replaced partially with glass powder.
5. The present study shows that there is a great potential for the utilization of glass powdering concrete as partial replacement of cement. About 30% of cement may be replaced with glass powder without any sacrifice on the compressive strength.

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