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The use of Partial Glass Powder as Cement Replacement in Concrete M20 Grade on Mechanical Strength

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Abstract: ***surely glass powder in concrete can be considered one of the most important or relevant fibers as partial replacement aiming to change or improving the properties of concrete. This work was made in the endeavor to know the influence of glass powder when is mixed or replacing cement in concrete using proportion 0%, 10%, 20% and 30%, using m20 grade of concrete. Considered two factors as age and mix proportion, was found the compressive results, also the result of tensile and flexural strength results at 3 days, another one at 7 days, at 28 days and 90 days curing concrete, the study was conducted, using cubes specimens after testes was found reporting that using glass powder in the m20 grade of mix design of concrete as cement replacement shows many advantages in its application on concrete, not only in reducing the co2 emissions to earth's atmosphere as is written on the first part of this work but also the result show that the proportion up to 20% can improve its compressive strength in concrete, in terms of flexural strength was found increasing up to 10% of glass powder when used in concrete and was found also the optimal proportion in split tensile at 20% of glass powder.***

Keywords: glass powder, concrete, partial replacement

I. INTRODUCTION

The use of the glass powder generally in the concrete particularly in the investigation has been considered one of relevant points aiming to change improving the properties of concrete. Glass has been considered pozzolanic material [1, 2] and because of its chemical composition it can control not only properties in terms of structure mechanic but also the microstructure [1].

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Also, reuses of glass have been seen in various studies that can reduce CO_2 emissions to earth's atmosphere. [3, 4, 5]. In the book of Siddique R, (2008) was found that glass has thermal conductivity considered low, and comparing to the reference aggregate, can influence to cause a decrement of thoroughness of frost and can show a higher heat retention [6].

As many studies relate, surely glass has influence when is mixed with concrete. This study is regarding to discover the influence or effect of glass in concrete, when it considered a replacement by cement.

The research of Tamanna N, et all (2016) and the research of Taha Bashar and Nounu Ghassan (2009), is related that the first experiment using a glass as pozzolanic to substitute cement in some proportions was made by Pattengill and Shutt (1973), [7, 8].

Glass powder can be seen as the product found in various forms, as jars, windows, bottles, etc. So this product can be recycled to avoid some problems regarding to environment [9]. In other terms, recycling this waste that is abundant in different places can be considered a way to reduce the cost of material in some of the building projects [10].

The studies revels that, these recycled materials can be used into concrete to increase or improve the durability of concrete [7, 8] also in other hand to increase the long term strength. Knowing that the waste glass has pozzolanic properties was found that the reactivity of those properties are seen when the size is 0.075 mm or below [11], that can be reached by grinding operation with Ball Mill [7].

On the study of Afshinnia Kaveh and Rangaraju P. Rao (2015), the use of waste glass has shown an impediment, due to the their sources, different colors, make it having differences of temperature and incompatibilities in processing time because of the composition of glasses [12].

About glass powder to produce cement mortar, was reported that is there an increasing of slump flow while is increasing the glass powder and decreasing when is increasing the glass sand. Also was found a deterioration when is increasing proportion of glass powder in distinct proportions. The report also reveals that glass sand provides improvement of compressive strength and also a higher resistance. [13].

Analyzing concrete mixed with glass in terms of durability, Sara and Jorge (2012), they reported the performance of concrete with glass, and related that was found decreasing the compressive strength due to the weak interface that is inside the hardened paste of cement and glass. Also reported workability result, and was affected, and the water absorptions was found with the similar results of the control concrete, the shrinkage was found also similar to reinforcement concrete. [14].

Omran Ahmed and Tagnit- Hamou Arezki (2016) they related that the activity of pozzolanic of the fiber used in this experimental (glass powder) can provide after some ages of curing a better characteristic on the ownership strength. They found that the glass powder was providing the reduction of risk in terms of reinforcing by steel when the oxidation is influenced by chloride [15].

Investigating the ground waste glass making substitution with cement, Shao Yixin *et al* (2000) they found that particles of ground glass with size less than 38 μm had a pozzolanic behavior where the expansion was reduced. The smaller glass in terms of size was found taking to higher compressive strength [16].

This experimental study is presenting the report or performance when used glass powder in concrete as cement in the proportions 0,0%, 10,0%, 20,0%, 30,0%, and where the 0,0% proportion is without glass, considered as a reference control, used to comparison.

This experimental has aim to find optimal replacement of Glass powder in M20 concrete using IS: 456 (2000). This experiment was conducted finding the ownership strength of concrete.

A. *Experiment significance*

Using glass as cement substitution in concrete is relevant issue not only due to the situation of the world nowadays in municipals regions with their wastes materials that can compromise the environment but also to reduce the cost of materials when is producing concrete. The study of influence of glass in concrete is the most important investigation nowadays.

II. MATERIALS AND METHODS

A. *Materials*

1) *Cement, Water and Aggregates*

To perform this experiment, water, fine aggregate and coarse aggregate were used. The cement used was the grade of 43 according to IS 8112.1989 [17], in the table 1 below is illustrated the properties of cement according to [17, 18, 19], the water used in concrete mix design had a 6 - 8 of pH, actually the normal water was used according to IS 456 (2000) [18, 19, 20], also was considered in this experiment the fine aggregate and coarse aggregate and the chemical composition of glass powder can be found in the table 2.

Table 1: Properties of cement in term of physical and chemical

Content	Requirement
Physical properties	
Minimum compressive strength	
3 day	23
7 day	33
28 day	43
Fineness	
Minimum specific surface (m^2/kg)	225
Soundness, expansion	
Le Chatelier test (mm), Max	10.0
Setting time (min)	
Initial, min	30
Final, max	600
Chemical Properties	
Loss on ignition (%), max	5.0
MagnesioMgO (%), max	6.0
Total sulphuric anhydride (SO_3)	3.5

2) *Concrete Mix*

To manufacture of the concrete mixed with glass powder was mixed with cement at the same amount and sand, after that gravel and other remained sand was mixed. After this was added water to start to saturate the particles, also was mixed others materials existing eventually. The experiment was conducted for M20 grade using w/c=0.5 and mix design of 1: 1.5: 3.

To perform this study, the glass powder were added into concrete mix in proportions of 0,0%, 10,0%, 20,0%,30,0%, in volume.

3) *Specimens and performing tests*

To perform the tests in laboratory, was casted compressive strength, with a cubical specimen of 150mm x 150mm x 150mm according to IS: 516 –1959 [23], the cube specimens used were metal. To perform the test for tensile was used the specimen of 150mm x 300mm according to IS: 5816 – 1999 [24]. And finally was casted flexural strength in the specimens size 150mm x 150mm x 700mm, as is written in IS: 516 –1959 [23].

Table 2: Chemical compositions of Glass

Chemical compositions of Glass						
	Glass	Reference	LCD Glass	Reference	Glass	Reference
SiO2	32.15	21	62.48	13	67.72	22
Al2O3	12.87	21	16.76	13	_	_
Fe2O3	0.36	21	9.41	13	_	_
CaO	40.67	21	2.7	13	67.72	22
MgO	6.05	21	0.2	13	6	22
SO3	4.95	21	4.95	13	0.17	22
Na2O	0.28	21	0.64	13	_	_
K2O	0.51	21	1.37	13	_	_
TiO2	_	_	0.01	13	_	_
P2O5	_	_	0.01	13	_	_

B. *Methods used in the experiment*

The method that was used in this investigation was for to discover the hardness regarding to strength of concrete after dried specimen half hour at 3rd, 7th and 28 days, and finally also 90 days.

1) *The compressive strength*

All tests regarding to mechanical strength discussed in this work were tested in the experimental till 28 days and 90 days.

In the test after application of the axial compressive load were found the ultimate strength, after was calculating dividing the maximum load through its section area and was found the compressive strength, the proportion of proportions is illustrated in the table 3.

Table 3: Concrete mix proportions for compressive strength test

Component	0.0% G.P.	10.0% G.P.	20% G.P.	30.0% G.P.
	w/c=0.5 Content Kg/m^3			
Cement	12.15	10.94	9.72	8.51
Glass Powder	0	1.22	2.43	3.65
Fine aggregate	18.23	18.23	18.23	18.23
Coarse aggregate	36.45	36.45	36.45	36.45

2) *Flexural strength test*

The experimental study was concerned about determination of flexural strength, and in the control mix was found that in the mix proportion of 30% were 17.01 kg of glass powder using the mix proportion of 1: 1.5: 3: 0.5 following the IS 456 (2000) for M20 grade concrete [20]. To be found flexural strength, the concrete were placed on two supports and applying load until collapsed was getting the amount of this test. Generally the mix proportion of glass powder in the concrete can be seen in the table 4.

Table 4: Concrete mix proportions for Flexural strength test

Component	0.0% G.P.	10.0% G.P.	20% G.P.	30.0% G.P.
	w/c = 0.5 Content Kg/m^3			
Cement	56.70	51.03	45.36	39.69
Glass Powder	0	5.67	11.34	17.01
Fine Aggregate	85.05	85.05	85.05	85.05
Coarse Aggregate	170.1	170.1	170.1	170.1

3) *Splitting tensile strength test*

The study as concerned about determination of tensile strength, the control mix was found in the mix design of 1: 1.5: 3: 0.5 as IS 456 (2000) for M20 grade concrete [20]. This test was performed in cylindrical specimen where horizontally were placed in the ring, the force was applied until a facture appear. The mix proportion is in the table 5.

Table 5: Concrete mix proportions for splitting tensile strength test

Component	0.0% G.P.	10.0% G.P.	20% G.P.	30.0% G.P.
	w/c = 0.5 Content Kg/m^3			
Cement	19.09	17.18	15.27	13.36
Glass Powder	0	1.91	3.82	5.73
Fine Aggregate	28.63	28.63	28.63	28.63
Coarse Aggregate	57.26	57.26	57.26	57.26

III. RESULTS AND DISCUSSIONS

A. *Compressive strength*

At the room temperature the specimen was cured, for measure the compressive strength, was used the average of three specimen for each proportion in 0%, 10.0%, 20.0%, and 30.0%, the code proportion used is in the table 6

Table 6: Code proportion used

MIX CODE	M0	M10	M20	M30
MIX PROPORTION	0%	10,0%	20,0%	30,0%

According to the results, glass powder when used in concrete improves the compressive strength or can be said that glass powder can alter properties of concrete. Also this can be analyzed in terms of manufacturing costing of concrete.

The effect of replacement for 10%, and 30% was found decreasing compressive strength at 3 days, 7 days and 28 days of testing compared with concrete without glass; however the proportion of 20% was found almost showing the same result with the reference concrete at 28 days, but for 3 and 7 days, the compressive strength is increasing. At 90 days the 20% glass powder as cement partial showing some increasing compared with that of 28 days and the control mix.

The concrete with glass powder must decrease the compressive strength due to the water that still in mixes but as increasing time the results it shows changing to higher strength as in 28 days and 90 days. This effect on compressive strength is shown in the fig. 1 and fig. 2.

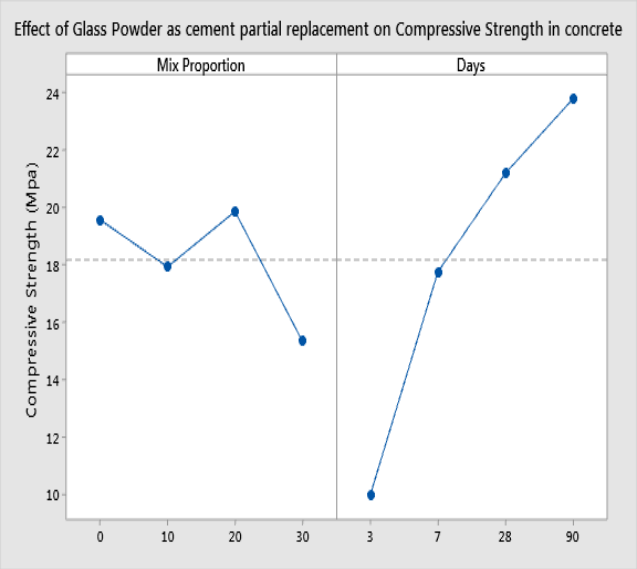

Fig. 1: Glass Powder in concrete on Compressive Strength

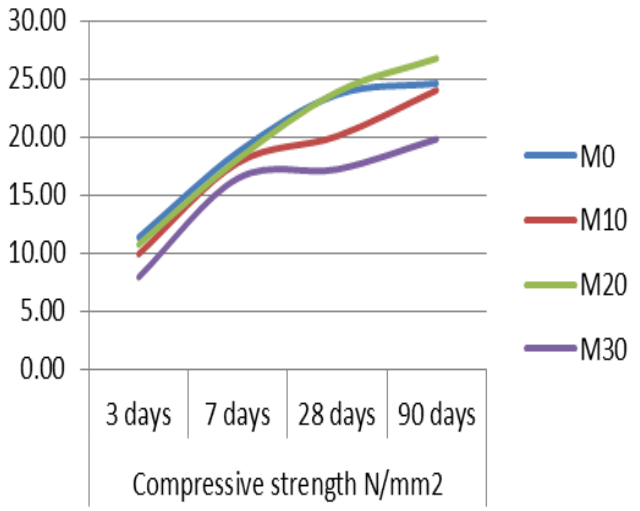

Fig. 2: Glass Powder in concrete on Compressive Strength

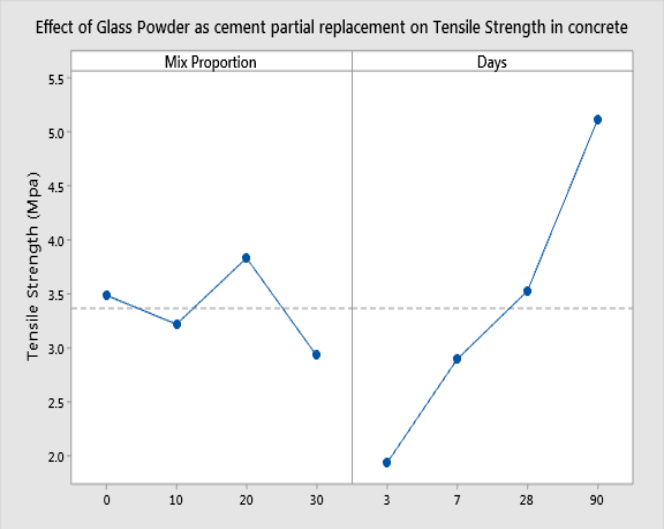

Fig. 3: Glass Powder in concrete on Tensile Strength

Concrete mixed with glass was found decreasing result on compressive strength when increasing the temperature because the elevated temperature was dissipating the water retained in the mix, and this phenomenal was so much easily in the concrete mixed with glass than concrete without glass since doesn't consume water.[6]

Kumar (2013) related that the substitution of glass in proportions of 20%, 30% and 40% can increase the compressive [11].

Elaqra Hossam A. (2019) reported that convetional mixing using glass, has shown that until 28 days the compressive strength is less at 10% and 30% of proportion, but was found 20% as optimum compressive strength with increasing at 90 days [9].

Islam G.M. S et al (2016) they also found that at 90 days, the 20% proportion was 2% more higher than the control mix [10]

Kamali and Ghahremaninezhad (2015) they incorporated glass powder in concrete as cement substitution and were found improvement on compressive [5]. Siad Hocine (2016), reported the compressive strength in mortar was found decreasing compared with that considered reference mixture. [25].

B. Split tensile strength

This experimental study was conducted using IS 5816 – 1999 to determine the tensile strength, thus the standard size used to perform were300 mm and 150 mm a cylindrical specimen.

The results, show that tensile strength at 28 days is decreasing when is increased amount of glass, 10%, 20% of glass as substitution in concrete found higher in 90 days, however 30% of proportion mix was less than the control mix design. The Glass Powder on Tensile Strength illustrated in fig. 3 and 4.

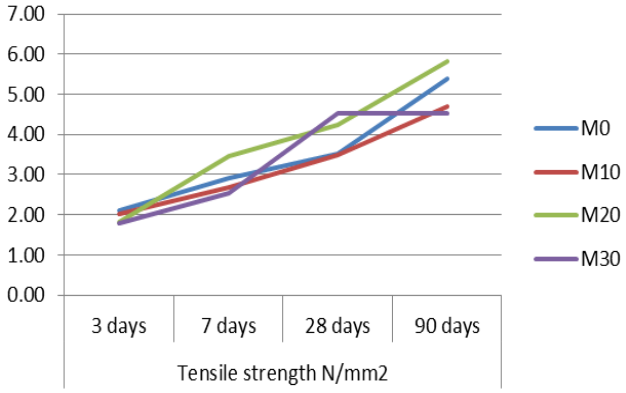

Fig. 4: Glass Powder in concrete on Tensile Strength

Studying possibility using the glass, Kumar et al (2013) reported that tensile was found increased in 4.4% actually when the replacement was 40% [11].

The results of tensile strength presented by Meena M.K. et al (2018), reported the increasing of strength at 30% of mix proportion with glass powder at 28 days, however was found the optimum split tensile strength from 25% till 30% [26].

Omran Ahmed and Tagnit- HamouArezki (2016) found that the results regarding to tensile strength at 28 days was increasing for the concrete with 35% glass powder replacement compared with the control mix [15].

C. Flexural Strength

The flexural strengthwas determinedin three specimens at 3days, 7days , 28days and 90 days. The specimen were subjected to bending tests, a concentrated load was applied to the concrete specimen to find the properties, this tests was conducted using IS: 516 –1959.

According to the results was found that incorporate the glass powder in concrete the flexural strength was increasing till 10% of proportion showing that incorporation of glass as cement is better than reference concrete on flexural. The effect of Glass Powder on Flexural (Mpa) in concrete can be seen in fig. 5 and 6.

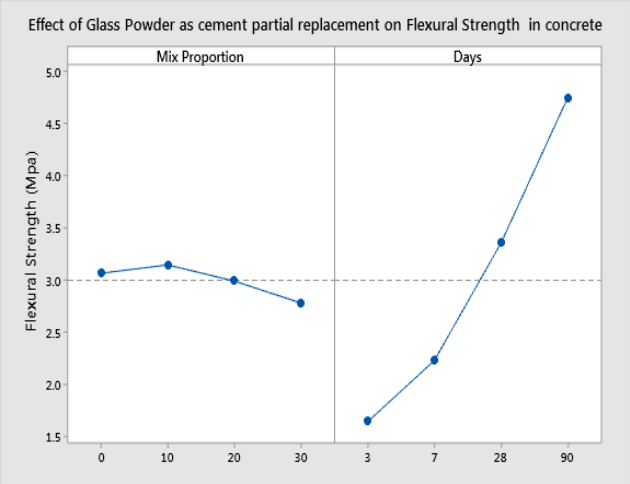

Fig. 5: Glass Powder in concrete on Flexural Strength

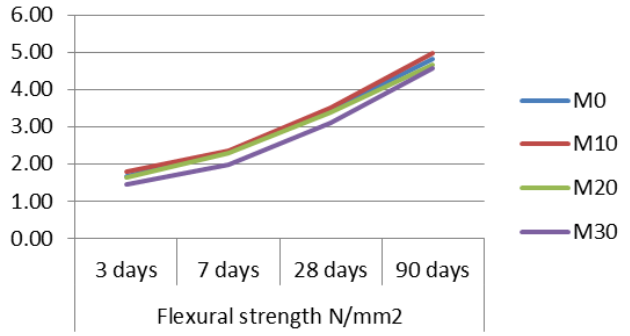

Fig. 6: Glass Powder in concrete on Flexural Strength

Kumar (2013) found that flexural strength increase in 83.07%, 99.07% and 100% in the proportions of 20%, 30 and 40% respectively [11].

Meena M.K. et al (2018), reported that replacement in 30% glass powder in the mix at 28 days increase the flexural, also was found that the optimum can be obtained in the range 25 – 30% glass powder in concrete [26].

Omran Ahmed and Tagnit- HamouArezki (2016) found that flexural strength of concrete mixed with glass is higher compared to the reference concrete at 28 days [15].

IV. CONCLUSION

- Using glass powder in concrete to substitute partially cement shows many advantages in its application on concrete.
- Was found that amount of glass powder, generally improves up to 20% in terms of compressive strength in concrete.
- In the study was conclude that increasing the glass powder up to 10% of mix proportion the flexural strength of the concrete was improved and after that percentage of proportion was found flexural strength decreased.
- In terms of tensile strength of the concrete, conclude that 20% is optimum at 90 days.
- With the usage of glass powder in this experimental, can be conclude that the effect of this fiber can be seen early on the test but it comes clear up to 90 days.

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