Mechanical Properties of The Glass Fiber Reinforced Concrete With Partial Replacement of Coarse Aggregate With Pumice

K Priyanka[1], S Sivacharan[2], S Ganesh[3], P Ravi Kishore[4]
[1] Dept of Civil Engineering
[2]Asst. Professor& HOD,, Dept of Civil Engineering
[4]Asst. Professor, Dept of Civil Engineering
[1, 2, 4] Aditya College of Engineering and Technology, Surampalem.
[3]Ward Planning and regulations secretary, Narsipatnam Municipality,MA&UD.

Abstract- *Concrete is the most used material in the world next to water. Though concrete is very good at compression it is very weak in tension. In order to enable the concrete to overcome the tension cracks the concept of fiber reinforced concrete was evolved.Along with this the self-weight of the concrete is also very high depending on the unit weight of coarse aggregate which is influencing the design and estimation of the structure. This gave a push to work on light weight aggregates using which the self-weight of the structure can be reduced.*

In the present work it is proposed to identify the mechanical properties at 7days & 28days, and self-weight reduction in the M30 grade concrete with partial replacement of coarse aggregate with pumice stones in volume batching at 10%,20%and 30% variation. Along with this glass fibers are added at 0.1%, 0.2%,0.3% and 0.4% to the concrete. Strength and durability are studies for M30 grade concrete in present work.

Keywords- Fiber reinforced concrete, glass fibers, light weight aggregate, pumice, mechanical properties.

I. INTRODUCTION

Most of the normal weight aggregates of normal concrete are natural stones like granite. As the amount of concrete used increases, natural environments and resources are being over-developed. Synthetic lightweight aggregates produced from environmental waste, such as fly ash, etc., are the new sources of structural aggregates. Lightweight aggregate concrete improves design flexibility and enables significant cost savings, quadrature reduction, cyclic loading improvements, long spans, excellent fire ratings, thinner sections, smaller structural members, less reinforcement for cement and reduced foundation footprint. The weight of lightweight aggregate concrete is generally 25% to 35% less than the conventional concrete, but the strength is similar to that of normal weight concrete.

Conventional cement concrete is a heavy material having a density of 2696Kg/m. The weight of a structure made of this concrete is large compared with the load applied, and in the case of a member in a curved shape, the reduction of the quadrature is relatively small. High-rise buildings can save construction costs and manpower.

Lightweight aggregate is a relatively new material. For the same crushing strength, the density of concrete made from these aggregates can be as low as 35% lower than normal weight concrete. In addition to reduced self-weight, the modulus of elasticity is low and the proper ductility of lightweight concrete can be beneficial to structural seismic design. Another unique advantage of this material is its high fire resistance, low thermal conductivity, low coefficient of thermal expansion and low erection and transportation costs for assembled members

Light weight concrete

Structural lightweight concrete has an internal density (unit weight) of 1440 ~ 1840kg /m^3 compared to normal weight concrete with density of 2240 ~ 2500kg / m^3. The main use of structural lightweight concrete is to reduce the dead load of concrete structures, and structural designers can reduce the size of columns, foundations and other load bearing elements. Structural lightweight concrete mixtures can be designed to achieve similar strength to normal weight concrete.Structural lightweight concrete provides more efficient strength-to-weight ratio of structural elements.Concrete density can be reduced to about 160 kg / m^{3}by completely replacing ordinary heavy aggregate with lightweight aggregate.

Light weight aggregates can be classified into following categories

1. Naturally occurring substances- pumice, foamed lava, volcanic tuff, and porous limestone.
2. Industrial by-products – fly ash, blast furnace slag, hematite and burned bricks.
3. Naturally occurring materials that requires further process – clay, shale, slate and vermiculite etc.,

Figure 1: Pumice stone

Fiber

As concrete is weak in tension than compression, to reduce the tension cracks we are using fibers as reinforcing materials. Most commonly used fibers are Glass fibers, carbon fibers, steel fibers, synthetic fibers, nylon fibers. Glass fibers are used as reinforcing materials in present work.Glass fiber reinforced concrete (GFRC) is less prone to corrosion as the glass fibers are resistant towards corrosion.A matrix of glass fibers in different orientations are used to develop a Glass fibers to be used in structural strengthen of strictures post damage. Fiber is described with a parameter called "aspect ratio". Generally, aspect ratio of fibers ranges from 30 to 150. The diameter varies from 0.25 to 0.10 mm. Use of fibers improves mechanicals properties of concrete like compression strength, flexural strength, split tensile strength.

II. OBJECTIVE OF WORK

The main aim is to study the Mechanical properties of pumice aggregate glass fiber concrete at 7 days and 28 days, asses the self-weight reduction of M30 grade concrete and durability studies after curing with 5% HCL acid.

III. EXPERIMENTAL STUDIES

The Experimental studies were conducted on mechanical properties and unit weight of of M30 grade concrete of using pumice stone glass fiber reinforced concrete. The purpose of using glass fibers to enhance the mechanical properties like compression strength, flexural strength, split tensile strength. Light weight aggregates (pumice stones) plays an important role in reducing the unit weight of the structure and to improve insulation properties. The glass fiber content varies from 0, 0.1%, 0.2%, 0.3%, 0.4%. Coarse aggregates are being replaced with pumice stones at percentage of 0%, 10%, 20% and 30%.

Durability studies were conducted on M30 grade concrete reinforced with glass fibers and partial replacing coarse aggregates with pumice stones using 5% HCL curing for 28 days after normal curing.

IV. RESULTS AND DISCUSSION

Mix proportion for M30 grade concrete mix is 1:1.35:2.89. (Addition of pumice stones)

M-1-cement (100%) + Sand (100%) + Coarse aggregates (100%) +pumice stones (0%)
M-2-cement (100%) + Sand (100%) + Coarse aggregates (90%) +pumice stones (10%)
M-3-cement (100%) + Sand (100%) + Coarse aggregates (80%) +pumice stones (20%)
M-4-cement (100%) + Sand (100%) + Coarse aggregates (70%) +pumice stones (30%)

Table 1: Test results of compressive strength by using pumice stones

S. NO	% of Pumice	7days strength (MPa)	28 days strength (MPa)
1	0	24.96	39.41
2	**10**	**26.85**	**41.52**
3	20	25.52	40.52
4	30	24.98	39.58

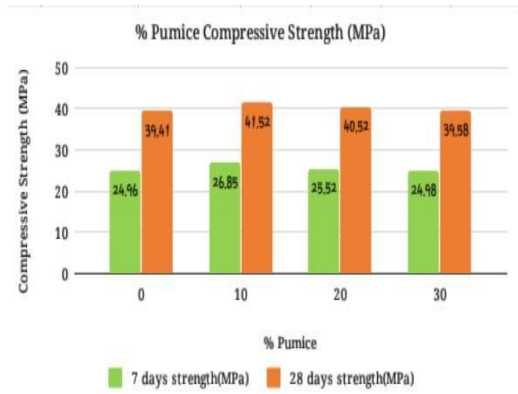

Figure 1: Comparison of compressive strength by using different percentage of pumice stones

Table 2: Test results of split tensile strength by using pumice stones

S. NO	% of Pumice	7days strength (MPa)	28 days strength (MPa)
1	0	2.81	3.98
2	**10**	**2.96**	**4.12**
3	20	2.91	4.09
4	30	2.83	3.99

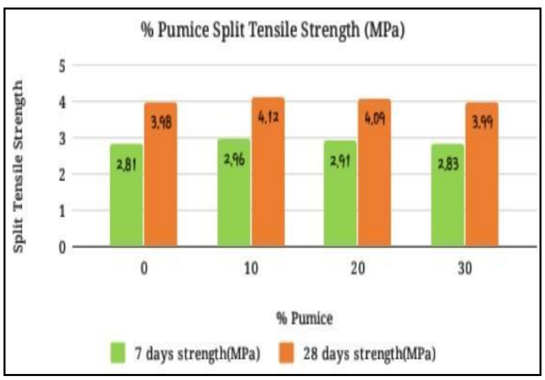

Figure 2: Comparison of split tensile strength by using different percentage of pumice stones

Table 3: Test results of flexural strength by using pumice stones

S. NO	% of Pumice	7days strength (MPa)	28 days strength (MPa)
1	0	3.76	4.12
2	**10**	**3.85**	**4.31**
3	20	3.82	4.21
4	30	3.78	4.13

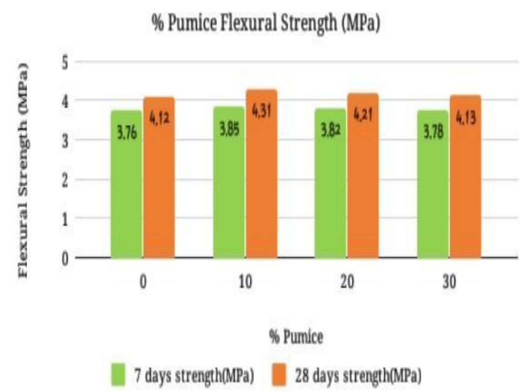

Figure 3: Comparison of Flexural strength by using different percentage of pumice stones

Optimum mix result

Mix proportion for M30 grade concrete mix is 1:1.35:2.89. (Addition of 10% pumice stones and Glass fiber)

M-1-cement (100%) + Sand (100%) + Coarse aggregates (90%) +pumice stones (10%) + Glass fiber (0%)

M-2-cement (100%) + Sand (100%) + Coarse aggregates (90%) +pumice stones (10%) + Glass fiber (0.1%)

M-3-cement (100%) + Sand (100%) + Coarse aggregates (90%) +pumice stones (10%) + Glass fiber (0.2%)

M-4-cement (100%) + Sand (100%) + Coarse aggregates (90%) +pumice stones (10%) + Glass fiber (0.3%)

M-4-cement (100%) + Sand (100%) + Coarse aggregates (90%) +pumice stones (10%) + Glass fiber (0.4%)

Table 4: Test results of compressive strength by using 10% pumice stones and glass fibers

S. NO	% of Glass fiber	7days strength (MPa)	28 days strength (MPa)
1	0	26.85	41.52
2	0.10	27.86	41.95
3	0.20	28.32	42.54
4	**0.30**	**29.56**	**43.42**
5	0.40	28.12	42.31

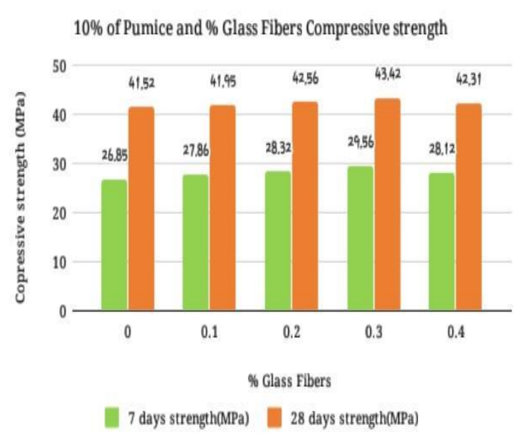

Figure 4: Comparison of compressive strength by using 10% pumice stones and different percentage of glass fibers

Table 5: Test results of Split tensile strength by using 10% pumice stones and glass fibers

S. NO	% of Glass fiber	7days strength (MPa)	28 days strength (MPa)
1	0	2.96	4.12
2	0.10	3.12	4.21
3	0.20	3.23	4.26
4	**0.30**	**3.35**	**4.38**
5	0.40	3.15	4.15

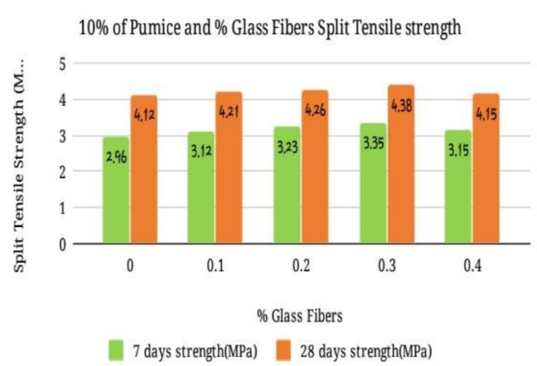

Figure 5: Comparison of Split tensile strength by using 10% pumice stones and different percentage of glass fibers

Table 6: Test results of Flexural strength by using 10% pumice stones and glass fibers

S. NO	% of Glass fiber	7days strength (MPa)	28 days strength (MPa)
1	0	2.96	4.12
2	0.10	3.12	4.21
3	0.20	3.23	4.26
4	**0.30**	**3.35**	**4.38**
5	0.40	3.15	4.15

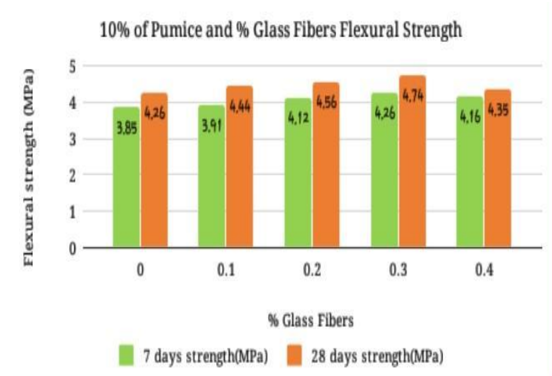

Figure 6: Comparison of Flexural strength by using 10% pumice stones and different percentage of glass fibers

Self-weight test results

Table 7: Test results of Self-weight by partial replacement of coarse aggregates with pumice stones

S.NO	% of pumice stones	Unit weight (Kg/m3) Pumice stone
1	0	845.52
2	10	485.35
3	20	320.78
4	30	294.12

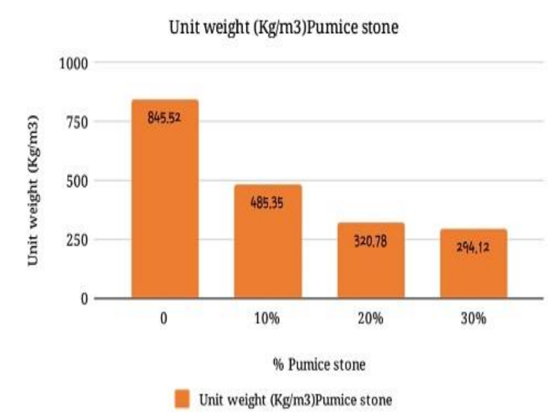

Figure 7: Comparison of unit weight by using different percentage of pumice stones

Durability results

Table 8: Test results of Durability by curing with 5% HCL

% Glass fiber	% Weight loss after 28 days	28 days strength (MPa)	28days strength (MPa) (5%HCL)	% Strength loss
0	2.23	41.52	38.86	6.41
0.1	2.36	41.95	39.56	5.70
0.2	2.56	42.56	39.92	6.20
0.3	2.85	43.42	41.25	5.00
0.4	2.96	42.31	39.56	6.50

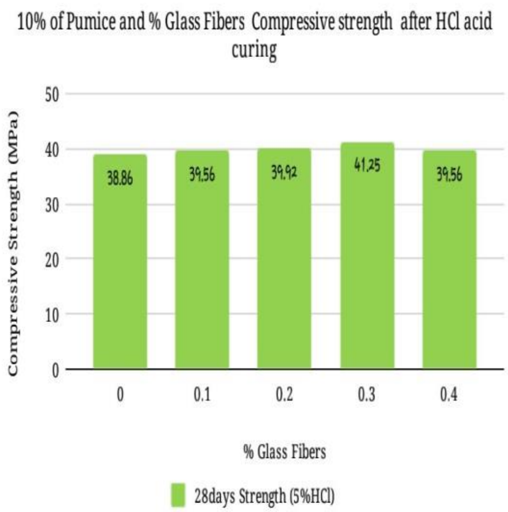

Figure 8: Comparison of Compression strength by using 10% pumice stones and percentage of glass fibers after HCL acid curing

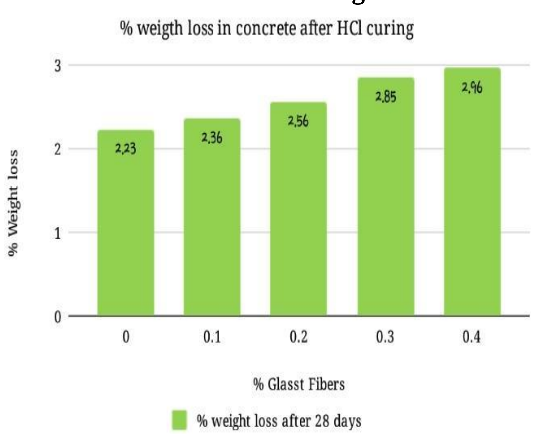

Figure 9: Comparison of weight loss by using 10% pumice stones and percentage of glass fibers after HCL acid curing

V. CONCLUSION

1. The replacement of coarse aggregate with 10% of pumice aggregates has resulted in increased strength properties at both the 7 days and 28 days with 5.35%, 3.52 % and 4.61% increase in compression strength, split tensile strength and flexural strength respectively when compared with the conventional concrete.
2. The addition of glass fibers with 0.3% has resulted in increased strength properties at both the 7 days and 28 days with 4.58%, 11.27% and 6.31% increase in compression strength, split tensile strength and flexural strength respectively when compared with the conventional concrete.
3. The addition of fibers has greatly influenced flexural and tensile strength properties, along with it was observed that addition of fibers has resulted in delayed crack propagation.
4. The use of prewetted pumice aggregate may also helped in reducing the heat of hydration. Also use of pumice aggregate in the concrete has decreased the self-weight of the concrete with a large variation of 40% reduction in the concrete at 10% pumice. This will influence the design parameters of the structures making very economical.
5. The durability studies of the pumice aggregate glass fiber reinforced concrete resulted that there is no much effect under 5% HCl curing for 28 days compared with conventional concrete.

REFERENCES

[1] Chandramouli K.1,"Strength Properties Of Glass Fiber Concrete"Vol. 5,No. 4, April 2010.Issn 1819-6608.
[2] J.D.Chaitanya kumar " Experimental Studies on Glass Fiber Concrete" American Journal of Engineering Research (AJER) 2016.
[3] D.Neeraja,“Experimental Investigations on Strength Characteristics of Steel Fiber Reinforced Concrete”, IJSER Volume 2, Issue 07, (February 2013).
[4] AvinashGornale, S Ibrahim Quadri, Mehmoodquadri, Syed Md Akramali and Syed Sham Suddin Hussaini “Strength Aspects of Glass Fiber Reinforced Concrete”, IJSER, Volume 3, Issue, (July 2012).
[5] Prof. Jayeshkumar Pitroda, Dr. L.B.Zala and Dr.F.S.Umrigar, “Innovative use of paper industry waste (hypo sludge) in design mix concrete”, IJAET, Vol.4, Issue1, Mar.2013.
[6] Abdullah shahbaz khan, Ram panth, Gagan Krishna P.R. and Suresh G.Patil, “Structural performance of concrete by partial replacement of cement with hypo sludge (paper waste)”, IJETE, Vol. 1, Issue 7,Aug 2014.
[7] Milind and V. Mohod, “Performance of Steel Fiber Reinforced Concrete”, Volume.1, Issue 12(December 2012).
[8] A.Sumathi and K. Saravana Raja Mohan “Study on the Strength and Durability Characteristics of High Strength Concrete with Steel Fibers” IJCR.volume.08 (2015).

[9] A.M.Shende, A.M. Pande and M. Gulfampathan "Experimental study on steel fiber reinforced concrete for M-40 grade", IRJES 4, issue2, (February-2013volume).

[10] B.Vamsi Krishna et al., "A Study on the mechanical properties of light weight concrete by replacing coarse aggregate with (pumice) and cement with (fly ash)" IJERT, ISSN: 2278-0181,[Vol.4, Issue 8, August-2015 Pg.No (331- 336)]