MECHANICAL PROPERTIES OF GLASS POWDER AND TIN STRIPS BASED CONCRETE UNDER ACCELERATED CURING

Amritha P[1], Aparna Dandapani[2], Kezy Joy[3], Alwyn Varghese[4], Vivek K Viswanath[5]

[1,2,3]Student, [4,5]Assistant Professor, Civil Engineering,

Ahalia School of engineering and Technolog (India)

Today the construction industry is finding cost effective materials for strengthening the concrete. Waste management is becoming a major issue worldwide. One option for safe environmental and economic disposal of waste is to reuse them in building materials. Glass being non-biodegradable is not suitable for addition to landfill, and as such recycling opportunities need to be investigated. Use of metals as containers has become popular and safe now, especially to carry liquid. But its disposal is difficult. Due to high material consumption of the construction industry, the utilization of used glass as a partial replacement for fine aggregate in structural concrete is partially attractive. This paper aims to study the properties of concrete by partially replacing fine aggregate by crushed glass powder and soft drink tins strips as fibers. The study was conducted on the M25 mix with water cement ratio 0.40. The fine aggregate was partially replaced with glass powder at percentages of 10, 20, 30, 40 and 50. The addition of fibers was studied at various percentages of 0.5,1,2 and 3. Accelerated curing process was adopted. From the optimum percentage of glass powder replacement and fiber addition, the different hybrid was cast and studied its properties.

Keywords – Concrete, Fiber, Glass Powder, Replacement, Tin strips

I. INTRODUCTION

Concrete is the most used construction material. Plain concrete possesses two major drawbacks as a structural material. They behave in the brittle fashion and possess a very low tensile strength. It possesses a low modulus, limited ductility and little resistance to cracking. Micro cracks developing the material during its manufacture due to inherent volumetric and micro structural changes. Hence it is necessary to impart tensile resistance properties to concrete structural members to use it as a load bearing material. Concrete have comparatively higher compressive strength but lower tensile strength. Waste management has become a significant issue in today's growing society. Population levels around the globe are increasing rapidly, resulting in unprecedented levels of waste material. Waste utilization in cement and concrete should be maximized to achieve cost reduction, saving in energy, resource conservation, improved product quality, environmental protection and reduction in greenhouse gas emission and for improved durability. Most of the non-degradable waste materials are left as stockpiles, used as landfill material or illegally dumped in selected areas. Large quantities of this waste cannot be eliminated. However, the environmental impact can be reduced by making more sustainable use of this waste. Researchers into new innovative uses of waste materials are continuously advancing. These research efforts try to match societies need for safe and economic disposal of waste materials.Glass being non-biodegradable is one such material that is not suitable for addition to landfill. Fortunately, glass can be recycled indefinitely without any loss in quality, but first needs to be sorted by colour. This is an expensive process, and subsequently waste glasses is increasingly being used in application s were mixed colour is not an issue, such as an aggregate in civil construction. The construction industry presents an attractive market for the use of waste glass. One of the principal components of construction is concrete, due to its high compressive strength, durability, and ease of construction.

With natural aggregates within India being present in limited quantities, producing crushed aggregates for use in the construction industry is costly. Therefore it can be seen that incorporating recycled glass as aggregate in structural concrete has the potential to not only produce environmental benefits in the reduction of landfill and the consumption of raw materials but to also reduce costs for industry costs. The use of recycled waste glass in concrete has attracted much interest worldwide and numerous researches have been carried out, showing the possibility of use of waste glass as building materials by partially replacing concrete mixtures. The study conducted by M. Adaway et.al. [1]concluded that the compressive strength of the concrete was found to increase by the replacement of fine aggregate by glass powder. This can be attributed to the angular nature of the glass particles which facilitate better bonding with the cement paste. The research conducted by M. Iqbal Malik et.al. [2], EsraaEmaam Ali et.al. [3], S.P Gautam et.al. [4] proves glass powder as fine aggregate replacement increases the mechanical properties of concrete.

Reinforcing concrete with fibres can effectively improve the properties of concrete like mechanical strength, toughness, shrinkage, durability, etc. addition of fibres would act as a crack resistor and would substantially improve static and dynamic properties. The studies conducted by G.Muraliet. al. [5] and J. Raj Prasad et. al. [6] shows that waste materials including steel powder, lathe waster, soft drink tins can be used as fibers to improve the mechanical properties of the concrete. The study conducted by UroosaIqbalet. al [7] concludes that with the increase in size and percentage of the soft drink tin strips the workability of concrete decreases and the strength increases. From the study conducted by KampaRavinder [8], the addition of soft drink tin strips as fibers increases the mechanical properties of the concrete.

Concrete is generally weak in tensile strength and strong in compressive strength. The main aim of researches or concrete technologists is to improve the tensile strength of concrete. To overcome this serious defect partial incorporation of fibers occurs. Great quantities of steel waste fibers are generated from industries related to lathe, empty beverages, metal cans and soft drink bottles. This is an environmental issue as steel waste fibers are difficult to biodegrade and involves processes either to recycle or reuse. Hence the use of soft drink tin fibers increases tensile strength and helps to improve durability.

A hybrid concrete is the one in which more than one material is added to increase the mechanical properties of concrete. The environmental and economic concern is the biggest challenge concrete industry is facing. Today Construction industry is in search of new materials to replace natural resources. Hybrid concrete using glass powder as partial replacement of fine aggregate and soft drink tin strips as fibers increases the strength and durability of concrete and also enhance waste management. The glass, which is non-degradable waste material possess good filler property and thus can be used as a partial replacement for natural fine aggregate. The soft drink tin waste as fiber helps to increase the strength. Hybrid concrete using glass powder and soft drink tin strips is cheaper building material than the normal concrete.

II. OBJECTIVE

- To experimentally investigate the characteristics of HYBRID CONCRETE using waste materials.
- To compare the strength of conventional concrete with hybrid concrete using waste materials.
- To study the use of waste materials in concrete and enhancing waste management in an economic way.

III. MATERIALS

Cement: Pozzolonic Portland Cement of 53 grade available in local market was used in investigation. The mechanical properties of the cement used in this investigation are given in TABLE 1.

TABLE 1.Properties of Cement

Properties of Cement	Values
Specific Gravity	2.92
Normal Consistency	34%
Initial Setting time	>30 min
Fineness Modulus	4.6

TABLE 2. Properties of fine and coarse aggregate

Particulars	Fine aggregate	Coarse aggregate
Bulk density	1.586	1.630
Void ratio	0.6746	0.641
Specific gravity	2.65	2.67
Porosity	40.2%	39.09%

Fine aggregate: Manufactured sand is a substitute of river for construction purposes sand produced from hard granite stone by crushing. The crushed sand is of cubical shape with grounded edges, washed and graded to as a construction material. The size of manufactured sand (M-Sand) is less than 4.75mm.Locally available clean, well graded M-sand was used as fine aggregate. The properties of the fine aggregate are given in the TABLE 2. Figure 1 represents the particle size distribution curve of the M- sand.

Coarse aggregate: Crushed granite angular aggregate of size 20mm nominal size from local source was used. The properties of the coarse aggregate are given in the TABLE 2

Glass powder: Glass powder is obtained by crushing the beverage bottles. The glass powder is used as partial replacement of fine aggregate. The size of particles used is 0.006-1.18mm. The specific gravity of the glass powder was found to be 2.5. Figure 2 represents particle size distribution curve of glass powder.

Fibres: Soft drink tin cut into strips of size 3mmx10mm were used as fibers. The material of tin strip is aluminum. The density of fiber was found to be 1.75g/cm^3.

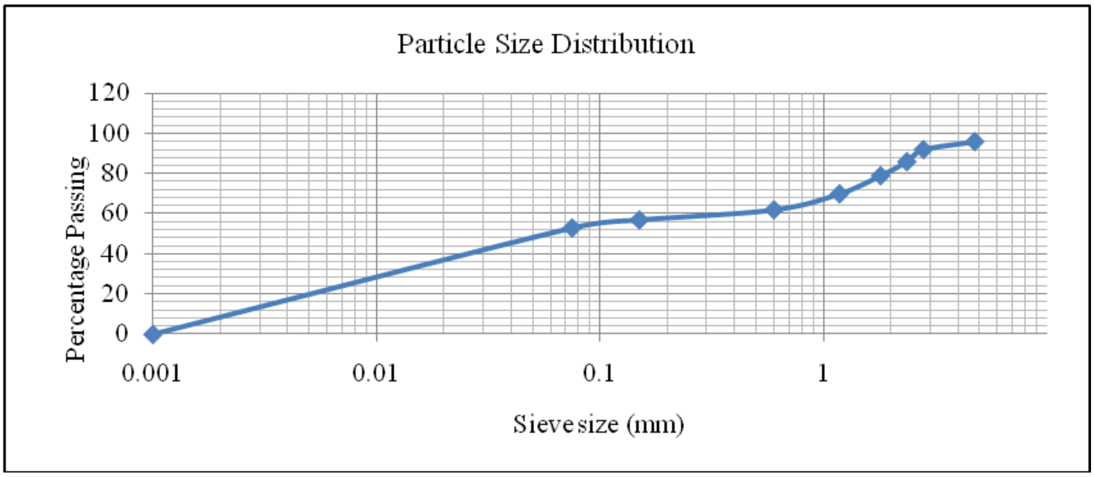

Figure 1 sieve analysis of M-sand

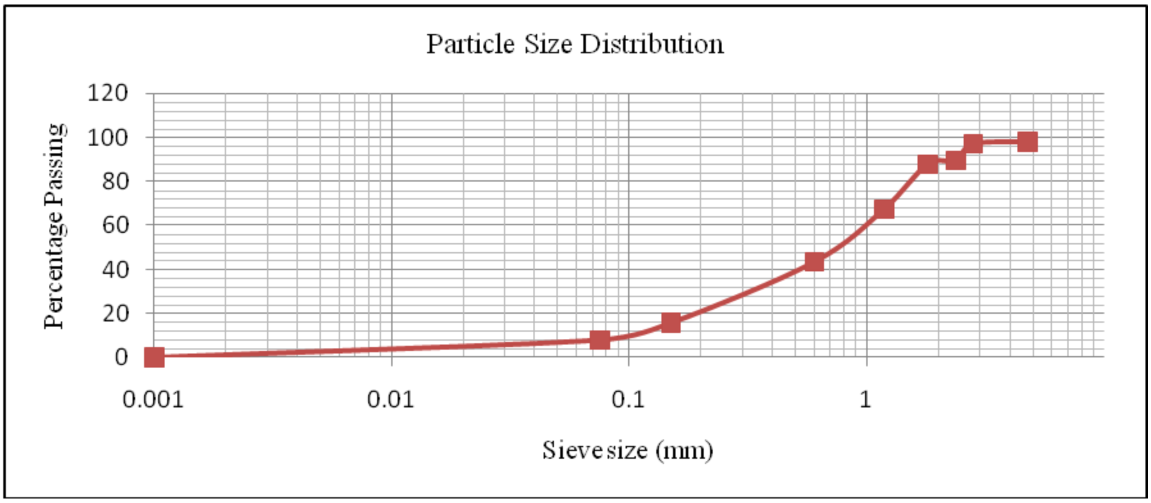

Figure 2 sieve analysis of glass powder

IV. METHODOLOGY

The beverage bottles and soft drink tins were collected. The bottles were crushed to make it into powder form. The glass powder was sieved and particles of size 4.75 to 600 micron were used for replacement. The well graded glass powder was used for partially replacing M sand. The tin was scratched to improve bonding in the concrete and was cut into strips of size 3mm X 10mm.

TABLE 3.Mix proportions

Cement	Fine aggregate	Coarse aggregate	Water
1	1.17	2.1	0.40

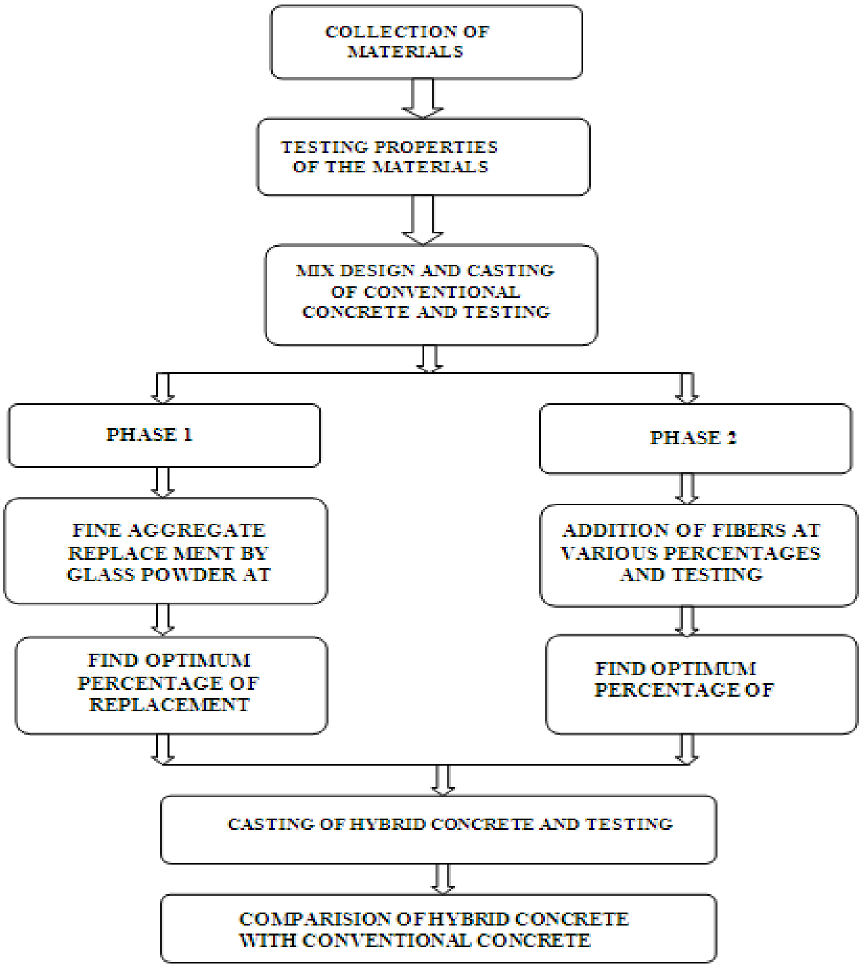

Figure 3 glass powder and tin strips

4.1 Accelerated Curing

Accelerated curing is any method by which high early age strength is achieved in concrete. The two method of accelerated curing are warm water method and boiling water method. To determine the early age strength, boiling water method of accelerated curing are adopted. The cubes of size 100mm X 100 mm X 100mm and cylinders of 150mm diameter and 300mm length was cured in the curing tank for three and half hours and then immersed in cooling tank for two hours. According IS: 516-1959 [9] for concrete mixes with aggregate size less than or equal to 20mm the cubes with size 100mm may be used. The specimen was tested in accordance with IS: 516-1959. As per IS: 9013-1978, [10] a correlation exists between the results obtained in concrete specimens, cured by accelerated method and cured by normal method, for mixes employing different materials and mix proportions. The corresponding strength at 28 days can be found out from the following correlation. The test results obtained were correlated with the help of graph for boiling water method in the IS: 9013-1978.

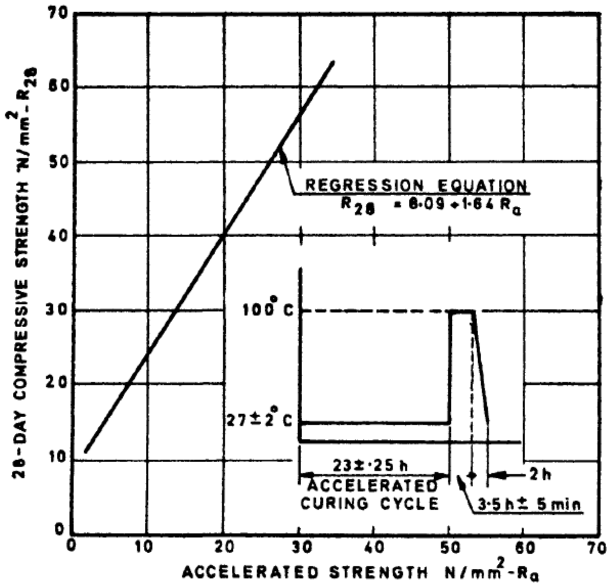

Figure 4 accelerated curing tankFigure 5 correlation chart for boiling water method

V. RESULTS

5.1 Glass powder replacements

The M-sand was replaced using varying percentages of 10,20,30,40 and 50. From the test results represented in TABLE 3 the optimum percentage was found to be 30%.

5.2 Fiber addition

The tin strips as fibers were added at percentages of 0.5, 1, 2, And 3. From the test results represented in TABLE 4, the optimum percentage was found to be 0.5.

TABLE 4. Test results of Glass powder replacement

Glass powder	Slump(mm)	Compressive Strength(MPa)	Tensile strength(MPa)
0	120	36	2.76
10	90	39	2.91
20	75	40.89	2.95
30	70	50.46	3.05
40	65	47.33	2.93

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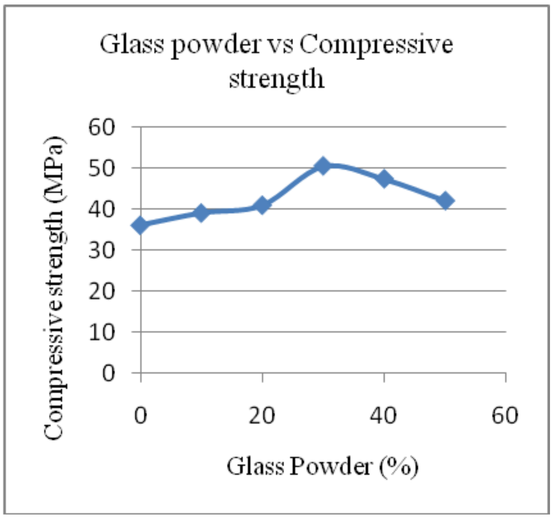
50	50	42	2.89



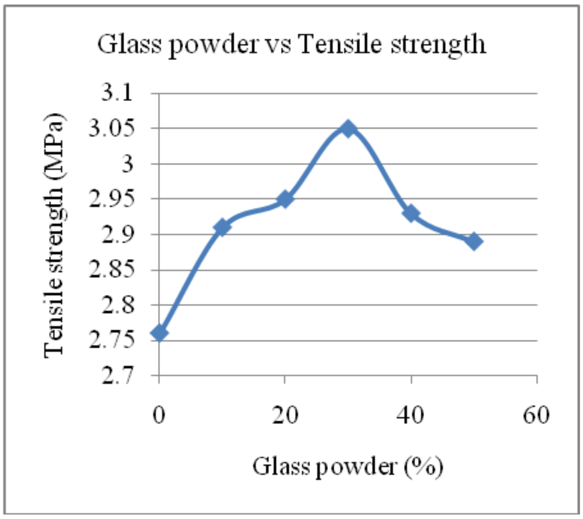


Figure 6 glass Powder vs compressive strengthFigure 7glass Powder vs tensile strength

TABLE 5. Test results of fiber addition

Fiber (%)	**Slump (mm)**	**Compressive strength (MPa)**	**Tensile strength (MPa)**
0	120	36	2.76
0.5	75	40.94	3.3
1	70	36.82	2.95
2	65	34.27	2.81
3	60	28.36	2.55

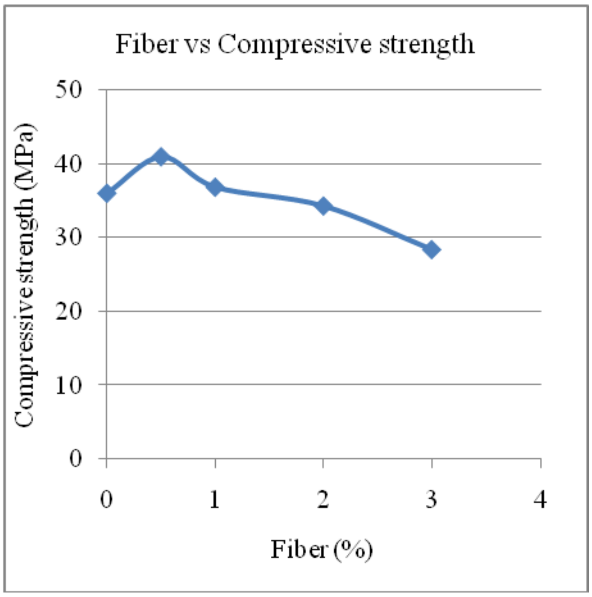


Figure 8 fiber vs compressive strength

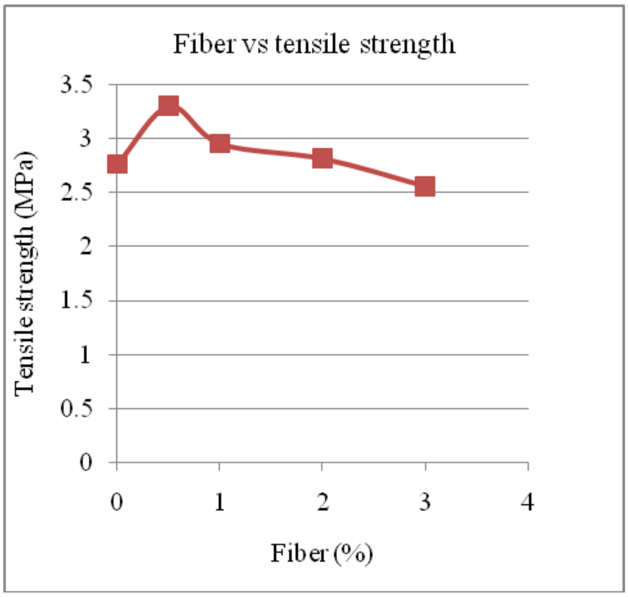


Figure 9 fiber vs tensile strength

5.3 Hybrid mixes

In case of hybrid concrete, it is not sure about desired results. Hence, nine different hybrid concrete mixes by varying glass powder and fiber percentages were tried. From the results in TABLE 5, none of the hybrid mixes obtained the results closer to control mix. The nine hybrid mixes are:-

$G_{30}F_{0.5}$	30% Glass Powder Replacement + 0.5 % Fiber addition
$G_{30}F_{1}$	30% Glass Powder Replacement + 1 % Fiber addition
$G_{30}F_{2}$	30% Glass Powder Replacement + 2 % Fiber addition
$G_{25}F_{0.5}$	25% Glass Powder Replacement + 0.5 % Fiber addition
$G_{35}F_{0.5}$	35% Glass Powder Replacement + 0.5 % Fiber addition
$G_{40}F_{0.5}$	40% Glass Powder Replacement + 0.5 % Fiber addition
$G_{45}F_{0.5}$	45% Glass Powder Replacement + 0.5 % Fiber addition
$G_{50}F_{0.5}$	50% Glass Powder Replacement + 0.5 % Fiber addition
$G_{35}F_{1}$	35% Glass Powder Replacement + 1 % Fiber addition

TABLE 6. Test results of hybrid mixes

MIX	SLUMP (mm)	STRENGTH TESTS	
		COMPRESSION(N/mm^2)	TENSION(N/mm^2)
0 MIX	120	36	2.69
$G_{30}F_{0.5}$	90	22.65	3.075
$G_{30}F_1$	80	21.1	2.55
$G_{30}F_2$	65	16.23	2.28
$G_{25}F_{0.5}$	80	24.49	2.307
$G_{35}F_{0.5}$	75	31.05	2.602
$G_{40}F_{0.5}$	70	26.15	2.386
$G_{45}F_{0.5}$	65	17.93	1.974
$G_{50}F_{0.5}$	60	16.4	1.88
$G_{35}F_1$	85	23.7	2.267

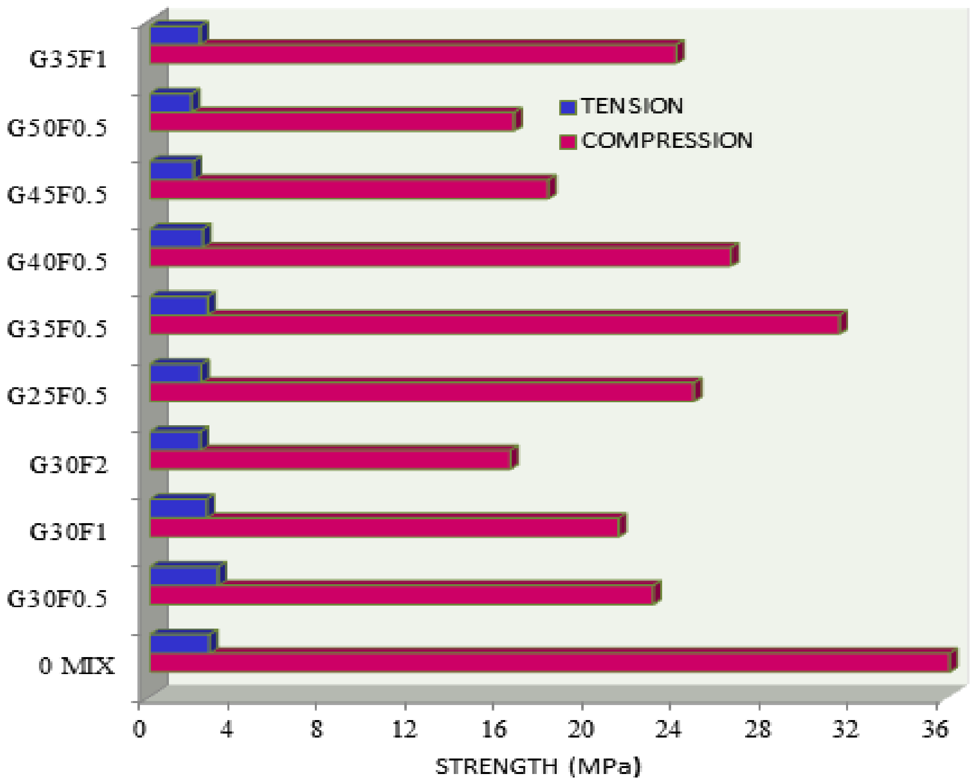


Figure 10 strength values of hybrid mixes

VI. CONCLUSION

- 30% percentage of glass powder replacement was found to be optimum. The compressive strength and tensile strength increment was found to be 40.1% and 10.5% respectively. The angular nature of the powdered glass increases the bonding in the concrete which aids to the strength increment.[1]
- 0.5% percentage of fiber addition was found to be optimum.The compressive and tensile strength increment was found to be 13% and 19.5% respectively. The addition of the tin strips as fibers reduces the micro cracks in the concrete thereby increasing the tensile strength.
- None of the hybrid mixes obtained the strength closer to that of control mix. This may be due to lack of bonding between the glass powder and tin strips.
- Both Glass powder and tin strips can be used separately in concrete to increase the mechanical properties of the concrete.

VII. SUGGESTIONS

The hybrid mixes do not have strength comparable to that of control mix. Hence glass powder as partial replacement for M- sand and tin strips as artificial fibers cannot be used together. It does not give the combined effect on concrete. But, glass powder and tin strips may be used separately in concrete for better results. The reasons for the failure of hybrid concrete using glass powder and tin strips may be:

- Lack of bond between glass particles and tin strips.
- The corrosion of the aluminum strips.
- Oxidation reaction between the constituent particles of the glass powder and tin strips.

The tin strips were scratched to improve the bonding in the concrete. So the protective coating to prevent oxidation in aluminum may get removed. Also curing in boiling water may accelerate the reaction to take place.For determining the exact reason for the failure of hybrid concrete future studies are required.

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