STRENGTH CHARASTERISTICS OF PARTIAL AND FULLY REPLACEMENT OF CEMENT BY USING GGBFS AND PARTIAL AND FULLY REPLACEMENT OF RIVER-SAND BY USING BOTTOM-ASH

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***ABSTRACT*: Concrete is the most extensively used construction material in the world. Concrete is normally prepared by using coarse aggregate, fine aggregate, cement and water measured by weight in a required proportion. These materials are obtained from natural resource. Continuous use of these materials on a large scale leads to their depletion causing strain on the environment. Large quantities of waste materials are produced from the manufacturing industry, service industry and municipal solid waste incinerators. The waste materials are gaining attention to use the materials as a substitute to natural aggregates or cement in concrete. The second most consumed product in the world is Cement. It contributes nearly 7% of the global carbon dioxide emission. GGBS which are considered as a more eco-friendly alternative to Ordinary Portland Cement (OPC) based concrete. By using this type of industrial by-products in concrete industry as a replacement for cement we can reduce the usage of cement which results in minimizing the emission of greenhouses gases into the atmosphere and also savings in cost. Bottom-ash is considered as alternate fine aggregate. By using this can able to prevent the scarcity of river-sand. In this research, this project focused on the effects of varies percentage of bottom ash and GGBS replacement on the concrete and also study compressive strength, tensile strength and of concrete containing bottom ash as river-sand replacement and GGBS as cement replacement. The strength is analyzed 7days and 28days. The strength for 0, 25, 50, 75, 100% replacement of bottom ash with fine aggregate and 0, 25, 50, 75, 100% replacement of GGBS with cement is higher or equal to conventional concrete.**

***KEYWORDS*: Bottom-ash and ground granulated blast furnace slag (GGBFS), cement, River-sand**

I.INTRODUCTION

1.1 General

Concrete is the most widely used construction material in the world and Ordinary Portland Cement (OPC) is the major ingredient used in concrete. The production of cement releases large amount of carbon dioxide (CO2) to the atmosphere that significantly contributes to greenhouse gas emissions. It is estimated that one ton of CO2 is released into the atmosphere for every ton of OPC produced. In view of this, there is a need to develop sustainable alternatives to conventional cement utilizing the cementations properties of industrial by products such as bottom- ash and ground granulated blast furnace slag.

Large quantities of waste materials are produced from the manufacturing industry, service industry and municipal solid waste incinerators. The waste materials are gaining attention to use the materials as a substitute to natural aggregates or cement in concrete. On the other side, the abundance and availability of bottom-ash ash and GGBS worldwide create opportunity to utilize these by-products, as partial replacement or as performance enhancer for OPC. Concrete is a widely used construction material for various types of structures due to its structural stability and strength.

The increasing demand for electricity resulted in construction of coal fired power plants. As the consumption of coal increases, the production of coal and it by-products also increased. The ash has to be disposed of either dry or wet to an open area near the plant or by mixing both the fly ash and bottom ash with water and pumping into artificial lagoon or dumping yards. The disposal of such large quantity of ash has occupied thousands hectares of land which includes agricultural and forest land and causes pollution of water bodies too. If these combustion byproducts are not utilized properly, there will be no enough space and the disposal of these by-products will be a problem. To minimize all these effects, a best alternative is to promote large-scale utilization of coal ash. The utilization of large quantity of bottom ash can mitigate or solve the disposal and environmental problems associated to it. Coal ash is a residue resulting from combustion of pulverized coal or lignite in Thermal Power Plants and these residues or byproducts are commonly known as Coal Combustion products or CCPs. In a dry bottom boiler, about 80 percent of the unburned material or coal ash is entrained in the combustion gases and is captured as fly ash. The remaining 20 percent of the ash is dry bottom ash collected at the bottom of the furnace.

This study shows the effect of mechanical properties of concrete in which the fine aggregates are partially replaced with varying percentages. Blast furnace slag is a byproduct of iron manufacturing industry. Iron ore, coke and limestone are fed into the furnace, and the resulting molten slag floats above the molten iron at a temperature of about 1500 degree Celsius to 1600 degree celsius. The molten slag has a composition of 30% to 40% silicon dioxide (SiO_2) and approximately 40% CaO, which is close to the chemical composition of Portland cement. After the molten iron is tapped off, the remaining molten slag, which mainly consists of siliceous and aluminous residues, is then rapidly water- quenched, resulting in the formation of a glassy granulate. This glassy granulate is dried and ground to the required size which is known as ground granulated blast furnace slag (GGBFS). The production of GGBFS requires little additional energy compared with the energy required for the production of Portland cement. The replacement of Portland cement with GGBFS will lead to a significant reduction of carbon dioxide gas emission and environmentally friendly construction material. It can be used to replace as much as 50% of the Portland cement when used in concrete. GGBFS concrete has better water impermeability characteristics as well as improved resistance to corrosion and sulphate attack. As a result, the service life of a structure is enhanced and the maintenance cost reduced. High volume eco-friendly replacement slag leads to the development of concrete which not only utilizes the industrial wastes but also saves significant natural resources and energy. This in turn reduces the consumption of cement.

1.2 Major need in concrete

- Cement
- GGBFS
- River-sand
- Bottom-ash
- Coarse aggregate

1.3 Objective

- To determine the durability of concrete by partial replacement of bottom ash and ground granulated blast-furnace slag (GGBFS).
- Tons of waste is being produced in thermal power plants and iron manufacturing industry they aren't recycled. But by using them in construction field, wastes can be reused, which will lead to a eco-friendly environment.

1.4 ADVANTAGES

- Recycling waste materials
- By used this can able to prevented 80 percentage of carbon-dioxide emission.
- It increases strength and durability of the concrete.
- It is cheap in cost and available material.

II. LITRATURE REVIEW

Kimmi Garg and Kshipra Kapoor [1] studied and experimented, it is proved that GGBS can be used as an alternative material for cement, reducing cement consumption and reducing the cost of construction. Use of industrial waste products saves the environment and conserves natural resources.

Vinayak Awasare et al., [2] analyses strength properties of partially replaced GGBS concrete. The flexural strengths achieved are 3.01Mpa, 3.45Mpa, 3.58Mpa, 3.44Mpa and 3.12Mpa at 0%, 20%, 30%, 40%, and 50% for GGBS concrete respectively for M20 grade concrete of OPC cement and crushed sand.This report shows that tensile strength also gives good performance for 20%, 30 % and 40% replacement which is more than normal plain concrete.

Yasutaka Sagawa and Daisuke Yam [3] study concluded that the specimens which include normal-strength concrete and high-strength concrete by changing W/B from 65% to 35% were examined. The effectiveness of GGBS on chloride ion diffusion coefficient was investigated by migration test. Moreover, the application of GGBS which has the surface is a 6000 cm2/g for bridge superstructures was presented.

D. Suresh and K. Nagaraju [4] review concluded that the movement of moisture of GGBS mixes, probably due to the dense and strong microstructure of the interfacial aggregate/binder transition zone is probably responsible for the high resistance of GGBS mix to attack in aggressive environments such as silage pits. GGBS is a good replacement for cement in some cases and serves effectively but it can't replace cement completely. But even though it replaces partially it gives very good results and a greener approach To construction and sustainable development which we are engineers are keen about today.

Vikas R Nadig et al [5] reviewed the Bottom Ash as Partial Sand Replacement in Concrete. This study reviews the characteristics of Concrete incorporated with Bottom Ash as partial replacement for fine aggregates, with a main focus on the mechanical properties such as Compressive strength, splitting tensile strength, flexural strength etc. Ten different research papers are reviewed in this study. The practical use of Bottom ash shows a great contribution to waste minimization as well as resources conservation and it is concluded that the workability of Bottom ash concrete reduces with the increase in bottom ash content due to the increase in water demand. The density of Bottom Ash concrete decreases with the increase in bottom ash content due to the low specific gravity of bottom ash as compared to fine aggregates & Compressive strength of sand replaced bottom ash concrete will be lower than normal concrete specimens at all the ages & Splitting Tensile strength of sand replaced bottom ash concrete will be lower than normal concrete specimens at all the ages.

K. Sathya Prabha et al [6] experimentally studied the properties of Concrete Using Bottom Ash with Addition of Polypropylene Fiber. In this study, the concrete mix design is done for M25 grade concrete. The mix is prepared for different combinations of 0%, 10%, 20% and 30% of replacement of sand by bottom ash with 0.5% of polypropylene fiber by total weight of the Cube. The mechanical properties were compared with control mix and it was found that the optimal combination as 30% bottom ash and 1.0% polypropylene fibre. Flexural strength was compared by testing beams of size 1.5 x 0.25 x 0.15m under two point loading. Results showed that there was no degradation of strength for beams with bottom ash as replacement for fine aggregates.

T.Subramani et al [7] studied on the partial Replacement of Cement with Fly ash and Sand with Bottom Ash and Glass Used in Concrete. In this study the behavior Of Partial Replacement of Cement with Fly Ash and Sand with Bottom Ash and Glass Used in Concrete. To attain the setout objectives of the present investigation, Partial Replacement Of Cement With Fly Ash And Sand With Bottom Ash And Glass Used In Concrete by 30, 40, and 50 % to produce Concrete. Reinforced Concrete (RC) is tested for Compression, split tension and flexural strengths. The results are quite encouraging for use of Glass in producing Concrete.

Remya Raju et al [8] studied on the strength performance of concrete using bottom ash as fine aggregate. This study was conceived following the general purpose of testing new sustainable building processes and modern production systems, aims not only at saving natural raw materials and reducing energy consumption, but also to recycle industrial by-products. The objectives of this study was to investigate the effect of use of coal bottom ash as partial replacement of fine aggregates in various percentages (0–30%), on concrete properties such as compressive strength, splitting tensile strength test, flexural strength and modulus of elasticity and also the effect of micro silica in bottom ash concrete having maximum compressive strength. The test results of this research work indicates that at fixed water cement ratio, workability decreased with the use of coal bottom ash as a replacement of fine aggregate in concrete. Compressive strength of bottom ash concrete at the curing age of 28 days was increased compared to control concrete. Splitting tensile strength of concrete improved at percentages of replacement of bottom ash. The modulus of elasticity decreased with the use of coal bottom ash at all replacement levels.

A S Cadersa et al [9] studied the Use of Unprocessed Coal Bottom Ash as partial Fine aggregate Replacement in Concrete. This study investigates the use of unprocessed coal bottom ash as fine aggregate replacement in structural concrete in an attempt to contribute to a sound management of coal ash on the island of Mauritius. The coal bottom ash was obtained from FUEL thermal power station and had a loss of ignition of 11%. Experiments were conducted by replacing fine aggregate with bottom ash by weight in varying percentages (20%, 30%, 40%, 60%, and 80% respectively). The results showed that an increase in bottom ash content causes workability and plastic density to decrease and bleeding to increase. Moreover, above 40% replacement of bottom ash, compressive strength, flexural strength, and modulus of elasticity decreased sharply. In addition, an increase in bottom ash content improved the drying shrinkage performance of the concrete. The research also shows that 20% is the optimum percentage replacement to achieve favorable strength and good strength development pattern as a normal concrete mix with time. Unprocessed bottom ash from FUEL power station can thus be used as fine aggregate replacement in concrete for that specific percentage replacement. However, investigation should be carried out on the durability of the concrete

III. MATERIAL PROPERTIES

CEMENT

Specific gravity of fly-ash is 3.15

GGBFS

Specific gravity of GGBFS is 2.85

BOTTOM-ASH

Specific gravity of river sand is 2.08

RIVER-SAND

Specific gravity of bottom-ash is 2.36

COARSE-AGGREGATE

Specific gravity of coarse aggregate is 3.10

IV. METHODOLOGY

4.1 Mix Design

Mix Proportion

S.No	Cement (kg)	Fine Aggregate (kg)	Coarse Aggregate (kg)	Water (litre)
1	1.652	2.394	5.089	179
2	1	1.44	3.08	0.55

4.2 Mix proportion for ternary blended concrete

S.No	% of partial replacement of cement by GGBFS and % of partial replacement of fine aggregate by Bottom-ash	Cement	GGBFS	Fine aggregate	Bottom-ash	Coarse aggregate
1	0% and 0%	1.652	-	2.394	-	5.089
2	25% and 25%	1.239	0.413	1.796	0.598	5.089
3	50% and 50%	0.826	0.826	1.197	1.197	5.089
4	75% and 75%	0.413	1.239	0.598	1.176	5.089
5	100% and 100%	-	1.652	-	2.394	5.089

V. TEST FOR CONCRETE

5.1 Test results for hardened concrete

S.No	% of partial replacement of cement by GGBFS and % of partial replacement of fine aggregate by Bottom-ash	Compression strength		Durability test Compression strength for 1% H_2SO_4 acid immersion		Tensile strength (28 days)
		7 days	28 days	7 days	28 days	
1	0% and 0%	19.63	29.77	14	25.23	0.80
2	25% and 25%	16.52	26.38	11.02	22.26	0.78
3	50% and 50%	11.87	23.52	10.52	20.25	0.75
4	75% and 75%	10.02	15.32	8.25	11.26	0.71
5	100% and 100%	5.63	10.01	3.52	8.23	0.67

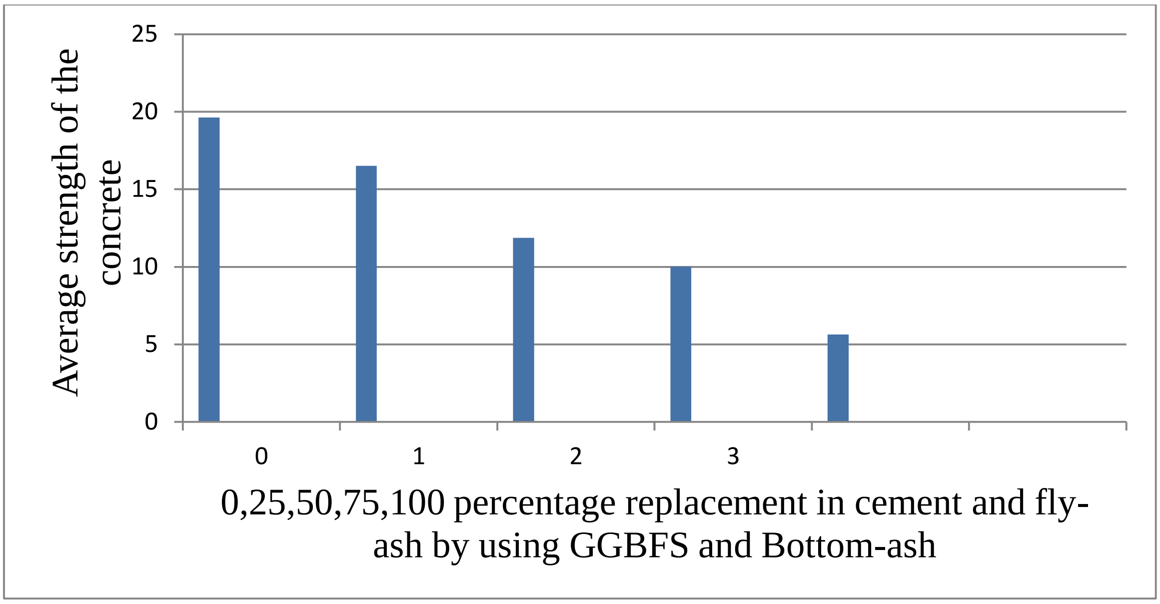

Fig.1 Compression strength result for 7th day test

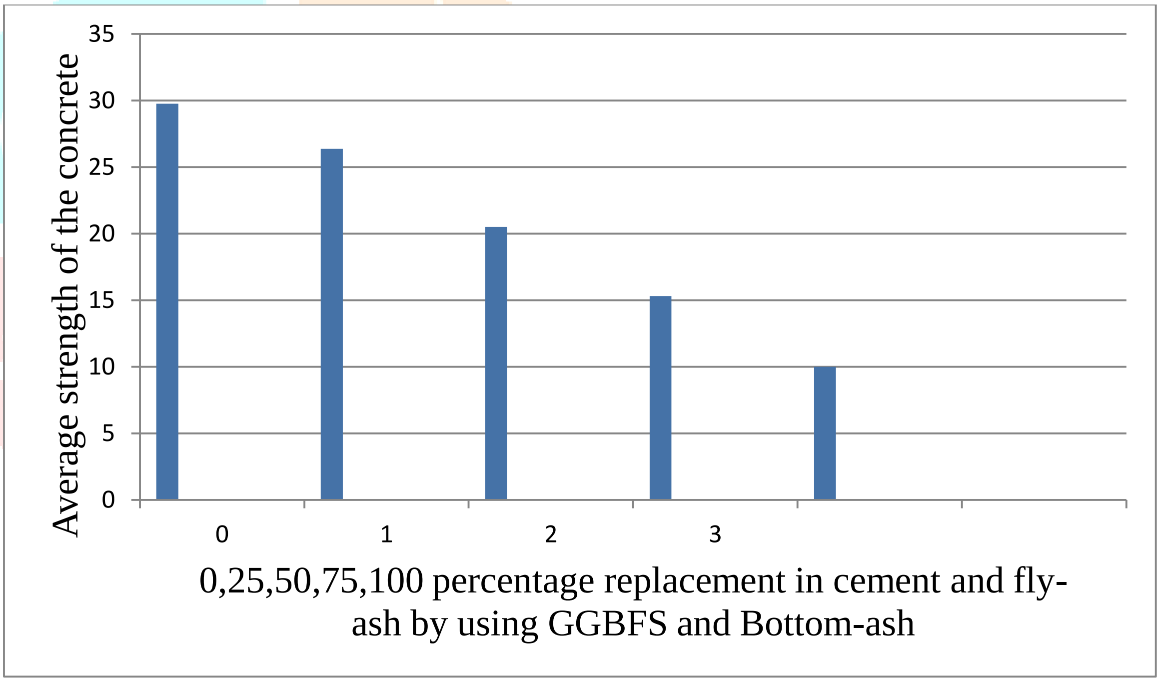

Fig.2 Compression strength result for 28th day test

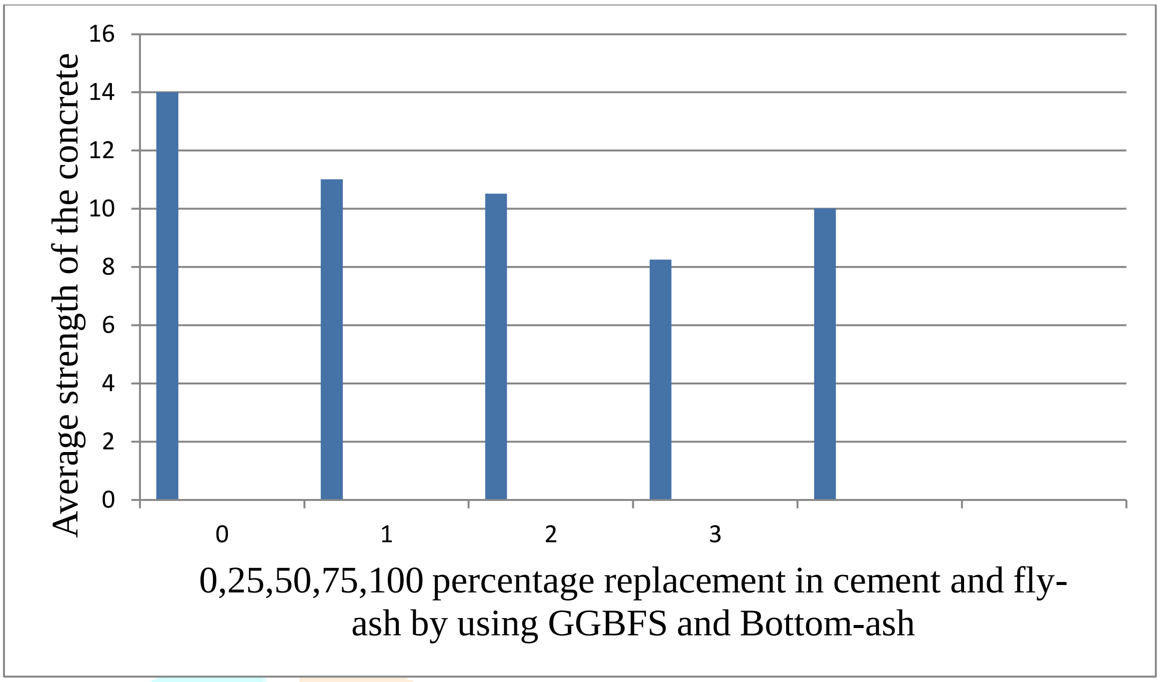

Fig.3 Compression strength for 1% H_2SO_4 acid immersion result for 7th day test

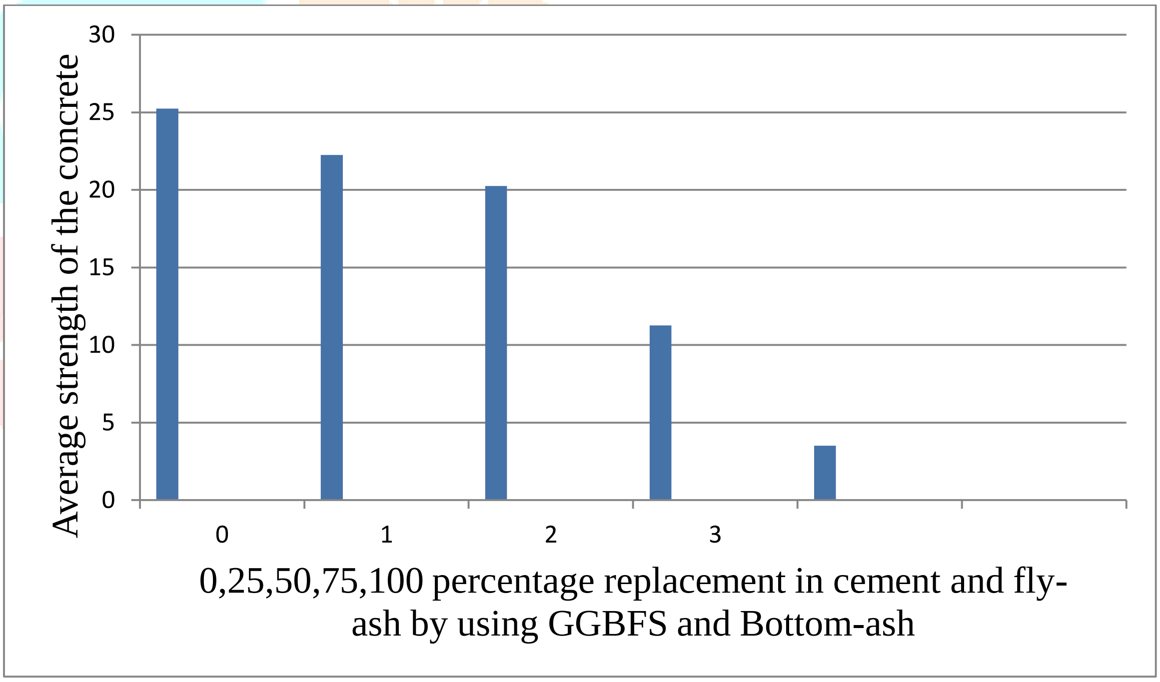

Fig.4 Compression strength for 1% H_2SO_4 acid immersion result for 28th day test

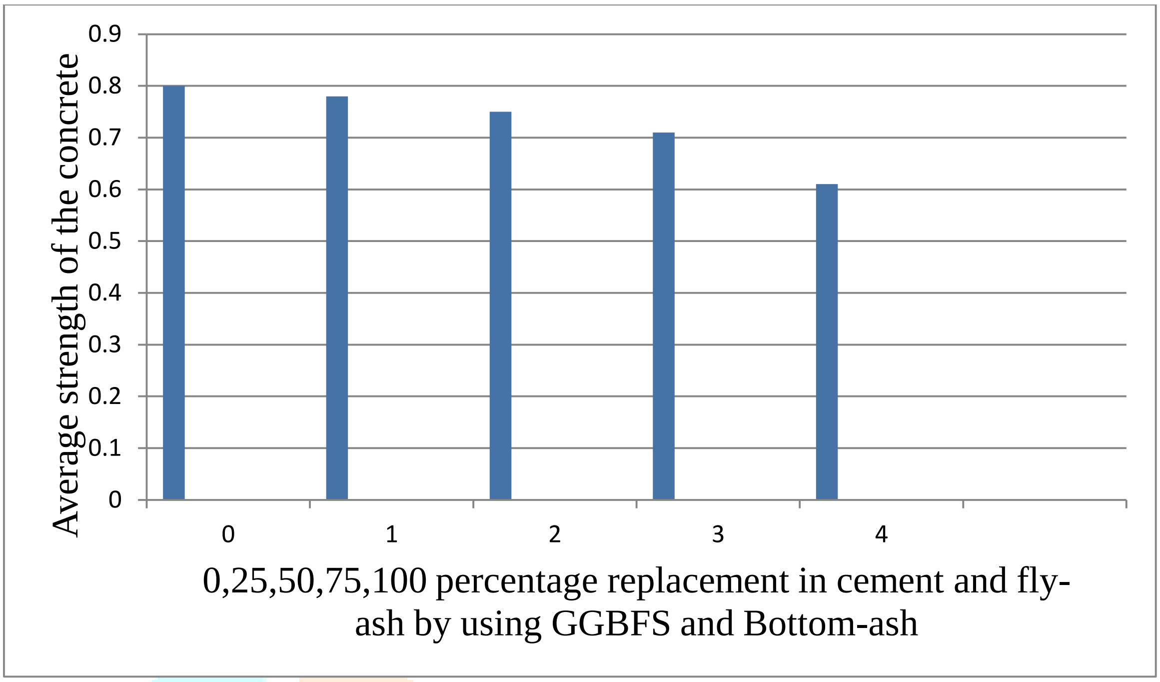

Fig.5 Tensile strength result for 28th day test

VI. RESULT AND DISCUSSION

The percentage of GGBFS and Bottom-ash increased the strength of the concrete decreased. Compare to all compositions 0% GGBFS and 0% Bottom-ash replacement given maximum strength. Partial replacement of 25% GGBFS and 25% Bottom-ash & 50% GGBFS and 50% Bottom-ash reached the target compressive and tensile strength. Partial replacement of 75% GGBFS and 75% Bottom-ash & 100% GGBFS and 100% Bottom-ash fail to reach reached the target compressive and tensile strength In this project says can use up to 50 percent replacement of GGBFS and Bottom-ash reached the target strength of the concrete.

VII. CONCLUSION

Replacement of GGBFS and bottom-ash in cement and fine aggregate gives good compressive and tensile strength of the concrete. By using this can able to recycle the waste material and also prevent the demand in construction material. But this composition strength is less compared to ordinary Portland cement concrete. But it reached target m_{20} strength of the concrete. So it can use as a replaced material for cement and fine aggregate. These recycled material also used to reduce the environmental effects

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