BEHAVIOR OF RECYCLED GLASS AS FINE AGGREGATE AND CEMENT WITH CONCRETE: A REVIEW

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Abstract: India being at its peak of developing stage, the demand of construction work has been enhanced exponentially, especially from the past few decades. The various materials used in production of concrete however have certain limitations and cause restrains in the utilization as they cause adverse effect in few ways. For example, the cement industries are responsible for increment in the emission of greenhouse gases ultimately leading to global warming and the use of natural sand has triggered lowering water table, exploitation of natural resources, erosion of river beds and sinking of bridge piers. An alternative method of production of concrete is a major concern. In the recent times, the concept of sustainable development has come in the limelight to reduce the environmental impacts. Glass is an inert material which could be recycled and used multiple times without changing its chemical properties since it is versatile, durable and reliable. The chemical property of waste recycled glass is similar to that of cement due to the presence of SiO_2, Al_2O_3 ,Fe_2O_3, Cao. So, there is a huge potential to use the waste glass in concrete constructions. This paper deals with the comparative study on the effect of compressive strength of concrete by replacing sand and cement separately with various percentage of waste glass in it and alkali silica reaction.

***keyword*:** Global warming; exploitation; sustainable development; cement; concrete; compressive strength; alkali-silica-reaction.

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. Being versatile and economical, concrete became prime construction material over the world, however, it has impacts on the environment Naik et.al (2008)[1].The global cement industry contributes about 7% of greenhouse gas emission to the earth's atmosphere. In order to address environmental effects associated with cement manufacturing, there is a need to develop alternative binders to make concrete.

The interest of the construction community in using waste or recycled materials in concrete is increasing because of the emphasis placed on sustainable construction. Sustainable construction practice means creation and responsible management of a healthy built environment considering resource efficiency and ecology Plessis (2007) [2].

Glass is an inert material which could be recycled and used many times without changing its chemical properties; it is versatile, durable and reliable. As a result, industry has made glass a marketable good, as glass production keeps increasing throughout the world.

Recently, Glasses and its powder has been used as a construction material to decrease environmental problems. The coarse and fine glass aggregates could cause ASR (alkali-silica reaction) in concrete, but the glass powder could suppress their ASR tendency, an effect similar to supplementary cementations materials (SCMs). Therefore, glass is used as a replacement of supplementary cementitious materials. To lower the amount of glass being discarded as well as to find use to the non-recycled glass in new applications the professional community is being pressurized by the environmental organizations as much of the glass produced in the world is discarded, land filled or stockpiled.

LITERATURE REVIEW:

FINE AGGREGATE:

M20-

Vijay Sekhar Reddy et.al (2015)[3] studied experimentally and concluded that 20% of replacement gave 29.84 MPa strength in 28 days . Fine aggregate in concrete was replaced by weight with sheet glass powder {10%,20%,30%,40% and 50%} by Mageswari et.al(2010)[4] and had conducted few tests to find compressive strength, split tensile test and cylinder test .It was observed that the replacement of 20% of fine aggregate with crushed recycled glass increases the compressive strength upto 40 MPa in 28 days.

According to R Ramasubramani et.al (2016)[5] in concrete when sand was partially replaced by glass powder the compressive strength was increased as the level of replacement of glass powder increased. The strength increased with the number of days of curing.

TABLE 1

Comparison of Compressive strength in MPa for replacement of fine aggregate with WG for M20 grade

Percentage of WG replacement with fine aggregate	**Vijay Sekhar Reddy et.al**	**Mageswari et.al**	R Ramasubramani et.al
0%	22.7	38	35
10%	25.88	39	35.8
20%	29.84	40	36.13
30%	24.66	35	36.7

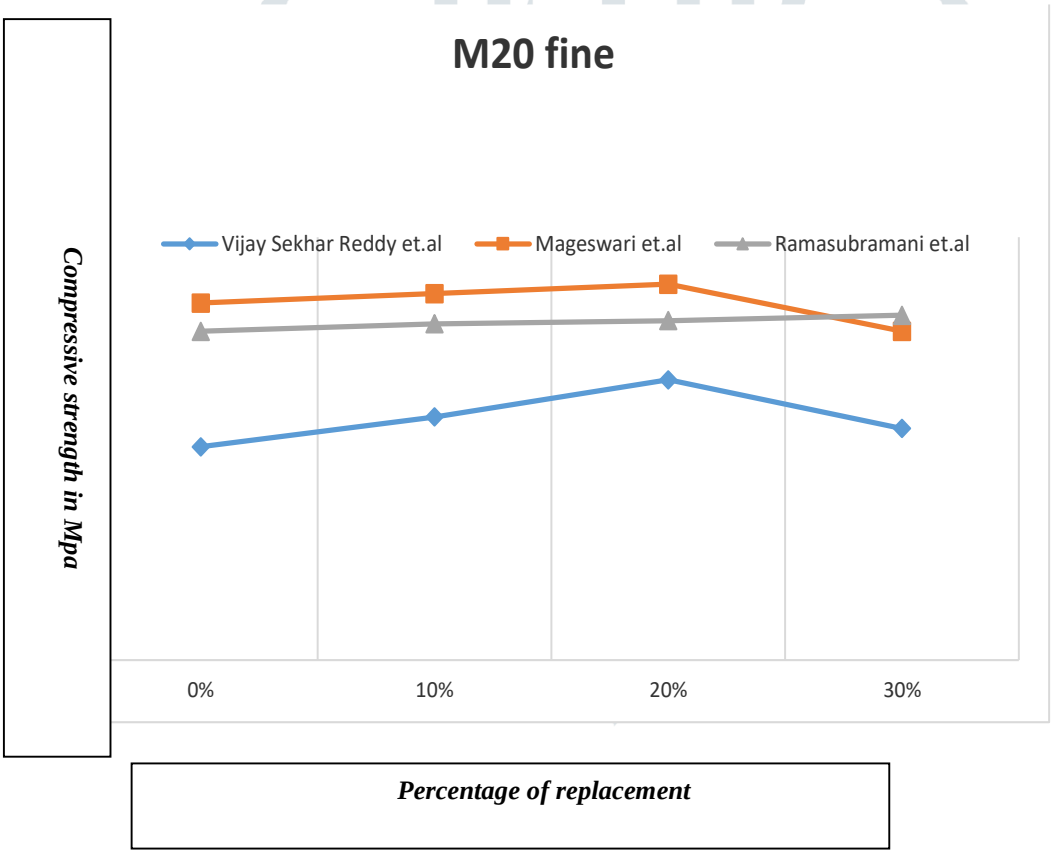

Fig 1: Comparison of compressive strength between different authors for replacement of fine aggregate with WG for M20 grade.

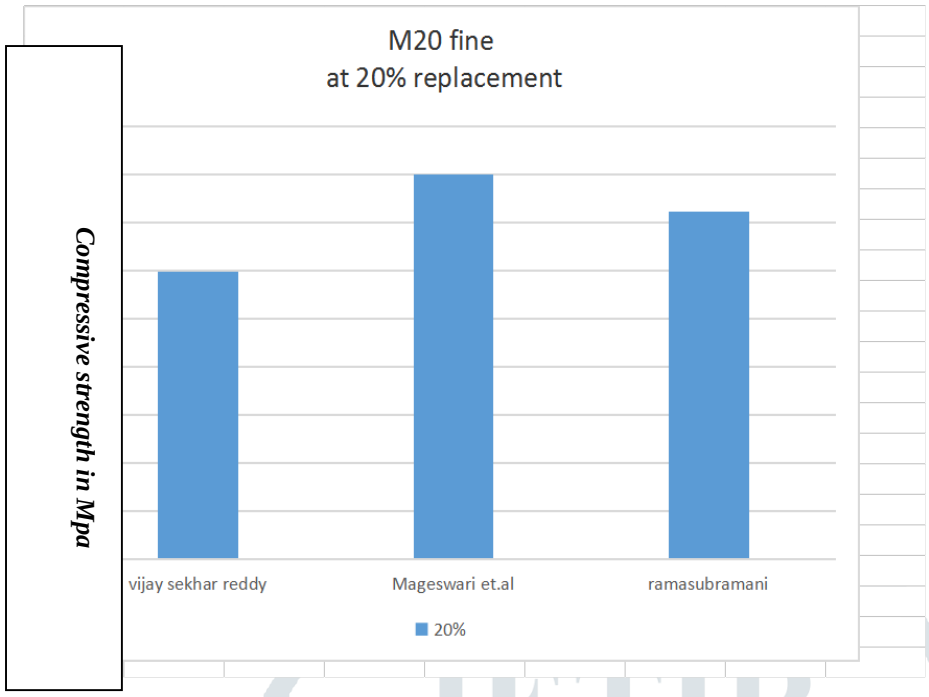

Fig 2: Comparison of compressive strength between different authors for 20% replacement of fine aggregate with WG for M20 grade.

***M30*:**

The maximum compressive strength attained was 38.3 N/ mm2 for 50% replacement at the end of 28 days. Abdullah Saand et.al (2017)[6] stated that there was a substantial increase in compressive strength of concrete upto 12% replacement of fine aggregate with WG. K..Aparna Srivastav et.al (2016)[7]concluded that compressive strength decreases when replacement percent of WGP with fine aggregate is more than 15%. Whereas On the contrary Tiwari Darshita et.al (2014)[8] disagrees with Vijay Sekhar Reddy et.al (2015)[3] and Mageswari et.al (2010)[4] and mentioned through his observation that 15% replacement of fine aggregate with glass powder gave compressive strength of 31 MPa and reduces even at 20% of replacement.

TABLE 2

Comparison of Compressive strength in MPa for replacement of fine aggregate with WG for M30 grade

Percentage of WG replacement with fine aggregate	**Abdullah Saand et.al**	**K..Aparna Srivastav et.al**	**Tiwari Darshita et.al**
0%	32	34.22	30
10%	35.5	37.15	30
20%	33	33.11	25
30%	26.5	33.11	22

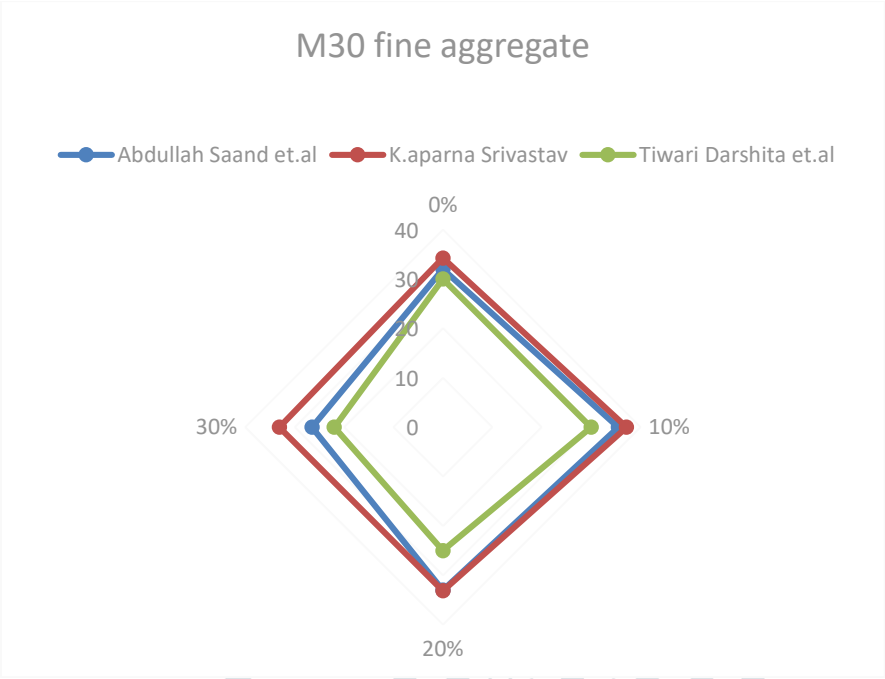

Fig 3: Comparison of compressive strength between different authors for replacement of fine aggregate with WG for M30 grade.

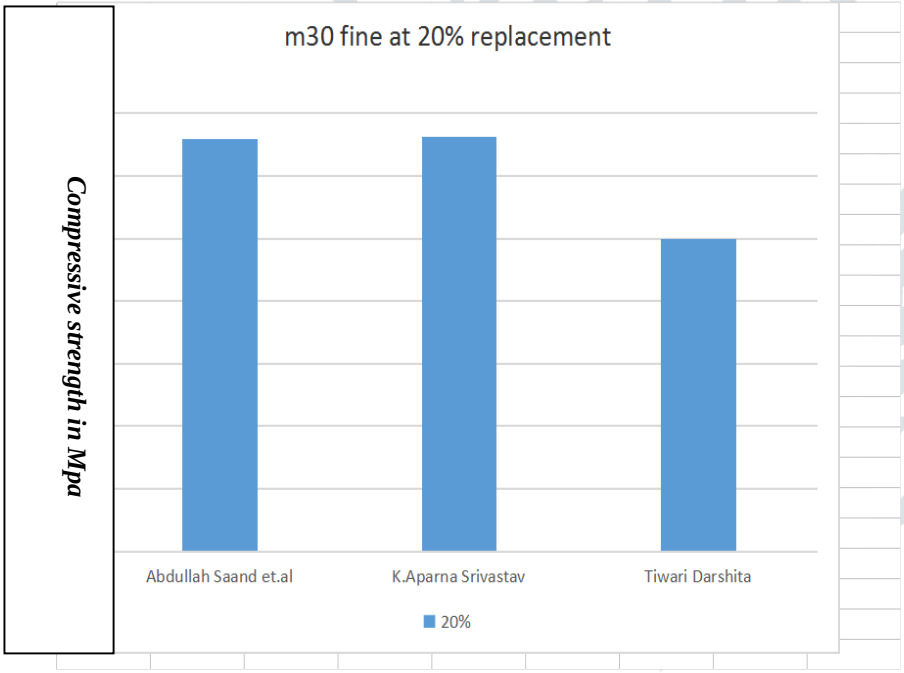

Fig 4: Comparison of compressive strength between different authors for 20% replacement of fine aggregate with WG for M30 grade.

The flexural strength and compressive strength was found to vary with different types of glass on a research study by Aseel B.Al-zubaid et.al (2017)[9] .It was observed that different types of glass has different chemical property and different rate of increment in strength.

CEMENT

M20:

An experimental research carried out by Sameer Shaikh et.al (2015)[10] on replacement of M20 cement by glass powder were used in terms of 5%, 10%, 15% and 20% in concrete. The limit of percentage replacement was restricted up to 20 % because he observed a substantial Decrease in compressive strength . On the other hand observation made by Manoj et.al(2016)[11].

TABLE 3

Comparison of Compressive strength in MPa for replacement of cement with WG for M20 grade of concrete.

Percentage of WG replacement with cement	0%	5%	10%	15%	20%	25%	30%
Sameer et.al	20	21	26	34	25	25	-
Manoj et.al	26.84	28.115	29.39	30.79	32.19	25.355	18.9

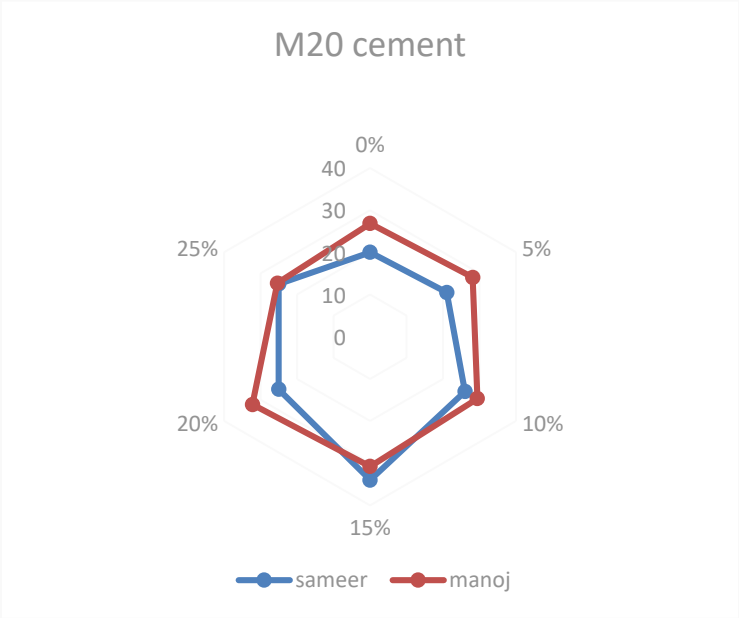

Fig 5 : Comparison of compressive strength between different authors for replacement of cement with WG for M20 grade.

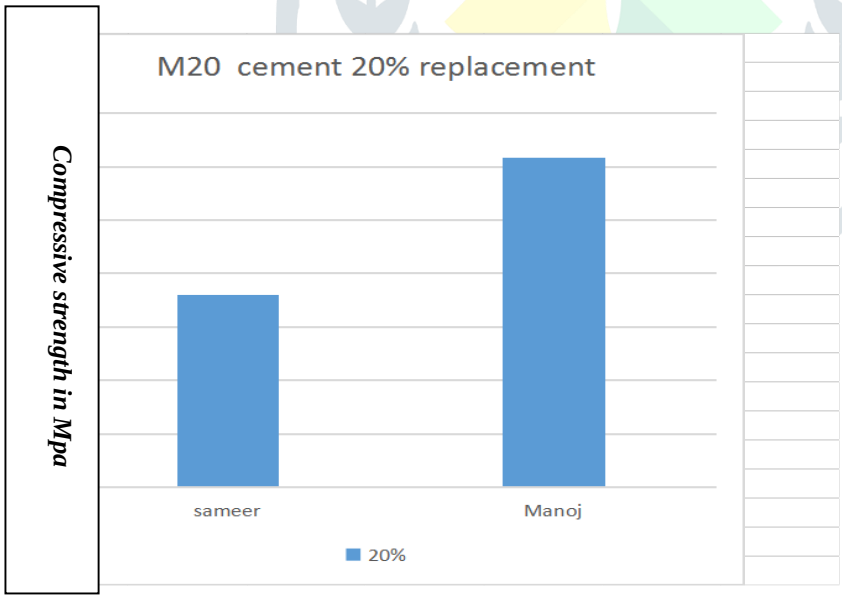

Fig 6 : Comparison of compressive strength between different authors for 20% replacement ofcement with WG for M20 grade.

M30:

Shilpa Raju et.al[12] revealed by replacing cement at the levels of 0%, 5%, 10%, 15%, 20%, 25%, 30% in M30 grade concrete with glass powder by weight compressive strength increases with increasing curing time.However she also added compressive strength increases upto 20 % replacement and then it decreases further. Jitendra et.al (2014)[13] agreed as he had observed Increment in compressive strength with rise in percentage of replacement of cement by glass powder only up to 20%**.** G M Sadiqul Islam et.al (2017)**[14]** contradicted both of them because his experiments showed a decline in the compressive strength at every percentage replacement of cement with glass powder by weight.

Gunalaan Vasudevan et.al[15] conducted an experimental study on compressive strength of concrete with replacement of waste glass with M30 cement and found that compressive strength decreased even at 5 % replacement of cement with waste glass powder and Aseel B.Al-zubaid et.al (2017)[9] also had some similar observation where he found that compressive strength decreased even at 5% replacement .

TABLE 4

Comparison of Compressive strength in MPa for replacement of cement with WG for M30 grade of concrete.

Percentage of WG replacement with cement	0%	5%	10%	15%	20%	25%	30%
Shilpa Raju et.al	27.05	28.58	29.77	31.56	33.50	30.52	24.22
Jitendra et.al	27.01	28.62	29.81	31.66	33.42	30.51	24.20
Gm sadiqul Islam et.al	34	33.5	33	32.5	32	27.5	27.5
Gunalaan Vasudevan et.al	33	29	25	29	32	32	
Aseel et.al	27.85	25.86	24.72	18	18	18	

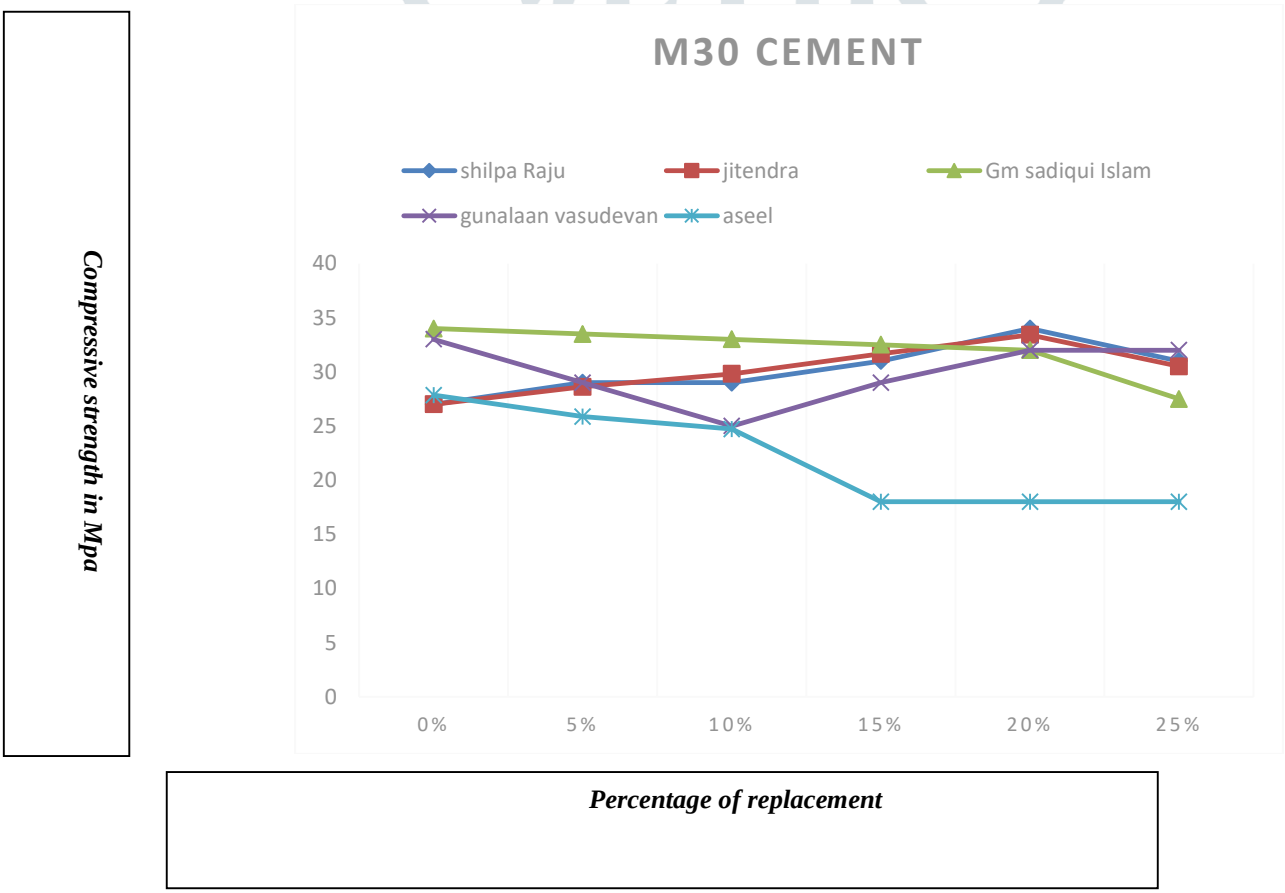

Fig 7: Comparison of compressive strength between different authors for replacement of cement with WG for M30 grade.

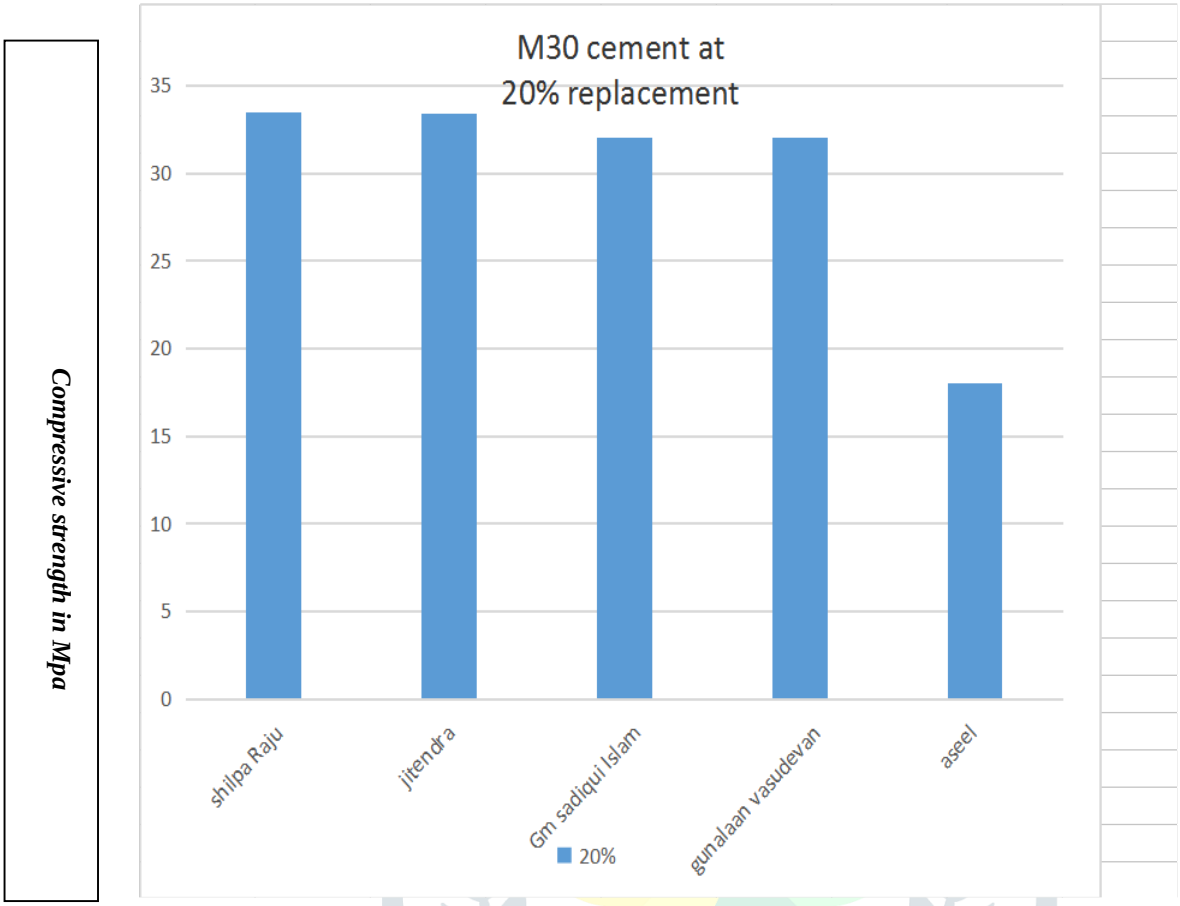

Fig 8: Comparison of compressive strength between different authors for 20% replacement ofcement with WG for M30 grade.

ALKALI SILICA REACTION:

Silica gel is formed by the reaction between alkalis in Portland cement and silica in aggregate. The volume of the gel increases when it absorbs water. The swelling of ASR gel develops hydrostatic pressure under confinement by cement matrix and aggregate. Al-Amarieh M et.al (2006)[16] stated if the internal pressure crosses the tensile strength, matrix cracks will be generated. However, ground waste glass showed no reaction in concrete when used as fine aggregate. Shayan and Xu et.al (2004) [17] reported that fine glass powder can incorporated into concrete up to 30% as a pozzolanic material in ASR. larger the particle size more is the probability of ASR occurrence. Hence proving the feasibility of the waste glass reuse as fine aggregate in concrete Shuhua Liu et.al (2015) [18] reported that with the increase of fineness and content of WGP, the ASR expansion can be reduced. Meanwhile it will add no ASR expansion when WGP size is less than 209.2μm and it shows certain inhibitory effect on ASR expansion.

CONCLUSION:

FINE AGGREGATE –

1. Crushed glass could be preferably used as fine aggregate because its chemical property is similar to that of cement presence of SiO_2 , Al_2O_3 ,Fe_2O_3, Cao.

2. The maximum compressive strength is achieved by concrete on replacing around 20% of fine aggregate by weight with the recycled glass.

3. The average compressive strength on 20% replacement was found to be 35.323 MPa for M20 grade of concrete.

4. The average compressive strength on 20% replacement was found to be 30.37 MPa for M30 grade of concrete.

5. It will add no ASR expansion when WGP size is less than 209.2μm and it shows certain inhibitory effect on ASR expansion.

6. WGP is more preferred as fine aggregate compared to coarse aggregate since its flat and elongated nature decreases the workability and increases the ASR expansion in concrete.

CEMENT-

1. 20% was the optimum level for replacement of cement with glass powder.
2. Due to the pozzolanic reaction of glass powder due to high silica content strength increases up to 20% replacement of cement by glass powder. Beyond 20%, the dilution effect takes over and the strength starts to drop.
3. The average compressive strength on 20% replacement of cement by weight in M20 grade concrete was found to be 28.595 MPa.

4. The average compressive strength on 20% replacement of cement by weight in M30 grade concrete was found to be 29.784 MPa.

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