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A Study On Partial Replacement Of Fine Aggregates By Using Crushed Glass And M-Sand In Concrete

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ABSTRACT

Depletion of natural resources is common phenomenon in developing countries like India due to urbanization and Industrialization involving construction of infrastructure and other amenities. In view of this, people have started for suitable other visible alternative material for concrete so that the existing resources could be to the possible extent, for the future generation. The propose of research is to study the STRENGTH OF CONCRETE using the waste of CRUSHED GLASS AND M SAND as Fine aggregate, to replace some portion in different percentage of coarse aggregates. The wastage of Crushed glass and M-Sand replaced as Fine aggregate 10% to 50 % by weight. This concrete will undergo various test after 7 days & 28 days and results are compared to the strength of conventional concrete, to determine the effective mix proportion.

To utilize the waste material in construction process also to minimize the cost of construction and this may adopt for new proposed construction. It will give new platform in future construction.

Keywords : Replacement of Fine aggregates in Concrete, Utilize waste material in Construction, Reduce the Construction cost.

CHAPTER 1
INRODUCTION
1.1 NEED FOR THE STUDY

Concrete is most widely used construction material today. Concrete has attained the status of a major building material in all the branches of modern construction. It is different to point out another material of construction which is all variables as concrete is the best materials of choice where strength, durability, permeability, fire resistance and absorbance resistance required. In the last dedicate construction industry has been conducted various researches on the utilization of waste products in concrete in order to reduce the utilization of natural resources. In this process different industrial waste materials such as brickbats, fly ash, furnace blag, quarry test, tiles waste, and broken glass waste, waste aggregate from demolition of structures, ceramic, insulator waste, etc. Has been tried as a variable substitute material to the conventional material in concrete.

Owing to liberalization, privatization and globalization, the construction of important infrastructure projects like expressways, airports, nuclear plants etc. in India is increasing year of year. Such developmental activities consume large quantity of precious natural resources. This leads to faster depletion of natural resources on one side and manifold increase in the cost of construction of structures on the other side pose severe problem for the construction sector. This problem is very severe in developing countries like India.

The high consumption of raw material by the construction sector, results in chronic shortage of building material and the associated environmental damage. In view of this, people have started searching for suitable other viable alternative which could be used either as an additive or as a partial replacement to the conventional ingredients of concrete so that the existing natural resources could be saved to the possible extent, and could be made available for the future generation.

Currently our country is taking major proposals to improve and develop its infrastructures by constructing buildings, power projects and industrial structures to emerge as major to economic power. To meet our growing infrastructures development a huge amount of concrete is required. Unfortunately, in India the disposal of waste is not much appreciable. In order to reduce the waste and minimize it, at present all the constructing minimize and ultimately reduce the construction cost.

Hence, at present all the construction industries are in research of the suitable and effective waste product that would considerably minimize the waste and ultimately reduce the construction cost. So, in this study waste crashed glass and M sand is used the partial replacement of coarse aggregate.

1.2 CRUSED GLASS:

Glass is a transparent material produced by melting a mixture of materials such as silica, soda ash and CaCo3 at high temperature followed by cooling during which solidification across without crystallization. It is widely used in our day to today life. It can be found in many forms including container glass flat glass such as windows, bulb glass and cathode ray tube glass. In the use of glass as aggregates in concrete as a great potential for high quality concrete development. It is shape and size distribution in glass concrete.

1.3 PHYSICAL PROPERTIES OF CRUSED GLASS:

The present investigation, to crushed waste glass used for the following testes.

- Specific gravity
- Sieve analysis
- Bulk density

Table 1.1 Properties of crushed glass

PROPERTIES	VALUES in (%)
Sio_2	70.22
Cao	11.13
$Al2O_3$	1.64
Fe_2O_3	0.52
Na_2O_3	15.26
Loss of ignition	0.84
Density	2.42
Properties of CG (crushed glass aggregate)	Values
Specific gravity	2.68

1.4 M - SAND

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`

Table 1.2 Properties of M Sand

Textural composition % by weight	**M SAND**
Coarse sand	28.1
Medium sand	44.8
Fine aggregate	27.1
Specific gravity	2.63
Bulk density	15.1
pH	10.11
Chemical composition of M sand	Si, Al, ca, mg, na, k, fe, etc

1.5 Advantages of M-Sand

- The cubically shaped particles give high strength and long life to concrete. The cubically shaped particles give high strength and long life to concrete
- Perfect grading and cubical shape of M-Sand provides 10-15% more compressive strength for concrete and 25-30% more strength for masonry works compared to crusher dust.
- Original M-Sand has minus 150 micron less than 10% and minus 45 micron less than 2% only. This helps the concrete to maintain water absorption rate of concrete less than 2% which helps to produce concrete of consistent quality.
- Original M-Sand is graded with precession by removing the micro fines correctly and thus it has higher 'Finesse Modules Index' compared to river sand and crusher dust. This gives good workability for concrete and masonry that help in easy and quick construction.
- Original M-Sand has two grades for concreting and plastering. This saves you the work of filtering the sand. Besides, as there is no loss of sand, you can save money on it.

1.6 OBJECTIVE OF THE STUDY

1. The objective of this study was to test the **Strength of Concrete** using the waste of **Crushed Glass and M-sand** as fine aggregate, to replace some portion in deferent percentage of aggregate.
2. The waste of **Crushed Glass and M-sand is** replacing as fine aggregate 10% to 50% by weight.
3. The mix design of concrete is to be calculated with reference to **IS 456-2000** and **IS 10262-2009** codes provision.
4. The results of **Compressive strength test, Split Tensile test, Flexural Strength test** of concrete at **7days and 28days** is determine and compared to strength on conventional concrete.

CHAPTER 2
TESTS ON MATERIALS

2.1 TESTS ON MATERIALS

These concrete making materials are further classified in to following:
1. Tests on cement.
2. Tests on Fine aggregate.
3. Tests on Coarse aggregate.
4. Tests on Water.

2.2 TESTS ON CEMENT

The cement tests are following:
i. Specific gravity of cement.
ii. Fineness of cement.
iii. Initial setting time of cement.
iv. Final setting time of cement.

Table 2.1 Specific gravity test on cement

Observation	Trial I	Trial II	Trial III
Weight of empty flask (W_1) gm	719	725	689
Weight of empty flask + Cement (W_2) gm	1300	1285	1189
Weight of empty flask + Cement + Kerosene (W_3) gm	1850	1875	1779
Weight of flask + Kerosene (W_4) gm	1535	1519	1416
Specific gravity $= \frac{(W_2 - W_1)}{(W_4 - W_1) - \{(W_3 - W_2)\}}$	3.12	3.80	3.64
Average Specific Gravity Value =	3.52		

Table 2.2 Fineness test on cement

Observation	Trial I	Trial II	Trial III
Weight of Cement Sample (W_1) gm	200	200	200
Weight of Residue after 15 minutes sieving (W_2) gm	7	9	6
Fineness (%) $= \frac{W_2}{W_1} \times 100$	7	9	6
Average Fineness Value =	7.3%		

Table 2.3 Initial and Final setting time of cement

Observation	Trial I	Trial II	Trial III	Average
Initial Setting Time (minutes)	35	33	35	30
Final Setting time (minutes)	636	633	604	630

2.3 TESTS ON FINE AGGREGATE

The Fine aggregate tests are following:
i. Specific gravity of fine aggregate.
ii. Fineness value of fine aggregate.
iv. Water absorption of fine aggregate.

Table 2.4 Specific gravity test on fine aggregate

Observation	**Trial I**	**Trial II**	**Trial III**
Weight of empty Pycnometer bottle (W_1) gm	655	660	640
Weight of Pycnometer bottle + One third fine aggregate (W_2) gm	1888	1800	1900
Weight of Pycnometer bottle + One third fine aggregate + Water (W_3) gm	2355	2385	2410
Weight of Pycnometer bottle + Water (W_4) gm	1660	1670	1670
Specific gravity $= \frac{(W_2 - W_1)}{(W_4 - W_1) - (W_3 - W_2)}$	2.29	2.60	2.42
Average Specific Gravity Value =	2.43		

Table 2.5 Fineness value of fine aggregate

S. No	**I.S. Sieves**	**Retained wt of aggregate (gm)**	**Cumulative weight retained (gm)**	**Cumulative percentage retained**	**% of passing**
1	4.75 mm	95	95	9.5	95.5
2	2.36 mm	33	128	12.8	92
3	1.18 mm	125	253	25.3	79.5
4	600 m	390	643	64.3	40.4
5	425 m	92	735	73.5	31.3
6	300 m	64	799	79.9	24.9
7	150 m	203	1002	100.2	4.6
8	75 m	46	1048	104.8	0
Fineness modulus = Cumulative percentage of aggregate retained / 100 = (9.5+12.8+25.3+64.3+73.5+79.9+100.2+104.8) / 100 = 4.70					

Table 2.6 Water absorption of fine aggregate

Observation	**Trial I**	**Trial II**	**Trial III**
Weight of empty Pycnometer bottle (W_1) gm	653	658	660
Weight of Pycnometer bottle + One third fine aggregate (W_2) gm	870	877	860
Weight of Pycnometer bottle + One third fine aggregate + Water (W_3) gm	1680	1673	1675
Weight of Pycnometer bottle + Water (W_4) gm	1550	1571	1552
Specific gravity (G)	2.5	1.8	2.605
Water content $= \frac{(W_2 - W_1)(G - 1)}{(W_3 - W_4) \times G}$	1.001	0.9	1.012
Average absorption value		0.98	

2.4 TESTS ON COARSE AGGREGATE

The Coarse aggregate tests are following:

i. Specific gravity of coarse aggregate.
ii. Fineness value of coarse aggregate
iii. Water absorption of coarse aggregate.

Table 2.7 Specific gravity of coarse aggregate

Observation	**Trial I**	**Trial II**	**Trial III**
Weight of saturated aggregate suspended in water with the basket (W_1) gm	674	674	674
Weight of empty basket suspended in water (W_2) gm	752	756	750
Weight of saturated surface dry aggregate in air (W_3) gm	2310	2304	2226
Weight of oven dried aggregates in air (W_4) gm	1555	1558	1551
Specific gravity = $\frac{(W_4)}{(W_3) - (W_1 - W_2)}$	2.66	2.61	2.60
Average Specific Gravity Value =	2.60		

Table 2.8 Fineness value of coarse aggregate

S. No	**I.S. Sieves (mm)**	**Retained weight of aggregate(gm)**	**Cumulative wt retained (gm)**	**Cumulative percentage retained**	**% of passing**
1	20mm	635	635	63.5	40.5
2	16mm	290	925	92.5	11.5
3	12.5mm	85	1010	101.1	2.9
4	10mm	25	1035	103.5	.5
5	4.75mm	5	1040	104.0	0
Fineness modulus = Cumulative percentage of aggregate retained / 100 = (64.0+92.3+102.0+104.0+105.0) / 100 = 4.64					

Table 2.9 Water absorption of coarse aggregate

Observation	**Trial I**	**Trial II**	**Trial III**
Weight of saturated surface dry aggregate in air (W_1) gm	3826	9950	9830
Weight of oven dried aggregate in air (W_2) gm	3790	9900	9800
Water Absorption = $\frac{(W_1 - W_2)}{W_2}$ X 100	0.94	0.5	0.406
Average Water absorption value (%) =	0.61		

2.5 TESTS ON WATER

The water tests are following:

i. pH value of water.

ii. Hardness value of water.

Table 2.10 Water Test results

Tests / Trials	**pH value**	**Hardness (mg/l)**
Trial I	7.2	590
Trial II	7.2	590
Average	7.2	590

CHAPTER 3
EXPERIMENTAL INVESTIGATION

3.1 PROPERTIES OF MATERIALS USED:

3.1.1 CEMENT

Ordinary Portland cement is the most important type of cement. The OPC was classified into three grades, namely 43 grade, depending upon the strength of the cement at 28 days, when tested as per 4031-1988. If the 28 days strength is not less than 43 N/mm^2, it is called 43 grade of cement and likewise. But the actual strength obtained by these cement at the factory are much higher than specified by BIS.

Table 3.1 Properties of 43 Grade Cement

S.No	Description of Tests	Results
1	Specific gravity	3.52
2	Normal consistency	33%
3	Initial setting time	55 mins
4	Final setting time	680 mins

3.1.2 FINE AGGREGATE

The size of the aggregate less than 4.75 mm is considered as fine aggregate. The main source of fine aggregate is that from river sand. The shape of sand is round and that of pit sand is irregular or partially round. The Specific Gravity of sand is 2.5.

Table 3.2 Physical Properties of Fine Aggregate

Physical properties	values
Specific gravity	2.43
Fineness Modulus	4.70

3.1.3 COARSE AGGREGATE

Size of aggregate bigger than 4.75 mm is considered as coarse aggregate and the main source of coarse aggregate is rock quarrying bounder on river bed. For our project we are considering 20mm size of coarse aggregate. The Specific Gravity of sand is 2.6.

Table 3.3 Physical Properties of Coarse Aggregate

Physical properties	values
Specific gravity	2.60
Fineness Modulus	4.64

3.1.4 WATER

Water is the important ingredients of concrete as it actively participate in chemical reaction with cement. Quantity and quality of water is required to be looked into very carefully. Optimization quantity of water is always required to get the best result. Whereas when quality is concerned the portable water should have a pH value from 6 to 8 and the water should be free from organic matter.

3.2 Concrete mix Design

M -20 Mix Deign as per IS – 10262- 2009

Stipulation for Proportioning

1	Grade designation	M20
2	Type of Cement	OPC 43grade
3	Maximum Normal aggregate	20 mm
4	Minimum cement content	300kg/m^3
5	Maximum water cement ratio	0.47
6	Workability compaction factor	0.9
7	Exposure condition	Mild
8	Degree of Supervision	Good
9	Type of Aggregate	Crushed Angular Aggregate

Test Data for Material

1	Cement used	Chettinad OPC 43grade
2	Sp. Gravity of cement	3.52
3	Sp. Gravity of Water	1.00
4	Chemical Admixture	Not Used
5	Sp. Gravity of Coarse Aggregate	2.60
6	Sp. Gravity of Sand	2.43

Target Strength for Mix proportioning

	Target Mean Strength for Mix Design	*fck = fck + tS*
1	Characteristic Strength @ 28 Days	20 N/mm^2
2	Target Mean Strength N/mm^2	*f ck = 20 + 1.65 X 4.6 = 27.6*
	Target Mean Strength	27.6 N/mm^2

Selection of water cement ratio

1 Maximum Water Cement Ratio required for target mean strength of 27.6 Mpa is 0.47 is lower than the maximum value of 0.55 prescribed for 'Mild' Exposure.

2 Adopted Water Cement Ratio

Selection of Water Content

1	Maximum Water content	186 lit.
2	Super plasticiser used	nil

Determination of cement content

Water – Cement Ratio 0.47

Water 186 lit.

Cement =186/0.47 = 372 kg/m^2 which is greater than 300 kg/m^2

This cement content is adequate for ' Mild' exposure condition.

Determination of coarse and fine aggregate contents

Considering maximum size of aggregate of 20 mm, the amount of entrapped air in the wet concrete is 2 percent.

$V = (w + c/s_c + 1/\rho \times f_a / S_{fa}) \times 1/1000$

$0.98 = (186 + 396/3.10 + 1/0.35 \times f_a / 2.53)\ 1/1000$

$F_a = 590 kg/m^3$

$V = (w + C/S_c + 1/1 - \rho \times C_a / S_{ca}) \times 1/1000$

$0.98 = (186 + 396 / 3.52 + 1/ 1- 0.35 \times C_a/2.80) \times 1/1000$

$C_a = 1211 kg / m^3$

3.3 MIX PROPORTION:

Table 3.4 Mix proportion

WATER	CEMENT	FINE AGGREGATE	COARSE AGGREGATE
186 lits/m^3	396kg/m^3	590 kg/m^3	1211 kg/m^3
0.47	1	1.49	3.1

The design is progressive corrected by trial mixes and final mix proportion of 0.47:1:1.49:3.10 has been adopted.

3.4 PREPARATION OF TEST SPECIMENS

Concrete is mixed according to desired mix design by replacing cement with required amount of replacement and specimens – cube, cylinder , PCC beams were casted. The following are amount replacing coarse aggregate with Crushed Glass and M- Sand.

Cement - OPC (Control)

10% Replacement (CG 5% + MS 5%+ OPC+90%FA+CA)

20% Replacement (CG 10% + MS 10%+ OPC+80%FA+CA)

30% Replacement (CG 15% + MS 15%+ OPC+70%FA+CA)

40% Replacement (CG 20% + MS 20%+ OPC+60%FA+CA)

50% Replacement (CG 25% + MS 25%+ OPC+50%FA+CA)

3.4.1 Cube

Cube model of size 150 x150 x 150 mm were used. The moulds were cleaned thoroughly using a waste cloth and then properly oiled along its faces. Concrete was then filled in mould and then compacted using a standard tamping rod of 60 cm length having a cross sectional area of 25 mm^2. Totally 64 nos of cubes were casted.

3.4.2 Cylinder

Cylinder moulds of diameter 150 mm and height 300 mm were used. The crude oil was applied along the inner surface of the mould for removal of cylinder from the mould. Concrete was poured throughout its length compacted well. Totally 64 nos of cylinder were casted.

3.4.3 PCC beam

Beam moulds of size 500 x 100 x 100 mm were used. The crude oil was applied along the inner surface of the mould for removal of cylinder from the mould. Concrete was poured throughout its length compacted well. Totally 20 nos of pcc beams were casted.

3.5 CURING OF SPECIMENS

The specimens were carefully casted and demouled after 24 hours, without disturbing the specimens, these were cured in the curing tank 7, 28, days.

3.6 TESTING OF SPECIMENS

3.6.1 Compressive Strength of Cubes

Concrete cubes of size 150 mm x 150 mm x 150 mm were cast and without crushed glass and M – sand . The maximum load failure was take and average compressive strength is calculated using the equation.

$$\text{Compressive strength } (N/mm^2) = \frac{\text{Ultimate load in N}}{\text{Area of cross section } (mm^2)}$$

3.6.2 Split Tensile Strength Test

Concrete cylinder size 150 mm x150 mm were cast using with and without crushed glass and M- sand . The maximum load failure was take and average spilt tensile strength is calculated using the equation.

$$\text{Split tensile strength } (N/mm^2) = 2P/ \pi LD$$

Where , P = Ultimate load at failure (N),

L= Length of specimen(mm),

D= Diameter of cylinder specimen(mm).

3.6.3 Flexural strength Test

PCC beams of size 500mm x 100 mm x 100 mm were cast using with and without crushed glass and M- sand . The maximum load failure was take and average flexural strength is calculated using the equation.

Flexural strength F = $3Pl/2bd^2$
F = Flexural strength in N/mm^2
P = Maximum Load in N
L = Distance between central lines of supporting rollers in mm
B = Average width of beam in mm
D = Average Thickness in mm.

3.7 COMPRESSIVE TEST

The compressive strength of the concrete was measured by preparing cubes of 150X150X150 mm mould size. The moulds were remould 24 hours and placed in the curing tank until testing dates. The test was conducted after 7, 28 days and the variation of the results were discussed as percentage with reference to the control sample. Table 4.8 shows the compressive strength of cubes of M20 grade concrete and Fig.4.8, Fig.4.9 show the compressive strength of cubes of M20 grade CG and M-Sand added concrete and with CG and M-Sand. From the results, it is found that, the compressive strength increase up to 10% to 50% replace level in case of 7, 28 days test when compared with conventional concrete. However, the results attained are above $20N/mm^2$ at all levels.

CHAPTER 4

4.1 PROCESS OF MANUFACTURING OF CONCRETE

Production of quality concrete requires care at every stage of manufacture of concrete. It is to be noted that the ingredients of good concrete and bad concrete are the same. If care is not taken, and good rules are not observed, the resultant concrete is going of bad quality. With the same material if intense care is taken at every stage, it will result in good concrete. Therefore, it is necessary for us to know are the good rules to be followed in each stage of manufacture of concrete for producing good quality concrete. The stages of manufacturing of concrete are:

1. **Collection of material**
2. **Preparation of mould**
3. **Batching**
4. **Mixing**
5. **Compaction of concrete**
6. **Finishing**
7. **Casting and curing of concrete**

CHAPTER 5

RESULT AND DISCUSSION

5.1 Result of compressive strength test

After a detailed study we have obtained the following results as show below

Table 5.1 Compressive Strength on M20 Grade of Concrete

Mix	% of CG & MS added	Compressive strength in N/mm^2					
		7Days			28Days		
		1st	2nd	average	1st	2nd	average
C0	**0%**	17.25	18.65	**17.95**	18.77	17.54	**18.15**
C1	**10%**	16.77	15.66	**16.22**	15.88	13.35	**14.62**
C2	**20%**	10.84	9.77	**10.31**	13.75	16.57	**15.16**
C3	**30%**	11.2	7.6	**9.4**	12.57	16.68	**14.62**
C4	**40%**	8.75	10.62	**9.85**	11.57	11.06	**11.32**
C5	**50%**	17.06	15.55	**16.31**	17.68	13.64	**15.66**

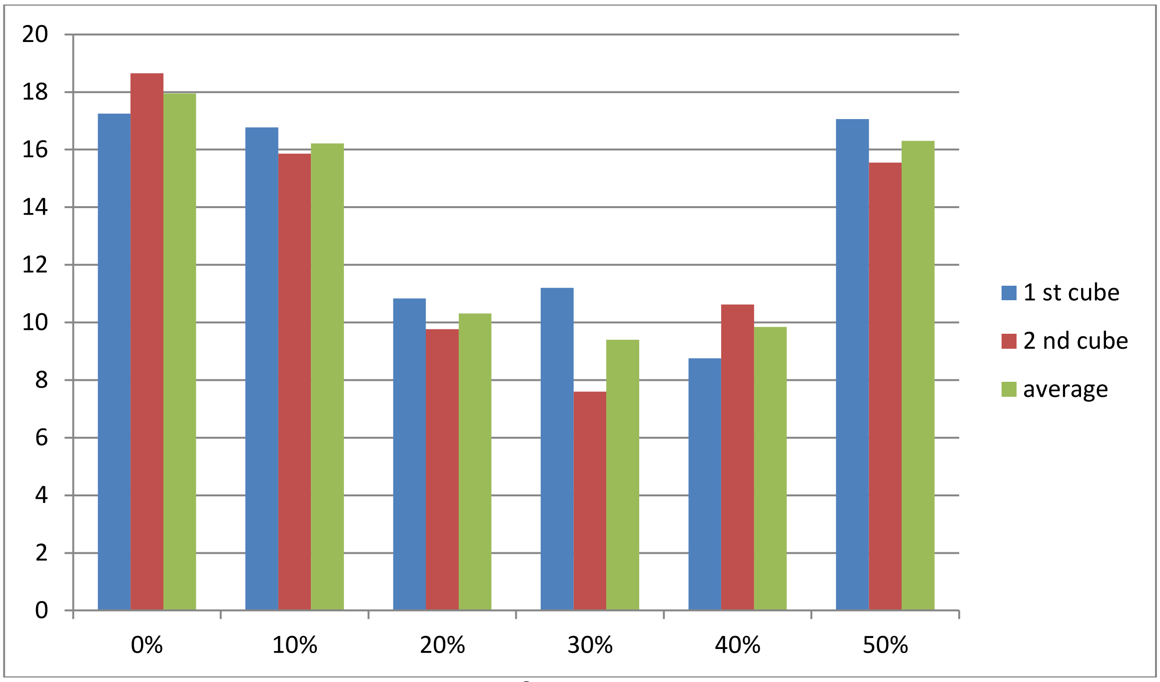

Fig 5.1 Compressive strength on 7 days N/mm^2

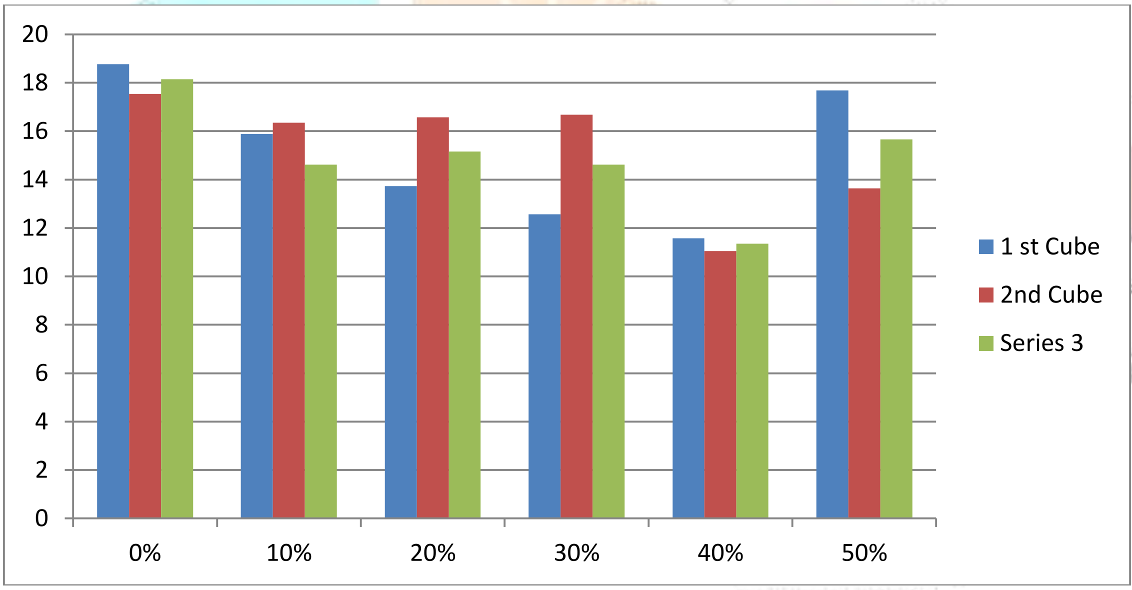

Fig 5.2 Compressive strength on 28 days N/mm^2

5.2 SPLIT TENSILE TEST

Split tensile test for the concrete was carried out according to BS 1881: Part 117:1983. Concrete cylinder of 150 mm diameter and 300 mm height were casted by using concrete. The moulds were removed after 24 hours and placed in curing tank until the dates. Table 4.3 shows the tensile strength of Crushed Glass and M-sand added concrete of M20 grade of concrete.

Table 5.2 Split Tensile Strength on grade M20 Concrete

Mix	%of CG &MS added	Split tensile strength in N/mm²					
		7Days			28Days		
		1st	2nd	average	1st	2nd	average
C0	**0%**	1.65	1.78	**1.72**	1.68	1.81	**1.95**
C1	**10%**	1.52	1.36	**1.44**	1.33	1.22	**1.27**
C2	**20%**	1.47	1.64	**1.55**	1.52	1.60	**1.56**
C3	**30%**	1.57	1.68	**1.63**	1.58	1.65	**1.62**
C4	**40%**	1.11	1.25	**1.18**	1.18	1.33	**1.26**
C5	**50%**	1.77	1.78	**1.77**	1.90	1.93	**1.92**

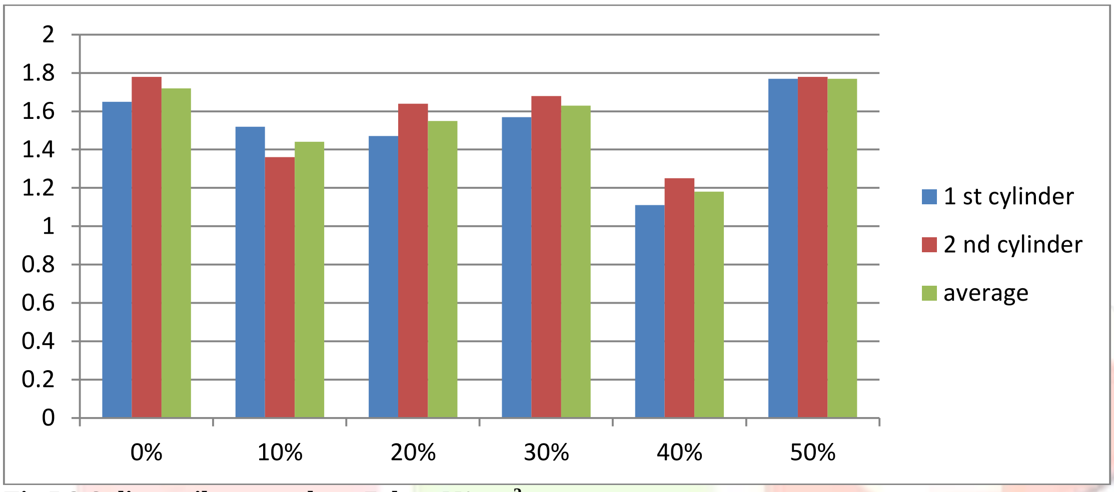

Fig 5.3 Split tensile strength on 7 days N/mm²

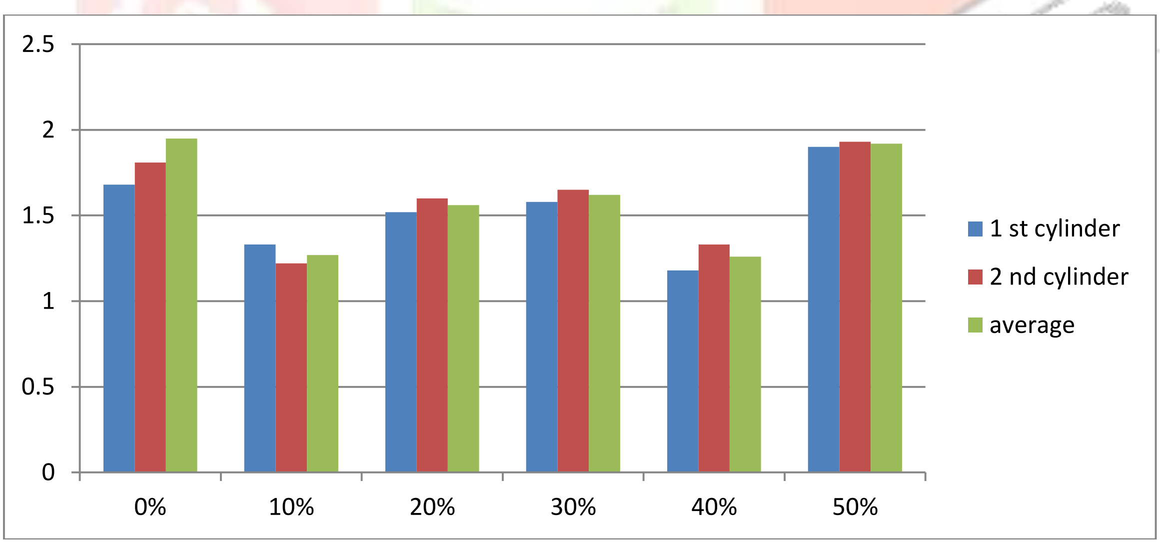

Fig 5.4 Split tensile strength on 28 days N/mm²

CHAPTER 6
DISCUSSION ON RESULT
6.1 DISCUSSION

Based on the results obtained from the research the following conclusion are drawn.

6.2 CRUSHED GLASS AND M-SAND

In this research two different combination of replacement of fine aggregate is used such as 10% to 50% in the concrete.

1. The concrete with 50% replacement of Crushed Glass and M-Sand as fine aggregate is used in this research and the,

7 Days:

- Compressive strength on 16.31 N/mm^2.
- Split tensile strength on 1.77 N/mm^2

28 Days:

- Compressive strength on 15.66 N/mm^2
- Split tensile strength on 1.92 N/mm^2.

CHAPTER 7
CONCLUSION

From the above discussion various conclusion can be made about our research,

The Crushed Glass and M-Sand are 50% replacement of fine aggregate produces approximately 90% strength of normal or conventional concrete. Hence the concrete with 50% replacement of Crushed Glass and M-Sand as fine aggregate can use in construction.

1. The crushed Glass are the glass which are slightly over burnt glass and thrown as wastes. This will be hard & absorb less water.
2. We can use these Crushed Glass and M-Sand concrete in major and inner structures and also in foundation.
3. A high amount of Crushed Glass and M-Sand aggregate reduces the unity weight of concrete.
   For example, On construction of a 10-story building, floors from ground floor to 5th floor can be build using conventional concrete and the remaining 6th to 10th floor can be build using Crushed Glass and M-Sand concrete.
4. Where ever compressive strength is not a criteria, the concrete made with alternate construction material such as Crushed Glass and M-Sand can be preferred.
5. The concrete made with alternate construction material like Crushed Glass and M-Sand can be used for partition & filling purpose & nailing purposes where the strength is not the criteria.
6. The Crushed Glass and M-Sand concrete reduce overall greenhouse gas emissions.
7. Crushed Glass and M-Sand concrete also gives cooling temperature to room.

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