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# "Recycling of Waste Glass as Partial Replacement of Sand in Concrete - Effects on Compressive Strength"

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**Abstract** - *Concrete industry is one of the leading consumers of natural resources due to which sustainability of concrete industry is under threat. The economic and environmental concern is the major challenge that the concrete industry is facing. In this thesis, the issues of economic and environmental concern are addressed by the use of waste glass as partial replacement of fine aggregates in concrete. Fine aggregates were replaced by waste glass powder as 5%, 10%, 12% and 20% by weight with water cement ratio 0.45 and 0.50 for M-25 mix. The concrete specimens were tested for workability and compressive strength at 7 and 28 days of age and the results obtained were compared with those of normal concrete. The results concluded the acceptability of using waste glass powder as partial replacement of fine aggregates up to 10% by weight for particle size of range 300 micron - 1.18mm. We estimate decrease in slump value, compaction factor and increase in compressive strength.*

***KEY WORDS: waste glass, concrete, compressive strength.***

## 1. INTRODUCTION

Waste management has become a remarkable issue in today's growing society. Population levels increases rapidly around the world, resulting in irregular levels of waste material. New and innovative methods of recycling need to be established in order to reduce this unprecedented waste around us. Glass being non-biodegradable material and is not suitable for addition to landfill. The construction industry presents an attractive market for the use of waste glass. One of the chief components of construction is concrete, due to its high compressive strength, durability and ease of construction. During the last decade, it has been documented that sheet glass waste is of huge volume and is increasing year by year in the shops, institutional areas, and factories. Using waste glass powder in the concrete construction sector is beneficial, as the production cost of concrete will go down. This move will serve two purposes; first, it will be environment friendly; second, it will utilize waste in place of precious and relatively costlier natural resources.

## 2. EXPERIMENTAL STUDY


**Fig.-1** Steps Involved In The Project

## 2.1 Materials

### 2.1.1. Coarse and Fine Aggregate

The aggregates used in this empirical study, were sourced from Indian suppliers and were readily available in the country. The coarse aggregate was of angular nature with a nominal maximum aggregate size of 20 mm. The fine aggregate was in the form of river sand, originating from the Raipur region. The physical properties of both aggregates can be seen in Table 1. Both coarse and fine aggregates used in this project conformed to requirements specified in Indian Standard.

**Table-1**: Properties Of Aggregates

| TYPES | PHYSICAL PROPERTY | RESULTS | REFERENCE |
|---|---|---|---|
| COARSE | Specific gravity | 2.83 | IS 2386-part III |
| | Fineness modulus | 7.57 | |
| | Water absorption | 0.15% | |
| FINE | Specific gravity | 2.62 | IS 2386:1963 part III clause 2.4.2 |
| | Sieve analysis zone | Zone II Grading | Table 4 IS 383:1970 |
| | Fineness modulus | 2.76 | IS 2386:1963 part I |
| | Water absorption | 0.60% | |

### 2.1.2 *Waste Glass*

Waste glass powder are commonly pointed in shape and some smooth and elongated particles .In this experimental study it passes through 2.36 mm IS sieve and retained on 300µm is used. It is similar to natural sand and exhibits properties of fine aggregate. Waste glass for this experiment was obtained from Shankar glasses situated at power house bhilai Chhattisgarh. Table 2 emphasizes the properties of waste glass powder.

**Table-2:** Properties of Crushed glass material

| PROPERTY | RESULT |
|---|---|
| SPECIFIC GRAVITY | 2.39 |
| FINENESS MODULUS | 2.52 |

**Fig.-2** Glass Waste Powder

### 2.13. *Cement*

Cement is an extremely ground material having adhesive and cohesive properties which provide a binding medium for the discrete ingredients. Ordinary Portland cement (Birla A1 premium) is utilized in the present examination. The properties of cement used are given below in Table 3.

**Table-3** Properties Of Cement

| PHYSICAL PROPERTY | RESULT | REFERENCE |
|---|---|---|
| Standard Consistency | 33% | IS4031(part4):1988 |
| Specific Gravity | 3.21 | IS 8112-1989 |
| Fineness Modulus | 1% | IS4031(part1):1996 |
| Compressive Strength 7-days | 34.6N/mm$^2$ | IS 8112-1989 |
| Compressive Strength 28-days | 53.06N/mm$^2$ | IS 8112-1989 |

**2.2 PROJECT DESIGN**
**2.2.1 Mixture design**

Concrete mix designs adopted throughout this study were undertaken in accordance with the procedure specified in Indian standards. All mixes were proportioned in order to achieve a design compressive strength of 31.5MPa after28 days. The type of cement used in this experiment is birla A1 premium OPC 53 grade conforming to IS12269-1987. The minimum and maximum cement content should be 320kg/m$^3$ and 450kg/m$^3$. As per our mix design calculation the ratio of M-25 grade of Cement concrete **for 0.45 w/c ratio is 1:1.8:2.5** and **for 0.50 w/c ratio 1:2.1:2.8 .**A control mix was produced containing only natural aggregate, with four resulting mixes incorporating waste glass as a partial replacement for fine aggregates in proportions of 5%,10%, 12%, and 20%. A summary of the individual mix designs is presented.

**Table-4** Concrete mix design summary for water cement ratio 0.45

| Mix Proportions | % of replacement | Crushed glass material | Fine aggregate |
|---|---|---|---|
| | | kg/m$^3$ | |
| Mix 1 | 0% | - | 765.76 |
| Mix 2 | 5% | 38.29 | 727.47 |
| Mix 3 | 10% | 76.58 | 689.18 |
| Mix 4 | 12% | 91.89 | 673.87 |
| Mix 5 | 20% | 153.15 | 612.61 |

The quantity of water, cement and coarse aggregate used in this mix proportions remains same and are given by,

| S.NO. | MATERIALS | PROPORTIONS |
|---|---|---|
| 1 | Water (L) | 191.58 |
| 2 | Cement (kg) | 425.73 |
| 3 | Coarse aggregate(kg) | 1083.11 |

**Table-5** Concrete mix design summary for water cement ratio 0.50

| Mix Proportions | % of replacement | Crushed glass material | Fine aggregate |
|---|---|---|---|
| | | kg/m$^3$ | |
| Mix 1 | 0% | - | 796.73 |
| Mix 2 | 5% | 39.84 | 756.89 |

| | | | |
|---|---|---|---|
| Mix 3 | 10% | 79.67 | 717.06 |
| Mix 4 | 12% | 95.61 | 701.12 |
| Mix 5 | 20% | 159.35 | 637.38 |

In this also the quantity of water, cement and coarse aggregate used in this mix proportions remains same and are given by,

| S.NO. | MATERIALS | PROPORTIONS |
|---|---|---|
| 1 | Water (L) | 191.58 |
| 2 | Cement (kg) | 383.2 |
| 3 | Coarse aggregate(kg) | 1086.44 |

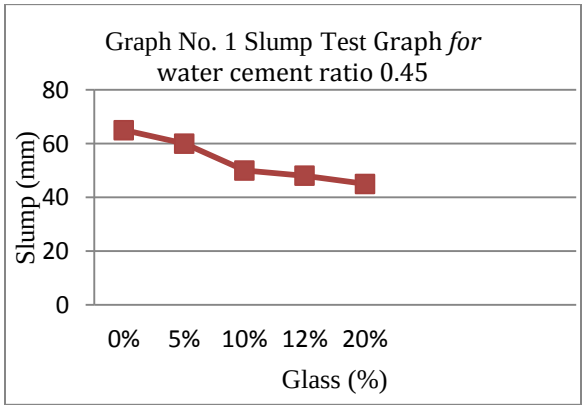
## 3. RESULTS AND DISCUSSION

The cement concrete cube of size 150mm×150mm×150mm were casted. These specimens are subjected to compression test after 7 and 28 days of curing. Henceforth, the results are tabulated accordingly. The mix with differ w/c ratio are compared with each other to find out the affect on the workability and strength of the concrete and as well as with the conventional concrete results and find out the optimum value of replacement for natural sand with crushed glass material.

### 3.1 Slump Cone Test:

**Table-6** Slump Height Values for water cement ratio 0.45

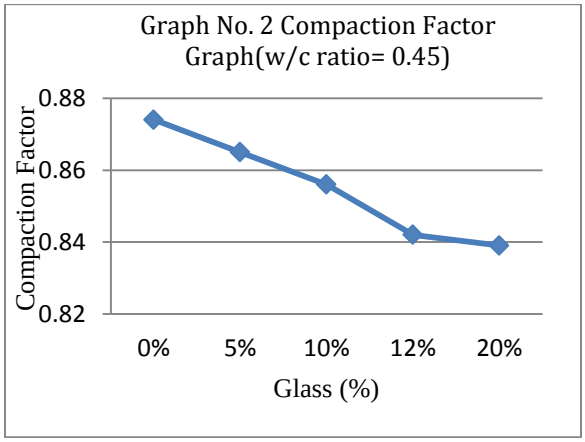
| TYPE OF AGGREAGRE (w/c ratio= 0.45) | | SLUMP (mm) |
|---|---|---|
| RIVER SAND | GLASS POWDER | |
| 100% | 0% | 65mm |
| 95% | 5% | 60mm |
| 90% | 10% | 50mm |
| 88% | 12% | 48mm |
| 80% | 20% | 45mm |



### 3.2 Compaction Factor Test:

**Table-7** *Compaction Factor Values for water cement ratio 0.45*

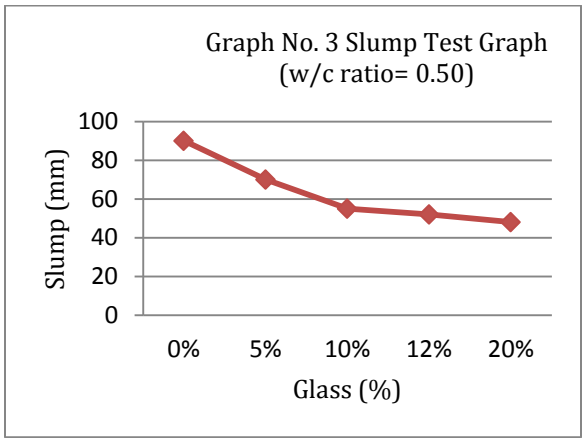
| TYPE OF AGGREAGRE (w/c ratio= 0.45) | | COMPACTION FACTOR |
|---|---|---|
| RIVER SAND | GLASS POWDER | |
| 100% | 0% | 0.874 |
| 95% | 5% | 0.865 |
| 90% | 10% | 0.856 |
| 88% | 12% | 0.842 |
| 80% | 20% | 0.839 |




### 3.3 Slump Cone Test:

**Table-8** Slump Height Values for water cement ratio 0.50

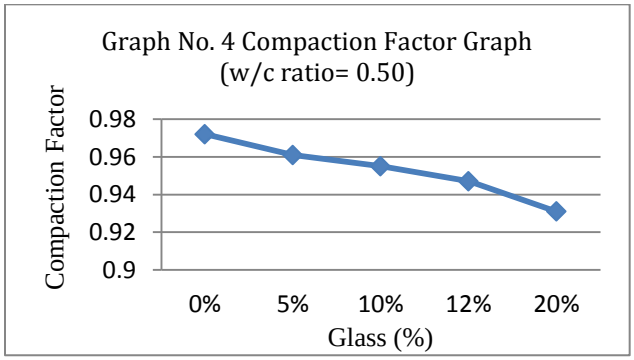
| TYPE OF AGGREAGRE (w/c ratio= 0.50) | | SLUMP (mm) |
|---|---|---|
| RIVER SAND | GLASS POWDER | |
| 100% | 0% | 90mm |
| 95% | 5% | 70mm |
| 90% | 10% | 55mm |
| 88% | 12% | 52mm |
| 80% | 20% | 48mm |




### 3.4 Compaction Factor Test:

**Table-9** Compaction Factor Values for water cement ratio 0.50

| TYPE OF AGGREAGRE (w/c ratio= 0.50) | | COMPACTION FACTOR |
|---|---|---|
| RIVER SAND | GLASS POWDER | |
| 100% | 0% | 0.972 |
| 95% | 5% | 0.961 |
| 90% | 10% | 0.955 |
| 88% | 12% | 0.947 |
| 80% | 20% | 0.931 |




**CONVENTIOINAL CONCRETE**

Conventional concrete was also known as normal concrete, which has ingredients such as aggregates, water and cement.

**Table-10** Test results for conventional concrete

| Tests | Curing days | w/c ratio | Strength ($N/mm^2$) |
|---|---|---|---|
| Compression test | 7 | **0.45** | 31.12 |
| | 28 | | 35.745 |
| | 7 | **0.50** | 23.12 |
| | 28 | | 30.02 |

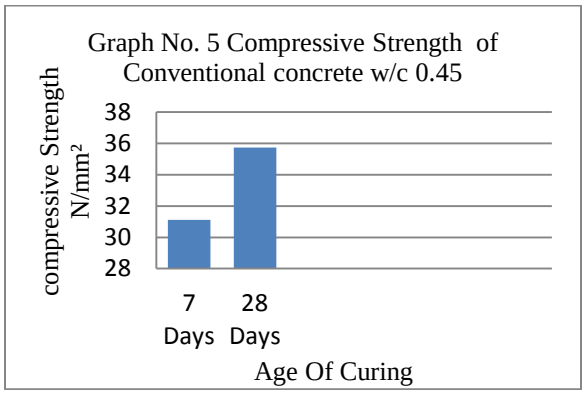
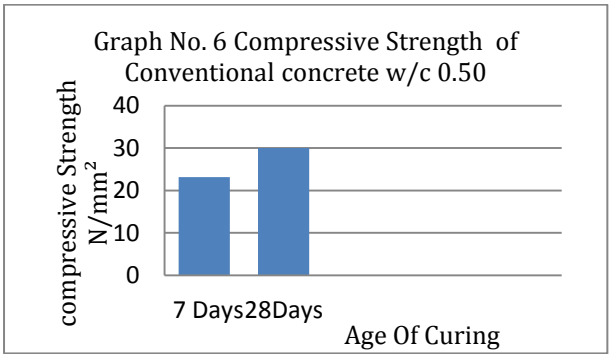


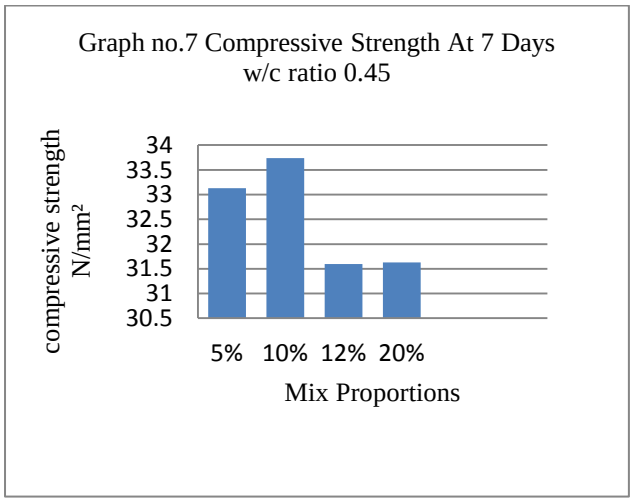

**Table-11** Test results for 7 days

| Mix | Age of concrete | W/C ratio | Compressive strength(N/mm²) |
|---|---|---|---|
| 5% | 7 | **0.45** | 33.13 |
| 10% | 7 | | 33.74 |
| 12% | 7 | | 31.595 |
| 20% | 7 | | 31.63 |
| | | | |
| 5% | 7 | **0.50** | 28.505 |
| 10% | 7 | | 29.24 |
| 12% | 7 | | 28.475 |
| 20% | 7 | | 27.91 |




**DESIGNED CONCRETE FOR VARIOUS MIXES**

The fundamental object in proportioning concrete mixes is the production of a durable material of requisite strength, watertightness, and other essential properties at minimum cost. To achieve this careful attention must be taken to selection of cement, aggregate, and water.



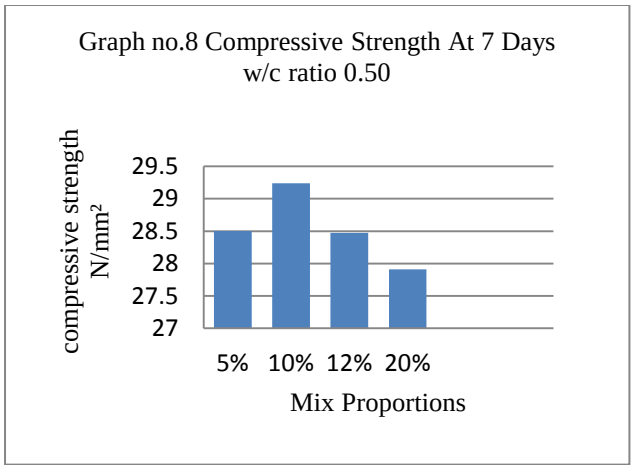
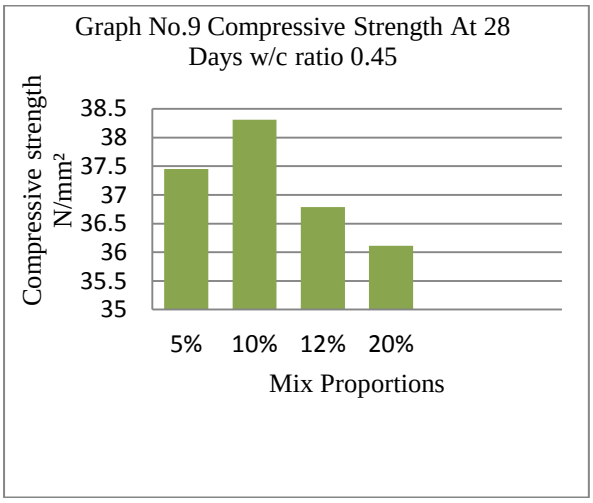
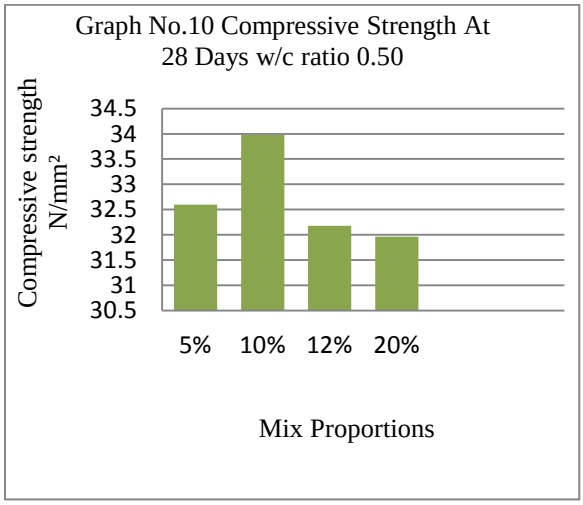




**Table-12** Test results for 28 days

| Mix | Age of concrete | W/C ratio | Compressive strength ($N/mm^2$) |
|---|---|---|---|
| 5% | 28 | **0.45** | 37.45 |
| 10% | 28 | | 38.31 |
| 12% | 28 | | 36.785 |
| 20% | 28 | | 36.115 |
| | | | |
| 5% | 28 | **0.50** | 32.595 |
| 10% | 28 | | 33.98 |
| 12% | 28 | | 32.075 |
| 20% | 28 | | 31.96 |



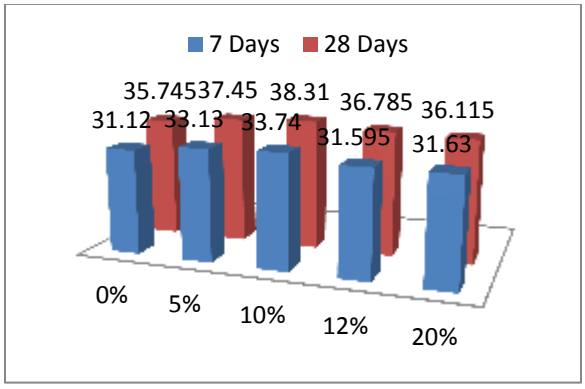




**Fig.-3** Compressive Strength Comparison **w/c ratio 0.45**

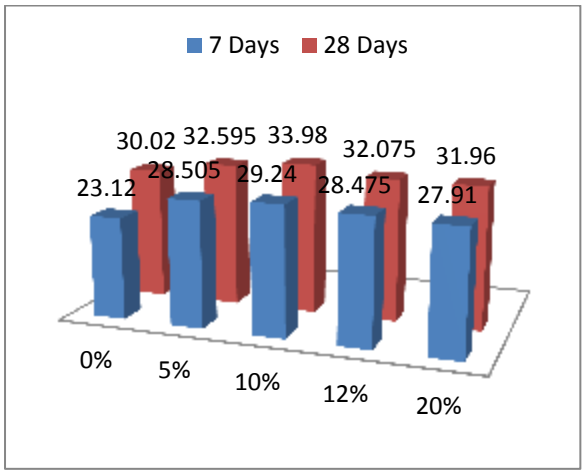



**Fig.-4** Compressive Strength Comparison **w/c ratio 0.50**

## IV. CONCLUSIONS

On the basis of results obtained, following conclusions can be drawn:

I. This experimental study required to identify the effects of using waste glass as a partial replacement for fine aggregate in concrete.
II. With increasing proportion of waste glass powder in the concrete mix the workability of the fresh concrete decreases, due to the angular nature of the glass particles.
III. Slump gradually decreased with increase in glass percentage.
IV. Compaction factor values gradually decreased with increase in glass percentage.
V. Compressive strength was found to increase with the addition of waste glass to the mix up until the optimum level of replacement. This can be attributed to the angular nature of the glass particles facilitating increased bonding with the cement paste.
VI. For both the water cement ratio i.e 0.45 and 0.50 upto 10% replacement of fine aggregates by waste glass showed optimum increase in compressive strength at 7 and 28 days.
VII. By using waste glass powder as partial replacement of fine aggregate, compressive strength increases up to 10% by 7.18% for 0.45 w/c ratio and 13.19% for 0.50 w/c ratio , but after that, it starts decreasing for 12% & 20%.
VIII. W/C ratio of 0.50 shows better result for M-25 grade of concrete mix and it is also higher workable than 0.45 w/c ratio.
IX. Use of waste glass in concrete can prove to be economical as it is non useful waste and free of cost.
X. Use of waste glass in concrete will remove the disposal problem of waste glass and prove to be environment friendly thus paving way for greener concrete.
XI. Use of waste glass in concrete will preserve natural resources particularly river sand and thus make concrete construction industry sustainable.

## REFERENCES

[1] Guatam, S. P., Srivastava, V. and Agarwal, V. C." Use of Glass wastes as fine aggregate in Concrete". J. Acad. Industries Res. Vol (16). 2012.

[2] Srivastava Ishan et al International Journal of Advance Research Ideas and Innovations in technology.Partial Replacement of Fine Aggregates with Waste Glass (Volume3, Issue4) 2017 ISSN: 2454-132X Impact factor: 4.295

[3] Rossomagina, A. S., Saulin, D. V. and Puzano, I.S. Prevention of Alkali-Silica Reaction in Glass Aggregate Concrete. Perm State Technical University, Rusia, pp.2. 2015.

[4] Adaway, M. and Wang, Y. "Recycled glass as a partial replacement for fine aggregate in structural concrete – Effects on compressive Strength" Electronic Journal of Structural Engineering, Vol. 14, No. 1, pp.116-122. 2015

[5] Malik, MIgbal, Bashir, M., Ahmad, S., Tarid, T., and Chowdhary, U."Study of Concrete Involving use of Waste Glass as Partial Replacement of Fine Aggregates". IOSR HJournal of Engineering India, July pp. 8-13. 2013.

[6] Scivacharam, S., Vikas, S., Agarwal, V. C. "Glass Waste in Concrete: Effect on Workability and Compressive Strength". International Journal of Innovative Research in Science, Engineering and Technology, Vol. 4, No. 9, pp 8142-8150. 2015.

[7] K.Rubini, Liya Sara Joy, Sanjana "An Experimental Study on Crushed Glass Material for the Partial Replacement of Natural Sand in Concrete" International Journal of Engineering and Technical Research (IJETR) ISSN: 2321-0869 (O) 2454-4698 (P), Volume-4, Issue-3, March 2016 .

[8] Prajakta N. Haramkar Sneha Maske, Rajesh M. Kushwaha, Rohit R. Sawalakhe,Jitesh R. Mahajan , Vrushabh kamdi "Partial Replacement Of Fine Aggregate By Using Glass Powder"

[9] Meyer.C, Egosi.N and Andela.C March 19-20, 2001. "Concrete with Waste Glass as Aggregate" International Symposium Concrete Technology Unit of ASCE and University of Dundee,

[10] Advanced Concrete Design by M.S.Shetty.

[11] IS 383 : 1970 'Indian Standard Code of Coarse and Fine aggregates from Natural Sources for concrete', Bureau of Indian Standards, New Delhi.

[12] IS 2386-part I, Methods Of Test For Aggregates For Concrete Part I Particle Size And Shape.

[13] IS 2386-part III Methods Of Test For Aggregates For Concrete Part Ill Specific Gravity, Density, Voids, Absorption And Bulking.

[14] IS 10262:2009 Indian Standard Concrete Mix Proportioning-Guidelines.