# Elastic Modulus and NDT Test on Concrete with Construction and Demolition (C&D) Waste

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***Abstract*-This paper presents the behavior of concrete using Fine Aggregate with Glass Aggregate and Coarse Aggregate with Recycled Aggregate replacement. In this work, to appraise the effect on M25 grade concrete with water cement ratio 0.45. The concrete waste is to be collected from the waste yard, segregated, crushed in jaw crusher, sieved, washed and used. The properties of material for cement, fine aggregate (M-Sand), coarse aggregate glass aggregate and recycled aggregate were studied for mix design. Replacement of Coarse Aggregate by Recycled Aggregate at regular intervals of 0%, 10%, 20%, 30% and 40%, replacement of Fine Aggregates by Glass Aggregate at 15% and cube and cylinder specimens were casted. The modulus of elasticity and density results were obtained with and without Recycled Coarse Aggregate replacement (and 15% replacement of M-sand by glass aggregate) were studied and the test results were compared with normal conventional concrete and non-destructive test such as rebound hammer test and ultrasonic pulse velocity measurement were studied for various replacements of fine and coarse aggregate. The results concluded the permissibility of using waste glass aggregate as partial replacement of fine aggregates up to 15% and recycled aggregate as partial replacement of coarse aggregates up to 30%.**

***Key words:*** **Construction and demolition waste (C&D waste), recycled aggregate, glass powder, young's modulus test, NDT test.**

## I.INTRODUCTION

The construction industry in India is booming. it is appropriate to link generation of C&D waste with the growth in India in 2010 may be estimated as 24 million tons. This is because there is no separate regulatory frame work for handling the construction and demolition waste management in India, as it is considered in the municipal solid waste management. Other than new construction,renovation or repair of buildings, demolition of an existing building/structure is the main cause of waste generationfrom the construction industry. In India, services of demolition contractors are taken when anold building is tobe demolished due to deterioration of the building or to make way for construction of a new building. These wastes are having different stream like Concrete, Tiles, brick, ceramics, asphalt concrete, Plaster, Glass, Metal and steel, Plastics, Wood, asphalt, etc.,

In this project we use waste concrete and waste glass as a replacement material in concrete. From literatures it was observed that the optimum percentage of replacement of fine aggregate with glass aggregate is 15% and coarse aggregate with C&D waste (Recycled aggregate) is 30% and Recycled aggregate should be washed after crushing. Permissibility of using waste glass powder as partial replacement of fine aggregates up to particle size of range 0-1.18mm. Solid waste management of C&D-waste done, when it uses in concrete. The sources of construction and demolition waste is shown in Figure 1 and Figure 2

Fig 1 Recycled CA

Fig 2 Recycled Glass aggregate

## II. EXPERIMENTAL PROGRAM

### *2.1 Materials Used*

#### *A. Cement*

Ordinary Portland Cement of 53 grade confining to (IS12269-2013) was used throughout the work. The mechanical properties of the used cement as determined by laboratory tests showed its suitability for concrete works. The

physical properties of OPC as determined are shown in Table 1. The cement satisfies the requirement of IS: 8112-1989.

*B. Fine Aggregate*

*Natural Aggregates*

Fine aggregate is obtained from locally available river sand and M-sand which is passed through 4.75 mm sieve.

*Glass Powder*

Available waste glass was collected and made into glass powder. Glass waste is very hard material. Before adding glass powder in the concrete, it has to be powdered to desired size. In this experiment glass powder having partials size less than 2.36mm was used.

Physical properties of natural aggregate and glass aggregates were determined and compared as shown in Table 2.

*C. Coarse Aggregate*

*Natural Coarse Aggregate*

Crushed granite aggregates particles passing through 20mm and retained on 4.75mm I.S sieve was used as natural aggregates which met the grading requirement of IS: 383 - 1970.

*Recycled Coarse Aggregate*

Crushed concrete waste passing through 20mm and retained on 4.75mm I.S sieve were used as recycled coarse aggregate and they met the grading requirements of IS: 2386 - 1983.

Physical properties of natural aggregate and recycled aggregates were determined and compared as shown in Table 3.

*2.2 Physical Properties of Material Test on Cement*

The physical properties of the used cement as determined by laboratory tests showed its suitability for concrete works. The physical properties of the cement used in this investigation are shown in Table 1

| Test conducted | Result | Requirements |
|---|---|---|
| Fineness | 8% | Not exceed 10% |
| Specific Gravity | 3.1475 | 3.10 to 3.15 |
| Consistency | 33% | 26% to 33% |
| Initial setting time | 75 minutes | Not less than 30 minutes |

*Test on Fine Aggregate*

The physical properties of the fine aggregate (Sample 1-River sand, Sample 2-M- sand, Sample 3 -Glass Aggregate) used in this investigation are shown in Table 2

**Table 2 Result of physical properties of the Fine Aggregate**

| Test conducted | Sample | | | Require -ments |
|---|---|---|---|---|
| | 1 | 2 | 3 | |
| Fineness modulus | 3.07 | 3.11 | 2.65 | 2.2 to 3.2 |
| Water absorption | 1.3% | 1.9% | 0.9% | 0.5% to 2.0% |
| Specific Gravity | 2.65 | 2.63 | 2.63 | 2.4 to 2.7 |
| Moisture content | Nil | Nil | Nil | Less than 1 % |

*Test on Coarse Aggregate*

The Physical properties of the coarse aggregate used in this investigation are shown in Table 3(**Sample 1 (Natural Aggregate), Sample 2 (Recycled Aggregate)**)

**Table 3 Result of physical properties of the Coarse Aggregate**

| Test Conducted | Samples | | Require -ments |
|---|---|---|---|
| | 1 | 2 | |
| Water Absorption | 0.8% | 0.4% | 0.1 % to 2.0% |
| Moisture Content | Nil | Nil | Less than 1 % |
| Crushing Strength Test | 25.7% | 27.6% | Not More than 30% |
| Aggregate Impact Value | 30% | 31% | Not More than 45% |

*2.3 Concrete Mix Design*

Concrete mix design for M25 grade is done as per IS: 10262 – 2009. The results of concrete mix design are tabulated in Table 4

**Table 4 Concrete Mix Design**

| Weight | W/C | Cement | FA | CA |
|---|---|---|---|---|
| $Kg/m^3$ | 190 | 420 | 692 | 1143 |
| Ratio | 0.45 | 1 | 1.64 | 2.71 |

*2.4 Investigations on Hardened Concrete*

To determine the modulus of elasticity, density and non-destructive test such as rebound hammer test and ultrasonic pulse velocity of concrete specimens with Replacement of coarse aggregate by C&D waste at regular intervals of **0%, 10%, 20%, 30%, and 40%,** replacement of fine aggregate by glass waste at (**15%)** cubes of size 150 mm and cylinders of size 150 mm diameter and 300 mm length were cast, cured and tested at 14 and 28 days after curing.

*2.5 Modulus of Elasticity of Concrete*

Young 's modulus, can strictly be applied only to the straight part of stress-strain curve.Tangent modulus is the slope of the tangent to any point in the inelastic region. Secant modulus is the slope of the line joining any point in the inelastic region to the origin. A line can be drawn connecting a specified point on the stress strain curve to the origin of the curve. Table 1 shows that results of young's modulus.

The Cylinder specimen was fitted with compression testing machine and subjected to compression up to % of ultimate cylinder compressive strength. The test set up is shown in Figure 1

Figure 1 Testing of Specimen for Young's Modulus test

**Table 1 Modulus of Elasticity of Concrete**

| MIX ID | Initial Tangent Modulus ($N/mm^2$) | Young's Modulus ($N/mm^2$) | Chord Modulus ($N/mm^2$) | Theoretical (5000 $\sqrt{fck}$) ($N/mm^2$) |
|---|---|---|---|---|
| **CM** | 43000 | 66000 | 32500 | 25000 |
| **15** | 46600 | 20000 | 27300 | 25000 |
| **15-10** | 17240 | 40000 | 23300 | 25000 |
| **15-20** | 15200 | 32000 | 73300 | 25000 |
| **15-30** | 28300 | 95000 | 20300 | 25000 |
| **15-40** | 38180 | 83330 | 33000 | 25000 |

*2.6 Rebound Hammer Test*

The compressive strength of the concrete cube specimens can be tested in a compression testing machine under a fixed load and then the compressive strength determined as per IS 516:1959 from the rebound number (rebound index) from rebound hammer test (Schmidt Hammer) can be compared.

The estimation of strength of concrete by rebound hammer method cannot be held to be very accurate and probable accuracy of prediction of concrete strength in a structure is ± 25 percent. The test conducted on cube specimen is shown in Figure 2

Figure 2 Rebound Hammer Test on cylindrical specimen

**Table 2 Rebound Hammer Test**

| MIX ID | Compressive Strength on cube($N/mm^2$) | |
|---|---|---|
| | **at 14 days** | **at 28 days** |
| 0 | 13.67 | 22.53 |
| 15 | 12.05 | 17.43 |
| 15-10 | 12.14 | 18.44 |
| 15-20 | 12.58 | 20.6 |
| 15-30 | 14.68 | 26.9 |
| 15-40 | 14.56 | 18.69 |

*2.7 Ultrasonic Pulse Velocity Test*

The ultrasonic pulse is generated by electro acoustical transducer. When the pulse is induced into the concrete from transducer it undergoes multiple reflections at the boundaries of the different material phases within the concrete. Due to the fact the rate of the pulses is nearly independent of the geometry of the material through which they pass and depends on its elastic properties, pulse velocity technique for investigating structural concrete.

**Table 3 Ultrasonic Pulse Velocity Test**

| Mix ID | Path Length (km) | Travel Time (Mic. Sec) | Velocity (m/s) | Quality of concrete |
|---|---|---|---|---|
| **0** | 0.3 | 71.1 | 2810 | Medium |
| **15** | 0.3 | 99.6 | 2010 | Medium |
| **15-10** | 0.3 | 77.7 | 2510 | Good |
| **15-20** | 0.3 | 94.3 | 1610 | Good |
| **15-30** | 0.3 | 100.2 | 1570 | Medium |
| **15-40** | 0.3 | 99.7 | 2010 | Medium |

*2.7 Density of The Concrete Specimens*

The properties of concrete are highly affected by its density. A higher strength of denser concrete is generally provided by denser concrete and it gives fewer number of voids and porosity. Smaller the voids in concrete, it becomes less permeable to water and soluble elements.

**Table 4 Density of the Specimen**

| Mix ID | Density of the specimens (Kg/m$^3$) | |
|---|---|---|
| | Cube | Cylinder |
| **M-0** | 2525.03 | 2475.84 |
| **M-15** | 2607.70 | 2521.50 |
| **M-15-10** | 2513.03 | 2428.58 |
| **M-15-20** | 2555.25 | 2465.28 |
| **M-15-30** | 2650.07 | 2475.84 |
| **M-15-40** | 2555.55 | 2538.11 |

## III. CONCLUSIONS

- From the Experimental study of concrete at 28 days, for **15%** of **glass aggregate** as partial replacement of fine aggregate and **30%** of **recycled aggregate** as partial replacement of coarse aggregate, the modulus of elasticity of concrete for the specimen of grade M25 is 95000 N/mm$^2$ as per IS 456-2000 the elastic deformation is 25000 hence the obtained result is good compared to control mix.
- The NDT Test(Rebound Hammer Test and Ultrasonic Pulse Velocity Test) values of concrete for **15%** of **glass aggregate** as partial replacement of fine aggregate and **30%** of **recycled aggregate** as partial replacement of coarse aggregate was found to be **better result compared to** control mix.
- From the Experimental study of concrete with glass aggregate as partial replacement of fine aggregate and recycled aggregate as partial replacement of coarse aggregate, it was observed that the compressive strength of concrete with **15%** of **glass aggregate** as partial replacement of fine aggregate and **30%** of **recycled aggregate** as partial replacement of coarse aggregate yields higher strength values than that of both conventional concrete and the concrete with **10 % ,20 % & 40%** replacement of recycled aggregate at both 14 days and 28 days.

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