# EXPERIMENTAL INVESTIGATION ON M20 CONCRETE WITH DEMOLITION WASTE

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***Abstract -*** *Natural resources of coarse aggregate are greatly affected by their extensive extraction for the concreting and road works. At the same time huge quantity of construction and demolished wastes are created in India. Concrete waste is the major part of it. Disposal of this waste is a very serious problem. Landfill is the only way to dispose it which requires huge land and it is not economical in present days. If some of the demolished waste materials are found suitable in concrete making, not only cost of construction can be cut down, but also disposal of waste material can be achieved. The utilization of construction and demolition waste has to be related to the application of quality guarantee systems in order to achieve suitable product properties. In this study , demolition waste have been used as partially replaced to the concrete cubes, cylinder and prism were casted and test results have been founded for compressive strength, flexural strength splits tensile strength after a curing period of 7 and 28 days. The results indicated effectiveness of demolition waste as coarse aggregate by partial replacement of conventional concrete by 15%, 30%, 45% and 60% without affecting the design strength. This paper recommends that the demolition waste can be used as an alternative construction material to coarse aggregate in concrete.*

***Key Words***: Coarse Aggregate Replacement, Workability, Compressive Strength, Flexural Strength, Split Tensile Strength, Demolition Waste Disposal, Demolition Waste Material.

## 1. INTRODUCTION

Concrete is the world's most consumed material. Aggregates are the major components of concrete and have a great effect on the engineering properties of the final concrete. Natural resources are greatly affected by their extensive use due to the increasing demand of concrete buildings. The negative consequences of the increasing demand for concrete include depletion of aggregate deposits environmental degradation and ecological imbalance. Rising construction costs and the need to reduce environmental stress to make construction sustainable, has necessitated research into the use of alternative materials especially locally available ones which can replace conventional ones used in concrete production. If some of the waste material is found suitable in concrete making with use of demolition waste.

In other hand huge deposits of construction wastes are created, consequently becoming a special problem of human environment pollution. For this reason, in developed countries laws have been bought into practice to restrict this waste in the form of prohibitions or special taxes existing for creating waste areas. Demand for construction aggregates in India amounted as 1.1 billion metric tons in 2014. It is increasing 7.7% per annum. Using of concrete waste as a coarse aggregate in concrete construction will be the suitable solution to solve the problem discussed above.

Construction and demolition (C&D) debris is produced during new construction, renovation and demolition of buildings and structures. C&D debris includes bricks, concrete, masonry, soil, rocks, lumber, paving materials, shingles, glass, plastics, aluminium, steel, drywall, insulation, asphalt roofing materials, electric materials, plumbing fixtures, vinyl siding, corrugated cardboard and tree stumps, in 1996 the U.S. produced an estimated 136 million tons of building materials, which can be a significant portion of total C&D materials discarded.

Construction and demolition waste is generated whenever any construction/demolition activity takes place, such as, building roads , bridges, fly over, subway, remodeling etc. it consist mostly of inert and non-biodegradable material such as concrete, plaster, metal, wood, plastics etc. A part of this waste comes to the municipal stream. These wastes are heavy having high density often bulky and occupy considerable storage space either on the road or communal wastes bin/container. It is not uncommon to see huge piles of such wastes which are heavy as well, stacked on roads especially in large projects resulting in traffic congestion and distruption. Wastes from small generators like individual house construction or demolition, find its way into the nearby municipal bin/vat/waste storage depots, making the municipal waste heavy and degrading its quality for further treatment like composting or energy recovery. Often it finds its way into surface drains, chocking them. It constitutes about 10-20% of municipal solid wastes (excluding large construction projects). It is estimated that the construction industry in India generates about 10-20 million tons of waste annually. Projections for building material requirement of the housing sector include a shortage of aggregates to the extent of about 55,000 million cu.m. An additional 750 milion cu.m. Aggregates would be required for achieving the targets of the road sector. Recycling of aggregate material from construction and demolition waste may reduce the demand-supply gap in both these sectors. While retrievable items such as bricks, woods, metals, tiles are recycled the concrete and masonry waste, accounting for more than 50% of the waste from construction and demolition activities, are not being currently recycled in India. Recycling of concrete like UK, USA, France, Denmark, Germany, and japan.

Concrete and masonry waste can be recycled by sorting, crushing and sieving into recycled aggregates. This recycled aggregate can be used to make concrete for road construction and building material. Work on recycling of aggregates has been done at central building material. Work on recycling of aggregates has been done at Central Building Research Institute (CRBI), New Delhi. The study report stresses the importance of recycling construction wastes, creating awareness about the problem of waste management and the availability of technologies for recycling, According to a study commissioned by Technology information. Forecasting and Assessment council (TIFAC), 70% of the construction industry is not aware of recycling technologies. The study recommends establishment of quality standards for recycled aggregate materials and recycled aggregate concrete. This would help in setting up a target product quality for producers and assure the user of a minimum quality requirement, thus encouraging him to use it.

These wastes are best stored at source, i.e., at the point of generation if they are scattered around or thrown on the road, they not only cause obstruction to traffic but also add to the workload of the local body. All attempts should be made to sick to the following measures.

All construction/demolition wastes should be stored within the site itself. A proper screen should be provided so that the waste does not get scattered and does not become an eyesore. Attempts should be made to keep the waste segregated into different vheaps as far as possible so that their further gradation and reuse is facilitated.

Material, which can be reused at the same site for the purpose of construction, evolving, making road/pavement etc. should also be kept in separate heaps from those, which are to be sold or land filled. The local body or a private company may arrange to provide appropriate number of skip containers/trolleys on hire which may be parked at the site removed with skip lifters or tractors as the case may be.

Whenever a new streamlined system is introduced in a municipality, the local body may consider using its old vehicles, especially, tractors and trailers or old lorries or tippers for this purpose. For large projects involving constructions of bridges, flyovers, subways, etc., special provisions should be made for storage of waste material. Depending on the storage, capacity, movement of the waste has to be planned accordingly. Otherwise, it would result in job constraint as well as traffic bottlenecks.

This subject is often neglected in case of repair/maintenance of road, water, pipes, underground telephones and electric cables etc. it is not uncommon to see that after such work, the waste remains piled for months on the roads or pavements. The concerned departments and contractors must co-ordinate with the municipality for removal of the debris generated. The municipality while giving permission for such work should clearly sort out the issue of removal of the debris and should insist that immediately after the job is over. The road should be repaired and brought back to its normal shape.

The use of these materials basically depends on their separation and condition of separated material. A majority of these materials are durable and therefore, have a high potential of reuse. It would however be desirable to have quality standards for the recycled material. Construction and demolition waste can be used in the following manner.

Metropolitan and mega cities usually generate huge quantities of wastes because of large-scale building and other developmental activities. They may identify suitable sites where such wastes can be temporarily stored and some physical treatment can be carried out. Compared to the general waste treatment/disposal/landfill site such sites may be suitably located near the municipal boundaries, because the inert waste do not cause odour or pollution, provided adequate steps are taken to reduce dust and noise during handling. Since these wastes are heavy, their transportation cost can also be reduced to some extent if the distance to be carried is less.

Being predominantly inert in nature, construction and demolition waste does no create chemical or biochemical pollution. The material can be used for filling/leveling of low-lying areas. In the industrialized countries, special landfills are sometimes created for inert waste, which are normally located in abandoned mines and quarries. The same can be attempted in our country also for cities, which are located near open mining quarries or mines where normally sand is used as the filling material. However, proper sampling of the material for its physical and chemical characteristics has to be done for evaluating its use under the given circumstances. Regression analysis method for predicting the 7 and 28 days compressive strength, flexural and split tensile strength of concrete is presented in this project. The proposed method is aimed at establishing a predictive relationship between properties and proportions of ingredients of concrete, compaction of concrete, weight of concrete cubes and strength of concrete.

This strength not only reducing cost of construction. Also safe disposals of waste material can be achieved. The use of cheaper material without loss of performance is very crucial to the growth of development of the countries. In this study, concrete waste coming from the demolition of a concrete building was crushed and directly used as a replacing material for coarse aggregate. The suitability or crushed concrete waste as aggregate is confirmed by conducting suitable tests as specific gravity, water absorption, sieve analysis, crushing value and impact value tests. At first a control concrete mix, prepared with natural aggregates and both the same cement amount and various test results are reported for comparison this study also experimental investigation done to study the effect of partial replacement of coarse aggregate on demolition waste concrete by 0%, 10%, 20%, 30%, 40%, 50% and 100% numerous tests are performed on wet concrete such as workability test, compaction factor test, and slump cone test. The tests on hardened concrete are compressive test, flexural and split tensile test.

## 2. METHODOLOGY

Methodology is the overall approach that underpins the project. In this chapter the methods followed to complete the project is discussed. The following representation shows the methodology being used.

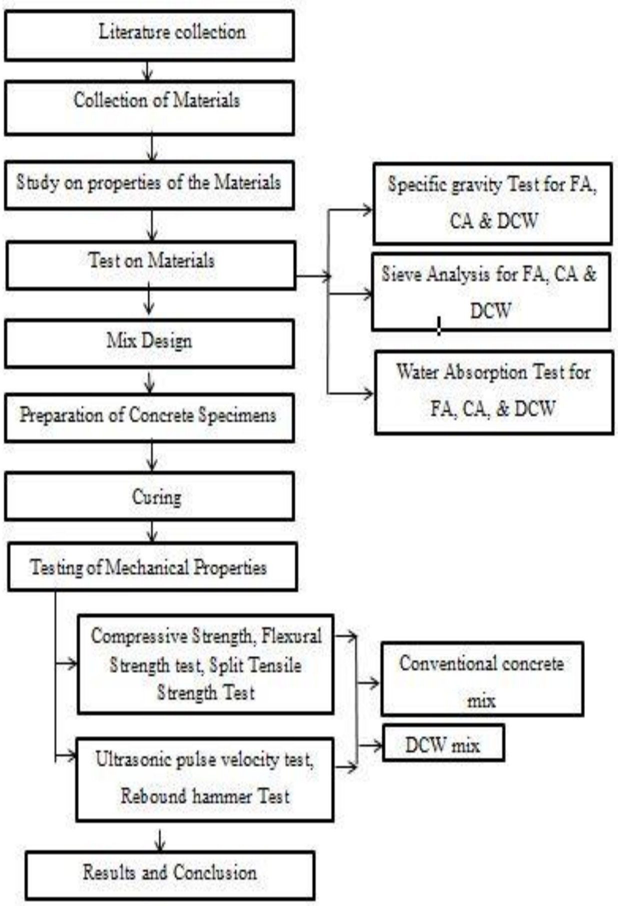


**Fig-1** Methodology

## 3. EXPERIMENTAL INVESTIGATIONS

### 3.1 Slump cone Test

Slump is a measurement of concrete's workability, or fluidity. It's an indirect measurement of concrete consistency or stiffness. A slump test is a method used to determine the consistency of concrete. The consistency or stiffness indicates how much water has been used in the mix. The stiffness of the concrete mix should be matched to the requirements for the finished product quality.

**Table 1 – Slump Cone Test Results**

| SL NO. | %REPLACEMENT OF DCW | W/C RATIO | SLUMP (mm) |
|---|---|---|---|
| 1. | 0% | 0.5 | 72 |
| 2. | 10% | 0.5 | 74 |
| 3. | 20% | 0.5 | 77 |
| 4. | 30% | 0.5 | 80 |
| 5. | 40% | 0.5 | 81 |
| 6. | 50% | 0.5 | 83 |
| 7. | 100% | 0.5 | 79 |

### 3.2 Density of Concrete

The density of concrete is a measure of its unit weight. Concrete is a mixture of cement, fine and coarse aggregate, water and sometimes some supplementary materials like fly ash, slag and various admixtures. A normal weight concrete weighs 2400 kg per cubic meter. The unit weight of concrete (density) varies depending on the amount and density of the aggregates, the amount of entrained air (and entrapped air,) and the water and cement content.

**Table 2 – Densities of various mixes**

| %REPLACEMENT OF DCW | WEIGHT IN Kg | DENSITY IN Kg/m$^3$ |
|---|---|---|
| 0% | 8.20 | 2429.63 |
| 10% | 8.43 | 2497.78 |
| 20% | 8.52 | 2524.44 |
| 30% | 8.63 | 2557.04 |

| | | |
|---|---|---|
| 40% | 8.70 | 2577.78 |
| 50% | 8.74 | 2589.63 |
| 100% | 8.78 | 2600.89 |

### 3.3 Compressive Strength Test

The compressive strength is the capacity of a material or structure to withstand loads tending to reduce size. It can be measured by plotting applied force against deformation in a testing machine. Some materials fracture at their compressive strength limit; others deform irreversibly, so a given amount of deformation may be considered as the limit for compressive load compressive strength is a key value for design of structures.

Compressive strength is often measured on universal testing machine, this range from very small table-top systems to ones with over 2000Kn capacity. Measurements of compressive strength are affected by the specific test method and conditions of measurement. Compressive strength are usually reported in relationship to a specific technical standard.

Concrete mixtures can be designed to provide a wide range of mechanical and durability properties to meet the design requirements of a structure. The compressive strength of concrete is the most common performance measure used by the engineer in designing buildings and other structures. The compressive strength is calculated from the failure load divided by the cross-sectional area resisting the load and reported in units of N/mm2

Following results are observed in compressive strength when natural aggregates were replaced with demolition concrete waste aggregates. However a decrease in compressive strength was observed when natural aggregates were replaced with those replacing materials but characteristic strength was achieved successfully. Values of compressive strength for various percentages of recycled concrete wastes were reported in Table and variation of compressive strength with age of concrete is shown in chart

**Table 3 – Compressive Strength test result**

| Age | 7 DAYS | 14 DAYS | 28 DAYS |
|---|---|---|---|
| **0%** | 14.07 | 19.085 | 24.1 |
| **10%** | 14.22 | 19.16 | 24.12 |
| **20%** | 15.55 | 20.075 | 25.86 |
| **30%** | 15.85 | 21.425 | 27 |
| **40%** | 15.30 | 20.91 | 26.52 |
| **50%** | 15.24 | 20.635 | 26.03 |
| **100%** | 14.49 | 19.38 | 24.2 |

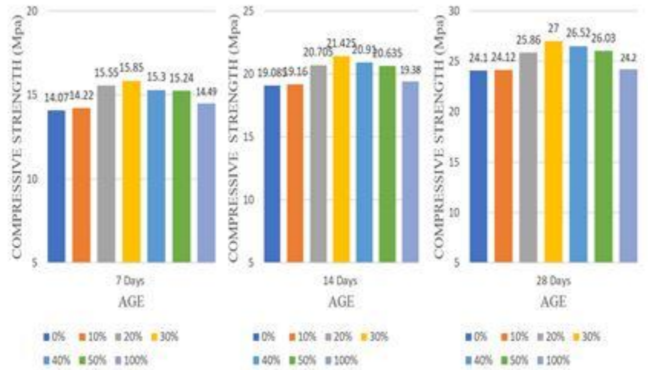


**Fig 2 – Compressive strength graph**

### 3.4 SPLIT TENSILE STRENGTH TEST

This is an indirect test to determine the tensile strength of cylindrical specimens. Splitting tensile strength tests were carried out an cylinder specimens of size 150 mm diameter and 300mm length at the age of 7 days and 28 days curing for the ultimate result using AIML compression testing machine of 2000Kn capacity as per BIS;5816-1970.

**TABLE 4 – Spilt tensile strength test result**

| Age | 7 DAYS | 14 DAYS | 28 DAYS |
|---|---|---|---|
| **0%** | 1.32 | 1.74 | 2.17 |
| **10%** | 1.41 | 1.815 | 2.22 |
| **20%** | 1.5 | 1.88 | 2.26 |
| **30%** | 1.69 | 2.11 | 2.54 |
| **40%** | 1.60 | 2.04 | 2.48 |
| **50%** | 1.55 | 2 | 2.45 |
| **100%** | 1.41 | 1.78 | 2.16 |

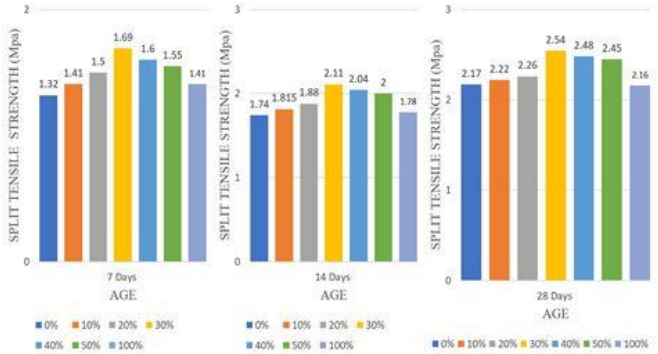


**Fig 3 – Spilt Tensile Strength graph**

### 3.5 FLEXURAL STRENGTH TEST

Flexural strength also known as modulus of rupture, bend strength, a mechanical parameter for brittle material, is defined as a materials ability to resist deformation under load. The transverse bending test is most frequently employed, in which a specimen having either a circular or rectangular cross- section is bent until fracture or yielding using a three point flexural test technique. The flexural strength represents the highest stress experienced within the material at its moment of rupture. It is measured in terms of stress, here given the symbol σ,

Concrete pavement carries load as a simple, plain, (non-reinforced) concrete beam. The strength of the concrete in flexure is the most important requirement. In previous labs then primary interest has been the compressive strength of concrete. This strength is used in the structural design of reinforced concrete, where tension, in which concrete is very weak, is assumed to be taken entirely by the reinforcing steel.

The rebars in concrete pavement are not important from the point of view of bending stresses. These are dowel bars at jpints and possibly shrinkage control bars. As the correlation between it and compressive strength is only approximate, it is usually measured directly and many specifications for concrete pavement specify only the flexural strength of the concrete and not the compressive. The flexural strength is referred to as the modulus of rupture of the concrete.

**Table 5 – FLEXURAL STRENGTH TEST**

| Age | 7 DAYS | 14 DAYS | 28 DAYS |
|---|---|---|---|
| 0% | 2.31 | 2.95 | 3.57 |
| 10% | 2.3 | 2.99 | 3.6 |
| 20% | 2.4 | 3.005 | 3.61 |
| 30% | 2.5 | 3.11 | 3.72 |
| 40% | 2.48 | 3.07 | 3.67 |
| 50% | 2.45 | 3.05 | 3.65 |
| 100% | 2.32 | 2.93 | 3.55 |

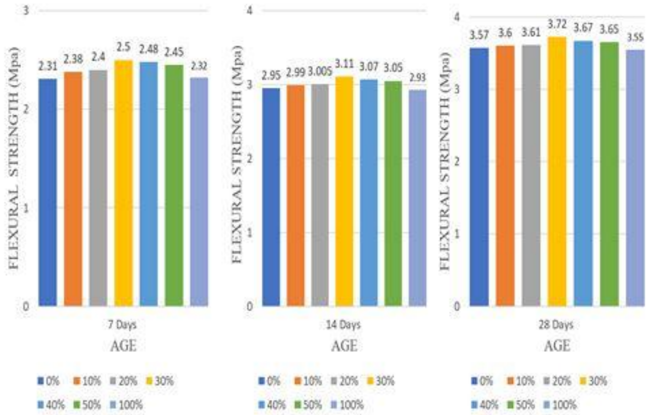


**Fig 4 – Flexural strength graph**

## 4. RESULTS AND DISCUSSION

The result of the investigation carried out for the selection of proper materials to arrive at the optimum mix proportions and the results of fresh as well as hardened property of coarse aggregate replaced concrete on several mix of concrete are illustrated below

### 4.1 Workability

Workability is found at 0. 5 water cement ratio and compared it shows the gradual decrement in workability with respect to increase in replacement percentage

### 4.2 Density

Density of each concrete mix is calculated from 28 days weight of each concrete mix and tabulated

**Table 6 - Density**

| %REPLACEMENT OF DCW | % INCREASE IN DENSITY WITH NORMAL CONCRETE |
|---|---|
| 0% | 6.54 |
| 10% | 6.91 |

| | |
|---|---|
| 20% | 7.28 |
| 30% | 7.65 |
| 40% | 8.02 |
| 50% | 8.27 |
| 100% | 8.37 |

### 4.3. Compressive Strength of cube

Compressive strength of each concrete mix is calculated for 7, 14, 28 days using compressive testing machine and load values. The values of compressive strength and fig shows the graphical comparison of compressive strength of each concrete. The 10 %, 20%, 30%, 40%, 50%, 100% mix increase the strength by 0.08%, 7.3%, 12.03%, 10.04%, 8.01% and 0.41% respectively.

### 4.4 Split tensile Strength of cylinder

Split tensile strength of each concrete mix is calculated for 7 and 28 days using compression testing machine and load values are given in table. The values of compressive strength and fig shows the graphical comparison of compressive strength of each concrete. The 10 %, 20%, 30%, 40%, 50% mix increase the strength by 2.30%, 4.15%, 17.05%, 14.29%, 12.90% respectively. But the 100% mix decreases the strength by 0.46%.

### 4.5 Flexural Strength of prism

Flexural strength of different test mixes are obtained by conducting three-point load test on prism of each mix in 7 and 28 days. Flexural strength of different mixes are tabulated in table and compacted graphically. The 10 %, 20%, 30%, 40%, 50% mix increase the strength by 0.84%, 1.12%, 4.20%, 2.80%, 2.24% respectively. But the 100% mix decreases the strength by 0.56%.

**TABLE 7 - % COMPARISON OF TEST RESULT**

| COMPARISON OF RESULT | | | | | | | |
|---|---|---|---|---|---|---|---|
| **AGE** | **0%** | **10%** | **20 %** | **30%** | **40 %** | **50 %** | **100 %** |
| | **COMPRESSIVE STRENGTH (Mpa)** | | | | | | |
| **7** | 14.07 | 14.22 | 15.6 | 15.85 | 15.3 | 15.24 | 14.49 |
| **14** | 19.09 | 19.16 | 20.1 | 21.43 | 20.9 | 20.63 | 19.38 |
| | | | | | | 5 | |
| **28** | 24.1 | 24.12 | 25.7 | 27 | 26.5 | 26.03 | 24.2 |
| | **SPLIT TENSILE STRENGTH (Mpa)** | | | | | | |
| **7** | 1.32 | 1.41 | 1.5 | 1.69 | 1.6 | 1.6 | 1.41 |
| **14** | 1.74 | 1.815 | 1.88 | 2.11 | 2.4 | 2 | 1.78 |
| **28** | 2.17 | 2.22 | 2.26 | 2.54 | 2.5 | 2.5 | 2.16 |
| | **FLEXURAL STRENGTH (Mpa)** | | | | | | |
| **7** | 2.31 | 2.3 | 2.4 | 2.5 | 2.5 | 2.5 | 2.32 |
| **14** | 2.95 | 2.99 | 3.05 | 3.11 | 3.1 | 3.1 | 2.93 |
| **28** | 3.57 | 3.6 | 3.61 | 3.72 | 3.7 | 3.7 | 3.55 |

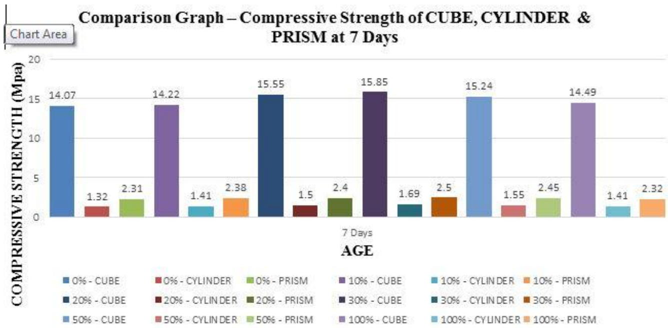


**Fig 5 – Comparison graph for 7th day test**

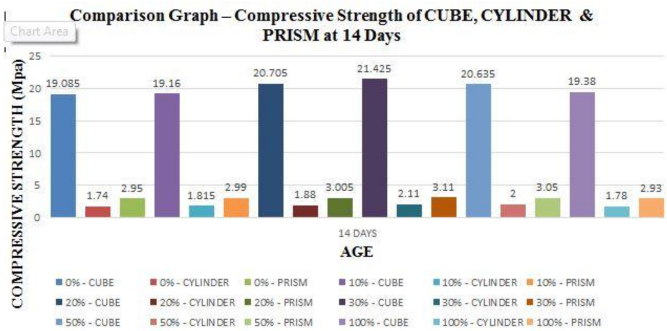


**Fig 6 – Comparison graph for 14th day test**

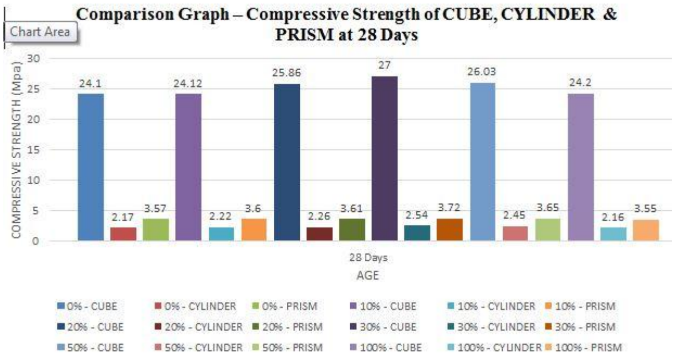


**Fig 7 – Comparison grapth for 28th day test**

## 5. CONCLUSIONS

This project have proven that good quality concrete could also be produced with partial replacement of natural coarse aggregate by shredded demolition concrete waste. The main objective of the work was to investigate the feasibility of using demolition concrete waste in concrete mixes instead of natural aggregate. This study included the preparation of concrete mixes containing varied percentage of shredded demolition concrete waste. Also this study included the evaluation of concrete properties in fresh and hardened states. The studied properties involved mix workability, compressive strength, density, flexural strength and tensile strength. According to experimental results, the use of demolition concrete waste in concrete mixes as an alternative of natural coarse aggregate is possible. The influence of concrete waste on concrete properties was studied.

The use of aggregates produced from recycled construction and demolition waste should be further promoted. Based on the experimental investigation reported in work, the following conclusions are drawn:

- The density of shredded concrete waste is about 0.96 of the dry density of natural aggregate, which is not much lower than natural aggregate concrete density.
- The sieve analysis curve of natural coarse aggregate and shredded demolition concrete waste is nearer and parallel to each other. These values satisfies the standard requirement of aggregate sizes recommended in IS383:1970
- The workability of coarse aggregate replaced concrete mix is lower than design mix. Workability decreases with respect to the increase in replacement percentage of coarse aggregate.
- The density of concrete increase gradually with respect to the increase in the replacement percentage.
- The compressive strength of concrete increases up to 30% replacement of coarse aggregate and it decreases with further increment in replacement percentage. Mix –A and Mix-B gives development of compressive strength up to 15.29% and 27.81% respectively than the reference mix(Mix-O).
- Mix-C and Mix-D results 7.59% and 11.64% decrease in compressive strength when compared to the reference mix.
- The flexural strength and split tensile strength of replaced concrete mix decreases till 30% replacement and it increases after that.
- Mix-A and Mix-B shows good increment in compressive strength with a tolerable reduction in workability, tensile and flexural strength. The density of Mix-A and Mix-B increases by 2.32% to 5.11% but this is close to the density of conventional concrete.
- Hence we suggest replacing the coarse aggregate by shredded demolition concrete waste from 15% to 30% in conventional concrete without adding any admixtures.

### 5.1 Recommendations for future studies

While studies have shown that shredded demolition concrete waste can be used as aggregate for new concrete. There is a need to obtain long-term in-service performance and life cycle cost data for concrete made with demolition concrete waste concrete to assess its durability and performance. If additional research supports the use of concrete buildings then existing specification should be revised to permit and encourage the use of demolition concrete waste as aggregate. Using demolition concrete waste in concrete mixes leads to conserve existing supplies of natural aggregate and to reduce the amount of solid waste that must be disposed of in landfills. Further testing and studies on the demolition concrete waste is highly recommended for application in high strength concrete. Below are some of the recommendations for further studies:

An important step in maintaining and encouraging the recyclability of concrete is the ability to separate other building materials like wood, bricks, polyethylene products, minerals etc, from the concrete construction that would either be incompatible in a common preparation process, or would at least restrict the recycling.

- It is recommended that adding admixtures such as super plasticizer and silica fume into the mixing to increase the workability
- More investigations and laboratory tests should be done on the strength characteristics of demolition concrete waste. It is recommended that testing can be done on concrete slabs, beams and walls. Some mechanical properties such as creeping and abrasion were also recommended.
- More investigations and laboratory tests should be done on the durability of recycled aggregate

concrete in new concrete, and its creep and shrinkage characteristics.

- The influence of contaminants in the demolished concrete from buildings should be carefully studied and investigated to extend life time of concrete made with demolition concrete waste.
- The fire-resistant property of recycled aggregates should be carefully studied.

More studies on the economic aspect of concrete processing and recycling.

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