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GREENCRETE FOR SUSTAINABLE CONSTRUCTION

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ABSTRACT

The use of recycle product is increasing with innovation in present scenario. The utilization of waste product in the manufacturing of new product is a challenging job. The natural resource decreases in a short period and therefore the use of waste product is necessary.In the construction field of the world, use of construction and demolished waste as alternative to coarse aggregate plays a vital role to save natural resources and it is economical. Natural sand is a prime material used for the preparation of concrete and also plays an important role in Mix Design. One such material is Quarry stone dust: a by-product obtained during quarrying process. Attempts have been made to study the suitability of Quarry dust as sand replacing material and it has been found that quarry dust improves the mechanical properties of concrete as well as elastic modulus.

This present work is an attempt to use Quarry Dust as partial replacement for Sand in concrete and demolished waste as partial replacement for coarse aggregate in concrete. The main object of this research is to determine the compressive strength, tensile strength, flexural strength. Various mixes were prepared for carrying out the research by varying the proportions of cement, sand and aggregates. All mixes were designed for characteristic strength (fck) of M20. The compressive strength, tensile strength, Flexural strength of concrete was tested in laboratory after 14 and 28 days of curing.

Keywords: Demolished waste, Quarry stone dust, M20, compressive strength, tensile strength, flexural strength

I. INTRODUCTION

Concrete is the premier construction material across the world and the most widely used in all types of civil engineering works, including infrastructure, low and high-rise buildings, defence installations, environment protection and local/domestic developments. Concrete is a manufactured product, essentially consisting of cement, aggregates, water and admixture(s). Among these, aggregates, i.e. inert granular materials such as sand, crushed stone or gravel form the major part. Traditionally aggregates have been readily available at economic price. However, in recent years the wisdom of our continuedwholesale extraction and use of aggregates from natural resources has been questioned at an international level. This is mainly because of the depletion of quality primary aggregates and greater awareness of environmental protection. In light of this, the availability of natural resources to future generations has also been realized. Given this background, the concept of sustainable development put forward almost a decade ago, at the 1992 Earth Summit in Rio de Janeiro, and it has now become a guiding principle for the construction industry worldwide.

In fact, many governments throughout the world have nowintroduced various measures aimed at reducing the use of primary aggregates and increasing reuse and recycling, where it is technically, economically ,or environmentally acceptable. For example, the UK government has introduced a number of policies to encourage wider use of secondary and recycled coarse aggregate (RCA- defined as minimum of 95% crushed concrete) as an alternative to naturally occurring primary aggregates. These include landfill and future extraction taxes to improve economic viability, support to relevant research and development work.

The developing country like India (Authors native land) facing shortage of good quality natural sand and particularly in India, natural sand deposits are being used up and causing serious threat to environment as well as to the society. The rapid extraction of sand from the river bed causes problems like deepening of the river beds, loss of vegetation on the bank of rivers, disturbance to the aquatic life as well as agriculture due to lowering the water table in the well etc. Therefore, construction industries of developing countries are in stress to identify alternative materials to replace the demand for river sand.

II. QUARRY DUST

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Quarry dust, a byproduct from the crushing process of stones (Blue metal) which is available abundantly from rock quarries at low cost in many areas can be an economical alternative to the river sand. Quarry dust can be defined as residue, tailing material after the extraction and processing of rocks to form fine particles less than 4.75mm. Quarry dust, which is generally considered as a waste material, causes an environmental load due to disposal problem. Quarry dust being by and large, a waste product, will also reduce environmental impact, if consumed by construction industry in large quantities. Hence, the use of quarry dust as fine aggregate in concrete will reduce not only the demand for natural sand but also reduces the environmental problems. Moreover, the incorporation of quarry dust will offset the production cost of concrete and hence, the successful utilization of quarry dust as fine aggregate will turn this waste material into valuable resource.

Quarry dust has been used for different activities in the construction industry such as for road construction and manufacture of building materials such as lightweight aggregates, bricks, tiles and autoclave blocks. Usually, quarry dust is used in large scale in the highways as a surface finishing material. Use of quarry dust as fine aggregate in concrete draws serious attention of researchers and investigators. The utilization of well graded, fines free quarry dust has been accepted as building material in the industrially advanced countries of the west for the past three decades. As a result of sustained research and development works under taken, with respect to increasing application of this industrial waste. The 3 level of utilization of quarry dust in the countries like Australia, France, Germany and UK has been reached more than 60% of its production.

The use of quarry dust in India has not been much, when compared with other advanced countries. Complete replacement of quarry dust in concrete is possible with proper treatment of quarry dust before utilization. Concrete containing quarry dust as fine aggregate is promising greater strength, lower permeability and greater density which enable it to provide better resistance to freeze/thaw cycles and durability in adverse environment. It is found that the strength and durability properties of concrete made of quarry dust are nearly 10% more than that of the conventional concrete. Thus, the quarry dust can be used for all types of concrete including self-compacting concrete, high performance concrete, pumpable concrete, roller compacted concrete, precast concrete products, brick work and plaster mortars, flooring and water proofing. The addition of quarry dust directly affects the workability, because the quarry dust has least permeability, more surface area and requires more water. Hence, in order to attain the desired workability at constant water cement ratio, super plasticizers can be used in quarry dust replaced concrete. The use of super plasticizer has driven major advancements in the area of concrete technology for the past few decades. Addition of super plasticizer increases the workability as well as contributes to improve the compressive strength of concrete. Concrete produced using quarry dust along with plasticizer shows improvement in compressive strength, higher flexural strength, abrasion resistance, and unit weight which are very important for reducing corrosion or leaching.

Fig: 1.1 Quarry dust

Advantages of quarry dust

The specific gravity depends on the nature of the rock from which it is processed and the variation is less.

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Physical and chemical properties

The physical and chemical properties of quarry dust obtained by testing the sample as per the Indian Standards are listed in the below table.

Table 1.1 Physical properties of Quarry dust and Natural sand

PROPERTY	**QUARRY DUST**	**NATURAL SAND**	**TEST METHOD**
Specific gravity	2.54 -2.60	2.60	IS2386(Part III)-1963
Bulk density (kg/m3)	1720- 1810	1460	IS2386(Part III)-1963
Absorption (%)	1.20- 1.50	Nil	IS2386(Part III)-1963
Moisture Content (%)	Nil	1.50	IS2386(Part III)-1963
Fine particles less than 0.075 mm (%)	12-15	6	IS2386(Part III)-1963
Sieve analysis	Zone-II	Zone-II	IS 383- 1970

Table 1.2 Typical chemical properties of Quarry dust and Natural sand

CONSTITUENTS	**QUARRY DUST (%)**	**NATURAL SAND (%)**	**TEST METHOD**
SiO_2	62.48	80.78	IS 4032-1968
Al_2O_3	18.72	10.52	
Fe_2O_3	6.54	1.75	
Cao	4.83	3.21	
MgO	2.56	0.77	
Na_2O	Nil	1.37	
K_2O	3.18	1.23	
TiO_2	1.21	Nil	
Loss of ignition	0.48	0.37	

III. DEMOLISHED CONSTRUCTION WASTE

Construction waste is generated whenever any construction/demolition activity takes place, such as, building roads, bridges, fly over, subway, remodeling etc. It consists 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 waste bin/container. It is not uncommon to see huge piles of such waste, which is heavy as well, stacked on roads especially in large projects, resulting in traffic congestion and disrupt. Waste 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, choking them. It constitutes about 10-20 % of the municipal solid waste (excluding large construction projects). It is estimated that the construction industry in India generates about 10-12 million tons of waste annually. Projections for building

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material requirement of the housing sector indicate a shortage of aggregates to the extent of about55,000 million cu.m. An additional 750 million 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, wood, metal, titles 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 and masonry waste is, however, being done abroad in countries like U.K., USA, France, Denmark, Germany and Japan. 58 Concrete and masonry waste can be recycled by sorting, crushing and sieving into recycled aggregate. 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 Research Institute (CBRI), Roorkee, and Central Road Research Institute (CRRI), New Delhi. The study report stresses the importance of recycling construction waste, 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 techniques. 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.

Fig: 1.2 DemolishedConstruction waste

Advantages of recycling of construction materials

- Used for construction of precast & cast in situ gutters & kerbs.
- Cost saving: - There are no detrimental effects on concrete & it is expected that the increase in the cost of cement could be offset by the lower cost of Recycled Concrete Aggregate (RCA).
- 20% cement replaced by fly ash is found to control alkali silica reaction (ASR).
- Save environment: - There is no excavation of natural resources & less transportation. Also less land is required.
- Save time: - There is no waiting for material availability.
- Less emission of carbon due to less crushing.

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Table 1.3 Physical properties of Recycled Concrete Aggregate (RCA)

TESTS	RESULTS	TEST METHOD
Maximum Size (mm)	18.7	IS: 2386 – 1963 (Part 1 & 3)
Fineness modulus	3.54	
Specific Gravity	2.72	
Bulk Density(kg/m3)	1741	
Water absorption %	1.73	
Aggregate Impact Value (%)	8.55	

IV. RESULTS AND ANALYSIS

Standard Mix Design For M20 Grade Concrete

1. Grade designation = M20
2. Type of cement = OPC 53 Grade
3. Maximum size of aggregate = 20mm
4. Minimum cement content = 250kg/m^3
5. Maximum water - cement ratio = 0.5
6. Workability = 100mm(slump)
7. Exposure condition = Severe
8. 8.Type of aggregate = Crushed angular aggregate
9. Maximum cement content = 400kg/m^3

A. Compression Strength Test

The specimen is tested by compression test machine *after*7 days, 14 days and 28 days of curing. Load should be applied gradually at the rate of 140kg/cm^{2}per minute till specimens fails, which is shown in Table 3.1 to Table 3.3. Load at the failure divided by area of specimen gives the compressive strength of concrete.

Table 3.1 Compressive strength (7 days test results)

REPLACEMENT DETAILS	SPECIMENS	7 days (N/mm^2)	AVERAGE COMPRESSIVE STRENGTH (N/mm^2)
Nominal Mix	CUBE 1	16.6	**16.9**
	CUBE 2	17.3	
	CUBE 3	16.8	
River sand (60%) + Quarry dust (40%) (fine aggregates being replaced partially)	CUBE 4	15.9	**16.3**
	CUBE 5	16.7	
	CUBE 6	16.4	

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CA (60%) + RCA (40%) (coarse aggregates being replaced partially)	CUBE 7	18.4	**18.1**
	CUBE 8	18.2	
	CUBE 9	17.7	
River sand (60%) + Quarry dust (40%) & CA (60%) + RCA (40%) (Both fine aggregates& Coarse aggregates being replaced partially)	CUBE 10	17.9	**17.6**
	CUBE 11	17.3	
	CUBE 12	17.5	

Table 3.2 Compressive strength (14 days test results)

REPLACEMENTDETAILS	**SPECIMENS**	**14 DAYS (N/mm^2)**	**AVERAGE COMPRESSIVE STRENGTH (N/mm^2)**
Nominal Mix	CUBE 1	20.9	**21.6**
	CUBE 2	21.8	
	CUBE 3	22.2	
River sand (60%) + Quarry dust (40%) (fine aggregates being replaced parially)	CUBE 4	20.8	**20.5**
	CUBE 5	20.4	
	CUBE 6	20.2	
CA (60%) + RCA (40%) (coarse aggregates being replaced partially)	CUBE 7	22.8	**23.4**
	CUBE 8	23.7	
	CUBE 9	23.6	
River sand (60%) + Quarry dust (40%) & CA (60%) + RCA (40%) (Both fine aggregates& Coarse aggregates being replaced partially)	CUBE 10	22.6	**22.2**
	CUBE 11	22.1	
	CUBE 12	21.8	

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3.3 Compressive Strength (28 Days Test Results)

REPLACEMENT DETAILS	SPECIMENS	28 DAYS (N/mm^2)	AVERAGE COMPRESSIVE STRENTH (N/mm^2)
Nominal Mix	CUBE 1	25.7	**25.1**
	CUBE 2	24.7	
	CUBE 3	25.0	
River sand (60%) + Quarry dust (40%) (fine aggregates being replaced partially)	CUBE 4	23.1	**23.6**
	CUBE 5	23.4	
	CUBE 6	24.2	
CA(60%) + RCA (40%) (coarse aggregates being replaced partially)	CUBE 7	26.9	**27.5**
	CUBE 8	28.1	
	CUBE 9	27.6	
River sand (60%) + Quarry dust (40%) & CA (60%) + RCA (40%) (Both fine aggregates& Coarse aggregates being replaced partially)	CUBE 10	25.1	**25.4**
	CUBE 11	26.4	
	CUBE 12	24.7	

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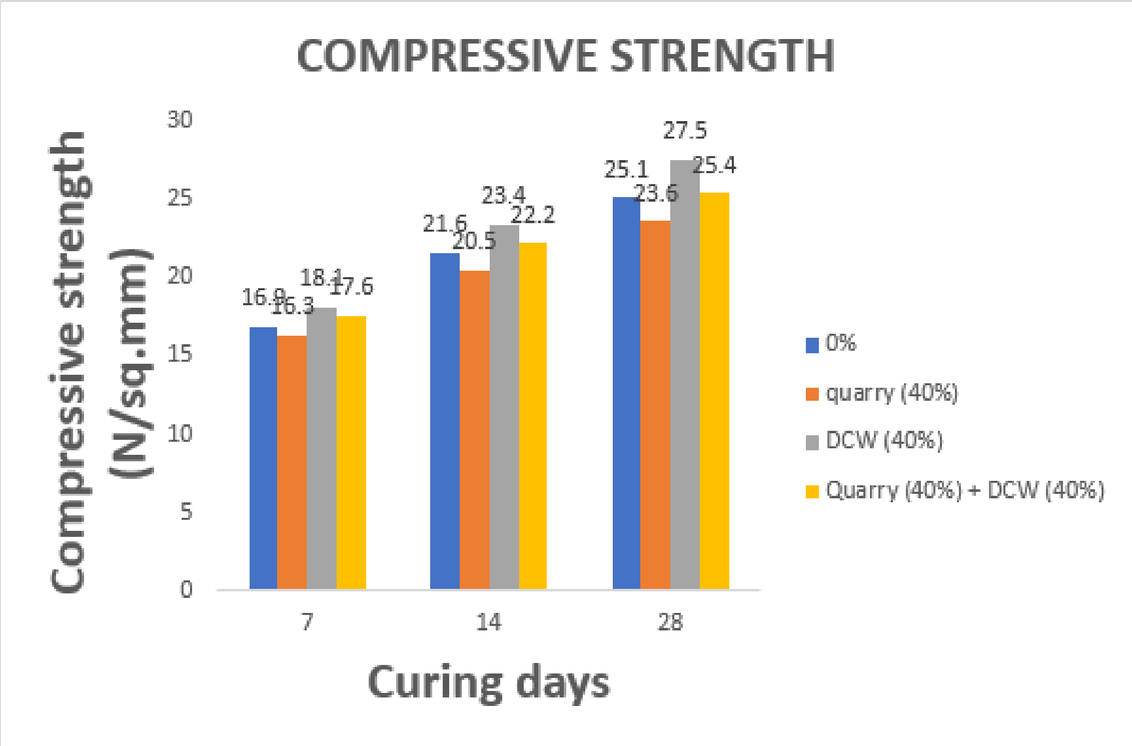

Fig:3.1 Compression strength test

B. Split Tensile Test

The tensile strength of concrete is one of the basic and important properties. Splitting tensile strength test on concrete cylinder is a method to determine the tensile strength of concrete.

The concrete is very weak in tensile due to its brittle nature and is not expected to resist the direct tension. The concrete develops cracks when subjected to tensile forces. Thus, it is necessary to determine the tensile strength of concrete to determine the load at which the concrete members may cracks.

Table 3.4 Split tensile strength

REPLACEMENT DETAILS	14 DAYS (N/mm^2)	28 DAYS (N/mm^2)
Nominal Mix	2.27	2.57
River sand (60%) + Quarry dust (40%) (fine aggregates being replaced partially)	1.94	2.12
CA (60%) + RCA (40%) (coarse aggregates being replaced partially)	2.63	2.89
River sand (60%) + Quarry dust (40%) &CA (60%) + RCA (40%) (Both fine aggregates& Coarse aggregates being replaced partially)	2.40	2.65

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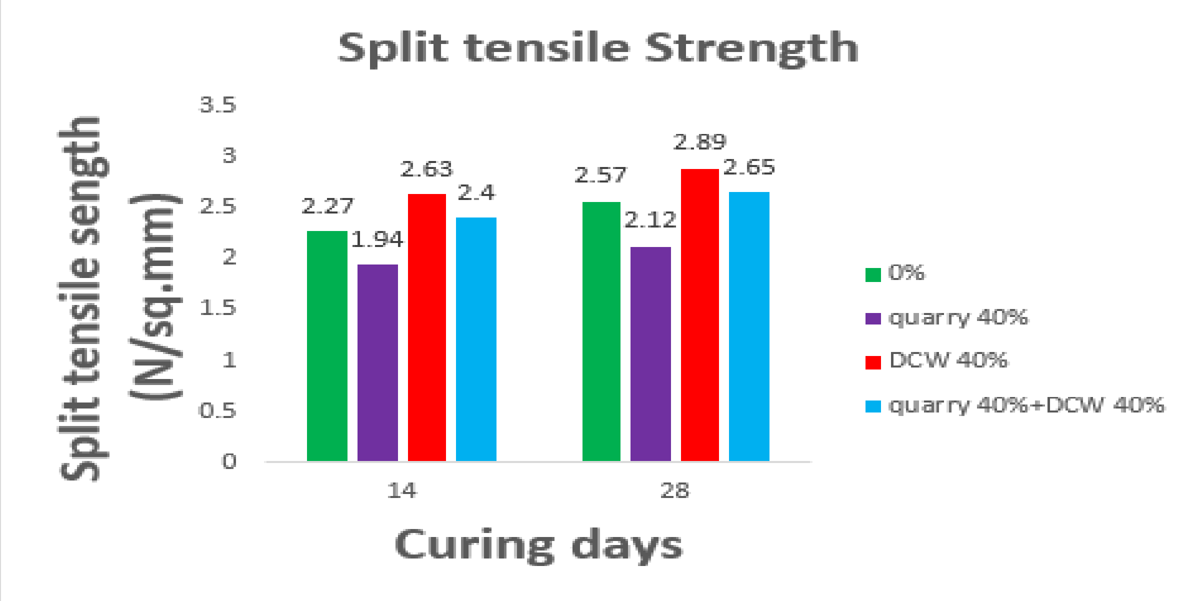

Fig: 3,2Split tensile strength

C. Flexural Test

Flexural strength is one measure of the tensile strength of concrete. It is a measure of an unreinforced concrete beam or slab to resist failure in bending. It is measured by loading 100mm x 100mm x 500mm concrete beam. The details of the tests were shown in the below Tables.

Table 3.5 Flexural strength

REPLACEMENT DETAILS	14 DAYS (N/mm^2)	28 DAYS (N/mm^2)
Nominal Mix	3.58	4.11
River sand (60%) + Quarry dust (40%) (fine aggregates being replaced partially)	3.43	3.94
CA (60%) +RCA (40%) (coarse aggregates being replaced partially)	3.76	4.30
River sand (60%) + Quarry dust (40%) &CA (60%) + RCA(40%) (Both fine aggregates& Coarse aggregates being replaced partially)	3.59	4.17

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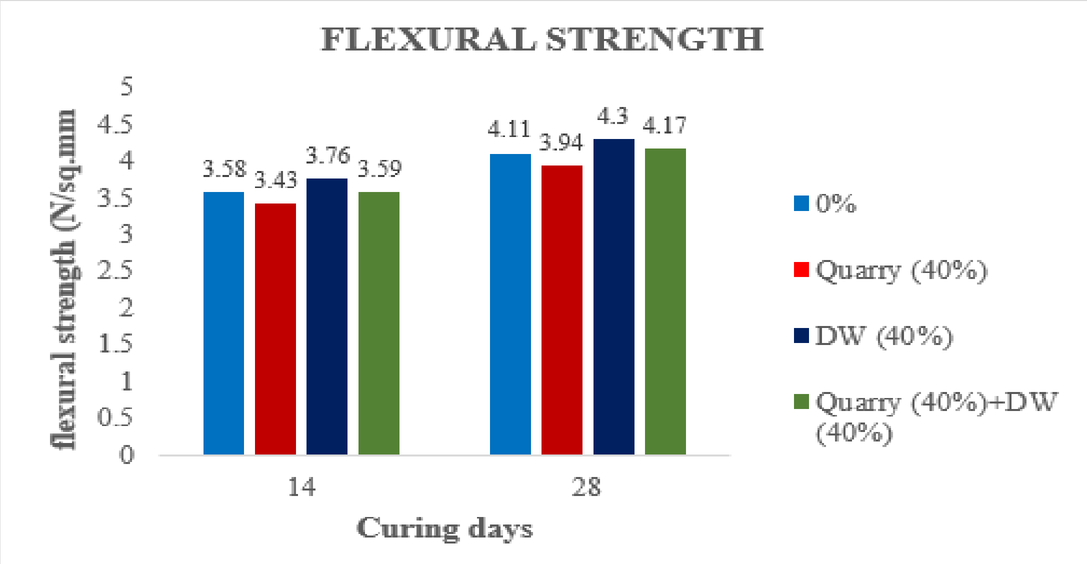

Fig: 3.3 Flexural strength test

V. CONCLUSION

Compressive Strength

- For River sand (60%) + Quarry dust (40%), the compressive strength has decreased to about 23.6 N/mm^2 from 25.1 N/mm^2 when compared to conventional concrete.
- For CA (60%) +Recycled Aggregate (40%), the compressive strength has increased to about 27.5 N/mm^2 from 25.1N/mm^2 when compared to conventional concrete.
- For River sand (60%) + Quarry dust (40%) &C.A (60%) + Recycled Aggregate waste (40%), the compressive strength has increasedto about 25.4 N/mm^2 from 25.1 N/mm^2 when compared to conventional concrete

Split Tensile Strength

- For River sand (60%) + Quarry dust (40%), the split tensile strength has decreased to about 2.12 N/mm^2 from 2.57 N/mm^2 when compared to conventional concrete.
- For CA (60%) +Recycled Aggregate (40%), the split tensile strength has increased to about 2.89 N/mm^2 from 2.57N/mm^2 when compared to conventional concrete.
- For River sand (60%) + Quarry dust (40%) &C.A (60%) + Recycled Aggregate (40%), the split tensile strength has increased to about 2.65 N/mm^2 from 2.57N/mm^2 when compared to conventional concrete.

Flexural Strength

- For River sand (60%) + Quarry dust (40%), the flexural strength has decreasedto about 3.94 N/mm^2 from 4.11 N/mm^2 when compared to conventional concrete.
- For CA (60%) +Recycled Aggregate (40%), the flexural strength has increased to about 4.30 N/mm^2 from 4.11N/mm^2 when compared to conventional concrete.
- For River sand (60%) + Quarry dust (40%) &C.A (60%) + Recycled Aggregate (40%), the flexural strength has increased to about 4.17 N/mm^2 from 4.11 N/mm^2 when compared to conventional concrete.

Due to use of recycled aggregate and quarry dust in construction, energy & cost of transportation of natural resources & excavation is significantly saved. This in turn directly reduces the impact of waste material on environment. Various tests conducted on recycled aggregates and quarry dust and results compared with natural aggregates and sand are satisfactory as per IS 2386.

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