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# An Experimental Study on the use of Recycled Aggregates and Partial Replacement of Cement with Hydrated Lime in Concrete

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## ABSTRACT

Worldwide, cities generate about 1.3 billion Tonnes of solid waste per year. Building materials account for about half of all materials used and about half the solid waste generated worldwide. The waste, generated in the construction, maintenance, repair and disposal phases of a building, is called Construction and Demolition (C&D) Waste. Management of C&D waste is a problem faced not only in India but by the global community and quantum of waste produced occupies a huge fraction of the total solid waste generation by mass. Furthermore, a continued environmental awareness instigates the pressure for reuse of construction materials instead of classifying them as waste materials. Using construction waste material as an aggregate for developing new concrete product is technically viable and may, in some circumstances, be environmentally beneficial. The recent government initiative to stop sand mining insists the need to recycle, reuse and substitute natural aggregates in order to ensure environmental sustainability. This research work aims at making one such experiment where recycled aggregates are produced from C&D waste thus paves a way, for the effective management of concrete debris. The concrete waste was collected from the waste yard in the college campus, segregated, crushed in jaw crusher, sieved, washed and used for concreting for a mix proportion of M30, as a replacement for natural course aggregates in proportions of 0%, 10%, 20%, 30% and 40% with replacement of 10% hydrated lime. However, further studies to determine the effect on durability and improvement on workability are necessary.

## I. INTRODUCTION

### RECYCLED AGGREGATES:

### A) PURPOSE:

To achieve sustainable issue in construction area, researchers and companies focus on using waste concrete as a new construction material. It is called recycled aggregate which can be produced by concrete crusher. The aggregates are categorized by size as coarse and fine aggregate. If recycled aggregates were practically useful in construction area, two aspects would be expected. One is illustrated at the beginning of introduction, the other one is that we could reduce consumption of natural aggregate resources. Although using recycled aggregates has great opportunity to preserve healthy environment, the properties and characteristics of recycled aggregates has not been fully investigated yet. Since it is hard to standardize the characteristic of recycled aggregates, all the researchers who study recycled aggregate should perform experiment of their concrete, which will be used for recycled aggregate, to gain the characteristics of their specimens. The characteristic of recycled aggregates could be different by its parent concrete because the parent concrete was designed for its purposes such as permeable, durable and high strength concrete. For example, water to cement ratio of parent concrete will give an impact on water absorption capacity of recycled aggregates which is related to characteristics of concrete issue such as durability, permeability, strength and elastic modulus.

### B) ADVANTAGES OF RECYCLING OF CONSTRUCTION MATERIALS:

1) Used for construction of precast & cast in situ gutters &kerb's.
2) 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).
3) 20% cement replaced by fly ash is found to control alkali silica reaction (ASR).
4) Save environment: - There is no excavation of natural resources & less transportation. Also less land is required.
5) Save time: - There is no waiting for material availability.
6) Less emission of carbon due to less crushing.
7) Up to 20% replacement of natural aggregate with RCA or recycled mixed aggregates (RMA) without a need for additional testing for all concrete up to a characteristic strength of 65 MPa.as per Dutch standard VBT 1995, is permitted.

### C) DISADVANTAGES OF RECYCLING OF CONSTRUCTION MATERIAL:

1) Less quality (e.g. compressive strength reduces by 10-30%).
2) Duration of procurement of materials may affect life cycle of project.
3) Land, special equipment machineries are required (more cost).
4) Very high water absorption (up to 6%).
5) It has higher drying shrinkage & creep.

### D) OBJECTIVES OF THE STUDY:

1) To find out the percentage use feasible for construction.
2) To reduce the impact of waste materials on environment.
3) To carry out different tests on recycled aggregates & natural aggregates & compare their results.
4) To find out the ways of cost saving such as transportation, excavation etc.

## II. MATERIALS

### 2.1. CEMENT:

Ordinary Portland Cement (OPC) 53 Grade which surpasses the requirements of IS12269-1987 Grade. It is produced by inter grinding of high grade clinker (with high C3S content) and right quality gypsum in predetermined proportions.

A cement is a binder, a substance used for construction that sets, hardens, and adheres to other materials to bind them together. Cement is seldom used on its own, but rather to bind sand and gravel (aggregate) together. Cement mixed with fine aggregate produces mortar for masonry, or with sand and gravel, produces concrete.

### 2.2. FINE AGGREGATE:

The sand used throughout the experimental work was obtained from the river Penna near Anantapur, Anantapur district, Andhra Pradesh. River sand locally available in the market was used in the investigation. The aggregate was tested for its physical requirements such as gradation, fineness modulus, specific gravity and bulking of sand in accordance with IS:2386-1963.The sand was surface dried before use.

**2.3. COARSE AGGREGATE:**

The coarse aggregate used for the experimental work is both natural and recycled aggregate. In this study, graded 20 mm crushed granite coarse aggregate was used as the natural coarse aggregate. Crushed aggregates of less than 20mm size produced from local crushing plants were used. The aggregates were tested for their physical requirements such as gradation, specific gravity and bulk density in accordance with IS:2386-1963

**2.4 RECYCLED AGGREGATE:**

Recycled aggregates are the aggregates produced from the processing of previously used construction materials such as concrete or masonry. Recycled aggregates consists of hard, graduated fragments of inert mineral materials, including sand, gravel, crushed stone, slag, rock dust, or powder.

**2.4.1. BENEFITS OF RECYLED AGGREGATE:**

- ✓ Save landfill space.
- ✓ Conserve natural resources by reducing the need for gravel mining, water, coal, oil and gas.
- ✓ When used as the base material for roadways, reduces pollution from waste transport to landfills and dumps.
- ✓ Create employment opportunities.
- ✓ Drags down material and waste transport expenses.

**2.5. WATER:**

Portable water is used for mixing and curing from the water supply network system as it was free from the suspended solids and organic material, which might have affected the properties of the fresh and hardened concrete.

**2.6. HYDRATED LIME:**

Lime is a calcium-containing inorganic mineral in which carbonates, oxides, and hydroxides pre dominate. In the strict sense of the term, lime is calcium oxide or calcium hydroxide. Calcium hydroxide is relatively insoluble in water, with a solubility product $K_{sp}$ of $5.5 \times 10^{-6}$. It is large enough that its solutions are basic according to the following reaction:

$$Ca(OH)_2 \rightarrow Ca^{2+} + 2\,OH^-$$

Limewater turns milky in the presence of carbon dioxide due to formation of calcium carbonate, a process called carbonation:

$$Ca(OH)_2 + CO_2 \rightarrow CaCO_3 + H_2O$$

**2.6.1. Chemical Composition:**

**Table 1**

| Chemical components | In lime |
|---|---|
| Specific Gravity | 2 |
| Ca O | >83.3 |
| $Fe_2 O_3$ | <2 |
| $Al_2 O_3$ | <1.5 |
| $SiO_2$ | <2.5 |
| $CO_2$ | <5 |
| $Ca CO_3$ | <10 |

Chemical properties of lime

- ✓ High - calcium lime : ($CaO \geq 90\%$) rich lime
- ✓ Calcium lime : $75 < CaO < 90\%$
- ✓ Magnesium lime : $MgO \geq 20\%$
- ✓ High magnesium (dolomitic)lime:$MgO > 25\%$

## III. MATERIALS USED AND THEIR PROPERTIES

This is Deals with the physical and chemical properties of various materials used in the preparation of the Recycled aggregates in concrete using recycled aggregates and hydrated lime relating to the project.

**3.1. CEMENT:**

**3.1.1. NORMAL CONSISTENCY OF CEMENT:**

**Table 2**

| Trail No | Weight of hydrated lime (gm) | Weight of cement (gm) | % of water added | Depth of penetration (mm) |
|---|---|---|---|---|
| 1 | 30 | 270 | 28 | 15 |
| 2 | 30 | 270 | 30 | 12 |
| 3 | 30 | 270 | 32 | 6 |

Consistency of cement

By adding lime to cement as an admixture of 10% of whole weight in each trail.

where the depth penetration of plunger is limited to 50 to 7 from bottom that % of water can be treat as consistency of cement.

Hence the Consistency of cement is 32%.

### 3.1.2 INITIAL SETTING TIME:

By adding lime to cement as an admixture of 10% of whole weight in each trail,

Weight of cement sample taken : 270gms

Weight of lime sample taken : 30 gms

Consistency of cement : 32%

Volume of water to be added : $(0.85\times\frac{32}{100})\times300$=81.6ml

The period elapsing between the time when water is added to the cement and the time at which the needle penetrates the test block to a depth equal to 5 to 7 mm from the bottom is taken as initial setting time and the needle makes an impression on the test block is taken as final setting time.

Initial setting time obtained= 45 minutes.

Final setting time = 280 minutes.

### 3.1.3. FINAL SETTING TIME:

Replace the needle (C) of the Vicat apparatus by the needle with an annular attachment (F). The cement shall be considered as finally set when, upon applying the needle gently to the surface of the test block, the needle makes an impression thereon, while the attachment fails to do so. The period elapsing between the time when water is added to the cement and the time at which the needle makes an impression on the surface of test block while the attachment fails to do so shall be the final setting time.

### 3.1.4. SPECIFIC GRAVITY OF CEMENT

Weight of empty specific gravity bottle $W_1$= 28.5gms

Weight of the bottle + cement $W_2$= 54.5gms

Weight of the bottle+cement and kerosen$W_3$= 85.5gms

Weight of bottle with fresh kerosene $W_4$= 70gms

Specific gravity of kerosene $G_k$= 0.79

At the time taking the samples the lime of 10% is added to the cement weight.

**CALCULATION:**

Specific gravity of cement $=\frac{W2-W1}{((W4-W1)-(W3-W2))\times0.79}$=3.13

### 3.1.5. FINENESS OF CEMENT:

1) Break down any air set lumps in cement sample with fingers.
2) Weigh accurately 100gms of the cement it on a standard 90microns IS sieve with the pan below to collect the sieved cement.
3) Sieve the sample continuously for 15 minutes.
4) Weigh the residue left on the sieve.

**Calculation:**

a) Weight of the cement taken on IS 90microns sieve = 100gms
b) Weight of the residue on the sieve after sieving = 4gms

$$\text{Fineness}=\frac{\text{weight of residue}}{\text{weight of initial sample}}\times 100=\frac{4}{100}\times 100=4\%$$

### 3.2. COARSE AGGREGATES:

### 3.2.1. WATER ABSORPTION AND SPECIFIC GRAVITY-WIRE BASKET METHOD:

This test helps to determine the water absorption and specific gravity of coarse aggregates as per IS: 2386 (Part III) – 1963. For this test a sample not less than 2000grams should be used.

**The apparatus used for this test are**:-

Balance: capacity not less than 3 kg, Oven, Wire basket, Tray: a shallow tray of area not less than 325 cm$^2$, Air-tight container, Clothes: two pieces of soft absorbent clothes not less than 750 mm x 450 mm.

**Procedure:**

Entrapped air is removed from the sample by agitating (dropping) the sample along with the basket in distilled water for about 25 times from 25 mm above the base of the tank at a rate of one drop per second. The aggregate and basket shall be completely immersed in the distilled water during the time of experiment. Shake the basket and the sample and weigh it in water at a temperature of 22°C to 32°C. Remove the basket and the aggregate from water and allow it to drain for a few minutes, after which the aggregate shall be gently emptied on to one of the dry clothes and the basket will be returned to the water, shaken 25 times and weighed. Surface dry the aggregate with the second cloth, transferring it from the first cloth when it removes no further moisture. Then the aggregate is weighed. Dry the sample in oven at 100°C to 110°C for 24 hours and then weigh it, after transferring into the air – tight container.

**Observations:**

1. Weight of the saturated aggregate along with basket in water, A=1342 g.
2. Weight of the empty basket in water, B=702g.
3. Weight of the surface dried saturated sample, C=988g.
4. Weight of the oven-dried sample, D= 985g.

**Specific Gravity** $= \frac{D}{C-(A-B)} = 2.8$

**Water Absorption** $= 100 \times \frac{C-D}{D} = 0.3\%$

**3.3. RECYCLED AGGREGATES:**

**3.3.1. WATER ABSORPTION AND SPECIFIC GRAVITY-WIRE BASKET METHOD:**

For this test a sample not less than 2000grams should be used.

**The apparatus used for this test are**:-

Balance: capacity not less than 3 kg, Oven, Wire basket, Tray: a shallow tray of area not less than 325 $cm^2$, Air-tight container, Clothes: two pieces of soft absorbent clothes not less than 750 mm x 450 mm.

**Procedure:**

The sample is placed in the wire basket and immersed in distilled water at a temperature of 22°C – 32°C for 24 hours ± 30 minutes. Remove the basket and the aggregate from water and allow it to drain for a few minutes, after which the aggregate shall be gently emptied on to one of the dry clothes and the basket will be returned to the water, shaken 25 times and weighed. Surface dry the aggregate with the second cloth, transferring it from the first cloth when it removes no further moisture. Then the aggregate is weighed. Dry the sample in oven at 100°C to 110°C for 24 hours and then weigh it, after transferring into the air – tightcontainer.

**Observations:**

Weight of the saturated aggregate along with basket in water, A =1796 g.

Weight of the empty basket in water, B= 480 g.

Weight of the surface dried saturated sample, C=1999g.

Weight of the oven-dried sample, D= 1989g.

**Specific Gravity** $= \frac{D}{C-(A-B)} = 2.9$

**Water Absorption** $= 100 \times \frac{C-D}{D} = 0.5\%$

**3.4. FINE AGGREGATE (River sand):**

Locally available natural sand with 4.75 mm maximum size is used as a fineaggregate. According to IS 383-1970 sand conforming zone for the given fine aggregate iszone-2.

**3.4.1. SIEVE ANALYSIS:**

**Table 3**

| S.No: | I.S. Sieves | Wt. of Sample Retain | % Retained | Cumulative % retained | % passed |
|---|---|---|---|---|---|
| 1 | 4.75 mm | 32 | 3.2 | 3.2 | 96.8 |
| 2 | 2.36 mm | 57 | 5.7 | 8.9 | 91.1 |
| 3 | 1.18mm | 277 | 27.7 | 36.6 | 63.4 |
| 4 | 600µ | 288 | 28.8 | 65.4 | 34.6 |
| 5 | 300µ | 260 | 26.0 | 91.4 | 8.6 |
| 6 | 150µ | 68 | 6.8 | 98.2 | 1.8 |

Sieve analysis

### 3.4.2. SPECIFIC GRAVITY OF FINE AGGREGATE:

**Table 4**

| Weights | Trail-1 | Trail-2 | Trail-3 |
|---|---|---|---|
| Wt. of pycnometer(W1) gms | 623 | 623 | 623 |
| W1+Wt. of dry sand(W2) gms | 1023 | 1024 | 1024 |
| W1+W2+Wt. of water(W3) gms | 1618 | 1628 | 1628 |
| W1+ Wt. of water(W4) gms | 1364 | 1374 | 1374 |

Sp.gravity of fine aggregate

### 3.5. HYDRATED LIME

### 3.5.1. SPECIFIC GRAVITY OF HYDRATED LIME

Weight of empty specific gravity bottle$W_1$= 28.5gms

Weight of the bottle with lime $W_2$= 55gms

Weight of the bottle with lime and kerosene $W_3$= 82gms

Weight of bottle with fresh kerosene$W_4$= 70gms

Specific gravity of kerosene G= 0.79

**CALCULATION:**

Specific gravity of hydrated lime $=\frac{W2-W1}{((W4-W1)-(W3-W2))\times 0.79} = 2.31$

### 3.6. FRESH PROPERTIES:

### 3.6.1.SLUMP TEST:

**Apparatus:** Slump cone, Tamping rod

**Procedure:** Place the cone on themetallic steel plate or any smooth surface. Fill the concrete in four layers each and tampered 25 times by tamping rod taking care to distribute the blows in evenly. After filling the top layer the concrete is struck off with trowel. The cone is removed from the concrete immediately in vertical direction slowly. This allows the concrete to subside. This subside is called a Slump.

**Table 5**

| % of recycled aggregates | Slump in mm |
|---|---|
| 0 | 43 |
| 10 | 41 |
| 20 | 35 |
| 30 | 46 |
| 40 | 43 |

Slump for various percentages of R.A.

### 3.6.2.COMPACTION FACTOR

The compaction factor test apparatus consists of two hoppers, each in the shape of frustum of a cone and one cylinder. The upper hopper is filled with concrete this being placed gently so that no work is done on the concrete at this stage to produce compaction. The second hopper is smaller than the upper one and is therefore filled to overflowing. The concrete is allowed to fall in to the lower hopper by opening the trap door and then into the cylindrical mould placed at the bottom. Excess concrete across the top of the cylindrical mould is cut and the net weight of the concrete in cylinder is determined. This gives the weight of partially compacted concrete. Then the cylindrical mould is filled with concrete in layers of 5cm depth by compacting each layer fully. The fully compacted weight is then determined.

**Table 6**

| % of recycled aggregates | Compaction factor |
|---|---|
| 0 | 0.8 |
| 10 | 0.77 |
| 20 | 0.82 |
| 30 | 0.79 |
| 40 | 0.83 |

Compaction factor for various percentage of R.A.

## IV. CONCRETE MIX DESIGN

This chapter deals with the design procedure adopted for use of recycled aggregates in concrete with the application of hydrated lime.

### 4.1. PRELIMINARY ANALYSIS:

In designing the mix it is most useful to consider the relative proportions of the keycomponents by volume rather than by mass.

- ✓ Water / Powder ratio by volume of 0.80 to 1.10
- ✓ Total powder content – 160 to 240 liters (400 – 600 Kg) per cubic meter.
- ✓ Coarse aggregate content normally 28 to 35 percent by volume of the mix.

- ✓ Water cement ratio is selected based on requirements in EN 206. Typically watercontent does not exceed 200 liter/m$^3$.

Generally, it is advisable to design conservatively to ensure that the concrete iscapable of maintaining its specific fresh properties despite anticipated variations in rawmaterial quality. Some variation in aggregate moisture content should also be expected andallowed for at mix design stage.

**4.2. Mix design for recycled aggregates with hydrated lime:**

**a) Design stipulations**

Characteristic compressive strength required in the field at 28 days=30Mpa

Maximum size of aggregate =20mm

Degree of quality control =Good

**b) Tested data for materials**

Specific gravity of cement =3.13

Specific gravity of Coarse aggregates =2.8

Specific gravity of Fine aggregates =2.7

**c) Target mean strength of concrete**

The target mean strength for specified characteristic cube is = 30+ (1.65×5)=38.25N/mm$^2$

**d) Selection of water - cement ratio**

FromIS:10262-2000 method, for target mean strength adopt W/C ratio of 0.45

**e) Selection of water and sand content**

From IS:456-2000 for 20mm max size of aggregate, Sand conforming to grading Zone II. Water content per cubic meter of concrete = 176 liters/m$^3$

Required water content = 176 liters/m$^3$

**f) Determination of cement content**

W/C ratio = 0.45

Water = 176 liters

Water content for 75mm slump = 181.28liters

Cement $= \frac{181.28}{0.45}$ =402.84kg/ m$^3$

But assuming IS 456-2000 code maximum cement content =380kg/ m$^3$

Admixture hydrated lime content $= \frac{10}{100}$×380 =38kg/ m$^3$

Only cement content=380-38 =342kg/ m$^3$

**g) Calculation of mix proportions:(for 1 cubic meter of concrete)**

1)Volume of cement = 342kg/m$^3$

2)Volume of water content =181.28liters

3)Volumeofaggregates=1-(0.109+0.181+0.0165) =0.69m$^3$

Mass of coarse aggregate =0.69*0.62*2.8*1000 =1197.84kg/m$^3$

Mass of fine aggregate =0.69*0.38*2.7*1000 =707.94kg/m$^3$

**Mix 30:**

**Table 7**

| Water | Cement | Fine aggregate | Coarse aggregate |
|---|---|---|---|
| 181.28 | 342 kg/m$^3$ | 707.94 kg/m$^3$ | 1197.84 kg/m$^3$ |
| 0.45 | 1.0 | 2.07 | 3.5 |

Density of concrete =2429.06kg/m$^3$

Hence the Mix is 1:2.07:3.5(Designed for M30)

**4.3.MIXING OF DIFFERENT PROPORTIONS OF MATERIALS:**

Through mixing of the materials is essential for the production of uniform concrete. The mixing should ensure that the mass becomes homogeneous, uniform in colour and consistency.

**4.3.1. MOULDS:**

The concrete is casted in to cube moulds of size 150mm×150mm×150mm and cylindrical moulds of 300 mm height ×150 mm diameter.

**4.3.2. PLACING OF MIX IN MOULDS:**

After mixing the proportions in the mixing machine, it is taken out into the bucket. The concrete is placed in to the moulds (cubes& cylinders), which are already oiled simply by means of hands only without using any compacting devises.

**4.4. CURING**

After 24 hours the specimens were removed from the moulds and immediately submerged in clean fresh water and kept there until taken out just prior to testing.

**4.5. EXPERIMENTAL RESULTS**

This chapter deals with the various mix proportions adopted in carrying out the experiments and experimental results obtained with respect to their compressive strength , split tensile strength , flexural strength and water penetration.

## V. RESULTS

**5.1. COMPRESSIVE STRENGTH TEST FOR CUBES:**

The cube specimen is of the size 150×150×150 mm. If the largest nominal size of the aggregate does not exceed 10mm. 10cm cubes may also use alternatively. Here, For M30Concrete, Having Mix proportion 1:2.07:3.5 Which was removed from curing on 6/3/2018and Tested on 6/3/2018.

**5.2.SPLITTING TENSILE TEST FOR CYLINDER (150mmdia ×300mm)**

For M30 Concrete, Having Mix proportion 1:12.07:3.5 which was Removed from curing on 6/03/2018and Tested on 6/03/2018. Cylinder had 15cm diameter and 30cm height.

**5.3. FLEXURAL STRENGTH TEST:**

Beam specimens of dimensions 150x150x695mm were prepared. During testing two point loading was adopted on an effective span of 400mm as per IS 516-1959. Flexural strength is calculated using the equation

$$(\mathbf{F} = \frac{\mathbf{PL}}{\mathbf{bd^2}})$$

Where, F= Flexural strength of concrete (in MPa).

P= Failure load (in N).

L= Effective span of the beam (695mm).

b = Breadth of the beam (150mm).

d = Depth of the beam (150mm).

**5.4 WATER PENETRATION TEST ACCESSORIES**

**Supply of Compressed Air**-Suitable arrangements shall be made for supplying compressed air at 5 kg/cm2 to 15 kg/cm2 to the permeability cell assemblies.

**Size of Specimens** -The specimens shall be cylindrical in shape with height equal to the diameter. The standard size of specimen shall have diameter (and height ) of 150 mm

**PRESSURE HEAD**

The standard test pressure head to be applied to the water in the reservoir should be 10 kg/cm$^2$. This may, however, be reduced up to 5 kg/cm$^2$ in the case of relatively more permeable specimens where steady state of flow is obtained in a reasonable time, and may be increased up to 15 kg/cm" for relatively less permeable specimens and while sensing could be ensured to be fully effective.

**Preparing the Specimen** - The specimen shall be thoroughly cleaned with a stiff wire brush to remove all laitance. The end faces shall then be sand-blasted or lightly chiselled.

**Test Temperature** -The test shall preferably be carried out at a temperature of 27$^o$Cf 2°C. In case arrangements are not available for maintaining the above temperature, a record shall be maintained of the actual temperature. An approximate correction may be made on the basis that each 5°C increase of temperature above the standard temperature, results in IO percent increase in the coefficient of permeability and vice versa.

**5.5. COMPARISION OF RESULTS:**

**Table 8**

| % of lime | % of cement | % of recycled aggregate | Compressive Strength (Cubes tested values) in N/mm$^2$ | | |
|---|---|---|---|---|---|
| | | | 7 days | 14days | 28days |
| 10 | 90 | 0 | 24.01 | 29.49 | 32.27 |
| 10 | 90 | 10 | 22.5 | 28.66 | 30.97 |
| 10 | 90 | 20 | 21.03 | 27.57 | 30.46 |

| | | | | | |
|---|---|---|---|---|---|
| 10 | 90 | 30 | 20.85 | 26.32 | 30.13 |
| 10 | 90 | 40 | 20.13 | 25.89 | 29.77 |

Results for M30 mix Plain concrete

Table 9

| % of lime | % of cement | % of recycled aggregate | Split tensile Strength (Cylindrical tested values) in N/mm² | | |
|---|---|---|---|---|---|
| | | | 7 days | 14days | 28days |
| 10 | 90 | 0 | 0.93 | 1.0 | 1.1 |
| 10 | 90 | 10 | 0.98 | 1.07 | 1.26 |
| 10 | 90 | 20 | 1.0 | 1.13 | 1.38 |
| 10 | 90 | 30 | 1.07 | 1.17 | 1.47 |
| 10 | 90 | 40 | 1.1 | 1.23 | 1.5 |

Results for M30 mix Plain concrete

Table 10

| % of lime | % of cement | % of recycled aggregate | Flexural Strength (Beam tested values) in N/mm² | | |
|---|---|---|---|---|---|
| | | | 7 days | 14days | 28days |
| 10 | 90 | 0 | 2.58 | 2.9 | 3.1 |
| 10 | 90 | 10 | 2.53 | 2.69 | 2.87 |
| 10 | 90 | 20 | 2.41 | 2.57 | 2.72 |
| 10 | 90 | 30 | 2.34 | 2.48 | 2.61 |
| 10 | 90 | 40 | 2.27 | 2.4 | 2.5 |

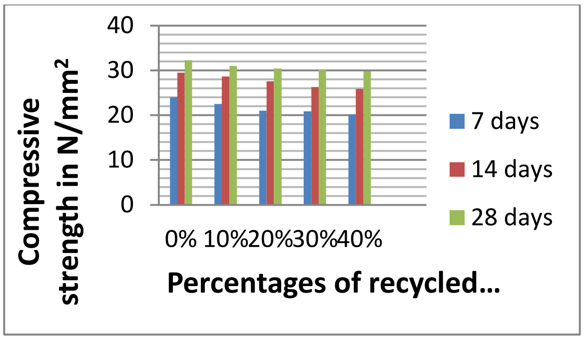
Results for M30 mix Plain concrete

Table 11

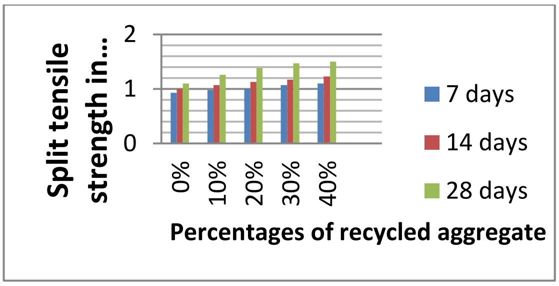
| % of Recycled aggregate | Water penetration at 28days (mm) |
|---|---|
| 0 | 22 |
| 10 | 23 |
| 20 | 25 |
| 30 | 25 |
| 40 | 27 |

Results for M30 mix Plain concrete

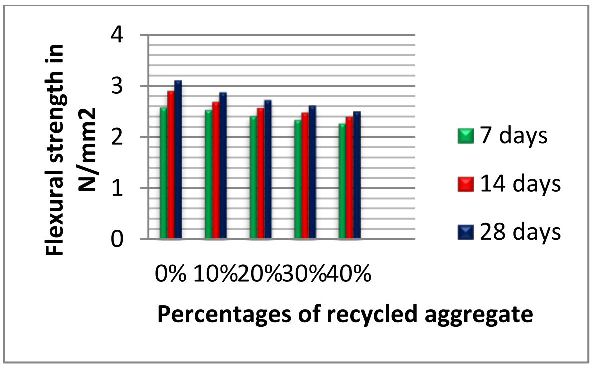
## VI. RESULTS & DISCUSSION



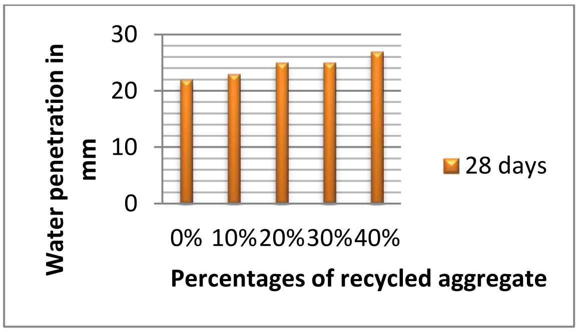

**Graph 1.** Shows the variations of compressive strength various mixes.




**Graph 2.** Shows the variations of split tensile strength various mixes




**Graph 3.** flexural strength




**Graph 4.** Water permeability at 28day

## VII. CONCLUSION

With the above results we can conclude the following

- Natural aggregate can be used with recycled aggregate with ratio 90:10, 80:20, 70:30 and 60:40.
- As the compressive strength of cubes for Conventional concrete for 28 days is 32.27 N/mm$^2$ when compare with 10%, 20%, 30% of recycled aggregate concrete and slightly less with 40% of recycled aggregate concrete for the mix design.
- As the split tensile strength for conventional concrete for 28 days is 1.1 N/mm$^2$ when compared increases slightly more with 10%, 20%,30% of Recycled aggregate concrete and 40% of recycled aggregate concrete.
- As the flexural strength for conventional concrete for 28 days is 3.1 N/mm$^2$ when compared decreased slightly more with 10%, 20%, 30% of Recycled aggregate concrete and 40% of recycled aggregate concrete.
- As the water penetration for conventional concrete for 28 days is increased slightly more with 10%,20%, 30% of Recycled aggregate concrete and 40% of recycled aggregate concrete.

**Scope for future investigation**

- The conventional concrete can be compared with recycled aggregate with super-plasticizer and different fibers.
- This can study with reinforcement for flexural strength.
- This can be compared with conventional concrete as well as recycled aggregate concrete with asbestos.
- This can compared with replacement of cement with fly ash.
- It will reduce the burden on natural aggregate, natural aggregate can be used for the other important purpose.
- Due to use of recycled aggregate in construction industry it can show impact of waste on environment.

## VIII. REFERENCES

[1]. Nelson and ShingChai NGO Research Project "High-StrengthStructural Concrete with Recycled Aggregates", submitted November2004, University of Southern Queensland Faculty of EngineeringSurveying http://eprints.usq.edu.au/21.

[2]. Ahmad S Subaih, Ahmad I El-Mankoush, Ali H el-Salmy and AmerhWadi, Recycling of construction & demolition debris as an aggregate for base, sub-base in roads and as well as in concrete, Graduation project2005.

[3]. Ramadan y.al Khatib, ahmad A. Khattab and salah a. Taha, Recycling "Construction and Demolition Wastes", Graduation project 1999

[4]. Xiao J Z. Recycled Concrete (2012). Beijing: "Chinese Building Construction Publishing Press", .

[5]. Butler L., (2012), "Evaluation of Recycled Concrete Aggregate Performance in Structural Concrete", thesis, The University of Waterloo, Canada.