Improving Ground Water Recharge Using Pervious Cement Concrete Made of Aggregates Recycled From Crushed Concrete Wastes

J.Jasmin[1], M.Kishore [2], M.Sai Vishwitha[3], M.Niranjan[4], M.Sai Kumar[5]
[1, 2] Dept of Civil Engineering
[1]Visvesvaraya Technological. University, Machhe, Belgaum, Karnataka, India
[2, 3, 4, 5]St. Martin's Engineering College, Secunderabad, Telangana, India

Abstract- *In our country most of the pavements are constructed by using cement concrete which is pervious in nature which will not allows the water into the layers of ground and reach the water table. In order to overcome this problem a pervious concrete block made by using recycled coarse aggregates, cement, admixtures, water which is used for the construction of pavements and pervious concrete is also used in parking areas, footpaths, low traffic areas, sidewalks, shoulders, residential roads, medians etc. In our project coarse aggregates are replaced with recycled coarse aggregates. Generally recycled coarse aggregates are prepared by crushing the cement wastes. By utilizing these materials we can construct a pervious concrete pavement which allows the water and we can improve ground water recharge. In our project tests on aggregates such as crushing value, impact test, water absorption test, specific gravity, abrasion test and compression test are conducted*

Keywords- Ground water recharge, pervious concrete, fly ash, water absorption, compressive strength.

I. INTRODUCTION

On our planet second most used material is concrete next to the water. Very large quantity of concrete is produced annually. However concrete is the material which can sustain for longer period. Due to the severe scarcity of infra-structural facilities such as houses, hospitals, roads etc in our country large quantities of construction materials are needed. Generally pervious concrete is produced without using fine materials. The main aim of this project is usage of recycled aggregates which are produced from cement concrete wastes (CCW) in the construction of pervious pavements which helps in improving ground water recharge.

At this present scenario there is a lot of cement concrete wastes in many of our major cities, due to rebuilding and reconstruction of structures such as residential buildings, hospitals, educational buildings, commercial buildings etc. so there is a lot of concrete wastes in the dump yards. So our main aim is to reuse the aggregates from concrete waste by recycling and proceeding for further standard test to reuse the aggregates which can helps greatly in improving ground water recharge. Now-a-days we are facing a severe water problem in some of the cities because, the water levels of ground water table is very low. So to improve the ground water recharge, we are using recycled aggregates.

In several articles and technical documents the incorporation of recycled aggregates in asphalt mixtures or in other type of layers for pavements, or even in other type of works, has also been recently described. A good way to contribute to the accomplishment of the aforementioned goals is to use reclaimed asphalt pavement and recycled aggregates (RCA) in asphalt mixtures.

Manufacture of recycled aggregates

The (RCA) recycled concrete aggregates can be manufactured in several steps:

1. **Evaluation of source concrete wastes:** The first step in the manufacturing of recycled concrete aggregates is to determine the quality of the source concrete wastes. Properties and records of source concrete like strength, durability and also composition are looked into deciding the proper source concrete wastes.
2. **Crushing of demolished concrete wastes:** This step involves the simple process of crushing concrete wastes into required size and quantity (size of 20-50mm).
3. **Removal of contaminants from concrete wastes:** contaminants such as reinforced steel, foundation materials, soli, asphalt concrete shoulders etc, are removed. Removal of contaminants can be achieved by many methods including screening or air separation, using electromagnets, demolition etc, some of the contaminants depending on the use of RCA can also be processed separately.

Advantages of Recycled Aggregates

- Reduces the amount of virgin aggregates to be created, hence less evacuation of natural resources.
- While being crushed into smaller particles a large amount of carbon dioxide is absorbed. This reduces the amount of CO_2 is the atmosphere.
- Cost saving – few research studies have shown a significant reduction in construction costs if RAC is used.
- Conserves landfill space, reduces the need for new landfills sand hence saving more costs.
- Creates more employment opportunities is recycling industry.

Applications of Recycled Aggregates

- Can be used in construction gutters and pavements etc.

II. METHODOLOGY

Materials used

- Cement
- Natural Coarse Aggregate
- Recycled Coarse Aggregate
- Fly Ash
- Water

1.0 Material properties:

The materials used in the present investigation are Ordinary Portland cement of 53 grades having a specific gravity of 3.01. Natural granite aggregate and aggregate recycled from crushed concrete waste passing through IS 20mm [12.5, 6.3 mm] sieve with specific gravity 2.68 and compacted density 1620 Kg/m3 is used. A view of constituent materials is shown in plate.

Properties:

1.1 Cement:

Cement is a binder, a substance used in a construction that sets and hardness and cam Bind other materials together. The most important type of cement is used in the components in the production of mortar in masonry, and of concrete, which is a combination of cement and an aggregate to form strong binding materials.

1.2 Natural Aggregates

Aggregate is type of material used in construction of pavements, including sand, gravel, crushed stones etc. The purpose of usage of aggregates are to improve strength, weight and economical.

1.3 Recycled Coarse Aggregate:

The large volumetric in-waste or by-product materials from industry are going to landfills and have been increasing with time. Recycling and reusing of construction waste is a viable option in construction waste management.

Figure No 2: Recycled Coarse Aggregate

1.4 Fly Ash:

Fly ash is a fine powder that is a by product of burning pulverized coal in electric generation power plants. Fly ash is a pozzolans, a substance containing aluminous and siliceous material that forms cement in the presence of water.

Table No: 1. Chemical composition of fly ash

Compound	Content %wt
Sio_2	59.00
Al_2o_3	21.00
Fe_2o_3	3.70
Cao	6.90
MgO	1.40
So_3	1.00
K_2o	0.90
LOI	4.62

Methodology Procedure:

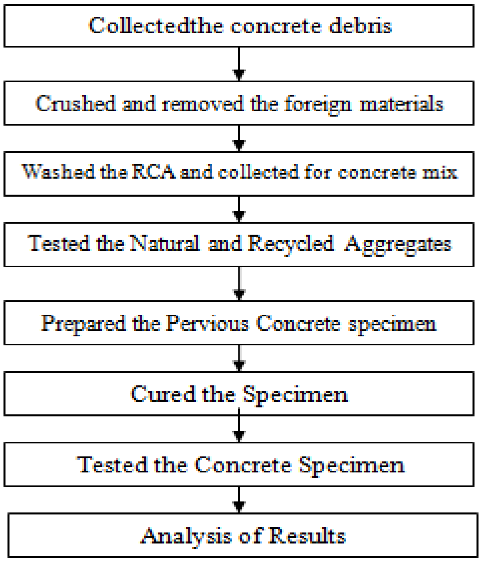

Figure No: 4 Concrete debris

- Collected the concrete debris and crushed with the help of compression machine and removed the foreign materials on it lime sand, cement etc., with the help of hammer and washed the RCA to remove tiny particles, tested the RCA and natural aggregates and prepared the concrete specimen.
- After curing the specimen, tested for compression strength.

III. STEPWISE PROCEDURE

- Prepare M20 grade
- concrete Casting cubes
- Curing
- Testing
- Prepare Concrete Mix

Procedure: Prepare M 20 grade concrete of 1:3 ratios .Apply Oil or grease to the moulds of size 150X150X150 after performing slump test cast the cubes and, place the casted moulds in the humid place for 24 hours. Then de-mould the cubes and place them gently in the curing tank, and set1 cubes are cured for 7days, set 2 & set 3 are cured at 14days and 28 days.

Take cement and coarse aggregate in 1:3 ratio of water content based on water cement ratio 0.34. Cement of 53grade of ordinary Portland cement, and recycled coarse aggregate passing through the IS 20mm sieve with specific gravity 2.05 and density 1050 kg|m^3.

This is the mix design proportioning to prepare concrete after preparing the M20 concrete mix design using IS mix proportion method IS 10262-2009perform the slump test and fills the moulds of size 150x150x150mm.

The concrete will be placed in the mould in the form three layers. Each layer will be compacted with 25 blows.

Curing

After 7, 14, 28 days of curing the specimens where taken out of the water and here allowed to dry under shade of few hours

Figure No 6: Curing

IV. TESTING OF SPECIMENS

Testing of specimens is done after the completion of curing process.

Figure No 8.1: permeable concrete block

Figure No 8: Testing the specimen

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- After curing the specimen, tested for compression strength.

Tests on Natural and Recycled Aggregates:

Aggregate plays an important role in pavement construction. Aggregates influence, to a great extent, the load transfer capability of pavements. Hence it is essential that they should be thoroughly tested before using for construction. Not only that aggregates should be strong and durable, they should also possess proper shape and size to make the pavement act monolithically. Aggregates are tested for strength, toughness, hardness, shape, and water absorption.

In order to decide the suitability of the aggregate for use in pavement construction, following tests are carried out.

1. Impact test
2. Crushing test
3. Specific gravity and water absorption test
4. Abrasion test

Aggregate Impact test:

The aggregate impact test is carried out to evaluate the resistance to impact of aggregates. Aggregates passing 12.5 mm sieve and retained on 10 mm sieve is filled in a cylindrical steel cup of internal diameter 10.2 mm and depth 5 cm which is attached to a metal base of impact testing machine. The material is filled in 3 layers where each layer is tamped for 25 numbers of blows (see Fig-3). Metal hammer of weight 13.5 to 14 Kg is arranged to drop with a free fall of 38.0 cm by vertical guides and the test specimen is subjected to 15 numbers of blows. The crushed aggregate is allowed to pass through 2.36 mm IS sieve. And the impact value is measured as percentage of aggregates passing sieve (**W2**) to the total weight of the sample (**W1**).

Aggregate impact value = (W1/W2) *100

Aggregates to be used **for wearing course**, the impact value **shouldn't exceed 30 percent**. For **bituminous macadam** the **maximum** permissible value is **35 percent**. For **Water bound macadam** base courses the maximum permissible value defined by IRC is **40 percent.**

Aggregate Crushing test:

One of the model in which pavement material can fail is by crushing under compressive stress. A test is standardized by **IS: 2386 part-IV** and used to determine the crushing strength of aggregates. The aggregate crushing value provides a relative measure of resistance to crushing under gradually applied crushing load.

The test consists of subjecting the specimen of aggregate in standard mould to a compression test under standard load conditions (See Fig-1). Dry aggregates passing through 12.5 mm sieves and retained 10 mm sieves are filled in a cylindrical measure of 11.5 mm diameter and 18 cm height in three layers. Each layer is tamped 25 times with at standard tamping rod. The test sample is weighed and placed in the test cylinder in three layers each layer being tamped again. The specimen is subjected to a compressive load of 40 tonnes gradually applied at the rate of 4 tonnes per minute. Then crushed aggregates are then sieved through 2.36 mm sieve and weight of passing material (**W2**) is expressed as percentage of the weight of the total sample (**W1**) which is the aggregate crushing value.

Aggregate Crushing Value = (W1/W2) *100

A value **less than 10** signifies an exceptionally **strong aggregate** while **above 35** would normally be regarded as **weak aggregates**.

Abrasion test:

Los Angeles abrasion test is a preferred one for carrying out the hardness property and has been standardized in India (**IS: 2386 part-IV**).

The principle of Los Angeles abrasion test is to find the percentage wear due to relative rubbing action between the aggregate and steel balls used as abrasive charge.

Los Angeles machine consists of circular drum of internal diameter 700 mm and length 520 mm mounted on horizontal axis enabling it to be rotated. An abrasive charge consisting of cast iron spherical balls of 48 mm diameters and weight 340-445 g is placed in the cylinder along with the aggregates. The number of the abrasive spheres varies according to the grading of the sample. The quantity of aggregates to be used depends upon the gradation and usually ranges from 5-10 kg. The cylinder is then locked and rotated at the speed of 30-33 rpm for a total of 500 -1000 revolutions depending upon the gradation of aggregates.

After specified revolutions, the material is sieved through 1.7 mm sieve and passed fraction is expressed as percentage total weight of the sample. This value is called Los Angeles abrasion value.

A maximum value of **40 percent** is allowed for **WBM base course** in Indian conditions. For **bituminous concrete**, a maximum value of **35 percent** is specified.

Specific gravity and water absorption test:

The specific gravity and water absorption of aggregates are important properties that are required for the design of concrete and bituminous mixes. The specific gravity of a solid is the ratio of its mass to that of an equal volume of distilled water at a specified temperature. Because the aggregates may contain water-permeable voids, so two measures of specific gravity of aggregates are used:

1. Apparent specific gravity and
2. Bulk specific gravity.

Apparent Specific Gravity, G_{app}, is computed on the basis of the net volume of aggregates i.e the volume excluding water-permeable voids. Thus

$$G_{app} = [(M_D/V_N)]/W$$

Where,

M_D is the dry mass of the aggregate,
V_N is the net volume of the aggregates excluding the volume of the absorbed matter,
W is the density of water.

Bulk Specific Gravity, G_{bulk}, is computed on the basis of the total volume of aggregates including water permeable voids. Thus

$$G_{bulk} = [(M_D/V_B)]/W$$

Where,

V_B is the total volume of the aggregates including the volume of absorbed water.

Water Absorption: The difference between the apparent and bulk specific gravities is nothing but the water permeable voids of the aggregates. We can measure the volume of such voids by weighing the aggregates dry and in a **saturated surface dry condition**, with all permeable voids filled with water. The difference of the above two is M_W.

M_W is the weight of dry aggregates minus weight of aggregates saturated surface dry condition. Thus,

$$\text{Water Absorption} = (M_W/M_D)*100$$

The specific gravity of aggregates normally used in road construction ranges from about 2.5 to 2.9. Water absorption values ranges from 0.1 to about 2.0 percent for aggregates normally used in road surfacing.

Shape test:

The particle shape of the aggregate mass is determined by the percentage of flaky and elongated particles in it. Aggregates which are flaky or elongated are detrimental to higher workability and stability of mixes. The **flakiness index** is defined as the percentage by weight of aggregate particles whose **least dimension is less than 0.6 times their mean size**. Flakiness gauge (see Fig-4) is used for this test. Test procedure had been standardized in India (**IS: 2386part-I**).The **elongation index** of an aggregate is defined as the percentage by weight of particles whose **greatest dimension (length) is 1.8 times their mean dimension**. This test is applicable to aggregates larger than 6.3 mm. Elongation gauge (see Fig-5) is used for this test. This test is also specified in (**IS: 2386 Part-I**). However, there are no recognized limits for the elongation index.

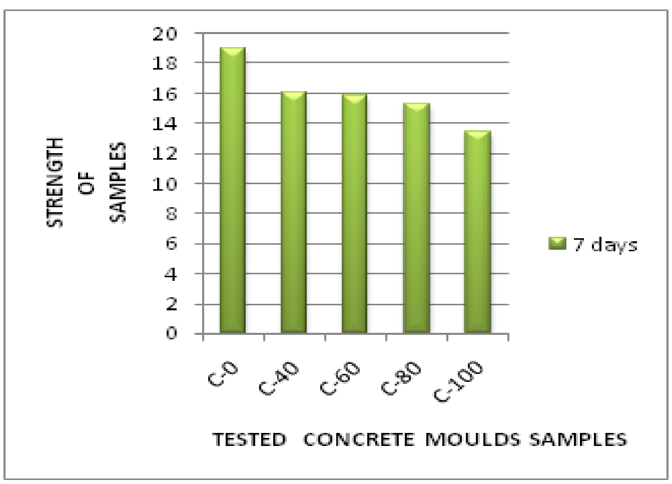
Tests on aggregates:

Table No. 5: Test Results of the Coarse Aggregates

Name of test	Test results		Permissible value	IS standard
	Natural aggregates	Recycled aggregates		
Aggregate impact value,%	18.89%	17.42%	Maximum 30%	IS:2386-Part IV:1963
Aggregate crushing value,%	15.5%	16.35%	25% Maximum	IS:2386-Part IV:1963
Water absorption,%	0.50%	0.78%	2% Maximum	IS:2386-Part III:1963
Specific gravity	2.82	2.87	2-3	IS:2386-Part III:1963
Los Abrasion value,%	19.0%	17.98%	Maximum 30%	IS:2386-Part IV:1963

Test on concrete mould:

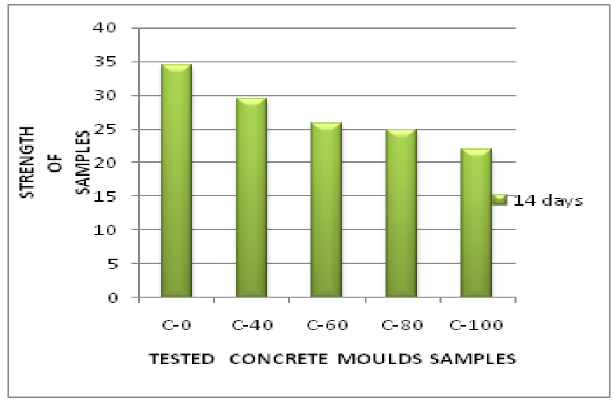
S.NO	NAME OF THE MIX	PERCENTAGE VOLUME REPLACEMENT OF COARSE AGGREGATE		COMPRESSIVE STRENGTH (N|MM²)
		NORMAL AGGREGATE	RECYCLED AGGREGATE	
1	C-0	100	0	19.00
2	C-40	60	40	16.00
3	C-60	40	60	15.85
4	C-80	20	80	15.3
5	C-100	0	100	13.4



Graph No :6.1 Compression Strength of 7days

Table No 7: compression test results for 14 days

S.NO	NAME OF THE MIX	PERCENTAGE VOLUME REPLACEMENT OF COARSEAGGREGATE		COMPRESSIVE STRENGTH (N|MM²)
		NORMAL AGGREGATE	RECYCLED AGGREGATE	
1	C-0	100	0	34.5
2	C-40	60	40	29.4
3	C-60	40	60	25.7
4	C-80	20	80	24.9
5	C-100	0	100	22



Graph No 7.1 compression strength of 14 days

Description:

C- Represents the percentage of concrete adding into the normal concrete mix with recycled coarse aggregate.

C-0 represents the concrete mix only with the normal aggregate with out adding the recycled coarse aggregate we got the compression strength value about 42.00.

C-40 represents the concrete mix with 60% of normal aggregate with replacement of 40% with the recycled coarse aggregate then we got the compression strength value about 36.7. we got the percentage of decreasing in compression strength about 12.62%.

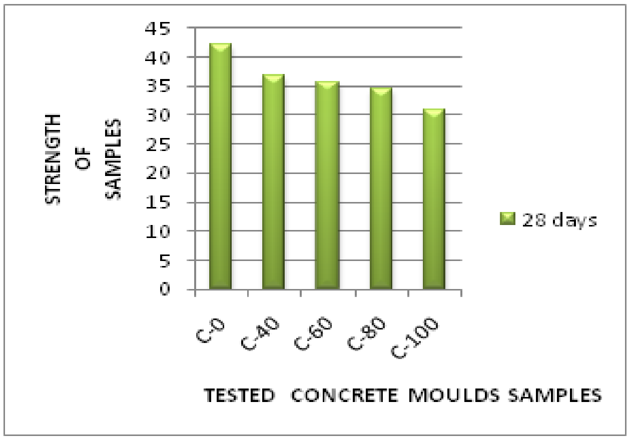
C-60 represents the concrete mix with 40% of normal aggregate with replacement of 60% with the recycled coarse aggregate then we got the compression strength value about 35.7. we got the percentage of decreasing in compression strength about 15%.

C-80 represents the concrete mix with 20% of normal aggregate with replacement of 80% with the recycles coarse aggregate then we got the compression strength value about 34.6. we got the percentage of decreasing in compression strength about 17.62%.

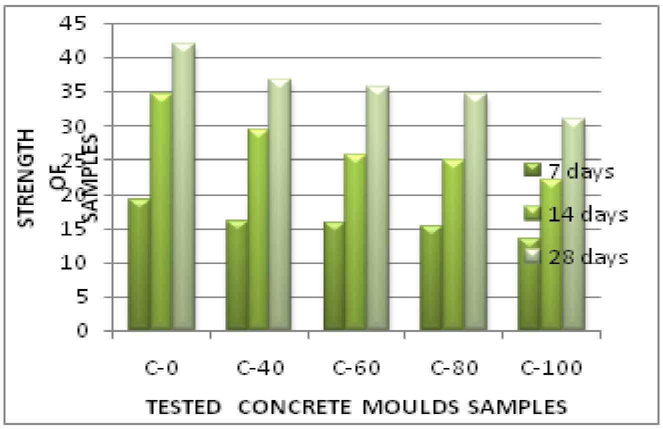
C-100 represents the concrete mix with 100% of the recycled coarse aggregate without having normal aggregate then we got the compression strength value about 30.8. we got the percentage of decreasing in compression strength about 26.67%.

Table No 8: compression test results for 28 days

S.NO	NAME OF THE MIX	PERCENTAGE VOLUME REPLACEMENT OF COARSE AGGREGATE		COMPRESSIVE STRENGTH (N|MM²)
		NORMAL AGGREGATE	RECYCLED AGGREGATE	
1	C-0	100	0	42.00
2	C-40	60	40	36.7
3	C-60	40	60	35.7
4	C-80	20	80	34.6
5	C-100	0	100	30.8



Graph No 8: compression strength of 28 days



Graph No : 9: Overall Compression strength of concrete moulds

V. CONCLUSION

- Pervious Concrete made of recycled CCW is a very cost-effective and environmentally friendly measure to support green, sustainable growth.
- Its ability to capture storm water and allow it to seep into the ground enables pervious concrete to a significant role in reducing ground water, reducing storm runoff.
- Recycled CCW in pervious concrete is an appropriate solution to the problems in recharging ground water.
- Pervious concrete using recycled CCW is economical, in that it minimizes the need for runoff retainers, reducing property costs.
- This in turn directly reduces the impact of waste material on environment.
- However in less quantity and can be recommended for lower grade applications like lower layers of roads such as sub base course and base course.
- Compressive strength of concrete will decrease with increase in percentage of recycled aggregates for 7, 14, 28 days.

VI. FUTURE SCOPE OF THE PROJECT WORK

- In the past due to the scarcity of cement, the Pervious Concrete has been used extensively.
- The Pervious Concrete has lost its importance after successful production of cement in large quantities.
- But now-a-days, the usage of Pervious Concrete has gained its popularity due to many advantages.
- So, in future to tackle aforesaid problems and to protect people from flood prone areas, the Pervious Concrete is one effective solution.
- By using the Pervious Concrete we can increase the level of ground water table & minimize the scarcity of water.
- By using recycled coarse aggregate we can save natural resources

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