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To Study the Suitability and Performance of Expanded Perlite Aggregate with Partial Replacement of Crushed Rock Fines as Fine Aggregate

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Abstract - *This project is carried out to extract the results of experimental work, carried out to investigate the optimum percentage of EPA in concrete to partially replace CRF which was used as fine aggregates effectively. Different mixing procedures of mixing of EPA with the CRF are also studied in order to attain more strength in the concrete. The different tests carried out in present work are workability property by slump cone test, density of concrete, mechanical properties by compressive strength test, Split tensile strength test, flexural strength test and durability test by Water permeability test, Rapid Chloride Permeability test, Acid Resistivity test, Sorpitivity test and the strength deterioration by the concrete exposed to different temperature and different duration is studied.*

The experimental work is carried out to determine the optimum percentage of EPA to replace the CRF effectively in concrete. In the first phase the mixing procedures of the concrete with EPA is studied and the strength is resulted. In the second stage, the optimum percentage of EPA that can be added to replace CRF is studied according to strength. In the third stage, durability tests of the optimum percentage of EPA mixed concrete is studied, in the fourth stage, the strength loss due to the exposure of different temperature to different duration is studied.

Key Words*: *Light Weight Concrete, Expanded Perlite Aggregates, Crushed Rock Fines

1. INTRODUCTION

1.1 GENRAL

Concrete is made up of mixing cement, gravel, sand and water. Concrete is being used in many purposes to make it suitable in different conditions. The higher self-weight is the great disadvantage of conventional concrete. Around 2200kg/m3 to 2600kg/m3 is the density of normal concrete. This weight is heavy as per its self-weight so it is termed as uneconomical. Many attempts have been made in the past to decrease the self-weight of the concrete. Reduced structural weight helps in higher economy

Expanded perlite aggregates (EPA) due to its low density, high absorption, low thermal and acoustic conductivity and very light weight property have much scope in construction sector. Perlite is the common name used for the naturally occurring siliceous rock.

1.2 AIM

The major aim of the project is to study the suitability of concrete mix procedures, durability and performance of Expanded Perlite Aggregates based concrete with the replacement of crushed rock fines (CRF) as fine aggregates in the concrete production.

1.3 OBJECTIVE OF PROJECT

1. To study and evaluate the behavior of EPA when added with the CRF in fresh state.

2. To study and evaluate the behavior of EPA when added with the CRF in hardened state.

3. To ascertain the structural behavior of the concrete using EPA.

4. To study the durability properties such as Sorpitivity, Water Permeability, RCPT & Acid Resistance.

5. To study the improvement in the properties of concrete with normal CRF and with partial replacement of CRF by EPA.

6. To know the suitable mixing procedure so as to obtain maximum strength in hardened concrete obtained with the replacement of EPA.

7. To generate more durable concrete.

8. To enhance the strength of the concrete where it is exposed to different exposures and durations of temperatures.

1.4 SCOPE OF THE PROJCECT

The main scope of the project work is to evaluate the various properties of the concrete by varying the percentage of Expanded Perlite Aggregate with the Crushed Rock Fines.

2. MATERIALS USED

The material properties used for making of motors is discussed. Physical and chemical properties of all ingredients used for the entire experimental work are resulted in this section. The raw materials used in the present investigation is,

1. Cement

2. Coarse aggregates

3. Crushed rock fines

4. Expanded perlite aggregate

4. Bonding agent

5. Water

3. STEPS CHOSEN FOR MIXING THE CONCRETE

The strength of concrete varies with the addition of EPA as a partial replacement of CRF was tended to vary with the mixing procedures. So a study was made in order to choose the suitable mixing procedures for the higher compressive strength gain.

Table 3.1 Procedure for mixing the concrete

Mix	Step 1	Step 2	Step 3	Step 4
M1	Adding gravel, CRF, cement	Mixed for 5 min	Adding water	Mixed for 5 min
M2	Adding water, cement	Mixed for 5 min	Adding gravel, perlite, sand	Mixed for 5 min
M3	Adding water, cement, perlite, sand	Mixed for 5 min	Adding gravel	Mixed for 5 min
M4	Adding water, sand, cement	Mixed for 5 min	Adding perlite, gravel	Mixed for 5 min
M5	Adding sand , cement, gravel, perlite, half of water	Mixed for 5 min	Adding another half of water	Mixed for 5 min

Table 3.2 Compressive strength of different mixing procedures of concrete

Mix	Compressive Strength (MPa)
M1	34.91
M2	24.3
M3	35.25
M4	34.8
M5	22.36

Since the compressive strength is maximum for M3 mixing procedure that is with the addition of water, perlite, sand, cement, and mixing it for 5 minutes then adding gravel and mixing 5 minutes is suitable considering the other types of mixing procedures.

4. MIX PROPORTIONS FOR THE ADDITION OF EXPANDED PERLITE AGGREGATES TO REPLACE WITH FINE AGGREGATES (FA)

The mix proportions for the addition of expanded Perlite aggregates have been tabulated below. EPA signifies expanded Perlite aggregates. The concrete cubes casted for different percentages EPA and the investigations will be carried out with respect to the Fresh and hardened properties of concrete.

Table 3.14 Designation and Mix Proportions

Mix Proportions Designation	Percentage replacement
C1	CRF AGGREGATES
TM1	95% CRF + 5% EPA
TM2	90% CRF + 10% EPA
TM3	85% CRF + 15% EPA
TM4	80% CRF + 20% EPA
TM5	75% CRF + 25% EPA

5 RESULTS AND DISCUSSION

5.1 WORKABILITY TEST ON CONCRETE

The workability test is been conducted as per IS: 1199-1959 for the various replacement percentages of SSS and also for the conventional concrete.

Table 5.1 Slump values for the replacement of EPA

Sl. No.	Design ation	Percentage replacement	Slump value (mm)
1	C1	CRF AGGREGATES	100mm
2	TM1	95% CRF + 5% EPA	90mm
3	TM2	90% CRF + 10% EPA	95mm
4	TM3	85% CRF + 15% EPA	60mm
5	TM4	80% CRF + 20% EPA	45mm
6	TM5	75% CRF + 25% EPA	30mm

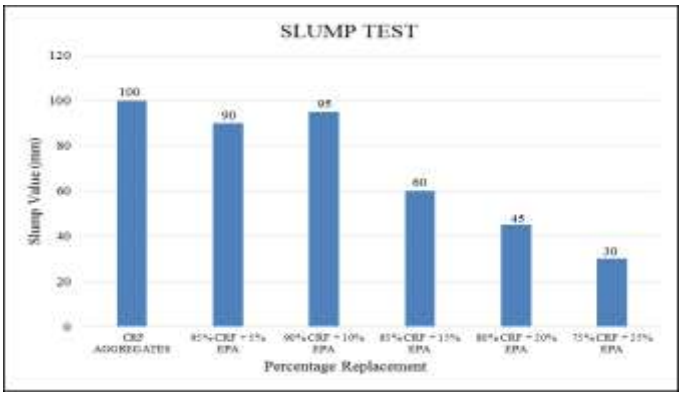

Figure 5.1 Slump Test Results

5.2 BULK DENSITY TEST

As per the procedure of IS-1199 Method of sampling and analysis of concrete is used.

Table 5.2 Bulk Density Test results for the replacement of EPA

Sl. No.	Desig nation	Percentage Replacement	Wet density (kg/m³)	Dry density (kg/m³)
1	C1	CRF AGGREGATES	2382	2381
2	TM1	95% CRF + 5% EPA	2338	2322
3	TM2	90% CRF + 10% EPA	2255	2223
4	TM3	85% CRF + 15% EPA	2187	2139
5	TM4	80% CRF + 20% EPA	2139	2075
6	TM5	75% CRF + 25% EPA	2094	2021

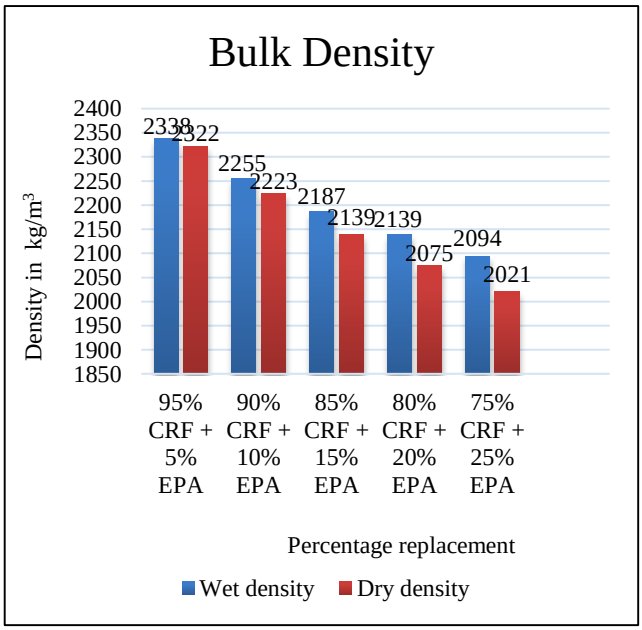

Figure 5.2 Bulk Density test results

5.3 COMPRESSIVE STRENGTH TEST

The determination of compressive strength was carried out as per standard practice IS 4031(part 6-1988).

Table 5.3 Compressive Strength results for the replacement of EPA

Sl. No.	Mix Designation	Percentage Replacement	Average compressive strength(N/mm²)		
			7 days	14 days	28 days
1	C1	CRF AGGREGATES	19.82	29.28	33.66
2	TM1	95% CRF + 5% EPA	17.08	26.10	32.40
3	TM2	90% CRF + 10% EPA	22.30	26.70	34.74
4	TM3	85% CRF + 15% EPA	20.23	24.52	33.33
5	TM4	80% CRF + 20% EPA	13.83	21.74	25.96
6	TM5	75% CRF + 25% EPA	12.54	19.58	21.36

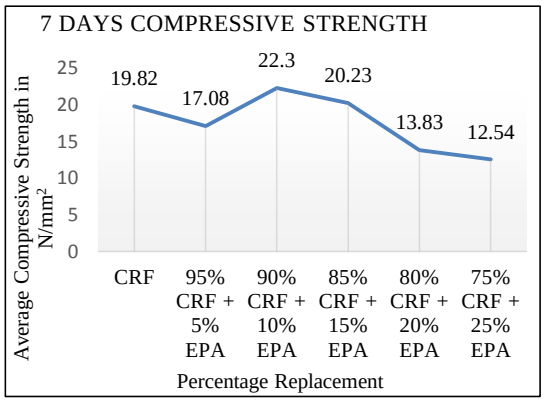

Figure 5.3 Compression Strength Test Results for 7 days curing

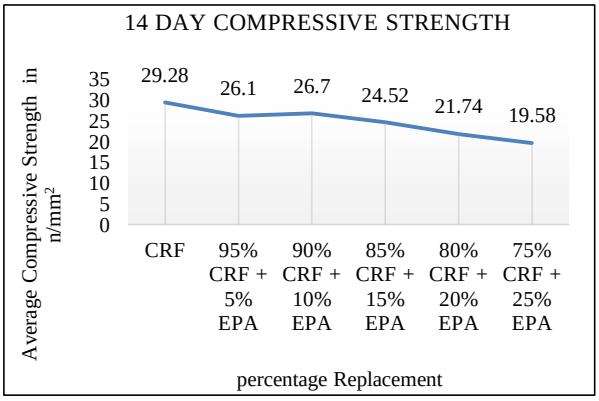

Figure 5.4 Compression Strength Test Results for 14 days curing

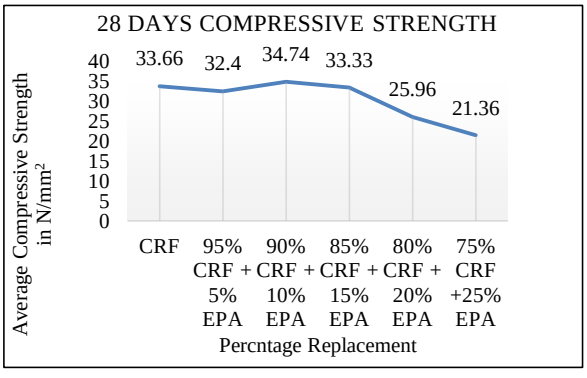

Figure 5.5 Compression Strength Test Results for 28 days curing

The strength parameters in the compressive strength of concrete for 7 days, 14 days and 28 days is shown in the above graphs. From the graph we can note that the compressive strength increases up to 10% replacement of EPA but with 15%, 20% and 25% the compressive strength decreases.

EPA being the light weight aggregate has less compression strength compared to other aggregates. 2.34% increment in the compressive strength is found at 10% replacement of CRF by EPA at 28 days when compared to normal concrete with the replacement of fine aggregate with CRF. Partial replacement percentage of EPA up to 10% was found to be beneficial.

5.4 SPLIT TENSILE STRENGTH TEST

The determination of Split tensile strength of the prepared samples was carried out as per standard practice. The following table shows the average split tensile strength of various samples after testing.

Table Table: 5.4 Split Tensile Strength results

Sl. No.	Mix Designation	Percentage Replacement	Average Split tensile strength(N/mm²)		
			7 days	14 days	28 days
1	C1	CRF AGGREGATES	1.25	1.79	3.18
2	TM1	95% CRF + 5% EPA	1.30	1.57	2.91
3	TM2	90% CRF + 10% EPA	1.48	2.34	3.12
4	TM3	85% CRF + 15% EPA	1.42	2.05	2.76
5	TM4	80% CRF + 20% EPA	1.35	1.68	2.07
6	TM5	75% CRF + 25% EPA	1.22	1.52	1.92

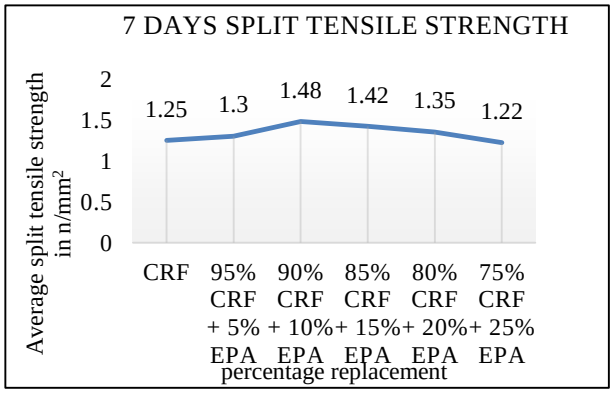

Figure 5.6 Split Tensile Strength results for 7 days

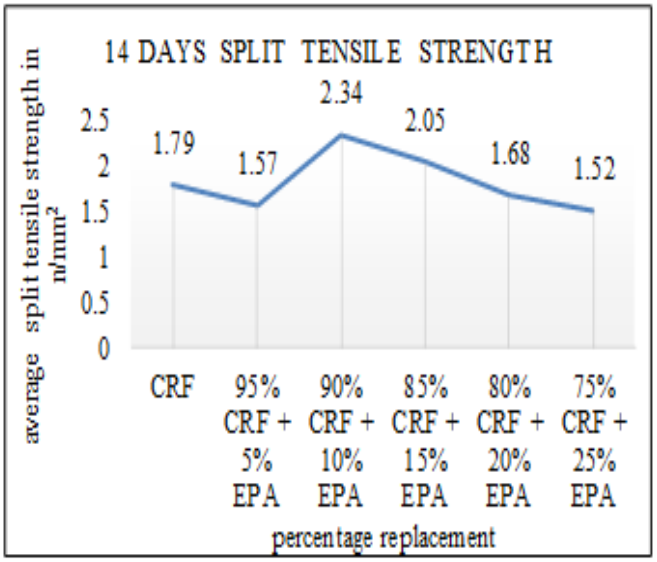

Figure 5.7 Split Tensile Strength results for 14 days

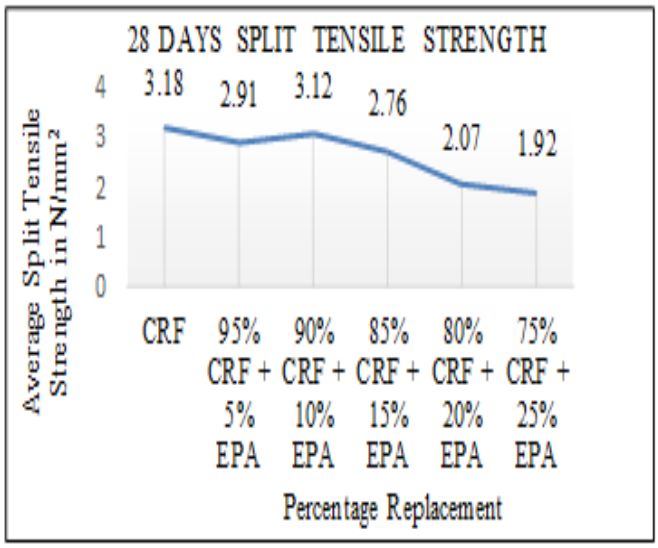

Figure 5.8 Split Tensile Strength results for 28 days

From the results obtained for the split tensile strength test, the higher split tensile strength is obtained for the 10% replacement of EPA by the CRF. In hardened concrete tests as the replacement percentage increases the strength also increases but up to certain limit beyond that the strength reduces as the percentage of replacement increases.

5.5 FLEXURAL STRENGTH TEST

The determination of Flexural strength of the prepared samples was carried out as per standard practice. The following table shows the average Flexural strength of various samples after testing. In this case Fine aggregates are replaced by partial amount of EPA.

Table 5.5 Flexural strength results for the replacement of EPA

Sl. No.	Mix Designation	Percentage Replacement	Average Flexural strength in N/mm²		
			7 days	14 days	28 days
1	C1	CRF AGGREGATES	2.34	3.20	5.75
2	TM1	95% CRF + 5% EPA	1.91	2.72	5.18
3	TM2	90% CRF + 10% EPA	3.26	2.94	5.55
4	TM3	85% CRF + 15% EPA	2.88	2.81	5.21
5	TM4	80% CRF + 20% EPA	2.15	2.56	4.48
6	TM5	75% CRF + 25% EPA	2.24	2.08	3.92

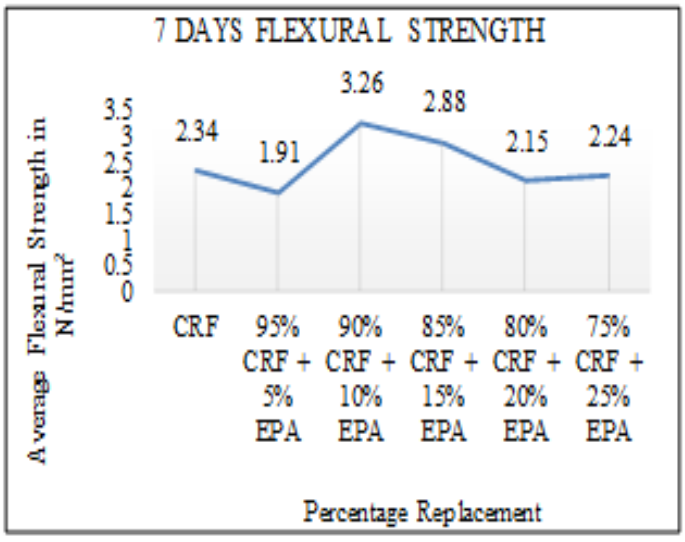

Figure 5.9 Flexural Strength results for 7 days

The Strength parameters in the Flexural strength of concrete for 7 days, 14 days and 28 days is shown in the above graphs. From the graph we can note that the Flexural strength increases up to 10% replacement of EPA and 90% CRF but with 15%, 20% and 25% the strength decreases gradually.

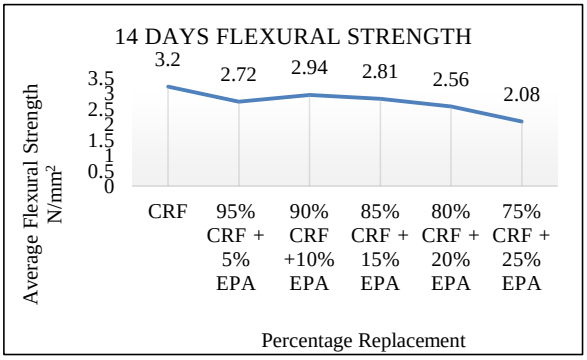

Figure 5.10 Flexural Strength results for 14 days

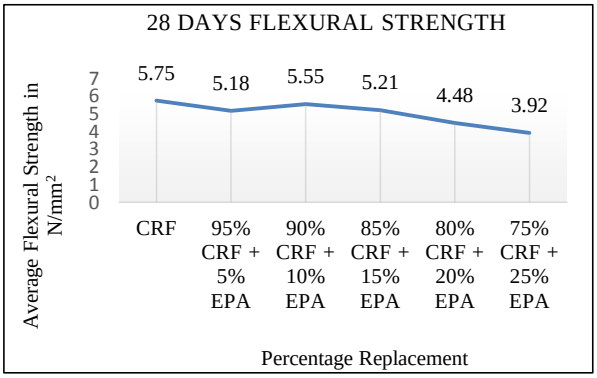

Figure 5.11 Flexural Strength results for 28 days

From the results obtained for the Workability test, Compressive strength test, Flexural strength test and Split tensile strength test the optimum replacement percentage of EPA to replace Fine aggregates is 10%. From the workability test results obtained it is seen that, the slump decreases as the replacement percentage increases but up to certain limit only i.e., up to 5%. At 10% there will be slight increase in the workability. Beyond this replacement limit there is no improvement in workability.

5.6 DURABILITY TESTS

The durability tests are conducted on control mix and 90% CRF + 10% EPA = M2 mix, based on slump and compressive strength results. The various durability test results are illustrated below.

5.6.1 WATER PERMEABILITY TEST

The test is carried out on 150 mm× 150 mm× 150 mm specimens after 28 days of curing in water. These specimens are usually subjected to 5 bar pressure for 72 hours. After 72 hours the depth of water penetration is recorded using water penetrometer.

Table 5.6 Water Permeability test results

Mix Designation	Percentage Replacement	Depth of Penetration (mm)
C1	100% CRF	10.08
TM2	90% CRF + 10% EPA	6.55

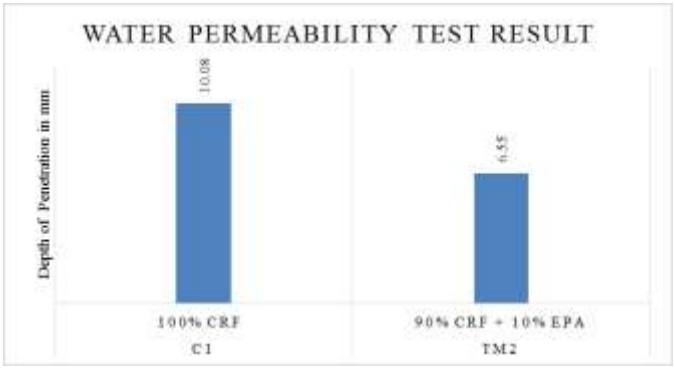

Figure 5.12 Water Permeability test results

5.6.2 RAPID CHLORIDE PERMEABILITY TEST (RCPT)

The electrical conductance of samples includes measuring the charges in coulombs to give a rapid result of its resistance to penetration of chloride ion. The RCPT test results are as follows.

Table 4.7 RCPT test results

Mix Designation	Percentage Replacement	RCPT Values in Coulombs
C1	100% CRF	1215.4
TM2	90% CRF + 10% EPA	792.5

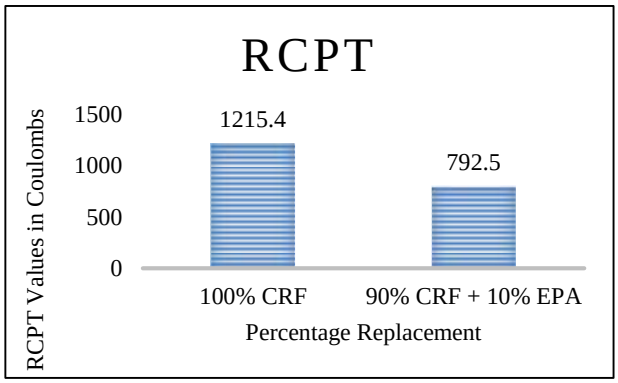

Figure 5.13 RCPT test results

5.6.3 ACID RESISTIVITY TEST

The loss in weight of samples is the difference between the mass of sample before immersion and the mass of sample after immersion in acid. The test results after submerging the samples for 90 days in H2SO4 solution is shown in the table below.

Table 5.8 Acid Resistivity test results

Mix Design ation	Percentage Replacement	Weight Before Immersi on (kg)	Weight After 90 days of Immersi on (kg)	Loss in Weig ht (kg)
C1	100% CRF	7.832	7.584	0.248
TM2	90% CRF + 10% EPA	8.054	7.758	0.296

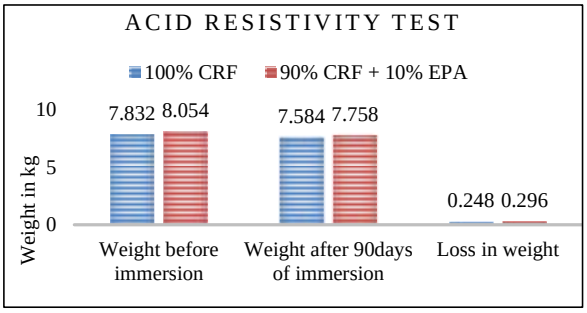

Figure 4.14 Acid resistivity test results

5.6.4 SORPTIVITY TEST

Table 5.9 Sorptivity test results

Mix No.	Percentage Replacement	Water absorbed by capillarity (kg)					
		15 min	30 min	1 hour	24 hours	48 hours	72 hours
C1	100% CRF	0.000020	0.000026	0.000039	0.000044	0.000048	0.000058
TM2	90% CRF+ 10% EPA	0.000008	0.000013	0.000018	0.000032	0.000036	0.000045

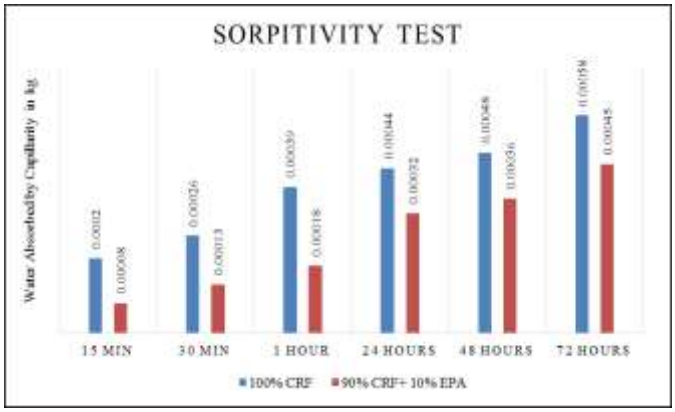

Figure 5.15 Sorpitivity test results

6. CONCLUSIONS

1. EPA fulfills the basic properties of fine aggregate. Hence it could be used as replacement for fine aggregate.
2. The suitable mixing of a concrete is found to be as adding water, cement, perlite and sand first, mixing it for 5 minutes and then adding the gravel and mixing it for 5 minutes.
3. From the workability and density check consequences it could be concluded that the workability of the concrete increases in the addition of 10% EPA & 90% of CRF.
4. From the outcomes, it can be concluded that strength in compression, tension and flexure will increase through adding 10% of EPA & 90% of CRF, but the strength decreases as % replacement of EPA increases.
5. Optimum mix of 10% EPA and 90% CRF gives better workability and improved flexural, compressive strength, and split tensile strength.
6. The durability tests Water Permeability, Rapid Chloride Permeability Test, Acid Resistivity and Sorptivity showed good results compare to normal concrete as combination of CRF and EPA is better and strong compared to 100% CRF.
7. The density of the concrete deceased with increase of EPA to the concrete when compared to 100% CRF.

7. SCOPE OF FUTURE STUDY

1. Various effects of other mineral admixtures such as Silica fume Fly ash, and Rice husk ash) mixture with perlite aggregate can be carried out.
2. Resistance to various other chemical attacks can be studied.
3. Studies can be carried out on structural behavior (beam and column) of perlite mixed concrete.
4. Determination of strength of perlite aggregate mixed concrete can be done for different grades of concrete

5. Other characteristics of strength and durability of concrete can be evaluated by different tests.
6. Recuring of the concrete after exposure to temperature can also be studied.

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