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COMPARATIVE STUDY OF ALTERNATE FORMS OF CONCRETE BY REPLACING BRICK BAT AND CLAY TILES AS COARSE AGGREGATE AND LEAD SLAG AS FINE AGGREGATE

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Abstract— Managing the construction demolition waste have become major concern across the countries and most of the demolition waste generated at site instead of recycling. The demolition waste is dumped to landfills. In this project small attempt is made to make use of recycled aggregates. The recycled aggregate used are crushed clay tiles and brick bats as coarse aggregate and lead slag an industrial by product as fine aggregate. Initially Crushed clay tiles and brick bats where partially replaced with coarse aggregate in concrete in percentage of 10%, 30% and 40% and mix was prepared. Cubes where casted and tested for 7,14and 28 days. In this project compressive strength, flexural strength and split tensile strength test were carried out on concrete specimens. From results obtained I came to know that crushed clay tiles and brick bats can be replaced by 30% beyond this strength factor has decreased. Further test was carried out by combining 30% crushed waste clay tiles and brick bats as constant and altering just lead slag as fine aggregate in percentage of 10%,20%,30%,40%,50% and 60%. From results obtained I came to know we can replace lead slag by 30% beyond that decrease in strength was noticed. Cost analysis was also carried out it was found that the cost of concrete made using recycled aggregate in this project is relatively lower than conventional concrete.

Keywords: Crushed brick bat, Crushed clay tiles and Lead slag.

1. INTRODUCTION

1.1 GENERAL

Due to increase in population, construction activities are taking place at a greater speed, the quantity of waste material have rapidly increased. The non-decaying waste materials will remain unutilized for thousands of years. The non-decaying waste materials will be a burden to the environment leading to waste disposal crisis. Waste accumulation is a problem which exists worldwide specially in densely populated areas like cities where disposing of the waste material is a major issue and the waste materials are either used has landfill material or left as stockpiles.

Hence, from the past two decades researches are being conducted on various alternate forms of coarse (e.g. Polymer resin, recycled crushed concrete, laterite stone, clay tiles, brick bats etc.) as well as fine (e.g., fly ash, sawdust powder, slag waste, glass, quarry sand etc.) aggregate. Conversion of solid waste (i.e., brick bats, clay tiles and lead slag) into construction materials will be discussed in this project. But main focus will be made on the utilization of waste brick bats, clay tile and lead slag as aggregate in concrete and conduct various tests. Also rate estimation is done for the concrete produced with alternate forms with conventional form of concrete

1.2 OBJECTIVE OF PROJECT

1. To recycle brick bat, clay tile and lead slag aggregate to minimize the risk of the environmental pollution.

2. The effect of adding lead slag to concrete as fine aggregate and brickbat & clay tiles as coarse aggregate to improve the properties of the concrete and make environment sustainable.

3. To compare cost and behavior of concrete made in this study with conventional concrete.

2. MATERIALS USED

The materials for this project where procured locally. Basic test where done on the procured material to determine its properties. Material used in this project are listed below.

2.1. CRUSHED CLAY TILES AND BRICK BAT

Waste Burnt Brickbats and Clay tiles are the major wastes products from the Clay Brick and Clay Tile manufacturing industry. Brickbats and clay tiles can be hundred percent recycled and has good performance. Brickbats and Clay tiles are prepared from hard laterite clay. In this project crushed brick bat and clay tiles where used as replacement material to coarse aggregate in concrete.

Fig- 1: Crushed brick bat and clay tiles

2.2 LEAD SLAG

In the pyrometallurgic process the dead batteries from vehicles and inverters are collected and submitted to the feeders at the lead industry. The feeder converts raw material into lead concentrate and in smelting process lead concentrate is sent to furnace. In furnace when the lead concentrate is subjected to 1100-1200 ºC metallic lead is obtained. Metallic lead is recovered from lead concentrate which generates great amount of by-product called lead slag. In this project lead slag is used has replacement material to fine aggregate.

Fig- 2: Lead slag in form of fine aggregate

3. MIX DESIGN

Mix design for concrete is designed to select suitable ingredients of concrete and to determine their relative proportions to produce grade of concrete with required workability and characteristic strength as economical as possible. Mix proportioning was done as per IS10262-2009. Mix ratio for M20 grade concrete is 1:1.9:2.8. All the tests were carried out at Trident RMC plant as per relevant codes and availability of equipment's.

Stipulations for proportioning

1. Grade designation: M20
2. Type of cement: 43 grade ordinary Portland cement (Conforming to IS:8112)
3. Aggregate size: 20mm down size
4. Aggregate type: Angular crushed aggregate

3.1 MIX PROPORTIONS FOR THE ADDITION BB&CTA AS COARSE AGGREGATE AND LEAD SLAG AS FINE AGGREGATE

The mix proportion for the addition of BB&CTA as coarse aggregate and lead slag as fine aggregate have been tabulated below in Table 3.1 for the same concrete cubes have been casted.

Table -3.1: Designation and mix proportion

Sl. No	Mix Design ation	Percentage replacement			
		Coarse Aggregate (CA)		Fine Aggregate (FA)	
		20 mm	BB& CTA	Sand	Lead slag
1.	S1	100%	-	100%	-
2.	S2	90%	10%	100%	-
3.	S3	70%	30%	100%	-
4.	S4	60%	40%	100%	-
5.	S5	70%	30%	90%	10%
6.	S6	70%	30%	80%	20%
7.	S7	70%	30%	70%	30%
8.	S8	70%	30%	60%	40%
9.	S9	70%	30%	50%	50%
10.	S10	70%	30%	40%	60%

4. RESULTS AND DISCUSSIONS

4.1 SPECIFIC GRAVITY AND WATER ABSORPTION OF THE MATERIALS

The results of Specific gravity and water absorption test which were conducted on materials used in this project are tabulated in Table 4.1.

Table -4.1: Specific gravity and water absorption results

MATERIAL	SPECIFIC GRAVITY(G)	WATER ABSORPTION (WA, %)
20MM COARSE AGGREGATE	2.68	1.1
BRICK BAT & CTA	2.22	12.86
SAND	2.65	3.9
LEAD SLAG	2.2	11.01

4.2 WORKABILITY TEST ON CONCRETE

The Workability test was carried out according to procedure mentioned in IS 1199-1959.

Table -4.2: Slump test values

Sl.No.	Mix Designation	Percentage replacement	Slump value (mm)
1	S1	100%CA & 100%FA	150
2	S2	10% BB&CTA & 100% FA	140
3	S3	30% BB&CTA & 100% FA	135
4	S4	40% BB&CTA & 100% FA	130

5	S5	30% BB&CTA & 10% LEAD SLAG	120
6	S6	30% BB&CTA & 20% LEAD SLAG	110
7	S7	30% BB&CTA & 30% LEAD SLAG	105
8	S8	30% BB&CTA & 40% LEAD SLAG	100
9	S9	30% BB&CTA & 50% LEAD SLAG	90
10	S10	30% BB&CTA & 60% LEAD SLAG	75

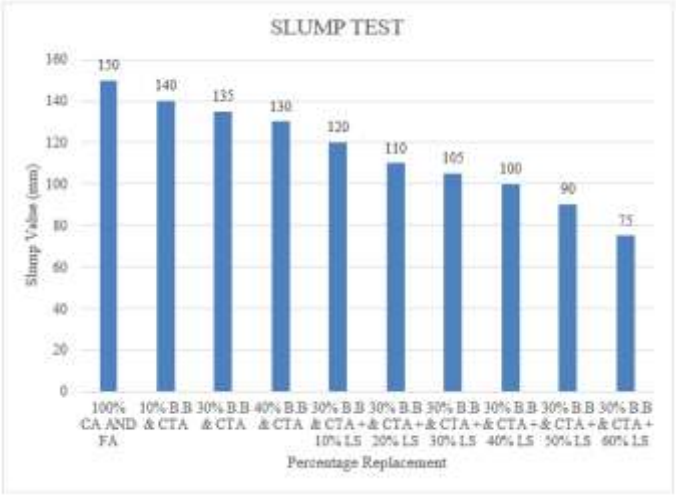

Chart -1: Slump test results

4.3 COMPRESSIVE STRENGTH TEST RESULTS

The Compressive strength test was carried out according to procedure mentioned in IS: 516-1959**.** About 90 cubes of dimension 150X150X150 mm where casted in this project and compressive strength of cube where checked on 7, 14 and 28 days. The values of compressive strength test conducted are presented in table 4.3.

Table -4.3: Compressive strength test results

Sl. No	Mix Designation	Percentage replacement	Average Compressive Strength (N/mm²)		
			7 days	14 days	28 days
1	S1	100%CA & 100%FA	23.86	27.61	34.20
2	S2	10% BB&CTA & 100% FA	21.52	25.69	28.69
3	S3	30% BB&CTA & 100% FA	22.63	26.70	29.31
4	S4	40% BB&CTA & 100% FA	20.23	24.12	27.10
5	S5	30% BB&CTA & 10% LEAD SLAG	19.62	22.32	25.43

6	S6	30% BB&CTA & 20% LEAD SLAG	20.36	24.62	27.00
7	S7	30% BB&CTA & 30% LEAD SLAG	22.49	26.11	28.12
8	S8	30% BB&CTA & 40% LEAD SLAG	21.36	24.23	26.42
9	S9	30% BB&CTA & 50% LEAD SLAG	19.21	22.69	24.02
10	S10	30% BB&CTA & 60% LEAD SLAG	16.33	17.86	19.11

Chart -2: Compressive strength test results for 7 days

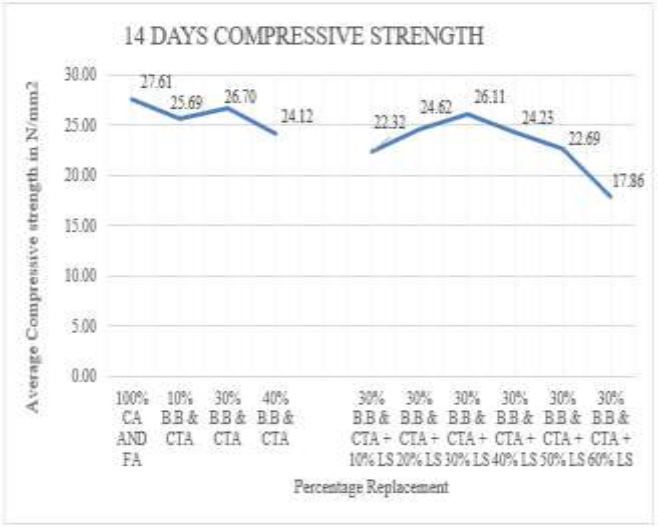

Chart -3: Compressive strength test results for 14 days

Chart -4: Compressive strength test results for 28 days

The compressive strength value obtained for different trial mix where plotted in graph and compression of results were done. From the result obtained we can conclude that we can replace recycled aggregate by 30% beyond this upon addition of recycled aggregate in concrete strength started decreasing. The compressive strength test result of concrete made of crushed brick bats, clay tiles and lead slag was 28.12 N/mm² for 28 days which is more than sufficient for M20 grade concrete.

4.4 BULK DENSITY TEST RESULTS

The bulk density test was conducted for each trial mix and the values where recorded. The results obtained during wet density test are presented in table 4.4. From the bulk density test results obtained the density of concrete made with recycled aggregate is less than the conventional concrete. The main reason is the weight of crushed brick bats & clay tiles are less then coarse aggregate (jelly). Therefore, the concrete made in this project can be used in light weight concrete construction.

Table -4.4: Bulk density test results

Sl. No	Mix Designation	Dry Density [Kg/m³]	Wet Density [Kg/m³]
1	S1	2400	2378
2	S2	2394	2329
3	S3	2381	2250
4	S4	2374	2216
5	S5	2406	2380
6	S6	2402	2320
7	S7	2390	2286
8	S8	2386	2280
9	S9	2360	2270
10	S10	2342	2260

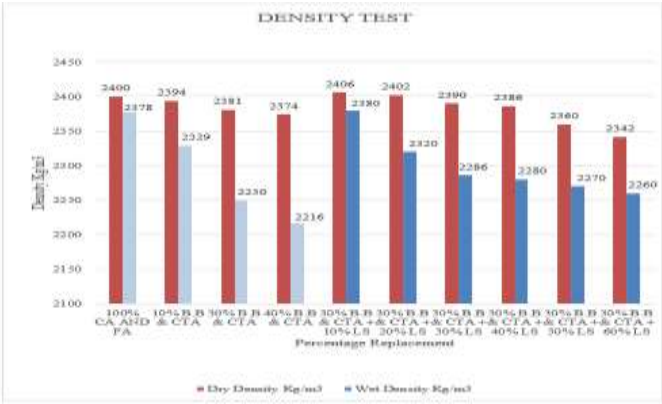

Chart -5: Bulk density test results

4.5 FLEXURAL STRENGTH TEST RESULTS

For each trial mix carried out beam of size 150X150X700mm where casted and tested for 7,14and 28 days curing period. The flexural strength test results obtained during each trial mix are tabulated in table 4.5 below. The 28 days flexural strength test results of concrete made with recycled aggregate found to be similar to that of conventional concrete. From the graph plotted shown in chart-6 we can see up to 30% addition recycled aggregate flexural strength where good and beyond 30% addition of recycled aggregate we can see decline in graph. Hence concrete made of recycled aggregate have good flexural property and also can resist all the stress and moment coming on it.

Table -4.5: Flexural strength test results

Sl. No	Mix Designation	Percentage replacement	Avg. Flexural Strength [N/mm²]		
			Days		
			7	14	28
1	S1	100%CA & 100%FA	2.12	3.23	5.33
2	S2	10% BB&CTA & 100% FA	1.90	2.68	4.62
3	S3	30% BB&CTA & 100% FA	2.12	3.00	5.15
4	S4	40% BB&CTA & 100% FA	2.06	2.38	4.26
5	S5	30% BB&CTA & 10% LEAD SLAG	1.81	2.39	4.40
6	S6	30% BB&CTA & 20% LEAD SLAG	1.92	2.48	4.62
7	S7	30% BB&CTA & 30% LEAD SLAG	2.10	2.77	4.97
8	S8	30% BB&CTA & 40% LEAD SLAG	1.80	2.47	4.26
9	S9	30% BB&CTA & 50% LEAD SLAG	1.76	2.20	3.73
10	S10	30% BB&CTA & 60% LEAD SLAG	1.50	2.00	3.37

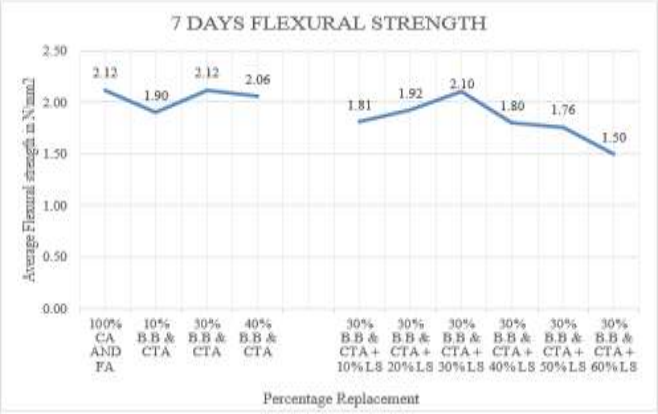

Chart -6: Flexural strength test results for 7 days

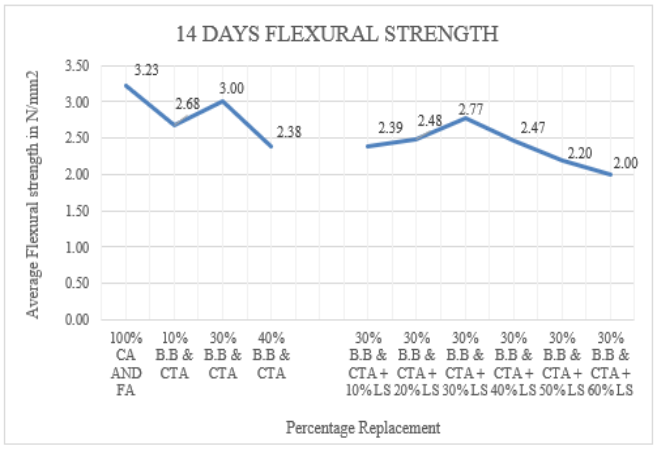

Chart -7: Flexural strength test results for 14 days

Chart -8: Flexural strength test results for 28 days

4.6 SPLIT TENSILE STRENGTH TEST RESULTS

For split tensile strength test 90 cylinder of diameter 150mm and length 300mm where casted in this project and split tensile strength test were conducted on 7, 14 and 28 days. The values of split tensile strength test obtained during testing are presented in table 4.10. The split tensile strength test value for concrete made of crushed brick bat, clay tile and lead slag is 3.12 N/mm^2 which is almost equal to normal concrete that is 3.20 N/mm^2. The results for split tensile strength test where good up to 30% partially replacement of recycled aggregate in concrete beyond 30% results started declining.

Table -4.6: Split tensile strength test results

Sl. No	Mix Design ation	Percentage replacement	Avg. Split Tensile Strength [N/mm^2]		
			Days		
			7	14	28
1	S1	100%CA & 100%FA	1.18	1.50	3.20
2	S2	10% BB&CTA & 100% FA	1.12	1.47	2.19
3	S3	30% BB&CTA & 100% FA	1.16	1.48	3.14
4	S4	40% BB&CTA & 100% FA	1.11	1.44	2.80
5	S5	30% BB&CTA & 10% LEAD SLAG	1.13	1.46	2.86
6	S6	30% BB&CTA & 20% LEAD SLAG	1.13	1.48	2.99
7	S7	30% BB&CTA & 30% LEAD SLAG	1.14	1.49	3.12
8	S8	30% BB&CTA & 40% LEAD SLAG	1.12	1.46	2.95
9	S9	30% BB&CTA & 50% LEAD SLAG	1.10	1.44	2.70
10	S10	30% BB&CTA & 60% LEAD SLAG	1.08	1.42	2.05

Chart -9: Split tensile strength test results for 7 days

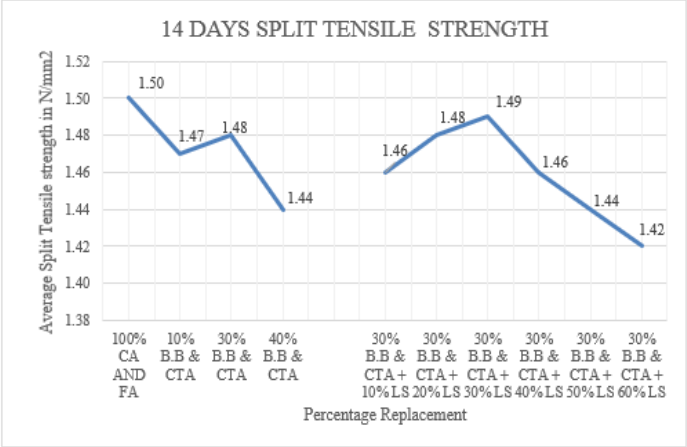

Chart -10: Split tensile strength test results for 14 days

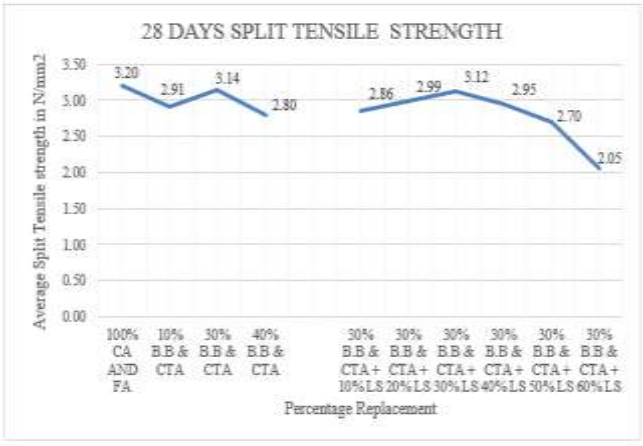

Chart -11: Split tensile strength test results for 28 days

4.7 REBOUND HAMMER TEST RESULTS

Rebound hammer test was conducted on concrete cubes to determine the quality and compressive strength of concrete. Testing was done on cube after 28 days of curing and rebound hammer test was carried out on the cubes having mix design S1, S3 and S7 which gave optimum results in compressive strength test. The values obtained during rebound hammer test is tabulated in

table 4.7. The values obtained in rebound hammer test is similar to the values obtained in compressive strength test. From test results we can say concrete made with recycled aggregate have good strength and quality.

Table -4.7: Rebound hammer test results

Sl. No	Mix Designation	Material Component	Position	Grade	Compressive strength [N/mm²]
1.	S-1	Cube	Vertical downward	M-20	32.3
2.	S-3	Cube	Vertical downward	M-20	28.75
3.	S-7	Cube	Vertical downward	M-20	27.6

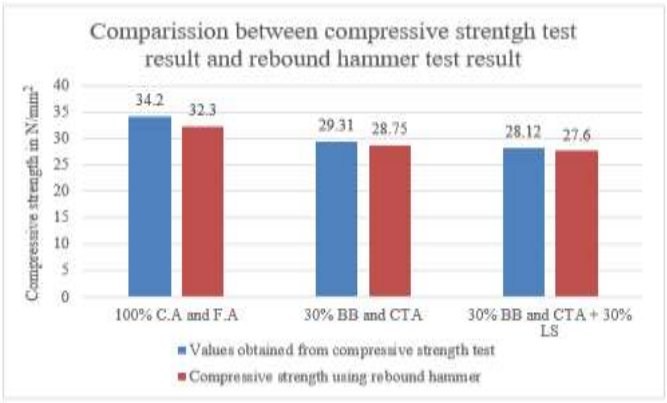

Chart -12: Comparison between compressive strength test result and rebound hammer test result

4.8 ACID RESISTIVITY TEST RESULTS

Acid resistivity test was conducted on concrete cube prepared in this project to determine the durability criteria. Main aim was to study the effect of sulphuric acid attack on concrete prepared in this project. Two concrete specimens where tested one having 100% CA and FA and other having 30% BB&CTA +30% LS percentage replacement in concrete. First concrete cubes where cured in water for 28 days. After that cube is removed form curing and the surface is cleaned and weighed. The specimens are then immersed in 3% sulphuric acid solution for 90 days. After 90 days specimen is removed from solution and loss in weight is determined. The values obtained are tabulated in table 4.8. From the results obtained we can conclude the behavior of concrete made in this project is same has the normal concrete when subjected to sulphuric acid.

Table -4.8: Acid resistivity test results

Sl. No	Mix Designation	Percentage replacement	Weight before Immersion [kg]	Weight after 90 days of Immersion [kg]	Loss of weight [kg]
1.	S-1	100% CA AND FA	8.56	8.32	0.24
2.	S-7	30% BB AND CTA +30%LS	8.06	7.79	0.27

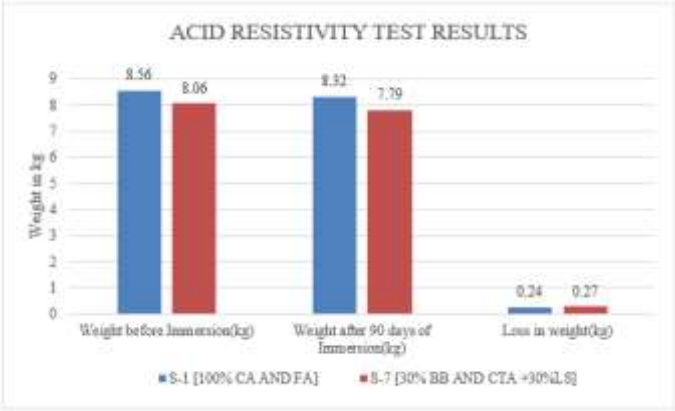

Chart -13: Acid resistivity test results

5. CONCLUSIONS

1. Lead slag used in this study matches the properties of fine aggregate hence can be used alternate material for fine aggregate.
2. From the compressive strength results obtained in this project, it can be concluded that up to 30% of brick bat &clay tiles as coarse aggregate can be replaced and up to 30% of lead slag as fine aggregate can be replaced in concrete.
3. From bulk density test value obtained we can say that Concrete made with brick bat and clay tiles has low density then conventional concrete. Hence concrete made in this project can be used for light weight concrete preparation.
4. Waste brick bat & clay tiles and lead slag an industrial by product are reused in making of concrete in this project. It helps to keep environment sustainable.
5. Since brick bat, clay tiles and lead slag can be used it will contribute to the conservation of both jelly and natural sand.
6. This concrete can be used in small structures where load coming on to the structures is less. Not recommended for high rise structures.
7. Cost of the concrete prepared from brick bats, clay tiles and lead slag is much economical then conventional concrete. Production in large scale can reduce the cost of the concrete per meter cube.

6. SCOPE OF FUTURE STUDY

1. Since lead slag can be down sized to any form. Lead slag can be replacement with cement and coarse aggregate and concrete can be prepared.
2. Since lead slag has same properties as that of jelly. Lead slag can be used in high grade concrete since lead slag is highly resistant to compression.
3. Other than compressive test, flexural test, tensile test. Other test can be performed for the same concrete done with brick bat & clay tiles and lead slag to determine other properties of concrete.
4. There is also scope for lead slag used in self-compacting concrete.
5. Admixture can be used for the mix done in this project to improve performance of concrete in various conditions.

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