PARTIAL REPLACEMENT OF FINE AGGREGATES OF FIRE BRICKS WITH FINE AGGREGATES IN CONCRETE

DISSERTATION II

Submitted by

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DECLARATION

I, Manoj Kumar (11610194), hereby declare that this thesis report entitled **"PARTIALLY REPLACED OF FINE AGGREGATES OF FIRE BRICKS WITH FINE AGGREGATES IN CONCRETE"** submitted in the partial fulfilment of the requirements for the award of degree of Master of Civil Engineering, in the School of Civil Engineering, Lovely Professional University, Phagwara, is my own work. This matter embodied in this report has not been submitted in part or full to any other university or institute for the award of any degree.

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CERTIFICATE

Certified that this project report entitled "**PARTIAL REPLACEMENT OF FINE AGGREGATES OF FIRE BRICKS WITH FINE AGGREGATES IN CONCRETE**" submitted by "**MANOJ KUMAR"** registration number 11610194 of Civil Engineering Department, Lovely Professional University, Phagwara, Punjab, who carried out this project work under my supervision.

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ABSTRACT

India is a developing country. Developing infrastructure leads to consumption of concrete. Sand have big value in concrete. But natural sands are limited resources that is why the partial replacement will contribute to a good point to the research area. Fire bricks are used to prevent the heat transfer in industries, lining furnace, and fire places. The waste material of fire bricks can be used as fine aggregates. Properties of fire bricks are increases the strength of concrete. This research able to reduce the dependency on sand and open a new option to dispose of waste fire bricks.

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CHAPTER-1

INTRODUCTION

1.1 CRUSHED BRICK AGGREGATES

Bricks are the common building materials which are used in construction these days. Crushed bricks in the form of aggregates finer or coarser are called crushed brick aggregates. Bricks are very easy available material. Because natural sand is limited natural resources thus a replacement need occurred. Brick aggregates are very low and its result in concrete is very good. Researcher has tested the aggregates bricks the got the higher compressive strength at 20% partially replaced the fine aggregate of bricks with fine aggregates of concrete. But some researcher found the decrease in the strength up to 40%. That is why is its great success to find the advantage of brick aggregates in concrete. Bricks are found in number of types because it is common usable material. The types of bricks aggregates like common burnt clay bricks aggregates, calcium silicate bricks aggregates, engineering bricks aggregates, concrete bricks aggregates, fly ash clay bricks aggregates, crushed spent fire bricks aggregates, fired brick aggregates, recycle bricks aggregates. Brick aggregates directly affects the concrete properties when concrete are in fresh state and hardened state. Fire bricks are used for inner lining of kiln meant for firing. Due to continuous exposure to high degrees of temperature about 1,800 to2,100ºC for twelve to eighteen days, if any brick keeps less strength or low strength which desired then let it out and put a new brick. The usage or replacement of fire bricks is periodical in nature in metallurgical based industries. The fire bricks disposed off after use are called as Spent Fire Bricks.

The Spent Fire Brick which are the waste should be through properly without causing environmental problems in the vicinity of dump. Usually the waste materials are disposed by land filling. In the similar manner the spent fire bricks are also used as land filling material. The fire bricks so generated as waste, first of all clean it and after then crushed till get fine aggregates. The fineness modulus of crushed spent fire brick powder is nearly equal to river sand used in concrete. As such, the crushed spent fire brick can be used in place of river sand partially in making the concrete. Bricks are made from the burnet fire clay. Bricks are formed in the kiln at 1300°C for 10 to 15 days.

1.2 HISTORY OF BRICK AGGREGATE CONCRETE

People from 7000 BCE have been using bricks. Turkey is that country where first brick is found. On that time bricks were dried in sun light. This sun dried brick is not sufficient strength. But fired brick were very high resistance. In any condition fire brick gave very suitable results. That is why it used in permanent structures. In the construction of buildings, bricks are generally used more than wood than other materials. Now these days many types of machineries are available. With the help of these machineries many types of these bricks are made with different shapes and with different materials. But clay is the first preference for fire bricks. Apart from this, materials such as calcium silicate and concrete are also used much more. Many materials are available now but most using is clay on industry level. In 2007 bricks made with fly ash. And fly ash are using for making roads on footpath and residential areas. Fly ash are taken from thermal power plants.

1.3 ADVANTAGES AND DISADVANTAGES OF HIGH PERFORMANCE CONCRETE

Advantages:-

1. Light weight concrete as compare to conventional concrete.
2. Height strength gives in compression, during tension and in flexure also.
3. Low cost as compare to conventional concrete.
4. Easy to transport.
5. Natural aggregates are the natural resources and which are limited. Thus brick aggregates concrete can be best cheap material instead of natural stones.

Disadvantages:-

1. Lower density.
2. Lower stiffness.
3. Permeable material which causes the higher void ratio.

CHAPTER: 2 REVIEW OF LITERATURE

2.1 LITERATURE REVIEW

2.1.1 Partially replaced of fine aggregates of concrete by fine aggregates of crushed bricks

River sand is most common fine aggregates are used in concrete. River sand is most suitable fine aggregates in concrete. Due to the excessive production of the river sand is banned by government in India. Thus replacement of sand becomes need in last two decays. Number of researches occurring in world on replacement of sand by number of material like waste glass powder, spent fire bricks, crushed brick fine aggregates, crushed coarser aggregates, fly ash, etc. Brick aggregates are very easily available at very low cost. It may be recycled from destroyed buildings, bridges, and any other destroyed structures.

A. Siva *et al.,* 2017, bricks are easily available material. Bricks normally used as the non-bearing wall structure. In this experiment when fine aggregates are partially replaced by crushed bricks in proportion of 10%, 15%, 20%, 25% then found that the workability of concrete is decrease. Compressive strength of is obtained maximum when added 20% of crushed fire bricks. Because crushed fire brick is made of plastic and non-plastic clay. It put into kiln at 1300C for 10 to 15 days. Then its property gets totally changed. The unit weight of fire brick is 20KN/m. crushed fire brick is sieved on 4.75 mm sieve and who passed from the sieve of 4.75 mm sieve and not passed from 75 micron IS- sieve and then partially replaced from fine aggregates.

Table 2.1: Properties of the aggregate of fine

S.N.	Characteristics	Result value
	Sand type used	Sand of river
1.	Specific gravity for fine aggregates	2.61
2.	Moisture content	2.5
3.	Net water absorption	0.9

4.	Fineness modulus	3.1
5.	Grading zone	II

Table 2.2: Properties of Crushed Spent Fire Bricks

S.N.	Characteristics	Value
1.	Specific gravity	2.66
2.	Net water absorption	0.8 %
3.	Fineness modulus	2.98
4.	Grading zone	II

For test the of split tensile strength measured from cylinder is made of 150mm x 300 mm size for M30 concrete grade after partially replacement. After made this keep for 24 hours and curing done up to 28 days. Fine aggregates of fire brick gives higher compressive strength when replaced 20% with fine aggregates. This compressive strength is 1.2% in higher. But strength of split tensile is get less if percentage is increasing more than 20%.

S. Keerthinarayana et *al.,* 2017, As per IS 6 and 8 specifications, the fire bricks are made from plastic and non-plastic clay. These bricks are fired in oil kiln and temperature increased up to 1350°C these are fired in oil-fired kiln at a temperature of 1,300°C. Table 1 shows the physio-chemical properties of the fire bricks.

Table 2.3 Physical properties and properties of chemicals of fire bricks

S.N.	Properties of fire bricks			
	Physical	Values of results	Chemical	Result
1	Bulk for density in Kg/m3	2,000	Aluminum as Al_2O_3 , [%]	30…40
2	Porosity, [%]	25…30	Iron as Fe_2O_3 , [%]	2…2.5
3	Size tolerance, [%]	±2	Silica as	57…65

			SiO2 , [%]	
4	Working temperature, [°C]	1,300…1,400	Alkalis	Trace

Bricks are fire brick are fired at 1750 to 2200 ºC for thirteen to twenty days. If any brick keeps less strength or low strength which desired then let it out and put a new brick. Then, the SFB is an industrial solid waste to be disposal off properly and. First of all these cleaned and crushed into fine aggregates. The concrete contains 62 to 81 percent volumes by coarse and fine aggregates. Performance is totally depend upon the properties like chemical and physical properties. Crash Spartter was compared with fire of bricks, as well as the place of aggregates, with different physical-chemical properties and sands of original creations.

Table 2.4: properties of fire bricks and properties of sand

Tests are done	Result values						
	sand	CSFB					
		S1	S2	S3	S4	S5	Average of values
Specific Gravity	2.31	2.33	2.45	2.23	2.47	2.38	2.37
Bulk density, [kg/m3]	1,247 (1,509)	1,306 (1,551)	1,355 (1,555)	1,296 (1,498)	1,322 (1,551)	1,295 (1,497)	1,315 1,530
Moisture content, [%]	0.03	0.95	0.91	0.96	0.99	0.92	0.95
Water absorption, [%]	0.94	0.81	0.85	0.79	0.78	0.89	0.82
Fineness-Modulus	2.40	2.38	2.37	2.32	2.24	2.43	2.34
pH	7.1	8.40	8.32	8.20	8.44	8.42	8.36

Table 2.5: composition of crushed bricks and sand.

Element	Observed values(result)						
	sand	CSFB					
		S1	S2	S3	S4	S5	Average of values
Silica or SiO2,[%]	90..95	58.2	57.1	56.7	56.9	58.9	57.6±0.947
Iron as Fe2O3,[%]	2.68-8.25	2.41	2.32	2.59	2.4	2.38	2.42±0.101
Aluminum as Al2O3,[%]	0.005-0.01	34.2	34.92	33.7	33.9	34.6	34.3±0.492
Calcium as CaO, [%]	0.9-1.8	2.48	2.56	2.41	2.46	2.76	2.53±0.137
Magnesium as MgO,[%]	0.02-0.7	0.95	0.98	0.91	0.93	0.92	0.94±0.027
Sodium as Na2O,[%]	0.01-0.1	0.25	0.21	0.22	0.19	0.28	0.23±0.035

Table 2.6: distribution of fine aggregates particles

IS sieve size mm	Result					
	sand	CSFB				
		S1	S2	S3	S4	S5
10	100	100	100	100	100	100
4.75	100	100	100	100	100	100
2.36	94.41	92.01	93.1	90.9	93	95.89
1.18	82.50	79.04	82.2	77.4	83.3	79.01
0.60	61.02	61.1	60.0	66	62.01	57.65

0.30	11.201	12.6	11.0	11.89	13.3	9.78
0.15	1.501	1.54	1.39	1.69	1.60	1.16

Compressive strength the sample cube is taken 150 x150*150 mm.

Table 2.7: Compressive Strength for Cubes

Crushed bricks (%)	Compressive strength in MPa		
	7 days	14 days	28 days
0	14.24	17.26	22.1
5	11.81	15.27	17.72
10	15.07	17.30	18.24
15	16.12	22.51	23.51
20	22.18	22.83	23.97
25	26.39	25.94	25.64
30	26.16	20.80	22.10

When crushed spent fire brick is partially replace with fine aggregate then maximum compressive strength is obtained at 25 to 30 % of CSFB for 14 days as well as 28 days.

Table 2.8: Split Tensile strength of concrete.

Crushed bricks	Split tensile strength in MPa		
	7 days	14 days	28 days
0	1.410	1.519	1.979
5	1.384	1.503	1.560
10	1.472	1.759	1.848
15	1.780	1.985	2.141
20	2.061	2.170	2.240
25	2.779	2.581	2.457
30	2.319	2.390	2.389

Test result is same as compressive test result that when CSFB is adding 25 to 30% then tensile strength also increased. Flexure strength is determine by applied the load and when crack in concrete are visible noted that values. Dimension for rupture modulus is 150*150*700 in meter are taken. If more than 600mm span then 100*500 mm with 450mm span and applied point load.

Table 2.9: Flexural Strength test results

Crushed bricks	Flexural strength, [N/mm2]		
	7 days	14 days	28 days
0	2.101	2.319	2.649
5	2.512	2.413	2.526
10	2.750	2.650	2.749
15	2.846	2.746	3.120
20	3.149	3.059	3.837
25	3.499	3.289	3.026
30	2.410	2.701	2.815

When adding CSFB then flexural strength also increase and maximum value is obtained at 20 to 25% of CSFB.

R. Srinivasan *et al.,* 2010, Spent Fire Bricks" or called SFB, walls and chimney lining produces waste material. Now this material using for partial replacement with sand in concrete. Concrete is contain all aggregates 65 to 81% volume of concrete. The properties of concrete also depends on physical properties and chemical properties.

(Naik 1987, IS: 383, 1970, IS: 10262, 1981).

Table 2.10: Physio-chemical properties of the fire bricks

S.N.	Physical	Values	Chemical	Values
1	Bulk density	2000 kg/m3	Aluminum as Al2O3	30-40%
2	Porosity	25-30%	Iron as Fe2O3	2-2.5%
3	Size tolerance	± 2%	Silica as SiO2	57-65%

4	Working temperature	1300-1400ºC	Alkalies	Trace
5	Crushing strength (cold)	24.5 –27 N/mm2		

In CSFB the aluminum content is very high. Fire brick contains the silica and aluminum and also iron. Crushed spent fire brick having more calcium which help to increase the value of strength of concrete. In fire brick decrease the silica value and increase the alumina up to 35.34%. Fire bricks sources can easy to find. CSFB can be taken in low coast industries. Industry waste is same problem as construction waste. Test on crushed fire bricks is same as river sand and belongs from Zone-II. The CSFB seems to possess Pozzolana properties, as it contains silica, alumina, and little calcium. The SFB may aid in enhancing the bench-marked thermal performance of concretes.

Tiwari Darshita *et al.,* 2012, as per IS-10262, cubes is formed of grade for M20, M25, and M30. The cubes is crushed in labs and follow the criteria of IS code of 1343-1980. The crushing strength is measure for 3days, 7days, 28 days. And observed that for M20 grade in which sand is partially replaced by the brick powder. When added 10% brick powder the compressive strength is decreases and when added 20% brick powder the strength is increased. If increased the brick powder more than 20% then decrease the compressive strength of M20 grade concrete.

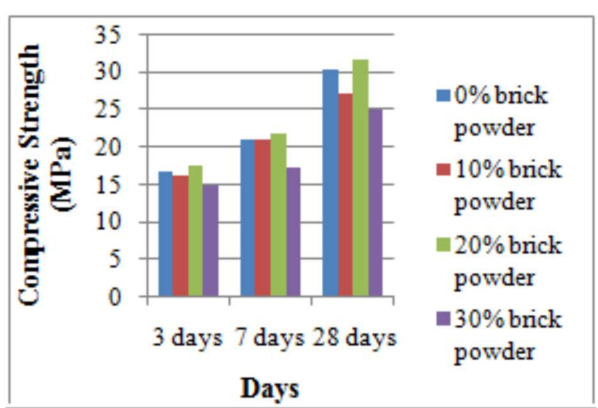

Figure 2.1: compressive strength for M25 concrete with fire brick powder

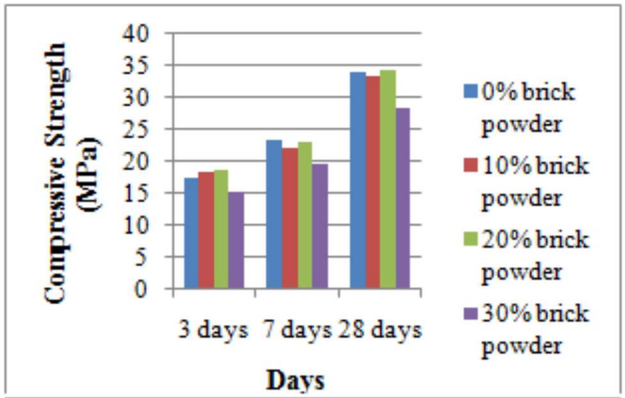

Figure 2.2: compressive strength for M25 concrete with fire brick powder

Same things happen when takes the M25 grade sample. For 3days when added 10% brick powder then strength then slightly decreases the compressive strength when added 20 % the compressive strength is increased and when further increased up-to 30 % rick powder the strength will decreases. For 7 days M25 grade strength is increased at 20 % replacement of brick powder with fine aggregates and when further increased or decreased then strength will decreased. For 28 days M25 grades when the result is same the maximum compressive strength is found when 20% brick powder is added. The size of brick powder and sand is taken who passes the IS sieve 4.75 mm and retained on 75 micron.

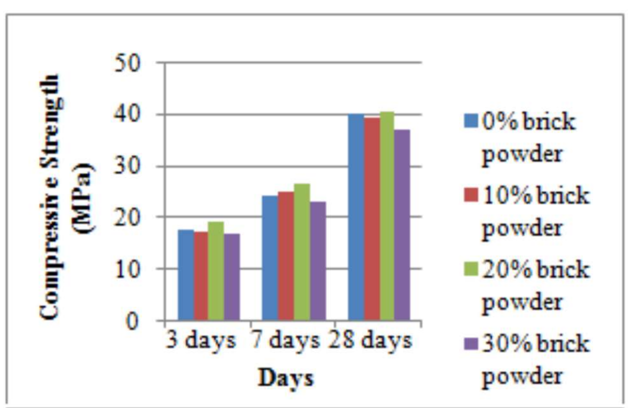

Figure 2.3: Compressive strength of M30 with brick powder.

The maximum strength is gained when 20% brick powder is added for M30. Strength is observed for 3, 7 and 28 days.

Bhoria B.V. ***et al.*****, 2013,** the spent fire bricks are belongs from Zone-II. This property required for make best concrete. Maximum strength is gained when fire brick powder is added 25% which is replaced with fine aggregates in concrete. Fire bricks are made from plastic and non-plastic clay. The different materials should be homogenous and can bear high compression for concert into any shape. These are fired in kiln of oil and temperature 1550ºC. After it cleaned and crushed into fine aggregates.

Veerni Lakshmi. ***et al., 2016*****,** Usually the Fire bricks are used for inner lining of kiln meant for firing. Due to continuous exposure to high degrees of temperature about 1,800 to 2,100ºC for a period of eleven to seventeen days, which brick are damage those brick is throughout and new raw brick is placed. The usage or replacement of fire bricks is periodical in nature in metallurgical based industries. The fire bricks disposed off after use are called as Spent Fire Bricks. The fineness modulus of crushed spent fire brick powder is nearly equal to river sand used in concrete. As such, the crushed spent fire brick can be used in place of river sand partially in making the concrete.

Table.2.11: Physio-Chemical Properties of Sand and Crushed spent fire brick

S.N.	Properties of Material	Sand	crushed spent fire brick
1	Specific Gravity	2.53	2.53
2	Fineness Modulus	2.36	2.65
3	Bulk Modulus in loose state	1548	1437
4	Bulk Modulus in compact state	1696	1696
5	pH value	7.2	8.01
6	Percentage of Silica	90-95%	37%
7	Percentage of Alumina	0.005-0.01%	50%

8	Water absorption	0.94%	1.50
9	Stability and Reactivity	No	No

Both sand and crushed spent fire brick aggregate have almost the same specific gravity, fineness modulus, bulk density, porosity and pH value. Whereas, % of silica, % of Alumina, % of water absorption were found to be different and The crushed spent fire brick was made of very fine clay material, it keeps to very high temperature during manufacturing, but does not affect the quality of concrete when used as an ingredient. The suitability of crushed spent fire brick aggregate as an ingredient in making concrete was investigated for in this study proved good. The natural sand was partially replaced by different % of crushed spent fire brick for arriving at the optimum % of replacement that gives maximum strength. As per the mix design, the river sand was partially replaced by Crushed Spent Fire Brick in 10%, 20%, 30% 40% and 50% and specimen were cast as per the procedure laid down in IS 456-2000. After 24 hours, the test specimens were demoded and cured and tested after 7 days for Compressive Strength. The test results are tabulated as follows.

Table 2.12: days Compressive Strength of concrete for different % of crushed spent fire brick

S.N.	% of crushed spent fire brick replaced	7 days Compressive Strength in N/mm2
1	0%	22.15
2	10%	22.67
3	20%	27.33
4	30%	28.74
5	40%	26.59
6	50%	27.03

It was observed that concrete with 30% replacement gave maximum strength and the maximum 7 days compressive strength is 28.74 N/mm2 .A Total of 18 Cubes, 18 Cylinders and 18 Prisms 6 beams were cast to carry out the experimental study. Minimum of 3 specimens were cast as stipulated by IS Code 456:2000 for 3, 14 and done for 28 days. Cast of size of cube 150×150×150mm, Cylinders of size 150×300mm, Prisms of size 100×100×500mm and RCC beams of size110×210×1600mm, curing them in water for 7days, 14 days and 28 days. After curing the sample tested for compression strength, split tensile and flexure Strength. The test were done as per specifications in IS 516-1959. The aggregates are replaced with 10%, 20%, 30% 40% and 50% for measure the comressive strength of concrete and The optimum % of crushed spent fire brick that has given maximum strength was found to be at 30% replacement for 7 days. The slump decreases with increase in % of crushed spent fire brick. The compressive, tensile and flexure strength with partially replaced with fine aggregates in concrete. The increase in compressive strength was 29.75 %.

- The increment in Split tensile strength was 15.24 % at 7 days, 25.97 % at 14 days and 38.07 % at 28 days
- The increase in Flexural strength was 0 % at 7 days, 19.23 % at 14 days and 38.74 % at 28 days

M. Usha *et al.,* 2016, in this experiments the bricks are taken from the damage buildings. It makes in finer form who passes from 4.75 mm IS sieve and retained on 0.075 micron. In this experiments the brick powder is replaced with sand at 15%, 20% and 25%. Design mix is used for M25 grades. The tensile, compressive strength is checked out and found that the no compressive strength is increased at 20% at 7, 14 and 28 days. For split tensile strength found that when replacement is done at 20% the tensile strength is also increased at 7, 14, and 28 days. For flexure replacement but when replacement is further increased then decreases the flexure strength at 7, 14 and 28 days. And concludes that strength is increased at replacement of 20%.

A. Nisha Devi *et al.,* 2017, glass powder is partially replaced with cement. And fine aggregate of fire bricks are partially replaced with fine aggregates. In this experiments glass powder increase the workability and fire brick powder act as a filler in concrete and increases the flexure strength, ductility, compressive stress, tensile strength.

Table: 2.13 Properties of fire brick

S.N.	Properties fire bricks	Fire bricks
1	Fineness modules	2.34
2	Specific gravity	2.65
3	Water absorption	0.9%

In this project the glass powder is replaced with cement at 10%, 20% and 30%. Fire brick powder is replaced at 10%, 15%, 20%, and 25%. Ordinary Portland cement are used which having 43 grade. Fire brick powder belongs from Zone-II. For compressive strength cube is formed of 150x150x150 in mm. and is measure after the 3, 7 and 28 days.

Table 2.14 Slump Value for Fresh Concrete

S.N.	Description	Percentage	Slump
1	Normal concrete	0	40
2	Fine aggregates are replaced by CSFB	10	36
		15	34
		20	31
		25	24

Crushed spent fire brick is gives higher compressive strength at 20% replaced. More than 20% it reduces the strength.

Split tensile strength increases at 20 % replacement of fine aggregates of fire brick. When replacement further increases the tensile strength is decreases.

Gopinandan Dey *et al, 2013*, six nos. cubes are formed compressive strength. And twelve cubes are formed for different temperatures. Three cubes are formed for flexure strength. Design mix is made for M30. Strength is increases with the increases temperature. Strength of concrete gradually increases up to 600 degree Celsius. And after 600 degree Celsius the strength of concrete is gradually decreases and strength at 28 days decreases 60 to 70%. Crushed bricks result is better in M25 and 35 and suitable water cement ration is 0.35 to 0.35.

Table 2.15 Strength of concrete

Water cement ratio	Water (Kg)	Cement (Kg)	Coarse aggregate (Kg)	Fine aggregates (Kg)	Superplasticizer (Kg)	Slump (mm)	Compressive strength (MPa)	Flexural strength (MPa)
0.45	171	380	857	564	3.3	135	28.67	4.40
0.40	171	430	850	534	3.3	125	31.94	4.80
0.35	157	450	870	522	4.5	140	38.72	5.13
0.38	171	450	842	529	3.3	80	39.67	5.60

Chapter: 3 RESEARCH METHODOLOGY

3.1 In this project, increasing the strength of concrete from partially replaced the fine aggregates of fire bricks with fine aggregates in concrete. The design mix of concrete is based on IS: 10262: 2009. This design mix used for ordinary Portland cement. This proportioning to achieve the compressive strength of at standard age than normal concrete. Fine aggregates of fire bricks which are replacing with fine aggregates in concrete having IS: 6 specification. The replacement is done at different percentage which increasing the compressive strength of concrete. Fire brick are made from clay and having rich amount of alumina which increase the strength of concrete and make more fire resistant. Fire bricks are uses where the high temperature like boiler industries, power plants. Waste fire bricks are used for replacement in concrete. The test are conducted for physical properties of materials. The physical properties of river sand and fine aggregates of fire bricks are near about same. Ordinary Portland cement are used in this experiments which having 43 grade. Test are conducted on cement are Consistency, Fineness, Initial and Final setting time and specific gravity and soundness of cement. Test on fine aggregates are conducted fineness modulus, sieve analysis, specific gravity, water absorption, particle size distribution for fine aggregates. Test are conducted for Coarse aggregates for particle size distribution for Coarse aggregates, specific gravity of Coarse aggregates, abrasion value for Coarse aggregates. After material testing test the cubes of concrete are formed at different percentage replacement with fire brick fine aggregates.

3.2 Design specification

1. Material testing.
2. Target strength
3. Ratio of water and cement.
4. Water content
5. Cement content
6. Find out the volume for Coarse aggregate & fine aggregate in proportions.

3.3 MATERIALS

3.3.1Cement

Cement used as a binding material in constructions. It becomes harden when comes with the contact of water. Cement used to bind the building materials. ‘Cement’ names comes from ancient roman emperor. Opus caementicium is called Roman concrete. Roman concrete is based on the hydraulic setting. But modern cement is based on the Portland cement which are using in this project.

3.3.1.1 Types of cement

1 OPC (Ordinary Portland cement)
2 Portland blast furnace cement
3 Portland Pozzolana cement

4 Rapid hardening cement
5 vii. Portland silica fume cement
4 viii. Masonry cements
5 ix. Expansive cements
6 White cement
7 Black cement
8 Colored cement
9 Slag-lime cements
10 Geo polymer cements

3.3.2 Fine Aggregates

Fine aggregates are formed by disintegration of rocks by natural weathering or by man-made. River sand are mostly used in construction. Its particle size is lesser than silt but greater than coarse aggregates. Composition of sand varies because depend upon their parent rock and environment condition. But major content in soil is silicon dioxide or SiO2. Fine aggregates or sand are also classified in two categories are coarse sand and fine sand. For RCC constructions coarse sand are used while for decoration purpose like plastering fine sand are used in construction. Less than 4.75 mm size aggregates are called fine aggregates. Fine aggregates are limited resources they cannot formed quickly in nature. Thus the large stones are crushed in crusher and makes desired size of partials. According to IS specification finer aggregates are four types from Zone-1 to Zone- 4. In Zone-1 to Zone-4 fine aggregates passes 90% to 100% from 4.750 mm IS sieve. And 0% to 14.99% passes from 150 micron IS sieve it's depend upon the grading of Zone.

3.3.3 Coarse Aggregates

The aggregates which retains on 4.75mm IS sieve that are called coarse aggregates.

- **Natural aggregates**: aggregated which are formed by natural disintegration process are called natural aggregates.
- **Crushed aggregates**: aggregates which are crushed in stone crusher machines. This is artificial and very fast process.

According to size is described in grades like 20mm, 12.5mm, 40mm, and 16mm. Its mean 20mm passes through the IS 20mm sieve according to its grades. From the Roman Empire tha coarse aggregates are used. Coarse aggregate are very hard, impermeable, high crushing strength. Thus it is used for making foundations, drainage work, bridges for railway and highways. Fine aggregates and course aggregates are used 68% to 80% volume of concrete. Which shows its importance in concrete. Coarse aggregates are comes in different shapes like round, sub round, angular, sub angular. Angular aggregates are most suitable for construction. Coarse aggregates are also used like different stones like marbles, coconut shell aggregates, fire brick aggregates are also used in concrete.

3.3.4 Fine Aggregates of Fire Bricks

Fire bricks are formed similar to ordinary brick but they are fired at very high temperature like 1300ºC. It has higher content of aluminium and manufactured as per IS: 6 and IS: 8 specifications. Fire bricks are denser which gives more resistance to abrasion, lower thermal conductivity, it absorbs the heat but not transfer to its surrounding. Due to exposure in very high temperature like 1300ºC for 12 to 15 days. They loss of some mechanical and physical properties and replaced that brick by a new brick. That deformed fire brick can be used in concrete as a fine aggregates. Fire bricks are easy available materials. Because every state are growing with industrialization in India. Fire bricks are using for protect the transferring the heat to surrounding. Fire brick fine aggregates can be best alternates for partially replacement with sand. Fine aggregates of fire brick are obtained from the crushing of fire bricks. Aggregates which passes from 4.75mm IS sieve that can be used as fine aggregates.

3.3.4 Water

Water for construction of concrete structure should be same quality as drinkable water. The strength of concrete is totally depend upon the water thus water should be free from any type of dust. Impurities like suspended solid, dissolved salts organic matter. Which can change the properties of concrete. These impurities can be changed setting time, hardening, strength, durability and etc.

Water should be tested from an approved lab and should be checked regularly.

Chapter: 4 RESULTS AND DISCUSSION

4.1 Tests on cement

4.1.1 Standard consistency of cement

Table 4.1 consistency of cement

S.N.	Weight of cement (gm.)	% of water added	Volume of water (ml)	Penetration from bottom of mould (mm)
1	350	24	84	36
2	350	28	98	34
3	350	32	112	10
4	350	36	126	6

Standard consistency of cement (P) = 36%

4.1.2 Initial setting time of cement

Mass of cement = 350 gm.
Gauge time = 3 mins.
Needle = 1 mm2 are and 50 mm long
Consistency of cement (P) = 36%
Quantity of water (Qs) = 0.85P
P = [(36/100)*350]
Qs = 0.85 * [(36/100)*350] ml
= 107.1 ml

Table 4.2 Setting time of cement

S.N.	Times (minutes)	Initial Reading (mm)	Surface penetration (mm)	Penetration from bottom of mould

1	0	40	0	40
2	5	40	0	40
3	10	40	3	37
4	15	40	3	37
5	20	40	3	37
6	25	40	4	36
7	30	40	4	36
8	35	40	4	36
9	40	40	4	36
10	45	40	4	36
11	50	40	5	35
12	55	40	5	35
13	60	40	6	34
14	65	40	6	34

Initial setting time = 30 mins
Final setting time

(1) Attach the needle with rod
(2) Release the road.
(3) Note the time when needle does not penetrate.
(4) Final setting time recorded is 572 mins.

4.1.3 Fineness modulus of cement

(1) Cement weight (w1) = 100 gm.

(2) Weight of cement retained on 90 micron cement (w2) = 15 gm.

(3) Weight of cement collected in pan (w3) = 85 gm.

Fineness modulus of cement = (w3/w1)*100

= (85/100)*100

= 85%

Table 4.3 Properties of cement:

S.N	Cement Properties	Observed Values
1	Specific gravity	3.151
2	Normal consistency	36%
3	Initial setting time Final setting time	30 mins. 572 mins

4.2 Tests on fine aggregates

4.2.1 Specific gravity of sand

Table 4.5 Specific gravity of sand

S.N.	Weight of Pych. Empty (gm.) W1	Weight of Pych+dry sand W2	Pych + dry sand + water (gm.) W3	Pych +water (gm.) W4	Specific gravity of sand (gm.) (Gs)	Oven dried weight (gm.)	Weight of sand sample (gm.)
1	620	1120	1791	1486	2.564	496	500

Weight of tray + oven dried sand = 954 gm.

Weight of tray empty = 458 gm.

Oven dried sand weight = 954 – 458 gm.

= 496 gm.

Weight of sand (sample) = 500 gm.

Gs = [(w2-w1)]/ [(w2-w1)-(w3-w4)]

= [(1120-620)]/ [(1120-620)-(1791-1486)]

= 500/195

= 2.564

4.2.2 Water absorption test for sand

Table 4.6 Water absorption for sand

S.N.	Weight of empty tray (gm.)	Weight of tray + oven dried sand (gm.)	Oven dried sand (gm.)
1.	458	954	496

Percentage of water absorption of sand = [(weight of sand sample – oven dried sand)/ (oven dried sand)] * 100

= [(500-496)/ 496] * 100

= 0.8

4.2.3 Particle size distribution of sand

Table 4.7 Sieve analysis done for Fine Aggregate

S.N.	IS Sieve size (mm)	(1) Weight retained (gm.)	(2) Percentage of weight retained	(3) Cumulative weight retained	(4) Cumulative percentage of weight	Percentage finer 100 – column (4)

			(%)	(gm.)	retained (%)	
1	10	0	0	0	0	0
2	4.75	9	0.6	9	0.6	99.4
3	2.36	226	15.067	235	15.67	84.33
4	1.18	360	24	595	39.67	60.33
5	0.60	290	19.33	885	59	41
6	0.30	344	22.93	1229	81.93	18.07
7	0.15	40	2.67	1269	84.60	15.40
8	Pan	231	15.4	1500		0
9	Total	1500			281.47	

Fineness Modulus = ∑ Column (4)/100 =281.47/100 =2.81

Zone – II

Sand type: Medium Sand

4.3 Tests on coarse aggregates (20mm)

4.3.1 Specific gravity test for coarse aggregates and also the water absorption test for coarse aggregates.

Table 4.8 Specific gravity and water absorption test of coarse aggregates

Weight of Sample of coarse aggregates (w1) (gm.)	Weight of pychnometer + water (w2) (gm.)	Weight of pychnometer +aggregates + water (w3) (gm.)
505	1520	1810

W4 = w3 – w2
= 1810 – 1520
= 290

Oven dried coarse aggregates = 498 gm.

Specific gravity of coarse aggregates (Gca) = 498/ (498-290)
= 2.3

Water absorption of coarse aggregates (%) = [(505-498)/ (498)]*100
= 1.41 %

4.3.2 Fineness modulus for coarse aggregates

Table 4.9 Fineness modulus for coarse aggregates

IS sieve size (mm)	Retained weight (Kg)	Cumulative retained weight (Kg.)	Percentage of retained weight (%)	Cumulative of retained percentage (%)
63	0	0	0	0
50	0	0	0	0
40	0	0	0	0

25	0	0	0	0
20	0.03	0.03	0.55	0.55
16	3.2	3.23	58.18	58.73
12.5	1.7	4.93	30.91	89.64
10	0.4	5.33	7.27	96.91
6.3	0.15	5.48	2.72	99.63
4.75	0	5.48	0	99.63
Pan	0.02	5.5	0.37	
Total	5.5			445.09

Fineness modulus of coarse aggregates = 445.09/100 = 4.45

4.3.3 Loss Angels abrasion test for coarse aggregates

Weight of sample (w1) = 5000 gm.
Weight retained from 1.7 mm sieve (w2) = 4435 gm.
No of ball used = 15
No of rotations = 500
Speed = 30 rpm

Abrasion value = [(w1-w2)/w1]*100
= [(5000-4435)/500]*100
= 11.3 %

4.4 Design mix of concrete as per (IS: 10262: 2009) Indian standard method

Design mix having following steps:

1. **Target strength (Fck')**

Fck' = fck + 1.65s

s= standard deviation
= 4 n/mm2 for M25 (from table 1)
fck = characteristics compressive strength of concrete
= 25 N/mm2

Fck = 25 + (1.5x4)
= 31.6 N/mm2

2. **Water cement ratio (w)**

Grade of concrete = M25
Concrete type = PCC
Environment exposure = extreme

Cement content maximum = 280 Kg/m3
Maximum free water cement = 0.40

3. **Maximum water content**

Maximum size of aggregates = 20 mm
Maximum water content = 186 Liter.

If slump is more than 50 mm then 3% water is more added

= [186/ (3/100)] + 186 = 191.5 Liter.

4. **Cement content**

Water and cement ratio = 0.40
Cement content = 191.5/0.40 (for slump = 65 mm)
= 478.75 Kg/m3

5. **Volume find out in proportions**

Nominal size of aggregates = 20 mm
Zone-II
Volume of coarse aggregates per unit volume of total aggregates = 0.6
Volume of fine aggregates = 1-0.62
= 0.38

6. **Design for M30 strength**

Grade of concrete = M25
Cement type used = OPC of 43-Grade
Nominal size of aggregates (maximum) = 20 mm
Cement content (minimum) = 478.75 Kg/m3
Water and cement ratio = 0.40
Workability = 65 mm (slump)
Exposure condition = extreme
Type of aggregates = sub angular

Material Test result values:
Specific gravity of cement = 3.151
Specific gravity of fine aggregates = 2.6
Specific gravity of coarse aggregates = 2.3
Water absorption of fine aggregates = 4 gm.
Water absorption of coarse aggregates = 5.76 gm.

7. **Calculations for Mix proportions**

- Concrete volume = 1m3

- Cement volume = [{(cement mass)/ (Cement's specific gravity)}x (1/1000)
  = [{(478.75)/ (3.15)} x (1/1000)]
  = 0.15 m3
- Water volume = [(water mass/ water's specific gravity) x (1/1000)
  = (140/1) x (1/1000)
  = 0.140 m3
- Total aggregate volume = Total concrete volume – cement volume – water volume
  = 1-(0.15+0.140)
  = 0.71 m3
- Coarse aggregates' mass = (Total aggregate volume) x (coarse aggregates volume)x(coarse aggregates' specific gravity)x1000
  = 0.71x0.62x2.3x1000
  = 1012.46 Kg.
- Fine aggregates' mass = (Total aggregate volume) x (fine aggregates volume)x(fine aggregates' specific gravity)x1000
  = 0.71x0.38x2.6x1000
  = 701.48 Kg

Table 4.10 Proportion for concrete M25

Proportion of concrete (ratio)			
Cement	Fine aggregates	Coarse aggregates	Water
1	2.53	4.13	0.93

CONCLUSION

- Target strength is designed 30 MPa for M25 grade of concrete.
- Procedures are also based on literature reviews.
- Abrasion values for coarse aggregates are 11.5 which are less than 40.
- Water absorption for coarse aggregates and fine aggregates are less than 2%.
- Test on materials are not exceed permissible values.
- Specific gravity of fine aggregates of fire bricks is same as the specific gravity of sand.
- Both fine aggregates are satisfying Zone-II.
- Fine aggregates of fine brick aggregates and sand having same water absorption value is 0.8%.

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