EXPERIMENTAL STUDY ON MORTAR AND FLEXURAL BEHAVIOUR OF FERROCEMENT PANEL WITH PARTIAL REPLACEMENT OF BIOMEDICAL WASTE ASH WITH CEMENT

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ABSTRACT
Biomedical waste means waste generated during the diagnosis and treatment of human beings and animals. They are classified as hazardous and non-hazardous waste. The non-hazardous wastes are the general waste. The hazardous waste includes infectious waste, pathological waste, genotoxic waste, pharmaceutical waste and chemical waste. They contain heavy metals, pressurized containers and radioactive waste which are toxic, harmful, carcinogenic and infectious. The most important method used for the treatment of the hazardous waste is the incineration method. The ash is disposed on barren land and as landfills which when inhaled causes health problems to human beings. Hence proper steps must be taken to dispose the waste ash in a better way. Ferrocement is a system of reinforced mortar or plaster. The work is concentrated on two major aspects, first part of the present study has been focused on the effect of biomedical ash on compressive strength in mortar mix and the second part of the work focusing the behaviour of ferrocement slabs under flexural loading both with the replacement of cement by various percentages. The result obtained from this work is expected to be useful in determining the strength of mortar mix and ductility of ferrocement slabs subjected to similar types of loads and thus will help towards designing ferrocement elements to withstand repeated flexural loading with optimal replacements. The strength of ferrocement slabs with various replacements and its characteristics are also discussed by comparing it with the nominal ones.

1. INTRODUCTION

Cement is the most important binding material used all over the world for most of the constructions. But cement industry is one of the primary producers of carbon-dioxide, a major greenhouse gas which has its own environmental and social impact. Carbon dioxide is produced when calcium carbonate is thermally decomposed this is when it is heated to very high temperature in order to form clinkers. On the other hand, various steps are taken in order to reduce the amount of production of cement to save the environment. Hence cement is being replaced with different materials. These materials are either partially or completely replaced with cement and their physical characteristics are tested and compared with the nominal mixes. There are different types of cements available, but the commonly used cements are Ordinary Portland Cement(OPC) and Portland Pozzolana cement(PPC). These differ primarily in their composition, PPC commonly had pozzolan material added to cement. The pozzolan commonly used is the fly ash, which is one of the coal combustion products composed of fine particles that are driven out of the boiler with flue gases. The name Portland cement was given by Joseph Aspdin in 1824 due to its similarity in colour and its quality when it hardens like Portland stone. Portland stone is white grey limestone in island of Portland, Dorset.

1.1 OBJECTIVE

1) To find the optimal amount of water cement ratio for the mortar mix.
2) To study the compressive strength of various mortar mix with corresponding to the replacements.
3) To study the behaviours of slabs with addition of superplasticizer.
4) To study the crack patters and deflection with respect to the loadings.

1.2 SCOPE

1) Mortar mix 1:2 with the water-cement ratio 0.35 casted in moulds of size 70x70x70cm with replacements of biomedical ash for cement as 0%, 5%, 10%, 15%, 20% and 25%.
2) The compression strength for the mortar mix is to be tested.
3) Ferrocement slabs are casted with mortar mix 1:2 and water-cement ratio 0.35 with super plasticizer 0.02% of weight of cement in moulds of standard size 500x150x25mm in volume fractions of 3.16% and 4.22%. The same replacements of 0%, 5%, 10%, 15%, 20% and 25% are casted.
4) The slabs are to be tested for flexural strength.

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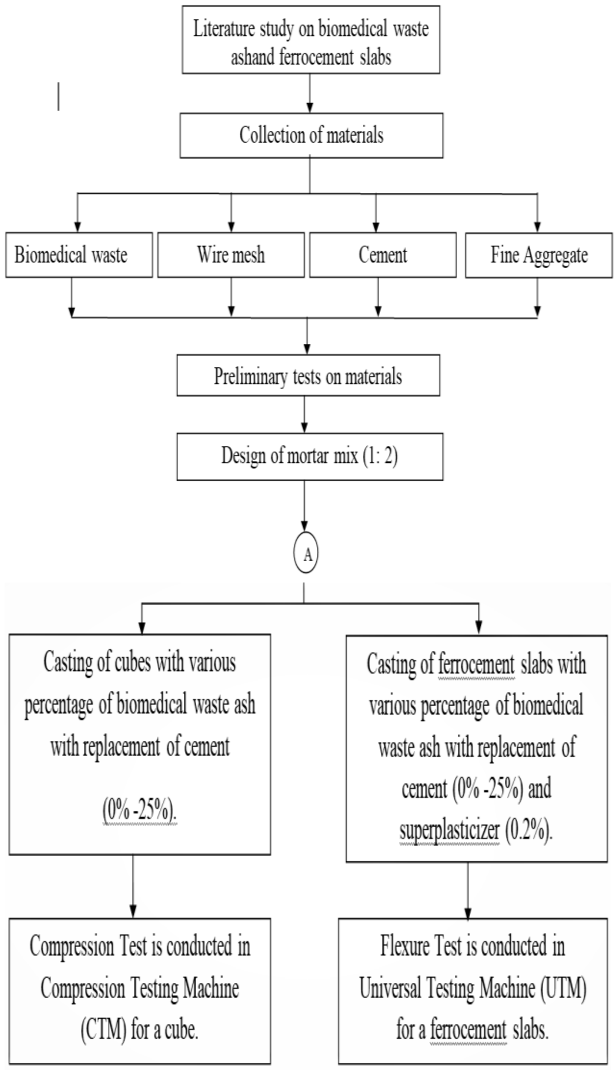
2. METHODOLOGY



3. MATERIALS

3.1 Cement

Ordinary Portland Cement (OPC) from Dalmia cement factory is used. One of the methods of specific gravity of cement is to use liquid such as kerosene, which does not react with cement and water in a density bottle. The Physical Properties of Cement are shown in table 1.

Table 1. Physical Properties of Cement

Name of the tests	Tested value
Standard consistency test	31 %
Initial setting time	37 min
Fineness	6 %
Specific gravity	3.15

3.2 Fine aggrgate

River sand passing through 4.75mm sieve is used. Physical properties of aggregates determined as per IS 2386 – 1968. The physical properties of fine aggregate are shown in table 2.

Table 2. Test results of Fine aggregate

Description	Fine aggregate
Specific gravity	2.60
Water absorption	1%
Sieve analysis	Conforming to zone III
Fineness modulus	2.87%

3.3 Wire mesh

Steel mesh reinforcement is broadly used as the main and characteristic reinforcing for industrial concrete floor slabs and shortcrete. The main reason for addition of meshes to mortar is to develop the post cracking response of the concrete i.e., to improve its energy absorption capacity and apparent flexure.

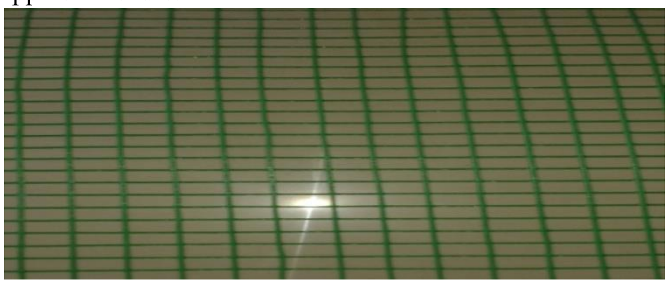


Figure 1. Wire mesh

3.4 Super plasticizer

The super plasticizer composed of Sulphonated Napthalene Polymers, in accordance with IS9103-1999, was used as the chemical admixture. It was a type F high range water reducing admixture complying with ASTM C-494. It was a brown liquid instantly dispersible in water, with a specific gravity was 1.22.

3.5 Water

Ordinary potable water, free from suspended particles and chemical substances was used for both mixing and curing in all the experimental investigations.

3.6 Bio medical Ash

Bio medical ash from Medicare enviro systems, Thanjavur, Tamil Nadu, India is used. The density of flyash was found in the range 0.37-0.82 kg $m^{-3}$and the density of bottom ash was found in the range 0.732-1.04 kg m^{-3}.

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Figure 2. Bio medical Ash

3.7 Concrete mix proportion

Mortar is prepared by calculating the exact amount of cement, sand and water by considering the appropriate mix design (1:2), water-cement ratio (0.35) and super-plasticizer (0.2%). At first the cement and sand were mixed dry. Water and super-plasticizer is gradually added to the dry mix and is mixed by using shovel.

Table 3. Material required for 1m^3 of Concrete (Kg/m^3)

Mortar Mix	1:2
Biomedical ash	5%,10%,15%,20%,and 25% of total Cement by weight
Water binder ratio	0.35
Super plasticizer	0.6% of total Cement by weight
Mesh	Galvanized weld mesh
Number of layers	3 layers and 4layers

4. TESTING RESULTS

4.1 Compression Test

The compressive strength of the cubes for 28 days of mortar mix 1:2 is shown in the Table 6.1 and Figure 6.1.

Table 4. 28-dayCompressive strength of mortar cubes

Specimen Designation	Amount of biomedical ash replaced	Weight (gm)	Area of cube (mm^2)	Compressive strength (N/mm^2)
CM	0%	800	4900	54.28
BM_5	5%	778	4900	53.87
BM_10	10%	786	4900	54.48
BM_15	15%	739	4900	54.89
BM_20	20%	771	4900	49.38
BM_25	25%	765	4900	41.42

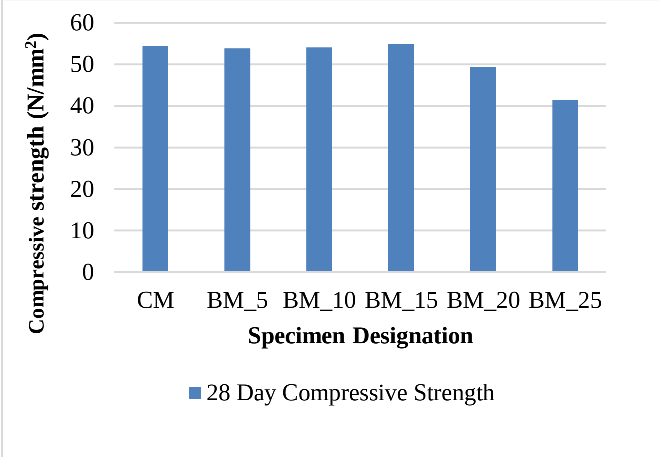

Figure 3. Compressive strength of Concrete

From the results it is clear that the,

1) Compressive strength of the nominal when compared with the design cubes BM_15 replaced mix shows 1.9% increase than the nominal mix.
2) The **BM_5** and **BM_10** specimens showed nearly 0.8% to 1.5% decreased compressive strength than the nominal mix. This shows that these replaced specimens have achieved nearly equal compressive strength to the nominal mix.
3) The other specimens **BM_20** and **BM_25** have 10% to 20% decreased compressive strength when compared with the nominal specimen.

4.2 Various test results of Ferrocement Slabs

Table 5. First crack load

No.of Layers	Specimen	First crack load
3	FSB0_T	2.5
	FSB5_T	2.3
	FSB10_T	2.4
	FSB15_T	2.7
	FSB20_T	1.5
	FSB25_T	1.2
4	FSB0_F	3
	FSB5_F	2.5
	FSB10_F	2.7
	FSB15_F	3.2
	FSB20_F	2
	FSB25_F	1.9

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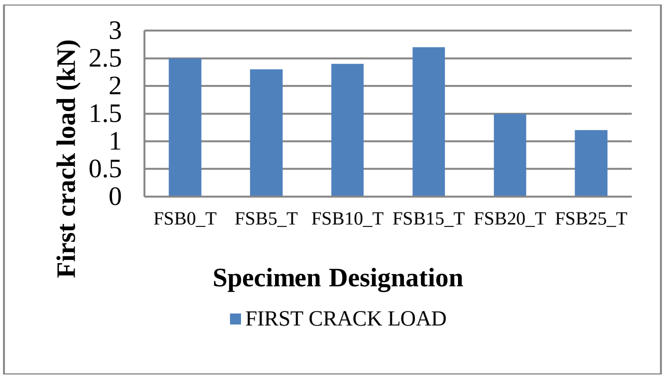

Figure 4. Variations of first load of three layered slabs

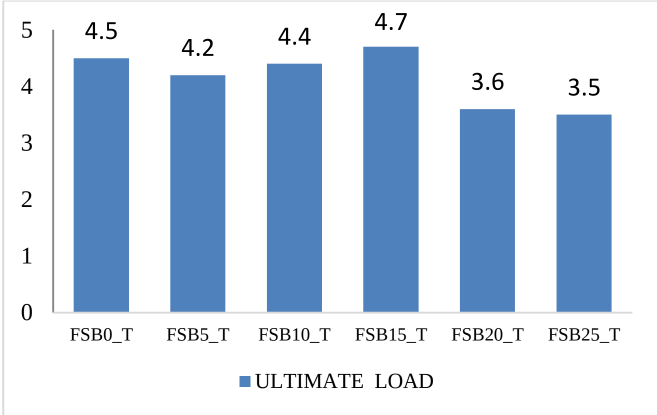

Figure 6. Ultimate load of three layered slabs

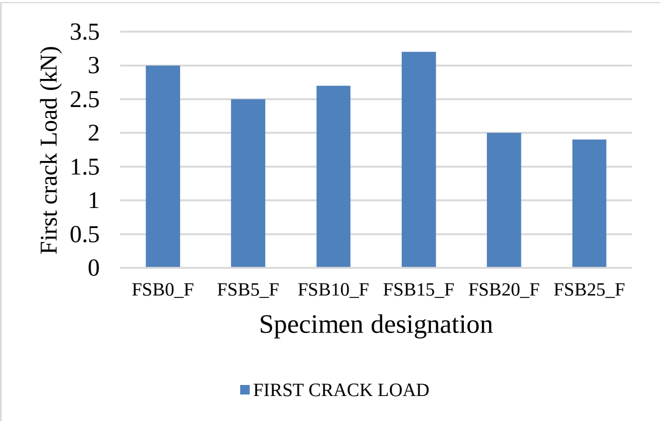

Figure 5. Variations of first load of four layered slabs

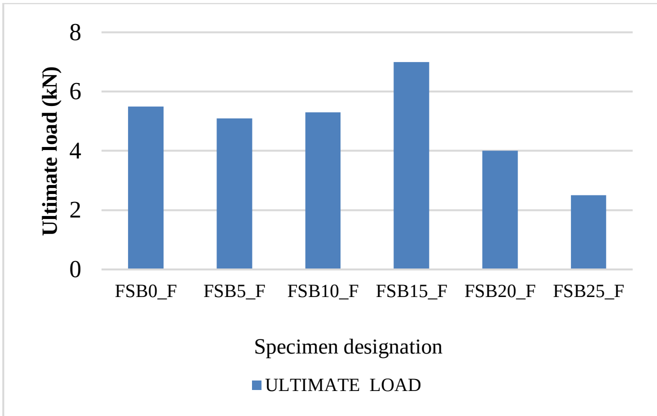

Figure 7. Ultimate load of four layered slabs

4.3. Ultimate load of ferrocement slabs

Table 6. First crack load

No.of layers	Specimen	Ultimate load
3	FSB0_T	4.5
	FSB5_T	4.2
	FSB10_T	4.4
	FSB15_T	4.7
	FSB20_T	3.6
	FSB25_T	3.5
4	FSB0_F	5.5
	FSB5_F	5.1
	FSB10_F	5.3
	FSB15_F	7
	FSB20_F	4
	FSB25_F	2.5

4.4 Ductility Behaviour of ferrocement slabs

Ductility ratio is computed as the ratio of deflection at ultimate load to that at the onset of yielding. It is an important factor which indicated the overall strength of various structural components.

1) In three layered slabs of volume fraction 3.16%, the replaced slab **FSB15_T**showed 12.5% increased ductility factor value than the nominal**FSB0_T** and the other replaced slabs also showed up to 1% to 5% increased ductility factor except **FSB25_T**.
2) In four layered slabs of volume fraction 4.22%, the replaced slab **FSB15_F**showed 11.33% higher ductility value than the nominal**FSB0_F**slab and the other slabs showed 1.1% to 6.5% increased ductility value.
3) It is evident that, the slab **FSB15_F** also showed higher ductility factor value than the other nominal and design slabs.
4) It can be inferred that optimum replacement produced higher ductility strength. Due to its higher ductility it can be effectively used in earthquake prone areas.

Table 7. Ductility factor of slabs

Specimen	Deflection at yield load	Deflection at ultimate load	Ductility

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FSB0_T	7.1	7.54	1.02
FSB5_T	10.2	11.12	1.04
FSB10_T	8.2	9.12	1.07
FSB15_T	8.9	9.63	1.13
FSB20_T	10.9	11.4	1.07
FSB25_T	10.9	11.96	1.05
FSB0_F	10.9	11.15	1.06
FSB5_F	9.1	9.5	1.09
FSB10_F	9.5	10.2	1.11
FSB15_F	7.2	8.2	1.19
FSB20_F	10	11	1.10
FSB25_F	9	9.8	1.08

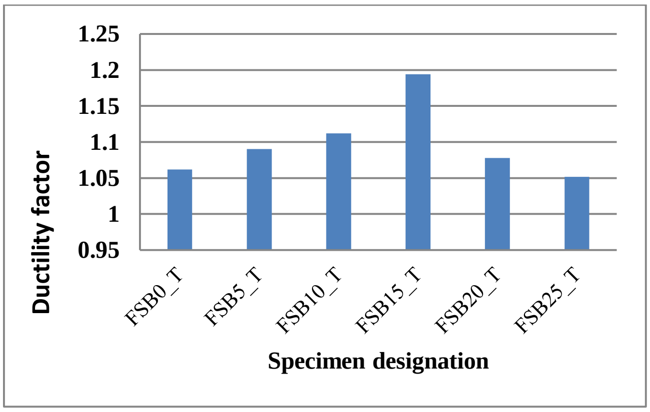

Figure 8. Variation of ductility factor in three layered slabs

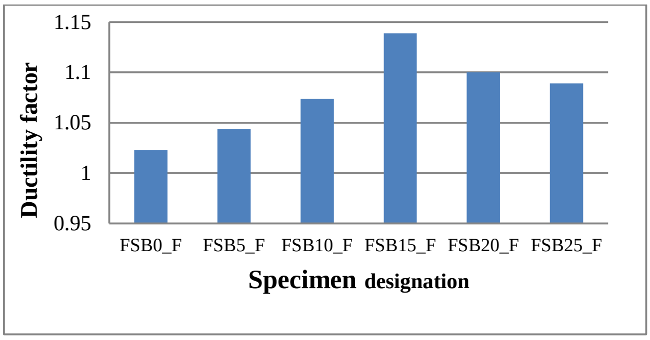

Figure 9. Ductility factor of four layered slabs

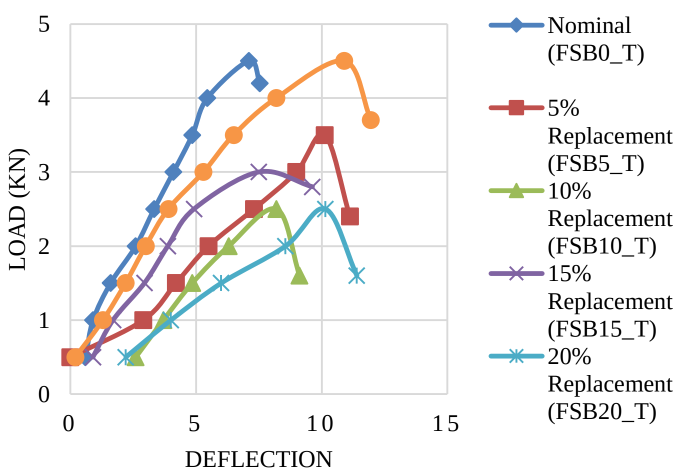

Figure 10. Load vs deflection curve of three layered slabs

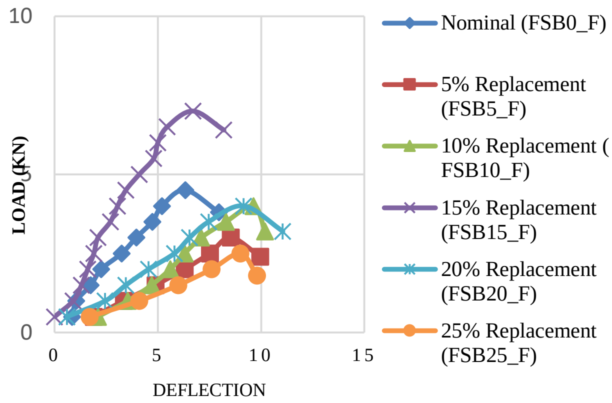

Figure 11. Load vs deflection curve of four layered slabs

5. CONCLUSION

1) The compressive strength of BM_15 is 1.13% higher than the controlled mix CM.
2) The First crack load of FSB15_F is 6.67% higher than other controlled and replaced slabs.
3) The ultimate load of FSB15_F is 27.27% greater than all other slabs.
4) The ductility factor of FSB15_F is 11.33% greater than other slabs.
5) From the load deflection curves, it is evident that the ultimate load carrying capacity of specimen FSB15_F reached a maximum load of intensity 6.4kN with a corresponding deflection of 8.2mm.
6) Thus 15% replacement of biomedical ash FSB15_F is the optimal amount of replacement, which provides more strength in compression and flexure values in all aspects.

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