

**STUDY ON DUCTILITY AND CRACK BEHAVIOUR OF ENGINEERED
CEMENTITIOUS COMPOSITES BASED FERROCEMENT****S.Ramesh*, B.Jose Ravindraraaj, R.Ram Kumar, G.Ashok**

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ABSTRACT

The Reinforced cement concrete structure shows good behaviour at all loading conditions but it is bulky and has increased cost. In order to reduce the self weight the ferrocement panels can be used in place of reinforced cement concrete. As ferrocement panels are thin elements consisting of cement mortar and reinforced with closely spaced galvanised steel wire mesh it shows improved ductile behaviour. The cost of manufacture of ferrocement panel can be brought down by using engineered cementitious composite which is a fibre reinforced cement based composite material. It is systematically engineered to achieve high ductility under tensile and shear loading. It holds promise in enhancing the safety durability and sustainability of infrastructure.

In this study the Engineered cementitious composites comprising of cement, fly ash, fine aggregate, high range water reducing agent and poly propylene fibre are used. The ferrocement panel due to thermal and shrinkage effects results in formation of non structural cracks. This affects the durability of ferrocement panel. These cracks can be arrested with the help of poly propylene fibers employed in ECC.

The quality of ferrocement panels had been studied by Ultra-sonic pulse velocity test which is a non destructive test. The results of the test indicated excellent concrete quality grading for ferrocement panels with 1% and 1.5% of poly propylene fibers. It is evident that the fibers in ferrocement panels play a vital role in arresting cracks. The four point loading test on various panels was done using universal testing machine and the respective ductile behaviour was observed. The ferrocement panels with 1.5% poly propylene fibers shows good ductile nature after reaching its ultimate load carrying capacity. It is evident that the ferrocement panels show increased ductility with increase in the volume fraction of poly propylene fibers.

KEYWORDS: Ferro cement, Wire mesh, Engineered Cementitious Composites, Fibres, Super Plasticizer, Fly ash, Poly propylene Fiber.

INTRODUCTION

Ferrocement is a type of thin reinforced concrete commonly constructed of hydraulic cement mortar reinforced with completely infiltrated, closely spaced layers of continuous and relatively small size wire mesh. It plays a major role as a thin reinforced concrete product and as laminated cement-based composite, Ferrocement panels are used in several applications both in new structures and members like walls, roofs, columns, beams etc.

According to ACI Committee “Ferrocement is a type of thin wall reinforced concrete commonly constructed of hydraulic cement mortar reinforced with closely spaced layers of continuous and relatively small size wire mesh. The mesh may be made of metallic or other suitable materials.”

MATERIALS AND METHODS**Cement**

Portland cement is generally used in ferrocement. But the type of cement should be selected according to the need or environment in which the structure is built, for example Ordinary Portland cement mentions the strength characteristics of cement and its specific use or application. Mineral admixtures, such as fly ash, silica fumes, or blast furnace slag, may be used to maintain a high volume fraction of fine filler material as well as to enhance the properties at wet and hardened state.

Aggregate

Only fine aggregate is used in ferrocement. Coarse aggregate is not used in ferrocement. Normally, the aggregate consists of well graded fine aggregate (sand) that passes a 2.34 mm sieve; and since salt-free source is recommended, sand should preferably be selected from river-beds and be free from organic or other deleterious matter. Good amount of consistency and compaction is achieved by using a well-graded, rounded, natural sand having a maximum top size about one-third of the small opening in the reinforcing mesh to ensure proper penetration. The moisture content of the aggregate should be considered in the calculation of required water.

Water

In ferrocement, the water used for mixing cement mortar should be fresh, clean and fit for construction purposes; the water of pH equal or greater than 7 and free from organic matter like silt, oil, sugar, chloride and acidic material.

Fly ash

Use of fly Ash concrete with very low permeability will delay the arrival of carbonation and chlorides at the level of the steel reinforcement. Fly Ash is a finely divided silica rich powder that, in itself, gives no benefit when added to a concrete mixture, unless it can react with the calcium hydroxide formed in the first few days of hydration. Together they form a calcium silica hydrate (CSH) compound that over time effectively reduces concrete diffusivity to oxygen, carbon dioxide, water and chloride ions.

Fly ash is a by-product from coal fired electricity generating power plants. The coal used in these power plants mainly composed of combustible elements such as carbon, hydrogen and oxygen (nitrogen and sulfur being minor elements), and non-combustible impurities (10 to 40%) usually present in form of clay, shale, quartz, feldspar and limestone. As the coal travels through the high temperature zone in the furnace, the combustible elements of the coal are burnt-off, where as the mineral impurities of the coal fuse and chemically recombine to produce various crystalline phases of the molten ash. the molten ash is entrained in the flue gas and cool rapidly, when leaving the combustion zone (e.g. from 15000c to 2000c in few seconds), into spherical, glassy particles. Most of the particles fly out with the flue gas stream and therefore called fly ash. The fly ash is then collected in electrostatic precipitators or bag houses and the fineness of the fly ash can be controlled by how and where the particles are collected.

The materials used in this experimental investigation includes

- Cement
- Fine aggregate
- Fly ash
- Steel wire mesh
- Poly-propylene fiber.
- Super plasticiser (GLENIUM B233)

Figure:



Figur -1 poly Propylene Fiber.



Figur -2 Casting of Ferrocement Panels.

RESULTS AND DISCUSSION

COMPRESSIVE STRENGTH TEST RESULTS

Table -1, Compressive Strength Test Results

Specimen	Compressive strength 7 days MPa	Compressive strength 28 days MPa
V1	36	39
V2	32	37
V3	33	39
V4	35	41
V5	34	38

Figur- 3, Compressive Strength Test Results

ULTRA-SONIC PULSE VELOCITY TEST:

Table -2, Ultra-Sonic Pulse Velocity Test Results

SPECIMEN	PULSE VELOCITY (m/s)	QUALITY GRADING
V1	3771	GOOD
V2	3919	GOOD
V3	4613	EXCELLENT
V4	4679	EXCELLENT
V5	3898	GOOD

The Ultrasonic pulse Velocity test results are also note worthy. The same specimen with 1.5% of poly propylene fibers has shown pulse velocity of 4679 m/s. The result of control specimen is 3771 m/s. Hence from above results the ECC based ferrocement panes are proven to be stronger for compression loads

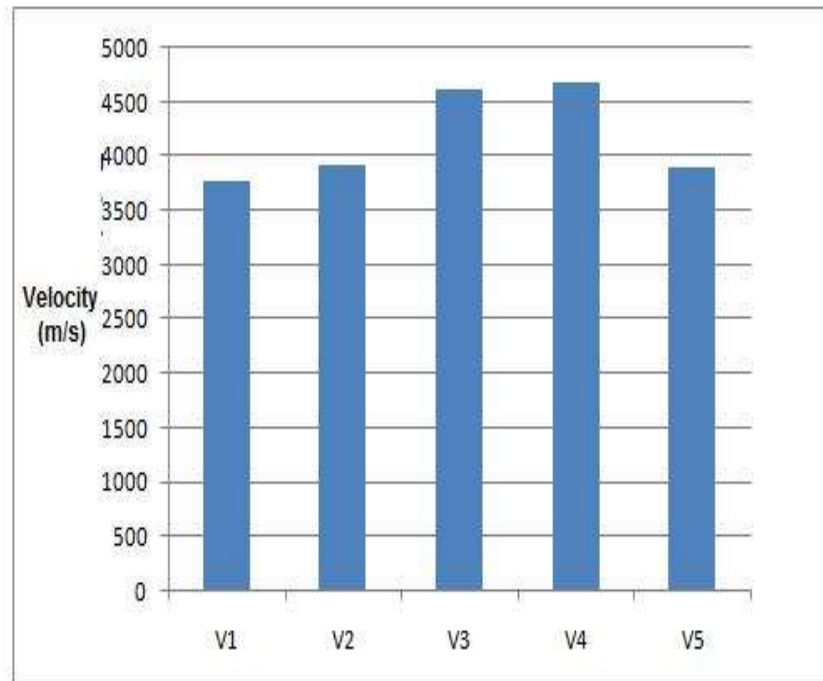
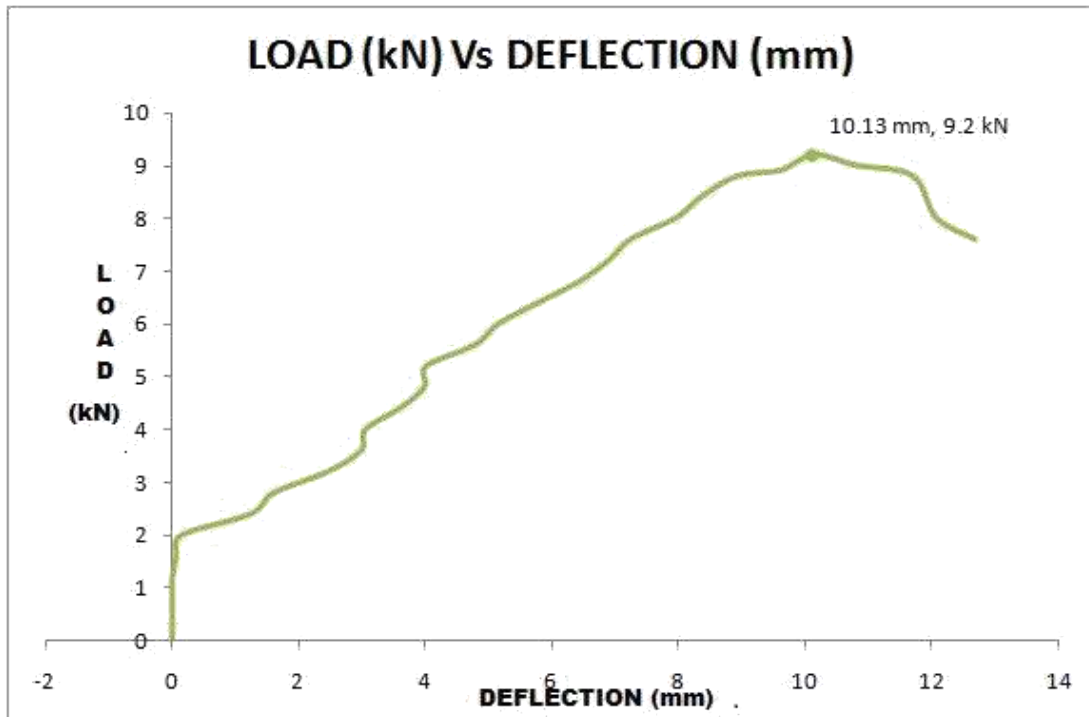


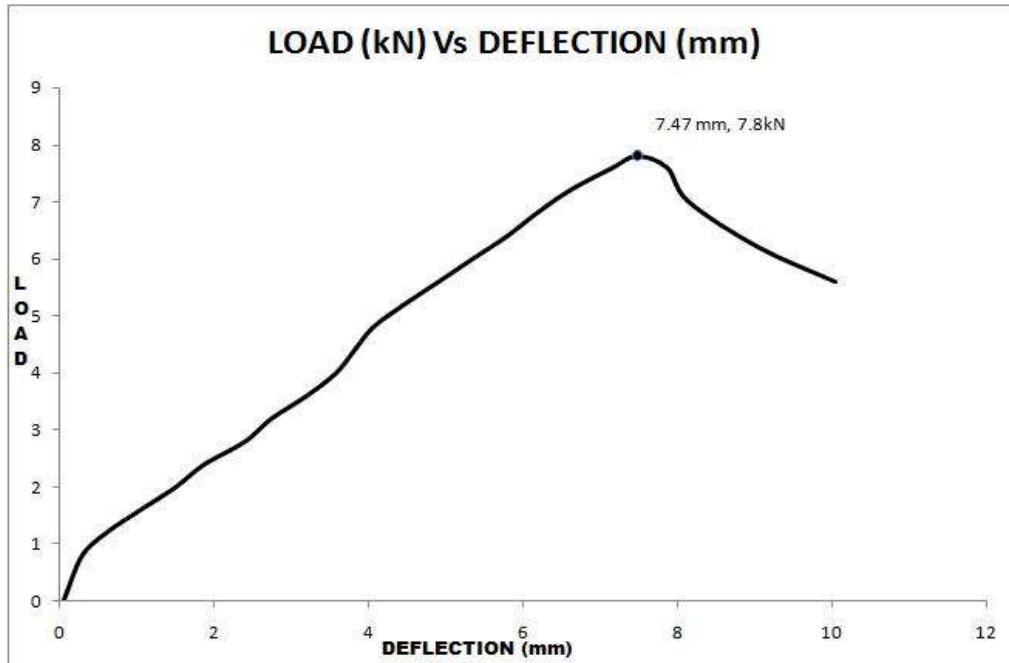
Fig -4, Ultrasonic Pulse Velocity Test Results

FOUR POINT LOADING TEST:

The four point loading test is performed for various ferrocement panel specimens and the graphs were plotted for the loads and their corresponding deflections are shown in figures below

SPECIMEN	VOLUME FRACTION OF FIBER (%)	CRACKING LOAD (kN)	ULTIMATE LOAD (kN)	Maximum deflection (mm)
V1	0	7.2	7.8	7.47
V2	0.5	8.2	8.9	9.16
V3	1.0	9.0	9.2	10.99
V4	1.5	9.2	9.4	16.23
V5	2.0	8.9	9.6	15.48





Load Vs Deflection Curve for Control Specimen

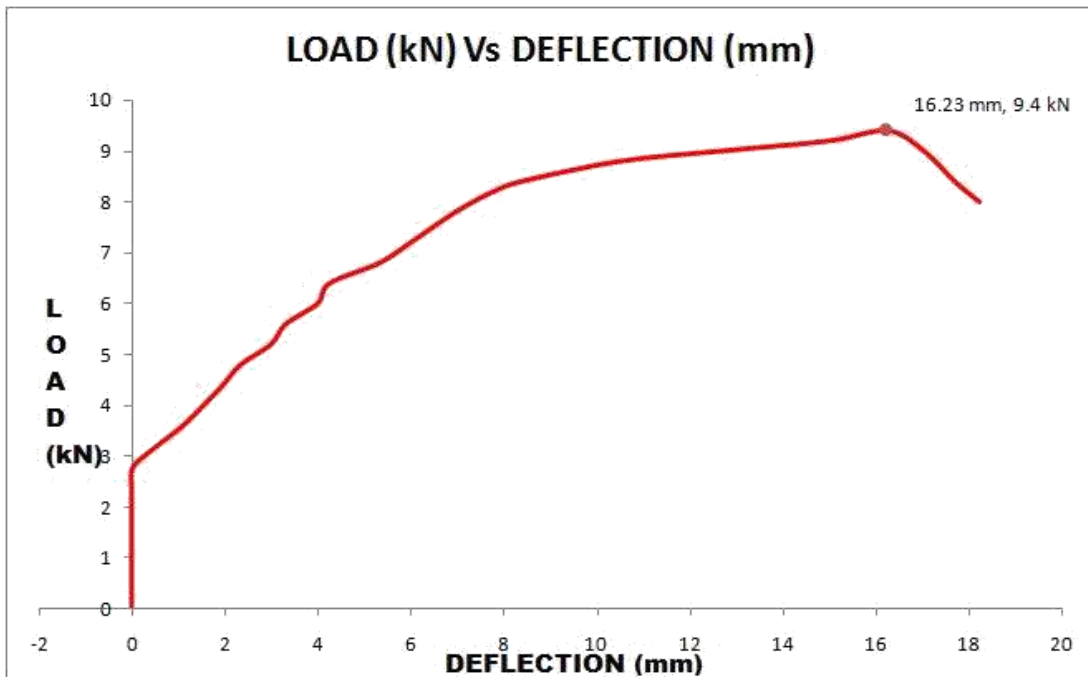


Fig – 6 Load Vs Deflection Curve for Specimen V2 (0.5% Poly Propylene Fibre)

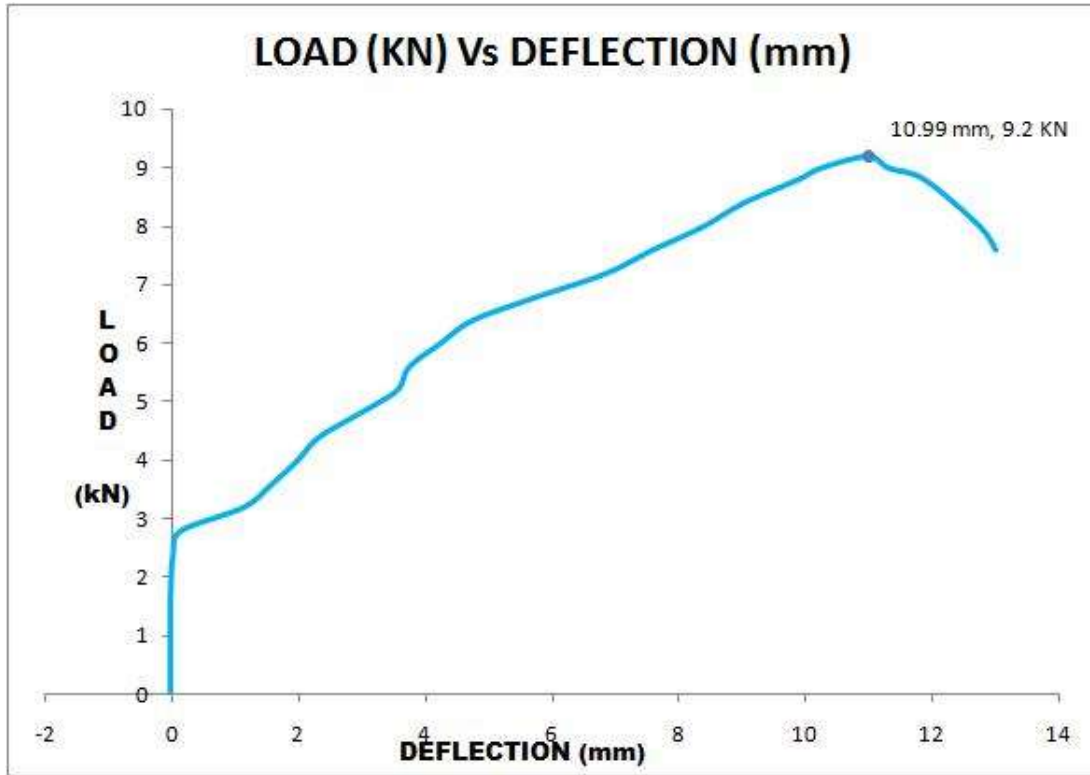


Fig 5.5 Load Vs Deflection Curve for Specimen V3 (1.0% Poly Propylene Fibre)

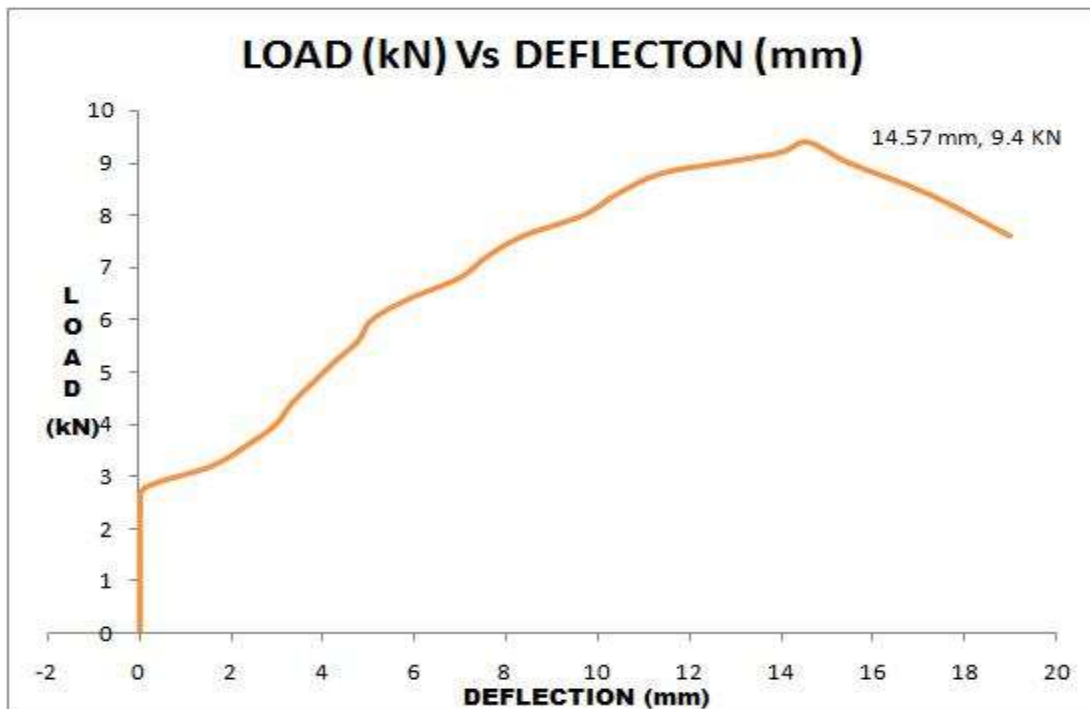


Fig 5.7 Load Vs Deflection Curve for Specimen V5 (2.0% Poly Propylene Fibre)

The load vs deflection curve for all ferrocement panels is plotted and the following inferences were made:

- The ferrocement panel (control specimen, V1) shows maximum deflection of 7.47mm with a maximum load carrying capacity of 7.8 kN.
- The ferrocement panel incorporated with 0.5% poly propylene fibre (V2) shows maximum deflection of 10.13mm with a maximum load carrying capacity of 9.2 kN.
- The ferrocement panel incorporated with 1.0% poly propylene fibre (V3) shows maximum deflection of 10.99mm with a maximum load carrying capacity of 9.2 kN.
- The ferrocement panel incorporated with 1.5% poly propylene fibre (V4) shows maximum deflection of 16.23mm with a maximum load carrying capacity of 9.4 kN.
- The ferrocement panel incorporated with 2.0% poly propylene fibre (V5) shows maximum deflection of 14.57 mm with a maximum load carrying capacity of 9.4 kN.
- The ferrocement panel with 1.5% poly propylene fibre (V4) shows optimum ductile behaviour as it shows better deformation even after it reaches its ultimate load carrying capacity even though specimen V5 shows good result but it does not shows good performance when compared with specimen V4.

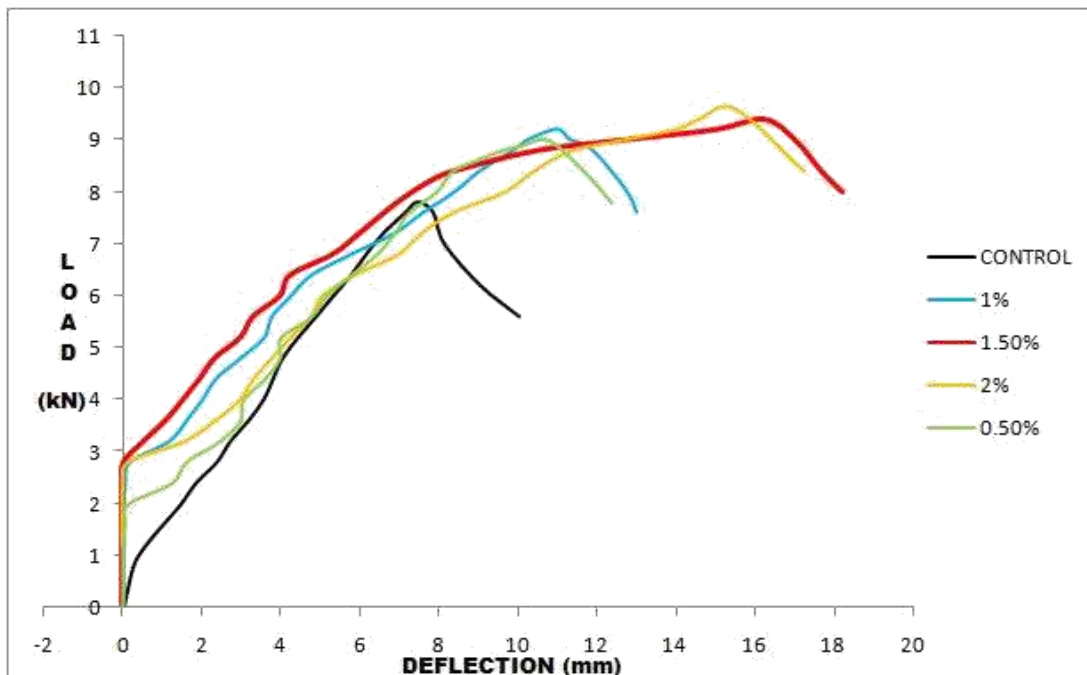


Fig 5.8 Comparative Results

CRACK PROPAGATION:

The cracks formed on all ferrocement panels were having following characters:

- The first crack is formed on the section at which the load applied.
- The crack propagates both in width-wise and depth-wise on increasing the load gradually.
- The crack patterns are almost similar for all types of specimens.



Fig 5.9 Crack Pattern in Ferrocement Panel

CONCLUSION

- The ECC based ferrocement panels have improved compressive strength than ordinary ferrocement panel.
- The poly propylene fibres employed in the ferrocement panels shows excellent concrete grading quality as observed through Ultrasonic pulse velocity test with an optimum value of 1.5% of poly propylene fibre.
- The ferrocement panels casted using engineered cementitious composites shows higher ductility when compared with ferrocement panels casted using cement mortar.
- It is evident that the ductile behaviour of the ferrocement increases with the increase in volume fraction of poly propylene fibre. The optimum volume fraction of fibre content is 1.5%.
- The ferrocement panel specimen with 2.0% of poly propylene fibre shows maximum deflection but it is not ductile when compared with specimen containing 1.5% of poly propylene fibre. which shows prolonged deformation even though it reaches its ultimate capacity.

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