Structural Performance of Various RCC Elements with ULCC and ECC

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Abstract -*This paper investigate the performance of dual layer concrete structures with Ultra Light weight Cement Composite (U.L.C.C) and Engineered Cement Composite (E.C.C). Four types of novel steel fibre reinforced ULCC's with different densities ranging from 1250 – 1550 kg/m³whereproposed. Low density of ULCC is achieved by using cenospheres from coal fired power plants. ULCC has a high compressive strength upto 60 MPa. Conventional concrete and Fiber reinforced concrete has brittle nature which affect the durability of structure. So a high ductile performance cement based material required for structural applications especially in seismic region ie, Engineered Cement Composite (ECC)which has a unique combination of low volume fibers and different composites so as to impart high ductility and tensile strength*

Key Words: *Ultra Light weight Cement Composite (U.L.C.C) Engineered Cement Composite (E.C.C).Cenospheres*

1. INTRODUCTION

Ultra lightweight cement composite (ULCC) is a type of novel composites with low densities typically less than 1500 kg/m3, high compressive strengths more than 60 MPa with specific strength of up to 47kPa/(kg/m3)[1].Ultra-lightweight cement composite (ULCC) has attracted extensive research interests in both civil and offshore engineering constructions due to its high specific strengths[1]. In order to satisfy different engineering construction demands, four types novel steel fiber reinforced ultra-lightweight cement composite (ULCC) with different densities ranging from 1250 kg/m3 to 1550 kg/m3 were proposed.

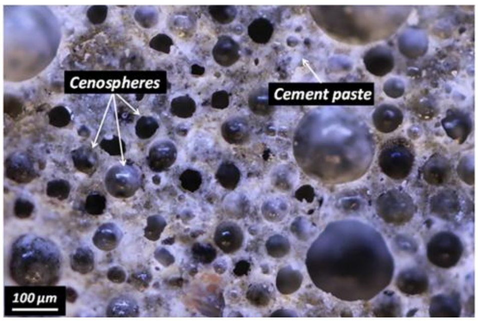

Fig -1 Components of ULCC

Ultra-lightweight cement composite (ULCC) contains smooth steel fibers, Ordinary Portland cement, Water, Silica fume, Chemical admixtures, Cenospheres. The cenospheres are hollow alumino-silicate spheres with particle sizes ranging from10 to 300 mm. The main benefits of using lightweight concrete is that we can reduce the self weight of structural members and overall structures, allowing smaller sizes of structural members and less reinforcing materials. Thus requirements for foundations and transportation cost can be reduced significantly. In addition, it allows for easy and rapid installation at construction sites due to its lower self-weight, thereby saving time and improving productivity in construction. With the industry's consistent pursuit for lighter construction material, ultra-lightweight concrete emerges as a promising solution.

Engineered Cementitious Composite (ECC) is an different type of cement mixture with exceptional composition of low volume fibers and different composites so as to impart high ductility, high tensile strength besides capability to repair. Both Conventional concrete and fiber reinforced concrete is brittle in nature and hence cracks easily under mechanical and environmental loads and affect the structures durability. Efforts to improve the brittle nature of conventional concrete resulted in development of ECCs contribution of durability under a broad range of environmental exposure,

2. FINITE ELEMENT MODELLING

2.1 General

To investigate structural performance of rcc structures with ulcc and ecc, Modeling of structure was done using SOLID186 element of ANSYS 16.1

2.2 Scope

In this project flexural performance of RCC beam with single and dual layer concept In this project flexural performance of RCC beam with single and dual layer concept, axial performance of RCC column with core concept were studied.

2.3 Geometry and material properties

The beam model has a span of 1800mm and a depth of 200mm and width of 150mm. the beam models are provided with reinforcement bars of diameter 8mm are provided at top and three bars of 12 mm diameter is provided at bottom. Stirrups of 8mm diameter bars are provided at a spacing of 160mm. Four models of beam were analyzed with same geometry with variation in density. Models were ULCC 1250,1350, 1450 and ULCC 1550 where 1250, 1350, 1450, 1550 indicates respective density of the model.

The column model has a square section and height of 1200mm with width of 140mm. Four number of 8mm diameter bars are provided as reinforcement bars and 6mm diameter bars are provided at a spacing of 100mm at mid span and 50mm spacing at top and bottom span. Four models of column were analyzed with same geometry with variation in density. Models were ULCC 1250,1350, 1450 and ULCC 1550 where 1250, 1350, 1450, 1550 indicates respective density of the model.

The slab model is designed as a square slab of length 1800mm and a depth of 120mm. ten 10mm diameter bars are used as reinforcement bars at a spacing of 200mm in both direction as top compression and twenty 10mm diameter bars at 90mm spacing as upper horizontal bars and eighteen 10mm diameter bars at 100mm spacing as lower vertical bars is provided. Four models of slabs were analyzed with same geometry with variation in density. Models were ULCC 1250,1350, 1450 and ULCC 1550 where 1250, 1350, 1450, 1550 indicates respective density of the model.

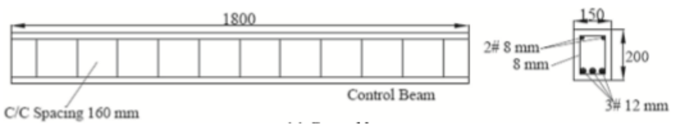

Fig -2 Geometry of Dual layer beam with ULCC and ECC

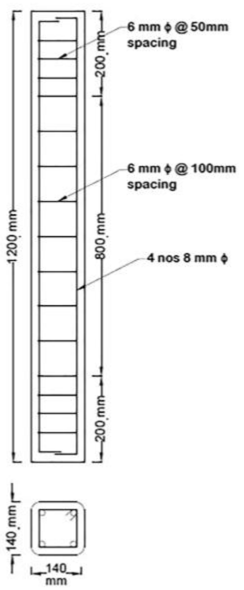

Fig -3 Geometry of Dual layer column with ULCC and ECC

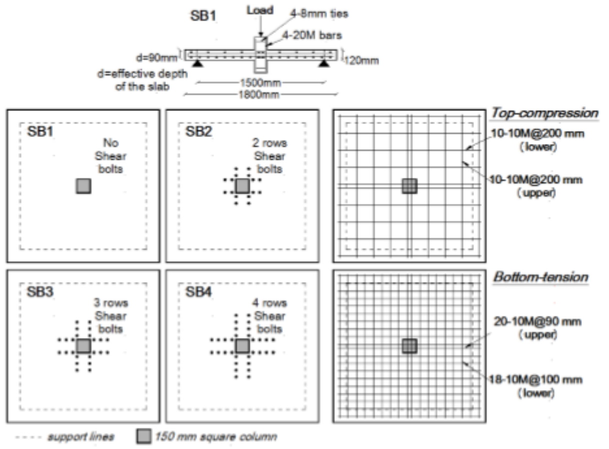

Fig -4 Geometry of Dual layer slab with ULCC and ECC

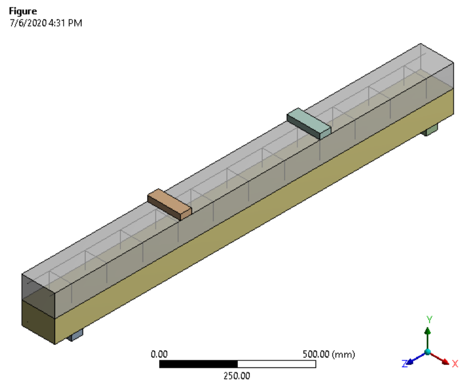

Fig -5 Model of Dual layer beam with ULCC and ECC in ANSYS

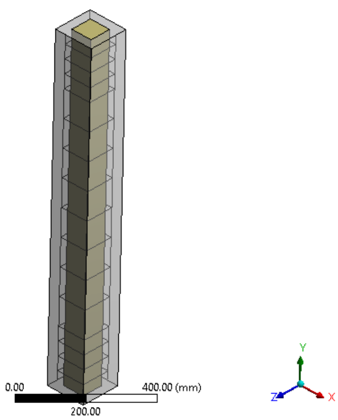

Fig -6 Model of Dual layer column with ULCC and ECC in ANSYS

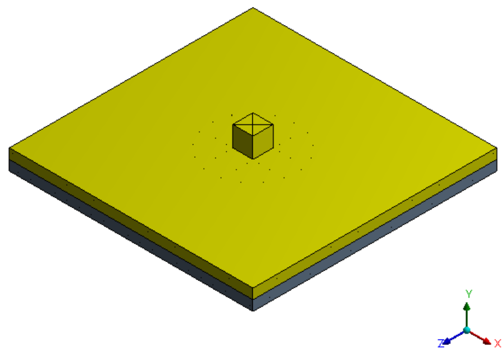

Fig -7 Model of Dual layer slab with ULCC and ECC in ANSYS

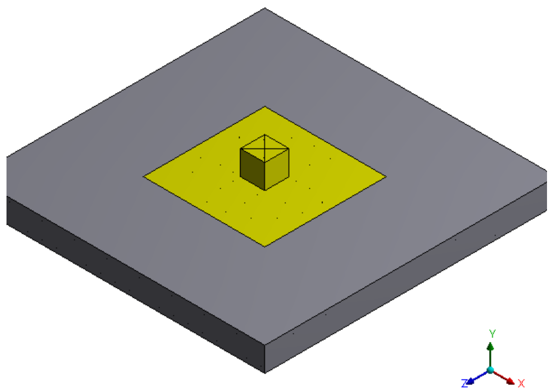

Fig -8 Model of Dual zone slab with ULCC and ECC in ANSYS

Table -1: Material properties of E C C

Compressive strength (MPa)	20-95
Ultimate tensile strength (MPa)	4-12
Ultimate tensile strain (%)	1-8
Flexural strength (MPa)	10-30
Young's modulus	6.35 MPa
Poisones ratio	0.15
Density	2067 kg/m³

Table -2: Material properties of ULCC

	ULCC 1250	ULCC 1350	ULCC 1450	ULCC 1550
Density (kg/m³)	1250	1350	1450	1550
Compressive Strength(MPa)	48.03	52.12	61.07	70.06
Tensile strength(MPa)	2.03	2.21	2.35	3.03
Elastic modulus (MPa)	11880	13640	15520	17650

2.4 Boundary condition

To stimulate real conditions, The beam model is provided with a simply supported condition with four-point loading, The column model is provided a fixed support at the bottom with axial loading at the top and The slab model is provide with supports in 4 sides as two way slab with loading at the center of the slab.

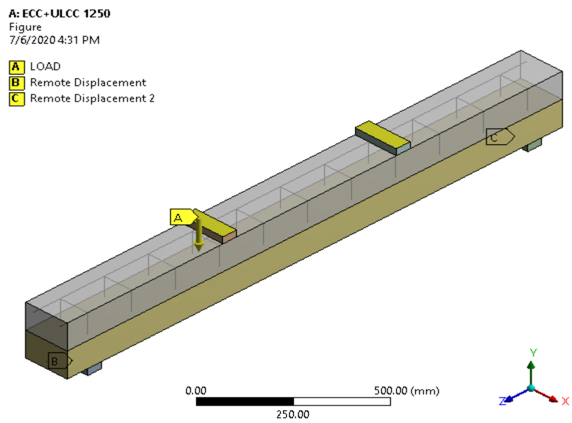

Fig -9 Boundary condition of Model with Dual layer beam with ULCC and ECC in ANSYS

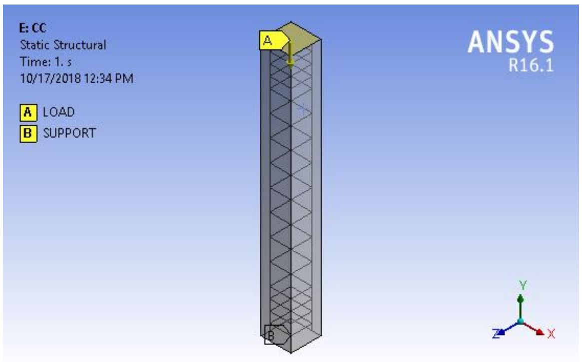

Fig -10 Boundary condition of Model of Dual layer column with ULCC and ECC in ANSYS

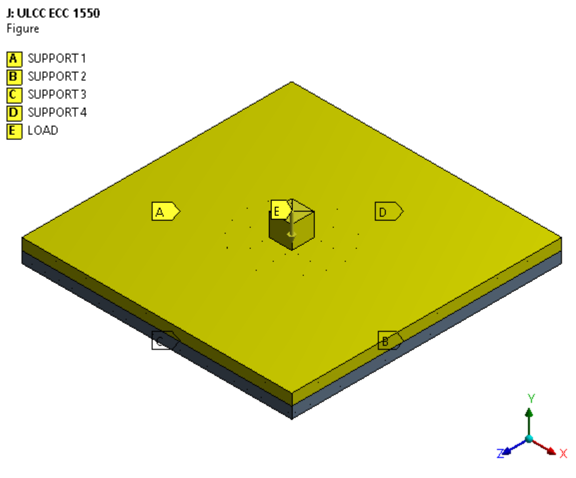

Fig -11 Boundary condition of Model of Dual layer slab with ULCC and ECC in ANSYS

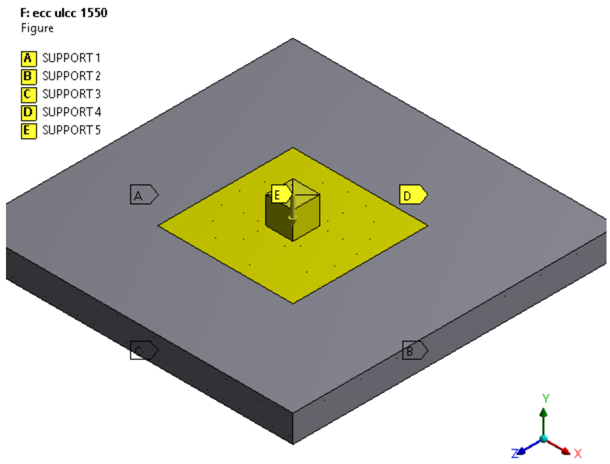

Fig -12 Boundary condition of Model of Dual zone slab with ULCC and ECC in ANSYS

3. RESULTS AND DISCUSSIONS

3.1 Four-point loading test on beams

Dual layer beam models with ULCC and ECC is subjected to a four point loading and total deformation and ultimate load is found for each model and the beam model with highest load carrying capacity is found. Mainly four models of beam were analyzed with same geometry with variation in density. Models were ULCC 1250,1350, 1450 and ULCC 1550 . The figure below shows the total deformation of the best beam model which is ULCC 1550.

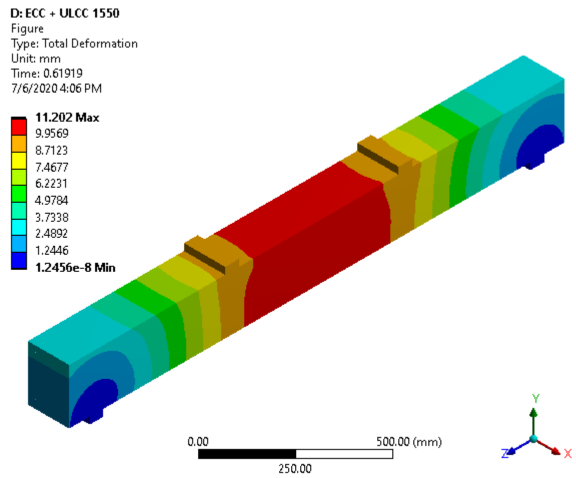

Fig -13 Dual layer beam with ULCC and ECC

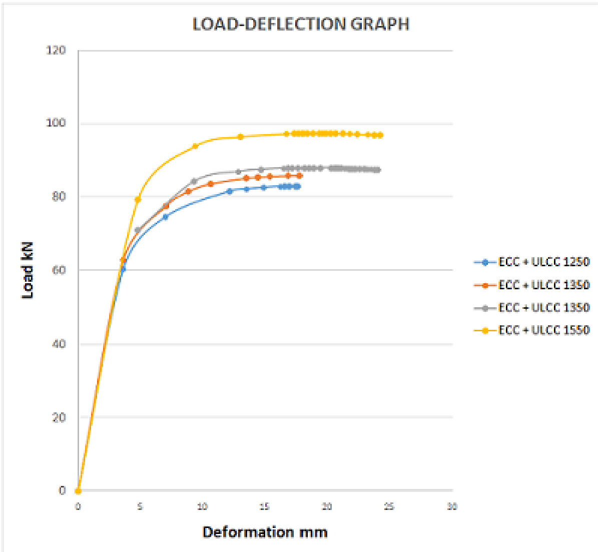

Chart -1: Load deflection comparison graph of beam models

3.2 Axial -loading test on columns

Dual layer column with ULCC and ECC is subjected to a axial loading and total deformation and ultimate load is found for each model and the column model with highest load carrying capacity is found

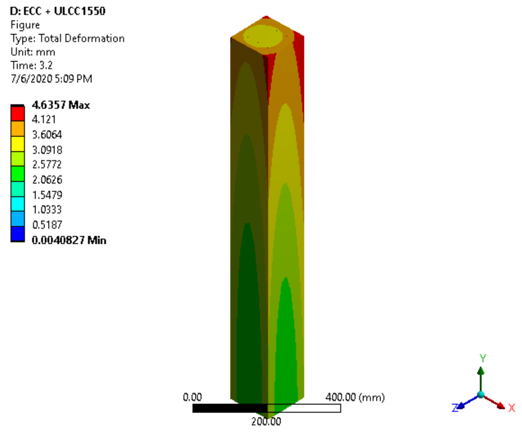

Fig -14 Total deformation of Dual layer column with ULCC and ECC

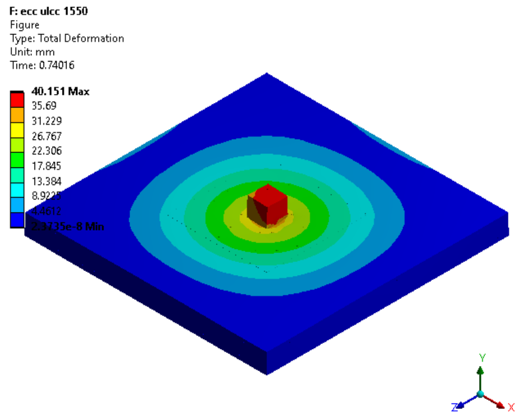

Fig -15 Total deformation of Dual zone slab

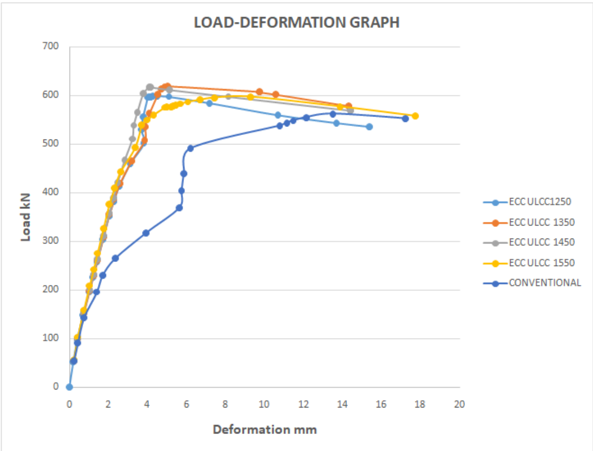

Chart 2: Load deflection comparison graph of column models

3.3 loading test on slabs

Dual zone slab models and Dual layer slab models are subjected to a loading at the mid-point of the slab and total deformation and ultimate load is found for each model and the slab model with highest load carrying capacity is found for both dual zone slab models and dual layer slab models.

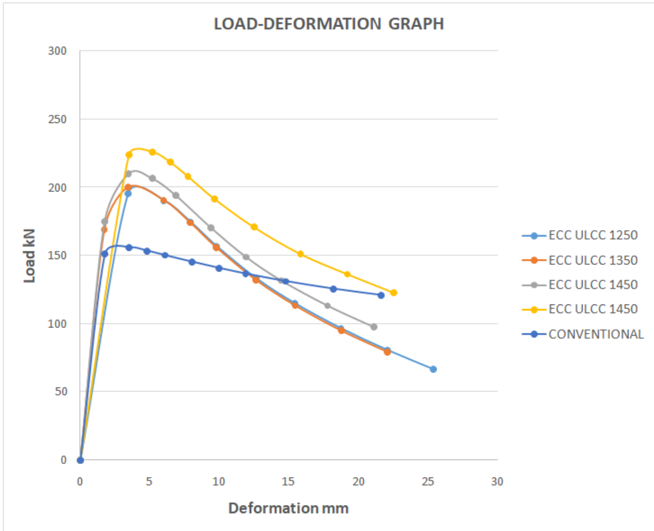

Chart -3: Load deflection comparison graph of Dual zone slab models

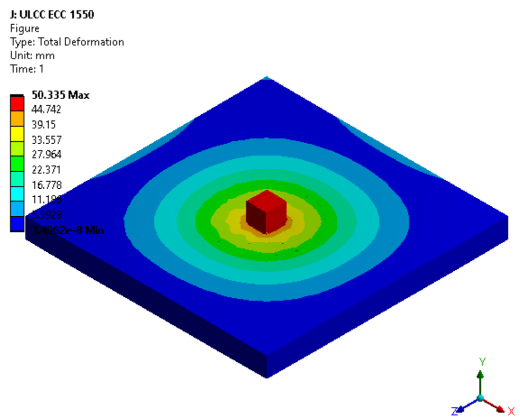

Fig -11 Total deformation of Dual layer slab

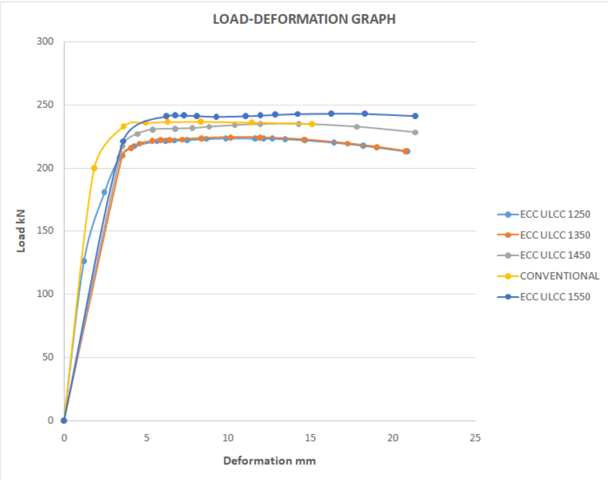

Chart -4: Load deflection comparison graph of Dual layer slab models

4. CONCLUSIONS

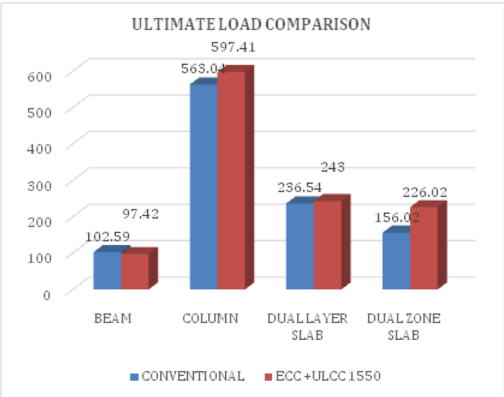

Chart -5: Load comparison graph of all models.

In this study, comparison of dual layer RCC elements against the conventional single layer is done using the help of ANSYS 16.1 and following conclusions were arrived.

- Dual layer RCC elements have higher load carrying capacity when compared to the conventional concrete.
- Comparing ULCC 1250, 1350, 1450 and ULCC 1550, ULCC 1550 has higher load carrying capacity. Ductile nature can be improved by using ECC along with ULCC as dual layer.
- In column, there is an increase of 6.10% in ultimate load. In dual layer slab, there is2.73% increase in ultimate load. While in case of dual zone slab, there is 44.86 % increase in load carrying capacity.

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