Comparative Study of Ferrocement Panels Under Blast Loading by Finite Element Method Analysis

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Abstract - *The expanded count of terrorist attacks for the most part over the most recent couple of time has demonstrated that impact of Blast loads on structures is a genuine issue which we ought to be considered during configuration procedure of structures in spite of the fact that these sorts of terrorist strikes are extraordinary cases made by man dynamic loads i.e. Blast loads are really needed to calculate with great attention just like wind and seismic loads. Also, the investigation of behavior of ferrocement composites under Blast loading that are utilized as lasting formwork in conventional reinforced concrete structures is introduced in this report. Single ferrocement panel specimens are tested experimentally and analytically under Blast load and also the load deflection behavior is then studied.*

The main aim of this research is to compare the behavior of the ferrocement concrete Blast loading. In this research the Ferrocement panel with layered mesh modelled in ANSYS Workbench.

The panels with different sizing are tested analytically under blast loading in ANSYS Workbench and compared behavior of ferrocement panels.

Key Words: *Ferrocement, Blast resistant design, blast waves, explosive effect, finite element method.*

1. INTRODUCTION

The main aim of this research is to study the behavior of the ferrocement concrete under Blast loading and study of Blast resistance of ferrocement concrete in comparison with normal concrete. Blasts and types of Blasts have been explained in brief firstly. Furthermore, the normal parts of Blast procedure had displayed to explain the impacts of Blasts on structures. To obtain a superior comprehension of Blasts and attributes of Blasts will empower us to make Blast safe structure planning and considerably extra productively. Fundamental methods for expanding the limit of a structure to give protection from the dangerous impacts is talked about both with a planning and designing methodology. Harm to the peoples, deaths and social frenzy are aspects that must be limited if the danger of bomber activity can't be ceased. Planning and design of the structures to be completely bang safe is certifiably not a reasonable and affordable alternative, present time designing and engineering learning can improve the new as well as old edifices to reduce the effects of an Blast.

2. AIM

➢To analyze behavior of ferrocement composites under the blast loading by using Finite Element Method

3. OBJECTIVES

➢ To study the behavior the ferrocement panels undergoing blast loading.

➢ Comparative study of ferrocement panels with varying thickness against blast loading.

4. METHODOLOGY

Table-1: Material Properties (adopted for Ferrocement Panel Modeling of size 600mm x 600mm x 18mm (2 Layer of Meshes))

Property	Mortar	Welded Mesh
Compressive strength [N/mm2] (experimental data)	53	1.2 mm diameter 15 mm ×15 mm Spacing
Young's modulus (E) [N/mm2] (theoretical data)	2000	1.3×10^5 N/mm2
Poisson's ratio μ (theoretical data)	0.11	0.3
Density[kg/m3] (theoretical data)	2080	7850

5. MODELLING IN ANSYS

5.1 MODELLING OF FERROCEMENT PANELS

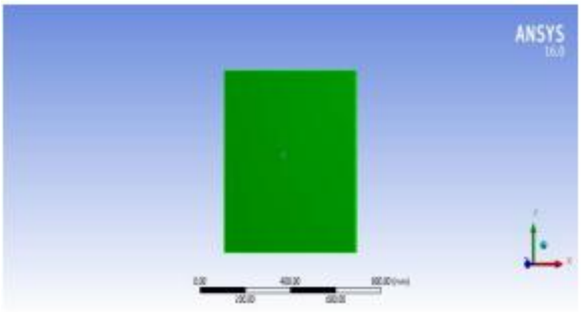


Fig-1(a) Slab

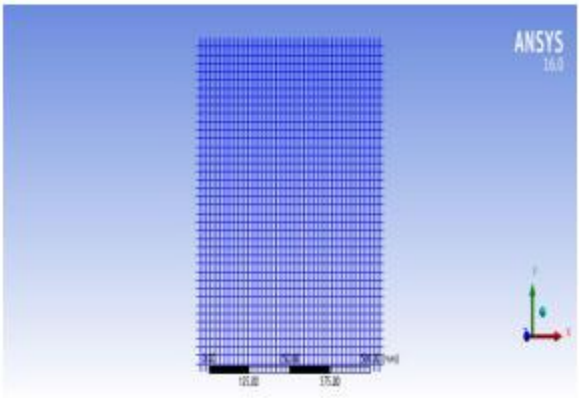


Fig-1(b) Mesh

5.2 DEFINITION OF BLAST LOAD

A blast is a quick release of potential energy described by a splendid flash discharged as a capable of being heard blast. Some portion of energy is discharged as warm radiation streak and a section is coupled into the air as air impact and into the soil ground as ground shocks both as radially expanding shock waves.

Calculation of Peak Overpressure:

Equivalent of TNT- 100 g

Scaled Distance

$$Z = \frac{R}{\sqrt[3]{W}}$$

Where, R is the distance from the point of interest (m) to the detonation source and W is the weight (more absolutely: the mass) of the explosive (Tons).

For 20 cm Standoff Distance, **Z= 4.25m**

Kinney [10] presents a formulation that [10] is based on chemical type Blasts. It is described by following equation and has been used extensively for computer calculation purposes.

$$P_{so} = P_o \frac{808\left[1+\left\{\frac{Z}{4.5}\right\}^2\right]}{\left[\left[1+\left\{\frac{Z}{0.048}\right\}^2\right]+\left[1+\left\{\frac{Z}{0.32}\right\}^2\right]+\left[1+\left\{\frac{Z}{1.35}\right\}^2\right]\right]^{0.5}}$$

Where Z(m/kg1/3) is the scaled distance, Equation and P0 is the ambient pressure.

5.3 ANSYS

5.3.1 ANSYS INC

Table 3. Blast Pressure for 100TNT charge

Sr. No.	Stand-off Distance in cm	Scaled Distance (Z)	Pressure (KN/mm2)
1	20,25 and 30	4.25	6.122

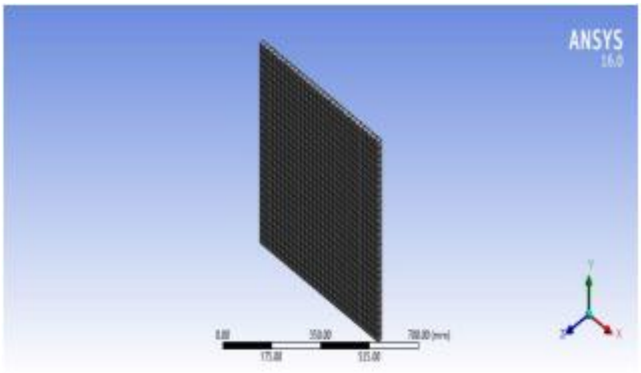


Fig. 2 Ferrocement Panel

5.3.2 MODELING IN ANSYS OF FERROCEMENT PANLES UNDER BLAST LOADING

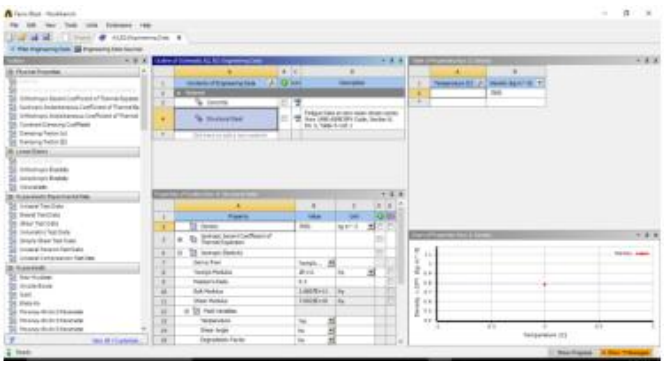


Fig. 3 Adding material in Ansys

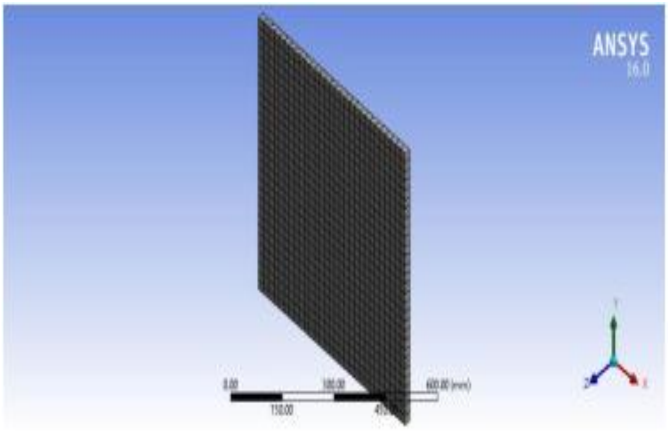


Fig. 4 Modelling of ferrocement panels in Ansys

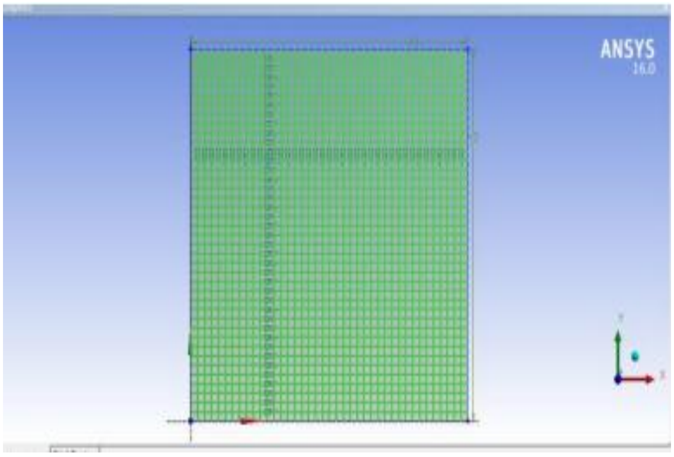


Fig. 5 Meshing Ferrocement Panel

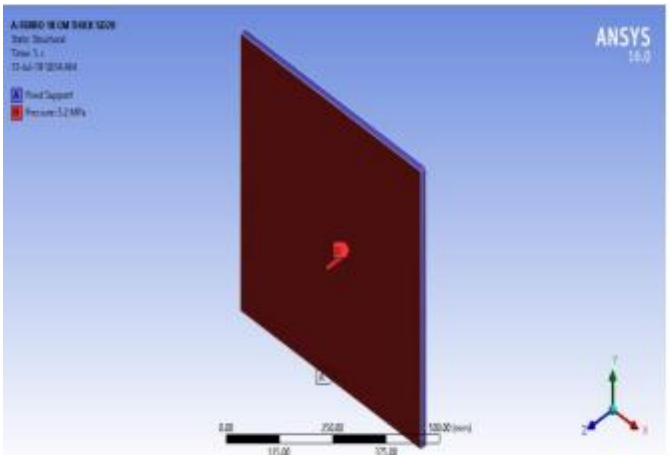


Fig.6 Preparation Applying Pressure on Ferrocement Panel

6 RESULTS

6.1 Ferrocement Panel With 2-Layered wired Mesh And 18mm Thickness with standoff distance of 20cm.

6.1.1 Total Deformation

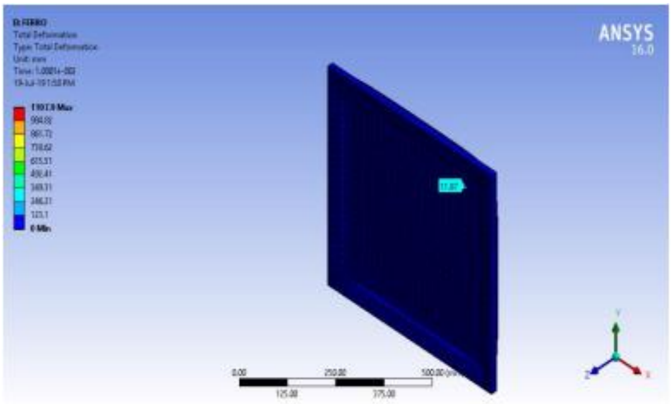


Fig. 7 Total Deformation

6.1.2 Equivalent Stress-

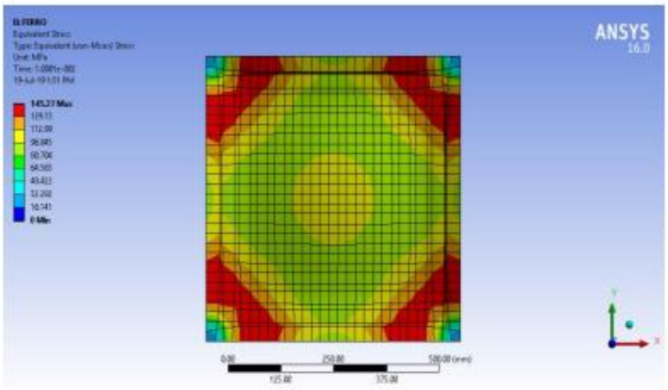


Fig. 8 Equivalent Stress

6.1.3 Equivalent Elastic Strain-

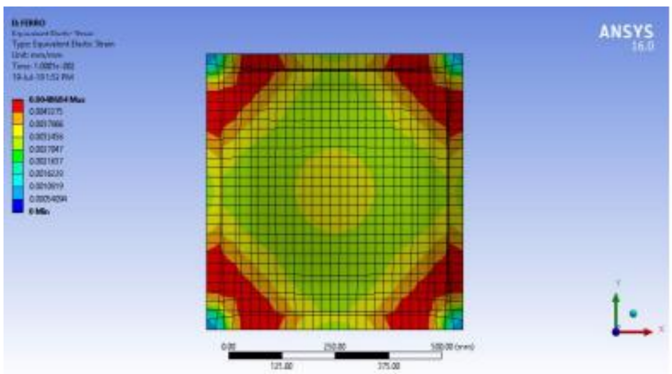


Fig. 9 Equivalent Elastic Strain

6.2 Ferrocement Panel With 2-Layered wired Mesh And 18mm Thickness with standoff distance of 25cm.

6.2.1 Total Deformation

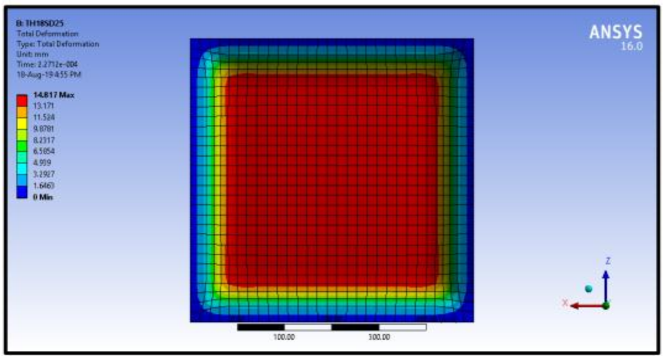


Fig. 10 Total Deformation

6.2.2 Equivalent Stress

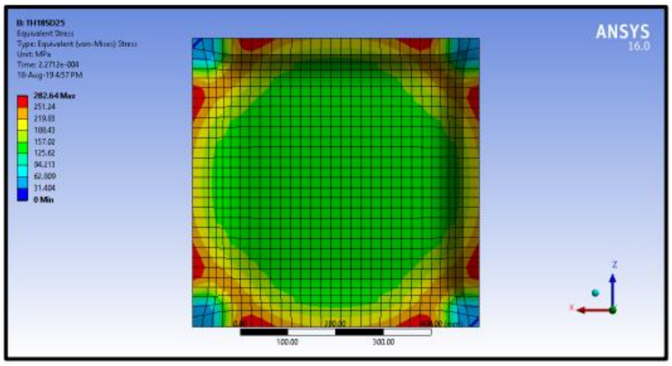


Fig. 11 Equivalent Stress

6.2.3 Equivalent Elastic Strain-

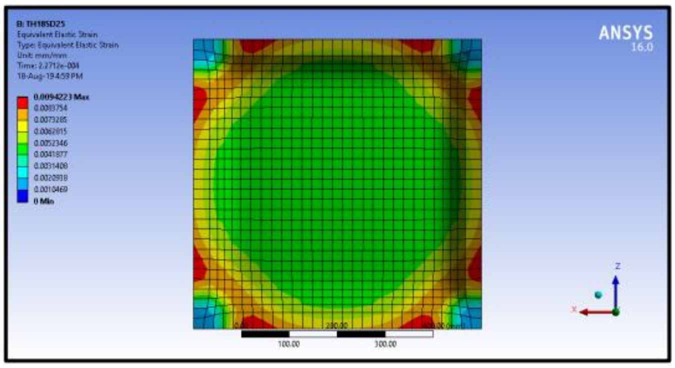


Fig. 12 Equivalent Elastic Strain

6.3 Ferrocement Panel With 2-Layered wired Mesh And 18mm Thickness with standoff distance of 30cm

6.3.1 Total Deformation

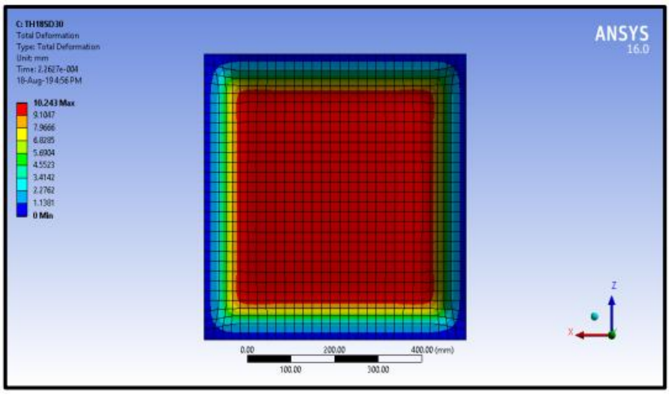


Fig. 13 Total Deformation

6.3.2 Equivalent Stress

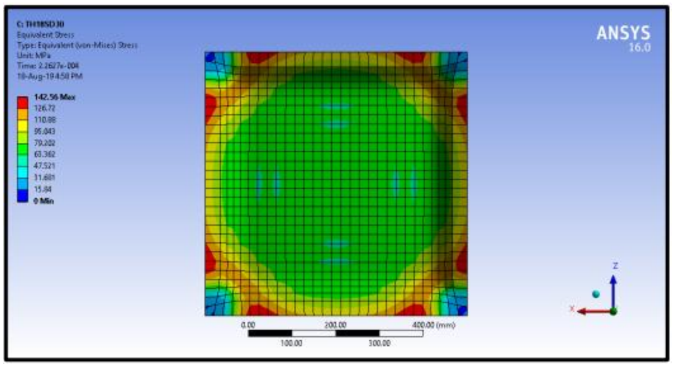


Fig. 14 Equivalent Stress

6.3.3 Equivalent Elastic Strain-

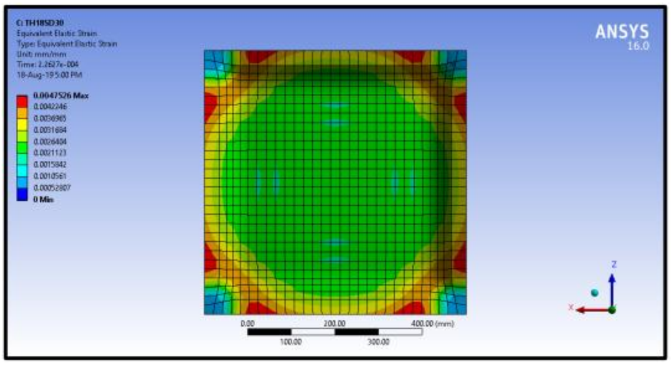


Fig. 15 Equivalent Elastic Strain

6.4 Ferrocement Panel With 3-Layered wired Mesh And 25mm Thickness with standoff distance of 20cm:

6.4.1 Total Deformation

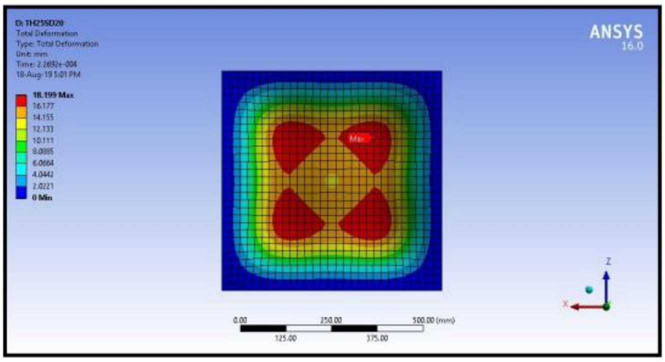


Fig. 16 Total Deformation

6.4.2 Equivalent Stress-

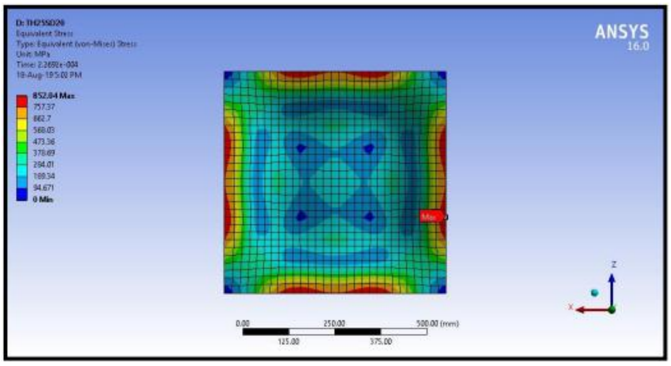


Fig. 17 Equivalent Stress

6.4.3 Equivalent Elastic Strain-

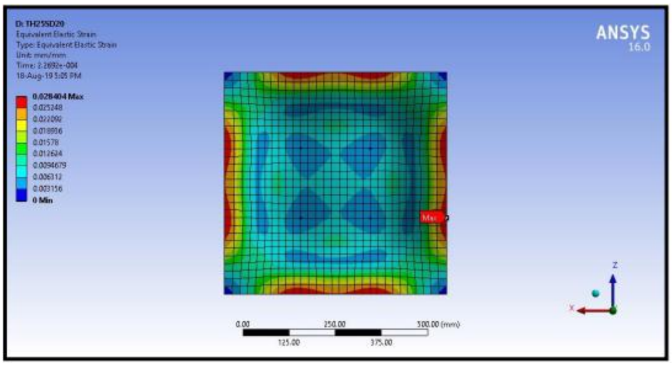


Fig. 18 Equivalent Elastic Strain

6.5 Ferrocement Panel With 3-Layered wired Mesh And 25mm Thickness with standoff distance of 25cm:

6.5.1 Total Deformation

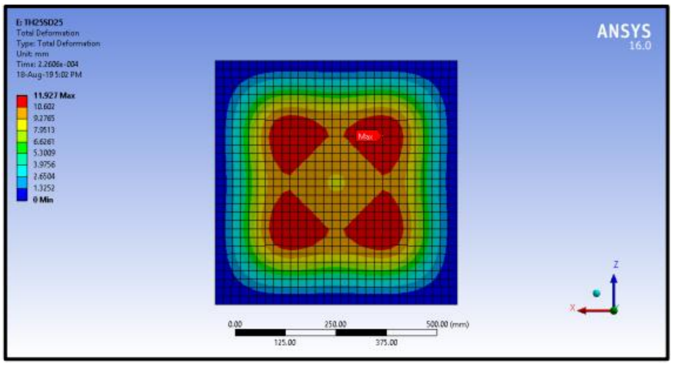


Fig. 19 Total Deformation

6.5.2 Equivalent Stress-

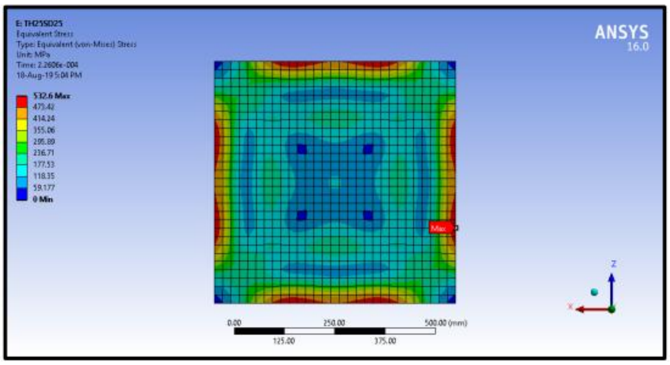


Fig. 20 Equivalent Stress

6.5.3 Equivalent Elastic Strain-

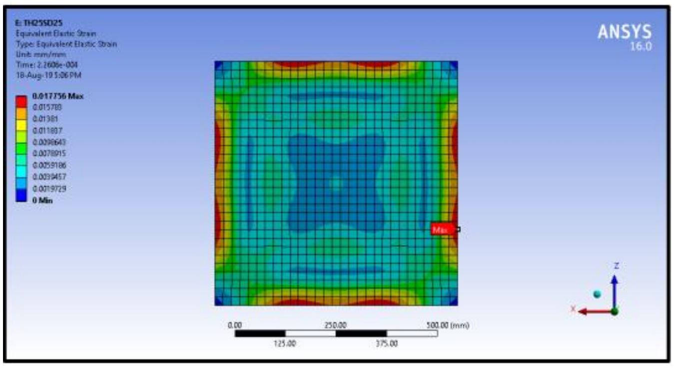


Fig. 21 Equivalent Elastic Strain

6.6 Ferrocement Panel With 3-Layered wired Mesh And 25mm Thickness with standoff distance of 30cm:

6.6.1 Total Deformation

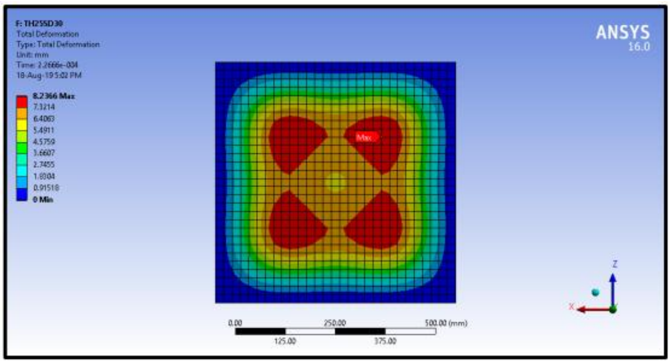


Fig. 22 Total Deformation

6.6.2 Equivalent Stress-

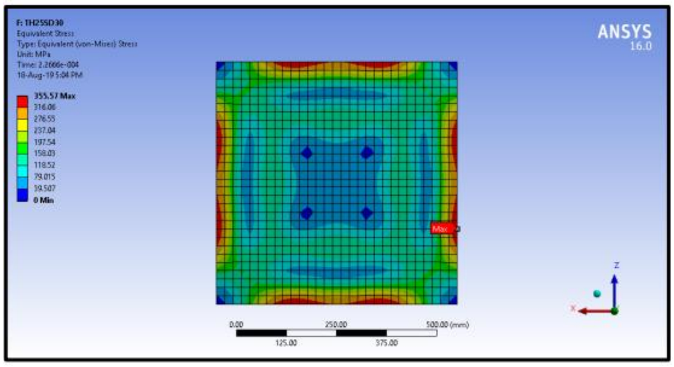


Fig. 23 Equivalent Stress

6.6.3 Equivalent Elastic Strain-

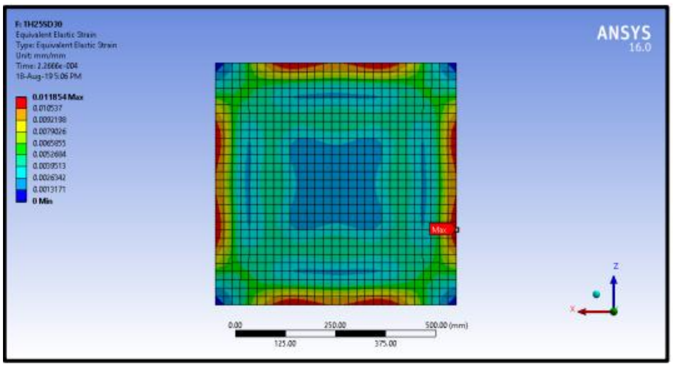


Fig. 24 Equivalent Elastic Strain

6.7 Ferrocement Panel Results for 2-Layered wired Mesh And 18mm Thickness.

Table 4. Ferrocement Panel Results 2-Layered wired Mesh And 18mm Thickness.

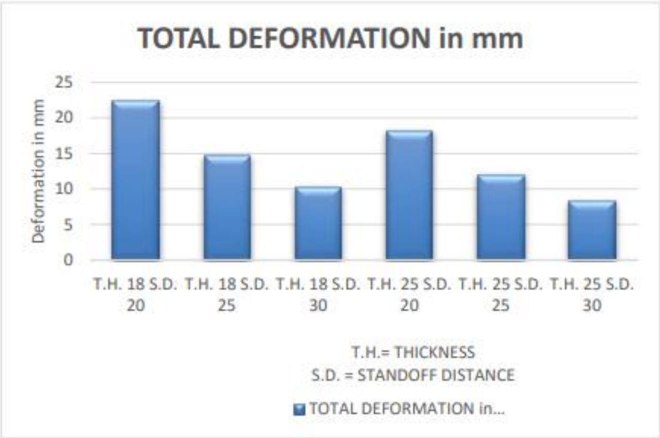
Result	**Ferrocement Panel**		
Standoff distance	**20**	**25**	**30**
TOTAL DEFORMATION in mm	22.446	14.817	10.243
EQUIVALENT STRESS MPa	561.79	282.64	142.56
EQUIVALENT ELASTIC STRAIN	0.0087	0.00942	0.00475

6.8 Ferrocement Panel Results for 3-Layered wired Mesh And 25mm Thickness.

Table-5 Ferrocement Panel Results for 3-Layered wired Mesh And 25mm Thickness.

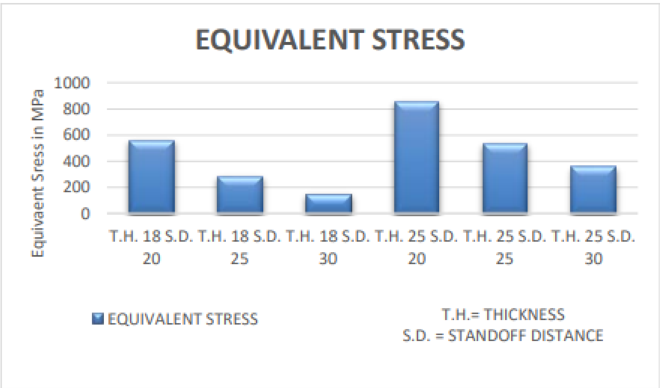
Result	**Ferrocement Panel**		
Standoff distance	**20**	**25**	**30**
TOTAL DEFORMATION in mm	18.199	11.927	8.2366
EQUIVALENT STRESS MPa	852.04	532.6	355.57
EQUIVALENT ELASTIC STRAIN	0.0284	0.0177	0.0118

TOTAL DEFORMATION



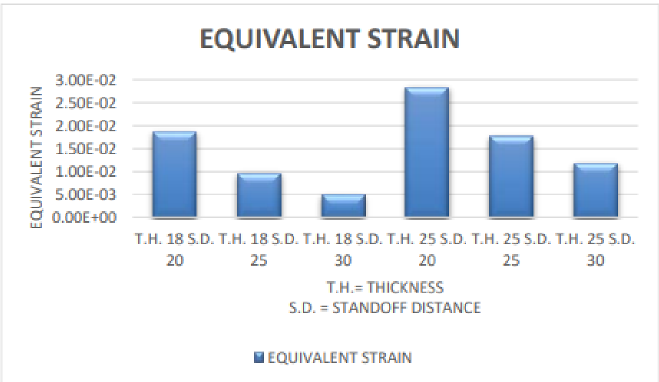
Graph 6.1 Total Deformation for Various Standoff Distances

EQUIVALENT STRESS



Graph 6.2 Equivalent Stress for Various Standoff Distances

EQUIVALENT STRAIN



Graph 6.3 Equivalent Strain for Various Standoff Distances

7 CONCLUSIONS

- It is observed that total deformation for ferrocement panel with 18 mm thickness is average 23.98% greater than deformation in 25 mm thickness ferrocement panel.
- Equivalent stresses developed in ferrocement panels 25 mm thickness are nearly 46.97 % more than stresses developed in 18mm thickness ferrocement panel.
- Equivalent Elastic Strain developed in ferrocement panels 25 mm thickness are nearly 58.63% more than stresses developed in 18mm thickness ferrocement panel.
- The proposed methodology can be used for improvement in design criteria for ferrocement or other concrete composite elements subjected to air Blast loads.
- For longer Stand-Off distance both panels with 25mm thickness are more durable and provide good resistance to Blast as compared to 18 mm thickness panels, so from design point of view 25 mm thick ferrocement panel is preferred.
- In case of edifices which possess greater threat of occurrence of Blast, ferrocement panels with more thickness and a greater number of wire-meshes is recommended.

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REFERENCES

1. ANSYS AUTODYN User Manual (2007), Version 16.0, Concord (CA, USA) Century Dynamics, p. 528

2. IS 4991 (1968), Criteria for blast resistant design of structures for explosions above ground., BIS, India

3. U.S. Army COE (USACE). (1990). "Structures to resist the effects of accidental explosions." TM 5-1300, Dept. of the Army, Washington, DC.

4.Unified Facilities Criteria (UFC 3-340-02), (2008), "Structures to Resist the Effects of Accidental Explosions".

5.Alok Goyal, "Blast resistant design: Critical issues, proceedings of the sixth structural engineering convection", pp IPXI-1-10, Dec 2008

6. Ray Singh Meena, BE thesis report, National Institute of Technology, Rourkela (2009).

7. P.B. Sakthivel, "Ferrocement construction technology and its application-A Review", The International Conference on Structural Engineering, Construction and Management at Kandy, Sri Lanka on December 15-17,2011, pp 2-12

8. M. Saleem, "Flexural Behavior of Ferrocement Sandwich panels", Cement Concrete Composites, Jan-1991pp 21

9. A. Jagannathan "Study of flexural behavior of ferrocement slab reinforced with PVC coated weld mesh" IJERD, Vol-1, July-2012, pp 50-57

10. R. Phalke "Flexural Behaviour of Ferrocement Slab panels using welded square mesh by incorporating steel fibers" IJRET, Vol-3, May-2014, pp 756- 763.

11.Kinney G, Graham K (1985) Explosive shocks in air. Springer, New York

12. Ray Singh Meena, BE thesis report, National Institute of Technology, Rourkela (2009).

13. Mir. M. Ali, "Protective design of concrete buildings under blast loading" submitted to School of Architecture, Structures Division, University of Illinois at Urbana-Champaign, USA