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USE OF FERROCRETE TECHNOLOGY IN NUCLEAR SHELTERS

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ABSTRACT

Nuclear Shelter is a structure constructed to safeguard its inhabitants from external attacks of nuclear explosions which may prove fatal. At present shelters are constructed of heavy materials like R.C.C., steel, stone etc. These shelters are effective but are very bulky and difficult to construct. New upcoming materials and techniques can replace the conventional RCC heavy structures with optimized solutions. Ferrocrete is a versatile material which has very good mechanical properties especially under dynamic loads, most of the time failure of bunkers occurs due to less efficiency of the material in dynamic load conditions. Under this topic we study the R.C.C. and ferrocrete properties and behavior of the same as a construction material and structure of nuclear shelter. Energy exerted by fission of one pound of nuclear material is equivalent to eight thousand tones of TNT (Trinitrotoluene). The nuclear shelter has to sustain great quantum of energy in form of pressure and shockwaves in few milliseconds thus structural material should be ductile and tough. Ferrocrete being more ductile than RCC can be casted into any shape & size, for the inspection & comparison of the same a module of nuclear shelter was modeled and tested in ANSYS software which gave fair results in context of deflection & stress in the favor of ferrocrete. From the study and analysis ferrocrete is a better alternative for construction of nuclear shelters and any other structures.

Keywords : Nuclear shelter, ferrocrete, nuclear blasts, ANSYS.

1. Introduction

Nuclear shelter is constructed to safeguard its inhabitants from external attacks during nuclear explosions which may prove to be fatal. At present nuclear shelters are constructed of heavy materials like R.C.C., steel, stone etc. These shelters are effective but are very bulky and difficult to construct confidentially as time & men required are more. As the work is heavy, heavy machineries are deployed which can be easily traced by enemies. To cover-up this activity extensive efforts have to be taken which prove to be unnecessary and uneconomical. Due to all these factors conventional bunkers prove less efficient and need a better option.

Ferrocrete is a type of reinforced concrete in thin elements constituting of micro concrete of hydraulic cement, reinforced with layers of continuous netting, in wire, with relatively small diameter. The net may be metallic or other material. Ferrocrete proves to be a better construction material for shelters on account of possessing superior properties in terms of strength, weight & method of construction. It can be casted into any shape and size thus is ductile, ferrocrete can also be precast and erecting work can be done on site.

2. Methodology

2.1 Identification of the problem.

- Construction of bunkers and shelters on site is a heavy cumbersome job
- Duration of construction
- Weight to strength ratios
- Dynamic behavior of RCC

2.2 Use of ferrocrete as one of the solution.

- Study Properties of ferrocrete.
- Using the benefits of shape in the bunker and shelter construction.
- Using ferrocrete precast sections for construction.

2.3 Analysis using High end software ANSYS.

- Analyzing the bunker design prepared by Defense Research and development Organization on ANSYS to study its behavior under blast effects.
- Designing and analyzing the design of a bunker with same loading conditions as DRDO but using ferrocrete as construction material.
- Comparison of the results.
- Stress development comparison.

3. Problem statement:

- A cylindrical module of nuclear shelter loaded with 45 KN/m^2 from top 32 KN/m^2 from sides and 100.66 KN/m^2 from bottom as dead load, live load & overburden pressure.
- The module is subjected to nuclear explosion of 1-megatonne equivalence.
- Distance from ground zero = 1 mile (1609 m)
- Diameter of module = 2.4 m
- Length of module = 3.6 m
- Depth of module below ground surface=2.5 m
- Static overpressure of 275.115KN/m^2

Table No. 1: Details of modules analyzed in ANSYS

Material	Ferrocrete	RCC
Thickness	100 mm	300 mm
Grade of matrix	Comp. Strength 53 Mpa	M50
Reinforcement	2 layers of 0.75 inch gauge mesh	#16 @ 200 c/c TMT bars

RESULTS OF RCC NUCLEAR SHELTER

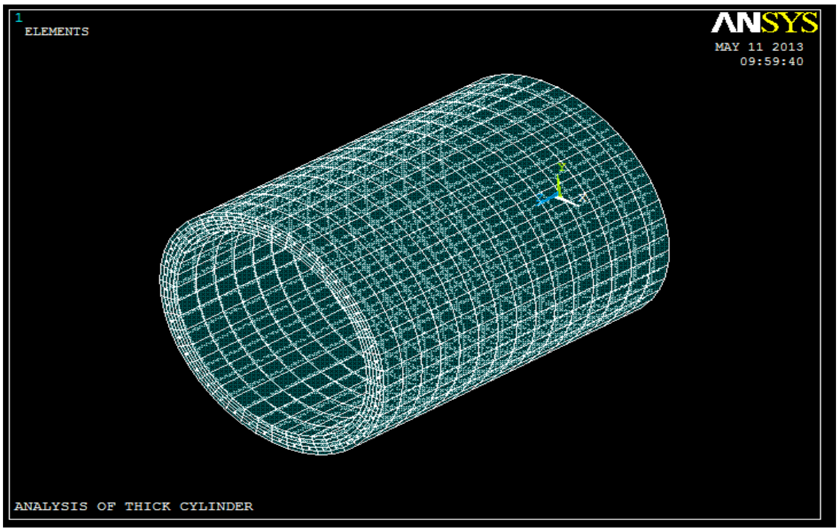

Fig 1 Shape of RCC Nuclear Shelter

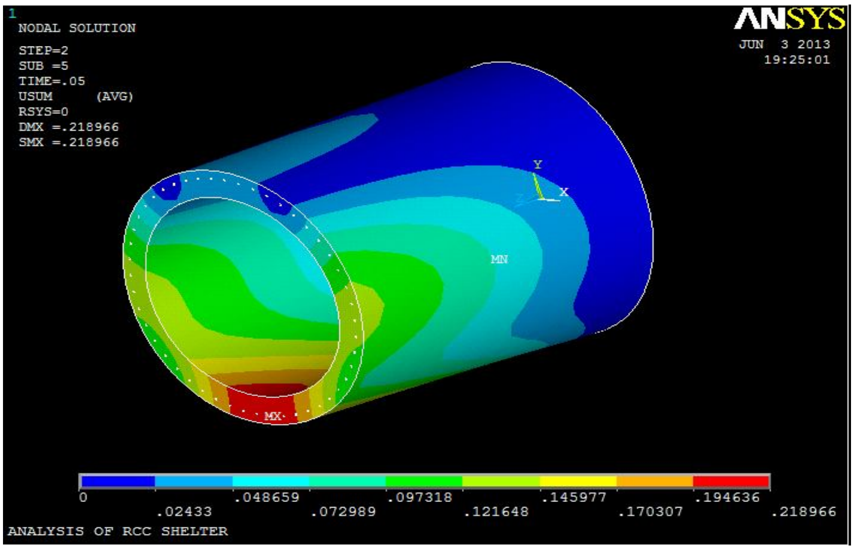

Fig 2 Deformation (Displacement Vector) of RCC Nuclear Shelter

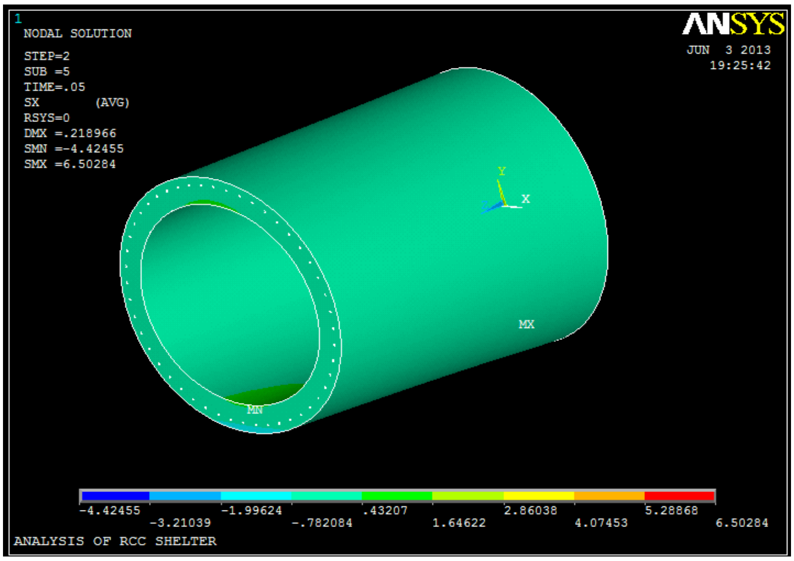

Fig 3 Stress In X Direction of RCC Shelter

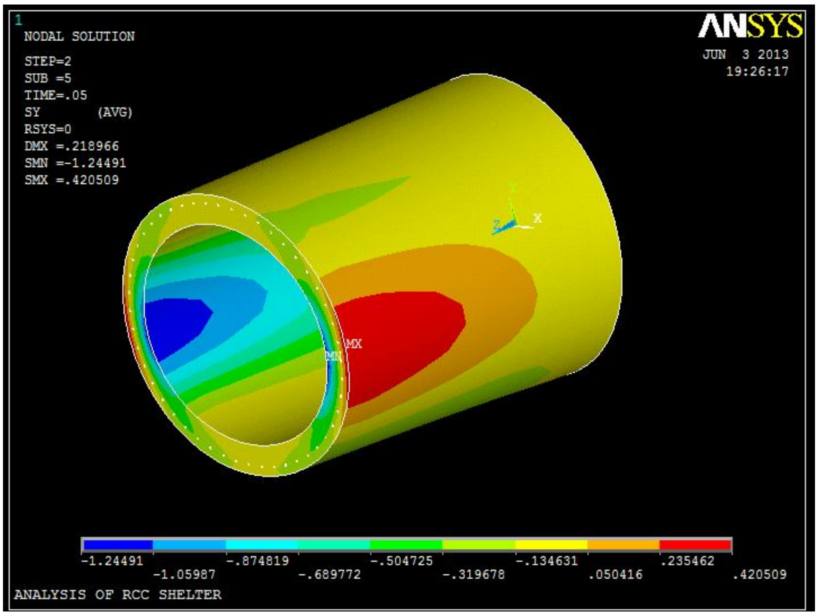

Fig 4 Stress in Y Direction of RCC Shelter

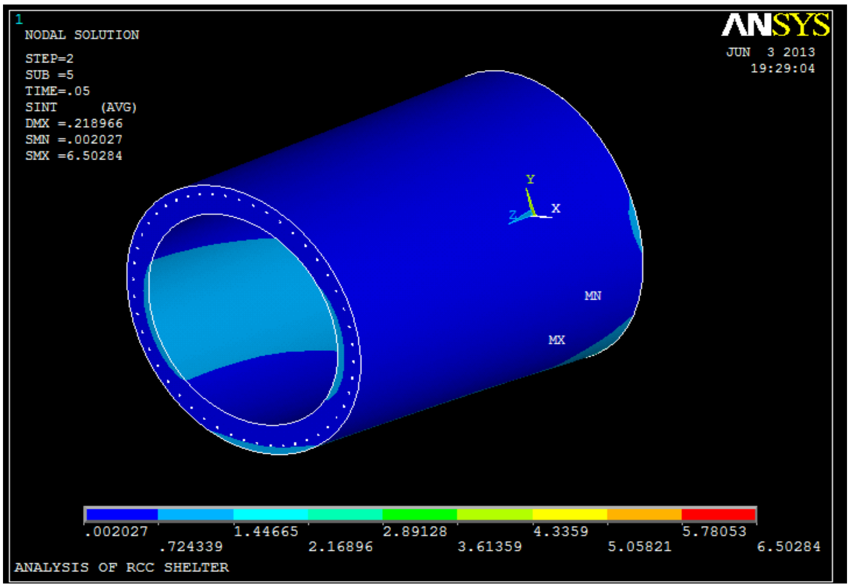

Fig 5 Stress Intensity for RCC Shelter

RESULTS OF FERROCRETE NUCLEAR SHELTER

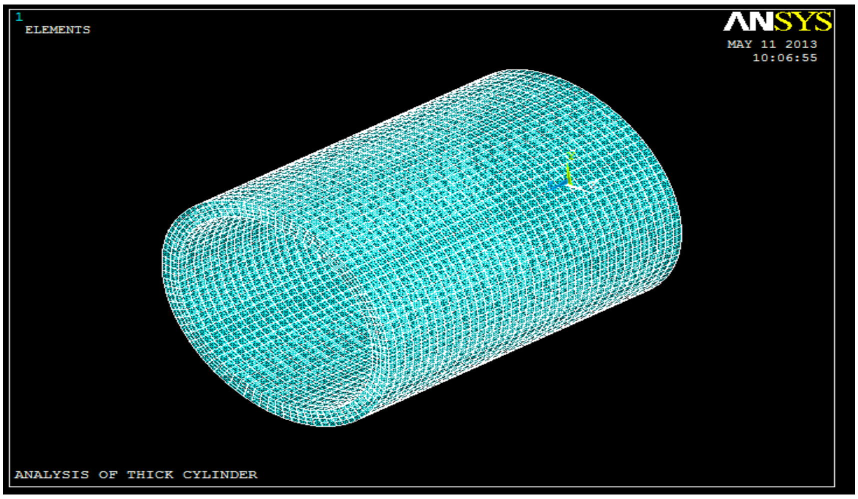

Fig 6 Shape of Ferrocrete Nuclear Shelter

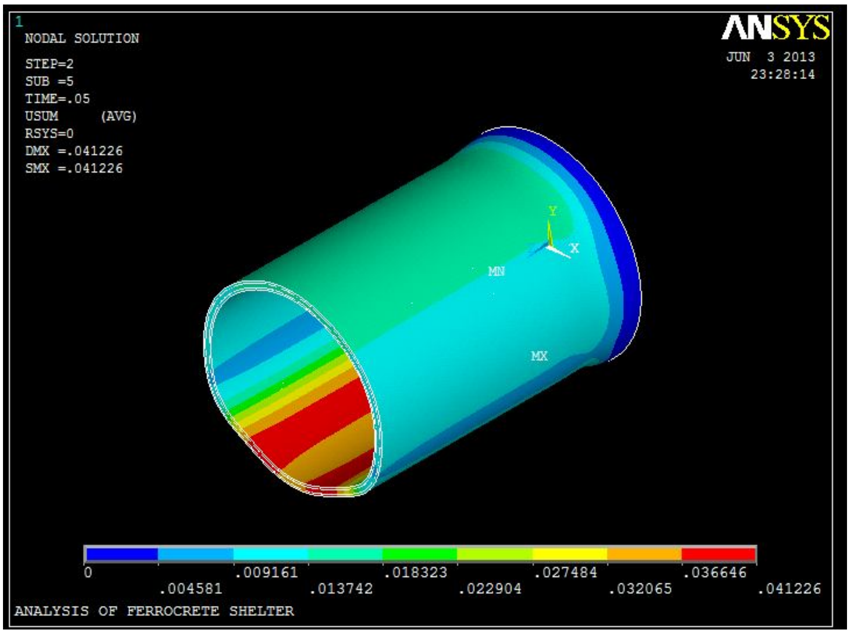

Fig 7 Deformation (Displacement Vector) of Ferrocrete Nuclear Shelter

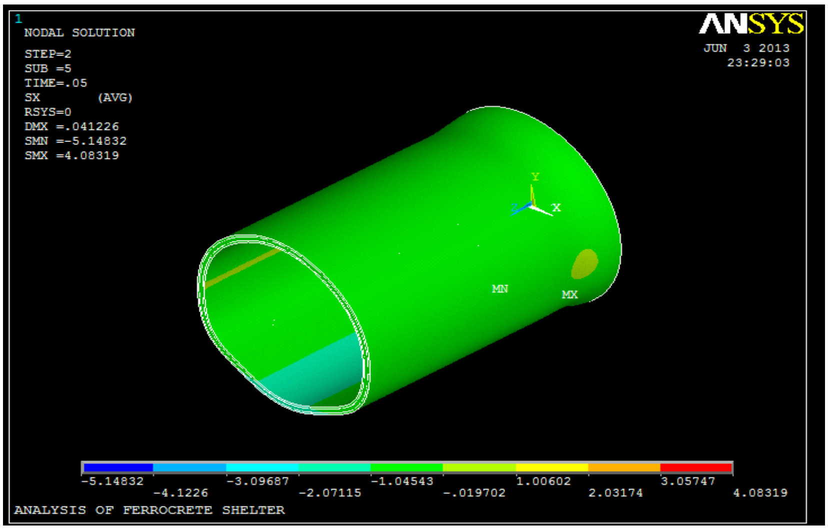

Fig 8 Stress In X Direction of Ferrocrete Shelter

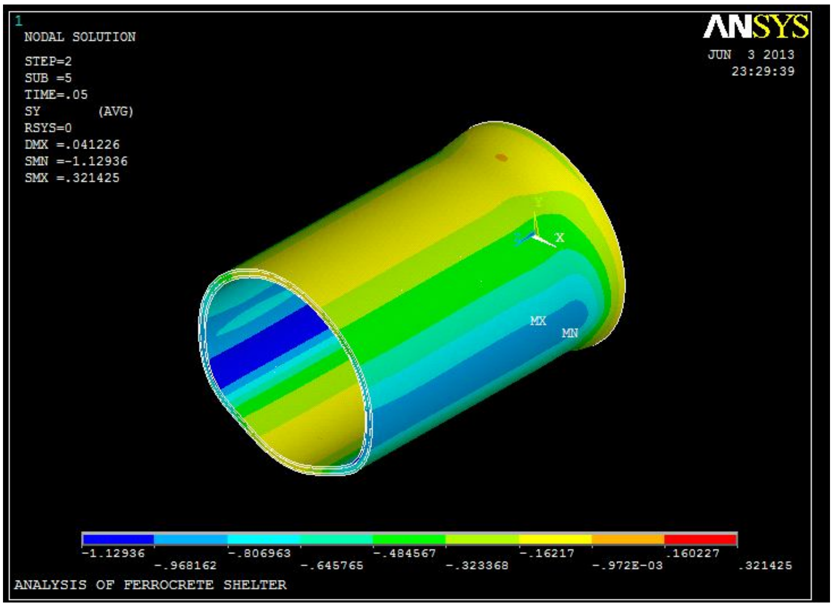

Fig 9 Stress In Y Direction of Ferrocrete Shelter

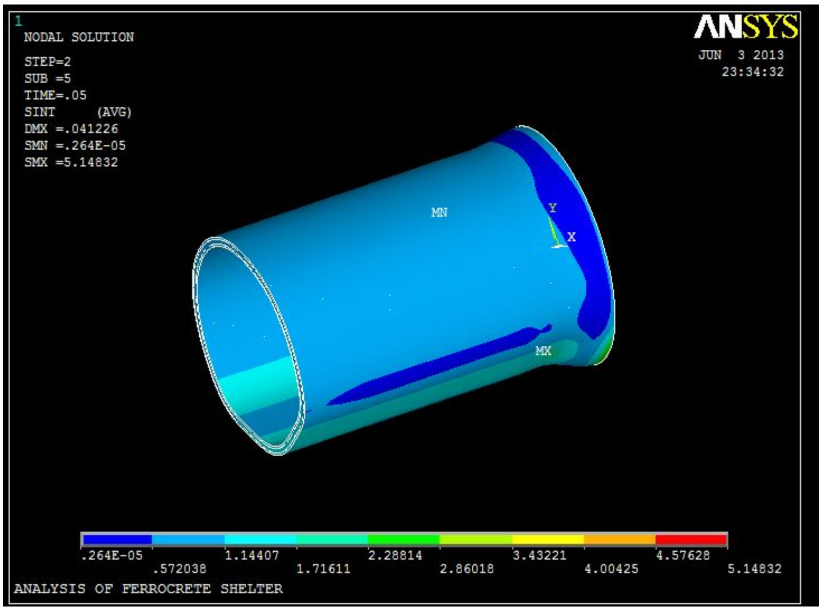

Fig 10 Stress Intensity For Ferrocrete Shelter

4. Result & Discussion

Table 2: Summarized results from ANSYS analysis

Material	RCC	Ferrocrete
Displacement Vector (mm)	0.218	0.0412
Stress in X direction(MPa)	6.502	5.14
Stress in Y direction(MPa)	1.24	1.13
Stress in Z direction(MPa)	1.552	2.25
Stress Intensity (MPa)	6.502	5.148

The analysis gives us a clear picture that the deformations and stresses developed in ferrocrete are less compared to RCC shelter. This is due to the dispersed reinforcing pattern and good bond strength developed in the Ferrocrete shelter.

For heavy loadings the stresses are high in RCC shelter, also the crack development tendency of concrete is more due to being brittle material which is objectionable and undesired for a good quality design of nuclear shelter. Ferrocrete is ductile compared to RCC, the stress and crack development in this material is also less comparatively. The deformation of the ferrocrete in comparison to RCC is less & hence is more stiff material suitable for more superior quality shelters.

5. Conclusion:

From the studies made on conventional concrete, it has been observed drawbacks like inconsistent quality, strength; also the mould ability is not possible with R.C.C. in irregular shapes and profiles. Nuclear explosions induce lot of load & stresses on shelters, which is difficult to be resisted by conventional RCC. The observed deformations in RCC are more as compared to ferrocrete; also the cracks that develop at same level of stress in Ferrocrete are very less in numbers & size which protects occupants from danger of radioactive contamination. The staggered fashion reinforcement pattern by use of wire mesh plays important role for proper distribution of stress as compared to the concentrated reinforcing pattern of conventional reinforced concrete with steel bars. Thus, ferrocrete will be a good alternative material for construction of future shelters overcoming the problems faced by conventional shelters i.e. safety and durability.

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