Computational Structural Design and Finite Element Analysis of Fire Cracker Safety Rooms

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***Abstract*— Many studies reveals that the improper structural design of fire cracker safety room which leads to increase in loss of life. Hence we took our study to explore a new design of safety room to withstand such a high pressure and also to study the exploded material movement during the explosion with respect to wall thickness, shape of the room, roof design. Here in explosion of the room the three major parameter took a vital they are wall thickness, shape of the room, roof design, where these parameter holds varying values which should be studied and evaluated inorder to achieve an ideal design of the safety room. Hence three values of each parameter have been taken to achieve the level of accuracy. By using taguchie technique we are getting twenty seven combinations of these parameters, which can be find out using MINITAB software. For this twenty seven combination we are designing the 3D model of the room using the software PRO-E. For evaluating these model we are importing the model to finite element software ANSYS, where the exploding pressure is given with respect to the constrains. From the stress and deformation results obtained from the ANSYS software we are evaluating the exact parameter for which the design is ideal. For the final evaluation of the results we are again using the MINITAB software, in which SN ration and MEAN values graphs are plotted to explore the exact value of the parameters for ideal safety room design.**

***Keywords*— ANSYS,Firework industries,shape of room,wall thickness,roof design**

I.INTRODUCTION

Fireworks industries are mostly prone to fire and explosion. Hazardous chemicals are being used to produce light and radiant effects during the display of the firework crackers. It is reported that, accidents in fireworks industries lead to loss of human lives.The main objective of this research work is to focus on control methods on effects of fireworks explosion accidents. In general, fireworks accidents can't be avoided but accidents can be controlled by such control methods.Sivakasi supplies firecrackers and sparkers for all important ceremonies. For the colour effect of fireworks, toxic heavy metals like barium, aluminum, lead, mercury salts, antimony, copper, and strontium can be used in firework compositions. The smoke from fireworks consists mainly of fine toxic dusts that can easily enter the lungs. They are more harmful to the society as they pollute our environment which affects the infants, children, pregnant women, patients and senior citizens.

II.LITERATURE REVIEW

Bruce Ellingwood, E.V. Leyendecker and James T.P. Yao (1983) illustrated the need of incorporating the effects of abnormal loads in codes and standards for the design of structures. Abnormal loads, which usually are not considered in structural design because of their low probability of occurrence, may initiate a catastrophic failure if they occur. A case study shows that the probability of structural failure due to a gas explosion in a residential compartment may exceed probabilities associated with unfavourable combinations of ordinary design loads. Therefore, specific provision is needed in design standards to mitigate the effects.

Christopher D. Eamon, James T. Baylot, and James L. O'Daniel (2004) analysed concrete masonry unit walls subjected to blast pressure with the finite element method, to develop a computationally efficient and accurate model. Concrete masonry unit walls subjected to blast pressure were analyzed with the finite element method, with the goal of developing a computationally efficient and accurate model. Wall behaviour can be grouped into three modes of failure, which correspond to three ranges of blast pressures. Computational results were compared to high-speed video images and debris velocities obtained from experimental data. A parametric analysis was conducted to determine the sensitivity of computed results to critical modelling values. It was found that the model has the ability to replicate experimental results with good agreement. However, it was also found that, without knowledge of actual material properties of the specific wall to be modelled.

III.SCOPE AND OBJECTIVES

Analytical studies were conducted with help of ANSYS software to study the Static and Dynamic analysis of fireworks industrial buildings under impulsive loading.Totally 27 models were studied with various geometrical configurations in plan (9 models each for square, rectangular and hexagonal configuration). For all these three geometrical configurations, the plan area was kept equivalent to the plan area of the conventional unit, that is $10.8m^2$ (3.6 x 3 $=10.8m^2$). The equivalent room dimension required for a square shape room for manufacturing shed of firework industry is 3.3m x 3.3m. ANSYS studies were conducted on 3.3m x 3.3m square model to suit the area of industrial unit as $10.8m^2$. The explosive loading of $600kN/m^2$ was considered

Material properties

Parameter	***Brick Masonry***	***RCC***
L x B	3.60m x 3.0m	
Density	1900kg/m^3	2400kg/m^3
Young's Modulus	1.2 x10^4 N/mm^2	2.3 x10^4 N/mm^2

Loading parameter

Parameter	**Maximum value**	**Unit**
Static pressure Pso in bars	25.163	Bars
Shock pulse duration tb in milliseconds	0.450	Millisecond
Time of drag td in milliseconds	0.630	Millisecond
Equivalent Pressure	6.75	Bars
Equivalent Impulse	320.625	Ps (N– msec /m^2)
Time Period	0.303	Seconds
Peak ground Acceleration	587	G

Note: 1 bar = 100kN/m^2

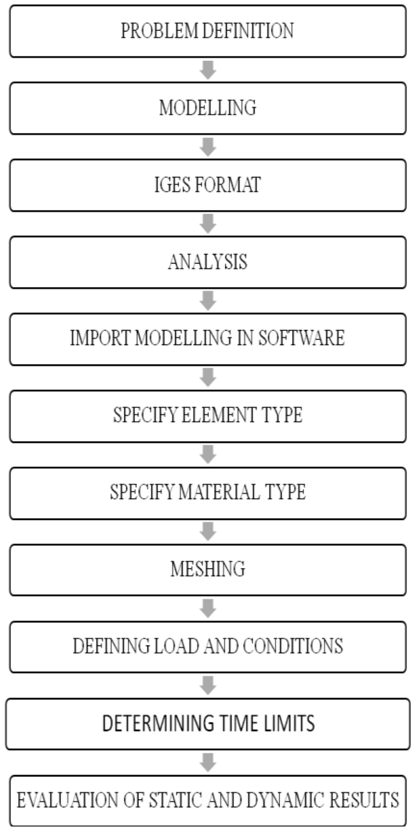
Static and Dynamic impulsive load of 600kN/m^2 was applied on all the walls as uniform pressure acting on the walls. Finite element studies were conducted on brick masonry model of wall thickness 115mm,150mm,230mm.RCC roofing of 100mm thickness were taken into account various shapes such as flat, sloped and curved were considered in this study. The deflection behaviour of model structures was studied using ANSYS (version 12) software.

OBJECTIVES

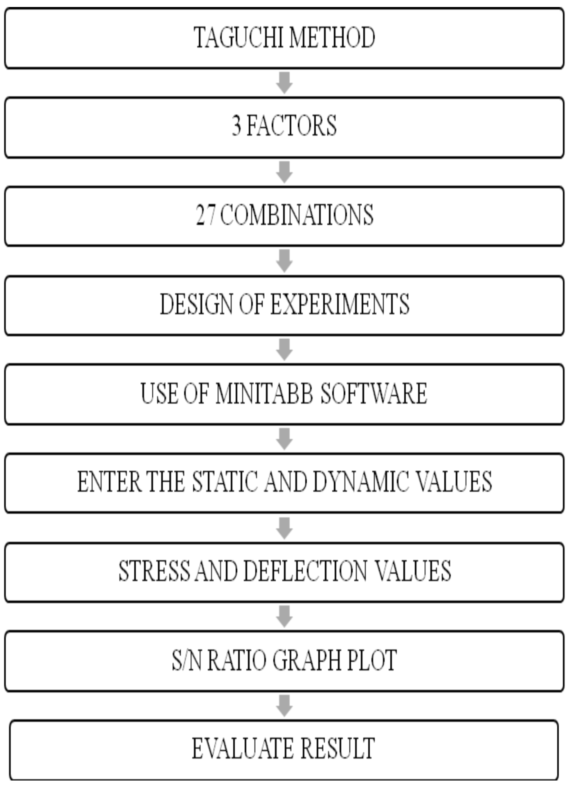
- Identification of Risks in fireworks Industries.
- Performing modelling structure for Fireworks industries.
- Analysing the modelling structure by

    1. Static analysis
    2. Dynamic analysis

IV.METHODOLOGY



ANSYS MINITABB



TAGUCHI FACTORS PRECEDENCE

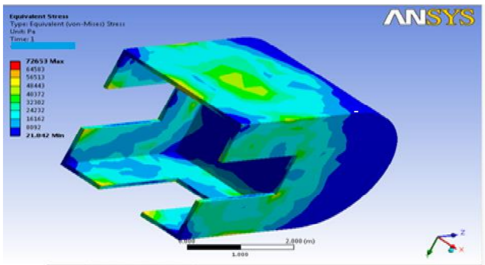
	Factors/parameters name	Level 1	Level 2	Level 3
	WALL THICKNESS(mm)	115mm	150mm	230mm
	SHAPE OF THE ROOM	SQUARE	RECTANGLE	HEXAGONAL
	ROOF DESIGN	FLAT	TAPERED	CURVED

V. RESULTS AND DISCUSSIONS

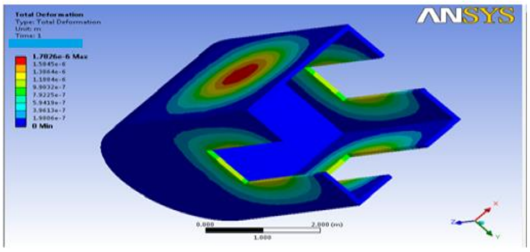
115- Square –Curved

Static

The Equivalent stress on walls by dynamic analysis.Minimum stress value can be obtained at all ends.Maximum stress value is obtained on the side walls in bottom direction.Static loading is considered

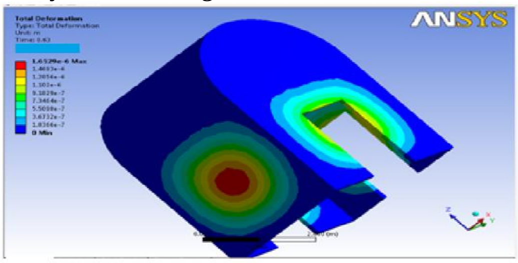


The Total deformation on walls by static analysis.minimum stress value can be obtained at all ends.maximum stress value is obtained on the entire walls in all direction.static loading is considered

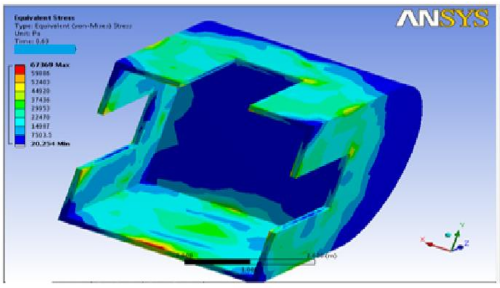


Dynamic

The Total Deformation on walls by dynamic analysis.Minimum stress value can be obtained at all ends.Maximum stress value is obtained on the all direction.Dynamic loading is considered.



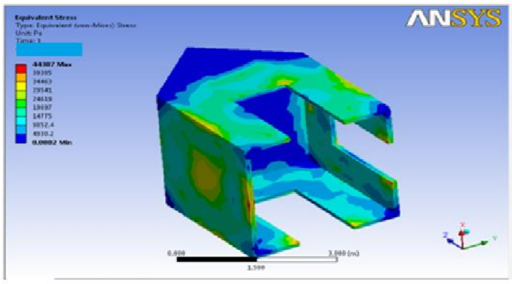
The Stress on walls by static analysis.Minimum stress value can be obtained at all ends.Maximum stress value is obtained on the entire walls in all direction.Static loading is considered.



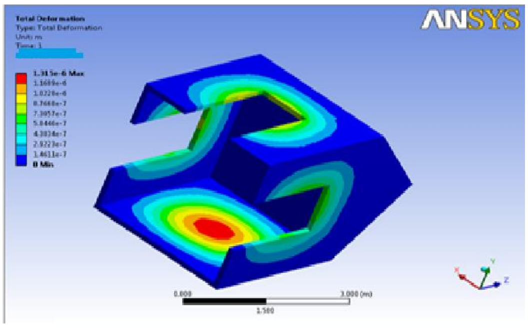
115-Square-Tapered

Static

The Stress on walls by static analysis.Minimum stress value can be obtained at all ends.Maximum stress value is obtained on the entire walls in all direction.Static loading is considered.



The Total deformation on walls by dynamic analysis.Minimum stress value can be obtained at all ends.Maximum stress value is obtained on the side walls in bottom direction.Static loading is considered



Dynamic

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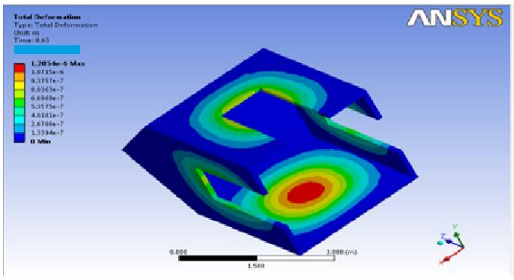

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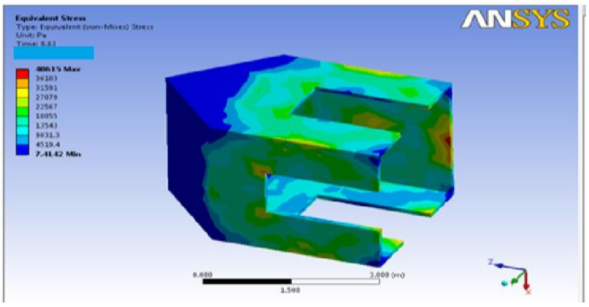
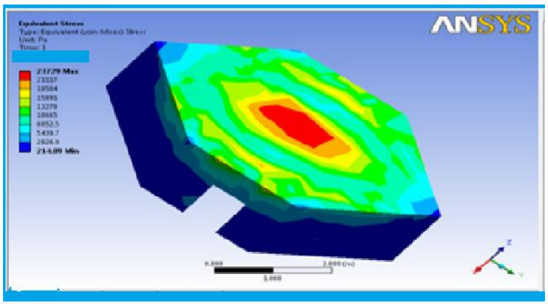


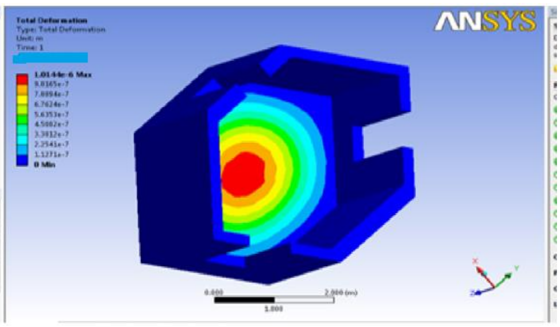
230-Hexagonal-Flat

Static

The Stress on walls by static analysis.Minimum stress value can be obtained at all ends.Maximum stress value is obtained on the entire walls in all direction.Static loading is considered.

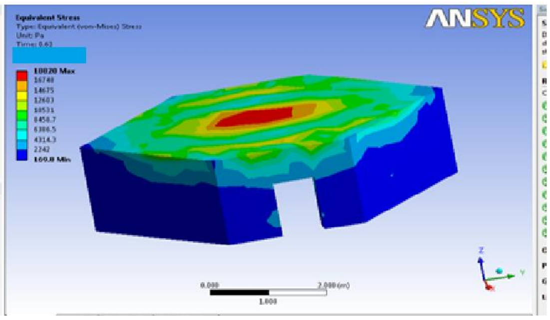


The Total deformation on walls by dynamic analysis.Minimum stress value can be obtained at all ends.Maximum stress value is obtained on the side walls in bottom direction.Static loading is considered

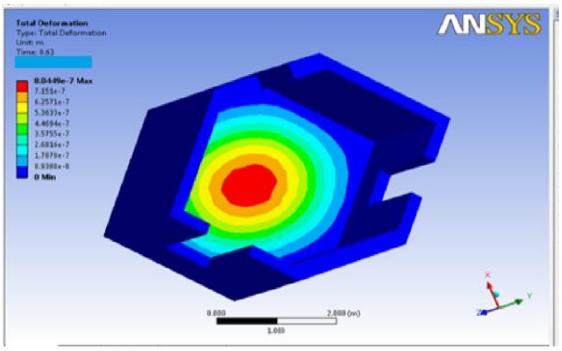


Dynamic

The stress on walls by dynamic analysis.Minimum stress value can be obtained at all ends.Maximum stress value is obtained on the all direction.Dynamic loading is considered.



The Total Deformation on walls by dynamic analysis.Minimum stress value can be obtained at all ends.Maximum stress value is obtained on the bottom direction.Dynamic loading is considered.



VI.CONCLUSION

Finite element studies were conducted on brick masonry model of wall thickness 115mm,150mm,230mm. RCC roofing of 100mm thickness were taken into account various shapes such as flat, sloped and curved were considered in this study. The deflection behaviour of model structures was studied using ANSYS (version 12) software.The deflection behaviour of brick masonry under pyrotechnic explosive loading is studied in both static and dynamic analysis.In Taguchi method Main effects graph and interaction graph is plotted using MINITAB-15, statistical software from the main effects plot seen that slopes of line is reducing in the order Wall thickness,Roof Design,shape of the building.The models of 27 combinations were developed and tested.From the final results of stress and deformation value, three combinations **115mm square tapered, 115m square curved, 230mm hexagonal flat** was considered as safe building structure.

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