BEHAVIOUR OF MULTI-STOREYED BUILDING UNDER BLAST LOADING

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ABSTRACT:-

This paper presents the information for making the multi-storey building safe under the effect of different intensity of blast loading at varying standoff distance by using the shear wall and also compares the result of bare frame and shear wall frame structure, the result of this is compare in the STAAD Pro V8i, in which maximum displacement value at nodes and analysed. The aim of this study is (1) to subject concrete structure to different blast load by varying parameters related to it and to analyse a concrete structure against the abnormal loading conditions that require detailed introspection of the blast occurrence phenomenon. (2) To analyse given structure subjected to above said loading with the help of software and (3) to compare the result of shear wall and bare frame structure. The surge of energy is investigation with a collapse assessment of a usual frame structure building.

INTRODUCTION:-

For the last few years, rebel activities in addition to related intimidation have been a rising concern throughout the world which not only impacts the human life but also leads to loss of property, both structural impacts and its corporeal integrity. Special prominence has also been agreed to nuisance such as explosion and seismic activity. Knowledge about the growth in this aspect is made accessible mainly through the publication of the Ministry of Defence, community institutes and other law-making offices. Because of various accidents as well as intentional events, the reaction of different components of structure impacted by blast loading has been a matter of key concern and endured study attempt in previous years. The otherwise predictable structures, predominantly those higher than requisite grades, are generally not designed to withstand explosion or blast loads; though designed at due magnitudes of designing loads are considerably less than that produced by majority of blast, conservative structures and buildings are vulnerable to damages from blasts. Keeping the same in mind, all concerned, such as engineers developers and architects are increasingly concerned about finding solutions to potential blast conditions, in order to guard edifice occupants as well as the structures.

To ensure sufficient prevention adjacent to explosions and blasts, the construction and design of community buildings have received transformed concentration of architects and civil engineers. Though problems arise with these complexities that include time dependent finite deviations, higher strains, and non-linear non elastic behaviour of material, have led to various assumptions, approximations that could simplify such models. Such models span the whole range of sophistication starting with single degree of freedom systems up to programs of general purpose finite element including ANSYS, STAAD Pro.

LITERATURE REVIEW:-

The essential element is the load that has been produced from a source of explosion, how it interacts with the given structure and how the structure responds to such a load. A source of explosion may include a gas, a highly explosive material, nuclear substances or dirt materials. The common features of an explosion and a blast wave phenomenon have been presented with reference to a discussion of TNT (trinitrotoluene) equivalency, keeping in regard, the blast scaling laws. The characteristic features of an incident that are overpressure-loading due to an atomic weapon, conventionally high explosion and unconfined vapours of a cloud explosion have been addressed that follow a description of other blast loading elements that are associated with the flow of air and the process of reflection. Fertice G., has extensively studied the structures and the computations of the impacts of blast loading on superstructures.

1. Ruiyang Zhang et al. (2015) studied how the blast loads value i.e. in kg converts into impact load i.e. in kN is applied to node of frame structural building by using Hopkinson's law (Baker 1973), mills(1987), Lam et al.(2004) and Bulson(2004) equations. The five-story base isolated building structure is taken comparison was conducted at different standoff distance with different load amount and further, he compares this result with earthquake-affected buildings of different cities. The main comparison was conducted between fixed structure base systems, base isolated structure system containing linear elastomeric bearing and with tuned mass dampers. Where the result shows the value of earthquake is much less as compared to blast effect of 500kg and 1000kg is explained by (Zhang & Phillips, 2016).

2. J. M. Dewey, in 1971, had studied the blast wave-properties of the waves that were obtained from different particle trajectories. For the first time, he had introduced the effect of spherical as well as hemispherical types of TNT (trinitrotoluene) in a blast wave and had obtained the density all over within the flow, applying the Lagrangian's conservation of mass equation which helped to calculate the pressure having assumed the adiabatic flow for each element of air between the different fronts of a shock. The temperature and the speed of the sound were found from the values of density and pressure, the ideal gas equation of states being assumed.

3. T. Ngo, et al. (2007) in their study on "Blast loading and Blast Effects on Structures" gave an overview on the testing as well as the design of structures subjected to explosive load observable fact to understand explosive loading and for their dynamic response to different structural elements. This study relates the design procedure for high concentration blast and its impact.

PROBLEM DESCRIPTION:-

Specifications	Data
Story Height	3 m
Number of stories	5
Number of bays in X direction	8
Number of bays in Z direction	8
Bay Length in X direction	3m
Bay Length in Z direction	3m
Beams	0.6 x 0.3m
Columns	0.6 x 0.6m
Shear wall thickness	0.25m
Concrete grade used	M 30
Floar load	5 kN/m^2
Soil condition	Hard
Damping ratio	5%
Blast load quantity (TNT)	100,200,300,400,500Kg

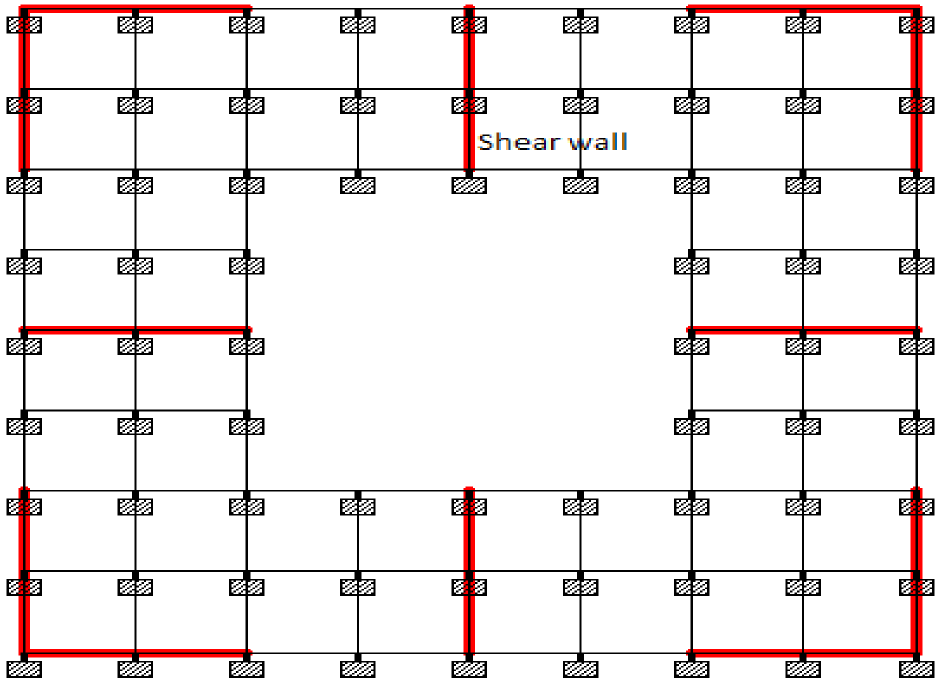


Fig: location of shear wall of frame structure building.

WAVE FORMATION:-

As the process of expansion starts, the overpressure of the blast front drops progressively; the shock wave pressure behind the front is not steady, rather it decreases constantly, at a short duration, at a specific distance from the epicenter of the blast, the pressure at the beck of the shock front falls to lesser as compare to adjacent environment and it's called negative-phase/suction pressure.

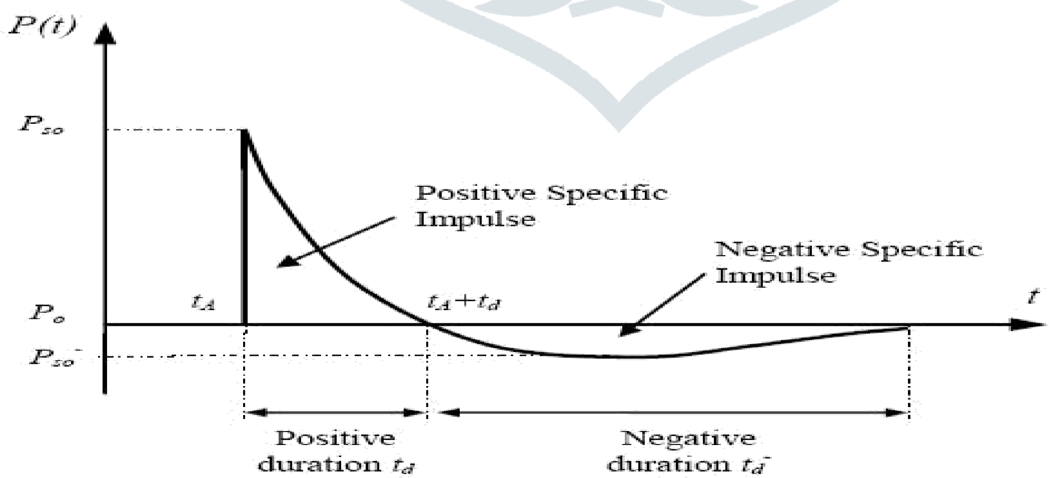
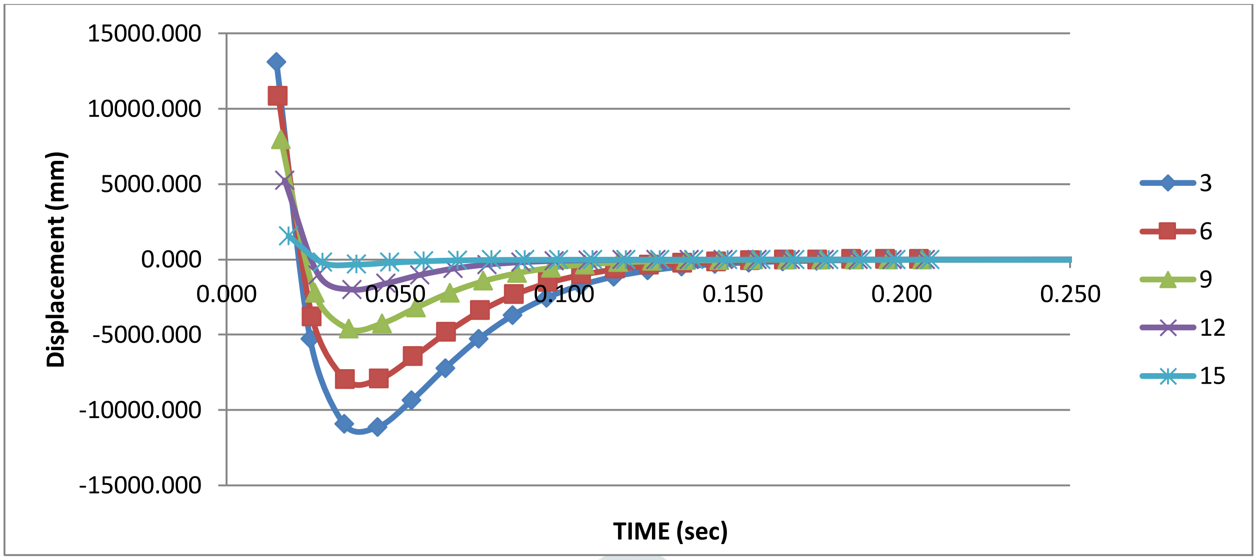


Fig: wave formation of blast



Wave formation of 400kg TNT at 15m standoff distance

RESULT AND DISCUSSION:-

Different STAAD models generated were analyzed, the results of analysis have been discussed in this section. It contains different amount of TNT and varying standoff distance. Each case has its own maximum and minimum displacement which was found by using STAAD Pro V8i. Two different framed structures were used. In one of the cases, we used simple concrete bare frame having only beams and columns, whereas in the other case we used concrete framed structure with shear wall. Maximum overall displacement in the building was chosen to be the main criteria for the comparisons of results all displacements value is in mm.

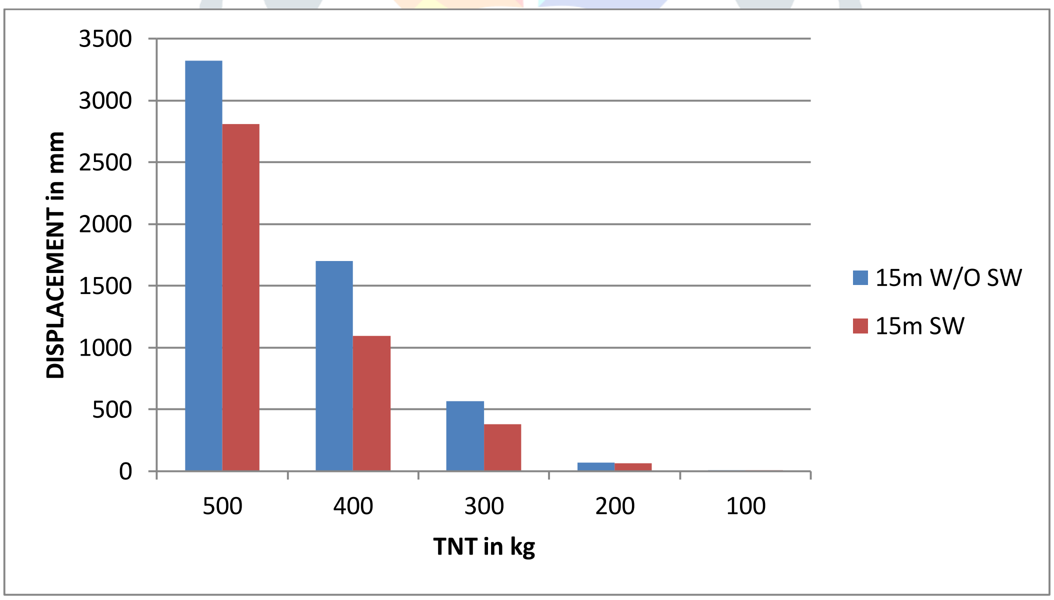
Maximum over all displacement depends upon various parameters such as Standoff distance in mm and amount of TNT used in kg. Table no. 7 shows the maximum value of drift in each case. As we compare the trend of 15m standoff distance with varying TNT, it shows the decrease in displacement as the amount of TNT is reduced in kilograms.

STAND OFF DISTANCE	CASE	TNT kg 500	400	300	200	100	
15m	W/O SW	3320.84	1701.74	567.24	67.22	0.957	DISPLACEMENT in mm
	SW	2807.5	1092.51	378.02	64.72	0.95	
20m	W/O SW	228.09	72.36	33.028	7.85	0.075	
	SW	243.99	59.05	33.25	7.328	0.079	
25m	W/O SW	66.9	31.7	8.97	0.735	0.022	
	SW	64.09	29.71	8.32	0.522	0.031	
30m	W/O SW	19.82	6.59	1.1	0.05	0.021	
	SW	18.4	6.11	1.033	0.054	0.03	

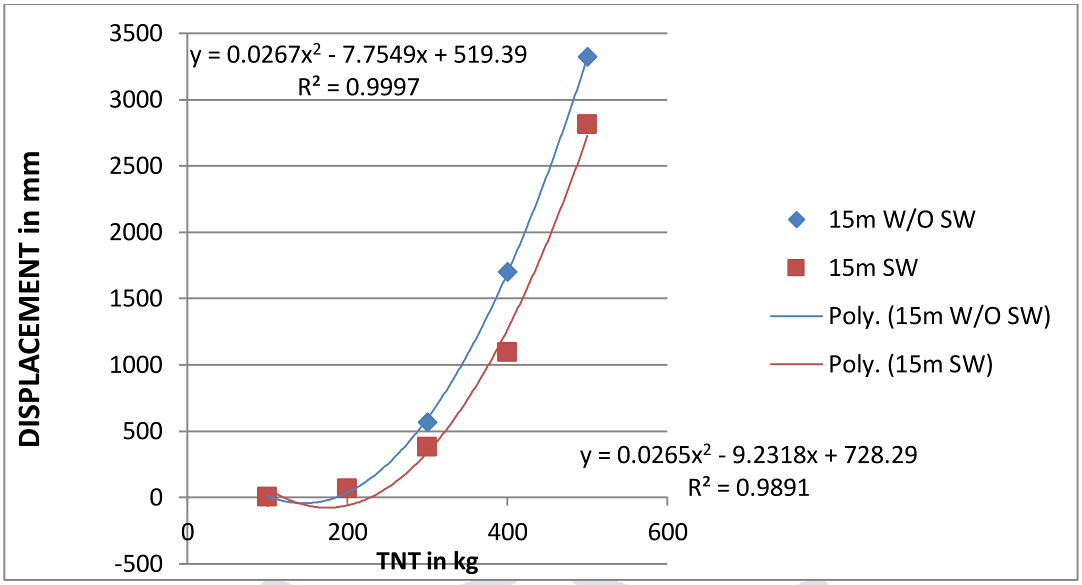
Maximum value of displacement at each blast load category and standoff distance.

CASE FIRST: 15m STAND OFF DISTANCE WITH CHANGING LOAD.

For a displacement of 15m, the trial loads were taken as 500kg, 400kg, 300kg, 200kg and 100kg and we checked the displacement or drift occurring in body which is shown in bar graph. There are two cases that were considered first being bare frame structure or without shear wall case and second one with shear wall case. The graph contains two colors, blue and red. Blue represent bare frame and red represent shear wall case.



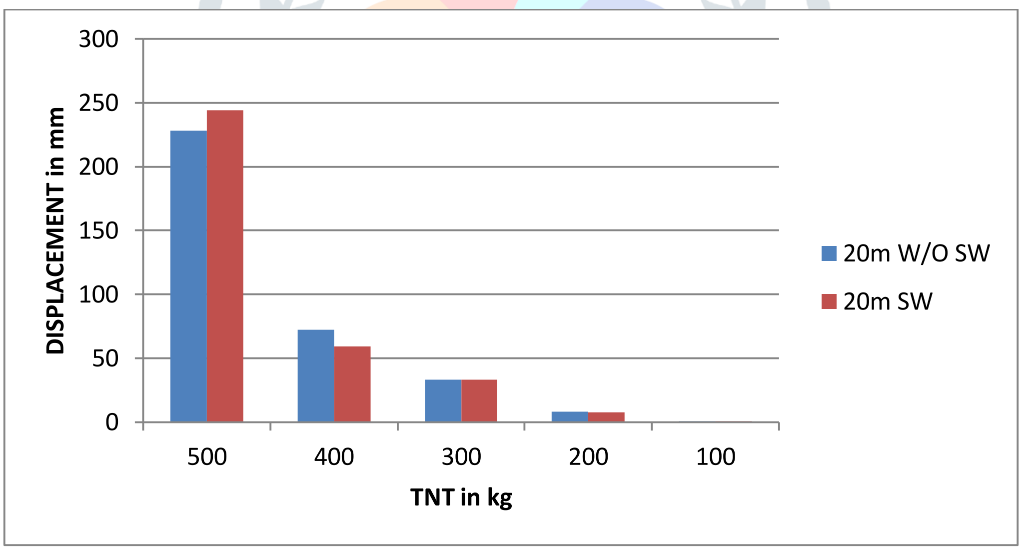
Bar chart comparison between shear wall and w/o shear wall



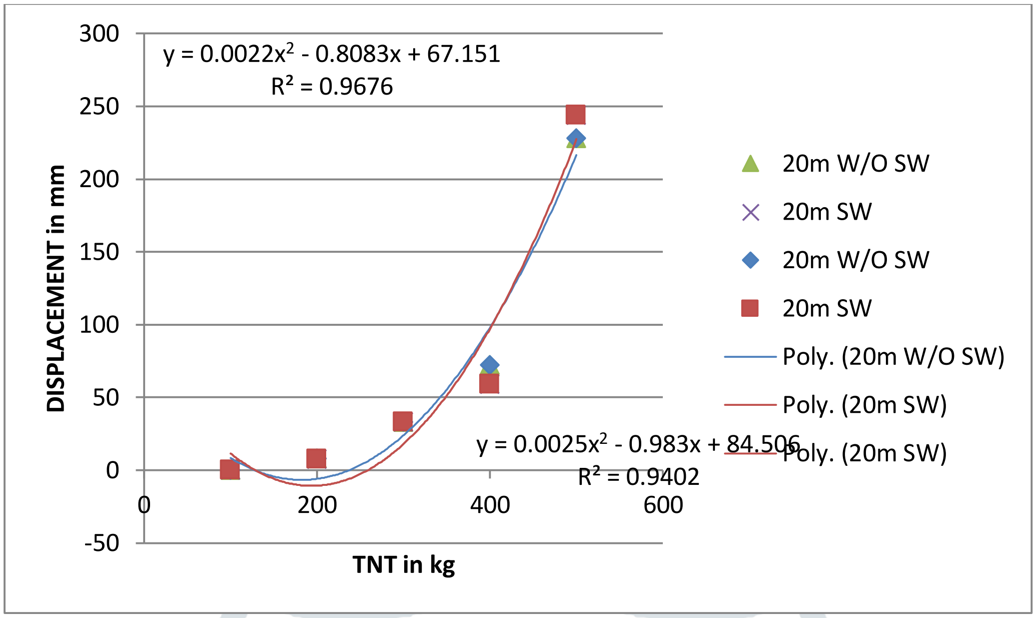
Regression constant curve at 15m

CASE SECOND: 20m STANDOFF DISTANCE WITH CHANGING LOAD.

For a displacement of 20m, the trial loads were taken as 500kg, 400kg, 300kg, 200kg and 100kg and we checked the displacement or drift occurring in body which is shown in bar graph. There are two cases that were considered first being bare frame structure or without shear wall case and second one with shear wall case. The graph contains two colors, blue and red. Blue represent bare frame and red represent shear wall case.



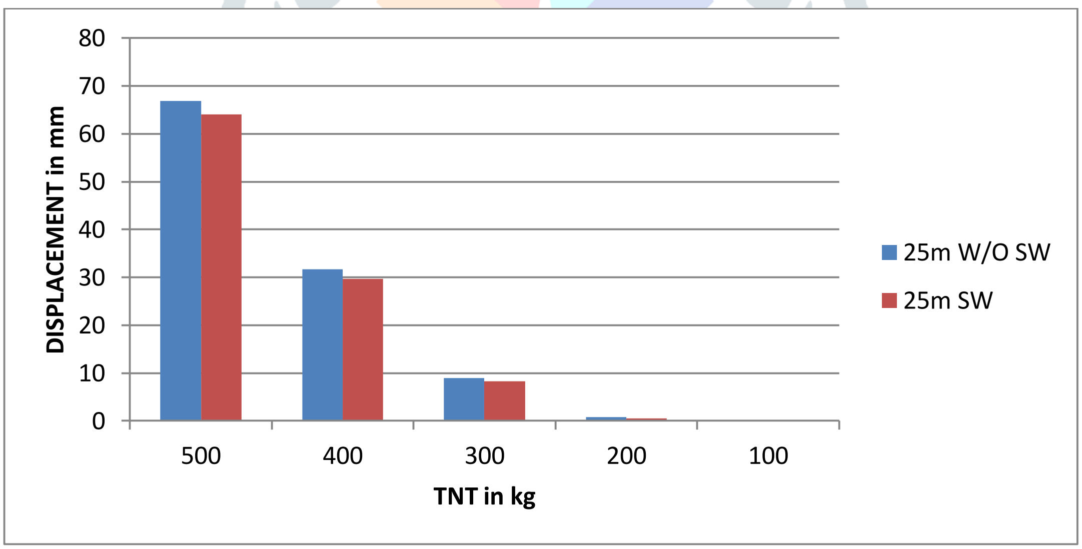
Comparison b/w shear wall and w/o shear wall in 20m standoff distance



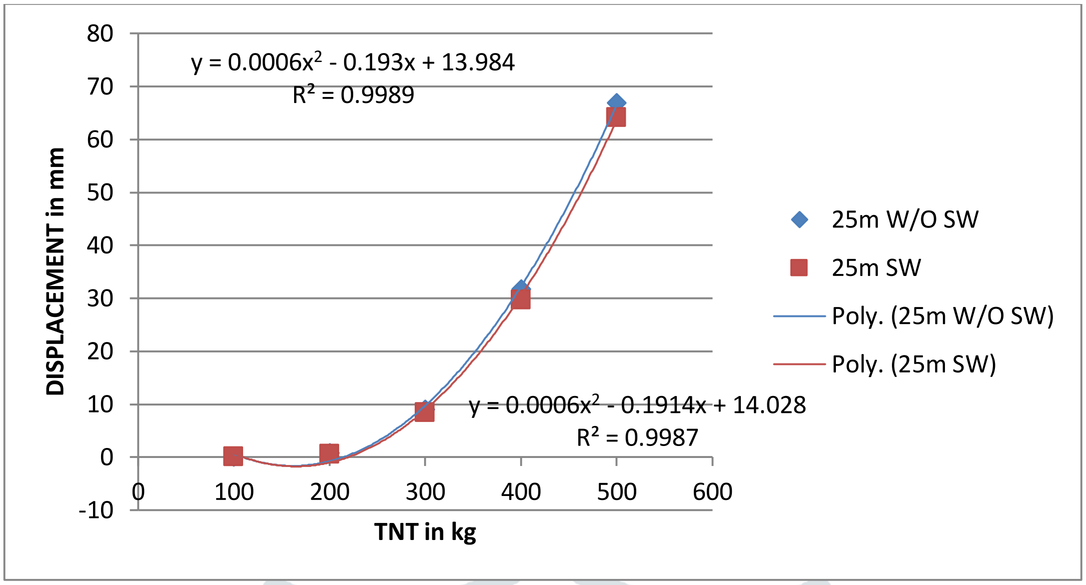
Regression constant curve at 20m

CASE THIRD: 25 M STANDOFF DISTANCE WITH CHANGING LOAD.

For a displacement of 25m, the trial loads were taken as 500kg, 400kg, 300kg, 200kg and 100kg and we checked the displacement or drift occurring in body which is shown in bar graph. There are two cases that were considered first being bare frame structure or without shear wall case and second one with shear wall case. The graph contains two colors, blue and red. Blue represent bare frame and red represent shear wall case.



Comparison b/w shear wall and w/o shear wall at 25m standoff distance



Regression constant curve at 25m

CASE THIRD: 30m STANDOFF DISTANCE WITH CHANGING LOAD.

For a displacement of 30m, the trial loads were taken as 500kg, 400kg, 300kg, 200kg and 100kg and we checked the displacement or drift occurring in body which is shown in bar graph. There are two cases that were considered first being bare frame structure or without shear wall case and second one with shear wall case. The graph contains two colors, blue and red. Blue represent bare frame and red represent shear wall case.

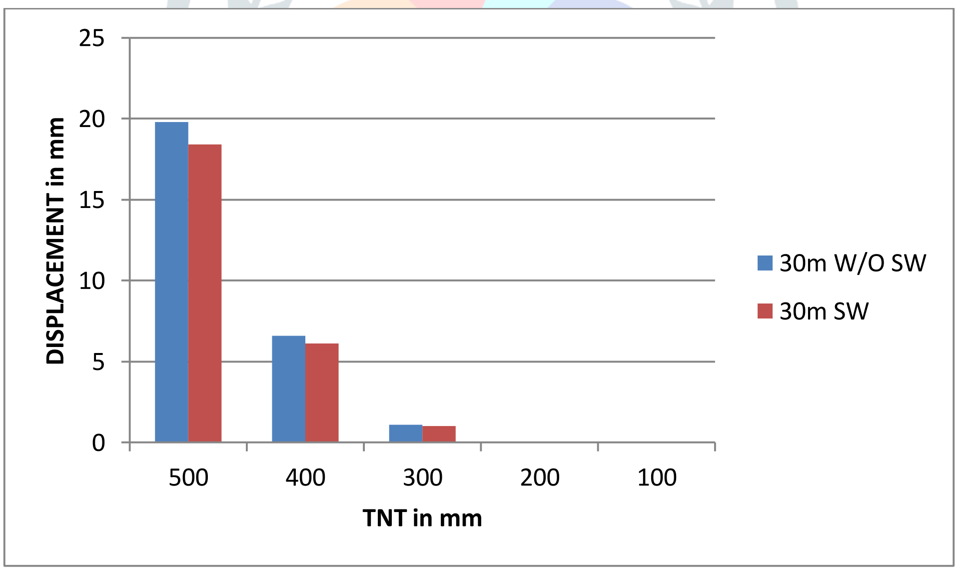


FIGURE 1: Comparison b/w shear wall and w/o shear wall at 30m standoff distance

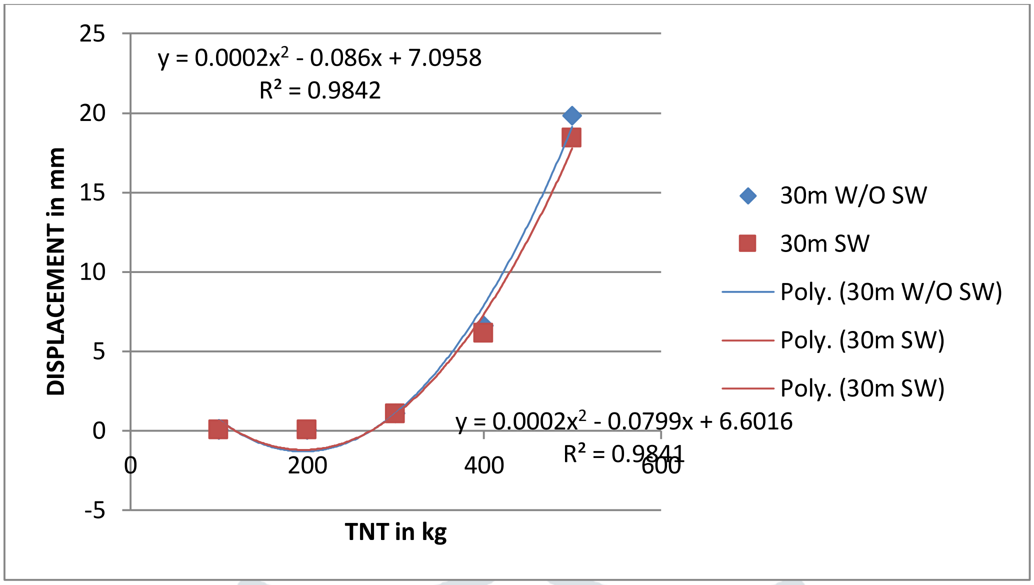


Figure 2: Regression constant curve at 30m

CONCLUSION:-

1. The blast loads, cause formation of maximum reactions on nodes of structure leading to the collapse in shear of joints and even the total collapse of structure as well.
2. The structure was analyzed using Staad Pro V8i. The explicit dynamics clearly specify that the effects of an explosion are largely dependent upon :
    - Standoff distance
    - Blast weight.
3. Large deformations were occurred if the quantity of blast weight is more, even for the same value of standoff distance as is clear from the graphs.
4. Higher stress values were observed for higher values of blast weight in comparison with the lower blast weights as can be seen from the table and graph.

SCOPE OF FURTHUR WORK:-

The following may be considered for the possible extension to the work presented herein.

1. Verification of pressure computation done by Friedlander equation approach using any STAADPRO V8i.
2. Exploring the possibility of disproportionate collapse of concrete building structure considered due to column failure.
3. In depth failure analysis of column and walls facing blast considering high-strain rate loading.(is.6922.1973, 1973)

REFERENCES:-

A S Patil, P. D. K. (2013). TIME HISTORY ANALYSIS OF MULTISTORIED RCC BUILDINGS FOR DIFFERENT SEISMIC INTENSITIES, *2*(3), 194–201.

Army, D. of. (n.d.). tm_5_1300_1990.pdf.

Børvik, T., Hanssen, A. G., Langseth, M., & Olovsson, L. (2009). Response of structures to planar blast loads - A finite element engineering approach. *Computers and Structures*, *87*(9–10), 507–520. https://doi.org/10.1016/j.compstruc.2009.02.005

Daniel Ambrosinia, Bibiana Luccionib, Gerald Nurickd, Genevieve Langdond, N. J. (2009). THE EFFECT OF CONFINEMENT AND STAND-OFF DISTANCE IN, *XXVIII*, 3–6.

Dewey McMillin & Associates, Emeritus, Dept. Physics & Astronomy, U. of V. (n.d.). Dewey Paper #23.

Draganić, H., & Sigmund, V. (2012). Blast loading on structures. *Tehnički Vjesnik*, *19*(3), 643–652.

G.I. TAILOR(1939). (1939). The air wave surrounding an expanding sphere, (December 1939), PG.292.

Hugo bachmann, Thomas Wenk, P. linder. (1996). time history 10_vol11_6791.pdf. ? □□.

Marchand, K. A., & Alfawakhiri, F. (2004). Blast and Progressive Collapse. *Facts for Steel Buildings*, *2*(2), 1–67.

Médici, E. F., & Waite, G. P. (n.d.). Experimental Laboratory Study on the Formation of Multiple Shock Waves observed during Volcanic Eruptions.

Meghanadh, M., Pradesh, A., Reshma, T., & Pradesh, A. (2017). BLAST ANALYSIS AND BLAST RESISTANT DESIGN OF R . C . C RESIDENTIAL BUILDING, *8*(3), 761–770.

Pandey, A. K., Kumar, R., Paul, D. K., & Trikha, D. N. (2006). Non-linear response of reinforced concrete containment structure under blast loading. *Nuclear Engineering and Design*, *236*(9), 993–1002. https://doi.org/10.1016/j.nucengdes.2005.09.015

Safety_Stand_Off_Distances_Card. (n.d.).

Shallan, O., Eraky, A., Sakr, T., & Emad, S. (2014). Response of Building Structures to Blast Effects, *4*(2), 167–175.

Shope, R. L. (2006). Response of Wide Flange Steel Columns Subjected to Constant Axial Load and Lateral Blast Load. *Civil Engineering*, *Doctor of*, 1–417.

STAADPro V8i theory mannual

Unde, A. B., & Potnis, S. C. (2013). Blast Analysis Of Structures, *2*(7), 2120–2126.

Vijay, A., & Subha, K. (2017). EFFECT OF LONGITUDINAL REINFORCEMENTS IN REINFORCED CONCRETE PIERS SUBJECTED TO BLAST LOADING, *8*(11), 73–79.

Zhang, R., & Phillips, B. M. (2016). Performance and Protection of Base-Isolated Structures under Blast Loading. *Journal of Engineering Mechanics*, *142*(1), 04015063 1-12. https://doi.org/10.1061/(ASCE)EM.1943-7889

J.M. Dewey (1971), "The Properties of Blast Waves Obtained from an analysis of the particle trajectories", Proc. R. Soc. Lond. A.314, pp. 275-299.

Alexander M. Remennikov, (2003) "A review of methods for predicting bomb blast effects on buildings", Journal of battlefield technology, vol 6, no 3. pp 155-161.

M. V. Dharaneepathy et al. (1995),"Critical distance for blast resistance design", computer and structure Vol. 54, No.4.pp.587-595.