A Research On Behavior Of Tall Structure Under Blast Loading

Deep Modi[1], Kishan Pala[2], Aakash Suthar[3]

[1]M.Tech Student, L.J. University, Ahmedabad
[2]Kishan Pala/[3]Aakash Suthar, Assistance Professor, structural Engineering Department, L.J. University, Ahmedabad, India.

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Abstract - *Today's A detailed study of the progressive collapse analysis of multi-story buildings subjected to blast loading is now required due to the severe damage to property and life caused by recent terrorist attacks on the infrastructure. Research has typically been conducted using the Alternative Path Method (APM) with sudden column removal while neglecting the ideal site for blast loading. In this thesis, 3D models of a steel building with six stories and direct blast load modelling are suggested. Additionally, the impact of blast loading has been assessed at numerous sites. Two different types of explosive events—vehicle-borne and package bomb—have been taken into consideration. By employing a numerical model of the structure created with the " STAAD PRO " SOFTWARE, the blast load is analytically computed. By using a published example of a 20-story steel building that was subjected to blast load, the numerical model is validated. The collapse of steel buildings has been postulated as a possible outcome of the finite analysis, and proposals have been made to control it. By using a published example of a 7-story steel building that was subjected to blast load, the numerical model is validated. The collapse of steel buildings has been postulated as a possible outcome of the finite analysis, and proposals have been made to control it.*

Key Words: Steel Structure, Blast, STAAD PRO, APM, Collapse, Vehicle Bomb, Package Bomb, G+20 Storey.

1.INTRODUCTION

The investigation of blast impacts on structures has been the subject of formal technical investigation for more than sixty years. An explosion caused by a bomb inside or in close proximity to a building can led to damage to the building's external and internal structural frameworks, the collapse of walls, the fragmentation of large areas of windows, and so forth. Loss of life and injuries to occupants can occur due to various factors, including direct blast effects, structural collapse, fire, and smoke.

Traditional structures are generally not designed to withstand blast loads, and because the magnitudes of design loads are significantly lower than those produced by most explosions, traditional structures are susceptible to damage from explosions. The loading from a blast and its effects on a structure are influenced by several factors, including the weight of the charge, the location of the blast (or standoff distance), and the geometric configuration and orientation of the structure (or direction of the blast). The structural response will vary depending on how these factors come together.

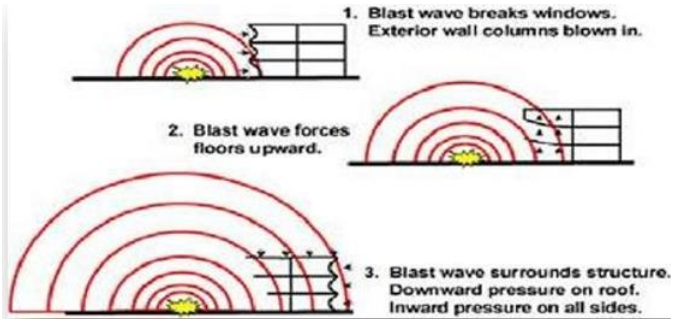

Figure 1: Collapse mechanism due to blast wave.

The initial manifestation of the explosion's shock wave is observed to induce the fragmentation of windows, exterior walls, and exterior columns, as illustrated in the visual representation displayed in figure 1.

Following this, the vigorous character of the shock wave impels the elevation of the floors and slabs, as depicted in the graphical depiction provided in figure 1.

Lastly, the shock wave envelops the edifice, leading to a downward force exerted on the roof and inward pressure exerted on all sides of the structure, as presented in the illustrated representation appearing in figure 1.

The occurrence recognized as air blast encompasses a blast wave that provokes an augmentation in air pressure in the proximity of a architectural formation.

In the event of immediate ground disturbance, when an explosive is either partially or fully submerged beneath the exterior of the ground, it yields a lateral oscillation of the ground, resembling an earthquake but with a discernible frequency.

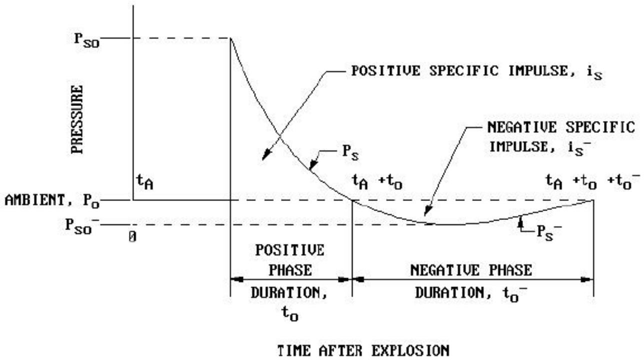

Figure 2: Incident and reflected pressures on building

The An abrupt increase in magnitude and release of energy in an extreme manner, typically accompanied by the production of exceedingly high temperatures and the expulsion of gases, is defined as an explosion. Explosions can manifest in either the form of deflagration or detonation, contingent upon the rate of combustion during the event. Deflagration occurs as a result of the ignited reaction of thermal conductivity, whereby the subsequent layer of colder material is ignited by the hot burning material and subsequently combusted. which entails a supersonic exothermic front that rapidly accelerates through a medium, ultimately leading to the propagation of a shock front directly in its path.

- Yang Ding [1] demonstrates that whereas moment columns are good at resisting blast loads, gravity columns are significantly impacted by it. According to Yang Ding , there is a significant risk of VBIEDs (vehicle-borne improvised explosive devices) in external columns. For this reason, having a structure with a moment frame at the exterior face is essential for effective explosion resistance.

- H.M.Elsanadedy[2]Analyze the six-story steel-framed building in Riyadh that was the target of a terrorist assault and offer a preventive method to lessen the impact of the blast load by limiting vehicle access to the building via perimeter control. If this isn't feasible, the outside exposed ground floor column could need to be strengthened with a double-walled façade system, diagonal bracing, steel plate additions, concrete encasement, or shear walls.

- Feng Fu [3] After analyzing the 20-story building for interior blast events, it was determined that a package bomb could only seriously harm specific structural members and that it would be difficult to blow up the entire structure. By improving the column's ductility and shear capacity, this effect can be mitigated.

- Jenny Sideri[4] demonstrates how, once the explosion attack has ended, the building's big column section with the perimeter moment-resistant frames acts as a safety valve to maintain the system's structural integrity. Additionally, he looks into buildings with inside rigid core RC, and he comes to the conclusion that the reaction of the entire system cannot be stabilized by an external column.

- Yang Ding [5] conducted an analysis on steel frames subjected to confines explosion and post-explosion fire. He concluded that the exterior face of the steel frame should have MRF (Moment Resistance Frame) columns. Additionally, he concluded that the corner compartment is subjected to a combined hazard case, while the peripheral compartment is the weakest part for fire cases alone.

2. NUMERICAL STUDY

In the numerical study carried out herein, the G+20 storey steel building is considered. Figure 1 and 2 show 3D view and elevation of steel building in staad pro.

The details for generating structural model in the software are given as follow:

Height of parking storey: 3.5 m
Height of storey (other than parking): 3 m
Span of bay in X direction: 7.5 m
Span of bay in Y direction: 6.25 m
Plan dimension of building: 37.5 x 37.5 m
Number of storey: G + 20
Grade of steel: Fe 345

Loading: Dead Load, Live Load, Wind Load, and Blast Load.

Load combination consider for blast load are
1.2DL+LL+BL
DL+0.35LL+BL
DL+0.25LL+BL

Comparative analysis is carried out for the same for different criteria like displacement, stress and cost impact.

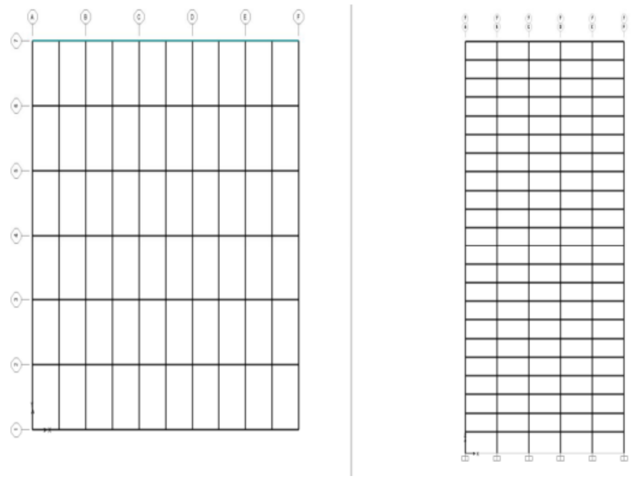

Figure 3: Plan And Elevation Of Steel Building

2.1 PROBLEM DESCRIPTION

First of all, consider the buildings subjected to a burst with a yield comparable to many tons of trinitrotoluene (TNT) at a specific standoff distance. The problem is described as follows:

The internal blast event's intensity is measured at 0.025t and 0.015t, whereas the exterior blast event's intensity is measured at 0.1t, 0.2t, and 0.3t (VBIED). Ten and twenty meters are considered the stand-off distances for external blast events. Four positions are taken into account for internal explosion events: the corner column at the parking lot, the center column at the parking lot first floor, the midstory, and the top story. Sixty models were analyzed in all.

3. BLAST LOAD CALCULATION

Based on the specification to IS 4991: 1963, blast load pressure on the building in form of a triangular load is calculated as follows:

Characteristic of Blast

Scaled Distance, X = D/W [9]
Where, D = Distance of the building from the ground zero
W = Explosive charges in Tonne

Here, assuming Pa = 1.00 kg/cm2 (Ambient Air Pressure)
Internal blast pressure is calculated as
ΔP = 13 (W/V)[6]

Metric pressure is in bar, W is the mass of explosive in kg, V is the confined volume of air in cubic meter.

3.1 BLAST PARAMETERS

For the value of scaled distance, various blast parameters are selected from the table 1 of IS 4991:1968.

These parameters are:

- Pso = Peak Side on Overpressure (kg/cm2)
- Pro = Peak Reflected Overpressure (kg/cm2)
- Q0 = Dynamic Pressure (kg/cm2)
- Td= Duration of Equivalent Triangular Pulse (Milliseconds)
- T0 = Positive Phase Duration (Milliseconds)
- Td = Value corresponding to X/W1/3
- T0 = Value corresponding to X/W1/3

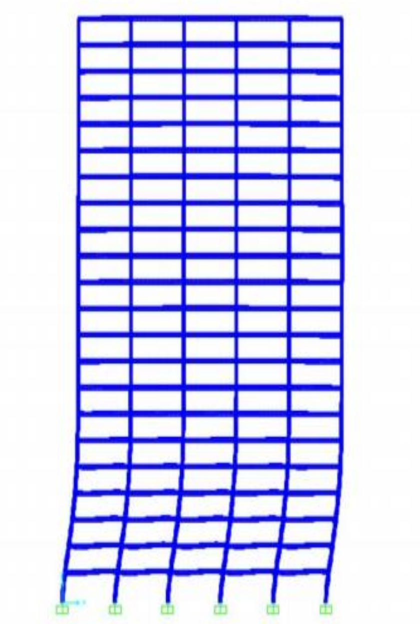

Figure 4: Deflected Shape of Building

4. EXPERIMENTAL RESULTS

Comparing the result for different geometries with different loading condition for displacement and stresses.

4.1 Displacement

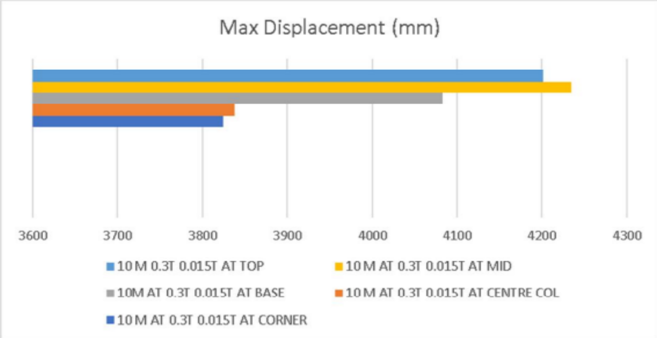

Chart-1 Displacement for value of combination of 10 m at 0.3t and 0.015t as internal blast

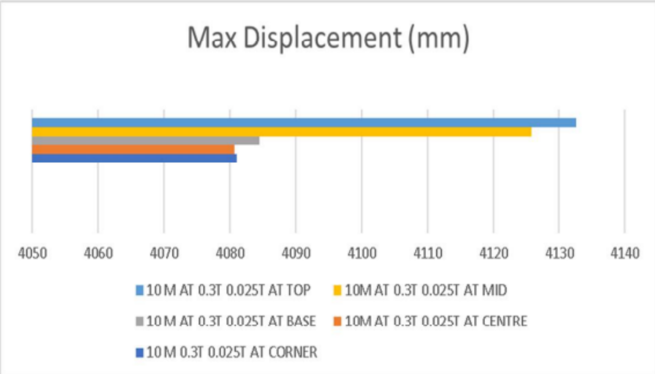

Chart-2 Displacement for value of combination of 10 m at 0.3t and 0.025t as internal blast

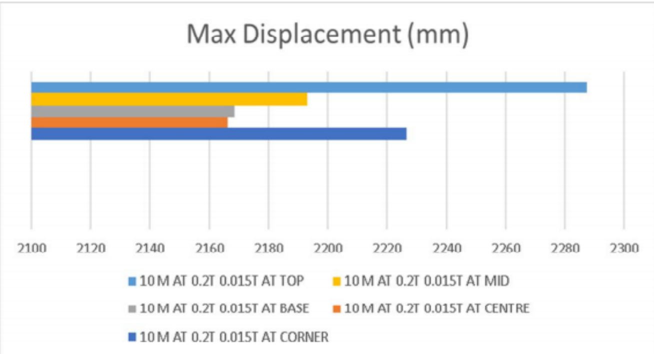

Chart-3 Displacement for value of combination of 10 m at 0.2t and 0.015t as internal blast

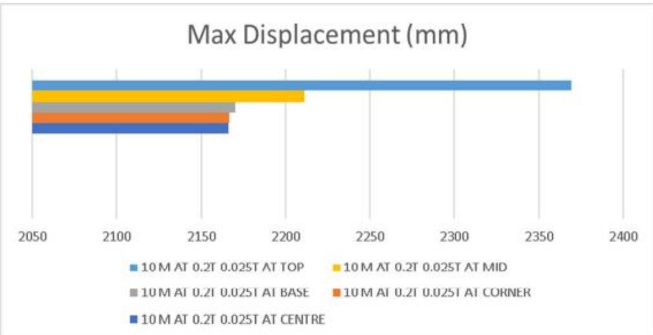

Chart-4 Displacement for value of combination of 10 m at 0.2t and 0.025t as internal blast

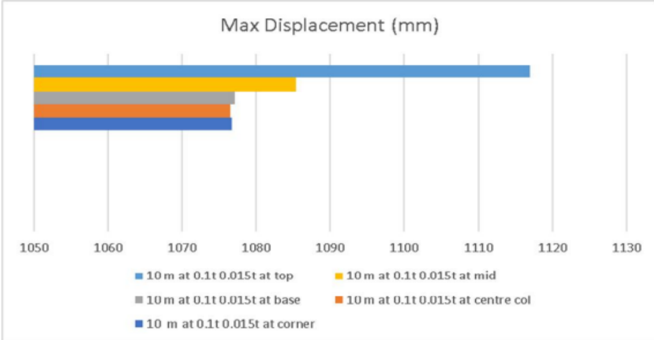

Chart-5 Displacement for value of combination of 10 m at 0.1t and 0.015t as internal blast

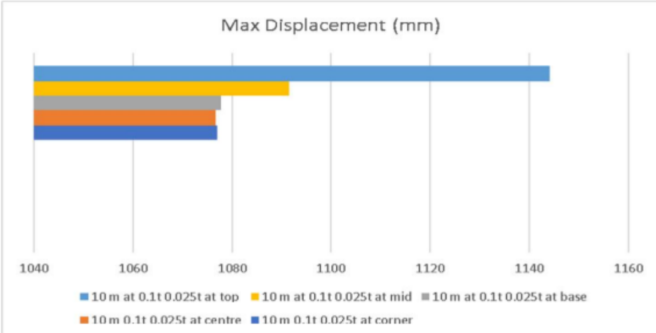

Chart-6 Displacement for value of combination of 10 m at 0.1t and 0.025t as internal blast

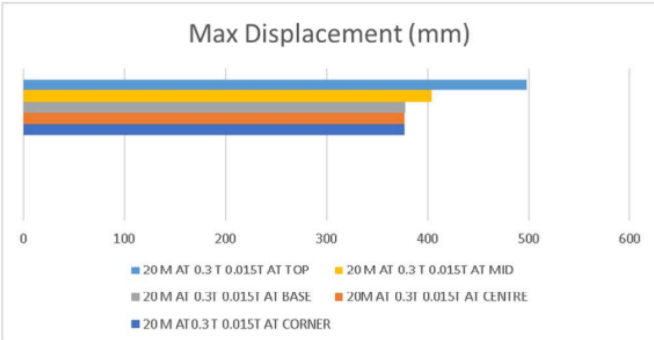

Chart-7 Displacement for value of combination of 20 m at 0.3t and 0.015t as internal blast

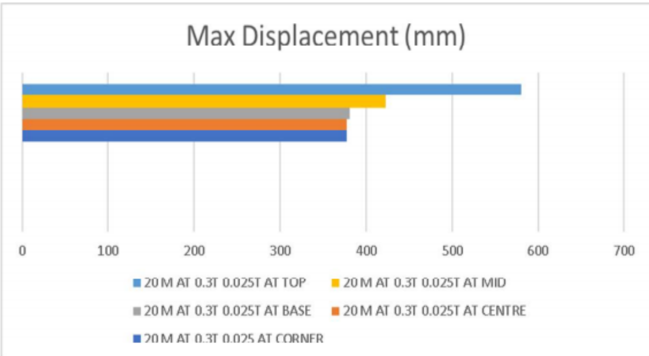

Chart-8 Displacement for value of combination of 20 m at 0.3t and 0.025t as internal blast

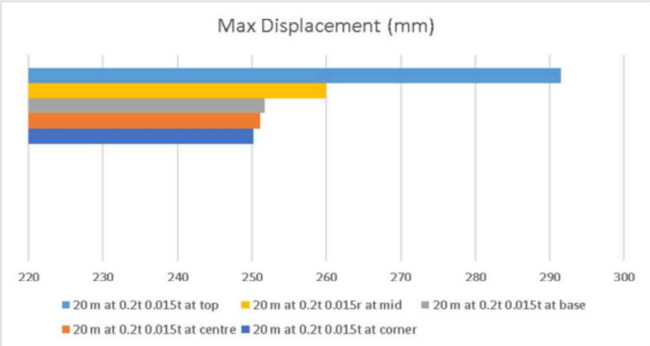

Chart-9 Displacement for value of combination of 20 m at 0.2t and 0.015t as internal blast

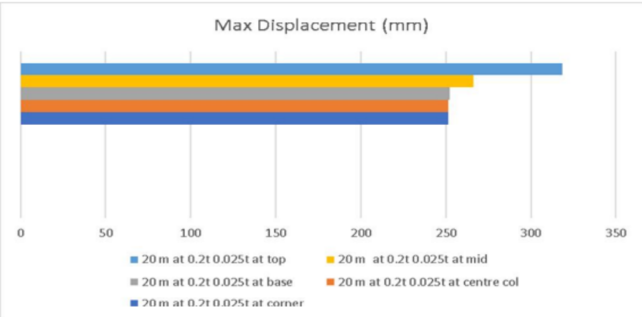

Chart-10 Displacement for value of combination of 20 m at 0.2t and 0.025t as internal blast

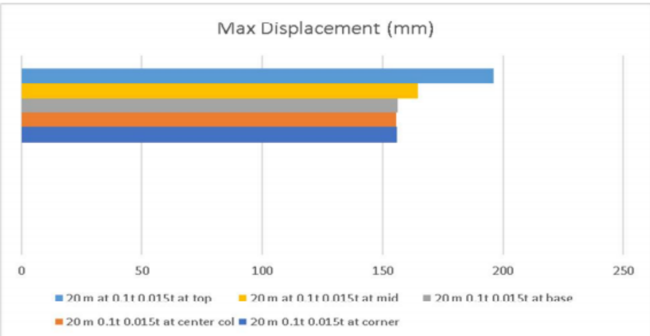

Chart-11 Displacement for value of combination of 20 m at 0.1t and 0.015t as internal blast

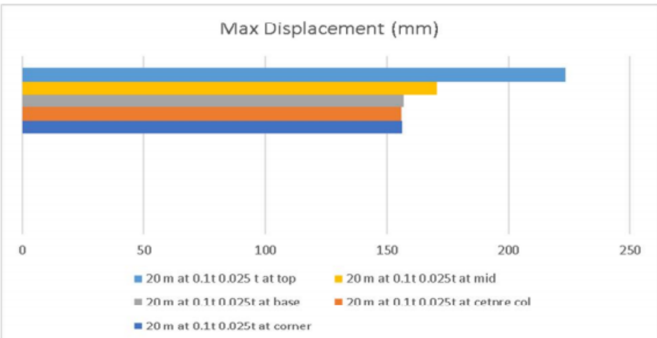

Chart-12 Displacement for value of combination of 20 m at 0.1t and 0.025t as internal blast

4.2 Stress Result

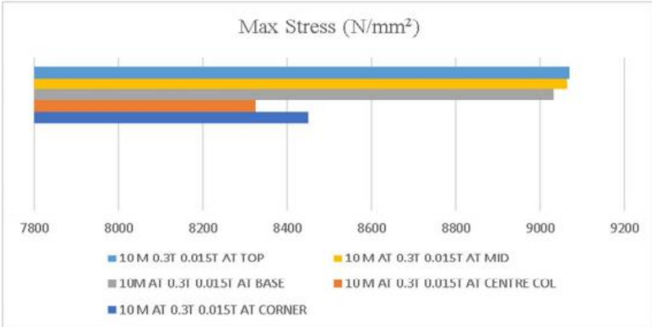

Chart-13 stress for value of combination of 10 m at 0.1t and 0.015t as internal blast

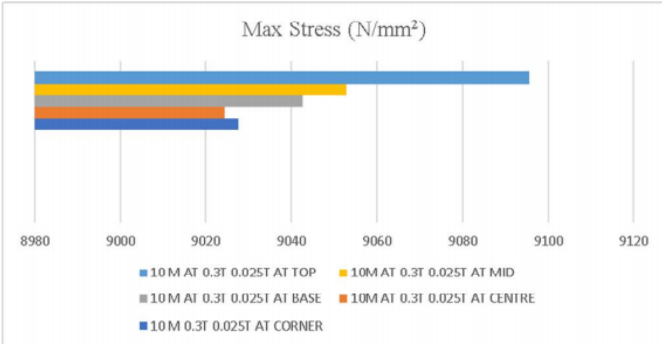

Chart-14 stress for value of combination of 10 m at 0.1t and 0.025t as internal blast

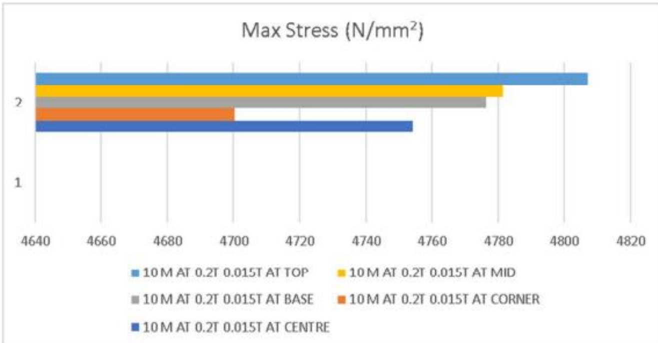

Chart-15 stress for value of combination of 10 m at 0.2t and 0.015t as internal blast

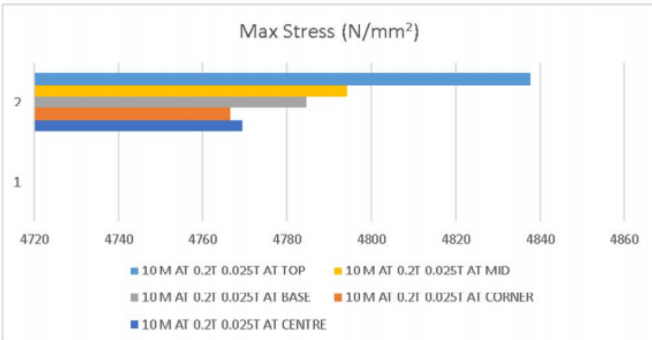

Chart-16 stress for value of combination of 10 m at 0.2t and 0.025t as internal blast

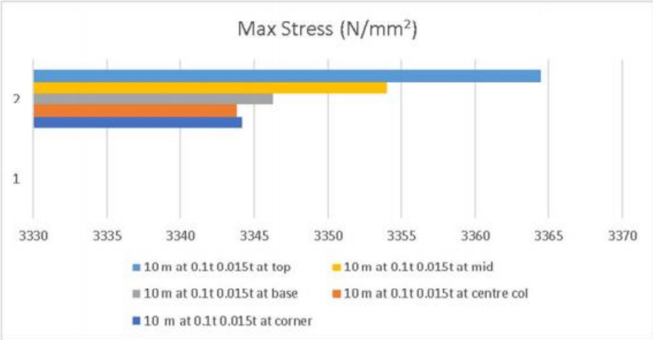

Chart-17 stress for value of combination of 10 m at 0.1t and 0.015t as internal blast

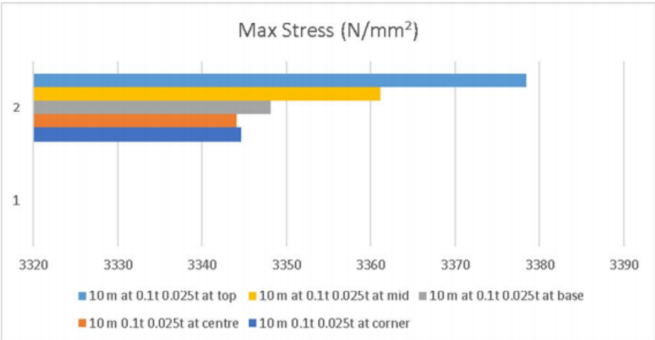

Chart-18 stress for value of combination of 10 m at 0.1t and 0.025t as internal blast

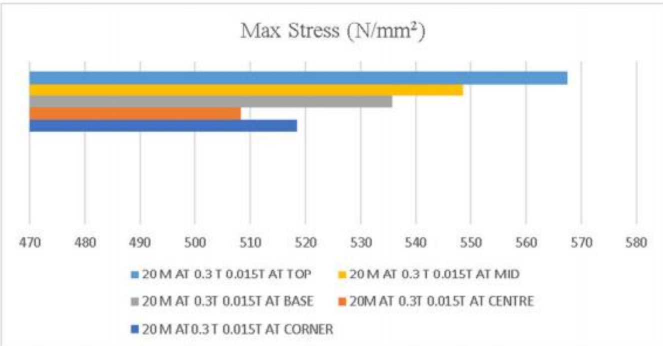

Chart-19 stress for value of combination of 20 m at 0.3t and 0.015t as internal blast

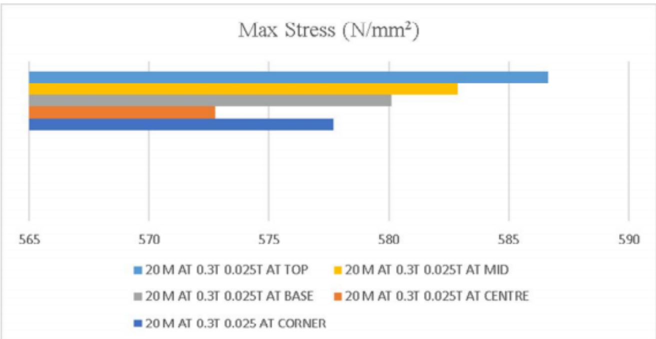

Chart-20 stress for value of combination of 20 m at 0.3t and 0.025t as internal blast

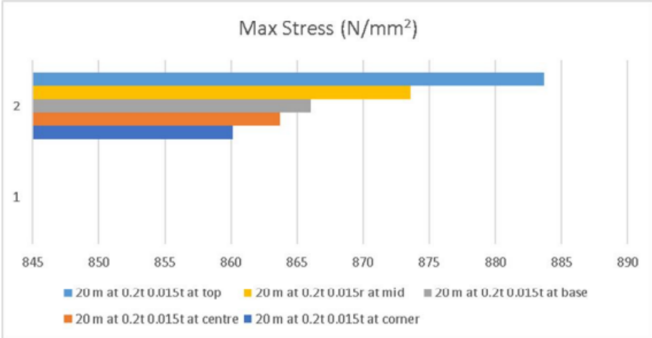

Chart-21 stress for value of combination of 20 m at 0.2t and 0.015t as internal blast

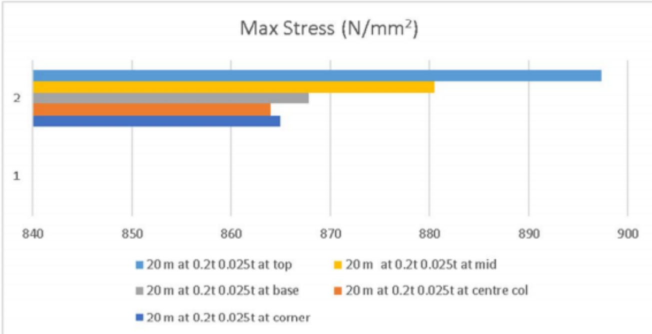

Chart-22 stress for value of combination of 20 m at 0.2t and 0.025t as internal blast

5. CONCLUSION

The largest charge of 10 m with an external blast of 0.3 tonne and an inside blast of 0.025 tonne at the top location yields the maximum displacement and stress value, as per the data. Therefore, for blast resistant design, the same cross section qualities should be included throughout all storeys. It is advised that appropriate security measures be taken for the important structure, or that appropriate measures be taken to ensure that the explosion occurs as far away from the structure as possible. Tree plantations and other obstacles should be positioned in front of the structure to resist blast load and safeguard it.

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