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EVALUATION OF ENGINEERING DEMAND PARAMETERS OF RC MULTI-STOREY BUILDING SUBJECTED TO EXTREME BLAST EVENT

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Abstract. Extreme occurrences, as an example blast loads and strong earthquake motion, cause nonlinear behaviour in the framework of construction and cause significant damage. For use in blast engineering with a performance-based approach, sample intensity measurements, and engineering demand parameters were presented[2]. The indirect impacts can join to hinder or forestall opportune departure, in this manner adding to additional casualties. Moreover, significant disasters caused by gas-compound explosions impose tremendous dynamic loads on many structures, a great deal more than the initial loads Because of the dangers of such extreme stacking, Over the last three decades, efforts have been undertaken to create methodology for underlying structural assessment and planning to mitigate impact loads. This Study manages analyzing the conduct of built up substantial construction under blast loading that could be useful in planning a design fit for adjusting to such impacts. The behavior of a basic multi-story building to constant axial and lateral blast loads was investigated. The response of a building to blast loads was studied using STAAD pro software. Then, a horizontal impact load was applied and the reaction of a Central and Front confronting Beams and Columns were dissected in STAAD expert by looking at its bending moments and shear forces with and without impact load and furthermore plotting appropriate charts. The research and design of blast-resistant structures necessitated comprehensive knowledge of blast processes as well as the dynamic response of various structural elements. This research provides a thorough examination of the effects of blast on structures.

Keywords. STAAD Pro, Blast Load, Building Response, Overpressure, Effect

1. Introduction

Tension or impact of a truck bomb or quarry causes the impact burst close to or inside the structure. This damages the structure both externally and inwardly (underlying frames), resulting in partition implosion, window suffocation, and the shutdown of basic life-wellbeing structures. Structures, bridges, pipelines, modern plants, dams, and so on are vital designs that play an important role in the nation's economy and must be protected from dynamic and wind stress[5].

These designs must be protected against the impacts that will almost certainly be the targets of terrorist attacks. It's difficult to break down the construction's powerful reaction to impact stacking, as a result of the non-linear behavior of the material. Blasts bring about enormous powerful loads more prominent than the design loads for which the constructions are investigated and planned. Analysis and plan of impact loading requires definite information on impact and its peculiarities. This blast wave lasts only a few milliseconds or microseconds, resulting in a dynamic blast load with a very high magnitude and frequency. The nature of a blast load is impulsive, i.e. high magnitude pressure for a short period of time [9].

Blast repercussions for structures have been the subject of official specialized examination a period of more than 60 years.An detonation of a bomb inside or near a structure can result in terrible harm to the structure's outer and , collapsing walls, blowing out wide swaths of windows and disrupting basic life-wellbeing frameworks[3]. The effect of trash, fire, and smoke are all possible causes of death and harm to residents. [9]. The erratic effects can compound to stifle or prevent easy evacuation, in this way adding to extra casualties. Also, significant calamities coming about because of gas-compound blasts bring about huge dynamic burdens, more prominent than the original loads, of many designs.

Performance-based blast engineering is added to the new performance-based earthquake engineering technique. For sample intensity measurements, blast engineering, engineering demand factors, and the level of performance are suggested [2]. Performance-based blast engineering is quite similar to the ATC-58 project's second-generation performance-based earthquake engineering methodology. Sample intensities engineering performance standards and demand parameters were developed for use in performance-based blast engineering.[2]

I.Objectives

To analyse the design against the strange loading conditions like impact loads, and so forth requiring point by point comprehension of impact peculiarity.

To concentrate on the dynamic reaction of different underlying components like column, beam in RCC structures.

II. Study Objectives

In order to accomplish the goal previously introduced goals the accompanying undertakings have already been done:

1. A model is being created. Create a G+3 structure in STAAD PRO.
2. Computation of the blast loading on the multi-storey building.
3. Investigation of Columns and Beams of a Building under Blast load utilizing STAAD PRO.
4. Assessment of Beams and Columns' Bending Moments and Shear Forces with and without Blast Load.
5. Assessing the deflection of building under Blast loading condition.
6. Getting a conclusion by comparing the values of Bending moments and Shear forces of beams, columns with and without Blast load.

III. Work and Methodology

In this study, STAAD PRO Software is used to evaluate the building's response to a blast load. STAAD PRO is used to model a G+3 RCC building (fig 1). The goal is to use software to apply a model with a blast load to assess the attitude of beams and columns in a building, as well as plot a graph for beams and columns and study their behaviour.

Building Specifications:

- Total Height of Building = 12m
- Story Height = 3m

Foundation Depth = 3m

- Beam Size = 230mm X 380mm
- Column Size = 230mm X 450mm
- Support Condition = Fixed
- Slab thickness = 125mm

Thickness of Infill = 230mm and 115mm

- M20 Concrete Grade
- Fe 415 Steel grade.

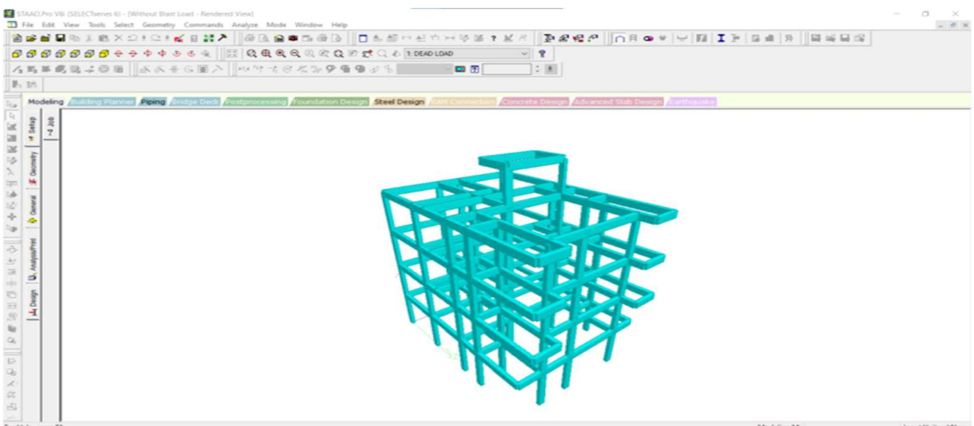


Figure 1: Rendered view of a Building in STAAD-PRO

Load Calculation:[8]

A. Dead Load:

1.Load on the wall: 230mm wall: - brick density (20kN/m^3) X (wall height) (3m) -beam depth (450 mm) X wall thickness (230mm) = 11.73kN/m

2. Wall Load: 6.0 kN/m for a 115mm wall

3. Load on the parapet wall: 3kN/m

B. Live Load:

1. Part II: 2kN/m^2 live load (according to IS 875:2015)

C. Floor Load:

1. Floor Load: Concrete Slab Thickness (0.125mm) X Density (25kN/m^3) = 3.5kN/m^2

2. 1kN/m^2 floor finish

3.4.5kN/m^2 is the total floor load.

D. Blast Load Calculations (IS 4991-1968.) [8]

The Calculations of Front Face

As a result of the shock wave hits vertical face of a building, the tension on the front face grows rapidly to the reflected over pressure genius supplied by the following condition.:

$P_{ro}= P_{so}$ X$((2+(6\ P_{so})/P_{so}+7P_a))$

Pa denotes the ambient atmospheric pressure, which is assumed to be 1 kilograms per square meter.

Table 1 of IS 4991-1968 shows the value of Pro.

Assume that a 1000 kilograms explosive is placed 27 meters from the structure.

Pso/Pa= 1.80 on the peak side of the overpressure ratio (Table 1 , IS 4991-1968)

As a result, the Overpressure Reflected at Its Peak will be Pro.= Pso X ((2+(6 Pso)/Pso+7Pa)

Pa denotes the ambient atmospheric pressure, which is assumed to be 1 kg/cm^2.

IS 4991:1968 provided the formula and values.

Taking the value of Pso as 1.8, the value of Pro is 5.81 $Kg/cm^{2.}$

We get 570 kN/m^2 by converting 5.81kg/cm^2.

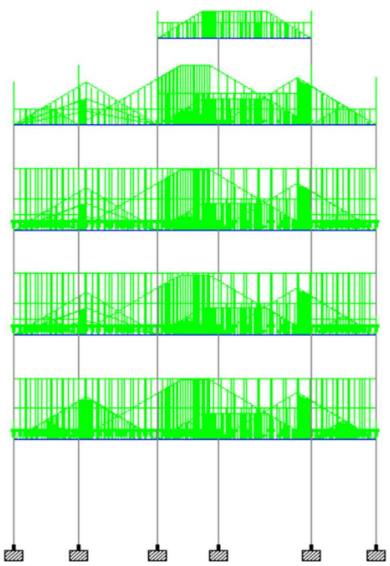


Figure 2: Structure Under Gravity Load

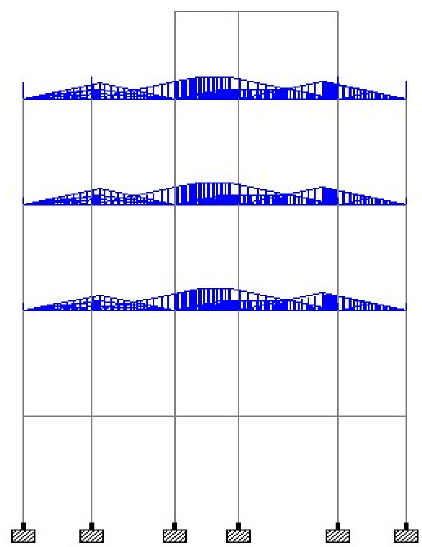
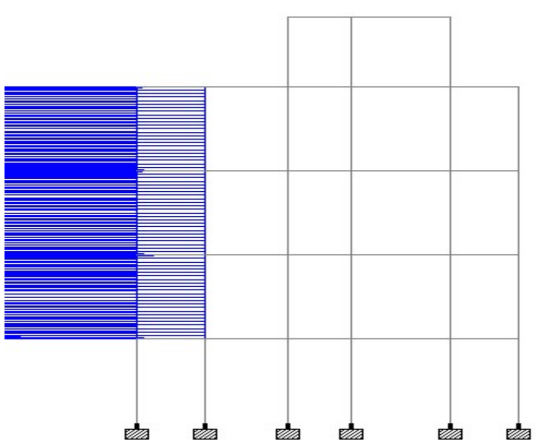


Figure 3: Structure under Live Load



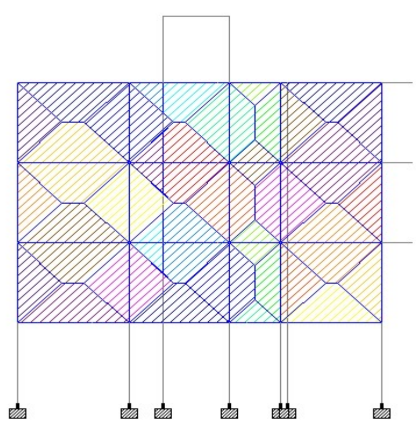


Figure 5: A view of a from the side, blast load (Front view)

Figure 6: The Structure Under Blast Load (Side View)

IV.Results

1. Bending Moment for Column ultimately leads to the reinforcement in concrete. The more the bending moment more will be the amount of reinforcement required for the Safe design of the member. Here In column the amount of bending moment in centre column is the combination of all the bending moment transferred from the columns to the centre (Fig7,8,9,10) So the moment in centre column is much more than the normal bending moment (Table 1)

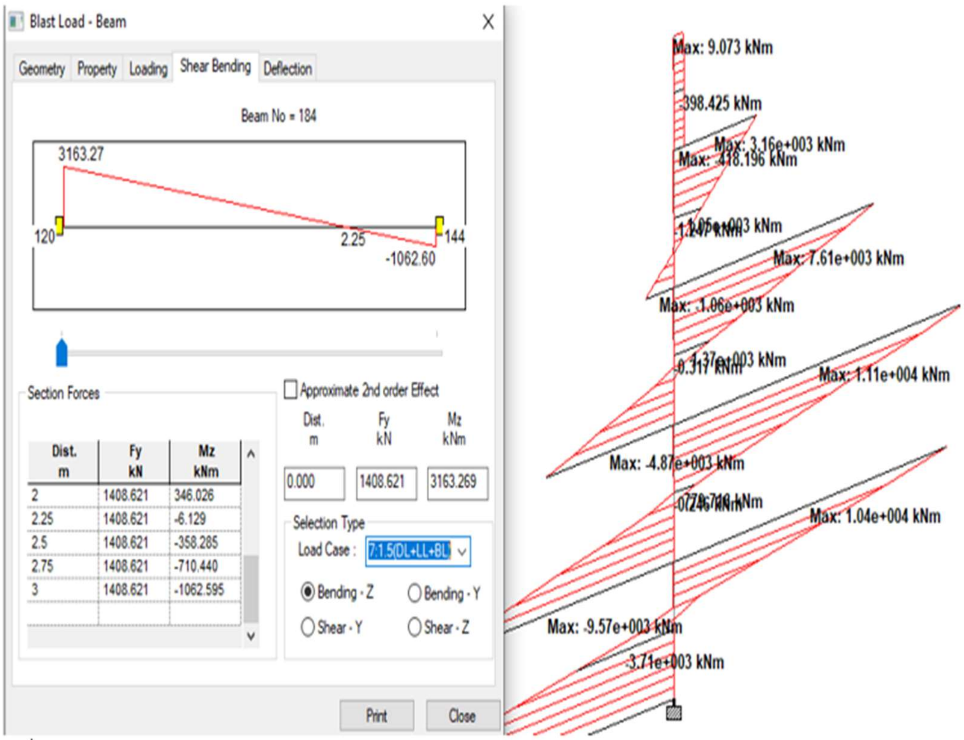


Figure 7: Subjected to a Blast Load, the Bending Moment of Central Column No. 184

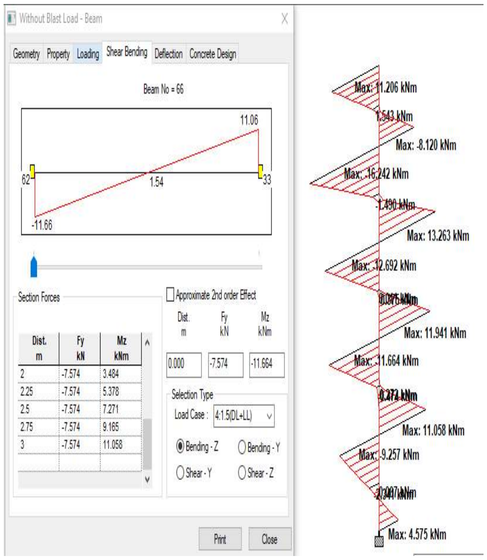


Figure 8: Central Column No. 66 Bending Moment in the Absence of a Blast Load

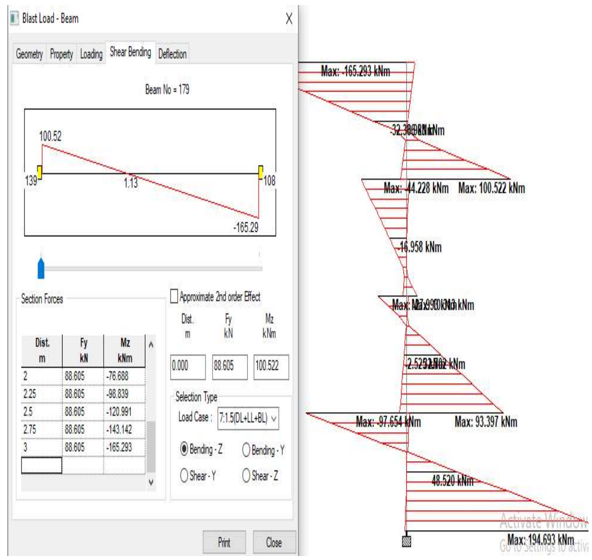


Figure 9:Subjected to a Blast Load, the Bending Moment of Front Column No.179

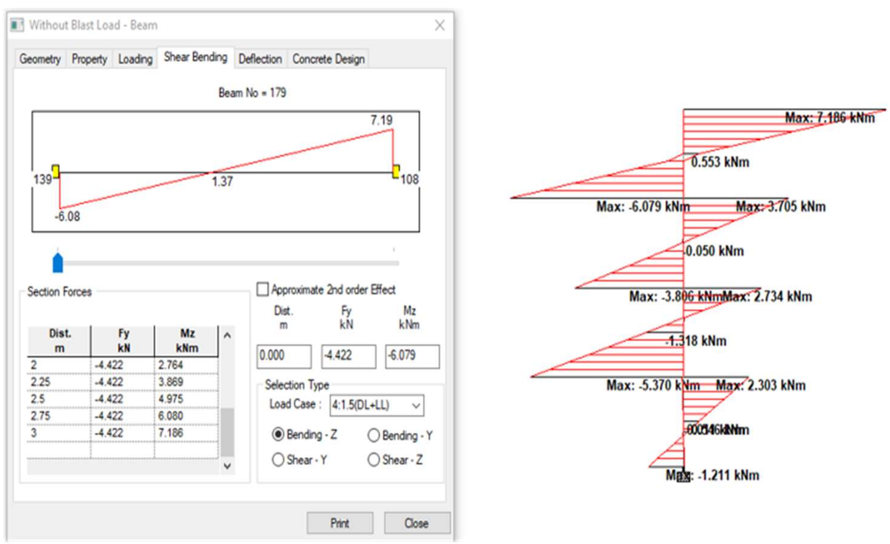


Figure 10: Front Column No.179 Bending Moment in the Absence of a Blast Load

TABLE I. The central and front columns' bending moments are compared.

Position	***With Blast bending moment.***	***Without Blast bending moment***
Centre Column	10405.00 KN-m	16.242 KN-m
Front Column	193.693 KN-m	7.22KN-m

2. **Shear force for Column:** Shear Force mainly is related to the shear reinforcement of the member. When the shear force increases the amount of stirrups and the distance between

them increases. Just Like bending Moment the shear force also for member located at the center of the structure is more than the shear force of the member located at the face of the building.(Table II)

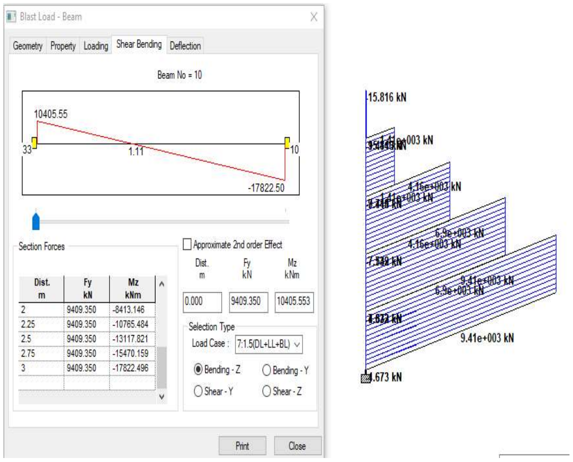


Figure 11: The shear force of Central Column no.10 under blast load

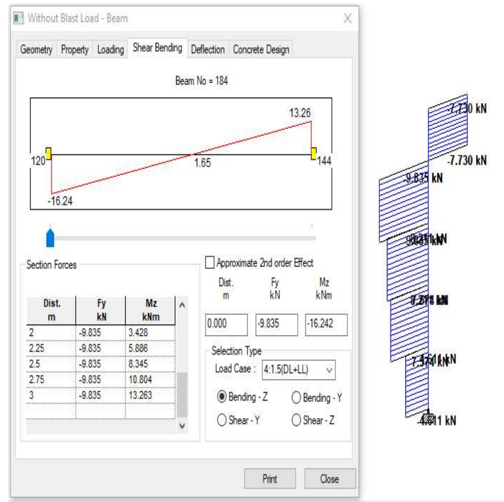


Figure 12: Shear Force of Central Column no.184 without blast load Condition.

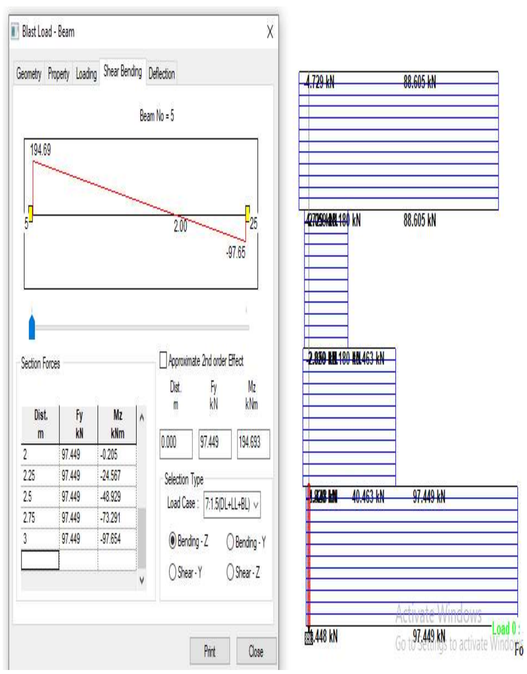


Figure 13: Shear Force in Front Column No. 5 under Blast Loading

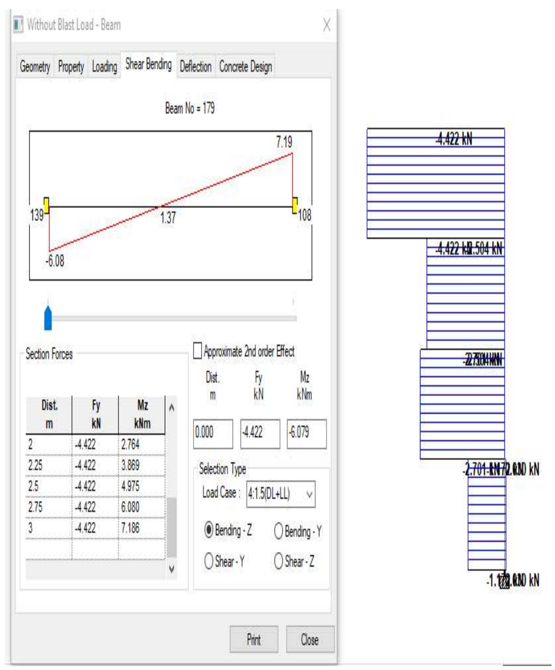


Figure 14: Shear Force of Front Column no.179 without blast load Condition.

TABLE II. Comparison of Shear Force between Central and Front Columns.

Position	*With Blast Shear Force*	*Without Blast Shear Force*
Centre Column	9409.00 KN	9.00 KN
Front Column	97.00 KN	4.33 KN

3. Bending Moments for Beam

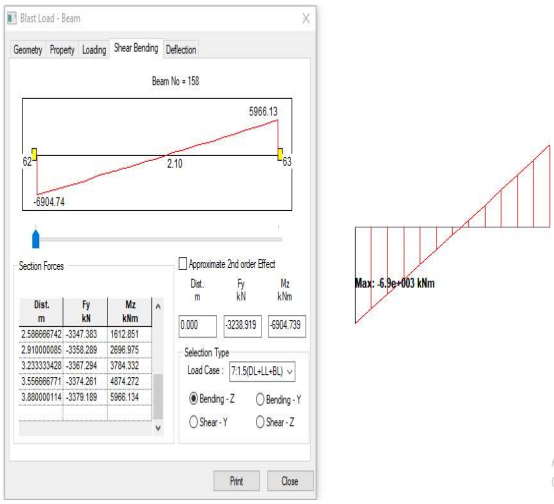


Figure 15: The Bending Moment of Central Beam No.158 when subjected to a Blast Load

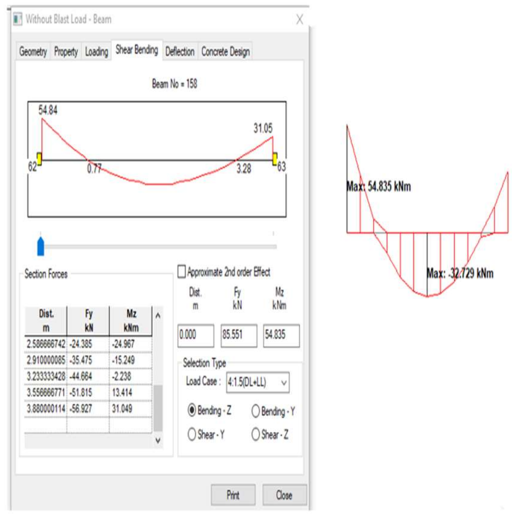


Figure 16: Bending Moment of Central Beam No.158 in the absence of a blast load.

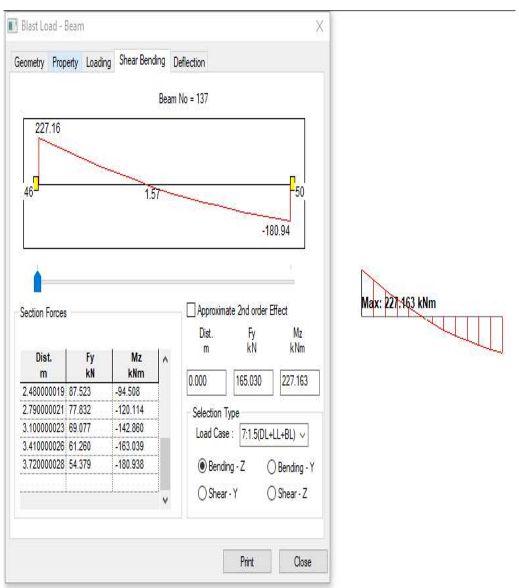


Figure 17: Frontal Bending Condition Beam no. 137 of Beam 137 with Blast Load.

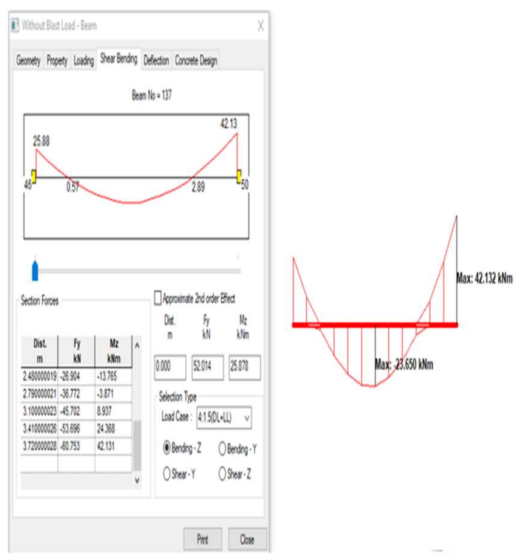
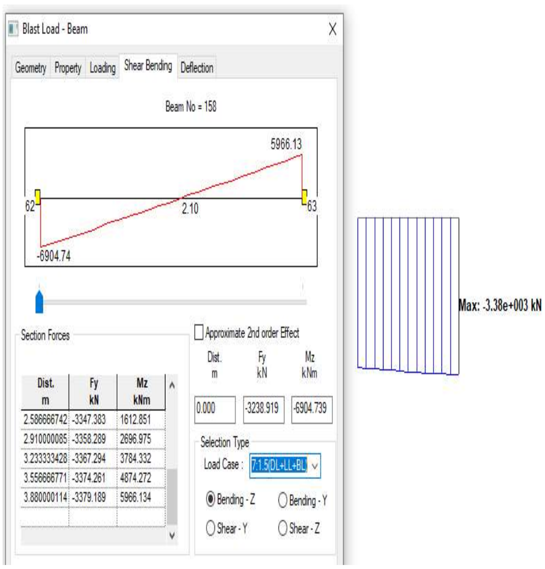


Figure 18: Bending Moment of Front without blast load Condition

TABLE III. Bending Moment Comparison of Central and Front Beams.

Position	***With Blast bending moment.***	***Without Blast bending moment***
Centre Beam	6903.739 KN-m	54.55 KN-m
Front Beam	227.163 KN-m	25.66 KN-m

4. Beam shear force.



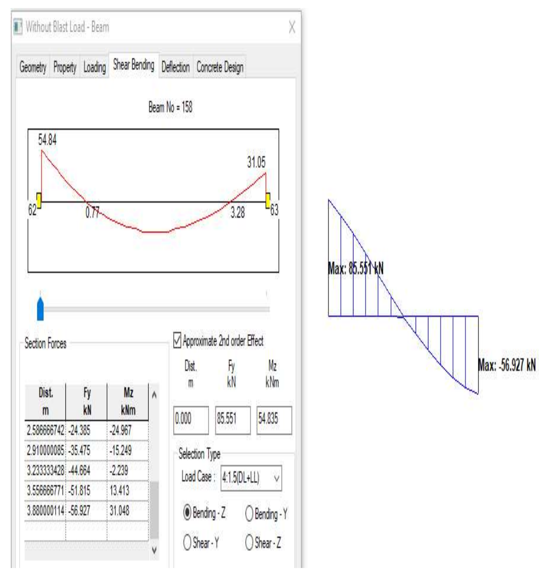
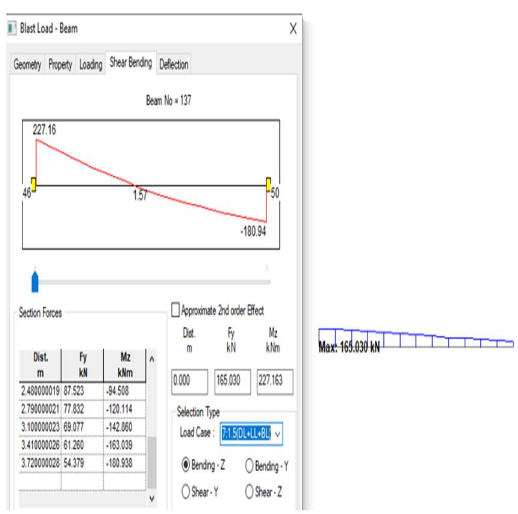


Figure 19: Central Beam No. 158 Shear Force with Blast Load Condition.

Figure 20: Shear Force of Central Beam no. 158 without blast load Condition.



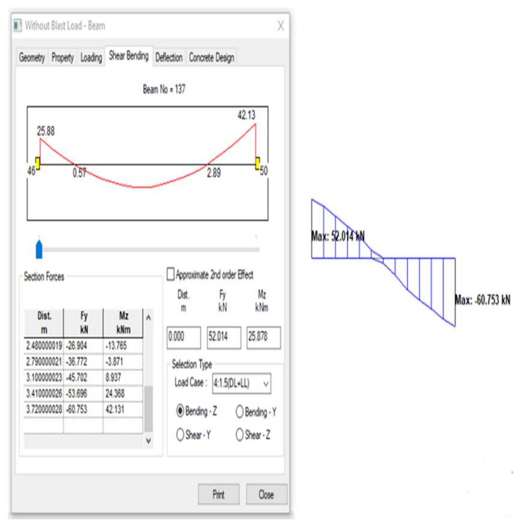


Figure 21: Shear Force of Front beam no. 137 with blast load Condition.

Figure 22: Shear Force of Front beam no. 137 without blast load Condition.

TABLE IV. Comparison of Shear Force between Central and Front Beams.

Position	***With Blast Shear Force***	***Without Blast Shear Force***
Centre Beam	3239 KN	86.66 KN
Front Beam	168 KN	51KN

5. Displacement

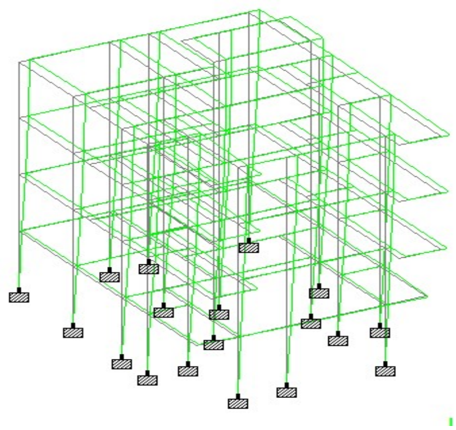


Figure 23: After the blast, the building was displaced (Isometric view)

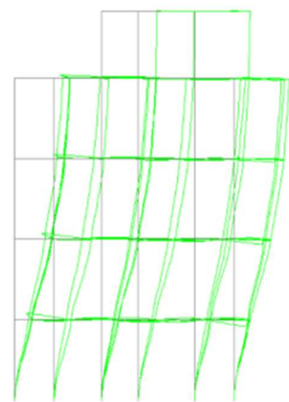


Figure 24: After the blast, the building was displaced (Front view)

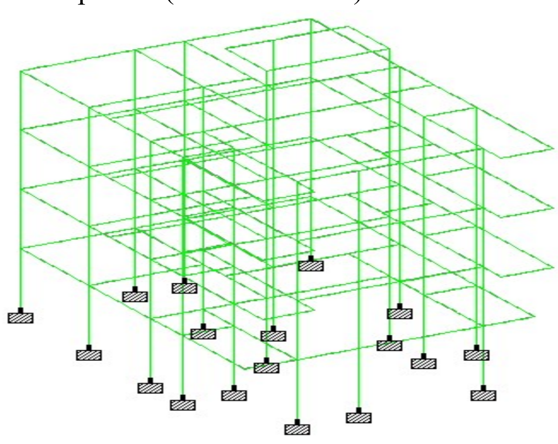


Figure 25: Before the blast, the building was displaced (Isometric view)

TABLE V. Comparison of Maximum Displacement of building before and after blast.

Condition	***Displacement***
Blast Load	354 mm
Without Blast Load	2.268

V. Conclusion

From the above outcomes it is inferred that,

1.The Bending Moment of the Column and Beam in Blast load condition is more than the bending moment in structure without blast load.(Table III)

2.The shear force of the beam and column with blast load is more compared to the shear force in a structure without a blast load.

3.The size of the beam and column in gravity loading will not be suitable for the blast load conditions due to more reinforcement and concrete is required for the total safe design of the structure.

4.It will be better to design a structure with sacrificial cladding and sandwitch element to mitigate the blast.(Fig 11)

5.The amount of deflection can be reduced by the increasing the size of the members of the structure.

References

[1] Ghobarah H. and Biddah.(**1999**), "Response Based Damage Assessment of Structures" *Earthquake Engng*. *Structure Dynamics*. 28, 79*Ð*104 (1999).

[2] Andrew W.,Hamburger R.,Mahoney M.. (**2003**), "Performance based engineering of Buildings for extreme events" *AISC-SINY Symposium on Resisting Blast and Progressive Collapse,*

[3] Guzman Philip. and Ishiyama Yuji (2004), "Collapse Assessment of Building Structures using Damage Index"*13th World Conference on Earthquake Engineering, Vancouver, B.C, Canada, August 1-6, , Paper No. 0734*

[4] John R. and WoodsonM.R. et all (2004) "Earthquake Resistant and blast resistant a structural comparison" *13th World Conference on Earthquake Engineering Vancouver, B.C., Canada August 1-6, 2004 Paper No. 887*

[5] Yu Chi Sung, Chin-Kuo Su, Chuan Wei Wu and I Chau Tsai (2005), "Performance Based Damage Assessment of Low-Rise Reinforced Concrete Buildings." *Journal of the Chinese Institute of Engineers, Vol. 29, No. 1, pp. 51-62* .

[6] Yancha shi Z., Lian and Hong Hao (2010),"A new method for progressive collapse analysis of RC frames under blast loading" ELSEVIER Engineering Structures32 (6) 2010, PP 1691-1703

[7] Asprone D,Jalayer F., A.Prota, G.Manfredi (2010) "Dynamic response of multibody structure subjected to blast loading" ELSEVIER Structural Safety Volume 32, Issue 1, January 2010, Pages 25-34

[8] Indian Standerds IS 4991-1968 Criteria For Blast Resistant Design of Structures Above Ground

[9] Shirbhate P.A.,Goel M.D.(2020)"Acritical review of Blast Wave Parameter And Approaches for Blast Load Mitigation" *Archives of Computational Methods in Engineering,,pages 1-18*

[10] Bhagvat S.R.,Patil P,(2020)"Effects of Blast Load on Structures"IJMERMCE,Volume 5,Issue 6 ,

[11] Boyna S.R.Sekhar J.,(2018)"Blast load Analysis and Effects on High Rise Structures "International Journal of Civil Engg. And Technology"Volumn 9,Issue 8pp340-347

Kashif Q,Varma M.B (2014) "Effect of Blast on G+4 RCC Frame Structure" *International Journal of Emerging Technology and Advanced Engineering, Volume 4, Issue 11.*