INDIAN JOURNAL OF SCIENCE AND TECHNOLOGY

RESEARCH ARTICLE

OPEN ACCESS

Received: 24-02-2023

Accepted: 02-06-2023

Published: 22-07-2023

Citation: Aurtherson PB, Ram KH, Kailordson KS, Christopher CM, Jesumanen J (2023) Analytical Investigation of Blast Loading Impact on High Rise Structures. Indian Journal of Science and Technology 16(28): 2118-2125. https://doi.org/10.17485/IJST/v16i28.415

* **Corresponding author**.

pbaurtherson1@gmail.com

Funding: None

Competing Interests: None

Published By Indian Society for Education and Environment (iSee)

ISSN
Print: 0974-6846
Electronic: 0974-5645

Analytical Investigation of Blast Loading Impact on High Rise Structures

P Babu Aurtherson[1]*, K Hari Ram[1], K Sanu Kailordson[2], C Mahil Christopher[2], J Jesumanen[2]

1 Professor, Department of Mechanical Engineering, DMI Engineering College, Aralvoimozhi, Tamil Nadu, India
2 Assistant Professor, Department of Mechanical Engineering, DMI Engineering College, Aralvoimozhi, Tamil Nadu, India

Abstract

Objectives: To accurately describe the blast loads on the buildings, the ten storey building is proposed in this study. The primary reaction of the design is analyzed by utilizing the SAP2000 program. Based on IS 4991-1968 code the impact waves are evaluated. To achieve low base shear the proposed method compared with the existing methods like 3, 5, 7 and 9 storey buildings. **Methods:** The Dynamic exploration is prompted by time history analysis. The tall building structures of RC frame are analyzed with the standoff distances of 30m, 40m, 50m and 60m respectively. The four distinct framework's sidelong removals, float, and base shear are investigated in this study. **Findings:** The balanced RC framed constructions are more stable under impact stresses than non-even RC framed structures. The base shear under an earthquake is easily decreased by using the best-sized beams at the top levels of the building. When compared to the conventional techniques, the proposed method achieves low shear base by using the better sized beams. **Novelty:** The importance of a structure subjected to blast load increased due to accidental events or natural occurrences. It is inevitable that blasting will produce vibration waves, which cause the structural damage. The majority of earlier research has focused on 3, 5, 7 and 9 storey buildings and it not exactly predict the blast load. In order to accurately describe the blast loads on the buildings a more in-depth analysis is required. Therefore this study proposed the 10 storey building, which accurately describe the blast load on buildings and achieves less base shear (3200KN) compared to the existing methods.

Keywords: RC Frame; SAP2000; Blast Loading; High Rise Structure; Symmetrical And Unsymmetrical RC Frame

1 Introduction

The explosions are caused by two chemicals mixing at a high temperature, resulting in the release of energy and hot gases into the surrounding atmosphere. The hot gases generated by the blast fill the surrounding space. A structure should be designed to resist explosions[1,2]. The Blast loads are considered to be impulsive loads due to their explosive effect that occurs very rapidly [3]. Generally, conventional structures are not built to withstand blast loads because it is difficult to analyse the dynamic response of blast-loaded structures; this difficulty may be brought on by factors like the impact of high strain rates, the behaviour of nonlinear inelastic materials, the unpredictability of blast load calculations, time-dependent deformations, or high design as well as construction costs. It has become necessary to investigate ways to mitigate the blast loading risk associated with conventional RC structures due to their limitations in absorbing blast loads [4,5]. Therefore, this study examine the dynamic response of the blast loaded structures [2]. Has mainly focused on one or two building components like beam and column. A more thorough analysis is required when every building component is important. Nevertheless, in future it has to be focused on more building block components. To overcome this issues, the suggested work focused on more building components like roof, floor, slab, elevations and foundation.

In [6] the author developed the nonlinear dynamic finite element simulations by using LS-DYNA in order to analyze a progressive collapse of an 8-story steel framed building. Nevertheless, the Finite element modelling is affected by beam to column connections and composite slabs as the modelling parameters. Therefore, better finite element tool is needed, in this study, the SAP2000 is used for the finite element simulations, which is the better alternate solutions for LS-DYNA. In high-rise buildings, the outriggers system has proven to be an effective lateral load resisting device for reducing vibrations and lateral displacement while enhancing rigidity. To study the structural behaviour since, there is a greater scope in future for the symmetrical and asymmetrical techniques in high rise structures [7,8]. Therefore, closed symmetrical and unsymmetrical RC frame as well as open symmetrical and unsymmetrical RC frame are analyzed in the investigation to determine the behavior of structures.

In this study, the tall building structures such as closed symmetrical and unsymmetrical RC frame as well as open symmetrical and unsymmetrical RC frame are analyzed in the investigation. These frames are known to be presented to a specific structural load at different distances such as 30m, 40m, 50m and 60m respectively. The primary reaction of the design is analyzed by utilizing the SAP2000 program. The four distinct framework's sidelong removals, float, and base shear are investigated in this study. In order to accurately describe the blast loads on the buildings when every building component is of relevance, a more in-depth analysis is required. Therefore this study proposed the 10 Storey building to accurately describe the blast loads on the buildings. The comparison graph for base shear is obtained for various story building with the proposed 10-storey building. As a result the proposed method attains less base shear (4626KN) when compared to the conventional techniques

2 Methodology

The SAP2000 is the finest software for examining and planning the building. The approach for investigating the limited component is used in this software. The type of primary examination that affects the structure's response to dynamic stresses is dynamic examination. Dynamic exploration is prompted by time history or response range analysis. The intensity of the dead load, live load at different floor levels are examined. The lateral displacement, storey drift and base shear is measured for different standoff distances.

2.1 Description of the structure

The importance of a structure subjected to blast load increased due to accidental events or natural occurrences. It is inevitable that blasting will produce vibration waves, which cause the structural damage. The majority of earlier research has focused on 3, 5, 7 and 9 storey buildings and it concentrate only one or two building blocks, so it not exactly predict the blast load. In order to accurately describe the blast loads on the buildings a more in-depth analysis is required. Therefore this study proposed the 10 storey building and it focused on more building components like roof, floor, slab, elevations and foundation to accurately describe the blast on buildings. As a result the proposed method attains less base shear than the existing techniques.

The bar's standard element is 600 x 400mm and the segments has a height of 850 x 850 mm. The pieces have a thickness of 150mm and the width of the outer divider is 230mm. The structure is illustrated using the sap2000 Finite Element tool.

M30 is the solid evaluation that was used. The development model's assistance requirements have been established.

According to the calculation, the centre to-focus plan is 24 m long and 24 m broad. There are four length bayous with a 6m long middle to focus breadth and four length bayous with a cross over 6m range. The floor is 3 m tall. The 3D view of the symmetrical and unsymmetrical open and close RC frame structure is represented in Figure 1 (a) and (b).

The solid system of the home is used to construct R.C frames and exterior dividers for closed constructions.

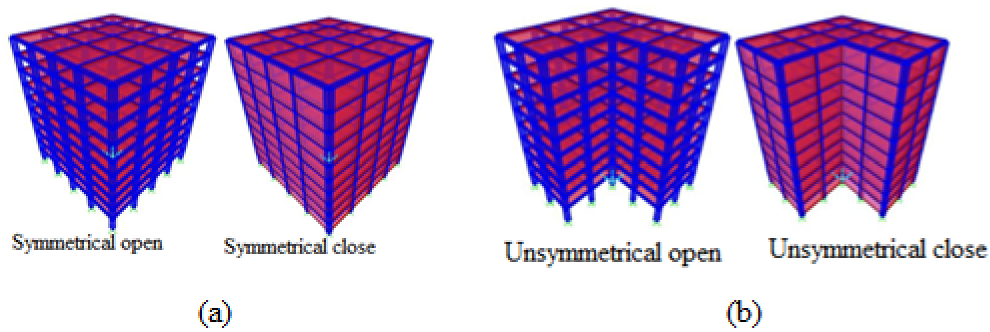

Fig 1. (a) 3D view of symmetrical (b) Unsymmetrical open and close RC frames

2.2 Loads of the structure

The study examined at the intensity of dead load and live load at various floor levels and roof elevations which are given below,

2.2.1 Dead load

Dead loads are caused by the constant weight exerted by permanent components such as beams, slabs, columns, and walls. Dead loads exerted by these components are vertical and it is calculated as follows,

Slab weight = $0.1X25 = 3.75\ kN/m^2$

Additional dead load weight for all floor levels $= 2.25\ kN/m^2$

Total dead load (all floors except roof) $= 6\ kN/m^2$

Additional dead load weight for roof $= 0.25\ kN/m^2$

Total dead load (for roof) $= 4\ kN/m^2$

2.2.2 Live load

A live load is classified as moving or movable and it is not impacted or accelerated by any external forces. Live loads are brought into a building by an occupant.

Live load for all floors except roof $= 3\ kN/m^2$

The roof level live load is not considered.

2.2.3 Blast load

The Blast Load is the force applied to a structure or object by the impact of a blast wave, which consists of both overpressure and impulse or duration causing structural damage on both exterior and interior surfaces.

Charge weight of explosive, $W = 1000\ kg\ TNT$

Factor of safety $= 1.2$

Effective charge weight, $W_S = 1200\ kg\ TNT$

The various standoff distance, R considered are 30 m, 40 m, 50 m and 60 m respectively.

Scaled distance, $Z = \frac{R}{W_S^{\frac{1}{3}}}$

The scaled distance is varied for each pitch distance. When employing AT (anti-terrorist), the scaled distance is utilized to get characteristics such as reflected pressure, time of travel, shock velocity, load duration and impulse.

3 Result and Discussion

The dynamic analysis is based on RC defined designs with standoff distances of 30 m, 40 m, 50 m, and 60 m. Based on IS 4991-1968 code the impact waves are evaluated. SAP2000 software is used to dissect the shot waves on the construction side. The consequences of the four models with various environmental load circumstances are examined. The boundaries tested are parallel motions, daze drift and base shaving. The results obtained for lateral displacement, storey drift of symmetrical and unsymmetrical RC frame and base shear at different standoff distance is discussed below. The comparison graph is obtained for base shear with the existing methods. The proposed technique achieves less base shear pf (3200KN) when compared to the conventional methods.

3.1 Lateral Displacement

In lateral displacement, the parallel dislodging is prompted by the sidelong power at each step of the framework. The maximum sidelong ripping is displayed for the highest level. The consequences for various models under varying conditions are discussed in detail. Under unusual circumstances, the effects of side relocations are investigated freely for four related variations.

The values obtained for lateral displacement of closed symmetrical RC frame at different standoff displacements is represented in Figure 2 (a) and (b), from the figure it is observed that the lateral displacement is higher in 30m and lower in no blast when compared to the other standoff distances.

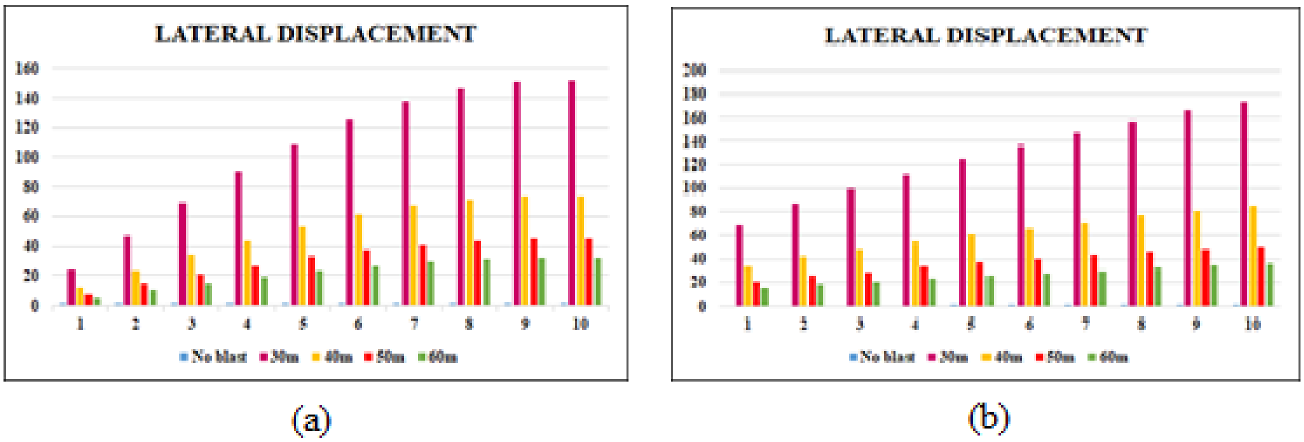

Fig 2. Variation of displacements for Closed (a) Symmetric and (b) RC frame at different standoff distances

The values obtained for lateral displacement of open symmetrical RC frame at different standoff displacements is represented in Figure 3. As illustrated in figure the lateral displacement is lower in blast load and higher in 30m when compared to the other standoff distances.

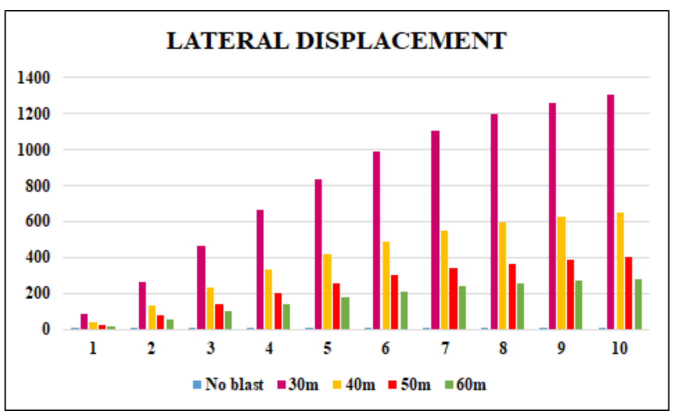

Fig 3. Variation of displacements foropen symmetrical RC frame at different standoff distances

The values obtained for lateral displacement of open unsymmetrical RC frame at different standoff displacements is represented in Figure 4. From the graph it is observed that the lateral displacement is high in 30m and low in blast load when compared to the other standoff distances.

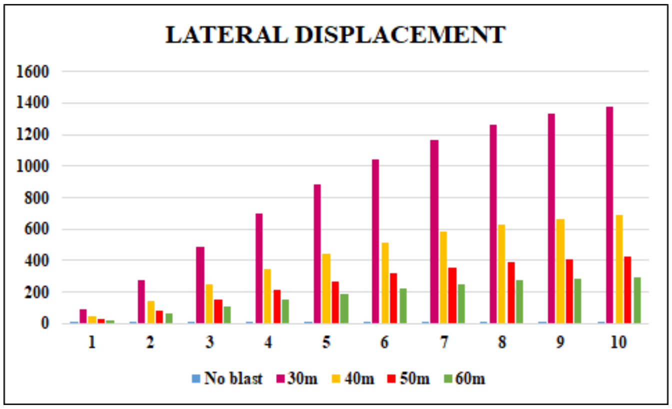

Fig 4. Variation of displacements for open unsymmetrical RC frame at different standoff distances

3.2 Storey Drift

The storey drift processes from one step to the next, either upwards or downwards. The store drift need exceed more than 0.004 times the shop's height.

The permissible storey drift of each storey $= 0.004\ x\ 3000 = 12mm$

The storey drift is disregarded because its value is near zero in the absence of a blast load condition. The values obtained for storey drift of closed symmetrical RC frame at different standoff displacements is represented in Figure 5. From the observation of the figure it is noted that the storey drift is higher in 30m and lower in 60m, when compared to the other standoff distances.

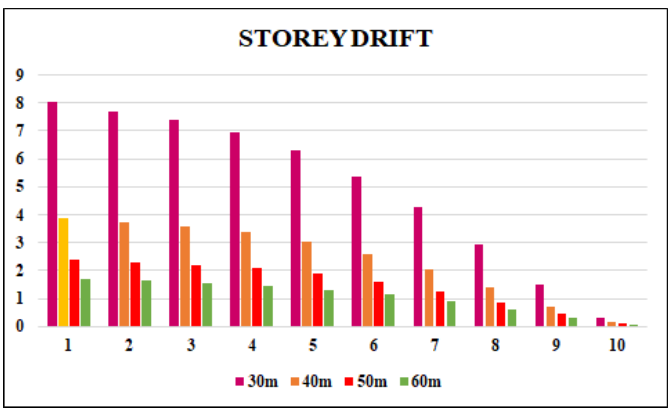

Fig 5. Variation of storey drift for closed symmetric RC frame at different stand off distances

The values obtained for storey drift of closed unsymmetrical RC frame at different standoff displacements is represented in Figure 6. Compared to other standoff distances, low storey drift is occurred in 60m and high in 30m as specified in below figure.

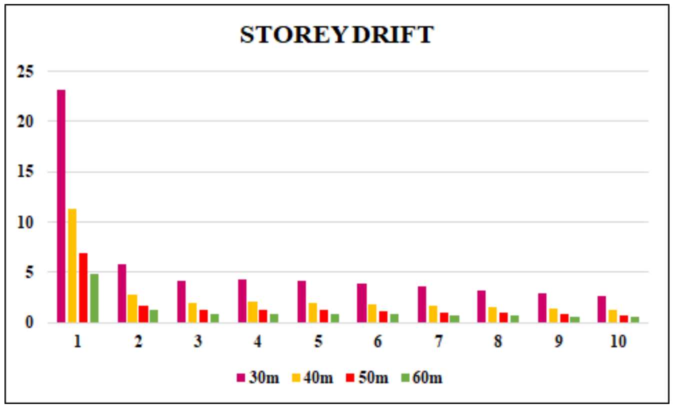

Fig 6. Variation of storey drift for closed unsymmetrical RC frame at different stand off distances

The values obtained for storey drift of open symmetrical RC frame at different standoff displacements is represented in Figure 7. From the graph it is analyzed that the storey drift is high in 30m and low in 60m compared to the other standoff distances.

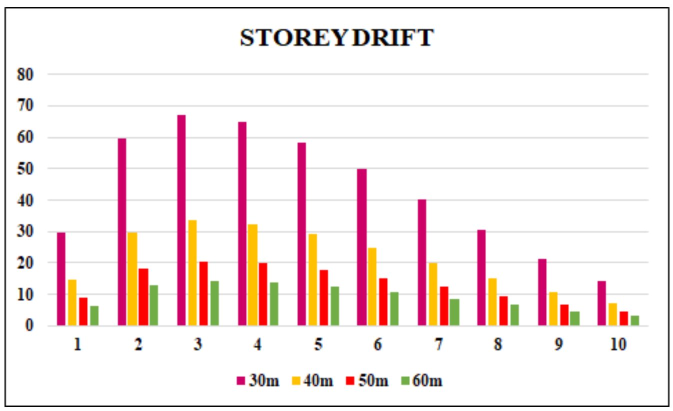

Fig 7. Variation of storey drift for open symmetric RC frame at different stand off distances

The values obtained for storey drift of open unsymmetrical RC frame at different standoff displacements is represented in Figure 8. From the observation of the figure, the storey drift is occur high in 30m and lower in 60m compared to the other standoff distances.

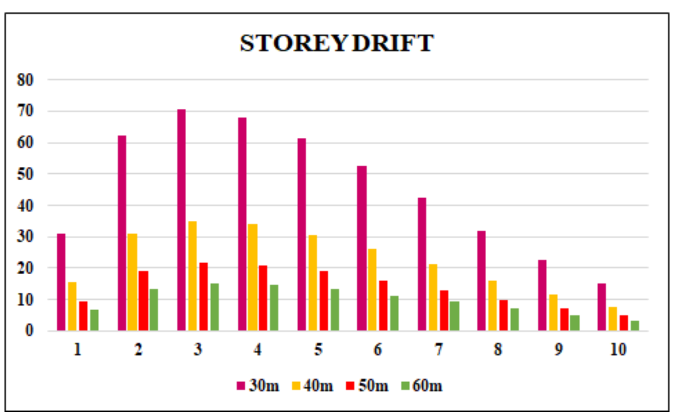

Fig 8. Variation of storey drift for openun symmetrical RC frame at different standoff distances

3.3 Base Shear

Base shear is the force, measured in kilotons, which is discovered at the base of a structure that has been subjected to various stresses. Figure 9 specifies the base shear with the standoff distances, from the figure it is analyzed the proposed base shear with standoff distances like 30m, 40m, 50m and 60m is obtained. The low base shear is achieves at 3200 KN in 60m than the other standoff distances, which has 27510.13, 36404.12 and 103354.2KN.

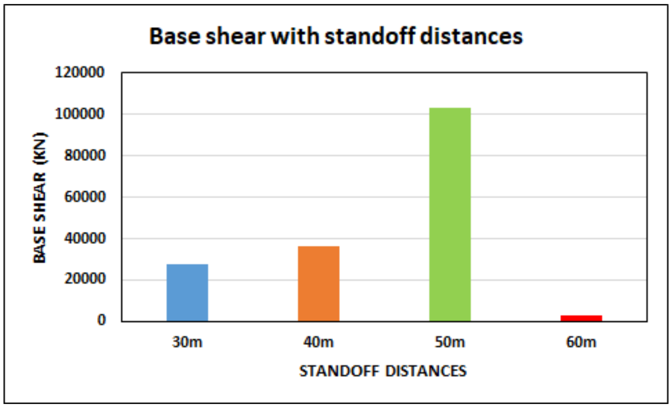

Fig 9. Base shear with standoff distances

The comparison of base shear with different storey building is illustrated in Figure 10. The proposed technique of base shear with the standoff distance of 60m is taken to compare with the existing methods. From the figure it is noted that the proposed technique attains lower base shear of (3200KN) when compared to the conventional techniques like 3, 5, 7 and 9 storey buildings of (4200, 3800, 3700 and 3400KN)[9].

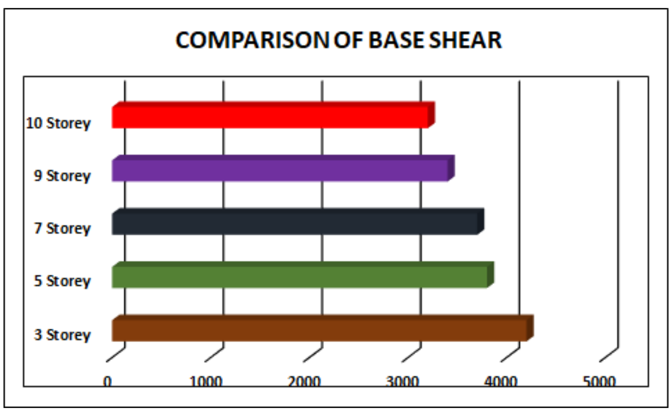

Fig 10. Comparison of base shear

4 Conclusion

The importance of a structure subjected to blast load increased due to accidental events or natural occurrences. It is inevitable that blasting will produce vibration waves, which cause the structural damage. The majority of earlier research has focused on 3, 5, 7 and 9 storey buildings and it not exactly predict the blast load. In order to accurately describe the blast loads on the buildings a more in-depth analysis is required. Therefore this study proposed the 10 storey building, which accurately describe the blast load on buildings. The suggested work focused on more building components like roof, floor, slab, elevations and foundation to accurately describe the blast on buildings. Because existing works has only measured one to two building blocks. In this study, the tall building structures such as closed symmetrical and unsymmetrical RC frame as well as open symmetrical and unsymmetrical RC frame are analyzed with the different distances such as 30m, 40m, 50m and 60m respectively. The primary reaction of the design is analyzed by utilizing the SAP2000 program. The four distinct framework's sidelong removals, float, and base shear are investigated in this study. Non-even dwellings have the highest rate of displacement. Along these lines, it is possible to determine that balanced RC framed constructions are more stable under impact stresses than non-even RC framed structures. In comparison to open RC framed designs, closed RC framed structures are more stable under impact loads. The comparison graph for base shear is obtained for various storey building with the proposed 10-storey building. As a result the proposed method attains less base shear of (3200KN) when compared to the conventional techniques. It is advised that the current Building Regulations and Design Standards should be revised to incorporate provisions for preventing progressive collapse as well as guidelines for abnormal load scenarios. Ductility requirements is needed in further studies to improve a building's performance under heavy load circumstances.

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