OPEN ACCESS

International
Journal
Of Modern Engineering Research (IJMER)

Comparative Analysis of Deformation Under Blast Load Conditions With And Without Shear Walls

Jagdish Kumar Sah[1], Durgesh Nandan Verma[2, *], Dr. Ranjan Kumar[3]
Department of Civil Engineering,
Dr. K.N. Modi University, Newai (Rajasthan), India
*[1]jsah530@gmail.com; [2, *]durgeshnandan.civil@gmail.com; [3] hod.civil@dknmu.org*

Abstract: *Blast loading on structures has become a significant concern in modern engineering, especially in regions prone to terrorist attacks or accidental explosions. Understanding the background of blast loads and how shear walls can control them is crucial for designing buildings that can withstand such events. Blast loading refers to the sudden release of energy resulting from explosions. This energy propagates through the surrounding air as a blast wave, exerting immense pressure on nearby structures. The effects of blast loading can be devastating, causing structural damage, collapse, and loss of life. For a structure to handle lateral forces like wind and seismic forces, shear walls are used as structural features. They normally consist of reinforced concrete or steel panels that provide stiffness and strength to a building's frame, helping it withstand horizontal forces. While shear walls are primarily implemented to resist lateral loads, they can also offer significant protection against blast loads. The effectiveness of shear walls in controlling blast loads stems from their ability to dissipate and redistribute the energy transmitted by the blast wave. When subjected to an explosion, shear walls absorb some of the energy through deformation and flexural resistance. This reduces the impact on the primary structural frame and helps reduce damage to the building.*
Keywords: *Blast load, Shear wall, Steel plated Shear wall, RCC structure.*

I. INTRODUCTION

Building engineers have been focusing a lot of attention on the reaction and harm evaluation of structures exposed to blast loading in the past few decades because of the rise in terrorist attacks on structures. Considering the blast could occur at any location in regards to the building and at any intensity, blast loading is basically unexpected. The explosion could occur below, on the ground, or in the air. The position of a blast affects the kind of loading it causes on structures. An air blast exposes a structure to sudden air pressure, while a surface blast exposes it to ground shock as well as air pressure. These days, strength of the structure and collapse resilience are essential areas of study for both the safety assessment for existing structures and the design of modern ones. Usually, a structure becomes safe if its design capacity is achieved or surpassed by the loading caused by its design behaviors. Analyzing a structural system's structural performance in various situations related to accidents is another design approach. Whenever unexpected loads occur due to accidents like crashes, earthquakes, collisions, blasts, etc., and the planned acts are difficult to accurately predict during the structure's design life, this technique becomes appropriate. Furthermore, it has been more important in recent years to learn about the events related to explosive exposure and damage to buildings and facilities that have been observed at risks of this type. This is because terrorist explosions and accidents are growing worldwide. During these conditions, focus needs to be given to the reason for the collapse of the structure. Destruction to significant structural operations (slab, columns, decks, etc.) which results in a failure of the structural system, or destruction of large structural units (columns, slabs, decks, etc.) that reduces immediate structural collapse Known as zipper-type collapse.

Blast load

Blast loads are sudden and powerful forces generated by explosions, capable of causing devastating damage to structures and infrastructure. Whether resulting from accidental events like industrial accidents or deliberate acts of terrorism, understanding blast loads is crucial for designing buildings and facilities that can withstand such extreme forces. Blast loads manifest as shockwaves that propagate rapidly through the surrounding air, exerting immense pressure on nearby structures. The severity of the blast and its impact on structures depend on various factors, including the type and size of the explosive device, the distance from the explosion, and the surrounding environment. The effects of blast loads on structures can be catastrophic, leading to structural failure, collapse, and loss of life.

Effect of Blast load

The effects of blast loads on structures can be severe and wide-ranging, posing significant challenges to their integrity and safety. Understanding these effects is crucial for designing buildings and infrastructure that can withstand explosive events effectively. Blast loads can cause various types of structural damage, including deformation, cracking, and fragmentation. The intense pressure generated by the blast wave can exceed the capacity of building components, leading to localized or widespread failure. Structural component such as columns, beams, slabs, and walls may experience bending, buckling, or collapse under the dynamic forces exerted by the blast. Blast-induced damage to key structural elements can trigger progressive collapse, where the failure of one component initiates a chain reaction of structural failures throughout the building. Progressive collapse poses a significant risk to occupant safety and can result in catastrophic collapse of the entire structure. Designing buildings to resist progressive collapse is essential for mitigating the effects of blast loads. Explosive events can generate airborne debris, fragments, and projectiles that can penetrate building envelopes and cause secondary damage to structural elements and occupants. Fragmentation from blast effects, as well as the disintegration of building materials, can produce hazardous projectiles capable of causing injury or further structural damage.

Shear wall

In the realm of structural engineering, shear walls stand as stalwart defenders, safeguarding buildings against lateral forces like wind, seismic activity, and even blast loads. These vertical elements, strategically positioned within the framework of a structure, provide essential resistance to horizontal forces, ensuring stability and structural integrity. At its core, a shear wall is a vertical component designed to resist lateral loads by transferring them to the building's foundation. Typically constructed from reinforced concrete or steel, shear walls possess remarkable strength and stiffness, allowing them to effectively counteract the forces that would otherwise cause swaying, distortion, or collapse in a building during adverse conditions. The concept of shear walls dates back centuries, evolving alongside advancements in construction techniques and materials. Initially employed in masonry structures, modern shear walls now find application in a diverse range of building types, from residential high-rises to industrial complexes and even critical infrastructure like nuclear power plants. The effectiveness of shear walls lies in their ability to dissipate and redistribute lateral forces.

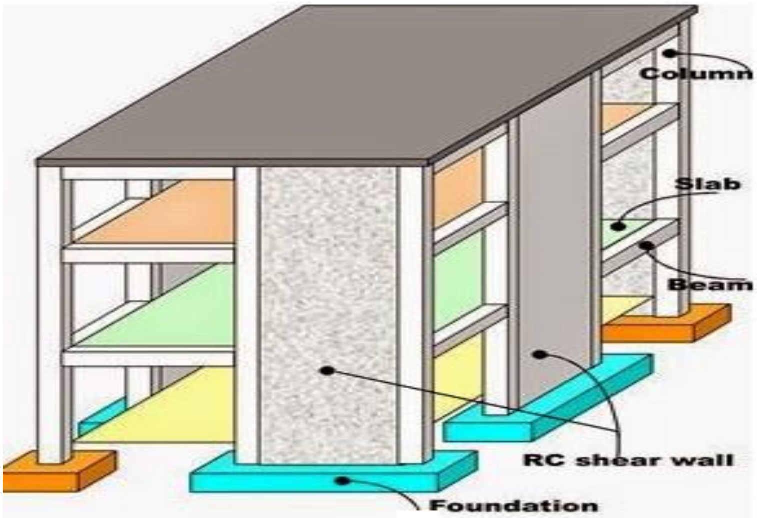


Figure 1 Shear wall attached on Structure

Types of Shear Wall
Shear walls come in various types, each designed to fulfill specific structural requirements and constraints. Here are some common categories of shear walls:

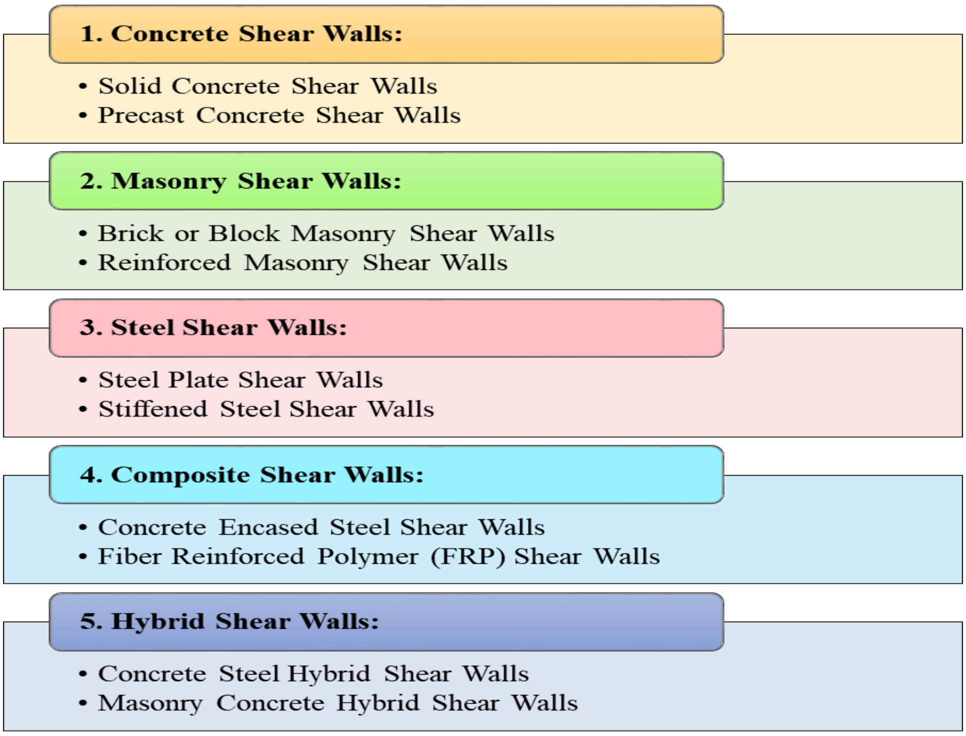


Figure 2 Different kind of Shear walls

Effects of Shear wall on blast load

- Shear walls are strategically positioned within the building's framework to help distribute and redirect blast forces away from critical structural components. By providing a continuous vertical load path, shear walls can help channel blast pressures down to the building's foundation, reducing the impact on vulnerable areas.
- Shear walls possess inherent strength and stiffness, allowing them to absorb and dissipate some of the energy transmitted by the blast wave. When subjected to blast loads, shear walls undergo deformation and flexural resistance, helping to dampen the effects of the explosion and reduce the overall damage to the structure.
- The presence of shear walls can enhance the overall structural integrity of a building, making it more resistant to blast-induced deformations and failure modes. Shear walls act as vertical barriers that resist lateral displacement and distortion, thereby improving the building's capacity to resist the dynamic forces generated by the blast.
- Shear walls help reduce the risk of progressive collapse, where localized damage or failure propagates throughout the structure. By providing additional lateral stability and support, shear walls can help prevent the spread of blast-induced damage and limit its extent, thereby minimizing the risk of catastrophic collapse.

II. PROBLEM STATEMENT

The problem statement aims to investigate the efficacy of shear walls in mitigating deformation caused by blast loads in structures. By conducting a comparative analysis, this study seeks to assess the extent to which shear walls contribute to reducing deformation under blast load conditions. The research will involve analyzing structural models subjected to blast loads, both with and without shear walls, to quantify and compare their deformation responses. Key parameters such as displacement, deflection, and strain will be evaluated to determine the effectiveness of shear walls in resisting blast-induced deformation. Additionally, factors such as shear wall configuration, material properties, and placement within the structure will be considered to understand their influence on deformation mitigation. The findings of this study will provide valuable insights into the role of shear walls in enhancing the blast resistance of structures and inform future design practices aimed at improving structural resilience against explosive events.

III. OBJECTIVES

- To develop finite element models of structural configurations with and without shear walls subjected to blast loading conditions.
- To simulate blast loading scenarios using appropriate blast pressure profiles and boundary conditions.
- To analyze and quantify the deformation responses, including displacement, deflection, bending moment of structures with and without shear walls.
- To evaluate and compare the effectiveness by using shear walls in mitigating deformation under blast load conditions.
- To provide recommendations for optimizing shear wall design and placement to enhance the blast resistance and mitigate deformation in structures.

IV. METHODOLOGY

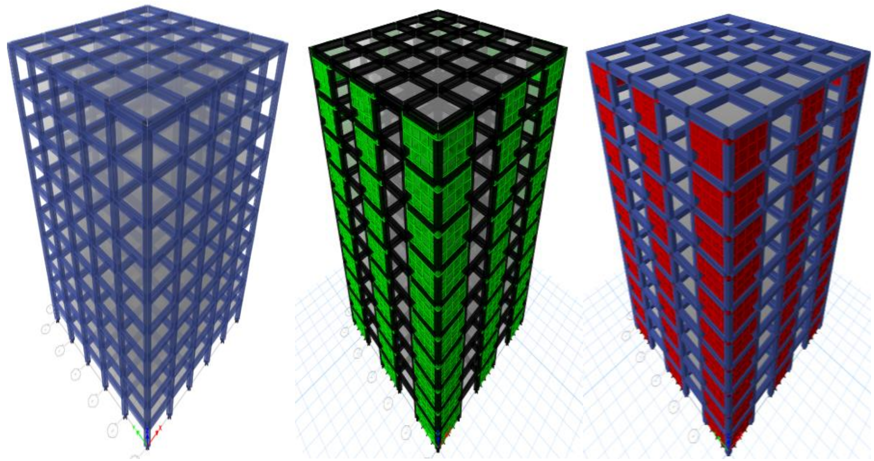
In this Section Analyse G+10 floor RCC structure with or without shear wall and an another situation with a steel plated shear wall in all cases we used blast load condition to perform this assessment time history method was used in CSI ETABS software.

Geometrical Analysis

Case-1: Bare frame Structure with Blast load

Case-2: Bare frame with shear wall Structure with Blast load

Case-3: Bare frame with Steel Pated shear wall Structure with Blast load



Case-1 **Case-2** **Case-3**

Figure 3 Three-Dimensional View of structure in varying cases

V. RESULT AND DISCUSSION

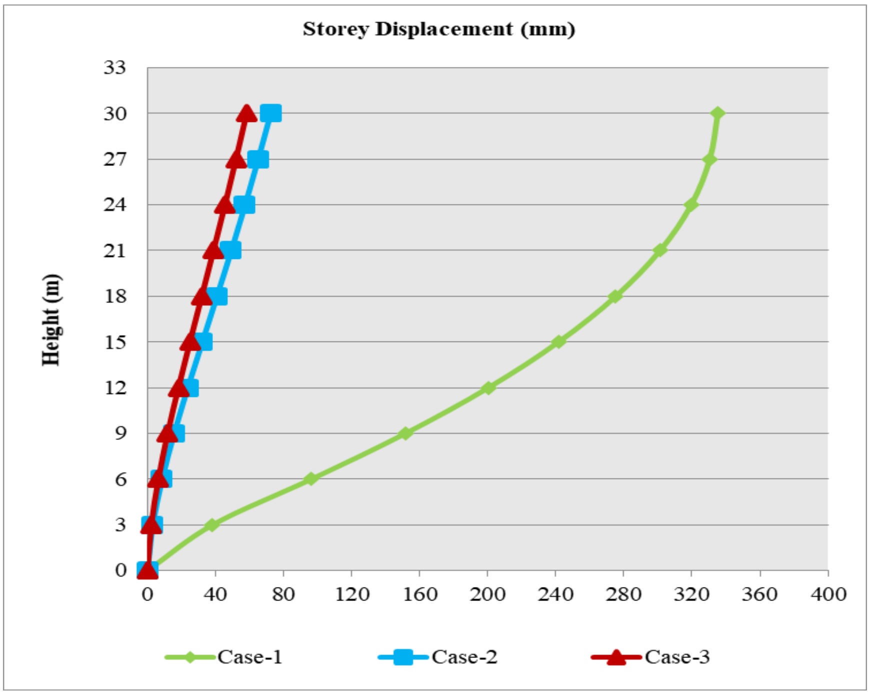


Figure 4 Storey Displacement of Structure with and without shear walls

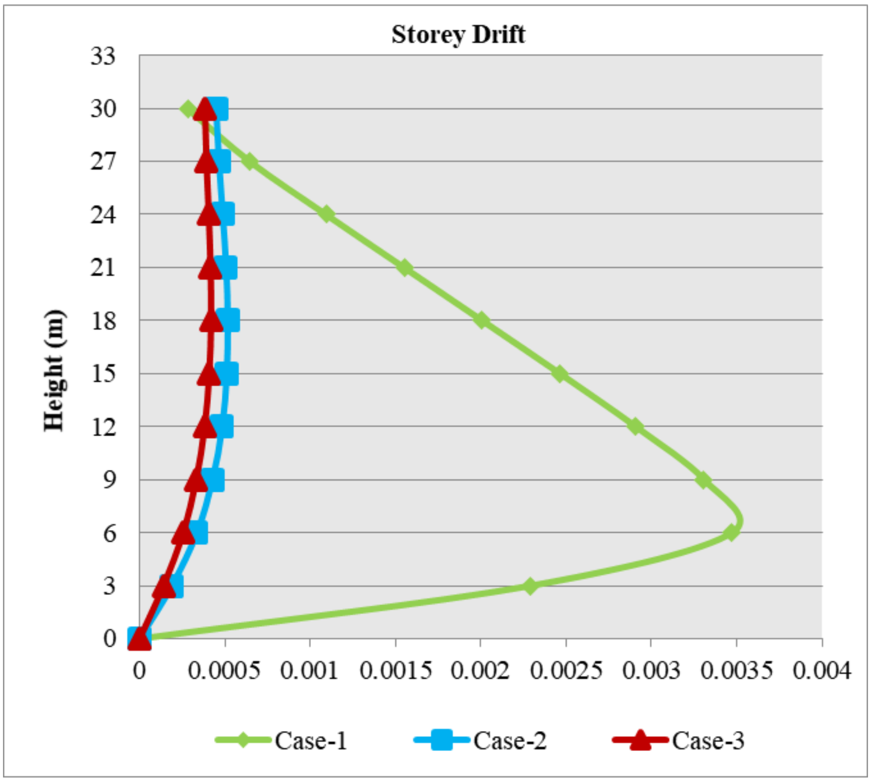


Figure 5 Storey Drift of Structure with and without shear walls

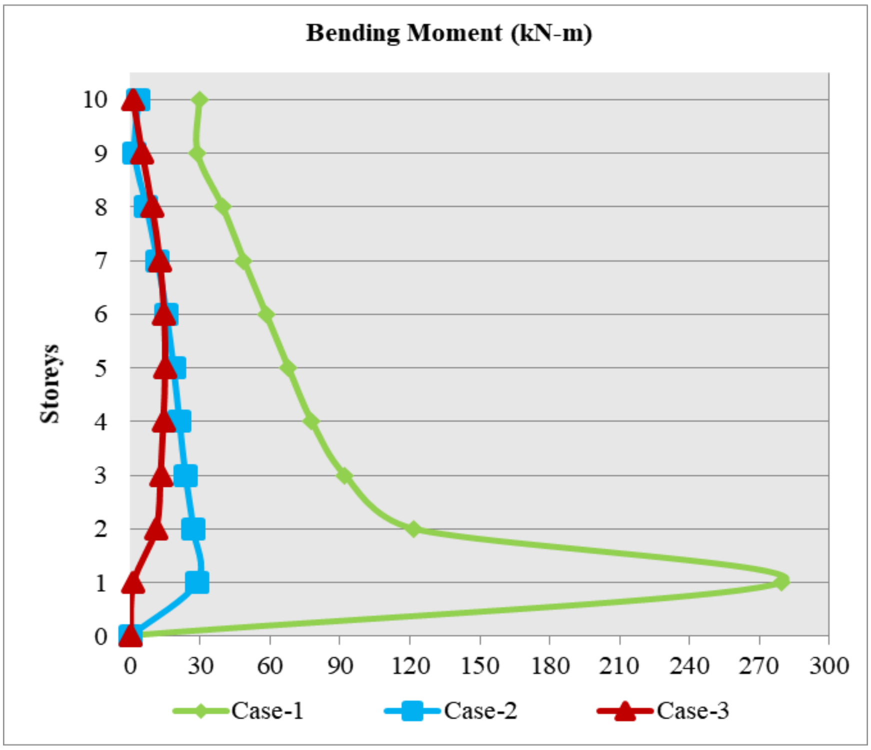


Figure 6 Bending moment of Structure with and without shear walls

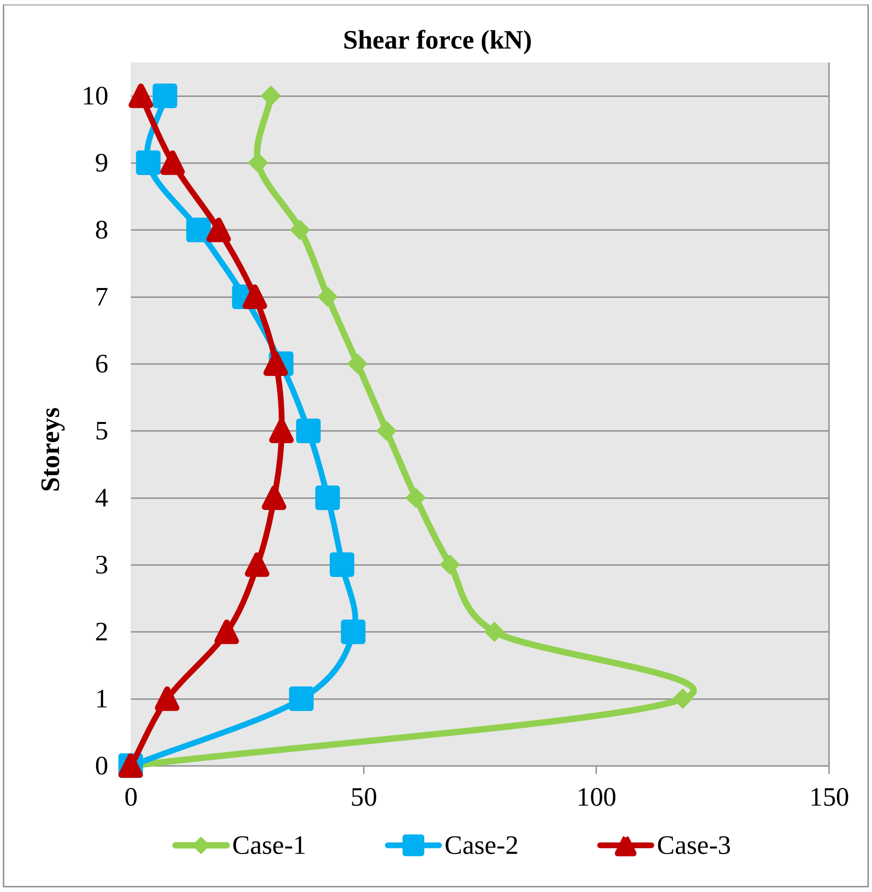


Figure 7 Shear force on Structure with and without shear walls

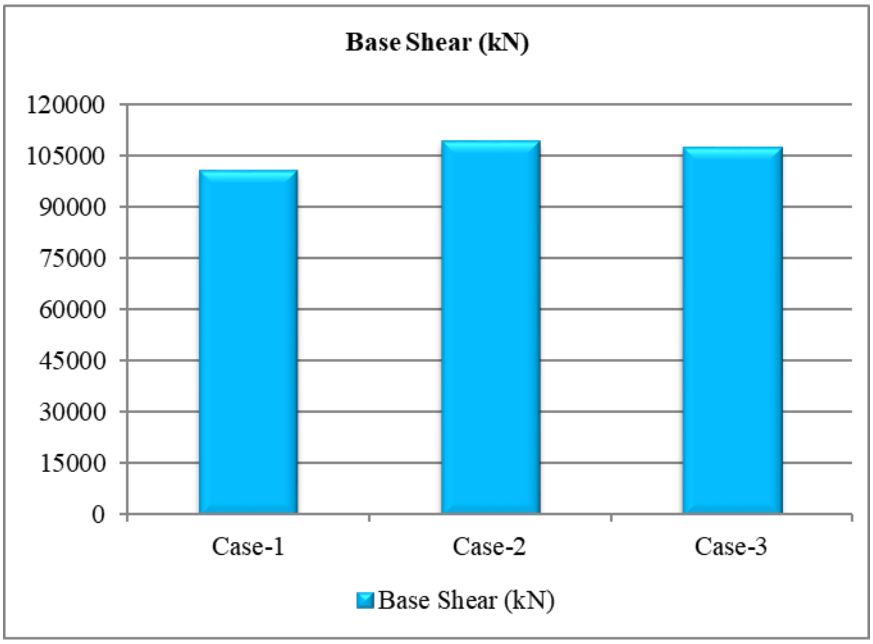


Figure 8 Base Shear of Structure with and without shear walls

VI. CONCLUSION

The structure's maximum displacement, disregarding shear walls, under the load combination of 1.2 (DL+LL+BL) amounted to 335.56mm. Incorporating RC shear walls in the model notably decreased this displacement by 78.40%, resulting in a reduced displacement of 72.39mm. Alternatively, replacing the RC shear walls with steel plated shear walls produced a displacement of 58.58mm, show casing an 82.53% reduction in displacement compared to the original configuration. It was concluded that maximum reduction of joint displacement occurred with steel plated shear walls.

The structure's maximum storey drift, disregarding shear walls, under the load combination of 1.2 (DL+LL+BL) amounted to 0.00347. Incorporating RC shear walls in the model notably decreased this storey drift by 85.15%, resulting in a reduced storey drift of 0.000515. Alternatively, replacing the RC shear walls with steel plated shear walls produced a storey drift of 0.000419, show casing an 87.92%reduction in storey drift compared to the original configuration. It was concluded that maximum reduction of storey drift occurred with steel plated shear walls.

The structure's maximum bending moment, disregarding shear walls, under the load combination of 1.2 (DL+LL+BL) amounted to 279.76kN-m. Incorporating RC shear walls in the model notably decreased this bending moment by 89.79%, resulting in a reduced bending moment of 28.55kN-m. Alternatively, replacing the RC shear walls with steel plated shear walls produced a bending moment of 14.90kN-m, show casing a 94.67%reduction in bending moment compared to the original configuration. It was concluded that maximum reduction of bending moment occurred with steel plated shear walls.

The structure's maximum shear force, disregarding shear walls, under the load combination of 1.2 (DL+LL+BL) amounted to 118.55kN. Incorporating RC shear walls in the model notably decreased this shear force by 59.67%, resulting in a reduced shear force of 47.81kN. Alternatively, replacing the RC shear walls with steel plated shear walls produced a shear force of 32.39kN, show casing a 72.67%reduction in shear force compared to the original configuration. It was concluded that maximum reduction of shear force occurred with steel plated shear walls.

The structure's maximum base shear, disregarding shear walls, under the load combination of 1.2 (DL+LL+BL) amounted to100130.84kN. Incorporating RC shear walls in the model notably increased this base shear by 8.62%, resulting in a reduced base shear of 108768.29kN. Alternatively, replacing the RC shear walls with steel plated shear walls produced a base shear of 106781.30kN, showcasing a 6.64% increment in base shear compared to the original configuration. It was concluded that maximum increment of base shear occurred with RC shear walls.

REFERENCE

[1]. Kumawat, Kirtika, et al. "Seismic Response of Stiffness Irregularity at Ground Floor with and without Shear Walls." Journal of Scientific Research and Reports 30.1 (2024): 12-24.

[2]. Ciabattoni, Micol, Francesco Petrini, and Stefano Pampanin. "Multi-hazard design of low-damage high-rise steel–timber buildings subjected to wind and earthquake loading." Engineering Structures 303 (2024): 117522.

[3]. Hosseini, Mahdi, et al. "Performance of composite shear walls strengthened with FRP and subjected to blast load." Revista de la construcción 22.2 (2023): 431-454.

[4]. Aurtherson, P. B., et al. "Analytical Investigation of Blast Loading Impact on High Rise Structures."Indian Journal of Science and Technology 16.28 (2023): 2118-2125.

[5]. Ghanbari, Hamid, Eysa Salajegheh, and Javad Salajegheh. "Performance assessment of seismically-designed steel moment-resisting structures against numerically-simulated blast wave propagation." Numerical Methods in Civil Engineering 7.3 (2022): 54-65.

[6]. Prajapat, Ramkesh, Mahendra Meghwal, and Ramana PV. "Computational Intelligence on High Rise Structure with Effect of Diverse Load Conditions." International Research Journal on Advanced Science Hub 3.Special Issue 6S (2021): 111-117.

[7]. Hasrat, Hussin Ahmad. "Comparative Study of Various High Rise Building Lateral Load Resisting Systems for Seismic Load & Wind Load: A Review." (2021).

[8]. Farahmand‐ Tabar, Salar, and Payam Ashtari. "Simultaneous size and topology optimization of 3D outrigger‐ braced tall buildings with inclined belt truss using genetic algorithm." The Structural Design of Tall and Special Buildings 29.13 (2020): e1776.

[9]. Kadhum, Ali Kifah, and Lina K. Kadhum. "Architectural and structural design to compare the effect of blast load on irregular buildings from view point steel braces." International Journal of Psychosocial Rehabilitation 23.06 (2020).

[10]. Tetougueni, Cyrille Denis, Paolo Zampieri, and Carlo Pellegrino. "Structural performance of a steel cable-stayed bridge under blast loading considering different stay patterns." Engineering structures 219 (2020): 110739.

[11]. Tolani, Sunita, et al. "Effect of surface blast on multistory buildings." Journal of performance of constructed facilities 34.2 (2020): 04020015.

[12]. Pawar, Vedant, Vasheemraja Gani Abdul, and Nilesh Baglekar. "Design of Structural Components against Blast Load." International Journal of Scientific & Engineering Research ISSN 2229-5518 (2020).

[13]. Wang, Gaohui, et al. "A state-of-the-art review on blast resistance and protection of high dams to blast loads." International Journal of Impact Engineering 139 (2020): 103529.

[14]. Roy, Shivananda, Krishnendu Chowdhury, and Abhishek Hazra. "Study on the behavior of single storied R/C framed structure under blast loading and seismic excitation." International Research Journal of Engineering and Technology (IRJET) (2020).

[15]. Gajewski, T., and P. W. Sielicki. "Experimental study of blast loading behind a building corner." Shock Waves 30.4 (2020): 385-394.