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ANALYSIS OF INELASTIC MULTI-STOREYED STRUCTURE SUBJECT TO BLAST LOADING

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Abstract: A thorough understanding of the behavior of multi-storey structures subjected to blast loading is necessary due to the growing threat of terrorist attacks and unintentional explosions. The dynamic response and inelastic behavior of such structures under blast loading scenarios are examined in this study. Numerous parameters, including material qualities, structural configurations, and blast characteristics, are analyzed through numerical simulations and analytical methods to determine their impact on the structural reaction. The goal of the project is to shed light on how to improve multi-storey buildings' blast resistance through the creation of efficient design methods and mitigating actions. Important discoveries about failure modes, energy dissipation mechanisms, and structural deformation are presented, emphasizing the intricate relationships that exist between the blast wave and the structural system. The analysis's findings improve structural engineering procedures for guaranteeing that buildings are resilient to risks brought on by explosions.

I. INTRODUCTION

The risk of terrorist acts and unintentional explosions in recent years has made it even more crucial to comprehend how multi-storey buildings react dynamically to blast loads. In order to ensure the safety and resilience of structures in urban contexts, engineers and researchers face daunting obstacles due to the intricate interaction between the blast wave and the structural system. Under such severe stress circumstances, inelastic behavior—which is characterized by structural deformation and damage becomes a serious concern. Thus, it is imperative to conduct a thorough analysis and evaluation of how multi-storey buildings might react in the event of blast loading. In order to provide light on the dynamic response and failure mechanisms of multi-storey structures, this study focuses on examining their inelastic behavior under blast loading. Various aspects, including material properties, structural configurations, and blast characteristics, will be examined to clarify their influence on the structural performance through the use of numerical simulations and analytical methodologies. To improve the blast resistance of multi-storey buildings, effective design techniques and mitigation measures must take into account the intricate interactions between these components. By offering insightful information about the behavior of multi-storey structures under blast loading conditions, we hope to further the field of structural engineering practices. This work seeks to support the establishment of strong design guidelines and risk mitigation techniques for strengthening the resilience of buildings against blast-induced hazards by identifying critical parameters impacting structural reaction and failure mechanisms. The analysis's conclusions have important ramifications for enhancing urban infrastructure security and safety in the face of changing threats. In order to investigate the impacts of seismic pounding in a continuous row building system, Anagnostopoulos (1988) idealized each building as a bilinear force-deformation inelastic structure with a single degree of freedom (SDOF). Jeong-Hun Wonet al. (2015) investigated the effects of earthquake pounding on the bridge piers by analyzing the dynamic responses of a three-span simply supported steel girder bridge. Mehdi Ghandil and Hasham Aldekh (2016) investigated how symmetric buildings next to one another responded to fictitious seismic pounding while taking SSI into consideration. Using nonlinear finite element analysis, Robert Jankowski (2016) et al. investigated the effect of infill panel presence on the reaction to mutual pounding between multi-story buildings placed in series during an earthquake. The effects of a blast on a five-story reinforced concrete building were examined by Hytham Elwardny et al. (2017), taking into consideration the TNT explosive material placed in the ground floor columns. Mate et al.'s (2017) study on seismic pounding makes use of the lumped mass model to improve understanding of the macro-behavior of structures and to make it easier to create straightforward processes for dealing with this problem. Using the time history analysis approach, Nan Jin and Yong-Qiang Yang (2018) investigated the impact of pounding and earthquake features on the ideal parameters for an anti-collision system. The study conducted by Mennatullah Talaat et.al. (2022) reveals that the response of the lighter, more flexible inelastic design can be greatly influenced by structural contacts. In a paper published in 2022, Ahmeteugreul Toy et al. proposed a 3D nonlinear finite element model to analyze how reinforced concrete structures will react to blast loading under various TNT mass, statistical system, and reinforcement ratio variations.

II. BEHAVIOUR OF BLAST LOADING

The concepts of fluid dynamics and thermodynamics control the complicated behavior of blast waves. An explosion's abrupt energy release causes a shockwave to develop quickly and spread outward from the point of detonation. This shockwave consists of a leading shock front and a blast wave, which is a zone of high pressure gas. The behavior of a blast wave is defined by many essential features:

1. Shock Front :- The blast wave's leading edge, or shock front, is where a sudden spike in pressure happens. As it travels at supersonic speeds away from the explosion's source, the surrounding air is compressed, suddenly increasing pressure.
2. Overpressure :- Overpressure, also called peak pressure, is the most pressure the blast wave may apply to nearby objects and structures. Usually, it is measured in relation to atmospheric pressure, which is represented in kilopascals (kPa) or pounds per square inch (psi). The amount of overpressure that damages human bodies and structures depends on its severity.
3. Positive Phase :- As the shockwave goes through, there is a sharp rise in pressure that indicates the positive phase of the blast wave. Direct structural damage, such as structural deformation, displacement, and fragmentation, can result from this phase.
4. Negative Phase :- There is a negative phase that comes after the positive phase, when the pressure falls below atmospheric levels. During this stage, objects and debris may be drawn back towards the explosion's source by suction forces that may be created. By putting additional dynamic loads on the structure, it can potentially contribute to structural collapse.

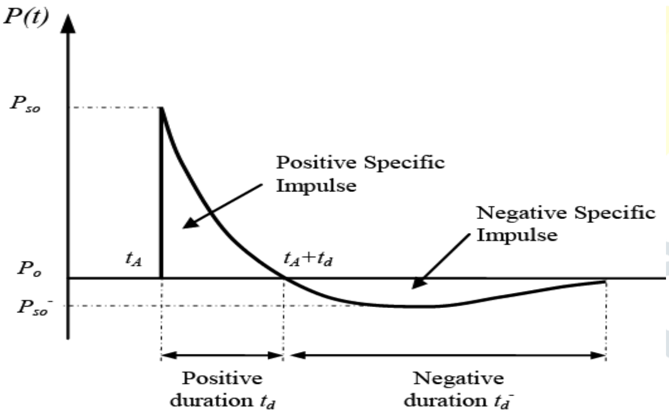

Fig. 1:- Propagation of blast wave

5. Duration :- The length of the blast wave, which is frequently expressed in milliseconds, affects how much damage and structural response there is. While longer-duration explosives can induce progressive failure and collapse over a greater region, shorter-duration blasts may only cause localized damage.
6. Reflection and Refraction :- Blast waves cause reflection and refraction when they interact with their surroundings. When a blast wave comes into contact with a surface, it reflects, which makes it bounce back and spread out in different directions.

III. METHODOLOGY

3.1 Pushover Analysis

A building that is expected to deform inelastically can have its displacement demand determined using pushover analysis, a streamlined analysis method. The connection between Roof displacement (Δ) and base shear (Vb) are developed. Pushover analysis, a technique for gathering data from structural response under monotonic loading, is employed in this study to assess the regular structure's seismic damage. A high-rise concrete observation structure's damage is evaluated using an accumulative dissipated. At the ultimate displacement one the damage scale returns to normal. The total energy degraded during the pushover analysis is divided by the ratio of the energy dissipated up to that displacement, excluding the energy lost as a result of the yield displacement, to determine the damage scale at any given displacement.

energy function. The damage state of the structure is ascertained at any displacement using the capacity curve. To show the extent of the structure's damage at each displacement, a damage scale is proposed.

3.2 Time History Analysis

The real three-dimensional building is converted into a one-dimensional elasto-plastic stick system because it is very challenging to think of a non-linear, inelastic building in three dimensions. This offers the story-wise hysteresis plot and the time history displacement plot with remarkable ease. This could be used in the damage index computation in Excel format. Modiϐied Park and Ang model represented by the equation 1 is used to get the structural damage index for four ground motions. D = Xm−Xy+ β ∫dE ……..(1)
Xu−Xy QyXu

The following are the parameters in the damage model: The damage should be calculated based on the total cumulative energy dissipated in the hysteresis, which is represented by dE. Qy is the configuration's yield strength that corresponds to the yield displacement; Xy is the yield displacement of the structure; Xm is the maximum displacement of each cycle of the hysteresis; The ultimate displacement of the structure under monotonic loading is denoted by Xu. The value of β is contingent upon the characteristics of the earthquakes; in this study, 0.4 is the value assigned to it,

an acceptable marginal error of 2.02%. Thus, SAAP2000NL software is used for the project's ongoing work.

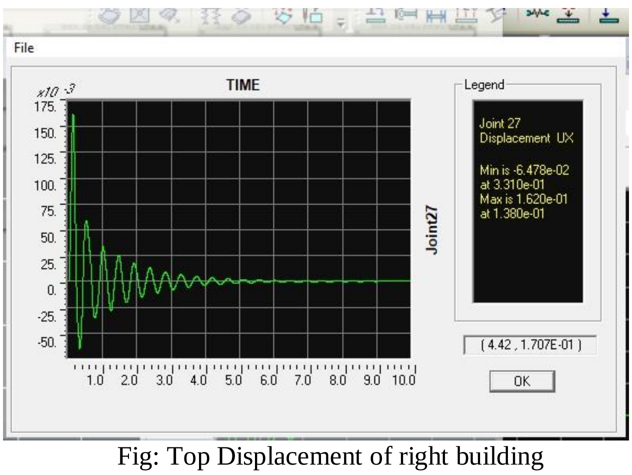

Fig: Top Displacement of right building

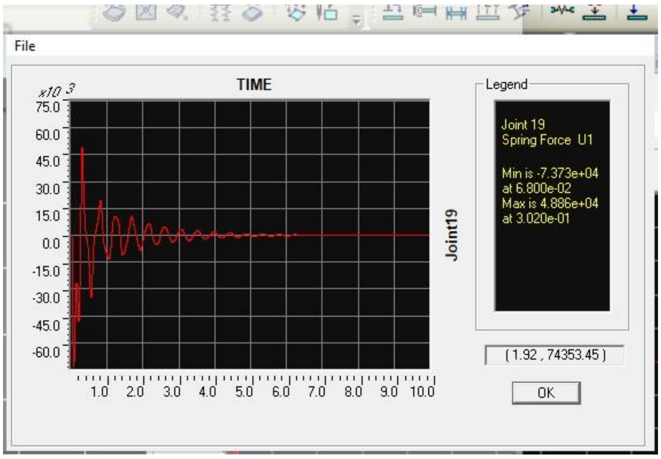

Fig 2: Base Shear of right building

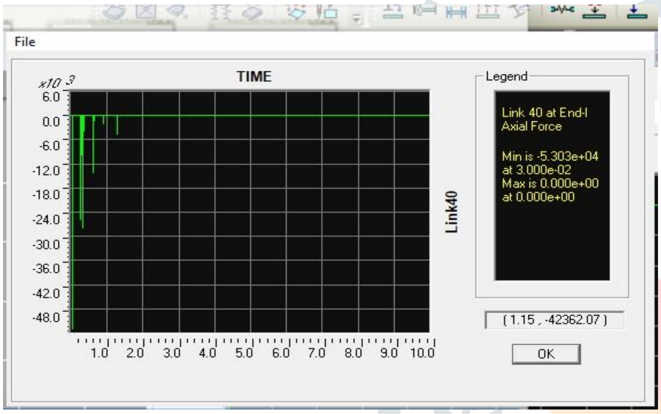

Fig : Pounding of right building

IV. CONCLUSIONS

1] The findings from the buildings that were subjected to blast loads with various standoff distances and charge weights show that base shear pounding and top displacement are less common when the blast source point is located far from the building's front face.

2] The building responds more in terms of displacement and pounding when the standoff distance and blast charge weight are lower. Consequently, the answer can be stated as having an inverse relationship with the standoff distance and charge weight.

3] The safe standoff distance between a building and a blast is defined as the distance at which the building will be least affected.

4] The installation of tuned mass dampers at the top of the left building reduces storey displacement and drift by 49.43% when compared to bare frame buildings.

5] Compared to bare frame buildings, storey displacement is reduced by 23% by installing steel mass dampers at the bottom periphery of the building.

6] Consequently, the installation of steel bracings and tuned mass dampers makes the building more resistant to blast loads.

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