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Behavior of RCC Structural Members for Blast Analysis: A Review

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ABSTRACT
In today's scenario threat of enemies and terrorist attack is increasing. Therefore consideration of blast load in analysis and design is essential. A bomb explosion within or nearby outside the building can cause catastrophic failure of building. Blast loads have, in the recent past, become important service loads for certain categories of structure. An important task in blast resistance design is to make a realistic prediction of blast pressure. The distance of explosion from the structure is an important datum, governing the magnitude and duration of blast loads. In the present study, the RCC frame was analyzed by using conventional code for gravity loads using moment resisting frame. The blast load was calculated using UFC-340-02 (2008) or IS 4991-1968 for 500 kg and 100 Kg TNT at standoff distance of 10m and 30m from face of column at first floor level. The triangular impulse was applied as nodal time history at all front face joints. The analysis was performed using Computer aided software. The response of structure of will be evaluated under various blast scenarios. The response will be checked for safety of the structure on many parameters like displacement, acceleration and velocity.

Keywords: Blast Load on Structure, Blast Phenomena, Blast Pressure, Structural Performance.

I. INTRODUCTION

Blast is a pressure disturbance caused by the sudden release of energy. People often think of blasts in terms of explosions such as the detonation of an explosive charge. However, there are many other blast sources that have the potential to cause damage. Blasts are not always caused by combustion; they can also result from any rapid release of energy that creates a blast wave, such as a bursting pressure vessel from which compressed air expands, or a rapid phase transition of a liquid to a gas. As the shock or pressure wave strikes a wall or other object, a reflection occurs, increasing the applied pressure on the surface. This reflected pressure is considerably higher than the incident or free-field pressure wave. As the stand-off distance increases, the duration of the positive-phase blast wave increases resulting in a lower-amplitude. Charges situated extremely close to a targeted structure impose a highly impulsive, high intensity pressure load over a localized region of the structure.

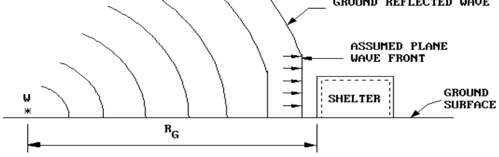

Fig.1 Surface Burst Blast Waves.

II. PRESENT STUDIES

Following are researchers, who have worked on Blast analysis by using Computer aided software.

Due to the threat from such extreme loading conditions, efforts have been made during the past three decades to develop methods of structural analysis and design to resist blast loads. The analysis and design of structures subjected to blast loads require a detailed understanding of blast phenomena and the dynamic response of various structural elements. A comprehensive overview of the effects of explosion on structures. An explanation of the nature of explosions and the mechanism of blast waves in free air is given. This paper also introduces different methods to estimate blast loads and structural response [1]. The analysis of the structural failure of building caused by a blast load. All the process from the detonation of the explosive charge to the complete demolition, including the propagation of the blast wave and its interaction with the structure is reproduced. The problem analyzed corresponds to an actual building that has suffered a terrorist attack. The paper includes comparisons with photographs of the real damage produced by the explosive charge that validates all the simulation procedure. The collapse was due to a gravitational mechanism originated by the destruction of the lower columns [2].

Analyze the real behavior of steel structure which subjected to blast loads with different charge weights at the same building situation. The blast load was determined as a pressure-time history. the industrial structure analyzed subjected blast load the structure is steel structure having Bomb explosion at standoff distance 4.5 m for charge of 10 kg , 50 kg and 100 kg charge [3].

The nonlinear analysis of a structural steel frame subjected to blast loads. The analysis involves the use of a beam and hinge model similar to what can be used for a nonlinear seismic design. For simple steel frames in typical petrochemical plant applications, the use of a nonlinear hinge model provides a reasonable level of accuracy [4].

Blast resistance design of Commercial buildings. For many urban settings the proximity to unregulated traffic brings the terrorist threat to or within the perimeter of building. For these structures blast protection has the more modest goal of containing damage in the immediate vicinity of the explosion and the prevention of progressive collapse. This paper considers the design features of a typical 8 story office. Conclusions are made after analyzing after structural features of the building and recommendations is given for each structural member such as beam, column, and slab [5].

This paper has shown Blast loading on structures. The paper describes the process of determining the blast load on structures and provides a numerical example of a fictive structure exposed to this load. The blast load was analytically determined as a pressure-time history and numerical model of the structure was created in SAP2000. The results confirm the initial assumption that it is possible with conventional software to simulate an explosion effects and give a preliminary assessment of the structure. And conclusion is made the explosion in or near the structure can cause catastrophic damage to the structure, formation of fragments, and destruction of life - support systems [6].

Finite element package Staadpro is used to perform the analysis In order to validate the use Staadpro for blast analysis following experiment is performed. a study of distant blast on the structure is made to find the variation of forces in foundation like axial force, shear force and bending moment by varying amount of explosive and also by varying the distance of explosion from the building. Buildings of various heights are analyzed so that effect of height to resist blast is also studied. Load is applied in the form of time history loading. And conclusion is made building having more than 6 floors there is less probability of overturning and crushing failure, however great care need to be taken to resist shear force and bending moment [7].

In design procedures, both types of collapse should be taken into consideration. In order to face such a complex problem, it is essential to determine the key parameters in blast load response. For this reason, a sensitivity analysis was developed. Numerical simulations by means of the previous SDOF model have been developed, considering different load scenarios and beam geometrical and strength characteristics. In this way, it is possible to search for any correlations between the response of the SDOF in terms of the different parameters defining the dynamic problem: peak load, span length, etc. [8].

Low - energy pyrotechnic explosive loading on brick masonry structures and the influence of various structural members in resisting the collapse. Different openings and incorporation of lintel and plinth beam are dealt in this study. The static response of brick masonry in the event of accidental explosion is analyzed using the model proposed by ANSYS software. Analytical studies were conducted using ANSYS to study the deflection behavior of structure. It was observed that, by providing additional structural elements, the resistance of brick masonry against accidental overloading can be improved considerably so that progressive collapse of the entire structure can be avoided. This paper concludes that an alternate construction material is to be considered for the construction of fireworks and match works industrial buildings, which can perform satisfactorily than conventional brick masonry [9].

Blast response mitigation strategies become either difficult or impossible later on. Blast response mitigation strategies can be incorporated in the structural design at concept stage, leading to a well-designed and -constructed structure that can exhibit improved blast resistance and at the same time maintain its architecturally appealing appearance.

Apart from describing functioning of the commonly adopted measures, emphasis has been laid on the mechanics of the sacrificial blast wall and design using various materials used for its construction [10].

Slurry Infiltrated Fiber Reinforced Concrete (SIFCON), a type of FRC with high fiber content as an alternative material to Reinforced Cement Concrete (RCC). SIFCON has high energy absorption capacity, higher strength and it is highly ductile. Space framed models are developed and time history analysis is carried out for blast load using the software .The properties of SIFCON and RCC are derived from the experiments. The dynamic characteristics such as fundamental frequency, mode shapes are evaluated. The displacement time history response of frames with SIFCON and RCC due to blast load is compared. The results showed that the reduction in the displacement of about 25-30 % is Achieved using SIFCON [11].

Investigate some of the special aspects of the response of steel structures to blast loading. Composite and light steel constructions are investigated and simplified examples. The needs for special design and construction considerations, as well as additional research studies are concluded [12].

Carried out the effects of blast loads on multistory steel buildings. The results obtained are targeted towards improving the design of buildings such as hospitals and defense offices which must maintain some level of serviceable operations in the event of an explosive attack. A dynamic load model for blast effects is developed and used to assess the performance of several multistory steel buildings designed for current code prescribed seismic loads, using parametric dynamic analysis [13].

Local failure of a primary structural component induced by direct air-blast loading may be itself a critical damage and lead to the partial or full collapse of the building. As an extensive research to mitigate blast-induced hazards in steel frame structure, a state-of-art analytical approach or high fidelity computational nonlinear continuum modeling using computational fluid dynamics was described in this paper [14].

H-shaped steel frame column under a blast loading with different conditions was numerically developed, using finite element method (FEM) The two ends of the column were fixed and applied with a vertical load to simulate the responses of a bottom column of a steel frame structure under a blast loading by changing stand-off and the weight of the explosive, and the height of the column [15].

In progressive collapse capacity of steel moment frames using alternate load path method. Nonlinear dynamic analyses were performed for progressive collapse assessment. Linear dynamic analysis method was used for comparison. Then, a nonlinear dynamic analysis was carried out to examine the response of the frames in external blast and sudden column loss scenario [16].

Numerical analysis of an industrial structure, subjected to blast load. The results are compared for severity, and the remedial measures shall be discussed. By adopting the remedial measures, the analysis shall be performed again and the effects will be compared with the earlier results of a normal structure [17].

Blast loads are applied on the structure in the form of time history loading. Finite element package Staadpro is used to perform the analysis in this work. In order to validate the use staadpro for blast analysis following experiment is performed. In present work a study of distant blast on the structure is made to find the variation of forces in foundation like axial force, shear force and bending moment by varying amount of explosive and also by varying the distance of explosion from the building. Buildings of various heights are analyzed so that effect of height to resist blast is also studied. Load is applied in the form of time history loading [18]. Methods for assessing the effect of explosive action on buildings and sensitivity analysis was developed in design procedures, both types of collapse should be taken into consideration. In this work, the Authors investigate the resistance of flexural elements under blast load, focusing only on local failure in bridge structure [19]. The response of steel frame building subjected to blast loading was examined by calculating blast load manually using a procedure and applying on joints. Response of steel column subjected to amount of pressure exerted by different charge weights and at different standoff distance and progressive energy collapse of steel column is examined using Ansys Explicit dynamic and Ansys Autodyn [20].

Investigation of behavior of various bridge components during blast loads through a high fidelity finite element model of a typical highway bridge Computer programs, such as LS-DYNA offer detonation simulation capabilities to propagate blast loads through air medium. However, blast pressures generated by such programs are significantly different than those by ConWep, a computer program based on semi-empirical equations [21].

Bridges in America are of special importance. The analysis of these bridges should be carried out for different loading conditions. Bridges are normally designed for dead load, live load and other occasional loads. American Association of State Highways and Transportation Officials (AASHTO) have specified for the ship impact, seismic vulnerability and also against vehicular collisions. But there are no definite structural design criteria for the bridges under typical blast loadings. The “progressive collapse” approach of the bridge was also carried out to know the exact behavior with the formation of the plastic hinges under the impact of blast loadings [22].

The application of blast loads on bridge components has been presented. This approach can apply realistic loads and can simulate both reflection and diffraction of blast loads. Using this approach, verification of simulation of blast loads in LS-DYNA has been carried out by using available blast tests on two types of beams. A high fidelity model of a typical three-span highway bridge has been developed for investigation of blast load effects on a three-span reinforced concrete bridge. It is observed that the range of demands imposed on bridge components during blast loads may be significantly higher than those during other extreme hazards [23]. Analysis of highway bridges under blast loads requires accurate generation and application of blast loads and good understanding of the behavior of components of bridge. The purpose of this paper is to introduce some ideas about blast load generation method like pressure wave method, detonation simulation method, hybrid blast load method and multi-Euler domain method. Also verification of blast load results using hybrid blast load method and multi-Euler domain method included in this paper [24].

Analytically investigate the blast-response and behavior of multihazard-resistant bridge piers having circular- shaped, concrete-filled steel tube (CFST) columns. Fiber-based dynamic analyses showed that high-frequency modes of vibration have some influence on the structural response when subjected to blast loading. This study shows that different values of the shape factors, β (which reduces blast pressures when applied to a circular column), must be used with different analytical methods, along with assumptions and conditions behind these different analytical methods [25]. Effects of blast loads on bridge substructures are presented, and structural design and retrofit solutions to counter these effects are discussed. Case studies demonstrate the use of simple models to analyze concrete piers. The modeling concept, determination of peak overpressures, and inherent assumptions are described, and empirical deformation-based damage criteria that are used to estimate the level of damage are presented [26]. Nonlinear dynamic numerical modeling and analysis of concrete panels subjected to blast loads is presented. Reinforced concrete panels of dimension 1.0 1.0 m and different thicknesses and supported on four sides are subjected to blast loads produced by the detonation of high explosive charges. The modeling and analysis was conducted using ANSYS AUTODYN solver. The accuracy of the model is verified against experimental results of blast load tests on reinforced concrete horizontal slabs subjected to the detonation of high explosive charges above them. The model was capable of simulating the observed damage and displacement with reasonable accuracy. The performance was evaluated in terms of maximum displacement, extent of damage and energy absorbed [27].

The numerical simulation of the structural damage of a steel truss bridge subjected to blast loading with the aid of a hydro code is presented. A three-dimensional nonlinear finite element model of an actual bridge has been developed based on the drawing design of the Minpu II Bridge in Shanghai. The effects of mesh size on pressure distribution produced by explosions are also studied. Through the comparison between the calculation results and the experimental values, the reliability of the calculation is validated. All the process from the detonation of the explosive charge to deck crack, including the propagation of the blast wave and its interaction with the structure is reproduced. The numerical results show the damage of bridge parts and provide a global understanding of bridge under blast loads [28]. The dynamic response of vertical wall structures under blast loading. Blast loading is simulated by the form of dynamic excitation in time based on some assumptions to assure physical nature of dynamic problems. The vertical wall structure is modeled by plates restrained in an edge and fixed in four edges is surveyed both linear and nonlinear response under explosion. The nonlinear dynamic analysis is considered with cracked behavior of the plate. The governing equation of motion of the structure is established by Finite Element Method with quadrilateral 4 nodes elements and integrated by constant acceleration method of Newmark's family. BLAST SHELL program which analyzed the behavior of shell under blast loading is built on MATLAB software [29].

The main advantage of performance based design is the predictable seismic performance with uniform risk. The reliability of this approach may ultimately depends on the development of explicit and quantifiable performance criteria that can be related to the calculated response parameters such as stress, strain, displacement, acceleration [30]. Performance of a building with soft story at different level along with at GL using nonlinear static pushover analysis. From analysis they found that plastic hinges are developed in columns of ground level soft story which is not acceptable criteria for safe design. They suggested retrofitting with shear wall for safe performance of building. They also found that after retrofitting the base shear carrying capacity is increased by 19.22 % to 34.64% [31].

In flat slab building slab is directly supported on column without provision of beam. Because of absence of beam lateral stiffness of building get reduced. For better performance of flat slab building against lateral loading elements like shear wall can be constructed [32].

III. CONCLUSION

Based on the studies so far carried out by several researchers following conclusions can be drawn.

1) Blast load varies with time and distance. The behavior of structure greatly depends on charge of explosive and its standoff distance.

2) Due to sudden released explosive energy causes failure of structure such as collapse the structure, damage of structural elements and crack formation in structure.

3) Blast analysis needs to carry out by keeping in

view the terrorist activities in today's scenario for the important structure.

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