Review on Transient Effects of Blast Loads on Framed Structures

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Abstract— Need for analyzing certain important structures to resist blast load is gaining importance day by day due to increase in terrorist activities from the recent years. The level of damage produced in a structure depends on charge weight, a distance of building from point of explosion. The present study is concerned with the review of study on transient loading and its effects on RCC framed structures. The parameters like nodal velocities, nodal accelerations were studied.

Key words: Blast Loads, Time History Analysis, Blast Phenomena, Standoff Distance, Charge Weight/TNT

I. INTRODUCTION

The possibility of reinforced concrete structures getting exposed to blast loading due to intentional or accidental explosions has notably increased in recent years. Due to increase in accidental and intentional explosions, medium to high rise buildings can be exposed to those types of blast pressures. The provisions to consider for blast loading for structures are not yet well established as the blast event are often extreme events and it is challenging to quantify design parameters to be included in design for blast loading. The effect of blast load is significantly different from other typical dynamic loads due to its large magnitude and short duration. The speed with which a blast load is applied exceeds the loading rate of an earthquake by several orders of magnitude. Blast pressure may exceed hundreds and even thousands of kilo newtons per square meter, but may last only a hundredth or even a thousandth of a second. The guidelines for the blast loading are published in Indian code IS 4991-1968.

The blast effects are presented by a wave of high intensity that spreads outward from the source to the surrounding air. As the wave propagates, it decreases in strength and speed. The maximum pressure experienced by the structure subjected to blast loads depends on the scaled distance which is the function of distance of the structure from the center of spherical charge and charge mass as a factor of TNT.

Special importance has been given to the blast loads on landmark structures, such as high-rise buildings in metropolitan cities; the explosion of explosives (Bombs, TNT, etc.,) inside and around buildings can cause impacts on the structural integrity of the building components, such as damage to the external and internal structural frames and collapse of walls. Moreover, loss of life can result from the collapse of structure.

II. METHODOLOGY

The software application of modern analysis problems reduce the work of Structural engineers to go by manual methods.

The basic steps involved in Time History Analysis of a RC structure

1) Develop the frame of the building and give support, properties of beams and columns.
2) Define the Time History Loads in definitions.
3) Apply the time history loads for different beam-column joints on the front face of the building frame which is opposing to blast.
4) Apply loads as per IS codes (dead load, live load, time history load)
5) Analyse the nodal displacements, velocity with variation of time, nodal acceleration, maximum shear force, axial force and bending moment of beams.
6) Analyse the time history graphs and verify the results.

III. LITERATURES REVIEWED

Suraj D Bhosale et al. 2016 studied on Dynamic Analysis of RCC Frame Structure subjected to Blast Loading without infilled wall in Multi Storey Building. The study includes the Six Storey RCC frame for a charge weight of 100 kg TNT and 30m standoff distance. Blast loads are calculated manually as per IS 4991-1968. The peak pressure is developed when the blast wave strike the surface of the building which is perpendicular to the direction of propagation of wave and the pressures obtained in Table 1 of IS 4991-1968 are converted into force by multiplying with area contributing to beam column joint acting on the front face of the building which are applied using force time history in STAAD Pro which lasts for a very few milliseconds and maximum nodal displacements, velocity, acceleration, maximum shear force, axial force and bending moment of beams and exterior columns are studied.

Rishabh Joshi 2016 studied on Transient Effect of Blast loads on RCC Building. The study includes the RCC frame of length & width of 6m and height 3.1m. Initially efforts has been made to determine the effect of 1000 kg C4 explosive material; as an equivalent weight TNT on different surfaces of a building model at a standoff distance of 22.5m. Further attempts has been made to determine the effect of distance of blast for same explosive material on building surfaces at stand off distances of 10m, 18.5m, 22.5m and 27m. The effect of different explosives i.e., TNT, C4, RDX and PETN on building surfaces at constant standoff distances of 22.5mhas also been determined and maximum nodal displacements are studied.

Deepthi Shree S. Aithal et al 2017 studied on Parametric Study of Multi Storey Building for Blast Load. The study includes the Unsymmetrical Building without shear wall, with shear wall without opening, with shear wall with openings for a charge weight of 0.04 Tons or 40 kg and standoff distance of 30m. Blast loads are calculated manually using the IS 4991-1968 and the pressures obtained are converted to force by multiplying it with its contributing area and applied on the front face of building which are

applied using force time history analysis in STAAD Pro and maximum storey displacement and storey drift are studied for without shear wall, with shear wall without openings, with shear wall with openings for an Unsymmetrical building.

M. Meghanadh et al 2017 studied on Blast Analysis and Blast Resistant Design of RCC Residential Building. The study includes a G+5 Residential Building frame for a charge weight of 100 kg TNT and 40m standoff distance. Blast loads are calculated manually as per IS 4991-1968. The peak pressure is developed when the blast wave strike the surface of the building which is perpendicular to the direction of propagation of wave and the pressures obtained in Table 1 of IS 4991-1968 are converted into force by multiplying with area contributing to beam column joint acting on the front face of the building which are applied using force time history in STAAD Pro which lasts for a very few milliseconds and Maximum Nodal Displacements and Velocity with variation of Time are studied.

Zubair I. Syed et al 2016 studied on Performance of a Earthquake- Resistant RCC Frame Structures under Blast Explosions. The study includes a Sky Scrapper. Structures were exposed and was investigated under different blast scenarios by varying scaled distances and explosion charge weights to study the structural response. The blast load parameters are calculated using UFC 3-340-2 manual and shear-force, maximum moment are studied using ETABS 2015.This research is to identify structural response and safe standoff distance required for an earthquake resistant building to avoid failure of column exposed to blast loading.

Jiji Madonna et al 2016 studied on Analysis of High Rise Building subjected to Blast load. The study includes a Sky Scrapper. This study was concerned with analysis of blast loading considering the variations in charge weight and standoff distances. In this both regular and irregular buildings are analyzed. Blast parameters are calculated using TM 5-1300 manual using AT Blast Software. For regular building a charge weight of 700 lbs and 1400 lbs for a different stand-off distances of 5m, 10m and same for irregular building and Joint acceleration, storey drifts, storey shear and storey displacements are studied using ETABS 2015.

K. Swathi Ratna et al 2016 studied on Analysis of RCC and SIMCON Buildings subjected to Blast Effects. The study includes a 15 Storey building. Both Reinforced cement concrete and Slurry infiltrated Mat Concrete(SIMCON) high rise buildings were subjected to blast effects and their fundamental frequencies were determined. Slurry infiltrated Mat Concrete is well suited for novel repair, retrofit and new construction solutions that lead to economical and improve the structural performance of the concrete structures. Blast parameters are calculated using IS 4991-1968. Time History Analysis was carried out in ETABS software to find out the effect of Buildings subjected to Blast loads and to study the behavior of both RCC and SIMCON buildings.

Quazi Kashif et al 2014 studied on Effect of Blasts on G+4 Reinforced cement concrete framed Structure. The study includes the effect of blast loading on a five storey RCC building. Effect of variable blast source weight is calculated by considering 30m distance from point of explosion. The magnitude and pressure time history of of the blast load is calculated using the Table 1 given in IS 4991-1968 and numerical model of the structure was created in SAP 2000. For a constant standoff distance of 30m and for a variable charge weight of 100 kg and 500 kg TNT is considered. The influence of the lateral load response due to blast in terms of Peak deflections, velocity, acceleration, inter storey drifts is calculated and compared.

B. Patil Vijay et al 2016 studied on Effect of Blast Load on Soft Storey Building. The study includes a fictive structure subjected to blast load. Effect of variable blast source weight for 100kg, 200kg, 300 kg, 400kg, 500kg TNT is calculated for 30m standoff distance. The blast loads are calculated using IS 4991-1968. Blast loads are applied on the structure in the form of time history loading and numerical model was created in SAP 2000 for Bay Frame and Soft Storey Building. The result shows that due to infill there is significant reduction in displacement, velocity and acceleration. The influence of blast load in terms of Peak Deflection, Velocity and Acceleration is determined and compared for buildings without in fill wall and building with soft storey and results are compared.

S.M. Jayashree et al 2013 studied on Dynamic Response of space framed Structure subjected to Blast Load. The study includes an attempt made to use SIFCON- Slurry Infiltrated Fiber Reinforced Concrete a type of FRC with high fiber content as an alternative material to RCC-Reinforced Cement Concrete. Slurry infiltrated fiber reinforced concrete has high energy absorption capacity, higher capacity, higher strength and it is highly ductile. Different frame models were developed and time history analysis is carried out for blast load using the software package SAP 2000. The displacements time history response of frames with SIFCON and RCC due to blast load is compared

Choachen Zhai et al 2016 studied on Experimental and numerical investigation into RC beams subjected to blast after exposure to fire. The study includes a performance of RC structures subjected to blast loadings after fire exposure, a series of model tests on RC beams were carried out. The beams were firstly fired on three surfaces following the temperature time history suggested by ISO 384 in a furnace and blast tests were then performed by a developed blast test set up. An Finite element model was developed to further study the dynamic response of the RC beams after numerical simulation of exposure to fire by software ABAQUS. The developed numerical method was validated against the test data. Experimental and numerical results showed that more and more cracks emerged at the mid span zone of the beam under blast loadings as the fire duration increased, and the peak residual displacements of RC beam increased nearly linearly with the fire duration. RC beams after fire exposure suffered greater blast- induced damage than those were not exposed to fire.

Sarita Singla et al 2015 studied on Computation of Blast loading for a Multi Storeyed Framed Building. The study includes a Three Storeyed framed building. Effect of variable blast source weight is calculated for a variying standoff distances adopting wave scaling laws given by U.S. Army technical manual (UFC 3-340-02). Blast pressures are computed using correlation between blast pressure and scaled distance based on charts given in U.S. Manual. Time

history loading is also obtained with parameters of peak reflected over pressure and positive phase duration of blast.

Zeynep Koccaz et al 2008 studied on Architectural and Structural Design for Blast Resistant Buildings. The study includes the enhancement of building security against the effects of explosives in both architectural and structural design process and the design techniques that should be carried out. To have a better understanding of explosives and characteristics of explosions which will enable us to make blast resistant building design much more efficiently. Essential techniques were followed to increase the structural integrity of a building exposed to explosive effects is discussed both with architectural and structural approach.

Amol B. Unde et al 2013 studied on Blast Analysis of Structures. The study includes and made to understand the properties of blast wave by estimating the blast wave parameters for various charge amounts placed at various distances. The Effect of TNT explosive on a column foundation for various amount of TNT charge at various distances is investigated for model buildings of various floors and presented in this paper. The blast parameters are calculated using IS 4991-1968 using the finite element package STAAD Pro.

A.V. Kulakarni et al 2014 studied on Analysis of Blast Loading Effect on High Rise Buildings. The study includes a 30 storey high rise reinforced concrete structure. The fundamentals of blast hazards and the interaction of blast wave with structures are examined in this study, it is about the lateral stability of a high rise building modelled using SAP 2000. The modelled building was subjected to two different charge weights of 800 lbs and 1600 lbs TNT at a two different standoff-distances of 5m and 10m. The blast loads are calculated using the methods outlined in section 5 of TM 5-1300 and a non-linear modal analysis is used for the analysis of the dynamic load of the blast. The parameters like total drift and the inter- storey drift.

IV. CONCLUSIONS

The explosions near the structure can cause catastrophic damage, hence these loads should be considered in analysis. It is not economical to design all buildings for blast loading. On the basis of present study, the following conclusions may be drawn.

1) Blast wave takes millisecond to reach the building from the side of explosion and affect the building.
2) Maximum Nodal Velocity is time dependent, which increases linearly. At one storey it reduces gradually and increases linearly, which indicates that blast profile was applied onto the building.
3) Maximum Nodal Acceleration is time dependent, which increases linearly. At one storey it reduces gradually which indicates that blast profile was applied onto the building.
4) The maximum deformations were obtained on the front face of the structure. For close range explosions displacements on the front face are critical but as the distance from the structure increases displacements on front face are reduced for the building model.
5) It is observed that with increase in distance there is significant decrease in the deformations in the building. Therefore for close range explosions additional reinforcement is needed, while for distant explosions conventional reinforcement provides sufficient ductility.

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