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Performance of Various Structural Parameters of Buildings under the Composite Action of Blast Load and Earthquake

Natish M. Sayyed[1], Amey R. Khedikar[2]

[1]Student, Tulsiramji Gaikwad-Patil College of Engineering and Technology, Nagpur , India
[2] Asst. Professor Civil Engineering Department, Tulsiramji Gaikwad-Patil College of Engineering and Technology, Nagpur, India

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Abstract - *A bomb explosion within or immediately nearby a building can cause catastrophic damage on the building's external and internal structural frames, collapsing of walls, blowing out of large expanses of windows, and shutting down of critical life-safety systems. Loss of life andinjuries to occupants can result from many causes, including direct blast-effects, structural collapse, debris impact, fire, and smoke. The indirect effects can combine to inhibit or prevent timely evacuation, thereby contributing to additional casualties. In addition, major catastrophes resulting from gas-chemical explosions result in large dynamic loads, greater than the original design loads, of many structures. 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. Studies were conducted on the behavior of structural concrete subjected to blast loads. These studies gradually enhanced the understanding of the role that structural details play in affecting the behavior. 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. This gives a comprehensive overview of the effects of explosion on structures. The objective of this paper is to show that we can analyses the blast loading analytically as well as on software too. Nowadays, there are various terrorist attacks happened in our country and therefore for the security the structure we should design our structure by considering blast load. Security of structure against the effects of blast in both architectural and structural design process. This paper also introduces different methods to estimate blast loads and structural response.*

Key Words: Earthquake, Blast Loading , E-Tab , Time history data, Analytical Method,

1. INTRODUCTION

Earthquakes are most unpredictable and devastating of all-natural disasters. Earthquakes have the potential for causing the greatest damages among all the natural hazards. Since earthquake forces are random in nature and unpredictable. They not only cause great destruction in human casualties, but also have a tremendous economic impact on the affected area. The concern about seismic hazards has led to an increasing awareness and demand for structure designed to withstand seismic forces. When a structure is subjected to ground motions in an earthquake, it responds by vibrating. Those ground motion causes the structure to vibrate or shake in all three directions; the predominant direction of shaking is horizontal. During an earthquake, the damage in a structure generally initiates at location of the structural weakness present in the building systems.

In the past few decades considerable emphasis has been given to problems of blast and earthquake. The earthquake problem is rather old, but most of the knowledge on this subject has been accumulated during the past fifty years. The terrorist activities and threats have become a growing problem all over the world and protection of the citizens against terrorist acts involves prediction, prevention and mitigation of such events. In the case of structures an effective mitigation may also be thought in the terms of structural resistance and physical integrity. If the structures are properly designed for these abnormal loads damage can be contained. Additionally, in order to ensure safety of existing structures against such events, an evaluation procedure for their inspection and eventual retrofit is needed. On the other hand, this topic is the interesting one in military circles and important data derived from the experience and tests have been restricted to army use. Nevertheless, a number of publications are available in the public domain and published by the US agencies. Analysis of structures under blast load requires a good understanding of the blast phenomenon and a dynamic response of structural elements. capabilities. It is shown that, with the present knowledge and common software, it is possible to perform the analysis of structures exposed to blast loads and to evaluate their response. Disasters such as the terrorist bombings of the U.S. embassies in Nairobi, Kenya and Dar es Salaam, Tanzania in 1998, the Khobar Towers military barracks in Dhahran, Saudi Arabia in 1996, the Murrah Federal Building in Oklahoma City in 1995, and the World Trade Center in New York in 1993 have demonstrated the need for a thorough examination of the behavior of columns subjected to blast loads. To provide adequate protection against explosions, the design and construction of public buildings are receiving renewed attention of structural engineers. Difficulties that arise with the complexity of the problem, which involves time dependent finite deformations, high strain rates, and non-linear inelastic material behavior, have motivated various assumptions and approximations to simplify the models.

1.1 Objectives

- To study the Etabs software for easy analysis of blast load and to design the blast or Earthquake resistant structures.
- To Study the Blast Load and its impact on various Parameters of Structures.
- To study the dynamic response of various structural elements like column, beam, slab and connections in steel and RCC structures.
- To analyse and design the structures against the abnormal loading conditions like blast loads, strong wind pressure etc. requiring detailed understanding of blast phenomenon.

1.2 Problem Statement

To understand and to minimise the effect of blast loading on structures. The key elements are the loads produced from explosive sources, how they interact with structures and the way structures respond to them. Explosive sources include gas, high explosives, dust and nuclear materials. To minimize the structural damage and causes due to earthquake and blast loadings for this it is important to gather the available literature review on explosives, blast phenomena, blast wave interaction and the response of structures to blast loads.

2. Literature Review

C. V. R. Murty,Rupen Goswami ,Gujarat State Disaster Management Authority, Book on Some Concepts in Earthquake Behaviour of Buildings.

This book explains concepts in behavior of buildings during earthquakes. The book dwells on basic concepts in earthquake resistant design of buildings, first describes these at a conceptual level and then articulates further with numerical examples. It is an attempt to respond to some of the frequently asked questions by Architects and Structural Engineers regarding behaviour of Reinforced Concrete (RC) and Steel buildings under the action of lateral loads, especially during earthquakes. Since most buildings built in India are made of RC, the dominant set of examples used is of RC buildings. But, with no loss of generality, the broad concepts discussed in this document are valid for both RC and Steel buildings. Also, the discussion is limited to normal

buildings without any special devices, like base isolation and other energy absorbing or dissipating devices. Also, specialised systems (like post-tensioning slab systems and nuclear power plants) are not in focus. This book employs exaggerated deformation shapes to emphasise deformations, and thereby, to develop the most needed intuition of structural behaviour of buildings during earthquakes and its consequences on earthquake-resistant design.It explains In summary, the loading imposed by earthquake shaking under the building is of displacement-type and that by wind and all other hazards is of force-type. Earthquake shaking requires buildings to be capable of resisting certain relative displacement within it due to the imposed displacement at its base, while wind and other hazards require buildings to resist certain level of force applied on it While it is possible to estimate with precision the maximum force that can be imposed on a building, the maximum displacement imposed under the building is not as precisely known. For the same maximum displacement to be sustained by a building wind design requires only elastic behaviour in the entire range of displacement, but in earthquake design there are two options, namely design the building to remain elastic or to undergo inelastic behaviour. The latter option is adopted in normal buildings, and the former in special buildings, like critical buildings of nuclear power plants. Only a select set of the concepts of earthquake behaviour is discussed in this book. This is not an exhaustive list of all concepts relevant to earthquake behaviour, analysis and design. Also,many of these concepts are interrelated; the book does not attempt to discuss these interrelationships. It is hoped that the discussions presented in this book will help architects and engineers undertake seismic design of buildings with greater clarity and confidence, especially when using the concepts presented.

A. Gupta, T. Ngo P. Mendis & J. Ramsay "Blast Loading and Blast Effects on Structures

This paper conclude that for high-risks facilities such as

public and commercial tall buildings, design considerations against extreme events (bomb blast, high velocity impact) is very important. It is recommended that guidelines on abnormal load cases and provisions on progressive collapse prevention should be included in the current Building Regulations and Design Standards. Requirements on ductility levels also help improve the building performance under severe load conditions.

Hrvoje Draganic, Vladimir Sigmund , BLAST LOADING ON STRUCTURES.

The explosion in or near the structure can cause catastrophic damage to the structure, formation of fragments, destruction of life-support systems (air conditioning, sprinklers). Injuries and deaths can be caused by exposure to explosion wave front, collapse of the structure, impact of parts, fire and smoke. Secondary effects of the explosion can hinder or even prevent the evacuation of people from the structure causing additional injuries and deaths. Blast load for close explosion was determined and simulated on a model building using SAP2000, the conventional software for the static/dynamic analysis of structures. Loading was defined as a record of pressure over time (pressure-time history) with the parameters calculated by the available literature. Since the model structure was close to the source of detonation, it was not necessary to determine the loading on the structural surfaces, the structure is piecewise loaded. It was necessary to analyze the loading for each point. The aim of the analysis of the structure elements exposed to blast load is to check

their demanded ductility and compare it to the available ones. This means that non-liner analysis is necessary and simple plastic hinge behaviour is satisfactory. Deformation history of particular points of interest was calculated and checked against the deformation limits in order to estimate the post-blast state of the element. In elements exposed to distant explosions, conventional reinforcement provides sufficient ductility, while for close explosions additional reinforcement is needed. The Croatian national legislation and also Euronorms have no guidelines for design of buildings to blast loads. It is shown that the effects of blast loading can be taken into account for structural design by the use of available literature. Available commercial software for structural analysis should be directed towards familiarizing the phenomenon of the internal explosion. Thus a complete picture of the explosion effects on the structure can be obtained.

3. EXPLOSIONS AND BLAST PHENOMENON

Explosive is widely used for demolition purposes in: military applications, construction or development works, demolitions, etc. It is, also, a very common terrorist weapon as it is available, easy to produce, compact and with a great power to cause structural damage and injuries. Estimated quantities of explosive in various vehicles are presented in Tab. 1.

Table 1 Estimated quantities of explosives in various vehicles

Vehicle type	Charge mass / kg
Compact car trunk	115
Trunk of a large car	230
Closed van	680
Closed truck	2 270
Truck with a trailer	13 610
Truck with two trailers	27 220

In order to be able to use explosives they have to be inert and stable, which means that the explosion is a triggered, rather than a spontaneous reaction. The explosion is a phenomenon of rapid and abrupt release of energy. Speed of the reaction determines the usefulness of explosive materials that can be condensed, solid or liquid. When they detonate they disintegrate emitting the heat and producing gas. Most of the explosives detonate by a sufficient excitation and convert into a very hot, dense gas under high pressure that presents a source of strong explosive wave. Only about one third of the total chemical energy is released by detonation. The remaining two thirds are released slowly in the blasts as the explosive products mix with the surrounding air and burn. The explosion effects are presented in 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 (Fig. 1).

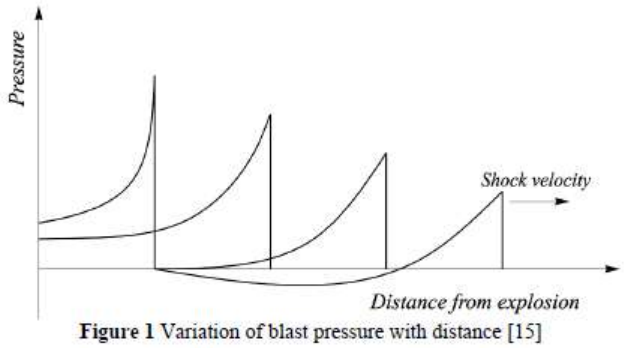

Figure 1 Variation of blast pressure with distance [15]

3.1 Types of Explosion

In general, an explosion is the result of a very rapid release of large amounts of energy within a limited space. Explosions can be categorized on the basis of their nature as physical, nuclear and chemical events.

In physical explosion: - Energy may be released from the catastrophic failure of a cylinder of a compressed gas, volcanic eruption or even mixing of two liquid at different temperature.

In nuclear explosion: - Energy is released from the formation of different atomic nuclei by the redistribution of the protons and neutrons within the inner acting nuclei.

In chemical explosion: - The rapid oxidation of the fuel elements (carbon and hydrogen atoms) is the main source of energy.

The type of burst mainly classified as

a. Air burst

b. High altitude burst

c. Under water burst

d. Underground burst

e. Surface burst

4. SOFTWARE ANALYSIS OF BLAST

For the software Analysis of blast load in Etab 2016 software the methodology will be Time history Analysis. Blast analysis can be carried out in ETABS 2016 by performing a time history analysis in which the blast loading is applied, typically using a triangular time function (i.e. function that varies linearly from full value to zero). The behavior of the structure under the effect of blast loading can be studied from the output generated by the ETABS 2016. For most realistic results a very small time step is required to obtain a stable solution. Reducing the time step size will increase the accuracy, the time step size of 0.01s with 4000 time steps is taken for all models.

5. FAILURE MODES OF BLAST-LOADED STRUCTURES

Blast loading effects on structural members may produce both local and global responses associated with different failure modes. The type of structural response depends mainly on the loading rate, the orientation of the target with respect to the direction of the blast wave propagation and boundary conditions. The general failure modes associated with blast loading can be flexure, direct shear or punching shear. Local responses are characterized by localized bleaching and spalling, and generally result from the close-in effects of explosions, while global responses are typically manifested as flexural failure.

6. CONCLUSIONS

Based on the studies available in the literature, the ultimate objective is to make available the procedure for calculating the blast loads on the structures with or without the openings and frame structures. Also to study the dynamic properties of reinforcing steel and concrete under high strain rates typically produce by the blast loads. From this part of the study, an understanding of how reinforced concrete columns respond to blast loads was obtained. The aim of this paper is to discuss about the use of computer software for the easy analysis of blast load. So that we can improve the blast load design to prevent the building collapse. Technical information has been collected, adapted and presented in this report for the calculation of the external explosion loads to be considered in the blast protection design of a structure. Empirical methods for the prediction of blast loads have been chosen as this is closer to the traditional engineering design approach. Available commercial software for structural analysis can be used for design purposes, while further analysis should be directed towards familiarizing the phenomenon of the internal explosion.

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REFERENCES

1. C. V. R. Murty,Rupen Goswami ,Gujarat State Disaster Management Authority, Book on Some Concepts in Earthquake Behaviour of Buildings.
2. IS 456:2000 Indian Standard Plain and Reinforced Concrete Code of Practice.
3. A. Gupta, T. Ngo P. Mendis & J. Ramsay “Blast Loading and Blast Effects on Structures
4. IS 4991-1968 Criteria For Blast Resistant Design Of Structures For Explosions Above Ground
5. U.S. Army Corps of Engineers (1990) TM 5- 1300,

   Structures to Resist the Effects of Accidental Explosions, US
6. Moon, Nitesh N. Prediction of Blast Loading and its Impact on Buildings, Department of Civil Engineering, National Institute of Technology, Rourkela, 2009.
7. Kazuhiro Kitayama, Shunsuke Otani and Hiroyuki Aoyama Pacific Conference on Earthquake Engineering, Wairakei, New Zealand, August 5 - 8, 1987, Vol. 1, pp. 315 - 326.
8. CAI (1965), Earthquake Resisting Buildings: Requirements and Design Procedure for Concrete Construction, the Concrete Association of India, Bombay.
9. Mays G.C., Smith P.D., (2001) “Blast effects on buildings - Design of buildings to optimize resistance to blast loading”, Tomas Telford.
10. Hand book for blast- resistant design of buildings.