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STUDY ON THE EFFECT OF BLAST LOAD ON INDUSTRIAL STRUCTURE – A CRITICAL REVIEW

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Abstract — *This study investigates some of the special aspects of the response of industrial steel structures to blast loading. A hemispherical surface burst for various explosives, weights of charge and standoff distance are considered for generating the surface blast loading. The main parameters consider in this study are displacement, demand capacity ratio(D/C) by providing different blast mitigation system and compare the blast load effect with or without mitigation system.*

Keywords- *Blast Load, Industrial Steel Structure, Displacement, D/C. ratio, Software, Mitigation system.*

I. INTRODUCTION

Explosions are widely used for demolition purpose such as in construction or development works, military applications and destruction. But also it is common to use in terrorist activities and easy to produce with a great power to cause structural damage and injuries. The blast load effect of different explosives depend on two factors, the charge weight (W), and the standoff distance between the blast source and target(R). The main objective of this study is to understand the effect of blast loading on industrial steel structure using various explosives,weights of charge and standoff distance by providing blast mitigation system.

Now days many industries impart a major part in the growth of countries, due to this terrorist attack occur on the industrial structure. Due to blast, pressure wave produced surrounding the building structure by this building is damage and completely collapse hence the behavior of structural components Subjected to blast loading has been the subject of considerable research effort in recent year to prevent the building component to completely collapse.

II. LITERATURE REVIEW

Mohammad M. Abdallah and Bashir H. Osman [1] studied the effect of surface burst explosion on steel structure behavior under three different weight charges at the same stand-off distance. A several points were selected at the model front façade to calculate the reflected pressure and the duration time, and then the pressure-time history functions defined for each member by using SAP2000 software. Based on the maximum displacement the moment connection joint frame was a bit better than the pin connection joint frame to resist blast load due to the moment connections.

Young Seo Hwang, James C. Anderson, [2] considered a hemispherical surface burst for various explosive weights and standoff distances are considered for generating the air blast loading. Linear and nonlinear analyses are conducted for these loadings. Air blast demands on the structure are compared to current seismic guidelines. These studies present the displacement responses, story drifts, stress distributions and inelastic demands. The 1000 lb explosive, a standoff distance of greater than 15 feet should provide adequate protection for this structure.
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Andrew Appelbaum, [3] carried out the effects of blast loads on lateral force resisting systems in hardened 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.

Fatih Tahmilci, Middle East Technical,[4] introduced basic blast induced damage event, consequently prevention against progressive collapse, summarize analysis approaches and procedures of General Services Administration Progressive Collapse Analysis Design Guidelines, 2003 and nonlinear analysis method for progressive collapse proposed by Guo and Gilsanz, 2003. They all classify regular steel braced frame type building up to a charge weight of 4535 kg ANFO within a standoff distance of 5 meters with assumption of no blast wave reflection from nearby structures (assumption is due to lack of information about nearby structures) as not prone to progressive collapse.

Tod Rittenhouse, Peter DiMaggio and Mohammed Ettouney,[5] investigates some of the special aspects of the response of steel structures to blast loading. The distinctive features of steel systems, including connections, splice, and thin-walled sections and their vulnerabilities to blast loading, are presented and discussed. Also, vulnerabilities of composite and light steel constructions are investigated and simplified examples presented. The needs for special design and construction considerations, as well as additional research studies are concluded.

Guzhao Li, Paul Summers, Keith Clutter, and David Bonaventure.[6] developed a finite element model for the OHP structure using the general-purpose finite element program ABAQUS/Standard, and the structure was evaluated for the blast loads using the procedures in 2010 ASCE Guidelines, “Design of Blast Resistant Buildings in Petrochemical Facilities”. In addition, the OHP structure was also evaluated for normal design loads such as wind loads and seismic loads based on 2006 International Building Code.

E. P. Stoddart,M. P. Byfield and A. Tyas.[7] the development of an accurate frame modeling approach that achieves a realistic treatment of joint response without significantly increasing the computational requirements. The method utilizes simplified connection models using rate-dependent nonlinear springs which, when assembled, allow arealistic representation of the connection behavior. The method is found to be capable of modeling strain-rate dependent material property effects with a high degree of accuracy and coping adequately with the force and rotation combinations which develop during blast response. Increased rotation rate, which occurs as a response to blast loading, is shown to modify the rotational stiffness in joints which can in turn lead to increased dynamic shear forces.

W. L. Bounds, Amol Ganpatye, George Miller,[8] the nonlinear analysis of a structural steel frame subjected to low level far field blast loads. Such blast loads are considered typical for buildings designed for petrochemical plants. The analysis involves the use of a beam and hinge model similar to what can be used for a nonlinear seismic design. An example frame, based on Chapter 12 of ASCE 2010, "Design of Blast-Resistant Buildings in Petrochemical Facilities", is analyzed. The resulting dynamic response is compared to a simpler SDOF equivalent analysis and a to more comprehensive nonlinear finite element analysis. For simple steel frames in typical petrochemical plant applications, the use of a nonlinear hinge model provides a reasonable level of accuracy.

Darell Lawver, David Vaughan, Darren Tennant and Jim Weeks,[9] discussed the current blast resistant design technology and demonstrate how it has been used in the protection of structures against future terrorist attacks. The paper will discuss historical and current approaches used to determine structural response to blast loading. The paper will demonstrate the impact of advanced finite element methods in the design of structures to resist blast loading with emphasis on economical construction and better understanding of complex response modes. Discussion of the critical need for test validation of advanced methods will be included.

Shlomo Ginsburg, A. M. ASCE and Uri Kirsch. [10] discussed some aspects of analysis and design of protective structures are discussed. It is demonstrated that parametric analyses can be used to obtain an approximate model for reanalysis. The suggested design process is based on a multilevel scheme involving a few separate design spaces, each of which contains a class of variables of the same type. The variables are classified as cross-sectional, structures dimensions, and relative location (distances) variables. Using equivalent charge, ideal load histories and response functions, and the multilevel scheme methods of optimization for each level are chosen.

Kyungkoo Lee and Taejin Kim and Jinkoo Kim,[11] studied the 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.

B. X. Qi1, S. Yan2, W. Li3 and X. J. Li.[12] H-shaped steel frame column under a blast loading with different conditions was numerically developed, using finite element method (FEM) by considering the strain rate effect to materials and the coupled effect of explosive, air, and steel together, to simulate the response in the middle span, failure modes, shear strain responses at both ends of the column. 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.

H. R. Tavakoli , F. Kiakojouri,[13] investigated 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.

Amr A. Nassr, Aff.M.ASCE, A. Ghani Razaqpur, Michael J. Tait, Manuel Campidelli, and Simon Foo, [14] studied, full-scale field tests were performed on wide-flange steel columns subjected to high-intensity, short-duration, out-of plane blast loads in addition to a static axial load equal to 25% of the column static axial capacity, applied through prestressing. The effects of charge size and stand-off distance on columns behavior were investigated by measuring their time-dependant deformations using a variety of measuring devices.

Feng Fu,[15] considered 20 storeys building to perform the progressive collapse analysis using the finite element package ABAQUS, a 3-D finite element model. Shell elements and beam elements were used to simulate the whole building incorporating non-linear material characteristics and non-linear geometric behavior, the structural behavior of the building under the sudden loss of columns for different structural systems and different scenarios of column removal were assessed in detail.

Javad Yazdanseta and Mahbobe Taheri,[16] studied the main substation building located at Esfahan refinery plant in Iran is considered. A nonlinear static analysis is used to assess accurately the post attack behavior of structural elements that are not removed from the building by the blast loads in their corresponding damaged states and also seen that the preliminary design of building subject to typical loads is to be changed to make the building blast resistant. Because of removal of damaged column the members that originally spanned a single bay must now span two bays and they have to be strengthened to develop positive moments.

Christian Ma´laga-Chuquitaype, Ahmed Y. Elghazouli and Radu Enache,[17] examined the contribution of secondary (or gravity) frames to the mitigation of collapse in steel buildings subjected to extreme loading conditions arising from multiple hazards. By considering side sway and vertical mechanisms as representative of most building collapse modes, this study evaluates the effects of various secondary-frame parameters on the overall building collapse capacity. This study offers a fundamental step towards the formulation of design and assessment strategies that incorporate secondary systems into a multi-hazard structural evaluation framework.

Theodor Krauthammer, Hyun Chang Yim, Serdar Astarlioglu, and Joonhong Lim,[18] utilized available steel connections, unreinforced and reinforced with respect to earthquake load, this numerical study was performed to develop a better understanding as to the behavior of moment resistant steel connections under blast loads, identify possible performance deficiencies, and provide recommendations for research that could help to remedy such difficulties

IV. CONCLUSION

From the above literature it is concluded that the rigid diaphragm is effective in distributing the blast loads from the front face to the other frames on the perimeter provided the pressure does not enter the building. A Blast Resistance Ductile Connections (BRDC) is capable of significant plastic deformation can dissipate energy from blast and reduce the amount of lateral force transferred to a building's main lateral force resisting frame. All the structural members and beam to column connection at the possible column removal level should also be designed to at least twice the static axial force.

Still today there are no work done on the industrial steel structure against the blast load so, in my study I will consider effect of blast loading on industrial structure for various explosives, weights of charge and standoff distance are considered for generating the surface blast loading and also the main parameters consider in my study are displacement, demand capacity ratio (D/C) by providing different blast mitigation system and compare the blast load effect with or without mitigation system.

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