Analytical Tools for Progressive Collapse Analysis under Explosion

Gholamhosein Liaghat [1], Seyed Reza Mohammadizadeh [2]

1- Professor, Applied Mechanics Group, Tarbiat Modares University, Tehran, Iran
2- M.Sc Student, Applied Mechanics Group, Tarbiat Modares University, Tehran, Iran

Ghlia530@modares.ac.ir
Reza29m@yahoo.com

Abstract

This paper will review the tools that are available for progressive collapse vulnerability analysis under explosion and compare them in term of capabilities and ease of use.Three usual methods which are used in designing explosion resistant structures are the indirect design approach, the alternate path design approach and the specific local resistance direct design approach.The differences between progressive collapse analysis and routine structural analysis, the needed capabilities in computational tools, comparing available tools and verification of predictive capabilities will be investigated in this paper.

Keywords: Explosive loading, Progressive Collapse, structure.

1. INTRODUCTION

The dynamic behavior of materials is an area of study that is completely different from static behavior of materials. The processes that occur when bodies are subjected to rapidly changing loads can differ significantly from those that occur under static and quasi-static situations.[1] As we know, The behavior under explosive loading is an important kind of dynamic behavior that can cause high strain rates and large deformations in buildings and structures which may manifest itself in the feature of Progressive Collapse. That means a collapse initiates at a part of a structure and because of connectivity of structure and effect of explosion, can progress thorough the whole structure and results in complete failure.

Progressive collapse analysis are intended to determine the capacity of structure either to resist an explosion, thereby preserving the load carrying capacity of the critical elements, or to redistribute gravity loads of a critical load-bearing element is removed.

While many of references related to progressive collapse agreed on common features- continuity, ductility, and energy absorption-that structures should possess to help prevent progressive collapse , few of them offered any quantitative analytical approaches for evaluating the potential for progressive collapse. The scarcity of research in the field of Progressive Collapse prevention and the difficulty for most structural engineering firms to perform advanced(geometric and material nonlinear) finite element computations in an economical and timely manner has lead to development of broad guidelines that are open to many interpretations. For example ASCE 7-98[2] describes protection through “an arrangement of the structural elements that provides stability to the entire structural system by transferring loads from any locally damaged region to adjacent region capable of resisting these loads without collapse.” From this approach, ASCE 7-98 discusses three design alternatives. The alternatives are the indirect design approach, the alternate path design approach and the specific local resistance direct design approach. The Alternate Path Approach presumes a critical element is removed from the structure, due to an explosive loading, and the structure is required to redistribute the gravity loads to remaining undamaged structural elements. The method of Specific Local Resistance requires all critical gravity load-bearing members to be designed and detailed to be resistant to postulated explosive loading. The merit of these approaches and the computational features that are required to perform the required analysis are presented in the following sections. The indirect design approach does not require analytical investigation and will not be discussed here.

The response of either elements or the structure to explosive loading conditions is most likely to be dynamic and nonlinear , both geometrically and in material behavior. Therefore, the analytical methods that are required to determine the response of the structure must represent the sudden application of the explosive loading, the dynamic behavior of materials under very high strain rates, the inelastic post-damage behavior of the materials and the geometric nonlinearity resulting from large deformations.