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Blast Resistance Capacity of Seismically Designed Building Frames

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Abstract

Because of the inherent uncertainty in the blast loading caused due to terrorist attacks, most buildings are not designed for blast loading, but they are routinely designed for earthquake demand. If the blast resistance capacity of the seismically designed building can be evaluated, the risk of the blast loading caused due to the terrorist attacks can be reduced by upgrading the seismic design of the building. With this background in view, the present paper investigates the blast resistance capacity of a 6 storey building frame designed for extreme peak ground acceleration (PGA) levels of 0.5g, 0.4g, and 0.3g. The 3D model of the 6 storey building is designed according to Indian Standard (IS) codes for the above mentioned extreme level earthquake. Designed buildings are subjected to surface blast of 500 kg of TNT(trinitrotoluene) at different standoff distances ranging from 5m to 30m. The time histories of the blast loading due to air pressure and ground shock are modeled by those existing literature. A nonlinear time history of analysis (NTHA) of the frame is performed in SAP 2000 for surface blast and the simulated earthquakes from the specified response spectrum in IS code. NTHA results for both cases are compared to evaluate the relative performance of the three different seismically designed buildings to the surface blast loading. The response quantities of interest include maximum drift, maximum top displacement, and number of hinges formed. The results of the study indicate that for the near blast conditions the blast resistance capacity of the building increases with the increase in the PGA values for which the building is designed. By upgrading the seismic design by 0.1g, the blast resistance capacity increases manifold for near blast conditions. Thus, by updating the seismic design of a building, the risk of blast loading in the design may be considerably mitigated.

Keywords: Surface blast, RC building, Nonlinear Time History Analysis

1. Introduction

In the recent past, important buildings have become a common target of terrorists as it causes both financial loss and a large number of casualties. In such cases, a major part of the casualties is caused due to the structural damage. Some guidelines are available [1–4], which provide empirical charts and equations to calculate blast load on structures and design recommendations. Also, different guidelines are published for reducing the risk of progressive collapse of structures [5–7]. Despite this, blast loading is rarely taken into account in the design of buildings because there are a large number of uncertainties involved with this load. The location of the blast source and its intensity are always uncertain and also, consideration of blast loading in design will be very uneconomic. So, the conventional design process involves earthquake and wind loads only.

Blast and earthquake load are different. The blast load is of shorter duration and higher magnitude than the earthquake load. But, the design of structure for both loads involves providing sufficient strength and ductility to resist these loads. Some researchers examined the blast resistance capacity of earthquake-resistant buildings [8,9]. Draganic and Sigmund [8] found that conventional reinforcement in elements provides adequate ductility when these elements are subjected to distant explosions, while for near blast condition additional reinforcement needs to be provided. Kyei and Abass [9] studied the effect of blast loading on seismically detailed RC columns and concluded that by reducing the spacing of transverse reinforcement in columns, lateral displacement can be reduced for near blast conditions. Thus, the structure which is designed for earthquake loading may resist blast load also to some extent. Therefore, the blast resistance capacity of a building designed for different levels of earthquake intensities should be properly evaluated in order to reduce risk of the blast loading by upgrading the seismic design of the building.

The literature on the effect of aboveground blast on structures mostly considers air pressure effect on structures [10–12], whereas, a surface explosion exerts both air pressure and ground shock effect on the nearby structure. There is very little literature available on surface blast effect with consideration of both ground shock and air pressure effect on structures. Wu and Hao [13] developed empirical equations to predict air pressure and ground acceleration produced by a

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