A Complete Guide to Blast-Resistant Design of Low Rise Reinforced Concrete Buildings

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Summary

The Portland Cement Association's Blast Resistant Design Guide for Reinforced Concrete Structures provides a practical treatment of the design of cast-in-place low rise concrete structures to resist the effects of blast loads. The Guide is a self-contained reference document that contains chapters on basic security design principles, blast pressures and building loads, analysis and element design, detailing and progressive collapse. Numerous examples based on a hypothetical office building and multiple explosion scenarios are provided to illustrate key concepts associated with blast-resistant design.

Keywords: reinforced concrete, blast resistance, security design, antiterrorism, low-rise buildings.

1. Introduction

The Portland Cement Association's Blast Resistant Design Guide for Reinforced Concrete Structures provides a practical treatment of the design of cast-in-place low rise concrete structures to resist the effects of blast loads. This guide distils the most important information from leading sources with regard to reinforced concrete design, to produce a blast-resistant design methodology that is efficient, useable and effective. And, the guide includes chapters on topics such as protection levels, load determination and dynamic analysis to provide a complete reference that takes the designer through all steps of the blast-resistant design process.

2. About the Guide

The Guide is a self-contained reference of necessary (though not necessarily sufficient) procedures for blast-resistant design of low-rise reinforced concrete structures. It can be used as a road-map for the design process from preliminary security design considerations to fine points of reinforcement detailing.

The Guide is organized into six chapters, each of which is overviewed in this paper:

1. Preliminary Materials
2. Design Parameters
3. Blast Pressures and Building Loads
4. Analysis and Element Design
5. Blast Resistant Design Concepts and Member Detailing
6. Progressive Collapse

The Guide does not provide an exhaustive prescriptive treatment of blast resistant design topics; to do would make for an unwieldy manual, and not engage the understanding of the designer. Rather, emphasis is placed on the discussion of behaviour and the reasoning that underlies the various procedures, so that users of the Guide can extrapolate from the material as necessary for their specific application. The Guide mostly

presents current practice, however the chapter on Blast Resistant Design Concepts and Member Detailing provides a fresh treatment, reflecting a recent trend to apply seismic design concepts to blast-resistant design.

An example low-rise office building is used throughout the Guide as a basis for examples of blast calculations, response analysis and member design.

While the majority of the Guide distils the essential aspects of established blast resistant design, the chapter on Blast Resistant Design Concepts and Member Detailing provides a fresh treatment, reflecting a recent trend to apply seismic design concepts to blast-resistant design. Specifically, the Guide provides two independent approaches, or paths, to achieving blast resistance; response limits and minimum detailing recommendations. These two paths can be informally associated with strength and ductility, respectively (Figure 1).

Response limits vary with Level of Protection (LOP), and are incorporated into the analysis and design process. LOP I, which provides the least protection, allows the greatest inelastic response (rotations and ductility ratios). LOP IV, which provides the greatest protection, targets essentially elastic response. This range in expected damage and deformation will primarily manifest itself in member sizing, with LOP IV members being substantially larger and heavier. As such, the primary effect of the deformation requirements is to increase the strength of the structural members.

Minimum detailing recommendations generally serve to provide sufficient ductility, continuity and alternative load paths and load-carrying mechanisms. Detailing recommendations are the same for all LOP. For the LOP I, the detailing is necessary for the members to be able to achieve the specified deformation requirement. For LOP IV, the detailing recommendations provide increased margins against uncertainty. This combination of constant detailing across LOP (providing consistent ductility) and scaled deformation requirements (resulting in increasing member size and capacity) results in increasing toughness from LOP I to LOP IV, and a balance between design economy and protection.

3. Discussion

The PCA Blast Resistant Design Guide provides a self-contained reference on the subject as related to low-rise, reinforced concrete building design. Features of the Guide include a consistent methodology that takes the user from planning stages through detailed element design and examples for load determination, structural analysis, member design and progressive collapse mitigation. The design and detailing guidelines are drawn from a combination of proven seismic and blast resistant design procedures, to provide and achievable and economical methodology.

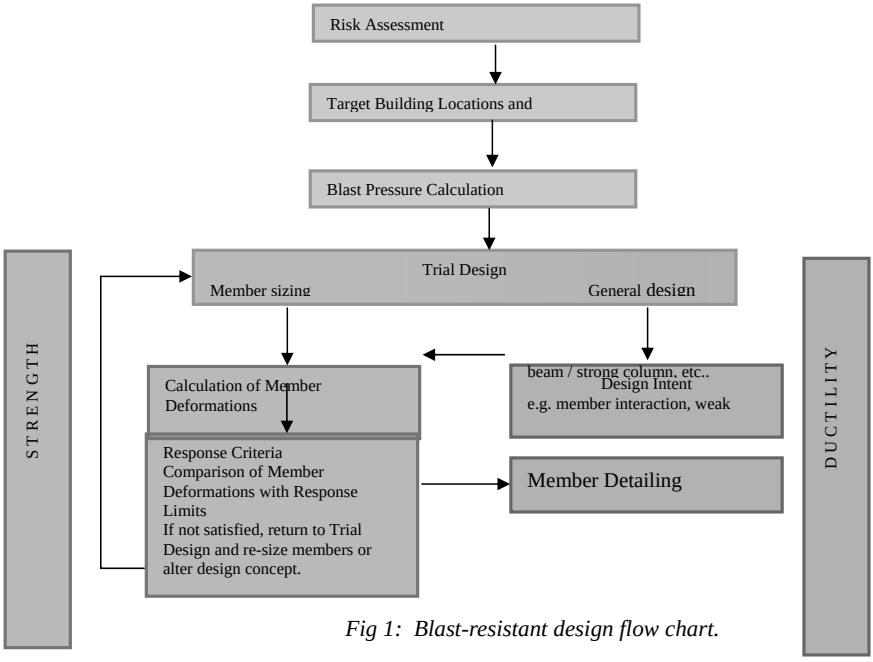

Fig 1: Blast-resistant design flow chart.