Antiterrorism Design for Buildings
Industry Develops a Standard for Blast-Resistant Design, with Emphasis on Explosive Devices

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The events of September 11, 2001, had a profound impact on the building design community.

Although the weapons employed that day were fully fueled commercial aircraft, the industry turned considerable attention to the most common tactic historically employed in terrorist attacks around the world: the improvised explosive device. While information for addressing this threat existed, it was largely confined to military and other government publications that were neither readily available nor directly applicable to facilities constructed by the private sector.

Recognizing this, in 2002 the Structural Engineering Institute of the American Society of Civil Engineers (ASCE) initiated an effort to develop a new ANSI-accredited standard for the planning, design, construction and assessment of new and existing buildings subject to the effects of accidental or intentional explosions. Six task committees have been developing the mandatory provisions and accompanying commentary. The resulting document, Standard for Blast Protection of Buildings, is now in draft form, and the committee expects to ballot it sometime in 2007.

General Provisions
Chapter 1 of the new standard, “General,” addresses the scope of the document, appropriate qualifications for its users, and the definitions, symbols and notation that are common to all sections.

Chapter 2, “Design Considerations,” outlines the minimum requirements for a valid risk assessment when project criteria are not established by applicable law, owner policy, recognized industry standards or other prescriptive means. Components include consequence, threat, vulnerability and risk analysis, as well as risk acceptance by the building owner. The standard also provides some suggestions for non-structural risk reduction measures.

Chapter 3, “Performance Criteria,” specifies design objectives; levels of protection for overall damage and the behavior of individual elements, glazing and doors; and corresponding response limits for simplified analysis. (See Table 1.) Much of this information is derived from current Department of Defense antiterrorism guidance. The standard also provides for the modification of element strength to reflect actual vs. specified values, strain rate effects, and the presence of loads other than blast.

Blast Characterization
Chapter 4, “Blast Loads,” provides basic procedures for calculating design loads due to an external or internal explosion using relevant parameters such as the type and quantity of

<table>
<thead>
<tr>
<th>Level</th>
<th>Design Objective</th>
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<tbody>
<tr>
<td>I (Very Low)</td>
<td>Collapse prevention</td>
</tr>
<tr>
<td>II (Low)</td>
<td>Life safety</td>
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<tr>
<td>III (Medium)</td>
<td>Property preservation</td>
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<tr>
<td>IV (High)</td>
<td>Continuous occupancy</td>
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Table 1: From “Standard for Blast Protection of Buildings.”
explosive, its distance from a responding element, and the angle of incidence of the shock wave or the volume of the confined space. (See Figure 1.) More sophisticated approaches are permitted for all structures and required for irregular structures.

Chapter 5, “Fragmentation,” prescribes design requirements and analytical procedures for taking into account the effects of fragments, whether from the explosive casing (primary) or damaged elements (secondary). Although this phenomenon is usually neglected, risk assessment may indicate that it should be included in certain situations.

**Modeling and Analysis**

Chapter 6, “Structural Systems,” describes several different approaches to evaluating elements that are subject to blast effects, from simple pressure-impulse diagrams and single-degree-of-freedom approximations to complex finite element formulations. It also discusses material-specific considerations for the flexural, shear and axial response of elements to blast loading, as well as the relevant characteristics of various types of structural systems.

Chapter 7, “Protection of Spaces,” applies to areas within a building that need extra resistance to blast effects, such as loading docks, mailrooms, stairwells and safe havens.

Chapter 8, “Exterior Envelope,” contains provisions for the first line of defense against an external explosion, including the roof, exterior walls, windows and doors. Glazing behaves very differently from other materials in response to blast loads and requires special treatment, particularly in a retrofit situation.

**Other Considerations**

Chapter 9, “Materials Detailing,” outlines the construction features that concrete, steel, masonry and fiber-reinforced polymer elements must have in order to meet the levels of protection specified in Chapter 3 and satisfy the assumptions underlying the analysis methods described in Chapter 6.

Chapter 10, “Guarded Perimeter and Standoff Distance,” suggests site elements that can contribute to the protection of a building, such as barriers, landscaping and blast walls.

Finally, Chapter 11, “Performance Qualification,” indicates procedures that can be followed in order to demonstrate compliance with the standard as a whole, such as peer review of calculations and drawings and full-scale testing of components. (See Figure 2.)

**Conclusion**

In the wake of September 11, 2001, structural engineers concerned about the threat of terrorism against their projects had little guidance on what to do to protect facilities from blast effects. In the near future, ASCE will provide detailed recommendations for assessing the blast resistance of buildings in a document that will be accessible to all practitioners.