Fire Wall Structural Stability

by Anthony C. Meister, P.E.

The concept of a fire wall, which is a method of effective fire separation of a structure into two buildings, was fairly consistent between the three legacy model codes that predated the *International Building Code* (IBC). Much like the IBC, the 1999 edition of the Building Officials and Code Administrators International, Inc., *National Building Code* prescribed fire resistive capacity based upon occupancy classification and use. The 1997 *Uniform Building Code* (UBC), published by the International Conference of Building Officials, included similar but nonspecific structural stability criteria—prescribing a "complete separation" between buildings through the use of an "area separation wall" and fire resistive criteria based upon the type of construction classification. Finally, the *Standard Building Code*, published by the Southern Building Code Congress International, Inc., did not include any structural stability criteria but required a stricter fire-resistance rating of 4 hours for any fire wall.

Although the specific provisions of the previous codes varied, there was sufficient consistency to achieve today's unity. However, there remains a level of confusion in the building design community regarding the distinction between the differing ideas of structural stability versus structural independency. This is evidenced by the common assertion that "A fire wall is required to be structurally independent," which reveals a misunderstanding of the intent of the structural stability requirements given in the IBC for fire wall construction.

The stability performance prescription given in IBC Section 705.2 reads:

> Fire walls shall have sufficient structural stability under fire conditions to allow collapse of construction on either side without collapse of the wall for the duration of time required by the fire-resistance rating.

Note that while this provision can include structural independence, it does not demand it. What it does is establish, in general, a degree of separation as well as a level of redundancy (assuming that construction on either side of the fire wall may fail and collapse, but not both sides simultaneously). With an inherent assumption of a worst-case fire scenario in which active fire protection features such as automatic sprinklers are not operational, the structural stability requirement is one of the higher levels of redundancy for fire wall building separations, making them distinct from fire barrier walls.

Thus, the assertion that "A fire wall is required to be structurally independent" is not necessarily incorrect, but dependent upon what is considered the object of independency. For example, only in rare conditions would a fire wall be required to be completely structurally independent from any other support system, such as a roof or floor diaphragm. Nonetheless, the phrase has been repeated so many times that many do not realize that the requirement is not in the IBC except for in a very specific and unusual case.

Types of Fire Walls

There are at least three identifiable types of fire wall approaches used to separate buildings: a single wall and party (common) wall, also known as a tied fire wall; a double wall; and a cantilevered independent wall.

Single Fire Wall

The most common fire wall design is a single wall that relies upon the roof or floor diaphragm for structural stability. This approach might more correctly be characterized as a structurally dependent wall system—the fire wall is tied to both diaphragms, relying on each for structural stability but not at the same time; if one side of the diaphragm is damaged by the effects of fire, the other diaphragm is

required to support the assumed load induced during collapse. The intent is not to preclude damage to the fire wall but to prevent a dangerous collapse while limiting the possibility of fire spread for the duration specified.

In order to accomplish these goals, it is recommended by intent, although not prescribed by the IBC, to limit continuous structural members from passing perpendicularly through the fire wall. Member supports and the structural system with respect to the fire wall are recommended to be conceptualized as pin-connected, allowing rotation to occur upon failure. The integrity of a fire wall during a fire should not be jeopardized by the installation method of members such as continuous bar joists or wood or steel beams passing through the fire wall unless a structural engineer can account for the effects of collapse on either side during a fire. Many designers are familiar with a "fire cut" at supports of wood member. In the days when unreinforced masonry buildings were popular, wood beams and joists were typically built into the bearing walls. The idea of having an angled cut was intended to ensure that the wood member, rotating due to the effects of a fire, would not damage the fire wall when the roof or floor collapsed.

Another consideration is the effect of height when a building collapses. Without implying a limitation on the use of fire walls in multistory buildings, the stability prescription during collapse may present a significant challenge as building height and number of stories increases. Therefore, the benefit of an independent, vertical (gravity) double wall support system has greater merit as the fire wall height increases or when diaphragms supporting a single wall are not the same height.

Double Fire Wall

A double fire wall approach uses two independent walls having the same required fire resistance connected to their own supporting roof and floor diaphragms. This fire wall system is redundant and dependent upon its own diaphragm but independent of the other diaphragm and structural system. If one side of the fire wall and diaphragm system is jeopardized by the effects of fire, the second is expected to remain. This approach is often used for building additions, and may offer a solution for the use of fire walls in multistory buildings or those having dissimilar roof heights.

A challenge posed by use of a double wall arrangement is that exiting may be restricted. If the egress path is through such walls, a vestibule and side-swinging doors may need to be provided. Some building and fire safety officials have accepted a fire resistive vestibule rated the same, including the ceiling, as the fire wall to allow this configuration, and the *International Building Code Commentary* provides language to support this concept.

Cantilevered Fire Wall

A cantilevered fire wall does not rely upon either the floor or roof diaphragm systems, and adjacent roof diaphragms are expected to be completely structurally independent. More common in the past—when insurance perspectives drove fire protection criteria—but rarely used today, this type of wall is self-supporting and is the only kind of fire wall that can be truly described as independent.

Through a reference in the *International Fire Code* (IFC) to National Fire Protection Association (NFPA) 30B, *Code for the Manufacture and Storage of Aerosol Products*, the IBC includes one provision by which a cantilevered fire wall becomes mandatory. The general scoping section of IFC Chapter 28, which addresses the use and construction of aerosol warehouses, requires compliance with both the IBC and NFPA 30B. Section 6-3.6.3 of the NFPA standard, in turn, requires that aerosol warehouse buildings be freestanding and independent of other uses unless a cantilevered fire wall having 4-hour fire resistance is provided between uses.[1]

It is of interest to note that Section 307.8, Number 15, of the BOCA code required adherence to NFPA 30B. The code also addressed the unique challenges posed by aerosol warehouses in Section 707.1.2, requiring that they be

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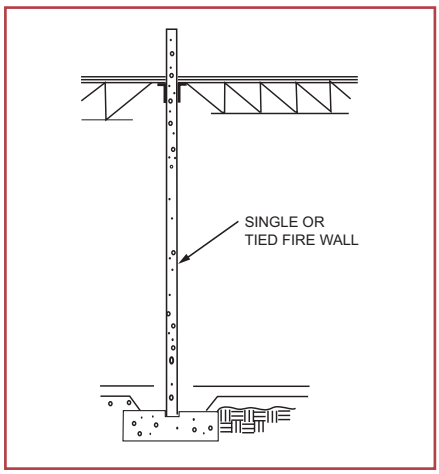

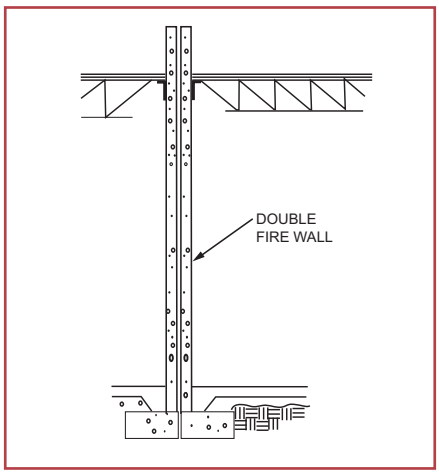

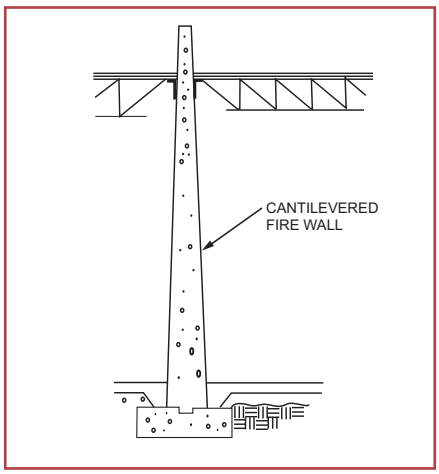

detached from other buildings but allowing other uses in the same structure if separated by a 4-hour fire wall. Much has been learned regarding the special fire protection needs of aerosol warehouses,[2] and there is still work to be done to ensure that fire walls in aerosol warehouses are designed to withstand the energy of an aerosol container projectile. However, because single and double fire wall systems provide equivalent levels of redundancy, a freestanding and structurally independent cantilevered fire wall is not a necessary prescription.

Conclusions

Except in unusual circumstances, most fire wall designs should be considered structurally dependent with respect to their supporting diaphragms. A fire wall design must offer not only an appropriate fire resistive capacity but sufficient detail addressing stability under fire and collapse conditions. Fire wall designs should also consider collapse conditions affected by dissimilar heights and multiple stories.

Finally, the language of the IBC and the IFC provisions for aerosol warehouses, which directly references NFPA 30B for a freestanding or cantilevered fire wall, should be reconsidered. The IBC and IFC are the appropriate locations to prescribe the fire resistive construction requirements for such building areas. ◆

Notes

1. NFPA 221, *Standard for High Challenge Fire Walls, Fire Walls and Fire Barrier Walls*, Appendix A.6.3 clarifies that a "freestanding wall" is equivalent to a cantilevered wall.
2. See, for example, the United States Fire Administration "Report on the Sherwin-Williams Paint Warehouse Fire, Dayton, Ohio," available online at *www.interfire.com/res_file/pdf/Tr-009.pdf*.

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