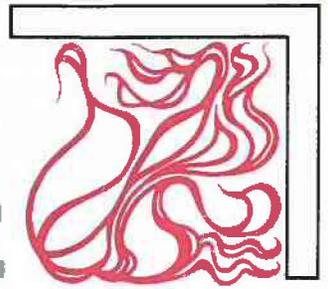


fire protection planning report



BUILDING CONSTRUCTION INFORMATION FROM THE CONCRETE AND MASONRY INDUSTRIES

NO. 2 OF A SERIES

Six Fundamentals of Firesafety in Buildings

Fire in a high-rise building can mean flame and smoke beyond the reach of firemen's ladders and hoses, but the risk associated with fire and smoke is usually lower in a high-rise than in other buildings. Each year there are about 12,000 fire deaths in the United States. Of these, an average of fewer than 12 occur in high-rise buildings. Both large and small cities have tall buildings with excellent safety records. The reason is that for years building codes have required fire-resistive, compartmented construction for high-rise buildings. If building codes are changed to provide less restrictive structural requirements, then poorer performance should be expected.*

No single firesafety measure represents the optimum answer for all types of buildings, and there are no magic answers to the problems of fire protection. There are, however, six fundamentals of high-rise building design, construction, and materials that are necessary to safeguard individuals, property, and the community from fire. Together they are the basis of a total system of firesafety. Similar principles also apply to low-rise residential buildings such as townhouses and garden apartments.

The fundamentals of firesafety, as stated by the Fire Safety Committee of the Concrete and Masonry Industry, are:

1. The fundamental axiom in firesafety for high-rise buildings is that the building must remain intact throughout the fire and offer refuge for the occupants until they can be evacuated. There must be no structural failure should there be a burn-

*Most codes define a high-rise building as more than six stories, or 75 to 80 ft. in height. This is generally considered the greatest height that a fire department can reach with aerial ladders from the exterior. A building need not be a towering skyscraper to be termed a high-rise structure.



TOP: This is Chicago, with 800 high-rises of 10 stories or more. The structural integrity of these buildings must be maintained even under the most severe fire conditions.

BOTTOM: Occupants of this medium- and high-rise building are protected from fire with concrete walls and floors.

- out in any portion of the building.
2. New building code regulations for high-rise buildings should be directed towards reducing fire hazards that are not now adequately regulated.
3. Compartmentation, smoke control, and early detection constitute a viable basis for high-rise firesafety.
4. Use of combustible structural elements, insulation, and finishes should be carefully restricted and controlled.

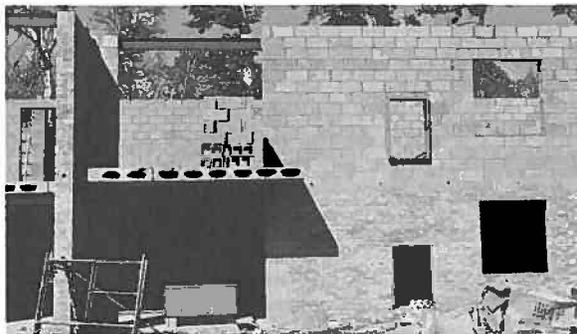
5. Automatic fire-suppressing systems (sprinklers) should be required for hazardous areas and for occupancies with high combustible contents.
6. Automatic fire-suppressing systems (sprinklers) should be in addition to compartmentation within a story.



Fire departments are not equipped to fight high-rise fires from the outside that are above 75 ft. Firefighters must work on the inside above the level of the sixth floor and should be protected by the structural integrity of the building.



Concrete compartments in buildings provide refuge from fire. They also prevent fire from spreading, thus permitting quick suppression and reducing danger to occupants.



Occupants of low-rise apartment buildings should have the same fire protection as occupants of high-rises. This low-rise has interior concrete masonry firewalls plus exterior walls of brick and concrete masonry as well as precast concrete floors.

Structural Integrity and Compartmentation

Although each of the six fundamentals of fire-safety is important, structural integrity and compartmentation are of primary significance. A building must not collapse and the occupants must be protected from fire and smoke until they can be evacuated. If these factors are lacking, the other fundamentals become irrelevant. This report concentrates upon this first fundamental.

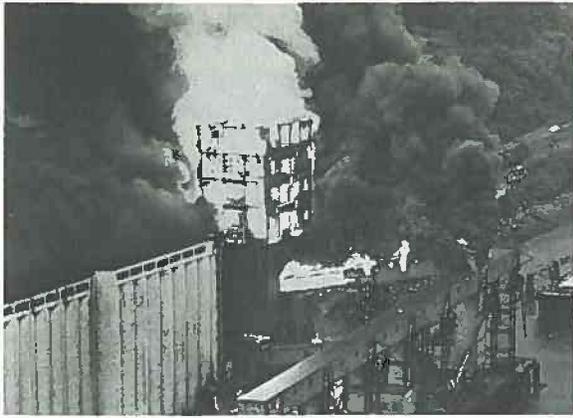
Choosing concrete and masonry, traditionally fire-resistive, noncombustible materials, is the most practical and economical way to get maximum fire protection at minimum cost. Buildings constructed with these fire-resistive structural elements will withstand fire for longer periods of time than structures built of combustible materials. It is nevertheless imperative that detection and suppression be achieved quickly before the fire can cause serious structural damage.

Structural integrity with compartmentation is needed for fire suppression. Firemen, unable to fight the fire from the exterior above the sixth-floor level, must reach the fire from the interior of the building. If fire occurs in the upper levels of very tall buildings, it takes considerable time for the firefighters to get to the burning area. Because the occupants must have safe places of refuge until their evacuation is possible and the firefighters must have safe and efficient access, the building construction must have fire-resistive characteristics that will protect the structural elements from serious damage. Failure of a structural element may trigger more extensive building collapse or breaching of fire barriers.

What About Compartmentation?

The compartmentation of the building—division of areas into small units by using concrete or masonry walls and concrete floors—provides an effective means of controlling and limiting the spread of fire within a building. Because the occupants of a high-rise building cannot be evacuated quickly, they must remain in places of refuge from fire and smoke during the time it takes to extinguish the fire or until they are evacuated. Compartmentation is essential for that purpose.

Compartmentation with concrete or masonry also retards the spread of fire and smoke in low-rise apartment buildings, thus protecting the occupants from careless acts of neighbors. Unfortunately, however, many low-rise apartment buildings are not compartmented.



This fully sprinklered heavy-timber, metal-clad building in Canada had a history of malfunctioning sprinklers. Unfortunately, sprinklers were turned off when employees thought an alarm was false. Result: \$10 million property damage, five dead, 16 injured.

Buildings may be compartmented vertically and/or horizontally. Vertical compartmentation consists of dividing the building into sections by isolating each story or group of stories with fire-resistive floor construction, thus keeping the fire confined to the story of its origin. Horizontal compartmentation is achieved by dividing each story into two or more areas of approximately the same size with fire-resistive walls between them. Both vertical and horizontal compartmentation have proved effective in restraining the spread of fire.

Floors and Walls

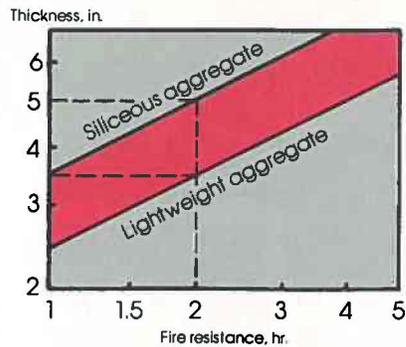
Noncombustible floors and walls having at least a two-hour fire-resistance rating are ideal for compartment construction. Concrete and masonry are noncombustible structural materials for such construction. They neither add fuel to the fire or emit toxic gases.

Depending on the type of aggregate used, reinforced concrete floors from 3½ to 5 in. thick will provide a two-hour fire resistance rating. The building design must ensure that the fire-resistive floor is supported by equally fire-resistive construction.

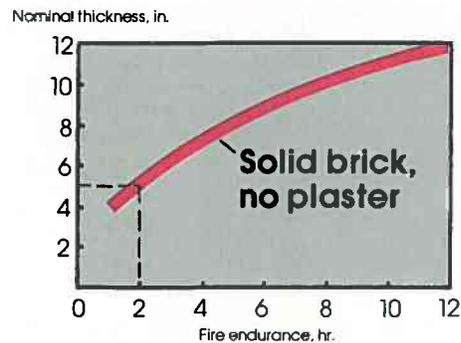
Masonry walls for compartments also provide safety during and after severe fire exposure. They do not twist and buckle, and they continue to support beams and roof.

Concrete floors and masonry walls are usually capable of being repaired rather than replaced after severe fire exposure, thus saving time and money. Also, compartments of concrete and masonry provide fail-safe firesafety independent of sprinkler systems, which must be rigorously maintained to ensure proper operation.

Fire Resistance of Concrete



This chart relates fire endurance to thickness of concrete floors. Depending on the type of aggregate used, concrete floors from 3½ to 5 in. thick are ample for a two-hour fire rating. Concrete walls have essentially the same fire endurance-thickness relationship.

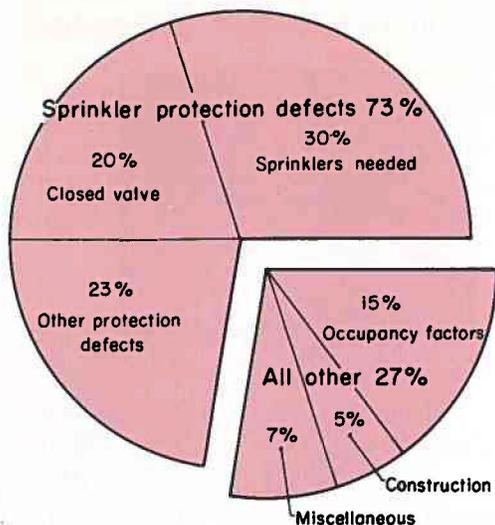


For hundreds of years brick masonry has been used successfully for fire resistance. This chart shows that two-hour fire resistance can be obtained with 4½ in. of brick masonry. (For fire resistance of concrete masonry walls, see *Firesafety in Residential Buildings*, SR172H, Portland Cement Association.)

A Word About Sprinklers

The basic function of an automatic sprinkler system is to protect life and property by extinguishing or controlling a fire until such time as the fire services can act. Historically, sprinklers have provided efficient protection, particularly for manufacturing and storage facilities. Sprinkler systems are essential in hazardous occupancies, for large floor areas, and where highly combustible contents are involved.

Automatic sprinkler systems can be used in conjunction with fire-resistive construction and compartmentation as a total system of firesafety. They should be required for hazardous areas and occupancies with highly combustible contents, but not to reduce structural fire resistance or replace compartmentation. Reducing structural fire resistance of walls and floors because of the installation of sprinklers may not be safe and is presently



This analysis of 666 fires in sprinklered factory buildings of over \$50,000 each, with a total loss of \$182 million, shows that 73% of the loss was incurred because of defects in sprinkler protection. Defects included closed valves (20%), insufficient sprinklers where fire started or entered (30%), and other defects such as inadequate water supply (23%). Source: Factory Mutual System.

not supported by experience. The record of sprinkler reliability is substantially less than is generally supposed or publicized.

For sprinklers to function in the event of fire requires that a valve be opened automatically or manually to activate the system. The sprinkler system must also be inspected and maintained on a continuing basis. This involves the possibility of human error or mechanical malfunctions that may lead to failure of the system at the time it is needed.

Reasons Sprinklers Fail

Here are a few of the many reasons for the failure of a sprinkler system:

1. Sprinklers shut off before fire.
2. Sprinklers shut off during fire.
3. Weak water supply—inadequate pressure or volume. Water pump failure.

4. Sprinkler piping clogged.
5. System out of service because of explosion, earthquake, or freezing.
6. Insufficient sprinkler protection (fire overwhelms system).
7. Piping or fittings broken.
8. Obstruction of sprinkler discharge.

Sprinkler systems are expensive and should not be required indiscriminately. They may be necessary as a life-safety measure but should never be used to justify lessening the structural integrity of the building. In the event of a sprinkler failure, all that stands between the fire and the safety of the building occupants is the protection afforded by the fire integrity of the structure, smoke control, and compartmentation.

Summary

High-rise buildings should be built with the following basic firesafety measures:

1. Two-hour or more fire-resistive construction so that structural failure will not occur should there be a burnout in any part of the building.
2. Compartments that will prevent fire from spreading and provide places of refuge for the occupants.
3. A sprinkler system, when practical, in addition to fire-resistive construction, compartmentation, and early-detection equipment.

Organizations represented on the CONCRETE AND MASONRY INDUSTRY FIRESAFETY COMMITTEE

BIA	Brick Institute of America
CRSI	Concrete Reinforcing Steel Institute
ESC&SI	Expanded Shale Clay and Slate Institute
NCMA	National Concrete Masonry Association
NRMCA	National Ready Mixed Concrete Association
PCA	Portland Cement Association
PCI	Prestressed Concrete Institute

PORTLAND CEMENT  ASSOCIATION

An organization of cement manufacturers to improve and extend the uses of portland cement and concrete through scientific research, engineering field work, and market development.

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