fire protection planning report

BUILDING CONSTRUCTION INFORMATION FROM THE CONCRETE AND MASONRY INDUSTRIES

NO. 10 OF A SERIES

Confirmed: Fire Losses in Multifamily Buildings Depend on Type of Construction

Fig. 1. A rapidly spreading apartment fire. Multifamily buildings built of combustible construction permit fire to quickly spread and endanger the lives and property of every occupant. Multifamily buildings should be designed and constructed so that each unit can sustain a complete burnout without affecting adjacent areas.

Highlights of This Issue

- As the fire resistivity of multifamily residences increases, fire losses—measured by extent of flame spread, average dollar loss per fire, and number of injuries per fire—all decrease.
- As the number of living units in multifamily residences increases, fire losses increase.
- In residences with over 20 living units and built of wood-frame construction, injury losses and property losses are significantly greater than in any other combination of construction type and building size.
- Recommendation: The use of wood-frame construction for multifamily residences with over 20 living units should be prohibited.

The second phase of a study of the relationship between construction type and fire losses in multifamily residences has been completed.

The new data strongly reinforce conclusions from the first phase that the fire-resistive qualities of construction play an important part in limiting losses from fire. Based on three measures of fire losses, the report shows a close relationship between construction type and extent of fire losses. As the fire-resistive qualities of a construction increase, fire losses decrease.

The report of the second phase (Ref. 1) was prepared by the University of Maryland's Department of Civil Engineering under a grant from the United States Fire Administration (USFA). The information was developed by analyzing data obtained from the USFA Fire Data Center using the National Fire Incident Reporting System (NFIRS). The second phase combines new USFA data with the data used in the first report.

U.S. FIRE LOSSES

Approximately 6500 fire deaths occurred in the United States in 1980. In addition, 30,000 civilians

and 98,000 firefighters were injured and over $6 billion worth of property was destroyed. Residences have the worst experience for loss of life and property from fire in the United States. They are responsible for over 80% of all fire fatalities, 70% of all injuries, and 50% of all property losses. (Ref. 2)

Approximately 20% of all residential fires occur in multifamily buildings. Very often these structures are built to the same standards and with the same type of combustible building materials as single-family homes. This multiplies the fire danger in multifamily buildings, because residents and their property are much more vulnerable to fire exposure resulting from the negligent actions of their neighbors than are people living in single-family homes.

DATA BASE

Fire data are collected by NFIRS from states voluntarily participating in the program. In the first phase of this fire-loss study, data were received from five states for 1975 through 1977. In the second phase, data for 1978 included 10 new states (see Fig. 2). Up to and including 1978, NFIRS has data on 59,495 fires in multiple family residences, of which 35,908 are fires with a known extent of flame damage.

The study was intended to investigate only the effect of construction type. Therefore, it was necessary to exclude fires that were confined to the area of origin since these small fires would not be significantly affected by the construction type of the structure. The NFIRS provided a data base of 8023 fires that met the required characteristics and were analyzed in the study.

CONSTRUCTION TYPE AND BUILDING SIZE

In addition to the relationship between construction type and fire losses, the size of these multifamily residential buildings was also investigated to determine the relationship between building size and fire losses.

The NFIRS coding system classifies construction into eight types, described in Table 1. All states except California follow this coding system. The NFIRS classification of construction types found in the model building codes is given in Table 4.

California classifies construction into four types, depending on the combustibility of major structural elements. Table 2 describes these four types.

Because of this difference the data are analyzed separately for California and for all states except California.

The NFIRS system describes the size of the building by the number of living units in each building. These building categories are listed in Table 3.

Table 1. NFIRS Construction Types

1. **Fire Resistive**
   A totally noncombustible building in which no structural steel is exposed and all vertical openings are protected by approved doors. The fire-resistant covering of the steel is typically very heavy: poured concrete, brick, concrete block, or similar material.
2. **Heavy Timber**
   A typical mill-constructed building in which the load-bearing walls or columns are masonry or heavy timber and all exposed wood members have a minimum dimension of two (2) inches. If steel or iron columns are used, they should be protected by a fire-resistant enclosure.
3. **Protected Noncombustible**
   A totally noncombustible building in which no structural steel is exposed. All vertical openings are protected by approved doors. The fire-resistant covering of the steel is typically light: gypsum board, sprayed fire-resistive covering, rated ceilings, and similar materials.
4. **Unprotected Noncombustible**
   A totally noncombustible building in which the structural steel is exposed to the effects of a fire.
5. **Protected Ordinary**
   The load-bearing walls are *masonry*. Columns are protected by a fire-resistive covering. The *underside* of all wood floor and roof decks is protected by a fire-resistive covering.
6. **Unprotected Ordinary**
   The load-bearing walls are *masonry*. Columns, wood floor and roof decks are exposed and unprotected from fire.
7. **Protected Wood Frame**
   Walls, roofs, and roof structure are wood framing. The interior wall and ceiling surfaces of habitable spaces are protected by a fire-resistive covering. *A brick-veneer building falls in this category because the wall structure is wood framed. But for any wood-frame building if the basement does not have a fire-resistive ceiling protecting the underside of the first floor, the building should be classified in the unprotected-wood-frame category.*
8. **Unprotected Wood Frame**
   Walls, floors, and roof structure are wood framing. There is no fire-resistive covering protecting the wood frame. A typical residential garage would fall in this category.

Table 2. California Construction Types

Type	Exterior wall	Interior wall	Floor and roof construction
A	N	N	N
B	N	N	C
C	N	C	C
D	C	C	C

N = Noncombustible
C = Combustible

Table 3. NFIRS Building Categories

Category	Number of units
I	3-6
II	7-20
III	over 20

Fig. 2. In the 1980 study ten additional states were added to the NFIRS program.

FINDINGS

The method of evaluating the contribution of construction type in minimizing fire losses is based primarily on the following three measures or parameters available from the fire data:

1. Extent of flame damage
2. Property loss in dollars
3. Injuries and fatalities

The reported findings of the study are as follows:

Fire losses (measured by flame damage, property loss, and injuries) in multifamily residences are dependent on type of construction. In particular, the following are construction types in decreasing order of ability to minimize fire losses:

Type 5 Protected Ordinary
Type 6 Unprotected Ordinary
Type 7 Protected Wood Frame
Type 8 Unprotected Wood Frame

For California the similar ranking is

Type A
Type B
Type C
Type D

Because data available for study are highly concentrated in construction types 5, 6, 7, and 8, the ranking is based on a comparison of these types only. However, data from all eight NFIRS types can be very useful in assessing the influence of building construction on fire losses. *From this study the general trend of the data reveals that as the fire resistivity of the construction decreases, fire losses increase.*

The investigation also determined that fire losses are dependent on the size of the structure. *Losses increase as the number of units in multifamily residences increases.* Of the building categories shown in Table 3, the greatest relative losses occur in Category III (over 20 units).

Of particular importance, *the data revealed that injury losses and property losses in residences with over 20 units and of wood-frame construction (types 7 and 8) are significantly greater than any other combination of construction type and building size.* This important finding is examined more closely in the following sections.

EXTENT OF FLAME DAMAGE

The extent of flame damage describes essentially the extent of the burned or charred area in the structure. According to the National Fire Incident Reporting System Handbook, the extent of flame spread "provides one means of describing the magnitude or seriousness of the fire" and "can be used for evaluating the effectiveness of built-in fire protection features designed to limit fire spread." "The confinement and extinguishment of a fire is influenced by many factors, including structural compartmentation." However, by analyzing "the extent of flame spread for many fires, the effect of individual factors [in this case, construction type] can be determined." (Ref. 3)

The effect of construction type on the extent of flame damage is best determined by analyzing fires that extend beyond the area of origin, called extended fires. Since the first barriers to the spread of fire in a residential building are the walls, floor, and ceiling assembly, the efficiency of these structural elements in confining the fire to the space of origin is measured in terms of the percentage of extended fires penetrating this first line of defense. Values are presented in Fig. 3.

Table 4. NFIRS Classification of Construction Types Found in Model Building Codes

Code	Construction type									
	Fireproof		Noncombustible			Heavy timber	Ordinary		Frame	
							Protected	Unprotected	Protected	Unprotected
BBC 1978	1A	1B	2A	2B	2C	3A	3B	3C	4A	4B
SBC 1976	I	II	—	IV-1	IV-0	III	V-1	V-0	VI-1	VI-0
UBC 1976	—	1-FR	II-FR	II-1	II-N	IV-HT	III-1	III-N	V-1	V-N
NBC 1976	Fire resistive		Limited combustible			Heavy timber	—	Ordinary	—	Wood frame
	Type A	Type B	Protected		Unprotected					
Md. study 1979	1		3		4	2	5	6	7	8

Note: A building meeting a model building code classification, such as BBC type 3B, would receive the NFIRS classification of type 5. However, a building classified as an NFIRS type 5 would not necessarily meet the specifications to be classified as a BBC type 3B.

Fig. 3A
Extent of Flame Spread
All States Except California

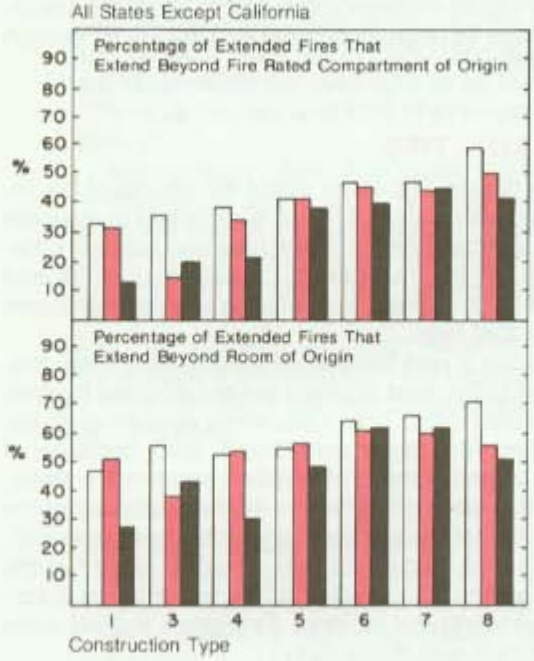


Fig. 3B
Extent of Flame Spread
California

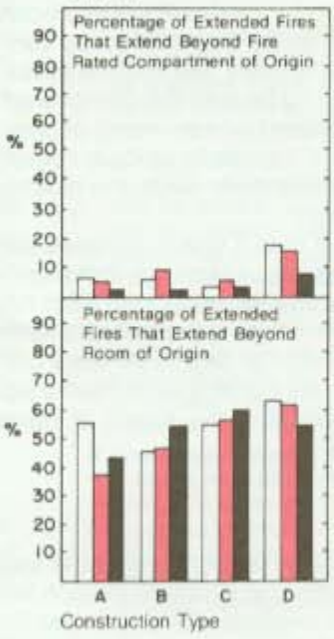
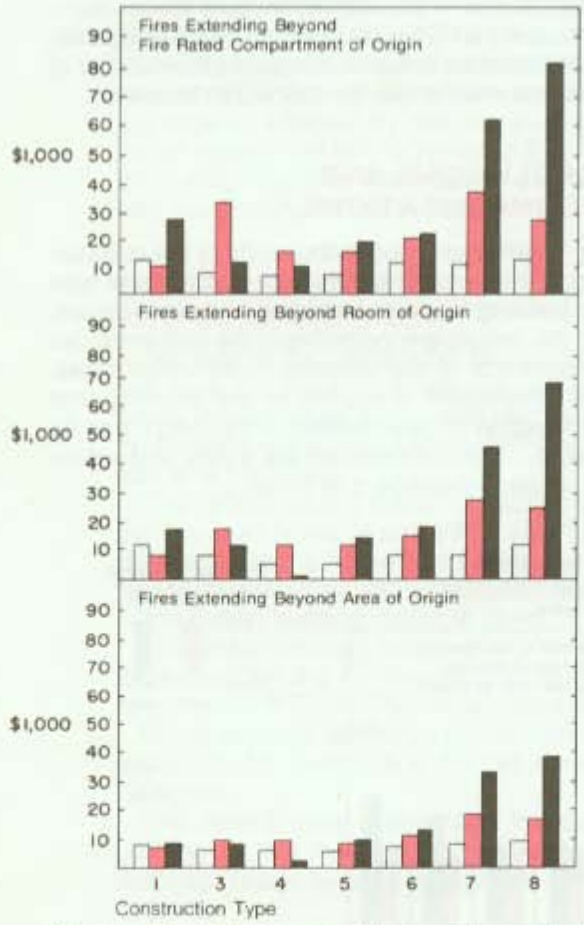
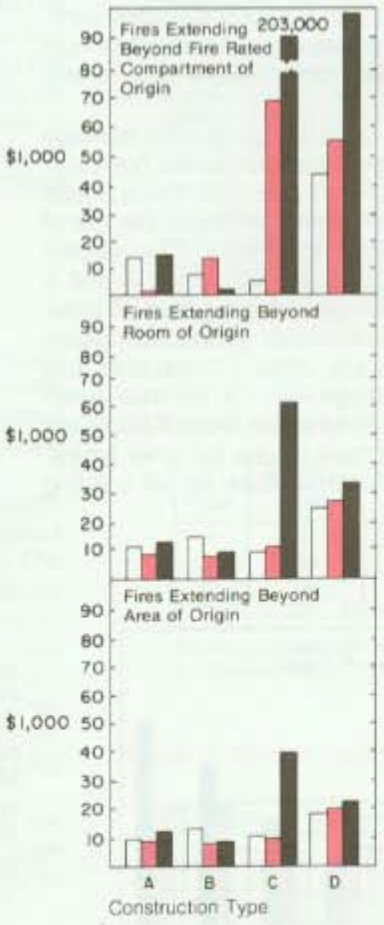


Fig. 4A
Average Losses Per
Fire in Dollars
All States Except California



Note: Insufficient data for construction type 2 (heavy timber) for statistically meaningful values.

Fig. 4B
Average Losses Per
Fire In Dollars
California



The data indicate that for construction types 5, 6, 7, and 8 (protected ordinary, unprotected ordinary, protected wood-frame, and unprotected wood-frame) and for all building categories combined (three units and over), *the relative probability of flames extending beyond the room of origin and beyond the fire-rated compartment of origin increases as the fire resistivity of construction decreases.* This is particularly evident in building category I (3 to 6 units).

From the California data it was determined that for all building categories combined (three units and over), the type of interior wall construction has a significant effect on reducing the extent of flame damage. Also, for buildings of 3 to 20 units both interior and exterior wall constructions have a significant effect on reducing the extent of flame damage.

PROPERTY LOSS

The NFIRS data provide an estimate of the total dollar loss for contents and structure in each fire. Fig. 4 indicates the average dollar loss per fire measured in terms of the extent of flame damage. Values were computed by dividing the total dollar loss by the corresponding number of fires. This information can be used to compare the relative performance of the type of construction and the effect of building size on fire losses. Those combinations of building size and construction type in which large dollar losses occur are readily identified.

The data reveal a large increase in fire damage measured by average dollar loss as the fire resistivity of the construction is reduced. There is also a marked increase in losses per fire as the size of multifamily residences increases. The largest losses occurred in construction types 7 and 8 (wood-frame) in buildings with more than 20 units. This particular combination produced losses much greater than any other comparable loss values. Even in buildings with 7 to 20 units, average loss per fire in construction types 7 and 8 are greater than the average values for other types.

Observing the California data for all building categories combined (three units and over), average losses in construction types C and D are nearly twice as large as comparable values for types A and B.

CASUALTIES

The greatest concern about the effects of fire relates to life safety. Thus, it is important to evaluate the effects of construction type and building category on the number of casualties (injuries and deaths) sustained by analyzing past performances in actual fires.

Since it was felt that casualties from fires confined to the area of origin are not affected by construction type, only casualties occurring in extended fires were considered. Also, because of the limited number of fatalities recorded, a statistically meaningful analysis was not possible for the fatality data, and only injury data were presented.

The injury data include persons injured at the scene as a result either of the fire or of the action of handling the incident. Firefighter injuries were included with these data.

Fig. 5 presents the number of injuries per 100 fires. *The data indicate for construction types 5, 6, 7, and 8 that an increase in injuries per 100 fires occurs as the fire resistivity of the construction is reduced.* This is particularly evident in structures with more than 20 units. *Also, all the data indicate a consistent increase in injuries as the number of units in a multifamily residence increases.*

CONCLUSIONS AND RECOMMENDATIONS

The information used in the study of the relationships between fire losses and construction type and building size was based on actual fire losses, and the results are indicative of the real-world fire performance of the different construction types. This information, if applied to the planning and construction of new multifamily buildings, can be most valuable in increasing life safety and reducing property damage due to fire.

Fig. 5A
Injuries
All States Except California

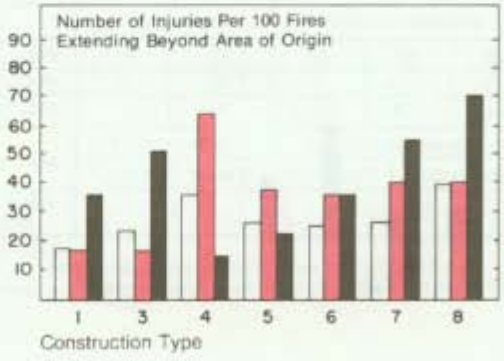


Fig. 5B
Injuries
California

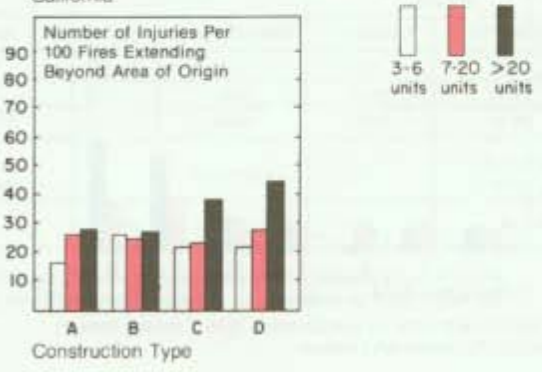


Table 5. Number of Living Units Issued Permits in United States (Thousands of Units)

	1978	1979	1980	1981
One and two family	1509	1643	859	714
Multifamily	466	617	465	407
% multifamily of total	24	31	35	36

Multifamily housing units represent an increasing portion of the housing market. *Source: F. W. Dodge—Contract Construction Awards*

The report recommends that "serious consideration should be given to prohibiting the use of wood-frame construction [types 7 and 8] in multifamily residences with more than 20 living units." This is based on the high average property losses and injuries experienced in this combination of building size and construction type. If the same fires had occurred in buildings of ordinary construction (types 5 and 6), the report estimates there would have been a 12% savings in the total dollar loss from fires extending beyond the area of origin and a 60% reduction in injuries.

As the mix of residential construction shifts towards an increasing proportion of multifamily residential units where residents are subject to the action of their neighbors, the potential increases for greater danger of loss of life and property from fire. See Table 5.

By using concrete and masonry in the construction of new multifamily buildings, the added safety of fire-resistive, noncombustible construction is provided. As identified in this study, the use of noncombustible construction is most effective in minimizing fire damage measured by extent of flame spread, dollar loss, and casualties.

By analyzing a large body of fire data, the importance of construction type in the firesafety of multifamily buildings has been evaluated. This information is important if rational decisions regarding firesafety are to be made based on reliable information of past performance. Since little information has been published about the performance of multifamily residential buildings in fires, this study represents a significant step forward in understanding fire behavior in such occupancies.

REFERENCES

1. *A Study of Fire Losses in Multi-Family Residences* by J. Colville and B. Behanami, Department of Civil Engineering, University of Maryland, 1982, prepared for the Federal Emergency Management Agency, United States Fire Administration. Available from National Technical Information Service—order No. PB82214701.
2. *Fire Facts*, 1982 Edition, National Fire Protection Association.
3. *National Fire Incident Reporting System Handbook*, Federal Emergency Management Agency, U.S. Fire Administration, National Fire Data Center, August 1980.

Fig. 6. Many communities are shifting some of the burden for fire protection to the private sector. Often they require all multifamily buildings to be built with fire-resistive noncombustible construction separating each dwelling unit in order to limit the spread of fire and contain it at a manageable size.

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Printed in U.S.A.

SR243.01B