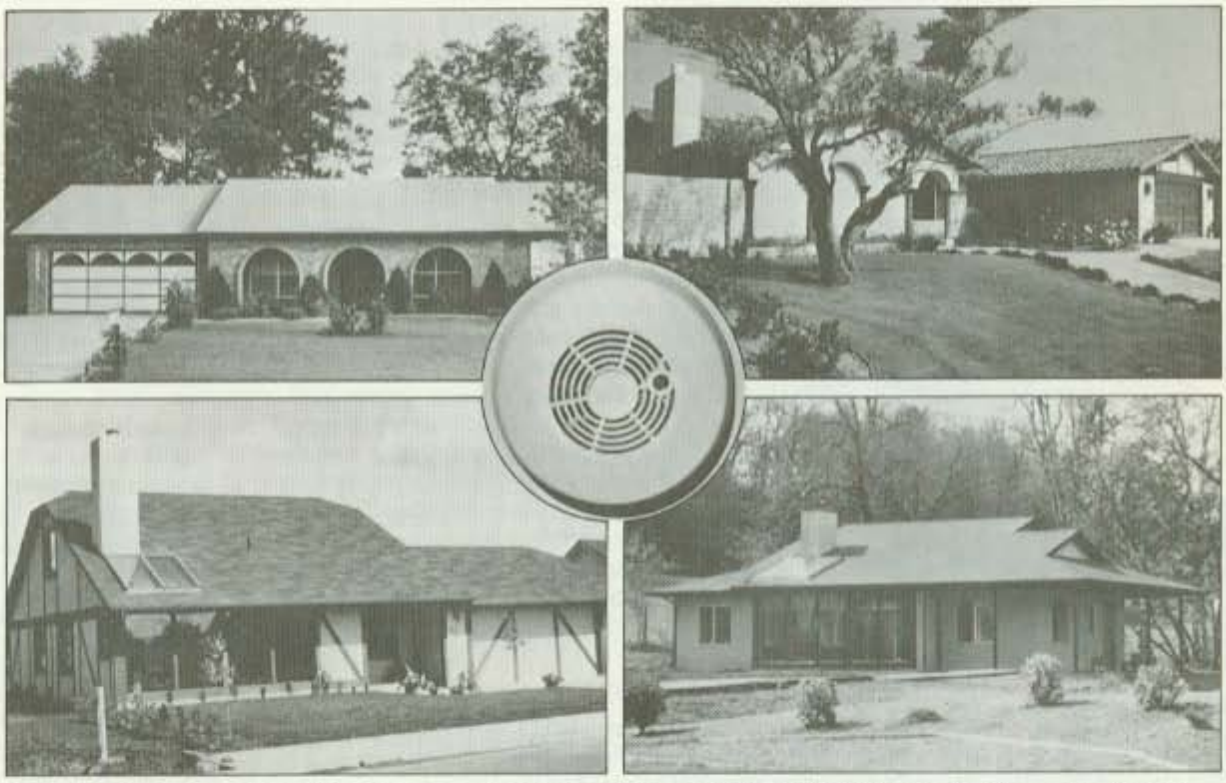
fire protection planning report

BUILDING CONSTRUCTION INFORMATION FROM THE CONCRETE AND MASONRY INDUSTRIES

NO. 12 OF A SERIES

Constructing Firesafe Single-Family Homes



Smoke detectors on every level of the house and an emergency escape plan are primary elements for home firesafety. Favorable room layouts and exit design, and use of noncombustible construction materials can be incorporated in the design to make homes more firesafe.

Single-family dwellings rank first in the incidence of United States fire losses. In 1981 the U.S. Fire Administration reported that of all structure fires, those in dwellings accounted for 27% of all property loss, 50% of all injuries, 52% of all fires, and 64% of all deaths. (See Table 1.)

Indications are that energy conservation efforts may be contributing to the fire problem in single-family homes. Introduction of cellulosic and plastic insulations and greater use of solid fuel and portable heating equipment have increased fire hazards. Contents of single-family dwellings are also changing. There are more electrical appliances and, consequently, more ignition sources. The expanded use of plastics in furnishings not only has added to the fuel load, but has also increased toxicity level of products of combustion.

Not all innovations and technological advances aggravate the fire problem. For example, the use of smoke detectors is beginning to reduce residential fire losses. Other innovations such as residential sprinklers and cable-operated alarm systems may also help cut fire losses.

Innovation and new technologies are also emerging in construction methods. The use of noncombustible materials in traditionally all-wood

Fig. 1 Where Fires Start
(All household fires: fatal and non-fatal)

Derived from *"Highlights of the National Household Fire Survey."* U.S. Department of Commerce, National Fire Prevention and Control Administration.

Fig. 2 Where Fatal Residential Fires Start

From *"A Study Of Fatal Residential Fires,"* NFPA No. FR72-1, 1972. © 1972 National Fire Protection Association.

houses is gaining acceptance as new building systems bring down costs. Using noncombustible building materials in a single-family dwelling offers several advantages. One is energy conservation. Concrete and masonry add thermal mass that helps lower fuel bills and reduce required levels of insulation. Passive solar designs that take advantage of this mass effect, as well as earth sheltered housing, are now quite popular. Another advantage is firesafety. Noncombustible materials will not add fuel to a fire nor support combustion in concealed spaces. They do not generate toxic gases or smoke and will act to confine and limit fire to the area of origin.

This report will examine the firesafety problems found in single-family homes and suggest ways to improve firesafety through proper design and construction. It will also explore new materials and systems that are making the use of firesafe noncombustible materials easier and less costly.

Where, When, How of Dwelling Fires

The first step will be to examine fire-loss statistics and the characteristics of residential fires. The "how" or causes of dwelling fires are presented in Table 2. Heating is the leading cause of fire, smoking the leading cause of deaths, cooking the leading cause of injuries, and arson the leading cause of property loss.

The time when dwelling fires are likely to occur is related to the leading causes. Most heating fires, for instance, occur between the hours of 5:00 a.m. and 3:00 p.m. and again between 6:00 p.m. and midnight. Cooking fires usually occur in late afternoon hours between 3:00 p.m. and 6:00 p.m. Arson fires are started after midnight to about 5:00 a.m. when detection is least probable. Fatalities usually occur at night when the occupants are asleep and are not immediately alerted to fire, smoke, and toxic gases spreading throughout the dwelling.

Where do dwelling fires start? These data are presented in Fig. 1, which was taken from the 1974 report, "Highlights of the National Household Fire Survey."(1) Data on the origin of fatal residential fires, presented in Fig. 2, were taken from the 1972 report, "A Study of Fatal Residential Fires."(2) Fig. 1 indicates that 65% of all fires start in the kitchen. Next is the living room with 12%. However, Fig. 2 shows nearly 40% of fatal fires begin in the living room, den, or family room, and the basement accounts for almost 26%. Although only 4% of all fires start in the basement, they are responsible for nearly 26% of all fatal fires. This indicates the severe danger associated with fire in basements.

Table 1. Federal Emergency Management Agency Estimates of Fire Loss by Type of Occupancy—1981

Causes	Fires	Deaths	Injuries	Property Loss
Dwellings	52%	64%	50%	27%
Apartments	14%	17%	16%	7%
Mobile Homes	3%	9%	3%	14%
Other Residential	2%	4%	4%	2%
Total Residential	71%	94%	73%	50%
Other Structural	29%	6%	27%	50%
	100%	100%	100%	100%
Total Structural	1,003,775	6,491	27,685	$5,910,593,000

Table 2. Federal Emergency Management Agency Estimates of 1981 Causes of Fire Losses in Dwellings

Causes	Fires	Deaths	Injuries	Property Loss
Heating	30.6%	12.5%	14.3%	17.5%
Cooking	14.5%	5.4%	19.8%	5.8%
Incendiary/Suspicious	9.9%	8.4%	7.8%	18.5%
Smoking	5.7%	25.5%	14.3%	6.4%
Electrical Distribution	7.0%	6.6%	6.4%	10.5%
Other	32.3%	41.6%	37.4%	41.3%
	100.0%	100.0%	100.0%	100.0%
Total Dwelling	522,175	4,144	13,851	$1,602,693,000

Basement Fires

The large number of fatalities resulting from basement fires should be a major consideration in

design and construction. A basement fire can burn undetected for a long time, transmitting toxic gases and smoke up through the house and trapping occupants on upper floors.

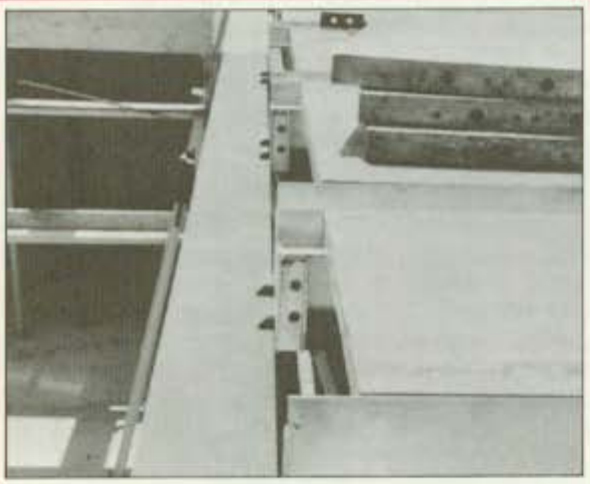
In an excellent report by E.L. Gallagher titled "Residential Fire Safety, Prevention Detection Survival Escape," [3] the basement is identified as one of the most dangerous rooms for a fire to occur. As Gallagher points out, data on fire origins do not account for the fact that 50% of U.S. homes have no basements according to Census Bureau statistics. [4] In households with basements, approximately 8% of fires start there and result in nearly 52% of the fatal fires.

The floor system above a basement is quite important. If combustible, as is usually the case, the floor will contribute fuel to the fire and readily permit passage of flames and smoke. The typical wood floor achieves a fire endurance of only 10 to 13 minutes before flame-through occurs. [5] Shortly thereafter it collapses.

Recent fire load surveys of single-family dwellings conducted by the National Bureau of Standards [6] indicate that the mean fire load (contents and finish) in basements of single-family detached homes is 17 lb per sq ft, and the total, weighted, mean fire load (contents and finish) for single-family dwellings is 13 lb per sq ft. These fuel loadings are high enough to warrant greater fire resistance in the floor assembly, perhaps 30 minutes or more for life safety and an hour or more for property protection.

Another concern in basement construction is the use of an all-wood foundation. Unlike a concrete block or cast-in-place concrete basement that can survive a severe dwelling fire, a wood basement may be totally destroyed. Some insurance companies will not insure homes with wood basements and others require higher premiums for them. Some communities, such as the city of Los Angeles, do not permit wood basements to be built.

Data for avenues of fire spread indicate that the lack of firestopping in wood walls and partitions and in ceiling and attic spaces is a primary means for fire spread. Fire can travel from a basement, through a wall assembly, and up to the first and second floors before it is detected. Open doors and stairwells also are primary avenues for flame and smoke. [7]



New Residential Floor Systems

The above photograph shows a new cast-in-place concrete joist floor-forming system for single-family residences. It is unique because the same forms used to cast the foundation walls are combined with new joist forms to construct a floor-form system quickly and economically. The 2½-in. slab has wire mesh reinforcement and the 7½-in. joists use one No. 6 rebar.

The completed floor has all the qualities of solid concrete construction—durability, no vibration or squeaks, and excellent noncombustible fire resistance—at a competitive cost.

Other concrete floor systems include precast hollow core planks and a combination of precast beams and cast-in-place floor slab.

For more information write: Director, Building Design and Construction Department, Portland Cement Association, 5420 Old Orchard Road, Skokie, Illinois 60077-4321.

Firesafe Design and Construction

Building codes and standards set a minimum level of fire protection for new construction. Often, however, this level of firesafety can be improved at little or no expense through proper design and construction. In addition, many of the features that increase life safety will also provide better property protection. The general principles of firesafety that need to be applied are:

1. Maximize occupant safety by using favorable room layouts, proper exit design, and automatic fire detection.
2. Minimize the development and spread of fire through the choice of proper materials and construction methods.
3. Minimize potential occurrence of a fire by proper installation of gas and electric utilities.

Room Layout and Exit Design

Favorable room layouts can improve firesafety by isolating locations where fire is most likely to start. Clear paths from basement to top floor and from living spaces to sleeping spaces should be avoided. All living and sleeping rooms should provide two ways of escape. One may be a suitable window. Exiting from the second floor can be improved if the windows open onto a porch, garage roof, or balcony. In two-story homes the second floor stairs should end near an outside door, and basement stairs should open away from the entryway.

Sleeping areas should be isolated from living areas and closed off with a door. All bedrooms should have doors, preferably of solid-core con-

Fig. 3 Applications of fire safety principles to a ranch home

FIRESAFETY FEATURES

1. Sleeping areas isolated from the living areas and closed off with a door
2. First-floor windows provide an alternate escape from sleeping areas
3. Exit from bedroom area is adjacent to outside door
4. Two ways out from all locations
5. Smoke detector outside bedrooms

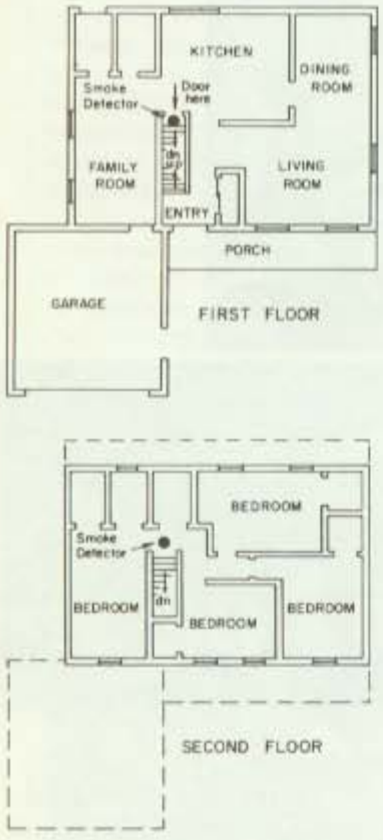


Fig. 4 Firesafety principles applied to a two-story home

FIRESAFETY FEATURES

1. Stairs from second floor sleeping area direct to outside door
2. Living spaces off-set from second floor stairway
3. Two ways out from living spaces
4. Second floor bedrooms have window opening onto a roof surface
5. Smoke detector at top of both stairs

struction. Adjoining garages, workshops, and utility rooms should be cut off by fire-rated construction. Lower floors should be separated from upper floors by a solid-core door. Similarly, the basement should be isolated from the first floor.[9] Examples of good spatial arrangement and exit design for a ranch and two-story house are presented in Figs. 3 and 4.

Smoke Detectors

Because of their ability to give early warning to both smoldering and flaming fires, smoke detectors are a primary element in home firesafety. Since most fatal fires occur during the evening hours when occupants are asleep, a smoke detector should be located outside each sleeping area. In addition, National Fire Protection Association Standards[10]recommend smoke detectors on each story of the family living unit including the basement. For increased protection it is recommended that additional detectors be considered in areas separated from smoke detectors by a door.

Materials of Construction

Interior finish materials are known to have a significant effect on life safety. They can affect the time to flashover, contribute to fire extension by flame spread over their surfaces, add fuel to the fire, and develop smoke and toxic gases. Noncombustible materials such as plaster, ceramic, concrete, concrete block, and brick are ideal materials since they do not contribute fuel, produce smoke, spread the fire, or emit toxic gases. They also can extend the time between ignition and flashover by 2 to 3 times more than a combustible material. Using these materials can provide a considerable increase in survival time in a burning building.[7]

"Construction materials should preferably be noncombustible or of low combustibility, contributing little, if any, fuel to a fire. They should resist passage of fire from one area to another, have low surface flame spread, and contribute little, if any, smoke."[9] Homes built of concrete, concrete block, and brick offer excellent fire resistance and receive preferred insurance premiums. These materials also offer superb durability and low maintenance. New systems have made their use more affordable than ever. (See boxed material.)

Firestopping

Barriers to restrict the spread of fire vertically inside walls and horizontally through ceiling spaces are required by building codes. This is called firestopping. The lack of firestopping in wood-frame construction provides a primary avenue for flame travel. Firestopping is often ignored by contractors trying to save time and money or unknowingly omitted by those who aren't aware of its importance.

Noncombustible concrete, concrete block, and brick require less firestopping than wood-frame

construction and will not support combustion in concealed spaces. Firestopping around openings in walls and floors for pipes and ducts is easily accomplished using mineral wool insulation.

Exterior Protection

The need for exterior protection depends on the surroundings. Obviously, combustible siding materials may be subject to ignition from adjacent building fires, brush fires, arson and malicious mischief, and even accidental outdoor cooking fires. Noncombustible exterior walls limit damage from both interior and exterior fires. Solid noncombustible construction or veneers of brick, concrete block, stucco, adobe, stone, and cement shingles are recommended.

Surface flame spread and smoke should be of particular concern when installing thermal insulation. Because glass fiber and rock wool are noncombustible, they are preferred. Cellulosic or foamed plastic insulation should be labeled as fire-retardant and covered with a thermal barrier, such as plaster or gypsum wallboard, or placed in the cores or cavities of masonry walls.

In attached single-family dwellings, 2-hour fire-resistant walls or fire barriers separating living units are particularly valuable. A concrete, concrete block, or brick wall from ground level through the roof can prevent the spread of fire from one dwelling to another.

Fire-retardant roof coverings are also important. A review of 119 conflagrations in the United States since 1900 indicates that wood-shingle/shake roofs were a contributing factor 58% of the time.[7] Roof covering is available with varying fire-retardant ratings; "A" for severe fire exposure, "B" for moderate exposure, and "C" for light exposure. Any one of these should be adequate unless there is a severe threat from adjacent properties or from brush fires; then, an "A" or "B" roof is recommended.

Utilities

The recent increase in use of solid fuel and portable heating equipment has led to a corresponding increase in the number of heating fires. The principal cause seems to be improper installation of equipment. Often the equipment is located too close to combustible construction or furnishings. Installation instructions should be carefully followed, and a professional installer should perform the work.

The wave of new electrical consumer goods and appliances entering the marketplace may also affect the number of electrical fires in dwellings. The basic circuit permitted by code in a new residence is typically a 15-amp grounded circuit using No. 14 wire. Installing a minimum 20-amp circuit (No. 12 wire) would increase capacity and margin of safety with little difference in cost.[9] Ground-fault circuit interrupters installed in each branch circuit can provide significant protection against electrical shock and electrical fires caused by high-resistance faults. If initially installed with the building's service equipment, there is little additional cost.[8]

Conclusion

Careful planning for room layout and exiting in the design of single-family homes can greatly improve firesafety. Also, the choice of construction materials figures significantly in regard to the development and spread of fire. Use of noncombustible materials is recommended since they

(1) Do not add fuel to a fire
(2) Do not support combustion in concealed spaces
(3) Do not generate toxic gases or smoke
(4) Will act to confine and limit the fire to the area of origin

Many new and innovative systems and materials have emerged that are making the use of firesafe noncombustible building materials easier and less costly.

Surface-Bonded Block

A Strong, Fast, and Inexpensive Alternative

Surface-bonded block is a method of laying concrete blocks without mortar. First, blocks are dry-stacked one on top of another. Then both sides of the wall are troweled with a portland cement coating mixed with chopped fiberglass for strength. The surface-bonded block walls can be used below and above grade. The method is fast, strong, and more economical than a block-in-mortar wall.

For more information write: National Concrete Masonry Association, P. O. Box 781, Herndon, Virginia, 22070.

GFRC Arrives On The Scene

Glass fiber reinforced concrete, or GFRC, is making its way onto the scene as a lightweight, inexpensive, noncombustible building material. GFRC is made of a portland cement and aggregate slurry reinforced with short glass fibers. The glass fibers, which are randomly dispersed throughout the mixture, prevent the propagation of microcracks.

Currently, GFRC is used primarily in lightweight building panels for new construction and renovations. GFRC single-skin panels are typically ⅜ in. thick plus the thickness of any exposed-aggregate finish. Multiple-skin panels, called sandwich panels, usually have two outer skins of GFRC, each ¼ to ½ in. thick and separated by an insulating core of expanded polystyrene foam, lightweight insulating concrete, or other thermal insulating material. This produces a panel with the desired thermal or fire-resistive properties. In addition to wall panels, GFRC is being used in all types of cladding units, permanent formwork, and roofing shingles.

GFRC is also entering the modular and mobile home market, primarily as a roofing and siding material. As indicated in Table 1, fires in mobile homes are responsible for a disproportionate number of deaths and property loss. The use of an economical noncombustible building material in modular and mobile homes will improve their firesafety.

For more information write: Prestressed Concrete Institute, 201 N. Wells St., Chicago, Il. 60606, or Director, Building Design and Construction Department, Portland Cement Association, 5420 Old Orchard Road, Skokie, Illinois 60077-4321.

A new house built with walls of glass fiber reinforced concrete and rigid polystyrene insulation is assembled in five hours. This new technology for affordable homes is available to all builders.

References

1. *Highlights of the National Household Fire Survey*, U.S. Department of Commerce, National Fire Prevention and Control Administration, 1974.
2. *A Study of Fatal Residential Fires*, NFPA No. FR 72-1, National Fire Protection Association.
3. *Residential Fire Safety, Prevention Detection Survival Escape*, Edward L. Gallagher, 1977.
4. *Statistical Abstract of the United States 1982-83*, U.S. Department of Commerce, Bureau of the Census.
5. *Fire Endurance Tests of Unprotected Wood-Floor Construction for Single-Family Residences*, B.C. Son, National Bureau of Standards, July 1973.
6. *Single-Family Residential Fire and Live Loads Survey*, Lionel A. Issen, Center for Fire Research, National Bureau of Standards, NBSIR 80-2155.
7. *The Effect of Structural Characteristics on Dwelling Fire Fatalities*, W.J. Christian, Fire Journal, January 1974.
8. *Fire Safety in Housing, A Manual of Recommended Design and Construction Practice*, U.S. Department of Housing and Urban Development, 1975.
9. *Home Safe Home, Fire Safety on the Job Begins with Fire Safety at Home*, Factory Mutual Engineering Corporation, 1978.
10. *Household Fire Warning Equipment*, Standard No. 74, National Fire Protection Association.

Organizations represented on the CONCRETE AND MASONRY INDUSTRY FIRESAFETY COMMITTEE

BIA	Brick Institute of America
CRSI	Concrete Reinforcing Steel Institute
ESCSI	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

Concrete and Masonry Industry Firesafety Committee

5420 Old Orchard Road, Skokie, Illinois 60077-4321

Printed in U.S.A.

SR252.01B