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
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.

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)

**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-
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 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.

"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 56% 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.

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**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 micro-cracks.

Currently, GFRC is used primarily in lightweight building panels for new construction and renovations. GFRC single-skin panels are typically 3/8 in. thick plus the thickness of any exposed-aggregate finish. Multiple-skin panels, called sandwich panels, usually have two outer skins of GFRC, each 1/4 to 1/2 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-resistant 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, Ill. 60606, or Director, Building Design and Construction Department, Portland Cement Association, 5420 Old Orchard Road, Skokie, Illinois 60077-4321.

References


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

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