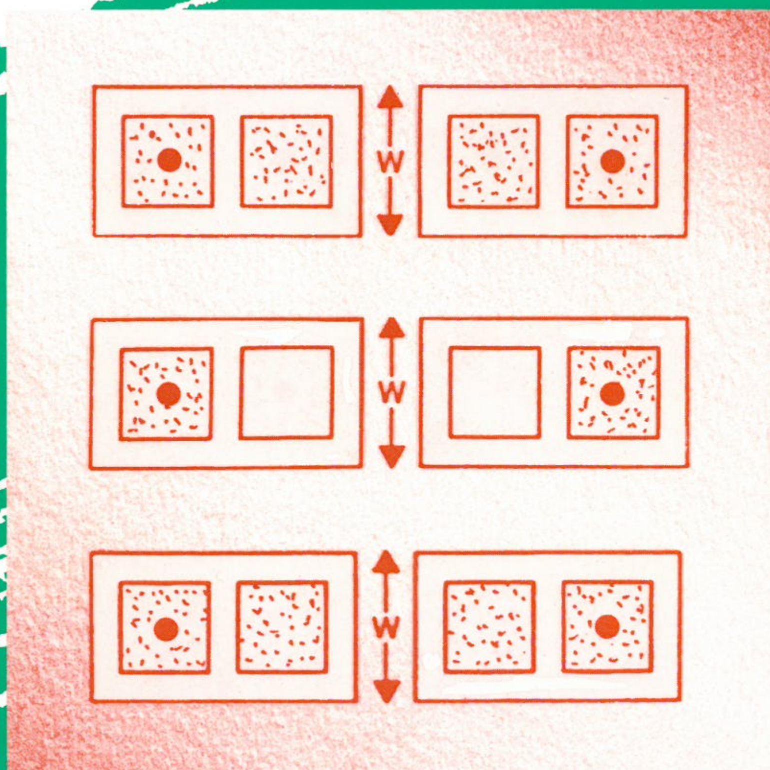
Fire Resistive Construction Using Concrete Masonry



Concrete Masonry Association
of California and Nevada

Fire Resistive Construction Using Concrete Masonry

Using concrete masonry to provide built-in fire resistance is the subject we discuss in **Fire-Resistive Construction Using Concrete Masonry.** We begin by asking the question, "Why Use Concrete Masonry?" We'll answer by discussing the multi-functional attributes of concrete masonry which enhance its utility as a fire-resistive construction material. You'll learn about the fire performance characteristics of concrete masonry including its inherent fire resistance qualities and noncombustibility. Applications requiring fire-resistive construction will be pointed out along with specific design criteria for determining how to select concrete masonry units to achieve the desired or required fire resistance ratings. All of this and more is contained in **Fire-Resistive Construction Using Concrete Masonry.** This booklet is one of a series describing the complete range of performance qualities of concrete masonry. Please contact the publishers for more information.

PREFACE

For the designer concerned with either satisfying fire code requirements or providing for a client's additional life safety and property protection needs, concrete masonry is an effective and cost efficient solution. Using simple proven construction techniques, concrete masonry assemblies have demonstrated continuing structural performance even after severe fire exposure. As part of a series of design guidance booklets, **Fire Resistant Construction** shows how this multi-functional product can provide fire resistance to separate adjacent buildings, isolate hazard and protect property and lives.

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SECTION 1 WHY USE CONCRETE MASONRY?

Although well known in the construction industry for its excellent fire-resistive and noncombustible qualities, concrete masonry is often overlooked as a truly multi-functional construction product. Concrete masonry, when properly integrated into a building design, can serve many useful purposes to achieve total building performance. This can be done both efficiently and cost effectively if the designer takes into consideration the multiple characterisitcs that concrete masonry possesses.

Obviously, concrete masonry can serve to provide a high degree of fire resistance to separate adjacent buildings or multiple uses, isolate hazards, or to provide protection of one occupant or tenant from another. It can be used to satisfy code requirements for occupancy separations and area separations as well as the needs of insurance underwriters for subdividing buildings for the purpose of determining the maximum insurable loss or to isolate fire hazards. It can also be used to provide highly fire resistive separations between individual dwelling units in a multi-family residential occupancy (apartment building) or between guest rooms in a hotel or motel. Concrete masonry can serve to protect building occupants from the careless acts of their neighbors.

Concrete masonry is also noncombustible and, therefore, will not contribute to the growth of a fire in an area enclosed with concrete masonry walls. It can contain a fire to the room or area of origin and can protect the interior of the building from an adjacent building fire or other outside exposure fire. It can prevent mass conflagration fire scenarios involving many buildings such as those recently experienced in apartment complexes in Anaheim, CA. and Dallas, TX. where fire spread via combustible exterior walls and roofs. Because it does not burn, concrete masonry will not contribute to the production of smoke or other toxic products that are off-gassed during a fire. It can actually help to contain such by-products of fire by standing steadfastly in place to resist the spread of fire and smoke to other areas of the building. Its excellent noncombustibility characteristics and inherent fire resistance make concrete masonry a wise choice to combat the consequences of fire.

1.1 Versatility of Concrete Masonry

Concrete masonry is also an excellent load bearing material which can be used to form bearing walls to support the structure of the building. Reinforced concrete masonry can be used to construct buildings many stories high. Properly located bearing walls can also serve as fire separation walls to subdivide a building into smaller compartments to prevent large scale fire spread throughout a given floor area or to isolate fire hazards. Load bearing exterior walls provide additional protection against exterior fire exposure and help to contain a fire within the building to prevent it from exposing adjacent structures. In areas where wildland fires may be prevalent, concrete masonry exterior walls can offer the building owner a great deal of security and relieve his fear of the devastation such fires can cause.

Concrete masonry can also be effectively used where sound control is either mandated by codes or desired by the building owners or project developers. Its mass tends to dampen sound transmission and reduce noise, especially in the higher frequency ranges. This is important in sound-sensitive occupancies such as multi-family residential apartment buildings, hotels, and motels. In these types of structures, the multi-functional uses of masonry can best be demonstrated by the separation walls between occupants or guests. They can be used not only as fire barriers to separate guest rooms or apartments but also as load-bearing walls designed to reduce sound transmission. This is truly an example of the multi-functional benefits of concrete masonry.

Another area where masonry is finding its way into more prevalent use is in those jurisdictions where passive solar heating and cooling are being mandated by state and local codes or where energy conscious building owners realize the need to reduce their energy costs. Concrete masonry performs a useful function in reducing total energy costs by serving as internal thermal mass walls for the purpose of thermal energy storage. Such walls can also serve other useful purposes as described above. These walls can work silently to help the building cope with the extreme demands of summer and winter. Proper design of glazing and overhangs in conjunction with thermal storage walls can result in reduced heating costs in the winter as well as reduced cooling costs in the summer.

The internal thermal mass of concrete masonry walls allows it to absorb significant heat during the day to be released after the sun has gone down to continue to warm the house. This thermal lag then helps to keep the house cool during the summer months by absorbing the heat created by the warm summer days and releasing it to the outside through vents and fans at night when the outside air is cooler. This thermal lag can be determined based on the thickness of the masonry wall for the given climatic conditions and passive solar designs.

Because masonry is durable and requires low maintenance, its life cycle costs are significantly less than other more conventional building materials. Its ease of inspection during construction allows it to be erected quickly and with little delay which would otherwise occur waiting for a building inspector to arrive on the scene to inspect framing elements before they are closed in. This attribute of concrete masonry alone could prove invaluable in a large multi-building project where the time to complete the project is critical in terms of getting the project into the marketplace and reducing the high costs associated with construction loans.

Because of its inherent fire safety and because it is truly a multi-functional building product, concrete masonry is the ideal choice for many construction projects. When the total costs of a project are considered (including the life cycle costs for owner-retained projects), it becomes very obvious that concrete masonry is the right choice.

1.2 Fire Performance Characteristics of Concrete Masonry

Since concrete masonry is inherently fire resistant and noncombustible, it does not rely on any special additives, fire retardant treatments, or "gimmicks" to provide the necessary fire resistance and noncombustibility codes and insurance companies mandate and the public demands. Furthermore, concrete masonry walls used as fire separations can be readily constructed and require little inspection whereas other materials and methods of fire-resistive construction often require complex and intricate construction techniques to achieve a fire-resistive rating. This can result in time delays associated with detailed inspection requirements. Other materials cannot even be rendered noncombustible with fire retardant treatments or special applications and, therefore, cannot qualify for many situations where codes and standards require noncombustible construction throughout a building. Obviously, the less combustibles used to construct a building means the less opportunity for fire to gain a destructive foothold.

Later on in this manual design criteria will be provided to indicate how the fire resistance rating of a concrete masonry wall can be determined based upon its "equivalent thickness" and the aggregate used to manufacture the concrete masonry unit. Concrete masonry walls can provide fire resistance ratings from one hour up to four hours and more with as little as 4" nominal block. Because of its inherent noncombustibility and fire resistivity, it can stand up to the most severe fire exposures with little but superficial damage resulting. It is extremely stable when exposed to fire. Concrete masonry walls are resistant to penetration by falling debris or objects. Many tests and actual fire experience have shown that concrete masonry walls can withstand the impact, thermal shock, and eroding effects of a pressurized water stream discharging from a fire hose nozzle immediately after being exposed to fire temperatures in excess of 2,000°F for durations of more than 4 hours. The resultant damage is often nothing more than superficial crazing. With a fresh coat of plaster, the masonry wall can be placed back in service almost immediately.

Other studies have shown that the strength of concrete masonry walls after fire exposure is usually sufficient to allow them to be continued in use without the need to make structural repairs. This is an extremely important benefit in the use of concrete masonry walls in those occupancies where the relative frequency of fire is high such as in multi-family residential apartments. The excellent fire performance of concret masonry coupled with its inherent strength, ease of repairability, and durability makes concrete masonry the logical choice to use for fire barriers and bearing walls to separate individual tenants in a multi-family housing project. Because it withstands fire so well and rquires virtually no repair after fire exposure, it allows a multi-family building to be put back in use almost immediately and prevents adjacent tenants from having to be relocated while repairs are made. Concrete masonry walls can be used to contain a fire to the unit of origin and thus prevent the disruption of the living conditions of the other occupants in a multi-family building. This could be a most desirable characteristic in a highly competitive rental market.

Because concrete masonry is also highly resistant to penetration, it is less likely to be violated by the building occupants and thus will remain as a durable fire-resistive barrier to separate adjacent occupants. Other wall assemblies containing structural concealed spaces can be readily violated and their fire resistance severely impaired by penetrations for telephone and electrical wires, plumbing and mechanical piping, and access openings. Furthermore, it is not uncommon to find large openings created in other types of readily penetrated fire separation walls in order to allow for the passage of persons and machinery without providing the appropriate protection of those openings. This is a rare event with a concrete masonry wall since it requires a great deal of effort to create a door opening where it was not originally designed.

Documented inspection reports by local fire departments have clearly demonstrated that fire separation walls constructed of other than concrete masonry are often violated by various penetrations or openings, thus negating their benefit as a fire separation intended to contain fires and prevent them from spreading from one side of the wall to the other.

SECTION 2 USES OF CONCRETE MASONRY FOR FIRE RESISTIVE DESIGN

Concrete masonry walls can serve many useful functions while satisfying state and local code requirements as well as insurance underwriters' criteria for insurable risks. Such walls can be used to provide fire-resistive building separations or serve as compartmentation walls to contain fire within specific area limits of the building, to separate hazards or to create areas of refuge, for example. They may also be used to provide tenant separations and enclose elevator lobbies.

Concrete masonry walls can provide excellent fire protection for various shaft enclosures including exit stairs, define areas of refuge by creating horizontal exits, and protect exit passageways. Concrete masonry walls can also serve as fire-resistive exterior walls to contain fire within a building and to protect the building from fires in adjacent buildings or from other exterior fire exposures including wildland fires.

Other fire-resistive design uses of concrete masonry include fireproofing steel columns and the physical protection of less durable types of fireproofing used to protect steel columns. It can also be used where noncombustible construction is required.

2.1 Building Separations

One of the most prevalent uses of concrete masonry is in the construction of area separation walls which subdivide a building into smaller separate and distinct buildings for the purpose of applying requirements of the building code. Such area separation walls, in effect, function similar to fire walls required by insurance companies for the ultimate protection against fire spread. By creating such "fire walls," concrete masonry area separation walls can be used to limit the size of the building in order to reduce the costs of construction mandated by the building code. The smaller the floor area, the less fire resistive and noncombustible the separated buildings must be to satisfy code requirements. The proper location of area separation walls used to reduce the area of the buildings separated by such walls can also result in the avoidance of automatic sprinklers where state and local building codes may require sprinklers based upon the area of a building or the number of dwelling units, apartments, or hotel or motel guest rooms.

Because an area separation wall defines separate buildings, wherever an area separation wall is installed, the structures on both sides of that wall become truly separate buildings. Thus, other provisions of the code can be applied separately to each building rather than to the entire structure as a whole. Other examples where code requirements can be avoided by installing area separation walls include the elimination of fire alarm systems and standpipes. Since many jurisdictions have sprinkler ordinances based on the calculated fire flow for the building, subdividing the building into smaller areas with area separation walls can reduce the required fire flow and thus eliminate the requirement for automatic sprinklers.

Fire walls normally required by insurance underwriters are intended to minimize the total risk to which an insurance company will be exposed should a devastating fire occur. Fire walls are intended to stop a fire dead in its tracks and prevent it from spreading to the other side of the fire wall. A fire wall is expected to perform even if the automatic sprinkler system should fail. Thus, it represents the ultimate in passive fire protection and stands as a demarcation of the maximum forseeable loss that an insurance company considers when developing its insurance rates for a given structure. When a building is subdivided by such fire walls, insurance rates can often be significantly reduced because the total area of insurable building at risk is reduced. Often, insurance companies will relax their requirements for other built-in fire protection features when fire walls are provided.

2.2 Compartmentation

Area separation walls and fire walls constructed of concrete masonry represent one form of compartmentation on a large scale. However, on a smaller scale within an individual building or area of a building defined by area separation walls of fire walls, compartmentation is an important concept for providing a reasonable level of fire safety for the protection of the building contents as well as the building occupants. Proper use of compartmentation walls to subdivide floor areas can result in significantly lower fire losses due to the containment of fire and smoke spread. Consequently, a reduction in additional damage incurred during fire fighting activities may also result.

Inherently stable and fire-resistive concrete masonry compartmentation walls will stand up to and resist the most severe fire exposure without significant damage, deterioration, or structural failure. Such compartmentation walls can be used to separated different occupancies where the code mandates fire-resistive separations or to provide smoke barriers to protect against smoke spread from one area of the building to another. This is especially important in those occupancies where people may be sleeping or where they may be under institutional care and unable to take care of themselves in a fire emergency.

Obviously, concrete masonry walls can be extremely useful in the separation of fire hazards from the rest of a building. Such hazards may be represented by the storage and use of flammable and combustible liquids or for storage of combustible goods, for example. Separation of hazards may be mandated by insurance underwriters to minimize the risk from fire or by risk managers and loss prevention personnel who have identified those high risk areas of their building which need to be properly separated in order to control the risk posed to the rest of the building by an unwanted fire. Such separations of hazards can greatly assist corporate policy makers in setting up their fire insurance or self-insurance programs and appropriately managing their risks while ensuring continuity of operations. Fires that originate in high risk areas isolated and enclosed by fire resistive concrete masonry walls will have minimal impact on the rest of the building since the masonry walls will do their job to contain the fire to the compartmented risk.

Compartmentation may also serve the important function of creating areas of refuge into which people can exit on the same floor of a building to escape the ravages of an unfriendly fire. This can be an extremely useful tool for the designer who wishes to eliminate additional exit stairs that take up valuable space in buildings or to reduce travel distances to required exits. It is also helpful in those occupancies where people are not able to move on their own accord. They can be moved horizontally by staff rather than evacuated down exit stairs which would require much more time and effort as well as a great deal of supervision. Properly designed area of refuge compartmentation walls using concrete masonry can provide as much as 2 to 4 hours of fire protection. Protected by such walls, the occupants can wait out the fire until the fire department arrives and extinguishes the fire.

Elevator lobbies enclosed with concrete masonry walls may also serve as areas of refuge for the handicapped from which they can be evacuated via the elevators. Handicapped persons can feel more secure knowing they are waiting in an area enclosed by concrete masonry walls which will protect them against the attacking fire until they can be rescued by the fire department. These compartmentation walls used to enclose elevator lobbies can also protect against the vertical spread of fire and smoke via the elevator shafts which has been shown to be a prevalent mode of fire and smoke travel in tall buildings such as witnessed during the MGM Grand Hotel fire, for example.

Compartmentation walls can also serve as tenant separation walls where either the building code mandates them or it is desirable to provide fire-resistive separations between occupants or tenants in the same building. These concrete masonry walls can provide an excellent fire-resistive barrier between individual dwelling units in a multi-family apartment building or between individual guest rooms in a hotel or motel. Occupants who may be asleep and thus not aware of a developing fire condition created by their neighbor or an adjacent occupant can sleep easier knowing that concrete masonry fire-resistive compartmentation walls separate them from their neighbors' negligent acts.

Tenant separations of such occupancies as multi-tenant warehouses or offices can provide not only fire-resistive separations but security separations to protect the valuables of one tenant from the adjacent tenant or even from outside intervention. Because concrete masonry walls are so difficult to penetrate, they are less likely to be violated and will remain secure and in place for an indefinite period of time. They can also stand ready to resist the ravages of fire and prevent it from spreading to other tenants in a multiple tenant building. This can prove invaluable in maintaining a building in the marketplace and keeping it in operation with minimum turnaround after a fire. Statistics have clearly shown that most businesses that suffer a severe fire very seldom recover, even when they have adequate insurance. Therefore, any fire that spreads from one tenant to another is likely to cause a loss of multiple tenants and the subsequent demise of the building as the tenants go elsewhere to find rentable space.

2.3 Shaft Enclosures

Vertical shafts in buildings are usually the culprit in allowing fire and smoke to spread rapidly to floors remote from the fire floor. There have been numerous documented cases where fire extension has occurred because of improperly protected shafts. Concrete masonry is an excellent product to use for the construction of shaft enclosures because of its inherent fire resistance and noncombustibility and because of its stability and durability both during and after a fire exposure.

Utility shafts used to house mechanical systems including duct work and return air plenums, plumbing shafts, and electrical raceway shafts can all be readily protected with concrete masonry walls. Such walls can be easily erected from the floor side of the shaft. Where the utilities pass into or out of the shaft and through the concrete masonry enclosure, they can be properly fire stopped using a variety of materials and methods now available in the marketplace which have been specifically tested to prove that such penetrations can be made through these walls without degrading the fire resistance rating and integrity of the shaft enclosure. Thus, smoke and fire can be stopped in their tracks and prevented from spreading to multiple floors beyond the floor of fire origin.

More importantly, elevator shafts enclosed with fire-resistive concrete masonry walls can not only prevent vertical fire spread but also protect the elevators from fire damage so that the fire department can use them to fight fires in tall buildings. Obviously, elevators should not serve as exits; however, they can provide a ready means of access to floors well above ground level and save the fire department much valuable time, energy, and manpower trying to reach the seat of the fire. If the elevator cab and cable as well as the operating machinery are properly protected with fire-resistive concrete masonry walls, there is little chance that the fire will threaten the operation of the elevators. Then they could successfully be used by the fire department during fire fighting operations.

Because concrete masonry walls are stable under fire exposure conditions, they will not tend to buckle or bend so as to create openings between the floor slab and the wall itself or allow cracks to occur through which fire and smoke can then gain access to the shaftway. They will also maintain their integrity while objects may be falling from the concealed ceiling space. Such objects might otherwise penetrate a wall not constructed of concrete masonry and impair its fire-resistive effectiveness.

Probably the most important shaft enclosure is that used to enclose the exit stairways in a multi-story building. Since stairways are generally required to have a 2-hour fire resistance rating, concrete masonry walls make an ideal choice to protect the occupants using such enclosures to escape the building.

Stable concrete masonry walls can allow the occupants adequate time to use the stairways to escape to grade level while keeping them protected from the extreme heat, flames, and smoke generated by a fire. Concrete masonry's excellent thermal resistance to heat penetration makes it a good choice to provide protection of the building occupants in stair enclosures.

Stair enclosures can serve a dual function by also providing the fire department with safe access to the fire floor or the floors above the fire floor in order to check fire extension or to rescue occupants. Stair enclosures protected with concrete masonry walls can remain tenable and relatively cool for more than enough time to allow fire fighters to successfully control and extinguish the fire. They can serve as an area for fire department staging operations. In the stairway fire fighters can connect their standpipe hoses and make their attack on the fire floor. Such protection would certainly instill confidence in the fire fighters because they are protected by durable and stable concrete masonry fire-resistive walls. Similar points can also be made for elevator lobby enclosures using concrete masonry walls since they not only serve as an area of refuge for handicapped occupants, for example, but they can also serve as a staging area for fire department operations including rescue.

In evaluating the excellent fire performance characterisitcs of concrete masonry walls, it becomes readily obvious that they are the most logical choice to protect and enclose vertical shafts in multi-story buildings to prevent the vertical spread of fire and smoke.

2.4 Exterior Walls

Typically, building codes require exterior walls in close proximity to interior lot lines or adjacent buildings to have a fire resistance rating in order to protect the adjacent building from a fire within the building or to protect the building from an adjacent building fire. Concrete masonry is well suited to meet the code requirements for fire-resistive exterior walls. Not only can they resist direct flame impingement, but they also have excellent resistance to radiant heat.

Many construction types also require bearing walls to have a fire resistance rating. Where bearing walls are also exterior walls, then the use of concrete masonry can take advantage of the excellent load bearing and fire-resistive characteristics of that material to satisfy both code requirements. Again, because of concrete masonry's inherent noncombustibility, fire resistance, and structural stability, it can prove to be an excellent material for exterior wall construction in these applications. Not only will the concrete masonry wall withstand exposure from exterior fires such as adjacent structures, wildland fires, etc., but it will also contain a fire within the building to prevent it from exposing adjacent buildings or other exposures while also remaining in place to support the building structure.

Just as importantly, noncombustible concrete masonry exterior walls can prevent the ignition of a building when exposed to a brush fire or other exterior fire, thus avoiding the type of fire storm that occurred in apartment complexes in Anaheim, CA. and Dallas, TX. Those fires involved rapid fire spread through multiple apartment buildings which had combustible exterior siding as well as wood shake roofs. Such an occurrence would be highly unlikely in building developments constructed with concrete masonry exterior walls.

2.5 Exits

Exit construction is probably the most critical component of buildings and one most closely regulated by the building codes. Since it is essential that occupants be able to safely escape or move to a safe area during a fire, the exit components used to provide that level of protection should be reliable, durable, and able to provide the required degree of fire resistance without compromising the exit system. Concrete masonry walls provided to protect exits are an ideal solution.

The exit system of a building generally starts with 1-hour fire resistive corridors that connect occupied spaces with the exit stairs or provide passage to an area of refuge through a horizontal exit. The exit stairs provide a protected path of travel (enlcosure) that leads to the exterior of the building either directly or through exit passageways to the exterior of the building. Exit passageways may also be used to solve travel distance problems in very large floor areas by providing a highly protected path of travel from any location on a floor to the exterior of the building or to an exit stair enclosure. Horizontal exits can also be used to subdivide very large floor areas or long buildings so as to provide areas of refuge and reduce the need for additional exit stairs or exterior doors that would otherwise be required to satisfy travel distance limitations or to provide additional exit width.

It is critical that exit stair enclosures especially in high rise buildings provide sufficient integrity and fire resistance to withstand any anticipated fire to allow the occupants a safe path of travel out of the building. Because vertical shafts are a prime pathway for fire, smoke, and hot gas spread through buildings it is doubly important to insure that vertical stair enclosures are properly protected. The occupants of the building must be assured a safe path to escape the fire floor, and stairs should not serve as a conduit to spread fire and smoke throughout the building. Furthermore, the responding fire department may use the exit stairs to gain access to the fire floor and as a staging area for fighting the fire.

A special type of stair enclosure known as a smokeproof enclosure provides even more reliable protection of the exit stair enclosures by the use of a separate ventilated vestibule which is intended to capture any smoke before it can enter the exit stair enclosure. These vestibules provide an excellent location from which the fire department can make their initial attack on the fire floor. Many fire departments prefer to use the exit stair enclosures to reach the upper floor rather than relying on the elevators which may not perform reliably under fire conditions.

Concrete masonry with its high degree of fire resistance and its inherent noncombustibility will remain in place during the most severe fire exposure and thus maintain the integrity of the exit stair enclosures for reliable and safe exiting. Because concrete masonry is not likely to be penetrated by maintenance personnel or other persons interested in installing various utilities throughout the building or by falling debris during a fire condition, it provides for a high degree of integrity against fire exposure.

Where 1-hour corridor walls are required such as in a multi-family apartment building or a hotel or motel, concrete masonry walls can be used to provide the fire-resistive protection as well as to serve to reduce sound transmission between the corridor and the apartment unit or hotel guest room. Such corridor walls may even serve as bearing walls to take advantage of the excellent load bearing capabilities of concrete masonry. By using concrete masonry for the construction of these walls, there are no combustible concealed spaces for fire, smoke and hot gases to spread through. Because concrete masonry is extremely stable under fire exposure conditions, there is less likelihood that fire door frames will warp or the walls deform causing gaps to occur between either the door and the frame or the frame and the wall. Such gaps would allow smoke, flame, and other products of combustion to escape from the room of origin and threaten the protected exit enclosures.

A technique for reducing the number of required exit stairs in multi-story buildings that is not often considered by designers is the horizontal exit. A horizontal exit is simply a 2-hour fire-resistive wall that completely subdivides a floor into separate areas known as areas of refuge. Such walls are continuous from outside wall to outside wall and through all concealed spaces and are constructed tight to the underside of the floor or roof slab above. Fire doors in these walls are considered exits and travel distance can be measured to these doors, thus eliminating the need to provide an exit stair to satisfy travel distance requirements. Horizontal exit walls can also be used to increase exit capacity since the width of the doors in these walls can be added to the exit width serving the area separated by the horizontal exit wall.

For example, in a building where the travel distance to an exit is limited to 150 feet, the exit stairs are connected by a 1-hour fire-resistive corridor, and the travel distance within the room or space adjacent to the corridor is 50 feet; then the remaining allowable travel distance would be 100 feet. Therefore, the greatest separation allowed between exit stairs would be 200 feet. However, if a horizontal exit wall is installed to subdivide the building in half, the travel distance could be measured to the fire doors in the horizontal exit wall, doubling the distance between exit stairs to 400 feet for this example. Thus, in relatively long buildings, horizontal exit walls can provide an economy in construction as well as additional space by eliminating the need for another exit stair. Where it may be desirable to minimize the width of the exit stairs in large area buildings, horizontal exits may be used to provide additional exit width up to a maximum of 50% of the total exit width required.

The perfect choice for constructing such horizontal exit walls is concrete masonry because of its high degree of fire resistance and its excellent stability under fire exposure conditions. Also because of its thermal mass, it will tend to keep the temperature in the area of refuge tenable for a long period of time which gives the occupants additional safety. They can move horizontally to the area of refuge where they can remain until the fire is extinguished or they are rescued. This approach to exiting is especially critical in buildings where the occupants are not capable of self-preservation under emergency conditions such as in hospitals, nursing homes, and other institutions. Thus, they can be evacuated horizontally from the fire area to an area of refuge on the opposite side of a horizontal exit wall.

Exit passageways are used to connect exit stair enclosures located in the interior of the building with the exterior at grade or to allow for extremely large floor areas where the travel distance would otherwise restrict the separation distance between exterior walls in the building. Exit passageways provide a highly protected horizontal path of travel similar to exit stair enclosures for vertical travel. Since the entrance into an exit passageway can be considered as the exit for the purpose of determining travel distance, exit passageways of any length can be used to satisfy the travel distance requirements of the building code. When constructed of the same fire resistance ratings and opening protectives as for exit stair enclosures, they can serve as an extension of the exit stairs located in the center core of the building by connecting them to the exterior.

Concrete masonry walls should be the logical choice for the construction of these exit passageways since they are inherently fire-resistive and very stable under fire exposure conditions. Concrete masonry can maintain the fire-resistive integrity of these passageways and provide suitable bearing surfaces for the top closure of the exit passageway to achieve a totally enclosed exit pathway. This is especially important in high ceiling areas such as large open warehouses. Where relatively short floor-to-floor heights are available, then the concrete masonry walls can be constructed tight to the underside of the floor above providing the appropriate protection necessary for exit passageways. However, they are especially useful in large area buildings to satisfy travel distance requirements and, therefore, can serve the dual purpose of providing proper structural support for the top of the exit passageway enclosure as well as the required fire-resistive integrity of the enclosure.

Exit passageways in concept are simply exit stairway enclosures turned horizontally. Both exit stair enclosures and exit passageways have no restrictions on the total length of travel allowed within such enclosures. The code presumes that an adequate degree of fire resistance is required to provide for the ultimate protection of the occupants using these enclosures. Therefore, the occupants should be sufficiently safe that they can take as long as needed to travel through these enclosures to reach the exterior of the building. To assure this high level of fire safety, the designer would be wise to select concrete masonry to construct these enclosures.

2.6 Other Uses

Concrete masonry units are sometimes used to provide fireproofing for structural steel columns in buildings. Because of their thermal mass and structural stability, they can protect columns for several hours from severe fire exposure. In other applications where spray-on types of fireproofing are used to protect structural steel columns, concrete masonry may prove useful for impact protection to prevent the fireproofing from being damaged or knocked off. Such applications might occur in a parking garage structure, or a warehouse or industrial building where forklift trucks are used.

Wherever noncombustible construction is desired for insurance purposes or for peace of mind or where required by the building code, concrete masonry makes sense. It is inherently noncombustible; and, due to its structural make up and configuration, it does not provide a continuous combustible concealed space where smoke, hot gases, or other products of combustion may travel from the fire area to remote areas throughout the building. Concrete masonry walls will also help to retard the rapid spread of fire and will absorb a great amount of the fire's energy, thus reducing the energy available for attacking combustibles in the building. And, of course, insurance companies develop very favorable rates for buildings constructed of concrete masonry walls throughout.

In summary, it becomes readily evident that concrete masonry can cost effectively provide built-in property protection as well as life safety. It can be used to contain a fire as well as to protect the building occupants in order for them to escape. It can provide protection for the fire department during their fire fighting operations, and it can reduce the overall property loss that may be suffered during an unwanted fire. Concrete masonry reduces insurance costs and requires little, if any, maintenance. Concrete masonry walls can extend or even save the life of a building attacked by an unwanted fire. It certainly saves lives and gives the designer confidence that he has selected the proper construction material. The multi-functional aspects of concrete masonry make it the ideal building material where property protection and life safety are important considerations in building design.

SECTION 3 SPECIAL DESIGN CONSIDERATIONS

This section discusses special design considerations that require more specific knowledge of the technical issues and design criteria necessary to ensure proper design and construction of various fire-resistive assemblies used to satisfy building code requirements. It also guides the designer in determining the appropriate thickness of concrete masonry units to achieve the desired degree of fire resistance. Armed with this information, the designer can provide cost effective code complying concrete masonry walls that will do the job required by the building code for the intended degree of fire resistance.

3.1 Area Separation Walls

Probably the least understood construction assembly regulated by the building code is the area separation wall. The Uniform Building Code uses the term area separation wall to describe a wall which performs similarly to the fire wall prescribed in the other national model building codes. This wall is intended to subdivide a structure into completely separate buildings for the purpose of applying the requirements of the building code. When a structure is properly subdivided by area separation walls, each segment so created is considered a separate entity (building) in terms of applying the applicable provisions of the building code including type of construction versus area limitations, exits, fire resistance, automatic sprinklers, fire alarm systems, standpipe systems, etc. In other words, separate buildings are created with the intent that a fire in one building will not breach the area separation wall and spread to the adjacent building. This concept is critical to understanding how area separation walls should be designed and constructed to assure that a fire on one side of the wall will not spread to the other side.

The key to an area separation wall is to provide a complete and continuous separation from the foundation of the building through all intervening floors to or through the roof. Thus, and architect might envision a vertical plane having the appropriate fire resistance of 2 hours or 4 hours (depending on the type of construction) which when inserted vertically into a building would cut the building into two completely separate parts. With this concept, it becomes obvious that horizontal offsets are not acceptable since they provide a structural weak point in the wall assembly.

The structural integrity of area separation walls is also critical since an area separation wall should be designed to remain in place even when construction on one side of the wall is destroyed or collapses due to a fire exposure. If the wall cannot remain in place while total destruction by fire of the opposite side occurs and the fire is allowed to pass to the opposite side, the purpose of the area separation wall is defeated. Area separation walls are critical since the building code allows structures so subdivided to be considered separate buildings. As discussed earlier, building code requirements can also be minimized by properly subdividing buildings with area separation walls. If this tact is taken, then the designer should get assurances that the wall will perform as intended.

Thus, special attention is required to the interface of the wall with the roof and with the use of parapets to prevent the fire from spreading across the area separation wall. Openings must be properly protected and limited as mandated by the building code. Openings should be kept to a minimum since they are the obvious weak points in the area separation wall construction. Where area separation walls intersect exterior walls, particular attention should be given to assure that there will not be a readily available pathway for fire, smoke, and other products of combustion to circumvent the area separation wall.

However, the building code does not provide sufficient guidance to the designer to determine how to deal with the interface of an area separation wall with the exterior wall. The designer should realize that the intent is to prevent fire spread around the area separation wall so that the ideal design would be to have the area separation wall pass entirely through the exterior wall construction. Where this is impractical, the exterior wall should at least be noncombustible at the location of the interface with the area separation wall and proper fire stopping should be provided to prevent the circumvention of the area separation wall by fire gaining access to the concealed space within the exterior wall. More ideally, if the exterior wall were constructed of concrete masonry similar to the area separation wall, then the intersection need only be properly caulked with a fire-resistive compound such as used to seal penetrations in fire-resistive assemblies. Such a construction joint, when properly sealed, should prevent the passage of flame and hot gases as well as smoke.

Since the structural integrity of the area separation wall is essential to its proper performance, it should be designed to withstand any stresses caused by the structural members attached to the wall or to allow those structural members to release under fire exposure conditions. The ideal area separation wall would actually be two independent walls constructed back to back. Since this is difficult to accomplish with typical frame construction, concrete masonry walls would be the ideal choice. They can also be reinforced with pilasters or by reinforced concrete masonry construction techniques similar to that used for seismic considerations. Filling all the voids with concrete will also increase the fire resistance rating of the wall. In essence, an area separation wall should either be a cantilevered wall attached with its structural support at grade or an infill wall between pilasters that provide the required vertical stiffening and lateral support.

Particular attention must be given to assure that the floors of the building do not pass through the area separation wall construction, thus violating its fire resistive integrity. Special details may be needed where the floor construction structural supports are perpendicular to the area separation wall. There are appropriate design techniques that can be used to allow the area separation wall to serve as a bearing wall without jeopardizing the integrity of the wall under fire exposure conditions.

Ideally, area separation walls should also pass through the roof construction and terminate in a parapet at least 30 inches high above the roof. Of course, this is not always practical nor desirable because of aesthetic considerations or because of the need to reduce the potential for roof leaks. The building code allows area separation walls to stop at the underside of the roof deck based on very specific details as to how this can be accomplished in order to maintain the fire-resistive integrity of the area separation wall and minimize the potential for fire spread over the area separation wall via the roof construction.

Because area separation walls are a critical structural element of the building, they should be carefully designed and constructed with materials suitable to serve the intended purpose. Concrete masonry is the ideal construction product for area separation walls. As discussed earlier, it has a high degree of built-in fire resistance, it is also inherently noncombustible, and it has excellent structural stability and durability even during the most severe fire exposure conditions. Since it is less susceptible to penetrations, it provides a continous protective barrier against potential fire spread. Concrete masonry walls are readily inspected during construction and can be erected very quickly. Concrete masonry walls do not require complex construction details or adherence to special criteria to assure that they will provide the degree of fire resistance required The well-designed area separation wall using concrete masonry can also be recognized as a fire wall by insurance underwriters and help to reduce the overall impact of insurance costs on the building as well as to protect against the total destruction of a building due to a single fire incident.

The designer may also be surprised to find that concrete masonry area separation walls can be used to subdivide wood frame structures even in Seismic Zones 3 and 4. Such walls can be used where wood shear walls provide lateral bracing up to a maximum of two stories in height with a maximum height of 12 feet per story. These walls can be as thin as 6 inch nominal block if the appropriate aggregate and percent solids (equivalent thickness) are provided as discussed in Section 3.3. Thus, two story apartment houses and hotel/motels of wood frame construction can be subdivided with area separation walls so as to avoid the requirement for automatic sprinkler protection mandated by the building code when such occupancies exceed more than 15 dwelling units or contain 20 or more guest rooms. Thus, concrete masonry area separation walls can be an economical and cost effective alterntive to complete automatic sprinkler protection in such occupancies.

3.2 Exterior Walls

Since the Uniform Building Code no longer allows the compartmentation option for high rise buildings, the issue of exterior wall construction is somewhat unclear regarding spandrel wall protection and the interface of floor slabs with the exterior wall. At least when compartmented high rise buildings were designed, a fire-resistive spandrel wall was required to separate exterior window openings located above one another in order to retard the spread of a fire from window to window via the "leap frog" effect. Furthermore, the fire rated floor assembly was required to be extended to and constructed tight against the exterior wall so that the fire-resistive separation required between stories could be maintained in order to prevent the spread of fire, smoke, and hot gases beyond the floor of fire origin.

Nevertheless, the designer and the building owner should be aware that the building code intends that fire spread be contained to the floor of fire origin. The protection of spandrel walls between window openings located vertically above one another and fire stopping the intersection of the fire-resistive floor with the exterior wall are critical components of that protection scheme. Since the exterior wall becomes the weak link in the containment of a fire to the floor of origin, it seems appropriate that concrete masonry exterior walls would serve to enhance this fire-resistive separation. Concrete masonry walls are extremely stable under fire exposure conditions and have a high degree of fire resistance. Furthermore, they do not provide a continuous path of concealed spaces through which fire and hot gases could spread around the floor and attack the floor above.

The stability of concrete masonry walls will allow for traditional construction techniques to be implemented to protect the intersection of the fire-resistive floor slab with the exterior wall. Other types of exterior wall systems will tend to warp and buckle under severe fire exposure, thus creating voids (which might otherwise have been properly fire stopped) that allow the passage of flame, hot gases, and smoke around the floor slab. If adequate spandrel walls are not provided, the fire will eventually spread from window to window such as vividly demonstrated by the Hilton Hotel fire in Las Vegas, NV. where fire spread up the exterior of the building at the rate of approximately one floor per minute for 22 stories.

Another consideration a designer should be aware of when providing for fire-resistive exterior walls is a provision that relaxes the requirements for determining the degree of fire resistance necessary for exterior load-bearing walls based on UBC Standard No. 43-1, the test for fire resistance ratings. The Uniform Building Code allows the criteria for heat transmission and passage of flame and hot gases to be based on that required for a nonload-bearing wall due to its proximity to an adjacent property line or building rather than on the requirement for the fire resistance of the exterior load-bearing wall as a structural element. This is commonly known as the separation of end points criteria. It is based on the assumption that an exterior load-bearing wall is intended primarily to provide structural stability to the building whereas a nonload-bearing exterior wall is intended to provide protection against exterior fire exposures.

This distinction is especially important when evaluating the requirements for the fire resistance of an exterior wall since an exterior wall is required to protect against fire exposure from both the interior and the exterior of the building. Concrete masonry walls, because of their symmetrical construction, provide the same degree of fire resistance from either side and thus are ideally suited for exterior wall protection. Since concrete masonry walls may often be used as exterior load-bearing walls, the code may allow the use of thinner exterior walls provided they satisfy the structural bearing criteria to be used where these walls are required to have a fire resistance rating. The designer should check Chapter 43 of the Uniform Building Code for more specific details.

It should be noted that concrete masonry walls can provide structural fire resistance for significantly greater fire durations as determined by fire test than as non-structural fire barrriers. In other words, concrete masonry walls are extremely stable and retain a high percentage of their original load carrying characteristics when exposed to fire whereas they will allow for the passage of sufficient heat to assign a fire resistance rating at lower value than would be the case if it were strictly based on its structural characteristics under fire exposure conditions. Nevertheless, concrete masonry walls still provide an extremely high level of fire protection and fire resistance when used as fire barriers. In fact, fire resistance ratings as high as 4 hours or more can be easily achieved for both load-bearing and nonload-bearing walls. See Section 3.3.

3.3 Calculated Fire Resistance

Typically concrete masonry units (concrete block) come in nominal thicknesses ranging from 4 inches to 12 inches. Depending upon the aggregate used and the amount of void spaces they contain, these concrete masonry units can provide fire resistance ratings from 1 hour to 4 hours or greater. Generally, fire resistance ratings greater than 4 hours are not utilized since the building code does not specify a fire resistance rating for any wall construction greater than 4 hours even including area separation walls.

Since concrete masonry units can be hollow or solid, load-bearing or nonload-bearing, the amount of voids or the percent of total solids in a given concrete block or concrete masonry unit can vary significantly. Therefore, the building code recognizes the concept of equivalent thickness which, simply put, determines the total amount of the volume of solids in a concrete masonry unit. Conceptually, this could be accomplished by taking the concrete masonry unit, crushing it and then recompacting it into the original nominal length and nominal width to determine its equivalent thickness. Another way of looking at this concept is if the voids were removed, then the solids remaining when compacted together in the original nominal length and width would represent the actual equivalent thickness of the concrete masonry unit.

The Uniform Building Code provides the following formula for determining equivalent thickness:

$T_E = V_n/L \times H$

where –

V_n = the net volume of the aggregates of the block (gross volume less the volume of voids), in cubic inches

L = the actual length of the block (not the nominal length)

H = the actual height of the block (not the nominal height).

It should be noted that when determining the equivalent thickness of a concrete masonry wall, the thickness of any plaster, lath, and gypsum wallboard can be included in the equivalent thickness. This assumes that the plaster or lath and gypsum wallboard covers the entire face of the wall for the same thickness. When a concrete masonry unit has all of its cells filled with solid grout, then its equivalent thickness is equal to the actual thickness of the concrete masonry unit, i.e., a 6-inch nominal thickness block completely filled with grout would have an equivalent thickness of 5⅝ inches (6-inch nominal dimension minus 3/8-inch mortar joint equals 5⅝ inches actual thickness).

Recent changes to the Uniform Building Code recognize that a concrete masonry unit having the equivalent thickness required for a 2-hour fire resistance rating can have its fire resistance rating increased to 4 hours when the cores which are not grouted are filled with silicone perlite loose fill insulation; vermiculite loose fill insulation; expanded clay, shale, or slate lightweight aggregate; or sand or slag having a maximum particle size of ⅜". This increase in fire resistance rating is only permitted for block having a nominal thickness of 8 inches or greater. Refer to the appropriate UBC Standards for the particular details regarding the standards for these fill materials.

With the advent of blended aggregate technology for the manufacturing of concrete masonry units, the equivalent thickness is still based upon the formula prescribed above, however, the fire resistance rating is determined by the percent of volume of each aggregate used by interpolating between the volume of equivalent thickness values for each specific aggregate. When the aggregates blended consist of fine aggregates (passing a No. 4 sieve) of calcareous or siliceous gravel and expanded slag or pumice or expanded clay, shale, or slate, they require the application of a special formula to determine the equivalent thickness provided for the fire resistance rating required. Chapter 43 and Table No. 43-B of the Uniform Building Code should be referred to for specific information.

Where concrete masonry units are manufactured with aggregates of limestone, cinders, or air cooled slag which are blended with any other aggregate or combination of aggregates, the criteria mentioned above for blending two or more aggregates must be followed.

For those cases where concrete masonry units are manufactured from a single aggregate, the designer can refer to the accompanying tables to determine the nominal thickness of concrete masonry units necessary based on the aggregate and the desired fire resistance rating. It should be noted that the minimum equivalent thickness of the concrete masonry unit is based on the minimum web and shell face thicknesses or percent solids mandated by the applicable UBC Standards for the specific type of concrete masonry units. For more precise information in order to minimize the costs of providing the intended fire resistance, the designer should refer to the particular block manufacturer's literature for the equivalent thickness required of his block for a particular fire resistance rating. These tables are only provided as a guide to the designer to give him an appreciation for the size of concrete masonry units needed to provide the typical fire resistance ratings required by the building code.

In many instances, especially for interior wall applications, the concrete masonry wall may be covered with gypsum wallboard to provide a finish. In those cases the gypsum wallboard on the fire exposed side can be used to reduce the required thickness of the concrete masonry unit or, conversely, to increase its fire resistance rating since the thickness of the gypsum wallboard can be added to the equivalent thickness of the concrete masonry unit to determine its fire resistance rating. If symmetrical fire resistance is required, then the gypsum wallboard must be installed on both sides of the concrete masonry wall in order to add the thickness of one layer of gypsum wallboard to the calculated equivalent thickness for the concrete masonry wall.

For example, let's say it is desired to provide a 4-hour area separation wall to subdivide a building of Type 1-Fire Resistive construction. The available concrete masonry units in the area use calcareous gravel aggregates. It is also desired to utilize this area separation wall as a load-bearing wall using 8-inch solid block. From Table 4 it can be seen that such a wall will provide at least a 3-hour fire resistance rating. In fact, in accordance with Table No. 43-B of the Uniform Building Code, a 3-hour fire resistance rating can be achieved with 5.3 inches equivalent thickness for calcareous gravel aggregate concrete masonry units. Since a 4-hour wall would require 6.2 inches equivalent thickness based on the same table, then it is necessary to provide a minimum additional equivalent thickness of 0.48 inches (6.20 inches - 5.72 inches). This can be achieved by installing ½" thick gypsum wallboard on the fire exposed face of the wall. This will add ½" equivalent thickness which is greater than the 0.48 inches equivalent thickness required. However, since the fire resistance rating of the area separation wall is required from both sides of the wall, it will also be necessary to provide ½" gypsum wallboard on the opposite face of the wall. Thus, a finish of ½" gypsum wallboard installed on both sides of an 8" solid load-bearing concrete masonry block wall with a calcareous gravel aggregate will provide at least a 4-hour fire resistance rating and will also have an architectural finish.

Several other options to achieve the 4-hour fire resistance rating based upon the calcareous gravel aggregate concrete masonry unit are available. One option is to use a 10" solid load-bearing block which would provide an equivalent thickness of 7.22 inches. Another option is to utilize an 8-inch load-bearing block specially designed with 2-¼" thick face shells to provide a 4 hour fire resistance rating. See Table 4. A third option would be to fill all the voids in the 8-inch block with solid grout which would achieve an equivalent thickness of 7.63 inches. Thus, a designer has many options available at his disposal to design for concrete masonry walls used as fire-resistive barriers or exterior walls.

The fire resistance rating of the wall will depend upon the type of aggregate of the concrete masonry unit, the percent of solids of that unit, and whether or not the unit will be filled with grout or other insulating materials or covered with gypsum wallboard or plaster. For more detailed information, the designer should refer to NCMA - TEK 80A (10B) - 1985 available through CMACN.

3.4 Fire Tests Vs. The Real World

For over 50 years, the design of fire resistive assemblies has been based on the concept of fire load. Simply stated, the fire load is the available fuel that can be consumed by a fire in a building. It consists not only of the combustibles contained in the basic building construction and structural elements but also those combustibles added to the building as interior finish, furnishings, and contents. A rough rule of thumb is that for every 10 pounds per square foot of combustible loading, a 1-hour fire would result if the total fuel load were consumed. Thus, in a building containing a fire load of 20 pounds per square foot, for example, a fire allowed to burn uncontrolled would be expected to burn for approximately 2 hours. This fire duration is based on the temperature-time curve established in UBC Standard No. 43-1 (ASTM E119) for testing fire rated assemblies used in building construction. The basic characteristics of this particular curve have also not significantly changed for more than 50 years. Thus, present day fire-resistive assemblies are based on technology more than 50 years old.

However, today's world is significantly different than that of 50 years ago. For example, much of the contents of present buildings consist of man-made materials such as polymers and plastics which have a much greater heat content and rate of heat release than the more traditional cellulosic materials such as wood, cloth, and paper. The science of fire has also advanced to the point where we know that a fuel load in and of itself is not an accurate determination of the anticipated fire severity or fire duration. Other factors that play as important a role in determining the duration and severity of a fire include the size of the compartment in which the fire is located, the linings of the compartment walls and ceilings, the ventilation, the types of combustibles and their configuration as well as their geometry in relation to each other and to the compartment. Recent studies seem to suggest that the traditional fire test and the traditional fire load concept may not be an accurate measurement of actual fire severity. In fact, it appears that fire loads may actually be higher than presently estimated for various occupancies and that the severity and duration of fires resulting from such fire loads may also be greater. This means that fire-resistive assemblies used in today's buildings may require a factor of safety built in.

This factor of safety should not only be reflected in a fire resistance rating greater than what the code may require or what may be calculated for a given occupancy, but also in the method of construction of the fire rated assembly. If the assembly requires many different components to achieve its fire rating and they must be installed in a meticulous way that demands attention to detail and close inspection of the assembly, in the real construction world it can only be expected to provide a fire resistance rating somewhat less than the tested design suggests. This is a fact of life based upon today's construction techniques and level of quality control on construction projects.

A designer might then be somewhat concerned as to how he can best provide the level of fire resistance that he needs not only to satisfy the building code but also to satisfy his professional integrity and concern that true fire resistance will be provided. Concrete masonry can give the designer that assurance. Myriad fire tests of concrete masonry walls have clearly demonstrated that concrete masonry has superior fire resistance to other construction materials and assemblies of materials and that it is extemely stable under the most severe fire exposure conditions. Furthermore, it includes: evacuation alarm systems (fire alarm systems), mechanical smoke control systems, and manual fire suppression provided by the fire department.

Passive fire protection relies upon built-in building elements that require no action to accomplish their design intent. Generally, passive fire protection limits the spread of an unwanted fire as well as its direct impact on a building and its occupants and contents through such strategies as the control of building size and use and the materials of construction. Examples of passive fire protection include; limits of building height and area based on the structural fire-resistive integrity of the construction elements; the subdivision of buildings into compartments with fire-resistive barriers; the provisions for remote exits from the building accessed via fire rated enclosures; and the use of areas of refuge separated by fire-resistive barriers.

Hand in hand with this concept of balanced design or the strategic use of both active and passive fire protection strategies is the issue of properly protection versus life safety. Using the balanced design approach, it is also appropriate to address both the protection of property as well as the need to protect the lives of people that use buildings. Again the trend of the building code approach appears to favor life safety at the expense of property protection. In and of itself, increased emphasis on life safety cannot be faulted, however, when it begins to degrade the level of fire protection provided for the building and its contents, then there is a need to make some adjustments in the code philosophy.

A great deal of the increased property damage resulting from fires in this country in favor of enhanced life safety is due to the use of "trade-offs" to encourage the economical use of active fire protection systems. Rather than codes requiring additional active fire protection systems such as automatic sprinklers, because of the added costs of such systems, pressure has been brought to bear to allow the trading-off of passive built-in fire protection in order to reduce the costs of construction to offset the increased costs of the active fire protection systems. Such examples include the reduction in fire resistance ratings of structural elements and fire-resistive barriers when an automatic sprinkler system is installed throughout the building. However, concrete masonry is able to maintain a significant percentage of its loaa carrying capabilities after fire exposure. It does not deform nor significantly deteriorate during fire exposure.

It is simple to install and it is simple to inspect. It follows the axiom that the simpler one keeps something, the better chance there is that one will get what was designed. Concrete masonry does not rely on any special gimmicks or construction techniques to achieve a given level of fire resistance. Once constructed, it stands as a durable barrier to the spread of fire, smoke, and other products of combustion.

The same cannot be said for more elaborate construction assemblies requiring framing and membranes attached with fasteners to the framing. Close attention must be paid as to the quality and type of membrane used to cover the framing, the size of the framing members, and the type and spacing of the fasteners, as well as the protection of the joint assemblies. It must always be kept in mind that fire tests are performed in laboratories under well-controlled conditions with assemblies installed under exacting tolerances which may not be representative of actual field conditions. However, with concrete masonry the construction details are not exacting and the installation techniques are very basic and staightforward. Thus, what you see is truly what you get.

SECTION 4. BALANCED DESIGN

There are basically two general approaches that are used to provide for fire protection in buildings. They are categorized as active and passive methods of fire protection. When used together, they represent a balanced design approach to effective fire protection. Such an approach is generally synergistic, i.e., the net result is greater than the sum of the impact of the individual components both in terms of greater protection and increased probability of success. Building codes are a compendium of active and passive fire protection approaches, but whether or not the approaches are balanced is truly another question. The trend has been toward more active fire protection with the use of mechanical/electrical devices and equipment such as smoke detection and automatic sprinkler systems to detect and suppress fires automatically. Other examples of active fire protection show this is a false economy in that a mechanical system is not foolproof and does not perform 100% of the time. Therefore, without the appropriate passive fire protection built into the structure coupled with the failure of an active fire protection system for which trade-offs were allowed, total destruction of a building could result from a fire. Many major property damage fires have cleary demonstrated this case.

It would be more appropriate, especially in view of a building owner who wants to provide a cost effective approach to fire protection for his building, to use a total systems approach to develop the strategies necessary to provide an acceptable level of fire protection and life safety for the building, its contents and occupants. Such an approach would consider the reliability of active and passive methods of fire protection as well as the probability of successful performance of the various components. Also factored in would be maintenance that would directly impact the reliability and probability of successful performance. A probability analysis of successful performance could be developed and an appropriate level of redundant fire protection could be prescribed in order to provide a reasonable level of fire protection without trading-off one type of fire protection for another.

An example might better illustrate this total systems approach. Take a multi-family residential apartment building which is two stories high and wood frame construction. If a fire starts within an apartment unit, it will soon flashover and then eventually spread to other units on the same floor. If the fire is located on the first floor of the building, it may even spread to the second floor unless adequately contained or unless the fire is detected sufficiently early that it can be suppressed before it becomes a threat. Many fire protection experts today believe that by sprinklering a wood frame apartment building, the fire problem can be solved. However, should the sprinkler system fail or should a concealed fire develop which could not be extinguished by the sprinkler system, then it is highly likely that the entire structure will be destroyed by fire and the lives of many people significantly disrupted by such an event.

By installing 4-hour fire-resistive separations between each apartment unit, the anticipated fire would not be expected to extend beyond the apartment unit of origin with the additional benefits that sound transmission between units would be controlled and energy savings could be realized because of the thermal mass of such walls. Nevertheless, there could be significant fire damage suffered by the occupants of that unit with the possibility that the lives of the occupants could be threatened. A balanced approach might look at utilizing the 4-hour fire-resistive barriers in conjunction with an automatic smoke detection system which would detect the fire sufficiently early to notify the occupants so that they could escape or take action to combat the fire. The smoke detection system could also notify the fire department so that they could respond sufficiently earlier to prevent the total destruction of the unit of origin.

Another possible balanced approach would be the use of 4-hour dwelling unit separations with automatic sprinkler protection which would provide an even higher level of life safety and property protection since an automatic sprinkler system with a high probability of successful performance would control a fire in its early development stages, thus preventing significant property destruction and preserving the lives of the occupants located in the unit of origin. The 4-hour barriers would stand to protect against the failure of the automatic sprinkler system and to contain the fire, smoke, and other products of combustion until the sprinkler system had done its job. With this approach the occupants of the adjacent units would not be adversely impacted by the fire condition and would probably be able to remain in their units while the unit of fire origin was being restored.

A more global approach to balanced design has to do with community master planning for fire protection. The development of new communities always poses a challenge as to how to most cost effectively provide basic fire protection to the residents of that community. It is totally unrealistic to rely strictly upon the fire department to provide adequate fire protection. Conversely, it would be cost prohibitive to require that all buildings be so isolated from each other and provided with the state-of-the-art in fire protection design so as to preclude fires from destroying more than the immediate area of origin, thus a balanced approach is necessary.

In effect, the building code is a tool for community master planning, but it is a tool that does not spell out clearly defined goals and objectives to determine what is a cost effective approach. Obviously, regulating the types of construction allowed within the community by minimizing the size of buildings or by subdividing buildings with fire walls or compartmentation walls and providing adequate spatial separations between buildings and fire-resistive exterior walls can achieve a basic level of passive fire protection in the community. By the mandating the use of automatic sprinklers and smoke detection systems and requiring minimum water supplies for fire fighting purposes to be available at any location throughout the community, the appropriate built-in active fire protection systems can be incorporated and then supplemented with the fire suppression forces of the community fire department. A cost effective balance can be achieved between the active fire protection provided by the community through the fire department and the active and passive fire protection built into the buildings constructed within the community. Incentives can also be offered to developers that provide the appropriate built-in fire protection features. Such incentives can help to offset the economic impact of fire protection. These incentives might include increased construction densities, reduced minimum street widths, increased fire hydrant spacings, reduced fire flows, etc.

In any case, concrete masonry fire-resistive walls can play an important role in establishing a level of passive fire protection that, when used in conjunction with active fire protection systems, can provide an acceptable level of fire safety for buildings, building contents, and the occupants of those buildings. Concrete masonry can also serve to contain the destructive effects of a fire and to protect the lives of the occupants from the products of combustion such as smoke, heat, flame, and hot gases resulting from unfriendly fires. Concrete masonry walls stand firm as a built-in passive fire protection feature that will be there to stop a fire in its tracks.

SECTION 5. SUMMARY

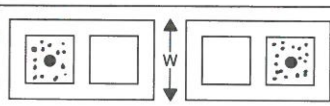
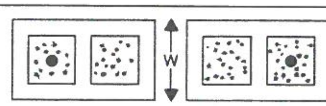
Concrete masonry is probably the best suited construction material available in the market-place today for use in constructing fire-resistive walls in buildings. Concrete masonry means confidence: confidence that the fire protection you design is the fire protection you get; confidence that the fire-resistive wall will be there when its needed; confidence that it is safe because it cannot burn and is structurally stable; confidence that it reduces liability because of its inherent fire resistance and noncombustibility and because it shows that the designer has expended the extra effort to provide good fire protection; confidence that it has an inherent safety factor built in. Concrete masonry fire resistance is much more durable and lasting and certainly more stable in response to fire than other types of materials and assemblies. A little bit of concrete masonry can go a long way toward providing a reasonable level of fire protection.

Concrete masonry makes even more sense since it has great utility in the construction business. Its multi-functional characteristics coupled with its durability and low maintenance make it an ideal construction material. It can satisfy the needs of a building designer or owner on many fronts. Properly designed and located conrete masonry fire-resistive walls can provide cost effective functional structures that will withstand the ravages of fire.

Concrete masonry is cost effective. Because it is multi-functional, its installation costs are not truly representative of its actual impact to the overal costs of the construction project. Where other materials or multitudes of assemblies of materials may be necesary to perform the functional needs of the building desired by the owner, concrete masonry walls can be used to satisfy those needs in one package. The life cycle costs of concrete masonry are extremely low compared to many other construction materials. When such costs as maintenance, insurance, and business interrruption are included, it becomes obvious that concrete masonry is a truly cost effective product.

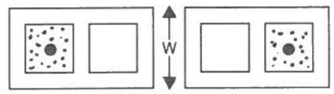
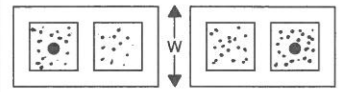
A professional designer who desires to serve his client well by providing a cost-effective, functional, and aesthetically pleasing structure would do well to integrate concrete masonry into the total building design. By selecting concrete masonry, the designer will be able to instill confidence in the owner that his building will endure and withstand the ravages of fire in order to protect the owner's investment and limit his liability.

**TABLE 1:
FIRE RATINGS OF CONCRETE MASONRY WALLS
EXPANDED SLAG OR PUMICE AGGREGATES**

Width (W)		Fire Resistance Ratings	
			
Nominal	**Specified**	**Partial Grouted or Hollow Masonry**	**Solid Grouted Masonry**
4″	3⅝″	Less than 1 Hour	2 Hours
6″	5⅝″	1 Hour	4 Hours
8″	7⅝″	2 Hours	4 Hours
8″ (Special)	7⅝″	4 Hours	4 Hours
10″	9⅝″	3 Hours	4 Hours
12″	11⅝″	4 Hours	4 Hours

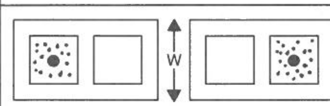
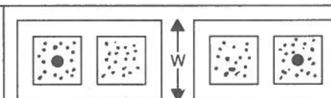
(See notes page 21.)

TABLE 2:
FIRE RATINGS OF CONCRETE MASONRY WALLS
EXPANDED CLAY, SHALE OR SLATE AGGREGATES

Width (W)		Fire Resistance Ratings	
			
Nominal	Specified	Partial Grouted or Hollow Masonry	Solid Grouted Masonry
4″	3⅝″	Less than 1 Hour	2 Hours
6″	5⅝″	1 Hour	4 Hours
8″	7⅝″	2 Hours	4 Hours
8″ (Special)	7⅝″	4 Hours	4 Hours
10″	9⅝″	2 Hours	4 Hours
12″	11⅝″	3 Hours	4 Hours

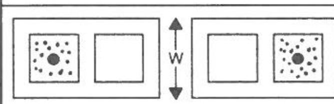
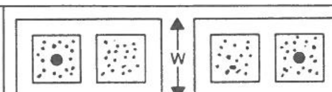
(See notes page 21.)

TABLE 3:
FIRE RATINGS OF CONCRETE MASONRY WALLS
LIMESTONE, CINDERS OR AIR-COOLED SLAG AGGREGATES

Width (W)		Fire Resistance Ratings	
			
Nominal	Specified	Partial Grouted or Hollow Masonry	Solid Grouted Masonry
4″	3⅝″	Less than 1 Hour	1 Hour
6″	5⅝″	1 Hour	3 Hours
8″	7⅝″	1 Hour	4 Hours
8″ (Special)	7⅝″	3 Hours	4 Hours
10″	9⅝″	2 Hours	4 Hours
12″	11⅝″	3 Hours	4 Hours

(See notes page 21.)

TABLE 4:
FIRE RATINGS OF CONCRETE MASONRY WALLS
CALCAREOUS OR SILICEOUS AGGREGATES

Width (W)		Fire Resistance Ratings	
			
Nominal	Specified	Partial Grouted or Hollow Masonry	Solid Grouted Masonry
4″	3⅝″	Less than 1 Hour	1 Hour
6″	5⅝″	1 Hour	3 Hours
8″	7⅝″	1 Hour	4 Hours
8″ (Special)	7⅝″	2 Hours	4 Hours
10″	9⅝″	2 Hours	4 Hours
12″	11⅝″	2 Hours	4 Hours

(See notes page 21.)

NOTES: These notes refer to Tables 1, 2, 3, 4, (pages 19 and 20).

1. The fire resistance ratings of the various thicknesses of concrete masonry walls (reinforced or solid grouted) have been calculated based on Uniform Building Code Table No. 43-B Items 5-1.1 through 5-1.4 by the equivalent thickness method using the minimum thicknesses of the face shells and webs specified in UBC Standard No. 24-4 for hollow load-bearing concrete masonry units. Individual block manufacturers may have higher ratings based on specific fire tests or a greater percentage of solids provided.

2. For concrete masonry walls using 2-hour block (minimum 8 inch nominal thickness), the fire resistance rating can be increased to 4 hours when the cores which are not fully grouted are filled with any of the following:

a. Silicone-treated perlite loose-fill insulation conforming to UBC Standard No. 43-10.
b. Vermiculite loose-fill insulation conforming to UBC Standard No. 43-11.
c. Expanded clay, shale or slate lightweight aggregate conforming to UBC Standard No. 26-3.
d. Sand or slag having a maximum particle size of 3/8 inch.

3. The 8 inch special block is manufactured with minimum 2¼ inch thick face shells which are thicker than those specified in UBC Standard No. 24-4.

4. When determining the equivalent thickness of a concrete masonry unit, the calculated thickness may include the thickness of gypsum wallboard or portland cement plaster or 1½ times the thickness of gypsum plaster properly applied to the wall.

5. For determining the fire resistance ratings of concrete masonry walls using blended aggregates, refer to Footnote 14 to Table No. 43-B of the Uniform Building Code.

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