BUILDING CONSTRUCTION & DESIGN
VIEWPOINT

Addressing concerns of building, fire, and government officials, designers, developers,builders

Volume 1 Number 1 (1999)

Use of Masonry and Hollow-Core Concrete

Key to improving Building Codes

This wooden frame development is like a horizontal lumber yard waiting for a match!!!

660 deaths, 5000 injuries & $718,000,000 lost in 1997

INTRODUCTION

Over the last several years, fatalities, injuries and property loss in structural fires have fluctuated. In 1997, there were 660 fire deaths, 5000 injuries, and $718 million lost in property damage in low-rise multi-family dwelling (LRMFD) buildings[1]. Significant consistent improvement of these numbers can only be achieved through code-mandated increased levels of protection. Currently, model building codes [BOCA National Building Code[2] , Standard Building Code[3], the Uniform Building Code[4] , (and the final draft of the developing International Building Code [5])] require 1-hour fire resistant rated tenant separation walls between dwelling units. Based on this nation's fire record, one hour is not sufficient. What's worse is that building codes typically offer tradeoffs that permit a reduction in building fire resistance when automatic sprinklers are installed. Utilizing tradeoffs to improve firesafety is flawed logic, as a tradeoff is nothing more than a substitution of one component for another in an attempt to maintain the status quo. How then can this philosophy be expected to improve on the current US fire loss record? The answer is simply, "it can't!" Conversely, upgrading building codes to offer better fire protection to the residents, property owners and the community at large is clearly a sound approach. Code provisions requiring 2-hour masonry and concrete building construction supplemented by automatic detection and suppression systems (sprinklers) will achieve this goal.

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PURPOSE

The purpose of this publication has the following objectives:
(1) to offer support for upgrading local building codes that will increase the firesafety of LRMFD's

(2) to examine the superior performance of masonry and concrete under standard fire test conditions versus that of other types of building construction commonly used in LRMFD's

(3) to show that masonry and concrete LRMFD construction is not overly expensive as compared to wood frame due to the property insurance savings that are associated with masonry and concrete.

CONSEQUENCES OF FIRE

When fire strikes in residential occupancies, the related injuries and deaths are often the focus of the local news media. What seldom gets reported is the impact that these events have on the community and the survivors who must try to piece their lives back together. The extent of human suffering is far reaching. Residents of units affected by fire and smoke damage must cope with the reality of immediate and unexpected homelessness. Many will lose belongings that have irreplaceable sentimental value. Owners of small storefront businesses may lose their livelihood along with the capability of financially supporting their families. Some will fare worse by suffering the loss of family members or pets.

On a different level, the building owner is also subjected to emotional anxiety. Regardless of who or what has caused the fire, the owner is exposed to legal liability and is likely to become the target of subsequent lawsuits. His or her life becomes entangled in a trail of paperwork emanating from legal action and the unenviable task of enduring the claims settlement process. Decisions on in-situ repairs or reconstruction must be made and are often dictated by the adequacy of the property insurance limits specified in the building's insurance policy. If the extent of damage is too severe, the owner is less likely to want to start over. Many times, the owner will opt to collect the insurance money and just walk away from the ambitious chore of reconstructing. This action creates additional homelessness and eliminates significant tax revenue to the community that would otherwise be brought in. For a 20-25 unit apartment building in the Chicago area, for example, this can be as much as $25,000 annually. Storefront units that the community has grown to depend on and that have often become part of a

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THE CONSEQUENCES OF THIS WOOD FRAME STRUCTURE FIRE ARE OBVIOUS community's identity are lost forever. Family owned grocery stores, restaurants, currency exchanges, clinics and so forth, are typical examples of small local businesses that provide an important role in serving the community members. Tax dollars that these businesses bring in are also lost.

COMPARTMENTATION VERSUS SPRINKLERS

In recent years, the trend in building codes has gone in a direction of emphasizing life safety at the expense of property protection. Advancements in sprinkler technology focusing on residential design applications have reacted to, as well as fueled this code movement leading to a mainstream perception that sprinklers are more life-safety oriented. This is somewhat ironic, considering that automatic sprinklers were originally invented to provide property protection. Compartmentation, on the other hand, while having a greater correlation to property protection today, had much stronger ties to life safety protection years ago. This integration of using each type of protection system for the preservation of both life safety and property has led to philosophical differences in arguments of compartmentation versus sprinklers, as the better form of protection. Given the aforementioned trend in codes, the popularity of sprinklers prompted the establishment of tradeoffs in construction features as monetary incentives to getting sprinklers installed. These types of incentives, which commonly include reductions in fire resistance ratings of wall or floor assemblies, increases in allowable heights and areas, lengthening distances of egress, etc., are commonly known as sprinkler tradeoffs.

Many developers are quick to utilize and support these tradeoffs because of their primary interest in reducing first costs or construction costs. Unlike the residents, property owners, and members of the community who remain as the users of the property, the developers are seldom around to suffer negative consequences once the building is built - they are usually 2 blind trusts removed. As stated previously, utilizing tradeoffs cannot improve the fire-safety record because they are only intended to maintain the status quo. Knowledgeable, quality developers that understand this begin with the concept of first constructing fire resistance and compartmentation into the structure and then use sprinklers and smoke detection devices as supplemental protection features. This approach to building fire-safety is known as balanced design.

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In conjunction with balanced design's impact on improving fire safety, the use of hollow core concrete planks and masonry construction within this framework can result in insurance savings that over the long run can far exceed the amount of first costs savings that arise from utilizing tradeoffs. This is verified in the life cycle cost analysis, indicating that the break-even payback periods are relatively short in comparison to the typical life of a building (see Table 3).

Better quality and durability of a masonry and concrete structure, plus the savings in insurance costs to the prospective owner, makes it easier for the developer to sell his product. So contrary to a common myth, masonry and hollow-core construction is not cost prohibitive to the detriment of community development. In addition, users of the building gain peace of mind from living in a structure possessing superior firesafety design features. Two-hour fire-resistance rated masonry and hollow-core construction combined with compartmentalized dwelling units is designed to contain a fire to the unit of origin and withstand a burn out of the combustibles typically found therein. Belongings of occupants in neighboring units are provided an extra measure of protection and the occupants, themselves, are given additional time to safely evacuate the building. The inherent fire resistance of masonry and hollow-core precast concrete slabs perform even if sprinklers do not function properly or fail to operate altogether. When all else fails, the structure's ability to withstand and protect against fire is the last line of defense. There has never been a masonry wall or precast concrete plank that has ever burned!

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FIRE PERFORMANCE VERSUS FIRE RESISTANCE

The above sections have touched on the senselessness of utilizing sprinkler tradeoffs. Specific reference was made to the sacrificing of a structure's fire resistance as one common type of tradeoff. While this practice is strongly opposed, something also needs to be said about the difference between fire resistance and fire performance. Fire resistance is an inherent physical property of a material. As it relates to building codes, however, it is mainly the

NOTE HOW THE FLOORS ARE COMPARTMENTALIZED WITH THE USE OF HOLLOW-CORE PRECAST PLANKS

measure of an assembly's ability to resist a standard fire exposure for a designated period of time. The method of establishing fire resistance ratings of building elements and assemblies, in order to meet code requirements, is done by having a representative test specimen successfully pass the ASTM E119 standard fire test. This permits assemblies of unlike construction and material types to achieve equivalent fire resistance ratings.

For wall assemblies, ASTM E119, Standard Test Methods for Fire Tests of Building Construction and Materials [6] specifies that hose stream criteria be met when the desired rating of the assembly is not less than 1-hour. This hose stream portion adds a measure of durability to the fire test that distinguishes the fire performance of specimens having identical fire resistance ratings. The intent of the hose stream test is to permit an evaluation of one assembly's post fire ability to withstand the effects of impact, lateral load, thermal shock and erosion from an applied water jet against another. Although, it should be mentioned that the hose stream test is not intended to simulate conditions that are typical during manual fire fighting operations at a real building fire.

Masonry and concrete specimens, because of their superior durability, are routinely subjected to the hose stream test following exposure to fire for the full duration of the fire resistance test period. Conversely, panel-and-stud assemblies are hose stream tested using a specimen that has only been fire tested for the lesser of 1/2 the desired fire resistance period, or that not to exceed one hour. This is known as the duplicate specimen test, whereby two specimens are tested simultaneously and one is removed from the furnace at the aforementioned time for hose stream testing. Over the past several years, this unfair advantage of the duplicate specimen test toward assemblies of lesser durability than masonry and concrete has been debated within ASTM forums in an attempt to eliminate it from the E119 standard. Due to the numbers of proponents that wish to retain the duplicate specimen test for political reasons, however, the attempts to correct this unwarranted inequity have been unsuccessful. Industry is continuing to work on this within codes and standards arenas and additional information can be obtained by contacting the editor, MCAC.

Although change has been difficult to come by at the national level, some progressive states have acted and a few success stories have surfaced. In the State of New York, code authorities have recognized the value of more durable construction by locally amending the Code to require fire walls to pass the hose stream test after having survived the fire test for the full fire resistance period. The City of Chicago hasn't followed suit, but first-hand information from building superintendents and fireman of some of the City's suburban structures reveals that fires occurring in residential units were routinely handled by making sure the entrance doors of the units were shut so the fire was contained to the unit of origin. Certainly, this makes a strong case for the use of more durable construction such as masonry and concrete.

CMU sample passes the hose stream test. While the Panel-and-stud assembly (Inset) virtually disintegrates.

This same level of durability does not apply to gypsum wallboard assemblies. In fact, gypsum wallboard has such non uniformity, even within the same product line, that testing laboratories must be very selective in the panels they choose when performing reproducibility tests. Masonry and concrete specimens do not have a similar history to warrant such action.

At the national level, the International Building Code (IBC) is generally being developed by abstracting the lowest common denominator of protection features from the 3 current US model building codes. Keep in mind, that model codes are only minimum codes and it appears that the IBC that is scheduled to debut in the year 2000 will be even more diluted. Many states permit amendments to be made to these codes prior to their legal adoption as the state code. Whenever building codes can be upgraded at the local level, this should be done in order to create a higher standard of safety and living for the communities that the codes are intended to serve.

INSURANCE SAVINGS WITH CONCRETE AND MASONRY

Thus far, the attributes of masonry and concrete have been discussed with respect to the superior performance characteristics they possess as fire resistant materials. This section illustrates the cost benefits that are gained through property insurance savings by constructing with masonry and concrete. The analysis that follows uses well established life-cycle cost techniques.

The insurance rates in Table 1 are average rates for Cook County, IL and were provided by one of the largest commercial insurers of multi-family buildings in the United States. Rates include fire, extended coverage, and business interruption (loss of rents) based on 12 months rental income. An insurance deductible of $500 applies.

During an interview with a high-ranking insurance company representative, it was indicated that while rates are based on historical claims experience rather than building construction classification, the influence of combustible construction is clear. A record of the poor fire history of wood-frame multi-family buildings justifies the high rates that are presented in Table 1. The influence of combustible construction is further emphasized by the practice of applying rates from the "Masonry" category to a "Fire Resistive" building when a wood roof is added to the structure.

Table 2 provides comparative cost information related to building construction, sprinkler and alarm installation and annual property insurance for a fire resistive structure versus one of wood frame. The insurance premiums were developed from rates shown in Table 1 with appropriate modifiers applied for the presence of automatic sprinklers, detection devices and central station alarm systems installed. Building values are based on a 3-story, 18,000 sq. ft. multi-family building in Cook County, Illinois.

Table 1. Average Insurance Rates Per $1,000 Building Value Based on Construction Classification.

Building Construction Classification [1]	Property Insurance Rates for Non-sprinklered buildings (Case 1)	Property Insurance Rates for Sprinklered Buildings (Case 2)	Property Insurance Rates for Buildings with Sprinklers and Central Station Alarms (Case 3)
Frame	$4.80	$3.84	$3.60
Masonry	$3.06	$2.45	$2.30
Noncombustible	$1.72	$1.38	$1.29
Fire Resistive	$1.47	$1.18	$1.10

[1]Construction classification terms originate from the insurance industry and are defined as follows.

Frame - exterior walls of wood, stucco on wood or metal on wood, with floors and roof of wood or steel frame.

Masonry - exterior walls are of brick, brick on block, concrete block, or concrete, with floors and roof of combustible material.

Noncombustible - exterior walls are of brick, brick on block, concrete block, or concrete, with floors of noncombustible material.

Fire Resistive - exterior walls are reinforced concrete (or masonry) or steel encased in concrete, with fire-resistive floors and roof.

Table 2. Comparative Cost Information Based on Construction Classification

Building Construction Classification	Building Costs without Sprinklers[1] (Case 1)	Building Plus Automatic Sprinklers (Case 2)	Building + Automatic Sprinklers & Alarms[3] (Case 3)	Annual Property Insurance Premiums (Case 1)	Annual Property Insurance Premiums (Case 2)	Annual Property Insurance Premiums (Case 3)
Frame	$1,220,220	$1,256,220	$1,266,220	$5,857	$4,824	$4,558
Fire Resistive	$1,281,230	$1,311,830	$1,321,830	$1,883	$1,543	$1,457

[1] Sources: Cost per sq. ft. estimate developed from Kiley & Allyn, 1998 National Building Cost Manual, 22nd Edition, Craftsman Book Company; cross referenced with 1998 Commercial Square Foot Building Costs, Saylor Publications, Inc.7,8

[2] Source: Estimated from multiple quotes received from sprinkler contractors in Chicago area.

[3] Source: Estimate obtained from major national central station supervisory company.

Payback/Life-Cycle Cost Analysis

Parameters: 3-story, 18,000 sq. ft. multi-family building in Cook County, IL., Comparative analysis of frame and fire resistive construction for sprinklered buildings having detection devices and central station alarm supervision (balanced design); Building owner leveraged at 20%, i.e. 80% loan-to-value, 10-year, fixed 7.375% mortgage rate, amortization period of 25 years, no points at closing (Citibank source); 1.49% rate of inflation based on Consumer Price Index for Sept. 1998.

Modified Uniform Present Worth Formula:

$$P = A[(1+e)/(i-e)][1 - ((1+e)/(1+i))n]$$

where:

- P = present worth of annual insurance savings
- A = annual insurance savings
- i = interest rate on mortgage
- e = rate of inflation on insurance costs
- n = time horizon for payback

EXAMPLE:

For comparison of a fire resistive and a wood frame structure, both utilizing a balanced design approach to fire-safety (sprinklers, detectors & alarms), A = $3,101 with the leveraged amount of construction deficit at $11,122. Substituting $i = 0.07375$ and $e = 0.0149$ into the equation,

P = $11,274 > $11,122 for a payback period of n = 4.2 years.

If one uses an inflation rate of 5.32% which is the average rate over the last 29 years, the payback period is reduced to 3.8 years. Table 3 shows the results of similar analyses for different scenarios of protection for the two types of building construction.

Table 3. Payback Periods to Overcome 20% Leveraged Construction Cost Differences for Various Protection Scenarios

Construction & Protection combinations	20% Equity Construction Cost Difference	Present Worth of Annual Insurance Savings	Corresponding Payback Period (years)
Non-sprinklered Fire Resistive vs. non-sprinklered frame	$12,202	$12,269	3.5
Sprinklered Fire Resistive vs. Sprinklered Frame	$11,122	$11,167	3.9
Non-Sprinklered Fire Resistive vs. Sprinklered Frame	$5,002	$5,150	**1.9**
Balanced Design Fire Resistive vs. Balanced Design Frame	$11,122	$11,274	4.2
Non-sprinklered Fire Resistive vs. Balanced Design Frame	$3,002	$3,017	**1.2**

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The findings indicate that the payback period for masonry and hollow core precast concrete construction combined with a balanced design approach is not significantly greater than that utilizing other types of construction and protection alternatives. The increased time frame and dollar amount is a small price to pay considering the superior improvement in fire protection. The results support that upgrading the local codes to mandate masonry and concrete construction, supplemented with sprinkler, detection and alarm protection for LRMFD's, will not create an undue hardship on the prospective owner of the building.

The question that must be asked is with this very short payback of the small initial cost increase:

Why are some local municipalities still allowing combustible types of multi-family construction?

Just because a multifamily structure is clad with brick does not mean that the fire protection is built into a structure.

Does the municipality want redevelopment or growth just for the sake of growth? Or does the municipality want quality, planned growth that forms a stable, durable tax-base - that is an asset to the community - not a future property maintenance nightmare!

Summary

The highlights of this brochure are summarized as follows.

Local building codes should be strengthened beyond model codes (where permitted) to improve the US fire record pertinent to low-rise multi-family dwellings (LRMFD's).

There is no justifiable reason to permit continued use of sprinkler tradeoffs, as this will only maintain the status quo of the US fire experience.

! Masonry and concrete elements subjected to standard fire testing demonstrate superior performance compared to other material assemblies commonly found in LRMFD's.

LRMFD's constructed of masonry and concrete supplemented by automatic sprinkler, detection and alarms systems are not cost prohibitive, contrary to popular belief.

Insurance savings associated with masonry and concrete LRMFD's result in payback periods that are not overly burdensome to prospective building owners, thereby creating a strong platform in support of upgrading local building codes.

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We would like to hear your comments. Send them to:
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