






	<h2 style="text-align: center;">Fire Safety with Concrete Masonry</h2>
<p>Continuing Education Services</p>	<p style="text-align: center;">Program Code: FTFCM</p> 

	<h2 style="text-align: center;">AIA Disclaimer Notice</h2>
<p>Continuing Education Services</p>	<p>The New England Concrete Masonry Association is a Registered Provider with The American Institute of Architects Continuing Education Systems. Credit earned on completion of this program will be reported to CES Records for AIA members. Certificates of Completion for non-AIA members are available on request.</p> <p>This program is registered with the AIA/CES for continuing professional education. As such, it does not include content that may be deemed or construed to be an approval or endorsement by the AIA of any material of construction or any method or manner of handling, using, distributing, or dealing in any material or product. Questions related to specific materials, methods, and services will be addressed at the conclusion of this presentation.</p>


	<h2 style="text-align: center;">Learning Objective</h2>
<p>Continuing Education Services</p>	<ul style="list-style-type: none"> • Fire statistics and trends • Concepts of balanced design for fire safety • Methods of evaluating fire ratings for concrete masonry

	<h2 style="text-align: center;">The Overall Fire Picture - 2006</h2>
<p>Continuing Education Services</p>	 <ul style="list-style-type: none"> • The U.S. has one of the highest fire death rates in the industrialized world (ranging from 9.8 to 25.1 deaths per million population depending upon size of community). • 3,245 civilians lost their lives in fires (1 every 162 minutes). • 16,400 civilian injuries occurred in fires (1 every 32 minutes). • 106 firefighters were killed in duty-related incidents.

	<h2 style="text-align: center;">The Overall Fire Picture - 2006</h2>
<p>Continuing Education Services</p>	<ul style="list-style-type: none"> • Fire killed more Americans than all natural disasters combined. • 81 percent of all civilian fire deaths occurred in residences. • Just under 1.6 million fires were reported. Many others went unreported, causing additional injuries and property loss. • Direct property loss due to fires was estimated at \$11.3 billion. • An estimated 31,100 intentionally set structure fires resulted in 305 civilian deaths. • Intentionally set structure fires resulted in an estimated \$755 million in property damage. <p><i>Source: National Fire Protection Association Fire Loss in the U.S. During 2006 and USFA's Firefighter Fatalities in the United States in 2006</i></p>


	<h2 style="text-align: center;">The Station Nightclub Rhode Island</h2>
<p>Continuing Education Services</p>	 <p style="text-align: right;">February 20, 2003</p>

Why is America Burning?



... when we have the best firefighters and equipment?
 ... when we have the best designers and researchers?
 ... when we have the most regard for human life?

It's in the choices we make.





Referenced NCMA TEK

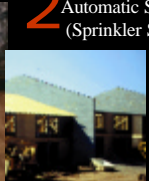
- TEK 7-1A: Fire Resistance Rating of Concrete Masonry Assemblies
- TEK 7-2: Balanced Design Fire Protection
- TEK 7-6: Steel Column Fire Protection

Components of Balanced Design


1 Automatic Detection Systems (Alarms)



2 Automatic Suppression Systems (Sprinkler Systems)



3 Compartmentation - using non-combustible materials (Concrete Masonry)



Balanced Design Table

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Table 1— Fire Safety Function of Balanced Design Concept (continued)

Function	Automatic Detection	Automatic Suppression	Compartmentation
Limits the extent of contents damage	●	●	●
Limits the extent of structural damage	●	●	●
Low installation costs	●	●	●
Low maintenance costs	●	●	●
Limits repair time due to fire damage	●	●	●

● Considered to be effective
 ● Considered to be partially effective
 ● Considered to be ineffective or only slightly effective

Balanced Design Table

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Table 1— Fire Safety Function of Balanced Design Concept (cont.)

Function	Automatic Detection	Automatic Suppression	Compartmentation
Controls fire/limits fire growth	●	●	●
Provides smoke, toxic fume barrier	●	●	●
Provides fire barrier	●	●	●
Limits generation of smoke/toxic fume	●	●	●
Allows safe egress	●	●	●
Provides refuge	●	●	●
Assists fire fighting efforts	●	●	●
Reduces fire and rescue response time	●	●	●
Difficult to vandalize/arson	●	●	●
Performance requires little maintenance	●	●	●

Reliability Through Redundancy

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1. Automatic Detection

2. Automatic Suppression

3. Compartmentation

Active Systems

Passive System

Consider the reliability of protection from individual components v.s. Redundancy provided by the complementing features of all three when combined.

Purpose of Fire-Resistive Assemblies

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- Provide safe egress of building occupants
- Provide for the fire service to make an interior fire attack
- Provide protection for the building
- Provide protection to adjacent structures and property

Types of Fire Assemblies
Reference: IBC 2003 and 2006

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- Fire Partition - vertical assembly designed to restrict spread of fire.*
- Fire Barrier - **fire-resistance-rated** vertical or horizontal assembly designed to restrict spread of fire.*
- Fire Wall - **fire-resistance-rated** extending continuously from the foundation through the roof with **sufficient structural stability** under fire to prevent collapse.*

* Note: Requires openings to be protected.

	<h2>Independent Support to Prevent Firewall Collapse</h2>
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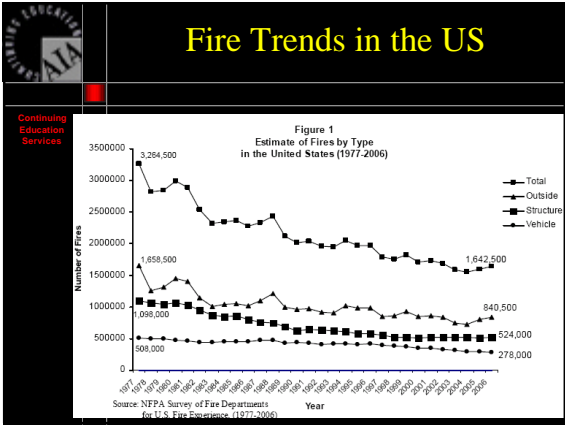
	<h2>Firewall Performance</h2>
<p>Continuing Education Services</p>	

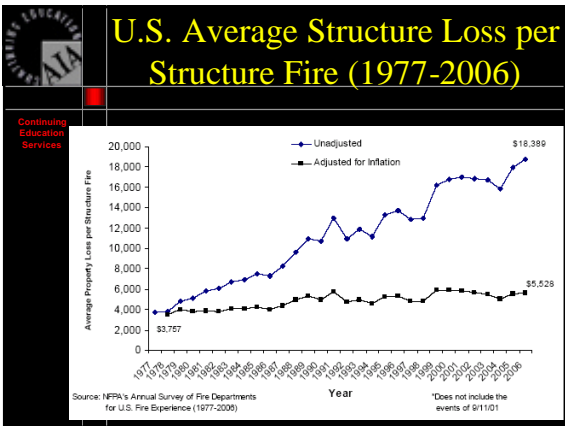
	<h2>Firewall Performance</h2>
<p>Continuing Education Services</p>	

	<h2>Firewall Performance</h2>
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	<h2>Firewall Performance</h2>
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	<h2>Consequence of No Firewalls</h2>
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Robustness

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Egress Protection

Hardened walls

Stair and Elevator Shafts

Fire Tests of Building Assemblies

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- Establishes fire endurance rating
 - End Point, 4h, 2h 1h etc.
- Standard ASTM E 119 provisions
 - Structural acceptance criteria
 - Fire barrier acceptance criteria
 - Controlled fire tests
 - Conduct of fire tests
 - Performance limits


Provide a specific standard fire exposure against which assemblies can be evaluated


Building Assembly's Resistance to Heat Transfer


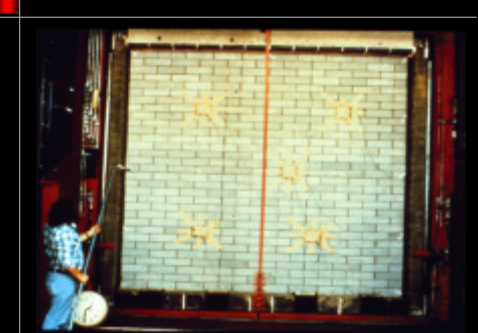
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Time - Temperature Curve - ASTM E 119



time (hr)	temperature (deg F)
0	0
0.5	1000
1	1500
2	1800
4	2000
8	2300


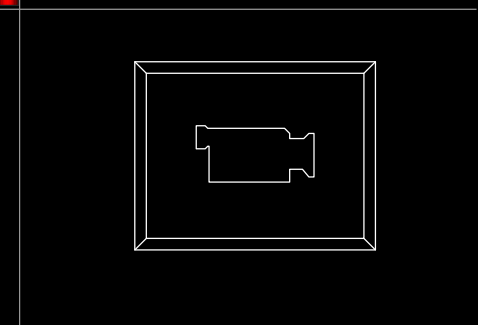
	<h2 style="color: yellow;">ASTM E119</h2> <h3 style="color: yellow;">Conditions of Acceptance</h3>
<p style="color: red; font-size: small;">Continuing Education Services</p>	<p>FOR WALLS AND PARTITIONS</p> <ul style="list-style-type: none"> • Resistance to heat transfer <ul style="list-style-type: none"> – Temperature rise less than 250 degrees on the unexposed side of the wall • No flame or gases passing through <ul style="list-style-type: none"> – Cotton swab observation • Carry structural load • Structural resistance to hose stream <ul style="list-style-type: none"> – Stream cannot penetrate wall

	<h2 style="color: yellow;">ASTM E119 End Point Criteria</h2>
<p style="color: red; font-size: small;">Continuing Education Services</p>	<p>FOR WALLS AND PARTITIONS</p> <ul style="list-style-type: none"> • Temperature on unexposed side of wall rises more than 250 degrees • Flame or gases pass through wall <ul style="list-style-type: none"> – Cotton swab ignites • Wall collapses under load • Hose stream penetrates wall

	<h2 style="color: yellow;">ASTM E119</h2> <h3 style="color: yellow;">Fire Testing a Masonry Wall</h3>
<p style="color: red; font-size: small;">Continuing Education Services</p>	

	<h2 style="text-align: center;">ASTM E119 Hose Stream Test</h2>
<p style="color: red; font-size: small;">Continuing Education Services</p>	<ul style="list-style-type: none"> • The wall specimen is subjected to impact, erosion, and cooling effects of hose stream • Not required for ratings less than 1 hour • Duplicate specimen allowed <ul style="list-style-type: none"> – Heated to 1/2 fire rating period – Need not exceed 1 hour • Optional - full fire endurance test specimen • Apply water from hose in sweeping motion for 2-1/2 minutes

	<h2 style="text-align: center;">By virtue of the duplicate test specimen provisions - these all are 2-hour rated walls</h2>
<p style="color: red; font-size: small;">Continuing Education Services</p>	

	<h2 style="text-align: center;">E 119 Hose Stream Test on Concrete Masonry Walls</h2>
<p style="color: red; font-size: small;">Continuing Education Services</p>	

Concrete Masonry Fire Ratings

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ASTM E 119

Three methods for determining ratings:

1. Fire Testing
2. Listing Service
3. Calculation Method

Concrete Masonry Fire Ratings

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Three methods for determining ratings:

1. Fire Testing
2. Listing Service
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Underwriter's Laboratory

UL 618
Standard for Safety for
Concrete Masonry Units

Concrete Masonry Fire Ratings

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3. Calculation Method

Fire Test Data - Calcareous and Siliceous Aggregate

Fire Resistance (minutes)	Equivalent thickness (in)
50	2.5
75	3.0
100	3.5
125	4.0
150	4.5
175	5.0
200	5.5
225	6.0
250	6.5

Equivalent Thickness

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Equivalent Thickness, T_e , is the solid thickness that would be obtained from the same volume of concrete without cores.

$T_e = \% \text{ solid} \times \text{actual thickness}$

UL 618

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- Restricted to:
 - width > 7-5/8 inches
 - height < 8 inches
 - length < 18 inches
- Aggregates - ESCS, pumice, coal cinders, natural
- Specifies aggregate type, cement-aggregate ratio, face shell and web thickness and equivalent thickness
- Not referenced by building codes


UL Fire Resistance Ratings


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Minimum face shell and web thickness

Type of aggregate	2 hours		3 hours		4 hours	
	Face shell thickness (in)	Web thickness (in)	Face shell thickness (in)	Web thickness (in)	Face shell thickness (in)	Web thickness (in)
Expanded clay, shale, or slate	1-1/8	1	1-3/8	1	-	-
Expanded slag	1-1/8	1	1-3/8	1	1-5/8	1
Natural	1-1/4	1	1-1/2	1	2-1/8	1-1/2

ASTM C90: 8 in - FST = 1-1/4 in, WT = 1 in
 10 in - FST = 1-3/8 in, WT = 1-1/8 in
 12 in - FST = 1-1/2 in, WT = 1-1/2 in

	<h2 style="text-align: center;">Concrete Masonry Section of ACI 216/TMS 0216.1 - Chapter 3</h2>
<p style="color: red; font-size: small;">Continuing Education Services</p>	<ul style="list-style-type: none"> • Equivalent thickness <ul style="list-style-type: none"> – UngROUTED or partially grouted – Solid grouted – Air spaces and cells filled with loose materials – Finishes/coverings • Concrete masonry wall assemblies <ul style="list-style-type: none"> – Single wythe – Multi-wythe – Expansion or contraction joints • Reinforced concrete masonry columns • Lintels • Structural steel column protection

	<h2 style="text-align: center;">ACI 216.1/TMS 0216.1</h2>
<p style="color: red; font-size: small;">Continuing Education Services</p>	<ul style="list-style-type: none"> • Referenced by the current International Building Code • Referenced in the 1999 BOCA National Building Code* • Referenced the in the 1999 Standard Building Code* • Presented in NCMA TEK 7-1A <p style="font-size: small;">* <i>BOCA and SBC is now superseded by IBC in most jurisdictions</i></p>


	<h2 style="text-align: center;">Equivalent Thickness Method</h2>
<p style="color: red; font-size: small;">Continuing Education Services</p>	<p>Fire ratings for concrete masonry walls are a function of:</p> <ul style="list-style-type: none"> • Aggregate type • Equivalent thickness

Table 3.1—Fire Resistance Rating of Concrete Masonry Assemblies

Aggregate type	Minimum required equivalent thickness for fire resistance rating in. ^{A, B}				
	1 hr	1½ hr	2 hr	3 hr	4 hr
Calcareous or siliceous gravel (other than lime stone)	2.8	3.6	4.2	5.3	6.2
Limestone, cinders, or air-cooled slag	2.7	3.4	4.0	5.0	5.9
Expanded Clay, expanded shale or expanded slate	2.6	3.3	3.6	4.4	5.1
Expanded slag or pumice	2.1	2.7	3.2	4.0	4.7

A Fire resistance ratings between the hourly fire resistance rating periods listed shall be determined by linear interpolation based on the equivalent thickness value of the concrete masonry assembly.

B Minimum required equivalent thickness corresponding to the fire resistance rating for units made with a combination of aggregates shall be determined by linear interpolation based on the percent of volume of each aggregate used in the manufacture.

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Expanded slag or pumice	2.1	2.7	3.2	4.0	4.7

Blended Aggregate Example

The required equivalent thickness of an assembly constructed of units made with expanded shale (80% by volume), and calcareous sand (20% by volume) to meet a 3 hour fire resistance rating is:

T_1 for expanded shale (3 hr rating) = 4.4 in. (112 mm)
 T_2 for calcareous sand (3 hr rating) = 5.3 in. (135 mm)
 $T_r = (4.4 \times 0.80) + (5.3 \times 0.20) = 4.58$ in. (116 mm)

	<h2 style="color: yellow;">Increasing Fire Resistance Ratings</h2>
<p style="color: red; font-size: small;">Continuing Education Services</p>	<ul style="list-style-type: none"> • use more lighter weight aggregates in production of CMU • increase actual thickness of CMU • increase percent solid of CMU • fill the cores of the hollow CMU (sand, grout, insulation) • use multi-wythe masonry and/or veneer • apply wall finishes or coverings

	<h2 style="color: yellow;">Filling Cores</h2>	
<p style="color: red; font-size: small;">Continuing Education Services</p>	<p>When the hollow cores of concrete masonry are filled, the equivalent thickness is considered to be the actual thickness of the concrete masonry unit.</p> <p>Thus all filled 8-inch and many 6-inch CMU have 4 hour ratings.</p>	

	<h2 style="color: yellow;">Multi-wythe Masonry</h2>
<p style="color: red; font-size: small;">Continuing Education Services</p>	

Multi-wythe equation

Clay Brick Concrete Masonry
 Air Space

$$R = (R_1^{0.59} + R_2^{0.59} + R_3^{0.59})^{1.7}$$

$$R = (1.25^{0.59} + 0.3 + 2.46^{0.59})^{1.7}$$

$$R = (1.14 + 0.3 + 1.7)^{1.7}$$

$$R = (3.14)^{1.7}$$

R = 6.99 hours

Finishes and Coverings

FIRE EXPOSED SIDE

NON-FIRE EXPOSED SIDE

Finishes and Coverings on Non-Fire Exposed Side

Type of finish and/or covering applied to slab or wall	Type of material used in concrete masonry units	
	Siliceous or carbonate aggregate concrete masonry unit	Expanded shale, expanded clay, expanded slag, or pumice less than 20 percent sand
Portland cement sand plaster or terrazzo	1.00	0.75
Gypsum-sand plaster	1.25	1.00
Gypsum-vermiculite or perlite plaster	1.75	1.25
Gypsum wall-board	3.00	2.25

¹ For portland cement-sand plaster 5/8 in. (16 mm) or less in thickness, and applied directly to concrete masonry on the non-fire-exposed side of the wall, multiplying factor shall be 1.0.

Note: TMS/ACI table shown. IBC does not contain the values for gypsum-wallboard.



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Questions

Thank you for your time!

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