Provisions of ACI/TMS 216.1 – Concrete and Masonry Fire Resistance Calculation

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ACI/TMS 216

- Joint ACI/TMS Committee
  - TMS = The Masonry Society
- Develops Standard ACI/TMS 216.1 – *Code Requirements for Determining Fire Resistance of Concrete and Masonry Construction Assemblies*

- Why do we need this?
- What does it say?

Why do we need ACI/TMS 216.1

- Determining fire resistance of building elements
- Several methods (International Building Code – IBC Chapter 7)
- Testing – ASTM E119 or UL263
- Prescriptive Detailing – within IBC
- Alternative means and methods
  - Listing services
- **Calculated Fire Resistance**

Fire Tests of Building Assemblies

- Governed by ASTM E119
  - Structural acceptance criteria
  - Fire barrier acceptance criteria
  - Control of fire tests
  - Conduct of fire tests

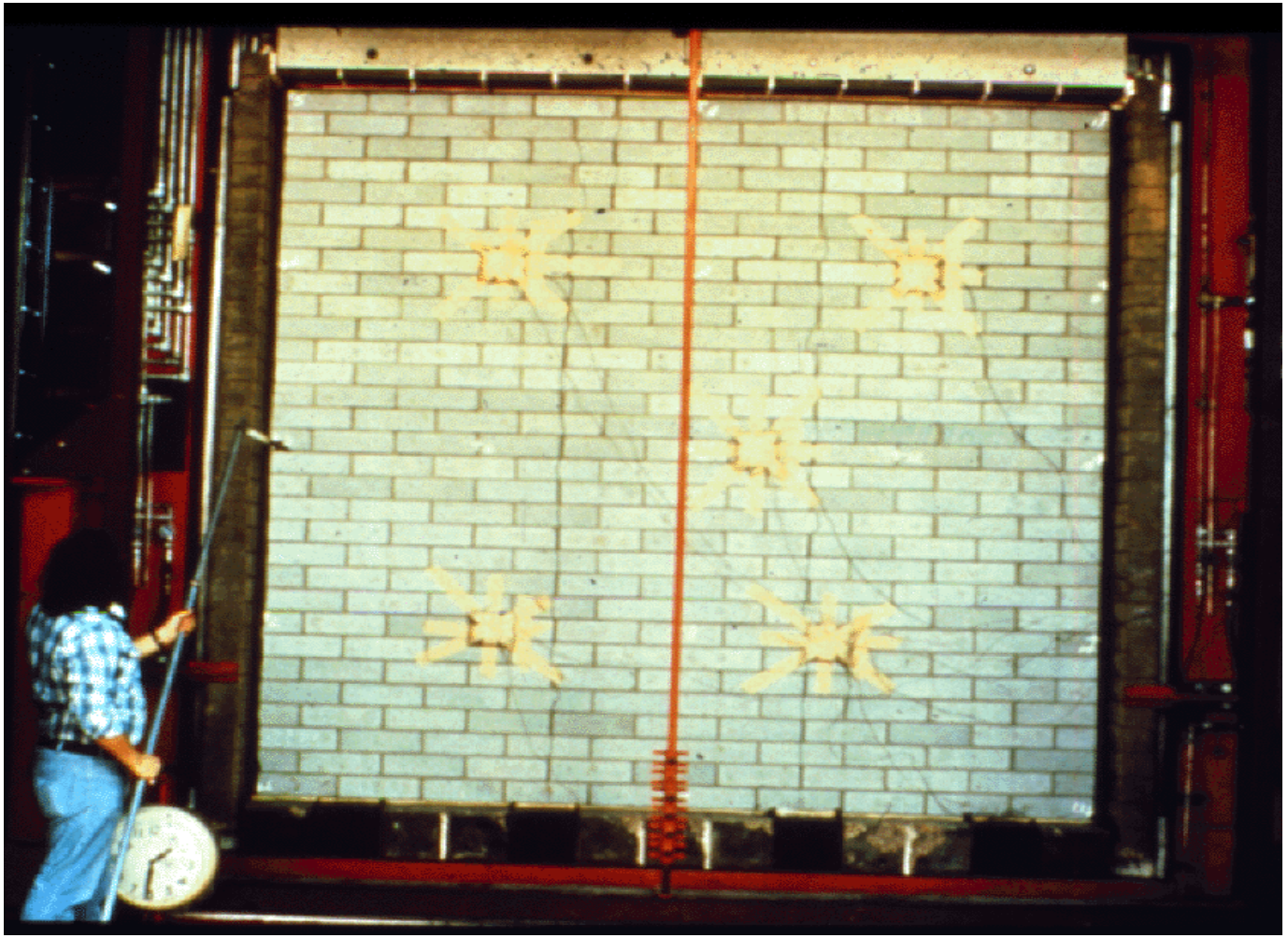
- Provides a specific standard fire exposure against which assemblies can be evaluated

ASTM E119 Conditions of Acceptance

FOR WALLS AND PARTITIONS

- Resistance to heat transfer
  - Temperature rise less than 250 degrees on the unexposed side of the wall
- No flame or gases passing through
  - Cotton swab observation
- Carry structural load
- Structural resistance to hose stream
  - Stream cannot penetrate wall

ASTM E119 Fire Testing a Masonry Wall



Physical Testing

- Fire are VERY expensive
- Most concrete and masonry assemblies fail predictably
  - Temperature rise failure criterion typical
- Because of this, ACI/TMS 216.1 was developed to provide calculation methods for determining fire resistance
  - Based on historical, empirical data

Prescriptive Approach

- Acceptable methods for determining fire resistance of concrete and masonry building assemblies
  - Walls, floors, roof slabs, beams, columns, lintels, etc.
- Used for design and analysis purposes - based on fire exposure and end point criteria of ASTM E119
- Contains graphical and numerical approaches

Contents of ACI/TMS 216.1

- Concrete
- Concrete Masonry
- Clay Masonry
- Column Protection
- Lintels
- Effects of Finishes

Concrete

Table 4.2—Fire resistance of single-layer concrete walls, floors, and roofs

Aggregate type	Minimum equivalent thickness for fire-resistance rating, in.				
	1 hour	1-1/2 hours	2 hours	3 hours	4 hours
Siliceous	3.5	4.3	5.0	6.2	7.0
Carbonate	3.2	4.0	4.6	5.7	6.6
Semi-light-weight	2.7	3.3	3.8	4.6	5.4
Lightweight	2.5	3.1	3.6	4.4	5.1

Concrete

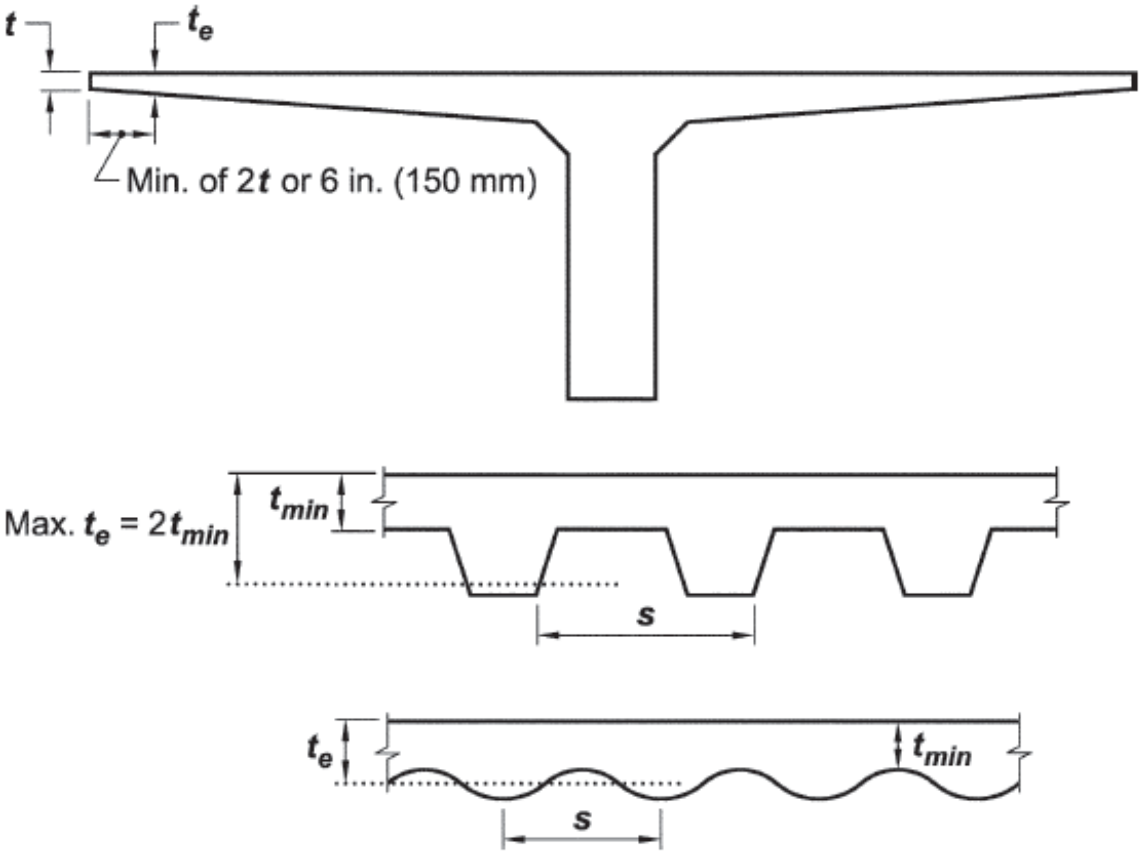


Fig. 4.2.3—Equivalent thickness of flanged, ribbed, and undulating panels.

Concrete

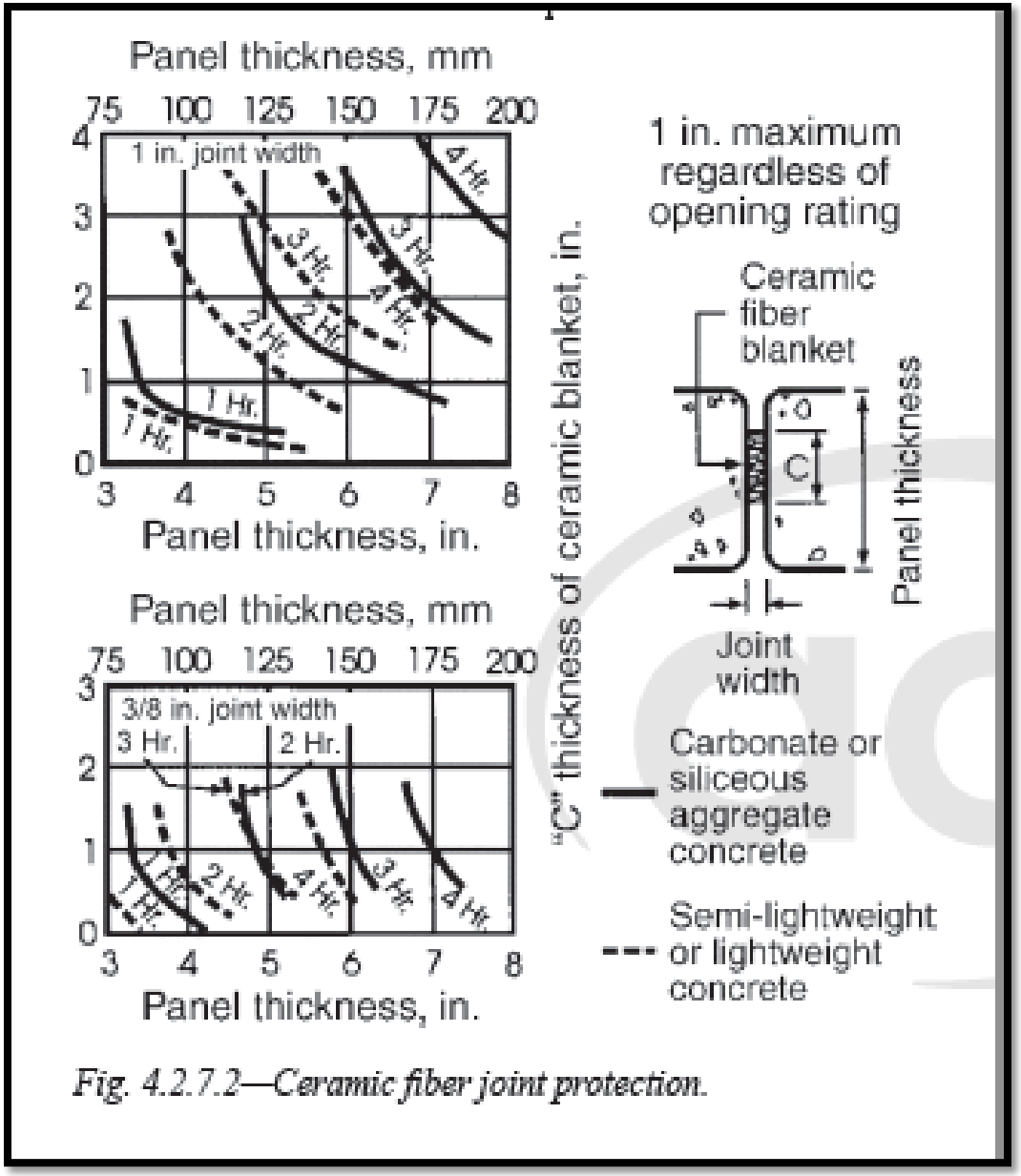


Fig. 4.2.7.2—Ceramic fiber joint protection.

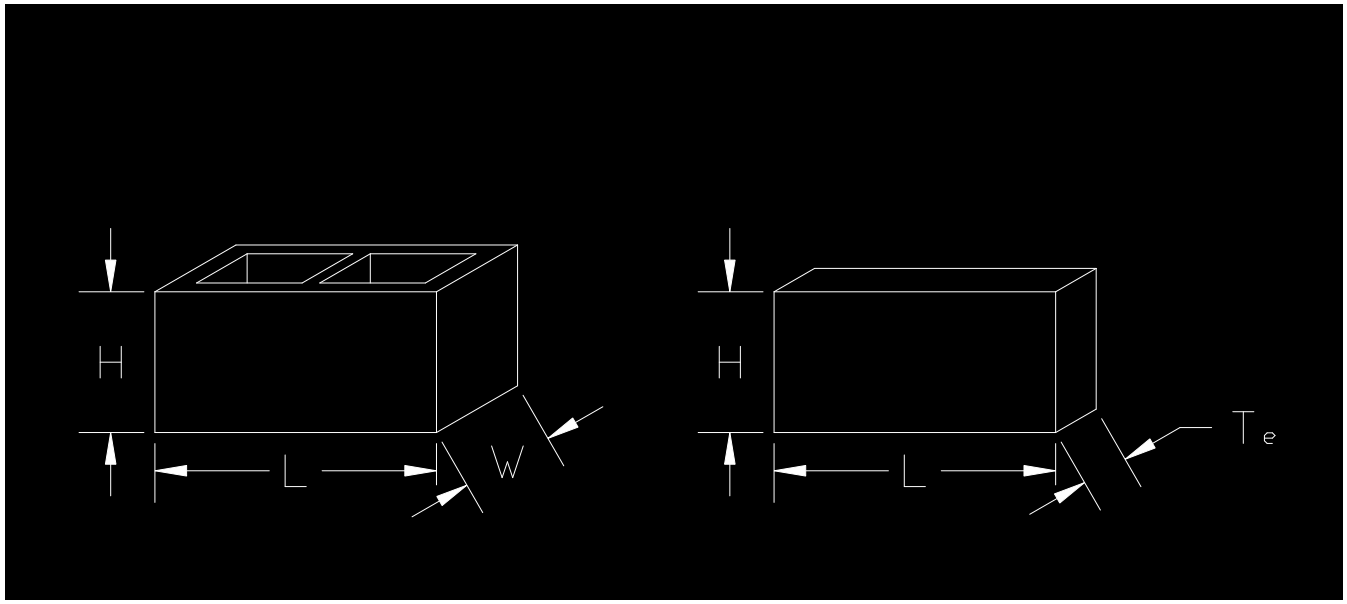
Concrete Masonry

Table 5.1a—Fire-resistance rating of concrete masonry assemblies

Aggregate type	Minimum equivalent thickness T_e for fire-resistance rating, in.[†]						
	1/2 hour	3/4 hour	1 hour	1-1/2 hours	2 hours	3 hours	4 hours
Calcareous or siliceous gravel (other than limestone)	2.0	2.4	2.8	3.6	4.2	5.3	6.2
Limestone, cinders, or air-cooled slag	1.9	2.3	2.7	3.4	4.0	5.0	5.9
Expanded clay, expanded shale, or expanded slate	1.8	2.2	2.6	3.3	3.6	4.4	5.1
Expanded slag or pumice	1.5	1.9	2.1	2.7	3.2	4.0	4.7

Equivalent Thickness

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



T_e = % solid x actual thickness

Clay Masonry

Table 6.3.1—Fire resistance of clay masonry walls

Material type	Minimum equivalent thickness for fire resistance, in.*†‡			
	1 hour	2 hours	3 hours	4 hours
Solid brick of clay or shale§	2.7	3.8	4.9	6.0
Hollow brick or tile of clay or shale, unfilled	2.3	3.4	4.3	5.0
Hollow brick or tile of clay or shale, grouted or filled with materials specified in 6.2.3	3.0	4.4	5.5	6.6

Column Protection

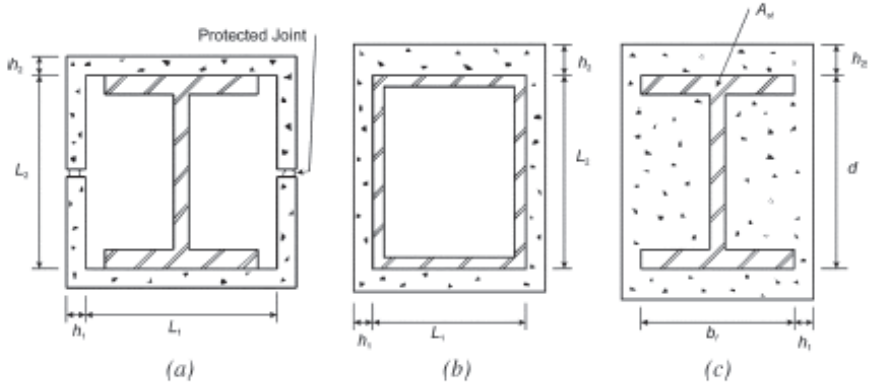


Fig. 4.6—Concrete-protected structural steel columns: (a) precast concrete column cover; (b) concrete-encased structural tube; and (c) concrete-encased wide flange shape.

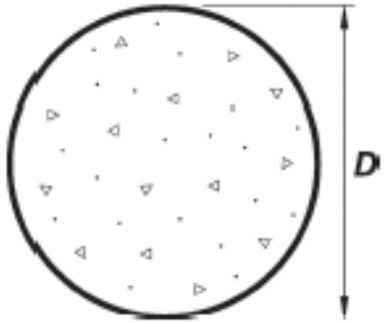
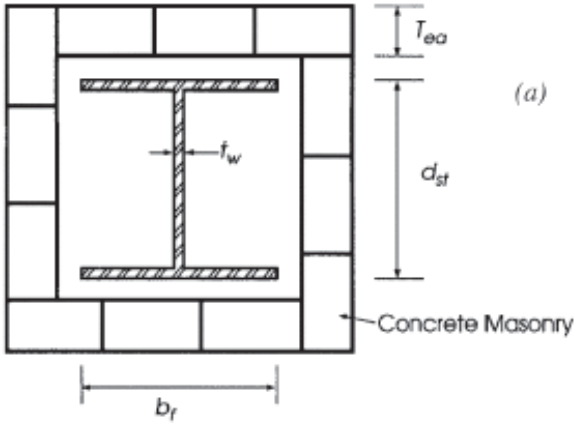
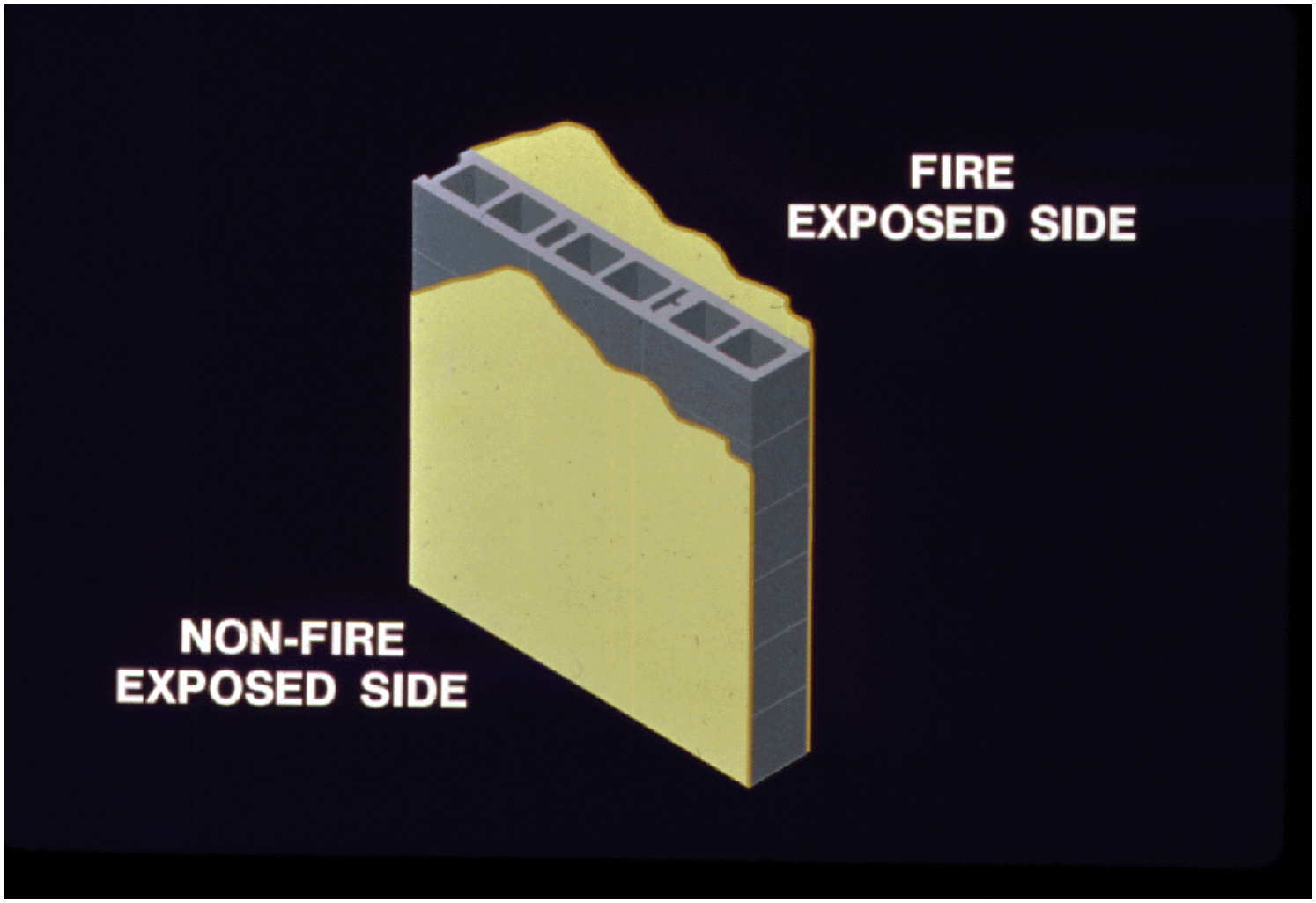


Fig. 4.7—Concrete-filled structural steel columns.



Finishes and Coverings



Surface Finishes

Table 7.2.2—Multiplying factor for finishes on non-fire-exposed side of concrete slabs and concrete and masonry walls

Type of material used in slab or wall	Type of finish applied to slab or wall			
	Portland cement-sand plaster* or terrazzo	Gypsum-sand plaster	Gypsum-vermiculite or perlite plaster	Gypsum wallboard
Concrete slab or wall				
Concrete—siliceous, carbonate, air-cooled blast-furnace slag	1.00	1.25	1.75	3.00
Concrete—semi-lightweight	0.75	1.00	1.50	2.25
Concrete—lightweight, insulating concrete	0.75	1.00	1.25	2.25
Concrete masonry wall				
Concrete masonry— siliceous, calcareous, limestone, cinders, air-cooled blast-furnace slag	1.00	1.25	1.75	3.00
Concrete masonry—made with 80 percent or more by volume of expanded shale, slate or clay, expanded slag, or pumice	0.75	1.00	1.25	2.25
Clay masonry wall				
Clay masonry—solid brick of clay or shale	1.00	1.25	1.75	3.00
Clay masonry—hollow brick or tile of clay or shale	0.75	1.00	1.50	2.25

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

Surface Finishes

Table 7.2.3—Time assigned to finish materials on fire-exposed side of concrete and masonry walls

Finish description	Time, minutes
Gypsum wallboard	
3/8 in.	10
1/2 in.	15
5/8 in.	20
Two layers of 3/8 in.	25
One layer of 3/8 in. and one layer of 1/2 in.	35
Two layers of 1/2 in.	40
Type "X" gypsum wallboard	
1/2 in.	25
5/8 in.	40
Direct-applied portland cement-sand plaster*	
Portland cement-sand plaster on metal lath	
3/4 in.	20
7/8 in.	25
1 in.	30
Gypsum-sand plaster on 3/8 in. gypsum lath	
1/2 in.	35
5/8 in.	40
3/4 in.	50
Gypsum-sand plaster on metal lath	
3/4 in.	50
7/8 in.	60
1 in.	80

*For purposes of determining the contribution of portland cement-sand plaster to the equivalent thickness of concrete or masonry for use in Tables 4.2, 5.1a, or 6.3.1, it shall be permitted to use the actual thickness of the plaster or 5/8 in., whichever is smaller.

Summary

- ACI/TMS 216.1 is a code referenced calculation method for determining fire resistance of concrete and masonry elements
- Based on historical data of ASTM E119 tests
- Provides a variety of calculation methods for a wide range of concrete and masonry assemblies
- Prescriptive/empirical method

Questions?

- Thank you

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