Structural Fire Engineering & The I-Codes

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Overview

- Structural Fire Engineering
- US Regulatory Environment
- IBC and ICC Performance Code
- Implementation
- Conclusions

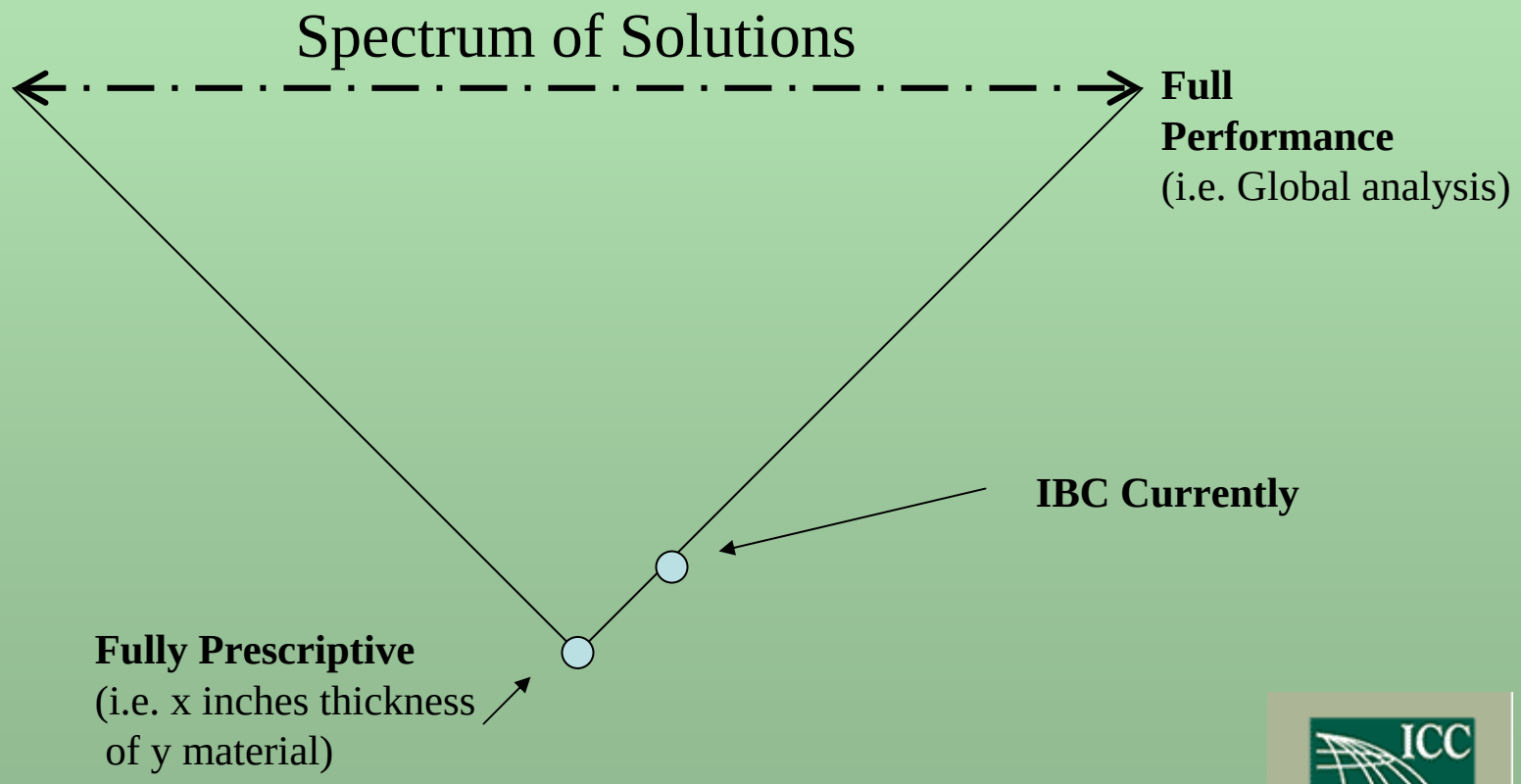
Structural Fire Engineering

- Departure from Traditional Methods
  - ASTM E119 - furnace
- More realistic
- Structural Fire Engineering
  - Thermal – Boundary Conditions
  - Mechanical – temperature affects on materials
  - Structural – Performance of structure

US Regulatory Environment

- Prescriptive methods in current codes
- Designers and Code officials (AHJ's) trained and familiar with prescriptive methods of fire resistance
- Performance Designs infrequent
- Equivalencies

Level of Performance



I-Codes

- *International Building Code (IBC)*
- *ICC Performance Code For Buildings and Facilities (ICCPC)*

IBC

- Primary building code
- Prescriptive fire resistance
- Chapter 6 prescribes fire resistance rating based upon type of construction
- Chapter 7 Provides methods to achieve and how to achieve the fire resistance rating
- No connection to structural provisions in Chapter 16 or material specific chapters

Table 601

Type of Construction Structural Frame Ratings (ASTM E119)								
IA	IB	IIA	IIB	IIIA	IIIB	IV	VA	VB
3	2	1	0	1	0	HT	1	0

Chapter 7

- **Structural/Insulation/Integrity**
- **Structural addressed in**
  - **714 Fire Resistance Rating of Structural Members**
    - **714.1 Requirements.** The fire-resistance rating of structural members and assemblies shall comply with the requirements for the type of construction and shall not be less than the rating required for the fire-resistance-rated assemblies supported.

ICCPC

- Performance Code
- Provides
  - Administrative provisions
  - Design performance levels
  - Topic specific intent statements
- Not intended to provide specific solutions
- A framework document

ICCPC Structural example

- **Chapter 17 Fire Impact Management**
  - **1701.1 Objective.** To provide an acceptable level of fire safety performance when facilities are subjected to fires that could occur in the fire loads that may be present in the facility during construction or alteration and throughout the intended life.

ICCPC Example

1701.2 Functional statements. Facilities shall be designed with safeguards against the spread of fire so that no person not directly adjacent to or involved in the ignition of a fire shall suffer serious injury or death from a fire, and so that the magnitude of the property loss is limited as follows:

- Performance Group I—High
- Performance Group II—Moderate
- Performance Group III—Mild
- Performance Group IV—Mild

ICCPC Example

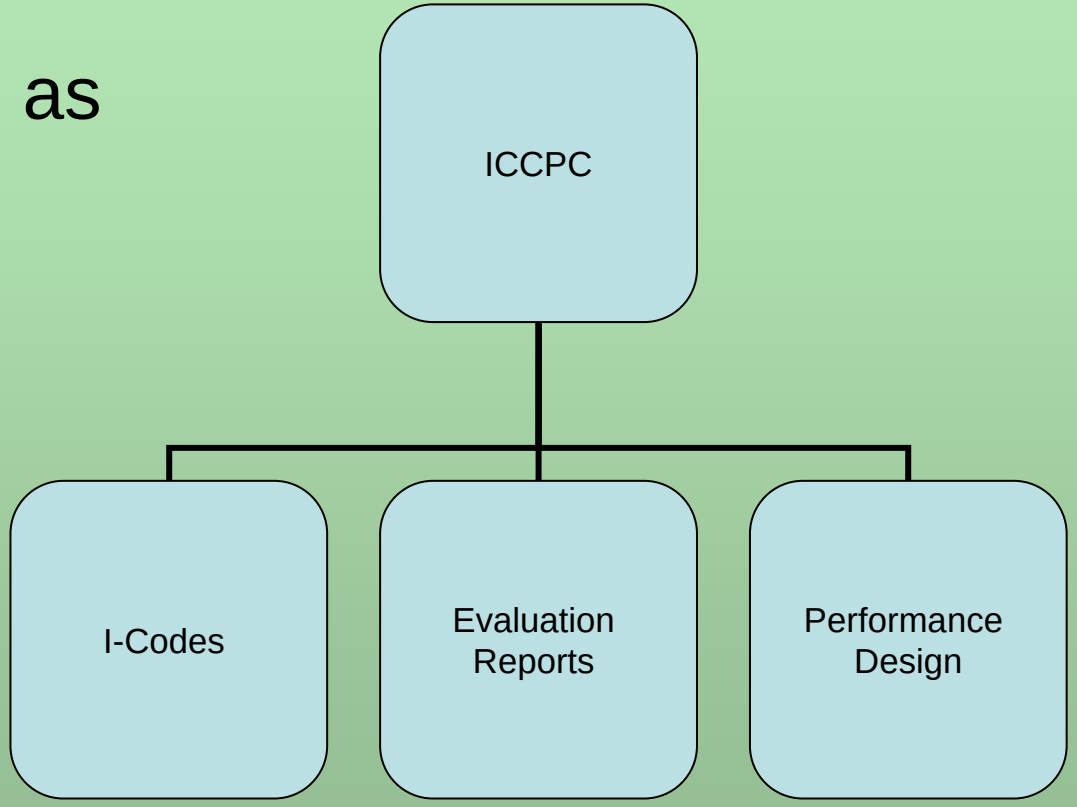
- **Functional statement continued**
  - **1701.2.7 Structural integrity.** Facilities shall be arranged, constructed and maintained so as to limit the impact of a fire on the structural integrity of the facility.

ICCPC

- **Performance Requirement**
  - **1701.3.11 Structural members and assemblies.** Structural members and assemblies shall have a fire resistance appropriate to their function, the fire load, the predicted fire intensity and duration, the fire hazard, the height and use of the building, the proximity to other properties or structures, and any fire protection features.

IBC & ICCPC Relationship

- ICCPC intended as an overarching document
- IBC is a set of solutions



Implementation

CODE CHANGE PROPOSAL 06/07

703.3 Alternative methods for determining fire resistance. The application of any of the alternative methods listed in this section shall be based on the fire exposure and acceptance criteria specified in ASTM E 119 <u>or a credible worst case design based fire exposure and acceptance criteria as agreed with the building official</u>. The required fire resistance of a building element shall be permitted to be established by any of the following methods or procedures:

Implementation

CONT.

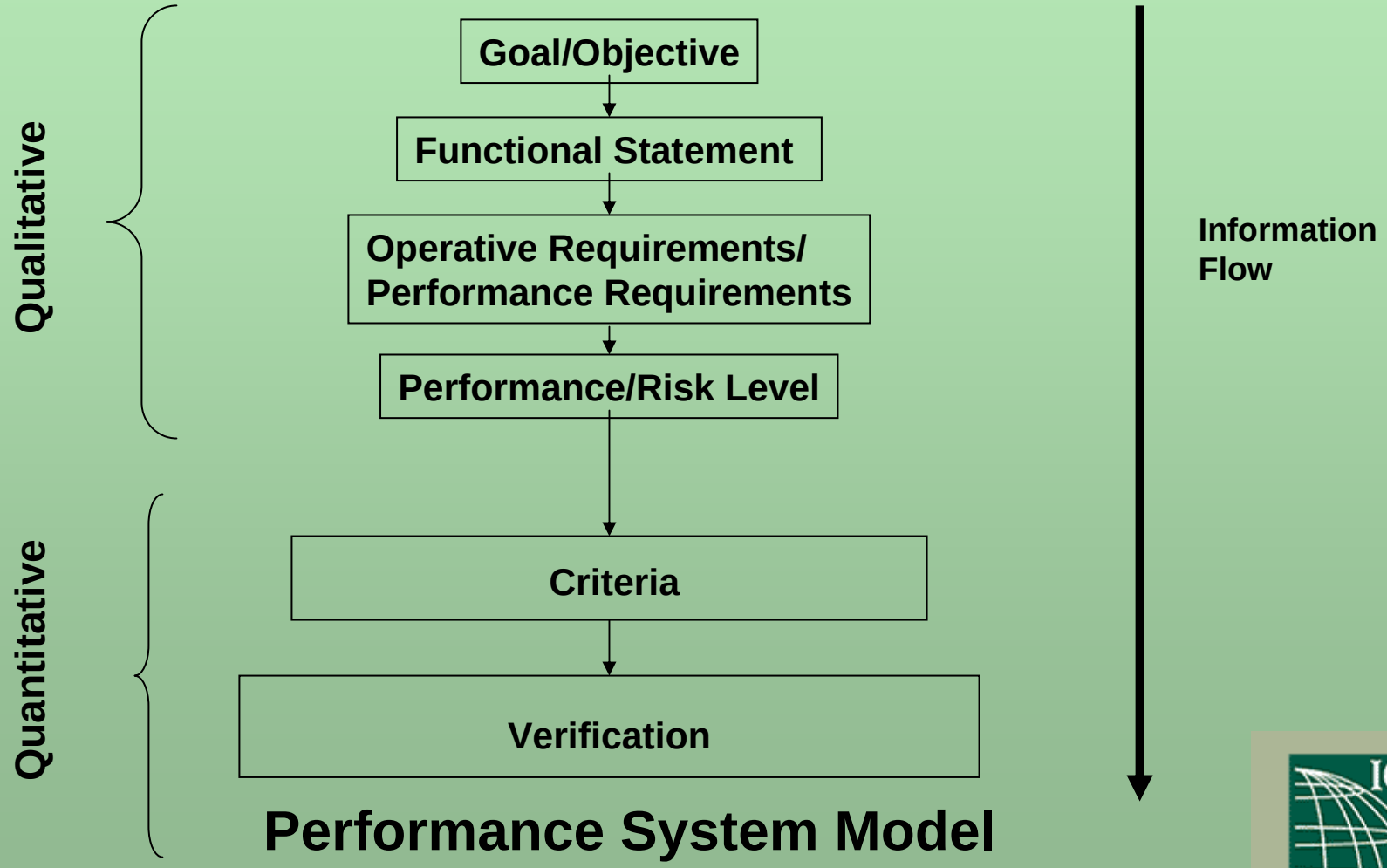
1. Fire-resistance designs documented in approved sources.
2. Prescriptive designs of fire-resistance-rated building elements as prescribed in Section 720.
3. Calculations in accordance with Section 721.
4. Engineering analysis based on a comparison of building element designs having fire-resistance ratings as determined by the test procedures set forth in ASTM E 119.
5. Alternative protection methods as allowed by Section 104.11.
6. Global structural analysis of a whole frame or assembly including: exposure to a series of credible worst case design fires, the relevant heat transfer calculations to the structural members, the relevant loads, the relevant failure modes during fire exposure, the temperature-dependent material properties and member stiffness as well as the effects of thermal expansion. The impact of deformations on compartmentation shall also be taken into account.

Implementation

	Tabulated Data	Simplified Calculation Methods	Advanced calculation models
Member analysis	Yes Standard Fire Only	Yes Standard fire and parametric fire*	Yes Only the principles are given
Analysis of parts of the structure	NO	YES Standard Fire and Parametric fire*	Yes Only the principles are given
Global Structural Analysis	NO	NO	Yes Only the principles are given

Abbreviated from EC2, 2002 – alternative methods of verification for fire resistance (Buchanan, 2003)
* Parametric fire – determined on the basis of fire models and the specific physical parameters defining the conditions in the fire compartment.

Implementation



Performance System Model

Implementation

- How much in codes?
- Needs
  - Design Fires
  - Failure/Performance criteria
  - Standard Development
    - SFPE – Calculating Fire Exposures to structures (In process)
    - SFPE – Thermal response of Structures to Fire (In Process)
    - Structural Response standard necessary

Conclusions

- Regulatory arena accustomed to prescriptive fire resistance. No link in IBC between fire and structural (Chapter 6 and 7 and chapter 16)
- Structural Fire Engineering possible through equivalency process
- Implementation can be at various levels
- Before more mainstreamed implementation is possible
  - Suite of standards necessary
    - Thermal – Boundary Conditions
    - Mechanical – temperature affects on materials
    - Structural – Performance of structure
  - Design fire scenarios and Performance criteria in regulatory format similar to structural loads