Innovations in Building a Safer World

Cairo, Egypt

An Introduction to Performance Based Design in NFPA 5000, *Building Construction and Safety Code*

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Agenda

1. **Background and Philosophy of Code**
2. Code Administration (Chapter 1)
3. **Goals and Objectives (Chapter 4)**
4. **Performance Based Design Approaches (Chapter 5)**
5. Occupancy Classifications/ Hazard of Contents (Chapter 6)
6. **Occupancy based Rules for Assembly**, Educational, Mercantile, Business, Industrial and Storage (Chapters 16,17,27,28,29 and 30)
7. Special Structures (Chapter 31)
8. Special Construction (Chapter 32)
9. High Rise (Chapter 33)
10. High Hazard Contents (Chapter 34)

Format

- Code format is occupancy based
- Committees have responsibility for one chapter or 8 chapters
- This model familiar to LSC users
- Occupancy base:
  - What am I building
  - Start with that chapter
  - Gain access to other relevant chapters and sections
- Utilize annex text as appropriate

Format

- GENERAL
- OCCUPANCIES
- STRUCTURAL
- MATERIALS
- BUILDING SYSTEMS

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GENERAL

- Chapter 1 Administration
- Chapter 2 Referenced Publications
- Chapter 3 Definitions
- Chapter 4 General
- Chapter 5 Performance-Based Option
- Chapter 6 Classification of Occupancy, Classification of Hazard of Contents, and Special Operations
- Chapter 7 Construction Types and Height and Area Requirements
- Chapter 8 Fire-Resistive Materials and Construction
- Chapter 9 Reserved
- Chapter 10 Interior Finish
- Chapter 11 Means of Egress
- Chapter 12 Accessibility
- Chapter 13 Encroachments into the Public Right of Way
- Chapter 14 Safeguards During Construction
- Chapter 15 Building Rehabilitation

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OCCUPANCIES

- Chapter 16 Assembly Occupancies
- Chapter 17 Educational Occupancies
- Chapter 18 Day-Care Occupancies
- Chapter 19 Health Care Occupancies
- Chapter 20 Ambulatory Health Care Occupancies
- Chapter 21 Detention and Correctional Occupancies
- Chapter 22 One- and Two-Family Dwellings
- Chapter 23 Lodging or Rooming House Occupancies
- Chapter 24 Hotels and Dormitory Occupancies
- Chapter 25 Apartment Buildings
- Chapter 26 Residential Board and Care Occupancies
- Chapter 27 Mercantile Occupancies
- Chapter 28 Business Occupancies
- Chapter 29 Industrial Occupancies
- Chapter 30 Storage Occupancies
- Chapter 31 Occupancies in Special Structures
- Chapter 32 Special Construction
- Chapter 33 High-Rise Buildings
- Chapter 34 High Hazard Contents

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STRUCTURAL

- Chapter 35 Structural Design
- Chapter 36 Soils, Foundations, and Retaining Walls
- Chapter 37 Exterior Wall Construction
- Chapter 38 Roof Assemblies and Roof Structures
- Chapter 39 Flood-Resistant Design and Construction
- Chapter 40 Quality Assurance During Construction

MATERIALS

- Chapter 41 Concrete
- Chapter 42 Aluminum
- Chapter 43 Masonry
- Chapter 44 Steel
- Chapter 45 Wood
- Chapter 46 Glass and Glazing
- Chapter 47 Gypsum Board, Lath, and Plaster
- Chapter 48 Plastics

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BUILDING SYSTEMS

- Chapter 49 Interior Environment
- Chapter 50 Mechanical Systems
- Chapter 51 Energy Efficiency
- Chapter 52 Electrical Systems
- Chapter 53 Plumbing Systems
- Chapter 54 Elevators and Conveying Systems
- Chapter 55 Fire Protection Systems and Equipment

ANNEX INFO

- Annex A Explanatory Material
- Annex B Vermin Proofing
- Annex C Flood Resistant Construction
- Annex D Construction Types and Enhanced Fire Compartmentation Requirements
- Annex E Non-Mandatory Informational References
- Index

General Information

- Chapter 1 Administration
  - Scope
  - Purpose
  - Application
    - New
    - Moved buildings
    - Existing buildings
  - Equivalency
    - Design, standards, systems, materials, methods, structural units

General Information

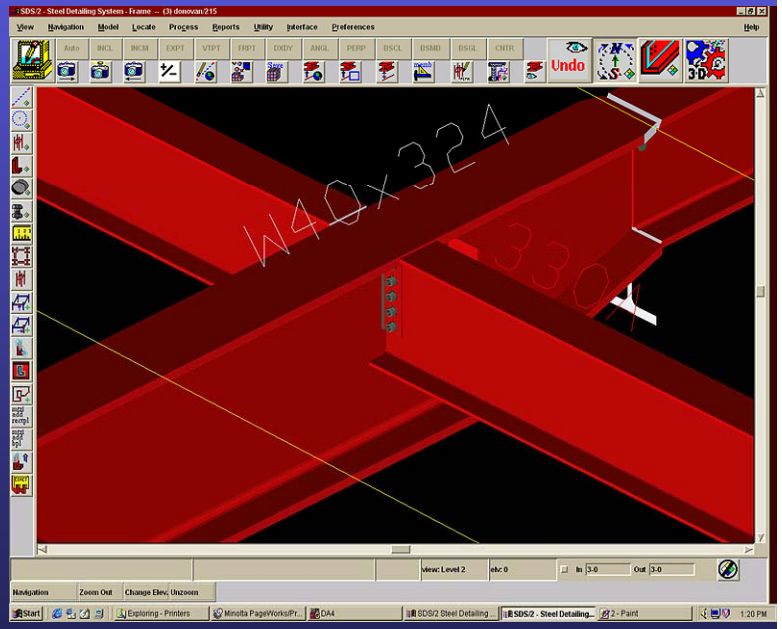
- Chapter 1 Administration (cont)
  - Enforcement Provisions
    - Organization
      - Building department
      - Reports/records
      - Board of appeals
      - Unsafe building provisions
    - Permits, Plans, Inspections
      - Inspections for:
        - Foundations
        - Framing
        - Roofing
        - Reinforcing Steel
        - Insulation
        - Masonry

General Information

- Chapter 4 General
- Code will set broad goals…
  - Safety, health, building usability, public welfare
- And objectives…
  - Fire, structural failure, building use, interior environment, lighting, sanitation, accessibility, exterior environment
- That can be satisfied through
  - Prescriptive design approaches
  - Performance-based design approaches

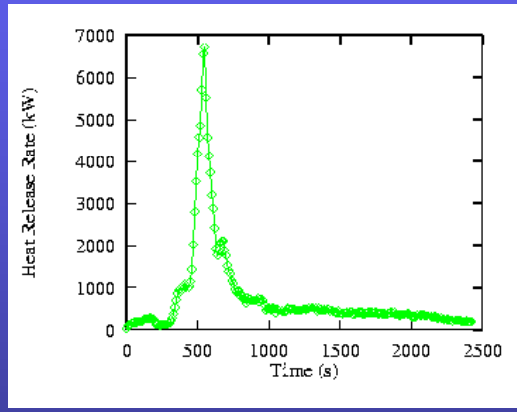
NFPA 5000 Chapter 4

- Goals and objectives defined and linked in four* broad areas
  - Safety
  - Health
  - Usability
  - Public welfare
  - * (Property protection)
- Further divisions for:
  - Specific hazard
  - Specific outcome



NFPA 5000 Chapter 4

- Safety from fire
  - Goal: a. occupants reasonably safe from fire b. fire fighters and first responders
  - Objective: a. occupants have time to relocate or defend in place b. first responders have protection for SAR operations



NFPA 5000 Chapter 4

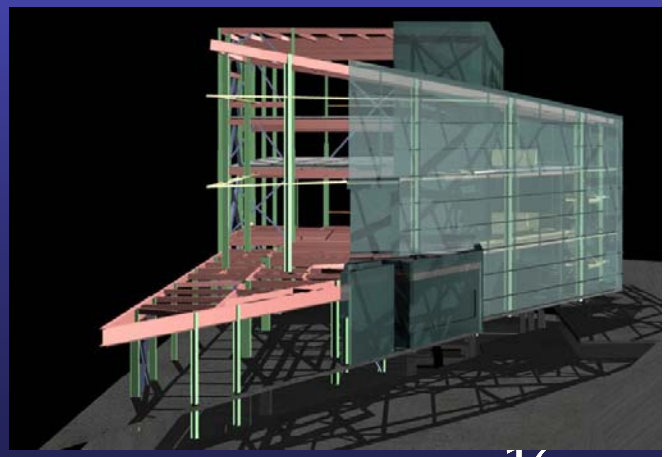
- Safety from structural failure
  - Goal: establish low probability from local/global collapse; falling debris hazards;resisting reoccurring loads
  - Objective: resist combination loads
    - Dead, live, impact, soil, hydrostatic, rain, snow, flood, ice, seismic, fire (post 11 September)

NFPA 5000 Chapter 4

- Safety during building use
  - Goal: safe during normal use
  - Objectives: protect against falls, crowd movement, notification of emergency events, identification of hazards, glazing protection
- Safety from hazardous materials

NFPA 5000 Chapter 4

- Health goals/objectives divided into 6 categories
  - Indoor environment
  - Noise/vibration
  - Surface water entry
  - Contaminants
  - Lighting
  - Sanitation



NFPA 5000 Chapter 4

- Usability goals/objectives relate to:
  - Accessibility
    - To building
  - Barrier free use
    - Within building
  - Function
    - Operation and purpose

NFPA 5000 Chapter 4

- Public welfare goals and objectives encompass
  - Energy efficiency
  - Cultural heritage preservation
  - Mission continuity
  - Environment

Performance Based Design

- 1995 — NFPA “white paper” on performance-based design option
- Define limits, intent, process and procedure
- Prescriptive-based Document:
  - Prescribes level of safety/protection
  - Specifies exact systems and arrangements
  - Assumes that acceptable “minimum” level of protection is achieved — if you follow the rules
  - Cookbook or recipe approach to protection
- Performance-based Document
  - Design process which utilizes a solution or set of solutions to achieve a specified goal

Performance Based Design

- Atrium Smoke Control
  - 6 air changes per hour
  - Maintain smoke layer interface $\geq$ 6 feet above highest walking surface for 1.5 X egress time or 20 minutes, whichever is greater
- Fire Barrier Wall
  - 8-inch thick brick and mortar
  - 2-hr fire resistance rated
  - Withstand maximum fire exposure for evacuation time plus 30 minutes

Performance Based Design

- Requires a true team (stakeholders) approach to agree on outcomes
  - Building owner/operator
  - Code officials (building, fire, electrical, plumbing, mechanical)
  - Engineer
  - Architect
  - Community
- No two necessarily alike
- Will share some, but not all solutions
- Suggested process includes:
  - Goals
  - Condition/characteristics of occupants, contents, facility
  - Objectives and criteria
  - Hazards to protect against

Performance Based Design

- Prescriptive codes
  - One size fits all
  - Limited choices
  - Restraints on creativity
  - Safe
  - “Reasonable Man” defense
- Performance Codes
  - Code writers must do a better job
  - Adaptable to many circumstances
  - Team oriented
  - Technology tied to outcome or criteria

NFPA 5000 Chapter 5

- Performance based design (PBD)
- Build on NFPA 101 model
- Follow NFPA primers on PB design options
- Address broader scope of hazard
- PBD option to:
  - Minimize impact from fire
  - Maintain structural integrity to:
    - Manage loads
    - Serviceability level
    - Immediate occupancy performance
    - Prevent catastrophic failure

NFPA 5000 Chapter 5

- Will provide performance criteria and design hazard scenarios for:
  - Fire
  - Structural design
  - Building use

NFPA 5000 Chapter 5

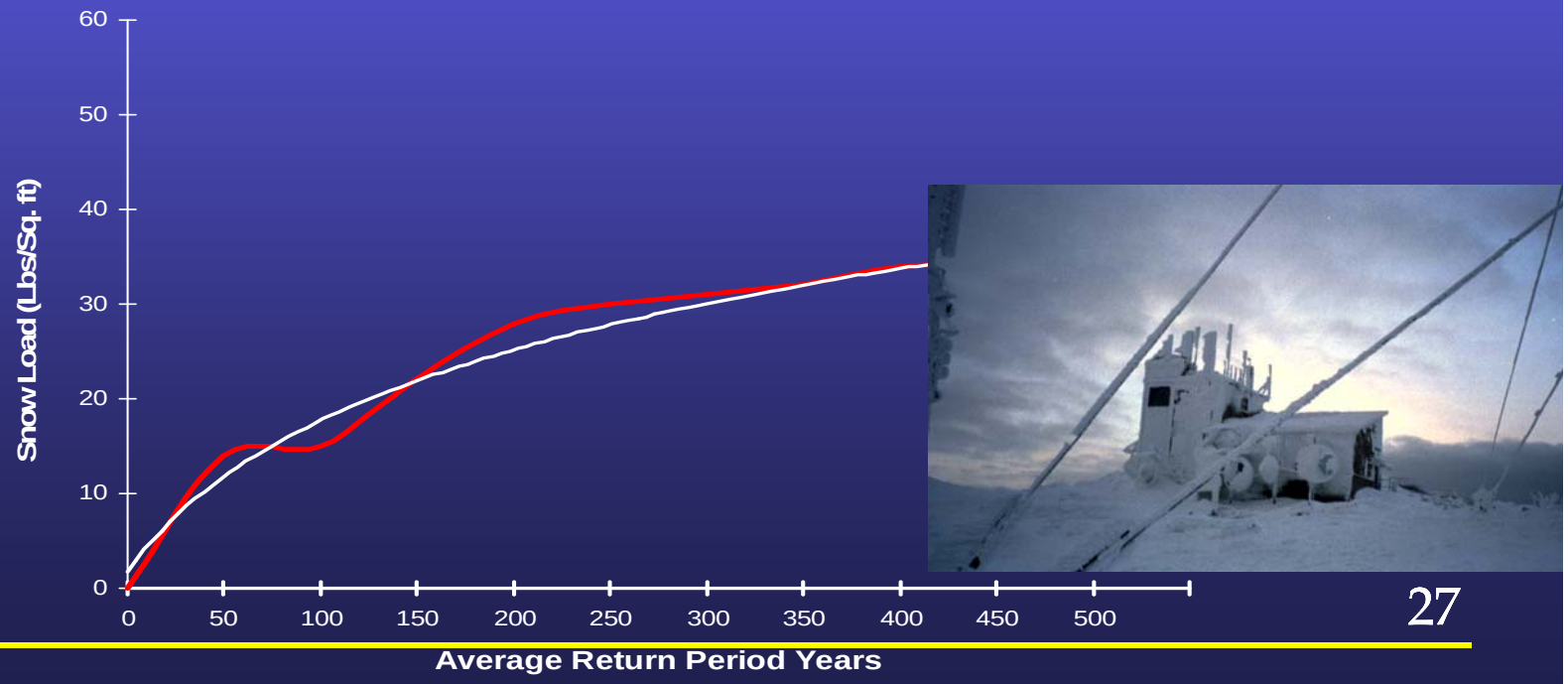
- Performance-fire event
  - Prevent ignition
  - Control spread
  - Prevent thermal failure of structural members
  - Relocate occupants to safe area
  - Time to execute SAR
  - Prevent spread to adjacent buildings

NFPA 5000 Chapter 5

- Performance-Structure
  - Combination loads
    - Dead, live, environmental, impact
  - Serviceability
    - No detrimental cracking or yielding
    - No permanent deformation or deflection
    - Nonstructural components in tact
  - Immediate occupancy
    - Minor, readily repairable damage
    - Continued occupancy possible
  - Collapse prevention
    - Affect rescue
    - Evacuate building

NFPA 5000 Chapter 5

- Light loading-frequent occurrence
- Moderate loading-occasional occurrence
- Severe loading-rare occurrence



Loading Severity

- Best estimate, based on historical experience that:
  - Probability of design load will be expected in some number of years (50 for most environmental loads) or;
  - Average time between expected reoccurrences of that design load
- May also be referred to as the **Hazard**

Siren, WI, June 20, 2001 -- An F-3 tornado on June 18 severely damaged the Dairy Queen that had just opened in April. Before the tornado, Burnett County had been under a major disaster declaration for flooding.

Photo by Jess Morgan/ **FEMA News Photo**

Sample Hazard Levels

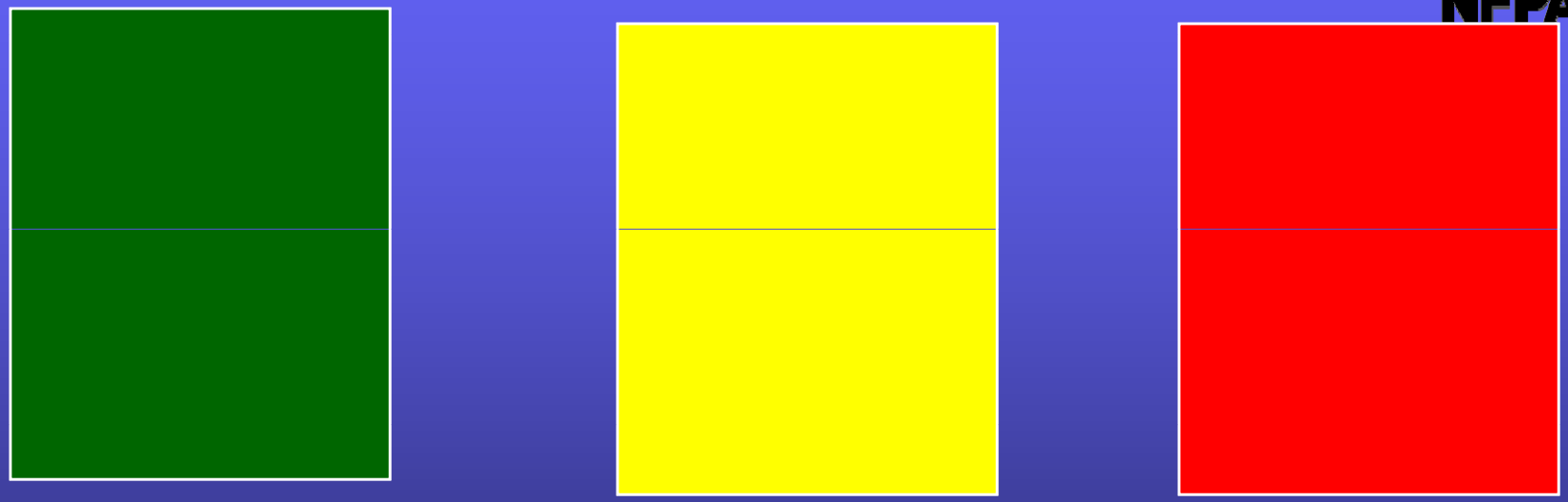
Probability of Exceedance

- 2 % per year
- 10%-ten years
- 10%-fifty years
- 2%-fifty years

Return Period

- 50 Years (snow)
- 100 years (wind)
- 500 years (wind)
- 2,500 years (seismic and live)

Performance Levels



Serviceability | Immediate Occupancy | Collapse Prevention

0 % → **Damage** → **99 %**

Performance Based Design Option

Design specifically intended to limit the consequences of one or more perils to defined acceptable levels

- *Perils addressed:*

  Fire

  Dead

  Live

  Wind

  Snow

  Earthquake

  Flood

Design Scenario

- Structural Systems and Application of:
  - Design load severity
  - Maximum acceptable damage level or performance level

  - Loading or Hazard + Performance Level

• Seismic	Serviceability
• Wind	Immediate occupancy
• Snow	Collapse prevention

Serviceability Level

- Minimal structural and non structural damage
- Utilities are in tact/available
- Facility is available for immediate re-use
- Minimal $$ for repair

Immediate Occupancy Level

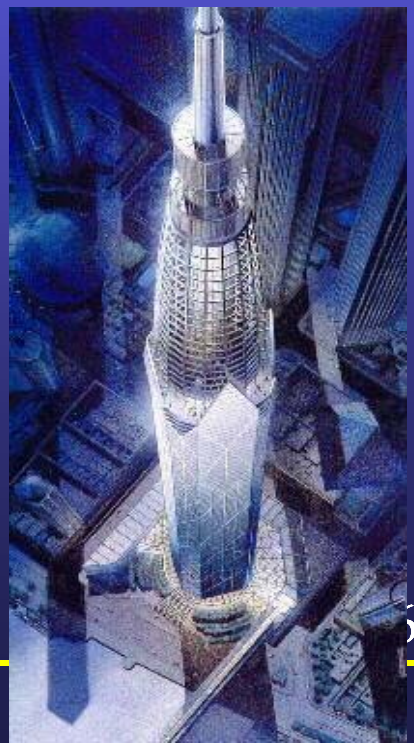
- Negligible/minimal structural damage
- Minor non-structural damage
- Building is safe for occupants, but not fully functional
- Some interruption to ‘normal’ operations
- Repair costs generally ≤ 15 % of building value

Collapse Prevention Level

- Extensive structural and non-structural damage levels
- Extended loss of use of the facility
- Repair costs approach replacement cost
- Repair costs generally ≥ 30 % of building value

The Future

- Performance-based design will
  - Alter role of code officials, architects and engineers
  - Allow fuller evaluation of all structures
  - Contribute to innovative design and cost effective methods and materials



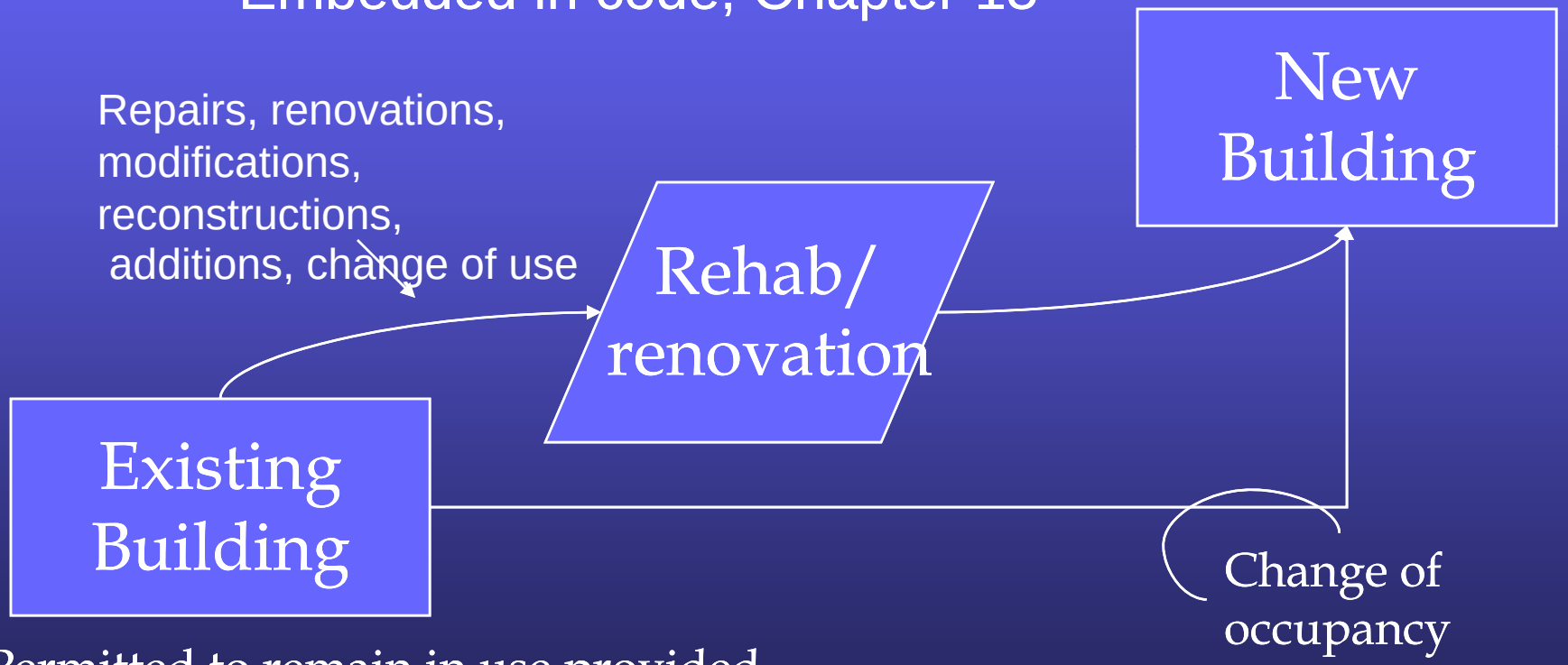
BUILDING REHABILITATION

Building Rehabilitation

- Chapter 15 applicable to:
  - Repair
  - Renovation
  - Modification
  - Reconstruction
  - Additions
  - Change of use
  - Change of occupancy

Building Rehabilitation

Embedded in code, Chapter 15



Permitted to remain in use provided no immediate hazards

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Chap 16 Special Provisions

Assembly Occupancies

- Life Safety Evaluation (LSE)
  - Occupant load is > 6000
  - Smoke protected assembly seating
  - Assessment of 10 specific attributes
- Smoke Protected Assembly Seating
  - Area not subject to smoke accumulation in seating area
  - Permits alternative design of egress and exit configuration
- Stages
  - Consistent with overall construction type
  - Smoke Control
  - Proscenium Walls
    - Curtains
- Projection Rooms

NFPA 5000 Chapter 32

Special Construction

Chapter 32 Special Construction

- Membrane structures
- Tents
- Awnings and canopies
- Marquees
- Outdoor signs
- Grandstands and bleachers
- Swimming pools and spas
- Cooling towers
- Temporary structures
- Masonry heaters

NFPA 5000 Chapter 32

Applicable to:

- Chapter 16, 32 & NFPA 102
  - Grandstands & Bleachers
  - Folding & Telescopic Seating
  - Tents
  - Membrane Structures
- Chapter 27 & 32
  - Signs, interior (Mall Signs) and exterior

NFPA 5000 Chapter 32

- Chapter 32 & Materials Chapters
  - Chimneys
  - Fireplaces
  - Swimming Pools
- Flood Design & Construction

Chapter 33 High Rise

- Defined as 75 ft. above lowest level of FD vehicle access
- Supplemental criteria for high rise largely independent of occupancy use
- Construction
  - Type I (442) when building height greater than 420 ft
  - Table 7.4.1

Chapter 33 High Rise

- Detection and Alarm Enhancements
  - Voice communication
  - Two way telephone communication between CCS and
    - Elevator car
    - Elevator lobby
    - Each floor level near exit stair
  - AS through out
    - Control valve and flow switch on each floor
  - Smoke proof enclosure for exit stairs

Chapter 33 High Rise

- Stand-by power
  - Class I, Type 60 to support
    - Fire Alarm
    - Fire Pump
    - CCS
    - At least one elevator
    - Mechanical equipment equip for smoke proof enclosure

QUESTIONS

Thank-you for your time and attention!

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