National Fire Academy

FESHE Model Curriculum

Pre-Fire Protection Engineering

February 2008

FEMA

Performance-based Design Fire Protection

Course Description: This course examined Performance-base Design of a building or facility based on performance goals and objectives, engineering analysis, scientific measurements and quantitative assessment of alternatives against the design goals and objectives using accepted engineering tools, methodologies and performance criteria.

Prerequisites:
Algebra
Fire Protection Systems
Fire Behavior
Building Construction

Outcomes:

1. Given examples of a performance-based design and a prescriptive-base design, describe the differences.
2. Given a fire spread scenario, explain the progression of the fire from start to extinguishment.
3. Given specific life safety criteria and non-life safety criteria requirements, determine whether a performance-based building design submitted for approval would meet the criteria of the local jurisdiction.
4. Describe the capabilities and limitations of the fire model(s) on which the design was based.
5. Evaluate performance-base design reports and verify whether documentation submitted is adequate.
6. Comprehend the types of building commissioning and acceptance testing associated with performance-based design buildings.
7. Identify and analyze field changes, building limitations, allowable alterations and renovations.
8. Describe the dynamics of fire.

Available Texts: *The Code Official's Guide to Performance-Based Design Review;* Society of Fire Protection Engineers and International Code Council
SFPE Engineering Guide to Performance-Based Fire Protection Analysis and Design of Buildings; National Fire Protection Association and Society of Fire Protection Engineers

Supporting References/Research for Faculty and Students:	**U.S. Fire Administration** *Building Construction, Combustible & Non-Combustible,* U. S. Fire Administration Publications: http://www.usfa.fema.gov/applications/publications See Arson, Fire Data, Fire Protection, Fire Service Operations, Hazardous Materials, Health and Safety, Wildfire Applied Research: http://www.usfa.fema.gov Research Reports: http://www.usfa.fema.gov Technical Reports: http://www.usfa.fema.gov/applications/publications Lessons Learned Information Sharing: Topical Fire Research Series: http://www.usfa.fema.gov/research Learning Resource Center: http://www.lrc.fema.gov **National Institute for Standards and Technology** http://www.fire.nist.gov: See Publications, FIREDOC (under Publications) Lessons Learned Information Sharing: **References** Society of Fire Protection Engineers: http://www.pentoncmg.com/sfpe/index.html **Current Events/News** http://www.firehouse.com http://www.fireengineering.com
Assessment:	Students will be evaluated for mastery of learning objectives by methods of evaluation to be determined by the instructor.
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Course Outline

Performance-based Design Fire Protection

I. Introduction

- A. Purpose
- B. Scope
- C. Comparison of Performance-Based Design with Prescriptive-Based Design
- D. Performance-Based Design Issues
- E. Performance-Based Design Submittals

II. Fire and Building Code Review

- A. Fire Protection Systems
- B. Means of Egress
- C. Structural Elements
- D. Interior Finish

III. Code Official's Role in Performance-Based Design

- A. Key Aspects of the Code Official's Role
- B. Building Commissioning and Testing
- C. Legal Liabilities of the Code Official

IV. Fire Dynamics

- A. Fire Triangle/Tetrahedron
- B. Ignition Process
- C. Fuel Characteristics
- D. Fire Development
- E. Growth Rate
- F. Structural and Building Contents Influences
- G. Ventilation
- H. Toxicity

V. The Performance-Based Design Process

- A. Scope
- B. Fire Safety Goals
- C. Fire Safety Objectives
- D. Performance Criteria
- E. Trial Fire Designs
- F. Evaluation of Trial Fire Designs
- G. Selection of the Final Trial Fire Design

VI. Fire Models

- A. Types of Models
- B. Uses and Limitations
- C. Factors Affecting Models Used
- D. Input Data
- E. Model Output

VII. Fire Tests

- A. Types of Fire Tests
- B. Uses and Limitations

VIII. Responsibilities of the Owner, Designer and Code Official

- A. Team Approach
- B. Owner Responsibility
- C. Designer Responsibility
- D. Code Official Responsibility

VIII. Performance-Based Design Team Member Qualifications

- A. Owner's Team Qualifications
- B. Reviewer's Team Qualifications

IX. Contract Review/Peer Review

- A. Contract Reviewer
- B. Peer Review

X. Defining Objectives, Functional Statements and Performance Requirements

- A. Objectives
- B. Functional Statements
- C. Development of Performance Requirements
  1. Life Safety Criteria
  2. Non-life Safety Criteria

XI. Design Fire Scenarios

- A. Identifying Design Fire Scenarios
  1. Probabilistic Approaches
  2. Deterministic Approaches
- B. Fire Characteristics
- C. Building Characteristics
- D. Occupant Characteristics

XII. Fire Protection Design Strategies

- A. Functional Statements
- B. Performance Requirements
- C. Trial Designs

XIV. Methods for Evaluating Designs

- A. Methods of Performance Assessment
- B. Levels of Design
- C. Deterministic and Probalistic Methods
- D. Methods for Addressing Limitations/Uncertainties

XV. Documentation

- A. Importance of Documentation
- B. Documentation Overview
- C. Responsibility for Providing Documentation
- D. Forms of Documentation
- E. Submittal Requirements

XVI. Building Commissioning and Acceptance Testing

- A. The Process of Commissioning and Acceptance Testing
- B. Evaluation of Acceptance Testing/Commissioning Results
- C. Evaluation of Materials and Methods

XVII. Field Changes and Adherence to Design Documents

- A. Quality Control During Construction
- B. Identification of Field Changes
- C. Reporting and Documentation of Field Changes
- D. Code Official Review and Acceptance of Field Changes

XVIII. Operations and Maintenance

- A. Operations and Maintenance Program
- B. Operation and Maintenance Manuals
- C. Limitations on Use of the Building
- D. Management of Change Protocol
- E. Facilities Staffing and Training Issues
- F. Testing and Maintenance
- G. Compensatory Measures
- H. Control of Fuel Loading
- I. Allowable Alterations
- J. Inspections by the Code Official

XIX. Managing Building Changes

A. Building Operations
B. Renovation Within the Scope of the O&M Manual
C. Renovation/Change of use Beyond Scope of O&M Manual

XX. Final Project of a Performance-Based Design

Advanced Concepts in Structural Fire Protection

Course Description: This course examines the principles and concepts for structural fire protection involving both fire resistance and the behavior (thermal strain, stress and fatigue) of structural components during fire conditions.

Prerequisites FESHE core courses or equivalent

Outcomes:

8. Analyze case studies from historical fires related to structural collapse and failure and emphasis on fire protection systems design.

9. Identify the principle structural components and evaluate the five types of building construction addressing special hazards and tactical considerations.

10. Develop and calculate approved fire resistance ratings employing established principles and models.

11. Describe the design objectives of fire resistance properties of assemblies including walls, floors, beams, columns, fire barriers and penetrations.

12. Describe the behavior of structural components and their mechanical properties (thermal strain, stress and fatigue) under fire conditions.

13. List and apply the “Ten Rules of Fire Endurance Rating”, according to ‘Harmathy’.

14. Evaluate occupancy designations and their respective fire resistance requirements according to state, local and regional building codes.

15. Describe the industry fire-resistive testing processes (e.g. ASTM E-119 test) for fire load, severity, and fire endurance according to NFPA and UL.

16. Evaluate the fire protection systems (e.g. spray on coatings, flame shields, encasements, barriers) for structural components in accordance with fire industry standards.

17. Identify the indicators of potential structural failure as they relate to firefighter safety and analyze the causes involved in the line of duty firefighter deaths related to structural firefighting.

18. Identify and analyze the causes involved in the line of duty firefighter deaths related to structural and wildland firefighting, training and research and the reduction of emergency risks and accidents

Supporting References/Research for Faculty and Students:

U.S. Fire Administration

Advanced Concepts in Structural Fire Protection, U. S. Fire Administration

Publications: http://www.usfa.fema.gov/applications/publications
See Fire Data, Fire Protection, Fire Service Operations, Health and Safety

Applied Research:
http://www.usfa.fema.gov

Research Reports:
http://www.usfa.fema.gov

Technical Reports:
http://www.usfa.fema.gov/applications/publications

Lessons Learned Information Sharing:
http://www.llis.dhs.gov/member/secure/index.cfm

Topical Fire Research Series:
http://www.usfa.fema.gov/research

Learning Resource Center:
http://www.lrc.fema.gov

National Institute for Standards and Technology

http://www.fire.nist.gov: See Publications, FIREDOC (under Publications)

Lessons Learned Information Sharing:
http://www.llis.dhs.gov/member/secure/index.cfm
http://www.usfa.fema.gov/applications/publications/techreps.cfm

References

NFPA and UL Codes and standards

Society of Fire Protection Engineers:
http://www.pentoncmg.com/sfpe/index.html

Current Events/News

http://www.firehouse.com
http://www.fireengineering.com
http://www.withthecommand.com

Assessment:

Students will be evaluated for mastery of learning objectives by methods of evaluation to be determined by the instructor.

Points of Contact:

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Course Outline

Advanced Concepts in Structural Fire Protection Systems

J. Introduction

- F. History of Structural Fire Protection
- G. Governmental Functions, Building and Fire Codes
- H. Design of Fire Protection
- I. Fire Loss Management and Life Safety
- J. Pre-fire Planning and Fire Suppression Strategies

XIII. Principles of Fire Protection

- E. Terminology and Definitions
- F. Occupancy Classifications
- G. Characteristics of Fire Protection Materials

III Structural Members

- D. Structural Design
- E. System Failures
- F. Fire Protection Materials
- G. Definitions, Descriptions

IV. Principles of Fire Resistance

- I. Standards of Material Construction
- J. Fire Intensity and Duration
- K. Assemblies
- L. Walls
- M. Floors
- N. Beams
- O. Columns
- P. Barriers
- Q. Penetrations
- R. Theory vs. Reality

V. Fire Behavior vs. Building Construction

- H. Flame Spread
- I. Smoke and Fire Containment
  1. Construction and Suppression Systems
  2. HVAC Systems

VI. Steel Construction

C. Definitions Of Structural Members
D. Fire Resistance and Fire Protection of Structural Members

VII. High Rise Construction

E. Protection Of Structural Members
F. Vertical and Horizontal Protection Design
G. Fire Protection and Suppression Systems
H. Elevators Design Of Protection Materials

Human Behavior in Fire

Course Description: This course provides fundamental information on human behavior as it relates to fire and mass casualties. Understanding human behavior is important as it relates to building design, evacuation and fire department operations. It is especially important where populations are large or include the disabled or persons having limited mobility.

Prerequisite: FESHE core courses or equivalent

Outcomes:

1. Categorize the types of behavior that people exhibit in fire situations as positive or negative as they effect emergency evacuation.
2. Outline three fire scenarios and describe the possible physiological impact each may have on building occupants and responding firefighters.
3. Identify four psychological traits of building occupants which may effect their identification of and response to a fire.
4. Perform algebraic estimates of occupant evacuation times from buildings.
5. Identify the two primary modeling techniques used to estimate evacuation times in large buildings and transportation facilities.
6. Identify at least four occupancies where human behavior and response characteristics are unique to occupancies and where there is a high potential life loss.
7. Write a summary of the human factors effecting high life loss in a major fire incident.
8. Identify five occupancies in your town/city/jurisdiction where human factors and building design may be factors in emergency evacuation. For one of these occupancies, list fire department procedures which should be implemented to deal with a major incident.
9. Develop a fire scenario and provide an estimate of the effective time of operation for the first responding firefighters.
10. Understand aspects of human behavior in mass casualties.
11. Identify and analyze the causes involved in the line of duty firefighter deaths related to structural and wildland firefighting, training and research and the reduction of emergency risks and accidents.

Available Texts:

SFPE Seminar: Human Behavior in Fire

SFPE Engineering Guide on Human Behavior in Fire

SFPE Engineering Guide on Estimating Fire Department Contributions toward Achieving Fire Safety Goals (draft)

SFPE SFPE Fire Protection Engineering Magazine, Fall 2005, Issue No. 28
http://www.pentoncustommedia.com/sfpe/articles/Fall2005

Supporting References

References

Purser, D. "Toxicity Assessment of Combustion Products", Proulx. G. "The Movement of People: The Evacuation Timing" Nelson, H.E., and Mowrer, F.W., "Emergency Movement", *SFPE Handbook of Fire Protection Engineering*, National Fire Protection Association, Quincy, MA, 2002, pp. 2-99 - 2:111

Society of Fire Protection Engineers:
http://www.pentoncmg.com/sfpe/index.html
http://www.peopleandfire.com/

Bryan, J. L., "Human Behavior and Fire", and Fahy, R.F., "Calculation Methods for Egress Prediction", *Fire Protection Handbook*, National Fire Protection Association, Quincy, MA, 2003, pp. 4-3 - 4-55.

Best, R.L., "Reconstruction Of A Tragedy: The Beverly Hills Supper Club Fire", *Southgate, Kentucky, May 28, NFPA, 1977.*

Review of 28 Egress Models. Kuligowski, E. D. NIST SP 1032; January 2005. Workshop on Building Occupant Movement During Fire Emergencies. Proceedings. Session 4.4. June 10-11, 2004, Gaithersburg, MD, Peacock, R. D.; Kuligowski, E. D., Editor(s)(s), 68-90 pp, 2005.
http://fire.nist.gov/bfrlpubs/fire05/PDF/f05008.pdf
http://www.pentoncustommedia.com/sfpe/articles/Fall2005Kuligowski.pdf

U.S. Fire Administration

Publications:
http://www.usfa.fema.gov/applications/publications/pubs_main.cfm
See Fire Protection, Fire Administration, Fire Service Operations
Applied Research:
http://www.usfa.fema.gov/dhtml/inside-usfa/research.cfm
Research Reports:
http://www.usfa.fema.gov/dhtml/inside-usfa/r_reports.cfm
Technical Reports:
http://www.usfa.fema.gov/applications/publications/techreps.cfm
Topical Fire Research Series:
http://www.usfa.fema.gov/dhtml/inside-usfa/tfrs.cfm
Learning Resource Center:
http://www.usfa.fema.gov/dhtml/inside-usfa/lrc.cfm

National Institute for Standards and Technology
http://www.fire.nist.gov: Fire Tests/Data, Software/Models, Publications, FIREDOC (under Publications)
http://fire.nist.gov/bfrlpubs/fire93/art090.html

Current Events/News
http://www.firehouse.com/
http://www.fireengineering.com/
http://www.withthecommand.com/

Assessment: Students will be evaluated for mastery of learning objectives by methods of evaluation to be determined by the instructor

NFPA Standards Addressed 1031

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Course Outline

Human Behavior in Fire

I. General Overview of Human Response to Fire

- A. Occupant Response Characteristics
  - 1. Familiarity with structure
  - 2. Pre-evacuation behavior
- B. Human Response to Cues
  - 1. Alarms, signs
  - 2. Preplanning/staff training
- C. Decision Making
  - 1. Panic as a rare occurrence
- D. Egress behavior and decision making

II. Impact of Environment on People

- A. Thermal
- B. Toxicity
- C. Visibility
- D. Psychological
  - 1. Perception of smoke and fire

III. Assessment of Occupant Movement in Buildings

- A. Evacuation Assessment Fundamentals
  - 1. Horizontal Flow
  - 2. Vertical Flow
- B. Modeling of Evacuation
  - 1. Hydraulic
  - 2. Behavioral
- C. Special Occupancies
  - 1. High Rise
  - 2. Health Care
    - a. Hospital
    - b. Board/care
  - 3. Public Assembly
    - a. Stadia
    - b. Arenas
  - 4. Residential
  - 5. Transportation terminals
  - 6. Hazmat occupancies
- D. Use of Elevators

IV. Fire Department Operations

A. Evacuation and Rescue
    1. Provide information to evacuees
    2. Occupant egress vs. fire department ingress
B. Firefighting
    1. Heat Stress
    2. Exposure to smoke, toxins and hazardous gases
C. Mass Casualties