NCDOI OSFM Evaluation Services

Scope of DOI White Paper: The Purpose of this document is to provide clarification on North Carolina State Code requirements to Code Officials (CEO) who are agents for the Authority Having Jurisdiction (AHJ).

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1.0 Definitions from Section 702 of the 2012 North Carolina Building Code and Section 202 of the 2012 North Carolina Fire Prevention Code

   A. Fire-Resistance Rating: The period of time a building element, component or assembly maintains the ability to confine a fire, continues to perform a given structural function, or both, as determined by the tests, or the methods based on tests, prescribed in Section 703 (of the North Carolina Building Code).

   B. Fire Resistance: That property of materials or their assemblies that prevents or retards the passage of excessive heat, hot gases, or flames under conditions of use.

2.0 The Purpose of “Fire-Resistance Ratings”

A. What is a “fire-resistance rating”?
   1. A fire resistance rating is a method or means to restrict the effects from the products of combustion for a predetermined period of time. Fire-resistance ratings can apply to and protect structural and non-structural elements of a building such as beams, columns, walls, floors and roof construction.
   2. This document addresses the more commonly recognized “passive” resistance systems, which can protect building elements. The code also permits “active” resistance systems such as the use of a fire sprinkler system to protect the integrity of a material or an assembly. Allowances for the use of “active” systems are typically prescribed by the code. An example is NCBC-Section 508.2.5 which permits some incidental accessory occupancies to be protected by an automatic fire extinguishing system in lieu of being separated from the remainder of a building by fire resistant rated construction.

B. Why are “fire-resistance ratings” used?
   1. No building, even one constructed with non-combustible elements, is considered “truly fireproof”. Combustible contents will usually burn first and the resulting fire could spread more quickly than if those non-combustible elements are protected by a fire-resistance rating:
   2. Restricting the spread of fire and resulting smoke, gases, etc. and/or extending the period of time before a building element or elements fails by having a fire-resistance rating should allow time for building occupants to safely egress the structure. It should also permit emergency fire personnel time to address the event.

C. What determines code compliance as a fire-resistance rating?
   1. Fire resistance ratings are determined by the performance of a material or an assembly of materials exposed to a simulated flashover fire. The rating is most commonly based on compliance with laboratory tests, but the rating can also be established by calculated methods contained in Chapter 7 of the NC Building Code.
   2. To be recognized by code as providing a fire-resistance rating, a material or assembly of materials must be tested. The intent of the test is to determine their fire-resistant properties and performance for resisting fire for a predicted length of time, i.e., the number of minutes or hours for which the material or assembly can contain or limit the spread of fire and/or restrict the thermal transfer of heat from a fire source to the protected component. The loss of this thermal protection can result in the spread of the fire and associated heat, smoke and toxic gases throughout the building, and ultimately can also result in failure of the building itself.
   3. The NCBC requires the fire-resistance rating for building elements, components and assemblies to be determined in accordance with the test procedures set forth in ASTM (2007 edition), UL 263 (2003 edition) or in accordance with NCBC-703.3 (Alternate Methods for Determining Fire Resistance). ASTM E-119 and UL 263
are addressed in Section 4.0 of this document.

4. Materials commonly installed to protect a building element from fire for a tested predetermined period of time are gypsum board, concrete, pre-manufactured concrete and clay block products. Spray applied protective systems and/or intumescent coatings are other methods recognized by the code under certain conditions to provide a fire-resistance rating.

5. The code also requires all penetrations (ducts, pipes, etc.), joints (connections, fasteners, etc.), and openings (doors, windows, etc.) associated with rated building elements, components and assemblies to be tested. The intent is for penetrations, joints, or openings to provide a similar degree of protection as the rated construction.

D. What can trigger the code requirement for “fire-resistance ratings” in a building?

1. The following are some typical examples where the NCBC and the NCFPC may require fire-resistance ratings:
   a. Buildings constructed with structural elements protected by fire-resistance rated systems are usually permitted by code to be taller, to have more stories and/or more square footage per floor than buildings with elements not having a fire-resistance rating. This is addressed in Chapter 5 of the NCBC.
   b. Frequently, buildings are designed for multiple uses that can result in the building having more than one occupancy classification. Because one classification may present a higher fire risk than another classification, the code may require fire-resistant rated construction to separate one, or more, occupancy type(s) from another. This is addressed in Section 508.4 of the NCBC.
   c. A building may have rooms or areas, referenced as “incidental accessory occupancies”, which have contents or serve a function that the code deems to present a special hazard or risk to life safety and property to the remaining areas of a building. To protect the remaining portion of the building, one solution by the NCBC is to separate these hazardous rooms/areas with fire-resistance rated construction. Incidental accessory occupancies are addressed in Section 508.2.5.
   d. A college building with laboratories and/or research facilities may house quantities of hazardous materials that exceed the limit of total fire load allowed by the NCBC and the NCFPC, thus requiring the occupancy type to be classified as “High-hazardous Group H”. However, by separating the building into areas of lesser size by fire-resistance rated construction in accordance with the code, the occupancy type could be classified as Business Group B which may have less code requirements than H occupancy. This compartmentalization is referred to by code as a “control area”, which is defined by the NCBC and the NCFPC as “Spaces within a building where quantities of hazardous materials not exceeding the maximum allowable quantities per control area are stored, dispensed, used or handled”. Control areas are addressed in Section 414 of the NCBC and Chapter 27 of the NCFPC.
e. The code requires means of egress components (i.e., corridors, vertical exit stairways, etc.) to be separated from the building with walls, floor and ceiling construction having a fire-resistance rating.

f. The code requires shafts (i.e. mechanical, elevator, etc.) to be separated from the remainder of a building by fire resistant rated construction because a shaft connects multiple floors. Floor openings through multiple stories allow smoke and gases to migrate from floor to floor sue to chimney effect.

E. Multiple safety benefits can be derived in a building having fire resistant rated construction if a fire were to occur. Some of the more significant benefits are as follows:

1. Fire-resistance rated construction can contain the spread of fire to allow time for occupants to evacuate the building safely and for emergency responders to enter, locate, and establish safe staging areas within the building to fight the fire until extinguished.

2. Structural integrity can be maintained for a longer period of time when the structural frame is fire-resistance rated, preventing early collapse during firefighting activities.

3. Based on the occupancy classification of buildings such as hospitals or nursing homes, non-ambulatory occupants may not be easily evacuated from a building during a fire event. Occupants may be directed to remain in a room protected by fire-resistant rated construction or relocated to a safe area of the building having fire-resistant protection until staff or emergency responders can safely evacuate them.

4. Fire-resistance rated construction can contribute to the protection of occupants in adjacent buildings, as well as their property and contents.

5. Although not directly linked to safety or code requirements, other potential benefits related to using fire-resistance rated construction are as follows:
   a. Limit the amount of building damage and its contents from fire to minimize business interruption, including loss of jobs.
   b. Limit the amount of building damage from fire to maintain the property tax base.
   c. Limit the amount of fire damage to a historical building to preserve the architectural significance.
   d. Fire-resistance rated construction can protect the environment by limiting the area of damage from fire, which can reduce:
      • Reduce the amount of hazardous emissions released into the atmosphere.
      • Reduce the quantity of construction debris deposited into a landfill.
      • Reduce the quantity of water and chemicals required to put out the fire and thus limit the amount of contaminated run off seeping into the ground water.
3.0 Determining Fire-Resistance Ratings

The traditional method to determine fire-resistance ratings for building elements has been based on prescriptive designs, as addressed in Chapter 7 of the NCBC. However, another approach in response to a fire, based on performance design, has been gaining popularity in recent years as this method provides more flexibility in the design of buildings while maintaining life safety.

A. Prescriptive Based Design Method

1. Historically, prescriptive based designs have been a reasonable and straightforward method for Authorities Having Jurisdiction to apply and enforce code. Most codes provided a “cook book” approach to calculating and/or evaluating fire-resistance ratings for buildings, based on their occupancy group and other determinants. For the most part, the NCBC and the NCFPC have prescribed what designers must do to comply with code. Buildings designed with this method have performed well in fire events, often resulting in minimal loss of life or property.

2. NCBC-Section 720 addresses acceptable prescriptive details of fire-resistance rated building components. Tables 720.1 (1-3) list specific building materials, assemblies, and states the minimum period of time each have been tested in accordance with ASTM E 119 or UL 263 to determine their fire-resistance rating.

3. NCBC-Section 721 contains procedures by which the fire resistance of specific materials or combinations/assemblies of materials, in terms of protection time, can be established by calculations. The fire-resistive time periods provided in this code section are derived from the testing of materials using ASTM E 119 or UL 263 to determine their fire-resistance rating.

B. Performance Based Design Method

1. In recent years, architects and engineers have proposed unique design features for incorporation in a building but these features were not always addressed prescriptively in the codes. Thus began the development of performance based designs, which can offer more design flexibility and options while continuing to address fire-resistance ratings associated with life safety for occupants and property preservation required by codes.

2. The 2012 International Code Council Performance Code (ICCPC) for buildings and facilities defines “performance based design” as “An engineering approach to design elements of a building based on agreed upon performance and objectives, engineering analysis and quantitative assessment of alternatives against the design goals and objectives using accepted engineering tools, methodologies, and performance criteria”. For more information on this topic, refer to the 2012 ICCPC. However, it should be noted that the North Carolina Building Code Council has not adopted this code in state.

3. The NCBC and the NCFPC, however, do recognize the need for alternative approaches to prescriptive requirements by including “equivalency” or “alternate material, design, or method of construction and design” clauses. Performance based designs are founded on codes acknowledging the need to allow alternative methods to the traditional “cookbook” approach. For code provisions related to alternate material, design or method (of construction), refer to Section 105 of the 2012 North Carolina Administrative Code and Policies and Section 104.9 of the NCFPC.
4. Because the process of developing concepts and the evaluation of a performance based design can potentially be complex, it is recommended that a qualified individual with a background in fire protection engineering be member of the design team. A fire protection engineer is trained to conduct a fire resistance analysis that can involve special tools, such as computer modeling, to predict results.

4.0 Testing for Fire Resistance

A. Importance of ASTM E 119 and UL 263
   1. The NCBC recognizes ASTM E119 and UL 263 as the standardized test method to determine the fire-resistance rating for various building components. The test measures the length, in time, of the fire-resistance characteristics of a material or an assembly of materials to endure a fire before allowing the passage of flame, excessive heat, smoke and/or toxic gases.
   2. A material or assembly of materials must comply with either ASTM E 119 or UL 263 when allowing “equivalency” or “alternate materials, designs and methods of construction and design” approaches to the prescriptive codes. NCBC-Section 703 states that “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 or UL 263”.

B. Overview of how ASTM E 119, Standard Test Methods for Fire Tests of Building Construction and Materials, is conducted (Note-Test procedures for conducting UL 263 are similar to those set forth by ASTM E 119):
   1. Fire resistance ratings required by the NCBC and the NCFPC for materials, for wall assemblies, floor/ceiling assemblies, roof/ceiling assemblies and for individual structural members are established by or based on testing in accordance with ASTM E 119 (or UL 263). The term “assembly” refers to a collection of components, structural and non-structural, arranged as the manufacturer intended to be installed to provide a tested fire-resistance rating. Fastening of components in an assembly is limited to the tested fastening method and arrangement. The results are provided as timed ratings on the tested assemblies that can be used in building components required by the code to prevent structural collapse, to compartmentalize a building, to protect an element of an egress system, or some combination of the three.
   2. An assembly or structural member is placed in a flat furnace in either the horizontal or vertical position, depending on in service use. If the specimen is a load-bearing element, a specific load is imposed on the specimen. The specimen is, then, subjected to a controlled flame introduced from one side of the assembly, simulating exposure conditions anticipated in actual field conditions. The temperature of the controlled flame is increased to a maximum along a specific time-temperature relationship that simulates a flashover condition. Columns are exposed to the heat source on all sides to simulate actual field conditions. Testing continues until one of the following three failure modes is observed:
      a. Structural collapse occurs, or
b. The temperature measured on the unexposed surface of the assembly exceeds 250 degrees Fahrenheit. This criterion is a measure of heat transmission through the assembly, or

c. When an opening occurs, cotton waste placed on the unexposed side of the assembly ignites. This criterion is a measure of the passage of flame and hot gases through the assembly.

3. Classification of the assembly is reported in hours based on the duration of the test.

5.0 References

A. 2012 North Carolina Building Code (NCBC)
B. 2012 North Carolina Fire Prevention Code (NCFPC)
H. Article entitled “Prescriptive to Performance-Based Design in Green Building” by Craig Hofmeister, P.E. published in the FPE Magazine by the Society of Fire Protection Engineers
J. Article entitled “Prescriptive or Performance: You Make the Call” Robert A. Neele, Deputy Superintendent, U.S. National fire Academy

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