

**INTERNATIONAL CODE COUNCIL (ICC)
Code Technology Committee (CTC)**

**INTERIM REPORT NO. 1 OF THE CTC
AREA OF STUDY – REVIEW OF NIST WTC RECOMMENDATIONS**

**March 9, 2006
Wyndham O'Hare
Rosemont, IL**

The CTC held a public hearing to receive written and verbal comments regarding CTC recommendations for the ICC Board-approved area of study entitled Review of NIST WTC Recommendations. This report includes the final interim recommendations for this area of study, approved by the CTC upon the conclusion of the public hearing on March 9, 2006. It should be noted that as an interim report, this does not complete this area of study. Other aspects of this area of study are still under investigation. The recommendations contained in this report will be forwarded to the ICC Chief Executive Officer in accordance with ICC Council Policy No. 5.

Scope: As noted in the CTC approved Scope & Objectives Statement, the scope of this activity is:

Review the recommendations issued by NIST in its report entitled “Final Report on the Collapse of the World Trade Center Towers”, issued September 2005, for applicability to the building environment as regulated by the I-Codes.

Recommendation: The CTC interim recommendation is to submit code changes to the 2006 International Building Code (IBC) in the 2006/2007 Cycle in response to specific NIST recommendations that the CTC views as not needing further study (see Page 2). CTC recommends further study on other aspects of this area of study.

Considerations:

- CTC interim findings do not address all the NIST recommendations but rather focuses on those determined by the CTC to be recommendations for possible consideration in the upcoming 2006/2007 Cycle.
- CTC has determined that many of the recommendation require additional supporting information in order for the CTC to further evaluate. CTC intends to continue to study this issue.
- Due to the comprehensive nature and inter-relationship of some of the recommendations, CTC has determined that some of the recommendations require further in-depth analysis.
- CTC has determined that some of the recommendations fall outside of the scope of the CTC as they are not topics regulated by the codes.

NIST Recommendation #2

NIST recommends that nationally accepted performance standards be developed for: (1) conducting wind tunnel testing of prototype structures based on sound technical methods that result in repeatable and reproducible results among testing laboratories; and (2) estimating wind loads and their effects on tall buildings for use in design, based on wind tunnel testing data and directional wind speed data.

CTC proposed change to the 2006 IBC:

1609.1.1 Determination of wind loads: Wind loads on every building or structure shall be determined in accordance with Chapter 6 of ASCE 7. The type of opening protection required, the basic wind speed and the exposure category for a site is permitted to be determined in accordance with Section 1609 or ASCE 7. Wind shall be assumed to come from any horizontal direction and wind pressures shall be assumed to act normal to the surface considered.

Exceptions:

1. Subject to the limitations of Section 1609.1.1.1, the provisions of SBCCI SSTD 10 Standard for Hurricane Resistant Residential Construction shall be permitted for applicable Group R-2 and R-3 buildings.
2. Subject to the limitations of Section 1609.1.1.1, residential structures using the provisions of the AF&PA WFCM.
3. Designs using NAAMM FP 1001.
4. Designs using TIA/EIA-222 for antenna-supporting structures and antennas.
5. Designs using wind tunnel testing in accordance with Section 1609.1.1.2

1609.1.1.1 Applicability. The provisions of SSTD 10 are applicable only to buildings located within Exposure B or C as defined in Section 1609.4. The provisions of SSTD 10 and the AF&PA Wood Frame construction Manual for One- and Two-Family Dwellings shall not apply to buildings sited on the upper half of an isolated hill, ridge or escarpment meeting the following conditions:

1. The hill, ridge or escarpment is 60 feet (18 288 mm) or higher if located in Exposure B or 30 feet (9144 mm) or higher if located in Exposure C;
2. The hill, ridge or escarpment is 60 feet (18 288 mm) or higher if located in Exposure B or 30 feet (9144 mm) or higher if located in Exposure C;. The maximum average slope of the hill exceeds 10 percent; and
3. The hill, ridge or escarpment is unobstructed upwind by other such topographic features for a distance from the high point of 50 times the height of the hill or 1 mile (1.61 km), whichever is greater.

1609.1.1.2 Wind tunnel testing. Where wind tunnel testing is used to determine design wind loads, such testing shall be in accordance with ASCE xx [Wind Tunnel Testing] – xx [Date].

Reasons:

In September 2005, the ICC Board of Directors assigned an Area of Study and Investigation to the Code Technology Committee (CTC) which included the review of the NIST WTC

Recommendations as contained in the since released Final Report on the Collapse of the World Trade Center Towers (NIST NCSTAR 1). For this specific proposed change, CTC is working in cooperation with the NIBS/MMC Committee to Translate the NIST World Trade Center Investigation Recommendations for the Model Codes.

The IBC requires that wind loads be determined in accordance with Chapter 6 of ASCE 7, with specific exceptions depending on the size, configuration and location of the building. Section 6.1 of ASCE 7-05 provides three procedures to determine design wind loads: Method 1- Simplified Procedure; Method 2- Analytical Procedure; and Method 3- Wind Tunnel Procedure. Due to unique wind load considerations for certain building configurations and locations, Section 6.5.2 of ASCE 7 - 05 further mandates compliance with either the wind tunnel procedure of Section 6.6 of ASCE 7 or requires the design to be based on recognized literature documenting the wind load effects. Section 6.6 of ASCE does not currently prescribe specific wind tunnel test procedures. These are being developed by an ASCE Wind Tunnel Testing standard committee.

The purpose of this change is not to mandate wind tunnel testing in the IBC, but rather to achieve uniformity in results where the design involves wind tunnel testing – either as required by ASCE 7 or where the designer determines that wind tunnel testing is to be used to determine the wind loads.

As of the submission of this proposal, it is CTC's understanding that the wind tunnel test standard is not complete but is under development.

NIST Recommendation #6

NIST recommends the development of criteria, test methods and standards: (1) for the in-service performance of sprayed fire-resistance materials (SFRM, also commonly referred to as fireproofing or insulation) used to protect structural components; and (2) to ensure that these materials, as-installed, conform to conditions in tests used to establish the fire resistance rating of components, assemblies, and systems.

CTC proposed change to the 2006 IBC:

1704.10 Sprayed fire-resistant materials. Special inspections for sprayed fire-resistant materials applied to structural elements and decks shall be in accordance with Sections 1704.10.1 through ~~1704.10.5~~ 1704.10.7. Special inspections shall be based on the fire-resistance design as designated in the approved construction documents. The tests described in this section shall be based on samplings of specific floor, roof and wall assemblies, and structural framing members. Special inspections shall be performed after the rough installation of electrical, sprinkler, mechanical and plumbing systems and suspension for ceiling systems, where applicable.

1704.10.1 Physical and Visual Tests. The following physical and visual tests are required to demonstrate compliance with the listing and the fire-resistance rating:

1. Condition of substrates.
2. Thickness of application.
3. Density in pounds per cubic foot (kgs per m³).
4. Bond strength -adhesion/cohesion (psf or kPA).
5. Condition of finished application.

~~1704.10.1~~ 1704.10.2 Structural member surface conditions. The surfaces shall be prepared in accordance with the approved fire-resistance design and the approved manufacturer's written instructions. The prepared surface of structural members to be sprayed shall be inspected before the application of the sprayed fire-resistant material.

~~1704.10.2~~ 1704.10.3 Application. The substrate shall have a minimum ambient temperature before and after application as specified in the approved manufacturer's written instructions. The area for application shall be ventilated during and after application as required by the approved manufacturer's written instructions.

~~1704.10.3~~ 1704.10.4 Thickness. The average thickness minus two times the standard deviation of the thickness measurements of the sprayed fire-resistant materials applied to structural elements shall not be less than the thickness required by the approved fire-resistant design. Individual measured thickness, which exceeds the thickness specified in a design by 1/4 inch (6.4 mm) or more, shall be recorded as the thickness specified in the design plus 1/4 inch (6.4 mm). For design thicknesses 1 inch (25 mm) or greater, the minimum allowable individual thickness shall be the design thickness minus 1/4 inch (6.4 mm). For design thicknesses less than 1 inch (25 mm), the minimum allowable individual thickness shall be the design thickness minus 25 percent. Thickness shall be determined in accordance with ASTM E 605. Samples of

the sprayed fire-resistant materials shall be selected in accordance with Sections 1704.10.[3]4.1 and 1704.10.[3]4.2.

1704.10.3.1-1704.10.4.1 Floor, roof and wall assemblies. The thickness of the sprayed fire-resistant material applied to floor, roof and wall assemblies shall be determined in accordance with ASTM E 605, taking the average minus two times the standard deviation of the thickness measurements of not less than four measurements for each 1,000 square feet (93m²) of the sprayed area on each floor or part thereof.

1704.10.4.1.1 Flat Decks. Thickness measurements shall be taken from a 12-in. (300-mm) square with a minimum of four measurements, symmetrically.

1704.10.4.1.2 Fluted Decks. Thickness measurements shall be taken from a 12-in. (300-mm) square with four random, symmetrical measurements within the square, including one each of the following: valley, crest and sides and report as an average.

1704.10.3.2-1704.10.4.2 Structural framing members. The thickness of the sprayed fire-resistant material applied to structural members shall be determined in accordance with ASTM E 605. Thickness testing shall be performed on not less than 25 percent of the structural members on each floor.

1704.10.4.2.1 Beams. Thickness measurements shall be made at nine locations around the beam at each end of a 12-in. (300-mm) length.

1704.10.4.2.2 Joists and Trusses. Thickness measurements shall be made at seven locations around the joist or truss at each end of a 12-in. (300-mm) length.

1704.10.4.2.3 W-Shape Columns. Thickness measurements shall be made at 12 locations around the column at each end of a 12-in. (300-mm) length.

1704.10.4.2.4 Tube and Pipe Columns. Thickness measurements shall be made at a minimum of four locations around the column at each end of a 12-in. (300-mm) length.

1704.10.4-1704.10.5 Density. The density of the sprayed fire-resistant material shall not be less than the density specified in the approved fire-resistant design. Density of the sprayed fire-resistant material shall be determined in accordance with ASTM E 605. The test samples for determining the density of the sprayed fire-resistant materials shall be selected as follows:

1. From each floor, roof and wall assembly at the rate of not less than one sample for every 2,500 square feet or part thereof of the sprayed area in each story.

2. From beams, girders, joists, trusses and columns at the rate of not less than one sample for each type of structural framing member for each 2,500 square feet of floor area or part thereof in each story.

~~1704.10.5~~ **1704.10.6 Bond strength.** The cohesive/adhesive bond strength of the cured sprayed fire-resistant material applied to structural elements shall not be less than 150 pounds per square foot (psf) (7.18 kN/m²). The cohesive/adhesive bond strength shall be determined in accordance with the field test specified in ASTM E 736 by testing in-place samples of the sprayed fire-resistant material selected in accordance with Sections ~~1704.10.5.1~~ 1704.10.6.1 and ~~1704.10.5.2~~ 1704.10.6.2.

~~1704.10.5.1~~ **1704.10.6.1 Floor, roof and wall assemblies.** The test samples for determining the cohesive/adhesive bond strength of the sprayed fire-resistant materials shall be selected from each floor, roof and wall assembly at the rate of not less than one sample for every ~~10,000~~ 2,500 square feet (929 m²) or part thereof of the sprayed area in each story.

~~1704.10.5.2~~ **1704.10.6.2 Structural framing members.** The test samples for determining the cohesive/adhesive bond strength of the sprayed fire-resistant materials shall be selected from beams, girders, joists, trusses and columns at the rate of not less than one sample for each type of structural framing member for each ~~10,000~~ 2,500 square feet (929 m²) of floor area or part thereof in each story.

1704.10.7 Primer, Paint and Encapsulant Bond Tests. Bond tests to qualify a primer, paint or encapsulant shall be conducted only when the fire-resistive coating is applied to a primed, painted or encapsulated surface for which acceptable bond-strength performance between these coatings and the fire resistive material has not been measured. A bonding agent approved by the SFRM manufacturer shall to be applied to a primed, painted or encapsulated surface where the bond strengths are found to be below minimum required values.

Reason: In September 2005, the ICC Board of Directors assigned an Area of Study and Investigation to the Code Technology Committee (CTC) which included the review of the NIST WTC Recommendations as contained in the since released Final Report on the Collapse of the World Trade Center Towers (NIST NCSTAR 1). For this specific proposed change, the CTC is coordinating their work with the ICC Ad Hoc Committee on Terrorism Resistant Buildings and cooperating with the NIBS/MMC Committee to Translate the NIST World Trade Center Investigation Recommendations for the Model Codes.

This proposed change does not address all aspects of NIST recommendation #6. This proposed change is limited to the necessary inspection parameters for spray applied fire resistant materials after installation and renovation of mechanical, plumbing, electrical and other similar systems.

Recommendation #6 also addresses the in-service performance (criteria for performance and durability such as bond strength) of spray applied fire resistance which requires further substantiation.

NIST Recommendation #7

NIST recommends the adoption and use of the “structural frame approach” to fire resistance ratings.

CTC proposed change to the 2006 IBC:

Part 1. Revise line 1, column 1 of Table 601 and delete Footnote a to Table 601 as follows:

Primary Structural structural frame^a See Section 714.1.1.

~~Footnote a. The structural frame shall be considered to be the columns and the girders, beams, trusses and spandrels having direct connections to the columns and bracing members designed to carry gravity loads. The members of floor or roof panels which have no connection to the columns shall be considered secondary members and not part of the structural frame.~~

Part 2. Revise Section 714.1 714.2, 714.2.1 and 714.2.2 as follows:

714.1 Requirements. The fire-resistance rating of structural members and assemblies shall comply with this section and the requirements for the type of construction as specified in Table 601 and shall be not less than the rating required for the fire-resistance-rated assemblies supported by the structural members.

Exception: (No change.)

~~**714.1.1 714.2 Protection of Primary structural frame members.** Protection of columns, girders, trusses, beams, lintels or other structural members that are required to have a fire-resistance rating shall comply with this section. The primary structural frame shall be the columns and other structural members including the girders, beams, trusses and spandrels having direct connections to the columns and bracing members designed to carry gravity loads.~~

~~**714.1.2 Secondary members.** The members of floor or roof construction which are not connected to the columns shall be considered secondary members and not part of the primary structural frame.~~

~~**714.2.1 714.2 Individual encasement protection.** Columns, Girders, trusses, beams, lintels, or other structural members that are required to have a fire-resistance rating and that support more than two floors or one floor and roof, or support a load-bearing wall or a non-load bearing wall more than two stories high, shall be individually protected on all sides for the full length, including connections to other structural members, with materials having the required fire-resistance rating.~~

~~**714.2.1 Alternative protection.** The structural members that are required to have a fire-resistance rating and are not required to be provided individual encasement protection according to Section 714.2 ~~Other structural members required to have a fire-resistance rating shall be protected by individual encasement protection, by a membrane or ceiling protection as~~~~

specified in Section 711, or by a combination of both. ~~Columns shall also comply with Section 714.2.2.~~

~~714.2.1~~ **714.3 Membrane protection.** No change

~~714.2.2~~ **714.4 Column protection above ceilings.** Where columns are required a to be fire-resistance rated rating, the entire column, including its connections to beams or girders, shall be provided individual encasement protection protected on all sides for the full column length. Where the column extends through a ceiling, the fire-resistance rating of the column shall be continuous from the top of the foundation or floor/ceiling assembly above through the ceiling space to the top of the column.

Reasons:

In September 2005, the ICC Board of Directors assigned an Area of Study and Investigation to the Code Technology Committee (CTC) which included the review of the NIST WTC Recommendations as contained in the since released Final Report on the Collapse of the World Trade Center Towers (NIST NCSTAR 1). For this specific proposed change, CTC is working in cooperation with the NIBS/MMC Committee to Translate the NIST World Trade Center Investigation Recommendations for the Model Codes.

This proposal is intended to address the NIST Recommendation #7 which is summarized as “NIST recommends the adoption and use of the structural frame approach to fire resistance ratings.” While the IBC currently contains this approach, the NIST team recommends that the concept be reinforced by incorporating text similar to that contained in Footnote a to Table 601 into the pertinent code text for a higher visibility and understanding by code users.

Part 1

The proposed modification to line 1, column 1 of Table 601 is not intended to revise the intent but to incorporate the revised term. In lieu of a footnote, reliance on the reference to the specific code text of Section 714.1.1 enables a better understanding of the requirements for the pertinent building elements.

Part 2

The modifications to the subsections of Section 714 are intended to retain the current intent. The assemblies for floors and roofs are not consistently referred to as “panels” and the apparent intent is to deal with “floor and roof construction”.

The modifications to the several subsections of Section 714 are intended to work in concert with the reference from Table 601 and consolidate text into a more efficient format without a change in intent.

714.1 – The section is revised by incorporating the requirement that the fire-resistance rating of structural members is to comply with “this section” and “Table 601”.

714.1.1 – Existing section 714.2 is not necessary and contains no particular requirements which are not contained in Section 714.1. The text of Section 714.1.1 was revised to more closely

resemble the current terminology in line 1 and footnote a of Table 601 which is “structural frame”. The incorporation of “other structural members” in Section 714.1.1 is to place reliance on the function of the member to determine its inclusion in the primary structural frame although a laundry list of commonly understood members is retained for understanding of the intent. The structural members named in the existing laundry list are included in the subsections which apply to such members. It should be noted that this section, as does the current footnote, does not consider the lateral load resisting system as part of the structural frame within the context of fire resistance ratings.

714.1.2 – This text is based on the second sentence of existing Footnote a to Table 601.

714.2 – The proposal utilizes the text and concept contained in existing Section 714.2.1. The inclusion of “encasement” in the section title is to enhance the focus of the section’s intent. The proposed deletion of “columns” from the laundry list is to eliminate the implication that columns are not required to be individually protected to their full height when protected by Section 711 - Horizontal Assemblies. Individual protection for columns is required by existing Section 714.2.2. This is addressed in proposed Section 714.4. The connections of these elements to other structural members are required to be protected for the continuity of protection.

714.2.1 – The proposal is based on the text in the second sentence of the existing Section 714.2.1 and is addressing those structural members which are not required to be individually protected according to proposed Section 714.2. The last sentence of existing Section 714.2.1 is not needed as proposed Section 714.4 exclusively deals with columns.

714.4 The proposal requires columns to be individually protected for the full column length and columns are not permitted to be protected by membrane protection.