ISSUE C

Code Change Proposal # 1

403.XX Spray-Applied Fire Resistive Materials (SFRM). The bond strength of the SFRM shall be as follows:

Height of Occupied Floors	SFRM bond strength	Density
More than 75 feet and up to 420 feet	430 psf	22 pcf
More than 420 feet	1,000 psf	40 pcf

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Code Change Proposal # 2

714.8 Spray-Applied Fire Resistive Materials (SFRM). Spray-applied fire resistive materials shall comply with the 714.8.1 through 714.8.4 .

714.8.1 Fire Resistance Rating. The SFRM shall be applied consistent with its fire resistance rating listing including, but not limited to, minimum thickness and dry density of the applied SFRM, method of application, substrate surface conditions, the use of bonding adhesives, sealants and reinforcing or other materials.

714.8.2 Manufacturer's Installation Instruction. The application of SFRM shall be in accordance with the manufacturer's installation instruction. The instructions include, but are not limited to, substrate temperatures and surface conditions, and SFRM handling, storage, mixing, conveyance, method of application, curing and ventilation.

714.8.3 Substrate condition. The SFRM shall be applied to a substrate in compliance with 714.8.3.1 through 714.8.3.3.

714.8.3.1 Surface Conditions. Substrates to receive SFRM shall be free of dirt, oil, grease, release agents, loose scale or point, primers, points and encapsulants other than those fire-tested and classified by a recognized testing agency, and any other condition that may prevent adequate adhesion. Primed, painted or encapsulated steel shall be allowed provided that testing has demonstrated that adequate adhesion is maintained.

714.8.3.2 Primers, Paints and Encapsulants. Where testing demonstates that adequate adhesion is maintained, SFRM shall be permitted to be applied to primed, pointed or encapsulated wide range steel shapes in accordance with the following conditions:

1. The beam flange width does not exceed 12 in. (300 mm); or
2. The column flange width does not exceed 16 in. (400 mm); or
3. The beam or column web depth does not exceed 16 in. (400 mm).
4. Bond tests conducted in accordance with ASTM E736 indicate a minimum average bond strength of 80 percent and a minimum individual bond strength of 50 percent, when compared to the bond strength of the SFRM as applied to clean uncoated 1/8-in. (3-mm) thick steel plate. The average and minimum bond strength values shall be determined based on a minimum of five bond tests conducted in accordance with A5TM E736.

714.8.3.3 Temperature. A minimum ambient and substrate temperature of 40^{o}F (4.44^{o}C) shall be maintained during and for a minimum of 24 hours after the application of the SFRM, unless the manufacturer's installation instructions allow otherwise.

714.8.4 Finished Condition. The finished condition of SFRM to structural members or assemblies shall not, upon complete drying or curing, exhibit cracks, voids, spalls, delamination or any exposure of the substrate. Surface irregularities of spray-applied SFRM are inherent with spray application and shall be deemed acceptable.

ISSUE C

Code Change Proposal # 3

1704.11 Sprayed fire-resistant materials. Special inspections for sprayed fire-resistant materials applied to structural elements and decks shall be in accordance with Sections 1704.11.1 through 1704.11.[5] 6 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, mechanical and plumbing systems.

1704.11.1 Physical and Visual Tests. The following physical and visual tests are required by the fire-resistance-rating:

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

1704.11.[1]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.

1704.11.[2]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.

1704.11.[3]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 1704.11.[3]4.1 and 1704.11.[3]4.2.

1704.11.[3]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*.

1704.11.4.1.1 Flat Decks. Thickness measurements shall be taken from a 12-in. (300-mm) square with minimum of four measurements, symmetrically.

1704.11.4.1.2 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.

1704.11.[3]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.

1704.11.4.2.1 Beams. Thickness measurements shall be made at nine locations around the beam at each end of a 12-in. (300-mm) length.

1704.11.4.2.2 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.

1704.11.4.2.3 W-Shape Columns. Thickness measurements shall be made at 12 locations around the column at each end of a 12-in. (300-mm) length.

1704.11.4.2.4 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.

1704.11.[4]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.

1704.11.[5]6 Bond strength. Except as required in Table 403.XX, 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 1704.11.5.1 and 1704.11.5.[2] 3.

1704.11.[5]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.

1704.11.[5]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.

1704.11.6.3 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.

* Standard deviation (σ) is used, in combination with average thickness, to ensure that the spray-applied fire resistive material (SFRM) is applied uniformly over the surface. Using average alone, it would be possible to have SFRM applied very thickly in some places and thinly in others and have an average thickness that suggests that the product application complies with the thickness requirements for the design fire-resistance rating. Use of standard deviation documents a minimum thickness of SFRM. Standard deviation is calculated by subtracting the average thickness from each measured individual thickness measurement, squaring the resulting difference, adding all of these values together, dividing by the number of samples and taking the square root of this value. See formula and example below.

$$\sigma = \sqrt{\frac{1}{N}\sum_{i=1}^{N}(x_i - \overline{x})^2}$$

The actual applied thickness of the SFRM, calculated as the average thickness minus two times the standard deviation, must be greater than or equal to the required thickness. $T_{avg} - 2\sigma \geq T_{req}$, where T_{req} equals the required thickness, T_{avg} equals the average thickness and σ equals the standard deviation. The following example shows the calculation of standard deviation:

Four measured samples equal 5, 6, 8 and 9 inches. The average value is 7 inches. Appling standard deviation,

$$\sigma = \sqrt{\frac{1}{4}\sum_{i=1}^{4}(x_i - \overline{x})^2}$$

$$\sigma = \sqrt{\frac{1}{4}\sum_{i=1}^{4}(x_i - 7)^2}$$

$$\sigma = \sqrt{\frac{1}{4}\left[(x_1 - 7)^2 + (x_2 - 7)^2 + (x_3 - 7)^2 + (x_4 - 7)^2\right]}$$

$$\sigma = \sqrt{\frac{1}{4}\left[(5-7)^2 + (6-7)^2 + (8-7)^2 + (9-7)^2\right]}$$
$$\sigma = \sqrt{\frac{1}{4}\left((-2)^2 + (-1)^2 + 1^2 + 2^2\right)}$$
$$\sigma = \sqrt{\frac{1}{4}\left(4 + 1 + 1 + 4\right)}$$
$$\sigma = \sqrt{\frac{10}{4}}$$
$$\sigma = 1.5811$$

The standard deviation, 1.5811, is now inserted into the formula to compare the actual applied SFRM thickness to the required thickness.

$T_{avg} - 2\sigma \geq T_{req}$

$7 - 2(1.5811) \geq T_{req}$

3.8378 inches $\geq T_{req}$