minnesota Concrete Council
Dedicated to Cast-in-Place Concrete

A Brief Comparison of Type I vs. Type IV Construction in the IBC

A BUILDING CODE PERSPECTIVE

BY LARRY FARRIS, CBO

1

Larry J. Farris – Director of Code Compliance, BKV Group

BKV GROUP

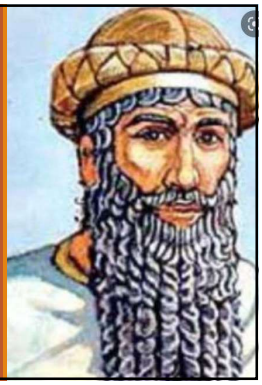
2

Type I vs Type IV…..but first how did we get here?

3

Building Codes

- King Hammurabi of Babylon enacted the first known building code in 1758 B.C – Established if a contractor built a house for another man, and it collapsed and killed the owner, the contractor was slain.
- Massive fires in London in 1666 and Chicago in 1871 led to building codes which addressed risks one building posed to adjacent buildings. Also addressed common walls and outlawed wooden chimneys.
- Catastrophic events always lead to changes to the building code.

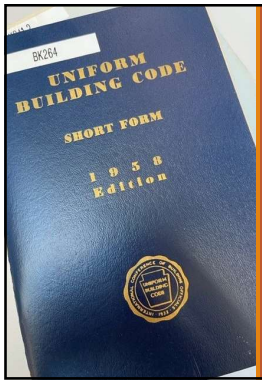


4

The Great Chicago Fire of 1871

- It was believed to have been started by a cow kicking over a lighted lantern.
- Burned from October 8 to October 10 and was finally stopped when it started raining.
- 300 People Died.
- 17,000+ structures were destroyed.
- $200+ million in damages.
- 3.3 square miles burned.
- The month after the fire, Joseph Medill was elected mayor on the promise that he would institute stricter building codes.
- Medill's victory may have been attributed to that fact that most of the city's voting records were burned in the fire, so it is believed that many people voted multiple times.

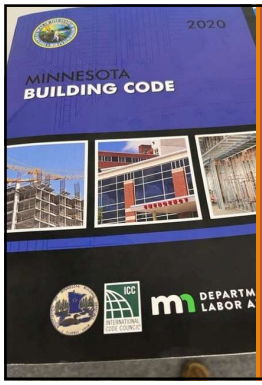
5



International Building Code History

- Prior to the IBC, there were 3 main codes used in the USA
- BOCA – "Building Officials and Code Administers International", Primarily used on the east coast and in some Midwest states
- SBCCI – "Southern Building Code Congress International" Primarily used in the Southeast United States
- UBC – (Uniform Building Code", Primarily used in the West and some Midwest states.
- By 2000 the IBC, "International Building Code" was established.
- A new version of the IBC is released every 3 years
- Minnesota State law requires a new version of the IBC every 5 years, meaning some IBC editions are never adopted.

6

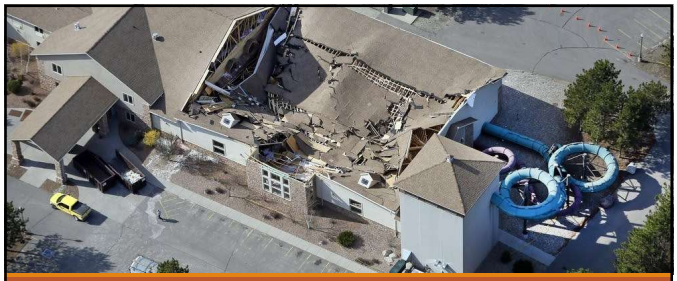


MN Building Code History

- 1971 – Minnesota passed into law requirements that established the Minnesota State Building Code.
- 1977 – Minnesota law established that the Minnesota State Building Code be expanded to apply statewide.
- 1979 – Minnesota passed a law allowing revisions to the mandatory application of the statewide building code. Essentially, the new law allowed for an extension of time for local governments to formally adopt the State Building Code.
- 1981 - Minnesota passed another building code related law allowing those municipalities with populations of less than 2500 to decide whether or not they wanted to keep or exempt themselves from mandatory application of the Minnesota State Building Code (except for provisions of the Minnesota Accessibility Code) if they were in a non-metropolitan county. This allowed smaller municipalities to opt out of the building code.
- 2008 - In 2008, Minnesota passed a law that made the Minnesota State Building Code the statewide construction standard for the purposes of design and construction for all construction projects within the state. Although not enforceable by those communitiesthat have not specifically adopted the code, the intent of the law was to create a more level playing field for all those involved in the industry.

- Source - MINNESOTA STATE BUILDING CODE, CODE ADOPTION GUIDE, Construction Codes and Licensing Minnesota Department of Labor and Industry, Code Services Unit

7



2015- Roof Collapses at Ottertail, MN Waterpark.

8

IBC Created Type I through Type V Buildings but today we discuss……..

Type I (The Eleven)

Type IV Heavy Timber (T3)

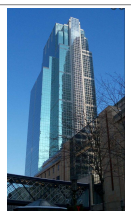
9

TYPE I

Types I construction are those types of construction in which the building elements listed in Table 601 are of Noncombustible Materials, except as permitted in Section 603 and elsewhere in this code.

STATS

- Steel or Concrete
- For most occupancy classifications, structures can be unlimited height and area.
- Type I has a Type I-A and Type I-B Classification.
- 2-to-3-hour Primary Structural Frame Fire Resistance Rating.
- 2-hour floor construction Fire Resistance Rating.
- Generally considered the safest building to occupy as it is the most fire resistive of all buildings.



GATEWAY TOWER (RBC) - MINNEAPOLIS

10

TYPE IV

Type IV construction is that type of construction in which the exterior walls are of noncombustible materials and the interior building elements are of solid wood, laminated wood, heavy timber (HT) or structural composite lumber (SCL) without concealed spaces. The minimum dimensions for permitted materials including solid timber, glued-laminated timber, structural composite lumber (SCL), and cross-laminated timber and details of Type IV construction shall comply with the provisions of this section and Section 2304.11. Exterior walls complying with Section 602.4.1 or 602.4.2 shall be permitted. Interior walls and partitions not less than 1-hour fire-resistance rating or heavy timber complying with Section 2304.11.2.2 shall be permitted.

REQUIREMENTS:

- Heavy Timber
- Very specific size requirements for building members, (beams, columns, joists, etc)
- No concealed spaces
- There are limits to height and area.
- Much more common in Europe but growing in popularity in the USA.

THRESHER SQUARE - MINNEAPOLIS

11

Chapter 5 – General Building Heights and Area

- Size Matters –
- The maximum height for a Type IV building is 85'.
- The maximum height for a Type I-A building is usually unlimited.

TABLE 504.3 ALLOWABLE BUILDING HEIGHT IN FEET ABOVE GRADE PLANE[a]

OCCUPANCY CLASSIFICATION	SEE FOOTNOTES	TYPE OF CONSTRUCTION									
		TYPE I		TYPE II		TYPE III		TYPE IV	TYPE V		
		A	B	A	B	A	B	HT	A	B	
A, B, E, F, M, S, U	NS[b]	UL	160	85	55	65	55	65	50	40	
	S	UL	160	85	70	85	75	85	70	50	
A-1, A-2, A-3, A-5	NS[b]	UL	160	85	55	65	55	65	50	40	
	S										
A-4	NS[b]	UL	160	85	55	65	55	65	50	40	
	S	UL	180	85	75	85	75	85	70	50	
A-1 Condition 1, A-3	NS[b,c]	UL	160	85	55	65	55	65	50	40	
	S	UL	180	85	75	85	75	85	70	50	
A-1 Condition 2, A-2	NS[b,c]	UL	160	85	55	65	55	65	50	40	
	S	UL	180	85							
I-4	NS[b]	UL	160	85	55	65	55	65	50	40	
	S	UL	180	85	75	85	75	85	70	50	
R[f]	NS	UL	160	85	55	65	55	65	50	40	
	S13D	60	60	60	60	60	60	60	50	40	
	S13R	60	60	60	60	60	60	60	60	60	
	S	UL	180	85	75	85	75	85	70	50	

12

Chapter 5 – General Building Heights and Area

- Size Matters –
- The maximum number of stories for a Type IV building is 6.
- The maximum stories for a Type I building is usually unlimited.

TABLE 504.4 ALLOWABLE NUMBER OF STORIES ABOVE GRADE PLANE[a, b]

OCCUPANCY CLASSIFICATION	SEE FOOTNOTES	TYPE OF CONSTRUCTION								
		TYPE I		TYPE II		TYPE III		TYPE IV	TYPE V	
		A	B	A	B	A	B	HT	A	B
A-1	NS	UL	5	3	2	3	2	3	2	1
	S	UL	6	4	3	4	3	4	3	2
A-2	NS	UL	11	5	2	5	2	5	2	1
	S	UL	12	4	3	4	3	4	3	2
A-3	NS	UL	11	5	2	5	2	5	2	1
	S	UL	12	4	3	4	3	4	3	2
A-4	NS	UL	11	5	2	5	2	5	2	1
	S	UL	12	4	3	4	3	4	3	2
A-5	NS	UL	UL	UL	UL	UL	UL	UL	UL	UL
	S	UL	UL	UL	UL	UL	UL	UL	UL	UL
B	NS	UL	11	5	3	5	3	5	3	2
	S	UL	12	6	4	6	4	6	4	3
E	NS	UL	5	3	2	3	2	3	1	1
	S	UL	6	4	3	4	3	4	2	2

13

Chapter 5 – General Building Heights and Area

Size Matters

The Maximum size or area in square feet of a Type I-A building of B Occupancy is unlimited.

The Maximum size or area in square feet of a Type IV, Heavy Timber building of B Occupancy is 108,000 square feet per story with a total maximum area of 324,000 square feet.

TABLE 506.2 ALLOWABLE AREA FACTOR (A = NS, S1, S13R, S13D or SM, as applicable) IN SQUARE FEET[a, b]

OCCUPANCY CLASSIFICATION	SEE FOOTNOTES	TYPE OF CONSTRUCTION								
		TYPE I		TYPE II		TYPE III		TYPE IV	TYPE V	
		A	B	A	B	A	B	HT	A	B
A-1	NS	UL	UL	15,500	8,500	14,000	8,500	15,000	11,500	8,500
	S1	UL	UL	62,000	34,000	56,000	34,000	60,000	46,000	22,000
	SM	UL	UL	46,500	25,500	42,000	25,500	45,000	34,500	16,500
A-2	NS	UL	UL	15,500	9,500	14,000	9,500	15,000	11,500	6,000
	S1	UL	UL	62,000	38,000	56,000	38,000	60,000	46,000	24,000
	SM	UL	UL	46,500	28,500	42,000	28,500	45,000	34,500	18,000
A-3	NS	UL	UL	15,500	9,500	14,000	9,500	15,000	11,500	6,000
	S1	UL	UL	62,000	38,000	56,000	38,000	60,000	46,000	24,000
	SM	UL	UL	46,500	28,500	42,000	28,500	45,000	34,500	18,000
A-4	NS	UL	UL	15,500	9,500	14,000	9,500	15,000	11,500	6,000
	S1	UL	UL	62,000	38,000	56,000	38,000	60,000	46,000	24,000
	SM	UL	UL	46,500	28,500	42,000	28,500	45,000	34,500	18,000
A-5	NS	UL	UL	UL	UL	UL	UL	UL	UL	UL
	S1									
	SM									
B	NS	UL	UL	37,500	23,000	28,500	19,000	36,000	18,000	9,000
	S1	UL	UL	150,000	92,000	114,000	76,000	144,000	72,000	36,000
	SM	UL	UL	112,500	69,000	85,500	57,000	108,000	54,000	27,000

14

Chapter 6 – Types of Construction

TABLE 601 FIRE-RESISTANCE RATING REQUIREMENTS FOR BUILDING ELEMENTS (HOURS)

BUILDING ELEMENT	TYPE I		TYPE II		TYPE III		TYPE IV	TYPE V	
	A	B	A	B	A	B	HT	A	B
Primary structural frame[f] (see Section 202)	3[g, h]	2[g, h]	1[h]	0	1[h]	0	HT	1[h]	0
Bearing walls Exterior [d, f] Interior	3 3[h]	2 2[h]	1 1	0 0	2 1	2 0	2 1/HT	1 1	0 0
Nonbearing walls and partitions Exterior	See Table 602								
Nonbearing walls and partitions Interior [f]	0	0	0	0	0	0	See Section 2304.11.2	0	0
Floor construction and associated secondary members (see Section 202)	2	2	1	0	1	0	HT	1	0
Roof construction and associated secondary members (see Section 202)	1[i, j]	1[i, j]	1[i]	0[j]	1[i]	0	HT	1[i]	0

For SI: 1 foot = 304.8 mm.

a. Roof supports: Fire-resistance ratings of primary structural frame and bearing walls are permitted to be reduced by 1 hour where supporting a roof only.

b. Except in Group F-1, H-1 and H-2 occupancies, fire protection of structural members in roof construction shall not be required, including protection of primary structural frame members, roof framing and decking where every part of the roof construction is 20 feet or more above any floor immediately below. Fire-retardant-treated wood members shall be allowed to be used for such unprotected members.

c. In all occupancies, heavy timber complying with Section 2304.11 shall be allowed where a 1-hour or less fire-resistance rating is required.

d. Not less than the fire-resistance rating required by other sections of this code.

e. Not less than the fire-resistance rating based on the separation distance (see Table 602).

f. Not less than the fire-resistance rating as referenced in Section 704.10.

15

Typical Type I-A Building Under Construction

16

Chapter 7 – Fire and Smoke Protection Features (Type I)

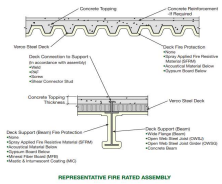
FLOORS & ROOFS

WALLS (COULD ALSO BE USED IN TYPE IV)

17

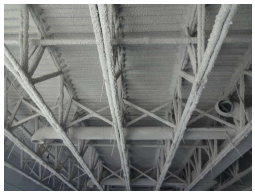
Type I Example Assemblies

COMPOSITE OR NON-COMPOSITE CONCRETE DECK



REPRESENTATIVE FIRE RATED ASSEMBLY

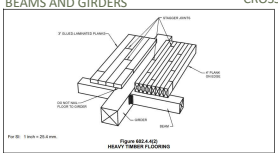
STEEL TRUSSES WITH SPRAY APPLIED CEMENTITIOUS FIREPROOFING



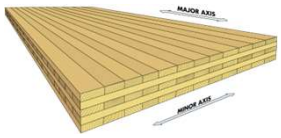
18

Type IV Example Assemblies

HEAVY TIMBER FLOORING WITH PLANKS, BEAMS AND GIRDERS



CROSS LAMINATED TIMBER FLOOR



19

Type IV Construction with a lot of beams and columns

20

Chapter 7 – Fire and Smoke Protection Features (Type IV)

FRAMING SIZES

TABLE 2304.11 MINIMUM DIMENSIONS OF HEAVY TIMBER STRUCTURAL MEMBERS

SUPPORTING	HEAVY TIMBER STRUCTURAL ELEMENTS	MINIMUM NOMINAL SOLID SAWN SIZE		MINIMUM GLUED LAMINATED NET SIZE		MINIMUM STRUCTURAL COMPOSITE LUMBER NET SIZE	
		Width, inch	Depth, inch	Width, inch	Depth, inch	Width, inch	Depth, inch
Roof loads only, or combined floor and roof loads	Framed beam or glued-laminated timber arches that spring from the floor line. Framed timber trusses	8	8	6¾	8¼	7	7¼
	Wood beams and girders	8	10	8	16½	8¾	8¾
Roof loads only	Columns (roof and ceiling loads). Lower half of wood-frame or glued-laminated arches that spring from the floor line or from grade	8	8	8	8¼	8¾	7¼
	Upper half of wood-frame or glued-laminated arches that spring from the floor line or from grade	6	6	6	6	6¾	6¾
	Framed roof trusses and other members not listed. Framed or glued-laminated arches that spring from the top of walls or wall abutments	4[a]	6	3[a]	6¾	3¾[a]	6¾

21

Chapter 7 – Fire and Smoke Protection Features (Type IV)

FLOORS

2304.11.3.1 Cross-laminated timber floors. Cross-laminated timber shall be not less than 4 inches (102 mm) in actual thickness. Cross-laminated timber shall be continuous from support to support and mechanically fastened to one another. Cross-laminated timber shall be permitted to be connected to walls without a shrinkage gap providing swelling or shrinking is considered in the design. Corbelling of masonry walls under the floor shall be permitted to be used.

2304.11.3.2 Sawn or glued-laminated plank floors.

Sawn or glued-laminated plank floors shall be one of the following:

1. Sawn or glued-laminated planks, splined or tongue-and-groove, of not less than 3 inches (76 mm) nominal in thickness covered with 1-inch (25 mm) nominal dimension tongue-and-groove flooring, laid crosswise or diagonally, $^{15}/_{32}$-inch (12 mm) wood structural panel or $^{1}/_{2}$-inch (12.7 mm) particleboard.
2. Planks not less than 4 inches (102 mm) nominal in width set on edge close together and well spiked and covered with 1-inch (25 mm) nominal dimension flooring or $^{15}/_{32}$-inch (12 mm) wood structural panel or $^{1}/_{2}$-inch (12.7 mm) particleboard.

22

Cross Laminated Timber

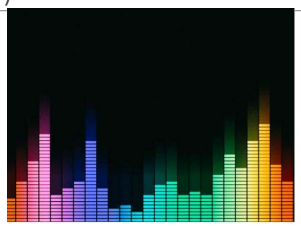
23

CLT Suppliers in North America

- Binderholz Mass Timber LLC – Atlanta
- DR Johnson Wood Innovations – Oregon
- Freres Lumber – Oregon
- Hasslacher Group – Chicago
- Mercer – Washington
- SmartLam NA – Montana
- StructureCraft – CANADA
- Vaagen Timbers – Washington
- Kalesnikoff – CANADA
- Element 5 – CANADA
- Structurelam - CANADA

24

Chapter 12 – Interior Environment (NOISE!!!)



25

Section 1206 – Only Applies to R-2

1206.2 Airborne sound
Walls, partitions and floor-ceiling assemblies separating *dwelling units* and *sleeping units* from each other or from public or service areas shall have a sound transmission class of not less than 50, or not less than 45 if field tested, for airborne noise where tested in accordance with ASTM E90.

1206.3 Structure-borne sound
Floor-ceiling assemblies between *dwelling units* and *sleeping units* or between a *dwelling unit* or *sleeping unit* and a public or service area within the structure shall have an impact insulation class rating of not less than 50, or not less than 45 if field tested, where tested in accordance with ASTM E492.

26

The "Mass Law" in Acoustics

According to the way of transmittance, the sound that people would like to insulate can be divided into air-borne sound (due to the vibration of the air) and solid-borne sound (due to the impact on solids or solid vibration). The sound permeation complies with the "mass law" in acoustics. The sound insulation property of wall or plate depends on its mass area ratio. The greater the mass is, the harder it is to vibrate this material, thus the better the insulating property will be. Therefore, it is better to choose dense and heavy material (clay brick, reinforced concrete, steel plate, etc) as sound insulating material.

27

Type I – Concrete typical STC/IIC Ratings

IIC Rating of Concrete Floors

Thickness	Concrete Slab	Composite (Ribbed) Slab	Hollow Core
4″	47/20	N/A	N/A
6″	53/27	51/21	48/23
8″	58/34	N/A	50/28
10″	59/31	N/A	N/A

Ratings Shown are IIC/STC
With the expanded use of Hollow Core construction, additional testing is required to ensure efficacy of parallel systems with their concrete slab or composite ribbed slab counterparts.

28

Type IV – CLT STC/IIC Ratings

Examples of Acoustically-Tested Mass Timber Panels

Mass Timber Panel	Thickness	STC Rating	IIC Rating
3-ply CLT wall[a]	3.07"	33	N/A
5-ply CLT wall[a]	6.875"	38	N/A
5-ply CLT floor[a]	5.1875"	39	22
5-ply CLT floor[a]	6.875"	41	25
7-ply CLT floor[a]	9.65"	44	30
2x4 NLT wall[b]	3-1/2" bare NLT 4-1/4" with 3/4" plywood	24 bare NLT 29 with 3/4" plywood	N/A
2x6 NLT wall[b]	5-1/2" bare NLT 6-1/4" with 3/4" plywood	22 bare NLT 31 with 3/4" plywood	N/A
2x6 NLT floor + 1/2" plywood[c]	6" with 1/2" plywood	34	33

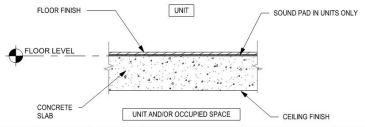
Source: Inventory of Acoustically-Tested Mass Timber Assemblies, WoodWorks[1]

29

Example of Floor Assembly of Type I Construction

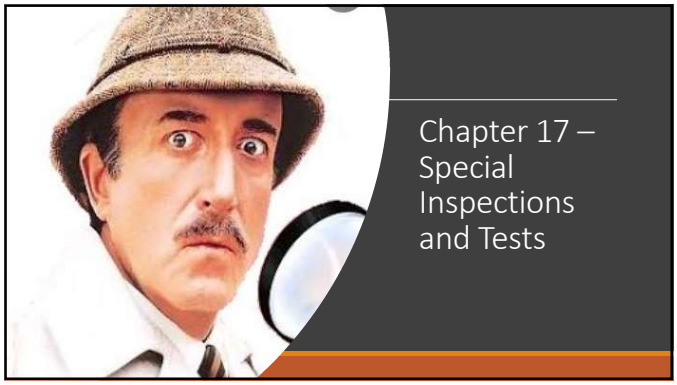
FP-2 POST TENSION CONCRETE SLAB AT OCCUPIED SPACE

NOTES:
1. ESTIMATED SOUND RATINGS
   - F-IIC 20-24 (6" THICK SLAB)
   - F-STC 54 (6" THICK SLAB)
2. MINIMUM SOUND RATINGS REQUIRED
   - F-IIC 45
   - F-STC 45



FLOOR TYPE	TOPPING		FIRE RATING	FIRE TEST	SOUND CONTROL	STRUCTURAL SYSTEM					CEILING FINISH
	TYPE	THICK				TYPE	THICK	SHTG	FRAMING	INSUL	
FP-2	NA	NA	1 HR	2020 IBC TABLE 722.2.2.1	SEE NOTES	PT	SEE STRUCT	NA	NA	NA	SEE RCP

30



Chapter 17 – Special Inspections and Tests

31

Multiple Inspections required for Concrete

Table 1705.3 Required Special Inspections and Tests of Concrete Construction

TYPE	CONTINUOUS SPECIAL INSPECTION	PERIODIC SPECIAL INSPECTION	REFERENCED STANDARD[a]	IBC REFERENCE
1. Inspect reinforcement, including prestressing tendons, and verify placement.	—	X	ACI 318: Ch. 20, 25.2, 25.3, 26.6.1-26.6.3	1908.4
2. Reinforcing bar welding:				
Verify weldability of reinforcing bars other than ASTM A706;	—X	XX	AWS D1.4/ACI 318: 26.6.4	—
Inspect single-pass fillet welds, maximum 5/16", and				
Inspect all other welds.				
3. Inspect anchors cast in concrete.	—	X	ACI 318: 17.8.2	—
4. Inspect anchors post-installed in hardened concrete members.[a]				
Adhesive anchors installed in horizontally or upwardly inclined orientations to resist sustained tension loads	X	X	ACI 318: 17.8.2.4/ACI 318: 17.8.2	—
Mechanical anchors and adhesive anchors not noted in 4.a				
5. Verify use of required design mix.	—	X	ACI 318: Ch. 19, 26.4.3, 26.4.4	1904.1, 1904.2, 1908.2, 1908.3
6. Prior to concrete placement, fabricate specimens for strength tests, perform slump and air content tests, and determine the temperature of the concrete	X	—	ASTM C172/ASTM C31/ACI 318: 26.5, 26.12	1908.1
7. Verify maintenance of specified curing temperature and techniques	—	X	ACI 318: 26.5.3-26.5.5	1908.9
8. Inspect prestressed concrete for:				
Application of prestressing forces; and	X	—	ACI 318: 26.10	—
Grouting of bonded prestressing tendons.				
10. Inspect erection of precast concrete members.	—	X	ACI 318: 26.9	—
11. Verify in-situ concrete strength, prior to stressing of tendons in post-tensioned concrete and prior to removal of shores and forms from beams and structural slabs.	—	X	ACI 318: 26.11.2	—
12. Inspect formwork for shape, location and dimensions of the concrete member being formed.	—	X	ACI 318: 26.11.1.2(b)	—

32

Special Inspections for Structural Wood for Wind Resistance in certain Exposure Category Areas.

1705.11.1 Structural wood.

Continuous special inspection is required during field gluing operations of elements of the main windforce-resisting system. *Periodic special inspection* is required for nailing, bolting, anchoring and other fastening of elements of the main windforce-resisting system, including wood shear walls, wood diaphragms, drag struts, braces and hold-downs.

Exception: *Special inspections* are not required for wood shear walls, shear panels and diaphragms, including nailing, bolting, anchoring and other fastening to other elements of the main windforce-resisting system, where the specified fastener spacing at panel edges is more than 4 inches (102 mm) on center.

33

Wood Special Inspections for Seismic

1705.12.2 Structural wood.

For the seismic force-resisting systems of structures assigned to *Seismic Design Category* C, D, E or F:

- *Continuous special inspection* shall be required during field gluing operations of elements of the seismic force-resisting system.

2. *Periodic special inspection* shall be required for nailing, bolting, anchoring and other fastening of elements of the seismic force-resisting system, including wood shear walls, wood diaphragms, drag struts, braces, shear panels and hold-downs.

Exception: *Special inspections* are not required for wood shear walls, shear panels and diaphragms, including nailing, bolting, anchoring and other fastening to other elements of the seismic force-resisting system, where the fastener spacing of the sheathing is more than 4 inches (102 mm) on center.

34

QUESTIONS

Larry Farris, CBO | Director of Code Compliance, Associate Partner
BKV Group | Architecture, Interior Design, Landscape Architecture, Engineering
222 North 2nd Street, Suite 101, Minneapolis, MN 55401
D: 612.373.9147 | M: 612.360.5606 | www.bkvgroup.com

35