APPLIED ARCHITECTURAL STRUCTURES:
STRUCTURAL ANALYSIS AND SYSTEMS
ARCH 631
DR. ANNE NICHOLS
FALL 2013

lecture
twenty eight

construction inspection & review

Office Hours

Professor Anne Nichols (845-6540)

	December 9 (Wednesday)	December 10 (Thursday)	December 11 (Friday)	December 14 (Monday)	December 15 (Tuesday)
8					
9					
10					
11					
12					
1					
2					
3					
4					

link to posted schedule

Supervision Practices - IBC

TABLE 1704.3
REQUIRED VERIFICATION AND INSPECTION OF STEEL CONSTRUCTION

VERIFICATION AND INSPECTION	CONTINUOUS	PERIODIC	REFERENCED STANDARD[a]	IBC REFERENCE
1. Material verification of high-strength bolts, nuts and washers:				
a. Identification markings to conform to ASTM standards specified in the approved construction documents.	—	X	Applicable ASTM material specifications; AISC 335, Section A3.4; AISC LRFD, Section A3.3	—
b. Manufacturer's certificate of compliance required.	—	X	—	—
2. Inspection of high-strength bolting:				
a. Bearing-type connections.	—	X	AISC LRFD Section M2.5	1704.3.3
b. Slip-critical connections.	X	X		
3. Material verification of structural steel:				
a. Identification markings to conform to ASTM standards specified in the approved construction documents.	—	—	ASTM A 6 orASTM A 568	1708.4
b. Manufacturers' certified mill test reports.	—	—	ASTM A 6 or ASTM A 568	
4. Material verification of weld filler materials:				
a. Identification markings to conform to AWS specification in the approved construction documents.	—	—	AISC, ASD, Section A3.6; AISC LRFD, Section A3.5	—
b. Manufacturer's certificate of compliance required.	—	—	—	—

Supervision Practices - IBC

5. Inspection of welding: a. Structural steel:	—	—		
1) Complete and partial penetration groove welds.	X	—	AWS D1.1	1704.3.1
2) Multipass fillet welds.	X	—		
3) Single-pass fillet welds > $^5/_{16}$″	X	—		
4) Single-pass fillet welds ≤ $^5/_{16}$″	—	X		
5) Floor and deck welds.	—	X	AWS D1.3	—
b. Reinforcing steel:	—	—	AWS D1.4 ACI 318: 3.5.2	1903.5.2
1) Verification of weldability of reinforcing steel other than ASTM A 706.	—	X		
2) Reinforcing steel-resisting flexural and axial forces in intermediate and special moment frames, and boundary elements of special reinforced concrete shear walls and shear reinforcement.	X	—		
3) Shear reinforcement.	X	—		
4) Other reinforcing steel.	—	X		
6. Inspection of steel frame joint details for compliance with approved construction documents: a. Details such as bracing and stiffening. b. Member locations. c. Application of joint details at each connection.	— — —	X — —	—	1704.3.2

For SI: 1 inch = 25.4 mm.
a. Where applicable, see also Section 1707.1, Special inspection for seismic resistance.

Steel Construction

- *proper grade material*
  - *– high strength bolts*
- *quality welds*
- *proper bolted conditions (ex. sc)*
- *fabrication and erection of steel frame connection details*

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Supervision Practices - IBC

TABLE 1704.4
REQUIRED VERIFICATION AND INSPECTION OF CONCRETE CONSTRUCTION

VERIFICATION AND INSPECTION	CONTINUOUS	PERIODIC	REFERENCED STANDARD[a]	IBC REFERENCE
1. Inspection of reinforcing steel, including prestressing tendons, and placement.	—	X	ACI 318: 3.5, 7.1-7.7	1903.5, 1907.1, 1907.7, 1914.4
2. Inspection of reinforcing steel welding in accordance with Table 1704.3, Item 5B.	—	—	AWS D1.4 ACI 318: 3.5.2	1903.5.2
3. Inspect bolts to be installed in concrete prior to and during placement of concrete where allowable loads have been increased.	X	—	—	1912.5
4. Verifying use of required design mix.	—	X	ACI 318: Ch. 4, 5.2-5.4	1904, 1905.2-1905.4, 1914.2, 1914.3
5. At the time fresh concrete is sampled to fabricate specimens for strength tests, perform slump and air content tests, and determine the temperature of the concrete.	X	—	ASTM C 172 ASTM C 31 ACI 318: 5.6, 5.8	1905.6, 1914.10
6. Inspection of concrete and shotcrete placement for proper application techniques.	X	—	ACI 318: 5.9, 5.10	1905.9, 1905.10, 1914.6, 1914.7, 1914.8
7. Inspection for maintenance of specified curing temperature and techniques.	—	X	ACI 318: 5.11-5.13	1905.11, 1905.13, 1914.9
8. Inspection of prestressed concrete: a. Application of prestressing forces. b. Grouting of bonded prestressing tendons in the seismic-force-resisting system.	X X	—	ACI 318: 18.20 ACI 318: 18.18.4	—
9. Erection of precast concrete members.	—	X	ACI 318: Ch. 16	—
10. Verification of in-situ concrete strength, prior to stressing of tendons in posttensioned concrete and prior to removal of shores and forms from beams and structural slabs.	—	X	ACI 318: 6.2	1906.2

For SI: 1 inch = 25.4 mm.
a. Where applicable, see also Section 1707.1, Special inspection for seismic resistance.

Concrete Construction

- *proper placement of all reinforcement*
  - *– welding*
  - *– splices*
- *mix design*
  - *– slump*
  - *– in-situ strength*
    - *cast cylinders*
    - *cylinder cores – if needed*

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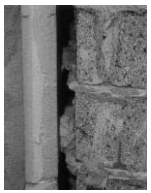
TABLE 1704.5.3
LEVEL 2 SPECIAL INSPECTION

INSPECTION TASK	FREQUENCY OF INSPECTION		REFERENCE FOR CRITERIA		
	Continuous during task listed	Periodically during task listed	IBC section	ACI 530/ ASCE 5/ TMS 402[a]	ACI 530.1/ ASCE 6/ TMS 602[a]
1. From the beginning of masonry construction, the following shall be verified to ensure compliance:					
a. Proportions of site-prepared mortar, grout and prestressing grout for bonded tendons.	—	X	—	—	Art. 2.6A
b. Placement of masonry units and construction of mortar joints.	—	X	—	—	Art. 3.3B
c. Placement of reinforcement, connectors and prestressing tendons and anchorages.	—	X	—	Sec. 1.12	Art. 3.4, 3.6A
d. Grout space prior to grouting.	X	—	—	—	Art. 3.2D
e. Placement of grout.	X	—	—	—	Art. 3.5
f. Placement of prestressing grout.	X	—	—	—	Art. 3.6C
2. The inspection program shall verify:					
a. Size and location of structural elements.	—	X	—	—	Art. 3.3G
b. Type, size and location of anchors, including other details of anchorage of masonry to structural members, frames or other construction.	X	—	—	Sec. 1.2.2(e), 2.1.4, 3.1.6	—
c. Specified size, grade and type of reinforcement.		X	—	Sec. 1.12	Art. 2.4, 3.4
d. Welding of reinforcement.	X	—	—	Sec. 2.1.10.6.2, 3.2.3.4(b)	—
e. Protection of masonry during cold weather (temperature below 40°F) or hot weather (temperature above 90°F).	—	X	Sec. 2104.3, 2104.4	—	Art. 1.8C, 1.8D
f. Application and measurement of prestressing force.	X	—	—	—	Art. 3.6B
3. Preparation of any required grout specimens, mortar specimens and/or prisms shall be observed.	X	—	Sec. 2105.2.2, 2105.3	—	Art. 1.4
4. Compliance with required inspection provisions of the construction documents and the approved submittals shall be verified.	—	X	—	—	Art. 1.5

For SI: °C = (°F - 32)/1.8.
a. The specific standards referenced are those listed in Chapter 35.

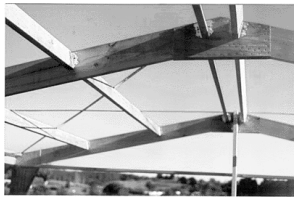
Construction Supervision

- *proper placement of all reinforcement*
- *prism construction*
  - *masonry*
  - *mortar*
- *hot/cold weather protection*
- *clear cavity*



Wood Construction

- *structural members*
  - *avoid damage*
  - *must be protected from exposure to weather and water*
- *connections & bracing*

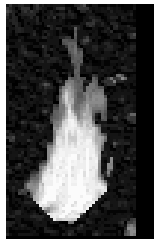


Fire and Life Safety

- *for the Design Professional*
  - *by Carl Wren, P.E.*
    Chief Engineer, Austin Fire Department
    - *Nuclear/Radiation Safety Engineering, ~29 years in Fire Protection – Former Commissioner, Texas Commission on Fire Protection, Former Member of Texas Task Force 1 - Firefighter, EMT, & Fire Inspector*
  - *guest lecture excerpts 2004 & 2008*

Fire and Life Safety

- *consequences, ex. 2005*
  - *3,675 deaths*
  - *17,925 injuries*
  - *$10,672,000,000 in property loss*
- *behavior & dynamics*
  - *a rapid (exponential growth), self sustaining oxidation process accompanied by the evolution of heat and light of varying intensities*



Fire and Life Safety

- human viability impacts
  - heat, smoke, oxygen deprivation
  - CO produced by combustion
- controlling factors of fire
  - available fuel supply
    - furniture, structure, other contents
  - available oxidizer
    - ventilated or unventilated, chemical oxidizers
  - impact of design, construction, occupancy

Fire and Life Safety

- development – heat transfer
  - conduction, convection, radiation
  - exponential
    - quickly exceed 500°C (932°F) even > 650°C (1200°F) at the ceiling of a confined fire within 4 to 5 minutes
    - post flashover (uncontrolled ventilation) ~600°F to >1800°F within a matter of seconds

Fire and Life Safety

- fire resistive construction (I-FR, IA)
  - concrete and protected steel
  - may or may not be compartmented
  - typical construction for high-rises
- typical hazards
  - fires are generally content fires
  - not a severe "collapse" hazard
  - spalling of concrete
  - central HVAC as a smoke travel path (also floor/ceiling penetrations and voids)
  - hazards may be most obvious on floor above fire floor
  - seek assistance in evaluating severe structural damage

Fire and Life Safety

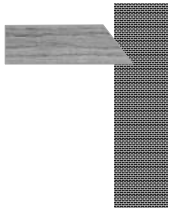
- high rise fires
  - 1911 Triangle Shirtwaist Company NY, NY
  - 1980 MGM Grand Hotel Las Vegas, NV
  - 1986 Dupont Plaza San Juan, Puerto Rico
  - 1988 1st Interstate Bank Los Angeles, CA
  - 1991 One Meridian Plaza Philadelphia, PA

Fire and Life Safety

- non-combustible or limited combustible construction (II-H, II-A)
  - metal, masonry, or concrete wall construction with metal roof
- typical hazards
  - unprotected lightweight steel roof joist & W's
  - roofs typically flat with combustible weather covering
  - ignition of built-up roofing may be above ceilings ABOVE fire sprinklers
  - concentrated roof loading by HVAC units, etc.
  - steel expands and loses 40% capacity after ~10 min at 593^{o}C (1100^{o}F)

Fire and Life Safety

- ordinary construction (III)
  - freestanding masonry or brick walls
  - solid wood joist flooring and roofing (typical within older buildings)
  - wood truss assemblies (typical in newer buildings)
- typical hazards
  - combustible concealed spaces
  - peaked roof concealed spaces
  - lack of or damaged draft or fire stopping
  - decorative parapet walls
  - "fire cut" beams



Fire and Life Safety

- heavy timber construction
  - wood frame or large cross section (8 in. min vertical members and 6 in. min horizontal members)
- typical hazards
  - high fuel load exclusive of contents
  - masonry wall collapse (similar to ordinary construction)
  - may survive long exposure, but control in advanced stages may be very difficult
  - radiant heat exposures may be extreme

Fire and Life Safety

- wood frame construction
  - light weight wood members typically consisting of wood 2 x's
- typical hazards
  - entire frame is part of fuel package
  - small dimension timber can be compromised more quickly than heavy timber
  - Braced Frame (mortised connections), Platform (sectional framing & multi-story), and Balloon Framing (fire & smoke travel paths)
  - failure of wood frame bearing walls may trigger simultaneous collapse of floors and/or roof

Fire and Life Safety *(from DHS training program)*

- *type V wood frame truss construction*

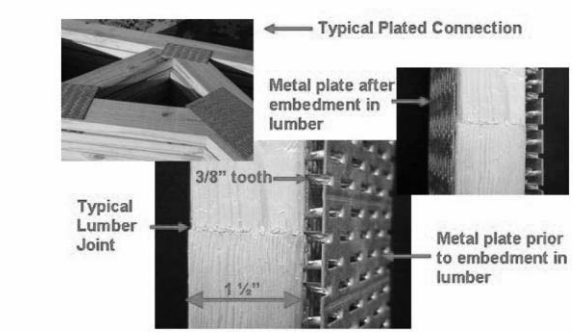


Figure 4— Metal tooth plate connectors like those shown are used extensively in lightweight parallel and pitch chord trusses. The multi-tooth plates are embedded into the wood fiber using high pressure.

Fire and Life Safety

- *what can I do?*
  - *break up the fuel continuity during construction and in the completed project:*
    - *fire barriers*
    - *open spaces*
    - *fire resistive and noncombustible construction*
  - *even the use of simple gypsum wallboard partitions and closed doors can help*

Fire and Life Safety

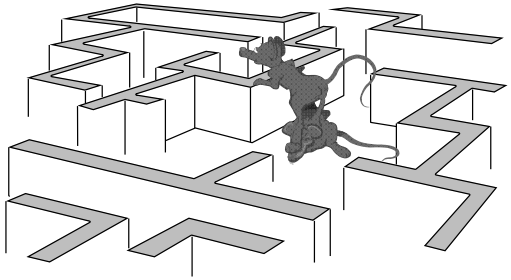
- *what can I do?*
  - *utilize wood carefully, install attic draft stops, early and correctly*

Fire and Life Safety

- *what can I do?*
  - *utilize fire detection and suppression systems wisely*

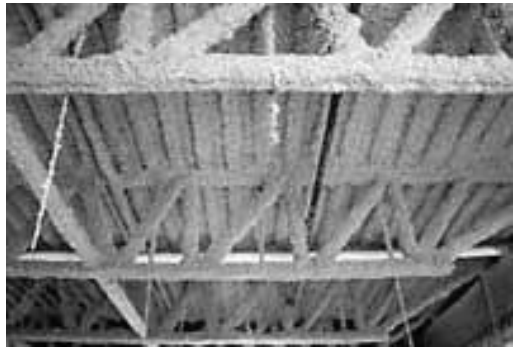
Fire and Life Safety

- *what can I do?*
  - *consider your occupants and realistic opportunities for people to escape*



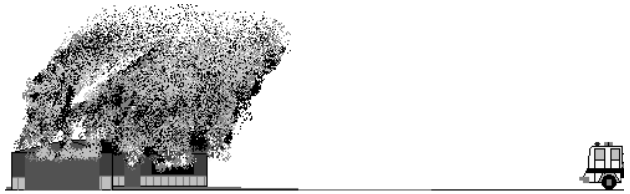
Fire and Life Safety

- *what can I do?*
  - *push for the durability of fire resistive coatings to be re-evaluated and improved*



Fire and Life Safety

- *what can I do?*
  - *consider the abilities and resources of firefighting and rescue personnel near your projects*
    - *be realistic*
    - *how they can reach the scene of the emergency*



Fire and Life Safety

- *what can I do?*
  - *use the rule of thumb of the emergency services - risk vs. benefit*
    - *risk (invest) a lot for a life (maybe even another life)*
    - *risk little for little gain*
  - *but again be realistic*
    - *we cannot and will not eliminate all risk*

Fire and Life Safety

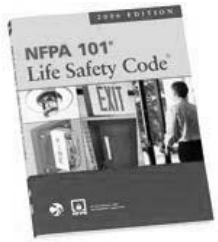
- *know the applicable codes*
- *understand the code and standards development processes*
  - *International Code Council (a consortium of ICBO, BOCA and SBCCI)*
  - *meant to create a single consistent series of codes for the USA (world?)*
  - *National Fire Protection Association (NFPA)*

Fire and Life Safety

- *International Code Series – e.g.*
  - *International Building Code (IBC)*
  - *International Fire Code (IFC)*

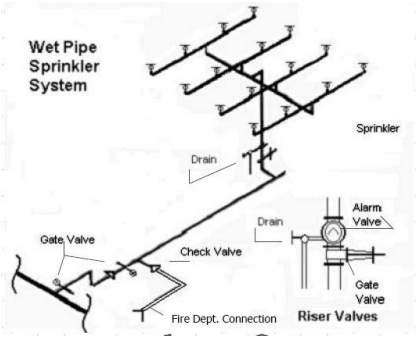
Fire and Life Safety

  - *NFPA 101, Life Safety Code (LSC 101)*
  - *NFPA 1, Fire Prevention Code (New UFC)*
  - *NFPA 70, National Electrical Code*
  - *NFPA 5000, Building Code (vs. IBC)*



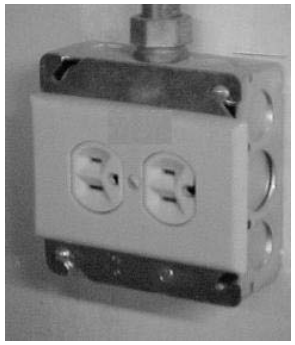
Fire and Life Safety

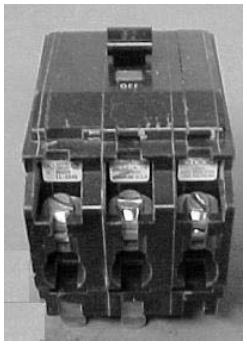
- *many other standards and codes*
  - *NFPA 14, Standpipes (Hose Systems)*
  - *NFPA 13, Fire Sprinkler Standard*



Fire and Life Safety

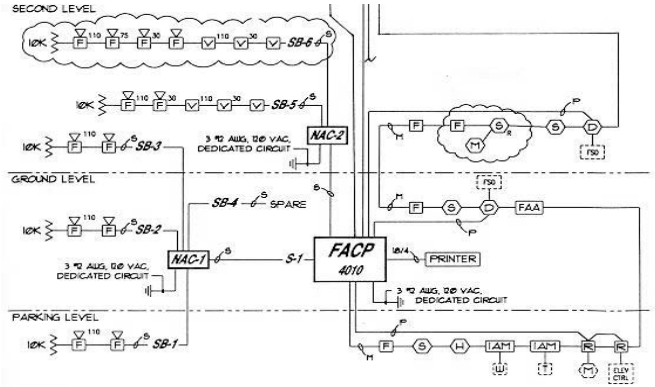
– *NFPA 70, National Electrical Code (NEC)*





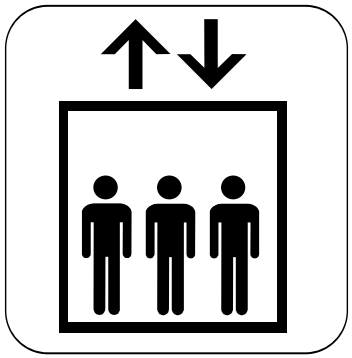
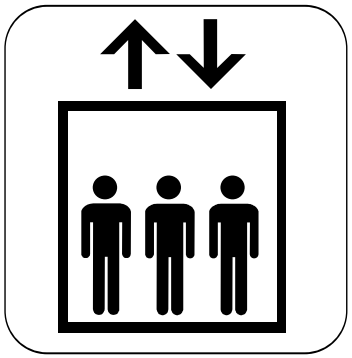
Fire and Life Safety

– *NFPA 72, Fire Detection and Alarm*



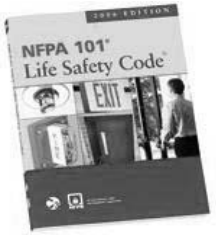
Fire and Life Safety

– *ANSI A-17.1 & A-17.3 Elevators*

Fire and Life Safety

- *performance based codes*
  - *NFPA 101, chapter 5*
  - *2003 ICC Performance for Buildings and Facilities*
  - *NFPA 5000, chapter 5*



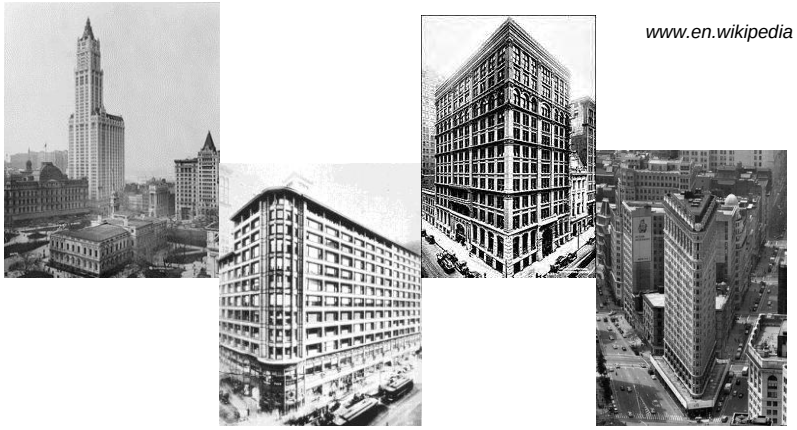
Fire and Life Safety

- *references*

1. *National Institute of Standards and Technology (NIST), Building and Fire Research Laboratory, "Fire on the Web, Fire Scenarios", http://fire.nist.gov/fire/fires/fires.html*
2. *"The Triangle Shirtwaist Fire", by Paul Rosa, History Buff.com, http://www.historybuff.com/library/refshirtwaist.html*
3. *Fire in the United States 1992–2001, Thirteenth Edition, October, 2004, U.S. Fire Administration, Federal Emergency Management Agency, Emmitsburg, Maryland 21727*
4. *FIRE LOSS IN THE UNITED STATES DURING 2002, by Michael J. Karter, Jr., National Fire Protection Association, Fire Analysis & Research Division, Quincy, MA, September 2003*
5. *FIRE LOSS IN THE UNITED STATES DURING 2003, by Michael J. Karter Jr., National Fire Protection Association, Fire Analysis & Research Division, Quincy, MA, October 2004*
6. *FIRE LOSS IN THE UNITED STATES DURING 2004, by Michael J. Karter Jr., National Fire Protection Association, Fire Analysis & Research Division, Quincy, MA, June 2005*
7. *FIRE LOSS IN THE UNITED STATES DURING 2005, by Michael J. Karter Jr., National Fire Protection Association, Fire Analysis & Research Division, Quincy, MA, July 2006*
8. *"Investigation Report on the DuPont Plaza Hotel Fire", National Fire Protection Association, Quincy, MA, 1987*
9. *"Investigation Report on the First Interstate Bank Building Fire", National Fire Protection Association, Quincy, MA, 1988*
10. *"Fire Investigation Report on the One Meridian Plaza Fire", National Fire Protection Association, Quincy, MA, 1991*

Structural "History"

- *by building system and relevance*



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Structural "History"

- *by building system and relevance*

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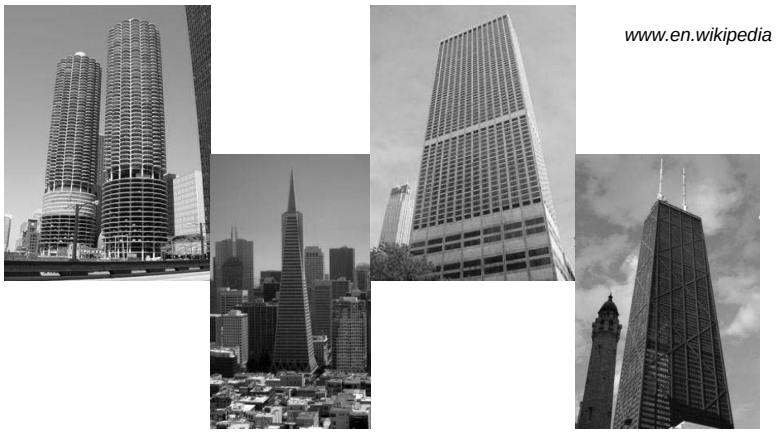
Structural "History"

- *by building system and relevance*



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Structural “History”

- *by building system and relevance*

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Final Exam Material

- *my list:*
  - *systems focus*
    - *general behavior, resistance to lateral loading (shear walls, etc.)*
    - *hazard considerations*
    - *behavior of elements*
      - *beams & columns (statics)*
      - *continuous beams, cables, arches, rigid frames, plates, grids, membranes, shells, nets*

Final Exam Material

- *my list (cont’d):*
  - *code and design requirements*
    - *methodologies by materials*
    - *construction supervision*
  - *system selection*
    - *wood, steel, concrete, masonry*
    - *component types*
    - *connections*
    - *foundations*