Course Intent

• To learn how to perform a structural plan review of simple commercial or residential projects.

- This course is for simple projects such as residential and small-to-moderately sized commercial only. Larger projects may require a more detailed review that should be performed by a licensed professional.

Introduction

• What items need to be reviewed?
  - Use & Occupancy
  - Type of Construction
  - Fire-rated Construction
  - Fire protection Systems
  - Means of Egress
  - Accessibility
  - Energy Efficiency
  - Structural Design
  - Mechanical
  - Plumbing
  - Electrical
  - …

- The mission of all building departments is to assure the public’s safety.
- What areas of the code are primary to “life safety”?
- What areas are secondary?
- Are we focusing our attention on the primary items?
Introduction

- This class is focused on the 2018 IBC and not the structural requirements outlined in the IRC.
- IRC R301.1.3:
  • "When a building of otherwise conventional construction contains structural elements exceeding the limits of... (the IRC), these elements shall be designed in accordance with accepted engineering practice."

Seminar Format

- A. Plan Review Process
- B. Load Paths
- C. Design Criteria
- D. Hazard Review
- E. Construction Plans
- F. Structural Calculations
- G. Specifications

Part A

Plan Review Process
Certifications

• When you get certified as a building plans examiner, how many questions do you have from Chapters 16-23?
• What types of questions are they?
• Is that what we should be looking at during a structural plan review?

Study Guides

ICC Performing Structural Plan Reviews

• “The purpose of a structural plan review is to determine that building structures…”
  • Comply with applicable standards of construction.
  • Use appropriate materials and methods.
  • Are safe for people and property.
  • Comply with code requirements.
Study Guides

1. Hazard Review
2. Construction Document Review
3. Calculations & Specifications Review
4. Components & Materials Review

Structural Review

- **Suggested Breakdown:**
  1. Hazard Review (30%)
  2. Construction Plans (60%)
  3. Structural Calculations (8%)
  4. Specifications (2%)

- This breakdown only applies to simple projects. More complicated projects may require an extensive review of the calculations and reports by a licensed professional.

Questioning an Engineer

- How many of you are comfortable questioning an engineer?

Plan Review Philosophy

- **WABO/SEAW: Structural Plan Review Philosophy**
  
  [Link: http://www.wabo.org/waboseaw-white-papers]
Plan Review Philosophy

Collaborative Effort:
• “Given the respective roles and responsibilities of the designer and reviewer, the process of ensuring a building conforms to the code should be a collaborative effort between the two.”

Plan Review Philosophy

Scope of Review:
• “… it should not necessarily be the reviewer’s primary focus to check the mathematical accuracy of the submitted calculations.”

Plan Review Philosophy

Engineering Judgment:
• “… if the design engineer is able to give a reasonable explanation, the reviewer should defer to the engineer’s judgment, particularly if the issue under discussion is not directly addressed in the code.”
• “Design engineers’ responses… should address the concerns expressed and promote a collaborative effort.”

Plan Review Philosophy

Engineering Judgment:
• “It is appropriate for a reviewer to ask an engineer to justify a design that directly contradicts a code requirement. For example, a reinforced concrete column that does not have ties or spirals at the code-required spacing should be questioned.”
Plan Review Philosophy

Plan Reviewer Judgment:

• “He or she should avoid delving into the minutiae of details and losing sight of the primary life-safety issues.”

• “In exercising his/her judgment the plan reviewer should refrain from imposing his/her own idea of what constitutes ‘best practices’ on the design engineer.”

Submittal Guidelines

Construction Documents:

 “…complete as necessary to verify code compliance and inspection in the field.”

Drawing List:

 “A list of drawings should be included on the plans to ensure the reviewer has a complete package when reviewing the application.”

WABO/SEAW: Structural Permit Submittal Guidelines

http://www.wabo.org/waboseaw-white-papers

Design Criteria & Construction Materials:

 “Specific items should be noted on the plans as specified in various code sections including Chapters 1, 16, 17, and 18. At a minimum this should include material specifications, loading criteria, and special inspection requirements.”
Submittal Guidelines

Accessory Documents:
- “Additional documents such as a design narrative, calculations, studies and reports should be provided to the extent necessary to clarify code compliance.”

Deferred Submittals:
- “Items not included but intended for later submittal to the building department should be clearly noted on the Drawings.”

Submittal Guidelines

- White Paper has several other good items…

Structural Calculations:
- “Include narrative description of design methodology and assumptions used in design of both gravity and lateral systems. The narrative should address any peculiarities and irregularities in the design.”

Load Paths

Newton's 3rd Law:
- “To every action there is an equal and opposite reaction.”

Load Path:
- How the loads are transferred from the point of origin to where they are resisted.
Load Paths

What causes vertical loads?
- Gravity

What causes lateral loads?
- Wind
- Seismic

What resists these loads?
- Ground

Parts of a Structure

- Beams, Headers, Columns, Bearing Walls
- Diaphragms (i.e. Floor or Roof)
- Vertical Lateral-Force-Resisting Elements
- Footings & Foundations
- Anything else?

Gravity Load Path

What loads need to be considered?
- Dead loads
- Live loads
- Snow loads
- Soil loads
- Hydrostatic loads
- Rain loads
- Flood loads

Gravity Load Path

Concentrated vs. Uniform Loads

CONCENTRATED LOADS 2x10 REQUIRED 12 FEET

UNIFORM LOADS 2x6 REQUIRED 12 FEET
Gravity Load Path

The gravity load path is pretty easy to follow.

- What are some common problems?

Lateral Load Path

Not as easily understood

- What loads need to be considered?
  - Wind
  - Seismic

Lateral Load Path

Wind:

- Wind acts against the sides of a building like the sail on a boat.
- The majority of forces are transferred up into the roof/floor while the rest into the foundation.

Lateral Load Path

Seismic:

- Ground shaking causes the structure’s mass to be accelerated back and forth.
- Forces are developed where the structures mass is the largest.
Lateral Load Path

Lateral-Resisting Elements:

- **Vertical:**
  - Shear Walls
  - Braced Frames
  - Moment Frames
  - Cantilevered Columns
  - Several more…

- **Horizontal:**
  - Floor Diaphragm
  - Roof Diaphragm

Lateral Load Path

Structure & foundations must resist…

- Sliding
- Overturning

Sliding Load Path:

![Diagram of sliding load path]

FEMA 232: "Homebuilder's Guide to Earthquake Resistant Design and Construction"
Lateral Load Path

Overturning Load Path:

Connections – Connections – Connections

Design must consider three load cases:

- Gravity design
- Lateral in one direction
- Lateral in opposite direction

- Load capacity of each building element and their connections must be calculated to resist all three loads and adequately transfer them to...
Part C

Design Criteria

Key items to keep in mind…
1) Risk Category
2) Ground Snow Load
3) Design Wind Speed
4) Wind Exposure
5) Soil Site Class
6) Ground Motions
7) Flood Design Data

1) Risk Category

- Previously “Occupancy Category”
- “Each building and structure shall be assigned a risk category in accordance with Table 1604.5.”

<table>
<thead>
<tr>
<th>RISK CATEGORY</th>
<th>NATURE OF OCCUPANCY</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>Buildings and other structures that represent a low hazard to human life in the event of failure, including but not limited to:</td>
</tr>
<tr>
<td></td>
<td>Agricultural facilities,</td>
</tr>
<tr>
<td></td>
<td>Certain temporary facilities,</td>
</tr>
<tr>
<td></td>
<td>Other storage facilities</td>
</tr>
<tr>
<td>II</td>
<td>Buildings and other structures except those listed in Risk Categories I, III and IV</td>
</tr>
</tbody>
</table>

International Code Council, 2018 IBC©
1) Risk Category

Detailed discussion about Risk Categories is provided in Section C1.5 of the ASCE 7-16 Commentary.

2) Ground Snow Load

Per IBC Figure 1608.2
- Used to determine design snow loads
- Based upon a 2% annual recurrence interval (i.e. 50-year snow event)
- Where applicable, use ASCE 7 – Chapter 7 to determine roof snow loads

3) Design Wind Speed Risk Category II

- 2009 IBC: Basic wind speed $\rightarrow$ 90mph
- 2012 IBC: Ultimate design wind speed $\rightarrow$ 115mph
- 2018 IBC: Basic wind speed $\rightarrow$ 100mph
3) Design Wind Speed

Ultimate Design Wind Speed ($V_{ult}$)
- $I_W$ has been incorporated into this wind speed.
- Risk Category II $\rightarrow$ see Figure 1609.3(1)
- Risk Categories III & IV $\rightarrow$ see Figure 1609.3(2)
- Risk Category I $\rightarrow$ see Figure 1609.3(3)
- $V_{ult}$ "determined by the local jurisdiction shall be in accordance with Section 26.5.1 of ASCE 7."
3) **Design Wind Speed**

**Local jurisdictions can estimate the design wind speed.**
- Adjustment must be based upon...
  - Meteorological data, and...
  - An estimated basic wind speed per Section 26.5.3.

This is very involved!

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4) **Wind Exposure**

If someone were to call and ask, what wind exposure would you specify for your jurisdiction?

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**Ultimate Design Wind Speed ($V_{ulc}$):**
- 115mph, Risk Category II
- 120mph, Risk Category III & IV
- 110mph, Risk Category I

**Farmington, Utah:**
- 140mph, Risk Category II
- 150mph, Risk Category III
- 160mph, Risk Category IV
- 130mph, Risk Category I
4) Wind Exposure

- **Surface Roughness B:**
  - “Urban and suburban areas, wooded or other terrain with numerous closely spaced obstructions having the size of a single-family dwelling or greater.”

- **Surface Roughness C:**
  - “Open terrain with scattered obstructions having heights generally less than 30 feet.”

- **Surface Roughness D:**
  - “Flat, unobstructed areas and water surfaces.”
4) Wind Exposure

**Exposure B:**
- Buildings ≤ 30 feet: Surface Roughness B for 1,500’
- Buildings > 30 feet: Surface Roughness B for 2,600’ or 20*building height, whichever is greater.

**Exposure C:**
- Shall apply to all cases where Exposure ‘B’ or ‘D’ do not apply.

4) Wind Exposure

**Exposure D:**
- Surface Roughness D for 5,000’ or 20*building height, whichever is greater.
- If Exp. B or C exist upwind and the site is within 600’, or 20*building height, from an Exposure D condition.

5) Soil Site Class

- Classifications moved to ASCE 7-16.
- **Based upon upper 100-feet**
  - Site Class A: Hard rock
  - Site Class B: Rock
  - Site Class C: Very dense soil and soft rock
  - Site Class D: Stiff soil
  - Site Class E: Soft clay soil
  - Site Class F: Soils requiring site response analysis
5) Soil Site Class

• If not defined, what should we assume?
  § 20.3.1: Site Class F
    ▪ Soils vulnerable to potential failure or collapse under seismic loading (i.e. liquefiable or collapsible soils)
    ▪ Peats or highly organic clays
    ▪ Very high plasticity clays (PI > 75)
    ▪ Very thick soft/medium clays (H > 120 ft)
  § 20.3.2: Site Class E
    ▪ Where it does not qualify as Site Class F and...
    ▪ Total thickness of soft clay > 10 ft.

6) Ground Motions

How many of you verify ground motions?

• Multiple options...
  • ASCE 7 Hazard Tool (seismic, wind, rain, flood, ice, snow & tsunami)
    ▪ $60 a year
    ▪ Search by map, address, or coordinates
  • ATC Hazards by Location (seismic, wind, snow, tornado)
    ▪ Free - Search by address or coordinates
  • SEAOC Seismic Design Map Tool (seismic only)
    ▪ Free - Search by address or coordinates

6) Ground Motions

- ASCE 7 Hazard Tool
- ATC Hazards by Location
- SEAOC Seismic Design Map Tool
7) Flood Design Data

Is there a flooding risk in your jurisdiction?

Flood Hazard Areas (FHA) are established by the local jurisdiction based upon the FEMA Flood Insurance Rate Map (FIRM), Flood Boundary and Floodway Map (FBFM), and other supporting data.

Flood hazard documentation must be prepared and sealed by a registered design professional.

7) Flood Design Data

IBC 1612.4: Flood Documentation

- **Not** subject to high-velocity wave action:
  - Elevation of lowest floor, including basement
  - Fully enclosed areas below flood elevation → Statement that design will allow for equalization of flood waters per ASCE 24

  - Dry floodproofing → Statement that complies with ASCE 24

- **Subject** to high-velocity wave action:
  - Elevation of lowest horizontal structural member
  - Statement that building is designed in accordance with ASCE 24, including…
    - Pile & column foundations
    - Structure anchored to resist flotation, collapse or lateral movement with wind and flood loads acting simultaneously
  - Statement that breakaway walls are designed per ASCE 24
Part D
Hazard Review

Hazard Review (30%)

1. Verify Project Location
2. Verify Ground Motions
3. Verify Snow Loads
4. Review Geotechnical Report
5. Review Geologic Hazards
6. Review Adopted Flood Maps

• Perhaps most important part of structural review!

I. Project Location

- Use Google Earth or other mapping software to verify project location.
- Make sure location matches what is shown in the geotechnical report and site plan.
- Note the following items:
  - Existing structures
  - Sloping site?
  - Appropriate Wind Exposure
  - Other Items?
2. Ground Motions

Site Class ‘D’

\[ S_{DS} = 0.568g \]
\[ S_{DI} = 0.355g \]

SDC ‘D’

https://hazards.atcouncil.org

3. Snow Loads

Verify Ground (\( P_g \)) and Flat Roof (\( P_f \))

- What is the ground snow load?
- What is the importance factor?
- What is the exposure factor?
- What is the thermal factor?

4. Geotechnical Report

Is a soils report required? (IBC 1803)

- Questionable & expansive soils
- High water table
- Deep foundations
- Variable rock
- Excavations near foundations
- Structural fill or CLSM
- S.D.C. ‘C’ or above.

4. Geotechnical Report

Basis of Investigation (IBC 1803.3)

- “…the number and types…shall be determined by a registered design professional.”
- Are 2 borings acceptable for the following?
4. Geotechnical Report

Basis of Investigation (IBC 1803.3)

- Civil + Structural Engineer Magazine, Dec. 2019
  - “But with no universal standard governing how much data must be collected during the investigation and written into the final report, the geotechnical engineer and owner are left to negotiate what should be included.”
  - “The geotechnical engineer wants the most thorough investigation possible and the owner wants to keep the cost of all geotechnical work as low as possible.”
- **Bottom line**... It is okay for us to question the number of borings performed during the investigation.

4. Geotechnical Report

IBC 1803.6: Report should provide...

- A plot showing locations of borings
- Complete record of soil borings
- Record of soil profile
- Elevation of water table
- Recommendations for...
  - Foundation type
  - Bearing capacity
  - Mitigation measures for expansive soils
- **Expected total & differential settlement**
- Compacted fill properties

4. Geotechnical Report

Allowable Bearing Pressure:

- The allowable bearing pressure is dependent upon...
  - Types of foundations
  - Applied loads
  - Soil type
  - Expected settlement

4. Geotechnical Report

Total & Differential Settlement:

- Total = maximum settlement beneath footings
- Differential = the uneven settlement that occurs
- Allowable bearing pressure typically considers...
  - Total settlement = 1-inch maximum
  - Differential settlement = ½-inch maximum
- Geotech may also specify minimum footing dimensions or additional reinforcing to limit expected settlement.
4. Geotechnical Report

**IBC 1803.5.12:** Additional items for SDC ‘D-F’...
- Seismic lateral earth pressure → 6-feet
- Potential for liquefaction
- Quantify consequences of liquefaction
- Liquefaction mitigation measures

4. Geotechnical Report

**IBC 1803.5.5:** Deep Foundations
- Recommended deep foundation types
- Recommended center-to-center spacing
- Driving criteria
- Installation procedures
- Field inspection & reporting procedures
- Load test requirements
- Reductions for group action

4. Geotechnical Report

*Is it okay to assume Soil Site Class ‘D’?*
- ‘D’ = stiff soil
- ‘E’ = soft clay
- ‘F’ = liquefiable/collapsible

4. Geotechnical Report

• Site Class E & F soils in high seismic regions require all footings to have "seismic ties" (**IBC 1809.13**).
4. Geotechnical Report

Concrete Durability (IBC 1904.1 → § 19.3.1 of ACI 318-14)

- Freezing (F0, F1, F2, & F3)
- Sulfate (S0, S1, S2, & S3)
- Permeability (P0, P1, P2, & P3)
- Corrosive (C0, C1, & C2)

- 0 = Not applicable
- 1 = Moderate
- 2 = Severe
- 3 = Very severe

4. Geotechnical Report

Concrete Durability (IBC 1904.1 → § 19.3.1.1 of ACI 318-14)

- "Design professional shall assign exposure classes… of structural concrete members."

Concrete Exposure Requirements

<table>
<thead>
<tr>
<th>Use</th>
<th>Exposure Classes</th>
<th>Fc (psi)</th>
<th>Maximum w/c Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Footings</td>
<td>F1, S0, P0, C0</td>
<td>4,500</td>
<td>0.45</td>
</tr>
<tr>
<td>Exterior Walls</td>
<td>F2, S0, P0, C0</td>
<td>4,500</td>
<td>0.45</td>
</tr>
<tr>
<td>Interior Walls</td>
<td>F0, S0, P0, C0</td>
<td>3,000</td>
<td>0.55</td>
</tr>
<tr>
<td>Interior Slab</td>
<td>F0, S0, P0, C0</td>
<td>3,000</td>
<td>0.55</td>
</tr>
<tr>
<td>Exterior Slab</td>
<td>F2, S0, P0, C0</td>
<td>4,500</td>
<td>0.45</td>
</tr>
</tbody>
</table>

4. Geotechnical Report

- Does the site plan match the project location?
- How old is the report?
- Is the Soil Site Class specified?
- Should “footing seismic ties” be required? (Site Class ‘E’ or ‘F’ only; see IBC 1809.13)
- Are foundations required to span a certain distance per the report recommendations?
- Are their special drainage requirements that should be noted on the plans?

5. Geologic Hazards

Are there other geologic hazards at your site?
5. Geologic Hazards

- State Hazard Maps
  - CA Department of Conservation
  - CA OES
  - Tsunami Research Center at USC
- Local Hazard Maps

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5. Geologic Hazards

Footings on Slopes:
- IBC Figure 1808.7.1
  - Ascending Slopes (IBC 1808.7.1)
  - Descending Slopes (IBC 1808.7.2)
- Alternate setbacks & clearances (IBC 1808.7.5)

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5. Geologic Hazards

IBC Figure 1808.7.1
- Descending: H/3, but not greater than 40-feet
- Ascending: H/2, but not greater than 15-feet

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5. Geologic Hazards

Ascending Slopes (IBC 1808.7.1)
- Clearance = “…sufficient distance from the slope to provide protection from slope drainage, erosion and shallow failures.”
5. Geologic Hazards

Descending Slopes (IBC 1808.7.2)

- Setback = “...set back from the slope surface sufficient to provide vertical and lateral support for the footing without detrimental settlement.”

6. Flood Maps

Verify that you are not in an FHA:

- Flood Zones A or V → Within FHA
- Flood Zones B or shaded X → moderate flood hazard
- Flood Zones C or unshaded X → minimal flood hazard

Sample Comments

Ground Motions:
When checking the ATC Hazards by Locations tool the design ground motions per the 2018 IBC appear to be $S_{DS} = 1.763g$ and $S_{D1} = 0.794g$. The value noted on the plans and in the calculations is $S_{DS} = 1.45g$. This is significantly less than noted above. Please address.

Flood Hazard Area:
The project is located within a flood hazard area as shown on the City’s current Flood Insurance Rate Map (FIRM). Please provide all necessary flood hazard documentation as outlined in IBC 1612.4.

Snow Loads:
Due to the elevation of the site, it appears that the design roof snow load will be greater than 30psf. Please confirm that a percentage of the snow was considered in the seismic weight of the structure as required by IBC 1608.2.
Sample Comments

Geotechnical Report #1:
The City requires that geotechnical reports submitted for review be dated no more than two years from the submittal date. Please provide an update letter from a geotechnical engineer stating that the recommendations in the report are still valid or stating what items may have changed.

Geotechnical Report #2:
The geotechnical report states that all concrete which is to come into contact with the site soils are to meet the ACI requirements for “Moderate” sulfate exposure. This requires a minimum $f'c = 4,000\text{psi}$, maximum $w/c = 0.5$, and Type II cement per IBC 1904.1. Please note these requirements on the structural general note sheet.

Geotechnical Report #3:
The geotechnical report classifies the site soils as Site Class ‘E’. As such all individual spread footings must be interconnected by means of seismic ties in accordance with IBC 1809.13. Please address.

Construction Plans (60%)

1. Civil, Architectural, MEP Perusal
2. General Structural Notes
3. Footing & Foundation Plan
4. Floor Framing Plan(s)
5. Roof Framing Plan(s)
6. Sections & Details
7. Miscellaneous

Part E
Construction Plans

60%

1. Civil, Architectural, MEP

What items need to be considered by SER/EOR?
- Retaining walls
- Dimensions
- Canopies
- Mechanical unit weights
- Suspended elements
- Check uses $\rightarrow$ appropriate live loads?
- Snow drift areas
- “See Structural”
2. General Structural Notes

A. Design Criteria
B. Material Requirements
C. Statement of Special Inspections
D. Deferred Submittals

A very important part of structural review!

A. Design Criteria

**IBC 1603.1.1:** Floor/Roof Live Loads

- Verify appropriate live loads per use of space → IBC Table 1607.1

Let’s look at two examples...
1. Roof Loads
2. Heavy Vehicle Loads

### Live Loads

**Accessible Roofs:** IBC Table 1607.1: Note ‘l’...

- **Part A:**
  - “Areas of occupiable roofs, other than roof gardens and assembly areas, shall be designed for appropriate loads as approved by the building official.”
- **Part B:**
  - “Unoccupied landscaped areas of roofs shall be designed in accordance with Section 1607.13.3.”
Live Loads

IBC 1607.13.3.1: Landscaped Roofs
- Live Load = 20psf
- Dead Load = weight of "saturated" materials
- Is 80pcf dead load sufficient?

Live Loads

IBC 1607.7: Heavy Vehicle Loads
- IBC 1607.7.1 – Loads
- IBC 1607.7.2 – Fire truck and emergency vehicles
- IBC 1607.7.3 – Heavy vehicle garages
- IBC 1607.7.4 – Forklifts and movable equipment
- IBC 1607.7.5 – Posting

Live Loads

• Heavy Vehicles = Gross Vehicle Weight Rating (GVWR) > 10,000#
• GVWR = Maximum allowable weight a vehicle can carry including itself.
Live Loads

**IBC 1607.7.2:** Fire Trucks
- Must be designed for the greater of...
  - Actual operational loads, including outrigger reactions
  - Live load specified in IBC 1607.7.1

Live Loads

**IBC 1607.7.3:** Heavy Vehicle Garages
- Rational analysis allowed, but LL shall not be < 50psf

**IBC 1607.7.5:** Max weight of vehicles allowed into a parking garage or other structure shall be posted.

Live Loads

**IBC 1607.7.4:** Forklifts and movable equipment
- “…structure shall be designed for the total vehicle or equipment loads… These loads shall be posted…”

Live Loads

- IBC 1607.7.2: Fire Trucks
- IBC 1607.7.3: Heavy Vehicle Garages
- IBC 1607.7.4: Forklifts and movable equipment
- IBC 1607.7.5: Max weight of vehicles allowed into a parking garage or other structure shall be posted.
A. Design Criteria

**IBC 1603.1.3: Snow Loads**
- This was checked as part of the “Hazard Review”. Now we simply verify that the values noted on the plans are correct.
  - Ground Snow Load ($P_g$)
  - Flat-roof Snow Load ($P_f$)
  - Snow Exposure Factor ($C_e$)
  - Thermal factor ($C_t$)
  - Snow Importance Factor ($I_s$)

A. Design Criteria

**IBC 1603.1.4: Wind Design Data**
- This was checked as part of the “Hazard Review”. Now we simply verify that the values noted on the plans are correct.
  - Basic Wind Speed
  - Wind Exposure
  - Internal Pressure Coefficient
  - Component & Cladding Pressures

A. Design Criteria

**IBC 1603.1.5: Earthquake Design Data**
- This was checked as part of the “Hazard Review”. Now we simply verify that the values noted on the plans are correct.
  - Risk Category
  - Seismic Importance Factor ($I_e$)
  - Mapped Accelerations ($S_e$, $S_i$)
  - Soil Site Class
  - Design Accelerations ($S_{D0}$, $S_{D1}$)
  - Seismic Design Category
A. Design Criteria

**IBC 1603.1.5:** Earthquake Design Data
- Additional items...
  - Analysis Procedure Used
  - Basic Seismic Force-Resisting System(s) → R
- *Are all systems listed?*

<table>
<thead>
<tr>
<th>Seismic Force-Resisting System</th>
<th>Ordinary</th>
<th>Intermediate</th>
<th>Special</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reinforced Masonry Shear Walls</td>
<td>R = 2.0</td>
<td>R = 3.5</td>
<td>R = 5.0</td>
</tr>
<tr>
<td>Special loads may be required for high seismic areas</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Example: Reinforced Masonry Shear Walls
- Ordinary → R = 2.0 ≤ 40% of special
- Intermediate → R = 3.5 ≤ 57% of special
- Special → R = 5.0 ≤ Required for high seismic

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A. Design Criteria

• IBC 1603.1.6: Geotechnical Information
• IBC 1603.1.7: Flood Design Data
  - This was checked as part of the “Hazard Review”. Now we simply verify that the values noted on the plans are correct.
A. Design Criteria

B. Material Requirements

Wood, Concrete, Masonry, Steel, etc.

• Are design/construction standards specified?
  • ACI 318-14
  • TMS 402-13
  • AISC 360-10
  • 2015 NDS, etc.

• Are materials and design strengths specified?
  • Concrete per IBC 1901.3, etc.
  • Do specific installations meet code?
  • Is concrete cover being met?
  • Is treated lumber and preservative fasteners called out?
  • Is extraneous information listed?
C. Special Inspections

History of Special Inspections

- Inspections of structural components were included in first edition of the UBC (1927)
- Term “Special Inspections” appeared in the 1961 UBC
- BOCA first introduced special inspection requirements in 1988.
- The 2000 IBC merged the UBC and BOCA special inspection provisions into Chapter 17.
- The requirements keep growing!

Can the architect or SER act as the special inspector?

Where are special inspection requirements typically provided?

Do only structural elements require special inspections?

IBC 1704.3: Statement of Special Inspections (SSI)

- Shall be prepared by the Registered Design Professional in Responsible Charge.
- Shall identify the following:
  - Work required to have special inspections or testing
  - Type & extent of special inspection or testing
  - Frequency (continuous or periodic)

Continuous:
- Full-time observation
- “100% of the work must be inspected and it must be inspected as the work is being performed.”

Periodic:
- Part-time or intermittent observation
- “The registered design professional… should indicate the frequency of inspection that is required. The frequency varies depending on the size and complexity of the project.” - Structure Magazine, May 2006
C. Special Inspections

• Bad Example:
  • Large single-story retail shell → CMU construction
  • Original plans provided the following:

  Special Inspection: Special inspection is required in accordance with IBC 1701.
  A. All concrete masonry units and reinforcing.
  B. Field welding.
  C. Epoxy bolts.

• Bad Example:
  • Our initial review comment stated the following:

    The “special inspection” portion of sheet Sxxx does not meet the requirements for a “Statement of Special Inspections” as required by IBC 1704.3. Not only should the items requiring special inspection/testing be noted, but the extent of the inspections/tests should be defined and the frequency (i.e. continuous or periodic) noted. Additional items requiring special inspection may include soils, concrete, etc. Please address.

C. Special Inspections

• Bad Example:
  • Revision #1 was as follows:

  Special Inspection: Special inspection is required in accordance with IBC 1701.
  A. All concrete masonry units and reinforcing, level II, periodic.
  B. Field welding. Periodic
  C. Epoxy bolts. If apply. During installation.
  D. Inspection of soil as noted on soil report. Periodic.

• See Handout for an example of what we should be seeing in relation to a Statement of Special Inspections.
C. Special Inspections

Exemptions:
• Not required for construction of minor nature.
• Group U occupancies accessory to R-3.
• Construction per conventional construction provisions.
• Approved fabricators (Certificate of Compliance)
• Isolated footings supporting 3-stories or less.
• Continuous footings supporting 3-stories or less of light-frame construction and designed using a concrete strength (f’c) of 2,500psi.
• Nonstructural slabs on grade, driveways, and sidewalks

D. Deferred Submittals

• Required for structural components in which the structural design has not been submitted.
• Does the B.O. have to allow them?
• Must be listed on the construction documents.
• Prior to submittal to the city, designs must be submitted to, and approved by, the EOR.
• None of the deferred submittal items shall be installed until submittal is approved by the city.

Should the following items be accepted as deferred submittals?
• Concrete mix designs
• Deep foundation systems
• Tilt-up panel lifting design
• Open web steel joists
• Prefabricated metal buildings
D. Deferred Submittals

**IBC 107.3.4.1:** “shall be submitted to the registered design professional in responsible charge who shall review them and forward them to the building official with a notation indicating that the deferred submittal documents have been reviewed for general conformance to the design of the building.”

2. General Structural Notes

A. Design Criteria
B. Material Requirements
C. Statement of Special Inspections
D. Deferred Submittals

*A very important part of structural review!*

3. Foundation Plan

**Frost Protection:**
- Verify footings meet required frost depth.

**Footing Thickness:**
- Plain Concrete ≥ 8-inches (IBC 1809.8)
- Reinforced ≥ 10-inches (Section 13.3.1.2 of ACI 318-14)
  - “Depth of footing above bottom reinforcement shall not be less than 6-in.”
  - Reinfocing required in SDC ‘D or above’
Foundation Plan

Holdown Sizes and Locations:

Footing Seismic Ties?
- Site Class ‘E’ or ‘F’, and...
- SDC ‘D or above’

Foundation Plan

Footing Concrete Strength
- $f'_{c_{min}} = 2,500$psi (Light-framed, ≤ 2 stories)
- $f'_{c_{min}} = 3,000$psi (All others)

Foundation Walls:
- Are they restrained?
- Is appropriate backfill material specified?
- Is foundation wall drainage provided?
4. Floor Framing

- Beam & joist sizes, spans, and spacing
- Column sizes
- Wall framing (stud size & spacing, reinforcement)
- Shear walls (sheathing, nailing, blocking, masonry)
- Uplift floor ties (holdowns, anchor bolts, sill plates, boundary reinforcement, etc.)
- Connection callouts (correct detail references)
- Diaphragm requirements (sheathing, nailing, blocking, steel deck, HSA’s, reinforcement, etc.)
4. Floor Framing
- Verify Trusses/Beams
- Locate Shear Walls and Verify Shear Transfer Details
- Verify Holdowns
- Verify that Snow Loads are Shown on Low Roof Plans

5. Roof Framing
- Beam & joist sizes, spans, and spacing
- Column sizes
- Assumed truss layout
- Design loads (i.e. unbalanced, sliding, & drift snow)
- Connection callouts (verify detail references)
- Diaphragm requirements (i.e. sheathing, nailing, blocking)
- Rooftop units and other projections
6. Sections & Details

Specific Material Requirements:
A. Wood Construction
B. Concrete Construction
C. Masonry Construction
D. Steel Construction

A. Wood Construction

Segmented Shear Walls:
- Allowable aspect ratios
  - Seismic → 2:1 (3.5:1 if reduced)
  - Wind → 3.5:1 (e.g. 8'-0" x 2'-3")
- Example: 9-foot wall
  - 2:1 → 4.5 feet
  - 3.5:1 → 2.57 feet
  - 43% reduction in capacity!

Perforated Shear Walls:

Shear Walls:
- All panels shall have 2x blocking
- 3x required when edge nailing is 2"o.c., or…
- 10d nails and 3"o.c., or…
- Panels applied to each face and they are not offset
A. Wood Construction

Perforated Shear Walls:
- Allowable aspect ratios
  - Seismic & Wind → 3.5:1
- Example:
  [Link](https://www.structuremag.org/?p=11564)

<table>
<thead>
<tr>
<th>% Full-Height Sheathing</th>
<th>Shear Capacity Adjustment Factor</th>
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<tbody>
<tr>
<td>10%</td>
<td>1.00 0.69 0.53 0.43 0.36</td>
</tr>
<tr>
<td>20%</td>
<td>1.00 0.71 0.56 0.45 0.38</td>
</tr>
<tr>
<td>30%</td>
<td>1.00 0.74 0.59 0.49 0.42</td>
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<tr>
<td>40%</td>
<td>1.00 0.77 0.63 0.53 0.45</td>
</tr>
<tr>
<td>50%</td>
<td>1.00 0.80 0.67 0.57 0.50</td>
</tr>
</tbody>
</table>

Wall Height (h) Maximum Opening Height Ratio & Height
- h/3 4'-0" 2'-8"
- h/2 5'-4" 3'-4"
- 2h/3 6'-8" 4'-0"
- 5h/6 8'-4" 5'-0"
- h 10'-0" 6'-0"

Design & Detailing:
- Each wall pier ≥ 2-feet
- Full-height segment at each end
- No out-of-plane offsets
- Collectors shall be full length
A. Wood Construction

Force-Transfer Shear Walls:
• Requires rational analysis
• Must define blocking, straps and holdowns
• Example:
  • [https://www.apawood.org/ftao](https://www.apawood.org/ftao)

Shrinkage:
• Wood walls supporting > two floors and a roof must provide an analysis of the potential shrinkage.

• The analysis should show that the shrinkage will not cause an adverse effect on the…
  • Structure
  • MEP equipment and systems
  • Roof drainage

Shrinkage:
• Western Wood Products Association – Tech Note: [https://www.wwpa.org/resources/?id=shrinkage-calculations-for-multistory-wood-frame-construction](https://www.wwpa.org/resources/?id=shrinkage-calculations-for-multistory-wood-frame-construction)
• Shrinkage Calculators:
  [http://www.cwc.ca/dimensioncalc/](http://www.cwc.ca/dimensioncalc/)
B. Concrete Construction

Concrete Piers:
- **IBC 1810.3.9.4.2** requires...
  - At least 4 vertical bars
  - \( \rho_{\text{min}} = 0.005 \)
  - \( \rho = 0.005 \)
  - \#4 \( \leq 14'' \)Ø
  - \#5 \( \leq 17'' \)Ø
  - \#6 \( \leq 21'' \)Ø
  - \#7 \( \leq 24'' \)Ø

Concrete Piers:
- Enclosed Ties
  - \#3 bar if \( \leq 20'' \)Ø
  - Otherwise \#4 bar
  - Spacing shall be least of...
    - 12d, vertical bar;
    - 1/2 least dimension of compression member; and
    - 12 inches

#4 \( \rightarrow 6'' \)
#5 \( \rightarrow 7.5'' \)
#6 \( \rightarrow 9'' \)
#7 \( \rightarrow 10.5'' \)

B. Concrete Construction

Concrete Piers:
- **Exceptions:**
  - Not required in Groups R-3 or U of 2-stories or less when...
  - Element is not subject to lateral loads, or...
  - Only supports posts from decks and patios and the calculated lateral does not exceed 200#
  - In these cases a single \#4 vertical bar must be provided without ties or spirals

B. Concrete Construction

Column Ties:
- **§ 25.7.2 of ACI 318-14** requires...
- **Minimum Bar Size**
  - \( \leq \#11 \) vertical bar \( \rightarrow \#3 \) ties minimum
  - 16d, vertical bars (e.g. \#5 bars = 10'')
  - 48d, tie bars (e.g. \#3 ties = 18'')
- **Least dimension of compression member**

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B. Concrete Construction

Column Ties:
- “Every corner or alternate longitudinal bar shall have lateral support provided by the corner of a tie. No bar shall be further than 6” clear from such a laterally supported bar.”

B. Concrete Construction

Column Ties:
- Anchor bolts placed in the top of column or pedestal shall be enclosed by lateral reinforcement that surrounds at least four vertical bars.
- Lateral reinforcement...
  - Shall consist of (2) #4 ties or (3) #3 ties
  - Must be distributed within the top 5-inches

C. Masonry Construction

Materials:
- CMU: 1,500psi min, 4,000psi max
- Grout: ≥ CMU, but not less than 2,000psi

Reinforcing:
- Maximum spacing
  - 1/3 length of wall, or...
  - 1/3 height of wall, or...
  - 48” o.c.

EXAMPLE
Given: 9-foot walls
- 25'/3 = 8.33'
- 9'/3 = 3.0'
- 48”

C. Masonry Construction

Reinforcing:
- Ratio of reinforcing
  - ρ_{min} ≥ 0.0007 in each direction (ρ_h, ρ_v)
  - ρ_{total} ≥ 0.002 (ρ_h + ρ_v)
- Plan Review Cheat Sheet...

Actual Reinforcing Steel Ratio (ρ_{act})

<table>
<thead>
<tr>
<th>Floor</th>
<th>25’/3</th>
<th>9’/3</th>
<th>48”</th>
<th>ρ_{h,c}</th>
<th>ρ_{v,cm}</th>
<th>ρ_{c,cm}</th>
<th>ρ_{c,cte}</th>
<th>ρ_{v,cte}</th>
<th>ρ_{act}</th>
</tr>
</thead>
<tbody>
<tr>
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<td>0.0006</td>
<td>0.0010</td>
<td>0.0014</td>
<td>0.0011</td>
<td>0.0016</td>
<td>0.0021</td>
<td>0.0018</td>
<td>0.0019</td>
<td>0.0019</td>
</tr>
<tr>
<td>2nd Floor</td>
<td>0.0010</td>
<td>0.0014</td>
<td>0.0018</td>
<td>0.0015</td>
<td>0.0020</td>
<td>0.0025</td>
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<tr>
<td>3rd Floor</td>
<td>0.0014</td>
<td>0.0018</td>
<td>0.0022</td>
<td>0.0019</td>
<td>0.0024</td>
<td>0.0029</td>
<td>0.0026</td>
<td>0.0027</td>
<td>0.0027</td>
</tr>
</tbody>
</table>
**C. Masonry Construction**

**Nonparticipating Elements:**
- If not intended to resist lateral forces...
- Must be isolated in their own plane per §7.3.1 of TMS 402-13

---

**C. Masonry Construction**

**Masonry Veneer:**
- **Height Limitations**
  - Wood backing ≤ 30-feet above noncombustible foundation (38-feet at gables)
  - Metal stud backing ≤ 30-feet above noncombustible foundation (Can be supported above this height)

---

**C. Masonry Construction**

**Masonry Veneer:**
- **Attachment Requirements**
  - Provide at least one anchor for every 2ft² of wall area
  - Space anchors at max. 32" horizontally and 25" vertically
  - Continuous #9 wire reinforcement at 18"o.c. to which anchors are attached is not longer required.

---

**D. Steel Construction**

**Protected Zones:**
- Areas of expected yielding
- Fabrication discontinuities are repaired
- Detrimental attachments are not permitted
- **AISC 341-10** requires drawings to show protected zones for...
  - Special Steel Moment Frames
  - Intermediate Steel Moment Frames
  - Special Concentrically Braced Frames
  - Eccentrically Braced Frames
  - Buckling Restrained Braced Frames
Demand Critical Welds:

- These are welds that…
  1. Are subject to yield-level stresses, and…
  2. Could cause catastrophic results if they fail
- AISC 341 requires that drawings show the demand critical welds for…
  - Special Steel Moment Frames
  - Intermediate Steel Moment Frames
  - Special Concentrically Braced Frames
  - Eccentrically Braced Frames
  - Column Splices
  - Column Anchorages

Demand Critical Welds:

- The plans must clearly identify the following…
  - Weld Filler Metal: CVN of 20ft-lbs at -20°F
  - Ultrasonic testing is required
6. Sections & Details

Connections:
- Primary Structural
  - Framing details
  - Foundation details
  - Joist-to-Beam
  - Beam-to-Beam
  - Beam-to-Column
  - Column-to-Foundation
  - Moment & Braced Frame Elevations
- Secondary Structural
  - Canopies
  - Parapets
  - Fascias

6. Sections & Details

Eave Blocking:

Interior Shear Walls:
- Direct connection (load path)
- Parallel to truss
- As in detail
- Engineered girder truss
- Perpendicular to truss
- Shear wall panels
- Truss blocking
6. Sections & Details

Concentrated Loads:
- Watch for specific point loads

6. Sections & Details

Gable Wall Bracing:
- Knee bracing or ceiling bracing at hinge points in gable walls.

6. Sections & Details

Steel Columns:
- Bolt embedment
- Bolt diameter
- Bolt spacing requirements
- Non-shrink grout
- Column-to-plate weld
- Base plate thickness

7. Miscellaneous

- Verify that structural drawings are consistent with architectural and MEP.
- Ensure dimensions are provided.
- Verify proper code references.
- Verify each sheet bears the seal of an appropriate design professional.
- Do structural irregularities exist?
Sample Comments

General Notes #1:
Please list all deferred submittal items on the cover sheet and note that they are to be reviewed by the Design Professional in Responsible Charge and that they are not to be installed until approval has been obtained from the building official in accordance with IBC 107.3.4.1.

General Notes #2:
The "special inspection" portion of sheet S001 does not meet the requirements for a "Statement of Special Inspections" as required by IBC 1704.3. All elements requiring special inspection must be noted, the extent of the inspection and testing listed, and the frequency (e.g. continuous or periodic) specified.

General Notes #3:
Please provide the material strength and specific construction requirements for the various construction materials. As an example, the block, mortar and grout strengths should be provided within the masonry notes.

Sample Comments

Wood Shrinkage:
No calculations were included for the analysis of wood shrinkage in the proposed structure. Per IBC 2304.3.3, a wood-framed structure supporting the framing of more than two floors and a roof must provide an adequate shrinkage analysis to the building official. Please provide a satisfactory analysis.

Column Ties:
Please review the lateral tie requirements shown in detail ______. Vertical bars should be tied in such a fashion as to ensure the maximum distance between laterally tied bars is less than or equal to 6-inches (see Section 7.10.5.3 of ACI 318).

Protected Zones:
Per IBC 2205.2.2, structural steel structures located within high seismic regions shall be designed and detailed in accordance with AISC 341. AISC 314 requires that drawings define and show protected zones. Protected zone requirements could not be found on the plans. Please address.

Part F
Structural Calculations

Common Relationships

Load 0 0 0
Shear Linear Linear Linear
Moment Linear Linear Parabolic
Calculations (8%)

1. Proper Code References
2. Wind Design
3. Seismic Design
4. Flood Design
5. Snow Loads
6. Do Calculations Match Plans?

1. Proper References

Structural Calculation Note #1:
Many of the calculations were performed in reference to outdated building codes and standards. Please confirm that calculations meet the requirements of the 2018 IBC and its referenced standards as listed in Chapter 35.

2. Wind Design

- We already checked this as part of the “Hazard Review” and when checking the design criteria on the structural general notes.

3. Seismic Design

- We already checked this as part of the “Hazard Review” and when checking the design criteria on the structural general notes.
- Verify that the appropriate SD50 and SDC are used in the lateral calculations.
4. Flood Design

• We already checked this as part of the “Hazard Review” and when checking the design criteria on the structural general notes.

If within a flood hazard area, flood hazard documentation must be provided per IBC 1612.4.

5. Snow Loads

• Verify that drift and sliding snow calculations have been provided.
• Perform a spot check that they match the loads shown on the plans.
• Overhangs shall be capable of supporting Ice Dams along the eaves. (2*P_f)

6. Do They Match Plans

• Perform a check of as many as possible.
Specifications (2%)  

- Do they comply with the structural plans, structural calculations, and geotechnical report?