Mid-Rise Wood Frame Buildings

Experiences from the Pacific Northwest

British Columbia
Building Enclosure Council

April 2009

Outline of Talk

- Regulations
- Key Issues
- Project Case Studies

Speaker Background

- General Manager - Walsh Construction Co.
  - Offices in Portland and Seattle

- Architectural background
- Formerly headed up Quality Group within WCC
  - Heavy focus on enclosure QA/QC
  - Expanding focus on sustainability and all broader measures of building performance
  - Also: fire & life safety, structural, MEP, finishes issues

REGULATIONS

Portland

- Regulated under Oregon Structural Specialty Code (OSSC)
  - UBC (model code until 2003)
  - IBC (model code since 2003)
- Allow four-story buildings of wood frame construction (i.e. Type V) - if sprinklered

- Local amendment approved in 1995 to allow five-story wood frame buildings

Portland – Amendment 95-25

- Established specific requirements for:
  - Construction type
  - Occupancy
  - Sprinkler protection
  - Height
  - Fire fighting access
  - Permit application process
  - Construction and inspection

Portland – Amendment 03-01

- 2003 revisions were developed to:
  - Clarify intent of original “Local Amendment 95-25”
  - Incorporate changes and additional requirements reflecting seven years of experience in construction of tall wood structures

chapter is in conflict with the Oregon Structural Specialty Code, the provision of this chapter shall take precedence, as authorized by the Director of the Department of Consumer and Business Services pursuant to Oregon Revised Statute 455.040.

24.95.020 Construction.
(Amended by Ordinance 181136, effective August 17, 2007.)

A. Single Construction. Single construction buildings complying with this chapter may be a maximum of five stories of Type V-1 Hour construction.

B. Mixed Construction. Six story buildings complying with this chapter may be designed and constructed where any basement or first story is constructed of Type I construction and a maximum of the top five stories are of Type V-1 Hour construction. The Type I construction shall be separated from the Type V-1 Hour construction above with a three-hour occupancy separation.

C. Construction Types. Type I and Type V-1 Hour construction shall be as specified in the Oregon Structural Specialty Code.

24.95.030 Occupancy.
(Amended by Ordinance 181136, effective August 17, 2007.)

A. Single Construction. In five story wood frame buildings of single construction as specified in Section 24.95.020 A, the occupancy of the top four stories of buildings shall be limited to Group R, Division 1 apartment occupancies. Occupancies located in the first story and basement shall be limited to those listed in Subsection C.

B. Mixed Construction. In six story buildings of mixed construction, as specified in Section 24.95.020 B, the occupancy of the wood frame stories of the building shall be limited to Group R, Division 1 apartment occupancy. Occupancies located in the Type I portion of the building shall be limited to those listed in Subsection C.

C. Other Occupancies.

(Amended by Ordinance 181136, effective August 17, 2007.) Commercial kitchen grease ducts and exhaust equipment shall comply with the requirements of the Oregon Mechanical Specialty Code and the provisions of NFPA 96, 2001 edition.
Ducts that serve Type I hoods and penetrate a floor shall be in a shaft enclosure of not less than 2 hour fire resistive construction.

24.95.040 Sprinkler Protection.
(Amended by Ordinance 181136, effective August 17, 2007.) All portions of the building shall be protected throughout by an automatic sprinkler system complying with U.B.C. Standard No. 9-1 (NFPA 13) as contained in the Oregon Structural Specialty Code. The automatic sprinkler system shall not substitute for one-hour fire-resistive construction and cannot be used for building area increases.

24.95.050 Height.
(Amended by Ordinance 181136, effective August 17, 2007.) Regardless of construction, the maximum height the building shall be 65 feet. The height shall be measured from the lowest level of fire department vehicle access to the highest point of any of the following:

A. top of parapet;

B. the highest point of coping of a flat roof;

C. the deck of a mansard roof; or

D. the average height of the highest gable of a pitched or hipped roof associated with the building façade.

Each portion of the building created by an area separation wall shall comply with this section. Where a portion of the building created by an area separation wall is not directly adjacent to approved fire

24.95.060 Fire Fighting Access.
(Amended by Ordinance Nos. 176955, 180917 and 181136, effective August 17, 2007.) Access to the building for fire fighting, rescue and related purposes shall be provided as follows:

A. Fire fighting access required. Subject to the approval of Portland Fire & Rescue, fire department vehicle access shall be provided that meets the following standards:

1. Location. Fire department vehicle access locations shall be on an access road.

2. Access to apartment units. At least fifty percent (50%) of all apartments with windows on the exterior façade shall be reachable by a ladder truck provided with a 100 foot aerial ladder and located on an access road.

3. Design standards for access road. An access road shall be provided as follows:

a. Classification. Access roads shall be either:

(1) A public street; or

(2) An area of the property set aside for access road purposes.

b. Location.

(1) Access roads shall be located along at least 2 sides of the building.

(2) The edge of access roads at the access location shall be no closer than 10 feet and no farther than 21 feet from the building.

c. Width. Minimum width for access roads shall be not less than one of the following:

(1) 20 feet wide where no parking is allowed; or

B. Interior Courtyards. Interior courtyards shall be not less than 30 feet in any interior dimension.

C. Stairways to the roof. Unless the roof has a slope greater than 4 vertical in 12 horizontal, at least fifty percent (50%), but not less than two stairways, in the building shall provide access to the roof.

1. Priority. The following stairways shall be included in those providing access to the roof. Access to the roof shall be provided by the stairways in the locations described below, in the following order of priority:

a. Stairways that are the most remote from fire department access.

b. Where corridors within the building are not continuous or looped, stairways located at each end of a corridor.

2. Design.

a. Ladder access to most units. Where all the apartments above eighty percent (80%) of the building perimeter have windows within reach of a 100 foot aerial ladder positioned at an approved fire department vehicle access location, stairway roof access may be provided by ships ladders and roof hatch devices as follows:

(1) Ladder design.

(a) The ladder shall be constructed of steel.

(b) The minimum width of the ladder shall be 30 inches between handrails.

(c) The rise and run of the ladder shall be 12 inches maximum and 5 inches minimum respectively.

(d) Handrails shall be provided on both sides of the ladder and shall extend to the

D. Each stairway shall include a Class I or III standpipe complying with the Oregon Structural Specialty Code.

24.95.070 Permit Application
(Amended by Ordinance Nos. 176955, 180917 and 181136, effective August 17, 2007.)

A. Plans and Specifications. Permit applications submitted pursuant to this chapter shall include the plans and specifications as required by the Bureau of Development Services and Portland Fire & Rescue.

B. Pre-application Conference. As early as practicable in the design process, the applicant shall have a per-application design conference with the Director and Portland Fire & Rescue.

C. Design considerations. As part of the permit application, the engineer of record shall document consideration of issues critical to the design of tall wood structures. Considerations shall include, but are not limited, to the following:

1. Splitting of wood members from shear wall nailing;
2. Differential shrinkage of wood, steel and concrete members;
3. Differential shrinkage of load bearing walls with and without wood panels;
4. Axial and flexural capacity of lower floor studs; and
5. Compression of lower floor wood plates.

24.95.080 Construction and Inspection.
(Amended by Ordinance Nos. 176955 and 181136, effective August 17, 2007.) In addition to inspections and special inspections specified in the Oregon Structural Specialty Code and Chapter 24.20 of this Title, the Director shall require the following for buildings constructed pursuant to this chapter:

A. Structural Observation: Structural observation shall be provided by the engineer of record. Reports of the structural observation shall be provided to the Director periodically during framing.

B. Special Inspection. Special inspection shall be provided to enhance attention on the key elements of the lateral force resisting systems of the building, including, but not limited to, the following:

1. The grade of structural wood panels used in the sheer walls and horizontal diaphragms;

2. The nail size and pattern of the sheer walls and horizontal diaphragms;

3. The framing, location and length of all shear walls;

4. The hold down installations at all shear wall locations;

5. The diaphragm chord, drag strut and related details;

6. The base plate bolting; and

7. The blocking to top plate nailing.

The special inspector shall be employed by the owner or shall be employed by the engineer of record acting as the owner's agent, and shall comply with the standards of Chapter 24.20 of the City Code.

Portland – Current Regulation

- Local amendments are out (maybe)…

- Portland appears to be heading toward reliance on OSSC provisions (based on IBC)
- Allow five story wood frame buildings of Type III-B construction
  - 75 foot height limit
  - Exterior walls must be non-combustible (FRT wood required)
  - Exterior walls must be two-hour rated if load bearing

Guidance Documents

- Portland City Code - Chapter 24.95
  - Special Design Standards for Five Story Apartment Buildings - 1995 (updated 2003)
  - aka Local Amendment 03-01
- City of Portland Code Guide
  - Wood Frame, Rated Construction - 1999
- City of Portland Interpretation
  - Acceptable Alternatives to Use of Fire Treated Wood in Exterior Walls of R-2 Occupancy Buildings of Type III Construction - 2008

CODE GUIDE

OFFICE OF PLANNING & DEVELOPMENT REVIEW

TOPIC: **Rated Wood Construction - UBC/6/#2**

CODE: **Structural Specialty Code: 1998 Edition**

APPROVED: **March 1, 1999** _____

REFERENCE: **Sections 606, 708 - 711 – Structural Specialty Code**

SUBJECT: **Wood Frame, Rated Construction**

QUESTION: How is one-hour fire resistance to be achieved in wood construction? What are acceptable designs and practices?

RESPONSE: One-hour wood construction is the most common of the rated construction built today. Yet many of the construction techniques and detailing are not commonly understood or practiced. Rated construction is a system of building components which protect a building from fire. A whole building can be of rated construction or just one element of a building. It is essential that the rated construction act as a whole. Integrity of the construction around openings and through wall and floor cavities is essential regardless of the purpose of the rated construction.

Purposes of one-hour construction:

- Higher level of overall fire safety than in non-rated building construction (may be required due to occupancy or in order to obtain larger building area or height).
- Protection of exterior walls located near property lines.
- Separation of occupancies and special use areas.
- Separation of building areas.

This code guide provides a summary of code requirements and acceptable practices for achieving one-hour construction. While rated construction can be accomplished with a variety of materials, this guide focuses on one-hour rated construction for wood frame structures. This guide is not intended to be used alone. It must be used in conjunction with the building code to be fully effective. Many of the techniques discussed in this guide, however, may be readily adaptable for use in other types of construction.

A. General Framing

1. General

   Sections 603.1, 604.1, and 606.1 of the Oregon Structural Code requires Type II One-hour, Type III One-hour and Type V One-hour buildings be of one hour construction throughout the building. In other types of construction, specific elements are frequently required to be of one-hour fire-resistive construction although the entire building is not of one-hour construction. Other code provisions based on occupancies require that buildings be of one-hour construction through-out.

2. Perpendicular and parallel framing

   Except at area separation walls (see Section G) or occupancy separation walls (see Section H) or exterior walls in close proximity to property lines (see Section I), the protection of framing does not need to be continuous through floor/ceiling or roof/ceiling assemblies. Figures B1 through B8, attached. See also Section C of this guide for Attic and Crawl space applications.

3. Protection of structural columns

   As part of the structural frame of the building columns need to be of materials which will resist fire for at least one-hour such as concrete or heavy timber; or enclosed (surrounded) by materials that will protect the column from fire for at least one hour.

   X Columns (including those of steel) located within one hour rated wall assemblies need not be separately protected.

INDEX OF 1-HR WOOD FRAME DETAILS

AREA SEPARATION WALL CONDITIONS

- **A1** CONVENTIONAL FRAMING ||
- **A2** CONVENTIONAL FRAMING ⊥
- **A3** MODIFIED BALLOON FRAMING ||
- **A4** MODIFIED BALLOON FRAMING ⊥
- **A5** CRAWL SPACE ||
- **A6** CRAWL SPACE ⊥
- **A7** JOG IN ATTIC
- **A8** ROOF / CEILING DETAIL ||
- **A9** ROOF / CEILING DETAIL ⊥
- **A10** CLARIFIED TRUSS ⊥
- **A11** PARAPET
- **A12** WALL JUNCTION W/ EXT. WALL
- **A13** JOINING WALLS

INTERIOR WALL CONDITIONS

- **B1** CONVENTIONAL FRAMING ⊥
- **B2** MODIFIED BALLOON FRAMING ⊥
- **B3** MODIFIED BALLOON FRAMING ⊥
- **B4** DIFFERING HEIGHT JOIST ⊥
- **B5** CONVENTIONAL FRAMING ||
- **B6** CORRIDOR FRAMING ||
- **B7** MODIFIED BALLOON FRAMING ||
- **B8** CORRIDOR DETAIL ||

EXTERIOR WALL CONDITIONS

- **C1** CONVENTIONAL FRAMING ||
- **C2** CONVENTIONAL FRAMING ⊥
- **C3** MODIFIED BALLOON FRAMING ||
- **C4** MODIFIED BALLOON FRAMING ⊥
- **C5** MODIFIED BALLOON FRAMING ⊥

EXTERIOR WALL / ROOF CONDITIONS

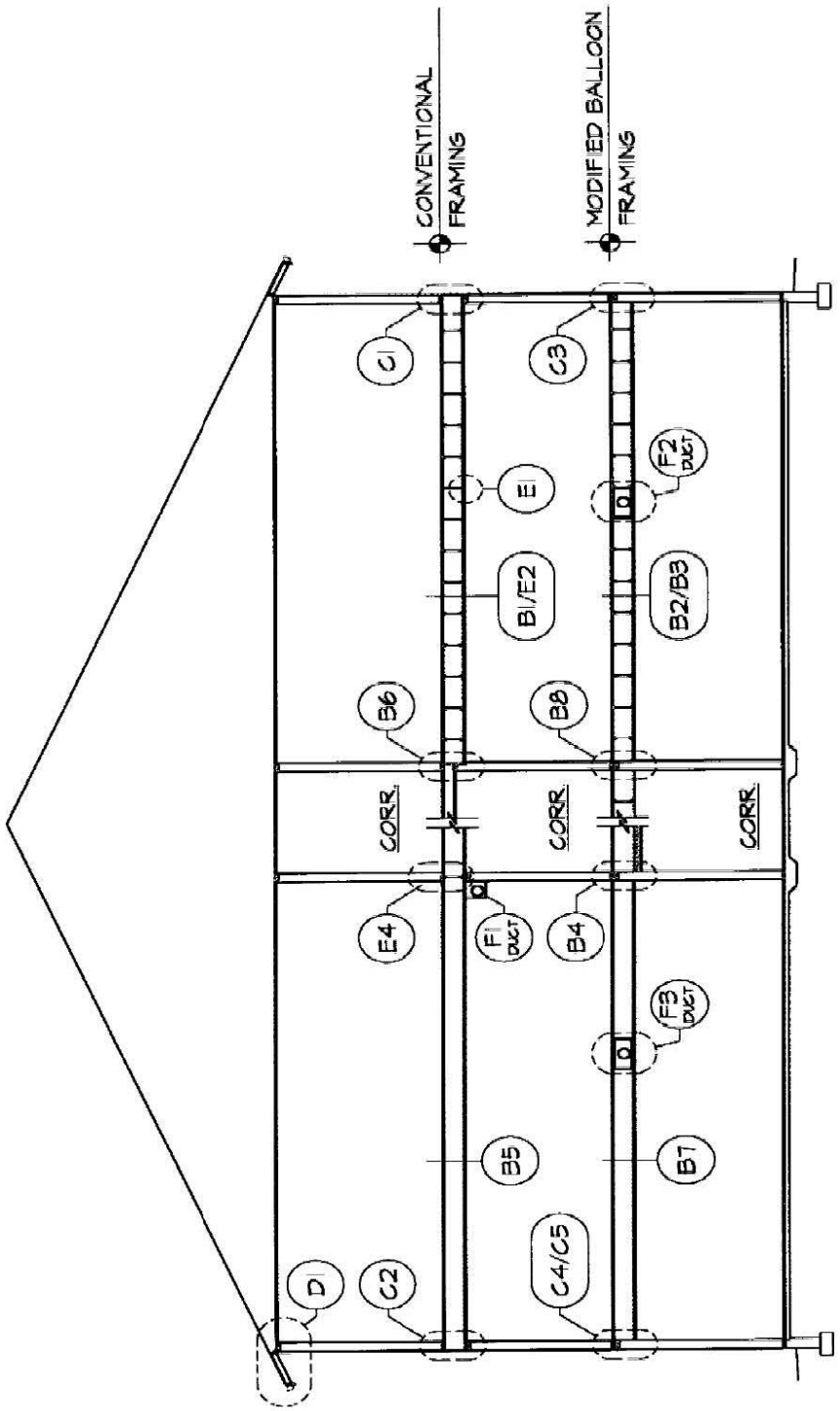
- **D1** EAVE BLOCKING
- **D2** TOP CHORD BEARING
- **D3** ROOF OFFSET DETAIL
- **D4** GABLE END
- **D5** GABLE END
- **D6** BOTTOM CHORD BEARING
- **D7** BOTTOM CHORD BEARING

1 HOUR WOOD FRAME DETAILS

- **E1** DRAFT STOPPING EXCEPTION
- **E2** DRAFT STOPPING-PARTY WALLS
- **E3** SMALL PENETRATION DETAIL
- **E4** FIRE BLK'G WALL DIAGRAM
- **E5** RECESSED ITEMS

MISCELLANEOUS DETAILS

- **F1** CONVENTIONAL DUCT
- **F2** ALTERNATE DUCT ||
- **F3** ALTERNATE DUCT ⊥
- **F4** TUB / SHOWER DETAILS



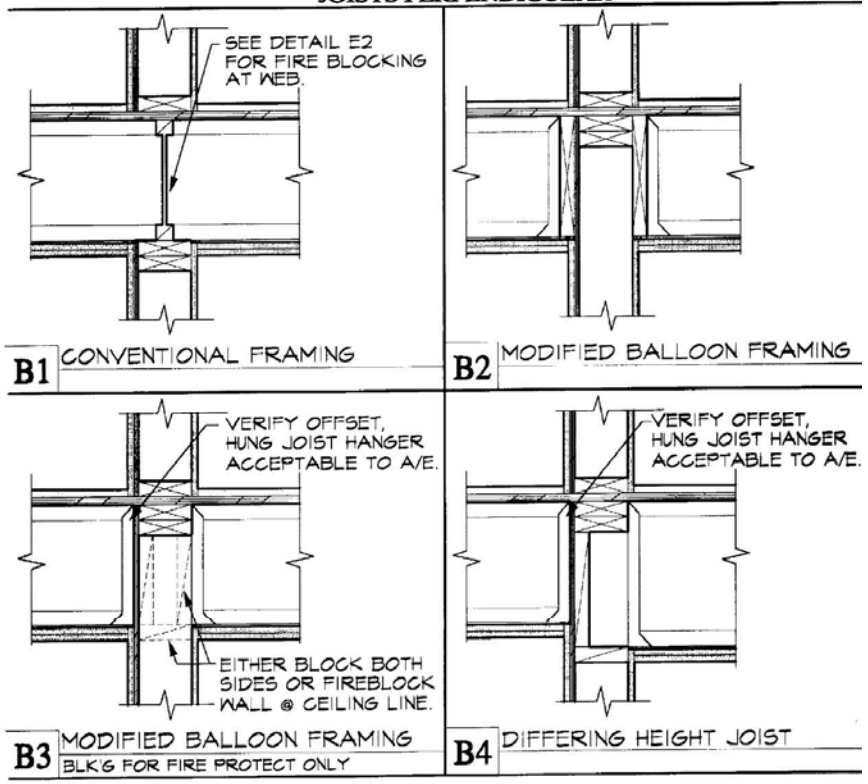
TYPICAL BUILDING SECTION / DETAIL LOCATOR

N.T.S.

INTERIOR WALL CONDITIONS

PRE-FABRICATED WOOD I - JOISTS

JOISTS PERPENDICULAR



B1 CONVENTIONAL FRAMING

B2 MODIFIED BALLOON FRAMING

B3 MODIFIED BALLOON FRAMING
BLK'G FOR FIRE PROTECT ONLY

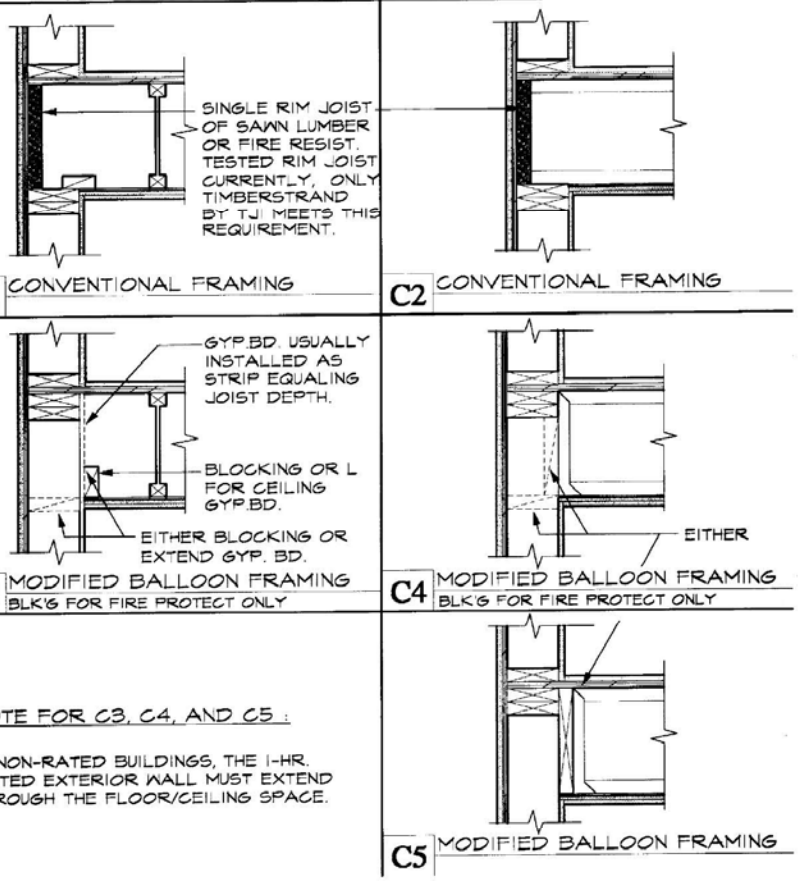
B4 DIFFERING HEIGHT JOIST

EXTERIOR WALL CONDITIONS

PRE-FABRICATED WOOD I - JOISTS

JOISTS PARALLEL

JOISTS PERPENDICULAR



C1 CONVENTIONAL FRAMING

C2 CONVENTIONAL FRAMING

C3 MODIFIED BALLOON FRAMING
BLK'G FOR FIRE PROTECT ONLY

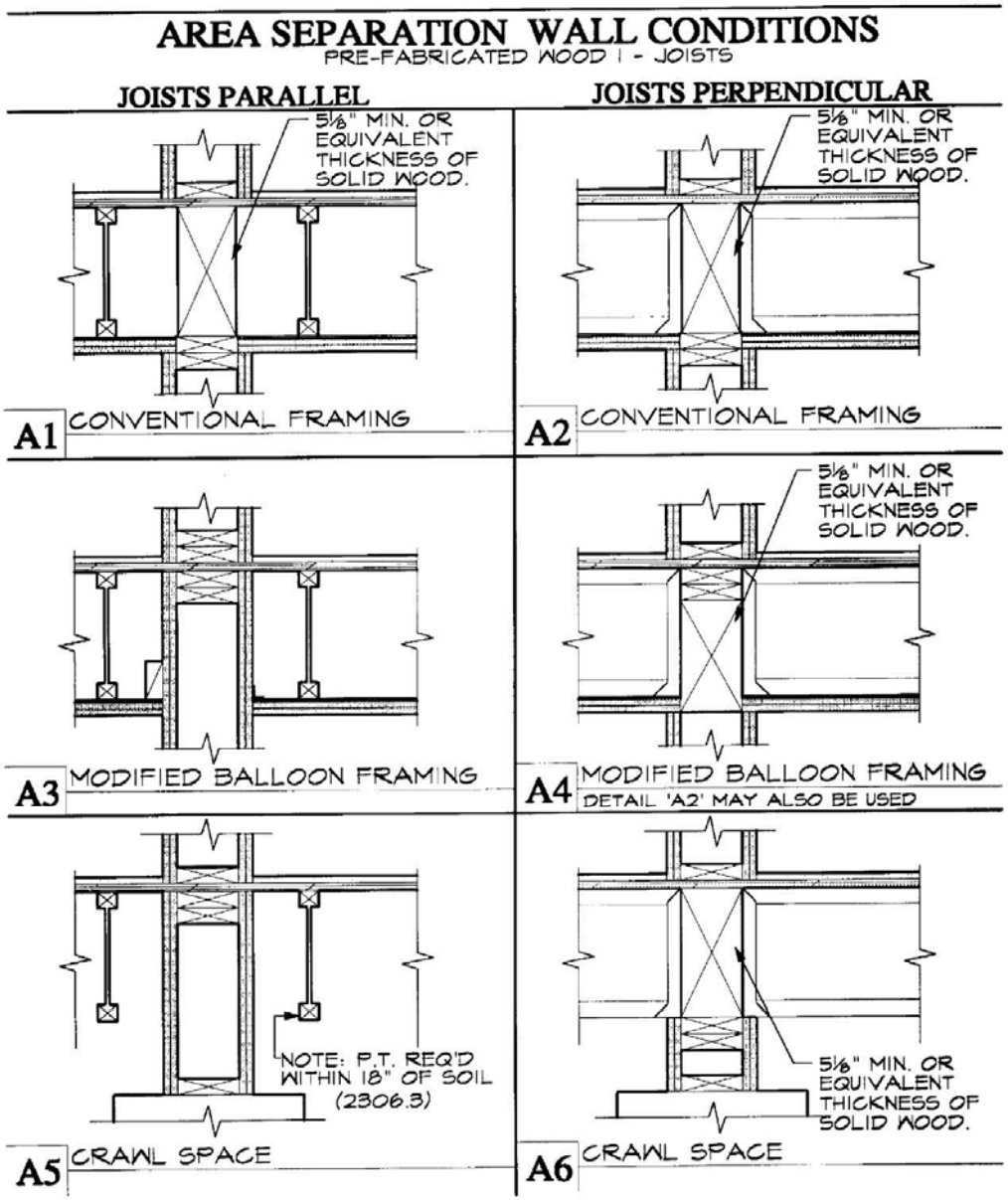
C4 MODIFIED BALLOON FRAMING
BLK'G FOR FIRE PROTECT ONLY

NOTE FOR C3, C4, AND C5 :

IN NON-RATED BUILDINGS, THE 1-HR. RATED EXTERIOR WALL MUST EXTEND THROUGH THE FLOOR/CEILING SPACE.

C5 MODIFIED BALLOON FRAMING


CC ESR 1153 CCMC


AREA SEPARATION WALL CONDITIONS
PRE-FABRICATED WOOD I - JOISTS
JOISTS PARALLEL
JOISTS PERPENDICULAR
5⅛" MIN. OR EQUIVALENT THICKNESS OF SOLID WOOD.
A1 CONVENTIONAL FRAMING
A2 CONVENTIONAL FRAMING
A3 MODIFIED BALLOON FRAMING
A4 MODIFIED BALLOON FRAMING
DETAIL 'A2' MAY ALSO BE USED
NOTE: P.T. REQ'D WITHIN 18" OF SOIL (2306.3)
A5 CRAWL SPACE
A6 CRAWL SPACE

Topic: Fire Treated Wood in Exterior Walls

Code: Oregon Structural Specialty Code, 2007 edition, Section 602.3

Subject: Acceptable Alternatives to Use of Fire Treated Wood in Exterior Walls of R-2 Occupancy Buildings of Type III Construction.

Question:

In buildings constructed of either Type III-A or III-B construction, the code permits the exterior bearing walls to be constructed with fire retardant treated wood where the wall is of a 2-hour fire rating or less.

Are there design alternatives or trade-offs the city could approve through a standard appeal that would allow the use of non-treated wood in lieu of fire treated wood in these assemblies?

This issue includes the condition in which the provisions of section 509.2 are utilized to construct a 5 story, Type III building above a 1 story, Type I-A building.

Answer:

In lieu of using fire treated wood, the Bureau of Development Services will grant the following options through an administrative appeal. Use of these options is restricted to buildings of Type III-A or III-B construction in R-2 occupancies.

Option A:

Option A:

- Exterior bearing walls to be at least two-hour rated assemblies, based on exposure from both sides (no treated wood required).
- Exterior non-bearing walls to be at least 1-hour rated, based on exposure from both sides (no treated wood required).
- Egress window in each bedroom.
- One-hour rated construction separating dwelling units (vertical and horizontal assemblies)

Option B:

- Exterior bearing walls to be two-hour rated assemblies, based on exposure from inside only (no treated wood required). Assembly may be either a tested assembly, or submitted with a Fire Protection Engineer's report.
- Exterior non-bearing walls to be at least 1-hour rated, based on exposure from one side (no treated wood required). Assembly may be either a tested assembly, or submitted with a Fire Protection Engineer's report.
- Selective Smoke Detection Coverage installed per NFPA 72, National Fire Alarm Code. Coverage shall be provided in the path of egress in and from the Type III portion of the building continuing to the exit discharge.
- Egress window in each bedroom
- One-hour rated construction separating dwelling units (vertical and horizontal assemblies)
- The base allowable building area specified in Table 503 for Type IIIA and IIIB (R2) is reduced to 12,000 square feet. Area increases per section 506 are allowed.

Seattle

- Regulated under Seattle Building Code (SBC)
  - Amended version of Washington State Building Code (formerly based on UBC, now based on IBC)

Seattle

- Provisions applicable to five-story wood frame buildings are “embedded” within the SBC
  - Type V-A Construction: Highest floor level shall be located not more than 75 feet above the lowest level of fire department access
  - R-2 Occupancy: Base allowable height = 4 stories / 50 feet
  - If building equipped with NFPA 13 sprinkler system, then allowable height increases 20 feet and one additional story is allowed, thus **5 stories / 70 feet** is the limit

KEY ISSUES

Key Issues

- Fire Safety
- Structure
- Building Enclosure

Fire Safety

- Fire-Rated Assemblies
  - Consistency of as-designed assemblies with referenced listings
- Detailing
  - Continuity of rating through assembly intersections

Fire Safety

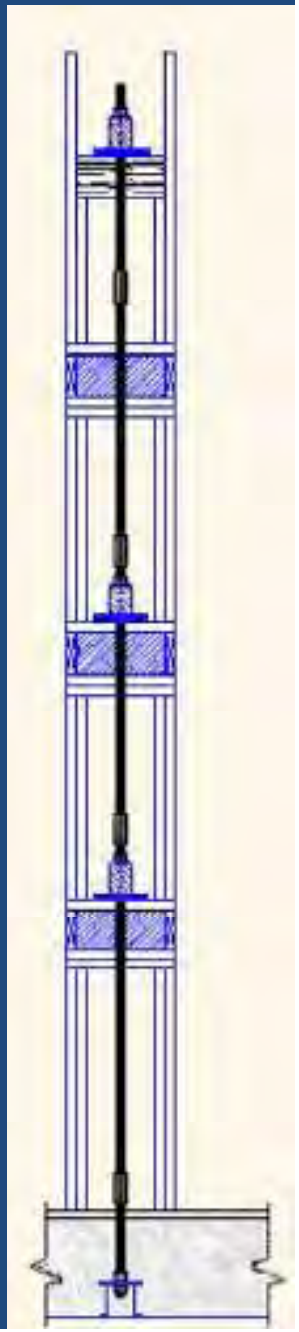
- Materials
  - Proprietary listings vs. generic listings
  - Type X vs. Type C gypsum board
  - Moisture tolerant gypsum products (for “pre-rock” applications)
  - FRT wood materials
- Construction Quality Control
  - Inspection of installed assemblies & details
  - Spot checks for materials, fastener type & spacing, blocking, etc. - compliant with assemblies / listings and details

Structure

- Increased Structural Loads
  - Increased gravity loads
  - Increased lateral loads
- Advanced Framing

Structure

- Wood Frame Shrinkage
  - Shrinkage information provided in Structural General Notes (or in “Shrinkage Schedule”)
  - Continuous rod hold-downs with shrinkage-compensating devices are needed
  - AVOID hybrid structures if at all possible! (i.e. mixing multi-story steel moment frames or CMU elevator cores with wood frame)



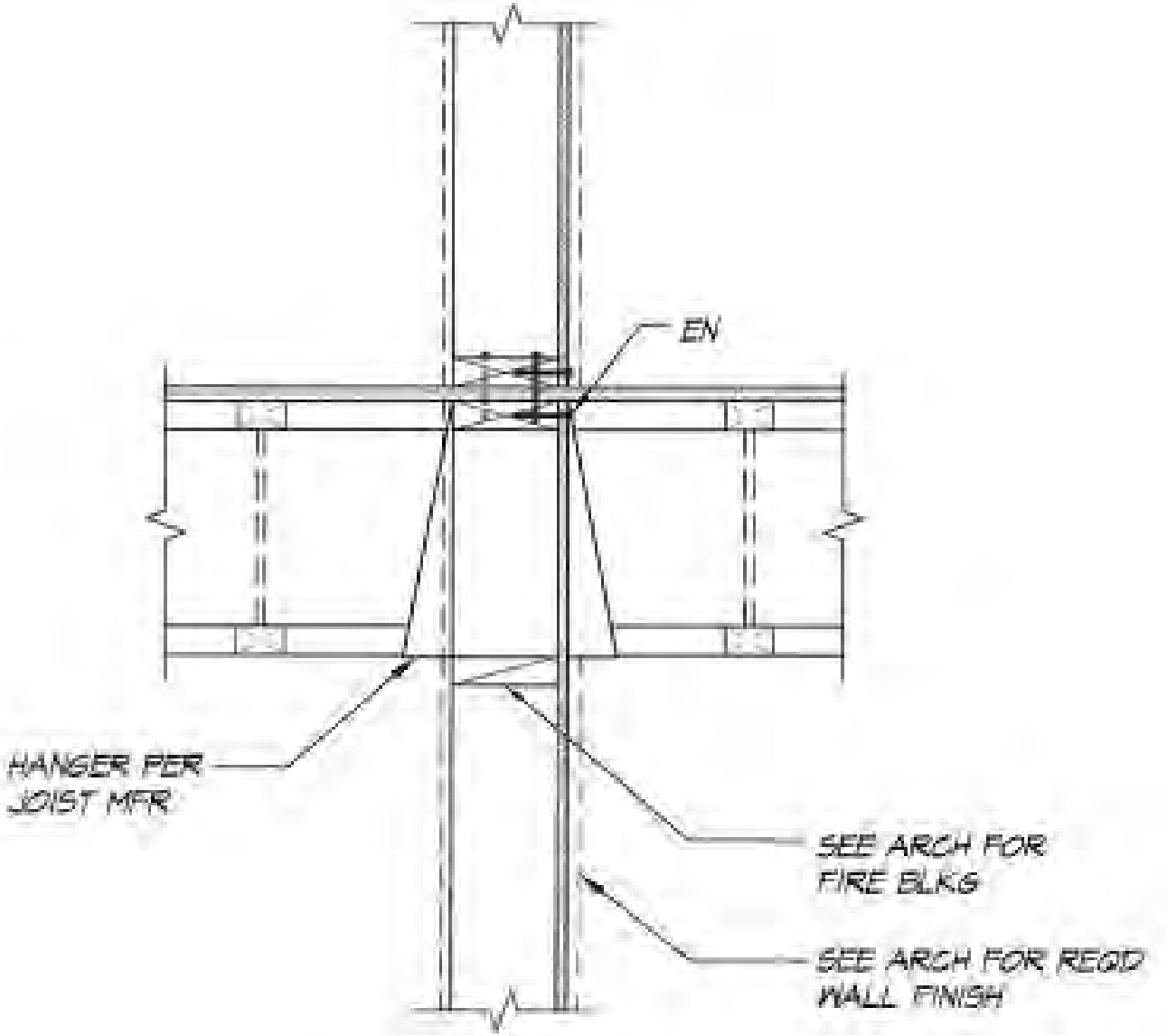

TROCAL

Structure

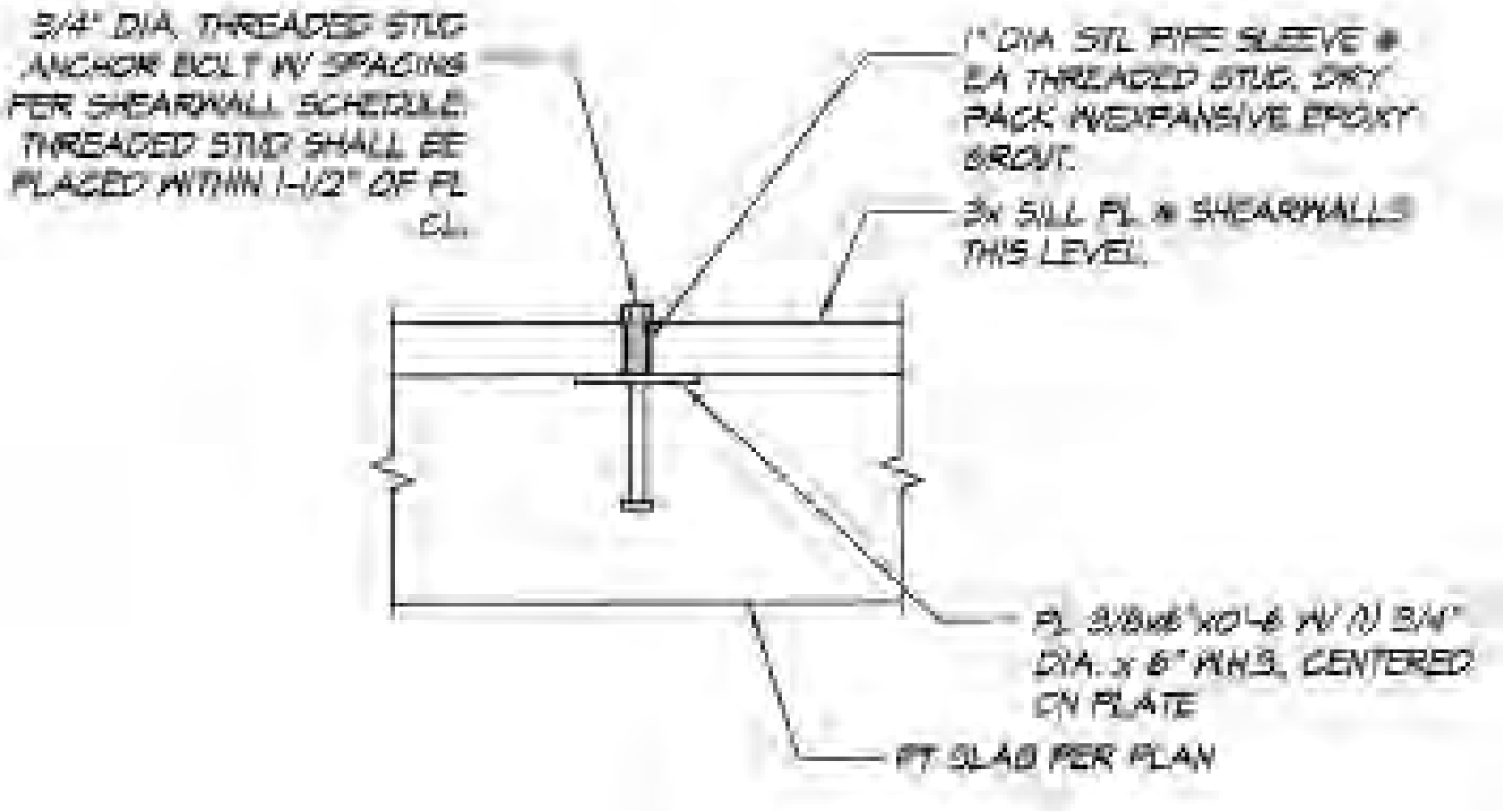
- Coordination of structural design with other systems
  - Cladding
  - MEP

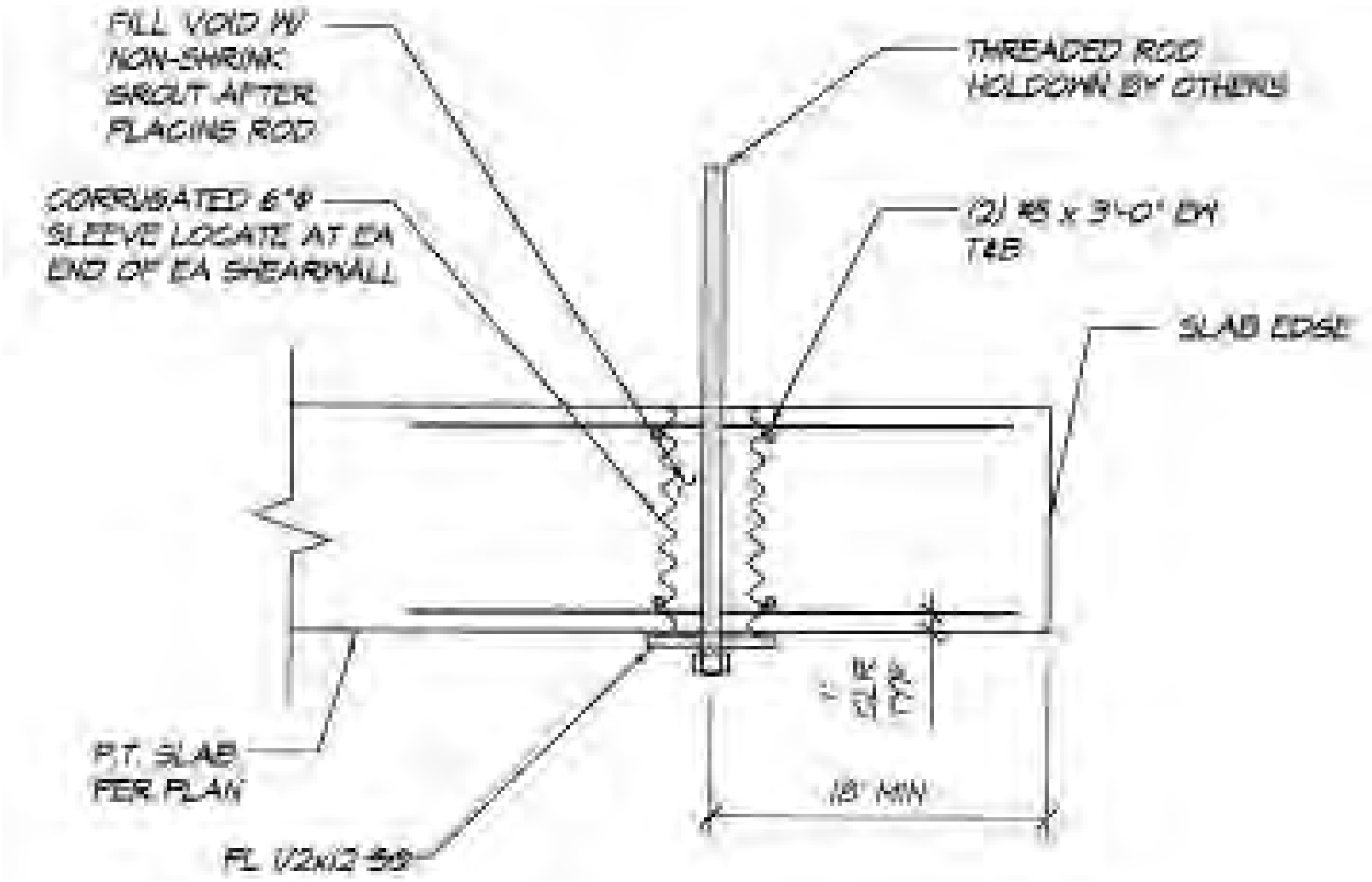
Structure

- Detailing
  - “Modified” platform framing
  - Anchorage details



BALLOON-FRAMED


3/4" DIA. THREADED STUD ANCHOR BOLT W/ SPACING PER SHEARWALL SCHEDULE. THREADED STUD SHALL BE PLACED WITHIN 1-1/2" OF PL CL.
1" DIA. STL PIPE SLEEVE @ EA THREADED STUD. DRY PACK W/EXPANSIVE EPOXY GROUT.
3x SILL PL @ SHEARWALLS THIS LEVEL.
PL 3/8x6"xO'-6" W/ (1) 3/4" DIA. x 6" A.B.S. CENTERED ON PLATE
FT SLAB PER PLAN


FILL VOID W/
NON-SHRINK
GROUT AFTER
PLACING ROD
CORRUGATED 6"ø
SLEEVE LOCATE AT EA
END OF EA SHEARWALL
THREADED ROD
HOLDOWN BY OTHERS
(2) #5 x 3'-0" EW
T&B
SLAB EDGE
P.T. SLAB
PER PLAN
FL 1/2x12 SS
18" MIN

Structure

- Detailing
  - “Modified” platform framing
  - Anchorage details
- Materials
  - “Dry” materials for plates, headers, etc.
  - Engineered wood products
  - Fasteners in contact with treated wood products
  - Quality of treated wood materials questionable…

Structure

- Construction Phase QA/QC
  - Special inspection by independent agency
  - Observation by structural engineer of record

Enclosure

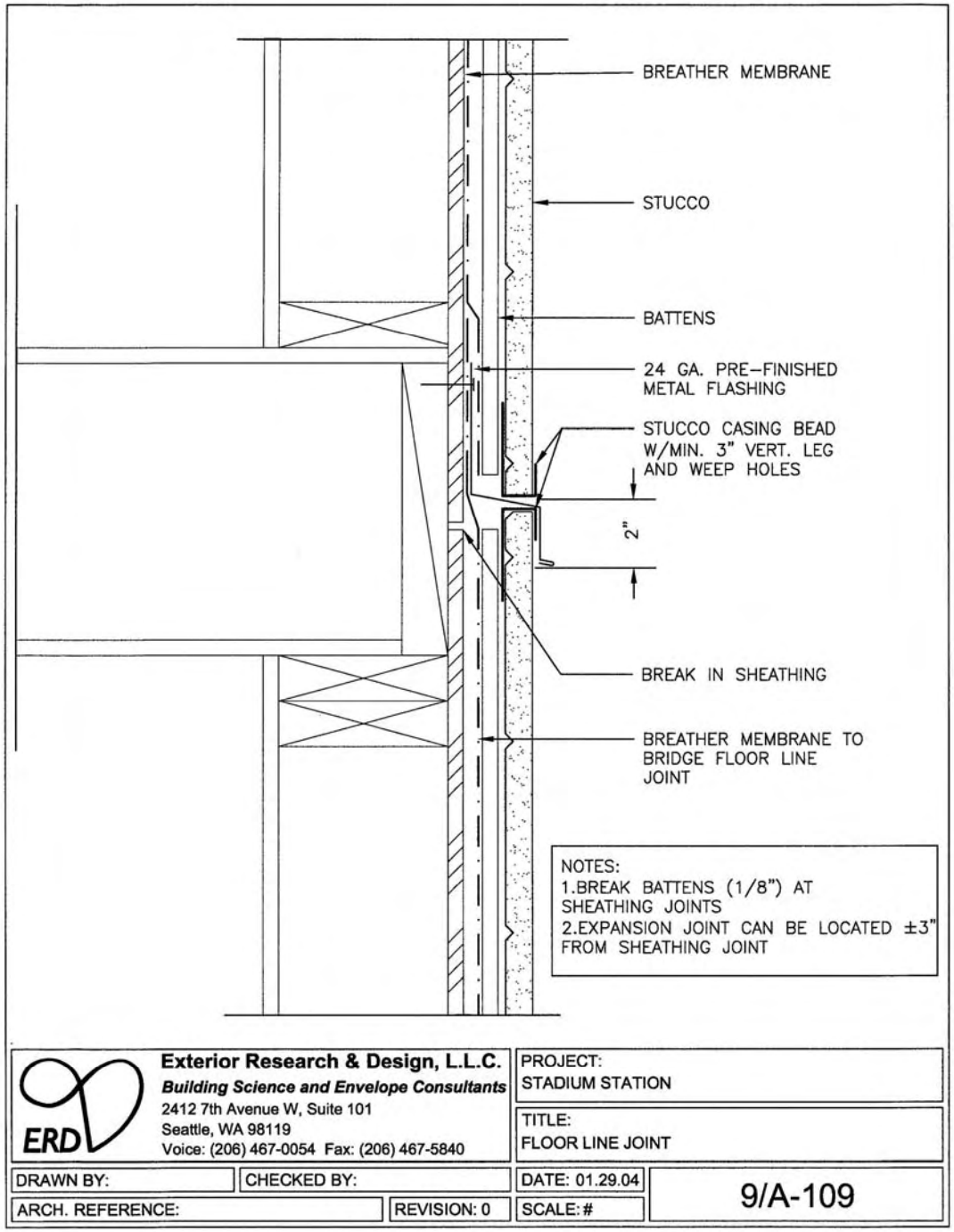
- Increased Environmental Loads
  - Increased wetting from rainwater
  - Increased pressurization from wind

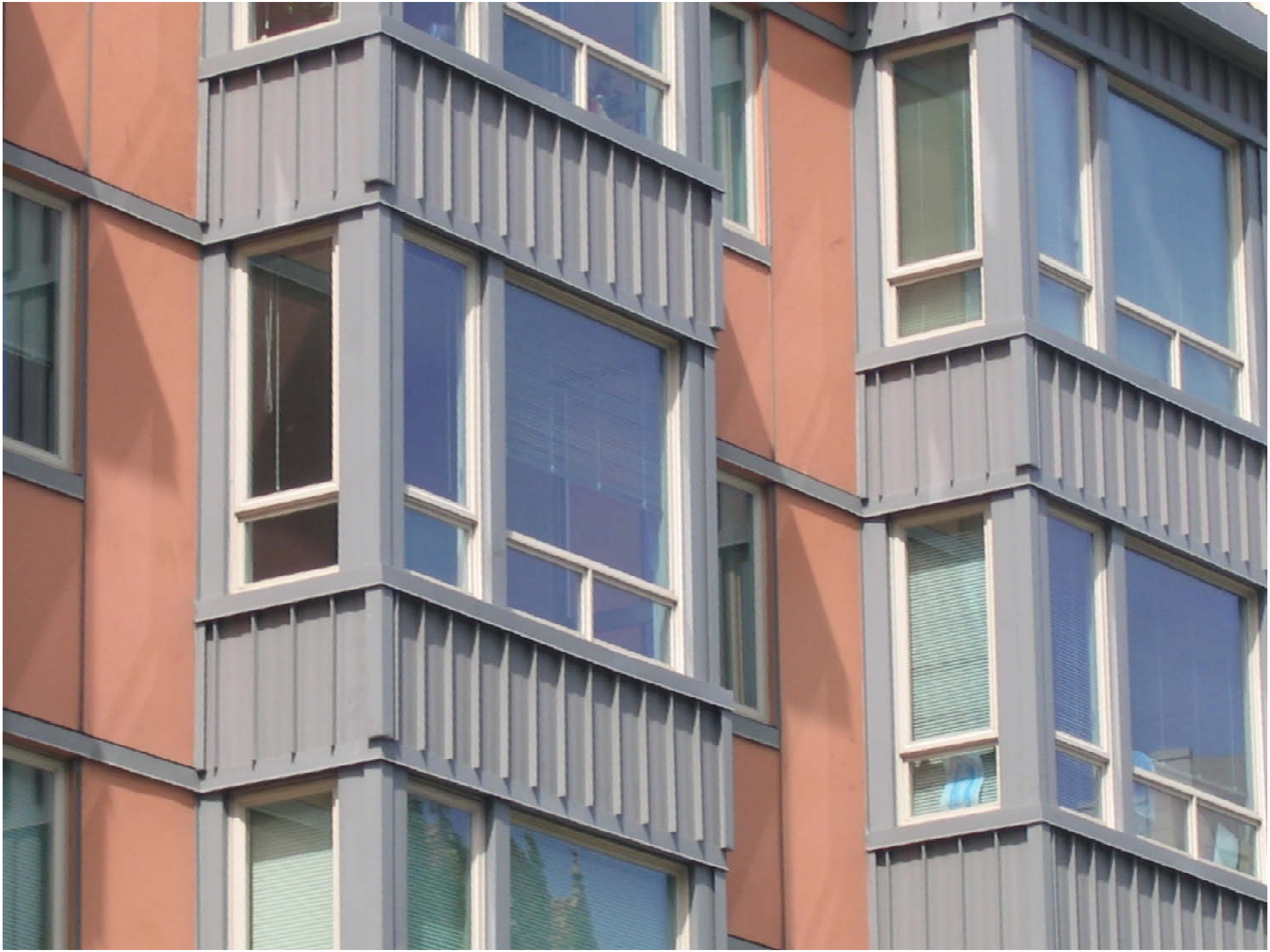
  - **Unquestionably this increase in loading demands more diligence in design, construction and maintenance of the building enclosure**

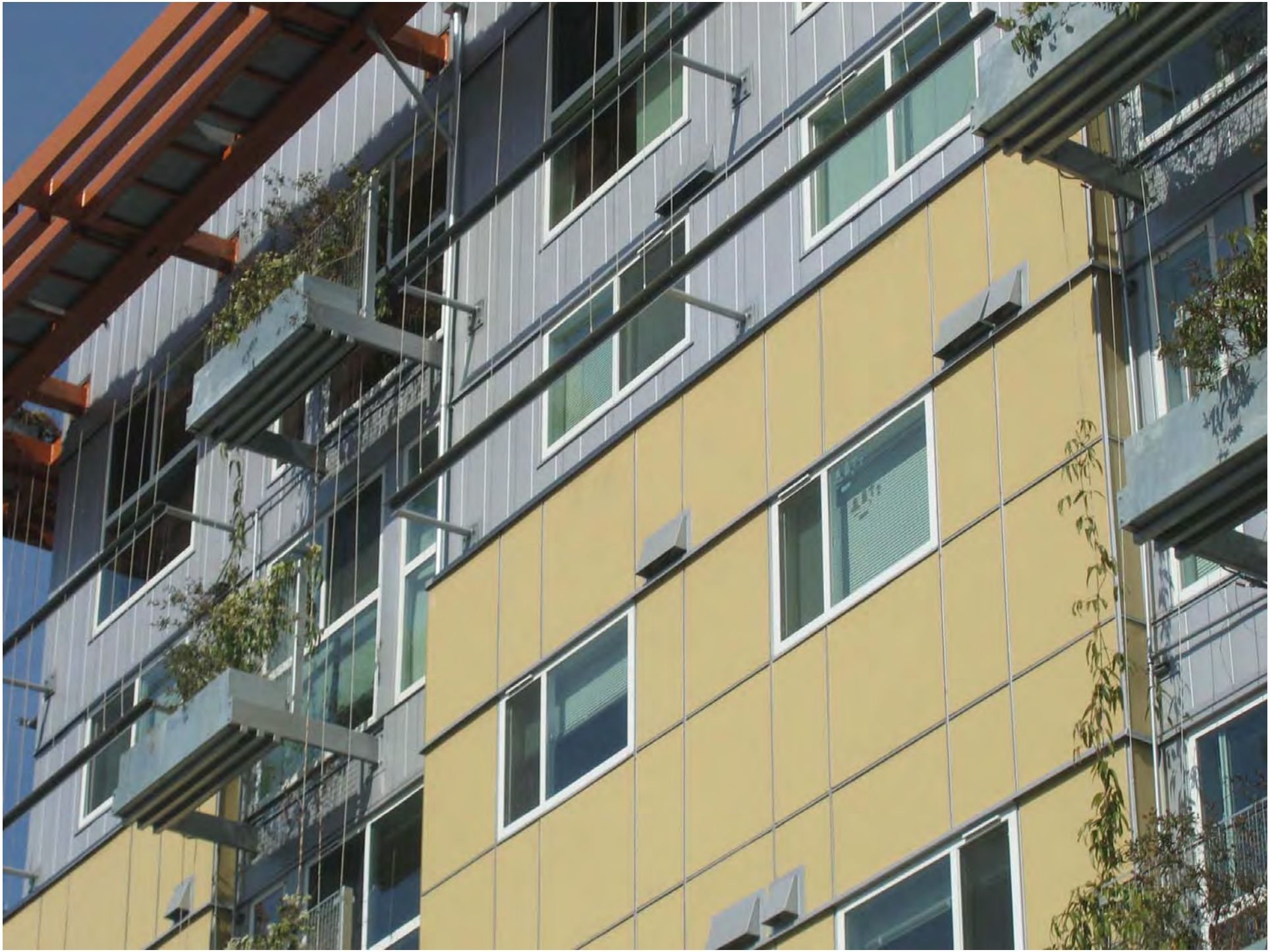
Enclosure

- Differential Movement
  - Frame shrinkage → interface with cladding system and other control layers
  - **Horizontal compartmentalization** is key strategy to manage movement

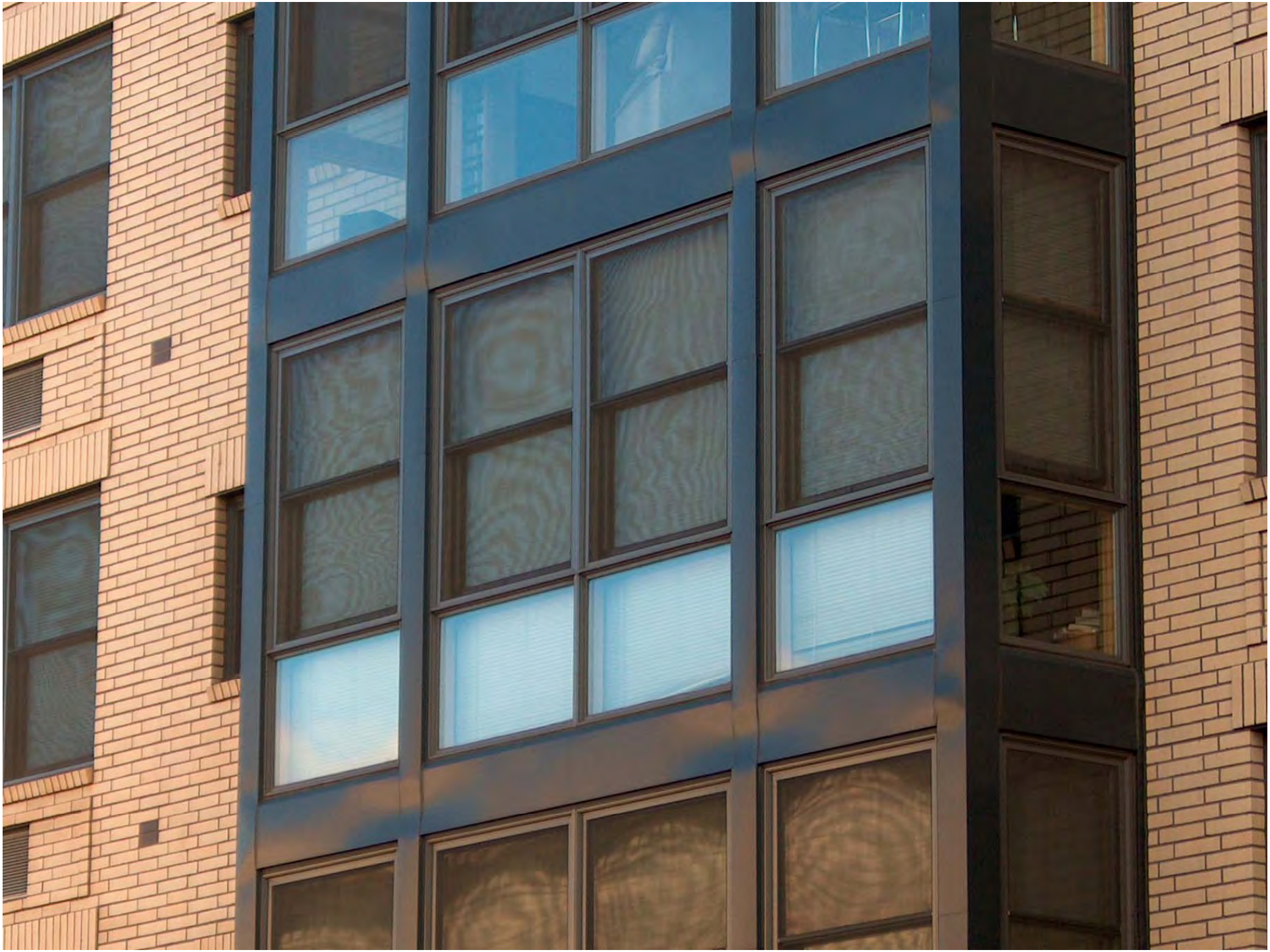
- Rain Penetration Control
  - Wall type selection → rainscreen / drained cavity
  - **Horizontal compartmentalization** is key strategy to manage moisture (wetting and drying)


BREATHER MEMBRANE
STUCCO
BATTENS
24 GA. PRE–FINISHED METAL FLASHING
STUCCO CASING BEAD W/MIN. 3" VERT. LEG AND WEEP HOLES
2"
BREAK IN SHEATHING
BREATHER MEMBRANE TO BRIDGE FLOOR LINE JOINT
NOTES:
1.BREAK BATTENS (1/8") AT SHEATHING JOINTS
2.EXPANSION JOINT CAN BE LOCATED ±3" FROM SHEATHING JOINT
ERD
Exterior Research & Design, L.L.C.
Building Science and Envelope Consultants
2412 7th Avenue W, Suite 101
Seattle, WA 98119
Voice: (206) 467-0054 Fax: (206) 467-5840
PROJECT:
STADIUM STATION
TITLE:
FLOOR LINE JOINT
DRAWN BY:
CHECKED BY:
DATE: 01.29.04
ARCH. REFERENCE:
REVISION: 0
SCALE: #
9/A-109






T&T GROCERY
ORIENTAL FOOD & GIFTS
ORIENTAL FOOD & GIFTS
ATM
Marlboro
4.25
SW JEFFERSON




BUILDING
1

Enclosure

- Rain Penetration Control
  - Wall type selection → rainscreen / drained cavity
  - Horizontal compartmentalization

- Windows
  - Performance ratings (structural, water, air)
  - Size and configuration
  - Type and material
  - Maintainability (glazing seals, interior glazing stops, etc.)

Enclosure

- Roofs
  - Roof tie-offs / access points to facilitate exterior wall maintenance
  - Green roofs becoming more commonplace:
    Significant additional structural and moisture loads to consider and manage!

Enclosure

- Construction Phase QA/QC
  - Coordination of the Work
  - Mockups
  - Inspection of installed assemblies & details
  - Field testing


Tyvek
COMMERCIALWRAP
DUPONT


Tyvek


Tyvek
COMMERCIAL WRAP
DUPONT
WaterBlock
Quality Windows


Tyvek
COMMERCIAL WRAP

CASE STUDIES