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APPEAL SUMMARY

Status: Decision Rendered

Appeal ID: 14936	**Project Address:** 909 SE 12th Ave
Hearing Date: 4/12/17	**Appellant Name:** Charles Kidwell
Case No.: B-006	**Appellant Phone:** 503-228-2840
Appeal Type: Building	**Plans Examiner/Inspector:** Brian McCall
Project Type: commercial	**Stories:** 7 **Occupancy:** M, R-2, S-2 **Construction Type:** I-A, III-A
Building/Business Name:	**Fire Sprinklers:** Yes - throughout
Appeal Involves: Erection of a new structure	**LUR or Permit Application No.:** 16-228563-LU
Plan Submitted Option: mail [File 1]	**Proposed use:** mult-family residence

APPEAL INFORMATION SHEET

Appeal item 1

Code Section	OSSC Sections 602.3 Type III
Requires	Type III construction is that type of construction in which the exterior walls are of noncombustible materials and the interior building elements are of any material permitted by this code. Fire-retardant treated wood framing complying with Section 2303.2 shall be permitted within exterior wall assemblies of a 2-hour rating or less. Requires: For Type IIIA buildings, OSSC 602.3 requires that exterior walls be of noncombustible construction or of Fire Retardant Treated Wood (FRTW) construction. Reference Information: The proposed project consists of a 5 Story Type IIIB Construction Residential building above a 2 Level 'Building Podium' comprised of two separate, one level Type IA Construction buildings stacked vertically. Podium level 1 contains Retail Commercial, Management & Residential occupancies. This building configuration was Granted by Appeal ID #13622, Case B-009 dated 6/22/2016.
Proposed Design	A. We request the use of regular wood stud framing with the stud cavity filled with mineral wool batt insulation instead of the Fire Retardant Treatment (FRT). The proposed four (4) wall assemblies addressed by this appeal are included in the appendix section of the attached white paper prepared by an Oregon Fire Protection Engineer. B. In addition to the above proposal the project will also satisfy the following conditions: Exterior bearing walls shall be protected based on their fire separation distance as defined in the OSSC as follows:

	a. Less than 10 feet: Protected on the inside with at least two layers of 5/8" minimum fire rated gypsum board. Protected on the outside with at least two layers of fire-rated gypsum sheathing or one layer of fire-rated gypsum sheathing and one layer of 5/8" minimum fire retardant-treated plywood. Alternatively, exterior bearing walls may be protected for fire exposure from both sides with a two-hour fire resistance tested assembly. b. Equal to or greater than 10 feet: Protected on the inside with at least two layers of 5/8" minimum fire-rated gypsum board. Protected on the outside with at least one layer of 5/8" minimum fire-rated gypsum sheathing. Exterior non-bearing walls shall be protected on the inside and outside with at least one layer of 5/8" minimum fire-rated gypsum board or gypsum sheathing. Non-fire-retardant-treated wood framing within exterior walls must be enclosed by gypsum board or gypsum sheathing, except where specifically noted. All openings in exterior walls for doors, windows or wall-mounted HVAC units and louvers must be protected with a sacrificial stud at the sides and top of the opening. The sacrificial stud may not be used to support a structural vertical load. All exterior wall coverings shall be of non-combustible material. Combustible roof sheathing and framing shall be protected from exposure to fire from above with gypsum-based products, fire-retardant-treated wood sheathing or similar UL tested products installed above or below the roofing membrane and/or rigid insulation. Selective smoke detection coverage shall be installed in the Type Ill portion of the building per NFPA 72, National Fire Alarm Code, beginning at the access point to the path of egress and continuing until reaching all exits. If the exit passes through a lobby or other intervening space, selective smoke detection coverage requirements shall be extended to such spaces until reaching the exit discharge. At least one operable exterior window shall be provided in each dwelling unit with a minimum opening width of 3-1/2 inches. Walls and floor assemblies separating dwelling units shall have tested fire resistance ratings of not less than 1-hour. 1he base allowable building area specified in the OSSC for R occupancies in Types Ill-A and 111-B construction shall not exceed 12,000 square feet. Area increases in accordance with the OSSC are allowed. All required egress stairs shall include access to the roof. Such access may be via any method listed in OSSC Chapter 10 for roof access. All penetrations through the exterior wall covering shall be fire-stopped at the exterior sheathing. "Penetrations" for purposes of this Guide includes elements such as conduits and piping and does not include "openings" such as doors, windows or wall-mounted HVAC units and louvers. Ducts and vents penetrating exterior walls shall be 26 gage minimum. No unprotected penetrations are permitted through the underside of fire-rated exterior wall projections that are required to be rated, including cornices, eaves, bays, exterior balconies, and similar projections extending beyond the exterior wall. Elevator hoistways opening directly into corridors shall be pressurized or have smoke tight protection as required for doors opening into fire-resistive corridors. Framing at walls, floors, ceilings and roofs must be constructed as specified in the graphic detail drawings numbered O - 19 contained in the City of Portland Code Guide OSSC/6/#4, unless greater fire resistance is provided. Conditions not covered in the guide must be constructed in accord1rnce with the OSSC.
Reason for alternative	The attached white paper provides the fire analysis that supports the use of mineral wool (aka Rock Wool) insulation in the wall cavity of untreated wood stud framing as an alternate to FRT wood stud framing permitted by the OSSC section 602.3. The analysis is based on published temperature data from full scale testing of multiple configurations of fire rated stud walls. The assemblies tested included 1 hour and 2 hour rated

assemblies, with and without insulation, insulations included fiberglass and Rock wool types. The analysis incorporates test data with the fire science fundamentals of gypsum calcification, pyrolysis of wood, and thermal conductivity of materials, accepted by the Society of Fire Protection Engineers, The National Bureau of Standards, and the American Wood Council. These are the accepted industry standards for this type of analysis.

The appeal includes 16 additional conditions requested by the City of Portland. The equivalency analysis included in the white paper is a straight comparison between untreated wood and FRT wood framed wall assemblies, without any benefit from these additional conditions. The analysis documented in the attached white paper concludes that untreated wood framed walls with mineral wool insulation will outperform FRT wood framed walls without such insulation.

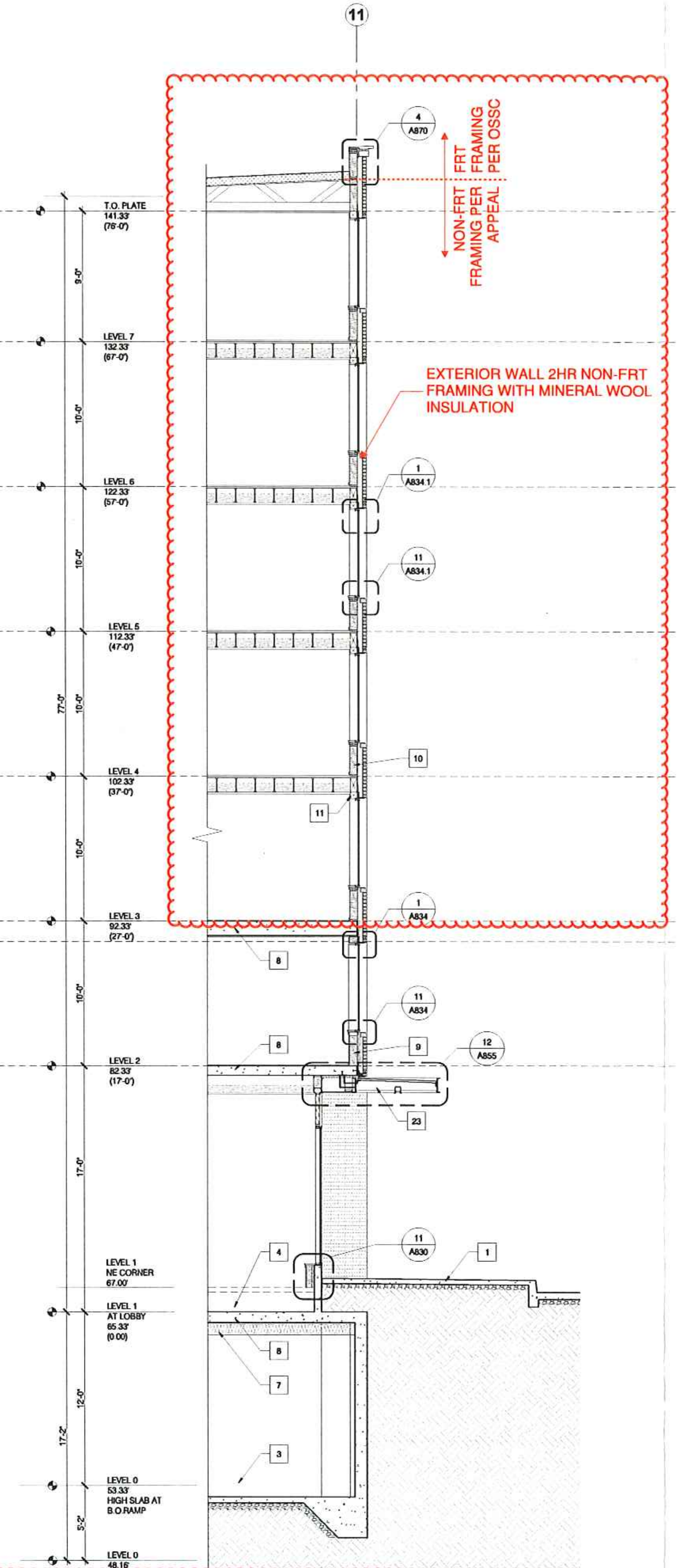
Therefore, we are very confident that the performance of mineral wool filled wood stud framed walls with these 16 additional conditions will far exceed the code intent of FRT wood framing. Hence, we urge you to approve this appeal request.

APPEAL DECISION

Use of non-fire resistant treated wood studs in Type IIIA construction: Denied. Insufficient test data to demonstrate equivalent protection. Appellant may contact Terry Whitehill (503-823-7639) with questions.

Pursuant to City Code Chapter 24.10, you may appeal this decision to the Building Code Board of Appeal within 180 calendar days of the date this decision is published. For information on the appeals process and costs, including forms, appeal fee, payment methods and fee waivers, go to www.portlandoregon.gov/bds/appealsinfo, call (503) 823-7300 or come in to the Development Services Center.

1/A621 ENLARGED ELEVATION
SCALE: 1/4" = 1'-0"



2/A621 WALL SECTION — TYPICAL WALL SECTION AT WOOD FRAMING
SCALE: 1/4" = 1'-0"

WALL SECTION GENERAL NOTES

NOTE: NOT ALL KEYNOTES ARE USED PER SHEET

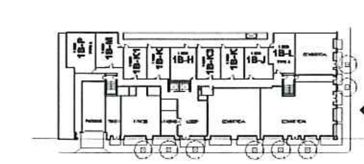
1. FLOOR TO FLOOR DIMENSIONS ARE TO TOP OF FLOOR SHEATHING, U.N.O.
2. WALL, FLOOR, CEILING, ROOF ASSEMBLY TYPES ARE REFERENCED ON WALL SECTIONS - SEE SHEETS A801-803 FOR ASSEMBLY TYPES
3. SIM. DESIGNATES THE DETAIL BEING REFERENCED IS MIRRORED

MATERIAL KEYNOTE LEGEND

- M1 BRICK, RUNNING BOND
- M2 FIBER CEMENT PANEL
- M3 STEEL CHANNEL
- M4 CMU BLOCK, SEALED
- M5 PORCELAIN PANEL
- M6 SMOOTH CONCRETE
- M7 ALUMINUM BOLT ON BALCONY SYSTEM - SEE KEYNOTE 20
- M8 ALUMINUM RAILING SYSTEM WITH GLASS INFILL PANELS - SEE KEYNOTE 18
- M9 INTEGRAL METAL VENT LOUVER
- M10 STOREFRONT GLAZING SYSTEM, TRANSPARENT AND TRANSLUCENT GLASS, SEE SCHEDULE
- M11 COMMERCIAL GRADE VINYL WINDOWS
- M12 STEEL CANOPY - SEE KEYNOTE 23
- M13 CLADDING/TRIM INFILL - SEE KEYNOTE 14
- M14 SHEET METAL COPING

WALL SECTION KEY NOTES

1. CONCRETE SLAB ON GRADE - SEE CIVIL DRAWINGS
2. HIGH SPEED COILING GRILLE PER DOOR SCHEDULE
3. SLAB ON GRADE WITH INTEGRAL FOOTING - COORDINATE SLAB SUBSTRATE AND SURFACE PREPARATION WITH STRUCTURAL
4. FOAM INSULATION BETWEEN SLABS
5. PEDESTAL PAVERS ON DECK - SEE DETAILS FOR WATERPROOFING
6. WOOD FENCE. SEE DETAIL 16/A831 AND LANDSCAPE DRAWINGS
7. UNDER SLAB INSULATION - REFER TO REFLECTED CEILING PLANS FOR EXTENT OF INSULATION WHERE APPLICABLE. INSULATION TYPE AND R-VALUE IS REFERENCED IN SPECIFICATION SECTION 07210 'SCHEDULE OF INSULATION VALUES'. ALSO SEE DETAIL 5/A866
8. ELEVATED PT SLAB - SEE STRUCTURAL DRAWINGS
9. LT GAUGE STEEL FRAMING - REFER TO STRUCTURAL STUD SCHEDULE AND ARCHITECTURAL WALL TYPES SHEETS A801-A802 FOR STUD SIZE AND DETAILS
10. WOOD FRAMING - REFER TO CONSTRUCTION ASSEMBLIES FOR DETAILS
11. HEADER - REFER TO HDR SCHEDULE BY STRUCTURAL FOR HEADER SIZE. B.O. HDR ELEV PER DOOR / SCHEDULE
12. LINE OF BUILDING BEYOND OR BUILDING SHOWN IN ELEVATION BEYOND
13. PILASTER - SEE4/A826
14. CLADDING / TRIM BETWEEN WINDOWS - COLOR PER ARCHITECT
15. THROUGH WALL FLASHING - SEE DETAILS ____
16. PRIVACY SCREEN
17. EXTERIOR GUARDRAIL WITH GLASS PANELS
18. EXTERIOR GUARDRAIL WITH HORIZONTAL METAL RAILING AND MESH PANELS
19. CUSTOM GRILL COVER AT THROUGH WALL PTAC UNIT (PACKAGED TERMINAL AIR CONDITIONER)
20. PREFABRICATED DECKS
21. EXTERIOR UNIT VENT
22. LIGHT FIXTURE PER SCHEDULE. SEE ELECTRICAL SHEETS
23. STEEL CANOPY
24. PLANTER - SEE LANDSCAPE
25. BBQ - SEE LANDSCAPE
26. FDC LOCATION - SEE SHEET 19/A830
27. HORIZONTAL CONTROL JOINT
28. VERTICAL CONTROL JOINT



KEY PLAN LEVEL 1

Leeb Architects
308 SW First Avenue
Suite 200
Portland Or 97204
Phone 503.228.2840
Fax 503.228.2907
leebarc.com

Project Title: MODERA BUCKMAN APARTMENTS
MILL CREEK RESIDENTIAL
220 NW 2ND AVENUE SUITE 900
PORTLAND, OR 97209

Drawing Title: WALL SECTION
Date: 02/17/2017
Scale: 1/4" = 1'-0"
Drawn By: JBJ, RI, JML
Project No: A16-16
Revision:

A 621

CODE UNLIMITED, LLC

White Paper - Fire Analysis of Fire Retardant Treated Wood Alternate

Prepared by: Code Unlimited

Address: 12655 SW Center Street, Suite 350, Beaverton, OR 97005

Date: 4/7/2017

Table of Contents

1. OVERVIEW

1.1 Project Overview

Leeb Architecture is designing the Modera Buckman building in Portland, Oregon. It is a seven story building that consists of five stories of Type IIIA construction placed on top of two stories of Type IA construction for parking (per previous appeal 13622). This is permitted by the Oregon Structural specialty Codes when separated by a 3 hour horizontal separation and other restrictions. The building is fully protected by automatic sprinklers, fire and smoke detection and a fire alarm system.

Type IIIA construction requires that exterior walls be of noncombustible construction or of Fire Retardant Treated Wood (FRTW) construction. The project proposes to use wood without the Fire Retardant Treatment (FRT). There are structural and environmental benefits for this approach.

1.2 Executive Summary

Fire-retardant treated (FRT) wood framing is permitted by code within exterior Type III wall assemblies with a fire-resistance rating of a 2 hours or less. This is based on the improved fire performance of such wood compared to regular wood of same species. FRT of wood delays ignition and resists "flame spread" once ignited. The proposed design uses tightly packed rock wool insulation between non-treated wood framing members in lieu of Fire Retardant Treated Wood (FRTW) to achieve equal or better fire performance.

Over the last several months Code Unlimited has analyzed this particular issue, namely the use of non-FRT wood in place of FRTW on multiple projects. This has been driven by many stakeholders within the Pacific Northwest region; local and state governments, universities and other research groups, manufacturers, real estate developers, and design and construction industry professionals. This white paper is the most current knowledge on this subject, based on rigorous analysis, review, and input, from senior fire protection engineers and code experts within our company.

The white paper is structured to give the reader a detailed understanding of the code regulations that are driving this requirement along with excerpts from the International Building Code (IBC) commentary to clarify intent where necessary. We also provide other code citations where prescriptively the Oregon Structural Specialty Code (OSSC) and the IBC permits the use of rock wool (aka mineral wool) as a means to delay ignition or fire and flame migration. This is provided as documentation of established tradition. Many code provisions have evolved initially out of traditional construction practices and then undergo rigorous analysis and/or testing to substantiate its performance in those applications. This white paper follows that time tested path by including a rigorous performance analysis based on currently available test data in support of non-FRT wood in an exterior wall of a type IIIA construction building.

Our analysis found that the fire performance of a non-FRTW framed wall with rock wool insulation is equal or superior to a FRTW framed wall. We also found support for the argument that this approach reduces the potential for chemical exposure to the environment and to the occupants of these buildings compared to the current practice of using FRTW.

1.3 Applicable Codes and Standards

Applicable Code or Standard
2014 Oregon Structural Specialty Code (OSSC)
2009 ASTME-84 Test Methods for Surface Burning characteristics of Building Materials – American Society for Testing and Materials
2007 ASTME E-119 standard Test Methods for Fire Tests of Building Construction and Materials – American Society for Testing and Materials

1.4 Additional References

[1] 2003 Ignition Handbook: Principles and Applications to Fire Safety Engineering, Fire Investigation, Risk Management and Forensic Science, Dr. Vytenis Babrauskas - Fire Science Publishers

[2] 2006 Performance of a Non-load Bearing Steel Stud Gypsum Board Wall Assembly: Experiments and Modelling, Samuel Manzello, Richard Gann, Scott Kukuck, Kuldeep Prasad, and Walter Jones - Building and Fire Research Laboratory (BFRL), National Institute of Standards and Technology (NIST), Weapons and Materials Research Directorate, US Army Research Laboratory, APG.

[3] 2007 Analysis of Inter-laboratory Testing of Non-loadbearing Gypsum/Steel-Stud Wall Assemblies, William Grosshandler, Samuel L. Manzello, Alexander Maranghides - Building and Fire Research Laboratory, Tensei Mizukami - Center for Better Living

[4] 1977 Effect of fire-retardant treatments on performance properties of wood. In: Goldstein, I.S., ed. Wood technology: Chemical aspects. Proceedings, ACS symposium Series 43. Washington, DC: American Chemical Society.

[5] 1992 Charring Rate of Wood for ASTM E119 Exposure, Fire Technology Volume 28, Number 1, Robert H. White and Eric V. Nordheim

[6] 1977 National Board of Standards Technical Note 945: An Investigation of the Fire Environment in the ASTM E 84 Tunnel Test

[7] 2007 Performance of a non-load-bearing steel stud gypsum board wall assembly: Experiments and modelling", Samuel L. Manzello, et al, Fire and Materials (Issue 31, pp 297-310) (this is an updated version of reference #2 above)

[8] 2016 Calculating the Fire Resistance of Exposed Wood Members, Technical Report No 10, American Forest & Paper Association, Inc, American Wood Council, 1111 19th St., NW, Suite 800, Washington, DC 20036

[9] 2015 A Model for predicting heat transfer through insulated steel-stud wall assemblies exposed to fire, Sultan, M. A.; Alfawakhiri, F.; Bénichou, N., Fire and Materials - 2001 International Conference, San Francisco, January 22-24, 2001, pp. 495-506

[10] 2010 Wood Handbook, Wood as an Engineering Material, Chapter 17 Fire Safety, Robert H. White and Mark A. Dietenberger, Forest Product Laboratory, United States Department of Agriculture Forest Service, Madison Wisconsin

2. PROPOSED WALL ASSEMBLY

The proposed design is to provide a 2-hour exterior wall assembly that consists of untreated wood stud framing with two layers of 5/8" thick type X gypsum board on the interior and one or two layers (depending on wall type) of 5/8" type X gypsum sheathing on the exterior side of the wall. Rock wool insulation will be friction fit between studs to fill the entire 6 inch nominal wall cavity. Details of the proposed wall sections are in the attached Appendix A. The conclusions of this report are limited to the proposed Wall types W-22 and W-24 included in Appendix A of this white paper.

3. ROCK WOOL USE PRESCRIPTIVELY PERMITTED IN CURRENT CODES

The 2014 OSSC section 602.3 for Type III, exterior wall construction, permits the use of fire retardant treated wood (FRTW) in lieu of non-combustible materials.

Rock wool barriers have been allowed in the codes as a means to retard or prevent the ignition of wood in concealed spaces, for some time now:

1. OSSC 803.11.1.1 allows untreated wood to be used for furred walls or ceilings where Non-Combustible construction is required when the cavity is filled with rock wool insulation.
2. OSSC 718.2.1(7) allows rock wool batts to be used as fireblocking to cut off concealed draft openings.
3. OSSC 718.3.1 permits the use of rock wool batts as an approved draft stopping material.
4. ORSC 316.5.3 permits the use of 1.5 inch thick rock wool to satisfy the requirements for an ignition barrier.
5. NFPA 13 section 8.15.1.2.17 allows untreated wood joist to be treated as FRT wood when the cavity is filled with rock wool insulation.
6. OSSC 722.6 contains procedures by which the fire resistance ratings of wood assemblies are established by calculations.

IBC Section 722.6 Commentary states:

"Rock wool insulation provides additional protection to wood studs by shielding the studs from exposure to the furnace, thus delaying the time of collapse."

OSSC table 722.6.2(5) allows glass fiber, or rock wool, or cellulosic fill within stud cavity prescriptively to increase the fire resistance of a wall assembly by 15 minutes.

7. IBC Section 602.2 Commentary:

"Fire Retardant-treated wood (FRTW), although combustible, is permitted in limited uses in building of Type I and Type II construction... it is not assumed to be fire-resistance rated, and generally does not afford any higher fire-resistance rating than untreated wood material."

4. PERFORMANCE BASED ANAYSIS AND VERIFICATION

The list of prescriptive provisions in section 3 establishes the code history use of mineral wool insulation to improve the fire performance of wood wall and ceiling assemblies. These provisions are an outgrowth of tradition and historical construction practice. The values assigned to these are generic values, based on historical data. These are valuable in establishing precedence and intent of the code requirements. Our analysis is based on the full scale test data documented in the research papers #2, #7, and #9 listed in section 1.4 in this white paper. The remaining references #1, #3, #4, #5, #6, #8, and #10, provide supporting evidence for the methodology used in this analysis as well as some other key metrics used in the analysis. The full scale testing was performed with 4 inch metal stud wall assemblies, while the wall assemblies analyzed in this white paper are nominal 6 inch wood assemblies. Wood is a non-conductor of heat and superior performer to metal within the context of this analysis. Our test data includes wall assemblies with both fiberglass and mineral wool insulation within the stud cavity. Mineral wool outperforms fiber glass insulation at higher temperatures. In these two cases as well as in all other cases, our analysis takes the conservative value when there are multiple data points available.

Building structural component fire performance is predicated on the type of fire exposure. Most commonly fire from combustible building contents or furnishings, expose the components such as walls of structural frame to heat from the fire, causing loss of structural integrity of the wall and its eventual collapse. The point at which the load-bearing components of a Type III wall (in this case, the wall studs) are exposed to heat from the fire, the building would have long since been evacuated and the space become untenable, as the temperature required to breach the gypsum board membrane would be beyond survivability. In this case, the sole concern is for the preservation of structural stability and protect firefighters and adjacent structures. The studs of the walls provide the necessary structural, load bearing capability to support the exterior wall. Gypsum board or other sheathing is solely relied on to provide resistance to the fire exposure in order to protect the load bearing members, its contribution to the structural strength of the wall is negligible. The Commentaries to section 722.6 of the IBC state "It is assumed that once the structural members fail, the entire assembly fails."

OSSC section 602.3 defines Type III construction as "that type of construction in which the exterior walls are of noncombustible materials and the interior building elements are of any material permitted by this code. *Fire-*

retardant-treated wood framing complying with Section 2303.2 shall be permitted within *exterior wall* assemblies of a 2-hour rating or less."

Fire retardant treatment of wood does not prevent the wood from decomposing and charring under fire exposure. The rate of fire penetration through treated wood approximates the rate through untreated wood. Fire-retardant-treated wood used in walls can slightly improve fire endurance of these walls, but, most of this improvement is associated with the reduction in surface flammability rather than any changes in charring rates

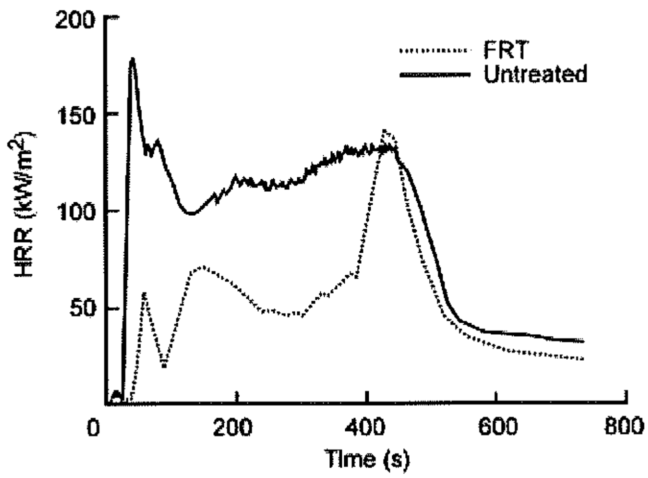


Figure 17–1. Heat release curves for untreated and FRT plywood exposed to 50-kW/m² radiance.

Fig.1. E84 Test Comparison (Wood Handbook Chapter 17)

The surface layer of FRTW is a fire retardant treatment that slows ignition by interfering with heat transfer to the material and chemically interferes with combustion. It does so by converting combustible gases and tars to carbon char at temperatures below 550°F[4,10] and releases carbon dioxide and water vapor which dilute the combustible gases. However, above temperatures of 550°F, outgassing and pyrolysis effects exceed the limits whereby ignition is interfered and FRT heat release and burning rates compare to untreated wood of the same variety. Charts of the ASTM E84 (Standard Test Method for Surface Burning Characteristics of Building Materials) heat release rates (Fig. 1) show that, at about 420 seconds (7 minutes), the heat releases rate (HRR) for FRTW and non-FRTW are virtually identical, indicating that, after the fire retardant treatment has been exhausted, the non-FRT and FRT wood studs will perform similarly.

Once the gypsum layers are compromised, the fire is free to attack the exposed studs. However, charring and consumption of the studs begins before failure of the gypsum membrane, as heat is conducted to the edge face of the studs and to the stud wall cavity by conduction through the gypsum board. In the stud wall cavity, the temperatures are already well over the autoignition temperature of wood and the point at which FRTW becomes ineffective (550°F) by the time the two gypsum board layers have been compromised. Although the standard stud begins charring sooner than the FRTW stud, total time to fail for the standard stud is much longer due to the insulative effects of the rock wool, slowing progressive char over the longer dimension (side) faces of the stud by preventing heat transfer to the stud cavity.

Above 550°F, FRTW studs behave similar to a standard wood studs and charring continues until it fails in load. Char rates for softwoods such as used in framing lumber are at an average rate of 1.5 in/hr [8]. By calculating the heated perimeter of the wood studs for an uninsulated, code-accepted FRTW stud and a rock-wool insulated standard stud, and using the average char rate, a time to failure of the two studs can be determined.

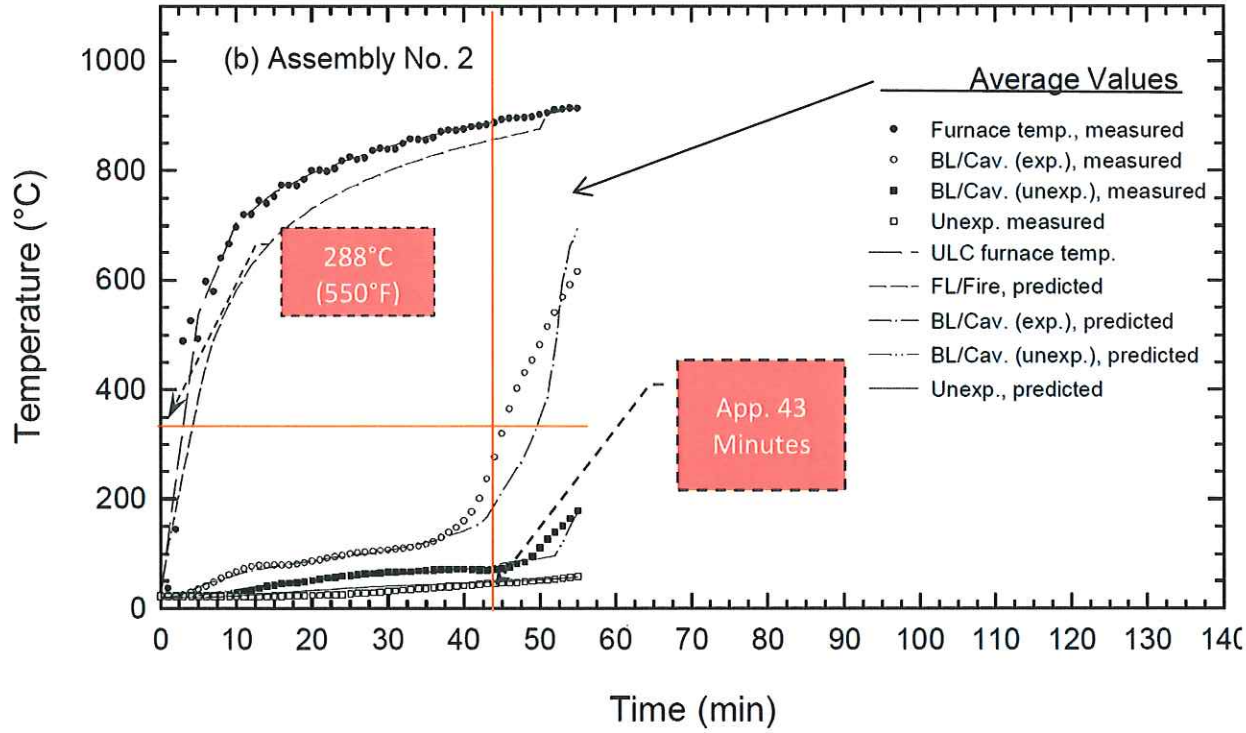
The effective heated perimeter of a 2" x 6" nominal FRTW stud is 12.5 inches at the point of its ignition. The effective heated perimeter of a rock wool insulated stud is only 1.5 inches at the same point, although the point of ignition is approximately 7 minutes earlier due to the effects of FRT and the delay of ignition of the FRTW stud. As the studs are consumed by charring, the 3-sided attack[8] on the FRTW stud results in much more material loss due to charring and more rapid reduction in load-bearing capability. While there is some charring of the sides of the standard stud, especially nearest the exposed edge, the insulative properties of the rock wool significantly slow charring and loss of material.

OSSC Table 722.6.2(2) states that the time assigned for contribution of the wood frame to fire resistance is 20 minutes. Within that time, the fire is assumed to consume sufficient of the stud framing to compromise its structural strength such that it fails under load. Thus it was assumed that, once the FRTW studs reach the point where the fire retardant treatment no longer interferes with charring, the stud will have 20 minutes of load-bearing capability before failure. This occurs with approximately 25% of the original stud cross-section remaining after charring. A similar failure point was used for analysis.

OSSC Table 722.6.2(5) notes that "Additional Protection" can be provided to a wall for fire rating purposes by the addition of rock wool insulation at a specified minimum density. The Commentaries for IBC section 722.6 note that "Rock wool insulation provides additional protection to wood studs by shielding the studs from exposure to the furnace, thus delaying the time of collapse." Rock wool does this by insulating the sides of the studs from direct heat and flame exposure and by interfering with flame spread by conduction, radiation and convection within the wall cavity. In this respect, the assembly is superior to FRTW with only fiberglass insulation, in that its ability to interfere with ignition is not compromised by high exposure temperatures. Rock wool has a melting point of 2150°F and can withstand a 4 hour test per ASTM E119 time-temperature curve, where the fire temperature reaches a maximum temperature of 2000°F, well above the temperatures expected in a flashover fire condition.

Unlike a simple, 2-hour rated FRTW stud wall, rock wool provides protection on the sides of the studs, ensuring the main route of burn-through to be in the longest dimension of the lumber (See Fig 4-6). In FRTW, fire attack, once the thermal membrane has been compromised, is on three sides of the stud and burn through of the stud is much more rapid. Use of rock wool insulation is specified as it has greater refractory qualities, higher installed density and remains in place long after fiberglass insulation has melted away.

Clearly, there is an advantage to the use of rock wool in the wall that an ordinary FRTW assembly does not match.



Legend

SL - Gypsum Board Single Layer BL - Gypsum Board Base Layer FL - Gypsum Board Face Layer
Std. - Stud Cav. - Cavity Exp. - Exposed Side Unexp. - Unexposed Side Fire - Directly exposed to furnace

Figure 2: Time vs temperature curve – Double Layer 5/8" Gypsum Board, Studs 16" O.C.[9]

Note: Line (open dots) for temperature at inner surface of base layer, exposed side. This is temperature of stud cavity/edge of stud.

Derivation Calculation

Utilizing test data from reference document #9, (equation #10) and Fig. 2 above. The calculated stud surface temperature can be derived and graphed.

Eq. 10[9]

$$T_m^{j+1} = T_m^j + \frac{\Delta t}{(\rho_i c_i)_m^j (\Delta y)^2}\left\{\left[\frac{(k_i)_{m-1}^j + (k_i)_m^j}{2}\right](T_{m-1}^j - T_m^j) - \left[\frac{(k_i)_m^j + (k_i)_{m+1}^j}{2}\right](T_m^j - T_{m+1}^j)\right\}$$

The calculated time to autoignition temperature for several depth increments into the mineral wool insulation (long direction of stud) are displayed below. (See Fig. 2A)

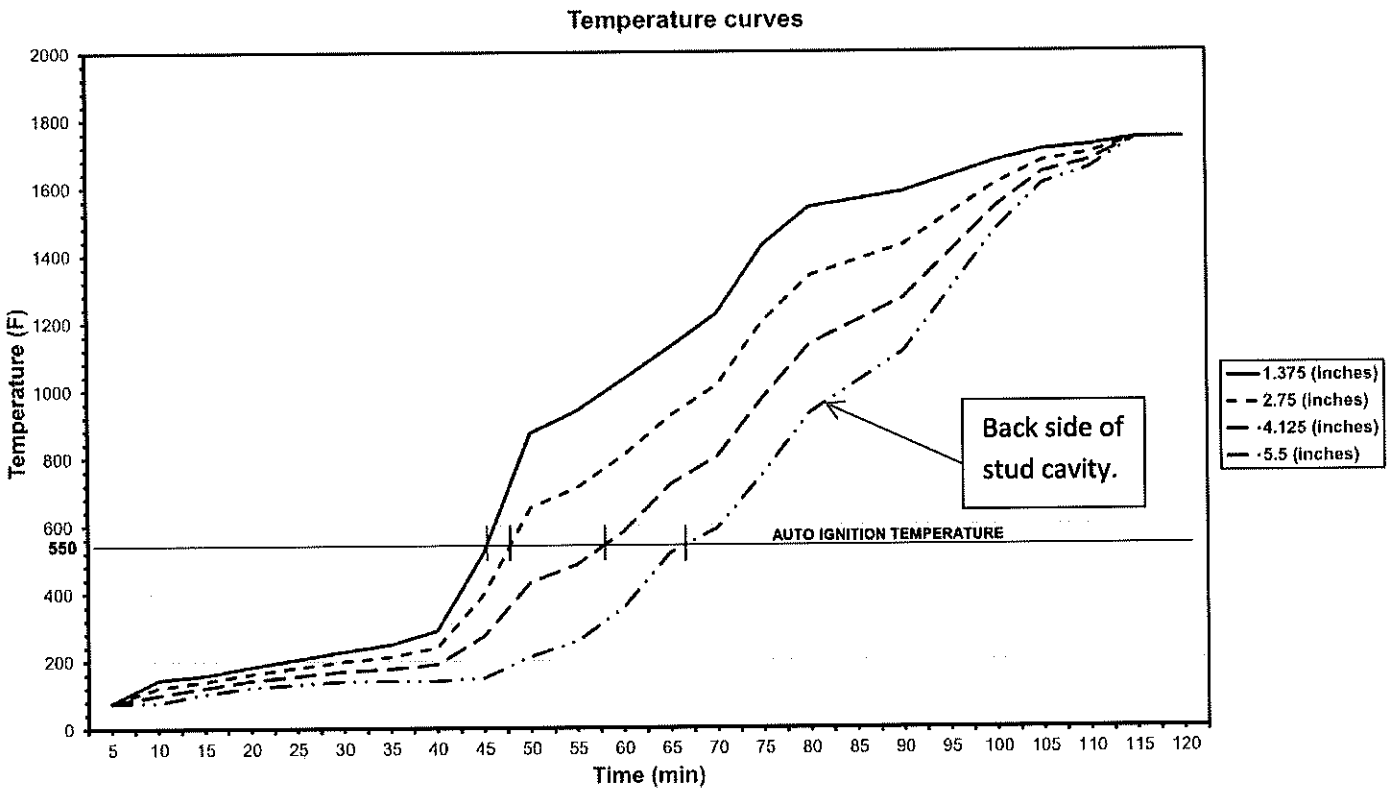


Figure 2A: Time vs Stud Surface Temperature curve – Calculated per Eq. 10.[9]

5. FIRE RESISTANCE COMPARISON

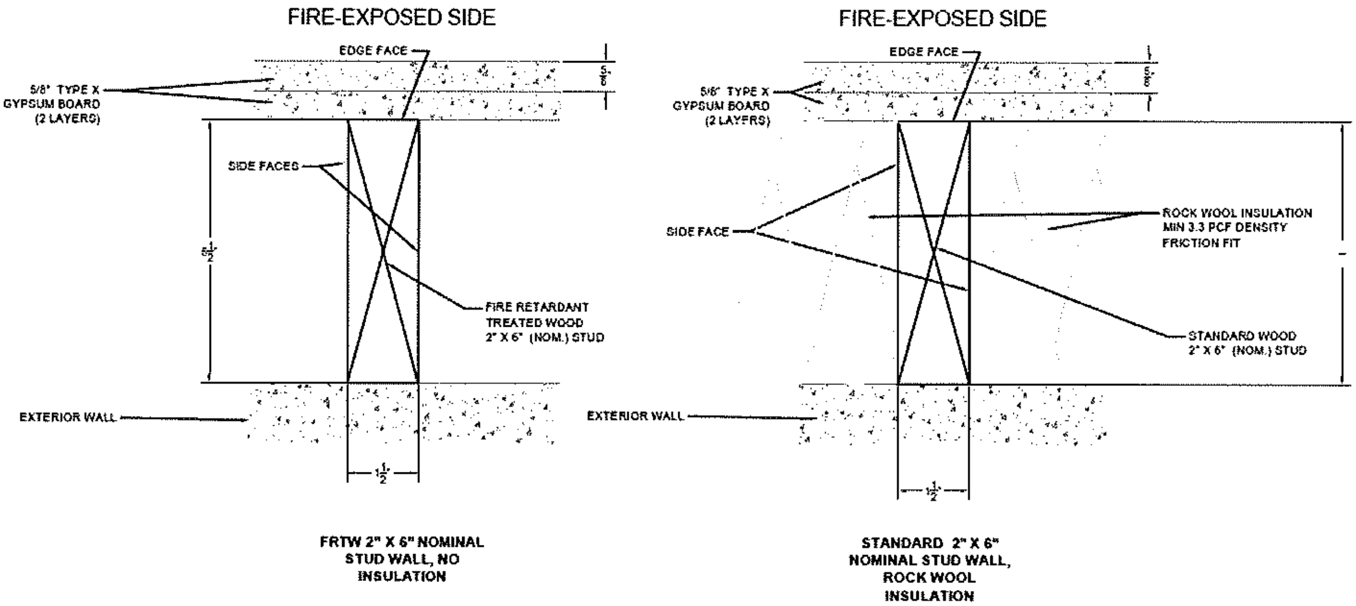


Figure 3: FRTW and Mineral Wool Stud Walls

Note: Figures 3-6 do not show composition of the exterior (non-fire exposed) side, as other constructions, allowed by code for non-fire exposed assemblies, may be used. All wall types shall be 2-Hr rated as shown in Appendix A. In all cases addressed by this report, the Fire Separation Distance is greater than 10' and fire resistance rating may be calculated from the fire exposed side only in accordance with OSSC section 705.5.

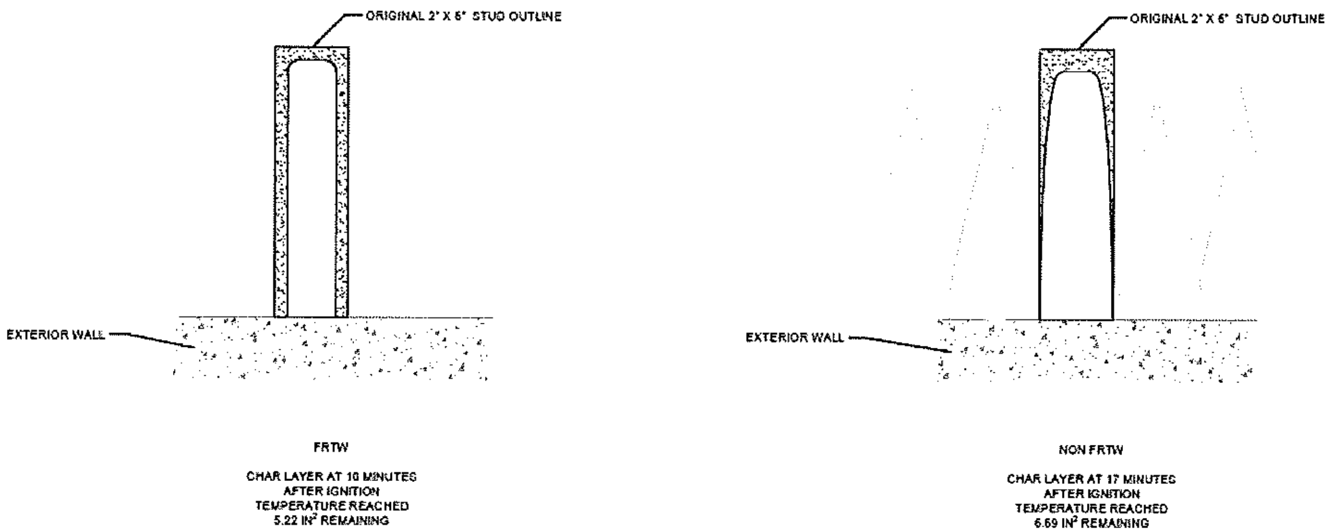


Fig 4: FRTW and non-FRTW Stud Wall at 60 Minutes After Fire Exposure of Gypsum Board Wall

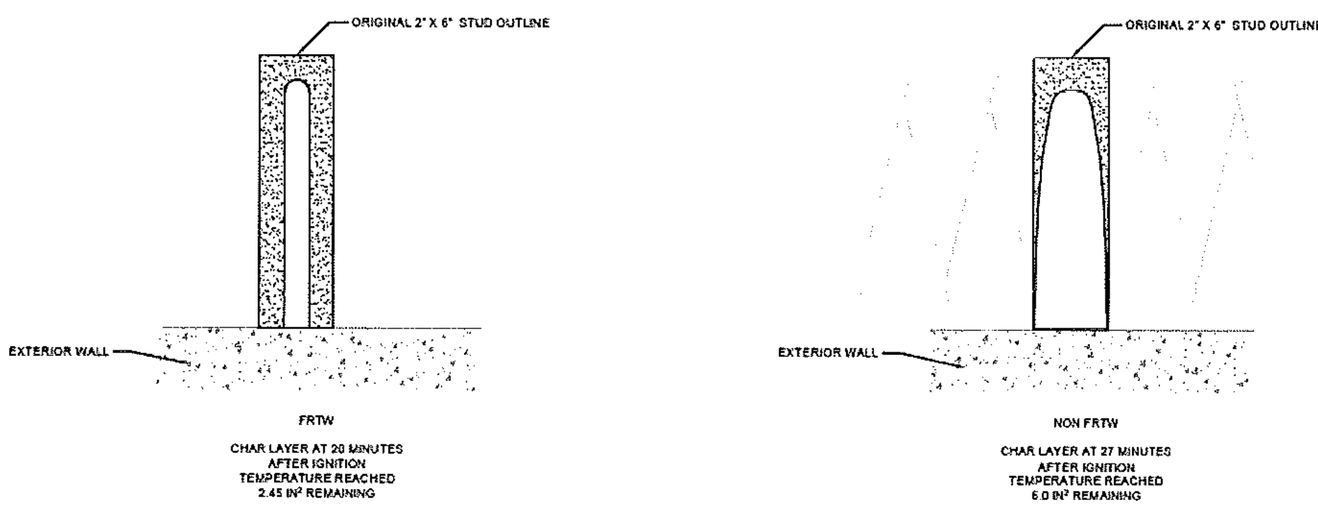


Figure 5: FRTW and Non-FRTW Stud Walls at 70 Minutes After Fire Exposure of Gypsum Board Wall Point of FRTW Wall Failure

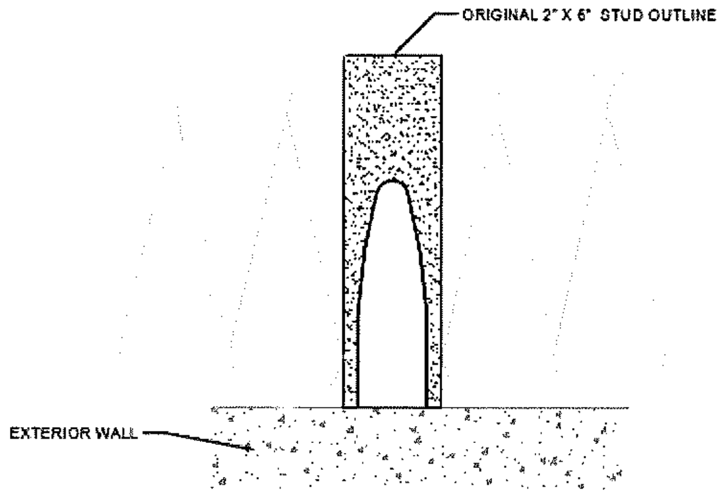


Figure 6: Non-FRTW Stud Wall at Failure at 112 Minutes – Reduced Cross Sectional Area Equivalent to FRTW at Failure

Charring and loss of load-supporting cross-section of the wood studs begins at approximately 43 minutes after exposure of the wall to fire, as heat conducts through the gypsum board and the temperature at the inside face of the gypsum board wall reaches the autoignition temperature of wood. Ignition of the FRTW is delayed by approximately 7 minutes by the action of the fire retardant treatment. By approximately 50 minutes after exposure, both studs are experiencing charring.

At 60 minutes after exposure, approximately 50% of the allowable cross-section of the FRTW stud has been consumed by charring. Somewhat less (27%) of the insulated non-FRTW stud has been consumed at the same point, due to the effects of rock wool of rock wool in limiting heat transfer to the wood.

At 70 minutes, the FRTW has lost sufficient cross section that it fails in load. At this point, approximately 25% of the original FRTW stud cross-section remains. However, only 39% of the insulated stud has been consumed.

At approximately 112 minutes, charring of the insulated non-FRTW stud reaches the point at which less than 25% of the original cross-section remains and the stud fails.

The table below provides a comparative analysis that clearly shows that standard wood framing with rock wool insulation performs better than FRT wood framing under fire conditions.

Time Interval (minutes)	Description	FRTW Stud Reaction	Standard Stud with Rock Wool Insulation Reaction
t = 0	Gypsum board face of wall is first exposed to flames/heat, interior of stud wall at ambient temperature	None	None
t = 43	Temperature at edge face of stud attached to gypsum board exceeds autoignition point of wood (500°F), stud cavity of FRTW exceeds autoignition point of wood (500°F) (See Fig. 2)	FRT of wood stub inhibits ignition of FRT studs	Charring begins on narrow edge of stud (1.5" wide)
t=50	Chemical and mechanical inhibition of ignition of FRT wood exhausted	Charring begins on narrow edge of stud (1.5" wide) and along both exposed long faces (5.5" wide each)	Charring along wide faces nearest to the gypsum board (Autoignition temperature boundary at 2.75" depth)
t=60		Charring has consumed 50% of allowable	Charring has consumed approximately 27% of allowable (Autoignition temperature boundary at 4.125" depth)
t =70		Char layer exceeds allowable, insufficient cross-section of stud available to support load, stud fails	Charring has consumed approximately 39% of allowable (Autoignition temperature boundary at full depth)
t = 112.6			Char layer exceeds allowable, insufficient cross-section of stud available to support load, stud fails

6. ADDITIONAL BENEFITS

1. Depending on the species, type of product (stud, joist, plywood, beam), and its application (wall, floor, roof), the strength originally associated with wood is reduced when treated with a fire retardant. Therefore, the FRTW manufacturer is required to provide strength adjustments based on the intended use of the wood. This reduction in strength must be factored in to the structural design of the building. The effective spans and bearing capacity of the lumber is reduced, so beams are over-sized and more lumber is used in

the project than required with standard studs. Hence non-treated wood consumes less of the available resources and is structurally stronger than FRTW.

2. The process of pressure-impregnating chemicals into wood to achieve FRT lumber has a negative environmental impact, due to increased use of virgin chemicals and more waste chemicals that needs to be treated before it is discharged in to the sewer system. Additionally, there are health impact concerns regarding to the occupants of the building from a long term exposure to the chemicals used in pressure impregnation. Unlike the chemical FRT process, rock wool is made from an inorganic fiber that does not have adverse impacts on the environment or individual health of occupants.

3. Due to the potential corrosion of steel, hot-dipped galvanized fasteners are required over standard zinc-plated type, when using FRT wood. Rock wool is made from inorganic fiber, it does not reduce the strength of the wood, and does not require hot dipped galvanized fasteners. Hence, it is a better alternative for the environment and overall structural design.

7. CONCLUSION

Rock wool batt insulation will be friction fit between the 2x6 studs. Filling the entire depth of the wall cavity will provide better protection than FRT wood framing as permitted by OSSC 2303.2 and 603.2. The architect is proposing to use comfort batt insulation product by Roxul Company. The batt insulation will be 5.5 inches thick and will be friction fit within the stud cavity. This product is within the parameters of our analysis and the proposed wall assembly will exceed the performance of an FRT wood framed wall assembly. Code does not prohibit the use of better quality products than what is mandated; as this proposed assembly exceeds the base code criteria it will satisfy the code requirements.

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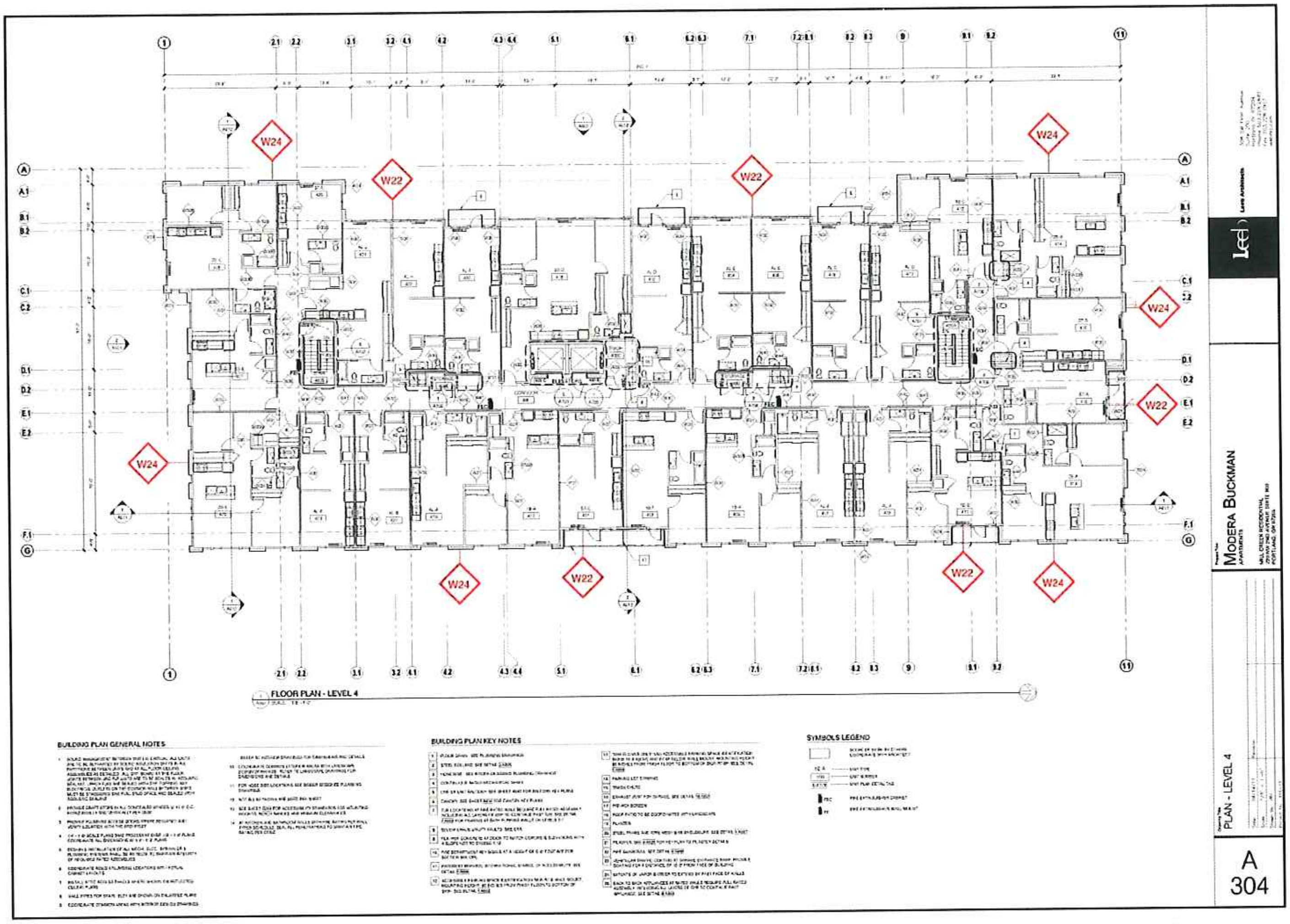
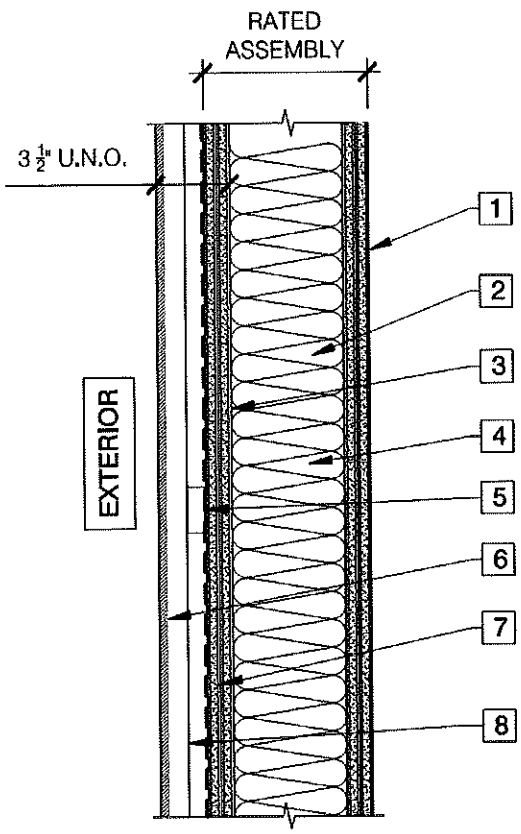
Fire Protection Engineer
Principal/Code Unlimited

Appendix A

Proposed Wall Sections



Appendix A Figure 1: Typical Floorplan (Floors 3-7)



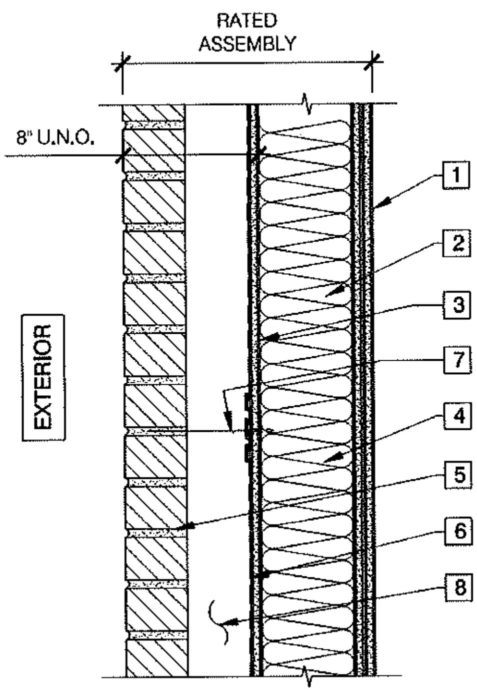
RAIN SCREEN DESIGN

ASSEMBLY LEGEND:

1 09250, (2) LAYERS 5/8" TYPE X GYPSUM BOARD FOR FIRE-RESISTANT USE
2 06110, 2x6 WOOD STUDS, SPACING AS SCHEDULED PER STRUCTURAL
3 06115, (2) LAYERS EXTERIOR DENSGLASS FIREGAURD GYPSUM SHEATHING
4 MINERAL WOOL BATT INSULATION FIT TIGHT TO CAVITY - R-21
5 7/8" HORIZONTAL RAIL
6 NON COMBUSTIBLE FIBER CEMENT EXTERIOR CLADDING ON RAIN SCREEN FURRING
7 07290, WEATHER RESISTANT BARRIER
8 1" VERTICAL FURRING STRIP

TYPE W22 - EXTERIOR COMBUSTIBLE - NON-SHEAR - WOOD FRAMING					
LOCATION(S): LVLS 3-7, EXTERIOR WALL AT RAINSCREEN NON-COMBUSTIBLE CLADDING					
MARK	STUD SIZE	FIRE		SOUND ATTENUATION	
		RATING	RATING SOURCE	STC RATING	RATING SOURCE
W22	2x6	2-HR	UL Design No. U301	NA	
* REFER TO STRUCTURAL FRAMING PLAN FOR WALL LOAD-BEARING AND STUD SCHEDULE. STUD SIZE AND/OR SPACING MAY VARY BY FLOOR.					

Appendix A Figure 2: W-22 Exterior Wall Type



ASSEMBLY LEGEND:

1 09250, (2) LAYERS 5/8" TYPE X GYPSUM BOARD FOR FIRE-RESISTANT USE
2 06110, 2x6 WOOD STUDS, SPACING AS SCHEDULED PER STRUCTURAL. PROVIDE STUD AT BRICK TIE AS REQUIRED
3 06115, (2) LAYERS EXTERIOR DENSGLASS FIREGAURD GYPSUM SHEATHING
4 MINERAL WOOL BATT INSULATION FIT TIGHT TO CAVITY - R-21
5 04200, BRICK MASONRY
6 07290, WEATHER RESISTANT BARRIER
7 MASONRY TIE AND CLIP
8 AIR SPACE

TYPE W24 - EXTERIOR COMBUSTIBLE - NON-SHEAR - WOOD FRAMING					
LOCATION(S): LVLS 3-7, EXTERIOR WALL AT BRICK					
MARK	STUD SIZE	FIRE		SOUND ATTENUATION	
		RATING	RATING SOURCE	STC RATING	RATING SOURCE
W24	2x6	2-HR	OSSC 2014 720.1 (2) ITEM 15-1.5	N/A	
REFER TO FIRE RATING SOURCE FOR WALL TYPE CONSTRUCTION AND MINIMUM FASTENER REQUIREMENTS. AT DOUBLE GYP LAYERS, STAGGER JOINTS WITH VERTICAL JOINTS OVER STUDS.					

* REFER TO STRUCTURAL FRAMING PLAN FOR WALL LOAD-BEARING AND STUD SCHEDULE. STUD SIZE AND/OR SPACING MAY VARY BY FLOOR.

Appendix A Figure 3: W-24 Exterior Wall Type