

# Development Services

## From Concept to Construction

Phone: 503-823-7300 Email: [bds@portlandoregon.gov](mailto:bds@portlandoregon.gov) 1900 SW 4th Ave, Portland, OR 97201

More Contact Info (<http://www.portlandoregon.gov/bds/article/519984>)



### APPEAL SUMMARY

**Status:** Decision Rendered - Reconsideration of ID 20825

<b>Appeal ID:</b> 21884	<b>Project Address:</b> 4804 SE Woodstock Blvd
<b>Hearing Date:</b> 9/18/19	<b>Appellant Name:</b> Charles Kidwell
<b>Case No.:</b> B-002	<b>Appellant Phone:</b> 503
<b>Appeal Type:</b> Building	<b>Plans Examiner/Inspector:</b> David Bartley
<b>Project Type:</b> commercial	<b>Stories:</b> 5 <b>Occupancy:</b> B, R-2, S-2 <b>Construction Type:</b> I-A, III-B
<b>Building/Business Name:</b> Modera Woodstock Apartments	<b>Fire Sprinklers:</b> Yes - Throughout
<b>Appeal Involves:</b> Erection of a new structure, Reconsideration of appeal	<b>LUR or Permit Application No.:</b> 19-117964-EA
<b>Plan Submitted Option:</b> pdf [File 1] [File 2] [File 3]	<b>Proposed use:</b> Multi-Family Residential

### APPEAL INFORMATION SHEET

#### Appeal item 1

<b>Code Section</b>	602.3 Type III Construction
<b>Requires</b>	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.
<b>Proposed Design</b>	<p>The Design consists of a 5 Story Type IIIB Construction Residential building above a 1-level Type IA Construction 'Parking Garage Basement'. The building consists primarily of residential group R-2 apartments/live-work units with some Group B lobby &amp; common area occupancies and Group M retail spaces on the ground floor. The building is fully protected by an NFPA 13 automatic sprinkler system, fire alarms and detection system.</p> <p>The proposed design is based on the 'Portland Code Guide - OSSC/6/#4' that allows Non - Fire Retardant Treated wood framing within exterior walls of R-2 occupancy buildings of Type III construction. The proposed design for this building meets the requirements for the Portland City Guide (OSSC/6/#4) except for the conditions #10 and #17.</p> <p>Note that fire apparatus aerial access for the full block building is available on the north and east frontages of the site (including the primary dominant street frontage on Woodstock Blvd.)</p> <p>Proposed Appeal Items:</p> <p>(RECONSIDERATION TEXT)</p> <ul style="list-style-type: none"> <li>For condition #10: The proposed (Type IIIB) apartment building above the (Type IA) parking garage level has been divided in half, using a 3 Hour Fire Wall to provide a horizontal exit between the two buildings. With the proposed horizontal exit division, the two building meet the Code Guide</li> </ul>

criteria for allowable area using 12,000 sf/floor per condition #10

The proposed apartment building has total area of 147,995 sf. With the horizontal exit division wall,

each building compartment is reduced to nearly half of the allowable area using the 12,000 sf basic

allowable area. The proposed building configuration will meet the maximum allowable building area.

See the attached Allowable are Building Summary (Exhibit 05 and 05B).

See attached Building Area Summary and Allowable Area Calculation Summary.

· For condition #17, details 6, 7 and 8 for sacrificial wood stud at window jambs and headers:

Exterior walls will be protected with non-combustible mineral wool insulation (in lieu of the Fire Retardant Treated wood framing) as explained in the attached white paper by Code Unlimited.

The exterior bearing walls in the Type IIIB buildings are permitted to be fire-retardant-treated (FRT) wood per 602.3. The proposed design consists of exterior walls with untreated wood stud framing with Roxul ComfortBatt mineral wool insulation at 2.0 lbs/ft

3 friction fit between studs to fill the entire 6" nominal

wall cavity. The attached white paper by Code Unlimited documents that this will exceed the performance of a traditional FRT wood wall.

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**Reason for alternative** As indicated in the Code Unlimited white paper, the use of FRT wood has several drawbacks, most notably that it:

reduces the structural strength of wood and requires more wood than a non-FRT wood wall, and the chemical used to provide the fire-retardant treatment has long term detrimental environmental impact.

Using conventional wood framing in conjunction with the proposed mineral wool insulation results in a

more fire-resistant building that is also more environmentally friendly.

The White Paper established that ordinary lumber 2" X 6" exterior wall framing with mineral wool insulation friction-fit between studs will provide superior performance to an FRTW framed wall. The reason for requesting the Alternate Means & Method of construction is to provide relief from some additional requirements (Items #10 and #17 details 6, 7, and 8) imposed by the Code Guide when non-FRTW

framing is provided. The attached white paper provides a fire analysis that supports the use of mineral wool insulation in the wall cavity of untreated wood stud framing as an alternate to FRT wood stud

framing, which is an exterior wall material permitted by the OSSC section 602.3. The analysis

· compares untreated wood and FRT wood framed wall assemblies

· is based on published temperature data from full scale testing of multiple configurations of fire rated stud walls

· concludes that untreated wood framed walls with mineral wool insulation will outperform FRT wood framed walls without such insulation.

The proposed design is in compliance with all other provisions of the Portland Code Guide (except as noted above) including:

· Provision of aerial access.

· The building will be equipped with an approved automatic sprinkler system.

· The ceiling cavity will be constructed of non-combustible materials; or the spaces between the top chord of the trusses and the ceiling will be filled entirely with non-combustible insulation per NFPA 13, 8.15.1.2.7. (This satisfies the requirements that there are no combustible concealed attic spaces).

· Exit stairs are extended to the roof in a 2-hour enclosure.

· The roof slope is essentially flat with a slope of 3/8" per foot (less than 33% slope).

- Approved access is provided to the roof from all the stairways.
  - Each roof hatch is a minimum of 36" x 96" and has a guardrail at the roof level.
  - The building is equipped with standpipes and at least one standpipe will terminate on the roof.
- This building, when constructed as outlined in the White Paper, will, from a fire resistance standpoint, outperform a comparable building that has FRT wood in exterior walls as permitted by OSSC 602.3. With these modifications, we believe a higher level of safety has clearly been provided for this project and we urge you to approve this appeal.

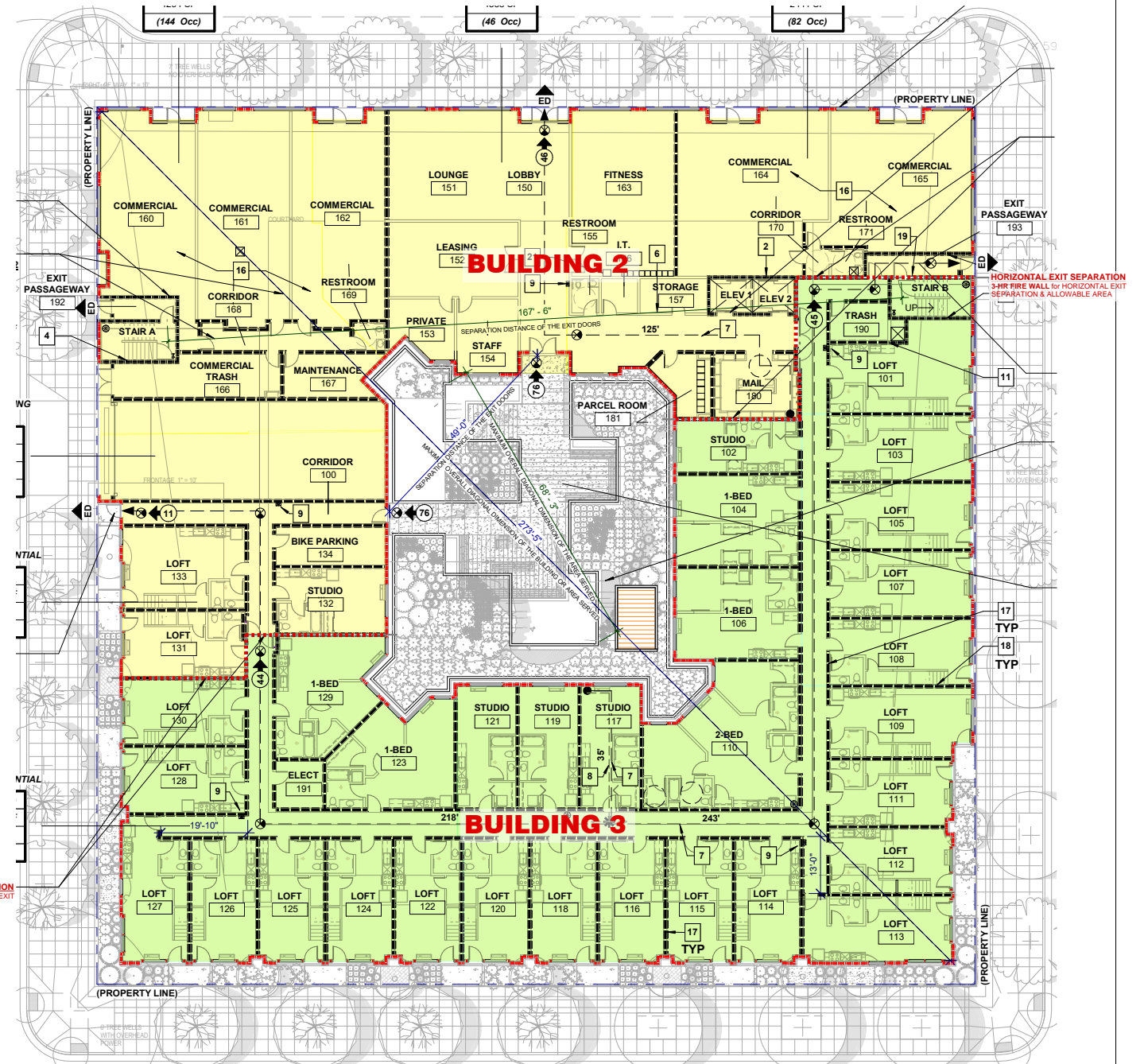
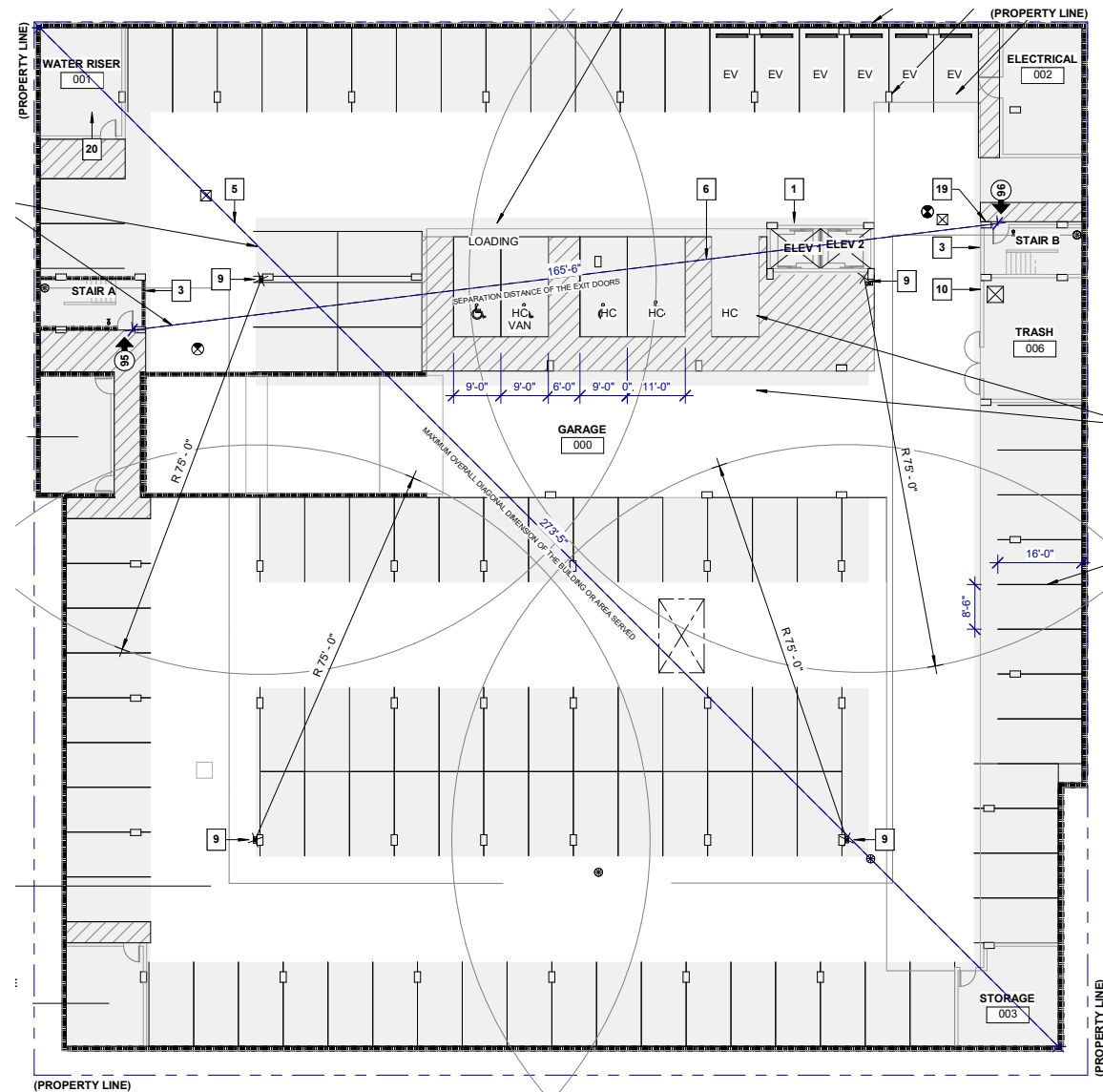
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## APPEAL DECISION

**Use of mineral wool insulation with non-fire resistant treated wood framing in exterior walls of Type III construction: Granted provided special inspection is performed for installation of mineral wool.  
Appellant may contact John Butler (503 823-7339) with questions.**

The Administrative Appeal Board finds with the conditions noted, that the information submitted by the appellant demonstrates that the approved modifications or alternate methods are consistent with the intent of the code; do not lessen health, safety, accessibility, life, fire safety or structural requirements; and that special conditions unique to this project make strict application of those code sections impractical.

Pursuant to City Code Chapter 24.10, you may appeal this decision to the Building Code Board of Appeal within 90 calendar days of the date this decision is published. For information on the appeals process, go to [www.portlandoregon.gov/bds/appealsinfo](http://www.portlandoregon.gov/bds/appealsinfo), call (503) 823-7300 or come in to the Development Services Center.



1  
01

## FLOOR PLANS - LEVEL 0 PARKING

SCALE: 1/32" = 1'-0"

## FLOOR PLAN LEVEL 1

SCALE: 1/32" = 1'-0"

0 8' 32' 64'



leeb

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MODERA WOODSTOCK

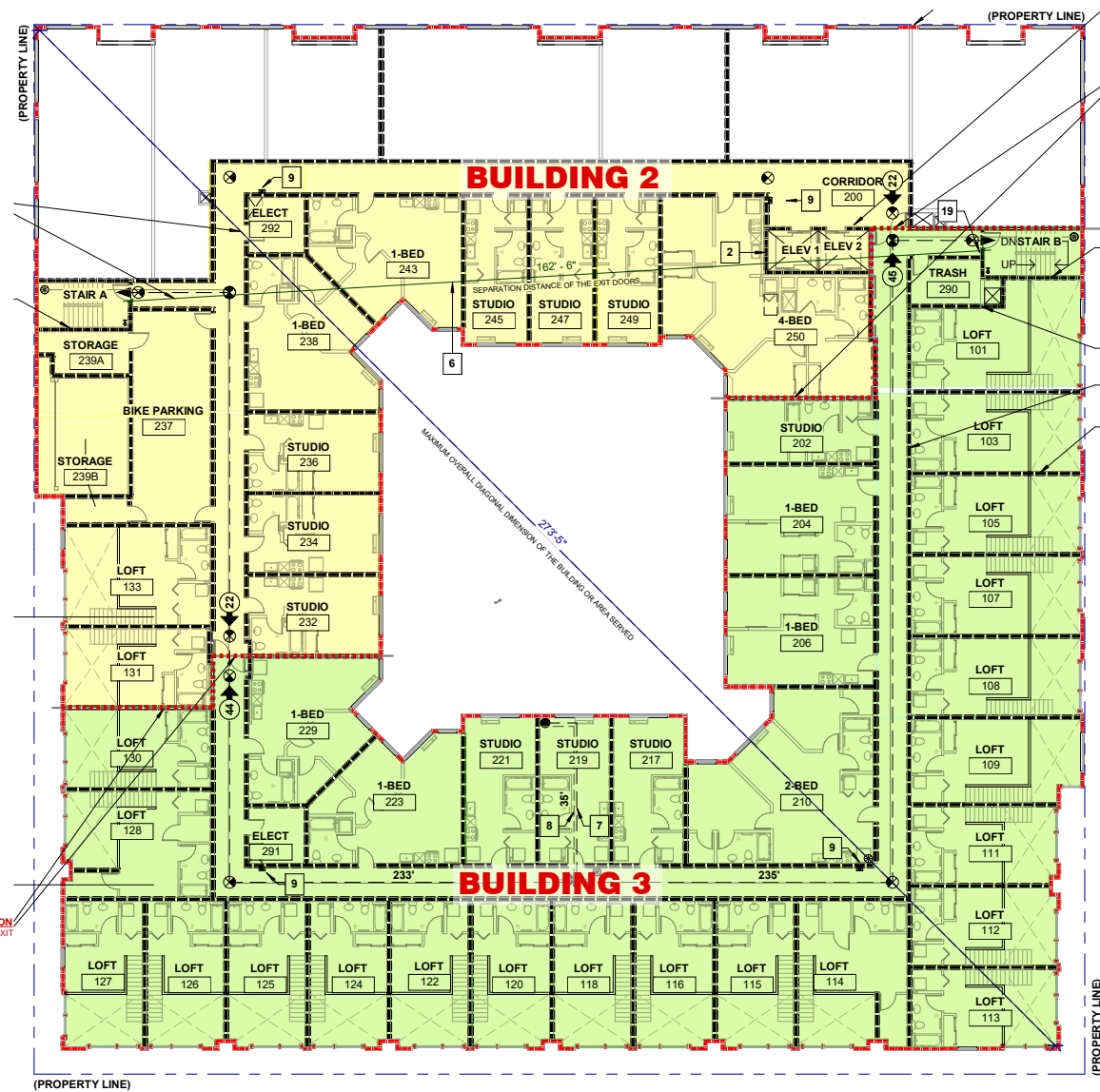
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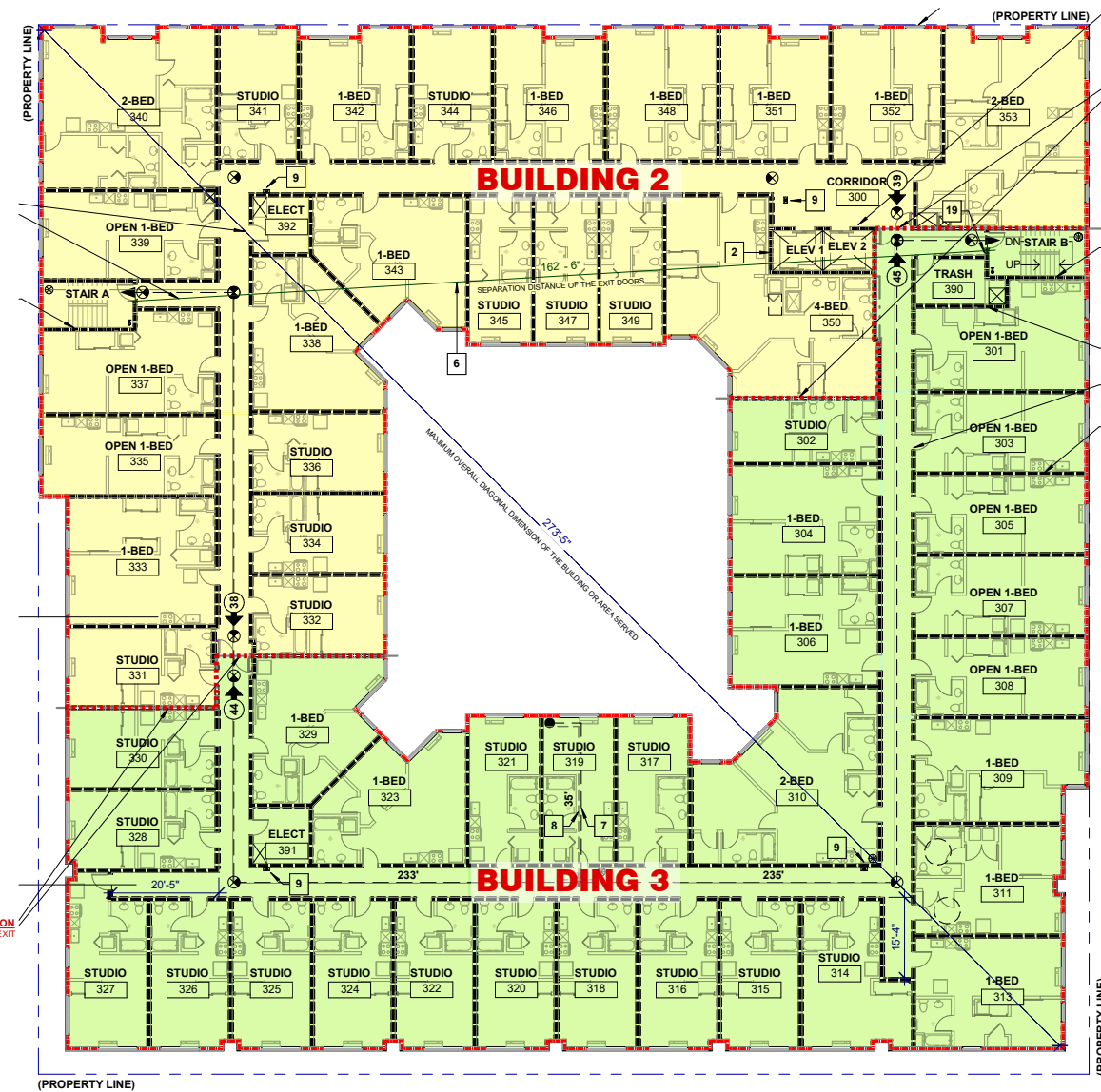
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HORIZONTAL EXIT SEPARATION  
3-HR FIRE WALL for HORIZONTAL EXIT  
SEPARATION & ALLOWABLE AREA



HORIZONTAL EXIT SEPARATION  
3-HR FIRE WALL for HORIZONTAL EXIT  
SEPARATION & ALLOWABLE AREA

1  
03

## FLOOR PLANS - LEVEL 2 AND LEVEL 3

SCALE: 1/32" = 1'-0"

0 8' 32' 64'



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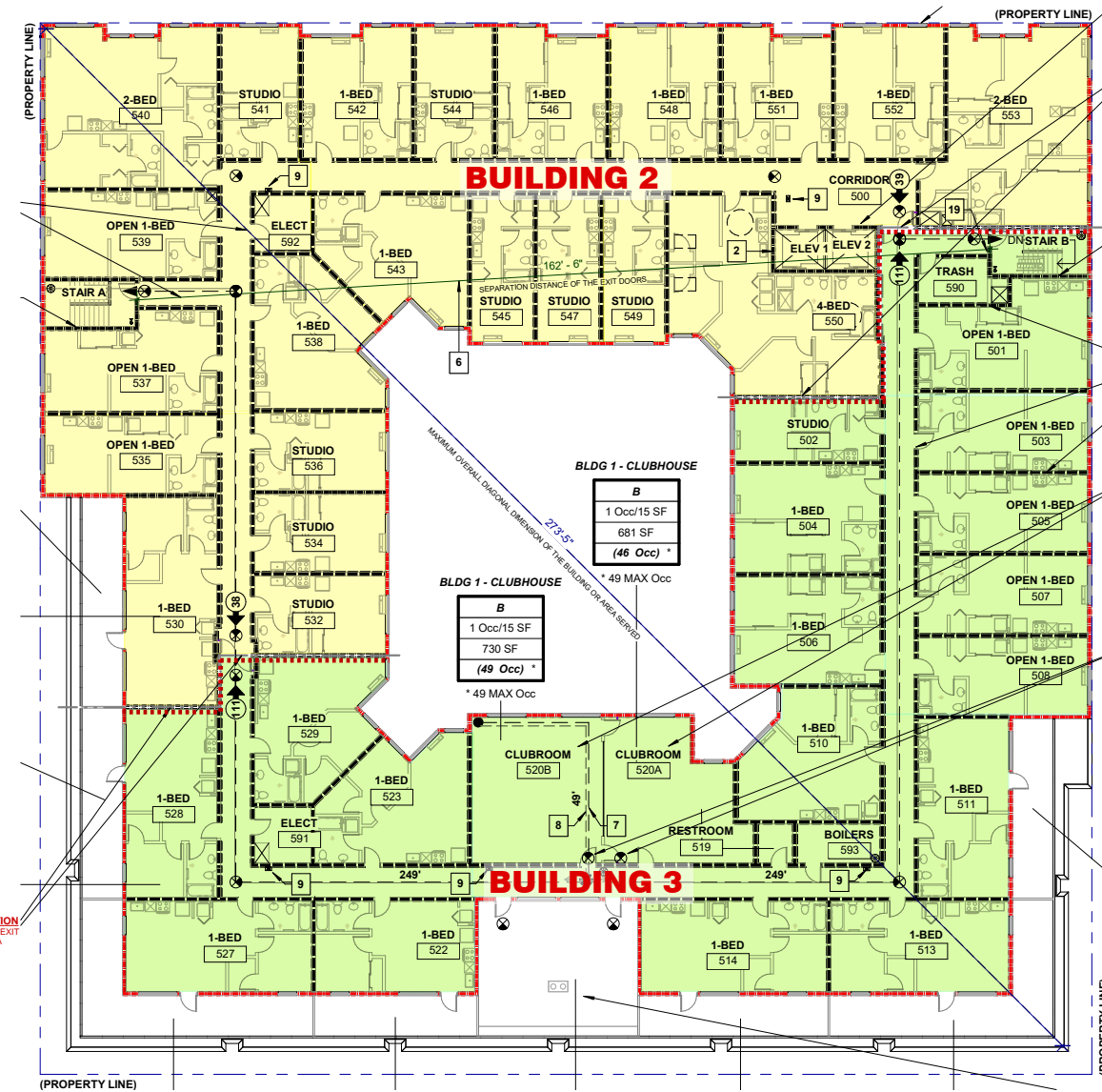
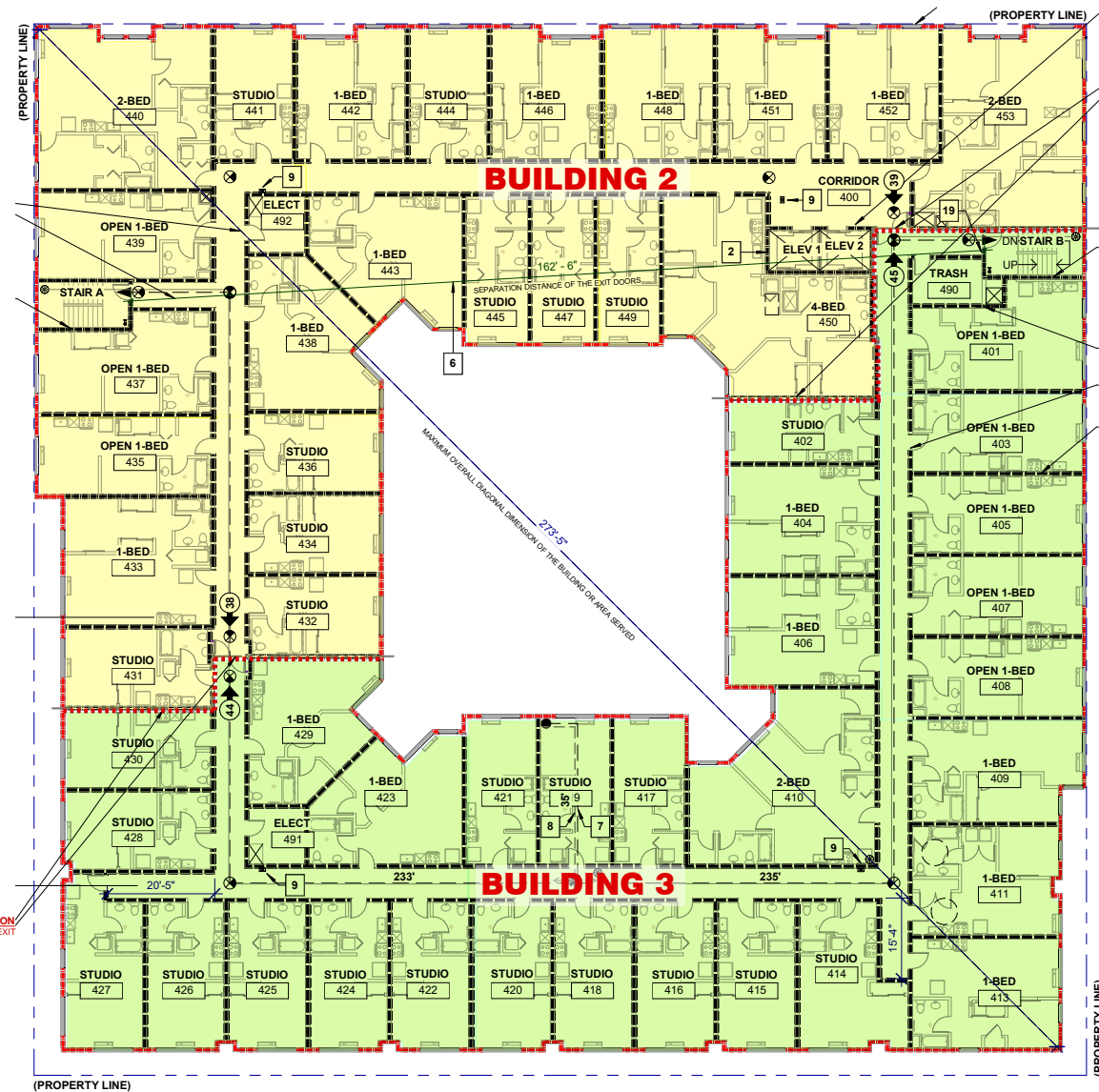
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02

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1  
04

## FLOOR PLANS - LEVELS 4 AND 5

SCALE: 1/32" = 1'-0"

0 8' 32' 64'



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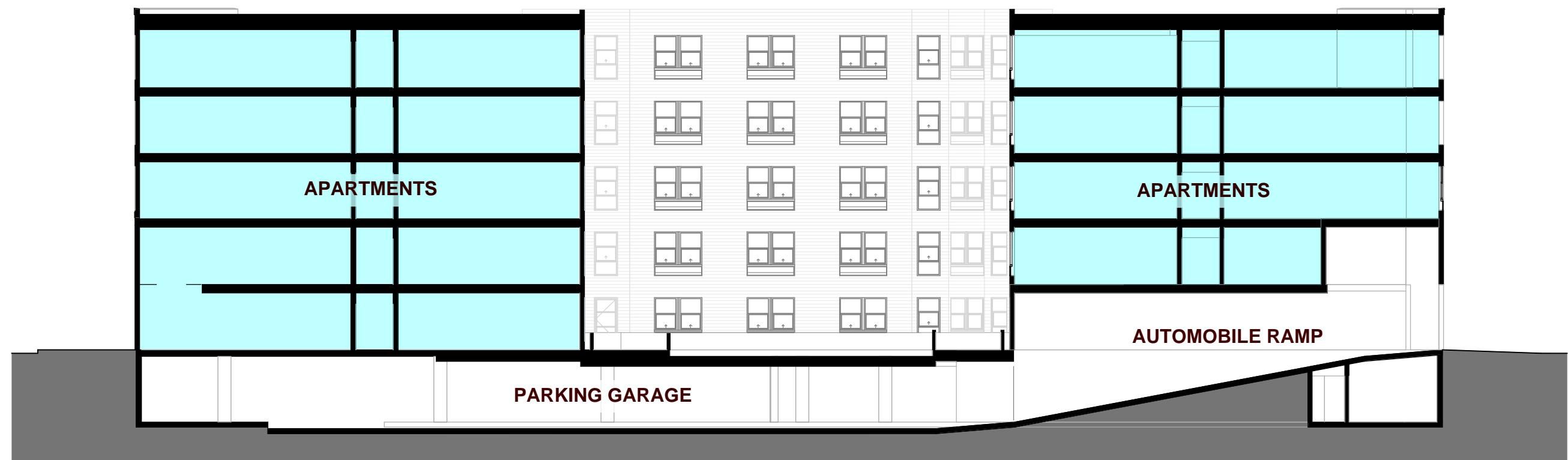
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03

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1  
05

## BUILDING SECTION - WEST TO EAST

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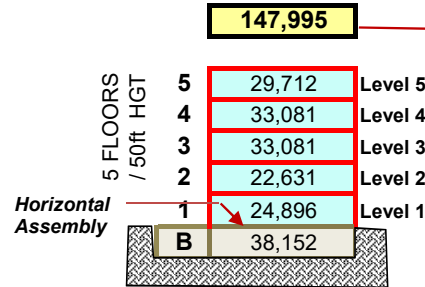
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04

All buildings w/ 'R' (Residential) Occupancies are required to have an Automatic Fire Sprinkler System throughout.



### ALLOWABLE BUILDING AREA (Type 3A or 5A Residential / Type 1A Podium)

		$A_t$		$A_t \times I_f$		$A_t \times I_s$		$A_a$	TOTAL
Occup. Group	Constr Type	Basic AREA	Frontage Increase Factor	Frontage Increase AREA	Sprinkler Increase Factor	Sprinkler Increase AREA	ALLOWABLE AREA (SF) per FLOOR	Story Increase Factor	ALLOWABLE BUILDING AREA (SF)
		(Table 503)							
		Maximum Floor Area cannot exceed the Total Allowable Building Area without Area Separation Walls							
R-2	3-B								
R-2	3-B								
R-2	3-B								
R-2	3-B	12,000	63%	7,560	200%	24,000	43,560	3	130,680
R-2	3-B								
S2	1-A	Unlimited							

Maximum Floor Area cannot exceed the Total Allowable Building Area without Area Separation Walls

Combustable 1-Hour-rated Wood Construction permitted

Area Separation Wall is Required

Area Separation Wall is Required

### FRONTAGE INCREASE

Building Frontage @ Public Way	Perimeter of Entire Building	1st Adjust Factor	Width of Public Way	2nd Adjust Factor	Total Frontage Area Increase	TOTAL PROPOSED BUILDING AREA (SF)	
						Level	Area
						Level 1	24,896
						Level 2	22,631
						Level 3	33,081
						Level 4	33,081
						Level 5	29,712
						<b>TOTAL</b>	<b>147,995</b>

### SUMMARY: Compartmentalized Building Areas (OSSC 506.1 & 506.4)

(Equation 5-1)  $A_n = \{A_t + [A_t \times I_n] + [A_t \times I_s]\}$

At			At x If		At x Is		Aa		TOTAL
Occup.	Constr	Basic	Frontage	Frontage	Sprinkler	Sprinkler	ALLOWABLE	Story	ALLOWABLE
Group	Type	AREA	Increase	Increase	Increase	Increase	AREA (SF)	Increase	BUILDING
		(Table 503)	Factor	AREA	Factor	AREA	per FLOOR	Factor	AREA (SF)
R-2	3-B	12,000	61%	7,377	200%	24,000	43,377	3	130,130
R-2	3-B	12,000	65%	7,776	200%	24,000	43,776	3	131,327

Building Compartment  
 Building Area - 2  
 Building Area - 3

Building Frontage @ Public Way	Perimeter of Entire Building	1st Adjust Factor	Width of Public Way	2nd Adjust Factor	Total Frontage Area Increase	PROPOSED Compartmentalized BUILDING AREA (SF)	
						Area	Area
383.5	443.5	0.25	30.00	30	61%		67,960
396	441	0.25	30.00	30	65%		80,035

### Building Frontage Increase

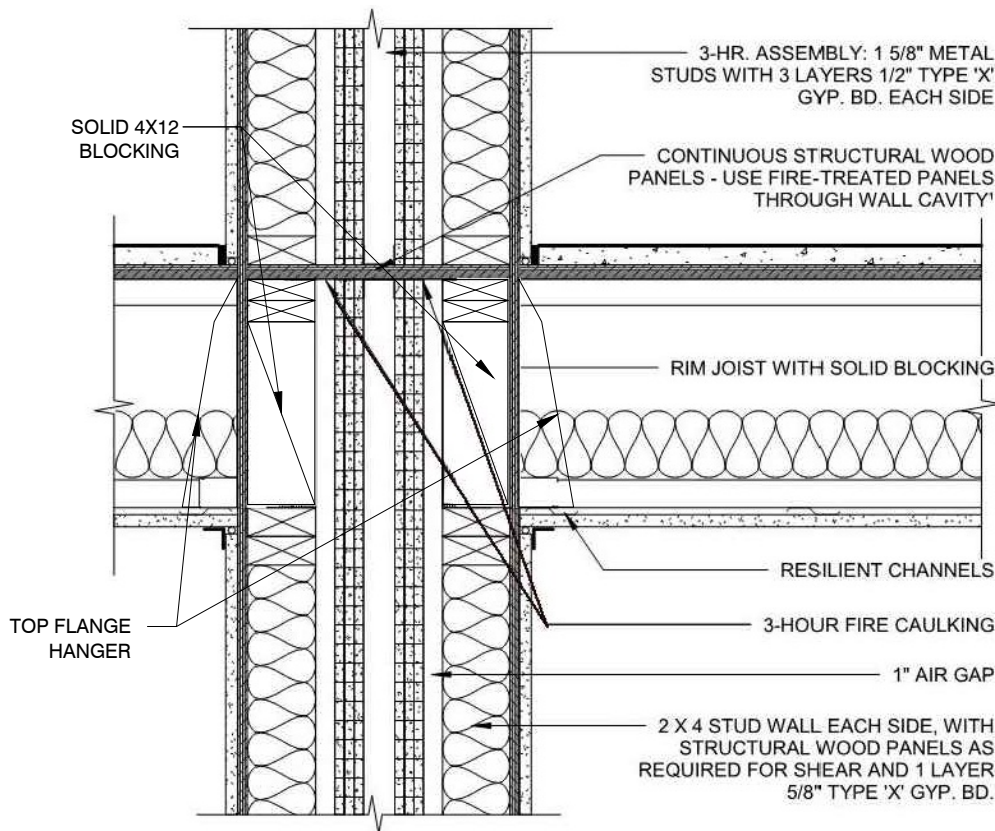
Building	North		East		South		West		Frontage Total (Ft)	Perimeter Total (Pt)	Weighted Width of Public Way (W)	Adjustment Factor (Af)	Frontage Increase (If) (Ft/Pt-.25)W/Af	OSSC Section
	F	P	F	P	F	P	F	P						
Building 2	199.5	229.5	38.5	44.5	0	0	145.5	169.5	383.5	443.5	30.00	30	61%	506.2
Building 3	0	0	156.5	171.5	190	215	49.5	54.5	396	441	30.00	30	65%	

### Weighted Width of Public Way (W)

Building	North		East		South		West		Frontage Total (Ft)	Area of Public Way Total (At)	Weighted Width of Public Way (W)	OSSC Section
	F	W	F	W	F	W	F	W				
Building 2	199.5	30	38.5	30	0	0	145.5	30	383.5	11,505	30.00	506.2.1
Building 3	0	0	156.5	30	190	30	49.5	30	396	11,880	30.00	

Building Area Summary										
Floor	Use	Occ	Bldg 1 Bsmt	Bldg 2 Area	Bldg 3 Area	Totals	Bldg 1 1	Bldg 2 2	Bldg 3 3	Totals
Level 0 (Bsmt)	Parking Garage	S-2	38,152			38,152	38,152			38,152
						0	0			0
Level 1	Apartments	R-2		2,134	17,710	19,844		2,134	17,710	19,844
	Lobby/Mgt	B		4,553		4,553		4,553		4,553
	Retail	M		6,735				6,735		
	Parking/Storage	S-2		499		499		499		499
Level 2	Apartments	R-2		8,339	14,292	22,631		8,339	14,292	22,631
						0		0		0
Level 3	Apartments	R-2		15,367	17,714	33,081		15,367	17,714	33,081
Level 4	Apartments	R-2		15,367	17,714	33,081		15,367	17,714	33,081
Level 5	Apartments	R-2		14,966	12,605	27,571		14,966	12,605	27,571
	Club House	A-3			1,411	1,411		0	1,411	1,411
	Club House Deck	A-3		0	730	730		0	730	730
Basement Area			38,152			38,152	38,152			38,152
Apt Bldg Area				67,960	80,035	147,995		67,960	80,035	147,995
TOTAL AREA						186,147	38,152	67,960	80,035	181,553





<sup>1</sup>CONSULT LOCAL JURISDICTION HAVING AUTHORITY FOR ACCEPTANCE OF FIRE-TREATED WOOD PANELS RUNNING THROUGH 3-HOUR ASSEMBLY IN THIS APPLICATION.

## 3-HOUR FIRE WALL AT FLOOR/CEILING

TYPE W43, INT. COMBUSTIBLE 3-HOUR FIRE WALL ASSEMBLY					
LOCATION(S): UNIT PARTY WALLS, CORRIDORS					
MARK	STUD SIZE	FIRE		SOUND ATTENUATION	
		RATING	RATING SOURCE	STC RATING	RATING SOURCE
W43	1 5/8" STL	3-HR	GA FILE NO. WP 3370 - UL U341	50-54	GA WP 5508, GA WP 2921 NGC 2636, 7-21-83
NOTES:					
1. REFER TO STRUCTURAL FRAMING PLAN FOR WALL LOAD BEARING AND STUD SCHEDULE. STUD SIZE AND/OR SPACING MAY VARY BY FLOOR.					
WALL DESCRIPTION: THIS WALL IS A COMBINATION OF TWO GA/UL WALL DESIGNS: WALL GA DESIGN WP 2932 IS SANDWICHED IN THE CENTER OF GA WALL DESIGN WP3370 AS ILLUSTRATED ABOVE AND DESCRIBED BELOW.					
GA FILE NO. 2932		PROPRIETARY			
GYPSUM WALLBOARDS, STEEL STUDS					
BASE LAYER: 1/2" PROPRIETARY TYPE "X" GYPSUM WALL BOARD APPLIED PARALLEL OR AT RIGHT ANGLES TO EACH SIDE OF 1-5/8" STEEL STUDS, 24" O.C., WITH 1" TYPE "S" DRYWALL SCREWS, 24" O.C.					
SECOND LAYER: 1/2" PROPRIETARY TYPE "X" GYPSUM WALL BOARD APPLIED PARALLEL OR AT RIGHT ANGLES TO EACH SIDE OF 1-5/8" STEEL STUDS, 24" O.C., WITH 1-5/8" TYPE "S" DRYWALL SCREWS, 24" O.C.					
FACE LAYER: 1/2" PROPRIETARY TYPE "X" GYPSUM WALL BOARD APPLIED PARALLEL OR AT RIGHT ANGLES WITH 2-1/4" TYPE "S" DRYWALL SCREWS, 14" O.C. SCREWS OFFSET 6" BETWEEN LAYERS.					
VERTICAL JOINTS STAGGERED 24" ON EACH LAYER AND SIDE. HORIZONTALS JOINTS NEED NOT BE STAGGERED.					
PROPRIETARY GYPSUM WALL BOARD					
AMERICAN GYPSUM COMPANY LLC TEMPLE INLAND				1/2" FIREBLOC TYPE "C" 1/2" TG-C	
GA FILE NO. WP 3370		GENERIC			
GYPSUM WALL BOARD, WOOD STUDS					
ONE LAYER 5/8" TYPE "X" GYPSUM WALL BOARD OR GYPSUM VENEER BASE APPLIED PARALLEL OR AT RIGHT ANGLES TO EACH SIDE OF DOUBLE ROW OF 2x4 WOOD STUDS, 16" O.C., ON SEPARATE PLATES, 1" APART WITH 6D COATED NAILS, 1-7/8" LONG, .0915" SHANK, 14" HEADS, 7" O.C. JOINTS STAGGERED 16" ON OPPOSITE SIDES. HORIZONTAL BRACING REQUIRED AT MID HEIGHT. (LOAD BEARING)					



Modera Woodstock



Experienced.  
Innovative.  
Trusted.

# CODE UNLIMITED, LLC

## White Paper - Fire Analysis of Fire Retardant Treated Wood Alternate

Project Name: Modera Woodstock Apartments

Client: Mill Creek Residential Trust

Prepared by: Code Unlimited

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

Date: 8/9/2019

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## 1. OVERVIEW

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### 1.1 Project Overview

The Modera Woodstock Apartments is a new project being constructed in Portland, OR. The project includes five (5) stories of Type IIIB construction over one (1) story of Type IA construction. The building is fully protected by automatic sprinklers, fire alarms and detection system.

Type IIIB construction requires that exterior walls be of noncombustible construction or of Fire-Retardant Treated Wood (FRTW) construction if the exterior wall can be 2 hour rated or less. The project proposes to use conventional wood studs 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 2 hours or less. This is based on the improved fire spread performance of treated wood compared to untreated wood of the same species. FRT of wood delays ignition and resists flame spread once it reaches ignition temperature. The proposed design of the exterior wall assembly uses compressed mineral wool insulation between non-treated wood framing members to provide equivalent protection to Fire Retardant Treated (FRT) wood wall assembly.

Code Unlimited has analyzed the issue of using non-FRT wood in place of FRT wood 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.

The white paper will provide the following information to show that the use of non-treated wood in Type III exterior wall assemblies with compacted mineral wool insulation is equivalent to FRT wood allowed in Type III exterior walls:

- A detailed understanding of the code regulations that are driving the requirement for FRT in Type III exterior walls, with excerpts from the International Building Code (IBC) commentary to clarify intent where necessary.
- Code citations in the Oregon Structural Specialty Code (OSSC) and the IBC where the use of mineral wool delays ignition and inhibits flame migration.

Many code provisions have evolved from traditional construction practices and then undergo rigorous analysis and/or testing to substantiate 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 assembly of a Type III construction building.

Our analysis found that the fire performance of a non-FRT wood framed wall with mineral wool insulation is equal or superior to a FRT wood framed wall. Research from other authorities shows that this approach also reduces the potential for chemical exposure to the environment and to the occupants of these buildings compared to the current practice of using FRT wood.

### 1.3 Applicable Codes and Standards

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#### *Applicable Code or Standard*

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*2014 Oregon Structural Specialty Code (OSSC)*

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*2009 ASTM E-84 Test Methods for Surface Burning characteristics of Building Materials – American Society for Testing and Materials*

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*2007 ASTM E-119 standard Test Methods for Fire Tests of Building Construction and Materials – American Society for Testing and Materials*

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### 1.4 Additional References

- <sup>1</sup> 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)
- <sup>2</sup> 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
- <sup>3</sup> 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
- <sup>4</sup> 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.
- <sup>5</sup> 1992 Charring Rate of Wood for ASTM E119 Exposure, Fire Technology Volume 28, Number 1, Robert H. White and Eric V. Nordheim
- <sup>6</sup> 1977 National Board of Standards Technical Note 945: An Investigation of the Fire Environment in the ASTM E 84 Tunnel Test
- <sup>7</sup> 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
- <sup>8</sup> 2010 Wood Handbook, Wood as an Engineering Material, Chapter 17 Fire Safety, Robert H. White and Mark A. Diitenberger, Forest Product Laboratory, United States Department of Agriculture Forest Service, Madison Wisconsin

## 2. PROPOSED WALL ASSEMBLY

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The proposed design is to provide a 2-hour exterior wall assembly that consists of untreated wood stud framing with one or two layers of 5/8" thick type X gypsum board on the interior and one layer of 5/8" type X gypsum sheathing or concrete masonry units on the exterior side of the wall (Non-Symmetric wall) for walls that are further than 10 feet from the property line. Rockwool insulation will be friction fit between studs to fill the entire 6-inch nominal wall cavity. The conclusions of this report are limited to the proposed Wall type shown in Figures 1-4 attached in Appendix A of this white paper.

## 3. ROCKWOOL USE PERMITTED IN CURRENT CODES

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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 if wall is 2-hour rated or less.

Rockwool has been allowed as a means to retard or prevent the ignition of wood in concealed spaces in the following code sections:

1. OSSC 803.11.1.1 allows untreated wood to be used for furred walls or ceilings where non-combustible or fire rated construction is required when the cavity is filled with a Class A material like mineral wool.
2. OSSC 718.2.1(7) allows mineral wool batts to be used as fireblocking to cut off concealed draft openings.
3. OSSC 718.3.1 permits the use of mineral wool batts as an approved draft stopping material.
4. ORSC 316.5.3 permits the use of 1.5 inch thick mineral 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 mineral 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:

"Rockwool 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 mineral 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 ANALYSIS AND VERIFICATION

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### Premise of Analysis

The list of prescriptive provisions in Section 3 establishes the code history of 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 #1 and #2 listed in Section 1.4 in this white paper. The remaining references, #3, #4, #5, #6, #7 and #8, 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 a superior performer compared to metal within the context of this analysis. The test data includes wall assemblies with both fiber glass and mineral wool insulation within the stud cavity. Mineral wool out performs fiber glass insulation at higher temperatures in terms of sag and ability to retain protection of the framing members. Our analysis takes the conservative value when there are multiple data points available.

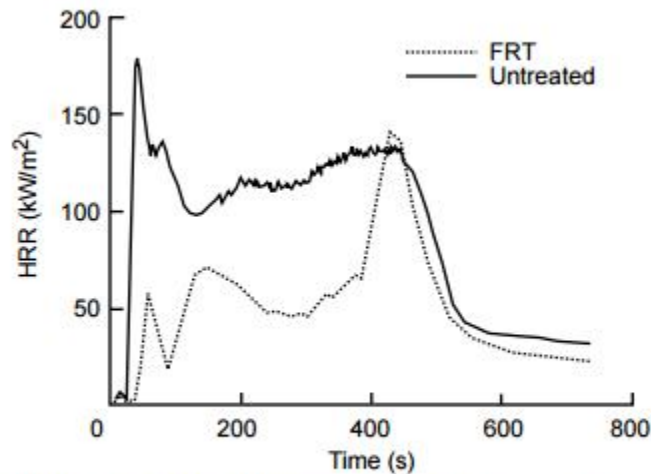
Building structural component fire performance is predicated on the type of fire exposure. Most commonly, fire from combustible building contents or furnishings expose the components, such as walls of structural frame, to heat from the fire, causing loss of structural integrity of the wall and its eventual 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 occupant survivability. In this case, the sole concern is for the preservation of structural stability, to protect emergency personnel, and reduce spread of fire to 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.



## Performance of FRT Wood



**Figure 17-1. Heat release curves for untreated and FRT plywood exposed to 50-kW/m<sup>2</sup> radiance.**

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

Fire retardant treatment is a pressure applied surface 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<sup>4,8</sup> and releases carbon dioxide and water vapor which dilutes the combustible gases. Above temperatures of 550°F, outgassing and pyrolysis effects of the FRT exceed the limits where the treatment inhibits ignition. Above 550°F, FRT heat release rate and burning rates become equivalent to untreated wood of the same species. 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 release rate (HRR) for FRT wood and non-FRT wood are virtually identical, indicating that, after the fire retardant treatment has been exhausted, the non-FRT and FRT wood studs will provide the same level of protection of structural integrity for fire migration and for ignition. The amount of additional wood charred in non-FRT wood is .105" (less than 1/8") than FRT wood.

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 auto ignition 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 mineral 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 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<sup>6</sup>. By calculating the heated perimeter of the wood studs for an uninsulated, code-accepted FRTW stud and a mineral-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 mineral 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<sup>6</sup> 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 mineral wool significantly slow charring and loss of material.

## Code Basis of Engineered Design Performance

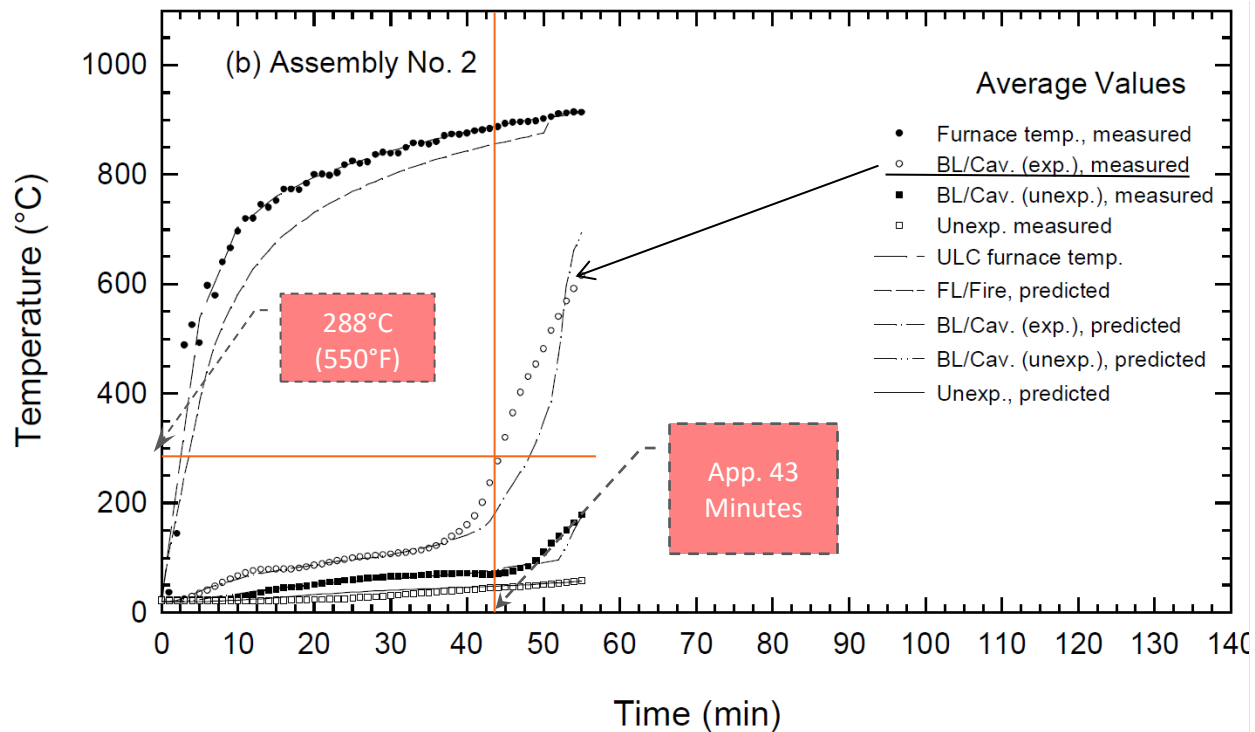
OSSC Table 722.6.2(2) states that the time assigned for contribution of the wood frame to fire resistance is 20 minutes. Within that time, the fire is assumed to consume sufficient of the stud framing to compromise its structural strength such that it fails under load. Thus it was assumed that, once 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 mineral wool insulation at a specified minimum density. The Commentaries for IBC section 722.6 note that "Mineral wool insulation provides additional protection to wood studs by shielding the studs from exposure to the furnace, thus delaying the time of collapse." Mineral 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. Mineral 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, mineral 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 mineral 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 mineral wool in the wall that an ordinary FRTW assembly does not match.

## Rational Analysis



### 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.<sup>7</sup>

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

### Derivation Calculation

Utilizing test data from reference document #7, (equation #10) and Fig. 2 above. The calculated stud surface temperature can be derived and graphed.

Eq. 10<sup>7</sup>

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

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)

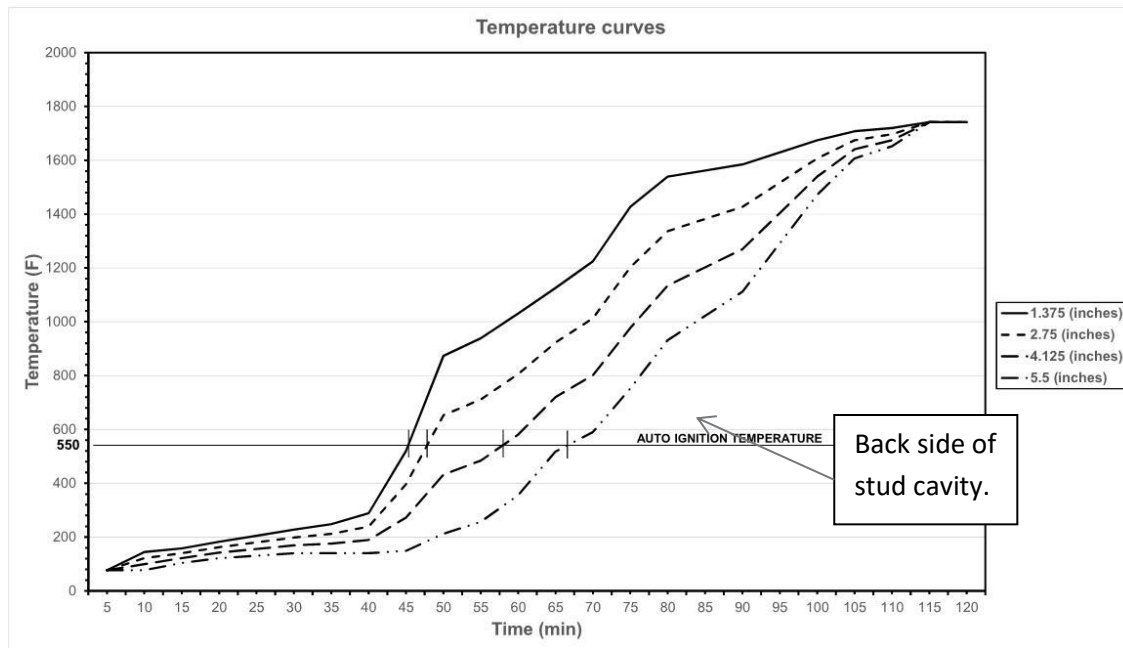


Figure 2A: Time vs Stud Surface Temperature curve – Calculated per Eq. 10.7

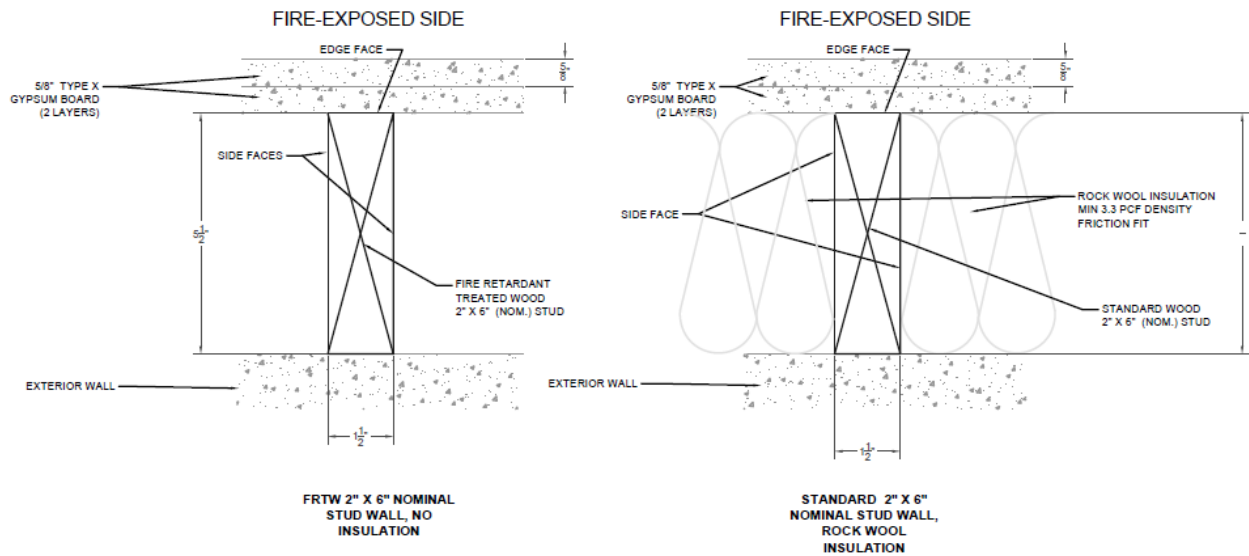
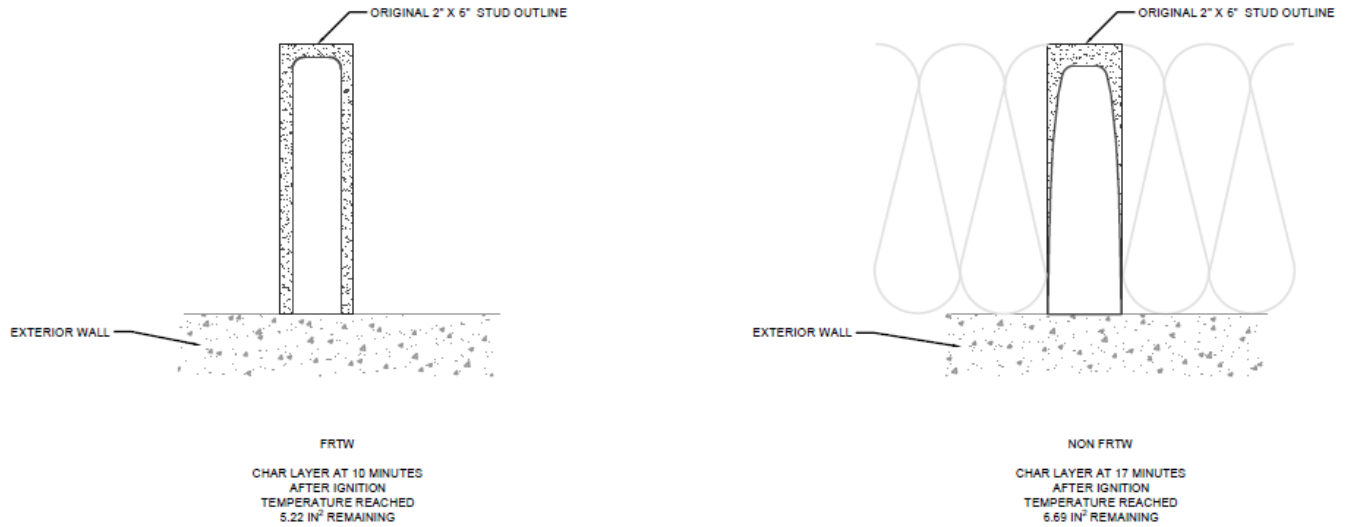


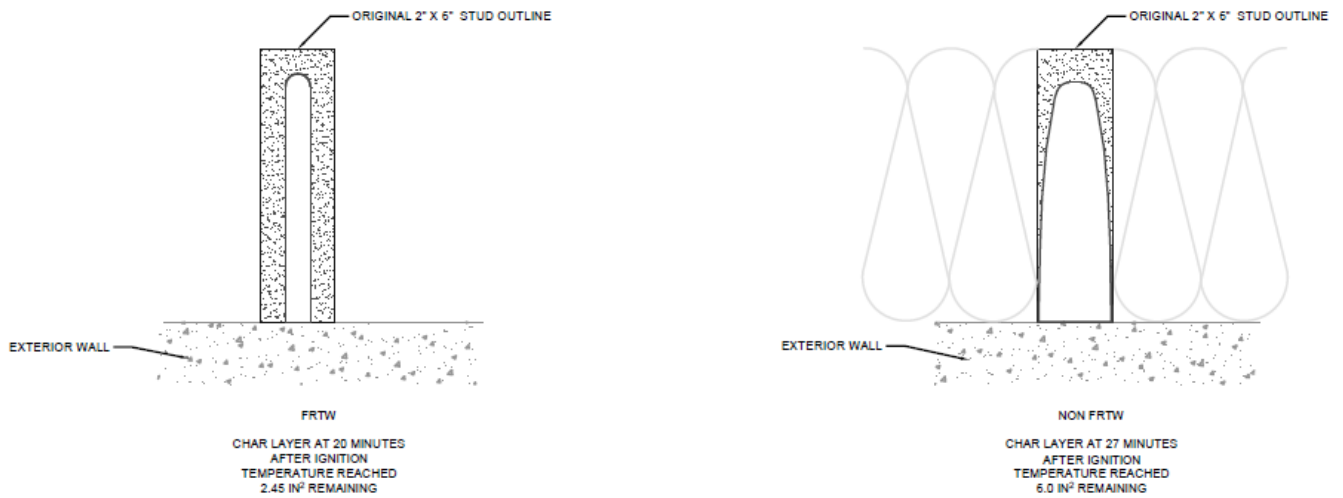
Figure 3: FRTW and Mineral Wool Stud Walls

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-hour 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.

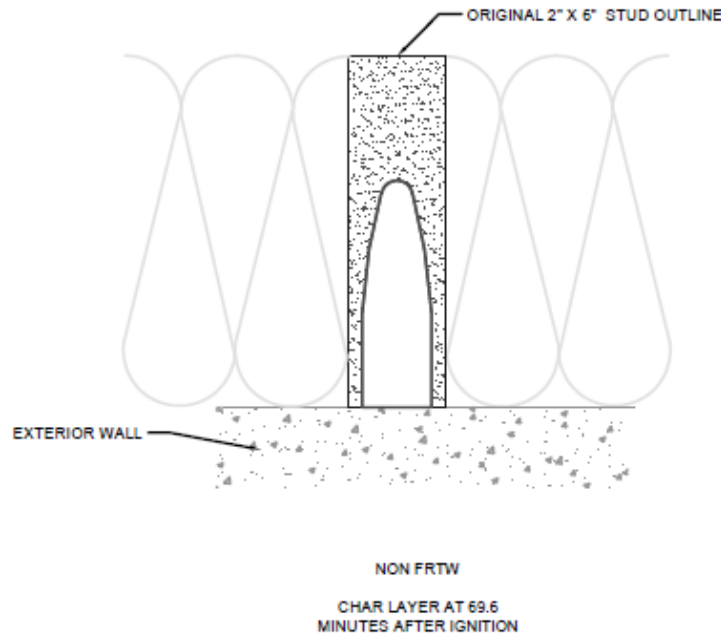
## 5. FIRE RESISTANCE COMPARISON



*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 auto ignition 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 mineral 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 mineral wool insulation performs better than FRT wood framing under fire conditions.



Time Interval (minutes)	Description	FRTW Stud Reaction	Standard Stud with Mineral 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 stud 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
t=60		Charring has consumed 50% of allowable	Charring has consumed approximately 27% of allowable
t =70		Char layer exceeds allowable, insufficient cross-section of stud available to support load, stud fails	Charring has consumed approximately 39% of allowable
t = 112.6			Char layer exceeds allowable, insufficient cross-section of stud available to support load, stud fails

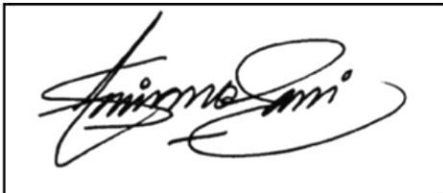
## 6. ADDITIONAL BENEFITS

- 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.

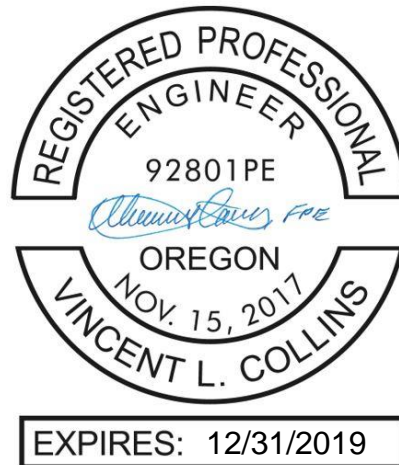
2. The process of pressure-impregnating chemicals into wood to achieve FRT lumber has a negative environmental impact, due to increased use of virgin chemicals and more waste chemicals that need to be treated before discharge into the sewer system. Additionally, there are health impact concerns to the occupants of the building from a long-term exposure to the chemicals used in pressure impregnation. Unlike the chemical FRT process, mineral 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. Mineral 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

Mineral wool batt insulation friction fit between the 2x6 studs and 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 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.



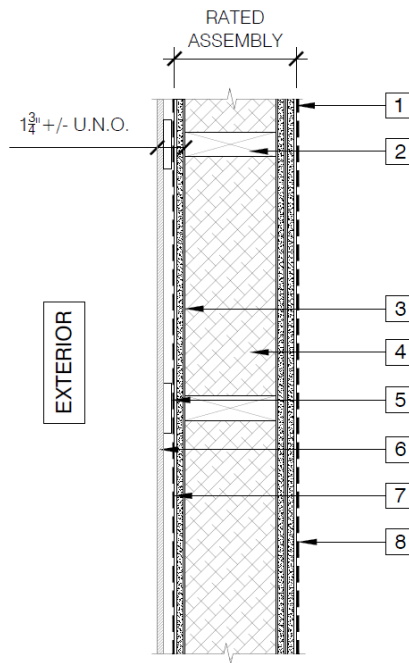
*Samir Mokashi*  
Principal/Code Analyst  
Code Unlimited



*Vincent Collins*  
Fire Protection Engineer  
Principal/Code Unlimited

# Appendix A

## Proposed Wall Section

**ASSEMBLY LEGEND:**

- 1 09 25 10, (2) LAYERS 5/8" TYPE X GYPSUM BOARD FOR FIRE-RESISTANT USE
- 2 06 11 00, 2x6 NON-FRT WOOD FRAMING, SIZE AND SPACING AS SCHEDULED PER STRUCTURAL
- 3 06 16 00, (1) LAYER 5/8" EXTERIOR GYPSUM SHEATHING
- 4 07 21 00, MINERAL WOOL INSULATION FIT TIGHT TO CAVITY, R-21, INS-2
- 5 07 46 00, NON-COMBUSTIBLE VERTICAL FURRING
- 6 07 46 00, NON-COMBUSTIBLE FIBER CEMENT SIDING
- 7 07 27 10, WEATHER RESISTANT BARRIER
- 8 09 90 00, INTERIOR FINISH PAINT OVER PRIMER - VAPOR RETARDER

WALL TYPE 10 - EXTERIOR WOOD FRAME WALL W/ FSD X > 10					
LOCATION(S): LVLS 1-5, EXTERIOR LOAD BEARING WALL W/ NON-COMBUSTIBLE EXTERIOR WALL COVERING					
MARK	STUD SIZE	FIRE		SOUND ATTENUATION	
		RATING	RATING SOURCE	STC RATING	RATING SOURCE
10	2x6	2-HR	CODE GUIDE*	NA	
* 2 HOUR RATED IN ACCORDANCE WITH CITY OF PORTLAND CODE GUIDE - TYPE III CONSTRUCTION - OSSC/6/#4.					



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MODERA WOODSTOCK

**CODE APPEAL**  
 08.09.19

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**W10**

Appendix A; Figure 1: Exterior Wall