

Report for
DMFCWBS, LLC

CTLGroup Report No. 055022

**Limiting Heights of Composite Wall
Assemblies Composed of Cold-Formed Steel
Studs Sheathed with 5/8-in. USG Sheetrock®
Brand Firecode Type X Gypsum Panels for
Interior Non-Load Bearing Walls Subject to
Uniform Lateral Loads
per AC86-10**

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Submitted by:
Tim D. Tonyan, Ph.D.
Frank H. Laux, S.E.
Jared E. Brewe, Ph.D.

COA # 184-001246

5400 Old Orchard Road
Skokie, Illinois 60077-1030
(847) 965-7500

9030 Red Branch Road, Suite 110
Columbia, Maryland 21045

www.CTLGroup.com



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**LIMITING HEIGHTS OF COMPOSITE WALL ASSEMBLIES COMPOSED OF COLD-FORMED
STEEL STUDS SHEATHED WITH 5/8-IN. USG SHEETROCK® BRAND FIRECODE TYPE X
GYPSUM PANELS FOR INTERIOR NON-LOAD BEARING WALLS SUBJECT TO UNIFORM
LATERAL LOADS
PER AC86-10**

by

Tim D. Tonyan, Ph.D.¹

Frank H. Laux, S.E.²

Jared E. Brewe, Ph.D.³

1. INTRODUCTION

The joint venture of Dietrich Metal Framing Clark Western Building Systems, LLC (DMFCWBS) produces a proprietary stud and track system for use in the construction of interior non-load bearing partition walls sheathed with gypsum board. This proprietary stud, collectively known as ProSTUD, consists of light-gauge cold-formed steel C-sections with cross-sectional features which enhance performance over traditional interior C-stud components.

The objective of the work described in this report was to calculate limiting heights for cold-formed steel stud interior non-load bearing wall panel assemblies based on stiffness and strength requirements of the composite system. The limiting heights analysis is required to obtain evaluation service reports from recognized code agencies. Design professionals use these limiting height values to select the appropriate member sizes for interior non-load bearing wall applications, which accommodate prescribed design load and deflection serviceability requirements.

Framing for these wall assemblies consists of a family of components fabricated from base metal thicknesses of 15, 22, 26, and 33-mil and available in stud depths of 1 5/8-in., 2 1/2-in., 3 1/2-

¹ Principal, CTLGroup, 5400 Old Orchard Road, Skokie, IL 60077

² Principal Engineer, CTLGroup, 5400 Old Orchard Road, Skokie, IL 60077

³ Associate II, CTLGroup, 5400 Old Orchard Road, Skokie, IL 60077

in., 3 5/8-in., 4-in., 5 1/2-in., and 6-in. The vertical drywall studs are secured between upper and lower horizontal track members. The steel components support 5/8-in. thick USG Sheetrock® Brand Firecode Type X gypsum panels across both faces orientated in the vertical direction. The wall assembly acts as a simply supported composite member resisting uniform transverse loading. The results of this work are an alternative to the sheathing-braced design referenced in building codes for cold-formed steel stud wall assemblies resisting transverse loads.

Structural Testing and Research Inc. (STaR), International Accreditation Service (IAS) Testing Laboratory TL-340, conducted wall panel tests for determining the limiting heights of composite walls constructed of gypsum board and steel studs. The test method is outlined below and presented in detail along with the results in STaR Technical Report No: 3100902C (Amended), “Composite Wall Testing of DMFCWBS, LLC ProSTUD™ with 5/8” Type X Gypsum Board”, dated January 12, 2010 (Amended 22 February, 2010). Data sheets for each individual test are presented in STaR Technical Report No: 3100902C-Test Data Sheets, “Composite Wall Testing of DMFCWBS ProSTUD™ with 5/8” Type X Gypsum Board – Test Data Sheets”, dated January 12, 2010.

As detailed and described in this report, CTLGroup, IAS Testing Laboratory TL-200, used load test results to calculate the controlling limiting wall heights. The specific subject of this report is the proprietary drywall stud and track system fabricated from light-gauge steel sheathed with 5/8-in. thick USG Sheetrock® Brand Firecode Type X gypsum panels oriented in the vertical direction across both faces.

2. WALL PANEL TESTS

The procedure for testing and evaluating the structural performance of cold-formed steel studs used in interior non-load bearing wall assemblies is defined by *ICC-ES AC86-10 – Acceptance Criteria for Cold-Formed Steel Framing Members – Interior Nonload-Bearing Wall Assemblies, approved February 2010* (AC86). This document is included as Appendix A of this report. A series of transverse load tests were conducted on various proprietary steel framing components manufactured by DMFCWBS. This program evaluates the structural performance of composite wall assemblies fabricated with the proprietary steel-framing members under uniform lateral loads to establish the limiting wall heights.

Tests were conducted at the Dietrich Metal Framing, Inc. test facility in Hammond, IN under the supervision of Mr. Thomas J. Lawson and Mr. Nagaraj Eshwar of Dietrich Design Group, IAS

Testing Laboratory TL-242. STaR personnel under the supervision of Steven R. Fox, Ph.D., P.E. witnessed the testing to collect and report on the results.

Tests were performed on 4-ft. wide walls for stiffness, flexural strength, and end reaction strength evaluation. Stud components were fabricated from base metal thickness of 15, 22, 26, and 33-mil and tested in depths of 1 $\frac{5}{8}$ -in., 2 $\frac{1}{2}$ -in., 3 $\frac{5}{8}$ -in., and 6-in. Two differing wall heights were tested for wall assembly stiffness and flexural strength evaluation, one height was tested for end reaction strength evaluation. The maximum stud spacing of 24-in. on-center was tested, along with select confirmatory tests of 12-in. on-center stud spacing. Testing of only the maximum stud spacing is allowed provided the results of the minimum spaced studs is within 15% of the results of the maximum spaced studs. Three identical tests for each combination of base metal thickness, stud depth, stud spacing, and wall height were performed.

The tests are reported in STaR Report 3100902C (Amended), which includes descriptions of materials and test specimens, test fixtures and setup, test procedure and results. Material properties of the steel components and gypsum board used in the testing are tabulated in Appendix B. Steel stud material properties were used to normalize test results per AC86 Section 3.3.1.1.

Results from the tests are used in this report to obtain limiting heights based on deflection, flexural strength, and end reaction capacities. A summary of the test methods follows:

2.1. DEFLECTION LIMIT TESTS

Transverse load tests were conducted on short and tall wall assemblies which are used in combination to derive the limiting height. The deflection limit tests are used to obtain an average bending stiffness of the composite wall assembly, which is used to calculate the limiting heights based on wall assembly stiffness. During the test, mid-span lateral displacements of the wall specimens were monitored as the specimen was subject to uniform transverse air-pressure loading. Specific deflection targets defined as $L/360$, $L/240$, and $L/120$ (where L is the span length of the specimen) were achieved and the load required to displace the specimen was measured. As allowed by AC86, if a deflection of $L/120$ cannot be obtained, a target of $L/180$ was permitted. The combination of deflection target and applied load were used to determine the wall assembly stiffness, which in turn was used for stiffness based limiting heights.

2.2. FLEXURAL STRENGTH TESTS

After cycling through the deflection test procedure described above, each wall panel test specimen was loaded to failure. According to AC86, “failure is defined as when the maximum pressure cannot be sustained without the sudden or continuous movement of the test assembly.” That maximum failure pressure was set as the controlling peak test load for flexural strength based limiting heights.

2.3. END REACTION TESTS

End reaction tests were conducted on short, 4-ft walls to prevent a flexural failure mode in the test panels. This configuration would impose shear, web-crippling, or connection shear failure modes, as much as possible. The maximum applied pressure from each test was set as the controlling peak test load for end reaction strength based limiting heights.

3. LIMITING HEIGHTS DERIVATION

Test results are used to calculate limiting heights of composite interior non-load bearing wall assemblies subjected to uniform lateral pressure. The calculations were performed for base metal thickness of 15, 22, 26, and 33-mil; stud depths of 1 5/8-in., 2 1/2-in., 3 1/2-in., 3 5/8-in., 4-in., 5 1/2-in., and 6-in.; and stud spacings of 12-in., 16-in., and 24-in. on-center. The uniform lateral pressures considered were 5, 7.5, 10, and 15 psf with associated deflection targets of L/360, L/240, and L/120. The limiting heights calculations follow the method prescribed by ICC-ES AC86. Calculation summary sheets for each wall assembly are included as Appendix C of this report.

An overview of the calculation procedure follows:

3.1. LIMITING HEIGHTS BASED ON WALL ASSEMBLY STIFFNESS

Calculations for stiffness based limiting heights were in accordance with Section 3.2 of AC86. As stated in Section 3.2.1: “Wall assembly bending stiffness, EI , shall be based on the equation for midspan deflection of a simply supported beam with uniformly distributed loading over its entire span.” That equation is:

$$\Delta = \frac{5wL^4}{384EI} \quad (\text{Eq. 3.1a})$$

where Δ = midspan deflection
 w = uniform load
 L = span length
 EI = composite bending stiffness

Rearrangement of the variables in Equation 1a into terms of known quantities results in:

$$EI = \frac{5WsL^4}{384\Delta} \quad (\text{Eq. 3.1b})$$

where W = uniform load applied to the specimen
 s = stud spacing
 L = span length of the test specimen
 Δ = midspan target deflection of the test specimen

The midspan displacement of the test specimen is derived from the incremental deflection measured from the previous set deflection after release of load to the current set deflection following application of load. Set deflection refers to the deflection measured 5 minutes after either the release or application of a load increment.

For a specific test result with a known span length, measured uniform lateral pressure, and measured displacement, a distinct wall assembly composite bending stiffness, EI , is calculated.

With the composite bending stiffness established, the limiting height for a given uniform lateral pressure and deflection target can be determined. Rearrangement of Equation 1b can be performed to solve for the limiting height, H , as follows:

$$H^4 = \frac{384EI\Delta}{5ws} \quad (\text{Eq. 3.1c})$$

Setting the midspan displacement, Δ , equal to the target deflection limit of H/360, H/240, or H/120 results in the following:

$$H = \left(\frac{384EI}{5wsa} \right)^{\frac{1}{3}} \quad (\text{Eq. 3.1d})$$

where w = specified design lateral pressure of 5, 7.5, 10, or 15 psf
 s = stud spacing
 a = specified deflection target in terms of a fraction of the span length equal to 120, 240, or 360

Linear interpolation is prescribed in AC86 to obtain the limiting wall heights between the derived short wall limiting height and the derived tall wall limiting height. The interpolation is as follows:

$$L_{LH} = \frac{(L_1 \times H_2) - (L_2 \times H_1)}{H_2 - H_1 - L_2 + L_1} \quad (\text{Eq. 3.1e})$$

where L_{LH} = interpolated limiting wall height
 L_1 = actual span of the short test assembly
 L_2 = actual span of the tall test assembly
 H_1 = derived limiting height for a specific deflection target and design load based on the controlling EI value from short-span wall test data
 H_2 = derived limiting height for a specific deflection target and design load based on the controlling EI value from long-span wall test data

These interpolated limiting heights are controlled by the following criteria set forth in AC86:

- 3.2.3.1: If H_1 is greater than $2H_2$, then H_2 shall be used rather than L_{LH} .
- 3.2.3.2: If the value of H_1 is less than L_1 for any specific design load and deflection target combination, then L_{LH} shall be discarded and the wall assembly shall not be permitted to resist that specific design load and deflection target.
- 3.2.3.3: In no case shall L_{LH} be greater than $(H_1 + H_2)/2$.
- 3.2.4: The value of L_{LH} shall be less than $2L_2$.

3.2. LIMITING HEIGHTS BASED ON WALL ASSEMBLY STRENGTH

Calculations for strength based limiting heights were in accordance with Section 3.3 of AC86. It stipulates that “When the wall assembly construction deviates from the AISI-S211 provisions, limiting wall heights based on strength characteristics of the wall assembly may be derived in accordance with the provisions of this section.” Wall assembly strength limiting heights are controlled by flexural, shear, and web crippling strength. As described in the test methods, this requires two different tests to determine the limiting strength criteria.

3.2.1. Flexural Strength

AC86 Section 3.3.1 provides the following formula for derivation of wall assembly limiting height based on flexural strength:

$$L_f = \sqrt{\frac{R_s P L_t^2}{\Omega W}} \quad (\text{Eq. 3.2a})$$

- where
- L_f = limiting height based on flexural strength
 - R_s = adjustment factor
 - P = controlling peak test load
 - L_t = span of test assembly
 - Ω = factor of safety
 - W = specified design lateral pressure of 5, 7.5, 10, of 15 psf

The adjustment factor used to account for material variability (yield point or thickness) is determined by the following equation:

$$R_s = \left(\frac{F_{y\text{-specified}}}{F_{y\text{-tested}}} \right) \times \left(\frac{t_{\text{specified}}}{t_{\text{tested}}} \right) \leq 1.0 \quad (\text{Eq. 3.2b})$$

- where
- $F_{y\text{-specified}}$ = specified yield stress of the steel
 - $F_{y\text{-tested}}$ = specified yield stress of the steel
 - $t_{\text{specified}}$ = design steel thickness specified in the evaluation report or the coil steel thickness specified in the quality documentation, as applicable
 - t_{tested} = measured steel thickness

The factor of safety, Ω , used in Equation 2 is determined in accordance with Section F1.2 of AISI-S100. The resistance factor equation from Chapter F of AISI-S100 and a sample calculation are shown in Appendix D.

Linear interpolation is permitted between multiple test heights to derive the limiting heights based on flexural strength, up to twice the height of the tested assembly. For flexural strength based limiting heights, the mean value of the short and tall wall assemblies was used as the interpolated value.

3.2.2. End Reaction Strength

AC86 Section 3.3.2 provides the following formula for derivation of wall assembly limiting height based on end reactions strength:

$$L_r = \frac{R_s B L_t}{\Omega W} \quad (\text{Eq. 3.2c})$$

where

- L_r = limiting height based on end reaction strength
- R_s = adjustment factor
- B = controlling peak test load
- L_t = span of test assembly
- Ω = factor of safety
- W = specified design lateral pressure of 5, 7.5, 10, or 15 psf

The adjustment factor and the factor of safety used follows the same method as that of flexural strength.

3.3. CONTROLLING LIMITING HEIGHTS

For each specific combination of stud depth, stud spacing, deflection limit and design lateral pressure, the controlling limiting height is the lesser of the stiffness-based and the strength-based limiting heights.

4. TESTED STUD DEPTH EVALUATION

For tested stud depths, the derivation of limiting heights is straightforward. Test results are used to determine the wall assembly stiffness and strength and the derivation of controlling limiting heights proceeds as shown above. A detailed sample calculation for tested stud depths is provided in Appendix E.

4.1. FLEXURAL STIFFNESS

For tested stud depths, an average composite bending stiffness of three identical test specimens is used in the calculation of the final limiting height for each wall assembly. The calculation for the stiffness based limiting heights proceeds as described in Section 3.1.

4.2. FLEXURAL STRENGTH

Wall assembly flexural strength is controlled by the strength of the stud plus the contribution from the gypsum board sheathing. The primary failure mode for the test is local buckling of the compression flange of the stud approximately at midspan. Once the controlling peak test load is determined, the derivation of the flexural strength based limiting heights proceeds as described in Section 3.2.1.

4.3. END REACTION STRENGTH

Wall assembly end reaction strength is controlled by the shear strength of the stud, the web crippling resistance of the stud, and stud pullout and shear at the connection to the bottom track. Multiple failure modes occurred during testing: 1 5/8-in. stud depths typically resulted in flexural failure from local buckling of the compression flange; 2 1/2-in. and 3 5/8-in. stud depths typically resulted in the stud pulling out of the track, and 6-in. stud depths typically resulted in web crippling or gypsum board collapse. With the controlling peak load determined, the derivation of the end reaction strength based limiting heights then proceeds as described in Section 3.2.2.

4.4. STUD SPACING EVALUATION

Tests were conducted on wall assemblies with studs spaced at 24-in. on-center. AC86 allows only testing the maximum considered stud spacing provided the results of the minimum spaced studs is within 15% of the results of the maximum spaced studs. Select 12-in. stud spacing configurations were tested to satisfy this requirement and to verify the extrapolation scheme. A detailed sample calculation for intermediate stud spacings is included in Appendix E.

4.4.1. Extrapolation of Stiffness

Wall assembly bending stiffness, EI , values were derived per stud from the 24-in. on-center wall tests. For configurations with studs spaced at 12-in. and 16-in. on-center, Equation 3.1d accounts for the variable stud spacing.

4.4.2. Extrapolation of Strength

Wall assembly controlling peak load values for configurations with studs spaced at 12-in. and 16-in. on-center are derived from the peak load values obtained from the tested configurations with studs spaced at 24-in. on-center. Accounting for the full 4-ft. test panel the derived controlling peak load can be found as:

$$\begin{aligned}(P_{12})(12/48) &= (P_{24})(24/48) \\ P_{12} &= (P_{24})(4/2) \\ P_{12} &= 2P_{24}\end{aligned}$$

$$\begin{aligned}(P_{16})(16/48) &= (P_{24})(24/48) \\ P_{16} &= (P_{24})(3/2) \\ P_{16} &= \frac{3}{2}P_{24}\end{aligned}$$

A similar relationship is used in the derivation of the controlling peak load for end reaction strength based limiting heights:

$$\begin{aligned}B_{12} &= 2B_{24} \\ B_{16} &= \frac{3}{2}B_{24}\end{aligned}$$

The derivation of the flexural strength and end reaction based limiting heights then proceeds as described in Section 3.2.1 and 3.2.2, respectively.

5. INTERMEDIATE STUD DEPTH EVALUATION

Tests were conducted on wall assemblies with stud depths of 1 5/8-in., 2 1/2-in., 3 5/8-in., and 6-in. The proprietary stud family includes additional stud depths of 3 1/2-in., 4-in., and 5 1/2-in. To derive limiting heights for these intermediate depths, relationships were developed between results from tested stud depths and relevant stud depth parameters. A detailed sample calculation for intermediate stud depths is provided in Appendix F. The linear relationships used for stiffness and strength are shown in Appendix G.

5.1. INTERPOLATION OF STIFFNESS

The EI values are expressed in terms of wall assembly stiffness based on the combined stud contribution and contributory width of the gypsum panel to the overall assembly flexural stiffness. The averaged EI values are dependant on the stiffness of the material, E , (which will remain consistent throughout) and the moment of inertia, I , of the composite section. The moment of inertia can be found to be proportional to the *square of the stud depth*, d^2 , due to the parallel axis theorem where $I_x = I_{CG} + Ad^2$. A linear relationship was developed between the square of the stud depth and the calculated wall assembly stiffness, which was used to determine stiffness for intermediate stud depths. These linear relationships are shown in Appendix G for each base metal thickness. The calculation for the stiffness based limiting heights then proceeds as described in Section 3.1.

5.2. INTERPOLATION OF FLEXURAL STRENGTH

The peak flexural load is used in the determination of the limiting height based on flexural strength. This load is dependant on the wall assembly test height and the wall assembly strength capacity. For comparison, the peak load needs to be converted to a moment to account for the differing tested wall heights. The moment demand of the wall assembly from the peak flexural load is found from the following equation:

$$M_d = \frac{P \cdot 4ft \cdot L^2}{8} \quad (\text{Eq. 5.2a})$$

where M_d = demand moment of the wall assembly
 P = controlling peak test load
 L = span of test assembly

The strength capacity of the wall assembly is dependant of the moment capacity of the composite wall section. The moment capacity of a steel section is found from the allowable yield stress and the section modulus:

$$M_n = S_e f_y \quad (\text{Eq. 5.2b})$$

where M_n = moment capacity of the wall assembly
 S_e = section modulus
 f_y = yield strength of section

The section modulus is derived from the moment of inertia, I , divided by the distance to the extreme fiber, y . Since I is proportional to d^2 as shown above, and y is proportional to d , the

section modulus is considered to be proportional to d . The contribution of gypsum board to moment capacity is determined from the area and strength of the material and the distance to the neutral axis. Since the material parameters remain constant, the distance to the neutral axis is the remaining variable, which is also proportional to d .

A linear relationship was developed between the tested stud depth and the tested wall assembly moment demand. This relationship was used to determine the moment demand for intermediate stud depths, which are then used to derive the peak flexural load for use in flexural strength limiting heights. These linear relationships are shown in Appendix G for each base metal thickness. For ProSTUD 25 (15 mil) and 20HD (26 mil), a linear relationship was used between 2 ½-in. and 6-in. due to the scatter and relationship between data points. The derivation of the flexural strength based limiting heights then proceeds as described in Section 3.2.1. The factor of safety used in the limiting height equation was the minimum value since all flexural strength tests used the minimum value.

5.3. INTERPOLATION OF END REACTION STRENGTH

The failure mode of the end reaction tests depends on the depth of the tested stud section compared to the tested span length. For shallow stud depths, flexural failure of the stud becomes the critical mode of failure, whereas for deeper stud depths, web crippling becomes the dominant failure mode. Using web crippling as the controlling failure mode, AISI-NAS Equation C3.4.1-1 for web crippling strength would indicate that the following would provide an appropriate proportional relationship to the end reaction strength:

$$1 - C_h \sqrt{h/t} \quad (\text{Eq. 5.3a})$$

where C_h = web slenderness coefficient, taken as equal to 0.2
 h = flat dimension of web, taken as equal to stud depth
 t = web thickness

This relationship was developed for the 4-in. and 5 ½-in. interpolated stud depths due to the failure mode of the deeper stud depth end reaction tests. For the 3.5-in. stud depth, flexural strength becomes the dominant mode of failure and this relationship is no longer valid and no longer results in a controlling limiting height. A piecewise linear relationship between B and the result of *Equation 5.3a* was used between the bracketing stud depths for each interpolation. The derivation of the end reaction strength based limiting heights then proceeds as described in Section 3.2.2. The factor of safety used in the limiting height equation was the worst case of the stud depths bracketing the interpolated stud depth.

6. LIMITING HEIGHT RESULTS

The calculated limiting heights based on the testing and analyses described above are tabulated and are shown in Table 1 titled, "Limiting Heights for Interior Non-Structural Composite Wall Panels using DMFCWBS ProSTUD Components."

7. LIMITATIONS ON APPLICATION OF TEST RESULTS IN DESIGN

The results of this work are an alternative to the sheathing-braced design referenced in building codes for cold-formed steel stud wall assemblies resisting transverse loads. The greater of the published composite limiting height or the AISI calculated non-composite limiting height of the sheathing-braced stud is intended to be used for design.

The limiting height values presented in this report are appropriate for the design of interior non-load bearing walls made with DMFCWBS proprietary steel framing members. Use of the reported results for walls with different stud spacing, or substantially different wall configurations, should only be done by a licensed professional engineer with a clear understanding of the test methods and calculation procedures used to generate the reported results from the tests.

The following condition of use is in accordance with AC86 Section 6.1.4: "The interior nonload-bearing wall assemblies shall be limited to interior installations where the superimposed axial load is zero pounds."

8. CODES AND REFERENCED STANDARDS

ICC-ES AC86-10, Acceptance Criteria for Cold-Formed Steel Framing Members – Interior Nonload-Bearing Wall Assemblies, International Code Council Evaluation Service, Whittier, CA, approved February 2010

AISI S100-2007, North American Specification for the Design of Cold-Formed Steel Structural Members, American Iron and Steel Institute, 2007 Edition

Limiting Heights for ProSTUD 25 with 5/8" USG Sheetrock® Brand Firecode Type X Gypsum Panels													
Stud Depth (in)	Stud Spacing (in)	5 psf			7.5 psf			10 psf			15 psf		
		L/120	L/240	L/360	L/120	L/240	L/360	L/120	L/240	L/360	L/120	L/240	L/360
1 5/8	12	14' - 4"	11' - 4"	9' - 11"	12' - 6"	9' - 11"	8' - 5"	11' - 4"	8' - 10"	---	8' - 2" f	---	---
	16	13' - 0"	10' - 4"	8' - 10"	11' - 4"	8' - 10"	---	10' - 4"	7' - 10"	---	---	---	---
	24	11' - 4"	8' - 10"	---	9' - 11"	---	---	8' - 9" f	---	---	---	---	---
2 1/2	12	17' - 2"	13' - 7"	11' - 11"	15' - 0"	11' - 11"	10' - 5"	13' - 6" f	10' - 10"	9' - 4"	8' - 10" f	8' - 10" f	---
	16	15' - 7"	12' - 4"	10' - 10"	13' - 6" f	10' - 10"	9' - 4"	11' - 8" f	9' - 10"	8' - 2"	---	---	---
	24	13' - 6" f	10' - 10"	9' - 4"	11' - 0" f	9' - 4"	---	9' - 6" f	8' - 2"	---	---	---	---
3 1/2	12	20' - 0"	15' - 10"	13' - 10"	17' - 6"	13' - 10"	12' - 1"	15' - 10" f	12' - 7"	11' - 0"	10' - 5" f	10' - 5" f	9' - 6"
	16	18' - 2"	14' - 5"	12' - 7"	15' - 10" f	12' - 7"	11' - 0"	13' - 9" f	11' - 5"	10' - 0"	9' - 0" f	9' - 0" f	8' - 6"
	24	15' - 10" f	12' - 7"	11' - 0"	12' - 11" f	11' - 0"	9' - 6"	11' - 2" f	10' - 0"	8' - 6"	---	---	---
3 5/8	12	21' - 0"	16' - 8"	14' - 7"	18' - 4"	14' - 7"	12' - 9"	15' - 11" f	13' - 3"	11' - 7"	10' - 6" f	10' - 6" f	9' - 11"
	16	19' - 1"	15' - 2"	13' - 3"	15' - 11" f	13' - 3"	11' - 7"	13' - 10" f	12' - 0"	10' - 4"	9' - 1" f	9' - 1" f	8' - 10"
	24	15' - 11" f	13' - 3"	11' - 7"	13' - 0" f	11' - 7"	9' - 11"	11' - 3" f	10' - 4"	8' - 10"	---	---	---
4	12	22' - 1"	17' - 6"	15' - 4"	19' - 4"	15' - 4"	13' - 5"	16' - 11" f	13' - 11"	12' - 2"	11' - 2" f	11' - 2" f	10' - 4"
	16	20' - 1"	15' - 11"	13' - 11"	16' - 11" f	13' - 11"	12' - 2"	14' - 8" f	12' - 8"	10' - 10"	9' - 8" f	9' - 8" f	9' - 2"
	24	16' - 11" f	13' - 11"	12' - 2"	13' - 10" f	12' - 2"	10' - 4"	12' - 0" f	10' - 10"	9' - 2"	---	---	---
5 1/2	12	26' - 11"	21' - 4"	18' - 8"	23' - 0" f	18' - 8"	16' - 4"	19' - 11" f	16' - 11"	14' - 10"	13' - 1" f	13' - 1" f	12' - 10"
	16	24' - 5" f	19' - 5"	16' - 11"	19' - 11" f	16' - 11"	14' - 10"	17' - 3" f	15' - 5"	13' - 5"	11' - 4" f	11' - 4" f	11' - 4" f
	24	19' - 11" f	16' - 11"	14' - 10"	16' - 3" f	14' - 10"	12' - 10"	14' - 1" f	13' - 5"	11' - 5"	9' - 3" f	9' - 3" f	9' - 3" f
6	12	28' - 0"	22' - 9"	20' - 6"	24' - 1" f	19' - 11"	17' - 11"	20' - 10" f	18' - 1"	16' - 3"	13' - 8" f	13' - 8" f	13' - 8" f
	16	25' - 6"	20' - 8"	18' - 7"	20' - 10" f	18' - 1"	16' - 3"	18' - 1" f	16' - 5"	14' - 9"	11' - 10" f	11' - 10" f	11' - 10" f
	24	20' - 10" f	18' - 1"	16' - 3"	17' - 0" f	15' - 9"	14' - 2"	14' - 9" f	14' - 3"	12' - 8"	---	---	---

NOTES:

- Allowable composite limiting heights are calculated using ICC-ES AC86-2008. In accordance with current building codes and AISI design standards, the 1/3 Stress Increase for strength was not used.
- The composite limiting heights provided in the tables are based on a single layer of gypsum board complying with ASTM C1396.
- The gypsum board must be applied full height in the vertical orientation to each stud flange and installed using minimum No. 6 Type S Drywall screws spaced a minimum of 12-in on-center to the framing members in accordance with ASTM C754-2004.
- No fasteners are required for attaching the stud to the track except as detailed in ASTM C754-2004.
- Stud end bearing must be a minimum of 1 inch.
- Minimum material yield strength equals 70 ksi for 15-mil studs.
- 'f' adjacent to the height value indicates that flexural stress controls the allowable wall height.
- 's' adjacent to the height value indicates that shear/end reaction controls the allowable wall height.

Limiting Heights for ProSTUD 20 with 5/8" USG Sheetrock® Brand Firecode Type X Gypsum Panels													
Stud Depth (in)	Stud Spacing (in)	5 psf			7.5 psf			10 psf			15 psf		
		L/120	L/240	L/360	L/120	L/240	L/360	L/120	L/240	L/360	L/120	L/240	L/360
1 5/8	12	14' - 9"	11' - 8"	10' - 3"	12' - 10"	10' - 3"	8' - 9"	11' - 8"	9' - 2"	---	10' - 0" f	---	---
	16	13' - 5"	10' - 7"	9' - 2"	11' - 8"	9' - 2"	---	10' - 7"	8' - 1"	---	8' - 8" f	---	---
	24	11' - 8"	9' - 2"	---	10' - 3"	---	---	9' - 2"	---	---	---	---	---
2 1/2	12	18' - 5"	14' - 8"	12' - 9"	16' - 1"	12' - 9"	11' - 2"	14' - 8"	11' - 7"	10' - 2"	11' - 6" f	10' - 2"	8' - 7"
	16	16' - 9"	13' - 4"	11' - 7"	14' - 8"	11' - 7"	10' - 2"	13' - 4"	10' - 7"	9' - 0"	9' - 11" f	9' - 0"	---
	24	14' - 8"	11' - 7"	10' - 2"	12' - 9"	10' - 2"	8' - 7"	11' - 7"	9' - 0"	---	8' - 1" f	---	---
3 1/2	12	22' - 9"	18' - 1"	15' - 10"	19' - 11"	15' - 10"	13' - 10"	18' - 1"	14' - 4"	12' - 6"	13' - 6" f	12' - 6"	10' - 11"
	16	20' - 8"	16' - 5"	14' - 4"	18' - 1"	14' - 4"	12' - 6"	16' - 5"	13' - 1"	11' - 5"	11' - 8" f	11' - 5"	9' - 11"
	24	18' - 1"	14' - 4"	12' - 6"	15' - 10"	12' - 6"	10' - 11"	14' - 4"	11' - 5"	9' - 11"	9' - 6" f	9' - 6" f	8' - 7"
3 5/8	12	23' - 9"	18' - 11"	16' - 6"	20' - 9"	16' - 6"	14' - 5"	18' - 11"	15' - 0"	13' - 1"	14' - 1" f	13' - 1"	11' - 4"
	16	21' - 7"	17' - 2"	15' - 0"	18' - 11"	15' - 0"	13' - 1"	17' - 2"	13' - 7"	11' - 10"	12' - 3" f	11' - 10"	10' - 3"
	24	18' - 11"	15' - 0"	13' - 1"	16' - 6"	13' - 1"	11' - 4"	15' - 0"	11' - 10"	10' - 3"	10' - 0" f	10' - 0" f	---
4	12	25' - 4"	20' - 1"	17' - 7"	22' - 1"	17' - 7"	15' - 4"	20' - 1"	15' - 11"	13' - 11"	14' - 3" f	13' - 11"	12' - 1"
	16	23' - 0"	18' - 3"	15' - 11"	20' - 1"	15' - 11"	13' - 11"	18' - 3"	14' - 6"	12' - 8"	12' - 4" f	12' - 4" f	10' - 11"
	24	20' - 1"	15' - 11"	13' - 11"	17' - 7"	13' - 11"	12' - 1"	15' - 4" f	12' - 8"	10' - 11"	10' - 1" f	10' - 1" f	9' - 5"
5 1/2	12	30' - 11"	24' - 7"	21' - 6"	27' - 1"	21' - 6"	18' - 9"	24' - 7"	19' - 6"	17' - 0"	16' - 5" f	16' - 5" f	14' - 11"
	16	28' - 2"	22' - 4"	19' - 6"	24' - 7"	19' - 6"	17' - 0"	21' - 8" f	17' - 9"	15' - 6"	14' - 3" f	14' - 3" f	13' - 6"
	24	24' - 7"	19' - 6"	17' - 0"	20' - 5" f	17' - 0"	14' - 11"	17' - 8" f	15' - 6"	13' - 6"	11' - 7" f	11' - 7" f	11' - 7" f
6	12	33' - 10"	26' - 0"	23' - 0"	29' - 7"	22' - 8"	20' - 1"	25' - 10" f	20' - 7"	18' - 3"	17' - 0" f	17' - 0" f	15' - 11"
	16	30' - 9"	23' - 7"	20' - 11"	25' - 10" f	20' - 7"	18' - 3"	22' - 4" f	18' - 9"	16' - 7"	14' - 8" f	14' - 8" f	14' - 6"
	24	25' - 10" f	20' - 7"	18' - 3"	21' - 1" f	18' - 0"	15' - 11"	18' - 3" f	16' - 4"	14' - 6"	12' - 0" f	12' - 0" f	12' - 0" f

NOTES:

- Allowable composite limiting heights are calculated using ICC-ES AC86-2008. In accordance with current building codes and AISI design standards, the 1/3 Stress Increase for strength was not used.
- The composite limiting heights provided in the tables are based on a single layer of gypsum board complying with ASTM C1396.
- The gypsum board must be applied full height in the vertical orientation to each stud flange and installed using minimum No. 6 Type S Drywall screws spaced a minimum of 12-in on-center to the framing members in accordance with ASTM C754-2004.
- No fasteners are required for attaching the stud to the track except as detailed in ASTM C754-2004.
- Stud end bearing must be a minimum of 1 inch.
- Minimum material yield strength equals 65 ksi for 22-mil studs.
- 'f' adjacent to the height value indicates that flexural stress controls the allowable wall height.
- 's' adjacent to the height value indicates that shear/end reaction controls the allowable wall height.

Limiting Heights for ProSTUD 20HD with 5/8" USG Sheetrock® Brand Firecode Type X Gypsum Panels													
Stud Depth (in)	Stud Spacing (in)	5 psf			7.5 psf			10 psf			15 psf		
		L/120	L/240	L/360	L/120	L/240	L/360	L/120	L/240	L/360	L/120	L/240	L/360
1 5/8	12	15' - 3"	12' - 1"	10' - 7"	13' - 4"	10' - 7"	9' - 1"	12' - 1"	9' - 7"	8' - 1"	10' - 7"	8' - 1"	---
	16	13' - 10"	11' - 0"	9' - 7"	12' - 1"	9' - 7"	8' - 1"	11' - 0"	8' - 6"	---	9' - 7"	---	---
	24	12' - 1"	9' - 7"	8' - 1"	10' - 7"	8' - 1"	---	9' - 7"	---	---	7' - 10" f	---	---
2 1/2	12	18' - 10"	15' - 0"	13' - 1"	16' - 6"	13' - 1"	11' - 5"	15' - 0"	11' - 11"	10' - 5"	12' - 8" f	10' - 5"	8' - 10"
	16	17' - 2"	13' - 7"	11' - 11"	15' - 0"	11' - 11"	10' - 5"	13' - 7"	10' - 9"	9' - 4"	11' - 0" f	9' - 4"	7' - 10"
	24	15' - 0"	11' - 11"	10' - 5"	13' - 1"	10' - 5"	8' - 10"	11' - 11"	9' - 4"	7' - 10"	9' - 0" f	7' - 10"	---
3 1/2	12	23' - 6"	18' - 8"	16' - 3"	20' - 6"	16' - 3"	14' - 3"	18' - 8"	14' - 10"	12' - 11"	15' - 1" f	12' - 11"	11' - 3"
	16	21' - 4"	16' - 11"	14' - 10"	18' - 8"	14' - 10"	12' - 11"	16' - 11"	13' - 5"	11' - 9"	13' - 1" f	11' - 9"	10' - 3"
	24	18' - 8"	14' - 10"	12' - 11"	16' - 3"	12' - 11"	11' - 3"	14' - 10"	11' - 9"	10' - 3"	10' - 8" f	10' - 3"	8' - 10"
3 5/8	12	24' - 5"	19' - 5"	16' - 11"	21' - 4"	16' - 11"	14' - 10"	19' - 5"	15' - 5"	13' - 5"	15' - 4" f	13' - 5"	11' - 8"
	16	22' - 2"	17' - 7"	15' - 5"	19' - 5"	15' - 5"	13' - 5"	17' - 7"	14' - 0"	12' - 2"	13' - 4" f	12' - 2"	10' - 6"
	24	19' - 5"	15' - 5"	13' - 5"	16' - 11"	13' - 5"	11' - 8"	15' - 5"	12' - 2"	10' - 6"	10' - 10" f	10' - 6"	---
4	12	26' - 1"	20' - 8"	18' - 1"	22' - 9"	18' - 1"	15' - 10"	20' - 8"	16' - 5"	14' - 4"	16' - 3" f	14' - 4"	12' - 6"
	16	23' - 8"	18' - 10"	16' - 5"	20' - 8"	16' - 5"	14' - 4"	18' - 10"	14' - 11"	13' - 0"	14' - 1" f	13' - 0"	11' - 3"
	24	20' - 8"	16' - 5"	14' - 4"	18' - 1"	14' - 4"	12' - 6"	16' - 5"	13' - 0"	11' - 3"	11' - 6" f	11' - 3"	9' - 9"
5 1/2	12	32' - 1"	25' - 6"	22' - 3"	28' - 1"	22' - 3"	19' - 5"	25' - 6"	20' - 3"	17' - 8"	19' - 2" f	17' - 8"	15' - 5"
	16	29' - 2"	23' - 2"	20' - 3"	25' - 6"	20' - 3"	17' - 8"	23' - 2"	18' - 5"	16' - 1"	16' - 7" f	16' - 1"	14' - 0"
	24	25' - 6"	20' - 3"	17' - 8"	22' - 3"	17' - 8"	15' - 5"	20' - 3"	16' - 1"	14' - 0"	13' - 7" f	13' - 7" f	12' - 1"
6	12	34' - 3"	27' - 2"	23' - 9"	29' - 11"	23' - 9"	20' - 9"	27' - 2"	21' - 7"	18' - 10"	20' - 1" f	18' - 10"	16' - 6"
	16	31' - 2"	24' - 9"	21' - 7"	27' - 2"	21' - 7"	18' - 10"	24' - 9"	19' - 7"	17' - 2"	17' - 5" f	17' - 2"	14' - 11"
	24	27' - 2"	21' - 7"	18' - 10"	23' - 9"	18' - 10"	16' - 6"	21' - 7"	17' - 2"	14' - 11"	14' - 2" f	14' - 2" f	12' - 10"

NOTES:

- Allowable composite limiting heights are calculated using ICC-ES AC86-2008. In accordance with current building codes and AISI design standards, the 1/3 Stress Increase for strength was not used.
- The composite limiting heights provided in the tables are based on a single layer of gypsum board complying with ASTM C1396.
- The gypsum board must be applied full height in the vertical orientation to each stud flange and installed using minimum No. 6 Type S Drywall screws spaced a minimum of 12-in on-center to the framing members in accordance with ASTM C754-2004.
- No fasteners are required for attaching the stud to the track except as detailed in ASTM C754-2004.
- Stud end bearing must be a minimum of 1 inch.
- Minimum material yield strength equals 65 ksi for 26-mil studs.
- 'f' adjacent to the height value indicates that flexural stress controls the allowable wall height.
- 's' adjacent to the height value indicates that shear/end reaction controls the allowable wall height.

Limiting Heights for ProSTUD 33MIL with 5/8" USG Sheetrock® Brand Firecode Type X Gypsum Panels													
Stud Depth (in)	Stud Spacing (in)	5 psf			7.5 psf			10 psf			15 psf		
		L/120	L/240	L/360	L/120	L/240	L/360	L/120	L/240	L/360	L/120	L/240	L/360
1 5/8	12	15' - 10"	12' - 7"	11' - 0"	13' - 10"	11' - 0"	9' - 7"	12' - 7"	10' - 0"	8' - 6"	11' - 0"	8' - 6"	---
	16	14' - 5"	11' - 5"	10' - 0"	12' - 7"	10' - 0"	8' - 6"	11' - 5"	8' - 11"	---	10' - 0"	---	---
	24	12' - 7"	10' - 0"	8' - 6"	11' - 0"	8' - 6"	---	10' - 0"	---	---	8' - 5" f	---	---
2 1/2	12	20' - 0"	15' - 11"	13' - 10"	17' - 6"	13' - 10"	12' - 1"	15' - 11"	12' - 7"	11' - 0"	13' - 10"	11' - 0"	9' - 7"
	16	18' - 2"	14' - 5"	12' - 7"	15' - 11"	12' - 7"	11' - 0"	14' - 5"	11' - 5"	10' - 0"	12' - 1" f	10' - 0"	8' - 6"
	24	15' - 11"	12' - 7"	11' - 0"	13' - 10"	11' - 0"	9' - 7"	12' - 7"	10' - 0"	8' - 6"	9' - 11" f	8' - 6"	---
3 1/2	12	25' - 7"	20' - 4"	17' - 9"	22' - 4"	17' - 9"	15' - 6"	20' - 4"	16' - 2"	14' - 1"	16' - 7" f	14' - 1"	12' - 4"
	16	23' - 3"	18' - 6"	16' - 2"	20' - 4"	16' - 2"	14' - 1"	18' - 6"	14' - 8"	12' - 10"	14' - 4" f	12' - 10"	11' - 2"
	24	20' - 4"	16' - 2"	14' - 1"	17' - 9"	14' - 1"	12' - 4"	16' - 2"	12' - 10"	11' - 2"	11' - 8" f	11' - 2"	9' - 8"
3 5/8	12	26' - 1"	20' - 9"	18' - 1"	22' - 10"	18' - 1"	15' - 10"	20' - 9"	16' - 6"	14' - 5"	17' - 4" f	14' - 5"	12' - 6"
	16	23' - 9"	18' - 10"	16' - 6"	20' - 9"	16' - 6"	14' - 5"	18' - 10"	14' - 11"	13' - 1"	15' - 0" f	13' - 1"	11' - 3"
	24	20' - 9"	16' - 6"	14' - 5"	18' - 1"	14' - 5"	12' - 6"	16' - 6"	13' - 1"	11' - 3"	12' - 3" f	11' - 3"	9' - 9"
4	12	28' - 1"	22' - 3"	19' - 5"	24' - 6"	19' - 5"	17' - 0"	22' - 3"	17' - 8"	15' - 5"	17' - 7" f	15' - 5"	13' - 6"
	16	25' - 6"	20' - 3"	17' - 8"	22' - 3"	17' - 8"	15' - 5"	20' - 3"	16' - 1"	14' - 0"	15' - 3" f	14' - 0"	12' - 3"
	24	22' - 3"	17' - 8"	15' - 5"	19' - 5"	15' - 5"	13' - 6"	17' - 8"	14' - 0"	12' - 3"	12' - 5" f	12' - 3"	10' - 7"
5 1/2	12	34' - 7"	27' - 6"	24' - 0"	30' - 3"	24' - 0"	21' - 0"	27' - 6"	21' - 10"	19' - 1"	20' - 4" f	19' - 1"	16' - 8"
	16	31' - 5"	24' - 11"	21' - 10"	27' - 6"	21' - 10"	19' - 1"	24' - 11"	19' - 10"	17' - 4"	17' - 7" f	17' - 4"	15' - 1"
	24	27' - 6"	21' - 10"	19' - 1"	24' - 0"	19' - 1"	16' - 8"	21' - 10"	17' - 4"	15' - 1"	14' - 5" f	14' - 5" f	13' - 2"
6	12	36' - 9"	29' - 2"	25' - 6"	32' - 1"	25' - 6"	22' - 3"	29' - 2"	23' - 2"	20' - 3"	21' - 1" f	20' - 3"	17' - 8"
	16	33' - 5"	26' - 6"	23' - 2"	29' - 2"	23' - 2"	20' - 3"	26' - 6"	21' - 0"	18' - 5"	18' - 3" f	18' - 3" f	16' - 1"
	24	29' - 2"	23' - 2"	20' - 3"	25' - 6"	20' - 3"	17' - 8"	22' - 8" f	18' - 5"	16' - 1"	14' - 11" f	14' - 11" f	14' - 0"

NOTES:

- Allowable composite limiting heights are calculated using ICC-ES AC86-2008. In accordance with current building codes and AISI design standards, the 1/3 Stress Increase for strength was not used.
- The composite limiting heights provided in the tables are based on a single layer of gypsum board complying with ASTM C1396.
- The gypsum board must be applied full height in the vertical orientation to each stud flange and installed using minimum No. 6 Type S Drywall screws spaced a minimum of 12-in on-center to the framing members in accordance with ASTM C754-2004.
- No fasteners are required for attaching the stud to the track except as detailed in ASTM C754-2004.
- Stud end bearing must be a minimum of 1 inch.
- Minimum material yield strength equals 33 ksi for 33-mil studs.
- 'f' adjacent to the height value indicates that flexural stress controls the allowable wall height.
- 's' adjacent to the height value indicates that shear/end reaction controls the allowable wall height.