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REVIEW OF STRAPPING VS. K BRACING

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OVERVIEW

One of the most fundamental components when constructing with light gauge steel is the bracing used to provide lateral strengthening to the structure. Lateral strengthening prevents the structure from buckling when a horizontal load is applied. However, a common misconception made by builders is that one can use strap bracing, K-bracing and bracing boards in combination on the same wall as layers on top of each other. This implies that their accumulative capacity outperforms the functional capacity of a single type of bracing used.

As a result of this misconception, builders have utilised a combination of all three braces to achieve the required bracing requirement when the existing brace is not sufficient. However, due to different ductility properties of the different braces, the braces do not yield their maximum capacity. Therefore, the differential properties in ductility prevent these braces from being used together because whilst one brace is providing full support, the second brace type will lack in performance. Australian Framing Solutions (AFS) approached Scottsdale Construction Systems (SCS) with a requirement to understand the most efficient way of improving the lateral bracing options.

SCS worked with the AFS team to:

i) Develop a plan

ii) Model and analyse

iii) Testing scenarios

iv) Report of the findings which will be made available to the Scottsdale network of fabricators.

It is currently understood most builders use K-Bracing in a narrow wall area such as 450mm. However, this method of bracing does not provide the sufficient bracing capacity and thus does not equate to an economically viable solution when comparing to the cost of labour and materials. This is predominantly a factor as K-Bracing yields a very high ductility which makes it considerably prone to deflection even when subjected to a 1kN axial load. As a result, K-Bracing capacity is almost negligible in terms of cost when comparing it to the more viably applicable solution being the strap bracing. Therefore, K-bracing is not a recommendable solution for bracing in this situation.

Prior studies conducted by other regions, in particular the USA, have indicated that K- Bracing is not the most efficient method for restraining the lateral loads within a structure. Scottsdale performed a series of tests to determine the most effective bracing method, using the following:

i.) 30mm strap bracing

ii.) K-bracing

iii.) 150mm strap bracing

Scottsdale selected the 150mm Strap Bracing as it can be made available as offcuts from the mother coil, thus making it cost-efficient as well. Scottsdale subsequently fabricated a 2.4 m by 2.4 m walls with G550-C90_37_0.75 wall studs. A series of test were conducted using 30mm strap bracing, 150mm Strap Bracing and 450mm K bracing in combination with Rivets and TEK screws.

TESTING PROCEDURE

To obtain quantitative data on K-Bracing and Strap Bracing performance, Scottsdale fabricated a 2.4m x 2.4m Light gauge steel wall frame. The wall consisted of 4 Stud Braces with a profile of C90_37_0.75. The different bracing types were then integrated into the wall separately to perform a series of testing scenarios using 0.75 - 30mm strap, 0.95 - 150mm strap and 450mm K-Bracing with various screw configurations. The selected strap material is G550. The bracing and screw configurations can be viewed in Table 1. To understand the bracing capacity of Strap Bracing and K-Bracing, a hydraulic-jack was mounted to the top corner of the frame, which simulated lateral loading on the wall frame. The force applied was incrementally increased with each brace until structural failure occurred. Structural failure in the wall was not only determined visually but also through the force meter no longer increasing. The following bracing setup is shown in the images below.

STRAP BRACING: 30mm

The 30mm Strap Brace integrated into the wall frame.

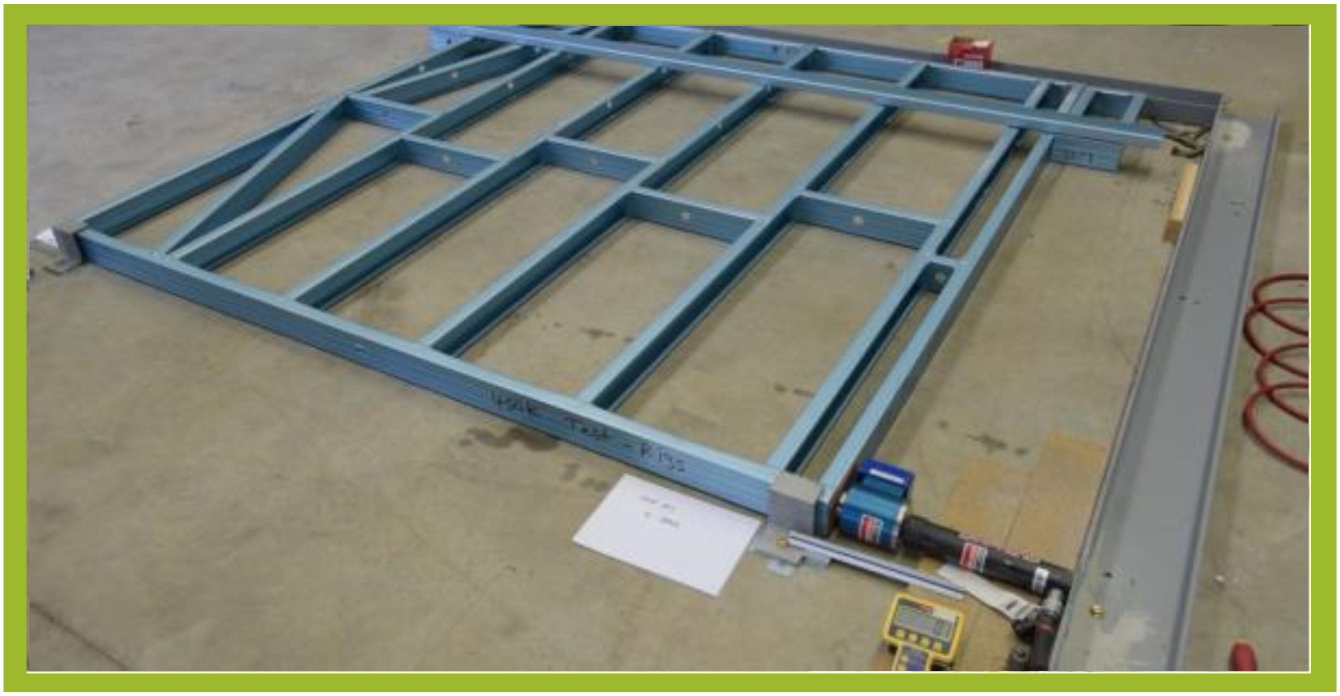
STRAP BRACING: 150mm

The 150mm Strap Bracing integrated into the wall frame.

The 150mm Strap Bracing integrated into the wall frame.

K BRACING: 450mm

The 450mm K-Bracing setup integrated into the wall frame



The 450mm K-Bracing setup integrated into the wall frame

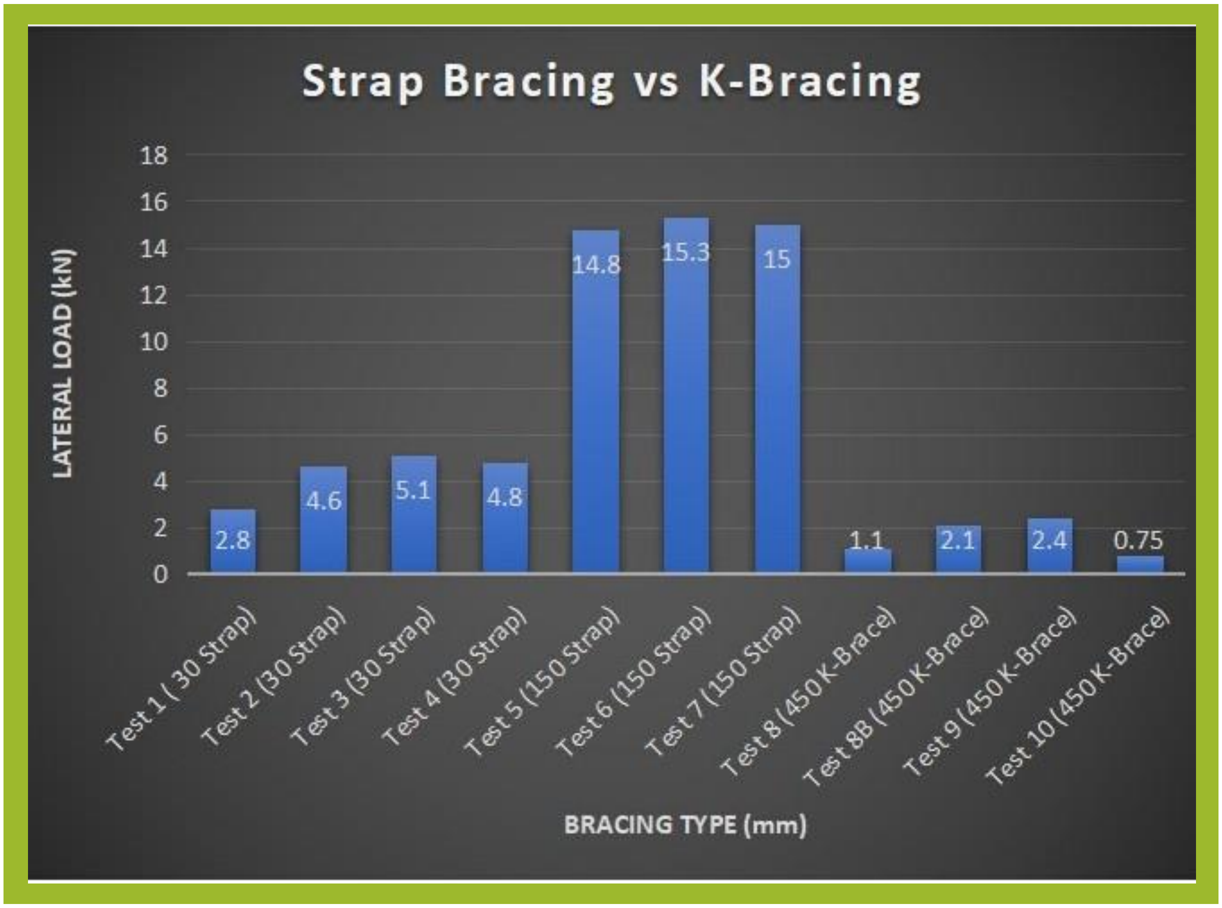
RESULTS

Experimental data from testing:

Test No	Wall Thickness (mm)	Bracing Type	Screws	Lateral Load (kN)	Comments
1	0.75	30 mm Strap	4	2.8	Just a test sample with wrong strap position
2	0.75	30 mm Strap	2	4.6	Bottom chord failure – at the tie-down (loaded side)
3	0.75	30 mm Strap	2	5.1	Bottom chord failure – at the tie-down (loaded side)
4	0.75	30 mm Strap	2	4.8	Bottom chord failure – at the tie-down (loaded side)
5	0.75	150mm Strap	22	14.8	Wall Top Chord failure
6	0.75	150mm Strap	22	15.7	Wall Bottom Chord failure near tie-down
7	0.75	150mm Strap	22	15	Failure at the tie-down. B/B studs with 2 L bracket should have been given more capacity
8	0.75	450 K-bracing	R + T	1.1	Top chord at K-brace (Only single rivet was used at noggin)
8B	0.75	450 K-bracing	R + T	2.1	The same specimen used for test 5. Nog connection failure
9	0.75	450 K-Bracing	R + T	2.4	(Only single rivet was used at noggin) TC, BC and nog connection failure Deflection is around 100 mm
10	0.75	450 K-Bracing	R + T	0.75	Permanent deformation occurs at 2 kN at the top plate, the test was continued, failure occurs at 3 kN TC failure, BC tie-down failure

The table provides the number of tests conducted using Strap Bracing and K-Bracing with varying Rivet and TEK screw combinations used at the connection points of the braces. Explanations of the cause of failures are also provided for each testing condition.

ANALYSIS



The experimental data displayed represented in a bar graph.

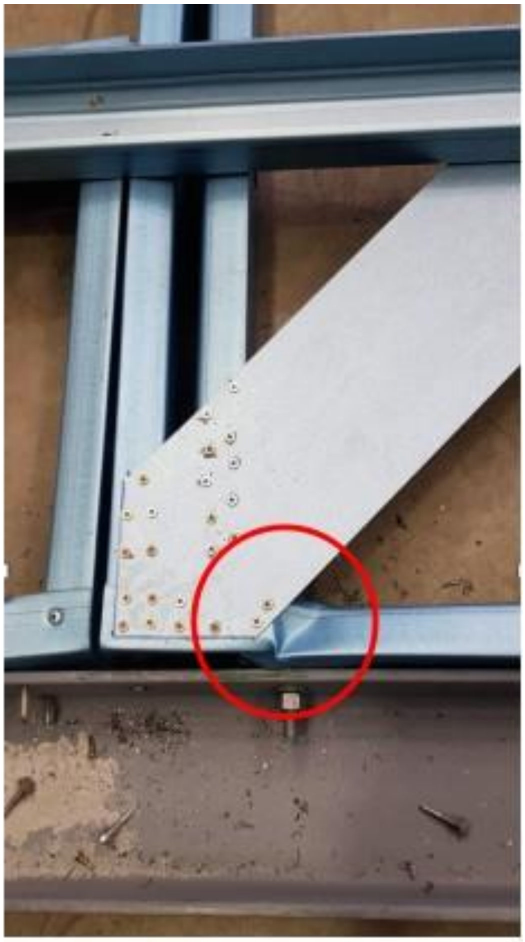
When observing the data presented in Figure 4, it is clear that the strap bracing greatly outperforms the K-bracing significantly. The 150mm Strap Bracing failed a lateral loading force of 15.3 kN as opposed to the 450mm K bracing, which yielded a much lower lateral loading before 2.4 kN structural integrity was compromised. This result was expected due to the mechanical nature of a K-brace under lateral loading, which makes it prone to deflection. The deflection sustained by the 450K-Brace at 2.4kN was measured to be 100mm, which far exceeded the deflection induced through Strap Bracing. Due to this nature, structural failure occurred at much lower lateral forces when compared to strap bracing as shown in the graph.

The damaged sustained by both braces are shown in Figure 5. Due to the deflecting nature of the K-bracing, structural failure occurred at the TC, BC and Noggin connections.

This generated a region of high stress and axial forces occurring between the upper and lower wall members, resulting in buckling of the steel members. In comparison, the 150mm Strap Bracing connection face was not compromised under loading conditions. However, damage to the lower wall member was sustained, causing the wall member to buckle. This indicates that if the wall was constructed with 0.95mm light gauge steel as opposed to 0.75mm, the loading capacity of the 150mm Strap Bracing would be much greater. This translates to greater performance in structural integrity when subjected to lateral loads.

COMPARISON OF K-BRACE AND 150mm STRAP BRACE FAILURE

450mm K-BRACING CONNECTION



150mm STRAP BRACING CONNECTION

DESIGN CAPACITIES

Design capacities were calculated by using the test outcomes of 150mm strap bracing. The calculations were conducted in accordance with Section 8 of AS/NZS 4600:2018.

V_{SC} was calculated to determine the sampling factor kt-min.

$$V_{sc} = \sqrt{k_f^2 + k_m^2}$$

Where

V_{sc} = Coefficient of variations of structural characteristic

K_f = Coefficient of variations for fabrication

K_m = Coefficient of variations for material

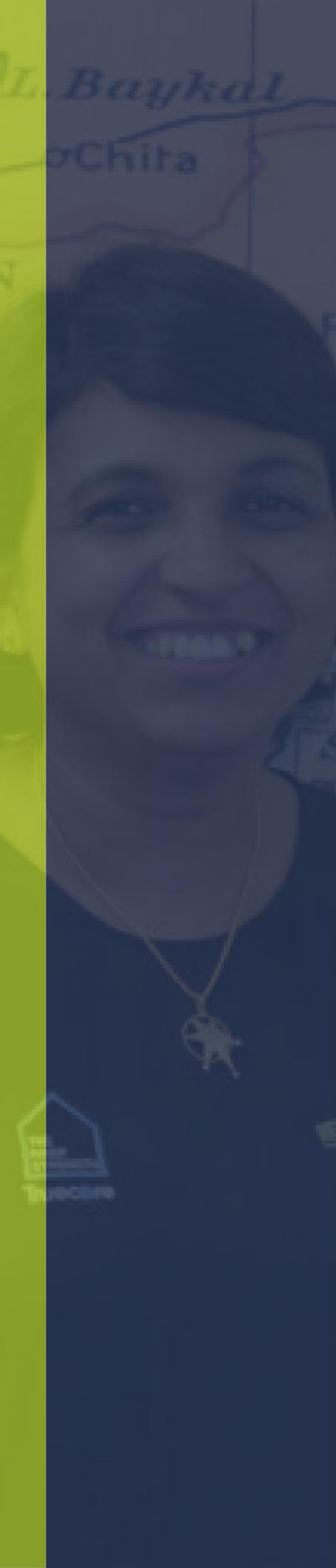
- The specimens were fabricated by number of people, so K_f was used as 0.07.
- Test specimens were fabricated using different steel coils. So K_m was used as 0.075.
- Therefore V_{SC} = (0.072+0.0752)0.5 = 0.10 = 10 %
- Additional, AS/NZS 4600 recommends using V_{SC} as 10% for member strength. Since all the 150 mm straps failed by wall members, V_{SC} was considered as 10%.

Therefore k_{tmin} = 1.33. Minimum test capacity = 14.8 kN
Final Design capacity = 14.8/1.33 = 11.1 kN

RECOMMENDATION

As shown in the data collected through experimentation of Strap bracing and K-Bracing, it was evident that Strap bracing is the most suitable bracing method in comparison to K-Bracing. Strap Bracing not only provides far greater bracing capacity performance but it is also significantly more cost-effective to manufacture. Therefore, based on the conclusive findings of this report, Scottsdale can highly recommend 150mm Strap bracing over K-Bracing and other traditional bracing methods.

For further information, please contact Scott Kimble for consultation on similar analysis and review projects by our engineering team. scott.kimble@scottsdalesteelframes.com



ABOUT THE AUTHOR

Dr Thanuja Ranawaka. B.Sc. Eng. (Hons.1), MSc. (SL), PhD (QUT), MIEAust, CPEng, NER, RPEQ Thanuja is a Structural Engineer at Scottsdale Construction Systems with more than 15 years of experience in Light Gauge Steel engineering. Thanuja completed her thesis at the Queensland University of Technology in 2006 on "Distortional buckling behaviour of cold form steel compression members at elevated temperatures".

Thanuja has extensive knowledge of structural analyses and design in light gauge cold-formed and structural hot-rolled steel includes in-depth knowledge in conceptual and detailed design complying with following design codes: AS/NZS 4600, AS/NZS 1170 Part 0, 1, 2, 3 and 4, NZS 1170 Part 5, AS 4100, Building Codes of Australia, NASH Standards, USA Standards, British standards, European Standards and South African Standards.

Thanuja is a current Standard committee member of NASH Australia and NASH New Zealand.

ABOUT SCOTTSDALE

Scottsdale Construction Systems based in Brisbane, Australia has been operating since 1995. Scottsdale is dedicated to innovating, manufacturing, delivering and supporting the most globally advanced light gauge steel (LGS) wall frame & roof truss technology.