BLIND BOLTED CONNECTIONS IN LOW RISE BUILDINGS USING UNFILLED HOLLOW SECTION COLUMNS

Michael Notini[1], Emad Gad[1], Saman Fernando[1], Helen Goldsworthy[2],

ABSTRACT: *This paper investigates the use of a blind bolted moment connection for unfilled hollow section columns in low rise buildings where no additional lateral bracing is required. Design aids have been developed that intend to give designers a sense for the spans and spacing between frames that could be achieved and the column and beam sizes required to meet both strength and serviceability requirements under code specified loading. Further, a parametric study is presented to demonstrate the effectiveness of using reinforced concrete link beams between shallow pad footings in reducing lateral deflections. The results of this study show that for a moment resisting frame using the blind bolted moment connection with pinned base supports connected by a concrete link beam, the lateral deflection is significantly lower than an equivalent frame with no link beam or cross bracing. This observed lateral deflection was found to be only slightly higher than if the frame were to have fixed base supports. The presented frame design table has been modified to include the enhanced results using the concrete link beam, that is shown to allow for longer spans and spacing between frames improving overall applicability.*

KEYWORDS: Blind bolts, side connection, moment connection, link beam

[1] Michael Notini, Faculty of Engineering & Industrial Sciences, Swinburne University of Technology, Hawthorn, Australia. Email: mnotini@swin.edu.au
[1] Emad Gad, Faculty of Engineering & Industrial Sciences, Swinburne University of Technology, Hawthorn, Australia. Email: egad@swin.edu.au
[1] Saman Fernando, Faculty of Engineering & Industrial Sciences, Swinburne University of Technology, Hawthorn, Australia. Email: msfernando@swin.edu.au
[2] Helen Goldsworthy, School of Engineering, The University of Melbourne, Melbourne, Australia. Email: helenmg@unimelb.edu.au

1 INTRODUCTION

Structural hollow sections offer significant benefits compared to open sections. They are less prone to buckling, offer a larger load carrying capacity per weight ratio which results in slender and aesthetic columns that offer enhanced fire and corrosion protection compared to open sections [1].

Traditionally beam to hollow column connections have been pin connections involving welded fin/cleat plates which are then bolted to open beam sections. Recently developed moment connections to hollow columns involve welding such as the Duragal® system [2] as shown below in Figure 1. The Superpod® passive house system is another frame that uses moment connections involving welded tabs to columns, which are in turn bolted to hollow sections using through bolts [3]. Such welded connections often incur tolerance issues and significant attention to construction sequence.

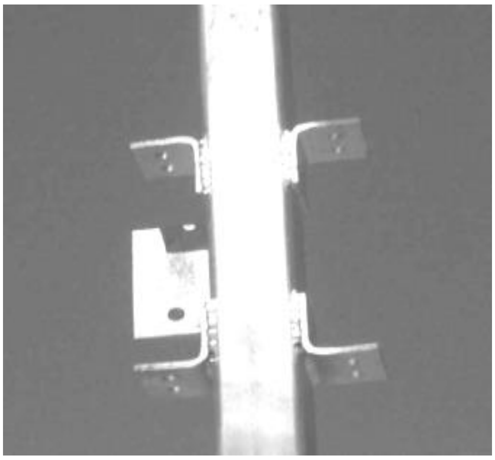

Figure 1: *Duragal® house frame moment connection used in residential development*

Weld-free hollow section connections have been developed using a type of bolt that requires installation access from the exterior face of a hollow section known as the blind bolt. Currently there are several blind bolts available on the market with differing properties and installation methods; however they all offer the ability to be fastened via access to only one side of a joint which is greatly beneficial to hollow section connections that incur limited access during installation amongst other applications such as bridge and ship building. One such type of bolt is the ONESIDE™ blind bolt developed by AJAX Engineered Fasteners that offers full structural capability unlike other blind bolts on the market [4].

[5] Presents a recently developed moment resisting hollow section connection that utilizes blind bolts. Referred to as the channel side plate connection, it requires additional cut lengths of the hollow section column that are then bolted to the top and bottom of a beam and then transfers the beam load to the sides of the hollow section column through bolted side plates as shown in Figure 2 below. By transferring the load of the beam away from the face and to the sides of a hollow section, the channel side plate connection avoids flexible column face deformation that simple, blind bolted T-stub face connections incur.

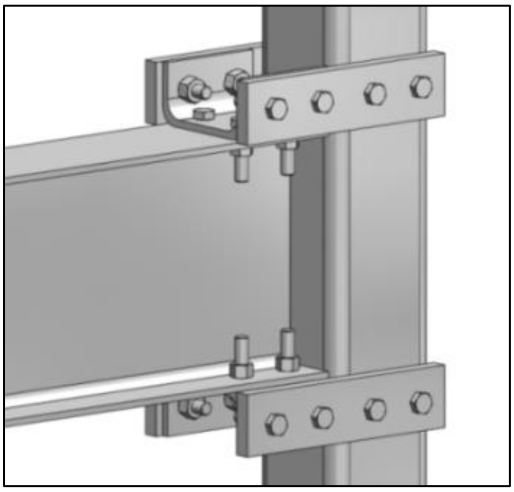

Figure 2: *Channel side plate connection*

Physical tests were conducted on a specimen connecting a 310UB 32.0 universal beam and a 150SHS6.0 hollow section column. The tested channel side plate connection was found to have a stiffness of 17,000kN.m/ rad which is considered a rigid connection for an unbraced frame system under the Eurocode 3 classification (BSI, 2008). This stiffness was later validated through finite element modelling and a simplified model based on the component model method from Eurocode 3 [5].

2 INITIAL FRAME STUDY RESULTS

This paper investigates a hollow section framing option utilizing the recently developed channel side plate connection for low rise applications that intends to give designers a sense of the member sizes required. A case study has been considered using a basic three bay, 9.2 m high structure as shown in Figure 3 below. Frame analysis was performed using the general purpose structural analysis and design program SPACE GASS (Version 11.04).

A 120mm thick reinforced concrete slab (Unit weight 25 kN/ m^3) was assumed for levels one and two along with a live load of 3 kPa and a super imposed dead load of 1.5 kPa. The lighter weight roof was subjected to a live load of 0.25 kPa and a super imposed dead load of 0.5 kPa based on code

specified loading given in AS/NZS 1170.1 stated in [6].
A 1.05 kPa ultimate wind load was estimated.

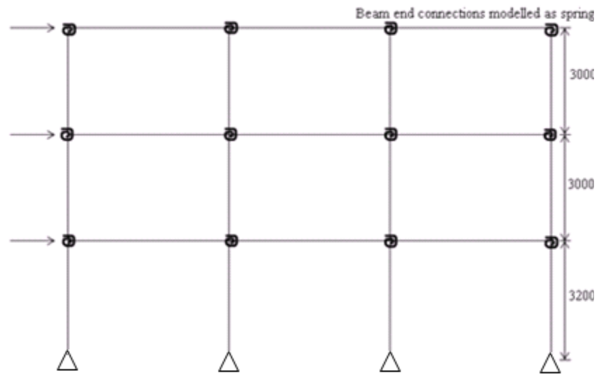

Figure 3: *Three storey moment resisting frame modelled in SPACE GASS*

Using the simplified component model to determine connection stiffness presented in [5], spacing between frames has been varied between four to six meters, whilst preliminary spans were initially varied between four to eight meters in order to determine the beam and hollow section sizes required for a moment resisting frame to meet both strength and serviceability requirements. Figure 4 and 5 below present these results.

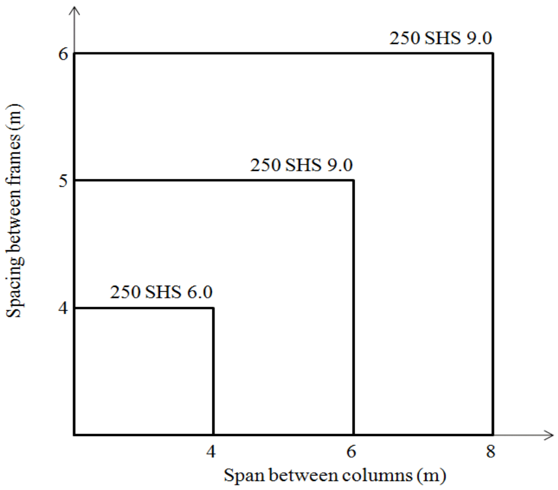

Figure 4: *Minimum column size design aid*

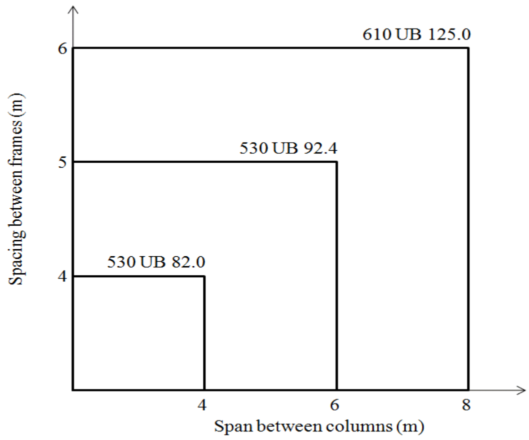

Figure 5: *Minimum beam size (b) design aid*

It can be seen from Figure 4 and 5 above, that for the above three bay frame with a span between columns of six meters and a spacing between frames of five meters, 250SHS 9.0 hollow section columns and 530UB 92.4 I beams would be required to meet the serviceability requirement due to the governing first storey lateral deflection.

3 REDUCING LATERAL DEFLECTION TO INCREASE SPAN AND SPACING BETWEEN FRAMES

While the channel side plate connection can be seen to be effective in providing a moment resisting connection to hollow sections for low rise structures, section two showed that considerably large member sizes are required to achieve modest spans and spacing between frames, thus solutions to limit the governing lateral deflection need to be considered.
Cross-bracing certain bays are one such common method, however they are often considered undesirable in the sense that they result in large obstructions in between columns for frame structures that require open areas such as warehouses and office buildings.
The inclusion of fixed footings in the model was found to have a significant effect in the reduction of lateral deflection. The feasibility of fixed base supports must be addressed for low rise structures as they incur considerably larger costs compared to shallow pad footings.
Lastly, the reduction in frame lateral displacement due to the inclusion of a 500 x 300 mm reinforced concrete link beam connecting shallow pad footings was investigated. The link beam was modelled with a Young's Modulus of half of the 34.5GPa for concrete with a compressive strength of 40MPa in Space Gass to allow for concrete in a cracked state. The results of the analysis showed that the link beam had a profound impact on

reducing the governing first storey lateral deflection for an unbraced frame using 460UB 67.1 I beams with four meter spans between 200SHS 6.0 columns and four meter spacing between frames as shown in Table 1 below.

Table 1: *Lateral deflection using shallow pad footings with concrete link beam*

Frame Support Fixity	First storey deflection, Δ (mm)	Corresponding Δ/ Floor Height
Shallow pad footings (no link beam)	15	1/211
Shallow pad footings (with link beam)	5	1/640
Fixed base supports	4	1/800

4 REVISED DESIGN WITH REINFORCED CONCRETE LINK BEAMS

As found in section three, moment resisting frames with longer spans and spacing between frames utilizing the channel side plate connection could be made possible through the use of a reinforced concrete link beam connecting shallow pad footings. Figures 6 and 7 below demonstrate the spans and spacing between frames achievable through the use of a reinforced concrete beam linking shallow pad footings that substantially reduces lateral deflection.

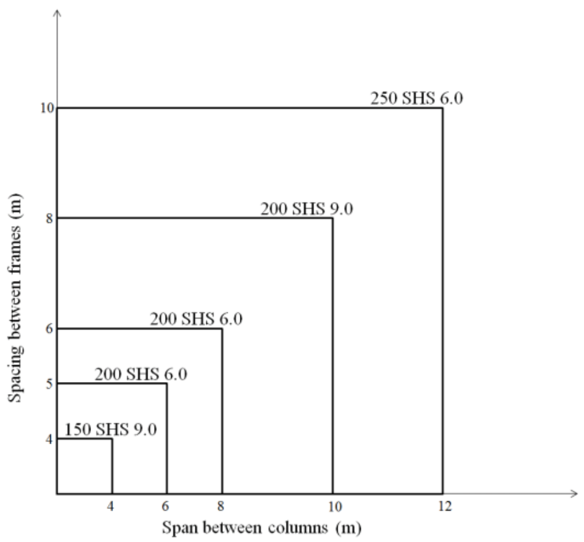

Figure 6: *Minimum column size enhanced design aid*

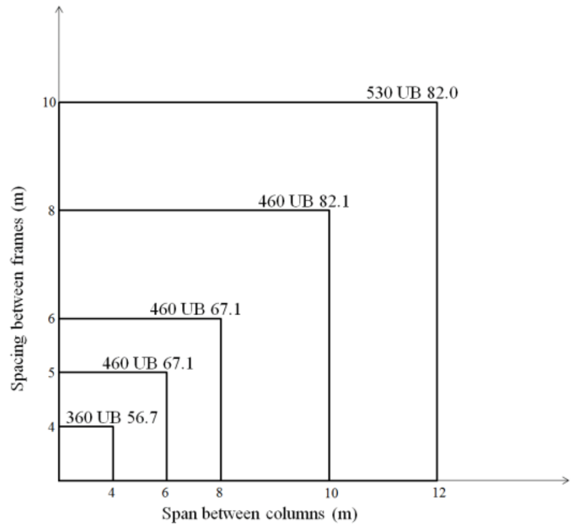

Figure 7: *Minimum beam size enhanced design aid*

5 CONCLUSIONS

Using a simple component model for stiffness for the blind bolted channel side plate connection presented in Lee et al., 2011, a SPACE GASS analysis has been performed for an unbraced moment resisting frame using unfilled hollow sections. An initial frame study found that while the channel side plate connection could be used in a moment resisting frame on shallow pad footings, it could only be utilized for spans up to eight meters and spacing between frames up to six meters. A design aid has been produced to show the large member sizes required to meet strength and serviceability requirements.

Methods of reducing governing lateral deflection were explored including bracing bays, implementing fixed base supports and the inclusion of a reinforced concrete link beam running between shallow pad footings. Frame analysis showed that the link beam significantly reduced lateral deflections to just higher than if fixed base supports were modelled. Enhanced design charts for the moment resisting frame with link beams has been presented showing considerably larger spans and spacing between frames are possible. The results of this frame study using the simplified component method to estimate connection stiffness present promising results for a weld free alternative framing solution and should be further explored and validated through further finite element modelling.

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