Blind Connections in Low Rise Buildings Using Unfilled Hollow Section Columns

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• Research Aim & Objectives
• Current State of the Art Connections for Unfilled Hollow Sections in Low Rise Structures
• Blind Bolts Review
• Blind Bolted Connections Review
• Case Study Findings
• Future Work
Research Aim & Objectives

The aim of this research is to investigate blind moment connections that present access issues to unfilled hollow sections in low rise structures.

Objectives Include:

• Research of blind bolts and connection types to unfilled hollow sections
• Adjusting stiffness design models based on beam and column tube sizes
• Design case study looking at a 3 storey frame in Melbourne to investigate feasibility of blind connections
• Increasing lateral stiffness of design frame to reduce column and beam sizes that use blind connections

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Current State of the Art

- Structural hollow sections offer significant benefits compared to open sections
- Larger load carrying capacity per weight ratio, enhanced fire protection and less prone to buckling
- Connections generally limited, as installation access is limited to outside of hollow section
- Welded connections are traditionally adopted
- Fin/ cleat plates for connecting beams to hollow section columns
- Cap plates for connecting hollow section columns to one another
Different system developers are attempting to create alternative moment connections for moment resisting frames

Generally require welded components such as tabs

Superpod® is one such example that uses through bolts between welded tabs to create a moment connection in which tolerance issues and attention to construction sequence must be addressed

Blind bolted connections developed to present cost effective and easy fastening to unfilled hollow sections

Require limited fabrication of components
Blind Bolts

• Several blind bolts available in the market
• Only the Ajax ONESIDE Blind Bolt offers the full structural capability as it does not rely on deformability of any components

Aspects of the Ajax ONESIDE include:
• Higher shear capacity than standard 8.8 grade bolts through use of a shear sleeve
• Ease of installation compared to welded connections
• Requires an installation tool that can only be used for specific bolt sizes

Superpod® passive house system steel frame (steel Australia, 2014)

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AJAX ONESIDE™ structural fastener components

For more in-depth information about the range of ONESIDE™ optional components, please contact your authorised AJAX ONESIDE™ distributor.

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Blind bolted connections for unfilled hollow sections include have been developed as part of Dr. Jessey Lee’s (2011) thesis.

These include:
• Simple T-stub Connection
• Extended T-stub Connection with Backface Support
• Channel Side Plate Connection
• Simple face connection where beam flanges bolted to T-stems that are blind bolted to tube

• Advantageous in that connection can be used to all four faces of column tube

• Limited Connection Stiffness

T-Stub Connection Lee (2011)
• Found to be **semi-rigid**, increasing plate thickness increases stiffness of the connection

• Considerable deformation due to flexible column face as shown

• Stiffness of 3,000 – 5,000 kN.m rad observed through experimental testing and finite element modelling

![Moment rotation curve for T-Stub Connection](image)

*Failure of tube face and deformed shape of connection components Lee (2011)*

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Extended T-Stub Connection

- Flexible column face deformation reduced by connection T-Stub connection to a back face support or another T-Stub connection through channels on column sides
- ‘Bulky’ connection appearance is a drawback and could present clearance issues
- Side channels to be thicker than column to reduce outward pull as shown due to loading
- Stiffness of 17,000 kN.m rad observed through experimental testing and finite element modelling

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Deformation of connection at failure Lee (2011)

Moment rotation curve for Extended T-Stub Connection Lee (2011)
Channel Side Plate Connection

- Requires half of an SHS cutoff to be bolted to the top of beam and then to side plates that are then blind bolted to hollow section.
- Requires bolts to be fully pre-tensioned to achieve sufficient initial stiffness for connection.
- Flexible column face deformation reduced as load transferred to column sides.
- Stiffness of 17,000 kN.m rad observed through experimental testing and finite element modelling.
- Features a ‘neat’ connection appearance that could be useful if required to be placed between walls or partitions and areas presenting clearance issues.

Moment rotation curve for Channel Side Plate Connection Lee (2011)
Blind Connections Case Study

- 3 storey frame in Melbourne assumed with shallow pad footings (pinned supports)
- Adopt channel side plate
- Modelled in SpaceGass

**Loading Assumptions**

- 120mm thick composite slab assumed
- Ultimate Wind Load: 1.05kPa
- Floor S.I.D.L: 1.5kPa
- Floor Live Load: 3kPa
- Roof S.I.D.L: 0.5kPa
- Roof Live Load: 0.25kPa
Various design arrangements tested with varying connection stiffness for blind bolted connections under S.L.S and U.L.S.

Initial results showed that channel side plate connection could be used.

Modest spans and spacing between frames up to 8 meters and 6 meters respectively (requiring 610 UB 125.0 and 250 SHS 9.0 and four blind bolts).

Larger size beams and columns are required to satisfy the drift limits at the ground level.

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Initial minimum hollow section size (a) and beam size (b)
Parametric study conducted to investigate lateral deflection due to governing wind load:

- Cross bracing bays
- Implementing fully fixed footing supports
- Rigid, reinforced concrete link beams linking shallow pad footings

Elevation view of reinforced concrete link beam for design
• Parametric study carried out on an unbraced, three bay moment resisting frame using channel side plate connections with spans of 6 meters and spacing between frames of 5 meters using 460 UB 67.1 beams and 200 SHS 6.0 columns

• Cross bracing bay(s) and fixed base supports are effective in reducing lateral deflection

• Frame Lateral deflection using link beam slightly higher to that of an equivalent frame on fixed base supports.

<table>
<thead>
<tr>
<th>Frame Support Fixity</th>
<th>First storey deflection, Δ (mm)</th>
<th>Corresponding Δ/ Height</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shallow pad footings (no link beam)</td>
<td>15</td>
<td>1/211</td>
</tr>
<tr>
<td>Shallow pad footings (with link beam)</td>
<td>5</td>
<td>1/640</td>
</tr>
<tr>
<td>Fixed base supports</td>
<td>4</td>
<td>1/800</td>
</tr>
</tbody>
</table>

Reduced deflections due to fixed base supports versus reinforced concrete link beam

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Future Work

Another aspect of blind connections is column – column connections where installation access presents an issue especially for modular construction.

Installation of prefabricated module units

Brooklyn Building, New York

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• Designed to meet full tension capacity of column tube
• Requires installation access only from top of the column
• Does not rely on a threaded rod that runs the height of the tube
• Construction sequence has been completed, finite element analysis underway
• Prototype to be tested at Swinburne University of Technology will be fabricated shortly

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Summary

- Review of blind bolts and recently developed blind bolted connections
- Blind bolted connections to hollow sections can have sufficient stiffness to be classified as rigid.
- Use of reinforced concrete link beams can be effective in reducing the lateral deflection for pin supported frames
- A new innovative column to column blind connection is being developed to allow for reliable modular constriction where access is limited.

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