Structural Steel Reuse Protocol

Author: *Alistair Fussell*
Affiliation: *Steel Construction New Zealand Inc.*
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Introduction

There is an increasing awareness of the potential environmental benefits of using salvaged structural steel sections, otherwise known as reuse steel, from old buildings, principally in terms of reduced green house gas emissions. Furthermore, steel buildings designed with end-of-life reuse in mind have the potential to be profitably mined for future reuse upon demolition rather than be an expensive liability for the building owner.

Examples of Reuse Steel

While end of life reuse is not an established practice for steel buildings, there have been successful examples where it has been done. In Canada the University of Toronto Student Centre completed in 2004 featured 16 tonne of salvaged structural steel (figure 1). This represented 5% of the 300 tonnes used in the project. In spite of the lack of established market in Canada for reuse steel, the use of salvaged steel for the project was believed to be cost neutral (Edmond, 2009).

Figure 1 University of Toronto Student Centre (photograph courtesy Halsall Associates Ltd)

In the United Kingdom a warehouse and an associated office building built in 2006 were designed to allow easy disassembly and to maximise potential steel reuse (Figure 2). It has been estimated 80% of the building steelwork will be re-usable. All steel elements were hard stamped with the section size and grade to allow easy identification following deconstruction (Barrett Steel Buildings, 2009).

Figure 2 ProLogis Heathrow Warehouse (Barrett Steel Buildings, 2009)

The British Constructional Steelwork Association's new regional Yorkshire office was built with 82 tonne of salvaged steel. The 1800m^2 building was fabricated entirely out of steel from an old warehouse. All the sections were disassembled and refabricated (BCSA, 2008).

Figure 3 British Constructional Steel Association Yorkshire Office

At the end of a building's life, materials are more likely to be salvaged if they are easily removed and segregated. The Steel Reuse Protocol has been prepared to maximize the end of life reuse of structural steel from old buildings. The Protocol addresses designing for deconstruction, guidelines for "as-built" information to simplify end of life grading, assessing salvaged structural steel and deconstruction.

Design for Deconstruction

Steel offers the opportunity to design buildings that can easily be dismantled and their components reused. This occurs more readily when the following features are incorporated into the design and detailing:

- Minimise welding and maximizing bolting so fittings can easily be removed.
- Minimise notching and cranking of sections
- The use of industry standard connections such as found in SCNZ report 14, Steel Connect (Hyland et. al. 2007).
- The use of long span beams that can be cut to usable lengths. Specify column splices every three or four stories to maximize salvageable lengths.
- Minimise concrete encasement of steel work

- Rationalise member sizes to limit the number of section sizes used.
- Where possible use a simple regular structural layout. Any future dismantler will find it easier to sort and sell members of a similar size and length.
- Use fewer but larger members
- Where feasible try to minimise coatings that will hinder visual inspection. If a fire engineering approach is adopted the passive fire protection requirements can in many instances be reduced.
- Where possible eliminate beam stubs from columns (Christmas tree configuration) to maximize salvageable beam lengths
- Provide ready access to connections to simplify disassembly
- Composite floor construction is a cost effective and material efficient flooring solution. However steel beams acting integrally with metal deck slabs by means of shear studs are difficult to disassemble. A floor arrangement that lends itself to some degree of non-composite construction is the parallel beam approach that features non-composite continuous twin spine beams placed either side of the columns. These support rib beams which run either simply supported or continuously over the top of them. This option is worth considering at the preliminary design stage.
- Separate gravity and lateral load resisting structure to maximize the use of simple beam connections. This will minimize the number of column locations requiring stiffeners and or doubler plates. This approach will also result in a cost effective solution.
- Provide "as built" information and permanent member marking to ensure end of life traceability of steel (see next section, Identifying Structural Steel).

Identifying structural steel

Good as-built information and a permanent marking system to ensure traceability greatly simplifies the task of identifying the grades and sizes of steel sections. This information, including any drawings, specifications, mill certificates and shop drawings necessary to designate all the structural steelwork should be included in the local authority building consent data base for ease of retrieval at the of the life of the structure.

The simplest method for ensuring section traceability is to hard stamp the fabricator's mark number on each component of steel. This will link the component to its shop drawing information. Hard stamping can be achieved using a powder activated hand tool. Some automated beam-line fabrication systems have the facility to hard stamp as well. For ease of locating mark numbers in the future, it is recommended they are placed not less than 500mm from one end of the member.

It is becoming increasingly common for steel constructors to have 3D modelling software and in some cases production management software. This type of software has exporting functions that allow members schedules with steel grades, member sizes, mill certificates and other fabrication information to be exported in Excel format. Data files of this information can then be added to the consent documentation lodged with the appropriate Local Authority or the owner. When end-of-life traceability of the structural steel is required, it is important to consult the project steel constructor to discuss how this might best be accomplished with their current technology. The structural drawings should note that the steel elements must be marked for future reuse.

Steel section as-built information is typically only available for more recent projects. Where the steel grade is not known, the Structural Steel Code NZS 3404 (SNZ 1997) offers designers the option of using significantly reduced mechanical properties or they may be established by testing in accordance with BS EN 10002-1 (BSI 2001). To determine the appropriate f_y and f_u from test data, the provisions of NZS 3404 (SNZ 1997) section 17.5 Prototype Testing may be used. An example of the use of this procedure is found in Steel Advisor article MAT 1001 (Hyland, 2007).

Assessing the condition of old steel

Not all structural steel from existing buildings will be suitable for reuse. This may be due to the nature of loading. Cyclic loading leading to fatigue crack development may limit the re-usability of the steel. Deterioration due to corrosion during the life of the building or damage sustained during demolition are also factors.

At the end of the life of the structure a structural engineer will be required to identify salvageable material. Guidance that may assist with the assessment process is increasingly available (Bussell, 1997),(Fujita, Iwata, 2008).

Deconstruction

End-of-life reuse of structural steel sections will require a change in approach to the demolition task. Deconstruction has been defined as a demolition method where the structure is carefully and methodically disassembled so as to salvage many components as possible (Webster 2006). Current demolition practice is driven by the relative cost of scrap and salvage steel, and time constraints. The recent high value of scrap steel has made salvaging steel for reuse unattractive to demolition companies. It is anticipated in the future the economics of reselling salvaged material, driven possibly by government legislation and/or the cost of disposing of building waste, will make deconstruction a viable approach.

Some modular structures such as portal framed structures are presently dismantled, relocated and reassembled. It is possible for contractors using current demolition practices to salvage steel beams from composite floor systems. To maximize the quantity of re-useable steel sections appropriate techniques such as torch cutting rather than mechanical shearing are required. There are increased safety risks with this demolition approach. If you have a client who is keen to salvage steel sections from an existing building, particularly one with a composite floor slab, contact an experienced demolition contractor to ascertain the feasibility of such an approach. Bolted connections may be dismantled using a combination of gas cutting bolts and impact wrenches (Fujita, Iwata, 2008).

Conclusion

There are environmental benefits from reusing structural steel salvaged from old buildings. To maximise end-of-life reuse, good as built information ensuring end-of-life traceability is important along with appropriate demolition techniques. The Steel Reuse Protocol outlines simple steps using current shop drawing modelling and fabrication technology to ensure steel is readily identified at the time of demolition.

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