CWCT CURTAIN WALL INSTALLATION HANDBOOK

Chapter 8 Brackets and fixings

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This handbook was written by the Centre for Window and Cladding Technology (CWCT) as part of its training programme to improve the standard of curtain wall installation.

It will be of benefit to all those installing, or supervising, the installation of curtain walling and other glazed building elements.

This is one of eight chapters from the CWCT Installers' handbook.

Introduction

The installation of facades and façade elements is one of the more complex operations on a construction site. It requires a range of skills and knowledge yet has not been recognised as a particular skill or trade. Façade failure, particularly water leakage, is the most common cause of failure in new buildings.

This handbook brings together advice on installation of curtain walling including all the major components: frames, gaskets, sealants, finishes, glass and fixings. It is based on experience gained by CWCT in setting up training centres for installers and in training main contractors' site supervisors.

The book explains why things should be done and highlights those things that are most critical to the success of curtain wall and window installation.

This Handbook is a guide to achieving better curtain wall installation. However, it is not a substitute for care and diligence, nor should it be a substitute for proper training. Full details of CWCT's training programme are available at http://www.cwct.co.uk/installers.

8 Brackets and fixings

- **Function**

Brackets and fixings are used to attach curtain walling and windows to the supporting structure.

Windows are normally located within the supporting wall so that vertical loads are transferred to the structure by bearing at the window cill. Fixings are required to hold the frame securely in position and resist horizontal loads. Fixings may pass directly through the frame into the supporting structure. Alternatively a strap or lug may be attached to the frame and fixings pass through the strap into the supporting structure, Figure 8.1. The use of lugs or straps is essential for factory glazed windows. When through fixing care is needed to avoid crushing or distortion of the frame.

Curtain walling is normally positioned in front of the supporting structure and brackets are required to connect the curtain wall to the structure. Fixings are then required to attach the brackets to the structure.

- **Performance of Brackets**

Brackets are required to perform a number of functions as described below.

Loads

Vertical forces due to dead loads and horizontal forces due to live loads are transferred to the structure by the brackets. To transfer these loads two types of connection are required:

a) Support brackets are required to carry dead loads and these will prevent vertical movement of the mullion relative to the supporting structure. Only one support bracket is necessary for each length of mullion and provision of additional supports is undesirable as movement will be restricted (see below).

b) Restraint connections are required at both top and bottom of mullions to resist wind loads.

Two possible bracket arrangements for a single storey height mullion are shown in Figure 8.2. The top hung arrangement is more common but the bottom supported arrangement may be used, particularly for low rise construction. Where mullions span more than one storey restraint connections are usually provided at the intermediate floors.

Adjustment

All brackets should provide adjustment in three directions to overcome dimensional variations.

Means of adjustment include:

- Slotted holes for fixings
  These may need to be combined with serrated surfaces to prevent further movement after adjustment or low friction surfaces to permit movement by sliding after installation;

- Site-drilling or welding after positioning of components
  This may be used for final fixing after initial fixing with slotted holes.

  It is likely to be less successful for fixings into concrete as the required hole positions may coincide with reinforcement;

- Shims, packing pieces or washers
  If excessive thicknesses are used nuts may not engage fully with bolt threads and bending stresses may be induced in bolts.

  Packing pieces may also reduce the contact area between components increasing stresses and inducing additional bending;

- Sliding connections;

- Channel fixings - Comments for slotted holes apply:

Movements
Design of brackets needs to take account of movements of the curtain wall and structure to avoid:

- Imposing loads on the curtain wall for which it has not been designed

- Breakdown of seals due to large movements being transferred from the frame to the curtain wall

For stick curtain walls, vertical movements are usually accommodated in the splices between mullions which allow the sections of mullion to slide vertically but transfer horizontal load.

Movements which cause shear of the curtain wall can usually be accommodated by rotation of the mullion/transom joints provided there is sufficient clearance between the frame and the infill.

Although vertical movements will normally be greater than horizontal movements, horizontal movements must also be considered.

All brackets should allow the required amount of movement after fixing. Movement accommodation should not be sacrificed to achieve fit of incorrectly sized elements and components.

Resistance to corrosion
Two forms of corrosion warrant consideration:

- General corrosion of individual components including brackets, fixing bolts and curtain walling
- Bi-metallic corrosion resulting from contact between components made from different metals.

Requirements for corrosion resistance also apply to fixings and are described in the materials section below.

Buildability
Cladding is often erected at height in inclement conditions. Connection details should therefore be simple to construct, to improve safety and reduce the risk of poor workmanship.

Brackets which are capable of being lined and levelled in advance of cladding erection can produce overall cost benefits.

• Fixings

Fixings are required to attach curtain wall brackets and windows to the structure. A wide variety of proprietary fixings is available.

The selection of suitable fixings for a particular application depends on a number of requirements including the magnitude of the loads to be carried, the nature of the loads (shear, tension or compression), thickness of the fixture (including provision for packing or shims), the substrate and the required life of the fixing. Substitution of a specified fixing by an alternative type requires a reappraisal of all these factors.

The load which fixings are required to carry varies greatly. Window frames will normally be secured with a number of fixings at intervals around the perimeter, Figure 8.3, giving fairly small loads at each fixing. A fixing for a curtain wall bracket will carry the total wind load for a larger area of cladding, Figure 8.4. The curtain wall fixing will also have to carry the dead load.

The load from the curtain wall bracket may be carried by one or two fixings giving little scope for load redistribution in the event of failure whereas failure of a single window fixing may be accommodated with little difficulty.

The performance of curtain wall fixings is therefore more critical to the safety of the installation.

Fixings may be required to connect to steel, concrete or masonry. Brackets for curtain walling are commonly fixed to concrete floor slabs but can be fixed to the structural steel frame. Window frames are commonly fixed to masonry but may be fixed to concrete.

Steel
Fixings to steelwork are normally bolts which may connect directly to structural steel sections or to cleats welded to the sections.

Any welding should normally be carried out by the steelwork fabricator prior to delivery to site.

Concrete
Fixings to concrete may be cast-in place or post installed. Cast-in place fixings are positioned in the formwork prior to casting the concrete and usually take the form of channels with T-head bolts or internally threaded sockets, Figure 8.5. There are three forms of post-installed fixings related to their method of load transfer as follows:

- Expansion anchors in which a metal cone is drawn into a metal sleeve or shield causing friction against the sides of the hole, Figure 8.6. In torque controlled fixings the expansion occurs as the fixing is tightened. In displacement controlled fixings the sleeve is forced over the cone using a hammer and a separate operation is required to connect the fixture to the installed fixing.

- Undercut anchors in which the end of the hole is enlarged allowing the end of the anchor to expand without inducing stress in the substrate, Figure 8.7. Mechanical interlock then provides resistance to pullout.

- Bonded anchors in which the anchor is held in the hole by resin which may either be introduced in the form of a glass capsule or may be injected from a cartridge, Figure 8.8. Resin anchors transfer the load over the whole of the bonded length giving lower contact stresses than other types of fixing.

The performance of fixings in concrete depends on the strength of the concrete and density of aggregate. The choice of appropriate fixings will also take account of the practical problems of either securing the fixings to the formwork or alternatively drilling holes in the hardened concrete.

Masonry
Masonry can be a difficult material to fix into due to the wide range of strength of masonry materials, the presence of voids within the masonry units and the presence of mortar joints. Fixings should normally be located within the masonry unit rather than the mortar joint. Fixings for use in masonry include expansion anchors, bonded anchors, screws and specialist fixings designed for use in low strength materials, particularly aerated concrete

Some expansion anchors with metal sleeves and cones are suitable for use in masonry but similar anchors with plastic sleeves and plastic wall plugs are also available. These may be standard wall plugs were the plug is embedded fully within the masonry and expands when a conventional screw is inserted, Figure 8.9, or frame fixings where the plug extends through the fixture into the masonry and may be expanded by a screw or nail, Figure 8.10.

When perforated masonry units are used it may be necessary to use longer fixings which will pass through several webs of material to provide a secure fixing.

Bonded fixings may be used in solid masonry in the same way as they are used in concrete. However where hollow masonry units are used it may be necessary to use a net sleeve to contain the injected resin, Figure 8.11.

Screws which will cut their own thread in predrilled holes in masonry materials are available, Figure 8.12.

Specialist fixings for use in aerated concrete include plastic plugs with fins which are hammered into predrilled holes, Figure 8.13, and anchors which are grouted into an enlarged hole using a cement grout, Figure 8.14.

Materials

Brackets may be manufactured for a particular installation requiring the specifier to select the appropriate material. Brackets may be made of aluminium, steel or stainless steel. In most cases proprietary fixings will be used and the choice of material depends on what is available. Fixings are commonly available in stainless steel or zinc plated and passivated steel. Most stainless steel fixings are available in grade 1.4401(316) but some are also available in other grades. Fixings may also be available in hot dip galvanised steel and unprotected carbon steel.

Aluminium and stainless steel are durable in most conditions but stainless steel is available in different grades and an appropriate grade should be selected. Carbon steel components require protection which is commonly provided by galvanising or zinc plating. Galvanising gives greater protection than zinc plating but is less durable than stainless steel.

Aluminium, zinc coated steel and stainless steel are generally compatible in situations which are likely to occur in practice. Although there is an increased risk of corrosion of aluminium when it is in contact with stainless steel the risk depends on the relative areas of the materials.

Stainless steel fixings for aluminium components are therefore acceptable whereas aluminium fixings for stainless steel are not.

The specifier should have taken into account the durability of the materials used and the specified material and finish must not be changed without his agreement.

Installation

General

- Before installation all fixings should be checked to ensure that they are of the specified type, size and material. Fixings must be installed in accordance with the manufacturer's instructions.

- Setting out is required before fixings can be installed. Setting out should be related to the site datum rather than local features such as the slab edge or nearby column.

- The correct equipment is required. Some fixings require special tools supplied by the fixing manufacturer and may not operate correctly it alternative tools are used.

Cast in fixings in concrete

- Fixings should be securely fixed in place before placing the concrete
- The concrete should be allowed to cure before applying load to the fixings

Post drilled fixings

- Drill hole to correct diameter. Drills become worn with use and need to be replaced at intervals. Percussive drilling is normally required for concrete but when drilling into weak materials rotary drilling may be required to prevent enlargement of the hole.

- In all cases the hole must be deep enough to allow the fixing to be inserted to its full depth.

  For some fixings a greater depth of hole will not affect the fixing performance. However, for some types of fixing, for example bonded fixings with resin capsules and some displacement controlled expansion anchors, an overlong fixing hole may prevent the correct operation of the fixing.

- Ensure holes are square to the surface.

- Ensure minimum edge distance and spacing is provided. Reducing the edge distance and spacing reduces the strength of the fixing.

- Ensure reinforcing steel is avoided and agree procedures to be adopted where holes conflict with reinforcement. Reinforcement should only be cut with the agreement of the structural engineer and when the cut reinforcement will not affect the operation of the fixing.

- Where holes are aborted, due to hitting reinforcement or for any other reason, procedures for filling aborted holes and minimum spacing for replacement holes must be agreed.

- Clean hole thoroughly: blowing is usually sufficient for mechanical anchors, brushing is required for bonded anchors.

- For bonded fixings ensure temperature and moisture conditions are suitable and allow resin to cure before applying load.

- Position fixing correctly.

- Tighten to specified torque using calibrated torque spanner.

  If too low a torque is used the anchor may not clamp the fixture securely when subject to tensile load and expansion anchors may not give the required pullout strength. Too high a torque may damage the fixing material or may break the bond of resin anchors.

- Fixings should be marked for example by spraying with paint to indicate that the correct torque has been applied.

Packing and shims

- Shims should be made of material with suitable strength and durability. Plastic shims may be used when fixing window frames but metal shims should be used when fixing brackets. When metal shims are used the metal must be of sufficient inherent durability for the exposure conditions and be compatible with other metals with which it may come in contact.

- Shims should be of sufficient size to prevent concentrated loads.

- Use of shims will lead to increased bending stresses in fixings subject to shear load. The maximum thickness of shims should be specified and not exceeded.

Slotted holes

- Where slotted holes are used to provide adjustment it is important to use washers which are sufficiently thick to bridge the slot without deformation.

- Where slotted holes are used to provide adjustment but additional movement is to be prevented during the service life a means of locking the fixing is required. Friction under the clamping action of the fixing is not sufficient.

- This is usually achieved by the use of serrated surfaces. The pitch of the serrations must be selected to give sufficiently fine adjustment.

Testing

- In most cases proprietary fixings can be used in situations covered by the manufacturer's test data however occasionally testing may be required to check the suitability of fixings. This is most likely to occur when fixing to an existing structure and the properties of the substrate are unknown.

- To check the quality of installation a proportion of the installed fixings may be tested. The test load must be sufficiently high to give a meaningful test but not so high that correctly installed fixings are damaged. Testing is more likely to be required for curtain wall fixings than for window fixings.

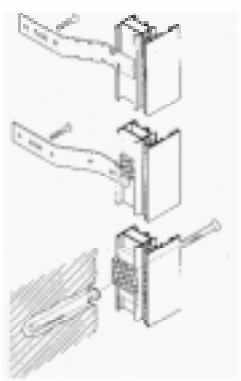

Figure 8.1 Fixings for windows

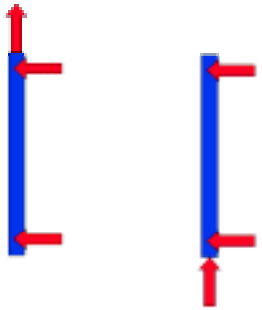

Figure 8.2 Support and restraint of curtain walling

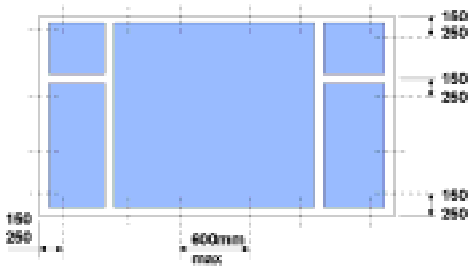

Figure 8.3 Fixing points for PVC-u windows

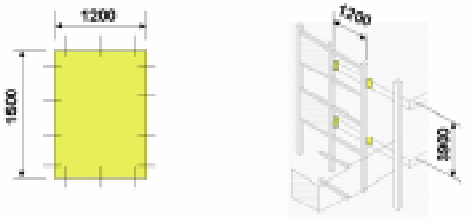

Figure 8.4 Spacing of fixing points

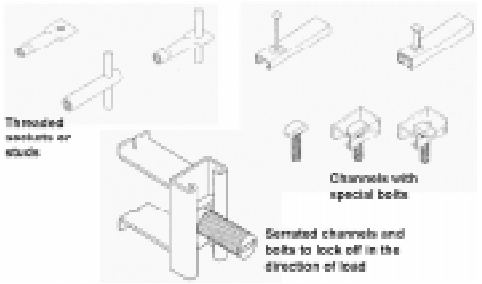

Figure 8.5 Cast-in place fixings

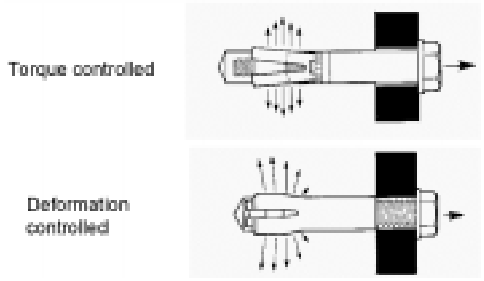

Figure 8.6 Expansion anchors

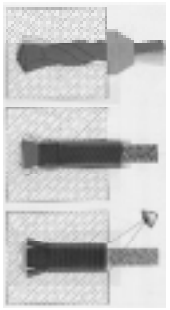

Figure 8.7 Undercut anchors

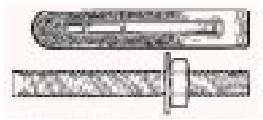

Figure 8.8 Resin anchor

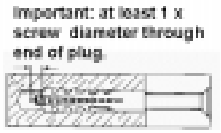

Figure 8.9 Wall plugs

Figure 8.10 Frame fixings

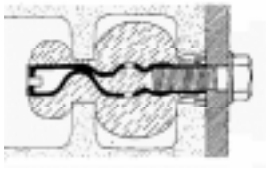

Figure 8.11 Resin fixing with net sleeve

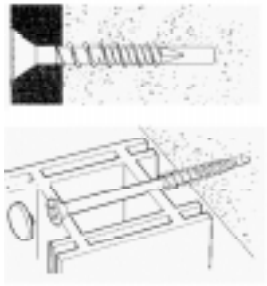

Figure 8.12 Self drilling masonry fixings

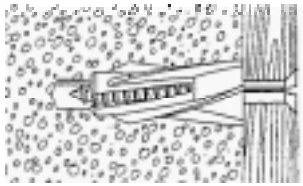

Figure 8.13 Plastic plug with fins

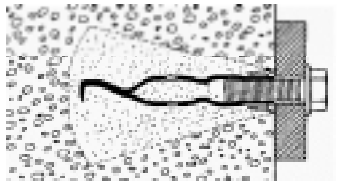

Figure 8.14 Grouted in anchor