CWCT CURTAIN WALL INSTALLATION HANDBOOK

Chapter 3 Frames

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Centre for Window and Cladding Technology
November 2001

ISBN 1 874003 96 3

Published by
Centre for Window and Cladding Technology, University of Bath, Claverton Down, Bath BA2 7AY

This handbook was part-funded by the Department of the Environment, Transport and the Regions under research contract number 39/03/272 cc 862.

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.

3 Frames

- **Function**

Frames may be used for windows, glazing screens and curtain walls. In all cases the frame is composed of a series of profiles assembled to form the frame and designed to support glazing or other infill panels. For windows, assembly of the frame, and sometimes glazing, is carried out before delivery to site whereas for glazing frames and curtain walls at least some, and in some cases all, of the assembly work will be carried out on site.

- **Frame materials**

Framing materials are selected largely on the basis of individual or corporate preference. They are chosen because of the specifier's familiarity with the material or for reasons such as 'green issues'. Each material offers different benefits and this may determine the choice of material. The principal materials used to form glazing frames are:

- **Timber**

Traditionally used as a framing material, today both hardwood and softwood are used. Timber suffers from rot but modern timber treatments combined with good design and workmanship give an acceptable life. However regular maintenance of finishes is required. Timber windows may be produced with a drained glazing cavity but many are undrained and rely on a single outer seal between glass and frame to keep out the water. Water ingress following failure of the seal can then lead to failure of the edge seal of double glazing units. Many windows have a limited depth of rebate restricting the width of glazing unit that can be accommodated.

Timber has been used for glazing screens but this is not common.

Timber is used as a solid section and is thus relatively stiff. It resists bending and torsion well and hardware can be attached to the frame with little difficulty.

- **Steel**

Steel was introduced as an alternative to timber for window frames. Originally hot rolled sections were used but today steel is used as cold-formed sections to make window and door frames. Steel windows are galvanised and powder coated and may today be double-glazed. The hardware is usually an integral part of the window. Steel windows allow the use of slender sections yet are robust and are comparatively secure, if secure hardware is used. Steel has obvious advantages when making fire resistant glazing screens and windows.

- **Aluminium**

Aluminium has been used as a framing material for some fifty years. Aluminium does not suffer badly from corrosion and is easy to form and finish allowing many different designs. Aluminium is used as hollow sections and is relatively flexible in bending and torsion. Hardware often has to be matched against a particular profile. Because of the hollow and complex profile cross sections achievable with aluminium it is easy to make drained and ventilated or pressure equalised windows.

Aluminium is a very good conductor of heat. To meet requirements for low thermal transmission aluminium profiles are thermally broken with either a polyamide or resin element between inner and outer aluminium sections. The latest proposals for improving the thermal performance of windows will require improved thermal breaks.

Aluminium is the most common frame material for stick system curtain walls, glazing screens and shop fronts. It is also commonly used as a framing system to support rainscreens.

- **PVCu**
PVCu is a flexible material that is normally internally reinforced with steel or aluminium to give it the required strength and stiffness. As with aluminium it is easily formed to produce a wide variety of profiles. When first introduced it was generally used white without any finishes but it is now widely available in coloured form, either using coloured material, foil finishes or specialist paints. It is dependent on reinforcement for its strength and hardware should be fastened through to the reinforcement. Many PVCu profiles are multi-chambered and it is essential that they drain correctly.

PVCu is now used to construct glazing screens and low rise curtain walling. The structural elements are PVCu clad aluminium and these form the supporting grid for PVCu framed windows.

- **Composites**
The use of composite frames allows the designer to use the advantages of different materials for the inner and outer parts of the frame. Common combinations are:

Aluminium - PVCu
Aluminium - Timber
Stainless Steel - Aluminium
Bronze - Aluminium

Composite frames are used to improve thermal performance (heat loss), reduce the risk of condensation, give a more durable outer weathering surface, give different appearances to the inner and outer finishes.

• Window types

There are many different types of window in use. Some of these are traditional designs, others are copied from traditional designs elsewhere and some have only become possible with the use of modern materials and hardware.

The window types commonly used in the UK are:

Fixed light	Vertical slider
Side hung vent	Horizontal slider
Projecting side hung	Horizontal pivot
Top hung vent	Vertical pivot
Projecting top hung	Off-set vertical pivot
Tilt-turn	

These are shown in Figure 3.1. The drawing notation used is in accordance with BS4873 in which the arrow drawn on the glazing points toward the hinges.

UK practice has been to use a solid line for open out windows and a dotted line for open inward windows. This is different from practice in some European countries and it should be clearly established which convention is being used.

• Window selection

The types of frame used on any particular contract will depend on a number of factors. These include:

- **Maintenance**
Windows that can be cleaned from the inside of the building may be preferred where it is possible to use a large proportion of opening windows. Framing materials that require little maintenance are also preferred.

- **Safety in use**
Windows have to be safe in use. They may have to meet any of these needs:
- be safe to clean and maintain

- provide a fire escape route
- prevent people from falling out
- not obstruct paths and passages when open

- **Ventilation**
Windows of different types give different ventilation patterns in a building Figure 3.2. The size of the opening sash will determine its weight and the hardware to be used.

- **Local custom**
Windows will often be selected to match those on nearby buildings. For refurbishment they are normally chosen to follow the style of earlier windows. On listed buildings and in conservation areas it may be a requirement that particular windows are used.

- Size of opening
The size of window opening will depend among other things on the lighting requirements, view, allowable heat loss and appearance of the window.

- Preferred material
Framing materials may be selected on the basis of cost, durability, strength, appearance. Increasingly whole life costs and environmental issues are being taken into account.

- Glazing material
The glazing or infill material may affect the choice of framing material. The frame has to support the weight of the glazing and accept glazing units of the required thickness.

- Appearance
This probably has the greatest influence on the selection of framing materials. Both the available finishes and the slenderness of the frame are factors.

• Window frame construction

Window frame construction is governed firstly by the type of framing material and secondly by the style of the window. The following are typical cross sections through window frames:

- **Timber**
There are no timber systems but there have been standardised designs. Timber is machined to a profile from hard or softwood and joined by tenon joints and finger joints to produce glazing frames. Today timber windows are available factory-painted and glazed.

- **Steel**
Hot rolled sections have traditionally been used to make window and door frames, Figure 3.3. They are of welded construction and are robust but the range of sections available is limited.

Cold-formed sections are available as proprietary systems Figure 3.4. The corners are normally cleated rather than welded. Care should be taken that frames are not racked or otherwise distorted during installation as the corner joints may be damaged.

- **Aluminium**
Aluminium can be extruded in an infinite number of complex shapes and to very close tolerances Figure 3.5. Window and wall framing systems consist of a number of profiles to facilitate extrusion and assembly.

Aluminium profiles are formed into frames by the use of mechanical joints. Window frames comprise a main framing member that provides the strength and stiffness and an extruded glazing bead that generally clips into place to retain the glazing in a drained glazing rebate.

Aluminium frames are thermally broken to make them more energy efficient and reduce the risk of condensation forming.

- **PVCu**

PVCu framing members are formed into window frames either by heat welding the members at mitred joints or by mechanical joints. Heat welded joints are more common and provide a clean seal that keeps water out of the frame. Window frames comprise a main framing member that provides the strength and stiffness and an extruded glazing bead that generally clips into place to retain the glazing in a drained rebate, Figure 3.6.

Many window suppliers are now able to supply an additional outer frame of galvanised steel. This can be built into a new wall allowing the window to be fitted sometime after the bricklaying has been completed.

- **Composite**
Frame construction depends largely on the material of the main or central element. For instance a timber window is made and then clad with plastic or metal. The jointing technology has to take account of the materials to be joined and the presence of different materials and is generally more complex than for non-composite frames.

• Doors

Doors are constructed from all of the framing materials. In general doors are made from larger sections. This is due to their size but also due to the robustness requirements, particularly for commercial buildings. The most commonly used framing materials are aluminium, hardwood and PVCu.

• Tolerances

Overall tolerances for windows and doors are set out in the British Standards for each framing material. Tolerances are defined in terms of height, width and difference between diagonals (or squareness). They are (in mm):

Material	Width	Height	Diagonal
Timber	± 2	± 2	3,5 or 10**+**
Steel	± 1.5	± 1.5	4
Aluminium	± 1.5	± 1.5	4
PVCu	± 3	± 3	4

+depending on size of window

Particular manufacturers will be able to make windows to greater accuracy. However they may not be able to do so for very large windows. The tolerance achieved with a composite frame should be the greater of the above when considering both materials.

The squareness of a fixed frame may change if it is fixed incorrectly to the wall. That of an opening frame may change as it is glazed. Squareness should be checked before and after installation.

The rigidity of a window frame depends on the presence of the glazing and the positioning of the setting blocks. The use of factory glazed windows can overcome this problem. However care is still required with the frames of doors and opening lights.

• Curtain wall sections

Stick system curtain walls comprise mullion (vertical) and transom (horizontal) framing members. Curtain wall frames act structurally to resist wind loading and to carry the weight of the wall. A typical profile is shown in Figure 3.7.

The profile comprises an outer section that serves to hold the infill material in place, prevent water penetration and form an air seal. The inner section comprises a hollow structural box the depth of which determines the strength and stiffness of the section.

Most curtain walls are constructed from aluminium profiles. Some walls are constructed as an assembly of windows with PVCu frames. These are supported in a structural frame the mullions and transoms of which are aluminium sections sheathed with PVCu.

Stick curtain wall members are delivered to site machined and cut to length. A high degree of accuracy is required in cutting to length. Slight variations in the length of members will result in the erected frames being out of square or distorted whereas if all the elements are consistently over or under size the frame can be erected square but the final bay may have to be manufactured specially to fit the remaining gap. The tolerance for these elements should be agreed at the design stage. Framing members may be pre-assembled as ladder frames or unitised walling.

Framing members may be designed to retain the infill panels in a number of ways:

- **Pressure cap**
The most common means of retaining glazing in a curtain wall frame is by using a pressure plate which secures the glass in the glazing rebate around the full perimeter of the glazing unit.

Pressure caps are secured in position by screws which must be either tightened to a required torque or to a stop where the pressure cap makes contact with the frame.

- **Structural silicone glazing**
Structural silicone provides a means of retaining glass without the need for external components. It is therefore possible to obtain a smooth façade.

It is important that the structural silicone should be applied under controlled conditions in a factory. This should ensure a clean environment and controlled curing times.

To achieve this the structural silicone is normally used to attach the glazing to a carrier frame that is then fixed to the curtain wall frame using mechanical fixings.

- **Bolted connections**
Bolted connections have been developed as an alternative means of achieving a smooth façade. Bolted connections can be used with glazing units and single glass.

• Rainscreen frames and rails

Rainscreen is a layered form of construction comprising an outer cladding or rainscreen, a cavity and a backing wall. Rainscreens may be constructed in various ways. Panels may be supported by a masonry or concrete backing wall via brackets or timber battens. Alternatively the rainscreen panels may be supported by rails spanning between floors or a frame consisting of vertical and horizontal members.

The frame may be of similar proportions to a curtain wall frame and span from floor to floor as a self contained, integral, rainscreen. Alternatively sections of lighter weight may be used attached to a background wall for support.

Frame members are made from aluminium profiles or cold formed steel sections. The tolerances on components are similar to those achievable for curtain walls.

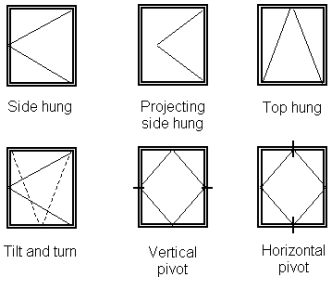

Figure 3.1 Window types

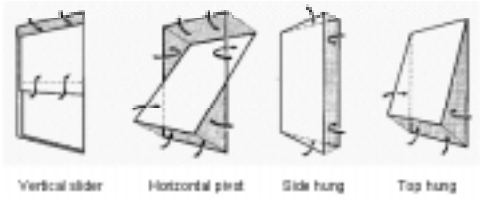

Figure 3.2 Window types

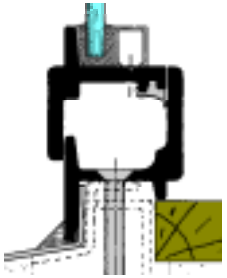

Figure 3.3 Hot rolled steel window frame

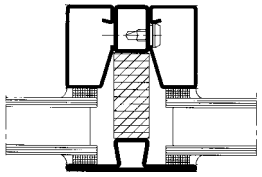

Figure 3.4 Cold formed steel glazing frame

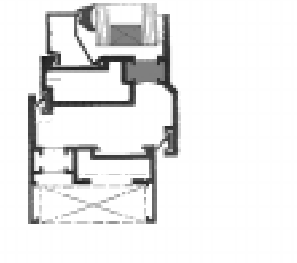

Figure 3.5 Aluminium window frame

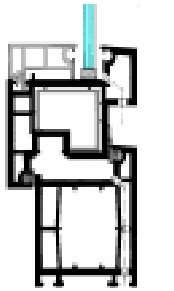

Figure 3.6 PVCu window frame

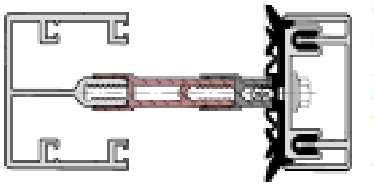

Figure 3.7 Aluminium curtain walling frame