Aluminium Window

GOOD INDUSTRY PRACTICES

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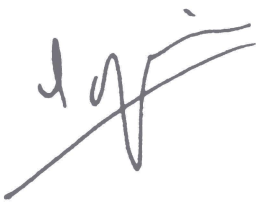
Foreword

The Building and Construction Authority (BCA) has been promoting the use of Construction Quality Assessment System or CONQUAS 21 as the de facto national yardstick for measuring the workmanship quality of building projects. To meet the rising expectation of the homeowners, the Quality Mark (QM) Scheme was launched in July 2002 to promote a higher consistency in workmanship standards for residential developments.

Besides setting standards and assessing the level of workmanship through CONQUAS 21 and QM Schemes, BCA is developing a series of publications called the CONQUAS 21 Good Industry Practices Guides to share with the industry good work practices adopted by practitioners and contractors who consistently deliver high quality work.

This "Good Industry Practices – Aluminium Window" is part of the CONQUAS 21 Enhancement Series on Good Industry Practices. Windows are major components of buildings. This guide provides simple and practical tips to users on how good quality fabrication and site installation can be achieved. Common defects associated with aluminium window as well as their causes and preventive measures are also highlighted. Photographs and graphical representations are used extensively in the guide to provide easy reference and better illustration of the practices.

It should, however, be pointed out that this guide is not meant to dictate how aluminium window must be designed and installed. It only serves to illustrate some of the good practices designers and contractors have adopted while designing and installing aluminium window. We gratefully acknowledge the contributions of these practitioners and trust that the industry will find this publication useful in its pursuit of quality excellence.



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Acknowledgement

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Contents

1. Introduction

Windows are major components of buildings. A recent survey conducted by BCA on private residential buildings showed that water seepage through windows is a common building defect which is unacceptable to owners. In addition, CONQUAS assessment data on *Window Watertightness Test* show that even newly completed buildings have a small but significant rate of water seepage. Beside water seepage defects, CONQUAS results also show that, poor jointing and material/ component damages are major defect areas for windows.

In general, a window is designed to:

- provide view;
- admit light;
- allow for natural ventilation; and
- give a pleasing façade.

Window design and installation should also cut down noise transmission, reduce solar heat gain, keep out rainwater and provide security to the occupants.

Window can be fabricated from a variety of materials, for example, timber, plastic, metal, etc. It is a system and comprises various components as follows (Figure 1.1):

- head;
- jamb;
- sill;
- sash;
- mullion;
- transom; and
- accessories

Due to volume constraint, this guidebook focuses on aluminium frame windows which are commonly used in the local industry, with emphasis on enhancing watertightness performance and minimizing physical defects of the windows.

For more information on the safety aspects on installation and maintenance of windows, please refer to the specific requirements for the installation and retrofitting works relating to windows prescribed in the Building Control Regulations. The Fifth Schedule of the Building Control Regulations specifies the performance-based requirements on the design of windows. The acceptable solution is based on compliance to SS 212 Specification for Aluminium Alloy Windows. In addition, only trained and approved contractors registered in BCA Contractors Registry under the regulatory workhead RW01 can carry out installation and retrofitting of windows.

Figure 1.1: Components of window

2. Design

It is critical to consider the following factors in window design:

- type of window system;
- type of framing system;
- structural support; and
- weathering resistance.

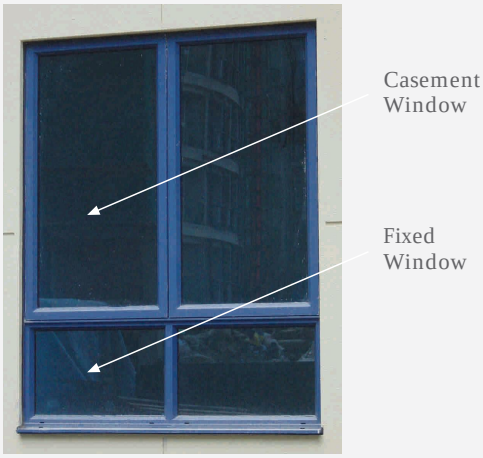
Other design considerations such as accommodation of building movement, drainage path and internal frame ventilation are equally important, however, due to volume constraint, this guide focuses on the four factors listed above.

2.1. TYPE OF WINDOW SYSTEM

Windows are usually classified according to the types of operation as follow:

- fixed glass;
- casement;
- top hung (awning);
- bottom hung (hopper);
- sliding;
- louvred; and
- bay window.

Table 2.1 Common types of windows used in the local industry

Type of Window	Description
1. Fixed Glass 	• Has a fixed glazed sash • Designed mainly for providing view, admitting light and for aesthetics purposes
2. Casement 	• Sash opens on hinges, pivots or friction stays • Allows airflow through almost the entire area of the window opening • Designed mainly for providing view, admitting light, allowing for natural ventilation and for aesthetics purposes

Type of Window	Description
3. Top Hung (Awning) 	• Similar to casement window, except that the sash is connected by friction stays at the top of the window frame • Designed mainly for providing view, admitting light and allowing for natural ventilation
4. Bottom Hung (Hopper) 	• Similar to top hung window, except that the sash is connected by friction stays at the bottom of the window frame • Designed mainly for providing view, admitting light and allowing for natural ventilation
5. Sliding 	• Consists of two or more sashes, which slide horizontally or vertically along tracks • Does not require space for swinging of sashes, hence, useful at locations next to passage ways • Except for specially designed window, not possible to achieve ventilation through the entire window opening • Designed mainly for providing view, admitting light, allowing natural ventilation and for aesthetics purposes
6. Louvred 	• Comprises horizontal glass panes, which are either fixed at an angle, or adjustable to control the amount of light and ventilation through the window • Designed mainly for admitting light and allowing for natural ventilation

Type of Window	Description
7. Bay Window 	• Generally comprises a series of windows assembled in a polygonal arrangement • Projects outward from the external facade of a building • Designed mainly for providing view, admitting light and allowing for natural ventilation. Can be a pleasant element to a building façade.

2.2. TYPE OF FRAMING SYSTEM

There are generally three methods of fixing the window frames to the wall structures:

- sub-frame system;
- cast-in window system; and
- lug system

In general, the sub-frame and cast-in window system have better watertightness performance than the conventional lug system.

2.2.1. SUB-FRAME SYSTEM

This system has a sub-frame that is cast in or anchored onto the wall structure. The main window frame is subsequently mounted onto the sub-frame at a later stage when all other trades have completed their works (Figure 2.1).

Figure 2.1: Sub-frame system

a) Installation of sub-frame at an earlier construction stage.

b) Installation of main frame at a later stage of construction.

The main advantages and disadvantages of the sub-frame system are summerised in Table 2.2.

Table 2.2 Advantages and disadvantages of sub-frame system

Advantages	Disadvantages
• Generally has better weather tightness performance • Can be used for precast or cast in-situ wall systems which do not require plastering • Allows greater flexibility in the sequencing of works of other trades; the sub-frame is installed first so that wet trades around the window can be completed before subsequent installation of the main frame and • The outer frames are installed after all wet trades around the windows are completed and hence, are subject to lower risk of physical damages	• Smaller dimensional tolerances of the wall opening are allowed

2.2.2. CAST-IN WINDOW SYSTEM

For cast-in window system, the frames are cast together with the precast façade. This helps to raise site productivity and achieve higher workmanship quality in the installation of the window frames. Through eliminating the need for site grouting or application of sealant to seal the gaps between the window frame and wall, cast-in window system has superior watertightness performance over the conventional lug system.

The main advantages and disadvantages of the cast-in window system are summerised in Table 2.3.

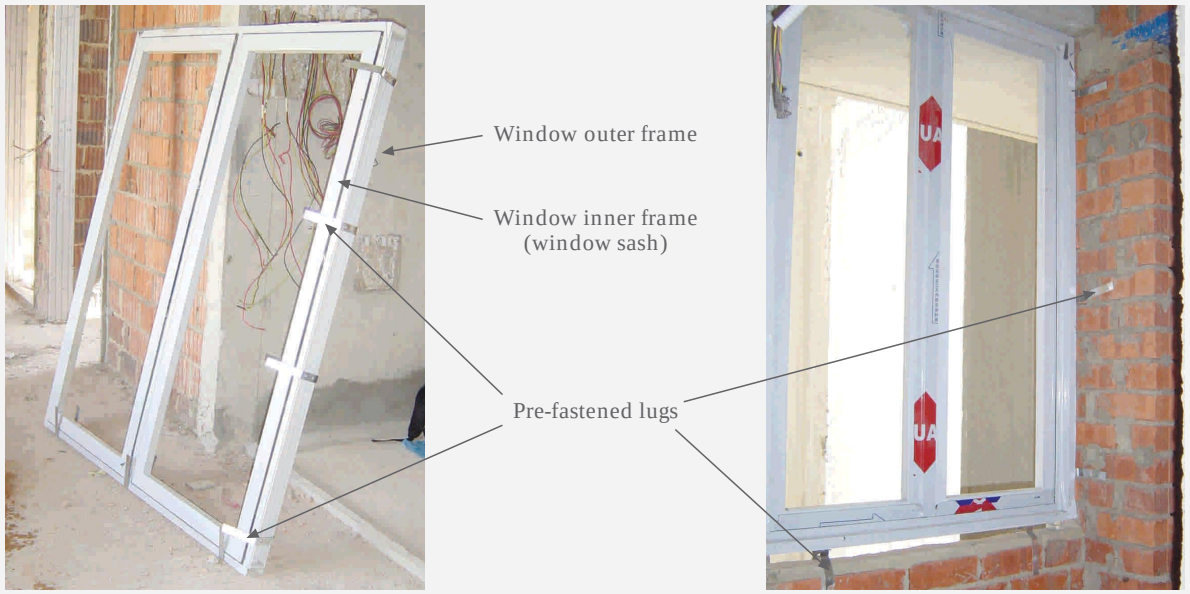
Table 2.3 Advantages and disadvantages of the cast-in window system

Advantages	Disadvantages
• Eliminate the need for site grouting or application of sealant to seal the gaps between window frames and walls • Superior watertightness performance • Installation of window main frame is carried out at the precast yard where tighter quality control is easier to administer	• Require close coordination between window supplier and precaster • Rectification and replacement could be more costly

2.2.3. LUG SYSTEM

The conventional lug system, which is commonly used in the local industry, comes with pre-fastened galvanised straps/brackets.

Figure 2.2: Lug system



a) Window frame prior to installation

b) Installation of window frame by ramsetting the straps to the wall

The frame is mounted in position by ramsetting the straps/ brackets to the wall as shown in Figure 2.2. The lug system is commonly used for installing window frame on plastered walls where the lugs can be fixed to the wall and embedded in the plaster.

The main advantages and disadvantages of the lug system are summerised in Table 2.4.

Table 2.4 Advantages and disadvantages of the lug system

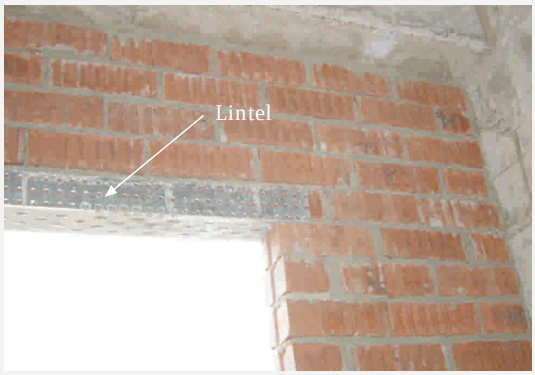
Advantages	Disadvantages
• Less stringent dimensional tolerances for the structural openings since the lugs are adjustable	• Quality of finishing and watertightness performance is highly workmanship dependent • The outer frames, which are installed at the early stage of construction, are vulnerable to damages by works of other trades

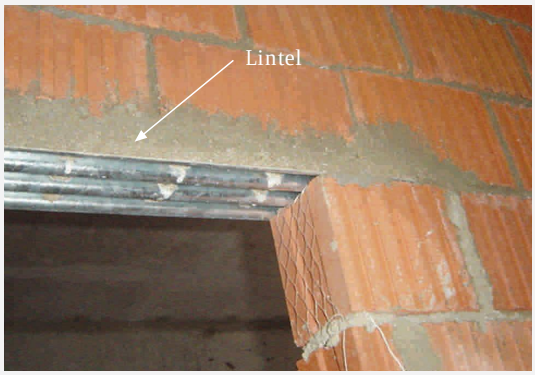
2.3. STRUCTURAL SUPPORT

Inadequate design may transfer the vertical load from the wall/structure above the window to the window frame and glass panel. This induces stresses on the frame and glazing, and affects the ease of operation of the window. Vertical loads above the window must, hence, be designed to be transferred to a lintel or other structural system to minimise deflection in the window (Figure 2.3).

Similarly if the window abuts the structural beam above, details must allow for the beam to deflect downwards without overstressing the window.

Figure 2.3: Types of lintel used for window





2.4. WEATHERING RESISTANCE

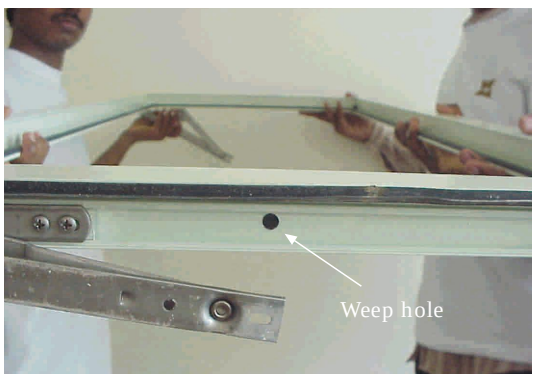
When in its closed position, window must be effective in shutting out the rain water. There are several ways that the design of window system and building architecture can help to improve the watertightness performance of the windows.

2.4.1. WINDOW DETAILING

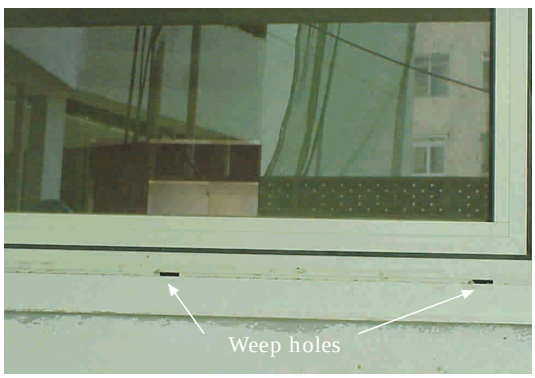
Weep holes should be provided in the frames, window sashes and sliding tracks to drain off any incidental water (Figure 2.4). Window sill should be designed with adequate slope away from the sash to provide effective water run off from the window (Figure 2.5).

Gaskets of suitable profile should be provided at appropriate locations to achieve effective watertightness of the windows.

Figure 2.4: Provision of weep holes to drain off incidental water

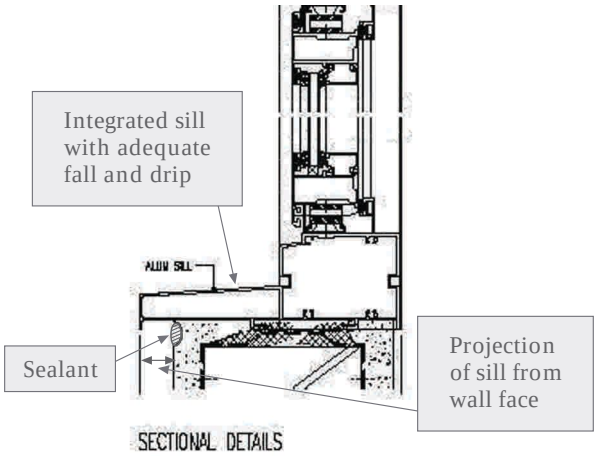


a) Weep hole under window sash



b) Weep holes in outer frame

Figure 2.5: Design of window sill to minimise water seepage



2.4.2. WALL OPENING

For lug systems, the size of the wall opening should allow a gap of 7-25mm between the wall and window frame (Figure 2.6). This gap should be properly sealed to ensure watertightness at this location. Sealant or non-shrink grout (mixed with waterproofing additives) can be used to seal the gap, depending on the gap size as shown in Table 2.5.

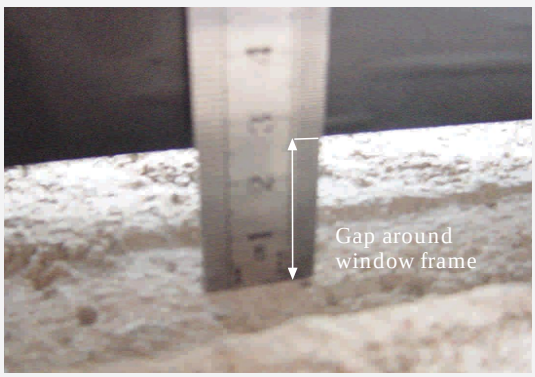
Table 2.5 Type of gap sealing method

Gap Size	Type of Sealing
7mm – 10mm	Use backer rod and sealant
11mm – 25mm	Use non-shrink cement grout + waterproofing additives and complete with sealant.

For gap size less than 7mm, the side wall should be chipped off and made good to the suitable gap size.

Undesirable large gap (more than 25mm) filled with cement mortar has a high tendency of mortar shrinkage. This could lead to cracks which diminish the water tightness defence. For such large gap, reduce the opening size by topping up the gap with chipping concrete.

Figure 2.6: Dimensional control of wall opening

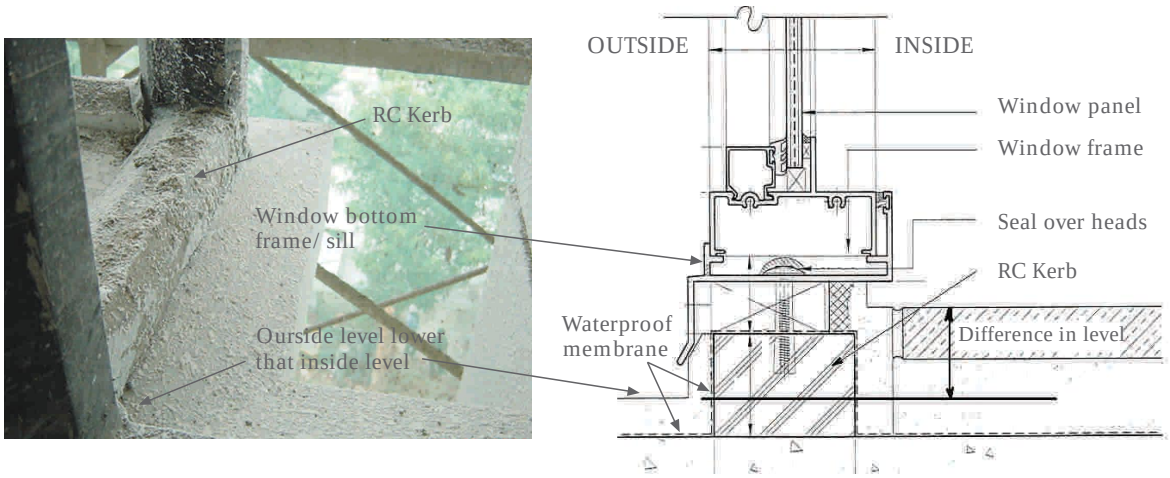


Window frame should be installed on a levelled sill or parapet wall. Prefabrication technology provides better dimensional control than cast in-situ RC walls and brickwalls. Sill and parapet wall surface should slope outwards for efficient water run-off. This helps to minimise the accumulation of water puddle that could lead to water seepage through imperfections of surface or joints.

For enhanced watertightness performance, waterproofing membrane can be applied over the joint area between the wall and window frame. Sealant should also be applied along the perimeter of the window frame.

For full-height windows, an effective way to minimise water seepage is to elevate the window from the finished floor level and to provide supplementary waterproofing barrier. This could be achieved by building up a RC kerb for mounting of the bottom frame of the window (Figure 2.7).

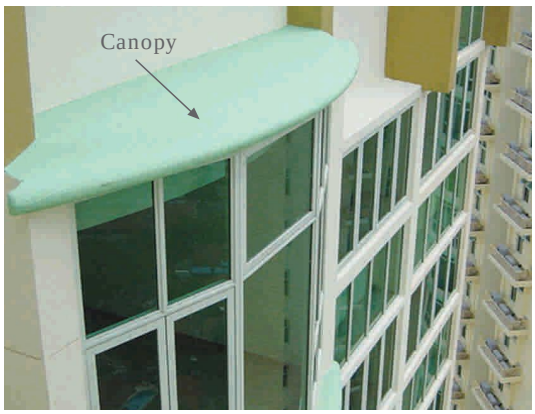
Figure 2.7: RC kerb for elevating frame from floor level



2.4.3. ARCHITECTURAL DESIGN

Windows that are subjected to direct impact of wind-driven rainfall face a higher risk of water seepage. Recessed windows and provision of shielding features (Figure 2.8) are effective ways to protect the windows from direct rainfall or accumulated flow of water along the vertical façade directly above the windows. In addition, the provision of run-off ledge sloping away from the window sill (Figure 2.9) minimises water ponding and reduces the possibilities of water seepage through the joints.

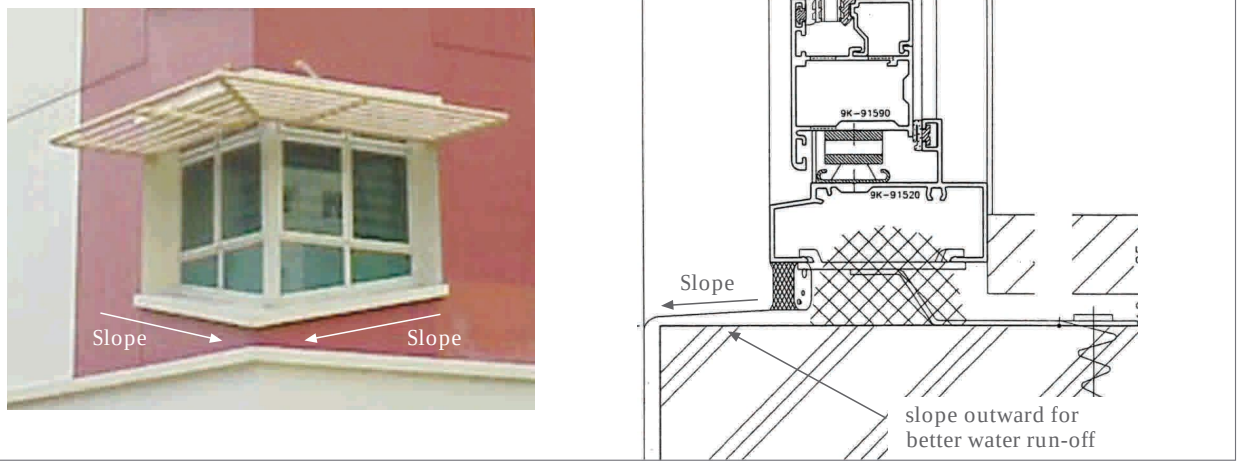
Figure 2.8: Design features to minimise direct rainfall on the windows



a) Canopy over window

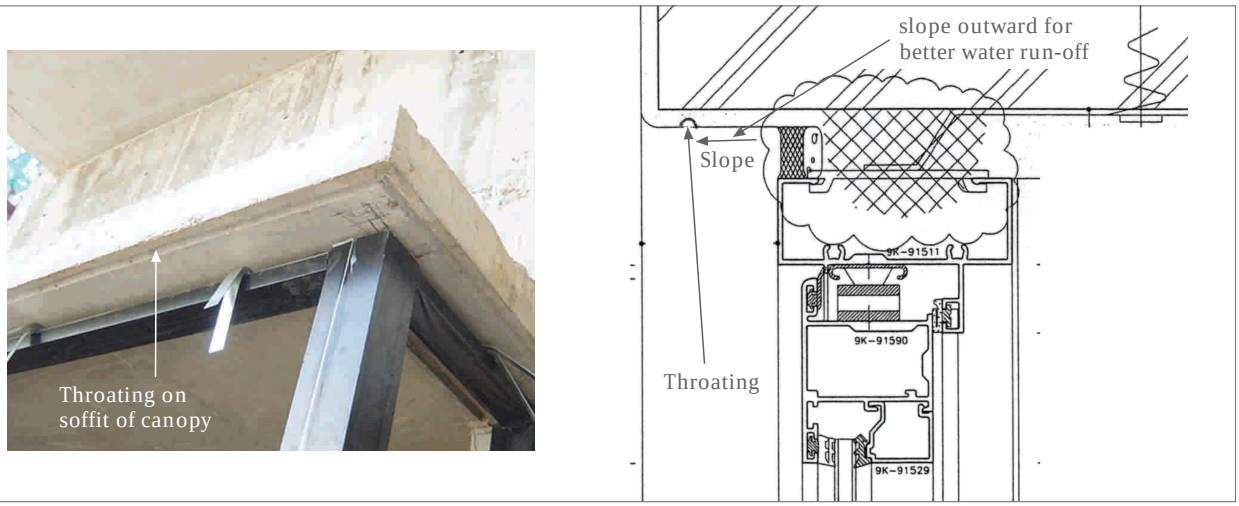
b) Recessed window

Figure 2.9: Sloping ledges to minimize water seepage



For canopy overhanging above the window, a drip line or 'throating' should be provided on the soffit of the canopy to prevent rain water from flowing towards the window (Figure 2.10).

Figure 2.10: Throating on soffit of canopy



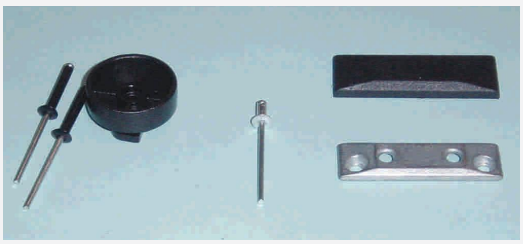
3. Material Selection

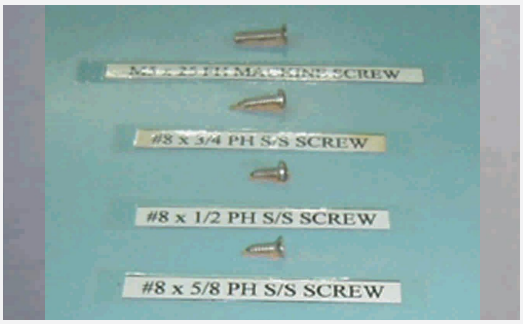
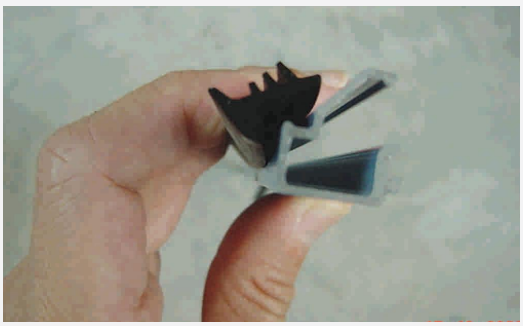
The main components of a window system include: -

- window frame;
- glazing;
- metal lugs, straps and brackets ;
- operating & bearing devices;
- fasteners and fixings;
- setting blocks;
- gaskets;
- sealant; and
- protective materials

Table 3.1 Major components of window

Components	Description and Specifications
1. Frame 	• Extruded aluminium members shall be fabricated from designated treated alloy 6063T4, 6063T5 or 6063T6 complying with BS EN 755 • Type of finishes for aluminium frame include: – Anodic coating to 25 microns (average) minimum complying with BS 3987 – Liquid organic coating complying with AAMA 2605 – Powder organic coating complying with BS 6496 or AAMA 2604 – Combined coating complying with JIS H8602 The minimum thickness of coating shall be 9 microns for the anodic coat and 7 microns for the liquid organic coat
2. Glazing 	• Type and quality of glass should comply with BS 952: Parts 1 and 2. • Other glass types include: - – Laminated glass complying with SS 341 – Heat strengthened glass complying with SS 341 – Toughened glass complying with SS 341 – Insulated glazed units complying with BS 5713 or equivalent and – Glass with low emissivity coating

Components	Description and Specifications
3. Metal lugs, straps, brackets and anchor bolts  	• Material used include: - – Stainless steel complying with BS EN 10088 – Aluminium complying with BS EN 755 • Steel should be finished with one of the following methods: - – Zinc plating and passivating in accordance with classification Zn 3 (minimum) of BS 1706 and chromate passivation in accordance with Class 2C and 2D of BS 6338 – Hot dip galvanising in accordance with SS 117 to a minimum coating mass of 460g/m^2 – Sprayed zinc coating according to BS EN 22063 – Electro-galvanising or lead and chromate free primer complying with SS 494
4. Operating and bearing devices   	• These include hinges, geometry stays, pivots, skids, rollers, stoppers, handles and other hardwares • Geometry stay shall be capable of complying with BS 7479/ ISO 9227 • Material used include: - – Alumninium equal to that of frame finish in item 1 – Stainless steel type minimum 304 complying with BS EN 10088 – Zinc die-casting alloy A complying with BS 1004, nikel chromium plated in accordance with BS EN 12540 with liquid or powder organic coated finish in accordance with BS 6496 – Steel finished to classification Zn3 (minimum) in accordance with BS 1706 and chromate passivation in accordance with BS 6338 • Friction stays complying with stainless steel type minimum 304 complying with BS EN 10088 with endurance test complying with SS 212

Components	Description and Specifications
5. Screws 	• Stainless steel type minimum 304 complying with BS EN 10088
6. Setting blocks 	• Setting blocks to be made of silicone rubber, neoprene or EPDM of appropriate hardness and resistance to compression set • Compound used in the blocks must not leach out or migrate over time and cause staining of the window, as well as deterioration of the block
7. Gasket 	• Made of neoprene or EPDM • Material should not react with the aluminium finishes, glass or other glazing materials. Gaskets should be tested to ASTM C509 and C864

Components	Description and Specifications
8. Sealant 	• Compatibility of sealant and substrate ought to be assessed prior to use. Sealant should be tested to ASTM C920 • To be selected and installed in accordance with BS 6213 • Silicone sealant to comply with BS 5889 • Polyurethane sealant to comply with BS 5215 • Designed sealant geometry (and cross section) should accommodate the anticipated substrate movement • Do not use acid curing sealants • Sealant should be used in accordance with manufacturer's directions, particularly relating to the use of primer Sealant to have:- – Backer rod- non-gassing polyethylene closed cell form – Primers and joint preparation materials- as recommended by the sealant manufacturer
9. Protective materials  	• Windows should be protected throughout the construction process. This includes protection to the frames, glass, handles, etc • Protection should remain in place until all works that could potentially damage the window system/components have been completed • Materials used should be compatible with the finishes of the protected surfaces • Material used should be subsequently removed without detriment to the finishes of the protected surfaces (See Chapter 9 for more details on protection)

Note:
All material specifications should refer to the Singapore Standard SS 212 Specification for Aluminium alloy windows. References are also made to the National Productivity and Quality Specifications (NPQS)

4. Fabrication

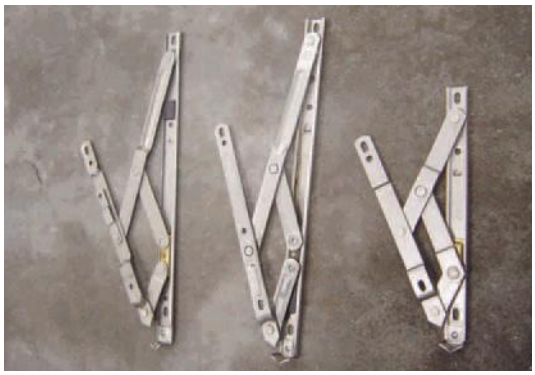
Assurance on the quality and performance of windows starts in the factory where the various components of the window system are fabricated and assembled.

4.1. MOCKUP AND SAMPLES

Mock up of the window configurations, colours & finishes, as well as samples of the associated hardwares and accessories should be made available in the factory for reference (Figure 4.1 & 4.2).

Figure 4.1: Mockup of window

Figure 4.2: Samples of associated window hardwares and accessories



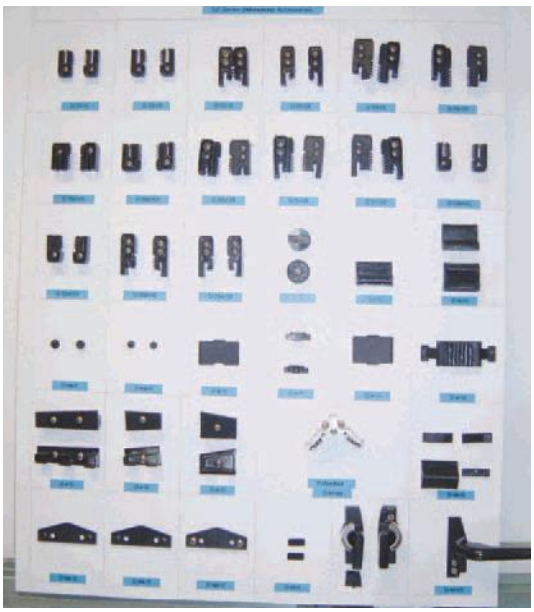
a) Friction stays

b) Operating devices and bearing devices

c) Handles

d) Fasteners and fixings

e) Gaskets and fixing screws



f) Components for windows

4.2. FABRICATION TOLERANCES

The following tolerances should be achieved during fabrication:

Window Frame		
1.	Length	±1.5mm
2.	Straightness	±1.5mm
3.	Accuracy on angles	±2°
4.	Accurancy on sides	±1mm
5.	Accuracy on diagonals	±2mm

Source: National Productivity and Quality Specification (NPQS)

Glass Panels		
1.	Height	±2mm
2.	Width	±2mm
3.	Straightness of edges	±1mm
4.	Tolerances on insulating glazed units	As allowed by BS 5713

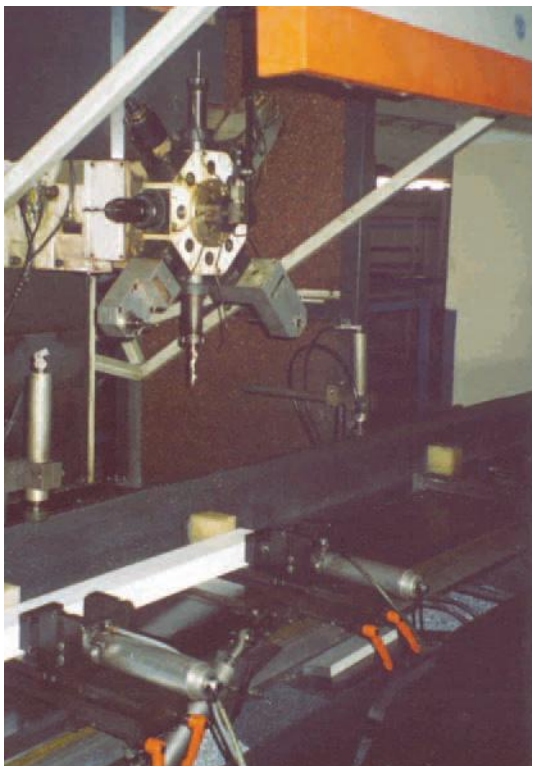
Source: National Productivity and Quality Specification (NPQS)

4.3. FABRICATION AND ASSEMBLY OF WINDOW FRAME

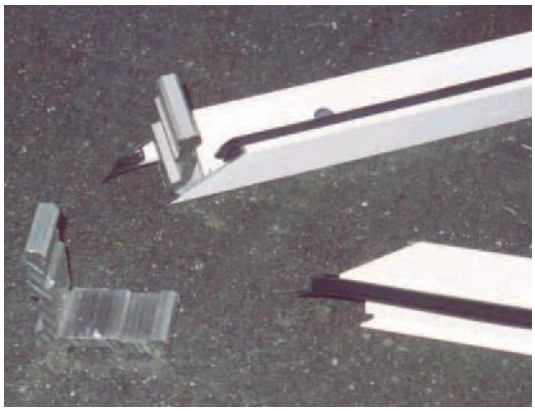
High quality windows can be effectively achieved by fabricating and assembling as many components as possible in the factory. This helps to minimise site assembly where quality control is more difficult.

The use of mechanical tools, including jigs and computerised machines are useful in achieving the required fabrication tolerances.

Figure 4.3: Use of cutting and drilling machines



a) Computerised drilling machine



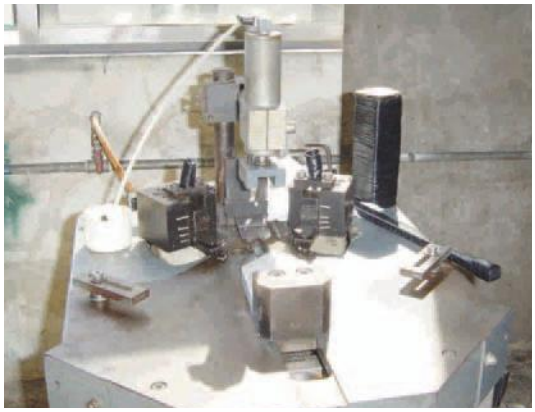
b) Precision cutting gives high dimensional accuracy

Frame assembly could be carried out on elevated workbench. The workbench surfaces should be padded to prevent scratches and other physical damages to the frames (Figure 4.4).

Figure 4.4: Workbench

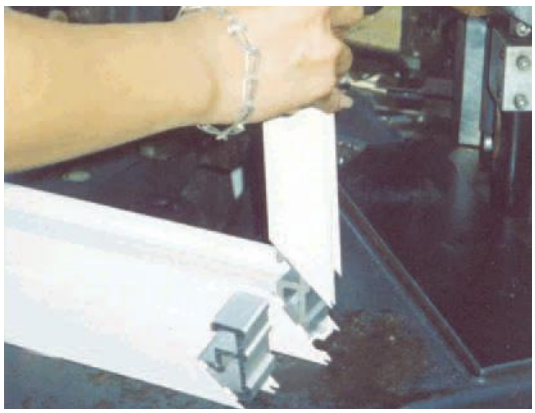
Assembly of the window main frame and sash inner frame using a crimping machine produces strong and quality joints. Sealant should be applied to the joining edges prior to assembly for enhanced watertightness performance (Figure 4.5).

Figure 4.5: Assembling of window frame (Crimping method)



a) Crimping machine for mitre joint

b) Application of sealant on mitre edge



c) Joining of frame components

d) Securing of frame

Alternatively, the frame could be secured using screws (Figure 4.6).

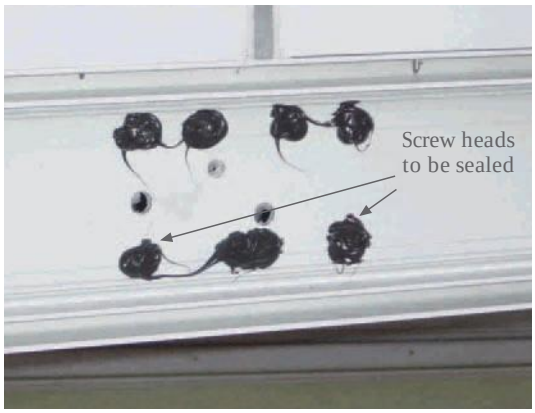
Figure 4.6: Assembling of window frame (Screw joint method)

a) Jointing frame

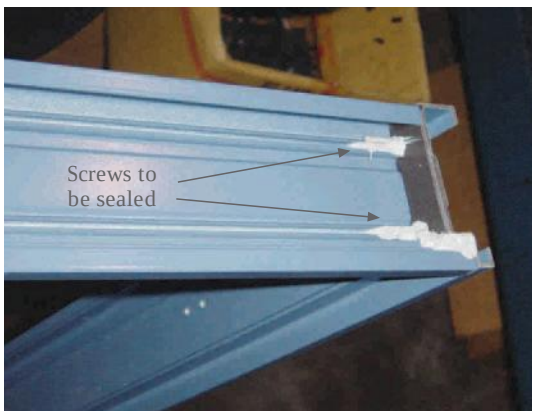
b) Tightening screw for joint

All screws and screw holes for assembly of components should be sealed with sealant. Sealing pads should be provided at frame intersections to ensure watertightness at these locations.

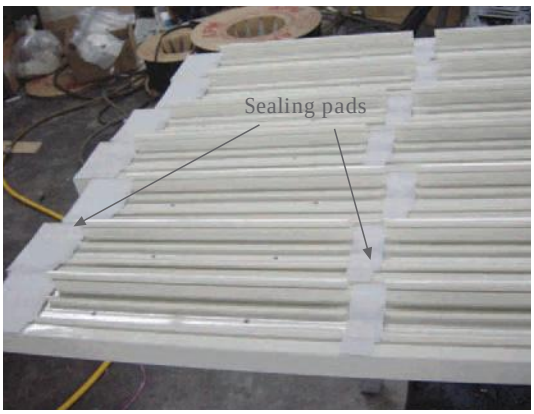
Figure 4.7: Waterproofing of frame



a) Screw heads sealed with sealant



b) Screws sealed with sealant

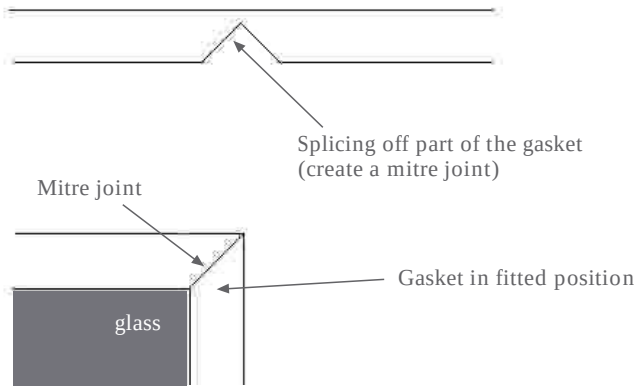


c) Sealant pads

4.4. GLAZING

For better quality, glazing work should, as far as possible, be carried out by skilled installers in the factory. The gasket used should be of a continuous length, with splices made at appropriate locations for good fitting around the corners of the glass panel (Figure 4.8).

Figure 4.8: Installation of gasket



a) Splicing of gasket to fit around corner of glass

b) Gasket is spliced for good fit at the corners

c) Mitre joint at last corner of the gasket

When assembling the frames, ensure that the gasket fits properly to the glazing and the frames are properly aligned. A suitable tool should be used to knock the frames in place. The tool should come with suitable padding to prevent damage to the frames (Figure 4.9).

Figure 4.9: Assembling of frame

a) Place frame in place

b) Knock frame in place

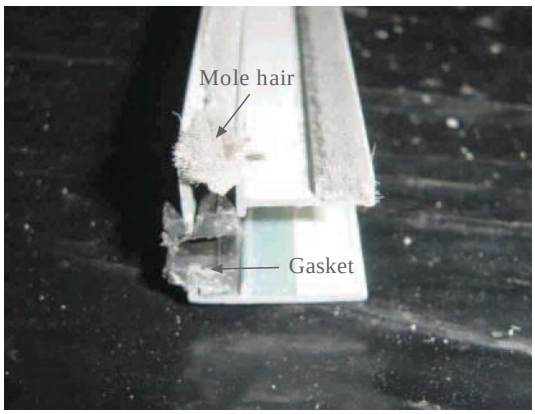
c) Ensure frame is fitted properly all round

d) Secure the frame with screws

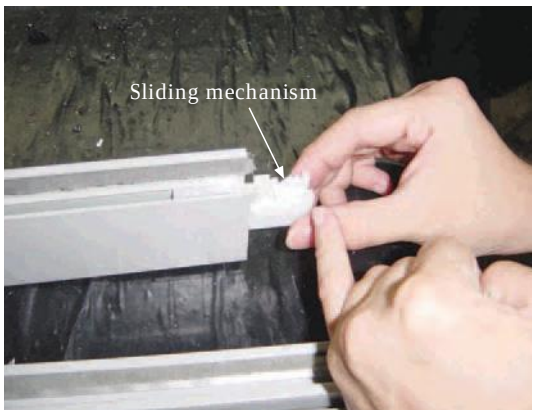
For sliding window panel, mole hair and gasket should be inserted to provide additional barrier to water penetration.

The sliding mechanism, consisting of the rolling mechanism should be inserted into the window panel. Capping devices are used to ensure that the sliding mechanism remains in place.

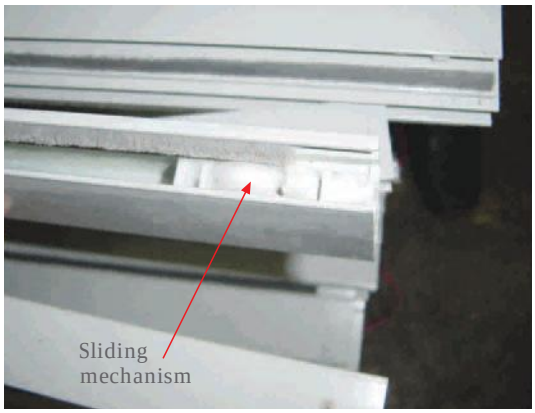
Figure 4.10: Insertions in sliding window frame



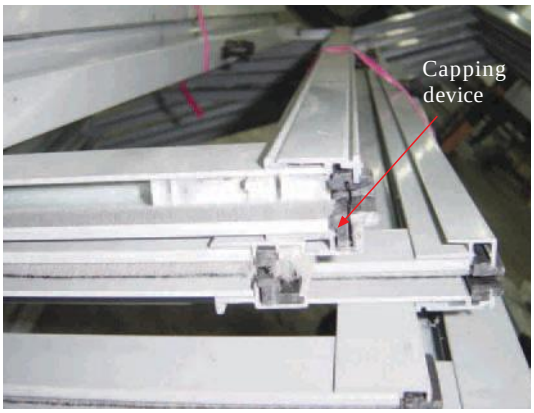
a) Insertion of mole hair and gasket



b) Insertion of sliding mechanism



c) Sliding mechanism in position



d) Capping devices in position

4.5. PROTECTION

All exposed parts of the aluminium frame/ sections must be protected with suitable protective tapes (Figure 4.11). The tapes used should not leave stains on the surface of the frames nor damage the frame finishes during removal. Corrugated cardboard may be used beneath the protective tape to give additional protection to the frame.

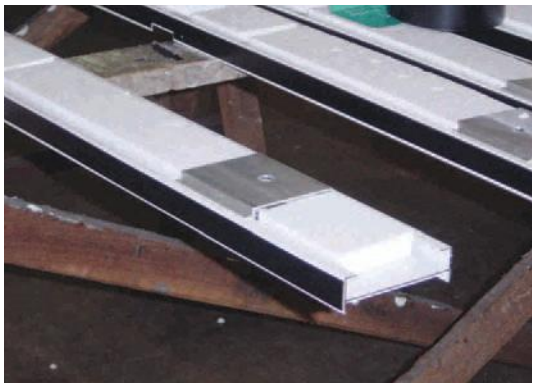
Figure 4.11: Protection of frame

a) Protective tape

b) Protection of frame

For slender frame sections, styrofoam strips can be inserted as shown in Figure 4.12 to maintain the rigidity and prevent deformation of the frame during delivery, storage and handling. In addition, corners of frames should be protected to prevent damages during delivery and storage. All glazing should also be protected with suitable materials.

Figure 4.12: Protection of frame for delivery



a) Insertion of styrofoam strips to maintain rigidity of slender frames

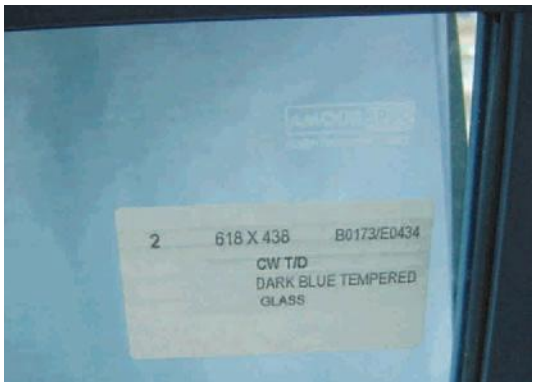
b) Protection of the corners of assembled frames

4.6. LABELLING

All fabricated frames, window sashes and glass panels should be properly labelled for ease of identification (Figure 4.13). The frames should be arranged in batches for delivery to site (Figure 4.14). Suppliers should plan the delivery of windows in accordance with the installation schedule to minimize storage and handling on site.

Figure 4.13: Labelling of frames, sashes and glass panels

a) Label on frame



b) Label on sash/ glass panel

Figure 4.14: Completed frames arranged in batches for delivery to site

5. Delivery, Storage And Handling

5.1. DELIVERY

Before delivery, windows and its various components should be fully protected to ensure the components remain in good condition until they are ready for installation.

All materials for delivery should be verified against the quantity and batch number stated in the delivery order. All required accessories, including friction stays, handles, locking devices, fixing, etc. should be delivered together with the main components. Materials could be packed in either steel pallets or skids.

Upon delivery on site, the materials should be checked for damages during transportation and that the delivered materials are in compliance with the specifications. Any damaged or incorrect materials should be returned to the factory.

Figure 5.1: Packing for delivery

5.2. STORAGE

Delivery of materials should be carefully planned according to the installation schedule so that only the required quantity of materials are stored on site, where the possibility of damages is higher. Just-in-time (JIT) inventory management system is effective in minimizing unnecessary handling, storage and damages to the materials.

Proper site storage is important in preventing damages to the window components. A suitable storage location should be:

- sheltered from weathering and fallen objects; and
- located for ease of material handling and distribution.

Components should be placed on timber bases to avoid direct contact with the floor. Glass panels should be stored in pallets with individual glass panel separated from one another by protective sheets to avoid scratches and other damages. The glass panels should also be protected from exposure to water which may result in “rainbow” effect and jeopardize the visual properties of the glass.

In addition, the various components should be arranged according to the installation sequence to facilitate ease of retrieval, i.e. to minimise searching and unnecessary shifting of materials which may lead to damages.

Figure 5.2: Poor site storage arrangement

5.3. HANDLING

Large window units and components which cannot be delivered via staircases should be hoisted in pallets to each floor before distributing to the different areas for installation. In cases where window frames need to be hoisted without the pallet, the frames should be handled only at the designed strong points.

Large pieces of glass panel should be handled with care using suction cups as shown in Figure 5.3.

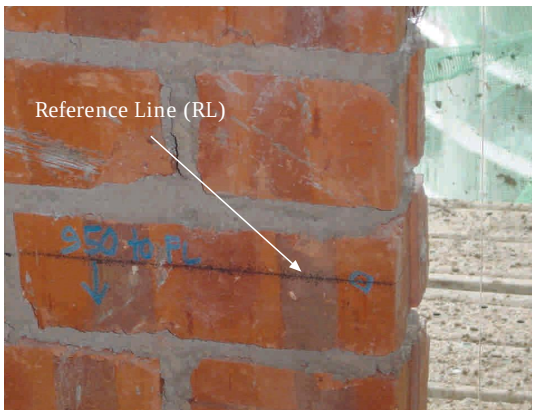
Figure 5.3: Proper handling of glass using suction cups

6. Preparatory Works

Proper dimensional control and setting out of the wall opening are critical in ensuring the quality of window installation. Precast facades provide superior dimensional control than the cast in-situ RC walls and brickwalls and require less preparatory works. Reference line (R.L) should be set up at appropriate location to facilitate proper alignment of the wall openings and installation of the window frames.

Close dimensional control on wall opening should be exercised to ensure the gap between the wall and window frame is within the range of 7-25mm wide.

Figure 6.1: Verification of setting out and dimensions of wall openings



a) Dimension check with reference to the RL

b) Gap size must be checked against the specified allowable width

The use of cement grout to fill up large gaps should be avoided as this may lead to cracks in the grout which would lead to water seepage through the building envelope.

Wall openings that are too large (i.e. gaps that exceeds 25mm) should be reinstated by concrete filling to within the specified tolerances. Undersized openings, on the other hand, should be chipped off and made good to the specified sizes (Figure 6.2).

Figure 6.2: Reinstating the wall opening to the required size

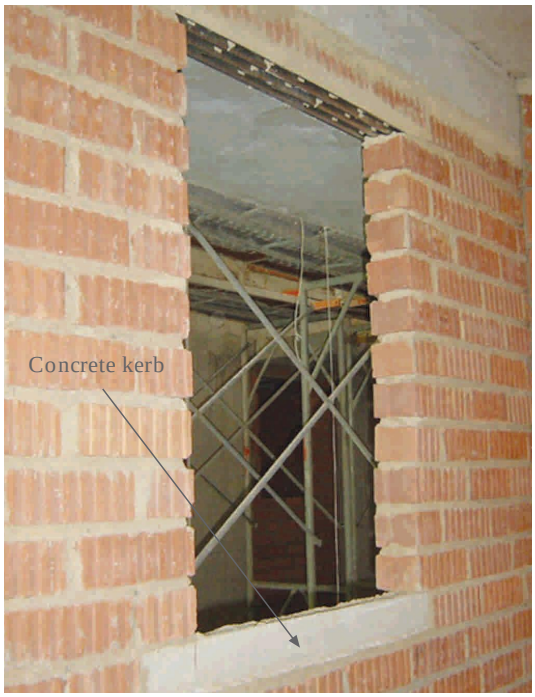
a) Reinstating oversized opening with concrete

b) Reinstating undersized opening by hacking

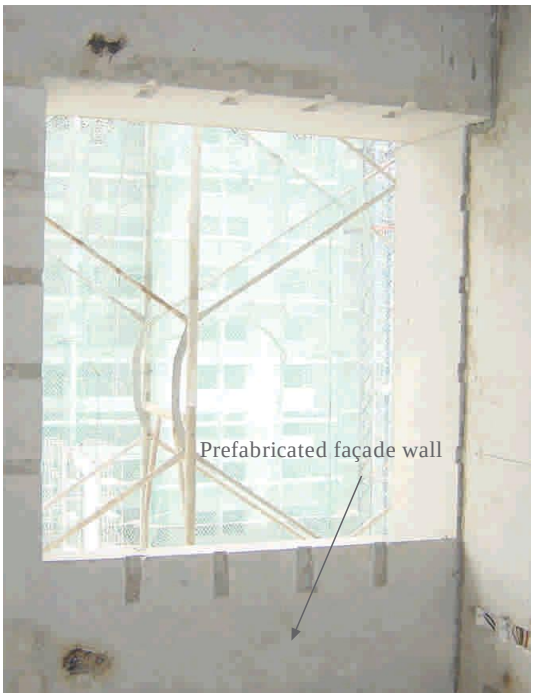
The wall opening should be checked for defects, such as, honeycomb and chipped edges. All defects must be rectified prior to window installation.

To facilitate proper positioning and installation of the window frame, the lower edge of the wall opening should be levelled as discussed in Section 2.4.2. For brickwall, it is a good practice to provide a concrete kerb at the lower edge of the wall opening. For RC walls, the bottom edge of the wall opening should be made good with cement grout.

Figure 6.3: Base for siting of window frame



a) Concrete sill to be cast at the lower edge of the opening in brickwall



b) PC wall provides better dimensional control and edges of the opening are levelled and smooth

7. Installation

Window installation involves the fixing of window frame at an earlier construction stage and subsequent installation of the window sashes. This is a highly workmanship dependent process. Only trained and approved contractors registered in BCA Contractor Registry under the regulatory workhead RW01 can carry out installation and retrofitting of windows.

7.1. INSTALLATION OF WINDOW MAIN FRAME

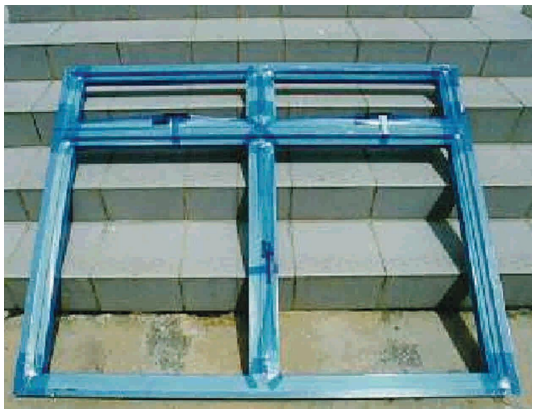
There are three window framing systems commonly used in the local industry. These are cast-in window system, sub-frame system and lug system.

7.1.1. CAST-IN WINDOW SYSTEM

The implementation of cast-in window system requires coordination between the window fabricator and the precaster.

Proper handling and protection are important throughout the precast process, delivery and erection of the precast wall panels. Protection of the frames should remain intact throughout the construction phase to avoid physical damages to the frames, which could be costly to rectify or replace.

Figure 7.1: Casting of window frame in precast wall panel



a) Window frame must be protected throughout the fabrication and construction process

b) Setting out of window frame in precast wall panel casting mould

c) Casting of precast wall panel

d) Completed cast-in window frame

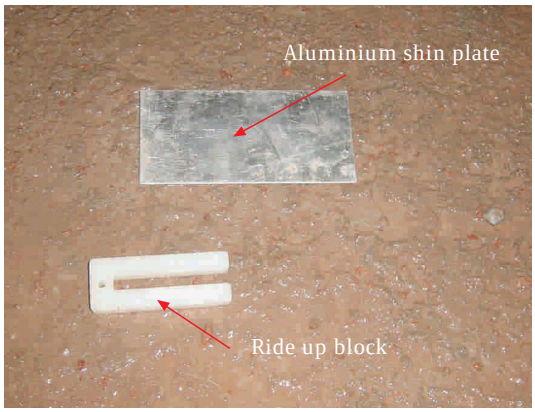
7.1.2. SUB-FRAME SYSTEM

The sub-frame system comprises a sub-frame which is either cast in or anchored to the wall. The main frame is then installed onto the sub frame at a much later stage of the construction.

- Installation of sub-frame

Proper alignment and setting out of the sub-frame is crucial in ensuring the ease of operation of the window (Figure 7.2).

Figure 7.2: Positioning of sub-frame



a) Positioning of sub-frame using ride up blocks or aluminium shin plates

b) Checking of plumb and alignment of sub-frame

After confirming the setting out of the sub-frame, anchor the sub-frame to the wall. Sub-frame should be temporary stiffened with timber packs near the point of anchoring/ bolting as shown in Figure 7.3.

Figure 7.3: Fixing of sub-frame

a) Insertion of stiffeners near the anchoring/bolting points

b) Fixing of sub-frame to the wall

Anchor/bolt heads and joints between external wall and sub-frame should be sealed with sealant for effective watertightness as shown in Figure 7.4.

Figure 7.4: Sealing of anchor/bolt heads and joints between external wall and sub-frame

a) Sealing of anchor/bolt heads

b) Sealing of joints between external wall and sub-frame

Protective tapes should remain intact throughout the subsequent construction works. The temporary stiffeners should also remain in place prior to installation of the inner frames (Figure 7.5).

Figure 7.5: Protection of sub-frame

a) Protective tapes on window frame

b) Temporary stiffeners

• Installation of main frame

After completion of all the wet trades around the window opening, the main frame is then fixed onto the sub-frame. Prior to fixing the main frame, the sub-frame should be checked for any physical damages. Any damaged sub-frame should be repaired or replaced. Setting out of the sub-frame should also be verified before the installation of the main frame.

The sub-frame should be cleaned and clear of dust and debris. Dust and debris accumulated in the sub-frame could affect the alignment and fixing of the main frame. It may also cause blockage to the weep holes, resulting in overflow of incidental water into the interior.

Figure 7.6: Preparation for installation of main frame

a) Verifying setting out of sub-frame

b) Clearing dust and debris from sub-frame

The installation of main frame should be carried out only by trained and approved contractors registered in BCA Contractor Registry under workhead RW 01 as shown in Figure 7.7.

Figure 7.7: Installation of main frame

a) Fitting the main frame onto sub-frame

b) Fitting of the finishing trim. Millet should be used to knock the finishing trim in place

7.1.3. LUG SYSTEM

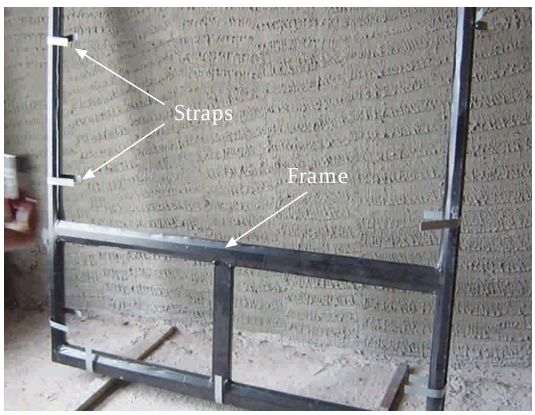
• Installation of frame on brickwall

Before installation of the window frame, the following checks should be carried out:

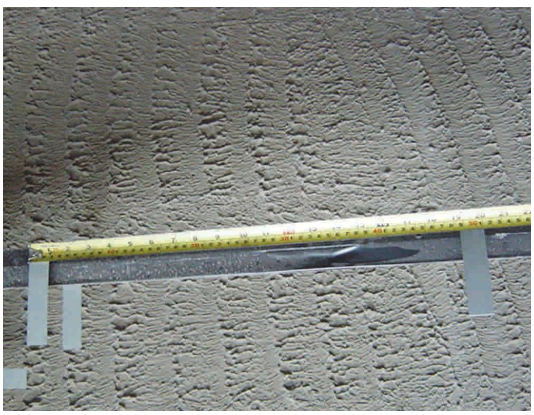
- wall opening should be checked for any physical defects. Any defects should be rectified before installation proceeds;
- wall opening should be cleaned and wetted as shown in Figure 7.8; and
- window frame should be checked for any damages, and should come with the correct number / spacing of galvanised straps (Figure 7.9). Defective frames should be replaced.

Figure 7.8: Clean and wet the wall surface around the opening

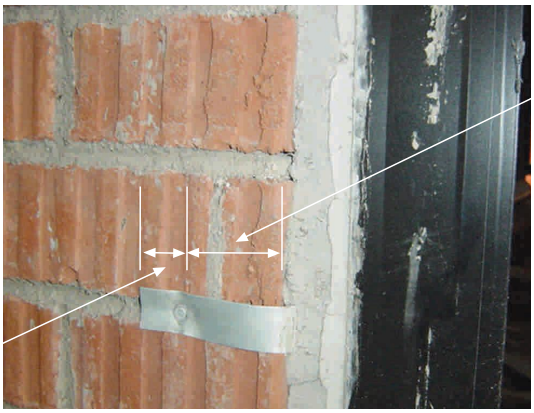
Figure 7.9: Check the number, dimensions, and spacing of galvanized straps



a) Check numbers of straps



b) Check spacing of straps



c) Check dimension for ramsetting

Timber V-shaped wedges are commonly used to temporarily hold the window frame in position within the wall opening as shown in Figure 7.10. The window frame is then checked for plumb, levellness and alignment (Figure 7.11). Tolerances that are stated in Table 7.2 should be followed when installing the window frame.

Figure 7.10: Use of V-shaped timber wedges for positioning of frame

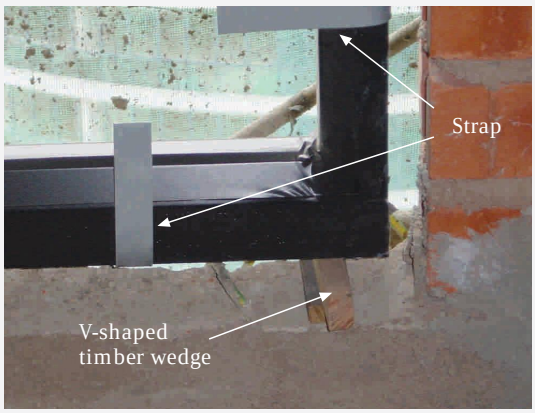
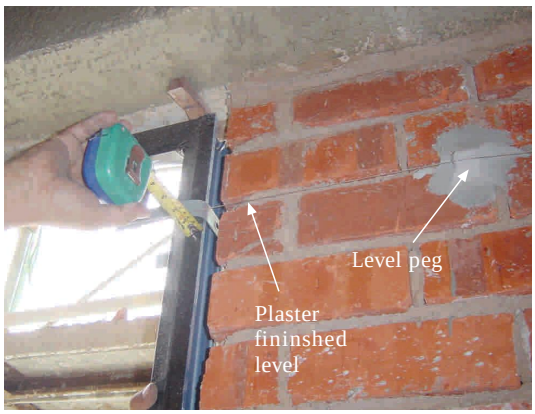


Figure 7.11: Checking the plumb, levellness and alignment of window frame

a) Check plumb of frame

b) Check alignment of frame

c) Check alignment of frame



d) Check positioning of the frame with reference to wall

Table 7.2 Tolerances for Installation of Window Frame

Items	Tolerance
Horizontal and vertical position on elevation from site datum	± 10mm
Horizontal position relative to adjoining wall finishes	± 2mm
Level	± 2mm in any one structural bay
Plumb	± 2mm in any one-storey height
Plane	± 2mm in any one storey height or structural bay width
Intersection	± 2mm in alignment in any direction between any two adjoining windows

Source: National Productivity and Quality Specification (NPQS)

After confirming the position of the frame, the galvanised straps are ramsetted to the wall. When ramsetting the straps, the plumb line should be maintained to ensure proper alignment of the frame.

The levellness and squareness of the installed frame can be checked by carrying out a diagonal dimensional check as shown in Figure 7.12.

Figure 7.12: Fixing of window frame

a) Ramset the straps to the wall after confirming the positioning of the frame

b) Check diagonal dimensions after installation

- Installation of frame on precast and cast-in situ RC walls

The lug system can also be used on precast and cast-in situ RC walls which are finished with skim coat. In such cases, recesses of 20mm deep (as shown in Figure 7.13) should be provided to accommodate the installation of the straps/brackets. These recesses should be provided during the casting of the RC walls and in accordance with the specified spacing of the straps/brackets.

Another method for fixing the frame to skim-coated precast or in-situ RC wall is to anchor the frame to the concrete wall. A bottom frame is installed on the bottom edge of the wall opening. Proper alignment and levellness must be verified before sealant is used to seal the gap between the wall and the bottom frame to ensure watertightness at this location.

The window main frame is then held in place within the wall opening using timber wedges, and checked for alignment, plumb and squareness. Next, the frame is fixed to the wall using anchors of adequate size and length required to support the size and weight of the window system.

Figure 7.13: Recesses formed in RC wall to accommodate the straps/brackets

Figure 7.14: Installation of frame using anchors

a) Check the levelness of the bottom frame

b) Apply sealant along the bottom edge of the wall

c) Install the bottom frame and seal the gap between wall and bottom frame

d) Check the alignment of the main frame

e) Fix the main frame to the wall

f) Anchor of adequate length and size should be used

7.1.4. SEALING OF GAP BETWEEN WALL AND WINDOW FRAME

The gaps between the window frame and wall must be properly sealed to prevent water seepage at these locations. Depending on the size of the gap, waterproof grouting or sealant can be used.

- Application of sealant

Sealant could be used to seal the gap between wall and window frame if the gap size is between 7-10mm.

Before the application of sealant, clean the aluminium window frame with white spirit using a clean rag. The frame and wall surfaces around the gap should be protected with masking tape to prevent the sealant from staining these surfaces and to obtain a neat sealant joint.

Backer rod should be used to achieve better compactness of the applied sealant. To obtain a complete seal, apply sealant by pushing the bead forward into the joint cavity.

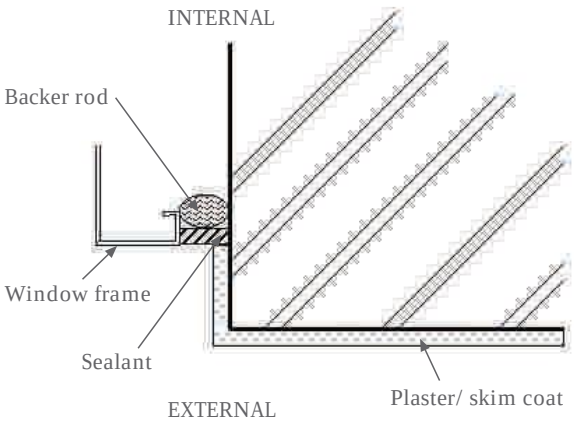
The joint should have continuous caulking to ensure that all areas are filled. Remove the excess sealant and tool the joint to achieve a smooth surface.

Figure 7.15: Application of sealant

a) Protection of the frame with masking tape

b) Protection of the wall with masking tape

c) Application of sealant



d) Application of sealant with backer rod

- Grouting

Gap between 11-25mm could be sealed by grouting. Before commencing the grouting work, it is important to check that the protective tape on the window frame is intact. Any damaged or loose protective tape must be replaced to prevent staining to the frame.

Wall surface to receive the grout should be cleaned with water to remove any dust and loose particles and to minimise water absorption from the grout by the masonry wall (Figure 7.16).

Non-shrink grout should be used to prevent cracks and water seepage around the window. For better performance, the mortar mix ratio should be 1 part of water to 3 parts of concreting sand. Approved waterproofing compound could be added to the mortar mix to enhance the watertightness performance of the grout.

Figure 7.16: Cleaning surface to get rid of dust and particles

For effective grouting, a suitable grouting gun should be used. Timber strip could be used to provide a firm backing during grouting to enhance compactness of the grout as shown in Figure 7.17.

Figure 7.17: Grouting process

a) Mortar mixed with waterproofing compound

b) Use of suitable grouting gun

c) Use of timber strip as backing

d) Tooling the grout to give a neat surface

Allow the grouting to cure for 2-3 days, and check for any defect such as cracks and voids. Any defect should be rectified before proceeding to the next stage of work.

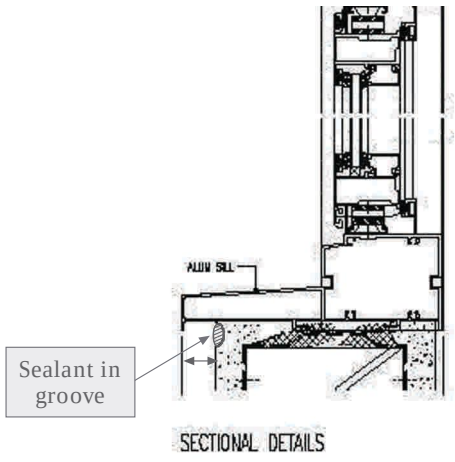
7.1.5. WATERPROOFING

It is recommended that a layer of approved waterproofing membrane be applied over the external surface of the joint areas between the wall and window frame before plastering or skim coating of the external walls. This will help to enhance water tightness at these areas (Figure 7.18).

Figure 7.18: Application of waterproofing membrane over the joint area

During plastering, a groove line should be made on the external face of the wall around the perimeter of the window (Figure 7.19). Sealant is then applied over these groove lines after the plaster is completely cured. The surface to receive the sealant should be cleaned and free of oil.

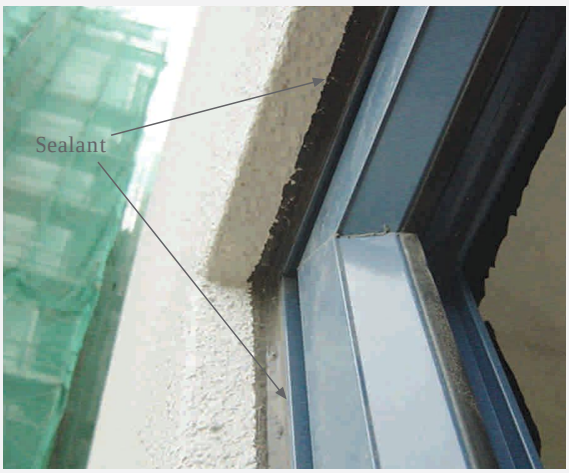
Figure 7.19: Sealant application



a) A groove line to be created around the perimeter of the window to receive sealant

For wall with textured coating, the sealant must be applied before the texture coating, as the coating in the groove will affect the adhesion properties of the sealant. Polyurethane sealant should be used where sealant is to be painted over.

Figure 7.20: Application of sealant between window frame and the wall surface



7.2. INSTALLATION OF WINDOW GLAZING

It is recommended that glazing work for inner glass panels be carried out in the factory, where higher work quality can be achieved. Where this is not possible, glazing work must be carried out on site with proper handling and good workmanship. For fixed glass panels, glazing is usually done on site.

This section will discuss the good practices to be adopted when carrying out glazing works on site.

For glazing work in the factory, refer to Chapter 6 on Fabrication.

7.2.1. PREPARATORY WORKS BEFORE GLAZING

The protective tapes should only be removed when glazing works is to be carried out. The following verification works should be carried out prior to glazing work:

Verification	Illustration
Window Frame	
• Inner frame and associated hardware should be checked for defects. Damaged frames or hardware should be replaced. • Inner frame should be cleaned and free from dust and debris.	
• Weep holes in the inner frames should be cleared of blockage to allow discharge of incidental water.	

Verification	Illustration
Glass Panel	
• Compliance with physical specifications such as dimensions of panel	
• Labels on the glass panels should be checked against the window schedule. • For tempered/ laminated glass, check for the associated logo/ trademark labels. • The orientation of the glass panels should be standardised such that the positioning of these logos/trademarks is consistent	
Gasket	
• Gasket should be checked for any physical damages. Defective gasket should not be used. • Gasket should be free from dust and dirt to ensure good grip onto the frame and beadings.	
• Profile of the gaskets should be compatible with that of the beads used to secure the glass panels.	

7.2.2. GLAZING OF GLASS TO INNER FRAME

There are generally two installation arrangements when glazing the glass panels to the inner frames of casement, top hung or bottom hung windows. Glazing can be carried out either before or after the inner frame is installed onto the main frame. The glazing process is similar for both arrangements. However, extra care should be exercised when carrying out glazing work on inner frame which has already been fixed onto the outer frame, with emphasis placed on safety of the workers and material handling outside the building envelope.

Large glass panels should be handled with suction cups as shown in Figure 7.21. Spacer blocks are normally used to temporarily hold the glass panel in place.

Figure 7.21: Glazing of glass to inner frame

a) Inserting glass panel onto the window frame

b) Use of spacer blocks to hold the glass panel in place

Gasket used should be of a continuous length, and should be carefully spliced at appropriate locations to go around the corners of the glass panel. A suitable tool can be used to press the gasket into the gap between the glass panel and the inner frame to obtain a good fitting to hold the glass panel in place and to prevent water seepage.

Figure 7.22: Installation of gasket

a) Estimate the length of the gasket required

b) Splice the gasket to fit the corners of the glass panel

c) Tooling the gasket in place

The glass panel is then secured in position using aluminium beads. The profile of the beads should be verified for compatibility with the gasket used. Millet or the back of rubberized screwdriver can be used to knock the beadings in place. Poorly fitted beading will result in gaps and misalignment of joints.

Figure 7.23: Securing the glass panel with beadings

a) For glazing before installation of inner panel

b) For glazing after the installation of inner panel

After the installation of beadings, the gap between the glass panel and the bead should be sealed. Suitable sealant applicator and sealant should be used in accordance with the specifications. The frame and glass should be protected with masking tapes prior to sealant application. A simple tool as shown in Figure 7.24 can be used to give a neat finish. The masking tape should only be removed after the sealant is dry.

Figure 7.24: Application of sealant

a) Use of suitable sealant & sealant applicator

b) Surfaces should be protected with masking tape

c) Use of simple tool to achieve a consistent finish

7.3. INSTALLATION OF WINDOW INNER FRAME

7.3.1. CASEMENT/ TOP HUNG/ BOTTOM HUNG WINDOWS

The inner frame of casement window is fixed to the main frame using friction stays. The friction stays should be fixed using adequate number of stainless steel screws or rivets of sufficient size, depending on the size and weight of the inner frame. For better watertightness, seal screw or rivet heads with sealant.

The alignment and operation of the window panel should be checked before and after installation.

The installation of top hung or bottom hung window panels are similar to that of the casement window.

Figure 7.25: Installation of inner panel of casement window

7.3.2. SLIDING WINDOWS

Sliding windows are installed in 2 stages - installation of main window frame with the sliding tracks at an early construction stage, and installation of the sliding panels at a later stage of construction works.

Extra precaution should be exercised to prevent debris from filling up and damaging the sliding tracks. Dirt or debris must be cleared and the tracks should be properly cleaned prior to the installation of the sliding panels.

Proper labelling is important to ensure that the correct sliding panels are delivered and installed on site as shown in Figure 7.26.

Figure 7.26: Checks to be carried out prior to installtion

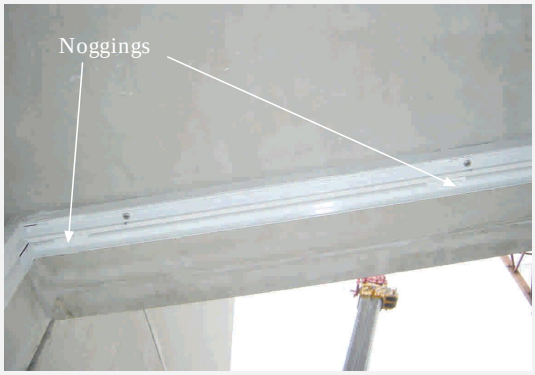
a) Check that correct panels are delivered

b) Check for correct orientation of panel

Protective tapes on the frames should only be removed prior to the installation of sliding panels.

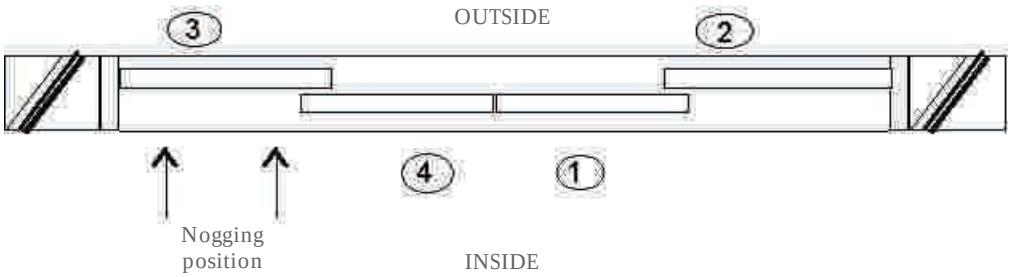
Sliding panel is installed by slotting the panel into the upper frame track and then inserting the panel onto the bottom track. To do so, the installer has to identify the noggings in the sliding frame. Noggings, as shown in Figure 7.27, are cut-outs in the frame track to allow for the insertion of the panel.

Figure 7.27: Noggings in frame for insertion of sliding panel



Installer must check the designer's plan to determine the installation sequence of the sliding panels. Figure 7.28 shows an example of the installation sequence for a 4-panel sliding window design.

Figure 7.28: Determine the sequence of panel installation



Upon completion of the installation of the window panel, installers should check that the sliding window configuration is according to specifications. Safety screws or safety devices are then installed to prevent dislodgment of the panels. The choice of safety device depends on the design of the window.

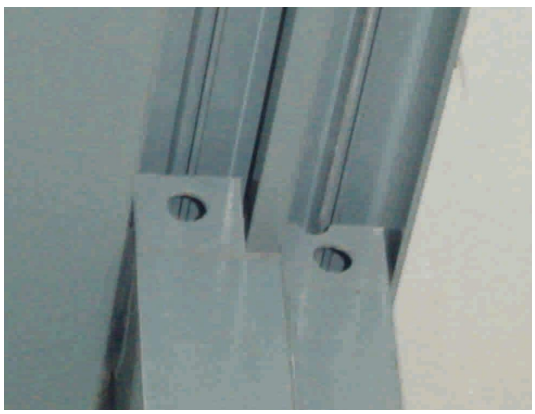
Sliding window tracks should be cleared of debris/ dust prior to handover.

Figure 7.29: Sequence of installation of sliding window

a) Insert the panel to the top track

b) Position the bottom groove to fit the panel onto the bottom track

c) Ensure the panel sit correctly on the bottom track



d) Ensure the panel fit properly onto the top track

e) Ensure the panel configuration is as specified by the Designer

f) Fasten the safety screws at nogging areas

Figure 7.30: Method of preventing window panel from being removed/ dislodged

a) Safety screw

b) Safety device

7.4. INSTALLATION OF FIXED GLASS PANEL

Fixed glass windows are commonly used in local buildings. The installation process involves slotting the glass panel into the glass pocket at the bottom frame and securing the panel in place using aluminium beadings.

While it is a common design to install the glass panel from the outside of the building as shown in Figure 7.31, a better design is to allow the installation of the glass panel from inside the building.

In general, fixing of the aluminium beadings should start with the top beading followed by the side beadings. The beadings are knocked in place using millet or the back of the rubberized screwdriver to give sufficient hold on the glass.

Figure 7.31: Fixing of beadings to secure the glass panel

a) Slot the glass panel into the “pocket”

b) Fix the bead to the top of glass panel

c) Secure the top beading

d) Secure the side beading

Spacer blocks are used to press the glass panel against the beadings. The gap between the glass panel & beading could either be sealed by approved sealant or by insertion of gasket in accordance to the Designer’s specifications.

Figure 7.32: Installing the gasket

a) Insertion of spacer blocks

b) Insertion of gasket

7.5. INSTALLATION OF ACCESSORIES

Window installation is completed with the fixing of accessories, including handles, locking devices, etc. Alignment of the accessories should be checked during and after installation. Precaution should be taken to avoid damage to glass panel and window frame in the course of fixing the accessories.

The accessories should be protected until all construction activities are completed.

Figure 7.33: Installation of handles

a) Fixing of handles

b) Protection of handle after installation

7.6. WATERTIGHTNESS TEST

Water seepage through windows is one of the major problems in Singapore.

Laboratory tests are not able to detect water seepage problems caused by poor workmanship during installation of the window system. Field watertightness test should, hence, be carried out to verify the watertightness performance of the installed windows.

The following parameters are used in CONQUAS 21 field watertightness test:

Water intensity	300mm/hr 1 litre/min/m of joint
Wind Pressure	240 Pa
Nozzle inclination	90° to wall
Distance of nozzle from wall	200mm
Sample	1 sample = 2m length of joint
Spray duration	10mins

No sign of seepage should be detected throughout the test.

Figure 7.34: Conduct field watertightness test

a) Portable pump with hoses

b) Lightweight nozzles
(viewed from outside the building)

c) Mounted nozzle heads
(viewed from inside the building)

Figure 7.35: Detection of water seepage

a) Seepage through gasket

b) Seepage through joint in frame

8. Protection And Cleaning

8.1. PROTECTION

Protection should be provided to all vulnerable surfaces such as the frames, glass panels, handles, etc. Protection of the windows starts in the factory and should remain intact throughout the construction process until the windows are scheduled for final cleaning and handing over.

Material used for temporary protection must be compatible with the protected surfaces and should not stain the finishes of these surfaces. It is important that the life span of the protective tapes be considered to ensure that the quality of the tapes is maintained throughout the construction process.

Figure 8.1: Protection of components for delivery and storage

a) Installation of protective tape on frames

b) Protection for delivery

Figure 8.2: Protection of frame throughout construction process

a) Protective tape on window frame

b) Protection at access-prone location

c) Box-up protection for bottom frame of full height window

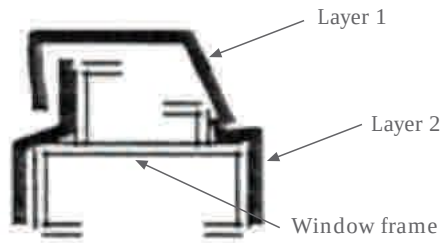
Figure 8.3: Protection of window after installation

a) Protection of glass panel

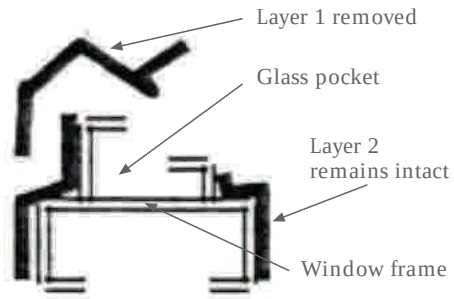
b) Protection of accessories

It is a good practice to adopt a multi-layer protection system, such that different layers of protective tape can be removed as installation progress on site (Figure 8.4).

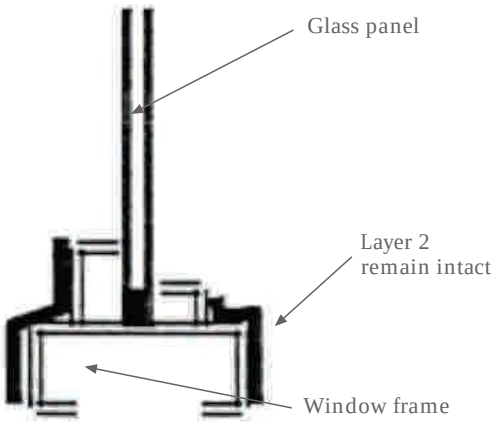
Figure 8.4: Multi-layer protection system



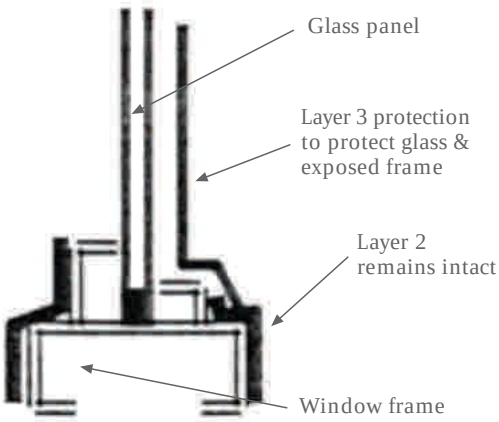
a) Two separate layers of protection on frame



b) Removal of protective layer 1 for glass panel installation



c) Installation of glass panel



d) Glass protective tape (layer 3) is been applied to protect the glass panel and exposed frame.
Layer 2 & 3 would be subsequently removed after the completion of all works.

Signage, as shown in Figure 8.5, should be placed to remind workers not to open the windows unnecessarily to avoid damages to the window frames, glass panels and accessories.

Figure 8.5: Keep the window closed after installation

8.2. CLEANING

Protective tapes should only be removed prior to cleaning. The glass panels should be wetted with water and snap blade should be used to remove cement or other stains. The glass panels should then be cleaned with soapy water of mild detergent using a glass wiper. Proper access, such as staging and gondola, should be provided for cleaning of external windows. Safety measures should be strictly adhered to by the workers while carrying out cleaning work.

Figure 8.6: Cleaning of external windows

9. Common Defects And Remedies

Designers and site supervisors should understand the common complaints and defects related to window installation and how to prevent them.

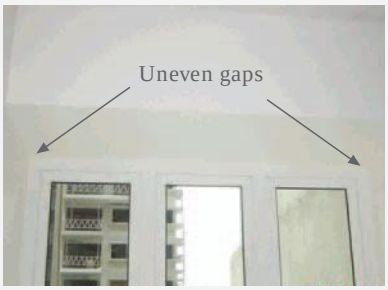
The occurrence of defects in windows is usually caused by poor design, use of inferior or non-compatible materials, poor workmanship during fabrication and installation or mishandling.

The following are some common defects in aluminium frame window installation:

Table 9.1 Common Defects

Common Defects	Possible Causes	Recommendations
(A) Functionality		
1. Water seepage through window frame  	• Poor workmanship during fabrications and installation of frames and gaskets • Poor detailing of top frame	• To review the design to ensure suitable drainage paths exist with sufficient ventilation and internal air seals in the window frames • To shield the window from direct rainfall through better design • To fabricate and assemble as many components as possible in factory • To use mechanical tools to achieve the required fabrication tolerances • To ensure the use of gaskets with compatible profile • To ensure no physical damages to the frames and gaskets • To carry out field watertightness test

Common Defects	Possible Causes	Recommendations
(A) Functionality		
2. Water seepage through joints between window frame and wall	• Poor tolerances of wall openings • Poor workmanship during grouting/ sealing of gaps 	• To shield the window from direct rainfall through better design • To use precast walls for better dimensional tolerances and finishing • To ensure the size of the gap between wall and the frame conform to the specified tolerances • To ensure correct usage of grout and sealant to seal the gaps, depending on the gap sizes • To ensure proper application and compacting of grout or sealant • To carry out field watertightness test
3. Difficulty in opening and closing of glass panel (for casement window)	• Misalignment of frames and glass panels • Improper installation of friction stays and pivot hinges • Improper protection resulting in debris ingress to friction stay track	• To verify the alignment and plumb of the outer frames and inner panels • To check the physical conditions of friction stays • To lubricate the pivot hinges • To clear track off all debris
4. Difficulty in sliding of inner panel (for sliding window)	• Improper alignment of frames and inner panels • Damages to rollers and sliding tracks	• To verify the alignment of the outer frames and inner panels • To protect the sliding tracks during installation. Dirt or debris must be cleared prior to installation of inner panels • To restrict the usage of the sliding windows prior to handing over

Common Defects	Possible Causes	Recommendations
(B) Alignment & Evenness		
1. Misalignment 	• Improper setting out of wall openings • Improper alignment and plumb of window frame during installation	• To check that the setting out of wall opening conform to specifications • To verify the alignment and plumb of window frame during installation
(C) Joints & Gaps		
1. Untidy joints between window frame and wall 	• Poor workmanship during installation	• To protect the frame with suitable tapes during application of sealant or during painting
2. Gaps at window frame corner 	• Poor workmanship during fabrication and installation • Mishandling during delivery and storage	• To carry out cutting and assembly of frames using mechanical tools • To protect the frames during delivery and storage
(D) Materials & Damages		
1. Stained glazing	• Inadequate protection during delivery, storage and installation	• To protect the glazing properly. Protection should remain intact until all works are completed

Common Defects	Possible Causes	Recommendations
(D) Materials & Damages		
2. Poor frame finish 	• Poor workmanship during fabrication • Poor rectification works	• To inspect the quality of finishes before delivery and prior to installation • Any rectification works should be carried out effectively
3. Mortar droppings and paint drips on frame 	• Inadequate protection during installation	• To provide adequate protection to the frame. Protection should remain in tact until all works are completed
4. Physical damages and scratches on frame and glazing  	• Inadequate protection during fabrication, delivery, storage and installation	• To inspect the component before delivery and prior to installation • To provide proper storage space • To minimize unnecessary handling during delivery, storage and installation • To provide adequate protection to frames and glazing. Protection should be kept in tact until all works are completed

Common Defects	Possible Causes	Recommendations
(E) Accessories Defects		
1. Loose or improperly installed gaskets  	• Use of gaskets with incompatible profile • Use of gaskets with inadequate length • Poor workmanship during installation	• To check that gasket size and profile are compatible to the frame • To ensure that sufficient length of gasket is used • To ensure proper workmanship during installation, especially at the corners
2. Physical damages 	• Inadequate protection during fabrication, delivery, storage and installation	• To provide adequate protection for all accessories. Protection should be kept in tact until all works are completed

Appendix A

Sample Inspection and Test Plan (ITP)

Project:_____

Scope of Work: Aluminium Windows

S/No	Activity	Responsibility	Inspection Method	Requirement Reference	Acceptance Criteria	Frequency	Records
1	SUBMISSION						
1.1	Shopdrawings	MC/ADOC	Review	–	Approved	Initially	Approved submissions
1.2	Test reports	MC/ADOC	Review	–	Approved	Initially	Approved submissions
1.3	Technical data	MC/ADOC	Review	–	Approved	Initially	Approved submissions
1.4	Window samples	MC/ADOC	Review	Section 4	Approved	Initially	Approved samples
2	INCOMING MATERIALS INSPECTION						
2.1	Window frames	MC/ADOC	Visual/ specifications	Section 3	As per approved samples & conform to specifications	Each delivery	Delivery document
2.2	Ramset impact bolts/ anchors	MC/ADOC	Visual/ specifications	Section 3	Conform to specifications	Each delivery	Delivery document
2.3	Cement grout & waterproofing compound	MC/ADOC	Review/ specifications	–	Conform to specifications	Each delivery	Delivery document
2.4	Glass panels	MC/ADOC	Visual/ specifications	Section 3	As per approved samples & conform to specifications	Each delivery	Delivery document
2.5	Window accessories	MC/ADOC	Visual/ specifications	Section 3	As per approved samples & conform to specifications	Each delivery	Delivery document

Prepared by _____ Verified by _____ Approved by _____

Date _____ Date _____ Date _____

LEGEND MC – Main contractor ADOC – Architect/ Designer/ Owner/ Clerk-of-works

Sample Inspection and Test Plan (ITP)

Project: _____

Scope of Work: Aluminium Windows

S/No	Activity	Responsibility	Inspection Method	Requirement Reference	Acceptance Criteria	Frequency	Records
3	PREPARATION						
3.1	Mock-up unit in showroom (if required)	MC/ADOC	Visual/ Measurement	Section 4	Approved by ADOC	Initially	–
3.2	Cleaning of surface of opening	MC/ADOC	Visual	Section 7	–	Before installation	–
3.3	Check dimensions of wall opening	MC/ADOC	Visual/ Measurement	Section 7	Conform to approved shop drawing	Before installation	Checklist
4	INSTALLATION OF MAIN FRAME						
4.1	Check window for any damages	MC/ADOC	Visual	Section 7	–	Before installation	Checklist
4.2	Check nos. and spacing of galvanised straps (for lug system)	MC/ADOC	Visual/ Measurement	Section 7	Conform to specifications	Before installation	Checklist
4.3	Check alignment and plumb of window is within tolerance	MC/ADOC	Visual/ Measurement	Section 7	Conform to specifications	Before installation	Checklist
4.4(a)	For lug system – Check ramset dimension	MC/ADOC	Visual/ Measurement	Section 7	Conform to specifications	Before installation	Checklist
4.4(b)	For anchorage system – Check anchor size and length	MC/ADOC	Visual/ Measurement	Section 7	Conform to specifications	Before installation	Checklist

Prepared by _____ Verified by _____ Approved by _____

Date _____ Date _____ Date _____

LEGEND MC – Main contractor ADOC – Architect/ Designer/ Owner/ Clerk-of-works

Sample Inspection and Test Plan (ITP)

Project: _____

Scope of Work: Aluminium Windows

S/No	Activity	Responsibility	Inspection Method	Requirement Reference	Acceptance Criteria	Frequency	Records
5	GROUTING AND SEALANT APPLICATION						
5.1(a)	For lug system – Check cement grout used	MC/ADOC	Visual	Section 7	Conform to specifications	Before installation	Checklist
5.1(b)	For anchorage system – Check sealant used	MC/ADOC	Visual	Section 7	Conform to specifications	Before installation	Checklist
5.2	Check that joints are completely filled	MC/ADOC	Visual	Section 7	Compact. smooth & flushed surfaces	After grouting/ sealant application	Checklist
5.3	Remove surplus grout/ sealant	MC/ADOC	Visual	Section 7	Surface is clean	After grouting/ sealant application	Checklist
6	WATERPROOFING						
6.1	Waterproofing to external joint areas	MC/ADOC	Visual	Section 7	Even application with good coverage	After waterproofing work	Checklist
7	INSPECTION OF INNER FRAME						
7.1	Check frame for damage	MC/ADOC	Visual	Section 7	No damage	Before installation	Checklist
7.2(a)	For casement/ top hung window – Check installed friction stay	MC/ADOC	Visual	Section 7	Conform to specifications	After installation	Checklist
7.2(b)	For sliding window – Check installed safety screw/ device	MC/ADOC	Visual	Section 7	Conform to specifications	After installation	Checklist

Prepared by _____ Verified by _____ Approved by _____

Date _____ Date _____ Date _____

LEGEND MC – Main contractor ADOC – Architect/ Designer/ Owner/ Clerk-of-works

Sample Inspection and Test Plan (ITP)

Project:_____

Scope of Work: Aluminium Windows

S/No	Activity	Responsibility	Inspection Method	Requirement Reference	Acceptance Criteria	Frequency	Records
8	INSTALLATION OF GLAZING						
8.1	Check glass for damage	MC/ADOC	Visual	–	No damage	Before installation	Checklist
8.2	Check glass identification	MC/ADOC	Visual/ Measure	Section 7	Conform to approved shop drawing	Before installation	Checklist
8.3	Check weep holes	MC/ADOC	Visual	Section 7	No blockage	Before & After installation	Checklist
8.4	Check installed gasket	MC/ADOC	Visual	Section 7	Clean and no damage	Before & After installation	Checklist
9	INSTALLATION OF ACCESSORIES						
9.1	Check accessories	MC/ADOC	Visual	Section 7	No damage	Before & After installation	Checklist
10	FINAL INSPECTION						
10.1	Cleaning	MC/ADOC	Visual	Section 8	Surface is clean	At completion	–
10.2	Protection	MC/ADOC	Visual	Section 8	Finished works are protected	At completion	–
10.3	Work acceptance	MC/ADOC	Visual	Section 8	As per specifications	At completion	Inspection records
11	WORK HAND-OVER						
11.1	Rectification/ Replacement works	MC/ADOC	Visual	–	–	At hand-over	–
11.2	Inspection by owner	MC/ADOC	Visual	–	–	At hand-over	–

Prepared by _____ Verified by _____ Approved by _____

Date _____ Date _____ Date _____

LEGEND MC – Main contractor ADOC – Architect/ Designer/ Owner/ Clerk-of-works

Appendix B

Sample Checklist for In-process Inspection of Aluminium Window Installation

Project: _____

Location: _____

	Checklist	Acceptance Criteria/ Requirement reference	Date of Inspection	Remarks
	PREPARATORY WORK			
1.	Size and type of window to be installed	Conform to approved shopdrawings		
2.	Dimension and setting out of opening	Conform to approved shopdrawings		
3.	Cleanliness of surface of opening	No debris and dust Surface is level and in good condition		
	INSTALLATION OF MAIN FRAME			
4.	Type and size of frame	Conform to approved shopdrawings		
5.	Physical conditions of frames	No physical damage		Replace or rectify
6.	Setting out for main frame	Conform to design drawing by ADOC		
7.	Plumb and alignment of frame	Conform to ADOC's specifications		
8.	Position of galvanised straps/ anchorage points	Conform to ADOC's specifications		
9.	Size and type of ramset/ anchor	Conform to ADOC's specifications		
10.	Earthing of frame where applicable	Conform to ADOC's specifications		
11.	Gap between frame and wall/ column	Conform to design drawing by ADOC		
12.	Grouting/ application of sealant	Proper compactness; • No gap or void in the grouting/sealant • Grouting/ sealant to be tooled to give neat surface or edge • 2-3 days curing of grouting		
13.	Protective materials	Protective materials to remain intact after work		Replace protection tape if tape is damage/ loose
	WATERPROOFING			
14.	Application of waterproofing to external joint areas	• Conform to ADOC's specifications • Even application with good coverage		

LEGEND MC – Main contractor ADOC – Architect/ Designer/ Owner/ Clerk-of-works

Sample Checklist for In-process Inspection of Aluminium Window Installation

Project: _____

Location: _____

	Checklist	Acceptance Criteria/ Requirement reference	Date of Inspection	Remarks
	INSTALLATION OF INNER FRAME			
15.	Type and size of frame	Conform to ADOC's specifications / approved shopdrawings		
16.	Protection material	Protection tapes or sheets to be intact		Replace protection tape if tape is damaged/ loose
17.	Physical conditions of frames	No physical damage		Replace or rectify
18(a).	Friction stay (for casement/ top hung window)	Conform to ADOC's specifications		
18(b).	Safety screw/ device (sliding window)	Conform to ADOC's specifications		
19.	Joints and mitres	Joints and mitres should be accurately assembled and rigidly connected		Replace frame if jointing of frame is poor
20.	Sealant caulking	To have complete seal with neat edges		
	GLAZING			
21.	Type, size and thickness of glass	Conform to ADOC's specifications		Replace glass if it does not conform to specifications
22.	Glass	Glass to be protected with strippable films on both surfaces		Replace protection tape if tape is damage/ loose
23.	Physical conditions	No damage or scratches and other physical defects.		
24.	Gasket	• Tight fitting of gasket to secure glass • No physical defect on gaskets • No gap at corners of gaskets		
25.	Sealant caulking	To have complete seal with neat edges		
LEGEND	MC – Main contractor	ADOC – Architect/ Designer/ Owner/ Clerk-of-works		

Sample Checklist for In-process Inspection of Aluminium Window Installation

Project: _____

Location: _____

	Checklist	Acceptance Criteria/ Requirement reference	Date of Inspection	Remarks
INSTALLATION OF ACCESSORIES				
26.	Handles/ ironmongery	Proper functioning of handles and ironmongery		
27.	Operation	Ease of opening and closing		
28.	Protective materials	Protective materials to remain intact.		Replace protective tape if tape is damage/ loose
FINAL INSPECTION				
29.	Physical conditions	• No visible scratches / damages • No sign of corrosion in ironmongery • No mortar dropping/ paint drips		
30.	Gap between window leaf and frame	• No rattling noise and wind howling • No sign of rainwater seepage • No visible gap		
31.	Sealant works	Complete seal and with neat edges		
32.	Hinges, handles, locking devices	In correct position/ good fit/ good working order.		
33.	Operation	Ease of opening and closing		
34.	Cleaning	Conform to ADOC's specifications		
35.	Work acceptance	Conform to ADOC's specifications		
36.	Final protection	Conform to ADOC's specifications		
WATER-TIGHTNESS TEST TO WINDOWS				
37.	Conduct in-house water tightness test	No seepage		

LEGEND MC – Main contractor ADOC – Architect/ Designer/ Owner/ Clerk-of-works

References

The Singapore Standard SS 212- Specification for Aluminium Alloy Window, Standards, Productivity and Innovation Board, Singapore

Standards referred to in the SS 212 are:

Standards	Description
SS 117	Hot dip galvanized coatings on iron and steel articles
SS 341	Safety glazing materials for use in buildings (human impact considerations)
SS 494	Lead and chromate-free primer for iron and steel substrates
ISO 9227	Corrosion tests in artificial atmospheres -- Salt spray tests
BS 952 Part 1 BS 952 Part 2	Glass for glazing. Classification Glass for glazing. Terminology for work on glass
BS 1004	Specification for zinc alloys for die casting and zinc alloy die castings
BS EN 755	Aluminium and aluminium alloys. Extruded rod/ bar tube and profiles.
BS 3987	Specification for anodic oxidation coatings on wrought aluminium for external architectural applications
BS 5215	Specification for one-part gun grade polysulphide-based sealants
BS 5713	Specification for hermetically sealed flat double glazing units
BS 5889	Specification for one-part gun grade silicone-based sealants
BS 6213	Selection of construction sealants. Guide
BS 6338	Specification for chromate conversion coatings on electroplated zinc and cadmium coatings
BS 6496	Specification for powder organic coatings for application and stoving to aluminium alloy extrusions, sheet and preformed sections for external architectural purposes, and for the finish on aluminium alloy extrusions, sheet and preformed sections coated with powder organic coatings
BS 7479, ISO 9227:1990	Method for salt spray corrosion tests in artificial atmospheres
BS EN 10088-1 BS EN 10088-2	Stainless steels. List of stainless steels Stainless steels. Technical delivery conditions for sheet/plate and strip for general purposes
BS EN 22063	Metallic and other inorganic coatings. Thermal spraying. Zinc, aluminium and their alloys
BS EN 12540	Corrosion protection of metals. Electrodeposited coatings of nickel, nickel plus chromium, copper plus nickel and copper plus nickel plus chromium
AAMA 2604	Performance requirements and test procedures for high performance organic coatings on aluminum extrusions and panels
AAMA 2605	Performance requirements and test procedures for superior performing organic coatings on aluminum extrusions and panels
ASTM C509	Specification for elastomeric cellular preformed gasket and sealing material
ASTM C920	Specification for elastomeric joint sealants
ASTM C864	Specification for dense elastomeric compression seal gasket setting blocks, and spacers.
JIS H8602	Combined coatings of anodic oxide and organic coatings on aluminium and aluminium alloys

Singapore National Productivity and Quality Specifications (NPQS)- A1-20 Specification for Windows.

The HDB Residents' Handbook- Your Household and Maintenance Guide, Housing and Development Board.

CONQUAS 21 Standards