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

<table>
<thead>
<tr>
<th>Type of Window</th>
<th>Description</th>
</tr>
</thead>
</table>
| 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 |
<table>
<thead>
<tr>
<th>Type of Window</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>3. Top Hung (Awning)</td>
<td>• Similar to casement window, except that the sash is connected by friction stays at the top of the window frame&lt;br&gt;</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>4. Bottom Hung (Hopper)</td>
<td>• Similar to top hung window, except that the sash is connected by friction stays at the bottom of the window frame&lt;br&gt;</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>5. Sliding</td>
<td>• Consists of two or more sashes, which slide horizontally or vertically along tracks&lt;br&gt;</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>6. Louvred</td>
<td>• Comprises horizontal glass panes, which are either fixed at an angle, or adjustable to control the amount of light and ventilation through the window&lt;br&gt;</td>
</tr>
</tbody>
</table>
### Type of Window

| 7. Bay Window |

### Description

- 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

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### 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.

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### 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).

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**Figure 2.1: Sub-frame system**

- **Window sub frame**
- **Window main frame**

**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 summarised in Table 2.2.

### Table 2.2 Advantages and disadvantages of sub-frame system

<table>
<thead>
<tr>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Generally has better weather tightness performance</td>
<td>• Smaller dimensional tolerances of the wall opening are allowed</td>
</tr>
<tr>
<td>• Can be used for precast or cast-in-situ wall systems which do not require plastering</td>
<td></td>
</tr>
<tr>
<td>• 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</td>
<td></td>
</tr>
</tbody>
</table>

#### 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 summarised in Table 2.3.

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

<table>
<thead>
<tr>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Eliminate the need for site grouting or application of sealant to seal the gaps between window frames and walls</td>
<td>• Require close coordination between window supplier and precaster</td>
</tr>
<tr>
<td>• Superior watertightness performance</td>
<td>• Rectification and replacement could be more costly</td>
</tr>
<tr>
<td>• Installation of window main frame is carried out at the precast yard where tighter quality control is easier to administer</td>
<td></td>
</tr>
</tbody>
</table>
2.2.3. LUG SYSTEM

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

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 summarised in Table 2.4.

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

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.
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

<table>
<thead>
<tr>
<th>Gap Size</th>
<th>Type of Sealing</th>
</tr>
</thead>
<tbody>
<tr>
<td>7mm – 10mm</td>
<td>Use backer rod and sealant</td>
</tr>
<tr>
<td>11mm – 25mm</td>
<td>Use non-shrink cement grout + waterproofing additives and complete with sealant.</td>
</tr>
</tbody>
</table>

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 watertightness defence. For such large gap, reduce the opening size by topping up the gap with chipping concrete.
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
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 or overhang