Windows

Windows are available in all kinds of materials. The choice of material has repercussions on the structure and the design of both window and façade. Therefore the most common window constructions and their specific materials are being introduced.

Timber windows and timber/ aluminium composite window

Timber window constructions are based on developments over a hundred years (21). As such, there is a wide variety of designs in use today. The type of timber used must demonstrate resistance to temperature and humidity fluctuations as well as pest-resistance. When designing timber windows (23) several factors need to be considered:

- Water penetrating into the construction must be carefully re-channeled to the outside.
- The rebate area inside the construction must be vented.
- Exposed edges need to be appropriately spaced in relation to other components so that they can dry out completely.
- The edges of the window frame must be chamfered carefully.
- Water should not be allowed to penetrate into the corners of the window. That is why timber windows typically do not have mitred joints in the lower corners. Instead the lateral frame section is one continuous part from top to bottom.

Timber windows have to be impregnated with wood preservative to protect against mold and insect infestation. The surfaces of timber windows need regular maintenance and periodic re-coating. The lower sections of the window frame are particularly exposed to the weather. Therefore metal weatherboards are often mounted onto the structure. One variant is the timber/aluminium window (25) with an aluminium cladding covering the entire exterior window frame. Well-maintained timber windows can last a very long time. The psychological aspect of timber plays a major role. Timber is nice and easy to work with and is conceived as a 'warm' material. However, ecological aspects need to be considered. The use of tropical wood, for example, is disputable in spite of its longevity if the origin is not certified; generally, wood from sustainable forestry is preferred.

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Traditional window fitting
Fittings on folding shutters with a steel sleeve in the stone column as counterpart.

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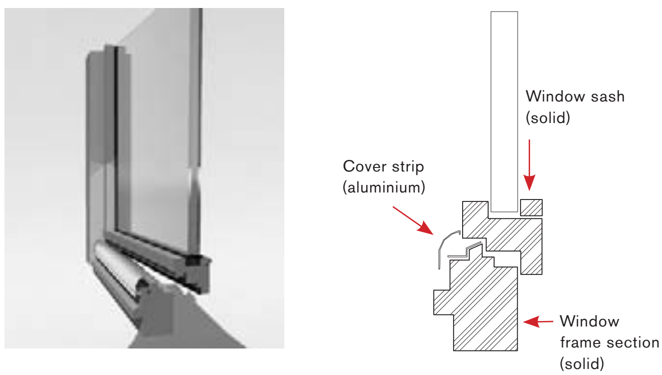
Motorised windows
Motorised windows with concealed conduit in the frame structure.



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Schematic representation of a timber window
Timber window constructions are based on developments over hundreds of years. As such, there is a wide variety of designs in use today.

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Extruded aluminium sections
The design of the mould permits very detailed profiles.

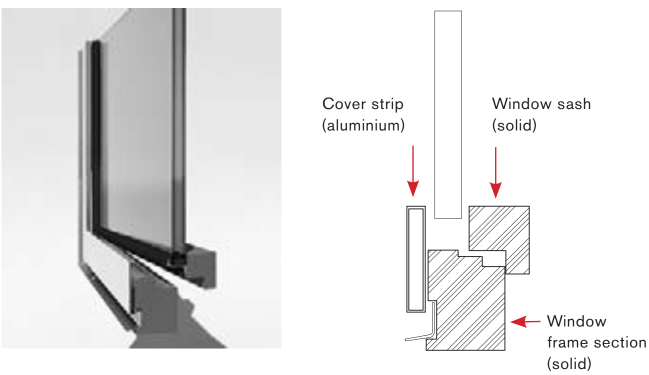
26

Corner bracket
The inserted corner bracket connects two aluminium sections. The edges are then bonded and pressed.

Aluminium windows

Fig. 24 clearly shows the unique cross-section of extruded aluminium sections that are used for aluminium windows. The design of the mould permits very detailed profiles. Rubber seals can be inserted directly and reinforcement bars provide structural integrity. Since aluminium is an excellent heat conductor this type of window consists of an inner and an outer shell that are connected by heat-insulating plastic profiles (27). The sections are therefore called aluminium-plastic composite sections. The corner joints can be plastered and painted. The sections are cut to length and necessary recesses for fitting components and similar parts are milled prior to assembly. The sections are connected with corner brackets (26), glued, pressed or riveted in place. In rare cases the sections can be joined by welding prior to coating, then ground and painted.

Aluminium windows have several advantages: maintenance is simple and undemanding. They are easy to work on and feature high manufacturing accuracy that translates to very close tolerances and thus tightly sealed joints. In the long term these properties can compensate for the higher purchase costs – one reason why they are mainly used for large projects. Aluminium windows offer good heat and sound insulation properties.



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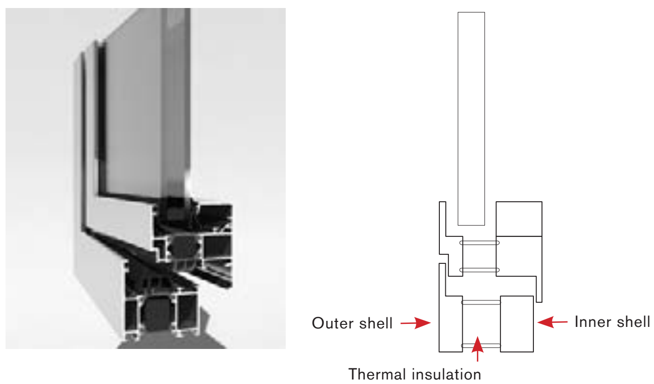
Schematic representation of a timber/aluminium window
The weathering side of the window is protected by aluminium cladding.



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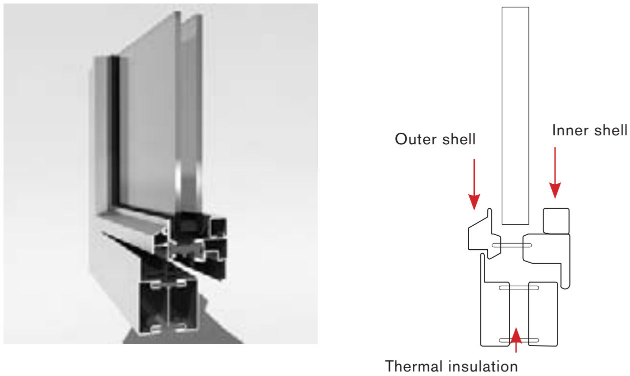
Schematic representation of an aluminium window
Since aluminium is an excellent heat conductor this type of window consists of an inner and an outer shell that are connected by heat-insulating plastic profiles.

Steel windows

Steel windows are assembled from cold-rolled hollow sections. The profiles are made by folding the sheet metal. As with aluminium, steel sections require thermal separation of the inner and outer shell by means of heat-insulating plastic profiles (28). New window sections made of stainless steel reduce the amount of material in the centre zone, specific recesses decrease the heat transfer, and a plastic section as thermal separator is no longer necessary.

Steel sections are characterised by high bending and torsion strength. This might be advantageous, especially if the structural integrity of the frame is essential. However, they are more expensive than comparable aluminium options. Special care must be exercised regarding protection against corrosion. Here stainless steel sections offer particular safety in use. Steel sections come off well when comparing fire protection properties and are thus often the first choice.



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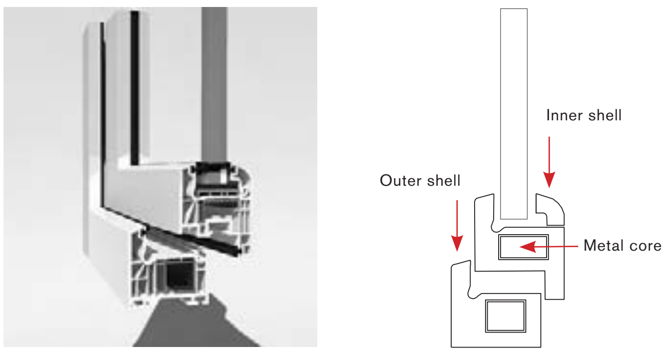
Schematic representation of a steel window
The folded steel profile is clearly visible.

uPVC windows

Similar to aluminium windows plastic windows consist of several sections. An extrusion process is used to manufacture these sections (29).

Numerous types of plastic materials are used for window constructions. However, the material most commonly used is uPVC, not least due to its impact and scratch resistance. But the thermal properties of uPVC are inferior to those of other materials used in façade construction. Solar radiation can cause dark sections to heat up to 80°C (176°F) which in turn can lead to deformation. Coloured sections are made by adhesive bonding of a dyed top coat onto the base material. This process reduces the price advantage compared to other materials. Since uPVC windows are not particularly rigid, their installation sizes are limited. The sections are often reinforced with alloy tubing. The size of the fittings needs to be dimensioned accordingly.

The benefits of uPVC windows are easy handling; low cost and resilience during installation; protection against corrosion is not needed, eliminating any related problems. However, uPVC windows do not provide effective resistance against fire.



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Schematic representation of a uPVC window
Metal rod inserts in the frame improve the structural integrity, realised here in the form of a metal core.

GRP windows

The application of glass-fibre reinforced plastic sections for window construction has been pushed on over the last years. GRP sections are manufactured by pultrusion, and due to the composite material's very good loadbearing capacity and low thermal conductivity they offer advantages over aluminium window sections. GRP window sections can be very slender and do not require insulation bars, but their application is restricted compared to aluminium sections due to significantly higher manufacturing cost. The manufacturing process is much more elaborate than an extrusion process, resulting in a very small product portfolio. From a constructional viewpoint GRP sections offer advantages and their slender profile appeals to architects. However, it remains to be seen how far the material will be applied in practise.

Assembly

The façade industry constantly searches for new manufacturing and assembly methods. The trend leans towards reducing in situ assembly times. This would shorten the construction period and reduce potential scheduling conflicts with other subcontract work. Assembly at the construction site also means higher risks due to changing weather conditions. At 5°C (41°F) or less it becomes very difficult to install sealing systems safely. Assembly inside a factory building is usually cleaner and more controllable. Also, it is easier to resolve possible defects and problems.

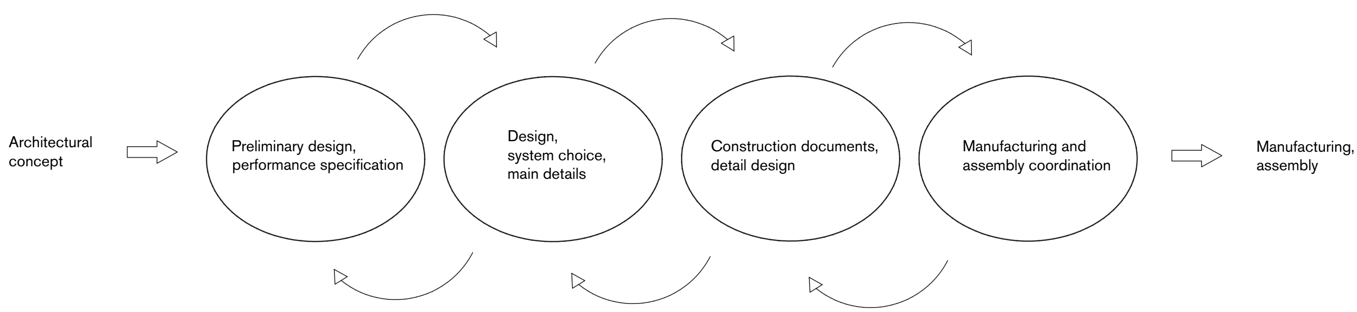
However, prefabrication of elements into larger units does have its disadvantages: typically the elements are more complex and need to be dimensioned to account for stress during transportation. Immediately assembling the elements in situ requires extensive planning of the structural joints and permissible tolerances of the shell of the building are limited. Mounting units on the shell of the building must be installed with great accuracy because tightly planned construction logistics do not allow for delays. Transportation too can cause trouble. If materials (such as a glass pane) are damaged during transport this might not only mean the material itself needs to be replaced, but possibly entails re-manufacturing of the entire element.

All this raises several questions that need to be considered before choosing either the post-and-beam or unit system façade:

- What are the manufacturing processes of the contracting company and how knowledgeable is the team?
- What type of manufacturing equipment is available on the factory premises?
- What season will the assembly take place and how much time is allotted?
- What is the scope of the project and does it include a sufficient number of repetitive parts to warrant a systemised solution?
- What are the transportation options and what hauling devices will be used?
- What is the expected quality of the shell of the building in terms of tolerances?
- What are the properties and condition of the interfaces with adjacent subcontract works?

The construction of a façade is a process that begins with the architectural concept and ends with the assembly of the final product. However, this is not a linear process but rather depends on regular feedback (30) arising from complex decision making and communication processes. One example: while planning the assembly process it becomes apparent that a unit system façade solution is more economical then the type of structure previously chosen. This can lead to significant design modifications because the sectional width for this structure might be very different than that of the previous design. To achieve a well-controlled process it is therefore important that all members of the planning team possess a good basic knowledge of the principles of construction. Also, communicating all decisions made in the process is essential.

The construction industry is in transition from the traditional building trade to industrial production. Due to technological developments such as the Internet a vast amount of information about new materials and production methods is readily available – not only related to the construction industry but other disciplines as well. Architects and designers strive to put such new insights into practice. There is an enormous drive toward technical innovation and we can expect this to affect the construction of façades. Rising quality standards, shorter construction times and an acute awareness of energy consumption will help develop the façade into an increasingly complex product. Architects have to rise to the challenge and adopt systemised solutions as a viable design alternative.



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Design process for a façade
Designing a façade is not a linear process but rather depends on regular feedback.