



## Modern Facades made of Glass

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Barbara Siebert, born 1967, received her civil engineering degree from TU München. After some years as employee in a consulting office, she is now working in the consulting office Ingenieurbüro Dr. Siebert with special field of application of glass. The doctor's thesis about the calculation of point helded glasses was accepted 2003.

### Summary

Glass as a building material is used in a multitude of new applications like modern glass facades. These have to fulfil basic aspects like protection against climatic influence and environmental pollution, protection against fire and burglary. Important points in these times are a contribution to a positive energy balance. In this paper different types of facades, which can be used for small buildings just as for high rise tall buildings are presented; second facades, point fixed glazing, sound panels and facades with channel shaped glass are shown. In the field of point fixtures many different kind of fittings are possible for different applications of facades. An important field is the rehabilitation of old buildings with a new façade to get buildings with a positive energy balance and a low CO<sub>2</sub> emission. For the presented façade-types technical aspects like principle design rules and static calculation of glass are presented. Finally some build examples are presented.

**Keywords:** Facades; high-rise buildings; glass constructions; point-fixing system; safety aspects; Finite-Element-Analysis.

### 1. Introduction

In the contemporary architecture transparent elements of glass are widespread, also for façades of buildings. Facades have to fulfil many requirements, so for transparent facades many important aspects have to be considered. There are problems due to solar input, sun protection, CO<sub>2</sub> emission and problems due to static calculation and remaining load carrying capacity of the glass elements.

### 2. Types of Facades

#### 2.1 Single-Skin Facades

The advantage of one single layer for facades is of course the low cost. The façade has to take over the task of insulation, sound control and ventilation. In case of high rise buildings with large transparent facades additional elements are necessary for cooling like air conditioning, inner or outer sun protection and special coating of the glass or special sound control glass. An outer sun protection is of course more effective than an inner sun protection, but it is more sensitive to wind influence. So a single-façade is not the best choice for high rise buildings with large transparent facades concerning the CO<sub>2</sub> balance and the well-being of person living or working in the building.

#### 2.2 Double-skin Facade

In case of increasing transparency of the façade, there is also an increasing solar input. To safeguard the well-being of the user and providing a worst CO<sub>2</sub>-balance by providing any cooling or air conditioning systems, double skin facades are the best choice, especially for high rise buildings. The characteristic of a double skin façade are two layers: The outer layer has the function as weather protection. The outer layer is not openable and in most times made of monolithic glass. The inner layer has the function as insulation element, so the glass type is insulation glass. The gap between inner and outer layer is ventilated, there are little openings in the outer façade to reach sufficient ventilation. It is possible to open the inner layer, so it is possible for the user to regulate

the climatic surroundings inside the building individually. In the gap between the layers an outside sun protection can be installed which is protected against weather and wind influence.

### 2.3 Monolithic glazing

For some applications monolithic glazings are used like walls for sound protection, second facades for rehabilitation of old building or new facades e.g. covering concrete parts of building. In case of courtyards interesting solutions are possible.

## 3. Structural Design of Facades

### 3.1 Basics

An important point is the knowledge about the different types of glass and breaking behaviour (Fig 1). Starting from recent research work at present a design code based on fracture mechanics and in line with the actual concept of partial safety factors is at development stage.

It must be sure that a glass construction cannot collapse in case of breakage of glass, so that the safety of people, e.g. falling against a glass facade is guaranteed. Depending on the kind of application the testing of residual resistance is done with different testing methods.

The bearing for glass elements can be linear or at points. New solutions like the undercut method or a fixing only in the gap of the glass leads to very transparent constructions.

### 3.2 Static Calculation of glass

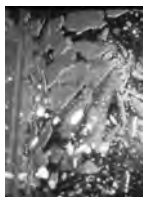
Because of the brittle behaviour of glass the static analysis has to be done very careful, especially in case of point fixed constructions (Fig. 2). In case of all-line supported glass panes it can be important or useful to take care of the nonlinear effects.

### 3.3 Additional Requirements: Thermal Behaviour and Bomb blast

A optimal design of Double Skin facades depend on many aspects like the distance between inner and outer façade and the situation and size of the openings in the outer facade. At present there are many investigations about the blast resistance of windows. In case of a terrorist attack with an explosion near a façade there is a high risk of injuries caused by glass fragments of facades.

## 4. Examples

In the full paper some examples are presented like the High raised building "Münchner Tor", Façade of the theatre "Kammerspiele München" and a Façade in Sevilla (Fig. 3, 4, 5).



*Fig. 1*  
*ESG*



*Fig. 2*  
*Analysis*



*Fig. 3*  
*Münchner Tor*



*Fig. 4*  
*Kammerspiele*



*Fig. 5*  
*Facade Sevilla*

## 5. Conclusions

Modern facades has to fulfil many tasks, so it is important to have knowledge about the basics of glass and its breaking behaviour but also to have knowledge about the different facade types and products like new interlayer or new fixing systems to fulfil the requirements. Glass is a fascinating material to build with, but there are some important problems to be recognized for planning and design to get a safe construction. Further investigations and research has to be done.

## 6. References: See full paper