CONSTRUCTIONAL CLASSIFICATION OF CONTINUOUSLY AND POINT FIXED CURTAIN WALL SYSTEMS

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ABSTRACT
This study concerns the classification of glazed wall systems which is studied as a part of the MSc Arch Thesis (İlhan, 2004) named The Evaluation of Curtain Wall Systems in The Context of The Connection Type for Structural Frame to Glass Lite. The aim of the study is to classify the curtain wall systems and to assist the development of the evaluated products. In this context, curtain wall systems will be classified with respect to type of Structural frame to glass lite connection in the context of connection points, which are widely used recently in our country and furthermore will be defined in detail.

Keywords: Continuously Fixed Systems, Curtain Wall Systems, Point Fixed Systems

INTRODUCTION
The façades and the mass impact of façades play a leading role in the perception of the architectural product. The façades, by the use of curtain wall systems which are defined beyond the concept of metal-framed glazing, have now reached to a progressive definition that aims to enclose the building. By the avant-garde designs of the architect; façades, that are the reflections of the user’s/client’s abstract and concrete demands, have not only a representational role but also try to meet the user comforts conditions.

During the process of architectural evolution, one of the most influenced items of architecture under the effects of mankind’s development and change has been façades, in particular for this century: curtain walls. Le Corbusier in short states the importance of the issue as: “…the history of architecture is the history of the struggle for windows.” Having knowledge of the recent curtain wall systems,
which can be regarded as the history of the future, is essential for appropriate
design.

Today the aim of designing curtain wall systems does not only cover the represen-
tational, aesthetic and comfort expectations of buildings but also conservation
of energy is of great importance. Considering the present serious decrease of nat-
ural energy supply flow, the aim is to reduce the amount of energy consumption
for the physical requirements of buildings. In correlation with the concepts of
ecology and sustainability in architecture, curtain walls are designed to achieve
the optimal standards which respond to the changing physical conditions. There-
fore it is of importance to be familiar with the curtain wall systems and compo-
nents before starting the design process.

CLASSIFICATION OF CURTAIN WALL SYSTEMS

Curtain wall systems are vertical building envelope, composed of thin and light,
transparent, semi transparent or opaque glazed components, whose dead and
dynamic loads are transferred to the structure of the building with the use of
adjustable connection components and thus carried accordingly.

It is possible to classify curtain wall systems in various ways. Classification is
defined in short as the partition of subjects or phenomenon and related informa-
tion with respect to their distinctive properties. According to this definition, cur-
tain wall systems, may be classified by the identification of variables and the
organization of these variables in an appropriate detail. Then curtain wall systems
can be classified,

With respect to the number of skin;
  • Single skin façades;
  • Double skin façades.

With respect to the number of skin and layers;
  • Single layer, single skin façades;
  • Multi layer, single skin façades;
  • Single layer, multi skin façades;
  • Multi layer, multi skin façades.

With respect to system components and the relations in between; according to
structural frame;
  • Stick system;
  • Panel system.
According to the type of connection type between structural frame to glass lite

- Continuously fixed systems;
- Point fixed systems.

According to the type of installation;

- Stick system;
- Semi panel system;
- Panel system.

The principle for carrying the covering component in curtain wall systems depends on the transfer of loads to the structural grill, which affects the component, by means of connections. Considering the glass panel as a covering component, is under the affects of dead load which is caused in its plane by its own weight and live loads which are perpendicular to its plane formed by wind, etc. The tensions caused by the dead and live loads, are transmitted to the connections between the glass panel and the structural frame. These connections that work for the load transmission between the components of façade system, are designed either as point or continuously with respect to the loads they carry and properties of the components they are going to connect.

CONTINUOUSLY FIXED SYSTEMS

Continuously fixed systems are formed by the use of mechanisms that consist of pasted/glued and/or compressed based fixing mechanisms to connect the glass lite to structural frame. Because the glass lite is subjected to regular compression along the edges, deformations are limited. Continuously fixed systems are divided into three groups according to connection type of glass lite to structural frame as followed.

- Pressure plate systems;
- Structural sealant systems;
- Combined systems.

**Pressure Plate Systems**

The main component of this system is a pressure plate that compressed the glass lite along the edges from the outside of the lite to inside. The principle behind the load transfer of connections is the use of frictional surface developed by compressing the glass lite (Aygün, 1996).

The gaskets or foam tapes that act as a pad between the glass lite and the pressure plate, have a good coefficient of friction and won’t loose its elasticity under load.
bearing are used in frictional surfaces. If it is between the pressure plate and structural frame, thermal breaks are used because of the high amount of thermal conductivity of aluminum. Also a covercap is located over the pressure plate to cover the connection bolts and to achieve an aesthetic façade view.

**Figure 1.** Pressure Plate System

**Structural Sealant Systems**

Structural sealant systems are mainly based on structural sealants that are capable to connect the glass lites to the structural frame. The glass lite can be bonded the structural frame either directly or by the use of a glazing inlay (Elmahdy & Comick, 1988).

During the installation of the system by the use of glazing inlay, the connection between the glass and the glazing inlay is realized by the structural sealant. Then the panel fixed mechanically to the structural frame that hanged the building

**Figure 2.** Structural Sealant Systems
structure. If the glazing inlay is not used, the glass lite is glued directly to the structural frame with structural sealant (Amstock, 1997).

When structural glazing was introduced to the construction industry, only silicone sealants could be used. So such systems are named as structural silicone systems. Structural sealant systems can be divided into two groups as; two-sided structural glazing and four-sided structural glazing.

**Combined Systems**

In combined systems both mechanisms, pressure plate and structural sealant, are used. While the pressure plate is used for horizontal connections on the other hand structural sealants are used for vertical ones. The use of many connection mechanisms and fixings are caused the façade system being more sophisticated and problematic (Aygün, 1996).

![Combined Systems Diagram](image)

**Figure 3. Combined Systems**

**POINT FIXED SYSTEMS**

The glass panes are fixed together without using metal frames or mullions. The system allowed designers to glaze large openings in buildings, to create light and space with a minimum of visual barriers (Button & Pye, 1993).

Glass panes act as floor slabs against the wind loads. Glass panes that are bent by the effect of wind load transfer the loads to the connections. The glass pane is distorted at a higher degree if the connections are point fixed and thus a bending moment is concentrated around these points. On this account the type and the
thickness of the glass pane and the fixing mechanisms are important to create a flexible joint to accommodate movements and dimensional tolerances.

The glass lites, have a big size, in point fixed glazing systems are subjected to bending moment due to the dead load of glass panes. By the affects of bending momentum the surface of the glass pane is in tension. In the situations in which these tension stretches are consistent the resistance of the glass decreases to almost one third and the holes widen (Schittich & Staib, 1999). Wider holes generated the fractures thus it is essential to take precautions to prevent this situation. As a principal to avoid such kind of fractures, toughened glass lites have to be used and instead of being sat on, glass lites should be hung to building structure.

The principle behind the design of the fittings for a point fixed system is that all in-place forces transferred between components are resisted by friction developed at the metal/gasket/glass interfaces, arising from the tension developed in the fixing bolts. Such fittings must be designed to neutralize the moments developed by wind loads while the glass panes transferred lateral and vertical forces and, allow the glass panes for movement in three directions. As it is seen how to transfer forces and how to bear the glass panes make the design of point fittings essential. From the standing of this point, various connection mechanisms used in point fixed system will be detailed as below.

**Cylindrical Hole and Standard Bolt Fittings**

For this kind of fitting, the dead load due to the glass weight is concentrated in the area around the hole itself. In the area of the holes usually the highest stresses appear. The glass is rigidly connected to the supporting bracket. This fitting does not allow any differential movement between the glass and the supporting structure. It could not be used in conjunction with sealed insulating glass units or nonvertical applications (Amstock, 1997).

**Bolt With Plate and Counter Plate (Patch Fitting)**

It is the upper version of the previous case. The principal behind the design of the fitting is that the patch fitting and the supporting bracket are tightened against the glass by means of the bolt. The dead load of the glass pane is supported by the plates fixed to the glass. The bolt hole in this case is not directly supporting the load. Similarly to the previous cases, the glass and the supporting bracket are rigidly connected, and therefore differential movement is not possible. The risk of fracture is related to size of plates.

**Countersunk Hole and Countersunk Bolt Fitting**

This assembly produces a flush and uninterrupted glass wall. Any applied load (dead load, wind load, impact) concentrates in the area around the countersunk hole. Concentrated high stresses, along with imperfections on the surface of the
countersunk hole, may easily cause a breakage to start in that area. Differential movement between the glass and the structure is not possible in this system.
Countersunk Hole and Spring Plate

This system allows the glass some movement in respect of the supporting structure and also gives the glazed area a completely flush appearance. Movement is possible through the use of spring plates and countersunk bolts located between the glass and the supporting bracket. It should be noted however that, once the bolt is tightened to the supporting bracket, and when glass deflection occurs, due to e.g. the wind load, the area around the hole is supporting a considerable stress concentration.

The articulated connection permits the designer to prevent the moment transfer between the supporting bracket and the glass pane at a small range. So the location of the articulation is essential for the amount of moment. It is capable of fix-

Figure 7. Countersunk Bolt Fitting (CMI ltd)
Figure 8. Relation between The Outside Articulation and Moment (Krewinkel, 1998)

Countsunk Bolt Fitting
ing either single or insulating toughened glass to any structure. Such fittings are divided into two groups as outside articulation and inside articulation.

**Outside Articulation**

Movement is possible through the use of spring plates and countersunk bolts located between the glass and the supporting bracket. It should be noted, the connection between the bolt and the supporting bracket is rigid, and the connection between the glass pane and the bolt is articulated. As indicated in the below figure, when the articulation is located outside the glass plane, a bending moment is created inside the glass pane \( M_E = G x e \).

**Inside Articulation**

The inside articulation permits the designer to predict a hole in the glass that will never be loaded in bending, even under wind deflection and structural movement. All the loads to be considered in the calculation are in the vertical plane or perpendicular to it.

The swivel articulated joint type consists of a countersunk hole on the glass and a mushroom head with concave dish coupled with threaded disc screw fixing unit clamped to the glass hole and fastened onto the supporting stainless spider arm behind the glass panel. The swivel joint fixing on the glass panel is free to rotate at a 10 degree angle in any direction and laboratory tests show that the actual stress around the glass hole is reduced to 70% compared to the standard type of conventional fixing [www.metroglass.co.nz]. So the load bearing capacity of the system is increased and thinner glass panes can be used.

![Swivel Articulated Joint](image)

**Figure 11.** Swivel Articulated Joint (CMI ltd)
CONCLUSION

In this study a classification is proposed according to *Connection type of structural frame to glass lite;* and two group of system alternatives; continuously fixed systems and point fixed systems are defined. It is observed that adhesion and/or compressed based fixing mechanisms are used for the continuously fixed mechanisms and the fixing components have alternative systems mentioned as below;

- Pressure plate systems;
- Structural sealant systems (structural silicone systems);
  - Two sided structural silicone systems;
  - Four sided structural silicone systems;
  - Combined systems;

The Point fixed systems (structural glass systems) are designed through the mechanisms mentioned below which are basically defined according to the distribution of the loads affecting the façades and distribution of the load of the glass panel to the building.

- Cylindrical Hole and Standard Bolt Fittings
- Bolt With Plate and Counter Plate (Patch Fitting)
- Countersunk Hole and Countersunk Bolt Fitting
- Countersunk Hole and Spring Plate
  - Outer articulation
  - Inside articulation

Table 1, identifying the distinctive properties of each alternative, can provide guidance for selecting the appropriate system.

This study is intended to support the decision-making process of these practitioners in the AEC industry. Awareness and some basic knowledge of the curtain wall system types has benefits especially for façade designers and also contractors involved in building projects since this decision taken at the element level will have positive or negative effects on the performance of other elements thus determining the failure or success of the entire project. Prospective work may include the development of a more analytical method for selection, taking into account the various quantitative and qualitative design parameters.
### Table 1. Classification of Curtain Wall Systems

<table>
<thead>
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<th>Properties</th>
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### REFERENCES


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