CURTAIN WALL SYSTEMS

by

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ABSTRACT

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In recent years, curtain wall has become popular. It is built of using variety of new and lightweight material.

In this report it will be attempted to give a general description of types, function, material, etc., of curtain wall. Then, a more detailed research will include comparison of its different systems, their application, design criteria, and special features.

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CHAPTER 1

INTRODUCTION

The beginning of curtain wall development logically but somewhat tardily followed after the invention of the skeleton frame. It replaced the masonry facing and infilling with a light prefabricated exterior skin suspended in front of structure-like curtain. Mass production can provide modular components that can be combined into imaginative designs by varying form, colour, texture, and basic materials.

There is no doubt about the technical progress that has been made in recent years. By spread of prefabrication techniques the refinement of components has been accompanied by a reduction in the number of site operations. The industry has developed new, light, insulating materials, better sealants and original surface treatments. Curtain wall is largely free of major stresses and built of a variety of lightweight material each with its own specific properties.

Curtain walls are designed either as custom products or on the basis of one of the many standard wall systems available. The custom curtain wall is intended for one particular building. Its material composition and design characteristics are partly predetermined, partly arrived at during development in the light of the specific conditions applicable to the building in question. Standard wall systems can be used for a variety of buildings. Within certain limits such systems must be flexible enough to permit the use of different materials and some variation in design.

CHAPTER 2

GENERAL CONCEPT

Curtain walls are exterior walls with the following characteristics:

- they are suspended in front of the structural frame
- their own dead weight and the wind loads are transferred to the structural frame through point anchorages
- the design of the points between curtain wall elements and the fastening technique permit the erection of continuous wall surface of any size

Curtain walls may be distinguished from infilling walls by the first and second of the above characteristics, namely erection in front of the structural frame and the point transfer of dead and wind loads. Infilling walls are fixed to the structural frame on all four sides or at least on two opposite sides, the dead weight of such walls and the wind loads are transferred to the frame through continuous connections. Either the entire structural skeleton or just the spandrel beams or columns are directly visible in elevation.

With curtain walls, the structural skeleton is set back behind the facade. It is not an explicit element in the design, though the columns may be discernible behind a transparent skin. In most cases curtain walls are composed of elements of uniform size but there are also possibilities of achieving other effects. By adding different elements we can indirectly express the spandrel beams or the columns or the entire structural grid.

2.1 HISTORY

The curtain wall actually has existed for centuries. They were built when the Greeks and Romans used post-and-linted construction, filled in with brick, stone, or concrete, for enclosure. Stained glass curtain walls were used in the medieval cathedrals with arches supported upon columns. The early skyscrapers utilizing skeleton construction had curtain walls of glass and metal or masonry. The Chrysler Building which pioneered the use of exterior stainless steel, is actually enclosed by a curtain wall, composed of tons of masonry set into place piece by piece. Tremendous progress has been made in wall construction since Chicago's Monadnock Building was built in 1893 with bearing walls of masonry 6 ft. thick. Instead of such massive walls requiring months to build we now have a very thin wall that can be erected in a few days.

Today, the results of new technology and design are apparent from the time of the early prototype skyscripers, the need has existed for the type of wall available today. But only in the last several years the designer has had a protective covering for the major structure of the building that exploits our present-day manufacturing, prefabrication, and erection methods. There are two main reasons for the development of the new curtain walls: (1) in a building in which the frame carries all the loads, the wall of the past has no logical place, and 2) the new walls make use of the technological advances made in building materials and methods.

2.2 TYPES OF WALLS

2.2.1 Grid Construction

They consists of a rectangular grid of vertical and horizontal members, framing openings filled with inserts or glass. The inserts and glazing are the space-enclosing elements of the grid curtain wall, while the grid itself forms the framework, wihtin which these are installed. Normally only the grid is attached to the supporting structure, to which it then transfers the entire weight of the curtain wall plus possible wind loads.

2.2.2 Panel Construction

The term 'panel construction' is applied to wall assemblies consisting of large story-high or half story-high panels fastened either directly or indirectly by means of second framing to the supporting structure.

The only components of panel curtain walls are the panels themselves, which combine the twin functions of enclosing space and transferring the dead and live loads to the supporting structure. The most important structural characteristic of such panels is their jointless, continuous outer surface.

2.3 FUNCTION

The curtain wall functions as a filter for the elements, fire, people, animals, sounds, odors, and anything else that might pass into or out of a building. The main problems in its design are those elements that resist the passage of these items, or concurrently, allow their passage when desired. The wall must be a barrier but a flexible one. It is called upon to filter primarily the following: precipitation, wind, fire, temperature, condensation, view, light, sound.

2.4 ASSEMBLY

Curtain wall components are assembled in many different ways. The major part of the assembly of curtain walls is generally done in the shop, since this procedure is usually less expensive, faster, more accurate, and better controlled. For walls assembled from standardized parts, much of the assembly is also done in the shop but sometimes the insertion of the panels is accomplished in the field. Industrial walls may be assembled by either method, or they may be assembled as they are erected. The choice between the three methods for industrial walls depends primarily on the type of wall units employed and the conditions at the job site.

2.5 ERECTION

It is hard to overstate the advantages of erecting curtain walls from inside the building. There are the obvious savings in construction costs due to the elimination of scaffolding and to the greater efficiency possible in working from the floor to floor of a building rather than from scaffolds. But beyond that, inside erection can be accomplished much faster, without the costly delays caused by the weather. The importance of such erection increases as the height of the building increases. In single-story buildings, outside erection is both practical and often employed. For multi-story buildings (other than those with structural cantilevers projecting outside the face of the wall), there is virtually no factor in favour of outside erection. It is important to provide for the removal and replacement of units after erection, since it is almost impossible to erect a large wall without damaged units or surfaces. To insure closer control and more accurate placement, fasterners for attaching components to the structure should be applied in the field.

CHAPTER 3

MATERIAL

It is hard to imagine a building material that has not been used or at least considered for curtain walls. Stainless steel led the way in some of the earliest installation. Aluminum was used in spectacular walls for the Alcoa Building in Pittsburgh and its successors. The designer who wishes to use a curtain wall today is confronted by a wide variety of available materials. In the final selection of any curtain wall system, material, or component, the end desired and the function to be performed must be kept firmly in mind.[2,3]

3.1 STEEL AND STAINLESS STEEL

The steel usually takes the form of structural shapes and sheets, particularly thin sheets. Structural shapes and sheets are hot-rolled products. Most of the structural shapes used in curtain walls are standard window sections. In some instances T-sections, angles, channels, tees and zees are employed.

Steel sections exposed to the weather are liable to rust unless their surfaces are very thoroughly protected. Corrosion not only shortens the life of such members, it also spoils the appearance of the facade. Among the many chemical and mechanical surface treatments available the following have proved particularly suitable for steel curtain wall components:

a) hot galvanizing by dipping in molten zinc. The zinc combined with the pickled, degreased surface of the steel parts, forming a dense, corrosion-resisting coating.

b) electrogalvanizing.

c) phosphatizing as a rust-proofing process.

d) paint in combination with one of the three processes mentioned above.

Stainless steels are low-carbon alloy steels with a chromium content of at least 12%. Other alloys also contain 8-12% nickel and about 2% molybdenum. Stainless steels are resistant to atmospheric weathering, water, and most acids. They do not require additional surface protection, regular cleaning to remove adhering particles of dirt is sufficient.

Stainless steels can be worked in the same way as ordinary steels. In principle they are also suitable for extrusion.

3.2 ALUMINUM

Today the word 'aluminum' is commonly applied not only to the chemical elements but also to the numerous alloys of aluminum with other metals. For building in general and curtain wall construction in particular the most important of these alloys are those with manganese (Mn), magnesium (Mg) and silicon (Si), the alloys with copper being unsuitable for curtain walls. When exposed to air, aluminum and its alloys become coated with a natural layer of oxide. Under normal atmospheric conditions anodization is an excellent means of protecting aluminum surface. In industrial areas or in cities with serious air pollution problems there is a danger that metallic impurities in the air may combine with moisture to form galvanic cells on the surface of aluminum.

3.3 BRONZE AND BRASS

Bronze and brass are alloys of copper. True bronze is an alloy of copper and tin varying only slightly from a 90% copper and 10% tin composition. Brasses, on the other hand, are alloys with at least 50% copper and zinc as the main alloying constituent.

Like all copper alloys they have good resistance to corrosion. Like aluminum all copper alloys form a surface layer of oxide, the patina. The natural process of oxidation can be anticipated by chemical treatment. In this way a uniform surface is obtained.

3.4 WOOD

Since wood has a relatively low coefficient of expansion, the thermal stresses can be ignored and the joints between wooden frames made permanently fixed. This is in keeping with the limited possibilities of working and shaping wood, which permit only the simplest of solid cross sections.

Combinations of wood and aluminum is also possible. The aluminum forms a weatherproof skin, while the wood has a structural function.

3.5 CONCRETE AND ARTIFICIAL STONE

True suspended curtain wall grids in concrete or artificial stone are perfectly feasible. Of course, concrete and artificial stone sections are considerably heavier than the corresponding sections in metal or wood. Moreover, the tolerances are greater and the joints with spandrel panels, fixed glazing and windows are harder to design. In most concrete or artificial-stone curtain wall systems the spandrels are poured at the same time as the frame. Such units are more correctly described as panels, even though the finished facade may be characterized by a rectangular pattern of intersecting ribs.

3.6 PORCELAIN ENAMEL

Porcelain enamel which might more properly be called vitreous enamel in order to distinguish it from paints is a completely inorganic substance. Closely akin to glass, its primary function in curtain wall design is the coating of other materials to impart qualities these do not normally possess. Among such properties are highly permanent color in a wide range, weather resistance, ease of cleaning, and long life.

3.7 GLASS

Glass in its usual forms is a plastic, noncrystalline high-viscosity liquid. Composed of a complex mixture of oxides of silicon and metals with alkaline earth oxides, glass is workable only at high temperatures. Most processes are continuous from raw materials to the finished products. For these reasons the manufacturer ordinarily acts also as the fabricator. This procedure makes more coordinated control of the products possible than with most other materials, but it may serve to stultify creativeness and imagination in the development and use of glass products. They enjoy a wide spread vogue in curtain walls and are used as glazing, curtain wall spandrels and panels.

3.8 PLASTIC

Plastics are largely made from common elements such as oxygen, nitrogen, hydrogen, chlorine, and carbon, all of which are readily obtainable and virtually inexhasutible. The plastics have been used in curtain-walls as panel facings, adhesives and sealers.

The following table shows the typical physical and mechanical properties of curtain wall materials.[2]

Property	Aluminum (3003)	Stainless steel (302)	Porcelain enamel	Copper alloys (Muntz metal)	Copper	Carbon steel (SAE 1020)	Glass	Reinforced plastics[1]
Density, lb per cu in.	0.099	0.29	0.09–0.11	0.303	0.322	0.284	0.09	0.066
Hardness (Brinell)	28–55	160–400	4–6[2]	80–145	42–100	130–205	5–7[2]	90–120[3]
Tensile yield strength (0.2 per cent offset), 1,000 psi	6–27	30–165	18–32[4]	18–60	10–48	40–62	1–4[5]	25 up
Tensile ultimate strength, 1,000 psi	16–29	90–190	38–48[4]	52–80	32–52	60–104	6–7	35 up
Young's modulus of elasticity, 10^6 psi	10	28	—	13	16	30	9 up	2.5 up
Modulus of rigidity, 10^6 psi	—	12.5	—	—	—	11.6	4–30	2.5 up
Elongation in 2 in., per cent	4–30	55	to 48[4]	10–45	5–45	6–35	—	—
Fatigue strength 1,000 psi	7–10	30–55	—	—	—	33	—	—
Impact strength (Izod value), ft-lb	—	115–140	—	—	—		8–60[6]	5–25
Melting point, deg F	1,190–1,210	2,550–2,590	1,200–1,900	1,660	1,980	2,760	230–430[7]	250
Thermal expansion coef., in. per in. per deg F × 10^{-6} (32° to 212° F)	12.9	9.6	8–12	10.8	9.3	6.7	4.5–5.0	16
Thermal conductivity, Btu per in. per sq ft per deg F per hr (32° to 212° F)	1,070–1,340	113	3–9	870	2,700	360	3–9	1.5
Resistance to abrasion[8]	C	A	B–C	C	C	B	A	C

CHAPTER 4

DESIGN CRITERIA[1,2,3,4]

4.1 LOADS

Curtain walls are loaded horizontally by the wind and vertically by their own dead weight. As distinct from the variable dead weight of the curtain wall which depends on the type of construction and materials employed, the wind loads are fixed by national and local building codes. The wind pressure maps and tables have been generally accepted as a sound basis for design.

Winds produce suction as well as pressure on the face of a building. These negative forces are important in dimensioning anchors, fasteners and glazing beads installed from the outside. In hurricanes far more glass is blown out of buildings than into them.

4.1.1 Wind Load

The wind loads acting on a curtain wall are transferred through fasteners to the supporting structure. Thus, the curtain wall is stressed in bending. Its own weight acts as a vertical force. Accordingly, the elements of a curtain wall must be designed for direct stress and beinding combined. The dead weight of the wall results either in tensile stress (if units are suspended) or in compressive stresses (if the units stand on their bottom edge). In design for combined bending and tension there is no need to provide for buckling, but buckling is a distinct possibility where bending and compression are involved. Both ways of attaching curtain wall units to the structure: suspending them from the top and supporting them at the bottom are possible and used in practice, although suspension from the top is generally preferred. In this case, if the construction is relatively light (max. 15.5 lb/sq. ft. of wall surface), the units are customarily designed only for bending and the direct tensile stresses neglected.

The fact that the curtain wall is stressed in bending means that all the components subjected directly or indirectly to wind loading must be made of material capable of resisting bending action.

It is known from aircraft construction that in certain areas of bearing faces so called peak stress may occur, whose location and size must be precisely determined. A slab-shaped multi-storey building in a windstorm is nothing but a bearing wing, stressed by compression and suction. At the edges of the bearing face (sides of the building) the strongest suction will occur. This knowledge is of major importance in designing lightweight curtain wall elements. For economic reasons it is, therefore, advisable to specify wind tunnel tests for buildings in exposed positions, in groups and of over average size, in order to grasp the critical areas exactly and to dimension the crossbracing and means of fixing correctly.

4.1.2 Resistance to Bending

This is an important aspect of designing a curtain wall and the ways of making curtain wall construction capable of resisting bending must be considered.

In grid construction the wind loads acting on the spandrels, fixed glazing and windows are transferred to the grid and from the grid to the structural frame. Usually the vertical members of the grid, or mullions, span between floors, while the horizontal members span between mullions. Vertical members spanning from floor to floor must be designed for axial stresses and bending, the bending generally being critical, since the axial stresses are due only to the wall loads, which, of course, are relatively light. In this case, the bending is in one direction only and it is in this direction that the mullion must have its greatest stiffness and strength. The best mullion sections, therefore, are those with their greatest depth at right angles to the face of the wall, for example rectangular box sections with thick flanges and thin webs, or channels and T-sections again with heavy flanges and thin webs.

Members spanning horizontally, are stressed in bending in two directions, both by the wind loads acting horizontally and by the dead loads acting vertically. In this case the best section is one with approximately the same strength and stiffness about both axes, a hollow member with a square cross section for example.

Curtain wall panel units have thin, continuous and jointless outside facing with a limited ability to resist bending so that some form of stiffening must be introduced. There are various ways of doing this such as: the outside facing may be fluted or corrugated, or it may be given three-dimensional rigidity by being stamped into convex or concave shapes. The effect is similar to that obtained with the thin sheet used in building automobile bodies or the span of the panels may be reduced by means of a secondary skeleton fastened to the main structure. The rigidity of panels faced with sheet metal depends primarily on the rigidity of the facing itself. Thin, flat facing has almost no resistance to bending. Lightweight and regular reinforced concrete panels, on the other hand, can be made very thin and still remain strong enough to resist bending.

4.1.3 Elastic Deformation

The elastic deformation of curtain walls is a consequence of the bending due to wind loads. All the elements exposed to the wind deflect in the direction in which the wind loads act. The degree of elastic deformation is variable. It depends on the stiffness and the modulus of elasticity of the components. An effort should be made to balance these deflections, which to a large extent determine the tightness and proper functioning of the joints.

Fixing the theoretically permissible deflection is both a structural and a cost problem. Because of the extreme precision of the joints excessive deflection may easily spoil the fit between parts and this in turn may result in leaks. Deflections can only be kept small by using heavier members or by introducing additional fasteners and supports to shorten the span.

4.2 THERMAL INSULATION

An important feature of curtain wall construction is the use of highly efficient thermal insulation, the lightness of which is of great assistance to the designer in his efforts to reduce the weight of the wall to a minimum. The materials used for thermal insulation are of low density and to some extent porous and sensitive to moisture and the weather, moreover, they have little strength in tension or compression.

Accordingly, they need to be weather-proofed, and both faces must be protected from mechanical shock.

The insulation zone of a curtain wall is typically composed of the following parts:

- an exterior weather-proof skin
- the thermal insulation
- inside facing to protect the insulation from mechanical damage

In some form or other, these three elements are to be found in every insulated curtain wall. The standard solution is employing thermally insulated spandrels with glazing in between.

4.3 PROTECTION FROM PRECIPITATION

The primary problem in dealing with precipitation is what to do with rain. If it can be excluded from the building by the curtain wall, as it must be, then other forms of precipitation will cause little trouble. Ordinalry, if rain is kept out, little trouble may be expected with dust, dirt, smog, or other foreign matters. It may be necessary in certain areas, on the other hand, to pay more attention to the problem of smog or dust than to that of precipitation. But the basic problem remains the same. To provide a tight covering for the building that will prevent outside foreign matter from penetrating to the inside surface.

The question of prevention of moisture penetration through the wall breaks itself into two parts: 1) water entering the interior through the wall surface, and 2) water entering the interior through the joint.

The more porous materials, like stone or masonry, allow water to be siphoned through their surfaces to the inside. Furthermore, the problem of waterproofing the joint in this type of construction is greatly multiplied, because of the vast number of joints.

In the new types of curtain walls, on the other hand, the exclusion of precipitation can be complete and absolute over nearly all of the exposed surface. The joint then becomes the critical element in the protection that must be afforded from precipitation.

4.4 FIRE PROTECTION

The first principles in designing a curtain wall for fire protection are these:

1) Fire must be prevented from entering building from outside.

2) Fire must be prevented from spreading from the inside to other nearby structure.

3) Fire must be prevented from spreading from one floor to another or from one room to another by passing through the exterior wall and back into the adjoining space.

4) Smoke and gases must be controlled.

Fire protection requirements are based on the national codes. These codes are extremely influential and almost all have included performance-type provisions in their latest revisions.

4.5 CONTROL OF CONDENSATION

Basically, the wall must be leakproof. Its design must provide means for preventing moisture in all its forms from entering the building interior. Water entering the wall can negate the effect of insulation and eventually will destroy many types. It can cause corrosion of metal surface. Alternate freezing and thawing of water within the wall can cause buckling and deformation of the assemblies. Moreover, the building exterior facing can be streaked and discolored by the flow from within the wall of water containing foreign matter. During certain seasons, the interior face of the wall may be subject to condensation that will strike the plaster or other finishes.

The major method of controlling condensation (and rain) consists of vapor barriers placed within the wall. These barriers are quite effective if properly installed and watertight. Plumbing may be provided within the wall for collection and disposal of the condensed water.

4.6 SOUNDPROOFING

According to the law of mass, light curtain walls, with their relatively low dead weight, have sound-proofing properties much inferior to those of heavy load-bearing walls, the weight of which is considerably greater, if only for structural reasons.

The various parts of a curtain wall, metal, glass, etc., are good conductors of sound. Airborne noise originating from sources inside a room is transmitted through solids and partially re-radiated into adjacent rooms. In the same way, impact noise is communicated to the curtain wall through fasteners and connectors, transmitted through the curtain wall and re-radiated into the interior of the building at some other point. The transfer of sound energy to the curtain wall can be prevented by suitable acoustical measures, such as lining rooms with sound-absorbing materials and laying floating floors.

4.7 JOINT

Whether a curtain wall functions properly largely depends on the design of the joints between its components. The joint has multiple functions to perform. A good joint design must a) prevent air and water leakage b) provide flexibility for large tolerances in building construction, for expansion and contraction due to temperature changes, and for removal of components c) control moisture by drainage and by ventilation, and d) prevent through conductivity of metals. It should provide for simple fabrication and efficient erection.[2,3]

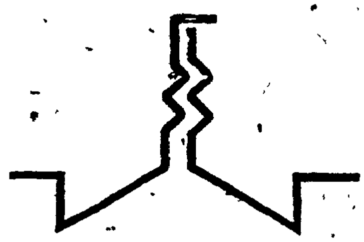
4.7.1 Types

4.7.1.1 Lap Joints

The use of lap joint is restricted almost entirely to systems employing metal wall cladding. The overlapping of the panels is inconspicuous and the scaly structure of the wall hardly noticeable. If thicker panels, flat slabs of concrete for example, are used, the scaliness of the surface will be much more pronounced.

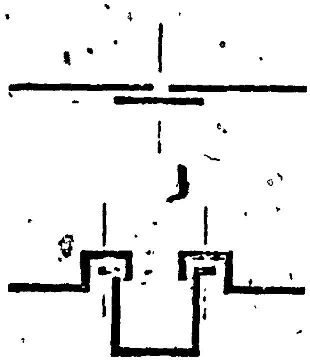
4.7.1.2 Mating Joints

They are used to connect prefabricated mechanically fastened panels, the metal edges of which have been bent to form vertical, interlocking jaws. Simple mating joints can also be formed at the edges of concrete panels. Metal is the best material in which to design mating joints of complicated shape.



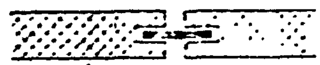
4.7.1.3 Batten Joints

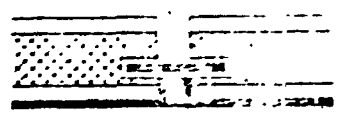
They are used in connecting frames and panel units and are particularly suitable for vertical joints, less so for horizontal joints since in this case the top of the joint framed between batten and frame or panel is hard to seal and offers no sure guarantee against the penetration of moisture. Battens are fitted over the joints between frames and panels and clamped in place.



4.7.1.4 Spline Joints

Spline joints are suitable for connecting frames. Extrusion is the only process capable of turning out sections with a sufficiently close fit. They can be introduced in both horizontal and vertical directions.





4.8 SEALANTS

Sealants prevent water, wind, and dust from penetrating the joints. If the joints aren't properly sealed, extensive structural and aesthetic damage will be caused. Sealants should have the following criteria: a) have long life b) resist drying out or becoming brittle c) readily and permanently adher to materials of wall d) stretch to compensate for expansion and contraction of the wall e) have an extremely low shrinkage factor f) non staining g) of uniform consistency h) weatherproof i) simple to apply j) non-corrosive k) attractive in appearance, l) easy to replace.

Any sealant is compounded of a base plastic polymer and those additives that enhance or suppress its inherent properties towards a desired end (such as fillers, plasticizers, curing agents, solvents, pigments, etc.) Base polymers establish the general sealant performance. How a sealant elongates, compresses, recovers, ages, weathers, and reacts with water, solvents, acids and alkalies, electricity, and temperature is largely the responsiblity of the base polymer.

Some principal sealants include: oil-basec caulks, butyl caulks, latex caulks, acrylic sealants, polysulfide sealants, urethane sealants, polymercaptan sealants, and silicon sealants. The silicon sealant costs more than many other quality elastomeric sealants, but it is a superb sealant for use in curtain walls. Its shrinkage is insignificant. It is accompanied by fine gunnability and workability, very stable viscosity, and excellent resistance to weathering and moisture. The following table shows the characteristics and properties of sealing compounds.[6]

CHARACTERISTICS AND PROPERTIES OF SEALING COMPOUNDS[6]

		Butyls		Acrylics		Polysulfides		Polyurethanes	
	Oil Base	Skinning Type	Non-Skinning Type	Solvent-Release Type	Water-Release Type	One-Component	Two-Component	One-Component	Two-Component
Chief ingredients	Selected oils fillers, plasticizers, binders, pigment	Butyl polymers, inert reinforcing pigments, non-volatile plasticizers and polymerizable dryers	Butyl polymers inert reinforcing pigments, non-volatizing and non-drying plasticizers	Acrylic polymers with limited amounts of fillers & plasticizers	Acrylic polymers with fillers and plasticizers	Polysulfide polymers activators pigments, inert fillers curing agents, and non-volatilizing plasticizers	Base polysulfide polymers activators, pigments plasticizers fillers Activator accelerators, extenders, activators	Polyurethane prepolymer, filler pigments & plasticizers	Base polyurethane prepolymer filler, pigment plasticizers Activator accelerators, extenders, activators
Primer required	in certain applications	none	none	none	none	usually	usually	usually	always
Curing process	solvent release, oxidation	solvent release oxidation	no curing remains permanently tacky	solvent release	water evaporation	chemical reaction with moisture in air & oxidation	chemical reaction with curing agent	chemical reaction with moisture in the air	chemical reaction with curing agent
Tack-free time (hrs)	6	24	remains indefinitely tacky	36	36	24	36–48	36	24
[1]Cure time days	continuing	continuing	N/A	14	5	14–21	7	14	3–5
Max. cured elongation	15%	40%	N/A	60%	not available	300%	600%	300%	400%
Recommended max joint movement, %	±3% decreasing with age	±7½%	N/A	±10%	±5%	±25%	±25%	±15%	±25%
Max joint width	1″	¾″	N/A	¾″	⅜″	1″	1″	¾″	1″
Resiliency	low	low	low	low	low	high	high	high	high
Resistance to compression	very low	moderate	low	very low	low	moderate	moderate	high	high
[2]Resistance to extension	very low	low	low	very low	low	moderate	moderate	high	high
Service temp range °F	−20° to 150°	−20° to 180°	−20° to 180°	−20° to 180°	−20° to 180°	−40° to 200°	−60° to 200°	−25° to 250°	−40° to 250°
Normal application temp range	+40° to +120°	+40° to +120°	+40° to +120°	+40° to +120°	+40° to +120°	+40° to +120°	+40° to +120°	+40° to +120°	+40° to +120°
Weather resistance	poor	fair	fair	very good	not available	good	good	very good	very good
Ultra-violet resistance, direct	poor	good	good	very good	not available	good	good	poor to good	poor to good
Cut tear, abrasion resistance	N/A	N/A	N/A	N/A	N/A	good	good	excellent	excellent
[3]Life expectancy	5 to 10 years	10 years +	10 years −	20 years +	not available	20 years +	20 years +	20 years +	20 years +

CHAPTER 5

DIFFERENT SYSTEMS, THEIR USE, APPLICATIONS & DESIGN FEATURES

Many different systems have been used in different places of the world with their special features. Here we try to discuss the most currently used systems.

5.1 IN CANADA

In Canada, some systems are introduced by Pittco, Atlas, Indal, etc., which will be first discusssed in more detail.

5.1.1: Pittco's 25A Curtain Wall

This system employs continuous outdoor aluminum retainer with snap-on cover mouldings for both vertical and horizontal mullions. 2 1/2" wide structural tube members are available in different depths to meet required wind and shear loads. Face modulings permit reveals varying from 3/4" to 5 inches.[8]

5.1.1.1 Fabrication:

a) Curtain wall framing shall be designed to accommodate glazing throughout, held in an aluminum grid system. The system shall hold the glass firmly and yet be sufficiently flexible to permit movement of the metal and glass caused by deflects due to wind pressures and thermal expansion and contractions.

b) It shall be made water tight with a minimum dependence on sealants or caulking materials. The horizontal assemblies shall be perforated to provide drainage and ventilation to the exterior.

Supporting structure shall consist of vertical aluminum tubes which run continuously from floor to floor and secured to the structure with steel anchors. Horizontal aluminum tubes shall be of sizes indicated, but between the vertical and fastened securely thereto by firmly seated screws into concealed brackets.

c) All metal to metal joints which require sealing to maintain water-tightness shall be designed and assembled with a ribbon of buty l tape 3-301-24, 1/8" x 1/2" thick which shall be compressed by approximately 50% of its thickness when the joint is secured.

d) At proper intervals not over 30" apart, vertical and horizontal expansion members must be provided.

e) Aluminum surfaces that come in contact with masonry materials shall be coated with bituminous paint.

f) At a curtain design wind load, maximum deflection in both the vertical and horizontal mullions shall not exceed 1/175 of the span of these members. Maximum design stress shall not exceed 13,000 psi.

5.1.1.2 Installation

a) The nominal face of the curtain wall should be plumbed and aligned in a single vertical plane and shall orient all horizontal and vertical elements at right angles. All components shall be straightened so that glazing and expansion rabbets will be, in every case, square, flat plumb, and true to dimension. Fixed supporting connections shall be drawn up to safe tension to avoid all future shifting of glass-clad wall components. Sliding connections shall be adjusted to permit necessary relative motion between elements.

b) Intersections with other work such as flashing and coping perimeters, shall be carefully fitted and coated to prevent galvanic action and caulked to establish and maintain a watertight framework.

c) Dry glazing shall be accomplished through the use of the aluminim retainer which provides a firm clamping grip on the glass. Contact between the retainer and glass shall be cushioned by the application of a vinyl gasket.

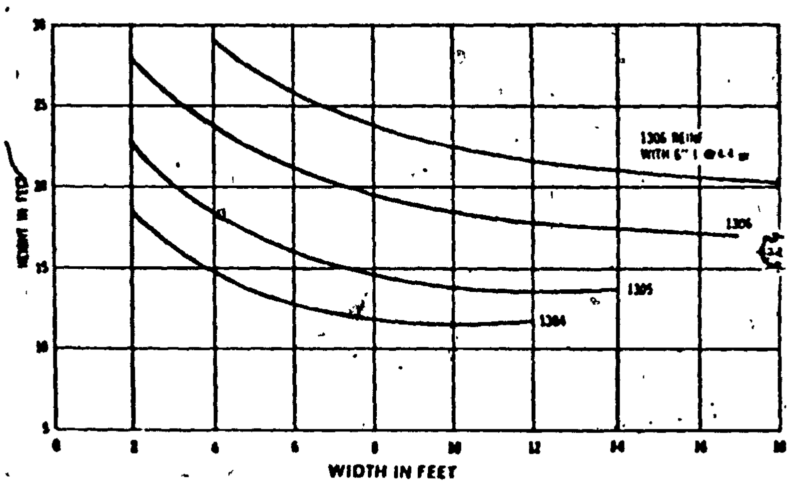
d) Seal joints must be used between masonry and metal with caulking material to provide a weathertight installation.

5.1.1.3 Wind Load Consideration

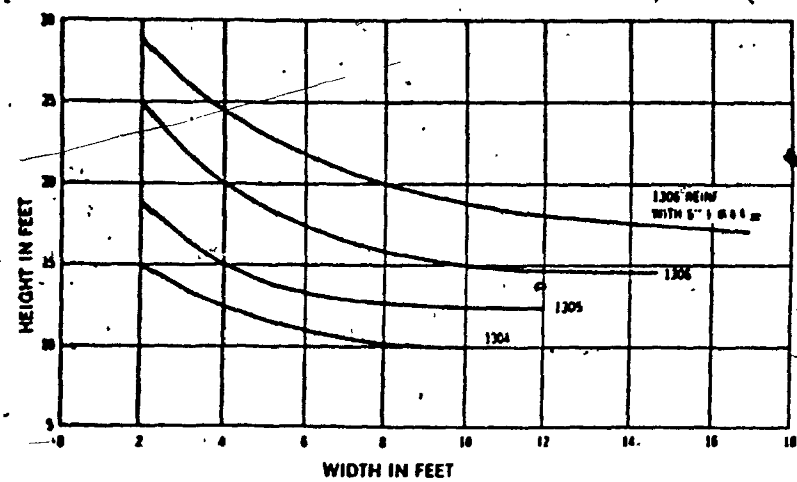
The design load for a particular project should include appropriate factors for gusts, elevation above grade, surrounding terrain or structures, etc., as well as a reasonable safety factor.

Curves shown below indicate span and modules which can be supported by mullions, under the designated load with maximum deflection at center equal to 1/175 of span.

For 15 lbs/sq ft wind load:



For 25 lbs/sq ft wind load:



5.1.1.4 Application

Here are some of its applications in buildings:

Pacific Centre (Vancouver, B.C.)

This is a 30 storey building. The curtain wall is made of aluminum with Kalcolor finish, 1/4" and 3/8" solabronze polished plate glass and harmonizing spandrelite.

Banque Canadienne Nationale, (Montreal, Quebec)

This is a 30 storey building. The curtain wall is made of aluminum with duracron finish, 1/4" solargrey polished plate glass and insulated aluminum panels as spandrels with duracorn finish.

Place de Ville, (Ottawa, Ontario)

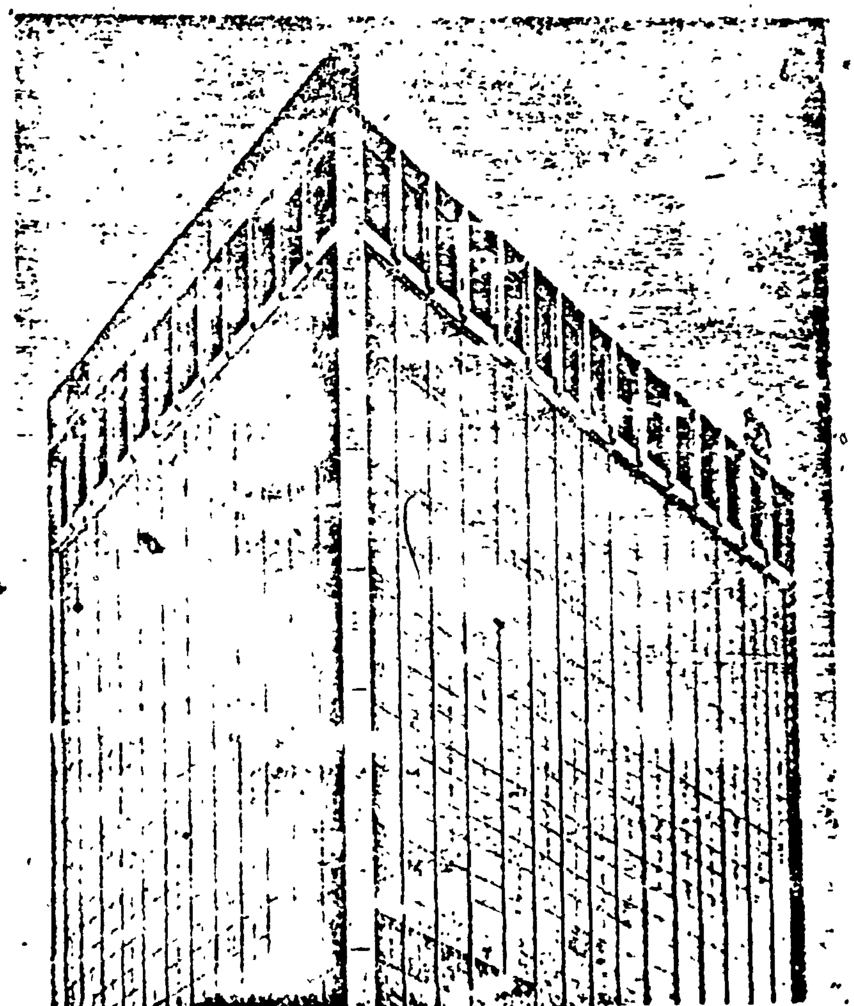
This is a 29 storey building. The curtain wall is made of aluminum with Duracron finish, pennvernon greylite and aluminum duracorn finish as spandrels.

Bentall Centre Tower III

This is a 32 storey building. The curtain wall is made of aluminum with kalcolor finish, 1/4", 3/8", 1/2" solarbronze, and harmony bronze spandrelite.

Lloyd D. Jackson Square (Office Tower, Hamilton, Ontario)

This is a 24 storey building. The curtain wall is made of aluminum with kalcolr finish, 1/4" bronze heat absorbing plate glass, and 12 GA. steelalloy panels for spandrels.



Bentall Centre Tower III (Vancouver, B.C.)

5.1.2 Atlas's Mac 700 Curtain Wall

These are large size profiled modular units weighing a fraction of that of precast concrete. They are molded with the normal smooth mineral fiber cement finish which weathers to a light grey-buff tone and doesn't require paint. Exterior finish of stone aggregate or other finishes can be applied locally.

Panels are normally hollow which permits on-site application of continuous insulation, vapor barrier, and interior finish. The span capability is up to 14' unsupported spans under 30 psf wind load. Maximum deflection less than L/360 with a safety factor of 3.[8]

5.1.2.1 Design Features

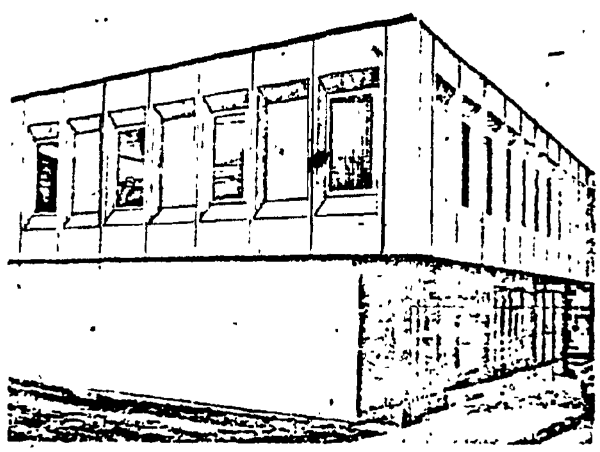
It has extremely wide scope in design with the ability to vary overall panel heights, window dimensions and locations, insulations and finishes and even assembly details. It has standard width for 5' or 8' design modules, with height variable to 14' and depth of 10" edge. The hollow units permit foamed-in-place or rigid insulation and continuous or panelled interior finish. Window panels accept standard aluminum, zipper gasket or sealed window units; frames depressurized and vented inside panels. Vented points prevent entrapment of moisture within panels and pumping action of rain water. The heat loss through anchorages is minimized by low mass of panels. Therefore, the main advantages of the Mac 700 are: lightness, non-combustibility, thermal insulation, condensation control, durability, attractiveness, design freedom and standard component economy.

5.1.2.2 Assembly

Using this system, large areas are covered quickly and economically; fixed from inside of the building. Insulation and interior finish is applied from the inside of the building after panel installation. If desired, a mullion may be used to divide the 6' wide window opening into two openings to specified widths. Window opening or recess can be located at will vertically in panel but not closer than 1' - 8 3/8" from top or bottom. Groove can be used in vertical edge to receive neoprene tube for air pressure equilization chamber.

5.1.2.3 Applications

Some applications of this system are: J. Brockhouse and Company (Canada) Ltd. (Bramalea, Ontario), L. D. Pillon, Inc. (Val d'Or, Quebec), and Huron Memorial Hospital (Bad Axe, Mich.).



L. D. Pillon Inc.

5.1.3 Indal Ltd.'s Aluminum Curtain Wall

This system is applicable for low rise and high rise buildings. It has high design flexibility by means of inter-mixing verticals and horizontals of different depths. Also, combinations of exterior caps, their material finish and choice of elements, extend the design freedom. The concept of rain screen pressure equalization is used in this system and also air and vapour seal with controlled expansion. For the strength and integrity of the whole system, tubular members with shear block joint connections are used. Exterior glazing simplifies construction and optimized air, vapour, and water seal effectiveness. The use of space-R polymer tapes with the pressure plate on the exterior in combination with the interior neoprene bulb, eliminates the adverse effect of tolerances and provides an extremely weather-proof wall.[8]

5.1.4 KALWALL Curtain Walls

Kalwall is a translucent sandwich type structural building panel formed by permanently bonding Filon translucent fiberglass reinforced polyester panels to an aluminum grid core. Filon skins used for Kalwall panels have a special resin-enriched surface. The bond is uniform and has a great strength. The grid core is constructed of mechanically interlocked extruded I-beams.

Filon panels are manufactured with fiberglass and tough parallel nylon strands for extra strength. This special reinforcement gives Filon a uniform thickness.[8]

5.1.4.1 Features

a) Low U-factors reduce heating and cooling expenses. Span glass fibers inserted between facing materials during manufacture increases insulating efficiency.

b) Filon panels are highly resistant to damage from throwing of falling objects.

c) It weighs only 1.5 lbs/sq. ft.

d) Clamp-tight installation system provides a positive, weathertight seal. Closures have a continuous screw-clamp action along perimeter.

e) Kalwall insulated opaque panels are available in many different materials such as filon, asbestos-cement of porcelain enamel.

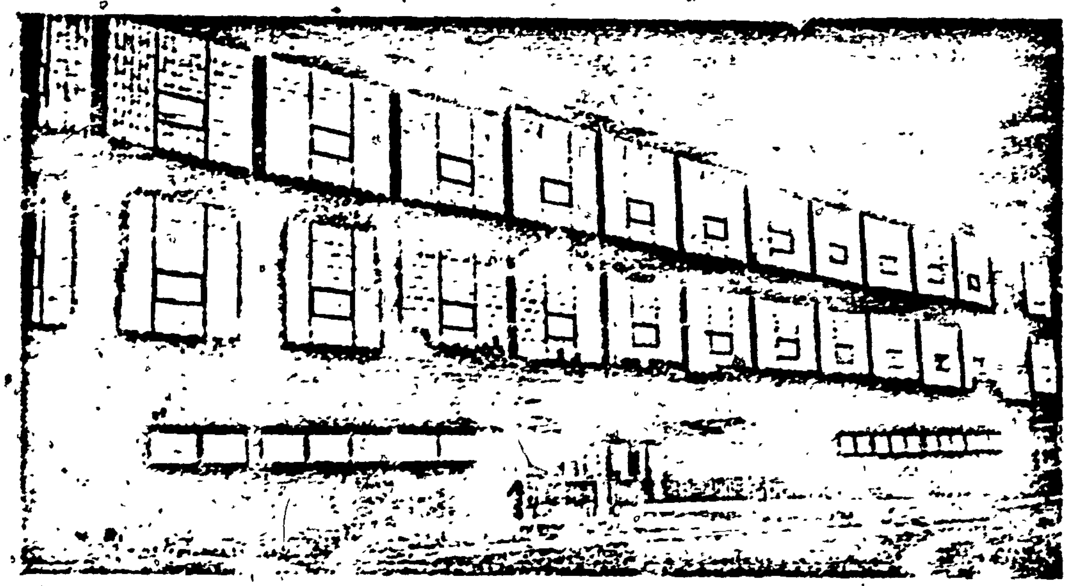
f) It has an average loss of 29 to 32 decibles in the normal frequency range for sound transmission.

g) There is no break in face material at 90 lb. impact.

h) The coefficient of expansion is approximately 1.24×10^{-5} in/in/^{o}F or approximately 1/8" in 8' for a temperature change of 100^{o}F.

5.1.4.2 Applications

Some of its applications are: Central Public School Gymnasium, Cornwall, Ont., and Glenwood United Church, Windsor, Ontario, and New Brunswick Institute of Technology, Moncton, N.B.



New Brunswick Institute of Technology.

5.1.5 Translucent Panels (San Pan Inc.)

It is made of rigid grid core of welded aluminum I-sections sandwiched between fiberglass reinforced translucent plastic skins. Aluminum is bonded to plastic under controlled heat and pressure. It is light weight with heat insulation, sound insulation, light diffusion and shatterproof. Dubl-insulated panels are filled with Insul-Hair (spun fiberglass) and has extruded aluminum framing system.[8]

5.1.5.1 Specifications

a) Exterior skin should be fiberglass reinforced plastic sheet of uniform color and thickness. Exterior face shall have a special protective surface, chemically bonded to basic sheet during a cure, for maximum resistance to erosion and weather.

b) Interior facing skin shall be fiber-glass reinforced polyster skin, of high quality with uniform color and thickness.

c) Adhesives used in the translucent panels shall be black, especially formulated for the purpose used, and bond shall be of uniform thickness and width in the finished panel. There shall be a minimum bond panel ratio (square inches/square feet) of 13.5. Bond area times bond strength at 78^{0}F shall exceed 1450 lbs. per square foot of panel area.

d) The requirements for adequate strength and suitable characteristics are as follows:

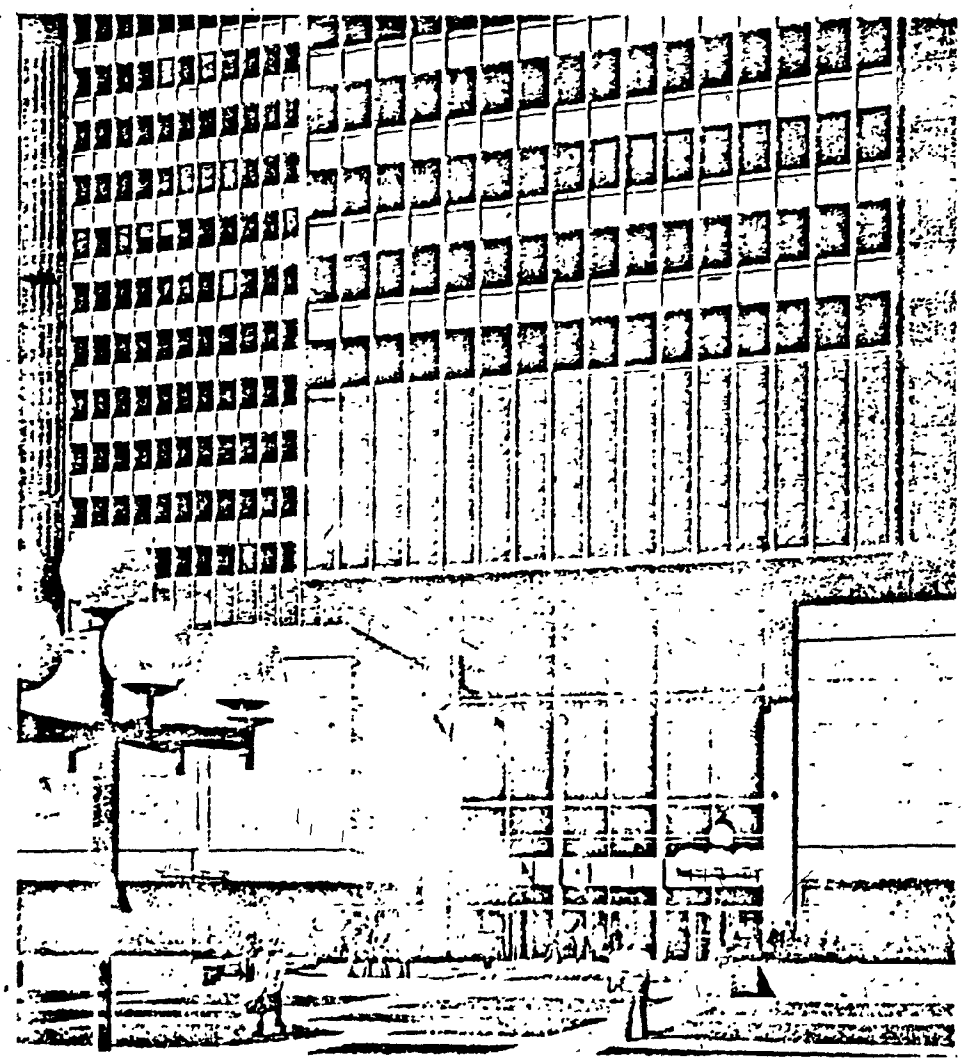
1. Sound transmission average shall not exceed 33 decibles.
2. Thermal conductance - "U" factor at 15 MPH wind velocity shall not exceed 0.52 BTu/square foot/hour/F.
3. Panels shall be able to successfully withstand repeated changes in temperature and humidity, similar to procedures outlined in ASTM D.1037-55T.

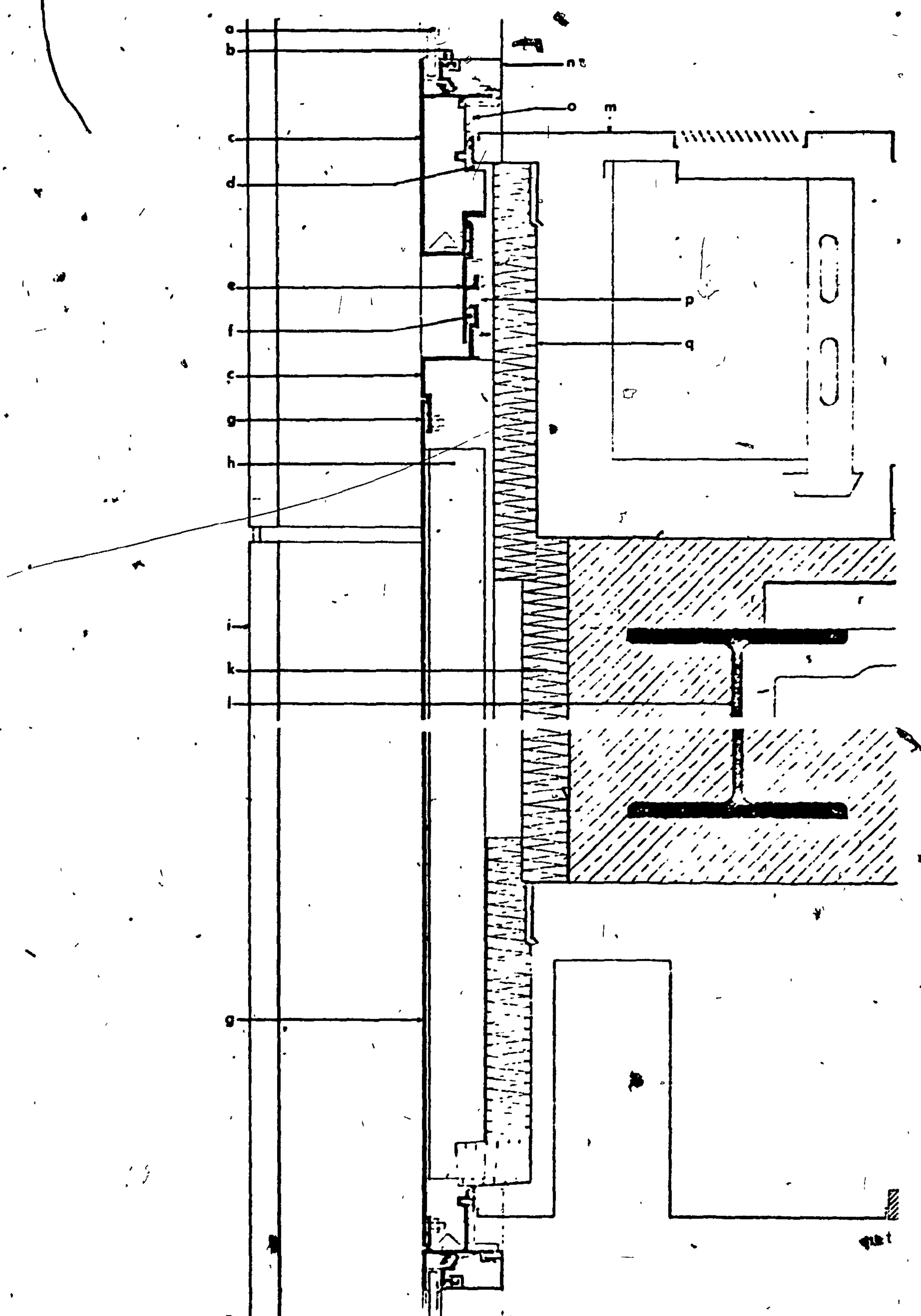
5.1.5.2 Applications

Some of its applications are: Centre L'Apprentissage (Sherbrooke, Quebec) and Sexton Memorial Gymnasium (Nova Scotia Technical College, Halifax).

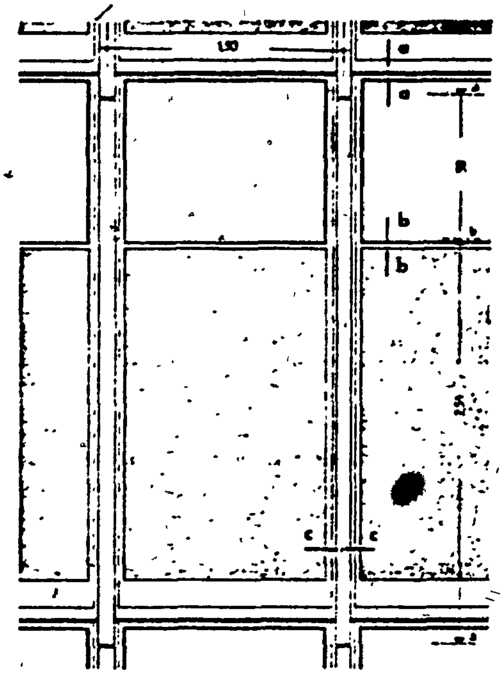
5.1.6 Curtain Wall in Aluminum and Glass Used in Place Ville Marie (Montreal)

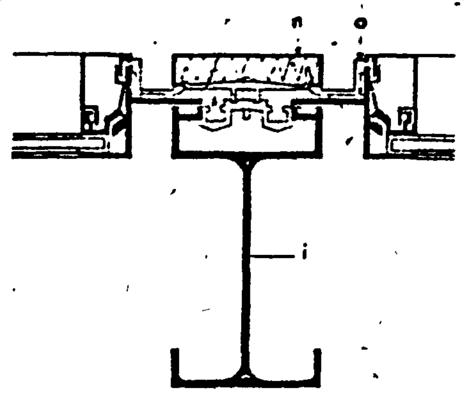
This is a tall office block in the centre of Montreal. Apart from the vertical mullions the entire outer skin is flush. The continuous aluminum sections, the flat aluminum infill panels and the flush glazing of the windows give a light appearance to the building. (The height of the curtain walling from pavement level is 185 metres with an area of 55,000 square meters. Special neoprene sealing strips were fixed to the frames prior to glazing.[5]





Vertical Section of Curtain Wall.





Vertical Section and Plan of Curtain Wall:

a) 6 mm grey tinted glazing b) vinyl sealing strips c) profiled aluminum sheets d) neoprene spacer e) connecting panel f) neoprene sealing strip g) 3mm infill panel h) angle stiffener i) stanchion k) 37mm glass fibre slab fixed to concrete with adhesive l) steel edge beam m) sheet steel casing o) neoprene anti-condensation seal p) stainless steel fixing q) aluminum sheet cladding r) sheet steel floor panel s) sprayed asbestos fire protection t) suspended ceiling.

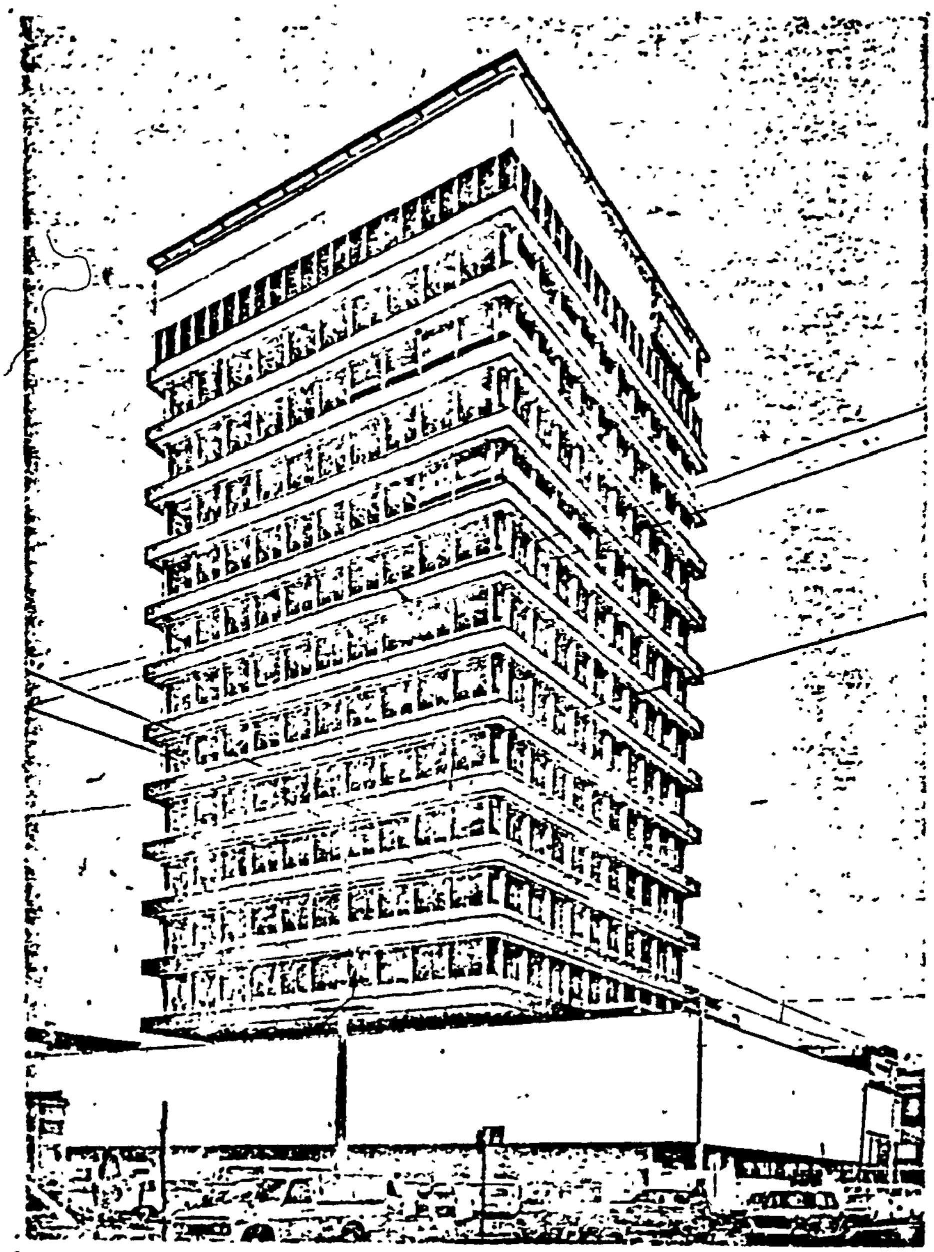
5.2 OTHER COUNTRIES

5.2.1 The Norcor Building (South Africa)

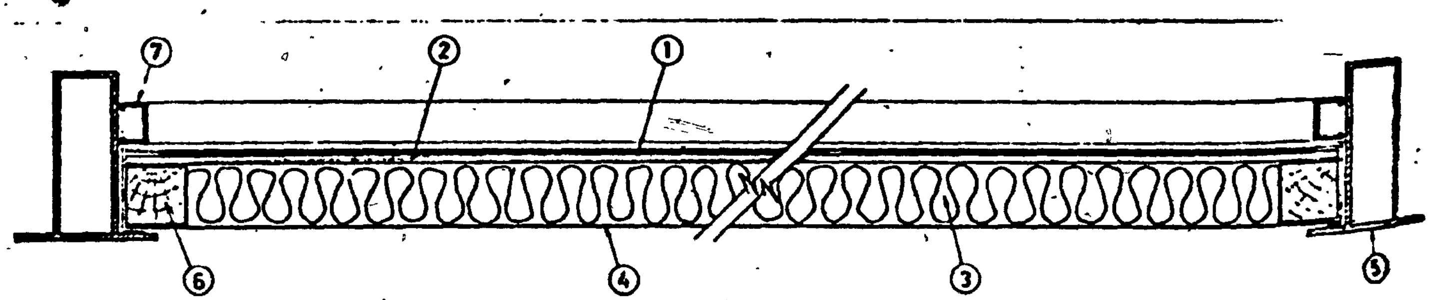
Stainless steel for the curtain walls were chosen due to the very high corrosion resistance and durability obtained when using thin gauge materials and also for the attractive appearance in using stainless steel. Thinner gauges are possible when compared to other materials less resistant to corrosion and aging. The saving in thickness and low maintenance offsets initial unit cost of stainless steel over the long term.

Stainless steel curtain wall panels were provided continuously below windows at each floor, on the face of the cleaners walk protection and above the windows to the double volume area containing the suspension framework. The panels on the projecting faces at the cleaners walk are 24 gauge 0.84 mm deep on outer face with 10 mm pressed asbestos cement core and 26 gauge galvanized steel back plate. The front and back plates were laminated under heat and pressure to the core.

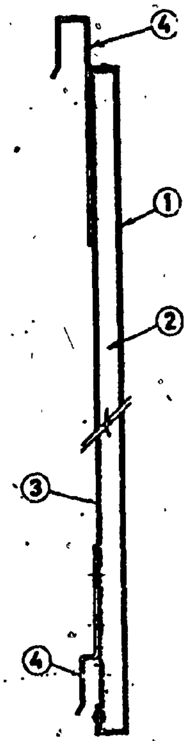
Panels under the windows are 0.525 m deep, glazed into mullions and consist of 24 gauge stainless steel with 3 mm tempered hardboard backing, 2 cm polyurethane core injected under pressure to 12 kg per sq m density and 20 gauge primed steel backplate. This provided the panels with a thermal transmission value of 0.12 to 0.16 BTu's. All stainless steel for the panels had a protective plastic coating to the polished surface which was retained throughout manufacture and erection, only being removed after completion of the building.[16]



A view of the building.



Horizontal section through stainless steel spandrel panel. 1. 24 gauge stainless steel. 2. 3 mm thick tempered hardboard 3. Polyurethane infill 4. 20 gauge backing sheet primed for painting 5. Window mullion 6. Timber framing piece 7. Glazing bead.



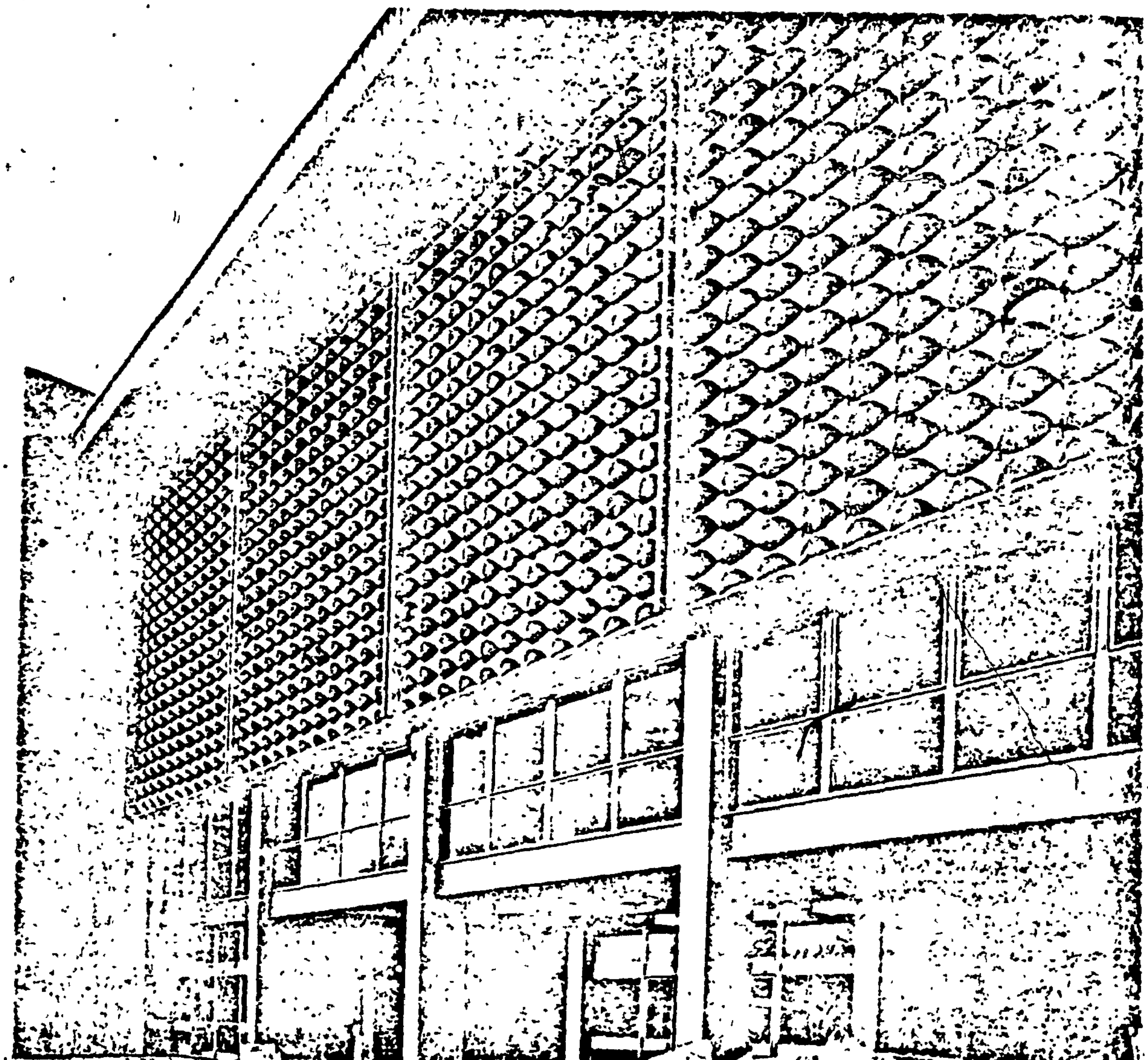
Vertical section through stainless steel girder panel.

1. 24 gauge stainless steel
2. 10 mm thick cement-asbestos core
3. 26 gauge galvanised iron backing sheet
4. steel cleat pop riveted to galvanised iron.

5.2.2 Maisons-Laffitte Race Course (France)

Stainless steel curtain wall were used which have a surface area of about 4.400 m^2, and is fitted with units either fixed or opening on a swivel, with bases in enamelled glass or triplex. The steel fittings used in the construction of the curtain walling include special profiles and sills in 15/10 mm stainless steel sheeting. Omega sections with rebated flanges serve as load bearing elements. Fixed to the steel framework by means of special brackets, they allow the curtain walling to be adjusted. Vertical profiles in the form of strips of stainless steel sheet 30/10 mm thick are used to join the frame bands to the loadbearing units.

Along the facades of each floor level, there are decorative bands formed by trough-type units consisting of pressed sheets formed with a diamond pattern. The frame bands are joined to the load bearing elements and to the strips by means of squares forming fish joints. The frames can be installed whether opening on a swivel or outwards, the solid parts being sandwiched with glass or with stainless steel sheeting. These solid parts are made of stainless steel 15/10 mm thick.[17]



The rear elevation.

5.2.3 Ecole Polytechnique (Paris)

The curtain wall of the central groups of the new buildings of the Ecôle Polytechnique at Palaiseau (Paris) will be discussed here. The posts of the supporting framework of the floors were assembled from anodized aluminum plating, of natural colour. These assemblies, made up before oxidation, have shapes which enable them to receive the filling elements of the curtain wall. The curtain wall comprises, per section, three vertical stiffeners of extruded aluminum, fixed to the concrete floors at their two ends. These mullions divide the span of 6m, between two posts, into four divisions almost equal.

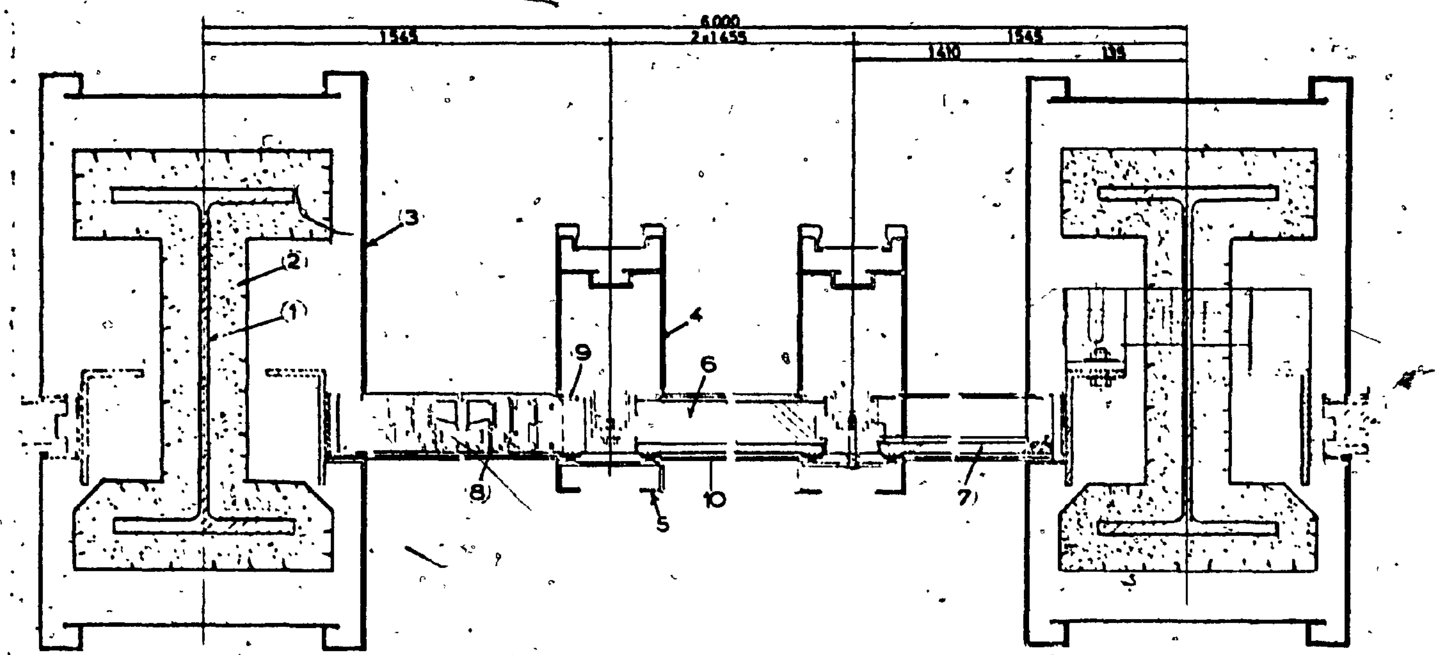
The filling between the mullions (or between the latter and the main posts) consists of insulating sandwich panels comprising from the interior to the exterior: 1) a galvanized steel sheeting 2) a panel of wood particles 3) a mass filling of polyurethane 4) an enamelled glass of bronze tint.

Impreviousness between the panels (or the glazing) and the mullions is ensured from the outside, by neoprene joints, and from the inside, by joints previously beaded, for limiting crushing. The resistance to fire of two hours for the curtain wall was obtained by the following devices, which play the part of a bulk head between the facade panels and the floors, hindering the spreading of the fire from one store to another:

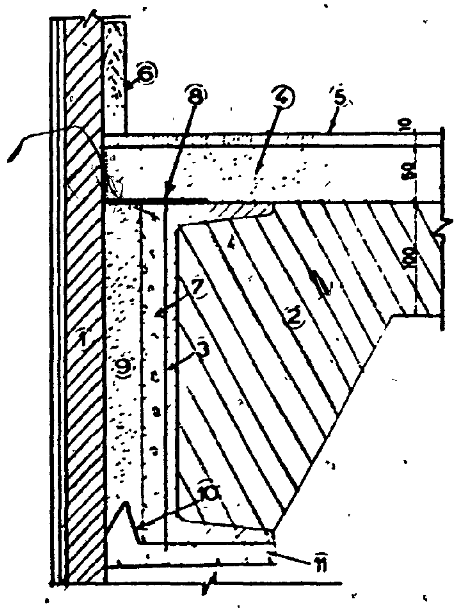
a) a pressed plate 10/10 mm thick, welded to the lower flange of the UPN 300 section, which forms a nose-piece over the whole periphery of the floors, this plate rests on the other hand, on the facade panel. Its internal face received a layer of asbestos.

b) a plate 30/10 mm thick welded to the upper flange of the same section and fixed to the panel, which it must support in case of fire

c) Between the two plates, the section and the panel, a packing of "Cafco-Roxor" insulating material.[18]



Horizontal section of the curtain wall. 1) main posts IPE 300 2) Pyrok protection 3) Assembly of aluminum sheeting 4) Internal mullion 5) External mullion 6) Insulating sandwich panel 7) Fixed glazing 8) Opening frame. 9) Joint previously beaded, for limiting curshing 10) Neoprene joint.



Protection against fire in the edge of the floors.

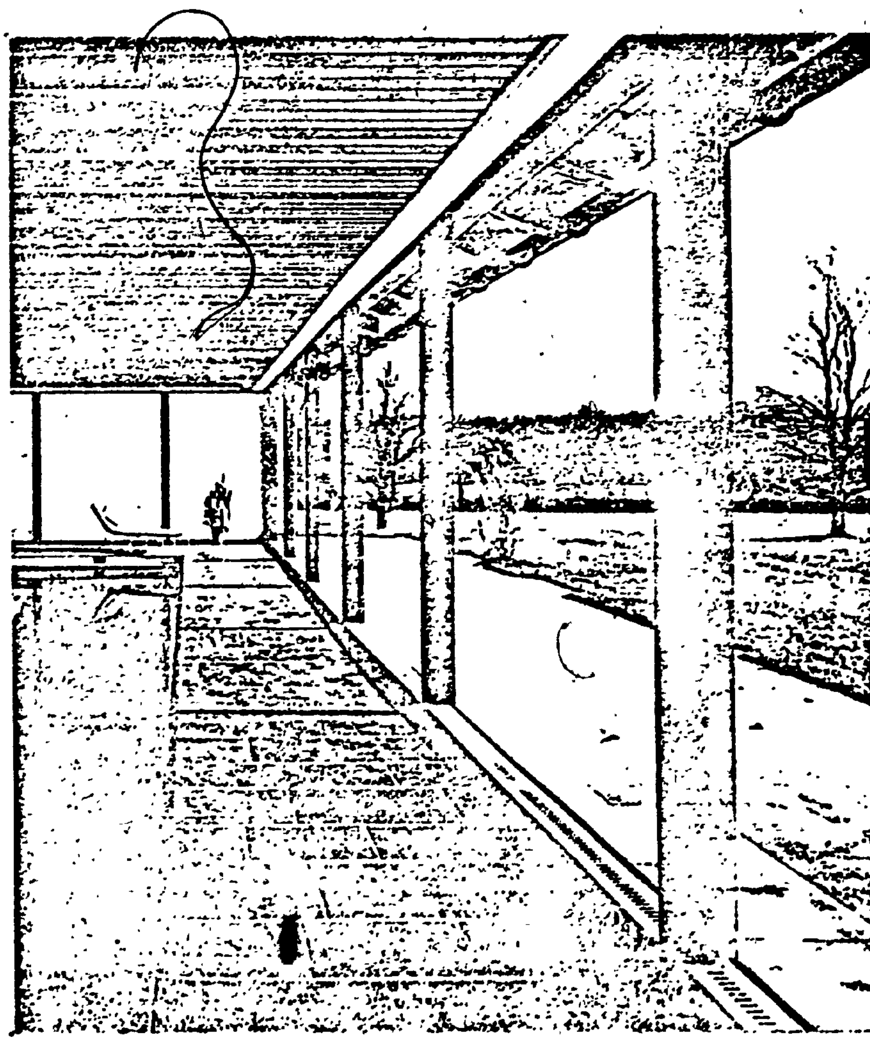
1) panel of the curtain wall 2) nose-piece of the concrete floor 3) Section UPN 300 4) Covering 5) Carpeting 6) Timber plinth 7) projection of cement-vermiculite 8) steel sheeting 30/10 mm 9) Cafco-Roxor packing 10) pressed plate 10/10 mm 11) Asbestos layer.

5.2.4 Integrated Curtain Walls (J. Gartner Company, West Germany)

These curtain walls, classed as "integrated" or multi-purpose walls are among the range of hot-rolled steel sections, i.e. the rectangular hollow section. The essential aim has been to combine in the external walls with their mullions and beams two distinct groups of functions, that is, on the one hand, enclosure, ventilation, warming and air-conditioning for occupied internal spaces and, on the other hand, the function of structural support whereby horizontal and vertical loads are transferred to the foundations. A scheme of this kind offers numerous advantages, of which we can mention the following:

- Windows and infill panels are fixed by simple methods directly to the external wall framing
- The whole external wall acts as a space-heater. A large area of insulated glazing is warmed by transmitted and radiated heat. The unpleasant chill usually felt near windows is eliminated and the room is permeated by a uniform warmth, giving occupants a sense of comfort and wellbeing.
- Because of the large heating surface a lower flow temperature is permissible, hence saving of energy and reduced heating cost.
- The external wall framing is prefabricated by light-weight constructional methods from hollow sections, hence quicker completion, saving of time and expense.

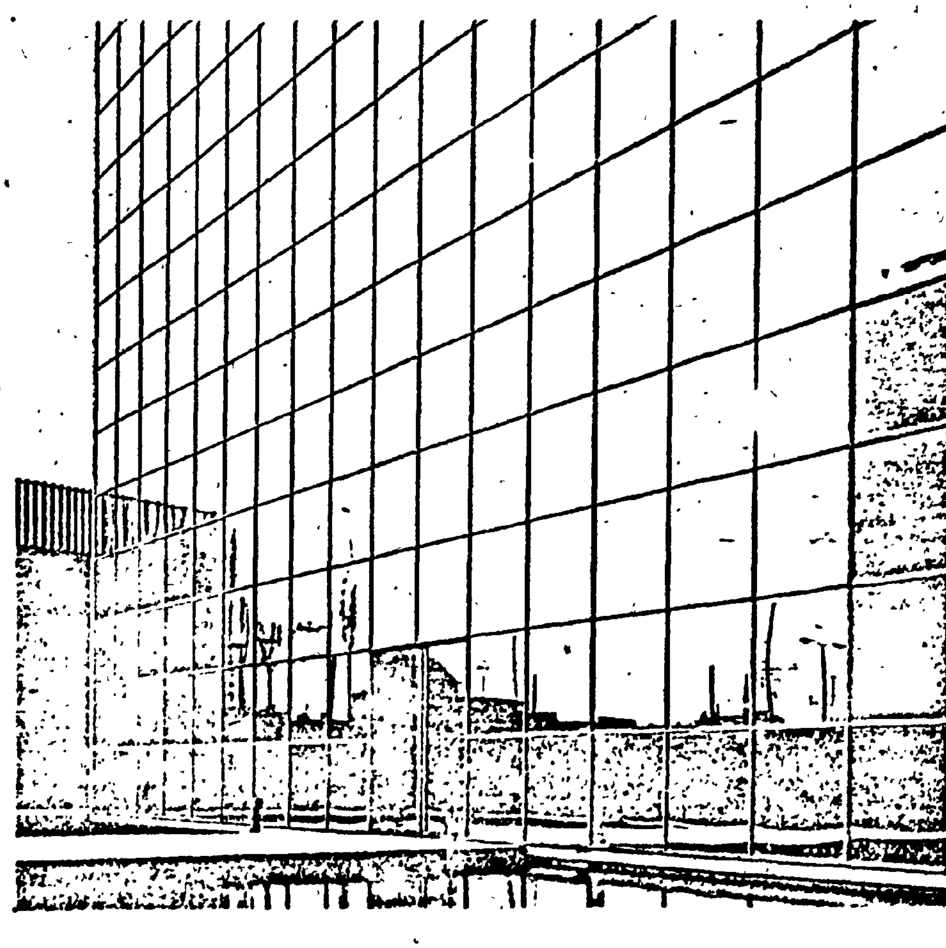
One of the many applications of it is a private swimming bath at Gundelfingen-on-Danube. To its vertical members, "thermopane" double glazing or panels filled with foamed polyurethane are fixed by screws through profiled plastic coated fillets. The main supporting members are connected to hot-water feed and return pipes. The feed temperature is about 50°C and is regulated to suit the external temperature. The return temperature varies from 40° to 46°C. The framework and glazing cannot "steam-up" because of their high surface temperature, which never falls below dew point, so that condensation is impossible. This means that the moisture content of the internal atmosphere may rise above normal, thus reducing need for air changes and additional running costs entailed.[19]



5.2.5 The Hague Office Building (Holland)

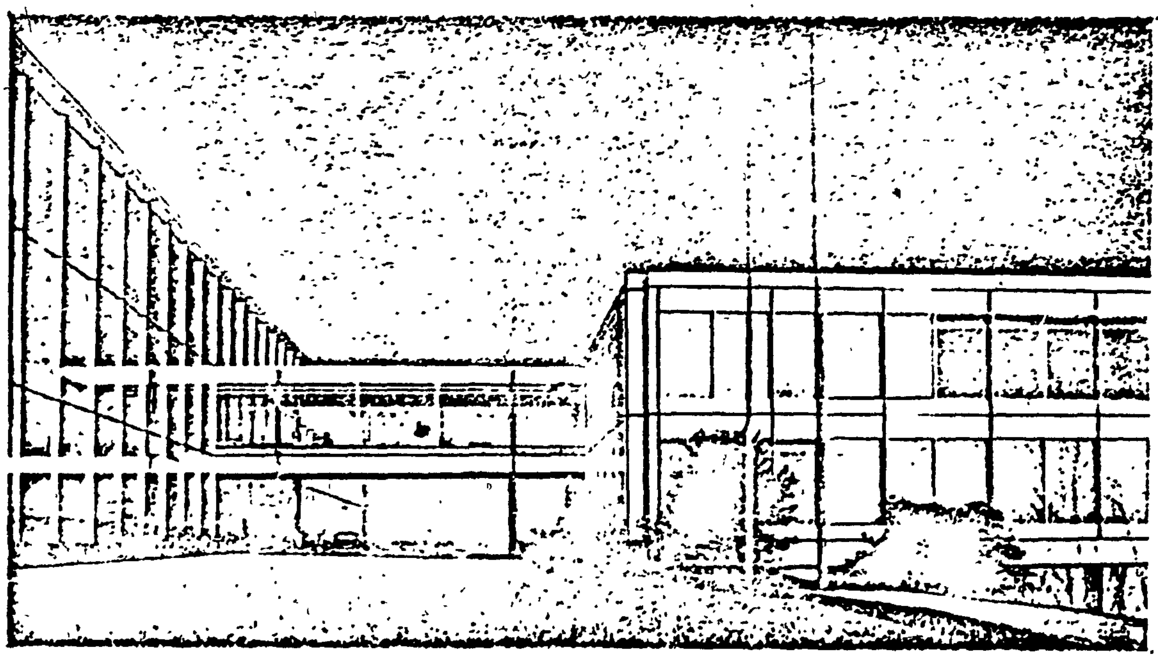
The site is on the outskirts of the Hague's centre near Holland'spoor Station, beside the main six-lane road leading to the Amsterdam-Rotterdam motorway.

The curtain wall of the building is made up of a special aluminum extrusion; proprietary solar-reflecting double glazed units form vision panels; and spandrel panels are similar proprietary units consisting of solar-reflecting toughened glass and inner steel panels. The external wall zone contains, within its 250 mm overall thickness, mullions/transoms, glazing/spandrels, thermal insulation, innerleaf, firestop panel, sill unit/convector housing and power/telephone perimeter distribution.[20]



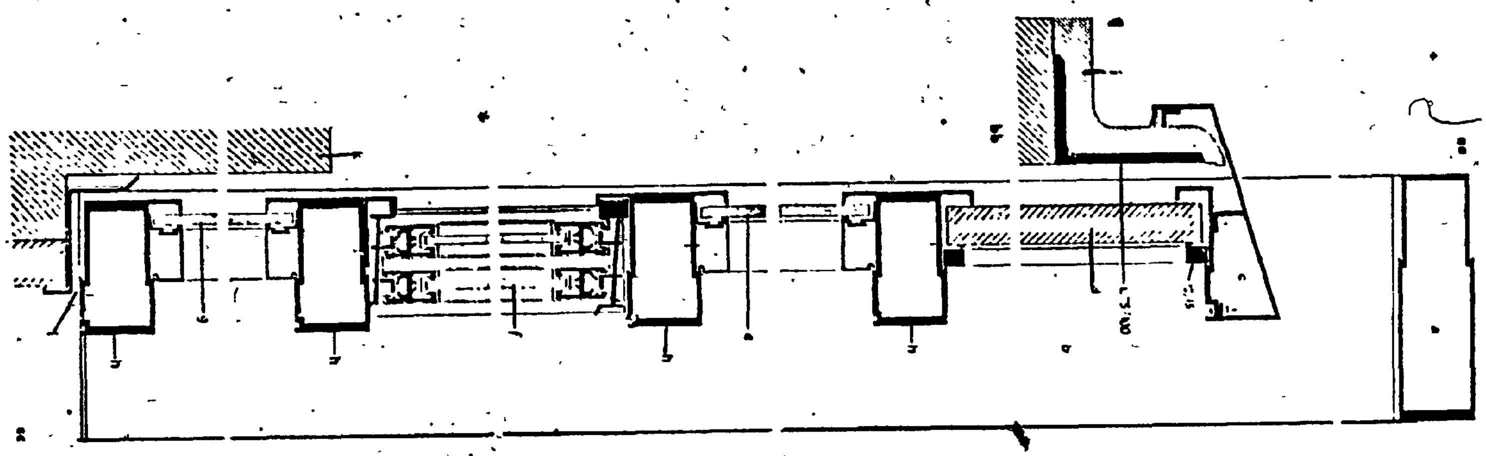
5.2.6 Office Building (Dusseldorf).

The reinforced concrete structural mullions are at 7.50 m centres and 4-10 m high. The building is clad with aluminum frames with fixed insulating glazing. Each storey high unit is 3.75 m wide coupled top and bottom with a spandrel, 72 cm deep. The spandrel panels consist of an external aluminum sheet 2.5 mm thick, a frame and a 12.50 mm thick internal plaster slab and aluminum foil as a moisture barrier. The space between (40 mm) is filled with an insulatnt. The horizontal edge sections of the spandrels, 8 cm wide and recessed 4 cm, are designed to take wind loads and provide a weatherproof vertical expansion joint. The double-glazed panels are set almost flush with the aluminum spandrel sheet to avoid any horizontal breaks in the elevational treatment. Wind loads are transmitted to the frame by the aluminum mullions at top and bottom connections, and all unit junctions are provided with plastic extrusions to allow for noiseless movement.[5]



5.2.7 Castrol House (London)

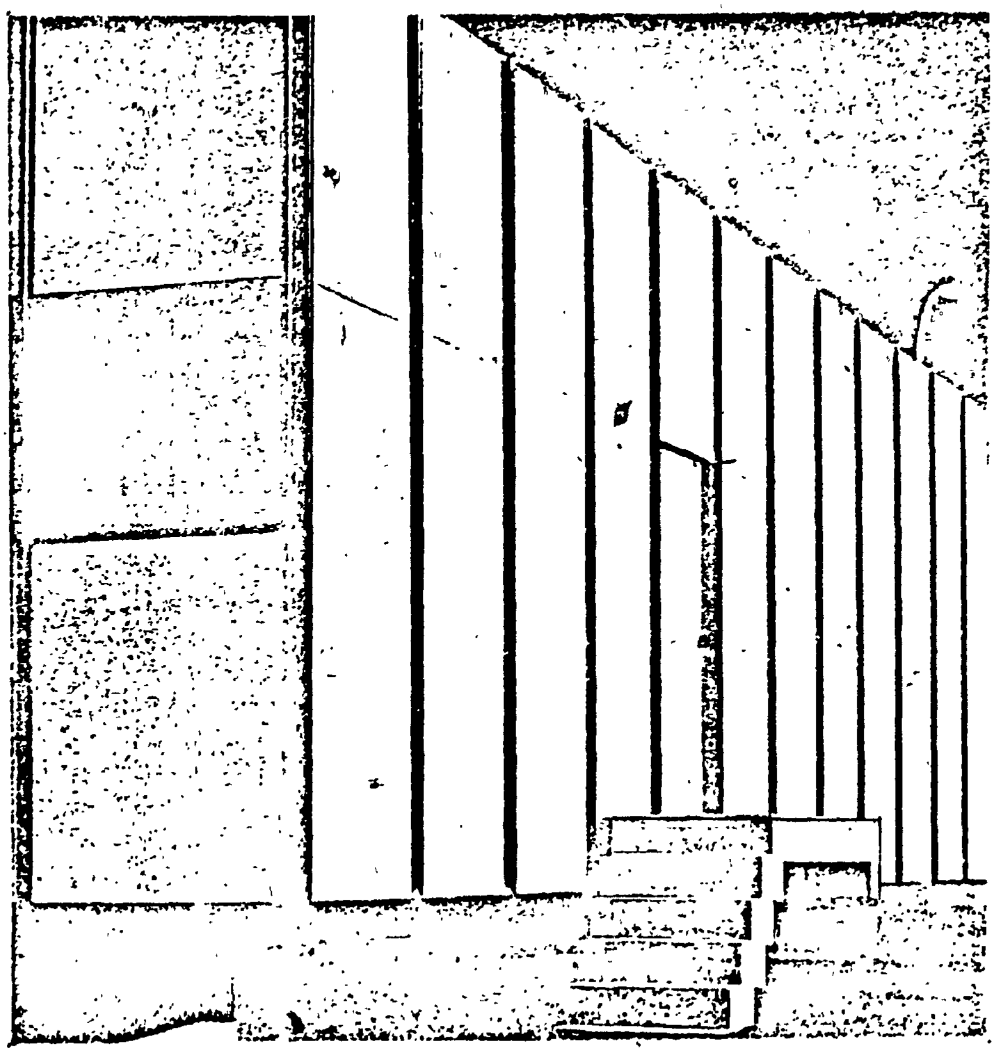
The building group comprises a three-storey Podium and a fourteen-storey tower. The curtain walls are constructed in aluminum. In the lower building the vertical mullions are black and the horizontal rails considered silver. Windows are mostly horizontal sliding. The panels of the tower block and the north elevation of the three-storey building are of 1/4 in. colrexglass, elsewhere while silian marble.[5]

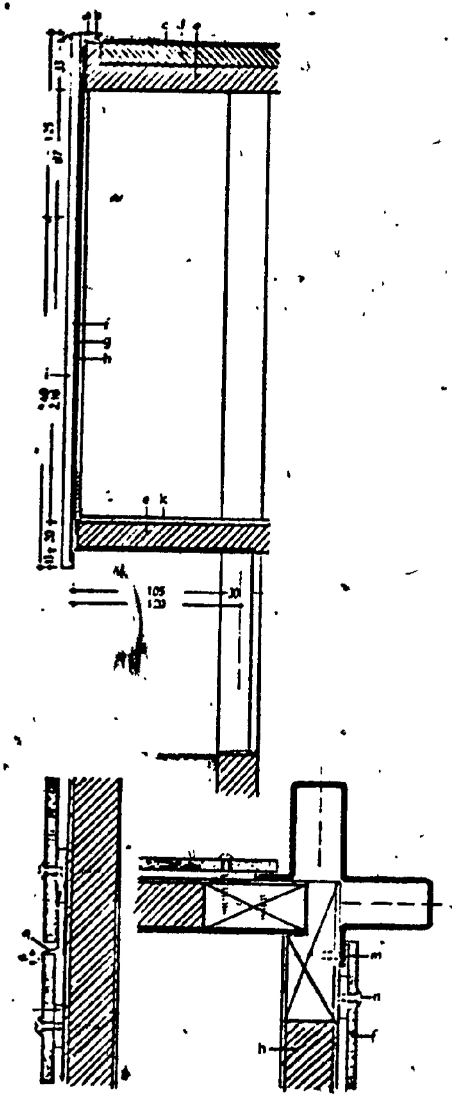


a. Silver anodised aluminum parapet rail
b. Vertical fins carrying the window wall and panels
c. Coping in silver anodised light metal
d. White Sicilian marble infill panels
e. Fixed glazing
f. Sliding window, silver anodised
g. White opaque glass
h. Special anodised aluminum extruded box section
i. Asphalt
k. Brickwork
l. Condensation outlet

5.2.8 Warehouses, Offices, and Exhibition Building in Biel

Walls of basement and columns are in reinforced concrete. For concrete wall construction the prefabricated panels of 37 mm Pavatex (woodwool) are covered with natural grey 7 mm asbestos panels leaving a 7 mm gap for ventilation.[5]



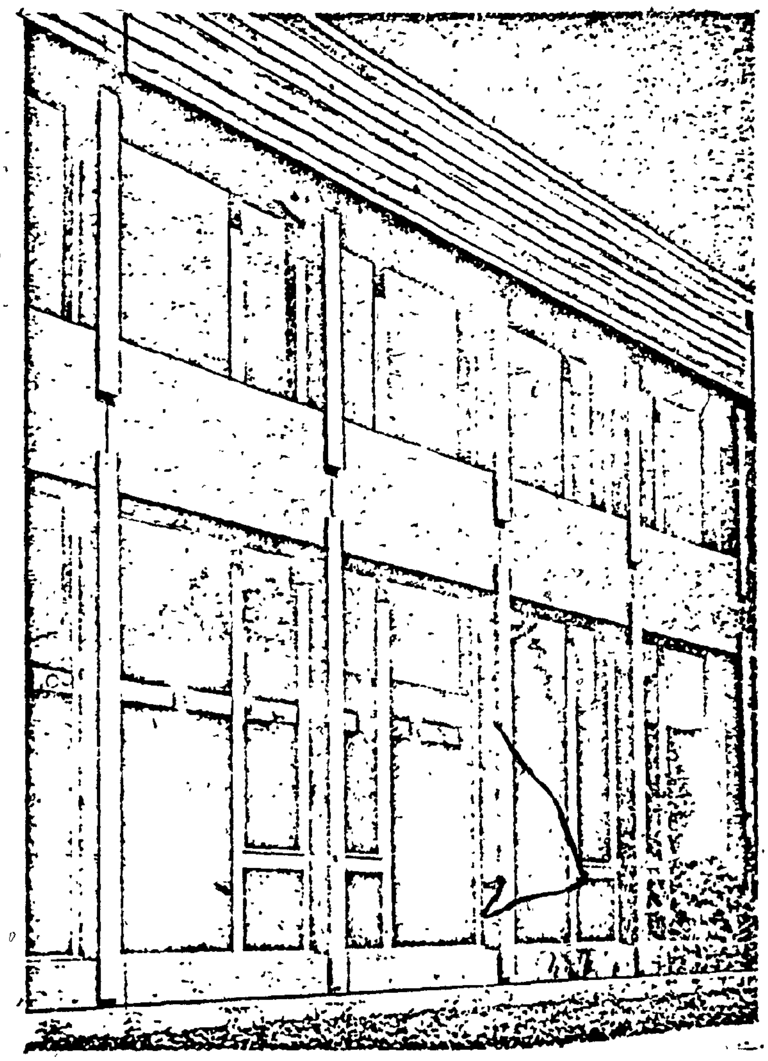


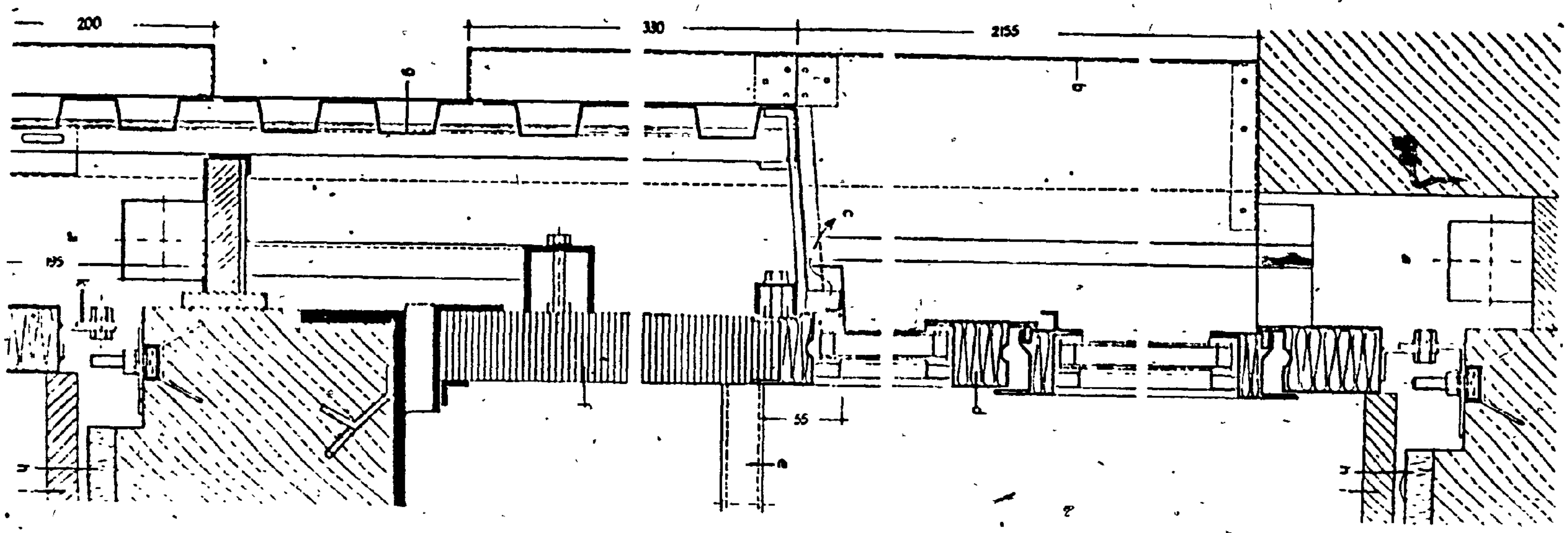
Section of the curtain wall:

a. coping b. Timber 50 mm x 100 mm c. chippings d. insulating screed e. reinforced concrete roof slab f. Eternit, 7-8 mm g. Air gap, 7 mm h) Pavatex Panel 37 mm thick i. Cominco pressed steel section k. Maxidur screed l. cork, 20 mm m. sealing strip n. dome-headed screw o. timber (p) Pavatex tongue q. sealing at horizontal point with aluminum flashing.

5.2.9 College of Economics and Social Science, St. Gallen

The building is of reinforced concrete with steel curtain wall panels. The steel cladding frames are inserted between the bays and form the external cladding. To achieve an accurate finish, precise control of the shuttering of the concrete members was essential.[5]



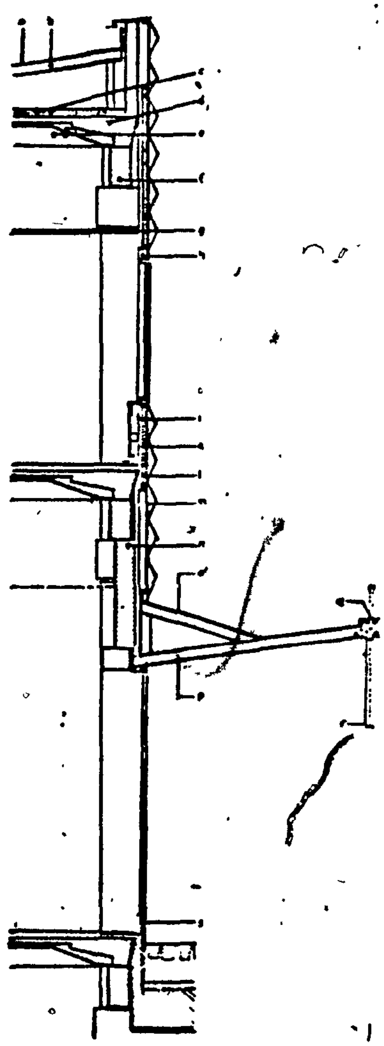


Vertical section of the curtain wall.

a. external blind box b. column c. ventilation of the spandrel d. mineral wool insulation in steel window sections e. window sill f. insulated internal spandrel g. profiled stiffener glued to spandrel panel h. 20 mm cork i. timber cornice k. window fixing adjustable vertically and horizontally.

5.2.10 Department Store (Stockholm)

This group of buildings with a floor area of 84,000 square meters is in the centre of the residential district. It consists of eight two-storey shops and offices. The wall illustrated is clad with profiled aluminum sheet panels.[5]



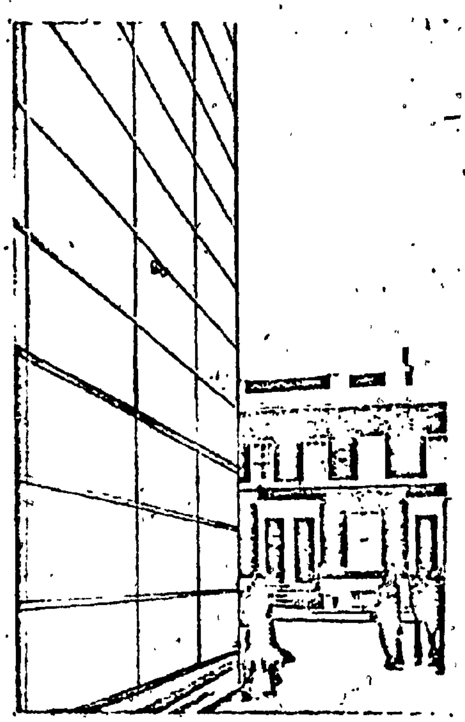
Elevation of the curtain wall —

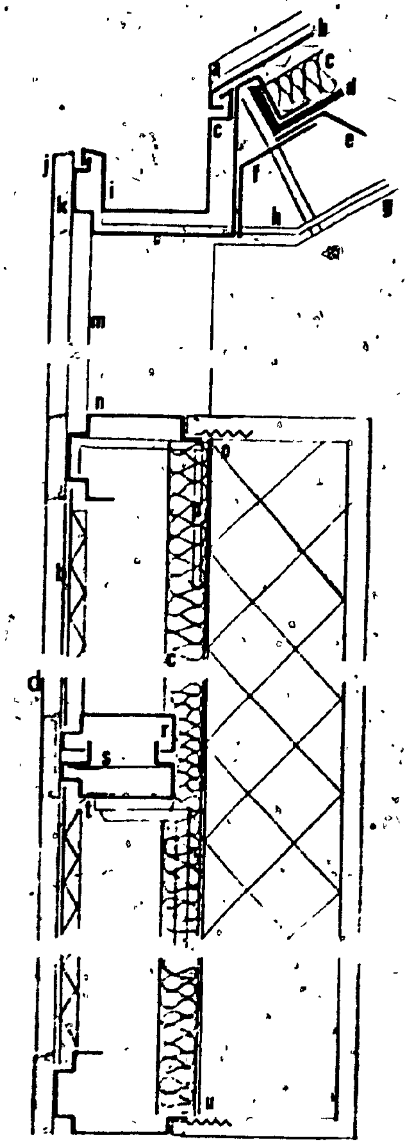
a. copper roofing on timber panels.
b. rafter
c. woodwool
d. 6 cm concrete topping
e. Precast prestressed concrete ceiling slab
f. precast prestressed concrete beams
g. aluminum ceiling
h. blind box
i. 1·30 cm plaster boards on 3/4" timber panels
k. 7 cm woodwool
l. 3·20 mm asbestos-cement panels on 3/4 in timber panels
m. Enamelled aluminum sheets
n. 25 cm thick light concrete
o. Copper sheeting on timber
p. Pine boarding
q. Fixing for fascia panel
r. Roller-blind box
s. Granite plinth

5.2.11 Morley College (Lambeth, London)

It has a skin of brown glass and porcelain enamelled, steel panels bonded to asbestos-cement sheets. All framed in galvanized steel with cover strips of integral anodized aluminum. Curtain wall upright and horizontals at floor level split for acoustic reasons.

The skin was specially designed because standard curtain walling, which is all in aluminum, was too expensive. A clip on strip in deep-etched anodic aluminum conceals the inner parts of cheap galvanised steel and overlaps the glass of the windows or the enamelled steel surface of the asbesots cement panels.[21]





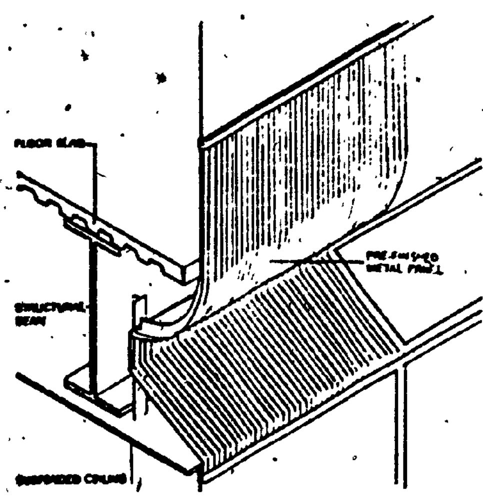
Detail Section through curtain wall.

a. cover strip as on vertical curtain wall; b. brown vitreous enamel steel, factory bonded to asbestos/cement sheet c. fiberglass quilt d. continuous steel angle e. exposed metal decking as structural roof f. pre-finished pressed steel fixed with pop rivets g. top of re beam h. 10-gauge cleat to support gutter j. snap-on cover strip in brown anodized aluminum k. extruded aluminum bead m. bronze tinted heat absorbing glass n. 14-gauge pressed steel o. concrete block p. fixing cleat q. re column r. bottom member of curtain walling frame to floor above s. sound-absorbent quilt t. top member of curtain walling frame to floor below u. re downstand beam v. mullion formed of three pieces of 14-gauge galvanized pressed steel to give acoustic separation.

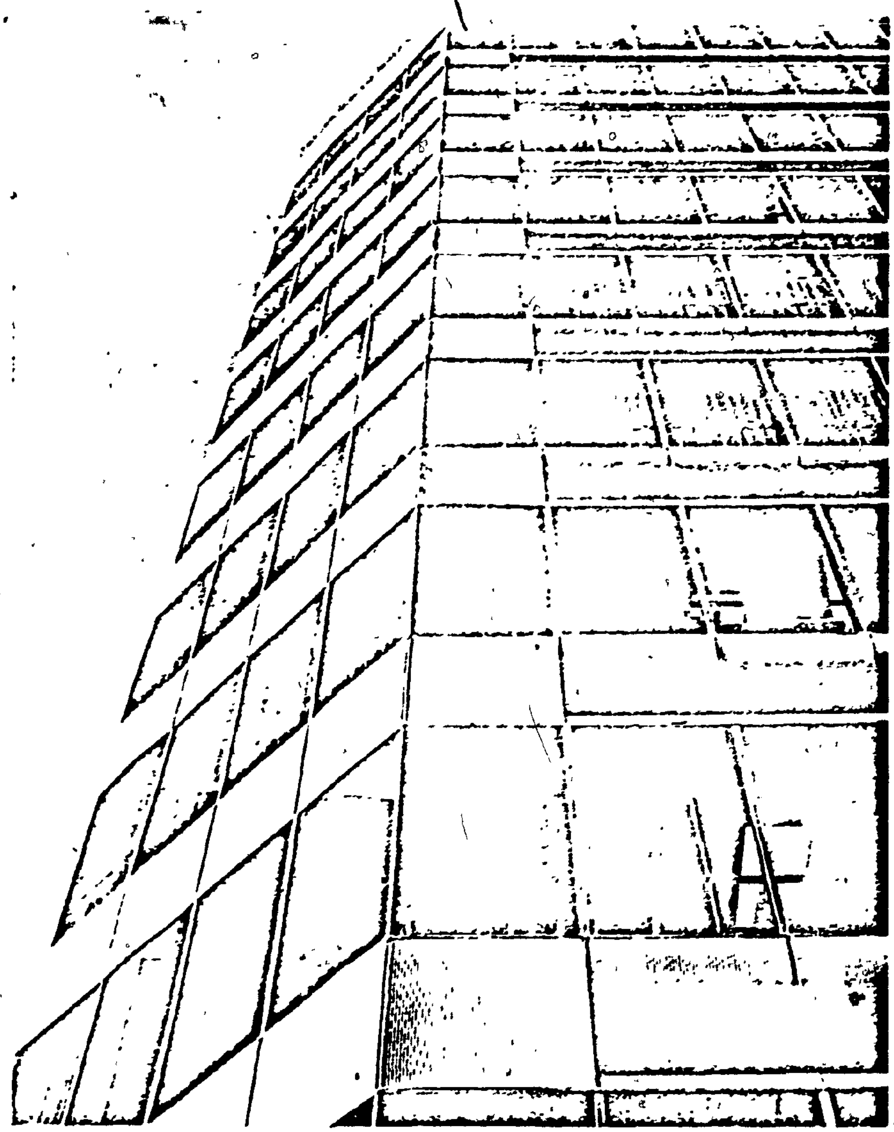
5.2.12 Wells Fargo Bank Building (Oakland, California)

The curtain wall of this building engages a bronze-tinted glass and flourocarbon coated corrugated steel sheet in an intricate interplay with the sun and the building's surroundings. The main elevations typically run a horizontal glass band flush with the leading panel edge (to facilitate reflections). Below the glass, the panel continues downward and curves behind the window sill to intersect the floor beam and anchor assembly in a brief vertical passage. A straight beveled surface slopes downward and forward to the window head and glass to repeat the sequence. At the corners of this rectangular building are 45 degree curtain walls of floor-to-ceiling glass flush with spandrel panels.

The metal panel used for the building's curtain wall is warnel, a stamped sheet metal coated with PPG Duranar, a fluorocarbon finish. Warnel panels can be used involving questionable imitation of brick, stone, and wood. However, here the sheet metal was used for its own sake. Its panel has simple 1/2 in. wide and 3/16 in. deep corrugations. Although discrete corrugations are not visible from afar, their ability to stand out in relief creates soft-battered forms, reinforced by the gray-brown coloration.[22]



Curtain Wall Panel



Wells Fargo Bank Building

CHAPTER 6

CONCLUSIONS

There is no doubt that the light curtain wall is regarded as the ideal complement to the load bearing structural frame. Every curtain wall has to be designed in relation to local climatic and atmospheric conditions, the particular function of the building it encloses and certain economic factors. A satisfactory design is only possible if the curtain wall enters into the planning from the very beginning. The reciprocal influences are too many and too intricate for the question of the curtain wall to be set aside for later consideration. The relationships that have been traced between the different kinds of curtain wall construction and their design possiblities should enable the designer to evaluate the alternatives and their chances of successful realization.

Following are some general considerations which should be looked for in the design and selection of curtain wall systems: structural integrity, resistance to air and water infiltration and air vapour exfiltration, heat loss and heat gain, resistance to condensation forming on inner surface, reduction of glaze and solar heat gain. Thermal comfort in the window zone, provisions for thermal differential mvoements, sound insulation, separateion between floors, simplicity of interfacing with ceilings, floors, partitions, durability of glazing and sealing systems, durability of materials and finishes, provisions for tolerance compensation at the interface with the structure and method of exterior cleaning.

Taken as a whole, a properly constructed curtain wall offers a wealth of interesting design possibilities. Different effects can be achieved by varying the rate of solid to transparent surfaces, by choosing different surface treatment and by controlling the properties of the grid.

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