Helwan University
Engineering Faculty
Architecture Depart.

Existing Building Re-Skin

Thesis

Applicative research in Building Technology for partial fulfillment of Master of Engineering

By

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List of symbols and abbreviations

HDB	Household Building
ETFE	Ethylene Tetraflulene Ethylene
HD	Hunter Douglas
BBRI	Belgium Building Research Institute
CW	Climate Wall
DSF	Double Skin Facade
BF	Buffer
SB	Shaft-Box
BW	Box-Window
C	Corridor
MS	Multi-Storey
SW	Swindow
MSFs	Muliple-Skin Facades
MV	Mechanical Ventilation
LED	Light-Emitting Diode
SMA	Shape Memory Alloy
LEED	Leadership in Energy and Environmental Design
U- value	the measure of the rate of heat loss through a material
Low E	The Energy saving benefits
HVAC	Heat, Ventilation, Air Condition
HEQ	High Environment Quality
LAVA	Laboratory for Visionary Architecture
UTS	University Technology Sydney
KDa	Klein-Dytham architects
PH	A pH value of 7 is neutral, the same as that of pure water. Lower values indicate increasing acidity and higher values indicate increasing alkalinity
K values	thermal conductivity values
SMA	System Memory Alloy

Background:

The concept of building skin appeared as a result of high building technology through later decades. That concept was developed from building external wall and building façade ideas, so building skin have many definitions.

Michael Davies first suggested a building skin concept with variable characteristics in 1981. He presented the idea of a multifunctional skin that could act as a nanometric absorber, radiator, reflector, filter, and transfer device. (1)

Recently, building skin is defined as a multilayered (or, and) multipurpose organ that shifts from thick to thin, tight to loose, lubricated to dry, across the landscape of the body. Skin is a knowledge-gathering device responds to heat and cold, pleasure and pain. It lacks definitive boundaries flowing continuously from the exposed surfaces of the body to internal cavities. (2)

The "skin" of a building can account for between 15% and 40% of the total building budget, (3) and may be a significant contributor to the cost of up to 40% more through its impact on the cost of building services. In complex buildings, the mechanical and electrical services can account for 30–40% or more of the total building budget. Associated research being carried out on the programmed suggests that between 30% and 35% of the capital cost of a well-serviced, high-specification office building is attributable to building services, with 13–15% being attributable to what might be called environmental services: those services devised to control the internal/thermal and ventilation environment. So these costs are eventually added the lifetime costs of the systems involved, including maintenance, replacement and energy costs. (4)

The current buzzword is re-skinning, which takes re-cladding way beyond a simple facelift. The skin or envelope of the building is obviously a critical piece in the search for energy efficiency. Therefore, the question becomes how to take an existing building and re-skin in a way that makes the building more livable as well as cheaper to operate.(5)

(1) Davies, M., A Wall for all Seasons, RIBA Journal, Vol. 88, No. 2, February, 1981.
(2) Nicholas Goldsmith, Senior Principal of FTL Design Engineering Studio, New York, USA.[about: Ellen Lupton, Skin, 2002]
(3)Andrew Hall of Arup Façade Engineering, speaking at RIBA Advances in Technology Series, 'Advances in Cladding', Monday 7 July 1997.
(4) Michael Wigginton and Battle McCarthy: 'The Environmental Second Skin'. Research carried out for the UK Department of the Environment Transport and the Regions (first published at www.battlemccarthy.demon.co.uk/research/ environmentalsecondskins).
(5) www.thezeroprize.org, Zerofootprint All rights reserved

Research problem:

Nowadays, the world suffers from increasing earth temperature, which affects on consuming energy indoor by using mechanical cooling system.

So that, the trends of building systems go towards sustainable development, which gives high technology for controlling buildings environment. It was stimulated by the development of information technology and increasing sophisticated demand for comfort living environment and requirement for increased occupant of local environments.

In form of development building system, new methods appeared, which deal with building façade, some of these methods depend on traditional ways such as using materials with high factor of thermal insulation, or high technology ways such as double skin system; that for new building.

But the problem becomes, how can make the existing building more comfortable with environment by treatment their façade, to reduce cost of consuming energy through using the buildings,?

So, the research problem becomes:

Make existing buildings more comfortable for human and environment by dealing with their façades.

Research purpose:

The purpose of this research is to:

1- Draw attention to the building skin, including its functions and system, which assist in making vision about dealing with existing buildings façade.

2- Look at aims and advantages of building re-skin.

3- Focus on technologies applied for improving skin of existing buildings.

In addition, some projects about building skin, developing building façade and their re-skin will be showed, to help the researcher's vision.

At the end of research, we will show the conclusion and recommendations of the research, where the conclusion determines some principles and guidelines that should be considered at design re-skin and the recommendations, which could be performed as guide to re-skin building.

Research scope:

The scope of the study includes the following:

- System and materials of building skins.
- System and methods of buildings re-skin.

Research objective:

The objective of the research is to collect and analyze the data that help in re-skin design for existing buildings aiming to reduce energy consumption.

Research limitations:

The limitations of the study include the following:

- Construction building system.
- Available technology of building skin system
- Style of building façade and the range, which is given to change.

Introduction:

This chapter aims to recognize the building skin, which was developed from building external wall, and building façade concepts.

The concept of building façade will be shown, functions of building skin, and its system will be presented.

Building façade definition:

Façade is an interface between inner and outer space. [(1)]

Façade is the face of the building that shows its value and structure. [(2)]

Facade is the connection between inner and outer space.[(3)]

Building facade is a typical feature in all HDB building blocks, which is used to provide distinctive character and protection against otherwise hostile external elements. Façade elements can be designed for shading and insulation to the building and to reduce heat gain. There are various ways in which the facade can be treated to provide shading to the interior. Balconies are effective in shading the interior from the sun, whereas extended canopies, sun hoods or recessed windows may shade windows in the west-facing facades.[(4)]

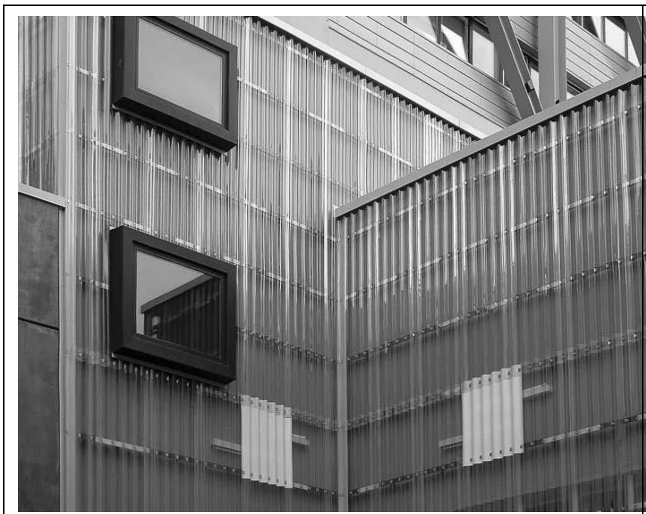


Fig. 1-1: Façade of building: Port Event Center, Düsseldorf, Norbert Wansleben, 2002
Source: Ulrich Knaack, Tillmann Klein, Marcel Bilow, Thomas Auer, Façades Principles of Construction, Medialis, Berlin, 2007, p. 15

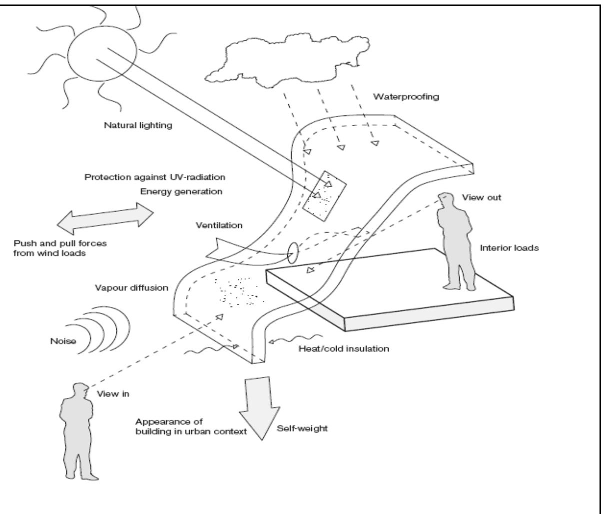


Fig. 1-2: Façade functions
Source: Ulrich Knaack, Tillmann Klein, Marcel Bilow, Thomas Auer, Façades Principles of Construction, Medialis, Berlin, 2007. p. 36

Façades are not limited to the actual space they occupy as part of the entire structure, but also influence the space in and around the building. A façade is the key element when observing a building from the exterior and has impact on the interior.[5]

[(1)] Amir Hossein Askari, and Kamariah Binti Dola, Influence of Building Façade Visual Elements on Its Historical Image: Case of Kuala Lumpur City, Malaysia, Journal of Design and Built Environment Vol. 5, December 2009, pp. 49–59

[(2)] Huxtable, A. L. (2004), Building Façade, Retrieved 15 Feb, 2007, from http:// www.class. uidaho.edu edu/ community research /facade_remodeling.htm

[(3)] Hayashi, T. (2004), Lasnamäe Track and Field Centre: Façade, MAJA, Estonian Architectural Review, Retrieved 7 September 2007, from http://www. solness.ee/majaeng/index. php?gid=60&id=323

[(4)] http://www.energysave.sg/index.php?option=com_content&view=article&id=76&Itemid=180, Housing & development board (energy safe)

[(5)] Ulrich Knaack, Tillmann Klein, Marcel Bilow, Thomas Auer, Façades Principles of Construction, Medialis, Berlin, 2007

Building skin definition:

Skin is a multilayered (or, and) multipurpose organ that shifts from thick to thin, tight to loose, lubricated to dry, across the landscape of the body. Skin is a knowledge-gathering device responds to heat and cold, pleasure and pain. It lacks definitive boundaries flowing continuously from the exposed surfaces of the body to internal cavities.[(1)]

Building skins are environmental filters, they are boundaries of personal property and they act as the transition between inside and outside. Pure skins are building envelopes where the roof and the exterior walls form one seamless whole without a transition, just like the human body. They do not need to express the inside of the building (as classic Modernists claimed), since they have been removed from the structure of the building. This is much like the bones of our body, which act in compression but require our pre-stressed tension skin to hold it all together. As a result, we are starting to see a whole new vocabulary for these architectural 'building skins'. [(2)]

Lightweight membranes became an environmental building element to be used in conjunction with other more conventional materials such as steel and glass.

Besides nanofibers, the advent of intelligent fabrics, woven photovoltaic skins, active shading systems built into the skins, and eventually our building skins will become like our own skin and those, which exist in the natural world. [(3)]

From previous, we can say that: façade means the envelope of building wall while skin means the layers, which the façade include.

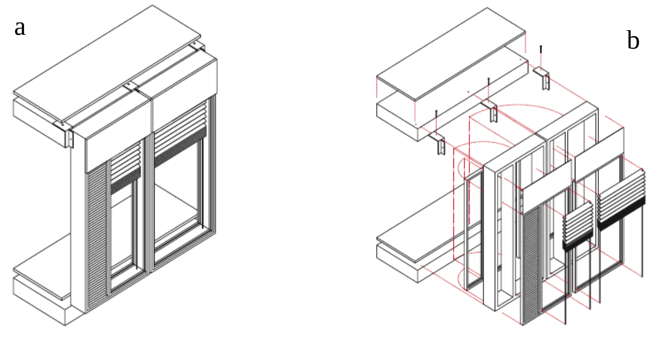


Fig. 1-3: The difference between building façade &skin

a- façade b- skin

Source: Ulrich Knaack, Tillmann Klein, Marcel Bilow, Thomas Auer, Façades Principles of Construction, Medialis, Berlin, 2007. p.104

1-1- Functions of building façade and skins:

1-1-1- Functions of building façade: [(4)] (Fig. 1-2)

- It defines the architectural appearance of the building,
- Provides views to the inside and outside,
- Absorbs push and pull forces from wind loads,
- Bears its self-weight as well as that of other building components.
- Allows sunlight to penetrate into the building while usually providing protection from the sun at the same time.
- Resists the penetration of rainwater and has to handle humidity from within and without.
- Provides insulation against heat, cold, noise and can facilitate energy generation.

[(1)] Nicholas Goldsmith, Senior Principal of FTL Design Engineering Studio, New York, USA.[about: Ellen Lupton, Skin, 2002]
[(2)] Nicholas Goldsmith, Senior Principal of FTL Design Engineering Studio, New York, USA.
[(3)] Ibid.(31)
[(4)] Ulrich Knaack, Tillmann Klein, Marcel Bilow, Thomas Auer, Façades Principles of Construction, Medialis, Berlin, 2007

1-1-2- Function of building skin:

- Make indoor more comfortable for human by saving energy consuming.
- Separate the indoor space and outdoor space with beautiful envelope.
- Save indoor spaces from the climate change in outdoor, which will save building energy consumption.
- Give special characteristics for buildings.

1-2- Systems of building skin:

There are three systems of building skin, their classification depend on the term system deals with degree of development concerning devices and improvements to types of building skin applied technical level. These systems include the following:

1-2-1- Traditional system:

Traditional building façade becomes a sealed skin- a barrier between the variable outdoor climate and the highly controlled indoor climate. [1]

Building materials affect characteristics such as thermal mass of wall façade and their insulation.

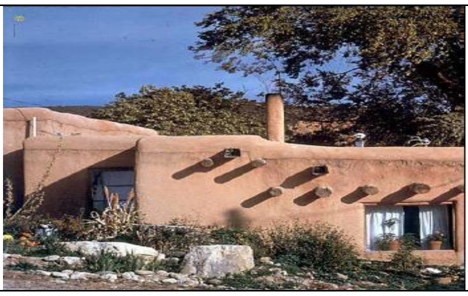
The rate of heat transfer through building materials and the effectiveness of thermal mass is determined by a number of parameters and conditions. Optimization of thermal mass levels depends on the properties of the building materials, building orientation, thermal insulation, ventilation, climatic conditions, use of auxiliary cooling systems, and occupancy patterns. For a wall material to store heat effectively, it must have high thermal capacity and a high thermal conductivity value, so that heat may penetrate through the wall during the heat charging and discharging periods.

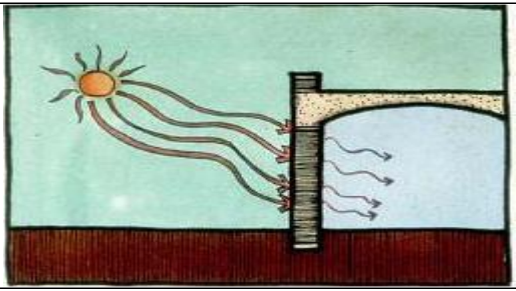
The distribution of thermal mass is based on the orientation of the given surface and the desirable time lag. During the night when outdoor temperatures are lower than indoor temperatures, it is possible to cool the structural mass of the building by natural ventilation. Such a technique, known as 'night ventilation' may contribute in decreasing the cooling load of air conditioned buildings up to 60%, or decreasing the hours of "free-floating buildings", i.e. of buildings not using a cooling system. (no mechanical air conditioning) up to 75%.

Phase change materials incorporated in plaster increases the heat storage capacity in the building and thus contribute in decreasing the average indoor temperatures.

MATERIAL	THICKNESS mm	TIME LAG hours
AAC	200	7.0
Adobe	250	9.2
Compressed Earth Blocks	250	10.5
Concrete	250	6.9
Double Brick	220	6.2
Rammed Earth	250	10.3
Sandy Loam	1000	30 days

Fig. 1-4: Material thickness & time lag





[1] John Pery, Maurya McClintock, The challenge of Green buildings in Asia, Sydney NSW, 2000

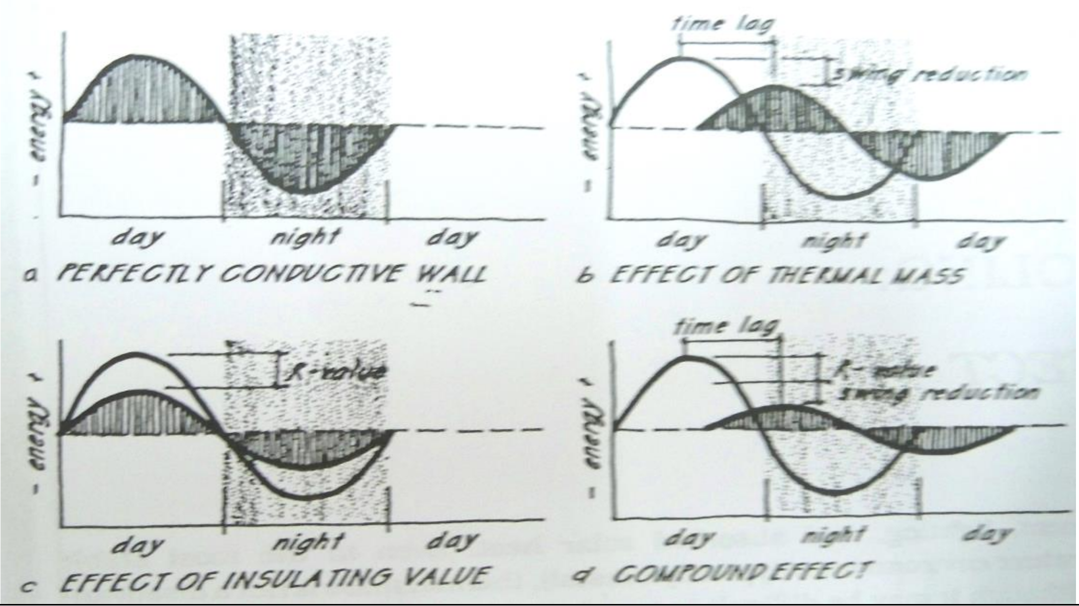


Fig. 1-5: Effect of thermal mass and insulation on interior temperature:

a- conductive, low-mass envelope (high swings, no lag)
b- high-mass envelope (uninsulated masonry; time lag plus reduced swings)
c- Insulated, low-mass envelope (reduced swing, no lag)
d- Insulated, high-mass envelope (masonry with exterior insulation; time lag with greatly reduced temperature swings)

Source: Guoqiang Zhang & Junli Zhou, Development of the Passive Cooling Technique in China1, HVAC Technologies for Energy Efficiency, Vol. IV-9-3, ICEBO2006, Shenzhen, China

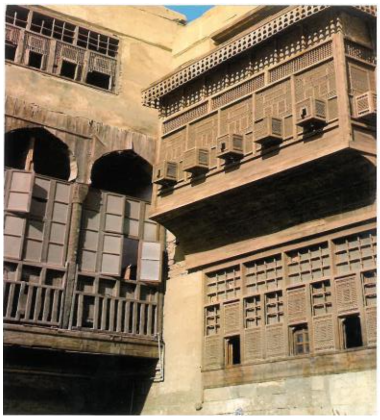


Fig. 1-6: Traditional wood window

Source: Ernst J.Grube & James Dickie & Oleg Grabar & Eleanor Sims & Ronald Lewcock & Dalu Jones &Guy T.Pethepbpidge, Architecture the Islamic world, London, 1995, p. 121

Fig. 1-7: Stone building façade

Source: Ernst J.Grube & James Dickie & Oleg Grabar & Eleanor Sims & Ronald Lewcock & Dalu Jones &Guy T.Pethepbpidge, Architecture the Islamic world, London, 1995, p. 118

1-2-1-a- Wood: (1)

Wood is a local building material, which can be used in a natural state or after industrialization; it retains its prime importance within the construction industry because of its versatility, diversity and aesthetic properties. (2)

(1) Andrea Deplazes, CONSTRUCTING ARCHITECTURE MATERIALS PROCESSES STRUCTURES A HANDBOOK, Birkhauser, Berlin, 2005

(2) Arthur Lyons, MATERIALS FOR ARCHITECTS AND BUILDERS, Elsevier, 2007


Fig. 1-8: Gridshell construction – Weald and Downland Open-Air Museum. Architects: Edward Cullinan Architects

Source: Arthur Lyons, MATERIALS FOR ARCHITECTS AND BUILDERS, Elsevier, 2007, p.113

Properties of wood:

Wood is a relatively good insulating material. The thermal conductivity of wood is around 0.13 W/mK for softwood and 0.20 W/mK for hardwood; this compares with figures of 0.44 W/mK for clay bricks and 1.80 W/mK for concrete. In comparison with steel or concrete, the thermal expansion of wood is so small that it is irrelevant in building.

In contrast to steel or concrete, wood remains unaffected by a wide range of pH values. Overall, working the material saves energy.

Wood types:

<u>- Plywood</u>

Plywood is made from at least three cross-banded plies (i.e. grain of adjacent plies at approx. 90° to each other). The plies are glued together with waterproof phenolic resin glue with the help of pressure and heat. After pressing, the edges are trimmed and the surface(s) sanded or otherwise processed. Plywood can also be moulded into virtually any shape by applying pressure, heat and moisture (moulded plywood).

Plywood is suitable for many applications. For example, it can be used as a bracing facade cladding.

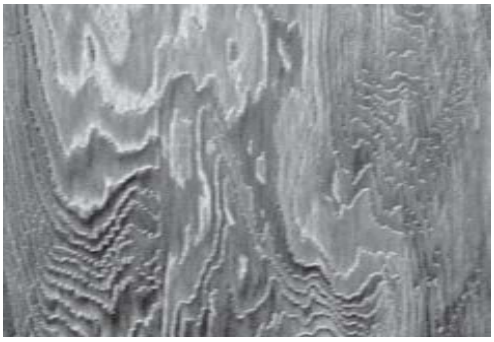


Fig. 1-9: Surface (peeled) of plywood The trunk is clamped in position and unrolled in order to produce veneers. This produces a relatively homogeneous surface with low contrast and irregular figure

Source: Andrea Deplazes, CONSTRUCTING ARCHITECTURE MATERIALS PROCESSES STRUCTURES A HANDBOOK, Birkhauser, Berlin, 2005. p. 86

<u>- Wood-based core plywood</u>

This is a type of plywood with a central core of timber strips, known as block board, lamin board or batten board depending on the width of the strips used.

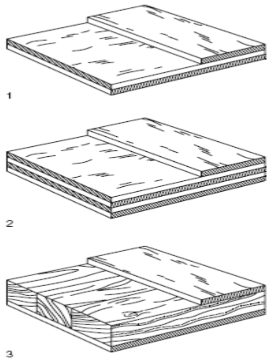


Fig. 1-10:Lay-up of plywood 1: 3-ply plywood 2: 5-ply plywood 3: Wood-based core plywood Source: Andrea Deplazes, CONSTRUCTING ARCHITECTURE MATERIALS PROCESSES STRUCTURES A HANDBOOK, Birkhauser, Berlin, 2005. p. 86	**Fig. 1-11:Surface (sliced) and edges of 3- and 5-ply core plywood In contrast to peeled veneers, the production of sliced veneers involves cutting the trunk into thin sheets.** Source: Andrea Deplazes, CONSTRUCTING ARCHITECTURE MATERIALS PROCESSES STRUCTURES A HANDBOOK, Birkhauser, Berlin, 2005. p. 86

- Multi-ply boards

Plywood with at least five cross-banded plies and a ply thickness of 0.8–2.5 mm is often known as multi-ply board. Multi-ply boards can be used for external cladding, even in severe weather conditions, or internal linings. The high load-carrying capacity of such boards makes them suitable for load-bearing applications as well.

- 3- and 5-ply core plywood

A 3- or 5-ply core plywood consists of cross-banded plies with thicknesses between 4 and 50 mm. These boards are primarily used as load-bearing and bracing sheathing in timber buildings, and as formwork for concrete.

- Solid timber panels

Three or more cross-banded layers of strips without any outer sheathing. These can be used as load-bearing plates, but must be protected from the weather.

Thermal Insulation**:**

Satisfactory thermal insulation can best be obtained with sandwich panels by using cores having low thermal conductivity, although the use of reflective layers on the facings is of some value. Paper honeycomb cores have thermal conductivity values (*k* values), ranging from 0.04 to 0.09 W/m·K (0.30 to 0.65 Btu·in/h·ft2·F), depending on the particular core construction.

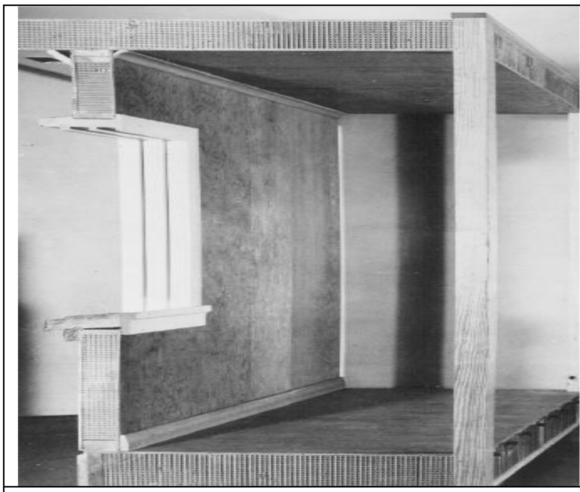


Fig. 1-12: Cutaway to show details of sandwich construction in an experimental structure
Source: Andrea Deplazes, CONSTRUCTING ARCHITECTURE MATERIALS PROCESSES STRUCTURES A HANDBOOK, Birkhauser, Berlin, 2005. p. 86

The *k* value does not vary linearly with core thickness for a true honeycomb core because of direct radiation through the core cell opening from one facing to the other. Honeycomb with open cells can also have greater conductivity if the cells are large enough (greater than about 9 mm (3/8 in.)) to allow convection currents to develop. (1)

An improvement in the insulation value can be realized by filling the honeycomb core with insulation or a foamed in- place resin. (2)

1-2-1-b- Concrete: (3)

Concrete is a mixture of cement, aggregates and water, with any other admixtures, which may be added to modify the placing and curing processes or the ultimate physical properties. Initially when mixed, concrete is a plastic material, which takes the shape of the mould or formwork. When hardened it may be a dense load-bearing material or a lightweight thermally insulating material, depending largely on the aggregates used. It may be reinforced or pre-stressed by the incorporation of steel. Its density is 220 kg/m^3 and heat resistance 0.08 R for thickness 25 cm.

Achieving re-skin for buildings can be depended on concrete material as pre-cast units. The additives to concrete before casting, control its characteristics, such as reduction of density and increasing of heat resistance. These additives comprise the following:

- lightweight aggregate such as furnace slag and parlite.
- Chemical additives as aluminum oxide (Al2o3) to obtain concrete full of air (gas) -Co2 & H2- .
- Addition of natural organic fiber: such as cactus fiber, banana peel, polymers….etc.

These additives increase heat resistance to 0.6 R for thickness 20 cm.

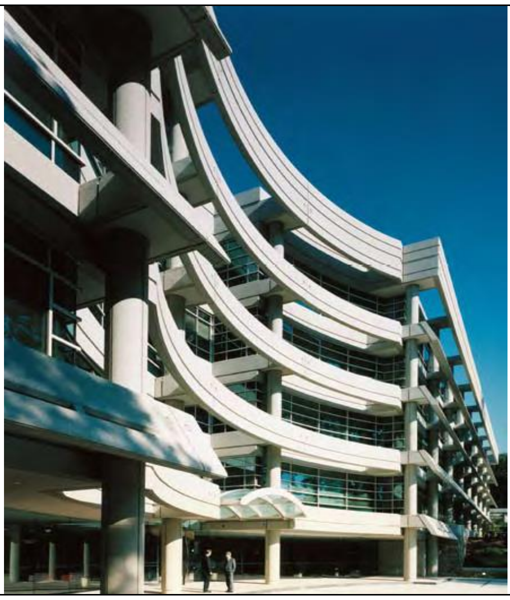


Fig. 1-13: United Parcel Services Corporate Offices, Atlanta, Ga
Source:http://www.sustainableprecast.ca/downloads/Precast_Achieves_Sustainability_Goals.pdf

Fig. 1-14: Scattered Site Housing, Chicago, Ill.
Source:http://www.sustainableprecast.ca/downloads/Precast_Achieves_Sustainability_Goals.pdf

Fig. 1-15: South Trust Bank of Charleston, S.C.
Source:http://www.sustainableprecast.ca/downloads/Precast_Achieves_Sustainability_Goals.pdf

(1) Forest Products Laboratory. 1999. Wood handbook—Wood as an engineering material. Gen. Tech. Rep. FPL–GTR–113. Madison, WI: U.S. Department of Agriculture, Forest Service, Forest Products Laboratory.
(2) Ibid. (18)
(3) أ.د. نادية محمد ثابت، مواد البناء الخفيفة- أساليب التصنيع ونظم التشييد-، بحث الاتجاهات الحديثة في العمارة وعلوم تكنولوجيا البناء، مارس 2004

Fig. 1-16: Centralia High School, Centralia, Ill.
Source:http://www.sustainableprecast.ca/downloads/Precast_Achieves_Sustainability_Goals.pdf

Fig. 1-17: The Ninth Square, New Haven, Conn.
Source:http://www.sustainableprecast.ca/downloads/Precast_Achieves_Sustainability_Goals.pdf

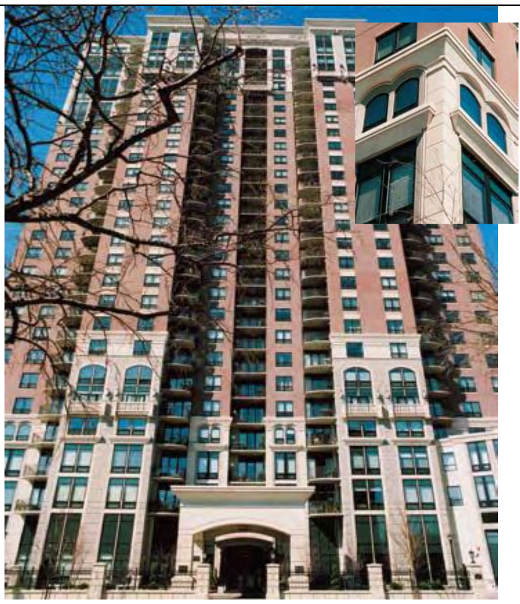


Fig. 1-18: Grant Park Tower, Minneapolis, Minn.
Source:http://www.sustainableprecast.ca/downloads/Precast_Achieves_Sustainability_Goals.pdf

Fig. 1-19: Church of Jesus Christ of Latter-day Saints, Lake Oswego, Ore.
Source:http://www.sustainableprecast.ca/downloads/Precast_Achieves_Sustainability_Goals.pdf

Fig. 1-20: Fairmont Hotel, San Jose, Calif
Source:http://www.sustainableprecast.ca/downloads/Precast_Achieves_Sustainability_Goals.pdf

Fig. 1-21: Phillips Communications, Lancaster, Pa.
Source:http://www.sustainableprecast.ca/downloads/Precast_Achieves_Sustainability_Goals.pdf

1-2-1-c- Metal:

This system makes use of metal panels as skin for building. Surface of these panels have treatment and include thermal insulation layers to suit local climate and its changes. Facade of Hunter Douglas Commercial. Building (**Fig. 1-22**) are composed of single skin facades are made from pre-coated aluminium and zinc/aluminium coated steel panels using the HD COLOR-COTE®. The façade include several shaped surfaces such as flat and curved surfaces. They provide subtle or distinct linear patterns in horizontal, vertical or diagonal directions. The range can be customized to fully integrate with the exterior of building architecture. [(1)]

- Advantages:
  - Neat concealed joints present a smooth uninterrupted appearance.
  - High strength - capability of withstanding high wind loads.
  - Extreme panel flatness combined with 'crisp' edges.
  - Range of varied sizes of facade elements.
  - Made to measure - ensures optimal performance with no waste and time-consuming processing on site.
  - Complete with engineered joint solutions
  - Ensuring strength and weathering integrity in operation.

Hunter Douglas Commercial, The Single Skin Facades

Coating Process, which combines high strength with corrosion resistance, ensuring a long life span and requiring minimal maintenance.

Fig. 1-22: Hunter Douglas Commercial
Source: Hunter Douglas Commercial Division of Hunter Douglas Limited, Copyright 2009 Hunter Douglas Limited [ABN 98 009 675 709]. ® Registered Trade Marks of Hunter Douglas Limited. C7970/11.2009, www.hunterdouglascommercial.com.au

Fig. 1-23: Hunter Douglas Commercial façade
Source: Hunter Douglas Commercial Division of Hunter Douglas Limited, Copyright 2009 Hunter Douglas Limited [ABN 98 009 675 709]. ® Registered Trade Marks of Hunter Douglas Limited. C7970/11.2009, www.hunterdouglascommercial.com.au

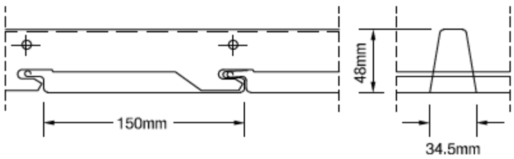


Fig. 1-24: Standard construction details
Source: Hunter Douglas Commercial Division of Hunter Douglas Limited, Copyright 2009 Hunter Douglas Limited [ABN 98 009 675 709]. ® Registered Trade Marks of Hunter Douglas Limited. C7970/11.2009, www.hunterdouglascommercial.com.au

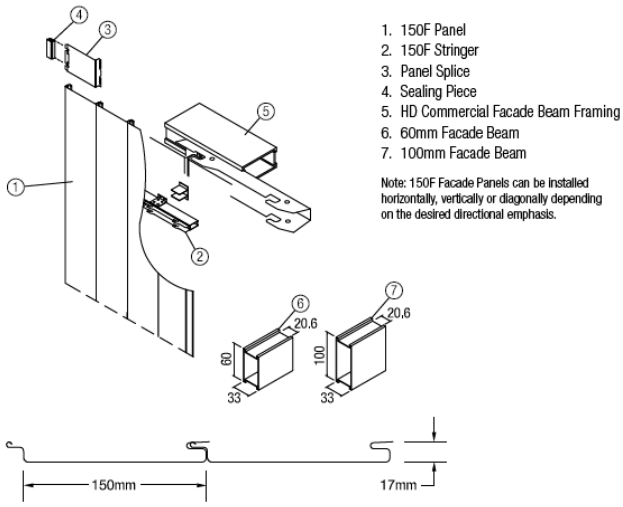


Fig. 1-25: Façade system overview
Source: Hunter Douglas Commercial Division of Hunter Douglas Limited, Copyright 2009 Hunter Douglas Limited [ABN 98 009 675 709]. ® Registered Trade Marks of Hunter Douglas Limited. C7970/11.2009, www.hunterdouglascommercial.com.au

[(1)] Hunter Douglas Commercial Division of Hunter Douglas Limited, Copyright 2009 Hunter Douglas Limited [ABN 98 009 675 709]. ® Registered Trade Marks of Hunter Douglas Limited. C7970/11.2009, www.hunterdouglascommercial.com.au

1-2-1-d- Glass :(1)

The term glass refers to materials, usually blends of metallic oxides, predominantly silica, which do not crystallise when cooled from the liquid to the solid state. It is the non-crystalline or amorphous structure of glass that gives rise to its transparency. (2) Glass has many treatments, which made its properties of strength, thermal and sound better.

Fig. 1-26: Glazed facade – Faculty of Law, University of Cambridge. Architects: Foster and Partners.
Source: Arthur Lyons, MATERIALS FOR ARCHITECTS AND BUILDERS, Elsevier, 2007, p.211

Fig. 1-27: Curved rhomboidal glass panes – Prada Store, Tokyo. Architects: Herzog and de Meuron.
Source: Arthur Lyons, MATERIALS FOR ARCHITECTS AND BUILDERS, Elsevier, 2007, p. 221

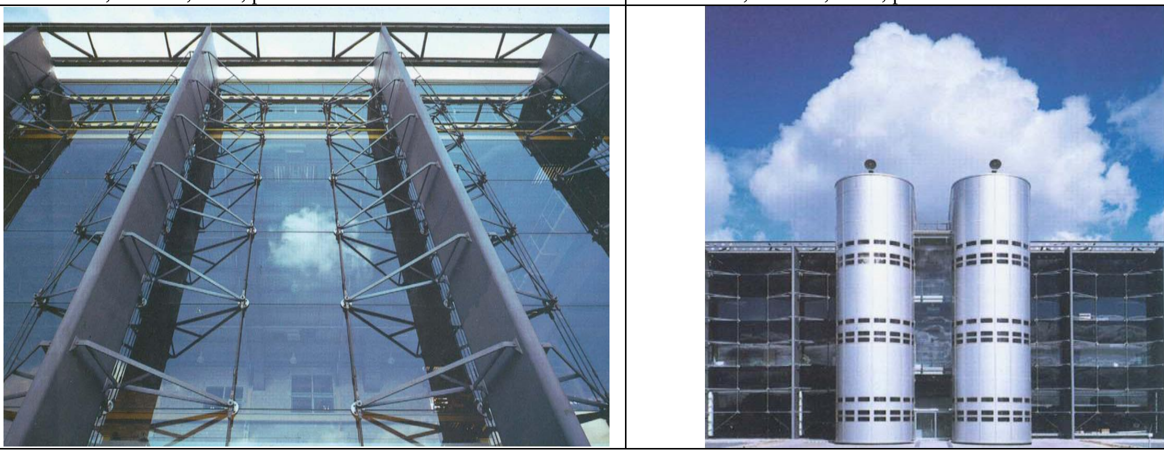


Fig. 1-28: Glazing system – Financial Times, Docklands, London. Architects: Nicholas Grimshaw and Partners.
Source: Arthur Lyons, MATERIALS FOR ARCHITECTS AND BUILDERS, Elsevier, 2007, p. 235

Types of glass: (3)

- Normal glass:

Normal glass is synonymous with flat glass irrespective of the process of manufacture. Float glass has a perfectly flat, brilliant surface, whereas sheet glass has slight distortions. Both are referred as annealed glass and can be processed to obtain many different varieties of glass for use in buildings.

(1) N.K.Garg, Use of Glass in Buildings, new age international, 2007
(2) Arthur Lyons, MATERIALS FOR ARCHITECTS AND BUILDERS, Elsevier, 2007
(3) N.K.Garg, Use of Glass in Buildings, new age international, 2007

The properties:

- High light transmission (80 - 90 percent)
- Optical clarity
- Can be processed to produce other glass types such as tempered, laminated and insulating.
- Density (approximate) : 2.42 – 2.52 g/cm3
- Tensile strength : 40 N/ sq. mm
- Compressive strength : 1000 N/ sq. mm
- Modulus of elasticity : 70 GPa
- Coefficient of linear : 9 x10 $^{-6}$ m / mK expansion
- Available thickness : 2 mm - 19 mm
- Normally available sizes up to : 2440 mm x 3660 mm (Bigger sizes can also be made)
- Colour : Clear, Grey, Bronze, Green, Blue and Pink.
- Thermal heat transmission: 5.73 w/sq-k

Fig. 1-29:Normal glass
Source: www.skyscrapernews.com

- Heat strengthened glass: [(1)]

Heat strengthened glass is a type of tempered glass which has been strengthened thermally by inducing a surface compression of 422 to 658 kg/cm2 as compared to a range of 770 to 1462 kg/cm2 in case of fully tempered glass.

Heat-strengthened glass continues to gain popularity and is often the choice of the design professional for vertical vision spandrel areas and for laminated sloped glazing. It is valued for its mechanical strength, which is twice that of normal annealed glass though half of fully tempered glass. With the exception of strength and breakage characteristics, heat - strengthened glass retains the normal properties of annealed glass, including chemical resistance, hardness, expansion and deflection. Heat-strengthened glass provides necessary resistance to thermal stress associated with high performance glazing materials such as tinted glass and reflective glass. It also provides necessary resistance to heat building up when using spandrel glass. Heat-strengthened glass with its flatter surface also results in the facade having less optical distortions.

Fig. 1-30: Heat strengthened glass
Source: N.K.Garg, Use of Glass in Buildings, new age international, 2007

- Reflective glass:

A metallic coating is applied to one side of the glass in order to significantly increase the amount of reflection by the glass of both the visible and infra-red

[(1)] N.K.Garg, Use of Glass in Buildings, new age international, 2007 (light and heat) range of the electromagnetic spectrum. This metallic coating can be applied to clear or body tinted glass. The reflective glass imparts a mirror like appearance to the exterior of buildings under most daytime conditions.

The properties:

- Increased aesthetic appeal.
- Gives enormous flexibility in designing the exterior due to availability of number of colours / shades
- Facilitates energy savings through reduction in interior solar heat gain and cost reduction in the cost of heating and cooling systems.
- Improves occupants comfort as interior temperature variations are less and easier to control.
- Varying degrees of light transmittance and varying reflectance.
- Reduces the air-conditioning load of the buildings

Fig. 1-31:Reflective glass
Source: N.K.Garg, Use of Glass in Buildings, new age international, 2007, p. 20

- Insulating glass unit:

The insulating glass is a prefabricated unit made of two or more glass panes, separated by a cavity and edges hermetically sealed together. This edge seal not only binds the individual sheets of glass together to maintain the mechanical strength of the joint but also protects the cavity between the glasses from outside influences. The moisture in the cavity between the two glasses is controlled by desiccants filled in the perforated spacer. The spacer can be aluminum, composite plastics etc. The spacer ensures the precise distance between the glass panes. The cavity normally filled with dry air but can be also filled with gases such as Argon, Krpton for better thermal performance or hydrogen fluro oxide for better acoustic performance. The low heat conductivity of the enclosed dry gas between the glass panes drastically reduces the thermal heat transmission through the glass 2.8 W/sqm-K as compared to 5.73 W/sqm K for normal glass. It also helps is reducing the direct solar energy specifically when the outer pane is a solar control glass.

The Properties:

- Heat transferred by conduction and convection due to temperature difference between the outside and inside is reduced to nearly half in case of normal glass thus reduces the heat flow / transfer & gain / loss). It is specifically very effective in winters as it saves loss of inner heat.
- The use of heat absorbing or heat reflective glass as outer glass further reduces the load on the cooling system.
- In case of monolithic glass, the temperature difference between the outside and inside of a room may lead to condensation in humid climate. The insulating effect of the air layer makes it difficult for the glass to become cold and is consequently avoids dew condensation.

- Insulating glass can significantly help in reducing the exterior noise pollution if the unit is made up of glass panes of asymmetrical thickness. The amount of sound reduction depends on the combination of the insulating glass. Using one or both panes of laminated or acoustic laminated glasses will drastically reduce sound transmission.
- It offers increased personal comfort and aids energy conservation. Because of its high insulation properties, the lack of cold or warm droughts leads to a pleasant internal environment. Strength to withstand wind load is also increased.
- Normally secondary seal is of silicone if the edges are exposed and of polyshulphide if the edges are framed.

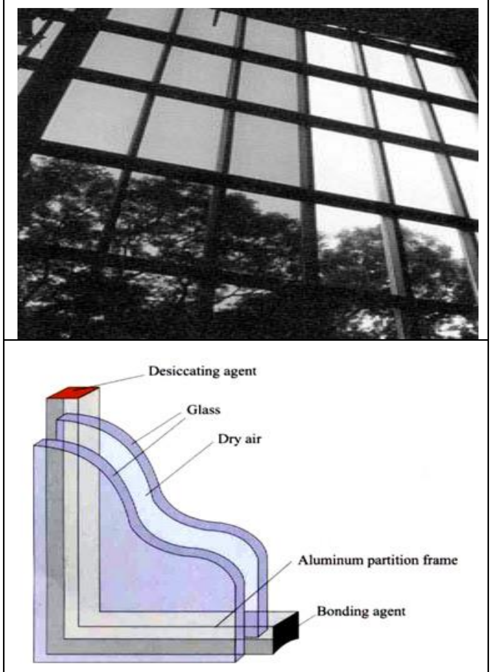


Fig. 1-32: Insulating glass unit
Source: N.K.Garg, Use of Glass in Buildings, new age international, 2007

Ex. Single-skin Glazed Façade System:

This system was designed and executed for south and west facades of the administrative headquarters building (General Health Insurance Company).(1) **(Fig. 1-34)**

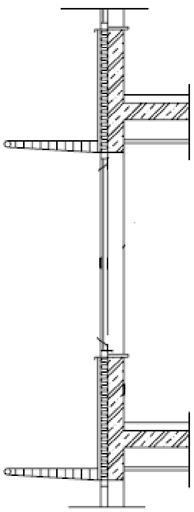


Fig. 1-33: Section in skin

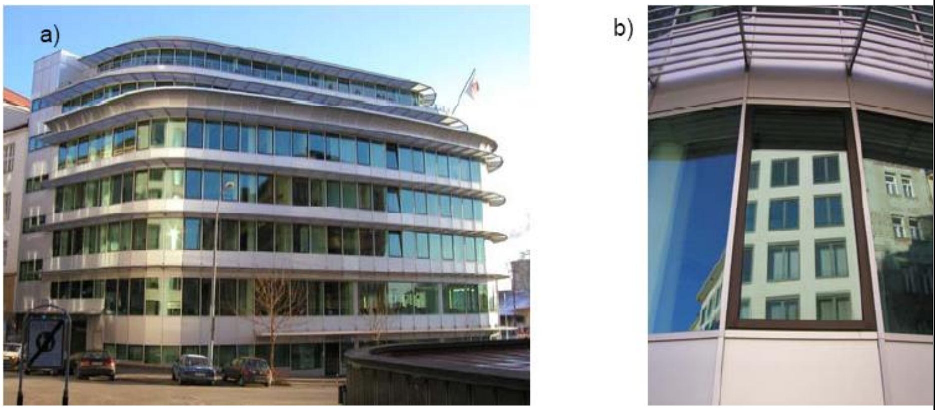


Fig. 1-34: Single-skin glazed façade system (General Health Insurance Company in Brno)
a) photograph of the west and south oriented glazed façades,
b) window segment of the façade
source: J. Mohelníková & D. Plšek, Energy Evaluation of Single and Double-skin Glazed Facades in Climatic Conditions of Central European Region, 2005, p. 2

(1) J. Mohelníková and D. Plšek, Energy Evaluation of Single and Double-skin Glazed Facades in Climatic Conditions of Central European Region, Faculty of Civil Engineering Brno University of Technology Veveri 95, 602 00 Brno CZECH REPUBLIC

1-2-2- Sub-tech system *[Louver, …etc.]*

This system includes the types of shading façade louver:

There are many systems can be used to shading façade, which can be used individually or combined, they are External Devices, Internal Devices, Fixed Devices, Adjustable Devices, Retractable Devices, Mid-Pane Devices

Shading Devices: (1) There are two primary classifications of shading devices: Fixed elements are mainly external, and include horizontal overhangs, vertical fins, combination of horizontal and vertical elements, and balconies. Internal elements include light shelves and louvers.

1-2-2-a- External Devices, Internal Devices:

External or internal shading device: It is recommended that moveable devices should be used to allow for greater control. The climate is not totally predictable and great fluctuations in temperature and solar radiation are likely.

To ensure that 'comfort conditions' are maintained, louvered systems or retractable blinds are recommended. A degree of occupant control over their own environmental conditions will help to improve their perception of comfort, and their acceptance of a wider comfort range.(2)

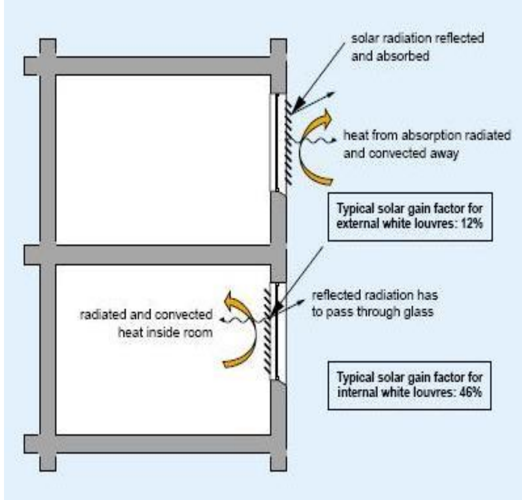
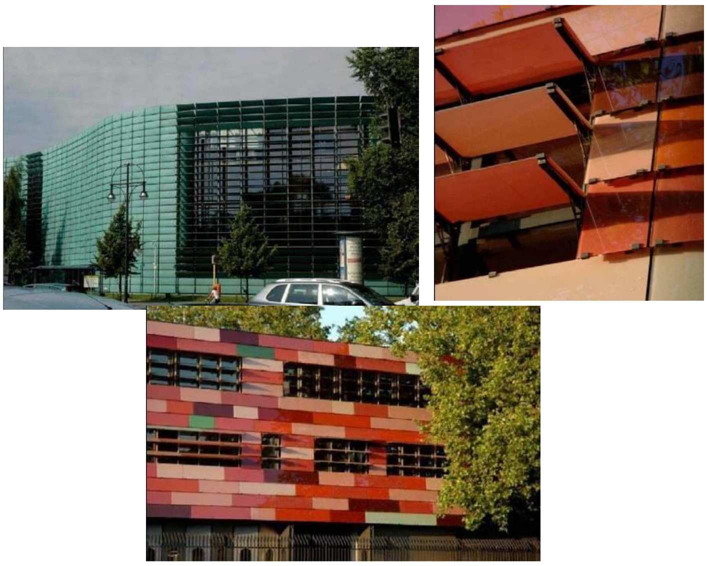
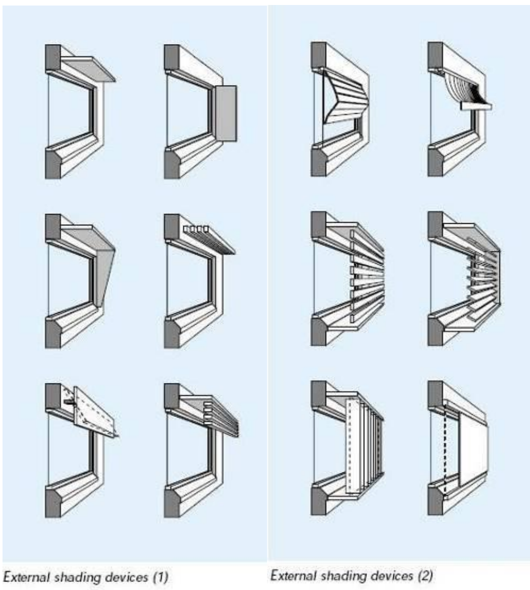


Fig. 1-35: External versus internal louvers
Source: Energy Research Group, University College Dublin, School of Architecture, Richview, Clonskeagh, Dublin 14, Ireland, Shading systems -Solar Shading for the European climates-, p. 7





(1) Ralf Cavelius, IZES GmbH, Charlotta Isaksson, AEE INTEC, Eugenijus Perednis, Lithuanian Energy Institute, Graham E. F. Read, NIFES Consulting Group, Passive Cooling Technologies

(2) Mat Santamouris, ENVIRONMENTAL DESIGN OF URBAN BUILDINGS An Integrated Approach, Mat Santamouris, 2006

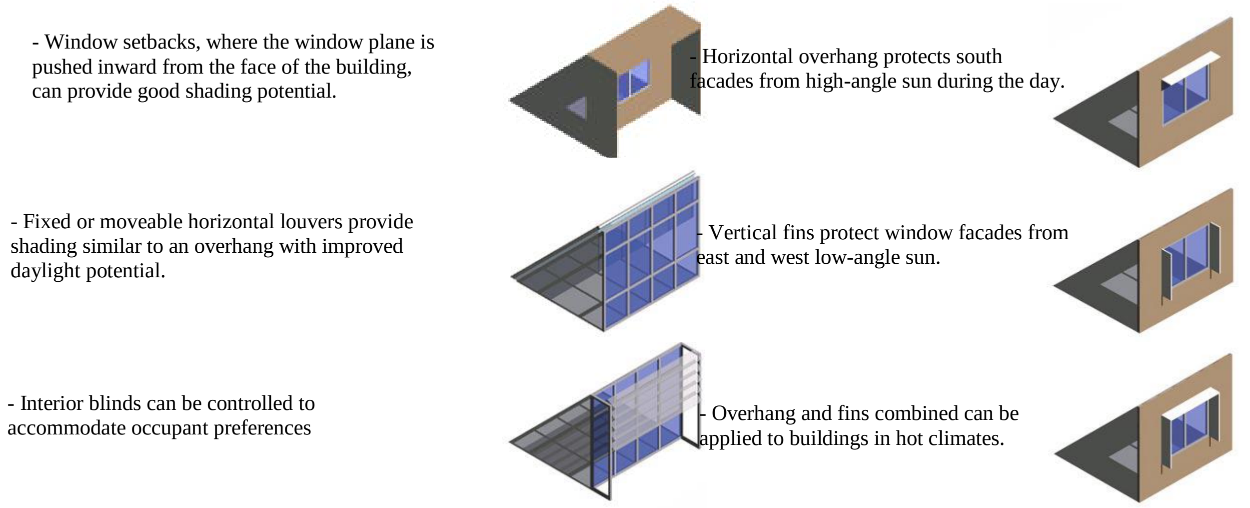


Fig. 1-36: External Devices

Source: Lawrence Berkeley National Laboratory, High-Performance Commercial Building Façades, 2006, p. 15
Energy Research Group, University College Dublin, School of Architecture, Richview, Clonskeagh, Dublin 14, Ireland, Shading systems -Solar Shading for the European climates-, p. 7

1-2-2-b- Fixed Devices:

Fixed elements are mainly external, and include horizontal overhangs, vertical fins, combination of horizontal and vertical elements, and balconies. Internal elements include light shelves and louvers.

1-2-2-c- Adjustable Devices:

Adjustable and moveable shading devices can be located externally, internally or between the panes of a double or triple glazed window. Adjustable elements can be external shading elements in the form of tents, awnings, pergolas, or internal elements such as curtains, venetian blinds, rollers, and window shutters.

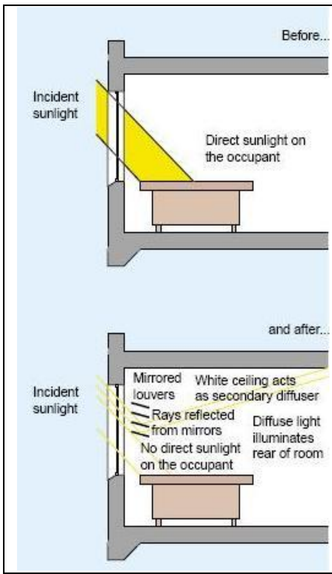


Fig. 1-37: Internal devices

Source: Energy Research Group, University College Dublin, School of Architecture, Richview, Clonskeagh, Dublin 14, Ireland, Shading systems -Solar Shading for the European climates-, p. 4

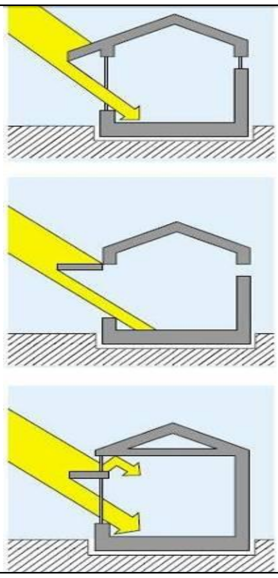


Fig. 1-38: Fixed devices

Source: Energy Research Group, University College Dublin, School of Architecture, Richview, Clonskeagh, Dublin 14, Ireland, Shading systems -Solar Shading for the European climates-, p. 8

Adjustability is most often found in internal shading systems, where manipulation is readily achievable and relatively inexpensive. However, it can be applied to external systems in certain circumstances. An external adjustable device can be manipulated to exclude or admit sunlight when required, and is particularly effective in dealing with low-angled direct sunlight, diffuse and reflected light. Unlike fixed shading, it can be operated such that internal illuminance is not excessively reduced. Adjustable external shading devices can reduce solar heat gain through windows to 10% of that incident on the façade.

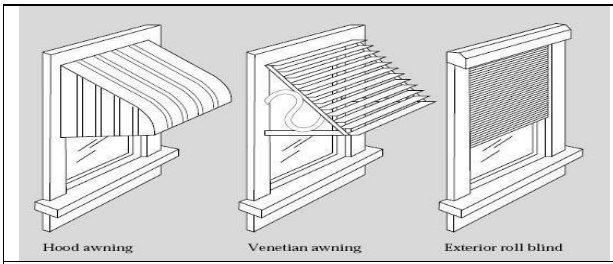


Fig. 1-39: A variety of exterior awning and shade styles are available

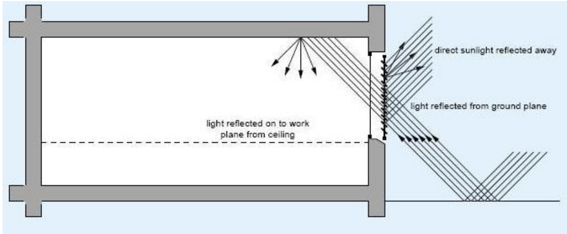


Fig. 1-40: Adjustable Devices
Source: Energy Research Group, University College Dublin, School of Architecture, Richview, Clonskeagh, Dublin 14, Ireland, Shading systems -Solar Shading for the European climates-, p. 9

1-2-2-d- Retractable Devices:

Retractable shading devices may be retracted to the upper or side portion of the window, or totally removed. Internal blinds and curtains fall under this category, as do external devices such as fabric awnings, louvers and shutters. These devices avoid the compromise between adequate shading in summer and adequate sun access in winter. Their use may compromise ventilation requirements when full shading is required during periods of overheating.[1]

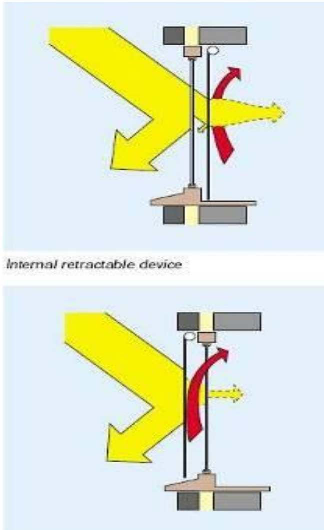


Fig. 1-41: Retractable devices
Source: Energy Research Group, University College Dublin, School of Architecture, Richview, Clonskeagh, Dublin 14, Ireland, Shading systems -Solar Shading for the European climates-, p. 9

1-2-2-e- Mid-Pane Devices:

Mid-pane shading devices may be located between the panes of a double glazed unit or, in some commercial buildings, within a curtain wall. Such devices, when accompanied by effective ventilation to the outside, combine the advantages of external and internal shades. Heat gains are dissipated to the outside, but the shades are protected from the severity of the outdoor climate. Mid-pane devices are particularly effective in controlling glare. [2]

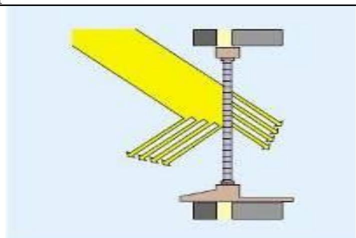


Fig. 1-42: Mid-pane device venation blind
Source: Energy Research Group, University College Dublin, School of Architecture, Richview, Clonskeagh, Dublin 14, Ireland, Shading systems -Solar Shading for the European climates-, p. 9

1-2-3- High-tech system: *[Double skin, …etc.]*: [3]

High-tech system of building skin is the current direction in designing building facade, such as: double skin, multiple- skin, and sensitive skin

1-2-3-a- Double skin:

The double skin is a type involving the addition of a second glazed envelope, which can create opportunities for maximizing daylight and improving energy performance. It has some advantages such as sound insulation, fire protection, aesthetic view and energy performance.

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(1) Austin Stack, John Goulding and J. Owen Lewis, Shading systems, University College Dublin
(2) Ibid. (8)
(3) Thornton Tomasetti, sports & entertainment, www.ThorntonTomasetti.com/skin

❍ Double skin conception:

According to the source book of the Belgian Building Research Institute [BBRI], (2002), "*An active façade is a façade covering one or several storeys constructed with multiple glazed skins. The skins can be air tighten or not. In this kind of façade, the air cavity situated between the skins is naturally or mechanically ventilated. The air cavity ventilation strategy may vary with the time. Devices and systems are generally integrated in order to improve the indoor climate with active or passive techniques. Most of the time such systems are managed in semi automatic way via control systems.*" (1)

Arons, (*2000*) defines the Double Skin Façade as "*a façade that consists of two distinct planar elements that allows interior or exterior air to move through the system. This is sometimes referred to as a twin skin.*" (2)

Uuttu, (2001) describes the Double Skin Facade as "*a pair of glass skins separated by an air corridor (also called cavity or intermediate space) ranging in width from 20 cm to several meters. The glass skins may stretch over an entire structure or a portion of it. The main layer of glass, usually insulating, serves as part of a conventional structural wall or a curtain wall, while the additional layer, usually single glazing, is placed either in front of or behind the main glazing. The layers make the air space between them work to the building's advantage primarily as insulation against temperature extremes and sound.*" (3)

According to Claessens and DeHerde "*a second skin façade is an additional building envelope installed over the existing façade. This additional façade is mainly transparent. The new space between the second skin and the original façade is a buffer zone that serves to insulate the building. This buffer space may also be heated by solar radiation, depending on the orientation of the façade. For south oriented systems, this solar heated air is used for heating purposes in the wintertime. It must be vented in order to prevent overheating in other periods.*" (4)

❍ Description of double skin façade: (5)

The BBRI, (2002) includes in the source book a satisfactory description of the structure of a double skin façade system. The layers of the façade are described below:

- Exterior Glazing: Usually it is a hardened single glazing. This exterior façade can be fully glazed.

Fig. 1-43: Double skin
Source: Lawrence Berkeley National Laboratory, High-Performance Commercial Building Façades, 2006, p.20

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(1) Belgian Building Research Institute (BBRI) (2002). Source book for a better understanding of conceptual and operational aspects of active facades. Department of Building Physics, Indoor Climate and Building Services, Belgian Building Research Institute. Version no 1. Web address: http://www.bbri.be/activefacades/index2.htm

(2) Arons, D. (2000). Properties and Applications of Double-Skin Building Facades. MSc thesis in Building Technology, Massachusetts Institute of Technology (MIT), USA. Web address: http://libraries.mit.edu/docs

(3) Uuttu, S. (2001). Study of Current Structures in Double-Skin Facades. MSc thesis in Structural Engineering and Building Physics. Department of Civil and Environmental Engineering, Helsinki University of Technology (HUT), Finland. Web address: http://www.hut.fi/Units/Civil/Steel/SINI2.PDF

(4) Claessens, J., & DeHerte, A. Active Solar Heating and Photovoltaics. Solar Energy in European Office Buildings. Energy Research Group, School of Architecture, University College of Dublin, Ireland. Web address: http://erg.ucd.ie/mid_career/mid_career.html

(5) Harris Poirazis, Double skin facades for office buildings, Lund university, 2004

- Interior glazing: Insulating double glazing unit (clear, solar control glazing, etc can be used). Usually this layer is not completely glazed.
- The air cavity between the two panes. It can be totally natural, fan supported or mechanically ventilated. The width of the cavity can vary as a function of the applied concept between 200 mm to more than 2m. This width influence the way that the façade is maintained.
- The interior window can be opened by the user. This may allow natural ventilation of the offices.
- Automatically controlled solar shading is integrated inside the air cavity.
- As a function of the façade concept and of the glazing type, heating radiators can be installed next to the façade.

❍ Classification of Double Skin Façades

Different ways to classify Double Skin Façade Systems. The systems can be categorized by the type of construction, the origin, destination and type of the airflow in the cavity, etc.

- Belgium Building Research Institute's (BBRI) classification of double skin façades based on facade's construction and inter-space ventilation type into: (1) interrupted and continuous type double skin façade **(Fig. 1-44)**, as follows: (2)

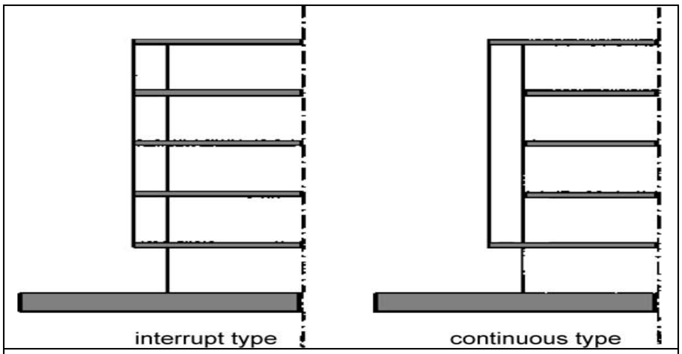

Fig. 1-44: Interrupted and continuous type double skin façade

Source: Zerrin Yılmaz & Ferit C¸ etintas, Double skin fac¸ade's effects on heat losses of office buildings in Istanbul, Energy and Buildings 37 (2005) 691–697, www.elsevier.com/locate/enbuild, p.692

- Climate wall:

This skin merges the climate façade/climate window concepts, the difference between them being the existence or lack of a window division. A climate wall is characterized by an external double glazed pane, an internal single glazed pane or curtain, a mechanical ventilation connection to the building ventilation system, and a small gap (~10 mm) under the interior pane that allows air to flow into the cavity. This arrangement is similar to a box-window.

- Double Skin Façade (DSF):

Buffer: the still air within the cavity acts as a thermal buffer. The cavity is connected to the outdoor air for pressure balance purposes. **(Fig. 1-45)**

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(1) Zerrin Yılmaz, Ferit C¸ etintas, Double skin fac¸ade's effects on heat losses of office buildings in Istanbul, Energy and Buildings 37 (2005) 691–697, www.elsevier.com/locate/enbuild

(2) Expert Guide,Part 2 Responsive Building Elements,IEA ECBCS Annex 44 Integrating Environmentally Responsive Elements in Buildings,Expert Guide – Part 2 Responsive Building Elements Editors: Øyvind Aschehoug, NTNU, Norway Marco Perino, Politecnico di Torino, Italy, November 2009, www.civil.aau.dk/Annex44

Shaft-box: The SB has a similar configuration to the box-window, except that the shaft box discharges exhaust air to a lateral building-height cavity. **(Fig. 1-46)**

Box-window: The façade is divided both vertically and horizontally, forming a box. **(Fig. 1-47, Fig. 1-48)**

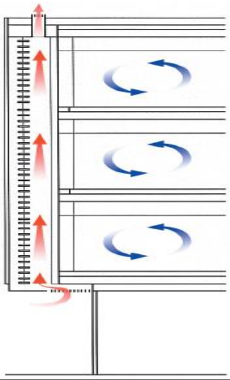

Fig. 1-45: Buffer System
Source: **Terri Meyer Boake, The Tectonics of the Double Skin,** WHAT ARE DOUBLE SKIN FAÇADES AND HOW DO THEY WORK?, p.3

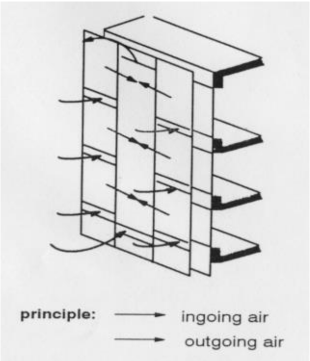

Fig. 1-46: Shaft façade
Source: Sini Uuttu, Study of Current Structures in Double-skin Façades, 2001, p.18

Fig. 1-47: Assembly of box double-skin façade units
Source: Sini Uuttu, Study of Current Structures in Double-skin Façades, 2001, p. 56

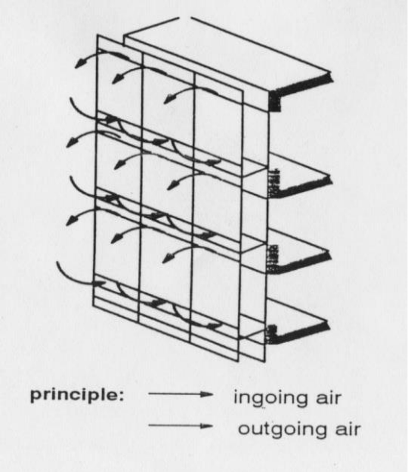

Fig. 1-48: Box double skin façade
Source: Sini Uuttu, Study of Current Structures in Double-skin Façades, 2001, p. 15

Corridor: The Façade is horizontally divided, forming a storey level corridor. Inlet and outlet openings are placed in such a way that the mixing of exhaust air and supply air to the above storey is avoided.

Multi-storey: It is a double skin facade with no cavity partitions. Louvered façades are a particular case of multi-story, in which the external skin is composed of louvers that can be moved from a closed to an open position. In the open position, they no longer act as a second skin.

Swindow: This is an automatically operable window, developed for natural ventilation purposes with the capability of being integrated with the Heat, Ventilation, and Air Condition (HVAC) systems. The basic configuration consists of a horizontally pivoted window that is hinged just above mid-height. When opened, the weight of the window is balanced with a counterweight located at the top of the window. Different constructions with the same working principle are used for exhaust and supply modes.

- The "Domat EMS" building

The "Domat EMS" building is a new construction designed for elderly people **(Fig. 1-50)**. In some houses the south façade is a solar wall with a latent heat storage layer (GLASSX type – **Fig. 1-49**). The façade is transparent and allow passing of daylight, with a light diffusing effect. The construction is made with a series of low emissive layers, that allow an excellent thermal insulation and, at the same time, permit daylight to pass through the façade. To avoid overheating during the summer period, a surface with a plastic transparent prismatic layer is included, this reflects or transmits the solar radiation as a function of the solar incident angle. The phase change material is hydrates salt, contained in plastic modular containers. (1)

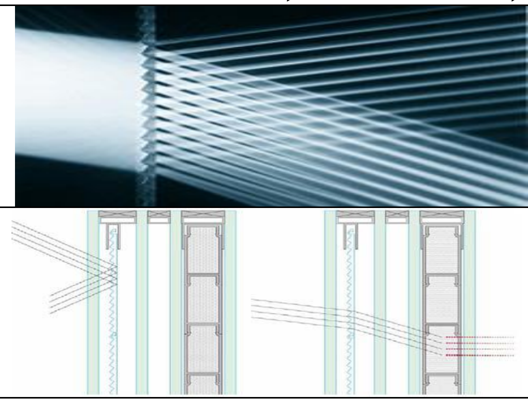

Fig. 1-49: "Domat EMS" building – Particular of the south facing solar wall (GLASSX type).

Fig. 1-50: "Domat EMS" building – Overall picture and some construction details.

Source: Expert Guide,Part 2 Responsive Building Elements,IEA ECBCS Annex 44 Integrating Environmentally Responsive Elements in Buildings,Expert Guide – Part 2 Responsive Building Elements Editors: Øyvind Aschehoug, NTNU, Norway Marco Perino, Politecnico di Torino, Italy, November 2009, www.civil.aau.dk/Annex44, p.157

- The Environmental Engineering firm of Battle McCarthy in Great Britain created a categorization of five primary types (plus sub-classifications) based on commonalities of façade configuration and the manner of operation. These are: (2)

- Category A: Sealed Inner Skin:

subdivided into mechanically ventilated cavity with controlled flue intake versus a ventilated and serviced thermal flue.

- Category B: Open able Inner and Outer Skins:

subdivided into single story cavity height versus full building cavity height.

- Category C:

Open able Inner Skin with mechanically ventilated cavity with controlled flue intake.

- Category D:

Sealed Cavity either zoned floor by floor or with a full height cavity.

(1) Expert Guide,Part 2 Responsive Building Elements,IEA ECBCS Annex 44 Integrating Environmentally Responsive Elements in Buildings,Expert Guide – Part 2 Responsive Building Elements Editors: Øyvind Aschehoug, NTNU, Norway Marco Perino, Politecnico di Torino, Italy, November 2009, www.civil.aau.dk/Annex44

(2) Harris Poirazis, Double skin facades for office buildings, Lund university, 2004

- <u>Category E:</u>

Acoustic Barrier with either a massive exterior envelope or a lightweight exterior envelope.

<u>Ex:</u> The double-skin glazed façade installed in the library building shown in **(Fig. 1-51),** It include a cavity between outer and inner glazed leaves which is ventilated during the summer season. In winter, the cavity is closed and it serves as a buffer zone for the building. In addition to the buffer zone effect, preheated air from the facade cavity is used for supplementary heating for a central ventilation system installed on the top floor of the building. [(1)]

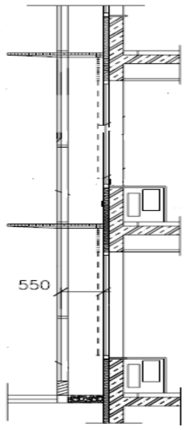

Fig. 1-51: Section in skin

Fig. 1-52: Double-skin glazed façade (Library building)
a) double-skin façade elevation photograph,
b) walkways of the double-skin façade cavity
source: J. Mohelníková & D. Plšek, Energy Evaluation of Single and Double-skin Glazed Facades in Climatic Conditions of Central European Region, 2005, p.3

❍ Advantages of the Double Skin Façade: [(2)]

Energy savings and reduced environmental impacts: In principle, Double Skin Façades can save energy when properly designed. Often, when the conventional insulation of the exterior wall is poor, the savings that can be obtained with the additional skin may seem impressive.

According to Oesterle et al., (2001) "*Significant energy savings can be achieved only where Double Skin Facades make window ventilation possible or where they considerably extend the period in which natural ventilation can be exploited. By obviating a mechanical air supply, electricity costs for air supply can be reduced. This will greatly exceed the savings mentioned before*". [(3)]

According to Arons, (2000), "*energy savings attributed to Double Skin Facades are achieved by minimising solar loading at the perimeter of buildings. Providing low solar factor and low U Value minimises cooling load of adjacent spaces*". [(4)]

Additionally, the operational costs versus construction/embodied energy impacts, so the Gartnet Company claims that the Double Skin Facades save natural resources by reducing energy consumption during the operational life of the building.

[(1)] J. Mohelníková and D. Plšek, Energy Evaluation of Single and Double-skin Glazed Facades in Climatic Conditions of Central European Region, Faculty of Civil Engineering Brno University of Technology Veveri 95, 602 00 Brno CZECH REPUBLIC
[(2)] Harris Poirazis, Double skin facades for office buildings, Lund university, 2004
[(3)] Oesterle, E., Lieb, R-D., Lutz, M., & Heusler, W. (2001). Double SkinFacades – Integrated Planning. Prestel Verlag: Munich, Germany
[(4)] Arons, D. (2000). Properties and Applications of Double-Skin Building Facades. MSc thesis in Building Technology, Massachusetts Institute of Technology (MIT), USA. Web address: http://libraries.mit.edu/docs

1-2-3-b- Multiple- skin:

Multiple-skin facades model are used in a whole building energy simulation to indicate the importance of a correct inlet temperature on the energy performance. Multiple-skin facades (MSFs) are regularly presented as being valuable solutions to put up with the desires of modern architecture. MSFs consist of two panes with a cavity in between, through which airflows by means of natural or mechanical ventilation. In the cavity, usually a shading device is provided. Generally, distinction is made between naturally and mechanically ventilated MSFs.

Extensive literature on MSF typologies can, amongst others, be found in The results of an energy performance assessment of multiple-skin facades are sensitive to a variety of parameters such as :[(1)]

- The correct application and accurateness of the climatic boundary conditions and the material characteristics.
- The accurateness and complexity of the MSF models.
- The accurateness of the energy simulation program and erroneous input by the program user.

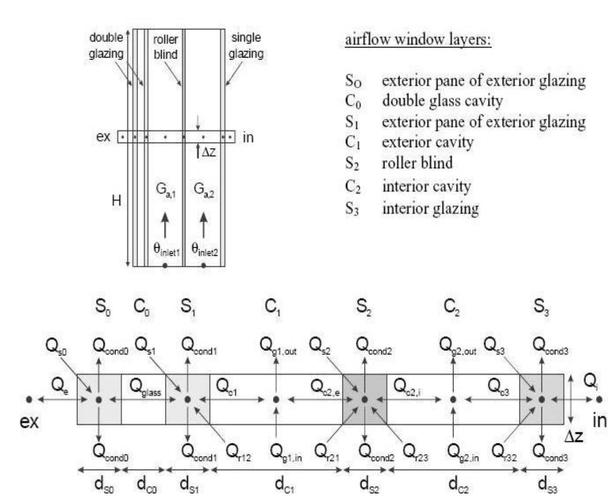

Fig. 1-53: Multiple-skin
Source: Dirk Saelens, Staf Roels, Hugo Hens, The inlet temperature as a boundary condition for multiple-skin facade modeling, Energy and Buildings 36 (2004) 825–835, www.elsevier.com/locate/enbuild

1-2-3-c- Sensitive skin: [(2)]

Sensitive skin is a large-area, flexible array of sensors with data processing capabilities, which can be used to cover the entire surface of a machine or even a part of a human body. Depending on the skin electronics, it endows its carrier with an ability to sense its surroundings via the skin's proximity, touch, pressure, temperature, chemical/biological, or other sensors.

❍ **Sensitive skin concept:**

Sensitive skin devices will make possible the use of unsupervised machines operating in unstructured, unpredictable surroundings—among people, among many obstacles, outdoors on a crowded street, undersea, or on faraway planets. Sensitive skin will make machines "cautious" and thus friendly to their environment. This will allow us to build machine helpers for the disabled and elderly, bring sensing to human prosthetics, and widen the scale of machines' use in service industry. With their ability to produce and process massive data flow, sensitive skin devices will make yet another advance in the information revolution.

The concept of sensitive skin, a prototype of a sensitive skin module is shown in **(Fig. 1-54)**. The module contains active infrared sensor pairs (LED detector), each of which can sense objects within a narrow cone at a distance up to about 20 cm.

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(1) Dirk Saelens, Staf Roels, Hugo Hens, The inlet temperature as a boundary condition for multiple-skin facade modeling, Energy and Buildings 36 (2004) 825–835, www.elsevier.com/locate/enbuild
(2) Vladimir J. Lumelsky, Fellow, IEEE, Michael S. Shur, Fellow, IEEE, and Sigurd Wagner, Fellow, IEEE, Sensitive Skin, IEEE SENSORS JOURNAL, VOL. 1, NO. 1, JUNE 2001

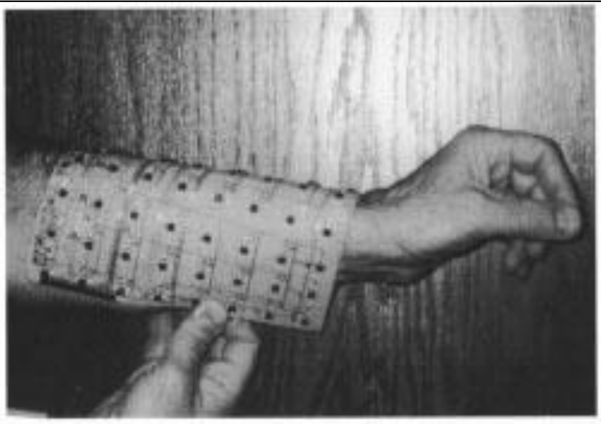


Fig. 1-54: Sensitive skin module: 8*8 = 64 infrared sensor pairs (LED's and detectors); the distance between neighboring pairs is 25 mm; surface mounting technology; Kapton substrate. (V. Lumelsky, Robotics Laboratory, University of Wisconsin-Madison.)
Source: Vladimir J. Lumelsky, Fellow, IEEE, Michael S. Shur, Fellow, IEEE, and Sigurd Wagner, Fellow, IEEE, Sensitive Skin, IEEE SENSORS JOURNAL, VOL. 1, NO. 1, JUNE 2001, p. 42

- **Description of sensitive skin:**

Sensitive skin systems require a fundamental turnaround in design paradigm. Today the designer adds sensors to a machine as needed, analyzing carefully how many sensors are required and in which places. There is a good reason behind this approach— individual sensors and their electronic control are relatively expensive; adding components decreases system reliability.

More than one sensor type may be necessary—proximity, touch, pressure, temperature, and chemical/biological sensing are a few examples. The functionality needed is quite generic, and so a few types of skin will cover a wide spectrum of applications. Such examples: the Intel's Pentium microprocessor has much more functional power than any of us needs, but—being mass-produced, it becomes an economically viable solution in a huge number of applications.

- **Requirements of sensitive skin devices:**

Four groups of research issues must be addressed in order to develop sensitive skin: Skin Materials, Sensing Devices, Signal and Data Processing, and Applications. Consider them one by one. [(1)]

- Devices skin Materials:

Sensitive skin material (substrate) holds embedded sensors and related signal processing hardware. It needs to be flexible enough for attaching it to the outer surfaces of machines with moving parts and flexible joints. The skin must stretch, and desirably shrink and wrinkle the way human skin does, or to have other compensating features. Otherwise, machine parts may become "exposed" as they move relative to each other. For example, Kapton material, by the Dupont Corporation, can hold electronics, can bend, but cannot stretch. Stretching is especially challenging, as it may require materials that have never been used in printed circuits. Wiring must keep its integrity when sensitive skin is stretched or wrinkled. This requirement calls for novel wire materials, e.g., conductive elastomers -flexible materials whose electrical conductivity varies- or vessels carrying conductive liquid or novel ways of wire design with traditional materials, such as helical, stretchable wires.

- Sensing Devices

Sensitive skin components have to be deployed in two-dimensional (2-D) or even quasi-three-dimensional (3-D), layered) arrays of sufficiently high density. A representative model would be a piece of skin of 1*1 m^2 , with sensors spread

[(1)] Vladimir J. Lumelsky, Fellow, IEEE, Michael S. Shur, Fellow, IEEE, and Sigurd Wagner, Fellow, IEEE, Sensitive Skin, IEEE SENSORS JOURNAL, VOL. 1, NO. 1, JUNE 2001 uniformly at a pitch of 1*1 mm, with the total of 1 million sensors. This model immediately points to the need to mass-produce sensitive skins as large-area integrated circuits. Smaller arrays may be of use as well: the key feature is that the skin should allow, by itself or with appropriate data processing, to identify with reasonable accuracy the points of the machine's body where the corresponding sensor readings take place.

Ideally, sensors and their signal processing hardware should be spread within the array so as to allow cutting it to any shape (disc, rectangle, an arbitrary figure) without losing the entire sensing and control functionality. This suggests interesting studies in hardware architecture. Any sensing modalities including proximity or tactile, discrete or continuous, are acceptable.

Sensor arrays with special or unique properties are of much interest, for example a cleanable and washable skin for "dirty" tasks in nuclear/chemical waste site applications; radiation-hardened skin for nuclear reactor and space applications; and skins that can smell, taste, or react to ambient light. The ability to measure distance to objects would be a great advantage for enabling dexterous motion of the machine equipped with the skin. For self-diagnosis and reliability, "self-sensing" ability of the skin is highly desirable; this may include sensing of contamination, dust, chemical substances, temperature, radiation on its surface, as also detection of failure of individual skin sensors and an ability to work around failed areas.[(1)]

- Signal/Data Processing:

The sampling rates of today's typical computer-controlled moving machines should be in the range of 30–50 Hz. Taking 50 Hz as an example, within the available 20 ms sampling period all skin sensors must be polled, information from those sensors that sense objects passed to the machine control and analyzed, and motion commands for the next step sent to the drive motors and executed. With possibly millions of sensors per 1 m^2 of the machine's surface, this requires a very high data bandwidth and sophisticated data processing algorithms. Large numbers of discrete sensors on the sensitive skin make it advantageous to use lower level data processing locally at each sensor. This can include analog-to-digital processing, sensor calibration, individual sensor based distance measurements, etc., and calls for highly parallel processing and efficient software architectures.

Ex: Sensitive skin, Kinetic Systems: [(2)]

Acclimation requires systems to change which often requires the use of moving parts, something that is typically avoided in building systems if possible. The ability to heal is crucial to the success of moving parts within biological systems because overtime the friction and stresses induced through motion causes wear. At this point in time, buildings do not have the ability to heal themselves, making it necessary for maintenance considerations to be made during the design of kinetic systems.

The Hyposurface, designed by Mark Goulethorpe's dECOi atelier, is a media wall that responds to user interaction, audio, and lighting, to create a dynamic wall for displaying 3D surfaces, patterns, and movements. The outer skin is composed of a repeated grid of triangular metal components whose position is adjusted perpendicular to the surface through a series of pneumatic actuators. The actuators of the system were chosen for their ability to limit friction between parts, allowing

(1) Vladimir J. Lumelsky, Fellow, IEEE, Michael S. Shur, Fellow, IEEE, and Sigurd Wagner, Fellow, IEEE, Sensitive Skin, IEEE SENSORS JOURNAL, VOL. 1, NO. 1, JUNE 2001

(2) Scott Crawford, A Breathing Building Skin: Designing with the Concepts of Biological Adaptation, Master of Science in Design Computing, University of Washington, 2010

less energy to be used during operation, while prolonging the life of the actuators by limiting wear. The system is assembled from an array of modular units which contain all the elements of the system, structure, mechatronics, and skin.

The method of integration between these systems potentially makes it difficult to extract and repair a single element of the system because rather than the layering of the system's elements being stratified they are interwoven. If more frequent maintenance is required of kinetic systems then their layering should acknowledge the life cycle hierarchy of the individual elements. Elements that need to be replaced or adjusted more often would ideally be located to facilitate ease of maintenance as opposed to elements such as the structure, which require less attention if any over the life of the entire system.

Another dynamic facade, the Pixel Skin 2.0, takes a similar approach to the Hyposurface of using an overall structure onto which the subsystems are attached, but in this case, the density of the layering in decreased, allowing for more direct access to all the subsystems. The elegance of this system gives more direct access to repairing the system particularly the Shape Memory Alloy actuators (SMA) which are used to create motion within the system. SMA actuators are a combination of nickel and titanium which has the property of being able to be bent, twisted and deformed, but return to a "remembered" shape when an electrical current is applied.

These actuators are not as powerful as the pneumatic actuators used in the Hypo surface,and for this reason the Pixel Skin had to be created as a lightweight system. The advantage of these actuators is that they are silent, frictionless, and have no moving parts. To be able to use this type of actuator the project had to consider the material's limits and capabilities.

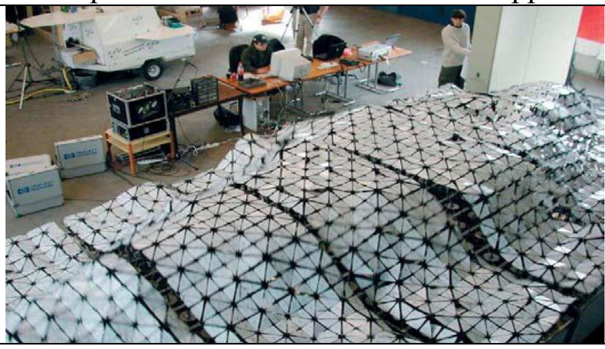


Fig. 1-55: Hyposurface by dECOi atelier
Source: Scott Crawford, A Breathing Building Skin: Designing with the Concepts of Biological Adaptation, Master of Science in Design Computing, University of Washington, 2010, p.10

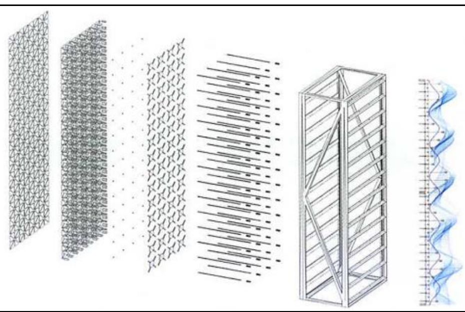


Fig. 1-56: Exploded axon of the mechanical systems of the Hyposurface by dECOi atelier
Source: Scott Crawford, A Breathing Building Skin: Designing with the Concepts of Biological Adaptation, Master of Science in Design Computing, University of Washington, 2010, p10

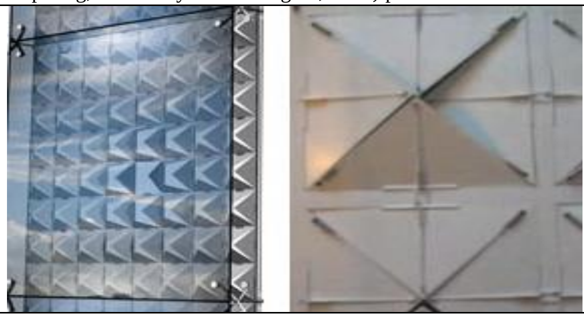


Fig. 1-57: Pixel Skin 2.0 by orangeVoid
Source: Scott Crawford, A Breathing Building Skin: Designing with the Concepts of Biological Adaptation, Master of Science in Design Computing, University of Washington, 2010, p.11

<u>Ex</u>: Sensitive skin, Responsive Systems :(1)

Systems with moving parts require a signal to tell them the correct time to respond. This can be as simple as flipping a switch to turn on a light bulb or a chain of events can lead up to the signal. Sensors give a system the ability to sense environmental changes

(1) Scott Crawford, A Breathing Building Skin: Designing with the Concepts of Biological Adaptation, Master of Science in Design Computing, University of Washington, 2010

so the system's behavior can change even without a person present. A single sensor could be used to control an entire system when the actuation threshold is reached, or multiple sensors might be used with a system that has a larger number of individual elements. This decision influences how specific the response of the system can be to changes in the environment. If each element has its own set of sensors then it can act independently of the other elements.

There is also the issue of how quickly and how often the system responds. The mobility of animals allows them to constantly react to changes within their environment, but this constant movement requires larger amount of energy than the more gradual response of plants. The design of any active system should take into consideration how often a response is necessary. A balance must be reached between the improved performance of a system and the energy required to attain that performance increase.

- **Advantages of Sensitive skin:[(1)]**

Sensitive skins will reduce the need for low value-added services by vastly expanding the reach of automated machinery. They will bring the kind of productivity gains to service industries that integrated circuits have brought to manufacturing. Machines that by virtue of their size, power, and operation of their moving parts can present danger to the surrounding objects or be damaged by them will be able to operate safely in their environment when equipped with the sensitive skin. For example, with the help of the sensitive skin covering its body, a semi-autonomous machine helper in a senior citizen's house or a robot probe in a deep space experiment will be carrying out its function without jeopardizing its own safety and that of the surrounding objects. No such machinery exists today. Automation for unstructured environments can completely transform the face of machine automation in the 21st Century. [(1)]

- Environment-friendly technology: For the first time in history, machines will be endowed with a capacity to be careful. By its very nature, sensitive skin will contribute in a dramatic way to the reversal of the well-known negative impact of machines on our environment, across a wide spectrum of natural and man-made settings.
- The role of computer revolution and office automation in the growth of economy and improved efficiency, which in turn affects the quality of life. Note the difference: while unstructured machine automation will have a similar effect on the economy, its use in service industry will have a direct impact on the quality of human life. Biology and medical science thrive to prolong human life; the unstructured machine automation will constitute a systematic effort by engineers to improve the quality of life.
- Acclimation is an integral function of building systems. A simple example is the ability for a building's skin to open or close such as with windows to control the flow of air and interior temperature. As technology has developed the means for acclimation has become more sophisticated.

Conclusion:

From this chapter we conclude two main points, as following:

1- In general, building skin means building façade with more comfortable with environment condition and saving energy.
2- Types of façade system depend on level of applied technology.

[(1)] Vladimir J. Lumelsky, Fellow, IEEE, Michael S. Shur, Fellow, IEEE, and Sigurd Wagner, Fellow, IEEE, Sensitive Skin, IEEE SENSORS JOURNAL, VOL. 1, NO. 1, JUNE 2001

Introduction:

The concept of re-skin appeared mostly 10 years ago by Zerofootprint•. According to its definition, re-skins mean" The current buzzword is re-skinning", which takes re-cladding way beyond a simple facelift. The skin or envelope of the building is obviously a critical piece in the search for energy efficiency. So the question becomes how make the existing buildings and their skin more livable as well as cheaper to operate.

For example, adding a new thermal cover can help reverse concrete's tendency to trap heat in the summer and release it during the winter. Nevertheless, more than just adding insulation, an integral part of a re-skinning project can also include efficient windows, better day lighting, incorporating solar, and new mechanical systems, as well as an enhanced appearance.

Re-skinning can also be used to house up-to-date pipes, ducts, and/or cables. Running these up the side of a building with a new 'skin' hiding the resulting mess, can be much more cost effective than installing them in more conventional ways.

Some projects, particularly glass re-cladding of masonry buildings, are not greeted with universal acclaim. Critics often bemoan the loss of distinctive and historic architectural features. Re-skinning can also sometimes be done as cheaply as possible with no regard for esthetics.

2-1- The aim of re-skin and advantages:

It is clear, that any solution to climate change will by definition have to be a solution to the built space in our cities. Rebuilding is not an option and traditional retrofitting is inadequate, and invasive. There is however another option—re-skinning. Usually necessary because a thermal barrier needs to be created to gain any significant energy efficiency, in general re-skinning and retrofitting investment on a global scale produce aim to:[(1)]

- Research and development of new materials, processes, and manufacturing technologies related to building retrofits;
- Infrastructure investment including large-scale energy-savings projects like district energy systems, solar arrays, geothermal, etc.;
- Millions of jobs globally to retrofit the thousands and thousands of buildings that are candidates for this type of renewal;
- Education and job training for a new generation of students required to support this expanding industrial sector.

• **Re-skinning has many advantages such as:**[(2)]

- □It can be used to hide a cheap retrofit;
- □It is potentially non-invasive;
- It can make a human building into a handsome green role model;
- It can be used to engineer an energy reduction of as much as 70%;
- □Re-skinning can be smart — software, solar, thermal, media, vegetation etc

• Zerofootprint is an organization dedicated to a mass reduction in global environmental impact.

(1) http://thezeroprize.com/images/ZFP_ReSkinning_Winners_2010.pdf , Zerofootprint,Re-Skinning Awards

(2) http://zerofootprint.theblogstudio.com/zerofootprint_templateFiles/images/reskin-our-cities.pdf, re-skin for our city, zerofootprint, 2009

Re-Skinning is to advance the state-of-the-art in retrofitting such built spaces through better design and improved materials and technology, thus creating retrofitting systems that can be scaled to a large number of buildings and deployed globally.

2-2- Technologies of improving skin for existing buildings:

To deal with the skin of existing building ,it is depending on the type of façade according to load bearing, so that it divides into two categories, load-bearing façade and non load-bearing façade.

2-2-1- Tech. applied for load-bearing façade: (1)

This façade cannot be removed or changed, so that dealing with it occur by windows and existing openings while the walls can be cladded by light materials. Generally, sub-tech of building skin system is suitable.

2-2-1-a- System of window:

- Single glazing:

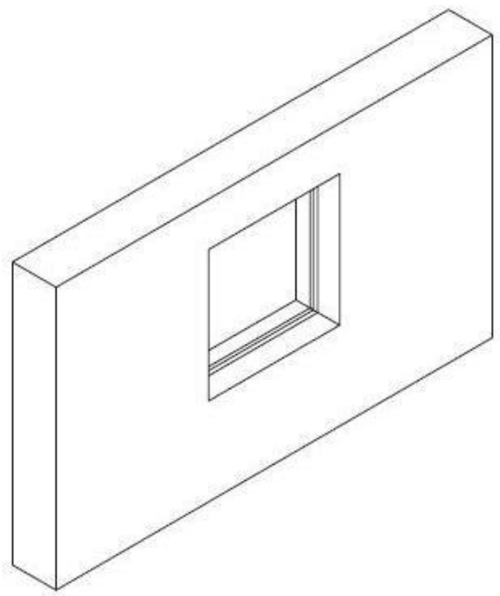


Fig.2-1: Single glazing Single glazing was used in apertures to provide natural lighting, to allow views out from inside the building and vice versa, and to prevent heat loss from the building. Various techniques were developed to join initially available small panes of glass so that larger openings could be filled. Source: Ulrich Knaack, Tillmann Klein, Marcel Bilow, Thomas Auer, Façades Principles of Construction, Medialis, Berlin, 2007. p. 15	**Fig.2-2:Weienhof Siedlung, Stuttgart, 1927, Ludwig Mies van der Rohe, Le Corbusier, Walter Gropius** Single glazing in steel window frames in a building complex at the Weienhof Siedlung in Stuttgart. The windows are positioned on the outside of the wall apertures to produce a flat façade. Source: Ulrich Knaack, Tillmann Klein, Marcel Bilow, Thomas Auer, Façades Principles of Construction, Medialis, Berlin, 2007. p. 15

(1) Ulrich Knaack, Tillmann Klein, Marcel Bilow, Thomas Auer, Façades Principles of Construction, Medialis, Berlin, 2007

- Box window:

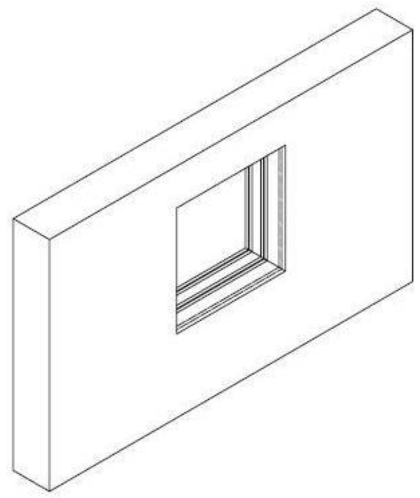


Fig.2-3:Box window

A box window is produced when a second pane of glass is installed to meet seasonal conditions. Depending on the temperature, the user can decide how many panes should be opened.

Source: Ulrich Knaack, Tillmann Klein, Marcel Bilow, Thomas Auer, Façades Principles of Construction, Medialis, Berlin, 2007. p. 20

Fig.2-4:Loggias in façade, Bilbao

These loggias built in front of the actual windows may be regarded as a variant of the box window: in spring and autumn, these spaces can be used as an additional room while in winter they are closed off to act as an extra climatic buffer.

Source: Ulrich Knaack, Tillmann Klein, Marcel Bilow, Thomas Auer, Façades Principles of Construction, Medialis, Berlin, 2007. p. 20

- Insulated glazing:

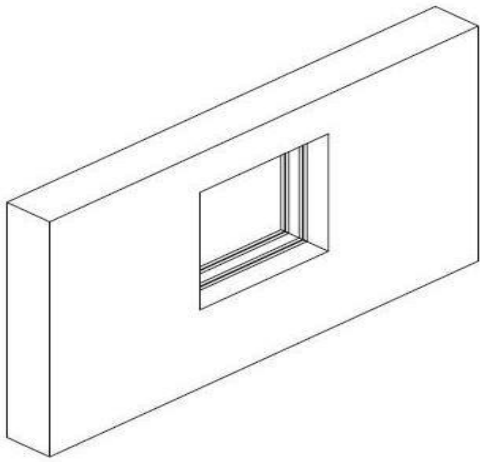


Fig.2-5:Insulated glazing

Two panes of glass permanently joined together to give insulated or double glazing a more effective barrier between the internal and external environments.

Source: Ulrich Knaack, Tillmann Klein, Marcel Bilow, Thomas Auer, Façades Principles of Construction, Medialis, Berlin, 2007. p. 21

Fig.2-6:Fondation Cartier, Paris, Jean Nouvel, 1994

The façade consists of single glazing on the left and double glazing on the right

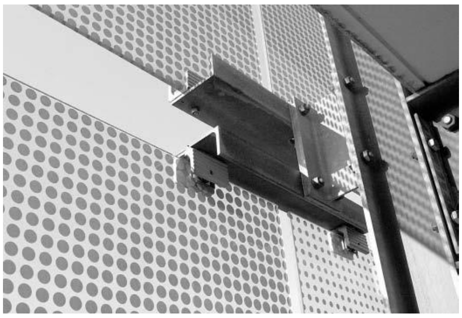
Source: Ulrich Knaack, Tillmann Klein, Marcel Bilow, Thomas Auer, Façades Principles of Construction, Medialis, Berlin, 2007. p. 21.

- Fritted glass

Fig.2-7:Fritted glass

Using fritted glass is a simple method of sun protection. It provides great design flexibility for the façade. The image shows a façade with several densely fritted glass panes.

Source: Ulrich Knaack, Tillmann Klein, Marcel Bilow, Thomas Auer, Façades Principles of Construction, Medialis, Berlin, 2007. p.83



2-2-1-b- Cladding the wall

- Slate covering

Fig.2-8:Slate covering

A slate covering is effective at keeping wind-driven rain out of the building fabric, despite the gaps between neighboring slates, because of the overlapping manner in which the slates are laid. The top slate is always laid over the one below it with a certain overlap and then fixed on to the wall.

Source: Ulrich Knaack, Tillmann Klein, Marcel Bilow, Thomas Auer, Façades Principles of Construction, Medialis, Berlin, 2007. p.64

Fig.2-9:Use of cover strips in pitched roof construction

When plank sheathing is used in the construction of a pitched roof, a cover strip is screwed over each join between successive planks so that even if the planks warp no open joints are produced.

Source: Ulrich Knaack, Tillmann Klein, Marcel Bilow, Thomas Auer, Façades Principles of Construction, Medialis, Berlin, 2007. p.65

- Cladding the wall (Masonry cladding):

Fig.2-10:Masonry cladding taken from a housing development in Middelburg, the Netherlands

This double-skin construction consists of a concrete load-bearing layer with thermal insulation properties and a separate masonry weatherproof layer. The masonry is held in place by tie rods, which pass through the concrete layer. Following a procedure that is common in the Netherlands, the window frame is mounted before the masonry wall is built, which allows the latter to be adapted to suit the dimensions of the window. A waterproof membrane is mounted in the wall above the window, to allow water that has got into the wall to drain off again.

Source: Ulrich Knaack, Tillmann Klein, Marcel Bilow, Thomas Auer, Façades Principles of Construction, Medialis, Berlin, 2007. p.58

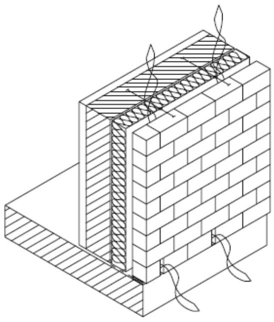


Fig.2-11:Sketch showing principle of masonry cladding

The load-bearing layer (here a concrete wall that also provides the thermal insulation) and the masonry weatherproofing layer are separated by an air cavity. Slits in the masonry act as air inlets. An impermeable membrane inserted into the wall is brought out near the bottom of the façade to allow water that got into the weatherproof layer to drain off.

Source: Ulrich Knaack, Tillmann Klein, Marcel Bilow, Thomas Auer, Façades Principles of Construction, Medialis, Berlin, 2007. p.58

2-2-1-c- Louver:

- Fixed louvers

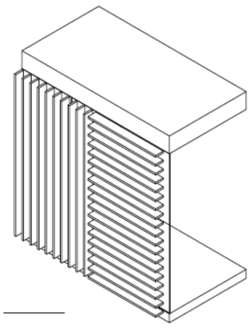


Fig.2-12:Fixed louvres

Fixed louvres can be arranged vertically as well as horizontally. Depending on the configuration the louvres can be adjusted by angling to improve shading. The method of cleaning the glass surfaces behind the louvres needs to be considered during planning.

Source: Ulrich Knaack, Tillmann Klein, Marcel Bilow, Thomas Auer, Façades Principles of Construction, Medialis, Berlin, 2007. p.81

- Venetian blinds

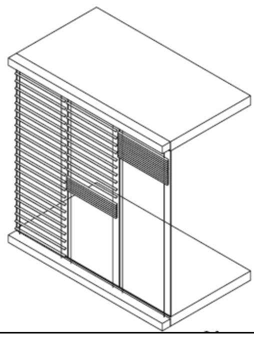


Fig.2-13:Venetian blinds

Venetian blinds are used extensively as sun protection .The market offers numerous systems of varying colours, types of construction and dimensions. Some Venetian blinds include a separate upper area with shallower louvre positions, allowing the sunlight to be directed deep into the room.

Source: Ulrich Knaack, Tillmann Klein, Marcel Bilow, Thomas Auer, Façades Principles of Construction, Medialis, Berlin, 2007. p.82

- Horizontal sliding shades	- Roller blinds

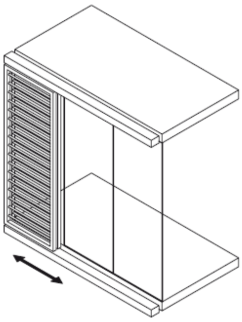



Fig.2-14:Horizontal sliding shades Horizontal sliding shades can be used in low-rise buildings. They can be motorised or controlled by hand. A wide range of infill materials such as metal mesh, grids, wooden slats or textiles offer many design options.	**Fig.2-15:Roller blinds** Textile roller blinds can be moved up and down on cable guides .The type of fabric used determines the degree of visual contact to the outside.

2-2-2- Tech. applied for non load-bearing façade: (1)

This façade can be removed or changed, so that dealing with it by replacing the existing wall with high-tech façade is possible. In general, depend on double skin.

- Double façade

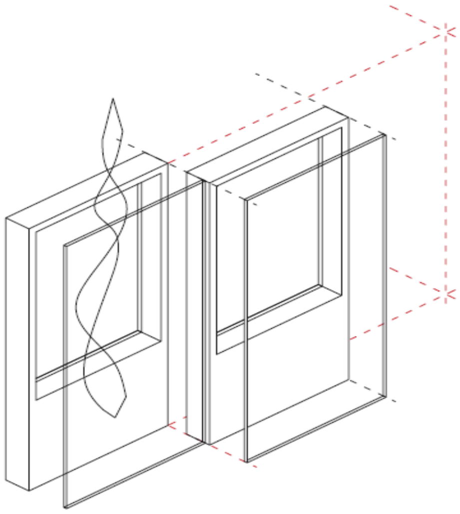


Fig.2-16:Double façade A double façade is obtained by adding an extra layer of glazing outside the façade to provide the building with ventilation or additional soundproofing. This system may be realised in various ways, depending on the functions desired and the requirements made on the façade. Source: Ulrich Knaack, Tillmann Klein, Marcel Bilow, Thomas Auer, Façades Principles of Construction, Medialis, Berlin, 2007. p. 29	**Fig.2-17:Single and double façade: Triangle Building, Cologne, Gatermann + Schossig, 2006** An example of the façade for a high-rise building offering different functions depending on the requirements. The single façade may be seen on the right of the picture, while on the left an additional layer of glazing has been added to create a double façade with a ventilated space between the two layers. Source: Ulrich Knaack, Tillmann Klein, Marcel Bilow, Thomas Auer, Façades Principles of Construction, Medialis, Berlin, 2007. p. 29

(1) Ulrich Knaack, Tillmann Klein, Marcel Bilow, Thomas Auer, Façades Principles of Construction, Medialis, Berlin, 2007

- Second-skin façade
- Box-window façade:

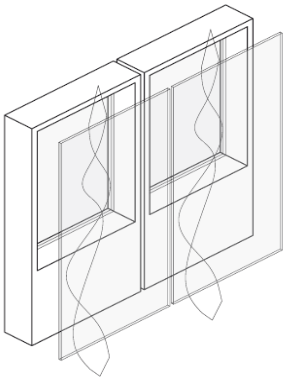
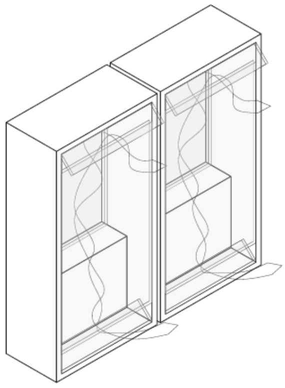
	

Fig.2-18:Second-skin façade A second-skin façade is produced by adding an external layer of glass to the inner façade. This has the advantage of being easy to construct but the disadvantages of limited control possibilities on the interior and the attendant risk of overheating. Source: Ulrich Knaack, Tillmann Klein, Marcel Bilow, Thomas Auer, Façades Principles of Construction, Medialis, Berlin, 2007. p. 30	**Fig.2-19:Box-window façade** Storey-high box windows with ventilation flaps at top and bottom offer the possibility of individual control Source: Ulrich Knaack, Tillmann Klein, Marcel Bilow, Thomas Auer, Façades Principles of Construction, Medialis, Berlin, 2007. p. 31
Fig.2-20:Box-window and second-skin façade On the left we see a window element added on the inside to form a box-window façade, while on the right an early example of a second-skin façade may be seen. This has been created by adding an additional layer of glass outside the basic façade. Source: Ulrich Knaack, Tillmann Klein, Marcel Bilow, Thomas Auer, Façades Principles of Construction, Medialis, Berlin, 2007. p. 30	

- Corridor façade:

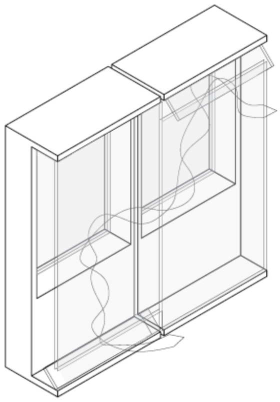


Fig.2-21:Corridor façade Corridor façades connect neighbouring double façade elements in order to permit staggered ventilation of the space between the two skins Source: Ulrich Knaack, Tillmann Klein, Marcel Bilow, Thomas Auer, Façades Principles of Construction, Medialis, Berlin, 2007. p. 31.	**Fig.2-22:Stadttor Building, Düsseldorf, Petzinka Pink und Partner, 1998** An early example of a corridor façade: the storey high façade elements have rotary timber baffles on the inside and a continuous glass skin on the outside. Source: Ulrich Knaack, Tillmann Klein, Marcel Bilow, Thomas Auer, Façades Principles of Construction, Medialis, Berlin, 2007. p. 31

- Shaft-box façade:

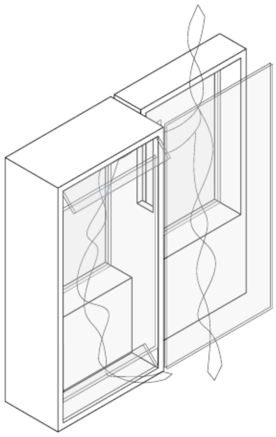


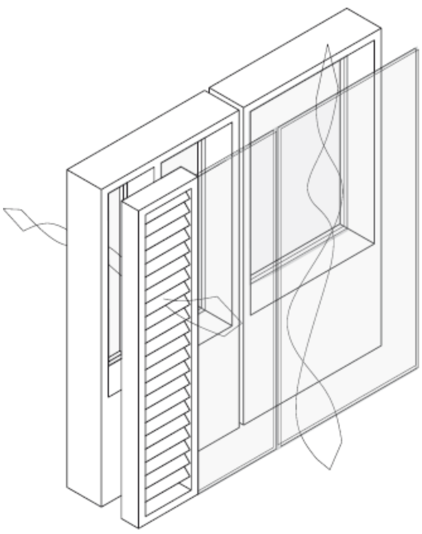
Fig.2-23:Shaft-box façade

Shaft-box façades, featuring box windows that release their exhaust air into a shaft that extends over several floors, offer a double façade system that requires complex installation but is highly effective.
Source: Ulrich Knaack, Tillmann Klein, Marcel Bilow, Thomas Auer, Façades Principles of Construction, Medialis, Berlin, 2007. p. 32

Fig.2-24:Photonics Centre, Berlin, Sauerbruch Hutton Architects, 1998

Early variant of the shaft-box façade, consisting of vertically separated ventilation shafts in the plane of the façade, which merge at the top for effective ventilation of the space enclosed by the double façade.
Source: Ulrich Knaack, Tillmann Klein, Marcel Bilow, Thomas Auer, Façades Principles of Construction, Medialis, Berlin, 2007. p. 32

- Alternating façade:



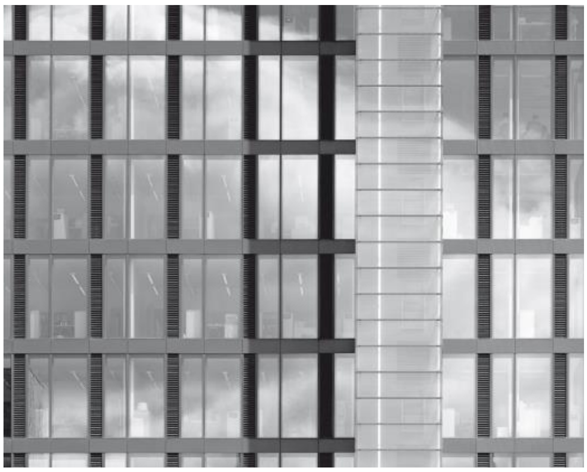


Fig.2-25:Alternating façade

In alternating façades, a second skin is added locally to a single-skin façade construction to give the benefits of the buffering effect of the double façade in the areas affected.
Source: Ulrich Knaack, Tillmann Klein, Marcel Bilow, Thomas Auer, Façades Principles of Construction, Medialis, Berlin, 2007. p. 33

Fig.2-26:Debitel Headquarters, Stuttgart, RKW Architektur + Stdtebau, 2002

RKW worked together with Transsolar Climate Engineering to develop an alternating façade for the Debitel head offices in Stuttgart. Different parts of the façade in this building were built as single-skin façade with a permanent louvre layer, single-skin façade with a louvre layer behind it and double façade.
Source: Ulrich Knaack, Tillmann Klein, Marcel Bilow, Thomas Auer, Façades Principles of Construction, Medialis, Berlin, 2007. p. 33

- Integrated façade:

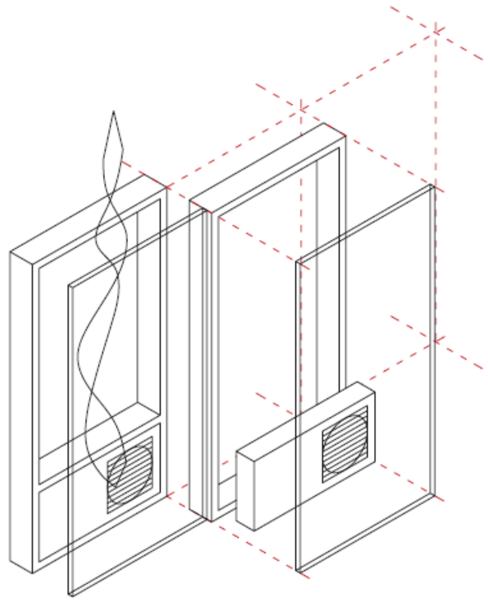


Fig.2-27:Integrated façade

The integrated façade incorporates not only ventilation functions as described above but also active environmental-control or lighting components.

Source: Ulrich Knaack, Tillmann Klein, Marcel Bilow, Thomas Auer, Façades Principles of Construction, Medialis, Berlin, 2007. p. 34

Fig.2-28:Post Tower, Bonn, Helmut Jahn, 2003

Helmut Jahn worked together with Transsolar Climate Engineering to develop one of the first hybrid façades for the Post Office Tower project in Bonn. Environmental-control modules built into the top part of the façade could be controlled locally as individual units.

Source: Ulrich Knaack, Tillmann Klein, Marcel Bilow, Thomas Auer, Façades Principles of Construction, Medialis, Berlin, 2007. p. 34

- History of adaptive façades:

Fig.2-29:Historic half-timbered house

The windows employ timber folding shutters to adapt to changing weather conditions. The layer of air between the glass and the folding shutters serves as thermal insulation

Source: Ulrich Knaack, Tillmann Klein, Marcel Bilow, Thomas Auer, Façades Principles of Construction, Medialis, Berlin, 2007. p. 87

Conclusion:

Technologies of improving skin for existing buildings depend on distribution of load bearing on facade (load-bearing or non load-bearing), and deal with openings and solid parts of façade.

Introduction:

The currant chapter aims to analyze some examples about building skin and re-skin, which help in determine suitable system of building skin to re-skin existing building. The analysis of examples include architect name, location of building, and project summary.

3-1- Building skin example:

Building skin examples include single skin, double skin, and sensitive skin projects.

3-1-1- Single skin project:

3-1-1-a- Project name: Print Media Academy. [(1)]

- **Architect:** Schroder Architeckten and Studio Architekten Bechtloff
- **Location:** Heidelburg, Germany
- **Façade Type**: two types of glass façade systems, single skin for atrium and double skin for office and lecture and laboratory spaces.

Project summary:

Two types of glass façade systems. Both systems are managed through a central building control that monitors the buildings interior, exterior and weather conditions, as well as user variables. The first facade system type, relates to the atrium, the second to the office and lecture and laboratory spaces.

The atrium offers a large common space, extending to the roof, connecting the building with elevators and escalators, which extends up to the roof. Contained with in the atrium is two large cylinders that contain conference spaces. The office and lecture rooms are accessed from the atrium space at each floor by a catwalk. These rooms have floor to ceiling glazing at both the exterior facade as well as at the atrium side, and are divided by wall partitions from each other.

Fig. 3-1: Atrium Facade of Print Media Academy (office and conference centre)
Source: www.journalist.heidelberg.com

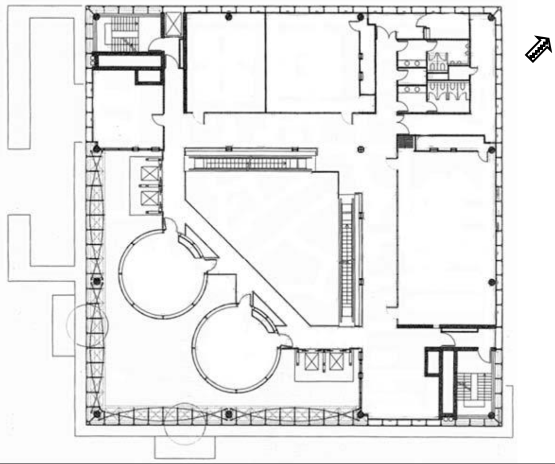


Fig. 3-2: Typical Floor Plan
Source: www.journalist.heidelberg.com

- **Façade construction**:

The method in which this project is developed generally treats each facade equally, with the exception of the atrium. This design consideration gives the building a monolithic presence.

The general orientation of the building at first glance seems not relevant. The atrium is located at the south and western corner. This serves two functions; the

(1) Terri Boake, Case Study Two"Print Media Academy", 2001

first is symbolic since it creates an appropriate entry presence to the street and its relation to the broader context of the city. The second serves to aid in the building environmental systems maintenance.

Locating the atrium to the southwest corner of the building is beneficial, since this allows the atrium to be enclosed by a single skin system of glazing. By placing the atrium away from the eastern facade, it delays solar heat gain that would come with the morning sun. At noon the sun would be sufficiently high enough that solar heat gain would be minimal, since the majority of solar heat is reflected by the glazing. The afternoon and evening solar effect would be brief and minimal, also building occupation would generally decrease as the day passed. Any solar heat gain is controlled utilizing a series of glazed strips that is operable by computer to manage the atrium environment. The glazed upswing units allow for variable exterior and interior air exchange, that result in climate control and fresh air change.

The office component of the building facade utilizes a more complex system of cross ventilated double skin glazed unit. The box unit comprised of a single glass pane at the exterior side and a seal double glass pane on the inner side. Between the two panes is a 46 cm air space with a metallic adjustable blind. This design with a few other components offers the user several options, that is complimented with a central building control that manages the general building environment.

The central building control deals almost exclusively with the maintaince of temperature control.

The solar heat gain is managed in two methods. The first system is the cross ventilation control that moderates the buffer space between the outer and inner glazing. This is done by opening sets of upswing glass louvers to allow outside

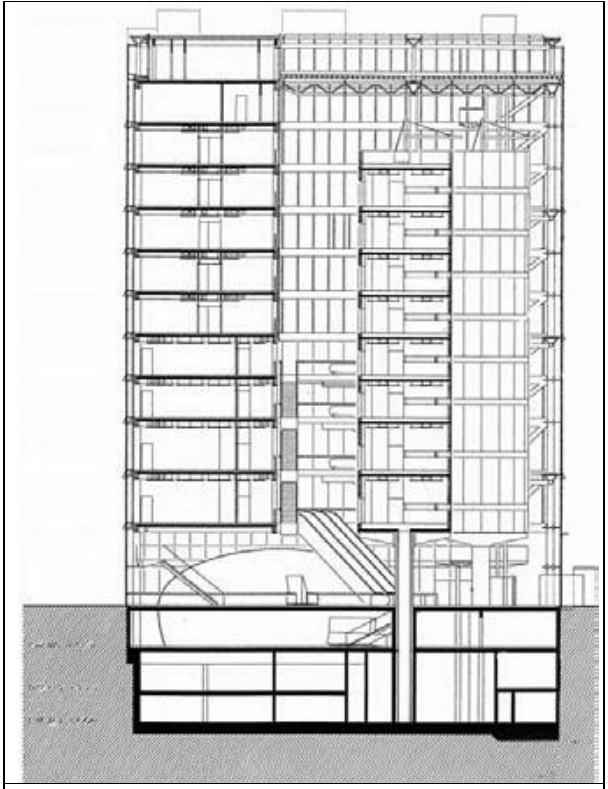


Fig. 3-3: Building Section
Source: www.journalist.heidelberg.com

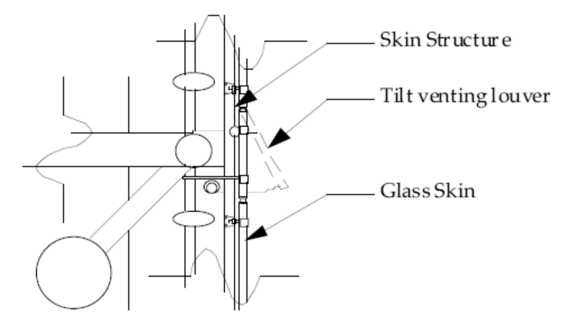


Fig. 3-4: Sketch detail of Atrium Skin
Source: www.journalist.heidelberg.com

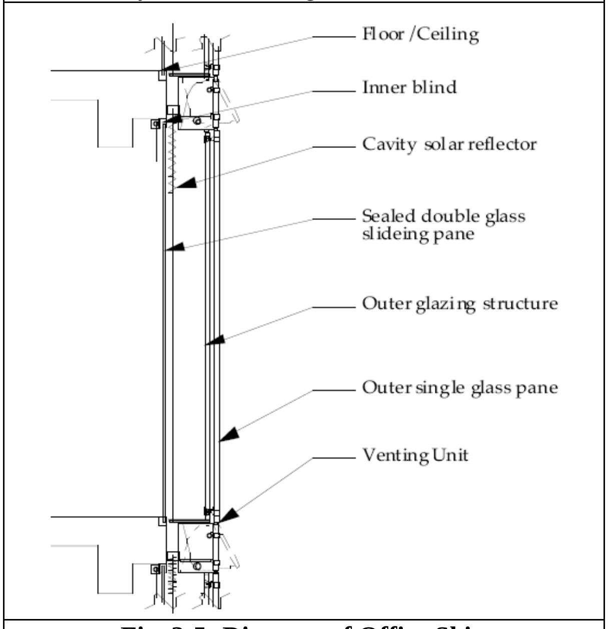


Fig. 3-5: Diagram of Office Skin
Source: www.journalist.heidelberg.com

airflow to pass through and push the heated air in the cavity out, thus cooling the building envelope.

The second system is the mechanical aluminum blind system that controls solar heat gain. These blinds roll down on the inside of the cavity and angle according to the suns angle. The aluminum reflects the solar heat into the box unit heating the buffer space. The louver venting system then manages the cavity to minimize building heat loss and gain.

Localized user control of the box unit, manage only qualities of natural ventilation and lighting. Fresh air can be gained by operating the inner window slider. The slider allows air from the office and cavity to exchange. The buildings central system then controls the rate of air flow into the cavity space, this is done by adjusting the exterior glass louver to harmonize building pressure and temperature.

Fig. 3-6: Atrium Interior
Source: www.journalist.heidelberg.com

3-1-2- Double skin projects:

3-1-2-a- Project name: ARAG 2000 Tower: [1]

- **Architect:** RKW, Düsseldorf, in collaboration with Norman Foster, London
- **Location of the building**: Düsseldorf
- **Façade Type**: The façade is designed as a shaft-box system.

Project summary:

- **Ventilation of the cavity**: Each of the box windows has its own 15 cm high air-intake opening in the form of a closable flap. Vitiated air is extracted into the exhaust-air shaft via a bypass opening. The shaft, in turn, is ventilated via louvers in front of the services story. In order to exploit the collector effect of the façade intermediate space more efficiently in winter, the air-extract shaft is also designed to be closed if required.

Fig. 3-7: View of ARAG 2000 Tower
Source: Harris Poirazis, double skin facades, A report of IEA SHC Task 34 ECBCS Annex 43, 2006, p.131

- **Façade construction Pane type**: – The inner façade layer was constructed with conventional vertically pivoting aluminium casements with low-E glazing.

[1] Harris Poirazis, Double skin facades for office buildings, Lund university, 2004

- **Shading device type**: Louvered blinds were installed in the outer third of the roughly 70 cm deep intermediate space between the façade layers.
- **Heat, Ventilation, Air Condition (HVAC):** The free window ventilation is possible for 50- 60 percent of the year. During periods of extreme weather conditions, a high level of thermal comfort can be attained with mechanical ventilation.

Fig. 3-8: View of the façade
Source: Harris Poirazis, double skin facades, A report of IEA SHC Task 34 ECBCS Annex 43, 2006, p.131

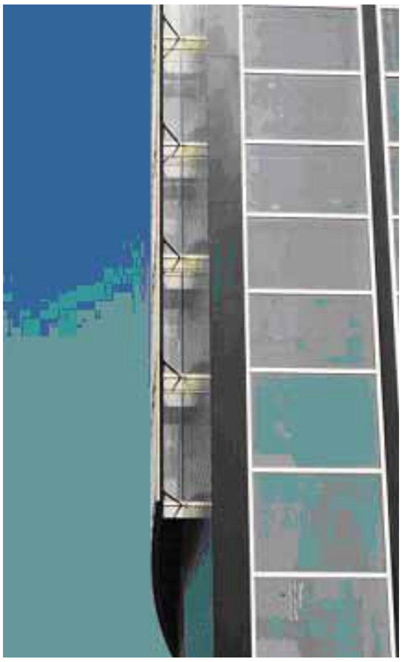


Fig. 3-9: View of the cavity
Source: Harris Poirazis, double skin facades, A report of IEA SHC Task 34 ECBCS Annex 43, 2006, p.131

3-1-2-b- Project name: Headquarters of Commerzbank: [(1)]

- **Architect:** Foster and Partners
- **Location of the building**: Frankfurt
- **Façade Type**: It consists of a three storey sealed outer skin, a continuous cavity and an inner façade with operable windows.

Project summary:

- **Ventilation of the cavity**: Two variations on the principle of the "buffer zone" for natural ventilation of the offices were used: as a double skin façade and as a winter garden.
- **Façade construction Pane type**: The outer skin consists of 1.4 □:2.25 m sheets Pane type of 8 mm toughned glass. The 12 cm high air inlets and outlets are located above and below the grey fritted glass cladding on the parapets; these vents are not closable.
- **Shading device type**: Air louvers were provided at the lower and upper ends of the cavity.

Fig. 3-10: Entrance of Commerzbank
Source: Harris Poirazis, double skin facades, A report of IEA SHC Task 34 ECBCS Annex 43, 2006, p.133

(1) Harris Poirazis, Double skin facades for office buildings, Lund university, 2004

Fig. 3-11: Commerzbank
Source: Harris Poirazis, double skin facades, A report of IEA SHC Task 34 ECBCS Annex 43, 2006, p.133

Fig. 3-12: Details skin
Source: Butterworth-Heinemann, Intelligent skins, Michael Wigginton and Jude Harris 2002, p. 81

Fig. 3-13: Interior of Commerzbank
Source: Harris Poirazis, double skin facades, A report of IEA SHC Task 34 ECBCS Annex 43, 2006, p.133

3-1-2-c- Project name: Debis headquarters: [1]

- **Architect:** Renzo Piano Building workshop, Paris, in collaboration with Christoph Kohlbecker, Gaggenau.
- **Location**: Berlin
- **Façade Type**: Corridor façade.

Project summary:

- **Ventilation of the cavity**: In a closed position, there is a 1 cm peripheral gap around the louvers (with an overlap of 5 cm). Opening the louvers to a greater angle results in only a small increase in the air-exchange rate. On the other hand, opening the external skin to a greater degree has a positive influence on the ventilation, since it helps to remove the heat in the intermediate space.

  During the summer, the exterior glass louvers are tilted to allow for outside air exchange. The users can open the interior windows for natural ventilation. Night-time cooling of the building's thermal mass is automated. During the winter, the exterior louvers are closed. The user can open the internal windows to admit to the warm air on sufficiently sunny days.

- **Façade construction Pane type**: The inner skin consists of a strip-window façade with

Fig. 3-14: South façade Debis headquarters
Source: Harris Poirazis, double skin facades, A report of IEA SHC Task 34 ECBCS Annex 43, 2006, p.136

Fig. 3-15: Cavity of Debis headquarters
Source: Harris Poirazis, double skin facades, A report of IEA SHC Task 34 ECBCS Annex 43, 2006, p.136

[1] Harris Poirazis, Double skin facades for office buildings, Lund university, 2004

double low E insulating glazing in aluminium frames. In every façade bay, there is a side and bottom-hung casement, supplemented by a motor-operated, bottom-hung top light. The solid up-stand walls on the room face are lined with insulated panels with a covering of toughened safety glass. On the west side of the building, the up stand walls are clad with terracotta elements fixed to an aluminium supporting structure, which forms the internal section of the three-bay outer façade elements.

Fig. 3-16: Openable exerior skin
Source: Harris Poirazis, double skin facades, A report of IEA SHC Task 34 ECBCS Annex 43, 2006, p.136

The floors to the façade corridors consist of sheets of toughened safety glass laid on metal gratings. This construction provides a smoke-proof division between the stories.

Walkway grills occur at every floor within the 70-cm wide interstitial space and are covered with glass to prevent vertical smoke spread between floors.

- **Shading device type:** Sliding louver blinds were installed in front of the inner façade. This allowed the sun shading to be located close to the inner skin, while at the same time still complying with airflow requirements into the rooms. In a closed position, there is a 1 cm peripheral gap around the louvers (with an overlap of 5 cm). The exterior skin consists of automated, pivoting, 12-mm thick laminated glass louvers. Minimal air exchange occurs through these louvers when Interior of Cummerbund.

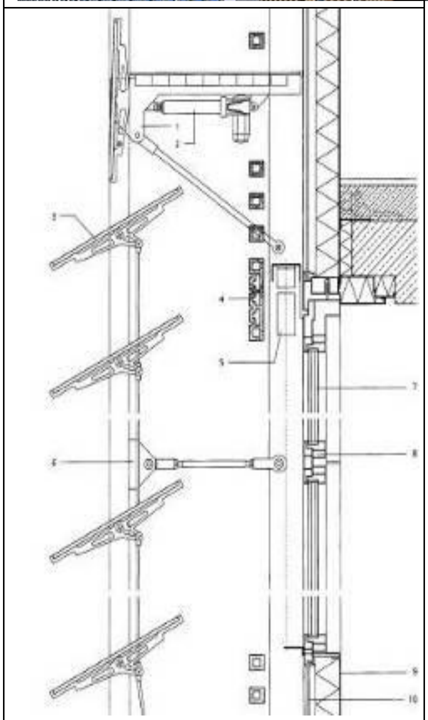


Fig. 3-17: Details skin
Source: Lawrence Berkeley National Laboratory, High-Performance Commercial Building Façades, 2006, p. 97
Bodart Magali & Gratia Elisabeth, Bibliography study of control strategies in buildings equipped with ventilated double-skin facades, 2003, p. 5

- **Heat, Ventilation, Air Condition (HVAC)::** The possibility of providing window ventilation for the rooms was also investigated. The scope for natural window ventilation is approximately 50 percent of the operating time in the upper part of the building and 60 per cent in the lower part. A mechanical ventilation plan was installed to provide partial air conditioning for those periods in winter and summer when extreme weather conditions prevail. The building is mechanically ventilated during peak winter and summer periods

(To< -5°C, To>20°C).The conditioned air is either cooled or heated and is injected continuously into the rooms, ensuring a threefold air change every hour (3 ach).

Comments the main objective of the clients and the planner was to create an environmentally sustainable and user-friendly building. Various measures were implemented with this in mind: the offices were provided with a natural system of ventilation (air-intake and extract); the air conditioning plant was reduced to sensible proportions; the thermal insulation was optimized and concepts were introduced for the improvement of the micro-climate (extensive roof planting, the recycling of rainwater, the creation of areas of water, etc.). To achieve these goals, large-scale investigations and research work were undertaken.

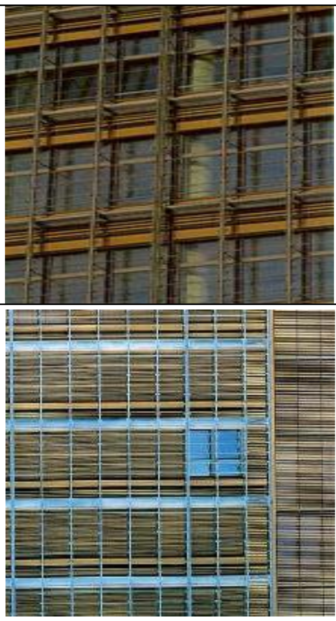


Fig. 3-18: Exterior façade

Source: Bodart Magali & Gratia Elisabeth, Bibliography study of control strategies in buildings equipped with ventilated double-skin facades, 2003, p. 5

3-1-3- Sensitive skin projects:

3-1-3-a- Project name:Institute du monde arable in Paris [1]

- **Architect:** Jean Nouvel
- **Location:** Paris, France
- **Façade Type:** sensitive skin, Building Acclimation

Project summary:

- **Façade construction**: The huge south-facing garden courtyard wall has been described as a 60m 'Venetian blind', although its appearance is more patently Islamic in decorative terms. It is, however, an ocular device of striking originality, made up of numerous and variously dimensioned metallic diaphragms set in pierced metal borders. These diaphragms operate like a camera lens to control the sun's penetration into the interior of the building. The changes to the irises are dramatically revealed internally while externally a subtle density pattern can be observed. Thus the whole effect is like a giant Islamic pierced screen, giving significance and an audacious brilliance to this remarkable building.
- **The facade system**: was designed to control the amount of light and transparency within the building through the manipulation of 30,000 apertures. A single panel, repeated across the entire south facade, is compromised of 240 motor controlled apertures (kinetic system) whose openness changes each hour in response to the measured exterior lighting conditions (sensing system).

  Unfortunately, the active life of the facade system was short lived due to mechanical functioning issues, illustrating the need for this type of system to address the wear and maintenance of moving parts. As with any active

[1] Paris galinsky travel pack, Summary descriptions of modern buildings to visit in and around Paris, galinsky 2004, www.galinsky.com

system there is an aspect of energy usage which must play a part in the design of the system. The apertures were not intended to constantly adjust their positions, but instead a time interval was established to control how often the sensors should be sampled and the apertures adjusted. (1)

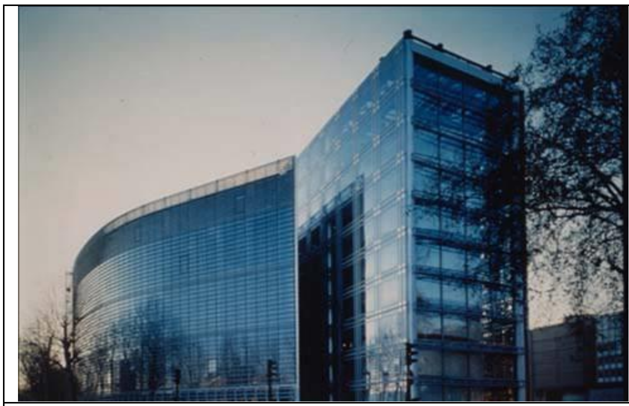


Fig. 3-19: The north-east facing walls are antirely glazed

Source: http://archnet.org/library/files/one-file.jsp?file_id=997

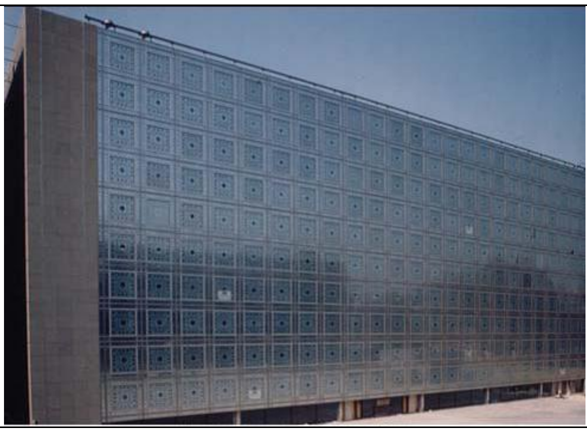


Fig. 3-20: The 30* 90 m south-west wall

Source: http://archnet.org/library/files/one-file.jsp?file_id=997

Fig. 3-21: The South-west facing walls

Source: http://archnet.org/library/files/one-file.jsp?file_id=997

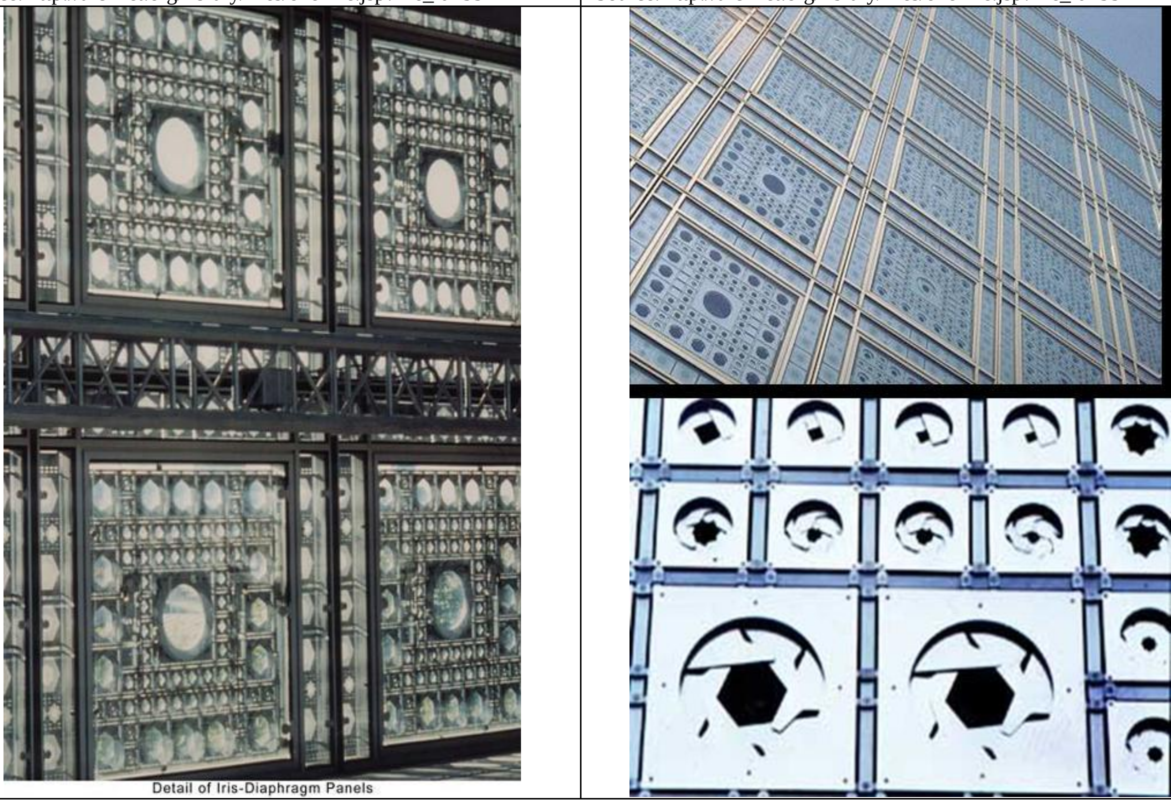


Fig. 3-22: Detail of lris-diaphragm panels

Source: http://archnet.org/library/files/one-file.jsp?file_id=997

(1) Scott Crawford, A Breathing Building Skin: Designing with the Concepts of Biological Adaptation, Master of Science in Design Computing, University of Washington, 2010

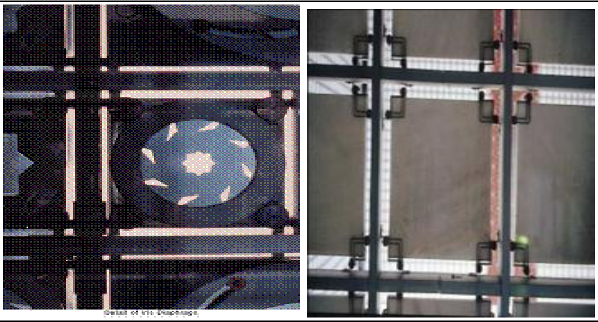


Fig. 3-23: Detail of panels
Source: http://archnet.org/library/files/one-file.jsp?file_id=997

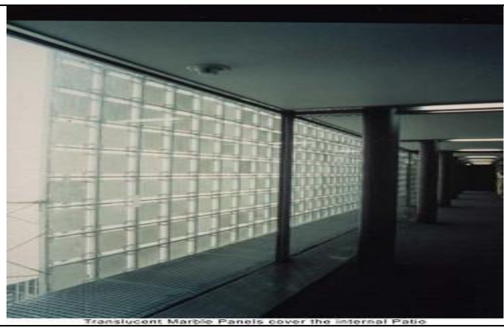


Fig. 3-24: Façade from indoor
Source: http://archnet.org/library/files/one-file.jsp?file_id=997

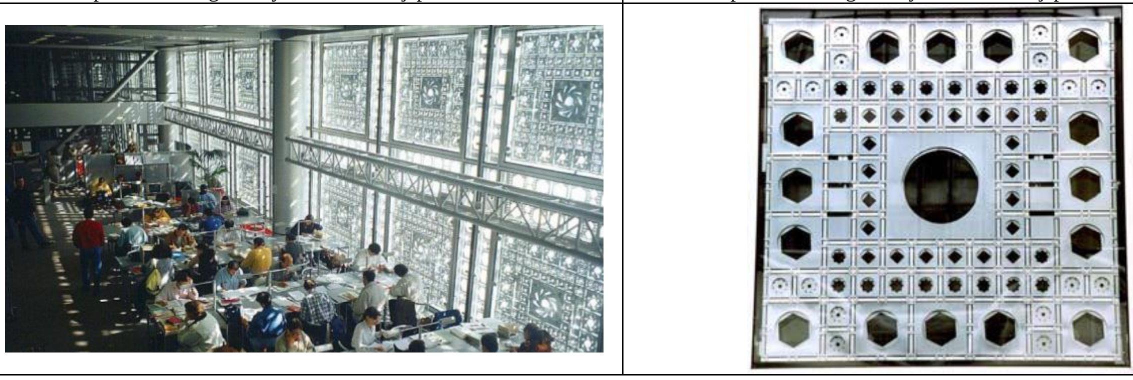


Fig. 3-25: Dynamic facade of Institut du Monde Arabe used to control lighting levels
Source: http://archnet.org/library/files/one-file.jsp?file_id=997

3-1-3-b- Project name: Flare-kinetic ambient reflection membrane. [(1)]

- **Date Constructed**: 2008
- **Design and development**: WHITEvoid interactive art & design
- **Location**: Berlin, Germany
- **Façade type**: kinetic

Project summary:

- **Technology:** metal elements moved by pneumatic pistons.
- **Elements:** specially designed reflecting shapes pixels formed by reflection of ambient light brightness of reflection controlled by position
- **Constructive features:** simple construction for high robustness and low maintenance independent weather conditions, independent of time of day, outdoor and indoor suitability.
- **The FLARE system**: flare is a modular system to create a dynamic hull for facades or any building or wall surface. Acting like a living skin, it allows a building to express, communicate and interact with its

Fig. 3-26: Building facade
Source: Media facades festival, www.mediaarchitecture.org

(1) Media facades festival, www.mediaarchitecture.org

environment

- **FLARE units:** the flare system consists of a number of tiltable metal flake bodies supplemented by individually controllable pneumatic cylinders. Due to the developed pattern, an infinite arrayof flakes can be mounted on any building or wall surface in a modular system of multiplied FLARE units.

  The FLARE system consists of a number of tiltable metal flake bodies supplemented by individually controllable pneumatic cylinders. Due to the developed pattern, an infinite array of flakes can be mounted on any building or wall surface in a modular system of multiplied FLARE units. (1)

  The system is controlled by a computer to form any kind of surface animation. Sensor systems inside and outside the building communicate the buildings activity directly to the FLARE system which acts as the buildings lateral line.

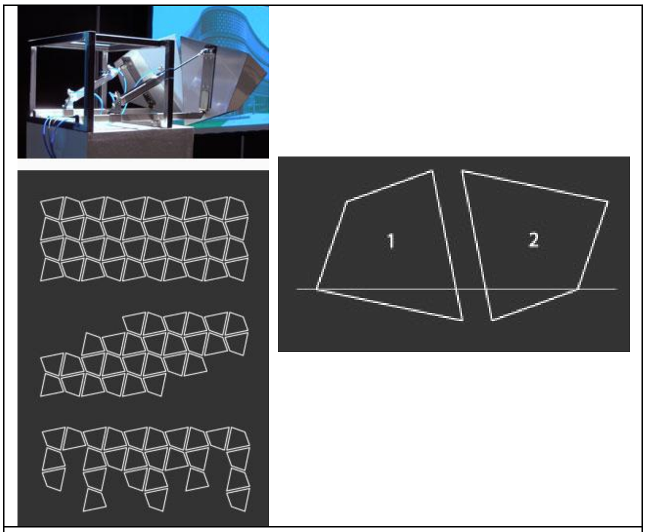


Fig. 3-27: FLARE units details
Source: Media facades festival, www.mediaarchitecture.org

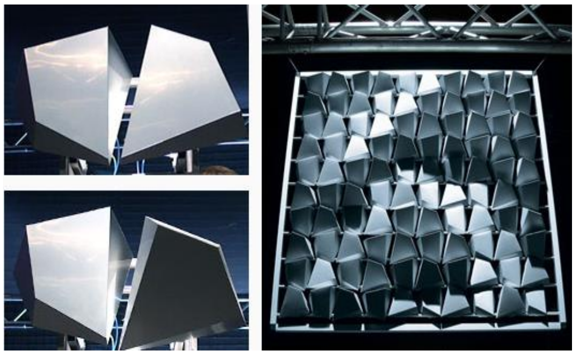


Fig. 3-28: FLARE units
Source: Media facades festival, www.mediaarchitecture.org

3-1-3-c- Project name: Kiefer technic showroom. (2)

- **Date Constructed**: Summer 2007
- **Architect:** Ernst Giselbrecht & Partner ZT GmbH
- **Location:** Steiermark, Germany. (3)

Project summary:

- **Project description**: Office building and showroom for representative functions and product presentation for a metal company
- **Structural work:** brick walls; reinforced concrete floors; steel columns filled with concrete along the facade
- **Facades**: aluminium-glass facade with vorgelagerten Putzstegen respectively facade of upgraded insulation, plastered in white.

(1) http://www.flare-facade.com/
(2) http://www.architonic.com/aisht/dynamic-facade-kiefer-technic-showroom-ernst-giselbrecht-partner/5100449
(3) http://www.nhit-shis.org/dynamic-facade-of-harald-kiefer-metallbau-office-by-ernst-giselbrecht-partner-zt-gmbh-architekt/

- **Sunscreens**: folding elements made of perforated aluminium, electrically driven In earlier times, façades were characterized by window arrangements and axes. They often featured surface relief with architectural elements from the relevant period or style. The structure of the façade also determined the ground plan; the greater the number of window axes in a room, the more important the function of the user.

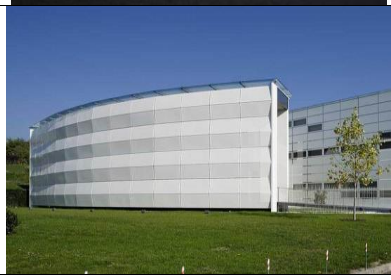


Fig. 3-29: Variety of Kiefer technic showroom's facade
Source: http://www.architonic.com/aisht/dynamic-facade-kiefer-technic-showroom-ernst-giselbrecht-partner/5100449

3-2- Re-skin examples: [1]

This title includes some examples about buildings re-skin for existing buildings, as follow:

3-2-1- Project name: 100 Park ave

- **Date Constructed**: 2006-2009
- **Developer / Owner**: SL Green Realty
- **Architect / Engineer**: MOED de ARMAS & SHANNON Architects, Robert Derector Associates (RDA) Consulting Engineers

Fig. 3-30: 100 Park ave before re-skin
Source: www.thezeroprize.org

[1] www.thezeroprize.org, Zerofootprint All rights reserved.

- **Location**: New York, U.S.A.

Project summary:

When 100 Park first opened its doors in 1949, the 36-storey, 825,000 square foot office block was the first glass and steel tower on Park Avenue, New York. After nearly six decades, however, the building looked dated and its once state-of-the-art building systems were becoming obsolete. An ambitious capital improvement program included window replacement and a composite metal panel over-cladding of the north and south façades; installation of a high-performance unitized curtain wall over the existing Park Avenue façade; a new, two-storey lobby and associated HVAC systems; and roof repair and rehabilitation. The building remained fully occupied throughout the re-skinning process. The re-skinning resulted in a 29 percent energy savings per year.

Fig. 3-31: 100 Park ave after re-skin
Source:www.thezeroprize.org

3-2-2- Project name:

222 Jarvis street

- **Date Constructed**: 2010
- **Developer / Owner**: Ontario Realty Corporation
- **Architect / Engineer**: WZMH Architects, Enermodal Engineering
- **Location**: Toronto, Canada

Project summary:

A unique example of Brutalist architecture from the 20th century, 222 Jarvis in Toronto is a nine-storey inverted pyramid structure built in 1971. Constructed in concrete, the lower floors have load-bearing perimeter walls that support the larger floors cantilevered above. Recognizing the structure's strong bones and iconic status, the Ontario government purchased the building in 2007. Its refurbishment is the flagship project for sustainable reconstruction of downtown office buildings. The building envelope upgrade will add insulation to the existing R3 concrete walls and above the parking level

Fig. 3-32: 222 Jarvis street before re-skin
Source:www.thezeroprize.org

Fig. 3-33: 222 Jarvis street after re-skin
Source: www.thezeroprize.org

ceiling to raise the building's overall thermal performance. The finished building will achieve LEED Gold status and stop 4,930 tonnes of CO_2 going into the atmosphere each year.

3-2-3- Project name:

355 Eleventh Street:

- **Date Constructed**: 2009
- **Developer / Owner**: Matarozzi / Pelsinger
- **Architect / Engineer**: Aidlin Darling Architects, Simain & Associates, CB Engineers
- **Location**: San Francisco, U.S.A.

Project summary:

Fig. 3-34: 355 Eleventh Street before re-skin
Source: www.thezeroprize.org

Fig. 3-35: 355 Eleventh Street after re-skin
Source: www.thezeroprize.org

355 Eleventh, San Francisco, is an historic and previously derelict turn-of-the-century industrial building now refurbished to be as beautiful as it is energy efficient. Part of this refurbishment is a new corrugated skin to replace the original, historically significant steel cladding. The skin is perforated with small holes designed to allow light and air to pass through new windows hidden behind it. This perforated barrier controls solar heat gain while enabling cross-ventilation of the interior. The double-skin façade becomes a screen for sunlight and air while maintaining the stoic, industrial character of the original building. Behind that screen new, operable windows allow user control of airflow. The final building received Gold-level LEED certification.

3-2-4- Project name:

Evergreen brick works

- **Date Constructed**: 2009-2010
- **Developer / Owner**: Evergreen
- **Architect / Engineer**: Du Toit Alsop Hillier, Diamond & Schmitt, Stantec, Halsall, AECOM
- **Location:** Toronto, Canada

Project summary:

Fig. 3-36: Evergreen brick works before re-skin
Source: www.thezeroprize.org

Evergreen is a Canadian non-profit organization with a mission to bring communities and nature together. It is now restoring Toronto's Don Valley Brick Works from a collection of deteriorating industrial buildings to a centre for urban sustainability. Energy conservation measures include high-efficiency building envelopes, operable windows and solar chimneys that minimize the need for mechanical ventilation and air-conditioning.

Fig. 3-37: Evergreen brick works after re-skin
Source: www.thezeroprize.org

Also included in the retrofit of this historic site is a solar co-generation system for power, heating and cooling and a biomass heating system using sustainably harvested waste wood from local industry and urban forestry programs. Smart building systems like intelligent building automation and lighting control systems make the Brick Works truly modern in their function. The Brick Works is seeking a LEED Platinum rating for a number of buildings in the complex.

3-2-5- Project name:

Gesobau Ag:

- **Date Constructed**: 2008-2009
- **Developer / Owner**: GESOBAU AG (State of Berlin)
- **Architect / Engineer**: Osawld Mathias Ungers (1964), DAHM Architekten + Ingenieure
- **Location:** Berlin, Germany

Fig. 3-38: Gesobauag before re-skin
Source: www.thezeroprize.org

Project summary:
When GESOBAU AG decided to modernize the 15,000 residential units it had built in the Mrkisches Viertel locality of Berlin in the 1960s, it devised a three-point plan that would be both economical and repeatable elsewhere. It would re-skin the buildings to enhance energy conservation while also converting heating and hot water systems to environmentally friendly technologies.

Fig. 3-39: Gesobauag after re-skin
Source: www.thezeroprize.org

In addition, GESOBAU instructed tenants on how to operate their apartments for optimum energy conservation using new smart technologies.

The first 538 apartments—shown here—were converted in 2008 and the project is due for completion in 2015. The primary energy saving as a result of the re-skinning is 71 percent of previous loads or 316 tonnes of CO2 annually.

3-2-6- Project name:

Hespeler library

- **Date Constructed**: 2007
- **Developer / Owner**: Cambridge Libraries & Galleries
- **Architect / Engineer**: Kongats Architect, Lam & Assoc., MTE Consultants
- **Location:** Cambridge, Canada

Project summary:

The Hespeler Library was originally constructed in 1922 with the assistance of a $14,500 Carnegie Foundation Grant. Wanting to showcase the original building while redeveloping the neighbourhood, owners Cambridge Libraries & Galleries along with Kongats Architects decided to selectively demolish mid twentieth-century additions to reveal the library's original structure. They then wrapped a glass envelope around the building.

Fig. 3-40: Hespeler library before re-skin
Source: www.thezeroprize.org

Fig. 3-41: Hespeler library after re-skin
Source: www.thezeroprize.org

The new, structurally glazed exterior is made from two layers of ceramic frit glass that modulate in response to interior activities allowing views in and out while also reducing solar heat gain.

A third internal layer filters sunlight through the use of a hand-woven textile that reflects the town's industrial past. The building's energy efficiency improved by approximately 67 percent over its original performance.

3-2-7- Project name:

Lennox addington hall:

- **Date Constructed**: 2010
- **Developer / Owner**: University of Guelph
- **Architect / Engineer**: Walter Agius Architect, Larkin Architect, Halcrow Yolles, Peter Di Lullo Eng., Engineered Assemblies
- **Location:** Guelph, Canada

Project summary:

Located on the northern edge of the University of Guelph's campus, Lennox Addington Hall is a large student residence complex constructed in 1970. Typical of this era of large

Fig. 3-42: Lennox addington hall before re-skin
Source: www.thezeroprize.org

building projects, Lennox Addington Hall had limited thermal insulation, consumed an excessive amount of energy, and suffered structural damage due to interior water vapour and exterior water penetration. This re-skinning project, designed by Larkin Architect, uses soya-based polyurethane foam insulation, extruded terracotta ceramic tile and an open jointed rain screen system.

Fig. 3-43: Lennox addington hall after re-skin
Source: www.thezeroprize.org

The project has set a precedent for the re-skinning of residential towers in Southern Ontario. Total energy savings exceeded 50 percent when compared to the existing building, and will remove 260 tonnes of carbon from the atmosphere annually.

3-2-8- Project name:

Nova scotia power:

- **Date Constructed**: 2010
- **Developer / Owner**: Nova Scotia Power
- **Architect / Engineer**: WZMH Architects, Enermodal Engineering, M&R Electrical and Mech.
- **Location:** Halifax, Canada

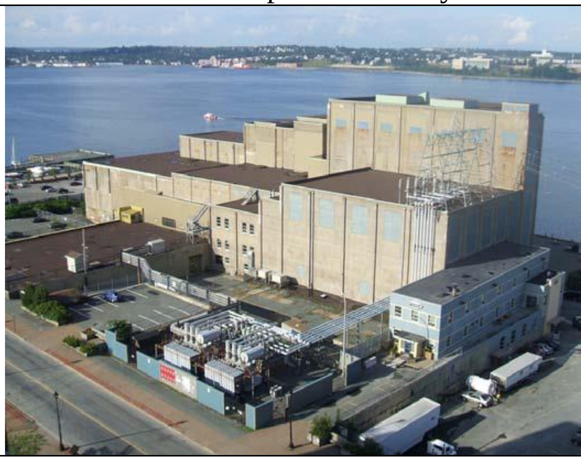


Fig. 3-44: Nova scotia power before re-skin
Source: www.thezeroprize.org

Project summary:

A decommissioned power plant on a five-acre site at the southern end of the Halifax downtown waterfront will become the headquarters of Nova Scotia Power. The project retains and adapts the original concrete-clad steel structure by re-skinning it in a tight building envelope to minimize energy loss. Existing piping from the Halifax harbour will carry sea water for cooling. The building will be the first major use of 'chilled beam' technology in Canada. Additional energy-saving strategies include the provision of heat recovery from HVAC systems, daylight and occupancy sensors for lighting, and solar panels for water heating and supplementary building heating. The building is a LEED Platinum candidate.

Fig. 3-45: Nova scotia power after re-skin
Source: www.thezeroprize.org

3-2-9- Project name:

Now house:

- **Date Constructed**: 2008-2009
- **Developer / Owner**: Now House Project
- **Architect / Engineer**: Work Worth Doing & Lorraine Gauthier

- **Location:** Toronto and Windsor, Canada

Project summary:

Now House is a process for retrofitting existing older houses to become net zero energy homes. The retrofit includes renewing or upgrading foundation walls, basement floor, roof, exterior walls, windows, electrical systems, lighting, HVAC, ventilation and water heating.

The first application of the Now House process was to a 60-year-old wartime house in Toronto, which is similar in layout and footprint to a million other houses in Canada where the process could be replicated. Already the Toronto house has acted as the prototype for the retrofitting of five similar houses in Windsor, Ontario, that are owned by a social housing agency. The original Now House re skinning and retrofit resulted in energy savings of approximately 70 percent per year for the existing bungalow.

Fig. 3-46: Now house before re-skin
Source: www.thezeroprize.org

Fig. 3-47: Now house after re-skin
Source: www.thezeroprize.org

3-2-10- Project name:

Paris docks:

- **Date Constructed**: 2008-2009
- **Developer / Owner**: Caisse des Dépôts
- **Architect / Engineer**: Jakob + MacFarlane Architects, RFR Engineers
- **Location**: Paris, France

Project summary:

Built in 1907 as an industrial warehouse for the Port of Paris, the Docks of Paris is a long concrete structure on the edge of the Seine river. In 2005, the city of Paris decided to create a new cultural program and building on the site. Architects Jakob and MacFarlane opted to retain the existing structure, adding what they call the 'Plug-Over—an external skin inspired by the flow of the Seine as well as the pedestrian promenades

Fig. 3-48: Paris docks before re-skin
Source: www.thezeroprize.org

along its banks. The overall skin is comprised of a glass exterior, steel framework, wood decking, and a grassed, faceted roofscape. The skin protects the existing structure by forming a new layer containing most of the public pathways through the building. The building was retrofitted to the High Environmental Quality (HEQ) Certivea guidelines. It achieves a 25 percent energy efficiency benefit over the design requirements.

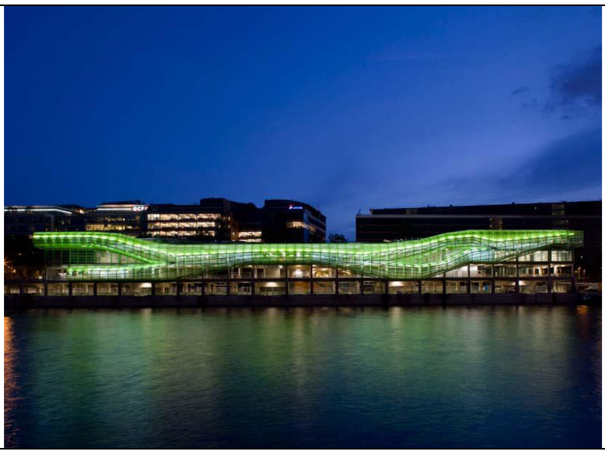


Fig. 3-49: Paris docks after re-skin
Source: www.thezeroprize.org

3-2-11- Project name:

Sparkasse Vorderpfalz

- **Date Constructed**: 2008-2009
- **Developer / Owner**: Sparkasse Vorderpfalz
- **Architect / Engineer:** Egon Wei (1974), Thiemo Ebbert - imagine envelope Architects (2009)
- **Location:** Ludwigshafen, Germany

Fig. 3-50: Sparkasse Vorderpfalz before re-skin
Source: www.thezeroprize.org

Project summary:

Sparkasse Vorderpfalz is a regional bank in Ludwigshafen, Germany, with its headquarters located on the most prominent square in the city centre. The project to refurbish the building's façade and services had to be carried out without affecting the bank's operations or damaging recent interior renovations. The re-skinning commenced in autumn 2006, with the improvement of the load-bearing structure and the removal of the original ventilated cladding.

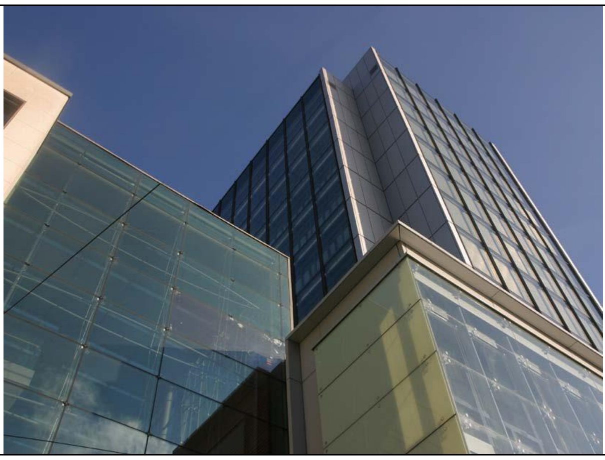


Fig. 3-51: Sparkasse Vorderpfalz after re-skin
Source: www.thezeroprize.org

The base zone was remodelled and secondary glazing added to the tower, with retrofitting of the primary façade of the tower and the corners completed in July 2009. The refurbished building has been certified as a 'Green Building' by the German Energy Agency.

3-2-12- project name:

Sydney tower

- **Date Constructed**: Proposal
- **Developer / Owner**: University of Technology, Sydney

- **Architect / Engineer**: Laboratory for Visionary Architecture
- **Location**: Sydney, Australia

Project summary:
The proposal of the Laboratory for Visionary Architecture (LAVA) to re-skin the University of Technology, Sydney (UTS) tower aims to transform the identity of the brutalist-style high-rise and reduce its carbon footprint. LAVA has developed a simple, cost-effective and easily constructed building skin that forms a translucent cocoon to create a micro-climate. The skin can generate energy with embedded photo-voltaic cells, collect rain water, and improve the distribution of natural daylight. It can also use available convective energy to power the building’s ventilation requirements, reducing HVAC dependency. The skin could. be applied to other similar existing structures inexpensively, contributing to a low cost, efficient way to beautify cities everywhere.

Fig. 3-52: Sydney tower before re-skin
Source: www.thezeroprize.org

Fig. 3-53: Sydney tower after re-skin
Source: www.thezeroprize.org

3-2-13- Project name:

Tomamu towers

- **Date Constructed**: 2006-2008
- **Developer / Owner**: Hoshino Resort Tomamu
- **Architect / Engineer**: Klein - Dytham Architects, Meiho Facility Works Ltd., Asahi Danke Co., Ltd & Horex Inc., Durock
- **Location:** Tomamu, Japan

Project summary:

The twin 40-storey hotel towers of the Alpha Resort stand in the beautiful forest covered mountains of central Hokkaido. Built during Japan’s economic bubble, the towers suffered spalling of the external tile cladding and condensation and dampness internally. The towers' new owners, Hoshino Resorts, asked Klein - Dytham Architects to develop an

Fig. 3-54: Tomamu towers before re-skin
Source: www.thezeroprize.org

external colour scheme to reduce the visual impact of the towers, as well as to re-clad them and improve their insulation. KDa decided to camouflage one tower to suit winter conditions and the other to suit summer. The external renovation is the first project of its kind in Japan. It required new skills and technologies including external insulation fitted by a specialist Canadian company. Re-skinned, the buildings consume about 30 percent less energy than they did prior to the retrofit.

Fig. 3-55: Tomamu towers after re-skin
Source: www.thezeroprize.org

3-2-14- Project name:

University of ulster:

- **Date Constructed**: 2008-2010
- **Developer / Owner**: University of Ulster
- **Architect / Engineer**: TODD Architects, BDP Engineers, DEGW Space Consultants
- **Location:** Belfast, Northern Ireland

Project summary:

The redevelopment of the University of Ulster's Belfast campus building to provide state-of-the-art facilities for 2,000 art and design students had to be undertaken without disrupting university activities. TODD Architects' approach was to extend the existing 1960s concrete framed building upwards and outwards, providing space for the students to be vacated from the top two floors of the old building, and enabling a new roof and cladding to wrap over the existing building, which was subsequently dismantled from within. Environmental measures include using exposed concrete slabs as a heat store, installing heat and CO2 sensors in every room to ensure the right levels of fresh air and heating, and reclaiming heat at the top of the first atrium. The final energy benefit to the retrofitted building was 64 percent over the original building.

Fig. 3-56: University of ulster before re-skin
Source: www.thezeroprize.org

Fig. 3-57: University of ulster after re-skin
Source: www.thezeroprize.org

3-2-15- Project name:

West park court:

- **Date Constructed**: 2007
- **Developer / Owner**: West Park Court Housing
- **Architect / Engineer**: Perfido Weiskopf Wagstaff & Goettel Architects, Donald Schock, P.E.
- **Location**: Pittsburgh, U.S.A

Project summary:

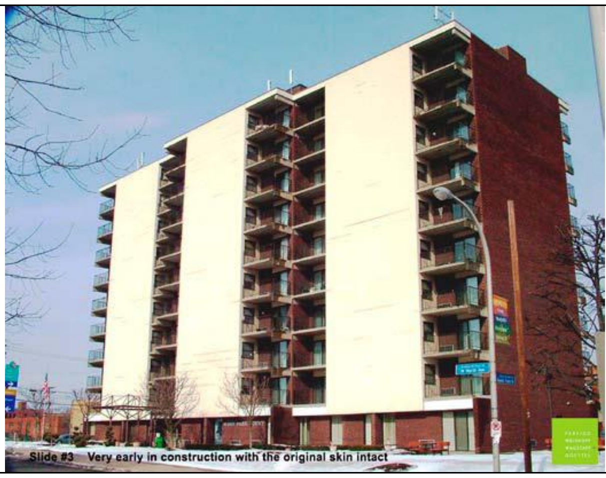


Fig. 3-58: West park court before re-skin
Source: www.thezeroprize.org

Fig. 3-59: West park court after re-skin
Source: www.thezeroprize.org

West Park Court is a prominent high-rise apartment building for low-income seniors in Pittsburgh, Pennsylvania. Constructed in 1979, it was originally clad with an exterior insulating and finish system known as EIFS or synthetic stucco. EIFS has proved problematic in the climate, and the EIFS on West Park Court began to show signs of failure within 10 years of construction. PWWG replaced the exterior envelope of West Park Court with a pressure equalized rain screen, which is more durable, less challenging to maintain, and far more energy efficient. In a process that would be replicable elsewhere, the new envelope was installed almost entirely from the outside, with very little impact on the residents. By simply adding a new skin to the building, the energy savings were 15 percent over the existing insulated building.

Conclusion:

From previous, Single skin with sub-tech and double skin of high-tech systems can be used to re-skin existing building, versus sensitive skin of high-tech system cannot be used to re-skin existing building.

Introduction:

The current chapter presents the conclusion and recommendations of the research; the conclusion determines some principles and guidelines that we must put into consideration when designing re-skin. These recommendations could be applied as a guide to re-skin building.

4-1- The conclusion:

The conclusion includes some main points that are concerned with: façade system, skin - improvement for existing buildings, and some principles and guidelines.

4-1-1- Façade system:

- Double skin façade is characterized by saving energy relying on natural ventilation, reducing the heat load of the solar rays, which provide comfortable environment for humanitarian activities inside the building rather than relying on air condition mechanical systems.
- Sensitive skin facade is characterized by suiting of the environment where it can change to suit the changes in the external environment (for example, during periods of sunshine and sunset), and allows adaptation of building systems which control the flow of heat inside the building.

4-1-2- Skin improvement for existing buildings:

We can improve existing building's skin by using the following technology:

- Clad the walls and change the type of glass openings to types with a characteristic of thermal insulation, in addition to use different types of shading façade louvers. This tech. can be applied to external load-bearing walls.
- Adjustments can be made to external walls with changing in the size and location of opening, in addition to the ability of changing exterior walls' places and moving them inside the building that allow using double skin facade system. This tech. can be applied to external non load-bearing walls.

4-1-3- Principle of re-skin design:

There are several principles, which should be taken into consideration. The most important are:

- Distribution of loads on external wall.
- Climate of building location.
- Style of building façade -Islamic or modern….etc….
- Speed of erection.

4-1-4- Guidelines for re-skin design:

To re-skin buildings, the following should be taken into consideration:

- Apply of prefabricated units to achieve high speed of erection.
- Dealing with external walls according to their types of load-bearing (Load-bearing walls or non load-bearing walls) -described in improving skin for existing buildings as previously mentioned.

4-2- The recommendations:

The following solutions could be applied as a guide to re-skin building, which can be divided into 2 main types according to load distribution:

- Load-bearing walls
- Non load-bearing walls

Besides, the treatment will vary from solid parts of façade to openings in façade.

4-2-1- Load-bearing walls:

In this type of external walls, we should take into account that the walls cannot be removed and the type of treatment must depend on light elements in order to be easily fixed. Hence, wood cladding should be used as well as changing glasses.

4-2-1-a- Openings of façade:

- Shading devices: roller blinds, Venetian blinds adjustable, retractable, and mid-pane devices could be used. (Fig. 1-40, 1-41, 1-42, 2-13, 2-15, 4-1, 4-2)

Fig. 4-1: The vertical screen shades the window
Source: shading out the heat, www.townsville.qld.gov.au

Fig. 4-2: Adjustable shading

- Using box-window (Fig. 2-3)
- Using traditional wood window. (Fig. 4-3)
- Using types of glasses, which have low thermal conductivity such as fritted glass, and reflective glass. (Fig. 2-5,2-7, 4-4)

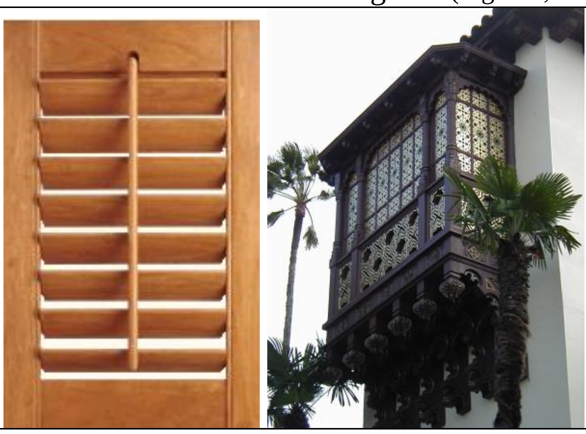


Fig. 4-3: Traditional wood window

Fig. 4-4: Reflective glass
Source: Kathy Dodson, Commercial Façade Improvement Grant Program Guidelines, 2009,

4-2-1-b- Solid parts of façade:

- Light materials like wood can be used in cladding. (Fig. 4-5, 4-6)

Fig. 4-5: Wood cladding
Source: External wood cladding, (www.woodforgood.com)

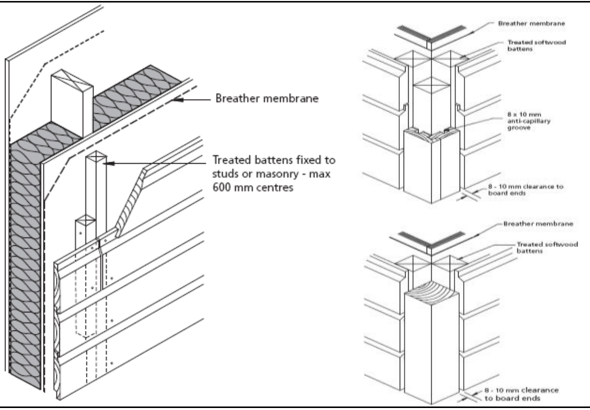


Fig. 4-6: Wood cladding details
Source: External wood cladding, (www.woodforgood.com)

4-2-2- Non load-bearing walls:

This type is flexible, as walls can be removed and distributions of openings can be changed.

4-2-2-a- Total façade treatment:

This type of treatment means dealing with all facades as one unit; it takes two directions:

- Transfer direction of façade into double skin that could be obtained by:
  - Fixing frame in building construction outside the building, and then fixing glasses unit on the frame, (Fig.4-7: 4-14) or
  - Using second –skin façade. (Fig. 2-18)

Fig. 4-7: Transfer the façade into double skin
Source: Butterworth-Heinemann, Intelligent skins, Michael Wigginton and Jude Harris 2002, p.125

Fig. 4-8: Glasses Fairmont Cladding

Fig. 4-9: Transfer of façade into double skin
Source: Lawrence Berkeley National Laboratory, High-Performance Commercial Building Façades, 2006, p. 64

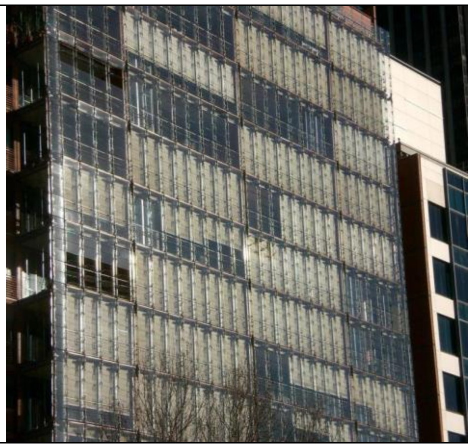


Fig. 4-10: –Clear glass – Manually operated blinds to control glare.
Source: AECOM Façade Engineering, Façade Retrofitting –Current Trends –Glare Considerations, 2009

Fig. 4-11: Double skin by using external glass wall
Source: Yu-Min Kim, Soo-Young Kim, Sung-Woo Shin,& Jang-Yeul Sohn , Contribution of natural ventilation in a double skin envelope to heating load reduction in winter, Building .and Environment 44 (2009) 2236–2244, p. 2237, journal homepage: www.elsevier.com/locate/buildenv

Fig. 4-12: Glass box
Source: Lawrence Berkeley National Laboratory, High-Performance Commercial Building Façades, 2006, p. 7

Fig. 4-13: Frame structure
Source: Sini Uuttu, Study of Current Structures in Double-skin Façades, 2001, p. 27

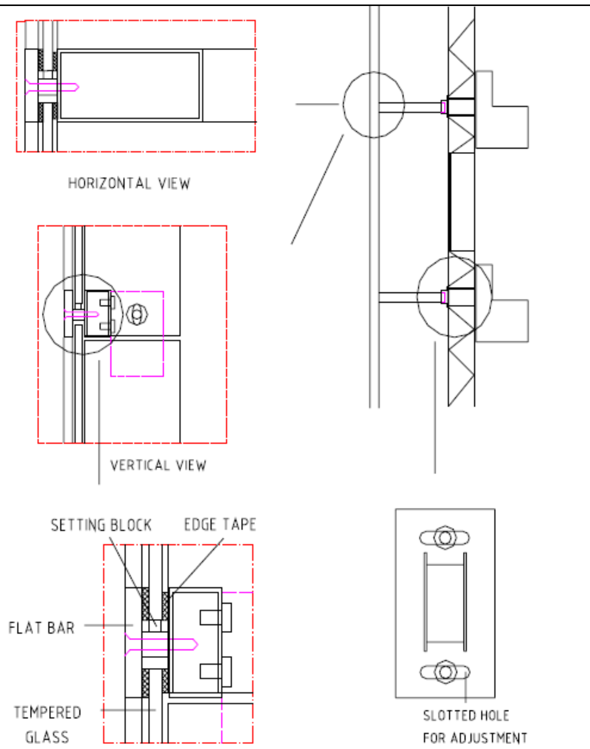


Fig. 4-14: Frame structure details
Source: Sini Uuttu, Study of Current Structures in Double-skin Façades, 2001, p. 28

- If the interior space allows removing and rebuilding external wall inside, so we can use: corridor façade, shaft-box façade, alternating façade, and integrated façade could be used. (Fig. 2-21, 2-23, 2-25, 2-27, 4-15: 4-18)

Fig. 4-15: Corridor façade

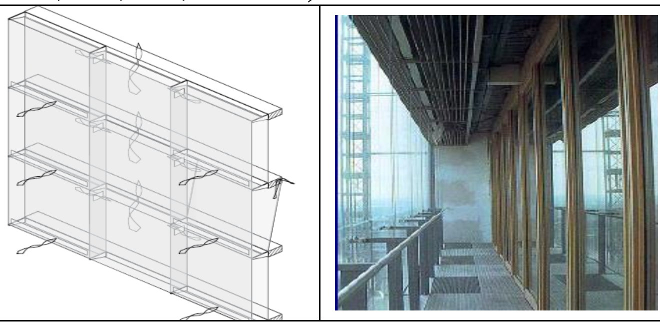


Fig. 4-16: Shaft-box façade
Source: Ulrich Knaack, Tillmann Klein, Marcel Bilow, Thomas Auer, Façades Principles of Construction, Medialis, Berlin, 2007. p.95

Fig. 4-17: Shaft-box façade with Venetian blinds
Source: Bodart Magali & Gratia Elisabeth, Bibliography study of control strategies in buildings equipped with ventilated double-skin facades, 2003

Fig. 4-18: Change external walls units

4-2-2-b- Openings in façade:

- Shading devices: roller blinds, external, internal, Venetian blinds, adjustable, retractable, and mid-pane devices could be used. (Fig. 1-40, 1-41, 1-42, 2-13, 2-15, 4-19: 4-22)

Fig. 4-19: Automated louvers
Source: Lawrence Berkeley National Laboratory, High-Performance Commercial Building Façades, 2006, p. 57

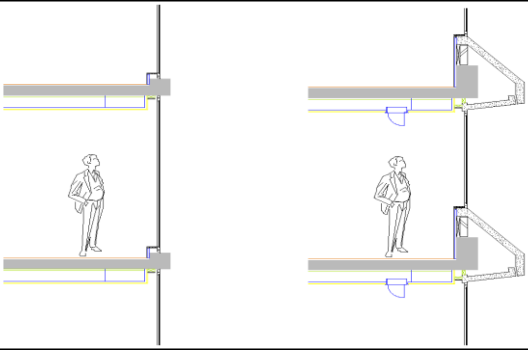


Fig. 4-20: Example of a façade retrofit and the increase of glazing
Source: AECOM Façade Engineering, Façade Retrofitting –Current Trends –Glare Considerations, 2009

Fig. 4-21: Overhang's, or 'Brise Soleil'
Source: Solar Shading Systems, PRO DUCTSEL ECTOR, Par louver systems Ltd, www.parlouvres.co.uk

Fig. 4-22: The Par combined Overhang/ Vertical Shading System
Source: Solar Shading Systems, PRO DUCTSEL ECTOR, Par louver systems Ltd, www.parlouvres.co.uk

Fig. 4-23: The Horizontal Fixed Louvre
Source: Solar Shading Systems, PRO DUCTSEL ECTOR, Par louver systems Ltd, www.parlouvres.co.uk

Fig. 4-24: The Par Glass Overhang
Source: Solar Shading Systems, PRO DUCTSEL ECTOR, Par louver systems Ltd, www.parlouvres.co.uk

- Using types of glasses, which have low thermal conductivity such as fritted glass, and reflective glass. (Fig. 2-5,2-7)
- Using pre-cast concrete units to make shading in windows. (Fig. 4-25)

Fig. 4-25: pre-cast concrete units

Source: The City of Oklahoma City Planning Department and Winter & Company, BUILDING CONSERVATION & REHABILITATION GUIDELINES FOROKLAHOMA CITY, 2010, p.49, www.winterandcompany.net Abbey Stone Products Limited,design inspirations, www. abbeystoneproducts. co. u k

- Using box-window façade. (Fig. 2-19)

4-2-2-c- Solid parts of façade:

- Cladding walls by using wood or stone such as ketton limestone and bath stone, or using rock-filled gabions in low height buildings. (Fig 4-26: 4-30)

Fig. 4-26: Building façade with wood cladding

Source: Osmo Holz und Color GmbH & Co. KG, 2010, www.osmo.com

Fig. 4-26: Fixing wood cladding details

Source: Osmo Holz und Color GmbH & Co. KG, 2010, www.osmo.com

Fig. 4-27: Rock-filled gabions.

Source: Arthur Lyons, MATERIALS FOR ARCHITECTS AND BUILDERS, Elsevier, 2007, p. 267

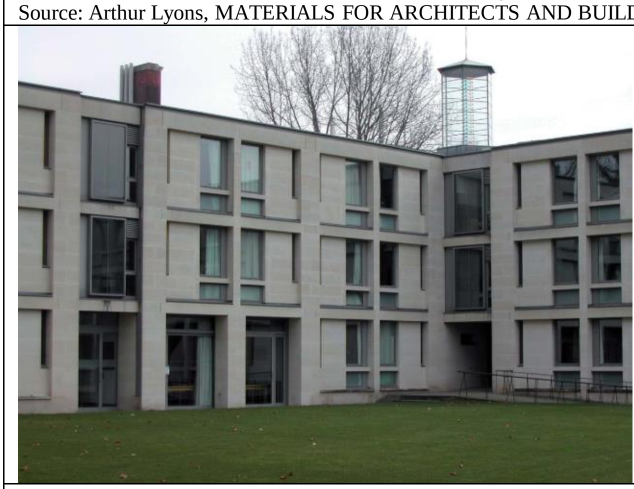


Fig. 4-28: Bath Stone

Source: Arthur Lyons, MATERIALS FOR ARCHITECTS AND BUILDERS, Elsevier, 2007, p. 261

Fig. 4-29: Ketton Limestone

Source: Queen’s Building, Cambridge, England, Michael Hopkins and Partners, 1995. Main façade.

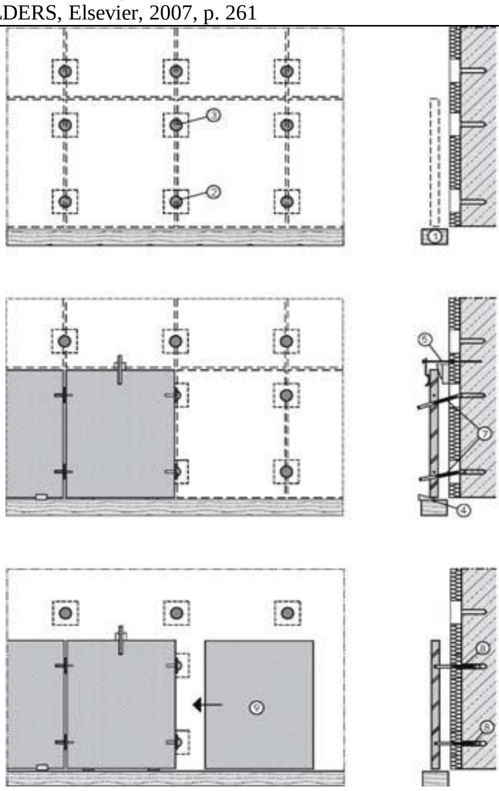


Fig. 4-30: Stone façade Fixed with cast-in dowels

- Using pre-cast concrete units as cladding for solid parts to make variety of façade levels, which achieve shading in facade parts, and reducing heat transfer from outside to inside. (Fig. 4-31)

Fig. 4-31: Pre-cast concrete units for solid parts of façade

Source: www.galinsky.com, 2004, www.abbeystoneproducts.co.uk

From previous: Building re-skin design is one of treatment types of buildings façade, which achieves comfortable environment and reduces consuming energy.

These types must be characterized by an easy high speed of erection, and they must achieve safety of building construction. The following points help in re- skin design for existing buildings.

- Principle of re-skin design

- Guidelines for re-skin

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هدف البحث:

جمع وتحليل البيانات والمعلومات التي تساعد في تصميم كساء جديد للمباني القائمة بما يحقق خفض استهلاك الطاقة أثناء تشغيل المبنى.

ولتحقيق هذا الهدف تناول البحث أربعة فصول وهي على النحو التالي:

الفصل الأول: كساء المبنى:

يتناول هذا الفصل دراسة تعريف كل من واجهة المبنى وكساء المبنى، حيث تُعرف واجهة المبنى على أنها الوجه الفاصل بين الفراغات الداخلية للمبنى والفراغ الخارجي، بينما الكساء فهو تطور للواجهة ويتضمن زيادة حماية المبنى من العوامل الخارجية. وتشتمل أنظمة كساء المبنى على الآتي:

1– **النظام التقليدي:** ويعتمد هذا النظام على الخصائص الطبيعية لمواد البناء المستعملة من عزل للحرارة ومقدار التخلف الزمني في النقل الحراري.

2– **النظام التكنولوجي المساعد:** والتي تتمثل في أنظمة الإظلال المختلفة وتضم الأنواع التالية:

الأدوات الداخلية والخارجية للإظلال external & internal devices، الأدوات الثابتة fixing devices، الأدوات القابلة للتعديل adjustable devices، الأدوات القابلة للسحب retractable devices، والأدوات الموضوعة في منتصف لوح الزجاج mid-pan devices

3– **نظام الكساء الحساس:** يعتمد هذا النظام على التكنولوجيا المتطورة في أنظمة ومواد البناء، ويضم نظام الكساء المزدوج ونظام الكساء الحساس.

الفصل الثاني: إعادة كساء المبنى:

يتناول هذا الفصل مفهوم إعادة كساء المبنى والذي طرحته منظمة Zerofootprint، وعرفته على أنه إعادة كسوة للواجهات البسيطة بهدف توفير الطاقة المستهلكة أثناء تشغيل المبنى وذلك مع ضمان صلاحية المبنى للاستعمال. حيث يهدف إلى استثمار البناء القائم بما يضمن خفض استهلاك الطاقة.

الفصل الثالث: دراسة تحليلية لبعض الأمثلة:

يتناول هذه الفصل عرض وتحليل لبعض المشاريع الخاصة بأنظمة كساء المبنى ومشاريع إعادة كساءها، ويستعرض هذا التحليل أسم المشروع وتاريخ الإنشاء، وأسم المصمم، ومخلص المشروع بما يتضمنه من شرح موجز لنظام الكساء المستخدم.

الفصل الرابع: النتائج والتوصيات:

يتناول هذا الفصل:

1– **بعض النتائج:** التي تم التوصل إليها من خلال الدراسة.

2– **بعض التوصيات:** المعطاة في صورة اقتراحات يمكن تطبيقها والاسترشاد بها في حالة إعادة كساء الواجهات.

ملخص البحث

مقدمة البحث:

ظهر مصطلح كساء المبنى –Building Skin– خلال العقود الأخيرة نتيجة للتطور التكنولوجي في مجال البناء، ويعتبر هذا المصطلح تطور لمفهومي الحائط الخارجي للمبنى -Building External Wall- وواجهة المبنى –Building Façade–.

أول من وضع هذا المصطلح Michael Davies عام 1981م حيث أشار إلى فكرة كساء المبنى متعدد الوظائف حيث يعمل كساء المبنى كماص وعاكس ومشع ومرشح وأداة تحويل يتم من خلال هذه الوظائف زيادة كفاءة الكساء من الناحية الوظيفية والتي تظهر بشكل أساسي في حماية المستخدمين من المناخ الخارجي وزيادة تكيف المبنى مع الظروف البيئية.

يُعرف كساء المبنى في الوقت الحاضر على أنه عنصر متعدد الطبقات أو متعدد الأغراض أو كلاهما، ويتغير سمكه من الرفيع إلى السميك، ومن الضيق إلى المخلخل، ومن اللين إلى الجاف، وتَباين هذه الخصائص يعطي الشكل المميز لكساء المبنى. ويتيح هذا التنوع خاصة مع الأنظمة الحساسة للواجهات (sensitive skin, devices) زيادة قدرة الكساء للتعرف على الحرارة والبرودة، وهذا يعني أن كساء المبنى يتحكم في مقدار التدفق المستمر من السطح الخارجي للكساء إلى الفراغات الداخلية للمبنى. منعكساً بذلك على مقدار استهلاك الطاقة أثناء تشغيل المبنى.

ونتيجة للأبحاث الدائمة في هذا المجال بدأ التوجه إلى المباني القائمة وإعادة كساءها –Re-Skin–، ويهدف مصطلح إعادة كساء المبنى -Building Re-Skin– إلى إعادة كسوة الواجهات البسيطة للمباني القائمة لتوفير الطاقة المستهلكة أثناء تشغيل المبنى مع ضمان توفير الراحة للمستخدمين.

مشكلة البحث:

حدث تغير في درجات حرارة الكرة الأرضية خلال الفترات الأخيرة حيث بدأت في الارتفاع بشكل ملحوظ. مما يؤثر بالتالي على زيادة استهلاك الطاقة داخل المباني نتيجة للاعتماد على أنظمة التكييف الميكانيكية.

فأصبح التوجه إلى مجال التنمية المستدامة في تصميم المباني من المجالات الهامة والتي تهدف إلى إنشاء مباني صديقة للبيئة ذات معدلات منخفضة لاستهلاك الطاقة. فظهرت نظم ومواد متقدمة في مجال البناء تحقق هذه المتطلبات للمنشآت المقامة حديثاً وتختص هذه النظم بالتعامل مع واجهات المبنى.

وبذلك أصبحت المشكلة تتمثل في المباني القائمة وكيفية تحقيق الاقتصاد في استهلاك الطاقة بها.

وعلى ذلك تتمثل مشكلة البحث في:

رفع كفاءة المباني القائمة لتحقيق المتطلبات الإنسانية والبيئية بالتعامل مع كساء المبنى.

جامعة حلوان
كلية الهندسة
قسم الهندسة المعمارية

إعادة كساء المباني القائمة

بحث تطبيقي في مجال تكنولوجيا البناء للحصول على درجة الماجستير في الهندسة

البحث مقدم من

المهندسة/ ريام محمد الصغير محمود

إشراف:

أ.د. نادية محمد ثابت

أستاذ دكتور بقسم الهندسة المعمارية- جامعة حلوان

2010 -2011