



## Double Skin Facade - Why Not?

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### ABSTRACT

For centuries architects focussed their artistic skills on the creation of a successful external appearance for their structures. This was often the subject of what the style to be chosen, but was also exploited as a medium for conveying new artistic stances.

The fact that facades are again becoming a subject for discussion is no doubt due to the growing importance of the building envelope with respect to energy consumption and options for exploiting natural forms of energy.

“Critical view of Facade’s Technology in Albania and possibilities of applications in our country”.

In the years '90, it was paid a minimum attention to the quality of realisation of facades; everything was strongly in respect to the requirement for dwelling. But, in last years it is a boom of new good buildings, which are accompanied with a progress in the construction forms, in architectonic style and in technics of construction’s materials use. It is to mention that Albanian Architecture is still far away creation of a identity, or a typical it’s style. There are a series of interesting projects and conspicuous buildings for e.g., Sky- Tower, Twin Tower in the main boulevard of Tirana, ETC-building and many other multistoried objects. But it is necessary to say that it is a stiffness in the manner of treating facades, constructive systems used and a small attention to the consumption of energy; and from this point of view we have a limited number of double facades in our country.

Good attention is to be paid to requirements on a facade as a result of internal needs, depending on the use of the building. Inevitable, these have to face up to very diverse local climatic conditions, which vary from region to region.

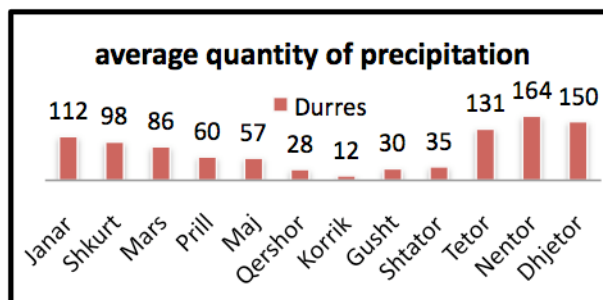
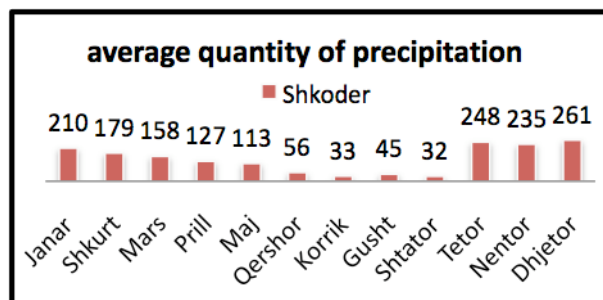
Solar radiation represents as a crucial factor of creation of weather change and the climate. Energy gained from solar radiation is the only source for Earth atmosphere, because all the other energy sources are insignificant in front of the energy gained from the sun such as: cosmic radiation, radiation from the other planets, inner heat of the earth etc. Overall quantity of energy gained from the solar radiation at first is due to reciprocal position of Sun and the Earth surface.

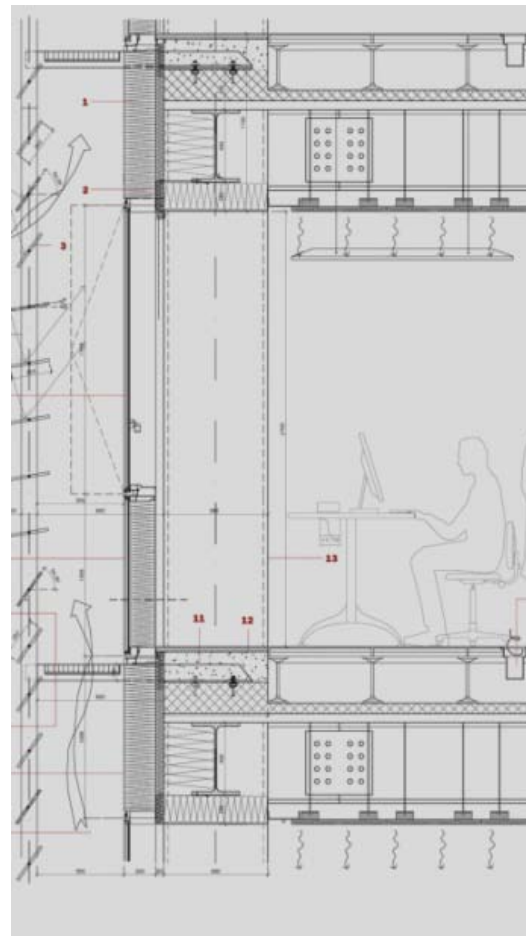
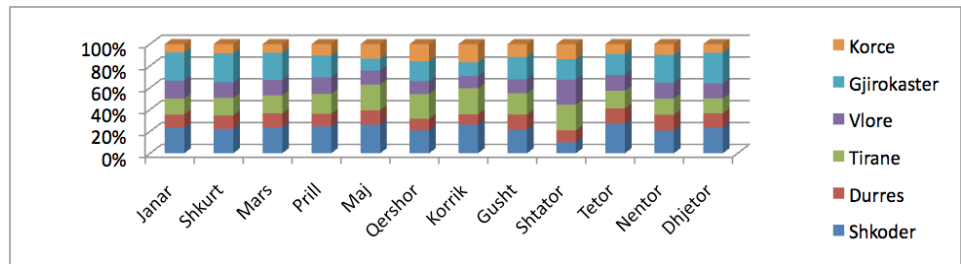
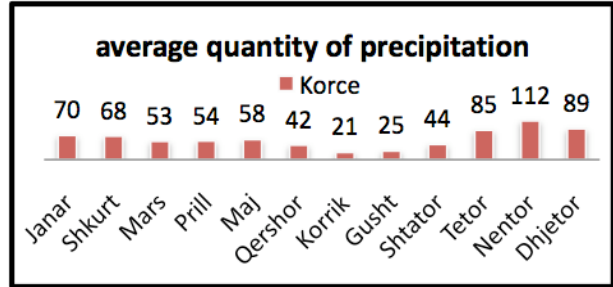
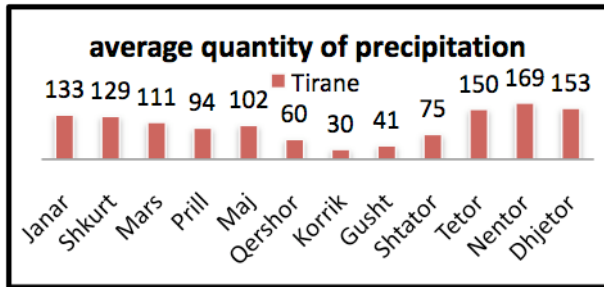
| Station     | I    | II    | III   | IV    | V     | VI    | VII   | VIII  | IX    | X     | XI   | XII  |
|-------------|------|-------|-------|-------|-------|-------|-------|-------|-------|-------|------|------|
| Tirane      | 8.15 | 10.93 | 16.58 | 19.73 | 22.82 | 23.45 | 23.12 | 21.07 | 17.17 | 12.92 | 9.17 | 7.17 |
| Durres      | 8.16 | 10.96 | 16.59 | 19.74 | 22.82 | 23.45 | 23.12 | 21.07 | 17.18 | 12.93 | 9.18 | 7.18 |
| Vlore       | 8.51 | 11.31 | 16.86 | 19.91 | 22.87 | 23.48 | 23.17 | 21.09 | 17.45 | 13.24 | 9.51 | 7.51 |
| Korce       | 8.46 | 11.36 | 16.82 | 19.88 | 22.86 | 23.48 | 23.16 | 21.09 | 17.41 | 13.18 | 9.46 | 7.46 |
| Gjirokaster | 8.66 | 11.46 | 16.97 | 19.98 | 22.89 | 23.50 | 23.19 | 21.10 | 17.57 | 13.36 | 9.66 | 7.60 |
| Shkoder     | 7.82 | 10.62 | 16.33 | 19.58 | 22.78 | 23.42 | 23.07 | 21.06 | 16.69 | 12.54 | 8.86 | 6.89 |

Height over the sea level and the relief are other factors that influence in creation of the climate. Average height over the sea level in our country is 708m, approximately twice than Europe. The more one country is over the sea level, the more is its influence over the climatic's elements.

As following is spread of overall radiation in a clean sky, when this radiation is conditioned only by the astronomic factors and the atmosphere's transparency. In kkal/cm square But, mean time a good attention is to be payed to the level of precipitations in our country, before experimentin with new technices of fcaes construction. So, for the main cities of Albania, we have a this table and grafics as follow:

| City        | January | February | March | April | May | June | July | August | September | Tetor | Nentor | Dhjetor |
|-------------|---------|----------|-------|-------|-----|------|------|--------|-----------|-------|--------|---------|
| Shkoder     | 210     | 179      | 158   | 127   | 113 | 56   | 33   | 45     | 32        | 248   | 235    | 261     |
| Durres      | 112     | 98       | 86    | 60    | 57  | 28   | 12   | 30     | 35        | 131   | 164    | 150     |
| Tirane      | 133     | 129      | 111   | 94    | 102 | 60   | 30   | 41     | 75        | 150   | 169    | 153     |
| Vlore       | 148     | 114      | 95    | 78    | 55  | 32   | 14   | 27     | 73        | 134   | 164    | 156     |
| Gjirokaster | 234     | 212      | 166   | 104   | 47  | 48   | 16   | 43     | 60        | 176   | 288    | 314     |
| Korce       | 70      | 68       | 53    | 54    | 58  | 42   | 21   | 25     | 44        | 85    | 112    | 89      |



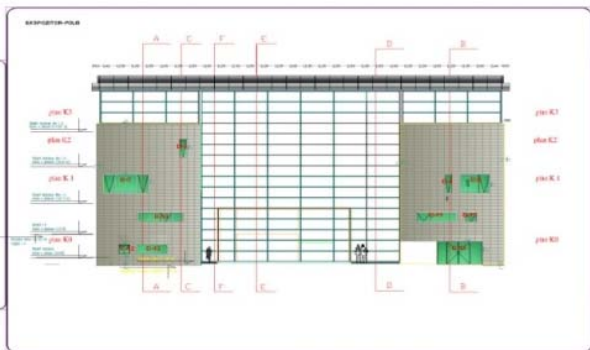
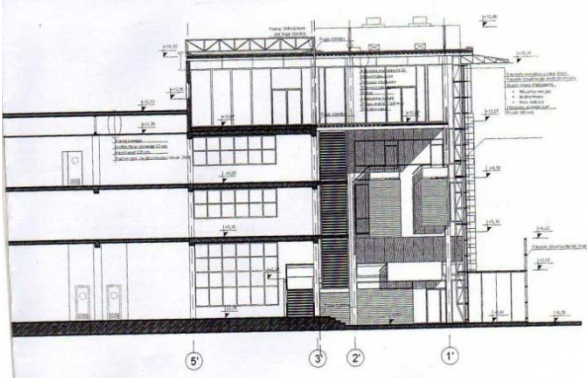


## European Trade Center. Designed by EDIL AL-IT Group.

ETC is a combination of traditional architecture and that modern. Object is located near by one of the most crucial axes of Tirana's city—Zhan D' Ark Boulevard . ETC is built in two different zones,so northern facade by the ring is in front of a very noise one as it is a commercial centre it is, while the facades from West and Sud have an orientation more convenient regardin to the solar efficiency.

## Universiteti Polis, Designed by arch. Eled Fagu

It is one of the few examples of double-skin facades in Tirana. That is located in Mezez-district of K ashar. Tirana

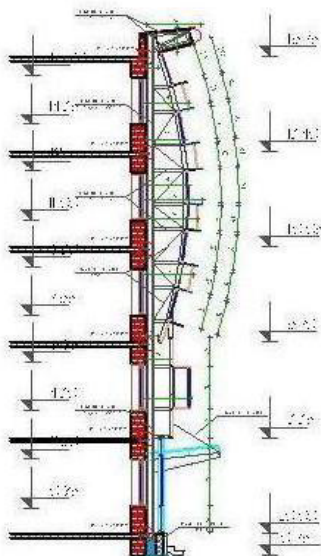


## Reconstruction of facades of the Ministry of Labour, Social Affairs and Equal Opportunities

Fascade is conceived to be completely covered that existing one, with structural glass & alucobond. Main volume has another treatment from the other part of the building, it means realising a soft arch, that comprise upper stories (2nd, 3<sup>rd</sup> and 4th).

In the very first impression it creates the idea of “scales”, that indeed hide existing conditioners, that were so annoying. It is considered for the façade of glass to have a distance that respect correctly functional process of devices.

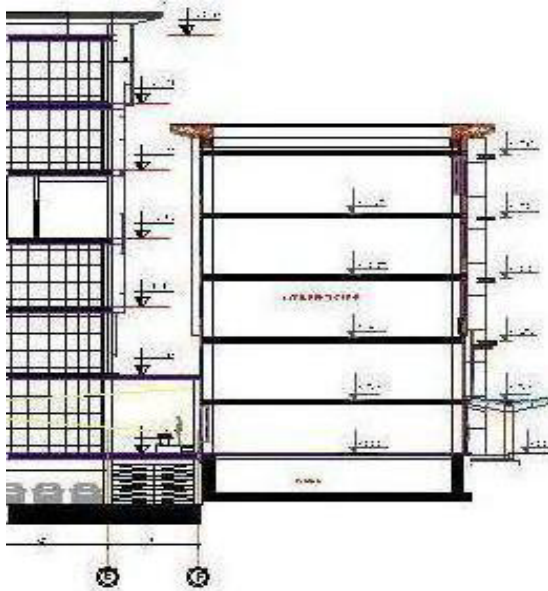
In the technical aspect, we have the use of selffixings bolts and metallic profiles. At the same time we have a hidden metallic truss for fixing glass elements and alucobond. In the upper part, in the tarace, it is thought for a overhang with a metallic skeleton, fixed in the existing tarace, and then covered with alukobond.



## **Addition and Reconstruction of the building of the Economics University of Shkodra “Luigj gurakuqi”, Faculty of Natural Sciences (old building)**

**Object location.** It is worked to create an univerty building to an high quality referring to the comleteling all the contemporary standarts of the high Education. This Object, is thought to be realised on the rear part of the old Building of the University ‘Luigj Gurakuqi’, Faculty of the Natural Sciences, and near the new Library of the students.

It has a big Screen up to 21.2m with 8.7m, which serves as a curtain with a ditance about 50cm. The new building has 6floors and underground. It was treated to in strytrual glass and alucobond, referring to the covering of facades.



## WHY DOUBLE-SKIN FACADES?

- It reduces the peak of wind pressure
- Improve the energy effect of Facade from:
  1. Heating of passive solar e, collected in winter
  2. Reduces thermal loss in winter
  3. Helps natural ventilation, and with the effect of louvers.
- Improve comfort of the building:
  1. Thermal: a) predicted  
c) temperatures according to that predicted
  2. Visual: a) day light factor  
b) wanted brightness  
c) good view

## INTERNAL AND EXTERNAL CONDITIONS

The facade is the separating and filtering layer between nature and interior spaces occupied by the people. The primary reason for creating an effective barrier between interior and exterior is the desire for protection against outside world. So this leads to control and regulatory functions being added to the protective functions. All of these requirements can be divided into two groups, depending on how the facade is being considered: the external conditions specific to the location and the requirements governing the internal conditions.

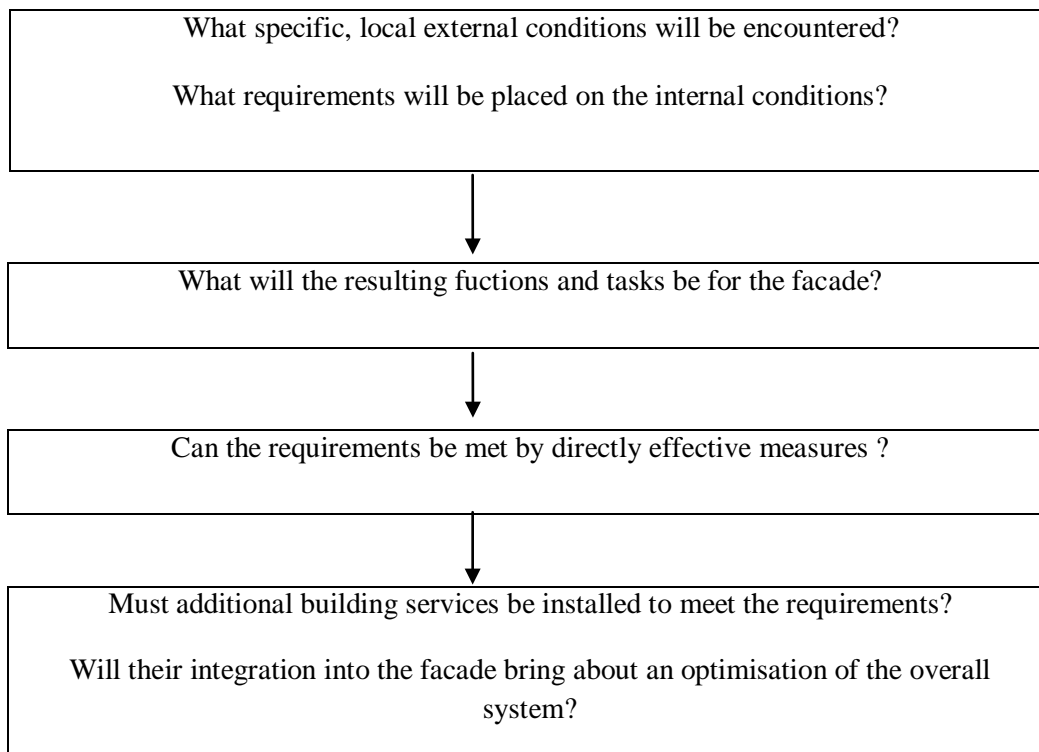
### The demands placed on the facade from outside and inside

As a rule, the external conditions can not be influenced by the design. They therefore represent a primary criterion even at the stage of choosing a plot of land.

The requirements placed on the interior climate, which are essentially determined by the term “comfort” are in certain circumstances, such as the desire for high artistic merit. These conditions mean that the facade has to provide protective and regulatory functions.

### The efficiency of a facade

A facade should be able to handle climatic tasks because that allows additional measures such as air conditioning.



Open bodies of water for cooling ( due to evaporation) or dehumidifying ( with a sufficient water-interior air temperature differential) can be employed externally zones. The heat radiation against which the building has to protected can, for example, be converted into electricity, or absorbed by collectors and used for hot water provision.

Apart from the influencing factors, we also have to employ a similar approach to conditions resulting from the context of the building as a whole.

## **External Conditions : Solar Radiation**

In terms of specific local external conditions, the SUN plays the key role. It is the most important direct and indirect Source of Energy and the foundation for all life on our planet. The quantity of solar energy incident on the Earth is equivalent to approx. 10000 times the current global energy demand ( an average energy flux of 1353 W is incident on every square metre of the outer limitsof the Earth atmosphere).

Facade design also calls for a thorough analysis of the following aspects and relationships:

- Solar altitude angle in relation to location, time of day, and season
- Quantity of radiation, depending on orientation and inclination of surface, location, time of day, and season.
- The various types of radiation (diffuse, direct and various wavelenths) and their magnitudes in relation to weather conditions, orientation, location, time of day, and season.
- The interaction with surfaces and materials.



- The anticipated quantities of incident energy in relation to weather conditions, orientation, location, time of day, and season.
- The relationship of the radiation with the heat requirement resulting from the intended utilisation.

## Thermal comfort

The internal climatic conditions have to meet certain requirements, which can be summed up by the term “thermal comfort”. The relevant influencing factors related to the construction of the façade are:

- Temperature of interior air. **(a)**
- Relative humidity of interior air. **(b)**
- Surface temperature of building components enclosing the room. **(c)**
- Airflow across the body. **(d)**

## Physical principles

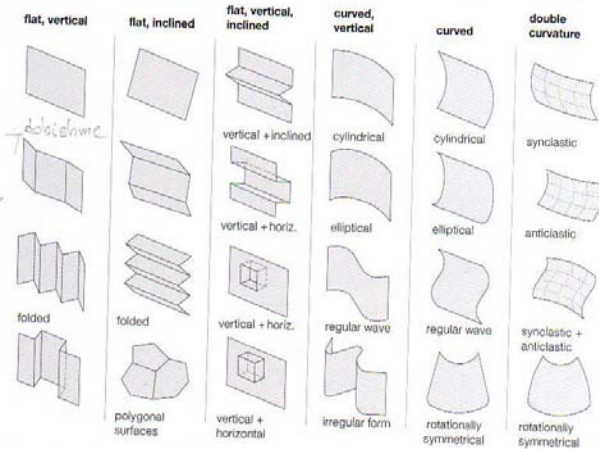
To understand the functions of the facade, we must look at the scientific principles of the construction, e.g. heat flow, water vapour pressure, radiation transfer.

### *Heat transfer*

Thermal energy always flows from the hotter (higher-energy) side to the colder side. Three basic principles govern the transfer of heat energy:

1. Conduction
2. Radiation
3. Convection

The thermal transmittance  $U$ - ( $w/m^2K$ ) may be calculated for plane components



### *Thermal conductivity and heat capacity*

Both of these factors depend on the properties of material generally increase with bulk density. However, the heat capacity of water represents a clear exception in comparison with common building materials.

## The Structural Principles of Surfaces

Facades are primarily planar structures positioned between the external and internal environments.

Regardless of what materials are employed, there are various applicable features and engineering design principles that are valid for the facades. A knowledge of these is helpful for the design process. A design principle indicates a fundamental solution for a defined construction task in accordance with predetermined functions. The structure of the facade is considered:

- In plane of the facade, and
- Perpendicular to the plane of the facade

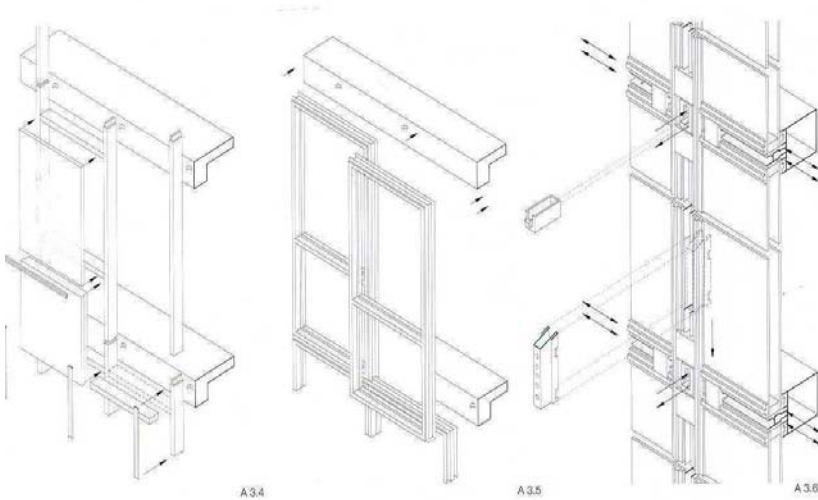
Facades can be assigned certain performance profile, which can vary across the surface, according to the catalogue of functions and requirements. The engineering principles and materials employed may require several functional and constructional “levels” perpendicular to the plane of the facade.

### Type of Facade

From a construction point of view, we can distinguish two fundamental types of facades:

- Loadbearing external wall.
- Non-loadbearing facing leaf.

In the first case, windows are formed or incorporated in a loadbearing external wall. These can be in the form of individual openings or can be combined to form continuous bands of windows horizontally (also storey-high) or vertically (also over several storeys).



The areas of the facade between the windows can be clad externally with sheet metal or opaque glass if necessary. Their external appearance then resembles that of a non-loadbearing facade.

### Method of construction

Distinguishing facades in terms of their method of construction concentrates on the fact whether individual components (e.g., posts, rails), or fully functioning modules (called elements) have to be delivered to and erected on the building site.

Facing leaves using a post-and-rail construction are very popular solutions. This form of construction uses sliding longitudinal and transverse connections between the posts and rails.

One essential advantage of this is that, contrasting with the situation on the building site, this work takes place under controlled, industrial conditions with a high degree of automation and a high level of accuracy. This type of construction also includes those prefabricated facades in which the façade sections are assembled to form frames by using T- and L-connectors.

Prefabricated facades consume more materials and more plant time, and require experienced designers and engineers. However, they are equally suitable for high-rise buildings and single-storey sheds and are preferred for those with a regular structural system.

## Sunshading

If it were possible to design a system to screen direct solar radiation and to admit all the diffuse light from the sky, then such a system would exhibit a reduction factor of 21%.

The shading and light-redirecting effects of variable louvre systems can be optimised by employing:

- High-level and eye-level louvers that can be set to different angles.
- Different reflectance values for top side and underside of louvers.
- Louvre surfaces with geometrical textures

Standard perforated louvre systems can result in a 50% increase in radiation transmission and a corresponding increase in the cooling load compared to a non-perforated system with a similar construction and surface finish. The deciding factor for the sunshade is not only the type of shading itself, but also its arrangement: **the further away from the building, the better!**

## Glass for sound insulation

The use of laminated glass with different pane thickness plus a heavy gas filling in the cavity between the panes, considerably improves the sound reduction index of insulation glazing. Whereas conventional double glazing (4mm+16mm+4mm) achieves a sound reduction index  $R_w$  of 30Db, an asymmetric arrangement (4mm+16mm+8mm) plus a suitable gas filling can achieve 35 Db.

## Glazing

Window and Facade constructions consist of the following functional elements:

- Glazing elements (e.g., panes of glass)

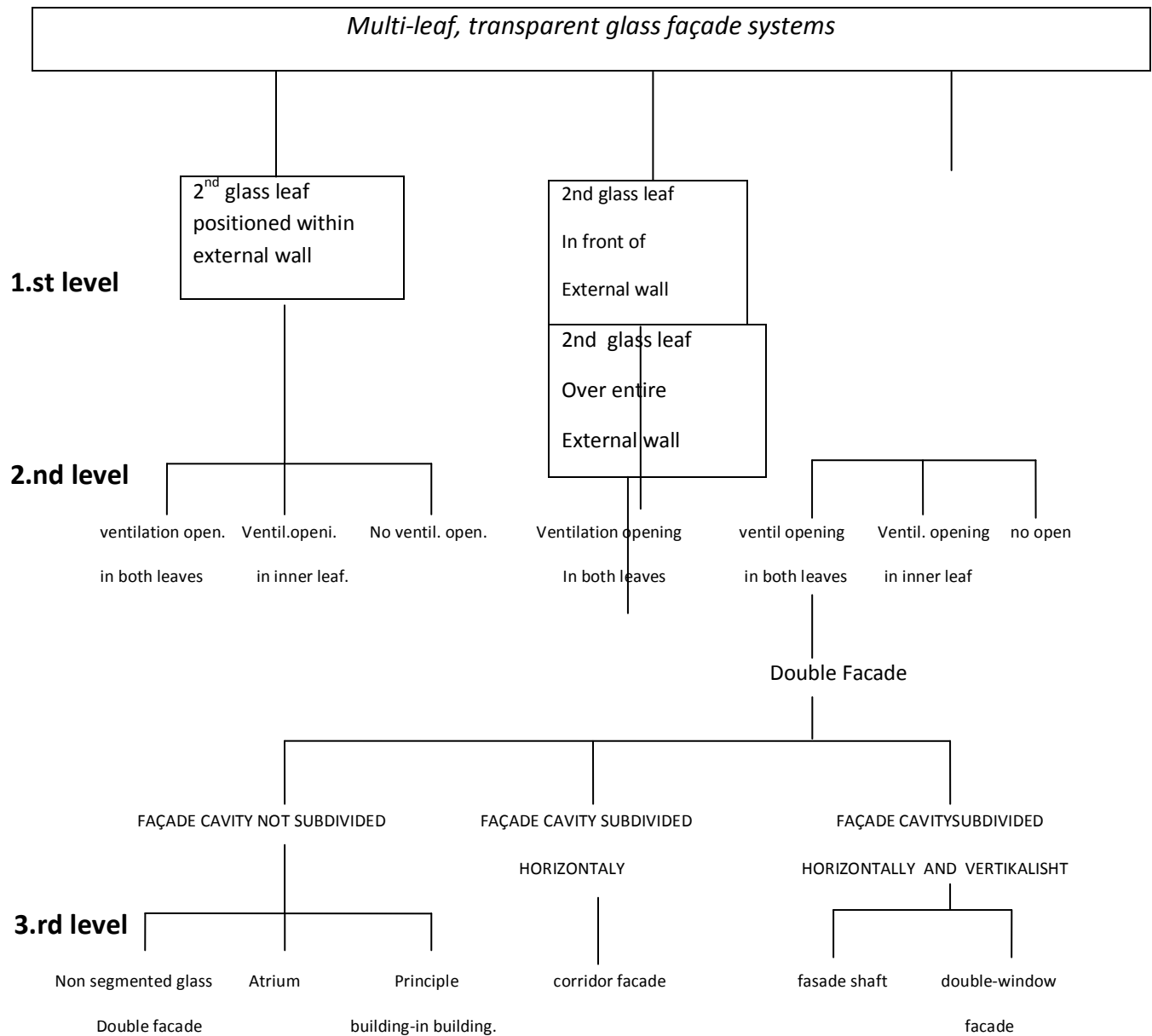
- Supporting construction (e. g., rails, frames)
- Fixings
- Joints (e.g.,EPDM. silicone)

## **The Glass Double Facade**

### **From storm window to glass double facade**

The development of multi – leaf, transparent building envelope is closely linked with the increasing use of glass in buildings. This was made possible by progress in manufacture of glass, such as the invention of the cast glass. The first references of the use of multi-leaf window systems are found in a publication dated from the late seventeenth century. Talking about improving thermal performance of windows, the use of a “double window” is recommended. During the eighteenth and nineteenth centuries, variations on this theme appeared –multi-leaf window constructions.

The possibility of improving the functional properties of single glazing by placing an additional glass skin in front was also used when glazing large facade openings.



1st level: Position of 2nd glass skin;

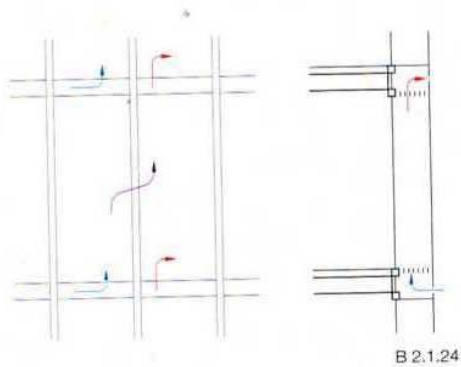
2nd level: Position of ventilation openings;

3rd level: subdivision of façade

New systems, such as exhaust-air windows and facades, in which the window or façade cavities are combined with the building's ventilation system to help control the interior climate, started to appear in the 1980s.

Advances in multi-leaf glass facade systems continued into the 1990s as the increasing demands of users and more stringent energy saving regulations favoured the development of “glass double-facades”. The potential for reducing energy consumption and optimising interior conditions makes the glass double facade one of the most interesting new developments in the facade sector..

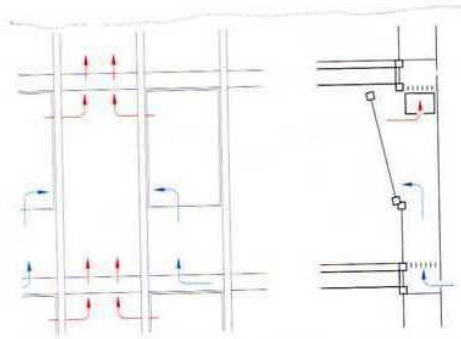
### *Corridor facade*



B 2.1.24

To minimise the risk of the outgoing exhaust air and the incoming supply air becoming mixed, the ventilation openings must be offset laterally or an adequate vertical spacing guaranteed. Spread-of-fire requirements can be met by providing a suitable designed corridor floor or ceiling. The segmentation prevents a build-up of heat at the top of the facade.

### *Shaft facade*



B 2.1.25

In contrast to the corridor facade, the shaft facade employs vertical separating elements to subdivide the facade cavity. The inner leaf of the facade alternates between shaft-like facade zones with a closed inner leaf, and sections designed like double windows with opening lights.. The temperature differential that ensues in the shafts and the resulting stack effect are exploited to improve the exchange of air between the cavity and the rooms behind.

Again, however, this type of facade suffers from spread-of-fire problems, the risk of supply and exhaust air becoming mixed during unfavourable weather conditions, and internal sound transmission problems.

### *Double – window facade*

In terms of its construction, this type of glass double facade is the most complicated because the cavity is separated horizontally, storey by storey, and also vertically, to form shaft-like sections. Each of these facade units has its own supply-air and exhaust-air openings. In contrast to non-segmented glass double facades and shaft facades, it is virtually impossible to exploit the stack effect to help move the air through the facade cavity. Sadequately sized ventilation openings are therefore essential if overheating problems are to be avoided.

## Costs and benefits

Glass double facade systems, depending on their design and construction, exhibit a wide range of functional characteristics. The merits of such facades are:



### RWE headquarters

Architect: Ingenhoven Overdiek Kahlen & Partner, Düsseldorf. 1996. Height of building = 127m, diameter = 32m, 29 floors.

optimise daylight utilisation,

- Natural ventilation options in very windy locations
- Avoidance of sick building syndrome due to better opportunities to realise user-controlled natural ventilation.
- Enhanced comfort because of the higher surface temperature of the inside of the facade during cold weather.
- Improvements to the energy balance thanks to the option of night-time cooling of buildings with exposed thermal masses.
- Better use of and protection for sunshading devices.
- Better sound insulation in noisy locations.
- The opportunity for storey-height glazing to optimise daylight utilisation.

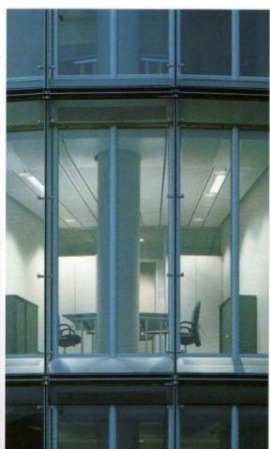
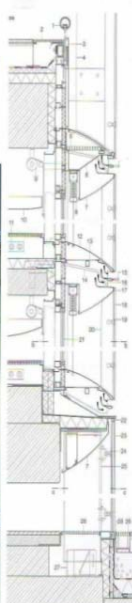
Reinforced concrete structure, Storey-height glazing to

8.4m high facade at ground level, extra clear glass with countersunk screwfixings, insulating glazing with toughened safety glass outside and laminated safety glass inside.

Centrally controlled sunshades ( in facade cavity) and anti-glare blinds ( in rooms). Standard floor with prefabricated double-window facade for natural ventilation, 1970 x 3591 mm. Alternate fixed and sliding (manually operated) glazed elements

Multi-functional ventilation element at floor level with air inlets and outlets offset laterally.

- 12 Multi-facade system: external glass, internal glass, double glazing
- 13 External glass: 12 mm toughened safety glass
- 14 Insulating glazing: 12 mm toughened safety glass / 12 mm toughened safety glass
- 15 Internal glass: 12 mm laminated safety glass
- 16 Multi-facade system: external glass, internal glass, double glazing
- 17 External glass: 12 mm toughened safety glass
- 18 Insulating glazing: 12 mm toughened safety glass / 12 mm toughened safety glass
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- 29 External glass: 12 mm toughened safety glass
- 30 Insulating glazing: 12 mm toughened safety glass / 12 mm toughened safety glass
- 31 Internal glass: 12 mm laminated safety glass



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High building RWE, contains an innovation which is completely based in DSF technology; it is natural ventilated, eventhough we have a “sky-scraper”. This building ensures inner opening windows in the inner skin with fixed panes on the outer skin. RWE has more a manual system than a system of activating of power that other buildinds have. The inner facade, is also completely high. Not all the pane are able to open, but these are high-storey opened in a wide of 15 cm. Having all the height opened, gives a stron feeling of natural ventilation and allow the same volume of air enter the floor level and exhaust at the ceiling level.

The windows can be opened vertically up to 10 cm from floor to ceiling height. Fig. 10 shows the results of the tracer gas measurement of the natural air change per hour for one office on the 1st floor and one on the 16th floor.

For the designer it is very important to estimate the natural ventilation of the facade space in order to calculate the temperature in the facade space and inside a naturally ventilated building. the air movement in the facade was measured with two thermo anemometers (measurement of air velocity).

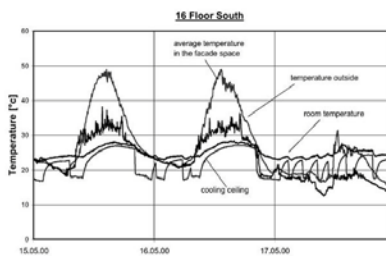


Fig. 9. RWE tower, temperatures in May.

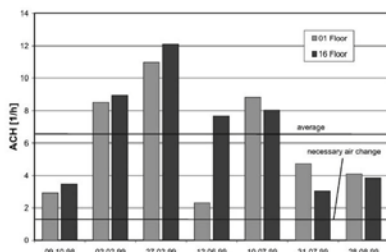


Fig. 10. RWE tower, natural ventilation of the offices.

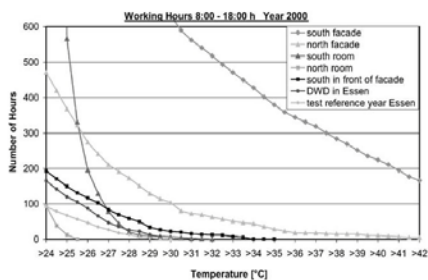


Fig. 11. RWE tower, number of hours above a certain temperature.

A very important aspect for the design of naturally ventilated buildings is the surrounding temperature.

### Air flow inside the double facade

The simulation of double facades with commercial dynamic thermal simulation programs and the prediction of the thermal behaviour is physically not problematic if the main input data is known.

In a detailed statistical analysis of a 1 year measurement in 15 min steps the correlation between wind speed, wind direction and the temperature difference with the environment was analysed with the generalised additive model in the program.

The factor (wind direction) stands for the influence of the wind direction, classified in 15° sections.

$V = \log(\tau) + \log(\text{wind speed}) + \text{factor}(\text{wind direction}) + c$  gives an overview of the quantity of the influence of the different parameters on the mass flow of air through the gap of a double facade.

For a planned new building it is very difficult to predict the influence of the wind on the ventilation in a double facade.

### Conclusions

The long-term measurements show that a double facade is reasonable to allow natural ventilation in high-rise buildings and buildings with high outside noise levels.

The advantages of double facades in the buildings measured are:

- wind protected sun shading elements (louvers) in the facade space;
- noise reduction;



- in buildings with ventilation systems (RWE Tower) the sun protection works under all wind conditions and has no negative thermal effect on the room temperature. The disadvantages of double facades are:
  - higher temperatures in front of the window than behind outer louvers;
  - relatively high investment costs (from approximately
    - 500/m<sup>2</sup> facade upwards for the complete facade);
  - higher cleaning costs.

The facade of the RWE building is an example of a fully glazed facade, which can be protected effectively from solar gains.

For specific locations (wind or noise) double facades save energy as compared with conventional solutions with full air conditioning. Nevertheless, they will not be the best choice for every building in every location.

For simulations it makes sense to use an average air change rate instead of trying to calculate a temperature driven ventilation of the facade gap.

Further ideas in planning double facades are to separate facade space and ventilation openings in order to prevent ventilation heat gains in summer. Another possibility to prevent extensive solar gains is to build smaller double facade windows instead of a fully glazed facade. Another expensive way to prevent overheating is to open the outer facade completely during hot conditions (Fig. 9 shows typical temperatures for a period in May 2000. During the day the cooling ceiling was not operated and the room temperature stayed below 28 °C. Generally, the cooling ceiling was always able to keep the room temperature at the adjusted level.

The average air temperature in the facade space rose up to 15° above the temperature in front of the facade.

Fig. 11 shows the number of hours during working hours when a certain temperature was exceeded during the year 2000.

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