Renovation of Buildings using Steel Technologies (ROBUST)

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WP 1.1
European case studies on over-cladding commercial and residential buildings

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EUROPEAN CASE STUDIES ON OVER-CLADDING

This series of Case Studies reviews recent experience of over-cladding in European projects in the residential, commercial and industrial sectors.

1 Renovation of office building "'t Casteelken" Rumbeke, Belgium

Originally the building was an industrial building, transformed as a brewery and lately into a cannery. The building is located on the main square of the village. The objective was to renovate three of the façades and build a horizontal extension comprising a reception plus show-room.

It was a requirement that the site work should not stop the daily activities of the show-room and of the company. Thus, the architect decided to build a second glass skin away from the original brick wall using a secondary steel structure. The existing brick walls were not in a good state and for this reason, the architect decided to use an exciting new façade treatment, which allows the visual communication between inside and outside, as shown in Figure 1 and Figure 2 below.

Figure 1 *View of the building after renovation*

Figure 2 *View of the space between the existing brick wall and new cladding*

2 Renovation of small commercial building "The fotoatelier", Schilde, Belgium

This shop is on the main commercial road that connects Schilde to Antwerp. The building was renovated using a mixture of materials. Stainless steel and glass are the only two materials visible.

Figure 3 *View of the shop before and after renovation*

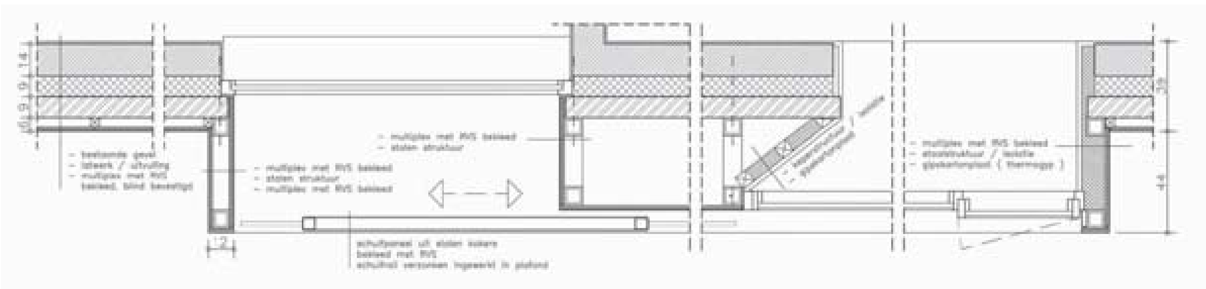


Figure 4 *Detail of the new façade*

3 Renovation of office building, Hasselt, Belgium

The original building had a reinforced concrete structure with prefabricated concrete façades, which were old and in a poor state. The objective was to renovate the façades (by aesthetic and functional renovation) and create a horizontal extension to the building, as shown in Figure 5.

The original façades were cleaned and refurbished before an active double skin was added. In this façade technique, the fresh air enters the offices via the corridors and it is evacuated via special holes in the façade. The space between the glass wall and the old façade is hermetically sealed and is always in negative pressure due to an external extractor ventilator on the top of the roof.

The glass façades work as an acoustic barrier against street noise. The existing structure could not support additional loads and for this reason, a light steel secondary structure was provided at the roof level. Access walkways were included to help during the maintenance of the two façades. The glass panels are glued to a stainless steel frame.

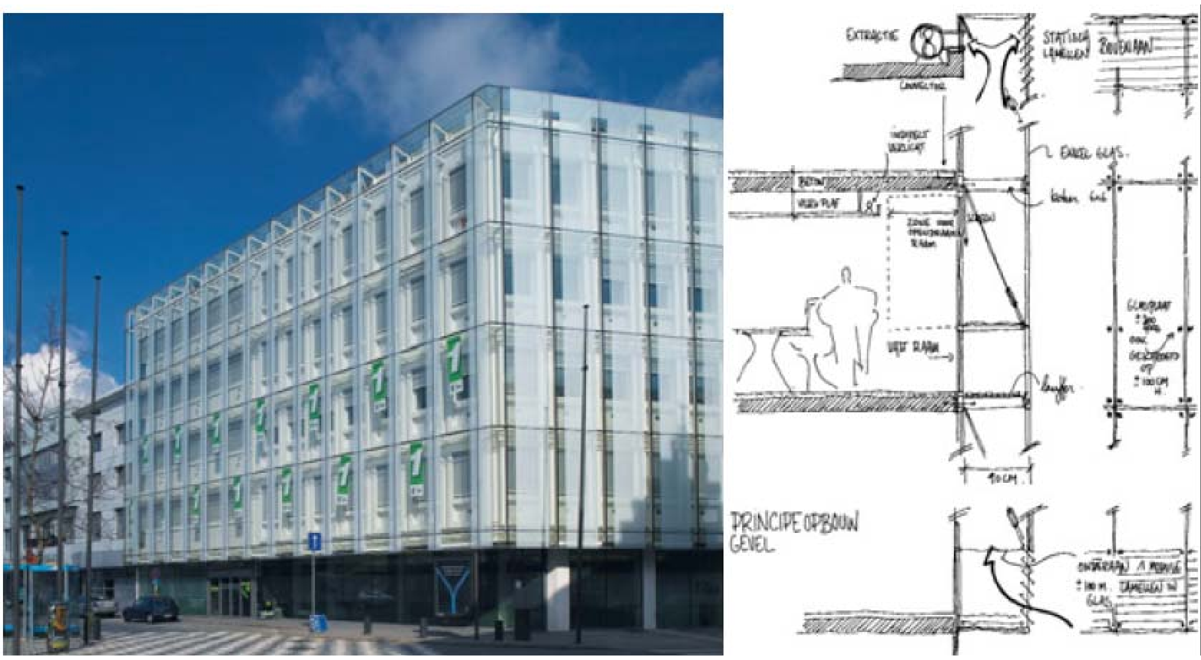


Figure 5 *View of the office building after renovation and the sketch of the new façade in operation*

4 Shop to office conversion, Chaudfontaine, Belgium

The change of use of the building from a shop to office led to the requirement for a different façade that permitted more light to enter and that gave more privacy to the office workers.

The façade was renovated by *Indaten* 35 mm thickness steel panels. The steel panels were cut and stiffened by side bending. The new metallic cladding was attached to the existing façade at a spacing of 120 mm from the existing façade to the new facade. Details are shown in Figure 6.

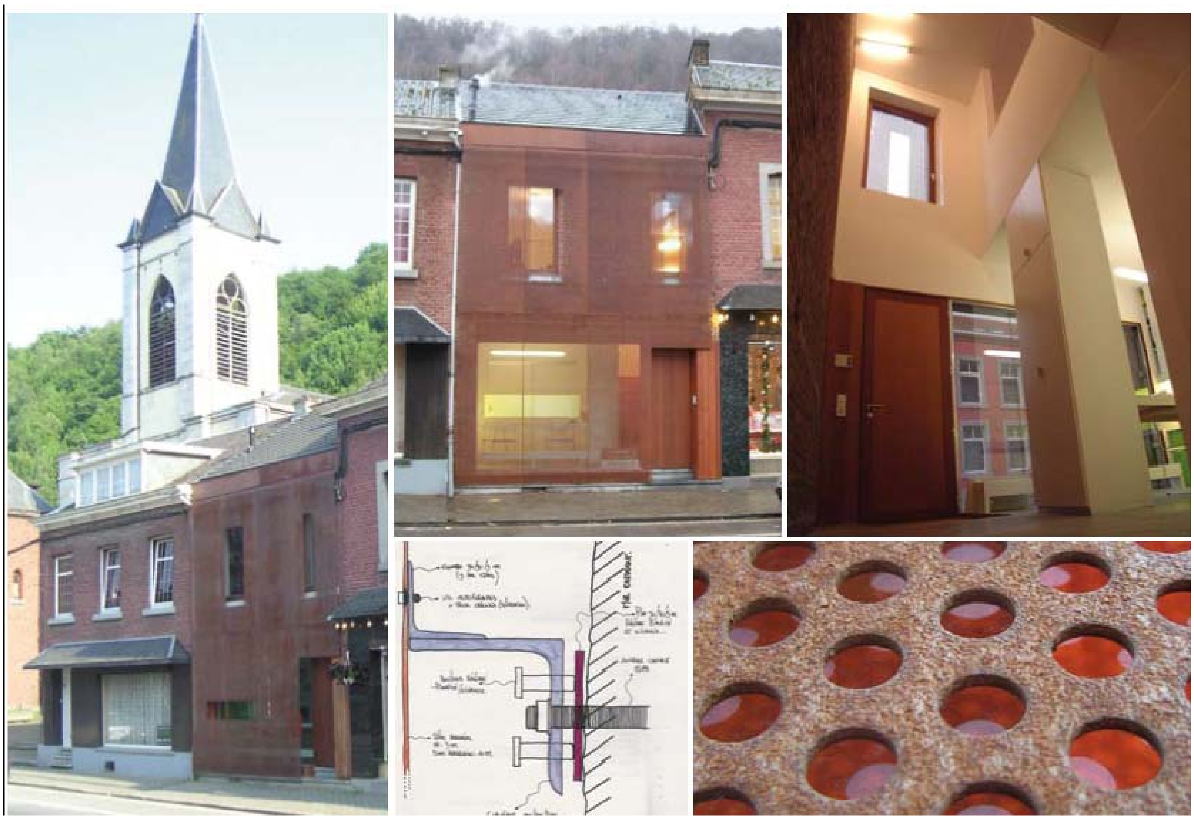


Figure 6 *View and details of the new façade*

5 Garage to library conversion, Antwerp, Belgium

The new Permeke library was opened in April 2005, in which an old automotive garage has been transformed in a library. The old roof shed structure was preserved and upgraded to give the maximum light possible to the users and the visitors to the library as shown in Figure 7. To translate the industrial character of the building, the façades were covered by galvanised steel plates. An insulation layer was added to the existing façade to provide the thermal insulation. The new façade was separated from the original façade by steel profiles. Details are shown in Figure 8.

Figure 7 *External view of the roof and internal view*

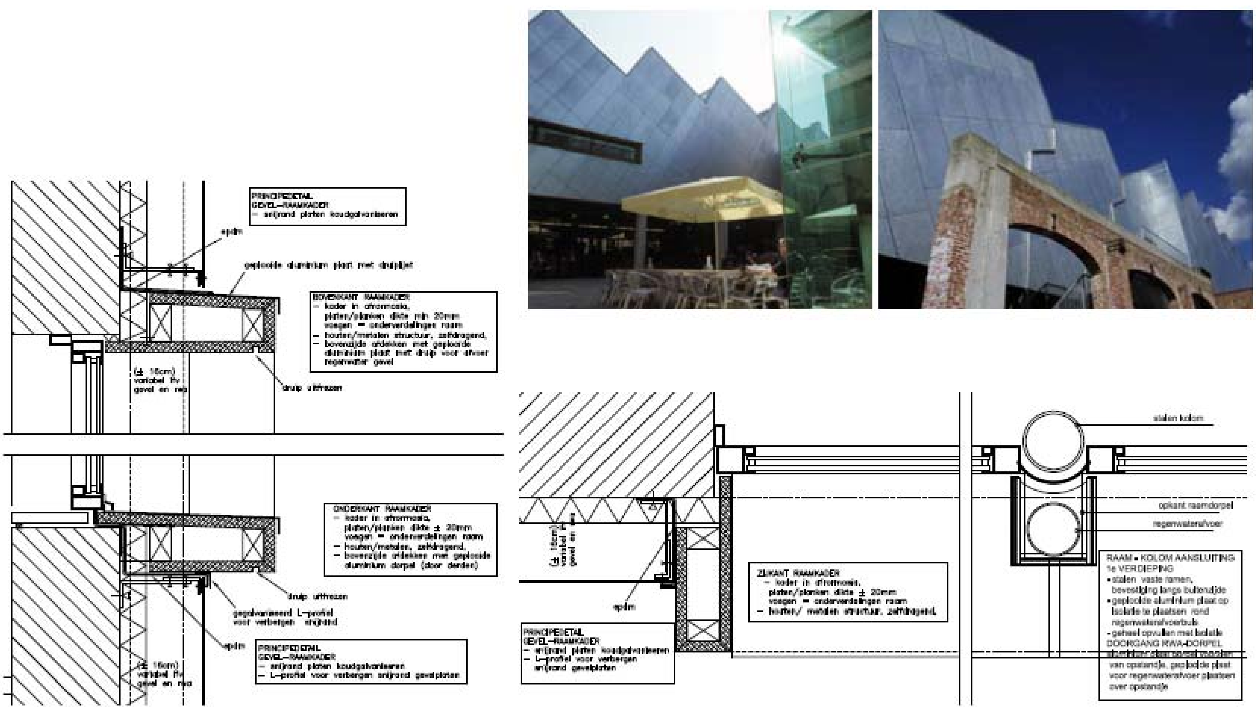


Figure 8 *Details of the façade*

6 Renovation of Hooge radd voor diamante, Antwerp, Belgium

The complex of existing offices for the “hooge raad voor” diamante needed an extension and the addition of adjacent factory space for diamond cutting. The architect managed to functionally and aesthetically merge the two buildings and to add four new floors. The new floors have a steel framed structure that supports the glass façades by ‘spider’ nodes welded to the steel structure. Vertical bars strengthen the structure at the position of the floor slab. Details are shown in Figure 9.

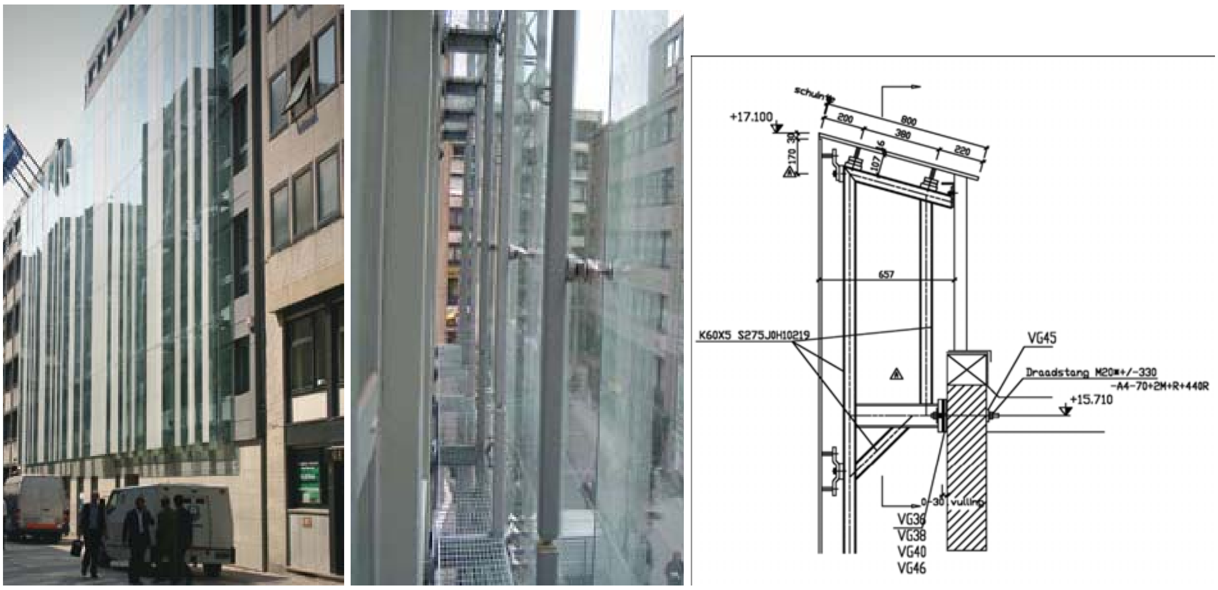


Figure 9 *View and detail of the glass façade and its attachment*

7 Madou Tower, Brussels

As one the the tallest tower buildings in Brussels, Tour Madou is 33 floors and 100 m high. It was built in the 1960’s close to the internal Brussels’ ring road. In 2002, the work of complete renovation was given to Assar architects and Archi 200. In total, 8000 m^2 area of new façade was added. The cladding of the tower was completely removed and a new thicker steel-glass skin was added.

This renovation received the Mipim Award in 2006 in Cannes for the best project completed between 2005 and 2006. Views of the tower, during and after renovation are shown in Figure 10.

Figure 10 *Tour Madou before and after renovation*

8 Il Sole 24 ore headquarters, Milan, Italy

Renzo Piano's complex project for the new Milan headquarters of Italy's financial daily newspaper, "Il Sole 24 Ore", is located in the "old" trade fair district, which is now undergoing radical transformation. This brown field site comprises a three sided, former industrial building between Viale Monterosa and Via Tempesta opening onto an inner court. The before and after images of the building are shown in Figure 11.

A truss of lanceolate-shaped steel girders support the roof, cantilevering out to form a protective canopy. The lightweight quality that the building exudes is achieved by the way the building mass and frontage have been broken up with vertical services and communication blocks. The space "lost" by this architectural design has been recovered by the addition of two storeys, the top-most level set back 4 m on the road-facing side and about 2.5 m on the courtyard side. The base of the building is clad in horizontal strips of "cotto" tiling, while the glazed frontage along Via Tempesta is articulated by three towers. The façades are reinforced by vertical glass elements and connected to the concrete floors by transparent horizontal, heat-resistant glass panelling.

The continuous glass wall covers the existing structure, shown in Figure 12. A transparent surface during the daytime, the building turns into a gently glowing volume at night, as if projecting outward the concentrated work going on inside as next day's newspaper goes to print. The roofing is a composite structure of alternating metal grid, screen printed glazing and brise-soleil strips. The effect is that of a continuous suspended structure hovering over the top floor. The lightness and transparency of the complex are strong metaphors well suited to the functions housed by the building. The green sun blinds on the glazed panels provide a freshness to an urban context.

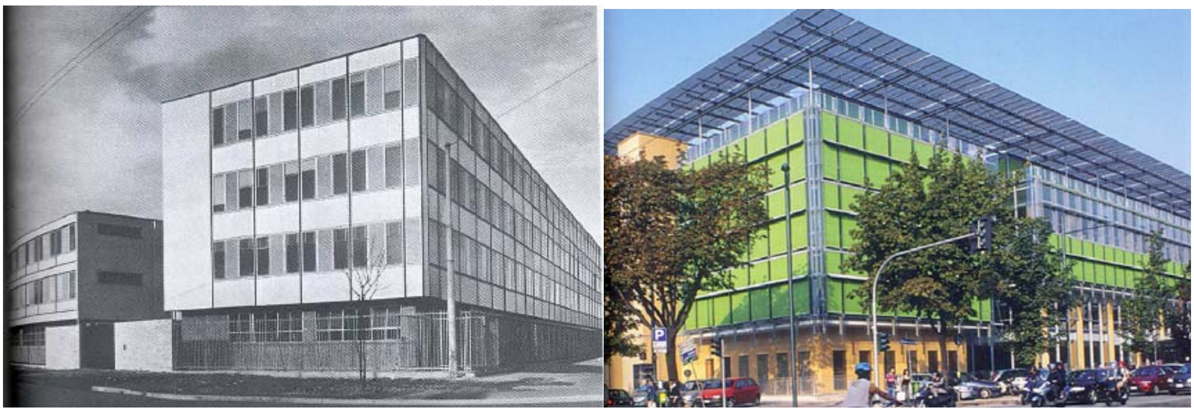


Figure 11 *Before (historical picture) and after renovation*

Figure 12 *Studio model, construction details and drawing of the connection to the existing structure*

9 Hines Office building, Begognone, Milan

The renovation of "Bergognone 53" complex in Milan, Italy was the result of an international competition by real estate developers, Hines. The former Postal Service building is located in a former industrial area and complete urban block, four building with an inner court built in the 1960's and 70's. Renovation preserved the existing internal space, whilst updating the design of the building for new functions. The before and after renovation images of this building are shown in Figure 13.

The 7 storey west-facing façade on Via Bergognone underwent the most extensive restructuring. The new transparent outer skin follows the modular structural frame of the block shown in Figure 14. The more exposed south-west side has a "second skin" projecting 600 mm that acts as a large sun blind or passive filter. This second layer reduces solar radiation, thereby lowering air-conditioning energy requirements. "Chilled" ceiling beams, partly behind perforated suspended ceilings, are connected to the ventilation system and to part of the lighting circuit. The internal courtyard was completely refurbished using a structure of suspended steel and glass, as shown in Figure 15.

A finned-tube battery using warm water in winter and chilled water in summer combines with optimal air flows to ensure comfort zone temperatures where needed. Energy saving is ensured by the combination of minimum external air ventilation and the building's diversified heat exchange distribution. Direct radiation, convection and induction, usually separately dealt with, are here combined to provide better air distribution in specific areas of the building.

An energy assessment was carried out in two stages: 3-D simulations using *Ecotect* software analysed the orientation and exposure to the sun to identify the most exposed façades during the summer, and the sun-shading requirements of the inner court. In the subsequent operational phase, winter and summer energy savings were quantified. The architectural model's overall energy consumption requirement has been calculated at 145 kW/m^2 for Building A, which represents up to 50% energy reduction. A similar façade in a standard cladding material would lead to 280 kW/m^2 energy consumption.

Figure 13 *View of the former Post Office, Milan before and after renovation*

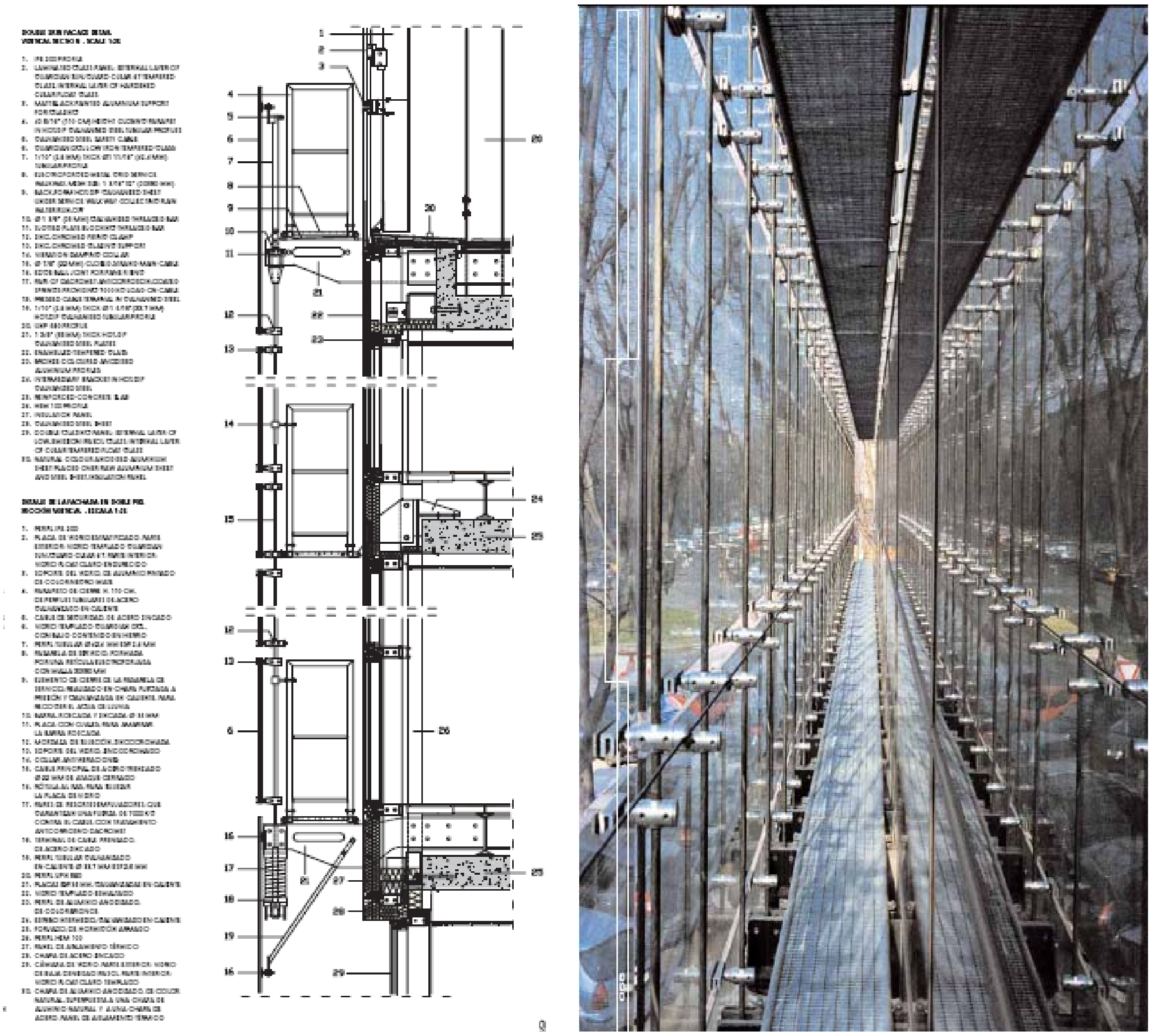


Figure 14 *Double skin façade details*

Figure 15 *Hines building – internal courtyard before and after renovation*

10 Torno Internazionale, Milan

In a former industrial area in Milan, a residential building has been transformed into the headquarters of Torno International. The building is composed of two parts designed by Studio Dante O. Benini & Partners, Architects. In 2001, the first part was renovated and the existing structure of the building was used to support a new glass façade. The double skin façade has thermal, humidity and wind velocity sensors that interact with the central system for heating, cooling and air flux that rise from the bottom to the roof. The “second skin” is composed by large glass panels (with silicon joints) supported by steel elements. The distance between the two façades is 600 mm in which centralised curtain rolls and maintenance ways are provided. Using thermal simulation, the double skin façade will pay for itself in 5 years of use. The before and after renovation images are shown in Figure 16.

The services and plant are protected by steel elements and they are positioned on the roof or suspended in the space between the façades. Details are shown in Figure 17

Figure 16 *Torno International building before and after renovation*

Figure 17 *Details of the new façade*

11 Blu building, Milan

The ‘Blu building’ is a former industrial building with a concrete structure and precast concrete panels that was renovated in 2007 to create an office building, as shown in Figure 18.

The existing structure was maintained while the existing façade has been refurbished. The new façade, built 200 mm from the existing façade, is made of glass and steel and it is connected to the existing façade via steel elements supported by light foundations. Between the two façades, air can flow, which is controlled by a sophisticated electronic device which keeps the building at an optimum interior climate.

Figure 18 *Blu building before and after renovation*

12 Renovation and extension of town hall, Haubourdin, France

The renovation of the city hall of Haubourdin was part of the HQE environmental approach. The façades had a particular treatment: a bow-window was added at the south-west façade of the first floor to reinforce the thermal summer and winter comfort. Also, a special opening seasonal system was used. During winter the space between the glass façade and the original façade is totally closed (double flux system is installed) and the air layer works as an extra insulation layer. In summer, the space between the two façades is open and a natural flux of air is allowed. The bow-window is made by a light steel structure. Details are shown in Figure 19.

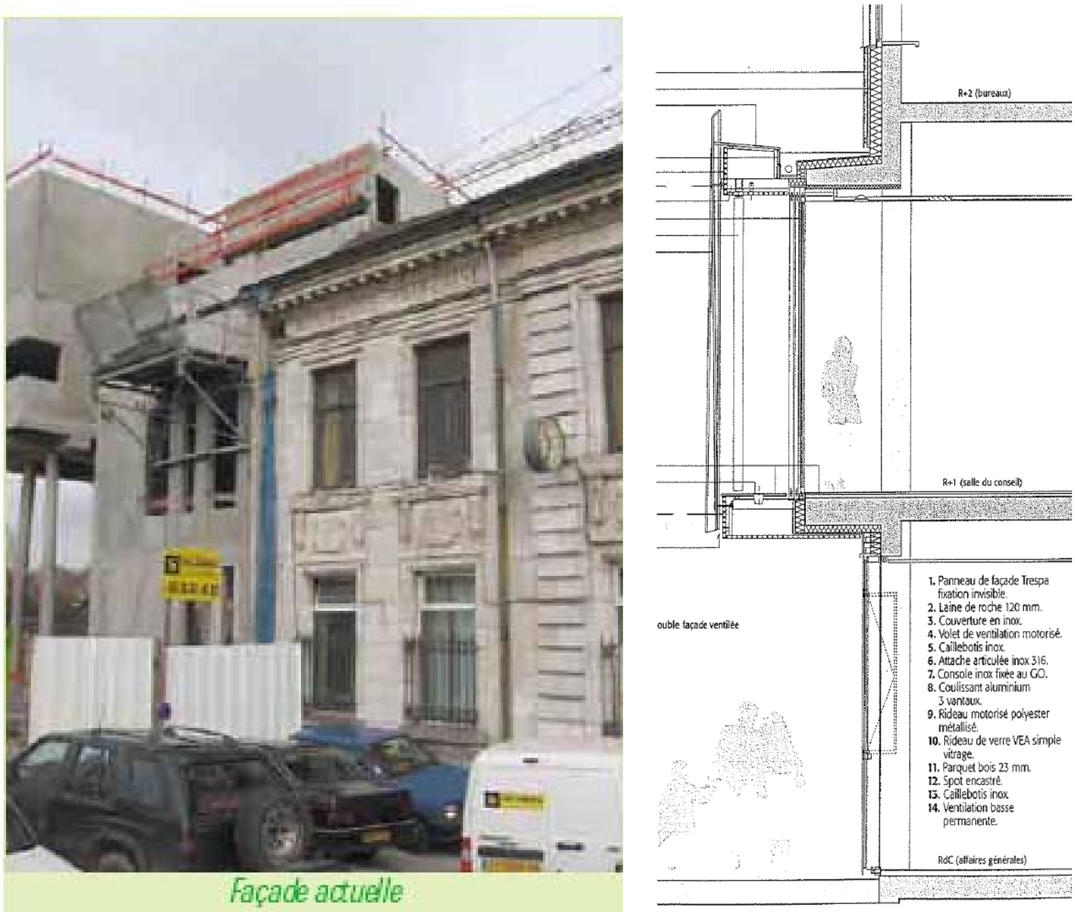


Figure 19 *Detail of new window structure and existing building*

13 Housing renovation, Köthen, Germany

In the town of Köthen in Saxony in Germany, masonry buildings of the 1930s were renovated and extended to provide new facilities using external modules and balconies. The original depth of only 7 m provided only a small living area to the apartments. Prefabricated balcony and bathroom modules are self supporting and the living space was increased. A general refurbishment of the façades was made via an external insulation layer and use of large steel cassette panels. The before and after images of the terraced housing are shown in Figure 20.

Figure 20 *Building before and after renovation using steel cassettes and balconies*

14 Housing renovation, Helsinki

The existing building in Helsinki was built in the early 1970s which consisted of a block with two-staircases serving 6 storeys. The original façades made in concrete prefabricated panels have been covered partly by a 130 mm brick layer. The new insulated lightweight façade consisted of plastic coated steel cassettes with 50 mm mineral wool behind. The construction process is shown in Figure 21. U-values below 0.2 W/m^2°C were achieved for the renovated housing.

Figure 21 *Façade renovation using steel cassettes in progress*

15 Over-cladding projects in Copenhagen, Denmark

In a western suburb called Rodovre in Copenhagen, one 8 storey and two 4 storey concrete blocks from the 1950s were over-clad using sub-frames of light steel. The buildings were also extended vertically using modular units to create new communal space, as shown in Figure 22. The new roof and glazed façade on the roof-top extension was supported by inclined tubular columns. The cladding panels were also prefabricated in colour coated steel. The economic justification was made partly on increasing the number of apartments from 400 to 466. The users of the building participated in the choice of the building style and the project is one of the most successful examples of over-cladding in Denmark.

Figure 22 *Rodovre project, Copenhagen showing roof-top extension and over-cladding*

'Hoje Cladsaxe' in a suburb of Copenhagen consists of five tower blocks of 16 storeys, two of 9 storeys and ten of 2 or 3 storeys. The buildings were over-clad using prefabricated light steel sub-frames which also provided self-contained balconies. Importantly, in this project, the urgent need was to prevent the further deterioration of the concrete, which meant that the exposed concrete had to be enclosed. Furthermore, a 20% energy saving was estimated for the over-clad buildings. This was one of the first over-cladding projects in Europe and was completed in 1993.

16 Over-cladding projects in Finland – Apartment building, Forssa

In Forssa near Tampere, Finland a 6 storey 30 year old former student dormitory was transformed into a modern apartment building using modular units. These modular units provided new bathrooms and also supported new balconies which spanned between them. The walls of the modules were designed as load-bearing (for vertical loads), but the modules are stabilised laterally by the existing building. The project was completed in 1995, and further projects were carried out in Finland using the same system.

Figure 23 *Installation of modular unit at Forssa*

17 Roof-top extension and over-cladding project in Finland – Hämeenlinna

A 4 storey student residence built in 1976 in the town of Hämeenlinna was extended vertically and over-clad using modular construction and light steel framing to create new communal space and apartments as shown in Figure 24. New lifts were also installed to give direct access to the 12 new roof-top apartments. The new floors were supported by the existing concrete cross-cables. The roof consists of light steel trusses. The renovation work was completed in only 4 months. The over-clad walls consist of lightweight panels with additional insulation. The project was completed in 1999.

Figure 24 *Renovated building in Hämeenlinnan, Finland*

18 Over-cladding of office building, Bournemouth

An 8 storey office building for the bank Lloyd's TSB was over-clad using large steel cassette panels supported on a light steel sub-frame that was directly attached through the existing tiled cladding to the concrete wall panels behind. Although the building was less than 20 years old, it was showing signs of deterioration and water ingress and over-cladding was the optimum solution. The original fenestration pattern was retained, but the new double glazed windows were installed level with the outer face of the new façade. The before and after renovation images are shown in Figure 25.

The light steel sub-frame used 70× 1.6 C sections that were prefabricated as panels and attached by L-shaped brackets to the existing facade. The large steel *Stratascreen* cassette panels were manufactured up to 1 m depth and 3 m length using an external facia of Corus HPS colour-coated sheeting**.** Insulation in the form of rigid mineral wool was attached to the existing façade to improve its thermal performance. The panels were designed to act as a 'rain-screen' to prevent ingress of wind-driven rain through pressure equalisation. In manufacture, the panels were 'rigidised' by a honeycomb core between the front and rear steel faces of the panel. These large rigid and flat cladding panels gave the building an aesthetic and modern appearance. Details are shown in Figure 26.

Figure 25 *Commercial building in Bournemouth before and after over-cladding*

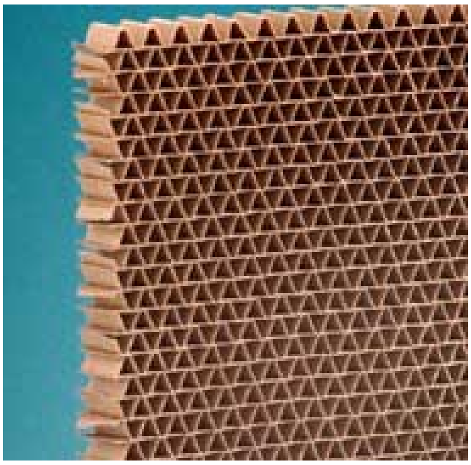
Figure 26 *Light steel sub-frame and steel cassette panels at parapet level*

19 Solar Façade in Freiburg

The south side of this residential building was over-clad in PV panels by Solar Fabrik AG in 2002.

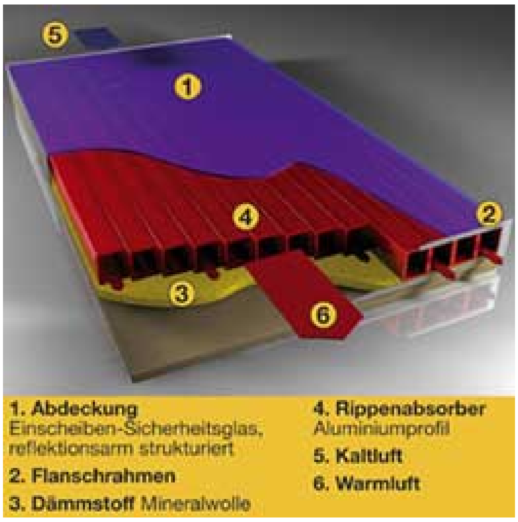
20 Over-cladding using 'Honeycomb' Panels, Erfurt

ESA - Solarfaçade has developed a 'honeycomb' insulated panel which was used to over-clad a 2000 m^2 wall of an office building in Erfurt.



21 Free' Heating by Solar-air collector in Berlin

A solar collector system has been developed by Grammer Solar & Bau and Schuco which is illustrated below. It was used to over-clad a 550 m^2 façade of an office building in Berlin. The peak output is 360 kWh and the overall air movement is 30×10^3 m^3/hour.



22 Over-cladding in Bielefeld

A residential building in Bielefeld was over-clad by Wagner & Co. The project included an integral solar collector system, which provided about 50% of the heating demand of the building.

23 Solar Tower at Freibury Station

PV panels by Solar-Fabrik were used to over-clad a tower next to Freiburg main station. The building is 60 m high and 240 PV panels were installed, which generate 24,000 kWh peak.

24 Over-cladding of Industrial Building in Duisburg

The Thyssen Krupp factory in Duisburg was over-clad using the Thyssen-Solartec panels. A total area of 1400 m^2 of amorphous PV panels generate 50 kW peak electrical energy.

25 Overcladding projects in Poland

In Poland, there is a strong social need to upgrade prefabricated concrete residential buildings to modern standards. Approximately 4 million apartments were built from 1967-89. Before 1974, most prefabricated concrete buildings were 'closed' systems in that all the walls are load-bearing. Later, 'open' systems used fewer load-bearing walls, which permitted more flexible planning of apartments.

The systems comprise of solid or hollow core precast concrete slabs and large double skin insulated wall panels in configurations of 5 to 16 strips. Five basic systems were used.

Before 1984, the U values for external walls and roofs were 1.16 W/m^2°C and 0.87 W/m^2°C respectively, which are very poor in relation to modern standards.

Over-cladding systems for these building types include:

- Insulated render attached to additional anchors fixed to the concrete panels
- Lightweight PVC panels attached to a timber sub-frame.
- Profiled metal sheeting with additional insulation.

In some systems, it is possible to remove and replace the external precast panels, although this is difficult when these panels perform an overall stabilising function.

A typical renovation project for an existing prefabricated concrete building is shown below.

26 Building extension using modules – Plymouth, UK

Unite is a major provider of student residences in the UK, and many of its buildings are renovated to modern standards. The completed roof-top extension is shown in Figure 27 Modular units were used to extend an existing 1940s building to create 20 new study bedrooms. An important factor in the choice of modular units was the speed of installation as the work was carried out in the winter of 2002. The façade panels were installed on site, and the whole project was completed in only 4 months.

The lightweight modules were supported on a grillage of steel beams placed on the existing roof. The modules were constructed with open sides in order to create larger spaces, as shown in Figure 28.

Figure 27 *Building extension using modules, Plymouth*

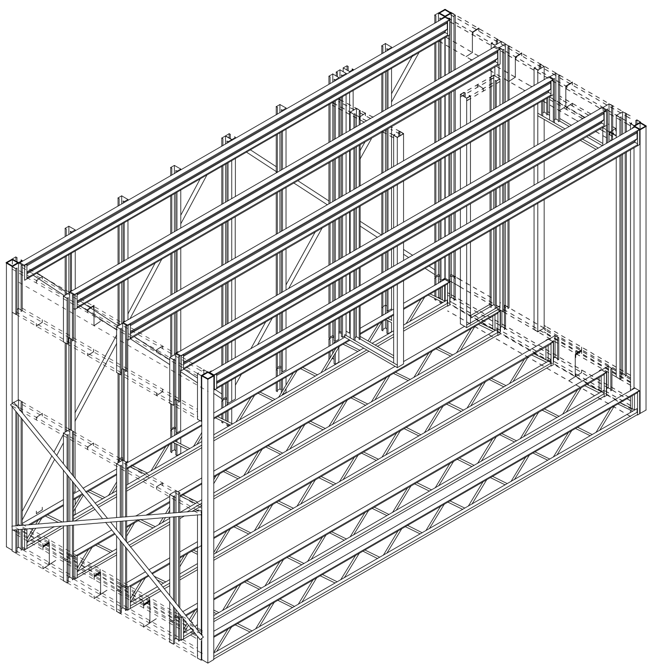


Figure 28 *Open sided module used in the roof-top extension*

27 Building extension – Lage Land, Rotterdam

Two four storey buildings in Rotterdam, dating originally from 1961, have been extended to create two new floors without having to move the occupants during the construction process. The use of light steel framing pre-fabricated and lifted into place as large elements, was sufficiently light that the light steel framing did not over-load the existing concrete structure. The installation work had to be carried out subject to the continued use of the building. The completed building is shown in Figure 29.

Cross-walls are located at 7.5 m spacing and the new 6.5 m high structure was supported on steel beams positioned on stub columns over the cross-walls in order to avoid excessive penetrations through the existing roof.

Light steel C section floor joists spanned between the beams and the floor surface was created by a self levelling gypsum screed placed on shallow steel decking attached to the joists. The 50 mm deep gypsum screed provided a flat, stiff and fire resistant floor. The overall floor depth was only 325 mm. The floors were pre-fabricated as large panels to speed up the installation process. details are shown in Figure 30

The two new floors of apartments, each of approximately 140 m^2 floor area, provide high quality open plan living at the top floor with 3 or 2 bedrooms configurations on the lower floor. Large windows and balconies were created in the front and rear façades by continuing the external columns vertically. The roof consisted of deep profiled decking spanning between the cross-walls on which rigid insulation boards and a water-proofing membrane are placed.

The NL research agency TNO carried out physical tests on the completed building and measured the natural frequency of the completed floors as 14 Hz which is much stiffer than the design value. The airborne sound reduction of the floors and separating walls was over 60 dB, which demonstrates the excellent in-service performance of this lightweight construction.

Figure 29 *Completed roof-top extension project in Rotterdam*

Figure 30 *Roof-top extension during construction*

28 Over-roofing projects in the UK

The Capella system, developed by Kingspan, is widely used in over-roofing projects, particularly in conversion of flat roofs to pitched roofs. The primary reason for the over-roofing is to prevent water ingress, but the thermal insulation can also be improved. The Capella system uses bolted C sections that are designed to span up to 15 m in a lattice form and roof slopes as low as 6° as shown in Figure 31. An over-roofing project for a hospital in Wakefield, Yorkshire is shown in Figure 32.

Figure 31 *Capella over-roofing system*

Figure 32 *Over-roofing of a hospital in Wakefield*

29 Roof-top extension and building conversion, Waterloo, London

The White House is a 2 storey extension of the former Shell Building in London that was renovated from offices to apartments. The completed roof-top extension is shown in Figure 33. The light steel roof-top extension was manufactured in light steel framing. An internal view is shown in Figure 34

Figure 33 *Completed roof-top extension Waterloo, London*

Figure 34 *Light steel separating walls used in the roof-top extension*

30 Concept study – Over-cladding in East London

As part of a possible renovation project in east London, a concept study was carried out using steel over-cladding panels and modules to create new facilities and to provide for private space. The concept study is illustrated in Figure 35.

Figure 35 *Concept study on renovation using modules*

31 Over-roofing of residential buildings in Glasgow, UK

Various local authorith high-rise apartment buildings have been over-roofed to provide a weather-tight enclosure and to conceal lifts and servicing equipment. Steel roof trusses were attached to the existing concrete panel structure, and profiled steel sheeting and insulation were attached to the trusses. An example of a completed building in Paisley near Glasgow, is shown in Figure 36.

Figure 36 *Over-roofing of concrete apartment buildings in Paisley*

32 Over-roofing of industrial building, Cheshire, UK

The Siemens factory at Congleton, Cheshire had a poor quality asbestos-cement roof that could not be easily and safely removed whilst the factory was in operation. It was decided to over-clad the building by providing a new roof to improve its weather-tightness and thermal insulation.

The over-roofing was carried by attaching a light steel sub-frame called *Instalok* to the existing purlins, and then by fixing 180 of mineral wool insulation and new profiled steel sheeting, along with new roof-lights and ventilators to the existing roof. The total roof area was 4000m^2 and the roof sheeting was Corus' HPS colour-coated R32/1000.

Figure 37 *Industrial building before and after renovation*

33 Over-roofing of German Sports Hall

The roof of a sports hall in *** was over-clad using Kalzip to create a curved shape. The completed building is illustrated below. The structure of the roof-top extension comprised light steel sections to which the insulated Kalzip roofing was attached.

34 Over-roofing of residential building, Nuremberg, Germany

A 4 storey residential building in Nuremberg was extended to create a new floor and curved roof. The building was also over-clad as shown below. The main contractor is BMS Gewerbebau.