INFOTUA

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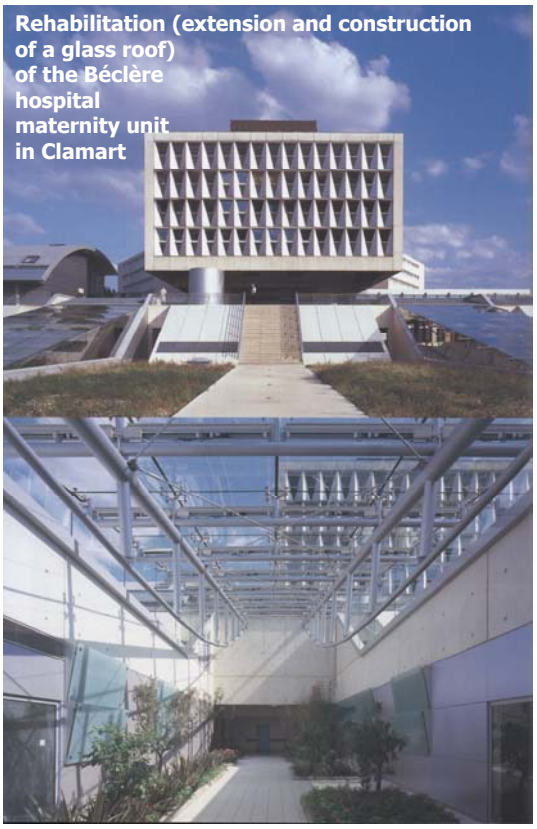
Steel and rehabilitation

Rehabilitation is the restoration of an old structure. Rarely promoted, seldom taught in schools of engineering and architecture, nevertheless it calls for specific expertise, numerous competencies and at least as much ingenuity and attention to detail as new construction. It is the precision surgery of the construction sector. It must take account of technical, regulatory, aesthetic, site, economic and environmental constraints in respect of which steel offers intelligent solutions. Why and how to rehabilitate, what advantages does steel offer in this field? That is the subject of this study.



Rehabilitation (extension and construction of a glass roof) of the Béclère hospital maternity unit in Clamart

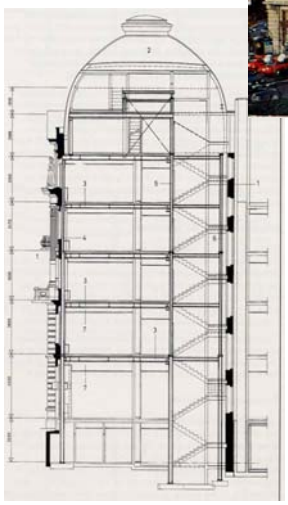
Archis : B. de Kosmy ; A. Kechichian ; F. Lavigne

• Several magnitudes of rehabilitation

Rehabilitation is the retention of part of a structure (facades or skeleton, in whole or in part) and the alteration, to a greater or lesser extent, of the rest. As opposed to deconstruction followed by newbuild. The term "rehabilitation" can cover various types of work on the building, from the most superficial to the most extensive:

- **renovation**, which can signify bringing the building up to current standards, enhancing comfort, appearance or safety… For example, it can involve rewiring, insulation work, changing doors and windows, etc. But also modifying the external appearance.
- **alteration**, which consists of updating the volumes to current tastes, for example adding mezzanines or galleries to a building.

One refers to rooftop additions, extensions, the addition or removal of floors, consolidation. A case in point is the Roemerhof (which has become the Union Bank of Switzerland, photos below), in Zurich, where the space was remodelled to optimise utilisation, retaining the facades and maintaining normal business activities. Another example: the PB12 Tower at La Défense (see p. 5). Objectives: modernisation of the facades, opening up to the exterior, 5000 m^2 increase in floor area, and adaptation of the building to current construction standards.



Behind the old facade of the "Roemerhof" in Zurich (above and left), built at the end of the 19th century, the 'interior was completely gutted and replaced by a steel frame with concrete floor slabs. The rehabilitation consisted of stabilising the interior, strengthening the foundations, demolishing the existing floors and finally reconfiguring the internal volumes.

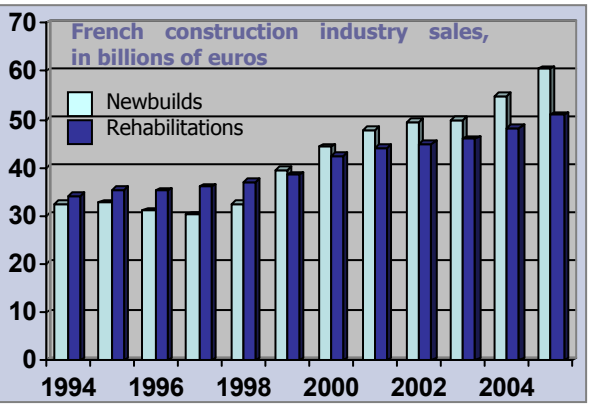
Archis : Baerlocher - Unger

Source of graph: DAEI
(Ministry of Infrastructure – Department of European and international affairs).

Rehabilitation: a market destined to develop in France

In France today, rehabilitation accounts for less than 50% of the total construction market (excluding civil engineering). According to Jean-Michel Dossier, (Department of Industry, Information Technology and Postal Services at the Ministry of the Economy, Finance and Industry), the size of the current building stock (30 million dwellings in France) provides an extremely large rehabilitation market.

The construction market is cyclical. The graph shows that since 1999, sales figures for newbuilds have grown more than those for rehabilitation. Forecasts for 2005 indicate a further increase in this differential, but logically this trend should reverse in coming years.



- **reconstruction** with preservation of the facades, which amounts to retaining only the external envelope or the overall volume and rebuilding everything else. This was the case with the Crédit Lyonnais building in Paris, whose interior was destroyed by fire and completely rebuilt.

Archi : J.J. Ory

In the case of the rehabilitation of the Crédit Lyonnais building in Paris, only the facades and part of the steel structure were retained.

- **Why rehabilitate rather than rebuild?**

In certain instances, the case for rehabilitation is unequivocal, usually for cultural, technical or site-related reasons.

- When a building is classed as a historic monument or is included in the national heritage register, obviously rehabilitation is the only option. To reinstate a property to its original condition (in the case of prestigious buildings such as the Grand Palais or the Baltard Market in Paris), one goes so far as to seek the original plans, sketches and moulds in order to produce exact replicas of the cast iron columns, etc.

- When one wishes to retain the original surface area and volumes. When one demolishes to rebuild, current planning regulations generally require a reduction of the building's volume. Only rehabilitation permits retention of its original dimensions.

- When the building is of great heritage value, in other words it has a style, an outstanding architectural quality that one wishes to preserve (ceiling height, large surface area…). An architectural masterpiece, this building will be easier to let and to sell if it is rehabilitated while retaining its character, its original appearance.

- When demolition presents vibration, nuisance, and rubble removal problems that are insoluble due to the building's location, its height, the safety of frontagers….

- When a building has to be brought up to current standards (thermal efficiency, fire, and in particular everything relating to emergency evacuation, health – for example asbestos, etc.). Or when the objective is simply to change the use of a structure (irrespective of age), by converting industrial premises into offices, or offices into residential accommodation… modifying certain structural data and loading assumptions, thus necessitating rehabilitation.

Sometimes, however, rehabilitation is simply an alternative to newbuild.

One must then assess whether rehabilitation is worthwhile: whether rehabilitation is attractive architecturally, financially, technically, environmentally, in terms of durability, time spent, return on investment… and how all this balances out. In other words, whether it is profitable, feasible and viable over the long term.

Jean-Marie Farsy, an economist specialising in steel, summarises it thus: "If it is a 1960s concrete building in la Courneuve, it would be quicker and cheaper to demolish and rebuild. If it is a 1920s building in a town, rehabilitation is better suited. If it is a 1960s or 1970s building in a town, but where there are regulatory compliance requirements (asbestos removal, for example), it is a dilemma. It would be necessary to study the matter more closely in order to determine the most appropriate solution: demolition-reconstruction, or rehabilitation."

It is by taking a holistic view of the structure, its location, its history, its condition, the extent of the work required, subsequent cost of maintenance, that one decides whether or not rehabilitation is cost-effective (and feasible).

Archis : B. Valero – F. Gadan

Before… after. The rehabilitation of Collège Pierre Corneille, in Tours, required only 3 months' work.
It is a 1969 building, of which only the structure was retained. The facades were totally renovated with smooth pre-painted steel cladding installed on a subframe, and additional projecting volumes were created.
Parts of the floors were deconstructed in order to produce a 3-storey concourse in the entrance area.

As a guide, extensive renovation of a school costs on average 30% less than a newbuild.

In any case, well before any work commences, even before the start of the project or the involvement of the architect, a feasibility study must be conducted and the budget prepared.

Rehabilitation necessitates a precise diagnostic survey of the building (see p. 4). Only a specialist can determine what type of metal (cast iron, iron or steel) was employed in a building and whether the materials can be retained.

Archi : Ch. Girault

The rehabilitation of the Petit Palais in Paris is an example of reinstatement: strengthening, but retaining the character and the volumes.

• What are the advantages of rehabilitating with steel?

When the original structure is in steel, it cannot be rehabilitated in concrete. On the other hand, when it is built of concrete, one has the choice of rehabilitation with concrete or steel. Thus, steel already has an advantage. What are the others and what dictates the choice of steel solutions for rehabilitation?

- Architectural diversity and freedom

The use of steel in newbuilds, but also in rehabilitation projects, offers exceptional architectural freedom and an unprecedented variety of forms: long spans, large adaptable floorplates, vast internal volumes… It offers potential for adaptation and transformation to meet changing needs and uses, in respect of both steel and concrete buildings. It enables the use of original forms and colours, as well as greater provision of daylight (greater transparency of the facade, longer spans).

- Ease and speed of execution

According to Jean-Marie Farsy, the two compelling arguments in favour of steel are the ease and speed of execution that it guarantees. When time is tight, steel is indispensable. It is assembled in a factory, like a Meccano set, and all that remains to be done on site is to erect the modules. Steel frames save time, but are also economical in terms of labour and equipment for the erection operation. Furthermore, steel offers the advantage of a network of competent contractors, with the expertise to employ it to optimum advantage.

- Adaptation to difficult conditions

Steel frames are also particularly suited where access is difficult, as is often the case in towns. Dominique Queffélec (the head of Arcora, consulting engineers) enumerates steel's advantages on "problematic" construction sites: construction sites where it is essential that they be clean or dry, or sites with difficult access, where steel's "Meccano assembly" quality is ideally suited.

Archis : G. Nicot – Eiffel entreprise

Dating back to 1887, Chartres cathedral (left) is a good example of the longevity of steel structures. Above, successful combination of steel with glass and wood (school at Ecully, in France), and with glass and brick (bank at Lodi, in northern Italy).

- Dependability of steel frames

Steel frames, usually manufactured on NC machines, are precise, and therefore cause few complications on site. They also offer an excellent strength/size ratio.

Steel frames are manufactured to very precise tolerances.

- Quality of steel construction products

Steels for construction are manufactured products, with guaranteed dimensional and mechanical characteristics. Envelope products offer a variety of finishes in terms of both form and colour, which combine easily with other materials.

In rehabilitation, a large tonnage of steel goes into finishing works (structural steelwork, steel joinery, decorative ironwork, hardware…). In schools, for example, for twenty years, wooden doors have been replaced with aluminium doors… which in turn are being replaced with steel doors, which are more resistant to impact and wear due to the material's elevated mechanical properties.

- Longevity of steel structures

Easy to maintain, without any disruption to the use of the structure (very important in the case of a bridge, in particular), steel structures are undemanding in terms of maintenance.

Protection of structures against corrosion or fire involves well-known, reliable methods. Following a fire, an explosion or an earthquake, the frame can be reinforced or replaced.

Steel is better able to withstand earthquakes by virtue of its ductility and its ability to withstand cyclic loads.

In the event of extreme stresses, steel construction offers greater possibilities of rehabilitation than other materials (e.g. the Toulouse Zénith – see p. 5 – where, following the explosion at the AZF plant, the roof frame withstood the explosion and required only minor repairs).

Archis : M. Gautrand – Ph. Després

Archi : R. Piano

- ***Environmentally friendly, minimal inconvenience for the neighbourhood***

Steel rehabilitation causes minimal disturbance to the neighbourhood. Time on site is short and inconvenience is minimised: less waste, less noise.
Furthermore, steel sections, widely used in construction, are produced entirely from recycled scrap. Lastly, all steels are infinitely recyclable, and end-of-life steel buildings can be deconstructed or dismantled.

- Comfort: Steel rehabilitation offers the possibility of adding insulation externally, enabling architects to give renovated buildings a more modern appearance. Steel provides good thermal and sound insulation.

- Lightness: Steel offers lightweight technical solutions enabling:

- the limitation of loads on existing structures;

- a reduction in the number and section of columns;

- construction of long-span floors, without impeding services.

Steel rehabilitation ensures lightweight structures, which makes it possible to add extra storeys while limiting the additional load on the foundations.

Rehabilitated grain warehouse in Hamburg

Archi : J. Stärmer

- ***Compliance with fire regulations***: fire resistance is no longer an obstacle to the use of steel. While safety legislation a few years ago might have appeared to be an impediment to steel, today European legislation, more realistic in terms of fire engineering, is more favourable. Provided that the building is equipped with a system for early fire detection and rapid evacuation of occupants and smoke extraction. Finally, being non-flammable, steel does not contribute any additional fire load in the renovation of a structure.

- Steel solutions underutilised in rehabilitation

Jean-Claude Dossier, of the Ministry of Industry, summarises steel's advantages thus: "Steel is very advantageous in rehabilitation. It takes up little space in relation to its load-bearing capacity, it can reinforce without disfiguring, combine with all materials, provide major benefits with regard to thermal and acoustic insulation. While complying fully with regulatory requirements, particularly with regard to fire. For example, steel could replace wood everywhere that there are problems with termites, in housing. Its capabilities are insufficiently utilised."

- **The diagnostic survey: the starting point for rehabilitation**

One of steel's advantages is that the structure can be examined, thus facilitating diagnostics.
The diagnostic survey is an essential prerequisite to the rehabilitation of a building: it involves a thorough examination, at the end of which it will be known on what basis and by means of what process the structure can be restored. The purpose of the diagnostic survey of a metal structure is to asses its loadbearing capacity, condition and stability.
When the building is some decades or even centuries old, the plans and calculations characterising the structure are no longer available.
Investigative work must be undertaken in order to understand the distribution of forces within the building.
Many questions must be answered: How is the frame constructed? Is it capable of supporting even a small additional load? Where are the supporting columns? What is hidden behind this apparently sound wall? Do the beams require strengthening? What design code was used for construction?

Thorough inspection of the joints is also required.

In the case of metal structures, the nature and the characteristics of the metal comprising the structure and the envelope must be identified: cast iron, puddled iron or steel (including the grade)?

The next step is to detect any toxic substances incorporated in the structure, to assess the build quality and the state of aging, to verify the dimensioning of the framework, to estimate costs. All this while taking account of developments in building practices, design codes and regulations.

The diagnostic survey is performed by specialist consulting engineers or even technical inspection bodies.

Rehabilitation of the French Embassy in Warsaw: high technology, lightness and daylight.

"This building was conceived in the 1960s by leading French architects. It was based on a metal structure, with numerous cast aluminium panels. Asbestos had been found and there was a desire to remedy the fact that the building had been designed in two separate parts, while retaining its identity and history.
We therefore carried out extensive rehabilitation of the facades and the structure, based upon opening the building more to the landscape and the town. High technology (spans of 22 metres each way), lightness and daylight are the watchwords of this project. And it is steel that makes it all possible."

Jean-Philippe Pargade, architect

Watchwords of the rehabilitation of the French Embassy in Warsaw: high technology by virtue of the long spans, lightness and daylight.

Archi : J. Ph. Pargade

• Rehabilitation and architecture: some examples of steel rehabilitation

Archi : F. Soler

For the rehabilitation of the Ministry of Culture in Paris, Francis Soler devised a stainless steel mantilla that confers a common signature on the three disparate buildings that comprise the Ministry.

- The Ministry of Culture in Paris

"I used steel for the external rehabilitation of the building, in order to confer a common signature on three dissimilar buildings. This stainless steel cloak (in total, 4000 panels 12 millimetres thick) confers unity on the Ministry. This steel lace is a bit like a Spanish mantilla, giving the buildings a single identity.

My starting point was a Renaissance work, that I reproduced and segmented on a computer and that I allowed to evolve in line with technical, structural, and daylight-related constraints. Thus, the design underwent a dozen transformations to result in an abstraction. It is design by default."
Francis Soler, architect.

- PB12 Tower at La Défense

PB12 Tower before (left), during (centre) and after (right) its rehabilitation.
The difficulty lay in the height of the building, the very tight timeframe, the need to provide stronger and less bulky load-bearing structures than the original concrete columns: a superlative market for steel.

In this rehabilitation, we retained only the building's central core and the concrete floor-plates. The architectural aim was to gain daylight and increase apertures. Steel made this possible. For example, we replaced 96 concrete columns at 1.48 metre spacing with 26 steel columns at 6 metre spacing, resulting in an immediate gain of space, volume and daylight. Steel also stood out as the optimal solution for technical reasons. The height of the building: it had to be possible to undertake the work storey by storey, without imposing too much additional weight on the foundations. The high workrate, not easily compatible with poured concrete. The need to support the existing concrete floors while remaining within a very small volume and retaining the floorplates' excellent flexibility. Here, steel's excellent strength/size ratio was a crucial advantage.

- Toulouse Zénith auditorium

The steel structure of the Toulouse Zénith, rehabilitated following the AZF explosion

Following the explosion at the AZF chemical plant, the Zénith, situated 2 km away, required rehabilitation. The structure had been subjected to stresses that had not been predicted in the calculations, deforming and cracking components. They had to be replaced without endangering the building (the largest Zénith in France, with 9,000 seats). An operation that was greatly facilitated by the fact that the structure is built of steel.

Archis : A. et S. Gresy

• Otua's activities to promote steel in rehabilitation

- Organisation of "technical seminars" on rehabilitation in April 2004, in partnership with CTICM.

Otua and CTICM invited engineers from firms of consulting engineers and construction companies, engineering and architectural students (120 people in all) to increase their awareness of rehabilitation using steel. Essentially, it covered the methodology for conducting the diagnostic survey of a building, the maintenance of civil engineering structures, all accompanied by practical examples: rehabilitation of the Ministry of Culture and the Grand Palais in Paris, the Toulouse Zénith, the French Embassy in Warsaw.

- Organisation of a seminar on "Steel and social housing" in Lille in May 2004

Seminar organised by Otua with the French Steel Construction Association and the bodies responsible for social housing in the Nord and Pas de Calais departments and Picardy. The purpose being to increase steel's share of the housing market (only 2% of housing is built of steel), by emphasising the scalable and economic aspects of this type of construction.

Archi : Valode et Pistre architectes

- **Courses organised by Otua two or three times a year for economists** from UNTEC (French National Federation of Construction Economists and Coordinators). Purpose: to ensure that economists have a good knowledge of steel and its advantages in construction in order to incorporate it at an early stage in their rehabilitation feasibility studies.