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Early Modern Architecture: How to Prolong a Lifespan

L'architecture moderne précoce: Comment prolonger une durée de vie

Frühmoderne Architektur: Verlängern der Lebensdauer

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SUMMARY

In Modern Movement architecture, the structural elements of a building - mostly concrete or steel frames - form an indissoluble part of the original design approach. Therefore, such elements are part of the historic value of these buildings. At the same time, modern architects strove after minimal constructions. Our problem today is, how to preserve these slender constructions in harmony with the original architectural concepts, so that the ideas of the original designers remain perceptible.

RÉSUMÉ

Dans l'architecture moderne, les éléments structuraux d'un bâtiment - essentiellement des cadres en béton ou en acier - représentent un élément fondamental du projet architectural original. Ainsi, ces éléments font partie de la valeur historique de ces bâtiments. En même temps, les architectes modernes visent à une construction minimale. Le problème actuel est de préserver ces structures minces en harmonie avec la conception architecturale originale, afin de respecter la conception primaire de l'architecte.

ZUSAMMENFASSUNG

In der modernen Architektur bilden die Tragwerkselemente eines Gebäudes, mehrheitlich Beton- oder Stahlrahmen, einen unverwechselbaren Bestandteil des ursprünglichen Projektes. Sie sind denn auch wichtig für den geschichtlichen Wert des Gebäudes. Gleichzeitig strebt die moderne Architektur nach minimalen Konstruktionen. Unser heutiges Problem besteht in der Erhaltung dieser schlanken Konstruktionen, denn die Harmonie mit der ursprünglichen architektonischen Konzeption soll gewahrt werden.

1. THE MODERN MOVEMENT

1.1. Previous history

The building tradition underwent great changes in the 19th century with the onset of industrialisation. In the old days, a few buildingtypes were fit for a variety of uses due to their neutral lay out. Therefore, buildings could easily be adapted to new functions, which resulted in a relatively long functional lifespan. Generally, the technical lifespan was in harmony with this principle, by producing firm and flexible constructions.
During the Industrial Revolution the briefs became more diverse and specific, and so did the buildings. Steammills, sanatoriums, locks and officeblocks, each required its own characteristic features. But steam was being ousted by other mediums, sanatoria became hospitals, wordprocessors are replacing the typewriter. Therefore it was not only the nature of the brief that changed, but also the period of such a use. Another important aspect was of course the application of new materials and new construction types that made use of the specific properties of these. This development had a major impact on the building practice and a tremendous effect on architecture.The techniques required for preserving buildings from the Industrial Age are therefore different from those appropriate to older ones.

1.2. Requirements and performance: a limited lifespan

In the period between the World Wars, these developments ultimately led to the pioneering work and revolutionary ideas of the designers of the Modern Movement. Around 1920 architects started to establish a direct link between the design, the technical lifespan of a building and user requirements. The consequent translation of these ideas into practice produced a specific movement in architecture, that came to be known in the Netherlands as 'het Nieuwe Bouwen'. Jan Duiker was among its protagonists. 'Het Nieuwe Bouwen' was not referred to as a style, as an aesthetic principle, but rather as a workingmethod, a way of thinking about building. Duiker set great value on the connection between form, function, applied materials, economy and time. User requirements and economy are the causes, form the result. If the function changes, the form looses its right of being and the building, as was frequently explained by themselves, should be either adapted or demolished. They regarded buildings as utilities with a limited lifespan by definition, sometime even as 'throw away' articles. This way of thinking formed the basis of what we consider normal practice today, but what represented a totally new and revolutionary point of view in those days. Therefore many of their buildings are highpoints in 20th Century cultural history .
Some famous examples in Holland are the Van Nelle factories in Rotterdam, by Brinkman and Van der Vlugt from 1925-29, the Gooiland Hotel, designed by Duiker for Hilversum in 1934, and his Zonnestraal Sanatorium in Hilversum, erected by the Diamondworkers Union in 1926-28 and now also a main monument of social history in our country.

Fig. 1. Sanatorium Zonnestraal (1926-28).

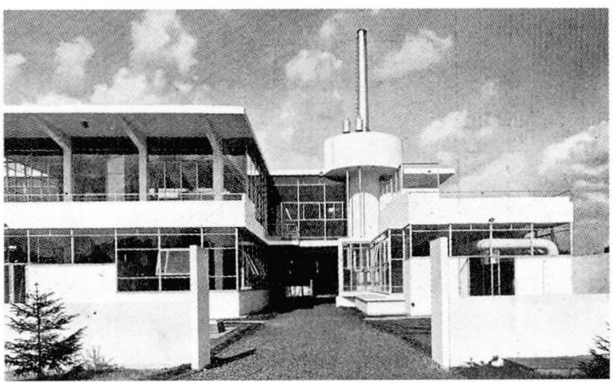

Fig.2. Gooiland Hotel (1934) in 1986.

1.3. Transitoriness of Modern Movement architecture

Duiker's work does not excel in properly detailed construction. Many of his buildings are now either dilapidated or even already demolished. This is largely because of his choice of materials and in the way these were used. Yet, there has too often been assumed that his constructions, that do not satisfy nowadays standards, arose from professional ignorance of the designers. For me that's too easy, since from documents as well as the constructions themselves can be learned that these designers must have been quite well aware of what they were doing. Apparently, other motives were in it as well, such as the acceptance of a limited technical lifespan as an answer to limited financial means, especially when also the functional life expectancy was limited. The issue of transitoriness of Modern Movement architecture should therefore be understood as being largely defined by the designer's approach. Obviously, this should have a great impact on how to restore these buildings.

1.4. Optimalisation

A rigorous distinction between loadbearing parts and infills was followed out, in order to attune each part to its proper function, making everything as 'monofunctional' as possible. For instance facades traditionally combined a loadbearing function with shutting out weather conditions. Obviously, this resulted in limitations as regards how and where the inside could be supplied with fresh air and daylight. By introducing a frame, the principles of the Modern Movement literally disclosed the buildings.
Another basic element was the use of prefabricated parts. This was closely related to the idea of varied lifespans, since it allowed the replacement of deteriorated parts without damaging others. Although common practice today, the prefabricated concrete parapet panels of the sanatorium are likely the first ones ever to be applied in the Netherlands.
By taking advantage of the specific qualities of materials, it was sought after to construct with a minimum of material used. The dimensions of the concrete beams for the sanatorium follow the moment diagram. Obviously, a lot of carpentry was needed to make the complicated shuttering, but in a period when labour was cheaper than materials, that was not uneconomic.
This strive after optimal construction is referred to by Duiker as 'spiritual economy', that 'leads to the ultimate construction (...) and develops towards the immaterial, the spiritual.' The 'art' of architecture is not in ornamentation, but in technology itself. The search for the optimum in materials and dimensions was considered a process combining the artists' inspiration and the engineers knowledge, an 'engineers-art'. He compared this with lucid Medieval cathedrals, Bach's fugues and the 'horrifying magnitude' of Einstein's theories.
The constructions he used can sometimes only be regarded as optimal, if a short technical life expectancy was being accepted as a starting point. In the case of the sanatorium this could be accepted, since tuberculosis was expected to be exterminated on short term.
Through this optimalisation, buildings were designed with an extreme sensitiveness concerning building physics. On the other hand - or therefore? - building physics were seriously studied by Duiker, Wiebenga, Van Loghem and some other designers of the Modern Movement in the Netherlands. Although identified as 'a great triumph in building construction', Van Loghem warned his collegues in 1936 'that the elimination of the loadbearing function true eliminated one problem, but that the requirements of 'Het Nieuwe Bouwen' on the other hand created at least ten new problems'.
In Holland there was a great interest in constructions as used in the USA, where the frame went through its adolescence. Wiebenga, structural engineer for a number of pinnacles in modern architecture in Holland, published a number of articles on buildings physics in frame-constructed buildings after his return from the USA. Van Loghem, as a convinced

socialist, meanwhile worked in Siberia and followed out series of experiments in building physics. Afterwards, he published a first reference work on building physics in Holland, since, according to him, many modern designers were not able to cope with the problems in building physics that had been introduced with 'het Nieuwe Bouwen' in the first place.

1.5. Duiker dilemma

It is easily understood that the idea of conservation is totally contrary to the concepts of the Modern Movement. According to these, a building's right to exist is not determined by its history, but by its usefulness. By deciding in favour of conservation of Duiker's buildings, we act against his principles at the same time: the 'Duiker dilemma'.
Still, I think there's a number of reasons to preserve this patrimony. First, the Modern Movement has been a fundamental turning point in building history. The quest for fundamental change in architecture in the late 19th century, for architecture that reflected the achievements of the industrial society, was principally answered for the first time.
The second point is, that contemporary architecture will loose an essential part of its history if we do not safeguard some of the early products of this unique approach. Even today, architecture is still deeply rooted in these principles.
Now how about Duiker's own remarks to do away with architecture after it performed its duties? Wasn't it Kafka who layed down in his will to have all his manuscripts destroyed after his death ...... and aren't we glad they didn't? Of course it makes no sense to use the provocative points of view of an emerging group of dissidents as a starting point for our attitude with respect to preservation of their built pamphlets in our time. What counts now, is the cultural impact of their works for today and for the future.

2. PRESERVATION

2.1. New approach required.

In view of these specific architectural principles, preservation of these buildings requires not only other techniques but just as well a totally new approach as compared to traditional conservation. First, a serious problem arises from the fact that many of these designers experimented with materials, constructions and details. Not only did they obviously lacked certain knowledge as compared to what we know today, but a problem just as well is that we do not yet know what exactly was their knowledge and what was beyond it.
I believe that the possibility to detect this original design approach in a restored building should be a determining aspect. Often, the value of a building is taken to mean nothing more than its perceptible impact, or even simply its appearance. If restoration does justice only to the appearance of a building, historical continuity will not adequately be guaranteed. So, just as well for the structural engineer dealing with the preservation of such constructions, quite a few questions emerge. How to deal with buildings where the bare constructions themselves are main part of the original design approach? How to restore them without the aspect of transitoriness being covered by advanced restoration technology for eternity, leaving an artificial memento behind? What can be learned by future students and architects about the concepts of functionality - according to me the key 'message' of the Modern Movement - when going through a restored Zonnestraal ?

2.2. Research

Buildings are sometimes altered so drastically that they do no longer bear any resemblance to their original state, let alone the conceptions they emerged from. Still, some of these buildings should be preserved, one way or another, in order to ensure historical continuity.

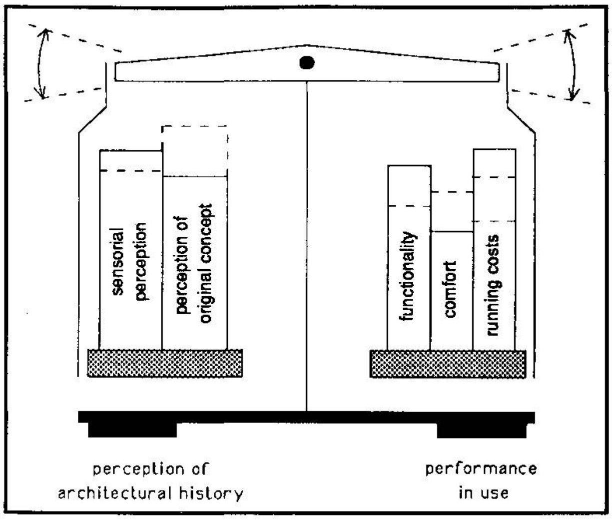

Fig. 3. The key problem is to maintain the correct balance between performance in use and the perception of architectural history. The original design approach is an indispensable element.

But which buildings should be protected and how can this best be achieved?
Numerous parties are involved in the decision-making process concerning conservation: owners and users, authorities and interested outsiders, each with their own legitimate requirements. Today, discussion between these parties can only take place if the objective aspects are being quantified and the subjective aspects are being identified and verified.
Professor Henket and myself, researchers at the TU Eindhoven, developed a method for preparing technical intervention models for restoration and for assessing and weighing up the consequences for a building, in the event of its being restored according to such a model. Numerous aspects are thereby being identified and surveyed, varying from architectural history to building physics, building technology and the annual running costs.
Each intervention has an impact on the balance between perception and use. The key problem is to maintain the correct balance between the intangible factors and the practical use. In order to determine this balance the numerous conceivable forms of intervention are classified and reduced to a number of intervention models, each with another philosophy:
- Model I: Restoring it uncompromisingly to its original state. This might be impossible technically. Still, it is an interesting option for comparison with other models.
- Model II: A variant of model I, but with small, imperceptible technical improvements.
- Model III: Pragmatic restoration, where changes in the nature of the building are introduced using contemporary methods and conceptions of architecture.
- Model IV: 'Ordinary' reuse for economic reasons; there is no question of restoration. This is interesting for comparing the costs of restoration with an everyday case of reuse.

Within these models, forms of intervention are outlined for facades, roofs and each of the different parts of the building. A selection of a particular model is based on the assessment of each models' properties as mentioned before. In 1990, the results of our research have been published, including an extended English summary (see litt. 1). The method has been tested in theory on the Zonnestraal Sanatorium and in practice on the Gooiland Hotel.

3. THEORY AND PRACTICE

3.1. Zonnestraal: a concrete frame

The sanatorium was founded by the Union of Diamond Workers. Money was extremely short, necessitating a cheap building method. Though the reason for not adopting the timber frame, eminently suitable for sanatoria, is still unknown, it is obvious that the building's function benefits from the slender, open construction. The pavilions illustrate how Duiker and Wiebenga incorporated the frame into their architecture. Each pavilion consists of two wings linked by a lounge, set at an angle of 45 ° to eachother to provide plenty of sun and an unhampered view. On the sunward side the rooms have balconies. A corridor on the north side connects the rooms. Across the corridor, a section is devoted to services. From layout to detail, the structure of the sanatorium is based on a 1m50 module. Even the

floor-height comes up to the module, creating a three dimensional grid. Until recently, the origin of this module was unknown but we have found a clue in the Dutch requirements for concrete of 1918. If slabs span 3m or less, the formwork might be taken away already after one week, instead of four. In view of the strict 6 months construction schedule, it is likely that the module emerged from this condition.
Generally, the frame consists in long girders, supported every 9m, that support the floors. Beams are haunched at the bearings to follow the moments and to take up shear forces. Consistent with the general principle, the girders cantilever 3m but here without a taper, to match the form of the steel window frames. Floorslabs span 3m, with a 1m50 cantilever at both sides. Between the girders are the patient rooms, the northern cantilever is the corridor, the southern one the balconies.
Being in such harmony with the function, the superstructure is a clear illustration of the design approach. The frame has been designed very light. If we consider the moment diagram of the girders, the combination of 9m spans with 3m cantilevers seems rather optimal and allowed the designers to reduce the dimensions of structural elements, thereby saving precious concrete. The combination of 3m spans with 1m50 cantilevers for floorslabs seems less economic where momentreductions are concerned. Yet it allowed slabs being 12cm thick at their supports and a mere 8cm in the middle of spans and at the cantilever's edges.
Even these thin floors are made with two layers of rebar, each with its own layer of light orthagonal rebar to spread tensions. One can easily imagine that there can hardly be any covering on the reinforcement in such cases.

3.2. Concrete technology

To fill the narrow and complicated shuttering, the concrete has been diluted considerably to make it more fluid. The undesirable watercement ratio as well as the inhomogeneous composition of the concrete resulted locally in an extreme low compression strength, in some columns not even more than that of wet sand. Also, alarming concentrations of gravel have been found. In the 1918 concrete regulations there were no restrictions as to the amount of water. Very fluid concrete was even favoured for narrow shuttering, to guarantee for the rebar to be fully covered. According to the existing literature at the time, very fluid concrete had a lower resistance to compression at first, but in the long run there was hardly any difference to be expected. In contrast, Wiebenga wrote in 1925 that the strength was reduced by adding water, so at the time of construction this was a known fact.
Due to the same reason, also the porosity is a serious problem. The carbonization of the concrete reaches beyond the rebar in most cases. In the upper floorslab also chlorides have been added, presumably to advance curing in winter situations.
After being abandoned, the windows of the pavilion have been broken and the frame is fully being exposed to the climate. The damage caused by corroding rebar is enormous and parts of the sanatorium are now certainly unsafe for an excursion of IABSE's members. The safety coefficient is negative for numerous elements of the frame and the pavilion has collapsed in theory. It is being supported by the light separation walls that, of course, were never meant to do so.

3.3. Restoration options for Zonnestraal

The pavilion could be demolished from the ground floor up and rebuilt with advanced contemporary techniques, using the original dimensions. The appearance of that replica could match the original to the full extend. This would come up to the the demand that one should be able to detect the original design approach. But are we talking about restoration here? In the internationally accepted Charter of Venice the authenticity of material is a main

item, but if we select this option, almost all materials will be renewed.
Another option is to repair and reinforce the frame with contemporary techniques. First of all, that will be far more expensive, but the authenticity of materials will be better guaranteed. Yet, then we have to accept principal and visible changes of the building, such as an increase of dimensions of the frame. So where's Duiker's concept of optimalisation? Also, we have to accept the unintended loadbearing function of the partition walls, which brings about a conflict with Duiker's ideas about frame and infill.
The conflict between the concepts of the Modern Movement and the restoring tradition are clearly illustrated by this example. Today, the future of Duiker's masterpiece Zonnestraal still is uncertain and the buildings stand unoccupied on the moors of Hilversum.

3.4. Gooiland: a corroded image

Duiker got the commission for the luxureous Gooiland Hotel and Theater in 1934. In the late 1980's, a serious threat was the technical condition of the facades: steelframed windows and cork-isolated steelpanels were corroded, the tiles were damaged by frost and the superstructure incidentally heavily corroded as well.
The steelframe is partly placed in a brickwork cavity wall: a peculiar mixture of a 'modern' frame with a traditional construction, that again looks like it was given a functionalist' image by the tile covering. The cavity was meant only to provide thermal isolation and was therefore not ventilated. The tiles were necessary to keep the water out, since by lack of ventilation, water could not vaporize and leave. But when the facades collect heat in the summer, the steel shows a relatively greater extension as compared to the surroundings and cracked the tiled surface. Through these cracks, water entered after all. Since the lead strips on the beams, meant to lead water outside, were cut shorter than originally intended, water could reach the steel. The beams corroded, increasing their volume and pushing the outer wall away.

3.5. The risk of thermal isolation

When testing our research method on the Zonnestraal Sanatorium and later in practice on the Gooiland Hotel, some remarkable conclusions could be drawn for both.
With buildings like this, of which the outer skin in fact is one enormous thermal leak, one should be very careful with increasing thermal comfort and to improving thermal behaviour of the constructions. Intervention in one part of the building, for instance the addition of double glazing, often makes other measures necessary elsewhere, such as the isolation of columns and beams in the facade by adding layers of plastered foam to avoid condensation. Quite easily, the lucid character of such a building will be completely lost this way.
Also, such interventions could have a negative effect on the running costs, as was the case for both buildings. In the first place, double glazing is expensive and lasts only approx. 19 years. This is a heavy burden on the annual budget, that is often not compensated with the savings in energy. Then, if we want this addition to comply with the building's historic character, so many individual technical solutions for windowframes etc. are necessary, that the costs of intervention easily become disproportioned. Finally, the sealing of contemporary windows is so effective, that mechanical ventilation could be required to avoid a condensation surplus, resulting in another increase of investments and running costs.
Obviously, with respect to both history and the running costs, it proves to be most advantageous to retain the original design virtually intact, in accordance with model II.
Then, annual running costs over a fifty-year period are lowest of all real restoration options (models I, II, III). The level of comfort is not very high under model II, so a use must be found which is appropriate to these characteristics.
The abovementioned factors led to the decision to restore Gooiland for its re-use as a

cultural centre, according to model II, applying single glazing in repaired steelframed windows. When the windows were being re-mounted, some 30 mm extra space was provided to apply incidental isolation to avoid direct thermal leaks to the superstructure. Also in the tiled parts some thermal isolation was provided where beams and columns are located, to prevent the steel from extreme extension. The foam is covered by a layer of cement on stainless steel mesh. To provide room for this incidental isolation and also to allow the tiles being atached in a slightly thicker layer of mortar than originally, the outer surface has again been moved outward approx. 30 mm. Also some ventilation was provided. In harmony with the choice for single glazing also the closed facades remained unisolated. One third of the steel in the facades had to be replaced.

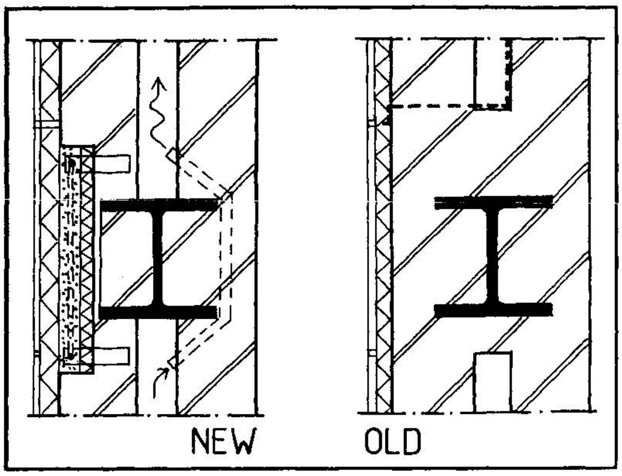

Fig. 4. The steel frame of the Gooiland hotel is placed in a brick cavity wall, a solution that caused severe damage. Today the steel is protected against extreme temperature changes

The main advantage of using our survey of models proved to be, that conclusions on the appropriate type of restoration can be drawn before restoration plans are actually developed. Also, the results of restoration with respect to maintenance and running costs will be known in advance. This way, a plan for restoration of Gooiland could be executed, that is in harmony with both its historic character and the contemporary requirements of the owner, as well as entailing the lowest possible annual costs. We hope to achieve such positive results for Zonnestraal one day as well.

5. DOCOMOMO

To conclude I would like to mention that an interdisciplinary and international network of experts exists that specifically studies the problems related to the restoration of Modern Movement buildings. DOCOMOMO is the International Working party for DOcumentation and COnservation of buildings, sites and neighbourhoods of the MOdern MOvement. The very diversity of participating countries and regions is indicative of the fact that no single universally applicable solution for the conservation of this architecture can be assumed. I have tried to illustrate that with the Zonnestraal case. On the contrary, it is the intention of DOCOMOMO to start and continue the necessary debate over the years to come, in order to arrive at a better understanding of this issue.
An international secretariat is hosted by our university, that publishes a newsletter twice a year. Our latest international conference was last year at the Bauhaus Dessau, Germany, and we hope to meet again in Barcelona in 1994. As secretary general of DOCOMOMO, I am happy to say that at the moment over 30 countries participate in DOCOMOMO, including a total of over 300 members.

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