ABSTRACT: In the post-war period many prefabricated systems for 3D building units were developed, but only few were successful on an international level. The Variel system, developed by the Swiss architect Fritz Stucky, was serial produced in large quantities all over the world. In Belgium, Eternit became a licensee of Variel in 1970 and soon afterwards the first Belgian Variel factory was built in Seilles. By the 1980s the market for prefabricated 3D units in concrete collapsed and also in Belgium Variel units were no longer fabricated. This paper goes into the technical evolution of the prefabricated Variel units built and designed in the 1970s and 1980s in Belgium by studying five designs of the Belgian architect Willy Van Der Meeren. During that period the span of the modules increased, the construction of the concrete slabs changed and the composition of walls, floors and roofs evolved to comply with new standards.

1 INTRODUCTION

In the post-war period many building systems for prefabricated 3D units were developed throughout Europe, but only few were successful. An example of the latter are the units designed in the 1950s by the Swiss architect and entrepreneur Fritz Stucky, known as the Variel system. By the 1970s, Variel modules were mass produced in 13 countries. One of the reasons for the success of the Variel modules, was their robust and polyvalent character.

The work of Fritz Stucky and the development of the Variel modules were the subject of an exposition in 2006 at ETH Zürich in Switzerland. The accompanying catalogue Werkserie. Fritz Stucky. Architekt und Unternehmer gives a good overview of the rise and fall of the Variel system between 1958 and 1982 and discusses the design and construction of projects all over the world, ranging from housing blocks, schools and offices to hospitals. The catalogue does not discuss the current state of the Variel buildings. Yet, a general and structural assessment of how the Variel modules have stood the test of time would be very useful for those involved in the renovation of these modules today, especially because some recent reports have pointed at problems with specific construction details (IRB 2009).

This paper shares the findings of the archival and onsite analysis of five buildings constructed with Variel modules that were designed and constructed by architect Willy Van Der Meeren (1923–2002) in Belgium between 1969 and 1981.

2 TOWARDS A 3D FRAME IN PRECAST CONCRETE

The first Variel system dates back to 1958, but Fritz Stucky and his team would continue to adjust and improve it until the 1970s. In 1961, a new firm Elcon AG was set up in Zug (Switzerland) to house the research center and sell Variel licenses in Europe and abroad. The architectural office Stucky and Meuli continued to bear the official responsibility for planning and realization.

The first version of the Variel system, the so called ‘Program 58’, was designed in 1958 and had
a load-bearing structure in timber and steel. The modules were completely finished in the factory and profitably transported to construction sites within a 200 km distance radius. In the following years, the load-bearing structure was transformed into a reinforced concrete frame with precast floor slabs in pre-stressed concrete and precast portal frames in the shape of an inverted U in reinforced concrete. This ‘Beton-Standard-Program’, developed in 1965, met the demands of the licensees who asked both for durable and fireproof materials and modules that were easy to combine in multi-storey buildings. In addition to the material, also the production method changed and evolved from a ‘static’ to a dynamic assembly line: the modules were put on a conveyor belt, rolling them from one assembly station to the next. In 1971, the E-program was designed for the French market, to construct apartment buildings up to eight storeys high. The dimensions were tailored to the size of the largest shipping containers, in order to transport them economically over distances up to 700 km via the road network, railroads or waterways.

By the end of the 1960s licenses were sold to Germany (1959), the Netherlands (1964) and France (1965) and more than 10,000 Variel elements had been produced (Jenatsch 2006).

3 THE VARIEL SYSTEM IN BELGIUM

In Belgium, Variel gained foothold in 1970: the Belgian company and material producer Eternit purchased a Variel license for Belgium and, also in 1970, Variel S.A. was established (Jenatsch 2006).

In the early 1970s, Variel modules were imported from Variel factories abroad: the more than 400 Variel modules for housing projects in Evere and Etterbeek by architect Willy Van Der Meeren were precast in France by a Variel licensee in Montsoult. In 1974 the first (and only) Belgian Variel factory was erected in Seilles. In 1976, this factory was sold to Jumatt, a contracting company that produced Variel units until approx. 1980.

A complete list of buildings constructed with Variel modules in Belgium does not exist. However, interviews with former employees of Variel S.A. in Belgium revealed that the system was used for a number of projects, ranging from small villas and larger housing projects, to schools and offices.

4 BUILDING DESIGNER VAN DER MEEREN

In Belgium, Willy Van Der Meeren used the Variel modules in five building projects, designed and constructed between 1969 and 1981: a project with 48 apartments for the elderly in Evere (1969–1972), the office building ‘Etercenter’ for Eternit in Kapelle-op-den-Bos (1974–1975), homes for 352 students (1971–1973), an extension to this student housing (1978–1979), and a building for socio-cultural activities (1980-1981) – the latter three were all commissioned by the Vrije Universiteit Brussel (VUB) and located at the university campus in Etterbeek.

How Van Der Meeren came in contact with the Variel system is not clear – possibly he read publications on the work of Fritz Stucky in internationally renowned architectural journals such as Bauen + Wonen, Werk and Detail (Jenatsch 2006). Throughout his career as an architect – Van Der Meeren preferred to call himself a ‘building designer’ rather than an architect – he showed a special interest in innovative building materials and techniques, mass or serial production, and ways to reduce building costs and construction time without impairing the architectural and technical quality of the building. From 1967 onwards Van Der Meeren used the SAR-grid for his architectural design sketches: the SAR-grid was developed in the Netherlands to stimulate the interaction between the design and the fabrication process (De Kooning 1997). Thanks to his distinct and remarkably consistent approach towards architecture, which can be characterized by means of key words such as rational, logic and social, Van Der Meeren is considered as one of the ‘25 Masters of Modern Architecture in Belgium’: “No other architect in post-war Belgium was so concerned with making good and cheap housing and achieved such pioneering results in this field as Willy Van Der Meeren” (De Kooning 1999). One of the first realizations that effectively illustrates this approach is the CECA house, a cheap workman’s house designed in collaboration with architect Léon Palm. The CECA house, based on a structural frame in steel and other prefabricated, modular building elements and materials, was an architectural interpretation of the slogan ‘Construire pour le plus grand nombre’. A second highlight in his career is the high-rise building with 105 apartments in Evere (1954–1960) for the public housing society ‘Ieder Zijn Huis’, presided by the socialist Mayor of Evere Franz Guillaume. A few years later, Van Der Meeren would again be appointed by Ieder Zijn Huis and Guillaume, to construct 176 apartments for the elderly. These low-rise apartment buildings, in the shadow of the 1950s high-rise block,
were constructed in three phases. The first two phases, constructed in 1957 and 1962, can be considered as a reinterpretation of the CECA house. For the third phase in 1969, Van Der Meeren relied on the Variel module. Also in 1969, Van Der Meeren was invited by Aloïs Gerlo, the first rector of the newly erected Vrije Universiteit Brussel, to teach ‘Theory of architecture’ at the department of civil engineering. His appointment in 1970 did not only lead to changes in the educational program, Van Der Meeren was also involved in the design of many new university buildings until his retirement in 1988 (De Kooning 1997).

5 HOUSING FOR THE ELDERLY IN EVERE (1969–1972)

For the third phase of the apartments for the elderly in Evere, Van Der Meeren introduced the Variel system. He concatenated 72 Variel modules in precast concrete (Beton-Standard-Program) to create three buildings with 16 apartments each. Each of the three buildings is made with 24 modules, measuring 2.70 m by 9.60 m, stacked two storey-high, and two central entrance halls, constructed in masonry (fig. 3). The Variel units were put next and on top of each other in a rather simple, straightforward way, except for the lateral shift of the modules in the middle of each block. In future projects, Van Der Meeren would show more ingenuity in the architectural configuration and combination of the modules, facing up to the limiting conditions of the original system.

The Variel units for the elderly housing were produced in the Sceper factory in Montsoult in France. Sceper S.A., a subsidiary of Dumez Bâtiment S.A., had taken over Variel France S.A. in 1968.

6 VUB STUDENT HOMES IN ETTERBEEK (1971–1973)

The end of the 1960s was a turbulent period for the educational landscape in Brussels: in 1969 a new university was founded, the Vrije Universiteit Brussel (VUB), detaching itself from the French-speaking Université Libre de Bruxelles (ULB). The Dutch-speaking university was located at a new campus in Etterbeek, with new auditoria, offices, research laboratories, sport and leisure facilities, and housing accommodation for students. In 1971 Willy Van Der Meeren was appointed to design some 350 housing units for students, which were to be ready by September 1973. Van Der Meeren’s first proposal of mobile homes in polyester was rejected as rector Gerlo questioned the durability and solidity thereof. Thereupon, still in 1971, Van Der Meeren came up with a new proposal, in concrete this time. Given the importance of building quickly and at low cost, preferably with prefabricated and industrialised building elements, Van Der Meeren again turned to the Variel modules.

In comparison to the apartments for the elderly in Evere, the housing complex for students was a much larger project. The combination and configuration of the modules thus became increasingly important. Van Der Meeren aimed at varied façades, irregular volumes and unexpected vistas. Yet creating a playful architectural layout with a rigid prefab system proved to be rather difficult: Van Der Meeren criticized the dimensions of the Variel modules, which were solely based on transportation conditions. As the width of a module was not a multiple of its length, the modules were difficult to link perpendicularly. Fritz Stucky would take this comment into account in later developments (De Kooning 1997).

Despite the inherent design inflexibility of the Standard-Beton-Program version of the module, Van Der Meeren nevertheless succeeded in creating an original and varied student village. He combined the stern Variel modules (measuring 2.70 m by 9.60 m) in such a way that variegated outdoor spaces, corners and walkways with a private, semi-public or public character were generated. As for the interior spaces Van Der Meeren came up with an architectural layout combining four Variel modules to create housing units for four students, with four private bedrooms, a common living room and two bathrooms. The design was appreciated on an international level as it was published in the journal Architectural Review in 1973.

During the design process, in June 1972, the Belgian company Variel S.A. invited Van Der Meeren to visit the German Variel factory of Karl Kühler in Göttingen. The one day study tour also included a visit to Variel projects in Germany and the Waldau University Hospital in Switzerland (VUB archive). Why Van Der Meeren was invited to the factory in Germany is not clear, as the modules were fabricated in the Sceper factory in Montsoult in France.

In September 1972 the final budget estimate was sent to the VUB by the consortium of the Antwerp company Van Riel & Van den Bergh and Variel S.A. Their building specifications describe the characteristics of the 364 Variel modules and 224 Variel roof elements to be constructed. Although it is not mentioned explicitly, the description is consistent with
the Standard-Beton-Program. The floor and accessible roof slabs in pre-stressed concrete were designed to resist a service load of 300 kg/m², the inaccessible roof slabs should resist 150 kg/m². The slabs consist of an 8 cm thick plate, supported by two longitudinal and three transversal ribs (fig. 4). A layer of 30 mm thermal insulation in expanded polystyrene was provided at the inside of the exterior wall and underneath the floor slab. A blanket of 60 mm glass fibre was applied in the cold roof.

During the fabrication of the Variel modules, it became clear however that some changes were necessary to assure the technical quality and durability of the elements. The changes were the direct consequence of a visit to the Sceper factory in Montsoult in December 1972 by the engineers Broucke, De Proost and Van Dam, representing the Belgian control office SECO. They looked into the prefabrication process and concluded that, as for the precast floor slabs, the minimum thickness of the concrete cover, as required by the Belgian norm NBN15 on concrete, was not guaranteed. Distance pieces were put in place to ensure the minimum concrete cover, yet the weight of the reinforcing bars pushed them into the EPS insulation layer at the bottom of the formwork. SECO asked to revise the production process and to attach the insulation layer after the casting process. 22 Variel modules that were already fabricated were rejected, yet SECO agreed to apply the remaining 15 floor slabs in units on the first level, where the risk of corrosion was reduced (VUB Archive).

As for the connection between the prefabricated portal frame and the floor slab, both pre- and post-tensioning systems were commonly applied in other countries. In North Germany and Switzerland the Dywidag system was mostly applied. In France the Freyssinet patent was prevailing (Jenatsch 2006). However, as most of the systems were patented, details were generally not provided in building specifications. The patent of Elcon AG ‘Brevet d’invention. Structure préfabriquée et procédé pour l’établissement de ses joints’, which was issued in 1971 in Belgium, more or less simultaneously with the design of the VUB student homes, mentioned two options. The first method (fig. 5, left) consisted of casting two short horizontal steel anchorage bars in the longitudinal ribs of the floor slab. The frame was then slid over the anchorage bars and fixed by post-tensioning the bars. This method implies that the floor slab was pre-stressed and that the capacity of the floor slab was not influenced by the condition of the anchorage bar. In the second method (fig. 5, right) the steel strands for post-tensioning the floor ribs ran through the columns of the frame, meaning that the anchors assure both the post-tensioning of the slab and the rigidity of the connection. In the latter case, the strands were inclined as they run through the rib. Visual inspection of the two anchorage points of the concrete frames did not give a decisive answer which of the two connection systems was used for the student homes.

After the concrete structure was cast and assembled, it was completed with partition walls and ceiling panels. Also the bathrooms and ducts for water, electricity and heating were provided in the factory. The semi-finished modules were then transported 300 km by truck from Montsoult to Brussels. The first modules arrived there on January 16, 1973. Upon the arrival of the Variel modules in Brussels, the main benefits of the system were immediately demonstrated: the first day, already five modules and four roof elements were installed by Van Riel & Van den Bergh. The construction pace would even increase during the following days, with the installation of up to ten modules and six roof elements in one day (Archive VUB). On the other hand, the benefits were not fully exploited, as it was decided not to order completely finished Variel modules yet semi-finished modules instead. Kitchens, façade cladding and aluminium window frames were installed onsite, and exactly these onsite interventions caused for a delay in construction times, yet without jeopardizing the deadline of September 1973.

Willy Van Der Meeren used various Eternit materials and products frequently and abundantly in his designs since the early 1950s. He also built two Eternit shops in Puurs and Mechelen in 1964 and 1965, and an office building on the Eternit factory site in Kapelle-op-den-Bos in 1974-1975. This ‘Etercenter’ contained not only offices but also served as a showcase for Eternit products (fig. 6). In this building, Van Der Meeren used several Eternit products like Glasal, Exterelo and Masal, as well as the Variel modules. As the Variel factory in Seilles was operational from April–May 1974 (Private Archive, 1975), the Etercenter is probably (one of) the first ‘Belgian’ Variel building(s) made in Seilles. The application of lighter façade panels was a direct consequence of the fabrication process in the Belgian Variel factory, which focused on dry assemblies. The reinforced concrete floor slabs and frames were not cast in the factory but imported from Beton-Son in the Netherlands. In the factory the frame was rigidly connected to the floor and subsequently the 3D frames were completed with infill walls and other elements. The building was meant to be the first phase of a much larger scheme. However, due to the enduring economic crisis of the 1970s, this larger scheme has never been executed.

8 EXTENSION OF THE VUB STUDENT HOMES IN ETTERBEEK (1978–1979)

Five years after the first students had moved into the Variel buildings, the VUB decided to build additional student homes, accessible for disabled people, as well as a building for socio-cultural facilities. In terms of planning, priority was given to the extension of the student homes, which were to be finished by October 1979, at the start of the academic year (fig. 7). To assure the seamless integration of the new buildings within the existing fabric, the university renewed the collaboration with Willy Van Der Meeren. In his turn, Van Der Meeren would again rely on the Variel system, for the same reasons as before (to increase the construction pace and minimize the building costs). One of the main differences with the 1972–1973 modules were the dimensions: following Van Der Meeren’s critique on the difficulties to link the modules perpendicularly, a new Variel module had been developed with modular dimensions in both directions (the new length of 10.80 m was the fourfold of the width of 2.70 m). As it was a relatively small extension, only 28 Variel modules were needed.

As for the construction of the modules, the Belgian Variel factory in Seilles had been taken over by the construction company Jumatt in 1976, which continued to produce Variel units in Seilles until approx. 1980. Jumatt sent in an offer in December 1978 to build the 28 Variel modules. As the floor span of the module was enlarged by 1.20 m, the maximum service load of the floor was reduced from 300 kg/m² to 200 kg/m², still in line with common values for maximum service loads in residential buildings (Van de Vooorde 2015). The offer mentioned that the floor slabs, 8 cm thick, were supported by two longitudinal ribs without transversal ribs. It specified that the 5 cm thermal insulation layer in expanded polystyrene was only to be attached after the concrete floor slabs were cast (VUB Archive). In general, the thermal performance of these units increased as double glazing was included and 6 cm glass wool insulation was applied in the front and side façades. The concrete panels in the front façades were substituted by lighter enamelled asbestos cement panels Glasal (fig. 8). Explicitly different from the earlier student housing, is the construction of the roof. While the original student homes were built with concrete roof elements and a cold roof construction system, the extension is built with a warm roof construction, in which the thermal insulation is applied on top of a steel frame with timber girders. One could think that the combination of steel and especially timber for the roof structure can be explained by the involvement of Jumatt, specialized in the prefabrication of buildings and bungalows with a structural timber frame. However, the change in material use is related to the assembly process in the Belgian factory in Seilles, which opted for dry assemblies from the start.
9 SOCIO-CULTURAL FACILITIES FOR THE VUB IN ETTERBEEK (1978-1981)

The building for socio-cultural activities was located on the outskirts of the campus, linking the university to its immediate surroundings. This location enabled Van Der Meeren to proceed more freely in the design of the building, independently from other buildings on the campus. Van Der Meeren combined the Variel modules in two perpendicular directions, taking full advantage of the modular flexibility he had suggested to Fritz Stucky. While the architectural configuration might seem somewhat conventional or straightforward, especially in comparison to the crisscross layout of the student houses, Van Der Meeren did introduce a new feature on the technical level. In cooperation with the VUB's building physics professor Jan Van Loeij, a passive solar energy system was integrated in the South-East and South-West façade of the building (fig. 9). This regained interest in passive solar systems must be seen in the context of the second oil crisis in 1979 and the increase of energy prices. The system consisted of a particular wall composition, called ‘Trombe wall’: a glass layer was positioned at the exterior of a matte dark concrete wall to enhance heat absorption. Via ventilation valves the interior air was directed along the hot concrete wall element in order to increase the room temperature. In summertime, the ventilation valves were closed to prevent overheating. As this system was investigated within a research project, both single glass sheets and double glazing were installed, to monitor the difference in efficiency (fig. 10). Only the sunny parts of the building were constructed with Trombe walls, while the other façades were finished with Glasal panels in a dark brown color.

The architectural drawings, signed by Van Der Meeren with a reference to Jumatt as general contractor, reveal that again some changes were introduced in the structural concept of the Variel modules. The roof of the first level was constructed in laminated timber beams. The roof of the ground level, which was designed as a terrace, was executed in concrete to resist higher service loads. Thermal insulation was installed on top of the floor slabs of the ground floor level. However, archival information and detailed drawings of the load-bearing structure, in particular the reinforcement in the concrete slabs and the connection between the floor slab and the frame, is lacking.

In 2015, the socio-cultural building was demolished to make way for a new university building. Prior to and during the demolition, destructive research was carried out in order to study the construction details of the Variel modules. Two differences with the earlier Variel modules were observed visually. First, the columns of the frame did not end in a console, but had straight, rectilinear ends. Secondly, not two but four anchor heads were clearly visible, consisting of semi-circular wedges and seven strand-tension cables (fig. 11). Further destructive investigations revealed that the tension cables ran from one frame, through...
the ribs of the floor slab, to the other frame. The rigid connection was thus realized by post-tensioning the system. The tension cables in the floor element were wrapped to avoid direct contact with the concrete. At its ends, running through the columns, the cable was covered by a plastic tube (fig 11). The grout inlet became visible. Although the anchor heads were corroded, the anchorage and the strands were in good condition.

10 CONCLUSION

The Belgian company Variel S.A. was founded in 1970 when Eternit bought an Elcon license. Nevertheless, the first prefabricated Variel units applied in Belgium had to be imported from the Sceper factory in France. As a consequence, some typical French building materials were introduced in these early projects, such as wooden Fontex-panels for the partition walls. The Belgian Variel factory, established in Seilles in 1974, made use exclusively of dry assembly techniques: the reinforced concrete slab, frame and roof elements were imported from the Netherlands. Next to concrete also timber and steel were applied for the construction of roofs, giving rise to their integration in the 3D-module in the factory. In addition, material for the front and back facades changed from concrete to (sandwich) panels and boards. When the Variel factory in Seilles was taken over by Jumatt in 1976 the preference for timber and lightweight panel structures remained. Although the Variel system was used throughout Europe, the system was adapted to the local context and the location of the factory, as is shown in the construction process, the applied construction technique and the materials of the ‘Belgian’ Variel modules.

Willy Van Der Meeren has built five projects in 1969–1981 in which prefabricated Variel modules were used. The five buildings, which were traced and documented via the VUB Archive and the WVDM Archive, testify of an innovative construction system, used on a European scale yet tailored to the local context. In addition, especially the 352 student homes at the VUB university campus in Etterbeek incorporate high architectural and spatial qualities, making it worthy to invest in their future preservation.

Although many Variel buildings in Europe and abroad have been renovated, the outcome is seldomly published. Such renovation reports however would enable to evaluate similar buildings and recognise which version of the system was applied. This kind of information is essential, not only to assess the soundness of a structure in the framework of a renovation or restoration campaign, but also to assess its heritage value. For the Variel buildings in Belgium, of which a number is also in need of renovation, in this research project information on the overall construction details and materials was gathered from the architectural plans and building specifications, in order to assess their structural concept and current state. Yet details about the amount, quality and position of steel reinforcement, the concrete composition and the post-tensioning system applied in the Variel units are missing. Indeed, this kind of information was not communicated to the architects and contractors involved, as the Variel units were delivered as ready-made building blocks at the construction site. Consulting the Variel factories is difficult as many of the companies involved went bankrupt or have not kept their archives of that period.

There is an urgent need for further in-depth research on the discussed Belgian buildings. The socio-cultural building, although perfectly sound, was demolished in the summer of 2015 to make way for a new building project at the same location. The Étêcenter soon faces the same fate. And the student village at the VUB campus is threatened by the university’s building projects, in spite of its unequalled spatial and architectural qualities and the fact that the structure has not yet reached its service life. The modules could fulfil their original function or incorporate a new function, either in the same location or moved to a new location. The destructive investigations that were carried out prior to the demolition of the socio-cultural building in 2015 shed light on restoration, renovation and dismantling options.

ACKNOWLEDGMENTS

The authors would like to thank Innoviris for its financial support, A&D 50 for giving access to the WVDM Archive, and former employees at the Variel and Jumatt factories in Seilles, for sharing their memories.
REFERENCES


Brussels, VUB Archive, Willy Van Der Meeren, *plannen en briefwisseling.*


Mechelen, WVDM Archive / A&D 50.

Mechelen, WVDM Archive / A&D 50.

Oudergem, Private Archive 1975.

**Système moderne de construction s’est imposé à l’Athénée Royal de Jambe (3ème tranche).** Variel s.a., 5210 Seilles (ref: MO/GE/7405/FL/5000).
