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THERMAL INSULATION IN BELGIUM BEFORE THE FIRST OIL CRISIS (1945-1975). A QUESTION OF ECONOMY AND COMFORT?

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Building materials, thermal insulation, Belgium, post-war, oil crisis

Abstract

The collective memory often places the emergence of insulation in the 1970s, after the oil crisis in 1973 had sent up energy prices. Yet the issue and application of thermal insulation is much older. Insulation, against both heat and sound transfer, became a popular theme in the specialized architectural and technical literature in Belgium in the early 1950s. From the end of the 1950s and the early 1960s, consulting agencies arose to conduct full thermal studies, helping to enhance the use of thermal insulation in the daily building practice. Especially during the 1960s, more or less simultaneously with new architectural trends towards ever lighter (and less inert) structures (e.g. the curtain wall), there was a growing conscience of heat losses, both because the waste of fuel and high heating expenses. We will analyze the applications, theory and debate on insulation in the contemporary literature: Who was promoting the use of insulation? Which type of insulation was used in Belgium after World War II? Which actors were involved in the dissemination of (knowledge on) thermal insulation? What were the principal and typical post-war arguments in the debate and discourse on insulation? How does the situation in Belgium compare to other countries? And if the technical performance of post-war insulation is negligible in comparison with the current products, what can we learn from the post-war history of thermal insulation?

This paper is based on a thorough study of post-war periodicals, normative documents, books and an international literature review. It fits within a wider research perspective, striving to map the evolution and impact of new construction techniques and materials in the post-war period (1945-1975).

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INTRODUCTION

In 1947, the American Paul D. Close wrote one of the first, internationally available post-war books on *Thermal Insulation of Buildings*. He was technical advisor for the insulation manufacturer Simpson Logging Company (Seattle) and former technical secretary of the Insulation Board Institute (Chicago) and the American Society of Heating & Ventilating Engineers (New York). The book counted just over 100 pages and included a list of 9 trade associations, 128 manufacturers and 169 trade names of insulation. Almost twenty years later, Close published *Sound control and Thermal Insulation of Buildings* (Close 1966). Compared to the 1947 version, the number of pages on thermal insulation had tripled. The list of the manufacturers and trade names was (probably too long and therefore) omitted, yet Close included new lists of federal specifications and standards by the American Society for Testing and Materials. In all, the book profited from the scientific progress that had been made since 1947, but the general structure and the main topics were relatively unaltered. In both editions, Close explained the basic principles and common types of insulation, as well as heat loss calculations. In addition, he discussed condensation prevention, the relation between insulation and comfort, and the economics of thermal insulation.

The comparison of the two books by Close gives rise to a number of questions. First of all, is the level of knowledge presented by Close specific for the US, or comparable to Europe and Belgium? How did the knowledge on thermal insulation influence the building practice? Which elements of the discourse are typical for the post-war period? And if the technical performance of post-war insulation is negligible in comparison with the current products, what can we learn from the post-war history of thermal insulation? To answer these questions and to assess the knowledge on thermal insulation in 1945-1975, the periodical press is a perfect means. Architectural and technical journals are an interesting, heterogeneous and rich source of information (Van de Voorde 2015). A close reading of the articles, documentation and advertisements in three Belgian post-war journals with a different profile and discourse (*La Maison* 1945-1970, *Architecture* 1952-1970 and *Bouwen en Wonen* 1953-1962) is confronted with normative documents (e.g. building specifications and regulations) and an international literature review.

THERMAL INSULATION IN THE POST-WAR PERIOD. A FLOURISHING MARKET

Thermal and acoustical insulation: two emerging niche products

In the first volume of *La Maison* (1945), two companies promoted the use of insulation materials: Isoverbel and Etablissement Ernest Lenders. Isoverbel is short for ‘isolation de verre belge’: it was a Belgian company that produced thermal and acoustical insulation materials made from glass (glass wool, glass silk and glass fibers) – the focus on glass is due to their origin in 1937 as the insulation department of the glass company Saint-Gobain. The second company, Etablissement Ernest Lenders, was both a research, design and consulting agency as well as a manufacturer and insulation contractor. Lenders specialized in acoustical insulation, and only a small part of their business was related to thermal insulation. The double expertise of companies in both acoustical and thermal insulation is not uncommon in the early post-war period. Although heat and sound transfer happen according to different rules, they were often dealt with together: as both concepts were situated in a niche and not yet fully understood by many architects and engineers, it was often opportune to combine them in one specialized company or consulting agency. A number of thermal and acoustical insulation products were also manufactured with the same materials, mostly of vegetal or mineral nature. In the early post-war period, the attention

for both heat and sound transfer in the architectural press increased, with even a small advantage for acoustical materials. This would change during the 1950s and especially in the 1960s, as the advance of synthetic thermal insulation materials accentuated the difference between the two.

The nature of insulation. Vegetal, mineral or synthetic

The different types and products of thermal insulation can be classified in various ways, for instance by their structure (e.g. fibers, granules or cells), by their form (e.g. panels, sprays, blankets), or, most commonly, by their physical nature, with vegetal, mineral or synthetic materials.

By far the most popular vegetal insulation material was wood, next to cork and linen. Wood is mostly used to create different types of fiber boards. To overcome the sensitivity of wood fibers to heat, moisture and chemical agents, two strategies were very popular: the surface of the panel was treated (for instance by a decorative finish or wood veneer) or the wood fibers were mixed with cement to 'stabilize' its characteristics. Although such panels adopt the low thermal conductivity of wood (thermal conductivity or λ-value commonly between 0,1 and 0,5 W/m°K), the insulation properties thereof were often secondary to the decorative or practical qualities (e.g. as a permanent mold for concrete). By current standards, some materials received the label 'insulating' rather quickly – in fact, it was not until the European standard 'Properties of thermal insulation products for buildings according to their application' (ISO 9774) was issued in 1990 that an internationally accepted maximum λ-value of 0,065 W/m°K was agreed (Meyer 1988).

As for mineral insulation materials, most commonly used are glass fibers, rock wool, (the now discredited) asbestos, cellular glass (monopolized by Foamglas), and expanded perlite and vermiculite. Opposite to wood fiber panels, (most) mineral insulation materials are fire-resistant, non-hygroscopic and rot-proof, while the λ-value is generally lower than 0,05 W/m°K. The main producers of mineral insulation materials in Belgium were Isoverbel, Isolex and Eternit. Isoverbel produced glass fiber insulation in bulk, as blankets (attached to cardboard, galvanized mesh or (tar) paper) and as (semi-)rigid panels. The Belgian company Isolex was very similar to Isoverbel: also a consulting agency, as well as producer and installer of glass fiber insulation, in various forms and dimensions. Next to selling their own glass fibers products, Isolex also marketed insulating cement mortars (as screed or as ceiling finish) and distributed glass fiber products of the American company Owens-Corning Fiberglas from the 1960s onwards. The Owens-Corning Fiberglas products (e.g. sheets and panels to insulate walls, roofs and ceilings) were also distributed in Belgium by Eternit. This Belgian company is known best for its asbestos products, which were used for insulation among other things (often mixed with cement or used in sandwich panels), yet Eternit actually had a broad range of mineral insulation products. For instance, Eternit also produced Menuiserite (boards with mineral wood and asbestos fibers mixed with cement), Lithoperl (expanded perlite, to be added to concrete, mortars and plasters, from 1957 onwards) and Glasal sandwich plates (with a core of polystyrene or Eterfoam, an insulation foam based on an expanded phenol-formalin resin). This latter is however no mineral insulation product, but belongs to the third category of synthetic insulation materials.

Compared to vegetal and mineral products, synthetic insulation products are relatively young. Many vegetal and mineral materials were used (long) before World War II: asbestos became popular during the Industrial Revolution, mineral wool insulation was commercialized in the 19th century (Bozsaky 2010), in the 1930s the European market for hard and soft board flourished (Bot 2009) – albeit that new production methods gave rise to new opportunities in the post-war period. The sudden and strong emergence of synthetic insulation materials originated in new developments in the modern chemical and petroleum industry shortly before and after World War II, mainly in Germany, the USA and the UK, bringing forth an ever-increasing number of

plastics. In 1946, 50.000 ton of plastics and synthetic materials were produced worldwide, a quantity that rapidly increased to 1.000.000 ton in 1960 (Bot 2009). The American Dow Chemical Company and the German BASF led the way in the production of (expanded) polystyrene and polyurethane products. Common for these synthetic insulation foams is a very low weight (usually less than 40 kg/m³) and a λ-value (far) below 0,05 W/m°K. In addition, they are generally inert, resistant to chemical and biological substances, yet highly flammable, so they are usually covered or used in floor or wall cavities. Nevertheless the 'appearance' of these plastic foams caused a revolution in the insulation market during the 1950s. In addition to the popular international products such as Styropor (BASF), Styrofoam and Roofmate (Dow), a (small) number of Belgian companies started to produce synthetic materials at the end of the 1950s, for instance Eternit (Eterfoam) and Isoverbel (Stryroverbel, based on expanded polystyrene).

Expanding the definition of insulation: boards, glass and concrete

The story of thermal insulation in the post-war period goes beyond the 'pure', primary insulation materials mentioned above. From the 1950s onwards, the insulation value of building materials in general was clearly appraised as an additional advantage and sales argument. The three main types of 'secondary' insulation materials that participate in this story are decorative panels, glass and concrete. The insulation value of decorative panels was upgraded by adding an internal layer of insulation material to transform them into sandwich panels. Glass was incorporated in the insulation discourse by means of double glazing, produced in Belgium since 1947. By using double glazing the heat loss was reduced with 50% and, because of the two-stage transition from cold to warm, also prevented condensation. The two most common brands in Belgium were Thermopane (produced by Glaver) and Polyverbel (manufactured by Univerbel) – when these two major glass manufacturers in Belgium merged into Glaverbel in 1961, only the production line of Thermopane was maintained. In addition to double glazing, very particular types of glass were developed, for instance athermanous glass (blocking radiation heat, e.g. Thermosol and Athermane K60), semi-reflecting glass (with a very thin metal coating, e.g. Stopray) or a particular type of double glazing with an internal (translucent) layer of glass fibers (e.g. Thermolux). For concrete, the problem of heat transfer was partially overcome with lightweight concrete, invented in the interwar period (especially in Sweden) and popular from the 1950s onwards throughout Europe - in 1954/1955a first Ytong factory was set up in Belgium. Lightweight concrete, referring to both gas concrete (e.g. Ytong, Siporex and Durox) and concrete with lightweight additives (e.g. Durisol, Argex), became popular, among other things, because of its low weight (making it easy to handle on the construction site) and its high thermal capacity: the U-value or thermal transmittance through a solid wall in gas concrete was generally between 0,07 and 0,08, compared to 0,3 for the then conventional brick cavity wall (Van de Voorde 2014).

The importance of 'secondary' insulation materials in post-war construction is assessed by an analysis of newly erected houses in Brussels published in *La Maison* in 1945-1970. Limiting us to the descriptions that specifically refer to the construction materials, 65 of 147 descriptions (or 44%) mention insulation materials. Specifying between primary or secondary insulation, in 12 % of the cases primary insulation was applied (glass fiber panels and blankets, wood fiber-cement panels, rock wool, expanded polystyrene, cork, etc.), 20% uses secondary insulation (lightweight concrete Ytong and Durisol, double glazing Thermopane and Polyverbel, insulating glass Thermolux, prefabricated boards and sandwich plates Glasal, Massonite, Linex, etc.), while 12% combines both. Taking in mind that these descriptions are far from complete, the actual use of insulation materials is probably even higher, corroborating the increasing presence of thermal insulation in the building practice and architectural press, even before the oil crisis in 1973.

THE DEBATE ON THERMAL INSULATION: AUTHORS, ACTORS, ARGUMENTS

Education and sensitization

Looking into the authors involved in the post-war insulation debate, different actors and organizations come to the fore. In 1952/1953 and 1956, *La Maison* published two series of articles on (thermal and acoustical) insulation by Antoine de Grave, engineer and chief inspector of buildings at the Ministry of Public Buildings. It is remarkable that a high-ranking official is one of the first to write (extensively) on the topic in the 1950s - even more so because apart from the commercial advertisement campaigns and some isolated, short articles, it was not until the late 1950s that thermal insulation became a recurrent theme in the architectural press. For instance in January 1958, the year of Expo 58 in Brussels, *Bouwen en Wonen* published an article on the thermal insulation of houses as an important source of cost reductions. In March 1959, they continued with a thematic issue on heat and sound insulation (including a compressed course of building physics). In 1959 *Bouwen en Wonen* also reported several times on the exhibition on heat and sound insulation which the journal co-hosted at the National Building Centre in Antwerp. This traveling exposition, in which the abovementioned companies Isoverbel, Isolex, Ytobel, Glaver and Univerbel were represented among others, was a German initiative: the Belgian industry, government and professional associations were apparently not yet equipped to organize such an event in 1959. Yet in Germany, as well as in the UK, there was already a law prescribing the use of insulation in houses at that time - in Belgium, France and the Netherlands such a law would only be issued in the 1970s (Guichard 1974; Bot 2009). However, the exhibition can be considered as a first step in an intensified, objective and broad debate.

Professional organizations and scientific institutions

Although the concept of the U-value or the thermal transmittance through a wall was already defined in the 1850s by the French physicist Eugène Péclet, (Koolhaas 2014), it only became important much later; the λ-value of materials appeared in the Belgian periodical press from 1959 onwards. The early 1960s saw the emergence of the 'heating engineer' and specialized consulting agencies: they calculated U-values and compared different insulation systems, which was increasingly indispensable in the flourishing insulation sector. Their independent character distinguishes them from the 'insulation contractors' such as Isoverbel and Lenders: these companies also offered thorough insulation design studies by specialized engineers in the 1950s-1960s, free of charge yet linked to the products they sold. The same strategy (scientific yet with a clear commercial undertone) is also illustrated by the advertisements wrapped as documentary articles (e.g. by Durisol, Styropor and Foamglas in February 1956, September 1960 and January 1961 in *Bouwen en Wonen*). In fact, it seems that the insulation companies increasingly insisted on a more scientific approach and debate. One of the first initiatives in this direction is the foundation of the Association for Thermal and Acoustical Insulation in 1962 (on which *La Maison* reported between October 1961 and June 1962). This national association gathered companies, public authorities and scientific institutions such as the Belgian Building Research Institute (BBRI). Shortly before, within the BBRI a technical committee was created on insulation, also demonstrating the professionalization of the sector. The objectives of both the national association (to stimulate mutual knowledge exchange and to inform the public at large) and the BBRI (to do scientific research in order to improve the best practices) are in line with the recommendations of the international energy committee of the Organization for Economic Co-operation and Development of 1962, which stimulated governments and professional associations to disseminate information and to issue minimal norms on thermal insulation (*Architecture* 1962 nr. 49).

Normative and legal context

During the 1960s, the BBRI published several technical reports on insulation, for instance on the insulation of flat roofs (1962) and the measurement of thermal conductance (1964). The BBRI also strove to increase the construction standards by means of the 'General Conditions for Private Constructions', co-edited with the Royal Federation of Architects' Associations (FAB) and the National Confederation of the Building Industry (NCB). In 1973, as part of the technical prescriptions on materials, 25 pages were devoted to thermal insulation, including basis concepts and criteria (e.g. thermal conductivity-values, avoiding condensation and thermal bridges), properties and application guidelines of insulation. These prescriptions were not mandatory yet a work of reference for architects and contractors in their daily practice.

The first norm on thermal insulation in Belgium (NBN B62-001) was issued in 1974 – the preparatory works were initiated in 1969 by the special commission of the Belgian Institute for Normalization (BIN) on 'Thermal Insulation of Buildings'. In March 1974, the norm was presented at a national colloquium, co-organized by the National Institute for Housing (NIH), the insulation association founded in 1962 and the BBRI, with the support of the Ministries of Economic Affairs, of Public Health, Environment & Family, and of Public Works. Antoine de Grave, then general director at the Ministry of Public Works, stated that the first Belgian norm was hardly innovative or trendsetting (de Grave 1974) – if public authorities issue laws or regulations, they usually fall back on a technological background and synthetize existing research and best practices. The Belgium norm was however somewhat different than its European counterparts such as the first French regulation, also issued in 1974: Belgium proposed a maximum heat transmission index T for each room (which was set at 0,9 W/m²°C), while many other countries such as France proposed a maximal G-value or heat transmission for the entire building. The 'Belgian' T-index was coupled with prescriptions on condensation and draught and a minimum thermal resistance of certain walls. In all, this norm reflected "a rational, global method to improve the thermal insulation of buildings and to reduce the energy consumption without decreasing the comfort of the inhabitants" (de Grave 1974). This twofold argument, of energy/economy and comfort, was not new but seemed to have been upheld already for three decades.

The commercial and scientific argumentation

Even long before regulations or building specifications relating to thermal insulation were issued, economy and comfort were keywords in the discourse on thermal insulation. Insulation companies especially focused on financial aspects to convince architects and house owners. Isoverbel for example used the slogan "Isoler, c'est épargner". In January 1958 *Bouwen en Wonen* had calculated that heat losses due to insufficient insulation rose up to 50%, yet that 35% could be prevented by including 10 cm of mineral wool in the walls and roof. On the other hand, the cost of insulation by specialized firms would amount to 10% of the total cost of the house. Illustrative of the economic argument is the book *Thermal design of buildings*, and especially its subtitle: a *guide to economically sound thermal design of heated, air conditioned or refrigerated buildings for use by architects, home builders, and building owners during preliminary design stages*. The book was meant as an easy-to-use guide which translates building performance into costs, because "dollars are easier to understand than Btu's" [Btu = British Thermal Unit] (Rogers 1964). Rogers also pointed out that the increasing use of glass should be taken into account: the average surface of glass in a building had doubled between two generations from 15 to 30% in the mid-1960s. Indeed, the post-war architectural trends towards more open, lighter and less inert structures (e.g. the curtain wall) stressed the importance of thermal design even further: in build-

ings with large glass surfaces, a basic level of comfort needed to be assured during the winter as well as during the summer (diminishing solar radiation) (*Architecture* 1962 nr. 49).

During the 1960s, the use of energy ascended because of a general economic expansion, an increase in new buildings (that needed heating) and higher comfort demands. This upward trend was altered in the early 1970s, when energy prices rose due to a global oil trading conflict. Almost simultaneously, in 1972, the Club of Rome's *Limits to Growth* had raised the public awareness on the finiteness of natural resources, in particular oil, causing a growing conscience of heat losses and related environmental aspects. The oil crisis created an insulation shortage in the US (Koolhaas 2014), while the production of thermal insulation in France and Germany (the two largest insulation markets in Europe) had doubled between 1979 and 1980 to meet increasing demands (Planche 1988). Although the two oil crises had caused a remarkable growth in the European market of thermal insulation (Wannous 2012), the question arises if this growth is to be considered as a (scientific) revolution, or whether this was result of a large scale application of scientific knowledge that was developed before. Bozasky, in his analysis of the history of thermal insulation from the ancient world to today, discerns five major phases, of which the second to last runs from 1950 to 2000: this phase starts with the development of synthetic insulation and ends with the return to natural, vegetal insulation materials because of disturbing CO_2-emissions and global warming (Bozsaky 2010). In this view, the oil crisis did not bring about new ideas but stimulated and was not a turning point, but accelerated the development of existing ideas.

CONCLUSION. ADDING TOT THE KNOWLEDGE ON POST-WAR INSULATION

As stated in the Introduction to *Twentieth-Century Building Materials*, published by the Getty Conservation Institute, "a country's use and development of building materials is a historic and cultural characteristic as distinctive as any other" (Tomlan, 2014). 36 materials are treated in this work of reference, yet thermal insulation is scarcely studied. Is thermal insulation not one of the historic and cultural characteristics of post-war society? Or should it not be taken into account in a conservation strategy? Looking into the performance of post-war thermal insulation today, admittedly its pure technical value is almost completely obsolete. In a time when 20 cm insulation is no exception in nearly-zero-energy buildings, building physicists hardly take into account the (remaining) value of the thin post-war glass fiber blankets or wood fiber-cement boards. Even for architects with an interest in heritage, the conservation of post-war insulation materials is all but evident, as the book by the Getty Conservation Institute illustrates. Is this because post-war architecture in general is not always highly appreciated? Or, if visual authenticity is the main concern in heritage strategies, is insulation irrelevant because often invisible?

As indicated in this paper, the historical significance of post-war insulation extends the purely technical performance. From a construction history point of view, it is interesting to comprehend the variety of systems and products in relation to the general technical progress of the building industry. Yet the history of insulation also reflects other aspects of the built environment. For instance there is a close relationship between the economic wax and wanes of the 20th century and the simultaneous periodic thickening and thinning of the building envelope (Koolhaas 2014). Thermal insulation is also linked to the scientific and industrial development of the chemical sector. If looked at closely, thermal insulation can tell us something about politics (to what extent does the government control the building practice?), environmental issues (e.g. in relation to the oil crisis), socio-economic concerns (reduction of heating costs), without forgetting evolutions in architectural style (increase of glass surfaces) and the professionalization of the construction industry (with new organizations and professions).

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