Embodied energy: historic buildings enjoy an advantage

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Historic buildings make a valuable contribution to climate protection

High-quality *Baukultur* creates buildings that are both durable and form a basis for future generations to achieve a more far-reaching social and economic development.[1] A long life expectancy entails a sustainable use of resources and allows embodied energy to be apportioned in an economical manner for the benefit of our climate. Historic buildings display the wealth of our architectural heritage in all European cultural landscapes. The climate crisis affects us all and the urgently needed energy transition will soon also prompt national lawmakers to act. Historic buildings are heavily affected by this as well. The experiences of the past few years in dealing with emotionally charged issues, such as *thermal renovation*, reveal that in many cases one does not do justice to the quality of historical structures.

Ten years ago, many people thought that if they opted for a diesel car, they were buying a clean vehicle. Since the diesel scandal, we know that the test set-up and electronic 'defeat device' delivered results that widely diverged from pollutant emission levels under real road operating conditions. We are faced with a similar dilemma when evaluating historical wall constructions and, above all, windows. What is decisive here is the calculation of the energy requirement over the entire life cycle, taking into account all climate-relevant energy factors: production; operational consumption; and recycling. On the other side of the fence, massive industrial interests seek to convince the public, and also lawmakers, that the construction systems they offer would reduce energy consumption. At the same time, pressure is piled up on historic buildings, inasmuch as it is suggested that the historic building stock is in great need of renovation and that these new types of construction systems would constitute suitable solutions.

The objective is the long-term survival of genuine historic buildings. This building stock is far more substantial than the relatively small proportion of buildings listed under the Austrian building preservation act. In order to achieve this objective, it is of great importance to prove, with the aid of studies, that historical built structures usually provide a very pleasant indoor climate and, owing to their structural features, may also display some advantages in terms of thermal building physics.

CO_2 pollution caused by the production of hydraulic cement

"Eight per cent of global greenhouse gas emissions can be traced back to cement production – which is more than global air traffic. If the annual cement industry were a country, it would emit as much CO_2 into the atmosphere as all of India",[2] an Austrian daily newspaper reported. It will certainly not be long before certificates must be issued for CO_2 pollution resulting from the production of building materials. This will have a considerable impact on the planning, construction and evaluation of built structures.

Cement and aggregates (such as gravel and sand) are the ingredients with which concrete is made. Every single year, approximately four billion tons of cement are produced and processed worldwide. In particular, emerging countries such as China, India and Brazil need millions of tons of cement for their infrastructure projects, such as dams, skyscrapers or airports. Demand in these countries has exploded since the turn of the millennium and even during the COVID-19 crisis demand did not collapse completely. In many countries, multi-story residential structures feature a massive use of reinforced concrete. Reinforced concrete is concrete strengthened by steel inlays and can thus be used in a versatile and highly resilient manner. The industry and people looking for accommodation, as well as building regulations, are all geared to this construction method. This construction method requires a lot of energy. This means that a great deal of 'embodied energy' is captured in these buildings.

Life-cycle costs are critical

Concrete is thus the defining material. The low cost of concrete structures is unbeatable under the current framework conditions. The entire construction industry is configured for this and offers system solutions for wall construction; these involve so-called external thermal insulation composite systems, highly-sealed windows, and room ventilation systems. These are optimised construction systems, whereby 'optimised' means that their properties in terms of structural engineering and structural physics match current requirements and, in many cases, even outstrip them. An essential point as regards such structures is that all parameters are fixed and poured into concrete at the time of construction itself: room size, the layout of windows and doors, and the positioning of shafts. Everything in connection with this hard shell is rigid and fixed – indeed, made of reinforced concrete. Later changes are not even considered. Generally-speaking, today when we look at 'construction costs', the focus is usually on investment costs for erecting a given property. These are the costs that are incurred to erect a building. The life-cycle costs of a house, however, also include its maintenance costs, management costs and the expected demolition costs. The expected useful life of a building is also quite decisive. For it makes a considerable difference whether it can be assumed that the construction costs will be spread over a utilisation period of one hundred years or only over fifty years.

Synthetic renovation and its limited useful life

Which components will have to be replaced during the life cycle? Today, in many cases, the issue of the durability of components is hardly considered. Synthetic building materials have only been in use for a few decades. Therefore, it is not possible to make an assessment of their durability or condition after a time span of one hundred years. As far as plastic window frame constructions are concerned, we know that chemical processes lead to so-called plasticisers starting to leach after only a few years, which results in the embrittlement of synthetic profile systems, subsequently leading to breakage. The advantage of contemporary wood or aluminium window frame constructions is that they only have a very low fracture behaviour. That being said, many complex and factory-made fitting parts are used in all of these constructions. Once the warranty period has expired, hardly any spare parts are available. This makes repairs practically impossible. The lack of repairability limits economic life to a few decades. As regards glazing, it usually consists of gas-filled insulating glass elements, the heat transfer resistance of which depends on the airtightness of the glass element. Only very limited long-term experience is available for these constructions, since they too have only been in use for about fifty years. The manufacturer's guarantees for certain U-values (thermal transmittance) are limited in time to approximately five to ten years. The extent to which these nominal values are undershot after twenty or thirty years would be the subject of material investigations yet to be conducted.

Thermal renovation: a potential structural damage trap

There is also a lack of long-term experience with regard to façade insulation based on thermal insulation composite systems using synthetic insulation materials, such as are used not only in new buildings but, above all, in the course of *thermal renovations.* Poor surfaces or planning and processing errors very often cause structural damage, which can provoke the growth of either moss or mould. This, in turn, can lead to health problems for occupants and require structural damage repair, which is associated with high costs in terms of time and money. For the damage remediation of structures using synthetic building materials generates high recycling costs owing to the hazardous-substance properties of such materials. All of the factors described above are cost drivers both in regard to running maintenance and the renovation of problematic structures such as those that are widely built today. The longer the observation and time frame of a building's life cycle, the more striking this is. Thus, taking responsibility for our climate means using resources sparingly and ensuring that building materials and structures are not fraught with problems, and will not become tomorrow's hazardous waste. Until now, it is also true that in the construction sector many clients have opted for the cheapest purchase price and paid little attention to follow-up costs and environmental impacts. Structures made of brick, lime mortar and timber have been trusted for many centuries and have proven themselves over this long period of time. For these reasons, such structures essentially have not changed over a long period of time.

… also flexible in the future

Modern built structures that rely heavily on synthetic materials cannot provide any evidence of their reliability. Relevant experience only goes back a few decades. During this observation period, however, it has been acknowledged that many construction components had a life expectancy of around thirty years. After that, replacement is necessary, which triggers costs flowing into the cost analysis of a building's life-cycle costs and also constitute an additional burden. Today, in many cases, it is difficult to predict from an economic point of view the management or renovation costs that can be expected if contemporary buildings are to fulfil a life expectancy of a hundred years or more. We can only anticipate the requirements of future generations of users to a very limited extent. Which inventions will change our lives? What will the world of work look like in forty years? Will the number of single person households continue to rise?

It is inherent in human nature to rarely think about periods of time that exceed one's own lifetime. Yet, like other historic buildings, houses from the late nineteenth-century *Gründerzeit* period are something suitable for many generations – this applies to both constructive and functional aspects. If one looks at the construction of historic buildings, one can easily see that in practice they are not made of concrete at all – and if they do, then it usually only involves structural changes that were carried out in the past few decades and might prove detrimental in the longer term.

The solid bricks of ancient buildings were mostly grouted with lime mortar and their walls were plastered with the same material. Only façade ornaments often made use of 'Portland cement'. At the same time, historic buildings can react to structural changes in a flexible way and can be adapted to changed requirements. Therefore, this type of structure is suitable for a long life expectancy and – under good maintenance – displays good energy values, so that a comprehensive thermal renovation is often not necessary at all. If we look at the façades of historic buildings, we can see that they have often remained practically unchanged for over a 100 years, a 150 years, or even longer. Their embodied energy can therefore be spread over a very long period of time and this factor gives historic buildings a very favourable total value. This is a benefit for our climate. Climate protection is a politically and emotionally supercharged topic. Hence it is particularly important in this context to distinguish between facts and 'beliefs'.

1 *Davos Declaration* 2018, p. 11, Article 13.
2 www.derstandard.at/story/2000102411187/boeser-beton-warum-zement-der-geheime-klimakiller-ist (accessed 06.09.2020).

Abstract

Les bâtiments historiques apportent une contribution précieuse à la protection climatique

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Les bâtiments historiques soulignent la richesse de notre patrimoine bâti au sein de l'ensemble des paysages culturels européens. La crise climatique nous menace tous et le tournant énergétique inéluctable incitera bientôt tous les législateurs à agir. Les bâtiments historiques sont touchés dans une large mesure par cette démarche. Les expériences de ces dernières années sur la manière d'aborder des thématiques sensibles tels que l'assainissement thermique révèlent que l'on ne réussit souvent pas à valoriser les atouts des constructions historiques.

Il y a de cela une décennie, nombre de personnes estimaient que, en achetant une voiture dotée d'un moteur diesel, elles utilisaient un véhicule propre. Depuis, nous savons que les installations de contrôle et la programmation des microprocesseurs fournissent des résultats qui s'écartent fortement des émissions de polluants dans la pratique quotidienne. Nous nous trouvons confrontés au même dilemme dans le cadre de l'évaluation thermique des murs et, avant tout, de la composition des fenêtres. Le point crucial réside dans le calcul des besoins énergétiques au cours de la totalité de leur cycle de vie, en tenant compte de l'ensemble des facteurs énergétiques liés au climat local, incluant la fabrication, les besoins caloriques courants et le recyclage.

Des procédés de fabrication novateurs ont été développés par l'industrie. Dès lors, la population et le législateur doivent être convaincus que ces nouveaux systèmes réduisent les besoins énergétiques des bâtiments. En parallèle, la pression que subissent les bâtiments historiques est renforcée du fait que l'on suggère que ces derniers exigeraient un degré de réhabilitation important et que ces nouveaux systèmes constructifs constitueraient des solutions appropriées.

En règle générale, de nos jours, la prise en compte du « coût de construction » se focalise avant tout sur l'investissement lié à la réalisation. Or, le cycle de vie d'une maison englobe également les coûts d'entretien et de gestion, sans compter ceux de la déconstruction ultime. Un autre critère décisif est celui de l'évaluation de la durée d'utilisation d'un bâtiment.

L'énergie grise peut dès lors être répartie sur une longue période, ce qui fait que les bâtiments historiques bénéficient d'un coefficient global très favorable. Cela exerce un effet positif sur notre climat, qui représente un sujet politique et émotionnel sensible. Il est dès lors primordial de faire la différence entre faits et « croyances ».