Durable past – sustainable future

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A durable and sustainable recent intervention on an existing building, arch. Braaksma & Roos (Gemeentemuseum, The Hague, The Netherlands) / *photo: A.Veldt*

Preface

It is a great pleasure and honour to contribute to this interesting publication on durability and sustainability of heritage buildings.

Being the director of the Gemeentemuseum in The Hague, an outstanding and unique heritage building, I am familiar with the always-present tension between future needs and historical value. The Gemeentemuseum is a masterpiece of Berlage, where everything is of high monumental value: the structure of the building, the bricks and stones, the tiles, the decoration, and even the furniture. However, we are a contemporary museum, which means that we need to meet standards in art conservation, crowd control and develop suitable presentation techniques. We respect the monument, want to keep the spirit of Berlage alive and at the same time need to evolve and stay up-to-date as a modern museum.

Heritage offers us a great potential for the future. In the cultural biography of our heritage buildings we can find the means to deal with the demands on continuity and change. This offers a solid foundation for a sustainable approach. We need good architects, researchers as a matter of fact, possessing the appropriate skills and attitude to deal with the complexity of the existing and its values. At Delft University of Technology, education and research on heritage and architecture have become a major issue. This publication contributes to the fundamental subjects of durability and sustainability.

It is a courageous effort to broaden the significance of sustainability to embrace more than just energy performance. The book is an invitation for the new generations of architects to reflect upon the importance of the existing and the necessity of well-considered interventions. The Rondeltappe Foundation from the city of The Hague is the founding father of the initiative to produce five publications on heritage and architecture, of which this is the first one. A book for educational purposes, dealing with both theory and practice.

I hope that all readers will find inspiration for good practice, and in a broader perspective, I hope that this book will contribute to a better knowledge-base for the transformation of our built environment.

Benno Tempel
Director Gemeentemuseum The Hague

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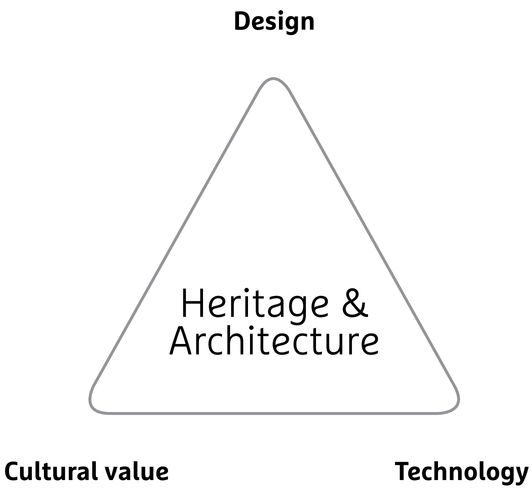
Introduction

The section *Heritage & Architecture* of the Faculty of Architecture at Delft University of Technology deals with the built environment in terms of conservation, refurbishment and re-use. Reflecting the department philosophy, this book focuses on the durability and sustainability of existing buildings (heritage in a broad sense, from historic buildings to listed monuments), considered in terms of material and building techniques, form and function, and part of the wider context of sites and cities. At the basis stands the Heritage triangle: Design – Cultural value – Technology.

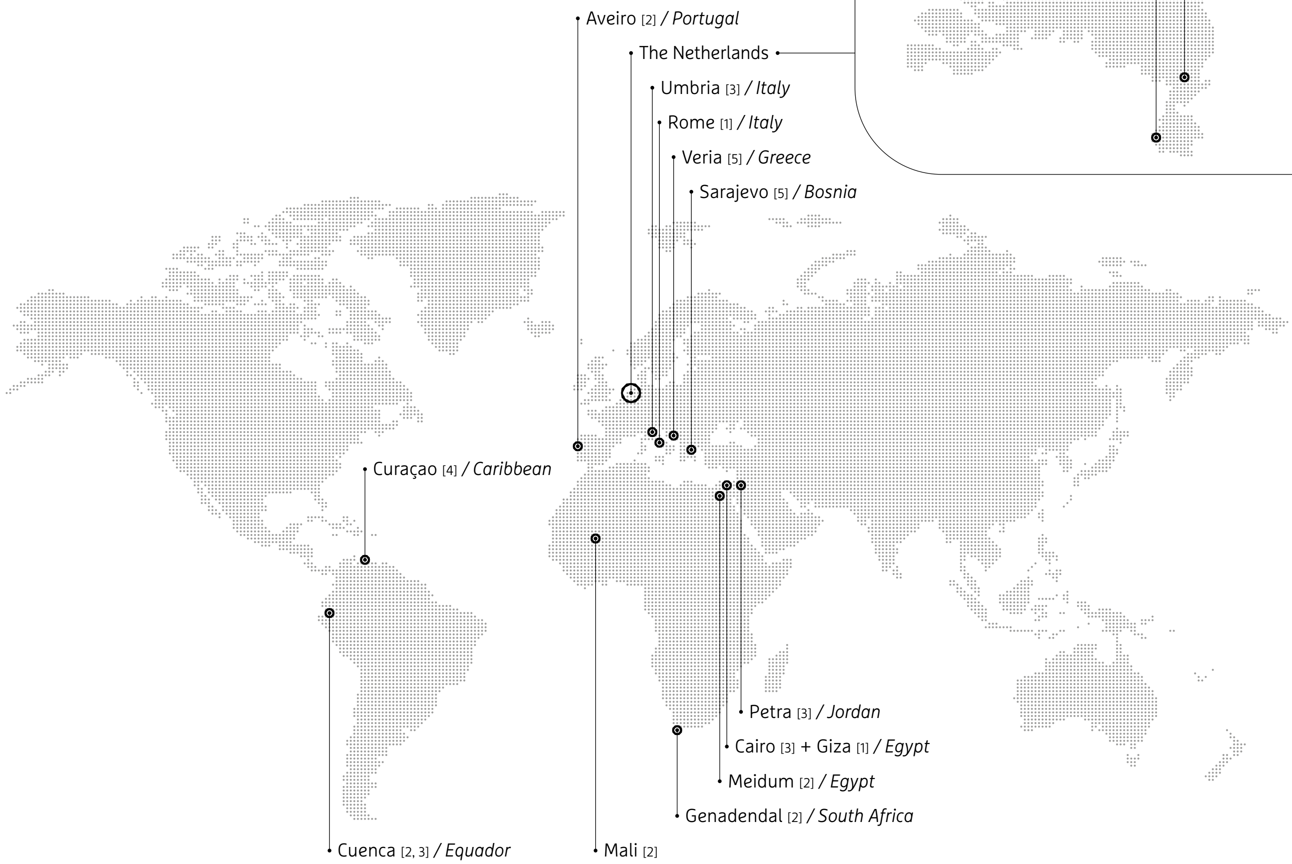


Understanding and preserving historic buildings, that is to say the memory of our past, a continuity is sought between past and present, directing the interventions for the future.

This book is meant for MSc education, but may be of interest for architects in general. It aims to inspire and challenge creativeness by showing examples from different parts of the world, most of which have been selected on the basis of the personal experience of the authors. It is not meant to be prescriptive, but to raise awareness of the importance of past building traditions and the perception of character and value of our built heritage. It is intended to encourage a conscious approach to the building from the level of the materials and their service life to that of the whole construction and its context.

Durable past – sustainable future

1 – Durable and sustainable constructions
2 – Adobe: clay as a sustainable and durable building material
3 – Learning from vernacular constructions: dealing with earthquakes
4 – Vernacular architecture and construction at Curaçao: integral design
5 – Sustainability and the city
6 – Conservation and re-use of monuments: the balance between Repair, Upgrade and Transformation
7 – Future developments



A glimpse of the literature on durability and sustainability shows how extensively these concepts have been discussed and how differently they have been interpreted and applied. The approach proposed in this contribution encourages a thorough study of the existing architecture, from mortars and bricks to complex constructions, from simple dwellings to industrial buildings, aiming at preserving its components and character, and all the same at achieving durability and sustainability. It is essential to know the past to entrust it to the future generations in a sustainable way [Hees v., 2004]: this is the mission of the department.

Nowadays, the architect should deal with the built heritage at all levels: realizing that an intervention in a building represents only a moment in its whole service life - even though it might have substantial consequences - will help define one's vision as an architect. Architects cannot be indifferent to the existing, which should become their primary source of inspiration.

It is clear that buildings evolve through time and that they can become complex and layered organisms. They contain a great variety of tangible and intangible information that can feed the design. Re-design of historic constructions should fit in a sustainable approach, and the definition of sustainable should be made broader, to meet the needs of a fruitful confrontation with our past. Sustainable thinking should nowadays not only include (embodied) energy and energy efficient use of buildings, but imply management as well, that is to say control over safety, health, efficiency, and an inspired re-use. Re-use plans should be centred on a sensitive appreciation of the value of the building and on its final user, man. The focus should be the life facilitated by the architecture, and the means used to host man and respond to the environmental challenges. Without that understanding a building remains a mere object consisting of materials that have been organized in a skilful way. Buildings and their sites need to be understood in terms of construction, use of materials, detailing and spatial qualities, but also as part of a social context implying interaction with the public space.

These elements are the source of the design, whereby the value of architecture emerges through all the involved matter. The interventions should enhance the potential of the materials and the techniques used. Analysing existing materials and techniques will be thus the first step to work on the durability and the sustainability of the building. The design (of the intervention) needs to limit waste and optimize the existing structure, considering its monumental value and striving for a well-balanced and environmentally well-considered plan.

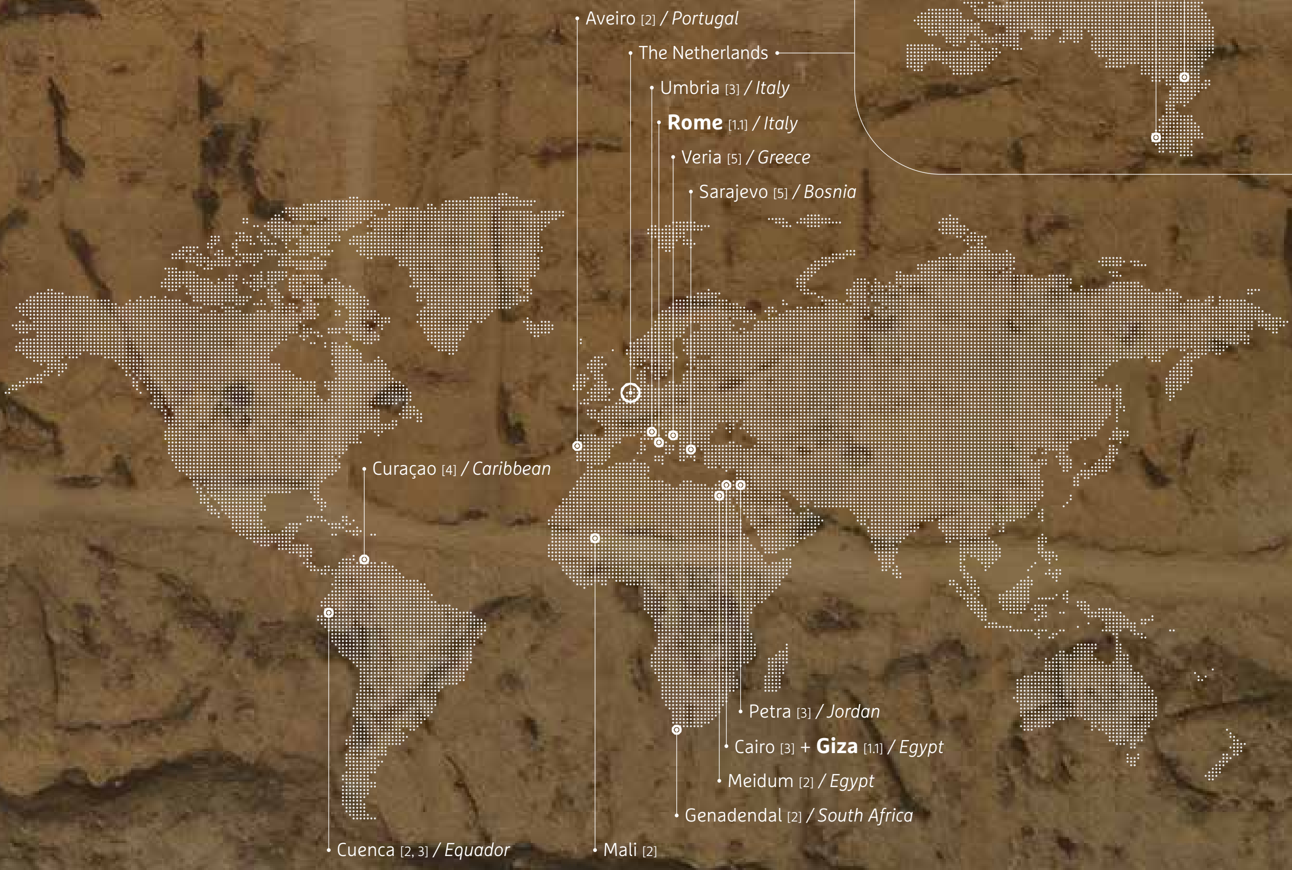
The architect's profile should also be redefined. Often the architect is merely an aesthetical director of the design, unable to cope with modern challenges, like energy saving and 'saving the planet' as a good place to live. In the past decades, the environment has often been neglected by constructing new buildings in existing cities, without any concern for the wanted quality. At present the (technological) answer to the question of sustainable development seems to be found. However, when handling with sustainability, insulation, solar-panels and passive housing are generally considered, and the focus is laid on quantitative and technological solutions, instead of on the development of a more fundamental approach, based on a thorough understanding of the potential of the construction[1].

In many cultures, in the past, sustainability used to be an integral concept, related with building traditions, crafts and daily life. With the increasing complexity of our society and the progressive shift from the local to the global scale, and, due to the (mis)belief that technology can solve (almost) everything, the past sustainable building tradition has often faded out, without being substituted by a new, equally effective one.
It is the architect who should let new values for sustainability emerge from the existing and match the modern demands.

1 At the beginning of the 1990s, when sustainability began to play a role in most Western countries, measurable/quantitative ambitions were required for several reasons, such as to make the advantages clear to stakeholders.

1 – Durable and sustainable constructions

1.1 – Durable past
1.2 – Approach on durability and sustainability for designers
1.3 – Vernacular constructions



1 – Durable and sustainable constructions

The pyramids in Egypt were erected for eternity: they were the symbol of the pharaoh crossing the border towards a timeless life. An everlasting service life might be considered as the ultimate form of durability and also in the preservation of our monuments one could try to strive for 'eternity'. In this context it is interesting to observe that the Cheops pyramid of Giza has turned out to be the longest surviving of the seven wonders of the ancient world.

1.1 – Durable past

When we compare the pyramid of ca. 4600 years of age with other monuments like the Pantheon in Rome (1900 years) or the Romanesque St. Servaas' basilica in Maastricht (900 to 1000 years), the last two may even appear rather young [FIG. 1.1, FIG. 1.2, FIG. 1.3, FIG. 1.4].

The service life of the monuments mentioned above is really amazing, when one realizes that the design service life for a civil construction like the tunnel under the Western Scheldt in the Netherlands was 100 years only!

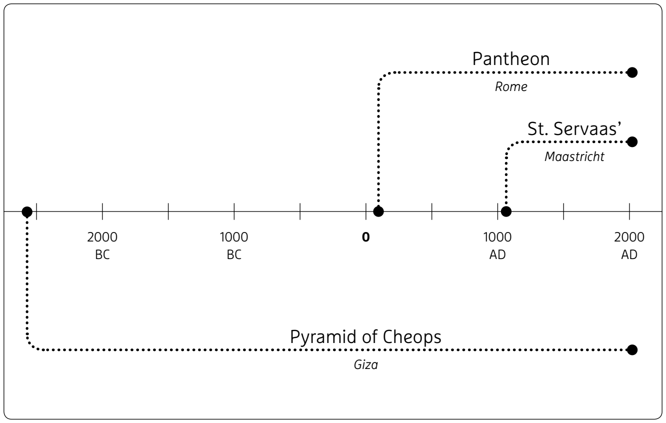


FIG. 1.1 Durability: two 'young' monuments (Pantheon of Rome and St. Servaas' of Maastricht) compared with one of the wonders of the ancient world

FIG. 1.2 Great (or Cheops) pyramid, Giza (Egypt) / *photo: R. v. Hees*

FIG. 1.3 Dome of the Pantheon, Rome (Italy) 2nd cent. A.D. / *photo: R. v. Hees*

FIG. 1.4 Apse of St. Servaas' basilica, Maastricht (The Netherlands), 11th cent. / *photo: R. v. Hees*

Definitions: 'Durable' and 'Sustainable'

It will be clear that some kind of relationship exists between durability and service life. But, what does *durable* mean? The word durable stands for *able to exist for a long time without significant deterioration*[1].
This is the classical definition of durable, which is thus for the components of building constructions - for materials and constructions - closely related to the concept of *service life*.

Especially since the energy crisis and the attempts to reduce CO2 emissions by the end of the 20th cent., another related term, *sustainability*, has very much been employed, either in a contrasting sense or in a complementary sense.

Sustainable means *relating to, or being a method of harvesting or using a resource so that the resource is not depleted or permanently damaged*[2]. The term sustainability is used in the sense of dealing in such a way with the needs of the present generation that the needs of future generations generations and people living in other parts of the world are not compromised. Sustainability has become a very important issue after the publishing of the UN Brundtland report 'Our Common Future' [Brundtland, 1987]. From this report comes the most often-quoted definition of sustainable development: 'development that meets the needs of the present without compromising the ability of future generations to meet their own needs'.

1 http://www.merriam-webster.com/dictionary/durable (accessed Dec. 2013)

2 http://www.merriam-webster.com/dictionary/sustainable (accessed Dec. 2013)

Many heritage buildings, apart from having a long service life, are sustainable as well [Ven, v. d. et al 2011] because they embody energy, gathered during their whole life cycle, from production and transport of building materials to construction and final destruction: the longer a building exists, the more sustainable it becomes from the materials and embodied energy point of view. For energy consumption, this may be less evident, as will be shown by some of the examples discussed in this book.
The concepts of energy consumption and resources should be further developed, to fit in our philosophy of intervention in the existing.
Existing buildings, as witnesses of the past, need to be preserved, even when they are given a new use: this is our starting point. Therefore, striving for the transformation of old architectures in green buildings according to accreditation systems like BREEAM or LEED[3] can not be our main aim, as too radical transformations will mean losing monumental value. However, the criteria indicated for the assessment of the sustainability, as well as other criteria, more related to monuments [cf. Nusselder et al. 2008], can be a source of inspiration for the architect.

The Council of the European Union recently[4] adopted quite important conclusions with respect to cultural heritage and sustainability:
'...cultural heritage consists of the resources inherited from the past ...It originates from the interaction between people and places through time and it is constantly evolving. These resources are of great value to society from a cultural, environmental, social and economical point of view and thus their sustainable management constitutes a strategic choice for the 21st century.'

In the case of vernacular architecture, the tradition guarantees durability and sustainability of the constructions, and therefore, any intervention on the existing needs to be done in line with the tradition; other constructions, and a good example is formed by old factories, will probably not possess the modern requirements to be called durable and sustainable. However, even when not matching the current requirements for green buildings, old structures are valuable historic reminders, and as such their re-use should be preferred above demolition and reconstruction according to the modern standards. Sustainable use of old buildings and monuments will lie in their flexibility and in the skilful adaptation of the existing features to modern needs. Historic buildings offer many potentials for a sustainable use in the future, but these potentials do not always fit into standardized solutions and assessment tools - they are not 'business as usual'.
The challenge for the designer is to reach the balance between historic significance of a building and future needs, and the added value that will emerge from it.

3 www.breeam.org; http://www.usgbc.org/leed

4 Conclusions on cultural heritage as a strategic resource for a sustainable Europe, Council of Europe, Council meeting Brussels, 20 May 2014

1.2 – Approach on durability and sustainability for designers

This book supports an integral approach to the re-use of heritage buildings, whereby the designer critically chooses intervention techniques and materials to ensure a sustainable future of the existing.
The idea was not to write the umpteenth book on sustainability and to just list examples of retrofitting and energy efficient interventions in existing buildings.
Offering inspiration is the main objective, as well as showing that one of the most interesting sources of inspiration can be found in buildings belonging to our past, as our heritage has always furnished interesting solutions to different sorts of problems. Furthermore it will be explained in what may consist the balance and sometimes the dilemma between durability and sustainability.

By diving into the past, an attempt was made into better understanding how *logical* both durability and sustainability can be and how close both are to functionality. This especially applies to several of the described situations in the past in which, notwithstanding scarcity of resources and materials, a vernacular architecture was created providing the perfect answer to environmental challenges and social requirements: an inspiring architecture.
It should always be kept in mind that durability and service life are very much related to the environmental context of the building, whereas sustainability is also strongly related to the social-economical context.

Some examples, resulting from vernacular construction and architecture in different parts of the world will first be described and discussed, as they provide inspiration for defining a view on durability and sustainability.
Also deficiencies in modern techniques and materials, sometimes used for maintenance and restoration of the vernacular architecture, will be discussed as they show how a limited view on durability may result in the opposite: a shorter service life and consequently less sustainability.
Vernacular architecture is based on local needs and materials. It reflects local traditions as well as the cultural and historical context it belongs to, which is characterized by certain social and environmental conditions: as a matter of fact we are talking about sustainable architecture 'avant la lettre' . Vernacular architecture is often considered to be little refined, which can be objected in many cases. Anyway, it can also be looked at as a very proper answer to given problems, and as such highly important as a source of inspiration for modern design.

Cases will be further handled with, focusing first on materials and masonry techniques to be preserved because of their intrinsic value, and finally on existing buildings to be re-used.
In modern times global advanced knowledge has to be tuned, in order to be applied to local and specific situations: this is a key to a sustainable approach in the design (of interventions).

Durability and sustainability also apply to towns and city districts in which the built environment presents a traditional character, or remind us of a certain historic period. The built heritage needs to be preserved and protected, as it embodies important cultural values, not only confined to the single buildings, but also concerning the relationship among them and involving the local landscape. Conservation of buildings and requalification of areas and cities will mean to finally achieve unity and upgrading of the quality of life of the inhabitants. As the ICOMOS Paris Declaration states, 'a development process [should be promoted] that incorporates tangible and intangible cultural heritage as a vital aspect of sustainability' [ICOMOS 2011].

A durable and sustainable approach towards conservation and transformation of urban landscapes will be discussed, whereby the significance lies in the built heritage and the final aim in the involvement of the inhabitants.

In the final chapter, 'lessons learned' will be handled with, that is to say the most important points emerged from the discussion will be referred to in order to outline the criteria supporting durable and sustainable interventions.

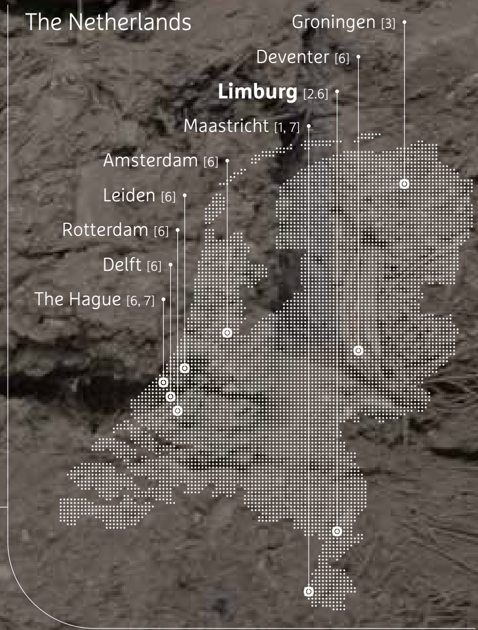
We will present different topics, introducing matters in general first, to go subsequently more into detail: the cases of the vernacular architecture at Curaçao and the re-use of the building of the Faculty of Architecture in Delft will make this line clear. From materials and problems of durability, the focus will be laid on damage due to wrong interventions and on new methods for repair, going sometimes as deep as describing some of the laboratory research necessary to solve the problems in a way, which is compatible with the historic fabric. When handling the problems of re-use and transformation of buildings, we will point at different measures to be taken to meet the need of the users, always trying to understand and respect the building, its character and historic value. Also here we will deepen the analysis to show solutions to problems of various nature, even though these solutions will not be necessarily 'tout court' exportable to other cases, as each case is different. Important is, however, to bear in mind the necessity of understanding the building, from the materials to the design, from the shell to the valuable details and to always decide on how to proceed in a well-considered way.

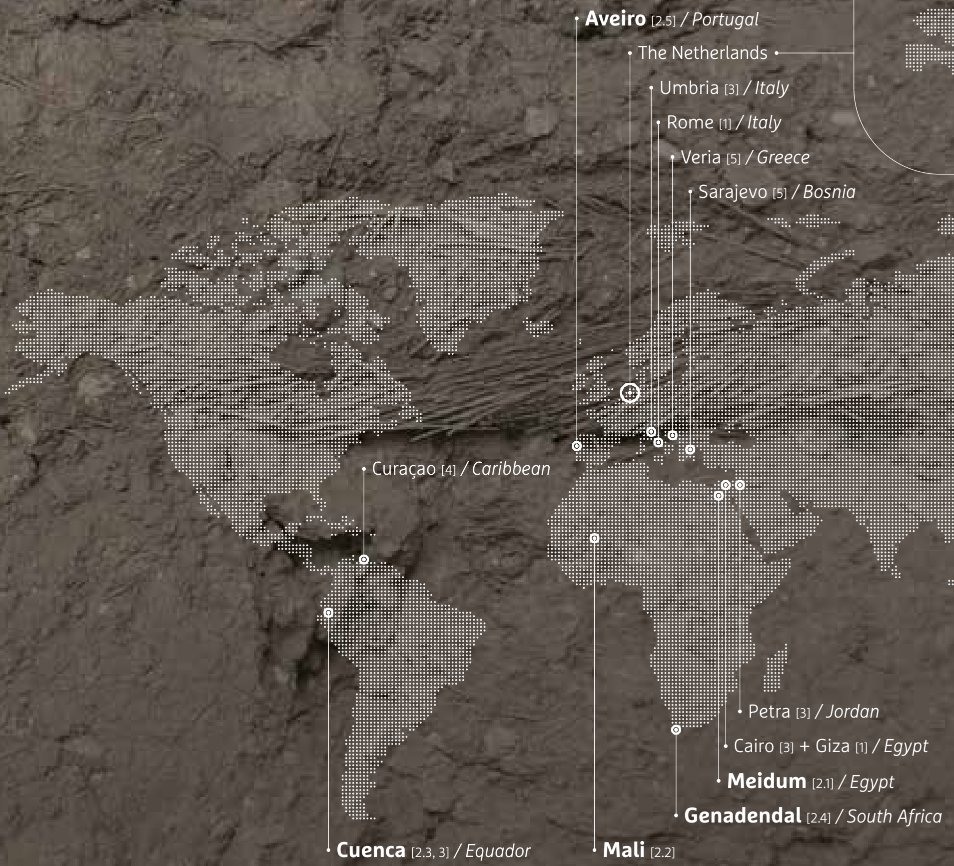
1.3 – Vernacular constructions

'Vernacular architecture', received this name by analogy with vernacular language, and in fact its relationship to the 'Western architecture' recalls the relationship between local language and national, or standard language. For a long time vernacular buildings were appreciated only for the ethnographical information they conveyed, and rather negatively defined as non-industrialized and non-western [Bourgeois et al., 1989]. The efforts of Bernard Rudofsky resulting in the 1960's in a book [Rudofsky, 1964] and an exhibition of pictures, *Architecture without architects*, were an eye opener also for the general public. The beautiful architectural unities or 'townscapes' shown were perceived as art, which led to a new definition of vernacular buildings as 'architecture', without any romantic association with concepts like *arcadia, natural and non–sophisticated*. New values were sought in vernacular architecture and eventually found, like geometrical subtle design, functionality, and beauty, maybe with a certain resentment against the ideal of 'purity' found in some strain of Modernism, entrusted to skeletal steel and glass and a sober aspect. Still, the reactions to Rudofsky's vision were originally not entirely positive, as the risk of an ethnocentric and thus partial approach was felt. In recent times, however, considering the neglected environmental demands in modern society, for example mud made buildings started to be perceived as a fantastic alternative, being non-industrial and free from our ideology of progress, and at the same time highly functional in responding to environmental and also social needs.

2 – Adobe: clay as a sustainable and durable building material

2.1 – General
2.2 – Mali
2.3 – Cuenca
2.4 – Genadendal
2.5 – Aveiro
2.6 – Adobe like materials: wattle and daub





2 – Adobe: clay as a sustainable and durable building material

Adobe (mud) is one of the most ancient building materials. Nowadays it has become quite popular again, in sustainable architecture, because it is easily renewable, the waste material is re-usable, with very limited employ of energy and has a natural source.

2.1 – General

The use of waste material is a recurrent practice over history; as an example the Gothic choir of the Utrecht Dom church can be pointed at, as it shows many stone blocks, originating from its Romanesque predecessor. The re-use of broken masonry waste materials in new concrete is another example. Also these kinds of re-use are in line with sustainable development. What makes adobe so attractive, however, is the very limited need of energy for demolishing an adobe construction and re-using the material.

To make adobe brick, sand, clay, straw and often animal excrements are mixed. After mixing, either the material is shaped by hand to form bricks (adobe bricks or green bricks) or moulds can be used. The resulting bricks are baked in the sun [FIG. 2.1].

FIG. 2.1 Fabrication of brick, Qasr in Daklah (Egypt) / *photo: D. Schultz*


FIG. 2.2 Mastaba, Meidum (Egypt) / *photo: D. Schulz*


FIG. 2.3 Mastaba, Meidum, adobe (Egypt), detail / *photo: D. Schulz*

Depending on the local environmental conditions adobe may even show a considerable service life, as is the case of the mastabas, the tombs of the Egyptian kings, from the times before the Old Kingdom; many of them are surviving after thousands of years [FIG. 2.2, FIG. 2.3].

It is interesting to notice that adobe is made by hand and baked in the sun, whereas modern materials like (fired) clay brick, concrete and steel are industrially made and fired or produced at much higher temperatures: they turn from soft to very hard and are perceived as cool and rigid materials whereas adobe even 'feels' softer and more natural. [Bourgeois et al., 1989, p. 43].
The adobe bricks are used to build structures, in which fresh adobe serves as mortar. Often a lime render is used as a protection of the surface against rainwater. Depending on the local situation and the groundwater table, a plinth consisting of cobblestone or rubble stone can be made, in order to avoid degradation due to rising damp and splash-up water. Sometimes, when the local earth possesses a too low binding capacity (very low amount of clay), an additional binder like lime is added to provide for enough cohesion in the material Examples from different parts of the world, ranging from Africa (Mali, South Africa) to South America (Ecuador), Portugal and even the Netherlands (the Southern part of the Province of Limburg) will be described.

2.2 – Mali

Mali is situated in the centre of the African continent. In Mali adobe has always been the traditional building material; adobe bricks are shaped by hand in a simple mould and then left to dry in the sun [FIG. 2.4]. Plain residential dwellings but also important public buildings like mosques were traditionally constructed in this material [FIG. 2.5]. Adobe walls are rendered with the same material adobe bricks are made of and need regular maintenance. The wooden beams protruding from the façade of the mosque and resulting in a quite expressive architecture [FIG. 2.5], fulfil a clear role in these maintenance activities: whenever substitution or repair of plaster is necessary, the plasterers will use the beams to sit upon during their work. This is a good example of early and natural integral approach to architecture, whereby the means of performing the foreseen maintenance are incorporated in the design and become thus a form of connection between the representative building and the local community.

FIG. 2.4 Production of adobe bricks ('green bricks') in Mali, Africa / *photo: L. Edelbroek*

FIG. 2.5 Adobe brick construction, rendered with adobe; the wooden beams protruding from the walls are used for maintenance activities (mosque in Mali, Africa) / *photo: L. Edelbroek*

FIG. 2.6 Crack patterns, like crazing, can easily occur in the adobe rendering of external walls (Mali, Africa) / *photo: L. Edelbroek*

Since Mali is a very large country, (with 1.2 million km^2 Mali is as large as Germany and France together), its climate differs considerably from north, to south[5]. The average temperature ranges from 24°C to 32°C. The North, being part of the Sahara desert, has a hot and dry climate, whereas in the subtropical southern part the climate is hot and humid. In the North the amount of rainfall is quite limited (<150mm[6] of rainwater per year), whereas in the South it reaches up to 10x as much (NB for the Netherlands the yearly average amount is ca. 750 mm).

In the very warm and dry period from November to May, the adobe plaster is due to undergo a strong drying shrinkage, resulting in the occurrence of crack patterns (crazing), which makes – as already explained – a regular maintenance most necessary [FIG. 2.6].

The here described situation is a good example of a sustainable construction tradition, which will have a future only when the maintenance tradition can be continued within a local cultural and economic system. As soon as one element in this balance changes, however, problems may occur.
The challenge for modern restoration would be to find more durable finishes that at the same time are compatible with the adobe substrate.
The challenge for modern society would be to find a way to maintain both the adobe buildings and the craftsmanship.

5 http://www.mapsofworld.com/mali/geography/climate.html (accessed April 2014)

6 1mm of rainfall exactly corresponds with 1 l/m^2

FIG. 2.7 Detail of window frame (casa Palomas, Cuenca, Ecuador) / *photo: R. v. Hees*

2.3 – Cuenca

In Cuenca, Ecuador, adobe was used as well. As the average amount of rainfall (ca. 900 mm per year) is quite high, and adobe is sensitive to erosion by rainwater, wall finishes were applied for protection: traditionally a lime wash or a thin lime based render was applied on the masonry to avoid the effects of rain water and the complete washing away of the material. The lime wash needs regular maintenance, which implies involvement and care of the inhabitants: this can be the Achilles' heel of adobe constructions.

In recent years, hoping to make maintenance easier, modern paints have been applied as well, which, however, in most cases do not perform adequately and are moreover difficult to be removed without damaging the substrate [FIG. 2.7, FIG. 2.8].

FIG. 2.8 Modern paint layer on an adobe wall construction (casa Palomas, Cuenca, Ecuador) / *photo: R. v. Hees*

Recent restorations in Cuenca

FIG. 2.9 clearly illustrates the sustainability of adobe: after the collapse of one of the wings of this building, the old pulverized material was gathered at the inner courtyard to be re-used after mixing and blending it with some new earth and water. This is a form of re-cycling. The collapsed wing will be thus completely re-erected, mainly making use of the original material.

Other than in comparable ways of re-using materials, like crushed masonry or concrete as aggregates for new concrete constructions, in case of adobe, almost no extra energy is necessary to produce the raw material again.

Maintenance and limited interventions

Also in the case of smaller interventions and repairs in existing buildings, whenever possible, part of the ancient material is re-used.
FIG. 2.10 shows how sometimes new materials are introduced in the construction, like a layer of brick masonry, however always acting in line with the tradition. The layer of brick masonry in this example, near horizontal surfaces like cornices that might collect rainwater, is used with the purpose of avoiding a quick decay of the adobe wall. Traditionally, rubble stone masonry is used at the ground level to minimize the effect of splash-up water and moisture from the soil [FIG. 2.11].

Renders need maintenance and are renewed with adobe prepared on the spot. [FIG. 2.11, FIG. 2.12, FIG. 2.13, FIG. 2.14].

FIG. 2.9 Use of adobe in a restoration in Cuenca. The old material of a collapsed wing of the building is collected for re-use (house in Cuenca, Ecuador) / *photo: R. v. Hees*

FIG. 2.12 Use of adobe for renders in a recent restoration (2010) (building in Cuenca, Ecuador) / *photo: R.v. Hees*

FIG. 2.10 A layer of brick masonry has been applied to better deal with the rainwater that can gather at the horizontal cornice (building in Cuenca, Ecuador) / *photo: R. v. Hees*

FIG. 2.11 Rubble stone masonry is used at the ground level to minimize the effect of splash-up (building in Cuenca, Ecuador) / *photo: R. v. Hees*

FIG. 2.13 Use of adobe for renders in a recent restoration (2010) (building in Cuenca, Ecuador) / *photo: R.v. Hees*

FIG. 2.14 Production of adobe for renders in a recent restoration (2010) (building in Cuenca, Ecuador) / *photo: R.v.Hees*

FIG. 2.15 Restoration works (house, Genadendal, South Africa) / *photo: L.Verhoef*

2.4 – Genadendal

In 1738 the first Moravian missionaries arrived at *Baviaanskloof,* (since 1808 renamed *Genadendal*), situated at ca.130 km from Capetown in the south-west part of South Africa. With the help of soldiers from the Dutch East Indies Company (VOC), they started the construction of a small house with a thatched roof, with walls most probably in adobe. Later on, the Missouri Warf and more dwellings were constructed, all of them in adobe. The historical houses, which can be found nowadays in Genadendal are mainly dating from the 19th cent., but all the same reflect the construction style of the beginning of the settlement, with their adobe walls and thatched roof constructions.

A restoration campaign undertaken at the beginning of the 21th cent. was carried out trying to preserve as much as possible the original materials and construction techniques of the traditional buildings [Du Preez et al 2009] [FIG. 2.15].
The whole project was community driven and meant to restore the pride of the inhabitants (90% of them are unemployed), and their awareness of the social and cultural identity of the place. To them, the whole responsibility was entrusted of maintaining the buildings after restoration.
The success of this operation was strongly connected with the attitude of the inhabitants towards their past and with the creation of the perspective of better economic circumstances. The awareness of the value of their traditions and heritage is a significant stepping stone for the people. This approach is an important prerequisite aiming at making all technical efforts put into the assignment successful and the whole project sustainable.

FIG. 2.16 Lack of maintenance (dwelling, Genadendal, South Africa) / *photo: L.Verhoef*

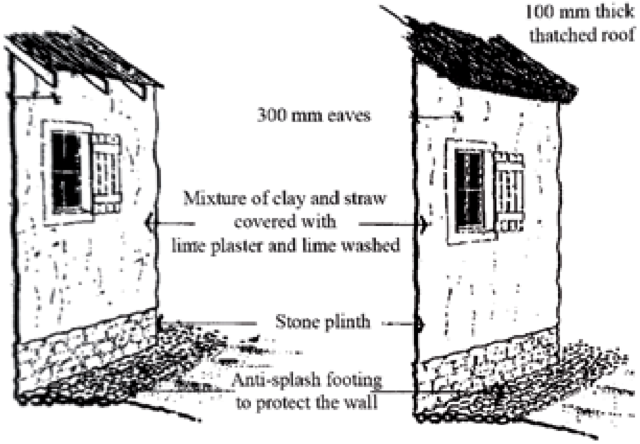


FIG. 2.17 Drawing showing the construction method and the materials used in Genadendal (South Africa) [Du Preez et al., 2009, p. 92]

The technical part of the project consisted in a careful implementation of new materials and construction elements where the traditional ones had suffered from severe deterioration caused by the natural environment and lack of maintenance [FIG. 2.16]. The weak soil had been the origin of settlement cracks, and large floods, made more severe by the location, surrounded by hills, had led to moisture related decay at the lower parts of the walls.

Protection of the adobe masonry against rainwater was achieved by the use of lime-based renders, as well as by the construction of a cobblestone plinth [FIG. 2.17]. Further, an improved drainage system allowed the buildings to better withstand the water flowing from the surrounding hills.

It is important to observe that the restoration of the adobe construction was part of an integral project that also included the upgrading of the houses by adding sanitary rooms on the backside, and adapting them to modern standards. Although this well-considered restoration campaign allowed the preservation of past building traditions, and, at the same time, made the masonry more durable and the houses more comfortable, a *sustainable future* for Genadendal will only be possible if a continuous active involvement of the inhabitants is achieved.

FIG. 2.19 Façades constructed in local adobe, finished with a lime render and decorated (houses, Aveiro, Portugal) / *photo: R.v.Hees*

FIG. 2.18 Detail of façade constructed in local adobe and finished with a lime render (houses, Aveiro, Portugal) / *photo: R.v.Hees*

2.5 – Aveiro

In the historic town of Aveiro, Portugal, the use of adobe was common until the mid-20th cent.. Many buildings in the historic city centre have been constructed in a special type of adobe, already mentioned in the introduction: the earth around Aveiro being very poor in clay was mixed with lime and water. This makes the local adobe very much similar to a mortar, be it that no special attention is paid to grain sizes etc. and that the mix is used to compose bricks in a mould, following the typical way of production of adobe bricks.
The walls are finished with a lime render, which can be smooth and simple or beautifully decorated [FIG. 2.18, FIG. 2.19].

The example of Aveiro shows that the quality of adobe could be improved in a relatively simple way, with the help of lime, in order to make it more durable and also how the lime render finish allows different architectural expressions.

FIG. 2.20 The timber frame buildings originally had an infill of wattle and daub on a wooden lattice (house, south of Limburg, The Netherlands) / *photo: R. v. Hees*

FIG. 2.21 Wattle and daub on a wooden lattice (house, south of Limburg, The Netherlands) / *photo: R. v. Hees*

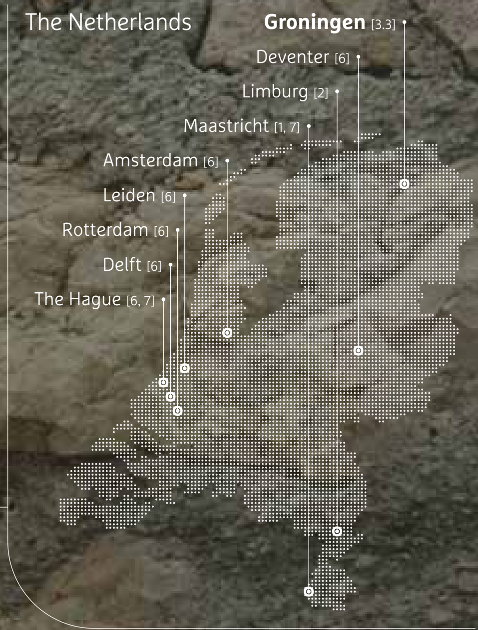
2.6 – Adobe like materials: wattle and daub

A more or less adobe like material is used as a kind of infill in the squares or panels of timber frame buildings, which are to be found in many parts of Europe, including the UK, the German Eifel and the Dutch province of Limburg. The infill is traditionally called *wattle and daub*. In this type of construction, a woven wooden lattice (branches of trees: thin branches -either whole, or more usually split- or slats between upright stakes) is daubed with a mortar, traditionally consisting of clay, sand and animal excrements [FIG. 2.20].

Next to the naturally available clay, sometimes (in the absence of enough clay in the earth) lime is used as a binder (cf. the adobe used in Aveiro), and aggregates include sand or crushed stone or limestone dust, whereas straw, hair or hay can be used as a reinforcement and to avoid too much shrinkage [Bankart, 2002].

The last example shows the use of a similar raw material (earth / adobe) within a different local tradition (the use of timber frames); the careful way of using the scarce, local resources is however quite comparable [FIG. 2.21].

3 – Learning from vernacular constructions: dealing with earthquakes



3 – Learning from vernacular constructions: dealing with earthquakes

Earthquakes may result in very severe damage to historic building constructions. Especially in solid masonry and rubble-stone walls, generally without so-called ‘through stones’. In those cases damage patterns like diagonal cracks or the collapse of the central parts of relatively slender walls often occur.

3.1 – General

At a first sight it may appear logical to *reinforce* vulnerable buildings after an earthquake, however it is only possible to follow this philosophy up to a certain extent. Using the *knowledge gained from experience*, people living in earthquake regions have often tried to adapt their constructions to the circumstances, and have often been quite successful. Generally speaking, better earthquake resistance is obtained by making the structure more ductile rather than making it stiffer. In this way it turns out to be possible to have no damage or at least less damage in case of earthquakes (cf. further the case of Veria).

Hence, a special challenge is posed when monuments and historic buildings in earthquake regions have to be restored. Being existing (old) buildings, an adaptation to modern earthquake standards is generally not possible; the intervention techniques to repair earthquakes damage [FIG. 3.1, FIG. 3.2] and to mitigate the envisaged effects of earthquakes to come, should be very well considered. In fact, available techniques need often to be adapted to the special needs of old buildings.

FIG. 3.1 Typical earthquake damage pattern: diagonal cracks in two different directions and X shaped cracks (house, Umbria, Italy) / *photo: R. v. Hees*

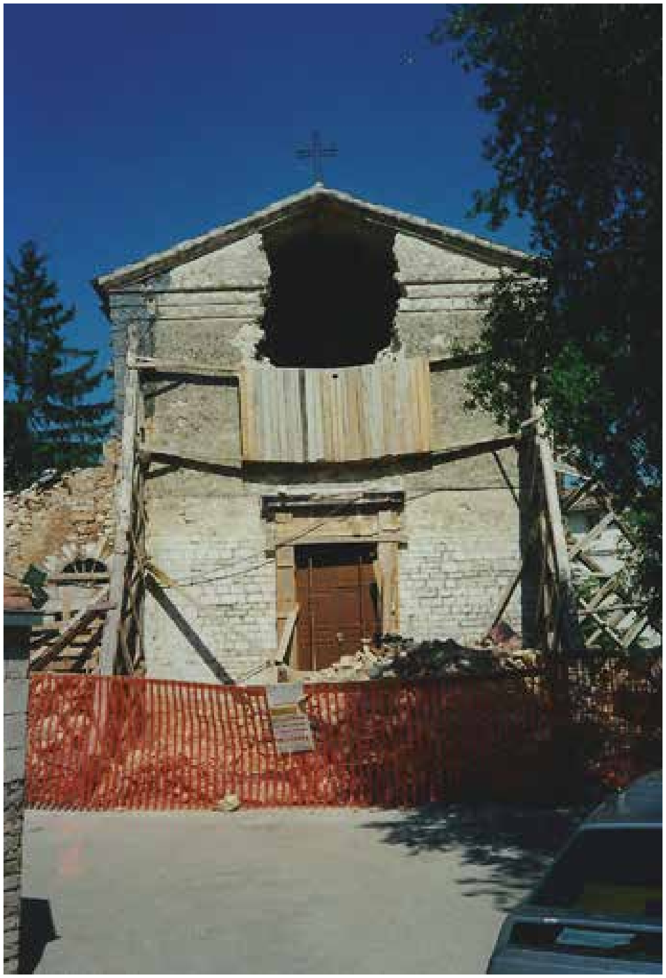


FIG. 3.2 Collapse of the central part of a slender wall (house, Umbria, Italy) / *photo: R. v. Hees*

As a matter of facts, mistakes have been made even in relatively recent times (for example in Umbria, Italian region, after the earthquakes of the 1990's, as will be described further on), by trying to introduce strong and stiff constructions or construction parts in ancient buildings, with the intention to make them better earthquake resistant.

Interventions more in line with the building tradition in these cases can contribute to a longer service life of historic constructions and iconsequently also to sustainability.

3.2 – Umbria

In the 1997, an earthquake in Umbria (italy), the magnitude of the foreshock was 5.8 on the Richter scale, which already caused damages. The main shock, however, occurring ca. 9 hours later, had a magnitude of 6.1 and was much more destructive, even causing the death of 9 people. Most dramatic was the death of two persons who were inspecting the damage caused by the foreshock to San Francesco's Basilica of Assisi.

Some of the severely damaged buildings suffered the consequences of 'anti-seismic' interventions with non-compatible materials and construction parts. An example of this approach is the concrete roof of a historic building, which had been added as an anti-seismic measure, but turned out to enhance risk dramatically, during the next earthquake, when it even caused the collapse of the whole third floor [FIG. 3.3].

The collapse was due to the fact that the roof construction was far too stiff in relation with the relatively weak historic masonry wall construction. Instead of the new roof being an effective kind of confinement of the walls, as it had been assumed, it led to their failure.

FIG. 3.3 Earthquake damage. The very stiff concrete roof structure of the historic building was the main responsible factor for the complete collapse of the third floor (house, Umbria, Italy) / *photo: R. v. Hees*

FIG. 3.4 Minaret damaged after earthquake (Al Faqahani mosque, Cairo, Egypt) / *photo: R. v. Hees*

3.3 – Similar solutions in different earthquake regions

Cairo

The city of Cairo (Egypt) is situated in an earthquake zone. The 1992 Cairo earthquake had its epicentre near Dahshur, a royal necropolis, situated at the west bank of the Nile, ca. 35 km south of Cairo and a magnitude of 5.8 on the Richter scale. Although this value is not extremely high, the earthquake was unusually destructive. It caused about 545 deaths and made 50000 people lose their home. For Cairo, this was the most damaging seismic event since 1847[7].
Some examples of structures suffering from earthquake damage, are the minaret of Al Faqahani mosque [FIG. 3.4, FIG. 3.5] and the nearby sabil, a historic public drinking fountain [FIG. 3.6].

Ancient structures, like some Coptic buildings in Cairo have been constructed in a way as to better deal with this type of sudden event, relying on the ductility that can be achieved in a masonry structure by the insertion of timber elements [FIG. 3.7].

To be noticed is also the timber beam supporting the arches of a Coptic church, which contributes to increase the ductility of the structure [FIG. 3.8].

These buildings could withstand the earthquake and the method used should be kept in mind when planning interventions in seismic areas.

7 http://en.wikipedia.org/wiki/1992_Cairo_earthquake (accessed Sept 2013)

FIG. 3.5 Diagonal cracks in different directions, visible after the 1992 earthquake (minaret, Al Faqahani mosque, Cairo, Egypt) / *photo: R. v. Hees*

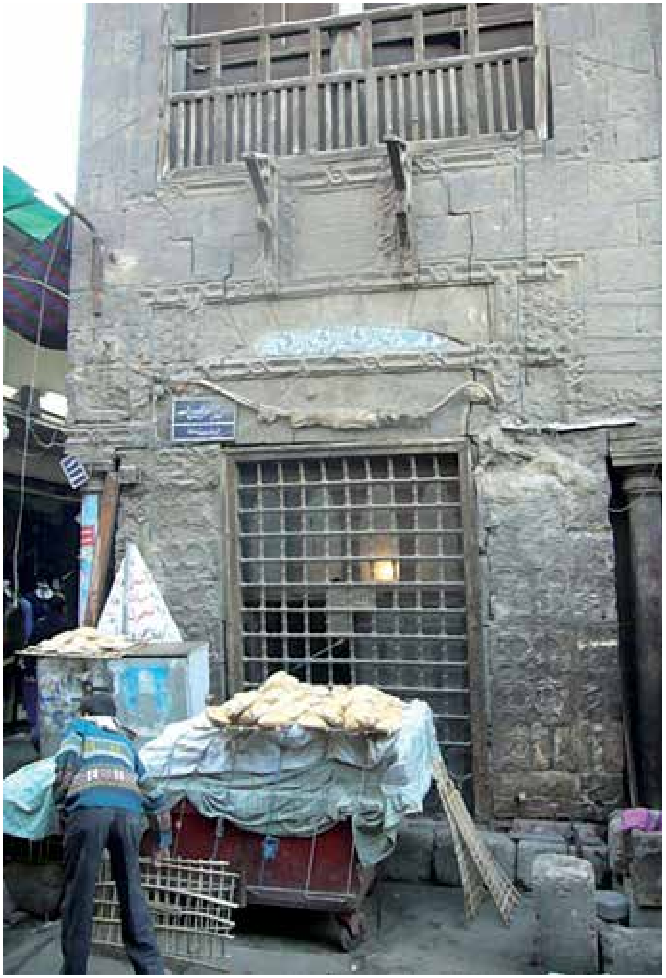


FIG. 3.6 Damage due to seismic activity (former sabil building, public drinking fountain, near Al Faqahani mosque, Cairo, Egypt) / *photo: R. v. Hees*

FIG. 3.7 Combination of brick and timber layers in the lower part of masonry walls (building, Coptic quarter, Cairo, Egypt) / *photo: R. v. Hees*

FIG. 3.8 Timber beam supporting the arches and contributing to the ductility of the structure (Coptic church, Cairo, Egypt) / *photo: R. v. Hees*

FIG. 3.9 Bamboo ready to be used as a ductile reinforcement in adobe walls (school building, Cuenca, Ecuador) / *photo: R. v. Hees*

Cuenca

The principle based on the ductility of materials can be found back in solutions applied in constructions all over the world. In the 2009 restoration of a historic school building in Cuenca (Ecuador) one of the intervention measures consisted of the introduction of bamboo as a ductile corner reinforcement of the adobe wall constructions [FIG. 3.9].

Petra

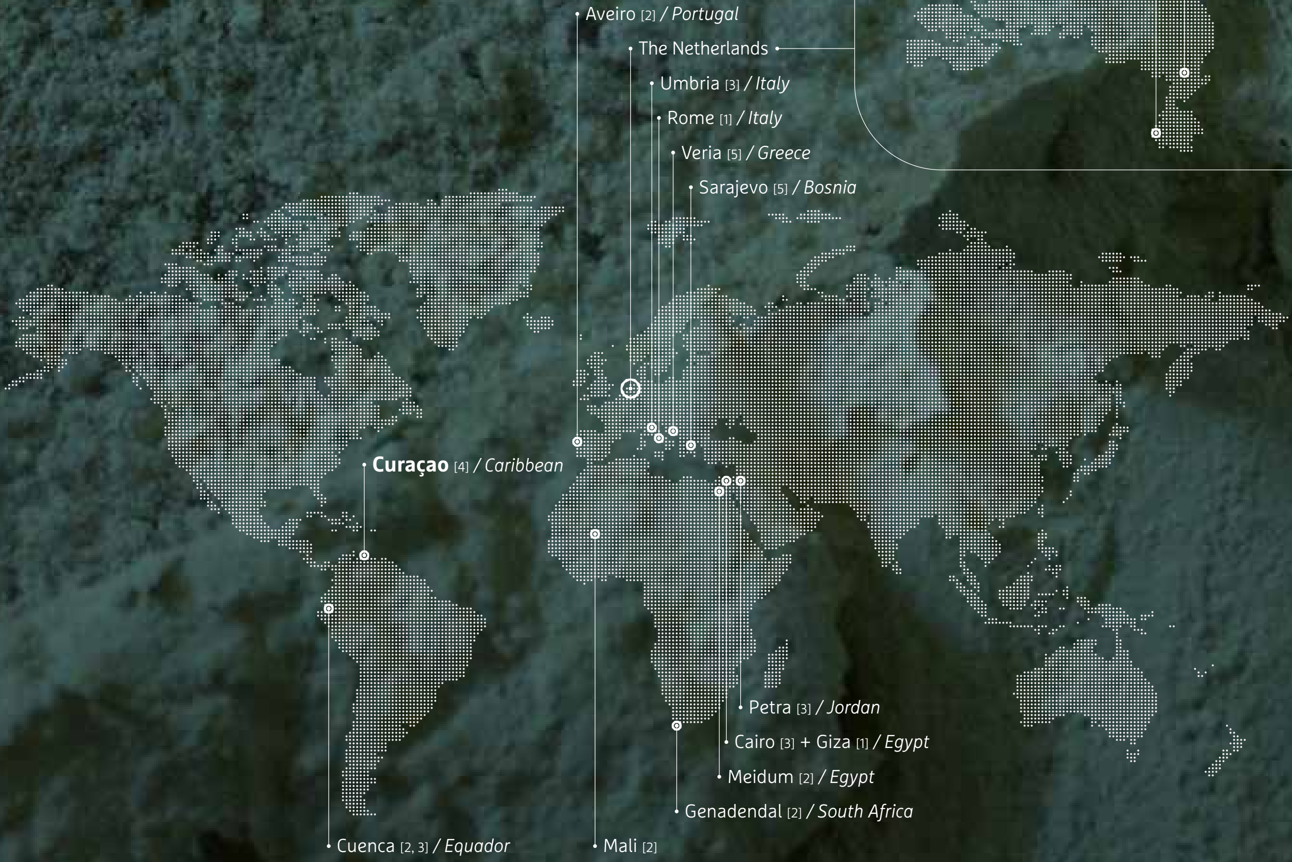
What is described above for Cairo and Cuenca, was supported by a recent study [Rababeh et al., 2014] carried out on historic buildings in Petra (Jordan). This study showed that structures with embedded wooden strings better resist earthquakes, than structures without wooden strings, as they possess a higher level of energy dissipation, which helps to avoid collapse.
The Qasr el-Bint temple in Petra, dating from ca. 30 BC, was built in sandstone blocks and is one of the locally best-preserved monuments: like the Coptic buildings in Cairo, it shows the use of wooden-string courses at regular intervals in its walls.

Groningen

In the Netherlands, a much discussed matter concerns the effects of relatively low magnitude (induced) earthquakes in the Province of Groningen, where gas extraction operations are carried out on a large scale. The situation is different from that in most of the known seismic zones, for several reasons, principally: 1) the magnitude is low and 2) the soil is very weak. Both aspects make it still difficult to judge the possible effects of future earthquakes as well as those of preventive measures Although little is known about the precise effects and risks for (historic) buildings in the Groningen area, one might assume that earthquakes can lead to damage patterns that are more or less similar to the ones described before.

More research is needed, though, for which the historic examples may offer inspiration. Perhaps also here, part of the solution might lay in relatively ductile intervention measures, like the ones described.

4 – Vernacular architecture and construction at Curaçao: integral design



4 – Vernacular architecture and construction at Curaçao: integral design

Curaçao is an island situated in the Caribbean at a short distance from the coast of Venezuela. The architectural style of representative buildings derives from the Dutch architecture of the 17th and 18th cent., while important elements in the design are based on the vernacular tradition and are strongly related to the local environment.

4.1 – Situation, climate and architecture

The climate at the island is tropical with a yearly average temperature of 27.5 ˚C. The relative humidity (RH) is 77% on average. The amount of rainfall is 600 mm a year (not so much less than the 750 mm in the Netherlands), but mainly concentrated in short but heavy showers during the months December, January and February. There is a continuous trade wind from the Northeast with a mean velocity of 7 m/s.

The climate and the locally available materials have always contributed to the character of the architecture for what concerned:

- the building materials (blocks and pieces of coral stone);
- the verandas giving protection against the strong sun;
- the system of gutters and aqueducts, leading to cisterns made in masonry and meant to deal with the always threatening shortage of fresh water.

FIG. 4.1 Use of verandas for protection against the sun (mansion, Curaçao, Caribbean) / *photo: R. v. Hees*

4.2 – Design of planters' mansions ('Landhuizen')

Most of the mansions at the planters' estates, were built between the 17th and the 19th cent.. In order to deal with the climatological conditions they were preferably situated at elevated locations, and constructed in such a way that they could optimally profit from the cooling effect of the NE trade wind. Verandas allowed making use of a ventilated and thus cool external living space, protected against direct sunlight [FIG. 4.1]. At the same time the verandas served as a protection of the interior space of the house, which in this way, could be kept cool and well ventilated thanks to well-positioned openings.

4.3 – Local building and construction techniques

The material generally used for the construction of the walls of all types of buildings was the local coral stone (blocks and pieces of coral), whereas bricks and tiles, originating from the ballast of Dutch ships, were occasionally used within the coral structures. For mortars, lime mortars and/or lime-mud mixes were used, which are in a certain sense comparable with the adobe described before. Traditionally, the walls were plastered (lime mortar) and painted (lime wash). This was done for two different reasons: i) to improve the aspect of the very irregular masonry and ii) to protect the walls from the influence of the weather during the wet period.

FIG. 4.2 System of aqueducts (house, Curaçao, Caribbean) / *photo: R. v. Hees*

FIG. 4.3 Composition of a cistern wall: coral stone wall construction with an internal cladding of 'IJssel clinkers' and a two or three layer render system on the inside (Curaçao, Caribbean) / *photo: R. v. Hees*

Collection of water

The shortage of natural sources of fresh water makes Curaçao very much dependent from rainwater, which, as mentioned before, falls in the rainy period in short and heavy showers. To collect rainwater, special systems of aqueducts running around the building façades became common, even in ordinary dwellings leading the water to a cistern [FIG. 4.2]. Much care was taken to make the construction of the cisterns as durable as possible, using the limited quantity of precious bricks in combination with high quality (low porous) mortars to guarantee a watertight coating at the interior of the cisterns. The cistern itself was constructed in coral stone masonry [FIG. 4.3].

From the description above two conclusions can be drawn:

- much care was taken to build in a durable and, at the same time, sustainable way (from the careful use of building materials to the collection of fresh water and the design focusing on natural cooling);
- durability and sustainability appear here as the logical and necessary result of a functional design, strongly connected with both the available materials and the necessities of life on the island;
- the local architecture seems to naturally originate form the place.

4.4 – Technical interventions in the 20th cent. and their impact: the increase of salt damage

In many ancient buildings at Curaçao, a strong degradation of walls and the composing building materials can be observed. The damage is mainly due to salt crystallization processes. This specific degradation process goes beyond the planters' estates and affects most Curaçao monuments dating from the period between the 17th and 19th cen.. The overall image of salt damage is deterioration of both plaster and paint. Recurrent damage types are blistering or peeling of paint layers and crumbling, powdering and delamination of plasters. These symptoms are generally found in combination with salt efflorescence. The damaging mechanism clearly occurs on both the interior and exterior faces of the walls.
Salt damaging processes, responsible for the severe deterioration of plastered wall surfaces, ornaments and details, lead to the necessity of a frequent maintenance and even complete restoration campaigns, in order to avoid a quick propagation of the damage. Maintenance generally consists of re-painting and local repair of plasters; however, the complete plaster layer often needs replacement. No matter which measures have been taken, generally the first signs of damage re-appear within a short time.
Salt damage is the result of a process through which salts are transported by moisture in the walls and towards the wall surface, where evaporation followed by crystallization occurs. The main type of salt is NaCl (see Van Hees 1991, Van Hees & Van Rijswijk 2005), originating from seawater. They may be present in the materials of the walls during the construction phase or be transported there later, due to environmental circumstances. It should be remembered that seawater was often used for making the mortars and that sand from the beaches and building stone from the sea were employed. Environmental sources of moisture and sea salts include droplets of seawater transported to the buildings by the wind (aerosol) and groundwater containing salts, penetrating the wall as capillary rising damp.

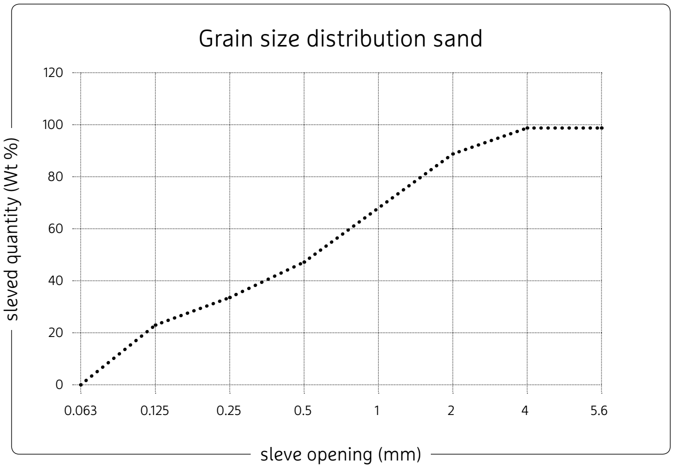


FIG. 4.4 Grain size distribution traditional crushed limestone sand; note the high percentage (ca. 25%) finer than 0.125 mm [Hees v. 2005]

Local mortars and better salt resistant plasters

The traditional mortars for masonry and plasters were lime based until the 20th cent., when Portland cement was introduced. From then on also the plaster made at Curaçao became sand-cement based and contained crushed limestone sand from the local mine company as aggregate.

The local sand is characterized by a large percentage of very fine particles [FIG. 4.4]. The obtained mortar consequently has a high capillary suction, which results, when used on salt loaded substrates, in a relatively quick saturation with salts. This explains the rather fast decay of repair mortars and plasters, due to salt damaging processes.

FIG. 4.5 With the use of 'better', more durable materials, sometimes damage is induced: here the plaster shows loss of cohesion (building, Curaçao, Caribbean) / *photo: R.v.Hees*

FIG. 4.6 Blistering of latex paint (detail of a painted plaster, house, Curaçao, Caribbean) / *photo: R.v.Hees*

Effects of 20th cent. interventions and maintenance

Before the 20th cent., plasters were usually covered with a whitewash and maintenance was performed with care, once a year or every two years. Hence a quite reasonable state of conservation of most heritage buildings existed.
It was mainly in the 20th C, when 'more durable' materials were introduced and used for maintenance and restoration that an increase in the velocity of the degradation process occurred. The new materials were stronger, cement based plasters or renders, and more water- and vapour-proof paints. However, instead of resulting in a longer service life, damages appeared, like those shown in FIG. 4.5 and FIG. 4.6 concerning a plaster and a latex paint.

FIG. 4.7 Damage to the plaster (synagogue, Curaçao, Caribbean) / *photo: R. v. Hees*

FIG. 4.8 Façade furnished with a salt resistant render system in 1994, situation 6 years later (synagogue, Curaçao, Caribbean) / *photo: R. v. Hees*

Moisture sources like rising damp, rainwater penetrating through defects in the paint, and leakages due to lack of maintenance of water transporting elements like gutters, downpipes and aqueducts allow transport of water and salts in walls, and cause damage [FIG. 4.7]. As a matter of fact, eliminating the ingress of water may be considered as one of the most important measures to be undertaken, together with the use of better salt resistant plasters. These could best be made using available, local materials.
First try-outs with better salt resistant prefabricated renders from Europe showed that these plaster systems had a potential in improving durability, i.e. the service life. The Curaçao synagogue served as a test project. Two different special render mixes (an accumulating and a salt transporting plaster system, see [Hees v. et al 2009]) imported from the Netherlands were applied, which proved successful as shown by their performance after 6 years [FIG. 4.8]. Presently ca. 15 years have elapsed and the condition of the plasters is still remarkable.

In the years following the execution of this project, several proposals have been made for the development of better salt resistant plasters, based on local materials. Merely considering the huge transport costs and the energy needed for importing mortars from overseas, it will become clear that the positive impact of a local development on sustainability would be considerable.

One of the research lines that has been investigated, was the use of local sand. The grain sizes of the sand, largely determine the size of the pores that will form in the plaster and consequently also its behaviour in terms of moisture and salt transport.Taking the finer sand fractions out, a more favourable pore size distribution was obtained [FIG. 4.9, FIG. 4.10]. The fractions used for the realization of the new mortar designs are shown in FIG. 4.11.

FIG. 4.9 The crushed limestone sand from the mine company at Curaçao, with quite some very fine grains / *photo: R. v. Hees*

FIG. 4.10 Sieving, even with simple means, results in rather coarse grained sand, as a basis for plasters that turned out to be better salt resistant. The remaining fine sand fraction can be used for other types of plaster and as a filler in other applications / *photo: R. v. Hees*

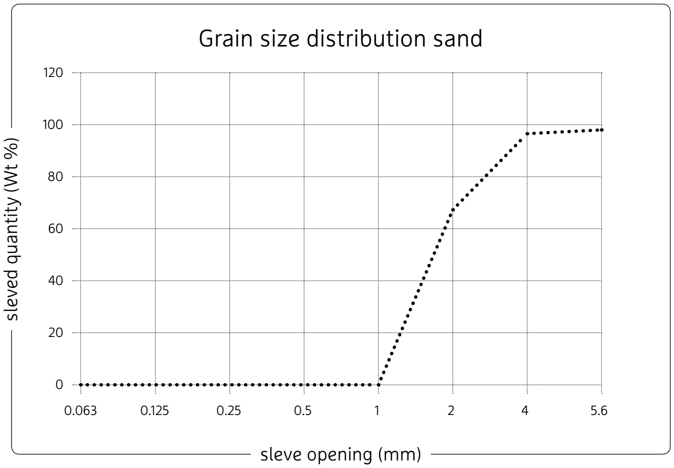


FIG. 4.11 Grain size distribution of traditional crushed limestone sand, where the fractions smaller than 1mm have been taken off. This sand would result in plaster mortars with a more favourable pore size distribution, able to mitigate the effects of crystallization damage up to a certain extent [Hees v. 2005]

FIG. 4.12 Preparation of test panels (house at Charloo, Curaçao, Caribbean) / *photo: R. v. Hees*

FIG. 4.13 Newly designed render compositions with assumed better salt resistant behaviour (house at Charloo, Curaçao, Caribbean) / *photo: R. v. Hees*

FIG. 4.14 Application of new render (house at Charloo, Curaçao, Caribbean) / *photo: R. v. Hees*

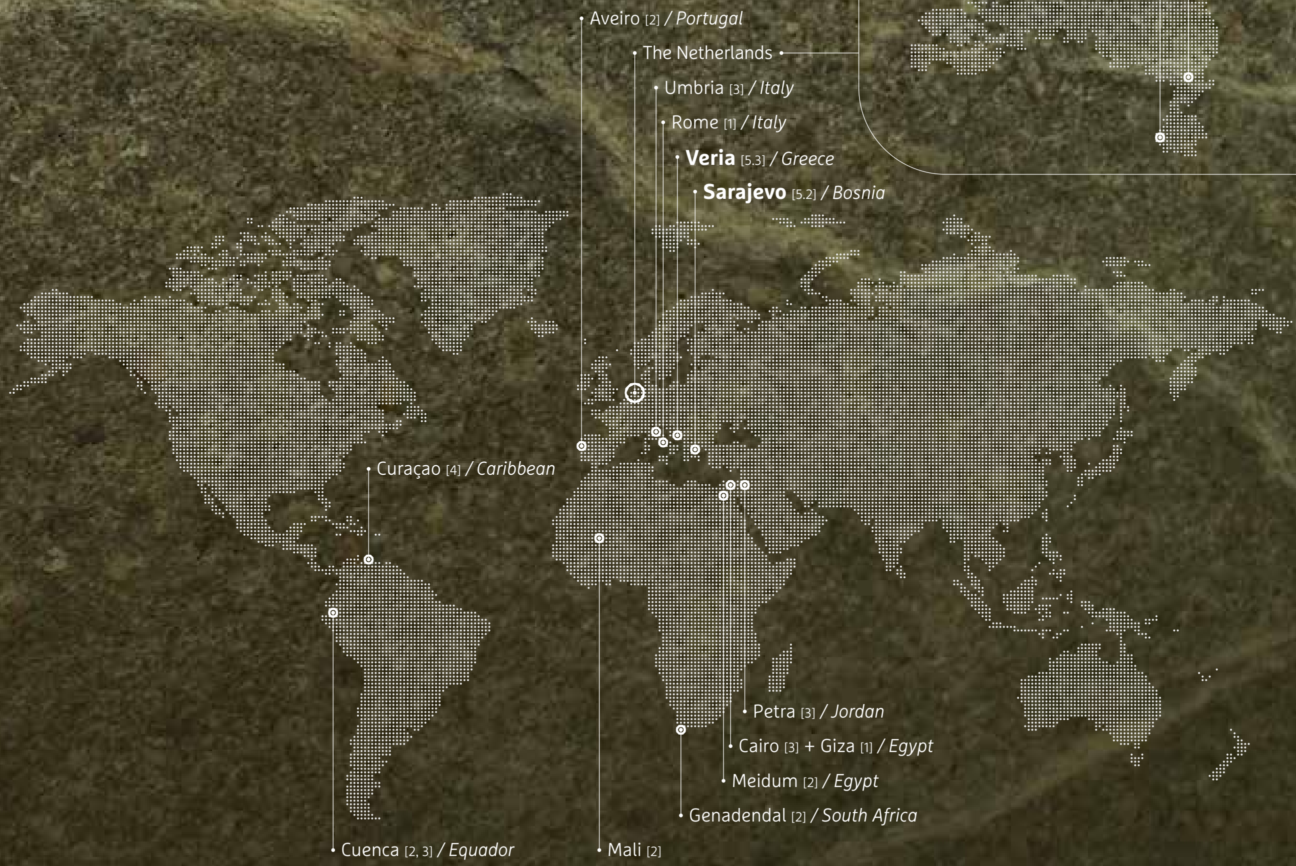
Once a promising design of a mortar mix has been achieved, aiming for a better salt resistant plaster, extensive tests are necessary. These include accelerated tests in laboratory and the application and monitoring of the plaster in a number of test panels *in situ*. This is an essential part of the research, because here aspects like workability and finally also performance under practice conditions can become clear [FIG. 4.13, FIG. 4.14].

The workability of new plasters can be very critical.
For example, at Curaçao, the plasterers stated that two out of four mix designs were difficult to work with; it is clear that for those two plasters there may be no future, unless their workability could be strongly improved.
The contribution to durability lays mainly in the longer service life of the plasters. The contribution to sustainability is to be found in global technical knowledge and the use of local materials, avoiding the necessity of transporting ready-made mortar mixes from Europe.

Although several test panels have been successfully applied [FIG. 4.12], this development has not been widely adopted at Curaçao, yet.

5 – Sustainability and the city

5.1 – General
5.2 – Sarajevo: the unity of the Mahala
5.3 – Veria: historic centers want a future



5 – Sustainability and the city

Vernacular and also traditional architecture of the past was in most cases durable and sustainable, and so where the cities and the villages where such building traditions thrived. Now-a-days architects have the task to go beyond the single building and to strive to make modern cities as durable and sustainable as those belonging to ancient traditions.

5.1 – General

The concepts of durability and sustainability can be applied also to cities or city quarters possessing a historic value. Houses, churches and representative buildings, in fact all urban spaces, form a unity and are connected by relationships deeply rooted in old local (building) traditions. The urban situation may provide us with a clue to understand cultural, social and religious relationships between people, and also to appreciate the way they faced environmental problems optimizing their architecture. Old societies and their architecture were often strictly bound. This link guaranteed a high degree of sustainability, also in terms of constant use and maintenance of the built environment, which is lost in modern times.

Being ‘living’ organisms, cities expand and their architecture is often modified or even destroyed in a superficial and unconcerned way, to meet the short term needs of a growing population and the demands of modern life. Such an approach, deprived of the issues of sustainability, is bound to result in severe loss of heritage and human values.

Therefore the language and aims of the buildings of a characteristic urban area should be thoroughly studied and understood before planning any intervention. Interventions are necessary in terms of conservation, upgrade of functions or re-use, but should be performed keeping an open dialogue with the existing constructions and traditions.

FIG. 5.1 Characteristic street of the historic center of Sarajevo, Bosnia / *photo: S. Op den Kamp*

Interventions

Even when deeply changed, a city may preserve monuments of the past which can be the way to trace its history back [FIG. 5.1].

Heritage buildings, strongly characterising a city, should be seen as stepping stones needing to be linked in a cohesive net, including also the surrounding, less valuable, buildings.

On this basis a new unity can be sought, involving also abandoned or neglected zones, which will acquire a new value. The use and appreciation of the whole city will make it sustainable. The ancient link between architecture and man will be thus recreated.

5.2 – Sarajevo: the unity of the Mahala

Sarajevo is located in Bosnia, a country with a strong islamitic tradition. The full appreciation of the architecture of Islamic cities calls for an approach including philosophical, religious and social aspects [FIG. 5.2]. The architecture of the *Mahala*, the residential unity in Bosnia, reflects a life style, strongly connected with the religion and the social relationships of Islamic Bosnian communities. In Sarajevo, *Mahalas* were erected on the top of the hills, around the business centre, on the sunny side of the city.

The *Mahala* is the traditional complex of houses with a public courtyard, accessible for women, on condition that they would be properly dressed, and a private backyard, where women could walk around more freely, also in terms of clothes.
The houses were in the proximity of a square, characterized by the presence of a baker's shop and a water source, and especially a mosque with a minaret. From the top of this vantage point, the call for prayers was entrusted to the voice of the muezzin (without loudspeakers!) and all the inhabitants of the Mahala were to hear it. The number and location of minarets and Mahalas was therefore dependent on the distance at which the call could be heard.

The courtyard [FIG. 5.3] was an important place for the life in the *Mahala*. Paved with stone pebbles forming decorative patterns, the yards were beautiful and well-kept scented gardens, with a fountain where people could wash and purify before the five daily prayers. Even the position of the fountain and the fountain itself, physically and mentally connected with daily life of the inhabitants, was an integral part of that cohesive and meaningful site.

FIG. 5.2 Interior view of a traditional house (Svrzo's House, Sarajevo, Bosnia) / *photo: S. Op den Kamp*

FIG. 5.3 A courtyard seen from the veranda of a traditional house (Svrzo's House, Sarajevo, Bosnia) / *photo: S. Op den Kamp*

FIG. 5.4 A beautiful and articulated veranda (Svrzo's House, Sarajevo, Bosnia) / *photo: S. Op den Kamp*

Men and women were assigned separated spaces in the house. They felt a strong bond with their home, as they spend their whole life in it. The stairs in the houses being rather steep, elderly inhabitants would occupy the premises on the ground floor. When someone died, the corpse was to be carried outside the house by two men, passing through an opening in the fence, and this habit determined the width of the opening. Also the cemetery was nearby, a green and peaceful place where people could go for a stroll. Green and built areas were daily used and maintained to meet the needs of inhabitants. The social and religious functions of the architectural complex, the *Mahala*, determined its form and location.

The houses (from ca. 1480 onwards) were constructed in a type of adobe, fabricated using local clay and straw, and the facades were white washed. In more recent times, beside adobe also fired brick was used. The ceilings were made of wood, and plaited wood was used to screen the sun. Other protections against the strong sun were formed by porches and roofs edges prolonged to form a veranda [FIG. 5.4]; the windows, rectangular in shape, were small. As already seen, when first describing vernacular architecture, also in the Islamic residential complexes sustainably was intrinsically present in the response to the environmental situation, both for what concerned the available materials and the climate. Such a climate design would not require any artificial cooling.

FIG. 5.5 Traditional veranda (Svrzo's House, Sarajevo, Bosnia) / *photo: S. Op den Kamp*

The *Mahala* tradition is still alive, as shown by the typology and the spirit of new buildings, furnished with yards and pergolas, substituting the traditional verandas, which like the old ones, are cool and pleasant places to be. The courtyard of the *Mahala* had also the very important function of forming a transitional space between inside and outside, private and public space, and as such represents a recurrent feature in the modern architecture of the city [FIG. 5.5, FIG. 5.6].

The *Mahala* and its built environment, including the minaret, represent a building tradition of the past responding to needs related to environment, climate, social and religious life. A tradition bound, sustainable architecture.

FIG. 5.6 Balconies of modern architecture. Modern balconies, like traditional ones, represent a transition area, between private and public sphere (apartment building, Sarajevo, Bosnia) / *photo: M. Kasimidi*

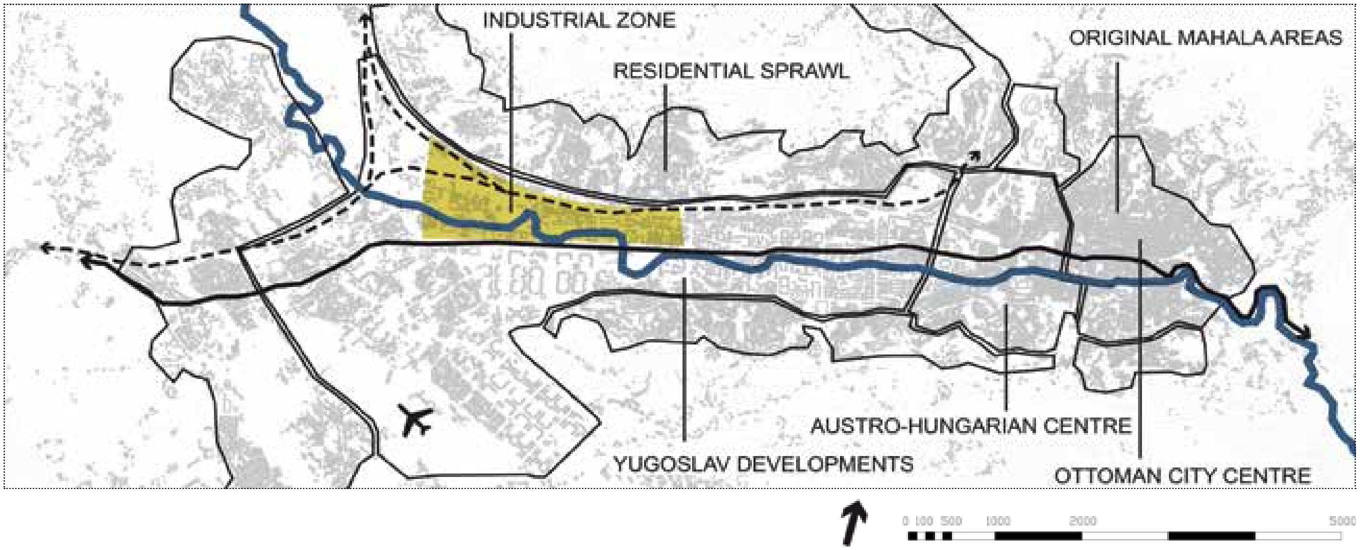


FIG. 5.7 Overview of the city, with the different historic and modern quarters and the industrial area / *drawing: M. Kasimidi*

The modern city

The city centre, originally comprising the essential buildings of the typical Islamic city, developed in the course of time to host architecture of different types, related to the changes introduced by the political rulers who governed the city. Built areas arose, and often the original care for buildings and sites was lost to large popular and industrial constructions. The city started to lose its unity as built areas become separated, instead of forming a continuous urban texture.

Since its foundation, Sarajevo has developed in different stages between the hills extending longitudinally from east to west, from the Turkish area, to the Habsburg quarter and finally to the twentieth century districts [FIG. 5.7]. The communist government in the second half of the 20th cent. had numerous dwellings built without sustainable living quality both in terms of housing and urban space. Moreover, they were located far away from the city centre.

Only recently (after the Balkan War) many illegal houses were erected on the hills around Sarajevo. The city is now-a-days fragmented, real public communal space is lacking and insufficient public trasportat makes the connection between the quarters difficult.

Neglect and abandon have further characterized the architecture of the city in the 20th cent. [FIG. 5.8].

FIG. 5.8 Industrial area (Novi Grad, Sarajevo, Bosnia) / *photo: M. Kasimidi*

A new *Mahala*?

Sarajevo offers an interesting challenge for students. A project of the 'Heritage Design, Technique & History' department aimed at bringing back identity and unity to the city, by planning the re-use of abandoned parts of the industrial area. A second city centre was to be developed, involving the factory buildings. Preliminary research was carried out stimulating awareness of the problems of the city and aiming at understanding the character and value of the traditional building techniques and materials, as well as the urban structure and landscape. Reference areas were the still unchanged parts of the city.

The new heart, located in a valley, on a site characterized by abandoned industrial heritage lies in the middle of non-connected and deteriorated communist quarters and post war illegal housing areas. It is close to no longer active public transport systems (train and streetcar-facilities).

This industrial heritage buildings and the whole site, do have the means to absorb and renew an inspiring city life becoming a second city centre. The main characteristic values of the site and of the industrial buildings should be adapted to a multifunctional public use. An efficient public transport system should be created making use of the existing structures to connect the different parts of the city. Linking urban areas, more unity is bound to be created, contributing to the improvement of social life and to increase the sustainability of the city[8]. Sustainability will thus result from the value embodied in the heritage buildings, the awareness of the citizens and their involvement in all parts of the city.

8 Sarajevo, Green Design studio, Technical University of Delft, 2013 supervisors: J. Roos, F. Koopman and H. Zijlstra (TU Delft, Faculty of Architecture), N. Pozder (University of Sarajevo, School of Architecture), students: Jaarsveld van W., Kamp op den S., Kasimidi M.

FIG. 5.9 Historical house (Veria, Greece) / *photo: K. Theologi)*

5.3 – Veria: historic centers want a future

The oldest part of the Greek city of Veria is characterized by houses all connected between them to form a unity and standing with their façades lined along narrow alleyways.

Originally, each housing block included a church, focus point of the social structure of the old city. Further, each unity was demarcated by a wall with a gate leading to the alleyway, and included a number of houses furnished with verandas, which opened towards a common courtyard. This idea of connecting buildings creating the courtyard was the answer to the needs of social life of the community, that is to say meeting and communicating, and a way to face warm summer climate conditions. Thanks to the connection with the enclosed courtyard, each unity would be permeable to the outer space, still maintaining its private structure.

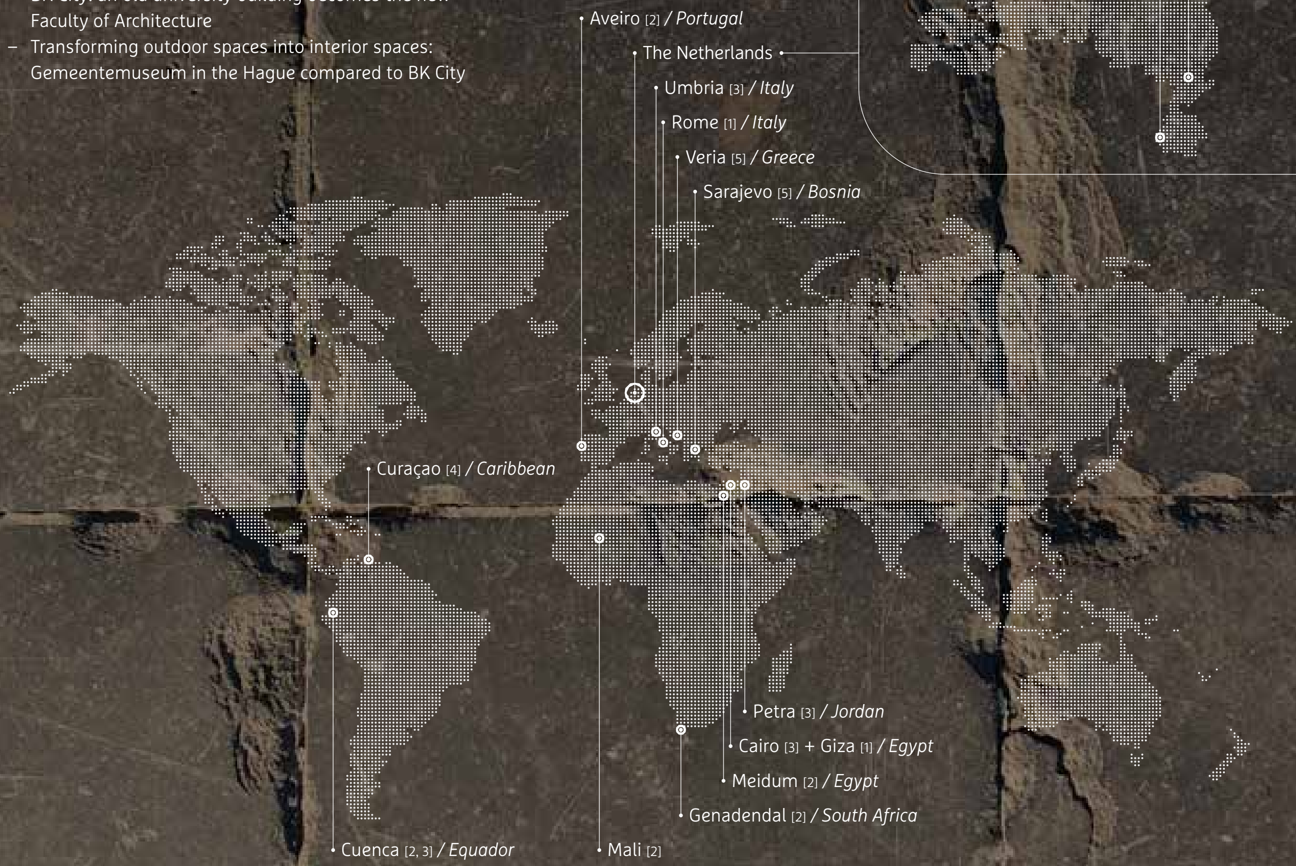
The churches date back to the 13th cent. and are sober outside, but decorated by frescos inside. The masonry, presently in a deteriorated state, due to lack of maintenance, shows an ingenious anti-seismic construction system. The walls are built in brick, a hand-made traditional material, with the insertion of wooden beams, meant to guarantee flexibility to the construction and thus better face the risk of earthquakes.

This urban structure, monument of historic, social and religious relevance, started to be altered and modernized in the 20th cent., when the buildings along the alleyways where demolished to make space for higher, modern constructions, no longer erected following the tradition.

FIG. 5.10 Historical houses (Veria, Greece) / *photo: K. Theologi*

In a recent European development programme, [Links, 2010-2012], attention was focussed on action plans aimed at improving the image of cities like Veria. An integral approach was promoted, which should start with the restoration of the unity of the historic centre, and include interventions on old and new buildings to recreate their original spirit of the city, and to make them more sustainable. Such an approach pleads for a sensitive way of understanding both the urban structure, the building and the construction technique and materials before planning any interventions. The vernacular, somehow imperfect character of the existing, should be the starting point to develop a line of intervention, using the solutions found in the past for making the existing durable, sustainable and suitable for living a modern life. Any restoration of the buildings should be aware of the sustainability of traditional building techniques and materials, and learn from the past how to handle with the present [FIG. 5.9, FIG. 5.10].

6 – Conservation and re-use of monuments: the balance between Repair, Upgrade and Transformation



6 – Conservation and re-use of monuments: the balance between Repair, Upgrade and Transformation

The challenge of transforming a historic building, giving it a new function and at the same time making it durable and sustainable is presently an important matter for discussion. 'Repair, Upgrade and Reformation' [Allan, 2012, p. 177] [FIG. 6.1] are the three poles to base the interventions upon, and being a base, they should be kept in balance.

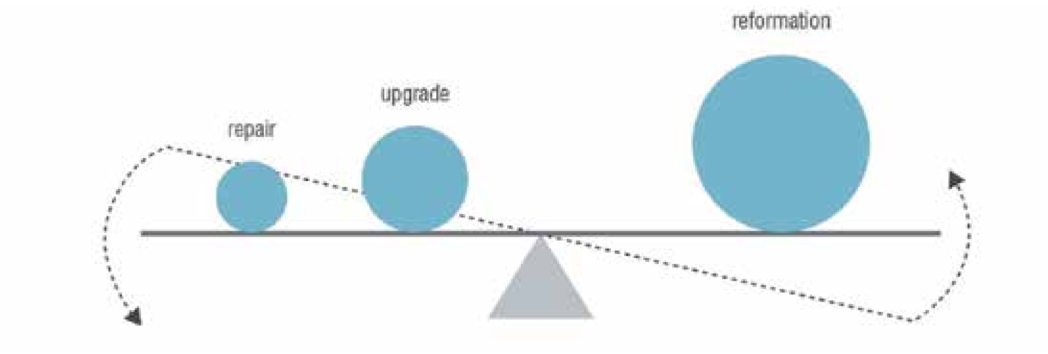


FIG. 6.1 Repair, Upgrade [performance] and Reformation [Allan, 2012, p. 177]

6.1 – General

Generally speaking, the restoration and re-use of an existing building should be carried out keeping the original materials as much as possible, improving their condition when deteriorated and avoiding unnecessary replacements. The authenticity of the materials and the building techniques can be thus preserved and the costs of the intervention can be limited. The very aim, though, will be the *final use* of the building: change, management and control of the life-cycle of the building [Brand,1997] should be the cornerstones of a sustainable intervention.

In a technical sense, the conservation should be done with methods and materials, which are effective and by no means introducing (new) damage.
The crucial point in the case or re-use, is how to preserve the main characteristics of the building in terms of heritage values, and still make it a sustainable and a pleasant place to be.

Some Dutch cases will be discussed, ranging from the preservation of the masonry walls of the oldest, still existing, stone house in the Netherlands, to the adaptation of ancient structures to meet new needs.
The necessity of a sensible and attentive approach to keep or modify the existing will become clear: interventions need to be tailor made, and nonetheless based on the mentioned principles. Durability can often be achieved keeping the existing materials, sometimes by better protecting them against environmental factors in order to stop a degradation process. Sustainability will result from the use of well-chosen materials for conservation and from the suitable design of indoor climate and installations. These will be rather matching the existing then intending to comply with standardized assessment tools and the modern norms on (zero) energy.

The preservation of the existing and the necessary modifications to meet new needs will be discussed. A sensible approach will derive from the study of the monument and heritage buildings, leading to understand its basic constituents and character, which will serve for further developments aiming at transforming it into an attractive place for modern occupants.

We will go more into detail describing the building of the Faculty of Architecture of the Delft University of Technology, to show the various solutions found to solve different problems and achieve durability and sustainability together with comfort, still maintaining the quality and the strength embodied in the structure.

6.2 – The conservation of the Sandrasteeg house in Deventer: from damage analysis to a durable and sustainable intervention

The Lebuïnus' church, sometimes described as the Oversticht Cathedral, dominates the town of Deventer. Erected by bishop Bernold in the 11th cent. in stone to replace a timber building, it is the grave church of St. Lebuinus, an Anglo-Saxon missionary, who, like the more famous Willibrordus and Bonifacius, tried to convert the Netherlands to Christianity in the 7th and 8th cent.. Near the church, and strongly connected to it, there is a house situated in the Sandrasteeg, which is also known as the oldest still surviving stone house in the Netherlands [FIG. 6.2].

Sandrasteeg house, Deventer

The oldest part of this building was erected in 1130 as the gate to the area of sovereignty around the Church. In the second half of the 12th cent. the gate building lost its defence function and was reconstructed to finally become a residential building, that the provost of the Chapter of St. Lebuinus started to use as his home [Kreek1996, Hees & Nijland 2012].

In old times, Deventer, a Hanseatic city, served as a staple-place of building materials, more specifically stone, transported from the Eifel region in Germany; main stone types were Römer tuff stone, already used by the Romans, and trachyte. This explains why tuff stone was used for the major buildings in Deventer, like the main churches and also the deanery. In the provost house the oldest parts consist of both tuff stone and trachyte.

FIG. 6.2 Conservation of the oldest stone house in the Netherlands (Sandrasteeg, Deventer, The Netherlands) / *photo: W. Quist*

FIG. 6.3 Transparent roof construction as a protection for the tuffstone in the historic wall (house, Sandrasteeg, Deventer, The Netherlands) / *photo: R. v. Hees*

Although Römer tuff stone is a quite weather resistant (durable) material, able to survive for centuries, a certain kind of weathering occurs after a long service life, making the material frost sensitive. During the restoration of 1991-1994[9] the treatment with a new consolidating agent was therefore considered. A stone consolidant is meant to reintroduce the internal coherence in a degraded material. However, from research carried out by TNO[10], it became clear that even this treatment would not have been a guarantee for frost resistance. Instead, TNO suggested to make sure that any water penetration in the material would be avoided, water being the essential factor for frost damage to occur.

The result was the design of a transparent glass roof by the restoration architect [FIG. 6.3]. The roof prevents the occurrence of a high water content in the tuff stone wall, without hindering the appreciation of the façade. Furthermore, such an intervention is fully reversible and also meant to avoid the use of chemicals and solvents.

The intervention on the façade is transferred to the level of the architecture, thus stressing the importance of the historical object.

9 Restoration architect: J. Kreek (Kreekarchitecten)

10 TNO – Netherlands Organisation for Applied Scientific Research, Technical Sciences

6.3 – St. Peter's church, Leiden: conservation of materials and improvement of heating system

St. Peter's church in Leiden is a listed monument, dating back to the 14^{th}-15^{th} cent. [FIG. 6.4]. Its historical importance lies also in the fact that it was the church of the Pilgrim Fathers, who departed in 1620 with the Mayflower to America. Presently the church has lost its religious function and its use has become multi-functional, hosting a vast range of activities, ranging from temporary expositions to concerts (the church owns an excellent and well known historic organ) and even dinner parties and exam sessions for the University of Leiden.

During the recent restoration (2001-2010)[11], the durability of the materials was checked and enhanced where possible. Otherwise, substitutions were done. The timber of the roof, suffering biological damage due to death watch beetle and fungi, was restored. The tiles of the roof were maintained and the natural stone was thoroughly inspected and substituted when necessary (which proved to be the case of some of the stone replaced in the previous restorations). TNO gave advice on the state of conservation of the stone, on how to approach the restoration of the doors of the organ, and – very important from a point of view of sustainable interventions – carried out research supporting energy performance and comfort.

Many energy performance measures have been taken in the end, including roof insulation, extra glazing for the stained glass windows [FIG. 6.5, FIG. 6.6], floor insulation and also a completely adapted (floor)heating system.

11 Restoration architect: P. Rietbroek (Veldman, Rietbroek, Smit)

FIG. 6.4 Exterior wall of transept (Peter's church, Leiden, The Nertherlands) / *photo: R. v. Hees*

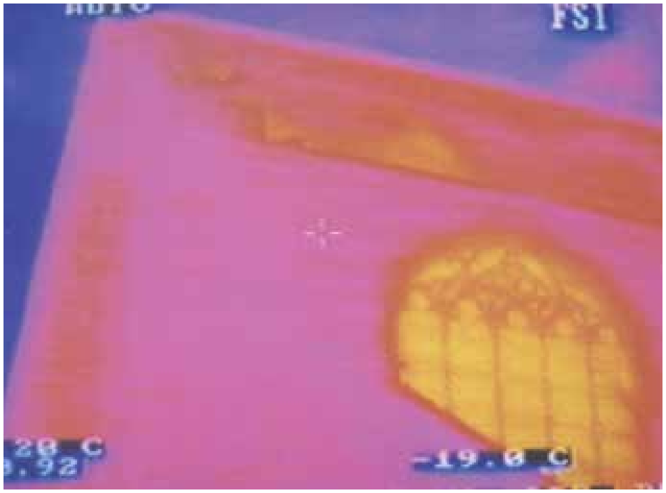


FIG. 6.5 Infra-red thermography photo, showing the heat losses mainly through windows and roof construction (Peter's church, Leiden, The Netherlands) / *photo: R. v. Hees*

FIG. 6.6 Test panels for external glazing in front of the stained-glass windows (Peter's church, Leiden, The Netherlands) / *photo: R. v. Hees*

A monitoring system was installed at significant places all over the building during the works to measure temperature, relative humidity of the air, dilation of cracks, and timber humidity. The aim was to foresee the effects of the planned interventions with regards to possible induced risks for the historic fabric.

The new floor heating system deserves special attention, as this, together with the other measures taken to improve sustainability, was essential in making the building suitable for hosting the foreseen activities.

The old heating system was situated very deep in the floor, under the thickest of the gravestones and had, as far as known, no suitable insulation underneath. This resulted in heat loss to the ground, in an enormous mass of material to be heated and consequently in an huge warm-up time.

In the restoration campaign, the idea was developed to have a new floor heating system, with the pipes situated closer to the floor surface and a very good insulation underneath.
As the thickness of individual gravestones and the number of very thick ones was not known beforehand, a sophisticated measuring system was used by TNO to assess the thickness of each gravestone in the church floor, in order to allow to assess whether a new heating system with shorter warm-up time, but having enough heating capacity, would be feasible. In this way it became clear that although the thickness of the gravestones was different, the envisaged heating system would be profitable.

FIG. 6.7 The *petit granit* gravestones furnished with concrete layer to enhance thickness, lying on the special floor where the heating pipes run (Peter's church, Leiden, The Netherlands) / *photo: R. v. Hees*

A new circuit of floor heating pipes was introduced in the place of the old one. All gravestones were lifted, taken out and given the same thickness by adding concrete to the backside of the thinner ones [FIG. 6.7, FIG. 6.8]. A limited number of too thick grave stones were not included in the circuit of the floor heating pipes. The pipes run now in a special floor just underneath the gravestone.
The result is a faster and less energy consuming heating system.

FIG. 6.8 View of the church during the works (Peter's church, Leiden, The Netherlands) / *photo: W. Quist*


FIG. 6.9 The concrete surface of the building has been insulated and plastered (Library, Betondorp, Amsterdam, The Netherlands, arch. D. Greiner) / *photo: S. Naldini*

6.4 – Betondorp, Amsterdam: thermal upgrade with external insulation

Thermal upgrading is certainly an important issue in sustainable interventions. But thermal upgrading in case of monumental and historic buildings is not straightforward. Thermal insulation, in order to be most effective, can best be applied on the 'cold', i.e. the external side of the wall. This allows an optimal use of the thermal inertness of the wall construction, both contributing to thermal comfort and avoiding the risk of interstitial condensation. It can also help keeping the wall construction dry, by hindering rainwater penetration; to meet these goals the so-called ETICS (External Thermal Insulation Composite Systems) have been conceived. For many monumental buildings, however, the external part can not be changed, as it is essential for the monumental value of the building. This is generally the case in countries like the Netherlands that have a strong brick masonry tradition.

Of course there are exceptions. An example, where such an intervention (ETICS) has been applied is the 'garden suburb' Watergraafsmeer, better known as *Betondorp* ('Concrete Village'), in Amsterdam [FIG. 6.9, FIG. 6.10] [Kuipers, 1987, Heinemann, 2013]. *Betondorp* was conceived between 1923 and 1925, on the basis of the designs of eight architects using nine different concrete systems. Some of the systems included a plaster finish. The project had an experimental character: the knowledge on concrete was scarce and many problems arose. Thereby moisture problems were most recurring and severe.

FIG. 6.10 Historic concrete building after restoration (Library, Betondorp, Amsterdam, The Netherlands, arch. D. Greiner) / *photo: S. Naldini*

In the restoration of the 1980s it was decided to hinder the ingress of water by means of an external insulation system. The monumental value of the village had at that time been recognized. The intervention was necessary, but needed to be respectful of the appearance of the buildings. It was decided to make use of thermal insulation slabs on which an external plaster would be applied[12]. The new finish of the concrete surface was considered to match the original one. Both energy consumption and comfort could thus be positively influenced, without radically altering the original aspect of the buildings. Such an intervention has a very high impact as it strongly contributes to a prolonged service life of the dwellings and their sustainability. Comfort for the inhabitants was enormously increased.

However, concerning the final aspect of the building, it can be objected that some of the fine contrasting elements in the façade, to which the architectural expression was originally entrusted, are lost, in particular the relationship between protruding and recessed elements, as the layer constituted by insulation and plaster is thicker than the original finishing. Still the solution was found acceptable by Monument care authorities. The intervention in Betondorp can perhaps be considered as an example of a compromise between the historic values of the building to be kept, and the comfort for the modern users to be achieved.

12 Restoration architect: O. Greiner (Architectenbureau Onno Greiner)


FIG. 6.11 Damages like cracks and peeling of paint may introduce risks for the internal insulation (windmill, Stavenisse, the Netherlands) / *photo: R. v. Hees*

6.5 – Thermal upgrade with internal insulation and its risks

One of the most diffused upgrading interventions for historic buildings with a monument-status, however, is the use of internal (wall) insulation. An interesting example of an intervention in this sense, is the Justus van Effen complex in Rotterdam, that will be handled with in this chapter. The contribution to sustainable development comes from the reduction in energy use, which goes together with an increase in comfort. This kind of intervention may have certain risks from a building physics point of view.

Risks of internal insulation

For quite some monumental buildings constructed in solid brick masonry, the application of internal insulation appears indeed logical [FIG. 6.11]. An example of a proposed intervention in a historic building, making use of internal insulation is shown in FIG. 6.12. The idea is to obtain a considerable reduction in the necessary heating energy.

From the drawing it is clear that the designer has taken into account the risk of the beam end becoming wet due to interstitial condensation: a damp proof layer has been proposed. The vapour tight connection between the damp proof layer and the beam is difficult to be reached. Besides, not always is the insulation work done properly and the risk of failure is then present. Furthermore, moisture might also come from an external source.

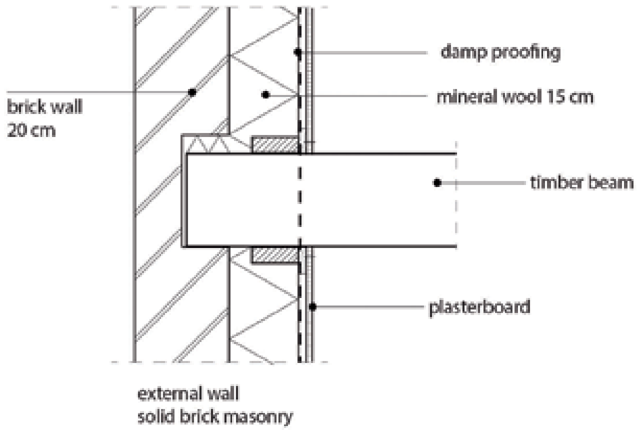


FIG. 6.12 Proposed solution of internal insulation of a wall in a historic building with timber beams. The idea is to prevent water vapour from reaching the beam ends by a very good damp proofing, which should be sealed hermetically all around the timber beam / *drawing: L. Miedema*

If water penetrating through the masonry can reach the wood, or vapour transport occurs, from the internal air, in case of failure in the internal damp proofing, the main risk is that a quick drying of the wood becomes impossible.
The risk for the beam ends is illustrated by FIG. 6.13, showing a beam end, protected by lead, in a not thermally insulated situation; the ingress of water could not be avoided, leading to rot of the wood.
Crucial both in the option with and without insulation is leaving space around the beam to allow ventilation of the beam ends and consequently the possibility to dry in case the wood does become wet.

FIG. 6.13 Timber beam in an external wall, showing rot even though it seems well protected by the lead; NB this underlines that drying, which is in this case very difficult, is the most important issue in order to prevent moisture problems from becoming severe (windmill, Stavenisse, the Netherlands) / *photo: R. v. Hees*

FIG. 6.14 Upper storey apartments of the Justus van Effen complex connecet by menas of a balcony, The Netherlands) / *photo: BK Visuals Bas van Kooij*

6.6 – Housing complex Justus van Effen: original construction found back and made almost zero energy consuming

The housing complex at the Justus van Effen street in Rotterdam was built in the 1920's as an innovative social housing unit by arch. M. Brinkman. As such it became a listed monument in 1985 [Molenaar, 2011; Hoogerland, 2010] .

Constructed in brick masonry, it consists of two storeys, joined blocks, forming a sort of yard, and crossed by the Justus van Effen street. Characteristic was the fact that the upper storey apartments, in the internal part of the complex, were connected by means of a large, continuous balcony, a sort of elevated street, directly accessible from the common spaces of the building [FIG. 6.14]. In the central body there were rooms owned in common: a bath area, a laundry room and airy room. On the ground floor, most apartments had a little garden.

In the 1980's some restoration and renovation work was done, which proved not to be well conceived, as the expected results of the intervention were not achieved. The apartments, at that time no longer meeting the life standard of the inhabitants, were merged into larger ones, and provided with independent installations, whereas the central baths and utilities lost their role. The windows frames in wood were substituted with aluminum ones, and the brick masonry was made water repellent. Later, in 1990's, the outer appearance of the masonry at the side of the yard was altered by applying a white mineral paint on the surface, to mask the shabby aspect of the façade caused by partial substitution of the bricks.

Within a short time the appearance of the building became shabby looking again, due to deterioration of the paint and the low quality of the window frames [FIG. 6.15]. The spaces once meant to be common had lost their original function and, neglected as they were, contributed to create the general feeling of neglect, making the inhabitants feel uneasy.

FIG. 6.15 Façade of one building showing damage (2009); to the left: paint removal - try out (Justus van Effen complex, Rotterdam, The Netherlands) / *photo: A. Acquebord*

FIG. 6.16 Justus van Effen complex after restoration (Rotterdam, The Netherlands) / *photo: BK Visuals Bas van Kooij*

The last restoration[13] (2000) was planned to give the building its original value back, and to make it into a pleasant place to live in, within the framework of a sustainable intervention. Under the motto in Dutch '100% MO-NU-MENT' meaning 100% (back to the) original monument and 100% adaptation to modern use, the work was carried out, following a new, integral, philosophy [FIG. 6.16].

This approach implied interventions at different levels, from masonry to window frames, and a reconsideration of the interior spaces and their functions. The aim was to point at the characteristics and at the relevant elements of the original building and work on them to reach the wanted goal, overcoming the difficulties inherent to the type of building and its age and the problems introduced by the restoration of the 1980's.

13 Restoration carried out by: Molenaar & Co architecten / Hebly Theunissen architecten and Michael van Gessel landschapsarchitect (landscape architects).

Closer to the building

The building was first studied as well as its premises and environment to outline its strong points, its potentials. And these were found to lie in the original concept, based on the integration of common and private spaces. The new approach aimed at re-establishing a function for the common spaces, and transforming the whole building into a agreeable and enticing place. Sustainability was found both in the flexibility characterizing the plans of the apartments, which could easily be altered to the satisfaction of different users, and in the thermal and acoustic improvements. Very important in this respect is the alteration of the floors, eliminating the timber beams. This all was reached without modifying the exterior of the building: here the original state (brick masonry, without paint layer) was recovered. At the level of the material, research was carried out to assess the quality and frost resistance of the brick and the risk of rainwater penetration. Damaged brick was replaced and joints re-pointed where necessary [FIG. 6.17]. The carried out plan included recovering the original, unpainted masonry, and applying a water-repellent treatment of the masonry, to avoid the foreseen problems related to rainwater penetration: due to the substitutions in the masonry, the treatment done in 2008 was no longer effective and a new treatment was done. The walls were internally insulated (18 cm thick layer) and the original window frames philologically reconstructed and furnished with good technical provisions. Insulating glass panels were used, and adequate ventilation was achieved. It should be reminded that the original window frames were already lost.

The presence of a central heating system had made the building unique at the time of its delivery and in the restoration concept the central body was given back the function of hosting the heart of the new central heating and cooling system. The system was connected to a geo-thermal heat storage system.

FIG. 6.17 Detail of wall with new bricks (house, Justus van Effen complex, Rotterdam, The Netherlands) / *photo: S. Naldini*

What could be used of the old building was used, be it the concept or a physical fabric, to be further integrated into a modern approach. Solar panels were intended to be placed on the flat roofs to provide energy for activating water pumps controlling the heating and cooling system. Due to economic reasons these could never be placed and the pumps are presently operated on mains power. The roof of the central body is the source for warm tap water. The floor heating is such as to guarantee an optimal use of energy, whereby limited temperature increase is sufficient. The building is now nearly zero energy consuming and also resource-efficient, in terms of limited waste of environmental resources, and the heritage value has been strengthened.

FIG. 6.18 Formar inner court, now conference and study room, designed by arch. W. Maas (Faculty of Architecture, TU Delft, The Netherlands) / *photo: R. van Hees*

6.7 – BK City: an old university building becomes the new Faculty of Architecture

How to make the existing structure not only durable, but also resource-efficient, through an environmental responsible approach. Here lies the focus of the intervention recently started for the building hosting the Faculty of Architecture in Delft. Before tackling the problem of the sustainability and indoor climate, it is interesting to retrace the history of the building and the events leading to its re-use.

An emergency driven re-use

When the faculty of Architecture of Delft University of Technology burned down, in May 2008, the urgency of accommodating a whole faculty led to the decision of re-using the old Chemistry building. Nicknamed 'Red Chemistry' [Macel, 1994], it was constructed in the 1920's (and completed in 1940's) by arch. J. Vrijman, but had never fulfilled its original function, and, having served for many year as TU board building, was left empty. A plan had already started aiming at the re-use of the old structure, transforming it into an apartment building, and a study on the history of the building and the feasibility of the plan had already been carried out[14] The change of function and users, though, required a great additional effort [FIG. 6.19].

The fact that the building was empty and available to harbour the Faculty of Architecture, in fact, did not imply that it could be directly used, as it had been abandoned for years. It needed restoration and transformation to meet the needs of the education of students, a complex process involving the creation of suitable interior spaces and also the shaping of a new appealing appearance [FIG. 6.18].

14 J. Roos (Braaksma & Roos Architectenbureau)

FIG. 6.19 Faculty of Architecture, Technical University (Delft, The Netherlands, arck J. Vrijman) / *photo: S. Naldini*

One of the main points in planning the interventions was that the character of the building needed to be thoroughly understood, in order to restore it, without running the risk of mystifying it or even losing its heritage value. The successful result obtained was possible thanks to a good co-operation of architects[15] and specialists and the support of stakeholders.

Especially the architects felt compelled to reach a good result, within the short time available, as they were working in fact for their own community. The co-operation meant exchange of points of view and proposals, and led to a fruitful confrontation tempering excesses and ending with universally accepted solutions.

15 The restoration was carried out by a team of restoration architects, coordinated by Braaksma & Roos. On the project and the involved architects and instances, cf. AA.VV. *The making of BK city, Bouwkunde, een jaar na de brand*, publ. of the Faculty of Architecture, TU Delft, ImPressed, Pijnacker, 2009

The restoration and adaptation of the building, i.e. the first phase of the planned works, were completed in May 2009; the works were carried out within the building tradition, which had characterized the original construction, that is to say that the transformations done were as little intruding and as effective as possible, and the materials used matched the original ones. The overall idea for BK-City (a main-structure consisting of street(s) and covered courtyards) as a 'public' structure, emerged from the commission of the dean Wytze Patijn and could not have been developed without a proper understanding of the history and identity of the building.

Looking for balance

'Looking for balance' describes the attitude that was followed in planning an integral approach, respecting the existing and anticipating the future.
The nature and the 'spirit' of the building were studied, and the building was defined as a place where use and culture were meant to meet in the course of time. What was found to be valuable in the building had to be made visible, or even placed into a new perspective. Valuable were surely the aspect and style of the building, with its classical form and some elements of the Amsterdam School. Brick, the traditional Dutch building material, together with natural stone, used for decoration, were suitable for a representative educational building of the beginning of the 20th cent. and were restored to increase their visual and historical value and to suggest continuity [FIG. 6.20].
However, it was also considered that the overall effect of the building on the users was somehow suffocating, due to the combination of the imposing style, large spaces and the disorienting structure.

The campus and the city

The university campus was conceived in the second half of the 19th cent., when the construction of new university buildings found place outside the historic centre of Delft.

FIG. 6.20 Traditional materials, brick and stone (Faculty of Architecture, TU Delft, The Netherlands) / *photo: Braaksma & Roos*

The campus developed in the course of the time at a growing distance from the centre, somehow loosing contact with it. With the creation of the Faculty of Architecture, the heart of the campus has shifted towards its north side, and the relationship with the heart of the historical city of Delft has become stronger.

The plan

The original Chemistry building was monumental and imposing, but had never been really appealing and was moreover rather confusing for visitors, due to its complex and somehow *imperfect* form, with too many fragmented spaces through which it was difficult to orient. The planned approach was based on a few, though important interventions, consisting in gaining more space and making the building design better intelligible for the users.

FIG. 6.21 Courtyard transformed into an interior space, interior (Faculty of Architecture, TU Delft, The Netherlands) / *photo: S. Naldini*

FIG. 6.22 Courtyard transformed into an interior space, exterior (Faculty of Architecture, TU Delft, The Netherlands) / *photo: S. Naldini*

Adding space and streamlining the interior plan

Two external courtyards were transformed into interior spaces using greenhouse elements, and a long corridor, a street indeed with side paths, was designed to connect the various parts of building [FIG. 6.21, FIG. 6.22]. The new building was altered inside to create a clear succession of large rooms meant for educational activities and related functions, and including ateliers, laboratories, conference halls, offices, restaurants and storage rooms: all spaces where the students could work, lessons could be given and visitors accommodated. Besides, long and wide corridors could stimulate contacts between them and the education staff. What is becoming increasingly evident is how successful the definition of the spaces has been: presently there are pleasant spaces where daily life and work concentrate and also attractive spaces to move about, sit, talk.

The building of the faculty of Architecture has become a place where the social and the cultural sphere could merge: a social and cultural master plan originated aiming at the creation of 'BK-CITY[16]', envisaged as a new public infra-structure consisting of street(s) and glass-covered squares, in which the potential of the building could be used, enhanced and intertwined in a self-evident manner [FIG. 6.23]. This public structure had always been the missing link, the reason why the old building was somehow dull and uninspiring. It had not been created for the users. Through the transformation the building has revealed its hidden beauty, and changed its greyish aspect into a colourful one. The members of the BK-community could meet on a regular basis in this vital urban and connecting structure. The joined effort of six architects produced thus a new world made of different places, colours and atmospheres, and developed within the framework of the master plan.

16 BK means *Bouwkunde, Faculty of Architecture.*

FIG. 6.23 Corridor connecting spaces and stimulating contact between users of the building (Faculty of Architecture, TU Delft, The Netherlands) / *photo: R. v. Hees*

FIG. 6.24 The imperfection of the original construction is left in sight reminding of the function as a laboratory (Faculty of Architecture, TU Delft, The Netherlands) / *photo: Braaksma & Roos*

FIG. 6.25 Accurate choice of interior decoration and furniture, in contrast to the rough parts visible (Faculty of Architecture, TU Delft, The Netherlands) / *photo: Braaksma & Roos*

A naked building

Having taken out all (dropped) ceilings, and having connected the spaces by opening new passages, the building emerged as a strong structure, with exposed materials, pipes and electrical installation, recalling the beauty of the imperfection [FIG. 6.24]. The infrastructure of technical installations left in sight, made the reinterpretation of the original idea of a laboratory emerge in a strong way, in the still informal atmosphere of an unfinished - naked - building.

The accurate choice of the design furniture and the creation of pleasant and surprising spaces inside, contributed to enhance the contrast between the grey shell and the cosy interior decoration, emphasizing the beauty of the latter and creating an attractive atmosphere [FIG. 6.25]. The choice of the red, violet, fuchsia and purple carpets was also meant to dampen the noise, like the large photo panels on some walls.

Even the library was made attractive and original with the central desk constituted of layers of unsold books, ordered by colour and shade, with a glass plate on top. This is also a durable way of re-using books.

The restored building was different from the original one, and yet very close to its original identity, and perfectly connecting past and future. In this sense, the building has become an icon of re-use. As such, in June 2011, it obtained the Europa-Nostra price in the field of conservation and the nomination for Dutch Renovation Award.

BK City

Still, the building presently needs improvement, especially for what concerns the indoor climate (upgrade) and sustainable repair of the structures. This is the focus of the second phase of the intervention, 'BK-City Stay!'[17], improving the comfort in a durable and sustainable way, of a building originally meant to be the temporary seat of the faculty.

A proposal to apply internal insulation on the walls was dismissed as too invasive for the type of building and also too expensive. Even the insertion of double window frames, which had been studied when apartments were to be created, appeared for the present situation not feasible: the accessibility and maintenance would be difficult and the insulation of the masonry piers in between windows virtually impossible in relation to the budget. However, double glass within the existing iron frame would be possible. The formation of a cold bridge in the window frame will be accepted and will become part of the *imperfect* building system. The window frames were treated *in situ* to be more durable.

The new ventilation system

The air-circulation system, which had been conceived in 2008 as a temporary solution, needed improvement, especially for what concerns the refreshment of the air.
The newly designed system is based on a natural ventilation concept. The starting point for planning the work was again the existing structure. Special attention was paid to the different orientations of the rooms, needing a tailored indoor climate approach, and to the existing ventilation openings, originally meant to serve the rooms where chemical experiments were to be done. These openings, furnished with moulded decorations looking like lion heads [FIG. 6.26], had never been used and were sealed with masonry fillings.

17 The original idea was to create a temporary seat for the University

FIG. 6.26 The lion head like ventilation openings (filling visible inside) (Faculty of Architecture, TU Delft, The Netherlands) / *photo: S. Naldini*

The new plan of natural ventilation is based on the most effective and still less intrusive measures possible: the 'lion heads' were freed from the filling and re-used and ventilation ducts were hung from the ceiling.

The Heat Recovery System

A ventilation duct, connected to a 'lion head', supplies fresh air to a heat recovery unit and to the room; in the unit, the heat from the room is transferred to the air from outside. The air is spread into the room through a ventilation hole. The warm air to be exhausted, having left the heat unit, goes through an exhaust duct and another 'lion head' and is finally eliminated [FIG. 6.27].
In FIG. 6.28, supply and exhaust ducts can be seen.
The exhaust air flows near the supply duct, thus heating up the fresh air. On the left a textile duct is visible, which swells when air is supplied. Through little holes the air is distributed in the room. The duct on the right used to serve as air supply duct in the ventilation system of 2008.

FIG. 6.27 Ventilation ducts connected with the 'lion heads' (Faculty of Architecture, TU Delft, The Netherlands) / *photo: S. Jansen*

FIG. 6.28 Supply (fabric) and exhaust ducts (Faculty of Architecture, TU Delft, The Netherlands) / *photo: S. Jansen*

FIG. 6.29 Windows in the glass walls of a former courtyard (Faculty of Architecture, TU Delft, The Netherlands) / *photo: S. Jansen*

FIG. 6.30 The original form of the roof (Faculty of Architecture, TU Delft, The Netherlands) / *drawing: Braaksma & Roos*

FIG. 6.31 Present situation of roof and windows; the frames are now aluminum (Faculty of Architecture, TU Delft, The Netherlands) / *photo: S.Naldini*

The ventilation of the courtyards is entrusted to the openings positioned on the roof and in the walls [FIG. 6.29], both at a higher level with respect to the people in the room. In the summer, a difference of 1-2 degrees, between the outside air and the air in the room will be sufficient to establish the necessary air movement for the cooling, whereby the heating in the winter will be ruled by an 'Air Handling Unit' positioned on the roof of the building.
The heating system for the building is based on a Combined Heat Power system.

Maintenance and improvement

The general maintenance of the building will also include the brick masonry, natural stone and the slates of the roofs. The roof will be given special attention. The roof originally reaching the string-course of the façade had been transformed already in the 1960's, before the re-use, in such a way that windows could be placed, to make the attic space utilizable. In 2008 these windows were found to be in a pretty bad state of conservation and were upholstered and painted in bright colours, those of the European flags. In this way the more informal atmosphere of the new faculty would be expressed by the exterior of the building and the international character of the faculty suggested. However, this solution was meant to be temporary, and a recently started intervention will substitute the windows with aluminium framed ones. The informal colouring as an expression of an 'in between' time is no longer valid. A neutral expressive and repetitive way of placing windows more belonging to the roof than to the façade, is the solution chosen, as an interpretation of the old slate roof ending on the stone cornice [FIG. 6.30, FIG. 6.31].

The level of sustainability, which can be reached in the second phase, will result from a compromise: improve the existing through an integral and innovative approach to reach a balance between historical/cultural, ecological, social and economic aspects.

FIG. 6.32 Former garden of the Gemeentemuseum (The Hague, The Netherlands, arch. Braaksma & Roos) / *photo: Dick Teske*

6.8 – Transforming outdoor spaces into interior spaces: Gemeentemuseum in the Hague compared to BK City

We have described the transformation of two external courtyards at the BK building. A greenhouse space frame was placed in the open area to create room for the students' ateliers, as well as for meetings and lectures. The yards have thus become amazing places, suitable for all envisaged aims. The idea of making the garden of the *Gemeentemuseum* into an agreeable place for the visitors (lingering, drinking coffee and relaxing) and external public (dinners, receptions, conferences …) [FIG. 6.32] is somehow similar to that of the university, but has a much deeper impact[18].

Dialogue

Very important was to find out how to make the outdoor space interior, without losing its character as an outdoor room and besides making the new construction dialogue with the architecture of H.P. Berlage. The intervention was meant to create architecture of great durability and sustainability showing very precise craftsmanship and love and care for materials and details, as expressed by the treatment of the 'skin' of his buildings. It was in fact decided to use Berlage's work as a starting point, focussing on his architectural style, a hybrid reminding of Italian Renaissance and the architecture of Frank Lloyd Wright, and the role assigned to colour and pattern of the brick masonry. The beautiful light falling in the museum from the windows overlooking the garden was definitely to be maintained. In order to leave the atmosphere undisturbed, a construction completely made of glass was designed, different from that of BK city where a more 'industrial' atmosphere had been created. [FIG. 6.33]

18 Arch. J. Roos (Braaksma & Roos architecten); M. Eekhout Engineering

FIG. 6.33 The new construction in dialogue wit the architecture of H.P. Berlage (Gemeentemuseum, The Hague, The Netherlands, arch. Braaksma & Roos) / *photo: A. Veldt*

In both cases an independent structure was engineered apart from the existing buildings. In the museum, the glass roof would be supported by eight metal and cladded columns, leaving the construction of the museum completely untouched, and giving the impression of being floating over the existing museum-building. Rainwater from the roof would be collected in invisible gutters.

The eight columns would be supported by the museum cellar built in 1998, and were thus erected where the concrete columns of the cellar stand: their structure, location and number were such that they could perfectly carry the weight of the glass.

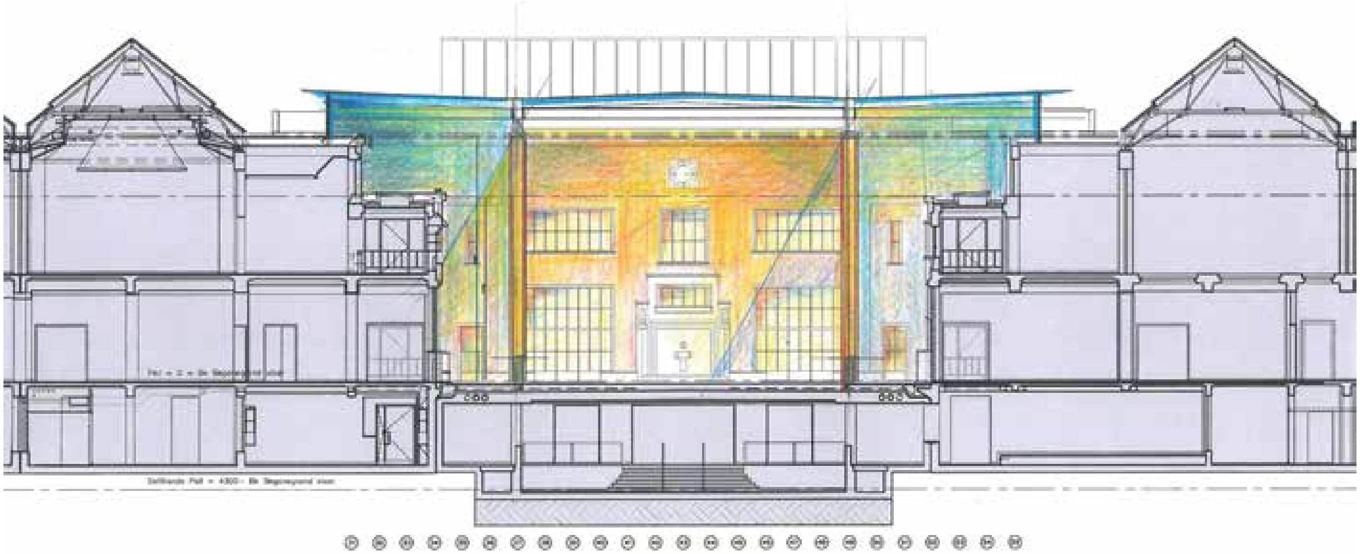


FIG. 6.34 Gemeentemuseum, The Hague, The Netherlands / *drawing: Braaksma & Roos*

Having studied the construction designed by H. P. Berlage it appeared that it would have not been possible to use the existing structure for achieving the goal, and this explains why it was decided not to build actually using the existing, but to create a continuity with Berlage's architecture on a different level.The position of the columns forms a pattern reminding of the traditional division in surfaces of the gardens in the past and which is in line with the geometry created by Berlage. The result is a 'pergola-construction', as an outdoor -interior reminding of the architecture of Berlage [FIG. 6.34]. The columns were designed, painted and treated in such a way that they could be felt as involved in a conversation with the walls of Berlage's surrounding building.

The columns support a grid of iron beams covered with insulated glass panes. All glass elements are fastened securely. All columns and beams are cladded with perforated aluminium (behind which installations/wires are hidden), which helps to comply with acoustic standards. Under the glass, an additional transparent layer contributing to the acoustic performance of the space has been inserted [FIG. 6.35].

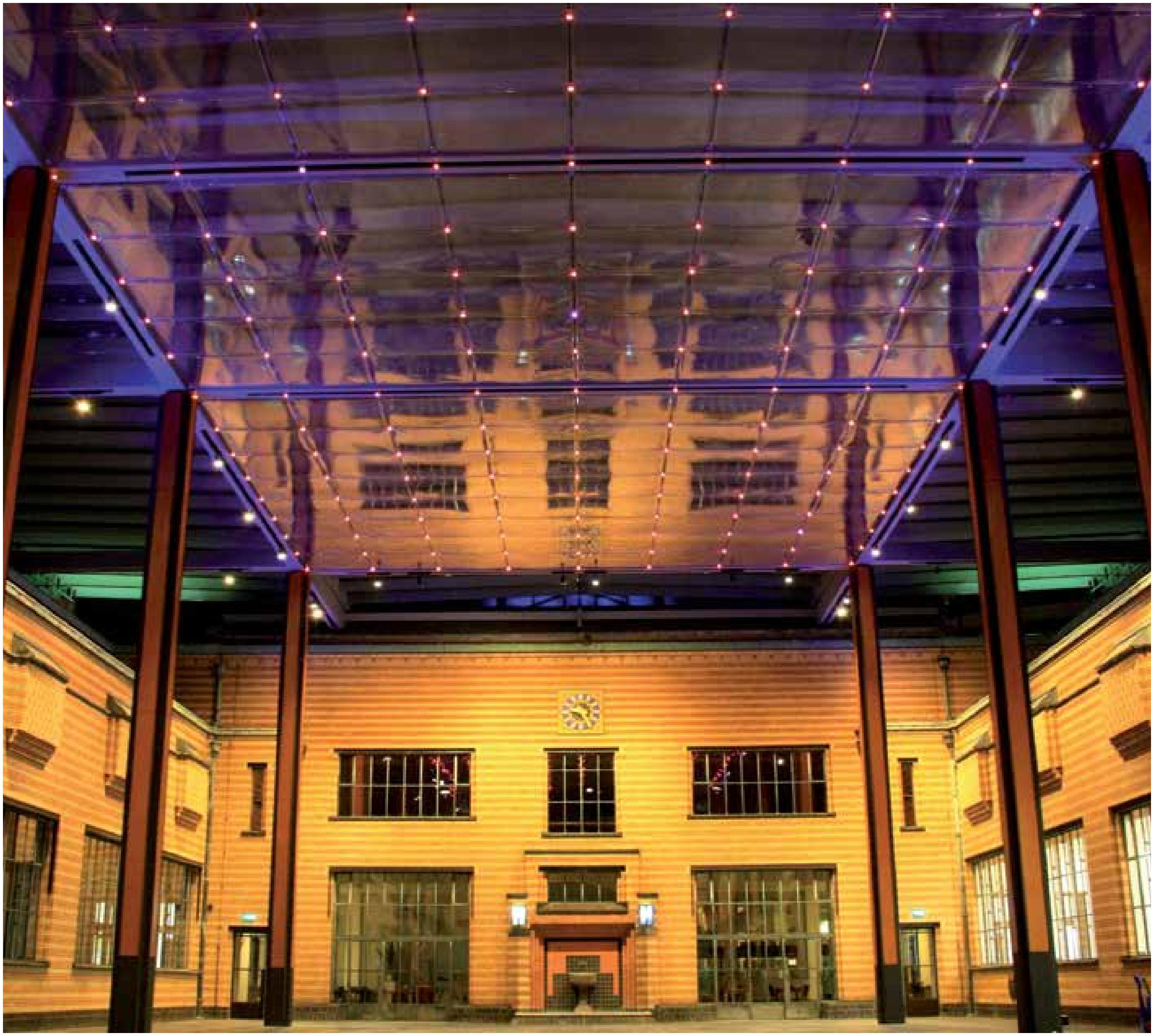


FIG. 6.35 Night view of former garden (Gemeentemuseum, The Hague, The Netherlands, arch. Braaksma & Roos) / bron: http://www.livingdaylights.nl/project/gemeentemuseum / *photo: Proliad*

FIG. 6.36 Craftsmanship: materials made according to traditional methods and selected for their properties and also colour (Gemeentemuseum, The Hague, The Netherlands) / *photo: Braaksma & Roos*

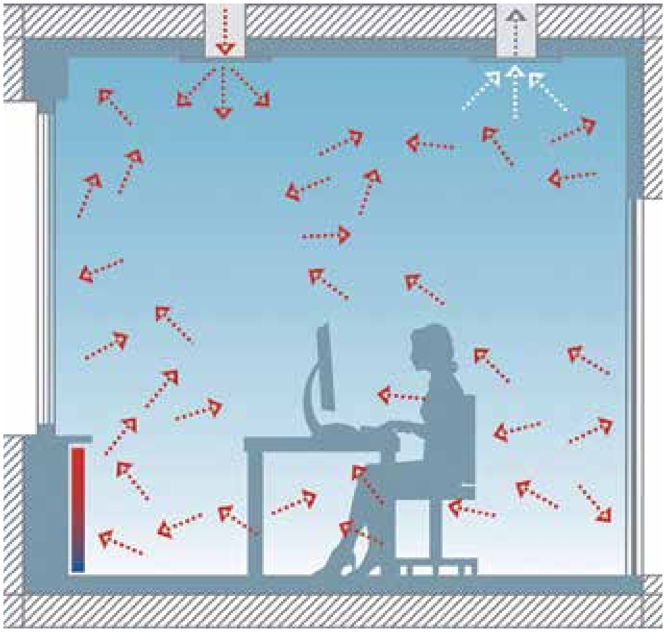


FIG. 6.37 The Ba-opt system / *drawing: Braaksma & Roos*

The floor was made in dark brownish-grey concrete to match the plinths of the original walls (thin copper expansion grooves have been made in the floor) and to enhance the light colour of the brick masonry. All construction elements have been fabricated and applied by high-level craftsmen, possessing good knowledge of the materials and their use [FIG. 6.36]. This was an innovative approach allowing to make the dialogue with Berlage - always so interested in all aspects of the materialization - very explicit and to have the existing and the new merge.

Sustainable climate design

In the large room made of low iron glass a system called Ba-Opt[19] was installed to guarantee a homogenous spreading of the air, which is reached by an optimalization of the amount and the rate of fresh air blown into the room. The system could be used without any intervention (e.g. insulation) on Berlage's walls. On the basis of a lightly increased air pressure, a quick air movement was achieved, which is not to be felt, but is enough to avoid temperature differences and cold downdraught [FIG. 6.37].

19 See also: www.baopt.de. It should be said that the Ba-Opt system cannot be applied *tout court* to all historic buildings, but possibilities and limits of its implementation need to be assessed beforehand.

FIG. 6.38 The glass structure floating on the existing walls in the transformed garden (Gemeentemuseum, The Hague, The Netherlands, arch. Braaksma & Roos) / *photo: A. Veldt*

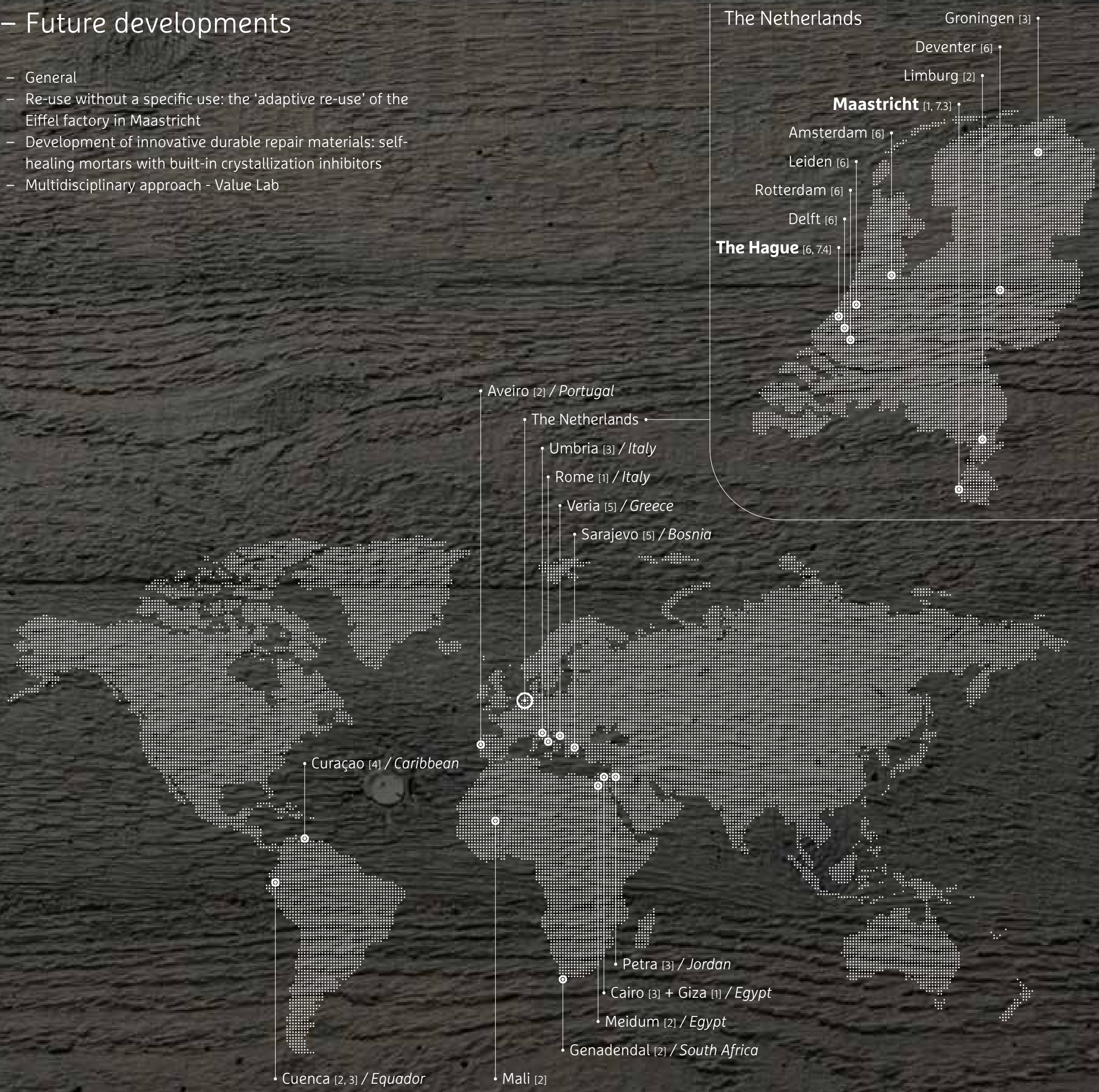
Integral approach

The glass construction is thus in line with Berlage's building, in terms of form and colours, does not hinder the ingress of light in the museum, and, although open and transparent, is thermally and acoustically insulated [FIG. 6.38]. In this sense the most essential heritage values of the building have been respected and even underlined by the detailing and the choice of materials of the intervention, whereas functional elements for the sustainable use, such as acoustic materials and thermal insulating glass have been applied. The materials used are products of good craftsmanship and have been coated, painted and applied in such a way as not to undergo deterioration processes. In this sense they are also durable. The new enclosed space can be defined as being sustainable.

The whole approach was based on the idea of an integral design, meaning to start from the study of the original materials and work in line with them and their use to clarify and enhance the heritage value of the building. The light, a most important element both for the added part and the main building, emerges as a most powerful element. The clue of the intervention on this special building consisted on 'going under the skin' of Berlage's architecture and act on the most essential values of the building: light and materials.

7 – Future developments

7.1 – General
7.3 – Re-use without a specific use: the ‘adaptive re-use’ of the Eiffel factory in Maastricht
7.2 – Development of innovative durable repair materials: self-healing mortars with built-in crystallization inhibitors
7.4 – Multidisciplinary approach - Value Lab



7 – Future developments

Innovative research towards the development of materials and a new designers' approach to buildings and whole city areas are described as promising for an increased durability and sustainability of our built environment.

7.1 – General

Durability in terms of service life of materials generally also means an increase in their sustainability: the initial cost in terms of energy spent for their fabrication, transport, use and maintenance is somehow spread over the time elapsed from the date of construction to the present. Some materials are more prone to decay and need maintenance and intervention for prolonging their service life. Much research is done to ensure a better resistance to environmental factors, especially when aggressive, as for example sea salt spray or acid rain due to environmental pollution.

Mortars and plasters are building materials, which deserve special attention, both for their broad field of application and their widespread use and for their susceptibility to decay processes. Prolonging the life in service of these materials, limiting the need of interventions and substitutions, is one of the challenges of modern science: both durability and sustainability can and will be strongly improved.

This chapter on future developments will start from the level of the materials. It will be shown how innovative materials can contribute to durability and sustainability, by presenting the state of the art of the research on self-healing mortars, being a potential solution to recurring problems of mortar deterioration. The horizon will be further widened showing how a durable and sustainable approach to existing buildings can be directed in the future, with the introduction of the concept of 'adaptability'. An 'adaptive re-use' solution will favour the future employ of the building, which will keep its main structure, though becoming flexible and suitable for meeting the needs of different users. As mentioned before, sustainability is not only related to energy saving and limited need of maintenance, but can be also found in the continuity of use.
Finally the innovative approach of the multidisciplinary Value Lab, based in The Hague will be briefly discussed.

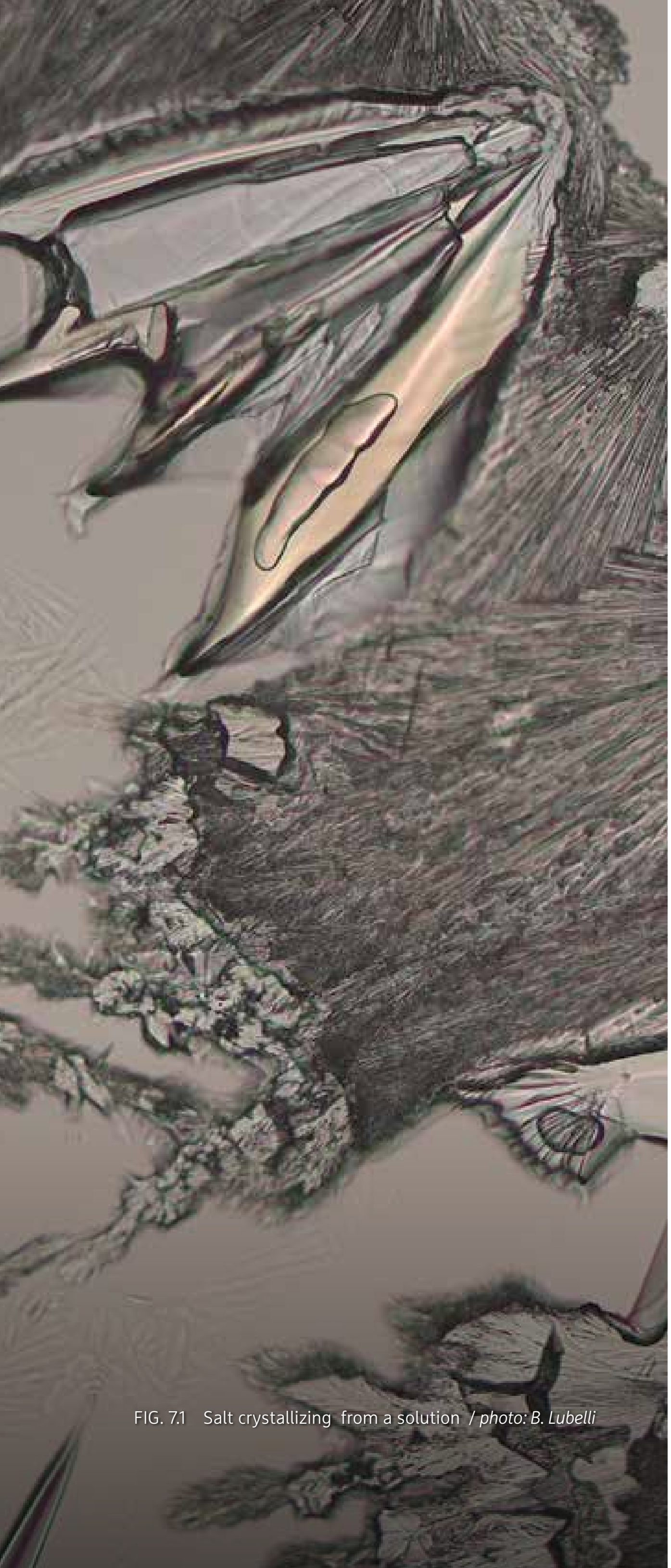


FIG. 7.1 Salt crystallizing from a solution / *photo: B. Lubelli*

7.2 – Development of innovative durable repair materials: self-healing mortars with built-in crystallization inhibitors

Self-healing of materials sounds like something very new, but the process has always occurred, even though it has been described as such only recently [Lubelli et al 2008, 20011, 2012, Zwaag Van der et al 2012]. As a matter of fact lime mortars applied in practice possess that property. The mechanism works as follows: mortars, during their lifetime, undergo many internal movements. These may be due to hardening and drying shrinkage at the beginning of their life, whereas later on also movements due to temperature changes or to vibrations may occur. The process of shrinkage, alternating with expansion may result in (little) cracks in the mortar. Cracks, being open to water penetration, may contribute to further material decay caused for example by processes like frost action or salt transport [FIG. 7.1].

At the same time however, something interesting happens: rain water penetrating in the mortar dissolves some of the binder of the lime mortar and subsequently the dissolved particles are deposited at the borders of the cracks; there they can slowly fill up the cracks [FIG. 7.2, FIG. 7.3]. Under certain conditions the binder of a lime mortar may dissolve and then recrystallize in another place.

The above described phenomenon is known as self-healing. It contributes to the durability of (lime) mortars. Of course some prerequisites are necessary: the surrounding conditions should be such that the mortar regularly gets wet and can dry again; this means that this process will for example not take place inside buildings. Further, the self-healing process cannot go on forever, because at a certain moment there would be too much of the binder dissolved and the mortar might become mechanically too weak.

FIG. 7.2 Self-healing in lime mortar (canal bridge in Amsterdam, The Netherlands) / *photo: R. v. Hees*

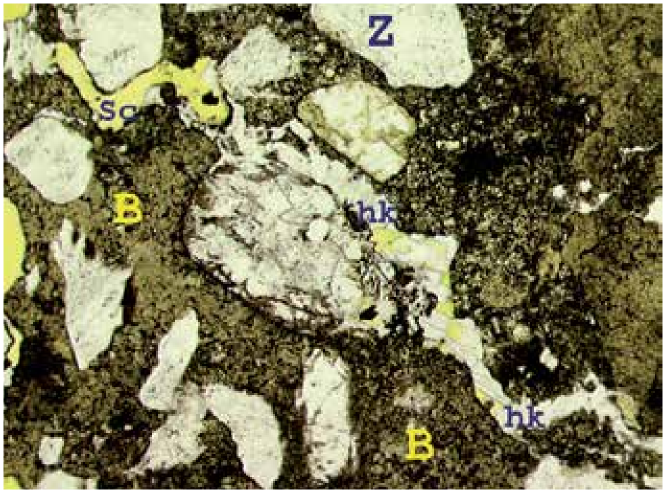


FIG. 7.3 Thin section of mortar showing a crack filled with precipitated lime (canal bridge in Amsterdam, The Netherlands) / *photo: R. v. Hees*

FIG. 7.4 Exfoliation and crumbling of plaster applied on a salt loaded substrate / *photo: R. v. Hees*

FIG. 7.5 Loss of adhesion and crumbling of plaster applied on a salt loaded substrate / *photo: R. v. Hees*

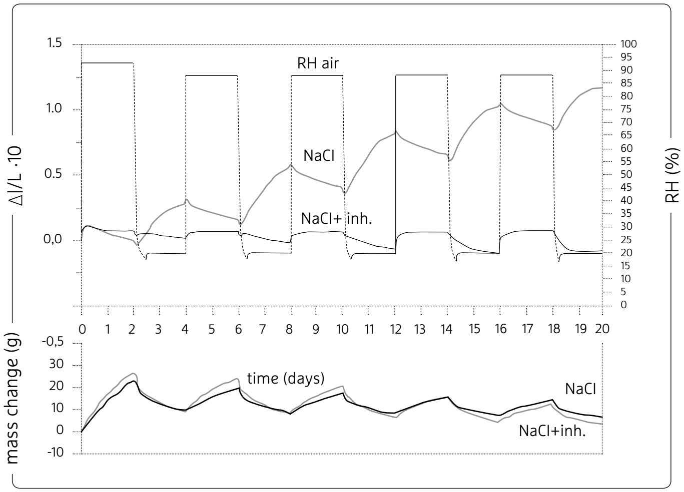


FIG. 7.6 Dilation (upper graph) and weight change (lower graph) of NaCl contaminated specimen with and without inhibitor during RH cycles [Lubelli, 2006]

FIG. 7.7 Sanding of the outer layer of the mortar in the presence of NaCl after 6 RH cycles / *photo: s Barbara Lubelli*

What is new now is the idea that such a process could perhaps be controlled and enhanced or optimized and could eventually be applied to hinder other degradation processes. At the Faculty of Architecture in Delft in 2013 a PhD research project was started to investigate the possibilities of self-healing of repair mortars for restoration purposes [Granneman, 2013]. One of the most recurrent degradation processes taking place in ancient materials (stone, brick, mortar) is salt crystallization resulting in different damage types like crumbling or sanding of the materials [FIG. 7.4, FIG. 7.5].

From other research performed in Delft [Lubelli, 2006] [FIG. 7.6], it was already known that certain chemical products (anti-caking agents, crystallization inhibitors) may have a positive effect in avoiding crystallization damage to mortars. In FIG. 7.7, a dilation experiment on mortar slabs performed in laboratory is shown. A mortar would, like all materials, expand, and shrink under the influence of changing RH (relative humidity of the air), where expansion occurs at high RH and shrinkage at low RH. In the presence of salts (such as NaCl, kitchen salt and also the main component of seawater) in the mortar, a strange phenomenon occurs. It leads to a completely opposite behaviour: shrinkage at high RH and expansion at low RH. And not only that: the expansion increases with each cycle and turns out to be irreversible.

The crystallization cycles in the presence of NaCl, without the addition of an inhibitor result in an irreversible change in length of the mortar slab and finally in severe sanding of its surface [FIG. 7.7], whereas, in case of the addition of an inhibitor to the salt solution, no irreversible length change and no damage occurs

It appears that the crystallization inhibitor is able to change the shape in which salts would crystallize (modifying the ‘crystal habit’), in this way becoming less dangerous [FIG. 7.8].

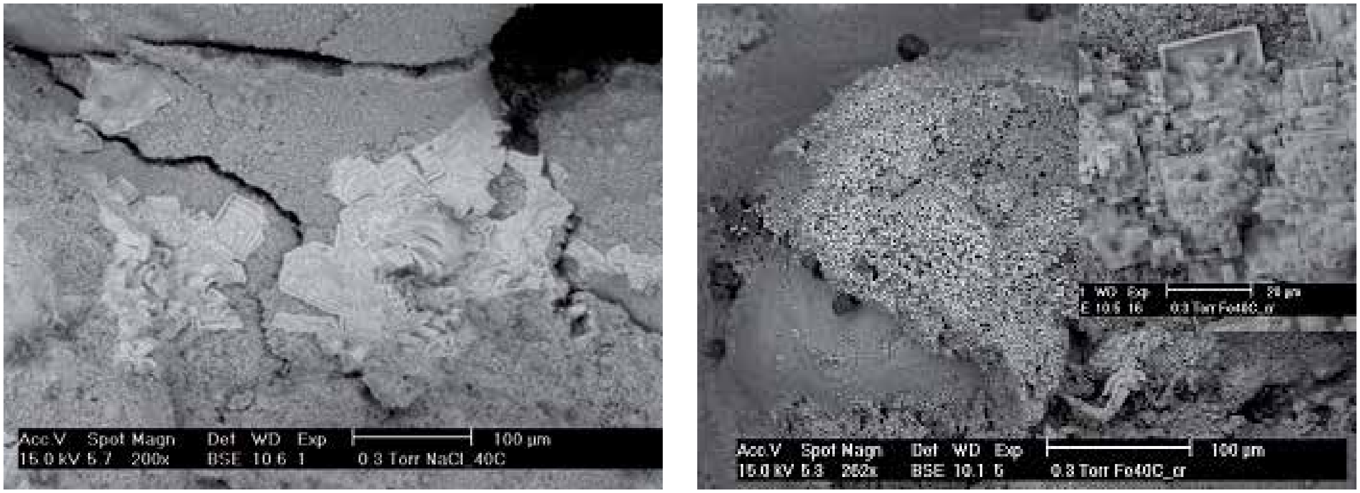


FIG. 7.8 Effect of crystallization inhibitor (sodium ferrocyanide) on the crystal habit of sodium chloride: sodium chloride crystallizing in the absence (left) and in the presence of inhibitor (right). In this case the inhibitor was added to the contaminating salt solution / *photo: s: Barbara Lubelli*

Although the effect was positive, it should be reminded that this result could up to now only be obtained in laboratory and that the inhibitor was added to the salt solution that was then sucked into the material. Of course this is not realistic for practice situations; therefore, the big challenge is to try to add inhibitor molecules to the mortar, in such a way that as soon as the salts would start to be absorbed by the (repair) mortar from a salt loaded substrate, the inhibitor would be triggered (activated) and would then prevent the occurrence of damage to the new mortar. It may be clear that such a method would be an enormous step forward and would both enhance durability of the mortar in its application and contribute to sustainability.

Although this research is just at the beginning, the potential seems huge as the built-in crystallization inhibitors might increase the expected service life of mortars and other building materials, like plasters (and perhaps even concrete) considerably, resulting in positive economic effects, since the cost of the maintenance of buildings (the costs of replacement of pointing mortars alone are amongst the most relevant of all yearly maintenance costs on Dutch listed monuments) would be considerably reduced.

Finally, salt crystallisation problems are expected to considerably increase in the central part of Europe under the influence of climate change [Nijland et al., 2010; Sabbioni et al, 2010]. This stresses the importance of this research line.

FIG. 7.9 Beautiful spaces and lighfall in old factory (Sphinx factory , Maastricht, The Netherlands) / *photo: Braaksma & Roos*

7.3 – Re-use without a specific use: the 'adaptive re-use' of the Eiffel factory in Maastricht

Re-using a factory, turning it into a building where people live and meet, implies the necessity of making it inviting and commodious. The sequence of the interior spaces within the austere and maybe unrefined shell, interesting technical solutions achieved and the feeling of imperfection, can all be turned into something surprising and beautiful. Small alterations not affecting the character and value of the building can make it sustainable, keeping its main qualities and making them more evident. *Creative engineering* is the clue to successful interventions requiring a tailor made approach [Roos, 2013]. The project of the re-use of the Eiffel factory will start soon and it is presented here, pointing at the *vision* behind it.

The proposed re-use project for the Eiffel building in Maastricht [FIG. 7.9, FIG. 7.10], a former sanitary furniture factory of Royal Sphinx Maastricht, can be called an 'adaptive re-use', a restoration aimed at making the existing building durable and sustainable, without imposing an explicit function. A well-considered restoration was planned for the structure to be used in many different, not anticipated, ways, and to become an open, comfortable and safe space. Limiting the restoration to ingenious, but minimal interventions, the character of the building will be left unaltered, still guaranteeing durability and sustainability, both in terms of materials and future use. The materials will be kept and upgraded when necessary and the building made ready to more than one destination.

The factory is a listed building belonging to the Dutch industrial heritage, as it embodies a layered historic past. This is a complex context, in which different values are interwoven, on the urban, historical, cultural, structural and technical level, which need to be taken into account in the planning of the interventions.

FIG. 7.10 The Sphinx factory (Maastricht, The Netherlands) / *photo: Braaksma & Roos*

FIG. 7.11 View of the interior: essential and unrefined spaces (Sphinx factory , Maastricht, The Netherlands) / *photo: Braaksma & Roos*

As a monument, the Eiffel building is a 'memory' of the past, but, as a building having lost its function, it needs to be made ready for any potential employment, to guarantee its future use and life. Being a factory, the building was constructed to achieve a high standard production process and needed to fulfil certain aims, whereby priority was given to efficiency, more than to comfort of workers, and to practical results, more then to style. Such results were to be reached using modern building materials like concrete, and suitable building techniques [FIG. 7.11. FIG. 7.12]. The Eiffel factory seems, at first sight, to be a mere functional building, but soon proves to be rich in surprising details and nuances.

FIG. 7.12 Different levels inside the factory (Sphinx factory, Maastricht, The Netherlands) / *photo: Braaksma & Roos*

FIG. 7.13 The sequence of windows is an important aesthetical factor as they animate the façade (Sphinx factory, Maastricht, The Netherlands) / *photo: Braaksma & Roos*

Identity

Many are the precious elements forming this unique building and needing preservation. The concrete slabs, often irregular in structure and bearing the signs of the formwork, and the imperfection of the steel window-frames and grids, so far away from the present idea of sustainability in terms of modern requirements, but still important to create relief in the long wall surfaces [FIG. 7.13] belong to the essential elements determining the perception of the building and revealing its character.
The re-use of the building requires well-considered solutions, in equilibrium between the preservation and enhancement of the value of the existing construction and the wanted flexibility to meet the needs of different potential users, guaranteeing a durable exploitation and easy management and maintenance. Such a far-reaching goal has to be achieved with very limited interventions and the minimum economic effort possible.
A feasible approach was planned for each problem to be solved, without applying a priori solutions, but always trying to be innovative within an established ethical and technical framework. A preliminary, deep-going study (building archaeology, materials and technical state of conservation) was done to better understand the building in all its aspects, from its volumes and internal connections of the various parts, to the materials and techniques used. Having assessed the state of conservation of all the components, and their value, compatible materials and suitable techniques were selected for the interventions.

FIG. 7.14 One chimney reconstructed to serve as a signal (Sphinx factory, Maastricht, The Netherlands) / *photo: Braaksma & Roos*

Toolbox

For the general plan of intervention, the words of the British architect John Allan can be again recalled: 'Repair, Upgrade (performance) and Transformation'. These three nouns suggest actions, which, concerning the Eiffel building, are to be performed in view of different possible functions. The restoration of façades and roofs is going to be done within the framework of the repair and upgrade actions and upgrade will be further achieved with the optimization of the heating and cooling systems as well as the fire prevention of the monument. The third action, the transformation of the existing will be taken down to a minimum, avoiding working at a given adaptation, to guarantee flexibility and adaptability in the future to various conceivable scenarios.

The steel windows will be restored but not substituted, keeping their single glass panes, to preserve their value as imperfect products of past craftsmanship. The shell of the building is in fact the real focus of all operations, and this is planned to be maintained as it is, including the open, continuous space inside which will be kept as well as the traces of time on the walls, being the ageing skin of the construction.

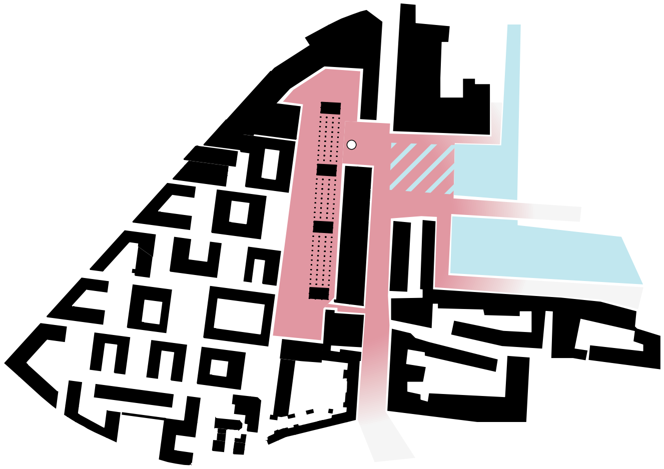


FIG. 7.15 The location of the Sphinx factory and the city center (Maastricht, The Netherlands) / *drawing: Braaksma & Roos*

The city

The Eiffel building is not only valuable as an architectural shape and a reminder of an industrial past, but also as part of a former industrial landscape, which will be transformed into a park, still sharing its identity with that of the factory. The factory is visible from the city centre and will work as a hinge, connecting the heart of the city with the park, and the urban centre with the former industrial area One of the destroyed chimneys of the factory will be reconstructed on the basis of the original one, but in a different material, to serve as a signal, a vertical post connected with the factory by means of glass bridges, to increase the visibility of the building and stress the idea of its capability of expanding in all dimensions [FIG. 7.14, FIG. 7.15].

In terms of durability, the restoration and improvement of the existing materials of the building will grant them a longer life in service, whilst the heritage values of the building are preserved.

A hypothesis of re-use of the basement, the intermediate and the top floors of the building was presented, showing how the functions envisaged could influence the interventions [FIG. 7.16]. The basement would be meant for public use and left as far as possible untouched.
The most relevant changes would occur in the top floors, where apartments could be hosted. In this case, the windows would be altered and made suitable for the daily use of the inhabitants, needing to easily open and close them. Thermal insulation will be then necessary and improved ventilation will be created.
The other floors would be approached in relation to their functions. In this way, sustainability will be aimed at, looking for optimal solutions in harmony with the existing, which will be kept undisturbed, and at the same time, made comfortable for the users. The shell of the building will be left untouched, being the main vehicle to transmit the significance of the building and the means to connect it with its environment.

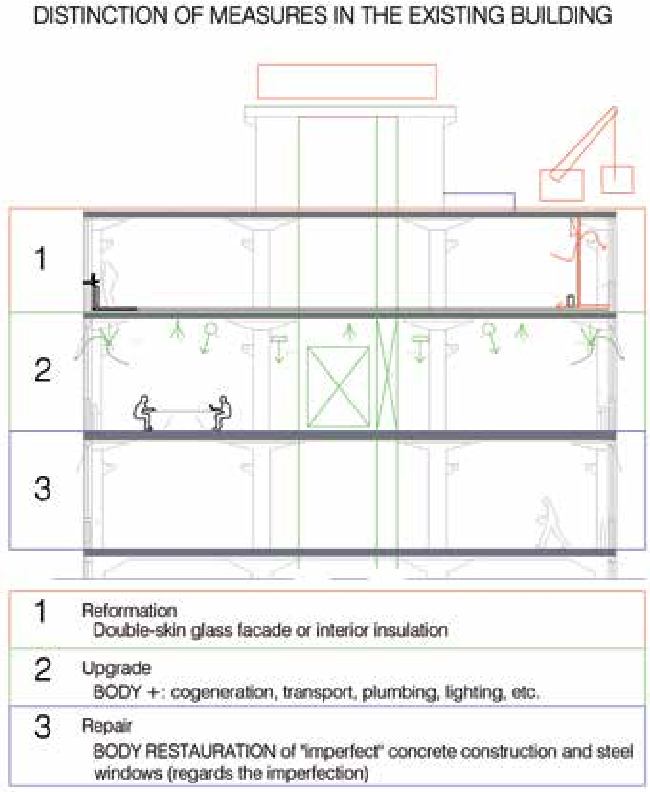


FIG. 7.16 Possible use of floors (Sphinx factory, Maastricht, The Netherlands) / *drawing: Braaksma & Roos*

7.4 – Multidisciplinary approach - Value Lab

When the heritage world started to pay attention to the conservation and the re-use of monuments, the focus was laid on single buildings. However, in the course of time, it was gradually understood that a heritage building may possess the strength to enhance also the significance of surrounding buildings, even when they are less valuable, and to provide the means for a requalification of the (urban) landscape [FIG. 7.17]. Architecture and landscaped were felt to be strongly related [cf. UNESCO Recommendation, 2011]. But now we know that there is more. The enormous quantity of vacant buildings in our environment, points at the need of a different approach.

The key concept of Value Lab is that urban (re-)planning cannot be separated anymore from the re-use and that it should involve heritage, ordinary buildings and their surroundings. This could only be achieved through a multidisciplinary co-operation. Value Lab – a collaboration of Braaksma & Roos Architecten, DELVA Landscape Architecture, The Cloud Collective, Witteveen+Bos and Alterra – has translated this philosophy into an innovative working strategy. Built environment and landscape are studied emphasising the aspects characterizing the site and offering potential in the area of sustainable interventions. A layered investigation is carried out, resulting in a precise assessment of the strong points of the site and its buildings, and leads to a design, in which different levels of value are assessed across a global scale: promising combination of elements can be further developed, considering also economic and social aspects.

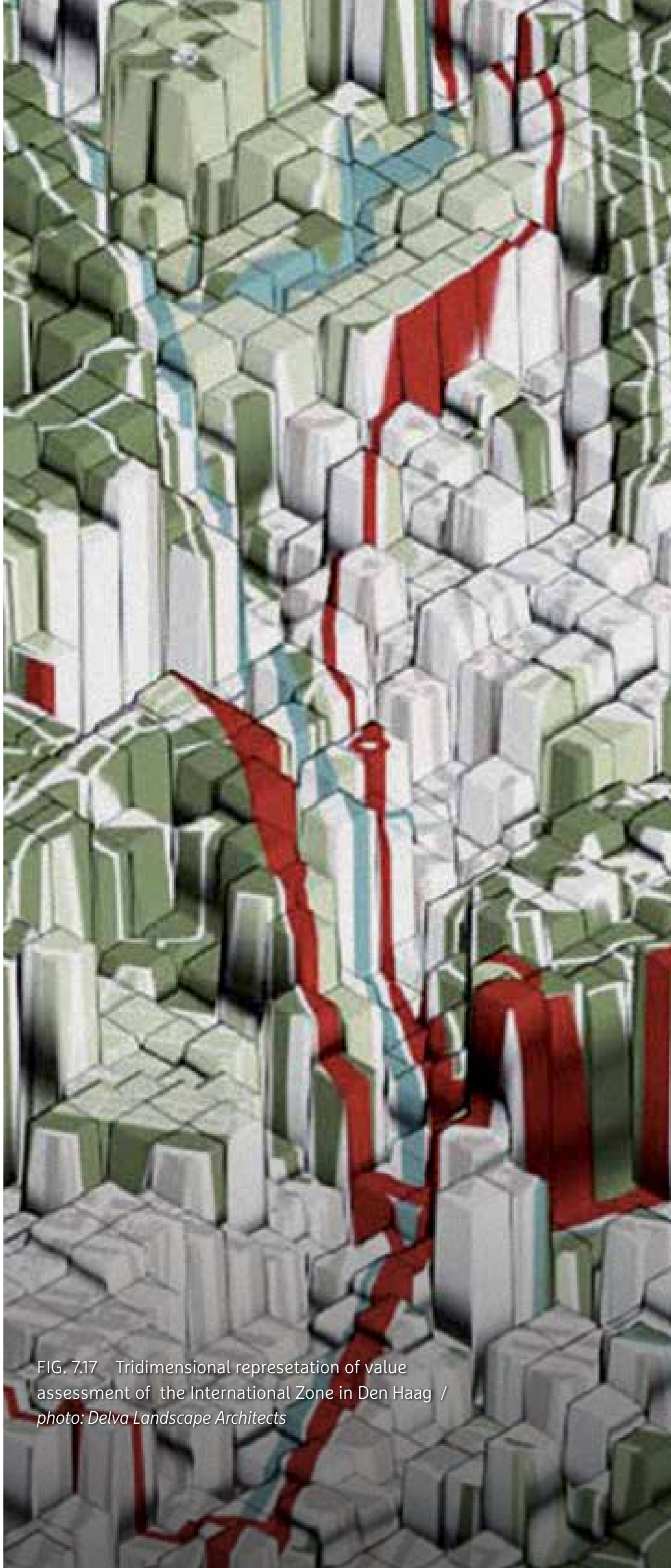


FIG. 7.17 Tridimensional represetation of value assessment of the International Zone in Den Haag / *photo: Delva Landscape Architects*

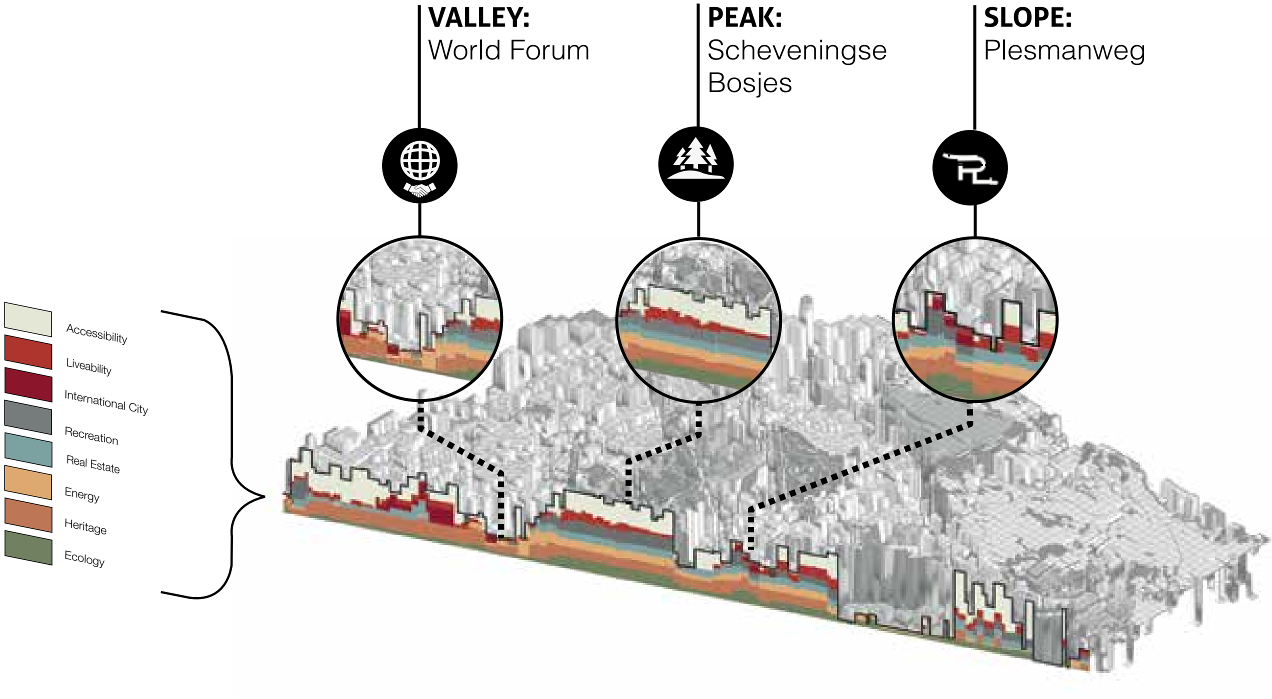


FIG. 7.18 Value Lab: investigation of the International Zone in The Hague (The Netherlands) / *drawing: Value Lab team*

In the study-project concerning the International Zone in The Hague the aim was to provide the existing with a new qualification, finding sustainable solutions for the future, and using the strategy mentioned above. This is a complex task but necessary for a thorough, integral (and thus sustainable) approach. The work began with an analysis of the area, aimed at the perception of the 'genius loci', the intrinsic value and the sense and power of the place. The essential features of the area were singled out from different points of view, like landscape and ecology or history and urban culture, and each of them was sized in terms of value. This material was expressed in 3D graphs, in which the *peaks*, *slopes* and *valleys* essentially represented the urban area with its strong and weak points [FIG. 7.18].

The ultimate goal was to plan an urban and landscape regeneration supported by economically adequate investments. The area of the International Zone was found to possess such economical and societal potentials, as to lift the quality and identity of the whole city of The Hague. Like the example of the sheet on the table shows [FIG. 7.19], lifting a peak will lift all the surroundings. The heritage buildings would be the leading elements of the rehabilitation, which would also concern many vacant buildings, susceptible to be the object of a sustainable development.

FIG. 7.19 The sheet gives an idea of the role of peaks, expected to be able to lift the surrounding slopes and valleys / *photo: Value Lab team*

The approach described here brings us back to the beginning of this book, that is to say to the definition of the philosophy of the section ‘Heritage & Architecture’. We need to understand our heritage buildings to be able to perform historically and technically correct interventions. This is the main assumption, but it is not enough: the concept of *built environment* is of primary importance and encompasses significant buildings, ordinary buildings, and the landscape. They *all* should be involved in the requalification. This will lead to sustainable heritage buildings in sustainable cities, seen as a unity including also the land, well maintained or uncultivated, but always possessing a ‘sense of place’. The character of the place and of the buildings needs to be the starting point, as preservation and alterations can guarantee only in this way continuity of use and involvement of the people, and finally sustainability.

8 – Lessons learnt

The past is a wise and inspiring teacher: staying close to the past means to derive knowledge, which can be used for a well-considered approach to achieve durable and sustainable interventions in historic buildings. Listed or not as monuments, buildings constructed in the past are memorials of construction methods and materials and reflect also steps in the development of social structures. In line with the phiplosophy of S. Brand [Brand S., 1994], some important considerations are made, emerging from the cases described in this book. They are the fundaments of the following seven ‘lessons learnt’.

8.1 – Integral approach toward complexity

Durability and sustainability are closely related to cultural and historic values, the environment, the present and future functionality of the construction, and the comfort and safety of the users. We need to assess, preserve and enhance durability and sustainability of the materials of a building, while designing its re-use. This implies considering various aspects related with life and function. The building needs to be made flexible and adaptable to different aims, which will increase the probability of a **continuous use**, avoiding abandon and subsequent neglect. While preserving the historic value and character of a building, special details in the construction can be emphasized, as well as qualities, letting a new and attractive identity emerge from the original one, and making people feel comfortable and safe in it. Modifying and optimizing the existing with relatively small interventions, much can be obtained. The function of the building or building part will guide the interventions, in pursuit of a balance between the existing, even when imperfect or unrefined, and the new. Therefore, although energy performance is a very important aspect to be taken into account when dealing with interventions in historic buildings, the above considerations are perhaps even more essential for the sustainable future of our built heritage[20].

20 Roos J. De duurzame ontwikkeling, op cit.

It should be kept in mind that **durability and service life** are very much related to the **environmental processes (moisture, frost, etc.)** affecting the building, whereas **sustainability** is also strongly related to its **socio-economic** context.

8.2 – Material and care

Any intervention on a historic building should be a **quality intervention**, also from the materials point of view: compatible but durable materials should be used in order to reduce the risk of the building becoming shabby looking after a short time and to contribute to a **low maintenance frequency**. Interventions on architecture belonging to the cultural heritage should be done with caution, which means that the behaviour of restoration materials under the specific circumstances should be known, before application. The introduction of intrinsically more durable, but incompatible materials, has often resulted in damage and decline, as the case of Curaçao showed. Any method of intervention should be assessed in terms of compatibility and expected success within the given environment of the object. The optimal materials for intervention should be **compatible** and **renewable**, as a guarantee for a long service life of the whole.

8.3 – Energy use

An important dilemma in nowadays striving for zero-energy buildings is how far one can go in monument-retrofitting without either impairing heritage values or creating risks for the historic fabric. **The focus for sustainability however should not only be on thermal insulation and energy performance, but also on alternative solutions. Global knowledge as well as innovative technologies and materials** can strongly contribute to durability and sustainability, as it is the case of systems modifying the climate of the monument, or the development of self-healing mortars. Further, the choice of repair methods and materials is of primary importance for sustainability. In principal the approach should be based on **adaptation to the existing**: the study of the materials and their condition will make it often possible to keep them and even improve them, avoiding substitutions and waste. There are attempts to develop instruments to deal with this kind of dilemmas, what to keep and what to substitute and how [Nusselder et al, 2008, 2011], but progress still has to be made.

8.4 – Flexibility

One of the qualities of a heritage building is intrinsically present in the building itself, and contributes to sustainability: a long service life. **Service life means usage, and a long term future usage should be the aim of any well-considered intervention.** What can guarantee its achievement is a **flexible renovation design**, making the building suitable for different functions. The building needs to be made attractive, and meet the needs of the users, while **preserving its character**, that only history and local context can reveal.

8.5 – Learning from the past

Vernacular architecture is strongly connected to landscape and available materials. It clearly expresses the **sense of place**, which is so important to understand a site. The intrinsic qualities of many examples of vernacular architecture are very inspiring, also for different environments. They show possible solutions and make clear that interventions in the existing should be based on a thorough **study of buildings and land**. Local and global knowledge need to merge, always being sensitive for lessons from the past.

8.6 – People

Interventions in the existing should be an answer to **societal needs** and aim at making both the buildings and their surroundings accessible and usable for the **people**: the bond which will result will guarantee their sustainable use and will support maintenance policies.

8.7 – Triangle

Heritage buildings are **testimonies of our past** and bear the traces of time: they need to be respectfully maintained and adjusted to serve new goals and continue their life in modern times, in a sustainable way. Architects and all those responsible for our heritage buildings should ideally move in the **triangle** formed by Design, Cultural Value and Technology to perform a balanced and well-considered intervention.

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Colophon

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The Rondeltappe Bernoster Kemmers Foundation was established in 1995 by architect Leendert Rondeltap from The Hague with the aim of purchase and conservation of Dutch Heritage Monuments.
Rondeltap was the architect of the Europa Hotel in The Hague, among other buildings, and was also professor Architectural Drawing at the Royal Academy of Visual Arts.
The Foundation can assign awards to priva Rondeltappe Bernoster Kemmers Foundation te persons or institutions.
In this framework, the Foundation has made a cooperation agreement with the faculty of Architecture of TU Delft: during five years, starting in 2014, annual publications will be issued in the Rondeltappe book series. The publications will be used for the MSc education of the section Heritage & Architecture of the Faculty of Architecture at Delft University.

To learn more about the objects belonging to the Foundation please refer to the website: www.stichtingrbk.nl.

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