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Resilience in architectural heritage
VAN GENDTHALLEN - AMSTERDAM
Resilience in architectural heritage
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INTRODUCTION

This chapter introduces the graduation project, together with a brief description of the design studio. It will also include the subject with a brief theoretical introduction. The chapter ends with the research question of this research report and the method that has been used with this research.

HERITAGE AND ARCHITECTURE

This research report is written for the graduation project of the ‘van Gendthallen’ in Amsterdam, as a part of the graduation studio of Heritage and Architecture at the Technical University in Delft. Dominant in the chair of Heritage and Architecture is the notion of dealing with existing buildings and their context. This notion is getting more important because a lot of buildings lose their function over time, leaving them vacant and unused. An intervention strategy can exploit the hidden potentials of a building, making it ready for future use. The intervention strategy starts by investigating and analyzing the existing building through different scales and time. Based on the viewpoint of sustainability, dealing with the existing offers a lot of possibilities. Instead of demolishing the vacant existing buildings, Heritage and Architecture seeks for possibilities to transform existing buildings for future use. The design methods presented by the chair of Heritage and Architecture, stress the importance of determining and subsequently elaborating the cultural historical values of a space. This approach appeals to me because it is a responsible way of acting within architecture. There lies a great opportunity on how to deal with the existing within the field of architecture.
INTRODUCTION

DESIGN OBJECTIVE
This project concerns the future of the ‘van Gendthallen’. The van Gendthallen are situated on the edge of the inner city of Amsterdam on the Oostenburger Island. The Oostenburger Island is part of the Eastern Islands which are former harbor islands. The building consists out of five giant halls and was an important part of Werkspoor/Stork. It was initially built to fulfill the delivery of 40 locomotives and 400 railroad carriages to South Africa. The ‘van Gendthallen’ and the Oosterburger Island had a great influence on Amsterdam and the Netherlands. Meurs (2008) explains that a building or site invokes certain feelings and memories, shows a certain degree of cohesion and illustrates established social views. These valuable characteristics of a site are the cultural-historical values of a site. This research report tries to implement the concept of resilience in a project dealing with architectural heritage.

PROBLEM
The long period of flourishing capitalism where fossil fuels were cheap and abundant, is characterized by the immense industrial development, urbanization, economic and population growth. "In the blink of an eye and with hardly a thought, our species has come to the verge of dominating everything that happens on the surface of the planet" (McKibben, 2008, p. 17). Unfortunately this period did not pass without causing global processes that impact cities today. Policy-makers and planners are trying to tackle these processes such as urban densification, the economic crisis and the environmental crisis.

Urban networks are defined by formal and structural characteristics of urban systems, where environmental factors seem subordinate. Conversely environmental sciences have not incorporated urban networks in their reasoning (Forgaci, 2014b). This defines the imbalance of city planning and environmental sciences. Therefore, the challenge is to seek new ways to incorporate the best of both professions to create sustainable cities.

As cities grow, the spatial morphology, infrastructures and services constantly need to adapt to absorb external changes and to meet the needs of the future users. There is a need for resilience within urban systems. Resilience is a relatively new concept that lacks a clear definition. Resilience generally refers to a system with the capacity to bounce back, adapt or transform in order to absorb external changes. These external changes can vary from societal to environmental changes (Forgaci, 2014b). Examples of societal changes are for instance: change of user, change of the number of people, change of owner or political changes. Examples of environmental changes are for instance; temperature changes, changes in the amount of rainfall or energy scarcity. The concept of resilience derives
from the field of ecology, and is recently also being used by urbanists. However its implication has not yet being adopted in the field of architecture. Therefore, there is a great potential to implement the concept of resilience in the designs of buildings.

**AIM**

It is important to understand that a design is subjected to external changes. When a design is not capable to absorb these changes, it is less likely to last a long time.

“All buildings are predictions. All predictions are wrong ... In the 1960’s Buckminster Fuller’s geodesic domes were a vision of the future, that turned out to have no future at all ... the domes were unable to adapt or grow, so they died” (Brand, 1994)

But if a designer embraces the fact that his design is subjected to change, he or she can respond to this fact by following resilient design strategies. Therefore a design or redesign of an urban system or a building is rather seen as a next chapter of a long lifespan instead of a final product.

The concept of resilience has great potential as a sustainable design strategy for projects dealing with architectural heritage. Architectural heritage has somehow proven its own resilience over time, because it is often adapted to new usage. Because of its scale, industrial architectural heritage is often seen as very resilient. Because of the large open spaces, they are easily transformed for new use. A resilient building such as the ‘van Gendthallen’ offers a great opportunity to elaborate its resilient character (fig. 1.4).

**RESEARCH QUESTION**

Research concerning resilience mainly focusses on ecological systems and to a lesser extent on urban systems. Resilience is still rarely discussed in relation to its applicability in the field of architecture, let alone the field of architectural heritage. The main challenge is to broaden the implementation of resilience in the field of architecture. This led me to the following research question.

How to ensure a resilient transformation when dealing with architectural heritage?
METHOD

This research report consists of a theoretical research regarding resilience and a practical implementation of a resilient strategy in a project that deals with architectural heritage. The method that I used for the theoretical research can be explained by a metaphor of a funnel. This means that I start with a broad theoretical framework, and when the research develops it is getting more specific till the point of the conclusion.

The theoretical research starts by describing the origin of the concept of resilience in the field of ecology. From there the research narrows down to resilience in the field of urbanism. The research continues by linking the concept of resilience to architecture and architectural heritage. The whole research is accompanied with several case studies, giving clear examples of practical implementations of the concept. The research ends with a description of the designproces project of the ‘van Gendthallen’. Because the project of the ‘van Gendthallen’ is not yet finished, the end design cannot be discussed in this research.

Resilience

The term of “resilience” derives from the Latin word ‘resilire’, which means ‘bounce’ or ‘jump back’ (Dipasquale, 2013). It is generally know as the capacity to absorb and even benefit from hazards regardless of their magnitude or occurrence (Forgaci, 2014b).

System

In this report the term (urban) system is used in the context of urban landscape. It is an urban fragment that is part of a bigger urban landscape (Forgaci, 2014b).

Spatial Morphology

Spatial Morphology is the relation between the shapes of the city in relation to the typology of its buildings. Morphological analysis is often used to get a better understanding of a city (Leupen, 2007).

External changes

Changes that influence a building. They vary from societal to environmental changes. Examples of societal changes are for instance: change of user, change of the number of people, change of owner or political changes. Examples of environmental changes are for instance: temperature changes, changes in the amount of rainfall or energy scarcity (Forgaci, 2014b).
A comprehensive analysis of the building and site has been done but it is not included in this research report. This chapter gives a brief summary of some important findings of the analysis of the ‘van Gendthallen’. It tries to capture its identity by determining the cultural historical values which are necessary for a resilient design.

**EASTERN ISLANDS**

The Oostenburger Island is part of the eastern Islands in Amsterdam. Over time, these islands have adapted to the changing environment. The construction of the eastern islands began in the 17th century. This was a century of massive industrial and economic development. From the beginning, the island where home to the VOC (Dutch East-India Company) and the admiralty of Amsterdam.

After the French occupation in 1813 the steam engine technology gradually changed the face of the islands. Large factories and industrial halls were built to accommodate the shipping industry. NDSM was one of the big shipping industry firms that was located on the islands. After the construction of the railway network in Amsterdam, the island was no longer connected to the important waterways.

The shipping industry collapsed and was replaced by industry where they produced locomotives and carriages. The islands were initially built near the borders of the city of Amsterdam. Yet due to the vast expansion of the city, the Islands are now situated near the heart of the city. On the south side of the island the new IJ-tunnel caused the Islands to become enclosed by the rest of the city center.

**IDENTITY - EASTERN ISLANDS**

- The Islands have been used for several industrial activities. The islands continually adapted to accommodate the needs of that time.
- The Oostenburger Island where home to the VOC (fig 2.1). The old structures are still present.
- Over time, the island got an introvert character because it got enclosed by the railway and the IJ-tunnel.
- The islands were originally situated at the border of the city. Due to the expansion of the city, the islands are now situated near the heart of the city.
- The islands were at first built for the harbor industry. This is still visible in the old water structures that are present today.
OOSTENBURGER ISLAND

The construction of the 'van Gendthallen' began in 1898 after the design of A. L. van Gendt. The halls were built for the production of locomotives and carriages for the company of Werkspoor/Stork. The whole island worked as one big production unit and is characterized by its large industrial grid as shown in figure 2.4.1. The waterways were used to ship raw materials to the Oostenburger Island. The materials were used for the production of locomotives and gas turbines. The central road in the middle of the Island was used to move products, but was also used by the workers themselves.

Figure 2.4.2 shows that a railway was added around 1950. This railway connects the island with a bigger railway network. This railway was used to ship products and created a new access road to the Island. Later in the second half of the 20th century, the industry moved away from the island. The connection with the water is gone as shown in figure 2.5.3. The island is now ready for redevelopment.

IDENTITY - OOSTENBURGER ISLAND

- The Island is characterized by its large industrial grid as shown in figure 2.4.

- The Island was used for several industrial activities. It continually adapted over time.

- The road in the centre of the Island was intensively used by the workers.

- Figure 2.4 makes clear that the whole island worked as one big production unit.

- The island is enclosed by water. The island has always made use of the waterways, but when the industry left, the connection with the water was gone.
The first three halls of the ‘van Gendthallen’ were built in 1898. They were built next to two already existing industry halls. Around 1910 the existing halls were partly replaced by the fourth and fifth hall which are still present today. In this period the ‘van Gendthallen’ are characterized by a clear floorplan (fig. 2.6.1). The first three halls are used for handling raw materials and hall four and five are used to assemble the locomotives. Figure 2.7.1 and 2.8.1 show that the flow within the building had a clear direction. Raw materials enter the building from the waterside and finished products leave the halls at the north side of the building.

In 1922 the hall four and five caught fire, so from 1923 till 1927 hall four and five were rebuilt. Figure 2.6.2 shows that later in 1950 the function changed. This makes the floorplan a bit harder to read. An important addition is the railway in the middle of the halls. It forms an important new passage that connects all the halls.

Around 1970 the halls were mainly used for the production of gasturbines instead of the production of locomotives. The van Gendthalen constantly adapted to new use in a very pragmatic way. After 1970 the van Gendthalen were used to house several small companies. The municipality of Amsterdam is currently working on making plans to transform the islands and the ‘van Gendthallen’.
The building characterized by its pragmatism. Basically the building can be seen as a covered overhead crane (figure 2.9). The cranes were needed to move heavy objects around. The roof kept the workers and the products save from weather influences. The ‘van Gendthallen’ is built in different phases, which is visible as well on the inside as on the outside. Each hall has its own character, but there are also strong interrelations between some of the halls. Hall one, two and three are strongly connected and separated by a wall from the other two halls. The building skin makes the five halls appear as one unit (figure 2.10). The identity of the ‘van Gendthallen’ is largely determined by the spatial effect of the halls (figure 2.11). The height and the gigantic depth of the halls in combination with the rigid rhythm of the columns and trusses give the halls a raw industrial character. These characteristics are the result of a series of pragmatic design decisions made over time.

**IDENTITY - VAN GENDTHALLEN**
- The ‘van Gendthallen’ are built in different phases. The historical layering of the building is visible from the inside and the outside.
- The ‘van Gendthallen’ are built in a very pragmatic way which is visible on the inside and outside of the building.
- For a long time, the halls functioned as one big production unit.
- A former railway connects all the five halls.
- The building is basically a covered overhead crane.
- The ‘van Gendthallen’ housed different functions and adapted over time.
- Hall one, two and three form a self-contained ensemble. A giant wall separates them from hall four and five. The building skin unites all the five halls.
- The spatial effect of the halls, caused by the dimensions and repetition of the columns and trusses give the halls an industrial character.
This chapter starts by explaining resilience in the context of ecology, followed by an explanation of urban resilience. Then it formulates a definition of the concept of resilience in the field of architectural heritage. Finally it describes design strategies to achieve resilience. The whole theoretical framework is visualized in a diagram which is shown at the beginning of every sub chapter.

**THEORETICAL FRAMEWORK**

**RESILIENCE IN ECOLOGY**

The concept of resilience was originally introduced by Holling (1973), who was active in the field of ecology. The traditions of analysis in theoretical and practical ecology have been largely inherited from the developments in the methodology of physics. Holling argues that the methodology of physics is less useful in the field of ecology. The methodology of physics tends to emphasize a quantitative view in their analytic approaches, where the attention is focused on achieving a constancy. An engineer for example, designs a system to perform a specific task under a narrow range of predictable changes. Slight departures from the performance goal of this system should immediately be counteracted. An engineer would like his system to deliver a constant performance, counteracting against predictable external changes. In the field of ecology, where ecological systems are continually affected by unpredictable external changes. The constancy of the behavior of an ecological system is subordinate whereas the long persistence in the face of changes becomes important. A long persistence of an ecological system suggest that it has a high capacity to absorb changes. Therefore Holling argued that within the field of ecology the attention should shift to a qualitative view. So you could say that the methodology of physics follows an equilibrium centered view, which says little about the transient behavior of an ecological system that is in a non-equilibrium state.

Holling (1973) explains that insect populations are generally contained within their borders by their natural enemies. However, there are always external changes that will disrupt this balance. With some insect species for example, specific climate conditions can cause large variations in population numbers. One might say that this is an example of a stable cycle with large fluctuation. However, it is more accurate to say that it is a cycle determined by the interaction between the insects and their natural enemies in combination with periodically changing climate conditions. The population is unstable, but is highly capable of absorbing extreme periodic changes. This is exactly the difference in methodology Holling addresses. The methodology of ecology usually focused on the stability of an ecological system. An ecological system is considered stable when it returns to an equilibrium state after being exposed to external changes. The more rapidly it returns to its former state, the more stable it is. Holling introduces a new non-equilibrium focused concept of resilience. He explains that; "... resilience is a measure of the persistence of a systems and of their ability to absorb change and disturbance ..." (Holling,1973, p.14)
between populations or state variables." (Holling, 1973, p. 14) A system can be highly unstable and still be incredibly resilient. A resilient system also has its boundaries, and when these are passed the system transits into another condition. Holling admits that the equilibrium centered view is analytically more tractable, but it does not represent a realistic explanation of a systems behavior. Resilience was thus in the beginning seen as a method to understand the ability of ecological system’s behavior. In short, resilience was originally seen as method to understand the ability of ecological systems to deal with external changes.

Over time Holling’s (1973) concept of resilience is adopted by other ecologists. Walker (1981) worked with (Holling) in 1981 on an article about the stability of ecological systems and resilience. Recently Carpenter and colleagues wrote an article about social-ecological resilience, because he noticed that the social and ecological systems can no longer be seen separate from each other because of the immense influence of human activities in ecological systems (Carpenter, Chapin, Folke, Rockstorm, Scheffer, & Walker, 2010). This is particularly interesting because social-ecological resilience establishes a link between resilience in the context of people and resilience in the context of the environment as interdependent systems. This link is relevant to the field of architecture, and urbanism in particular, because it discusses resilience in relation to people and their environment.

Carpenter et al. (2010) fear that the future of human well-being might be at risk if we pass a critical threshold that transforms our current ecological system into another condition. In this case they refer to the limits of a resilient system as explained by Holling (1973). Their fear is based upon the environmental problems caused by human activities. Preventing such a transition will require drastic changes in our society.

Part of the environment is the physical built environment which refers to human-made surroundings ranging from buildings and parks to cities and infrastructure. The physical built environment can be seen as a representation of society, because the physical built environment is shaped by the society itself. In time society influences the built environment and vice versa. The society influences the built environment by adapting it to fulfill current needs. The built environment can also influence the society by for example evoking certain emotions or by introducing new concepts for buildings that change our way of living. The Unite d’Habitation (fig. 3.2) by le Corbusier is a great example of a project who changed our perception of living in the city in a residential building. The mixed use building is basically a city within a city. The innovative spatial and functional design is optimized to serve the wishes of the user. Le Corbusier innovatively brings nature inside the building by designing rooftop garden.

As a result, when either society or the physical built environment gets more resilient, it will have a mutual effect on its counterpart (Meijer, 2010) so to improve resilience of the environment, the social resilience should be improved. Earlier I explained the concept of resilience with an example about an insect population. The insect population itself could absorb external changes and survive. The case of human-beings is fundamentally different. In case of the insects, the population size itself is the determining factor of its resilience and the climate condition is the external change at play. In case of human-beings the increasing population can be seen as an external change and the built environment should adapt to this change to prove its resiliency. The built environment and ecological systems have one significant thing in common; they have the potential of absorbing change.

1 Social resilience
Social resilience is the ability of the user to adapt to external changes. These changes can be a result of social, political and environmental disturbances. Social resilience of a community is not based on the individual but on the collectivity. To ensure resilience on the level of the collectivity, a change of mindset of people is needed which leads them to behave sustainable (Meijer, 2010).
URBAN RESILIENCE

The research of Carpenter (2010) about social-ecological resilience led to the adoption of the concept of resilience in the field of architecture and explicitly urbanism. Now the concept of resilience has been used widely in the field of urbanism. As cities grow, the spatial morphology, infrastructure and services constantly need to adapt to absorb external changes and meet the needs of the future users. Urban resilience is often defined as the capacity of a system to bounce back, adapt, or transform in response to disturbances. Urban resilience of the urban environment can be divided in two types: specified and general resilience (Forgaci, 2014b).

Specified resilience is an approach where a certain form of resilience is explicitly built in, to absorb specific external changes (fig 3.4).

In case of specified resilience the question: ‘resilience of what to what?’, should be answered (Walker & Salt, 2012, as cited in Forgaci, 2014b).

When talking about general resilience the question: ‘resilience of what to what?’ is irrelevant. General resilience is an approach where a system needs to have a certain immunity. It does not matter to what kind of external changes the system is immune. It is only important that an immune system can prepare and protect itself against as many external changes as possible. In that sense, general resilience is equivalent to immunity (Forgaci, 2014b). The challenge for urban resilience is caused by the increased complexity of urban networks and the unpredictability of external changes.

Forgaci (2014a) says that the unpredictability of external changes makes the central question ‘resilience of what to what?’ within specified resilience somehow impossible to answer, and therefore useless. For this reason, he claims that the approach of general urban resilience is better suited to be used in urban design projects. However, the approach of general urban resilience is rather idealistic, because it is impossible to be prepared for everything. Besides, there are methods to determine the probability of some external changes, so the question of ‘resilience of what to what?’ is to some extent possible to answer.

The perspective on resilience is strongly dependent on the perspective on vulnerability of a system. Vulnerability is important for the discussion of resilience for three reasons.
"First, resilience thinking helps provide an all-hazards approach, consistent with trends in hazards research to evaluate hazards holistically ... Second, resilience puts the emphasis on the ability of a system to deal with a hazard. It allows for the multiple ways in which a response may occur, including the ability of the system to absorb the disturbance, or to learn from it and to adapt to it, or to reorganize following the impact ... Third, because it deals with the dynamics of response to hazards, resilience is forward-looking and helps explore policy options for dealing with uncertainty and change." (Berkes, 2007, p. 284)

These three reasons show how hazard studies can help to measure the vulnerability of a system. This can help to identify where and how the concept of resilience can be applied. In this case a hazard does not necessarily indicate a disaster such as floods, earthquakes etc. Hazards can also be less drastic such as population growth, ageing of a city, frequency of changing functions of certain parts of the city etc. A hazard can be seen as an external change that might influence an urban system or building after it is built. Berkes (2007) claims that we will never fully be able to predict future changes and that we should focus on reducing the degree of uncertainty and at the same time try to develop new approaches to cope with change that cannot be predicted. This may seem paradoxical. On the one hand future changes are unpredictable and on the other hand we need to develop approaches to cope with these changes. But how can one develop an approach to cope with changes which are unpredictable? One must study and identify the hazards. What will be the frequency and intensity of these events and how can the built environment react to these changes? Resilience must be based on the environmental, ecological, social and economic drivers and dynamics of a particular place (Cadenasso, 2003). In other words, the context of a system determines what the hazards can be, and therefore what resilience means. This implies that an approach is needed that lies somewhere between the specified and general resilience. From a general perspective resilience is incorporated as much as possible. From a specified perspective the incorporated resilience is based on an analysis which makes the resilient measures more specific. So every project needs a thorough analysis of the context to identify its hazards and possibilities to incorporate resilience.

The analysis and conclusions of the context of the ‘van Gendthallen’ have already been discussed in chapter two. These conclusions have specified the external changes (societal and environmental) which are important in the specific case of the van Gendthallen. The possible external changes are taken into account during the design process of the ‘van Gendthallen’.

1Vulnerability
Vulnerability is the sensitivity of a system to external changes (Forgaci, 2014b). If a system is very vulnerable, it is very sensitive to external changes.
**Theoretical Framework**

**Resilience in Architectural Heritage**

If a building is not resilient, over time replacement will be its destiny. Arefi (2011) seeks to find the relation between resilience and architecture. According to Arefi there are three aspects that affect the resilience of a system: form, function and flow. Just as organisms adapt to their habitats, building forms can also adapt through, for example, a floorplan which allows a building to be expanded (fig. 3.6).

The function refers to the purpose of a building. Research shows that cities need both units that are highly specialized for a specific function and also units that are unspecialized and can house several functions (fig. 3.7). These units should be kept apart so that the adaptability of one unit would not disturb the functions and growth in the other (Arefi, 2011). The flow of a building is related to the flows of information, movement, services and people that form separate but interconnected webs of critical relationships. Building services as water, gas and air are handled by an Infrastructure of pipes. People require a different type of infrastructure, they meet and move through a building making use of public space and routes. The Rubik’s cube concept (fig. 3.7) is based on the premise that buildings change, but the infrastructures persist over time. The infrastructure ensures an interconnected web dat connects every part of the city.

**Heritage and Architectural Resilience**

Form, function and flow affect all the different layers of a building. The layers of a building are very important in the context of resilience because every layer has its own permanency and therefor require different design approaches during the design process. Brand (1994) distinguishes six building layers. The site is the most permanent and the stuff is interchangeable and the easiest to adapt. Brand argues that the temporary layer provides originality, whereas the more permanent layers provide continuity and restraint. An architect needs to be aware of the permanency of every layer in order to design a resilient building. Structure and site require the most attention because these are the most permanent layers. A lot of industrial buildings, including the ‘van Gendthallen’ are

---

- **RESILIENCE**
  - The capacity to bounce back, adapt or transform in order to absorb external changes
  - Environmental changes (climate change, floods etc.)
  - Societal changes (change of use, political change etc.)

- **FORM** (adaptive capacity of a form of a building)
- **FUNCTION** (the purpose of parts of a building)
- **FLOW** (the flow of services, people etc. within a city)

- **Heritage and Architectural Resilience**
  - General: Resilient to every possible scenario
  - Specified: Resilient to what? (based on hazard studies)

- **Values** (the cultural historical values of a building)
- **Adaptive Capacity**
- **Densification**
- **Redundancy**
- **Modularization**
- **Multi Scale Networks**
- **Connectivity**

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**Fig. 3.5** Resilience: ability of the built environment to adapt to change

**Fig. 3.6** The Rubik’s cube concept is developed by the University of Cincinnati School of Planning. It is used as an analogy to show the interchangeable forms, functions and flow of a city.

The infrastructure provides a flexible grid in which offers a lot of possibilities. (Arefi, 2011)
intentionally or unintentionally resilient. The structure design of these buildings is often very flexible, creating large spaces that can be used for any kind of usage. Another example is the design for the ‘kunststad’ in a former shipbuilding hall (fig. 3.8). They designed a new infrastructure and a flexible bearing structure within the halls. The new users can design their own spaces within the new structure. A more detailed description of this project will be included later in this research. The challenge when dealing with industrial heritage is to come up with a structure that can absorb external changes to be resilient.

Fig. 3.8 The ‘Kunststad’ was built in 2006 by a design of Dynamo Architecten. It a creative hub with studios for all kinds of artists. (www.ndsm.nl)

The three aspects Arefi (2011) discusses influence the resilience of a building and are perfectly applicable in new built architectural projects. However, since they say nothing about the cultural-historical values of a building a different approach is needed in projects of architectural reuse. When dealing with architectural heritage, these values should in particular be taken into account. A building or site invokes certain feelings and memories, shows a certain degree of cohesion and illustrates established social views. These valuable characteristics of a site are called cultural-historical values of a site (Meurs, 2008). These values can be determined by making a thorough analysis of the building and site. If the cultural-historical values are not taken into account, a building loses its value and therefore its resilience. This does not mean that an existing building is sacrosanct. “Redevelopment serves both the past and the future without either being subservient to the other” (Roos, 2007, p.12). When dealing with architectural heritage the continuity of the cultural historical values should be the first priority, in order to establish a meaningful relation with the existing. In order to apply resilience to projects of architectural reuse, it seems necessary to add a fourth aspect to the three aspects (i.e., form, function and flow) mentioned by Arefi (2011), namely the aspect of the cultural-historical values. This means that while assuring resilience, the cultural-historical values of the existing building or site should be maintained. Architectural heritage needs to be handled with care, because the cultural-historical values determine a building’s vulnerability. One could argue that the antonym of resilience is vulnerability, but architectural heritage forms an interface where these two opposites meet. When a redesign is made for a building and the cultural-historical values are elaborated or even enhanced, it can make a building even more resilient. It seems that the cultural-historical values are at the intersection of vulnerability and resilience and a proper reuse design can either worsen or enhance the resilience of a building.
This chapter describes several strategies to achieve resilience. These strategies are mainly used in the field of urbanism, but are also applicable in the field of architecture. As mentioned resilience is defined as the capacity of a system to absorb external changes. There are several strategies that can help to come up with a resilient design that is able to absorb external changes.

One of the main challenges when dealing with resilience of a building are the uncertainty and of changes it should adapt to. This challenge requires a thorough analysis to grasp the context of the building and define future possible future scenarios. In this chapter six active strategies and three passive strategies will be explained. All strategies try to ensure resilience. These strategies are derived from the field of urbanism but all have a potential to be successful in the field of architecture.

**ADAPTIVE CAPACITY**

The adaptive capacity is the capacity of a building to adjust to societal and environmental changes as mentioned in part one of this research (Carpenter et al., 2010). The adaptive capacity of a building has a positive influence on the long-term utility value of a building. This means that the building can accommodate different types of users for a long time span. The adaptive capacity is a collective noun to describe both flexibility and adaptability. These are the two fundamental principles for resilient architecture (Dipasquale, 2013).

Flexibility in this sense means that a space or a building can be used in different ways. The design is flexible and can adapt to the wishes of the user without altering itself. Adapting in that sense means altering the original design. One can adapt a building in various ways. The adaptive capacity has four design strategies of its own (Sarkis, 2009).

1. **Expandability:** Institutions such as universities, museums and hospitals are increasingly having difficulties in finding room for expansion. Designers are forced to forced to invent new typologies that can expand while maintaining their core values of identity. The previous chapter shows an image (fig. 3.6) of a housing project in Rotterdam. Expandability is ensured by a flexible construction and demountable and re-usable facade components.

2. **Versatility:** buildings can be designed in a way that it allows a variety for potential activities in the same space. The space changes in function while maintaining its character. This strategy is visible in the design for the Tate museum in London by Herzog & de Meuron (fig. 4.2). In order to accommodate a broad range of art, they designed a range of galleries differing in size. The great turbine hall which is often used to display various art installations, also shows versatility. The rest of the museum is organized around the big turbine hall.
3. Convertability: Buildings and spaces can physically adapt to the changing needs of the user, again without losing its character. This strategy is used designing the ‘Centre International du Design’ by LIN architects (fig. 4.3). The geometric building skin is adaptable. It responds to the needs of the user in terms of light and climate.

4. Fluidity: A design that evolves over time to accommodate changes in context and function. A project that evolves is the Fresh Kills Park in New York by James Corner Field Operations (fig 4.4). The planning of the park is broken down into three ten-year phases that are open to a variety of possibilities.

DENSIFICATION

Urban densification is a strategy that has been used repeatedly over time. In the middle ages, cities were dense because they needed to be enclosed within the city wall for safety reasons. Today, densification of cities is needed to avoid urban sprawl and land consumption (Dipasquale, 2014). Also densification contributes to the resilience of a city. Applegath (2012) states that density is the keystone of resilience. Dense urban centers use one third of the energy used in suburbs. Applegath suggests that city centers should be as dense as the market will allow. However, he does not suggest that we should build a dense city of sky scrapers. Instead, the density of a city should be optimized (Applegath, 2012). Optimizing density means that an urban system should be as dense as possible, but built space and public space should remain in balance. The ‘van Gendthallen’ offer great possibilities for densification. The giant halls are now as good as empty. Densification of these halls leads to a more resilient city. However, one should not ensure densification at the expense of the cultural historical values of the building. This leads to a great challenge in search of how dense the interior of the ‘van Gendthallen’ can get without losing its identity.

REDUNDANCY AND MODULARIZATION

Modular systems are more resilient than non-modular systems (Dipasquale, 2014). Redundancy and modularization spread risk and make a city less vulnerable to failure (Ahern, 2011). Simplicity in environmental, economic and social-cultural issues is a main feature of a resilient city. Simple systems are more resilient than complex systems require more maintenance (Dipasquale, 2014). In addition simple systems are easier for users to understand. Modularity helps an urban system to achieve this simplicity (Dipasquale, 2014). Applied to the context of a city, redundancy and modularization means that multiple elements of a city provide the same functions. In that way they are able to serve as a backup for each other. Redundancy and modularization are relevant for a resilient system, because they can maximize the active use.
of space and they allow for effective functioning of all kinds of activities (Dipasquale, 2014). When talking about a building, this could mean that several utility functions (e.g. bathrooms, kitchens, stairs) need to be incorporated in the design. The incentive is not so much to avoid failure, but more to incorporate flexibility. A surplus of strategically placed utility functions makes rearrangements within the design easier. It provides flexibility for future use. According to Applegath (2012) a perfect example that clarifies the modular and redundant principle is the co-generated district heating. Power and heat are generated by the same system in a single locally distributes plant. Each plant provides the power of several houses in its surroundings. However, it can also give excess power to back up other powerplants. Changes of failure are minimized. Another example is of a modular design principle is given in chapter 3 (fig. 3.7).

MULTI SCALE NETWORKS AND CONNECTIVITY

Forgaci (2014b) notices that the lack of connectivity is often a primary cause of malfunction of urban systems. He states that individual components of a system are subordinate. The interconnecting structure of these components, however, is most important. Growing urban systems have can expand easily because of the connectivity networks, already present in the urban system (Forgaci, 2014b). Ahern (2011) agrees by saying that multi-scale connectivity is important, because it improves the resilience capacity in a way that a city remains functional after connections inside a city are changing. Particularly when working with bigger buildings, multi-scale connectivity can have the same advantages as in cities. By ensuring interconnectivity in a building, it is more flexible for changing future use. The connectivity can both be visual and physical. It is all about establishing connections that can be useful in the present and the future. The Rubik’s cube concept (fig. 3.7) in chapter three already explained the importance of infrastructure. The infrastructure persists and buildings can change without having major consequences. Dynamoarchitecten also makes use of this strategy for the ‘Kunststad’ (fig. 3.8), by making a clear structure of streets that go through the new design. Within this structure, artist workshops have the freedom to change. For the ‘van Gendthallen’, which can basically be seen as an urban system, the infrastructural design decisions will be very important for it’s resilience.
**DESIGN TOOLS**

The strategies to resilience can be translated in several basic tools that can be helpful during the design process. Figure 4.6 shows a visual translation of the strategies of resilience into a set of design tools.

The first image is about simplicity. Simplicity can be understood as the readability of a design. It does not mean that a design should be elementary. It should be easy for a user to understand by knowing how it works. A clear infrastructure contributes to the simplicity of a building design. Modularity also helps to achieve simplicity. A rigid grid can help in making a modular design. A grid subdivides a space into small compartments. These compartments form the base for a modular design (fig 4.6.2). Several compartments together can form a cluster that functions independently. The independence of a cluster is achieved by implementing redundancy (fig 4.6.3). Every cluster might have its own service core (elevator, toilets, installations). Every independent cluster has its own connective infrastructure (fig. 4.6.4). The infrastructure is, in turn part of a bigger infrastructure that connects several clusters (fig. 4.6.5). The connections in a building design can both be physical and visual (fig 4.6.7). A modular building design is proven to be very flexible, because of the reallocation and expansion possibilities.
MS & R designed the interior of seven dilapidated warehouses. The project was awarded with a 2010 AIA Honor Award for Architecture. The Navy Yard served as a ship building and repair facility from 1868 till 1996. The old ship building and repair facility were transformed into a contemporary corporate campus with a strong connection to its history. This campus houses different clothing brands. The design provides a new design studio that embraces the typical remnants of the former ship building industry (Borges, 2013).

The interior concept of the building focused on equality by offering several public spaces to stimulate planned and accidental meetings. These public spaces contribute to the overall connectivity of the building. The entrance hall contains the largest public space and contrasts with the dense workshops (fig. 5.1, fig. 5.2). Between the open workspaces are collaborative workshops, for activities that require more privacy. The collaborative workshops are characterized by a new structure of steel columns and partition walls that create semi-open spaces. The materials are consistent with the industrial character of the building. The organisation and materiality of the new structure makes it very flexible and adaptable. The partition walls are relatively easy to rearrange.
and the spaces are easy to expand within the steel frame (fig. 5.4) (Borges, 2013).

A large infrastructure connects the public spaces within the building. Perimeter circulation provides viewlines to experience the length of the old warehouse halls. The design contains visual and physical connections between the different buildings to increase interaction and improve relationships between the different brands that are working on the campus. MS & R used a strategy that both improves the connectivity within the building and elaborates the cultural historical values of the building. The typical length of the halls is accentuated by long circulation paths, creating dramatic viewlines and ensuring resilience through connectivity (fig 5.2). The urban design also improves the connectivity between the halls by adding wide paths situated between the halls. (fig. 5.4). MS & R made rooftop skylights and reopenend, replaced and restored existing window to ensure enough daylight in the dense new program of the warehouses. The new ventilation shafts accentuate the immense length of the halls (fig 5.2) (Borges, 2013).
A former shipping industry building is transformed by Dynamo Architecten into a creative hub for artists, called the ‘kunststad’ (art-city). The design of Dynamo Architecten is rather pragmatic. To make optimal use of the space, dynamo architects used the densification strategy and used a solid mass as a starting point. From here they made stepwise interventions to come to the final design.

The first step was adding some streets to the solid mass, for connectivity (fig. 5.7.1). There is a rooflight above all the streets to make sure enough daylight gets in. A series of strips is what remains of the solid mass that was used as a starting point (fig. 5.7.2). The building strips are in conflict with the structure of the existing halls. Therefore these part of the initial mass are also removed (fig. 5.7.3). The approach of Dynamo Architecten shows that they interpretate the old shipping warehouse as urban fabric instead of normal building. In the next step they add a new infrastructure to the building mass, creating a main route and sub routes (fig. 5.7.4). The new infrastructure ensures a multi scale network that elaborates some important viewlines. The ‘kunststad’ is already looking a lot like a small city, with narrow alleys and some public squares to reduce the density (fig. 5.7.5). The streets and squares are meant to serve as a flexible space where artist can meet, practice and exhibit their work (fig. 5.5, fig. 5.6).

A rigid steel construction is added to the new mass to define the different workshops. Because of the construction the design becomes modular. The second floor has not been finished on purpose. This offers a lot of freedom to the future user, because he or she can design his or her own workshop. The steel construction improves the adaptive capacity of the building, because within this structure walls are easy to rearrange. Furthermore are workshops easily added or removed.
Fig. 4.7 The pragmatic design steps for the ‘Kunststad’
1. Solid building mass
2. Adding light streets
3. Removing parts that conflict with existing structure
4. Introducing a new infrastructure that elaborates important viewlines
5. Creating public squares to reduce the density (own img.)
Foster & Partners revealed a modular design for a creative community in the Dubai design district (D3). The D3 should serve as an incubator for local designers and artists. The modular design allows the creative community to evolve organically. The densification of the design is determined by external factors such as the amount of users. The building can adapt to any purpose. Foster and Partners were inspired by New York’s Meatpacking District and East London’s Shoreditch. They wanted to know what made these particular places popular and relevant for artists and designers. The new D3 design for the creative community includes flexible offices, communal facilities, flexible outdoor spaces and circulation space.

The design starts with a flexible single module (fig 5.10.1). This module serves as a workshop for artists. Within the structure of these modules the user has a lot of freedom to design his own space, because it is made out of adaptable components. A cluster of these modules sits alongside a so-called ‘core building’ (fig 5.10.2). These core buildings can be interpreted as a service core which includes the toilets, elevators, staircases etc. In the middle of a cluster is a small flexible courtyard (fig 5.9). Because of the ‘core buildings’ the overall design becomes very redundant. When one of the cores has a malfunction, the other service core can be used as a backup, making the design more resilient. The clusters are also placed within a bigger structure (fig 5.10.3). It is clearly visible that connectivity is ensured on different scales, from one single module to the whole design. A group of clusters forms a public square (fig 5.8). All the public squares are connected by an art boulevard (fig. 5.11). The art boulevard is used as a meeting place and a place where artists and designers can display their work.
Fig. 5.10.1

Fig. 5.10.2

Fig. 5.10.3

Fig. 5.11

The modular design by Foster & Partners for the Design District in Dubai.

1. Workshop made out of adaptable components.
2. A series of workshops forms a cluster with a service core and courtyard.
3. A series of clusters creates a public square.

(own img.)

Fig. 5.11 The clusters are connected by a large art boulevard that connects all the different parts of the design.

(www.dubadesigndistrict.com)
The design for the 'van Gendthallen' in Amsterdam has not yet been finished. That is why this chapter only discusses the design as it was presented during the midterm presentation of the project (P2 presentation). First the program will be explained. Secondly the design concept will be discussed following the provisionally design.

PROGRAM

As explained in chapter three, the change of the program of a building can be seen as an external change that should be absorb in a resilient design. However when designing a new building, the program cannot be seen as an external change because otherwise we end up designing only functionally neutral buildings.

“The debate on the nexus between specialized versus non-specialized forms and flexibility shows that cities need both narrowly specialized and unspecialized units, which should be kept apart so that adaptability in one would not disturb the functions and growth in the other” (Lynch, 1990, as cited in Arefi, 2011, p. 675).

Choosing a program for the ‘van Gendthallen’ depends on several factors: identity, resilience and context. The cultural historical values and the strategies to resilience are already discussed in previous chapters. The context covers the interests of the municipality, the inhabitants and other stakeholders of Amsterdam. An elaborate analysis of
the context has shown that the municipality of Amsterdam has the ambition to densificate the city. The city centre of Amsterdam attracts a lot of students and young starters. Instead of expanding the city borders, the municipality tries to densificate the city centre to meet the needs of the people of Amsterdam. The municipality purposes a urban design method by making use of clusters. The clusters are divided in three themes: cultural, event & congress and knowledge. The quality of the clusters lies within the exchange of knowledge and goods. These clusters also form a space where people with the same interests can meet. For the Oostenburger island the knowledge cluster in particular is interesting, because the municipality has a specific ambition to create a work-live environment. The current knowledge clusters in the Netherlands are often called a ‘campus’ and is mainly focussed on student activities. However, a knowledge cluster should also be focussed on businesses that can benefit from the collaboration with students. The University of Amsterdam (UVA) also promotes the collaboration of students and businesses. The UVA is fragmented all over the city and has the ambition to expand (fig. 6.1).

The ‘van Gendthallen’ offer a great possibility to fulfill the wish of the municipality to create a knowledge cluster on the Oostenburger island. This new cluster can become a platform where students and businesses share their knowledge and work together. The ‘van Gendthallen’
are situated near the city centre and are therefore in a perfect location for the expanding UVA. The Oostenburger island lies in one line with the central station, the public library and the main campus of the UVA (fig 6.2). The ‘van Gendthallen’ will function as the heart of the Oostenburger island as a place where students and businesses come together. This new function reflects the identity of the island by again becoming one collaborative unit that seeks connection with the rest of the city.

**URBAN DESIGN**
The urban design (fig 6.4) exploits the concept of resilience while elaborating the cultural historical values of the island. The new urban design tries to reestablish the lost connection with the city (fig 6.3.2). The ‘Dijksgracht’ is being extended so that it creates a route from the central station to the Oostenburger island and ensures connectivity. A connection with the waterfront is made by introducing a new water taxi stop. The introversion of the island slowly changes into extraversion. The historical layering of the island is made visible by bringing back the old water structures dating from the VOC-time (fig 6.3.3). The central access route is reused to become the main route of the island for cars and busses (fig 6.3.4). The new urban design is characterized by its large industrial grid referring to what the island used to be (fig 6.3.5). The ‘van Gendthallen’ have become an extension of the urban fabric (fig 6.3.6).
Fig. 6.4 The urban design for the Oostenburger island. (own img.)
BUILDING DESIGN - VAN GENDTHALLEN, AMSTERDAM

BUILDING CONCEPT

Densification is a strategy that is shared by the municipality and the university. It is also a strategy to achieve resilience and in addition it is also part of the identity of the island. The densification strategy is therefore used as a starting point for the building design (fig 6.5). The strategy used for the ‘van Gendthallen’ has a lot in common with the strategy for the Design District in Dubai (chapter 5).

The ‘van Gendthallen’ are interpreted as an extension of the urban fabric. A new infrastructure connects the different parts of the ‘van Gendthallen’ with the rest of the island. The infrastructure refers to the old railways in the halls. The ‘van Gendthallen’ are subdivided in three areas of densification, with the possibility to evolve organically. This gives users and future users the possibility to adapt the building to the current needs. A new modular structure is introduced to create a flexible structure which allows the different types of density. The different types of density also create different scales of intimacy where students and businesses can meet. Within the modular structure formal, informal, planned and accidental interaction will be possible.

PROVISIONALLY BUILDING DESIGN

Just like the ‘Kunststad’ project, the design process is rather pragmatic, starting with dense mass in the ‘van Gendthallen’. Hal one and three are used for private offices. Hal two houses the collective functions. This mass is supported by a steel structure, giving future users a lot of freedom in rearranging the design. According to Brand (1994), structure is one of the most permanent layer of a building. It is therefore also a very important layer, because it will probably not be altered very soon. The mass is enclosed by the main routes that go through the building. One route goes through hall four and the other route connects the five halls at the place of a former railway. Space around the columns is open to form subroutes. It also strengthens the effect of the length and height of the halls (fig. 6.6.1, fig. 6.8).

Daylight is very important in a dense design. Figure 6.6.2 show how some of the building mass is removed to make sure enough daylight enters the structure. A first step is mad in connecting the collective and private halls (fig. 6.6.3). In figure 6.6.4 is visible how the cultural historical values always are taken into account. The subroute is moved so that is does not break through the historical windows at the waterside. Some of the building mass is carved out to establish viewlines for all levels towards the waterside. To highlight some of the architectural elements of the ‘van Gendthallen’, the facade at the jacob boniusplaats is free from building mass (fig. 6.6.5). This also lets through more daylight in the lower parts of the building. The last step shows how the infrastructure connects all the parts of the building. Each hall has its own service core to ensure redundancy.
Fig. 6.8 Concept images of the design steps for the ‘van Gendthallen’.

1. Starting with a solid mass and an infrastructure with main routes and subroutes.
2. Voids are added to the mass to ensure enough daylight.
3. A new infrastructure connects all the halls.
4. The mass at the water side is carved out for better viewlines.
5. The facade at the zeemagazijnskade is also kept free from building mass, to make sure the architectural details of the ‘van Gendthallen’ are always visible.
6. A new infrastructure connects all the halls, every hall has its own service core to ensure redundancy.

(own img.)
Fig. 6.7 Concept image of hall two with collective functions as an auditorium, workspaces and toilets (own img.)
Fig. 6.8 Concept image of subroutes in the building (own img.)
The conclusions of the research and the practical implementation are described in this chapter. These conclusions are not final when it comes to the practical implementation, because it considers a provisionally design and not a final design.

**CONCLUSIONS**

Buildings are subject to time and external changes. A resilient design strategy is needed in order to design buildings that can absorb these changes. Resilience is a concept that originated from the field of ecology. It was later adopted by urbanists and slowly finds its way in the field of architecture. There are several strategies to achieve resilience in architecture: adaptive capacity, densification, modularity and redundancy, multi scale network and connectivity. These strategies fall short when dealing with architectural heritage. When dealing with architectural heritage, the cultural historical values should be taken into account. A thorough analysis of the context, site and building can help identify the cultural historical values. This adds a new dimension to the existing strategies of resilience. The cultural historical values of a building determine its vulnerability. One could argue that vulnerability is the antonym of resilience but architectural heritage form the interface where these opposites meet. An intervention can either worse or enhance the resilience of a building.

For the provisionally design of the ‘van Gendthallen’ the strategies of resilience are combined with the exploitation of the cultural historical value’s of the eastern islands, the Oostenburger island and the ‘van Gendthallen’. On urban scale this has led to a design that seeks connection by opening up to the rest of the city. The identity of the islands are maintained by referring to old water-, building- and infrastructures.

The design for the ‘van Gendthallen’ follows the strategies to resilience while utilizing the cultural historical values. The design is characterized by adding a new flexible steel structure. This structure offers the flexibility for the building to evolve organically. The rigid steel structure is consistent with the industrial character of the building. The density of the design is determined by its users. A new infrastructure connects all the parts of the dense new structure and the urban fabric. In this way the ‘van Gendthallen’ become an extension of the urban fabric.

All the design decisions are based on achieving a resilient design while elaborating its cultural historical values. There are endless possibilities for ensuring a resilient design in architectural heritage. The design for the ‘van Gendthallen’ merely shows one possible outcome.
This chapter contains a brief reflection of the research, the design and the relation between these two. It reflects on the method that was posed in chapter one.

At the beginning of this research report I explained the method that I used for the theoretical research by a metaphor of a funnel. I started with a broad theoretical framework, and when the research develops it narrowed down till the point of the conclusion (fig 11.1). This method worked more or less exactly as I had planned. However I noticed that in practice I often looked back at previous chapters to rewrite them. So the funnel principle worked and the topic narrowed down, but I also kept looking back at the broader framework which served as feedback for the rest of the research (fig 11.1).

The design process went almost the same. Starting on the scale of the city of Amsterdam and eventually narrowing down to the ‘van Gendthallen’ and its interior. But of course the design process is not a linear process. Sometimes conclusions on the scale of the interior, can have an effect for my design decisions on the scale of the city and vice versa. So same as with the theoretical research, the design process narrowed down to the scale of a building detail, but at the same time I kept looking back at design decisions I previously made and changed them where needed (fig 11.1).

But the most interesting part is how both processes, theoretical and practical worked together. In my case there was a constant interaction between these two processes. I constantly incorporated the conclusions of my theoretical research. As the theoretical research developed, the conclusions sometimes changed or were being extended. This affected the design as well. This happened on all the scales, therefor I was constantly working on different scales of the project (fig 11.1). This made the design process very dynamic and interesting. On the downside I could sometimes lose myself in little details, where I actually should jump to a bigger scale and see the building as a whole.

Part of my research are the case studies. These have been very helpful during the design process. I often looked back at my case studies when I encountered a problem in my own design. Especially the project for the ‘Kunststad’ in Amsterdam by Dynamo architecten was very helpful. I arranged a meeting with Peter de Bruin who is the owner of Dynamo architecten. He told me a lot about fire safety and climate installations. Different from the ‘Kunststad’ I used a concept where the building volumes can grow within the existing structure, when this is needed. The ‘Kunststad’ is developed in a low-tech manner, which is different from the approach I took.

The theoretical research and the analysis have led to a resilient design strategy where I implement a new structure in which the building can grow. The cultural historical values are incorporated within this structure. The strategy is applicable for other design projects, in particular projects dealing with industrial heritage. Of course every building has its own cultural historical values. That is why a thorough analysis of the context, building and structure is always needed. This helps to develop a structure that forms a base for a resilient design.


