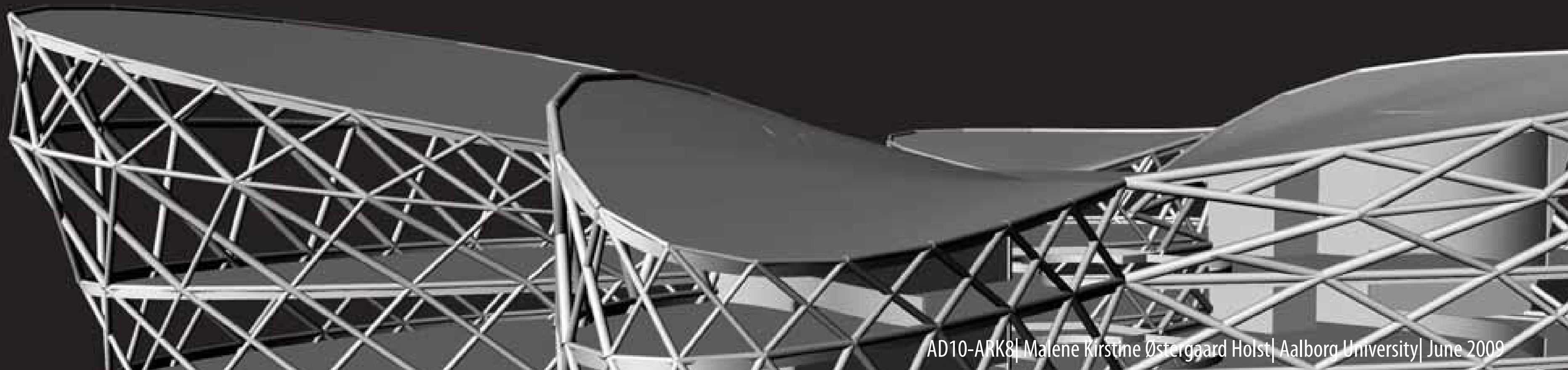
PERFORMATIVE TECTONICS|

|AARHUS MULTIMEDIA HOUSE



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SYNOPSIS

Architecture of the digital age contains a variety of directions and focal areas. By analysing architecture in the digital age and leading the conventional theory of tectonics up to the architecture of today, the term *Performative Tectonics* emerges.

Performative Tectonics is defined through parametric digital tools and possibilities of form modelling combined with the traditional values of tectonics brought up to a contemporary definition and use thereof.

With the framework of *Performative Tectonics* a multimedia house for Aarhus waterfront is designed with the parameters of being *A house of Democracy* and *A Centre of Knowledge*.

CONTENTS

PREFACE

This report is a result of a long term master thesis including a theoretical part and a practical part. The theory of the thesis founds the framework for the design assignment of a multimedia house at Aarhus waterfront.

During the last decade architecture developed through an increased use of digital tools has emerged, and today's eye-catching, organic architectural volumes are a result thereof. Digital architecture has become more and more integrated in the established contemporary architectural stage with architectural volumes, whose modelling cannot be solved without the creative use of the computer as a generative tool.

The generative tools in architecture are an example of today's design tools, and as architecture through history is developed according to the available tools, digital architecture is seen as a natural consequence thereof. With the computer as a determinant tool for the architect, is it natural that computer users have initiated the use of the computer according to the computer technology. Nevertheless the generative tools in design process are not yet settled in the architectural stage. It is still only the far-sighted practices that have integrated the digitally driven generative process into the design process. Generative design processes are still a research field, where the possibilities yet are to be surveyed. In this aim especially the tools by which the architecture is generated are of importance.

To give a perspective to the contemporary development it is found interesting and relevant to apply the profound values in architectural tradition. The architectural theory of tectonics with roots going back to Vitruvius and with a renaissance in the 1990's by Kenneth Frampton of whom it is said, that the reintroduction of the architectural term was caused as a counter-reaction of the increased use of digital media in architecture, by which he argued architecture looses its poetics and the relation to the site.

By analysing tectonics from a historical and methodological perspective and giving it a contemporary interpretation, the term is brought into today's architectural stage including digital architecture. Tectonics and architecture in the digital age have been analysed leading to the term *Performative Tectonics* that defines performative architecture with respect to tectonics, i.e. the parametric digital tools and possibilities of form modelling combined with the traditional values of tectonics.

With this framework of *Performative Tectonics* the state of art in terms of generative tools are analysed through case study research with the objective to analyse the possibilities design exploration within the evaluated tools for. The tools to analyse represent two different approaches to generative design. *eifForm* is structural optimisation and *GenerativeComponents* is an example of parametic modelling. The case study research intends to analyse the possibilities for generative design with the tools in terms of tectonics.

As the objective is to combine theory in practise; *Performative Tectonics* is used as the framework, while the case study research is the background to design an architectural piece. With parameters from *Performative Tectonics* and the case study the approach for the design is outlined. The design assignment is a competition concerning a multimedia house at Aarhus waterfront.

With the framework of *Performative Tectonics* is the Multimedia House a contemporary design proposal rooted the generative processes and tectonic values.

1 INTRODUCTION TO TECTONICS

1.1 CLASSICAL TIMES

The term tectonics originates from the Greek word tekton meaning carpenter or builder. In the later advancement of the concept it included the meaning for process of creation referring to the creation of artistic works, which included the aspects of skill, method, material, and even concept. [Liu 2006, p. 267]

Tectonic is an architectural theory that goes back to Vitruvius's Ten Books on Architecture, written in the period between 33 and 14 BC. [Kruft 1994, p. 21] In book 1 Vitruvius defines the fundamental aesthetic principles of architecture. Architecture must satisfy tree distinct requirements: Firmitas, Venustas and Utilitas. The first, Firmitas is the strength; it covers the field of static, construction, and materials. Venustas is the beauty that

1. Temple of Parthenon , Acropolis, Athens, Greece

2. Chiesa di San Giorgio Maggiore by Palladio, Venice, Ilaty

3. Sainte Chapelle, restored by Viollet-le-Duc

4. Notre -Dame de Paris restored by Viollet-le-Duc

includes all aesthetic requirements, where proportion is above all. Utilitas or utility is the last requirement, which refers to the use of the building and the guarantee for successful functioning. [Kruft 1994, p.24]

In theories of contemporary architecture the concept of tectonic has become unclear because of different approaches to the concept. To understand the different directions of tectonic, it is necessary to discuss the respect of the nineteenth-century architects in incorporating a steel frame into masonry construction. [Hartoonian 1994, p. 16] Already by the French Jesuit priest Marc-Antoine Laugier (1713-1769) the poetics of techne has been pushed into the background, still the French architect Eugène Emmanuel Viollet-le-Duc (1814 - 1879) suggests a structuralistic interpretation of the relationship between the architectural whole and its parts, between which he visualized a duality of form and construction. For Viollet-le-Duc the truth of architecture rest somewhere in between form and substance, or between architecture and construction. [Hartoonian 1994, p. 16] Given that the truth of architecture not rests in the empirical reality of its material, nor in its compositional form the phenomenological approach cannot in any circumstances prevail over structural analysis. The phenomenological approach can merely indirectly lead to essential being of the building, the area from where the architectural form flows out of the constructed reality. In this manner Viollet-le-Duc distinguishes between the essential being and its appearance, between phenomena and numena. [Frampton 1995, p. 53]

5. Theseion, Temple of Hephaistus in the Agora of Athens - the best preserved ancient Greek temple. The only one with a roof.

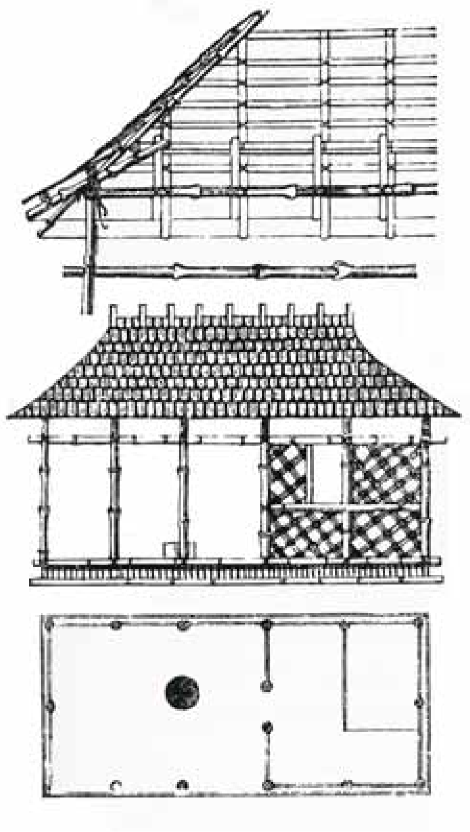
1.2 BÖTTICHER

In the 1840s the German architectural theoretician and archaeologist Karl Bötticher (1806-89) reveals a new direction of architectural theory by publishing the three volumes of *Die Tektonik der Hellenen* (The tectonic of the Hellenes) between 1843 and 1852. In his work the term tectonic is re-introduced into architectural literature. According to Bötticher architectural tectonics is simply forming a building, this agrees with the origin of the term signifying carpenter or builder. [Schwarzer 1993] In Greek architecture Bötticher found above all the realization of the formal principles of construction, he explains tectonic as the unifying whole binding all parts of the Greek temple together. [Frampton 1995, p. 4]

The new architectural theory proposes an integrated system of architectural expression, where the beauty of architecture is the explanation of the mechanical concepts combined with its artistic demands related to the imagination with equal precedence. [Frampton, 1995] Bötticher means the essence of architecture lies in functional needs and constructive forces. He distinguishes between *ontology* and *representation*, where ontology is the part of the building with a natural and cultural order. He describes it as mechanical processes and natural forces. The counterpart, representation is without function, it represents art which must refer back to utility and external nature and hereby should representation or ornament expose the essence of the construction. He describes it as "*a harmony between building and human culture brought about through the mediation of artistic ornament.*" [Schwarzer 1993, p. 267]

His theory is also described as first considerations of plan and structure, and then on the symbolism of structure in ornamental forms. [Schwarzer, 1993] As Bötticher describes it, the syntactical constructional concept distinguishes between the form of the work, the *Kernform* (core-form), by which he understands the structural framework – and the artistic form, the *Kunstform* (art form), the artistic character of the individual members. [Kruft 1994, p. 293] "The concepts of each part can be thought of as being realised by two elements: the core-form and the art-form. The core-form of each part is the mechanically necessary and statically functional structure, and the art-form, on the other hand, is only the characterization by which the mechanical-statical function is made apparent." [Frampton 1995, p. 82]

Bötticher's tectonics offered a detailed theory for iron construction in architecture. With the strength and structural properties it will become the basis for covering systems and structures. He insists that the tectonic expressivity of such an unprecedented system will have to model its representational form on some kind of reinterpretation of the principles of Hellenic architecture. According to Bötticher, this new material and its possibilities should synthesize the mechanical and the natural to reinterpret and transform the received iconography of classical form. In continuation he argues that "*the essence of pictorial art and its relation to nature rests in this interaction between concept and object, between invention and imitation.*" [Frampton 1995, p. 84]



6. The primitive Caribbean hut

1.3 SEMPER

The German architect, art critic and professor of architecture Gottfried Semper (1802-1879) publishes in 1952 Four Elements of Architecture. The work represents a new perception of the tectonic concept; it breaks with the Vitruvian triad of utilitas, firmatas and vesustas and announces a theory based on a division of the primitive hut into four basic elements; (1) *the earthwork*, (2) *the hearth*, (3) *the framework/roof*, and (4) *the light-weight enclosing membrane*. Through this classification Semper divides the building craft into two fundamental procedures: *the tectonics of the frame*, in which lightweight, linear components are assembled to include a spatial matrix, and *the stereotomics of the earthwork*, wherein mass and volume are conjointly formed through the repetitious piling up of heavyweight elements. [Frampton 1995, p. 5]

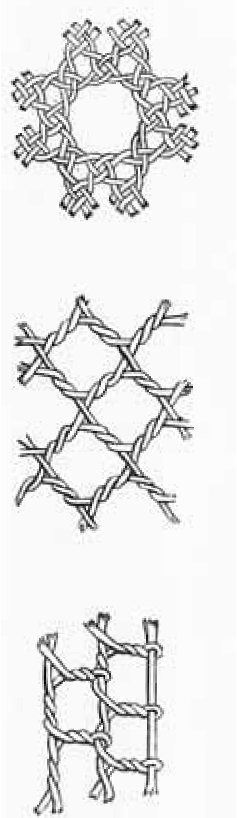
Semper's theory and division of the building crafts can be described by Bötticher's terminology. The tectonics and the stereotomics or the frame and the earthwork are the technical parts and can be described as ontological, where the hearth and the light-weight enclosing membrane are more symbolic or artistic elements, and can with Bötticher's terminology be described as representational. By comparing Semper and Bötticher's individually classification of the building and the building craft, it becomes clear that many of Semper's concepts of the relationship between structure and ornament derive from Bötticher. [Schwarzer 1993, p. 267]

Semper emphasize the distinction of tectonics and stereotomics by assigning certain tectonic crafts to each of the four elements. Textiles pertained to the enclosing membrane and thus to the side walls and roof, carpentry to the basic structural frame, masonry to the earthwork, and metallurgy and ceramics to the hearth. [Frampton 1995, p. 87] This association of tectonic with other constructive artefacts entangles architectural production with the existential aspects of life and thus Semper criticises the historicism and aestheticism of his time. [Hartoonian 1994, p. 3] This approach emphasizes Semper's nihilistic discourse, where he suggests that "*this process of disintegrating existing art types must be completed by industry, by speculation, and by applied science before something good and new can result.*" [Hartoonian 1994, p. 20] In this way he finds architecture not representational – as the common understanding of his time, where it is seen as an art form similar to sculpture and painting. Instead he argues that architecture rather is a cosmic or ritualistic art, analogue to music and dance. [Hartoonian 1994, p. 3] According to this approach the experience of architecture is depending on the context. The social, religious and political circumstances as well as the climate and the place define the perception of architecture and thus it has the capability to express something else than originally expected. This is consistent with the potential differences of tectonic, which can differ according to the sociocultural surroundings such as culture, climate or time. In for example the Japanese house the earthwork of the foundation has been eliminated to boulder footings, and the stereotomic walls have been extended to become roof and floor [Frampton 1996, p. 7].

Furthermore his statement refers to his perception and definition of art and style that arises out of three different causes, the separation between the arts and the original motifs, the devaluation of material and labour and lastly the disability of the art to fulfil a specific function in relation to a specific historical moment. [Frampton 1996, p. 87]

This is an aspect where Semper in some way is hostile to Bötticher, when he picks up Bötticher's distinction between Kernschema (basic schema) and Kunstschema (aesthetic schema), where Semper defines this distinction as cladding rather than a style. "*It is cladding, the symbolic expression of the variable factors that makes up the work of art, that makes style possible*"[Kruft 1994, p. 315]. This underlines Semper's definition of style, namely that "*style is the coincidence of the structure with the conditions of its origin.*" [Frampton 1995, p. 95]

The distinction between the four elements or especially tectonics and stereotomics is furthermore emphasised by the etymologically roots. The classification as stereotomics as the load-bearing masonry of some kind e.g. stone or mud-brick is indicated in the etymology of the word stereotomics. This is given by breaking down the word into the Greek *stereos* meaning solid and *tomia* meaning to cut. The difference between tectonics and stereotomics is furthermore reinforced



7. Examples of knots

by the German language, which differentiates between two classes of wall, *Die Wand*, indicating a screen-like partition, such as woven fabric or a wattle and daub wall and *Die Mauer*, signifying a massive fortification. [Frampton 1995, p. 5] The etymologically connection is also notable in the assigning of tectonic crafts to the different parts. In the German language he furthermore points out that Die Wand is cognate with Gewand meaning garment or robe, thus polycromy has its origins in the concept of a garment covering the earliest architecture. [Kruft 1994, p. 321]

Beside the four elements another significant element in Semper's tectonics is the joint or the *knot*, which he sees as the most significant basic tectonic element or as he describes it; "*the oldest tectonic, cosmogonic symbol*", from which follows the primary normadic building culture of the tent and its textile fabric. The focus on the joint implies Semper's fundamental syntactical transition between the stereotomics base of the building and its tectonic frame. According to Semper, it is exactly this transition that is the very essence of architecture. [Frampton 1995, p. 86]

1.4 SEKLER

The 20th century architect and architectural historian Eduard Franz Sekler (1920-) writes in 1965 the essay *Structure, Construction, Tectonics* as an attempt to increase clarity in what he sees as particular relevance of architecture, namely structure, construction and tectonics. [Sekler 1965, p. 89] In continuation of the emphasis on the three aspects, Sekler criticises that the former discussion of tectonics in architectural theory by Bötticher and Semper has remained incomplete until corroboration in the theory of the psychological investigations comprising empathy. This perspective has roots back to Vitruvius's Book IV, where he argues for a belief in a direct relation between man and the forms of architecture. [Sekler 1965, p. 90]

According to Sekler the distinction between the terms *structure* and *construction* have in daily use become unclear. This distinction and differentiation of the words is one of the fundamental aspects to understand Sekler's view on *tectonics*. He refers back to the real difference between the two words, where construction means something put together consciously a particular physical manifestation of the structural principle and structure is the much wider concept that refers to an ordered arrangement of the fundamental parts. In the architectural context structure is the overall concept. It refers to a system or principles of arrangement coping the forces of the building. In this way structure is the more general and abstract concept as opposed to construction, which refers to the concrete realisation of a principle or system, and thereby construction is the concrete realisation of the structure. On the concrete level, the construction is the method it includes the variation of a number of materials and construction methods, where the structure is the building principle such as post-and-lintel, arch, vault, dome or folded plate. [Sekler 1965, p. 89]

8. The ancient Triumphal Arch, Tyre, Lebanon.

9. Fan vaulting, Bath Abbey, Bath, England, 1860s.

Thereby the visual result is to be evaluated from two aspects; the assessment of the process of the construction, which can be reviewed in various ways, e.g. by the handling and selecting of material, procedures and techniques and by the appropriateness and efficiency of the given chosen system, which is the assessment of the structure. [Sekler 1965, p. 89]

Sekler introduces the term tectonic as the answer to the visual result that cannot be referred to as construction or structure alone. A result that is a relation of form to force, where there is a corresponding arrangement of the part of the building, such a result is to be described as tectonic. Tectonics is thus an expressive form that is representative of the other two modes, structure and construction.

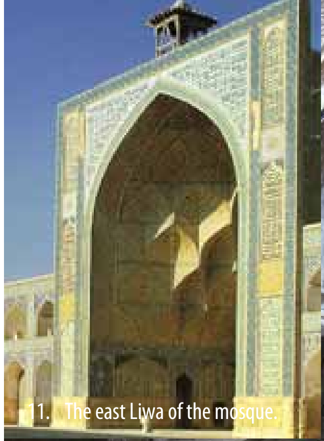
Like Bötticher and Semper, Sekler also assesses the etymological roots of tectonic. According to Sekler, tectonics derives

10. The Lion’s Gate at the entrance tothe Citadel of Myceanae is of one of the oldest types of architecture, post and lintel. It is dated circa 1240 BC.

from the same Greek roots as architecture and technology reminding about the basic human activity of giving visual shape to something new. The term was originally restricted to the craft of the carpenter and the builder – the ancient Greek *tekton*. [Sekler 1965, p. 89] The reintroduction of the term in the early 19th century by Bötticher did not mean according Sekler that the concept had been forgotten. He argues that the concept was discussed at length and had achieved a depth and precise meaning e.g. in French 17th- and 18th century writings. They argue, that a building must be built solid and also appears so, as they announce it; judgment must estimate it as such. [Sekler 1965, p. 90]

This angel to tectonics is consistent with Sekler's attitude to Bötticher's and Semper's tectonics, where he argues that there is a lack of the human perception or empathy of tectonics. Like the former mentioned theorist, Sekler also refers his view on tectonics to the Greek Doric temple, about which he argues that the tectonic statement is the play of forces, which provokes people's empathetic participation in the experience, by the articulation of the load and support. In this way, the temple is a unique architectural piece that always moves people as an architectural experience. [Sekler 1965, p. 93] One of the most convincing architectural tectonic pieces is by Sekler the great Persian mosque, the Masjid-i-Jami in Isfahan. It satisfies a convincing visual demonstration of the difference between structure, construction and tectonics. [Sekler 1965]

Tectonics is by Sekler the one of the three concepts, about which the architect is the undisputed master of the expression. Furthermore it is in this realm the architect can express and perform the artistic personality and character.



11. The east Liwa of the mosque.

12. Interior og the mosque.

13. The library of the Masjid-i-Jami mosque, Isfahan, Iran.
The most convincing architectural tectonic piece according to Sekler.

1.5 FRAMPTON

The British architect, critic, historian and Professor of Architecture Kenneth Frampton born in 1930, is the 1990s writer of tectonics. The tectonics of this period can be seen as a critical counterculture against the computer aided design. The tectonists claimed that the architectural production of seductive computer imagery failed to understand the intrinsic nature. Architecture is not to be generated through algorithmic potential of computer programs, but out of the tectonic capacities of actual materials. Frampton's book "Studies in Tectonic Culture" can be seen as an example of the work against the evolving digital culture. [Leach 2004, p. 4]

Frampton's tectonic is as Bötticher's built up with the concept of ontology oppositional to representation included by the scenographic in the spaces in the building derived from Heidegger's conception of the relationship of dwelling and building relying on the experience rather than the visual and scenographic. The facades with ornaments and the space behind are both in the representational category taking precedence. Frampton does not elaborate the spatial concept. He sees space as an abstraction in the building concept, and saves it to everything that is abstract. In this way space replicates abstraction in the instrumental relationship to the world. Frampton introduces the scenographic to the understanding of the visual representation of space, because the aesthetic quality of space is difficult it abstract and analyse, when the visual representation comes into its own in relation to the facades. According to Frampton space is supposed to be considered in terms of its economic and technical requirement and indifferent to the idea of site. There is a need for interaction as correspondence between site and architecture and between people and architecture, using the capacity of topography and perception. It is the interaction of the scenographic, technical and economic aspect that generates harmonious architecture. [Jameson 1997, p. 251]

1] The tactile relates to the sense of the materials, the perceptible, the tectonic is the understanding of structure and the telluric refers to laws of the earth and the traditional sacred structures, or contemporaneously speaking a systematic negation of the grid Rem Koolhass and Eisenman has been engaged in using. [Jameson 1997, p. 252] Frampton appreciates the local and regional architecture as the truly telluric-tactile construction. This is in accordance with his approach to the buildings' decoration that must grasp recognisable element from the national and cultural discourse of the building as the building must grasp the physical structure. This can be seen as Frampton's geopolitical proposal to mobilize a pluralism of regional styles with a view toward resisting and standardisation of a henceforth global late capitalism and corporatism.

He emphasizes how architecture reflects moment in history as new machinery is introduced and the information technologies has been evolved. There has been a transformation in built environment from a more visible and stylistic impact on nature.

Thus tectonic is the fundamental category consisting of a clear structure and overall constructional logic in interaction with the joint that can be described as the element, that by downward distribution of forces and pressure it not only reveals and acknowledges the site but also unveil and produces it in a creative sense.[Jameson 1997, p. 252] Tectonic means to express and reveal the true essence of the building and it arises in the concatenation where the gravitational forces are conducted to other building parts, more precisely where the transition possesses a technical transfer of the loads passing through a series of appropriate articulated transitions and joints. [Jameson 1997, p. 250] In this way the joint becomes the centre of attention, containing all three aspects in the articulation of the meeting of materials and types of structural elements performing the natural laws.

14. Bagsværd Church by Jørn Utzon, Copenhagen, Denmark. According to Frampton a tectonic piece of architecture, with the acoustical formed vault conducting the light.

1. 6 SUMMARY

In architectural theory the concept tectonic was introduced from classical times by the triad of Firmitas, Venustas and Utilitas. The triad represents the requirements of what defines aesthetics according to Vitruvius, but the triad has also formed the basis for future architecture and architectural theory, e.g Palladio's architecture in the renaissance were built after this perception. Up to the 19th century the concept tectonic was not further developed in architectural literature before the reintroduction by Bötticher. Bötticher was the first of four theorists to form the basis of the contemporary understanding of tectonics, where his theory constitutes one of the four directions.

The tectonics of Bötticher is built up with a distinction between ontology and representation, where ontology possesses a natural and cultural order, the mechanical processes and natural forces, and representation represents art that refers back to utility and thereby is an explosion of the essence of the construction. The distinction of ontology and representation is emphasized by the introduction of the concepts Kernform and Kunstform, by which Bötticher understands as the form of the work, the structural form and the artistic form, the artistic character of the individual members of the construction.

The tectonic direction of Semper is rooted in the division of the primitive Caribbean hut into four basic elements; the earthwork, the hearth, the framework/roof, and the lightweight enclosing membrane. Beside the four basic elements Semper divides the building crafts into two fundamental procedures, the tectonics of the frame and the stereotomics of the earthwork. Where stereotomics is the heavy construction and the tectonics is the fundamental structure. The stereotomics and tectonics are in this way both technical aspects or ontological in the terminology of Bötticher, where the hearth and the light-weight enclosing membrane are more symbolic or artistic elements or representational in the terminology of Bötticher. This division corresponds with Semper's view at architecture, namely that it is a cosmic or ritualistic art form rather than a representational art form similar to painting and sculpture. Furthermore Semper emphasizes the joint or knot in architecture. According to Semper it is in the joint the very essence of architecture is inherent, where the fundamental syntactical transition between the stereotomics base and the tectonic frame.

Sekler's position to tectonics emphasizes the division of the structure and the construction, where structure is the general system ordering the fundamental parts of the building coping the forces, and construction is the method to accomplish the structural system. According to Sekler tectonic is accomplished when a building can be described as neither structure nor construction alone but both modes are representative. There is a relation of form to force and a corresponding arrangement of all parts of the building. Simultaneously empathy must also be present in the building. To be tectonic architecture must provoke people's empathetic participation in the experience of it.

Like Semper describes the joint as the very essence of architecture Frampton sees the joint as the transition from where the tectonic arises in the concatenation of the downward distribution of the gravitational forces to other building parts. The joint is the centre of attention while it contains all the three values, the tactile, the tectonic and the telluric when the transition is the meeting of materials and types of structural elements performing the natural laws. The joint is also the fundamental element that reveals and acknowledges the site and furthermore unveils and produces it in a creative sense. It is the interaction of the scenographic, technical and economic aspect that generates harmonious architecture and it is in term of the economic and technical requirement and in correspondence between site and architecture and between people and architecture, using the capacity of topography and perception in which space is supposed to be considered. Tectonic architecture consists according to Frampton of a clear structure and overall constructional logic. The meaning of tectonic is to express and reveal the true essence of the building.

The four theoreticians have developed their specific direction for the tectonic concept, and it is possible to chose one direction and let it be the tectonic basic for this thesis, though it is found more pertinent to relate the four directions of tectonic to the contemporary architectural tradition.

Consistently there is a division of the structural part of the building and the aesthetics. The aesthetics or the art of the building must refer back to utility or to the mechanical part of the building. In this way, the development of the tectonic theory is still consistent with Vitruvius's triad. And inevitable the discussion of tectonics through generations has also brought much lucrative to the concept; broadly consisting of the seven parameters of: Structure, Construction, Interaction, Object, Detail, Joint and Material.

The focus on the joint by Semper can be useful as an articulation of architectural and tectonic choices. It is a very useful tool to accentuate parts of a building and as in Semper's spirit the transition between different part of the building e.g. the stereotomics base and the tectonic frame, though the emphasis or articulation of the joint is found useful in more occasions than the transition between the base and the frame. Sekler is emphasizing the empathy of a building or poetics of construction as Frampton emphasizes it, the quality of provoking people's empathetic participation of the experience. This quality is very consistent with the phenomenological approach to architecture, where perception is included as an important parameter. Especially in the discussion about space the term has proved its validity. In the tectonic perspective empathy or phenomenology is determinant to prove or emphasize the duality of architecture with this perspective.

The technical aspects of the building of which an emphasis is needed to accomplish a tectonic result, includes a large spread of themes. A natural theme to include is the structural theme, with a focus on the structural system and the constructive area with attention on the building method, the materials and constructive details e.g. details of joints. Furthermore there are several aspects that are relevant to include accomplishing a tectonic result of a building, for instance the indoor climate, the energy consumption and the acoustics. In this tectonic approach the attention is to the structural system and the construction with considerations of the other aspects.

15. Roof of British Museum Great Court, London, United Kingdom by Foster+Partners 2000

Keywords of tectonics of this thesis

Summing up the summary of this section gives some keywords for the tectonics of this thesis for the further development in terms of methodology, architecture in the digital age and finally the design.

1. Ontology and representation

Division in the structural part and the art of the building and the art of the building refers back to utility.

2. Structure and construction.

Division between the construction as the operation of realising the structural concept and the structure of the building.

3. Interaction and empathy

Interaction between site and architecture and between people and architecture including a phenomenological approach to valid the duality.

4. The joint

Focus at the joint as a generator of construction to emphasize the tectonics, while it links building parts, materials and structures of the whole architecture.

5. Material

The material is the central element of the building, why it is the element that represents the formation and composition of architectural construction.

2 METHODOLOGY

2.1 METHODOLOGY OF TECTONICS

Through the historical analysis of tectonics in the former section the concept is specified. Tectonics is according to Bötticher the amalgamation of representation and ontology. Despite Semper's theoretical approach to tectonics these two realms are the fundamental basis of the tectonic theory. Ontology and representation can more likely be translated to art and technology, by which tectonics can be seen as an amalgamation of. To understand the aesthetics of tectonics it is essential to look into the two parameters.

Thus tectonic can be seen as an architectural style with philosophical roots in a symbiosis of the art of the building and the mechanics of the building. Working with tectonics includes an approach from different theoretical backgrounds and the contradictory theories of positivism and phenomenology; the empiric analytic approach to verify technical data through causal and functional statements with the hypothetic deductive method and the more emotional phenomenology to analyse senses and the artistic poetry.

Art

The Greek term of art *τέχνη* or *techni* refers to a broad range of meanings, including mental dexterity, linguistic ability, and trickery as well as the skills of rulers and physicians. It is therefore implied something closer to craft and denied a privileged role to the work of art and to its creator. Works of art can be seen as a community's shared understanding, why the meaning of what it is to exist is inherently changed, each time at new artwork is added to a culture.

Art refers to various human activities and artefacts, not merely visual arts, which it most often is used to. It can also be applied to forms of art stimulating senses. Traditionally the term art is used referring to skills or mastery, which is consistent with the general art that is a product of human activity, made with intention or simulating the human senses and mind. This is in accordance with Aristotle's opinion of art that it is completing nature. The modern view rather that art possesses value independent of nature or as Heidegger declare in his work "Der Ursprung des Kunstwerkes" the essence of art is in terms of being and the truth. He argues that art is not only a way of expressing the element of truth in a culture, but the means of creating it, providing a springboard from which "that which is" can be revealed.

The Greek word for truth is αλήθεια or alitheia. Litheia means hidden and a- means not. In this context truth means the not hidden and the revealed. Thus it goes that the being as being is true and the true as truth is being. As the being is, it places itself and is in the not hidden. The truth in the middle of the being becomes the being. [Heidegger 1994, p. 15]

If art is a way of revealing the truth and the revealing of something must have taken place through a kind of a process, the producers of art as the architect must be a part of this process of revelation.

Heidegger describes the revealing of the truth in terms of architecture by the Greek temple. The temple does not picture anything while standing in the rocky canyon. Through the temple the God is present, and the presence is the prevalence and delimitation of the area as sacral. The temple meets the correlations around it and thus it reveals the truth in terms of the specific site, the society, the character of the users and the intention of the construction. And in physical terms the revealing of the truth is a coherence of the temple and its context. By the placement on the rock, the resting of the temple and the bearing of the rock are revealed. The glisten and shine of the stone is accentuated by the rays of the sun while the sun is accentuated by the shiny stones. Thus the temple and its context can be described as a revelation of each other in terms of fýsis, meaning the entirety and self of the appearance and emergence. Hence the coherence is how the temple expresses the truth of its intention. [Heidegger 1994, p.49]

Technology

Technology originates from the Greek *τεχνολογία* or *technologia*. Etymologically the word derives from *logos* meaning the theory about, and from *techni* containing the knowledge and activity of craftsman as well as the concept of art as former mentioned in the Greek translation of art. Thereby *techni* is the creation rather than the production of an artefact and it thereby contains a kind of poetry in the revealing of the art.

It is through *techni* the architect reveals, what is to be revealed – the truth, thus technology is the process. The discussion of technology contains the same aspects as the discussion of art. By comparing the different part the purpose of both technology and art becomes clear – it is a revelation of the truth. Technology is the process, through which the revelation is carried out, and art is the means, by which the presentation is revealed. Thus the difference is that art means the revelation and technology is the process in itself.

Thus the technology in the architectural piece can be seen as the processes behind the creation. It can be the manual and digital tools in the process. This can be described as a part of the process of revelation, and is supposed to contribute to the revealing of the truth of a building. The truth of the building is an abstract dimension, but searching the truth can be authenticity in materials, clarity in structure and construction, and the caring for the detail which are parameters matching the earlier definitions of tectonics.

Working with tectonics

Via the phenomenological philosophy the art of the building, the tectonics is a revelation of the two parts a building consist of; the technical truth such as the construction, structure or detailing, and the art or poetry revealing the main ideas and the essence of the building. Traditionally in the architectural praxis there has been a tendency to create forms and spaces from an artistic point of view and afterwards making the calculations and applying the technical parameters as construction and structure. Tectonic is the fine balance concerning both the artistic approach and the technical. Tectonics has emphasised its worth in the architectural arena breaking through this not properly thought architecture and proving a new procedure, where the technical aspects are important in the making of form.

The philosophy of Aristotle is positivistic and is based on the being of the object is in themselves, barely as a possibility in the object. Through a concrete form the being gets actuality and thus material and form is conjoined to a unit in the object. Aristotle handles the being on the basis of the theory of four causes. Causa materialis, the material of which an artefact consists of, causa formalis, the physical reason that cause an effect, causa finalis, the purpose a process must obey, causa efficiens, the ideas by which all in the world occurs in accordance with. [Delius 2000, p. 13-15] The four causes are the fundamental rules are the objects property and the principles of thinking. Thus the connection between them or rather between material, form, purpose and craftsman is described as amalgamated and the essential property of the object. Comparing this view with the tectonic theory the parallel is very evident, but the inclusion of the art or poetry is missing. Martin Heidegger discusses art as the inner nature or structure in his phenomenological philosophy. The addition of this perspective to the positivistic makes the integration of art and poetry united with material, form, purpose and craftsman.

Positivism: Empiric analytic theory

Tectonic can be seen as an interaction of engineering and architectural competencies. The engineering background utilises methods and models taking starting point in the measurable. The fundamental basis is a problem – a question – something to be explained. The answer states a hypothesis, a theory or a contention attached to a general theory and meanwhile it is general related to the question. Through induction, observance or analysis of the world of physics, a basis to derive theories tested through deductions in the world of physics. ”*A principle of induction would be a statement with help of which we could put inductive inferences into a logically acceptable form. In the eyes of the upholders of inductive logic, a principle* *of induction is of supreme importance for scientific method"* [Delanty & Strydon, 2003, p. 43].

The theories are in a process, where they are developed concurrently with elaborating tests, deductions on the real world. The objects to be analysed or observed are physically present and available, why the theories can be put forward and the physically data can be proved. In this way other competent persons will conclude the same by following the given method, and the statement can be characterized as objective.

Karl R. Popper (1902-1994), philosopher and professor among the most influential philosopher of science of the 20th century, describes it, "*Indeed, if there were such thing as a purely logical principle of induction, there would be no problem of induction; for in this case, all inductive inferences would have to be regarded as purely logical or tautological transformations just like inferences in deductive logic. Thus the principle of induction must be a synthetic statement; that is, a statement whose negation is not self-contradictory but logically possible*". [Delanty & Strydon, 2003, p. 43]

The deductive procedure can be used where there are general specified demands such as strength and climate. Thus there is an established general theory, built upon another general theory verified through deductions of calculations and tests in the physical world. This theory is a benchmark for what is predicted to hold and making a building safe. The benchmark is composed of formulas, and the task is to verify or falsify calculations. The theory of positivism or rather the empiric-analytic method is highly objective and built upon empiricism and analysis. Deductions and thereby the empiric analytic method is useful to test whether the structural system can hold or not. Calculations for the structural system or the indoor climate can be sees as deductions to the theory answering the problem whether the building satisfy the general demands. To meet being tectonic there must be an interaction with these structural considerations and form, and the art of the building. Consequently the construction is under development through the process as the more aesthetic parameters are. The two approaches to design interplay and give by symbiosis the final result. Like the empiric analytic theory the theory of the building is under development continuous and the deductions likewise. The building evolves concurrently with the different results of the calculations.

Phenomenology

The understanding of form and the ability to develop good spaces can be done through the empiric analytic method by e.g. questionnaires, videotaping or physical measurements. Though there is a tradition for the perception of the good spaces is related to the experience of the space, and that is related to the individual experiencing it.

As explained it is possible making empiric analytic deductions of human experience, which can develop theory about the good space in spite of the dependence of individual experience. The empiric analytic method independent of context as time and space is found less interesting as the phenomenological; a philosophy about the perception of phenomena with time and space as dependent parameters, always marking the perception of the experience of phenomena. Martin Heidegger describes it as "*Man depends upon himself the way in which he must take his stand in relation to whatever is as the objective.*"[Delanty & Strydon, 2003, p. 149]

According to Heidegger it is only possible to experience the appearing, producing and being of the phenomena while present. Ultimately this is the crux of every architectural action. Thus the phenomenological method is a distinctive kind of reflection. Instead of focusing on the consciousness on other things or phenomena, it is focusing on the way how these things are given to the consciousness. The human is very aware of which elements influencing the focus of the consciousness. Thus the basis is the consciousness of a thing and reflections over the different components of its consciousness and the way these components are related to each other.

Phenomenology is thus the active process of sensory perception. Thus subject opens its world and shows itself. The objects structure is not completely determent, merely some of the options that are culturally given to the subject. Thus the sensory perception defeats the dualism of body and mind, because observable objects can only be understood in relation to the subject, as a body entering the world. [Delius, 2000]

Hence it is important to make accordance of the statement and the phenomena, to be experienced. The purpose is to make consensus between the theories and the fields while consensus is an important notion of truth in the phenomenology. Maurice Merleau-Ponty describes it as "*every science secretes an ontology; every ontology anticipates a body of knowledge. It is up to us to come to terms with this situation and see to it that both philosophy and science are possible*." [Delanty & Strydon, 2003, p. 142]

The phenomenological method is useful in the experience of the good space and other qualities in space. As form giving inspiration reference projects can be experienced, either by being in it and making up one's mind about the feeling the architectures applies one. Another possibility is experiencing architecture through photography here it is important to be aware that the photography is a reflection of the architecture independent of time and space , and thus the phenomenological experience is an experience of the reflection and not the architecture itself. In the phenomenological mind it is important to be aware of the difference of the two occasions, while the photography is taken out of the context, which is against the phenomenological philosophy. Every phenomenon appears different and will be experienced likewise dependent on time and space. Phenomena always appear to us as a variant of a single life that ours is part of. [Delanty & Strydon, 2003, p. 145]

Hermeneutics

The integrated process of making of form or rather finding of form in terms of the parametric approach to tectonics it is necessary to have a reciprocal action between the empiric analytic approach and the phenomenological approach. The hermeneutics is the theory of interpretation. It is not reasonable trying to explain the phenomena from general formulas like science. Instead the hermeneutics tries to explain the meaning of the single phenomenon from its context. Hans-Georg Gadamer claims "*It might be described as the theory of the deductive method of testing, or as the view that a hypothesis can only be empirically tested – and only after it has been advanced*." [Delanty & Strydon, 2003, p. 44]

The hermeneutics takes as starting point that man is thrown into a world having a preceding understanding of it. Only from the horizon of what is already known is it possible to acquire some of the unknown constantly meeting one. By involving communicative with the unknown the achievement level and the horizon broaden. [Delius, 2000] "A person who has no horizon does not see far enough and hence overvalues what is nearest to him. On the other hand, '*to have a horizon' means not being limited to what is nearby but being able to see beyond it*." [Delanty & Strydon, 2003, p. 160]

The hermeneutic method is based on how the insight broadens the horizon and the broadened horizon broadens the understanding. "*- in fact, we miss the whole truth of the phenomenon – when we take its immediate appearance as the whole truth*." [Delanty & Strydon, 2003, p. 158] Thus the method is an interrelationship between the part and the whole or the text and the context.

Hence the hermeneutical method brings a broadened horizon to the tectonic thesis from its different fields. The method is like a spiral taking starting point in the problem relates to the part and responds to the whole with a new and widened understanding. Thus it is possible to relate to the part again with the increased understanding and responding to the whole.

2.2 SUMMARY

The tectonic methodology is a symbiosis of the empiric-analytic primary influencing the engineering aspects and the phenomenological approach in the assessment of the revelation of the truth of the building. Thus it is seen how the theories of phenomenology and positivism immediate are contradictory, but in terms of tectonics they are both influential and important. The hermeneutical method is binding all the parts to a whole in the up building spiral.

As the section of tectonics announces how the essence can be boiled down to the fusion between ontology and representation, exemplified by the strict technology and artistic poetry. The section of art and technology deepens into the concepts of tectonics with a phenomenological approach. Both are described as part of a revelation. Art is a way of expressing the element of truth and the means of creating it and providing a springboard presenting the revelation. Technology is the process, through which the revelation is carried out. Thus the difference is that art means the revelation and technology is the process in itself.

Hence the concept of tectonic can be described in terms of art and technology. This includes that the concept consists of the tools and the knowledge and techniques available – implied available at certain time.

The digital media is seen as a tool or a technology of today. Thus the amount of available knowledge increases with the digital media and the possibilities within e.g. in the potential in making technical optimal solutions from a positivistic viewpoint. Solutions generated by a computer possess the potential of being perfect solutions, while the computer generates the form from pure mathematical algorithms with the purpose of optimising in relation to specific matters. This is the complete positivistic approach, where the influence of human interaction during the process can be eliminated, and thereby the human impact will not be present in the design of the artefact. While the pure computational optimisation is purely positivistic it cannot solely reach tectonic design. The representation of the building or the poetics must likewise be taken into considerations to accomplish a tectonic result. Thus the ontological and representational part of architecture are to be working toward a revelation of all matters within and around the building, including construction, context, and intention to accomplish a tectonic design with respect to the concepts of art and technology.

Therefore the methodological procedure of this thesis is evolving building design from a tectonic perspective using the digital media.

Keyword of Methodology of Tectonics

Summing up on the methodology the cases in terms of tectonics consist of the duality of art and technology and the methodology attached to these cases likewise consists of a duality. The following keywords of methodology are specifying the aspects of methodology to bring on in the further development of the thesis in terms of architecture in the digital age, case study and eventually the design.

1. Empiric-analytic method

Representing the engineering optimisation and the technological part of tectonics

2. Phenomenology

Representing the empathy and interaction and the experience the appearing, producing and being of the phenomena in terms of the art of the building.

3. Hermeneutics

The concatenating of methodology of art and technology and representing the exploration of the horizon during the process to the design result.

2.3 METHODOLOGY OF CASE STUDY

In the former section working with tectonics has been further described on basis of the historical review of the architectural theory. Thus the definition of tectonics has been further developed in this analysis of the methodology within the concept. In the following the more concrete methodology of working with tectonics or rather analysing tectonics in terms of case studying is described. The following is merely a general approach to case study research and will therefore be less marked of the tectonic values.

Case study

Case study is a tool to improve the understanding of the state of art. In a frequently cited book concerning case study research, Robert Yin provides the following definition: "*A case study is an empirical inquiry that investigates a contemporary phenomenon within its real-life context, especially when the boundaries between phenomenon and context are not clearly evident*." [Groat & Wang 2002, p. 346]

According to Yin, there are five primary characteristics of a case study [Groat & Wang 2002, p. 346]:

1. A focus on cases in their contexts
2. The capacity to explain causal links
3. The importance of theory development in the research design phase
4. A reliance on multiple sources of evidence, with data needing to converge in a triangulating fashion
5. The power to generalise to theory

The five characteristics can be reorganised and reformulated to a method or procedure useful in case study in a tectonic context. Thus the following is the author's translation of the five characteristics to a procedure and explanation of the procedure in the tectonics context.

Preliminary considerations

Awareness of the context of the case, why the understanding of a case involves an understanding for the relation of the complex dynamics with which it intersects. [Groat & Wang 2002, p. 347]

Requirements to fulfil the theoretical concept of a case study

The requirements includes the capacity to explain causal links and multiple sources of evidence, while it is some aspects that by the author are considered as possible to have in mind while working with case studying, where the following statement is more decisive for the process of the study.

Multiple sources of evidence is a criteria, that refers to a wide perspective from the analyst point of view to the case, thus the entrance to a case study is with wide perspective. Parallel the capacity to explain causal links also refers to the procedure of working with case study. It is likewise a criteria possible of having in mind while working, since the criteria refers to the purpose and procedure of working. Hence these requirements are supposed to be in the consciousness during the case study to ensure the documentation of being a case study.

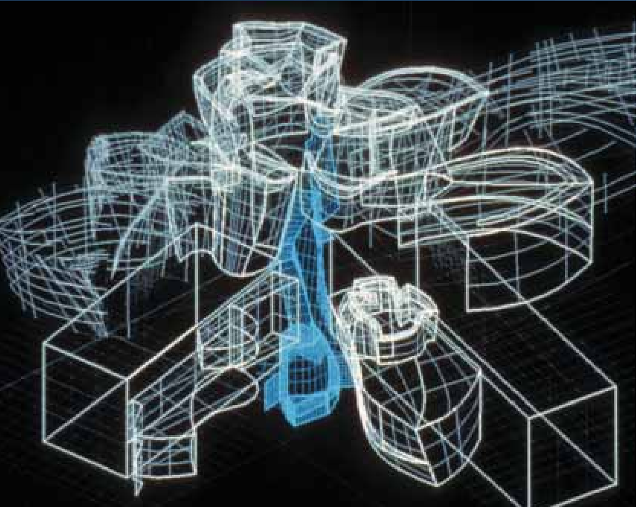
Hypothesis – Analysis – Thesis

The third and fifth criteria concerning the importance of theory development and the power of generalising to theory is being reformulated to a procedure for case studying. The complete research design should embody a theory of what is being studied. [Groat &Wang 2002, p. 352] Thus the case study analysis can be described as a tripart procedure, where the analysis consists of first a hypothesis – some chosen elements to focus the case study on, the second element is analysis consisting of studying and comparing some or a case, and finally the thesis in which the cases' units crystallise and through the thesis a comparison of the cases is possible. This procedure is parallel to the positivistic empiric-analytic method consisting of an initial theory that through inductions and deductions is verified or falsified, which develops a new theory.

The possibility of the comparison relies on the thesis derived from the hypothesis. Therefore the hypothesis must be documented in the beginning of the case study, thus it the initial theory can go through a process of deductions and inductions to develop the new theory or the thesis to compare with other thesis in terms of using case study as an analysis tool for comparing cases.

While the hypothesis thus is the preliminary theory of the object to analyse through case study, this preliminary theory must be documented and listed up making the reuse easy. Therefore before a case study the aspects to analyse must be listed up, thus there are some well-defined parameters to go through in the case study.


16. The Guggenheim Bilbao Museum, 1997 by Frank Gehry


17. The Guggenheim Bilbao Museum, 1997 by Frank Gehry

3 ARCHITECTURE IN THE DIGITAL AGE

For centuries an architect was not only involved with the spatial effects but also closely involved in the construction. The master builders from the Greek tekton (builder) to the medieval master masons had the central and most powerful position in the building procedure. In the mid-nineteenth century architecture and construction came further and further apart when the drawings became contract documents. This direction detached architects from the act of building – the design and construction were split from each other, and the architect had unintentionally lost the power they once had. [Kolarevic 2003, p. 58]

The twentieth century brought increased complexity in design as well as construction. This increased complexity necessitates increased specialization which emergences various design and engineering consultants. Concurrently with the advancement of the building industry the architects were increasingly losing the control and the decision making power and thus disassociated themselves from the rest of the building industry. [Kolarevic 2003, p. 58]

Breaking down the boundaries by computational tools

Presently it is the divisions of responsibility that forms the norm in the building industry today including the necessity of drawings. In Denmark they have introduced product model based design Det digitale Byggeri (The Digital Construction) former known from the aeronautical, automotive and shipbuilding. It is developed as an effort to promote the use of IT in the building industry, which before had been significant behind other industries. The introduction of The Digital Construction introduces Building Information Modelling as a tool to encompass the entire building in one model, which always is fully updated instead of an amount of drawings. The Building Information Model has proofed its usefulness in the process from the conceptual part to the detailing because it facilitates linking the conceptual ideas to some analysis programs for further development, in this way the comprehensive three-dimensional digital model is used from design to construction. The ability to digitally generate and analyse the design information and pass the same digital model on to production and manufacturing redefines the relationship between conception and production. The new digitally-driven processes provide an informational continuum, which emerges new synergies in architecture, engineering and construction, because the use of digital technologies crosses and decreases the boundaries of various professions. Thus "*The fission of the past is giving way to the digital fusion*." [Kolarevic 2003, p. 60] Design and construction can be seen as amalgamated, they are no longer separate realms, because builders and fabricators become involved in the earliest phases of design, and reverse architects participate in all phases of construction. By the amalgamation of professions with the digitally-driven processes the architects must be trained to be a master builder again to prepare the future generations for the emerging practices of the digital ages. Coping the task of being a master builder again by amalgamating the before separated enterprises demands defeating numerous obstacles and will be rewarded compellingly. [Kolarevic 2003, p. 62]

The structural engineer Cecil Balmond (1943 -) is one of the professionals that proclaim a need for requiring new strategies for recognising structural possibilities and improving the cooperation of the architect and the engineer. Balmond is the Deputy Chairman of Ove Arup and Partners Limited, and Arup Fellow and Director of the Advanced Geometry Unit


18. The Serpentive Gallery Pavilion, 2002, by Toyo Ito and Cecil Balmond


19. 18. The Serpentive Gallery Pavilion, 2002, by Toyo Ito and Cecil Balmond

(AGU). With this background, cooperation with some of the world's most influential architects and his particular interest in promoting an animate sense of geometry using numbers, mathematics and music as vital sources. He is specialized in design for buildings with innovative structures and he continues to promote engineering as a totally creative activity while he in the meantime proclaims that architecture and engineering require social as well as technical action. [Holm 2007] Balmond comments that there is a need for breaking down the barrier between the architectural aesthetic sphere and the engineering technical concerns and developing a synergic approach towards design through facilitating the design process through digital technologies. [Leach et al. 2004, p. 11]

The new collaborative partner

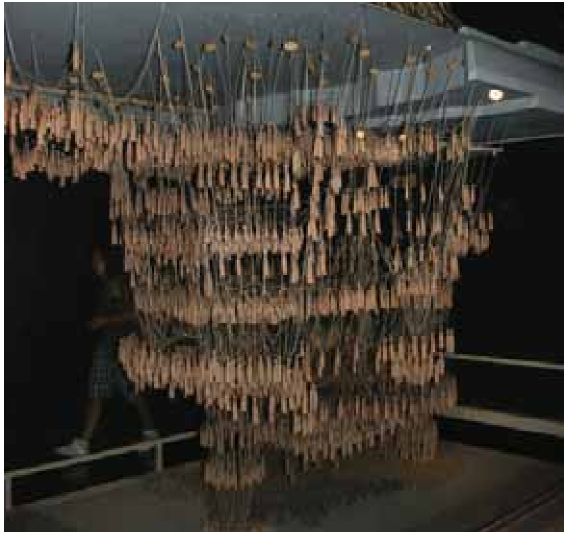
The influence of the digital media is increasingly being used in contemporary architecture. It is not only for representation as a visualisation tool but also opening up for digital generative processes, where the media is used as a generative tool for the derivation and transformation of form. According to Prof.Dr. Kristina Shea, University of Delft [Leach et al. 2004, p. 88-102] the digital designing tools have become an integrated part in the generative processes and the new way is considering the computer as a collaborative partner capable of generating ideas and solutions in response to robust models of design conditions and performance. With the capability of drafting and form-finding through the computational possibilities, the role of the computer has thus been updated to a collaborative partner, caused by the tight link between associative geometry, structural performance evaluation and structural optimisation. [Holzer et al., 2007, p. 631] In this way designing structure and architectural form is integrated through use of advanced software assisting form-finding as well as drafting, manufacturing and even project management processes. [Holzer et al., 2007, p. 630] Thus the digital generative processes widen the perspective in designing. The processes are opening up for new territory for conceptual, formal and tectonic exploration, where an architectural morphology is articulated focusing on emergent and adaptive properties of form. Using digitally generative processes enables various digitally based generative techniques to finding of form, why the emphasis shifts from making of form to finding of form. [Kolarevic 2003, p. 13]

Digital technology

The development of the technology has advanced the possibilities, thus it is possible not only to valid results through trial and error but making a continuous validation through the design process. The generative tool is software for generating novel structural forms with their own structural integrity and with a technology behind the already sophisticated use of genetic algorithms. [Leach et al. 2004, p. 75] Thus the former delimit use of the computational tools to valid results e.g. in testing the structural stability of the designs has now broadened the boundaries and advanced the possibilities of integrating the computational tools into the design process.

Digital tools in the design process

The first experiments using Computer Aided Design (CAD) as architectural software took place in 1990. The architectural software proved its insufficiency and instead software for aeronautical and shipping design showed possibilities in dealing with creative activities similar to the problems Antonio Gaudí dealt with 100 years earlier. [Leach et al., 2004, p. 31] Gaudí has become known as an architectural and technical genius in the tectonic arena caused by his generative processes as the hanging model. His method recovered efficiency in the



20. Hanging model of Gaudí 1852-1926

spatial distribution of material in a structurally appropriate manner. The solid geometry software based on aeronautical and shipping design was capable of doing almost all that was required. The only problem was memory shortfall, which has been diminished noticeably in recent years. Today we still rely on the software designed for engineering and vehicle design. [Leach et al. 2004, p. 31]

There are several ways to implement digital tools in the design process to accomplish a tectonic result, and new design approaches have evolved concurrently with the development of technology. Parametric design is an approach that can be seen as a best-fit method with possibility of a post- and pre- rationalising. [Leach et al. 2004, p. 34] Implementing the computational possibilities into the design process thus facilitates optimisation during the process. Hence the task is to understand the design variables their influences of the changes on one or more performances, to both meet design constraints and improve performances. [Luebkeman, C & K. Shea 2005, p. 18] Designing through declared parameters, rules, goals and constraints enables the designer to generate a variety of design solutions. Thus designing with parametric values defines a way of structuring geometrical entities through associative variables, relations and dependencies. Hence "*An object that has been designed reflects deliberate decision-making, not a serendipitous occurrence*" [Holzer et al., 2007 p. 631]. The digital tool not is merely a representative tool, but a generative element to clarify details or fundamental elements such as structure and construction in the design process.

Design by computational power

Using computers in design has through history proofed its importance. Though the designer wants to control what the computer is doing, such it is more like the drawing board, slide rule and model. With the constant improvement of the computer memory, the computer can also be used to generate geometric forms. The advantage of the computer is the enormous calculating power in terms of arithmetic which can make it follow simple rules quickly and reliably and giving the impression of intelligence. The designers role and unique ability in this relation is the ability of sensing, which always will differ the computer and the human. [Leach et al. 2004, p. 79]

There have generally been two starters of the theoretical foundation of the development of generative computational representations and processes: Natural analogy and logical basis. Historically speaking nature has been a wide source of inspiration – also in the hanging models of Gaudí was nature the inspiration in the generative methods of optimisation. Some of the generative computational processes are genetic algorithms, genetic programming, artificial life and particle

21. Museo mediterraneo dell' 22. arte nuragica e dell'arte contemporanea di Sant'Elia a Cagliari - Concorso Betile by Zaha Hadid

swarm optimization and self-organising systems. Likewise nature has particular analogy influenced the computer representation and generative processes by the steam of encoded bits that must be decoded to understand the object. Logical basis requires a study of the underlying logic and systems to form the rules that generate a language of valid objects. [Leach et al. 2004, p. 90] The two directions of computational generative design consist of genetic algorithm design and the evolutionary models of nature. The process of the genetic algorithms design is to define a set of generative rules, and defining their evolution and development to obtain the parameters to be mapped to a specific design context. In evolutionary design the candidate generated forms can be evaluated on the basis of their performance in a simulated environment. [Oxman 2006, p. 256]

Buildability

Generating form through computational creativity it a subject that has been debated for several decades. But with the present possibilities of instantaneously getting feedback on issues as space usage, structural, thermal, lightning, fabrication parameters the computer does not only offers possibilities of generating new forms but also relates to the efficiency of the building maintenance and consumption. [Leach et al. 2004, p. 89]

To work integrated with structure and form in the generative processes rules are developed on basis of existing classes of design as well-formulated relations between form and structure using a structural shape grammar, that can be used to generate design topology and geometry, giving the possibility to add, remove and modify primitives and connectivity while the structural system is maintained. [Leach et al. 2004, p. 91]

From digital pitfalls to serendipity

It is important in the generative process to include the telluric in the apparent freedom to avoid mistakes from the empty digital space. While the ability evolves with the technology the former major factors in building have been material, ability and need. Ability contains the ability to assemble, collaborate and communicate and need is the need for a shelter within its symbolic value of power, safe, utility and beauty. [Leach et al. 2004, p. 41] Those factors can still be seen as determinant factors in the building context, and then the question is to maintain the focus and ponder how to harness the ability of the digital creation to use materials and satisfy the need? [Leach et al. 2004, p. 45]

It is possible with the digital revolution to create and communicate virtual buildings this has called for a need to advance the ability of construction. In addition presently there has

22. With its informal atmosphere and unrivalled views out across the Tyne, The Sage Gateshead is one of the city's great social spaces as well as a regional music centre of international standing. The entire complex is sheltered beneath a broad, enveloping roof that is shrink-wrapped around the buildings beneath and extends over a public concourse.

23. The Sage Gateshead in the Skyline

evoke a need for diminishing the waste and thereby a priority of the environment. [Leach et al. 2004, p. 45] The simultaneously consideration of efficiency of form and the reality of construction is the essence of good engineering, instead of using the traditional method of trial and error physical models capturing the laws of physics and using them as important parameters in the development of the construction. Without the constraint of the physics it is important to ensure the continuation of the possibilities. [Leach et al. 2004, p. 46]

The ability of generating form free from old constraints is greater than ever. Now the challenge is in deciding what form is right and what rules and creative models should be followed. In these cases the participation of the engineer is crucial in the creation of form to remind the efficient use of materials from the old physical methods. There is a need for the form generating models that recognise the laws of physics and with the ability of creating minimum surfaces for compression, bending and tension. Furthermore there is a need for the virtual building model to link between the construction of the building and the design ideas, so the building and fabrication as well become a part of the design and the minimal use of materials. [Leach et al. 2004, p. 49]

Digital architecture

As mentioned above by use of parametric design software it is possible quickly to manipulate the designs by changing variables or parameters that defines the geometry whether it is complex organic forms or more regular shapes. Thus aesthetic, technical, and economic parameters can immediately be evaluated and accommodated during the design process, while the geometry concurrently automatically get updated with changes to the overall configuration. This praxis enhances the optimisation designs, while the response of the parts is fast and easy to implement in the overall geometry. Thereby the reaction to a part change is visible in the remaining parts and especially the overall structure.

The advantages are easy to find in the optimisation possibilities through parametric design. All though there has been a debate about whether the designer wants to do computer programming to achieve design results thus the designer is actively engaged in programming and thereby engaged in the design decisions through the parametric software or if the designer by the integration of the digital media in the design process participates passively in the process. By using off-the-shelf software the designers are passively accepting the limitations embedded in the program in codes and the graphical user interface. Only few architects are interested in becoming skilled programmers. Rivka Oxman describes the designer as a toolmaker of customised design media as a result of the more complex and demanding design processes by the multiple types of software, scripting languages, and the manipulation and maintenance of complex data models. According to Oxman the designer obtains a new role and becomes digital design specialists, especially in cases with parametric systems requiring specialist knowledge in order to operate and maintain. [Oxman 2006, p. 262] Foster+Partners and GehryPartners have been some of the far-sighted practices integrating computer programmers into the design teams. [ArchitectureWeek, 2008]

Digital design models

The shift, for the digital media from being a representational visualisation tool to being increasingly used in the generation and transformation of form, is the digital morphogenesis. This shift obviously has an impact on the design process. Oxman argues there is a need for reexamination of current design theories and methodologies in the form of a new theoretical framework suitable for the conceptualisation of digital design. This framework must be capable of contributing a relevant theoretical structure to the field, whereas its own theoretical disciplinary contents also must illuminate the basic parameters. [Oxman 2006]

The digitally generated forms are not designed or drawn but generated through an articulation of internal generative logic, which in an automatic way produces a range of possibilities, from which the designer chooses the appropriate formal proposition for further development. Thus computational digital architecture is defined by computationally-based processes of form origination and transformation and the digital morphogenesis is defined as the plural emphasises the inherent multiplicities in the underlying computational logics. [Kolarevic 2003, p. 13]

Prior research methodology and thinking has been centred on the analysis and formal modelling of behavioural, procedural and the cognitive activities of designing. The criticism is not on these methods, while they certainly have given a sound basis for identifying, comparing and transfiguring the differences between conventional paper-based design and mediated design environments. [Oxman 2006, p. 230] Also the traditional conceptual terms from Deleuzian philosophy such as non-linearity, inter-connectivity, continuity, networks, dynamism, diagram, design machines, etc. have been used characterising digital design. Among these the ideas of hyper-connectivity and non-hierarchical structures of organisation have also influenced the digital design theory. Thus the new framework needs to include the cross-disciplinary connections to the biological sciences, such as complexity theory, chaos, emergence, catastrophe theory, and bio-mimetics are now related to fields of emerging technologies from a research perspective. [Oxman 2006, p. 263]

In those terms Oxman presents five paradigmatic models to interpret digital design, wherein the methodological characteristics of these paradigms have been formulated relative to tradition theoretical concepts of design and to traditional models of design thinking. The five paradigmatic models are the following: The dual-process CAD model; formation; generation; performance; performance-based formation and performance-based generation and finally the compound integrated model. [Oxman 2006, p. 260]

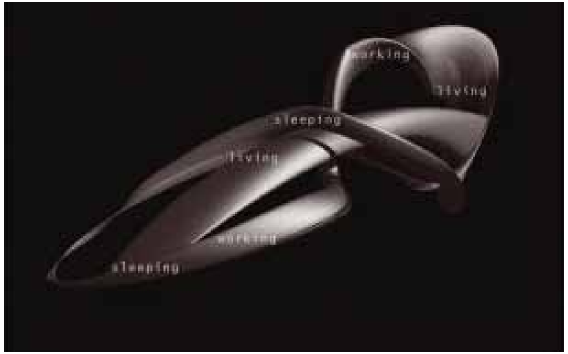
Oxman's introduction of new paradigmatic models relates to the established directions of computational design. The digital generative processes are opening up new and different territories for conceptual, formal and tectonic exploration.

3.1 DIGITAL ARCHITECTURAL STYLES AND METHODS

In the following architectural styles based on different digital methods and technology will be explained as a continuation of the digital design models and the appurtenant framework.

Topological transformations

The topological geometries have showed its particular potential in architecture in the emphasis of the shift away from particular forms or expressions to relations between and within an existing site and the purposed program. Thus the interdependence becomes the structuring, organising principle for the generation and transformation of form. Topology is a study of intrinsic, qualitative properties of geometric forms not normally affected by changes in size or shape. Hence topology can be seen as a motion towards the non-Euclidean spaces by means of *n* equations with *n* unknown quantities, which is the fundamental basis of splines, where a polynomial of low degree gives lines. Thus it started with Euclidean forms modelled toward non-Euclidean spaces. Important to emphasize is that by giving the topological structure a geometric architectonic form, the realm of the shape is within the Euclidean spaces. [Kolarevic 2003, p. 14]



24. Conceptual idea to Mobius House

25. Mobius house by UN Studio, Het Gooi, Netherlands, 1998

NURBS – Non-Uniform Rational B-Splines

NURBS have the widespread ability to construct a broad range of geometric forms, from straight lines to Platonic solids, and highly complex sculptured surfaces. Another appealing parameter is the easily control of their shapes by interactively manipulating the control points, weights and knots. This easily control reflects the minimum amount of data the computational modelling requires, which also is one of the decisive parameters for NURBS being the present most relied method for construction complex surface models. [Kolarevic 2003, p. 15]

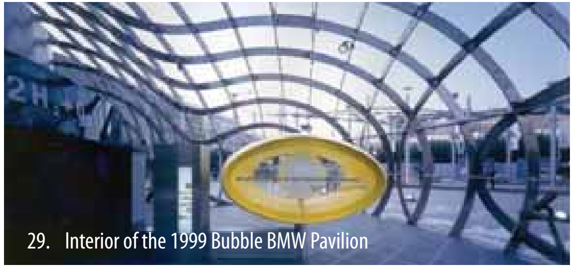
26. Dynaform by Bernhard Franken and ABB Architekten demonstrated how the dynamics of forces produce the motion and particular transformation of form. This design strategy utilised special effects programs borrowed from the film industry. These programs have the ability to simulate, following physical laws, the changes in the shape of an object when subject to force fields.

27. Visualisation of the 2001 Dynaform BMW Pavilion

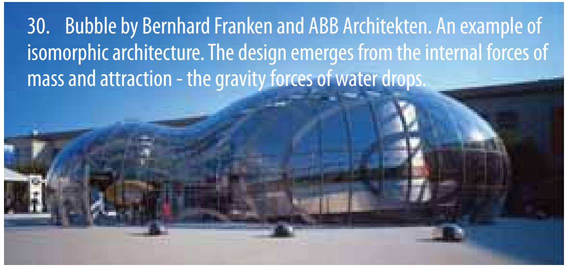
28. Interior of the 2001 Dynaform BMW Pavilion

Animate architecture

Animate architecture utilises a form of movement in the generation of design. One of the predominant architects in animate architecture is Greg Lynn, who was one of the first to use animation software. He argues that *"it is important for any parameter-based design that there be both the unfolding of an internal system and the infolding of contextual information fields."* [Kolarevic 2003, p. 19] Architectural form is not only a manifestation of the internal, parameter-driven relational logics, it also has to engage and respond to dynamics consisting of variable influences from the environments including the socio-economic context. Some of the modelling techniques in animate architecture or motion-based modelling are keyframe animation, forward and inverse kinematics, dynamics (force fields), and particle emission.



29. Interior of the 1999 Bubble BMW Pavilion



30. Bubble by Bernhard Franken and ABB Architekten. An example of isomorphic architecture. The design emerges from the internal forces of mass and attraction - the gravity forces of water drops.

Isomorphic architecture

Isomorphic architecture is influenced by the force fields. The architecture, also called blobs or metaballs, originates from isomorphic surfaces. It is amorphous objects constructed as composite assemblages of mutually-inflecting parametric objects with internal forces of mass and attraction. [Kolarevic 2003, p. 21] Thus it is developed through influence of force fields and thereby can be understood as from follows forces.

31. Üstra Office Building in Hannover, 1999 by Frank Gehry. An example of metamorphic architecture.

Metamorphic architecture

The metamorphic architecture or keyshape animation is a transformation by adding a fourth, temporal dimension to the deformation processes. Thus animation software literally expresses the space and form of an object's metamorphosis. [Kolarevic 2003, p. 22]Hence metamorphic architecture is where geometry has been exposed to a deformation or thereby being morphed into a new shape.

Genetic algorithms

Genetic algorithm is the key concept behind evolutionary architecture, where architectural concepts are expressed as a set of generative rules with the evolution and development digitally encoded. This architectural direction is also known as bionics, where the rules emerge from those who direct the genesis of the living organisms.

32. London Skyscrabers. Bishop gate tower by KPF is made only by Generative Components. Swis RE by Foster+Partners is formed by CFD.

Parametric architecture

Parametric design often entails a procedural, algorithmic description of geometry. [Kolarevic 2003, p. 18] Parametric design puts up parameters to describe form. By rules and mathematical calculation form is generated. Thus the form making can be done with consideration of pure mechanic forces. Through the parametric construction of the generating of design variations are easily made by transforming and manipulating the activated attributes. Thus different value assignments can generate multiple variations while maintaining conditions of the topological relationship. [Oxman 2006, p. 253] Currently it is the Gehry Technologies' Digital Project, based on *CATIA* and Bentley Systems' *Generative Components* that are primary digital technologies in designing parametric. Parametric systems are furthermore becoming cornerstones in the more complex performative architecture described below.

33. Swis RE Headquartersin London, 2004 by Foster+Partners. An example of parametric design generated by CFD analysis.

Performative architecture

This kind of architecture places broadly defined performance above form-making. The building performance is understood as financial, spatial, social, cultural, ecological and technical perspectives. Thus it uses building performance as a guiding design principle and through digital technologies of quantitative and qualitative performance-based simulation it offers a comprehensive new approach to the design. Among others the qualitative methods includes FEM (Finite Element Method) analysis to accurate the structural, energy and fluid dynamics for the building. CFD (Computational Fluid Dynamics) is another method primary used analysing airflows around buildings.

Foster+Partners can be seen as pioneers in the performative architecture. The Greater London Authority Headquarters from 2002 is optimised with respect to the energy consumption.

This optimisation causes the blobby form, and thus the shift in perceiving blobby architecture goes from form considerations to performative considerations. [Kolarevic 2003, p. 26] The considerations of different parameters in performative architecture can easily be linked to the digital tectonic architecture.

Thus it is seen in the overview of the digital architectural methods and styles how the emphasis varies from form finding in terms of formal considerations as in the topological to metamorphic and to form finding in terms of technical considerations potential in especially parametric and performative architecture.

34. The Greater London Authority Headquarters in London, 2002 by Foster+Partners is optimised with respect to the energy consumption.

35. The Greater London Authority Headquarters in London in night light.

3.2 DIGITAL TECTONICS

As this section discusses the emerge of the digital media as a generative tool in the architectural scene. In terms of this the aim is concatenating this with the conventional tectonics in the contemporary concept of digital tectonics. Thus with the possibilities of the digital media the values of the conventional theory remains a part of the contemporary architectural theory.

As described in the section the new techniques through the digital media can be used as an aesthetic manner handling complex compositions of shapes as in the isomorphic architecture or metamorphic architecture, or handling complex achieved shapes as animate architecture and topological architecture. The complexity in the achievement of the parametric architecture and performative architecture represents also handling of the digital media in aesthetic manner but this includes likewise the engineering perspective of optimisation.

In spite of the basis of Frampton's tectonics, namely a critical countermovement against computer aided design and the intension that computer aided architectural production fails to understand the intrinsic nature, while architecture is to be out of the tectonic capacities of actual materials. The intension is to consider the terms of tectonics in the context of the digital media. In extension to Frampton's countermovement against tectonics as computer aided design his own understanding of tectonic can be discussed. As the essence of tectonics can be described in terms of art and technology, which includes that the concept consists of the tools and the knowledge and techniques available at certain time, and thus the digital media is seen as a tool or a technology of today.

A new preliminary framework

Yu-Tung Liu and Chor-Kheng Lim analyse some cases of digital architecture with the purpose of adjusting and extending the conventional tectonic parameters to cooperate in the digitalised community. [Liu 2006, p. 271]

Through analysis of some digital architectural cases there are found, that the following characteristics must be included in the tectonic values: Motion, Information, Generation and Fabrication, while the digital projects uses dynamic processes like animation and morphing in the making or form evolution. Information is the new kind of building surface material while the digital space consists of immateriality. Generation is the automatic generating process of form or concept generated on the basis of the designers input to the application of software generative systems/algorithms. Finally fabrication is the new design process that emerges of the digital possibilities before the construction stage. Fabrication is the process of fabricating components and the method of construction. [Liu 2006, p. 286-287]

By the possibilities in the generative processes the digital technology can be described as a design medium rather than a design tool, while it has brought a new way of design thinking along with the new way of design making. [Liu 2006, p. 302] In these terms the listed new parameters to include for tectonic thinking are found valuable, while architecture needs to be he carefully thought to achieve being tectonic. Thus the considerations of the input into the generative processes including motion and information are part of carefully thought architecture achieved with the digital media. Furthermore the integration of the digital media into the architectural arena was among other aspects an attempt of bringing the fabrication or manufacturing closer to the concept as part of the form generation. With these considerations the listed four digital factors along with the seven classic factors is seen as an adequate framework for the new digital tectonics, where the new factors form a whole in interaction with the classic. The framework furthermore relates to the interrelationships between personal and socio/cultural levels of thinking, while the digital technology enables a production of unknown ideas through the generative processes and creates redefined domain knowledge for both personal and socio/cultural design thinking. [Liu 2006, p. 303]

Thus it is seen how the theory of tectonics is brought into the digital arena. The definition of tectonics has been under development since Vitruvius introduced the triparte values. As history has influenced the theory of tectonics and the theory has developed concurrently with technology e.g. the invention of cast iron and later steel. And even though the tectonics of Frampton was seen as a counter movement against computer aided design, the influence of the digital media to the theoretical direction of architecture must be seen as a self-evident consequence of the development – or rather all development.

The Performative Tectonic Architecture

Performative architecture is an established direction of computer aided design. While the performative architecture's task is placing financial, spatial, social, cultural, ecological and technical perspectives understanding the buildings performance above form-making, thus the guiding design principle is the building performance. Drawing a parallel to the tectonics (the tectonics of this thesis primarily influenced by Frampton) the guiding design principle is the structure of the building and the joint articulating the poetics of the building. The performative tectonic architecture's guiding principle is thus the technical perspectives understanding the structure of the building, which then is the determinant parameter above form-making – or rather the decisive parameter in the deliberate decision-making is the tectonic parameters. It is the tectonic parameters that are the defining rules, goals, and constraints defining the design solution.

The future possibilities

One of the tasks of today is in linking the parametric design software with the engineering analysis and optimisation processes for encouraging the concurrent work methodology across disciplines. Thus it is possible to assist form-finding as well as drafting, manufacturing and even project management processes.

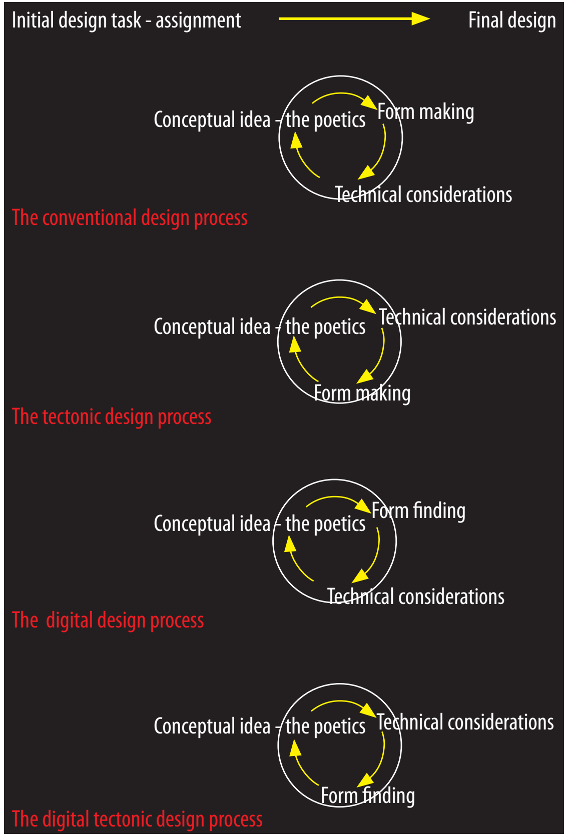
In the current practice the linking of form-finding software and optimisation software is primarily reserved to the engineers, especially mechanical engineering. The optimisation software is used in engineering design rather than as a creative element in the design process. Again the design software is behind other industries.

By linking of the optimisation software to form-finding software it enables the possibilities of optimising early in the design phase and using optimisation as a creative parameter. Thus the use of optimisation will be facilitated and incorporated in the generative process, and by adjusting the parameters the design are built upon, the designers can immediately get an optimised variation of the design. Hence optimisation will be a creative and active part of the design process. Optimisation as an active parameter in the creative design process also enables the use of optimisation in the early brainstorming phase where form is explored. And thereby optimisation can be used to derive design concepts. In this terminology optimisation architecture can become and architectural direction parallel to performative and parametric architecture.

3. 3 SUMMARY

This section presents different directions in computer-based design, each characterised by its architectural driver, whether it is particle flow, morphing forms or genetic algorithms. While the aim of this thesis is linking the traditional tectonics with the possibilities of the digital media, the attention is on the performative, while it is driven by performing different perspectives such as spatial, constructional or/and ecological perspectives. While the architecture already consists of performing a certain perspective, the obviously possibility is performing tectonics leading towards the digital tectonics and the performative tectonics.

Tectonics that is a pre-digital architectural theory is through the analysis still valued relevant in the digital architectural community. The demanding parameters of the conventional tectonics as listed in the tectonic section (Structure, Construction, Interaction, Object, Detail, Joint and Material) are



36. Diagram of the different outlined design processes.

broadened in the digital tectonics. This paradigm includes Motion, Information, Generation and Fabrication, which all are parameters that have proofed their relevance within the digital continuum by the possibilities with the digital media. Furthermore the including of the parameters can be seen as a natural continuation of the preoccupation of structure, construction and material, while the fabrication and generation by the digital media are linked closer to the concept and the former design considerations. Information is likewise a parameter that arguable can be seen as a natural continuation of the conventional parameters. Information is a demanding element in the digital design process and some even defines information as the new material. Questions about information and the designer's ability to handle the necessary information to generate design by the digital media have recently been part of the foundation in the discussion of the digital gener-


37. Skyline of the Thames

ated design, questioning the designer's active part of the process. Motion as the last perspective to include is a reaction of the dynamic design processes like animation and morphing in the making of form. The motion perspective is not valued relevant as the other three perspectives, while animation and morphing according to the typological definitions of digital architecture primarily defines the animate, isomorphic, metamorphic architecture and etc, where the tectonics as defined is within the performative architecture and by definition also the parametric that as described includes the more elaborated performative.

It is already seen how the computer goes from a tool to a collaborative partner in the design process. In terms of design the computer was previously broadly used by the designer in the visualisation of the design, and by the engineer in the engineering design as dimensioning of the elements in the structure. Thus both the engineer and the designer utilises the calculative power of the computer in the making of form. As mentioned above some far-sighted architects have already been using the computational tools as a generative element in the design process, thus the making of form changes to finding of form. The emphasis is not this change but the possibilities in integration the traditional tectonics into this new generation of design. Thus the digital tectonics embraces the finding of form and the technical considerations in the early design phase as the schematic diagrams in figure XX-XX show.

Hence the task is integrating the computational power earlier in the design process and as a generative or creative tool thus the finding of form through computational possibilities emerges. To accomplish a tectonic approach the generative design tools furthermore must be based on tectonic considerations. This is occasionally seen in the performative architecture, where the emphasis has been on the tectonic performance.

The offhand desire of the computational generation of design in the initial phase of the design is utopia, while the computer does not possess intelligence but only calculation power, while the initial considerations must be entered in the computer. Thus the computer's position in the design process is after the initial considerations as the concept or the poetics of the design, while the computer does not possess the ability of producing something from nothing. Though the integration of the computational power in the design process is not an unmovable element, different software comes into its own in different phases dependent on the aim of the software. Thus it is interesting analysing the qualities in different software for different phases in the design process. Being within the terms of tectonics the two kinds of computational methods in the generating of design or form finding is topology and shape optimisation and parametric generic tools.

To complete the utopian thinking of the computer in the design process generating design as a revelation without the designers input of initial considerations. If the computer was to design without input, the basis in terms of tectonic could be structural optimising. Thus would every design be equal, while the basis for the optimisation is equal, namely pure mathematical optimisation. Hence design would not possess any uniqueness or poetics; thereby the design would lose the qualities of uniqueness and poetics and become simplified objects. Furthermore the terms of uniqueness or poetics are also parameters to fulfil operating within the tectonics, thus a result generated purely through the computational optimisation does not possess the qualities or being tectonic.

In the discussion of implementing the digital media in the design process as a generative tool rather than just a visualising tool the role of the designer has been broadly discussed. There is a fear that the designer would lose its position as designer and simple becomes a passive observer in the design process. As former theoreticians have proclaimed the designer must become familiar with the digital tools and possess the ability of controlling them. Thereby a new discussion derives – whether the designer is supposed to possess the skills of programming and scripting. The opinion of this thesis is that the every designer does not need to possess the capability of programming and scripting, but in a design team it is lucrative to have the ability of programming and scripting. Thus the designers are in control of the computer and the results are not random but in continuation of the initial design concepts. It is not only the ability of programming and scripting the designer must acquire. As mentioned above also the participation of an engineer is crucial to remind the efficient use of materials from the old physical methods. Hence to accomplish a tectonic result the ability of programming and scripting must be present in the design team and the awareness of the physical constraints must not be forgotten.

38. Entrane to Swiss RE Headquarters

Keywords of architecture in the digital age including digital tectonics

The following keywords sums up to summary to the essential parameters for the further development of the thesis in terms of case study research and eventually the design.

1. Position in design process

The position of the use of computational power in the design process and the consequences derived from it.

2. Information

The conditions for the designers to use the digital tools in terms of programming, scripting and using of GUI.

3. Fabrication and Generation

The link between the concept and the former design considerations must be attached to fabrication and generations considerations in terms of understanding the process from design concept to building.

4. Topology and shape optimisation and parametric generic tools

The relevant methods for finding of form within the tectonic paradigm.

5. The tools

In the computer generated design the tools plays a decisive parameter, deriving the discussion of the designer impact as tool maker. Some decisive parameters are the constraints of the tools and the variables within the tools.

6. Physical constraints

Within the sphere the physical constraints are crucial as the participation of an engineer.

4. CASE STUDY – DIGITAL GENERATIVE TOOLS

The aim of the case study is crystallising the ability of the digital generative tools with tectonics. While the section of architecture in the digital age includes digital tectonics, the keywords already reflect the tectonic approach. The keywords of the conventional tectonics must still be included while the intentions of the thesis is linking these two architectural theories and therefore it would be insufficient barely including the tectonics in terms of architecture in the digital age. In terms of tectonics the methodology concerning the theory is also found relevant including, while it broadens the understanding of working with tectonics.

Keywords of tectonics

1. Ontology and representation
2. Structure and construction.
3. Interaction and empathy
4. The joint
5. Material

Summarising the keywords the tectonic approach encourages a construction of a clear structure and an easy comprehensible structural system with transparency thus the tectonics reveals the true essence of the building and furthermore keeping focus on logic in the materials and the joint.

Keywords of architecture in the digital age

1. Position in design process
2. Information
3. Fabrication and Generation
4. Topology and shape optimisation and parametric generic tools
5. The tools
6. Physical constraints

In terms of architecture in the digital age the summary of the keywords are considerations of the information as parts of the tools including considerations of the link from concept to fabrication which naturally leads to questioning the use of digital tools in different positions in the design process.

Keyword of Methodology

1. Empiric-analytic method
2. Phenomenology
3. Hermeneutics

Summing up these keywords the process with the generic tool must include both an empiric analytic part and a phenomenological combined by hermeneutics as the essence of tectonics.

Approach to case study

While the aim of the case studies is analysing some digital tools with focus on their ability in the intersection of the tectonic and digital architectural field, the summaries of the keywords of the different topics are found useful unifying.

The tectonic approach encourages a construction of a clear structure and an easy comprehensible structural system with logic in the materials and focus on the joint. In terms of the methodology of case study the first thing doing is identifying the context of the case including identifying the digital architectural paradigm and the characteristics of the tool. Thus considerations must be taken to the conventional tectonic values and the digital tectonic values linking the conceptual phase closer to the fabrication. Finally considerations of information broadly understanding the requirements for the designer to operate the tools, the needed input information partly defining where in the process the tool can be used.

Assuring the case study satisfies being a case study the general research methodology of a case study must also be accomplished. The five parameters are divided into two perspectives. Preliminary considerations and case study methodological approach. The preliminary considerations are aspects to have in consciousness while doing case study research and concerns parameter 1, 2, and 4. The case study methodological approach concerns parameter 3 and 5 and is reformulated to a procedure for case studying as a tripart procedure of Hypothesis – Analysis – Thesis.

The following parameters are the hypothesis for the case study as the questions deriving from the former sections. These parameters are the basis for the analysis and thereby the thesis deriving therefrom.

Case Study Parameters

1. A focus on cases in their contexts
2. The capacity to explain causal links
3. The importance of theory development in the research design phase
4. A reliance on multiple sources of evidence, with data needing to converge in a triangulating fashion
5. The power to generalise to theory

1. What is the context of the case and how does it influence the specific case?

2. In which digital architectural typology does the case work within?

3. How does the case work within the span of tectonic methodologies?

4. Availability in terms of clear structure and logical structural system?

5. Availability in joint and detailing?

6. Availability in linking concept, design and manufacturing?

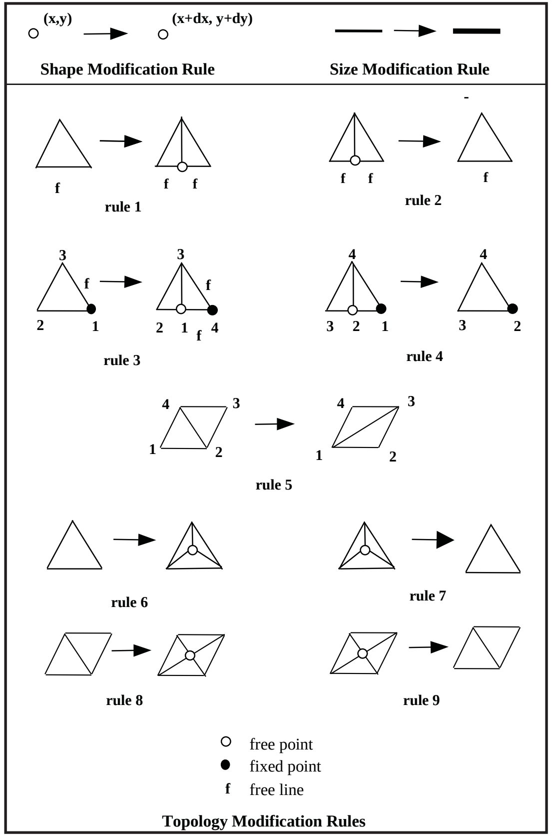
7. Requirements for the designer in terms of operating with the case?

4.1 EIFFORM BY KRISTINA SHEA

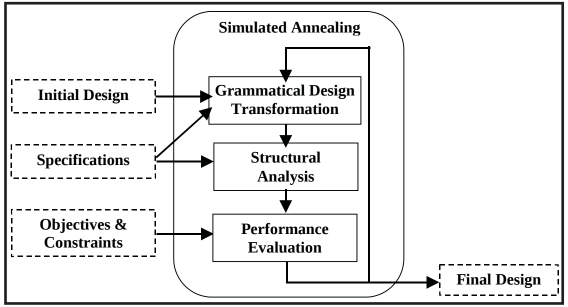
– a shape optimisation tool.

Introduction

eifForm is a generative structural design system based on shape annealing. Shape annealing is a generative design method that combines a shape grammar with simulated annealing to produce optimally directed designs of shape. Applied to structural design, a shape grammar is used to represent the relation between form and function in discrete structures through the specification of allowable shape transformations (fig. 39). These transformations applied recursively define a language of structural shapes. Structural shape annealing performs two primary tasks (fig. 40) 1) grammatical transformation of geometry and topology, and 2) interpretation of structural form using design cost metrics and constraints, which include structural behaviour. [Shea 2004, p. 6]



39. Topology modification rules from eifForm Manual



40. Overview of shape annealing for structural design

The software does not generate a single optimised solution but a variety of equally valid alternatives. *eifForm* generates forms in a stochastic, non-monotonic method. [Leach et al. 2004, p. 75] The program crystallises and resolves itself into a certain configuration based on chosen coordinates. The configured structural form will support itself against gravity and other prescribed loadings.

eifForm does not include a GUI containing the functions of the program. Though some functions are possible operating within the program, e.g. starting annealing or burst algorithm calculations and changing the view from geometric to stress etc, but the functions within the program are very limited. To operate the program XML scripting must be used.

XML provides flexible and adaptable information identification since it is a meta-language, allowing one to design their own customized mark-up languages for cost any type of document. Flexibility and interoperability make XML a favourite data format for two-dimensional web-graphics, archiving, encoding geotechnical information [Shea et al. 2003, p. 555] The XML model file for *eifForm* (fig. 41) consists from one top-level document element, called *EifForm*, which encapsulates a number of nested elements. *eifForm*'s input data has a hybrid character, and this is reflected in the four types of children elements of the *EifForm* element, namely, Settings, Structural-Properties, Obstacles and Design. [Shea et al. 2003, p. 556]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        <Section Area="50.0" Index="13" />
        <Section Area="50.0" Index="14" />
        <Section Area="50.0" Index="15" />
```


41. Example of XML *eifForm* input.

Tectonic approach

eifForm is interesting for this project as an example of structural optimisation software. As the section of Digital Tectonics proclaims a future possibility is in emerging of optimisation architecture, where optimisation is a creative element rather than just a tool for engineering design.

Thus the following represents experimentations with the optimisation software in terms of tectonics. The approach is what are the possibilities with structural optimisation software to generate tectonic architecture.

4.1.1 EXPERIMENT

The following represents the experimentation and analysis of *eifForm* through cases, conducting to answering the question of the case study hypothesis.

The experiment firstly divided into two sections, 1) Generating a roofing structure and 2) Generating a structure covering one side and the top. Both experiments are within the initial design phase, where the statement of the form is abstract. Thus there are searched for generation of form from a fragile foundation. First the attempt is to make the program generate form with the simplest input. The experiment explores for the possibilities of using the program in the early design phase, where the form is not established. Thus the attempt is generating structure with the simple input allowing the program to transform or generate as much form as possible. In the following the experiment is divided into several cases trying different aspects of the program.

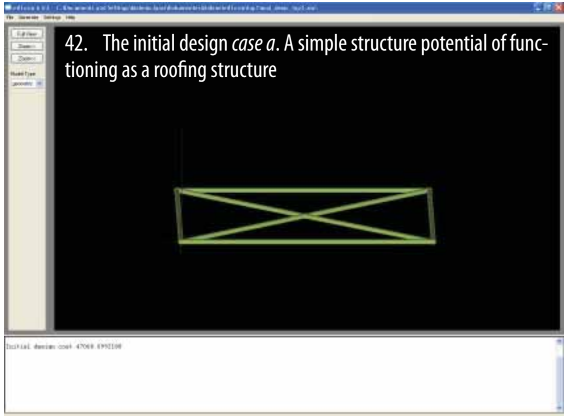
Case a – simple planar top structure

The first input is a simple cross structure (fig. 42). It is supported in each corner and in example *a* loaded in every joint, and secondly in example *b* load is only added in the not supported joint.

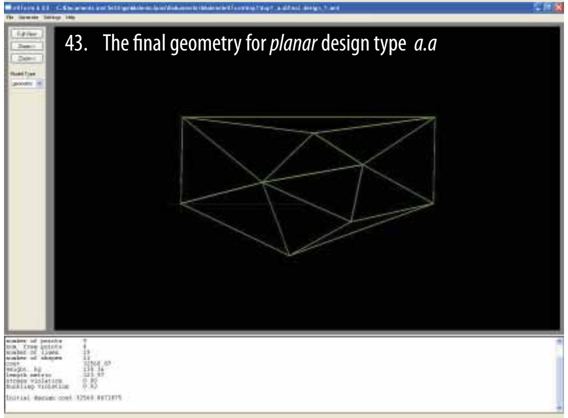
All transformation rules are allowed, to make the program test all possibilities for generating form with the given input.

a.a planar design type

In *case a.a* the design type is planar. Therefore the generated design is a planar solution. Three kinds of output are exemplified the final geometry, best geometry and one example of a stressed geometry of either the final or the best.This example does not generate as much form as wanted, while the result barely is a planar surface without including a volume. It is requested generating volume under the structure, thus the



42. The initial design *case a*. A simple structure potential of functioning as a roofing structure



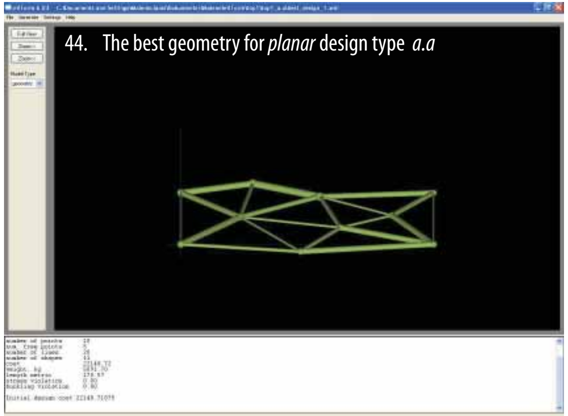
43. The final geometry for *planar* design type *a.a*

structure can be seen as a cover, either a roofing structure or a complete structure within itself.

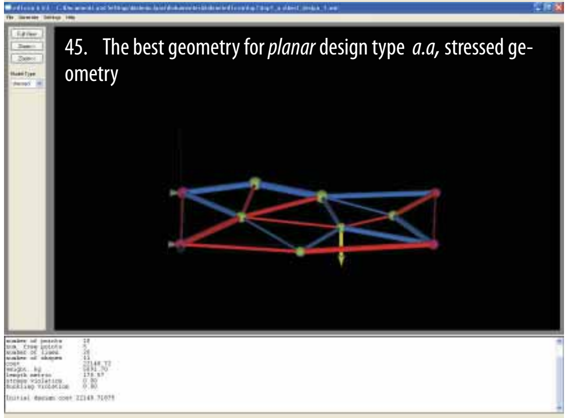
a.b freeform design type with loads at every joints

Case a.b is the same initial design and parameters, but here is the design type changed to freeform as an attempt of implementing volume in the generated structure. Immediately a noticeable difference appears, while the structure now includes a volume covered by the structure. Thus the example satisfies the requirement or generating a volume under the structure.

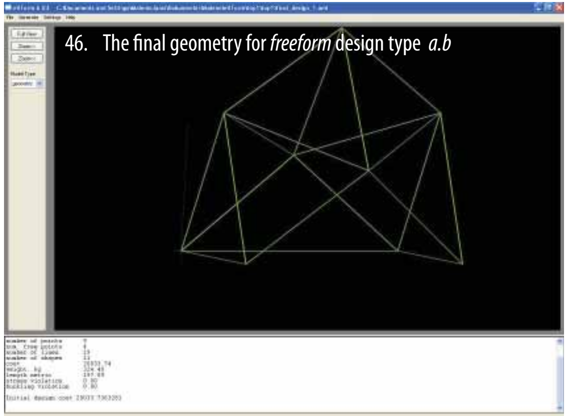
The final structure represents a symmetrical structure that potentially can be used as a roofing structure or a complete structure of a building. Therefore there are added loads at every joint, which is the case for a truss structure with a even distributed load.



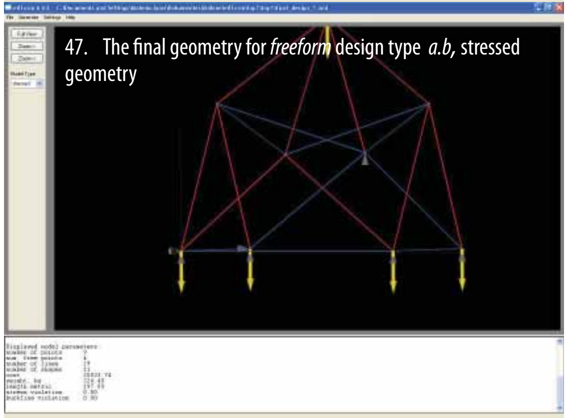
44. The best geometry for *planar* design type *a.a*



45. The best geometry for *planar* design type *a.a*, stressed geometry



46. The final geometry for *freeform* design type *a.b*



47. The final geometry for *freeform* design type *a.b*, stressed geometry

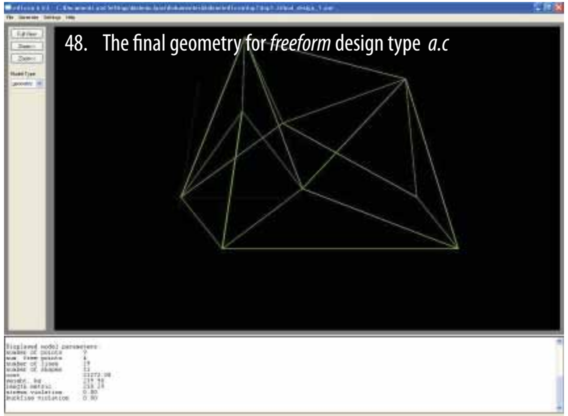
a.c loads at the not-supported joints

Case a.c is parallel to *case a.b*, but the loads are changed from being added to every joint to only being added at the not supported joint. Theoretically the change should not affect the design, while the loads in the supported joints are directly distributed, and therefore does not influence the design.

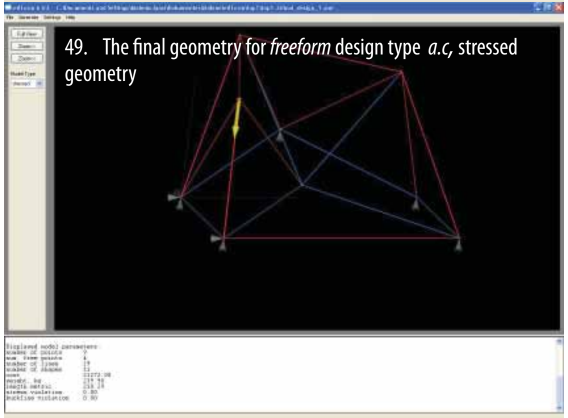
Though the final models of example *a.b* and *a.c* are very different this also is the case for the best models.

The difference in the final models must be explained by the different annealing process the two cases have been through.

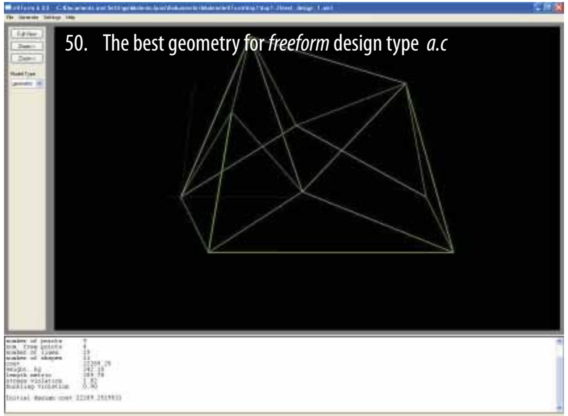
This case structure remained planar with the planar design type, and thus the program gave a proposal for a planar truss structure for instance for a roofing structure. While changing the design type to freeform, the structure lifted itself up during the optimisation. In terms of generating volume under the



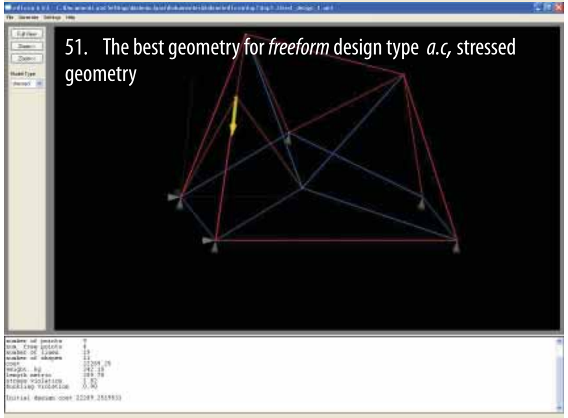
48. The final geometry for *freeform* design type *a.c*



49. The final geometry for *freeform* design type *a.c*, stressed geometry



50. The best geometry for *freeform* design type *a.c*



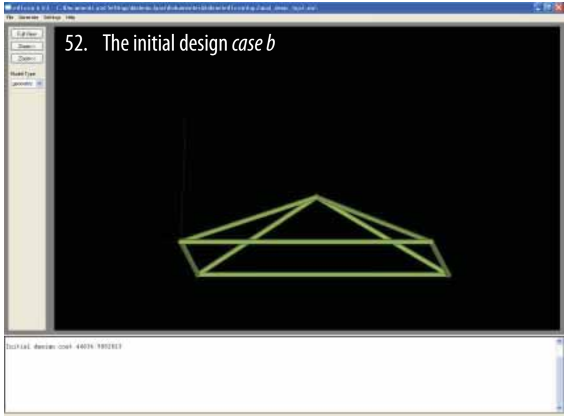
51. The best geometry for *freeform* design type *a.c*, stressed geometry

structure another iteration process is run on the case, where the central point is adjusted by being lifted up from the plane, and the remaining parameters are maintained.

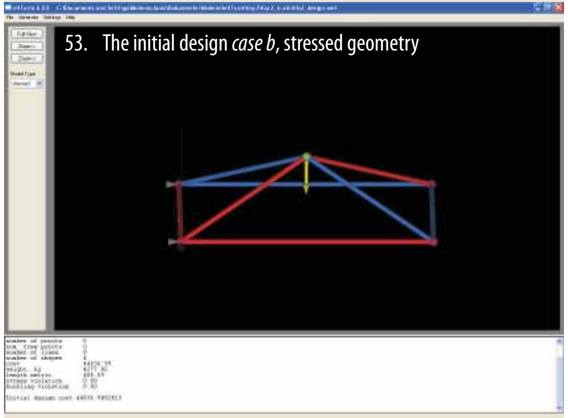
Case b – simple top structure

b.a planar design type

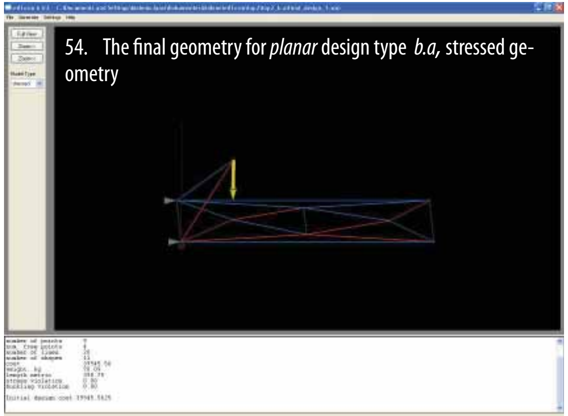
Case b.a has the same design type as *a.a*, namely a planar design type. Again it is seen, how a planar structure are generated in spite of the lifted input geometry. The lifted point is barely connected to the planar surface by 2, 3, or 4 bars dependent on the design iteration. In this example there are found three different examples of final design on the same input file. It is here seen how the stochastic program gives different results for each iteration process.



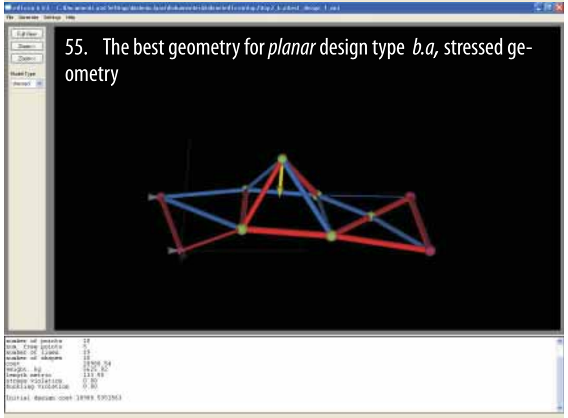
52. The initial design *case b*



53. The initial design *case b*, stressed geometry



54. The final geometry for *planar* design type *b.a,* stressed geometry

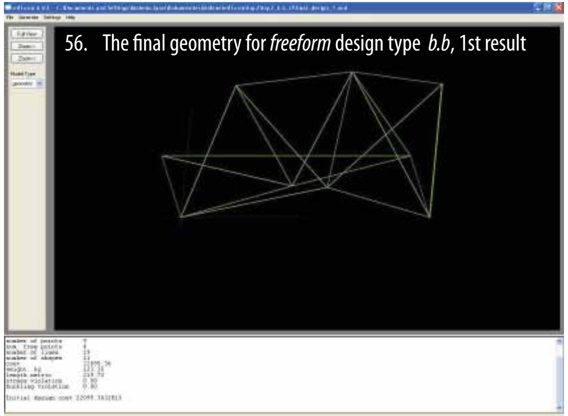


55. The best geometry for *planar* design type *b.a,* stressed geometry

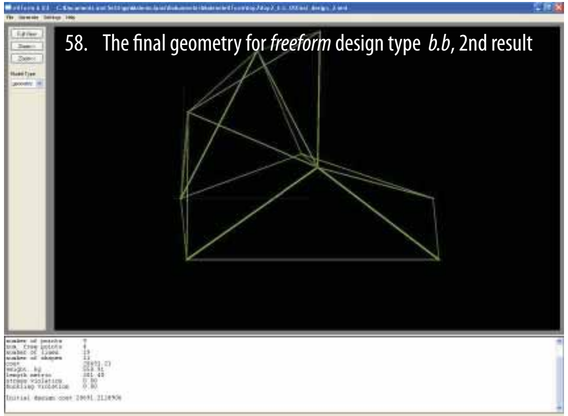
b.b loads at every joint

The input file in geometrically the same as *b.a*, but here the design type is again changed to freeform. Again the case is tested with loads at every joint, while is would be the actual case for a truss structure with an even distributed load.

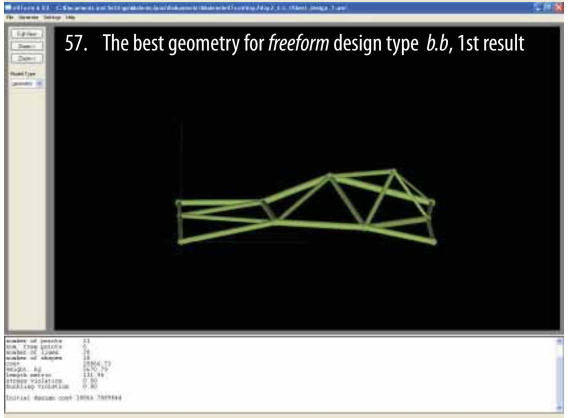
In this case there are generated three annealing processes to compare the results and take out the parallels. To get a deeper understanding the different iterations of the fist two processes are exemplified, to understand the noticeable difference in the final result. Already in the early iterations a difference in process one and two is emerging. Fig. 56-57 clearly represents a lower structure as the final design and the best design. Opposite a higher structure oriented in one half of the structure clearly appears in the early iterations for process two. Furthermore it is clear how process two (fig 58-59) retains the concept of the structure through the entire process. Opposite



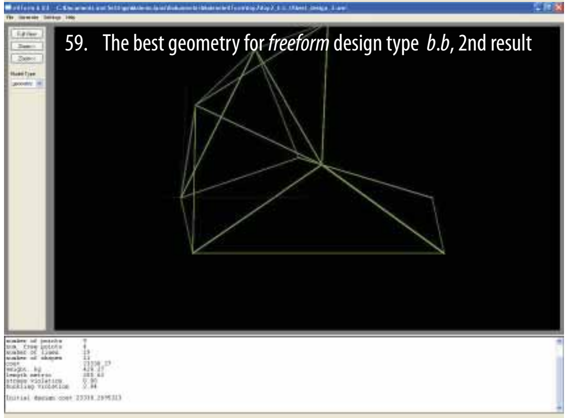
56. The final geometry for *freeform* design type *b.b*, 1st result



58. The final geometry for *freeform* design type *b.b*, 2nd result



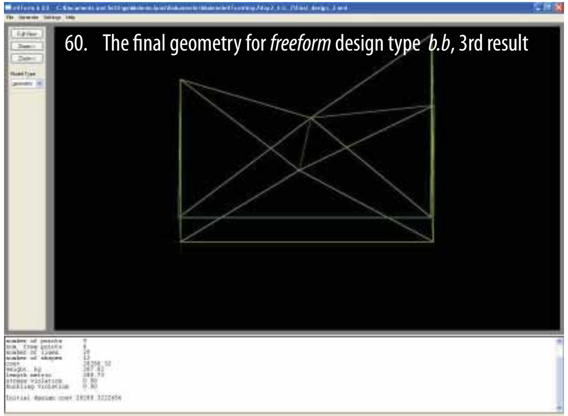
57. The best geometry for *freeform* design type *b.b*, 1st result



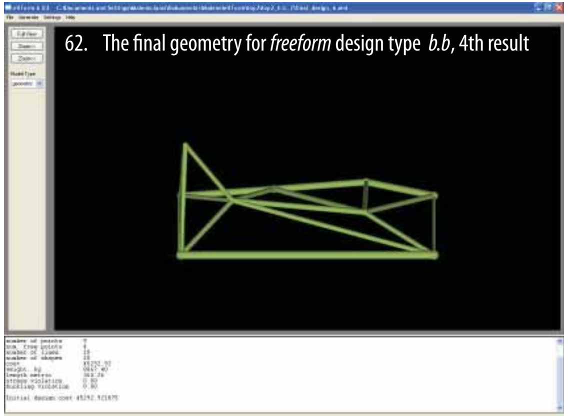
59. The best geometry for *freeform* design type *b.b*, 2nd result

process one experiments more with the structure, which also is reflected in the more differentiated best design from the final design.

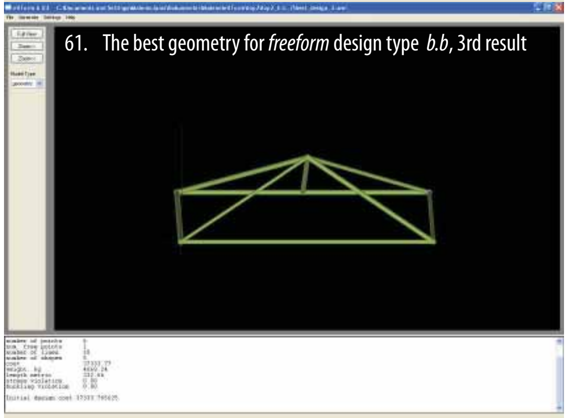
The result of the remaining cases gives three different final results. Roughly there are two tendencies in the final designs either the structure is parallel to the first process (fig. 60, 61 and 63) or more parallel to the second and third (fig. 62). Thus there must be attention at the programs potential of generating very different structure from the same input. Most remarkable different are the final designs compared to the best design, that clearly are more parallel to each other. The explanation on this is the way the program operates. Each process is unique and consists of 170 iterations where the program experiments in generating lines and points and moving them. Each procedure is unique while the program stochastically generates lines and points. In spite of the different



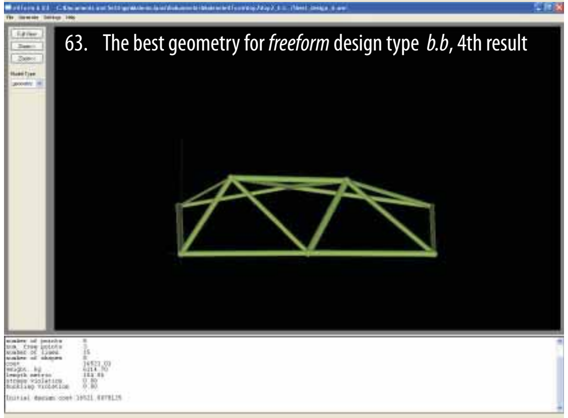
60. The final geometry for *freeform* design type *b.b*, 3rd result



62. The final geometry for *freeform* design type *b.b*, 4th result



61. The best geometry for *freeform* design type *b.b*, 3rd result



63. The best geometry for *freeform* design type *b.b*, 4th result

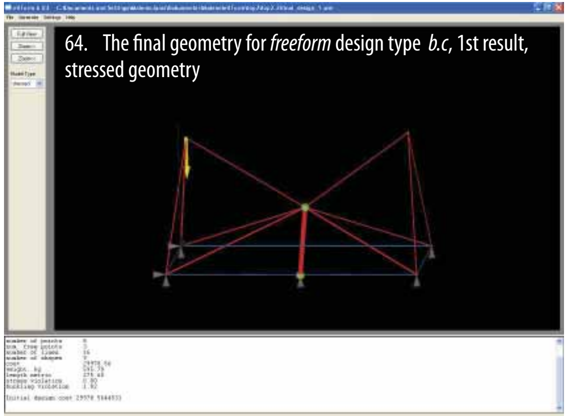
procedure of each process the best design are parallel, which is consistent with the perception of best optimised design. While in the input is the same the differences in the procedure just gives small variations of the best design compared to the final design(fig. 64-65), though a remarkable variation might appear (fig. 60-61) caused by the procedure. Hence by operating with the program the designer must be aware of the potentials of variety the program possesses.

b.c loads at the not-supported joints

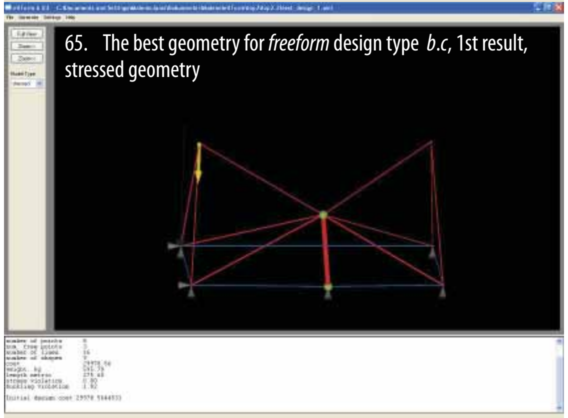
Parallel to *case a* it is found interesting with a more careful analysis of the parallels og the structure with load at every joint and with loads only at the not supported joints, while *case a* resulted in two very different final design as well as best designs for the same initial geometry. With the basis of nine final designs of *case b.b*, a profound basis of comparison is established. Likewise the former case, there are run nine annealing processes on this case, but only one is illustrated.

The former case illustrated the variety in the results, and this case is within the span of variety illustrated in the former case. The similarity is evident, with the precondition of the program's stochastic construction that gives individual processes to each design.

In this case the same tendency in a more remarkable difference in the final designs than the best designs is evident. Comparing *case b.b* and *b.c* with the profound basis of nine results there are found significant similarities in this case and *case b.b*. Therefore the conclusion of this question is, that the differences in the two final and best designs of *case a* were a result of the construction of the program stochastically generating structure. The program optimises realistic, and in the following cases it is not relevant testing with loads in the supported joints.



64. The final geometry for *freeform* design type *b.c*, 1st result, stressed geometry



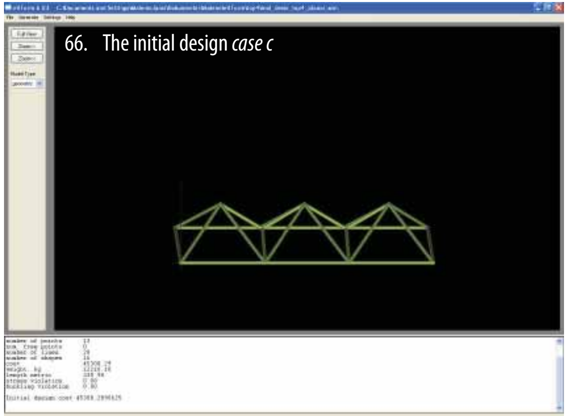
65. The best geometry for *freeform* design type *b.c*, 1st result, stressed geometry

Case c – elaborated top structure

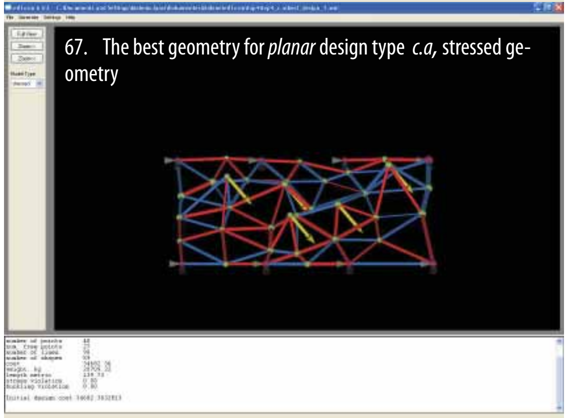
While the generated structure remains simple a more elaborated initial design geometry is tested into the program to analyse the structural difference in the final designs . The aim is to test the transformations in this structure compared with the structure of *case b*. Besides the geometric changes the remaining inputs are maintained except the allowed number of lines, that needs to be extended, while the before maximum of 20 is insufficient with the input geometry containing 28 lines. Consistent for this case is that it is only tested with loads at the not supported joints, as a result of the former case.

c.a planar design type

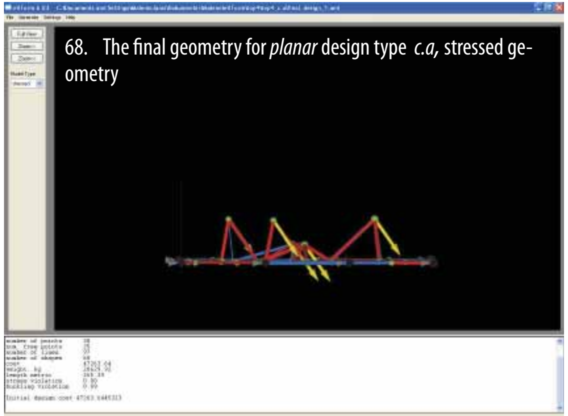
As earlier experimentations showed there is large differentiation in the final design dependent on the design type. With this more elaborated initial design it is interesting testing the



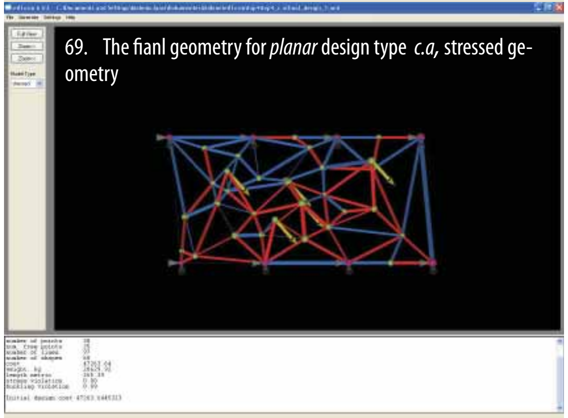
66. The initial design *case c*



67. The best geometry for *planar* design type *c.a*, stressed geometry



68. The final geometry for *planar* design type *c.a*, stressed geometry



69. The fianl geometry for *planar* design type *c.a*, stressed geometry

influence of the design type.

This case is generated with the planar design type, which clearly is seen in both the final and best result. While the design type is planar a planar surface is generated and the points out of the plane are either connected to the plane or the edge. While connecting the points to the plane instead of the edge a large bending in the joint emerges, hence collaborates this composition not with a clear and logic structure of the design. The limitations of the planar design type are exceeded; the planar design type is to generate 2D design rather than 3D.

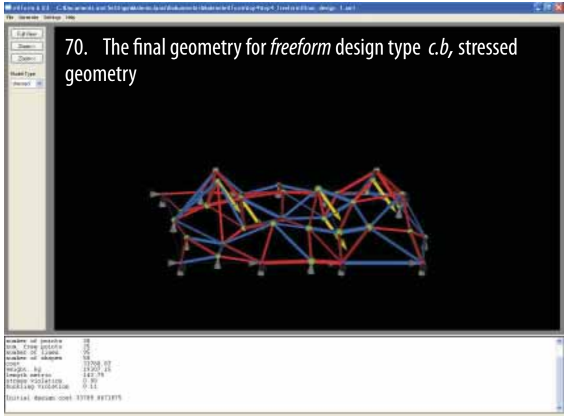
c.b freeform design type

In the former cases the freeform design type has been used while it is found more useful for this configuration than the planar. In this case the freeform design type gives a structure with volume. With perspective to Gaudí's hanging models and the parabolic structure generated therefrom, the freeform design type cannot satisfy this design typology. The reason is the programs construction of generating truss structure, while it optimises in terms of stress and tension and not the bending.

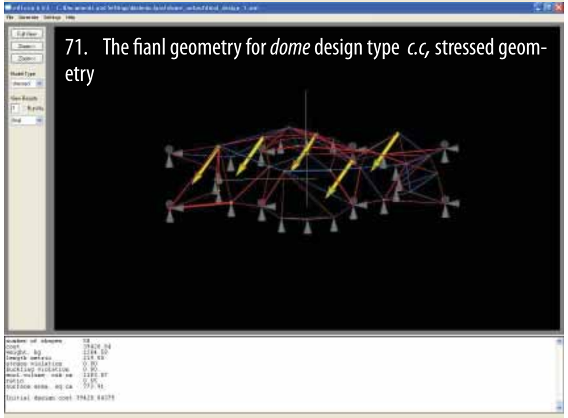
c.c dome design type

As an attempt of consider the tectonic parabolic structures of Gaudí the design type is set to dome design, to analyse is it better generates parabolic structures, where the vertical forces can be taken in plane in case of a surface structure instead of out of plane.

The final design is very close to the expression of a dome. To test if this allegation only is valid for one out of several iteration processes, there are run more processes on this case. The conclusion is as visible in fig. 71 that the consistence in the expression of the final design is general for this design type.



70. The final geometry for *freeform* design type *c.b,* stressed geometry



71. The fianl geometry for *dome* design type *c.c,* stressed geometry

Hence the already most used freeform design type is the design type that has the widest span.

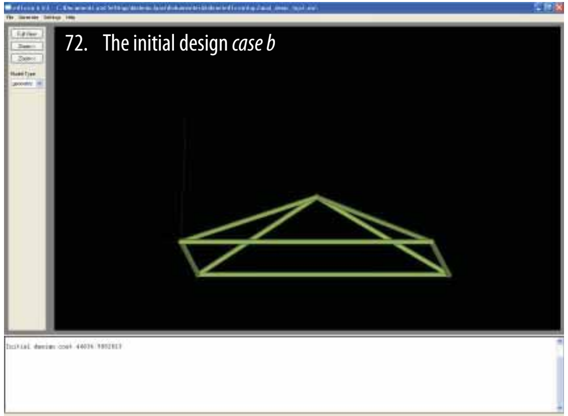
b.d second iteration process

As claimed in the introduction to this case the reason to change the initial design, to be more elaborated than in the former cases, is the thesis of generating more complex structures rather than the more simple as generated in the first cases. Therefore the initial design of *case b* is now annealed again, but with a change in the design parameters, namely setting the maximum number of lines to 100 as applied in the initial design of *case c*. Because of the continuation of the initial design of *case b*, this case is called *b.d*.

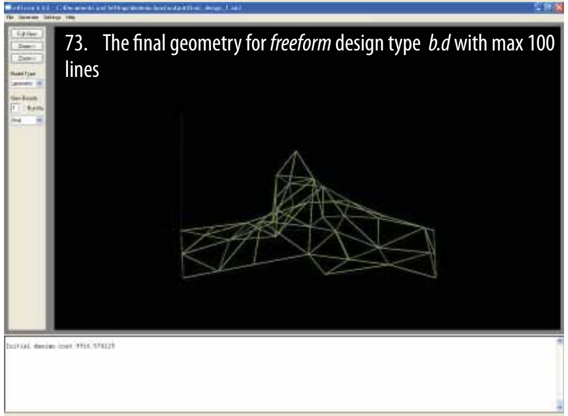
Already in during the first process the complexity of the design comes visible. This case shows the parallels to *case c* rather than the simplicity in *a* and *b*, and thereby the more elaborated initial design in *case c* is an unnecessary element, is the task merely is generating structure without remarkable strict constraints for the geometry of the design. Thus the maximum number of lines can thereby be seen as a determinant element for the design generation.

This case also entails another aspect of the program and the generation of truss structure. In case *a* and *b* the truss structure is very varying and there is apparently not a hidden order in the truss. Is *case c* and this case (*b.d*) a hidden order in the truss appears with the increased number of lines. Comparing the three final results (fig. 70, 71 and 73) the order in the truss appears clearly. There is a clear tendency for the same patters in the truss even though the configuration gives three apparently geometrically different final results.

Furthermore is a larger variation present in this case than in



72. The initial design *case b*



73. The final geometry for *freeform* design type *b.d* with max 100 lines

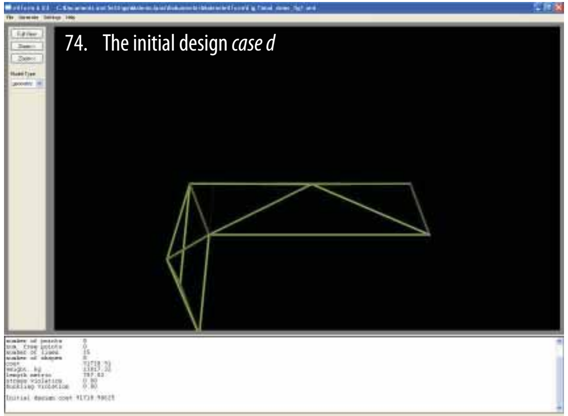
case c. The final designs possess as described a hidden order in the truss, but still the motion in the truss possess a large variation compared to *case c*. Therefore it is found as an advantage using the simplest input geometry.

Case d – side and top structure

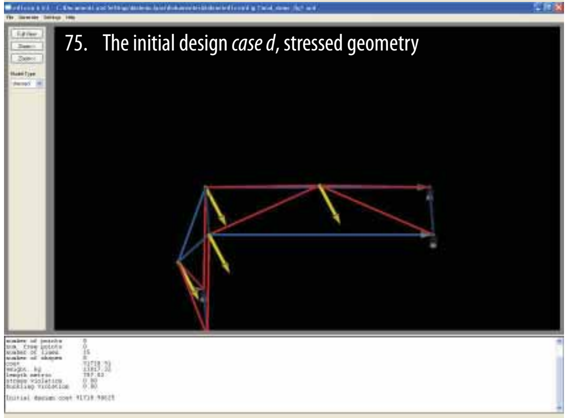
The aim of the following cases is to try not just generating a roofing structure but a structure connecting one side and the roofing structure.

d.a freeform design type

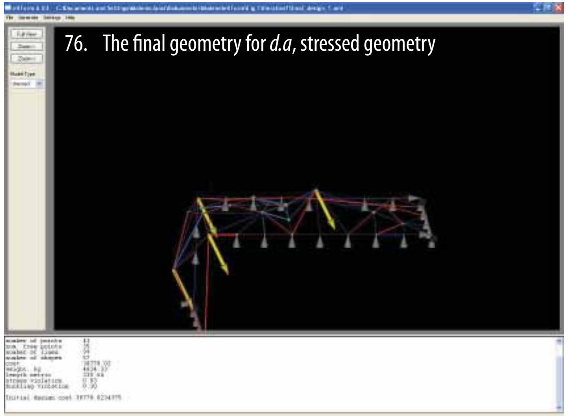
This case is with roots in *case b*, where there is added one side. The central point in the side cross is like the cross in the top also lifted from the plane. This is a necessity for making a structure the program accepts, while maintaining the central point within the plane creates an unstable structure according to the program, while there needs to be three composants for



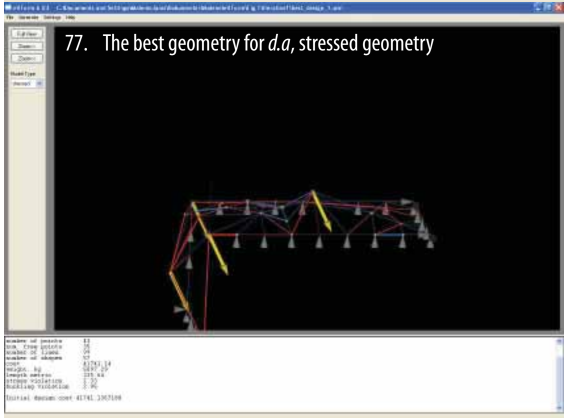
74. The initial design *case d*



75. The initial design *case d*, stressed geometry



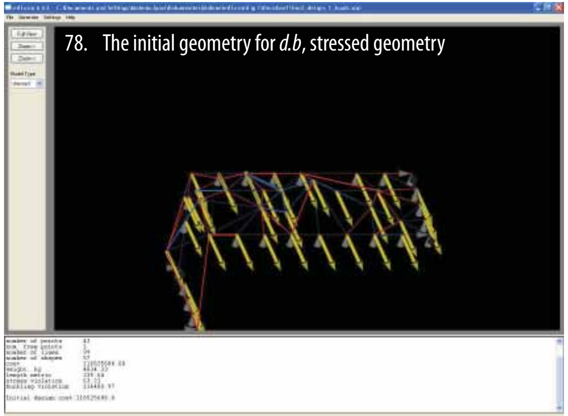
76. The final geometry for *d.a*, stressed geometry



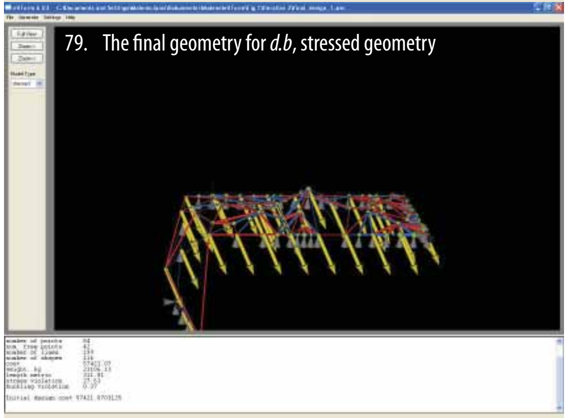
77. The best geometry for *d.a*, stressed geometry

each point.

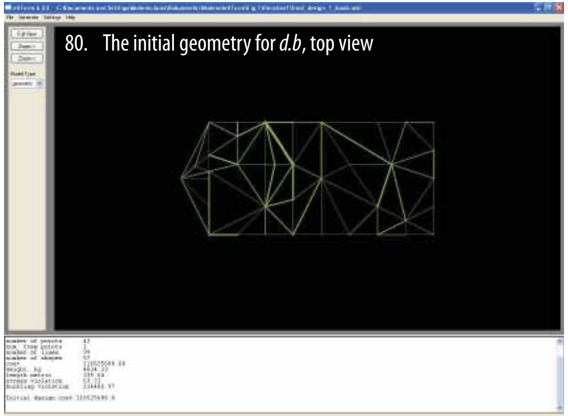
The final design generates the roofing structure parallel to the former examples where it was separated. The side structure remains very simple similar to the input geometry. The top structure becomes similar to the former cases, where the top structure is separated. An aim of this case was exploring the transformation of the edge of the side and top, why the joints in the edge not are supported. Immediately there is no transformation in the edge, the joints are maintained at the initial positions. The curiosity of this aspect is the author's effort of optimising the meeting of the top and side structure. Hence a solution to this question is better seen in the former cases, where volume is beneath the structure and it thereby includes space. Despite this not giving case in this coherence, the structure of a side and top structure is further tried out.



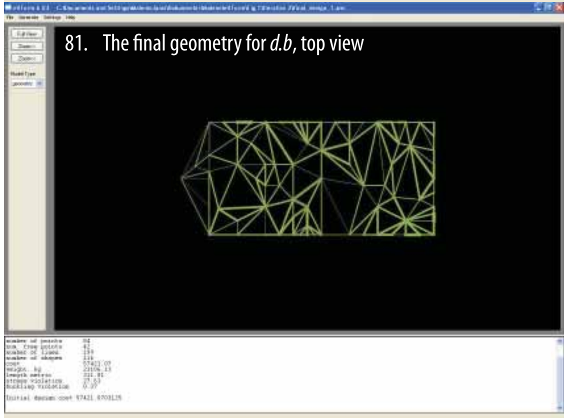
78. The initial geometry for *d.b*, stressed geometry



79. The final geometry for *d.b*, stressed geometry



80. The initial geometry for *d.b*, top view



81. The final geometry for *d.b*, top view

d.b second iteration process

This case is a continuation of case *d.a,* while the former case concluded that freeform possesses the most generative options by having the widest design possibilities. One generative parameter in *eifForm* is the allowance of generating new joints. This is seen as a positive element, but the program does not add loads to the new generated joints. This immediately give a wrong reflection of the reality if the loads on the joints are to be seen as an even distributed load on the surface the structure spans. Therefore this case is a second round of the iteration process. The final design result of case *c.b* is modified by adding loads to every joint. This input is thus the initial design for this case.

The final design is very similar to the input file. One explanation is that the maximum of lines remains the same, while there are not generated new lines and points. The existing is barely being moved and the cross sections are adjusted to the new loads(fig. 80-81).

Caused by the remarkable similarity of the initial design and the final design it is estimated that this second process is not a demand for a realistic generating of an optimised structure. This second generation is an option, which will be used in cases where it is the little adjustments that are required. Besides the similarity between the initial design and the final design there is also a remarkable similarity in the final designs (fig. 78-79). There are tested more cases than the demonstrated and the result is the same, a striking resemblance as seen in fig. 80-81.

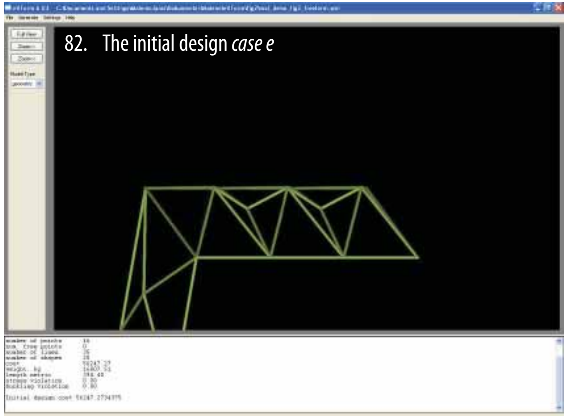
Thus this case also provides an example for how *eifForm* can be used in the later design phase, where adjustments of the input design is required rather than a total new concept of form in terms of the input information. This argument is verified both in terms of the similarity with the input design and the final design and further confirmed in the resemblance of the final designs.

Case e – elaborated input of side and top

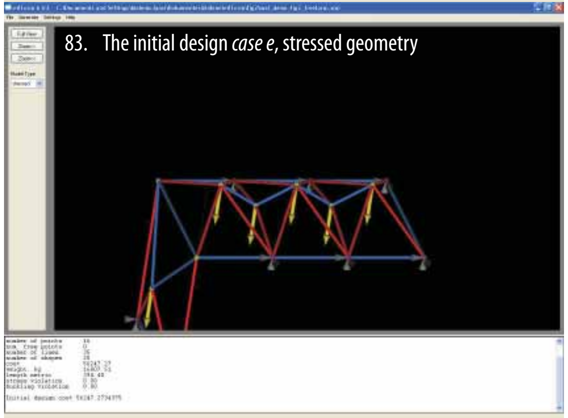
e.a freeform design type

As in the former cases designing a top structure, the more elaborated design input is also tried out in the case of a side and top structure. Thus this is likewise the former case an attempt of generating a structure connecting one side and the roofing structure but with basis on a more elaborated initial structure.

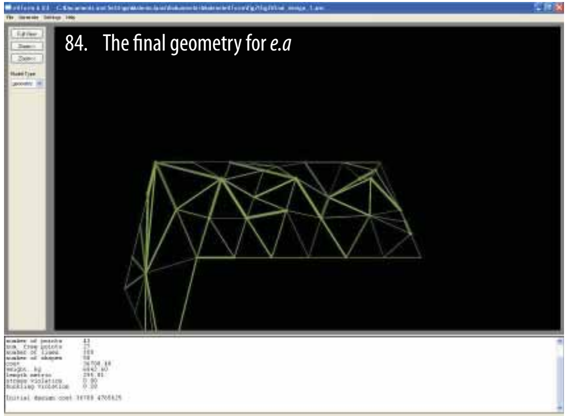
The differences in this case compared to the former case it not significant. The same simple structure in the side structure is passed on. Thus this case is very similar to the less elaborated initial design. This promotes the thesis from the cases of the top structure, where the simple input geometry gives the widest design possibilities.



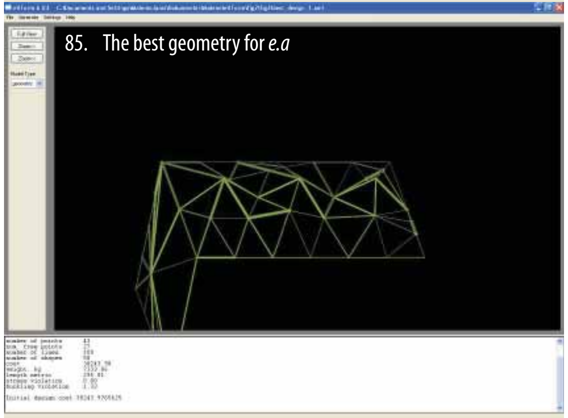
82. The initial design *case e*



83. The initial design *case e*, stressed geometry



84. The final geometry for *e.a*



85. The best geometry for *e.a*

4.1.2 THE CASE STUDY HYPOTHESIS

In the following the questions derived in the former section of approach to case study concerning the introduction of theories of tectonics and architecture in the digital age will be answered on basis of the cases described previously.

1. What is the context of the case and how does it influence the specific case?

The context of the case – the *eifForm* software contains different aspects.

The basis of the program is creating a truss structure and optimising by allowing appliance of joints and bars with an irregularity and thereby generating an optimised irregular truss structure. Thus the program's constraint is operating with trusses; and therefore operating with trusses is a requirement for a project in *eifForm*.

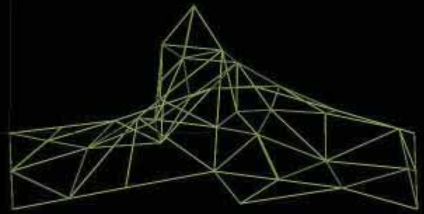
A constraint within the program is also lying in the truss construction. While the program operates with trusses it is the stress and tension in the bar elements, that are the demanding for optimising the whole structure. The bending moment in a structure is not taken account of, and thereby is the whole structure not optimised with respect to that matter.

Secondly an even distributed load in a truss structure is added by adding a load to every joint. In the optimisation process new joints are added to the structure, and meanwhile the load cases are not added to the joints. Though it is possible to manually add the joints afterwards and make the program run the optimisation again either with the same number of lines – and there by the same conditions as before. It is also possible to extend the optimisation procedure by allowing more lines. This case is done in the experimenting of *eifForm* and the impact of the loads at every joint is considered insignificant.

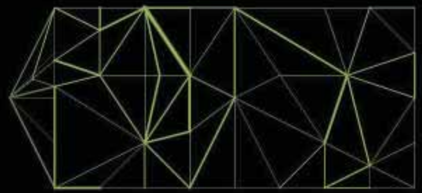
2. In which digital architectural typology does the case work within?

This answer derives from the former answer. As mentioned *eifForm* is structural shape optimisation software, concerning optimisation in terms of costs. Being it the software operates within the performative architectural typology, while the results from *eifForm* are performing structural optimisation, influenced by truss structure.

As the results of the cases show *eifForm* is not suitable for generating the entire design of a building, but rather the roofing structure, structural system or similar. The attention must be on the truss structure, while generating and optimising irregular trusses is the purpose the software is designed for. The software only operates with optimising the structural systems, and is not supposed to be forced to further use.



86. Example of an *eifForm* optimised truss structure.



87. *d.b*, example of optimised geometry after one iteration.

88. *d.b*, example for optimised geometry after two iterations.

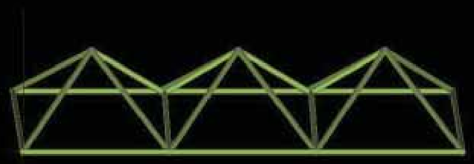
Hence the program operates within the performative architecture performing optimised structural systems within the framework of truss structures. An architectural project is as mentioned not supposed to be generated only by *eifForm*, and therefore other perspectives than structural optimisation will probably also affect the architecture partly generated in *eifForm*. Thereby operates *eifForm* with in the performative architectural typology performing structural optimisation but other perspectives will most likely also be performed in the architectural piece influences by the other tools of the project.

3. How does the case work within the span of tectonic methodologies?

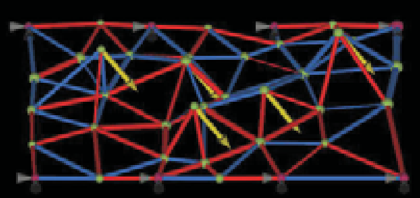
In terms of tectonic methodologies *eifForm* concerns only the empiric-analytic methods, while the *eifForm* optimisation is optimising by shape annealing. Annealing is an algorithmic optimisation approach which is a piece of mathematics, and thereby is the optimisation in terms of pure mathematics. Thus the optimisation is within the engineering methodology of positivism. With accordance to the section of methodology the empiric analytic approach is defined as a deductive procedure that can be used where there are some general specified demands such as strength. Thus there is an established general theory, built upon another general theory that is verified through deductions of calculations and tests in the physical world. This theory is a benchmark for what is predicted to hold and making a building safe. The benchmark is composed of formulas, and the task is to verify or falsify calculations. Thus the theory of positivism or rather the empiric-analytic method is highly objective and built upon empiricism and analysis. In continuations to this the deductions and thereby the empiric analytic method is useful to test whether the structural system can hold or not. Calculations for the structural system can be seen as deductions to the theory answering the problem whether the structure satisfy the general demands.

By explaining the methods of *eifForm* in terms of the empiric-analytic methods, the *eifForm* concept is optimising, and the optimisation is embedded in the established general theory. Thus the process of deductions is done in terms of optimising. In *eifForm* this is visible in the procedure of the 170 iterations testing new structural compositions or adjustments to the former composition with the perspective of optimising the structure in terms of the cost function.

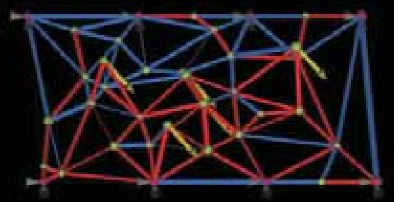
The use of only the empiric-analytic method in *eifForm* is in accordance with the engineering tradition focusing on utilising methods and models taking starting point in the measurable, and through induction, observance or analysis of



89. Exqmple of initial design *case c.*



90. Exampleof best geometry *case c.a.*



91. Example of fianal geometry *case c.a.*

the world of physics, a basis to derive theories tested through deductions in the world of physics emerges.

The software concerns only the empiric-analytic methodology there are no phenomenological considerations within the software, though it is possible to stop the annealing process during the optimisation, if a process-result is found more valuable than the final or best result. Thus it is possible continuing design on this rather than the fully optimised result. In spite of this possibility *eifForm* is evaluated as a pure empiric-analytic tool, while the aim of the software is within these terms and the phenomenological approach by the possibilities of evaluating the designs during the process is more farfetched than real.

4. Availability in terms of clear structure and logical structural system?

In terms of the clear structure and logical structural system *eifForm* possesses some tectonic qualities within the structural shape annealing optimisation. As described a condition for the software is operating within the field of truss structures. Truss structure is a clear structure, and in coherence with *eifForm* the clear structure is not always logic, while *eifForm* creates irregular trusses as the software allows and encourages irregularity. Despite the irregularities and multiplicities in the results of the examined cases they still represent a structural logic, why the distribution of forces within the structure can easily be understand as a logic use of the structure or a logical structural system.

Furthermore the results generated in *eifForm* represent a structural system, and thus there is a transparency in the results in terms of tectonics, while the structural system is the essence which also is what the results reveal. The postulate of *eifForm* not being appropriate for designing entire buildings possible brings indistinctness to the transparency, why the *eifForm* result only is seen as part of the building e.g. for roofing or as an internal structural system. For the last case the transparency will not necessary be appearing in the building, but the structural system will possess the same amount of logic as the visible.

Finally the case of truss structure also influence the appearance of the structural system and thereby the tectonic definition. Clearly there are some limitations in the truss structure, but that is just a condition for this program, and thus this condition must be accepted in the integration of the design process.

5. Availability in joint and detailing?

The software is not concerning about joints and detailing. In the cost optimisation the members of the truss are dimensioned in terms of material optimisation, and by doing that the members have different thicknesses, which gives some complications in the joints. In spite of the obvious complications the software does not deal with the joints and thereby neither the detailing. Though it is possible to credit the software for concerning of the detailing in the cost optimisation of the members, but in terms of detailing there are many lacks in just optimising with respect to the cost function. Thus even the detailing of the member's thickness is considered too primitive to fulfil the qualities of detailing.

6. Availability in linking concept, design and manufacturing?

The software is useful as an idea generator, while it with a relatively simple structure can bring out a more complex and optimised structure. The program is not designed for large structures, while the max lines is 240 and the max joint-members is 20. This also underlines the usefulness in the initial phase for form exploration, though the program is compatible with FEM and CAD programs while it is possible exporting from *eifForm* to dxf-files and it should be possible importing dxf-files and GC-files, even though the author did not have the great success doing that. Thus it allows usability of the program in the later phases of the design process, where *eifForm* can be used in adjusting the placements of joints and bars in an optimised structure as *case d.b* exemplifies. Hence *eifForm* is useful in both the initial form exploration and in the later adjusting. Using *eifForm* for adjusting the allowance of transformation must be confined while the program otherwise might give radical changes to the design. Still *eifForm* is limited to truss structure, and if optimisation on a truss structure is required in the later design process, some issues may occur in either the importance of files to *eifForm* or in scripting the model in XML.

In terms of manufacturing the program does not link to the final phase in the design process. The program can list up the optimised member sizes of the truss, making or ordering the members to the truss, but making fabrication plans or just plans, sections and elevations is not possible within the program. As mentioned it is possible exporting to CAD making the fabrication drawings there, but a lot of information gets lost in this process including the member thicknesses.

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```


92. Example of *eifForm* XML input file.

7. Requirements for the designer in terms of operating with the case?

The program is approachable on the assumption that the designer has the courage of scripting, while the input file must be an XML-file that is generated by scripting without GUI and help functions containing and describing scripting possibilities for XML or *eifForm*. Meeting this condition the program is not complex operating after reading the manual, which sometimes could be more elaborated. This is also the case for the program itself, that clearly is characterised by not being a commercial program but freeware.

As described the program operates with four types of child elements: Settings, StructuralProperties, Obstacles and Design. Into Settings the designer must enter the general information (fig. 92), thus the designer must consider which rules the generation allows, number of max lines etc. The precondition here is considerations of what to allow in the annealing. In StructuralProperties the designer must enter the assumed loads and materials and the associated properties (fig. 92). Here it is possible entering a prescribed load and some general properties for the material. In Design the geometric properties of the starting point must be entered; the initial section properties, placement of point and connecting points by lines (fig. 92). In this child element the designer must enter an idea of an initial design possible for optimising. The design must be a stable structure, why supports are added as well as loads and move conditions. Furthermore the type of the design must be entered, and the designer must chose between planar, freeform and dome structure.

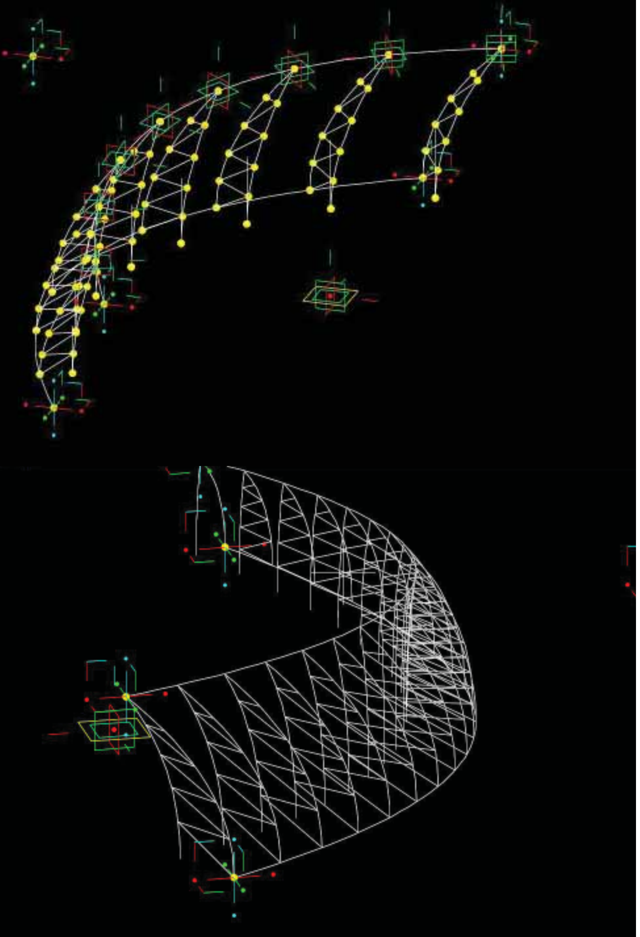
The obstacles element is mostly useful in 2D design, where it can be defined through 2D geometric obstacles that act as soft constraints and 3D performance goals of enclosure volume and surface area. The current implementation is limited to 2D obstacle.

The description above broadly embraces the needed information for the program to start generating. As readable and as mentioned previously the program is approachable after a quick introduction, subject to courage for scripting. The possibilities within the program is within the scripting in the XML-file, and the manual describes the possibilities with the program, which is rather simple compared to other generative software.

4.1.3 SUMMARY

eifForm surely offers possibilities for generative design within the tectonic framework, but still it does not fulfil the requirements of tectonics being the empiric-analytic, phenomenological, and hermeneutical methodology, and concerning clear structure, detailing, joint, and empathy for the architectural piece. In terms of tectonics the forces of the program is in the clear and logic structure the optimising annealing provides, corresponding the shortage of the program is the phenomenological approach, detailing of the joint and conditions of truss structure. Especially the condition of truss structure is a determinant aspect in the availability of the program in terms of tectonics – but also in terms of design or architecture in general. The condition of truss structure is very limiting for the broadly use of the program.

For generating design *eifForm* is found most suitable for the initial design process as an idea generator after the initial design considerations have been taken including accepting or requesting truss structures. In this case the program offers possibilities with the optimisation, while it generates design itself. It possesses the quality of generating design from a simple input, and by doing so *eifForm* can generate new interesting designs, that would not have derived without the irregular properties of the *eifForm* truss.



93. Screenshots from work with GenerativeComponents.

4.2 GENERATIVECOMPONENTS BY BENTLEY

Introduction

GenerativeComponents is an associative parametric design system that gives architects and engineers new ways to efficiently explore alternative building forms. Once the underlying logic and design relationships have been defined, the designer can create new options without manually building (or rebuilding) the detailed design model for each scenario. This has a profound effect on design by encouraging an iterative search for more efficient solutions, while *GenerativeComponents* at the same time offers increasing overall efficiency of more conventional aspects of design and documentation.

GenerativeComponents allows designers to work graphically, or to combine this with scripting and programming where appropriate. The designer's own scripts can define the geometric behavior of components even when these are being manipulated in dynamics. This integration of algorithmic design with conventional interaction based on direct manipulation allows *GenerativeComponents* to fully support alternative approaches to design that span the intellectual and creative spectrum. [Bentley]

GenerativeComponents supports different stages in the design process with a very precise yet malleable, generative approach to design. In approaching *GenerativeComponents* it is important to understand its construction and its potential in design. Essentially, it is a general purpose associative parametric modeler that offers a user many different ways to develop their design idea. In fact the system is an open-ended user extensible system with a set of primitives or Features, as they are referred to in the system. These Features may be geometry such as a line or a point, or numeric data such as a number specifying a length or how many elements exist in a design. Most importantly, the users can define their own design elements and extend the system to fit their design needs. The underlying associative architecture allows for the interoperability of all Features.

The program was commercially introduced August 2007 at the Smart Geometry Group. The Smart Geometry Group has been an important aspect in the development of the program that concerns user survey. Thus the program has been under development for years in closely collaboration with the Smart Geometry Group, where the users of the program have influenced in the development and the contents of the program. Among other things the open-ended user extensible system is a result of the Smart Geometry Group collaboration.

Tectonic approach

For this project the use of *GenerativeComponents* is interesting while the software represents the parametric approach to design. As the former experimentations represent optimisation as a generative approach, the following experimentations represent the parametric approach to design. The parametric construction allows addition of different parameters, and the parameters are potential of possessing tectonic values. Thus the values of the parameters is up to the designer, and thereby is it designers choise what the design is to perform.

Therefore the aim in the following is testing the possibilities with the parametric construction with the approach of what are the possibilities with parametric software to generate tectonic architecture.

4.2.1 EXPERIMENT

The following experiments are as a continuation of the case study of *eifForm* a case study of *GenerativeComponents*, where the parametric possibilities within the software in terms of tectonics are tested. Equally *eifForm GenerativeComponents* is to be analysed through some cases for afterwards answering the case study hypothesis questions.

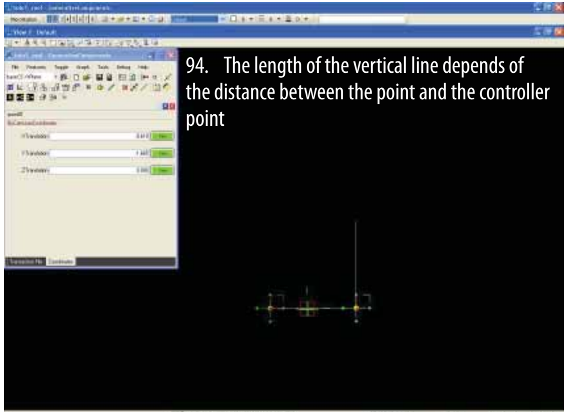
Firstly the following cases concerns the dominating tectonic parameter of structure and afterwards the performative perspectives is treated.

The experiments will be based on the different features the program possesses. The following experiments differ remarkable from the eifForm experiment, while eifForm itself generates design from a input, and GenerativeComponent is a parametric generic tool, thus the generation of design is more controlled by the designer.

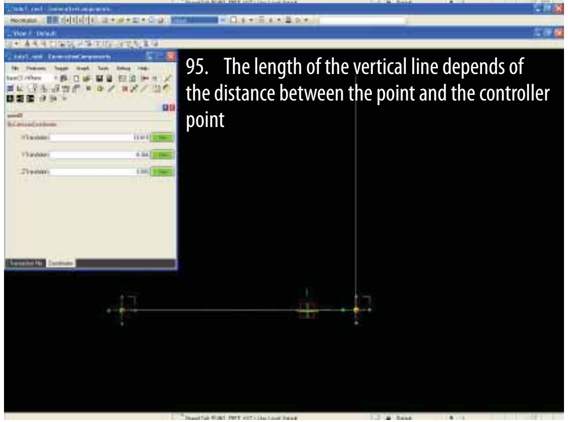
Case a – the parametric construction

The first experimentation is exemplifying the parametric construction of the program. For doing this a simple model is built upon parameters depending on the distance between points. This case is with the kept simplicity exemplifying the basic functions in the program of having an external variable influencing on another perspective. The case consists of a surface defined by points, whose height depends on the distance to a controller point.

First the controller point is created. The function of the point is exemplified in the first illustrations. The vertical line is dependent on the distance between the points. This feature will later be implemented in this case.

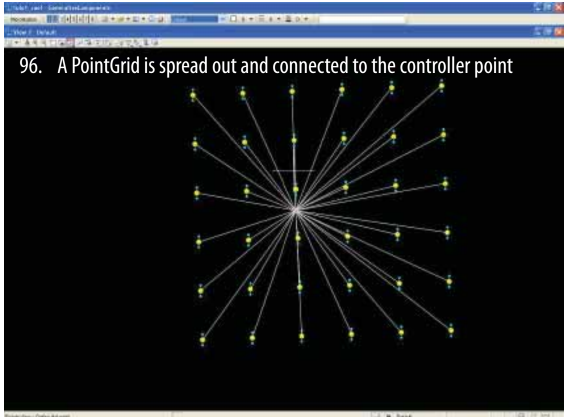


94. The length of the vertical line depends of the distance between the point and the controller point

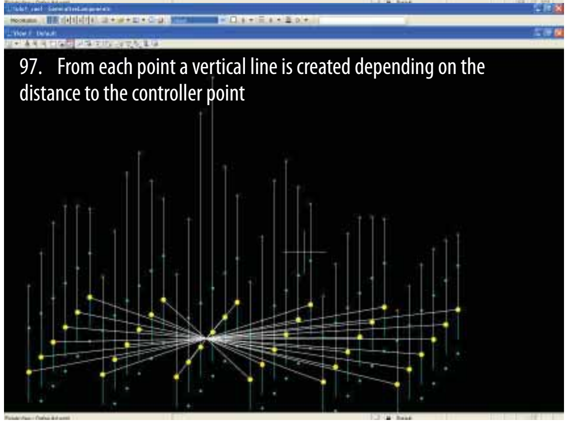


95. The length of the vertical line depends of the distance between the point and the controller point

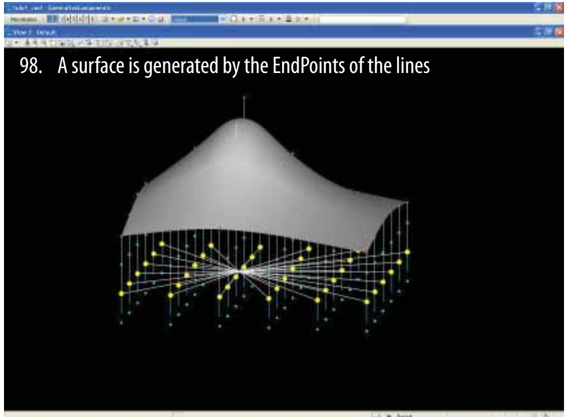
A PointGrid is spread out as a series of points. Thereafter the points in the PointGrid are connected to the controller point. To each point a vertical line defining a height is generated. Finally a surface defined by the endpoints of the height lines is generated. After finishing the simple model it is possible generating variations by moving the controller point. This case is kept very simple to illustrate some of the basics within the program e.g. the opportunities with controller points, that can define a variety of controlling possibilities. Furthermore the case illustrates the possibilities of building up a model where approximately every step rely on the previously. Finally the moving around of the controller point shows how the design adjusts to the variations or modifications of the construction of the design.



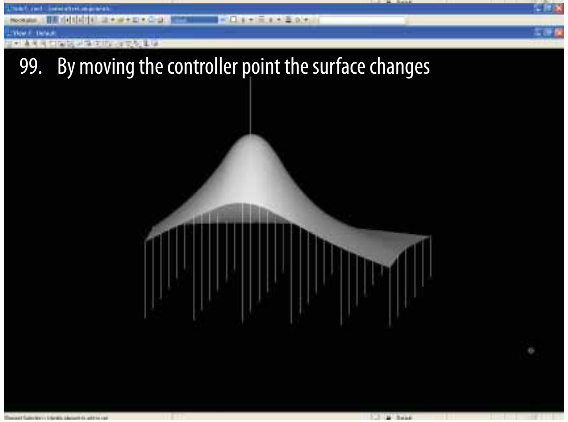
96. A PointGrid is spread out and connected to the controller point



97. From each point a vertical line is created depending on the distance to the controller point



98. A surface is generated by the EndPoints of the lines



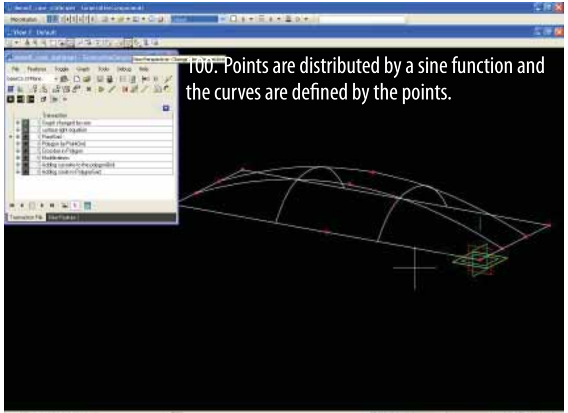
99. By moving the controller point the surface changes

Case b – adding features

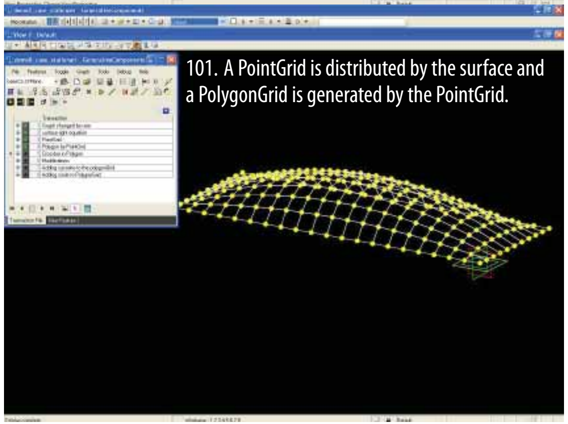
The dependency in the parametric consctuction exemplified in the former case is also available in terms of the structural system. With basis in the tectonic approach explorations of the structural system is an essential element for the tool to behave within in the terms of tectonics.

A simple feature with wide possibilities within the program is the possibility of generating a feature and adding it to a polygon grid. This feature is useful for applying a certain structure to a surface being the roof, the facades or an inner surface within the building. The following case is thought as a roofing element.

Exemplifying the feature of adding a feature to a polygon grid is done in the following. A PointGrid is generated by a surface that in this case is described qua a sine function defining the curvature of the roofing. The sine function describes placement of points that spans the surface. Thus the surface defines the form of the design, and if adjustments are wanted to the design later in the process, the surface is just to be adjusted by the parameters of which it is constructed. In this case a function.



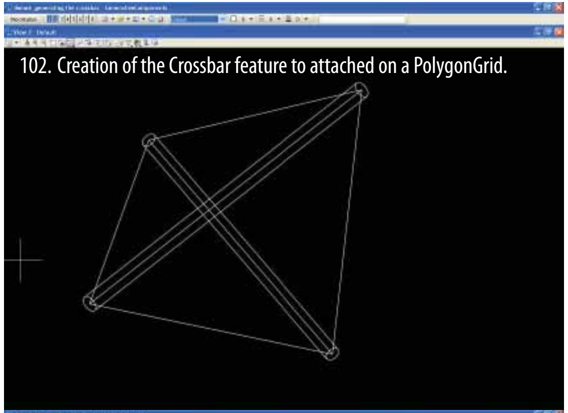
100. Points are distributed by a sine function and the curves are defined by the points.

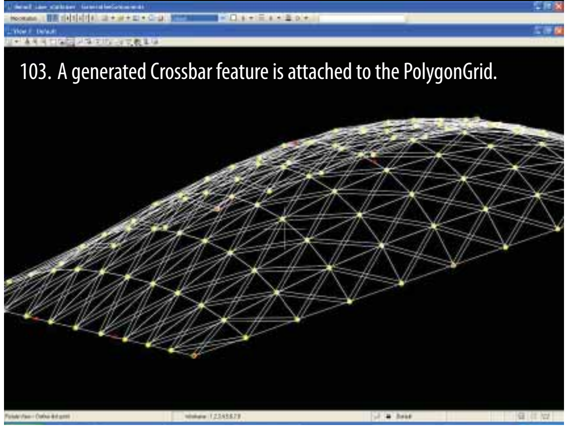


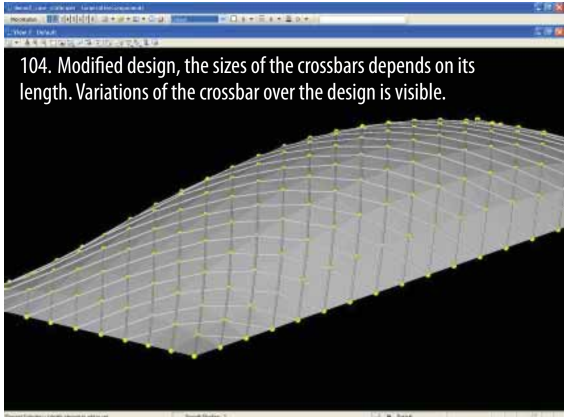
101. A PointGrid is distributed by the surface and a PolygonGrid is generated by the PointGrid.

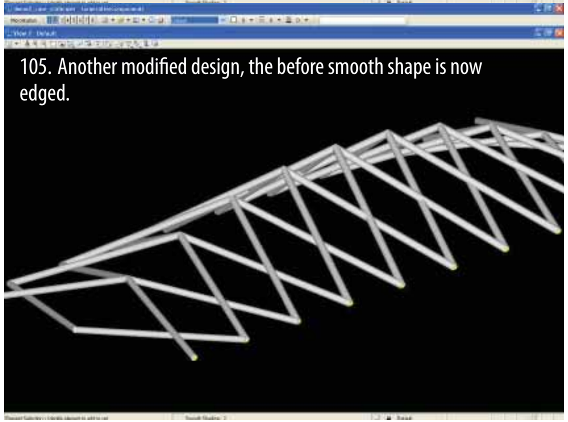
Separate from the surface the desirable feature to spread over the surface is generated. The structural element is a simple truss, which is added to the PointGrid. The thickness of the cones in the cross is depending on the length, and thus a variable is implemented in for the feature enabling a logical approach of a necessity of an increased cross section to larger spans. The effect of this variable is clearly visible in the exemplifications of different solutions with the cross.

This case is an exemple is a simple way to apply a structural system to a shape. By the appliance of the feature a trus is generated, and thereby is the structural system for the case generated. In this way the structural system may not be shaping the form, but the structural system possessing the possibility of being expressed as a facade element.


102. Creation of the Crossbar feature to attached on a PolygonGrid.


103. A generated Crossbar feature is attached to the PolygonGrid.


104. Modified design, the sizes of the crossbars depends on its length. Variations of the crossbar over the design is visible.

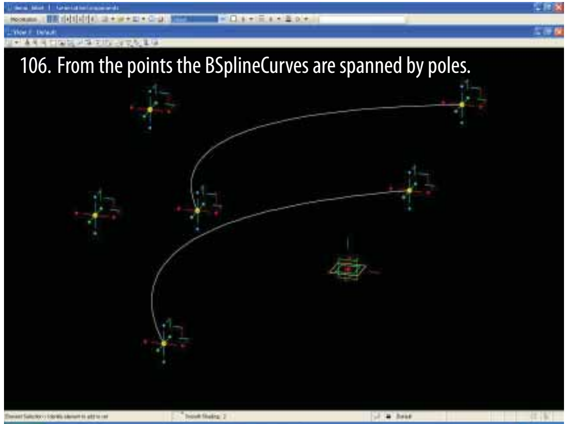

105. Another modified design, the before smooth shape is now edged.

Case c – structure by variables

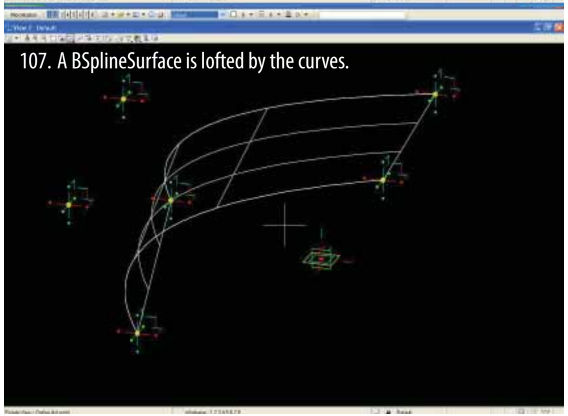
This case continues the former case with focus on the possibilities in the parametric construction of the program and the implementation of varibles into the design.

The principle of this case is constructing a structural system of columns or trusses controlled by an external form factor. Thus the case experiments in the development of structural systems coherently with development of the shape.

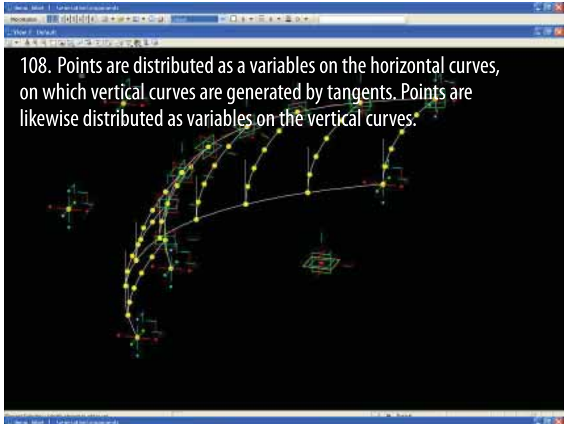
The form factor is controlled by a bottom and top curve spanning a surface potential of being a building surface. An equal amount of point is distributed on each curve defining the start and end point for the columns. The points are distributed by a variable, thus it is possible adjusting the amount of points and thereby columns. The columns are supposed to be triangular in the shape, why the points at the bottom curve are copied



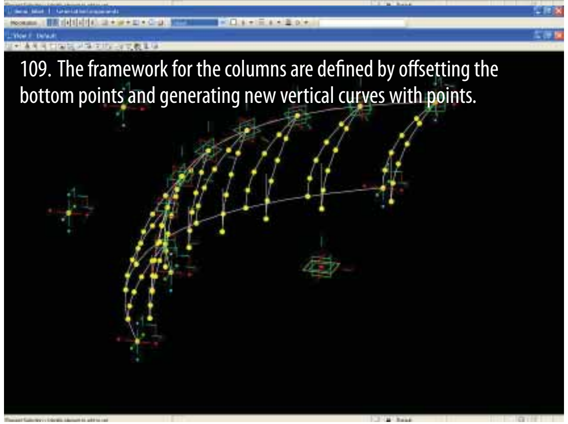
106. From the points the BSplineCurves are spanned by poles.



107. A BSplineSurface is lofted by the curves.



108. Points are distributed as a variables on the horizontal curves, on which vertical curves are generated by tangents. Points are likewise distributed as variables on the vertical curves.

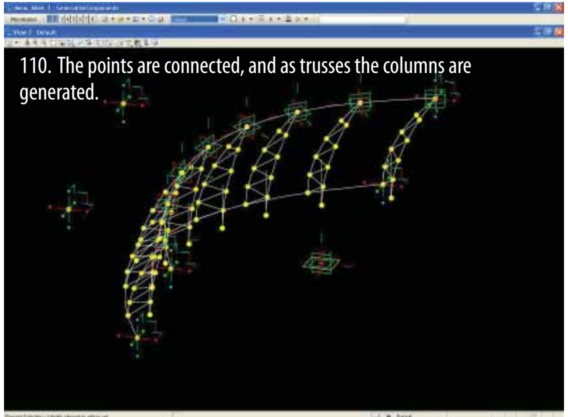


109. The framework for the columns are defined by offsetting the bottom points and generating new vertical curves with points.

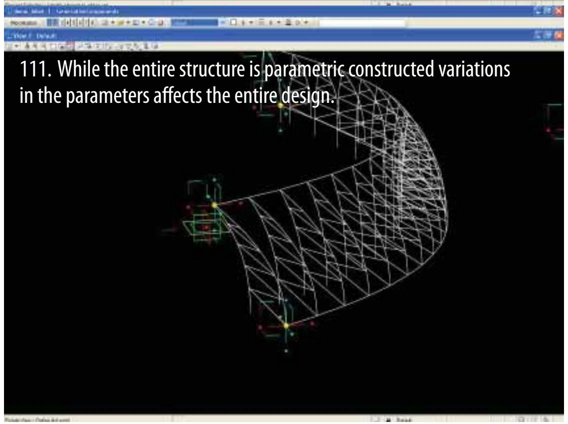
towards the centre of the shape. The distance between the points are dependent on the height of the columns, thus the width of the columns increases with the incensement of the height. The framework for the columns is defined from the description above. The design of the columns is the following.

c.a trusses

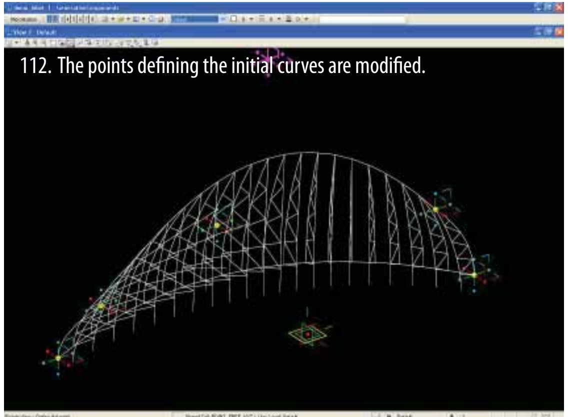
This case exemplifies the columns to be trusses. The truss of the column is created by connecting the points on the line defining the framework of the column. As the example illustrates the framework of the columns is defines in the previously description where every step relies on the previously step. In this way the construction of the design is parametric and the design adjusts according to modifications in the framework of the design. The figures illustrate the diversity the parametric construction entails.



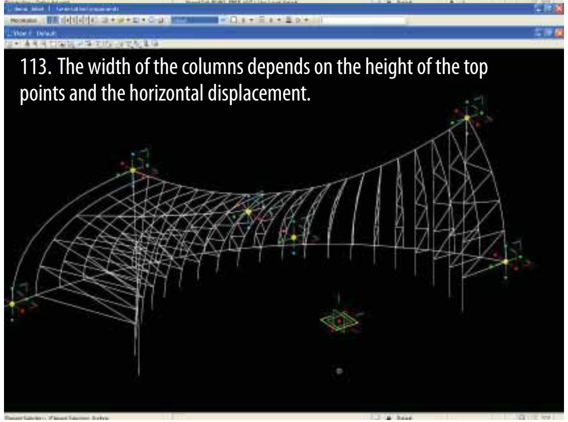
110. The points are connected, and as trusses the columns are generated.



111. While the entire structure is parametric constructed variations in the parameters affects the entire design.



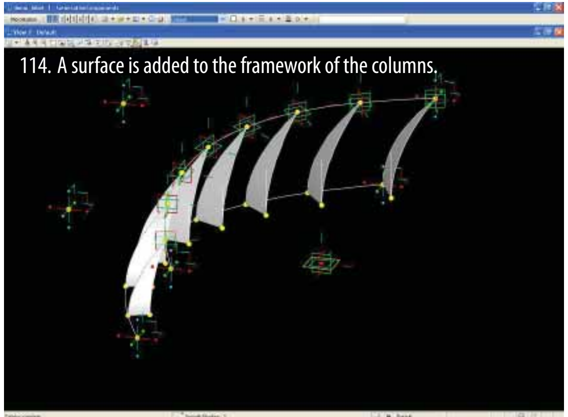
112. The points defining the initial curves are modified.



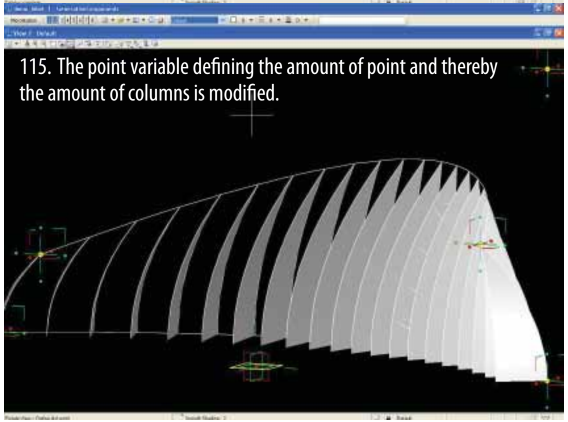
113. The width of the columns depends on the height of the top points and the horizontal displacement.

c.b solids

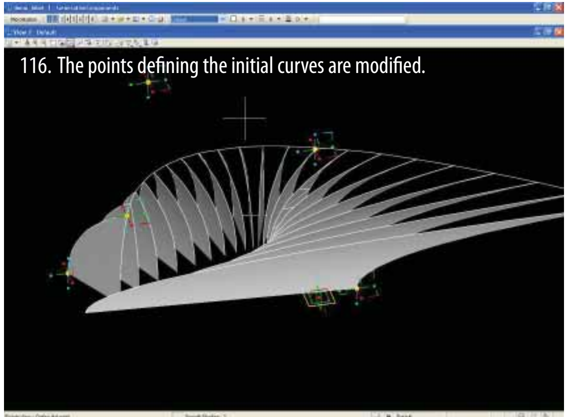
This example is an adjustment to the former case, where the trusses of the columns have been replaces with a solid or a hollow solid. The two cases are both results of the parametric construction, and it is evident how variations in the early design have e deeper impact than variations in the later design. The early and later design in the continuation refers to the chronological sequence, by which the generative model is created. The deeper impact on the early design compared to the later is a causality of the hierarchic structure of the program, which also can be seen as logic consequence. The variations in the early design in this case are within the overall from of the structure, and later in the process the model is generated with respect to the respective elements being first the placement of the columns in accordance with the overall form, after that the frame of the columns is defined and at last the final design of the columns.



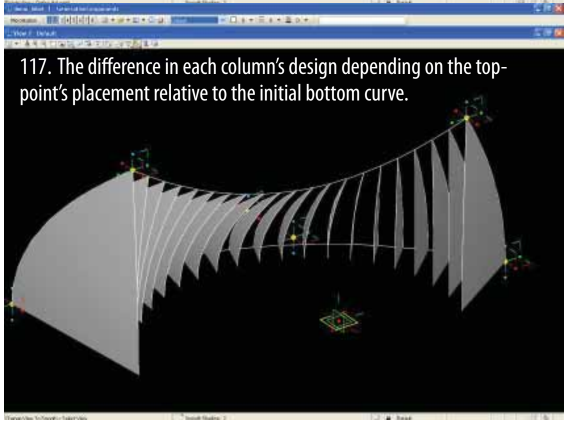
114. A surface is added to the framework of the columns.



115. The point variable defining the amount of point and thereby the amount of columns is modified.



116. The points defining the initial curves are modified.

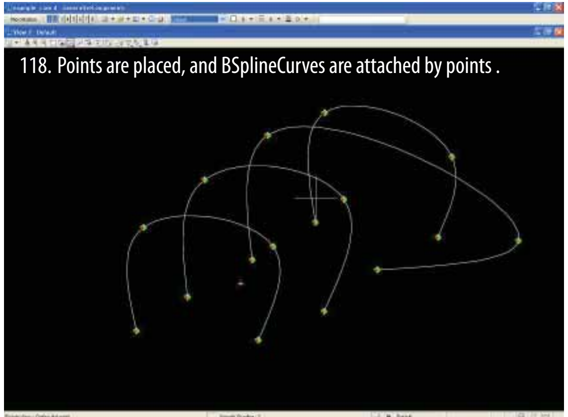


117. The difference in each column's design depending on the top-point's placement relative to the initial bottom curve.

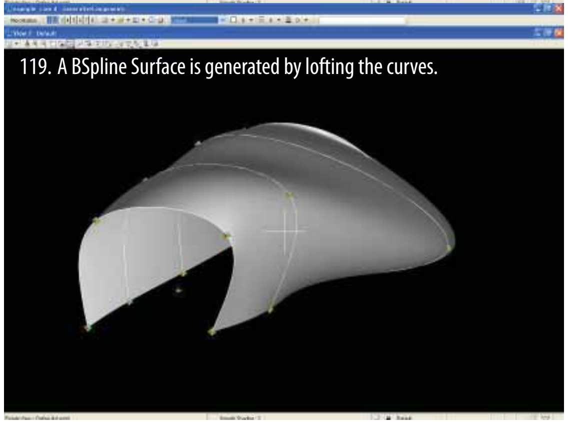
Case d – form by variables

In continuation of the former cases where the appliance and development of the structural system with variablea and dependencies have been in focus. This case is an example of controlling form by variables, which might have structural properties as well as tectonic or other relevant perspectves. Thus the overall form or design in the followng case is constructed with variables.

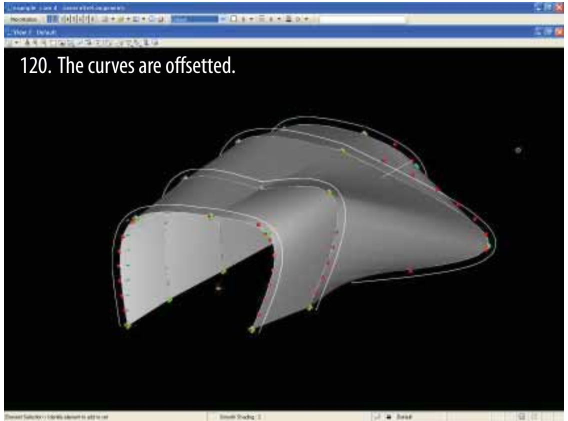
The procedure of the case begins by defining the variables in this case the point defining the overall form. By the points BSplineCurves are generated and afterwards a surface is generated on basis of the curves and thereby the original points. Thus the surface of the building is generated of the overall form of the design. It is possible offsetting the surface and thereby creating a gap for the construction of the building. This is showed in fig. 120. Within the gab or between the sur-



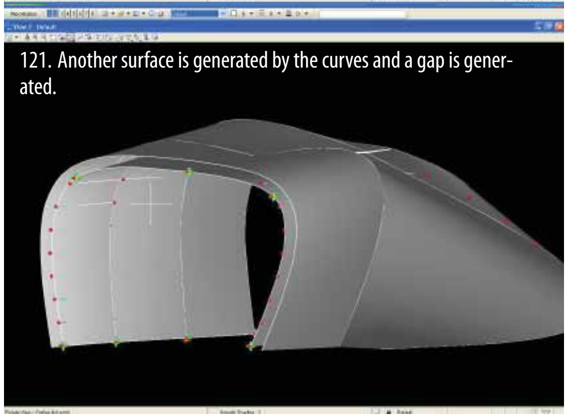
118. Points are placed, and BSplineCurves are attached by points .



119. A BSpline Surface is generated by lofting the curves.



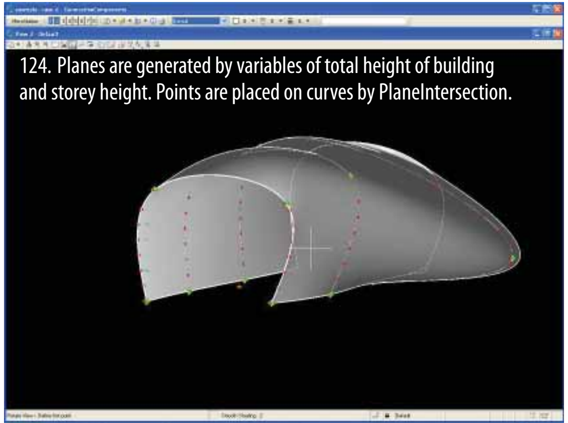
120. The curves are offsetted.

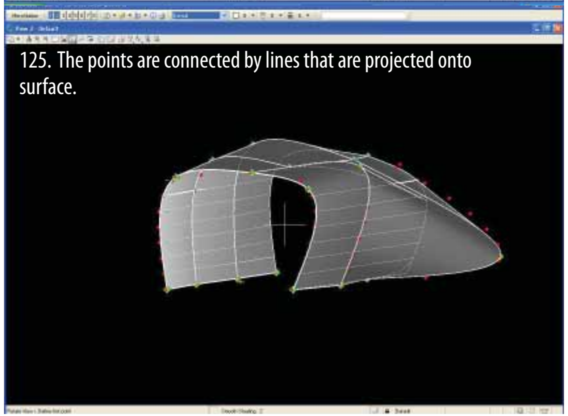


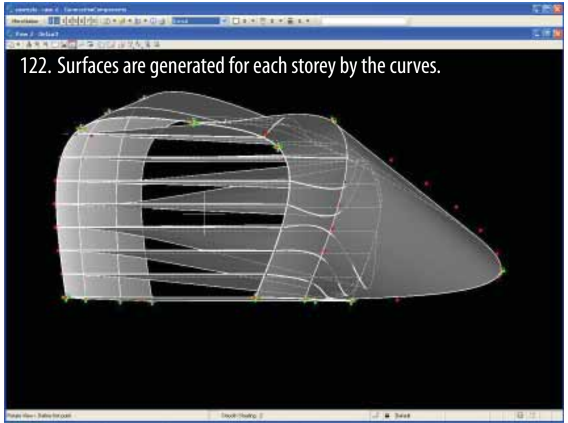
121. Another surface is generated by the curves and a gap is generated.

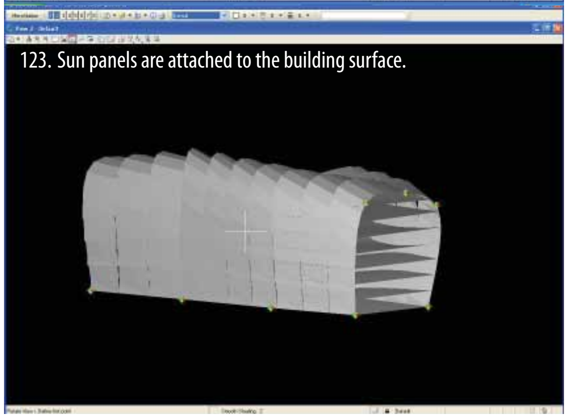
faces it is possible to attach the structure of the building, thus modifications of the points and thereby the shape continues to update the structure. In the following storeys are also attached to the surface, and they possess likewise the possibility of being updated according to the overall form.

The storeys are like the offset surface also attached to the surface. For generating the storeys planes are generated with respect to the total height of the building and the height of each storeys which both are implemented variables. At the intersection of the planes and the BSplineCurves, defining the surface, points are placed. These points are the basis for the planes or surfaces of each storey. In this way the storeys are generated with respect to the variables of the total height of the building, the height of each storey and the overall form of the building.


124. Planes are generated by variables of total height of building and storey height. Points are placed on curves by PlaneIntersection.

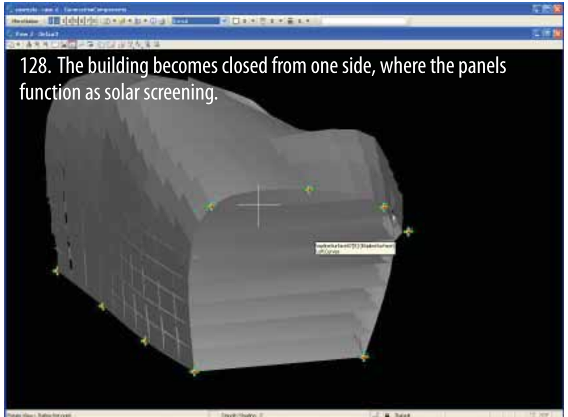

125. The points are connected by lines that are projected onto surface.


122. Surfaces are generated for each storey by the curves.


123. Sun panels are attached to the building surface.

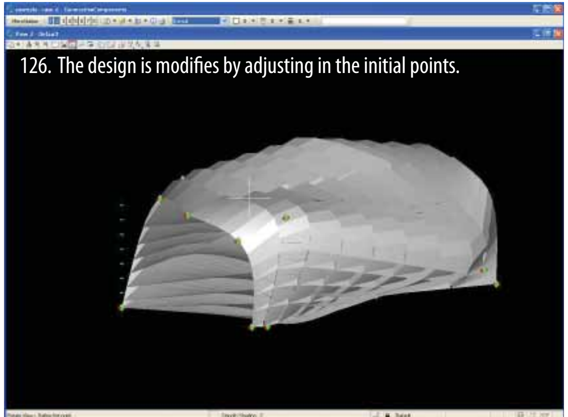
The former cases have already experimented with the feature of adding a feature to a surface or PolygonGrid, and likewise the former cases the interrelationship between the feature added and the shape and the shape becomes visible. In this case a panel is added, and it becomes visible how the feature provides a quality to the building of being open towards one side and closed to the other. The variable degree of the panel's openness is exposed.

This case combines elements from the former cases and provides a method of working with GenerativeComponents in terms designing an entire building. In terms of tectonics the possibilities of linking structure to the form and linking other parameters like form, structure or the next step in the design process.

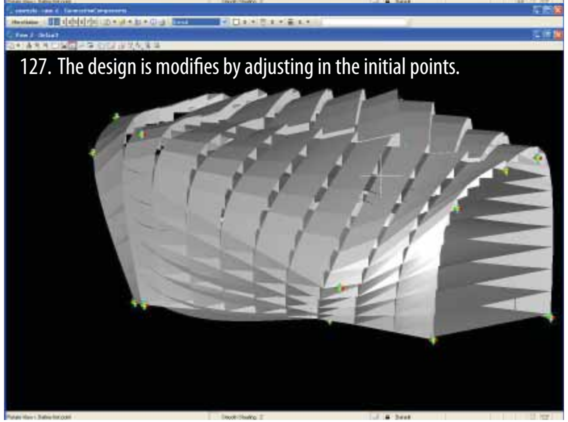


128. The building becomes closed from one side, where the panels function as solar screening.

129. Opposite the building opens from the other side letting in natural daylight.



126. The design is modifies by adjusting in the initial points.



127. The design is modifies by adjusting in the initial points.

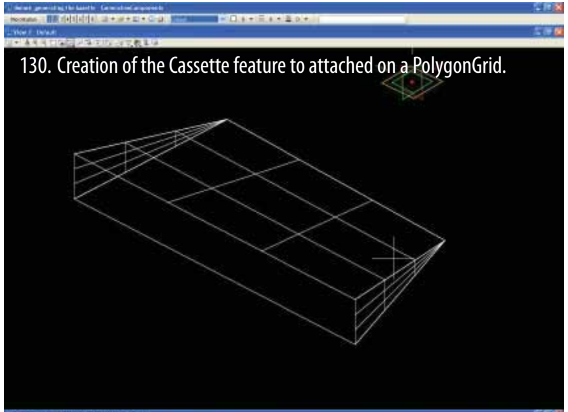
Case e – performative perspectives

Through the cases generating architecture with respect to tectonics hae been the theme. The program offers a wide range of possibilities and in the following the program is tested with respect to performative parameters.

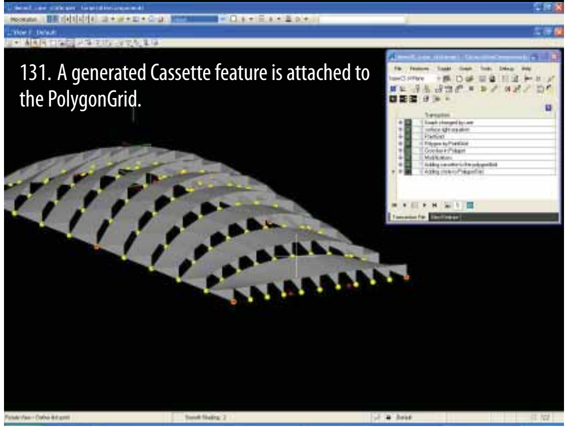
Some possibilities within the program have been demonstrated in terms of generating structural systems and generating form dependent on variables. As a continuation of *case b*, concerning adding features to a shape and thereby performing the value of the feature, features of other values are generated performing climatic values as aesthetic values. The basis of the shape is the same as in *case b*.

e.a performing climatic perspectives

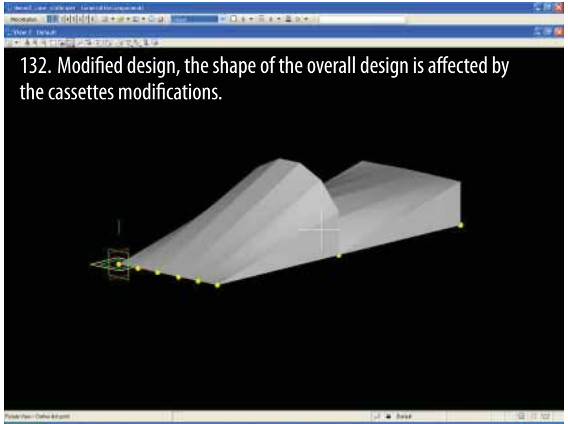
This case exemplifies how a feature possessing climatic perspectives can be added to a shape. The case can be seen with



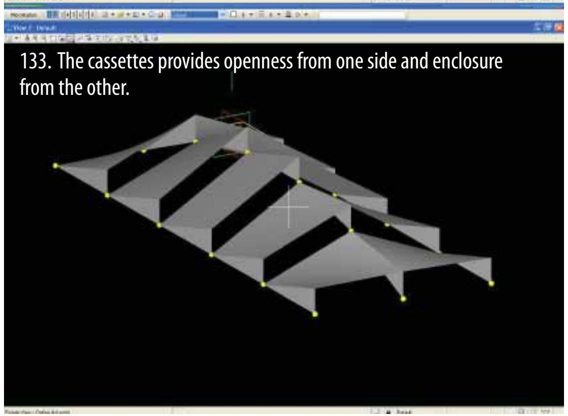
130. Creation of the Cassette feature to attached on a PolygonGrid.



131. A generated Cassette feature is attached to the PolygonGrid.



132. Modified design, the shape of the overall design is affected by the cassettes modifications.



133. The cassettes provides openness from one side and enclosure from the other.

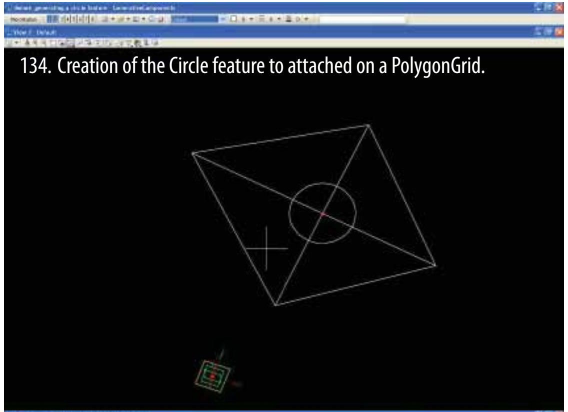
structural optics besides the climatic optics. A feature of a panel is generated and added to the PointGrid. The panel is generated thus is opens in one direction with respect to the size of the element, which could be dependent on the position of the sun. The panel that behaves relative to the sun also possesses the ability of being a structural system of the building. Thus is this feature an element performing structural properties and climatic properties.

b.c performing aesthetic perspectives

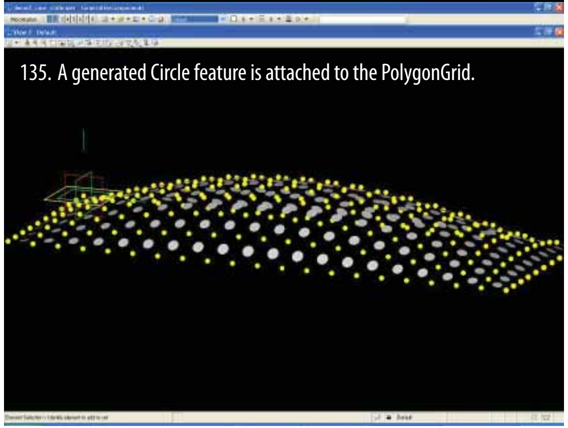
The potentials of applying a feature performing a certain value is not necessary performing structural properties even though the structural system is planned in the shape defining the form. This case exemplifyes how a feature with characteristics of being a pattern to the surface for pure visual properties.

A simple figure of a circle not connected to anything but placed between four points on the surface is added to the structure. By the simple figure of a circle this case exemplifies how a pattern can be created and spread over a surface or facade.

This case as an extension of *case b* shows the wide possibilities in generating a feature performing a certain perspective and adding it to a PointGrid. The element in the feature modifies itself with respect to the PointGrid, this is seen in *case b,* where the thicknesses of the cones is the variable. In the former case the openness of the panels are equally variable with respect to the sizes of each rectangle, and finally the sizes of the circle or the sizes of each pattern to be copied and spread out are likewise dependent on the sizes of the rectangle within the PointGrid, while the rectangle in these cases have been the basis of the features.



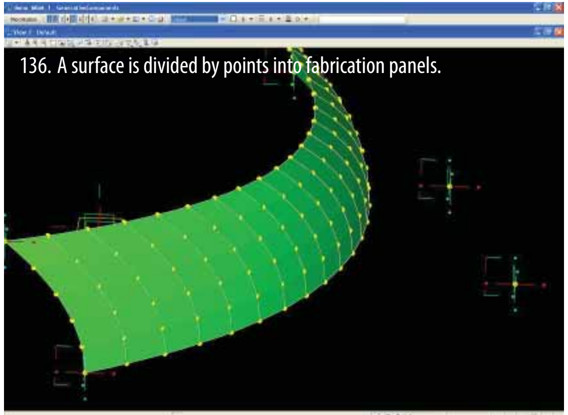
134. Creation of the Circle feature to attached on a PolygonGrid.



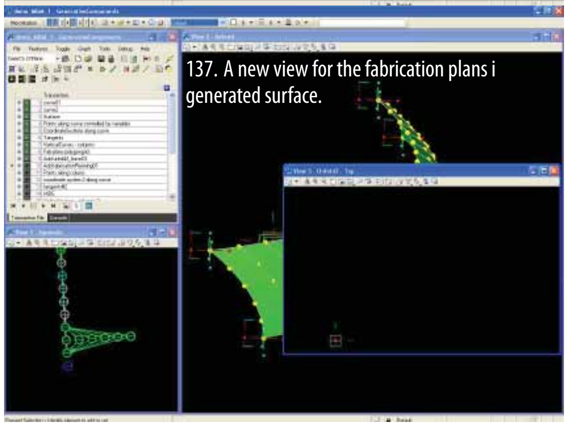
135. A generated Circle feature is attached to the PolygonGrid.

Case f – fabrication plans

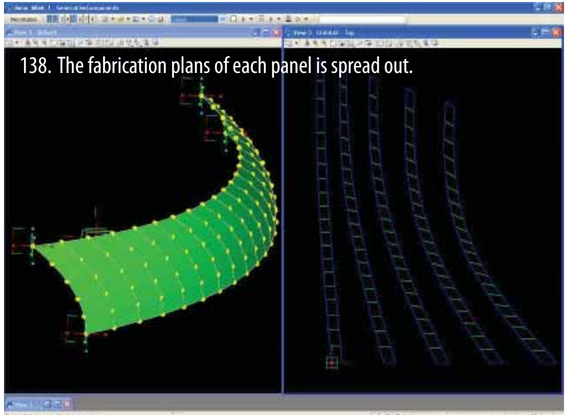
This design in this case is a surface spanning over two BSpline curves. A PointGrid is spread over the surface and a Polygon is attached to the PointGrid. The Polygon can be seen as a facade or surface of the facade. By making fabrication plan the exact panels of the facade is listed up, and thus it facilitates the actual construction and the planning of the construction. The fabrication plans are made in another Model or view making it easy exporting the plans for construction. In the last illustrations two examples of fabrication plans of the same model is generated. The difference is that the first figure illustrates the panels that are not corrected for non planar quadrangle, and the last figure is corrected for non planar quadrangles, while the panels are divided into triangles.



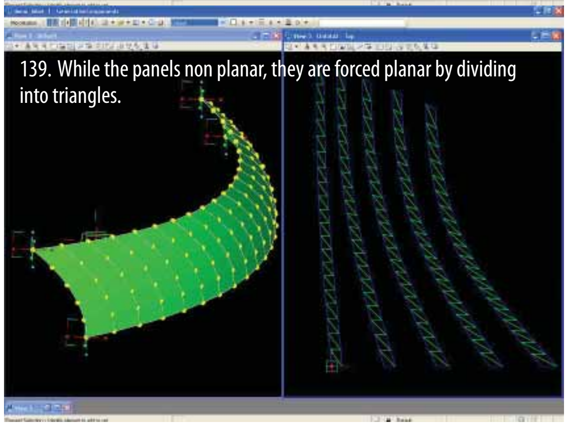
136. A surface is divided by points into fabrication panels.



137. A new view for the fabrication plans i generated surface.



138. The fabrication plans of each panel is spread out.



139. While the panels non planar, they are forced planar by dividing into triangles.

4.2.2 THE CASE STUDY HYPOTHESIS

In the following the questions derived in the former section of approach to case study concerning the introduction of theories of tectonics and architecture in the digital age will be answered on basis of the cases described previously.

1. What is the context of the case and how does it influence the specific case?

The context for *GenerativeComponents* is being a generic parametric tool. The program is a commercial program opposite *eifForm*. It is part of Bentley Systems, Incorporated, and is an extension of Bentley Mircostation and therefore compatible with Bentley Architecture, Structure and STAAD.Pro, in this way *GenerativeComponents* is part of a larger system of software, bringing opportunities to the program in the broadly possibilities of exporting and importing to and from other programs apparently without losing information. *eifForm* was limited to truss structures *GenerativeComponents* on the other hand with the parametric construction is able to generate all conceivable designs. Possessing the broad range of possibilities as *GenerativeComponents* the program also includes a complexity. The approach to *GenerativeComponents* is not apparently easy. An introduction to the program is required for learning about all the features the program possesses. The manual is more developed than *eifForm*, which also is a natural consequence of being a commercial program. It includes useful tutorials and a brief introduction to the program, but for learning about all the finesses and features of the program an introduction from a former user is valuable.

Thus the approach to the program is more complicated, but when the finesses and features reveals themselves for the user, the broad range of possibilities within the program derives. Possessing this broadness allows use of *GenerativeComponents* for many design solutions, thus the choice of using *GenerativeComponents* can be taken from the start of the design phase, and not after the project have proofed it operates within the sphere, where *GenerativeComponents* is useful. Though the use of *GenerativeComponents* for short and simple projects is not recommendable, while operating the program costs time and the GUI is not as easy approachable as others drawing programs, not possessing the possibilities of *GenerativeComponents*. In this way the GUI reflects the many possibilities within the program, and therefore use of the features is not clearly, while there are so many features.

In large scale projects or complicated projects the use of *GenerativeComponents* shows its benefits and shortage. A determinant shortage of the program is within the inherent scripting language that is a meta-language, and therefore the program can get relatively slow even with relatively small implementations or scripts. Though is it possible to prepare for contingency by scripting the design after different rules by making lists, but still the program requires a certain amount of memory. Memory shortfall has historically been an issue in the computer-based tools for designing and in general. With the continuous development of the computer, the memory shortfall in the long run is not seen as a direct reason to avoid *GenerativeComponents*, since the problem can be diminished by powerfull computers and by the ongoing development of computers. Decisively it can be a problem designing larger element with GenerativeComponents caused by memory shortfall.

2. In which digital architectural typology does the case work within?

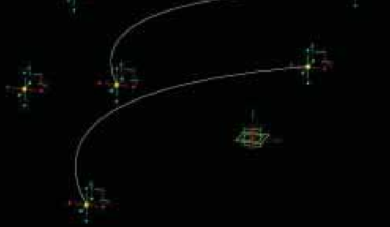
GenerativeComponents operates as a parametric generative tool, and thus it operates within the typology of parametric architecture and is also applicable within the performative architecture, enhance by the possibilities in linking the program to STAAD.Pro and the rest of Bentley software.

3. How does the case work within the span of tectonic methodologies?

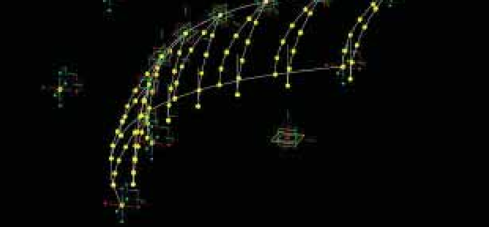
In terms of tectonic methodologies *GenerativeComponents* concerns not specified the empiric-analytic methods as *eifForm*. *GenerativeComponents* is with wide possibilities within the parametric construction not specified into a scientific philosophical methodology. Thus the program is not specified to either the positivistic and calculative engineering process or the phenomenological sensitive artistic design process. Actually the program possesses the possibility of combining the two methodologies and thereby the program can tentatively be defined as hermeneutical, while it possesses the possibilities of broaden the horizon through an iterative process.

With reference to the section of methodologies the definition of hermeneutics is the method that brings a broadened horizon to the tectonic thesis from its different fields. The method is like a spiral taking starting point in the problem relates to the part and responds to the whole with a new and widened understanding.

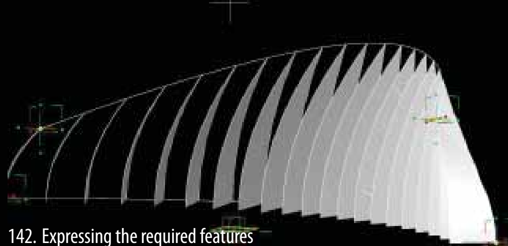
Exactly this methods is the possibilities within *GenerativeComponents* by linking to STAAD.Pro enables concerning of the part, developing and adapting the static perspective by the empiric-analytic method embedded in STAAD.Pro. Corresponding to the possibilities with the static considerations *GenerativeComponents* also provides possibilities for aesthetic considerations by 3D renderings and by the fabrication possi-



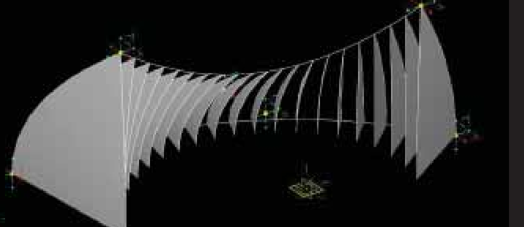
140. On basis of simple controllers



141. A structural system can be build



142. Expressing the required features



143. And easy modelled by the controllers.

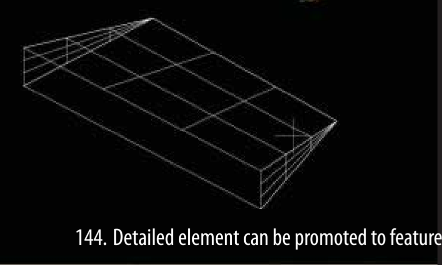
bilities within the program, where it facilitates physical model building from the digital model, by either fabrication plans or a 3D printer or laser cutter. Thus it is possible to evaluate the digital model by experience it, which is the definition of the phenomenological method. In this way *GenerativeComponents* is a generic parametric tool, that provides possibilities of relate to the part for afterwards retuning to the whole with an increased understanding. This is in accordance with the definition of the hermeneutical method, a theory of interpretation. It is not reasonable trying to explain the phenomena from general formulas like science. Instead the hermeneutics tries to explain the meaning of the single phenomenon from its context. The immediate context is here *GenerativeComponents'* context allowing the linking to e.g. STAAD.Pro, which concerns the empiric analytic methodology. Likewise *GenerativeComponents* facilitates the fabrication and thereby assists the phenomenological methodology. In this way the *GenerativeComponents* context is the context of the whole, and the other perspectives gives a part context explaining the phenomenon in the respective contexts, for responding to the whole with a new and widened understanding.

The linking with STAAD.Pro allows tests and analysis of the structural system, but it is a voluntary possibility, architects not necessary are using. And thereby the explaining of the phenomenon from the context being empiric-analytic and phenomenological is up to the user of the program. The integration of the methodologies is not inherent in the program, but a possibility in the program. Thereby the user must be focused on achieving a tectonic process by using the possibilities inherent in the program.

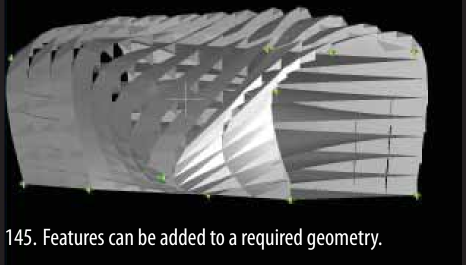
4. Availability in terms of clear structure and logical structural system?

By the construction of *GenerativeComponents* to promote parametric design, the possibilities of generating clear structure and a logical system is within the program. Compared to *eifForm* attention must be paid to the fact that the structural system generated in *GenerativeComponents* not necessary is logic or optimal, while the structure is generated by the designer and not by structural optimisation.

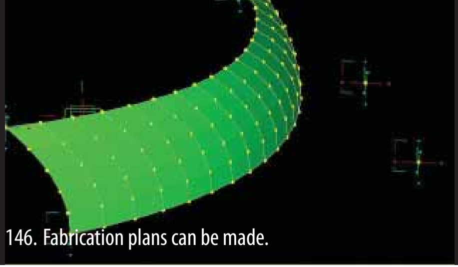
The hierarchic construction of *GenerativeComponents* allows different levels of detailing in the generating of the design. In terms of generating a clear structure one parameter to detail can be this perspective. In terms of this perspective it is seen in the previously cases how the comprehensive the possibilities of developing and adapting the structural system is within



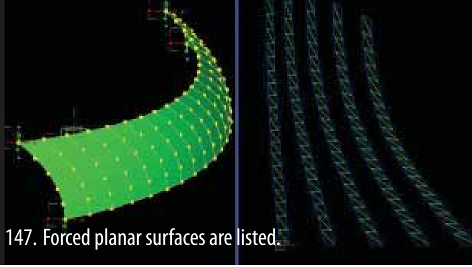
144. Detailed element can be promoted to features.



145. Features can be added to a required geometry.



146. Fabrication plans can be made.



147. Forced planar surfaces are listed.

the program.

5. Availability in joint and detailing?

As described above the hierarchic construction of *GenerativeComponents* allows detailing. Before the detailing was in larger scale namely the structural system, and concerning small scale detailing and joints the software possesses its possibilities.

Though designing details can generate some problems with the program. Designing exact details or detailing a specific object might result in hard computing demanding, advanced skills for scripting by the designer and a large memory for the computer. Thus the detailing is not always uncomplicated and easy approachable, but the software offers possibilities for detailing. Some of the software's approaches to detailing is within the possibilities of creating new features, the wide possibilities for scripting, and the possibilities of optimising the calculative processes of the computer e.g. by making lists.

6. Availability in linking concept, design and manufacturing?

GenerativeComponents is software that concerns the entire design process. It is possible using *GenerativeComponents* from conceptual phase to develop ideas. As an idea generator is not as generative as *eifForm*, while the designer itself enters all the information generating the design. In that way the design is a reflection or representation of the input. The design does not emerge automatically from a basically input. Actually the design is rather a reflection of the scripts in the program. By claiming this, the geniality of the design lies in the designing of the script. Meanwhile it possesses the wide perspective, while is not is limited to one kind of structures, all kind of designs can theoretical be made with *GenerativeComponents*.

The link to manufacturing is very present, while *GenerativeComponents* possesses features as fabrication plans, making it easier to physical build the digital model. This is useful during the design phase, where the digital models can be built physically and thereby better be evaluated by the designer, while the experience better is expressed through physical interaction rather than just observance through a monitor. Refering the phenomenological approach, the experience of an object must be with interaction with the object itself. By experiencing an object through photography or a monitor it is the reproduction of the object that is experienced. Thereby the link to manufacturing or fabrication is in continuation of the tectonic approach to design including a phenomenological approach as well as empiric-analytic.

The fabrication plans that have showed their usefulness during the design process surely also offers potential in the final production or fabrication, where the plans can facilitate the communication with the craftsmen and fabricators. In this way *GenerativeComponents* is part of the fabrication by clearing the communication to avoid misunderstanding and substandard construction for the specific case. The making of fabrication plans facilitates the comprehension of the design for outside parties which in the end can decrease the expenses.

The last perspective is one on the digital tectonic characteristics and the is here argued in terms the economic but the importance and relevance is also present in terms of guaranteeing the final result being as the intended design caused by economics, fabrication and communication.

7. Requirements for the designer in terms of operating with the case?

The program is not easily approachable, it requires a deeper introduction either by the manual and tutorials or preferable by a knowing user, that can pass along tips and knowledge about the features.

It is possible using the program without scripting if the scripting is a parameter daunting new users, though the same broad amount of possibilities is not present without scripting the features. If the designer wants to avoid scripting the design available is very simple, and the possibilities within the program is not taken advantage of. In this case the use of *GenerativeComponents* becomes rather absurd, while the parametric comstruction of the program not is used and in this case other 3D drawing programs are preferable caused by the complexity of the program.

As mentioned previously the GUI suffers by the many possibilities in the program. The possibilities cause a large variety of options and this variety in listed in a feature list, where experience with the list is required for understanding the logic in the construction.

4.2.3 SUMMARY

GenerativeComponents is with no doubt a program that offers a lot of possibilities within the term of parametric design. It is announced as the leading parametric generic program and the author agrees in this announcement.

The possibilities with *GenerativeComponents* are endless if the computer power is sufficient. Though is it a problem for the software that running it may be slow and include some computational disorders. Furthermore the GUI is difficult approachable caused by the many possibilities in the program. This causes that the use of GenerativeComponents so far is limited to a specialist group, that have been taught the program or have been used a large amount of time to get familiar with the program and the features within it.

GenerativeComponents is still a new program which is reflected in different continuations with the program. E.g. the help menu and the tutorials are incomplete and sometimes errors occur without an explainable reason. The program necessitates an amount of patience for learning and getting familiar with the features, the GUI and the unexplainable errors that occasionally occur.

In terms of tectonics the program is very competent with the parametric construction. It offers possibilities of handling the definitive parameters defining tectonics in terms of clear and logic structure, detailing and articulation of the joint. Digitally speaking the program facilitates the perspective of fabrication and generation. Methodological speaking it is within the hermeneutics permitting and facilitating phenomenological considerations as well as empiric-analytic. Though information and the user-friendliness is a question of adapting the methods within the program and customise oneself with the sophism of the program.

5 THEORETIC SUMMARY

By an introduction to the concepts of tectonics and architecture in the digital age, the conventional theory is brought up to the contemporary discussion of architecture. This is with focus on the recent years' development as a consequence of the emergence and development of the digital tools and the digital possibilities.

The five aspects from the conventional theory of *Tectonics* include 1) Ontology and representation, 2) Structure and construction, 3) Interaction and empathy, 4) The joint, and 5) The material. These five aspects are combined with further six aspects from *Architecture in the Digital Age* and the emerging of digital tectonics within the same age. These aspects are consisting of 1) Position in design process, 2) Information, 3) Fabrication and Generation, 4) Topology and shape optimisation and parametric generic tools, 5) The tools and 6) The physical constraints.

The two pair of keywords represent a section of analysis sharing the common method. Both sections are based on literature review and follow reflection and analysis of architectural pieces concerning the specific terms. The literature review of especially the tectonic section is combined with a profound analysis of the methodology behind the concept and an analysis of the scientific philosophy of the concept. By combining the analysis of the tectonics with an analysis of the methodology concerning it, a deeper understanding for the concept emerges.

As written in the section of tectonics there exists four main directions of tectonic developed by the four theoreticians Bötticher, Semper, Sekler and Frampton. For this thesis a single of these directions is not chosen as the tectonic basis. Instead it is found more pertinent to relate the four directions to the contemporary architectural tradition. The tectonic keywords are crystallised out from the consistent characteristics of the four theoreticians. The division of the structural part of the building and the aesthetics is seen as the general approach to tectonics, where the aesthetics or the art of the building must refer back to utility or to the mechanical part of the building.

This approach as the general approach combined with the other aspects in the outlined keywords of the section have been the basis for further analysis of architecture in the digital age where the focus is on the recent years development with the possibilities of the digital tools. The section presents a broad range of digital architectural directions. The parametric and performative architecture are found relevant in terms of tectonics as the theoretical approach to the architecture.

With a basis of the theoretical tectonic approach unified with the analysis of architecture of the digital age the focus is on the digital tools, the possibilities, the constraints, and the availability. *eifForm* and *GenerativeComponents* are analysed with the methodology of case study research, and the tools are evaluated on behalf of the tectonic possibilities within the use of the tool. *eifForm* as the non-commercial tool is by the latest released version 6.03 published in 2004 not developed in recent years, and the developer Kristina Shea seems not to be further developing the program. The tool possesses some qualities in terms of tectonics as clear and logic structure, but as a generative tool the program is delimited in the construction of software concerning truss optimisation. Furthermore *eifForm* concerns only the empiric-analytic methodology and elides the phenomenological and hermeneutical methodology, why there is a lack of concern of tectonic aspects as detailing, joint, and empathy for the architectural piece.

Analysing the other digital tool *GenerativeComponents* concerning parametric modelling and performative architecture, possibilities for digital generative design in terms of tectonics emerges. The program is very competent for the tectonic issue with the parametric construction. It offers possibilities of handling the definitive parameters of tectonics in terms of clear and logic structure, detailing and articulation of the joint. For the digital tectonics the software facilitates the perspectives that are found valuable in these terms being fabrication and generation. Even in terms of methodology the program facilitates operating within the span of the empiric-analytic method and phenomenology with the parametric construction promoting hermeneutics.

The theoretical analysis has contributed with a profound understanding of tectonics in the digital age. The term performative architecture and parametric architecture have been defined. Furthermore the concepts of *digital tectonics* and *per-*

formative tectonics have been developed as a consequence of the unifying of the conventional theory and the contemporary discussion of architecture with digital tools. By the analysis of the digital tools in terms of tectonics; *GenerativeComponents* is found useful and valuable in the generation of architecture or tectonics by digital tools.

This theoretical part of the thesis firstly concerns literature review combined with reflections of architectural pieces of tectonics, methodology, and architecture in the digital age. The case study research is also a determinant part of the thesis, whereas the practical examples in the analysis of the different tools exemplifies, how it is possible to work with tectonics and the digital media as two elements that complement each other and emphasise each possibilities in terms of generative architecture.

Hence this part of the thesis constitutes the framework of the further development of generating design with respect to tectonics by use of the digital media, primarily *GenerativeComponents* that is the leading parametric design software. Thus the approach of the following design process takes starting point in this theoretical part, to which there regularly will be referred back to. The keywords from each section that especially in the case study research possessed a determinant factor will also in the following be brought up for accomplishing a design that fulfils the requirements or perspectives from each section. Besides the keywords the knowledge accomplished in the case study research of the digital tools will be brought on, especially the approach of being a case study and concerning the determinant issues of tectonics and architecture in the digital age.

THE ASSIGNMENT

This chapter provides an introduction and accomplishment of the assignment of designing a multimedia house at Aarhus waterfront based on the framework defined through the theoretic part of the thesis. The Multimedia House at Aarhus waterfront has been an ongoing competition *MEDIASPACE – nyt centralt havnebyrum og multimediehus i Århus*, whereas schmidt/hammer/lassen architects' proposal won this spring. No attention has been paid to their proposal during this thesis.

6 DESIGN STRATEGY

While the design is to emerge from the theoretic framework defining the first part of the thesis, the design strategy likewise derives from the initial theoretical framework concerning tectonics and architecture in the digital age with focus on parametric and performative architecture.

Performative architecture is defined as parametric architecture performing certain aspects. *Performative Tectonics* is defined as the term where parametric architecture performs the tectonic values. Thus the parameters defining the performative perspective are based on tectonic values.

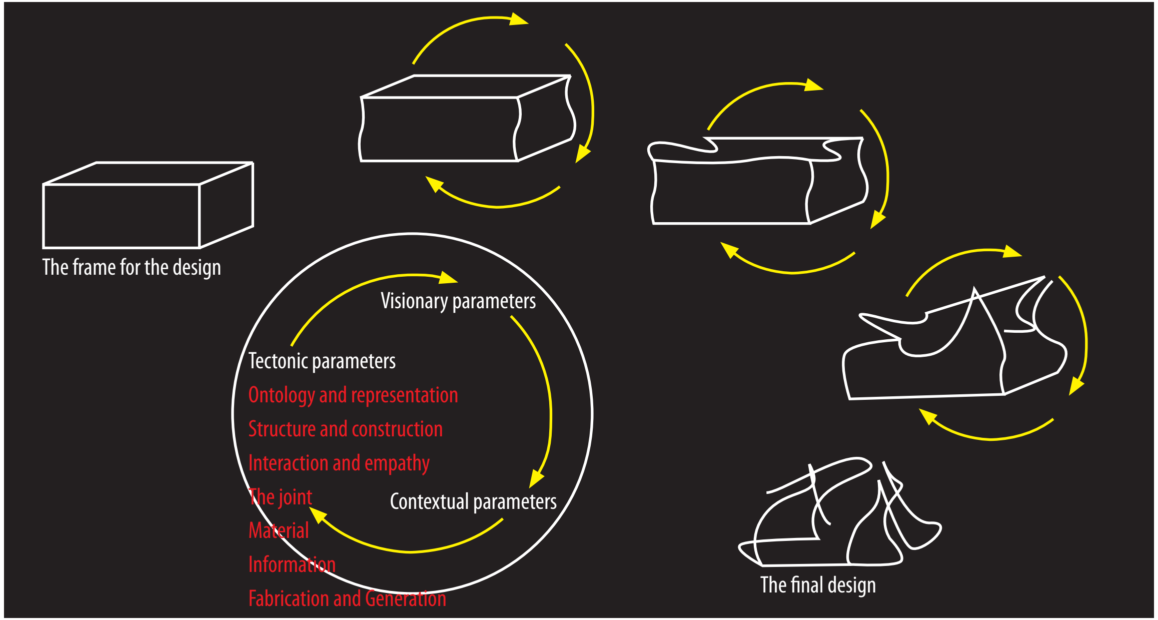
The design strategy is in coherence with the generative design approach where the digital tools possess a determinant influence in the generation of design. And as the performative value is tectonics the keywords from the former theoretical part defining the tectonic basis are relevant. The following consists of both the conventional and contemporary values of tectonics.

1. Ontology and Representation
2. Structure and Construction
3. Interaction and Empathy
4. The Joint
5. Material
6. Information
7. Fabrication and Generation

Especially the third tectonic value concerning *Interaction and Empathy* is a value of a high degree of relevance in development of digital architecture. This is in continuation of the discussion in the theoretical part concerning the importance of coherence between site and architecture for avoiding monotonous architecture without uniqueness. The discussion of monotonous architecture emerges from a critical approach to computer generated design, potential of generating design through solving of mathematical equations or algorithms, thus design is just calculation rather than creation. This otherwise tectonic parameter of *Interaction and Empathy* can be compared with the contextual parameters elaborated in the following.

The contextual parameters respond to the actual site and surroundings for the design. The contextual parameters are to be elaborated in the following through a contextual analysis. Furthermore the actual design assignment is also a decisive parameter, the definition, the vision and the function of the design object. The parameters concerning the actual object are likewise the contextual parameters to be elaborated in the following. These parameters are named the visionary parameters.

The aim is to combine these different perspectives of parameters thus each affect the design in different stages of the generation. Hence the design strategy is generating the design through interplay of the different perspectives, where both the tectonic approach will be decisive in the process as the framework for the project is tectonics, but also the visionary approach to the case will affect like the contextual perspectives.



148. The tectonic parameters generates the shape along with the visionary parameters of the Multimedia House and the contextual parameters of The Southern Bastion as an integrated process of several iterations.

7 VISION

The vision for the project is to be developed through the following analysis. At first the competition vision for the Multimedia House MEDIASPACE is evaluated. The vision for this project is an interpretation of the competition vision combined with visionary perspectives to other multimedia houses or libraries emerging through case studies.

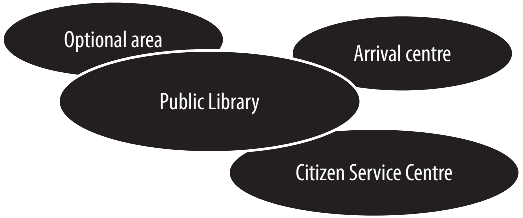
149. Visionary illustrations from the Competition Presentation

7.1 COMPETITION VISION FOR THE MULTIMEDIA HOUSE MEDIASPACE

The following descripes the vision for MEDIASPACE. Overall the competition both requires designing the actual multimedia house but also designing the urban harbour space with reference to "The Quality Manual"; a result of a competition from 1999 concerning planning the redesign of the harbour environment and the exposure of The Aarhus River.

Designing the urban harbour space treats designing an interconnected harbour space from the southern bastion to the northern bastion, designing of the exposure of the river outlet including redesign of The Europe Square. Reorganising the primary thoroughfares of Havnegade and Nordhavnsgade for minimising the traffic and redesigning the railway of Grenaabanen.

Concerning built area the competition concerns at first an arrival centre for the railway, a parking house and the multime-



150. Planned physical content of MEDIASPACE Library complex

151. Visionary illustrations from the Competition Presentation

dia house MEDIASPACE. Following a building corresponding MEDIASPACE is to be built at The Northern Bastion.

House of and for democracy

It is required that the multimedia house includes an Arrival Centre and a Citizen Service Centre. Furthermore an Optional Area for the purpose of renting out or to be used by MEDIASPACE. The entire building complex is calculated to be approximately 29.000 m^2. Besides the factual information of the building the competition presentation also announces the visionary approach for the centre. MEDIASPACE is supposed to be the house of democracy, a house of knowledge. The Multimedia part is the place where the citizens can increase their knowledge, a place to teach and learn, to search and meet, to be and stay – a place of democracy. The Citizen Service Centre is the place the public can seek advice from administration about public opportunities and where practical aspects as passport, driver license etc can be arranged. In other words a place to meet the democracy.

In continuation of the house being the place of democracy the multimedia house is a place for everyone, children of all ages, teenagers, adults and elders. Caused by the democratic approach the house is to be designed by a user centred mindset.

User centred mindset

It is essential for the multimedia house to ensure that citizens' encounter with knowledge, culture and the public system becomes enjoyable, appealing, fun and fascinating – never dull or a duty.

In this knowledge society paradigm, the building becomes a medium in the relationship and communication between: Users, Users and building, Users and media, and Users and staff. Users are all different. This difference is a resource driving the development of new ideas. The architecture should thus reflect and be conducive of diversity and complexity.

Multiple media

The ambition of the multimedia house is to be both a real and virtual place where citizens meet new media, knowledge and each other for many decades to come. The multimedia house should be adaptable and programmable to meet this ambition.

Human development and interaction should be both the starting point and the objective. The concept of multiple media communication involves all the senses. A variety of different spaces in the multimedia house provide a higher quality of communication for all the senses and intelligences. Workshops, experimental spaces and labs should be part of citizens' encounter with knowledge. Special attention should be paid to children and families. The upcoming generations are the fuel and energy of society. Experience, learning, play and having fun should be facilitated by the building.

A substantial part of the multimedia house is the library. For thousands of years, libraries have worked with various media: from clay tablets, papyrus, handwritten paper, and printed books to radio, television, video, the Internet, and e-books - and who knows what comes next. The library as institution has survived competition from other media by integrating them and adding an extra aspect: a social and meaningful context.

Until this decade, information and media were in short supply throughout history. The breakthrough of the Internet changed that. Instant information is now available everywhere. No one can keep up with the flood of information. Libraries have a new role in helping people select and add significance to information. A role to point out and highlight what makes a difference for the individual citizen and for the community. Thus the library focuses on information for the individual and meanwhile being the social and meaningful context. A challenge is to create architecture that provides a social and meaningful context for perception, recognition, selection and interaction.

Sociality and Individuality

A communicating building such as the multimedia house should encourage people to meet and act, and it should make people curious, perceptive and wiser. It should encourage learning and experience. As a public democratic forum, the multimedia house should catalyse situations in which people thrive, engage or relax.

The multimedia house should encourage the encounter between users and staff by providing places of interaction. The meeting between users as well as exchange, sharing and inspiration should be fostered and facilitated by the building. The multimedia house should also facilitate engaging moments in which people are open to involvement and involvement in numerous cultural, learning and democratic organisations and activities in the building. The multimedia house should be a refreshing, tranquil oasis where mental batteries can be recharged, with plenty of daylight and healthy, healing and holistic surroundings.

Different user segments have different preferences for media and content. The road to rational behaviour in searching for media and content should be straight, yet tempting people to use media and content they did not know they needed, but which could actually change their lives.

Knowledge and Learning centre

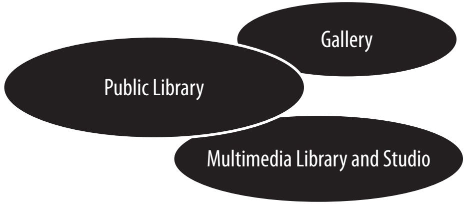
As knowledge is the subject for the multimedia house and the yardstick of the knowledge era is ”a difference that makes a difference”. The focus is centred on sender and receiver, while information is increased when the sender has structured and compressed his message to have a valuable meaning for the receiver when the receiver cares. By keeping in mind the concept of ”a difference making a difference”, the multimedia house should appeal to all senses, to Howard Gardner’s seven intelligences (linguistic, mathematical, physiological, social, spatial, musical and body kinetic intelligence), to the introvert and the extrovert, to right- and left half of the brain, etc.

The multimedia house should develop from passive to interactive. Life is dynamic, and with the vision about the growth of knowledge and the expanding knowledge of people, architecture becomes alive, changing according to the needs of the user. [Competition Presentation]

7.2 CASE STUDY MULTIMEDIA HOUSES

To wide the perspective and get a sufficient visionary approach the competition vision is combined with a case study of existing multimedia houses. The case study methodology relies on the theory from the Methodology Section 2.3 concerning case study research. By a reliance on multiple sources of evidence, data possess the ability of converging in a triangulating fashion, the power to generalise to theory emerges. Therefore three different cases are analysed to get general visionary perspectives for multimedia centres or extended libraries. The ground breaking and international know characteristic Sendai Mediatheque from 2001, the Danish Ordrup Library and Sports Facilities a combination of sports and educational facilities from 2008, and the Danish library in Kolding combined with hotel facilities from 2006 are the objects for case study research, while they possess broadness in functions and meanwhile are contemporary relevant.

152. The Library in Sendai Mediatheque, Sendai, Japan by Toyo Ito 2001



153. Physical content of Sendai Library complex

7.2.1 SENDAI MEDIATHEQUE BY TOYO ITO & ASSOCIATES

With the three sentences in the box the concept of Sendai Mediatheque is presented.

Multiple media

Designed from this concept, the Sendai Mediatheque is a centre for activities in the fields of art and film, serving as a public facility to help people freely exchange information with each other through various media and learn how to use that information. With the organisation of the public city library distributed at the 2nd, 3rd and 4th floor, the Gallery at 5th and 6th floor and finally the Multimedia Library and Studio at the upper 7th floor, the distribution of the different media throughout the building ensures people flow and freely exchange of information.

Aesthetic transparency

The Mediatheque is located on the tree-lined Jo-zenji Avenue

Sendai Mediatheque flexibly serves the needs of people by supplying the latest knowledge and culture.

Sendai Mediatheque maximizes networking potentials not through terminals but nodes.

Sendai Mediatheque serves all people including the impaired, users, providers, and people of different languages and cultures, through freeing them of all barriers. [Sendai Mediatheque]

154. Vision for Sendai Mediatheque

in Sendai, and with the transparent facade the activities in the building becomes visible from urban life. The main facade appears clear and aesthetic transparent with thin slaps towards the facade. Behind the facade the characteristic structural shafts of the building appear. The structural system consists of 13 independent steel-ribbed shafts that rise up from basement to the roof and 7 steel-ribbed honeycomb slabs.

Structural transparency and Functional transparency

The incorporation of the shafts as design elements in the otherwise open plans and curtain wall facades is an innovative approach to the general problem of generating open plans without columns and with vertical variety. The structural system of the building becomes transparent in a sophisticated way. Besides the innovative way of incorporating columns the shafts also possess the ability of being a vector for light and all the vertical connections including networks and systems for technological communication and the vertical mobility of elevators and stairs. In this way the shafts that already represents the structural transparency also contributes with functional transparency. Each shaft varies in diameter according to the inherent function and is independent of the facade, allowing for a free plan varying from floor to floor.

Sense of the surroundings, time and season

Through the transparency of the facade and the continuation of the curtain wall around the building and to the ground, the main entrance with double height hall is read as a continuation of the surrounding city. The transparent facade and shafts provides the sunlight shining into the spaces inside the building. The visitors can feel the green of Jo-zenji Avenue in summer, and thereby the building possesses a sense of the seasonal sceneries in Sendai.

Centre of democracy – informal meeting place

The Mediatheque is intended to express the fluid dynamics of the modern city with light and movement layered atop its physical structure and vibrate around vortexes of energy. [Webb, 2001] The Mediatheque is a significant place in the city as a centre of democracy, and it will continuingly show Sendai as progressive city of art and culture to the citizens and the visitors. The Mediatheque holds local and international events and activities.

For Japan, the Mediatheque is extraordinarily informal, with young friendly staff, and it has become a popular local resource; yet the atmosphere is as decorous as a scholars' library. Director Emieko Okuyuma observes: "*When we first announced this project, opponents thought it would be a dangerous monster. In fact, people have responded to the welcoming atmosphere and bright colours. Attendance is larger and younger than* *we anticipated*"" Given time, Ito's original vision may yet be fully realised. [Webb, 2001]

The Mediatheque is interesting from different perspectives to this project. The Mediatheque is a landmark for designing multimedia houses with the innovative thoughts about the transparency for making the entrance area appearing as an extension of the urban realm, the focus of informality in generating network and nodes instead of terminals, the focus of knowledge and freeing people of barriers. Besides these more visionary perspectives the building also contains remarkable tectonic perspectives. Thus the building is not only a case of a multimedia house, it possesses the quality of multimedia house visionary perspectives combined with tectonic perspectives.

155. The structural system of steel-ribbed shafts characterises the perception of the building inside and outside

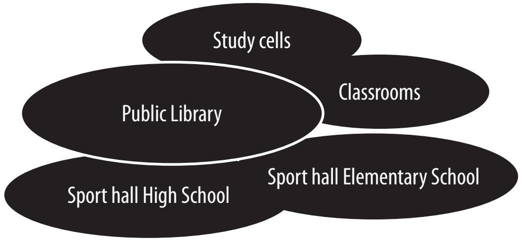
156. Ordrup Library and Multi Hall- Gentofte Bibliotekerne by Nord Arkitekter. Ordrup, Denmark, 2008.

7.2.2 ORDRUP BIBLIOTEK - GENTOFTE BIBLIOTEKERNE BY NORD ARKITEKTER

As the Mediatheque is an example of an international multimedia house a recent project in Denmark of Ordrup Library and Sports facilities represents a Danish multimedia house. The building opens August 2008 and contains sports halls for high school and elementary school and a library for citizen and high school students.

House of democracy – for every citizens

The vision for Ordrup Library is a multicultural house, were culture, library and sports together creates a recreational house for every citizen, with the potential of combining sports and exercise with information search, recreational reading and cultural experience. The integration of sport facilities in the building aims incorporating close collaboration with educational institutions using the facilities of sports and classrooms.



157. Physical contents of Ordrup Library complex

When physical culture meets science, literature and sociality in one house, new experiences are created together with acknowledgement of the good life for individual and community.

A house contains both a city quarter library that meantime is a high school library and sports facilities for leisure, elementary school and high school. The library's users are aware of the offers of sports and exercise while the library supports the house's health and sports profile.

[Gladbo 2006]

158. Vision for Ordrup Library and Sports Facilities

Integration of educational institutions

The house has three entrances one for the library, one for elementary school and one for high school. The otherwise closed southern facade transmits light and lights the building. The green colour continues through the entire building making a unifying element in the building and distributing to a sense of integration of the different element, the building consists of. Besides the sport halls there are several rooms for high school project work and classrooms for sport and exercise theory.

Multicultural and –functional

The approach for the complex has been that a library is not just a house for books and other materials. A library is not to be a house where the collections are the central. In spite the library is a place people want to go in their spare time, and in this way the library is part of a larger complex for culture, learning and activities. Thus this library is part of a complex also containing a sport hall, multihalls, exercise room, class-room, and auditorium and study cells, where the library is the central and unifying room placed as a wedge through the entire building at 1st floor.

This library focuses parallel to the multimedia house MEDIASPACE on a combination of different functions within the complex. This case concerns sports and exercise as the MEDIASPACE concerns the Civil Service Centre. Both cases have common focus on the library as a place to meet and stay caused by the other functions in the building. This library is interesting for the project as a case focusing on being a multicultural house of the broad culture appealing for every citizen as a recreational place in everyday life. In terms of tectonics the building does not possess any remarkable characteristics.

159. The interior is designed with focus on various oases of different character.

160. Kolding Library and Hotel by Arkitema, Kolding, Denmark 2008

7.2.3 KOLDING BIBLIOTEK BY ARKITEMA

User centred mindset

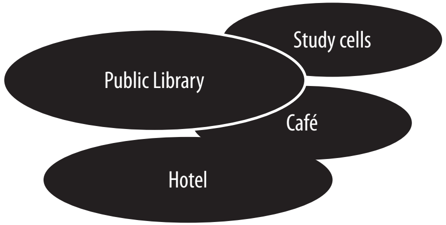
Kolding Library opened January 2006 with the intention of being an offer of the new millennium of a high profiled house of the citizens containing public city library, hotel, a café and study cells.

Knowledge and Learning centre

With the four sentences vision on the opposite page the library aspires to be a innovatory knowledge centre, which is considered an important prerequisite and framework condition to contribute the development of the citizens' knowledge and IT competencies, supported by education and learning in the increasing amount of educational institutions in the city.

Sociality and Individuality

The library creates space for the users to read, listen and work, where the physical space supports the reflection necessary for



161. Physical contents of Kolding Library complex

learning and development of insight. Thus the library is the citizens' meeting place, the common room, where the surroundings offer sociality and comfort. The library is a refuge where the senses, fantasy and intelligence can be challenged, meanwhile culture is explored. The library is a place to get in contact with culture and its many manifestations.

Aesthetic transparency and Functional transparency

Outwardly the library is open and welcoming taking part of a larger building complex including a hotel besides the library. The library is within the lower floors with large glass facades inviting in people with the aesthetic transparency. Mid in the library is the atrium as central element, from where it is possible to survey the entire library. There is also view over the square and the castle lake. The atrium provides natural daylight for the lower rooms as achieves and the storerooms. The atrium contributes to the intention of an open library that is inviting and easy to orientate in, and in this way the atrium contributes with functional transparency. The atrium and openness there from also contribute with the recreational outdoor area of the site by the lake and the castle, Koldinghus.

The functional transparency is further emphasised by the organisation of the library. The library is in principle one interconnected room divided into smaller rooms by patios and cores of stairs and toilets. The continuity in the room is strengthened by the unifying surface of the oak wood floor that by the wide stairs is moving to the upper floors.

Urban realm

A café forms a common area for the library and the hotel, where both guests and users can make use of the café. Thus the café is an implemented element in the complex contributing with an urban touch of being a gathering place where

The library is a high technological knowledge and learning centre with extensive service for traditional users as well as business and educational institutions.

The library is the citizens' inspiring and preferred gathering- and drop-in place where everybody regardless age, social and ethnic background meet to learn, experience and to immersing.

The library prioritises community and the cultural identity and focus on dynamic and diverse communication with involvement of relevant media and expressions.

The library is included in active innovative partnership with institutions and business concerning knowledge, learning and culture locally, regionally, nationally and internationally. [Kolding Bibliotek]

162. Vision for Kolding Library

people can meet regardless age, social status and ethnic background.

This case is interesting in terms of this project while the library is more isolated from the other function of a hotel in the building. The library has implemented the digital media in the focus on high technological knowledge and the focus on being an innovative knowledge centre encouraging development of the citizens' knowledge and IT competencies. Multiple media is a determinant element for the library in the focus of high technological knowledge and thereby the library can be characterised multimedia house. The other visionary perspective of being a preferred meeting place for the community is likewise in line with the vision for MEDIASPACE.

Kolding library is neither remarkable tectonic. The functional transparency is in continuation of the tectonic structural transparency, but it is farfetched to call the building tectonic.

163. Ground floor, with the stair in the front. The distribution and organisation is easy comprehensible .

7.2.4 SUMMARY

The first case Sendai Mediatheque concerns as headlines the characteristics of: Multiple media, aesthetic transparency, structural transparency and functional transparency, sense of the surroundings, time and season, and at last being a centre of democracy with informal meeting places.

The second case, Ordrup Library concerns being: A house of democracy – for every citizens, integration of educational institutions and the wide concept of being multicultural and –functional and thereby appeal to everybody offering recreational surroundings.

The last case, Kolding Library concerns: User centred mindset, being a knowledge and learning centre, containing sociality and individuality, aesthetic transparency and functional transparency and finally implementing an urban realm to the building.

By comparing the cases a general theory for multimedia houses emerges as result of the case study research. Each case represents certain perspectives meanwhile clear parallels through the cases emerge along with the divergence.

Commonly the libraries focus on the presence of multiple media as the demanding element in being a multimedia house and not just a library. The presence of multiple media is attempted emphasised through the presence of people contributing with knowledge. The approach to contribute with people to the building is by integrating the multimedia house in a building complex with focus on generating a synergy between different functions. The Mediatheque emphasises the synergy by a gallery, multimedia library and studio where the other projects include other functions to the building like MEDIASPACE includes the citizen service centre.

The democratic perspective is a commonly perspective to all cases reflected by the building being a place for and of democracy, the user centred mindset is an element directly reflected in the focus of the user but also reflected in the easy accessibility for the users in functional transparency. Furthermore the multicultural and –functional perspective also attempts to strengthen the sense of democracy by integration of different functions and thereby focus on different users and different use of the building.

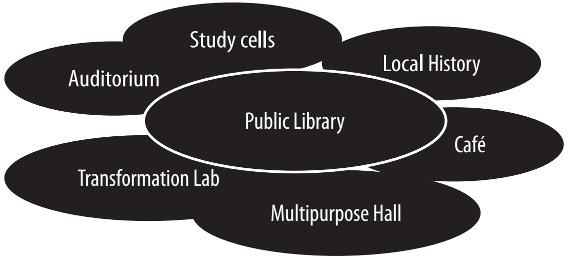
The focus of the building as a centre of knowledge and learning is another consistent perspective that in Ordrup Library is made clear with the educational connection, which in the other buildings is implementations of study cells, classrooms and auditoriums. Immersing is a parameter not directly highlighted through the classifications, though it is a parameter deriving from the focus of learning and acquiring of knowledge. Hence immersing can also be seen as the individuality in the parameter of sociality and individuality.

The Mediatheque is not merely is an example of a multimedia house, but also an example of tectonic architecture. Thus represents the Mediatheque a combination of a tectonic approach combined with a multimedia house vision. In this case the threefold transparency of aesthetics, function and structure is very characteristic. The structural transparency in the building contributes with both functional and aesthetic transparency which takes more part of the visionary parameters. In the visionary context the functional transparency strengthens the user mindset by the easy accessibility. Furthermore the functional and aesthetic transparency also provides a close connection to the urban realm through the glass facades.
This parameter is also present in Kolding Library that likewise opens the building towards the square and the recreational surroundings of the lake. In this way Kolding Library treats the perspective of functional and aesthetic transparency and thereby treats the tectonic parameter of interaction with the site giving sense of place, time and season.

Definition of a multimedia house

Summing up the visionary perspectives to multimedia houses, the perspectives also provides a characteristic of the parameters important in the definition of a multimedia house. The definition of multimedia house is a synergic library with focus on and presence of multiple media. Furthermore the multimedia house must justify its presence by providing physical surroundings for distribution, sharing and obtainment of knowledge and information.

7.3 VISIONARY PERSPECTIVE FOR THE MULTIMEDIA HOUSE



164. Physical contents of The Multimedia House

With basis of the competition presentation and the different and yet parallel cases the visionary perspectives of this specific project of designing a multimedia house for Aarhus Waterfront emerge as a delimitation and evaluation of the competition.

This thesis is delimited to concern a Multimedia House. Thus is the project delimited from the further aspects in the Competition Programme of a shared arrival centre with the Railway Station, Citizen Service Centre and the urban design task of minimising the traffic and redesigning the railway of Grenaabanen.

The Multimedia House is delimited from the competition starting point to be a library with café, multipurpose hall, local history and transformation lab, combined with an auditorium and study cells. By the delimitation and thereby the exclusion of the Citizen Service Centre the focus of the building is still being a house for the citizens, where the individual is in centre. Thus the democratic perspective consistent from the competition and the cases is continued combined with the User Centred Mindset.

Another determinant parameter from the Competition Presentation is the knowledge icon at the waterfront. Consistently with the cases the library as a centre of knowledge and learning continues being a visionary parameter together with the contemporary perspective to libraries consisting of multiple media as a consequence of the digital possibilities.

As a consequence of being a centre of knowledge and learning Immersing is a central perspective together with sociality and individuality that both strengthen the democratic view and the knowledge and learning perspective.

The social and democratic perspective is likewise present in the perspective of integrating a close connection to the urban realm or an urban touch in the building. Functional and aesthetic transparency are likewise seen as parameters in continuation of this perspective facilitating the use of the building for everyone and thereby emphasises the parameters the democratic approach. Furthermore is the aesthetic transparency seen as a parameter potential of enhancing the connection to the urban realm.

A House of Democracy

User Centred Mindset

Knowledge and Learning Centre

Multiple media

Immersing

Sociality and Individuality

Urban connection

Functional and Aesthetic transparency

165. Visionary parameters for The Multimedia House.

8 ROOM PROGRAMME

Room	Net m2	Net m2	Publ PC	Staff PC	Number seats	Books	Nearby
Arrival area		**610**					service zone, media
Square/Foyer (waiting, reception, meeting, experience, being)	410						
Café	200						
Media		**3.950**					Arrival area
Media, Local history, stacks, Guidance	2.700			10	50	269.000	
Oases	300				100		Media
PC - workstations	450		180				Media
5 help yourself areas of 10 m2	50		20				Media
TransformationLab	150						Media
1 reading room (quite compartment)	150				60		Media
1 reading room (living room, conversation) + newspapers	150				60		Media
Meeting, learning, reading		**1.565**					
Campaign activities and theme exhibitions	200			5			Arrival
Teaching area (30 pers)	100		30				Lounge
Multipurpose hall, scene and wardrobes.	500				330		Children's Theater
3 Labs (sound, pictures, IT, literature, reading)	120		25		15		Media, Lounge
2 external meeting rooms (60m2 og 100 m2)	160		3		60		
3 project rooms	150		3		45		
10 study cells of 8 m2	80		10		20		Media
1 hybrid learning space	80		16				Service zone, Media
Large flex. room 1	100		2		50		Square
Storage (tables, chairs etc.)	75						

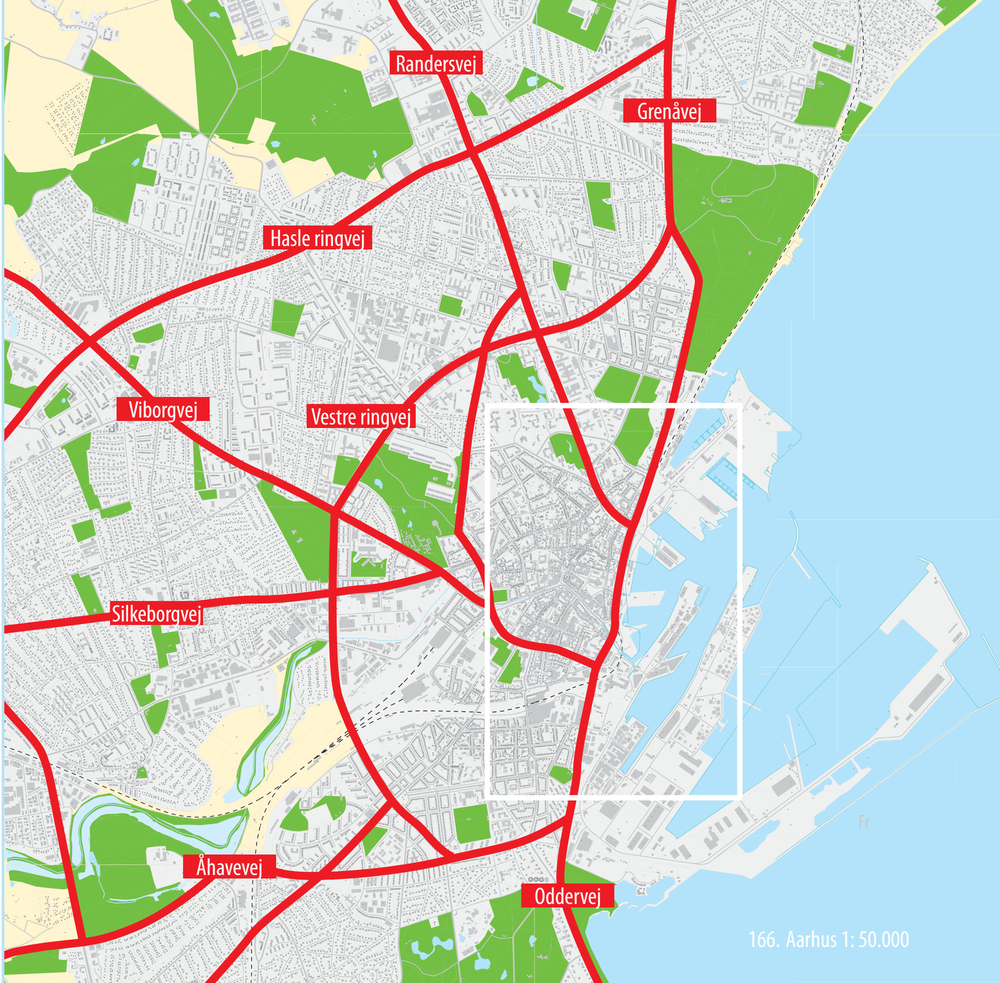
Room	Net m2	Net m2	Publ PC	Staff PC	Number seats	Books	Nearby
Children and families		**1.295**					
Oases	150				50		Inspiration and learning
Media						68.250	
Pc-workstations	125		50				
Guidance points	10		2				
Inspiration area	240						
Learning area	240						
The play library	240						Exterior, gaming area
1 Lab (drama /painting /etc.)	40		1		20		Children and family
Children's theater and film	150		2		70		Multipurpose Hall
Eating area	40				20		
Breastfeeding and baby changing zone	30				5		
Parking facilities for baby prams etc.	30						Arrival area
Tweens-area		**300**					Media, Children and fam.
Medialounge, gaming area, homework café	300		35		50		
Logistics		**720**		5	20		
Sorting system	400						Front, 24H return box
Packing room, acces to driving area (Basement)	100						Sorting system
24/H returning	5						Sorting system
Self pick up area (including check-out)	65						Front desk
Bookdrops	50						Square
Self check-out points	50						Media, Children and fam.
Front desk, incl. waiting area with benches	50						Self pick up area, sorting

Room	Net m2	Net m2	Publ PC	Staff PC	Number seats	Books	Nearby
Maintenance and operations (Basement)		**338**					
Repair in connection with sorting system	40						Sorting system
Repair shop ordinary issues	40						
janitor's office	30			3			Repair shop / sort. sys.
Box for values	10						
Cleaning facil. + storage	50						
Service and driving	48			6			Container yard / sort.sys.
Boiler and energy room/ approx. 2000m2 in gross factor							
Shelter / lock management / security monitors	20						
Servers and IT	50						
Staff fittness room, lockers and bathing facil.	50						
Storage in basement/ approx. 1000m2 in gross factor							
Administration section		**2.360**					
Main Library 20 employees	240			20	10		Meet. fac., Main Lib. admin.
Main Library 80 employees	720			60			Media, Children and fam.
IT and Communication 40 employees	480			40			
Libraries Management	20			1	16		
Libraires secretariat 5 employees	60			5			
Internal meeting and project rooms	225						Front desk and staff area
Staff cafeteria, kitchen and storage facil.	400				100		
Staff lockers	200						
Bathing facil.	15						
The Multimedia House net. m2		**11.138**	**379**	**155**	**1.151**	**337.250**	
Total gross m2 (net * factor approx 1,57)		**18.000**					

9 AARHUS

Aarhus is the second largest city of Denmark with 300.000 citizens centrally placed in Denmark. The city by Aarhus Bay is characterised by the educational institutions that attract thousands of students from the entire country. In various ways the city is leading nationally and internationally. The Aarhus area is increasing in both citizens and jobs and an amount of city development and infrastructure projects.

On the map at right the project area is framed and the primary thoroughfares of the city is highlighted.



166. Aarhus 1: 50.000

167. The Traffic flows at Aarhus waterfront 1:20.000

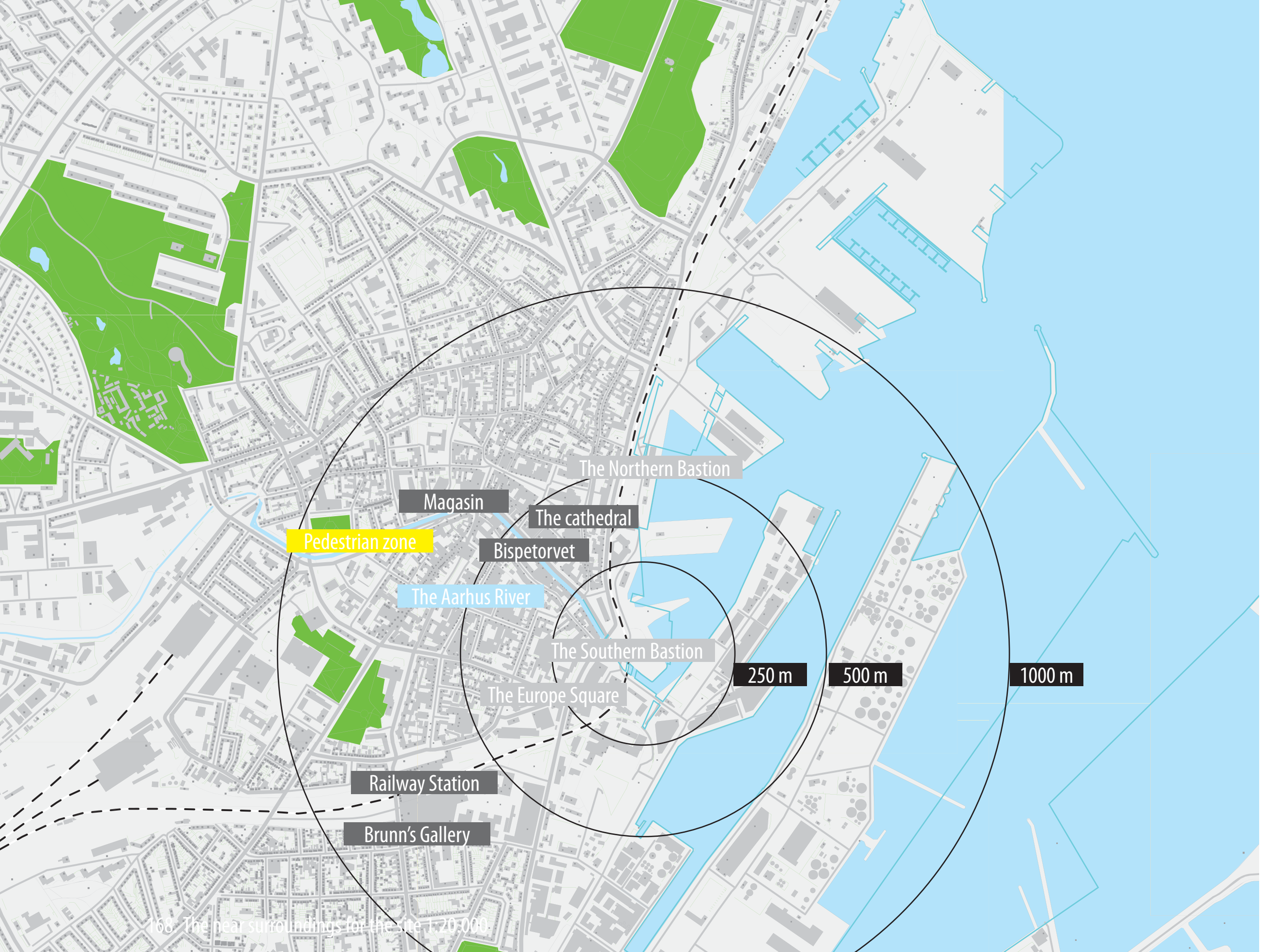
9.1 FLOWS

The traffic flows around The Southern Bastion, that is the competition site, are generally complex with different types of traffic in terms of cars, busses and trains. Havnegade and Nordhavnsgade pass each side of the Europe Square. Both roads are characterised with heavy traffic. Havnegade is loaded by an amount of cars and busses entering the city from south. Nordhavnsgade is loaded with the heavy harbour traffic og trucks entering the industrial harbour area. Grenaabanen, the railway, is between the roads and applies with trains to the otherwise heavily trafficked area. The Europe Square and the open areas in front of The Southern Bastion are today used as parking zones. This use is planned changed in continuation of the exposure of the river outlet. Thus the parking areas are not to be considered into the site plans, but rather a redesign of the open area combined with the river outlet and the public space around it in terms of making the link for pedestrians along the river.

From the Europe Square the link to the city along the river is characterised by a slow flow on foot to the centre and to the pedestrian zones. The flow is characterised by intimate urban spaces with small squares, urban river environment and the larger square of Bispetorvet next to the cathedral.

As a continuation of the river environment it is planned to incorporate a recreational connection for pedestrians and bikes by a promenade sequence along the waterfront. The recreational connection goes from the Southern Bastion towards north to The Northern Bastion.

The placement of The Multimedia House at The Southern Bastion near the centre of Aarhus gives a variety of influx of people to the site and the building. The Railway station is in the nearby and a parking house is planned near the water-



168. The near surroundings for the site 1:20.000

front, thus the approach to the site is easy both by private and public transportation. Furthermore the pedestrian zones, Magasin and Brunn's Gallery are also within a walk distance assuring a natural people flow in the area strengthened by the public realm along the river leading the pedestrians towards the harbour through The Europe Square.

169. Aarhus Waterfront with the site of The Southern Bastion 1: 10.000

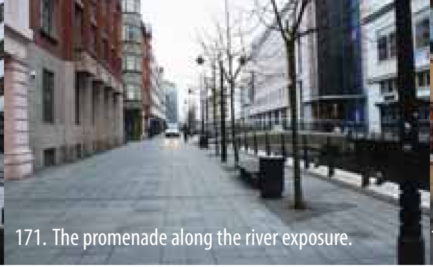
9.2 THE AARHUS WATERFRONT

In 1999 the city council organised a competition for Aarhus Waterfront, resulting in an overall plan for the area upon two fundamental elements to strengthen the interaction between the city, the harbour and the bay. The first element is a recreational connection through the waterfront from north to south, and the second element is establishing a large interconnected urban harbour space near the cathedral.

The waterfront is to be consistent of two bastions, that each in the future will appear with remarkable buildings. The use of the buildings and the urban harbour space will contribute activating the area and creating an active urban realm near the centre of the city.

The design of the building at southern bastion is to be coordinated with the exposure of the Aarhus River. Thus the river gets a remarkable and attractive outlet in interaction with the


170. The river exposure.


171. The promenade along the river exposure.


172. A compact alley along the river exposure.


173. The pedestrian zone from the railway station to the cathedral

new building.

The first stages of the river exposure appears today as an urban channel environment with built up areas from different eras. The street level houses a plentiful café environment(fig. 170), where a sunny promenade connects the area from Mølleparken to Europaplads, The Europe Square (fig. 171).

The character of the urban space along the river towards the harbour changes at The Europe Square, from compact urban spaces with intimate spaces and alleys to the harbours large dimensions and volumes (fig. 172).

The Europe Square is a large surface without continuation in pavements and clear directions in the architectural elements. The square is dominated by different types of traffic and is bounded by a dominating road system. In the middle is the significant Europe House a 12 storey office building.


174. The site The Southern Bastion from Mellemarmen. The Europa House is seen in the middle.

175. The Aarhus waterfront 1:20.000

Defining the project site

Towards west the medieval town centre with the cathedral bound the area by a closed five storey building along Havnegade/Skolebakken/Kystvejen towards the waterfront. The building is only interrupted by Skt. Olufs Gade with a little square and Skolegyde with the cathedral school from where there is a view to the cathedral. The cathedral school from 1905 by Hack Kampmann and Skolebakken 3 from 1957 by C. F. Møller are both preserved buildings.

The stretch of Havnegade/Skolebakken/Kystvejen is heavily trafficked and planned rerouted for reducing the traffic-related barrier between the centre of the city and the new urban harbour space. In the centre of the city several squares have been changed and restored in recent years for contributing to the attractive urban realm that characterises the area.

Towards east the competition area is bounded by "Mellemarmen" and "Kornpieren" two piers that functions as a harbour area with different harbour industry including shipyard and feedstuff industry. Among other buildings the area includes "De Fem Søstre", a building worthy of preservation.

Pier 2 and the coming northern bastion bound the area towards north.

Within the harbour space the Hack Kampmann's customs building "Toldkammerbygning" from 1897 and the cargo storehouse "Pakhus 13" from 1923 are preserved buildings.

176. Site photo, of the old trade harbour. Toldkammer and Pakhus 13 at right and the old city to the left.

177. Site photo of the old industry harbour. Mellemarmen with the harbour entrance at left.

History

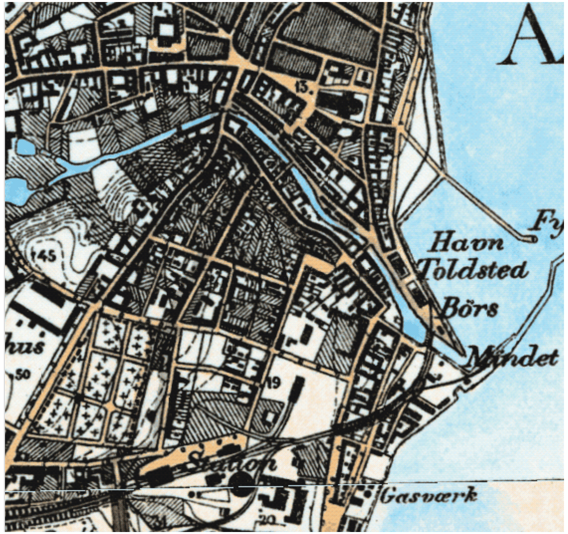
The southern bastion with the Multimedia House will be placed on one of the most historically interesting locations in Aarhus with the river outlet of Aros.

The first settlement in Aarhus or Aros, as the city then was names, took place in the last half on the 8th century, in the beginning of the Viking age. At this time Aros was about to be a well known city and a trade centre. It was in the immediate continuation of the river the fleet of the Vikings met, left, traded and plundered. From the river outlet the ships were sailed up the river to the carpenter, where the warships were built, repaired and stored in the winter. It was also through the outlet tradesmen and seafarers for centuries entered the city to load and unship goods to the city.

In The Middle Ages the city developed with the river until The Swedish wars that reduced the population to a third in the end of 1672.

Until 1719 the harbour remained a well-functioning export harbour and with the industrialisation the harbour was turned into the pulsating goods harbour today located in the new East Harbour.

The river was until the end of the 19th century an important transportation connection and in the 1950's the river was completely covered to solve the increased problem with car traffic. With the 1990's initiative for creating an urban harbour space with a recreational realm and connecting this area to the city centre the river was uncovered for contributing quality and atmosphere to the city life.



178. Historic map of Aarhus harbour with the river exposed and the outlet integrated in the harbour. The map is produced between 1842-1899.

179. Towards South. De fem Søstre.

180. Towards South-west. The river outlet.

181. Towards North-west. Traffic and old city.

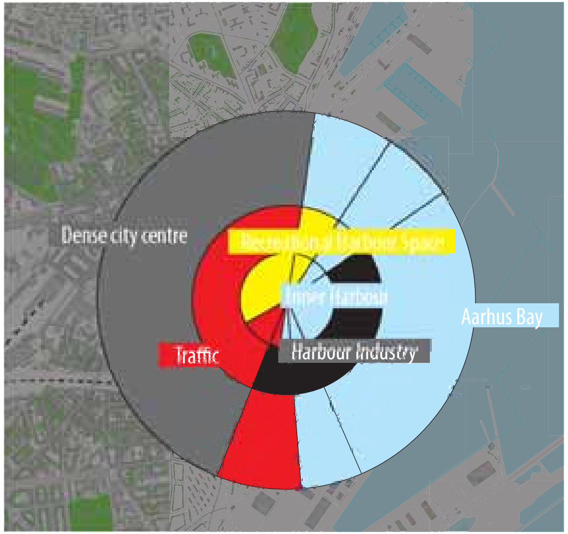
182. Towards West. The Europe House.

183. Towards West. The centre of roads and railway.

9.3 VIEWS

The surroundings of the site are very marked by the flows of the traffic, but also the harbour environment is a remarkable element in the surroundings. In the diagram the views around the site is arranged hierarchically by the nearest perceptions of the surroundings.

Towards east the nearest perceptions falls on the inner harbour surrounded by the piers with heavy harbour industry. In the horizon for approximately 180° the Aarhus Bay surrounds the site with a little slice towards northeast with clear view over the water. Towards west the nearest views are the recreational open harbour space and behind the determinant traffic by Nordhavnsvej, Kystvejen and Grenaabanen. Behind the traffic the city emerges with the high density of the centre and the old town core with the cathedral towards northwest.



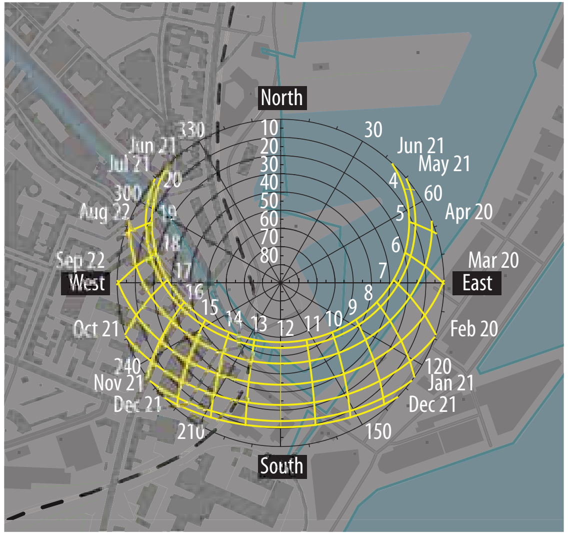
184. The determinant views from the site

185. Towards East. In the foreground the inner harbour is present and behind the entrance to the harbour between cranes, containers and ferries.

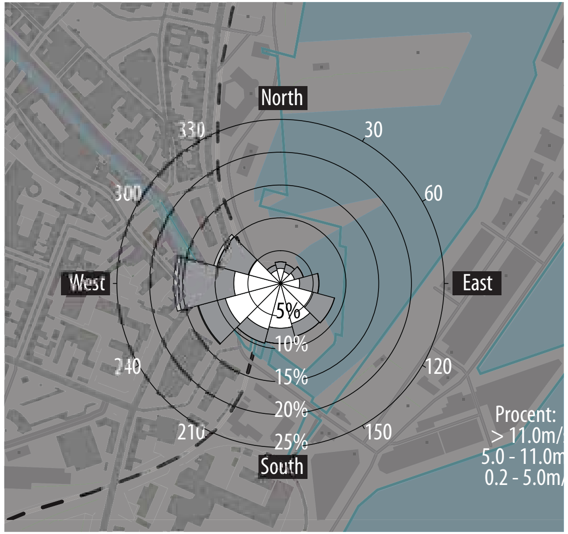
9.4 CLIMATE

Weather details are collected from DMI and the Solar Radiation Monitoring Laboratory at University of Oregon. The DMI data are from the nearest weather station at Tirstrup Airport 40 km outside the city. While the site is placed at the waterfront in the open harbour surroundings the wind conditions from the open airport are possible to implement in the site, since the site is not surrounded by dense city, which might have caused turbulence and irregularities to the wind conditions.

The sterographic sun diagram is from the actual site. In the winter the sun rides low on the horizon with a maximum azimuth angle of 15 degrees, and creates long shadows. At winter solstice the sun rises at 08:40 and sets at 15:30, while the sun is present at summer solstice from 04:30 to 21:00. The variations in the sun's ride contribute with a sense of time and season. Careful consideration of orientation of the buildings



186. Sun stereographic diagram

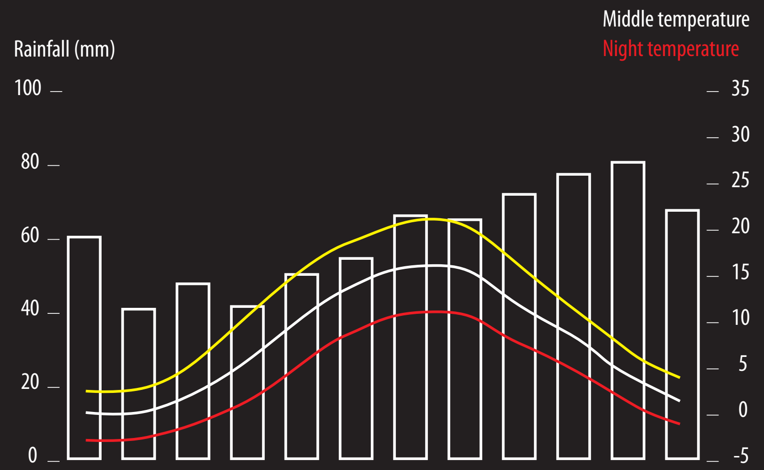


187. Frequency of wind speed and direction

openings could help harvest heat energy from the low winter sun.

The main wind direction is from west as most usually in Denmark. The average wind speeds especially from west are a little higher in winter and in the summer, but the variations are not large throughout the year.

Temperature and rainfall data from 1961 to 1990 shows, that the average temperature throughout the period is 7.7 and within the last ten years the minimum temperature is -20.9 for January 2003 and the maximum 31.9. The rainfall is lowest in spring and increases slowly over summer until fall, where it peaks.



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Rainfall (mm)	60	41	48	42	50	55	67	65	72	77	80	68	772
Rainfall days	11	8	10	9	9	9	10	10	11	11	13	12	122
Daily temperature	2.4	2.5	5.4	10.5	15.8	18.9	21.2	20.8	16.3	11.8	6.9	4.1	11.4
Middle temperature	0.2	0.1	2.3	5.8	10.8	14.1	16.2	15.9	12.1	8.7	4.4	1.8	7.7
Night temperature	-2.7	-2.8	-0.9	1.2	5.5	9.2	11.3	11.1	7.8	5.0	1.5	-0.9	3.8
Sunshine hours	41	68	112	164	208	212	194	190	130	86	59	44	1506

188. Average monthly temperature (degrees C) and average monthly rainfall (mm)

9.5 SUMMARY AARHUS

The context for the project being the site and its near surroundings is characterised by being a complex centre of different aspects. Through history the site has been of importance and interest; from the first settlements in Aarhus, the vikings use of the river, tradesmen and seafarers entering, loading and unshipping goods to the city, and industy's use of the harbour for production and distribution. From the emergence of the city the site has been an important place. With the replanning of the city to fullfil today's needs the site continues to be of importance. At the moment the site is characterised by being a traffic centre with cars, busses, trucks and trains ashore and ferries, containerships and other shipping at sea.

With the intention of changing the waterfront from a heavily trafficked area of industry to a urban realm of recreation and culture the complexity of the site continues being a centre of different aspects.

Thus the context of the project is characterised by being a trafficked centre that meanwhile ranges from the old harbour industry to the upcoming urban recreational realm at the waterfront, that is to be interconnected from south to north.

As the site is a complex centre of different aspects directly influencing the perception of the site and the site itself, the fact that the site is in the very centre of the city might pass by. The city demonstrates itself to the site by the interesting and remarkable views from the site. The medieval city towards west and along the waterfront towards North. Towards South the closed five storey building along the waterfront continues at first and breaks up to mix it self with the industrial context.

South-North-going interconnection

Reflection of the complexity of harbour industry combined with the recreational waterfront

Experiencing the site passing by by car, bus or train

Views of the old city towards West and North.

189. Contextual parameters for the multimedia house

190. Site phote. View of the harbour from central at site.

10 DESIGN

In the introduction to the assignment of the thesis the design strategy is outlined as an integrated process of iterations of tectonic parameters, visionary parameters and contextual parameters affecting each other in the different stages of the design process. Previously the parameters of the *7 Vision* and *9 Aarhus* have been analysed and transformed into the visionary parameters and contextual parameters for the design assignment.

10.1 METHODOLOGY

The actual method for the design process is founded in the strategy of integrated design with respect to the tectonic parameters, the visionary parameters, and the contextual parameters as described in section *6 Design Strategy*. The outlined method is combined with the possibilities of parametric modelling; the other theme of the theoretical part of the thesis. Through the case study of the two computational tools: *eifForm* and *GenerativeComponents* was analysed. The latter was found very useful for more complex modelling, whilst the design is to be created by different parameters.

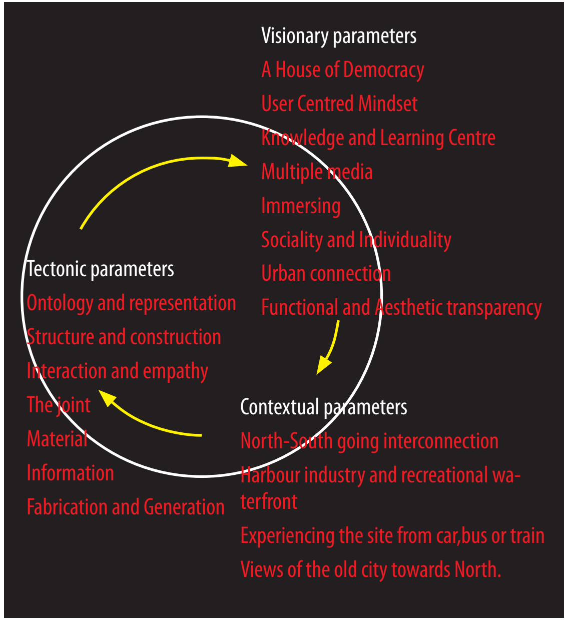
With this approach the design process takes form from the commencement of the parametric modelling. To facilitate incorporating the complex design process into software the design process is organised and divided into small steps under the two general terms of *Global Parameters* and *Local Parameters*.

10.1.1 GLOBAL PARAMETERS

These parameters are the superior parameters affecting the design. They are the foundation of the design and what defines this design and signifies this proposal for the competition from others.

1. The Contextual Parameters
2. The Visionary Parameters
3. The Tectonic Parameters

These three parameters drive the initial design of the project in a global model.



191. The tectonic parameters along with the visionary parameters of the Multimedia House and the contextual parameters of The Southern Bastion.

10.1.2 LOCAL PARAMETERS

Following and yet concurrently a model of local parameters is made concerning the essence of the building being this Multimedia House. These parameters reflect the design task and thereby the requirement of the building to fulfil the functional and actual requirements.

1. Room Programme
2. Room Distribution
3. Building Flow
4. Light Conditions and Views
5. Fire Conditions
6. Structural Conditions

Likewise the global parameters are to influence the design through different iterations, the local parameters are to influence the design and each other through the design process.

The division of the parameters in steps is a practical arrangement in the communication of the design process, since the parameters as individual parameters have been incorporated into the design process several times and in various ways, as a result of a circular design process rather than a linear. Thus is the following not a continuous timeline for the project with integration of one parameter by another, but a communicative arrangement of how the different parameters have been integrated in the process.

Initially the global parameters are driving the design giving a framework for further development by the local parameters. As the leading role shifts from the global parameters in the beginning to the local parameters afterwards, both categories are to influence the design all along the process. Thus are the local parameters in mind through the initial stages and the global parameters in the following stages, as the global parameters can be considered as the thread or concept of the project.

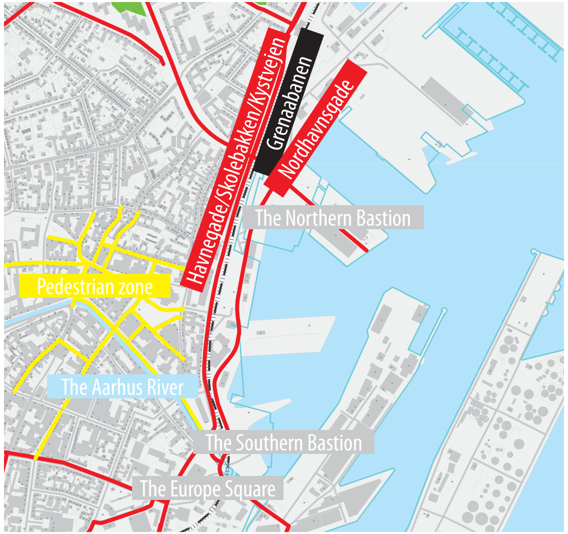
10.2 GLOBAL PARAMETERS

As described in the former section of methodology the global parameters are initially driving the design. In the following a model with respect to the global parameters is developed.

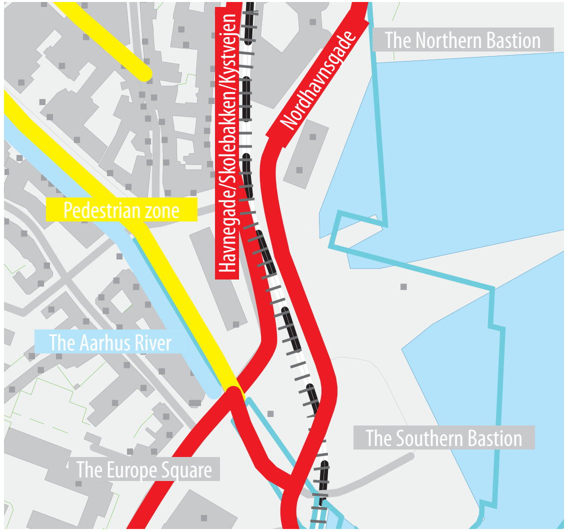
10.2.1 CONTEXTUAL PARAMETERS

This model takes origin in the context and how this influences the site and thereby the design. Initially the actual layout of the site, the surrounding flows, the traffic connections and the climatic aspects are of importance. The layout of the site is The Southern Bastion framed by the water quay defined in *The Quality Manual* for the waterfront.

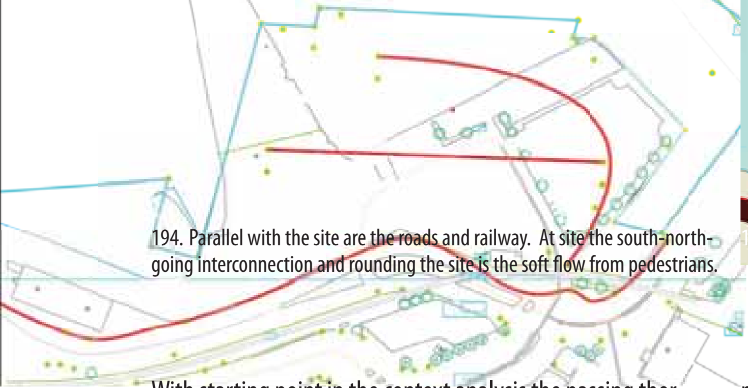
The model on the opposite page operates with defining the boundaries for the volume of the design with respect to the global parameters, thus is this rough outlining the volume of the design according to the contextual parameters.



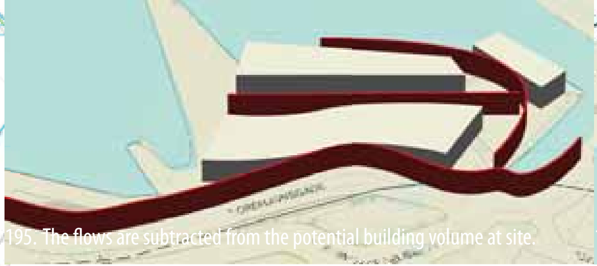
192. The Traffical flows at Aarhus waterfront 1:20.000



193. The Traffical flows at Aarhus waterfront 1:5.000



194. Parallel with the site are the roads and railway. At site the south-north-going interconnection and rounding the site is the soft flow from pedestrians.



195. The flows are subtracted from the potential building volume at site.

196. Volumes surround the open zones for public flows.

With starting point in the context analysis the passing thoroughfare define the site towards west and the water quay defined in the Quality Manual defines the site towards east (fig. 192-193). Thus is the actual layout of the site defined. The contextual parameters furthermore concern the desirable flows at site deriving from the contextual analysis. The flows to apply the site is the pedestrian flow from Aarhus River toward the waterfront giving a connection for the soft traffic from the pedestrian zone to the recreational urban harbour space and the south north going flow making a connection between the two bastions and thereby supplies to the interconnecting urban harbour.

The flows are included as parameters to interact with the volume of the building in terms of generating an interconnecting urban harbour space and furthermore to emphasise the interaction between building, context, users of the building and people passing by. To incorporate the flows a solid is placed at site and the flow have been added as subtracted volumes from the building solid. Thereby the potential area for the building volume at site is outlined by three volumes with respect to the south-north-going interconnection and the west-east-and-north-going flow from the river.

The volumes above illustrate the diagrammatic volumes defining the building outline and the diagrammatic sketches beside illustrates potential solutions of incorporating the flows into designed volumes and a building shape that interacts with the people at site.

This diagrammatic outlining of the potential building volume is to be further modelled with respect to the other global parameters by maintaining the flows and following with respect to the local parameters.

197. Sketches of volumes interacting with the flows at site.

10.2.2 VISIONARY PARAMETERS

Following the global model is further developed according to the visionary parameters. Again the analysis of the vision with both the competition presentation and reference projects forms the basis of the visionary parameters. The keywords of the visionary parameters are outlined.

According to the visionary perspectives (fig. 198) further reference projects are exemplified on the opposite page for inspiration and exemplification of different perspectives (fig.199-203) .

As the parameters prescribes a house of democracy with a user-centred mindset encouraging immersing, sociality and individuality meanwhile being the city's centre of knowledge and learning.

A House of Democracy

User Centred Mindset

Knowledge and Learning Centre

Multiple media

Immersing

Sociality and Individuality

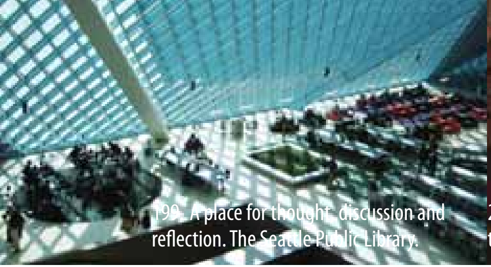
Urban connection

Functional and Aesthetic transparency

198. Visionary parameters for the multimedia house

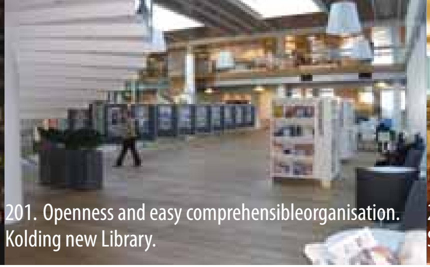
Based on these perspectives this model concerns the concept of the building outlined by the visionary parameters. Hence this model is founded on the essence of this library being a multimedia house with the specific visionary parameters for this house. In this way this model concerns the inside of the building, how it functions, how it is perceived, and what it exudes.

As a centre of knowledge and learning, information becomes an over all term as it is a source of knowledge. With a physical layout of the building to emerge from this perspective, knowledge is the continuous element of the building with islands of different functions fixed in-between the floating knowledge. The islands represent immersing, individuality and sociality according to different functions and positions they are placed in.



199. A place for thought, discussion and reflection. The Seattle Public Library.

200. Immersing and quiteness of traditional library. British Museum.



201. Openness and easy comprehensibleorganisation. Kolding new Library.

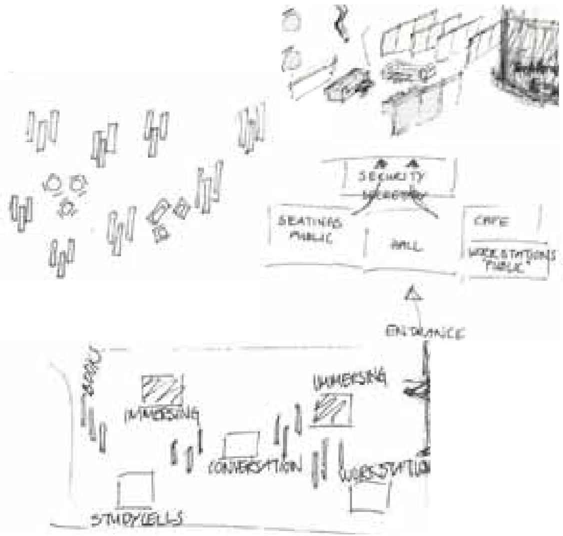
202. Informal meeting places inbetweens the book cases. Sendai Mediatheque

203. Public café and study area Hartley Library University of Southampton, UK

Information as a source of knowledge includes media as well as people. Therefore insists being a centre of knowledge and learning on appealing to everybody to get a wide perspective of knowledge. This is furthermore in continuation with being a democratic house, which also is a visionary parameter. The democratic approach encourages openness for everybody by light barriers between the inside and the outside – between the building and the city. The other visionary parameter of an urban connection is further in continuation of the house of democracy. A visual and functional transparency as parameters are a method for easy understanding of the building, thus it is easy accessible for everyone. By having functional and visual transparency a user-centred mindset is further included.

In this way the building is to be designed from the basis of having information floating all over the building with fixed islands of different functions in-between. Meanwhile there is a emphasis on the functional and visual transparency, thus the user has an overview and understanding of the building, how to use the building and how to be part of the building.

Beside sketches of layout principles derived from this approach are illustrated. The stketches all focus on media/knowledge/information as a floating element with fixed areas/oases in-between.



204. Sketches of library layout according to vision. Media as an overall element and relaxing, meeting, talking, being inbetween.

10.2.3 TECTONIC PARAMETERS

The tectonic parameters are the third parameter in terms of global parameters. As the visionary parameters are giving a visionary concept for the building the tectonic parameters are to be implemented in this concept to emphasise and clarify the visionary concept meanwhile being true to the tectonic qualities.

The tectonic qualities to implement in the building are outlined in the keywords derived in the previous section of tectonics (fig. 205). As the tectonic approach for this project emphasises clarity, logic and the joint, the tectonic parameters are seen as a logic continuation of the democratic values of functional and aesthetic transparency. The tectonic parameters add a third transparency to the former transparencies – the structural transparency as a result of a logic and clear structure easy to relate to and understand and expressing the flow of forces throughout the structure.

Ontology and Representation

Structure and Construction

Interaction and Empathy

The Joint

Material

Information

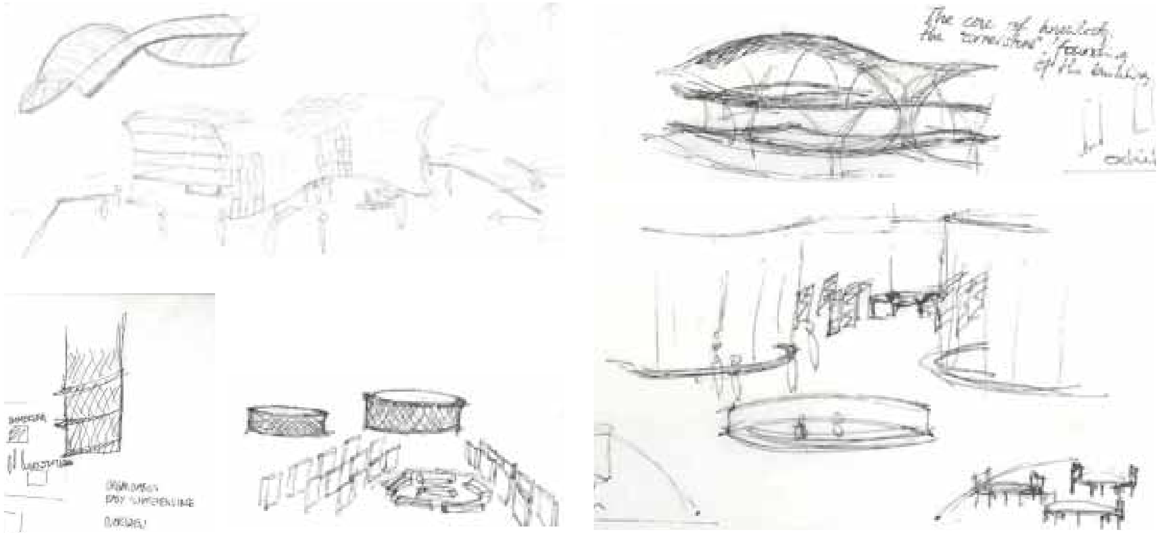
Fabrication and Generation

205. Tectonic parameters for the multimedia house

The transparent structure is to be visible emphasising essential elements of the building; the functional and conceptual joint or knots of the building. In this way the structure of the building is load bearing meanwhile representing the functional and conceptual joints of the building.

As knowledge is the floating element of the building with fixed islands of different functions, the logic consequence is that the islands are combined with the load bearing structure, thus the building is supported in the essential joints or *knots* representing immersing, individuality and sociality. Thus is the visionary parameters combined with the tectonic parameters.

The facade as the boarder between the building and the city, between in and out defines the physical framework of the house of democracy. In this way the facade represents an essential joint as the islands, and the tectonic parameters are to be implemented in the modelling of the facade, thus the facade will consist of a structural transparency easy to relate to and understand, inviting the user inside to participate in the house of democracy.



206. Sketches of different supporting structures in the facade and marking the floating islands inside the building according to the tectonic values and the other global parameters.

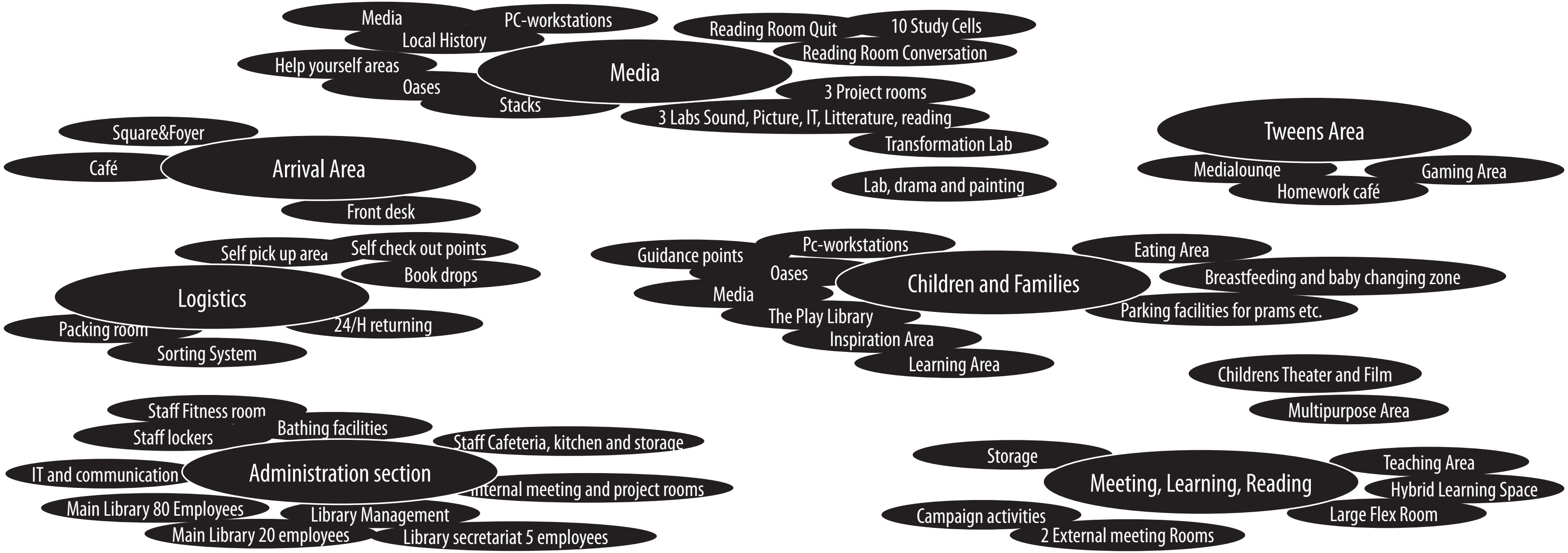
10.3 LOCAL PARAMETERS

With the global framework for the building the concept is outlined as a democratic house with floating knowledge in open plans interrupted with fixed islands that structurally and functionally represent the cores of the building. The building is to consist of the three transparencies – the aesthetic, functional and structural as an interpretation of the combination of the global parameters.

10.3.1 ROOM PROGRAMME

The first of the local parameters to affect the design is the actual room programme illustrated in section *8 Room Programme*. The room programme derives from the competition presentation with different delimitations and adjustments. In terms of local parameters the room programme is further evaluated and delimited and in the following the room programme is transformed to a diagram (fig. 209) where the rooms to each other according to the different sections they belong to. In the grouping of the rooms some are moved from one section to another, where it is found more consistent according the concept for the building. As the islands in-between media are to represent immersing, sociality and individuality, for instance the section "Meeting, Learning, and Reading" have been transformed to "Meeting, Learning, and Networking" since some of the reading functions have been incorporated in the media section and networking functions such as the public café have been added.

The visionary concept for the layout of open plans of knowledge with islands of different functions is especially appropriate in the media section with reading rooms, study cells and different labs, where media is the floating knowledge-element. In the administration section and the section of meting, learning and networking more regular rooms are required for the employees, for education and for external meetings. In these sections the concept will still be present, but in a less determinant character than in the media section, since the more regular rooms are more appropriate in a more conventional expression.

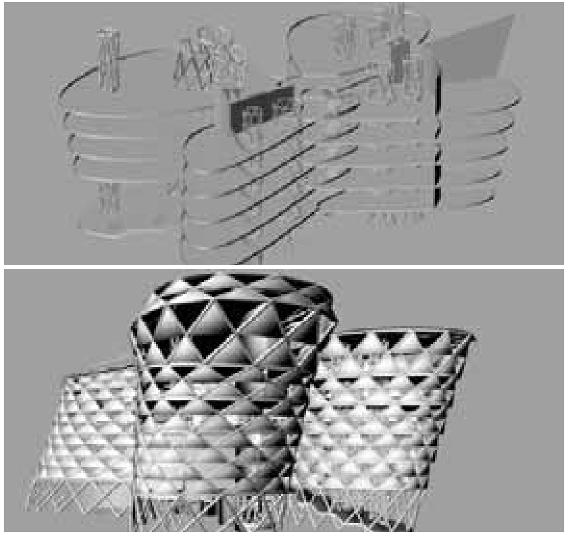


207. The room programme is translated to a room diagramme of 4 sections containing 7 subdivisions. The 4 sections are Media, Arrival, Administration and Logistics, and Meeting, Learning and Networking.v

After modelling the model according to the different parameters the room programme have been introduced again and more accurate than former (fig. 208-209). This time the emphasis has not only been on the organisation of the rooms according to each other, but the area of the rooms has been of importance. As the room organisation have been quit fixed according to previous considerations, the area have been a decisive parameter now.

Module lines for the room disposition have been drawn in an underlying layer, and projected to the specific planes or storey decks. Thus have the module lines been decisive for the rooms internal outlining for one thing to assure the inner load bearing walls are continuously on top of each other. Another aspect is getting continuity in the building, thus the user more easily can relate to the different floors and understand the building.

Since the rooms are of different sizes and functions the external boarder of the room – the facades have been a variable parameter. Thus have the modelling of the facades and the sloping thereof been related to the rooms inside. Combined with the rooms' functionality and sizes the climatic aspects have furthermore affected the sloping of the facade and thereby the placing of the rooms in different storeys according to sizes, thus a required sloping of the facade is achieved according to the sun's position.



208. The rooms are placed on top of each other by modul lines.
209. The facades slopes according to the rooms sizes and functions.

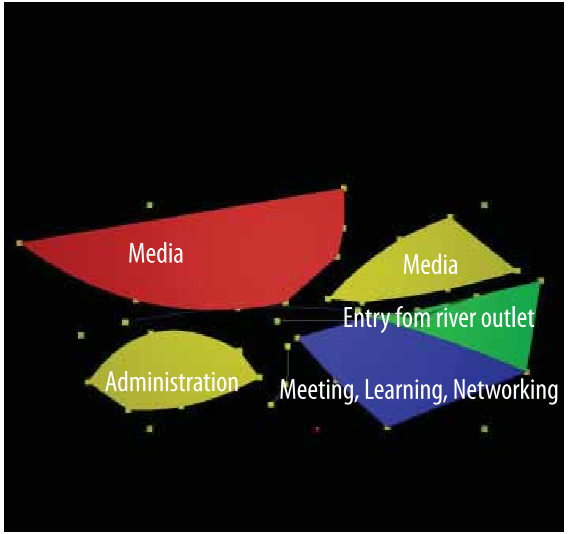
10.3.2 ROOM DISTRIBUTION

Distribution of the rooms is developed as a continuation of grouping the rooms into sections influenced by the near context. Initially the organisation is generated with respect to the global parameters in terms of the prescribed public flow south-north-going at site and rounding the southeast corner. The entry of soft traffic at site is in the southwest corner, where the site interacts with the river outlet and the urban river environment created along the river exposure. The entry goes from west towards east, and the direction turns to be parallel with the waterfront and go towards north.

In this way the southwest corner is the corner to interact with the urban environment of the river exposure and outlet. The corner encourages for a sliding transition from the urban river environment, to an urban part of the multimedia house, and to the central part of the multimedia house. Therefore is the public part of the building places here to minimise the transition from city to centre of building. Thus contains the southwest corner the more urban Meeting, Learning and Networking with the café at ground floor.

With the longitudinal division of the building by the public south-north-going flow, the building consists of an east part towards the water and harbour, where calmness of the water and the wide and infinite horizon is to inspire internal focus. The west part towards city is more affected by the impulses from the city and activity while this area is reserved for administration, logistics, meeting, learning and networking.

The northeast corner can be seen as a continuation of the movement from the river to the waterfront meanwhile the northwest corner deflects from the movement and turns towards the old city. Considering the northeast corner a continuation of the public movement encourages a difference in

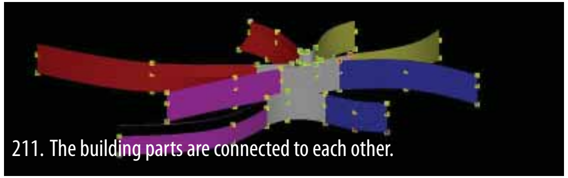


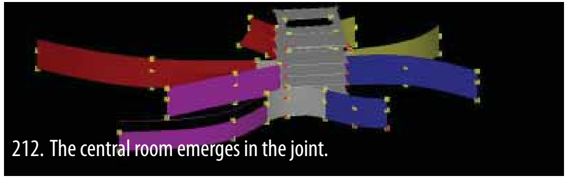
210. The building parts arranged according to the near context.

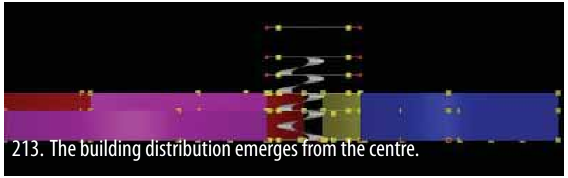
the southeast and northeast, where the northeast is thought as a continuation of the public flow, and thus more public, why it concerns sociality where the southeast part is about immersing and individuality since it deflects from the public movement and isolates itself towards the water.

By the near context and the grouping of the rooms into sections the building is divided into four main areas: The Open Media for conversation and sociality in Northeast, The Intimate Media for immersing and individuality in Southeast, Administration and Logistics in Northwest and The Public for meeting, learning, and networking in Southwest.

In terms of communication the building to the users, the functional sectioning of the building into four parts becomes a physical design parameter, which also is in continuation of the global parameters of dividing the building longitudinally.

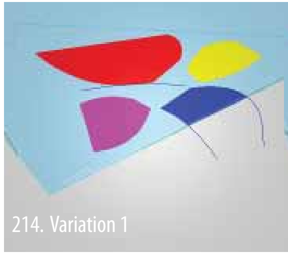

211. The building parts are connected to each other.

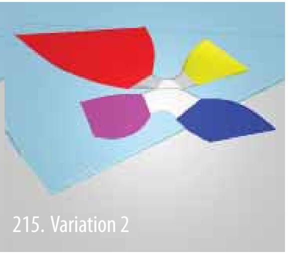

212. The central room emerges in the joint.


213. The building distribution emerges from the centre.

The building parts are to be connected in an essential joint for the building. The joint or *knot*, that binds the parts to a whole and from where the building emerges and from where the user has all the functions of the building. The distributing of the building is naturally placed in the *knot*, thus this becomes the physical central part of the building and also the central part for the activities (fig. 211-212).

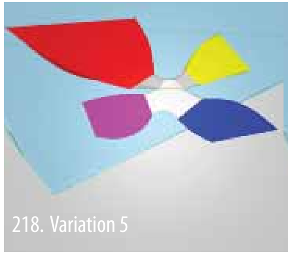
The composition of the volumes of The Open Media, The Intimate Media, Administration and Meeting, Learning, and Networking are to cooperate with the volume of the central of the building being the Arrival Area and Distribution. In the following illustrations the composition is modified with respect to the proportions, curvature, and composition to the other building parts. The fig. 214-225 illustrates the approach of generating different variations with respect to the same values and the final composition is the foundation for further development.


214. Variation 1


215. Variation 2


216. Variation 3


217. Variation 4

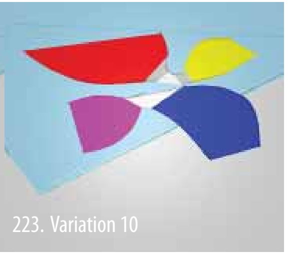

218. Variation 5


219. Variation 6


220. Variation 7


221. Variation8


222. Variation 9


223. Variation 10


224. Variation 11


225. Variation 12

10.3.3 BUILDING FLOW

Centrally placed in the building with connection to all the sections is the arrival area in close contact to the thoroughgoing public movement passing by outside and the café in the southwest part of the building.

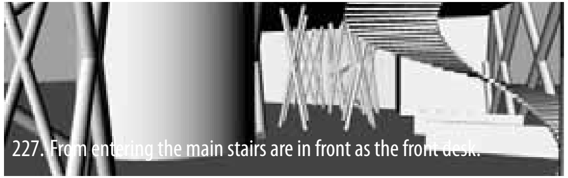
The main entrance for the building (fig. 226) is straight into the arrival area from west with the front desk and the central stairs in front. From the entrance the user is met with views through the building to the water, and views crossing the public flow to the east part of the building. Hence is the user presented to the entire building while entering.

I terms of the building flow the user have been in centre along with functional transparency thus there is an easy comprehension for the user to enter, understand and use the building. This is in continuation of being a house of democracy, where it is found evident that the building appeals to people and allows a fast understanding of the building for facilitating the use of the building.

With this approach the flow of the building has been under a development with a user-centred mindset. The user enters the building in the central part of the building, from where the logistics of the building emerges. In front of the entrance are the dominating stairs and the central lift that connect the building vertically giving a fast understanding of the logistics of the building (fig. 227-228).

Furthermore the functions in immediate continuation of the main entrance are also related to the ones who have reserved media and just want a fast pick-up and book drop, the experienced or inexperienced users who want assistance from the staff in the front desk and the ones who want to visit the café (fig. 227).

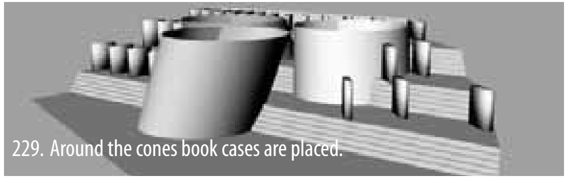
226. The entrance marked by large revolving doors as a weather porch.

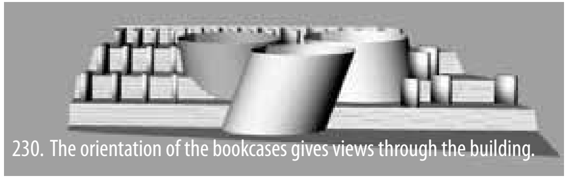


227. From entering the main stairs are in front as the front desk.

228. The arrival area is visual and functional transparent.

In terms of being a house of democracy it is additionally found important to give the user a sense of perspective of the building while using it. Caused by this parameters the orientation of the bookcases is done with respect to maintain views through the building, thus the user has an overview of the building and understands how to get from one point to another even though the user is in-between bookcases that often gives a feeling of enclosure. Thus are the bookcases oriented towards the centre of the building to provide open views from the centre and out (fig. 229-231).


229. Around the cones book cases are placed.


230. The orientation of the bookcases gives views through the building.


231. The book cases gives a dominating perception of the room.

Both east parts of the building are attached to the central part of the building at first floor to make a gap for the public south-north-going flow at site. This integrates the flow in the building thus people can pass through the building without being inside. Instead an area in transition of inside and outside is created under the framework of the building and protected by the building volume.

To achieve the gab between the central part and the two east parts they are being lifted allowing people to pass through underneath. To achieve a continuous flow from the central part of the building, the east parts are attached at first floor of the central room, thus a distribution to all building parts is possible from the centre of the building.

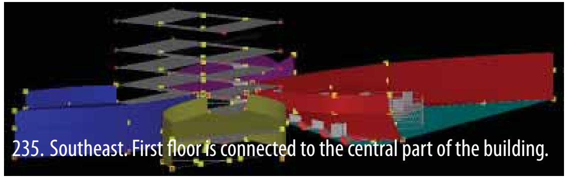
The bottom floors of the east part slopes from the attachment at first floor in the centre to the ground in the ends. To achieve a continuously movement the sloping is consists of the sections with steps and a larger landing containing oases or bookcases, thus an area is defined by each step towards the water (fig. 233) .

The same principle is used in north and south even though the characteristics differ from immersing in south to sociality in north. The difference in the characteristics is incorporated in terms of enclosure and variation in the types of the oases. In the south part immersing is incorporated by smaller defined areas for studying and individuality (fig. 237), where larger and more open areas characterises the north (fig. 234).

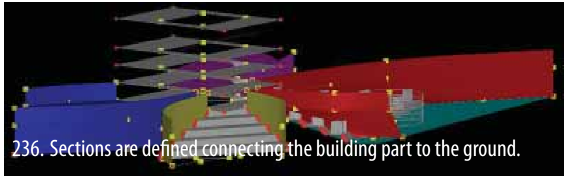
232. Northeast. The bottom floor is not connected to the building.

233. The sections of steps and defined areas are added to the section

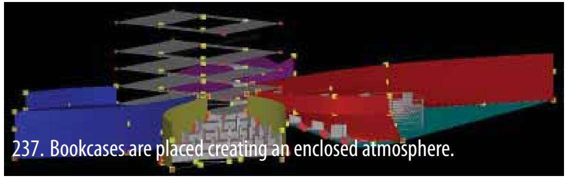
234. Bookcases are placed after the central principle..



235. Southeast. First floor is connected to the central part of the building.



236. Sections are defined connecting the building part to the ground.



237. Bookcases are placed creating an enclosed atmosphere.


238. View from the Administration Section towards the old city.


239. View from Meeting, Learning and Networkning towards the harbour industry, traffic and the city towards right.

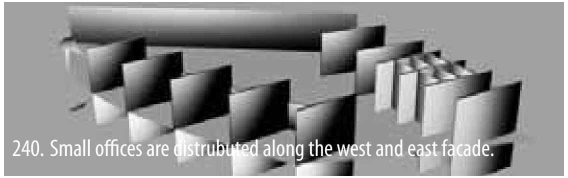
10.3.4 LIGHT CONDITIONS AND VIEWS

With media oriented towards the water for encouraging internal focus the oases are oriented towards the facade to provide natural daylight and views of the water and the quayside. Meanwhile are the more closed functions in terms of labs, project rooms and study cells centred towards the middle of the section in more enclosed areas, thus these functions are integrated in between the bookcases contributing to the integrated concept of floating knowledge and fixed islands.

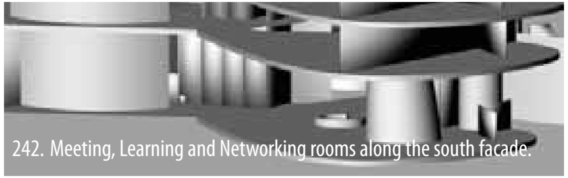
In the administration section the offices are along the north facade (fig. 240 -241) and meeting rooms and places for informal meeting are oriented in the centre. The offices are by the placement along the facade provided with the cold northern daylight. To increase the amount of daylight the facade is sloping inwards, thus the skylight also is included. Beside the light conditions the placement of the administration section is also caused by the views.

From the administration section the staff is provided with beautiful views of the old trade harbour with Toldkammeret and Pakhus 13 in the front, the beautiful city facade along the waterfront behind, and Riis Skov in the back (fig. 238).

In the southwest part of the building the learning environment are provided with views of the busy city life with traffic in the foreground the dense city behind and the old harbour industry towards south and southeast (fig. 239). Likewise the administration section the meeting rooms and informal meeting places are placed towards the centre of the building and the educational rooms, meeting rooms, multipurpose hall are placed towards the facade to allow daylight (fig. 242). Opposite the north facade the south facade slopes slightly outwards providing shade for itself in the summer, when the sun's position at sky is high and the risk of overheating is increased.


240. Small offices are distrubuted along the west and east facade.


241. Large office towards north and open offices along the other facades.

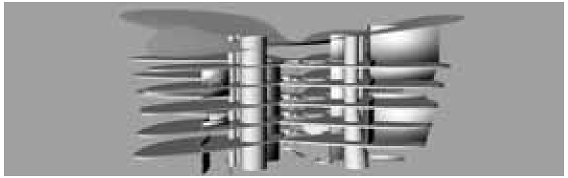

242. Meeting, Learning and Networking rooms along the south facade.

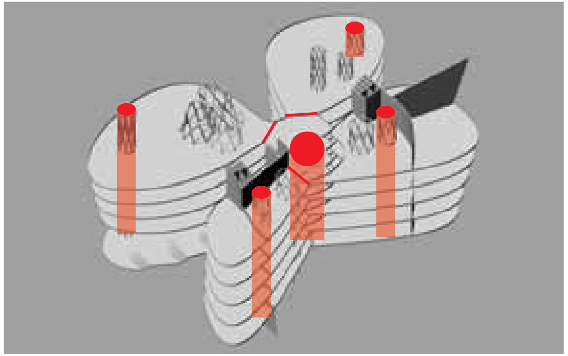
10.3.5 FIRE CONDITIONS

The division of the building into four main parts with the central connecting area incites dividing the building into five fire sections; one in the centre and further four in each building part with own fire escapes. The fire escapes are placed after the principle of one central escape route through the main stairs in the centre of the building and further four fire routes through the fire escape in each end of the building (fig. 244).

To maintain the open plans and the floating concept in the building it is desired to divide the building into fire sections without making fire walls. To accomplish continuation in the flows of the building and the concept of open plans full automatic fire curtains are installed at the entrance to each fire section fulfilling the demands for save fire sectioning.

The constructive material of the building is to satisfy the requirements for the category 3 that includes buildings sections for daytime accommodation for many people, where the person not necessary knows the escape routes. For a building with the floor at the upper storey more than 22 meters above ground the materials are to be within the category R120 and if the floor at the upper storey in between 12 and 22 meters above ground the materials are to be within category R60. Concrete for the walls will satisfy the fire demands. Furthermore concrete walls possess the quality of being robust to meet the use of the multimedia house as a public place for many people. Steel in the building is either to be protected by painting or fireproof insulation if terms of stone wool and or plasterboards.





243. Fire escapes in the west section centrally placed with the cones.
244. Fire escapes in all fire sections in each end of the building.

10.3.6 STRUCTURAL PARAMETERS

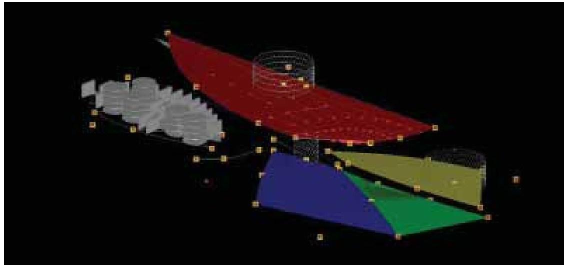
The local structural parameters are in close continuation of the global tectonic parameters since the tectonic parameters prescribe some solutions for the structural system. As defined in the global parameters the structural parameters of the model is a continuation of the visionary parameters and the concept for the building of integrating oases in-between media.

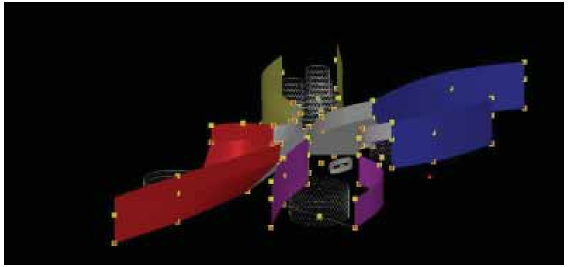
According to the global parameters the load bearing structure is to be present in the essential joints of the building defined as the facade, the boarder to the city, and around the islands. The structural system consists of a load bearing facade and load bearing cores in side the building. As the Administration section and Meeting, Learning and Networking contains more regular rooms, the structural system in these sections furthermore contains load bearing walls.

To meet the structural transparency and the tectonic approach to the structure, there has to be transparency and logic in the actual design of the structural system and the materials, making it easy understandable for the users of the building.

For the cores as well as the facade it is valid that the structure is to be possible of taking vertical and horizontal loads since especially the cores besides distribute the forces downward additionally functions as structural stabilising cores. The latter is a parameter of both structural importance and conceptual importance, since the cores of the building are the fixed islands in the ocean of floating knowledge and/or media.

With the required visual transparency in the building and the open facade that emphasises the contact to the city a structural truss system is found preferable, thus the structural system can be attached with glass or facade panels according to the functions behind and the required transparency. For





245. Adding load bearing structure to the cores.
246. Applying the facades as load bearing structure.

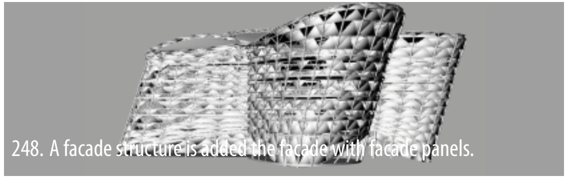
truss structures the stabile triangular structure becomes the obvious choice since it gives stability and works logically in the facade that towards north slopes inwards and towards south slopes outward.

With the logic of triangles different structures and facade panels are experimented, until a structural facade solution is found reflecting the shape of the building and thereby the flow or forces. Here the tectonic parameter of clarity and logic in the structure is of high importance. The structural system for the facade has been through selections in terms of expressing how the forces are taken through the truss, and how the structural system works.

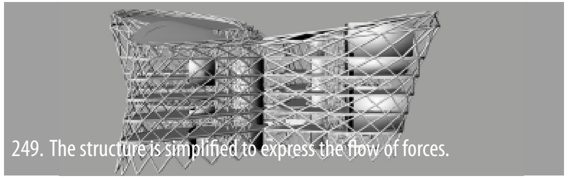
The structure of the facade has been important in the modelling of the facade. Meanwhile modelling the shape of the facade with structure the facades have been modelled without structure, to ensure a profound basis for the expression of the facades in trems of shape and structure. Thus is the facade a result of a combined modelling with and without the structure, thus the structure emphasises the expression of the facade and the facade possesses the desirable shape.

With a structural truss system steel is the obvious material caused by the stength for both tension and pressure. Concrete with the strength for pressure is suitable for the load bearing inner walls, not only for structural properties but also caused by the robustness for daily use in a public place and the fire

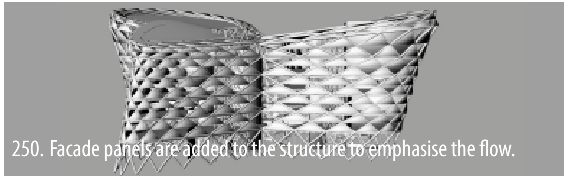
247. The facade to be modelled with respect to the curvature



248. A facade structure is added the facade with facade panels.



249. The structure is simplified to express the flow of forces.

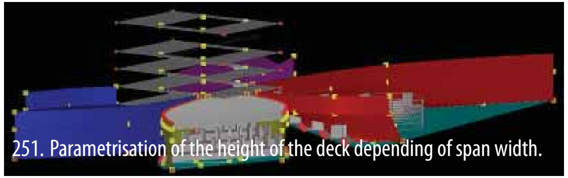


250. Facade panels are added to the structure to emphasise the flow.

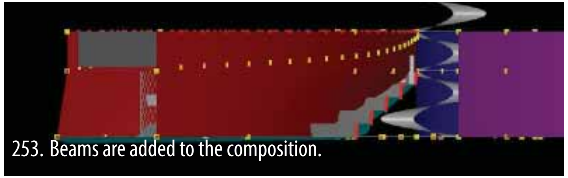
conditions. Since the facade panels not possesses any structural character a material that traditionally is used as building envelope rather than structural is chosen.

Placing the cones has been an iterative process between the structural perspectives, the visual perspective and the functional perspective. The decisive parameters in the process have been the span of the slopes, the composition of the cones in terms of functionality of the rooms and how the constellation is perceived. It has been of importance to maintain relatively not large spans approximately under 20 meters, to maintain a relatively normal height on the slaps, to avoid columns interrupting the floating open plans.

With the irregular forms of the slaps and the suddenly appearance of supporting cones the slaps are to be made of composite metal deck and concrete construction.

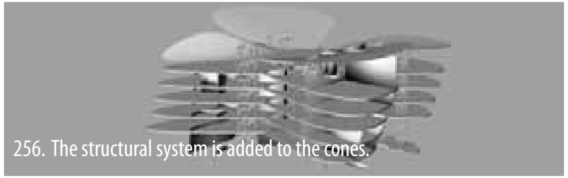

251. Parametrisation of the height of the deck depending of span width.


252. Points are placed with respect to distance between points and span.


253. Beams are added to the composition.


254. The model of suppoting walls with wide spans.


255. Cones are placed centrally to minimise the spans.

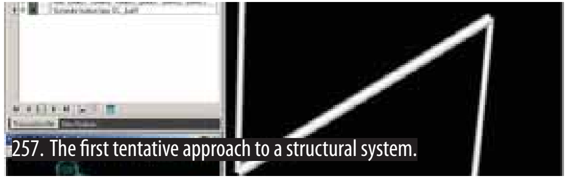

256. The structural system is added to the cones.

10.4 DETAILING FACADE PANELS

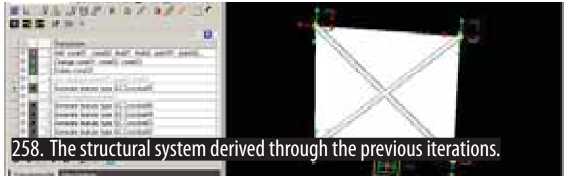
The facade system consisting of the structural load bearing system and the building envelope of glass and slate panels is developed through a detailing process in continuation of the previously describes process of structural parameters.

The facade panels are detailed by the same procedure used for generating the structural system. The panels are designed with focus to the actual panel, the constructive and structural system thereof, and with focus on the entire building model. The facade panels are developed through iterations of two different models. One model of the nearly complete building developed with respect to the local and global parameters (the global model), and one model of the facade panel itself(the local model).

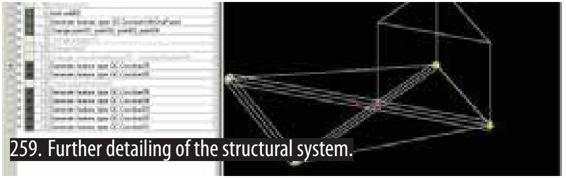
The facade panel are developed as demonstrated through the case study research. One module of the facade panel is



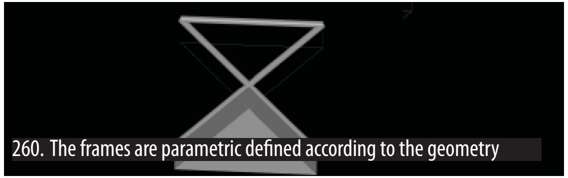
257. The first tentative approach to a structural system.



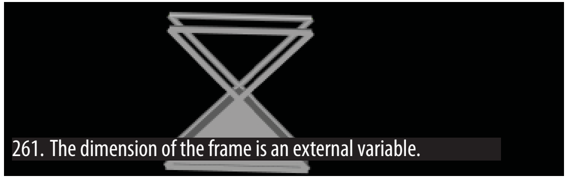
258. The structural system derived through the previous iterations.



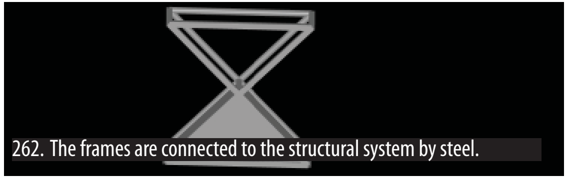
259. Further detailing of the structural system.



260. The frames are parametric defined according to the geometry



261. The dimension of the frame is an external variable.

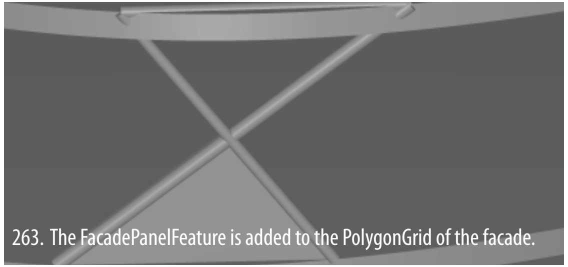


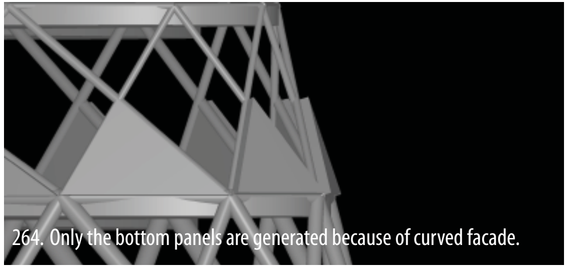
262. The frames are connected to the structural system by steel.

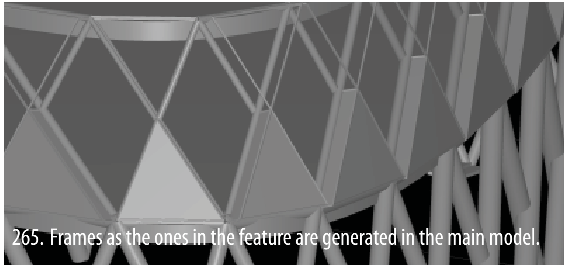
generated in a local model and promoted to a feature that can be attached to the global building model. By this procedure parametrisation of the facade element is facilitated.

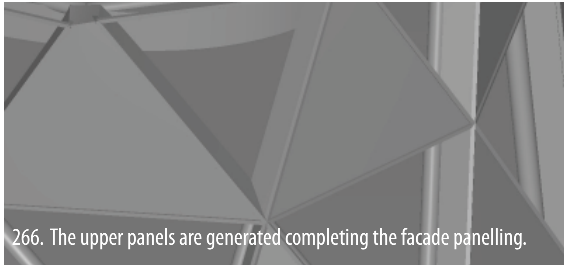
At the opposite page the generation of the local model is illustrated. From a tentative approach of a structural system, to the structural system derived through the the structural parameters described in 10.3.6. And through another run of iterations detailing the facade panel with respect to the structure and construction thereof.

The local model is generated with the loadbearing structural system interior the building dimensioned after the effective length and the distance between the cones. Attached to the structural system at the outside is the facade panel of slate as a fixed solid. The facade panels are attached at the outside to make the structural system interior to avoid having it in the


263. The FacadePanelFeature is added to the PolygonGrid of the facade.

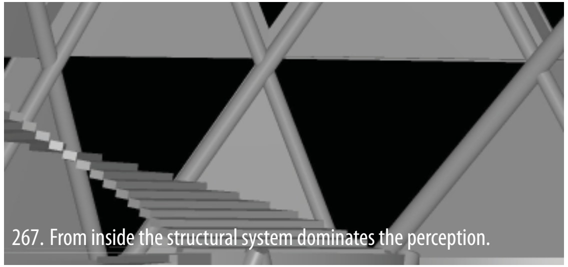

264. Only the bottom panels are generated because of curved facade.


265. Frames as the ones in the feature are generated in the main model.

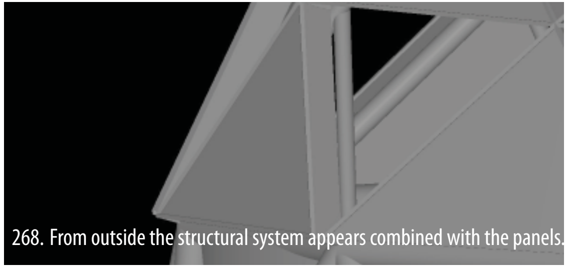

266. The upper panels are generated completing the facade panelling.

facade giving several and critical thermal bridges. The facade panled are thus fixed to the structural system by frames attached to the outer surface of the cones. The thickness of the slate panels is an external variable fixed to 400 mm to have slate at the outside, insulation and plaster at the inside. The frames are likewise a external fixed variable fixed to 50*50 mm aluminium frames.

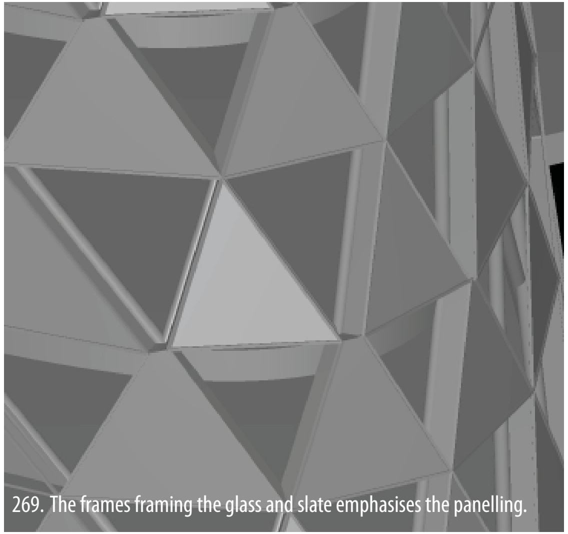
With the construction of the facade panel as generated the structural system appears clear and undisturbed from the inside, and it is possible to get close to the the loadbearing structure and touch it. From the outside the structural system is thus covered by the building envelope of glass and slate. Caused by the aesthetic transparent facade the structural system appears clearly from the outside as well.



267. From inside the structural system dominates the perception.



268. From outside the structural system appears combined with the panels.



269. The frames framing the glass and slate emphasises the panelling.

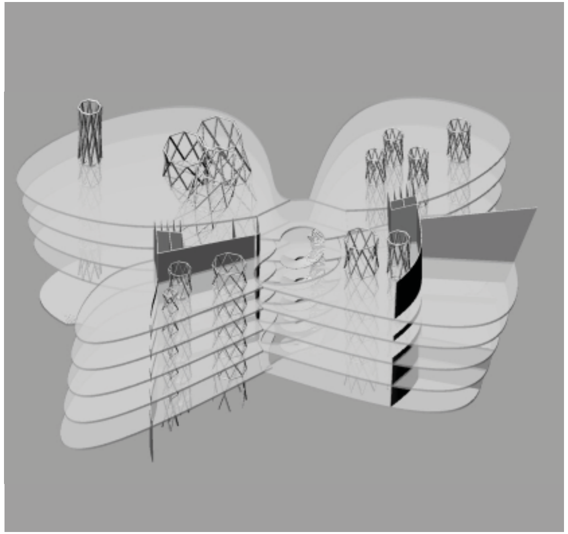
10.5 SUMMARY LOCAL AND GLOBAL PARAMETERS

While implementing the different local parameters the model has been under a continuously development according to the local parameters. During the process it is evident to evaluate the design concurrently, thus the parameter of being aesthetically pleasing also is incorporated through the process and not buried between the functional local parameters. Furthermore it has been important to maintain the thread of the project concurrently, while the implementation of the local parameters through the process is done with respect to the global parameters.

The parameter of being aesthetically pleasing cannot be assured by the process of incorporating the parameters, which merely assures that the different perspectives is considered and implemented in the design. The aesthetically pleasing parameter is a question of the designer's opinion – a matter of the hand and the eye to keep in the view through the process.

During this project the aesthetics is a question that have been evaluated in terms of the tectonic aesthetic values. Focus has been on the building in the context – the interaction of the building at site and the empathy of the building. The detailing – the emphasising and articulation af the joints, and how the structure of the building *the ontology* represents the essence of the construction and thereby refers the art back to utility. The structure is the technology that reveals the truth of the building.

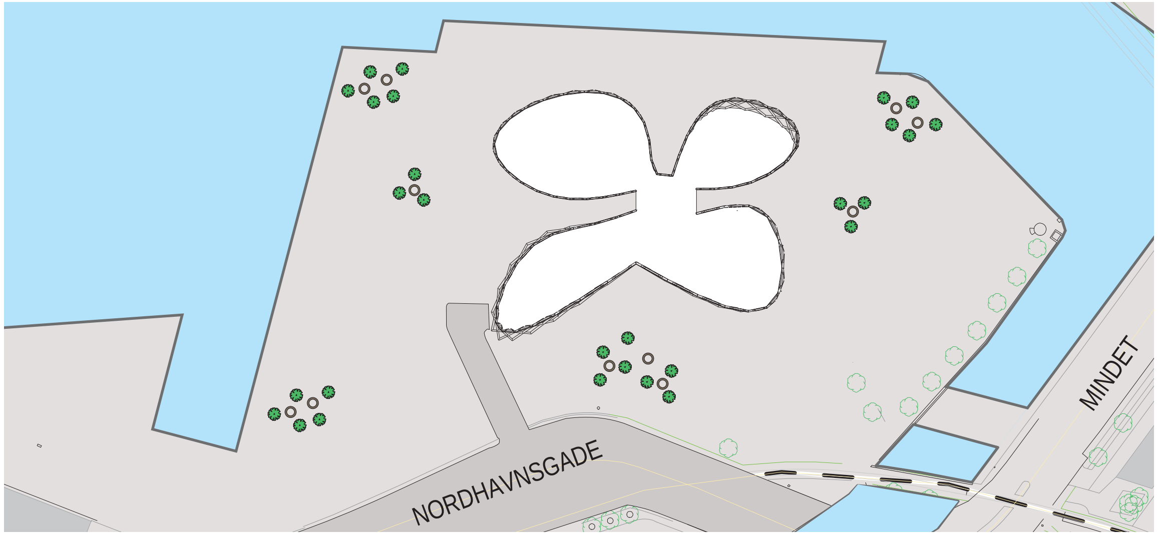
The aesthetic evaluation of the design has been integrated in the process, and especially in the evaluation of the expression of the building the parametric tools have been valuable, since it is possible to modify the parameters according to each other and evaluate variations of the same aspect.



270. The building consists of load bearing walls and cones.

10 PRESENTATION

At the Southern Bastion the Multimedia House stands as a sculptural icon of knowledge in interaction with the near context at site and related to the flows around. The building is to evoke empathy by people as they can interact with it by moving around and through meanwhile being outside. Thus creates the building a protected urban realm at the harbour front.



271. Siteplan, 1:2000 North

Passing the building in car from south at Havnegade/Skolebakken/Kystvejen and Nordhavnsgade or by train the building appears dynamic with the curved shapes, the sligthly sloping facade and the composition of the building volumes.

By passing the building on foot the building invites in with the public café. The café in the southwest corner has an urban character with the aesthetic transparent facade orientated as a natural continuation of the movement along the river towards the water front from the pedestrian zone and the railway station.

At the upper floors the triangular slate panels at the facade gives a visual heaviness and robustness of the building in interplay with the other harbour buildings. Meanwhile the slate panels gives a perception of robustness the glass panels and steel truss structure gives dynamic to the building together

272. The building from southwest.

with the curved surfaces. By the triangular facade panels of either glass or slate the structural system is emphasised and the flow of forces becomes visible and clear for the observer.

Passing the building at the city side, the pedestrian is leaded towards the entrance by the curvature of the building.

Around the café towards the water the opening through the building appears and the pedestrian gets the opportunity of continuing around the next building volume along the water quay or go through the building either towards the east or north quayside at site.

The opening gives a protected area for the pedestrians in the rainful, windy danish autumn and winter. Meanwhile opens the gap for an interaction of the pedestrian walking at the harbour to enter and use the building.

273. The building from south.

While entering the building the front desk is placed a little towards left with selfservice pick-up and book drop right behind. The main stairs and the lift are the characteristics in the arrival area right in front of the entrance. Towards rigth the public café starts with a central room of public pc-workstations.

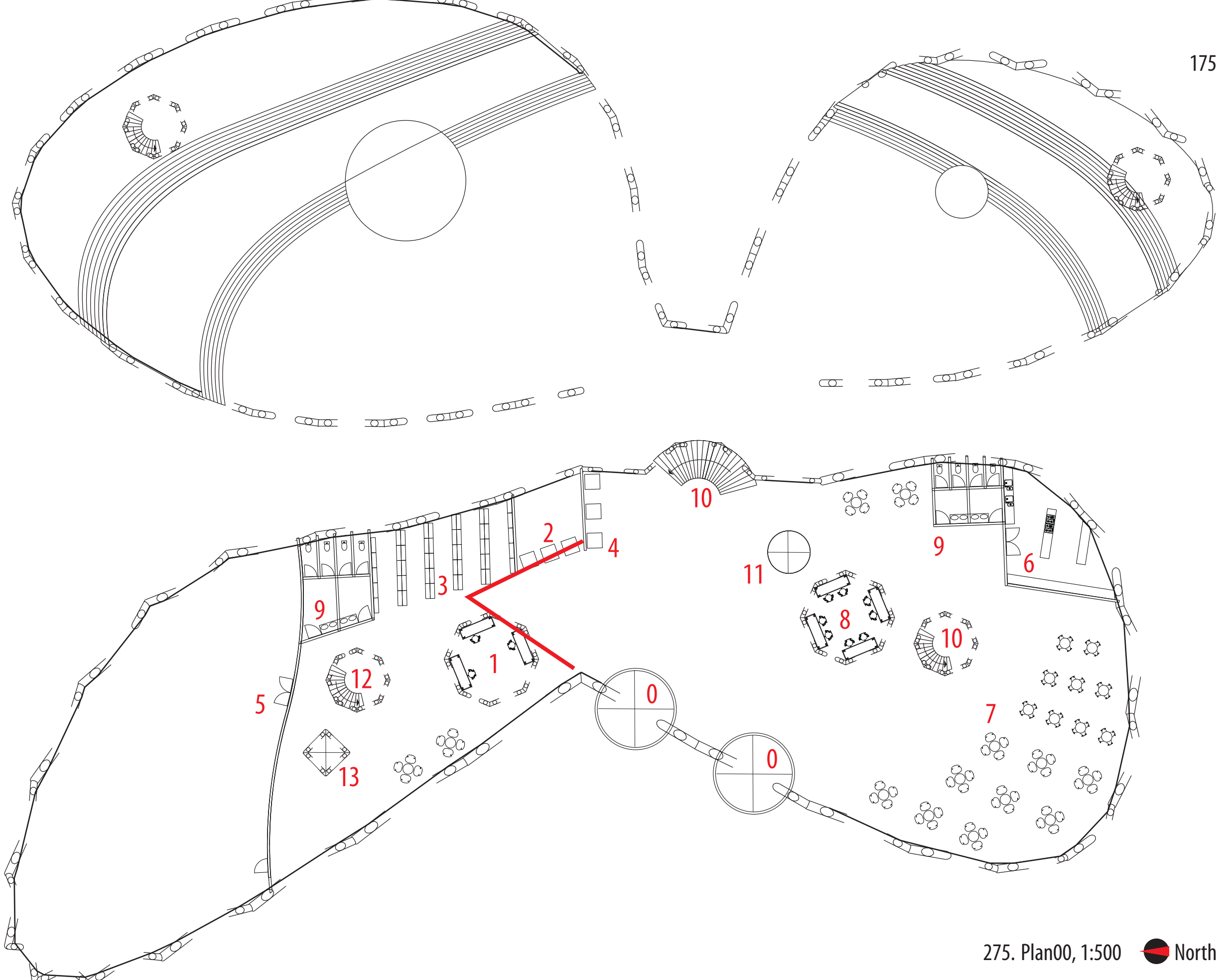
The arrival area opens upwards as an atrium. With the curved upper storeys and views of the water a dynamic and interesting experience of the building is established from the arrival. The curved lines are combined with the sculptural wide spiral stairs of concrete and the transparent glass and steel lift. Transparency and light are main charateristics of the arrival area contrastfully combined with black granite floor with wide terrazzo-inspired joints after the Palladiana principle explored by the italian renaissance architect Andreas Palladio (1508-1580).

274. View towards the café and arrival area from the the front desk.

PLAN 00

0. Main Entrance
1. Front Desk
2. Bookdrops
3. Self pick-up area
4. Self check-out points
5. Sorting System
6. Café kitchen
7. Café
8. Public PC-stations
9. Public toilets
10. Public Stairs
11. Main Lift
12. Staff Stairs
13. Staff Lift

< Camera position



275. Plan00, 1:500

The cores of public PC-workstations and the frontdesk at ground floor continues as meeting rooms and experience rooms at upper floors. The cores are framed by a similar truss as the facade and combined with glass panels where sound insulation is required.

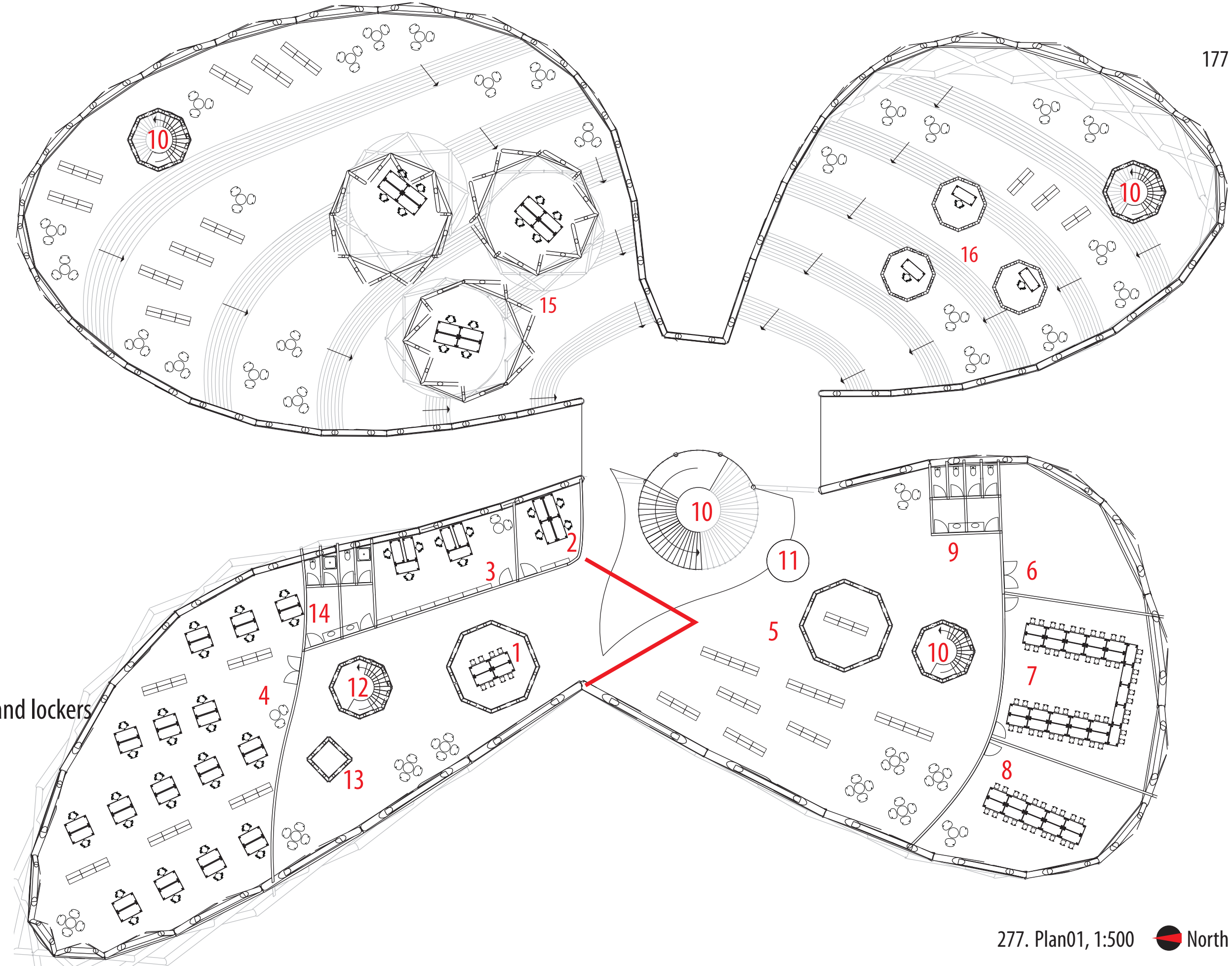
Entering the next storey the administration sections in north-west begins. All offices have visual transparency towards the centre by the half concrete wall with large windows. Along the eastfacade small offices are placed and at the end is a large open-plan office. Informal meeting areas and oases are placed in the centre of the section as the internal meeting room in the core of the section. The meeting room is replicated at the different storeys until the upper storey that contains a fitness room for the staff, as the storey concerns wellnes and benefits for the staff.

276. View in The Administration Section from walkway in the central room.

PLAN 01

1. Internal Meeting room
2. IT and Communication, 4 employees
3. IT and Communication, 6 employees
4. IT and Communication 30 employees
5. Campaign activities and theme exhibitions, 200 m2
6. Storage 70 m2
7. External meeting 100 m2
8. External Meeting 60 m2
9. Public toilets
10. Public Stairs
11. Main Lift
12. Staff Stairs
13. Staff Lift
14. Staff toilets, bath and lockers
15. Project rooms
16. Study cells

< Camera position



277. Plan01, 1:500 North

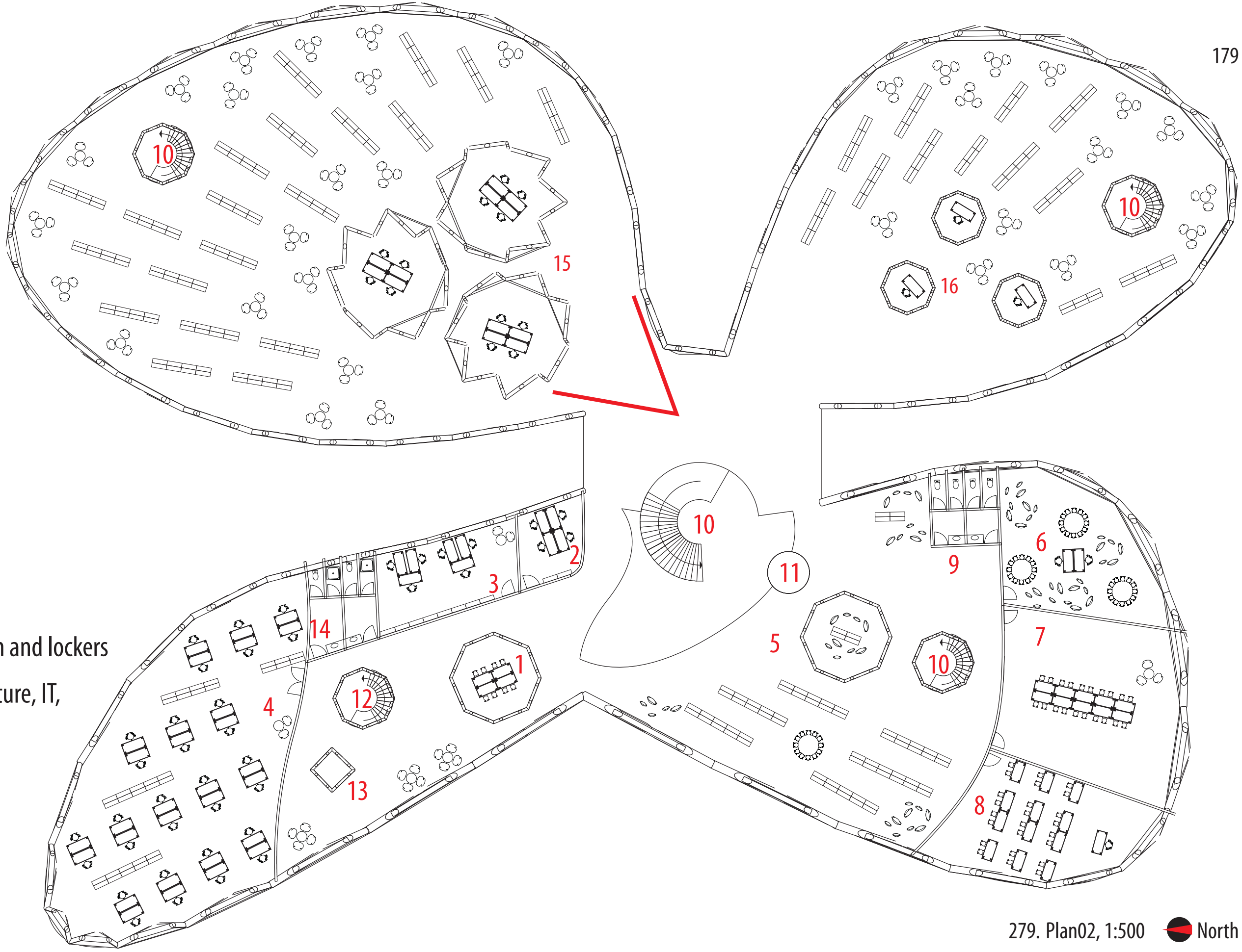
By entering The Open Media section from the centre the observer gets views through the building towards the water and The Northern Bastions. The bookcases are distributed thus an overview of the organisation is maintained while moving through the media. In between the bookcases oases are placed orientated towards the facade to have natural daylight for the readers. Centrally in the section three project rooms are placed easy to orientate around and from. The rooms rotates around themselves and approaches each other upwards in the building, thus they are connected at the two upper floors, where they have the function of being reading rooms.

278. View in The Open Media Section.

PLAN 02

1. Internal Meeting room
2. Management
3. Secretariat, 5 employees
4. Main Library 30 employees
5. The Play Library, 200 m²
6. Hybrid Learning Space 80 m²
7. Large Flex Room 100 m2
8. Teaching Area 100 m2
9. Public toilets
10. Public Stairs
11. Main Lift
12. Staff Stairs
13. Staff Lift
14. Staff toilets, bath and lockers
15. Labs (sound, picture, IT, litterature, reading)
16. Study cells

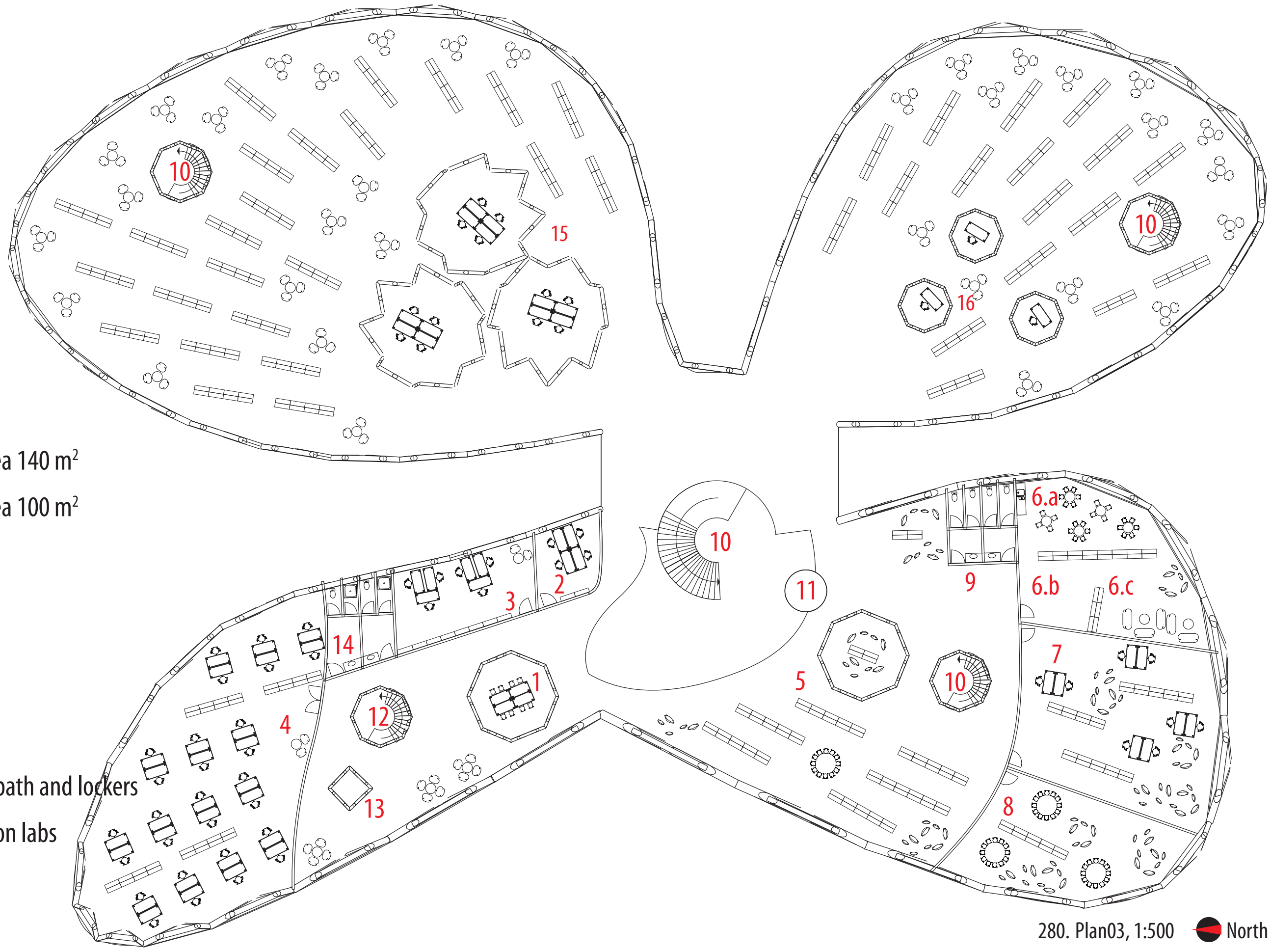
< Camera position



279. Plan02, 1:500

PLAN 03

1. Internal Meeting room
2. Main Library, 4 employees
3. Main Library, 6 employees
4. Main Library 28 employees
5. The Play Library, 200 m^2
6.a Eating Area 40 m^2
6.b Parking Facilities for baby prams etc. 30 m^2
6.c Breast feeding and baby changing zone 30 m^2
7. Inspiration Area 140 m^2
8. Inspiration Area 100 m^2
9. Public toilets
10. Public Stairs
11. Main Lift
12. Staff Stairs
13. Staff Lift
14. Staff toilets, bath and lockers
15. Transformation labs
16 Study cells

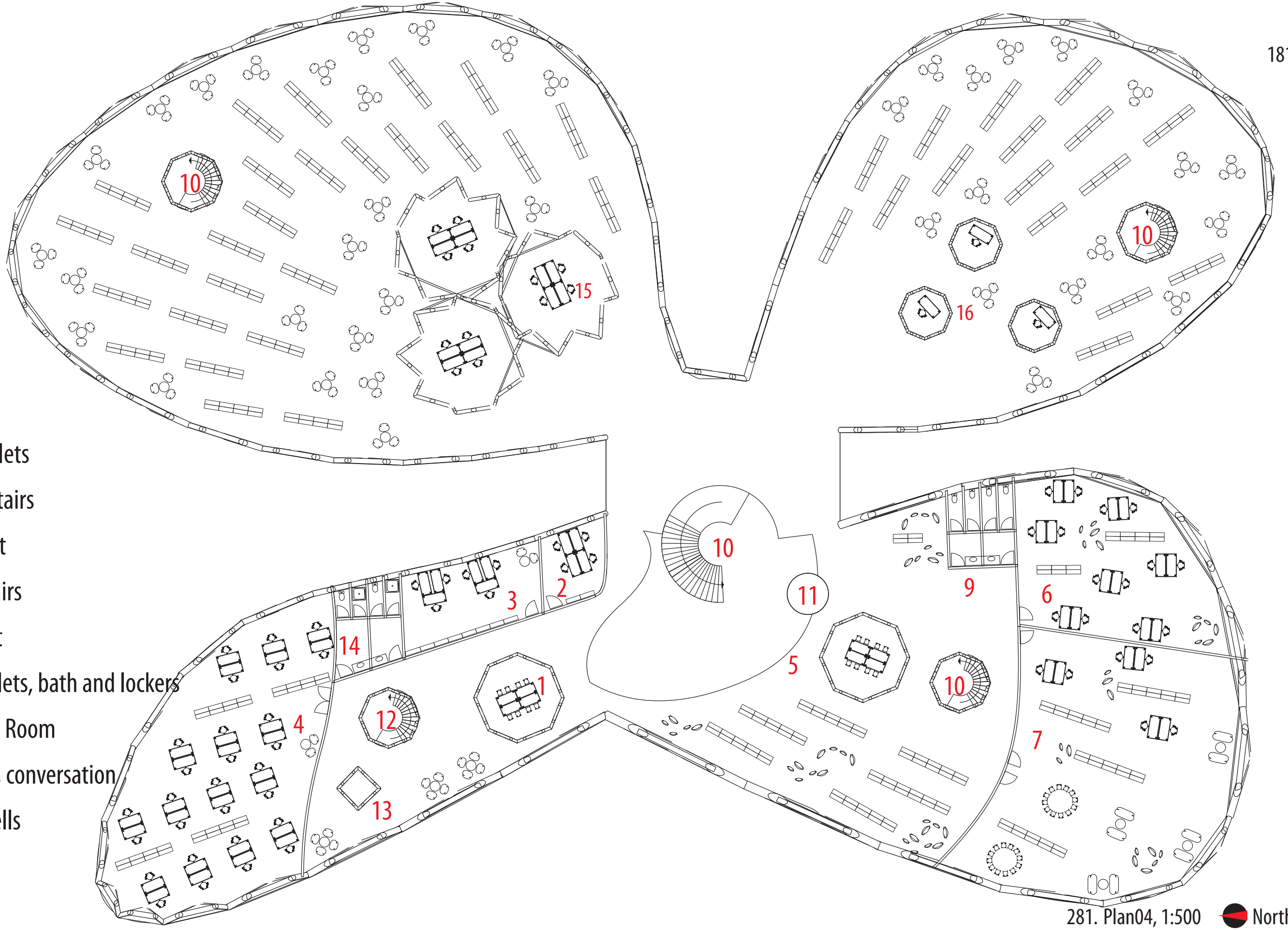


280. Plan03, 1:500

Plan 04

PLAN 04

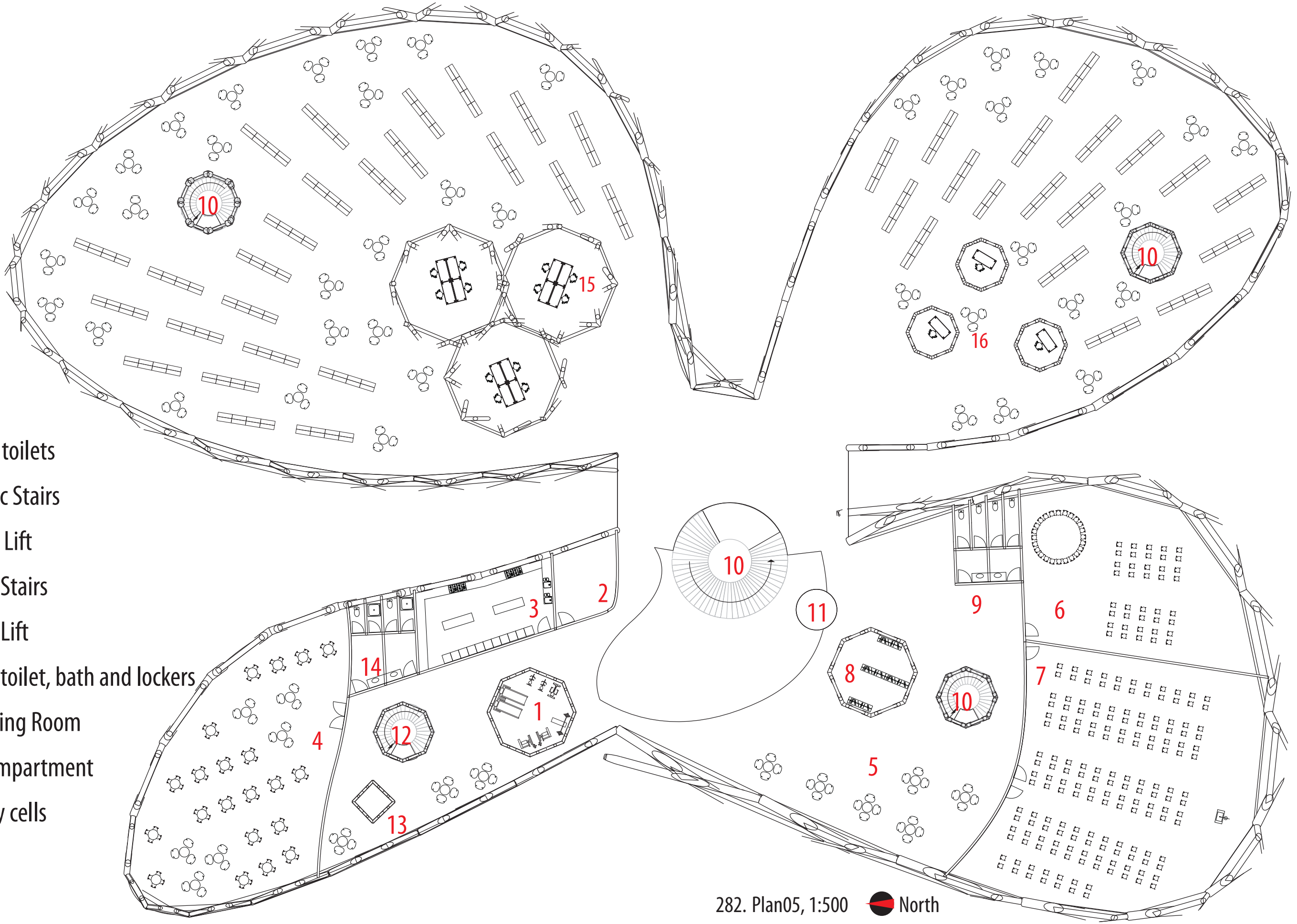
1. Internal Meeting room
2. Main Library, 4 employees
3. Main Library, 6 employees
4. Main Library 28 employees
5. Learning Area, 200 m^2
6. Tween Zone Homework Café 100 m^2
7. Tween Zone Medialounge, Gaming Area 200 m2
9. Public toilets
10. Public Stairs
11. Main Lift
12. Staff Stairs
13. Staff Lift
14. Staff toilets, bath and lockers
15. Reading Room living room, conversation
16. Study cells



281. Plan04, 1:500

PLAN 05

1. Staff Fitness Room
2. Storage 20 m^2
3. Staff Cafeteria kitchen
4. Staff Cafeteria, 84 seatings
5. Multipurpose Hall Lounge 150 m^2
6 Childrens Theater and Film 150 m^2
7. Multipurpose Hall 315 m^2
8. Multipurpose Wardrobe
9. Public toilets
10. Public Stairs
11. Main Lift
12. Staff Stairs
13. Staff Lift
14. Staff toilet, bath and lockers
15. Reading Room
Quiet compartment
16. Study cells



282. Plan05, 1:500 North

With a total area of 18.900 m^2 divided into four main sections the multimedia house meets the requests in the competition programme.

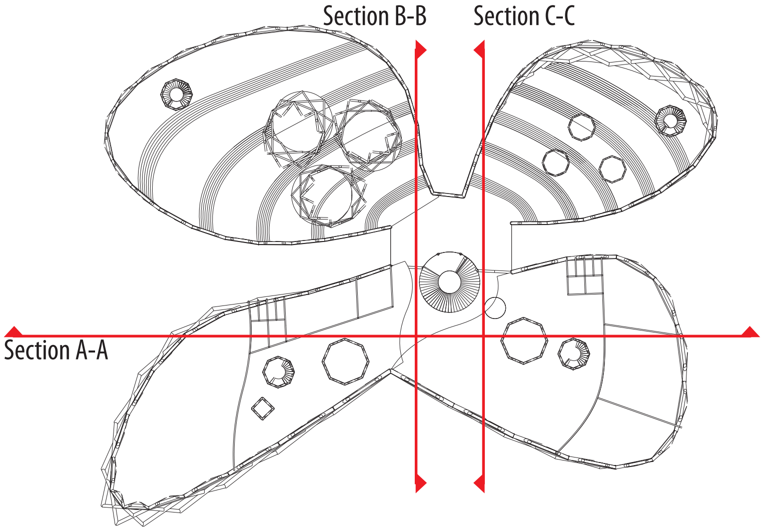
The public Meeting, Learning Networking
in southwest of 4690 m^2 containing 70.000 books.

The Intimate Media
in southeast of 3270 m^2.

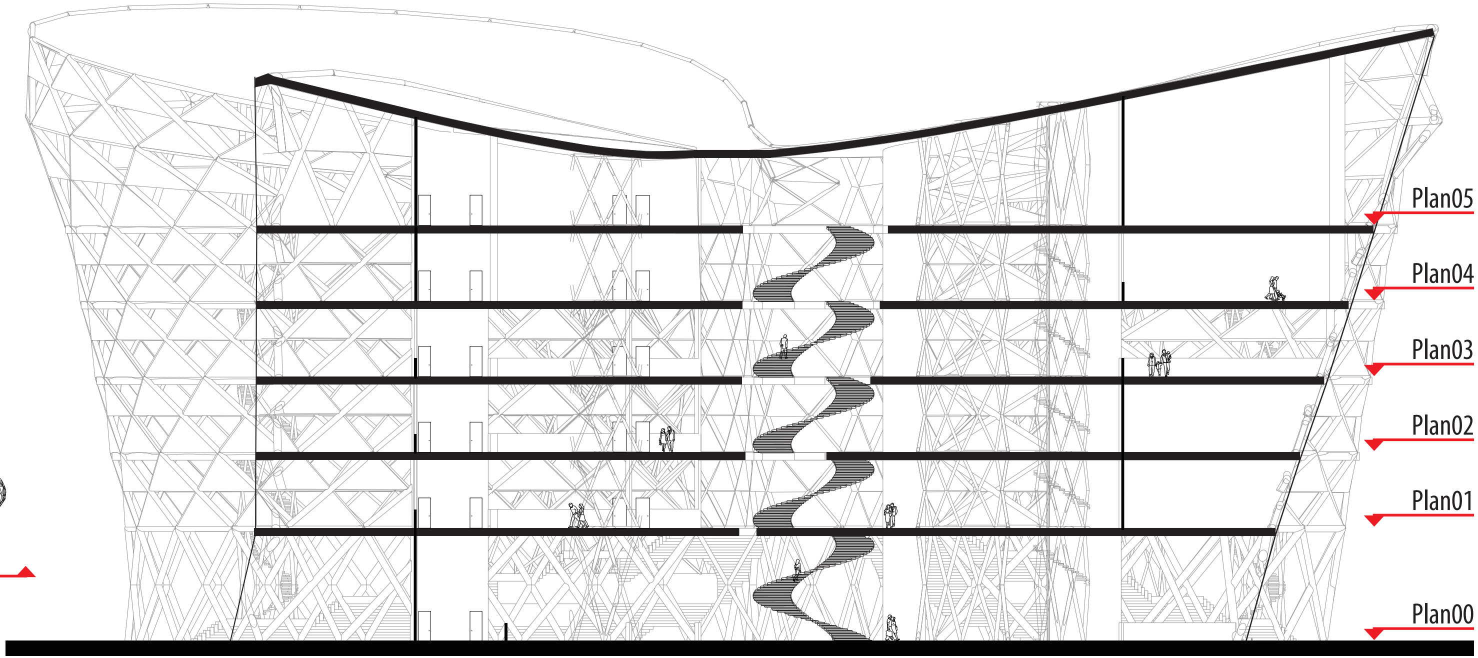
The Open Media
in northeast of 5250 m^2 with a total possession of 310.000 books together with The Intimate Media.

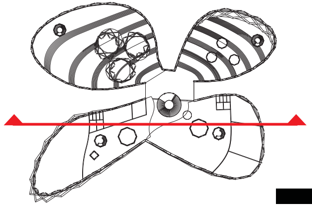
Administration and Logistics
of 3800 m^2 and the atrium of 620 m^2.

283. The building from northeast.


Section B-B
Section C-C
Section A-A

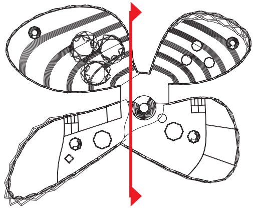
SECTION A-A

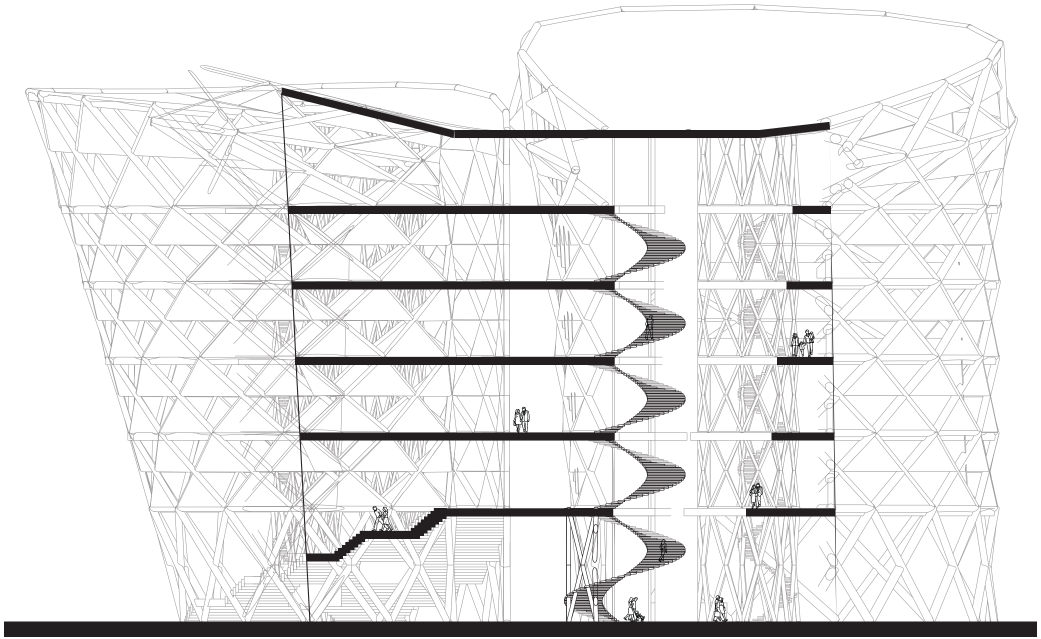




284. Section A-A, 1: 500.

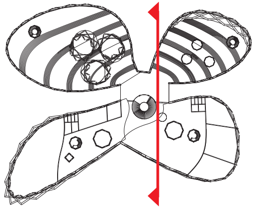
SECTION B-B

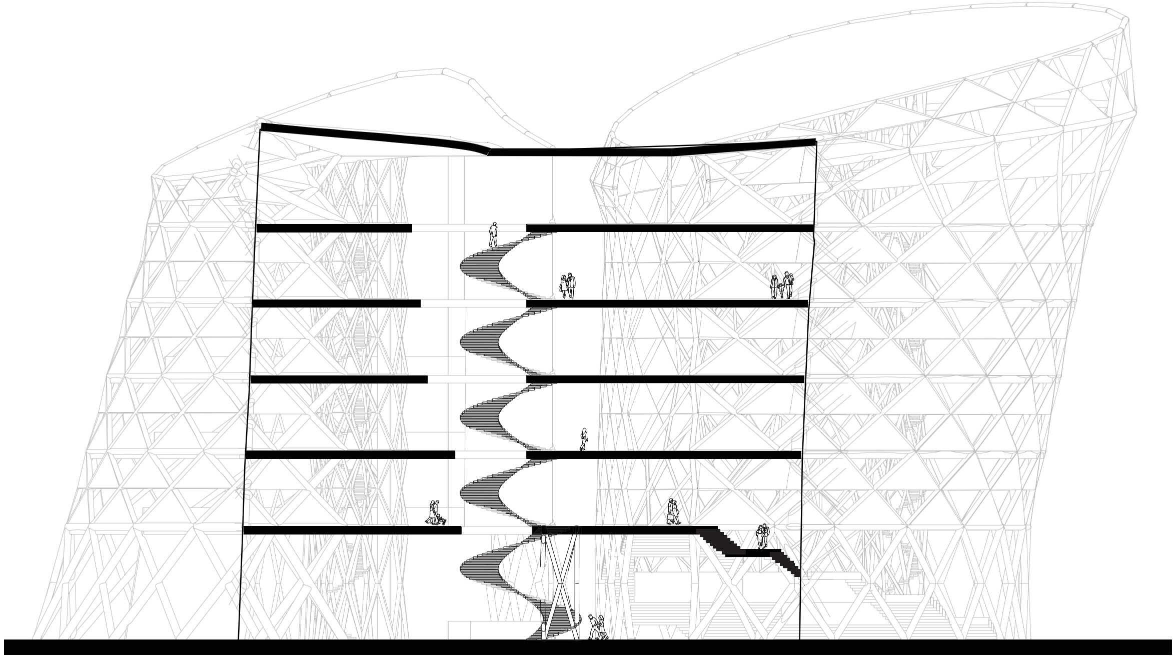




285. Section B-B, 1: 500.

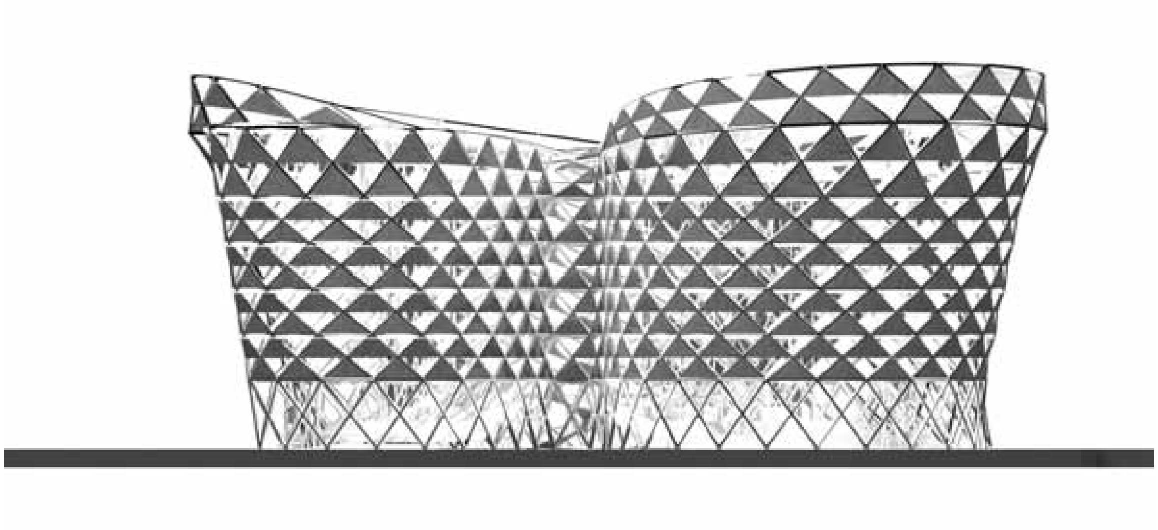
SECTION C-C





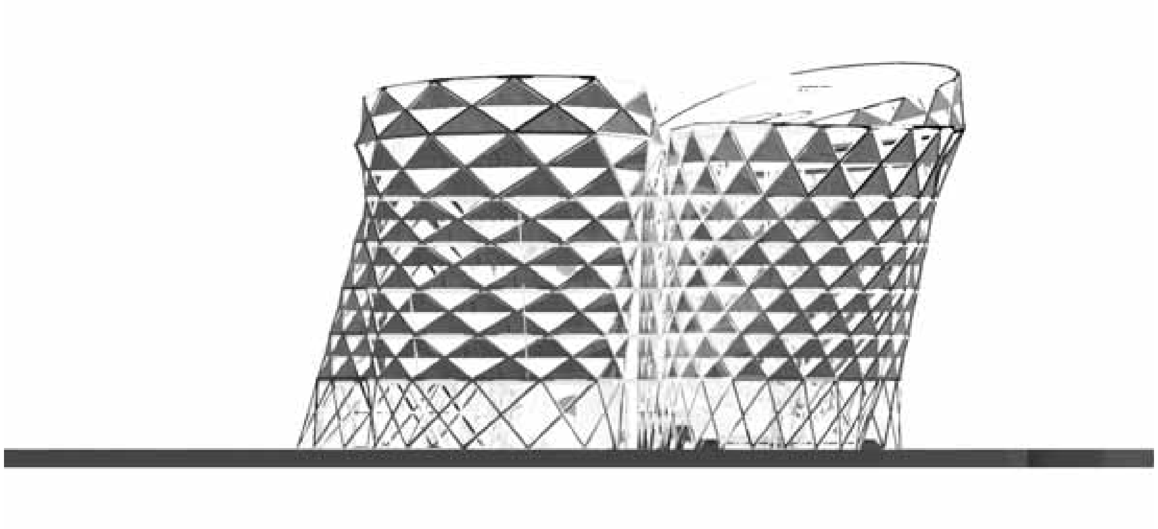
286. Section C-C, 1: 500.

WEST FACADE



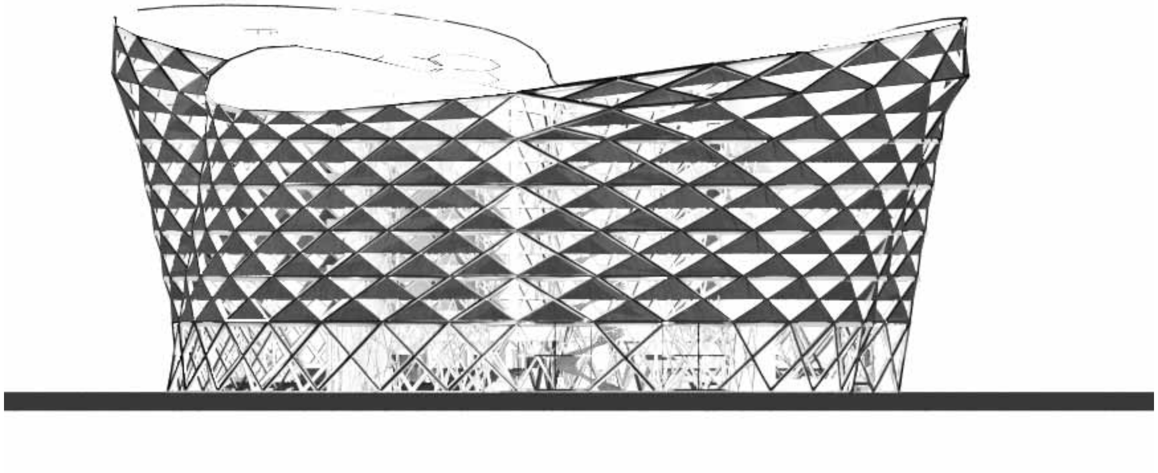
287. West Facade.

SOUTH FACADE



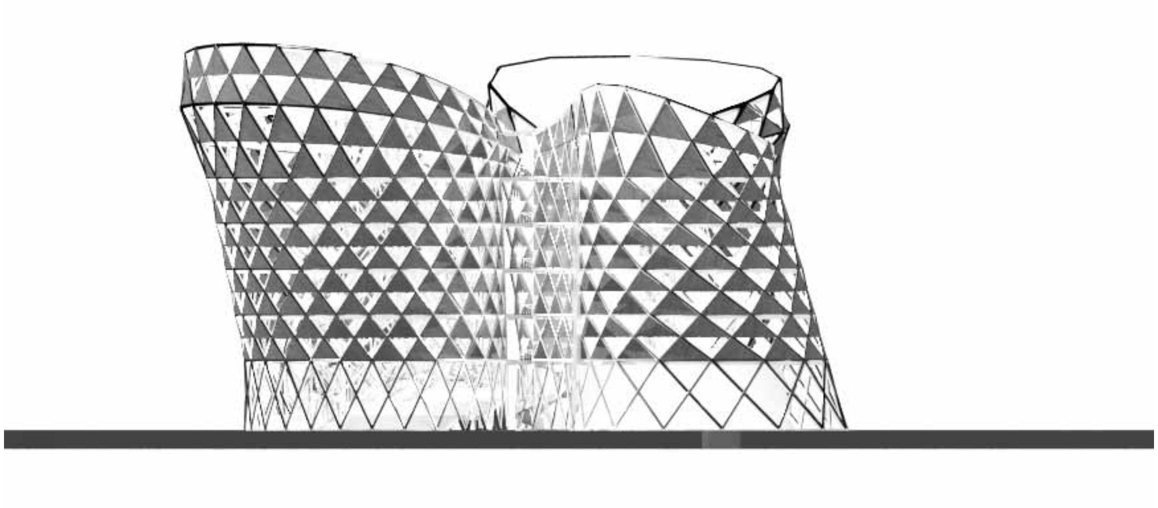
288. South Facade.

EAST FACADE



289. East Facade.

NORTH FACADE



290. North facade.

11 DESIGN SUMMARY

The Multimedia House appears dynamic at the water front and yet with a heaviness caused by the facade material of steel and slate. Slate appeals to the industrial harbour environment with the dark grey colour and matt surface. Slate is here in interplay with the old trade harbour evident in Toldkammeret and Pakhus 13 where slate traditionally is used for roofing. Thus is the material, characteristic for the perception of the building, in interaction with the context meanwhile it derives from elements at and around site. Observing the facade as a decorative element it is in accordance with Frampton's approach to the buildings' decoration that must grasp recognisable elements from the national and cultural discourse of the building as the building must grasp the physical structure. [p. 18]

The Multimedia House as an interplay of heaviness and dynamics adds an interesting element to the harbour environment, meanwhile the composition plays with the terms of tectonics as the lightweight enclosing membrane and stereotomics as mass and volume. [p. 12] Furthermore this interplay reflects the complexity at the site, the history, and use thereof. The heaviness refers to the harbour industry and the decisive role of the city's history the site has been part of. The dynamics refers to the actual perception of the site the observer gets today with the indefinable area of traffic, industrial history, trade history and the future recreational area. What is more the dynamics refers to the requested experience of the harbour as an active urban realm for recreation and activity. [p. 134]

Integrating the Multimedia House in the future recreational realm at the harbour and making the building add a perspective to the new harbour environment have been the decisive parameters for the design. At ground floor the facades are aesthetic transparent to emphasise the contact to the urban realm and to make the inside of the building part of the urban realm, thus the building interacts better with the site an invites both users and people passing by to use and enter the building. Combined with the aesthetic transparent facades the building opens by giving a protected room in the public realm beneath and between the building volumes. This is part of emphasising the interaction of the building at site to fulfil the visionary parameters of being a house of democracy but also an interpretation of Frampton's tectonic approach of revealing and acknowledge the site and unveil and produce it in a creative sense. [p. 19] The aesthetic transparent facade and the public room defined by the building frame the context for the user, thus a new understanding for the context is created by the framework of the multimedia house. The building incorporates the context by focusing of integrating views of the context and framing desirable perspectives. Lifting the building to allow people entering without actual entering inside is to give users and people passing by an experience of the site and a new experience of the harbour area. The Multimedia House gives a shelter for wind and rain in the public realm and thereby contributes to make the harbour an attractive place.

As mentioned the aesthetic transparency of the ground floor is a consequence of inviting people to use the Multimedia House. For the arrival area the functional transparency has likewise been decisive to give users an easy approach to the building and how to use it. The arrival area been designed with the existence of two segments of users; some wanting fast self-service, and others wanting fast service. The basic elements for both usages are orientated towards the entrance. This has given a logic structure in the layout of the building with the central atrium containing main functions for the library, main functions for the building distribution, and in continuation with the public Meeting, Learning and Networking. The purpose of the building's functional transparency is to make users unknowningly recognise the democracy "theme" and furthermore to accomplish people to thrive, engage and relax as the competition prescribes. [p. 111] The emphasis in functional transparency has given a logic structure in the organisation of rooms by the division into four main sections. With a section of Administration, a section of Meeting, Learning and Networking and two sections of Media altered possibilities are given to the use of the Multimedia House. In terms of fire, these four sections give potential in fire sectioning, and in terms of security, the division gives possibilities in closing the media sections if the building is to be used for other purposes. Attention is here paid to the multipurpose hall, external meeting rooms and teaching area in Meeting, Learning and Networking. The distinction of the social media and the individual media is to give the user clear directions for use of the library, quietness in one section and openness and sociality in the other.

The functional transparency of the Multimedia House is consequences of focus on the house of democracy during the design process. This value is a thoroughgoing parameter visible in clarity and simplicity in the plans for the building, and in the design of the bottom floors in the east parts. The sloping slaps with the bookcases oriented to give views through the building and maintaining perspective of the building is a result of the democratic approach. The downward sloping floors from the centre gives a raised entering to the room making users feel themselves in centre and having the perspective. In other words this makes users appear dominating in contrast to the building. This is also consistent with the visionary perspective that both human development and interactions should be the starting point and the objective. [p. 110]

12 REFLECTIONS

Designing with a parametric methodology has given an appealing process of varying focal points. The division of the process into main parameters of global and local parameters made the design approach accessible and gave structure to the process of various perspectives to incorporate.

The process of the global and local parameters gave some headlines for the project and thereby structure to a potential totally non-structured process. Structuring the process by parameters appeared to be an appealing methodology for this thesis, since it was easier to incorporate the different parameters and thereby assure implementation thereof in the design.

As well as parametrising helped structuring the design process, it came short in inspiration for the initial design. The parametric approach is rather a methodology to design with than a concept. The traditional design values of context and concept are still evident for the design since the design is to emerge from a concept and cannot purely emerge from being parametric. Though, the parametric approach gives advantages in the initial stage, where the concept can be developed by some parameters or values, as it is the case for this thesis. Hence is the criticism for digitally driven design processes not found appropriate, since the conventional architectural values of aesthetics, function, materiality and context still plays a determinant role in the design generation.

The project is built upon a parametric methodology and the parametric values it includes. Among others it is the values of being able to arrange the design by parameters; thus the design can be changed by parameters. In this design, this approach is most evident in the plans for the building, where module lines from an underlying layer are projected to the appropriate slaps. Thus have the facades become the variable for the individual slaps including the slap itself. The lines defining the walls are controlled by the module lines controlled by variables in a hierarchy above the hierarchy of the actual slap. By the hierarchic order in the variables with the module lines above the facades and slaps, changes in the module have a deeper impact in the design than the facades.

The parametric approach is consistently evident in the Multimedia House, where variation of the design is generated by changes in the variables. Beside the module lines the curvature in the facades, both vertically and horizontally combined with the composition of the building, has been object for modelling through several variations. [p. 157]

The possibility of controlling the design by parameters has been one aspect where the parametric approach has indeed proofed its value. Another aspect is the possibility of attaching models to each other even though they are independently developed. This method is especially being used in the design of the facade and the structural system, as it has been important to model the facade according to the practical local aesthetic parameters. The question, of how the facades appear and are perceived, is developed with focus on the vertical and horizontal curvatures, the composition of the different volumes according to each others, the closing of the building by the roof, and the joint between ground and facade.

One model of the facade has thus been generated with respect to the aesthetic and functional parameters. Meanwhile a structural model has been generated, with respect to especially the tectonic parameters of structural transparency, making a clear and logic structure reflecting the flow of forces. And with the perspective, that technology is the process, through which the revelation is carried out, and art is the means, by which the presentation is revealed. [p. 25] Thus it has been of great importance to express the facade by the structure qua emphasising the curvature and the expression of the facade by the structure. In the meantime the structure is true to the flow of forces by the curvature and expression of the facade.

The possibility of working with separate models has given possibility of developing both perspectives concurrently and separately. This has given the desired process for designing, because both two approaches have been developed individually according to their individual parameters. This has allowed a process, where both approaches to the facade have been through iterations of different parameters, and then afterwards and concurrently incorporated into each other. The possibility of designing with different models has thus allowed a level of detailing that otherwise would have been difficult if not impossible.

As the parametric modelling has proofed its value in various ways the parametric modelling however has become short in other aspects, whereas memory shortfall most distinctly stands out. *GenerativeComponents* has been the issue for design development as result of the theoretical part. With the case study research *GenerativeComponents* was found suitable for digital tectonic design generating. During the process of designing the Multimedia House by the software this conclusion is maintained, but the aspect mentioned in the summary of the program [p. 78] about memory shortfall is after the process of designing with *GenerativeComponents* found larger than anticipated during case study research.

Caused by memory shortfall the design process has been unpurposely interrupted at undesirable moments and some processes have dragged on longer than intended. The conclusion from the case study research not to avoid *GenerativeComponents* because of memory shortfall is maintained, but special hardware is required.

As there is hardware requirement for designing by the parametric tool *GenerativeComponents*, there have likewise been requirements for the designer in terms of programming and scripting. During the theoretical part of the thesis, the aspect of the designers need to possess these skills, is debated. It is found evident to possess the skills of programming and scripting, whilst using generative tools, for the designer to be active in the process and able to control the generative processes. Hereby becomes the computer a collaborative partner. [p. 36] The designer without the skills becomes passive in the process, being unable to understand the structure and construction of the design, and computer generated design becomes a question of serendipity and not a question of design generated by parameters.

Today computer generated design by scripting and programming is reserved to a relatively limited group of architects, there have been far-sighted to integrate computer programmers into the design teams.[p. 41]. With the state of art of software, it is evident to possess the skills of programming and scripting to take advantages of the opportunities in computer generated design. By time it might be a more common subject but today's requirements to the designer demand skills in terms of scripting and programming , whilst the basis of understanding the design is within the basis of understanding the scripting and programming underlying the design.

The process with *GenerativeComponents* has been profitable and interesting both in terms of parametric modelling, programming, scripting and especially designing with the parametric methodology. Though have the requirements for the computer to do a project as the multimedia house been too demanding. During the project *Grasshopper*™, a plug-in for *Rhino* has been released. It could be interesting comparing this software to *GenerativeComponents* and test the advantages and disadvantages to each other. *GenerativeComponents* has been interesting and fruitful in terms of tectonic and the case study research of the program in the theoretical part of the thesis has proofed its importance, since it has been possible to work both in the phenomenological methodology as the empiric-analytic. Conclusively *GenerativeComponents* is evaluated suitable for generating performative architecture and especially *Performative Tectonics* caused by the hermeneutic construction.

As the process reflects the parametric methodology, the process also reflects the shortage of a one-*wo*man-group. Ending the design of the Multimedia House with the attained result is found satisfying and yet with some dissatisfaction. The focus during the project of tectonics, parametric modelling, and the design assignment from the competition presentation have given a delimitation from climatic perspectives and dimensioning of the structure. It is desirable to have linked the *GenerativeComponents* model to analysing software as *Ecotect* and *STAAD.Pro* to have some empiric-analytic analysis during the process. The missing linking of the model to the analysing software has not just been a question of shortage in this project being a one-person-vehicle.

The possibilities in linking generative software to analysing software is an area for further research, since analysing software mostly has been for mechanical engineering and the generative software for architectural designing. The tension field of engineering science and architectural designing is found very interesting and architectural geometry in terms of architecture, civil engineering and mathematics is a desirable subject for further research.

The project thereby ends with further design aspects to develop and further research areas to study. This reflects the project as a long term master thesis containing a theoretical part and a practical part. The theory and the practice have been two elements for the thesis to develop concurrently and separately. The theory and practice have to cooperate, interact and challenge each other. Thus the result is a piece of architecture reflecting the methodology of the theoretical part employed in practice.

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