DEAF SPACE

INDIVIDUALITY + INTEGRATION

An extension of Gallaudet University, Washington D.C, USA

AALBORG UNIVERSITY // ARCHITECTURE & DESIGN // MSC04 ARCHITECTURE SPRING 2016

ALESSIA CHIAMBRETTO & ASTA KRONBORG TRILLINGSGAARD

COLOPHON

PROJECT TITLE
Deafspace - Individuality + integration - Gallaudet University

Architecture & Design MSc04 Architecture
Aalborg University

PROJECT CONTENT
Project period: 01.02.2016 - 25.05.2016
Exam date: 22.06.2016
Number of chapters: 9
Number of pages: 171

SUPERVISOR
Isak Worre Foged, Assistant Professor, MSc.Eng.Arch, M.Arch., PhD.
Department of Architecture, Design and Media Technology
Aalborg University
Denmark

TECHNICAL SUPERVISIOR
Søren Madsen, Assistant Professor, MSc, PhD.
Department of Civil Engineering
Aalborg University
Denmark

Alessia Chiambretto

Asta Kronborg Trillingsgaard

Ill 0.1 Illustration of the original Gallaudet University campus site

SYNOPSIS

This Master thesis evolves from the use of the Deafspace Design Principles, developed by Hansel Bauman, Gallaudet University, in implementation with architectural elements to create a similar perception of space for both hearing and deaf individuals and, therefore, to enhance the same behavior. This takes its departure by addressing the primary senses to extend the sensory reach of deaf individuals in a new development lot of Gallaudet University in Washington DC, USA. This has led toward a new high building density area, which fulfills the future development plans for the campus and city. The project focus in detail on the university parcel placed in a close connection to the gateway plaza, which serves as the new official entrance to the campus.
The university parcel consists of teaching facilities, a cafeteria and a visitor center. These units are joined by the gateway pavillion, which contrasts the three massive and enclosed volumes in shape, material and architectonic expression.
This approach informes about the technical focus of the project, where a number of materials and constructive solutions for different parts of the envelope have been studied in order to arise the sensorial awareness and open a more informative and intuitive dialectic with the users.
Tectonic solutions for deafspace architecture have been implemented from the urban scale to the construction detail, addressing the sensorial perception as the main driver throughout the whole design process.

PREFACE

"The Deafspace – Individuality + Interaction" is developed by Alessia Chiambretto and Asta Kronborg Trillingsgaard as a part of the 4th and last semester of the Master program in Architecture from The School of Architecture, Design and Urban planning in Aalborg University, Denmark. The objective of the thesis is the development of an extension of Gallaudet University in Washington DC, USA. The target users are Deaf and hearing individuals, which either study at or visits the campus. The project addresses several aspects including tectonics, Deafspace, construction, acoustics, social sustainability and technology on different scales and depths, within the project brief.

We would like to thank Hansel Bauman for the mail correspondence throughout the entire project and for meeting us during our visit at Gallaudet University in week 15, and also Gallaudet University for the hospitality and enlightenment on the Deaf community and Deaf way of being.
We also would like to thank our supervisors Isak Worre Foged and Søren Madsen for Their commitment and interest in the project and for encouraging us to form and extend new knowledge.

A special thanks goes also to our families and friends, that have followed us, not only during this semester, but thourghout our whole educational path, supported us even during the several project-related-moods and outbursts.

An extra special thanks goes to Erik Bredal Kristensen, who represented a solid support during the whole semester and who helped ensuring our well-being.

A final thanks goes to Granpa Mario, who brings inspiration even not being with us anymore.

MOMENTUM

ASTA

Since I was a little girl, I had a strong interest in buildings.

I was always amazed by how they affected me emotionally. I could feel the sad and sacred atmosphere by walking into a church or a chapel, due to the acoustics and the purity of the room, due to the way the light and shadows played in the space surrounding me. Certain materials' textures and reflection could create in me a sense of warmth which made me feel "home" and secure. I could feel amazed and inspired by the honest architectural expression that can be find in the little details. Details that complete and clarify stages of the narrative between the spatial and the emotional. [Frascari, 1984]

Due to this ability of buildings and their spaces to affect my emotional perception, the phenomenological character, the idea of creating frames that affect us every single day became a key interest and driver for pursuing architecture.

I have also experienced buildings that have a negative effect on me, both emotionally and practically. It seems to me that lately the true reason why we create buildings is forgotten in those ones. The inhabitants are forgotten somewhere in the design process, because of the nowadays high focus on the economy and energy consumption, which becomes often the exclusive argumentation for the chosen materials and architectural expression. This can lead to apathetic buildings, where it might become unpractically and emotionally difficult to live in.

Instead, I think inhabitants should be re-inserted in the puzzle of the architectural creation with the same weight of other parameters; they should be drivers for architectural expression.

I realized how important was this for me before starting my architectural studies, my curiosity toward the multiple solutions to integrate construction and emphasis, the practical and emotional. I soon realized how the key for creating spaces for inhabitants was the integration of different fields.

ALESSIA

When I think about why I chose to study architecture I cannot think about any specific moment when my experience of the built space made me think architecture was my future. Instead, I have very clear into my mind a series of atmospheres that I loved – and love – to live.
I love rainy days, they make me happy.
I know that most people would think thit is controversial, because a rainy day is grey, cold and humid; but I love rainy days because they give the space around us a certain kaleidoscope of smells. The music of rain hitting the ground, the buildings, the windows; the sense of warmth and the kindness of the taste of a cup of tea when looking at a thunderstorm from the inside of my house give me the impression I can grasp more of the whole around me. A rainy day represent for me a celebration of senses and suddenly I feel rooted to the place where I'm standing.
I love rainy days because they make me feel.

I decided to study architecture because I have always been

crafty. I love building objects myself, it requires skills, creativity and logic.
Logic. I always loved the order of math. Math, at the very core of its understanding, is the closest we have to a definition of cosmos - from the Latinized form of Greek *kosmos* "*order, good order, orderly arrangement*," a word with several main senses rooted in those notions: the verb *kosmein* meant generally "*to dispose, prepare," but especially "to order and arrange* (troops for battle), *to set* (an army) *in array*;" also "to establish (a government or regime);" "*to deck, adorn, equip, dress*" (especially of women) [Etymonline.com, 2016] - that cosmos that the Ancient Greeks tried to grasp with their harmonious aesthetic understanding.
Math is both science and art.

Due to this, during the first years of architecture studies, my attention was very much focused on the technical aspects of the building. A building worked when it was fulfilling certain numerical requirements.
This thirst for technical knowledge led me to move from mostly theory-oriented studies, typical of Italian education, to more pragmatic, knowledge-based way of teaching design.
Surprisingly, the more my knowledge of performance-aided-design is growing, the more my interest toward the intangible character of the spaces and places we create increases.
I have realized how certain buildings that I have visited make me feel like those rainy days, and how, some others, are very far away from exiting my sensory reach.

US

The decision to base the thematic research for our thesis on the phenomenological approach to architecture came to us naturally: it was suddenly clear that the reconciliation to and the increase of knowledge about the sensory approach to the built environment would have added a completeness to the studies we have been attending, until now. It is true that we are living an historical moment in which we have the need and responsibility to build following precise criteria in order to cope with the environmental situation we have created, but it is also important not to forget that what we construct is still for us to be inhabited, therefore should be not only environmentally respectful, but also appealing to its users. We believe that the inhabitants has been forgotten in the equation of creating architectural space.

Once the focus on the forgotten inhabitants and phenomenology was chosen, the opportunity presented by the Gallaudet University International Competition, which asked for the design of spaces for deaf people, who experience spaces differently because of their lack of hearing, represented to us the perfect challenge, allowing us to design within these subjects.

READING GUIDE

The report consists of 9 chapters; Methodology, Deafspace, Spatial Perception, Site Analysis, Spatial Program, Design Process, Presentation, Epilogue and Annex.

The Methodology consists of a description of the used methods and how these have been implemented in the process. The chapters Deafspace and Spatial Perception consist of the theoretical background and problem statement of the project. The Site Analysis chapter presents the problem boundaries that are determined by the location of the project. The Spatial Program presents the outcome of functions and the parameters needed to solve the problem within the boundaries of the project. The Design Process describes the evolution of the design and presents the argumentation for design choices and technical outcome from the set problem statement, boundaries and spatial program. The Presentation chapter contains the final outcome of the project. The Epilogue consists of the reflection, conclusion and references. The In the Annex further technical information are given.

Each chapter is numbered with a number and a corresponding illustration of the hand sign of the number in American Sign Language (ASL).
The Harvard method has been used for references,which are listed in the Epilogue. The Illustration is numbered according to the chapter and order in the specific chapter.

CONTENT INDEX

CONTENT INDEX

Implementation of methods

METHODOLOGY #1

IMPLEMENTATION OF METHODS

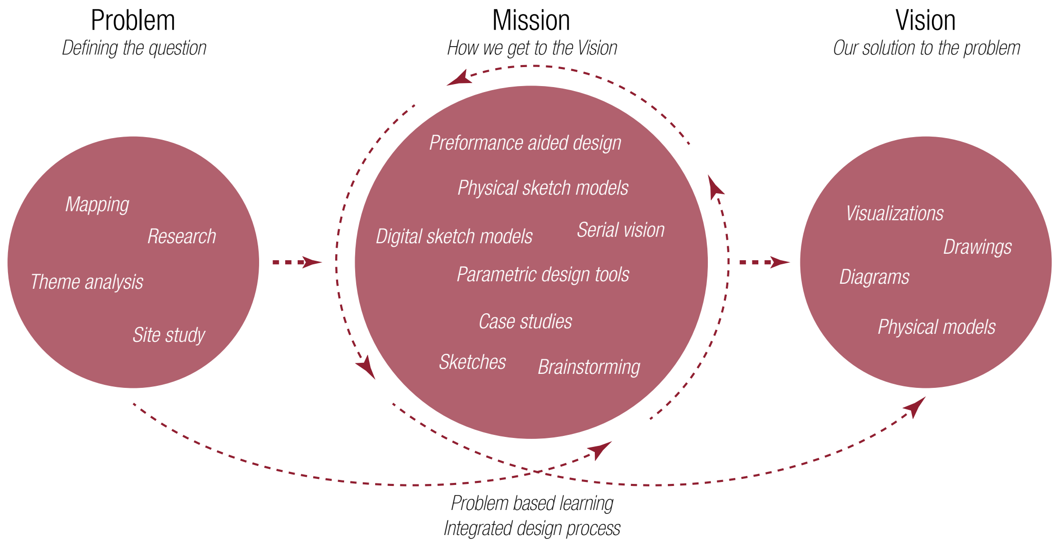
The use of the PBL method (Problem based Learning) is highly acknowledged on an international level and is used on all fields of study at Aalborg University [Askehave, 2015]. The method gives the opportunity for students to gain knowledge and learning independently, by use of theories and knowledge in projects with an identified problem, which is then to be formulated, analyzed and processed [Askehave, 2015].

The PBL is the foundation for achieving our personal learning and study objective during the thesis project. Besides the PBL method, several other methods will be used during the different phases and parts of the project from the very beginning to the final presentation of the project outcome.

The thesis process is divided in to three main parts: problem, mission and vision. From the defined problem, a vision has been formulated. The mission consists in the development of the solution to reach our vision.
They set the overall framework and working methods for the thesis project, process and learning.
Each section requires the use of several other methods. In the corresponding diagram, all the methods that are used in the project and are visually displayed according to the design phase of pertinence.

Besides the PBL method, the Integrated Design Process (IDP) is also used in terms of organizing the different phases, which improves the process for developing an integrated design outcome of the project [Knudstrup, 2005]. The different phases of the IDP is: problem/idea, analysis, sketching, synthesis and presentation.
The overall framework - problem, mission and vision - is further divided in to these phases. Among them there is a constant iteration along the process. The IDP gives the architect the opportunity to include the technical issues in the early phases, so they can become a tool for designing [Knudstrup, 2005].

The analysis phase consists of a Thematic Study of the project, consisting of research about the subjects relevant for the project and gaining a more aware understanding of how to pursue the design. Case Studies are also analyzed to understand the practical implementation of the theoretical knowledge in the design.
A second section is dealing with both objective and subjective analysis methods to get a larger aknowledgment



Ill 1.1 Methodology diagram containing the different analysis' methodes used in the different phases of the project

and experience of the context, the project site and its location. The analysis is made through the use of maps, pictures and facts from the competition brief, webpages and visiting the site and area.
The objective analysis method consists of Mapping, which is used to gain a better insight of the site, its context and its history. This allows us to understand the opportunities there might lie, based upon observations made on maps and facts that support it [Andersson and Gøtzsche Lange, 2013]. The subjective analysis is made through phenomenological methods like Serial vision, which is based on how the visual preception of the spaces affects us. It gives a deeper understanding of urban space equality and human perception of space [Andersson and Gøtzsche Lange, 2013]. This is done by moving through the space where flow, space, scale, color and textures are analyzed according to how the sensory perception of the body is affected, physically and emotionally.

Through the sketching and synthesis phases, both Digital and Analogue Methods are used in order to achieve the best design solution. To be able to achieve an integrated design solution and use the time efficiently, Performance-Aided-Design tools like grasshopper for Rhino mean while building designing and sketching in sketchup and Revit. It is quite usual that the more technical aspects of a design are implemented quite late in the process, which makes it difficult to make alterations of the design, because it is both expensive in time and money [Parigi, 2014]. In this case the money aspect isn't an issue, but the time is. The design freedom is also quite low at the end of the project, because of key decisions set by the design concept from the early phases. Implementing the PAD tools creates a higher possibility of extracting information's form the design [Parigi, 2014]. This information can be used for designing, allowing a higher possibility of achieving an integrated design solution [Parigi, 2014].

Together with the implementation of the performance aided design tools, analogue methods are used like Hand Drawings and Physical Sketch Models to get a quick understanding and feeling of the volume and discussing ideas and their opportunities in the design. The analogue methods are used mostly in the beginning of the sketching phase where volumetric studies, idea's brainstorming, and concepts need to formed and tested quickly.

CONTENT INDEX

DEAFSPACE #2

THE INCEPTION AND ISOLATION OF THE DEAF COMMUNITY

Educational institutions have an essential role for the deaf community. Unlike non deaf people, a school is not only for educational purposes, but a place where deaf people meet each other and often meet other deaf people for the first time. Through their educational years they have their primary social interaction with other people, which often result in lifelong friendships within the deaf community, because of -common the high focus on their way of communicate through sign language and visual orientation. [Jankowski, 1997].

In the nineteenth century the development of the deaf community in the United States evolved, when the first educational institutions for deaf people where founded. Before those educational opportunities, where limited within the United States borders [Jankowski, 1997]. Before the establishment of deaf educational institutions, deaf people lived relatively isolated, because most hearing people didn't use sign language and perceived deaf people, to be less intelligent as hearing people [Jankowski, 1997].
The first American school for the Deaf, where founded in 1817 in Hartford, Connecticut, by Mason Fitch Cogswell, Laurent Clerc and Thomas Hopkins Gallaudet. Several other educational institutions were founded afterwards often by people how also where deaf [Jankowski, 1997].
Through time American Sign Language (ASL) were naturally developed among the Deaf students. Being deaf and use sign language when communicating where essential in binding the Deaf people together. They cherish their common bond and often remained within the community by getting employed at the educational institutions for Deaf people. This increased the amount of teachers that where deaf themselves every year. They took through the years more and more initiative in their own education, and most educational institutions for deaf people has been founded by or being run by deaf people themselves [Jankowski, 1997].

The deaf community became an enclosed cultural environment, because of their mutual bond of being deaf that separated them from the 'hearing' society [Jankowski, 1997]. In many ways the deaf community is represented as a separated cultural society, like any other culture [Monaghan et al., 2003]. Being Deaf is a part of a deaf person's identity, which shaped a certain behavior, event and meanings of what is appropriate or not. Back in the late eighteen century, there was a growing resentment towards Deaf people, in the same ways as the immigrants that arrived to the United States in that time, just because of their cultural, communicational differences and behavior [Monaghan et al., 2003]. The use of sign language was banned from many educational institutions, and only oral communication methods where used (oralism), from the late eighteen to the mid nineteen century, in an attempt to protect, and include Deaf people in to the hearing society [Jankowski, 1997]. Even though sign language was banned from school, the deaf community persevered and kept developing sign language as their primary communication. The deaf community managed to reinstate sign language at the educational institutions in the late 1960's, because of academic results based on Deaf children of Deaf parents compared to Deaf children with hearing parents.
The border between the hearing society and Deaf community today is not as wide as back then, because of the implementation of speech training and lip reading at the educational institutions simultaneously with sign language (the combined system), which was proposed by Edward Miner Gallaudet (Thomas Hopkins Gallaudet son) in around 1990 [Jankowski, 1997]. The Deaf community still remains a close cultural society with a high identity focus on their Deafness, because they still don't have access to the public society [Jankowski, 1997].

The 'hearing' society today often refers to Deaf people as 'impaired hearing or 'hearing disabled', because of their lack of hearing and ways of communicating. This is partly lack of awareness of deaf people in the hearing society, which still creates prejudice and discrimination towards the deaf community [Jankowski, 1997]. The deaf community is still today working towards full participation in the public life in the hearing society [Jankowski, 1997].

GALLAUDET UNIVERSITY HISTORY

Gallaudet University is the only bilingual liberal arts university in the world where education and research programs for deaf and hard of hearing students are conducted in American Sign Language (ASL) and English.

The history of Gallaudet has been inextricably linked with the history of Deaf Culture in the U.S., since it was established in 1864, when President Abraham Lincoln signed the Gallaudet's chart, establishing the institution for the purpose of educating the nation's deaf and hard of hearing students.
Through an act of Congress in 1954, the entire institution became known as Gallaudet College in honour of Thomas Hopkins Gallaudet.
During the twentieth century, Gallaudet continued to grow as an educational institution and central point for the deaf community. In 1988, the Deaf President Now movement was a landmark event in Deaf Pride, where students of the University rebelled against the appointment of a hearing president in a protest that led to prominent media coverage and the naming of the University's first deaf president. This, not only brought the administration of Gallaudet more closely in line with the ethos of its student body, but the protests were also a landmark moment for deaf empowerment and self-determination. (Competitions.malcolmreading.co.uk, 2016)

The University today is viewed by deaf and hearing people community as the principal resource for everything related to deafness. Gallaudet leads the nation in research on communication access technology and services, deaf history and culture, and is a National Science Foundation Science of Learning Center, which conducts research on visual language and learning. (Competitions.malcolmreading.co.uk, 2016)

“Being deaf is about experiencing the world visually”

[Mills, 2006]

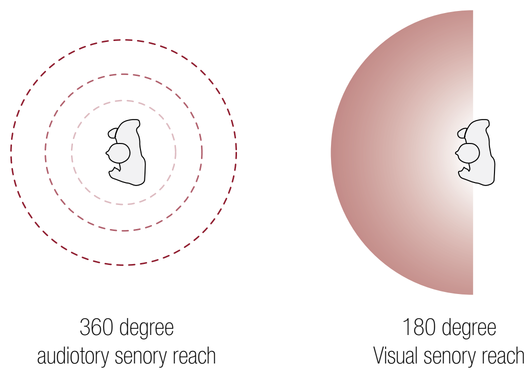
Mills, L. (2006). Look at me. Mooloolaba, Qld: Honeybee Creations.

DEAFSPACE ARCHITECTURE DEVELOPMENT

The core concept of Social sustainable development is determined by social equity, which is given by the opportunity to participate in social, economic, and the political life of the society. When this is not achieved, it could result in stressors, isolation and conflict which we often see taking shape as racism, prejudices and discrimination [Giovannoni and Fabietti, 2016; Basiago, 1999; Bauman, 2015]. Even though the deaf community has come a long way in the history, they are still experiencing a high amount of stressors, isolation and conflict in their everyday life in the main society. The deaf community considers itself as a culture in the same way as the hearing society consider another nationality as a culture, because of the use of another language, behavior, traditions and norms, which defines it [Malcolm Reading Consultants, 2015].

Many of the stressors daily experienced by deaf people is related to their interaction with the surrounding space, which is created for and by hearing people [Bauman, 2015]. This is mostly the result of the architects' modern paradigm approach towards creating architecture, which doesn't take Deaf people's visual communication and expression into consideration. The modern paradigm focuses on the creation of a beautiful building and afterwards takes inhabitants in to consideration [Bauman, 2015]. This creates a strong disconnection between the building and its habitants, which can lead deaf people to a feeling of isolation and alienation due to the difficulty to interact socially.
The social interaction and participation in the society is quite minimized for deaf people compared to hearing people, which makes the social equity uneven according to the core concept of social sustainability. The reasons of this inequality are to be found in the space that architecture surrounds which often minimizes opportunities of social interaction instead of emphasizing them. The ability to improve these conditions highly depends on the awareness on the social responsibility the society has [Giovannoni and Fabietti, 2016]. When concerning the creating of space with architecture, the architect is the primar responsible for the final outcome of it, depending on the decisions and considerations that has been made during the design process [Bauman, 2015].

According to Hansel Bauman (Architect and Executive Director of Campus Design and Construction at Gallaudet University) a more organic paradigm approach is needed to achieve a more empathic and integrated design solution for deaf people and their needs [Bauman, 2015]. Studies have shown that a building can have negative effect on people's identity development and their wellbeing [Bauman, 2015]. From the previous text on the deaf community it is very clear that the educational institution is the deaf society foundation for learning and cultural identity, which makes it even more important that schools adapt according to the students and their culture.



Ill 2.1 Showing sensory difference between deaf and hearing people [Sirvage, 2015].

DEAFSPACE DESIGN PRINCIPLES

For Deaf and hearing impaired people the hearing sense is either reduced or not present at all. This, compared to a hearing person, gives different kinds of struggles when interacting with the surroundings [Sirvage, 2015]. The main difference between a hearing and deaf person is the high different on sensory reach. A hearing person have 360 degrees sensory reach, which makes it possible to have a auditoria experience of what is happening outside of our visual field, compared to a Deaf person who only have 180 degrees visual sensory reach [Sirvage, 2015]. The minimized sensory reach causes a greater security risk when moving round, because the unawareness of what happening behind you, or around a corner, where the visual reach is limited [Sirvage, 2015].
The visual sense has become Deaf people primary way for orientation, spatial awareness and communication that maintain their cultural identity, but the lack of hearing still creates struggles and security risk when interacting with the built environment that is design by and for hearing people [Gallaudet University, 2015].

The architect Hansel Bauman has developed the DeafSpace Design guidelines, which is a catalogue with more than 150 architectural design principles that emphasizes five main points to improve the built environment for Deaf people. The goal with the implementation of these points is to enhance the idea of community buildings, higher opportunity for visual language and secure a higher personal safety and well-being [Gallaudet University, 2015].

Sensory reach

As mentioned earlier the visual reach is quite limited compared to the auditoria reach. Deaf people's spatial awareness and orientation of the activities taking places around them is important to maintain to enhance their well-being. They visually read their soundings like movements in objects, shadows, vibrations or facial, body expression of people around them. When these are designed in to their built environment it can extend the sensory reach to the 360 degree, like a hearing person, to have the same feeling of orientation and spatial awareness [Gallaudet University, 2015].

Space and proximity

When using sign language it is important to enhance a clear visual connecting, by standing in a distance to see the facial expression, but also ensure enough space for signing. The distance between people that are signing is usually larger than people speaking to one another, and it grows the more people there is in the conversation to maintain the clear visual communication among all parties [Gallaudet University, 2015].

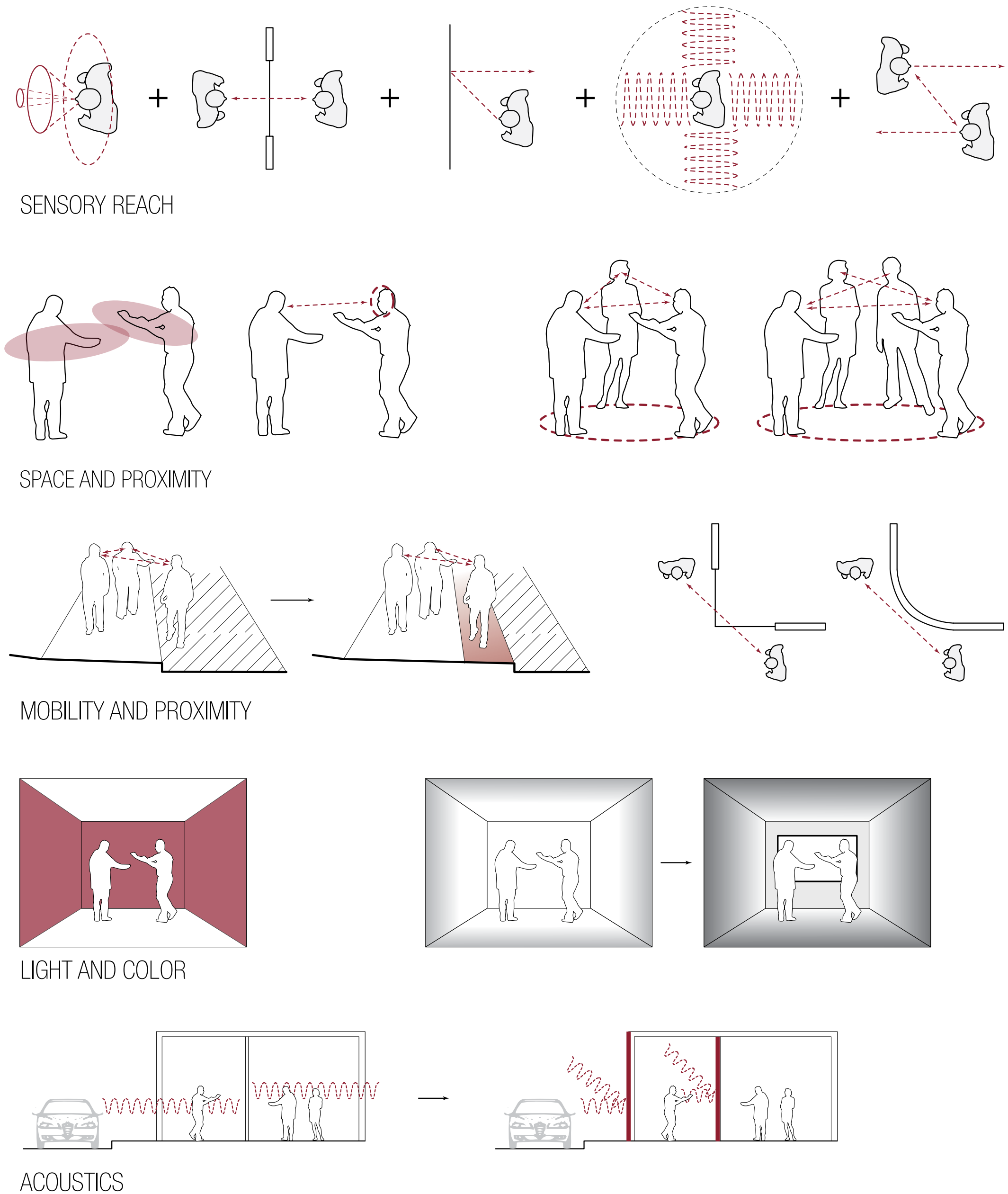
Mobility and proximity

A larger distance is often necessary to maintain clear visual communication when signing conversation is taking place while walking. Meanwhile they shift between the conversation and scanning their soundings to ensure to steer around obstacles and in the right direction. If the slightest obstacle is detected they alert the involved in the walking conversation, to adjust and then continue the conversation without interruption. These difficulties often appear as sidewalks, corners, columns etc [Gallaudet University, 2015].

Light and color

Unsatisfying light conditions such as shadows, glare and direct backlighting makes it difficult to obtain visual communication and also causes tired eyes, that can minimize concentration and make people physically exhausted. Architectural elements and electric lighting can be designed to provide a soft diffused light to make better conditions for visual communication and well-being. The choice of color that contrast the skintone can highlight a person that is signing and for visual orientation [Gallaudet University, 2015].

Acoustics
Hear impaired, have different levels of hearing and many used implanted hearing devices to improve their hearing. Many Deaf people do sense sound in different levels and is often a distraction, especially when using hearing devices. The distraction is caused by the reverberation and background noise from hard surfaces and can quite painful even for them that is using hearing devices, and therefore need to be minimized [Gallaudet University, 2015].



Ill 2.2 Selection of diagrams from the DeafSpace Design Principles describing the five points it consists of [Bauman, 2015; Gallaudet University, 2015]

IMPLEMENTATION OF THE DEAFSPACE DESIGN PRINCIPLES

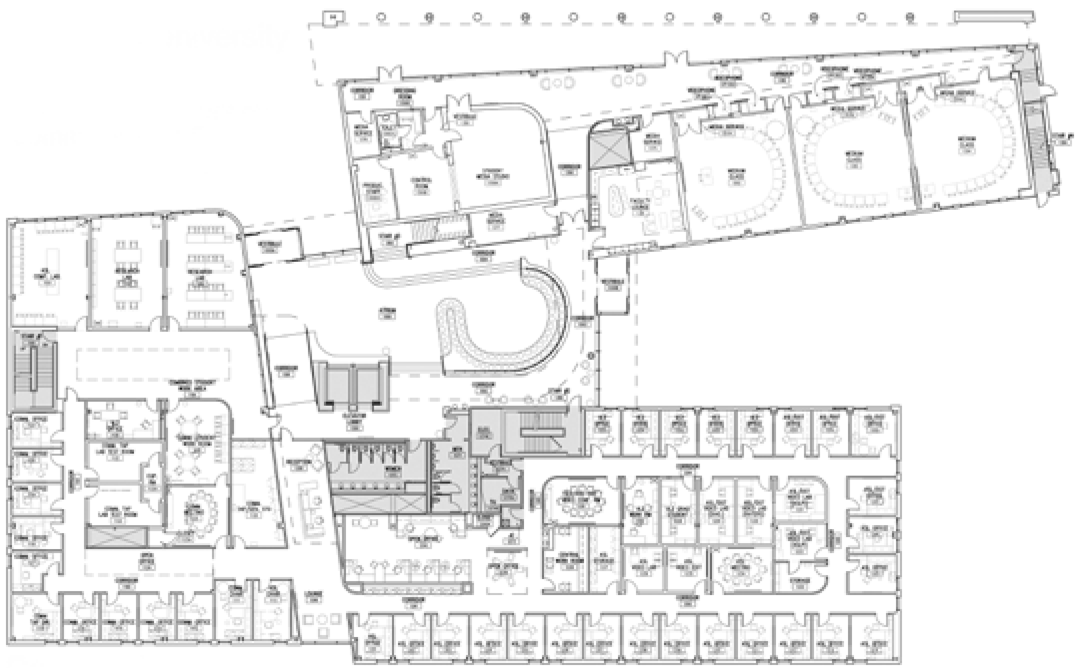
The deaf space principle is still being further developed at Gallaudet University by Gallaudet students, staff and faculty together with Hansel Bauman. The principles have been used for a few buildings, so far, and most of them are placed on the Gallaudet University campus site and has also been an important part of the development of the creation of deaf space [Gallaudet.edu, 2016]. Two of the buildings on the campus site, that has been a part of this development has been studied and compared to see how the design principles can be implemented and how spaces can positively and negatively affect the Deaf way of being.

SORENSON LANGUAGE AND COMMUN ICATION CENTER
By Smith Group Architects

Besides being an educational institution, Gallaudet University is also a leading international research center, within the American Sign Language (ASL), historic, and cultural and Deaf community [HEERY.com, 2016]. Sorenson Language and Communication Center (SLCC) is a three-storeys building, constructed in 2009, including educational and research facilities like computer laboratories, classrooms, offices spaces, audio-testing clinics and a central atrium were an integrated amphitheater-like seating area is made [HEERY.com, 2016].

This project became the starting point of the development of the Deaf Space design principles [Gallaudet.edu, 2016]. One of the key features for the design was the creation of the open, light and transparent connection between spaces to ease visual communication [Smithgroupjjr.com, 2016]. The project started out with a workshop with a gathering of deafs and professionals within the field, that collected a series of inputs for the further designing of the SLCC Building [Bauman, 2015]. This resulted in a building with a full-height glazed façade to a bright central atrium, with direct visual connection between all spaces like class rooms, offices ect. Special designed furniture was also made to emphasis and ensures visual connection [Smithgroupjjr.com, 2016].

Even though this building emphasized in many ways the Deaf way of being, by making these open spaces, higher the security with transparent elevators and gathering seating areas where the sensory reach was much better that seen in other 'regular' buildings, some new issue arises concerning light and privacy. According to Hansel Bauman it is a result of the common architect's modern paradigm approach of designing, where the aesthetic idea is shaping the building rather than going in to depth of the inhabitant's needs and way of living [Bauman, 2015]. The architects used Deafness needs for visual connection to communicate, to create a very large atrium space and direct visual connection between all spaces. But what was forgotten was the need for the dualism between the open spaces of visual accessibility and the private sphere of Deaf people's conversation, which is missing in the SLCC building at Gallaudet [Davis, 2013]. Many of the glazed walls and doors has been covered with paper or fabric because people feel to exposed.

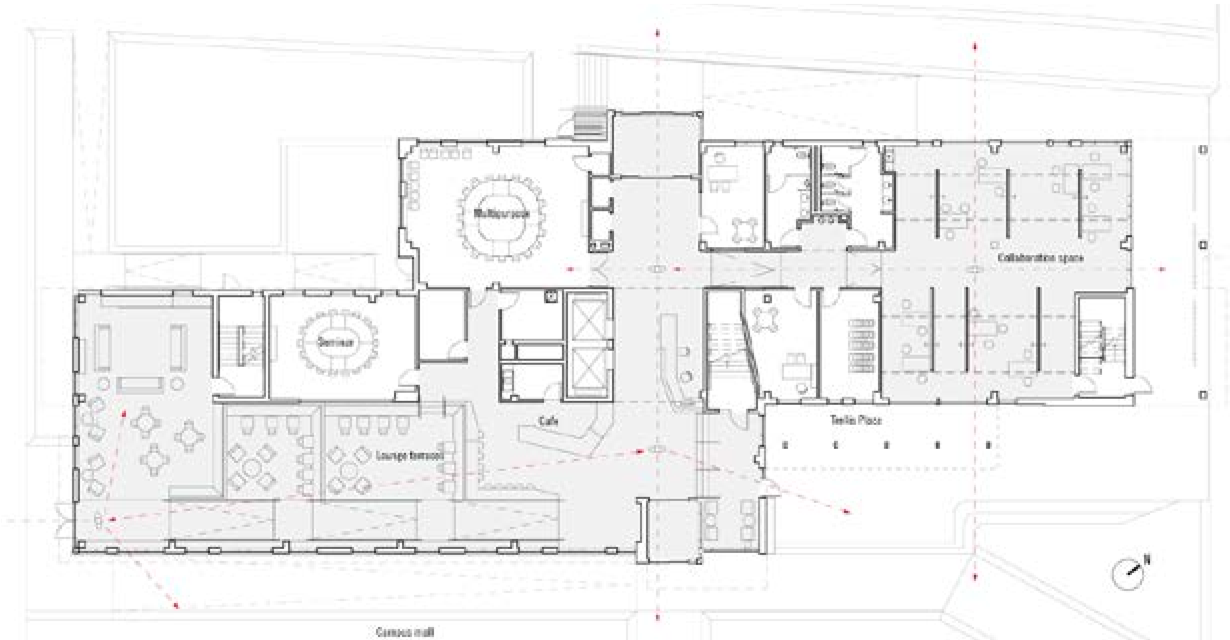


Ill 2.3 Ground floor plan of the SLCC building

Ill 2.4 Exterior image of the SLCC building

Ill 2.5 Interior image of the SLCC building, with a amphitheatre-inspired integrated seating arrangement for presentations and gatherings

DEAF SPACE



Ill 2.6 Ground floor plan of the LLRH6 building

Ill 2.7 Exterior image of the LLRH6 building and the sloping terrain

Ill 2.8 Interior image of the common room of the LLRH6 building, where the use of the landscape it is visual in the terraced levels.

LIVING AND LEARNING RESIDENCE HALL IV
By LTL Architects

The Living and Learning residence Hall IV (LLRH6) was constructed in august 2012 and is the first building developed and designed according to the cataloged with the DeafSpace design principles [Gallaudet.edu, 2016]. The five-floors-building serves as a residence hall and consists of functions such as kitchens, fireplace, common room, small fitness room, laundry room, seminar, terrace, multifunctional room, five apartments, and 46 suites, which consist of two double rooms and a bathroom each. In total the building can accommodate 164 students [Gallaudet.edu, 2016].

The building is very much related to its sloping landscape and the Victorian gothic style of the existing historic building on the campus site, by the use of materials like brick and slate together with the window pattern and sloped roof and ground floor [Gallaudet.edu, 2016]. Terraced sections of the common room on the ground floor following the landscape, gives the opportunity to have several small conversations or one whole of a lecture or a movie night, which creates a higher level of privacy to enhance the livability for Deaf people in their built environment [Bauman, 2015; Gallaudet.edu, 2016]. The common room and other gathering spaces is facing the Mall green and gives a clear visual connection from both inside and outside the building. The rooms have a high level of flexibility because of the high amount of doors that can be opened to extend the indoor space to the outdoor, when the weather is good [Gallaudet.edu, 2016].

The integrated use of the landscape to create the level of privacy gives a material grounding that stimulated the senses, together with the use of wood that both separates the room and creates warmth and comfort [Bauman, 2015; Gallaudet.edu, 2016].]. Deaf people were much more involved in the design process during this project and much more knowledge was gained through the creation of the design principles [Bauman, 2015]. This high integration of the principles was because of the more organic paradigm approach of designing, which focuses much more on creating Vernacular architecture. This has a higher emphasis and connection between the inhabitants and the buildings, making it much easier for deaf people to connect and use the spaces that they inhabit [Bauman, 2015].

DEAFSPACE SUMMARY

Ill 2.9

The history and development of the deaf society is quite short, because of late acknowledgment of the deaf people and their rights. Even though the equality between deaf and hearing in terms of education and economy is reached today [Giovannoni and Fabietti, 2016; Basiago, 1999; Bauman, 2015], the social inequality still remains, since the hearing society is still not aware about deaf people. This unawareness creates the fundamental issues in architecture that Hansel Bauman describes. Our built environment is made by hearing architects and many of them is unaware of how architecture often affect people without the auditory sense and how architecture even can endanger their personal safety [Bauman, 2015].
From the research one of the main issues still remaining is the balance between the privacy and public spaces in terms of extending the sensory reach. SLCC building is an example on how the good intention of the architect to strongly enhance visibility to extend the sensory reach instead creates issues for the inhabitants.

The development of the Deaf space design principles, gives some concrete tools and an understanding of how the spaces can be made to both accommodate both deaf and hearing users.

How to ease social intergration and interaction of Deaf people in the built environment and how to arise awareness now and in the future, when creating architecture.

CONTENT INDEX

SPATIAL PERCEPTION #3

TECTONIC: A KEY WORD TO GOOD ARCHITECTURE

Even in an architectural context, in colloquial usage, the difference between structure and construction is often blurred, and the word tectonic is rarely used.

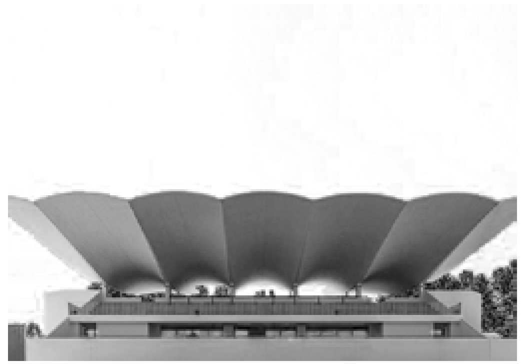
To better understand the difference between structure and construction a simple experiment of substitution can be done, as Eduard F. Sekler suggests: thinking about '*construction of society*' and '*structure of society*' it is easy to grasp the great difference. Construction carries the connotation of something put together consciously, while structure refers to an ordered arrangement in a wider sense. [Sekler, 1965]. With regard to architecture, structure, in the abstract sense, refers to a system of arrangement destined to cope with the forces at work in a building; construction, instead, refers to the concrete realization of the system, a realization which is carried out with a number of materials and certain techniques. In actual practice structural change and constructional effort should be inseparable and in continuous interaction. [Sekler, 1965; Pace, 2013]
The word "*tectonic*" reminds us of the basic human activity of giving visible shape to something new. [Sekler, 1965].

With an overview on the etymologic history of the word it is easily possible to understand how this concept is naturally connected to architecture.

Originally the word *tektonikos* referred to the craft of the carpenter and the builder, which in ancient Greek was called *tekton*. French 17th-18th century authors spoke of tectonics as the need to give a building visual qualities capable of convincing the viewer of its solidity and plausibility. In early 19th century, with an increased concern for a better understanding of Greek architecture, tectonic was one of the terms that was re-discussed and given greater depth and precision of meaning. [Sekler, 1965; Pace, 2013]

Ill 3.1 Mud huts of the Musgum tribe from Lake Tchad

Konrad Fiedler became extremely important for the understanding of 20th century art for having introduced the concept of '*pure visibility*' [Fiedler, 1970]. His thinking enabled the recognition of tectonic expression as one result of universal artistic activity. Through tectonics, the architect may make visible the intensified kind of experience of reality which is in the artist's domain – in the architectural case the experience of forces related to forms in a building. Thus, structure, the intangible concept, is realized through construction and given visual expression through tectonics. Around 19th century two German architects published books with the word tectonics in their titles: both Karl Boet-



Ill 3.2 Hipódromo de la Zarzuela, Madrid, Spain by Eduardo Torroja

ticher and Gottfried Semper treated as a key problem the relation of final and expressive architectural forms to prototypes born from technological, constructional necessities [Semper, 1989; Boetticher, 1832]. The discussion was splendidly corroborated by the psychological investigations of Theodor Lipps, whom, with his theory on aesthetics, had formulated and elaborated the concept of empathy [Lipps, 1903].

Ill 3.3 Torino Esposizioni, Torino, Italy by Pierluigi Nervi

Empathy is one operating concept in Heinrich Wolfflin's analysis of architecture: he recognized tectonics as the particular manifestation of empathy in the field of architecture [Wolfflin, 1976].

There are cases when a building is almost a perfect realization of a structural principle in terms of the most appropriate and efficient construction, leading to an unequivocal tectonic expression.

Such examples may occur in anonymous (or vernacular) architecture, as the "*mud huts*" of the Musgum tribe from Lake Tchad (Ill 3.1), or in high quality architecture. Example of this may be found in Torroja's buildings (Ill 3.2), Nervi's Exhibition Hall in Torino (Ill 3.3), which illustrates what himself calls 'a synthesis of static-aesthetic sensitivity, technical knowledge and mastery of execution' or the Unitarian Church in Madison, Wisconsin by Frank Lloyd Wright (Ill 3.4) [Sekler, 1965].

These are just very few examples showing how great architects have always handled elements of tectonic expression with extreme care and imagination. Among the three concepts, structure, construction and tectonics, the latter is the most autonomously architectural. [Pace, 2013]

Ill 3.4 Unitarian Church in Madison, Wisconsin, USA by Frank Lloyd Wright

THE ARCHITECTURAL VOICE

When a structural concept has found its implementation through construction, the visual result will affect the observer through certain expressive qualities, which are connected to the play of forces and corresponding arrangement of parts in the building, yet cannot be described in terms of structure or construction alone. These qualities are expressive of the relation form to force: tectonic. [Frampton and Cava, 1995]

Gottfried Semper gives a very clever explanation to this concept, in his works "*The Four Elements of Architecture"* [Semper, 1989] and *"Style in the technical and tectonic arts"* [Semper, Mallgrave and Robinson, 2004].
He shows us how the relation between the purpose of construction to its form is extremely affected by its ethnography and topography. Each material and construction technique is pertinent to a place and a specific historical and cultural moment, according to which specific forms can be developed. This means that to the same question there are several correct answers, thus challenging the *Theory of the Primitive Hut* of Marc Antoine Laugier. [Semper, 1989]
Gottfried Semper adds the notion of place to the function of form.

The expressiveness of a building is given by the art of putting together materials with certain techniques, both of which resembling their pertinence to a place, and both counteracting the external specific conditions.
The art of joining develops the whole out of innumerable details. Is in the detail that the answer to the form to force equation is found. The detail represents the technological advancement, meaning that it holds the ethnography of an architecture, telling the story of its place and its culture. [Frascari, 1984]
Details give signification of the whole to which they are inherent part, bringing together the tangible with the intangible. They are mean of expression of tectonic quality. [Frascari, 1984]

When architecture is freed of ornamentation, this allow the expressiveness - historically, aesthetically, functionally, personally, passionately - of the details to flourish, therefore, manifesting the innate purpose of the building. This honesty in the architectural expression gives each part of the building certain aesthetic, decorative qualities. [Loos and Opel, 1998]
When a building has such an expressive character, then it is able to appeal our minds and emotions in various ways, creating a feeling of comfort.

Our desire to feel a place with all our senses is given by our need to strengthen the sense of being in a place and to grasp the continuity of time. A building should be able to resist time, in order to exploit its monumental characteristic, meaning the ability to teach and to remember, as the word '*monumentum*' derives from the Latin verb '*moneo*', which means *'to convince, to drive attention, to remember*'. [Pace, 2013; Mabilia and Mastandrea, 2008]
A building should also naturally grow up in its surroundings by being expression of certain qualities that create a sensuous connection, awakening our memories, and strengthening one's sense of being. [Pallasmaa, 2008]

Ill 3.5 Essai sur l'Architecture, frontspiece by Charles-Dominique-Joseph Eisen

"It is not the reality of theories detached from things, it is the reality of the concrete building assignment relating to the act or state of dwelling that interests me and upon which I wish to concentrate my imaginative faculties. It is the reality of building materials, stone, cloth, steel, leather… and the reality of the structures I use to construct the building whose properties I wish to penetrate with my imagination, bringing meaning and sensuousness to bear so that the spark of the successful building may be kindled, a building that can serve as a home for man.

[Zumthor, Oberli-Turner and Schelbert, 2006]

SENSES

"That door handle still seems to me like a special sign of entry into a world of different moods and smells." [Zumthor, Oberli-Turner and Schelbert, 2006]

The third element in Vitruvius's description of architecture, following *utilitas* – utility - and *firmitas* - sound structure - is *venustas* - delight. This is the most complex and diverse component of architecture, for it involves how the architectural object engages all the senses, how it shapes our perception and enjoyment of the built environment. Its complexity lies in the involvement of the subjectivity of each individual and culture. [Vitruvius Pollio. and Morgan, 1960]

From the second half of the 20th century the quality of delight in architecture has assumed a more holistic character. *Venustas* started to be considered the mean though which an architectural integrity could be achieved.
Beauty lies in natural things. In nature things do not carry any message, they simply grow in the perfect place for them to grow and they take the shape that the environment better allows them to take. [Zumthor, Oberli-Turner and Schelbert, 2006]

This allow our emotions to emerge.

We should always aim at creating architecture which naturally grows in the place. If the building is accurately conceived in terms of place and functionality, it will develop an emotional power. [Zumthor, Oberli-Turner and Schelbert, 2006]

SEEING

The visual pleasure in architecture derives from our perception of it; from how the human mind receives and interprets visual data.
What we "see" is based on what we already know [Peter and Jones, 1963] and our mind seeks to place the information it receives into a unique pattern. When receiving unknown information, the mind organizes the data according to certain built-in preferences, aiming for order and regularity, or absolute uniformity. Though, if the information becomes purely repetitive, the mind will focus on the deviations from the anticipated pattern. [Mach, 1996]
There is also a kinesthetic, empathic bodily response to forms and lines. For example, the horizontal line is senses as being at rest, while the vertical is sensed as aspiration, assertiveness, there is a sense of dynamic equilibrium in verticality. [Mach, 1996]
This very short insight on the psychology of *Gestalt* shows how close what we see is to a total bodily response.
Still, we may have to make a distinction between the focused vision and the peripheral vision. In fact, while the former let us confronting with the world as mere spectators, the latter is the responsible for transforming retinal *gestalt* into spatial and bodily experiences, thus integrating us with space. [Pallasmaa, 2005]

Nowadays, the speed of technological advances is such that the sense of sight is the only one able to keep pace with it. Though, this is cause of a flattening of the perception of the world around us. This phenomenon creates a sense of detachment and alienation from the space surrounding us.
The reasons for this are to be found in the fact that the way we perceive a space, the way it sounds or smell, has equal weight for the human experience to the way it is seen. [Pallasmaa, 2005]

It is possible to say that, nowadays, the hegemony of sight and hearing over other senses, such as touch, smell and taste is accepted in the collective culture. This is so, especially because touch, smell and taste are considered private senses and not useful in terms of social interaction. Reasons of this are to be found in the shift from oral to written speech, a shift from sound to visual space, from situational thinking to abstract thinking [Ong, 1982].
However, the sense of sight it is a first step towards knowing the world, in fact, it can incorporate and even reinforce other senses. It also through sight that the other senses may a larger involvement in the experience of a place, but it is reductive, and dangerous, to think that sight is the

most immediate or important sense in the innate complexity, comprehensiveness and plasticity of our perceptual system. [Pallasmaa, 2005]
According to Pallasmaa, all the senses, including vision, are an extension of the tactile sense, as all the senses are specialization of skin tissue and all sensory experiences are modes of touching.

HEARING

"Sight isolates, whereas sound incorporates, vision is directional, whereas sound is omni-directional. The sense of sight implies exteriority, but sounds create and experience of interiority." [Pallasmaa, 2005]

Buildings can talk to us by returning sounds to our ears. Every building, every space has a characteristic sound. By listening to a place is possible to grasp an incredible amount of information. This knowledge, often, remains an unconscious background experience because of the overwhelming power of the sense of sight. [Pallasmaa, 2005]
Through sound it is possible to measure a space, to understand its materiality and, even, to grasp about the technical implementations in construction. It is possible to create an affinity with the place.
Every city has its specific echo, which depends on the pattern and scale of its streets and on the prevailing architectural styles and materials. The wide, open spaces of contemporary streets do not return sound and in the interiors of today's building reverberations are absorbed and censored. [Pallasmaa, 2005]

SMELLING

The olfactory nerve is the only direct connection between the brain and the outside world. The anatomical composition of our body tells a lot about the importance of smelling. The scent of a place creates in us persistent memories, much stronger than the ones in the retinal memory. The sense of smell is also an important factor in terms of social interaction, leading us toward places and people which smell is accepted by our brain. Reference [Pallasmaa, 2005]
Through smell we can sense the materials composing a place, the objects present in it, the age of the place and its use.
Every city has its spectrum of tastes and odours. The retinal images of contemporary architecture certainly appear sterile and lifeless when compared with the emotional and associative power of the olfactory imagery. [Pallasmaa, 2005]

TOUCHING

"Hands are a complicated organism, a delta in which life, from the most distant sources, flows together surging into the great current of action. Hands have histories; they can even have their own culture and particular beauty. We grant them the right to have their own development, their own wishes, feelings, moods and occupations", writes Rainer Maria Rilke in his essay on Auguste Rodin. [Pallasmaa, 2005]

Hands are incredible means of communication, among people and among people and the surroundings. Through the hand we can understand the texture, the weight, the density, and temperature of matter. Our hands are the door to the unknown: we shake hands of countless generations, as of countless buildings and rooms. Through our feet we measure gravity and we trace the texture of the ground and its steepness. With our skin we can sense temperature with incredible precision. [Pallasmaa, 2005]
Skin is mean for knowledge.

TASTING

"I would like to eat up this Verona touch by touch." [Ruskin, 2001

There is a subtle transference between the tactile and the taste experiences, which can be felt when the surrounding is such to allow an integrity of sensory perception.
Vision itself, the sense of detachment, can be transferred to a taste; certain colours and delicate details may evoke oral sensations. [Pallasmaa, 2005]
"Tasting" represent a very critical phase in the process of learning, between 0-3 years old. [Freud, Strachey and Richards, 1977]
Our sensory experience of the world originates in the interior sensation of the mouth, and the world tends to return to its oral origins. The most archaic origin of architectural space is in the cavity of the mouth.

The architectural experience brings the world into the most intimate contact with the body. A great architecture can empower our sense of being.
The primitive man used his own body in dimensioning and proportioning the system of his construction. He built what his body would allow him to do. Therefore, his architecture was intrinsically related to his existence. The architectural meaning derives from archaic responses which are remembered by the body. To be meaningful and create a sensation of comfort, architecture has to respond, to awaken the traits of primordial behaviour that has been passed down by the genes.

Architecture should relate to our collective historical memory of the place. Gottfried Semper cleverly explains, in "The four elements of architecture", that specific techniques and types of architecture develop according to what is available from nature. [Semper, 1989]

If architecture is created with respect of the nature of the place, a multi-sensory experience is most likely to be created: the qualities of space, matter and scale will be equally measured by the eye, the ear, the nose, the tongue, the skeleton and the muscle; strengthening the existential experience. [Pallasmaa, 2005]

Therefore, the timeless task for architecture is to create existential metaphors, by engaging with fundamental existential questions related to identity and memory, to interaction and separation, to societal and cultural order, to the structure of action and power. Architecture should become an integral memorable experience of our sense of being. [Pallasmaa, 2005]

Ill 3.6 Objects a Reaction Poetique by Le Corbusier, 1931

MATERIALS

Gottfried Semper revolutionary classification of architecture is based on the treatment of materials available in a place. Construction materials are well known, yet, to create architecture, we must learn how to handle them with acute awareness. [Semper, 1989]
Each material has specific properties - as compressive strength, elasticity, ductility, weathering, density, porosity, hygroscopy… - which defines what it is capable or non-capable of. According to its ability, each material pertains to a certain set of forms, which fully exploit its properties. [Semper, 1989] (Ill 3.7)

The research for the right materials is work of remembering. [Zumthor, Oberli-Turner and Schelbert, 2006)
Every design begins by questioning the materials, therefore the technologies, that best respond to the specific external condition, contemporarily allowing an objective sensuousness of architecture to arise. (Zumthor, Oberli-Turner and Schelbert, 2006] (Ill 3.8)
There is to be found the importance of knowing materials and their properties and using them in the way that suites best. Materials have the poetic power to awaken our sense of being, when treated with respect for their properties.
Natural materials, such as stone, wood and brick, express their age and history, the history of their origins and of human use. They show us the passing of time through weathering and through the technological implementations. This allows us to become convinced of the veracity of their matter in the continuum of time. [Pallasmaa, 2005]

Nowadays, technological evolution has led toward an unconscious use of materials. The shiny, glass and stainless-steel architectures represent mausoleums that deliberately aim at ageless perfection, where the dimension of time gets lost.
Only in recent decades, a new architectural conception has emerged, which employs reflection, gradation of transparency, overlay and juxtaposition to create a sense of spatial thickness, as well as subtle and changing sensations of movement and light. This new sensibility promises an architecture that can turn the relative immateriality and weightlessness of recent technological construction into a positive experience of space, place and meaning. [Pallasmaa, 2005]

LIGHT

Light is perhaps the most powerful element of perception of architecture. Light defines spaces as much as other physical elements of architecture. Louis Kahn saw Greek colonnades as an alternation of n*o-light, light, no-light, light*, and the results of his understanding of light and shadow are clearly shown in his works [Schielke, 2013].

The variation of light and shadow allows a physical understanding of a place, it shapes it, it elucidates its function, and it gives it measurability. According to the type of light, a building can show several settings.
Attention can be drawn with a focused light to highlight certain elements and specific spatial senses can be created, insight or outside the lit up area. Diffuse lighting creates a sense of privacy, individuality and calmness. Moving light gives life and dynamism to a space.
Light has a strong psychological effect. Thought light, it is possible to see colors which create specific psychological responses [Valdez and Mehrabian, 1994].

Important effect of the human mind is also given by the play of light and shadow. Homogeneous bright light paralyzes our imagination, while in an unfocused gaze, when the sharpness of vision is slightly suppressed, the mind can freely think. In moments of darkness or dim light, the mind is awaken by the sense of mystery created by the impossibility of seeing; distances become ambiguous and peripheral vision and tactile fantasy are called into play [Pallasmaa, 2005].
The art of "*chiaroscuro*" allow the architect the creation of spaces which arise our imagination and curiosity; the building becomes harder to foresee and much more attractive to human mind [Pallasmaa, 2005].

Ill 3.7 Colonnato di San Pietro, G. L. Bernini, 1650 ca., Città del Vaticano

SPACE

The history of architecture is the history of man shaping space. Spaces can be of many kinds.
The purely physical space is a building envelope containing a volume, creating a concavity, emptiness, specific light, air, receptivity and resonance. The perceptual space is the space understood through our senses; the whole body is engaged in it. The conceptual space – the mental gap between the above mentioned cases - is the space we carry around in our heads. The behavioral space is the space where we actually move. [Pevsner, 1968; Zumthor, Oberli-Turner and Schelbert, 2006]
Space can also be defined in terms of social interaction – the personal space – which is the distance that member of a species put between themselves. Human is extremely flexible in the determination of personal space, which can differ a lot according to the cultural implications. [Pevsner, 1968]
Architecture is a powerful determinant of behavior. *"We shape our buildings, and afterwards our buildings shape us"*. [Churchill, 1944] Space can suggest patterns of behavior by its very configuration, regardless of barriers; it can be highly directional or non-directional; static or dynamic; negative or positive.
Architecture should receive the human visitor and should enable him to experience it and live it. Architecture, through its components, should yield to the human perception rational hints about its space, in order to conceive a certain behavior. Simultaneously, architecture should hide its meaning and kindle its users imagination. The void embraced by walls and roof should maintain its vibrant mystery. [Zumthor, Oberli-Turner and Schelbert, 2006]
This constant tension and exchange among feeling – intended as responsive awareness leading toward emotional consciousness - and reason – intellectual, experiential, logic-driven knowledge - allows a progressive understanding of the whole.
The space we understand is the space we perceive and conceptualize. According to our conceptualization of the space, we will have a certain behavior in it. If the idea we create of space in our mind depends on the perception we have on it, then the latter becomes the tool through which we can shape behavior.

SPACIAL PERCEPTION SUMMARY

Senses become a tool for designing integration.

In this chapter we have illustrated the thematic analysis that has been carried through, with the intention of creating a series of ideas which lead us toward concrete design solutions.

The sketch represents diffirent architectural elements that can be used to adresse specific senses
The primary senses analysis and sensory approach to architecture find their implications in design solutions leading toward considerations on form, structure, materials, acoustics and light.

This kind of approach, unified with the use of DeafSpace Desing Principles, allows us the conception of a space which manages to extend the sensory reach of both hearing and non-hearing students.

The extension of sensory reach makes it possible for deaf people to have the same preception of space and thereby have same behavior and ease the intragtion and interaction in their built inviroment

Ill 3.8 The primary senses and architectural elements which address them.

building expressivity *3
senses: sense of being
integrity *4

+

materials: continuum of
time *5
light: imagination *6
space: behaviour *7

for

deaf community
normal hearing community
deaf cultural institution *2

toward

a paradigm of equality
and cultural identity

*1

integration *1

FORM

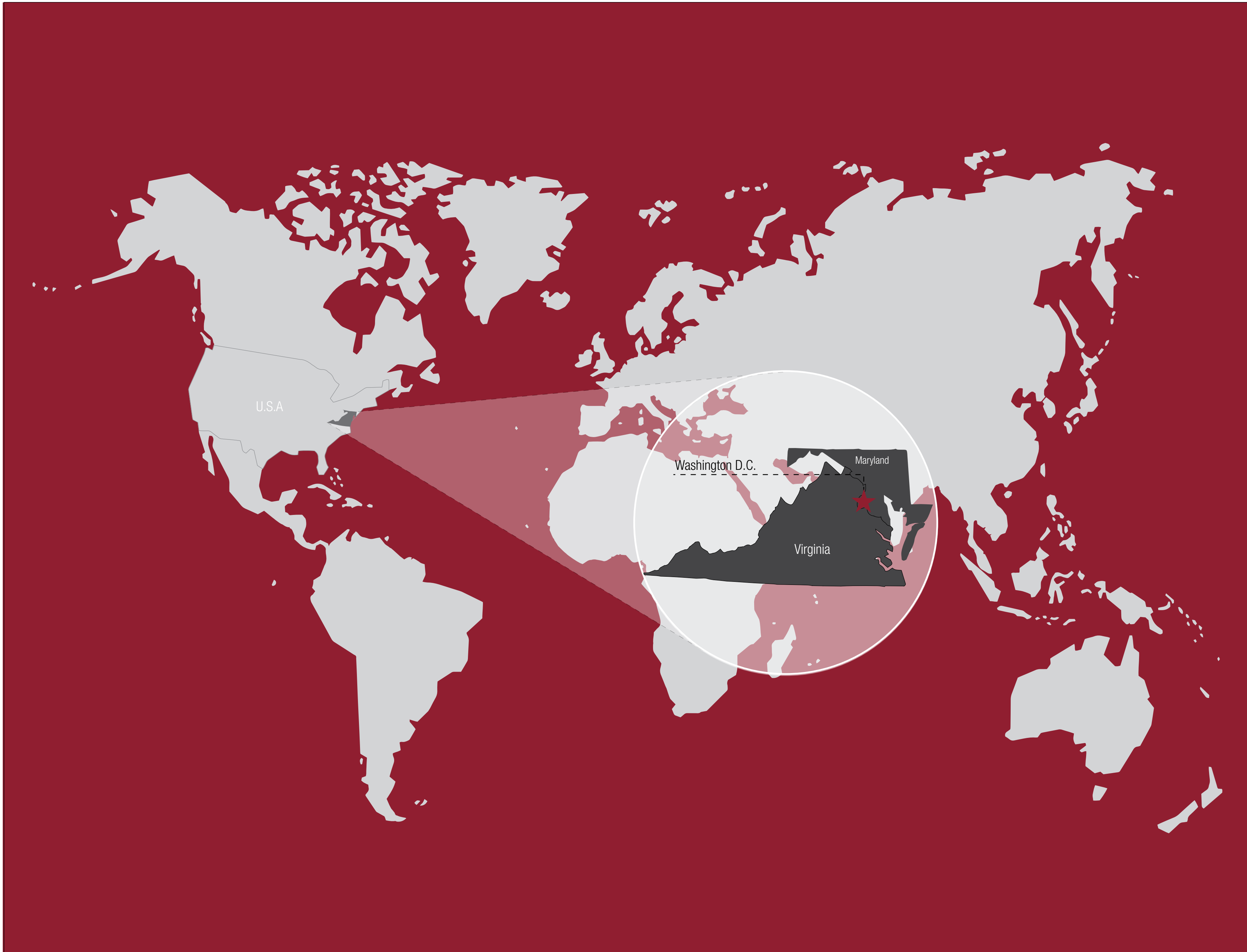
EXTERNAL CONDITIONS
site characteristics
climate
sustainability
applied forces
...

USERS
history
culture
needs
perception
behaviour
functionality
...

ARCHITECTURAL LANGUAGE
details
structure
light
acoustic
architect will
...

CONTENT INDEX

SITE ANALYSIS #4



Ill 4.1 Location of Washington D.C

PROJECT LOCATION

Ill 4.2 Location of Gallaudet University in Washington D.C

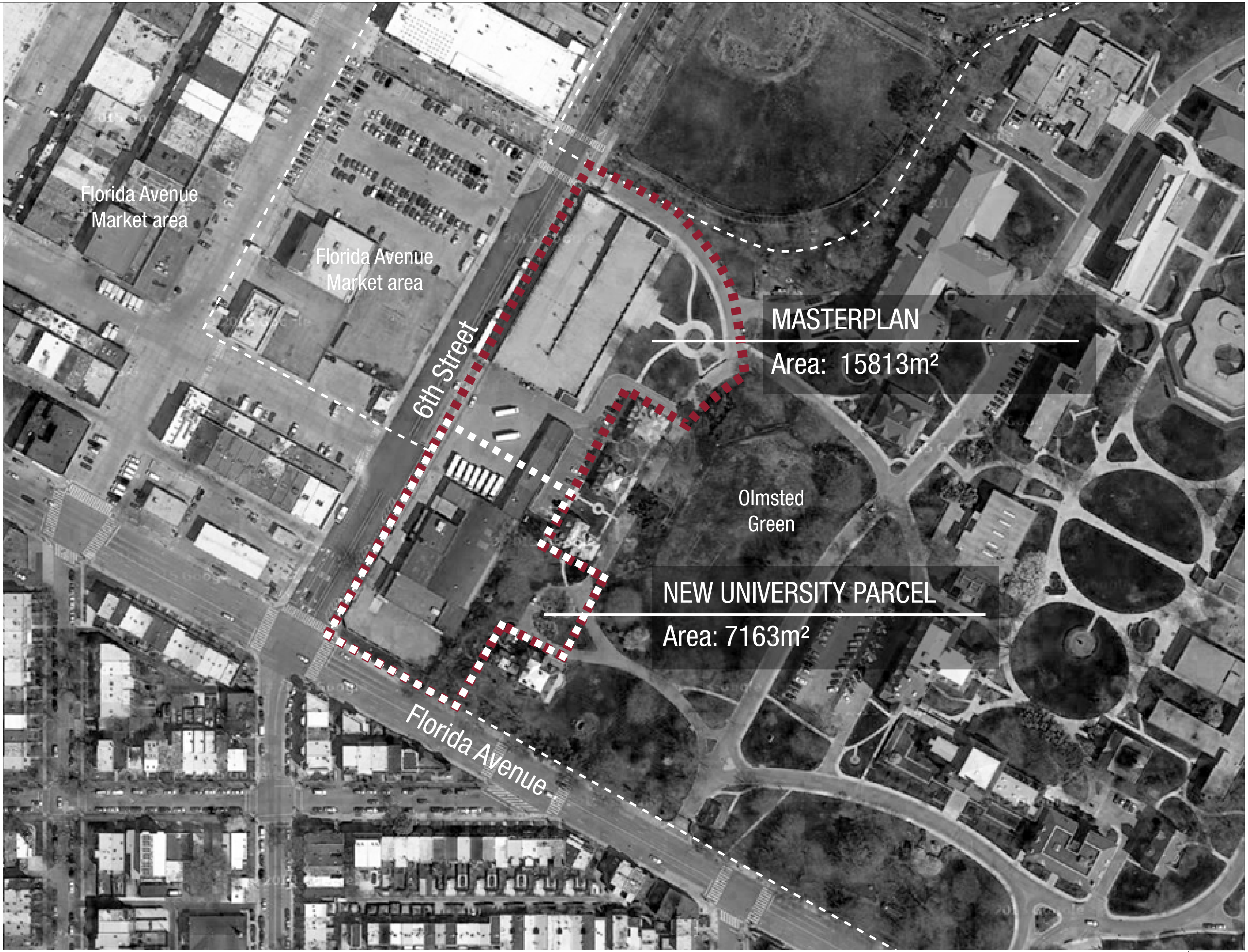
Gallaudet University is located in the North-East part of Washington, District of Columbia, between Maryland and Virginia, in the United States of America [denstoredanske.dk, 2016]. The city contains 5.5 million citizens, where approximately 105.000, of them, are deaf or have a hearing disability [Gallaudet University Library, 2014]. Washington D.C is separated from the contiguous states by the Potomac River. It is highly known for the home of the president, the Whitehouse, Pentagon and several educational institutions, museums and organizations. The city was inaugurated in 1800 a.C. and was named after the deceased president George Washington. A unique feature is that there aren't any skyscrapers, because of the city legislation, that prevent to constructions of buildings more than 10 floors [denstoredanske.dk, 2016].

SITE ANALYSIS

SPECIFICATION OF NEW UNIVERSITY PARCEL

This project is focused on the on the smaller part of the site placed in the South-West corner of the original campus site, between the Florida Market area, the 6th street and Olmsted Green. The red dashed line on ill. 4.4 defines the area that is going to be developing in a Master plan level. The white highlighted area in the same illustration defines the primary project area, which will be worked out more in detail in terms of designing and construction. All existing buildings is demolished and new one is built.

Ill 4.3 Location of site of Gallaudet University


Florida Avenue
Market area
Florida Avenue
Market area
6th Street
MASTERPLAN
Area: 15813m²
Olmsted
Green
NEW UNIVERSITY PARCEL
Area: 7163m²
Florida Avenue

GALLAUDET CAMPUS SITE

The original campus site was designed by Frederick Law Olmsted and his partner Calvert Vaux in 1866, and is an important historic landmark in the National Register of Historic Places [Gallaudet.edu, 2016]. The campus is today 400600 m2, and consist of 762000 m2 (floor area) educational, residential and support/service buildings, which includes the National Deaf educational center by Laurent Clerc [Gallaudet.edu, 2016]. The original campus site have co-existed with The Florida Avenue market area quite well for approximately 150 years, but after they bought a part of it for further expanding the campus, it is difficult for the university to gain full advantages of it and integrate it as part of the original campus site [Malcolm Reading Consultants, 2015]. There are almost 1500 students today that are mostly deaf, but also consist of hearing impaired and hearing students with a special interest within the deaf line of work and community [Competitions.malcolmreading.co.uk, 2016]. The campus has a relatively low density on 300 m2 per person, in comparison with 90 m2 of other urban campus [Malcolm Reading Consultants, 2015]. This creates logistics issues, of very long distance between functions, especially with the extension of the Florida Market area. This creates a problem for both teachers, students, and the life of the campus which is then limited to curtains areas of the campus site, where most of the functions are located [Malcolm Reading Consultants, 2015].

The original campus site is highly introvert educational and cultural environment, with high metal fences, brick walls and buildings enclosing it along the edge of the campus site [Malcolm Reading Consultants, 2015]. Each building on campus contains a mix of academic and residential functions. Olmsted Green is a recreational area, which serves as the original heart and meeting point for the campus site and students [Malcolm Reading Consultants, 2015]. Today the campus consists of four 'functional zones';

- The Original Olmsted Campus that was constructed in 1866. There is arranged Victorian/gothic buildings in a park-like setting around of Olmsted Green.
- The Gallaudet Mall expansion that was constructed in 1950-1958, consist an arrangement of modest, mid-century buildings, containing a library, gymnasium, the student union, dormitories and academic functions, around the central green.
- Hanson Plaza Expansion was constructed in 1965-1979 and is encircled by five residence halls for 1000 students.
- Clerc Center campus was constructed in 1966-1976. This area provides a preschool for 12th grade education, plus a health center and student cafeteria.

[Malcolm Reading Consultants, 2015]

The educational choices for Deaf people expanded in 1990 when the Americans with disabilities Act, where set in motion and legislated equal communication access for Deaf people [Malcolm Reading Consultants, 2015]. Gallaudet University has been a historical front figure for the development within the deaf culture in the United States of America since it was established, and wants to continue to do so, with a mission to

"Ensure the intellectual and professional advancement of deaf and hard of hearing individuals," [Gallaudet.edu, 2016]

This will ensure to that development of the campus site is expressive and responsive of the unique relationship

Ill 4.5 Functional division and destription of Gallaudet University Campus site

between the Deaf people and their built environment and develop a more innovative approach to planning of the campus and architecture, which they define as Deaf space [Gallaudet.edu, 2016]. They believe that the focus on the implementing and expand the awareness of Deaf people, will increase the integration of Deaf people in to the hearing social society [Malcolm Reading Consultants, 2015].

These visions are implemented in the Gallaudet 2022 Campus plan. The plans purpose is to articulate Gallaudet University academic vision and mission for the campus and provide a regulatory framework for physical progress of the facilities on campus [Gallaudet.edu, 2016]. The Plan consists of five main points:

- Growth of Accommodation enrolment
- Increase and improve housing conditions on the campus site
- Increase the density on campus and focus toward the Olmsted Green
- Increase accessibility and connection from the campus site to the city
- Create new connection, by building, with the local community

[Gallaudet.edu, 2016]

Gallaudet university is an important part of the Washington D.C., that they have a high beneficial value from, both cultural, economic, and educational, which makes the Universities relationship with its neighbors even more important, for the university to become an integrated part of the city [Gallaudet.edu, 2016].

SENSORY EXPERIENCE OF THE CAMPUS

When entering the campus area from the main gateway at Florida Avenue, the first thing that strikes is a drastic change from the noisy Florida Avenue road to the extremely silent campus site. The only sounds in the area are from the wind blowing in the many large trees, cars in the background and footsteps from the people walking in theis green-park-like scene. As a hearing person the silence, at a first glance is felt almost aggressively, impossible not to be noticed. Expenctations of sounds of people talking,typical of a campus, are crushed, creating all the subsequent emotions, as disappointment, surprise, curiosity, etc.

In The Original Olmsted Campus and Mall are visually appealing for the very spatious and horizontal disposition around the green settings, well contrasting with red brick Victorian and contemporary buildings, which allow the user to be persuaded with a feeling of calmness. The pathways and straight views between the buildings create a greater sense of orientation of the area and connection between the spaces. People are passing by on the pathways in the Mall, often in groups, signing while walking or standing still. Is easy to grasp group dynamics when groups of people are communicating.

Ill 4.6 The Campus Mall seen from the entrance of College Hall

Ill 4.7 Main entrance from Florida Avenue road with House One behind the trees

Ill 4.8 College Hall seen from the Olmsted green

Ill 4.9 Edward Miner Gallaudet Memorial building with the Mall behind it seen from Olmsted green

SERIAL VISION

Ill 4.10 Location of serial vision pictures.

Approaching the site, there is a quite limited accessibility both physically and visually. The separation between the campus area and its surroundings is amplified by the industrial building, parking house, the tall metal fences and red brick wall, plus the highly trafficked four lane Florida Avenue and 6th street (see pic 1-4 in ill 4.11). This kind of separation create a strong edge, when moving along the 6th street from the road intersection at Florida Avenue. On picture 5 in ill 4.11 the end of the parking house on 6th street the area opens up and exposes some green areas behind the campus edge. The space becomes more open toward Olmsted green and the large trees sounding it. Next to Olmsted green, the three dorms are visible, while the backside of the industrial building and parking house block the view towards the 6th street. Topography plays also its role in the spatial relationship at the edge of the campus (see pict 6 in ill 4.11). Moving further a feeling of closeness is emphasized by the use of vegetation (see pic 7-10). The dorms then cover the view to a small parking lot leading to the only open gate of the area (see pic 11 in ill 4.11).

With the boudaty wall in the back and looking toward the campus, it is possible to get a glimpse of the green settings near the dorms and Olmsted green (see pic 12 in ill 4.11).

Ill 4.11 Serial vision of the project site between the 6th street and Olmsted green.

SITE ANALYSIS

MAPPING

Two ways roads
One way roads

Ill 4.12 Private transportation routes by bike and car

Ill 4.13 Public transportation rutes by Metro and bus

TRAFFIC CONDITIONS

The site is partly surrounded by Florida Avenue road to the south and the 6th street to the west, which gives a high possibility for accessibility by car and by feet. Besides these two roads, near the site, 500 m North, is the New York Avenue road. The road leads diagonally from the White House (2,3 km away) out of the city in the North-East direction, and also divides the campus from the North part of the city. Smaller byway streets are located around the site in connection to the main roads and differ between being two-way or one-way roads, with parking along both sides of the streets.

The site is very well connected to the center and other districts of Washington DC through the NoMa-Gallaudet U Metro station and several busses stopping on Florida Avenue and Mt Oliver Road.

Ill 4.14 Access, main infrastructure and parking on the campus site

ACCESIBILITY TO THE CAMPUS SITE

The campus site is accessible through five gates placed around the edge, with the two main gateways towards Florida Avenue and West Virginia Avenue. The campus site has its own infrastructure of two-way roads connecting the four parts of the large campus site. Smaller parking lots a placed equally around the campus site, but because of the removal of the parking house and large parking lot next to the 6th street there is going to be a significant lack of parking spaces connected to the campus [Malcolm Reading Consultants, 2015].

URBAN SCALE

The buildings around Gallaudet University are not higher than 2-3 floors. The use of same typology gives an homogeneity to the different areas, creating a clear atmosphere for each district.
The buildings on the campus site,instead, differs a lot more in height, from one floor buildings to six floors. The scale of the campus buildings increases towards the center of the campus site.

Ill 4.15 Scale of buildings

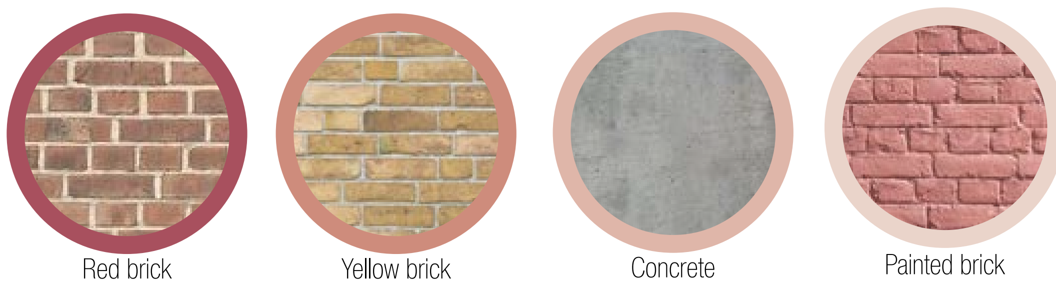
Ill 4.16 Green areas near and on campus

GREEN AREAS

The campus is characterized by the large amount of greenery and open green fields, consequence of the low building density of the campus.
This is greatly in contrast with the highly mineral surroundings, especially toward Florida Avenue Market area.
Outside the campus edge, the green areas are represented maynly by the old Bentwood Park and Brentwood Hamilton, placed close to the site toward North.

MATERIALS

The building material used are quite similar, and mainly consists of bricks in different colors and concrete elements. The use of materials and colors is divided in zones: the buildings made of red bricks is mainly placed on the campus and project site, concrete and yellow bricks in the Florida Avenue Marked area and the painted bricks in mainly placed in the residential area in the South.



Ill 4.17 Materials near and on the site.

Ill 4.18 Function organization on and near the site

Residential
Warehouses
Shops and resturants
P-house

FUNCTIONS ORGINAZATION

There are many different functions and services around the campus area. Most of the residences are placed South, while service facilities, as restaurants and shops, and industrial functions, as warehouses, are placed in the North-West direction of the site.

In the campus area, in the South-East, there are students college houses, called Ballard, Fay and Dension House. Souther on the campus site is House One which serves as the Universsity President home hosting VIP functions.

SITE ANALYSIS

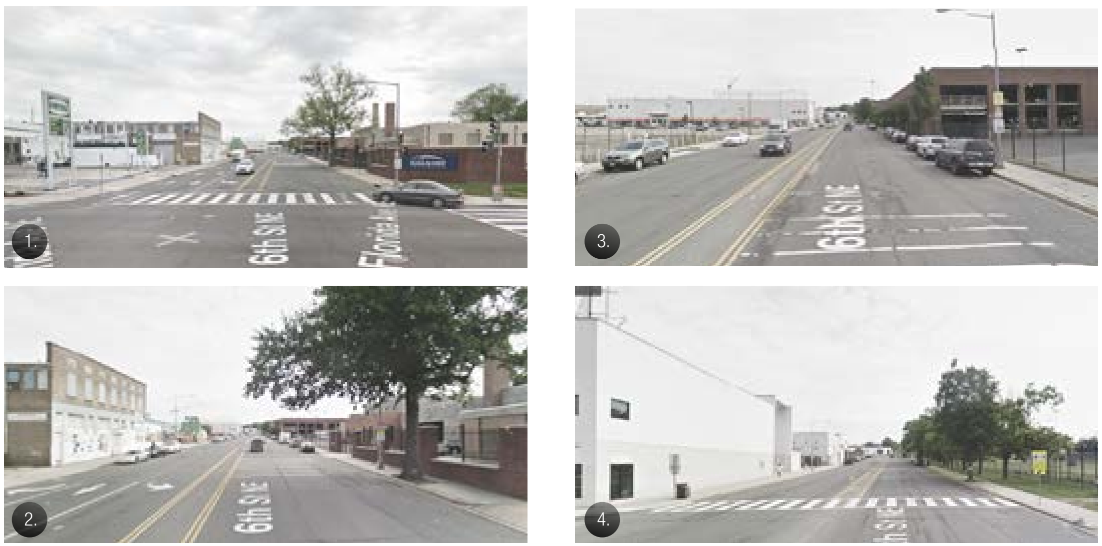
TOPOGRAPHY

The campus is located on the slope of Brentwood Hill, which rises in height in North-East direction, and tops at Clerc center part of the campus site. From the top the whole campus site is sloped towards the South-East, where Florida Avenue and West Virginia Avenue join.
The site is placed in lower part of Brentwood Hill. The site inclines 3,5m on a span of 120 m from the South-West corner to the North-East corner of the chosen site.

Ill 4.19 Topography lines on site

6TH STREET RETAIL CORRIDOR DEVELOPMENT

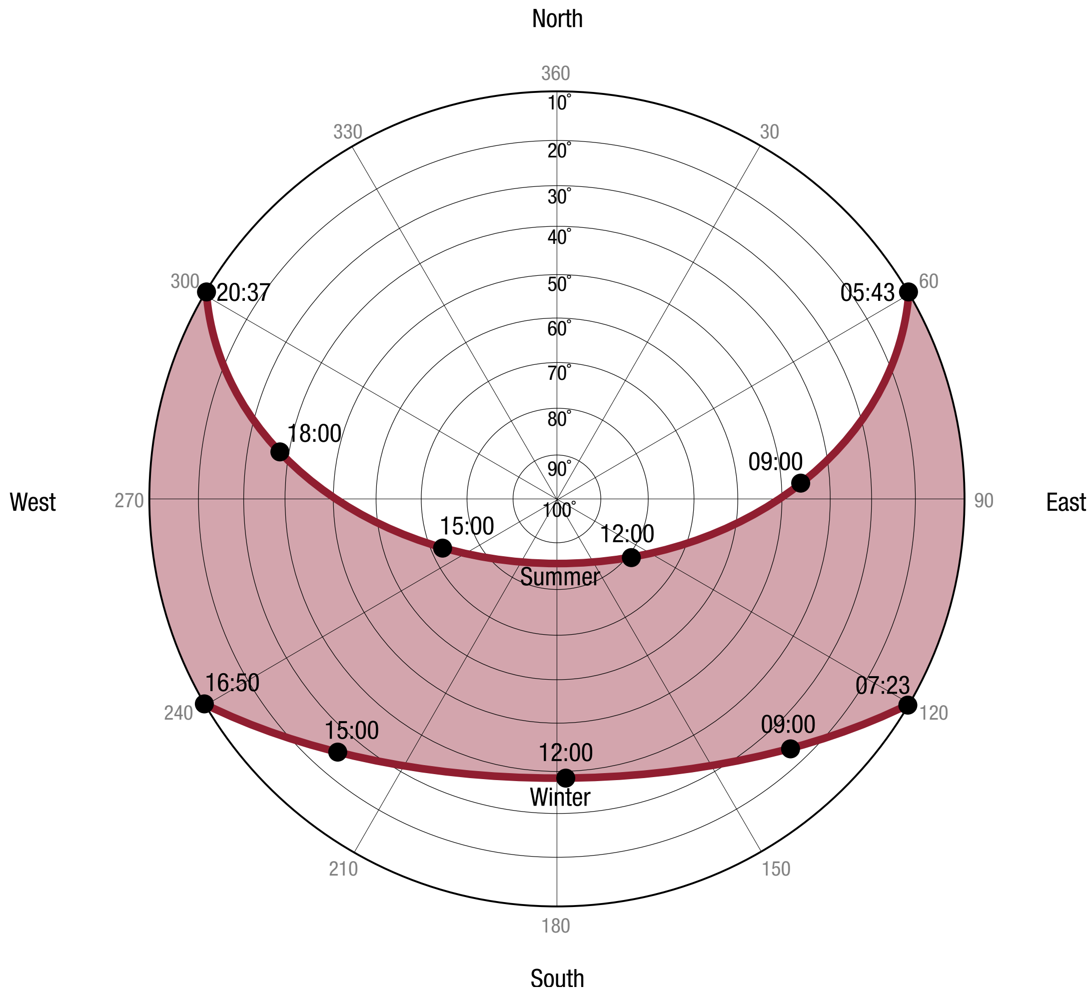
Ill 4.20 Description of the future development of the 6th street retail corridor and street view points



Ill 4.21 Description of the future development of the 6th street retail corridor and street view points

The placement of the 6th street, between Gallaudet campus site and the Florida Avenue Market area is quite unique and important for the future development for the city and the university. Because of its unique placement the Gallaudet University Foundation released back in 2013 a request of qualifications for the future development of the 6th street in to a retail corridor, with spaces for all kinds of retail, offices and residential spaces [Gallaudet.edu, 2016]. They are currently developing the urban structure on the 6th street, so to transform it into a pedestrian friendly street and emphasize its public environment. This includes the implementation of several pedestrian crossings, encourages the use of bikes.
The hope is that, with this vision, it will in the future become a cultural and creative district for all types of people and though that define its own unique identity [Gallaudet.edu, 2016].

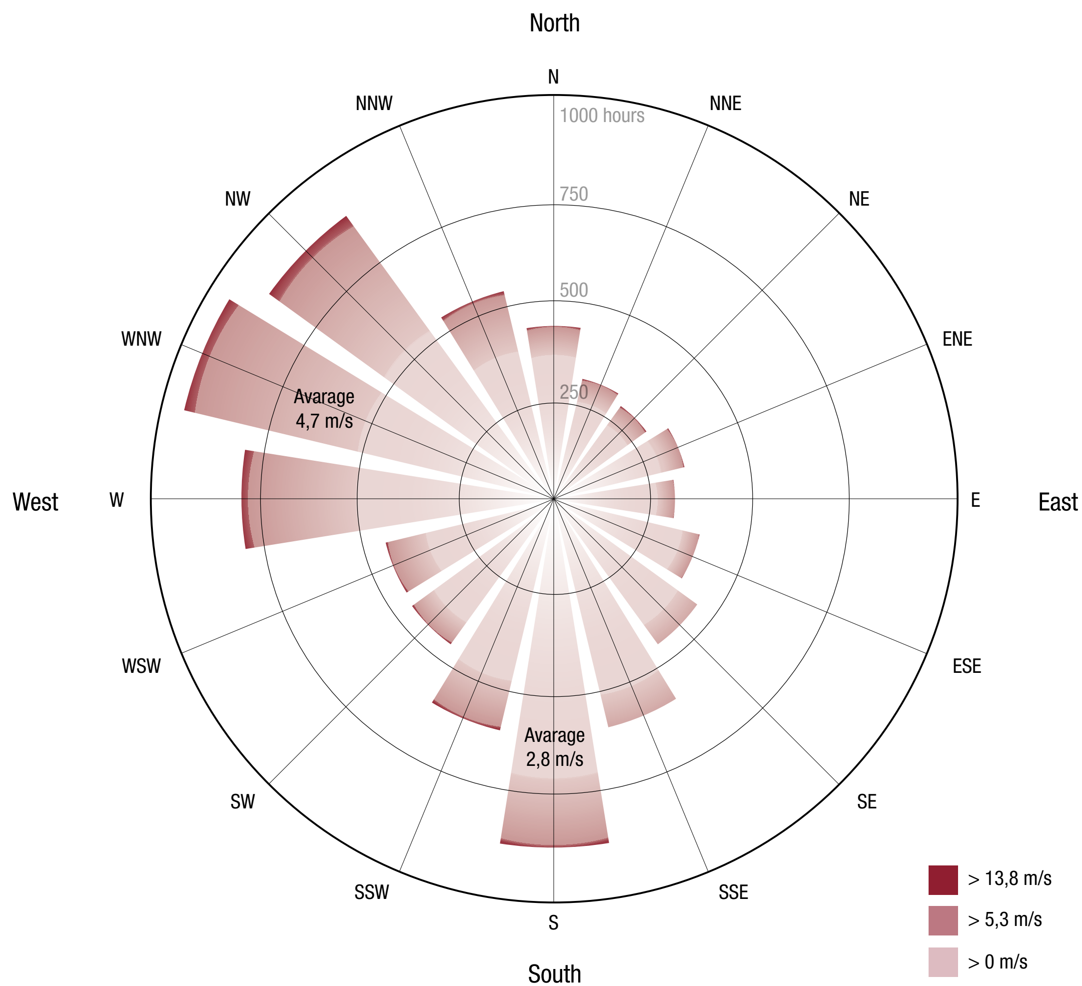
CLIMATE CONDITIONS



SUNPATH

The amount of sun hours and angle is significantly different from summer to winter in Washington DC, with 14 hours and 20 minutes sun in lightest period of Summer and 10 hours and 13 minutes of sun in the darkest period of Winter [meteoblue, 2016]. This gives also a quite big difference of the angels of the sun around noon, which differs approximately between 80 degrees in the Summer and 25 degrees in the Winter period [meteoblue, 2016].

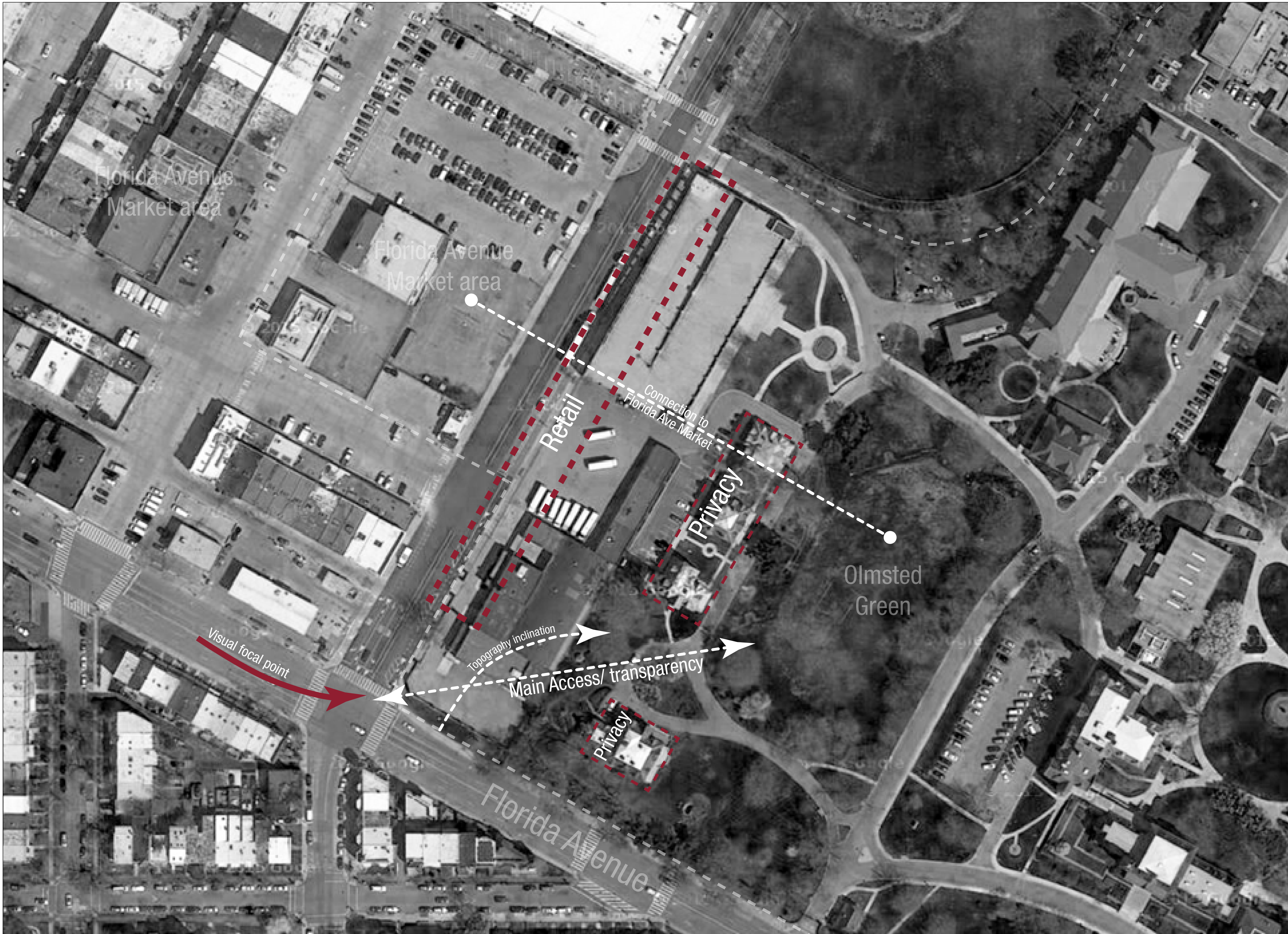
Ill 4.22 Sun path Diagram for Washington DC [meteoblue, 2016]



Ill 4.23 Wind speed and direction Diagram for Washington DC [meteoblue.com, 2016]

WIND

During the year the wind speed in Washington DC differs between min 0.2 m/s to max 16.9 m/s [meteoblue, 2016]. The strongest winds come from the South and North-West, as shown on the wind rose diagram.



Ill 4.24 Summary of the site analysis and research

SITE ANALYSIS SUMMARY

From the site analysis and research it is clear that the placement of the site brings up is quite interesting opportunities. The primary access to the site would be from the west by Florida Avenue, because of the placement of the NoMa-Gallaudet metro station and the Exit of New York Avenue in that direction. This makes the corner of the site (where the 6th street and Florida Avenue connects) a visual and access focal point for Gallaudet University. The topography inclines quite a lot in the South part of the site, creating great opprtunities for the outdoor area treatment or the building shape and division.

The site is placed between much defined functional districts of an industrial/retail area in the North-West, residential to the South and the campus site to the East. This together with the 21m wide roads defines an edge and a barrier, that makes it for the difficult to have a connection between each side of the 6th street. The future development of the 6th street needs to be taken in to consideration while designing, by making space for different type of retail towards the street. This also creates an opportunity to open the campus edge and visually expose Olmsted Green and create a more green and vibrant live in the original Olmsted campus site and industrial area. The placement of a second cafeteria might create a higher possibility of increasing the live and activities taking place in Olmsted Green, and also is needed because of the huge distrance there is to the first one placed in the Clerc Center part of the campus. Addition of student dormitories is needed with the extension of the university to Florida Avenue market area and the future goal to increase the number of students attending Gallaudet University. Parking is also needed with the future demolishing of the parking lot on Florida avenue market and the P-house just north of the site, especially with the future extension of the University.

The use of materials in the context is significant in the choice of material for the design, because of the clear division between them according to functions. With the choice of the red brick it will mostly relate to the buildings on campus site, while yellow brick and concrete will relate to the industrial area. Very significant is that it is all hard materials, which also give a choice of either relating to the context by continuing the use of hard materials or creating a contract by using materials like wood or metal plates ect. The placement of the three Student college houses, Ballard, Fay and Dension, plus House One is close to the site and the 6th street, therefore it needs to be taken into consideration in design decisions.

To be able to create the proper light conditions for visual communication inside the buildings, the sun path and angle are taken into consideration, so that design choises do not result in poor lighting conditions for activities or the use of sign language.

The future development of the edge between the 6th street and the campus site can be a way to give a much higher aknowledgment of the Deaf way of being and its culture and thereby make it easier for deaf people to interact in the hearing society.

CONTENT INDEX

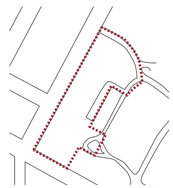
SPATIAL PROGRAM #5

GENERAL FUNCTION ORGANIZATION

The overall functional organization of the whole site is going to consist of the listed functions in ill. 5.1. The functions are listed according to what is needed for the future development of the area and Gallaudet University from the earlier analysis of the place and institutions. The illustration also includes where the function should be accessible from.

The car parking needs to be placed as a part of the site, because of the future demolishing of the parking lot on the 6th street and the existing P-house. Retail and offices are part of the future development of the area in and around the 6th street.
The placement of student dormitories and the cafeteria is both to enhance the amount of life in the area and on the Olmsted green and to create a shorter distance and extend the existing amount of cafeteria and student dormitories to meet the future increase of students on the university.

MASTERPLAN FUNTIONAL PROGRAM

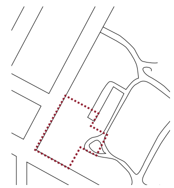


	Quantity		Total Capacity	Accessibility	
Functions	No.	m²		Campus	6th street
Retail	-	6100	--		●
Car Parking	-	2300	--	●	●
Student dormitories	2	8000	600	●	
Cafeteria	1	685	500	●	●
Gateway plaza	1	755	500	●	●
Visitor Center	1	307	--	●	●
Campus functions	1	1520	--	●	●

Ill 5.1 Function program of the whole masterplan site

SPATIAL PROGRAM OF THE UNIVERSITY PARCEL

NEW UNIVERSITY PARCEL FUNTIONAL PROGRAM - Gateway



	Functions	Quantity No.	Quantity m^2*	Capacity	Room height	Public	Private	Accessibility Groundfloor	Accessibility First floor	Visual connection non	Visual connection semi	Visual connection open
Gateway Plaza	Dining/meeting area	1	294	40-50	> 3m	●		●			●	●
	Event area	1	461	-	> 3m	●		●			●	●
Visitor center	Visitor shop	1	75	-	>3m	●		●			●	●
	Permanent exibitions	1	171	-	>3m	●		●			●	●
	Public Lavatory	2	6	-	3m	●		●		●		
	Info desk	1	24	3	3m		●	●				●
	Offices	2	10	1-2	3m		●	●			●	
	Meeting room	1	7	4	3m		●	●		●	●	
	Shop storage	1	14	-	>3m		●	●		●	●	

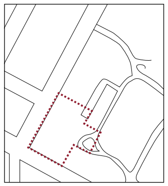
Ill 5.2 Room program for the Gateway related functions

The main focus is going to be on the new university parcel which is placed in the South part of the area that was specified earlier on ill 4.4. The New university parcel is going to consist of thefollowing main functions: cafeteria campus retail, teaching facilities and visitor center.

The three illustrations (5.2-5.3) describes morein detail the specific functions in terms of size, capacity, accessibility etc.

The placement of a new main gateway seems ideal because of it close connect to transportation and the future life and activities development, becoming also the meeting point for the many visitors Gallaudet University has.

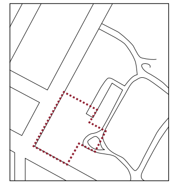
SPATIAL PROGRAM



NEW UNIVERSITY PARCEL FUNTIONAL PROGRAM - Cafeteria

	Functions	Quantity No.	Quantity m²	Total Capacity	Room height	Public	Private	Accessibility Groundfloor	Accessibility First floor	Visual connection non	Visual connection semi	Visual connection open
Costumers Area	Dining area (indoor)	1	434	400	> 3m	●		●			●	●
	Condiment area	1	10	-		●		●			●	●
	Service line	1	20	-		●		●			●	●
	Garbage/return area	1	10	-		●		●			●	●
	Public Restroom	2	30	-	3m	●		●		●		
Service Area	Service counter	1	9	-	> 3m	●	●	●			●	●
	Industrial kitchen	1	40	8	> 3m		●	●			●	●
	Dry storage	1	12	-	> 3m		●	●		●		
	Drinks storage	1	15	-	> 3m		●	●		●		
	Refrigerator/freezer	1	12	-	> 3m		●	●		●		
	Delivery area	1	6	-	> 3m		●	●		●	●	
Cleaning Area	Laundry	1	8	=	> 3m		●	●		●		
	Dishes	1	8	-	> 3m		●	●		●		
Employee Area	Employee room	1	25	8	> 3m		●	●		●		
	Restroom	2	8	-	> 3m		●	●		●		

Ill 5.3 Room program of the cafeteria and related functions



NEW UNIVERSITY PARCEL FUNTIONAL PROGRAM - Compus Retail

	Functions	Quantity No.	m²	Total Capacity	Room height	Public	Private	Accessibility Groundfloor	First floor	Visual connection non	semi	open
Printer Shop	Store space	1	72	-	> 3m	●		●			●	●
	Print equipment	1	28	-	> 3m		●	●		●	●	
	Storage	1	10	-	> 3m		●	●		●		
	Office	1	10	2	3m		●	●			●	
	Employee room	1	18	5	3m		●	●			●	●
	Restroom	1	8	-	3m		●	●		●		
LAN café	Computer room	1	68	-	> 3m	●		●			●	
Book store	Store space	1	140	-	> 3m	●		●			●	●
	Storage	1	10	-	> 3m		●	●		●		
	Office	1	10	2	3m		●	●			●	
	Employee room	1	18	5	3m		●	●			●	●
	Restroom	1	8	-	3m		●	●		●		

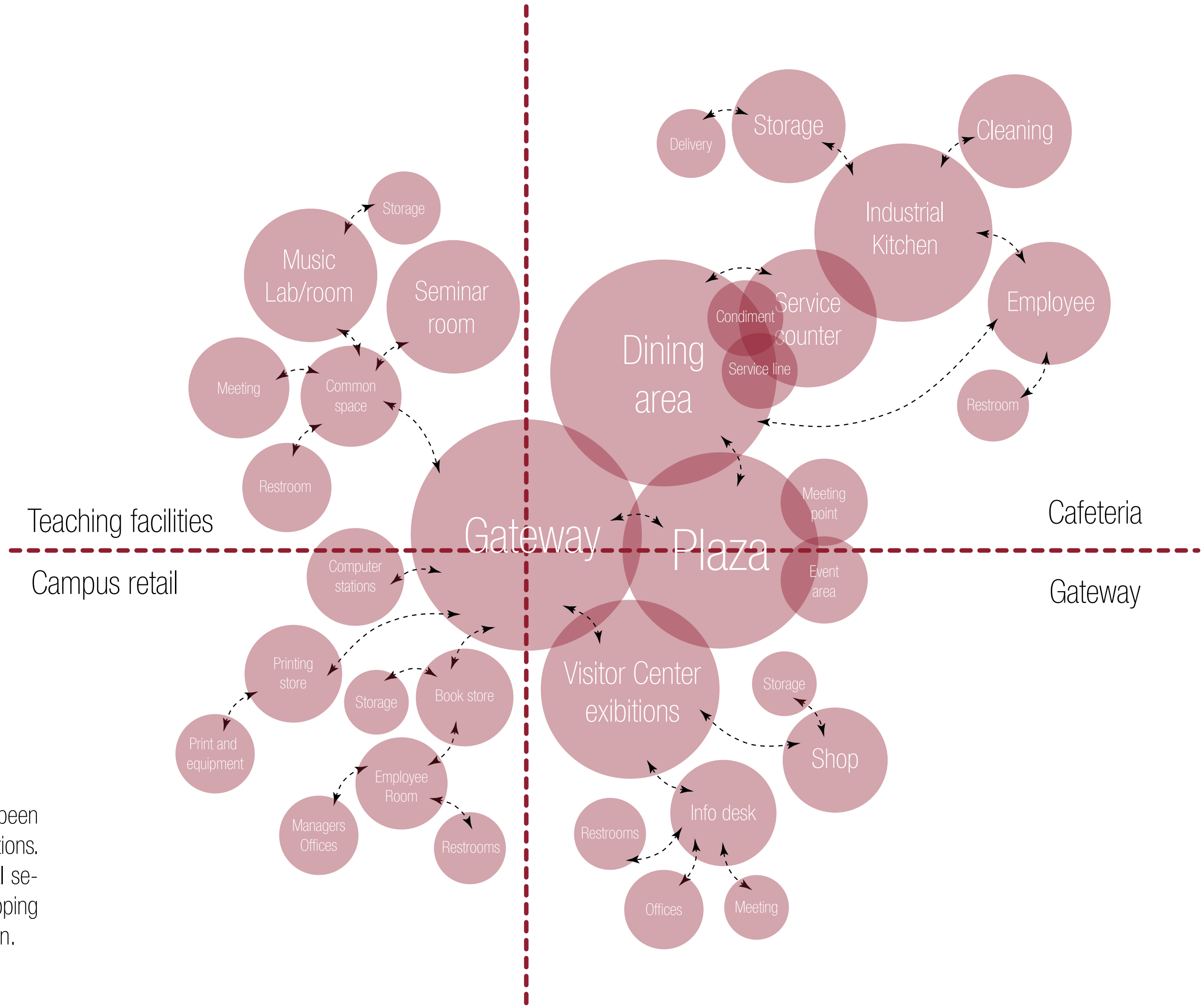
Ill 5.4 Room program of the campus retail

NEW UNIVERSITY PARCEL FUNTIONAL PROGRAM - Campus functions

	Functions	Quantity No.	m²	Capacity	Room height	Public	Private	Accessibility Groundfloor	First floor	Visual connection non	semi	open
Teaching facilities	Conference room	2	98	30	3m		●		●		●	
	Seminar room	4	36-42	20	3m		●		●		●	
	Auditorium	1	200	60	>3m		●		●		●	
	Storage	1	12	-	3m		●		●	●		
	Work room	16	6-10	4-6	3m	●			●		●	●
	Restrooms	4	25	-	3m	●			●	●		
	Common space	2	170	-	3m	●			●			●

Ill 5.5 Room program of theCampus functions

FUNCTION CONNECTION



From the spatial program ill. 5.5,this diagram has been made to illustrates the connections among all the functions. The arrows illustrates either a door or another spacial se-pration of the spaces. When the functions are overlapping thediagram illustrates a fluent visual or flow connection.

Ill 5.6 Functional connection diagram

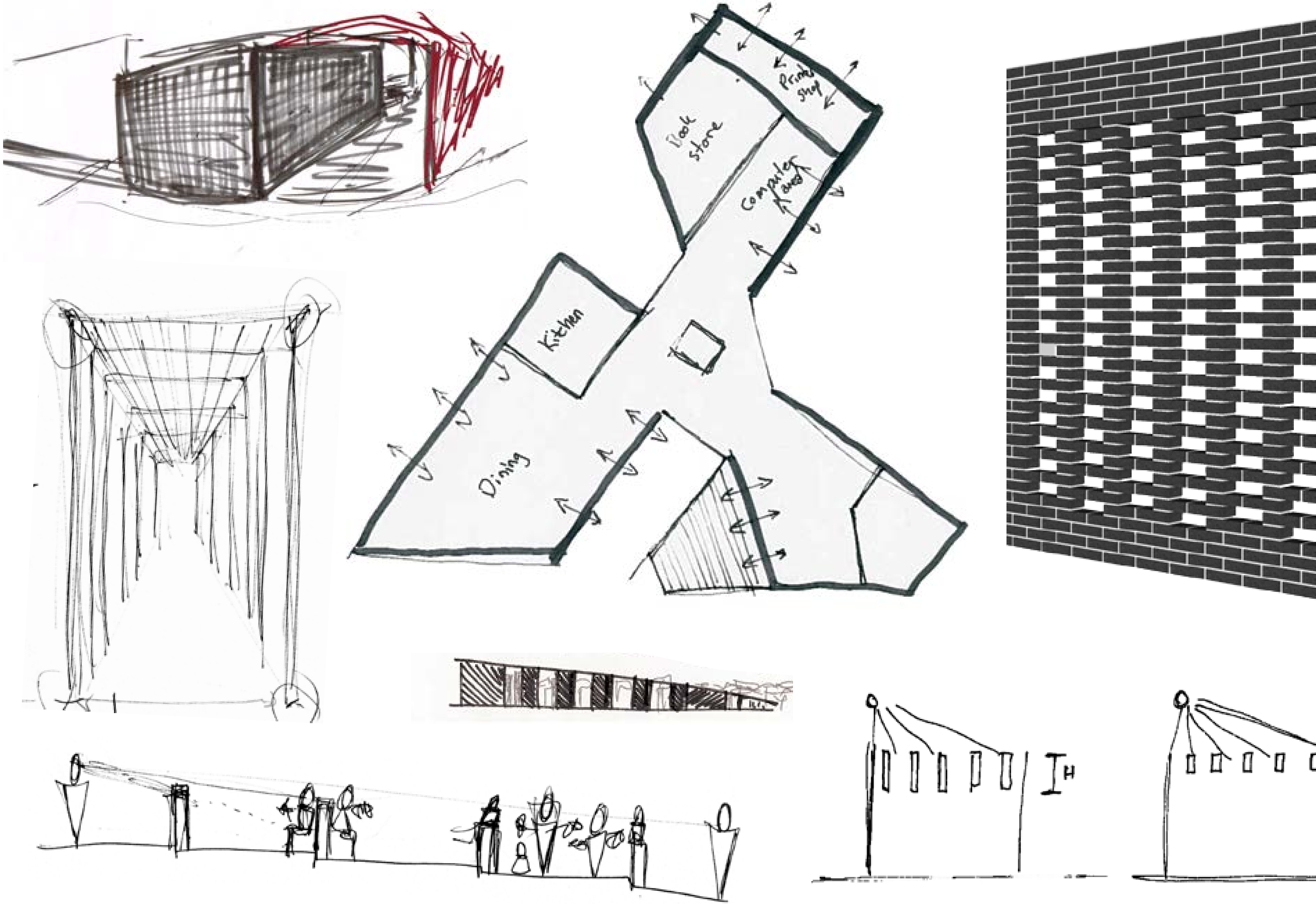
DESIGN PARAMETERS

	SPACE		DISTRIBUTION		ENVELOPE	
VISION OBJECTIVE	Intuitive understanding of space		Mobility and flow		Spatial awareness	
DESIGN PARAMETERS & CRITERIAS	Orientation and wayfinding	● ● ●	Visual reach	● ● ●	Differnt transparency levels	● ● ●
	Address peripheral vision	● ●	Use of ramps	● ●	Division of large internal spaces	● ●
	Address cognitive perception	● ● ●	Automatic doors	● ●	Materials	● ● ●
	Repetition of elements	● ● ●	Large entrances and corridors	● ●		
	Simple geometries	● ● ●	Informative pavement treatment	● ● ●		
	Flexibility	● ●				

	SOCIAL SUSTAINABILITY		LIGHTING		ACOUSTICS	
VISION OBJECTIVE	Interaction & integration		Avoid eyes stress		Avoid background noise	
DESIGN PARAMETERS & CRITERIAS	Physical and social edge dissolution	● ● ●	Diffuse lighting	● ● ●	Avoid echoes	●
	Deaf Community landmark	●	Daylight factor between 3 - 5%	● ●	Low reverberation	●
	Contextual connection	● ● ●	Smooth light transition from indoor to outdoor	● ● ●	Aim at very silent spaces (25dB = quite conversation)	●
	Emphasis the future devlopmentplan	● ●	Use colour that contrast skin tones	● ●		
			Electric control of articificial light	●		

From the theme and site analysis several design criteria and parameters has been formulated and are going to be the instruments for shaping the design through the design process. They are given points according to their level of involvement in the decision-making-process and detailing of the design solution, shown in ill. 5.6.

Ill 5.7 Design criteria and level of focus during the project



Ill 5.8 Design process sketches

VISION

The project consists of designing the new extension of Gallaudet University.
Our goal is to give this area an **identity** within its context.
The acquisition of a character will allow the **integration** of the area within the surroundings, therefore **dissolving the campus edge**, and fullfilling also the Washington DC and the Campus Development Plan.
To achieve so, the design is treated in such a way to inform and ease the **interaction** in the built environment among the deaf and hearing societies.

CONTENT INDEX

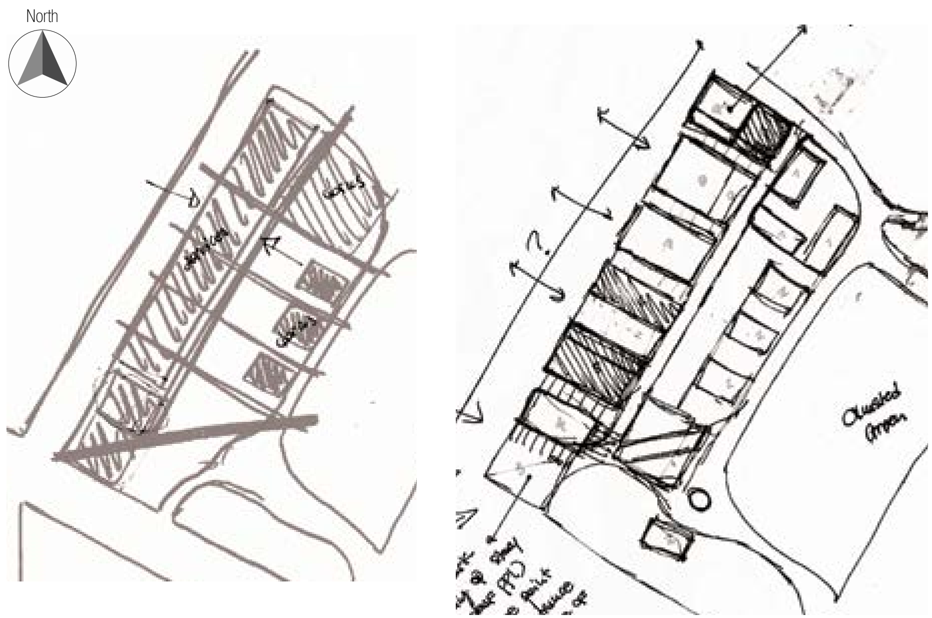
DESIGN PROCESS #6

CONTEXTUAL CONNECTION

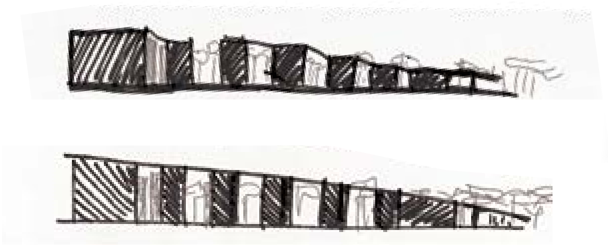
The whole site between the 6th street and the campus area was designed volumetrically though sketches and models. The main focus during this stage of the process was to dissolve the edge of the campus area, by creating straight visual connections to both sides, but still emphasis the future development on the 6th street by creating spaces for retail along the street and ensuring some visual privacy for the existing dorms next to Olmsted green (see ill 6.1).

Besides accommodating the future vision of the 6th street, campus related functions, as student dormitories, and a New university parcel including: visitor center, cafeteria and teaching facilities, are placed to reach a density between 100-150%, following the future development of the area (ill. 6.3). The vision of the Design principles has been a large influence on the on volumes orientation and placement on the site. This can be noticed in the straight views, the building volumes rising in scale towards the North-East, following the inclunation of topography and the sun path, allowing hierarchical organization of spaces and flows (ill. 6.3).

The South-West corner of the site is quite exposed and is the first to be seen by pedestrians of the campus area, when arriving from Metro and most busses. A placement

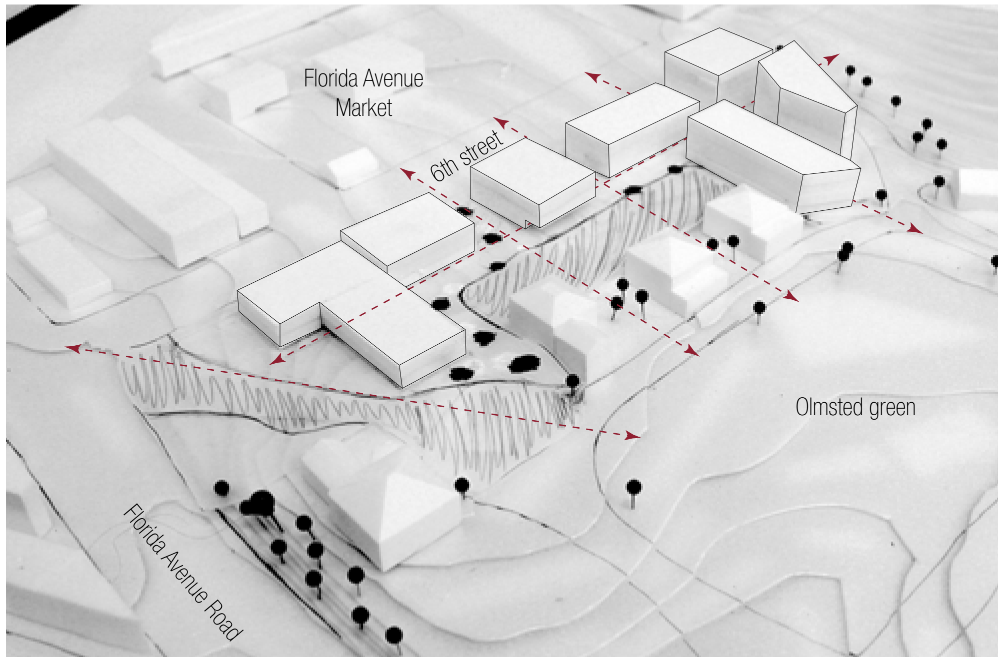


Ill 6.1 Plan sketches of the whole project area according to previous analysis and research



Ill 6.2 West elevation sketches experimenting with the scale of the building volumes

of the new university parcel and Gateway in this spot is to emphasize a straight-forward connection to the campus and its functions.
The shape of the buildings volumes and their scale also relates to the speed of the flow in the area. The volumes increase towards areas characterized by faster flows, where pedestrians and cars are passing by. While the scale decreases towards the South-West corner of the site, where flow is supposed to be of a slower type, as show on ill. 6.2. The level of detailing is also following this concept.



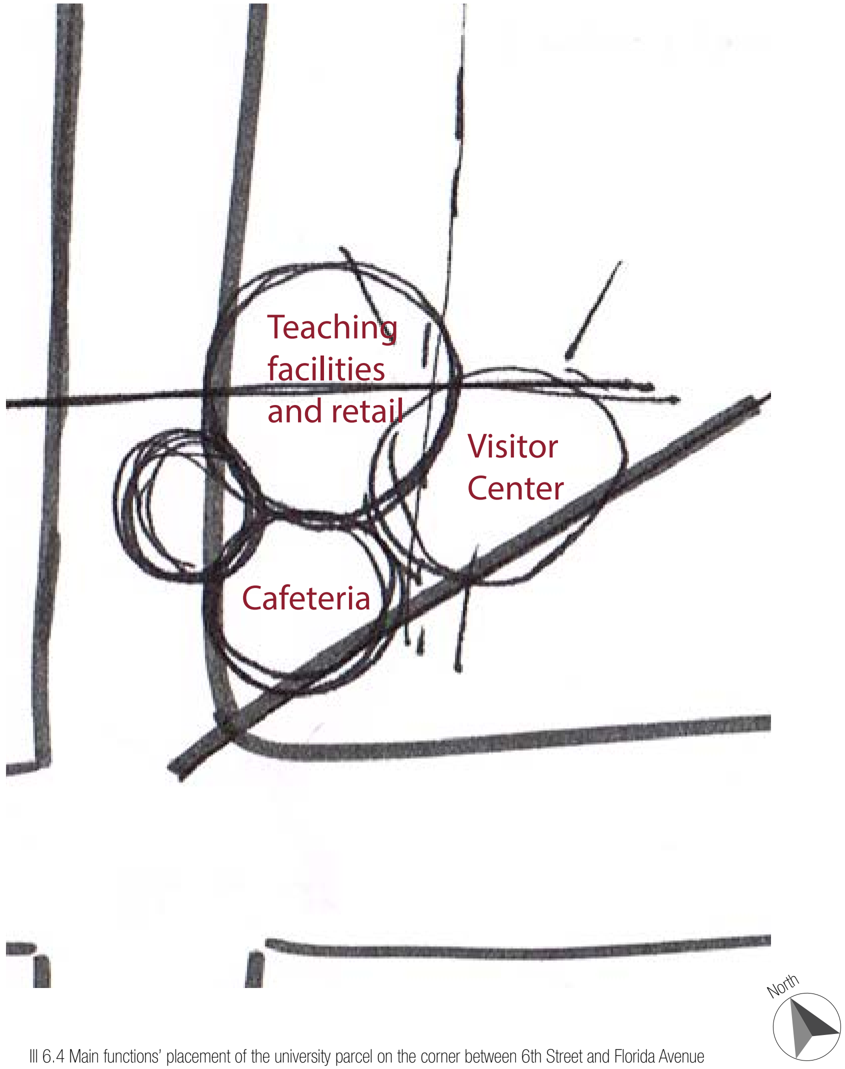
Ill 6.3 Volumetric studies of building shape, scale, views, assesbility, contextual connection and hierarchy of the spaces

CONCEPT DEVELOPMENT

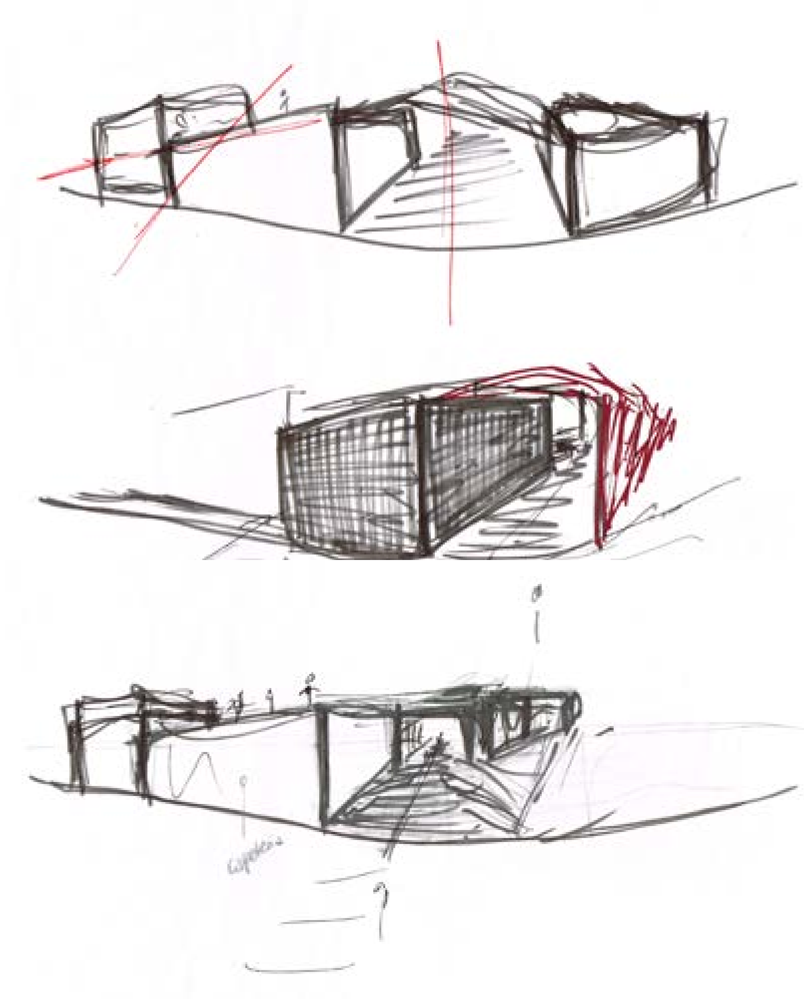
The placement of a new main entrance in the South-West corner of the site is ideal because of its close connection to trasportation infrastructures and thereby addressing the flow of pedestrians coming towards Galllaudet University.

The placement of the university parcel functions is based upon which flows they address and their connection to each other, but also to the whole organization of the site,previously stated. Ill. 6.4 shows the main organization. The cafeteria and visitor center are emphasising the direction and connection of the Gateway plaza and the retail and teaching facilities dialogue more with the other buildings on the site, as retail facilities and student dormitories and parking.

The principle of easing the orientation and way-finding in the area was experimented with in terms of enhancing directivity around and through the building. These principles evolved into the concept of using the contrast between massive volumes containing the main functions and a light, transparent inter-space, functioning as a gateway and transition area between outside and the building and among the units themselves, as illustrated in ill. 6.5, 6.6 and 6.7.

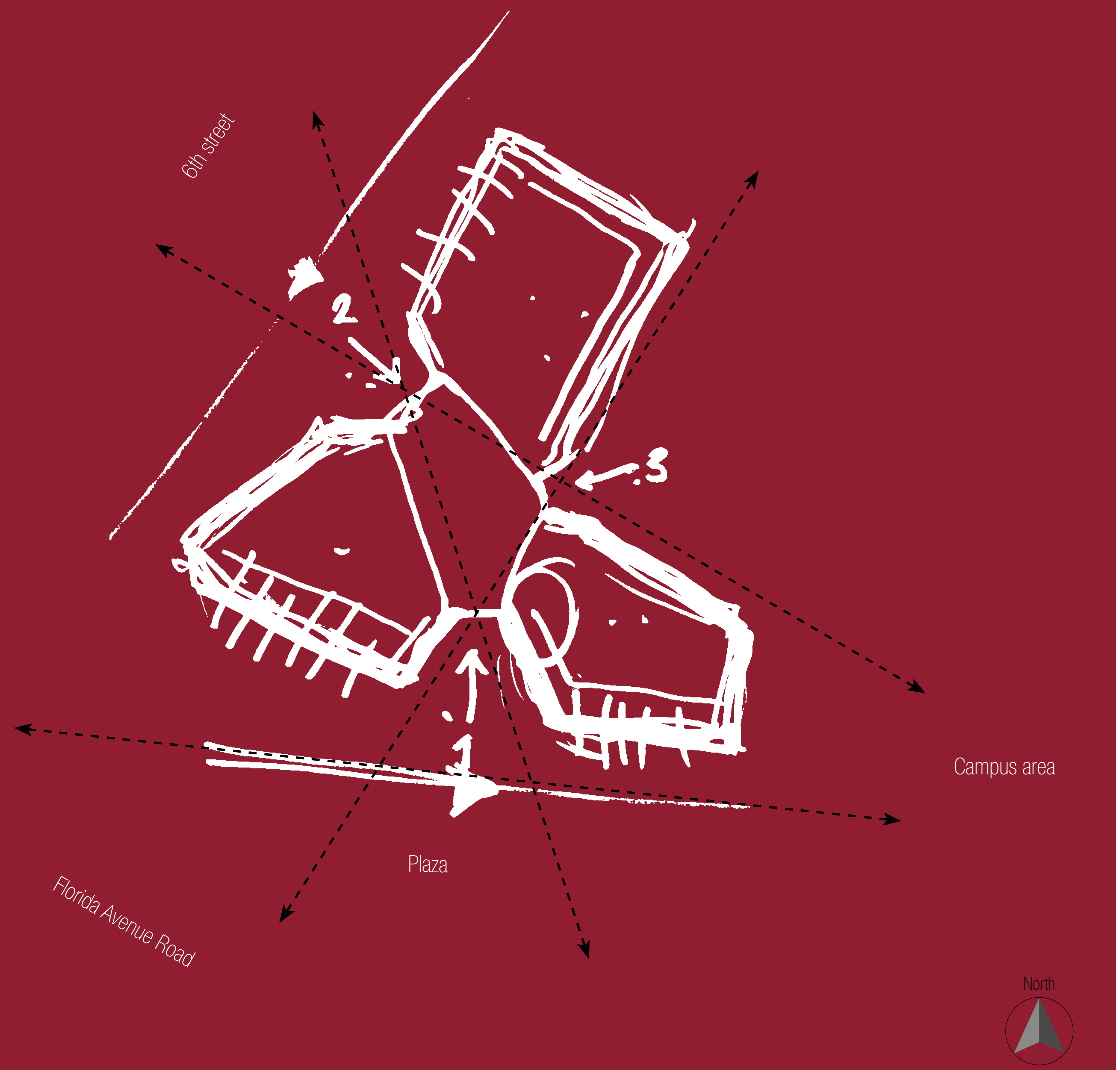


Ill 6.4 Main functions' placement of the university parcel on the corner between 6th Street and Florida Avenue

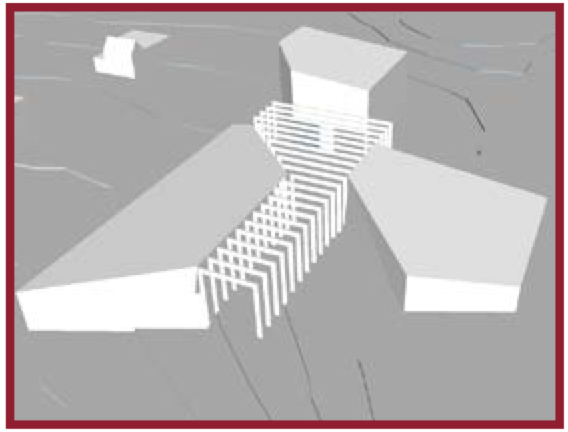


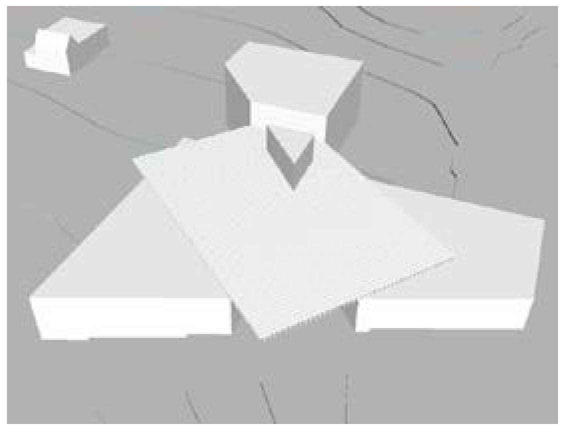
Ill 6.5 Conceptual perspective sketches of the contrast between massive and light structure, marking the transision area of the Gateway

DESIGN PROCESS



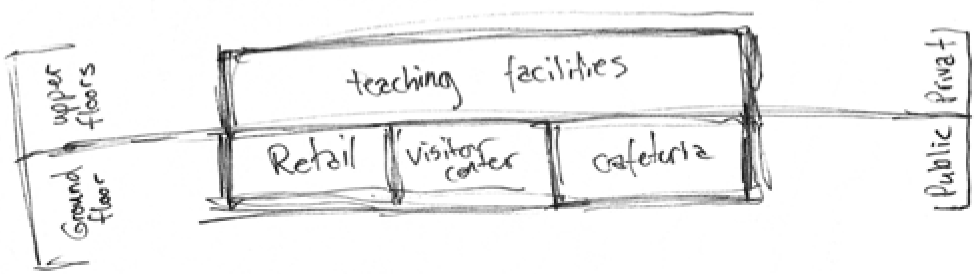
Ill 6.6 Conceptual plan sketches of the visual connection and directivity the Gateway creates toward all the surrounding spaces





Ill 6.7 Conceptual sketch model of the connection, directivity and transition of the Gateway

SPACE AND DISTRIBUTION



Ill 6.8 Sketch section of function organazation in terms of public and private accessibility.

The deaf space design principles have played a strong role in the design of the internal spaces from the large urban buildings scale to the construction details. This required a process going back and forward in scale to design and emphasize the deaf way of being, but also to relate to the context and the architectural concept.

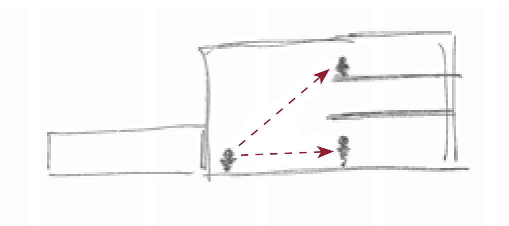
The placement of the functions has been done according to the contextual relation previously shown on ill. 6.5, but has also been carried through according to public/private relationship and general accessibility as described in the spatial program and ill. 6.9.

VISUAL REACH

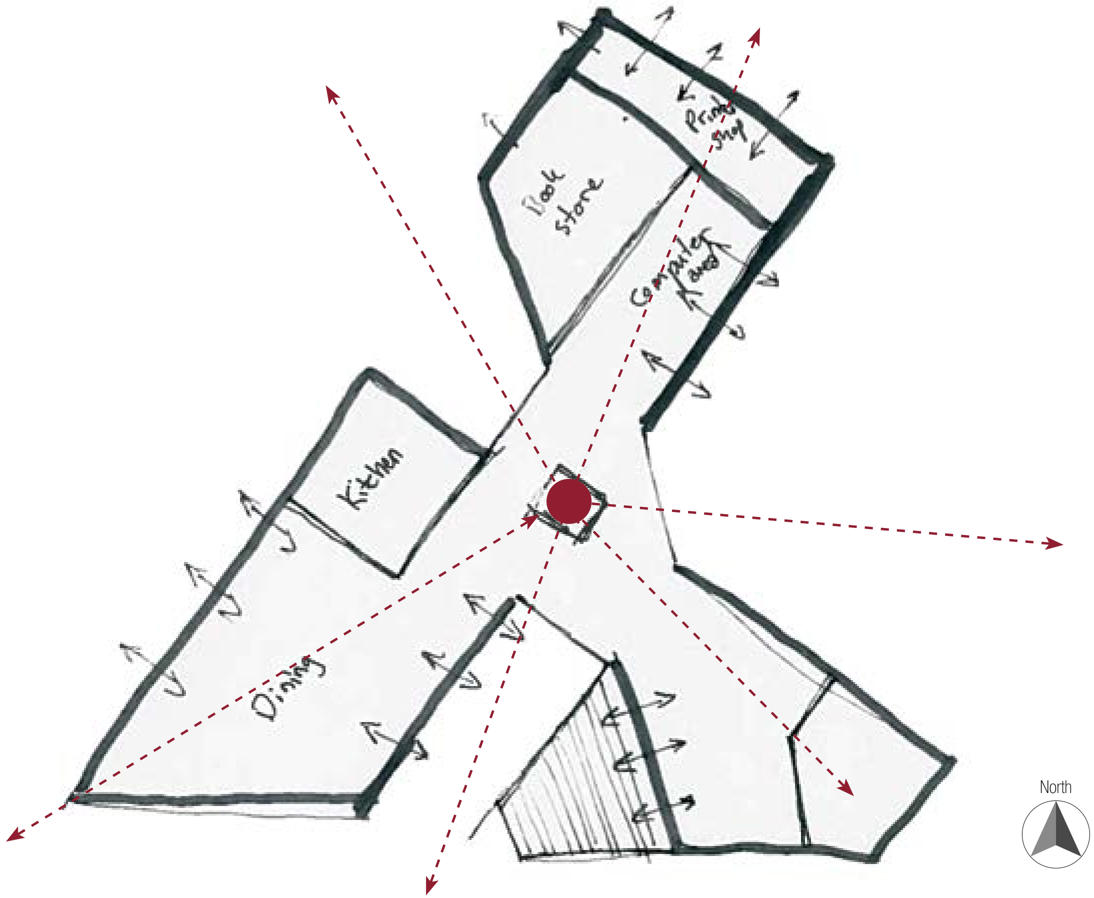
A key element in the design process was to create a logical design in terms of overview, orientation and way-finding for both hearing and deaf individuals.

From this the Gateway was further developed, in connection with the three main functions, to be the visual focal point to all the functions and outdoor spaces as illustrated in ill. 6.11.

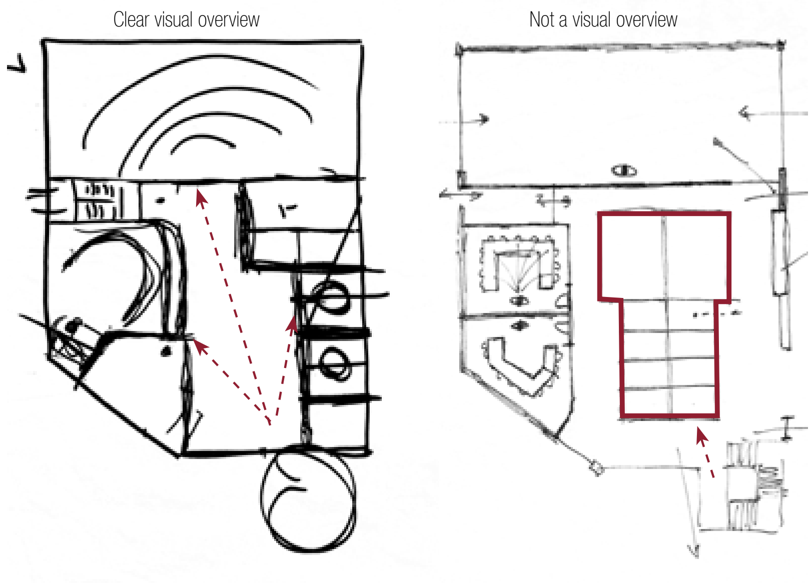
This concept of considering the gateway as the visual focal point is re-proposed in the interior design of the other units, like the visitor center on ill. 6.13, and the upper floors of the university facilities, as illustrated in ill. 6.12. By raising the height of the Gateway core it also provided a vertical visual connection from the ground floor as illustrated in 6.10.

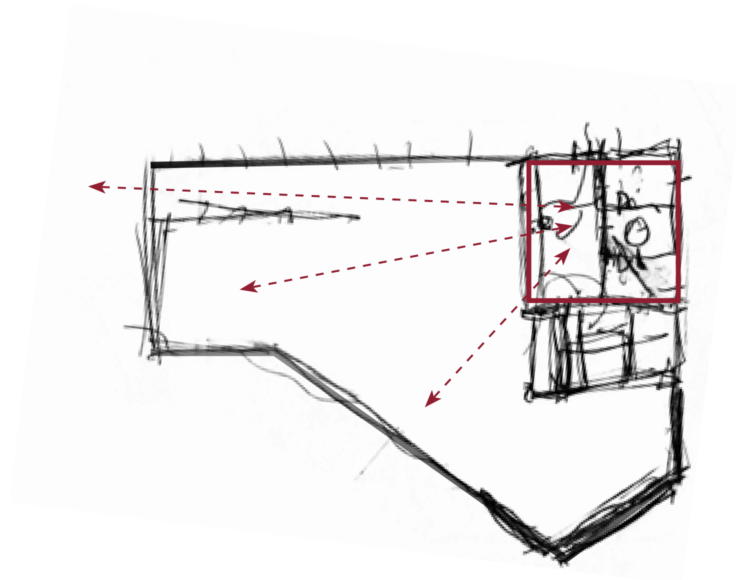


Ill 6.9 Section sketch showing the vertical visual connection between floors



Ill 6.10 Sketch of the visual connection from the Gateway core of the Ground floor



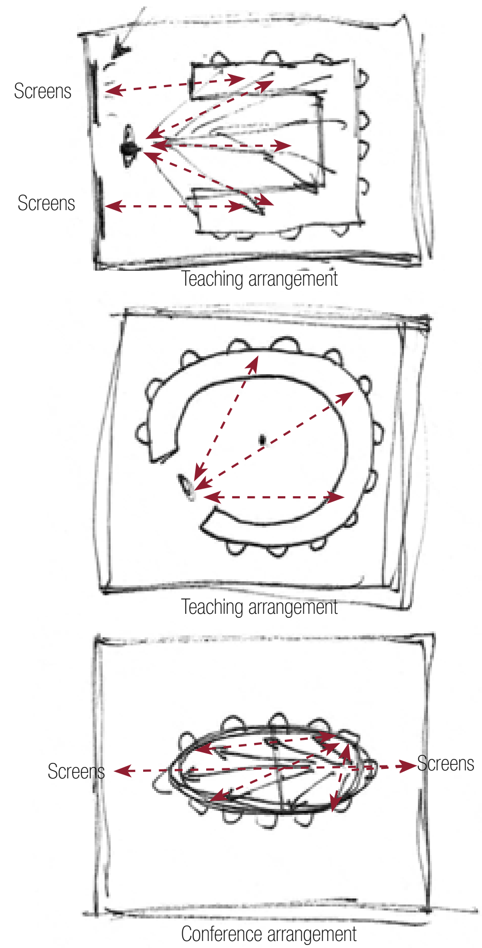


Ill 6.11 Sketch of how the teaching facilities is orginazed according to the Gateway core. Sketch to the right show clear visual connection to the functions with a common space in the center compared to the left sketch where the functions is cleating a visual barrier.

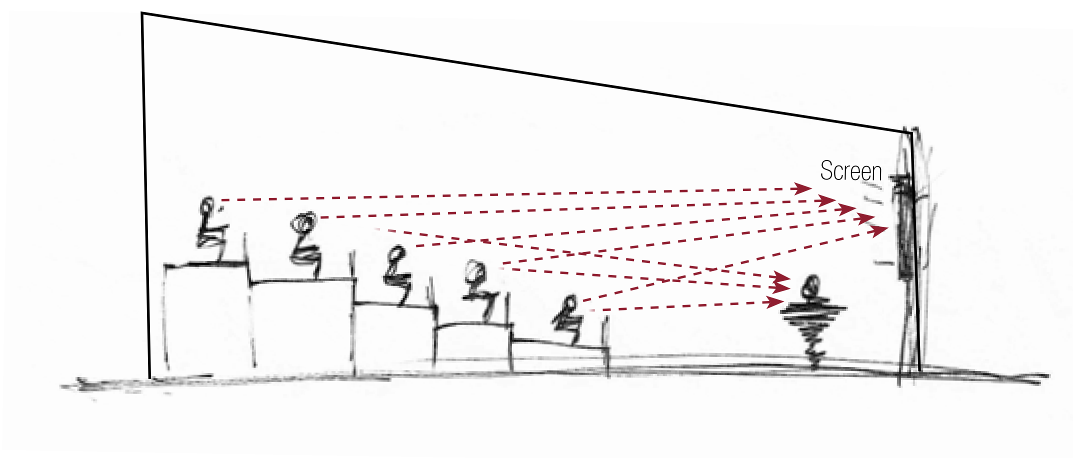
Ill 6.12 Plan sketch of the clear visibility between the visitor center to the gateway core and from the offices in the top right corner to the rest of the exibition space.

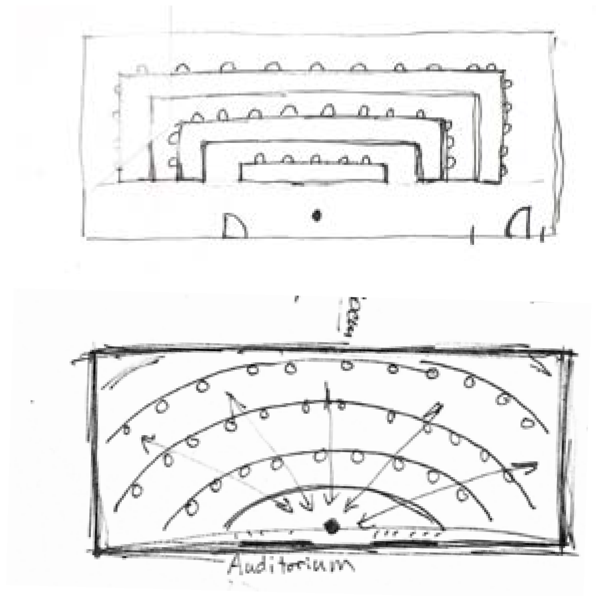
When working with the specific functions within the teaching facilities, different configurations were tested to ensure visibility among the audience/students and to the signing speaker/teacher to create an efficient and comfortable learning environment where the furnishing and dimensions of the rooms allow a high degree of flexibility.
Through the use of the deafspace design principles, there has been different configurations developed for each type of function.

For the seminar rooms, dimensions have been arranged in such a way to fit a small conference setting with a oval table seating and screens in each end both a horse-shoe arrangement of tables when it is used for teaching as illustrated in ill. 6.14.
With the conference rooms and auditorium the same principles has been used. A higher ceiling in the auditorium ensures a flexibility for the arrangement of several rows of seats on platforms as illustrated in ill. 6.15, and 6.16



Ill 6.13 Principles sketches showing different seating arrangement for the seminar rooms





Ill 6.14 Principles sketch showing seating arrangements on platform when several rows of seating is needed.

Ill 6.15 Principles sketch showing seats arrangements of the auditorium in plan

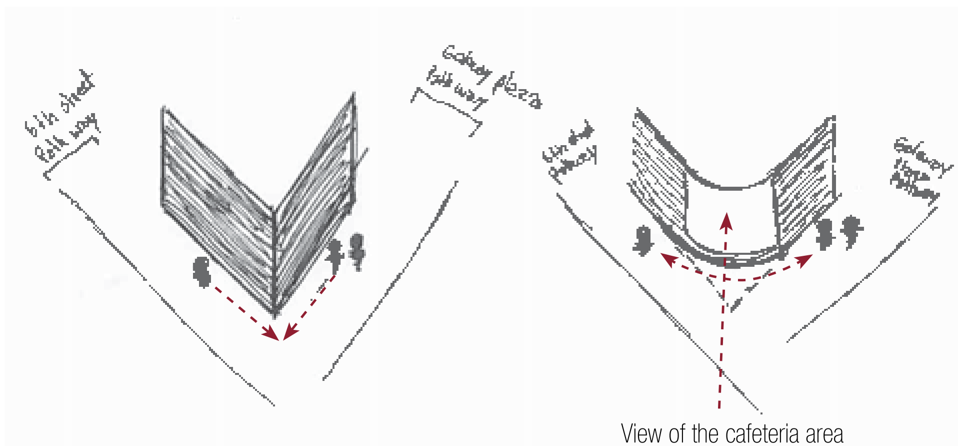
MOBILITY

While designing, the flow in the building had a fundamental role and helped in defining different uses of the spaces and possible situations that could occur in the transition areas.

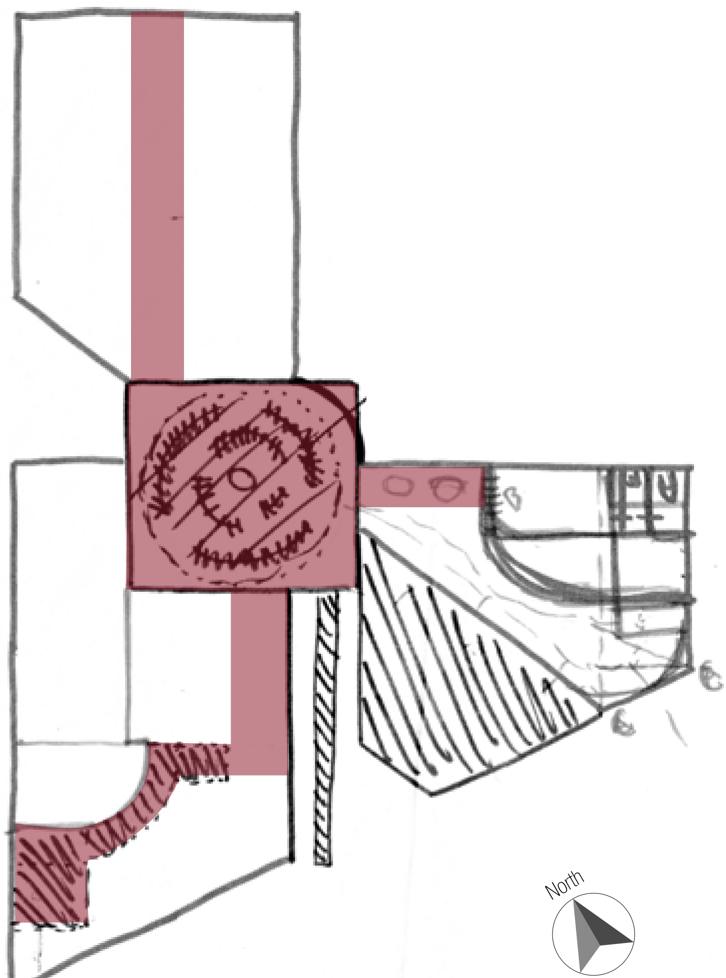
In general, to ease the transition though spaces it has been the main goal. This resulted in experimentations with level-free-access options like ramps, pathways of at least 1,8 m width and use of sliding doors at entrances and at main transition veins of the building, to ease continuity of conversation for deaf people, while walking.

Inspired by the deafspace design principles, architectural expediences have been used to ease the mobility of spaces, as creating round corners and shapes to increase a smooth flow, but also give a higher visual reach [Bauman, 2010].

The South-West corner of the cafeteria has a very pointed corner, which is very visible when entering the campus site from the city center and separated the 6th street from the plaza. The articulation of the corner is both concerning the movement and connection between the 6th street and the plaza, but also the visual effect that this space has one people entering the campus. As illustrated on ill 6.16, by rounding and glazing the corner, the movement is eased and visual awareness on the interior space is emphasized, when entering the plaza.
In the main transition areas of the building, beside keepinga high level of visual connection, the floor has been treated

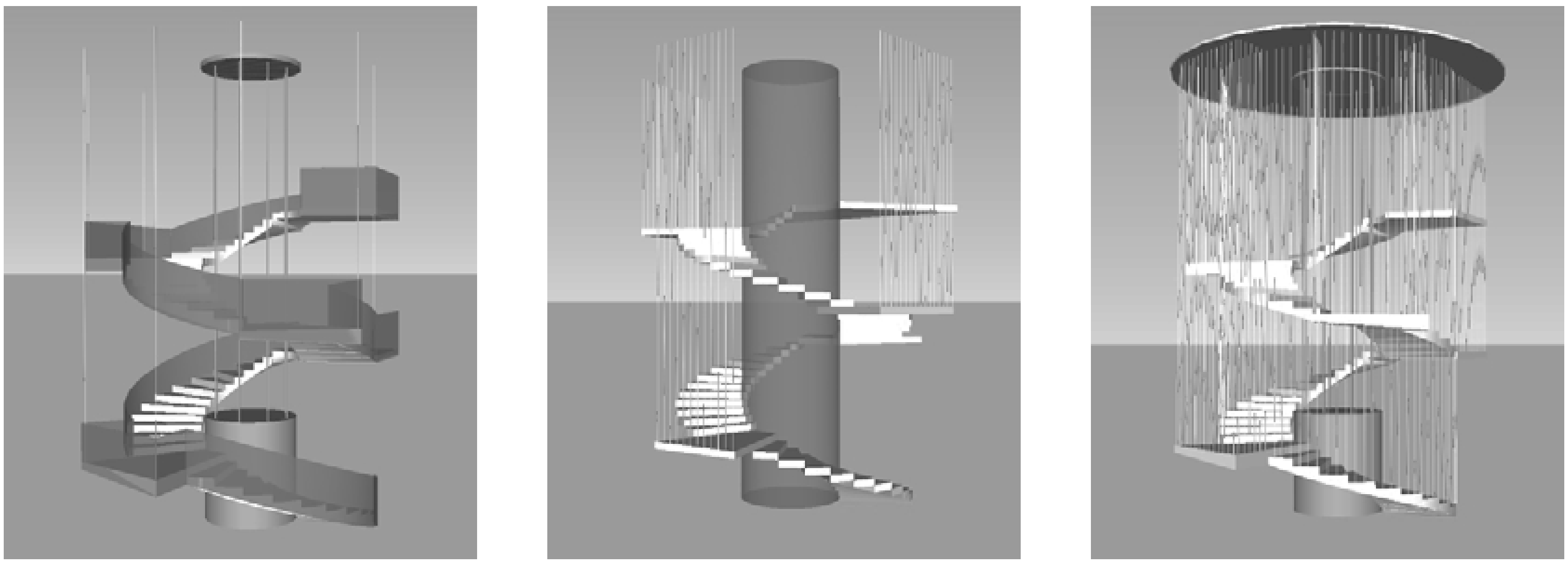


Ill 6.16 Principle sketch of the rounding the corner of the cafeteria ease the mobility and awareness of the internal space

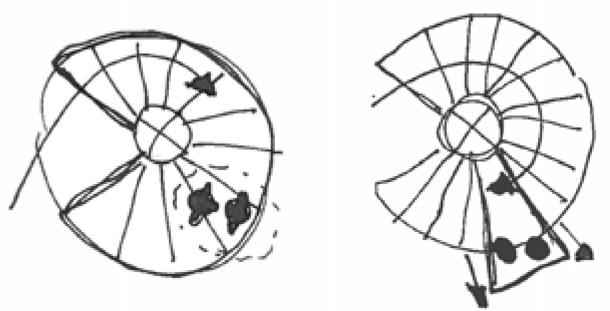


Ill 6.17 Plan sketch showing experimentation of the placement of the viabrating flooring.

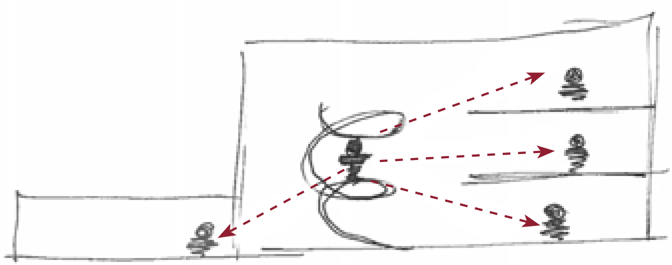
in such a way to arise awareness of people movement. For this, different solutions have been tested,also questioning the honesty in the use of materials according the materials properties and behaviour.
This change of material is both to mark a spatial division, but also used as an informative element. Ill. 6.17, shows and illustration of experimentation and placement of the different material flooring.
With the Gateway core as a central transition point it is ideal to place a staircase there as a vertical connection between all floors for the visual accessibility and orientation as illustrated in ill. 6.20.



Ill 6.18 Sketch models of staircase according to expression and structural considerations



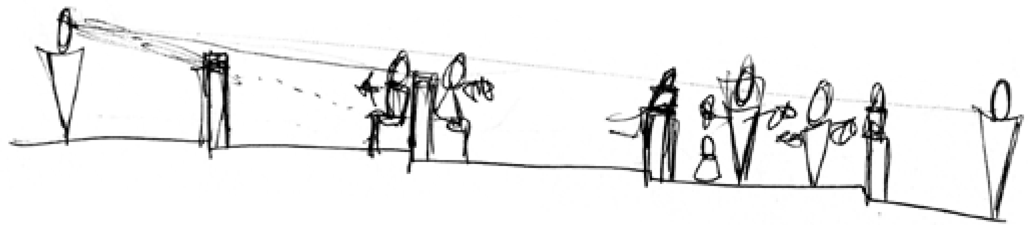
Ill 6.19 Sketch principles of spiral staircase in plan with and withouth the extending platform



Ill 6.20 Section sketch principle of the extended visual reach the staircase provide between floors

While designing the staircase, different types of situations that could occur in connection to deaf individuals were addressed.
The dimension of the staircase took it's departure from the minimum width of 1.8 m, minimum requirements for escape routes and making the step deeper to lower the inclination.

To follow the movement of the flow, the design was focused on a spiral shape staircase with a round elevator in the middle.
This staircase primary serves as transition between the floors, but with its central visual location in the building it also serves as a landmark or a place to meet fellow student or colleagues.
Walking on staircases takes the visual attention from the deaf individuals, so they stop on the staircase to have a conversation when seeing each other on the staircase [Bauman, 2010].
From this knowledge, experimentations were made with implementation of platforms that extends 1 meter beyond the side of the staircase as illustrated in ill 6.19. In connection with this different expression where made according to the structural stability of the staircase as ill. 6.18.



Ill 6.21 Principle sketch of leveling of spaces creating spatial pocket zones for seating and privat conversatings, while still maintaining a degree of visual overview.

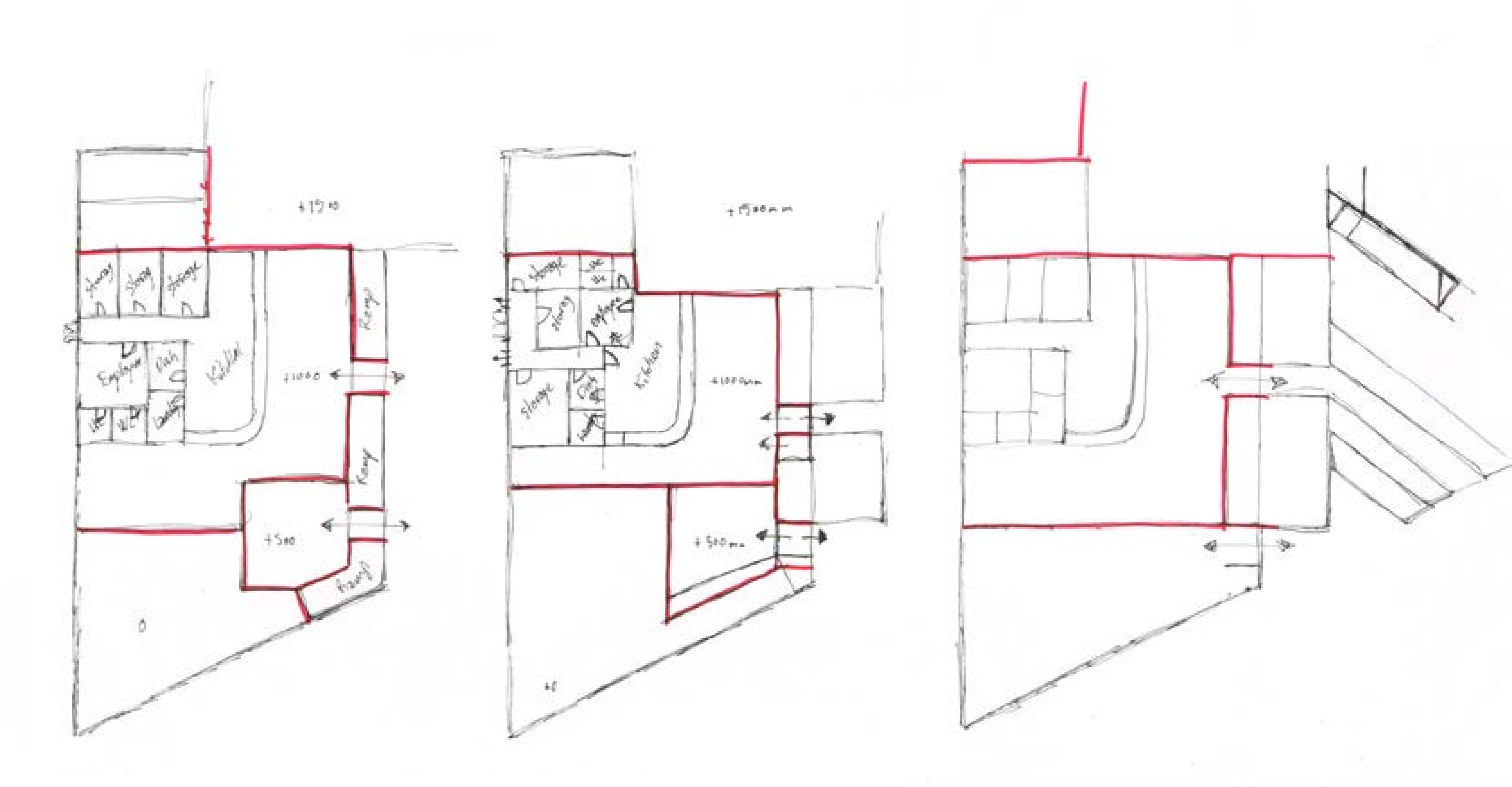
PUBLIC & PRIVAT SPHERES

Throughout the design process different element has been used to create spatial pockets to allow more private signed conversation and step aside from the transition areas. This has been experimented with in pathways between the teaching facilities, retail and the gateway, with the use of the columns.

The cafeteria dining area, Gateway core and visitor center are quite large spaces. Larger spaces with few sides can give difficulties in how individuals place themselves in space, because of the need of having our back sheltered and simultaneously control what/who is approaching [Gehl, 1971]. This is even more relevant in terms of deaf individuals, because of their lack of the auditorial sense and their visual way of speaking.

By transferring the idea of privacy in to a larger space, the dining areas has been levelled according to the topography to create pockets of zones for transition or seating, enhancing privacy and extending comfortable seating placement, but still maintaining the visual overview of the space as illustrated on ill. 6.21.

On the plan sketches of the cafeteria in illustration 6.22 different way of levelling and dividing the space is shown in connection to a fluent transition to the Gateway corridor and plaza to create a spatial connection with the ramp continuing fluently between the outdoor and indoor area.



Ill 6.22 Plan sketches of the cafeteria with experimentation on separation of the spaces in a fluent connection to the Gateway corridor and plaza

THE ENVELOPE

The envelope is an important part of the concept of the contrast between the massive volumes containing the main activities and the light and transparent core representing the transition space.
Different experimentations of treatment of the envelope has been made throughout the design process to accompany the concept, the deafspace principles and the tectonic ideas.

VISUAL AWARENESS

The tension between the public and private spaces was one of critical points of architecture when designing for deaf individuals, because of their visual convocations [Bauman, 2015].

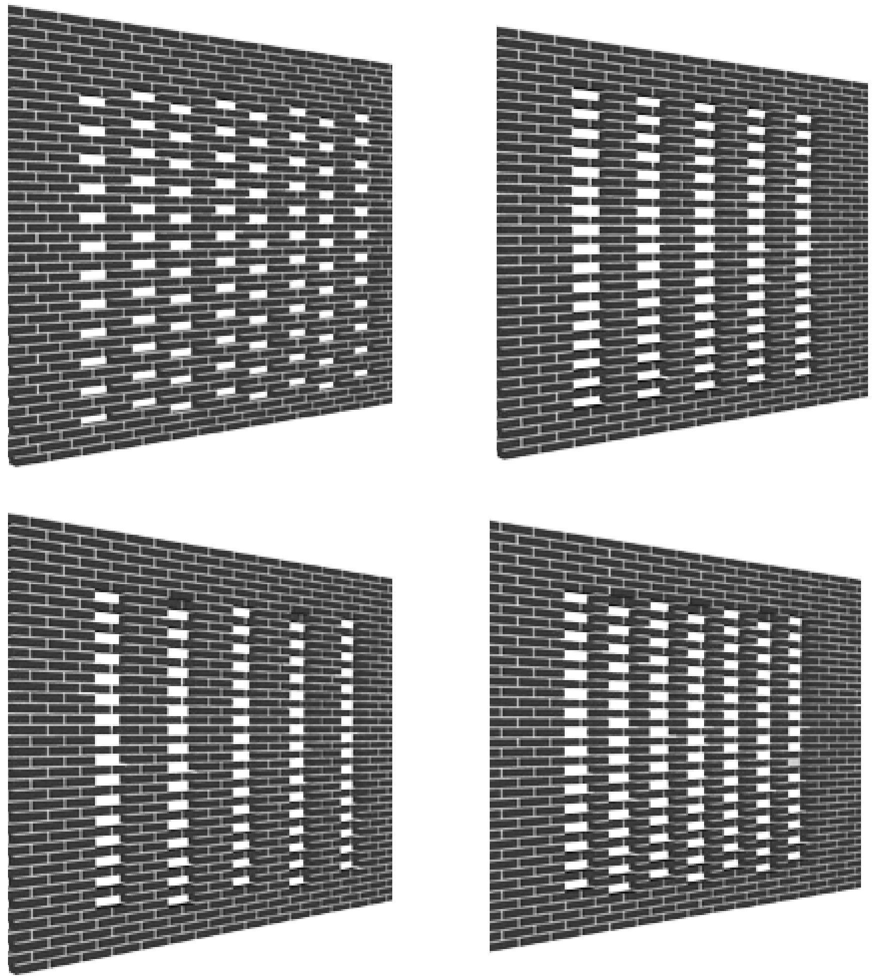
The different treatments and choice of materials of the exterior and interior walls evolved in experimentation on creating different degrees of visual awareness, instead of prioritizing on open visual reach that undermines privacy for deaf people. This has been done by creating the possibility of being aware of movement and events taking place

Ill 6.23 Sketch model of brick pattern and tranparency

around an individual, but not necessarily opeing a clear view toward who or what is occurring.

One of the materials chosen was brick for the exterior walls. Experimentations on the composition of the pattern types, in connection of the removal of some of the bricks to create different levels of transparency to make a degree of visual awareness from the internal in the external spaces, which is illustrated in ill. 6.23 and 6.24.

With the chosen brick pattern and transparency, daylight analysis were made to determent whether a proper amount of daylight in the internal spaces (see daylight simulations in annex 2 of the visitor center).



Ill 6.24 Experimentation of Brick patterns and tranparency level. The bottom right pattern where the final chose

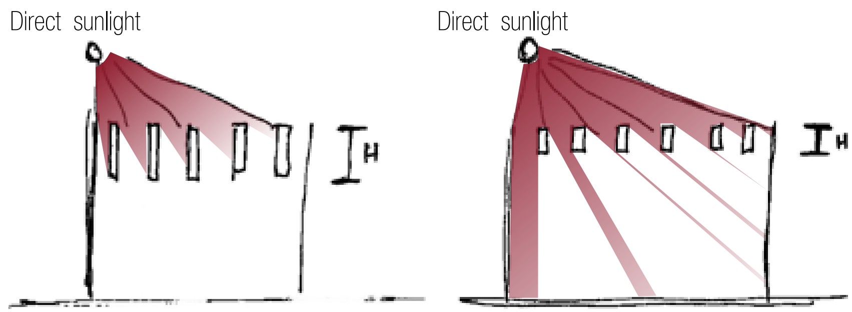
COLOR AND LIGHT CONDITIONS

Deaf individuals maintain spatial awareness by constant use of their peripheral vision, so they are able to have a conversation [Bauman, 2010]. The efficiency of the peripheral vision is highly affected by the light conditions and colour of the spaces, as descript in the Deaf design principles [Bauman, 2010].

Colour, texture and light conditions of the different elements has been evaluated according to the colour and light conditions provides to minimize stresses for the eyes and give a visual clarity for signing and a clear view of facial expressions.

The choice of the red brick is due to the connection to the existing context as well for the colour texture and structural properties of the material. Other colours as light blue and lime green, which very well contrast skin tones, are also used to mark areas and functions as well for the furnishing.

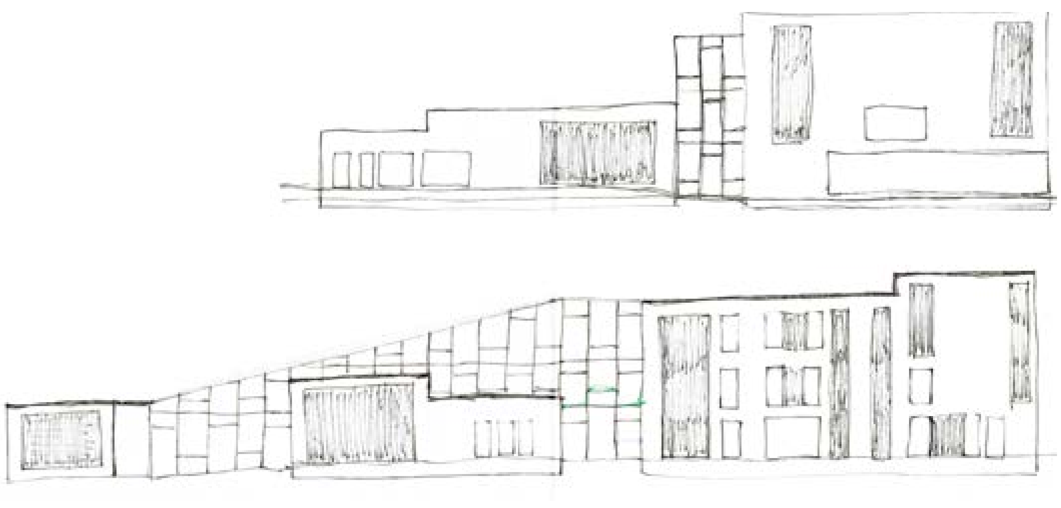
With a totally glazed Gateway and cafeteria roof, to pro-



Ill 6.25 Principle sketch of the beams and columes blocking the direct sunlight the higher the elements are.

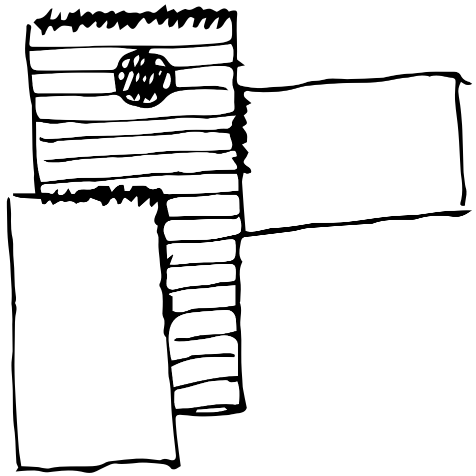
vide transparency for the movement and visual reach, the issues of glaring and bright surfaces needed to be taken in to consideration.
In principle, through the use of slim and tall beams and columns the direct sunlight can be block by it as illustrated in ill. 6.25. But due to functional and structural reasons theframes were placed too far from each other to make this effect work properly. Therefore, the issue was addressed with the implementation of prismatic glazing with a light transmittance of 15 % [Siteco.com, 2016] and daylight simulations were made to test the natural lighting conditions.

Daylight simulations have been made for the whole building to ensure an equal distribution of light and to guide the placement and height of the windows and brick pattern in connection to the functions. This was done considering also the facade expression (ill. 6.26) and the spatial experience intended for each space.
A selection of the daylight process and simulation is shown more in detail in Annex 2.

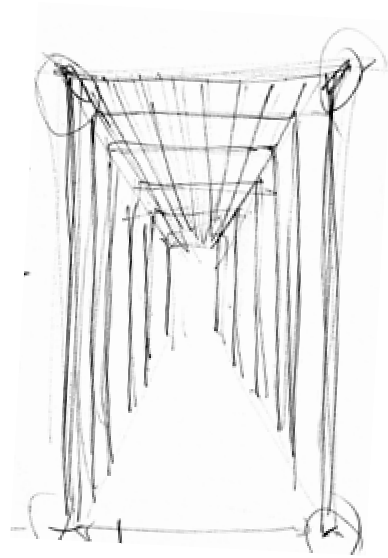


Ill 6.26 North and East elevation sketch of the composition of the brick pattern, window placement and frame pattern of the glazed panels of the Gateway.

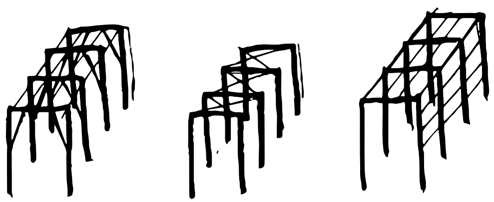
GATEWAY DESIGN



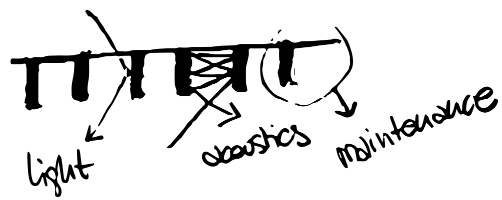
Ill 6.28 Roof view sketch showing the relationship between brick buildings and Gateway



Ill 6.29 Corridor gesture sketch.



Ill 6.30 Frames sketches



Ill 6.31 Roof sketch.

As afore mentioned, the Gateway has a strategic role, not only because is the crossroad of all the different flows of users inhabiting the building, but especially because it represents the entrance to it: it has to be advertising, directive, communicative and arising curiosity. Moreover, it has to act with the same character of a building envelope, therefore assuming features typical of something separating the outer space from the inner one (Ill. 6.28).
With these considerations in mind and with the goal of designing with a specific care for deaf people, the idea of creating a very simple space, characterized by the used of vertical lines, sign of movement for the cognitive perception (Böhme), very diffuse and high natural lighting and high level of visual transparency was created (Ill. 6.29).

This brought to working on a series of frames which led the user toward the core, in different ways according to the hierarchy of flows' direction.

Different materials have been taken into consideration, mainly steel and different kinds of wood, but being the Gateway an entrance and also an interface, the use of the latter seemed a right choice, not just in terms of the conceived feeling, due to kind of detailing, reflection of light, smell, but also for more functional reasons related to acoustics or space definition.

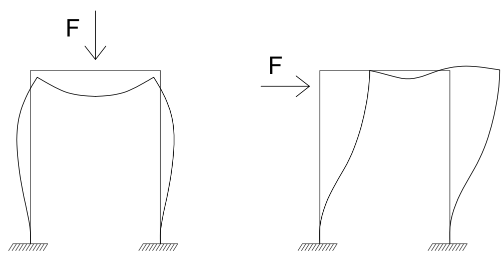
DESIGN PROCESS

Due to the wide span to be covered, with quite slender elements, a glue-laminated hard wood 36 was chosen, having this kind of product a good resistance to bending moment. This choice represented the best compromise fulfilling the aesthetic, functional and constructional considerations.
Even though the architectonic expression of this space was being created quite straightforward, considering the theoretical analysis and the feelings the spaces was supposed to conceive, different configurations has been thought through and weighted against the Design Criteria (pp. 73). This led to the awareness that other kinds of structural systems may have worked better in terms of stability alone, but they were not fulfilling aesthetic and cognitive-perception-related goals.

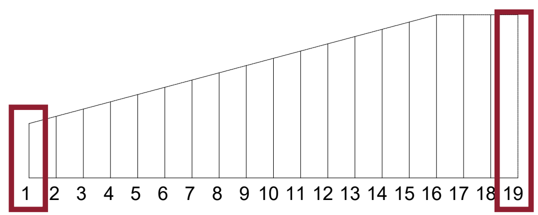
When the compromise among the architectonic expression, functionality and stability reasons was decided, the structural reliability and material utilization were tested and optimized.
Preliminary calculations for dimensioning the cross-sections of frame 1 and 19 were done (Ill. 6.34). These dimensions were used to complete the geometric definition of the Gateway and to run structure stability simulations with the plug-in Karamba.

Then the model was imported to Robot where a series of calculations were run in order to optimize the cross-section dimension of the frames, therefore optimizing the use of material. (Calculations in Chapter 9, Annex 4).

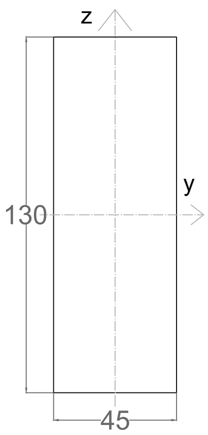
Ill 6.32 Joint and space definition.



Ill 6.33 Static scheme and deformation.



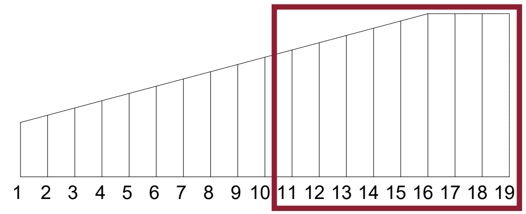
Ill 6.34 Gateway pavillion frames diagram.



GATEWAY CORE

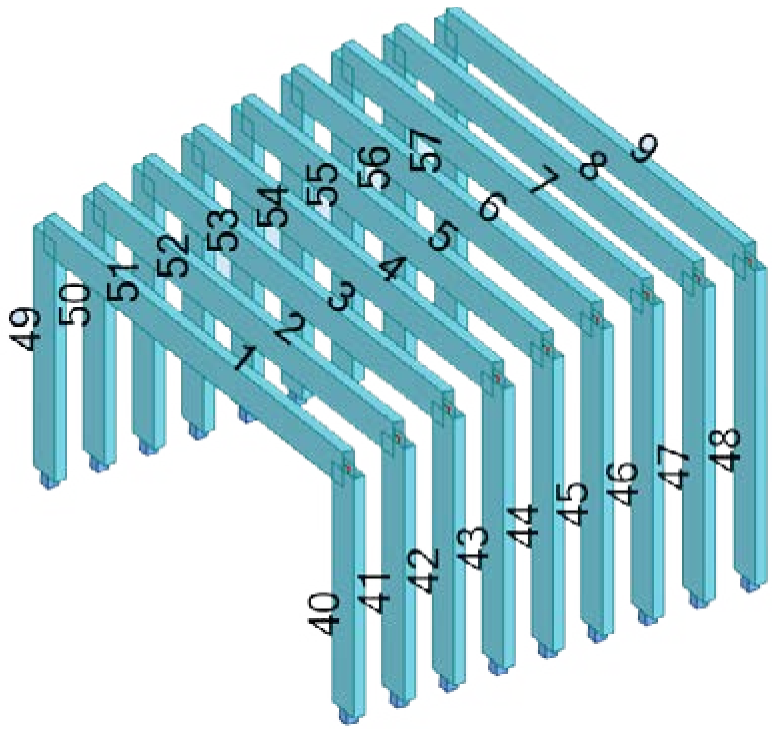
Frames cross-section: 130cm x 45 cm
Ratio: 0.79 < x > 0.93

For the Gateway core, consisting of frame n° 11-19, the shown cross-section was chosen since the utilization of- material resulted satisfactory.

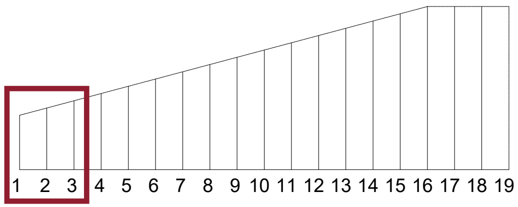


Member	Section	Material	Lay	Laz	Ratio	Case
1	All beams	GL36h	13.85	40.00	0.92	6 COMB1
2	All beams	GL36h	13.85	40.00	0.92	6 COMB1
3	All beams	GL36h	13.85	40.00	0.91	6 COMB1
4	All beams	GL36h	13.85	40.00	0.90	6 COMB1
5	All beams	GL36h	13.85	40.00	0.90	6 COMB1
6	All beams	GL36h	13.85	40.00	0.89	6 COMB1
7	All beams	GL36h	13.85	40.00	0.89	6 COMB1
8	All beams	GL36h	13.85	40.00	0.89	6 COMB1
9	All beams	GL36h	13.85	40.00	0.89	6 COMB1
40	All columns	GL36h	20.34	7.04	0.86	6 COMB1
41	All columns	GL36h	21.49	7.44	0.84	6 COMB1
42	All columns	GL36h	22.63	7.83	0.83	6 COMB1
43	All columns	GL36h	23.78	8.23	0.82	6 COMB1
44	All columns	GL36h	24.92	8.63	0.81	6 COMB1
45	All columns	GL36h	26.07	9.02	0.80	6 COMB1
46	All columns	GL36h	26.67	9.23	0.79	6 COMB1
47	All columns	GL36h	26.67	9.23	0.79	6 COMB1
48	All columns	GL36h	26.67	9.23	0.79	6 COMB1
49	All columns	GL36h	20.34	7.04	0.93	6 COMB1
50	All columns	GL36h	21.49	7.44	0.93	6 COMB1
51	All columns	GL36h	22.63	7.83	0.92	6 COMB1
52	All columns	GL36h	23.78	8.23	0.91	6 COMB1
53	All columns	GL36h	24.92	8.63	0.91	6 COMB1
54	All columns	GL36h	26.07	9.02	0.90	6 COMB1
55	All columns	GL36h	26.67	9.23	0.90	6 COMB1
56	All columns	GL36h	26.67	9.23	0.90	6 COMB1

Ill 6.35 Robot results, Gateway core.



Ill 6.36 3D image Gateway core with elements numbering.

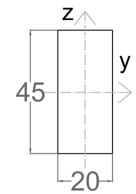


GATEWAY CORRIDOR

For the Gateway corridor, consisting of frame n° 1-10, a series of iterative calculations have been run, in order to find suitable cross-sections for each frame.

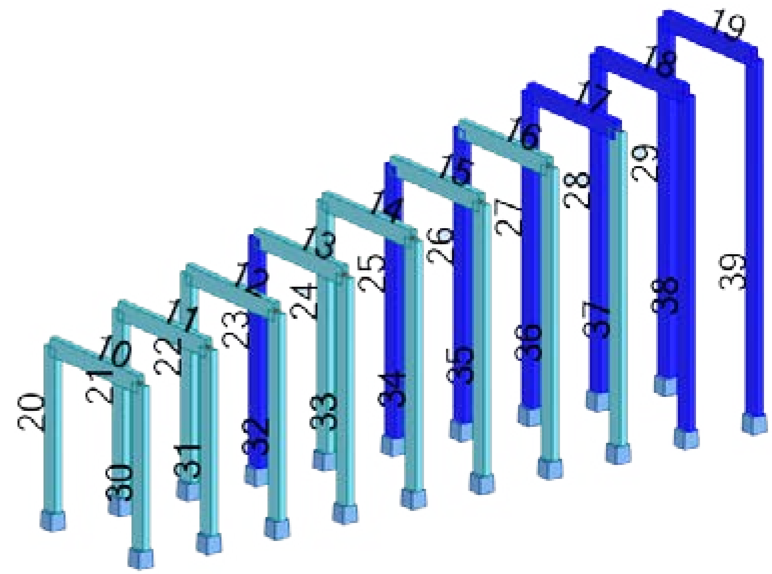
CROSS-SECTION 1

Frames cross-section: 45cm x 20 cm
Ratio: 0.42 < x > 0.96
Verified frames n°: 1-2-3

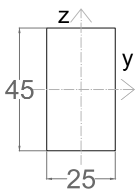


Member	Section	Material	Lay	Laz	Ratio	Case
10	All beams	GL36h	7.78	17.50	0.81	6 COMB1
11	All beams	GL36h	7.78	17.50	0.83	6 COMB1
12	All beams	GL36h	7.78	17.50	0.85	6 COMB1
13	All beams	GL36h	7.78	17.50	0.87	6 COMB1
14	All beams	GL36h	7.78	17.50	0.91	6 COMB1
15	All beams	GL36h	7.78	17.50	0.95	6 COMB1
16	All beams	GL36h	7.78	17.50	0.99	6 COMB1
17	All beams	GL36h	7.78	17.50	1.03	6 COMB1
18	All beams	GL36h	7.78	17.50	1.08	6 COMB1
19	All beams	GL36h	7.78	17.50	1.12	6 COMB1
20	All columns	GL36h	20.00	8.89	0.83	6 COMB1
21	All columns	GL36h	22.58	10.03	0.90	6 COMB1
22	All columns	GL36h	25.15	11.18	0.96	6 COMB1
23	All columns	GL36h	27.73	12.32	1.03	6 COMB1
24	All columns	GL36h	30.31	13.47	1.10	6 COMB1
25	All columns	GL36h	32.88	14.61	1.16	6 COMB1
26	All columns	GL36h	35.46	15.76	1.23	6 COMB1
27	All columns	GL36h	38.04	16.91	1.30	6 COMB1
28	All columns	GL36h	40.61	18.05	1.37	6 COMB1
29	All columns	GL36h	43.19	19.20	1.44	6 COMB1
30	All columns	GL36h	20.00	8.89	0.42	6 COMB1
31	All columns	GL36h	22.58	10.03	0.50	6 COMB1
32	All columns	GL36h	25.15	11.18	0.58	6 COMB1
33	All columns	GL36h	27.73	12.32	0.66	6 COMB1
34	All columns	GL36h	30.31	13.47	0.74	6 COMB1
35	All columns	GL36h	32.88	14.61	0.82	6 COMB1
36	All columns	GL36h	35.46	15.76	0.90	6 COMB1
37	All columns	GL36h	38.04	16.91	0.98	6 COMB1
38	All columns	GL36h	40.61	18.05	1.06	6 COMB1
39	All columns	GL36h	43.19	19.20	1.13	6 COMB1

Ill 6.37 Robot results, Gateway corridor, cross-section 1.

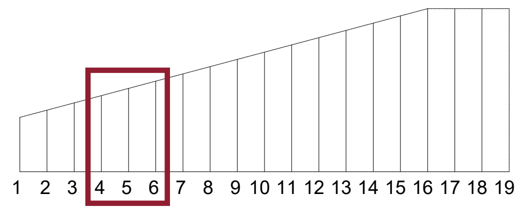


Ill 6.38 3D image Gateway core with elements numbering. Blue elements are not verified.



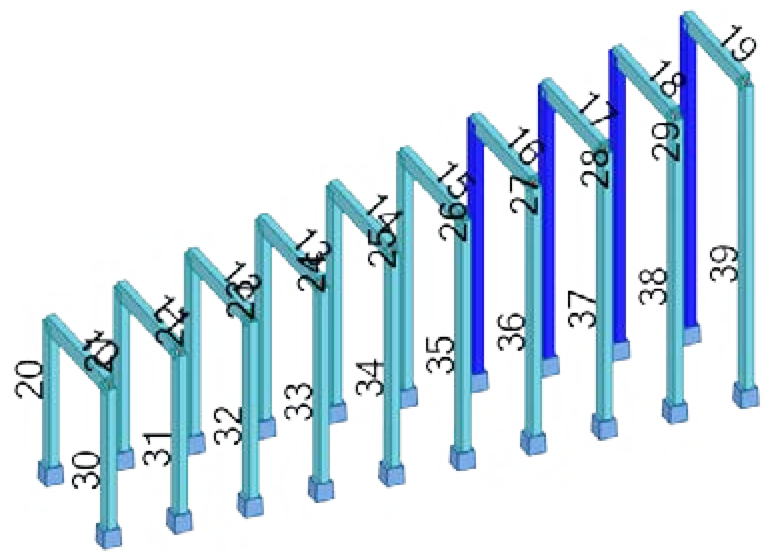
CROSS-SECTION 2

Frames cross-section: 45cm x 25 cm
Ratio: 0.50 < x > 0.97
Verified frames n°: 4-5-6

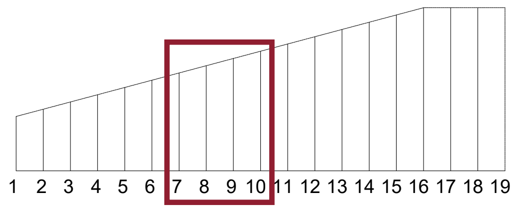


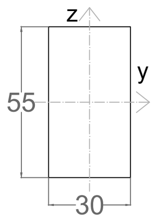
Member	Section	Material	Lay	Laz	Ratio	Case
10	All beams	GL36h	7.78	14.00	0.78	6 COMB1
11	All beams	GL36h	7.78	14.00	0.79	6 COMB1
12	All beams	GL36h	7.78	14.00	0.81	6 COMB1
13	All beams	GL36h	7.78	14.00	0.83	6 COMB1
14	All beams	GL36h	7.78	14.00	0.84	6 COMB1
15	All beams	GL36h	7.78	14.00	0.86	6 COMB1
16	All beams	GL36h	7.78	14.00	0.88	6 COMB1
17	All beams	GL36h	7.78	14.00	0.89	6 COMB1
18	All beams	GL36h	7.78	14.00	0.92	6 COMB1
19	All beams	GL36h	7.78	14.00	0.95	6 COMB1
20	All columns	GL36h	16.00	8.89	0.71	6 COMB1
21	All columns	GL36h	18.06	10.03	0.76	6 COMB1
22	All columns	GL36h	20.12	11.18	0.81	6 COMB1
23	All columns	GL36h	22.18	12.32	0.86	6 COMB1
24	All columns	GL36h	24.25	13.47	0.91	6 COMB1
25	All columns	GL36h	26.31	14.61	0.97	6 COMB1
26	All columns	GL36h	28.37	15.76	1.02	6 COMB1
27	All columns	GL36h	30.43	16.91	1.07	6 COMB1
28	All columns	GL36h	32.49	18.05	1.13	6 COMB1
29	All columns	GL36h	34.55	19.20	1.18	6 COMB1
30	All columns	GL36h	16.00	8.89	0.30	6 COMB1
31	All columns	GL36h	18.06	10.03	0.37	6 COMB1
32	All columns	GL36h	20.12	11.18	0.43	6 COMB1
33	All columns	GL36h	22.18	12.32	0.50	6 COMB1
34	All columns	GL36h	24.25	13.47	0.56	6 COMB1
35	All columns	GL36h	26.31	14.61	0.63	6 COMB1
36	All columns	GL36h	28.37	15.76	0.69	6 COMB1
37	All columns	GL36h	30.43	16.91	0.76	6 COMB1
38	All columns	GL36h	32.49	18.05	0.82	6 COMB1
39	All columns	GL36h	34.55	19.20	0.88	6 COMB1

Ill 6.39 Robot results, Gateway corridor, cross-section 2.



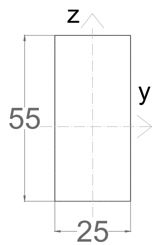
Ill 6.40 3D image Gateway core with elements numbering. Blue elements are not verified.





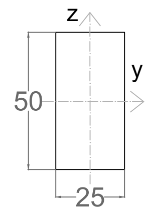
CROSS-SECTION 3

Frames cross-section: 55cm x 30 cm
Ratio: 0.35 < x > 0.80
Verified frames n°: 7-8-9-10
Frames are verified, but the use of material could be optimized.



CROSS-SECTION 4

Frames cross-section: 55cm x 25 cm
Ratio: 0.44 < x > 0.87
Verified frames n°: 7-8-9-10
Frames are verified, but the use of material could be optimized.



CROSS-SECTION 5

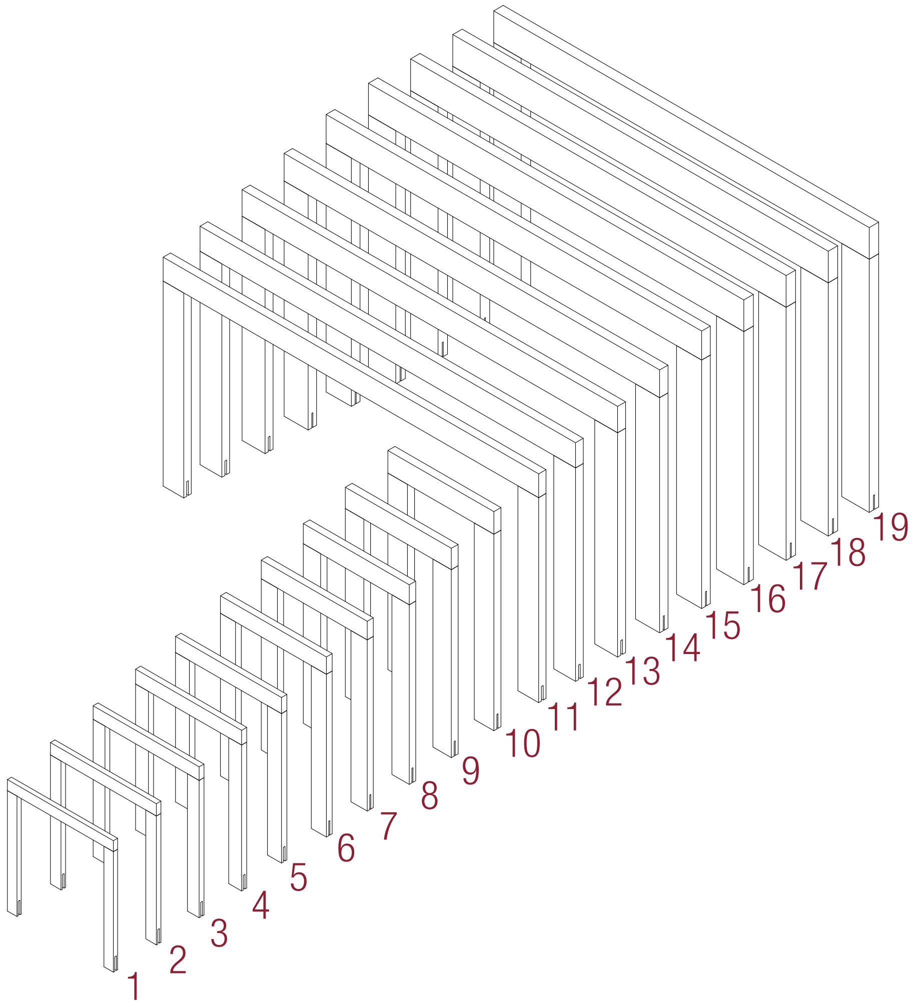
Frames cross-section: 50cm x 25 cm
Ratio: 0.55 < x > 0.97
Verified frames n°: 7-8-9-10
This cross-section is chosen because the utilization of material is satisfactory.

Member	Section	Material	Lay	Laz	Ratio
10	All beams	GL36h	6.36	11.67	0.74
11	All beams	GL36h	6.36	11.67	0.75
12	All beams	GL36h	6.36	11.67	0.76
13	All beams	GL36h	6.36	11.67	0.77
14	All beams	GL36h	6.36	11.67	0.78
15	All beams	GL36h	6.36	11.67	0.79
16	All beams	GL36h	6.36	11.67	0.80
17	All beams	GL36h	6.36	11.67	0.82
18	All beams	GL36h	6.36	11.67	0.83
19	All beams	GL36h	6.36	11.67	0.84
20	All columns	GL36h	13.33	7.27	0.50
21	All columns	GL36h	15.05	8.21	0.51
22	All columns	GL36h	16.77	9.15	0.52
23	All columns	GL36h	18.49	10.08	0.53
24	All columns	GL36h	20.20	11.02	0.56
25	All columns	GL36h	21.92	11.96	0.59
26	All columns	GL36h	23.64	12.89	0.61
27	All columns	GL36h	25.36	13.83	0.64
28	All columns	GL36h	27.08	14.77	0.67
29	All columns	GL36h	28.79	15.71	0.70
30	All columns	GL36h	13.33	7.27	0.18
31	All columns	GL36h	15.05	8.21	0.16
32	All columns	GL36h	16.77	9.15	0.20
33	All columns	GL36h	18.49	10.08	0.24
34	All columns	GL36h	20.20	11.02	0.28
35	All columns	GL36h	21.92	11.96	0.31
36	All columns	GL36h	23.64	12.89	0.35
37	All columns	GL36h	25.36	13.83	0.39
38	All columns	GL36h	27.08	14.77	0.42
39	All columns	GL36h	28.79	15.71	0.46

Member	Section	Material	Lay	Laz	Ratio
10	All beams	GL36h	6.36	14.00	0.76
11	All beams	GL36h	6.36	14.00	0.77
12	All beams	GL36h	6.36	14.00	0.78
13	All beams	GL36h	6.36	14.00	0.80
14	All beams	GL36h	6.36	14.00	0.81
15	All beams	GL36h	6.36	14.00	0.82
16	All beams	GL36h	6.36	14.00	0.83
17	All beams	GL36h	6.36	14.00	0.85
18	All beams	GL36h	6.36	14.00	0.86
19	All beams	GL36h	6.36	14.00	0.87
20	All columns	GL36h	16.00	7.27	0.53
21	All columns	GL36h	18.06	8.21	0.55
22	All columns	GL36h	20.12	9.15	0.57
23	All columns	GL36h	22.18	10.08	0.61
24	All columns	GL36h	24.25	11.02	0.64
25	All columns	GL36h	26.31	11.96	0.67
26	All columns	GL36h	28.37	12.89	0.71
27	All columns	GL36h	30.43	13.83	0.74
28	All columns	GL36h	32.49	14.77	0.78
29	All columns	GL36h	34.55	15.71	0.82
30	All columns	GL36h	16.00	7.27	0.18
31	All columns	GL36h	18.06	8.21	0.22
32	All columns	GL36h	20.12	9.15	0.27
33	All columns	GL36h	22.18	10.08	0.31
34	All columns	GL36h	24.25	11.02	0.36
35	All columns	GL36h	26.31	11.96	0.40
36	All columns	GL36h	28.37	12.89	0.44
37	All columns	GL36h	30.43	13.83	0.49
38	All columns	GL36h	32.49	14.77	0.53
39	All columns	GL36h	34.55	15.71	0.57

Member	Section	Material	Lay	Laz	Ratio
10	All beams	GL36h	7.00	14.00	0.77
11	All beams	GL36h	7.00	14.00	0.78
12	All beams	GL36h	7.00	14.00	0.79
13	All beams	GL36h	7.00	14.00	0.81
14	All beams	GL36h	7.00	14.00	0.82
15	All beams	GL36h	7.00	14.00	0.84
16	All beams	GL36h	7.00	14.00	0.85
17	All beams	GL36h	7.00	14.00	0.87
18	All beams	GL36h	7.00	14.00	0.88
19	All beams	GL36h	7.00	14.00	0.90
20	All columns	GL36h	16.00	8.00	0.61
21	All columns	GL36h	18.06	9.03	0.63
22	All columns	GL36h	20.12	10.06	0.67
23	All columns	GL36h	22.18	11.09	0.72
24	All columns	GL36h	24.25	12.12	0.76
25	All columns	GL36h	26.31	13.15	0.80
26	All columns	GL36h	28.37	14.18	0.84
27	All columns	GL36h	30.43	15.21	0.88
28	All columns	GL36h	32.49	16.25	0.93
29	All columns	GL36h	34.55	17.28	0.97
30	All columns	GL36h	16.00	8.00	0.23
31	All columns	GL36h	18.06	9.03	0.28
32	All columns	GL36h	20.12	10.06	0.34
33	All columns	GL36h	22.18	11.09	0.39
34	All columns	GL36h	24.25	12.12	0.44
35	All columns	GL36h	26.31	13.15	0.50
36	All columns	GL36h	28.37	14.18	0.55
37	All columns	GL36h	30.43	15.21	0.60
38	All columns	GL36h	32.49	16.25	0.65
39	All columns	GL36h	34.55	17.28	0.70

Ill 6.41



Ill 6.42 Gateway final 3D model

The Illustration 6.42 show the final outcome of the design of the Gateway.

At this point is is possible to reflect upon a series of considerations related to the nature of the structural elements and their behaviour.
This structure consists of a series of hyperstatic-rigid frames created by slender elements (h/d > 10). Slender elements, by definition, do not behave according the De Saint Venant Theory. In particular, when these kind of elements are subjected to compressive axial forces, their failure results in a phenomenon of buckling.
The critical load condition which will create buckling of the elements can be tested with the Euler formula:

$$P_{cr} = \frac{\pi^2 EI}{L^2}$$

It is possible to see how the critical load is dependent on the Young's Modulus and the second moment of inertia, therefore, dependent on the materials and the cross-sectiond area, and on the slenderness of the structural element, therefore, dependent on the overall geometry of the element.

This kind of calculation allow the verification of a satisfactory cross-seciton dimension for the elements subjected to axial compressive force.

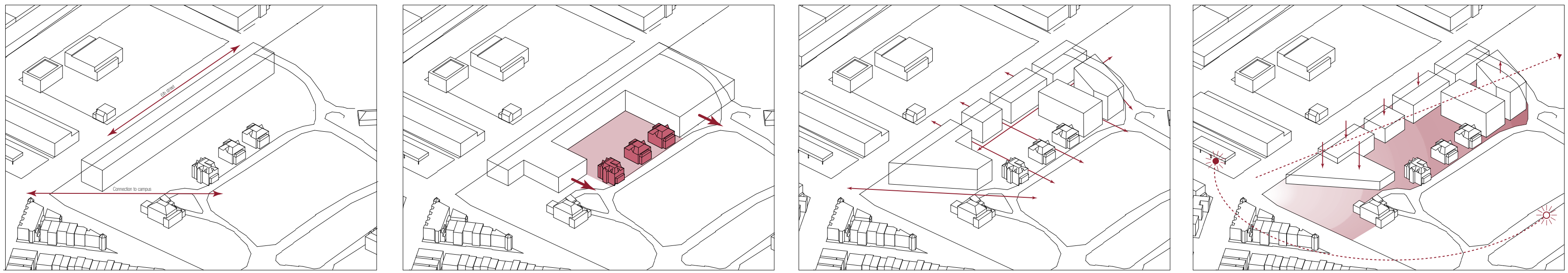
Further explanations about the structural behaviour of the frames subjected to applied forces related to bending moment and consequent deformation are in Annex 5.

CONTENT INDEX

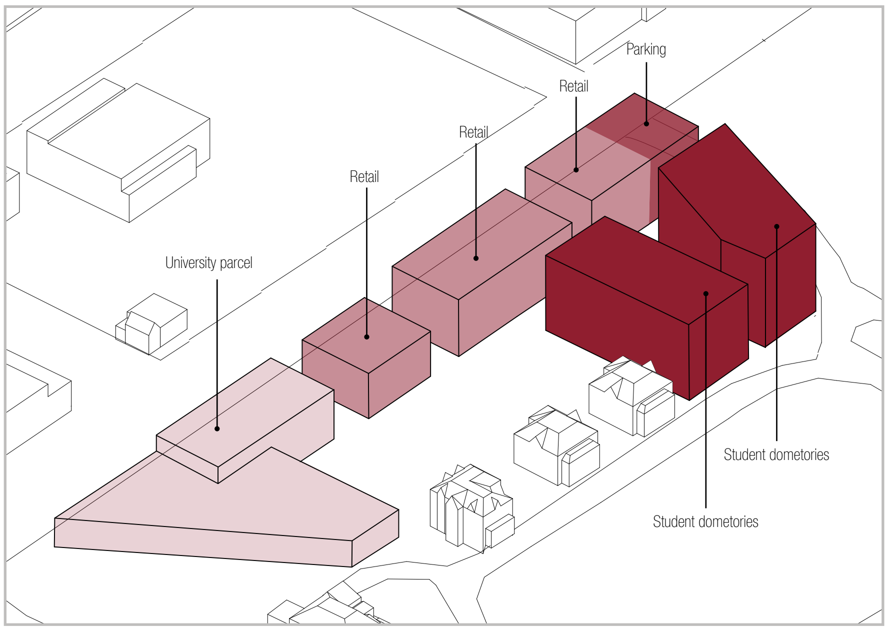
PRESENTATION #7

GATEWAY PLAZA PERSPECTIVE

The Gateway Plaza is the entrance to the campus site. It opens an overview toward Olmsted green in the background and a straight view to the university parcel.
Flow is fluently guided by the topography and the landscape treatment towards Olmsted green, dissolving the edge between the city and the campus green areas.



Ill 7.2 Conceptual diagram



Ill 7.3 Function distribution

MASTERPLAN 1:1200

North

The arrangement of the buildings of the whole site aims at dissolving the edge between the 6th street and the campus area and therby meeting the furture development of the area, striving for a stronger integration among Deaf and hearing communities.

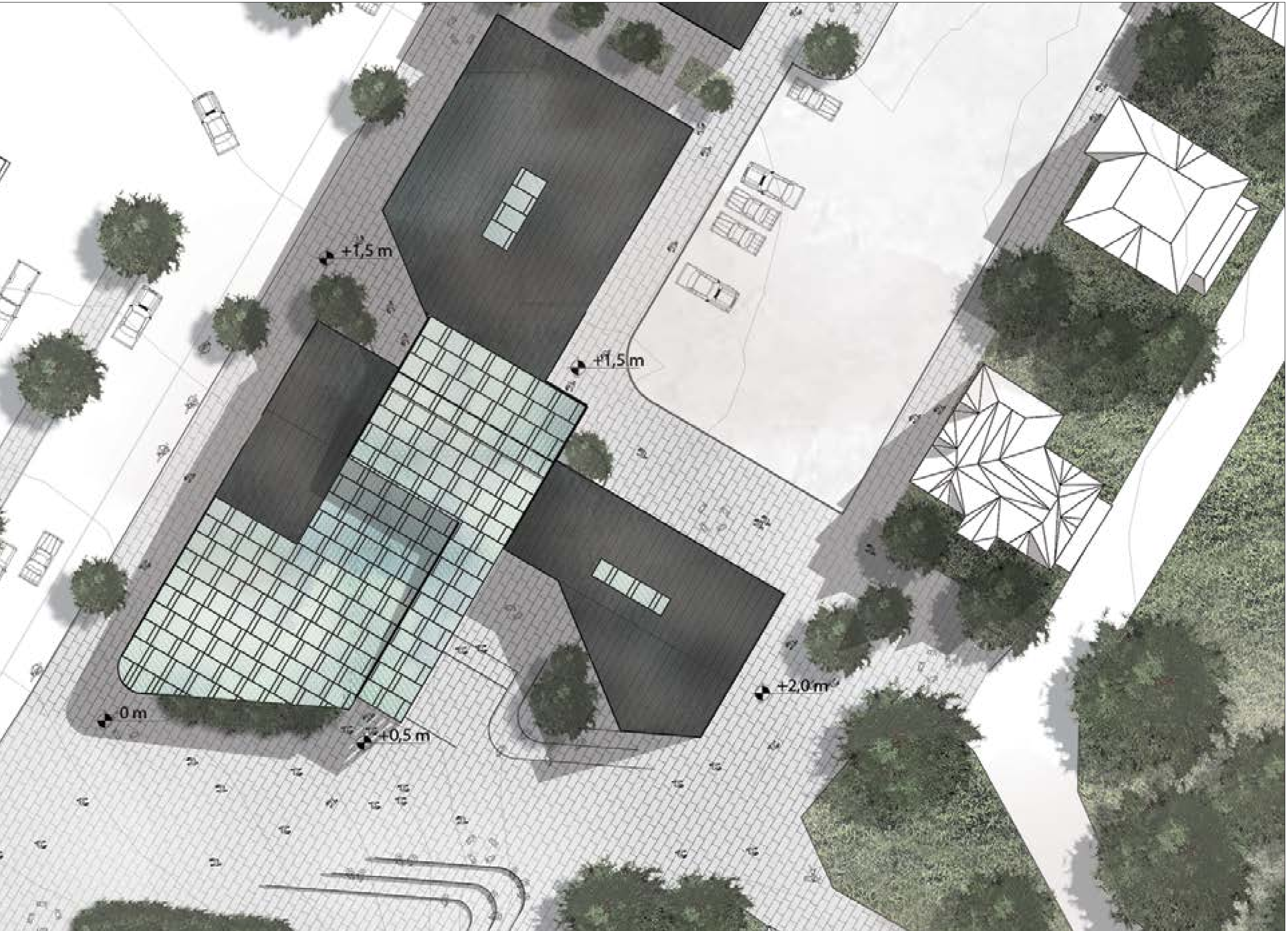
ELEVATION EAST 1:1000

ELEVATION WEST 1:1000

UNIVERSITY PARCEL MASTERPLAN 1:500

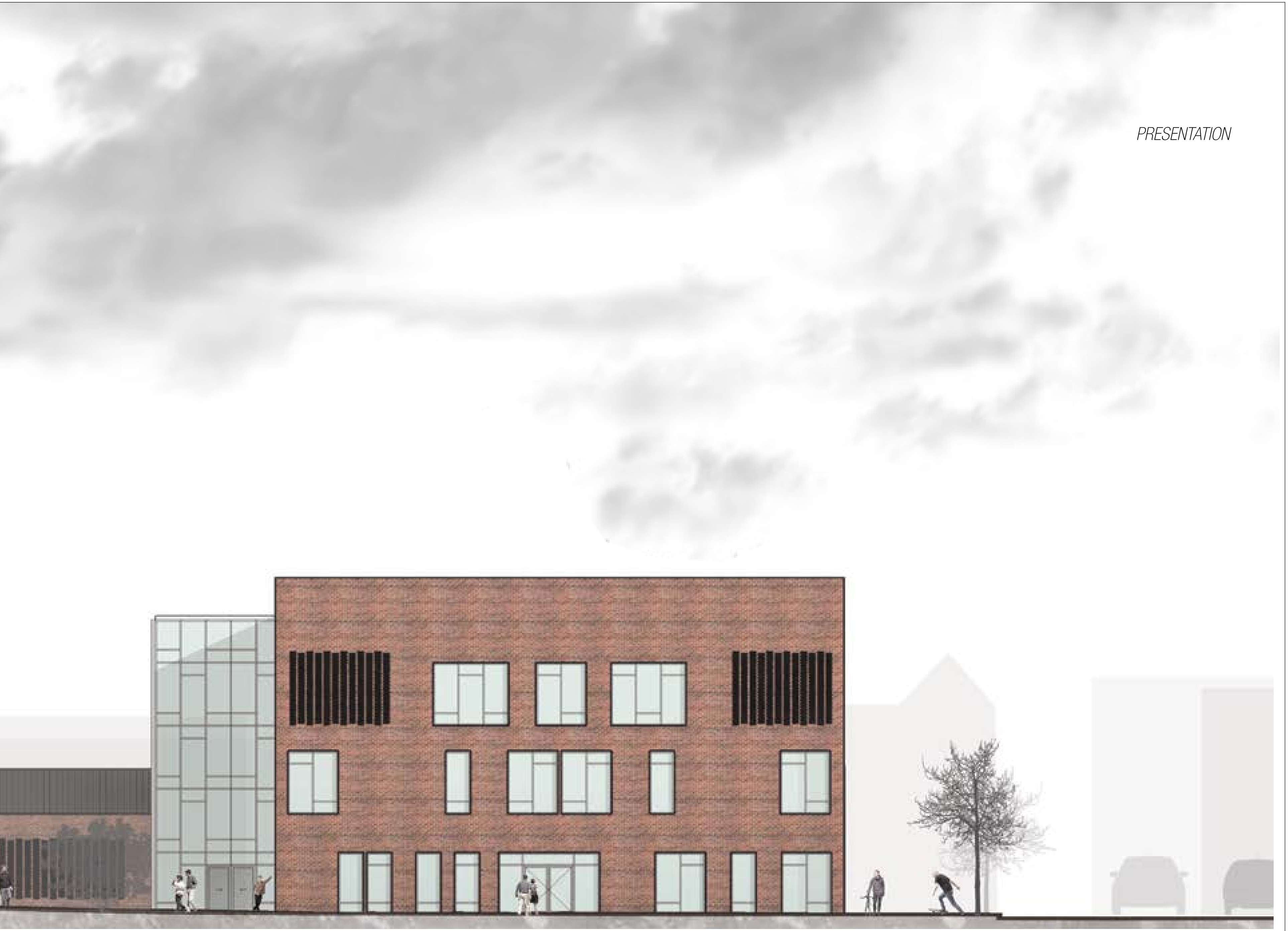
North

The University parcel is placed in close connection to the plaza and serving as the tractor point for gatherings and visitors coming to Gallaudet University.
It serves as a landmark in the area with its contrast between the massive and light building volumes that clearly marks the different character of the buildings of the area.

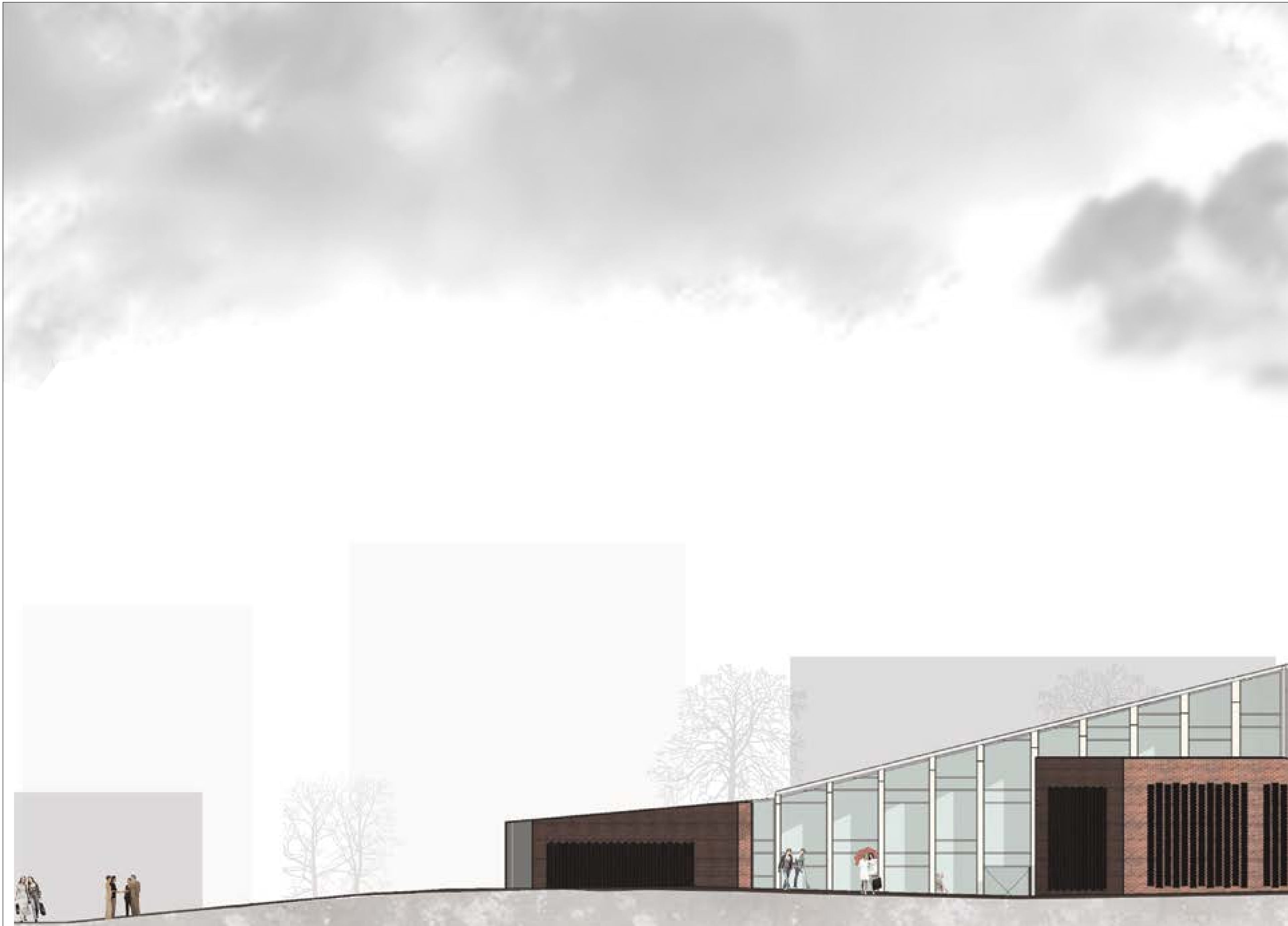

+1,5 m
+1,5 m
+2,0 m
0 m
+0,5 m

ill. ELEVATION SOUTH of university parcel 1:200

ELEVATION NORTH of university parcel 1:200



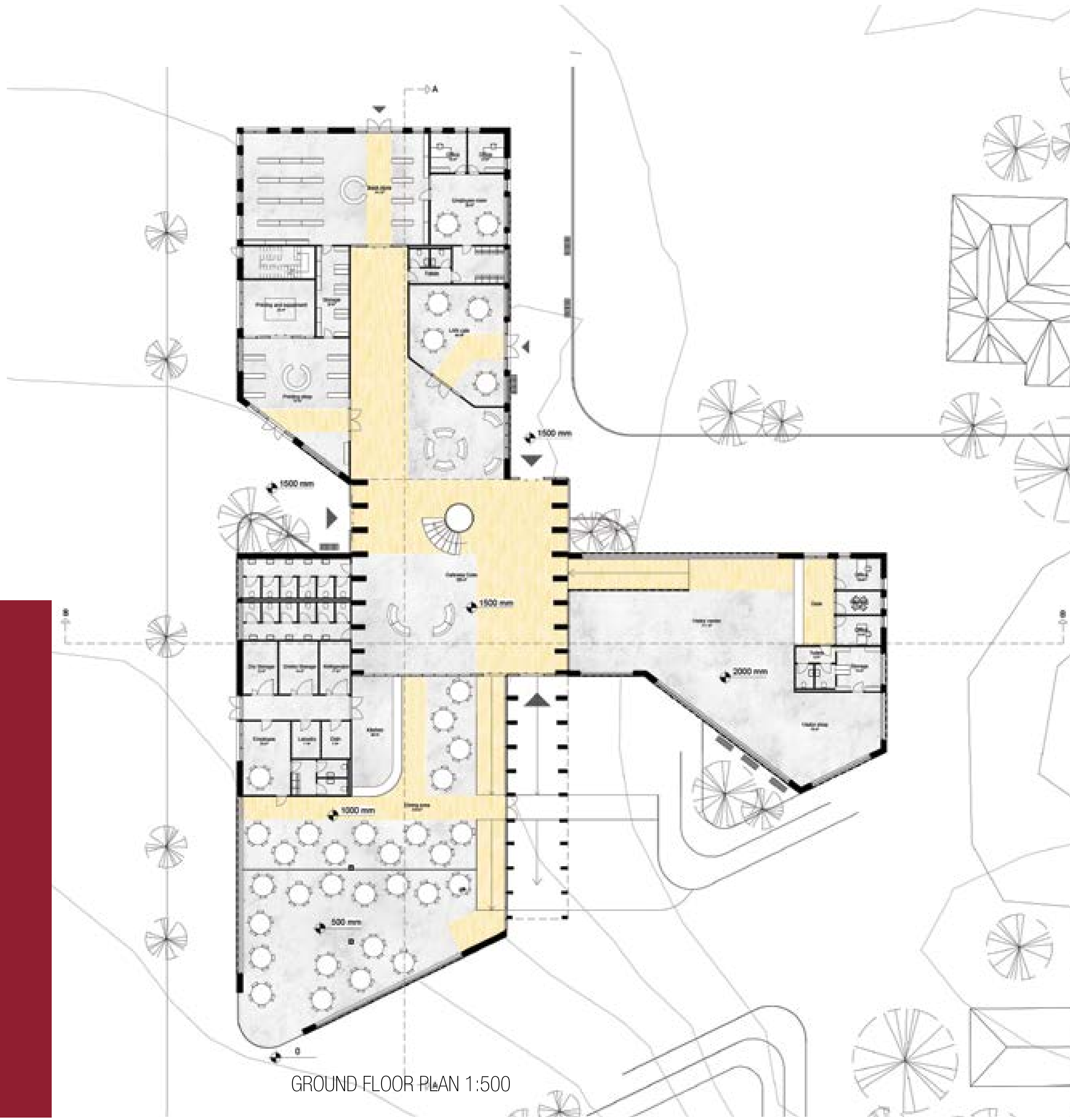
ELEVATION WEST of university parcel 1:200



ELEVATION EAST of university parcel 1:200

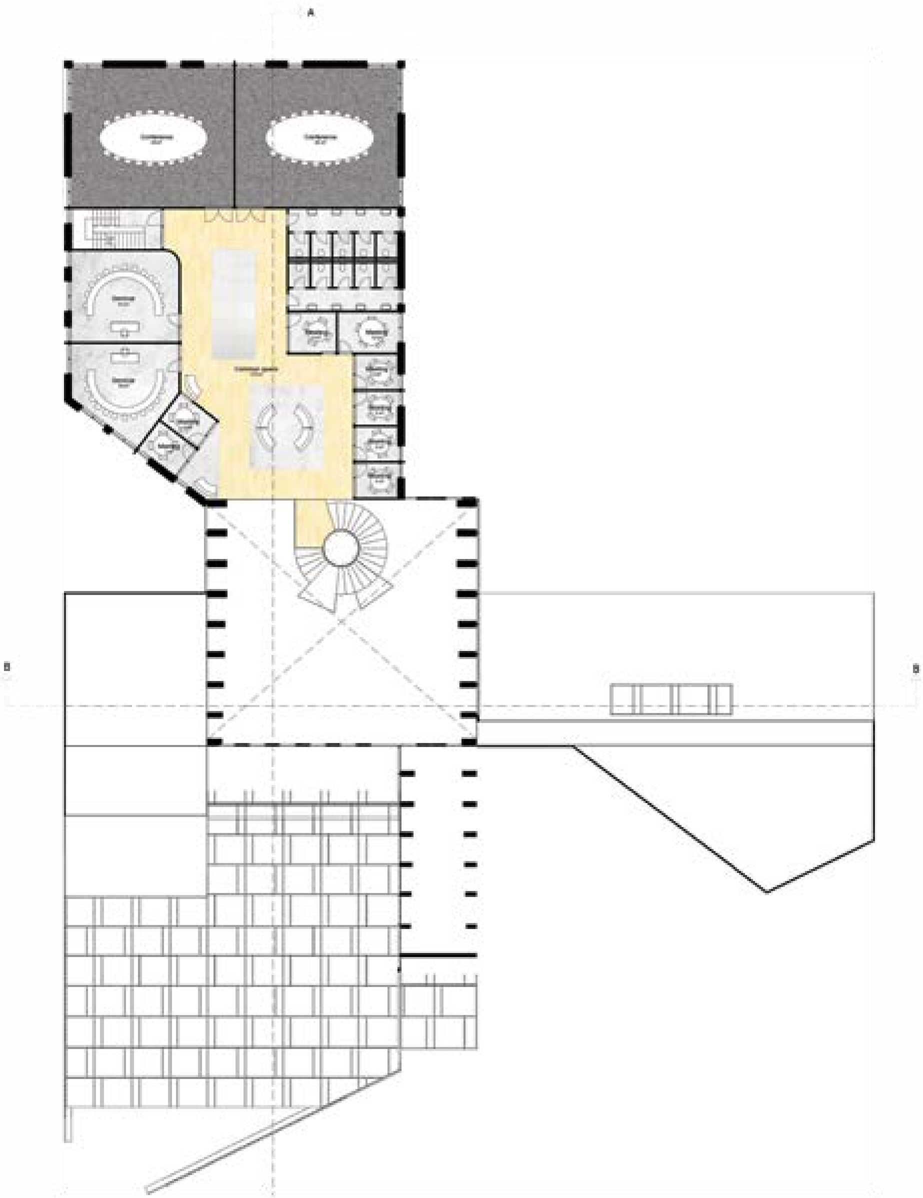
FLOOR PLANS 1:500

From the Plaza in the South, the building is approached though the gateway corridor to the core of the Gateway. The gateway core gives a visual connection between all the public functions and overview of every floor. When walking towards the different functions, a smooth movement has been secured by integrated ramps when the levels changes in the cafeteria and the Visitor center. The functions of the teaching facilities have all a visual connection to a central common room on each floor, providing an overview on the Gateway and a place to meet, talk or study. Each room is dimensioned to accompany a high flexibility among the different ways of placing furniture for visual reach while teaching.

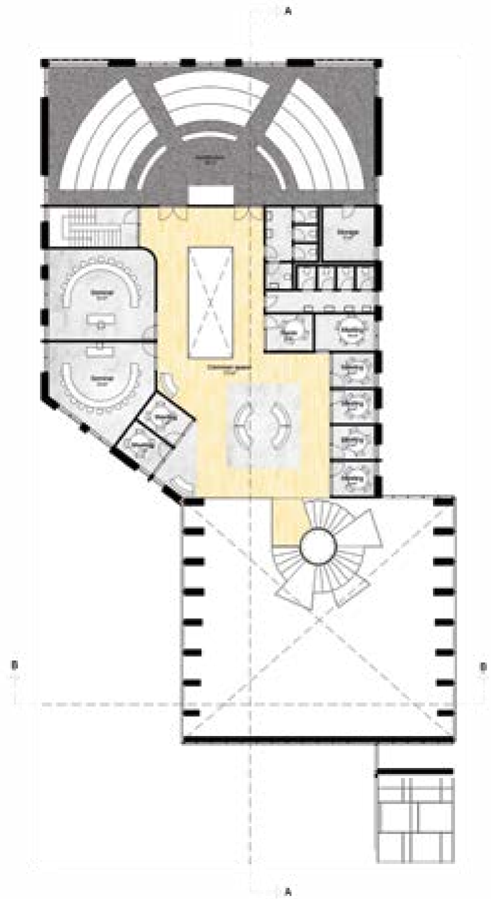


GROUND FLOOR PLAN 1:500

Ill 7.12



1. FLOOR PLAN 1:500

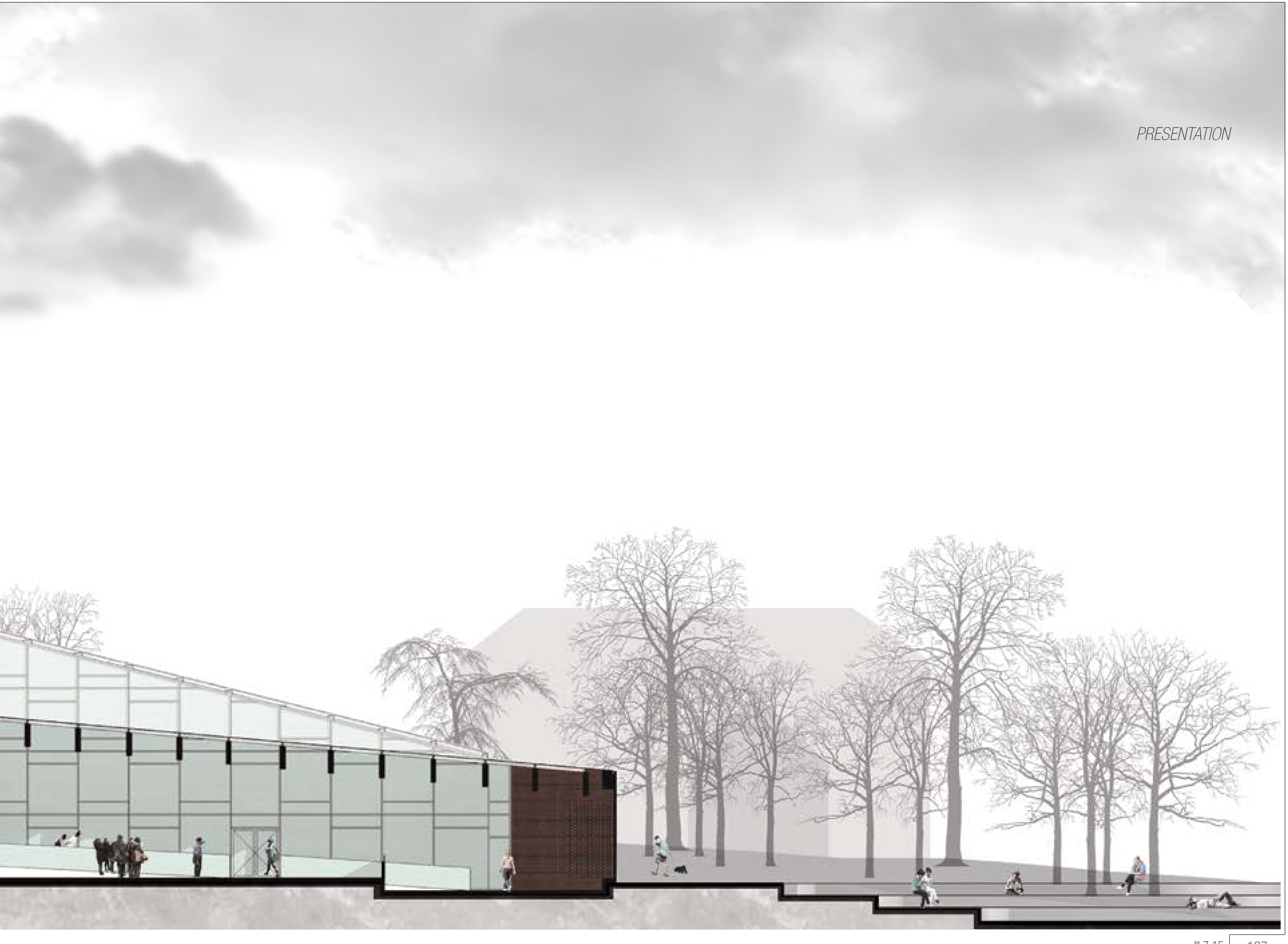


2. FLOOR PLAN 1:500

Ill 7.13

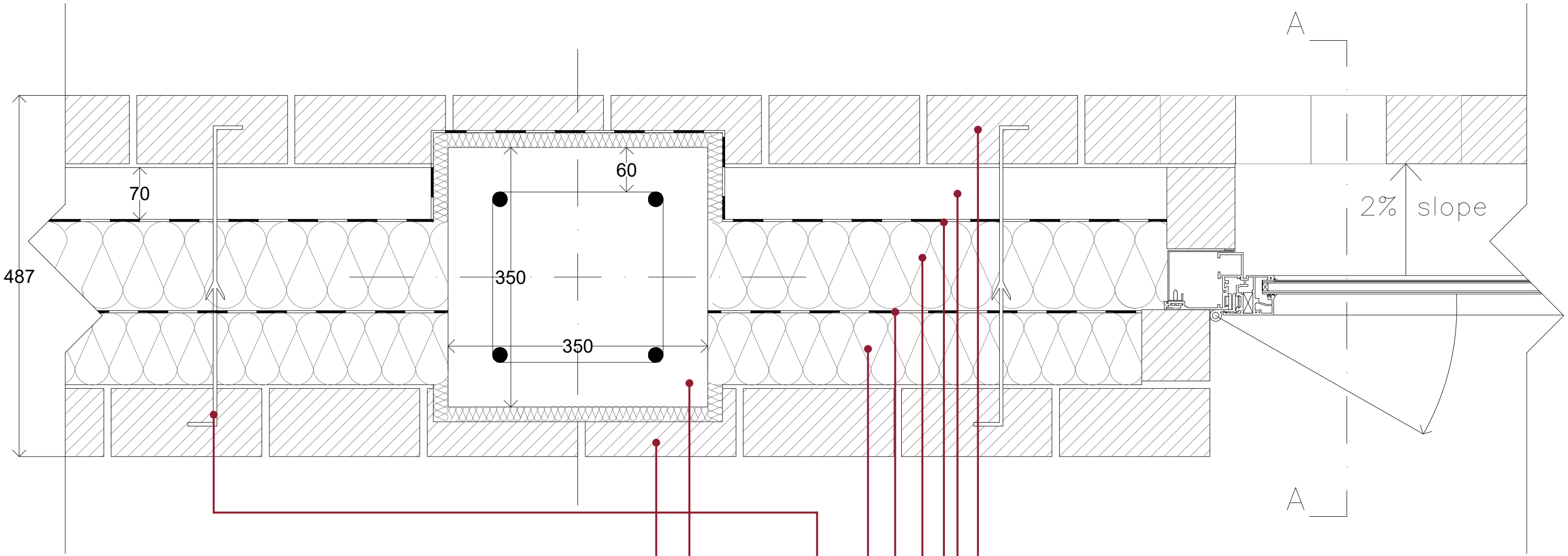
Ill 7.14

SECTION AA 1:200



SECTION BB 1:200

DETAIL 1 - BRICK WALL - PLAN 1:10

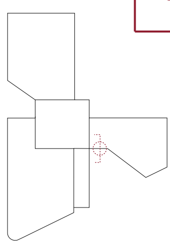


Brick work in American standard dimensions (h:57 mm, W: 92 mm L: 203 mm) with fuge/joints 10 mm between them
Air chamber 70 mm
Water proof film 8 mm
Rockwool thermal insulation 120 mm
Vapor proof film 3 mm
Acoustic insulation 95 mm
Binders
Reinforced concrete column 350x350 mm
Brick work in American standard dimensions with fuge/joints 10 mm between them

Window description:
Anodized aluminum frame UNI ARC 15 with inward opening swing and thermic cut double pane glazing 4-9-4 mm with argon filling

6TH STREET ENTRANCE PERSPECTIVE

The secondary entrance from the 6th street provides a visual glimpse of Gateway core and the life happening inside. The massive brick volume edge is cut off to lead the pedestrian flow toward the Gateway, and the brick treatment arise user curiosity and awareness.

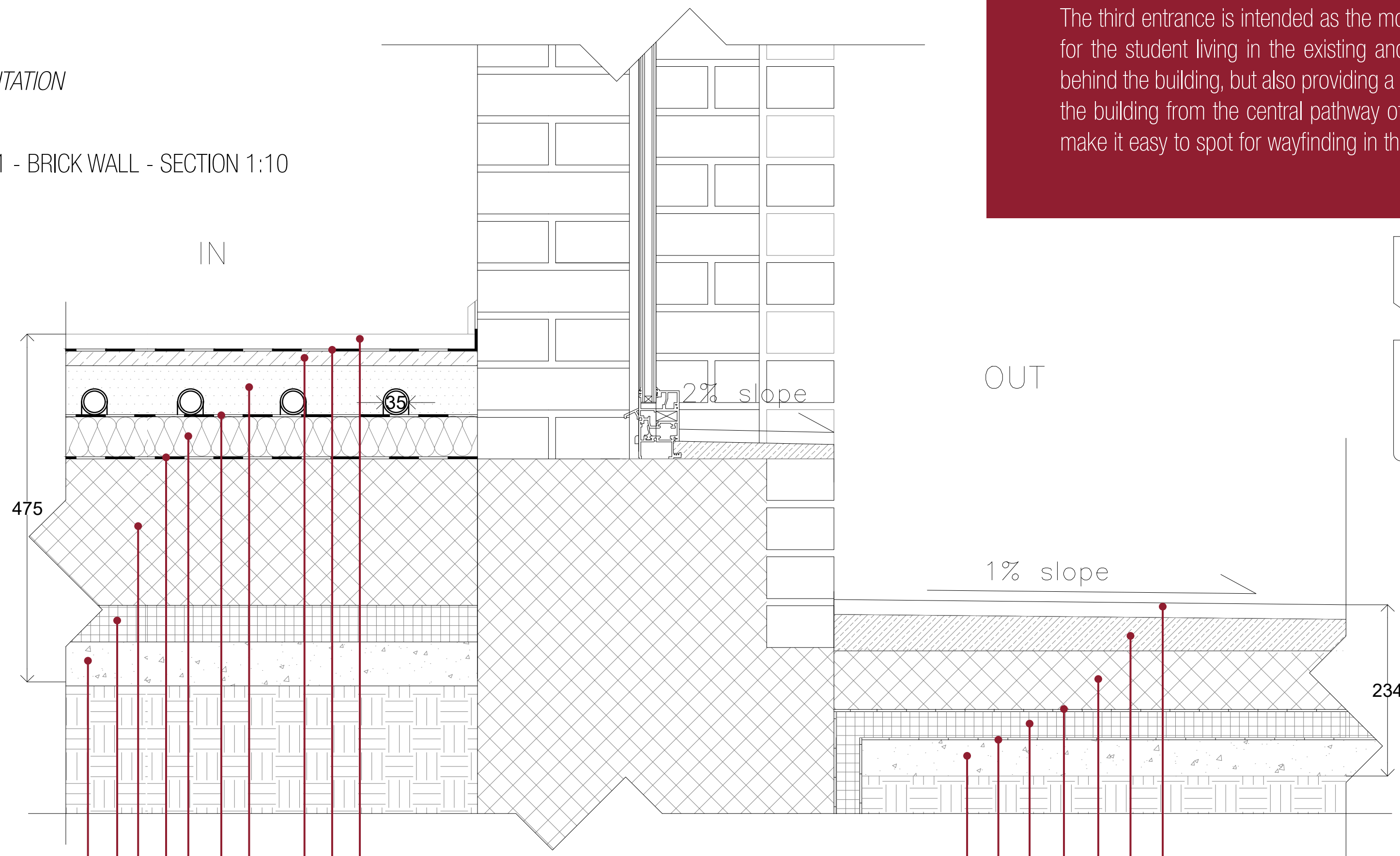


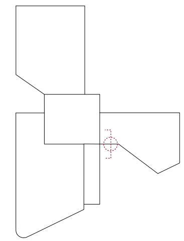
CAMPUS ENTRANCE PERSPECTIVE

The third entrance is intended as the most direct entrance for the student living in the existing and new dormitories behind the building, but also providing a visual view though the building from the central pathway of the whole site to make it easy to spot for wayfinding in the area.

PRESENTATION

DETAIL 1 - BRICK WALL - SECTION 1:10





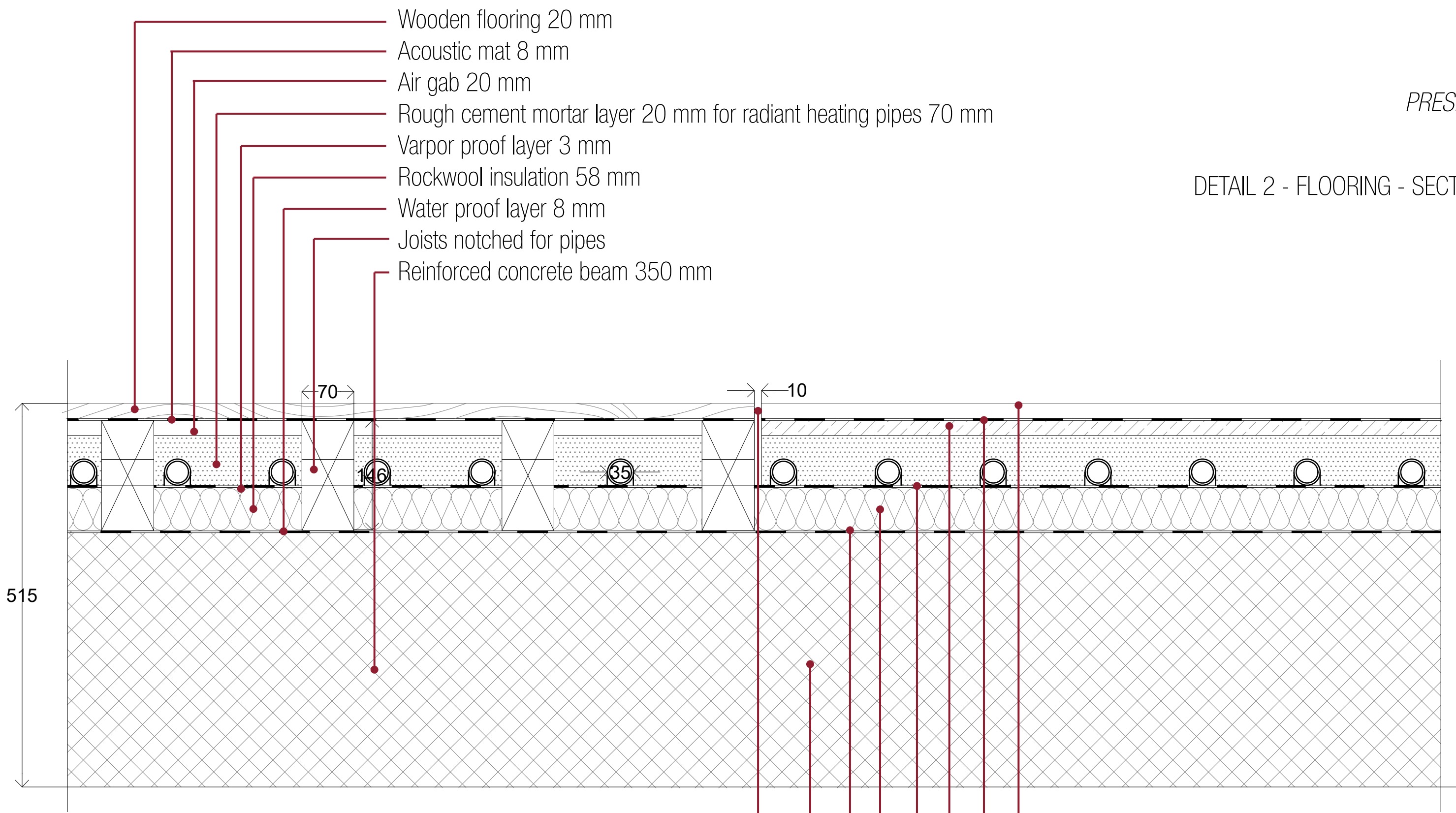

PRESENTATION

DINING AREA OF THE CAFETERIA PERSPECTIVE

The fluent movement from the Gateway core down to the different levels of the cafeteria gives a direct connection, visual and spatial, to the gateway corridor of the indoor to the outdoor ramp. The level creates a visual overview from the kitchen and service line on the middle level while giving a directivity of movement and privacy in a larger space.

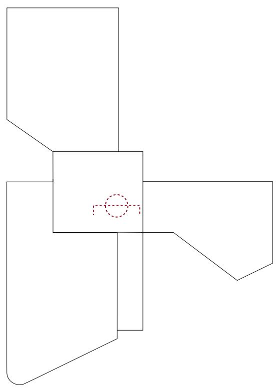

PRESENTATION

DETAIL 2 - FLOORING - SECTION 1:10

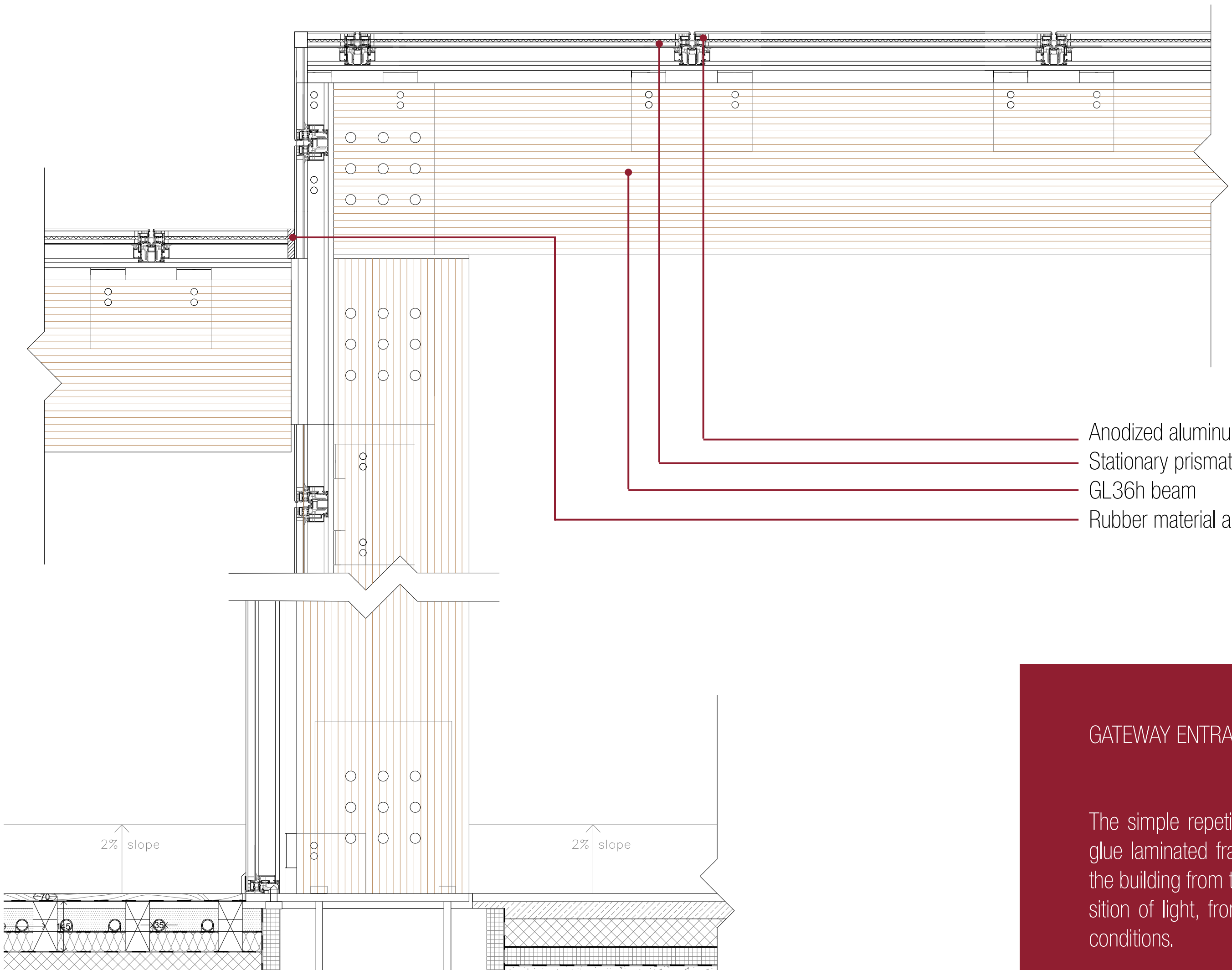


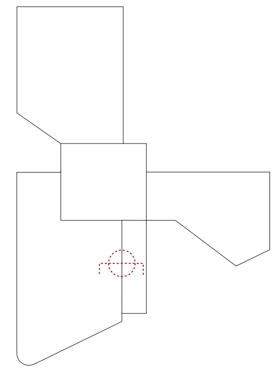
COMMON AREA OF TEACHING FACILITIES
2. FLOOR PERSPECTIVE

The teaching facilities are placed to the upper floors to provide environment more suitable for its functions, trying to emphasize silent spaces and reduce the visual connection. Here there is room for studying in the open common space or meeting rooms, enclosed by partly opaque glazing, to enhance privacy, but maintain the spatial awarenes.



DETAIL 3 - FRAME STRUCTURE - CONNECTION FROM CORRIDOR TO CAFETERIA - SECTION 1:10





GATEWAY ENTRANCE PERSPECTIVE

The simple repetition and fluent height inclination of the glue laminated frames leads the attention to the core of the building from the plaza and also provides a fluent transition of light, from the bright natural light to the interior conditions.

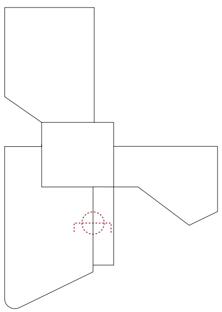

PRESENTATION

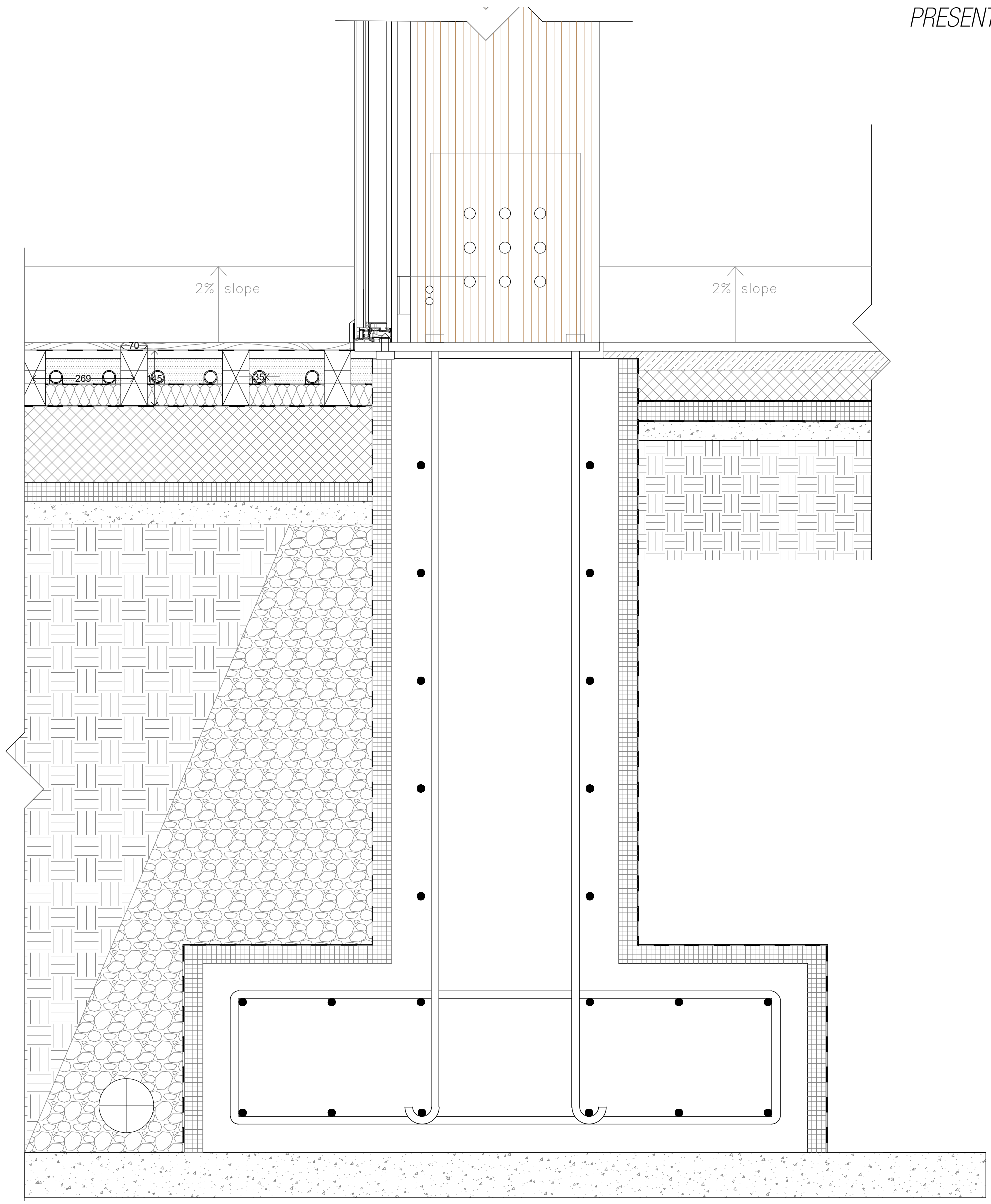
GATEWAY CORE PERSPECTIVE

When entering the building, from any of the entrances, the gateway core opens up in to a tall, light space, visually connecting visual all the functions together to this center point. The slim wooden frames shape small pocket spaces,allowing a play of the degree of transparency.

PRESENTATION

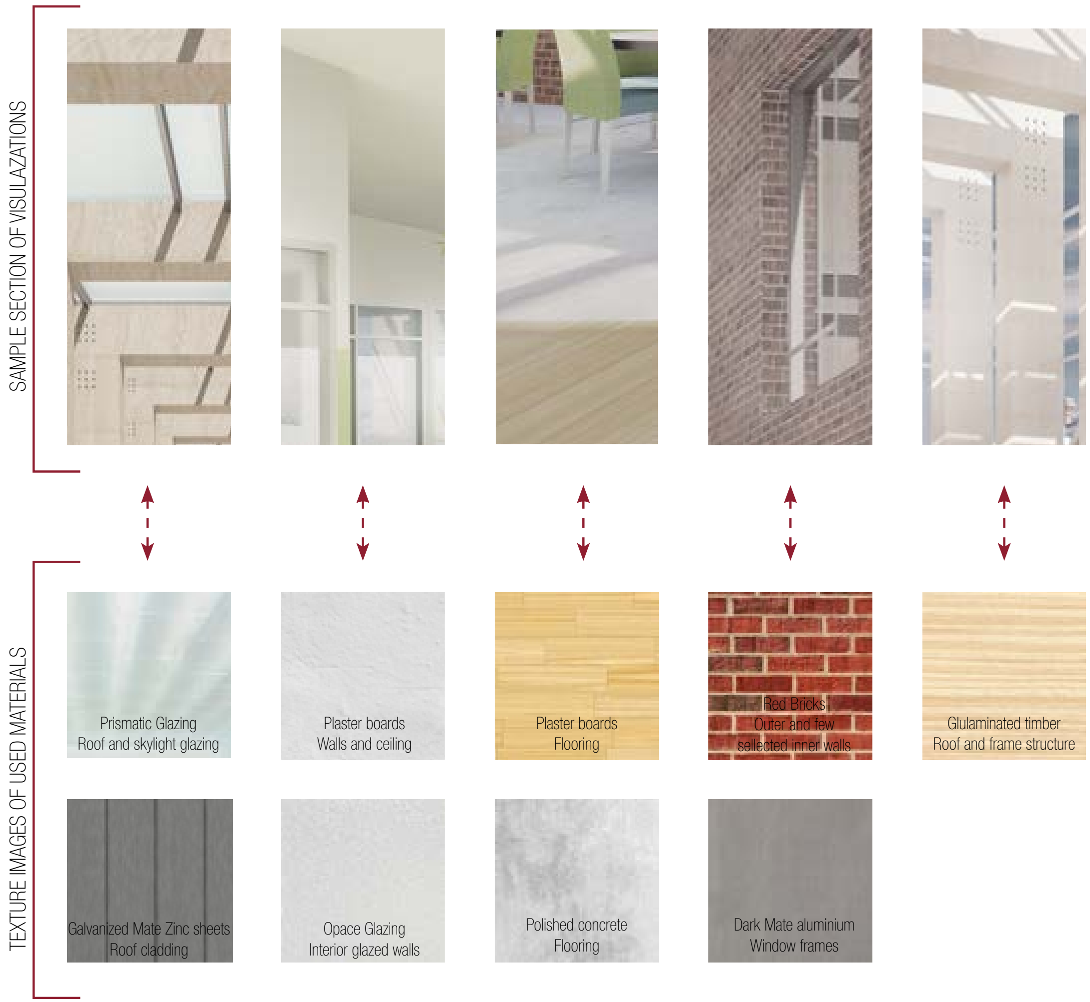
DETAIL 3 - FRAME STRUCTURE FOUNDATION - SECTION 1:10





MATERIAL COMPOSITION

The choice of material and colour have been based on contrast to skin tones, transparency level and structural properties needed.
The composition is based on a ply of contrasts, repeated throughout the whole project. The illustration shows texture images of the materials used in the project and where.



Ill 7.28 Material used in the project

VISITOR CENTER EXHIBITION AREA PERSPECTIVE

From outside the visitor center seems rather massive and enclosed volume, with a few windows for the offices and only the brick pattern opening on the rest of the facades. But inside a interplay between diffuse light and shadows from the pattern gives a sensory feeling of openess and light and allows a spatial awareness of activities taking place in the Gateway plaza and core.

EPILOGUE #8

INTRODUCTION

This chapter presents a conclusion and reflection upon the work carried forward the past semester.

The project is revisited, from the initial statements to the final outcomes, and it is weighted against the knowledge that has been gained.

As stated in the Semester Description the objective for the final semester is to define a problem and display the ability to achieve a design proposal in an integrated whole [Brunsgaard, 2016].

When our motivation and educational path (Introduction, Momentum, pp. 8-9) led us to choose this specific problem, elaborated in Chapters 2, 3 and 4, we had an un-written rule: the will to challenge ourselves with the complexity of a theme that went far off our knowledge and yet that would have gave us the possibility to specialize on a subject on which not much has been done yet, therefore trying to give a contribution, with this thesis project, which went beyond the fulfillment of the semester objectives.

CONCLUSION

The initial question of the project was how to create spaces where the Deaf and Hearing Communities can interact, feeling both integrated into the built environment.
In Chapter 2, Deafspace, an overview on the Deaf Community is given. Here the importance for the development of a kind of architecture for this specific community's needs is clearly shown.
The problem is tackled through the use of the deafspace design principles and architectural elements that address the senses in different ways, with the goal of creating a design that extendes the sensory reach and provides a step forward the creation of an equal perception of space between hearing and Deaf individuals.

In Chapter 3, Spatial Perception, the theoretical frame is explained. Being aware of the weight that built space has on individuals' behavior, as well as how individuals' behavior shapes the space, we conclude stating that integration among different communities is achieved through similar behavior, which is the result of a similar perception of space.
This work is giving an answer by trying to understand how to influence the perception of space, and by that extending the sensory reach by a specific use of elements of architecture. This is done at different scales, from the expedient of opening views and axes, to specific treatment and detailing of materials of the envelope, experiencing different transparency levels to emphasize awareness, but maintaining visual privacy. Other tools includes the vibrating flooring in transition areas, to ease mobility or specific care about lighting conditions and indoor walls finishing to ensure low eyes stress and propert environment for signing.

Besides addressing the problem of the relationship between built environment and deaf individuals, the project also solves the contextual issues and opportunities stated in Chapter 4, by dissolving the edge between the campus towards the 6th Street and opening up the campus toward the city, by creating a new main Gateway.
The Gateway creates a landmark for the community and an area where events and gatherings can take place for visitors, students and any other user.
The Whole site emphasize the vision for the future development of the campus and city area by increasing the density and ensuring space for both retail and campus related functions, as student dormitories, cafeteria and teaching facilities.

The Gateway pavillion, consisting of the main core and the entrance corridor, is the focus point of the project, that physically connects each building unit, and therefore have a central function in the project. This space is representation of the integration of the emphasis on deafspace, aesthetics, construction and functions, in to a tectonic design solution.
By contributing to this quite new discussion in the field of architecture with this project and analysis, we believe to have given inspiration for further studies about the creation of deafspace architecture.

REFLECTION

ON METHODS AND DESIGN PROCESS

A good level of production is not to be seen as an absolute value, but in function of time. This may seem an obvious statement, but it is not when the complexity of the problem and external conditions become drivers for changing the approach to methodology and design process.
During this semester we have experienced situations which have led us to a continuous re-adaptation of our initial general method and design process organization (Chapter 1, Methodology, pp. 12-15).

The complexity of the project and problems to address called for a combination between a puzzled approach and an iterative loop approach, typical of the Integrated Design Process. This was the result of the time frame and the need to work constantly back and forward from a large scale to the small detailing scale to address the overall requirements and architectural vision for the project and to to address the senses, construction and deafspace design principles all in once.

This approach was at the beginning confusing, but it allowed us to proceed quite far with the theoretical research, meaning that it allowed us to grasp a very high amount of information for each piece of the puzzle, for our design decisions. Despite pros and cons, it was the optimal working approach for our case, given our focus and time frame. This kind of approach, based on highly-informed design, led us to understand the true meaning of Integrated Design Process, referring to the ability of relating each design choice, despite the scale or the aspect that is being analyzed, to a main thread, represented by the theoretical approach to the project.

ON ACOUSTICS AND SUSTAINABILITY

Through the project it is possible to grasp a certain level of coherence between the theoretical research, the theme chosen and the outcome of the project. Though, it is also easy to understand which aspects could have been a bigger part of the design process and approached differently so that to have had a higher influence on the outcome of the project. Especially considering what could have been developed in a more empirical way, in order to add credibility to the choices made. To be pointed out, in particular, are acoustics and sustainability.

The acoustics aspects are part of the design criteria which helped making design decisions, but they were only used in theory in the decision making and not verified through the use of iterative test and analysis. In the Design Parameters (pp. 76-77) it is stated the will of creating very silent places, with less reverberation as possible and with very low background noise. This calls for the creation of spaces which distributes sound waves as good as possible, affecting the geometry of spaces and the roughness of surfaces at different scales, for highly absorbing surfaces in smaller rooms, and for an envelope with high phono-insulation properties. This theory and knowledge served as the basis for the choice of materials and spatial shape. In theory the choice of the brick, with it scattered surface, the envelope stratigraphy, and the slender wooden frame structure will efficiently serve the acoustic goals.

Tectonic was the focus upon this thesis and through the design process of this project, but sustainability is an also a necessary part of future development of architecture with the rising requirements globally. However, the social sustainability aspect of it has been a driver for the problem development from the beginning, therefore highly integrated into the design of the project, through the use of the deafspace design principles and addressing the sense with different architectural elements.
Economic and environmental sustainability hasn't been in focus during the project, but the theory has been used for some decision making during the process. With this in mind, if the project have had a higher focus upon sustainability and had been tested and verified empirically, some different choices could have been made, especially con-

cerning the overall layout and dimensioning of the building shape, to minimize façade area, therefore minimizing heat loss or concerning the construction and use of material for minimizing overheating.

Other considerations have been made in relation to the envelope and volumes design, still in terms of energy savings, as creating a high thermal mass envelope, by the use of bricks and a unheated Gateway area between, the three buildings, that ideally heats up due to green-house-effect in winter and cools down in summer where the there is a possibility of creating strong cross-natural-ventilation. A wide inclined surface, facing South could be used for placement of photovoltaic or solar panels.
None of these possibilities has been tested. This could have resulted in larger alterations of the design if the focus on sustainability would have been integrated part of the design process from the first stages of the project.

ON THE BASIS FOR FUTURE DEVELOPMENT OF DEAFSPACE ARCHITECTURE

The development of deafspace architecture it still a very new and ongoing process where there is still methods to discover in solving many of the issues of our built environment for deaf individuals.
This thesis is a result from ongoing studies and developed principles. From the beginning of the project our knowledge of deafspace and accessibility to the deafspace design principles were limited because of confidentiality issues related to the ongoing research. Most of the knowledge implemented from deafspace is from our own understanding and research of being deaf and analysis of case studies where the deafspace design principles has been used. The full knowledge of the specific principles came after visiting Gallaudet University and meeting Hansel Bauman. If the same amount of knowledge of the specific principles had been available from the beginning, some different design choices might have been made and the time used for exploring and understanding deafspace principles could have been used in deeper studies of the project or a larger integration of the design parameters that had the lowest focus during the design process.

An issue concerning deafspace, which still needs to be addressed, is the tension between the visual public and private life of signers, which Hansel Bauman also stated himself, in the recording of our meeting with him (see USB). This specific issue have been the main problem and focus though out the project, where the whole design concept, building layout, choice of material and construction has been based on enhancing the spatial awareness to ensure an extended sensory reach, but still keeping a high level of visual privacy. This is done with the final goal of creating an equal perception of space and behavior and enhance the possibilities of integration and interaction between hearing and deaf individuals.

The importance of this development it higher than we first thought, when we started the work. It has made us aware of an architectural issue, related to the importance of the auditory sense role for our perception of and behavior in space. We hope that this project will serve as a contribution for the future research and development of deafspace architecture.

REFERENCES

Baino, F. (2011). Science of materials. (lectures)

Basiago, A. (1999). Economic, social, and environmental sustainability in development theory and urban planning practice. 1st ed. [ebook] Boston: Kluwer Academic Publishers, pp.145-161. Available at: https://www.amherst.edu/system/files/media/0972/fulltext.pdf [Accessed 4 Feb. 2016].

Bauman, H. (2010). Gallaudet University - DeafSpace Design Guidelines. Washington DC: Gallaudet university.

Bauman, H. (2015). DeafSpace: A new architecture for more livable and sustainable world. [video] Available at: https://competitions.malcolmreading.co.uk/gallaudet/deafspace [Accessed 1 Feb. 2016].

Boetticher, K. (1832). Die Tektonik der Hellenen. Berlin.

Böhme, Gernot. On Beauty. 1st ed. 2010.

EN 1990 (2002) (English): Eurocode - Basis of structural design [Authority: The European Union Per Regulation 305/2011, Directive 98/34/EC, Directive 2004/18/EC]

EN 1991-1-1 (2002) (English): Eurocode 1: Actions on structures - Part 1-1: General actions - Densities, self-weight, imposed loads for buildings [Authority: The European Union Per Regulation 305/2011, Directive 98/34/EC, Directive 2004/18/EC]

EN 1991-1-3 (2003) (English): Eurocode 1: Actions on structures - Part 1-3: General actions - Snow loads [Authority: The European Union Per Regulation 305/2011, Directive 98/34/EC, Directive 2004/18/EC]

EN 1991-1-4 (2005) (English): Eurocode 1: Actions on structures - Part 1-4: General actions - Wind actions [Authority: The European Union Per Regulation 305/2011, Directive 98/34/EC, Directive 2004/18/EC]

EN 1995-1-1 (2004) (English): Eurocode 5: Design of timber structures - Part 1-1: General - Common rules and rules for buildings [Authority: The European Union Per Regulation 305/2011, Directive 98/34/EC, Directive 2004/18/EC]

Fiedler, C. (1970). Über die Beurteilung von Werken der bildenden Kunst. Wuppertal: A. Henn.

Denstoredanske.dk, (2016). Washington, D.C I Gyldendal - Den Store Danske. [online] Available at: http://denstoredanske.dk/Geografi_og_historie/USA_og_Nordamerika/USAs_storbyer/Washington,_D.C [Accessed 9 Feb. 2016].

Gallaudet.edu, (2016). Campus Design and Planning - Gallaudet University. [online] Available at: https://www.gallaudet.edu/campus-design.html [Accessed 11 Feb. 2016].

Gallaudet.edu, (2016). 2012 Facilities Master Plan - Gallaudet University. [online] Available at: https://www.gallaudet.edu/campus-design/2012-facilities-master-plan.html [Accessed 11 Feb. 2016].

Gallaudet.edu, (2016). Gallaudet University 2022 Campus Plan - Gallaudet University. [online] Available at: https://www.gallaudet.edu/campus-design/2022-campus-plan.html [Accessed 11 Feb. 2016].

Gallaudet University, (2015). What is DeafSpace?. [online] Available at: http://www.gallaudet.edu/campus-design/deafspace.html [Accessed 6 Feb. 2016].

Gallaudet University Library, (2014). Deaf population of the U.S. - Deaf Statistics - LibGuides at Gallaudet University Library. [online] Available at: http://libguides.gallaudet.edu/content.php?pid=119476&sid=1029190 [Accessed 9 Feb. 2016].
Gehl, J. (1971). Livet mellem husene. København: Arkitektens Forlag.

Giovannoni, E. and Fabietti, G. (2016). What is Sustainability? A review of the Concept and Its Applications. 1st ed. [ebook] Siena, Italy: University of Siena, pp.21-40. Available at: http://www.springer.com/cda/content/document/cda_downloaddocument/9783319021676-c1.pdf?SGWID=0-0-45-1429317-p175460664 [Accessed 4 Feb. 2016].
Jankowski, K. (1997). Deaf empowerment. Washington, D.C.: Gallaudet University

Laugier, M. (1977). An essay on architecture. Los Angeles: Hennessey & Ingalls. Press.

Lipps, T. (1903). Ästhetik. Hamburg: Voss.

Loos, A. and Opel, A. (1998). Ornament and crime. Riverside, Calif.: Ariadne Press.

Mabilia, V. and Mastandrea, P. (2008). Il primo latino. Bologna: Zanichelli.

Malcolm Reading Consultants, (2015). Gallaudet University, International Design Competition, Competition Conditions.

Malcolm Reading Consultants, (2015). Gallaudet University International Design Competition. [online] Competitions.malcolmreading.co.uk. Available at: https://competitions.malcolmreading.co.uk/gallaudet/ [Accessed 6 Feb. 2016].

meteoblue. (2016). Climate Copenhagen. [online] Available at: https://www.meteoblue.com/en/weather/forecast/modelclimate/copenhagen_denmark_2618425 [Accessed 14 Mar. 2016].

Meteoblue. (2016). Climate Washington D.C.. [online] Available at: https://www.meteoblue.com/en/weather/forecast/modelclimate/washington-d.c._united-states_4140963 [Accessed 16 Mar. 2016].

Monaghan, L., Schmaling, C., Nakamura, K. and H. Turner, G. (2003). Many ways to be deaf - International Variation in Deaf Communities. Washington, D.C.: Gallaudet University Press.

Pace, S. (2013). A world history of architecture in keywords. Tectonics.[lecture]

Pace, S. (2013). A world history of architecture in keywords. Monuments.[lecture]

Pallasmaa, J. (2005). The eyes of the skin. Chichester: Wiley-Academy.

Parigi, D. (2013). Performance-Aided-Design. (lectures)

Sekler, Eduard (1965) Structure, Construction, Tectonics, In: Kepes, Gyorgy (ed.) (1965) Structure in Art and in Science, Studio Vista, London, p.89-95.

Semper, G. (1989). The four elements of architecture and other writings. Cambridge: Cambridge University Press.

Sirvage, R. (2015). An insight of Deafspace. [video] Available at: http://tedxtalks.ted.com/video/An-Insight-from-DeafSpace-Rober [Accessed 8 Feb. 2016].

Siteco.com. (2016). Siteco Beleuchtungstechnik GmbH: Static prismatic systems. [online] Available at: http://www.siteco.com/en/products/daylight-systems/static-prismatic-systems.html [Accessed 10 Apr. 2016].

Vitruvius Pollio., Philandrier, G., Saumaise, C., Barbaro, D., Wotton, H., Baldi, B., Alberti, L., Meibom, M., Agricola, G., Montjosieu, L., Goldmann, N., Gaurico, P. and Laet, J. (n.d.).M. Vitrvvii Pollionis De architectvra libri decem.

Wolfflin, H. (1976). Prolegomena to a Psychology of Architecture. Boston, USA: Department of Architecture, M.I.T.

ILLUSTRATION LIST

Introduction:

0.1 Malcolm Reading Consultants, (2015). Gallaudet University, International Design Competition, Competition Conditions.

Methodology:

1.1 Own illustration

DeafSpace:

2.1 Own illustration

2.2 Bauman, H. (2015). DeafSpace: A new architecture for more livable and sustainable world. [video] Available at: https://competitions.malcolmreading.co.uk/gallaudet/deafspace [Accessed 1 Feb. 2016].

Gallaudet University, (2015). What is DeafSpace?. [online] Available at: http://www.gallaudet.edu/campus-design/deafspace.html [Accessed 6 Feb. 2016].

2.3 Gallaudet.edu, (2016). Sorenson Language and Communication Center - Gallaudet University. [online] Available at: http://www.gallaudet.edu/slcc/floor-plans.html [Accessed 24 Feb. 2016].

2.4 HEERY.com, (2016). Gallaudet University - Sorenson Language and Communication Center. [online] Available at: http://www.heery.com/portfolio/gallaudet-university.aspx [Accessed 18 Feb. 2016].

2.5 Human Circuit, (2016). Portfolio Detail - Human Circuit. [online] Available at: http://www.humancircuit.com/portfolio-details/?projectid=48&-catid=27&tab=&ind=14# [Accessed 17 Feb. 2016].

2.6 - 2.8 LTL Architects, (2016). Gallaudet University Residence Hall. [online] Available at: http://ltlarchitects.com/gallaudet-university-residence-hall/ [Accessed 20 Feb. 2016].

2.9 Bauman, H. (2010). Gallaudet University - DeafSpace Design Guidelines. Washington DC: Gallaudet university.

Spatial perception:

3.1 Fluidr.com, (2016). Fluidr / Search for photos and videos matching 'Mousgoum' sorted by relevance. [online] Available at: http://www.fluidr.com/search/all/Mousgoum [Accessed 18 Feb. 2016].

3.2 Divisare.com, (2016). Eduardo Torroja, Carlos Arniches Moltó, Martín Domínguez Esteban, Ximo Michavila · Zarzuela racetrack stands · Divisare. [online] Available at: http://divisare.com/projects/275790-eduardo-torroja-carlos-arniches-molto-martin-dominguez-esteban-ximo-michavila-zarzuela-racetrack-stands [Accessed 20 Feb. 2016].

3.3 StudyBlue, (2016). MUSIC 202 Study Guide (2012-13 Howard) - Instructor Howard at Brigham Young University - StudyBlue. [online] Available at: https://www.studyblue.com/notes/note/n/music-202-study-guide-2012-13-howard/deck/9722977 [Accessed 22 Feb. 2016].

3.4 Dwell, (2016). First Unitarian Society Meeting House by Frank Lloyd Wright in Madison, Wisconsin. [online] Available at: http://www.dwell.com/photo/353436/first-unitarian-society-meeting-house-frank-lloyd-wright-madison-wisconsin [Accessed 22 Feb. 2016].

3.5 Cloud-cuckoo.net, (2016). Wolkenkuckucksheim - Cloud-Cuckoo-Land - Vozdushnyi zamok. [online] Available at: http://www.cloud-cuckoo.net/journal1996-2013/inhalt/de/heft/ausgaben/109/Noell/noell.php [Accessed 17 Feb. 2016].

3.6 Didatticarte.it, (2016). La bellezza nell'imperfezione – DidatticarteBlog. [online] Available at: http://www.didatticarte.it/Blog/?p=2635&lang=fr [Accessed 18 Feb. 2016].

3.7 Panoramio.com. (2016). Panoramio - Photos by Francesco Fabiani. [online] Available at: http://www.panoramio.com/user/1617877 [Accessed 10 Apr. 2016].

3.8 Own illustration

Site analysis:

4.1- 4.5 Own illustrations

4.6-4.9 Own pictures

4.10 Own illustration

4.11 Own pictures

4.12 - 4.20 Own illustration

4.21 Google Maps, (2016). Google Maps. [online] Available at: https://www.google.dk/maps [Accessed 17 Feb. 2016].

4.22 - 4.24 own illustrations

Spatial program:

5.1 - 5.8 Own illustrations

Design Process

6.1 - 6.42 Own illustrations and pictures

Presentation:

7.1 - 7.27 Own illustrations

7.28 Polantis.com. (2016). [online] Available at: https://www.polantis.com/vmzinc [Accessed 20 May 2016].
Architekten24.de. (2016). [online] Available at: http://www.architekten24.de/projekt/plenarsaal-bayerischer-landtag-muenchen/uebersicht/4241/index.html [Accessed 20 May 2016].
Petersen-tegl.dk. (2016). [online] Available at: http://www.petersen-tegl.dk/produkter/d33# [Accessed 20 May 2016].
Amazon.com. (2016). [online] Available at: http://www.amazon.com/Etched-Glass-Window-Film-36-by-72-Inch/dp/B000Q3K2OO [Accessed 20 May 2016].
Buyqldtimber.com.au. (2016). [online] Available at: http://www.buyqldtimber.com.au/Species/southernpine.aspx [Accessed 20 May 2016].
Pinterest. (2016). [online] Available at: https://dk.pinterest.com/pin/516436282245620174/ [Accessed 20 May 2016].
Jupacolor.top. (2016). [online] Available at: http://jupacolor.top/light-wood-floors/ [Accessed 20 May 2016].
Hdimagelib. (2016). [online] Available at: http://hdimagelib.com/iron+metal [Accessed 20 May 2016].

7.29 Own illustrations

Annex

9.1-9.25 Own illustrations

CONTENT INDEX

ANNEX #9

ANNEX 1 - MATERIAL PROPERTIES

		WOOD	ROCK	BRICK	METAL	GLASS	POLYMERS	CONCRETE
	CHEMICAL BOND	Composite	Ionic/covalent	Ionic/covalent	Metallic	Ionic/covalent	Covalent+Van der Waals	Composite
	BOND STRUCTURE	Composite	Crystalline	crystalline	Crystalline	Amorphous	semi-crystalline	Composite
	STRUCTURE OF MATERIAL	Unisotropic Heterogeneous Orthotropic Hygroscopic Cellular	Unisotropic Homogeneous	Porous or solid Hygroscopic	Homogeneous isotropic	Homogeneous Isotropic Crystalline/amorphous	Homogeneous isotropic	Isotropic Heterogeneous Different levels of porosity
	CHEMICAL COMPOSITION	Natural composites of cellulose fibers embedded in a matrix of lignin: - Cellulose 40-50% - Hemicellulose 15-25% - Lignin 15-30%	Natural ceramic composites of one or more minerals The majoity of rocks minerals are silicates	Artificial ceramic product Raw materials: - Clay - Shale - Soft slate - Calcium silicates - Concrete Bonded by mortar	Ferrous metals are alloys of iron and carbon; they can be classified according to the quantity of carbon	Artificial ceramic product Inorganic oxides Silica	Artificial product -CH2-CH2-CH2 molecular chains with covalent bonding and Van der Waals forces between chains	Artificial ceramic product for 1m3 of concrete: - 0.1 m3 binder (cement) - 0.2 m3 water - Aggregates (0.25 m3 sand, 0.5 m3 gravel) - Additives
MECHANICAL PROPERTIES	COMPRESSION STRENGTH	Low	High	High	Low	High	Low	High
	TENSION STRENGTH	High	Low	Low	High	Low	High	Low
	TOUGHNESS	Mid	Low	Low	High	Low	Mid	Low
	HARDNESS	Low	High	Mid	Mid	High	Low	Mid
	ELASTICITY	High	Low	Low	High	Low	High/non-linear	Low
	PLASTICITY	Low	Low	Low	High	Low	High	Low
	BRITTLENESS	Low	High	High	Low	High	Mid	High
PHYSICAL	THERMAL CONDUCTIVITY	Low	Low	Low	High	Low	Low	Low
	THERMAL FATIGUE	Low	High	High	High	Mid	Low	High
	ELECTRICAL CONDUCTIVITY	Low	Low	Low	High	Low	Low	Low
	ACOUSTIC TRASMISSION ?	Low	High	Mid	High	High	Low	Mid
	OPTICAL PROPERTIES	Opaque	Opaque	Opaque	Opaque	Transparent	Opaque/transparent	Opaque
	DENSITY	Low	High	Mid	High	Mid	Mid	High
CHEMICAL	COMBUSTIBILITY	High	Low	Mid	Low	Low	High	Mid
	CHEMICAL INERTNESS	Low	High	High	Low	High	High	High

Ill 9.1 Brief description of the main construction materails. Through few chemical indications it is possible to better understand the selection of mechanical, physical and chemical properties that have been illustrated.
Each table entry gives general conventional indications on the main character of the material compared to the property, without further chemical doping of the material in order to modify its behaviour, as metal alloys or modification of chemical bond of polymers [Baino F. 2011].

	ROCK	BRICK	REINFORCED CONCRETE	WOOD
PRODUCTS	- Pavement cladding - Wall cladding - Blocks - Slabs - Polished/un-polished rock - Agglomerate stone binded with cement	- Solid brick - Cellular brick - Hollow brick - Mud-based bricks - Calcium-silicate brick - Granite, limestone, sandstone brick - Mattone block (row compressed hearth brick) - Concrete blocks - Cladding brick - Pavement cladding brick (sanpietrini)	- Poured in situ - Precasted - Pre-tensioned poured concrete - Pre-tensioned precasted concrete - Fiber-reinforced concrete - Polymer-impregnated concrete - Reactive-powder concrete - Panels - Blocks - Tiles - Pavement tile	- Timber - Plywood - Chipboard - Veneer - Woodwool - Laminated wood - Structural timber - Resins
WEATHERING	- Erosion due to water (material removal, salt crystallization, alveolization, acid deposition, calcite bi-carbonation, nitrification, sulfation) - Erosion due to acid water (vermiculite formation) - Erosion due to wind - Chromatic changes due to UV radiation - Thermal shocks (disintegration, flaking, exfoliation, swelling) - Biological weathering (autotrophs, eterotrophs	Highly depends on porosity and humidity. - Reversible expansion - Irreversible expension - Crystallization of soluble salts	Highly depends on porosity (Lyse's Rule: w/c) - Carbonation (rust) - Chlorides attack (corrosion of steel rebars, fast deteriortion of concrete) - Alkali-silica reaction (volume increment, cracks)	- Hygrometric weathering (shirinkage, cracks, pores) - Freezing-thawing cicles - Crystallization of soluble salts - Oxidation and breaking of cellulose molecules due to UV radiations (visual change, mechanical weakening) - Acid attack (mechanical weakening)
BUILDING TECHNOLOGIES	- Foundation - Walls	- Foundation - Walls - Roofing	- Foundation - Walls - Roofing	- Walls - Roofing - Insulation
STRUCTURAL TYPOLOGIES	- Post and lintel - Arches - Vaults - Domes	- Arches - Vaults - Domes	- Post and lintel - Arches - Vaults - Domes - Shells - Suspended shells - Catenary structures - Funicolar structures - Free-form structures - Folded-plates structures	- Post and lintel - Trusses - Arches - Vaults - Domes - Reciprocal structures - Folded-plates structures - Gridshells - Lattice shells and domes - Suspended shells

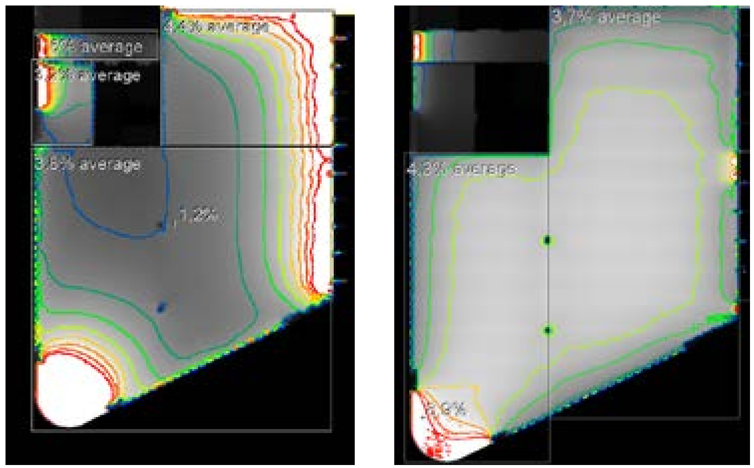
Ill 9.2 Architectural implementation comparison of selected materials [Baino F. 2011; Parigi, D. 2013]

ANNEX 2 - DAYLIGHT SIMULATIONS

The light conditions for the spaces are important to ensure a comfortable environment for everyone and create the right conditions for signing, which is illustrated in the Deaf space design principles.
Daylight simulations were made to test the spaces to aim at a daylight factor average between 3-5% in each room that require daylight where the min daylight factor shouldn't be below 2% and maximum 6%. These sets provide an equally distributed amount of light in each room and avoid glaring.
Because of the category setting in Revit that makes it difficult to assign a different light transmittance for different parts of a curtain system for the same simulations, the analysis and test has been made with an estimated average of the light transmittance. This of course does not give the complexly right daylight factor for the spaces tested, but it gives an overall estimation of light distribution and the effect the prismatic glazing would have when implemented.

CAFETERIA

The Dining area (ill 9.3) as it is 22 meter deep had some critical issues concerning an equal distribution of comtable daylight. The first simulation was made with a enclosed roof. The average of the is between the 3-5% DF, but when this average consist of a DF in the center of min 1,2% and

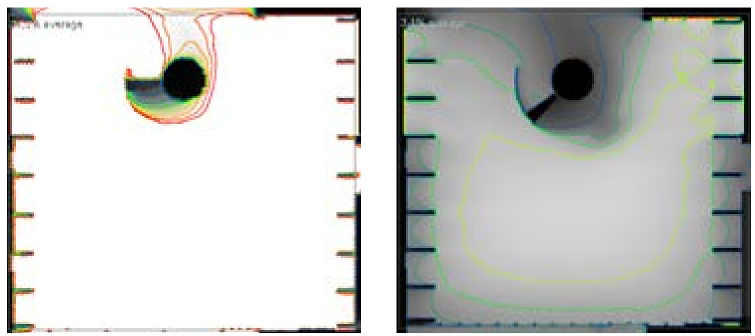


Ill 9.3 Dining area daylight simulations. First simulation on the left and secound simulation on the right

a max DF near the windows of 18,6%. The second simulation show with the implementation of the glazed roof with the prismatic glazing of 15 % and light transmittance of the windows in the façade on 60 %, which creates an more equal distribution of daylight for the space and with the high light transmittance on the windows in the walls the visual connection from inside to outside is still ensured.

GATEWAY CORE

The gateway core (ill. 9.4) had some critical issues concerning very high DF because of all the glazing, but the transparency of that space is important for the visual reach towards other spaces in the building as well as the visual connection from inside to outside. The prismatic glazing has been used on the roof of the Gateway core to reduce that daylight factor and give a more equal distribution, and a light transmittance of 60 % as been used for the glazed walls to reduce the light but also ensure transparency.

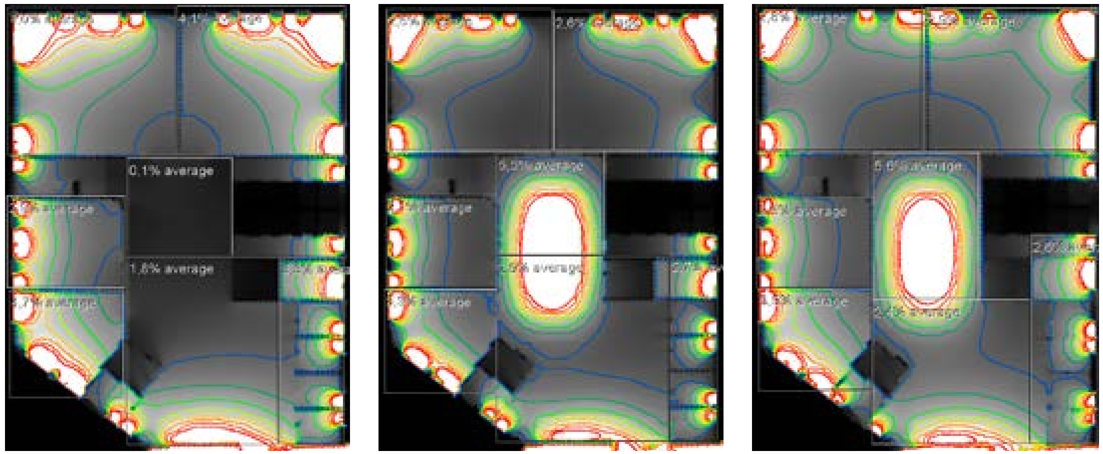


Ill 9.4 Gateway core daylight simulation first simulation on the left with no implementation of the prismatic glazing. The Secound on the right the prismatic glazing is implemented.

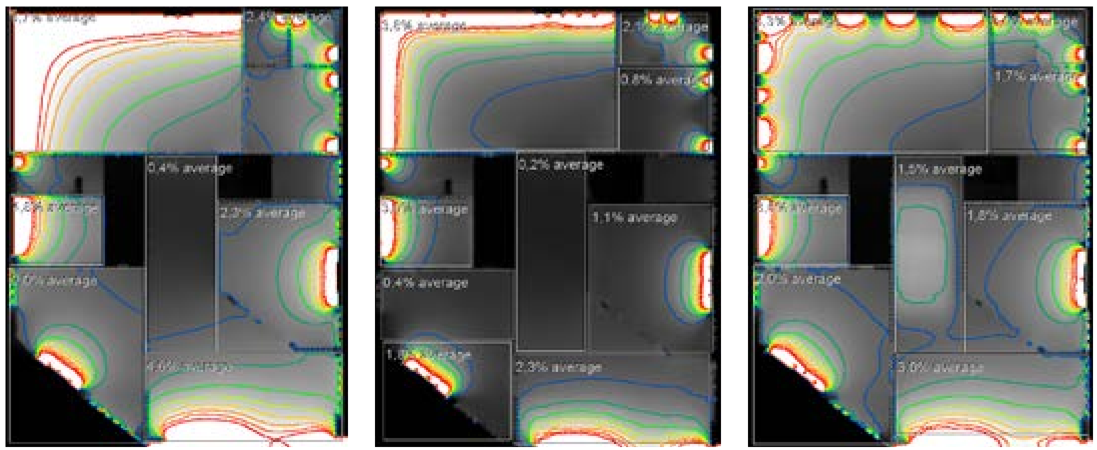
TEACHING FACILITIES

The building volume containing the campus retail (ill. 9.5) and teaching facilities (ill.9.6) is also deep which required that most of the functions where placed along the facades in order to get daylight, which created a central Space visual accessible for all the functions. With the implementation of a central skylight in the roof and cut though the floor underneath gave a lighter environment in these central spaces, but also gives a vertical visual connection between the 2 and 1. floor to give a greater spatial connection. Opaque glazing on the flooring between the ground floor and 1. floor has been implemented so the more public environment in the gateway area and campus retail doesn't disturb the 1. And 2. floor.

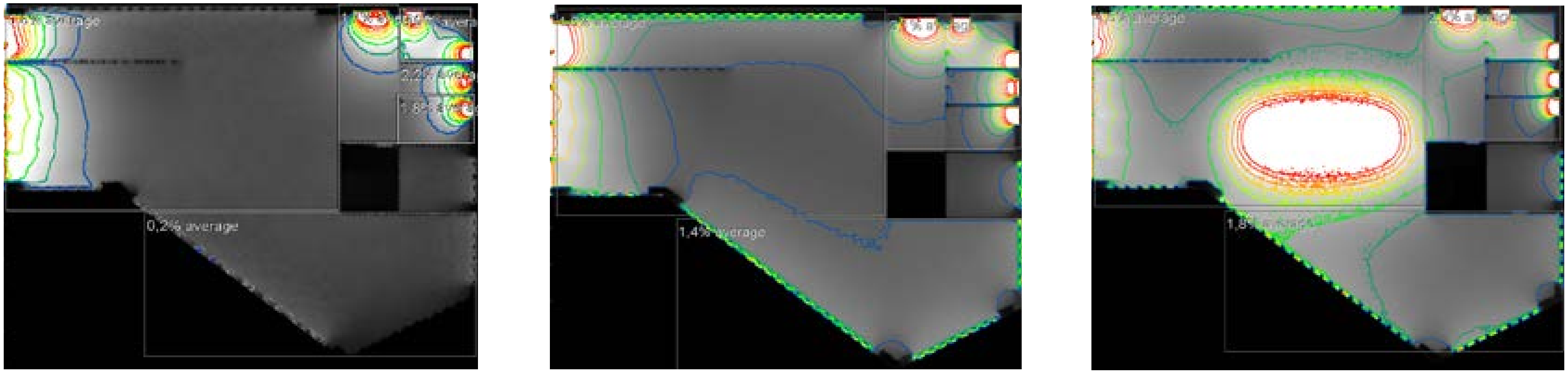
Windows in the façade as also been re-arranged to distribute the light more equally in the larger rooms as the conference and auditorium.



Ill 9.5 1. floor of the teaching facilities daylight simulations. First simulation from the left to the third on the right



Ill 9.6 Ground floor of the teaching facilities daylight simulations. First simulation from the left to the third on the right

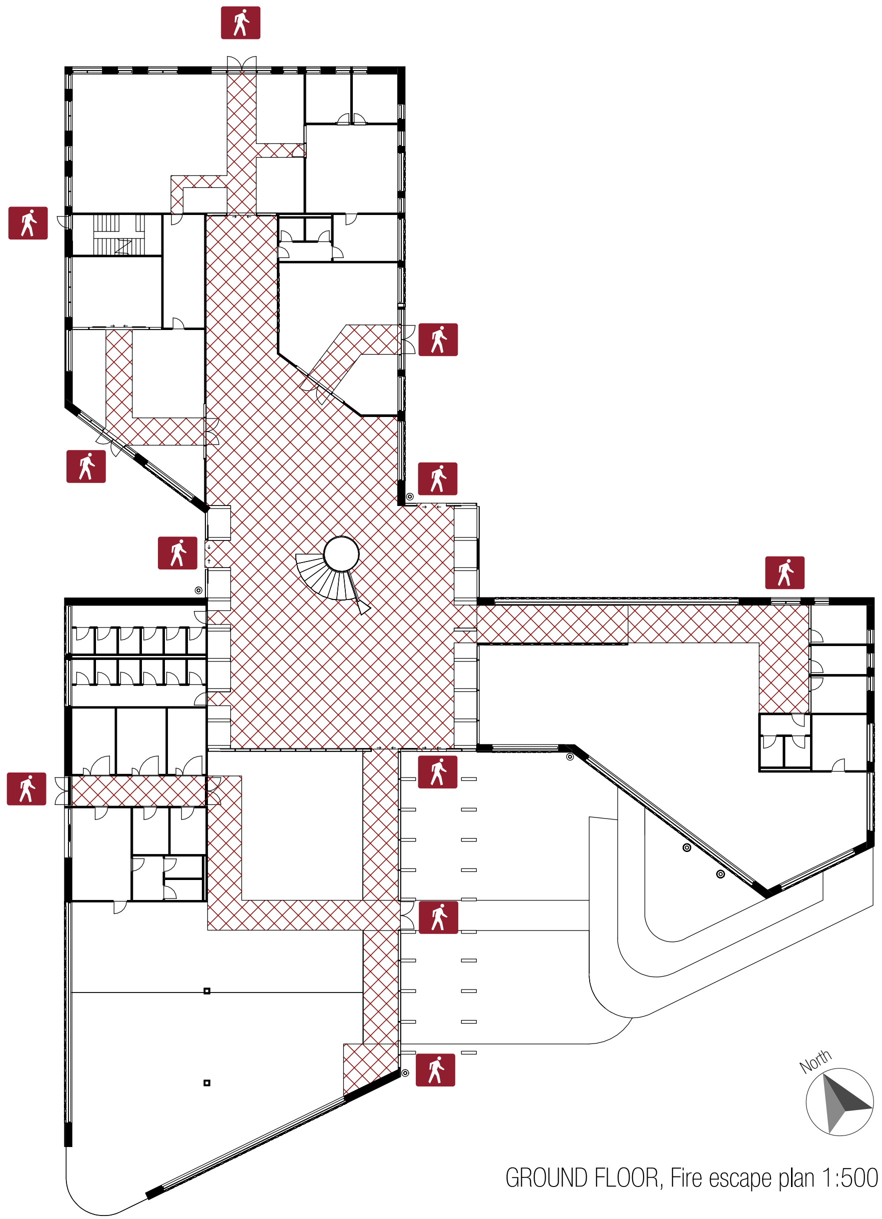


Ill 9.7 Daylight simulations of the visitor center. The first simulaton of the left towards the third on the right

VISITOR CENTER

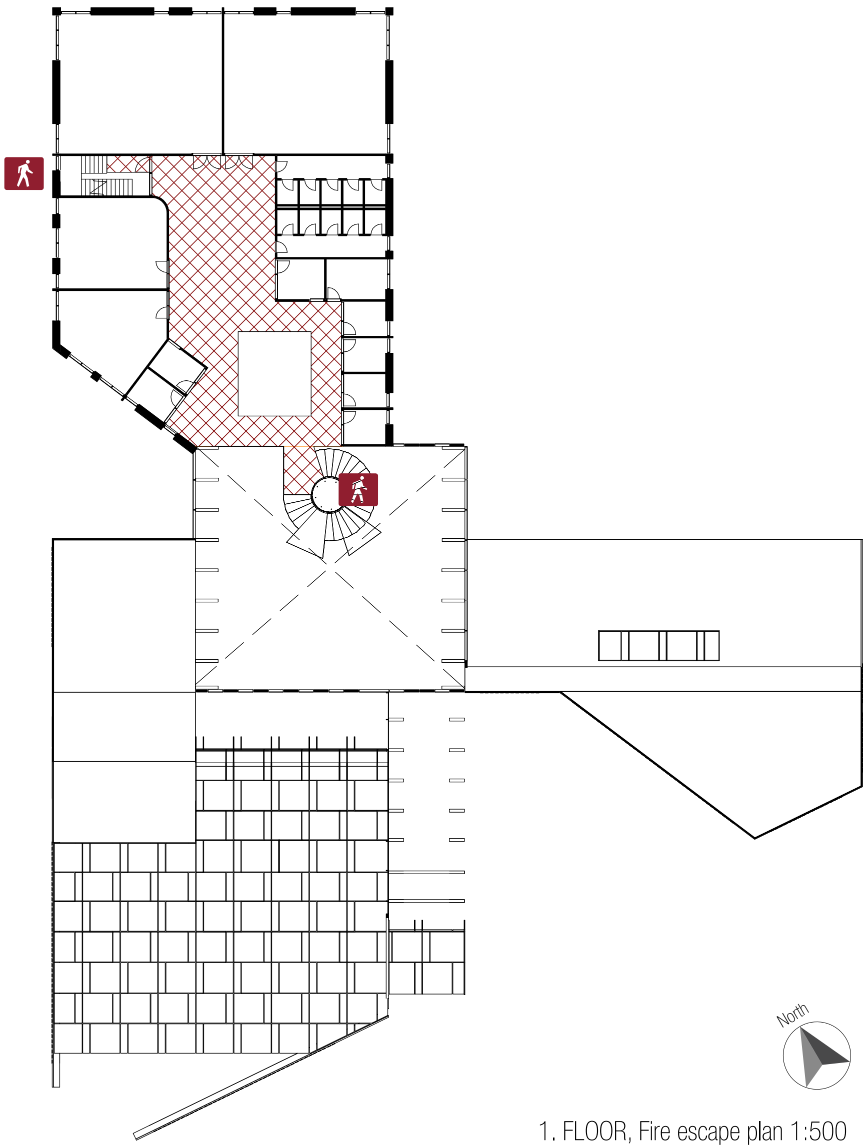
The visitor center is going to host exhibitions, reason why it is a more ennclosed volume where artificial light control is possible, but still provide light and a degree of visual reach in terms of the brick pattern. The first simulation shows the brick pattern implemented in the high of 3 meters. The first simulation compared to the second simulation where the pattern has been implemented in the height of 4 meters, so the light from the pattern reach further in to the space, also gives an unique characteristic framing the pattern and the light and shadow effect inside . The DF of the central space of the visitor center is higher by implementation of a small skylight with the prismatic glazing which is seen in the last simulation.

ANNEX 3 - FIRE ESCAPE PLANS



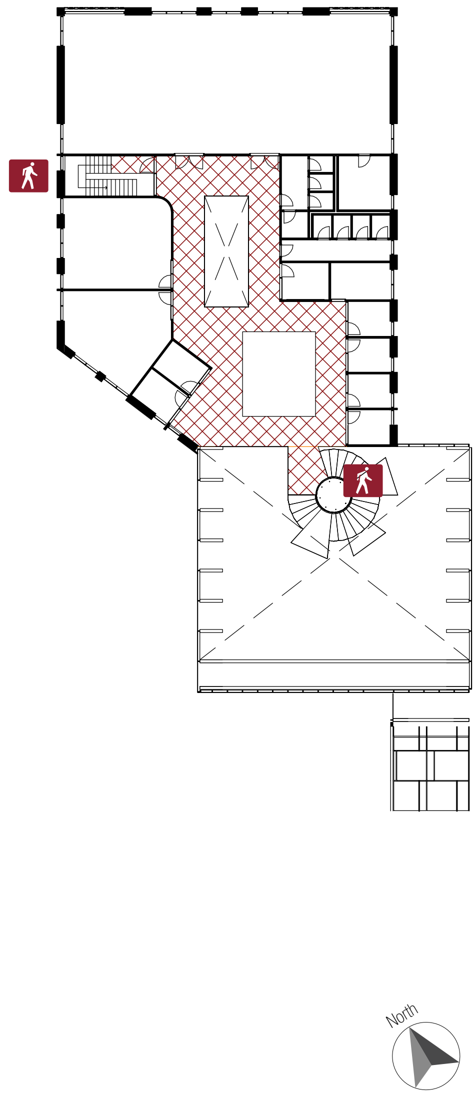
GROUND FLOOR, Fire escape plan 1:500

Ill 9.8



1. FLOOR, Fire escape plan 1:500

Ill 9.9



2. FLOOR, Fire escape plan 1:500

Ill 9.10

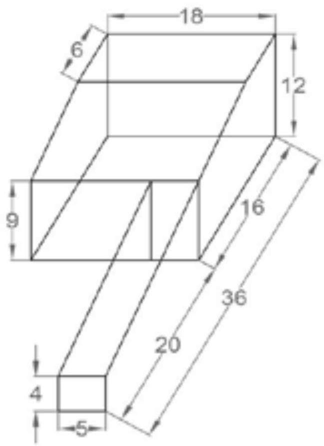
ANNEX 4 - STRUCTURE CALCULATION OF THE GATEWAY

METHODOLOGY

The Gateway design is informed of aesthetic, functional and technical aspects, which gravity on the design choices is weighted against the design concept.

The definition of the geometry has been refined with the parametric tool Grasshopper. With the plug in Karamba, load vectors and elements and joints characteristics are defined and first structural stability simulations can be run. This tool allows a quite straightforward iterative process, for which many solutions can be quickly tested.

Once the results become satisfactory, the structure is transferred to Autodesk Robot Structural Analysis for verification through a Finite Element Analysis. In Robot different Limit States can be tested and the cross section of elements can be optimized.



Ill 9.11

PROBLEM SETTING

References guide:

The calculations are carried forward referring to British Eurocodes, due to their free availability and due to the fact that data are given following the SI, therefore lowering the probability of mistakes due to conversion of units.

It has been verified that calculation methods were equal among the different regulations and were possible factors has been taken from the American Standards.

The ANSI (American National Standard Institute) and ASCE (American Society of Civil Engineering) are the organizations providing normatives for building design in the United States. Building regulations are updated every 5 years, but the only available version dates back to 2002.

Object of analysis: Gateway pavilion

Reason of choice: Structural challenges brought up during the design process

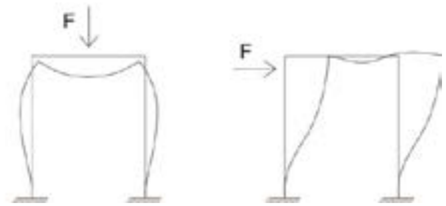
Objective of analysis: elements dimensioning according to applied actions

Fixed parameters:

- volume geometry (Ill 9.11)
- elements geometry
- structure type: hyperstatic rigid frame (Ill 9.12)
- inter elements spacing: 2 m due to aesthetic and functional considerations
- material: glue laminated hardwood GL35h due to its high resistance to bending stresses (EN 1991-1-1 (2002) EC1, Table A3, p. 34) and to aesthetic and functional considerations

Assumptions:

1. The Gateway pavilion is considered to be free standing
2. The vertical envelope considered is only the one enclosing the core, while in terms of horizontal envelope the whole area is taken into account. (Ill 9.11)



Ill 9.12

PERSISTENT DESIGN SITUATIONS

The Gateway reliability it is tested according its structural resistance and serviceability. This is done through a series of Limit States Analysis which will consider values of actions, materials properties and geometry of the model. (EN 1990 (2002), EC0)

Calculations are carried on persistent design situations, therefore in conditions of normal use, i.e. self weight and imposed loads. (3.2, p. 30, EN 1990 (2002), EC0)

Design working life category 4, 50 years building structures and other common structures (Table 2.1 p 28 EN 1990 (2002), EC0)

Service class C1 (EN 1990 (2002), EC0) = Nature of occupancy (SEI/ASCE 7-02 Table 1.1) III

Consequence Class CC2 (medium) (EN 1990 (2002), EC0)

PERMANENT ACTIONS (G) (EN 1990 (2002), EC0)/ DEAD LOAD (D) (SEI/ASCE)

As permanent action the self weight of the wooden bearing structure and the glazed panels (glazing – aluminium frame) are calculated. The variability of G is considered small enough to use one single value G. (4.1.2 EN 1990 (2002) EC0).

The self weight is calculated following the formula:

G = V · ρ · e

where V = volume

ρ = material density (kg/m³)

e = conversion factor kg/m³ to kN/m³ = 0.00981

The self weight of the glulam structure is calculated in Grasshopper

G = 1914 kN

V = 24.7 m³

γ = 25 kN/m³

G = 24.7 m³ · 25 kN/m³ = 617.5 kN

G = G + G = 1914 kN + 617.5 kN = 2351.5 kN

2351.5 kN / 1129 m² = **2.08 kN/m²**

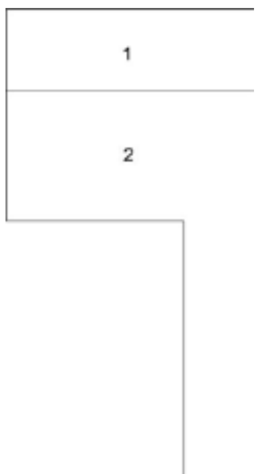
VARIABLE ACTIONS (Q) (EN 1990 (2002))

As variable actions snow load (S) and wind load (W) are calculated.

Washington DC is situated in an area not subjected to hurricanes, earthquakes and other climatic hazards with a high frequency.

Load due to fluids, rain load, earthquake load, ice load, accidental load and self straining load are not calculated.

SNOW LOAD (P) (EN 1991-1-3 (2003))



Ill 9.13

The snow load depends on the shape of the roof, the roughness of its surface, thermal properties, the proximity of nearby buildings, the surrounding terrain and the local meteorological climate. (Ill 9.13)

Snow load is assumed to be a static action on the structure. Conditions are assumed to be normal *(see p. 14 EN 1991-1-3 (2003) (English) Eurocode 1)*

The action of snow is calculated according the following formula

S = μ · C · C · s.

where μ: snow load shape coefficient

C: exposure coefficient C = 1.0: normal *(table 5.1 BS EN 1991-1-3 2003 EN 1991-1-3 2003 (E) p.20)*

C: thermal coefficient C = 1

s: characteristic value of snow load on ground = 20lb/ft² · 0.0479 (conversion factor) = 0.9 kN/m²
(SEI/ASCE TABLE C7-1)

μ = 0.8 μ = 0.8 (table 5.2 BS EN 1991-1-3 2003 EN 1991-1-3 2003 (E) p.21)

S = S = 0.8 · 1 · 1 · 0.9 = 0.72 kN/m²

Snow load Roof 1 S = 0.72 kN/m² · 283.8 m² = 204.3 kN

Snow load Roof 2 S = 0.72 kN/m² · 113.4 m² = 81.6 kN

Total snow load 285.9 kN; 0.75 kN/m²

WIND LOAD (EN 1991-1-4 (2005))

Wind actions fluctuate with time and act directly as pressures on the external surfaces of enclosed structures, and indirectly on the internal surfaces. Pressures act on areas of the surface resulting in normal forces to the surface of the structure.

The wind action is represented by a simplified set of pressures or forces whose effects are equivalent to the extreme effects of the turbulent wind.

According to the analysis of the site, there are two main wind directions: the strongest coming from North-West, and a secondary coming from South.

A worst case scenario is hypotized for the wind load calculations. The Gateway is considered to be freely standing in a wind open field, so the adjacent buildings to which it is connected are not taken into consideration.

Wind actions are calculated on the basic values of wind velocity or velocity pressure. The effect of wind on the structure depends on the size, shape and dynamic properties of the structure. The response of structure should be calculated according to peak velocity pressure at a reference height in the undisturbed wind field, the force and the pressure coefficients and the structural factor. The peak velocity pressure depends on the wind climate, the terrain roughness, orography and the reference height. The peak velocity pressure is equal to the mean velocity pressure plus a contribution of short-term pressure fluctuations.

CALCULATIONS

EN 1991-1-4 (2005) (English): Eurocode 1: Actions on structures - Part 1-4: General actions - Wind actions [Authority: The European Union Per Regulation 305/2011, Directive 98/34/EC, Directive 2004/18/EC] p. 18

Actual wind directions are considered rotated of 30.4° (clockwise) so that they result having a normal incidence with the volume under analysis.

WIND DIRECTION CONSIDERED: NORTH-WEST

<u>Basic wind velocity</u> (defined as a function of wind direction and time of year at 10m above ground of terrain category II) : $V_b = C_{dir} \cdot C_{season} \cdot V_{b,0}$

where C_{dir} : factor for direction of wind speed. C_{dir} = 1 (recommended value)

C_{season} : factor for wind speed season. C_{season} = 1 (recommended value)

$V_{b,0}$: basic wind velocity on ground (reference)

$V_b = 1 \cdot 1 \cdot 4.7$ m/s = **4.7 m/s**

<u>Mean wind velocity</u> $V_m(z) = C_r(z)\, C_o(z)\, V_b$

where $C_r(z)$: roughness factor, given in 4.3.2

$C_o(z)$: orography factor, taken as 1.0 unless otherwise specified in 4.3.3, $C_o(z)$ = 1

<u>Roughness factor</u> $C_r(z) = k_r \ln(z/z_0)$

where z: height of mid-point of the structure

z_0 : roughness length

k_r : terrain factor

Terrain category IV: Area in which at least 15 % of the surface is covered with buildings 1.0 10 and their average height exceeds 15 m z_0 = 1m z_{min} = 10m z = 8m

$k_r = 0.19\,(z_0/z_{0,II})^{0.07}$

$k_r = 0.19\,(1\text{ m}/0.05\text{ m})^{0.07} = 0.23$

$C_r(z) = 0.23 \ln(8\text{m}/1\text{ m}) = 0.20$

$V_m(z) = 0.20 \cdot 1 \cdot 4.7$ m/s = **0.94 m/s**

<u>Wind turbulence</u> $\sigma_v = k_r V_b K_I$

where K_I: turbulence factor K_I = 1 (EN 1991-1-4, recommended value)

$\boldsymbol{\sigma_v} = 0.23 \cdot 4.7$ m/s $\cdot\, 1$ = **1.08 m/s**

<u>Turbulence intensity</u> $I_v(z) = \sigma_v / V_m(z)$

$I_v(z) = 1.08$ m/s / 0.94 m/s = **1.15 m/s**

<u>Peak velocity pressure</u>: $q_p(z) = (1+7\, I_v(z))\, ½\, \rho\, V_m^2(z)$

Air density ρ = 1.25 kg/m³

$q_p(z) = (1+(7 \cdot 1.15$ m/s$))\, ½ \cdot 1.25$ kg/m³ $\cdot\, 0.94^2$ = **4.99 kN/m²**

WIND ACTIONS

BS EN 1991-1-4:2005+A1:2010 EN 1991-1-4:2005+A1:2010 (E) p. 24

The wind action is calculated according to the external wind pressure on the external surfaces, W_e.

$W_e = q_p(z_e)\, C_{pe}$

where $q_p(z_e)$: peak velocity pressure

z_e: reference height for the external pressure

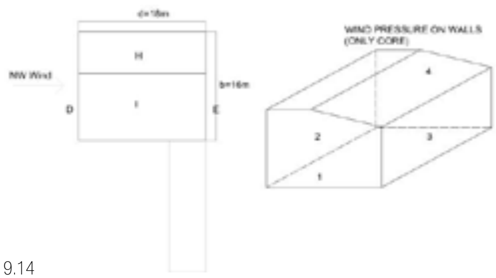
C_{pe}: pressure coefficient for external pressure

<u>Wind force</u> $F_w = c_s c_d \sum W_e A_{ref}$

where $c_s c_d$: structural factor $c_s c_d = 1$ for buildings lower than 15m (EN 1991-1-4 (2005), p. 28)

A_{ref}: reference area of the structure

FORCES ON CORE WALLS



Ill 9.14

External pressure coefficients on core walls C_{pe}

A	B	C	D	E
1.2	0.8	0.5	0.8	0.5

e=b or 2h (whichever is smaller)

e = b = 16m

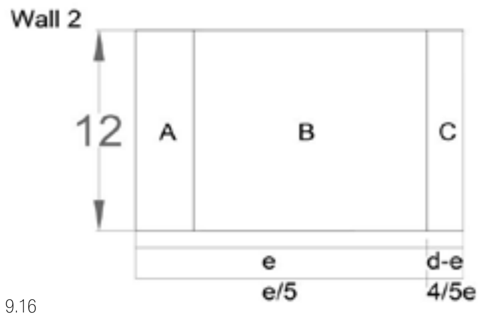
Ill 9.15

WALL 1 ZONE D

A_{ref} = 178.8 m² z_e = 5.25 m

W_e = 4.99 kN/m² · 0.8 = 3.99 kN/m²

F_w = 3.99 kN/m² · 178.8 m² = **714.8 Kn**



Ill 9.16

WALL 2 ZONE A,B,C

z_e = 6 m

ZONE A

A_{ref} = 37.4 m²

W_e = 4.99 kN/m² · 1.2 = 5.99 kN/m²

F_w = 5.99 kN/m² · 37.4 m² = **224.3 kN**

ZONE B

A_{ref} = 149.7 m²

W_e = 4.99 kN/m² · 0.8 = 3.99 kN/m²

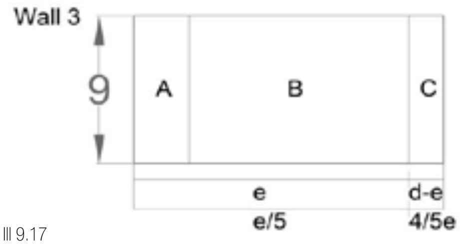
F_w = 3.99 kN/m² · 149.7 m² = **598.5 kN**

ZONE C

A_{ref} = 23.4 m²

W_e = 4.99 kN/m² · 0.5 = 2.49 kN/m²

F_w = 2.49 kN/m² · 23.4 m² = **58.5 kN**



Ill 9.17

WALL 3 ZONE A,B,C

z_e = 4.5 m

ZONE A

A_{ref} = 29.1 m²

W_e = 4.99 kN/m² · 1.2 = 5.99 kN/m²

F_w = 5.99 kN/m² · 29.1 m² = **174.5 kN**

ZONE B

A_{ref} = 116.5 m²

W_e = 4.99 kN/m² · 0.8 = 3.99 kN/m²

F_w = 3.99 kN/m² · 116.5 m² = **465.8 kN**

ZONE C

A_{ref} = 18.2 m²

W_e = 4.99 kN/m² · 0.5 = 2.49 kN/m²

F_w = 2.49 kN/m² · 18.2 m² = **45.5 kN**

WALL 4 – ZONE E

A = 178 8 m z = 5 25 m

W = 4.99 kN/m · 0 5 = 2.49 kN/m²

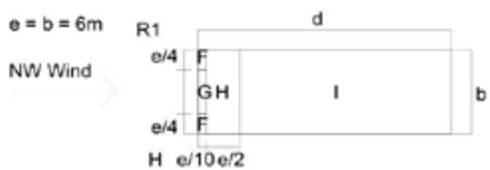
F = 2 49 kN/m · 178 8 m = 446.8 kN

<u>Total wind force on walls caused by NW wind</u> F_w = C_sC_d ∑ W_e A_{ref}

$F_{w,tot}$ = 1299 kN f_w = 1.78 kN/m²

FORCES ON THE ROOF

Ill 9.18



Ill 9.19

R1 – CORE – Flat roof, sharp eaves (Slope 5°< α< 5°)

External pressure coefficients flat roof, sharp eaves C

F	G	H	I
1 8	1 2	0 7	±0.2

ZONE F

A = 0 89 m

W = 4.99 kN/m · 1 8 = 8.98 kN/m²

F = 8 98 kN/m · 0 89 m = 15.98 kN

ZONE G

A = 1.98m

W = 4.99 kN/m · 1 2 = 5.58 kN/m²

F = 5 98 kN/m · 1 98 m = 11.85 kN

ZONE H

A = 15 1 m

W = 4.99 kN/m · 0 7 = 3.49 kN/m²

F = 3 59 kN/m · 15 1 m = 52 7 kN

ZONE I

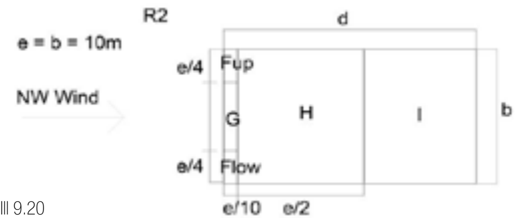
A = 94 5 m

W = 4.99 kN/m · 0 2 = 0.99 kN/m²

F = 0 99 kN/m · 94 5 m = 94 3 kN

W = 4.99 kN/m · 0 2 = 0.99 kN/m²

F = 0.99 kN/m · 94 5 m = 94 3 kN



Ill 9.20

R2 – CORE – Single pitched roof (14° slope)

External pressure coefficients 14° (α=15° according to "most similar" to reference table 7 3b), sloped roof sharp eaves C

Wind direction θ=90°

F up	F low	G	H	I
2 4	1 6	1 9	0 8	0 7
−0.2	−0.2	−0.2	−0.2	−0.2

ZONE F up

A = 2.5 m

W = 4.99 kN/m · 2 4 = 11.9 kN/m²

F = 11 9 kN/m · 2 5 m = 29 9 kN

ZONE F up –

A = 2.5 m

W = 4.99 kN/m · 0 2 = 0.99 kN/m²

F... ; . = 0.99 kN/m² · 2.5 m² = **2.5 kN**

ZONE F low -

A... = 2.5 m²

W... = 4.99 kN/m² · -1.6 = **-7.9 kN/m²**

F... = -7.9 kN/m² · 2.5 m² = **-19.9 kN**

ZONE F low +

A... . . = 2.5 m²

W... . = 4.99 kN/m² · 0.2 = **0.99 kN/m²**

F... . . = 0.99 kN/m² · 2.5 m² = **2.5 kN**

ZONE G -

A... = 5.1m²

W... = 4.99 kN/m² · -1.9 = **-9.48 kN/m²**

F... = -9.48 kN/m² · 5.1 m² = **-48.3 kN**

ZONE G +

A... . = 5.1m²

W... . = 4.99 kN/m² · 0.2 = **0.99 kN/m²**

F... . = 0.99 kN/m² · 5.1 m² = **5.1 kN**

ZONE H -

A... = 90.9 m²

W... = 4.99 kN/m² · -0.8 = **-3.99 kN/m²**

F... = -3.99 kN/m² · 90.9 m² = **-362.8 kN**

ZONE H +

A... . = 90.9 m²

W... . = 4.99 kN/m² · 0.2 = **0.99 kN/m²**

F... . = 0.99kN/m² · 90.9 m² = **90.7 kN**

ZONE I -

A. = 80.8 m²

W. = 4.99 kN/m² · -0.7 = **-3.5 kN/m²**

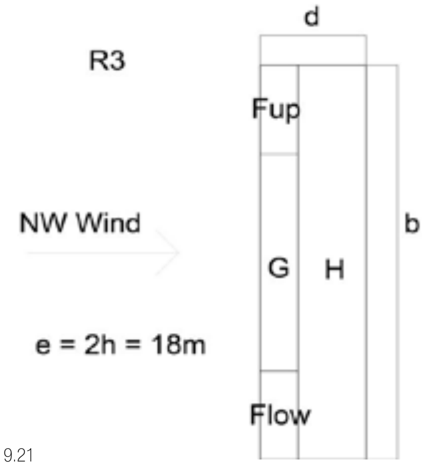
F. = -3.5 kN/m² · 80.8 m² = **-282 kN**

ZONE I +

A. = 80.8 m²

W... . = 4.99 kN/m² · 0.2 = **0.99 kN/m²**

F... . = 0.99 kN/m² · 80.8 m² = **80.6 kN**



Ill 9.21

R3- CORRIDOR – Single-pitched-roof (14° slope)

For external pressure coefficient see paragraph FORCES ON THE ROOF – CORR – SINGLE PITCHED ROOF (14°).

ZONE F up -

A... ; = 8.1 m²

W... ; = 4.99 kN/m² · -2.4 = **-11.9 kN/m²**

F... ; = -11.9 kN/m² · 8.1 m² = **-97 kN**

ZONE F up +

A... ; . = 8.1 m²

W... ; . = 4.99 kN/m² · 0.2 = **0.99 kN/m²**

F... ; . = 0.99 kN/m² · 8.1 m² = **8 kN**

ZONE F low

$A = 8.1\ m^2$

$W = 4.99\ kN/m^2 \cdot 1.6 = 7.9\ kN/m^2$

$F = 7.9\ kN/m^2 \cdot 8.1\ m^2 =$ **64.6 kN**

ZONE F low –

$A = 8.1\ m^2$

$W = 4.99\ kN/m^2 \cdot 0.2 = 0.99\ kN/m^2$

$F = 0.99\ kN/m^2 \cdot 8.1\ m^2 =$ **8 kN**

ZONE G

$A = 19.8\ m^2$

$W = 4.99\ kN/m^2 \cdot 1.9 = 9.48\ kN/m^2$

$F = 9.48\ kN/m^2 \cdot 19.8\ m^2 =$ **187.7 kN**

ZONE G +

$A = 19.8\ m^2$

$W = 4.99\ kN/m^2 \cdot 0.2 = 0.99\ kN/m^2$

$F = 0.99\ kN/m^2 \cdot 19.8\ m^2 =$ **19.7 kN**

ZONE H

$A = 66\ m^2$

$W = 4.99\ kN/m^2 \cdot 0.8 = 3.99\ kN/m^2$

$F = 3.99\ kN/m^2 \cdot 66\ m^2 =$ **263.5 kN**

ZONE H +

$A = 66\ m^2$

$W = 4.99\ kN/m^2 \cdot 0.2 = 0.99\ kN/m^2$

$F = 0.99 kN/m^2 \cdot 66\ m^2 =$ **65.8 kN**

Total wind force on roof caused by NW wind $F_w = C_sC_d \sum W_e A_{ref}$

$F_{w,tot} = 1247.9\ kN$ $F_w = 3.14\ kN/m^2$

In both cases, wall and roof, the wind action creates pulling forces.

VERIFICATION BY THE PARTIAL FACTOR METHOD (EN.1990.2002 EC0)

By using the partial factor method it is verified in all relevant design situations that no relevant limit state is exceeded when design values for actions or effects of actions and resistances are used in the model. For the selected design situation and limit states the critical load cases are combined. Actions that cannot occur simultaneously, for example due to physical reasons are not considered together.

COMBINATION OF ACTIONS

For each critical load case, the design value of the effects of actions (Ed) is determined by combining the values of actions that are considered to be occurring simultaneously. Each combination action is including a leading variable actions or an accidental action. The combination of actions is in accordance with 6.4.3.2 to 6.4.3.4

Since the material used is glue lam rated hard wood the combination of actions will be calculated in a permanent condition for the ULS and quasi permanent condition for SLS.

ULTIMATE LIMIT STATES

The following limit state is verified:

b) STR Internal failure or excessive deformation of the structure or structural members, including footings, piles, basement walls, etc.. Where displacements will affect the behavior of the structure, their effect must be taken into account.

For the ULS, the combination is considering the snow load as dominant. For this load case design values for material strength and design loads are used.

Accidental loads (P) are not taken into account.

$$\sum_{j\geq1}\gamma_{G,j}G_{k,j}+\gamma_{Q,1}\psi_{0,1}Q_{k,1}+\sum_{i>1}\gamma_{Q,i}\psi_{0,i}Q_{k,i} \quad \text{(EC0, equation (6.10a))}$$

Where "+" means "combined with"

G_k = 2.08 kN/m

γ = 1

γ = 1.5

Ψ = 0.5

Q = 0.75 kN/m

γ = 1.5

Ψ = 0.6

Q = 1.78 kN/m Q = 3.14 kN/m

1 · 2.08 kN/m + 1.5 · 0.5 · 0.75 kN/m + 1.5 · 0.6 (1.79 3.14) = 1.19 kN/m²

SERVICEABILITY LIMIT STATE

It addresses normal service conditions, as the deformation of the structure or vibration comfort.

For the SLS the combination is considering the snow load as dominant. For this load case design values for material strength and design loads are used.

Since the material used is glue laminated hard wood a quasi permanent combination is chosen for the SLS (EN 1995 1 1 (2004)).

$$\sum_{j\geq1}G_{k,j}\text{"+"}P\text{"+"}\sum_{i\geq1}\psi_{2,i}Q_{k,i}$$

G_k = 2.08 kN/m

Q = 0.75 kN/m

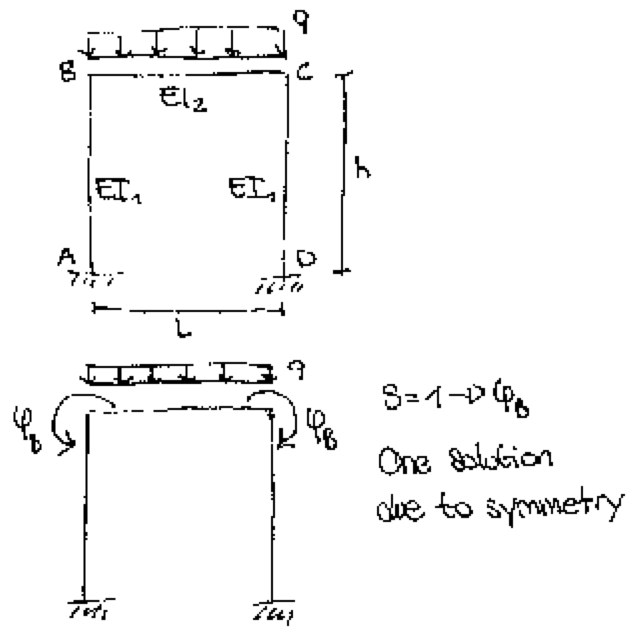
Q = 1.78 kN/m Q = 3.14 kN/m

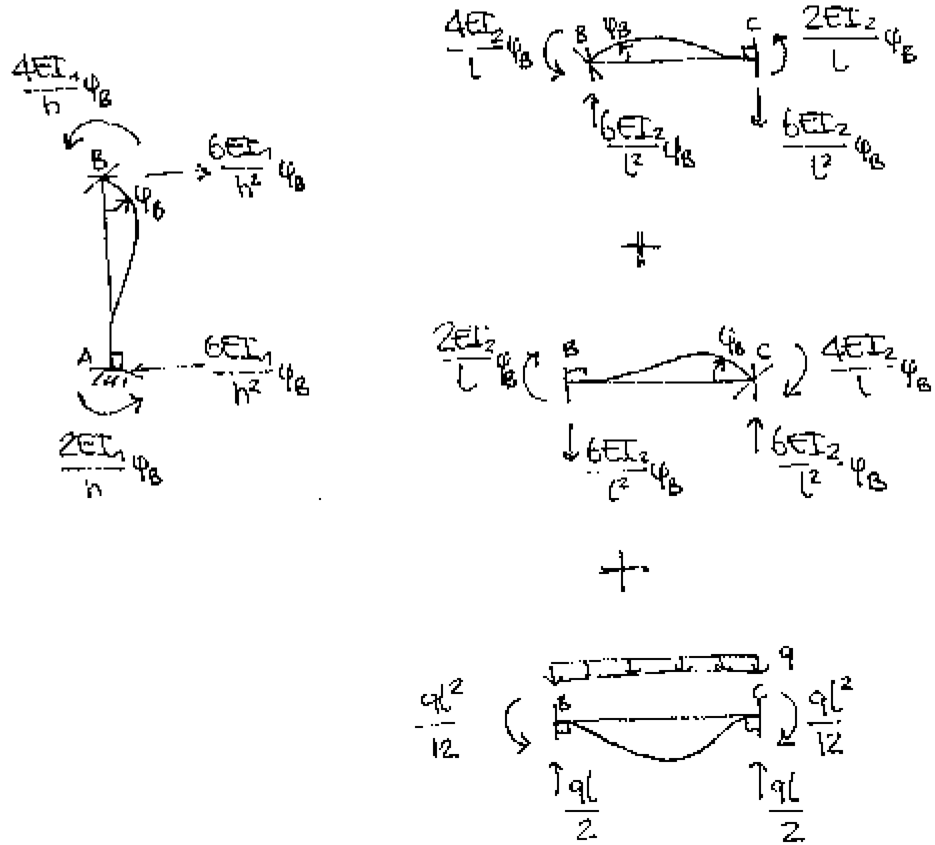
2.08 kN/m + 0.75 kN/m2 1.78 kN/m 3.14 kN/m = 2.09 kN/m²

ANNEX 5 - STRUCTURE BEHAVIOUR UNDERSTANDING

Any structural system, after being subjected to a force, always responds by finding an equilibrium between the nodal reactions to the applied force and the nodal displacements. The unknown values determining this equilibrium are given by a stiffness matrix.

The Illustration shows an example of the procedure to find the value of the nodal displacements, creating the stiffness matrix.
The used values are the result of the integration of the elastic line.

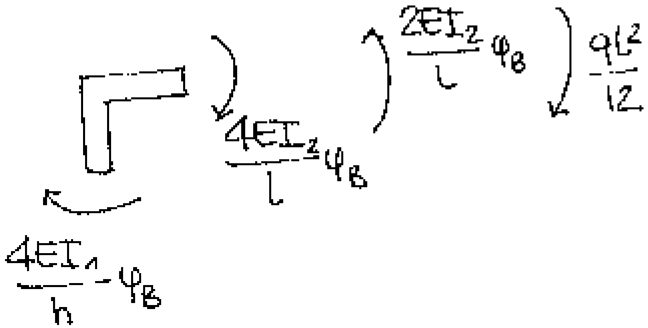




Ill 9.22

Ill 9.23

EQUILIBRIUM IN B



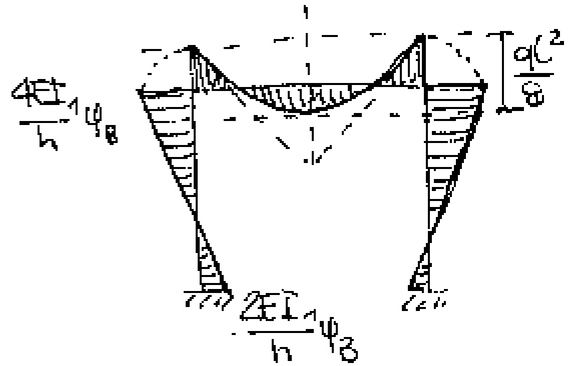
$$\sum \overset{\curvearrowleft}{M_B} = 0 \; ;$$

$$-\frac{4EI_1}{h}\varphi_B - \frac{2EI_2}{l}\varphi_B - \frac{ql^2}{12} = 0$$

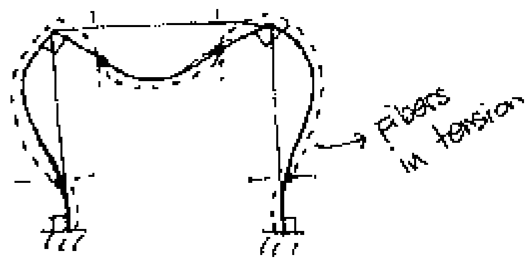
$$\varphi_B = -\frac{ql^2}{12\left(\frac{4EI_1}{h} + \frac{2EI_2}{l}\right)}$$

Ill 9.24

M_x DIAGRAM



DISPLACEMENT DIAGRAM



Ill 9.25