school of architecture & design aalborg

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introduction
vision

As the densification of the municipality of Aalborg increases the need for diversification arises. The city of Aalborg is currently in the process of evolving from its industrial past towards a knowledge-based future. This transformation enables the opportunity for growth in effected sectors, the education sector playing a crucial part in the evolvement of this change.

As the knowledge-based city of Aalborg has a need to generate or attract educated citizens in order to grow, the main University, AAU, has a need to expand and modify its structure.

This creates the opportunity for the Architecture and Design Department to become more centralized and united. The current situation is inconvenient in terms of maintenance, both economically and ergonomically. The disjointed structure of the A&D inhibits social interaction between students and the amalgamation of design ideas.

This thesis will propose an Architectural & Design School in Aalborg as a single and united entity. In the creation of a school that accommodates architectural and design education, there underlies a responsibility to utilize the space in an inspiring and vernacular way. Building an architectural institution enables the ability to create, but also the responsibility to serve as, an inspiring space that will contribute to the continual shaping of the region and its unique Nordic architectural style. The new buildings form language will aim to integrate in to the fabric of the city and depict itself as a benchmark for modern Nordic design within its urban environment.

In order to execute this kind of a building the need to understand the region in terms of cultural and pragmatic context is required. This will materialize in a new definition of vernacular architecture, an architecture that is prepared for the condition of the site whether it be climatic or social. This means that somehow the depiction of the society of the region needs to be imbedded in the DNA of the form language.

In order to succeed the need to be tectonic and sustainable in a Nordic context must be achieved architecturally and technically. Sustainable Design principles will be implemented in to the design using the IDP method. The ambition is to materialize a program composition that respect honesty, transparency and environmental awareness, producing something that is typical of the region and the rest of the Nordic countries, showcasing modern architectural design.

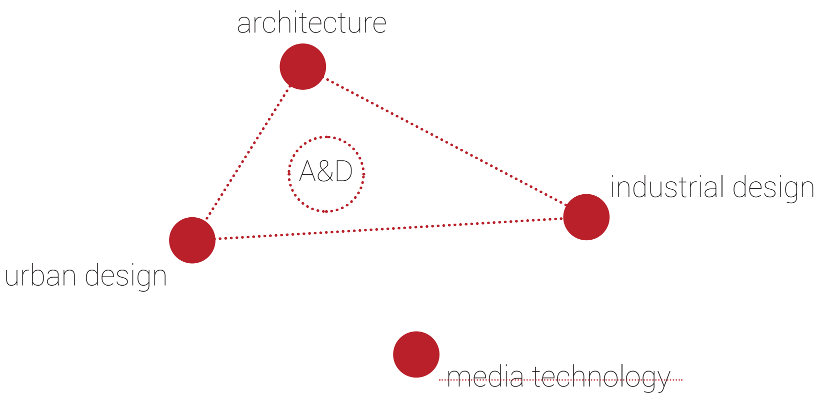
_Limitations

This report will present a design proposal for a building accommodating the architecture-, urban design- & industrial design-program, offered at the Architecture & Media Technology Department, Aalborg University.

This design proposal has the ambition to explore programatic and performative issues one can face when designing a school of architecture & design.

The Media Technology programs was chosen to be excluded in order to set limitations to the project in order to be able to work on a more detailed scale. Also decreasing the total square meters to handle the plot limitations.

This report is an attempt to rationally depict a process that generally was intuitive and non linear.



introduction
personal goal

In order for this project to be successful it has to provide good architecture holistically. The obsession with reaching certain energy-requirements on behalf of other architectural values will not take place.
To define balanced architecture there is a need to define the factors of our perspective of balanced architecture. The chosen factors can be displayed with the help of an AQAL-diagram taken from an article by Peter Buchanan [2].

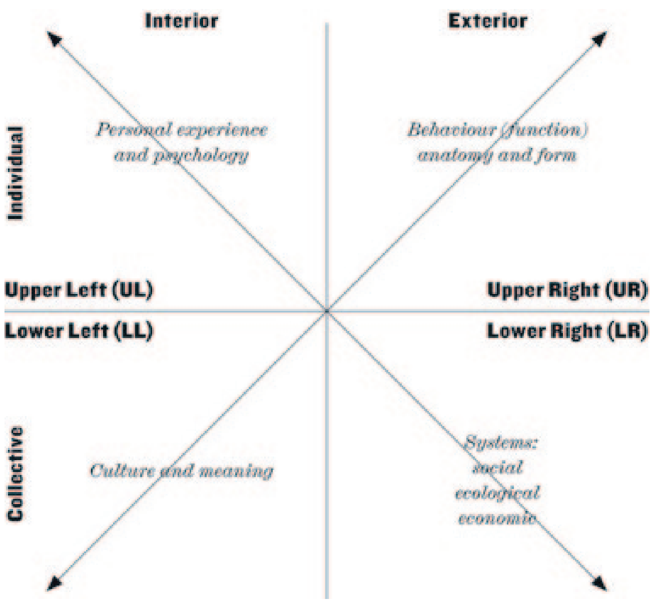


Fig 1. displays the general principle of the four quadrants

Fig 2. has parameters inserted

In the article, Rethinking Architectural Education [2], Peter Buchanan writes about skills, knowledge and competencies that the architecture student must reclaim with an evolved curriculum of the architectural education.
Fig.2 displays the different subjects that belong to the different categories of personal growth that an architecture student need to mature into.
The relevance of this overview for this project is evident as it is a learning process for us to develop our skills as architects, according to the AQAL
Also, by using this diagram as a compass, we can aim to spell the building grammatically correct according to extracts from all four quadrants.
Below is our interpretation of the quadrants, in how they can be applied in the architectural language of the building.

The four quadrants

_Delight _ *exploration of phenomenological approach, of how the space has an impact on the user, e.g. 'how to attract the flow of people in a certain direction'* [3]*; students, teachers and the public.*

Decorum *Reflecting Scandinavian culture and values, with accessibility and transparency.*

Commodity/Function *To create a student friendly environment, in terms of ergonomic and healthy working spaces.*

Firmness *To create a building with environmental awareness with the aim of fulfilling the 2015 standards according to the Low energy performance framework 7.2.4.2 BR10.*

Conclusion

We have no intensions in subordinate functionality over performance, poetry over measurable values.
The weight in this project is balanced personal growth by exploring the potentials of the building and thereafter allocate more time on the challenging aspects, whether it is sustainable technologies or tectonic execution.

introduction
design goal

The main design goals with this project can be narrated with the help of the three following perspectives:

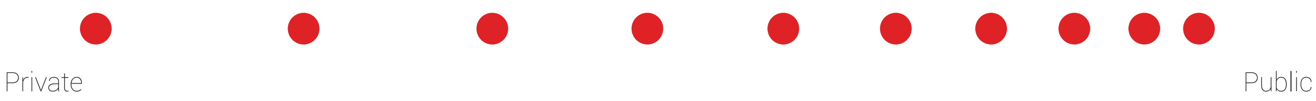
I. Outside Looking in, how its perceived by the public, non-users --> [gradient]

II. Inside Looking out, how its perceived by the users, students and staff --> [interaction point]

III. Inside Outside, a measurable performance of the indoor environment and the energy demand.--> [BR10-2015 framework]

I.
_Outside Looking In
As our building is situated on public ground, we need to create a profile that is open to the public.

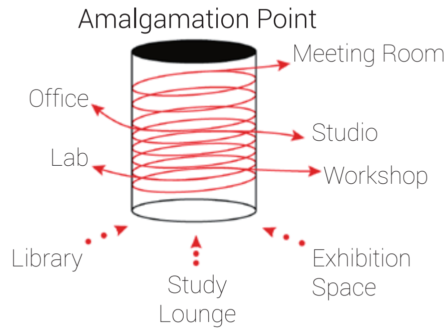
The transparency and openness which is embedded in the scandinavian culture needs to be present in the form and space of the building as of respect to the location. And as the location is a public park, the users should have the right to utilize it.
On the other side, the building needs to function and be practical, meaning having a hierarchy of privacy.
Therefore a gradient from public to private needs to be present, in terms of accessibility and spatial experience.



II.
_Inside Looking Out

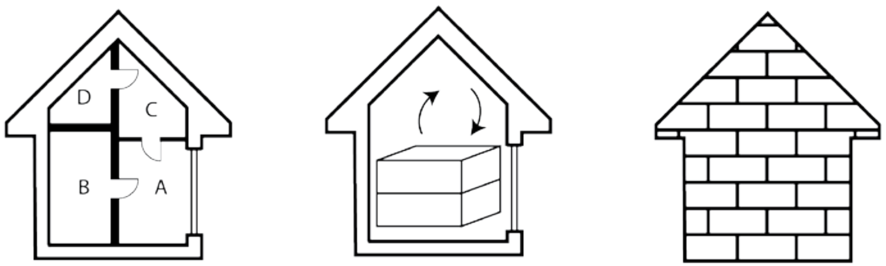
In order to enhance the learning experience for the architect & design student, an interaction between the students should take place to allow for amalgamation & interchange of ideas.

The movement through the building should also be a gradient experience, from openness to intimacy. The openness can refer to the space in which the interaction takes place, where students meet students/teachers, exchange ideas and have informal discussions. Intimacy can be the place where the individual have there private space in which the ideas take form.



III.
_Inside Outside

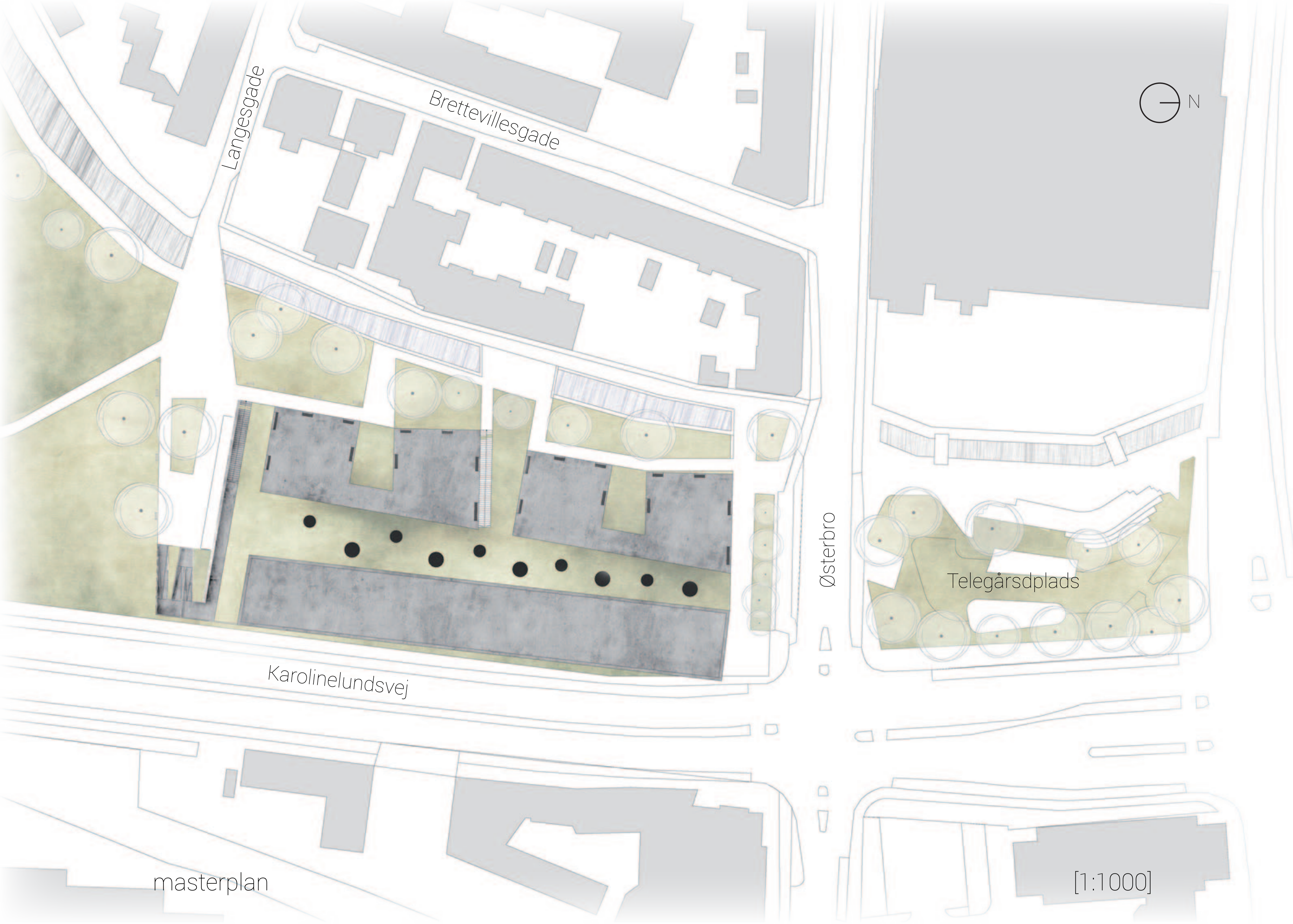
The aim is to fullfill the the 2015 standard according to the Low energy performance framework 7.2.4.2 BR10.
BR10 is also to be used in the indoor climate assesment.
The method in optimizing the energy demand and healthy indoor climate will be done through the;



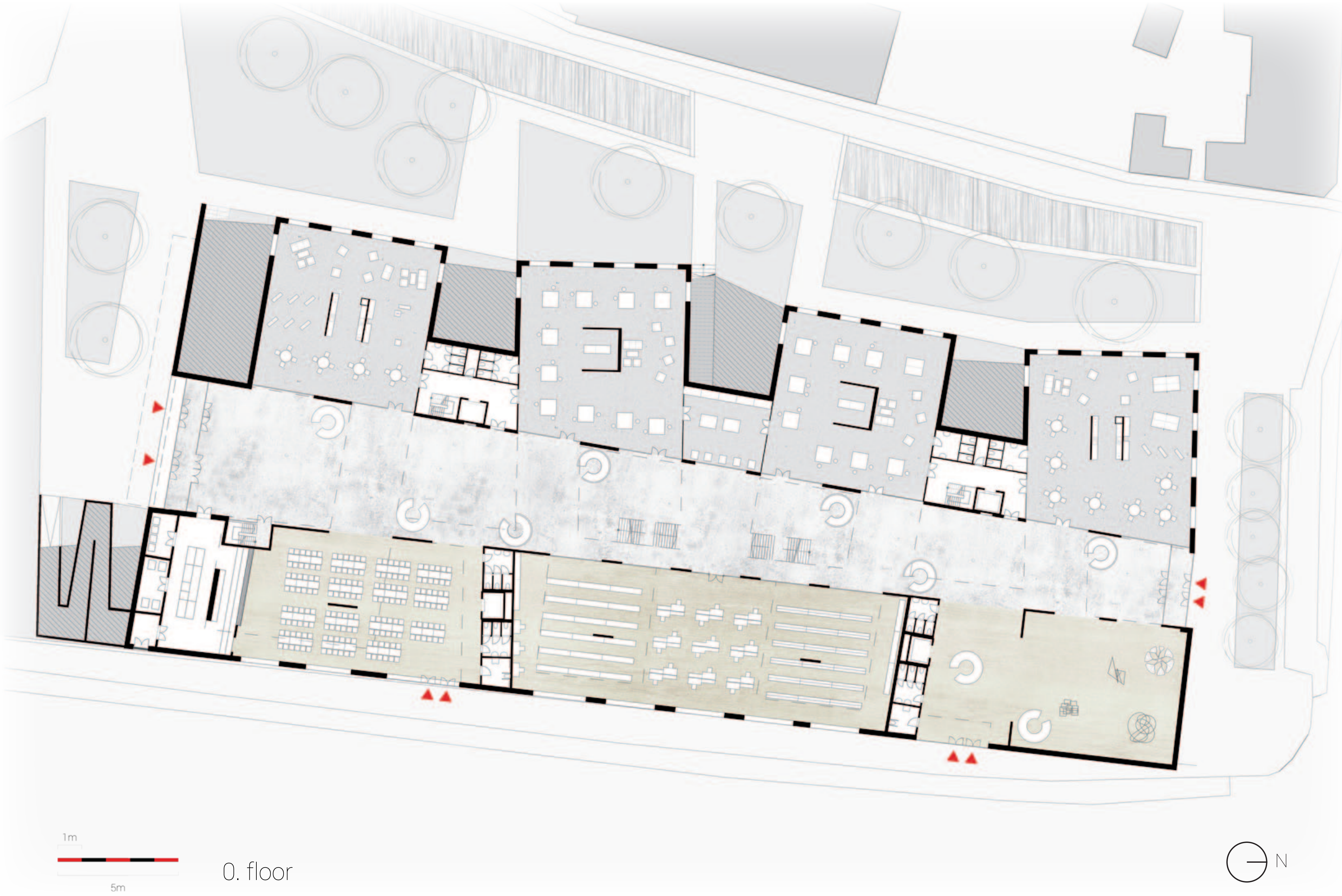
function disposition *building form* *material*

presentation

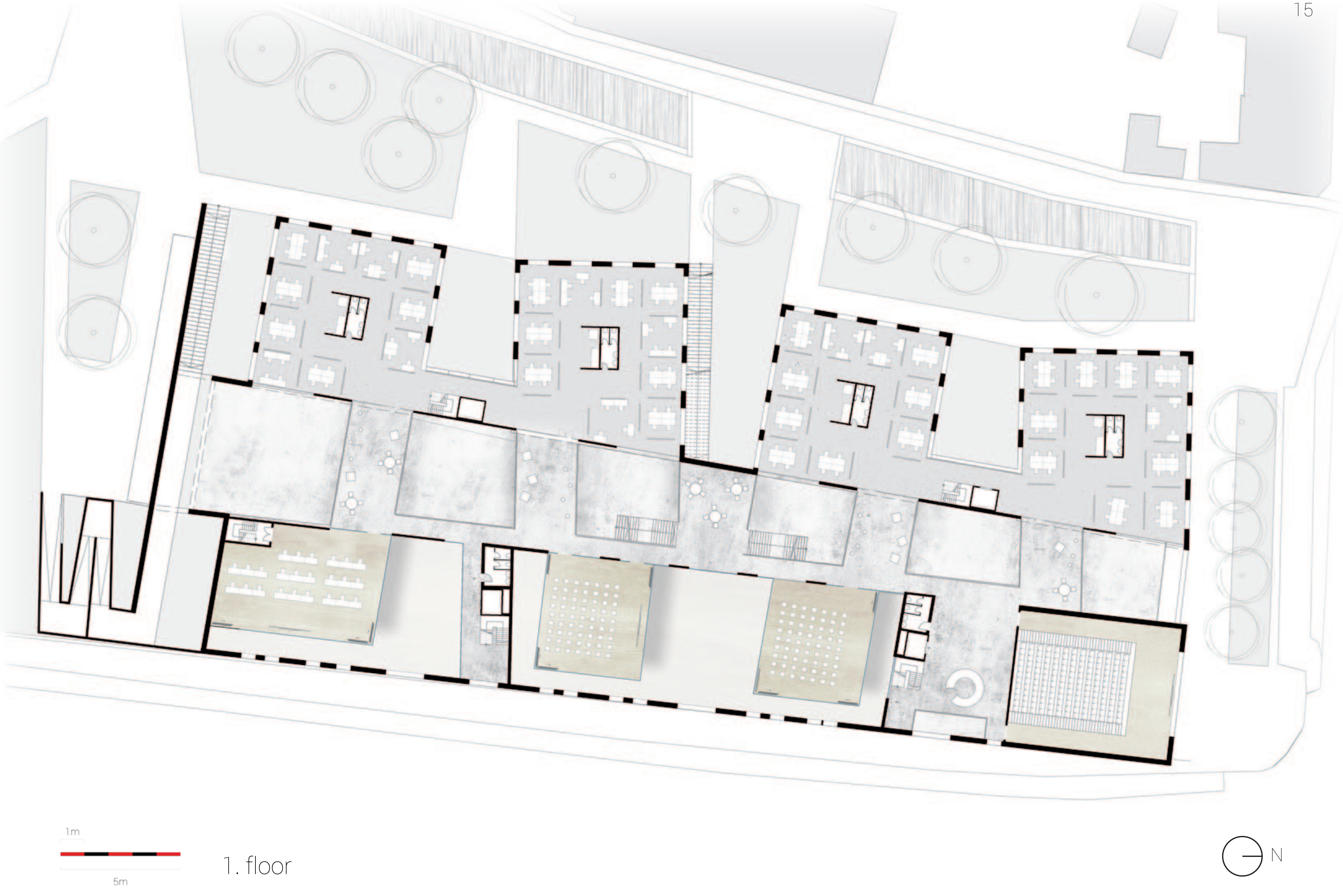
school of architecture & design


Langesgade
Brettevillesgade
N
Østerbro
Telegårsdplads
Karolinelundsvej
masterplan
[1:1000]


School of Architecture & Design



0. floor

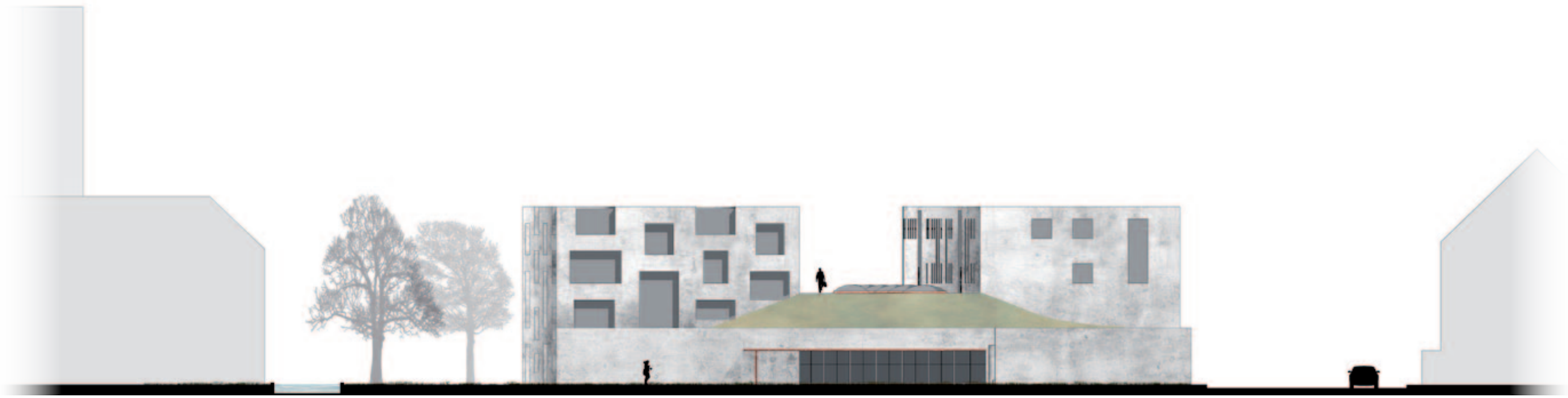


1. floor

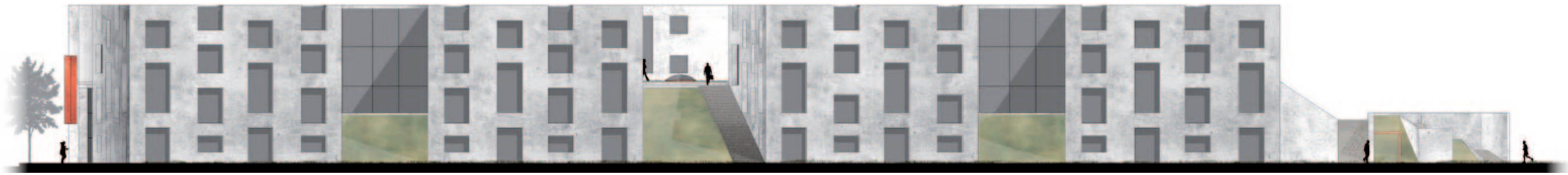
2. floor

3. floor

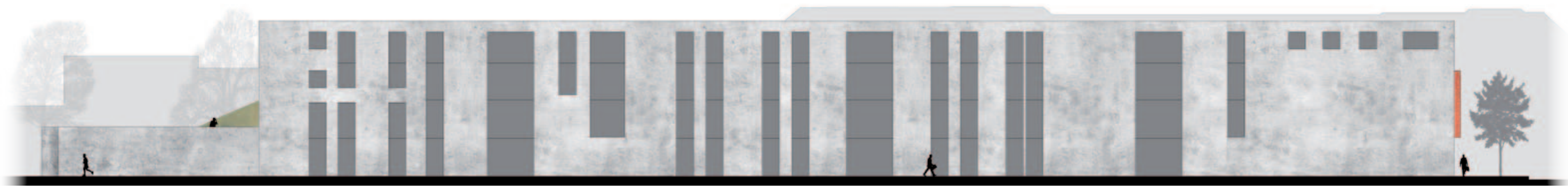
north elevation



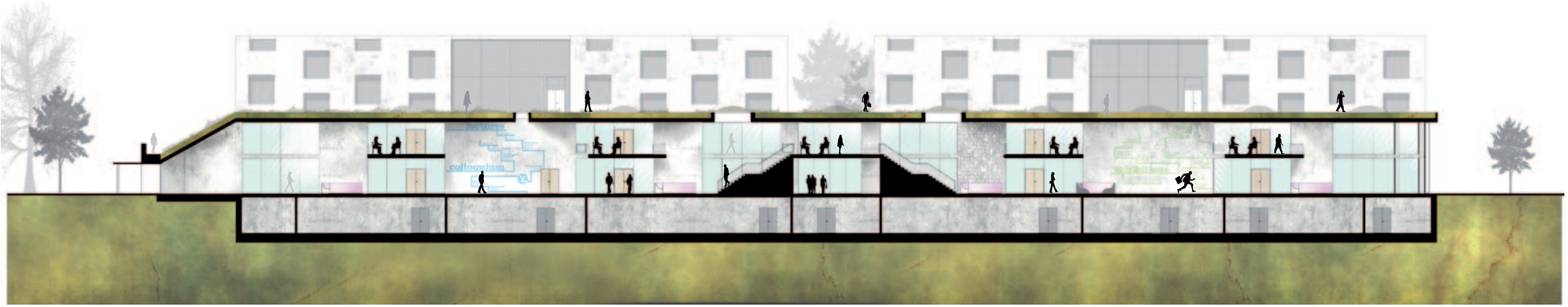
south elevation



west elevation



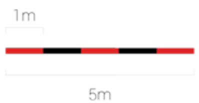
east elevation

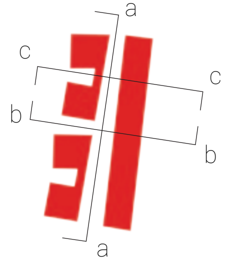


a-a linear section

b-b cross section

c-c cross section






lectures

_Aalborg School of Architecture & Design

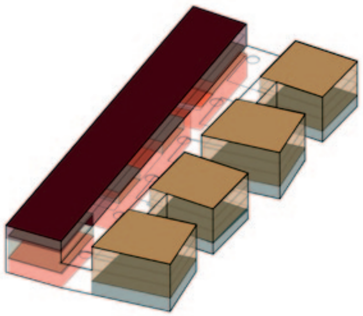
A design proposal accommodating a school of architecture & design with transparency towards the public.

As an extension of Karolinelund through the building, the public has access to the library, exhibition space and restaurant, having the opportunity to see architecture and design students manufacturing ideas along the way.

total space distribution

56% student
24% staff
20% public

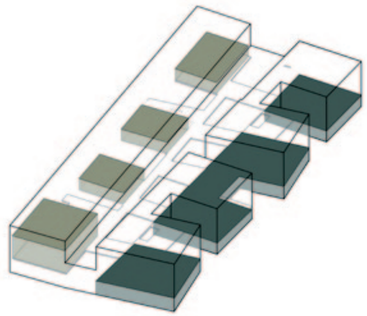
11 645 m²



learning facilities

auditorium
flexispace
workshop
studio support

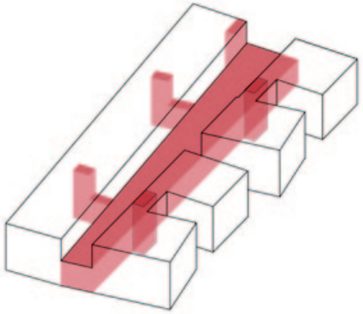
2035 m²



circulation space

circulation
study lounge
exhibition space

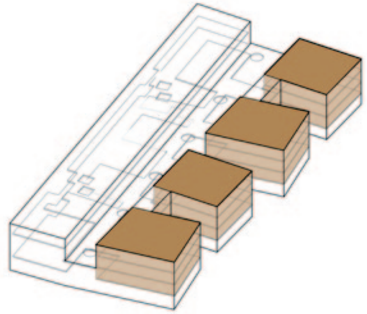
2770 m²



student facilities

group rooms
475 stud./year

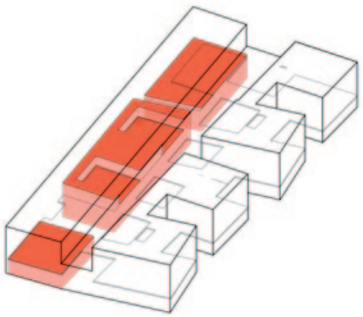
3610 m²



public functions

library
restaurant
flexispace

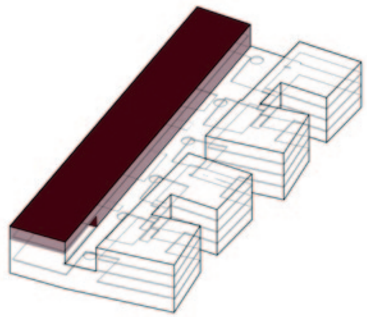
1405 m²



staff facilities

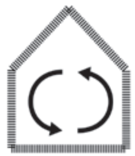
offices
meeting rooms
print & copy
common

1825 m²



2015 low energy standard

thermal mass



local & recyclable materials

healthy indoor climate

design process

input

initial thoughts
methodology

As the integrated design process, IDP, is the backbone of how the students work at the Architecture & Design Department, it will be used in our process of designing the Architecture school. This will help the process in integrating certain environmental strategies into the design.

The IDP is for the benefit of having a holistic view of the project where the technical challenges will be solved architecturally. In order to have an overview of what kind of steps are necessary and more or less the chronology in what challenges to tackle. It will therefore ease the communication between the group members and giving an understanding of the logical steps to take.

We are familiar with the general phases of the process (Problem/Idea-Analysis-Sketching-Synthesis-Presentation), and what each phase should include, based on Knudstrup M, Hansen H. The Integrated Design Process (IDP). [1]

It is important to make a conscious analysis before starting the design.

At the moment the necessary steps for the analysis are identified:

_Site Analysis

-Understanding the character of the site (genius loci)
-Functions in the area
-Sustainable possibilities of the area

concluding; the expression, character of the building

_Comfort Analysis

-thermal standards and guidelines for school environment

concluding; material choices, form and function allocation

_Analysis of Legislative Demands

-building codes and municipality documents

concluding; building form, material choice and space definition, based on energy goal

_Climate Analysis

for example;
>solar calculations of altitude and azimuth
>temperatures
>rainfall
>humidity
>wind roses

concluding; building form, environmental design strategies, material choice

These are the crucial pieces, apart from the program, that will effect the direction of this project. The reason why the program is not mentioned above is primarily because it is not in the category of measurable research, but rather something that we can form in our own liking. But of course under the frame of what is generally needed.

Important to mention is that the IDP will be the general philosophy in how we will approach design challenges, whether it is sustainable design or tectonic design.

initial thoughts
program & guidelines

The building program has been established primarily based on the building program [4] made by the Department of Architecture, Design & Media Technology for the new water front campus. As the purpose with our proposal is to accommodate the architectural-, urban design- and the industrial design-curriculum, the building program was modified, together with the support from our analysis.

With this building program, the possibility to define the space necessary to accommodate the different functions that synthesizes a functional architecture & design school is displayed. Through the analysis phase, the vision and character of the school was made, helping the overall conclusion of what space relations should be established.

Student facilities
(4 m^2/student --> 3600m^2) [4]
+
Seminar rooms (2): 400 m^2
Meeting rooms (5): 285 m^2
Archive & copy (1): 115 m^2

Total: 4400 m^2

Staff facilities
(Teacher --> 420 m^2)
(PhD --> 150 m^2)
(T&A --> 180 m^2)
+
Seminar room (1): 200 m^2
Meeting room (2): 115 m^2
Archive & copy (2): 230 m^2

Total: 1295 m^2

Labs/Workshop
(Model workshop (1): 315 m^2)
(Space/Form/Color (1): 105m^2)
(Product Design (1): 105 m^2)

Total: 525 m^2

Common Areas
(Library+Canteen/Cafe & facilities+Exhib. space+Study Lounge --> 800 m^2)
+
Auditorium (1): 400 m^2

Total: 1200 m^2

Total: 7420 m^2

FUNCTION	SIZE	QUANTATY	SIZE, TOTAL	ROOM HEIGHT	DAYLIGHT	CONNECTED TO
Entery/Lobby	-	1	-	-	***	-
Open Spcae	-	1	-	-	***	-
Studio/Group Room	-	6	ddd	4.5	****	-
Seminar Room	200	3	600	3	**	-
Kitchenette	-	6	-	-	**	x2 for studio/group room x1 for teaching staff x1 for T&A staff X1 LAB- Space/form/color x1 Auditorium/Study Lounge
Meeting Room	-	7	400	3	**	x5 for seminar/group room x1 for teaching staff x1 for T&A staff
Plotter & Scanner	-	2	-	-	*	x1 for stdudy lounge x1 studio/group-room or computer workshop
Copy/Printer & Archive	-	3	300	-	*	x1 for seminar or studio/group room x1 for teaching staff x1 for T&A staff
Computer Workshop	-	2	-	3	*	connecting to plotter & scanner
Model Workshop	?	1	?	6	*****	connection with office
Lab - Space/Form/ Color	350	1	350	6	****	connection with terrace northern orientation?
Lab - Product Des	350	1	350	6	****	-
Office - Teacher	12	35(35)	420	3	****	-
Office - PhD	18	8(15)	150	3	****	-
Office - T&A	22,5	8(15)	180	3	****	-
Auditorium	400	1	400	-	***	-
Cafe/Canteen	?	1	?	3	***	connection with kitchen
Study Areas/Lounge	-	1	-	3	****	-
Exhibition Space	-	1	-	3	*****	-
Library	_	1	_	-	***	-
Kitchen	?	1	?	-	**	x1 for Café/Canteen
Kitchen storage	?	1	?	-	*	x1 for Café/Canteen - kitchen
Operation facilities for kitchen staff	?	1	?	-	**	x1 for Café/Canteen - kitchen
Bathroom & Dressing	?	1	?	-	*	x1 for Café/Canteen - kitchen
General Toilets	?	?	?	-	*	-
		Total:	Total:			

Drawing Room_
- comprising 110 student jobs (18-22 groups)
- the possibility of division into 3 to 4 halls
- good daylight, good acoustics and climate conditions, flexible IT access

Seminar Rooms_
- various purposes, incl
  - seminar
  - critiques
  - hang things
  - examination
  - model work
  - IT-presentation
- Beginning of semester --> for lectures and courses
- End of semester --> space for project work, critique, exams, modeling etc.

Computer Workshops_
- Classroom with 28 computer stations
- 3D Scanner room
- Space for print; plot and 3d plot

Laboratory - Virtual Architecture and Design_
- 4 spaces, double height
- on ground floor
- artificial light
- related to join large multifunctional seminar
  - purpose of lab
    - video editing
    - VR presentation
    - Teaching lab
    - digital diatek
    - depot

Laboratory - Space, Form and Color_
- consisting of:
  - atelier (good daylight, north facing, exit to terrace)
  - Depot I.
  - Kichenette and changing
- purpose of:
  - photography of models
  - movies
  - life drawing
  - modeling

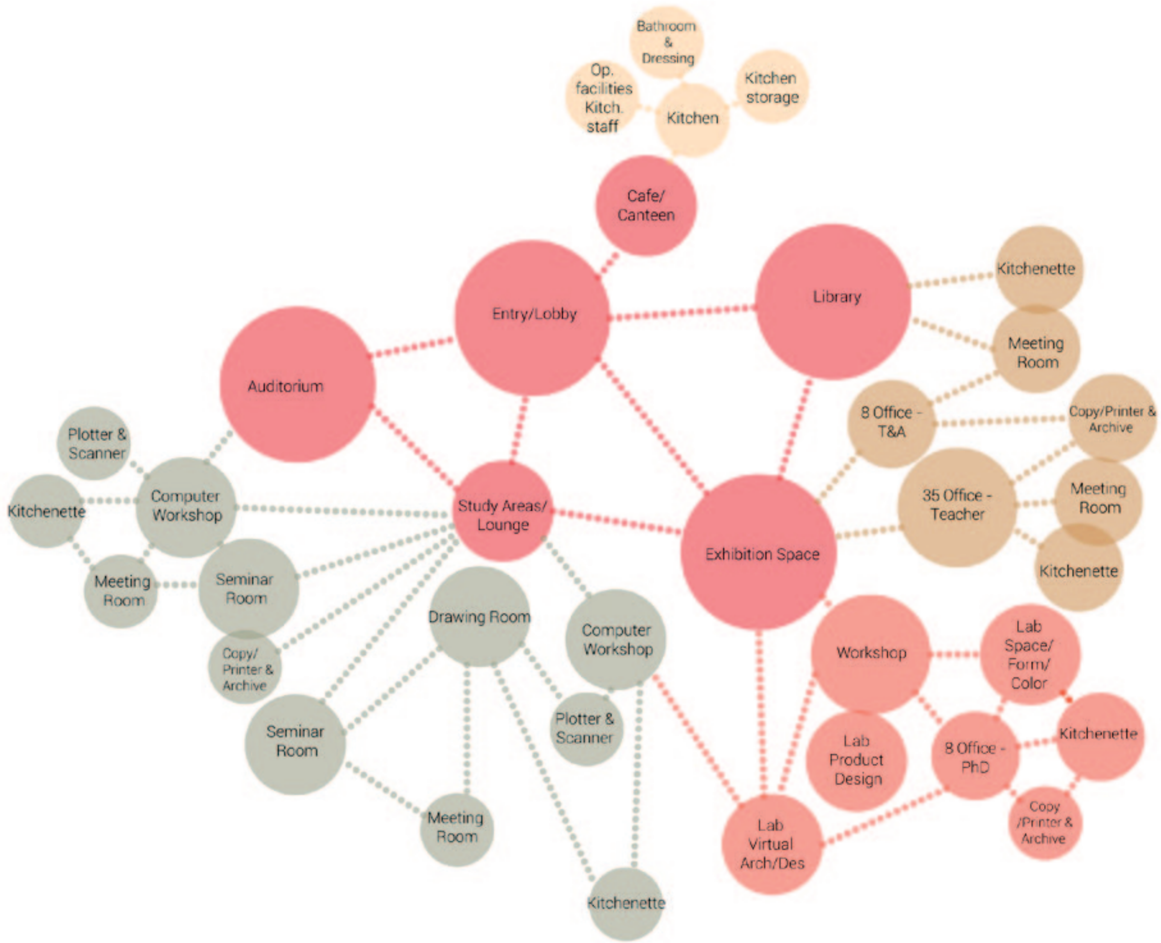
Laboratory - Product Design_
- double height space
- illuminated by daylight
- linked to model workshop
- consisting of:
  - 2 rooms for 3D scanning, 3D plot
  - 1 space for 3 D modeling workshop with CNC machines
  - 1 space for model & material collection

The Workshop_
- Model workshop:
  - Woodworkshop
  - Metalworkshop
  - Painting room
  - Plastic & pottery
  - an office
  - storage , 2 compartments

Office Space
- office areas include
  - Offices for permanent teachers.
  - Offices for PhD students.
  - Offices for external teachers.
  - Copying and printing.
  - Offices for externally funded researchers.
  - Office of Information Officer.
  - Learning Lab. (Space for teachers' information processing, including videoconference).
  - Seminar.
  - Meeting Room.
  - Copying and printing.
  - Kitchenette.
  - Offices for technical and administrative staff;
    - Department.
    - Secretariat. 2 compartments.
    - Studies / President.
    - Study Board Secretary.
    - Student Assistants. 2 compartments.
    - Students and office helpers.
    - IT staff.
    - Meeting Room.
    - Archive, depot, model room.
    - Copying and printing.
    - Kitchenette.

Common Areas
- Total approximate net area: 800 m^2
- Cafe / canteen.
- Study areas and student lounge.
- Exhibition halls.
- Joint Study.
- Operation facilities for kitchen staff.
- Bathroom with dressing.
- Kitchen.
- Kitchen storage, cold storage, waste.
- Library.
  - -A centrally located room that contains library classic, ie librarian and the relatively few physical materials standing on shelf or taken from other libraries.
  - -A small reading room / workspace for primary students.
  - - Information etc. can be done in building classrooms, cafe area, with other programs.
  - -The main source of information for all staff and students are Aubs e-resources.

Desired function relationship



site analysis
character

Karolinelund, Telegårdsplads and the plot next to the House of Music is in the progress of change and future of development. These three sites will accommodate the final stage of the green belt coming from the southern part of Aalborg city core, and will be categorized as a recreation area, a park and pathway accessible for the public.

We see high potential in placing the Architecture & Design School on the northern tip of Karolinelund. The site is very interesting, where the green landscape from the south melts with a hub of culture in the north. An area of transition, where the House of Music and Nordkraft create a "gate" where the old Aalborg in the west meets a new Aalborg in the east. Additionally, the critical junction of the park and the dense urban fabric can be bridged with the help of the proposal.

Fig 8.

1

2

3

4

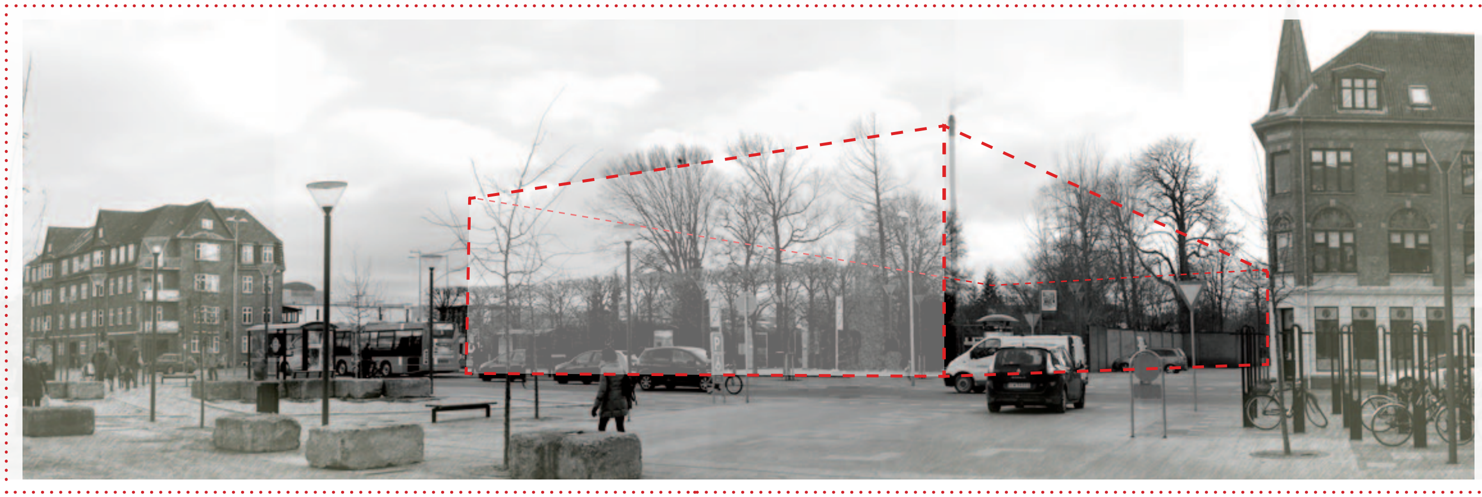
5

There lies complication to the site as its almost sacred for the reason of park status. But the difficulty of the site can also be a liberation, as the various limitations around, tightens and forces you towards a contextual architecture.
Moreover , combining such a function with the park can certanly enhance the cultural nature around this place without concentrating more on the harbourfront which seems to centralize this town at a high degree by now.

In the original building program [4] made by the Department of Architecture, Design & Media Technology of Aalborg University, it was requested for the building to express a welcoming design with a gradient, from public, to semi-public, to private spaces. In our opinion, we feel that the harbor is not the ideal place for this. The harbor has an attractive scenography, in which the public is given the chance to stroll along the harbor front, with visual facades along its path; the Limfjord to the north and the new built face of Aalborg to the south. With this site, the proposal can be integrated with the city, with the green path attracting the public, almost forcing them through the plot, and thereby interacting with it. The ambition is to take advantage of the circulation and the movement, caused by the green-belt, and allow the people to gradually fuse with the school and its gradient expression, in a non-intimidating setting.

_material mapping

In order to integrate a new building to the existing urban fabric its highly important to explore the built environment. Especially in this very vibrant constantly developing area a whole palette of different textures appear. By moving from the city center towards the harbour the city changes it's carachter towards a more industrial appearance.The old brick receeds into the blinding existence of the contemporary concrete.The old Tivol's area still has a lot of asphalt and concrete cover becasue of the old amusement attractions. Those should be revised in order to create a greener park for which the initiatives has already been taken by Aalborg municipality.
This material study helps us understand the environmental essence and the overall character of the site. It highlights the possible approach in addressing material choice based on the contextual texture palette.



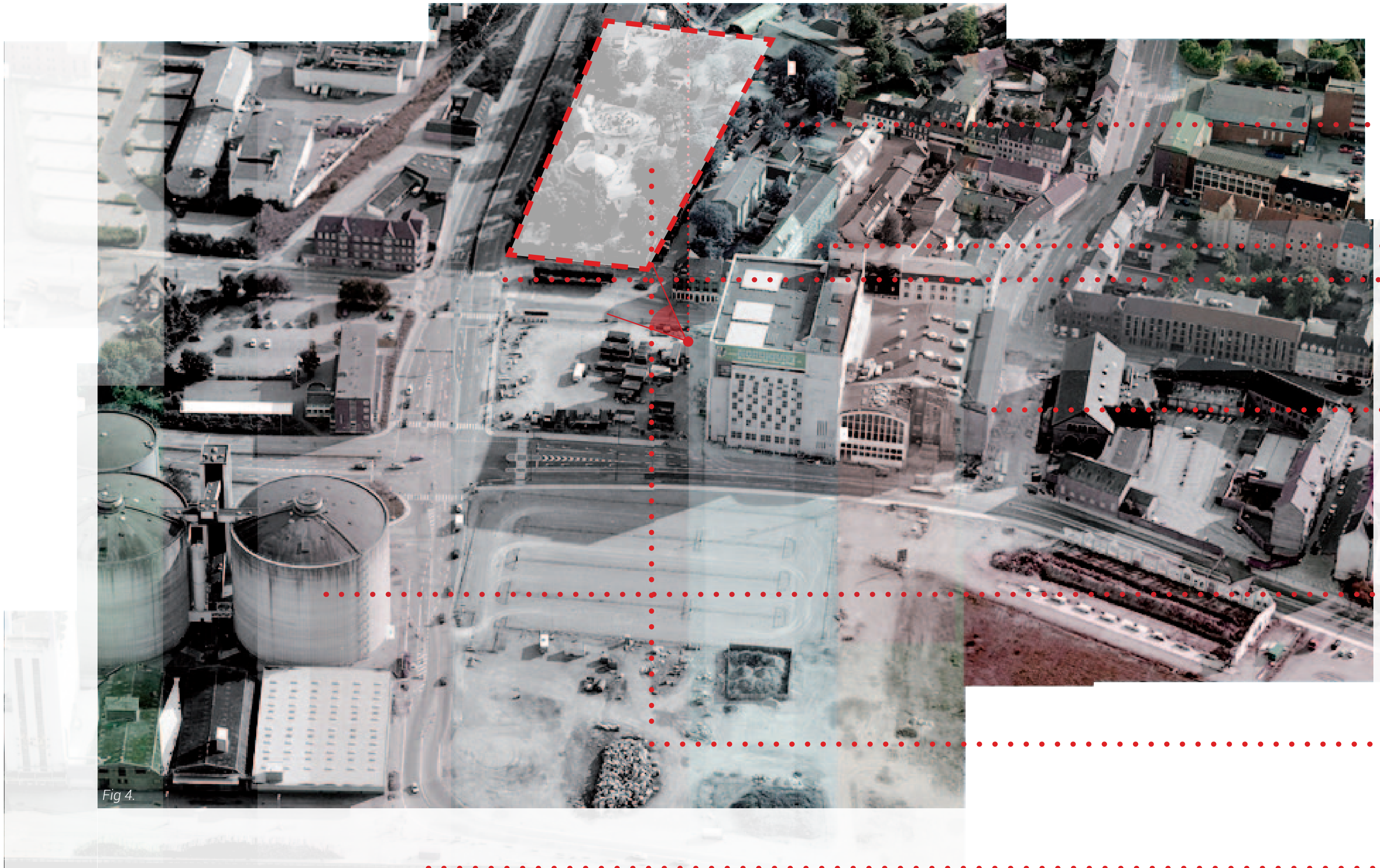


Fig 4.

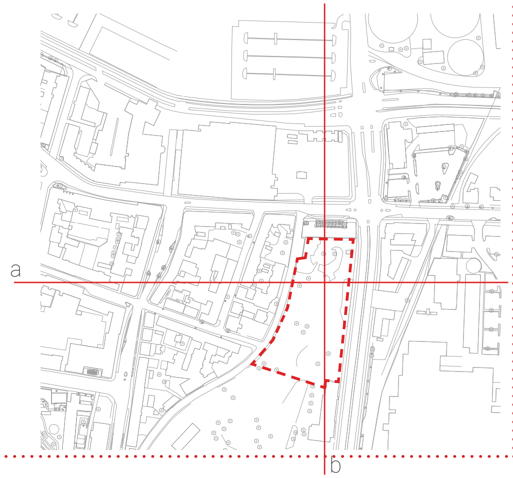

Fig 5.
Fig 6.
Fig 7.
Fig 8.
Fig 9.

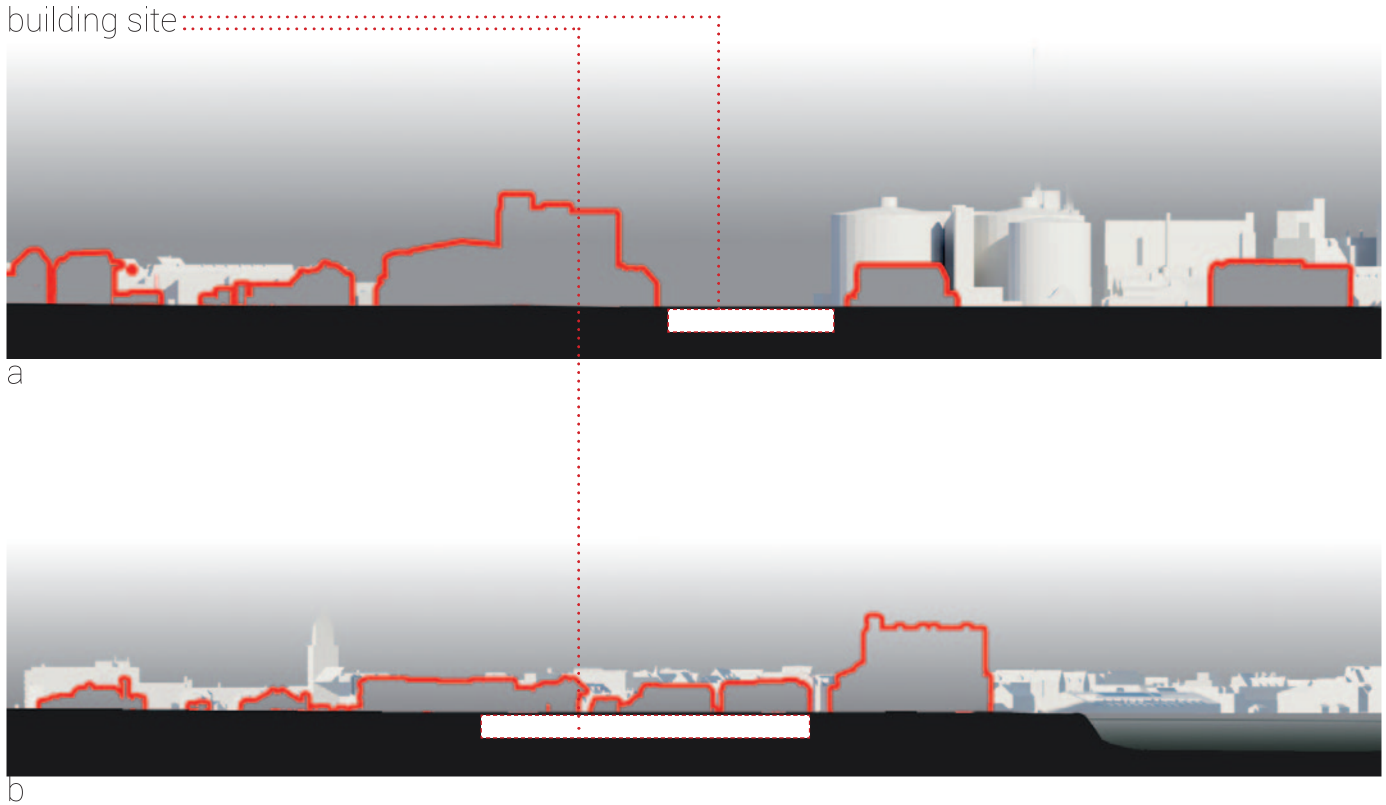
_topography profile

In the depiction of the character of the site, genius loci, two sections have been made in order to outline the topographic profile of the site.

In terms of measurable parameters, the height values of the surrounding buildings can be collected.

In terms of unmeasurable values, this analysis can aid in the form and proportion experimentation of the design.





Culture/Education & Student accommodation

This diagram displays buildings of interest in terms of culture & education and student accomodation.

Culture/Education

Student accommodation

Conclusion: These interest points can determine the access points and also the form of the building. Function disposition of program.

Movement & Circulation

This diagram displays the traffic pressure on the nearby roads and pedestrain paths that interact with the site.

Traffic pressure

Pedestrian movement

Conclusion: These circulation patterns can determine the access points and also the form of the building. Furthermore, the function disposition of program.

Present & Future Greenery/Recreaction

This diagram displays the current & the planned greenery and recreation areas.

Present Greenery/Recreation

Future Greenery/Recreation

Conclusion: These factors can determine appropriate environmental design strategies, landscaping, access points and form of the building. Also the function disposition of program

Residential, Commercial & Industrial zones

This diagram displays the zones that make the urban fabric around the site.

Residential

Commercial

Industrial

Conclusion: The information gives the character and vibrance of the area, determining the character in terms of sound, movement and thereby form/shape of the building. Also the function disposition of program.

<u>Center/Development Area/Development Direction</u>

This diagram displays the current city center, the main area of development and the direction of development.

City Center

Development Area

<u>Conclusion:</u> Showing the potential of the future area and confirming that Aalborg is developing eastwards. This justifies the location more, by recognizing the poetry of the old Aalborg rising towards the contemporary Aalborg by heading east through the A&D school. This can support the concept development and the building form.

site analysis
climatic

The ambition in how to project sustainability into our building lays in the choice of material, energy optimization through geometry and form. Meaning, reaching the 2015-energy standard, creating a healthy indoor environment, primarily through passive means, and expressing contextual architecture that do not isolate itself from nature, but embrace it.
This chapter addresses the sustainable possibilities of the site, the possibilities that are the initial factors that will help in reducing the energy requirements.

To raise an environmental awareness to the surrounding, the building needs to imply that it, in fact, takes advantage of its context in order to operate.
The discussion and conclusion within this segment of the report focus on the passive solutions that could be interesting in the further design development.

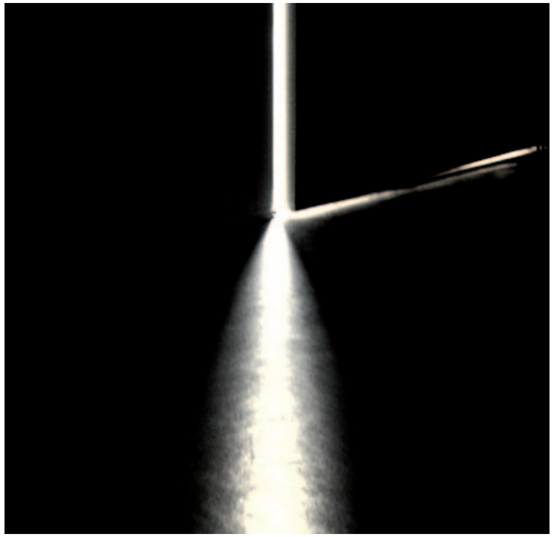


Fig 10. The shadow casting by the surrounding neighborhood with site specific sun altitude. (solar noon time for 2-spring equinox, 1-summer - and 3-winter solstice)

_ Sun-relation to the site;

Overall the site is well exposed of direct sunlight. Neighboring buildings are distributed with generous distances from the plot. The only building that marks it self out from an shading point of view, Nordkraft, is located north west of the plot. Meaning that it only casts shadow during late afternoon during summer time. The building, like most buildings in northern countries, needs to welcome the sun into the space during wintertime and shade it during summer time. This already indicates the strong design parameters affecting the form and window disposition of the building. In detail, it sets frame for possible construction methods such as double skin facades, direct solar gain heat spaces etc.

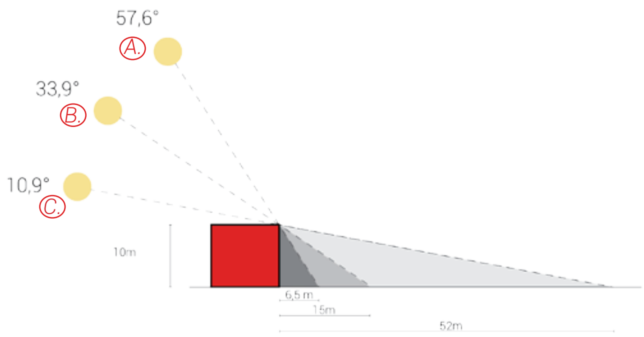


Fig 11. The shadow casting by a 10m high volume with site specific sun altitude. (solar noon time for B-spring equinox, A-summer - and C-winter solstice)

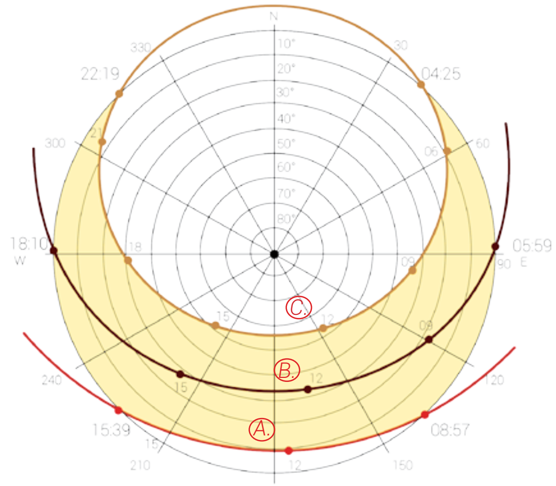


Fig 12. Sun-path diagram displaying the sun position during the day throughout the year (highlighting the spring equinox, summer - and winter solstice)

_ Wind-relation to the site;

The openness of the site gives way for wind exposure. And by the readings of the wind rose, the primary wind direction in Aalborg is southwestern and southeastern. The map of the site and Karolinelund shows no significant wind protection. This should be used in favor of natural ventilation. Concluding that it has significance when addressing the design in terms of overall shape of the building, possible air inputs, vertical volumes together with construction strategies as double-skin facades, etc.

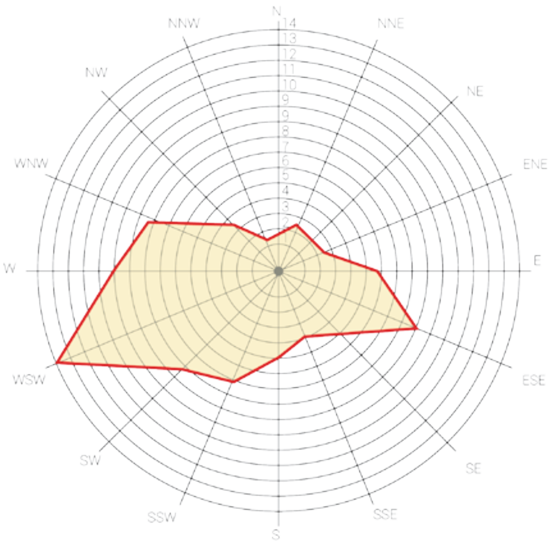


Fig 13. Wind-rose indicating the anual proportion of wind-direction

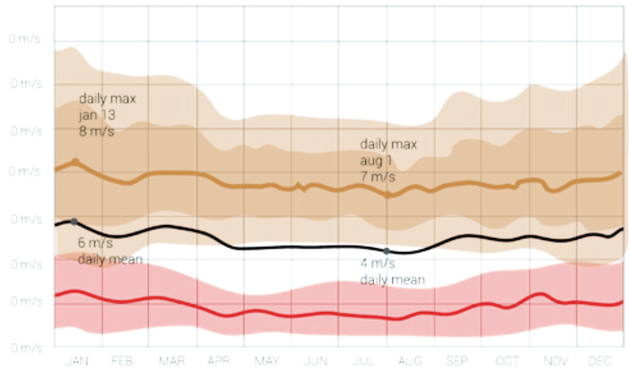


Fig 14. 'The average daily minimum (red), maximum (brown), and average (black) wind speed with percentile bands (inner band from 25th to 75th percentile, outer band from 10th to 90th percentile).' [5]

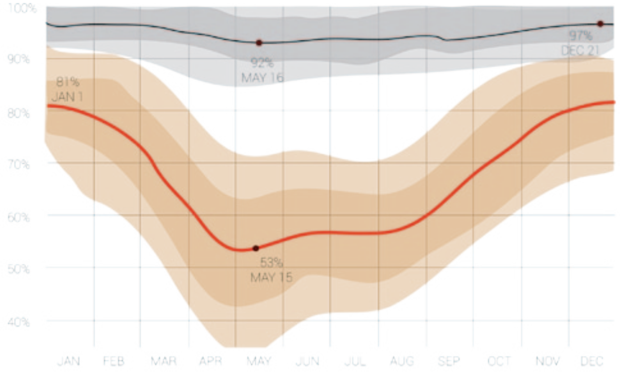


Fig 15. 'The average daily high (black) and low (red) relative humidity with percentile bands (inner bands from 25th to 75th percentile, outer bands from 10th to 90th percentile)'. [5]

_ Temperature and Humidity;

Investigating temperatures and humidity levels help setting limitations in what material and construction choices should be made in order to maintain good indoor climate and energy consumption.
Overall this data becomes more relevant further into the development of the project, when building method is evaluated, element connections, certain U-values or infiltration properties in the building composites are selected.

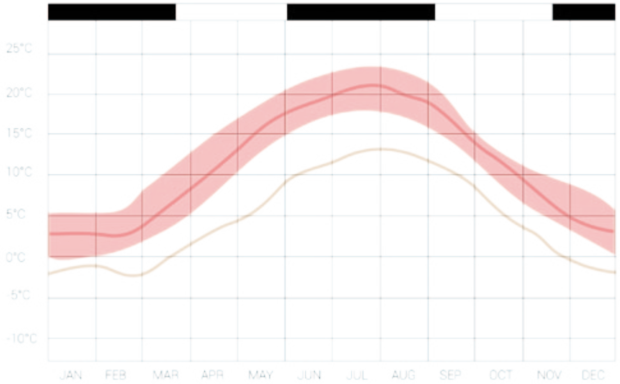


Fig 16. 'The daily average low (blue) and high (red) temperature with percentile bands (inner band from 25th to 75th percentile, outer band from 10th to 90th percentile)'. [5]

building performance
requirement & guidelines

The indoor climate is one, if not the main factor, in which the occupants of the building rely on, in order to fulfill the functions within the envelope.
The indoor climate consist of thermal environment, air quality, acoustic indoor climate and light conditions [10].

BR10, the Danish Building Regulations of 2010, states in chapter 6 - Indoor Climate that;
"Buildings must be constructed such that, under their intended operational conditions, a healthy, safe and comfortable indoor climate can be maintained in rooms occupied by any number of people for an extended period."

_Thermal Environment

Regarding the occupants thermal comfort is based on subjective (personal) and objective (environmental) factors. The subjective factors can be determined by the individuals metabolism, clothing and activity. While the objective factors are determined by the indoor environment of the building; air temperature, radiant temperature, relative humidity and air quality.
When designing an enclosed space, all of the objective factors get addressed by the choice of material, form and orientation of the building, the use of passive and active environmental design strategies etc.

This chapter defines the thermal conditions in which the occupants should be exposed to, according to regulations.

(6.2(1)) Thermal indoor climate is determined by the temperature of the air and surfaces, the air velocity and turbulence intensity and, to a lesser extent, by the humidity of the air; and the level of thermal comfort can be determined in the context of the human activity and clothing. For functional requirements and methods of specification, verification and monitoring of the thermal indoor climate, see DS 474, Code for thermal indoor climate. [10]

Conclusion:
With thermal environment as a parameter, one can be directed in the choice of material and the form finding of the interior space and exterior of the building.

_ Air Quality

Air quality defines whether the levels of pollution and other emissions in the air that effect the occupants, are acceptable from a health- and comfort-point of view. The quality of air can be regulated and modified with air flow, meaning how often the air, of the space, is replaced and thereby purified for the users.
This is directly connected to the ventilation system of the building, regardless if it is mechanical-, natural- or a hybrid-system.
From an energy perspective, it is more interesting to implement natural ventilation, as it does not require a mechanical device to circulate the air. But already, one can make the assumption, that a building solely dependent on natural ventilation, in a danish context, is quite unlikely.
To use natural ventilation during winter time require a lot of energy. As there is an underlying interest in keeping the energy consumption to a minimum, the likelihood of the use of a hybrid system would probably be the greatest.

6.3.1.3(2) Teaching rooms in schools etc. must be ventilated by ventilation installations comprising both forced air supply and exhaust and heat recovery.
Fresh air supply to and extraction from normal teaching rooms must be no less than 5 l/s/person plus 0.35 l/s/m2 floor area. At the same time, the CO2 content in the indoor air must not exceed 0.1% for extended periods.
If a ventilation system with demand-controlled ventilation is used, the specified air volumes may be deviated from when there is reduced demand. The ventilation during the hours of use may, however, not be less than 0.35 l/s per m2 floor area.
Where special constructional allowances are in place, for example greater room volumes per person, the use of several extraction options, including cross-ventilation options, the requirement for mechanical ventilation may be waived provided that a comfortable, healthy indoor climate is maintained. [10]

Apart from having a good circulation of air, the choice of materials in the building is essential.
Conclusion:
With the parameter of air quality, thus air movement, one can narrow down the form finding that enhance natural circulation of air and the choice of the material with little or non-polluting emissions.

_ Acoustic Indoor Climate

Sound pollution is another aspect that effect the wellbeing of an occupant.
BR10 states, in chapter 6.4, that; "*Buildings must be planned, designed, built and fitted out so as to ensure satisfactory sound conditions for the users.*"
In our case, it is worth recognize that there is semi-heavy traffic next to the plot which emite sound pollution. But taking into account that within the envelope of the building, there will be open spaces, multiple functions (such as workshop machinery), movement generated by a generous proportion of occupants, the main challenge is to control the amount of 'noise' within the building.
'Noise', in this case, is measured with dB, is regulated according to the following guidelines:

In teaching rooms from room floors and slabs in teaching rooms for woodwork or for singing and music ≤ 53 dB
Noise level
In teaching rooms from building services ≤ 30 dB
In teaching rooms from traffic ≤ 33 dB
(6.4.3(3)) Educational buildings
The functional requirement for educational buildings is deemed to be met if they are built in compliance with the following values:
Reverberation time, T
Classrooms ≤ 0.6 s
Teaching rooms for woodwork ≤ 0.6 s
Teaching rooms for singing and music smaller than 250 m3 (choral and acoustic music) ≤ 1.1 s
Teaching rooms for singing and music smaller than 250 m3 (electrically amplified) ≤ 0.6 s
Gymnasia smaller than 3500 m3 ≤ 1.6 s Gymnasia larger than 3500 m3 ≤ 1.8 s
Indoor swimming pools smaller than 1500 m3 ≤ 2.0 s
Indoor swimming pools larger than 1500 m3 ≤ 2.3 s
Common space and shared corridors used for group work etc. ≤ 0.4 s
Shared corridors not used for group work etc. ≤ 0.9 s
Stairwells ≤ 1.3 s Absorption area, A
Open plan teaching areas ≥ 1.3 x room floor area
Common space with a ceiling height greater than 4 m and a room volume greater than 300 m3 ≥ 1.2 x room floor area

Educational buildings
The functional requirement for educational buildings is deemed to be met if they are built in compliance with the following values:
Airborne sound insulation, R'w
Between teaching rooms and between teaching rooms and common space, horizontally ≥ 48 dB
Between teaching rooms and between teaching rooms and common space, vertically ≥ 51 dB
Between teaching rooms with connecting doors (total sound insulation of wall with a door, folding and mobile walls, glazed pan- els etc.) ≥ 44 dB
Between teaching rooms and common space with connecting doors (total sound insulation of wall with a door, folding and mobile walls, glazed panels etc.) ≥ 36 dB
For flexible partitions in open plan teaching areas ≥ 20 dB
Between teaching rooms for woodwork and other teaching rooms or common space ≥ 60 dB
Between teaching rooms for woodwork and common space with connecting doors (total sound insulation of wall with a door, folding and mobile walls, glazed panels etc.) ≥ 44 dB
Between teaching rooms for singing and mu- sic and between teaching rooms for singing and music and other teaching rooms or common space ≥ 65 dB
Impact sound level, L'n,w
In teaching rooms ≤ 55 dB *[10]*

Conclusion:
With the parameter of sound, one can narrow down the choice of material, function allocation, volume and shape of interior space.

_ Light Conditions

"*Workrooms, occupiable rooms, habitable rooms and shared access routes must have satisfactory lighting without causing unnecessary heat loads.*" is the general introduction of chapter 6.5 in [10].
One of the absolute initial parts of departure in the first design and form experimentation of a building, is daylight. It is a intuitive instinct in shapeshifting a concept in order to achieve the right lighting conditions. The light possess atmospheric qualities that is used to direct people, attract them to certain parts of the building during certain periods of the day. It stimulates movement but mainly it locates function. It determines where the living room, the kitchen, the bedroom etc, is placed and indicates where one would read a book.
With the guidelines of BR10 [5] the importance of creating a workplace which is well lit, wether artificial or natural, is stated, together with the importance of avoiding unnecessary heat loads.

Offices, Schools, Instutions and others
General lighting over 50 lm/W and for effect lighting and working lamps over 15 lm/W. *[10]*

Conclusion:
With this in mind, one can approach the form finding of the building with the parameter of light, where it is more important to provide natural daylight, how one can avoid big heat gain with certain displacement of windows etc, which not only effects the indoor climate but also the energy consumption.

_ Other Key - Numbers

Total energy consumption
7.2.4.2(1) Offices, schools, institutions and other buildings not covered by 7.2.4.1 may be classified as class 2015 low energy buildings when the requirement for supplied energy for heating, ventilation, cooling, domestic hot water and lighting per m2 heated floor area does not exceed 41 kWh/m2/year plus 1100 kWh/year divided by the heated floor area.
[10]

Insulation

U-Values (W/m2.K)	*Walls*	*Windows*	*Floor*	*Roof*
All climate zones	*0.3*	*1.8*	*0.2*	*0.2*

Airtightness
1.5 l/(s.m2) at 50 Pa

HVAC
Ventilations installations must incorporate heat recovery with a dry temperature efficiency of no less than 70%, with a COP of 3.6 in heating mode.
Heating and cooling systems must have time and teperature controls

Hot water
Domestic water systems supplied by a domestic ventilation heat pump must have a minimum COP (coefficient of performance) at the draw off point of 3.1

Skylights
Energy gains through rooflights must not be less than - 17kWh/m2/year (2015)

Windows
The energy gain through windows and glazed outer walls must not be less than - 33kWh/m2.year

Renewable energy
Solar heating systems must be provided when the expected daily hot water consumption exceeds 2000l and able to meet 95% of demand
[11]

Case Study

architecture schools
future education

These case studies will elaborate on two contemporary schools which are both specialized on educating architecture.
Both schools are shaped in a very modern way for up-to date needs. They are both from nordic regions -Norway, Sweden- which makes them more interesting in relation to this project, since nordic architecture and education culture has the same roots as Denmark. The two examples show two different approaches in programatic distribution.

Fig 17

Oslo school of Architecture
Jarmund/Vigsnaes Arkitekter

„Parts of the complex are torn down to bring light into the deeper parts of the building, structures are sandblasted to expose the consistency of the concrete, and the new building parts and walls are made transparent to secure an aimed social transparency of the institution."[6]

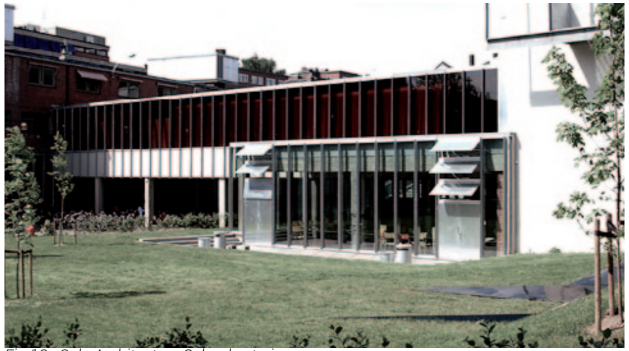


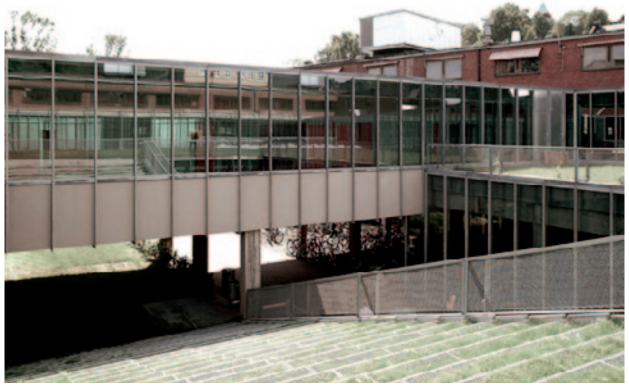
Fig 18.: Oslo Architecture School exterior

Oslo school of architecture was formed in 2001 in the base of an old industrial building (built in 1938) aiming the direction of revitalization of this area alongside the Akerselva river. The new school design respects the traditional look of the old building by commiting very radical changes in order to fulfill the needs of a completely different fuction. The first slab of the old building was cut out under the refurbishment process in order to lead more natural light to the ground level which holds the auditorium, workshops, library, exhibition places. All the desing studios and the classroms are located on the first floor together with a new construction of the bridge which spans over the entrance „promenade" hereby finishing the circulation loop which was started by the functional re-organization of the old edifice's U shape. [7]

Fig. 19.: Oslo Architecture School cafeteria

The building is very extroverted towards the inner courtyard, allowing social visual interaction even when students do not meet with each other in. The ground floor is very opened and generous in terms of space, hence comfortably providing possibilities for unequivocal movements. The ground floor also inhabits a cafeteria which faces towards the park. The green roof on the first floor is fully accessable and flows down to the park tieing together the building with the surroundings creating an architectural whole. All the administration offices and staff facilites are integrated in the second floor.[7]

Fig. 20.: Oslo Architecture School inner courtyard



„The addition aims to keep the workshop character of the existing building. The concrete structure was exposed and many materials were left unfinished."[6]

socialinteraction
transparency
material
circulation
interaction
hierarchy
workplace
intimicy
furnishing
layout
noise

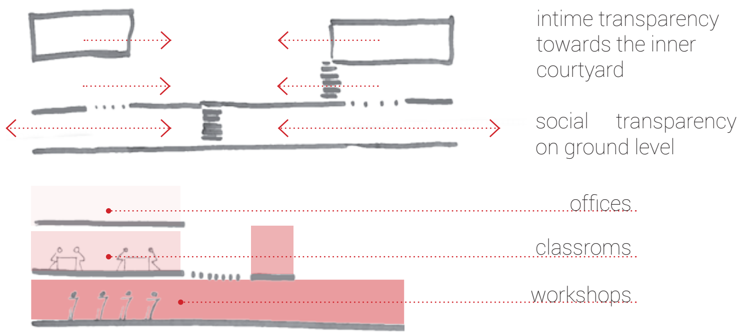



Fig. 21.: Oslo Architecture School ground floor


Fig. 22: Oslo Architecture School 1st floor


Fig. 23: Oslo Architecture School 2nd floor

Conclusion:

The most interesting part is to recognize how the original building was sculpted for architecture like a solid stone which only needs to remove the needless parts. There is an obvious hierarchy of spaces can be realized in terms of noise levels and the usage of the spaces. The ground floor has a more working, moving, energetic carachter. All the primarily communal functions are placed here. On the second floor there is even two more divisions in terms of privacy. The gangways tend to continue the spatial and functional nature of the ground floor as a corridor being a very important element of a school as a facility. From here there are several little bridges lead to the classrooms which are the space of creative design processes and another sort of mental status deserving more silence. It is a naturally balanced combination of intimicy -where student have they own little place of refuge and possibility to be alone with their ideas- , and the constructive work when they elaborate on building something. The building itself is an exhibition of „architecture" itself as a profession. Every element is loaded with the will of educating students for visual culture such as an academic lecture. Hence it is very important that an environment of learning is actually encapsulates the essence of this profession and serve as an inspiration nevertheless. The school has many niches and meeting places and a very welcoming public feeling on the ground floor.


Fig. 24.: OAS classroom


Fig. 25.: OAS workshop room


Fig. 26.: OAS classroom on 1st floor

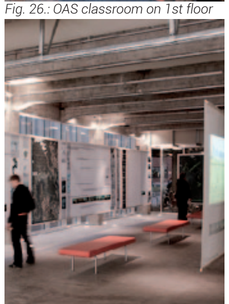


Fig. 27.: OAS exhibition room

Umeå School of Architecture
Henning Larsen Architects

„As a growth centre for future architecture, the main function of the building is to provide the framework for inspiration and innovation." [8]

Fig. 28.

We chose the Umea School of Architecture as a second case study for our project becasue it is a completely opposite approach of a contemporary design school project than the one on Oslo. This building is not a refurbishment, it is deliberately placed on the side of Umealven as an exhibition element being one item with the Museum of Fine Arts.
The building itself has a very simple cubic form and a casual larch facade which is
pierced through by a number of variations of square windows. The openness of the building supports the student's interaction and the exchange of the ideas. The interior consitst of stair systems and split floor levels where white boxes filtering the incoming sun rays. The strict rational division of the columns helps to devide the drawing rooms from each other. The drawing rooms are placed around the facades, on the perimeter where students have the maximum amount of daylight and the astonishing view of the river.[8]

As Louis Becker presented on the lecture which he held in the University of Aalborg, this school was created with several sustainable designing methods taken into consideration. Henning Laarsen Architects placed the windows according the sunlight focusing on the arrangement and the sizes of the windows. 30% of the whole facade area is transparent. Also since the whole building is one huge space the thermal mass of the enveloping structure effects positively in terms of indoor climate what is shown on the diagrams.[9]

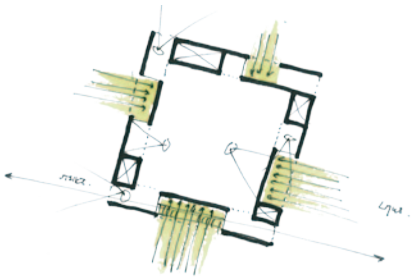


Fig. 29.: sketch

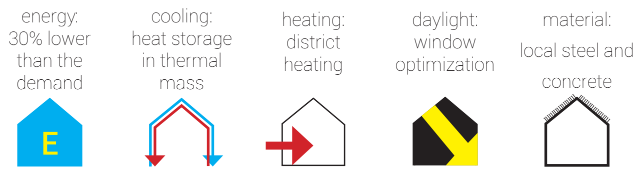


Fig. 30.: design strategies

Fig. 31.

Fig. 32.

Conclusion:

Umea school of architecture is a totally opposite, revolutionary approach to an education of an architect. It focuses on student interaction more than it is maybe necessary. There are many phases of a design process and they do not need the same environment always. Privacy should be a factor that is being highly unconsidered within this building. Since not everyone has a same pace of life and work, endurance of concentration (we have our own boilogycal clock inside us) it seems impossible that those students would not disturb each other. Amalgamation is necessary at a certain point and at a certain time but there is no such division here in terms of the functions of spaces like in the case of Oslo School of Architecture, there are no buffer zones, only conceptual ideas for creating a learning environment that is based on mainly student interaction and exchanging of ideas. It is important to note that the focus on sustainability, what is mixed with a very nordic style, defines this building's character. The facade is devided into 3 strips and the opening's density on the facades depend on which strip they belong to.

design process

output

discovering the building
contextually

When building in a public park one must admit that the land taken away for the footprint can not be given back in its identical quality. Therefore the interest in finding an alternative contribution rises...

Fig. 33.

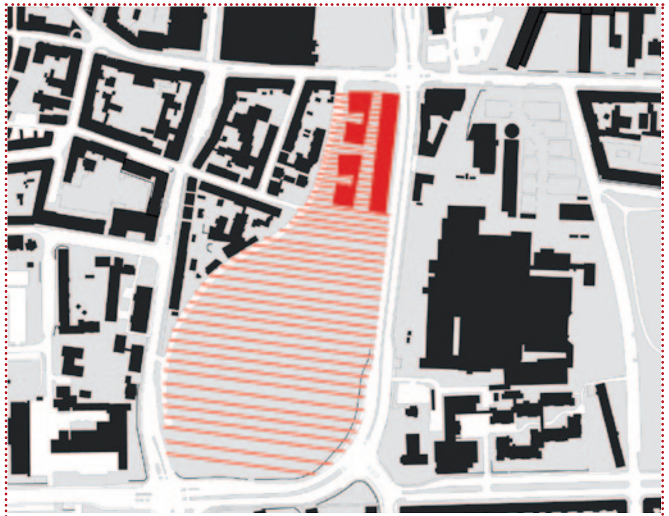
_From the Outside [Contextual]
To find the building, the site needs to be discovered and also deciphered.
The following steps present the main contextual features that was acknowledged through the design process.

The east side of the park is tangent to a main traffic route, meaning traffic noise.
The idea of a sound barrier could enhance the quality of the park.

Locate the main access points of the park.
The access points indicate where the primary movement comes from and ends up. This can hint the main movement patterns in the park

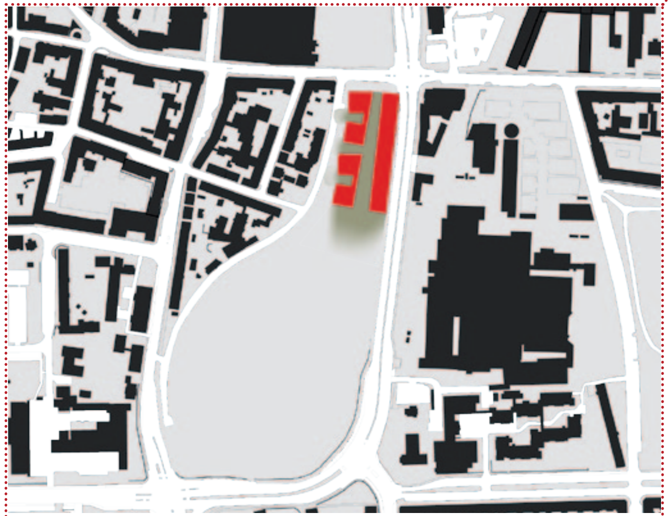
The full volume, set on 4 floors

Breaking the formality & introducing playfulness to the creative realm of the group room.



Open up the main passage towards the park, magnifying the densification in the north

Spliting up the volume to let the main movement through



The openings lead the park in between the volumes

_Conclusion

To cultivate a healthy relationship between the building and the site, there needs to be a dialogue.

In the design process the building opened up towards the site, keeping in mind the journey of the occupier and non occupier. Looking from the outside perspective (contextual), the building should be divided and let the context grow into it as much as possible. But with a limit, not compromising the relationship between the interior functions. Therefore the inside needs to grow together with the outside...

discovering the building
conceptually

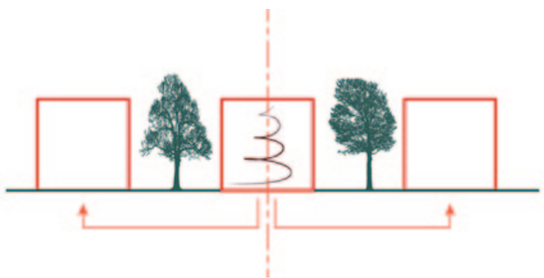
_From the Inside [Conceptual]
Together with the response from the site, the building grows from the inside out. As stated in the design goals, a place of interaction among students and staff is desirable. Meaning that before the user arrives to his destination, the journey should pass through a meeting space or amalgamation point.
One important aspect to consider is that on one hand the aim is to unify the department from its present disjointed character. On the other hand, creating one volume isolated from its context should be avoided.
This contradiction needs to be interpret in a way that make sense from both perspectives.
How to create an split up/unified department?

Two building bodies
- No clear meeting point, nor hierarchy
- No reason to enter one volume to reach the other
+ Integrated to site

One building body
- Strong seperation from the the site
+ Unified department

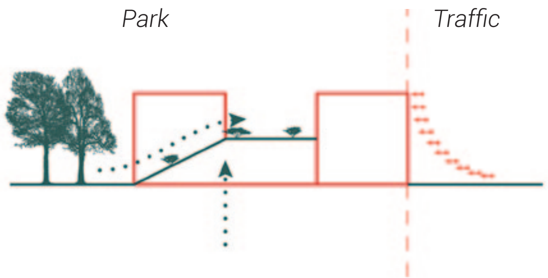
Four+ building bodies
- Un-predictable movement patterns by the users, therby hard to establish one meeting point
- Disjointed department
+ Integrated to site

Three building bodies
+ Accommodate central meeting point, allowing for amalgamation
+ Integrated to site
+ Possibility for public interaction



One central building, the main meeting point, distributing movement to the student group rooms and the staff offices.

Physically connecting the three building bodies, enhancing the unification.



Creating barrier towards the noise and the traffic and open up towards the park.

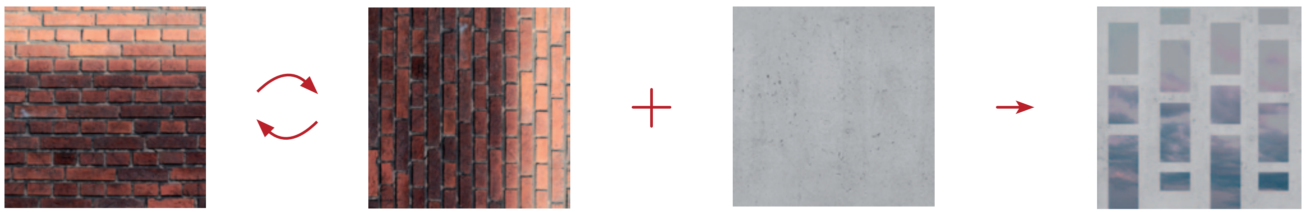
_Conclusion
Three building bodies work well for the intension of keeping the department together, with a meeting hub, and further, the creation of a gradient between public and private

_The Cube

The cube is a powerful archetype for an architect. It is a pure representation of space.

The genesis of the cube was first and foremost a response to the site, by opening up the west facade, breaking the formality & introducing playfulness to the creative realm of the group rooms.
The cube can also be seen as an abstraction of what once was, refering to the harsh industrial harbour, østrehavn, with its concrete covered silos. In a way one might compare the seed that once was within these sturctures, the grain for future development, now in the form of an educational facility with creative minds prospecting towards a knowledge based future.

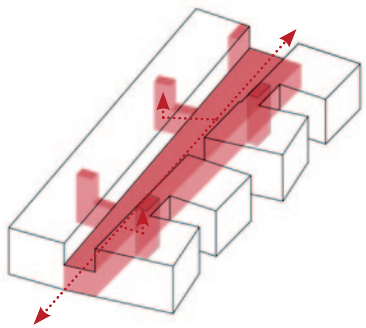
The facade composition can draw reference to the sequence of the brick wall, with the mortar separating the windows in a vertical axis.
The abstraction of the brick meeting the concrete marks the point of transition from the old brick town towards the contemporary concrete structures.



We believe that in order to add quality to the learning experience, a distinction should be made between the place of input (information, theory, inspiration, amalgamation) and the place of output (practical execution, idea experimentation, idea materialization).
The character of these places, we believe, should have different spatial qualities or atmospheres, in order to benefit their function.
The studio, the group room, is a place of refuge, an controlled environment, familiar, micro social climate, a safe place where the comfort allows you to fully focus on ideas.

_Interaction Hub

Not only physically, but also conceptually, a central part of the project, the amalgamation corridor is the spine that connects all the functions within the building. This is where people, occupants as well as non-occupants, meet, share ideas and get inspired for their prospective agendas.
The initial vision of this interaction hub derived from the aim to unify the architecture & design department, from its current disjointed situation. A situation that cause isolation that prohibits discussions, insight and constructive interaction between disciplines and class year within the department.
So by unifying the department in combination with the park, thus the public, the outcome shaped itself to a movement, either through the building, or in between the functions. This is the interaction hub.



building construction
materials & construction principal

In the junction between conceptual materiality choice and performance based materiality choice, the construction principal is defined.
In this case, conceptual materiality refer to what material is appropriate to the expression of the building and local character of the site. Performance based materiality aims toward environmentally friendly building, in the realm of energy consumption and healthy indoor climate.

_Materials
This concluded to a raw, clean and natural material expression in the project;

Character
- Raw as in empty and cold space to be absorbed by the user

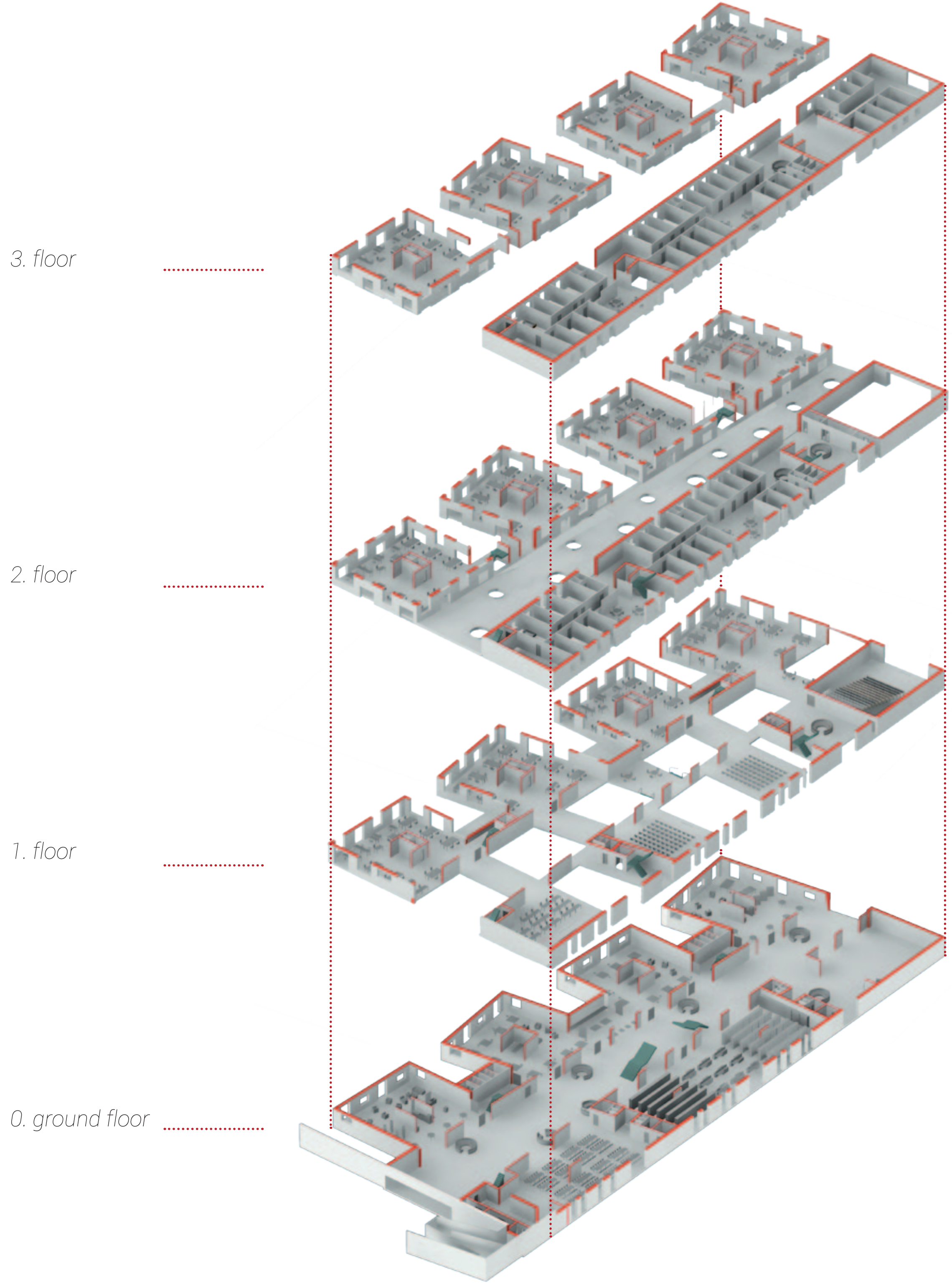
As students occupy their workspace, and personalize it with their own visions, inspirations, the space is there as an empty canvas, not interfering with the creative input and ready to be colorized by the occupants.

Indoor climate
- Clean & healthy, meaning materials that are as natural as possible, minimizing plastics and other air polluting materials

Energy Consumption
- Using local & recyclable materials to minimize the carbon footprint.

_Construction Principal

The system consist out of re-inforced concrete walls holding the concrete slabs in a conventional manner.
The diagram illustrates the location of these walls, indicated with red, and gives an approximate understanding of the span in which the slabs are stressed with.



building construction
details

The construction composites are based on concrete sandwich systems. In order to maintain consistency in the expression throughout the building, plaster walls and other surface finishes was avoided as much as possible. Installations, primarily ventilation pipes, were left exposed, occasionally covered by hanging acoustic panels where necessary.
The insulation consist of stone wool panels.
The external concrete finish is sprayed on top of the insulation,onto a reinforced steel net, creating a continuos render. This masks the floor division, enhancing a monolithic expression.

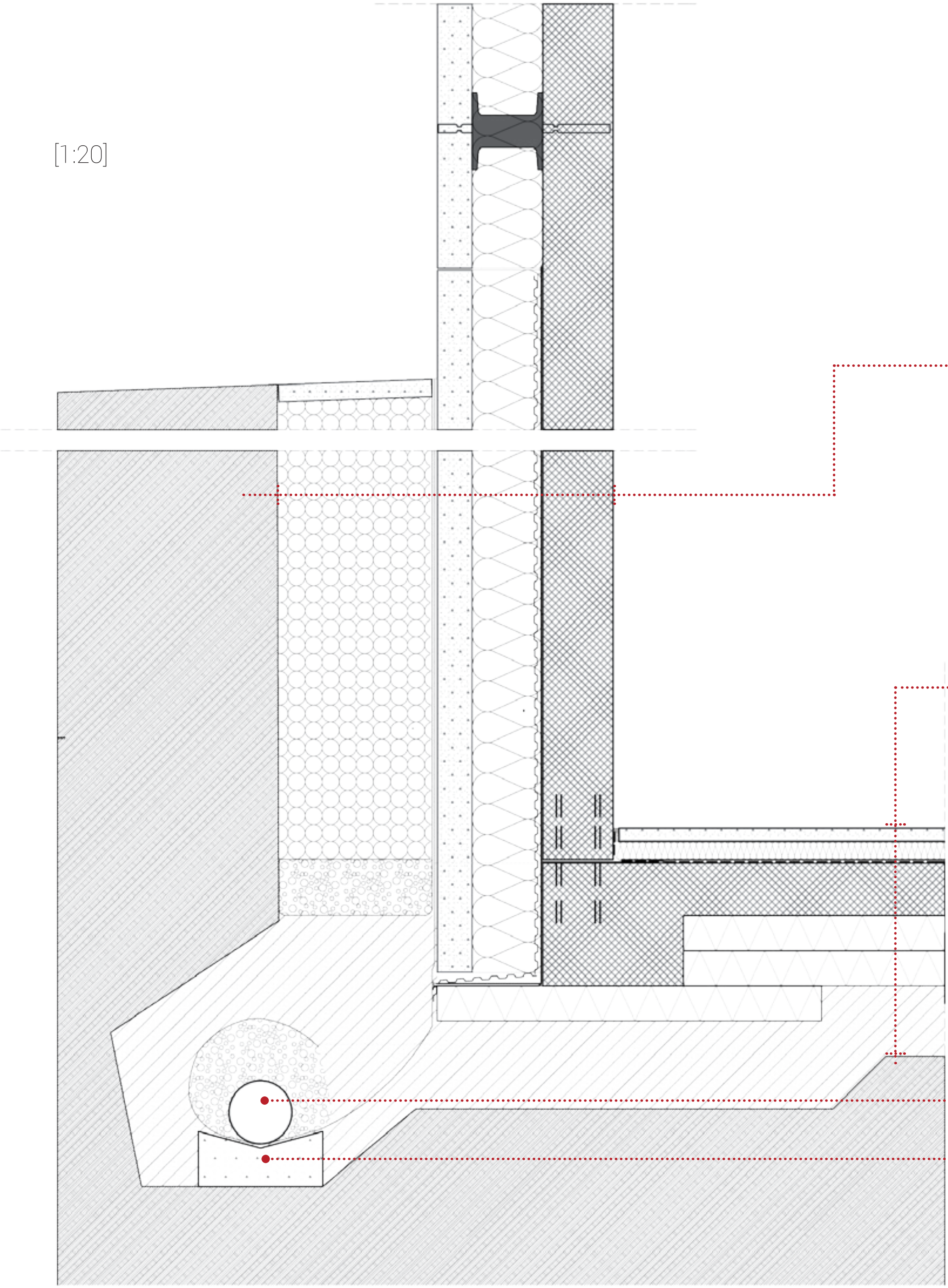
The average u-value for:

external walls	=	0.17 $W/m^2 K$
slabs	=	0.18 $W/m^2 K$
openings	=	1.2 $W/m^2 K$


D3
D4
D2
D5
D1

[1:20]

_D1



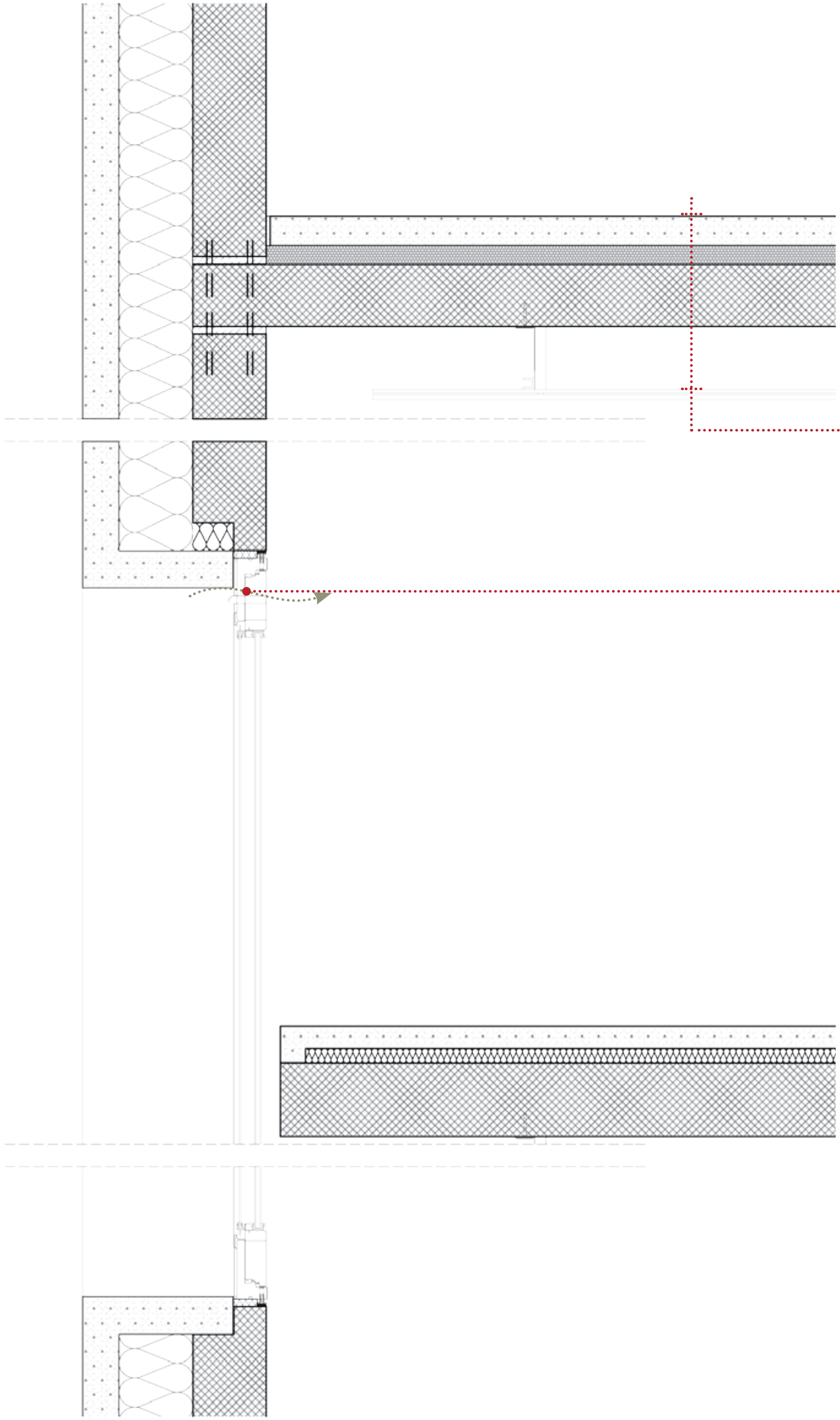
200 mm	re-inforced concrete (load bearing structure)
1	polyethylene drain membrane
200 mm	Rocwool Hardrock Element Batts
100 mm	surface treated concrete facade
1	getextile
450 mm	washed macadam
1	geotextile

40 mm	polished lightweight concrete floor
1	layer of plastic insulation
50 mm	Rockwool flexi insulation
1,5 mm	Sarnafil PVC waterproof membrance
350/150 mm	Reinforced concrete slab
2x100 mm	XPS insulation board
200mm	un-washed macadam
1	geotextile

ACO perforated plastic DRAIN 18 cm diameter

sub-concrete gutter with slope

_D2

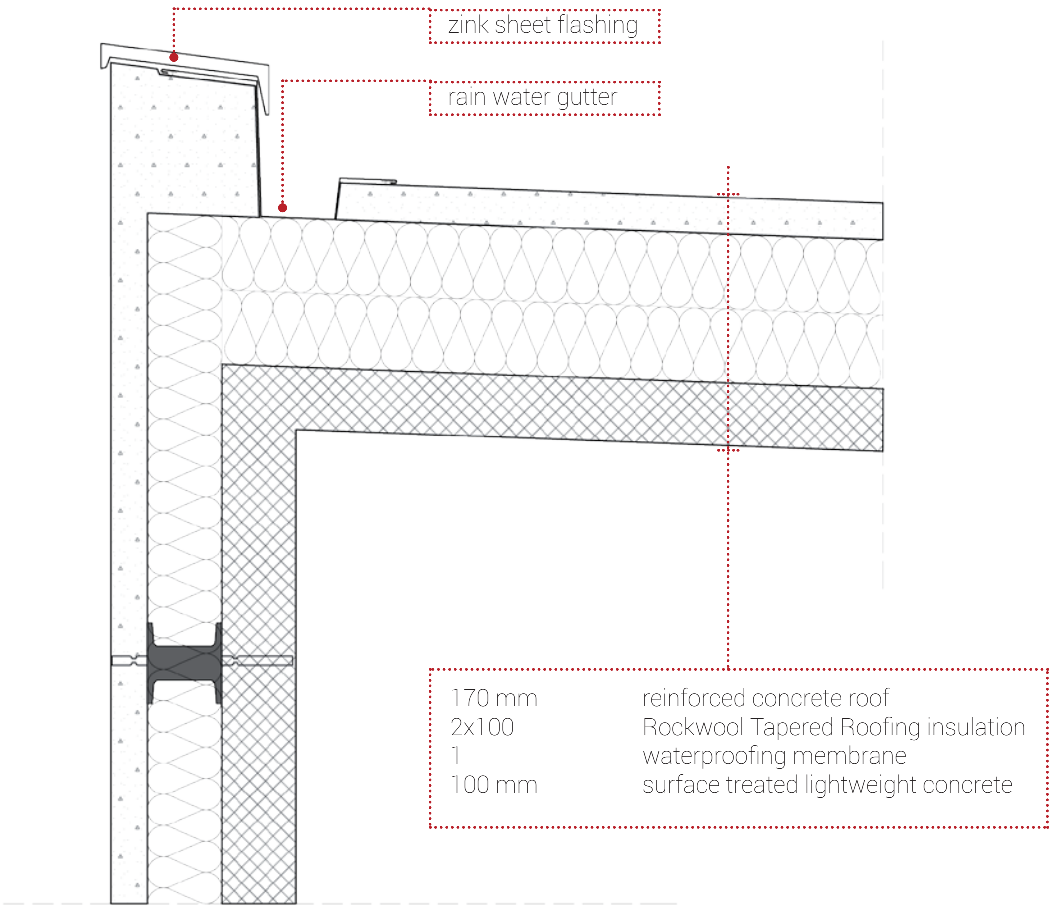


80 mm	polished lightweight concrete floor
50 mm	Rocwool Flexi insulation (acoustic)
170 mm	re-inforced concrete floor slab
	exposed ceiling
1	hanging accoustic panels

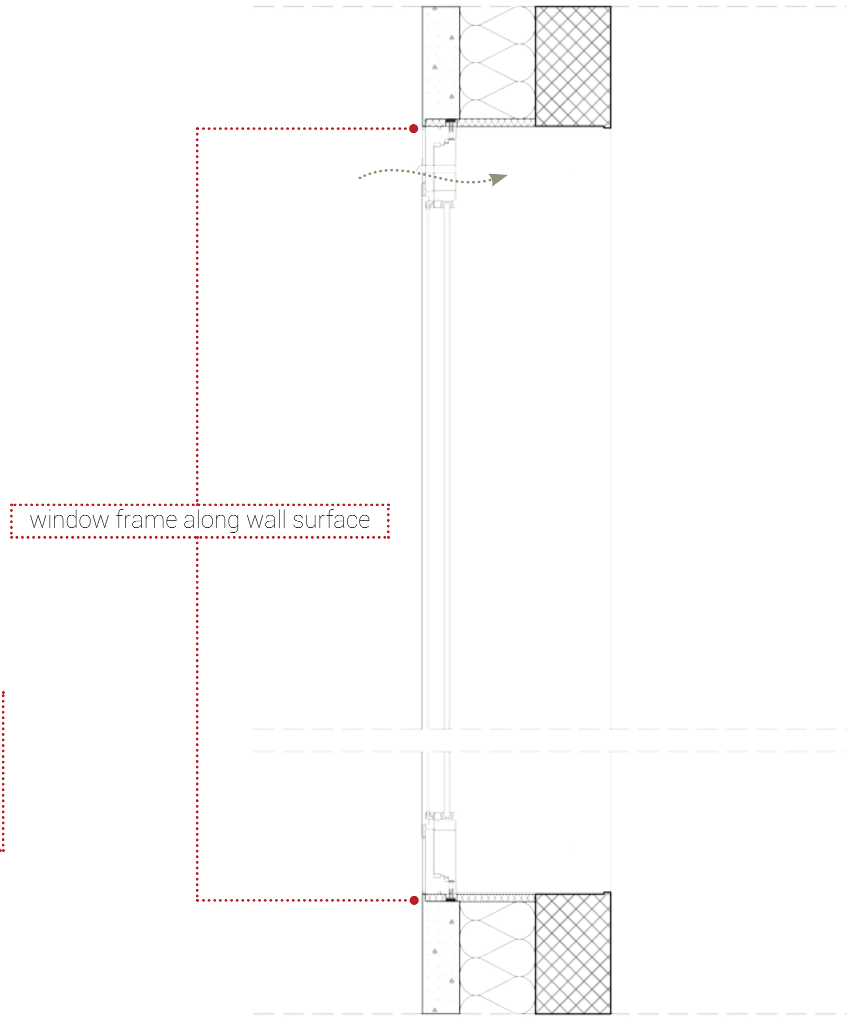
20 x 1500 mm frame integrated air inlet (for venting)

[1:20]

_D3

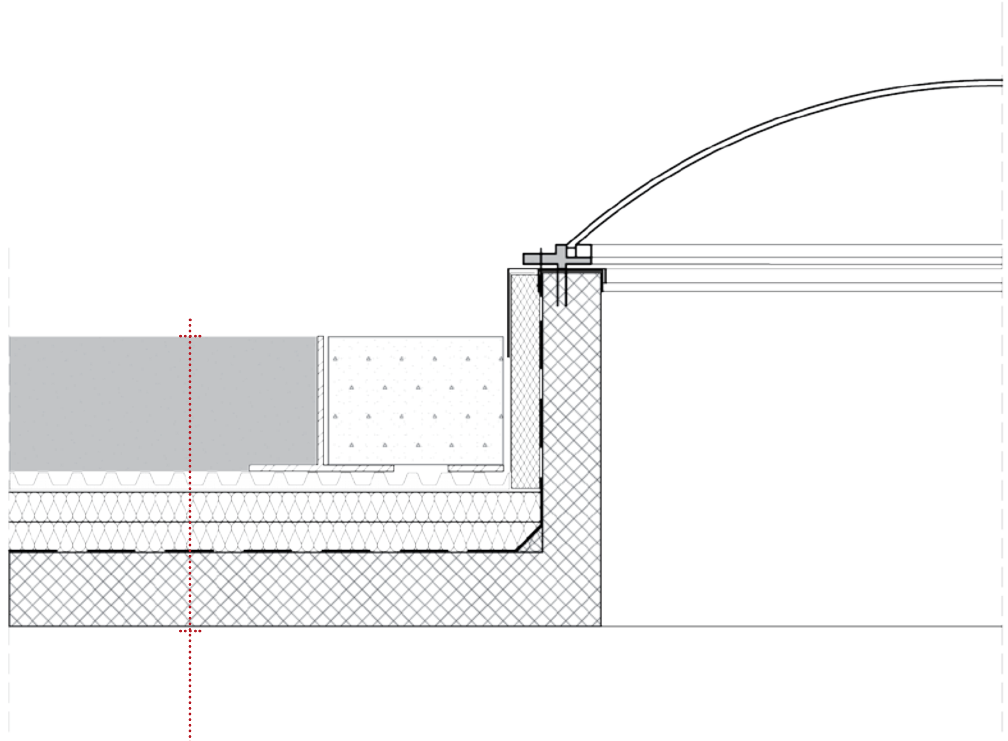

zink sheet flashing
rain water gutter
170 mm reinforced concrete roof
2x100 Rockwool Tapered Roofing insulation
1 waterproofing membrane
100 mm surface treated lightweight concrete

_D4


window frame along wall surface

[1:20]

_D5



200 mm	reinforced concrete roof
1	waterproofing membrane
2x80 mm	Rockwool Tapered Roofing insulation
45 mm	drainage layer
350 mm	soil

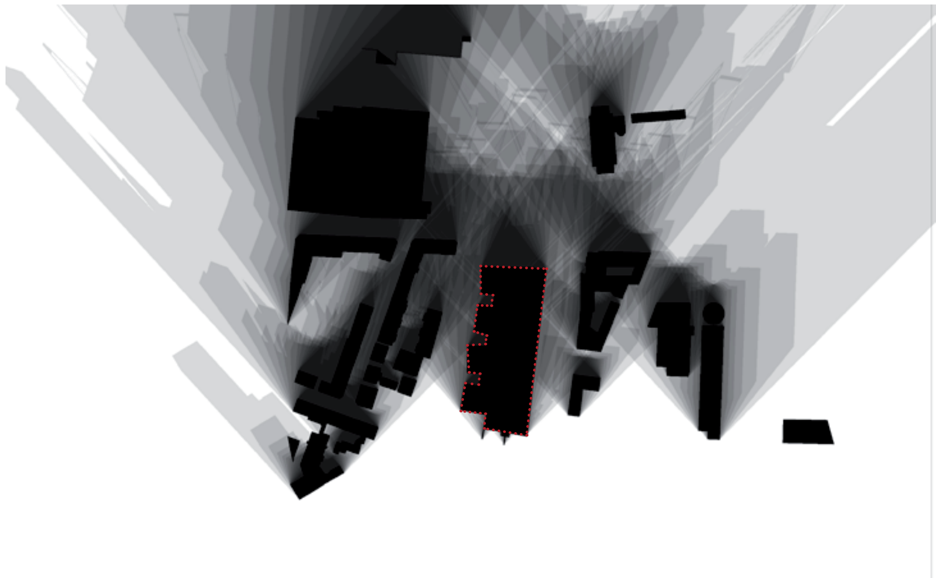
[1:20]

building analysis
sun

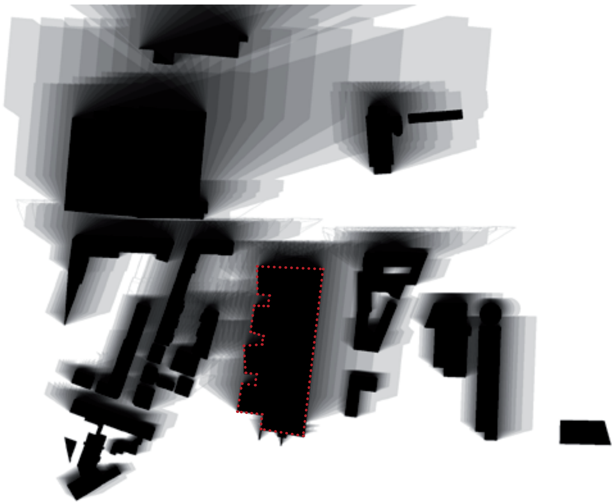
The purpose with the shadow study was to get an overview of the impact that the building volumes have on the site and its surrounding in terms of shadow casting.
There was no real issue as the height of the building was maintained around the contextual topography levels.
To get an annual overview the spring equinox, the summer and the winter solstice was used as reference days. *(refer to fig.4-5 under Site Analysis/Climatic)*
The day simulation span between 09-17.

_Conclusion
It is important to note that the park on the west side of the building is shaded a big portion of the year. This is taken in consideration when finalizing the master plan.

Winter Solstice (shortest day of the year)
This is when the shadows are the longest, as the sun is the lowest.



Equinox (equal day &night)
This occurs twice a year, around 20 march and 22 september.



Summer Solstice (longest day of the year)
This is when the shadows are shortest, as the sun is at its highest point.

building analysis
wind

The openness of the site gives way for wind exposure. And by the readings of the wind rose, the primary wind direction in Aalborg is southwestern and southeastern. The map of the site and Karolinelund shows no significant wind protection. This should be used in favor of natural ventilation. Concluding that it has significance when addressing the design in terms of overall shape of the building, possible air inputs, vertical volumes together with construction strategies as double-skin facades, etc.

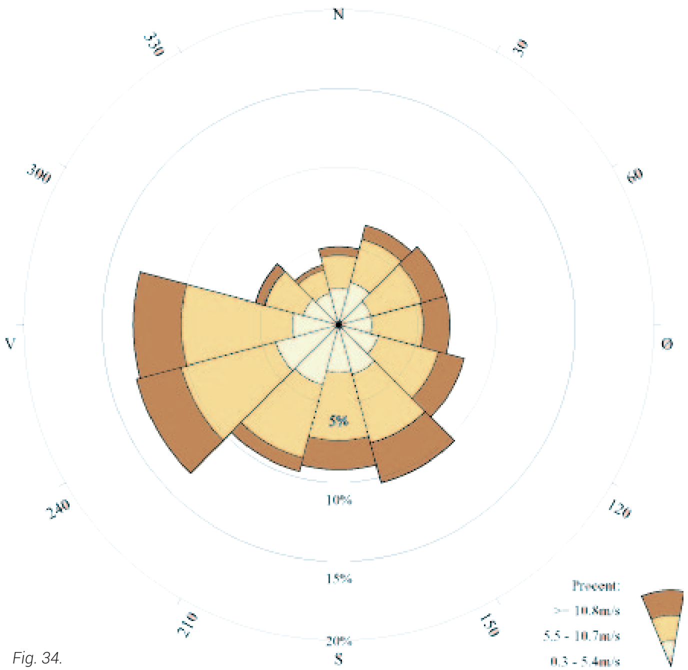


Fig. 34.

The table on the opposite page display the critical sections of where the wind might cause unpleasent outdoor environment around the buildings. The building typologies were extracted from the later phase of the design process, meaning that this study served more as guide in confirming where there might be problems. These studies where monitored 10 m above sea-level.

_Conclusion

By comparing the sixteen scenarios together, one can conclude that building typology B) displays the overall more favourable conditions


Building typology
Windload/Winddirection
A)
B)
C)
D)
Wind_SE_5m/s
16,93 m/s
0 m/s
14,81 m/s
0 m/s
14,95 m/s
0 m/s
17,58 m/s
0 m/s
Wind_SE_10m/s
17,29 m/s
0 m/s
17,59 m/s
0 m/s
18,13 m/s
0 m/s
17,89 m/s
0 m/s
Wind_W/SW_5m/s
16,93 m/s
0 m/s
17,26 m/s
0 m/s
14,95 m/s
0 m/s
17,58 m/s
0 m/s
Wind_W/SW_10m/s
24,45 m/s
0 m/s
23,59 m/s
0 m/s
23 m/s
0 m/s
22,61 m/s
0 m/s

building analysis
indoor climate

The indoor analysis has the purpose to show whether the space that is designed is usable.
In this segment the focus will be on the highlighted factors.

Air Quality
Temperature levels
Daylight factor
Accoustics *

The noise and acoustic properties will not be measured in this report. An assumption will only be made in the choice of material finishes. (find more on this; in the Design Process/Construction Principle)

_Air Quality/Temperature/Daylight_Requirenments

BR10 [*6.3.1.3(2)*] states: *'...the CO_2 content in the indoor air must not exceed 0.1% for extended periods.'*

Regarding the temperatures, it is assumed for rooms that are in use not to have lower temperature then 20 ^{0}C. Additionally it is stated that temperatures;

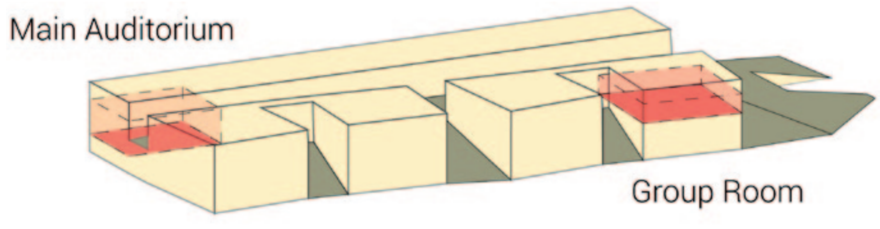
> 27 ^{0}C should not exceed 25 hours/year
>26 ^{0}C should not exceed 100hours/year

In terms of daylight, a dalightfactor of 4-5 should be reached around the working environment, where working desks are located.

_Air Quality/Temperature Levels_BSim

In order to get an understanding of the indoor qualities of the building, the analysis was carried out in two spaces, with opposite extremes.

- Group Room_Southern Cube_2nd Floor
  - Un-interupted sun-exposure
  - High people load during office hours
- Main auditorium_Main Building_2-3rd Floor
  - Non/Minimum sun-exposure
  - Very High People load during limited time

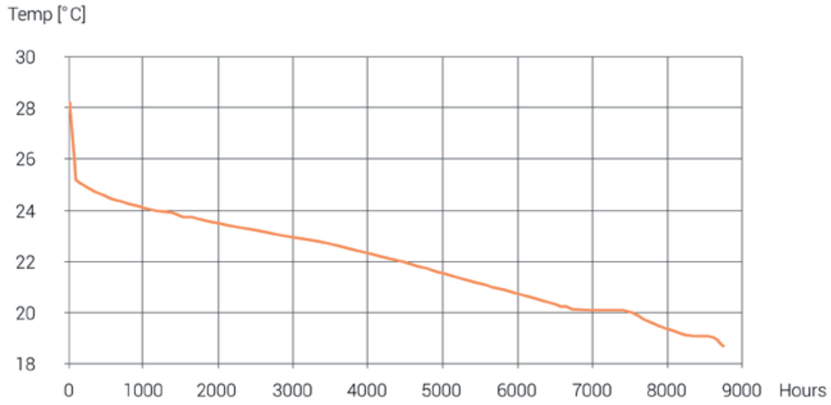


_Systems (group room)

The following table summarize the used values for each system.
note that the Air Change rate is higher then Natural Ventilation result, (please refer to Design Process/Natural Ventilation/Discrepancies)

System	Description	Control	Indication of Time
Human load (40 people)	40% 8-9 100% 10-17 20% 18-20	Standard activity	Mon-Fri Feb-May , Sep-Dec
Equipment(40 Laptops)	40% 8-9 100% 10-17 20% 18-20	Heat Load: 1 kW Air Prop: 0,9	Mon-Fri Feb-May , Sep-Dec
Infiltration	69% 1-9 100% 10-18 69% 19-24	Basic air change rate: 0,13 TmpF/P/WindF: 0	Mon-Sun Jan-Dec
Lighting	Task Light: 0,2kW General Light: 2kW Level: 200lux Type: Fluorescent Solar Limit: 2kW Exhaust Part:0	Light Control Factor 1 Lower Limit: 2 kW Temp. Max 25°C Solar Limit: 2kW	Mon-Fri 8-20 Feb-May, Sep-Dec
Venting	Basic air change rate: 5 TmpF/P/WindF: 0 Max air change: 5	Vent Ctrl SetP: 25°C SetP: 1000 co2-ppm Factort: 1	Mon-Fri May-Sep
Heating	MaxPow: 50kW Fixed Part: 0 Part to air: 0,6	*Heating Day* Factor: 1 Set Point: 20°C *Heating Night* Factor: 1 Set Point: 19°C	Day Jan-Apr, Sep-Dec Night Always
Ventilation	*Input* Supply: 0,4 Pressure Rise: 200Pa Total Eff.: 0,7 Part to Air: 1 *Output* Return: 0,4 Pressure Rise: 200Pa Total Eff.: 0,7 Part to Air: 0	Recovery Unit: 70% Heating Set Point: 20 Cooling Set Point: 25 Air Source: Outdoor	Mon-Sun 8-20 Jan-Dec

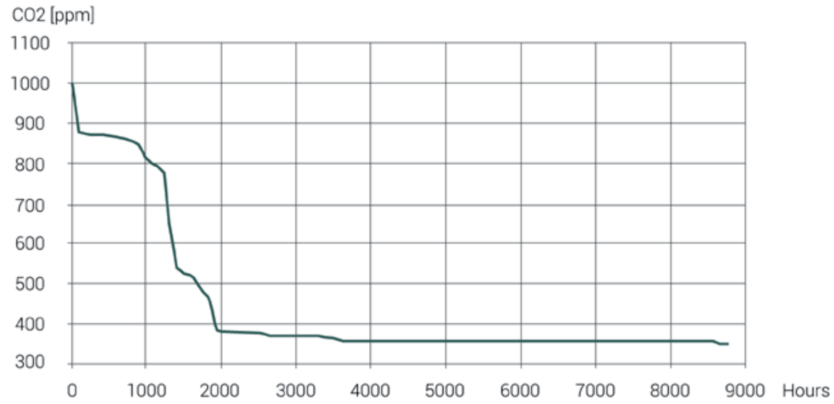
These graphs display the total hours of certain temperature and CO2 exposure, in the group room.

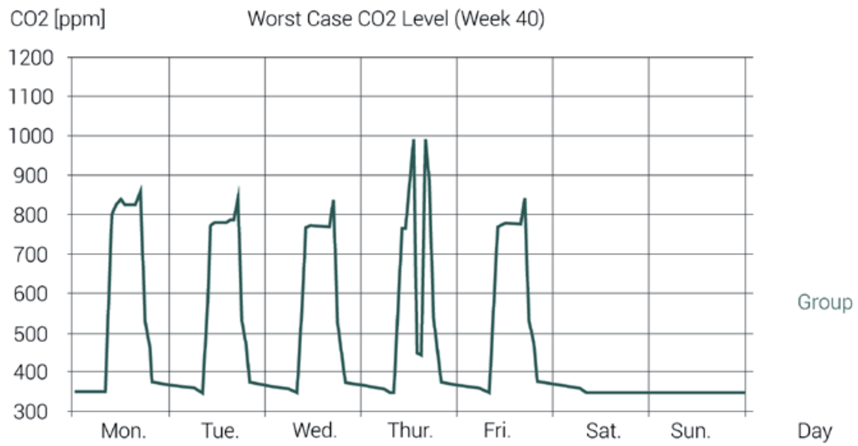


_Results

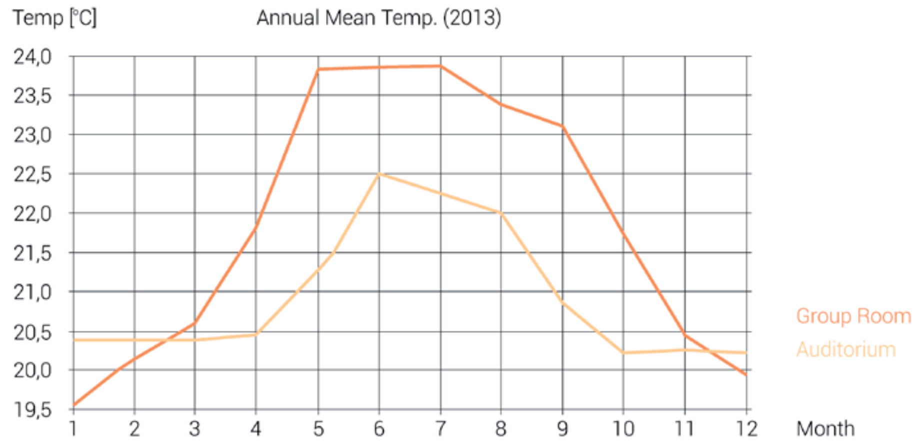
Group Room
> 27 ^{0}C = 7
> 26 ^{0}C = 40
< 20 ^{0}C = 1232 (Primarly during winter holidays)

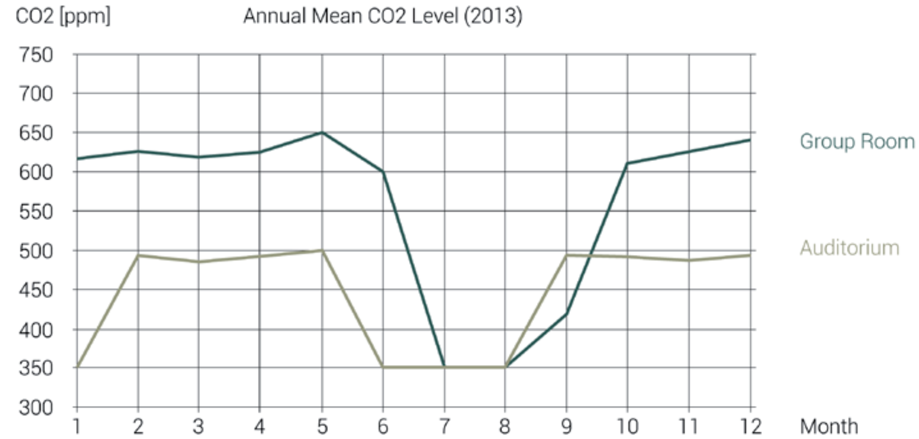
The group room has a more extreme environment compared to the auditorium, mainly because of its window-to-floor area, people load-to-room volume and its orientation.





These graphs display the annual mean temperature and CO2 levels, in the group room and the auditorium.
It gives an rough understanding of the fluctuation over the year.





_Results

Auditorium

> > 27 ^{0}C = 0
> > 26 ^{0}C = 0
> < 20 ^{0}C = 1188 (Primarly during winter holidays)

The northern orientation demands the space to be heated up, and ventilated mechanically most of the time. The irregular space usage and the size of the space, allows for the CO2 levels to be relatively low.

_Discrepencies

The group room model had long windows on each of the four faces, spaning the whole width of the face (offset 0,3m/0,9m sill). This was applied to give an worst-case scenario, more extreme thermal circumstances, as the facade exprssion was not fully defined at this point.
Accurate disposition for the windows was given during the daylight analysis.

_Conclusion

The overall values are within acceptable/good intervall. Meaning that with the current systems, the indoor quality fullfills the regulation and can accomodate the functions.
In practice alterations would be made in order to optimize the systems even further from an energy performance perspective. This will not be carried out in this report.
The energy calculation is made independantly, with reference to the above system values. (Please refer to Design Process/Energy Evaluation)

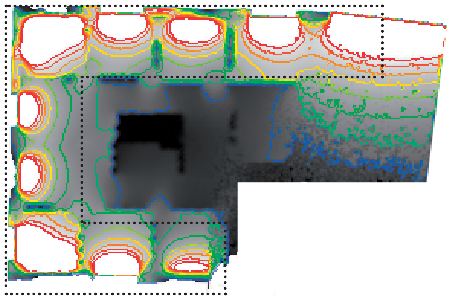
_Daylight Factor_Velux
The light study was carried out for a group room on the second floor, the ground floor main hall and the second floor main hall.

- The group room is relevant to mesure as its used for study and work.
- The main hall ground floor is the most de-prieved space of daylight
- The main hall first floor accommodates the study lounge.

Daylight Factor

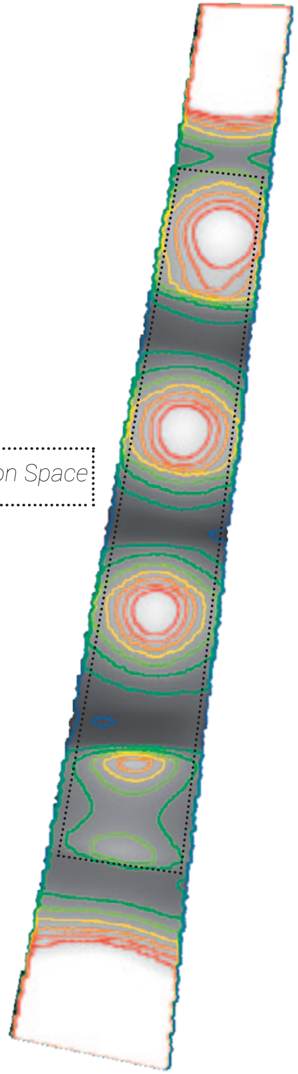
- 8
- 7
- 6
- 5
- 4
- 3
- 2
- 1

Group Room



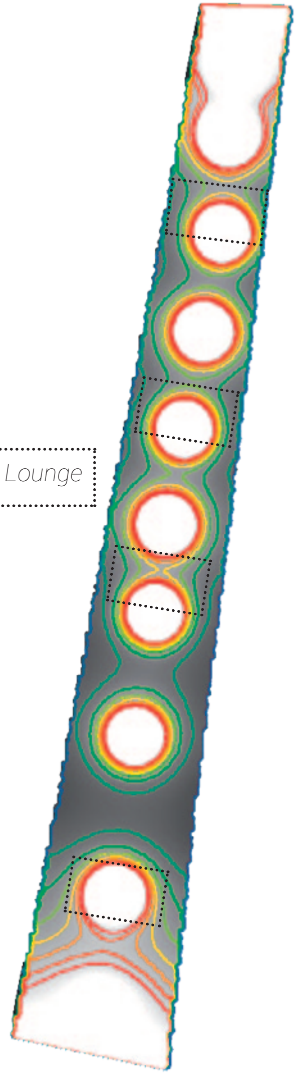
Work Area

Main Hall_0



Exhibition Space

Main Hall_1



Study Lounge

_Conclusion

With adjustments to the windows in the group rooms and introduction of skylights in the main hall, the daylight levels are good throughout the whole building volume.

Adding that the east and west facade light is not included in the main hall analysis, strengthening the notion of good indoor daylight conditions.

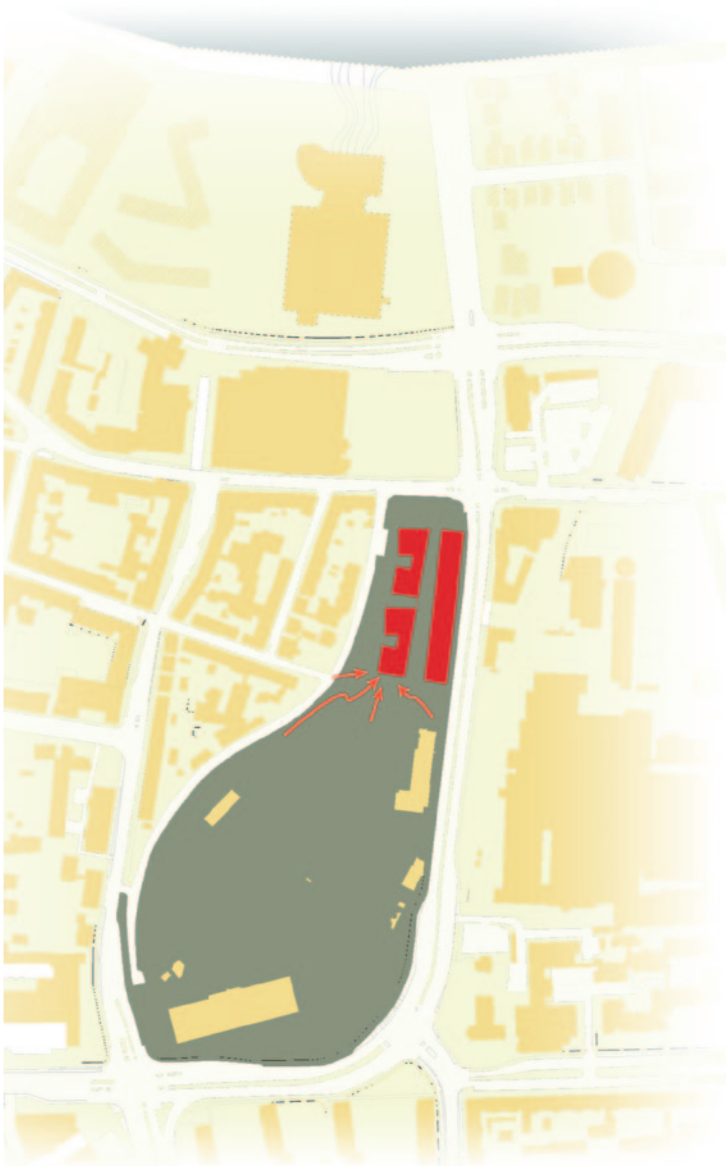
building performance
natural ventilation

With natural ventilation used during summer time, the annual energy demand will be lowered, if implemented correctly.
This segment contains the calculation confirming the possibility for natural ventilation and also that it could fulfill the desired air-change rate.
BR10 [*6.3.1.3(2)*] states: *'Fresh air supply to and extraction from normal teaching rooms must be no less than 5 l/s/person plus 0.35 l/s/m2 floor area'*

The following calculations are a continuation on the BSim monitored group room, as it is an extreme case, mainly because of the people load and the un-interrupted sun exposure.

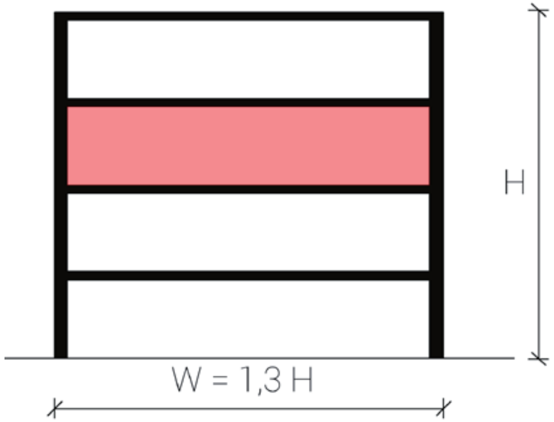
Wind-based Ventilation

The circumstances for wind-based ventilation are good, as the building volume is facing the main wind directions, W/SW & SE.
The context in which the wind pass is primarily through greenery, meaning that the air pollution is low.



_Cross Ventilation

W ≤ 5H → Confirms that cross-ventilation is possible. [12]

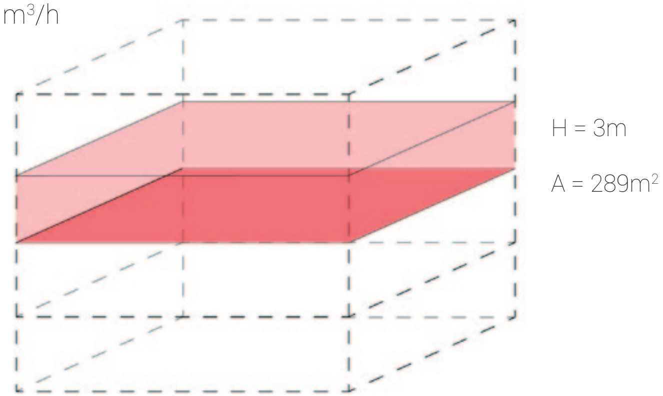


Air quality demand *(BE10)*: 0,35 l/s/m^2

Group Room: 289 m^2

289 x 0,35 = 101 l/s (necessary to vent the room) → 363 600 l/h → 363,6 m^3/h

(363,6 m3/h)/(289x3)m^3= $0{,}42^{h-1}$ (necessary to vent the room)



_Wind-induced Pressure Difference

$p_v = ½ \times C_p \times p_u \times V_{ref}^2 - P_i$

C_p = (see ref --> *windrose&windpressure coefficient data. Table A2.1 p.25* [12]) - 0 ^{o}

$C_{pwindward} = 0{,}7$

$C_{pleeward} = -0{,}5$

$P_{u(July)}$ = [16 mean, DMI] 1,225 kg/m^3

$V_{ref} = V_{meteo(aalb.)} \times k \times h^a$

$V_{meteo(aalb.)} = 10$ m/s

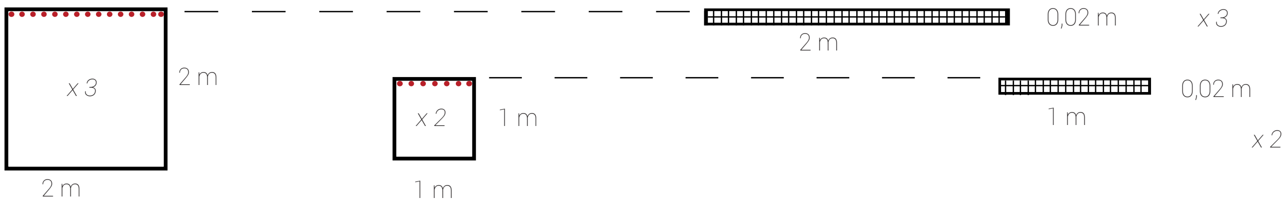
$k = 0{,}35$

$a = 0{,}25$

$h = 7{,}5$ m

$V_{ref} = 10 \times 0{,}35 \times 7{,}5^{0{,}25} = 5{,}8$ m/s

$$P_i = ½ \times P_u \times V_{ref}^2 \times \frac{(A_{in}^2 \times C_{pin} + A_{out}^2 + C_{pout})}{(A_{in}^2 + A_{out}^2)}$$



$A_{in} = 0{,}16$ m^2 $A_{out} = 0{,}16$ m^2

$$P_i = ½ \times 1{,}225 \times 5{,}8^2 \times \frac{(0{,}16^2 \times 0{,}7 + 0{,}16^2 \times (-2))}{(0{,}16^2 + 0{,}16^2)} = 2{,}06 \text{ Pa}$$

$p_{windward} = ½ \times 0{,}7 \times 1{,}225 \times 5{,}8^2 - 2{,}06 = 12{,}36$ Pa

$p_{leeward} = ½ \times (-0{,}5) \times 1{,}225 \times 5{,}8^2 - 2{,}06 = -12{,}36$ Pa

_Air Flow Rate

$$Q = C_{d1} \times A_{in} \sqrt{\frac{|C_{p1} \times p_u \times v_{ref}^2 - 2p_i|}{p_u}}$$

$$= 0,6 \times 0,16 \sqrt{\frac{|0,7 \times 1,225 \times 5,8^2 - (2 \times 2,06)|}{1,225}}$$

$$= 0,432^{h-1}$$

$0,432^{h-1} > 0,42^{h-1}$ → OK, regarding BR10

Calculation Based on [12]

_Discrepancies

The calculation assumed that the inlets and the outlets are placed on the southern and northern faces of the cube. The west and the east are also available, meaning a different scenario could be achieved.
Also, the C_p values assume that the wind hit the facade at a 0 degree angle, which is not the case, most of the time.

Furthermore, in order to get an accurate calculation, one should refer to *CR1752 Ventilation for buildings- Design criteria for the indoor environment.*

_Conclusion

The base Air Flow Rate is sufficient, but the additional 5l/person is not. This means that the current inlet and outlet size needs to be increased.

If the current Airflow is inserted into the BSim model;
- the $C0^2$ values are slightly worse, but still acceptable.
+ the average temperature is more stable.

building performance
energy evaluation

The energy goal for 2015-building standard ccording to BR10 [7.2.4.2(1)]: *'...requirement for supplied energy for heating, ventilation, cooling, domestic hot water and lighting per m2 heated floor area does not exceed 41 kWh/m2/year plus 1100 kWh/year divided by the heated floor area.'*

Area_A&D:	12 240 m^2 → 1100/12 240= 0,09
Energy Regulation_A&D:	41,09kWh/m^2 annual

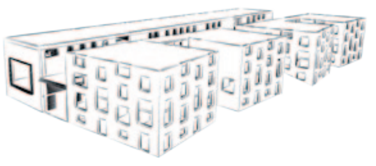
The chosen evaluation tool for this project was Graphisoft Archicad's Energy Evaluation extension.
With this tool, the possibility to use the working model (BIM) of the project and directly translate it to a Building Energy Model BEM. This enables higher precision in the calculation, as the actual geometries gets directly translated rather then simplified.
The ambition was also to get aquatinted with a tool that is not as nationally anchored like BE10.

In order to proceed with the calculation the following steps was taken:

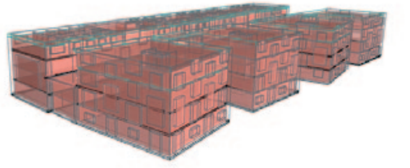
- *define each space within the building envelope with a 3 dimensional zone*
  make sure that the zone has space boundaries, meaning that all of its faces is in contact with either another zone or a building element, wall, slab roof etc.
- *define the building composites used in the building, meaning construction principles for the walls, slab, roof*
  *with appropriate U-values**
- *define construction principals for openings and transparent structures, doors, windows, curtain walls.*
  *with appropriate U-values**
- *define the systems of the building, meaning operation profiles, heating, cooling, lighting, ventilation -related information*

*The construction principals with corresponding U-values was based on products and construction systems mentioned in *design process_output/construction principle*

There is no consideration to economy related the chosen products nor the environmental design strategies.



BIM (Building Information Model)



BEM (Building Energy Model)

_BEM Parameters

Evaluation Parameters	Description		
Context Settings	Weather File: Copenhagen, DK Surrounding: Garden Soil type: Gravel		
Operation Profiles	65% Classroom Activity * 22% Circulation & Traffic 13% Unconditioned (Air)	Weekdays 2/1-15/6, 1/9-23/12: Allowed Temp.: 19-25 Internal Heat Gain: 38 W/m2 Weekends Allowed Temp: 18 Internal Heat Gain: 1 W/m2	Human Heat Gain: 100W per capita Service Hot Water Load: 60l/day per capita Humidity Load: 15l/day Interior Light: 0.50 W/m2 (LED)
Building Systems	Heating: District Cooling: Natural Service Water Generation: Cold: 10 °C Warm: 27 °C Ventilation: 1 h-1 *(Average for whole building)*		
Green Systems	Solar thermal collector: Hot water generation only ** Area; 2000 m2 (roof if desired) Angle to south; 4 Tilt angle: 0 Air to air energy recovery Fixed plate Efficiency; 90% Heat pump Source; Exhaust air Capacity; 1600 kW Hot water generation only*		
Construction	Please refer to design process_output/construction principle		

The following table shows the chosen parameters for the BEM model.

* In the operations profile, the system is limited to three functions. Meaning that a generalization is needed. In this case the air space and the circulation was grouped as separated functions and the rest (meaning the space occupying all the functions) was categorized as classroom.
This have a substantial effect on the accuracy of the calculation. For example the library or auditorium has the activity, hence energy demand, of an active classroom.
This was chosen as it was a compromise between all the functions added together.

** According to BR10 there must be a solar heating system providing 95% of the demand of domestic hot water, If consumption exceeds 2000l, which it does.
The building has more then 2400 m2 of roof to dispose for accommodating this equipment if desired.

_Result
Optimization on all aspects of energy efficient parameters has been made through the process of reaching the 2015- energy standard. As the generalization of function activity has been made, see above, the main inaccuracy was identified as the hot water generation.
The hot water generation may be to high as the program overestimate the hot water used based on standards per square meter. which may have an inaccurate outcome on this project as there is a tremendous space used for circulation, and plaza like space. (Hot water 60 l/day/capita)
This inaccuracy was compensated with a decrease of hot water temperature, currently 27 C. Additionally, as it still consume the majority of the energy, 194 MWh annually, 100% of the solar collector capacity is dedicated to supply its energy.

_Key Numbers

General Project Data		
Location:		
Primary Operation Profile:	Classroom (65%)	
Evaluation Date:	5/17/13 6:54 PM	

Building Geometry Data		
Gross Floor Area:	13747.49	m^2
Building Shell Area:	9193.04	m^2
Ventilated Volume:	38753.33	m^3
Glazing Ratio:	14	%

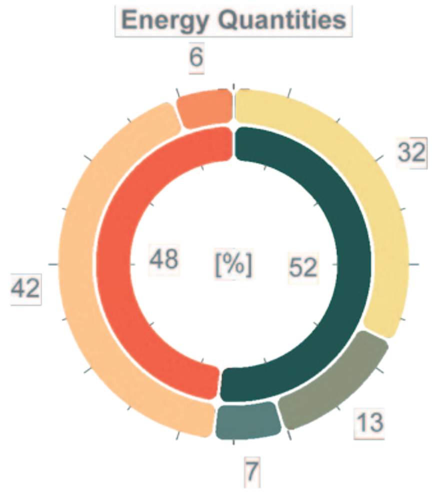
Building Shell Performance Data		
Air Leakage:	0.25	ACH
Outer Heat Capacity:	-	J/m^2K

Heat Transfer Coefficients	U value	$[W/m^2K]$
Building Shell Average:	0.37	
Floors:	0.18 - 0.18	
External:	0.16 - 0.18	
Underground:	-	
Openings:	0.64 - 6.77	

Specific Annual Demands		
Net Heating Energy:	1.06	kWh/m^2a
Net Cooling Energy:	2.65	kWh/m^2a
Total Net Energy:	3.72	kWh/m^2a
Energy Consumption:	40.32	kWh/m^2a
Fuel Consumption:	19.41	kWh/m^2a
Primary Energy:	53.64	kWh/m^2a
Operation Cost:	--	GBP/m^2a
CO_2 Emission:	4.24	kg/m^2a

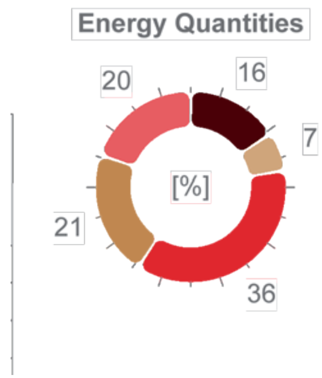
_Energy Consumption (by source)

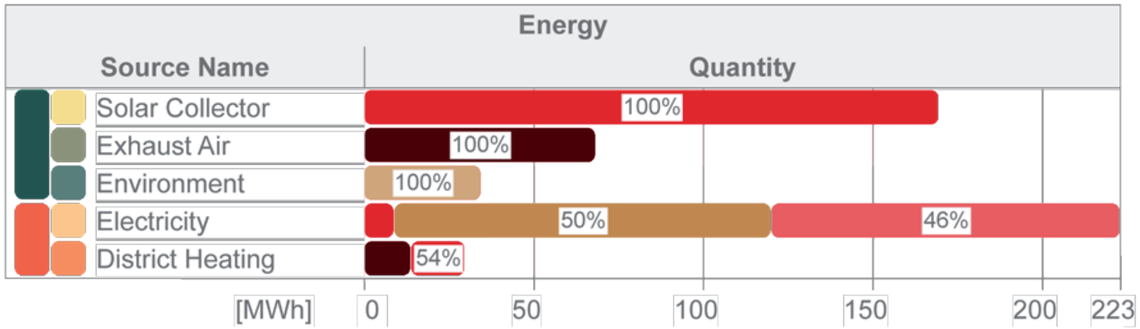
Source Type	Source Name	Energy Quantity MWh/a	Energy Cost GBP/a	CO_2 Emission kg/a
Renewable	Solar Collector	169	NA	0
	Exhaust Air	68		0
	Environment	34		0
Secondary	Electricity	223	--	48186
	District Heating	29	--	7088
Total:		525	Not Applicable	55275*



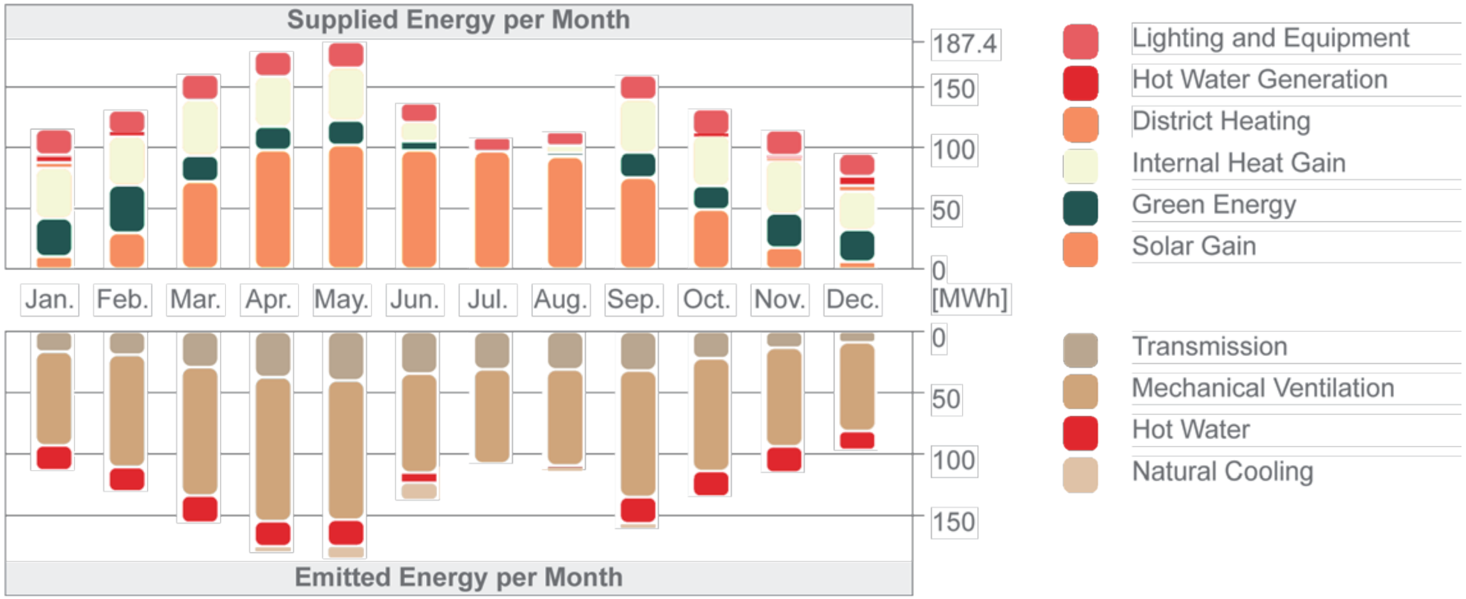
_Energy Consumption (by targets)

Target Name	Energy Quantity MWh/a	Cost GBP/a	Primary MWh/a	CO_2 Emission kg/a
Heating	82	0	13	3297
Cooling	34	0	0	0
Hot Water Generation	194	0	42	5720
Ventilation Fans	111	0	333	24028
Lighting & Appliances	102	0	308	22228
Total:	**525**	**NA**	**699**	**55275**





_Monthly Energy Balance



_Conclusion

The energy goal was reached, but it was not fully integrated in the design process more then on intuitive basis. The primary adjustments was made in the building systems and construction parameters, rather then form, orientation and other conceptual aspects.

in retrospect

Throughout the design process the proposal evolved from an architecture & design school character to more of an architecture & design hub character. This is actually what the design goals stated indirectly, but was not really understood until the final result was displayed. This refer to the big proportion of the space distribution dedicated to the public. In retrospect it makes sense, as the question of the plot taken away from the public somehow would be compensated, not allowing the proposal to be exclusively dedicated to the main users, meaning the students and the staff.

The main challenge and focus through this project was the balance between a functional circulation within the building envelope and the building relationship towards the site. The aim was to centralize the movement between the functions, allowing for the interaction of occupants and non-occupants. This had an effect on the footprint, increasing its size, complicating its relationship to the site.There is no ambition to postulate that something got solved but rather to acknowledge that the outcome is a direct product of our own priorities. The subjective focus was on creating an interesting relationship and movement between the functions, in parallel to a site specific expression.
The building is indeed anchored into its context, physically, with the landscape growing in between and to some extend on-top of the building. The initial ambition was to continue the north-south movement through the park on top of the building, creating an un-interrupted green path all the way to Telegårdsplads. This was later altered and compromised for the sake of the north and south entrances of the building. To have a strong axel through the amalgamation corridor, there was a necessity for a clear inside-outside point, an entrance with a strong presence.

From an performance based perspective, meaning energy consumption and indoor climate, the goal was measurably fulfilled. But wether or not the mean in getting there was integrated in the design process is questionable. As mentioned in the energy consumption chapter, the main alterations to the building was made on the construction, rather then the building form or functional disposition. With this said one can not exclude the fact that the initial design ideas always kept the performance optimization included on a more intuitive basis.

Overall, one can conclude that the program for this project might be to big in scale for the plot that was chosen. Then again, with this limitation remained, it contributed to a more context orientated design path, whether fortunate or not.
Regardless, a conscious analysis was made, with a design outcome that may not have been entirely foreseen, stating that the building rather then designed was discovered...

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_illustrations

if not stated elsewhere the illustration is of own production

Fig. 1-2.:
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Fig. 3.:
[Electronic print] Available at: maps.google.com

Fig. 4.:
[Electronic print] Available at: www.bing.com/maps

Fig. 5.:
[Electronic print] Available at: http://www.urban.aau.dk/education/images/nordkraft.jpg

Fig. 6.:
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Fig. 7.:
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Fig. 8.:
[Electronic print] Available at: http://us.123rf.com/400wm/400/400/johnjohnson/johnjohnson1006/johnjohnson100600031/7101582-worn-dirty-yellow-brick-wall.jpg

Fig. 9.:
[Electronic print] Available at: http://upload.wikimedia.org/wikipedia/commons/1/11/Desert_de_Retz_Grass.jpg

Fig. 10-11.:
[Electronic print] authors image

Fig. 12.:
[Electronic print] Available at: http://www.gaisma.com/en/location/aalborg.html

Fig. 13.:
[Electronic print] Available at: http://www.windfinder.com/windstats/windstatistic_aalborg.htm

Fig. 14-16.:
[Electronic print] Available at: http://weatherspark.com/averages/28821/Tirstrup-near-Aarhus-Central-Denmark-Region

Fig. 17.:
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Fig. 18.-27 :
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Fig. 28. :
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Fig. 29.-30 :
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Fig. 31.-32. :
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Fig. 33. :
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Fig. 34. :
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Page 91, Illustration
[Screenshot] taken from the movie; The Truman Show. Directed by Peter Weir, written by Andres Niccol. Paramount Pictures. June 1998.