

EXPERIMENTAL SOCIETY LAB



ABSTRACT

To date, an unprecedented number of 65 million people around the world have been displaced. Of this, 25.4 million are refugees (1). In Europe, almost three million people claimed asylum in the EU between 2015 and 2016. However there has been relatively little discussion within the architectural community as to how architecture should engage with and respond to this crisis. The question, though, for this project was not just how architecture could engage but how parametric architecture could bring benefits to this process. While the project pointed out some potentials, it encountered several complications which, eventually, show the limitations such an approach should overcome.

NDX

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01

THE RESEARCH

WHAT REFUGEES AND WHERE?

There are different perspectives to the refugee crisis in Europe: from the borders where displacement and temporariness are the key words, particularly in Italy and Greece, to the welcoming of refugees into the built-environment once those borders have been crossed, which instead requires a long-term vision. The former, with temporary facilities, such as refugees camps, is the most visible and the most discussed. However, the second stage, dealing with the reception and integration of refugees is much as intricate. The question is then, how can we, as architects respond to this crisis and welcome refugees in the built-environment? The first step was to identify the problematics, which was made by studying the asylum process faced by refugees in Europe, more specifically in the Netherlands.

1.1 THE ASYLUM PROCESS

1.1.1 ANALYSIS, PROBLEMATICS AND RECOMMENDATIONS

Once refugees arrive in the Netherlands and have submitted an asylum application, they are transferred to the first reception centre (Centrale ontvangstlocatie) where legal and health checks are carried out. This step should last no more than 4 days. The asylum seeker is then transferred to another reception facility (Procesopvanglocatie) for 12 days. Afterwards, they are moved to a regular reception facility (AZC), whose size vary from 200 to 1200 beds, until the outcome of their application. After (and if) their application is approved and they are officially registered as refugees, social housing is provided. Eventually, once the period of asylum protection is terminated, refugees either become citizens or permanent residents and need to start a new life outside the system. This means that, once more, they would have to find a new house. This process, typical of most EU countries, highlights the continuous shuffling around of refugees and, in practice, it is yet complicated by the shrinking supply of social housing in the Netherlands. This led to other forms of temporariness or prolonged times in the first 3 types of reception centres. And housing has indeed been identified as an urgent problem to be solved in relation to the integration of refugees in the Netherlands(2).

A third problematic in relation to the asylum process is the lack of self-sufficiency and active participation, in other words of employment or volunteering. Asylum seekers are not eligible to work in the Netherlands in the first six months. Afterwards, they can take on temporary work for a maximum period of 24 weeks every 52 weeks. However, not

only are they entitled to only 25 percent of their income and a maximum of 185 euros per months, but their employer has to apply for a work permit, which is granted only in case of insufficient labour supply. As a consequence, the number of refugees who have been able to find work is slim(3).

The advisory Committee on Migration Affairs (ACVZ) states that forced inactivity for many asylum seekers during their asylum procedure leads to passivity and isolation which ultimately have a negative impact on their health and possibilities to take control of their lives(4). This eventually leads to high rates of unemployment that are protracted into the period after asylum protection. Studies have, in fact, indicated that the insertion of beneficiaries of international protection in the Netherlands is complicated and this group is highly dependant on social assistance and has low participation rates(5). The Netherlands Scientific Council for Government Policy recommends to make use of the waiting period in the asylum centre in order for refugees to acquire necessary skills to enter the labour market(6).

Research on reception centres also highlighted a fourth problematic: the need for psychological or psychiatric support for asylum seekers and beneficiaries of protection, which is exacerbated by the social isolation experienced on arrival and during the stay at the reception centres(7).

The period in a reception centre can have some advantages, especially from a social point of view. Often, refugees develop friendships networks, which smooth the way towards social integration. Yet, since they are constantly moved to different reception centre, the current asylum process often thwarts this value.

1.1.2 INTEGRATION

The asylum process is strictly intertwined with the concept of integration, its final aim. While some of the aspects associated with integration have already emerged in the analysis of the process, it is worth looking at what “(refugee) integration” means, which allows to delineate the issues that need to be tackled.

1.1.2.1 WHAT IS REFUGEE INTEGRATION?

There is no universal definition of immigrant or refugee integration, neither there is one in international refugee law⁽⁸⁾. This is due to the fact that integration is often a subjective matter. Yet, many organisation and governmental bodies have developed different frameworks and parameters for assessing immigrant or refugee integration, which are indicative of the different perceptions of integration.

Many of these agree, however, on the understanding of integration as a two-way process, between refugees and welcoming societies, and most recognise different dimension: legal, economic and social-cultural. In the Stockholm Programme (2009), delineated by the European Union, integration is defined as comprised of the following different parameters:

- Employment: employment rate, unemployment rate, activity rate
- Education: share of low achieving 15 year olds in reading, mathematics and science; share of 30-35 year olds with tertiary educational attainments; share of early leavers from education and training
- Social inclusion: median net income; at risk of poverty rate; health status (good/ poor); property/non-property owner
- Active citizenship: share of immigrants acquiring citizenship; share of immigrants holding long-term residency; share of immigrants among elected representatives.

Other principles for refugee integration are listed in the Common Basic Principles for Immigrant Integration Policy (2004):

- a two-way, dynamic process;
- implying respect for values of the EU;
- employment forms a key part of integration and is central to participation;
- knowledge of the receiving society’s language, history, institutions is integral to successful integration;
- education is critical for active participation;
- access to institutions, goods and services equal to nationals is foundational to integration; interaction between migrant/citizen;
- practice of diverse cultures and religions to be safeguarded;
- participation in democratic process;
- mainstreaming integration policies;
- clear goals, indicators and evaluation mechanisms to adjust integration policy

The IET (Refugee integration Evaluation Tool), developed by the UN-HCR, is a tool to identify gaps and good practices. It covers four major areas with key sub-concepts:

- General consideration: impact of reception conditions on integration, the infrastructure to mainstream refugees and their special needs into different public policies
- Legal integration: residency rights for refugees and beneficiaries of subsidiary protection, family unity and reunification, and access to an effective nationality
- Socio-economic integration: housing, employment, lifelong learning, health, public relief and social security
- Socio-cultural integration: education, language learning and social orientation, building bridges and fostering participation

1.1.3 CONCLUSIONS AND OBJECTIVES

While the tools and frameworks are structured in different ways, it is obvious that some concepts are recurrent and are summarised by the IET, which is taken as the model around which the project's objectives are delineated. While legal integration goes beyond the scope of this work, the others are thus developed:

INFRASTRUCTURE TO MAINSTREAM REFUGEES

Reduction of stages of reception centres; smooth transition between asylum seeker - refugee - citizen

Humanise the asylum process by reducing the number of times a refugee or claimer is transferred to different reception centres. This allows for retention of a community feeling and offer the opportunity of feeling of permanency longed by refugees. This infrastructure should also be able to provide a relatively quick response to the arrival of refugees. The transition period between asylum-seeker, refugee and citizen has been identified as highly problematic, particularly "because of the urgency with which refugees have to leave reception centres or supported accomodation and the sudden possibility of everything now being able to start. This issue is rarely addressed specifically in integration related discourse but has considerable impact on refugees, their integration and the support that is able to be provided to them"(9).

SOCIO-ECONOMIC INTEGRATION

Housing, building and active participation: a unique solution; Public and semi public functions for employment; Public semi public function and materiality for psychological relief

The construction of new housing should be combined with the need of

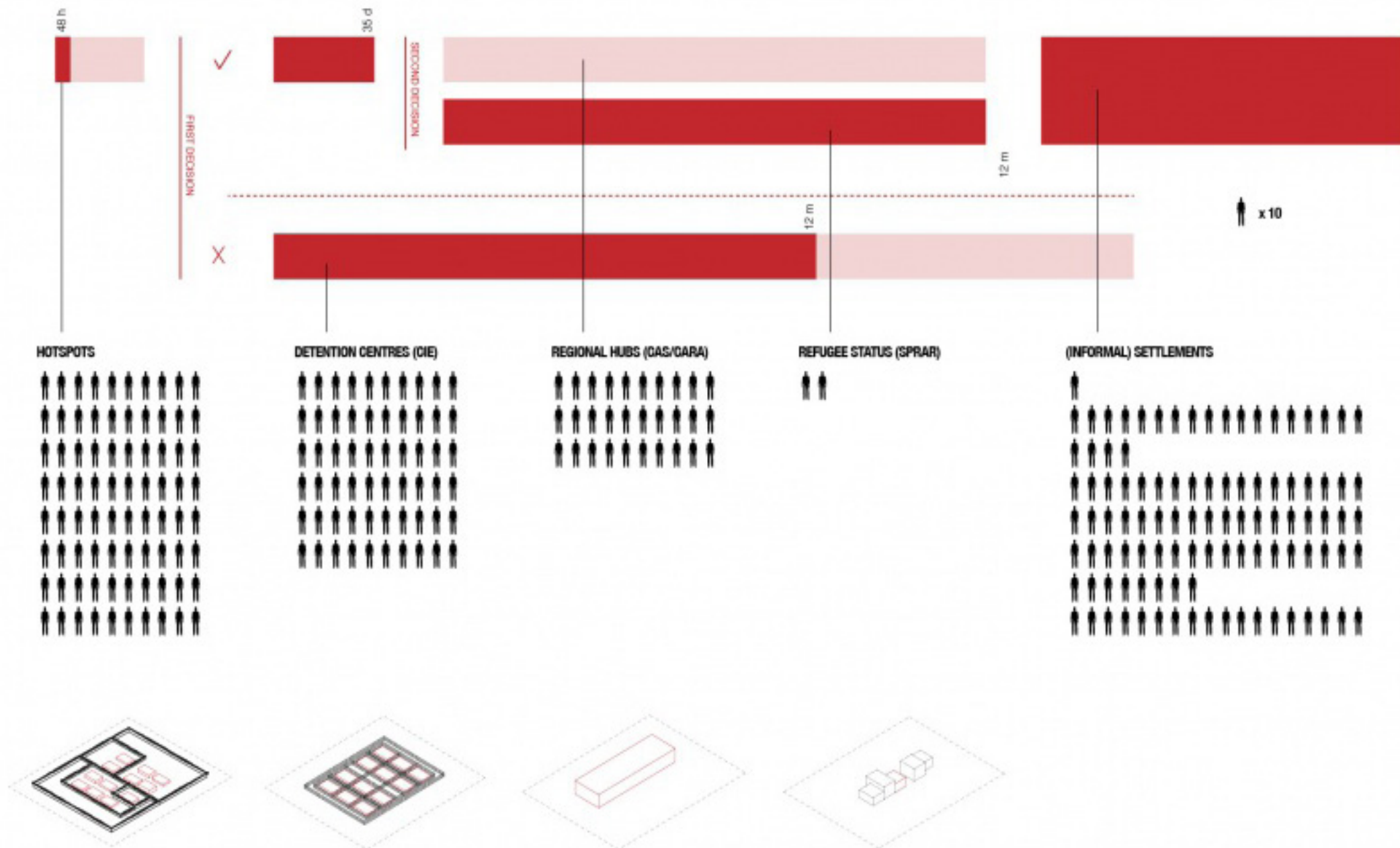
employment and lifelong learning. This can happen during the stay at the reception centre. Refugees would work on the construction of their housing themselves and/or would help in the designing - that could be a form of training that would help them earn a diploma and prepare them for a job, a form of active participation or, more simply, a form of being able to jump on the housing ladder. Opportunities for employment should however be wide ranging in order to empower refugees to access working opportunities in accordance to their wishes. A variety of functionalities should be integrated in the development, so that these could become new job opportunities. In this way, the new construction should become a small city-in-the-city and its opportunities guarantee a smooth transition once the asylum protection ends. Psychological relief and health can be promoted through the careful selection of functions, such as urban gardens and the feeling of the space, that is its materiality.

SOCIO-CULTURAL INTEGRATION

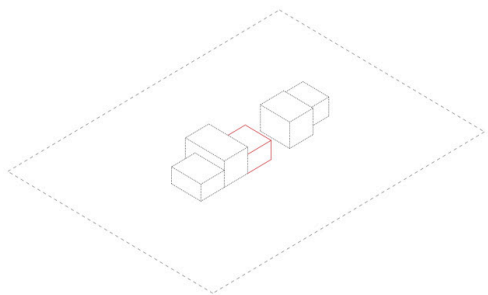
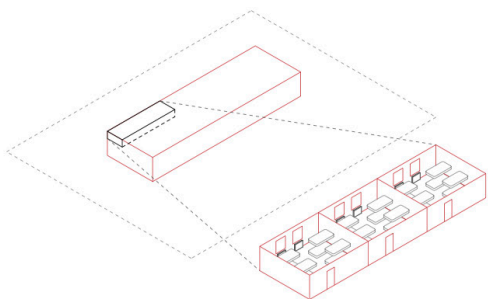
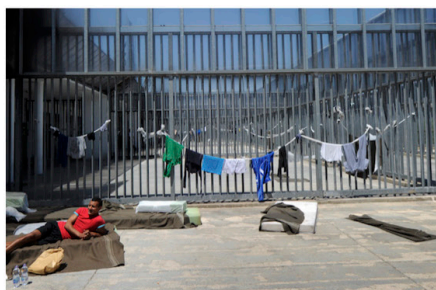
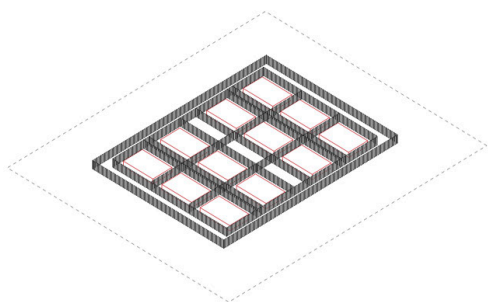
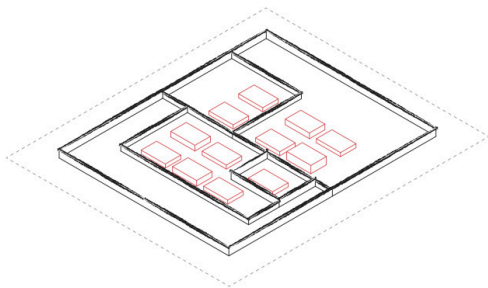
Functions for encouraging integration, best practices; the public spaces as spaces for integration

Offering spaces for learning the language and education, in particular those that can help in acquiring skills. "Building bridges" is also essential: firstly, it is concerned with the building of public and semi-public spaces that should guarantee the meeting of people from different backgrounds. In this sense, the concept of city-in-the-city should be expanded to include areas that can attract people, by the use of functions and by creating an interesting space. In order to build bridges, a variety

of refugees and locals should inhabit the building. In this way, the solution can also potentially help the Netherlands to better deal with its existing housing shortage. Finally, the meeting between different cultures should be encouraged by through specific functions, such as sports hall (which help the younger generations to connect) and events which are meant to foster integration. For this, the list of best practices compiled by the European Commission was used as a reference(10).



Initial study on the refugees crisis, highlighting the situation from the border reception centres to the city



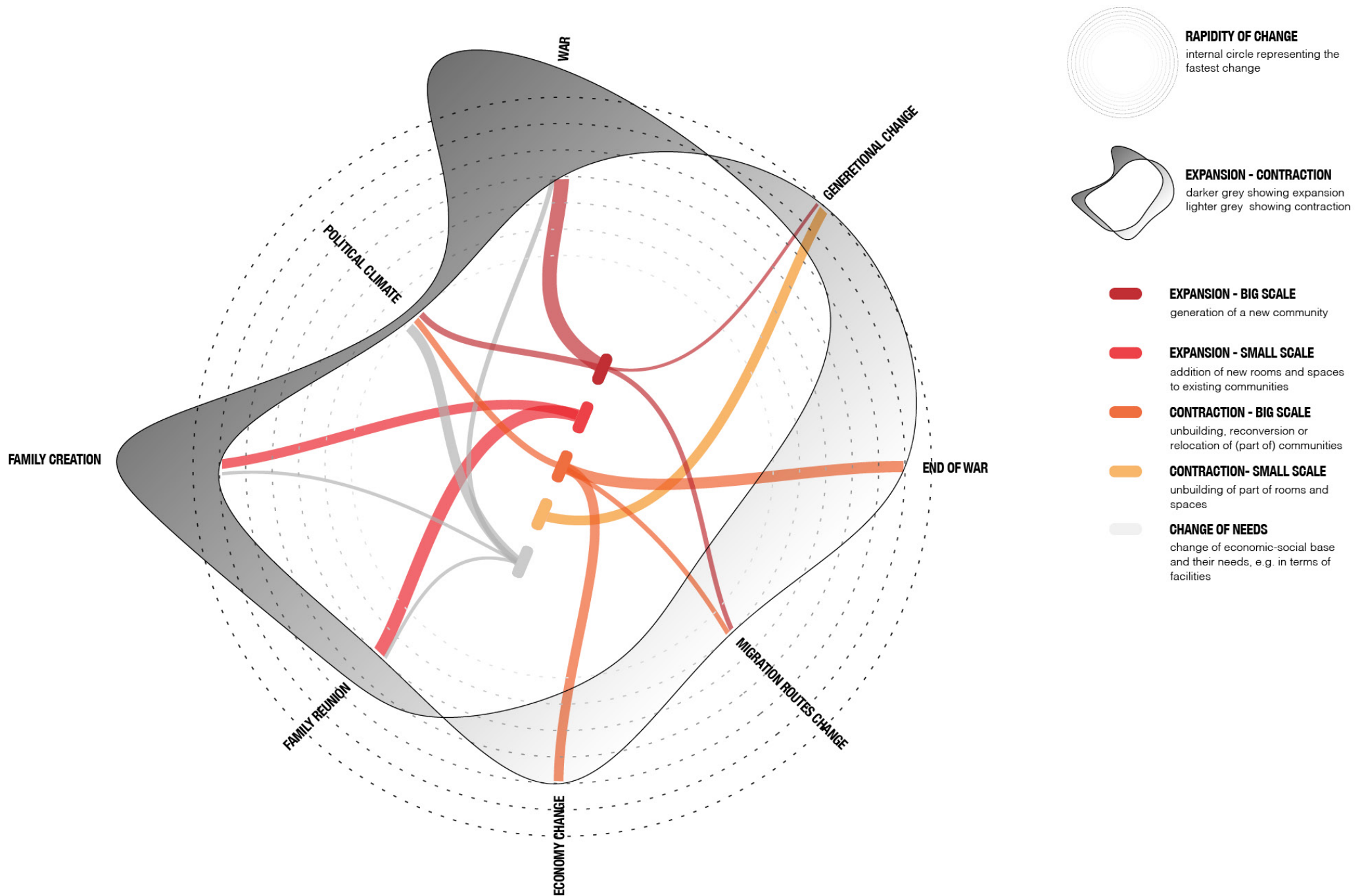


Diagram representing the high volatility with which refugees influxes can change

1.1 THE OTHER SIDE OF THE COIN: INFORMAL AND SELF-ORGANISED SETTLEMENTS

The second part of the research focused on informal settlements, built or created by refugees, in Europe. The objective was to imagine how a refugee society would develop if less restrained by external forces. In this view, informal settlements were considered as a sort of *tabula rasa*. This research was soon marked by the term “self-organisation”, expressing the spontaneous order out of seeming chaos, but also the individual ability to construct dwelling, enterprises and public spaces according to the means and tools at one’s disposal. The decision of focusing the investigation on these informal settlements rather than vernacular forms of architecture and societies of the different cultures of the refugee population derived from the belief that the refugee society cannot simply be described as the addition of individual cultures but rather a conglomeration thereof, in which some aspects prevail and others are abandoned.

1.2.1 CALAIS CAMP AND THE VLUCHTMAAT

Possibly the most famous of the informal settlements built by refugees in Europe is Camp Calais. This settlement is definitely one of the most prominent cases of self-organisation since it managed to thrive freely, at least until its forceful closure in 2016. This came about for several reasons: firstly for the fact that refugees did not want to be recognised by the French State in order to try their luck in the UK, the fact that it was supported throughout by several organisations, and eventually because the French State decided not to eradicate it and adopted an approach of ameliorate rather than destroy (In fact it built on the site its own refugee centre). However, the stance of the French

State changed in 2016 and, since then, the camp has not been reconstructed with the security that it once had. Yet, thanks to its fame, a large amount of secondary sources was composed and used for this research.

The research on the Calais Camp focused from its overall organisation down to the functions that are there present. By overlapping maps through time, it became visible how the crystallisation of the streets ended up in attracting and generating public spaces and public functions along these roads. Other tools that were used are comparative studies, which by means of juxtaposition allowed for the emergence of specific qualities as the result of self-organisation. To offer an example, the comparison with the state-funded containers - characterised by big containers, grid layout, surrounded by tall fences and fixed entrances - that were built on the camp shed light on the particular residential configurations that the inhabitants would favour, showing a preference for small buildings for one or two people, with a gradient of shared and semi-public spaces.

And this gradient became central in the next part of the research, as possibly one of the spatial features that can be representative of this culture. While the data extracted could not formally be considered quantitative as it would need a much larger set of samples, it is considered exemplar of how the research could be carried out. Yet, in order to transform the qualities into quantitative data and eradicate it from the construction of this particular settlement (such as lack of materials which influence for instance the sizes or their geometries), space

syntax tools were used. Space syntax is a methodology and set of tools, whose measures and distribution can be qualitatively translated into concepts of privacy and community (11). Particularly, the tool chosen at this level of analysis was the one of depth. Depth represents how many topological steps a space is distant from another, while their exact measurement is not relevant. This was developed according to five parameters, as in the following gradient: public (streets or squares); semipublic (f.i. shops or restaurants); functional spaces (f.i. Kitchens or workshops); services (f.i. Storage spaces or bathrooms); semiprivate (shared communal spaces); private (residential spaces). Depth can be seen from different point of views but here it has been chosen to always use the point of view of the public space in order to highlight this gradient but also the differences. The resulting diagrams reveal a complexity of connectivity, in which spaces are gradually moving towards the private areas but maintaining a high variegation and interconnectivity, aspects that the project yearned to reproduce.

Other cultural characteristics that were highlighted, that aimed at representing the conglomeration of the refugee society, reside in the functions present in Camp Calais. Most of these functions are those most likely to reflect points of intersection between different cultures. Others, instead, represent the obvious dissonance in the merging of the functions, for example when it comes to religion (both mosques and churches are present on site). Both these typologies, which range from more enterprise-based, such as spice shops or hammams, to religious ones and have emerged naturally as indications of the community needs. Others, furthermore, such as education or health facilities are

instead built by external actors, which highlights another important aspect: self-organisation eventually has to coexist with other organisational models.

1.2.1.1 DIFFERENT APPROACHES: ENABLEMENT, FACILITATION, ENCOURAGEMENT AND COERCION

For this reason, it is important to recognise the distinction between “enablement”, “facilitation”, “encouragement” and “coercion”. The latter is the approach that was adopted by the French State in building container houses that, as above-mentioned, did not consider the needs and wishes of the inhabitants and should not be replicated as such. “Enablement” and “facilitation”, on the other hand, express the desire of relenting parts of the design process to the user. The architect should then become a facilitator and the public the participant. Finally, “encouragement” calls for an approach in which the architect retains control of certain aspects, such as the introduction of education facility, in order to mitigate the negative aspects of the refugee society. In the case of Calais, one of such aspects can be explained with an analogy. When one volunteers’ association established “Sports Day”, they could observe the rift between the different ethnicities and communities in the camp. In order to promote inter-community sentiment, they introduced one simple rule: all teams had to be made up of different nationalities(12). This analogy contributed to the awareness that self-organisation is not necessarily the most beneficial balance to the community. In the case of the project here presented, such encourage-

ment should be applied to the aspect of integration with the welcoming society, which, in Calais, is not present.

A case where it is present, is instead that of the Vluchtmaat in Amsterdam, a self-organised community of refugees (also coordinated by volunteers's associations. This community, which took over a vacant building in the South-East of the city, lives side-by-side with several organisation or companies, hosted in the northern wing of building. Some of these organisations have a clear intent of engaging with refugees by offering job opportunities or volunteering, such as "Here to support" and "Atelier Chiara Scolastica Mosciatti". In this way, living and working for refugees are combined. Other organisations, while making the choice of settling here to support the project, do not engage the refugees, such as the Italian magazine +31Mag.nl . However, by paying the rent for their office space they cover many of the expenses of the building, which is part of a clear economic scheme to sustain the whole community.

1.2.2 CONCLUSIONS AND OBJECTIVES

Adding the conclusions of this research to the objectives outlined in the previous chapter:

REPRESENTATION OF CULTURAL CHARACTERISTICS

Gradient from public to private, high variegation and interconnectivity as representation of cultural characteristics; Public, semi public and semi private functions as representation of cultural characteristics

The project uses the analysis of Calais as representative of the refugee society, considered as the conglomeration of the different communities that is made of. More specifically, in order to create an objective indicator, it uses space syntax tools. The project should aim at reproducing its results, particularly the gradient from public to private, the high variegation and interconnectivity.

The functions chosen to promote employment should reflect those present in Calais, which are indicative of the functions that such society would need and wish for, and in the Vluchtmaat, which show the possibility of enabling and engaging with refugees while building an economic model that is advantageous for both the companies and refugees.

INTEGRATION OF THE USER

Customisation; interaction architect-user

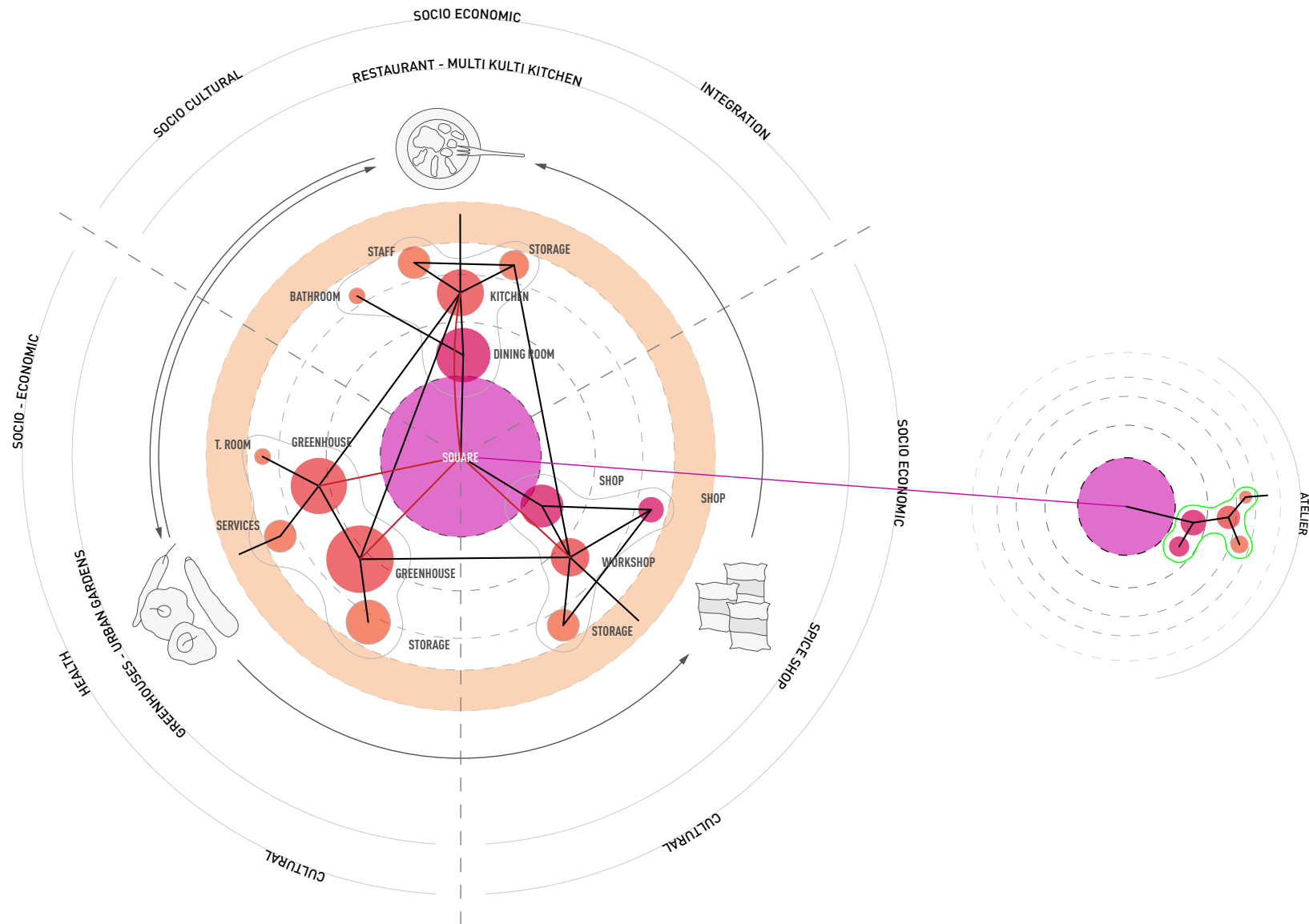
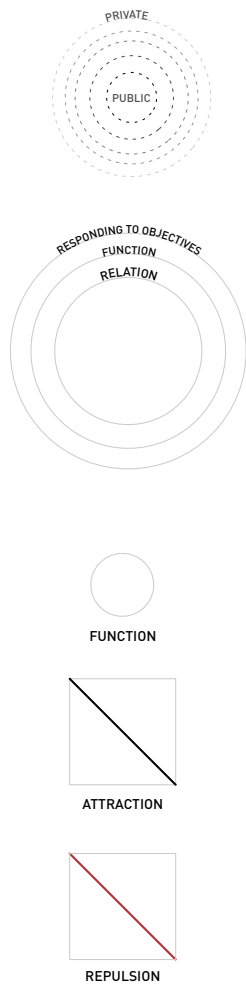
While the research in Calais show some of the functions and their characteristics, the aim would not be to copy-paste in the final project but rather let the entrepreneurial spirit of the refugees to be expressed. Additionally, the variegation of the society also calls for customised solutions for the individuals. For these reason, the architect should

facilitate and engage with the users and the community in the design so that they can have freedom to express their needs and wishes. He should consider the introduction of tools for enabling the participation of the user in the design process.

SOCIO-CULTURAL INTEGRATION

Functions for encouraging integration, best practices; the public spaces as spaces for integration

The research on Calais and the Vluchtmaat reasserted the need for building bridges, but this needs a clear motivating force, that is generally external. It therefore reasserted the need for the architect or volunteering associations to retain a degree of control for functions or spaces that could promote integration or bettering the conditions of the society.

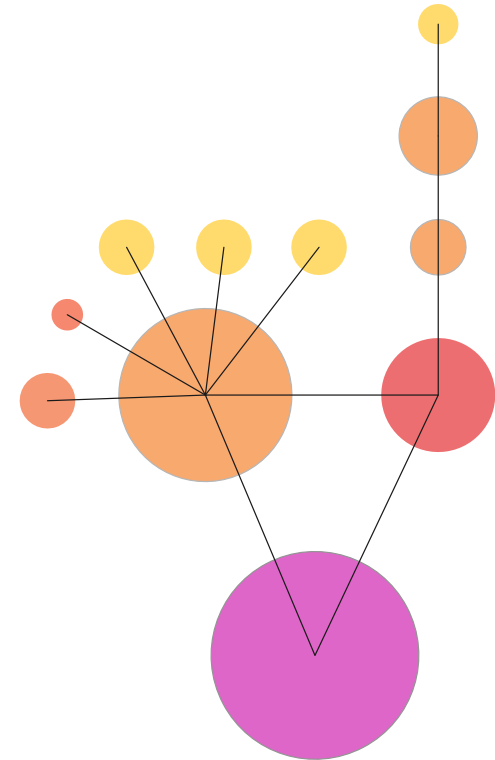


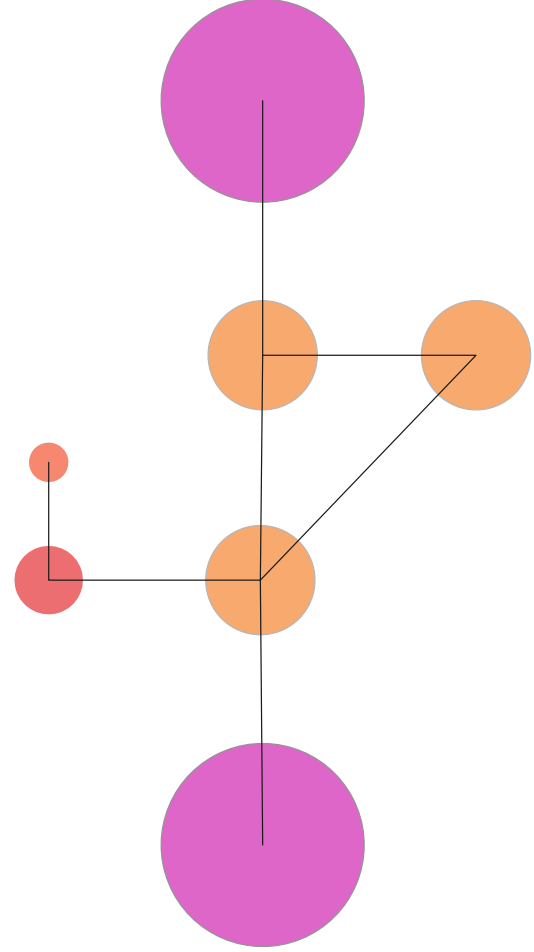
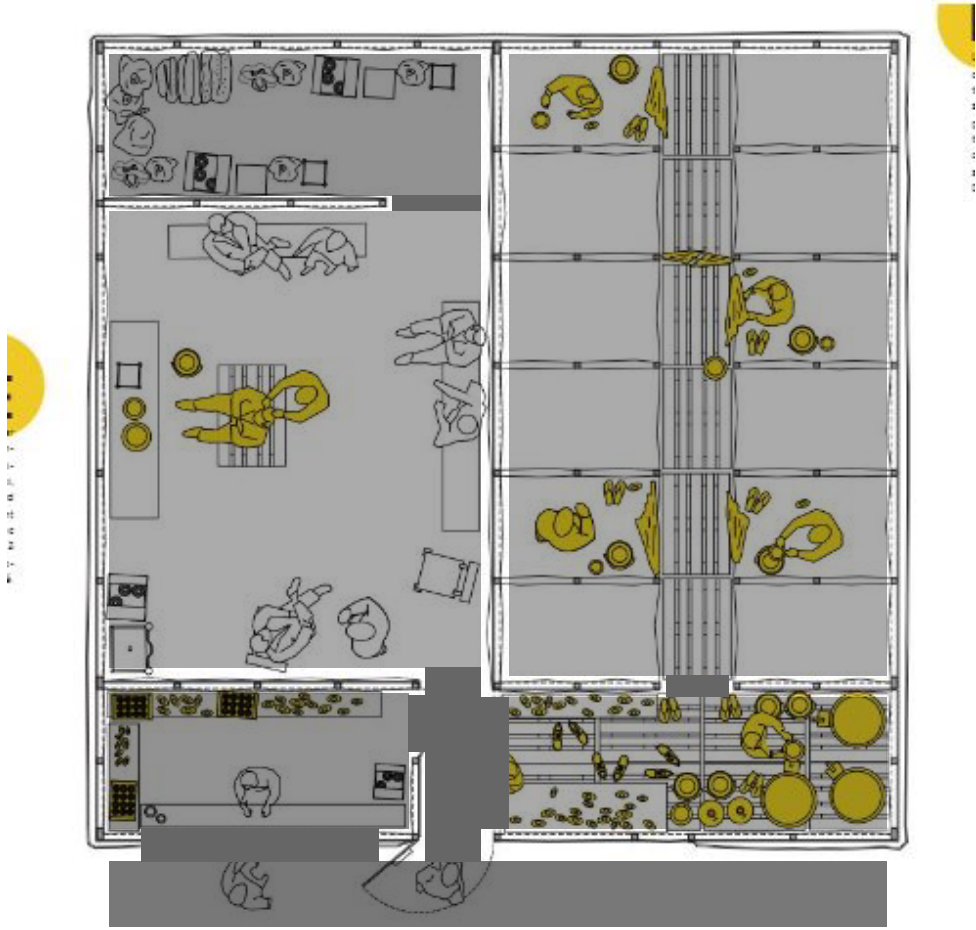
ils peuvent avoir du rat, il ne faut pas gêner
 et il y a aussi les habitants des containers,
 peuvent pas cuisiner alors ils ont fait...



YAC

bon du sud
 viennent via
 ils sont très
 pas de rats.

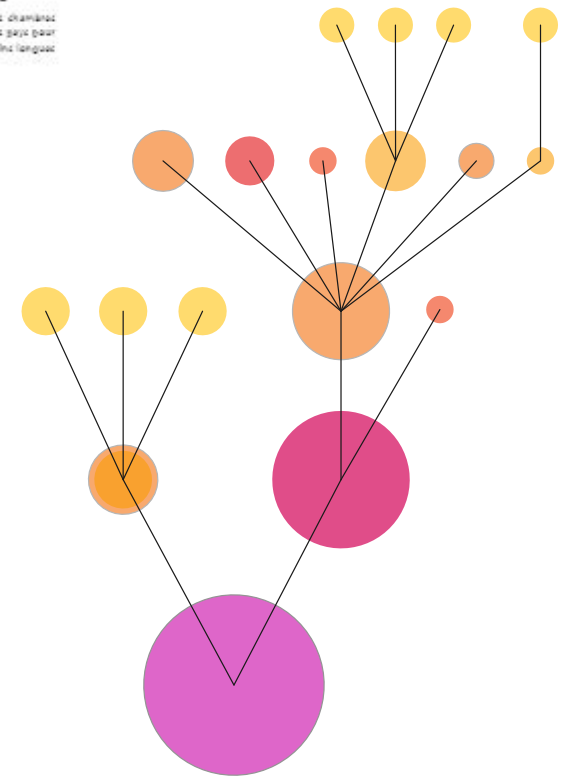
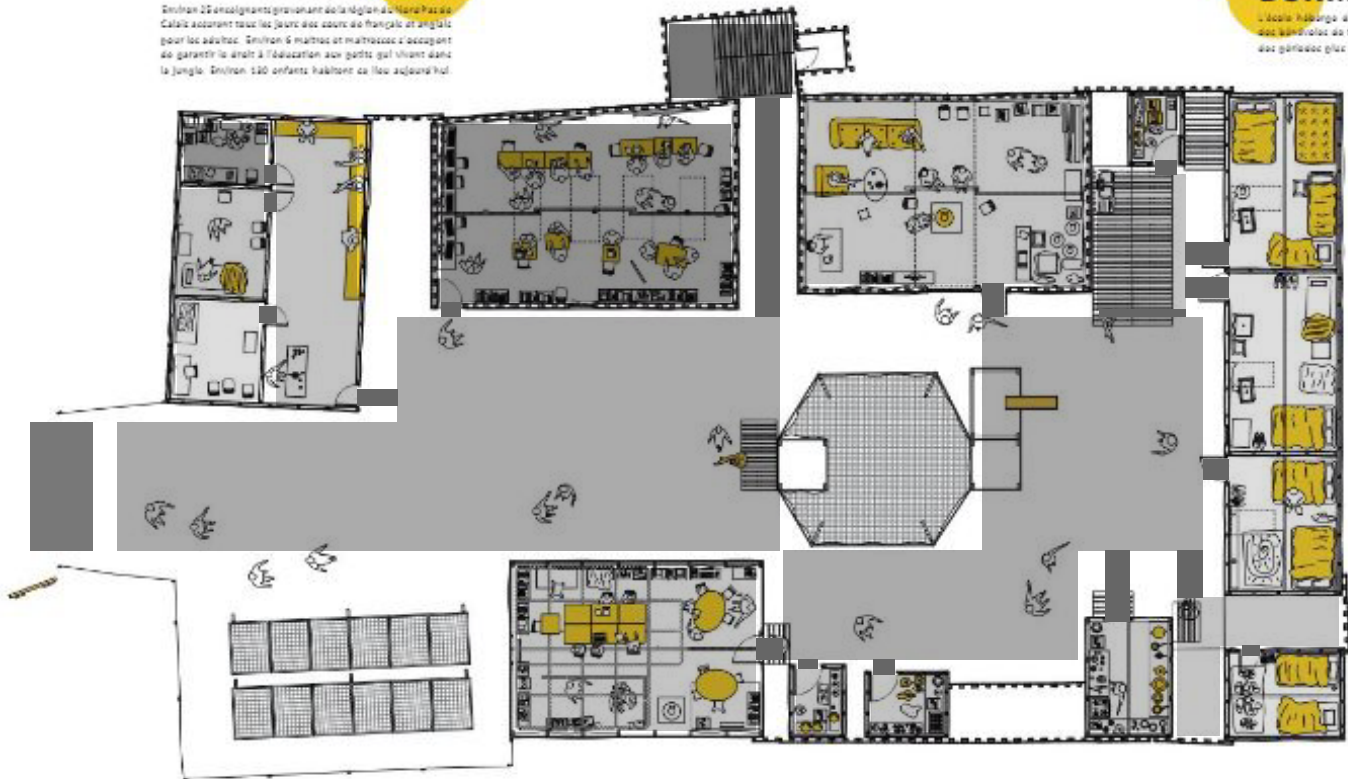




Environ 25 enseignants provenant de la région du Nord-Pas de Calais assurent tous les jours des cours de français et anglais pour les adultes. Environ 6 maîtres et maîtresses s'occupent de garantir le droit à l'éducation aux garçons qui vivent dans la jungle. Environ 120 enfants habitent de leur aujourd'hui.

DORMIR

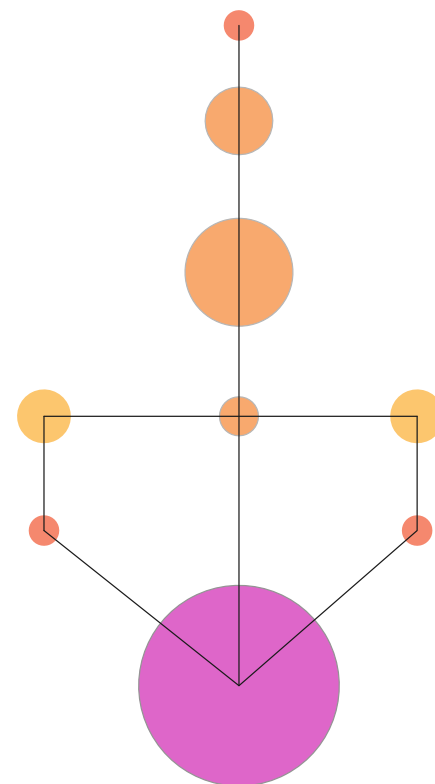
L'école héberge dans ses chambrées des dortoirs de tous les garçons pour des périodes plus ou moins longues.

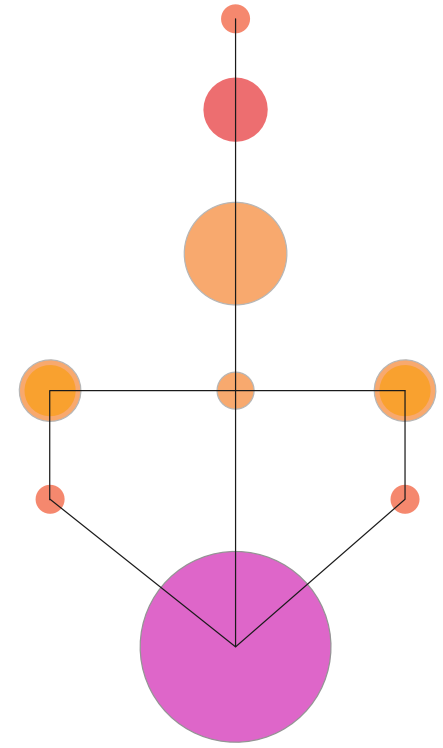


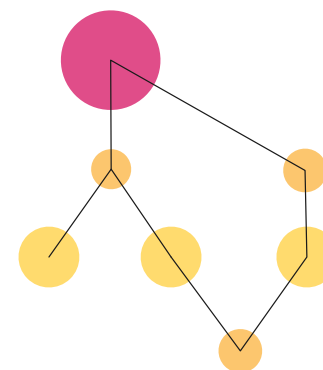
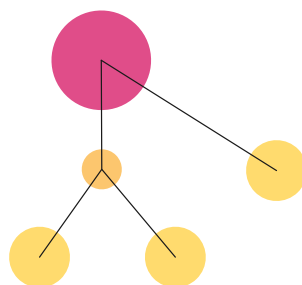
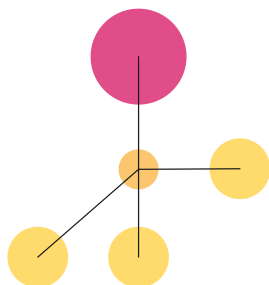
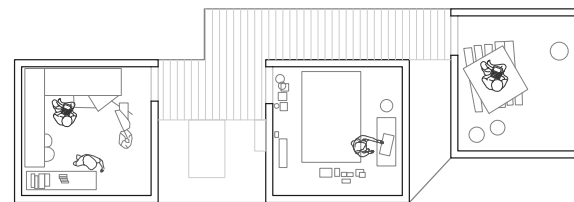
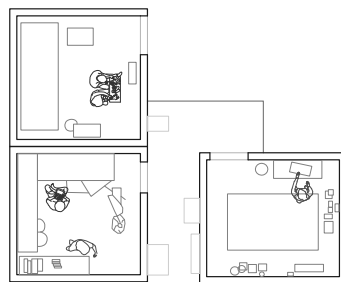
■ White Mountain, dont le nom (les nom-
montagnes d'Afghanistan) est inauguré

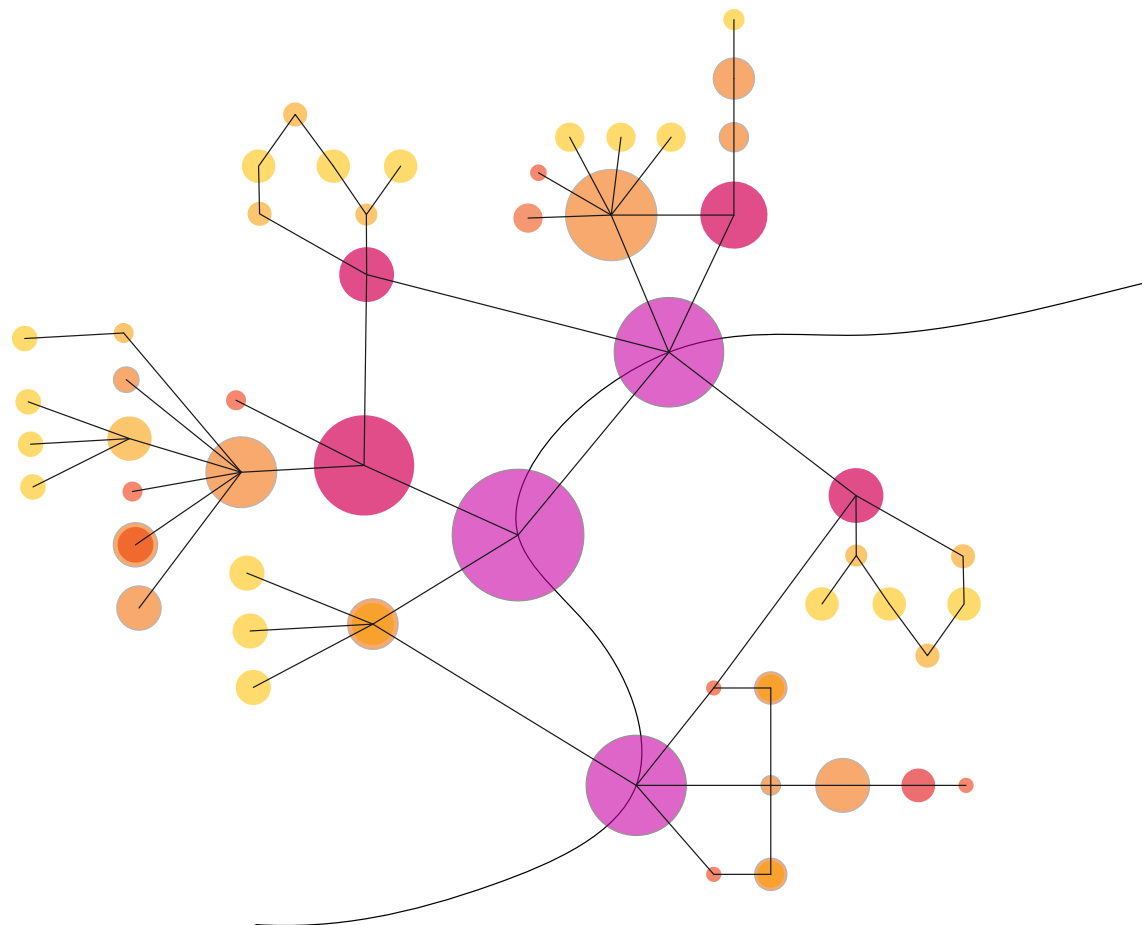


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HUISKAMER

restaurant de Vluchtmaat



Come the **20th of October** to enjoy the
hospitality and a delicious meal
at the **HUISKAMER**
restaurant de Vluchtmaat.

Joan Muyskensweg 32, 1114 AN Amsterdam Duivendrecht.



1.3 INCREMENTAL HOUSING: HOW CAN ARCHITECTURE FACILITATE SELF-ORGANISATION?

While Calais was useful in outlining particular aspects of this society, it also highlighted some major deficiencies. A system that is unrestrained in its development would not succeed. This is also extended to the construction of basic services of any urban development. The question that arose was: how to reintroduce a certain level of control while facilitating the user?

In order to answer this, architectural precedents in this field were analysed. The first, and most important, was Incremental Housing, an “affordable way to rapidly resettle families” that is conceived as a process rather than a final design^[13]. This process usually begins with a starter core and is, step-by-step, incremented to a full house by the inhabitants themselves, according to their needs and resources. A variety of approaches exist, from the core as one or more units (f.i. A kitchen or a bathroom) to the core as a lot with separating walls with utility connection potential. This core is, however, what exerts the control to guarantee a more organised development, while granting freedom in the next design phases.

Aravena, possibly the most known representative of Incremental Housing, adopts an approach with a high architect control. His designs often feature a half-built building, while the other half is left to the user to complete. In this way, “expansion happens thanks to the design and not despite it (...), so that we get a customisation instead of deterioration of the neighbourhood”^[14]. And, in fact, the approaches with little initial control have been demonstrated to have a detrimental effect on the final urban environment due to the lack of rules. Therefore, in Incre-

mental Housing, expansion should happen within certain limits, while the infrastructure should have been already built.

Finally, Incremental Housing also comprises teaching the inhabitants how to build their houses. This is often made through workshops and construction manuals.

Another example of self-organisation is the “Smart Price Houses”, developed by IBA Hamburg. The company only realises a basic structure, which contains the basic infrastructure. The future inhabitants finish the building themselves, with their own preferred layout and finishings. Variations happen in the amount and topology of volumes and voids. The company continues to offer support throughout the construction with publications of construction manuals, possible typologies and specialist help.

1.3.1 CONCLUSIONS AND OBJECTIVES

The conclusions of this research added to the conclusions so far:

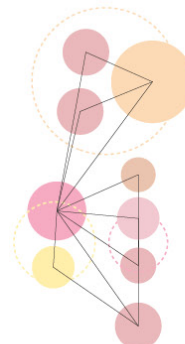
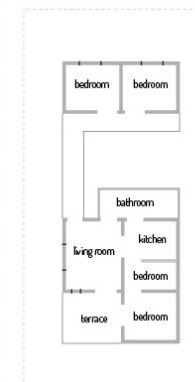
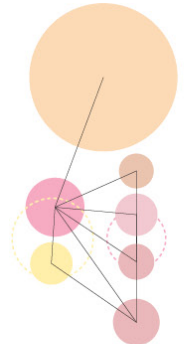
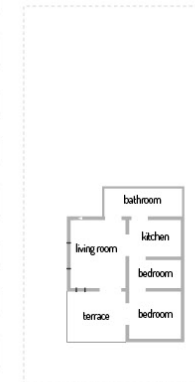
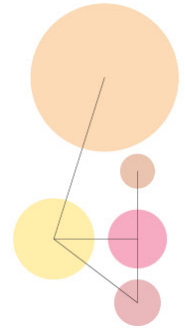
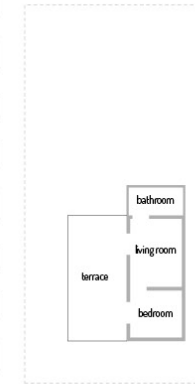
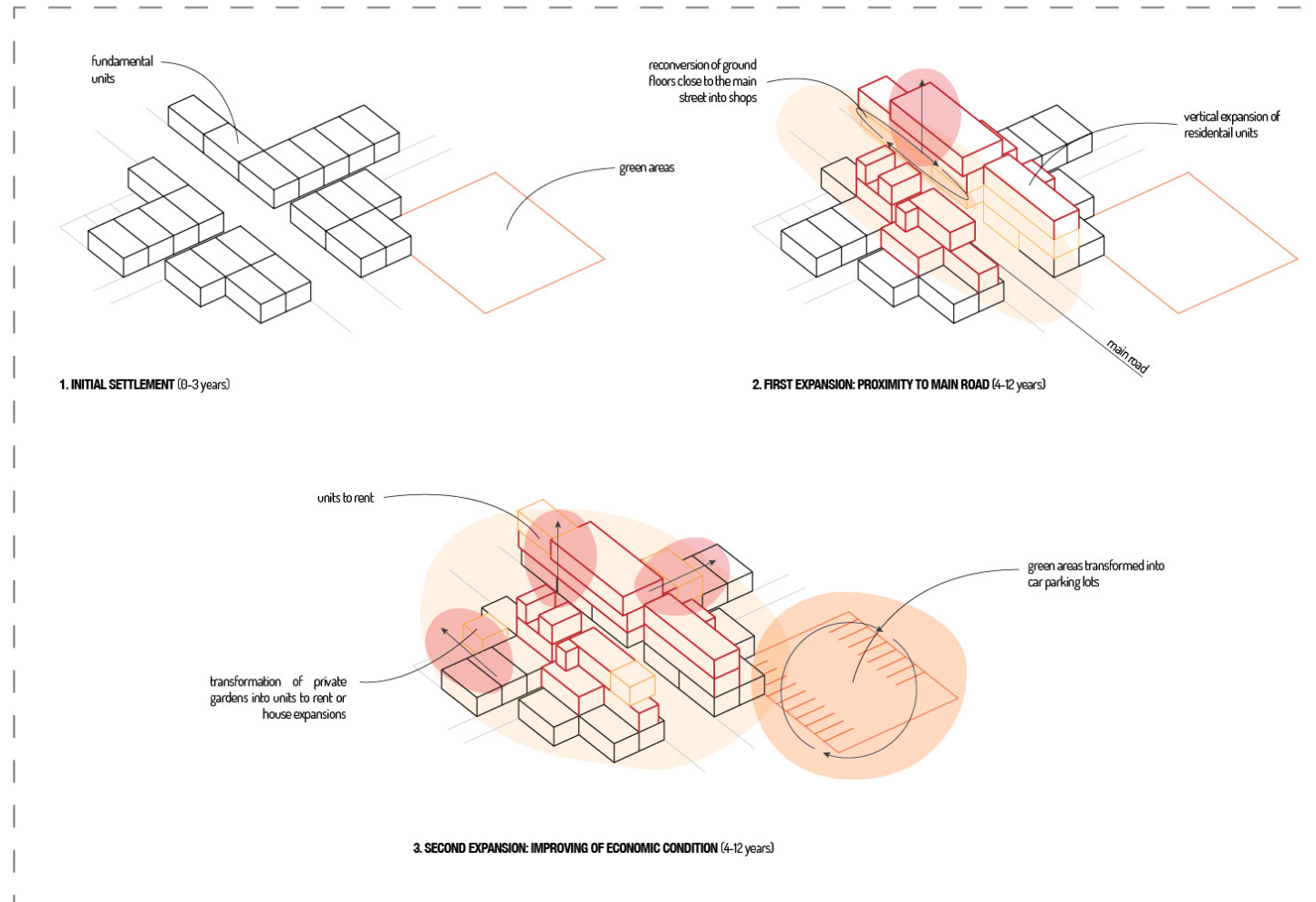
INTEGRATION OF THE USER

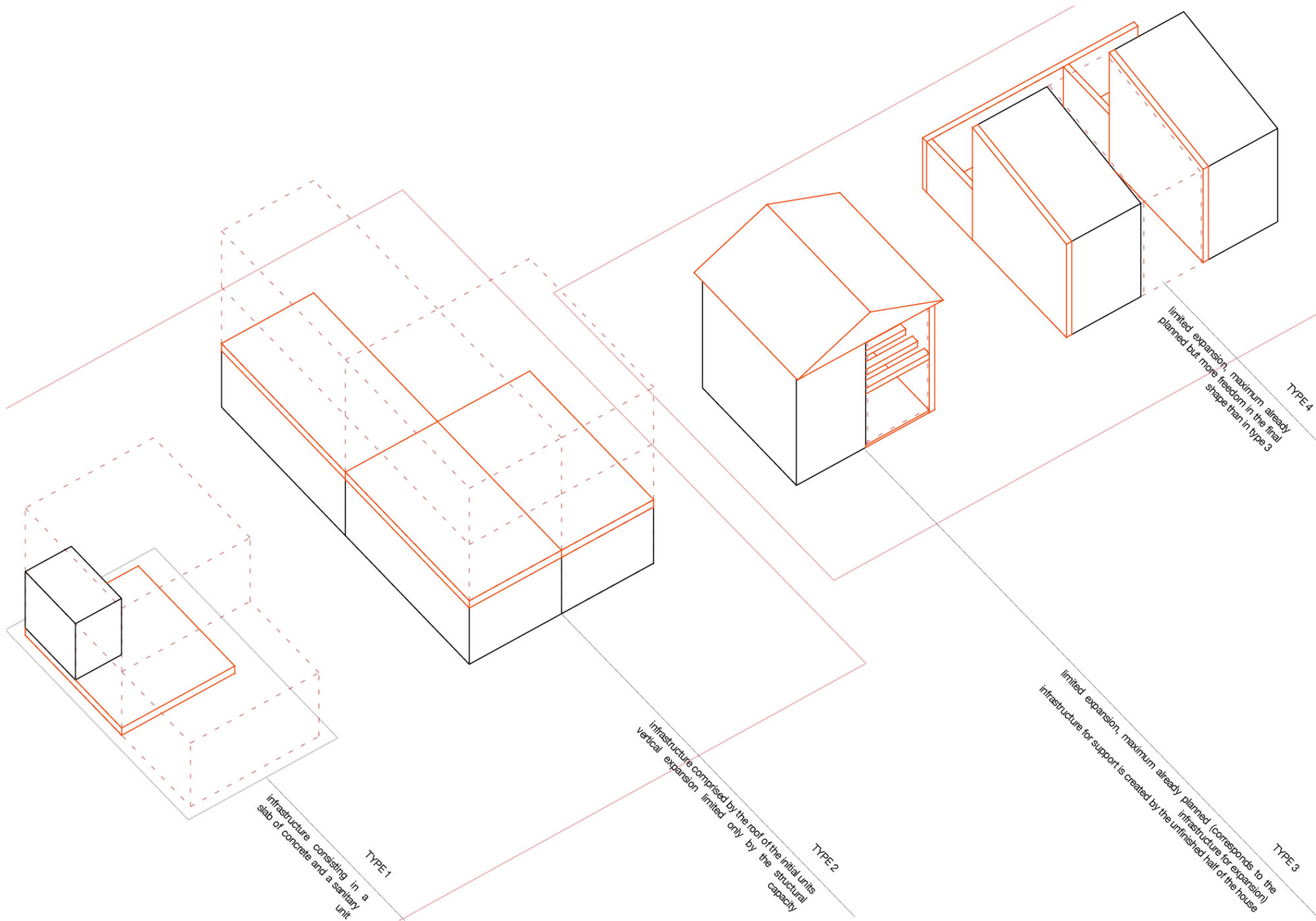
Defining limitations; fabrication directives

The research on Incremental Housing, however demonstrated the importance of establishing limitations to this freedom. The basic structure and infrastructure should be put in place by the architect, while the freedom can be maintained at the level of the layout. It also calls for the introduction of a system that considers fabrication and how this could be taught to the inhabitants, particularly through the production of a fabrication manual and workshops.



REFERENCE: INCREMENTAL HOUSING





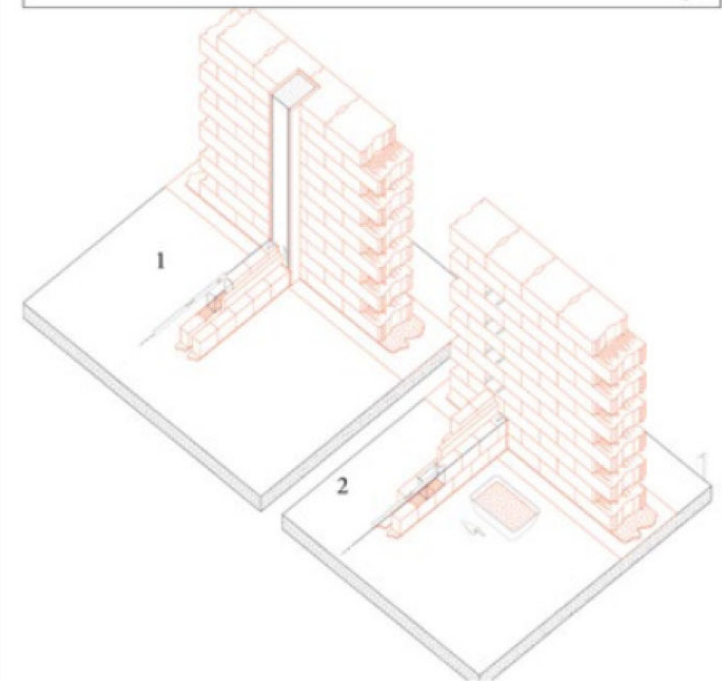


Smart Price Houses by IBA Hamburg

2.2

Die Außenwand - Wohnungstrennwand F90 A

Stand: 12/2012



Mauwinkel



Zellstock



Säge und
Nägel



Mörtel



Mörtelkelle und
Gummihammer



Wasserwaage



Dünnbettmörtel-
schlitten



Sigewinkel



Säge



Mauerverbinder



Akkschrauber



Hammer

Link: <http://www.ytong-silka.de/de/content/1189.php>

Literatur: Xella Baubuch 2011/2012 S. 211-215

1.4 THE SEARCH FOR A SITE CASE: THE MARCONI TOWERS

An aspect of the Dutch built-environment is the rising number of vacant office buildings. This growth accelerated at the turn of the century and received a further stimulus with the 2008 financial crisis. It is calculated that around 30 percent of office buildings in the Netherlands are currently vacant, the largest portion (around 50 percent) in the Randstad region. Since several reports have called attention to the shrinking supply of housing and specifically social housing in the Netherlands, it was decided to tap into this resource.

The decision fell upon the city of Rotterdam, possibly the Dutch city most open to innovation and transformations. More specifically, the complex of the three Marconi Towers on the western side of the city is the case site. Built in 1975, they were used for several tertiary functions, particularly offices, except for the eastern one, which accommodates the Rotterdam Science Centre. The two western towers lay vacant, particularly after the Municipality of Rotterdam moved its offices to Wilhelminakade.

The Marconi Towers offer several possibilities. Firstly, part of the infrastructure, such as the lifts' core and its structure would be reused, which would facilitate its construction, especially of residential areas. Secondly, it is part of a hub of innovation. And many of the startups or enterprises surrounding the towers already offer workshops on innovative or traditional technologies. Two, in particular stood out: Buurman, a shop and workshop that upcycles wood from construction sites, and m4h, that uses robots in construction. This offered the opportunity of integrating these resources into the project, as one of the objectives is

that refugees would participate in the construction and workshops is one of the methods for teaching. Thirdly, they comprise large floor areas that enable the possibility of creating coexisting public and private spaces. This last concept relates to that of a Vertical City, an evolution of what I have previously described as city-in-the-city.

By including a diversity of spaces and functions the tower would appeal to a large variety of people, which would facilitate the encounter between them and refugees. For the inhabitants, refugees and locals, the convenience would lie in being able to live, work and shop within the same area. This convenience means that the need for transportation is reduced and, in turn, so would be the environmental impact.

1.3.1 CONCLUSIONS AND OBJECTIVES

The conclusions of this research added to the conclusions so far:

SOCIO-ECONOMIC INTEGRATION

Changing the function of the building: a vertical city

Not only the functions should create job opportunities but they should create an engaging space which would be inviting to external people so that the public and semi public spaces can become a place for everyday meeting and integration. In order to do so, the concept of the city-in-the-city is updated to that of a Vertical City, which would improve the existing building for living and have a sustainable effect on the city itself.

INTEGRATION OF THE USER

Defining limitations

In the case of the Marconi Towers, limitations are already present, as the existing structure and infrastructure will be reused. In this case, it was then decided to adopt the approach of the lots with separating walls, which are defined according to the required square metres in the negative space of the public and semipublic areas.



ARCHITECTURE

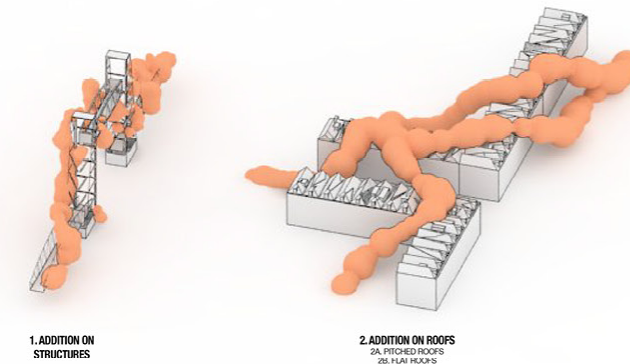
- Not weather resistant
- Pre-existing stable structure; addition can be heavy
- No problems with creating shadows on existing context but existing windows should be considered

SOCIETY

- Could become a hub of interconnection between locals and refugees
 - Large communal areas
- Fewer possibilities of green areas apart from the roof

EXPANSION

- Possibility of quick expansion and easy hacking thanks to pre-existing structure



ARCHITECTURE

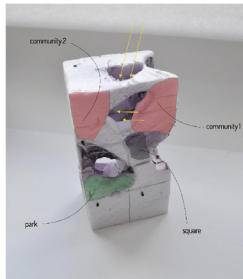
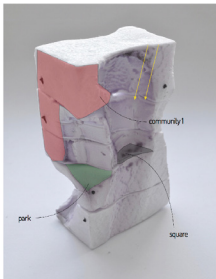
- Needs to be weather resistant
- Weight (flat roofs: medium; structures: medium -light; pitched roofs: light)
- Problems with creating shadows on existing context

SOCIETY

- Fewer possibilities of creating connections with the urban fabric
- Possibility of creating green areas

EXPANSION

- Strongly depending on the context



(top) diagram showing the different researches that were initially carried out in order to understand which urban space to use as a case study. (left) initial studies on the possibilities to use a tower as a vertical city

1.5 PARAMETRIC ARCHITECTURE, COMPUTATIONAL ARCHITECTURE, TECHNOLOGY: WHAT HELP CAN THEY PROVIDE?

This project started as an exploration into how to reconnect the field of architecture I am studying, parametric and computational architecture, with the objectives resulting from the research. In particular, how to integrate the user into the design process and translate the information into objective data. One of the processes of this translation has already been described, that is space syntax, aiming at translating cultural and societal data into parameters.

The research so far demonstrated the complexity of responding to the refugee crisis and the many dimensions it encompasses. Not only should it deal with the process of welcoming refugees but also with social, economic and cultural aspects. Moreover, it highlighted the variation of the refugee society(ies), which calls for customised solutions. The advantage of using parametric architecture in such a context would be that, by using parameters, such different factors could be integrated in a unique solution and, by changing the initial parameters, it would be able to change and adapt, tailoring its solutions. More specifically, it would be able to include in this process a series of architectural requirements (f.i. Space syntax or light).

In the specific case of self-organisation this would mean the user itself would be able to input the data. Whenever the user changes this initial data, the parametric system will create new variations, while checking that they respond to objective architectural requirements.

Additionally, the research on Incremental Housing delineated one of the objectives as providing information on the production techniques. A parametric framework has the possibility of reconnecting different

scales, from design to fabrication, into a unique process. Every time a new variation is created, all the information and requirements are calculate and included up to production.

Yet, it would be impossible to think of every variation possible so feedback from the user would need to be re-iterated in the design process: problem formulation and solutions always evolve together. How to get such feedback? As architects we are accustomed to looking at a design through renderings, sketches or physical models and interpreting how a building would look and feel spatially as a finished project. The same is not necessarily true for the users, who are not designing on a daily basis. Assuming that for the users the best way to understand a space is by looking and feeling it in 1:1 scale, what representation and communication tools can we use?

An emerging technology allows exactly this and that is Virtual Reality (VR). VR is a computer-generated environment that, to the person experiencing it, closely resembles reality (Collins Dictionary, 2014). As opposed to “viewing”, some define VR as “experiencing” because it is three-dimensional. Burdea and Coiffert describe VR as a “technology that adds the dimensions of immersion and interactivity to three-dimensional computer-generated models allowing explorations that is not possible with the traditional forms of representation”(15). The advantages of VR technology in designing has been noted before, as Wang explains: “Beyond allowing the addition of virtual entities to real-world views, VR technology enhances collaboration among members of design teams”(16). Yet, it must be noted that VR is not perfect

and the technology that have up to now still evokes a certain degree of surreality.

Through VR the user will be able to experience the space and give a feedback that will be interpreted and supplied back to the parametric framework, creating new variations. Eventually, enough feedback will be built for creating a parametric framework that allows the users to try different options and choose them to their liking.

A third subject that is part of the field of architecture I am studying is Robotic Building. The existence of the technology hub near the towers already highlighted the possibility of creating another set of skills for the refugees through robotic fabrication, which will be the preferred method of production.

1.3.1 CONCLUSIONS AND OBJECTIVES

The conclusions of this research added to the conclusions so far:

SOCIO-ECONOMIC INTEGRATION

Changing the function of the building: a vertical city

Not only the functions should create job opportunities but they should create an engaging space which would be inviting to external people so that the public and semi public spaces can become a place for everyday meeting and integration. In order to do so, the concept of the city-in-the-city is updated to that of a Vertical City, which would improve the existing building for living and have a sustainable effect on the city itself.

TAILORING THE SOLUTIONS - INTEGRATION OF THE USER

Parametric architecture: interaction design-user, from design to fabrication

The research so far demonstrated the complexity of responding to the refugee crisis and the many dimensions it encompasses. Not only should it deal with the process of welcoming refugees but also with social, economic and cultural aspects. Moreover, it highlighted the variation of the refugee society(ies), which calls for customised solutions. The advantage of using parametric architecture in such a context would be that, by using parameters, such different factors could be integrated in a unique solution and, by changing the initial parameters, it would be able to change and adapt, tailoring its solutions. More specifically, it would be able to include in this process a series of architectural requirements (f.i. Space syntax or light). The objective is, therefore to create a parametric process that is able to integrate these parameters and offer specific solutions.

The integration of the user in the design process will happen thanks to the use of parametric and computational frameworks. framework that responds to a series of architectural requirements (f.i. Space syntax or light), while including data that can be modified by the user. Whenever the user changes this initial data, the parametric system will create new variations, while checking that they respond to objective architectural requirements.

Additionally, a parametric framework has the possibility of reconnecting different scales, from design to fabrication, into a unique process. Every time a new variation is created, all the information and requirements are calculate and included up to production.

Virtual Reality: interaction design-user

Through Virtual Reality the user will be able to experience the space and give a feedback that will be interpreted and supplied back to the parametric framework, creating new variations. Eventually, enough feedback will be built for creating a parametric framework that allows the users to try different options and choose them to their liking.

1.6 FINAL CONCLUSIONS AND OBJECTIVES

1.6.1 INFRASTRUCTURE TO WELCOME REFUGEES

Reduction of stages of reception centres; smooth transition between asylum seeker - refugee - citizen

Humanise the asylum process by reducing the number of times a refugee or claimer is transferred to different reception centres. This allows for retention of a community feeling and offer the opportunity of feeling of permanency longed by refugees.

The transition period between asylum-seeker, refugee and citizen has been identified as highly problematic, particularly “because of the urgency with which refugees have to leave reception centres or supported accommodation and the sudden possibility of everything now being able to start. This issue is rarely addressed specifically in integration related discourse but has considerable impact on refugees, their integration and the support that is able to be provided to them”(17).

1.6.2 REPRESENTATION OF CULTURAL CHARACTERISTICS

Gradient from public to private, high variegation and interconnectivity as representation of cultural characteristics

The project uses the analysis of Calais as representative of the refugee society, considered as the conglomeration of the different communities that is made of. More specifically, in order to create an objective indicator, it uses space syntax tools. The project should aim at reproducing its results, particularly the gradient from public to private, the high variegation and interconnectivity.

Public, semi public and semi private functions as representation of cultural characteristics

The functions chosen should reflect those present in Calais, which are indicative of the functions that such society would need and wish for.

1.6.3 SOCIO-ECONOMIC INTEGRATION

Housing, building and active participation: a unique solution

The construction of new housing should be combined with the need of employment and lifelong learning. This can happen during the stay at the reception centre. Refugees would work on the construction of their housing themselves and/or would help in the designing - that could be a form of training that would help them earn a diploma and prepare them for a job, a form of active participation or, more simply, a form of being able to jump on the housing ladder.

Public and semi public functions for employment

Opportunities for employment should however be wide ranging in order to empower refugees to access working opportunities in accordance to their wishes. A variety of functionalities should be integrated in the development, so that these could become new job opportunities. In this way, the new construction should become a small city-in-the-city and its opportunities guarantee a smooth transition once the asylum protection ends. The functions chosen to promote employment should

reflect those present in Calais, which are indicative of the functions that such society would need and wish for, and in the Vluchtmaat, which show the possibility of enabling and engaging with refugees while building an economic model that is advantageous for both the companies and refugees.

Public semi public function for psychological relief; materiality

Psychological relief and health can be promoted through the careful selection of functions, such as urban gardens and the feeling of the space, that is its materiality.

Changing the function of the building: a vertical city

Not only the functions should create job opportunities but they should create an engaging space which would be inviting to external people so that the public and semi public spaces can become a place for everyday meeting and integration. In order to do so, the concept of the city-in-the-city is updated to that of a Vertical City, which would improve the existing building for living and have a sustainable effect on the city itself.

1.6.4 TAILORING THE SOLUTIONS - INTEGRATION OF THE USER

Parametric framework integrating architectural knowledge and allowing for customising solutions

The research demonstrated the complexity of responding to the refugee crisis and the many dimensions it encompasses. Not only should it deal with the process of welcoming refugees but also with social, economic and cultural aspects. Moreover, it highlighted the variegation of the refugee society(ies), which calls for customised solutions. The advantage of using parametric architecture in such a context would be that, by using parameters, such different factors could be integrated

in a unique solution and, by changing the initial parameters, it would be able to change and adapt, tailoring its solutions. More specifically, it would be able to include in this process a series of architectural requirements (f.i. Space syntax or light). The objective is, therefore to create a parametric process that is able to integrate these parameters and offer specific solutions.

Customisation; interaction architect-user

While the research in Calais show some of the functions and their characteristics, the aim would not be to copy-paste in the final project but rather let the entrepreneurial spirit of the refugees to be expressed. Additionally, the variegation of the society also calls for customised solutions for the individuals. For these reason, the architect should facilitate and engage with the users and the community in the design so that they can have freedom to express their needs and wishes. He should consider the introduction of tools for enabling the participation of the user in the design process.

Defining limitations; fabrication directives

The research on Incremental Housing, however demonstrated the importance of establishing limitations to this freedom. The basic structure and infrastructure should be put in place by the architect, while the freedom can be maintained at the level of the layout. It also calls for the introduction of a system that considers fabrication and how this could be taught to the inhabitants, particularly through the production of a fabrication manual and workshops.

In the case of the Marconi Towers, limitation are already present, as the existing structure and infrastructure will be reused. In this case, it was then decided to adopt the approach of the lots with separating walls, which are defined according to the required square metres in the negative space of the public and semipublic areas.

Parametric architecture: interaction design-user, from design to fabrication; Virtual Reality

The integration of the user in the design process will happen thanks to the use of parametric and computational frameworks. A framework that responds to a series of architectural requirements (f.i. Space syntax or light), while including data that can be modified by the user. Whenever the user changes this initial data, the parametric system will create new variations, while checking that they respond to objective architectural requirements.

Additionally, a parametric framework has the possibility of reconnecting different scales, from design to fabrication, into a unique process. Every time a new variation is created, all the information and requirements are calculated and included up to production.

Through Virtual Reality the user will be able to experience the space and give a feedback that will be interpreted and supplied back to the parametric framework, creating new variations. Eventually, enough feedback will be built for creating a parametric framework that allows the users to try different options and choose them to their liking.

1.6.5 SOCIO-CULTURAL INTEGRATION

Functions for encouraging integration, best practices; the public spaces as spaces for integration

Offering spaces for learning the language and education, in particular those that can help in acquiring skills. “Building bridges” is also essential: firstly, it is concerned with the building of public and semi-public spaces that should guarantee the meeting of people from different backgrounds. In this sense, the concept of city-in-the-city should be expanded to include areas that can attract people, by the use of functions and by creating an interesting space. In order to build bridges, a

variety of refugees and locals should inhabit the building. In this way, the solution can also potentially help the Netherlands to better deal with its existing housing shortage. Finally, the meeting between different cultures should be encouraged through specific functions, such as sports hall (which help the younger generations to connect) and events which are meant to foster integration. For this, the list of best practices compiled by the European Commission was used as a reference (18). The research on Calais and the Vluchtmaat reasserted the need for building bridges, but this needs a clear motivating force, that is generally external. It therefore reasserted the need for the architect or volunteering associations to retain a degree of control for functions or spaces that could promote integration or bettering the conditions of the society.

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02

THE DESIGN

2.1 MACRO²

2.1.1 HOW TO REUSE AN EXISTING BUILDING INTO A VERTICAL CITY: FORM FINDING

The public and semi-public functions that were initially defined were classified according to the parameters of an agent-based system. The three parameters that are used in agent-based design are: repulsion (two agents i.e. functions should not be close to each other), alignment and cohesion (both indicating that the functions should be close). Additionally, another parameter is considered: indifference (when the relation between the two functions is unimportant). These parameters are chosen for each relation and compiled in an excel file according to functionality, disturbance/privacy, equal distribution and closeness to the facade.

- Functionality = cohesion: Semi-public spaces such as restaurants and bars should have access to the public areas, namely squares and parks
- Disturbance/privacy = separation: Some semipublic functions (f.i. education) that require more privacy should not be next to the main areas but rather the streets
- Equal distribution: semipublic and public areas should not be repeated in the same area but equally distributed throughout the building
- Closeness to the facade: The largest functions in size are pushed towards the boundaries of the tower, that is the facades, and away from the lifts of the building (which are maintained as a perpendicular mobility) . In this way large openings can be made into the

facade to allow for penetration of sun into the core of the building.

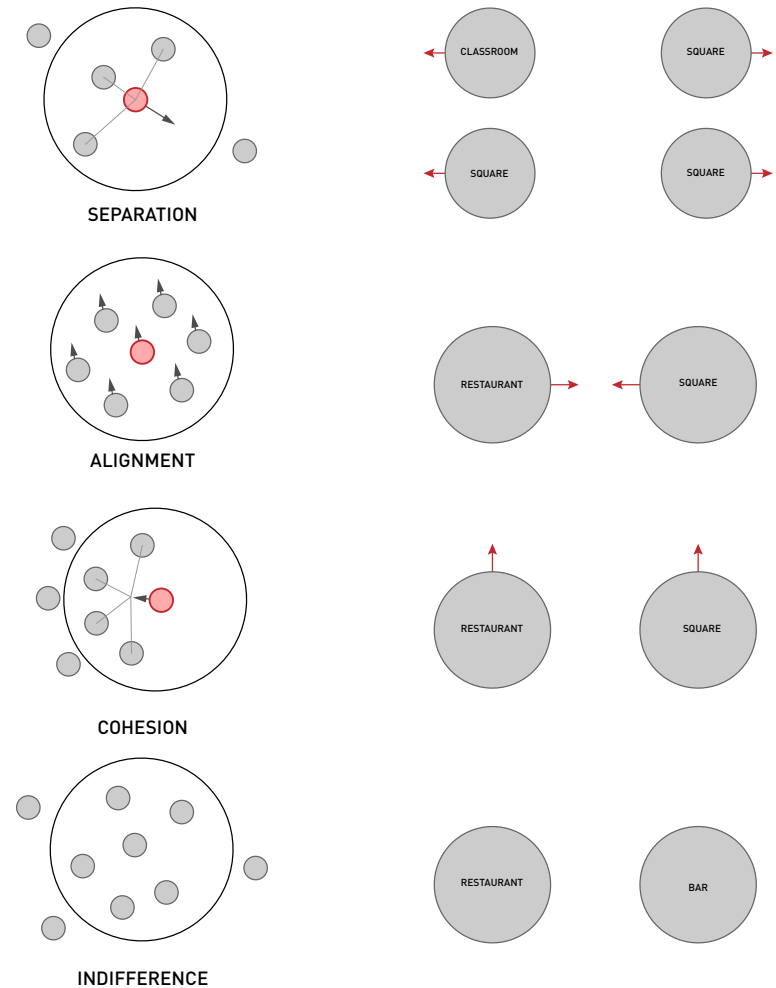
The paths i.e. the streets between the different spaces are then calculated in relation to the initial scheme of cohesion and optimised according to the principles of minimal path network, which denotes the shortest connections between the sets of nodes. The results are then used to carve from the existing set of floors in order to create the internal streets and public spaces.

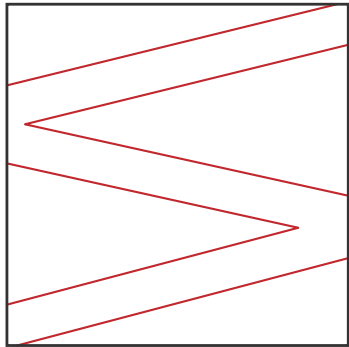
Since agent-based systems do not give a definite result but a variations of results, a second step uses a control system to define the selection and optimisation. In particular, this is done through sun analysis and path inclination to choose the best solution among the variations. As a result of the two optimisations, a further equal distribution measure is maintained. In fact, the sun analysis optimisation alone would select only those variations with a disproportionate number of openings to the south but these would have a very steep path inclination, not ideal for circulation and the concept of Vertical City.

A second process is then used to create the additions, which will be described in the next chapter. These additions, the semipublic spaces, will not be placed everywhere along the internal streets and public spaces, which are then either open to the facade (the majority of cases) or completely internal. This allows for spaces that are both internal and external. When the streets are open to the facade, the facade is offsetted to

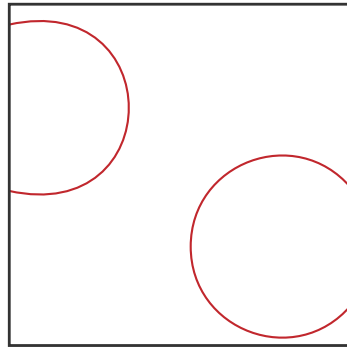
the private areas and the street becomes an outdoor street, whereas when additions are present, the facade is offsetted to the semi-public areas, therefore creating square or parks that remain indoors. In this way, the idea of the Vertical City is implemented by creating a variety of spaces that recreate different parts of a city.

2.1.2 A GROWING TOWER

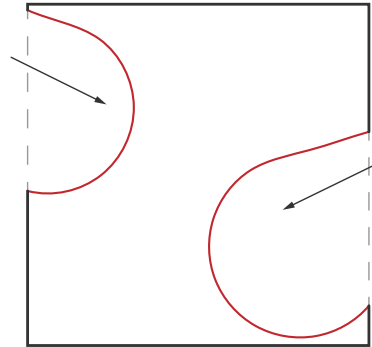




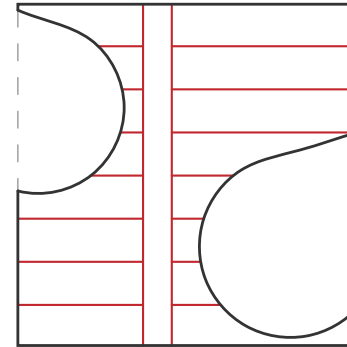
VOID AS CIRCULATION



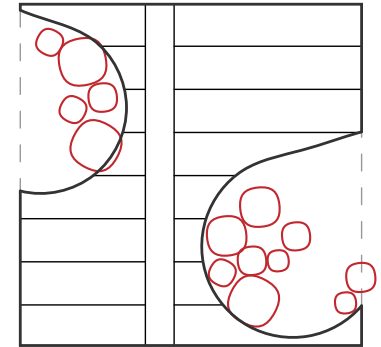
VOID AS PUBLIC SPACES AND
GREEN INTERIORS



VOID FOR LIGHT PENETRATION



EXISTING AS STRUCTURE, INFRA-
STRUCTURE AND RESIDENTIAL



ADDITIONS AS SEMI PUBLIC
SPACES

2.2 MACRO: THE GRADIENT FROM PUBLIC TO PRIVATE

2.2.1 REFORMULATING THE REQUIREMENTS

A second process is then used to create a differentiation of internal spaces, that is the addition. While in the first form-finding method, the spaces were defined only through their volume, by zooming into three floors, their spatiality is now redefined as a sequence of spaces. For instance, a restaurant is now revealed into its different functions: the kitchen, the dining room and the service rooms.

Similarly to the principles of attraction and repulsion that were used before, the broken-down functions are relocated in the space volume with those most public close to the square. The square is, instead, maintained in place as a carved entity. Eventually, the connections between the different spaces at this level are kept but redefined according to the new subspaces. For instance, The storage of the kitchen should be connected to the greenhouse so that produces can be exchanged. However, the connection between these two spaces does not have to be direct (as it would be with a bridge) but through a series of intermediate spaces. This means that instead of going directly from A to B, the connection will be A-C-D-B (the difference in length of these connections would be minimal as the area is limited). Obviously, this connections would anyway to respect those defined as repulsion in the previous step. Yet, this configuration will maintain a high interconnectivity, that ultimately guarantees a continuous circulation and exchange throughout the building. This would favour contact with people of the community and foster a sense of community. A third parameter that

was introduced from the research was that of not creating a physical barrier. However, since the space is going to be much more public than that of Calais, there was a need to maintain a certain level of privacy. By redeveloping the psychological relief requirement additional parameters were created. Neuroscientist Colin Ellard recommends the development of a “plethora of unique and lively buildings (...) as the holy grail in urban design is to produce some kind of novelty or change every few seconds, otherwise, we become cognitively disengage”(19). Such disengagement is undesirable from a psychological perspective: studies conducted by Merrifield and Danckert suggest that even small amounts of boredom can actually induce stress”(20).

Kaplan defines four principles that he believes “increase an individual’s preference for a specific environment”(21).

- Coherence: the degree to which an environment is organised as a whole.
- Legibility: the degree of distinctiveness through which the viewer is able to categorise the contents of the scene
- Complexity: the variety and number of elements to a scene
- Mystery: the amount of hidden information a scene contains

2.2.2 FORM FINDING: THE GYROID

The form-finding method that is here implemented is a minimal surface, that in mathematics is a surface that locally minimises its area. The specific type of minimal surface is the gyroid, an infinitely connected periodic minimal surface that contains no straight lines (Osserman 1986) that was discovered by Alan Schoen in 1970. In nature, it has been observed, for instance, in biological structural coloration of butterfly wings. It has been used in several engineering fields to turn bio-dimensional materials, such as graphene, into a three-dimensional structural material with low-density, yet high tensile strength.

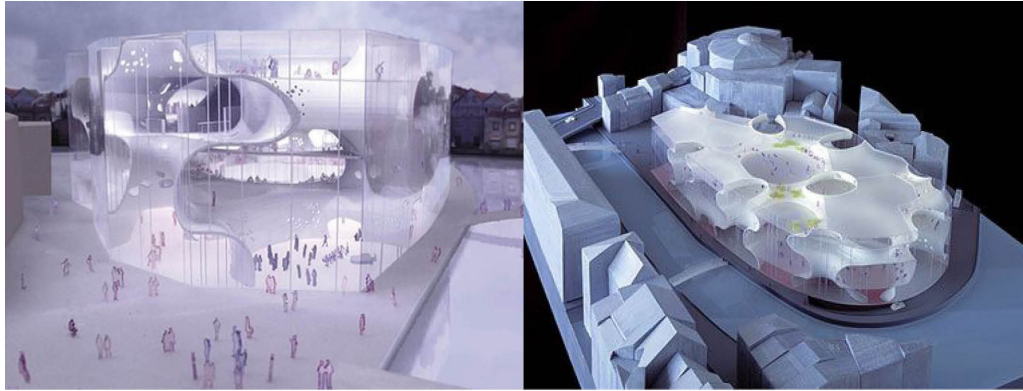
Spatially, the strength of the gyroid system is that it creates congruent labyrinths of passages, or interlocked spaces. Another important characteristics of the gyroid is the inclination. If the inclination is moderate, which would create a ramp, the connection between two spaces would be public. If the inclination is steeper, either stairs would be used or there would be no connection, which makes the space more private with, however, a visual connection. In this way, a series of connected spaces with different degrees of privacy between them is created and this is used to maintain a separation between public and private without a physical barrier. In other words, it indicates whether a space is either more private or more public, according from where it is more accessible, while maintaining a connection throughout. Finally, the gyroid can be implemented into different configurations, with different densities and different spatial configurations.

While it has been applied in architecture before, the solution was often quite rigid. As in the case of Toyo Ito, it was eventually sectioned into different floors and only kept at an large macro level. The objective was instead to be able to use the features of the gyroid system in an architectural and spatial way and this needed some modifications.

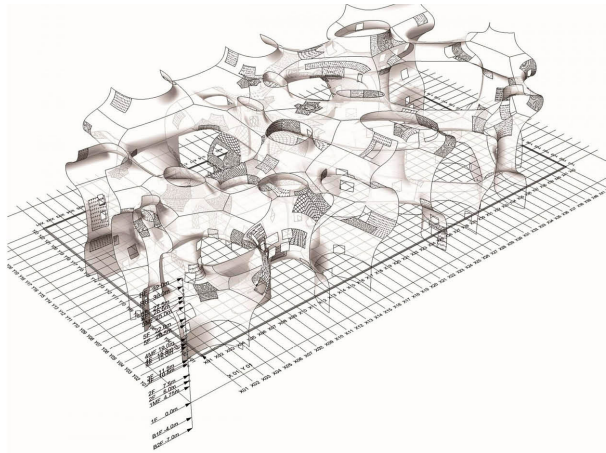
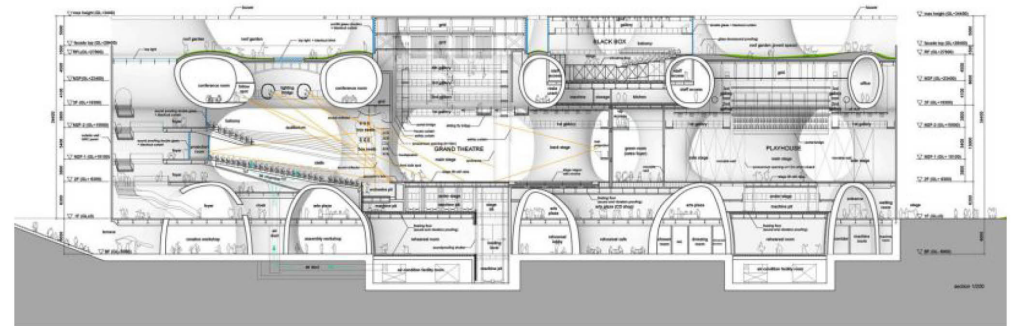
From a computational point of view, the gyroid is generally created through the mathematical formula $\cos x \sin y + \cos y \sin x + \cos z \sin x = 0$. However, this would create an identical or similar density throughout the whole. Another way to create the gyroid system is through the use of an electromagnetic field, a vector field that describes the magnetic influence of electrical currents and magnetized materials. Two points in space, of opposing poles (positive and negative), separated by a distance d , would create a field in which the charge is lower between them. This is later translated into a field of numerical values around them. By choosing a value x , a curve is created that connects all the points in the field that represent that value. In geometrical results, this means that a geometry is created around and between the two points, which appears elongated with the area around the two points being the largest in thickness. If the distance d is increased beyond a threshold t_1 , the geometry is only created around the two points but not between them. In the case of identical poles (both positive or both negative), the geometry would never be created between them, if not lower than a threshold value t_2 . In this case, in the area along the line that connects

the two points, the geometry assumes a squashed form instead.

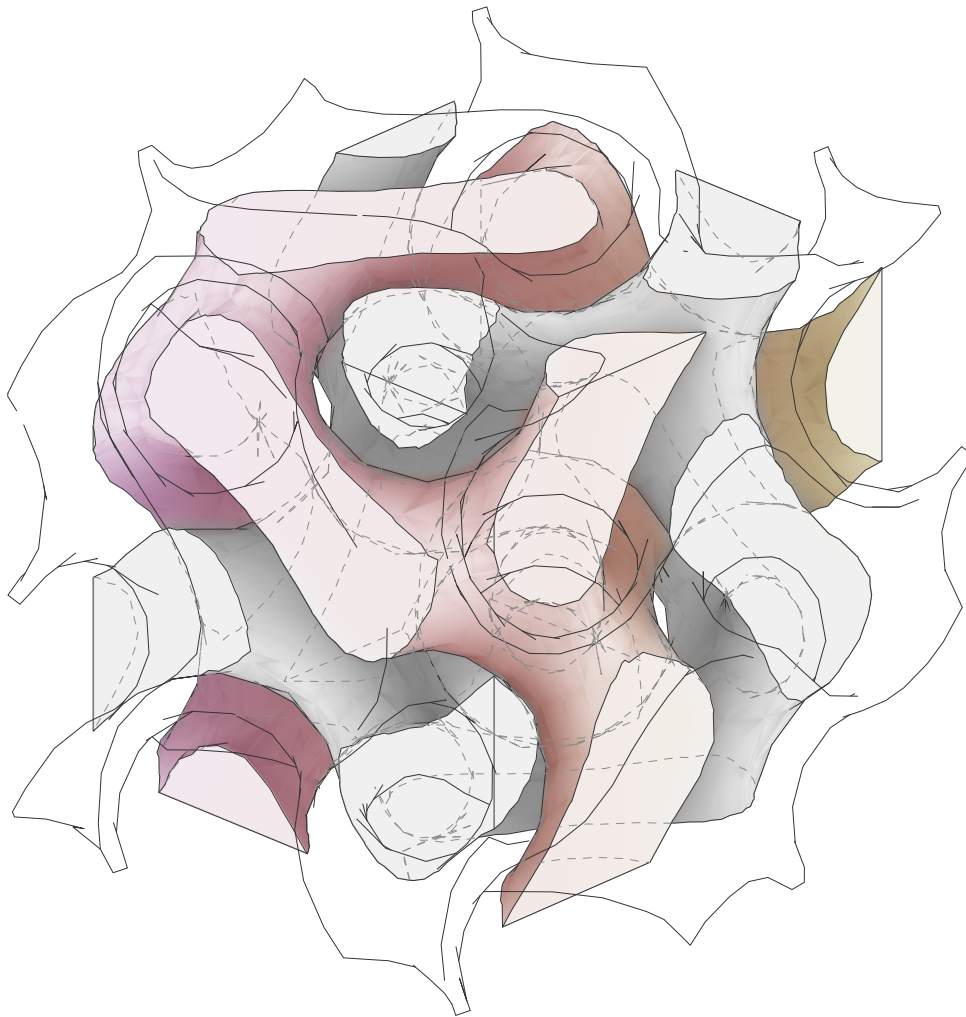
However, these basic principles become more complicate once other points are added to the initial two, which is necessary in order to create an architectural space. In this case, the thresholds defined before change according to the distance and the number of points in a manner that is difficult to predict.



Section S-1/200

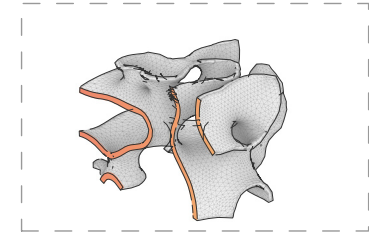
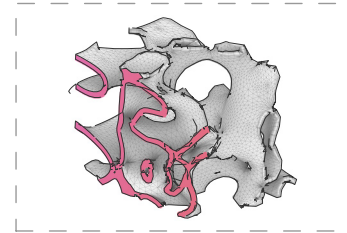
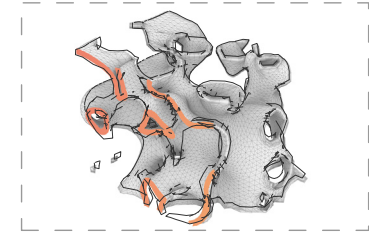
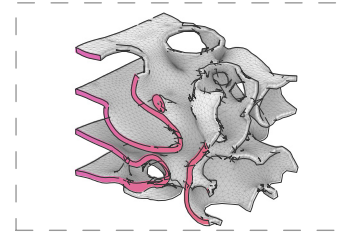


Toyo Ito's implementation of the gyroid principles

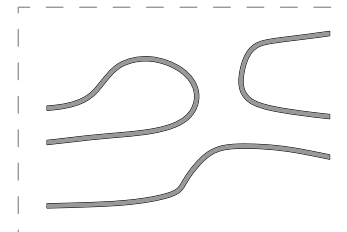


INTERLOCKED SPACES - CONGRUENT LABYRINTHS OF PASSAGES

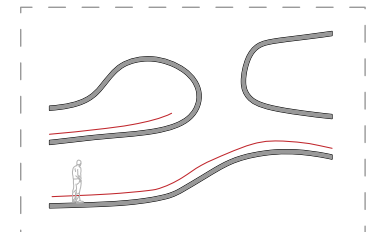
IMPLEMENTATION OF GYROID INTO DIFFERENT CONFIGURATIONS AND DENSITIES



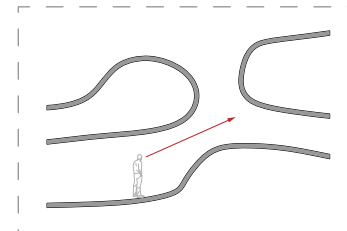
GYROID SPATIAL POSSIBILITIES



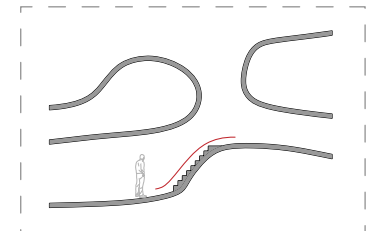
SEPARATION OF SPACES



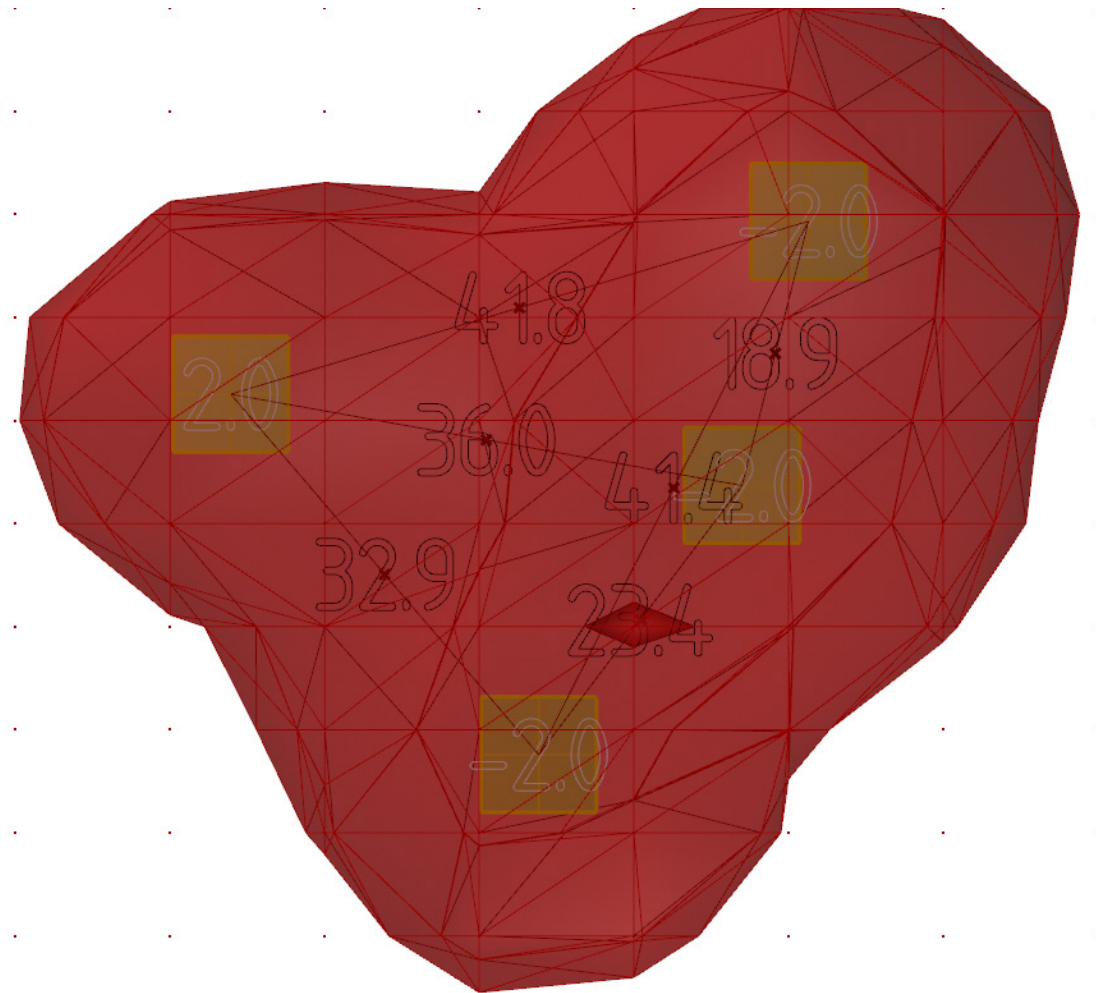
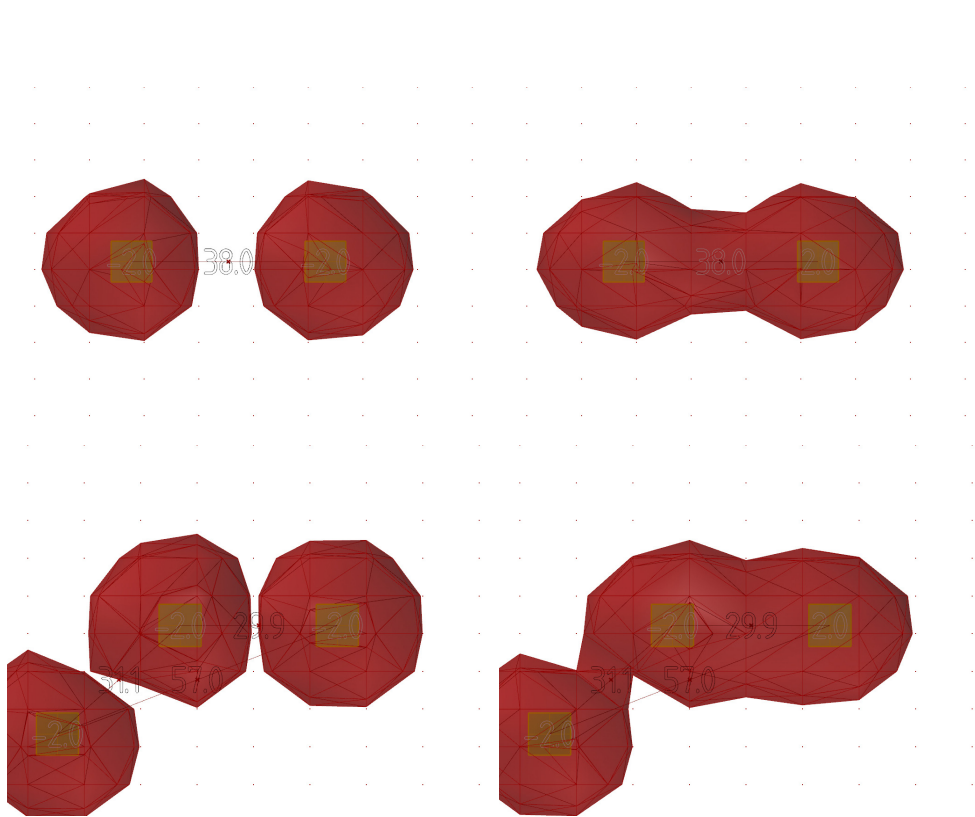
LOW INCLINATION: PUBLIC CONNECTION

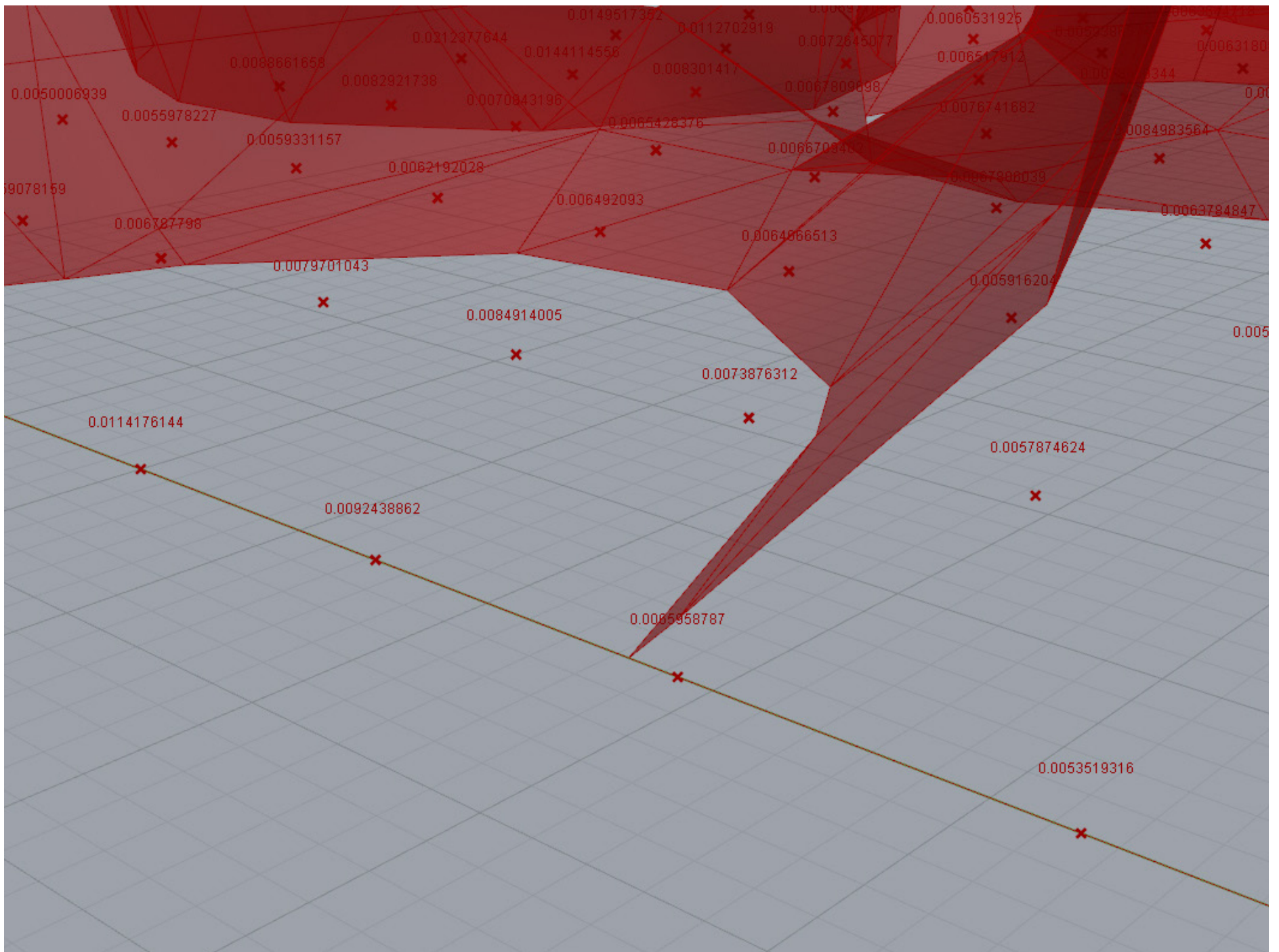


HIGH INCLINATION 1: VISUAL CONNECTION

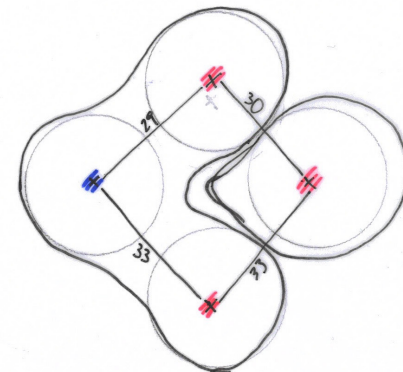
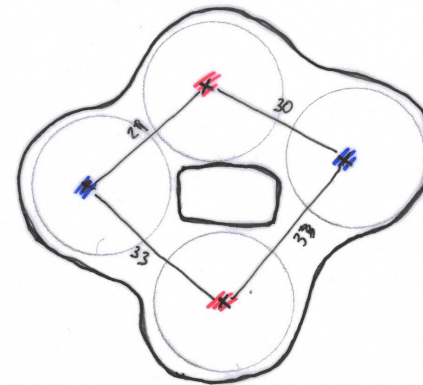
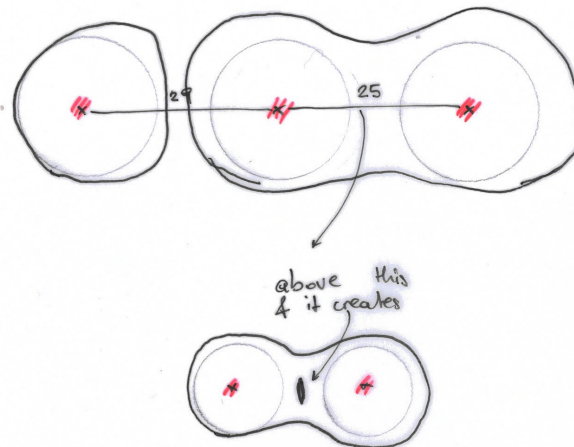
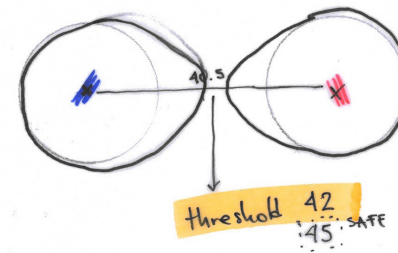
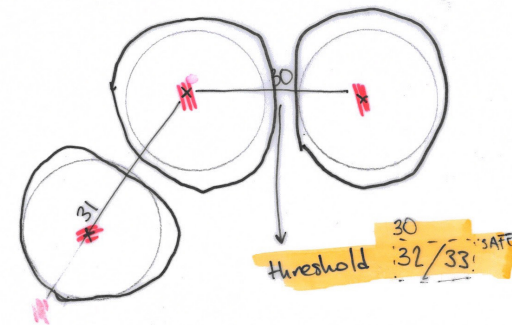
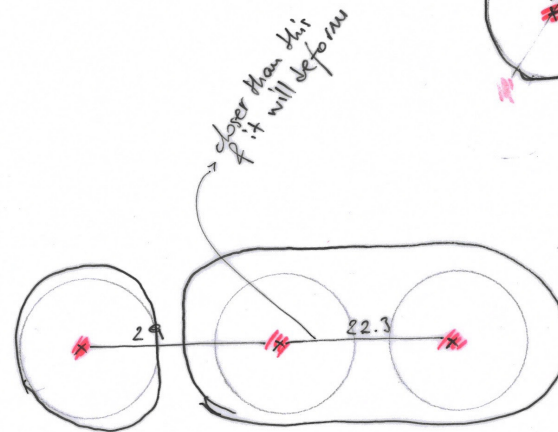
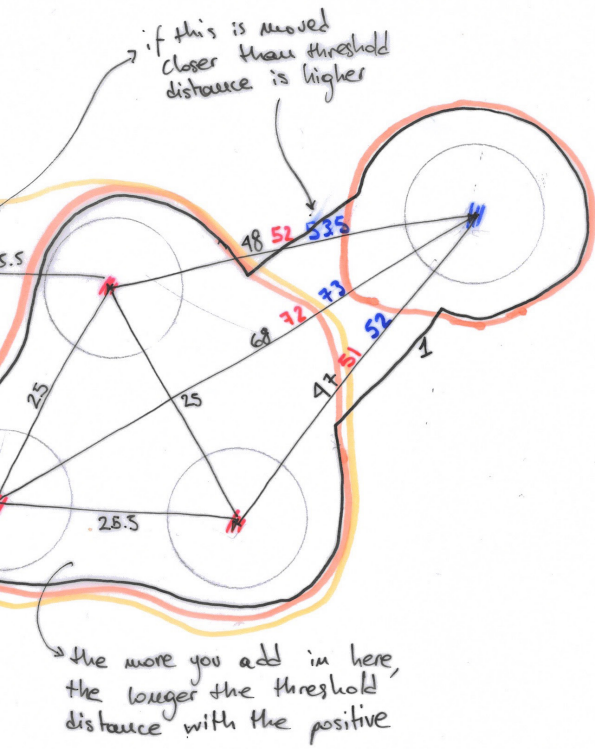


HIGH INCLINATION 2: PRIVATE CONNECTION



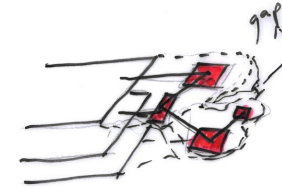


Visualisation of how a magnetic field works, by assigning values to points in space



① USE THE SAME SCRIPT

①A start from functions



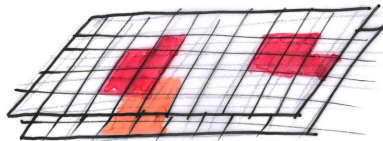
— NEED OF UNDERSTANDING THE SCRIPT

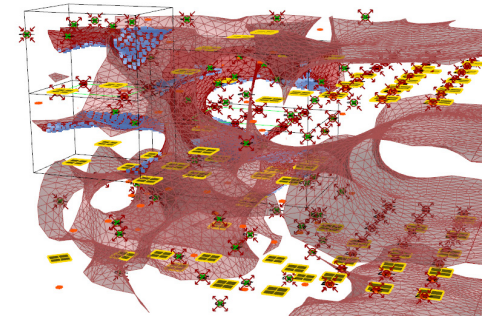
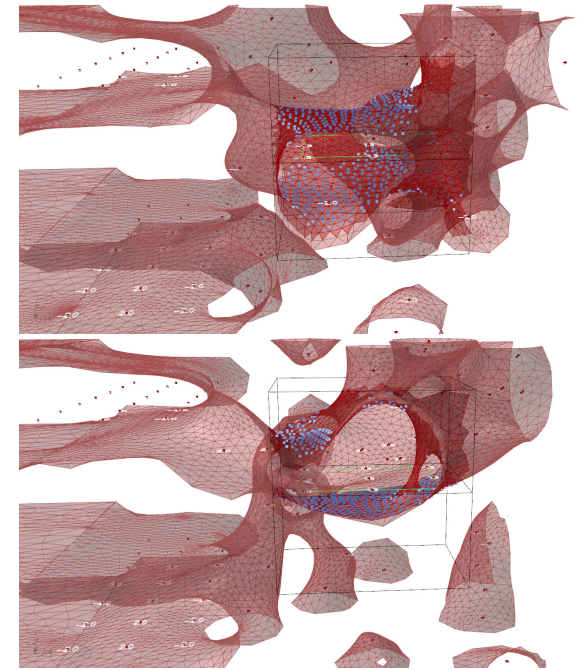
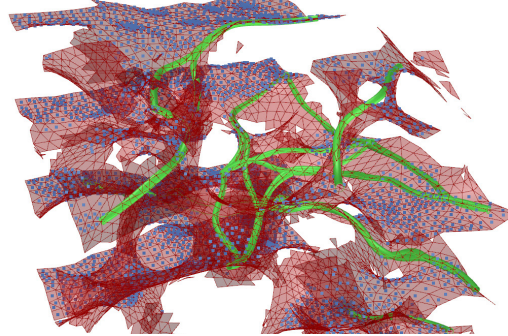
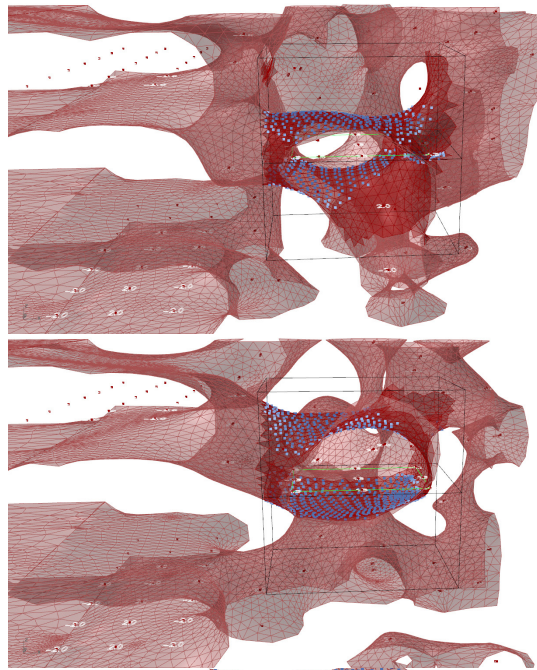
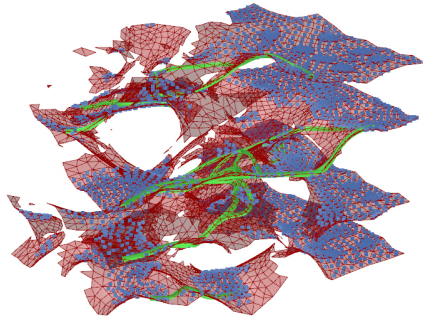
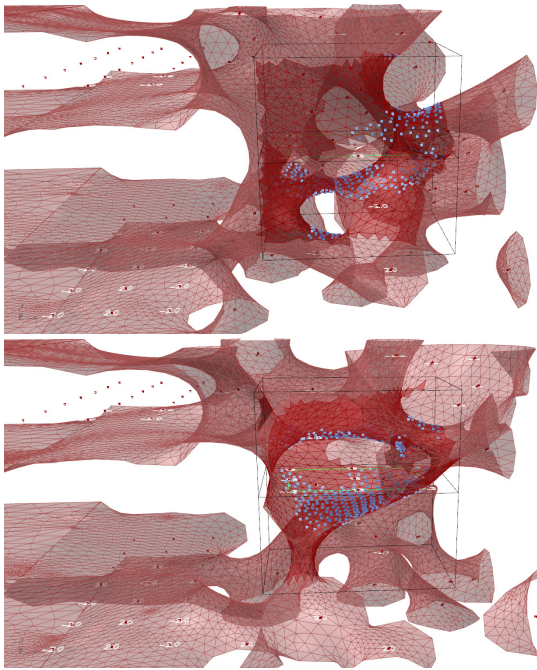
①B start from a "random" condition and optimise

— CONDITIONS FOR "OPTIMISATION"

①C "random" and then modify the shape

② USE ANOTHER SCRIPT THAT WOULD MIMIC IT





2.2.3 THE CONTROL SYSTEM

This meant that the system is hard to control, and other parameters needed to be introduced. Particularly, some parameters that were introduced dealt with how to create flatness and different sizes and heights. This was solved by using the initial functions and then deciding how many points per sphere there would be, of different poles and differently distributed, either flat or in height, according to the type of space that was to be created. Yet, a certain randomisation needed to be introduced until the desired conditions were met. Similarly to the first from-finding method, a system of analysis-and-choose needed to be introduced, made of objective spatial aspects. These are: correspondence to the initial connections (repulsion and attraction), inclination and levels of privacy required, depth (space syntax), integration (space syntax), choice (space syntax) and control (space syntax).

1. The correspondence to the initial paths is analysed by creating all the shortest paths between different nodes. Among these, those whose normal vector changes of more than 50 degrees compared to the z-direction are eliminated (i.e. the inclination is too steep to be walkable or be used with stairs). The final networks are tested against the initial paths (repulsion and attraction)
2. A parameter that is derived from the particular shape that is derived from the particular shape of the gyroid, is the inclination of the connections. The steeper the connection, the more private it becomes. This principle is used to understand the grouping of the function in

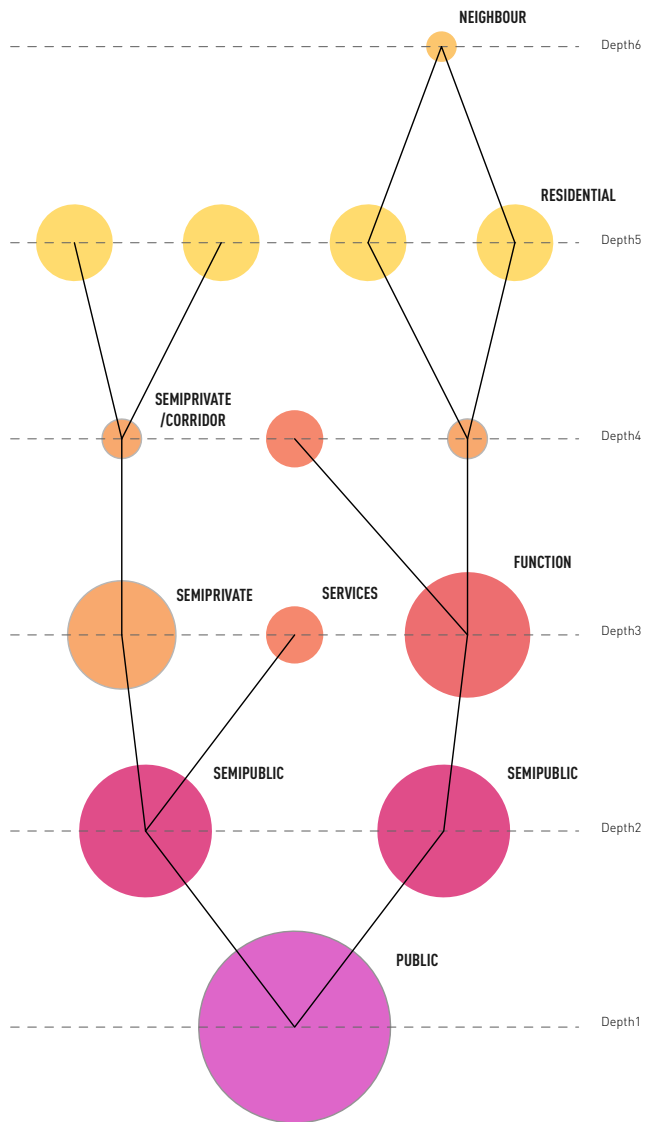
relation to their accessibility. The most important is that the semi public functions are easily accessible from the public ones.

3. Depth, a tool of space syntax. It measures “how many topological steps a single space is away from another one. A distance measured between two nodes on a graph is called the graph theoretical distance between them”(22). It gives an indication privacy and commonality. It is important to note that it depends on the point of view. Viewed from the public, the private areas should be at the maximum distances, as described in the chapter 2.
4. Integration, a tool of space syntax. Integration is the average depth of a space to all the other spaces in the system. It describes how easy it is to get to one segment to all other segments. the higher the integration value, the more likely for a space to be communal and the lower the integration value, the more private that space. Therefore public and semi public functions should have the highest values while private the lowest.
5. Control, a tool of space syntax. It intuitively indicates how strongly a vertex in a graph (a space in a configuration) is linked to other points in a superior manner. Public spaces should have the highest values, but so could have the private ones. It means that the spaces have both good connectivity.
6. Choice, a tool of space syntax. “It indicates how often a node (space) happens to be in a shortest path between other spaces, in other words: it measures the degree of choice each space represents

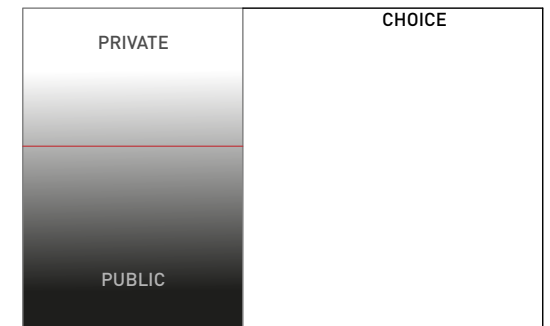
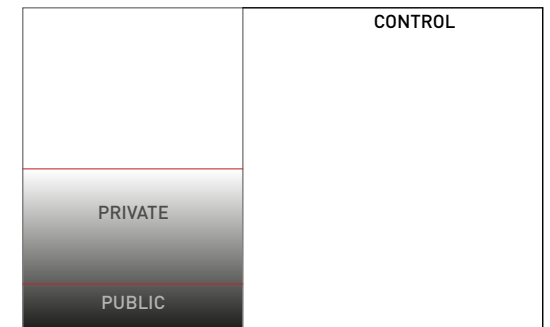
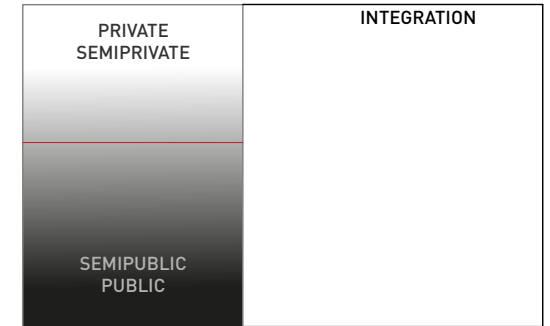
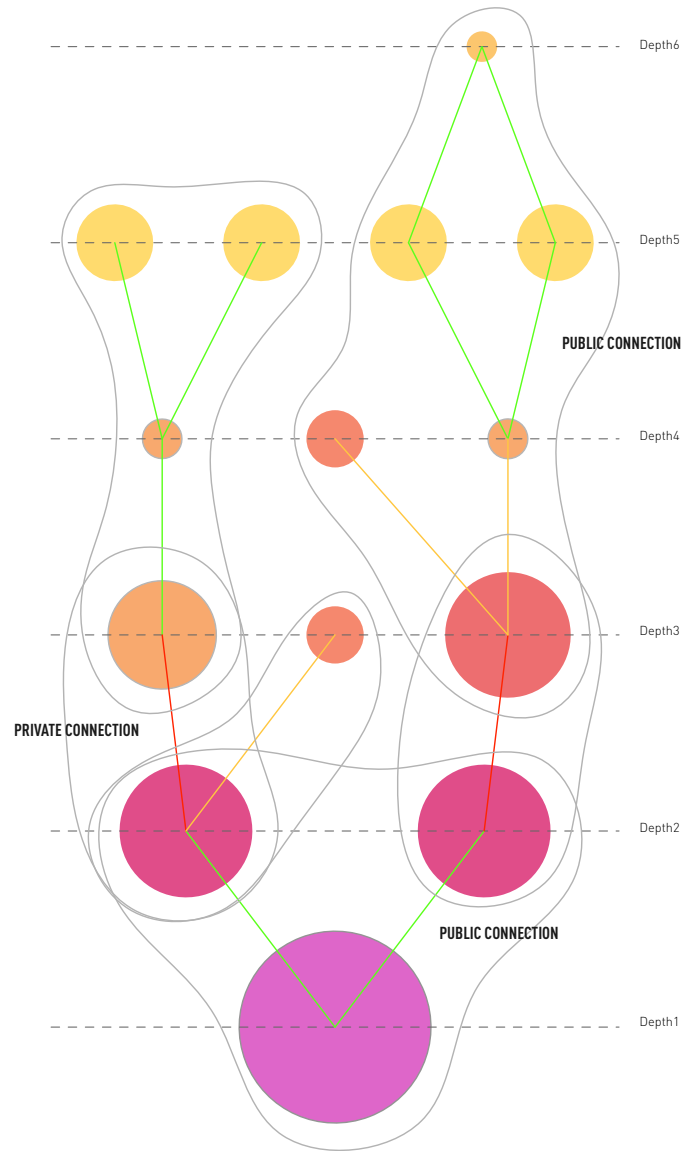
(how likely it is to be passed through) on all shortest routes from all spaces to all other spaces in the system”(23) . Private spaces should have low values, as they should not be passed through in order to reach other spaces.

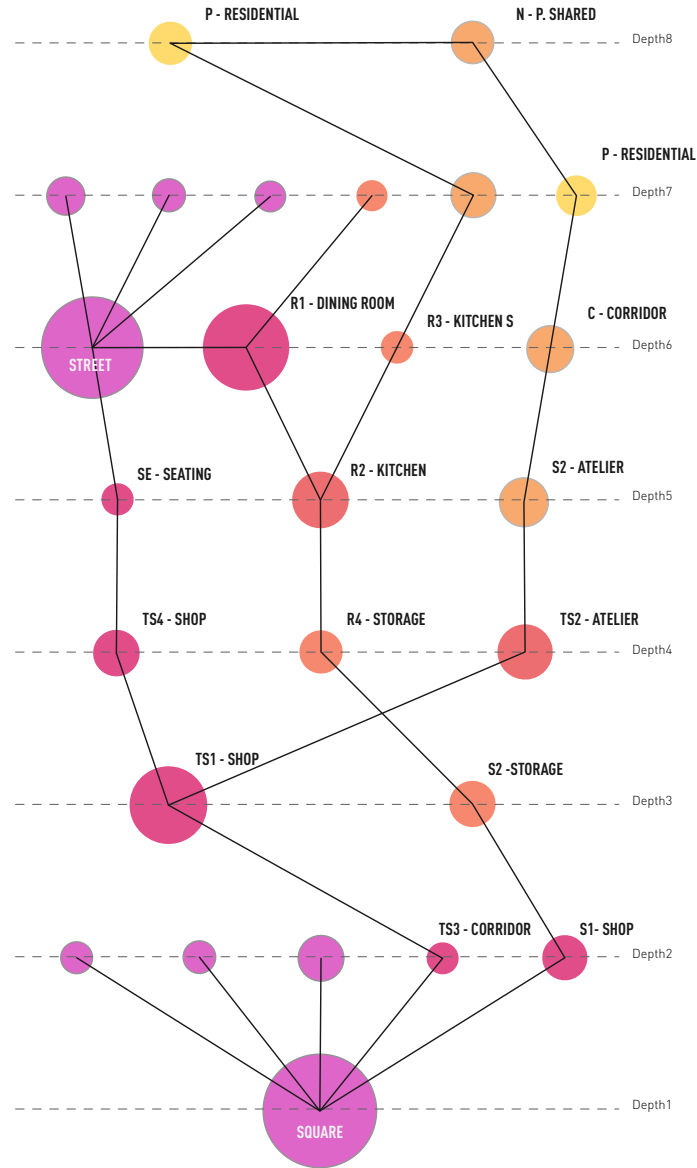
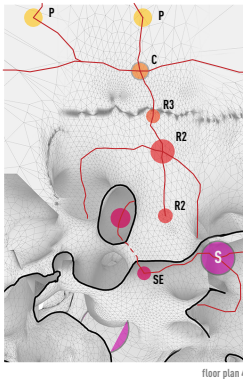
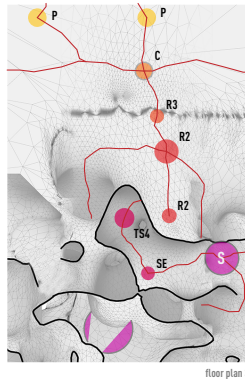
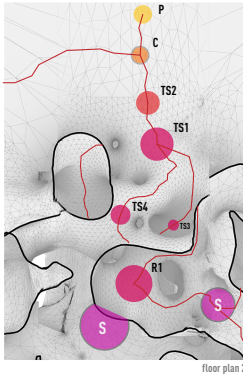
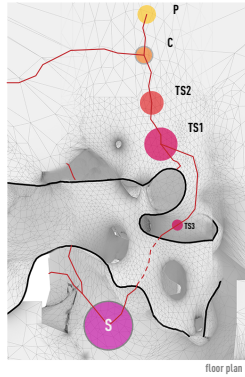
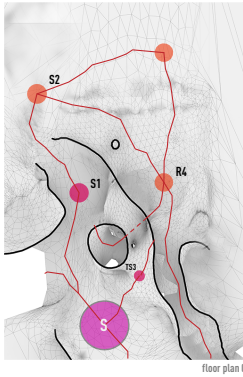
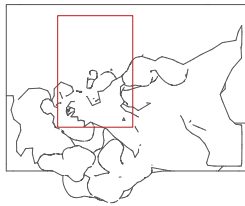
While the gyroid system naturally allows the penetration of light, this parameter was offsetted to after the design and analysis process. It was not possible to use light analysis and connection and configuration analysis at the same time because they would give contrasting results. The idea is to create “corridors of light”, so that light can penetrate through the building. This is created by using the centre point of the spaces that were created in the previous step and, by means of simplification, the lines that represent the sun direction at different hours for different season were traced. Where these lines intersect the mesh, it means a window should be created. However, this only gives an idea on the location of the windows but not of their topology or shape. The topology is chosen according to the amount of light that is required in the space and if the view is needed or not. For instance, the dining room of the restaurant requires both light and a view and therefore bigger windows, whereas the kitchen would mainly need light and therefore smaller windows. If both light and view are needed, the windows or their combination would be bigger, whereas if only light is needed the windows are smaller.

DEPTH GRAPH



INCLINATION GRAPH



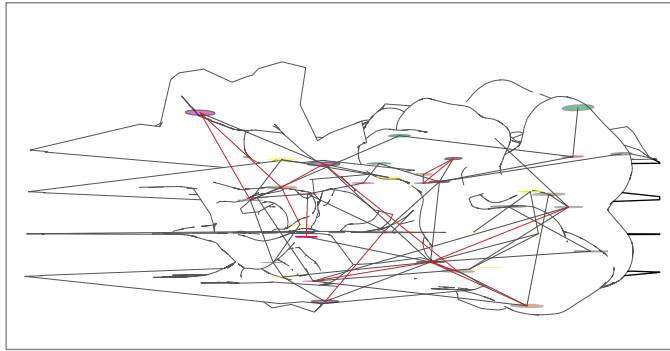


INTEGRATION	
SemiPrivate1: 0.549	
SemiPrivate2: 0.533	
Private1: 0.588	
Private2: 0.588	
PuCo1: 0.594	
PuCo2: 0.594	
PuCo3: 0.594	
StCo3: 0.639	
BathroomR: 0.639	
StCo1: 0.639	
StCo2: 0.639	
CorridorTS: 0.66	
ServicesCorridorR: 0.66	
Shop1S2: 0.754	
WorkshopTS: 0.763	
FoodRoomR: 0.763	
ServicesS2: 0.773	
Public: 0.784	
CorridorTS: 0.816	
ServicesR: 0.816	
Sitting: 0.852	
Street: 0.864	
Shop2TS: 0.864	
DiningRoomR: 0.864	
KitchenR: 0.904	
Shop1TS: 0.904	

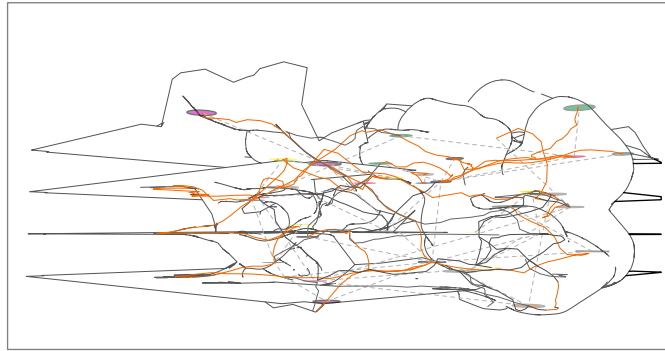
CONTROL	
StCo3: 0.2	
PuCo3: 0.2	
StCo2: 0.2	
PuCo1: 0.2	
PuCo2: 0.2	
StCo1: 0.2	
BathroomR: 0.333	
CorridorTS: 0.533	
Sitting: 0.7	
Shop1S2: 0.7	
Shop2TS: 0.833	
FoodRoomR: 0.833	
ServicesR: 0.833	
WorkshopTS: 0.833	
SemiPrivate1: 1	
Private1: 1	
Private2: 1	
ServicesCorridorR: 1	
CorridorTS: 1	
SemiPrivate2: 1	
ServicesS2: 1	
KitchenR: 1.333	
Shop1TS: 1.5	
DiningRoomR: 1.533	
Street: 3.833	
Public: 4	

CHOICE	
PuCo3: 51	
PuCo2: 51	
PuCo1: 51	
BathroomR: 53	
StCo2: 53	
StCo1: 53	
StCo3: 53	
SemiPrivate2: 113	
SemiPrivate1: 117	
Private2: 125	
Private1: 127	
Shop1S2: 141	
ServicesS2: 145	
CorridorTS: 147	
ServicesCorridorR: 147	
ServicesR: 153	
WorkshopTS: 171	
FoodRoomR: 171	
CorridorTS: 177	
Sitting: 187	
Shop2TS: 189	
DiningRoomR: 211	
Public: 231	
KitchenR: 253	
Street: 261	
Shop1TS: 265	

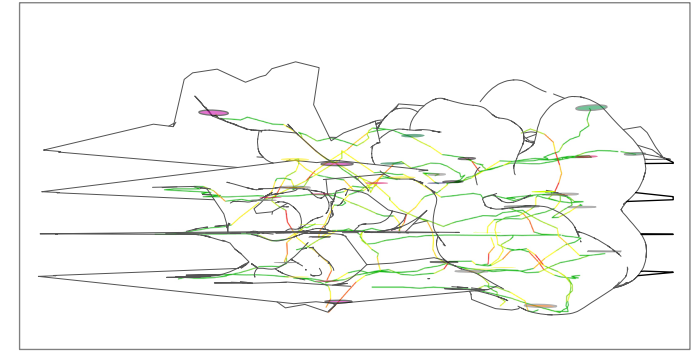
Implementation of space syntax in order to objectively understand the design and correspondence to the initial requirements



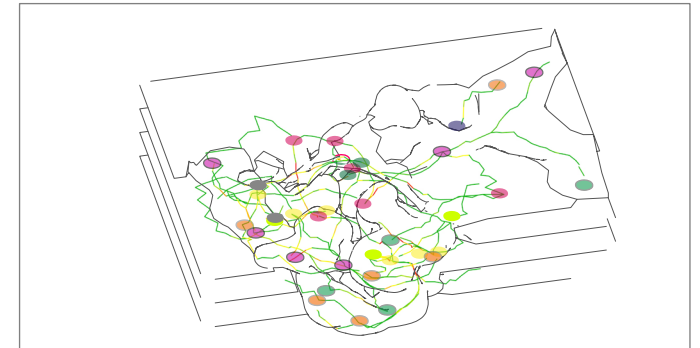
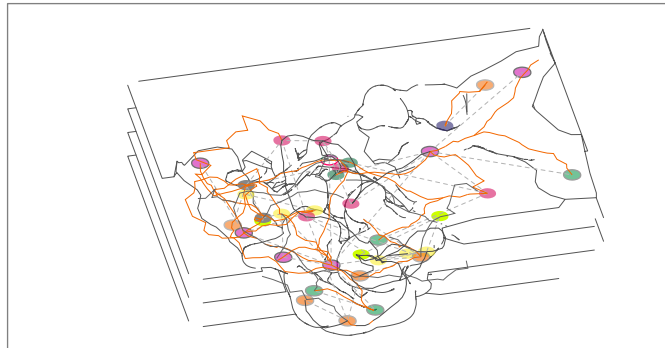
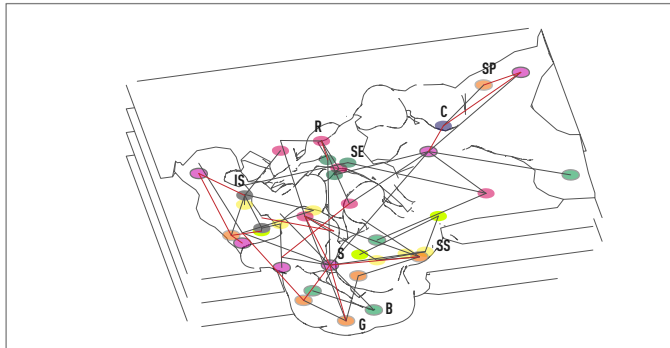
STEP 1



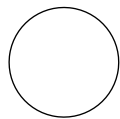
STEP 2



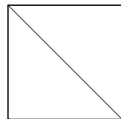
STEP 3



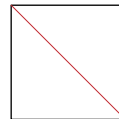
B - BALCONY
G - GREENHOUSES
R - RESTAURANT
SE - SEATING AREAS
SP - SEMIPRIVATE
SS - SPICE SHOP
IS - INTERNAL STREET
TS - ATTELIER
S - SQUARE AND STREETS



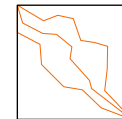
FUNCTIONS



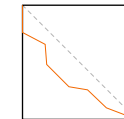
ATTRACTION = REQUIRED
CONNECTIONS



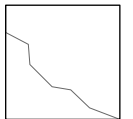
SEPARATION = PROHIBITED
CONNECTIONS



ALL THE POSSIBLE
CONNECTIONS



ATTRACTION PATHS
CONFIRMATION



PATHS NOT REQUIRED BUT
INDIFFERENT

2.3 THE MESO SCALE

2.3.1 THE DEVELOPMENT OF THE SEMI-PUBLIC FUNCTIONS

The process is then developed at a higher detail at a smaller scale (Meso scale). In this case, two functions are considered. The first is a textile workshop or atelier, which was derived by the experiences of the Vluchtmaat where artists and refugees work together, the second is the Multi-Kulti Kitchen, a project built on the framework of best practices of the European Union, that offers refugees the possibility to work in a restaurant, while also offering lessons of traditional cuisine, events that eventually turn into occasions of meeting and integration.

This event-based function is merged with a every-day function, which is the restaurant. In this way both the socio-economical and socio-cultural objectives are implemented. In this way occupancy is guaranteed and a stable job be offered, while also guaranteeing occasions of meeting and integration.

The event has been broken down into the different activities that is composed of. While teaching a traditional cousine is just the first step, it is often followed by sessions of cooking together but always maintaining a relaxed and social environment, where places reserved for sitting and chatting have to be maintained close by. The events eventually end in dinners together and they are often followed by presentations or discussions, but also dancing and film screenings. The aim was to integrate each of these functions into the spaces.

One of the main objectives related to this scale was how to create furniture according to the activities and the function but also to understand

how people could appropriate these spaces.

A research into furniture, particularly on furniture that follows activity and on the integration of freeform shapes and furniture was made. However, a question arose on the extent between freeform furniture, therefore following the shape of the gyroid, and the extent of standardised furniture. While freeform furniture has the advantage that it can be formed around body shapes and activity, certain activities and spaces such as the kitchen, have a much more functional meaning and need additional elements, particularly appliances. In this case, standardisation does make sense because it allows for quick replacements and overall for changes that might be needed. From this line of thought, two systems were developed: one that is more freeform, in which the activity is more important and one that can inglobate standardised objects.

The advantage of the gyroid system is also that it can already accommodate some of the shapes required by activities: it can be comfortable, for example, for sitting thanks to the fact that it offers an ergonomic back support. Moreover, it creates spaces that can accommodate some of the activities of the Multi-Kulti Kitchen: for instance, it creates a small stage for presentations, discussion or activities that involve dancing, while accommodating seatings on the sides.

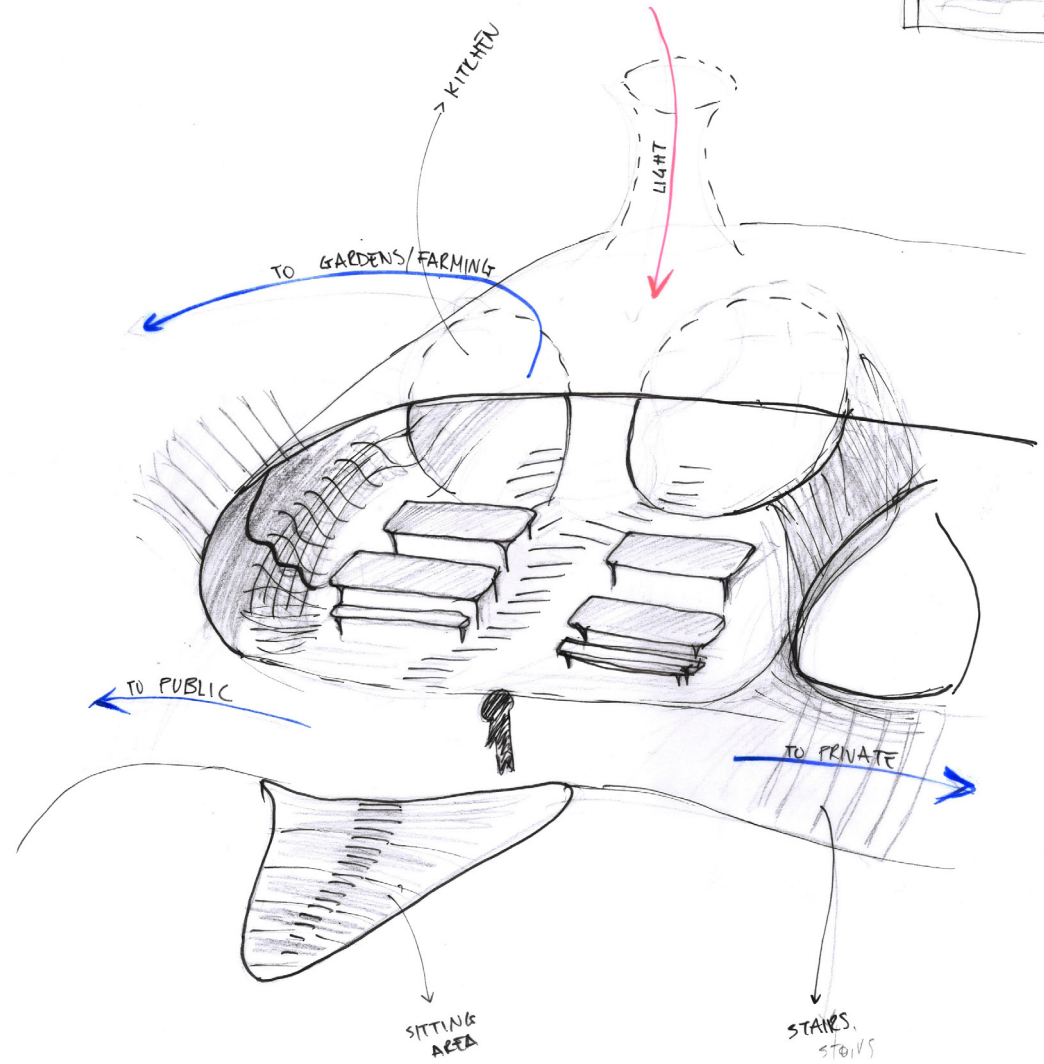
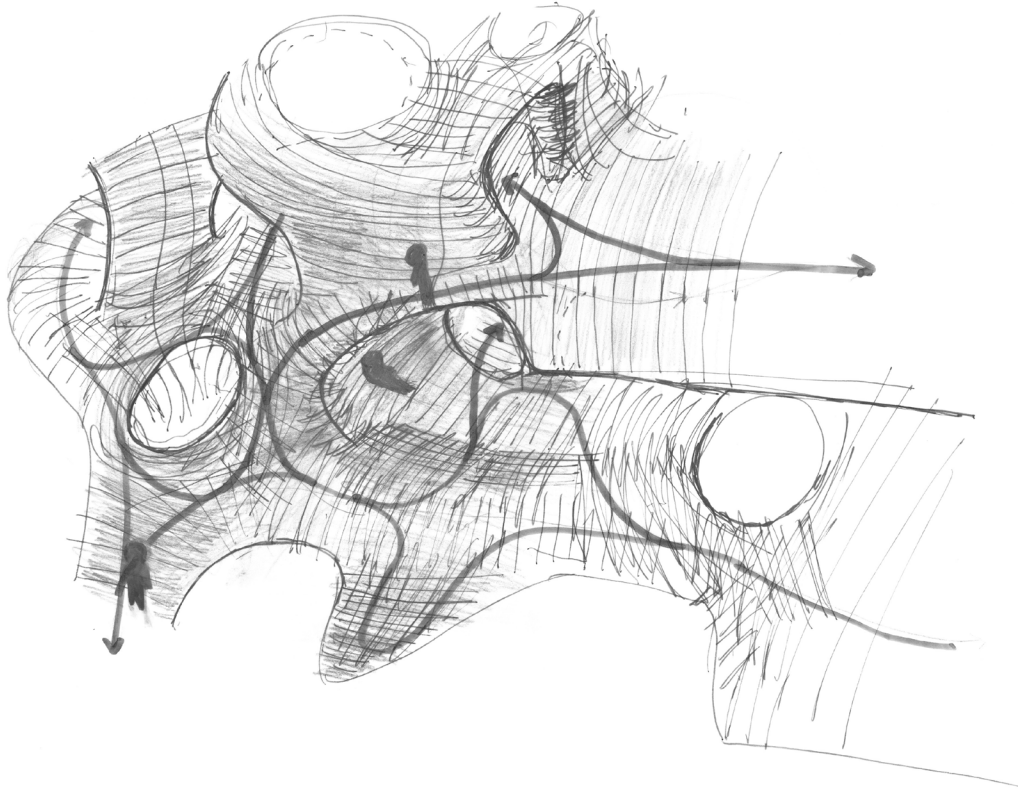
When freeform is allowed or required, the preferred method that was devised was to use the contour lines of the gyroid as a starting point. This is also used in the kitchen in order to create perfectly flat spaces

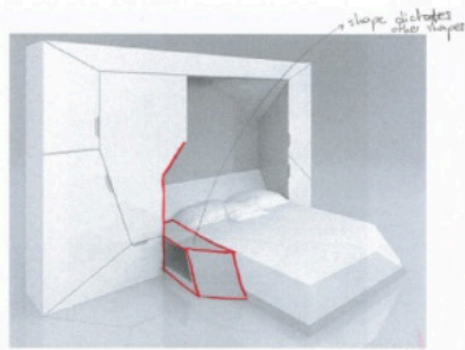
organised in steps.

When it comes to the kitchen, which is the most prominent example of where the furniture needs to follow standardisation principles, the furniture becomes more regular. A tool was created that could allow to find where different appliances could be placed and in which orientation. However, while this was a topological research, the final result still needed consideration on the integration to the existing shape and consideration of the final configuration in terms of the activity. This integration would happen especially at the perimeters of the space in order to create a smooth transition between the two systems. In order to maintain a language that is consistent throughout the spaces, also the shapes that do have appliances, the furniture is smoothened around the functions they contain but its derivation from functionalist principles is still visible and indicative of a different approach.

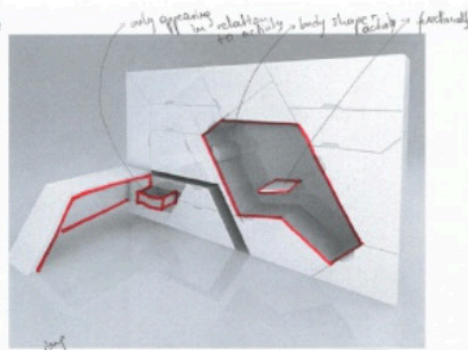
Furthermore, these activities that describe the Multi-Kulti Kitchen also maintain some cultural principles, as can be seen in the dining room, where areas where people can sit on the floor in order to eat are designed, while others use the stepped configuration to demonstrate another approach to it, as was seen in Calais.

Finally, the furniture is also the link between the more freeform additions and the regularity of the existing, and its transition from one system to the other is gradual in order to reconnect the two systems in a visual way as well.

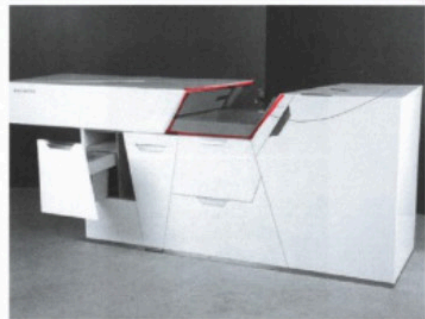




shape dictates other shapes

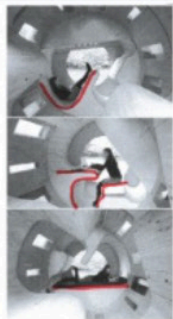


only appearing in relation to body shape - factually

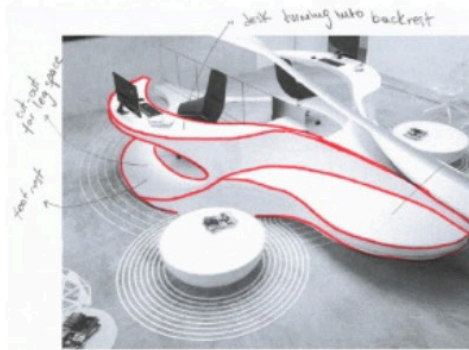


only appearing for this function

"skin" takes shape from furniture



body shape activity

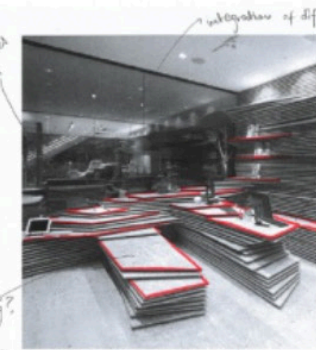


adjust for leg force

back turning into backrest

sliding

scaling



negotiation of different furniture within one component

table

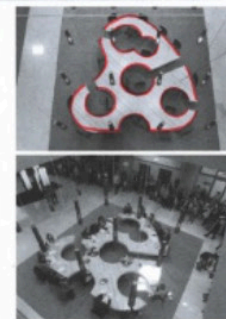
bench

shape in distance with skin

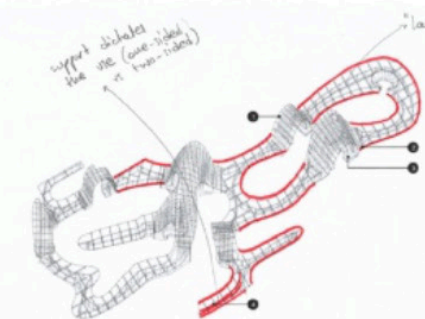


adjust for leg force

skin with different body shapes configurations



"landscaped" furniture



support dictates the use (one-sided use is two-sided)

"landscaped" furniture

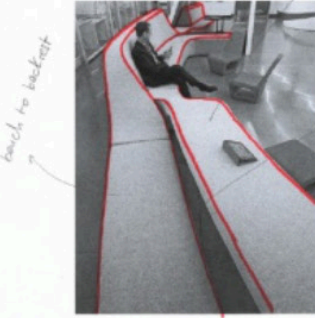
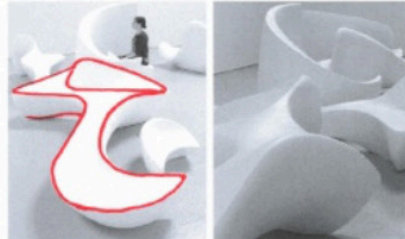


use and human body

movement as "extension"

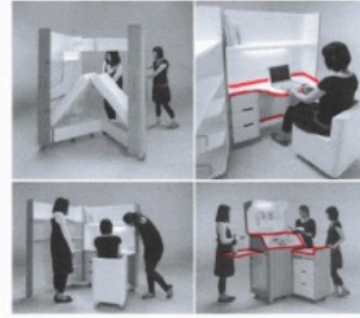


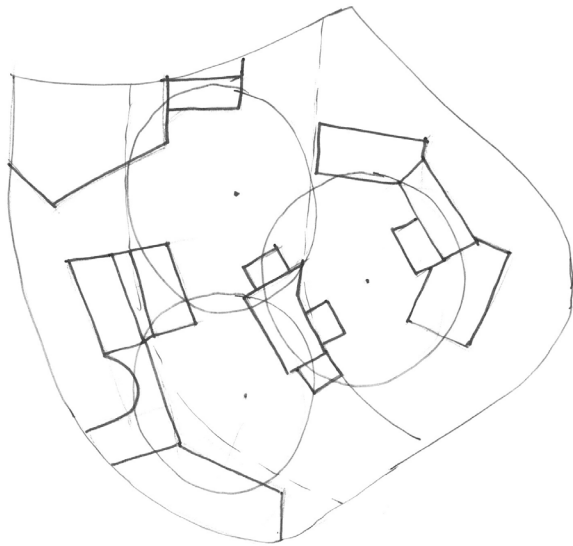
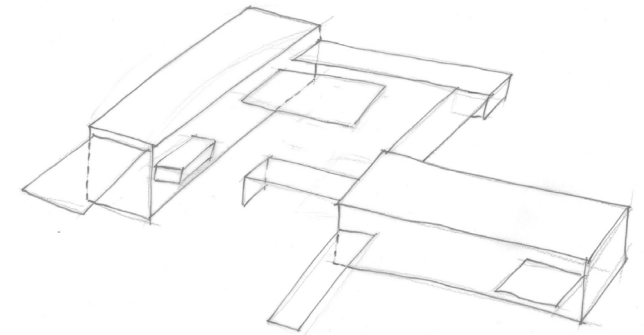
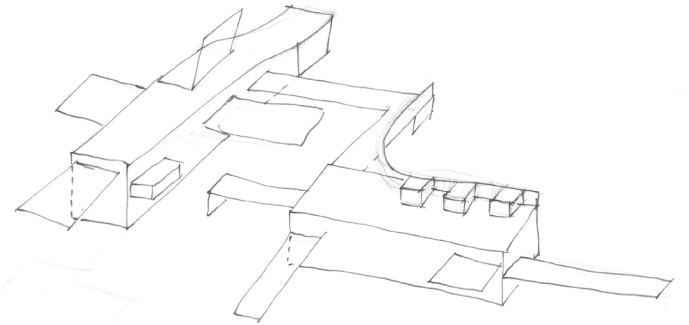
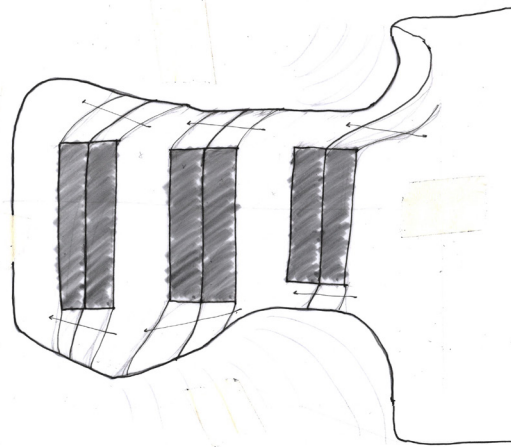
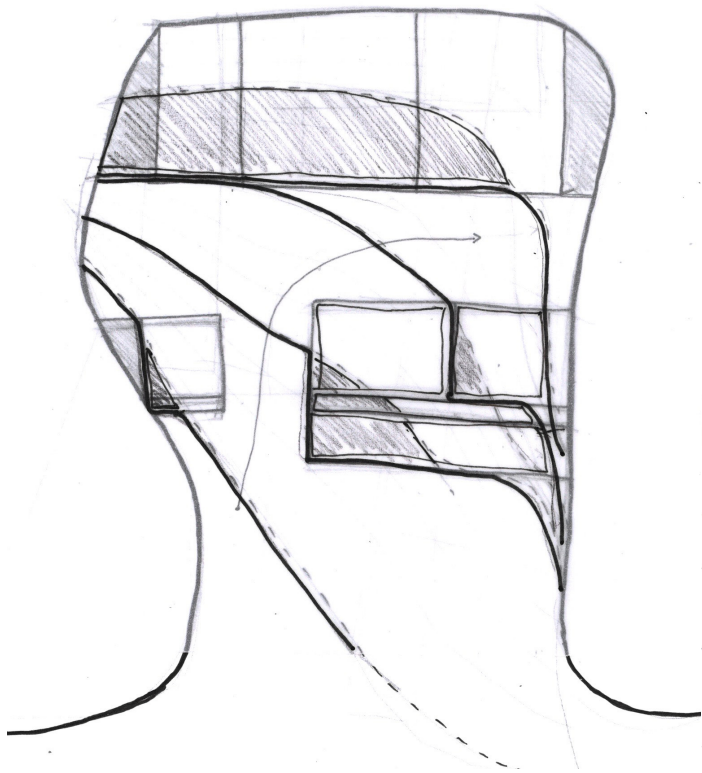
lead to desk

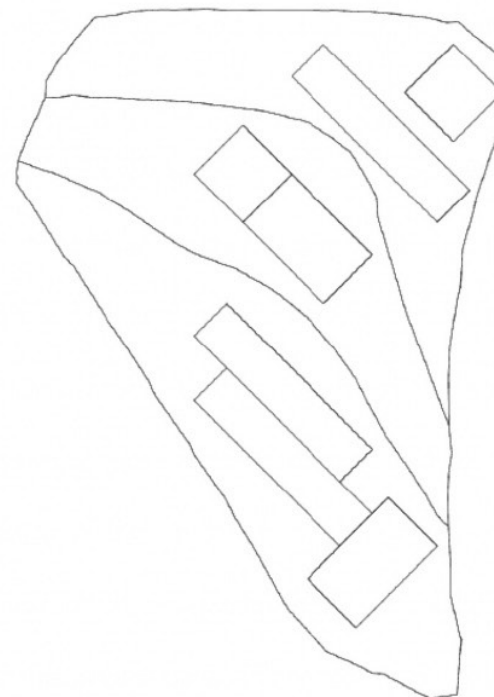
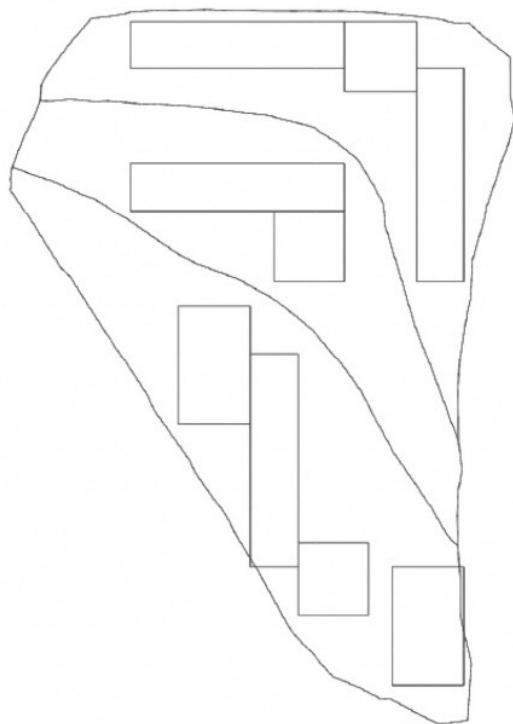
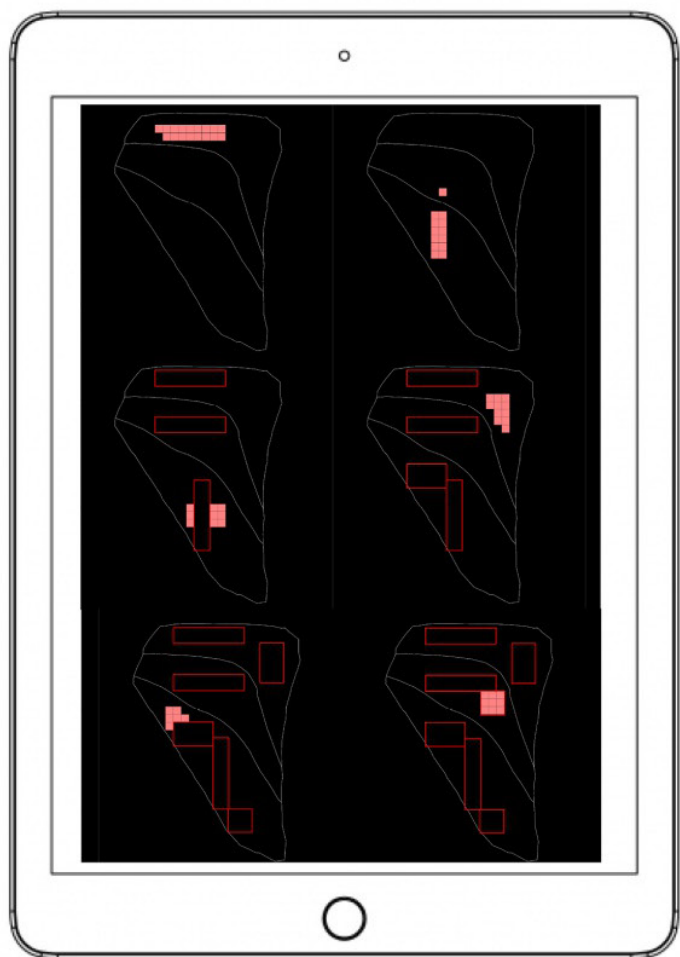


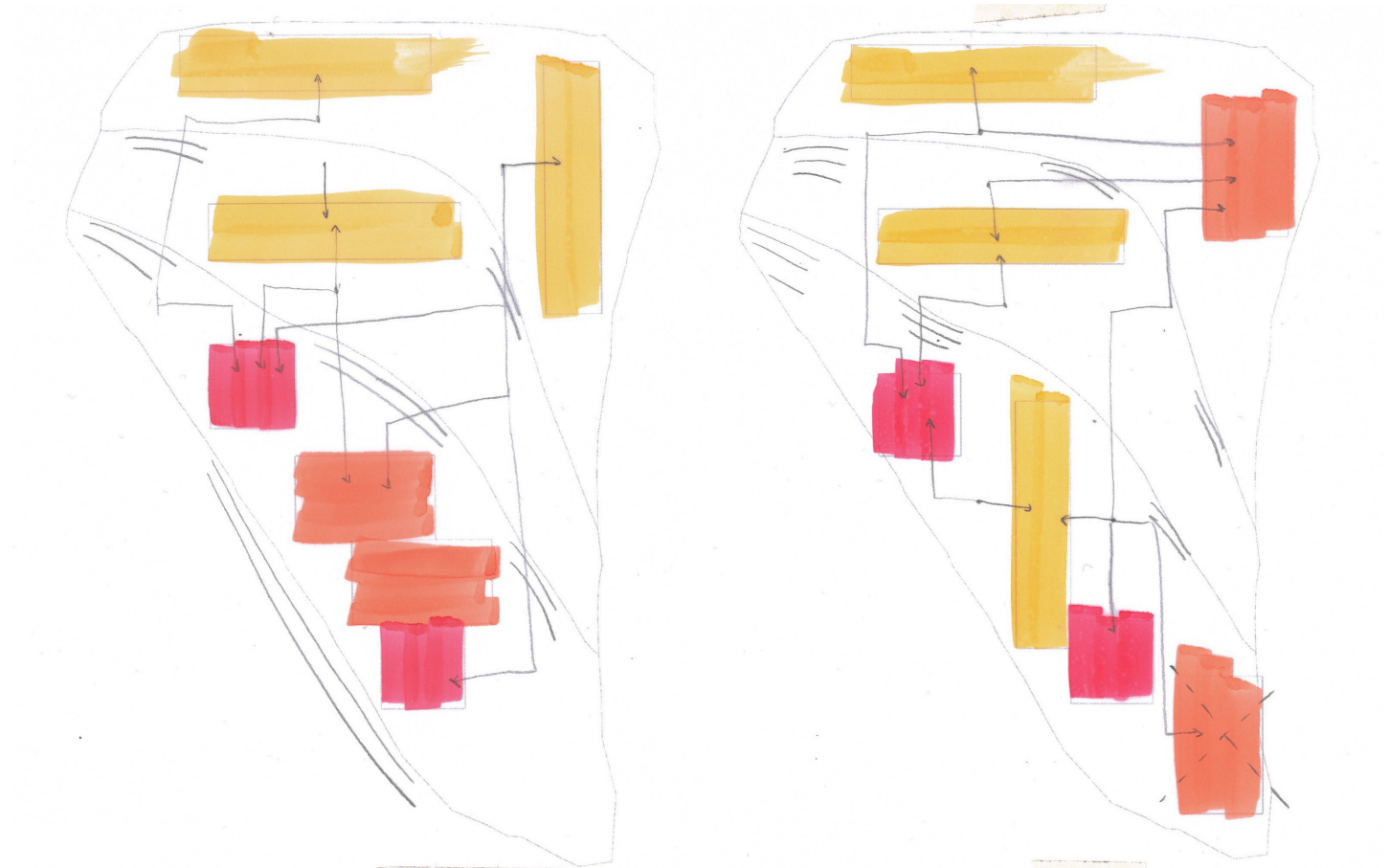
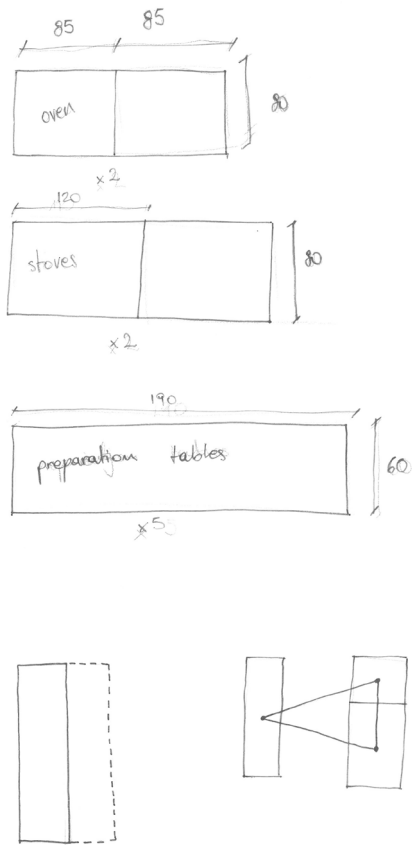
back to backrest

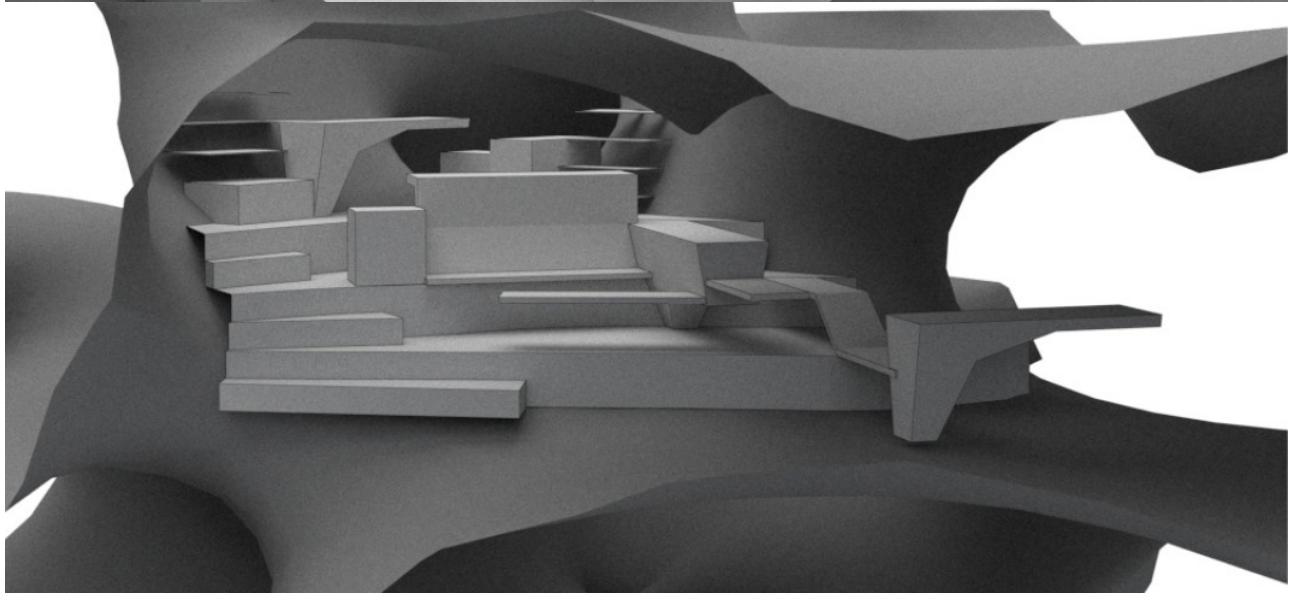
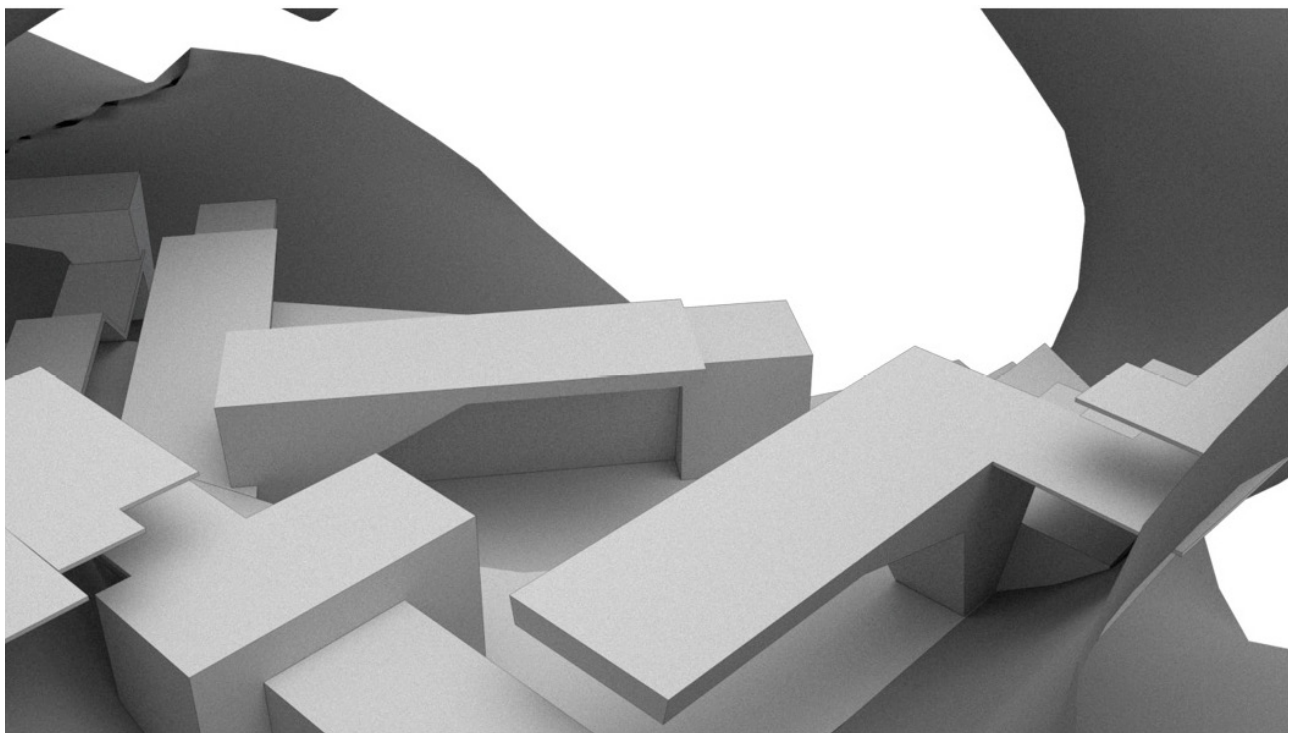
cut out from volume to surface











2.4 MATERIALITY

Once the initial shape is designed, a series of steps towards materiality and structural properties are taken.

Reconnecting to the theories of psychology and architecture, wood was chosen because, as a natural material, it would bring a positive physiological and psychological response and a sense of well-being (24). It is in contrast to the materials of the Modernist Architecture, which is characterised by cold, unwelcoming environments. Wood is moreover a sustainable (lower embodied carbon footprint) and light-weight material. However, it became soon clear that in order to respond to the structural requirements of the geometry, wood would not be sufficient alone and another material needed to be introduced. The options fell on either steel or concrete. The aim was to find a way that the new materials could work together. Research on steel demonstrated that, in order to create such a shape, an incredible amount of the material would have needed to be used, which is also extremely expensive. Furthermore, the structural integration with wood is limited since both materials are good for the same structural forces, that is tension forces. On the contrary, concrete behaves well in terms of compression but not in terms of tension. The research then wondered if wood could replace the tension elements (rebars) that are normally used in combination with concrete. The assumption was based on the collaborative behaviour that concrete and wood can achieve thanks to the compressive strength of the former and the tensile strength of the latter. On the hybridisation between wood and concrete. This was confirmed by the research project Timber Tower Research Project by SOM in collaboration with

Oregon State University, whose aim was to develop a structural system for high-rise buildings that use mass timber as the main structural element, in correlation to concrete (25). The purpose was to research CLT floor systems with a composite concrete topping slab. The program researched and proved key behaviours of timber-concrete composite floor systems including the effectiveness of composite action, two-way bending stiffness, and continuous beam behaviour. By means of simplification, when considering a beam under load, it will bend so that the top of the beam is under compression, while the bottom is under tension. While in a building of regular construction, as in the one tested in the Timber Tower Research Project, this would be applicable to the whole building, in the case of this project, the geometry is more complex, since the areas subjected to tensile and/or compression forces are not as clear. Additionally, another aim was to minimise the use of concrete and place only where needed. Wood followed this concept in terms of structural principles but also to be used in an architectural way and for windows where there is no concrete.

The first step was to understand where concrete is needed. First and foremost, it is necessary to understand how the additional structures would be supported. The initial structural system of the Marconi Towers is based on load-bearing façades with beams spanning from one side to another and meeting in the core. Once the tower is carved out, the structure that would be missing is instead offset to other areas, namely the separation walls of the private areas. In this way the structure can be consolidated before the addition. Subsequently, the

anchor points of the new structure are positioned on the sides, where the structure has been carved out and at the bottom, where the street is located.

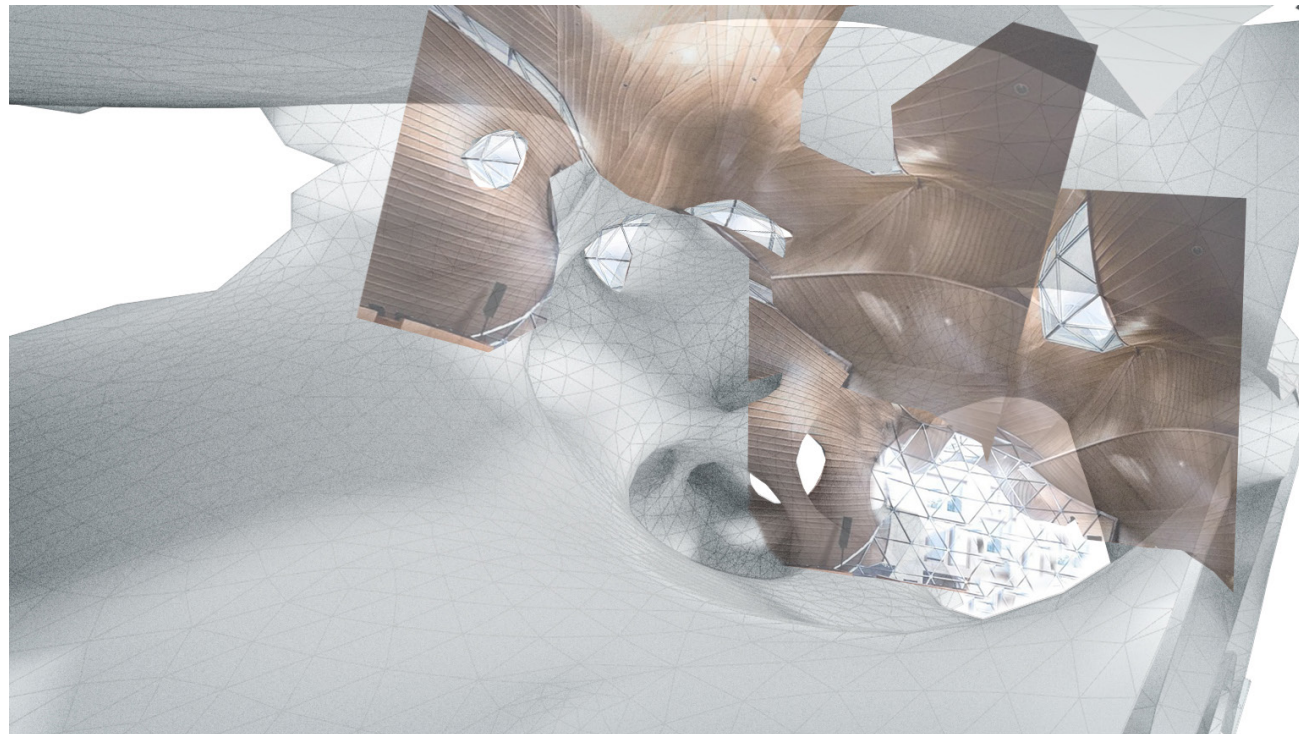
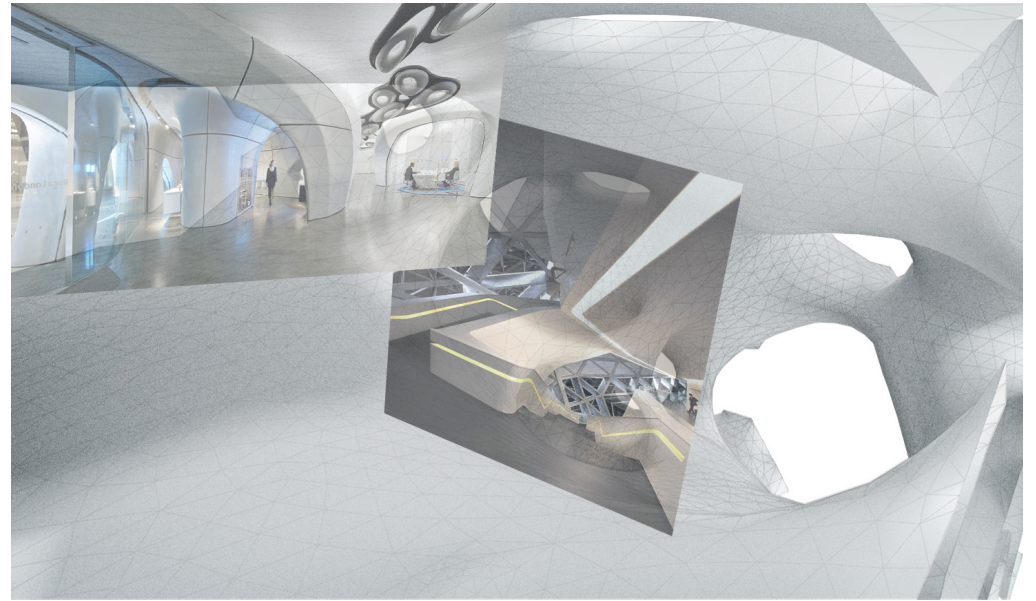
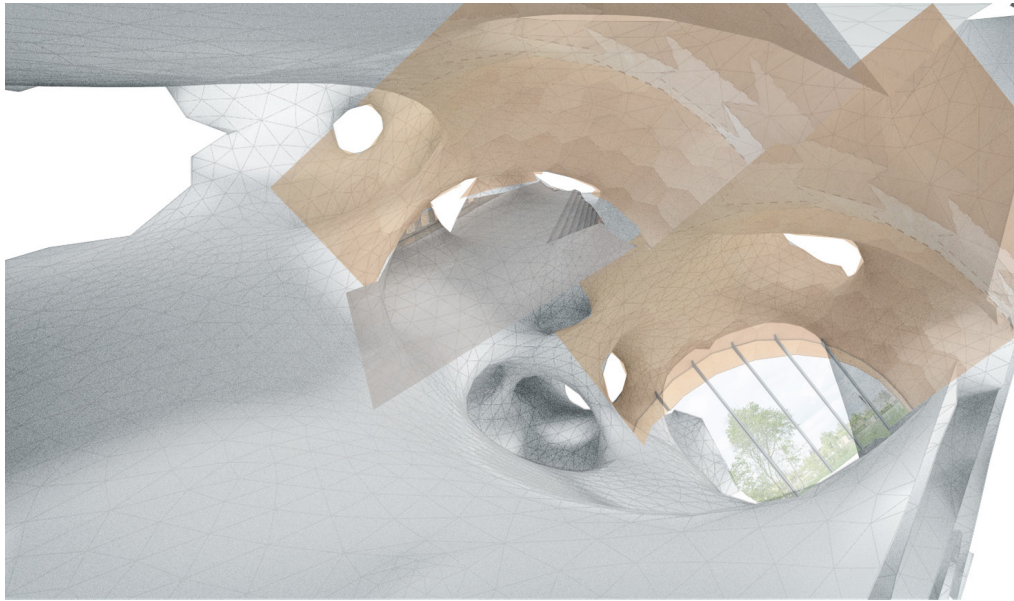
A first structural analysis, resulting in the lines of principal stresses, was made in order to understand the areas of highest concentration. This area corresponds to the placement of concrete. A second structural analysis on this area was made in order to understand the utilisation of the shell, resulting in the mapping of areas of compression, tension or both on both sides of the shell. Eventually this mapping is transformed into four colours, each identifying one case: only compression, only tension, compression on the top layer (thus tension on the bottom layer) and compression on the bottom layer (thus compression on the bottom layer). For each of the cases, the material distribution is calculated:

- Only compression: The only material that is needed is concrete
- Only tension: The only material that is needed is wood
- Compression on the top layer - tension on the bottom layer: combination of concrete and wood, with concrete on top and wood on the bottom
- Tension on the top layer - compression on the bottom layer: combination of concrete and wood, with concrete on the bottom and wood on the top

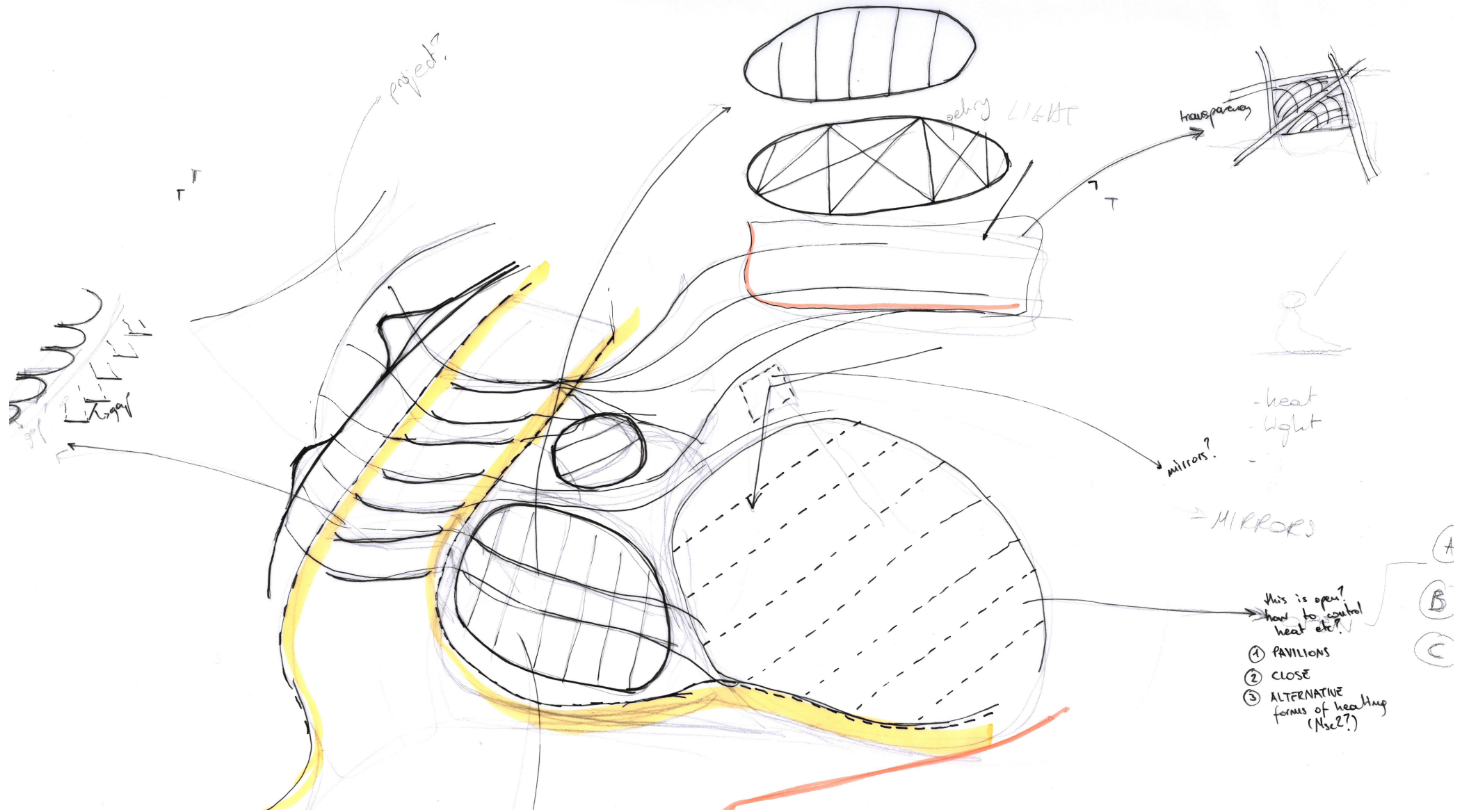
The resulting system consists of a continuous concrete layer that can

therefore discharge the forces to the anchor points. Similarly, the wooden structure is mostly continuous so that it can transform and discharge the tension forces to the compression areas. Moreover, concrete is present in higher quantities at the bottom of the structure and at the connections to the existing structure and gradually becomes less as the locations furthest from the anchor points, which have less weight to carry, and is replaced by wood.

Finally, a third material was introduced in order to respond to the needs of insulation and creating ergonomic and comfortable furniture. The material that best suited the requirements was EPS, which also offered the advantage of being used for the fabrication of concrete where wood would not be sufficient. The integration of this material with the others was particularly important in order to maintain the system to the greatest degree possible. In this way, despite the complexity of the system itself, the description of its production, for instance in a manual, could be more easily achieved. For this reason, the starting point was the previously described hybridization of concrete and wood. The latter makes use of additional shear connectors that allow to achieve composite action between the wooden beams and concrete. The solution was therefore to incorporate the same system for EPS.



Different materiality combinations that were initially thought of. Wood was eventually chosen as it is a natural material.



03

MATERIALITY AND D2RP&O REPORT

The research on materiality developed as a continuous design-and-analyse process, which meant that different aspects intersected each other at different moments in time simultaneously. For this reason, the research here presented is divided into categories but also makes reference to its chronological developments.

3.1 WOOD BENDING

Initially, as explained above, the research on materiality focused only on wood.

The aim was to create a lightweight structure that could reproduce double-bent surfaces, as the ones created by the gyroid, and be fabricated robotically without the use of moulds, which would inevitably invalidate the possibility of mass customisation required for this shape. Additionally, this material should not be created in a wasteful process, such as milling.

Several methods regarding the production of bent wood pieces were investigated. This was necessary in order to better define the topology of the wood beams.

The first step in the research on wood was to analyse the different existing systems for bending wood at medium-to-large scales: CNC, steam bending, CLT and veneer.

While CLT is the system that is widely used in large structures, its fabrication method requires the use of moulds, which was excluded as a starting point of the research. Veneer, on the other hand, is not structural. Finally, CNC methods of production are mainly based on the subtraction of material that be relatively wasteful. However, successful applications on double curved systems exist, even if these are achieved by means of rationalisation or simplification of the curvature.

This research revealed steam bending as a possible solution, in par-

ticular when made with wooden beams. Wooden beams were then chosen as the preferred topology, since they are easily available and can be bent into the right position with a relatively wasteless production process (they do not use moulds nor they go through a subtraction process).

The research was then extended to other methods of production of curved wooden beams. These methods are: laser-cutting, zipshape, kerf-bending and, as mentioned above, steam-bending. They differ in strength, amount of manual work required and correspondence with the computational model.

Laser-cutting has low strength (being hollow) but the highest correspondence to the computational model, since it is based on geometrical restraints and its bending characteristics can be engineered through the orientation of fibres. Steam-bending, on the other hand, is possibly the strongest. However, its final shape is highly dependent on the material characteristics, particularly the direction of fibres and presence of nodes and springback. Several ways have been studied before in order to reach a higher correspondence, especially by applying external constraints. However, their efficacy is still limited and some systems have used scanning as a method for assessing the correspondence of the final product to the computational model.

The research then attempted at understanding if the combination of

steam-bending and reduced kerf-bending could reach a higher correspondence, with kerf-bending acting as a constraint.

A beam was extracted from the project to test the possibilities offered by kerf-bending in determining the final shape. The first step was to minimise the control points of the beam, so to minimise the curvature to the essential. The trial consisted of kerf cuts made into an EPS beam, therefore eliminating on the constraints from the equation (i.e. the direction of fibres), with string that would form an arc-like shape on each of the sides in order to reproduce bending. The length of the strings in the computational model was calculated in order to be reproduced on the trial. In the case of robotic production, this data would be fed to the robotic arm.

The test, however, determined that torsion cannot be achieved with kerf-bending, therefore invalidating the system. For steam-bending the constraint would therefore need to be an external constraint, such as a wire rope, to maintain the beam into the required position, at least until the end of the drying process.

In relation to the topology of beams, it was deducted that beams should either maintain a relatively small curvature and/or it should be possible to divide them into pieces that contain little curvature and little torsion. Yet, the trial that was made with laser-cutting demonstrated the high-reliability in terms of correspondence to the computational model, as well as the ability to reach tight curvatures. This brought to the possible conclusion that:

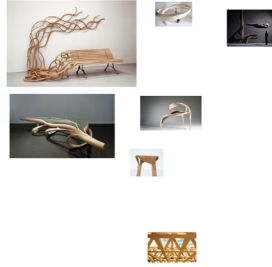
- beams that are structural should have low-curvature and bundled together at different points in space (since they would be cut into pieces). They would be produced with steam-bending
- beams that are only functional (i.e. that are used as formwork or to create closed and open surfaces) could be more free-form and produced with laser-cutting methods

For this reason, the system of “continuous beams”, which was initially implemented, needed to be modified, since it would not allow for the structural beams to always have points of connection. Other systems were then researched in order to simplify the curvature of the beams.

The system that was chosen is an agent-based system that, starting from initial guide curves, creates an agglomeration of curves that never intersect each other. It creates areas where curves converge and later diverge and areas where the beams are parallel to each other. It also calculates the length of the beams according to their curvature: longer where more rectilinear and shorter where more curved.

This system is, however, not entirely dissimilar from the “continuous beams”. Rather it allows for continuous beams that are parallel for those that are structural while the functional beams act as an infill.

STEAM



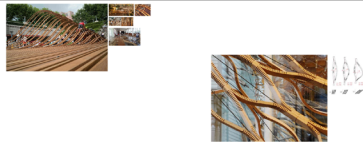
Small scale

CNC



XLAM

Medium scale

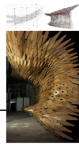


Big scale

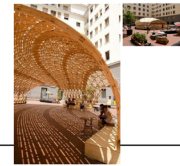


First analysis on systems used in order to create wooden structures according to different types and the sizes of the results

VENEER



OTHERS



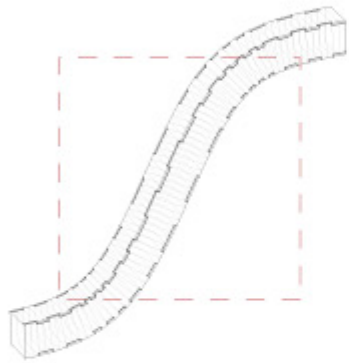
Medium scale

Big scale



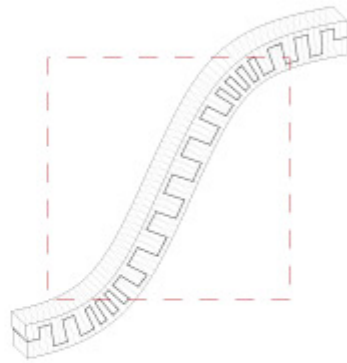
METHODS FOR BENDING WOOD

1. LASER-CUTTING



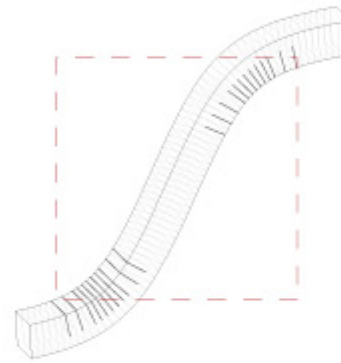
Low strength since it is void in the centre and thin on the sides
High amount of manual work
Micro control of torsion and bending: no possibility of mistakes because it relies on geometrical restraints

2. ZIP SHAPE



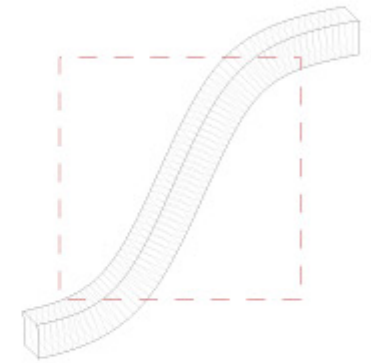
Low-medium strength since only a little strip of wood is left on the sides
Medium-high amount of manual working
Geometrical control of bending

3. KERF-BENDING



Medium strength
Missing the torsion movement through geometrical deformation, but it can be forced into a position with torsion
Difficult to maintain the shape in position through dry connections

4. STEAM BENDING



Possibly the highest strength
Any shape can be achieved but it needs to dry maintaining that position for relatively long hours
Strongly dependent on the material (e.g. presence of nodes) and no geometrical restraints are introduced in the process



ZIP SHAPE



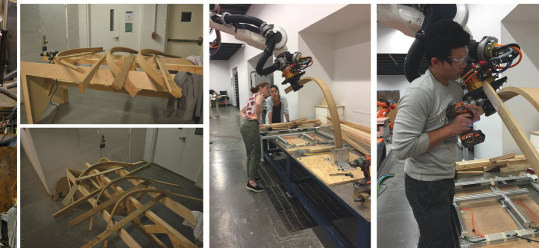
CONCRETE
Anders Kruse Rasmussen



FREEFORM STEAM BENDING
Richard Deacon



FREEFORM STEAM BENDING
Richard Deacon



ROBOTICS FABRICATION STUDIO
Richard Chow



ROBOTICS FABRICATION STUDIO - STEAM BENDING
Richard Chow

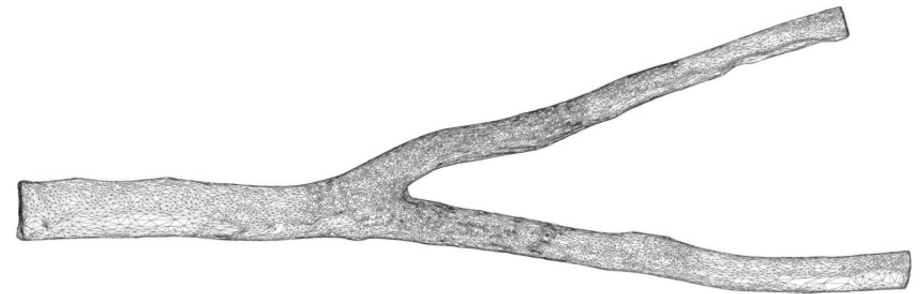
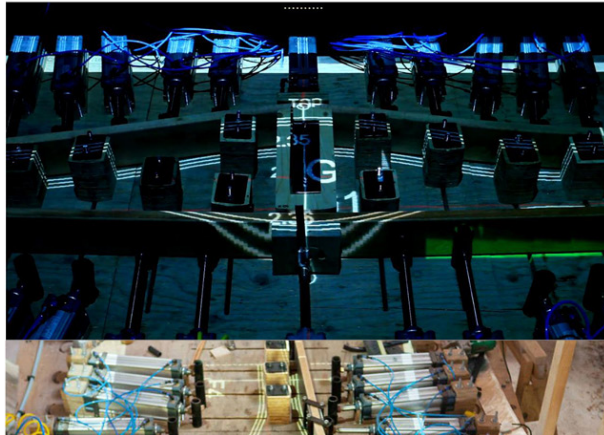


ALL BENT OUT
to keep the beam straight



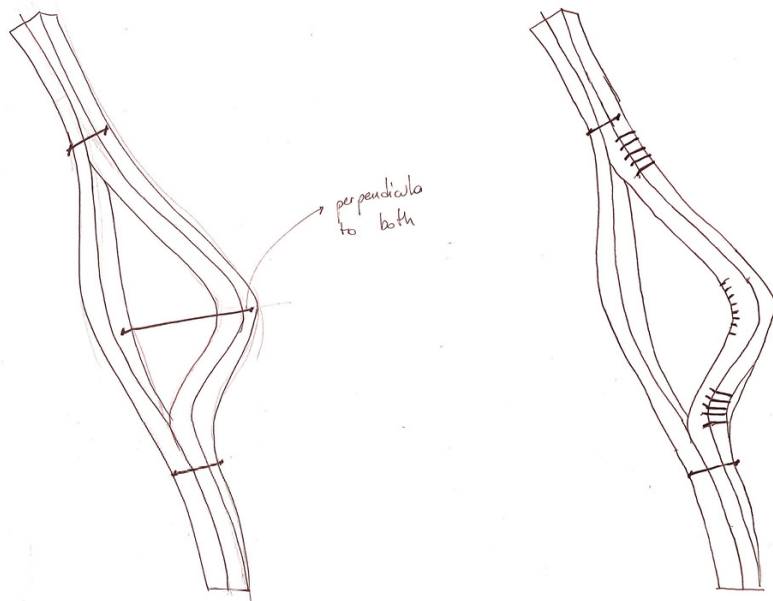
ROBOTICS FABRICATION STUDIO
Richard Chow

Different methods used to bend in wood beams (top, clockwise: zip shape, laser cutting, kerf cutting and steam bending) and several methods used in order to avoid springback

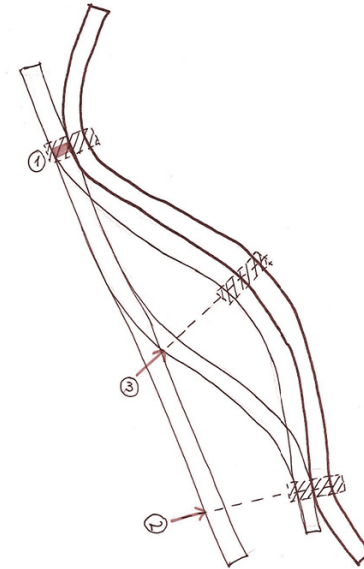


Fork 08_D02 scan mesh

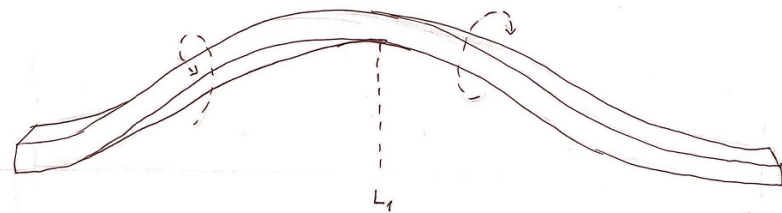
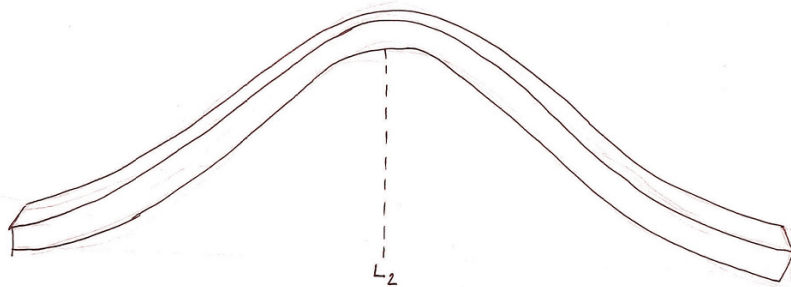
Two project demonstrating the possibility of (3d) scanning of wood beams in order to understand their bending behaviours and real-time curvature



FABRICATION METHOD
Fabrication method 2: Dry connections and kerf-cutting

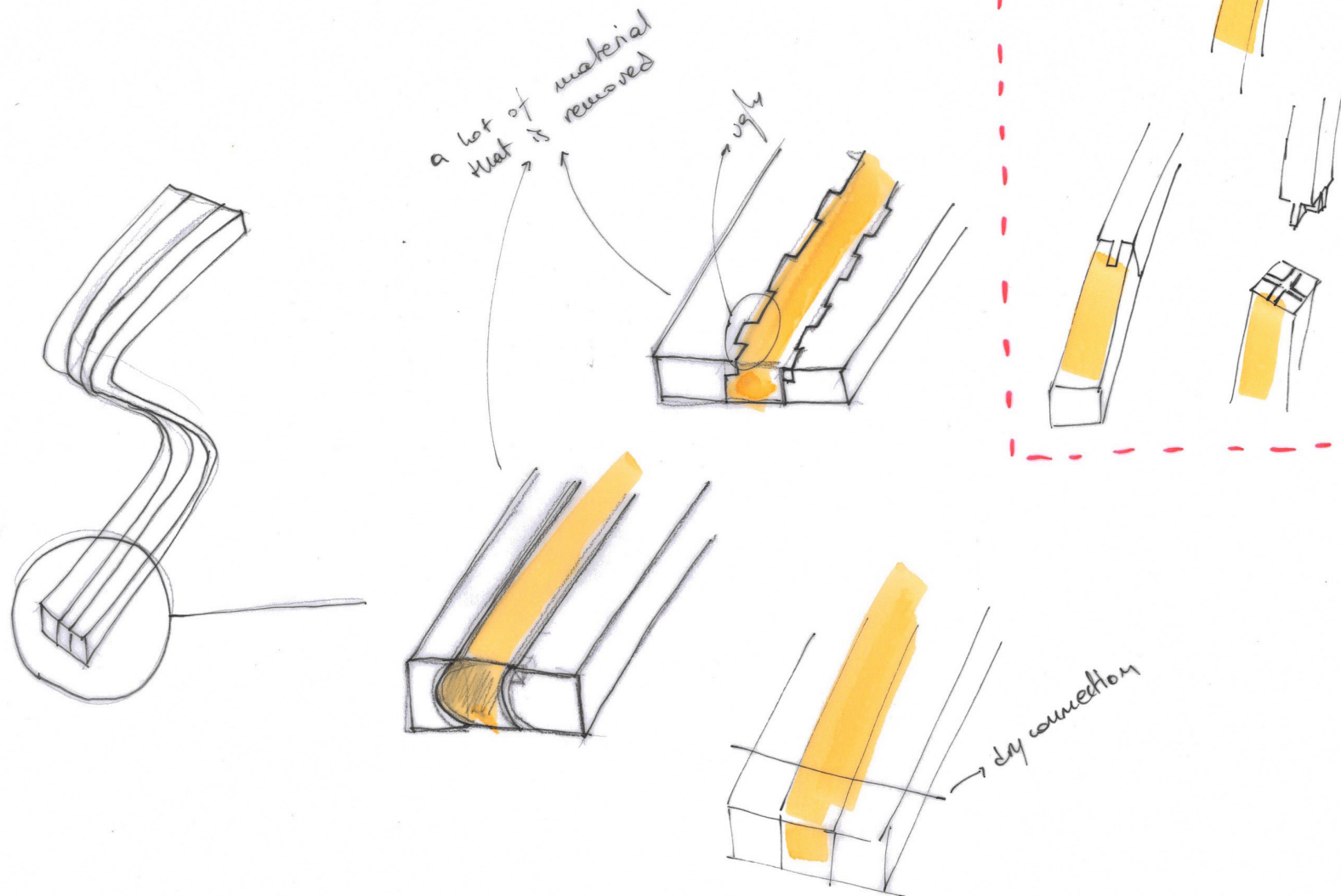


FABRICATION METHOD
Fabrication method 2: beams as moulds



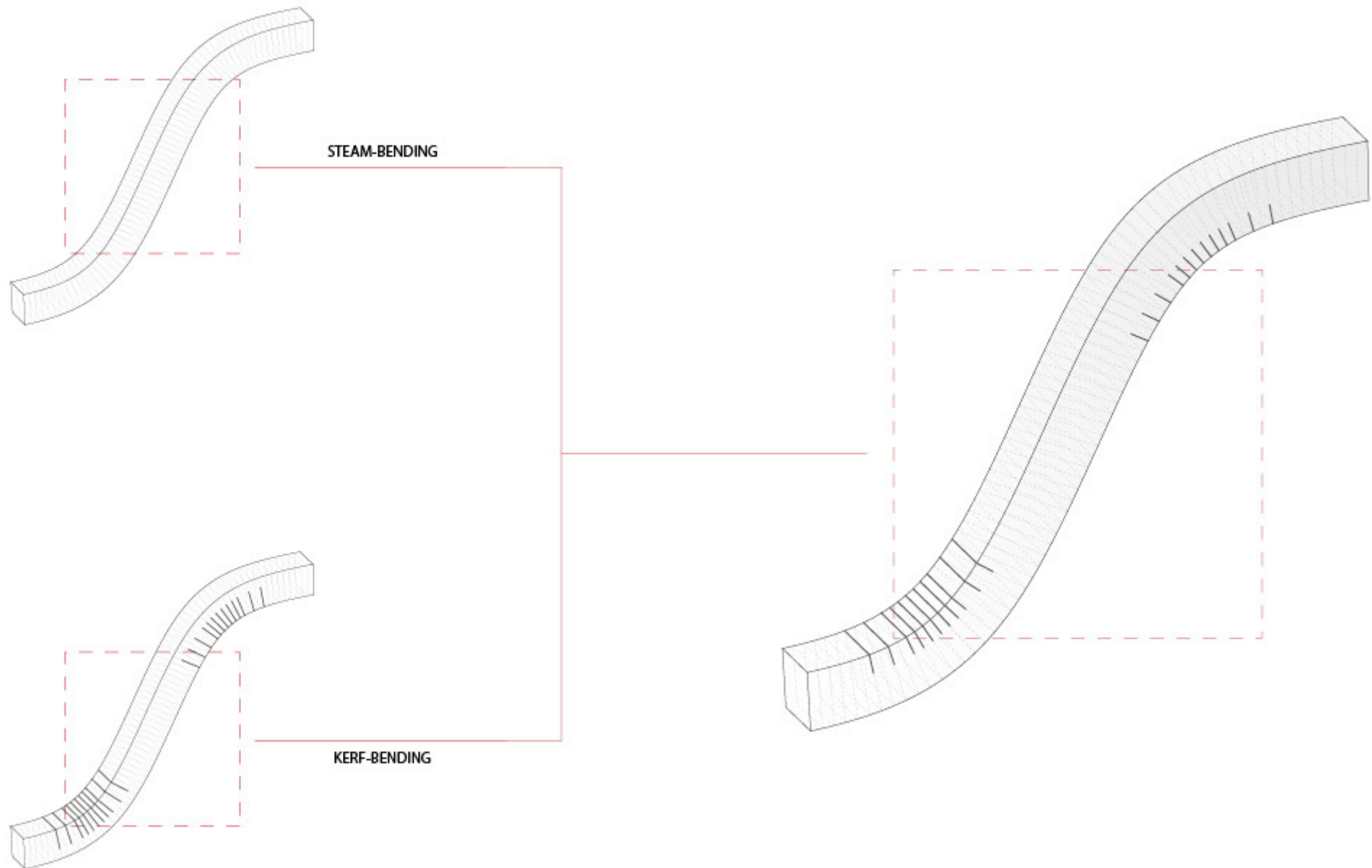
FABRICATION METHOD
Fabrication method 2: torsion?

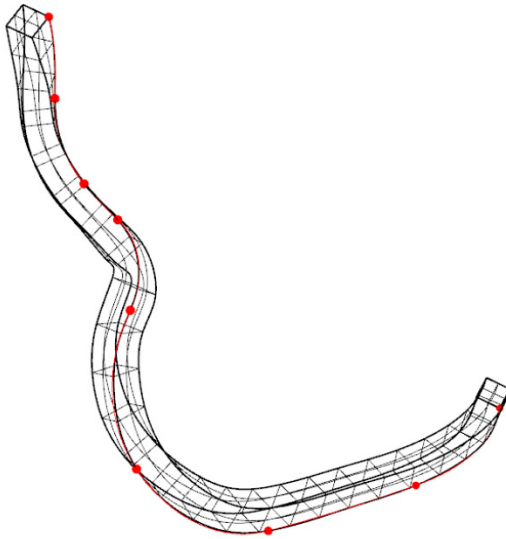
Remarks on beam connections and researches into simplification for guaranteeing correspondence to computational model



Study on the wood connections. Eventually dry connections were chosen as the other would be unrealistically hard to work once bent

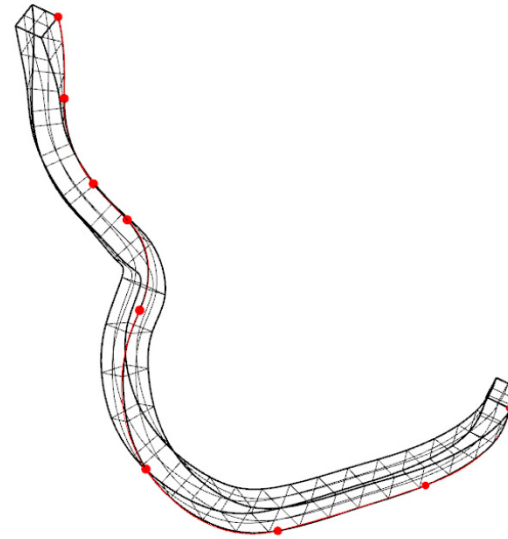
SELECTED METHOD





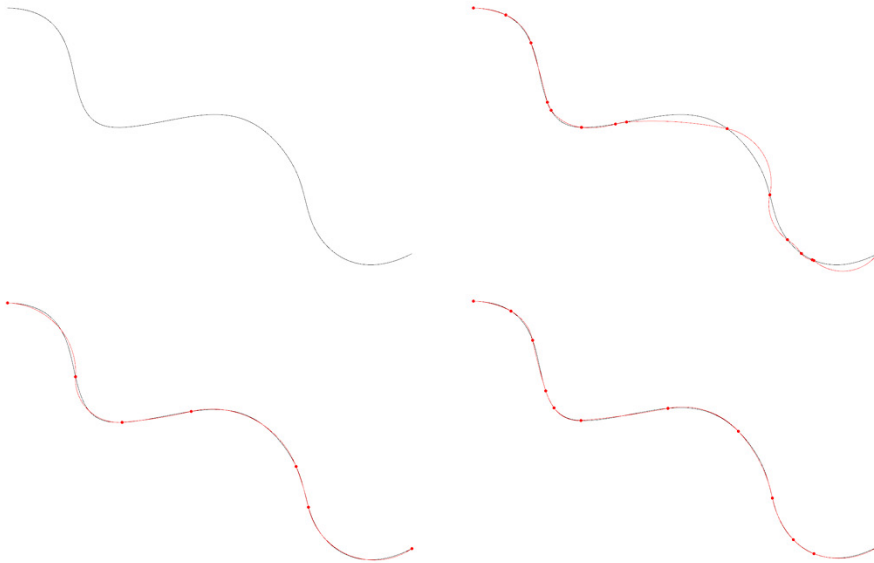
BEAMS TO ARCS

Simplification of beams in order to minimise the control points



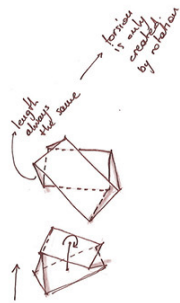
BEAMS TO ARCS

Simplification of beams in order to minimise the control points

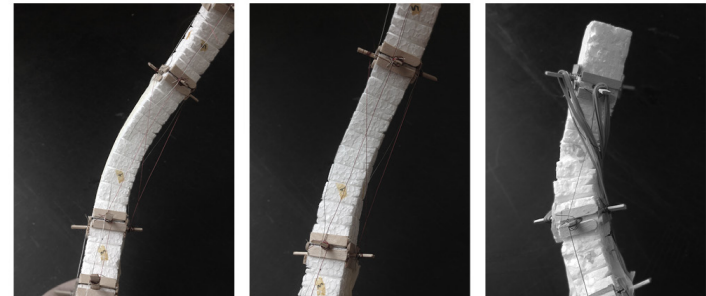
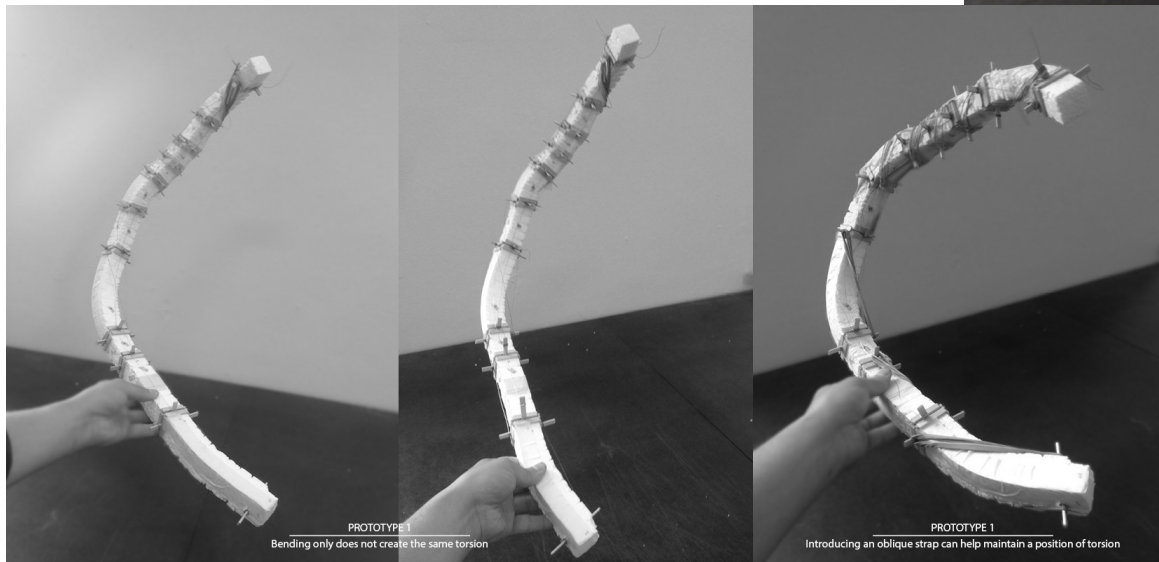


CURVES TO ARCS

Simplification of curves and beams with fewer control points to facilitate production

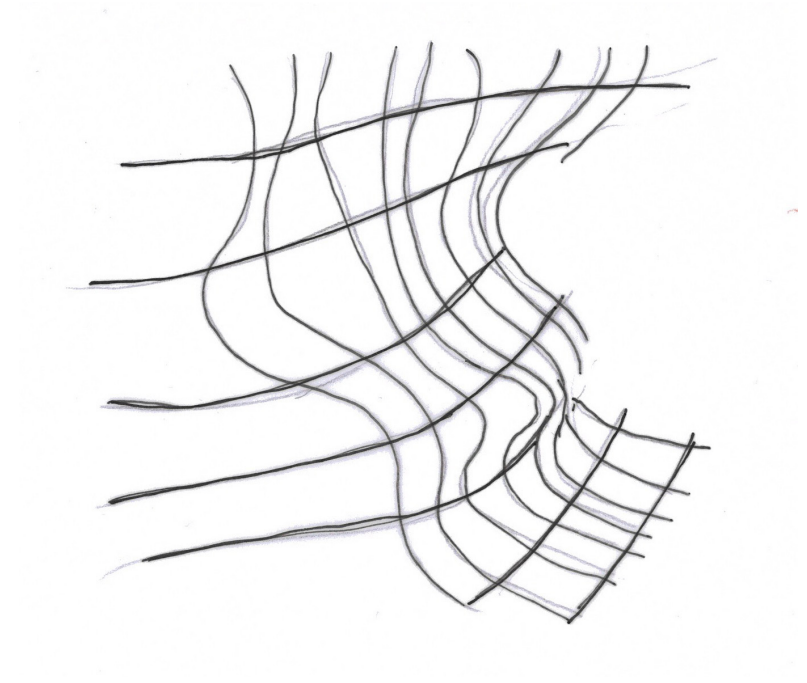


PROTOTYPE 1

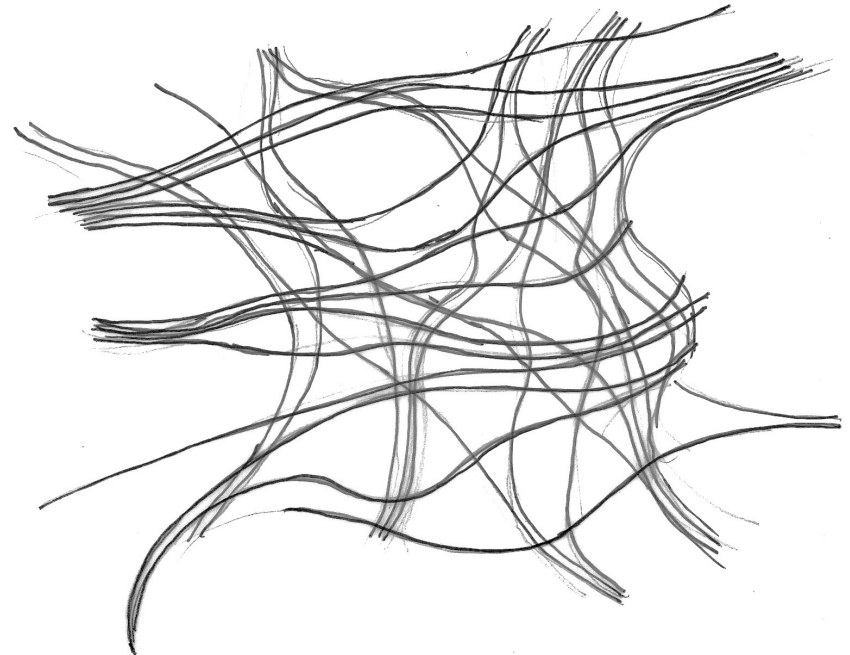
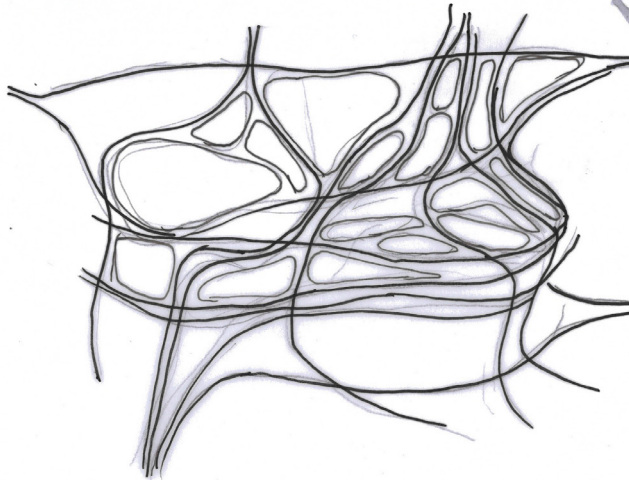
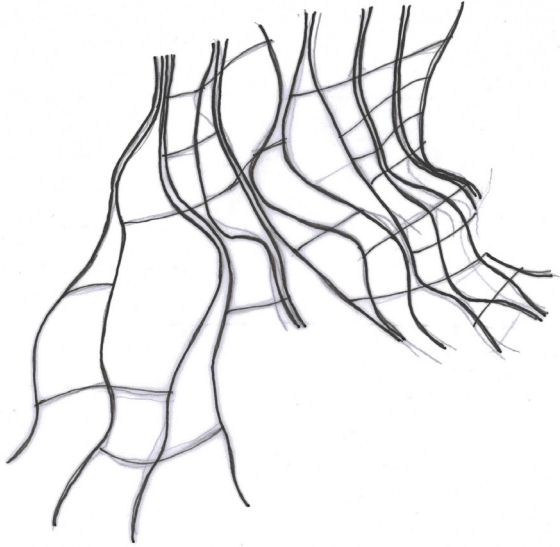


3.1.1 STUDY ON PATTERNS

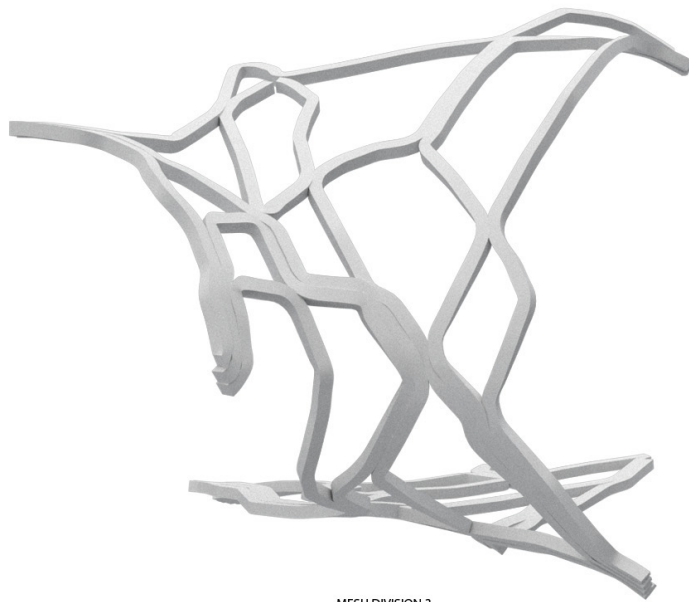
The study on patterns focused on structure that would be made of two layers of wood so that they could collaborate in avoiding springback after fabrication. However, they were also analysed in terms of the shape that would result from these systems, on its practicability in relation to ergonomic and production.



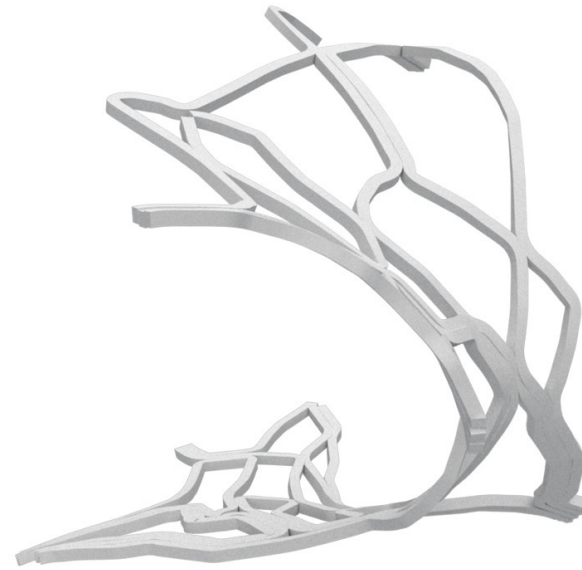
The research on pattern, trying to geometrically avoid springback by using wood in different directions



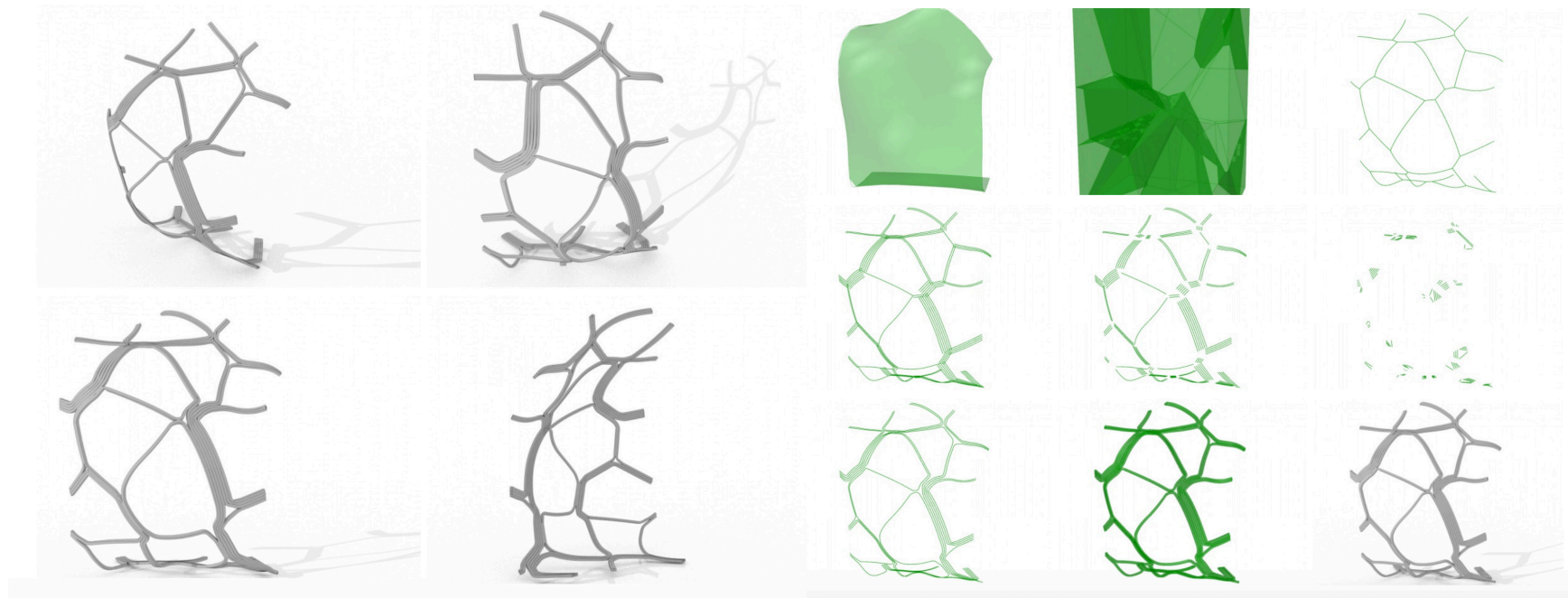
Different studies on the patterns that were classified according to possible strength, amount of curvature and the void-volume relation, and the typology of architecture (in this case furniture) that they would lead to



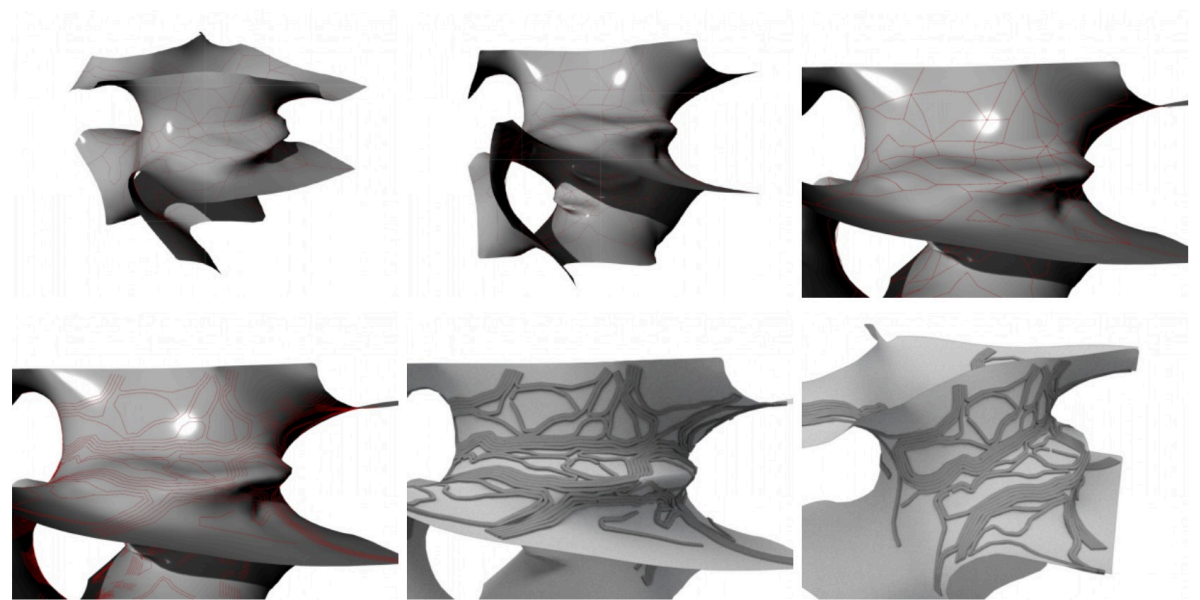
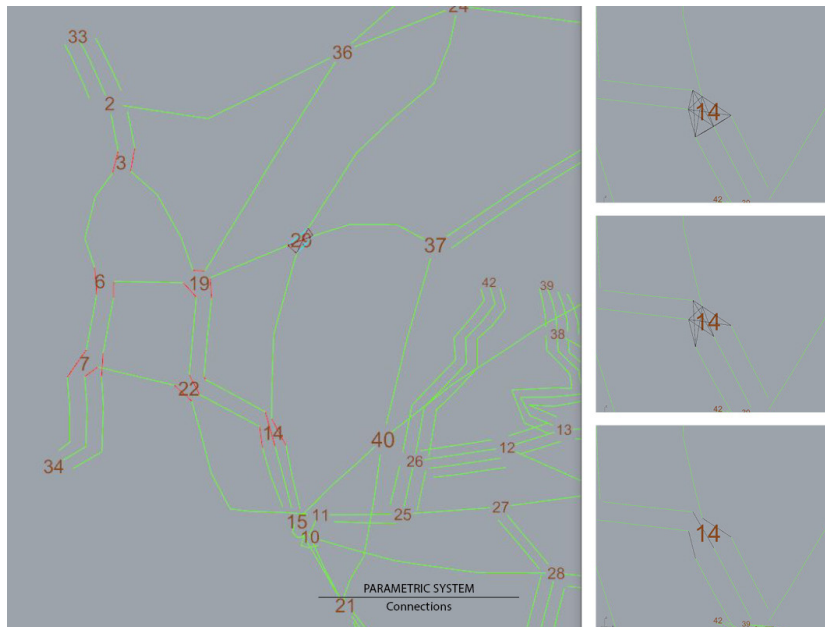
MESH DIVISION 3
Shortest walk



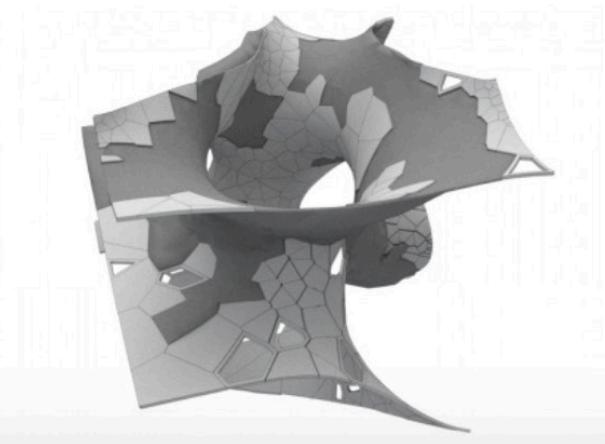
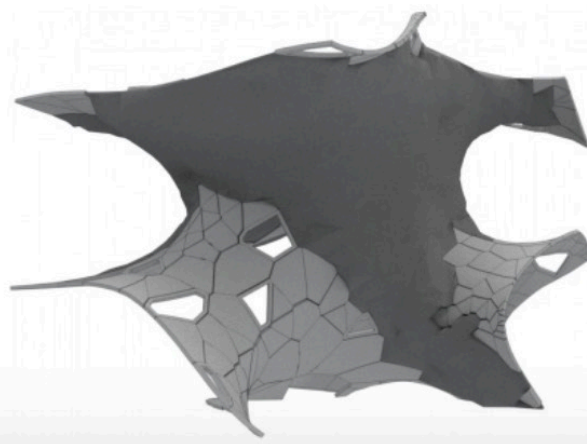
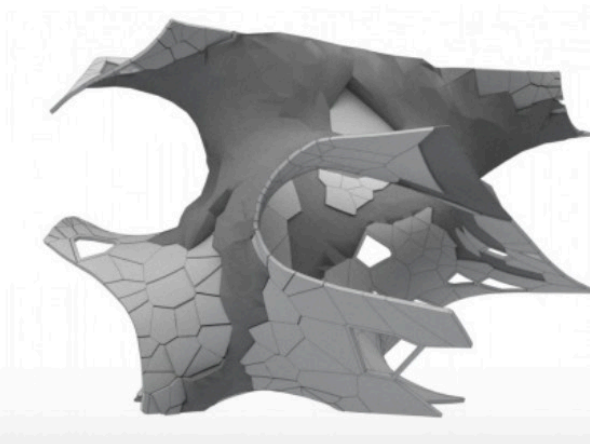
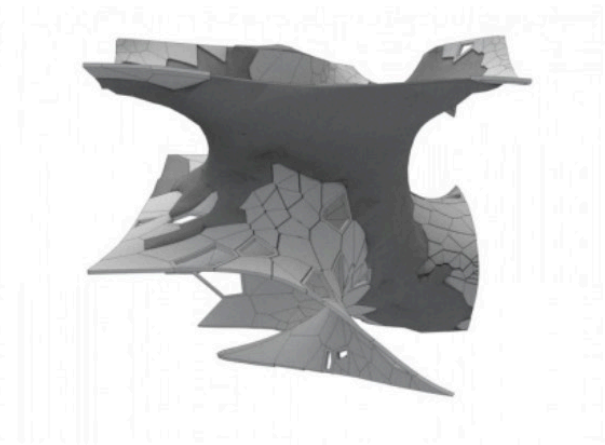
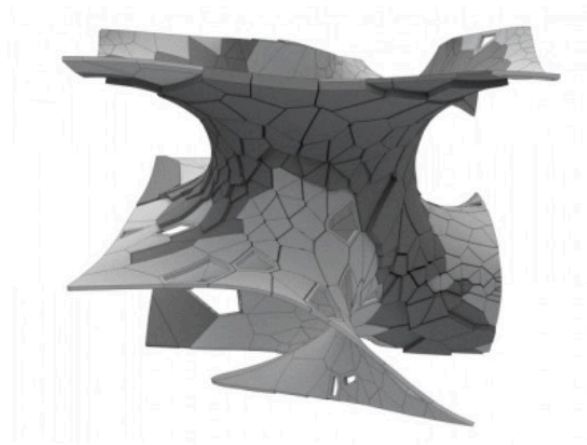
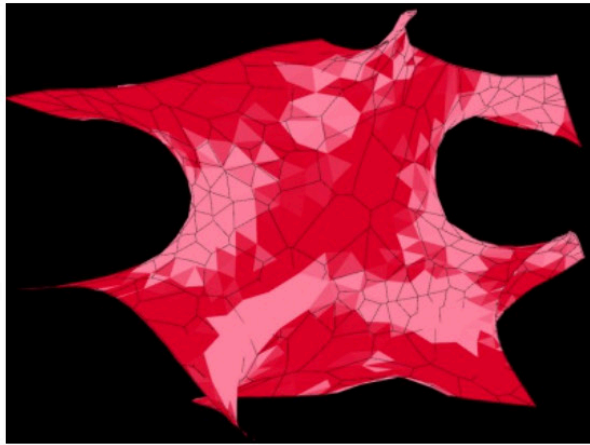
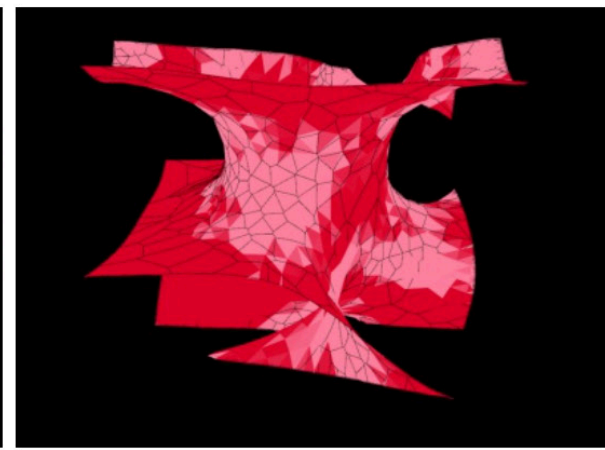
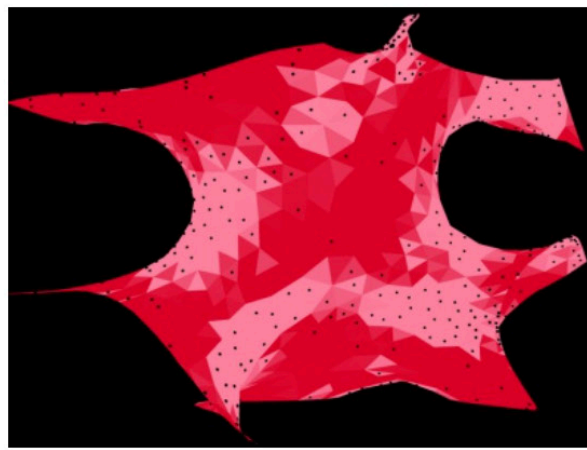
MESH DIVISION 3
Shortest walk



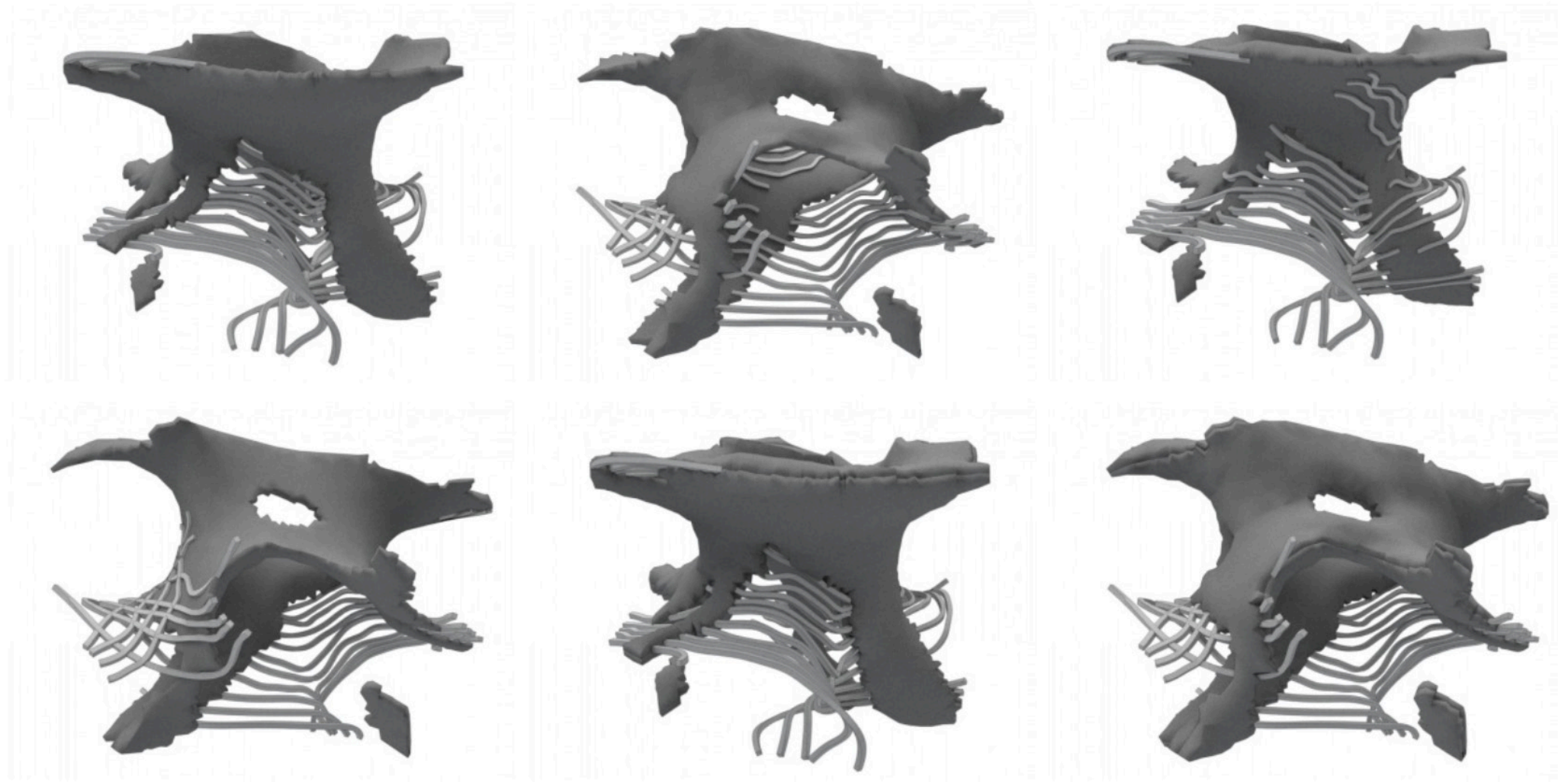
The first final pattern: continuous wooden beams that are never intersecting but rather converging and diverging. One of the final trials is here shown



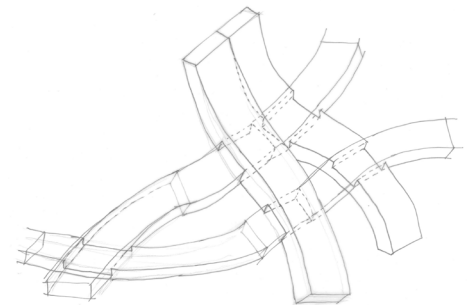
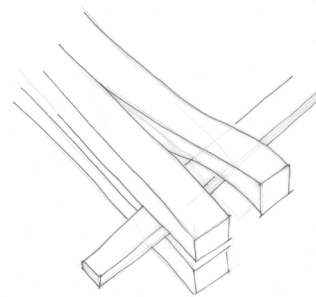
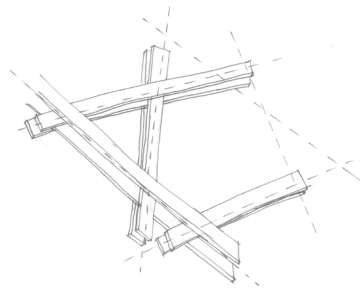
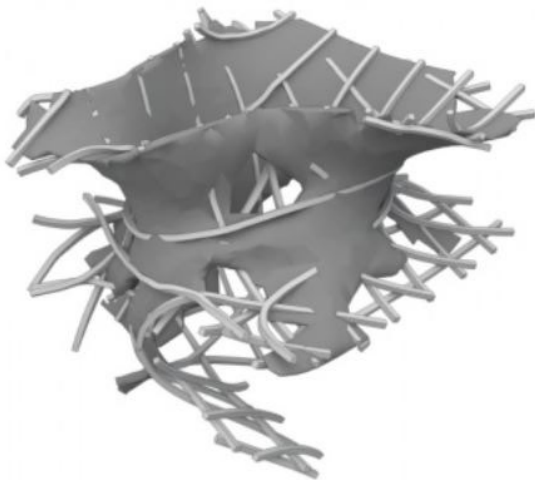
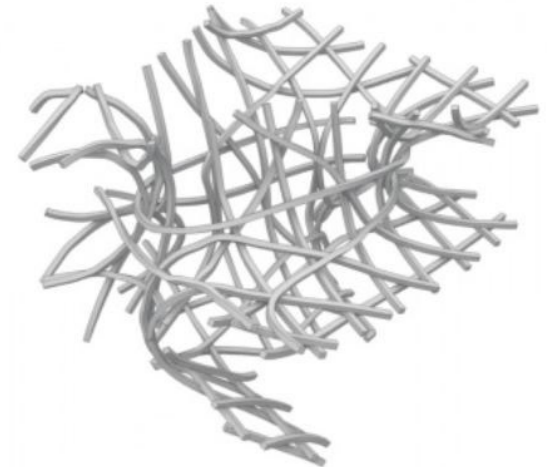
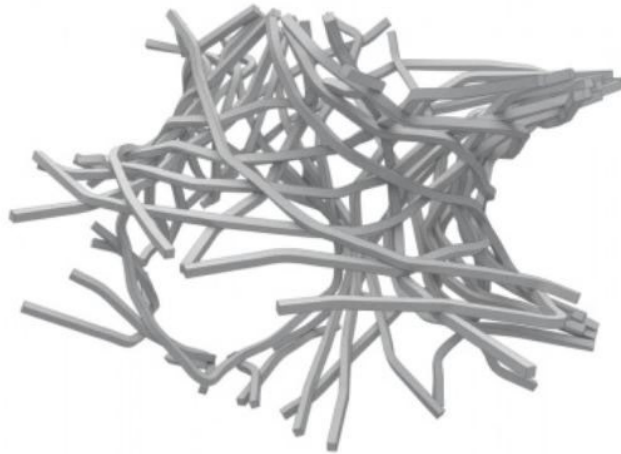
The first final pattern: continuous wooden beams that are never intersecting but rather converging and diverging. Also showing the application on a bench which shows how complicated the curvature of the elements would be



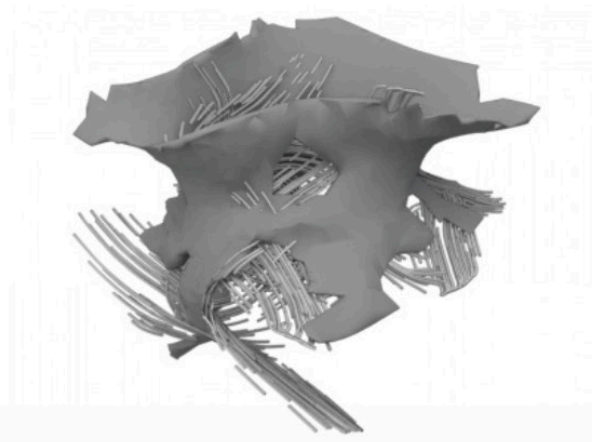
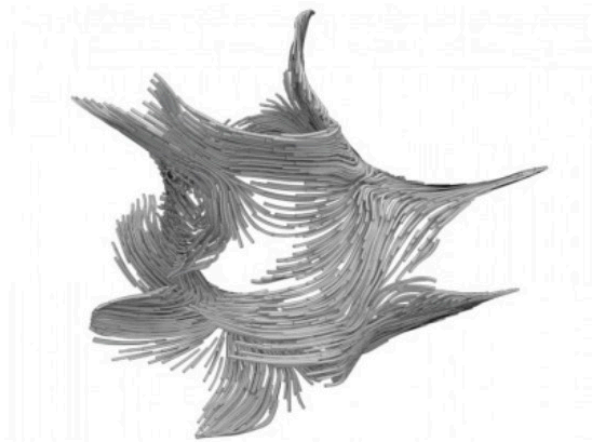
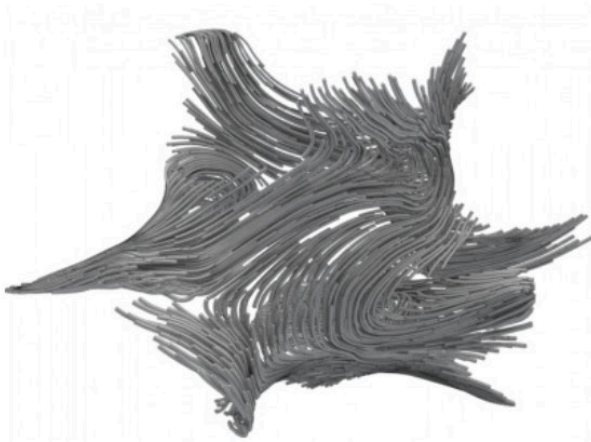
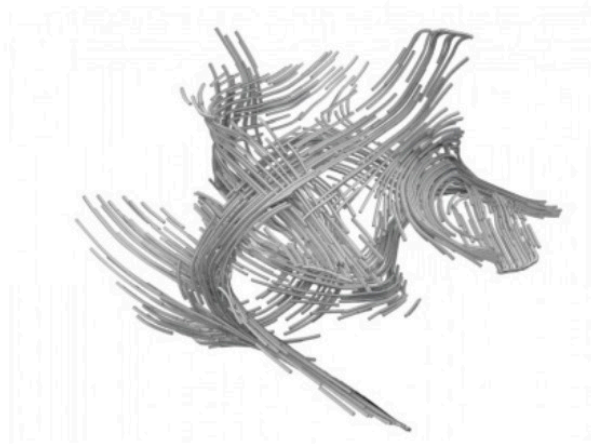
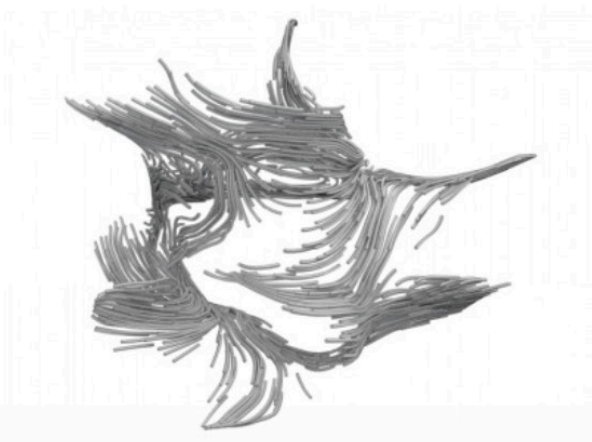
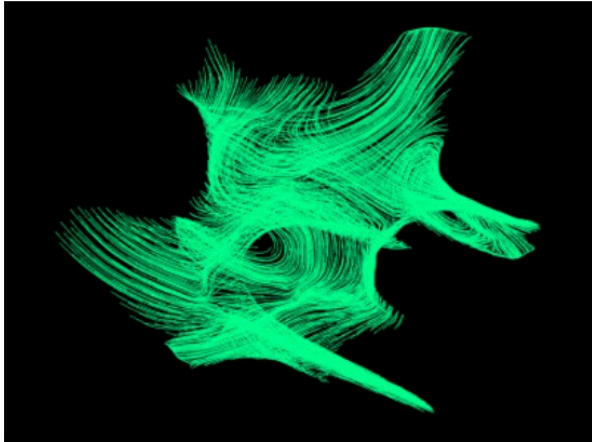
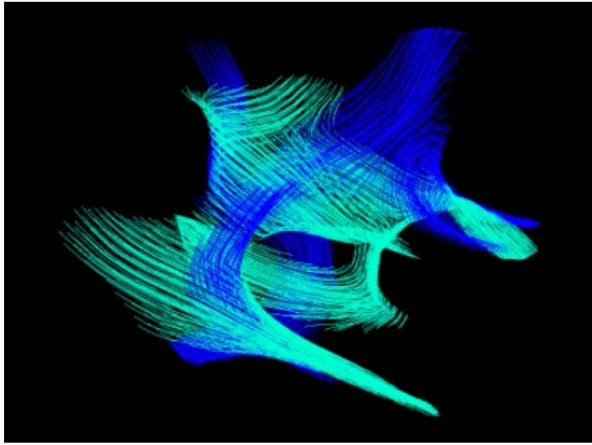
A simplification trial that temporarily abandoned the typologies of beams. A faceted wood surface that would be created by CNC production methods

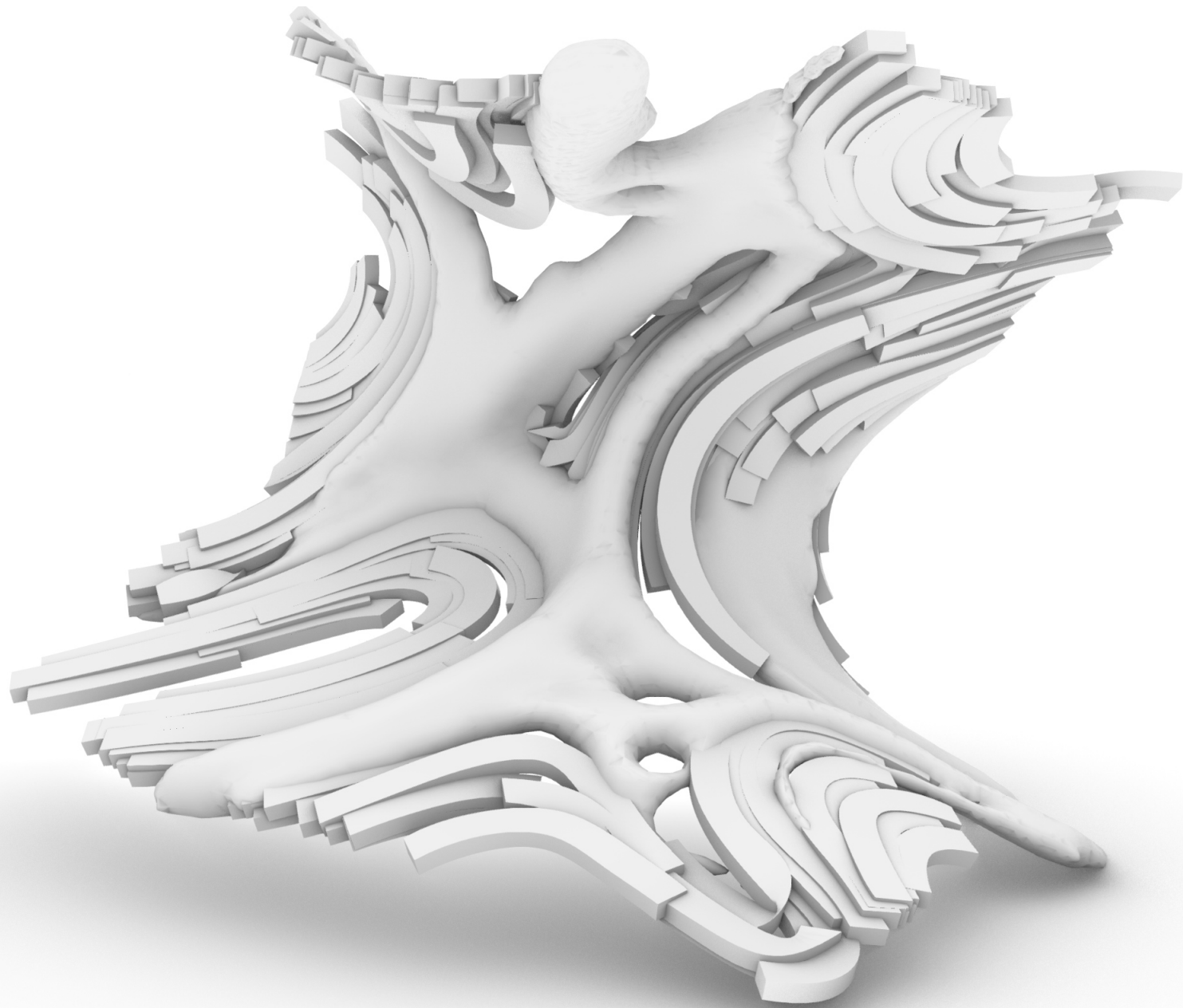


The most basic simplification of wooden beams, made of parallel beams only. In particular the question was if simplified wooden beams would better fit with concrete. It was eventually discarded



Hexagonal crossing beams. A system that is very stable but that in the case of the gyroid would be more difficult to apply due to the fact that it is not just a surface that could be projected to the ground. Thus the irregularity of the shapes





3.2 INTEGRATION OF WOOD AND CONCRETE

Since wood alone would not be able to support such a large structure, a second material needed implementing. Concrete was chosen as it has high compressive strength (which wood does not) and is easily moulded into double-bent geometries. Moreover, the two materials had the possibility of being combined for production purposes: wood acting as shuttering for concrete.

The research here presented is chronological and shows the first step towards the integration of concrete. This part of the research focused on the integration of the two materials, trying to maintain wood as primary structure. Simultaneously, it also shows a research into the topology of wood.

1. Concrete as a connector material to increase the strength of the wood structure. Wood topology made of continuous parallel, converging and diverging beams
2. Concrete position in relation to wood:
3. Inbetween, therefore acting as a connector or lying over it, in which case a continuous surface is created. Eventually this system was chosen as more compatible as concrete can only achieve strength if uninterrupted.
4. First trial on wood as formwork (shuttering) and on the geometry thereof.
5. Visualizing how wood could respond to the creation of void structures (double shells))

6. Research on windows which are double-bent surfaces

Once the need for continuous concrete surfaces was established, new configurations were tested on the gyroid shapes, while maintaining the formwork as made by primary (beams) and secondary elements (shuttering), which would be partly removed after casting. However this highlighted some problematics in relation to the integration of the two materials, particularly geometrically, while the small scale of the trials did not allow a full understanding of the structural characteristics.

The geometry for wood as shuttering was considered while maintaining a primary structure made of wood. This system was considered complicated, rather than complex, since it would be made with many small pieces of wood and, multiplied to the scale of the whole building, it would have required a great deal of manual work. Shuttering of wood should be made with the beams themselves in order to decrease the complicatedness of the system.



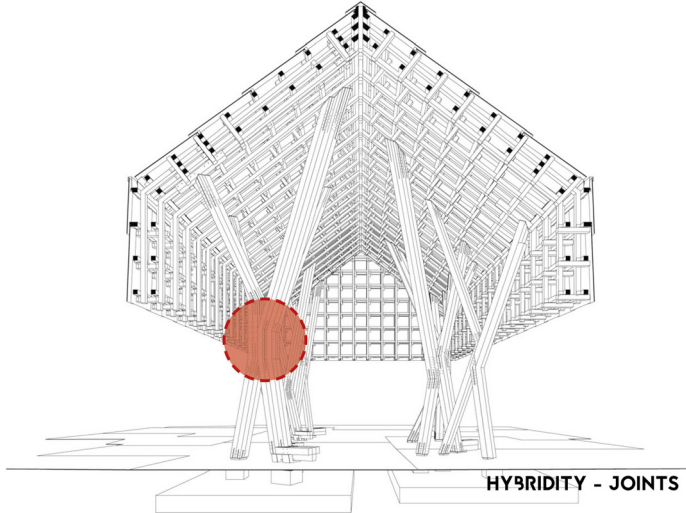
HYBRIDITY - JOINTS



HYBRIDITY - JOINTS



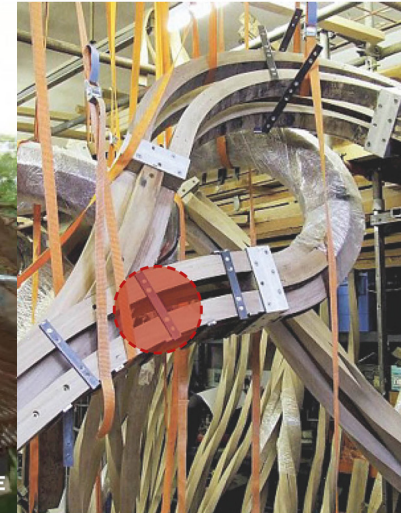
HYBRIDITY - JOINTS + SUBSTRUCTURE

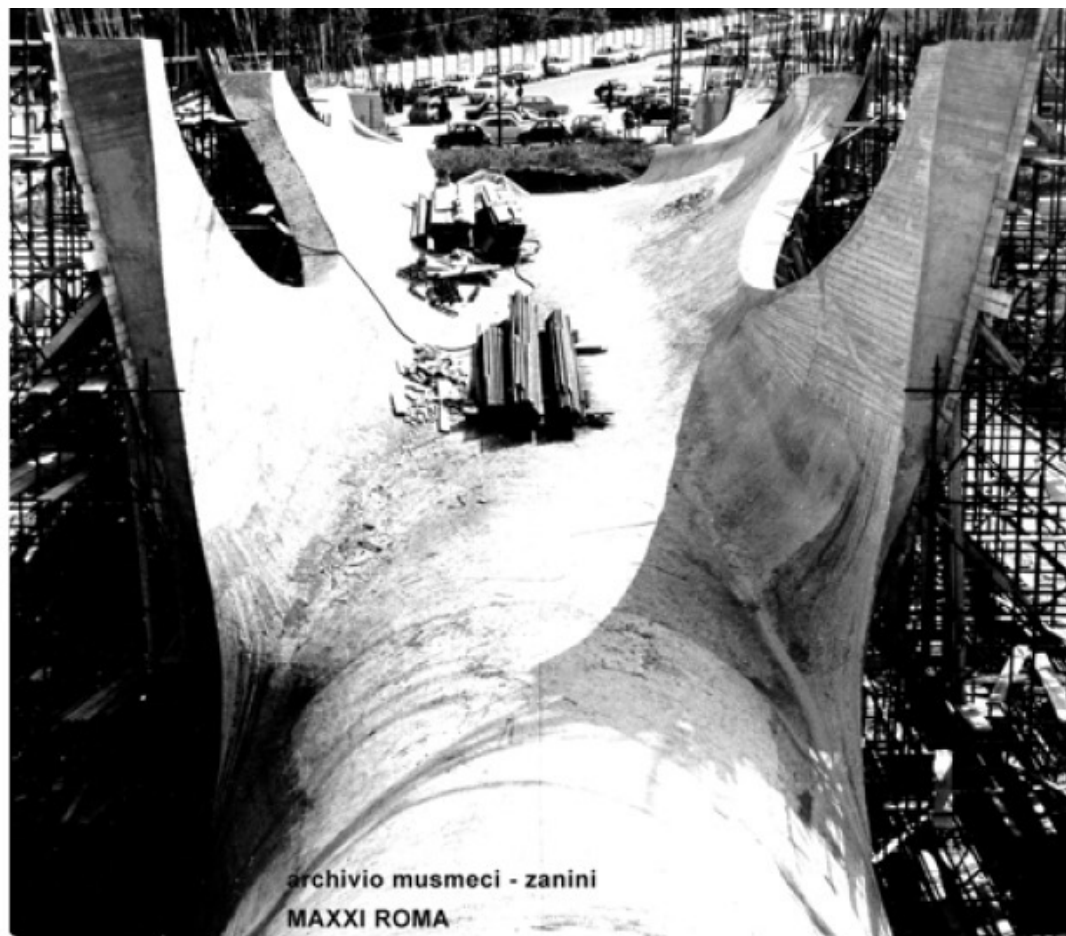


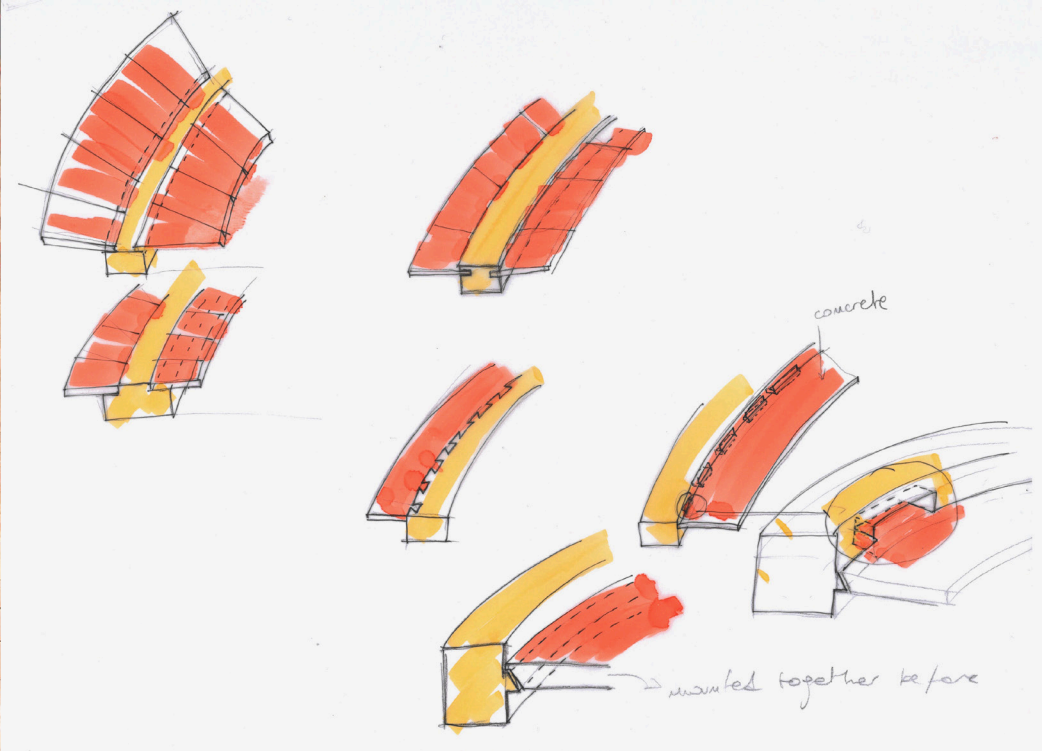
HYBRIDITY - JOINTS

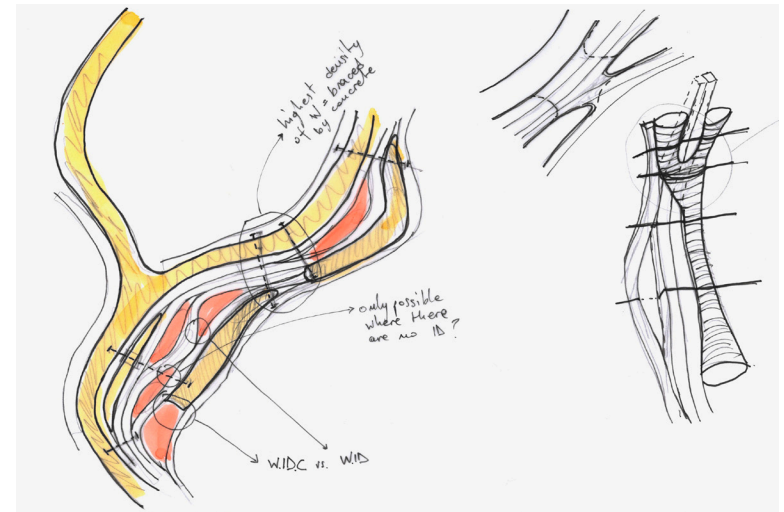
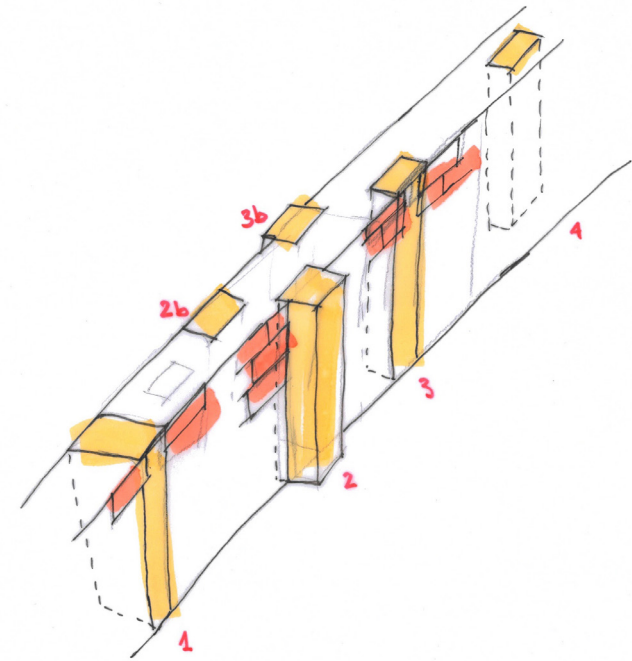
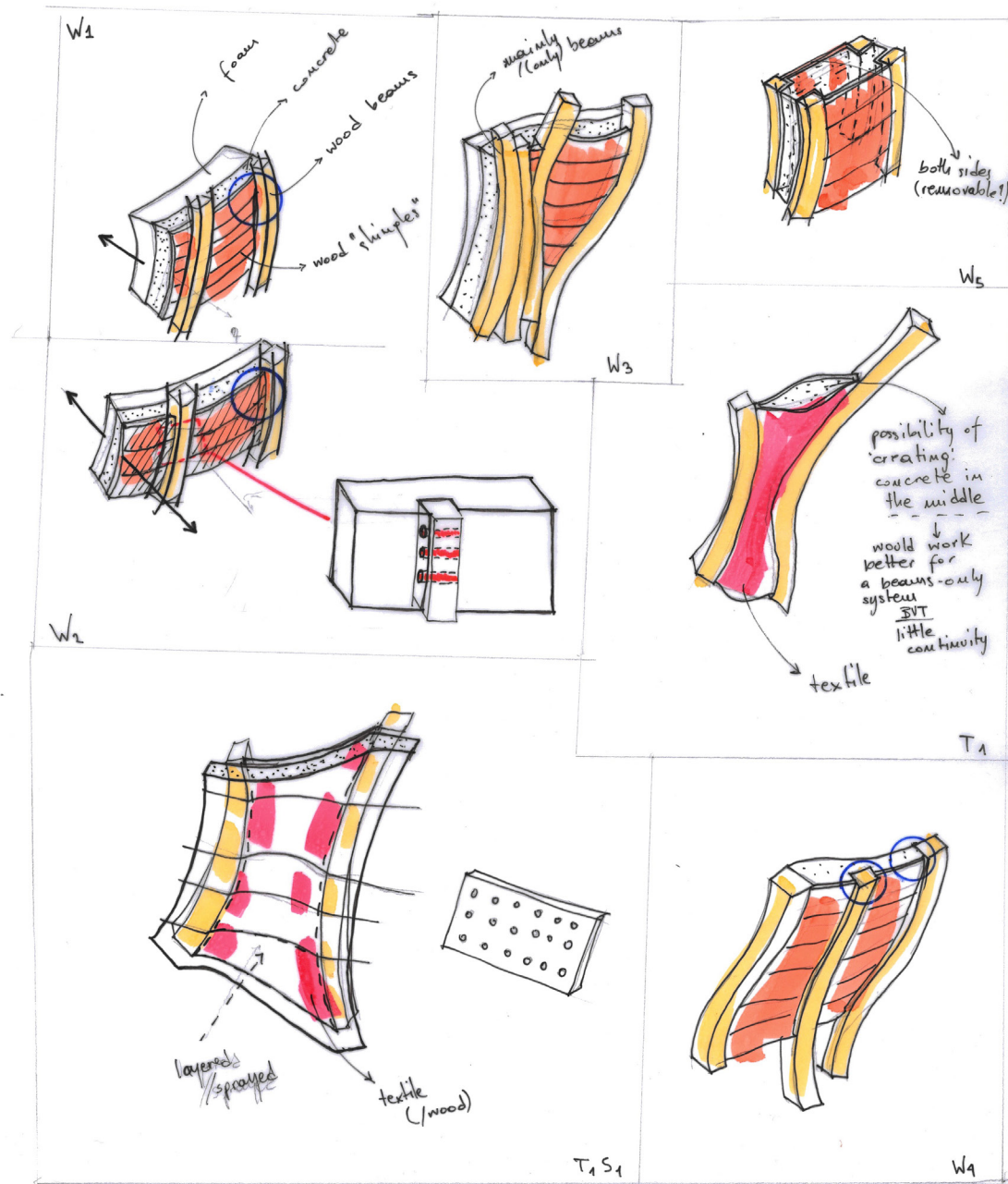


HYBRIDITY - SUBSTRUCTURE



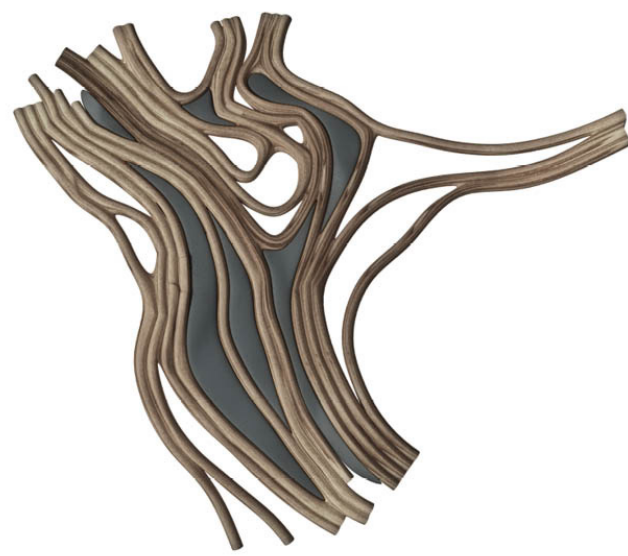
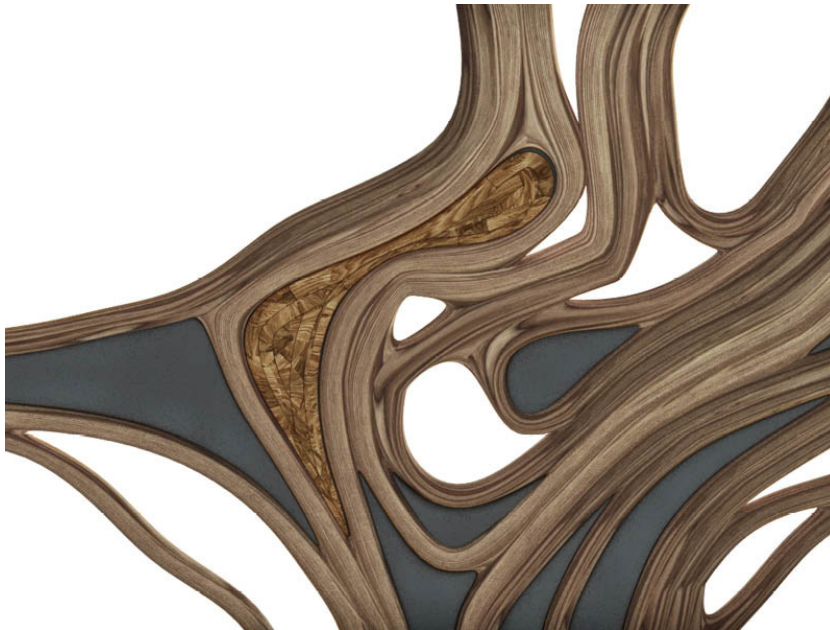






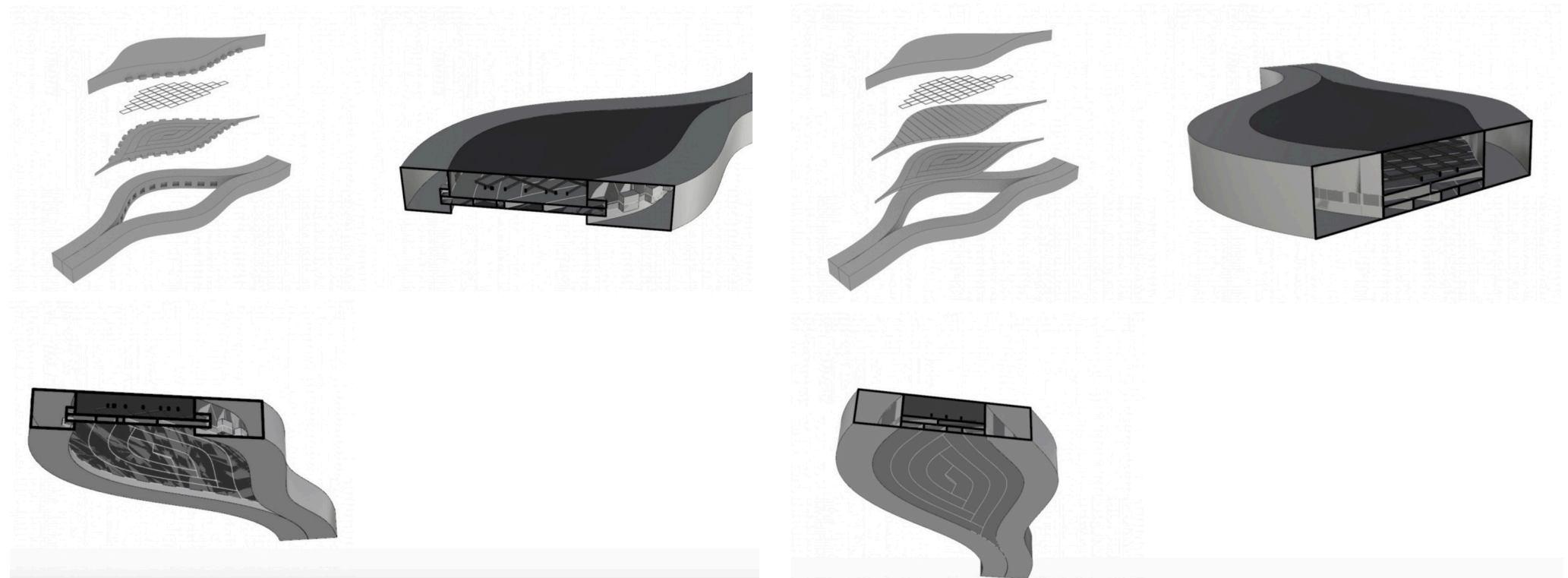
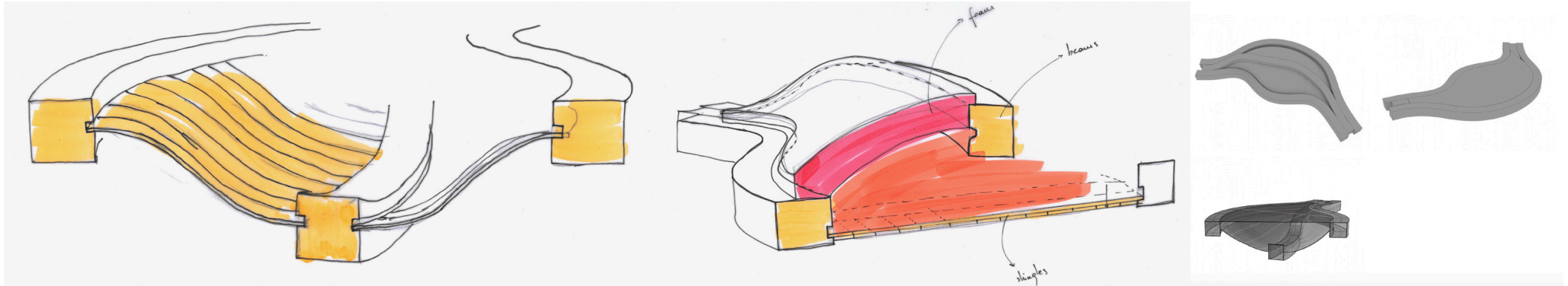


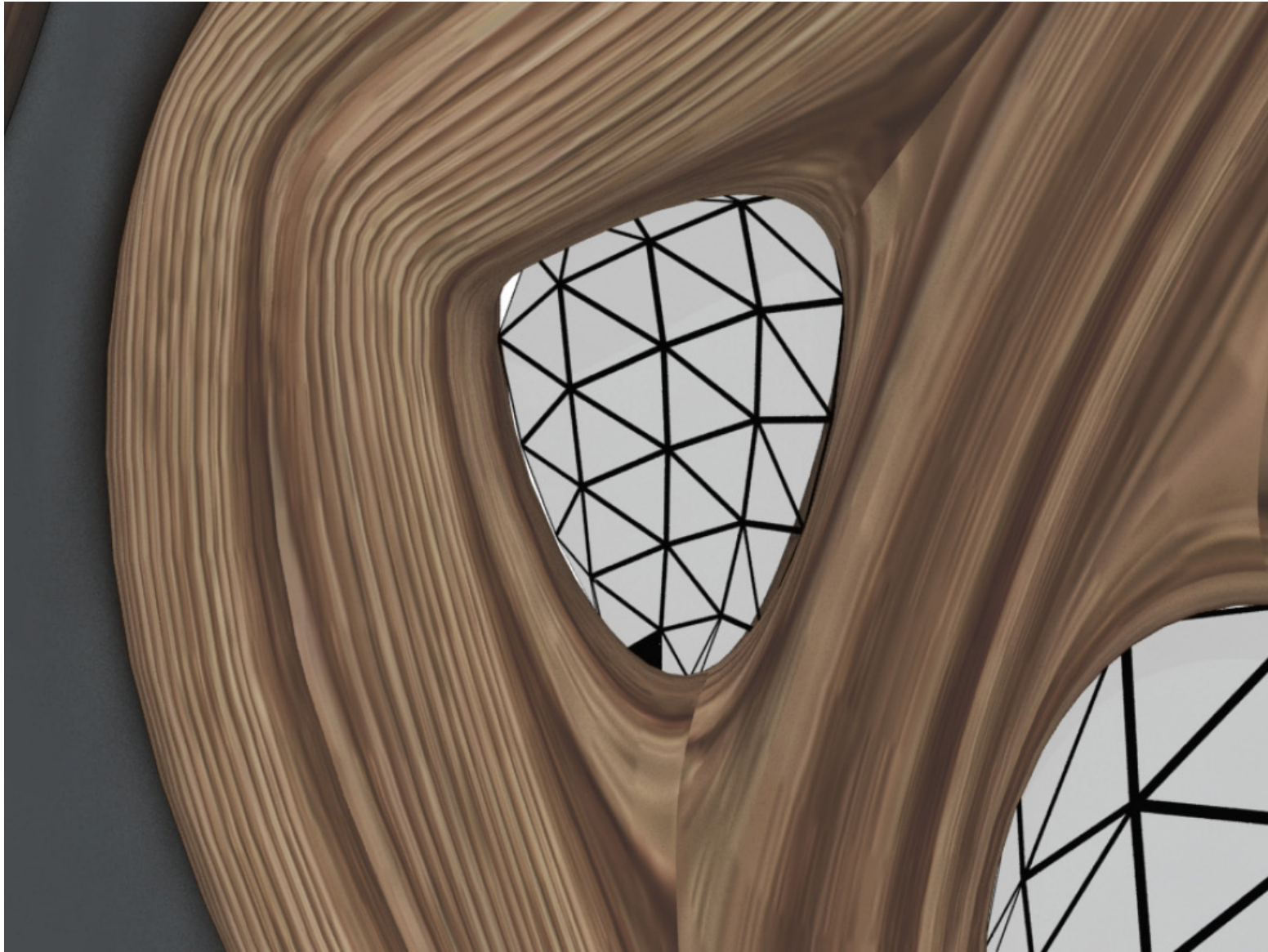
Initial visualisation of how wood and concrete could merge
Parameters: Concrete position in relation to wood (inbetween), changing direction of beams (vs.
linearity)

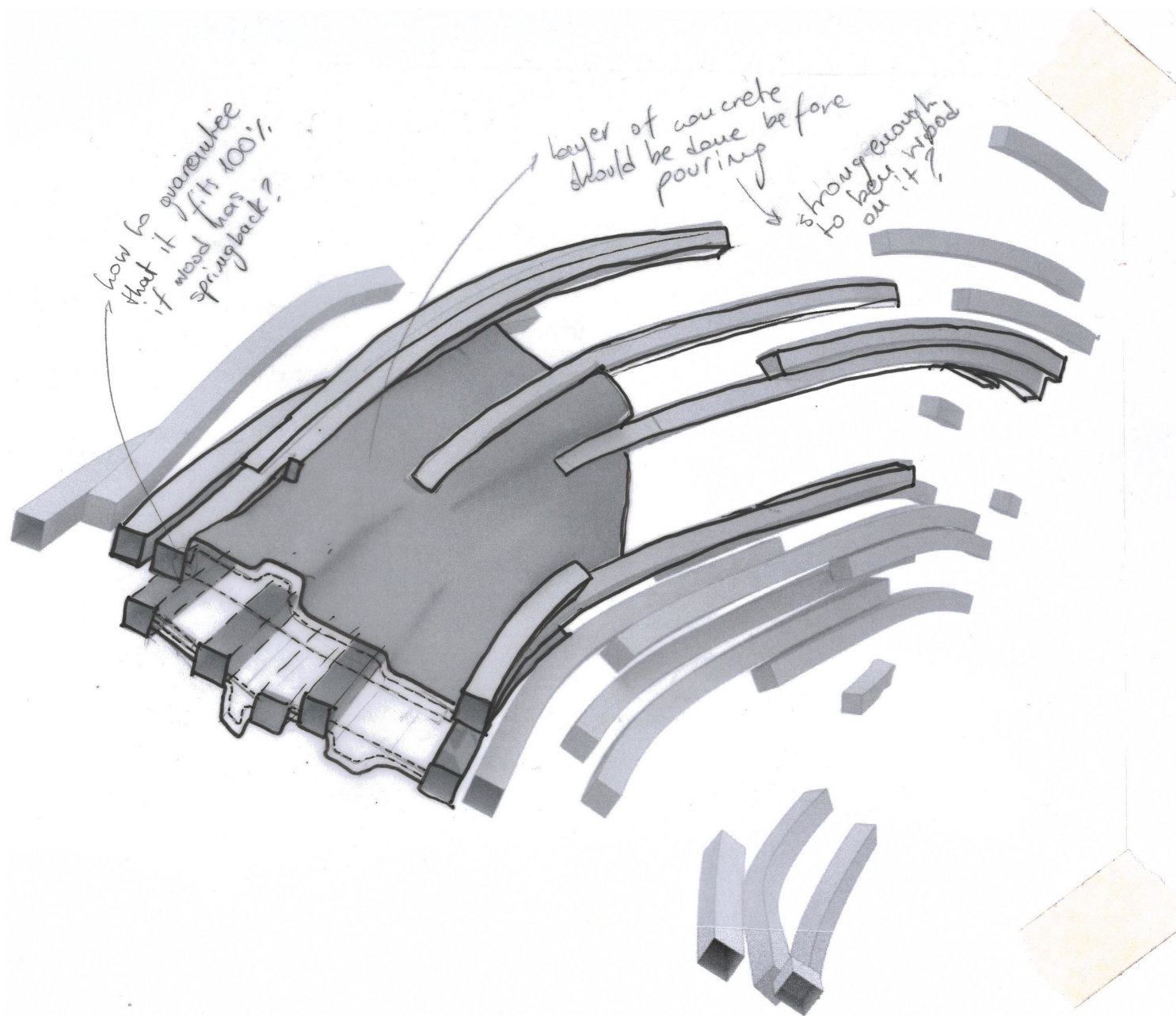
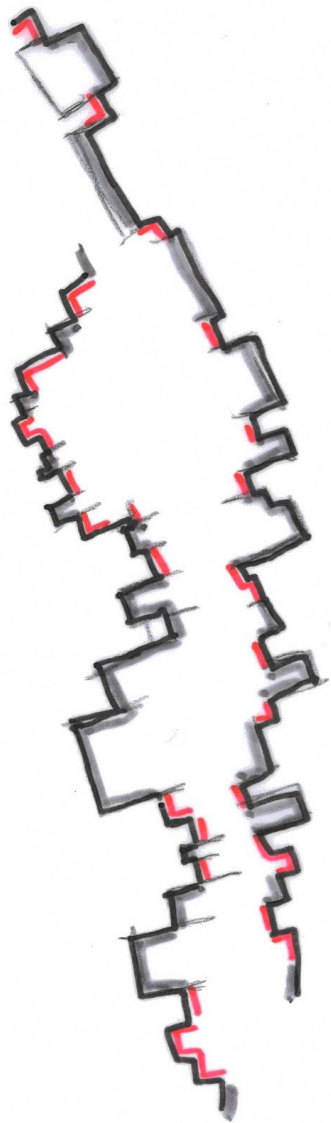


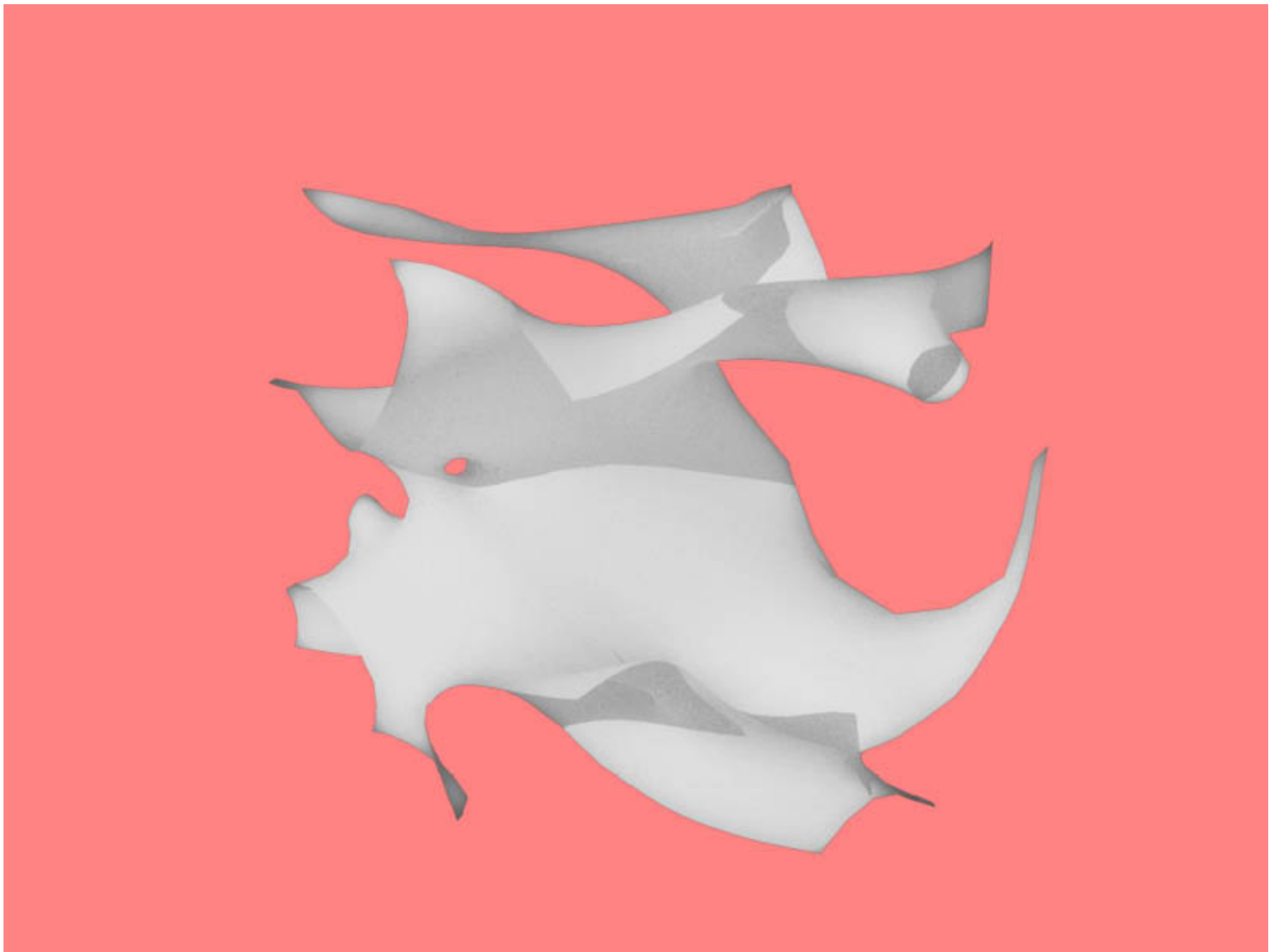
Parameters: Concrete position in relation to wood (inbetween vs. lying over), type of formwork to be implemented (textile vs. wood)









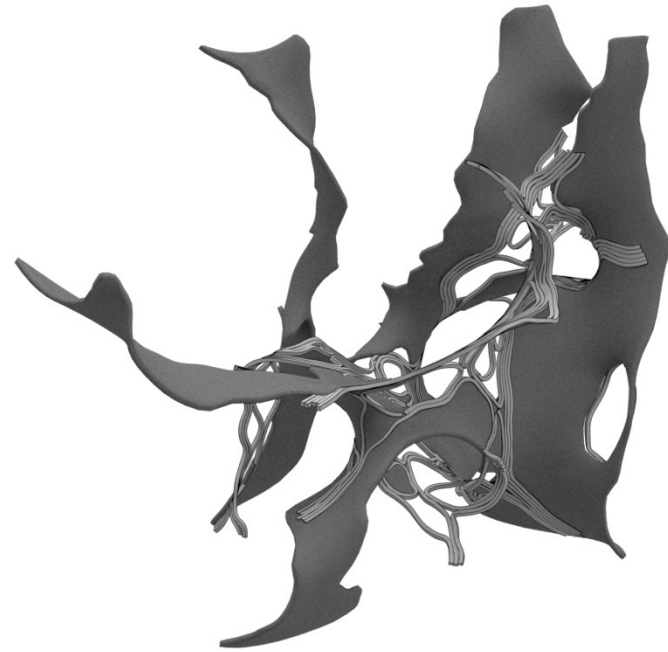
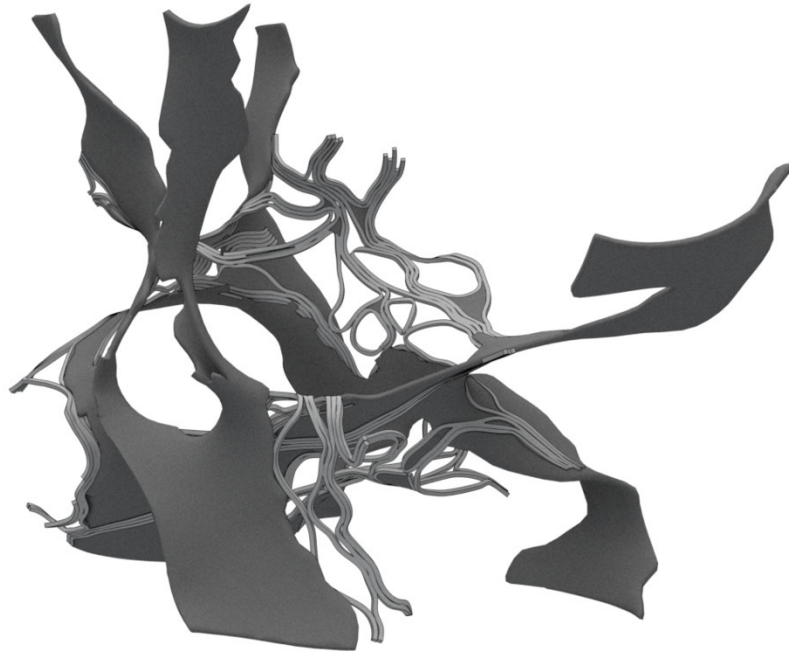
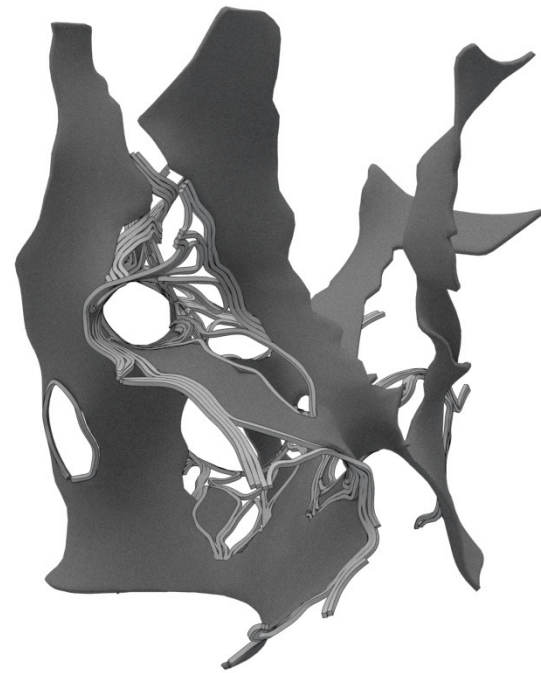
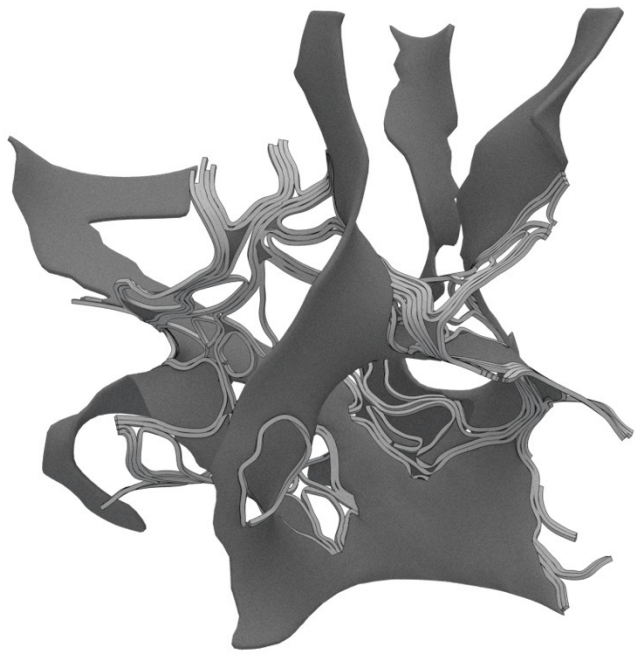


Gyroid fragment that was used to trial wood and concrete systems as shown in the next pages

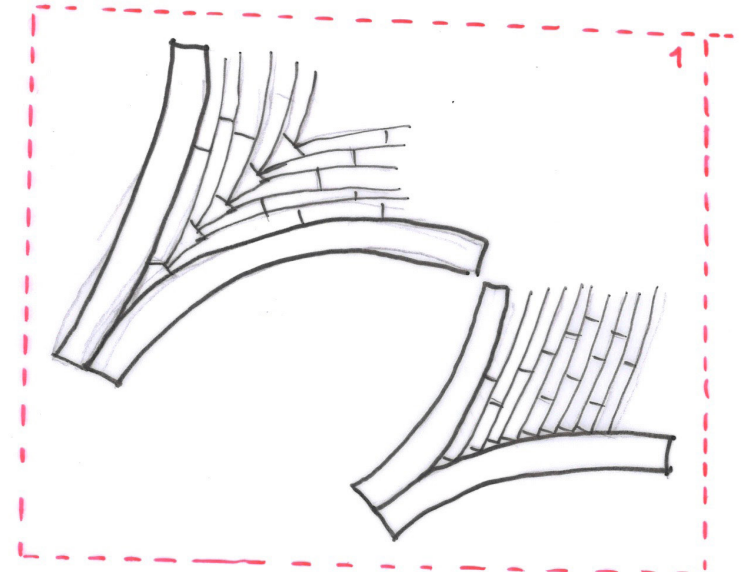
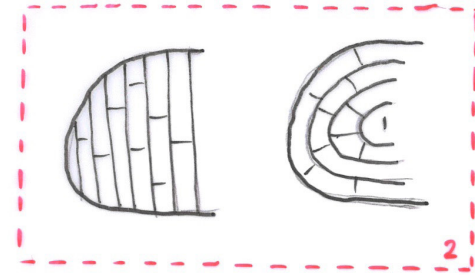
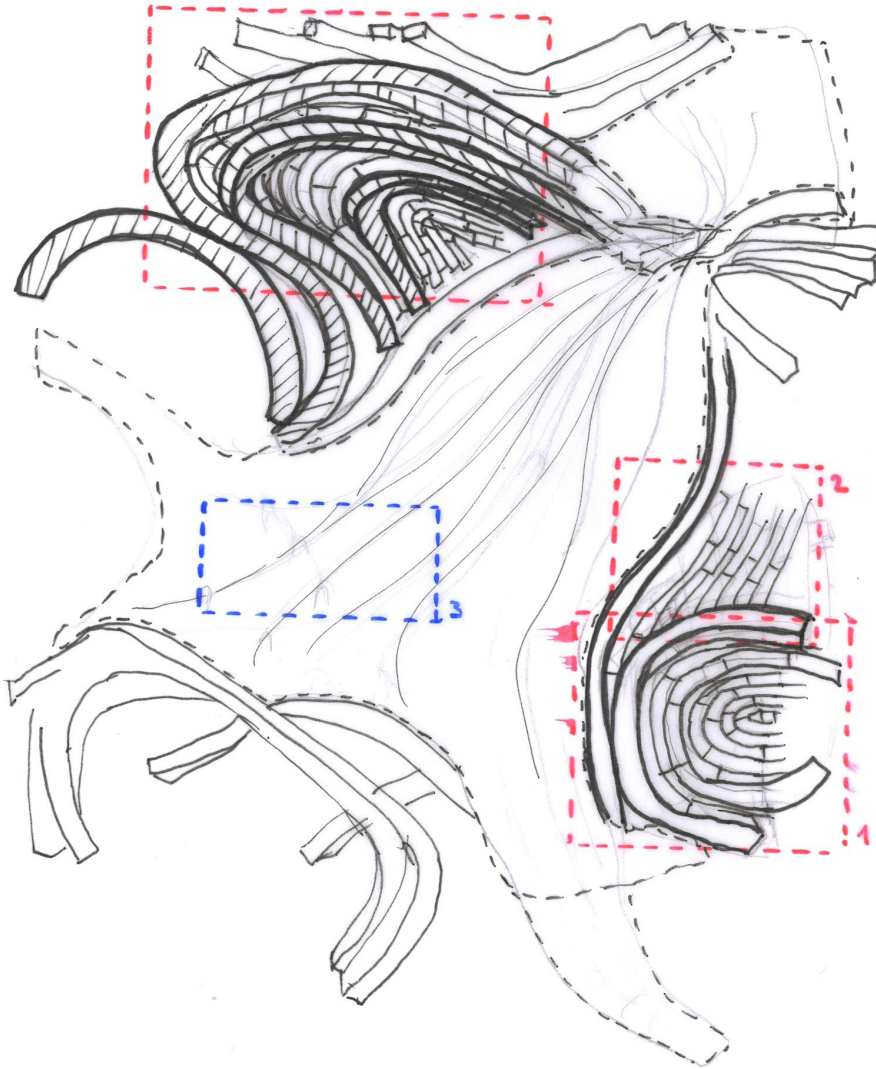
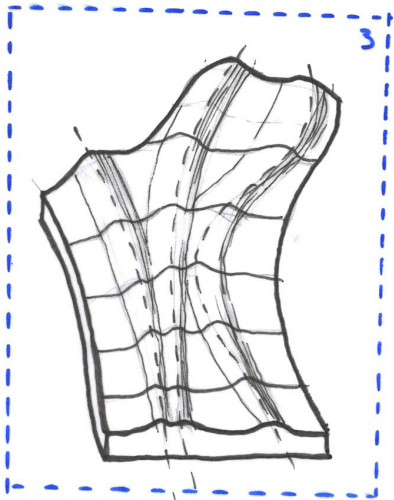








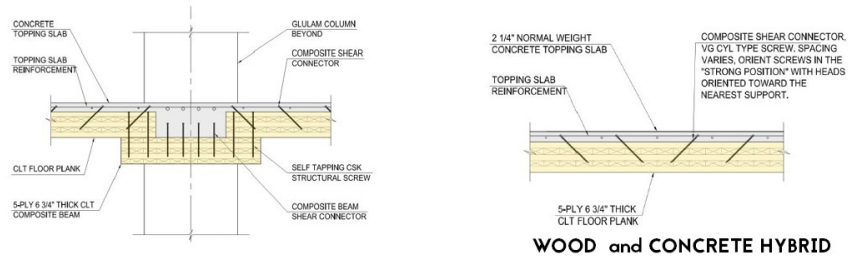
One trial that was considering the relation wood as architecture, concrete as structure. While relatively successful, the proportion of concrete needed increasing and the wooden beams were later found to be quite unrealisable due to their curvature



①



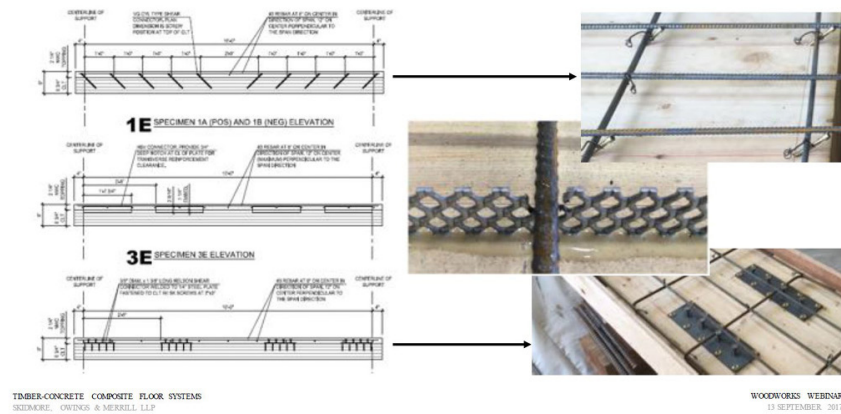
Figure 5: Model Building Typical Framing Zone Rendering



WOOD and CONCRETE HYBRID

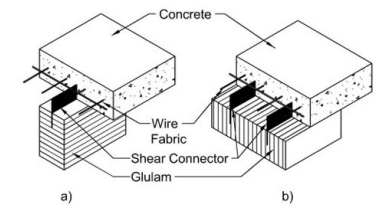
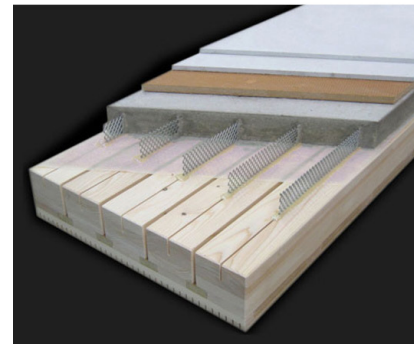


Connector Tests



TIMBER-CONCRETE COMPOSITE FLOOR SYSTEMS
SKIDMORE, OWINGS & MERRILL LLP

WOODWORKS WEBINAR
13 SEPTEMBER, 2017

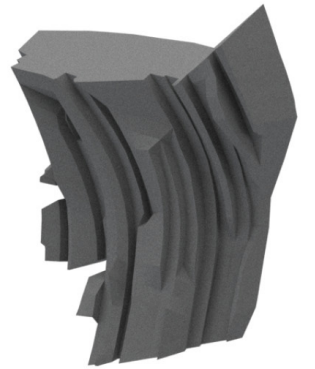
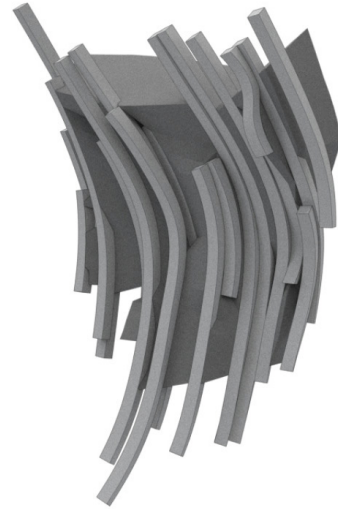
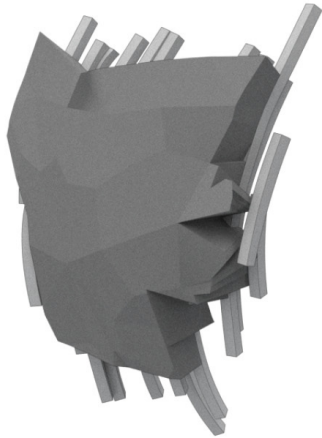
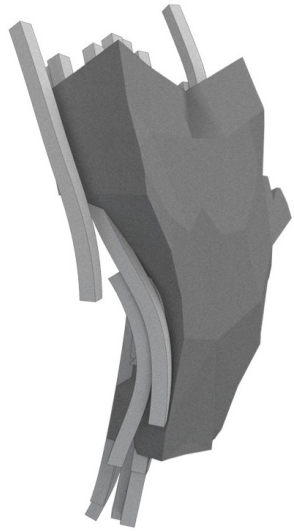
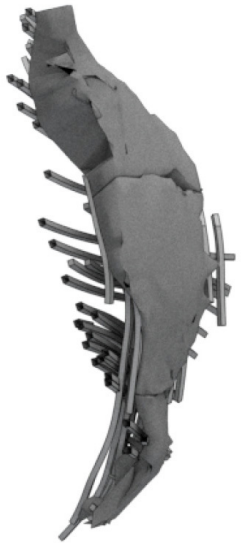
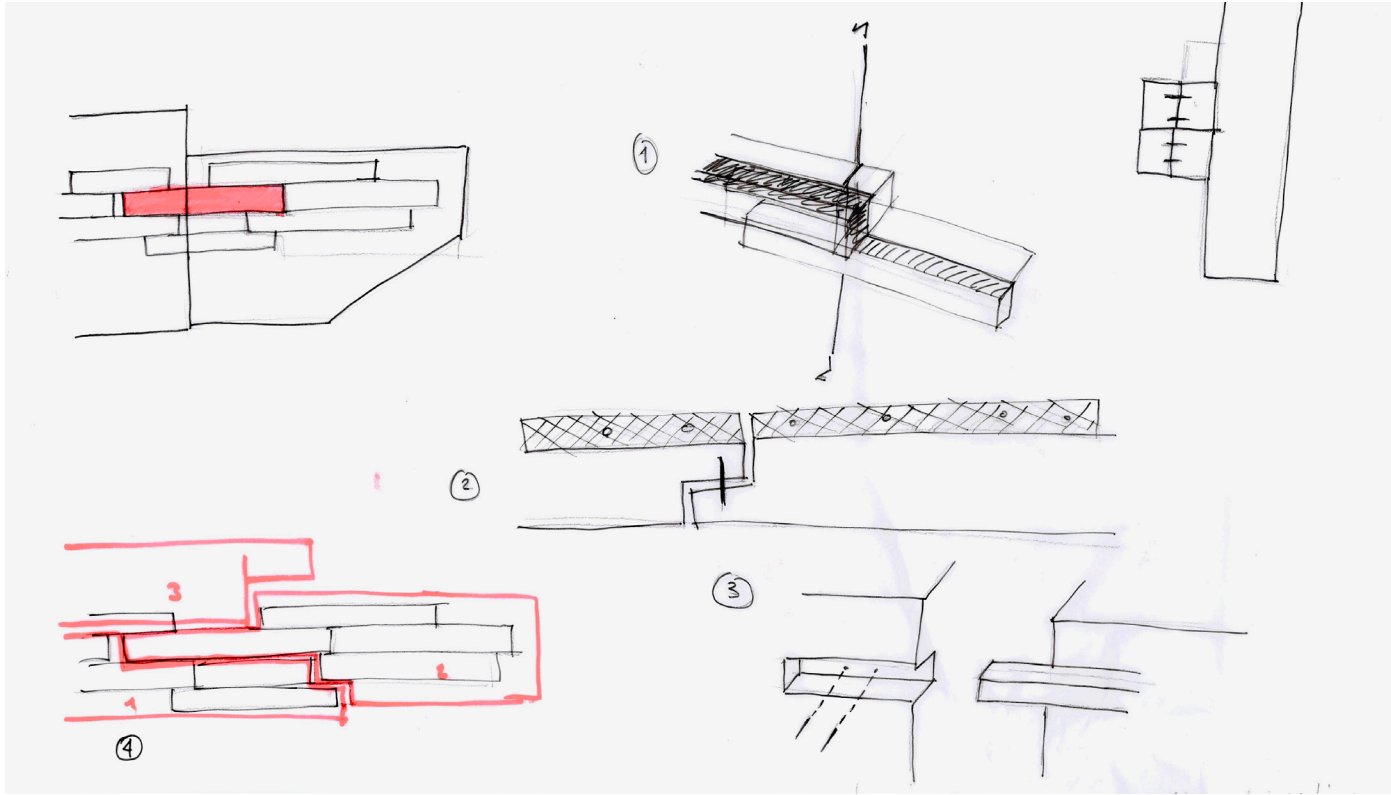


The final wood-concrete structural hybridisation system as was studied by SOM.

3.2.1 PARTITION INTO SMALLER COMPONENTS

This part of the fabrication dealt with how to separate the geometry into components that can be precast. Different systems were analysed:

1. Cutting through the bent pieces of wood would create an extremely complicated system in which wood would have to be bent and then cut
2. Number 3 shows the case in which wood is cast with one piece of concrete and inserted into another. In the latter, EPS would be milled so that it could replace the shape of wood. However, since it is a double-curved surface, the insertion would not always be possible.
3. The solution that was chosen is shown in the diagram 4: the concrete would be separated following the topology of wood. The different wood pieces, which are protruding from the concrete would then be reconnected.



3.2.2 PRODUCTION OF CONCRETE - CASTING

1. Flexible formwork - fabric in situ

- If made in situ, it would need additional customised supports, therefore losing meaning
- Shape would not correspond exactly to the computational mode

2. Rigid formwork - wood

- Completely enclosed wood that is difficult to achieve
- Need of additional side supports that would be more freeform than the existing one, thus losing meaning
- If the wood elements are not removable, there would be no concrete visible. On the other hand, if they are removable, they would need to be shuttering, which would further complicate the system

3. Rigid formwork - EPS

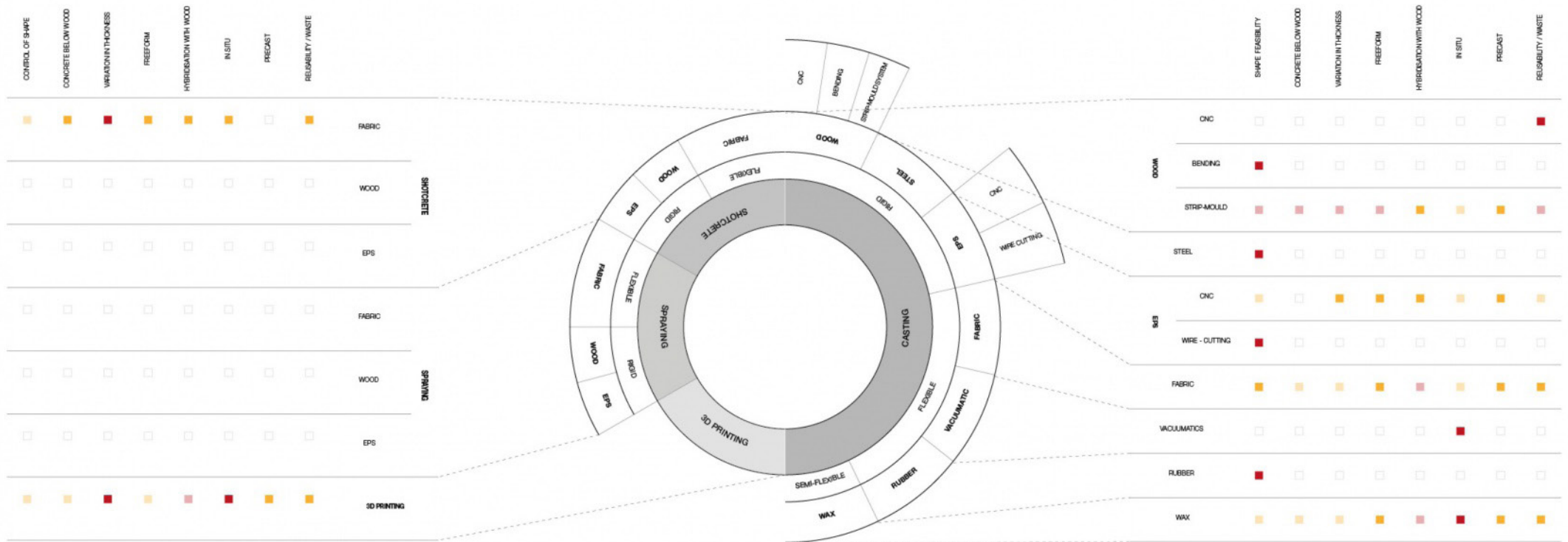
- The most convenient because concrete can be cast and then EPS recycled and milled into a new shape. Moreover, the parts that are carved from the EPS block can be compacted into a new EPS block

4. Shotcrete

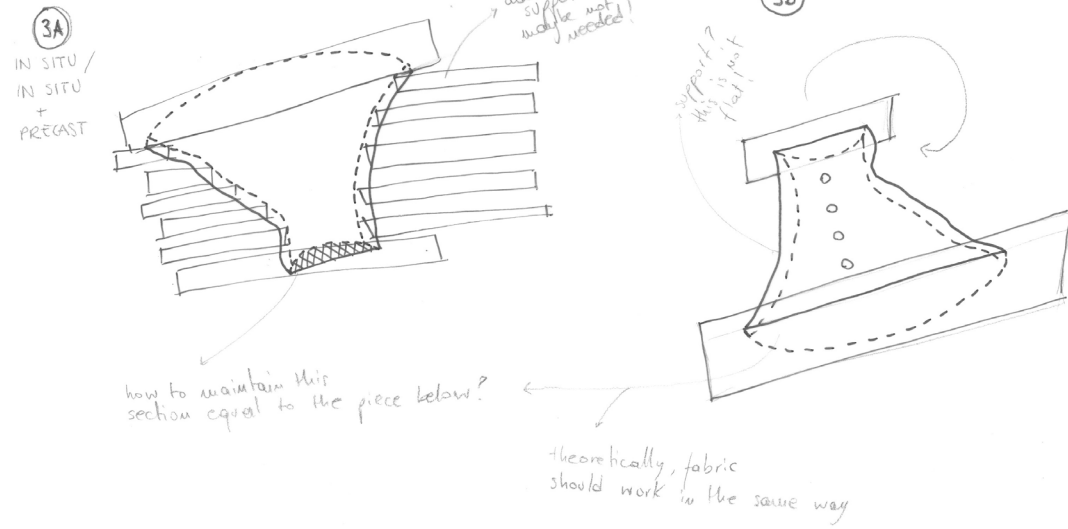
- This production method also uses fabric (as in the first case). Therefore it would need to correspond exactly to the computational model
- No possibility of creating variation in thickness since shotcrete only produces a layer of concrete of maximum five centimeters

also be left incorporated into the concrete to create either furniture or as an insulation material.

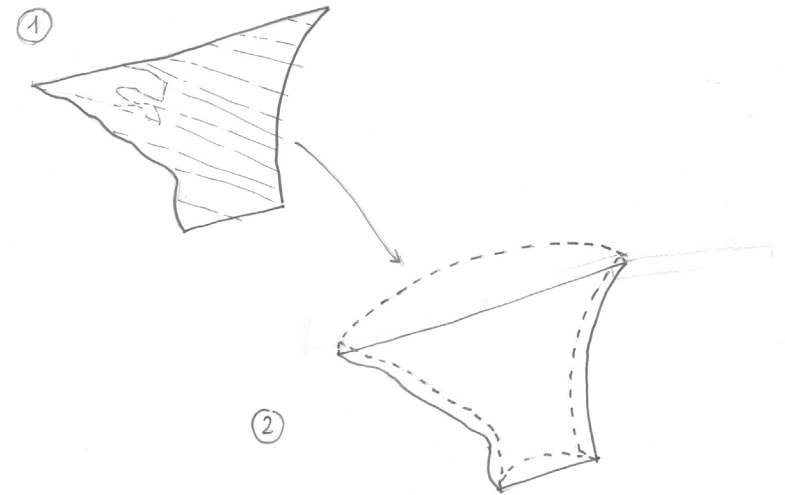
After this research EPS was chosen as the most suitable material since it can produce a seamless process without waste. Additionally, it can



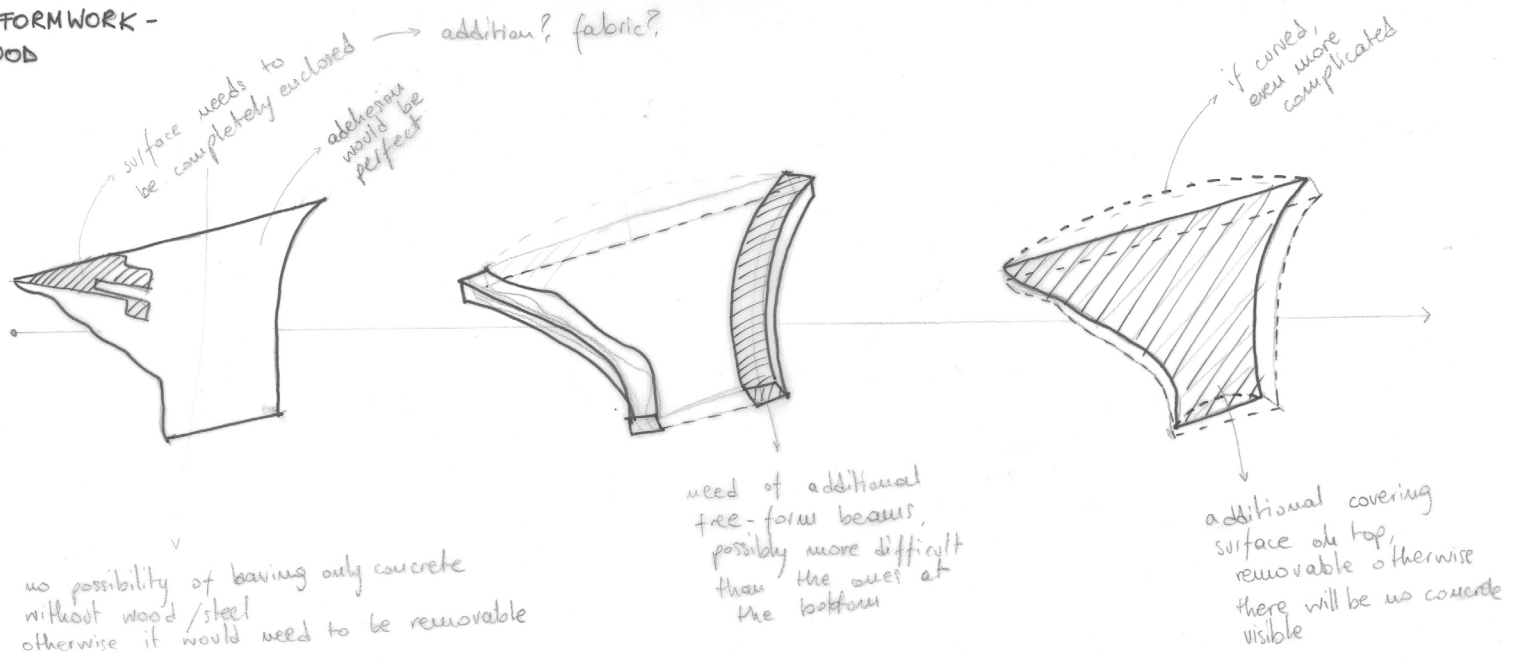
FLEXIBLE FORMWORK -
FABRIC INSITU + PRECAST (2)



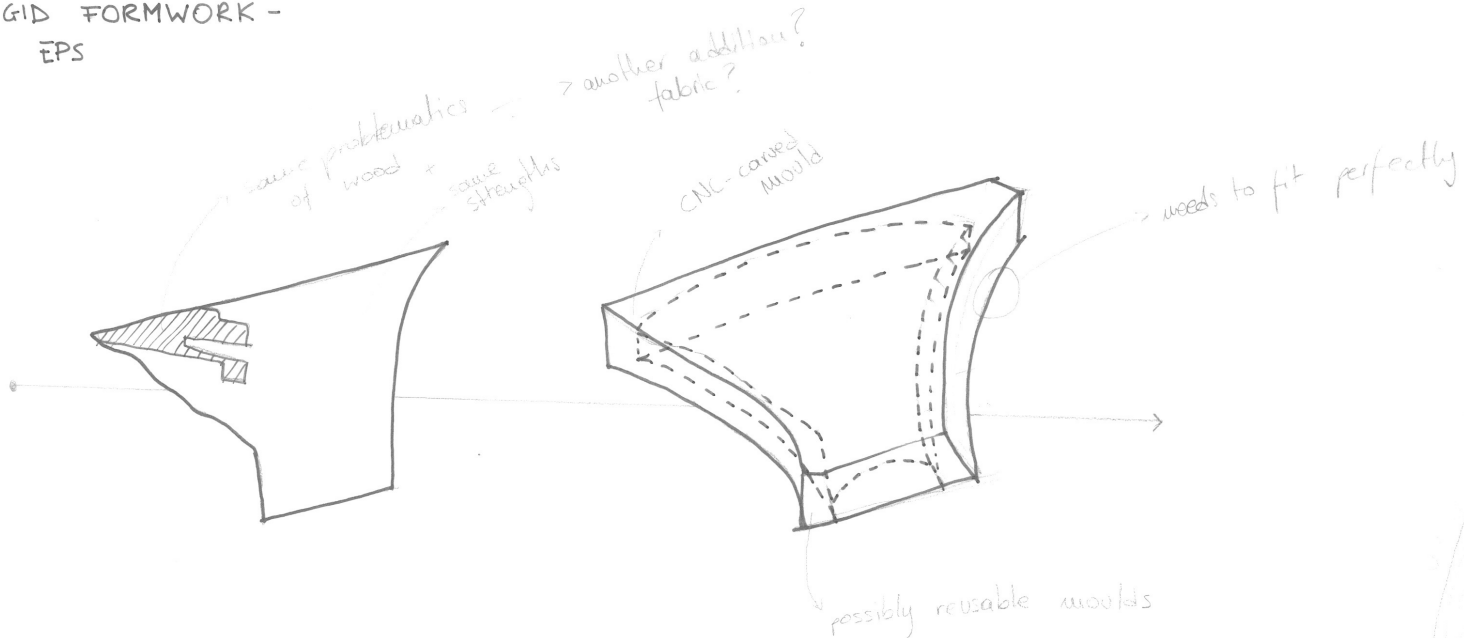
FLEXIBLE FORMWORK -
FABRIC INSITU + PRECAST (1)

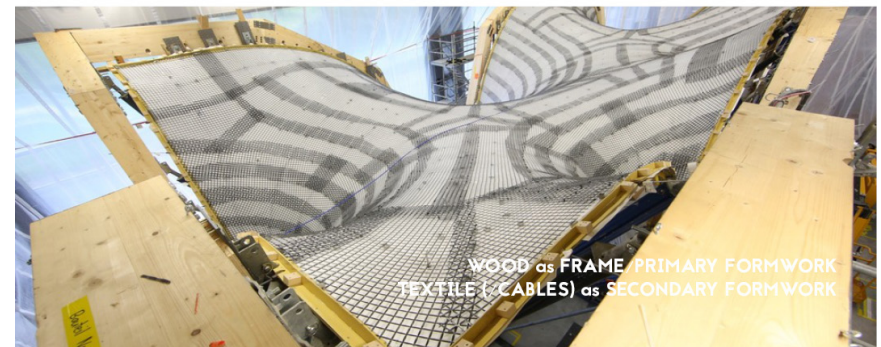
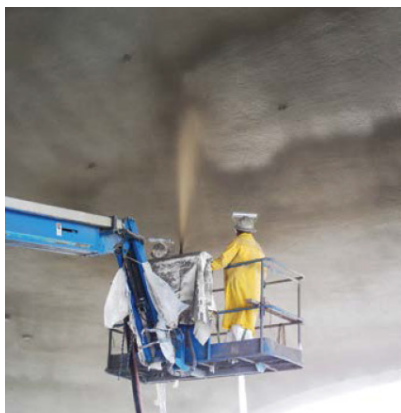
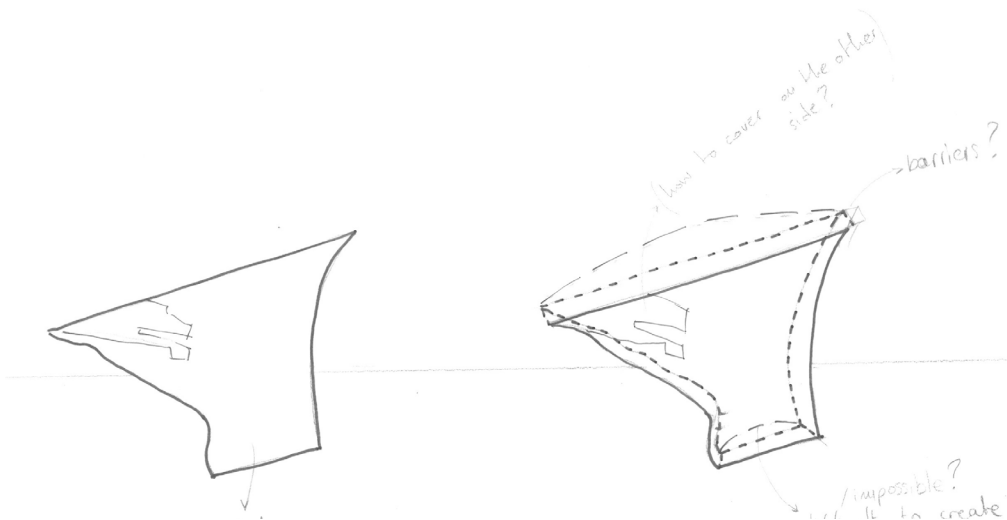


RIGID FORMWORK - WOOD



RIGID FORMWORK - EPS



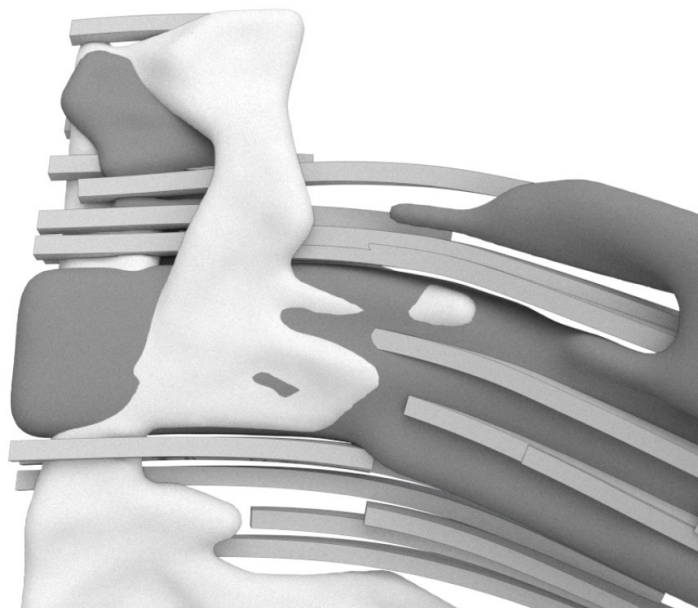
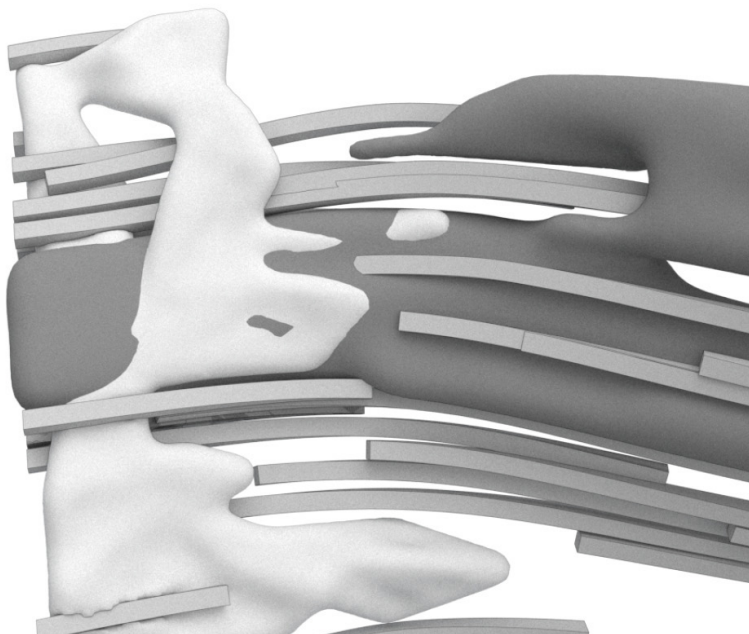
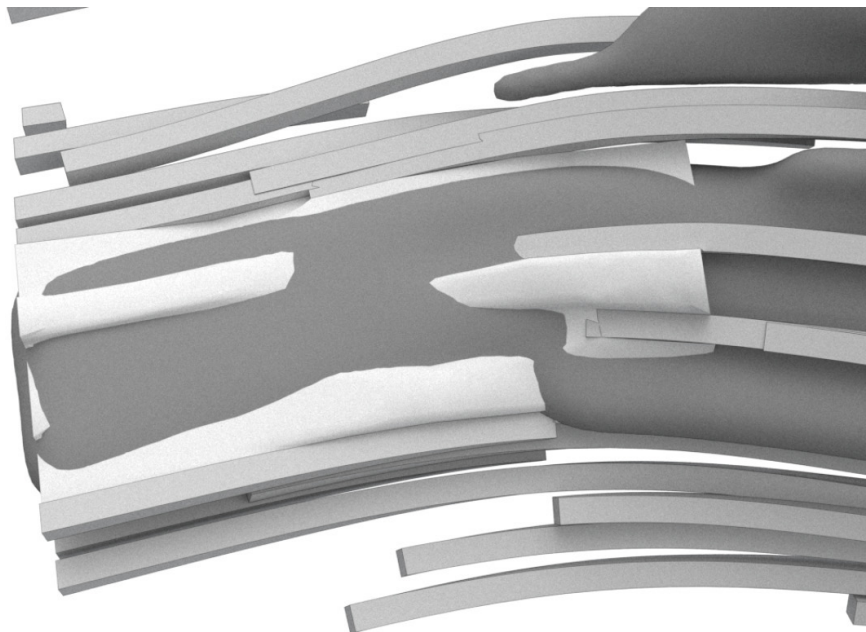
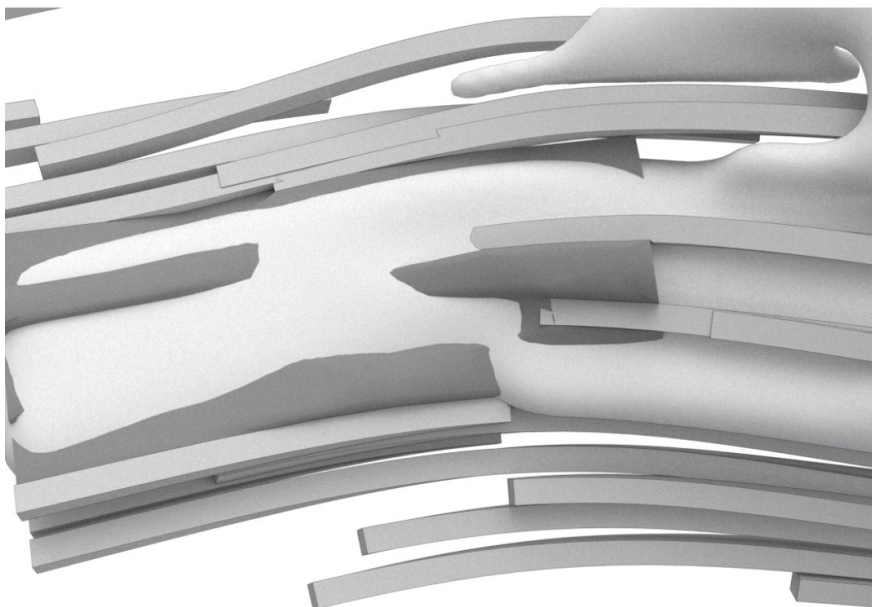


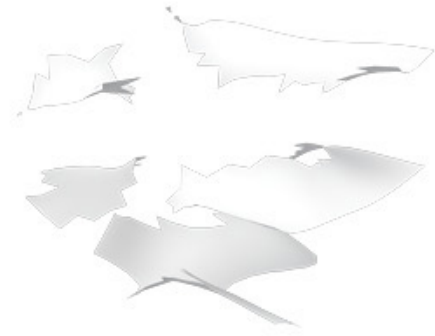
3.3 EPS

Finally, a third material was introduced in order to respond to the needs of insulation and creating ergonomic and comfortable furniture. The material that best suited the requirements was EPS, which also offered the advantage of being used for the fabrication of concrete where wood would not be sufficient. The integration of this material with the others was particularly important in order to maintain the system to the greatest degree possible. In this way, despite the complexity of the system itself, the description of its production, for instance in a manual, could be more easily achieved. For this reason, the starting point was the previously described hybridization of concrete and wood. The latter makes use of additional shear connectors that allow to achieve composite action between the wooden beams and concrete. The solution was therefore to incorporate the same system for EPS. Several trials were made in order to define how this would happen, as partly described in the chapter “Integration of wood and concrete”

Different possibilities for appropriation of the spaces were analysed through materiality, in particular EPS, which is possibly the most adaptable material among the three. It considers the flexibility in later changing the space

- All concrete: no appropriation, no flexibility
- Concrete floors, furniture made of EPS: appropriation possible but flexibility limited
- EPS floors, EPS furniture: appropriation possible, high flexibility





Floor



Sun



Artificial Light



Heating & Cooling



Concrete



Wood

Wood - Concrete - Insulation

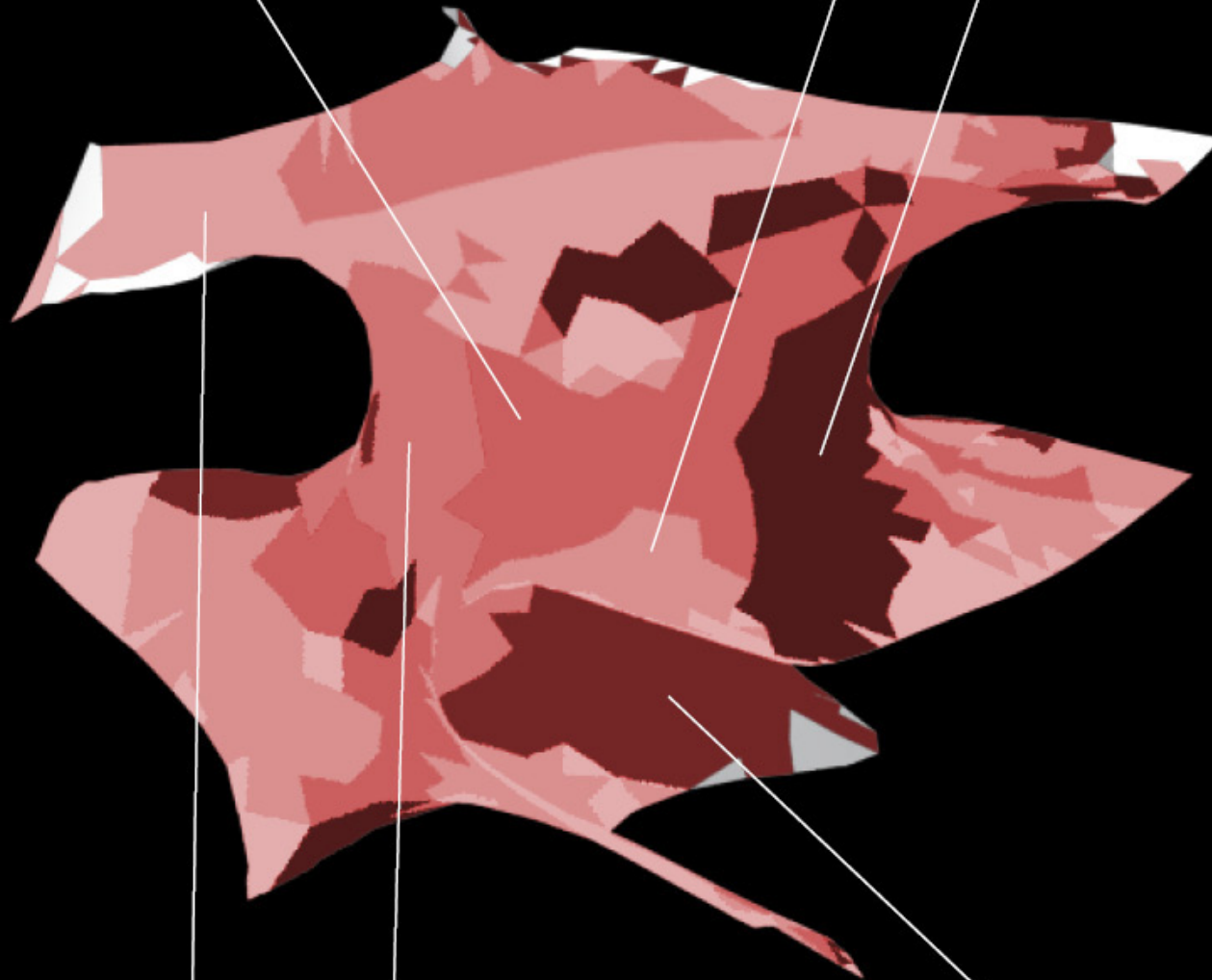
Wood - Insulation

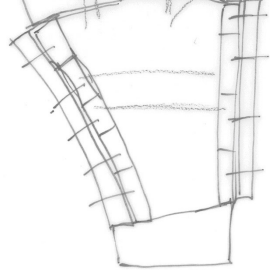
Concrete - Insulation

Concrete

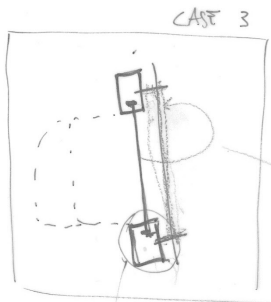
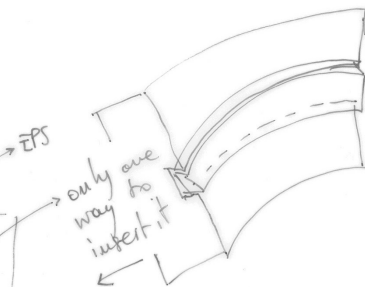
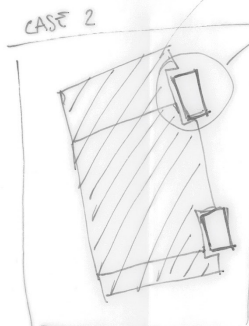
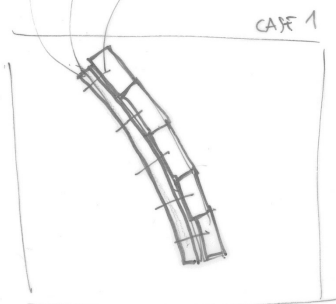
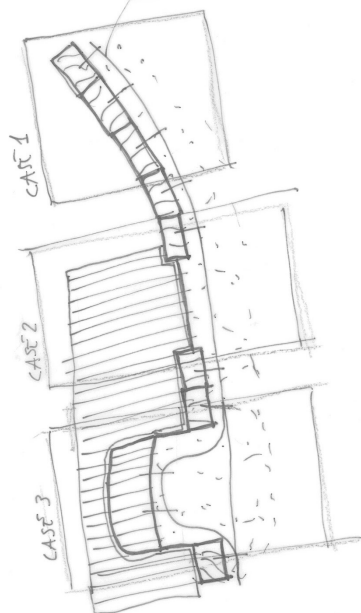
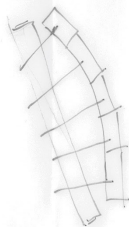
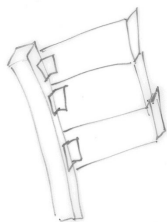
Wood - Concrete

Wood



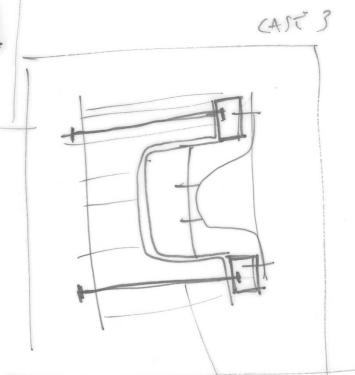


additional complication of such a waste
as in both or traditional methods
holes?

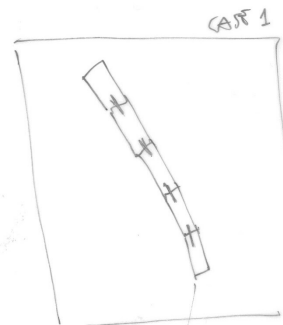
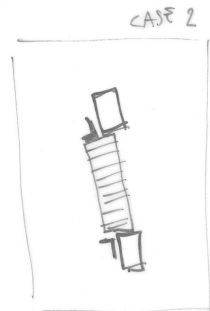


lots of holes

maybe move it here?



would be more simple



probably not straight enough

3.4 STRUCTURAL ANALYSIS OF GYROID

The research on the structural analysis is reported in the chapter on materiality as it was central in understanding the hybridisation of wood and concrete. In particular, it focused on how to understand the structural properties of gyroid structures.

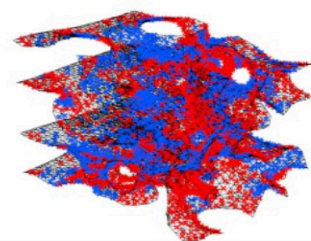
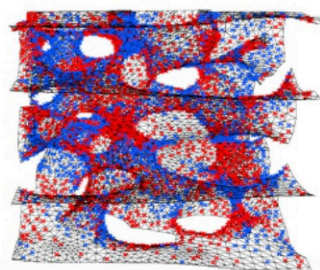
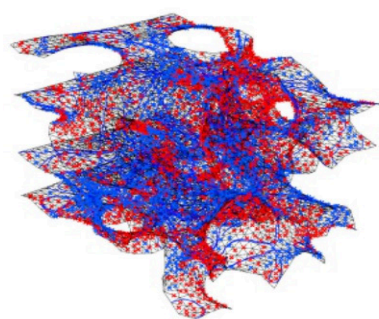
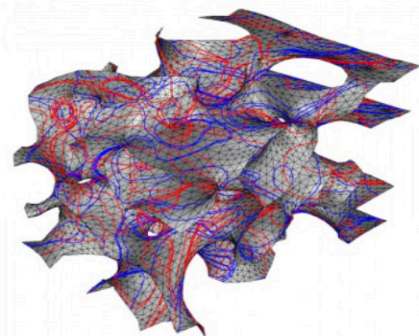
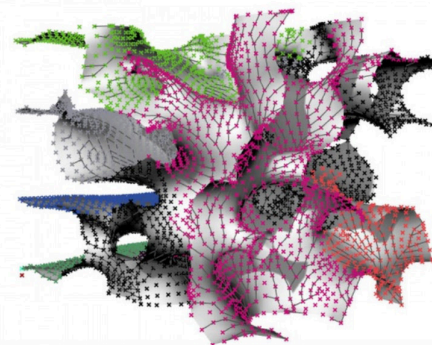
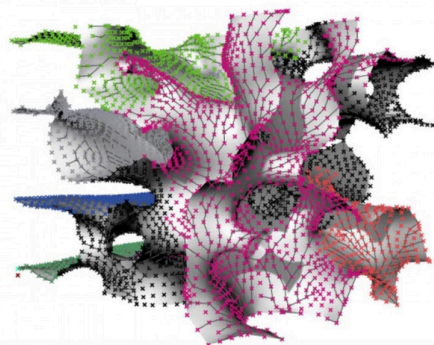
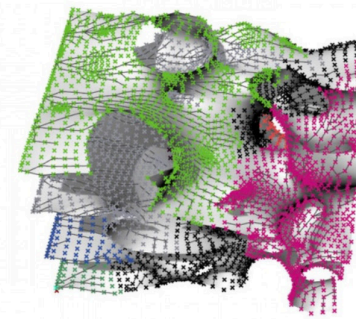
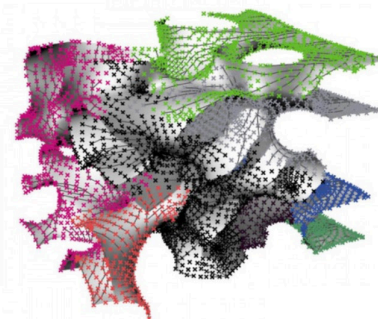
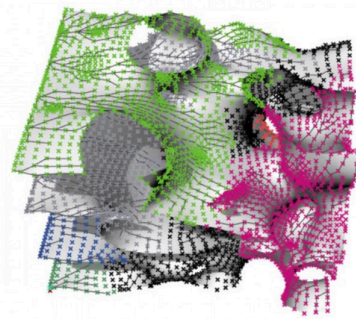
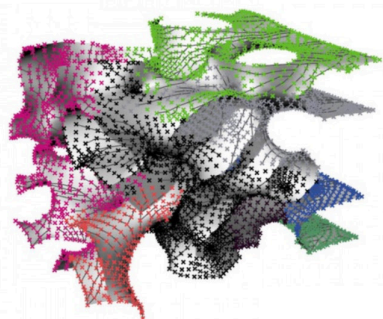
First attempts at understanding the structural analysis of gyroid structures, with two methods.

- The first shows the closest anchor point, therefore what point of the existing structure would have to support the new one. The anchor points are either located at the bottom or on the back side of the new structure, where the new floors would merge with the existing ones. This method was eventually discarded as it did not give enough information on the structural characteristics of the geometry.
- The second locates the areas of either higher compression or higher tension according to the force lines resulting from the utilisation analysis. This method, however, does not fully consider all the existing situation (only tension, only compression and compression+tension) and was eventually discarded.

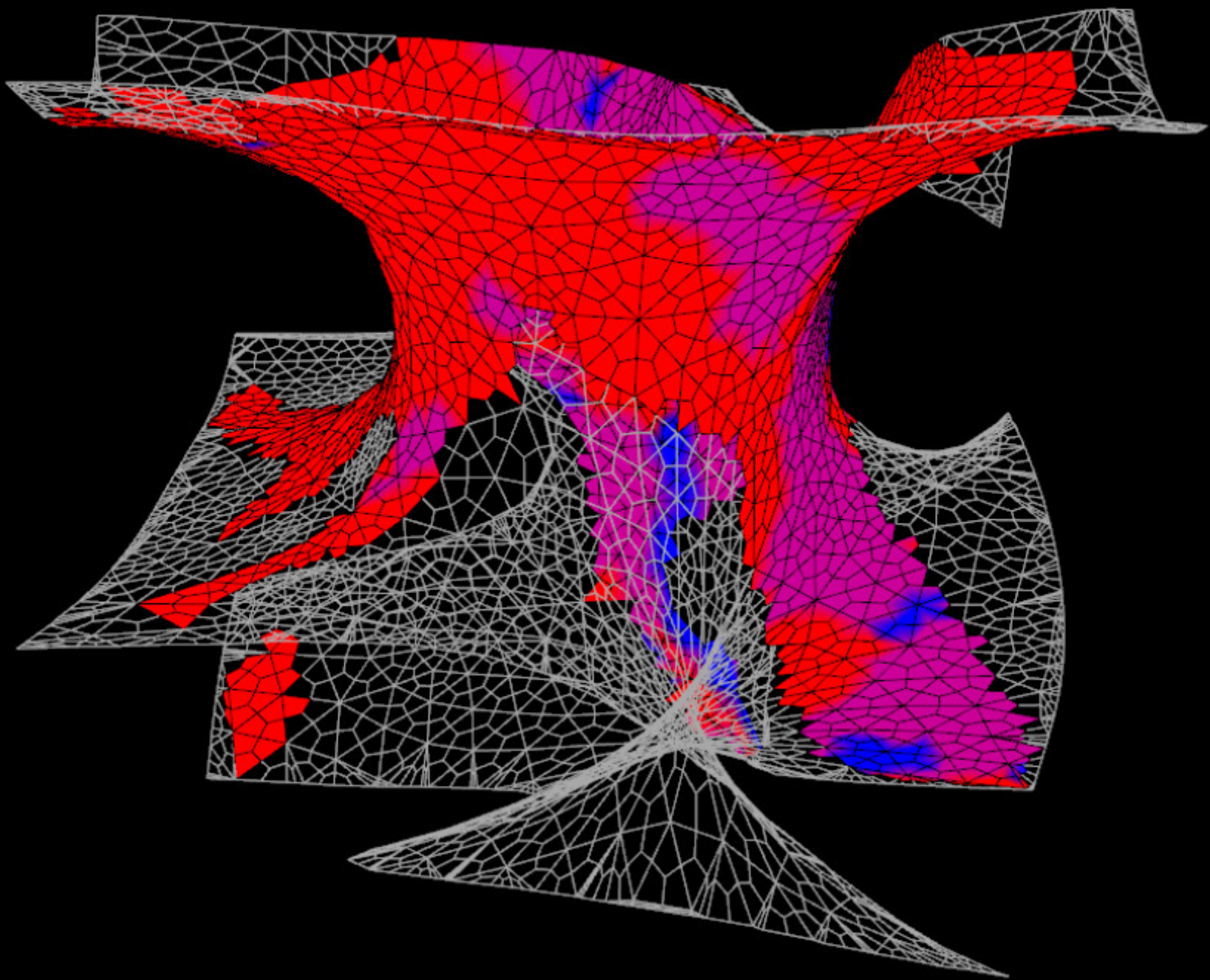
The final method uses the utilisation analysis in order to understand the forces on both sides of the shell, thus allowing for the understanding on where the materials (wood and concrete) need to be placed.

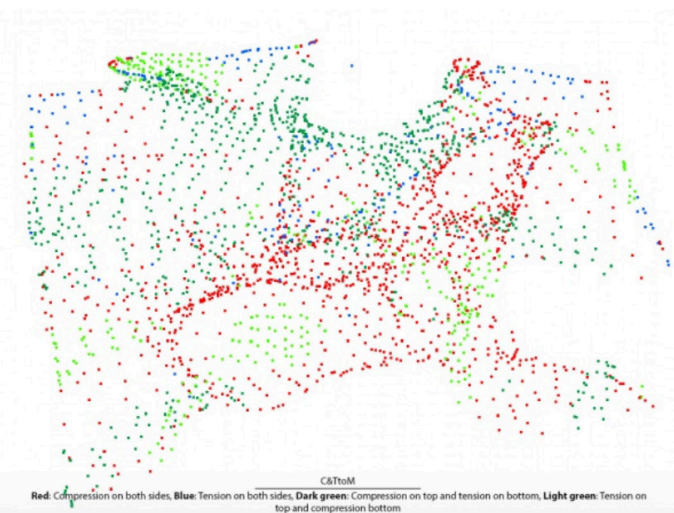
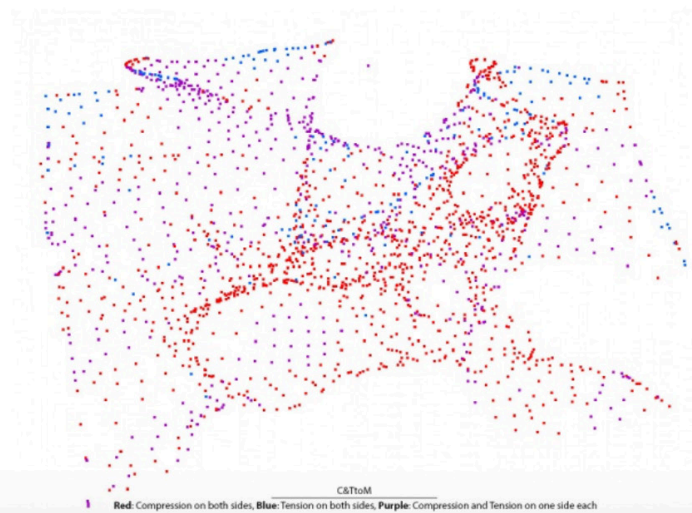
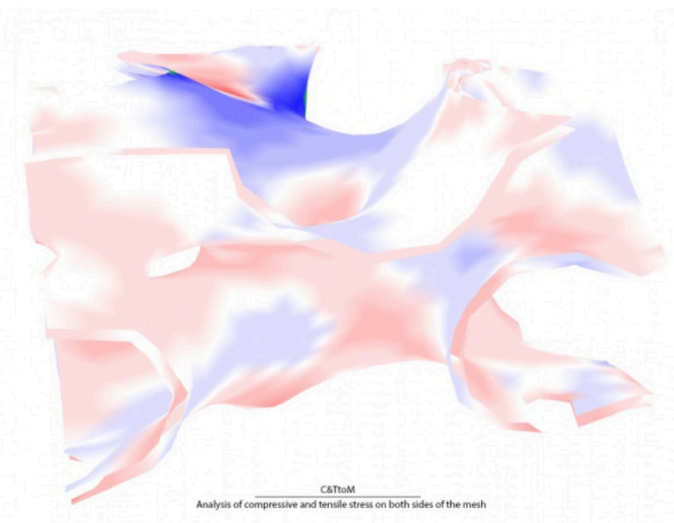
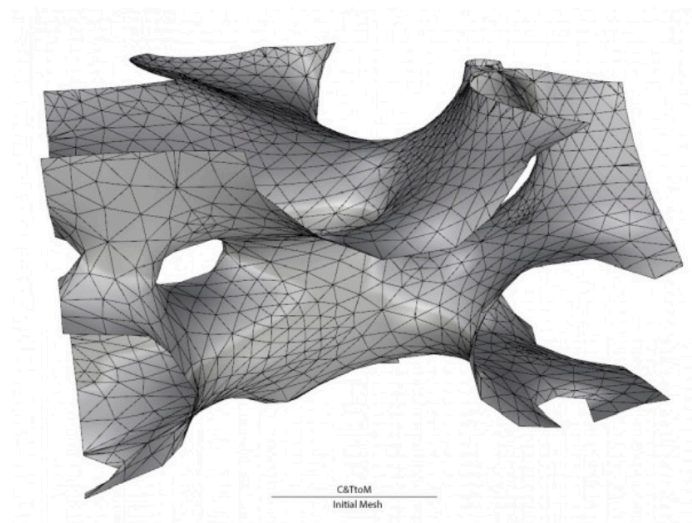
Moreover, it allows, by using the analysis of stress forces to understand

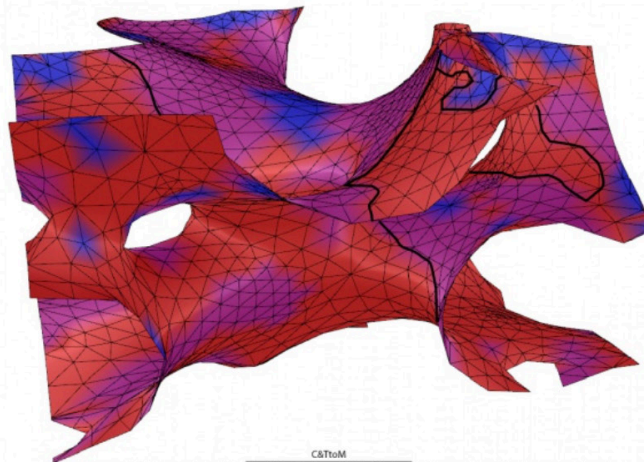
where concrete should be in greater quantities at a micro level. This was initially automated with the plug-in Millipede and then reintroduced through the plug-in Karamba3d.



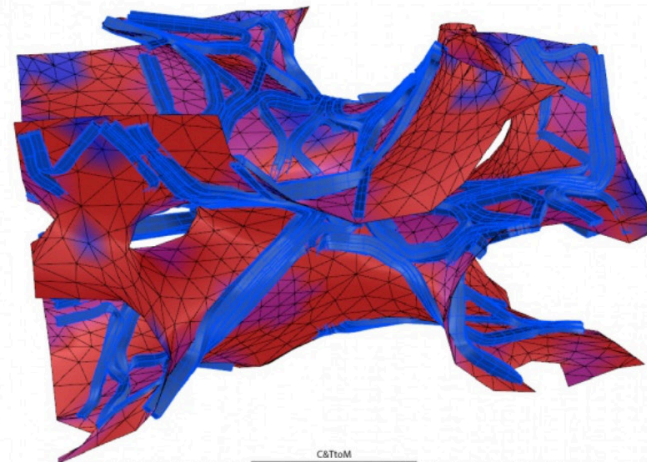




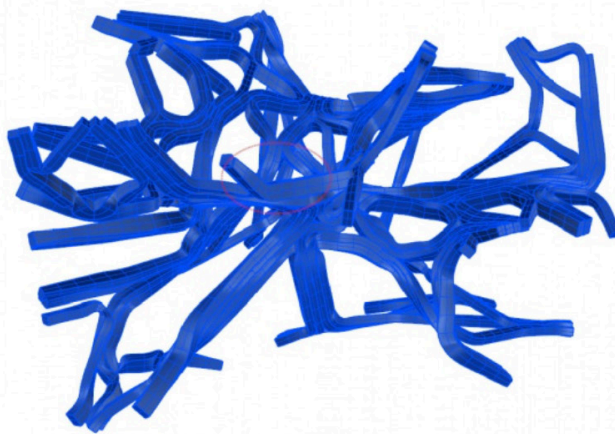




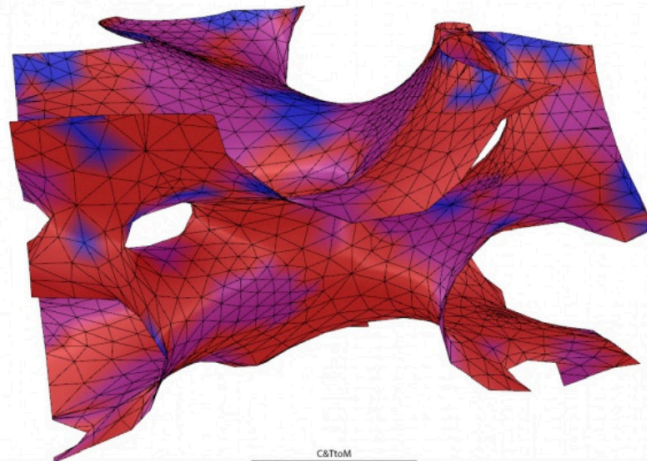
Division in zones - **Red:** Compression on both sides, **Blue:** Tension on both sides, **Purple:** Compression and Tension on one side each



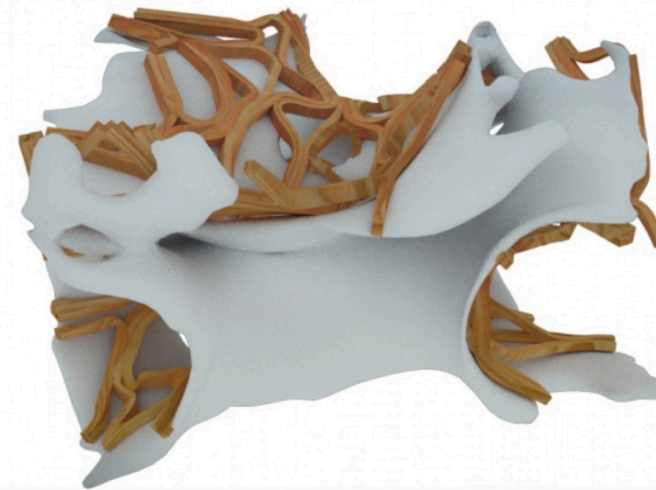
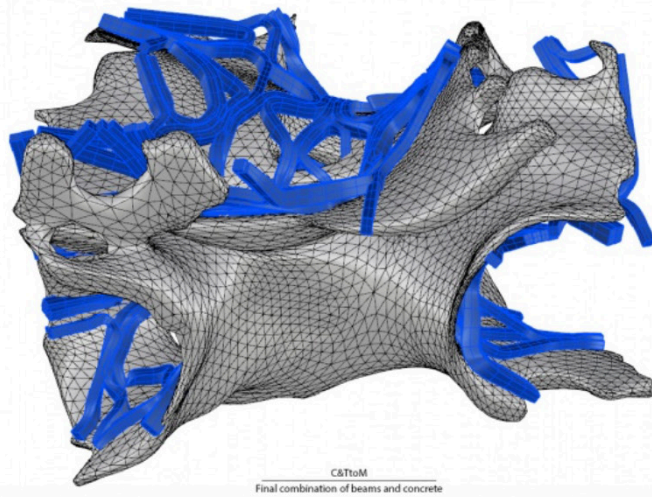
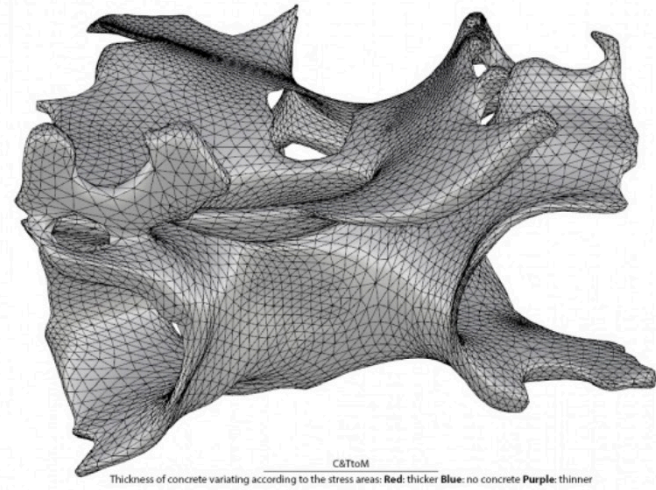
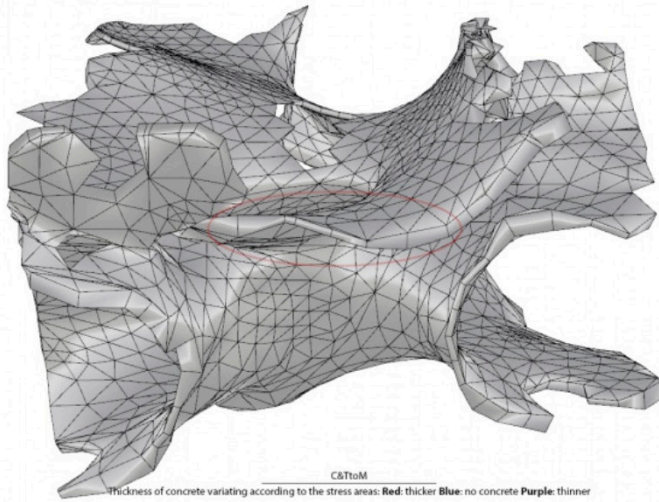
Beams as resulting from the division into zones: concentration in areas where their role is structural in addition to formwork



Thickness of beams varying according to their structural role: thicker in areas of hybrid structure concrete-wood, thinner in areas where wood is exclusively used as formwork



Red: Compression on both sides, **Blue:** Tension on both sides, **Purple:** Compression and Tension on one side each

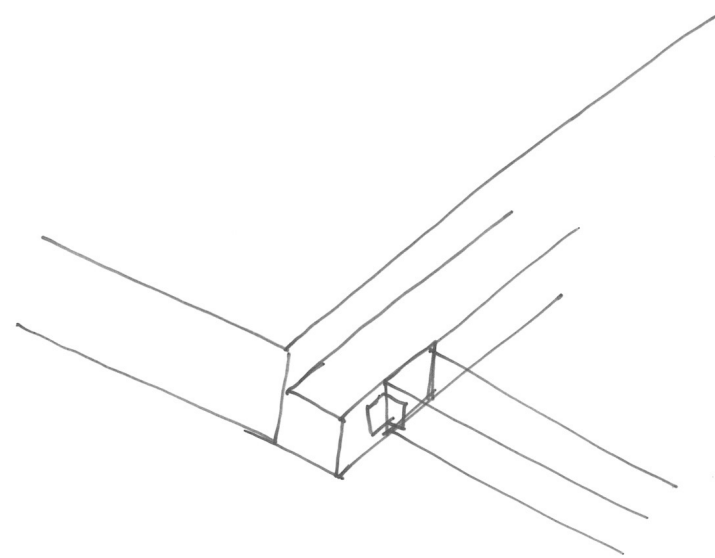
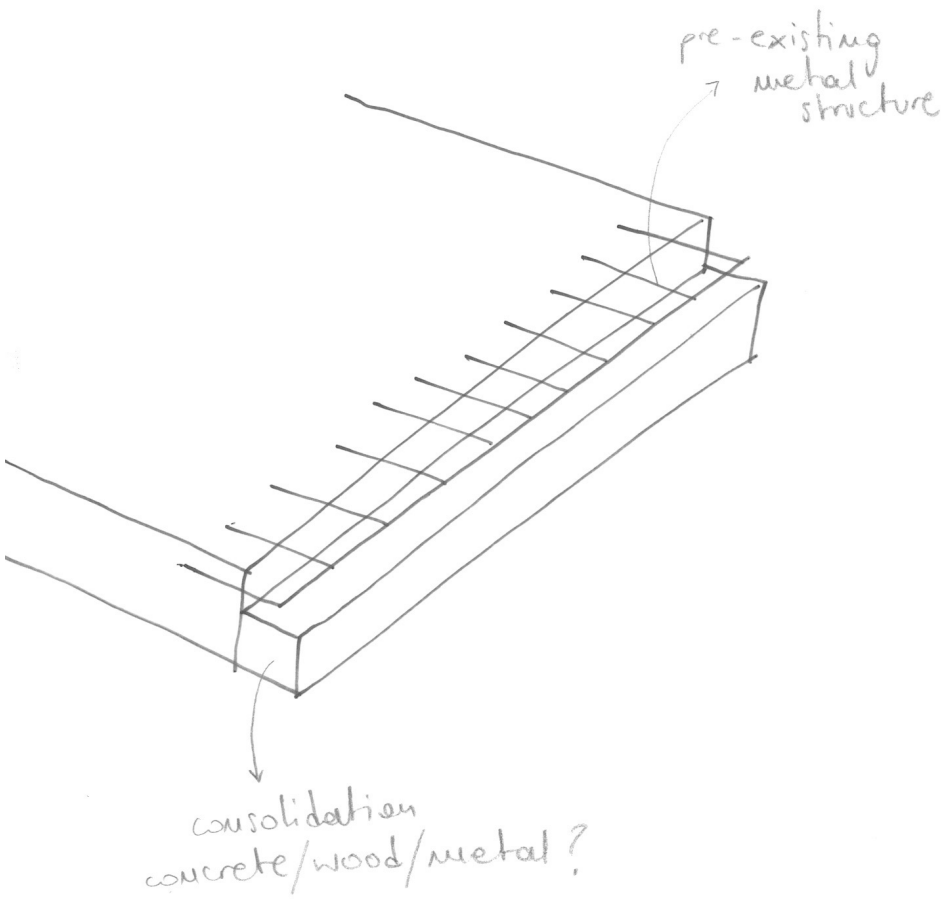


3.5 CONNECTING THE OLD STRUCTURE TO THE NEW ONE

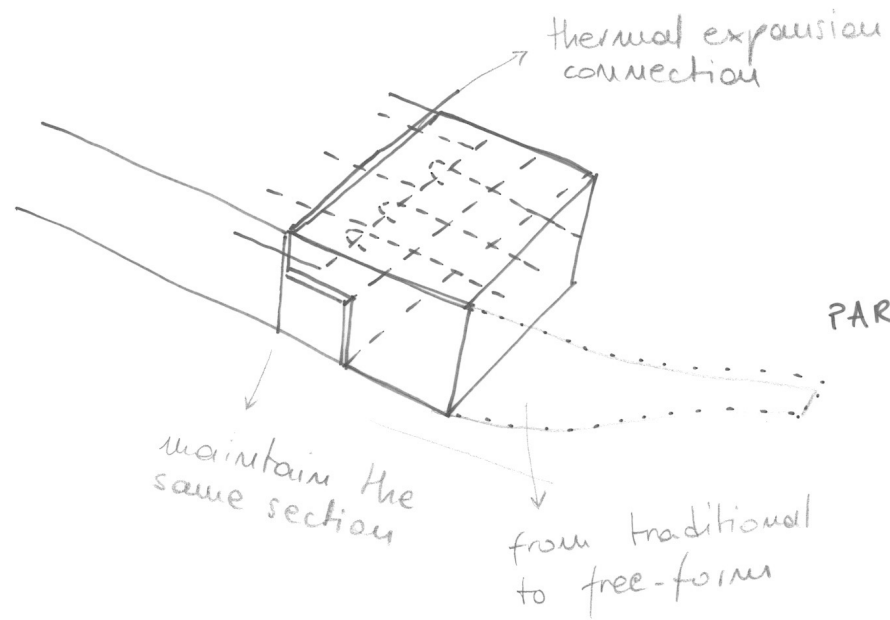
This part focused on how to use the existing structure in order to create a connection to the new one. The difficulty was in recycling it but also in creating a system that would go from the traditional to the freeform.

Steps are described as follows:

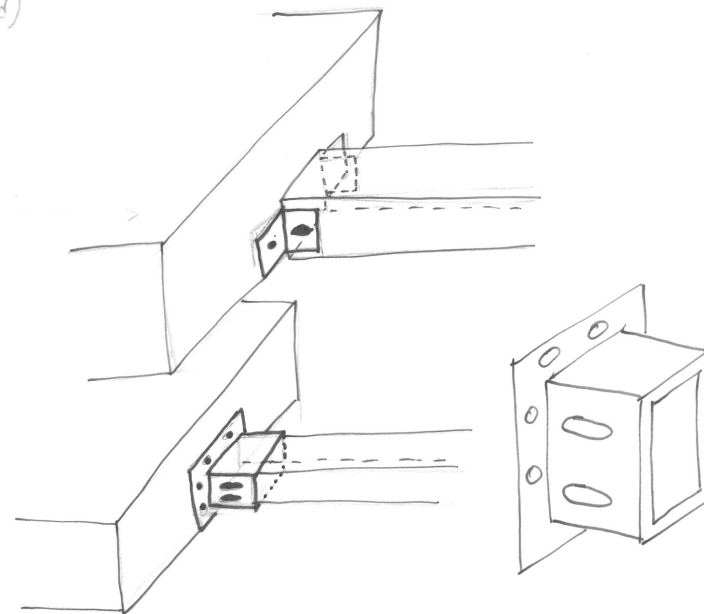
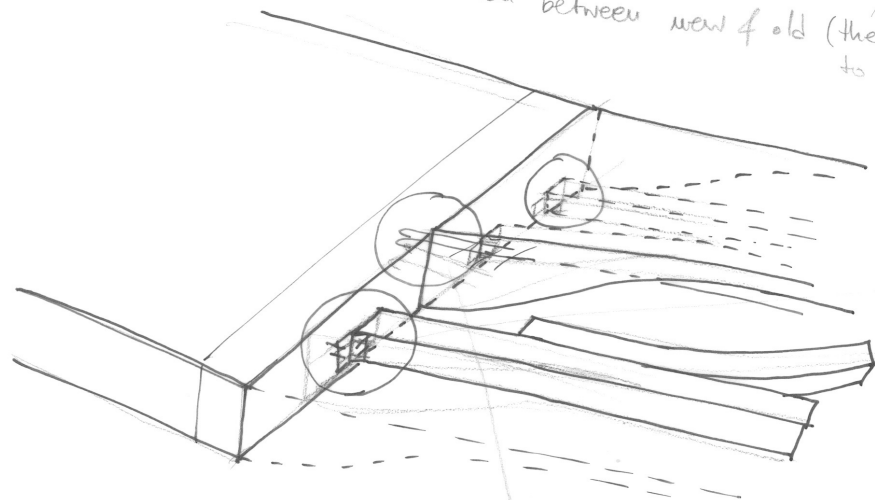
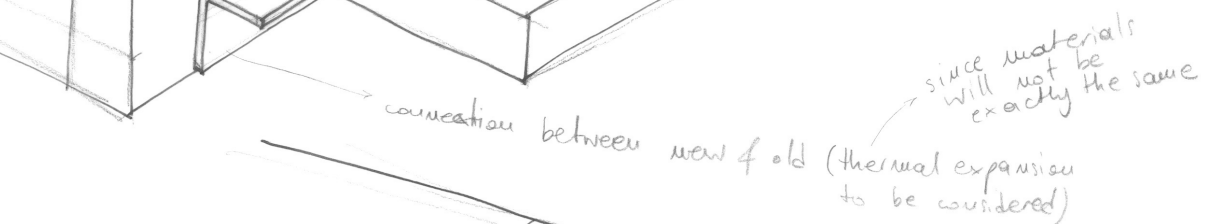
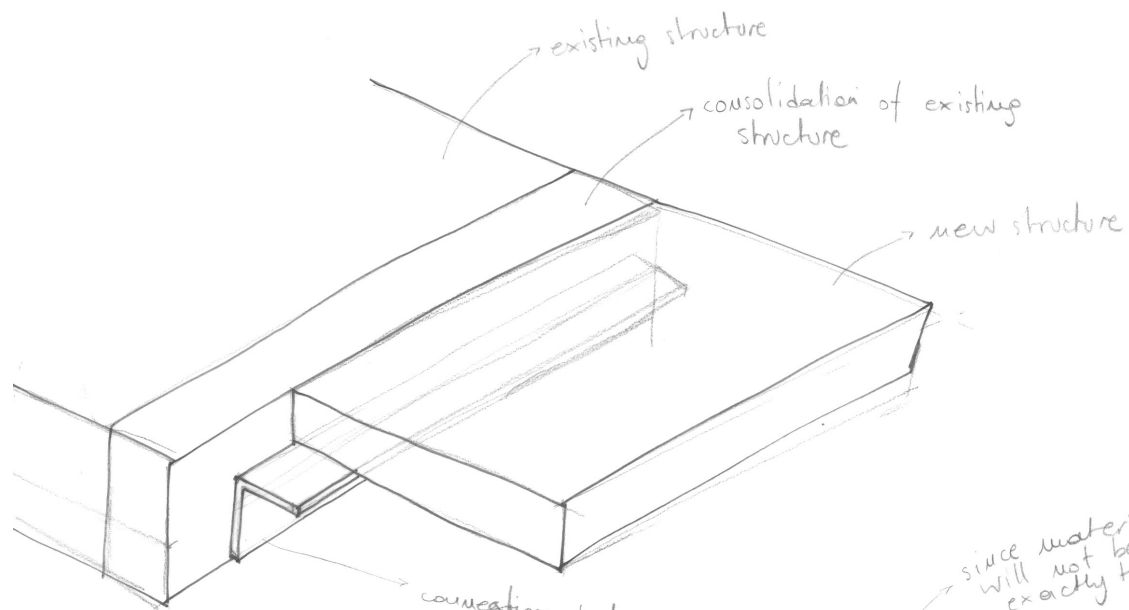
1. The concrete of the old structure would be broken and washed away by using water, which would expose the rebars.
2. The structure is then consolidated, by using another concrete beam at the top, in order to allow space for the wood beams connection
3. The new rebars are then connected to the old ones
4. Wood connections would be straightforward but need to consider the different expansion of the two materials

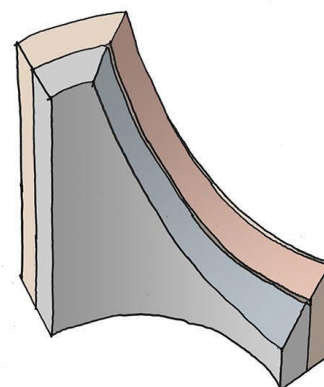
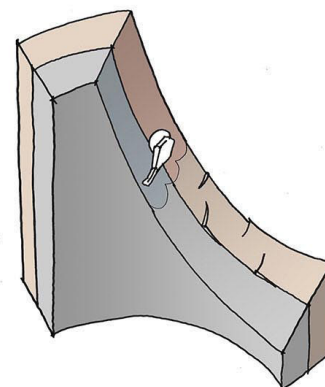
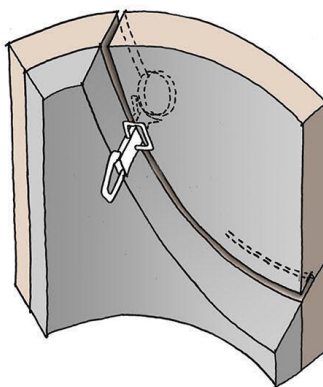
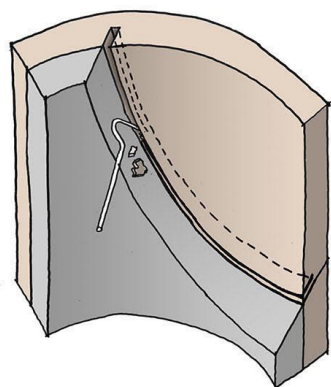
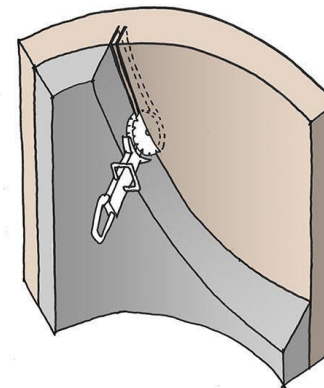
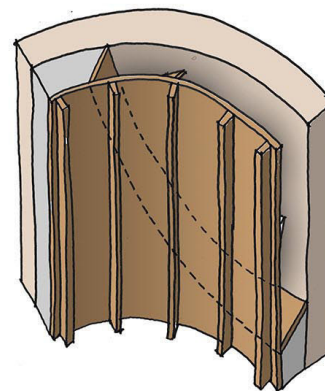
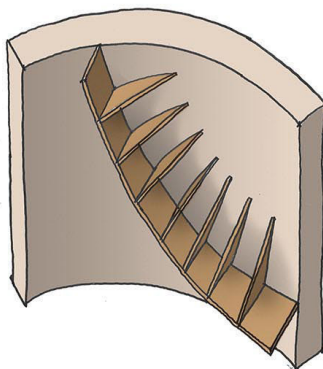
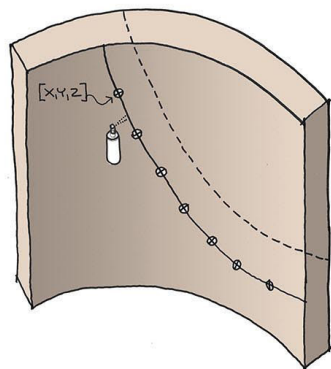


PART 1: WOOD



PART 2: CONCRETE







3.6 CONCLUSIONS

While wood beams offer the possibility of a relatively wasteless production process and the possibility of becoming structural components, complications arose in relation to the correspondence to the computational model. Particularly, this is caused by the fact that wood is a heterogeneous material, meaning that every section is different. This is caused particularly by the presence of fibres and nodes. In order to counteract these difficulties the wooden beams and systems that were chosen are characterised by:

- beams that are structural should have low-curvature and bundled together at different points in space (since they would be cut into pieces). They would be produced with steam-bending
- beams that are only functional (i.e. that are used as formwork or to create closed and open surfaces) could be more free-form and produced with laser-cutting methods

A second aspect was that on concrete and wood. Its structural integration, while still under research, has been proven by several studies. This project brought the addition of a computational model that can integrate the structural principles with the materiality distribution and topology. However the research on their integration demonstrated some difficulties. Firstly, wood is not as malleable and controllable as concrete, which means that the two materials offer different but contrasting geometrical and topological possibilities. While wood is quite

linear and it is the aggregation of its elements that creates a surface, concrete has higher freeform potential and is less constrained and this is quite evident in the case of this project, where a double-bent surface based on the gyroid is implemented.

Overall, the hybridisation between the two topology, rather than materials, is doubtful and it would be indicative of the need of using another method of production that would allow the wood to more closely resemble the characteristics of concrete, possibly CLT.

04

CONCLUSIONS

The project started from the question of how parametric architecture could engage with and bring a positive contribution to a socio-political problem, the refugee crisis.

The analysis of the problematics and characteristics of the latter highlighted the complexity and the many dimensions it involves. Any possible solution should deal with the process of welcoming refugees in the built-environment and society but also with a series of spatial, social, economic and cultural aspects that are inherently tied to it, which require a multi-disciplinary approach.

Other parts of the research accentuated the variegation of the refugee society, but also the self-organising spirit of some of its layers.

The advantage of using parametric architecture in such a context, it was envisioned, would be that, by using a parametric framework, such different factors could be integrated into a unique solution which, by changing some of the initial parameters, would be able to change and adapt, tailoring its solutions. Specifically, this framework would be made of variable and constant parameters, the former representing the changing cultural and behavioural characteristics of the refugee community, the latter architectural knowledge, from organisational to structural to fabrication.

In a more specific approach, parametric architecture could be used to respond to the variegation and self-organising characteristics of the community. In this view, a certain amount of parameters could be offered to each user and would be implemented in order to build their own houses. The use of Virtual Reality was envisaged as a tool to enable the participation of the user in the design process.

However the process proved difficult, especially because data was difficult to translate into variable parameters because of their qual-

itative, rather than quantitative, nature. This is a first step that any implementation of parametric architecture in social questions should be able to solve. The project offered an example through space syntax, which was used to both analyse the refugee camp in Calais, framing the behavioural and organisational characteristics of the society, and the correspondence of the design to these first analyses. This also showed that an abstraction is needed in order to be able to effectively transform data into usable parameters. Moreover, the parametric framework would allow for modifications at any step of the design, particularly through the selection of functions and their relations, which for example would change the design at both the macro² and the macro¹ scale.

However, it is clear that such description is less than a full description of the problem. Aspects, which could be described as individual or societal preferences (spatial, architectural or furniture related, f.i. eating by sitting on the floor or a separation male-female space within the house), that is qualitative data, are harder to integrate, particularly because of the variety and specificity of each. These would need a much more deeply developed computational framework because it needs to programme a larger number of design cases. It is, in fact, not just the parameter that would change, but the whole design logic.

This was the case of the design of the private areas, which the research recognised as the location where the most freedom for the user would take place, as social conflict are minimal. It was attempted to create a parametric system from the interface to the fabrication process. However, the implementation of this system proved particularly complicated for two reasons. The first concern regards the form-finding methods. The tests were made through the use of one single process similar to the ones implemented at the macro scales (based on the functions' relations, although in this case it was a particle, force based method).

In hindsight, the focus was excessively on the process and how the process itself of integrating the user could lead to a design. In this way, it was meant to integrate all the possible solutions. However, it became clear that it needs to be more specific, and particularly, to have a very specific design, although this would mean to drastically reduce the possibilities of integrating qualitative data. Secondly, while the assumption was that parametric architecture as facilitation of self-organisation works the best for the residential design, the research on welcoming refugees highlighted that the most suitable scenarios to improve the current situation are in the public sphere. And these two contrasting focuses, each requiring a different approach and design were difficult to explore at the same time.

Yet, the parametric processes implemented at the level of the macro and meso scales, which needed a design-and-analyse approach either because of their inherent characteristics (agent-based modelling) or complexity (gyroid system) were implemented through the use of variations and iterations. This process, step-by-step sedimenting new information, could eventually be beneficial in the case of integration of the user, as it would offer different options which would be analysed in a Virtual Reality Environment and, by means of comparison among the most liked, favour a reformulation of the parameters. However, this process would eventually need to be translated into linear or loop-based process as the iterations could be optimised and it would ease the integration of additional parameters.

Overall, the implementation and answering of the question was complicated by the fact that a comprehensive design needed to be carried out and its scales, from macro to micro, were largely different in size. Therefore the different parametric systems emerged disjointed, even if theoretically connectable (from form finding to materiality). If the

research methodology was to be reformulated, it would be more fitting to research a smaller scale, where fewer parameters need to be considered. This would also allow for a better investigation into how and which qualitative data could be used in a parametric framework, and their implementation into different parametric systems (recursion, particle-forced based, agent-based methods among others) would highlight the advantages they can bring. Eventually, this scale could really allow for a process that ranges from design to production.

