Transformable Room System
using CNC milling
to create transformable space
for Asylum Seekers Community
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Reference
I. Abstract

At this very moment, the number of refugees who swam into Europe is rising at a very high speed. The explosion of the refugees causes a lot of social and political problems. The number of asylum seekers in Netherlands who made an application for refugee status was 13000 in April, 2014, but now it is more than 40000 in October, 2015. With the help of COA (Central Organ Asylum Seekers), they try to deal with all the refugee issues. Every local authority is required to set aside housing for refugees but many argue that they do not have enough social housing to meet their quota. At the same time, the Asylum Seeker Center is not perfect and not flexible for families, also, the residents there do not have enough privacy.

The need to build more and better asylum seeker centers is obvious. The building need to have both privacy for individuals and flexibility for families. At the same time, the building need to be constructed as soon as possible.

By researching the transformability from different aspects, room space, room combination, urban flexibility and application flexibility, the transformable room system can be proposed. In order to build the system, digital fabrication technique might be used. Different ways of construction technique and transformable devices are compared, from architecture structure to interior elements are discussed to support the whole system.

Key Words:
Transformable, Flexibility, Privacy, Digital Fabrication, Design, Construction, Furniture.
II. Introduction

2.1 General Intro.
This paper is part of a graduation project in Architecture and Building Technology departments at Delft University of Technology. It is from the studio of Architectural Engineering. The first part is a general introduction of the design background and the main research question. The main part (chapter four) is divided into two aspects: design research and technique support. The purpose of this paper is to provide possible solutions for the refugee housing problem in Europe.

2.2 Background: Refugee crisis

2.2.1 Europe
The conflict in Syria continues to be by far the biggest driver of the migration. But the ongoing violence in Afghanistan, abuses in Eritrea, as well as poverty in Kosovo are the leading reasons for people to look for new lives elsewhere. As it is known that the Syrian civil war has caused a lot of people flee from their own country, the number of asylum seekers is experiencing an explosion in Europe. More than 980000 people crossed the borders in 2015, according to the EU statistics agency, Eurostat. [UNHCR,(2015)]. More than 942400 asylum clam were made in 2015. Among all these countries, Germany is the most popular destination for migrants which the number is 315000 by the end of October, Among all these displaced people, Syrians are the biggest group. (See Appendix 6.1)

2.2.2 Netherlands
Netherlands is home to people who are in danger in their own country. According to the Geneva Convention on Refugees and other international rules and agreements, Netherlands has signed the treaty and thus keeps his appointments.

The organization COA, Central Reception of Asylum Seekers, is taking their responsibility for taking care of all these displaced people in this country. All the asylum seekers need a certain procedure to have a legitimately living permission. After they come to this country, They will first go to the application center in Ter Apel and there they can learn the locations of the identification and registration. During this procedure they will be staying in some temporary or emergency tents or shelters, and then, they will be sent to the reception centers and waiting to be judged if they can get a temporary residence permit. This would take six months or longer because there are too many people waiting now. [COA, (2015)]

2.2.3 Asylum Seeker Centers in the Netherlands
There is a great need for new asylum seeker centers now, the existing ones can not fulfil the need of the number of new asylum seekers. Before May, 2014, the number of the residents in AZC stayed at 15000 in total, but it rose to 25000 in January 2015. Until October 2015, the data exploded to more than 40000 people, which is beyond the absorbing capacity of all the AZCs in Netherlands. So there is a great need of building more centers. (See Appendix 6.2.2)

As there is a great need from the refugees, the Dutch government spend a lot of money on all the refugee programmes. The total bill to the Dutch government for looking after asylum seekers reached €860m in 2015, according to cabinet figures. [Dutch News (2015, 6.2)]
Even over 25% of the Dutch government’s 2015 development aid budget is being spent on refugees. [Dutch News, (2015, 11, 27)]

The government need to take the responsibility to accept the exploding refugees. But to settle these people, the budget is really exploding. As an architect, to provide a cheap and efficient building system is quite important. Now among all these asylum seeker centers in Netherlands, there are centers which is specially for teenagers or families, but most of the centers are occupied by a mixture of three kinds of people: first, people who are waiting for the judging procedure to get a living permission, second, people who already have a permission but waiting for their housing to be assigned and third, people who get rejected and wait for a second try or wait to go back to their own country. They can be individuals or can be families, can be teenagers or old people. Everyone is different from each other and has his or her own culture backgrounds and living hobbies.

But in the existing buildings, the standard bedroom are two person shared bedrooms. Everyone got disturbed by his or her roommate because they have different living schedules, people do not have privacy that much. At the same time, families are always separated into several rooms. It could not adapt to different sizes families. (See Appendix 6.2.2)

2.3 Research Question

To create a better living environment for the residents of AZCs, the basic idea is the transformable individual rooms which could provide privacy but can also be combined to create family space. To realize this system, following questions are discussed in this paper.

The main research question is:
How to create a fast constructed transformable room system for asylum seeker community?

It could be defined in several sub-questions according to a scale from small to big:
How to create a transformable room?
How to combine and separate rooms easily?
How to create a better community space within the same space size?
What production techniques are suitable for creating the system?
What kind of furniture system could be used to support the system?
III. Methods

The research on existing AZC is done by literature research and making analysis of the centers. By visiting the existing AZCs, interviewing the officer, talking with the residents in the center, the existing situation is mapped and analyzed. From the analysis, the basic needs of the asylum seeker housing and where the improvement should be done can be listed. The final design objectives are decided in this way.

The objectives can be supplemented with research done on how to design a transformable room system. The research is done by design, from small scale to large scale. By using morphology as the main design method, all the possibilities are listed.

After the research of the transformable room system is done by design, the next part is to construct the system. This technical part is mainly done by literature study and case studies. By comparing all the possible construction solutions, the technical support for the transformable room system is analyzed.

Combining the system research done by design and technical research done by analysing, together is the start of a new building system for asylum seeker centers. In the conclusion part, the research is briefly examined according to the design objectives.
IV. Results

4.1 MAPPING OF EXISTING AZCS

4.1.1 Existing Situation

There are 75 AZCs in Netherlands now, and some of them are transformed from old buildings and some of them are newly built containers to fulfil the increasing housing needs of asylum seekers. But most of them cannot provide a comfort living circumstance for the users. Different problems are listed to show the basic needs of the asylum seeker centers. (see Appendix 6.2.2)

Lack of Housing
According to the data from COA, there were 24929 residents in the reception centers in 2014, but the number exploded to 42988 until November 2, 2015. The number of asylum seekers in October 2015 is beyond the top line of accommodate possibility. Due to various reasons, people cannot find a proper housing after they got a refugee status, some people cannot go back to their own country after the application is denied. (See, Appendix No.1, No.2) A lot of temporary housing for the future coming asylum seekers are needed and a lot of semi-permanent housings are also needed for the refugees.

Lack of Privacy
Among all these existing AZCs, most of the people are sharing bedrooms together, these roommates could come from one countries but also can come from different countries. They do not have their own space, and could easily be disturbed by their roommates. The most emergent thing they need is privacy.

Lack of Flexibility
Among all these displaced people who arrived in Netherlands, some of them are individuals, but some of them come to this country with their families. In this case, the size of the families can differ from one to another. The normal size of a family is 4 to 5 children with their parents, but sometimes, the number of the children could be 8, in both situation, it’s impossible to arrange one family into a big room or house. Most of the families are separated into several rooms, and sometimes mixed with other individuals. The necessity to create bigger rooms which could adapt to different sizes of families is quite important for the new center designs.

Lack of Community
In all the AZCs in Netherlands, all the residents have different backgrounds and religions, but now, they are living inside a same environment and sharing all the facilities together. If everyone just lives on their own, then the whole center would be boring and not good for their mental and physical health. It is quite important to create a cozy environment for all the residents. A community with all the facilities shared by the residents could advocate the relationship between the residents so that people could have a friendly environment to live in.
By analyzing the plan of existing AZCs, most of the residents are attributed into different 8 person groups. Each group share one kitchen, one toilet and one bathroom. According to the COA, each person have 5 m² bedroom space and 5 extra m² for other functions. The two persons’ bedroom is always around 10 m², within this 10 m², there are two beds, one shelf, sometimes with a desk and sometimes not. The space is filled with furniture and nearly no space left for activities. People always sit on their bed. The rooms without tables, people even need to hold their dishes in hand to eat something. At the same time, most of this 5 extra square meters are used as kitchen, toilet, bathroom, walking space and a small living room. But according to the interview, the shared living room is always not quite efficiently used. When they have visitors, they always prefer to stay in their own rooms or go out to the bigger communal space. (Resource, Appendix No.3)

As a result of the analysis mentioned above, in the existing AZCs, there is a lack of personal space, but the using of the communal space such as the living rooms is not sufficient at all. So the question is how to create a minimum individual space which could be used as multi-functions. To create multi-functional individual room, the room itself need to be transformable. At the same time, the rooms need to be combined or separated easily from each other so that it could adapt to different sized families.

To reach the maximum use of the minimum space of 5 m², multiple functions should be applied to an individual room, in this way, the user could change the room from bedroom to a living room, a study room, a party room as they want. Also, to fulfill the needs of different sized families, the individual room could be combined or separated with other rooms to make smaller or bigger space according to the users’ need.

The idea is to create a transformable room system for asylum seeker which is multi-functional and can be separated and combined with other rooms.

The Transformable Room System is not only about room itself, but it starts with 5m² room and spreads between different rooms, then the rooms formed into an organized living unit, then the relationship of the units is also part of the system to be discussed. Finally the possible implementation environment is also related to the system and need to be evaluated. To construct the system, all the techniques to support the 5m² room itself and the space inbetween the rooms and outside the rooms are all related to the Transformable Room System.


4.2 Objective

To provide more and better housing for asylum seekers, there are several goals to achieve in order to fulfill the needs of the residents.

**Efficiency**

As more and more people seek for asylum and more people get a living permission in the Netherlands, the need for more housing is the most urgent question. So how to build good housing using as little time as possible is very important. The need of speed is absolutely needed in the design and construction process.

**Privacy**

In all the asylum seeker centers, there are old and young, women and men, children and adult, all of them are from different countries and share different religions. Nobody is the same and everybody has his or her own habitat of living. So to provide privacy for each individual is quite important.

**Flexibility**

Among all the residents in the centers, there is a big proportion of families. Most of the residents now are from Syrian and they raise several children in one family, the number of the children are always different, so the size of the family is always different from one to another. To make the building flexible to adapt to different sized families is quite important.

**Affordability**

Since the government do not want to spend too much money on the refugees. So the price of the construction is an important criteria for judging if a design is good or not. To use the minimum money to achieve the maximum effect is quite important.

**Quality**

Though the AZCs are places for displaced people, try to provide a cozy environment has a significant effect on the residents’ mental health. The atmosphere created in the center should help the residents to get peace and cured.

**Durability.**

Since the building needs to be used as a semi-permanent place for refugees, the durability of the building and furniture is quite important. How long could it be used should also be taken into consideration.

**Sustainability**

If the idea of the new center is to save money and space, then, it should also save energy. From design perspective, the material used should be recycled, natural light should be used as much as possible.
4.3 Transformable Room System Design

Transformability within time and space

In order to create a transformable room system, time and space are the two main aspects to be considered.

First is about time, the transformability is required in every hour, because the daily activities could change a lot from morning to the evening. This could be called the first time level of transformability. At the same time, as the residents inside the AZC could change every week and every month, so the adaptability for different users in this longer period is also quite important, how to transform individual rooms into family rooms in the time of months are the second time level of transformability. If the residents need to stay for more than one months, then some space need to be transformed to provide public facilities for communal activities, so that from months to year is the third time level of transformability.

For the transformability of space, the first level is how to transform the 5 m² space into multi-functional rooms and the second level would be how to transform several individual rooms into bigger family rooms. The third level is how to organize these transformable room system into a larger public AZC space with multiple recreational space for all the residents. The last level is the transformability or adaptability in different environment.

In the following paragraphs, the transformable room system would be discussed from small scale to big scale, from inner transformability to urban flexibility and environment adaptability.

Figure 4.3. Transformability within time and space (own ill.)
4.3.1 Interior Flexibility (Flexibility in Hours)

As mentioned in the former chapters, the basic idea of the room system is transformable. Not only transformable between different rooms, but also inside a room itself. The functions could change during different periods in one day. To transform the room into different functions, the furniture need to be precisely designed to adapt to various possibilities.

According to the daily activities of the residents inside the AZC in Heerlen, their daily activities can be divided into several categories according to the noise level. Sleeping time, studying time, eating time and party time. Different furniture are needed for different activities. The basic furniture pieces are bed, shelf, desk/table, chair and sofa. For the new system, the rule is to be as cheap as possible, so the furniture could be combined and benefit from each other. So the basic pieces are bed, table and chair, shelf.

How to organize these inside a 5 square meter room with efficiency is quite a difficult task. The idea is to transform the whole 5 m² space into a 5 m² bedroom, a 5m² studying room, a 5m² party room and so on. In this way, a maximum use of a minimum space could be achieved and people will not feel be limited by the furniture around.

In order to free the 5 m² space for different functions, the furniture should be hid in a way when they are not needed. So a hiding layer is created using the original structure of CNC milling panels, it could also act as a shelf system for storage. Different ways of interior composition is compared below.

![Figure 4.3.1 Multi-functional 5 m² (own ill.)](image-url)
4.3.2. Room Combination Flexibility

Privacy VS Flexibility.

The best way to solve the privacy problem is to provide each individual his or her own room. If every asylum seeker could have one space which is totally under their control, then they will not be disturbed by others any more. According to the 5m2 bedroom per person rule, each person could have his or her 5 m² space as a basic volume. (See Appendix 6.2.3)

According to the previous mentioned transformable functions, this volume should be able to become a bedroom, a living room or a study room according to the user’s needs.

On the other hand, a big proportion of the asylum seekers are families. Which determines that they want to live together. If they are all separated and have their own rooms, they would not have a good space for family get-togethers. In this case, the flexibility for different sized families need to be solved.

Combination Mechanics:
There are several ways to combine the individual rooms. Dynamic way, Constructive way and Sliding way.

Dynamic Way:
With the help of wheels and tracks, the rooms could move and be connected together, but the price for lifting the whole building block up and moving it is quite expensive because most of the elements need to be made of metal and need to be super strong. Also the moving system is hard to be reused if the AZC is not needed and abandoned in the future. So the dynamic way cannot meet the requirements of affordability and sustainability.

Constructive Way:
With the help of easy demountable joints, the connection wall could be easily moved and new rooms could be added to the existing volume. This could help to expand the original living scale, and the size of the volume could be changed easily according to the family sizes.

Sliding Way
In this way of solution, the amount of rooms is first settled, the connection walls are transformable pieces, could be sliding doors or folding panels, If the residents in this group are all individuals, the sliding panels could be closed, if families are using this room block, then the panels could be opened and they can have a big family room and enjoy time together.

Choice of Transformable way/Sliding Way
With the dynamic way and constructive way, the transformable system could achieve its maximum flexibility for families, but the dynamic wheel system causes a lot of tracks on the ground, also, to move the heavy rooms, an automatically moving system is needed, the sliding wheels need to be super strong, also, after using it as an AZC, it is hardly to transform this track and wheel system into other functions, this would spend a lot of money, but the budget for this project should be as low as possible, so the Dynamic way of combining rooms are not chosen to be researched.

Compared to the dynamic way, the constructive way of combining two rooms is much cheaper. When there comes more residents, more rooms could be built. With demountable joints, the panels could be easily removed or installed as the users’ will. But the residents inside the AZCs are always changing, the asylum seekers transfer from one center to another quite often. So every time the residents change, the building volume need to be constructed again and again to be adaptable. As a result, using demountable joints would
be difficult and noisy. Also space would be needed when the connection wall is removed to create bigger space for families. So the constructive way cannot meet the requirement of efficiency.

The last solution is sliding way. With the settled elements, the building block is fixed on a large scale. But with the sliding wall panels, the separation inbetween different rooms could be opened or closed easily without removing any architecture elements. So the requirements of flexibility could easily be reached. By moving the panels to change the combination of rooms, it would not make too much noise which could fulfil the need of living quality. At last, there are a lot of existing products on the market which could be chosen. So sliding way could be chosen as a smart way of creating combination between rooms. With sliding way, flexibility, quality and affordability could all be achieved.

*Figure 4.3.2.A Combination Mechanics (own ill.*)
**Plan Combination:**

There are ways of creating a plan connection with the help of sliding walls. By opening or closing different sliding panels, the relationship between different rooms could be different two. In this case, different space could be created and used according to the resident’s need. (Figure 4.3.2.B)

![Figure 4.3.2.B Plan Combination (own ill.)](image)

**Section Combination:**

There are ways of creating a vertical connection between different rooms. Ladders is better to be used to save space for inner vertical connection. When the rooms are separated, the ladders could be used as book shelves, when connected, the plate on the first floor could be opened and the shelf could work as a ladder. At the same time, a public vertical staircase is also needed.

The vertical connection should be composed of inner-room ladder system and outer-space staircases. Both work together to form the maximum flexiblity of the room vertical combination.

![Figure 4.3.2 C Section Combination (own ill.)](image)

![Figure 4.3.2 D Section Combination example (own ill.)](image)
Room Combination Space Flexibility

Everyone has its own individual room, but when the nearby residents are one family, the sliding wall could be opened, then all the space could be connected and used as a whole family space. This kind of division is quite flexible, both on plan and sections, it’s fast and convenient for the fluent change of the residents.

Figure 4.3.2 E Room Combination Transformability (own ill)
Space quality is always important for the users. Though they are asylum seekers, they are human beings, they have their own needs for a space.

The existing situation is like this: with the analysis of the existing AZC in Heerlen, every 8 person share one living unit. The size of the unit is approximately 80 m², but as the plan shows, every bedroom is used by 2 person, and all the 8 persons share one kitchen, one toilet and one living room. But the real situation is that people are always disturbed by each other because the share bedroom has no privacy for them, also the living room is so small that some residents put their personal staff there and other people never want to use it any more. (see Appendix 6.2.3)

The existing situation in Heerlen is that the building has two floors and each floor accommodate 4 unit. In total, there are 64 people living in this new building block. The situation is that the residents could neither have their privacy for individual nor flexibility for family. There is no left over space for children to have fun, no left space for friends to enjoy some time together.

With the new room system, every resident has his or her own space of 5 m². but is the individual room system better than the original one? How to organize the individual rooms to make the whole system act efficiently? How to achieve a better space quality or atmosphere within the same sized space?

**4.3.3. Urban flexibility**

*Intro*

Space quality is always important for the users. Though they are asylum seekers, they are human beings, they have their own needs for a space.

The existing situation is like this: with the analysis of the existing AZC in Heerlen, every 8 person share one living unit. The size of the unit is approximately 80 m², but as the plan shows, every bedroom is used by 2 person, and all the 8 persons share one kitchen, one toilet and one living room. But the real situation is that people are always disturbed by each other because the share bedroom has no privacy for them, also the living room is so small that some residents put their personal stuff there and other people never want to use it any more. (see Appendix 6.2.3)

The existing situation in Heerlen is that the building has two floors and each floor accommodate 4 unit. In total, there are 64 people living in this new building block. The situation is that the residents could neither have their privacy for individual nor flexibility for family. There is no left over space for children to have fun, no left space for friends to enjoy some time together.

With the new room system, every resident has his or her own space of 5 m². but is the individual room system better than the original one? How to organize the individual rooms to make the whole system act efficiently? How to achieve a better space quality or atmosphere within the same sized space?

![Figure 4.3.3.A left: Plan of living unit in Heerlen (new containers) right: Hubble-bubble in the shared living room. (own ill.)](image)
**Better space quality within Limited Space**

Individual rooms provide the privacy for single persons. But in order to accommodate families also, the rooms need to be combined in a certain way. The way to combine individual rooms are discussed in Figure 4.3.3.B. The rooms are organized in a certain way according to the number of connected rooms, from one room as a unit until 8 room as a unit. As a result, different sizes of space are left and different qualities are created. From the analysis, several conclusions could be drawn as follows.

*Service area better to be aligned*

Since the infrastructure is quite important for the whole organization of the urban space. The From Figure 4.3.3 it’s clear to see that the service area is better to be organized in a rigid way or a grid system so that the pipes could be easily organized. the distance between service area is also related with the leftover space.

*Flexibility works better with two floors*

With the vertical connection inbetween two floors, bigger families could be accomodated. The adaptability of two floors is twice of the adaptability of one floor. Also, with two floors, the communal space could also be combined together to create better oppotunities.

*Smaller groups create average leftover space*

With each individual as one living block, the whole space is seperated averagely. The leftover space is more like corridors. Also there is a lot of traffic area, hence no large communal space could be created. But the space inbetween the living blocks can be quite active when the living blocks are partly open. The average configuration is quite similar when the living unit is below 3 person per unit.

*Bigger groups create bigger leftover space*

With 8 person organized in a centralized way, the left over space is the biggest. With bigger leftover space, it could be used as a big communal space. A lot of public activities could happen in a big open space.

*Conclusion*

It is clear that with the combination of individual rooms, the space for 64 people could perform much better than the existing situation in Heerlen. The living blocks are making a city by themselves, and creating private living space, inbetween semi-public space and big leftover communal space. The system could not only provide privacy for individuals, but also provide flexibility to accomodate families, the most important thing is that it could create much more effective communal space than the existing way of living unit.
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<th>left over space size</th>
<th>two floors ISO</th>
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<td><img src="image" alt="Two Floors ISO Diagram" /></td>
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<td>2</td>
<td>4</td>
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left over space type: corridor space

*figure 4.3.3.B Better Space within Limited Space (own ill.)*
<table>
<thead>
<tr>
<th>Side Space</th>
<th>Decentralized Square Space</th>
<th>Centralized Square Space</th>
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</thead>
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<tr>
<td><img src="image" alt="Side Space" /></td>
<td><img src="image" alt="Decentralized Square Space" /></td>
<td><img src="image" alt="Centralized Square Space" /></td>
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**Figure 4.3.3.B Better Space within Limited Space (own ill.)**
When public spaces are successful they will increase opportunities to participate in communal activity. This fellowship in the open nurtures the growth of public life, which is stunted by the social isolation of ghettos and suburbs. In the parks, plazas, markets, waterfronts, and natural areas of our cities, people from different cultural groups can come together in a supportive context of mutual enjoyment. As these experiences are repeated, public spaces become vessels to carry positive communal meanings. [Carr, 1933, p344]

The purpose of the public space could be used in different ways. It could be recreational space, natural space, commercial space, sports space and so on. But with the different organization of groups, the leftover space could be classified into different categories: corridor space, side space, decentralized square and centralized square. Different leftover space has its own space quality and could be used in different ways.

**Corridor space**
As the name shows it, the space is narrow and long and just next to the living block, the more open area of these space could be used as private talking area or thinking space, people would have a very cozy environment without disturbed by others. The more closed area is more like the territory of the living block itself, when the living block is opened, the inbetween space is defined by the users naturally. Children could play on the corridor while the parents are watching inside the living block. It’s a naturally growing space from the living area which could change into semi-communal space itself.

**Side space**
Side space is not small, but since it’s shape is quite long, it has its facing direction, it could be divided into several smaller area or it could be used as a whole.

**Decentralized square space**
Decentralized square space is always placed in between several living blocks and the area of each square is smaller than the centralized ones, so the space is better to be used by groups of people for certain purpose. This kind of purpose could change a lot, could be a reading area, a chess area and also could be a small garden for entertaining.

**Centralized square space**
Centralized square space means that the space is surrounded by residents, hence the space is quite important for all the users, its significance decides that these kind of space is better to be used as a public gathering area. It could be a big garden, could be an open music room and could also be a cafeteria for people to drink and talk. It could also become a large market for the residents.
Figure 4.3.3.C Proposal for Leftover Space (own ill.)
4.3.4. Application Flexibility

Application in different circumstance
The basic idea of the new transformable building system has a common applicability and could be used in different environment and To build new asylum seeker centers. there are three places where the new building blocks could be implemented. First is empty unused land,

Undeveloped land
Advantage : Easy implementation. Unlimited space Various Configuration Easily defined communal Space and Outdoor space
Disadvantage : Strong Climate Proof wall New facility built to rely on

Vacant Factory:
Advantage : Solve Vacancy Problems Existing Structure and Facade to provide Climate proof Existing facility to use
Disadvantage : No outdoor space Lack of Daylight and Ventilation. Limited Space

Existing AZCs:
a, Old building turned into AZC (figure 4.4.1.3)
Advantage : Existing facility to use Renovate the old building at the same time
Disadvantage : Existing building too complex Connection parts need well developed Limited space

b, Newly built containers (figure 4.4.1.4)
Advantage : Existing facility to use Easy connection joints
Disadvantage: Lack of space Lack of sunlight Communal space hard to create

For different application circumstance, it has different challenge and can result in different atmosphere and building cost.
Figure 4.3.4 Application Flexibility (own ill.)
4.4 Transformable Room System Construction

4.4.1 Digital Fabrication Comparison

Intro
Costs, time frames and quality are still the challenges for all planners in every construction project. But today it is not only the architect and engineer who organize construction tasks. For this reason it is seen to be necessary to achieve at a single, seamless flow of data from the setting of objectives through the design and manufacturing to the actual implementation as part of a cohesive process. That’s the reason why digital fabrication becomes quite a global trend for architecture design. In this project for building homes for asylum seekers, the speed is the best wanted, so digital fabrication techniques could be applied for its advantage of fast construction. On the other hand, there are so many options for digital fabrication technology, the 7 objectives of the whole project are the basic principles for making a technology choice for construction. So what kind of digital fabrication technique could be applied in this transformable room system?

Digital production technologies.
The digital production technologies can be divided into four principal areas: Generative procedures (e.g. 3D printing), Subtractive procedures (e.g. milling), transformative procedures (e.g. bending) and joining procedures (e.g. welding). All these methods lead to an increased efficiency in design and construction. But in order to achieve this efficiency, an understanding of the production technologies is required.
There are several technologies for construction industry, CNC precast concrete, 3D printing, CNC laser cutting, CNC jet cutting, CNC hot wire cutting and CNC milling. Each technique has its own specialty and need to be carefully evaluated which one could be applied in the transformable room system.

Comparison
CNC precast concrete
Traditional precast concrete elements are moulded by hand, this is why special shapes, openings and inserts can only be made with a large degree of manual effort. But with CNC-controlled moulding robot, framing elements can be controlled using CAD data and fixed with magnets. With the help of the robot, the efficiency of computer-aided production is 3.7 times higher than the manually produced ones. But since concrete is heavy, it is not a perfect material choice for flexibility.

3D printing on a large scale
This technique could be the future of free-form construction without moulds. The D-shape procedure transfers the principles of 3D printing to construction in a scale of 1:1, it’s based on 2-10mm thick layers of sandstone particles, which are bonded by an inorganic binding agent. But the maximum print size of this technique is 6M*6M, also, it’s a fixed construction block, which could not meet the need of flexibility.

CNC laser cutting
Laser technology is based on a high energetic light beam, one of the thermal separation procedures. The raw material being cut absorbs the energy contained in the laser and, as a result, heats up intensely in a very short space of time. Then a process gas blows the melted material from the incision downwards. 2D drawings are used for producing laser cut elements. The laser can either cut or engrave the material and in doing so can process nearly all solid-state materials. But the speed for cutting is high when cutting thin materials (0.5mm Finnish Cardboard, 6.0m/min), but the speed could be very low when cutting thick materials (e.g. 1m/min for 6.0mm MDF). In this way, the speed could not be guaranteed and
could not match the efficiency principle.

**CNC jet cutting**

CNC jet cutting is used primarily for 2D blank cutting of solid materials such as stone, metal or plastic. Water is formed into a jet at a speed of 1000m/s, and the energy is turned into kinetic energy which gives the jet its cutting effect. But when dealing with soft materials (e.g. paper, plywood, plastics), with the abrasive procedure there will be additional grinding particles in the cutting jet, which is not good for a finishing.

**CNC hot wire cutting**

It’s used for creating large volume geometries. The hot wire system only functioning well on the material of foam which is not a good solution as a main construction material.

**CNC milling**

There are three different kinds of material which could be milled, metal, wood and plastics. With this technique, both 2D and 3D components could both be produced. The precision of the processing is really high because the exact positioning of the component on the milling bench is related to the system zero point. With two or more axial mills, different geometries could be generated and it is quite useful for creating transformable joints and elements. There is a disadvantage of this technique because the amount of material used is high. But if recyclable material could be used, then this disadvantage could be saved.

**Choice of CNC Milling**

According to figure 4.4.1. With all the digital fabrication techniques, CNC precast concrete, the material is too heavy and the molds could not be recycled, thus it’s flexibility and sustainability is limited. For 3D printing, it prints exactly the shape designed, so it’s lack of flexibility for adaptions. With Laser cutting, it could make demountable joints to reach flexibility, but since the material is not that strong, the durability is quite limited. As for CNC jet cutting, there are multiple choices for the material, but for the quick and soft materials, there are grinding particles which is not good for the outcome. CNC hot wire cutting is too limited, it can only handle foam, which the durability could not be enough for the transformable system. Compared with all other technologies, CNC milling could tackle the main material like wood, metal and plastics, and also 2D and 3D objects can be generated which is perfect for demountable joints. It could be quite flexible. CNC milling is the better technique solution for fast constructed flexible building system.

To construct such a room system, there are different levels of elements need to be considered, the building elements, the room connection elements and the interior furniture elements. Since the CNC milling technology is chosen, the maximum use of this technique is supposed to be reached. With the using of digital fabrication joints, all the elements could be installed easily without professional training. Thus less accessories needed would be better.

<table>
<thead>
<tr>
<th>MATERIAL</th>
<th>CNC jet cutting</th>
<th>3D printing or a large scale</th>
<th>CNC laser cutting</th>
<th>CNC air cutting</th>
<th>CNC hot wire cutting</th>
<th>CNC milling</th>
</tr>
</thead>
<tbody>
<tr>
<td>CONCEPT/TYPE</td>
<td>stone, metal, plastic, wood</td>
<td>Ceramic, aluminum, plastics, paper, wood/Concrete</td>
<td>wood, metal, carbon/plastic</td>
<td>stone, metal, plastic, paper, wood/plastic</td>
<td>wood</td>
<td>wood, metal, plastics</td>
</tr>
<tr>
<td>JOINTS</td>
<td>no joints, no possibility</td>
<td>possible</td>
<td>possible</td>
<td>possible</td>
<td>possible</td>
<td>no possibility</td>
</tr>
<tr>
<td>SPEED</td>
<td>speed dependent</td>
<td>slow</td>
<td>depends on the material</td>
<td>depends on the material</td>
<td>fast</td>
<td>depends on the material</td>
</tr>
<tr>
<td>ADVANTAGE</td>
<td>function only 2 dimensions, and materials possible, no additional components</td>
<td>Free construction, organic structure possible</td>
<td>flexible, demountable, customization</td>
<td>possible to cut solid materials, flexible and demountable, customization</td>
<td>possible to produce large volume geometries, customization</td>
<td>2D and 3D objects possible to be produced, demountable joints possible, customization</td>
</tr>
<tr>
<td>DISADVANTAGE</td>
<td>heavy material limited, limited freedom for onesement</td>
<td>easy shape, impossible to add elements</td>
<td>the size is limited by the machine size consuming</td>
<td>when cutting materials paper, plastic, metal, additional grinding possible, tree consuming</td>
<td>Only foam to be produced, no demountable joints, only for temporary construction</td>
<td>Size of the component is limited by the machine, tree consuming</td>
</tr>
<tr>
<td>STABILITY</td>
<td>depend</td>
<td>depend</td>
<td>depend</td>
<td>depend</td>
<td>depend</td>
<td>depend</td>
</tr>
<tr>
<td>DURABILITY</td>
<td>depend</td>
<td>depend</td>
<td>depend</td>
<td>depend</td>
<td>depend</td>
<td>depend</td>
</tr>
<tr>
<td>EXHAUSTIVITY</td>
<td>depend</td>
<td>depend</td>
<td>depend</td>
<td>depend</td>
<td>depend</td>
<td>depend</td>
</tr>
</tbody>
</table>

Figure 4.4.1. Digital technique comparison (own ill.)
4.4.2 Room Construction

Into

With CNC milling technique, buildings or rooms could be constructed at a very fast speed. Everything could be manufactured in factory and installed on site. But there are so many structural system and joints on the current design industry, which one is better for the asylum seekers’ 5m² space and the whole transformable system?

In order to build the transformable room system, first, the structure and joints need to be easy assembled. Second, mainly the structure distance is for the size of the bedroom, but also the structure should be adaptable and flexible for bigger communal space. Third, the structure should have the possibility of adding new transformable furniture, which is the need for the inner change flexibility.

A comparison between three CNC-cut plywood Structure System is listed below.

The instant house [see Appendix 6.3.2.C]

The instant house projects is to provide a novel design and prefabrication process for mass customized emergency, transitional and development contexts. The construction system is meant to be constructed by a minimum amount of people, thus its components are small and light. The components are designed based on the shape design, so they are not supposed to be used in a new design with another shape. On the other hand, all joints of the instant house system can be assembled or disassembled with only a crowbar and a mallet. So it is quite easy to move the house and reconstruct it.

Structure Assembling:

Since it’s intended to be made by a minimum amount of people, thus its parts are small and light. The studs are 1220mm big which could easily be managed by one person. The design could be constructed by using one mallet. [Sass.D.2006]

Structure Flexibility:

Connection joints are dado tabs and slots. The design is able to adapt or extend into one direction (depending of the customization of the shape). But not possible for a new shape.

Inner Change Flexibility:

No. only possible for move between locations.

Wikihouse [see Appendix 6.3.2.B]

Wiki house is an Open Source construction set. The aim is to make possible for everyone to share, download, adapt and ‘print’ their own houses which are low cost, high-performance and suited to their needs, which they can quickly assemble without the need for conventional construction skills. It is a way of bringing digital fabrication to housing: radically lowering the barriers of cost, time and skill. (wiki detailz p2)

Structure Assembling:

1200*2400 grid, the basic structure is 300mm in width which are placed at every 900 mm. The portal frames are connected by the inner and outer sheeting to make the structure stabilized. Maximum room span is 3.6m, and the maximum elements are 2.4m in length and 1.2 m in width. Due to its materials and maximum sizes it’s safe to say that one person is able to carry the elements on their own. [Meeder. D, 2015, p 10]

Structure Flexibility:

S-joint; primary connector and secondary connector. Based on these joints, the system is open to generate different types of houses, but hard to adapt after assembling. It’s possible to add more portals but to change the width makes more challenging.

Inner Change Flexibility:

The structure has no possibility for inner changes or flexibilities. The components fit perfectly to one and another, but the wikihouse guide leaves no room for more infill.
The Haiti Shelter [see Appendix 6.3.2.C]
Similar to the project of L.Sass, this design is an answer to a world where natural violence is becoming more common because of human caused climate change, so the system is a cheap, flexible and quickly realizable post-disaster housing solution. It’s an open source system which can collectively evolve to suit different context. [Stoutjesdijk, P. M. M, 2014,]

Structure Assembling:
Two overlapping grid structures of 1200mm, of which one is moved 600mm in all three directions. On this grid structure the columns are placed. In between these columns are the girders and the infill are placed. The system is a combination between a balloon frame system where the outer sheeting instead of girts, to make the building rigid, and a column and beam system. [Stoutjesdijk, P. 64] According to the maximum size of most stock sheeting, the maximum size of the elements are 2440mm*1220mm. So the elements are suitable to be bought and carried by one person, the size is also suitable for most CNC routing machines.

Structure Flexibility
The structure itself has flexibility because it’s set in column and grid structures. The grid can be adapted according to the needs.

Inner Change Flexibility:
This system bears great adaptability for the structure. But the same as the Wikihouse system, it’s difficult to add extra interior components to the existing system quickly. The components fit each other perfectly and do not leave any room for introducing fast changes to the inner space.

Bone System[see Appendix 6.3.2.D]
It’s a CNC routing building system based on the “Bone Structural System”[A. Laval. 2005]. It consists of many columns and girders. There are slots inbetween to connect the girders on every side and height. This means wherever one would place a column and possible to connect the girders to it and create a floor, attaching space. This gives this system a high degree of adaptability. [Meeder. D. 2015. p 15]

Structure Assembling:
It’s also using maximum size of sheets which is 2440mm*1220mm, so it’s same as the Haiti SHelter, easy to carry and prefabricate.

Structure Flexibility:
The span could easily be changed on the grid system as if the columns and extra girders inside the box beam.

Inner Change Flexibility.
This system provides the possibility for adding more extra interior elements without changing the existing main supporting structure. In this case, the transformable devices could be added onto the existing structure system easily without disassembling the original structure.

Comparison and the choice of Bone System
As discussed above, the instant house and the wikihouse systems are lack of the flexibility of changing the span of the structure because everything is based on fixed elements, only possible for expanding in one direction. While the Haiti Shelter has the flexibility to change the building structure thanks to the columns and grid structure. But it’s lack of the flexibility for inner fast changes. But, since the bone system is based on columns and girder system, and there are slots on the system to easily add new structures. Which provide the structure flexibility and inner change flexibility at the same time. Which fulfil the needs of the Transformable Room System.
4.4.3 Room Combination (Sliding wall system)

**History:**
In the human history, different elements are used for space separation and combination. Since China’s Zhou Dynasty, screens and room dividers have been used to cover everything from unsightly kitchen doors to aristocrats changing clothes.

**Manual & Automatic:**
The folding screen developed through history. In the current market, there are two kinds of sliding wall system, manual sliding door system and automatic sliding door systems. Since the size of the room the refugee uses is small and the budget is quite low, so the automatic sliding wall system will not be discussed here.

**Material:**
The most used material for sliding doors is aluminum alloy, the second most used is MDF, also solid wood, glass, composite, melamine board, plastic, HPL/HPDL, cloth and other materials are used for sliding wall system. According to the 7 basic principle of judging, the sliding wall system needs to provide privacy, the main technique to manufacture is CNC milling system, so the wooden sliding wall system is chosen to do a deeper research.

**Structure Support:**
There are two ways of supporting a sliding wall panel with track mounting, top hung and bottom rolling. With a top hung sliding door, the entire weight of the door is concentrated on the building’s header. The building from which the door is supported should be strong enough to carry the door’s entire weight and the loads imposed. On the other hand, the bottom rolling door offers a far more design efficient building that will cost less. There is no need for the building to carry the door’s load up top. Instead, the bottom of the door carries the majority of the weight. In this occasion, a solid door hardware is needed to ensure the door panels be stable during operation. There is a side effect of these two kinds of supporting structure. With the top hung sliding wall system, the door panels are hung so that the floor space is freed and no big long tracks need to be mounted on the floor, only small guides elements. On the other hand, the bottom rolling sliding wall system would have both tracks on the ceiling and on the floor, the floor tracks are quite important for supporting and sliding. [AERO.DOOR. 2015]

Compared with top hanging, bottom support walls are more durable, it needs little adjustment once installed and should last the life of the building. So bottom supporting is selected for the transformable system.

![figure 4.4.3 sliding wall system selection](image)
**Operation Type**

For bottom supporting wall system, there can be different relationship between each panels. Three kinds in general, sliding, stacking and folding. For sliding panels, each panel has its own top hung or bottom support track, for stacking system, the panels can be rotated and stacked together, the last one is folding system, two or more panels could be connected together by hinges, and the top-hung or bottom support elements operates in a group of panels. With stacking or folding panels, there need to have special stocking space for the panels while the sliding way can be stocked just on the tracks itself. It will not take other space, that’s why it is chosen.

**Final Choice: Wooden sliding wall system**

Wooden sliding wall system are chosen for the design, because the material is more sustainable and also could be CNC milled, compared with other two operation types, it does not need extra space for stocking which could save space a lot.

**Acoustic Insulation Effect:**

The operable partition frequently only accounts for around 10% of all the surface areas in a room, it is immediately clear that the floor, ceiling, fixed walls, fixtures and fittings all have an effective sound attenuation achieved in a room. But the sound effect of the sliding wall system is quite important when it comes to analyzing the noise transmitted to “separate” rooms. The track rail, the floor and the surface of the panels are three important figures for sound insulation. The track rail should also provide a baffle for sound reduction. The floor where the panels stand needs to add acoustic breaks, and the surface differs when a sound reflection or sound absorption is needed, it could be a high reflection surface without acoustic or a low reflection surface. It need to be specially decided according to the real need. (see Appendix 6.3.4)
4.4.4 Room Furniture system

Intro
The key idea of the transformable room system’s interior is to hide furniture when it’s not needed. The basic elements needed is bed, shelf, table and chair. With the CNC-cut structures, part of the structure could act as a shelf itself. So only bed, table and chair need to be discussed. All these elements should function well when needed and hide well when not needed. So that the space could be maximum used. There are so many existing transformable furniture on the market, which one can fit the whole transformable room system better? According to the principle of efficiency, flexibility and affordability, the products are evaluated and compared as follows.

Bed
There are several ways to hide a bed and it will result in different spatial quality. Rotating, folding and disguising.

Murphy bed
With rotating bed or Murphy bed, the bed could be hided inside a shelf perfectly. Each set of the murphy kits are around 300 euro. The kits are made of steel, so it could be used for a long time.

Folding bed
A folding bed is also called a sofa-bed. It’s easy to use, it’s a chair when folded and become a bed when unfolded. The price for the folding kits is around 100 euro on the market. The connection kit is made of steel.

Normal bed (disguising)
By using a bed and hide part of the bed in the structure, it’s a disguising solution.

Choice of Murphy bed
With folding bed or normal bed, the space taken by the bed is big and the 5m² space could not be used efficiently. But with murphy bed, the space could be totally freed because it could totally be hided in the building structure, though it’s a little expensive, but using it can save a lot of space and the whole system could work more efficiently. So murphy bed is a better choice.

Fig. 4.4.4.A bed (own illu)
**Table**

Table is mainly used for eating, drinking and studying. The direction of the folding table could be different and would have a spatial effect on the room itself.

*Down-folding table*

Down-folding is composed of a surface and a supporting structure. The surface is supported by a triangular wood structure and all the elements are connected by hinges.

*Up-folding table*

The surface of the up-folding table is turned upwards when hided. When opened, there will be a connection chain to hold the surface.

*Free-folding table.*

This table is made by a crossing structure and it could be moved inside the space as the user wants.

*Choice of down-folding table*

Normally, a free folding table is in a foursquare shape and could be bigger than one person’s need. It’s better to be shared. On the other hand, both downfolding and up-folding tables are in a perfect size of individuals. With down-folding tables, the supporting structure of the table surface could hide behind the table surface, while with the up-folding tables, there need to be a certain lock place at the top to prevent the table surface from falling down. With up-folding tables, when it’s used, the chains could be an obstacle. With down-folding tables, when the surface is used, there will not be any obstacle. So down-folding table is a better choice. (see Appendix 6.3.5)

![Fig. 4.4.4.B table (own illu)](image)
Chair

Table is mainly used for eating, drinking and studying. There are three options for the chair. First bed as chair, second, folding chair mounted on the wall and the third is free move folding chair.

Bed as chair
It’s quite a fixed position, and it takes a lot of space in the daily life. So bed as a chair is not a proper choice for making the maximum use of the space.

Folding chair mounted on the wall
This kind of chair saves space a lot. When it’s not needed, the chair could be hided in the wall system and the whole space could be freed. It’s also kind of a fixed position, but since there are connection points on the wall, the chair could be changed in between several positions.

Free move folding chair
This option could be put anywhere as the user wants. When it’s not needed, it could be closed and put inside the storage space.

Choice of free move folding chair
Compared with the first two options, the bed as a chair takes too much space, the folding chair mounted on the wall have only several possible positions, but the free move folding chair could reach the maximum flexibility in the 5m² space. Its could be moved anywhere and does not take too much space for storage, it could be hided in the storage space or even hung on the wall. Also, when two rooms are combined together, the chairs’ position could also be easily changed. In this way, the interior of the combined space could be designed by the user themselves.

Fig. 4.4.4. C chair (own illu)
V. Conclusion & Discussion

How to provide a fast constructed transformable room system for asylum seeker community?
A community means different kinds of people, young and old, women or men, families and individuals. To provide a room system for asylum seeker community means to solve the most urgent problem for them, fast constructed housing, privacy, flexibility and community. It’s not only about room itself but it’s a room started system, it starts from a 5m² room and ends in various building environment. By doing a research on this system, most of the requirements could be solved and the living condition of the residents inside the AZC can be improved.

Efficiency for Construction
With the help of CNC milling technique, all the elements could be prefabricated in the factory and installed on site with a mallet. The fast flow of digital fabrication makes the gap between design and construction smaller. Thus it could be fast constructed.

Privacy for Individuals
By providing each individual each own room, everyone could have his or her own controlled space. People will not get disturbed by others. At the same time, with the transformable furniture, the user could enjoy always 5m² space for sleeping, 5 m² for eating, 5 m² for studying, chatting and so on. It’s not only 5m² any longer. The space could be used efficiently to its maximum possibilities.

Flexibility for families
With sliding wall system, the previous settled rooms could be combined and separated quite easily. In a settled 8 persons’ building block, the use of the 8 bedrooms could be changed freely according to the users’ composition, it could be shared by families, could also be filled with individuals, or used by a mix of families and individuals. With bigger building blocks, the adaptability for bigger families is better.

Affordability for government
Compared to the existing containers, Most of the material used for the building and the interior are made of wood. The materials is cheaper and could be recycled. Which could decrease the budget for construction to some extent.

Quality for all residents
With the use of multi-functional individual rooms and flexible combining systems, the original living room could be removed and combined into a bigger space, the combined communal space could be free used for various public activities. The size and shape has different variations to adapt to different activities. Thus, better space quality could be achieved within the original limited space size.

Durability for the users
Since the Bone system structure can be changed according to the needs, it’s easier for changing the space and how to use it. Which creates a durability for the building itself. The elements used for the combination and interior are mainly made by metal, which has better durability for turning up and down.

Sustainability for environment
Compared with the existing AZCs, the building system is mainly made of wood, which is quite a sustainable material itself. After the usage, the building elements could be recycled and used again. Thus, it’s a sustainable solution for the environment.
Conclusion:
As listed above, the system could meet the requirements settled at the beginning of the paper. It’s a system with different levels of transformability and adaptability. It could fulfill the needs of the residents in the AZCs.
With the new system, it could be built in undeveloped land, vacant factories, or even make extensions for existing AZCs. To some extent, the system could be used around Europe, to solve the shortage of housing for asylum seekers. It is quite a flexible system to be manufactured, mass customized and installed.

Limits and Recommendations
In this research, the transformable room system is divided into design and construction parts. Within the design part, the proposals for the left over space is quite a general try out, more research need to be done by analyzing the daily behavior and activities of the residents inside the centers. Also, the cost for the construction may also could be researched to support the idea of affordability.
For the technical part, most of the research is done by comparing the principles and existing products. But there is a lack of real model test in the technical part. All the research is still purely theoretical, more practical 1:1 model test needs to be done in the future development. Also, the future proposal for the center after the decreasing of the asylum seekers could also be discussed.
VI. APPENDIX

6.1 Mapping of the refugee crisis

6.1.1 Europe

![Map of Europe showing asylum claims](image)

**Figure 6.1.1.A Asylum Claims in Europe 2015**

**Figure 6.1.1.B Asylum Claims in Europe January-October 2015**

Source: Eurostat

Source: BBC (2015)
6.1.2 Netherlands

Figure 6.1.2.A Reception Centers in Netherlands

Figure 6.1.2.B Occupancy reception centers from 1995 to 2015

<table>
<thead>
<tr>
<th>Year</th>
<th>Occupancy</th>
</tr>
</thead>
<tbody>
<tr>
<td>1995</td>
<td>30,166</td>
</tr>
<tr>
<td>1996</td>
<td>29,680</td>
</tr>
<tr>
<td>1997</td>
<td>37,720</td>
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<td>54,070</td>
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<td>64,771</td>
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<td>87,705</td>
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<td>2011</td>
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<tr>
<td>2012</td>
<td>24,029</td>
</tr>
<tr>
<td>2013</td>
<td>42,988</td>
</tr>
</tbody>
</table>

source: COA (2015)
6.2 Mapping of the existing AZCs

6.2.1 site visit

The AZC in Heerlen is a very good one with advanced infrastructure. It’s composed of two parts, the old monastery building which transformed into a center now and the newly built containers. Inside this center, there are 400 residents now and it will be enlarged to 700 in the coming future.
The old building was built in 1836, used by Monastery and it changed into an AZC in 1994. Until now, the building is used as asylum seeker center. In 2015, the new containers were built to fulfil the need of exploding refugees.
Shared communal space (own ill.)

50 people Shared kitchen

Entertaining room (cafeteria included)

Computer room

Video-game room (for teenagers)

Newly built kindergarten (own ill.)

Separate building block, specially for children under 7
Bedroom space (own ill.)

Two persons’ room in the old
- A tank, a TV and two beds

Two persons’ room in the new
- A table, two chairs and two beds
Interview of the officer from the AZC in Heerlen

officer: Diana Wassen: Programme Supervisor of the AZC in Heerlen
(Q stands for question, D stands for Diana)

Q: Could you give us a brief introduction of the AZC in Heerlen?
D: Our center has 412 existing residents, and it supposed to hold 700 person in total in the future. Most of them come from Syria and Eritrea. The residents here have three identities, people who get a positive permission for the refugee status, people who get a negative answer and waiting to be sent back, and the third is people who just come and waiting in the application procedure.

Now we have recreational room, medical service, playing room for children. But as the building company is working outside the yard, there will be two extra building for refugees and the medical service, the storage and the organization for the procedure will also be moved to the new building.

There are also some external organizations active within this centre. For example Vluchtelingenwerk. This is an independent organization which helps refugees with their procedure. They provide information about the procedures and they provide counseling.

Also, we have a really good kinder garden which just became an official kinder garden (also independent from the COA) recently (September 2015). Actually it’s one of places where you could forget that you are in an AZC.

Q: How long do they stay here?
One month to a year. It really depends.

Q: Are these residents free to go outside?
D: Yes, they are allowed to go anywhere they want, but every Thursday morning they need to come back for a stamp check. Some of them could find a house outside the center, maybe a friend’s house, and the center will pay for the transportation fee.

Q: Is there any solution to help them to gain a new life?
D: We have volunteers who teach them Dutch language lessons, also, there is an organization called ROM to help them with different opportunities to work. They can work 23 hours week??If they can find a working contract, and 80% of the money will be taken by the center to pay the fee of the housing.

Q: Can the residents work to earn some money? How much can they earn?
D: Yes, we have a certain system for the residents to work. They can find a job inside the center, they can apply to be a host of a certain public area, to be a cleaner or become a technical worker after training. They can get around 11.30 euro each week. There are also examiners who check if the residents are doing their work properly, if not, they will be kicked out and another one will get the job instead of them. The competition is always fierce.

Q: What’s the main problem of the center now?
More housing are needed, and the houses are always not suitable for families. It’s difficult to arrange everybody into a proper room according to the different country, religion, culture background.

Q: How big is the family normally?
D: 4-5 children and their parents, we have got a family with 8 children before. Also, there
are a lot of individuals and sometimes just a couple.

Q: What’s the proportion of the children among all the residents?
It changes all the time, we do not really have a number, it fluctuates all the time.

Interview of two Syrian residents from the AZC in Heerlen

two individual men (A & B) come from the same 8 person unit, they shared one bedroom
A, B: both been in the center for 4 months, met each other in Amsterdam.
(Q stands for question, A, B stand for the two residents)

Q: Where are you come from?
A: Syria, Aleppo
B: Also Syria, Homs

Q: Do you like the center here?
A: Yeah, they are really helping us and providing us a safe home.
B: If I’m not here, I will be forced to fight in the war now.

Q: What’s the biggest problem of the housing?
A: The housing are good, but I really need more privacy. Though B and I are from the same country and have a lot in common, but we still have our own living hobbies, for example, if I sleep at 10 but maybe B like to listen to some music and watch some TV, then there will be noise for me.
B: Yeah, it’s better if we could have our personal rooms. So that I can have my own place to do something without disturbed.
A: And also the living room is not good, because C (another guy in the 8 person unit) always enjoys his hubble-bubble, the smell really make me sick, I want to change a room because of this.

Q: Do you have some religious problems in Netherlands?
A: I think Dutch people is really open to different religions, it allows every religion here. As you know, we come from different places and have different religions which is totally different from the religions here, We Syrian people always lack of regulations, what controls the society is only religion, which is bad.
B: The people always discuss their religion quietly. Which is bad. We came here, we are even and different religions should be treated differently.
Diana: We allow them to decorate their own room as their religion, but no religion parties are allowed here.

Q: What’s your plan for the future?
A: I might move to a friend’s house in Maastricht, maybe this weekend.
B: I’m also waiting for a housing nearby which should be assigned by COA.
6.2.3 plan analysis of several AZCs

**case I**

configuration and analysis (own ill.)

standart unit plan (own ill.)

**case II**

standart unit plan (own ill.)

configuration and Analysis
Case I: 8 persons are living inside a three-floor unit. On the ground floor, there are main living room and kitchen which is shared by all. On the first and second floor, most of the space is used as bedrooms except some circulation space. The bedrooms are mainly two-person rooms and individual rooms. The two-person rooms are around 10 m², and the individual rooms are 5.33 m² each.

Case II: 12 persons are living inside a two-floor unit. Each floor has one living room, and 12 persons are sharing one kitchen which is 16 m², the two-person rooms are 10 m², and the individual room is 5.3 m².

Case III: 7 persons are united on one floor. The main bedroom type is a four-person room and 3 individual rooms. The four-person room is 20 m², and the individual rooms are 5.3 m² each.
case IV

configuration and analysis (own ill.)

standart unit plan (Koff.A 2015, p 52)

configuration and analysis (own ill.)

case V

configuration and analysis (own ill.)
Case IV
7 person are sharing one unit, in this unit they have one bathroom, and on the whole floor, 52 people are sharing one kitchen together.

Case V
This is the case in Heerlen, 8 person are sharing one unit with a kitchen, a living room, a toilet and a showerroom.

Case Vi,
This is an old building which changed into AZC, thus, the room distribution is not that clear. They have 3 persons rooms and two persons rooms and individual rooms, there are big sharing living room and kitchen. which is quite unusual.

According to these 6 cases, the basic size for one person is 5m² bedroom and mostly two person would share a 10 m² bedroom. The living room and kitchen are always shared by all the residents.
6.3 CONSTRUCTION

6.3.1 structure system

*the instant house*

![Diagram of the instant house structure system]

**major element**
- Studs
- Dado (tab)
- Slots for brace

**minor element**
- Embedded dado
- Corner
- Angle corners

Wikihouse: Sequence of Assembly
Bone System

Click System

fixed moment

System of Assembly
Variations from the Bone system

source: Meeder. D, 2015, p 14
6.3.2 Sliding Wall System

different ways of sound transmission

In performing measurements between two rooms, the sound reduction value “R” derived from the sound level differential “D” (difference between source noise in transmission room L1 and sound level receiving room L2), the absorption area “A” of the receiving room and the test area “S” of the construction element.

\[ R = L_1 - L_2 + 10\log \left( \frac{S}{A} \right) \text{ dB} \]

source: Sound decisions with respect to insulating operable partitions.
6.3.3 Furniture System

Bed

Murphy Bed

A Murphy bed, also known as a wall bed, folding bed or hide-a-bed, is a functional furniture piece that can transform any room into a bedroom instantly. These beds utilize vertical space to store and display a bed without the obvious intrusion into valuable room space. They are the perfect addition to any room that doubles as the guest room, or for smaller bedrooms that have limited floor space. Murphy beds are lowered from their vertical position when in use, and can be lifted back into the vertical position in one quick movement, creating the ease of utilizing one room for multiple purposes.

Mechanism

The mechanism in a Murphy bed is the most basic element of its construction, as the mechanism dictates nearly all of the facets type. There are two main varieties of wall beds mechanisms, spring mechanisms and piston mechanisms. The key of both mechanisms are using the spring or piston to provide a thrust for the users when pulling the bed down or pushing the bed up.

Folding bed

with the folding mechanis, the bed could be easily turned into a small sofa.
**table**

The basic idea of a folding table is to hide the surface and structure when not wanted. The existing products on the market mostly are using the hinges to realize the hiding posture. The price for a stainless hinge is quite cheap, varies from 0.3-1 euro. Which is quite cheap.

**chair**

source: Alibaba, price for hinges
Tiny House Gear. 2015
Bless this stuff. 2015
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