UPGRADING A SHACK BY USING THE POTENTIAL OF WASTE MATERIALS

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ABSTRACT

South Africa is well known for its townships and informal settlement. With their residents having little to no income and with formal houses being too expensive, they are dependent on themselves for providing housing. The shacks found in the settlement are made by the residents and can be recognized by the use of different materials. The construction method shows technical faults and leaves space for improvement. Solutions have to be sought in affordable materials, making waste a good contestant. Statistics show the general waste currently generated in the country. This research focuses on the potential of waste in the improvement of shacks. Case-studies and personally carried out experiments support this research. Experiments pointed out that the material paper showed the most potential in improving the shack on the level of human comfort, by using it as an insulation.

KEYWORDS: *Settlement, South Africa, insulation, human comfort, waste, recycling*

I. INTRODUCTION

South Africa knows a lot of inhabitants migrating from the rural area to the urban area, in pursuit of a job and a better life. The first stop for a lot of these people are the informal settlements. With less to no money they try to build their own house. The houses in the informal settlements are called shacks, and are made from materials found or cheaply bought. The living conditions are harsh, and leaves lots of space for improvement.

By visiting one of these settlements in Johannesburg, called Zandspruit, I came face to face with the housing problem of these residents. And even though the conditions seemed harsh and rough, there was a strong sense of community. This made me want to focus on helping the residents, empower them by showing solutions to improve their living conditions in an easily manageable way that would be feasible. The realization of the already existing market and economy of contractors and construction workers made me decide to intervene less in this area. Instead of providing an entirely new building method, trying to help them improve and come up with solutions to existing problems will be more beneficial in the long run. This way the local economy will stay the same and my knowledge could be transferred to the community.

A lot of problems could be appointed within the local construction method, but the most important for me is the lack of focus on the human comfort inside the shack. As most residents build their house themselves with little to no money, comfort is not their first priority. For the improvement of the shack I therefore decided to do research on materials readily available, which resulted in the following research question:

What is the potential of waste materials in the role of upgrading a shack in a settlement?

This question will be answered by the use of the research by design methodology. The criteria for the improvements, like formulated before, is that it has to be easily manageable for the residents. This means using materials they can get without spending their income on it and

using tools they have already available. Working with the context given and reason from their point of view. Information will be collected from literary research and by corresponding with my contact in Johannesburg that works in the settlement. With the collected information the design or experimentation phase can start. This part mainly tests the feasibility of the improvements. To find out the needed materials and tools, and if the production process is easy and understandable.

II. WHY DO PEOPLE LIVE IN SHACKS?

The reason why people live in shacks can be found by looking into their income and the current construction economy. Both topics will be briefly discussed in this chapter.

2.1. Income and housing expenditure

Most residents of informal settlements fall within the LSM 1-3 income profile or lower. This profile indicates a monthly income of R.2114 (€ 133) (City of Johannesburg, n.d., p.38). Statistics show that around 19% of their income is spend on housing (Stats SA, 2017, p. 31). Taking this 19% over the income gives a monthly expenditure of R.402 (€25). But there is also a group that is not mentioned in this LSM profile, namely the population that has no income or an income between R.2 and R.8560 annually. A lot of the people living in these settlements are looking for a job, they most likely belong to this last mentioned group.

2.2. Costs of building a shack

The housing in informal settlements can be divided into two categories: the self-build and the prefab. The prefab shacks are being sold, according to a contractor, for R.2800 (€ 170) for a one-room shack and R.5500 (€ 334). for a two-room shack (Gontsana and Xi, 2014). This would take a resident from the lowest income profile 7 months of saving their housing expenditure. In reality this will take much longer, as this money already has an allocation. For the population in the no or lower income group, their budget might never come close to this.

The other category is the self-build shack. The most common building materials, wood and CGI sheets, might be seen as not expensive. But for the residents without an income will most likely be still out of reach. This makes them reach out to other resources. The next chapter discusses the local building materials, the materials used and the flaws that come with it.

III. THE LOCAL WAY OF BUILDING A SHACK

To point out the exact needs of improvement, the current building method in the settlement needs to be understood. First of all the used building materials will be named, after which the two building methods as mentioned in the previous chapter will be discussed. By analyzing these topics the exact technical flaws are being exposed, which is necessary in the process of finding ways of upgrading the shacks with waste materials.

3.1. Building materials

By analyzing photos and information found of and about settlements, a list can be created of materials that are used for the shacks. A division in materials can be made in relation with the building method (figure 1).

Figure 1: Shacks with different building materials in Zandspruit, Johannesburg. First one is prefab, the other two self-build (google maps, 2014)

The prefab shacks all consist out of wood and CGI sheets. Because of their equal size and their clean appearance, it can be said these are bought at a hardware store or builders warehouse. The self-build shacks show a big variety of materials. Wood and CGI sheets are still the main materials, but appear in all sizes and conditions. The materials that are also used to build with are: bricks, tarpaulin, plywood, cardboard, plastic, newspapers and tires. No structure can be recognized in the use of each material and all are differently sized and shaped, giving an indication of the position the residents are in.

This position can be better explained by looking into the origin of the building materials. The most common building material is the corrugated iron sheet. This material dominates the roofing market, and because of its low entry barrier can be produced relatively easy (cidb, n.d., p.19), causing it to be widely available. A division in state and quality of the CGI sheets can be found in the settlement. New, shiny and same sized sheets indicate the material being bought, whilst the more corroded and irregular sized sheets indicate them being second hand or found by the resident. Looking into materials like timber and brick, it is more difficult to conclude where these come from. They can be bought, but a deeper analysis of the waste streams in South Africa show that the construction and demolition industry produces a lot of waste (Department of Environmental Affairs, 2018, p.23), creating space for the residents to collect the materials like timber and brick. The analysis of the waste streams will be further discussed in the next chapter.

3.2. Building method

In the informal settlement Zandspruit, but probably in every settlement in South Africa, a local economy based on the building of shacks is present. Analyzing these small businesses gives a clear image of the local building method. As mentioned before, two building methods could be distinguished. The first method is the purchase of a prefab shack made by a local contractor. These shacks are made out of a main construction of wood, with CGI sheets attached to it as walls and roof (Gontsana and Xi, 2014). Each wall is constructed as a panel, after which all four panels are attached to each other creating the shack.

The second method is construction of a shack by the resident itself. These houses are characterized by the use of all different types of materials. Via personal communication I received a series of photos taken from a self construction project. The most important findings are listed below, the documentation of this project can be found in appendix 1.

Most important findings:
1. Only basic hand tools are being used, photos show usage of shovel, hammer, saw, nails
2. There is a large variety of building materials
3. The main structure is made out of timber, with beams that were made out of multiple pieces

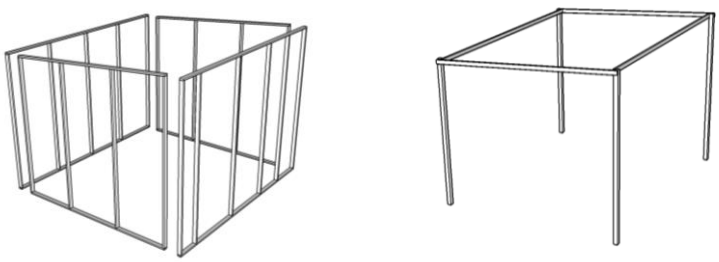

Figure 2: The two building methods compared. Left the prefab load-bearing construction and on the right the self-build load-bearing construction (Own image)

Viewing these finding in the larger scale of self construction of a shack, there can be concluded that all different types of materials are being placed together in order to create a house to the best ability. Even if this means the main structure can't consist out of one piece. And due to lack of both money and electricity, only the simplest of tools can be used for construction.

3.3. Technical flaws

After analyzing the local building methods, the conclusion can be drawn that it is very basic and leaves lots of room for improvement. The technical flaws that can be pointed out and for which solutions can be found, can be categorized into three main groups: construction, safety and human comfort. Construction in the sense of attachment of the roof to the main construction, as tires and other materials are placed on the roof to prevent it from flying off during a storm. Safety in the sense of usage of flammable materials to build the shack. In the category of human comfort multiple flaws can be pointed out, namely: lack of insulation, draughts due to bad connections between materials, leakage after heavy rain. These all can cause health issues.

IV. THE CURRENT WASTE SITUATION IN SOUTH AFRICA

Statistics from the national Department of Environmental Affairs (DEA, 2018, p.2) show that South Africa generated 108 million tonnes of waste material (59 million tonnes general waste, 48 million tonnes unclassified waste, 1 million tonnes of hazardous waste), of which only 10% was recycled or reused and the remaining waste ending up in a landfill. The DEA also made an estimation for 2016, where the total amount of waste was 3 million tonnes higher, but 25% would be recycled. But it should be noted that South Africa doesn't have a mature waste information system, and data collection and reporting isn't the best, making the presentation of real figures a difficult job.

Figure 3 shows an overview of the types of general waste generated in 2017. As can be seen metal waste, construction and demolition waste, and paper waste form the top three. The figure doesn't show the waste generation in each province, but with Gauteng having the highest population density (Department of Environmental Affairs, 2018, p.8), a big proportion of the generated waste as shown in the figure will be found in this province.

General waste overview

Table 5: Tonnages of general waste imported and exported in 2017 (in tonnes)

Waste type		Waste Generated	Imports	Exports	Total
GW01	General waste	1 770 009	2	4	1 770 009
GW10	Commercial and industrial	3 179 157			3 179 157
GW13	Brine				-
GW14	Fly ash and dust				-
GW15	Bottom ash				-
GW16	Slag				-
GW 17	Mineral waste				-
GW 18	WEEE				-
GW 20	Organic waste	1 166 731	4 048	298	6 656 234
GW 21	Sewage sludge				
GW30	Construction and demolition	2 172 319			5 360 556
GW50	Paper	3 571 632	58 548	129 375	3 635 825
GW51	Plastic	787 924	6 988	34 794	2 247 323
GW52	Glass	176 829	39 928	11	1 395 103
GW53	Metals	4 160 641	27 976	68 192	3 345 565
GW54	Tyres	165 763			221 751
GW99	Other	684 737		1 003	14 868 997
	Total general waste (t)	25 287 037	137 490	258 557	42 680 520

Figure 3: Overview of general waste in South Africa (Department of Environmental Affairs, 2018, p.23)

As said before, a large percentage of the generated waste ends up in landfill sites. Landfill sites are described as places for waste disposal by burial (Cambridge Dictionary, n.d.). Looking at the numbers, South Africa counts a total of 111 licensed treatment facilities, of which 26 are located in Gauteng. But Gauteng also knows at least 142 treatment and disposal sites, of which the majority are dumping or uncertified landfill sites (Department of Environmental Affairs, 2018, p.31). These statistics show that there are a lot of sites allocated for waste, and that most of them

don't consider the environmental impact. But the situation gets worse. With a growing population, a growing pile of waste and most landfill sites reaching their limits, the system to handle waste needs to change fast (Lindeque, 2018).

V. RESEARCH BY DESIGN

The investigation into the reason why people live in shacks and the local building method, in relation with the current waste situation in South Africa, sets a strong base for further research. Namely that this research should be focused on which materials show the highest potential to be easily managed and formed into an improvement for the shacks.

The usage of waste materials for the upgrading process could somewhat help the before mentioned waste problem in Gauteng. But more important, it will make adjusting the house affordable for the residents. At least two landfill sites are located within a 30 km distance of Zandspruit, where waste can be collected and brought back to be reused. But the waste generated in the settlement itself could also be used in the upgrading process.

5.1. Materials and their characteristics

The local building method, together with the list of generated general waste, helped me to make a decision about which material to research the potential of. These materials are: cardboard, plastic (bottles), paper and tires. To figure out the potential of the materials, their characteristic are mentioned in the table below. Strengths and weaknesses of each material are given, concluded by a mention of application or a conclusion.

Table 1: Material characteristics

	Strengths	**Weaknesses**	**Application / conclusion**
Cardboard	- Easy to work with - Available in large quantity	- Not waterproof - Different kinds and sizes - When wet or dirty not usable - Not fire resistant	- Application inside - Can be made waterproof and fire resistant by using additives
Plastic	- Easy to work with - Available in large quantity - Most products waterproof	- Needs cleaning before processing - Different kinds and sizes - Not fire resistant	- Application inside and outside - Can be made fire resistant/ fire retardant
Paper	- Easy to work with - Available in large quantity	- Not waterproof - Not fire resistant	- Application inside - Can be made waterproof and fire resistant by using additives
Tires	- Available in reasonable quantity - Water resistant	- Difficult to work with	- Application inside and outside

Most materials show the same characteristics, the weakness of being vulnerable to water being the biggest problem. This means they can only be applied inside or they have to be treated with a water repellent additive. The characteristics set the boundaries for what the focus of the design part of this research will be: human comfort. Improvement of the human comfort can for a big part be done from within the house, making it possible to use most of the materials mentioned before.

5.2. Case-studies and own experiments

The research into the before mentioned materials and their potential for shack improvement is divided into two different parts. Analyzing case-studies and carrying out own experiments. Focusing on what materials are used or could be used plays an important role in both cases. The analysis of the case-studies focuses on the feasibility of the project as well, and how many times it has been applied in a low income settlement. My own experiments focus more on the availability of waste materials in everyday life, as well as how easy it is and how long it takes to produce an improvement.

5.3. Inspiration sheets

The findings of both the experiments and the case-studies are bundled together in A4 sheets. These sheets are called 'Inspiration sheets' as they are meant to be handed over to the community to stimulate their creativity. It could be seen as a way of empowering the residents, to take initiative themselves to improve their house instead of waiting for outside help. They can decide to follow the steps explained on the sheets, or see it as inspiration and create something of their own.

To decide which projects should be portrayed on the inspiration sheets, I developed a selection procedure which can be found in table 2. Each project gets assigned a certain category per subject, as is explain in the table.

Table 2: Overview of subjects and categories

Subject/ Category	**1**	**2**	**3**
Tools	Hand tools	Small electric tools*	Big machinery
Materials collected	Zandspruit	Landfill / recycling	Hardware store/Shop
Additives	None	Natural **	Chemical / From hardware store
Time frame	Couple of hours	Whole day	Multiple days
Additional materials	None	One	Multiple

* Blender, paper shredder, drill machine
** Water, sugar, flower...

The projects suitable for the sheets should be easily manageable from the current position of the residents, as they are meant to empower them. So they should be able to create these products by following the sheets and without any further help. Therefore it is important to compare the before mentioned subjects and categories to the situation of the residents. Per subject there will be discussed what is manageable in the settlement and what isn't.

Tools: Hand tools are available. Because of lack of electricity and money the use of small electric tools shouldn't be counted on. Big machinery is not manageable.

Materials collected: All categories can be applied, but due to low income not feasible at all times. If the landfill site is too far away, travel costs might need to be paid. Materials from the store are quickly seen as too expensive.

Additives: All categories can be applied, but due to the low income in the settlement, going to the shop to buy additives is not desired.

Time frame: As the unemployment rate is high in South Africa, especially in the settlements, the money is a bigger problem than time. All categories in the subject time frame shouldn't be a problem.

Additional materials: All the categories can be applied for this subject, but there should be taken into account that the added materials should preferably also be waste materials and should not be bought.

A similar table will appear on the inspiration sheets. This way the residents have a quick overview of what to expect from the project and if it is manageable from their point of view.

5.4. Further research

After carrying out the first set of experiments and looking deeper into case-studies, I decided to do some further research into the use of paper as an insulation.

During the first set of experiments, shredded paper was soaked in water. This was made into paper pulp by using a blender and sieve, after which it was left to dry in the sun (see appendix 2). The end result of the experiment, the paper chunks, showed enough potential to decide to further research the processing. For the second round of experiments the wet paper pulp was pressed on moulds by hand (see appendix 3). This turned out to be managed very easily and a lot of variations were possible. During most of the experiments I used a blender and sieve, but shredding the soaked paper by hand and squeezing the water out works just as well.

Figure 4: The paper 'brick' filled with shredded paper
Figure 5: Variety of the end material (own image)

Figure 4 shows the last product of the experiment, a paper 'brick' that can be filled with insulation. As can be seen in figure 5, the final material can be used in different variations, and focuses mainly on the improvement of human comfort. The biggest downside of this type of insulation is the vulnerability to water, so to apply it, it has to be incorporated into the current building method in a smart way.

For applying the insulation on the roof, two constructions are possible. Figure 6 shows the placement of the insulation on top of the current CGI sheets. A tarpaulin is placed over the insulation as a water protector. Figure 7 shows a new construction. Instead of the CGI sheet being the main construction, new beams are placed to take over this role, and the CGI sheets are placed as a roof to make it watertight.

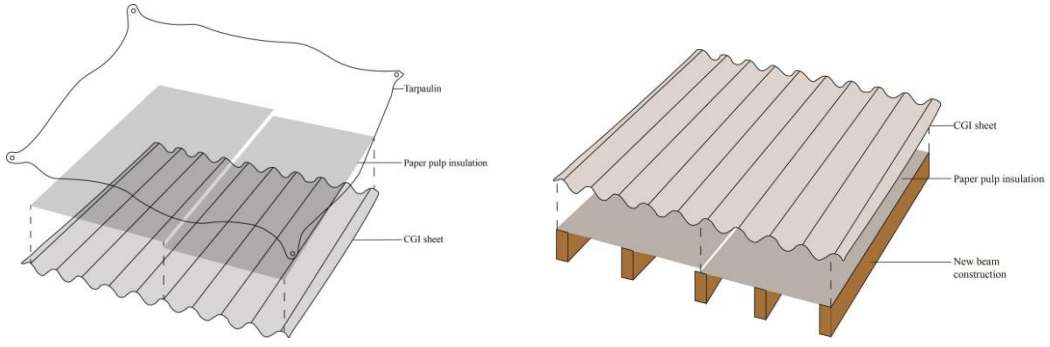

Figure 6: Placement of the insulation on the current construction (own image)

Figure 7: Placement of the insulation with a new construction method (own image)

Besides the roof, the insulation could also be placed alongside the walls. The placement should be indoors and many variations are possible. Most of these variations can be seen in figure 5, and their application can be seen in figures 8, 9 and 10. The application that is not displayed in a figure, is the use of water paper pulp as mortar or grout to fill up gaps in the construction.

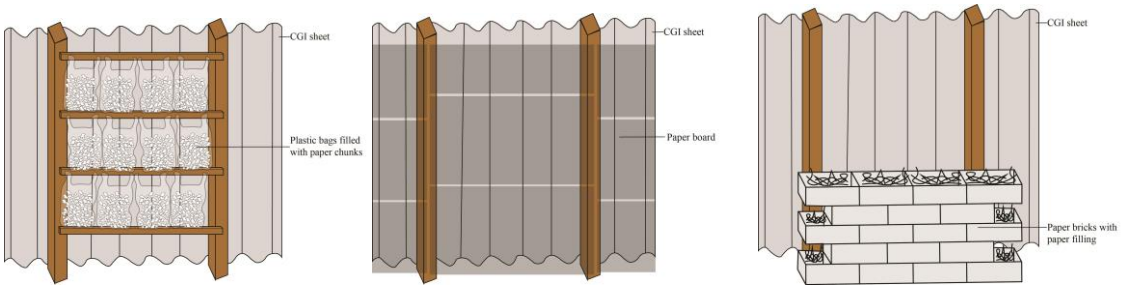

Figure 8: Paper chunks in plastic bags (or panels) attached to the walls (own image)
Figure 9: Paper boards placed alongside the walls (own image)
Figure 10: Paper 'bricks' filled with shredded paper and placed as a brick wall construction (own image)

VI. CONCLUSIONS

This research was focused on finding out what the potential is of waste materials in the process of upgrading a shack in a settlement. As in the current situation only a small percentage of waste generated in South Africa is being recycled, this leaves open a big opportunity for upcycling these materials.

Looking back at the analysis of case-studies and the experiments, paper shows to be the material with the highest potential for upgrading a shack in terms of human comfort. The overview of types of waste generated shows paper to be one of the largest, so there should be enough opportunities for the residents to get access to this material and to produce their insulation. This process can be performed by using only water, paper and a mold. Making it low-key and easily manageable for the residents. Water usage and the water scarcity situation in South Africa could be mentioned as a problem. But the water is only used for soaking of the paper and can be reused, so not much would be used for making big quantities of paper pulp.

Although the material shows a lot of potential and insulation is easy to produce, it does show some aspects that need further researching. The material isn't waterproof, so thus far it could only be used indoors. Research could be done into ways of treating the material to be waterproof without spending much money or preferably, any at all. But for now, the easy process and the abundance of paper waste makes it easy to replace an element that is damaged by water. Fire safety is the second aspect and should be researched according to the same goal. The current building method doesn't focus on fire safety and creates a shack with risk to burn down. Adding paper to the construction won't increase the risk that much. Besides, residents are aware of the living conditions and could decide for themselves of how much their indoor comfort is worth the risk.
The last aspect is the production process. During the experiments I used objects to put the paper pulp on, but the potential of a pressing mold hasn't been researched yet. This could increase the variations of how to use the material even more, might speed up the production process and increase the strength by compressing the pulp. To find out how well the material performs as insulation, the R-value should be measured by an expert.

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APPENDIX 1

The photos below show the process of building a shack in the settlement Zandspruit by oneself. The huge variety of materials and their sizes, show they are collected and maybe some are bought. But there is no regularity in it, which shows in the creation of main load bearing beams that consist out of multiple parts. The tools they used are all hand tools and very basic.

These photos are taken by my contact in Johannesburg at the end of March 2019.








APPENDIX 2

The experiments shown in this appendix are the first trials. Here I experimented with different materials to find out which showed the most potential. Each experiment will be discussed in terms of name, date, materials used, tools, goal, photos, result and findings.

2.1 Paper shreds

Name: Paper shreds

Date: 24-04-2019

Materials: Paper

Tools: Paper shredder

Goal: To create an airy material that can be used as insulation, used as a filling in a panel or bag.

Step 1: I Collected paper waste, and shredder by using a paper shredder

Step 2: Bag full of paper shreds as a result

Result and findings: The endresult is a big pile of paper shreds, which was fast and easy to make. If this was to be made in the settlement, the only problem might be the use of electricity to use a paper shredder. But, although it might be time consuming, the shreds could also be made by using a scissor or ripping it by hand. For the use of insulation it could be placed in a plastic bag and placed onto the wall.

2.2 Insulation panel

Name: Insulation panel

Date: 30-04-2019

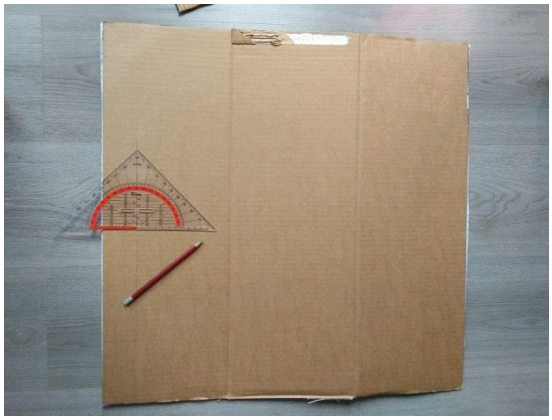
Materials: Cardboard, tape and paper shreds (from the first experiment)

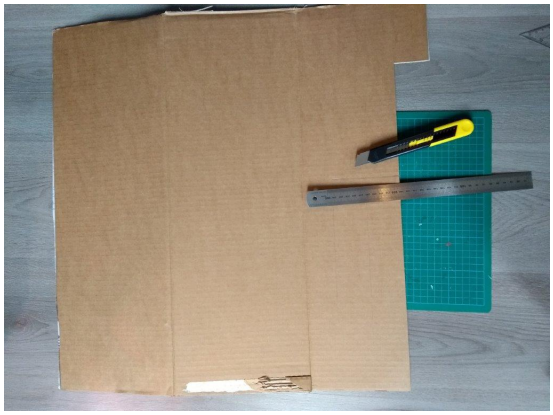
Tools: Stanley knife, ruler, pencil

Goal: To create a simple panel which can be filled with an insulating material. By creating openings, the panel can be filled/emptied/refilled at any moment.

Step 1: I took one single piece of cardboard to use as the main construction

Step 2: I had one cardboard box that could be cut into pieces





Step 3: I measured the box and drew the right measurments for the construction of the panel

Step 4: After drawing, I cut the cardboard into the right pieces

Step 5: I mounted the sidepanels onto the main board with the help of tape

Step 6: After mounting the rest of the cardboard onto the main booard, the panel was finished

Step 7: The openings can be filled with different types of materials, in this case I chose to use the paper shreds I made before

Step 8: After a few hours the tape failed and the panel fell apart

Result and findings: The first conclusion is that tape is not strong enough to withstand pressure for a long period of time. But these panels could of course also be put together with a different material. The openings in the panel make it possible to easily access the insulating material and replace it when needed. It also doesn't necessarily has to be paper shreds, but can be filled with a different material that has the same qualities. The structure of the panel doesn't seem strong enough to build entire inner walls without falling apart.

2.3 Insulation building block

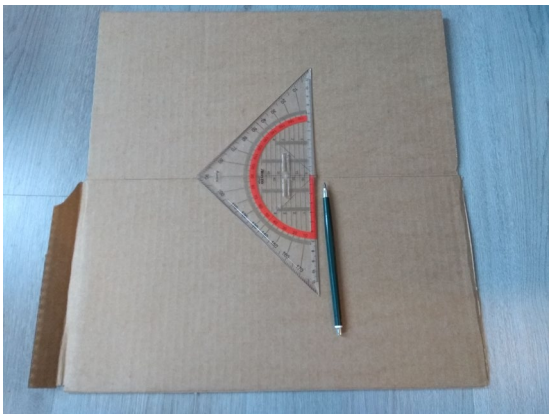
Name: Insulation building block

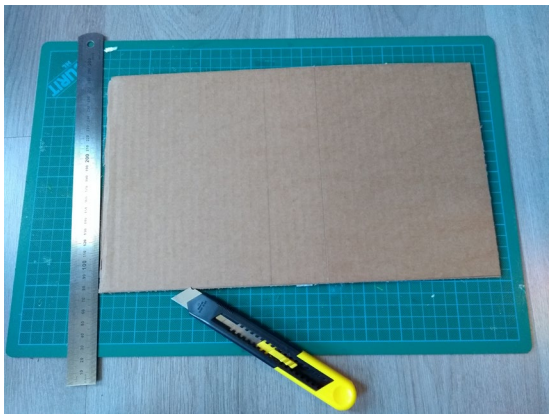
Date: 30-04-2019

Materials: Cardboard and paper shreds (from the first experiment)

Tools: Stanley knife, ruler, tape

Goal: To create a building block that can be easily handled and fabricated, and which can be filled with an insulating material.





Step 1: The right measurements are drawn on the cardboard

Step 2: Cut out the panels by using a ruler and knife

Step 3: The different cardboard pieces are ready and can be attached to one another by help of nails. Also tape or glue could be used

Step 4: The cardboard panel is ready and can be filled

Step 5: Here I filled the panel with paper shreds from the first experiment, but also plastic or a different material could be used as filling

Step 6: Multiple panels can create an inner wall that functions as insulation

Result and findings: The panels were relatively easy to make. These panels have the advantage that also smaller pieces of cardboard can be used. In comparison with the other created panel, this one can't be refilled when placed on top of each other. The construction of a wall might lead to instability issues.

2.4 Insulation paper pulp

Name: Insulation paper pulp

Date: 07-05-2019 & 08-05-2019

Materials: Paper and water

Tools: Paper shredder, bowl, blender, measuring cup, scissor

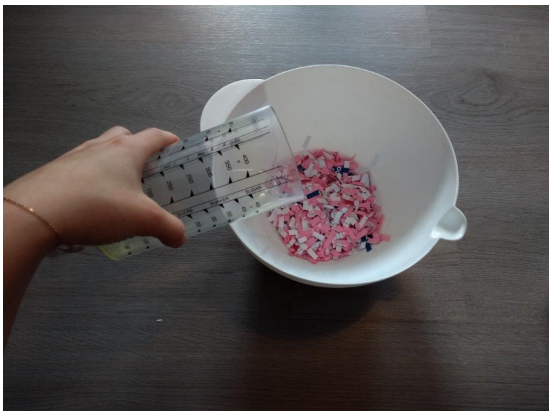
Goal: To create an airy material that can be used as insulation, used as a filling in a panel or bag.

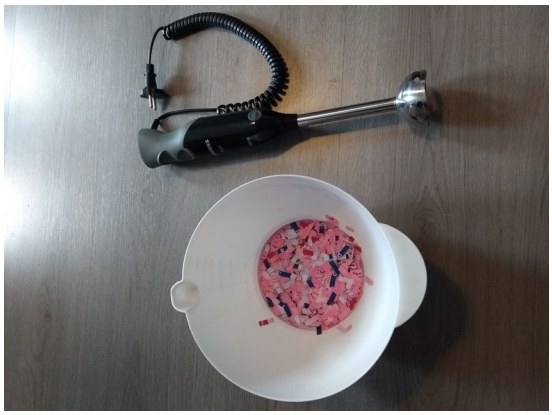
Step 1: Shredding 2 A4 papers by using a paper shredder

Step 2: Having a pile of paper shreds

Step 3: Cutting the paper strips smaller with a scissors

Step 4: Get a bowl and measuring cup with water ready





Step 5: Adding 200ml of water to the paper shreds

Step 6: By using a blender the paper shreds are made even smaller

Step 7: Adding 200ml of water to the paper shreds

Step 8: By using a blender the paper shreds are made even smaller

Step 9: Adding 200ml of water to the paper shreds

Step 10: By using a blender the paper shreds are made even smaller

Result and findings: The paper pulp was easy to make, but took a day to dry. The downside of this process was the use of a paper shredder and a blender, which could lead to a problem in the settlement if there is no excess to electricity. But the pulp could alsobe made by hand, but is more time consuming. The end result is a light material that could be used as filling of a panel.

2.4 Plastic bottles panel

Name: Plastic bottles panel

Date: 07-05-2019

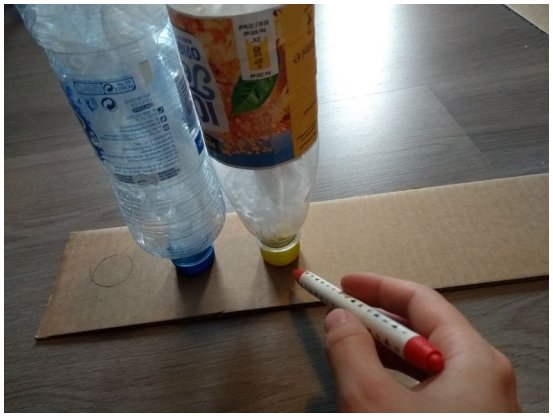
Materials: Cardboard, plastic, plastic bottles, tape

Tools: Stanley knife, pencil

Goal: To create a panel that could be used on the inside as insulation

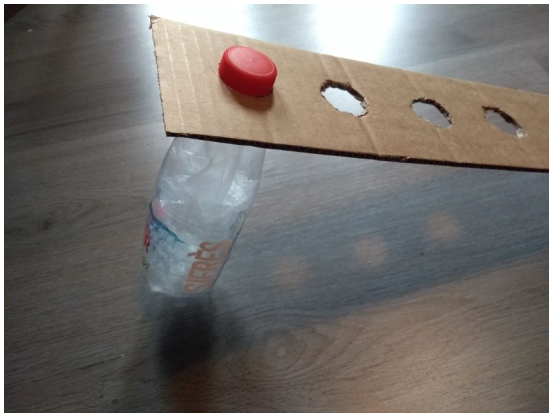
Step 1: Collect all materials and tools needed

Step 2: Fill each bottle with a piece of plastic. By putting only one piece inside the bottle, the air flow inside is stopped so the bottle can act as an insulator. If I were to put the whole bottle full with plastic the bottle would act as a conductor, making it meaningless for use as insulation



Step 3: The bottles are now all filled with a bit of plastic

Step 4: I drew rounds around the caps of the bottles to have the right distance for the placement



Step 5: The cirkles are cut out with a knife.

Step 6: The caps of the bottles were taken off, and the necks of the bottles placed in the openings of the cardboard. By screwing the caps back on the plastic bottles were secured.

Step 7: All plastic bottles are secured onto the cardboard.

Step 8: Making the rest of the panel by measuring and cutting the cardboard. The pieces are fixed together by tape. Instead of tape also glue or nails could be used.

Step 9: The final result.

Result and findings: The process of making a panel went really fast. The biggest downside I think is the limitation of the bottle sizes. They have to be all equal height in order to create one panel. This could make a fast procoess of creating panels slow down considerably if bottles need to be compared in order to be used together.

APPENDIX 3

The previous experiments were focused on waste in general and show a variety of materials. As the paper pulp showed a lot of potential, the experiments shown in this appendix are focused solely on the use of paper.

3.1 Paper pulp board

Name: Paper pulp board

Date: 24-05-2019

Materials: Paper, water

Tools: Oven tray, spoon, bowl, blender

Goal: To create a board that could be used on the inside as insulation

Step 1: Place the wet paper pulp on a mould, in this case I used my oven tray

Step 2: Press the paper pulp flat onto the mould. I used a spoon, but this could also be done with the hands

Step 3: Leave the tray out in a light place to dry

Step 4: The final result

Result and findings: The board is very easy to make, but took a bit of time to dry (1 day). The only downside is that I used a paper shredder and a blender, but the process of making the board could also be done completely by hand. The final result feels solid and easily handled, but is vulnerable to water damage.

3.2 Paper pulp bowl

Name: Paper pulp bowl

Date: 24-05-2019

Materials: Paper, water

Tools: Sieve, bowl, blender

Goal: To create a bowl/panel that could be used on the inside as insulation

Step 1: Place the wet paper pulp on a mould, in this case I used a sieve

Step 2: Press the paper pulp flat onto the mould. Now I used my hand, because I could press a larger surface at once, prefending the pulp from falling of the sieve

Step 3: Leave the model out in a light place to dry

Step 4: The final result

Result and findings: Just as with making the board, the bowl was easy to make and took the same amount of time to dry. The only challenge was pressing the pulp hard enough onto the sieve to not make it fall off. The downside is that I used a paper shredder and a blender, but the process of making the board could also be done completely by hand. The final result feels solid and easily handled, but is vulnerable to water damage.

3.3 Paper pulp hollow brick

Name: Paper pulp bowl

Date: 02-06-2019

Materials: Paper, water, plastic

Tools: Cake mold, bowls, blender, sieve

Goal: To create a panel that could be used on the inside as insulation

Step 1: 20 A4 papers were shredded to make this model and soaked in water for an hour

Step 2: The paper shredds were made into pulp by the use of a blender. Putting the pulp through the sieve got the unwanted water out

Step 3: I wrapped the cake mold in plastic to protect it. I pressed the paper pulp onto the form by using my hands

Step 4: After 3 days of drying the mould was ready

Step 5: The brick mold can be filled with insulating material, like the paper shreds

Step 6: To top of the mold pieces of the paper pulp board could be used.

Result and findings: The mold was easy to make, but took quite some time to dry. This was also because of the lack of sun, it might dry faster when placed in the sun in Johannesburg. With the steep sides it was difficult to cover all places with the paper pulp. In the final mold you can see some clear spots where the pulp is missing, especially on the edges and corners.

APPENDIX 4

The following pages show the inspiration sheets, which are the case-studies and own experiments combined on a sheet.

The following categories:

- Cardboard
- Paper
- Tires
- Plastic