GNG1103

Final Design Report

RAISING THE ROOF

Submitted by

[CONSTRUCTION TEAM 1]

[Chris Hamilton, 300048928]

[Steven Hoang, 300066576]

[Taylor Stephenson, 300074471]

[Orenvungi Ngullie, 300090816]

[Sarah Hayley, 300057763]

[Lawrence Carretas, 300089590]

[Zen Trozzi, 300063416]

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University of Ottawa

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Why the problem is relevant

The client has requested a design for a structure that is to be used as a shelter for victims of domestic violence in Ottawa. The design needs to be modular, cost efficient, and assembled by non-skilled labour. This report will describe the necessary design criteria for the modular home and the solutions, determined by the construction team, that satisfy the needs of needs of the structure.

Basic user requirements

The modular plans will include panels that can be carried by one or two people and easily assembled. Specifically, the panels will be two feet wide and eight feet long with the exception of the roof panels. The dimensions of the entire building can be expanded by placing panels side by side in either direction. Ideally, the structures should be easily placed in various configurations to create larger units depending on the needs of the client (group). Each structure should have an estimated lifespan of at least two years and be able to withstand Canadian winters. This life span will be achieved by using vinyl siding, asphalt shingles, vinyl flooring, and by elevating the structure from the ground.

The resources used need to be as cost efficient as possible; in other words, no unnecessary components can be included. Structural components will be the minimum size possible: 2x6's will be used for the floor, and 2x4's for the walls and the roof. Two emergency exits will also be included at a minimum: a 32" x 80" door on the front wall and a 24" x 24" window at the back wall. These two emergency exits are spread out to serve as two reliable exits in case of an emergency on either end of the home. All of the finishing materials chosen are also the most cost effective available. The modular design also allows for easy transportation, and lower carrying/occupying costs as the homes can be occupied sooner.

Using a modular design provides many benefits. The design of each panel can be modified to accommodate for different areas, each with different building codes. The modular design also allows the buildings to be placed in any terrain without the need for a foundation. The footprint of the buildings may be expanded and contracted and the modular design of the roof can be placed on any rectangular building; this reduces the time for more pre-planning phase and increases efficiencies in the assembly of the building.

The structures need to be able to accomodate young children. Electrical outlets need to be child-proof while electrical and plumbing need not to be easily accessible. A separate area will also be provided for infants, which can serve as a bedroom, as well as keep infants from wandering. Wheelchair accessibility is also an option and wheelchair ramps will be provided upon request as well as grab bars in the bathrooms and other accessibility features.

As the structures will generally house a family of four, a standard floor plan will be provided. This floor plan will be approximately 1500 square feet and will feature two bedrooms, a kitchen,

a bathroom, and an attic storage space. This floor plan will eliminate the need for decision making if a building needs to be constructed in limited time. As the structures are so versatile, the floor plan may be changed at any time.

Key aspects

Ease of Construction,
the design will be extremely cost effective and will not require skilled labour to assemble. The design is versatile and allows for changes in the client's needs as well as the building codes of different areas. These shelters will save the client time and money as opposed to building a conventional home.

1 Need Identification and Design Criteria

Problem: There is a lack of shelter space in Ottawa for women and their children.

To aid in solving this problem, a temporary housing option for one woman and any possible children is needed. This housing option should be able to accommodate the woman/family for at least one to two months. A miniature house which can be constructed and destructed easily is ideal.

This miniature house should be easily assembled by a normal resident with the inclusion of a construction manual. It should be able to withstand the different Ottawa climates throughout the year. The house should be able to be constructed on many, if not all types of land found in the Ottawa region. The house should have a pipe connection that can be hooked up to a water source and have safe electrification that can provide lighting and support different appliances. The house will be powered by solar panels laying on the roof of the house. The electricity should be able to power small appliances, as well as heat water in the home. The home should also be automated. The house must have room for a bed, suitable in size for a grown adult and teenager/child, as well as a separate bed for a baby or young infant if necessary. The house should also include room to store any personal belongings the women and/or family might bring along with them, as well as be able to store different necessities such as food. The home must also include a working washroom in which the guest can bathe, as well as a 2ftx2ft window, away from the door, as an extra emergency escape route in case of an incident.

Ideally, the home should be able to last for a couple years with little to no repairs needed. It should be built in a way that is as simple as possible to assemble or disassemble. It would be ideal to hold a hands-on training for the residents on constructing the homes and having to put them up properly, however, if this is not possible, the manual will suffice. It is ideal that the

home is built in a way that is accomodating to any residents who might have disabilities so that there are little to no restrictions on who may reside in the home. The house should have power outlets in order to plug in different appliances and personal gadgets. Ideally, room for a television and/or computer should be included. A small fridge should also be included for the residents to store their food and groceries. Since there is a possibility of children of all ages being brought to live in the house, it is ideal that the appliances are child-safe, when possible.

Due to the lack of space within the home, the insufficient energy being produced by the solar panels from the home, and the need for the home to be easily constructed and deconstructed, an oven and a dishwasher should not be included, as well as other larger appliances which consume more electricity than the home's renewable energy system will provide. When finishing the home, the floors must not be covered with carpeting, as carpeting is difficult to clean and may also trigger different allergies for some of the residents.

In conclusion, there is a great need for more housing as shelters in the region are at full capacity. The housing built should be able to accomodate a large range of women and their children, and should be a suitable and comfortable home for the residents during their temporary stay. The home should power itself, and should have running water, which can be solar heated. The home should also be able to function properly year-round in Ottawa weather, and be easily constructed and deconstructed on different types of terrain, by the average person.

Customer Need	Design Criteria
Simple to construct	Ease of construction, size of components, weight of components
Can be built to any size	Expandable, components rearrangeable
Needs to be durable	Lifespan of materials, durability, performance in cold weather
Needs to accommodate up to 1 adult and 3 kids	Floor area (ft^2), number of beds, number of rooms, appliances included, electrical and plumbing
Need a seperate area for the children	Area allotted to children's space (ft^2), safety features
Need storage space	Area allotted to storage space (ft^2), usable attic space (ft^2)
Should be aesthetically pleasing	Design that communicates both beauty and functionality
Low cost	Relatively inexpensive

Benchmarking

Specifications	Pre-fab houses (no foundation)	SIP Panels	Standard Construction
Cost	$77 - $95 / square foot	$120 - $160 / square foot	$170-$200 / square foot
Ease of Construction	Need professionals, don't need a foundation, minimal amount of on-site labour.	Need professionals, need a foundation, less on-site labour than standard construction.	Need professionals, maximum amount of on-site labour.
Durability	Needs to be adjusted due to frost heaving.	Can be damaged by high winds.	Strongest construction in comparison.

2 Conceptual Design

After comparing all of our ideas, we have decided to go with a wood design, as it is the most inexpensive. The design will be modular, and built in two foot wide panels before being shipped to the site. This method will make the assembly of the structure much easier, and will not require skilled tradesmen. The structure will also be expandable, and can be built to any size.

The final design will also include the following concepts:

- Utilize as many recycled materials as possible, such as re-use of scrap wood, siding, etc.
- Windows will face south to maximize heat in the winter.
- The roof will be a gable, to accomodate a solar panel system.
- There will be a place for a generator as a backup power supply.
- Beds will be able to fold up against the wall, in order to conserve space.

The following document describes the ideas and concepts that were suggested by each member of the construction group. The ideas will be compared and benchmarked, while the best will be included in the final project. A conceptual design will be put together using this information.

One option is to build a shelter using rammed earth walls, where sand and soil is packed tightly into thick walls, providing a cheap and effective structure. The walls can also be formed into any shape, and don't need any finishing material on the exterior walls. Another option is to use structurally insulated panels. These panels are 4' x 8' consisting of rigid foam sandwiched between two sheets of plywood. SIP panels have a high R value, and can be cut to any size. The most inexpensive option would be to frame 2' x 8' panels out of lumber and plywood. The design could be modular and expandable, so it could be built to any size.

The third option would be to use standard lumber, and build panels that can be assembled on site. This option would be the least expensive, and require the least amount of skilled labour.

The idea of having a small front porch would have been viable mainly due to many reasons involving the building of a modular home. There is lack of storage space and proper heat systems within the house and so building porches could help reduce heat loss within the house, and create useful storage space for coats and shoes, especially during the harsh Canadian winter days.

A wood stove was the least inexpensive fuel option as compared to gas, oil, pallet and coal. Wood burning stoves can be more efficient and provide much more heating power than an open fireplace.

Building rainwater catchment areas would help in the easy collection and use of water personally by the owners of the home. These are a relatively easy way to maintain water resources in a small house as these, and can significantly reduce water bills upon the families.

An option for the home is to use recycled materials specifically using recycled wood for the components. This allows the home to stay true to its carbon-free nature; functioning as a net-zero home while being made from net-zero materials. These materials are generally cheaper than newer materials as well. Overall, this is a good option for ensuring that this home will be beneficial to the environment as well as more affordable.

Another option for the home is to include a generator. A generator is an option to keep the house running electricity and hot water reliably unlike less efficient solar panels. A generator can act as a backup source of electricity should installed solar panels fail. This is beneficial for cases such as power outages.

We also want to ensure that the modular home is comfortable for everyone who lives in it; this is why it's a good idea to keep the home's aesthetics as neutral as possible. Examples include a neutral coloured interior such as interior walls, floors and furniture, as well as a neutral coloured exterior such as exterior walls, siding, door, window, roof, etc.

One option for the net zero modular home would be a closet. This is a very useful idea because a closet is a good place for storing items. A family that will be using this home will be bringing a couple suitcases which means they need a place to store their belongings. We will implement this in the final design.

Another option for the home is a home on wheels. Have you ever been in a car chase? Well here's your time to be in a home chase. Have you ever had someone run to your house and try to steal it? Well now you can run them over. In all seriousness, a home on wheels is useful incase an evacuation of the area is needed and you need to get somewhere quickly. As well, you will not need to take apart the home, you can just drive with it fully assembled. It's pretty much an RV.

One of the biggest struggles in building a small home is a lack of space. To make up for this lack of space, it would be beneficial to install different pieces of furniture, such as a dining room table and chairs which could fold into the wall (or be hung up on the wall) when not in use. The same can be done for a bed. This would allow for extra space inside the home when the different pieces of furniture are not in use.

In addition, a storage option is leaving under the bed empty. The bed would be able to be lifted easily, and underneath the bed frame would be storage for different items such as luggage, clothing, or personal belongings.

Another idea for a bed would be a bunk bed, with a desk below it. This would allow the homeowner a space to do work (or homework for children), while making good use of the vertical space.

Some of the idea that i came up with was a Flat roof. A flat roof would be beneficial in terms of surface area. Since it is not at an angle, the roof will have less space and will cost less to make. As well, it will take less effort to build the roof since it would just be a plywood on the top. This is a bad idea for a lot of reasons. The first reason is the only time you'll get direct sunlight is in the middle of the day when the sun is perpendicular to the roof. As well, during the winter, snow will get trapped on top and won't be able to get it down.

Hot water is a desirable aspect to any home, and so the gravity pressurized water heater would be a perfect implementation into our design. It uses water captured from the rainwater catching system, and fills two tanks. The first tank is larger than the second and it is placed high up near the ceiling. The second tank is placed on top of the wood stove. Water fills the higher up tank from the rain water catch. There would be a pipe coming from the bottom of the larger cold water tank that goes to the smaller tank on top of the wood stove. The force of gravity from the water in the cold water tank would pressurize the hot water tank as well as the cold water taps. Another pipe would connect the bottom of the hot water tank to the taps that need hot water.

A free means to heat the livable shed would be desirable, so a south facing window could be implemented. The floor should be able to act as a heat sink and absorb the sun's energy while it is available and free. The preferable material for the heat sink would be dark tile flooring, however cheaper alternatives are possible as well.

The thought of a food storage space in a building lacking connection to the electrical grid, would encourage anyone to do a bit of extra work for their modular home. There could be a tunnel that leads to an underground root cellar, using a ladder. There would be an initial phase to construction that would involve hollowing out this space and reinforcing it with chicken wire ferris cement. This would give the person living in the shed a means of preserving food.

3 Project Plan, Execution, Tracking & Bill of Materials

Task	Time to Complete
Floor Panel Construction	4 hours
Wall Panel Construction	10 hours
Roof Construction	6 hours
Window and Door Installation	2 hours
Siding Installation	2 hours

Material	Cost per unit	Quantity	Cost	Total cost
2x6x8’	$11	10	$110	**$490**
2x4x8’	$ 2	54	$108	
structural screws (box of 100)	$ 16	1	$16	
7/16” OSB	$ 15	9	$ 135	
Vinyl siding	$ 65 / box	1 box	$ 65	
J – trim	$ 7 / 10 feet	80 feet	$ 56	

4 Prototyping, Testing and Customer Validation.

We are doing this test to find any faults or errors in our design. By building and dismantling our prototype, we can identify any aspects that can be improved, and ensure that the design is structurally sound. The prototype proves that the structure can be easily assembled and will remain standing. The general objective is one of learning. We aim to learn of any improvements that can be made to our design.

In this prototype, the shed must be disassembled and reassembled in a different place. In order to do this, the roof must be taken down first. Once the roof is removed, the different wall panels can be taken down. Using a wrench and a drill, each of the screws and nuts can be removed from the panels.

To reassemble, the floor panels are placed and fastened together using screws. Next, the sill plates are screwed to the floor. Then the wall panels are placed on the sill plates and braced plumb. Top plates are attached on top of the walls, and the roof is constructed last.

Test Objectives Description

*What are the **specific** test objectives?*

- Our prototype needs to improve the livability of the shed, building Code and R-value improve livability.

Aspect 1: Window
Objectives:

1. Needs to meet Ontario Building Code as a means of egress.
2. Needs to be in an appropriate place.
3. Needs to be of appropriate material.
4. Needs to be a high enough R-value.
5. Needs to let in enough sunlight.
6. Needs to be big enough for people to escape.

Aspect 2: Door
Objectives:

1. Needs to meet Ontario Building Code as a means of egress.
2. Needs to have a high enough R-value.
3. Needs to be tall enough for a 6’ 4” person.
4. Add to the aesthetic appeal of a house.

Aspect 3: Siding
Objectives:

- 40 year longevity
- Protection against wind
- Protection against rain

- Protection against dust
- Prevention from wood rotting, mold growth, and other interior damage

Aspect 4: Roof Shape and Size
Objectives:

1. Sufficient size for solar panels
2. Sufficient slope to shed water
3. Low enough slope to make roofing easy
4. Weather conditions? -- rain or snow
5. Shape is suitable for harsh Canadian weather condition

Aspect 5: Roofing material
Objectives:

1. 25 year longevity
2. Able to withstand Canadian winter

*What **exactly** is being learned or communicated with the prototype?*

1. The general ease of construction
2. The structural stability
3. The most efficient process for assembly
4. The feasibility of incorporating other systems into the structure

What are the possible types of result? What are the criteria for test success or failure?

1. Success - the design is structurally sound and the assembly is very easy
2. Moderate success - the design is structurally sound, but the assembly is difficult
3. Moderate failure - the design does not hold its shape but the assembly is easy
4. Extreme failure - the structure collapses

How will these results be used to make decisions or select concepts?

The results will be used to identify any improvements. For example, we may need to change the type of fasteners used, or the structure may need more bracing to hold its shape. Other improvements may be stronger materials

5 Conclusions and Recommendations for Future Work

In conclusion, the shed was a complete success. It will definitely be used as a premium shelter. The objective of the project was to design a structure that was to be used as a shelter for victims of domestic violence in Ottawa, and we believe these victims will be very happy with their new living situation.

In particular, we proposed representations according to the necessary design criteria for the modular home and the solutions. This satisfied the needs of needs of the structure and the customer.

The economic evaluation was challenging in a number of ways, particularly in trying to obtain all resources and materials within the given budget. Thus, collecting economic data alongside and particularly with interviews and observation of local activities, might be advantageous.

If we were to design this project again, there are a number of changes that we would take. Most importantly we would make sure to capture the whole research process from the initial stage to the completion of the design.
For those doing this project in the future, there are several recommendations that would help improve future designs. The first recommendation is to use a roof with a better overhang, that will prevent water from entering into the trusses. This will make sure that the OSB does not get wet and deteriorate quickly. It is also recommended that future sheds use a more durable type of shingles, so that the shelter is resilient in Canadian Weather. If possible future designs should be made using plywood instead of OSB, for health reasons of the users.