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Individual Assignment II - Parametric Modeling

Civil Systems Engineering – Modeling Engineering Products

1. Design challenge for Timber Room Modules to balance two design parameters that influence physical embodiment and high performance criteria

While designing a timber room module, we have a lot of calculations to make. How much vertical load can the module take? How much will the production cost? How long will the production take? How much heat does the module loose through its construction? How much CO2 eqv. is emitted during production? How much CO2 eqv. is emitted during the disposal? How much recycled material is used in the product?

All these calculations serve the purpose of evaluating a design variant and assessing its performance. The calculation results can either be compared to each other, or they can be compared to high performance standards.

An important factor for a room is the living space available, so the chosen high-performance criteria chosen are room **volume** as well as **mass of consumed timber**, to be aware of resource consumption while ensuring a high quality product.

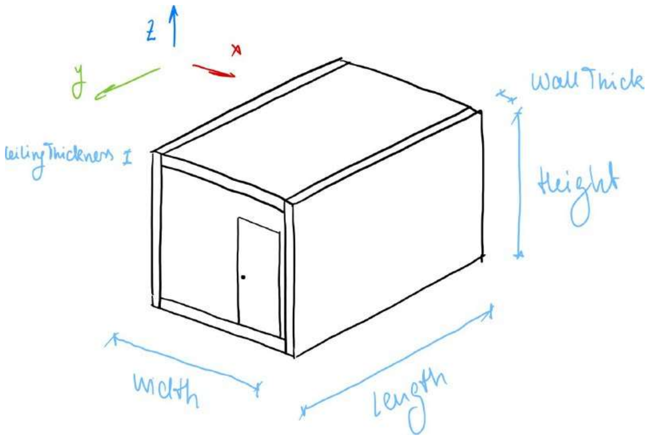
2. Model system with Dynamo BIM. Follow Bridge Tutorial. Geometric embodiment simple.

Defining input Parameter and their restrictions.

Input Parameter	Min. Value	Max. Value
Length	4m	8m
Width	2m	5m
Height	2.5m	3.5m
Thickness Wall	0.05m	0.2m
Thickness Ceiling	0.1m	0.3m

These parameters largely influence the structural analysis of the room module. The height, in combination with the connection of the wall influences the way and at which vertical load it will kink which makes it a relevant parameter and will be the controlling parameter in the following paper. The thickness of the wall changes the tension and torsion resistance of the wall, as well as influence thermal and acoustic insulation. The length of the module largely influences the bending of the ceiling.

The chosen criteria of the timber room module (TRM) designs would be calculated as such:



Volume = (Width-2*WallThickness)*(Length-2*WallThickness)*(Height-2*CeilingThickness)

Mass = ((2*Length*Height)+2*(Width-2*WallThickness)*(Height-2*CeilingThickness))*WallThickness + (Width-2*WallThickness)*Length*CeilingThickness

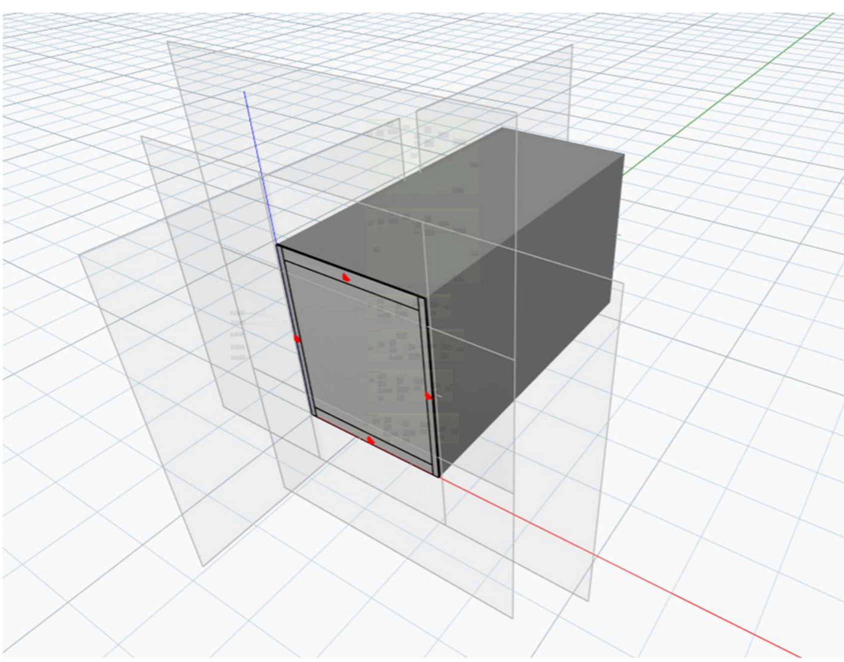
The model was transferred into Dynamo, each wall- and ceiling slab being modelled in dependence of the 5 input parameters to make a cuboid form.

First the long outer walls where created, with an origin point based on a plane to make the rectangle profile and swept into a solid body.

Next the floor slab was created, also with the same method of creating a rectangle along a plane and swept into a solid body.

Next the shorter walls were modelled and lastly the ceiling slab.

Everything was drawn relative to the 5 input parameters, as to enable a simple development of alternatives.



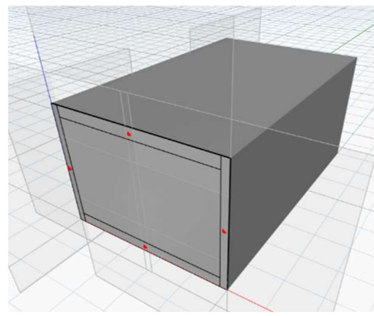
Lastly the formulas for high performance criteria where set as an output, to evaluate different variants according to their available room space and volume of timber, which combined with an assumed density of 500kg/m^3 [i].

3. Experiment with model and evaluate design space. Find 3 good alternatives and report engineering aspects behind each

With this parametric model, it is easy to create variants of the model and see how they affect our high performance indicators.

1. Alternative: Largest dimensions

Input Parameter	Max. Value
Length	8m
Width	5m
Height	3.5m
Thickness Wall	0.2m
Thickness Ceiling	0.3m



Volume: 34.36m^3

Mass: 48.86m^3*500kg/m^3=24.43 t.

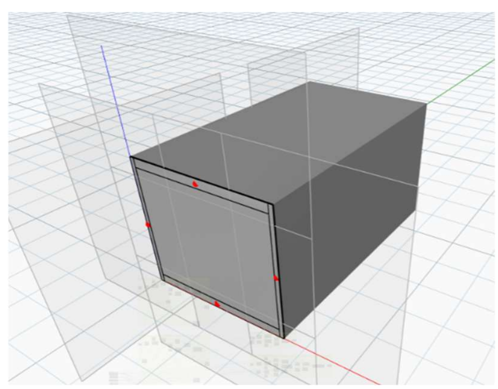
The larger dimensions of this alternative have structural advantages, as they can withstand more load and could hold more timber room modules stacked on top.

From a building physics point of view, the largest room volume also means more space that needs to be heated up and more surfaces open for maintenance against mold.

If we look at the efficiency of this alternative, we have 1.41m^3 space gained per t of timber built.

2. Alternative: Medium dimensions

Input Parameter	Med. Value
Length	6m
Width	3.5m
Height	2m
Thickness Wall	0.10m
Thickness Ceiling	0.2m



Room Volume: 18.74m^3

Mass: 15.036m^3*500kg/m^3=7.52t.

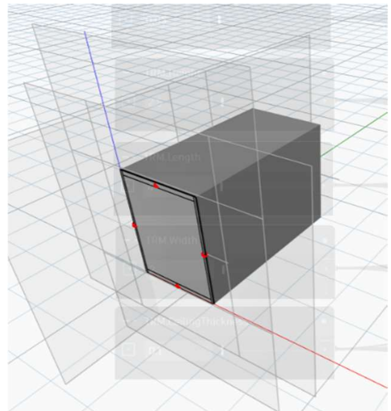
The medium dimensions allow a moderate amount of load on top, but are restricted in their structural properties. A thorough calculation needs to be made with the exact location and vertical load on the timber room module.

From a building physics point of view, the room volume means a manageable space to heat and maintain against mold.

If we look at the efficiency of this alternative, we gain 0.02m^3 space per built in t of timber, which is a lot less efficient than the 1. alternative.

3. Alternative: Smallest dimensions

Input Parameter	Min. Value
Length	4m
Width	2m
Height	2.5m
Thickness Wall	0.05m
Thickness Ceiling	0.1m



Available Room: 7.21 m^3.

Mass: 3.497m^3*500kg/m^3=1.75t.

The small dimensions make this alternative statically very inapt. To determine the exact load possible, a thorough calculation considering the location and environmental conditions.

Since the area of timber is very small, the building physics are very manageable to heat and maintain against mold.

If we look at the efficiency of this alternative, we gain 4.12m^3 of space per t of timber built in, making this the most efficient when comparing gained available room space and used mass.

[i] The Engineering ToolBox (2004) Wood Species – Densities [online] https://www.engineeringtoolbox.com/wood-density-d_40.html [last opened 08.01.23]