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FACULTY OF ENGINEERING
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TEAM 12
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METROWORKS

common roots urban farm

Vertical Growing System for Urban Farming

BACKGROUND

MetroWorks is incorporating vertical growing systems at their urban farm locations at BiHi Park, and Dartmouth Hospital, as HRM by-laws prohibit more than 10% of the parkland to be used for community gardens.

Ideally the structure will be capable of yielding more produce per square foot, than the existing 12x4 ft gardens beds, be capable of withstanding harsh Halifax weather, and be easily assembled and disassembled for storage and portability.

Further requirements included:

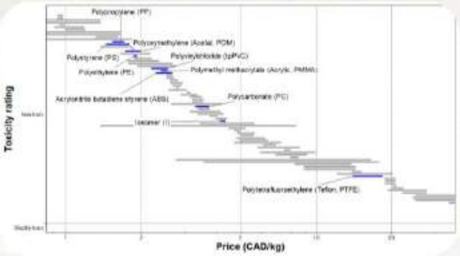
- Made of non-leaching, non-carcinogenic material;
- No moving, or power supplied parts;
- Withstand UV radiation;
- Easily accessible for all urban farmers; and
- Made as inexpensive as possible as MetroWorks is a non-profit organization.

BUDGET

Seeing as MetroWorks is a non-profit organization, budget was always a primary concern when developing the prototype phase of the design. Should the prototype be integrated further at the community gardens, the price per part would decrease, as more assemblies were manufactured.

- STEEL
  - Carbon steel for the supports and base plates.
  - \$56.75
- PLA/PETG
  - Used for 3D printed shell parts.
  - \$41.98
- ABS
  - Plastic sheets used for thermoforming shells.
  - \$78.60
- HARDWARE
  - Bolts, washers, nuts, & wingnuts for assembly.
  - \$49.36
- MDF
  - Used to CNC the plug of the thermoform.
  - \$22.40
- TOTAL BUDGET
  - \$249.09 - with excess of all materials.

SHELL MATERIAL SELECTION

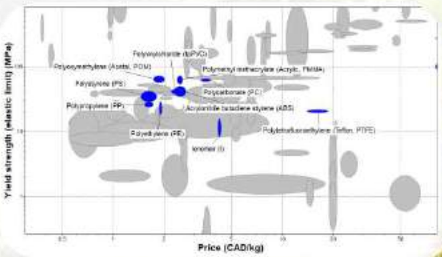


The most pressing requirement for the shell material choice was to ensure that there was no leaching of harmful compounds into the soil and produce. Though deemed non-toxic, some highlighted plastics still were not safe for garden use. Furthermore, price was factored in to give an estimate as to which sort of materials would be viable in creating inexpensive shell parts.

Yield strength of the viable plastics was also taken into account, to ensure there would be no breakage of the shell due to the weight of the soil, nor to extreme weather.

Based on these findings and additional research, the following plastics were deemed acceptable for the application:

- PLA;
- PETG; and
- ABS.



YIELD ANALYSIS

Yield calculations were based on planting leafy greens such as lettuce and mustard greens, both high demand crops for urban farmers.

A rough estimate of the square footage based on area of the base plate (shown):

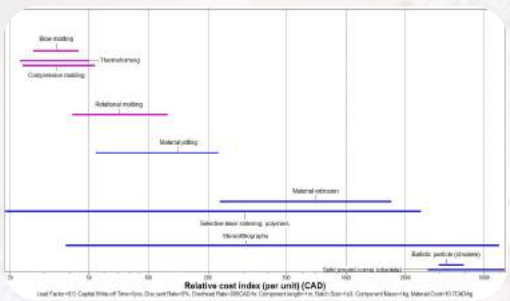
$$A = \frac{\sqrt{3}}{4} l^2 \cong 45\ in^2 = 0.3125\ ft^2$$

*The depth of each potting tier is also 8 in.

Since spacing room is needed between each vertical structure, it can be estimated that the square footage used is ~0.5 ft².

As leafy greens are planted 6 in apart, the vertical structure is capable of holding three crops per tier. With three tiers, an average of nine crops per structure is viable. Since the existing ground beds (12x4 ft), are capable of holding three plants per square foot (as they are sown in a row), the vertical structure allows for 6x produce yield per square foot.

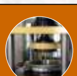
PROCESS SELECTION & MANUFACTURABILITY



Considering the acceptable materials in which the shell could be made from, only a few processes were able to be used to manufacture the part. This was further limited by the complex geometry, and included:

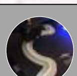
- Blow Molding;
- Thermoforming;
- Compression Molding;
- Rotational Molding; and
- 3D Printing (not shown in figure).

Therefore, based on the availability of resources, and the expense of certain applications, an Olympic style ranking system was used to determine the best method to manufacture the part. Note: this does not include the steel used to manufacture the frame.



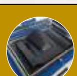
COMPRESSION MOLDING

- Fast process when setup;
- Expensive to outsource; and
- Unable to perform manufacturing from resources at Dalhousie.



3D PRINTING

- Relatively inexpensive process to produce multiple parts;
- Easily manufactured by self; and
- Very slow to produce one part.



THERMOFORMING

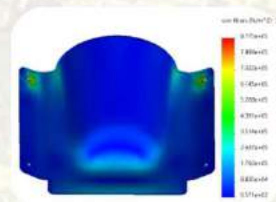
- Inexpensive to produce many parts;
- Easily manufactured by self; and
- Easily create multiple parts in a small timeframe

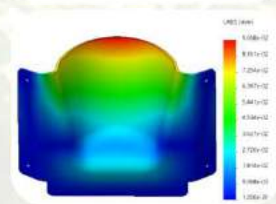
FINAL DESIGN

The final design measured 5 ft tall, and is capable of holding 2 to 4 tiers of plants, depending on the crop size. It is also easily assembled/disassembled, for ease of storage during winter months.

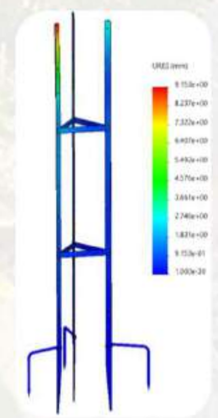
STRESS & DISPLACEMENT ANALYSIS

FEM analysis revealed a maximum concentrated stress around the shell screw holes of 877.5 kPa (top left). Washers were therefore used to bolt the assembly together and disperse the forces acting at these locations.





Additionally, the greatest displacement of the shell caused by the weight of the soil was less than 0.1 mm (bottom left). However, this analysis assumes the holes and bottom of the base are completely fixed.



Furthermore, when analyzing the steel frame assembly against 100 km/h winds (right), a maximum displacement of ~9 mm near the top of the structure was found. Note that this was performed with two base plates attached; the minimum number requirement to hold the frame together. However, the structure was designed to hold three tiers.