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OPTIMISATION OF A GREENHOUSE STRUCTURE

Chircan Eliza[1], Dimitriu Ștefan[2]
[1] Universitatea Transilvania, Brașov, ROMÂNIA, chircan.eliza@uitbv.ro
[2] Universitatea Transilvania, Brașov, ROMÂNIA, sdimi@unitbv.ro

Abstract *In the following paper we will analyze the best type of material that can be used on a green house in a mountain area. The purpose of the test is to find a good structure that will be resistant against a considerable amount of snow. The structure is a light small one that is destined to be used for home purpose, designed so that it can be easily built and maintained.*
Keywords: *green house, fiberglass, polyvinyl chloride, carbon fiber, finite element analysis, displacement*

1. INTRODUCTION

The greenhouse industry provides the consumer with a large amount of products. The different range of sizes is influenced by the type of crops that will be grown in it, the kind of consumer that buys it or the area in which the consumer resides in. Because the large variety of designs it is hard to find the one proper for your climate area.
Greenhouse usage is one of the most common ways to provide developed countries with fresh goods even during cold periods; therefore the production of the facility is influenced by the big demand of greens, leading to poor design and material usage.
It is important, even as a small consumer, to choose the right material when building or ordering a greenhouse. The most common choice is polyvinyl chloride (pvc) tubes. In the image below we can observe a greenhouse made of pvc tubes. This kind of material is very flexible and can hold a large amount of deformation without going in the plastic domain, therefore regaining its own shape after deformation.

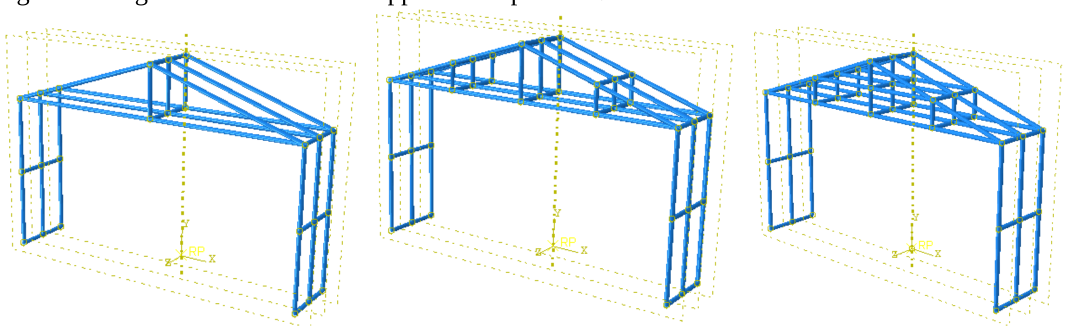
Figure 1: PVC tube greenhouse collapsed and after deformation[7]

From the wide range of materials on the market we choose three kinds of tubes: composite fiberglass hollow tubes (Figure 2: a), composite carbon fiber hollow tubes (Figure 2: b) and PVC hollow tubes (Figure 2: c).

Figure 2: a. fiberglass [5]; b. carbon [8]; c. pvc [6].

2. FINITE ELEMENT ANALYSIS

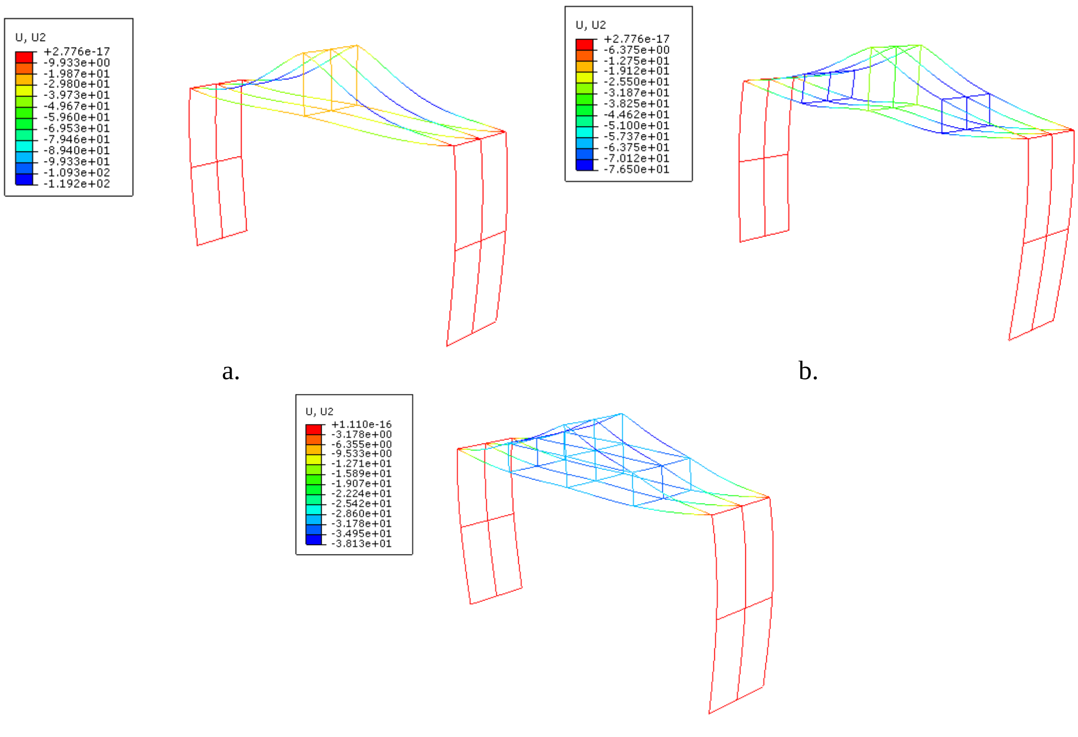
From the wide range of designs we chose a house like greenhouse which is easy to build by using connectors and polycarbonate panels on the sides or polyethylene film. We will take in discussion the roof area that will be covered with film. The base surface is sitting directly on the ground and it’s pined to it. As shown in the figure bellow, there are three types of greenhouse sections. The difference between them is the amount of beams used to support the roof section.
The first type of greenhouse section is the simplest one, the roof being supported only on the cross beams; the following ones bring more elements that support the top beams.



a. b. c.

Figure3: The three types of structures used in the analysis
a. Structure 1; b. Structure 2; c. Structure 3.

The design was also improved to find the structure in which the displacement has the most uniform distribution, therefore the smallest values. The load used was an equivalent of 30kg of snow per cubic meter.
In the image bellow is presented the deformed states of the three structures that were chosen. The best behavior is observed in the most complex frame, in which the amount of material is bigger that in the first one. Even thou there are a few more beams, the structure is still a lightweight structure because the material are very light.



a. b.

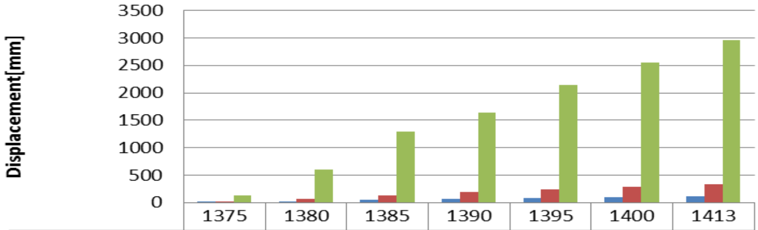
c.

Figure 4: Deformed states of different structures.

3. RESULTS

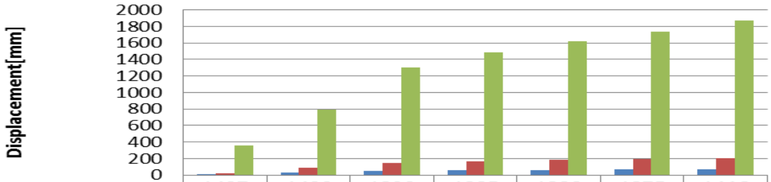
After performing the finite element analysis there were chosen a number of 7 nodes for the first two and for the third one 8 nodes, from which there were taken the displacement values. The nodes are from the diagonal beam of the roof, the one that is the most deformed.

In the first chart below we have the results for the first kind on structure, the simplest one. The deformations are the biggest in this case, because the roof is supported only in three points. As the design changes, the deformation is reduced considerably over 50%.



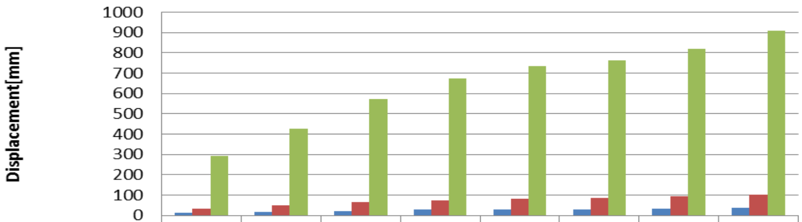
	1375	1380	1385	1390	1395	1400	1413
CF Structure 1	5.223968	23.7839	45.0186	66.3679	85.7309	101.466	118.238
FG Structure 1	14.641	66.6725	126.185	186.01	240.0264	284.352	331.347
PVC Structure 1	130.938	596.489	1287	1635.8	2148.58	2548.67	2962.81

a.



	1407	1400	1390	1385	1380	1375	1446
CF Structure2	9.28229	31.3459	51.7592	59.1049	64.698	69.2009	74.5032
FG Structure2	26.0411	87.9561	145.22	165.815	181.481	194.09	208.873
PVC Structure2	356.298	788.208	1301.14	1485.44	1625.4	1737.48	1868.99

b.



	1531	1535	1540	1545	1550	1560	1490	1500
CF Structure3	11.7042	17.0728	22.8132	26.9559	29.3591	30.5643	32.8166	36.3291
FG Structure3	32.8139	47.862	63.9477	75.5506	82.2737	85.094	91.9148	101.781
PVC Structure3	293.628	428.236	572.048	675.699	735.639	764.82	821.103	909.668

c.

Figure 5: Graphical representation and values of displacement for all three chosen materials: a. structure1; b. structure2; c. structure3.

4. CONCLUSION

The presents results show that even thou the deformation is reduced by adding additional elements to the roof section the values remain a concern regarding pvc pipe structure, which is also the most commonly used. The best choice in this case it the carbon fiber composite pipe. No matter how we changed the structure of the roof, the pvc structure will never reach the deformations of the most simple composite carbon fiber tube structure.

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