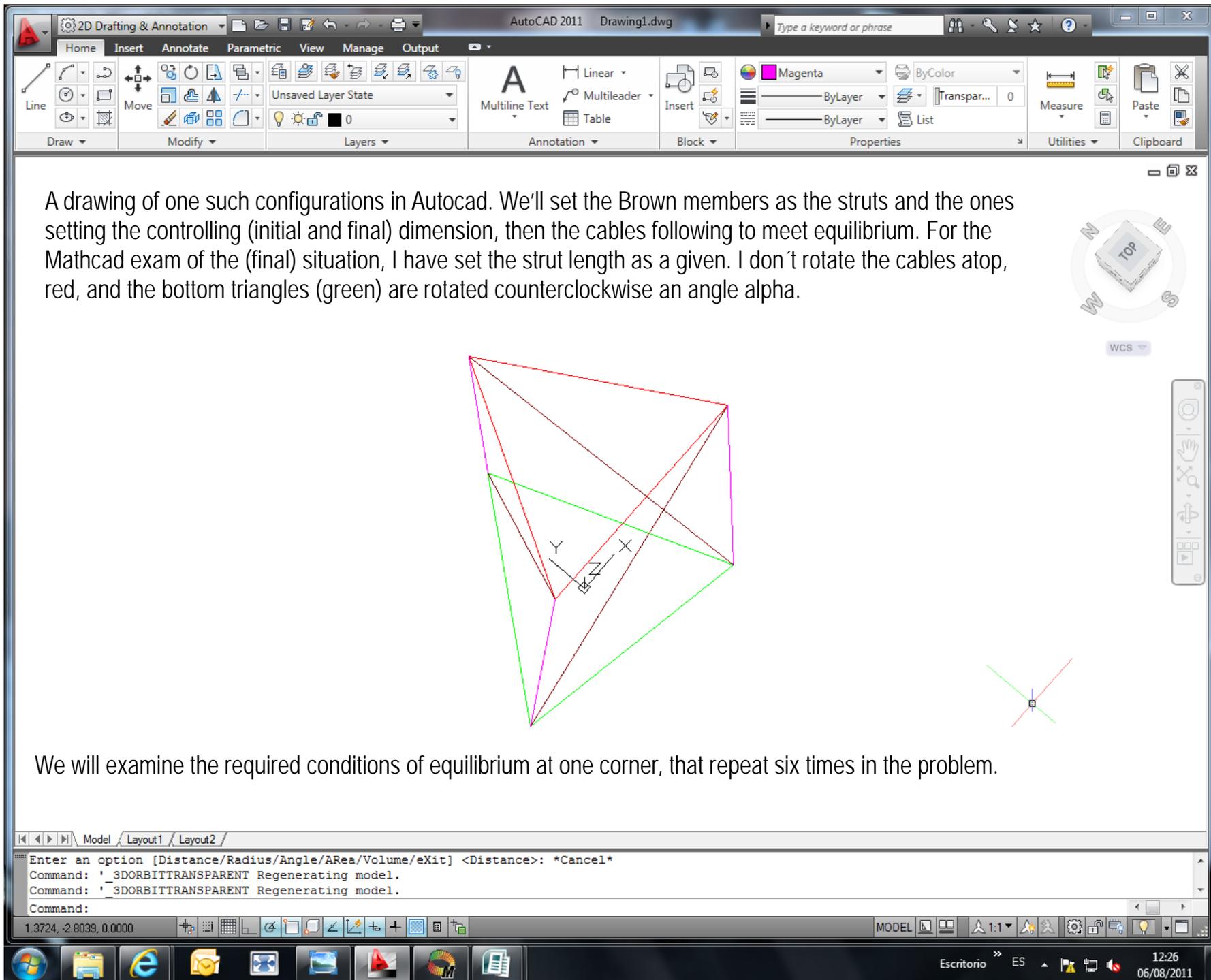


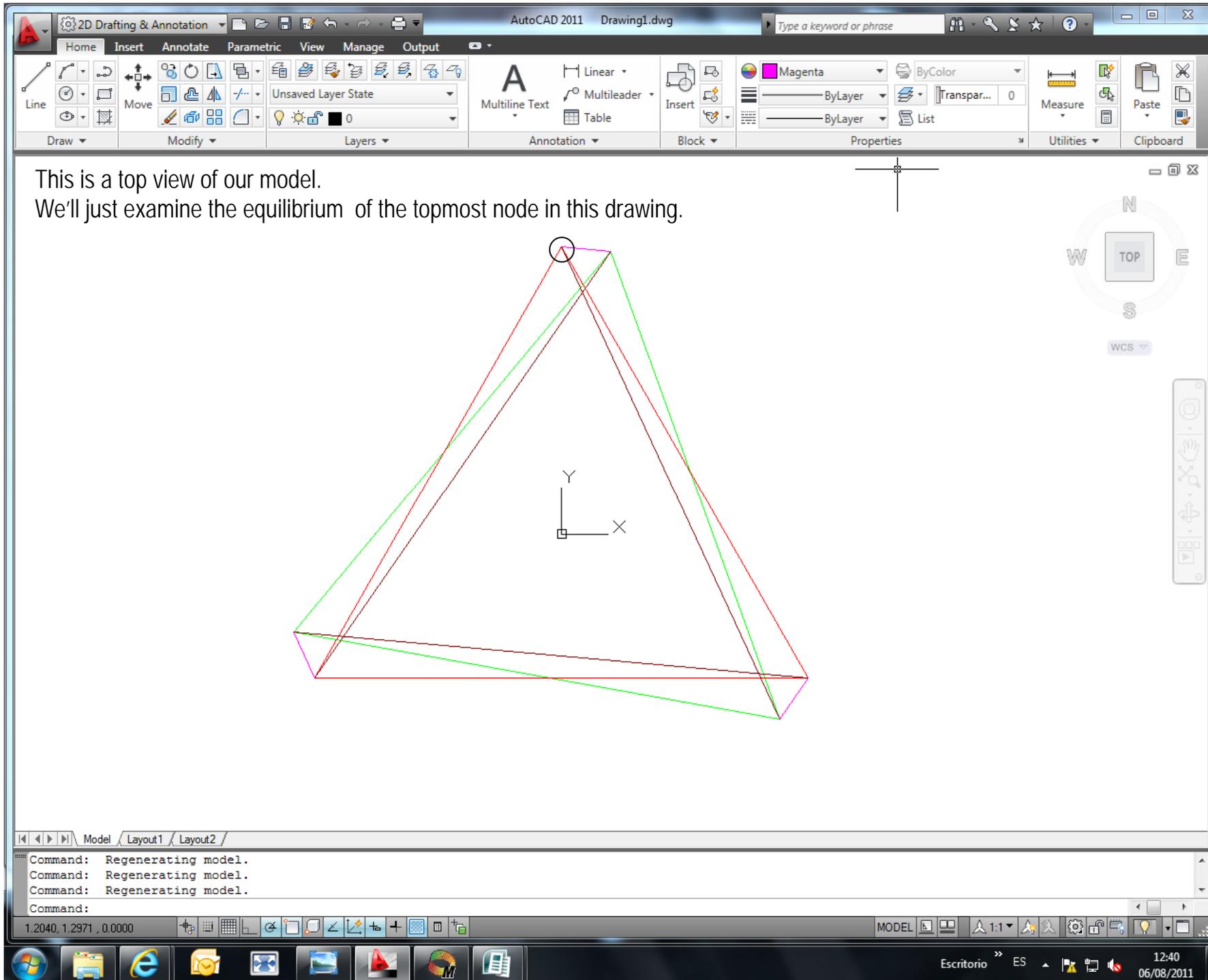
The Structure we'll be investigating

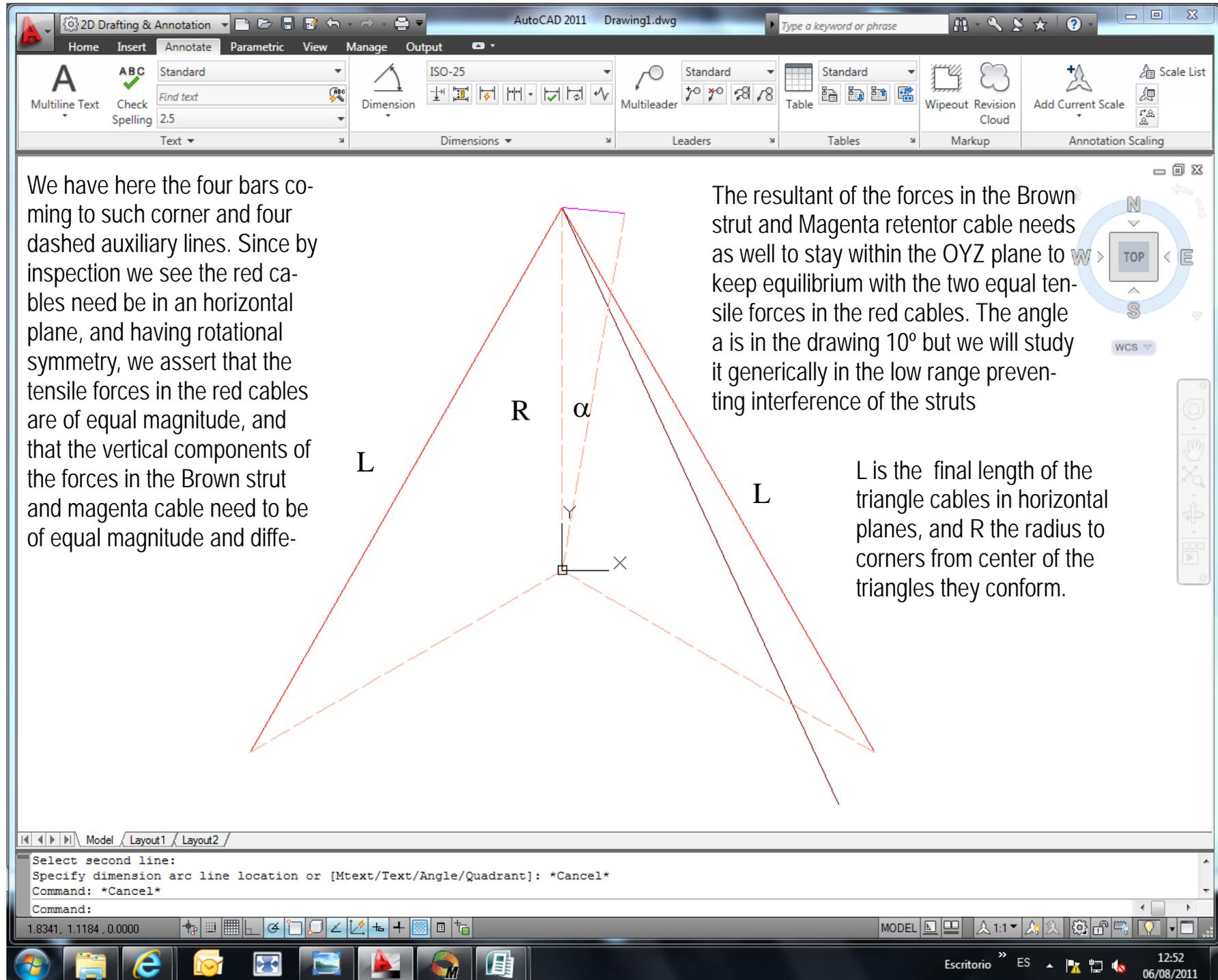


A drawing of one such configurations in Autocad. We'll set the Brown members as the struts and the ones setting the controlling (initial and final) dimension, then the cables following to meet equilibrium. For the Mathcad exam of the (final) situation, I have set the strut length as a given. I don't rotate the cables atop, red, and the bottom triangles (green) are rotated counterclockwise an angle α .



We will examine the required conditions of equilibrium at one corner, that repeat six times in the problem.



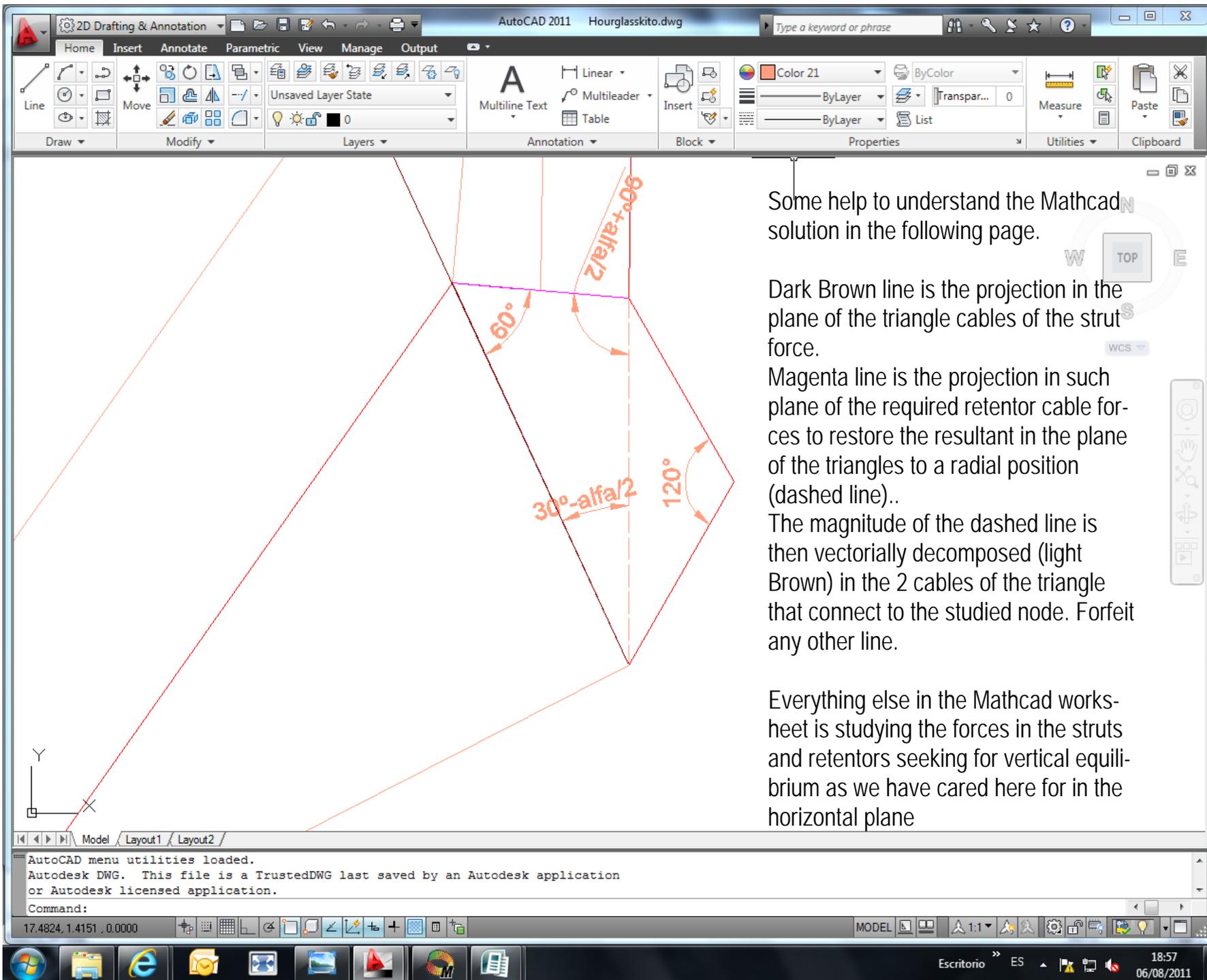


We have here the four bars coming to such corner and four dashed auxiliary lines. Since by inspection we see the red cables need be in an horizontal plane, and having rotational symmetry, we assert that the tensile forces in the red cables are of equal magnitude, and that the vertical components of the forces in the Brown strut and magenta cable need to be of equal magnitude and diffe-

The resultant of the forces in the Brown strut and Magenta retentor cable needs as well to stay within the OYZ plane to keep equilibrium with the two equal tensile forces in the red cables. The angle α is in the drawing 10° but we will study it generically in the low range preventing interference of the struts

L is the final length of the triangle cables in horizontal planes, and R the radius to corners from center of the triangles they conform.

Select second line:
Specify dimension arc line location or [Mtext/Text/Angle/Quadrant]: *Cancel*
Command: *Cancel*
Command:



Some help to understand the Mathcad solution in the following page.

Dark Brown line is the projection in the plane of the triangle cables of the strut force.

Magenta line is the projection in such plane of the required retentor cable forces to restore the resultant in the plane of the triangles to a radial position (dashed line)..

The magnitude of the dashed line is then vectorially decomposed (light Brown) in the 2 cables of the triangle that connect to the studied node. Forfeit any other line.

Everything else in the Mathcad worksheet is studying the forces in the struts and retentors seeking for vertical equilibrium as we have cared here for in the horizontal plane

Catenaryworks problem

$s := 4\text{-m}$ length of the struts $R := 1\text{-m}$ radius from center to vertex of the triangles $L := 2 \cdot R \cdot \cos(30\text{-deg})$ $L = 1.732\text{ m}$ side of the equilateral triangles of cable

$s_p(\alpha) := 2 \cdot R \cdot \left(\sin(30\text{-deg}) \cdot \sin\left(\frac{\alpha}{2}\right) + \cos(30\text{-deg}) \cdot \cos\left(\frac{\alpha}{2}\right) \right)$ projected length on horizontal plane of the struts

$\gamma_s(\alpha) := \arcsin\left(\frac{s_p(\alpha)}{s}\right)$ angle the struts form with the vertical $h(\alpha) := s \cdot \cos(\gamma_s(\alpha))$ overall height of the outfit

$c_p(\alpha) := 2 \cdot R \cdot \sin\left(\frac{\alpha}{2}\right)$ projected length on horizontal plane of the retentor cables at faces

$\gamma_c(\alpha) := \arctan\left(\frac{c_p(\alpha)}{h(\alpha)}\right)$ angle the retentor cables at faces form with the vertical

$f_{sp}(\alpha) := 1\text{-tonf} \cdot \frac{\sin\left(90\text{-deg} + \frac{\alpha}{2}\right)}{\sin(60\text{-deg})}$ projection of the compressive force in the strut when the radial force is 1 tonf

$f_{cp}(\alpha) := 1\text{-tonf} \cdot \frac{\sin\left(30\text{-deg} - \frac{\alpha}{2}\right)}{\sin(60\text{-deg})}$ projection of the tensile force in the retentor cable when the radial force is 1 tonf

The proportion between these two forces ensures the resultant is in the radial direction. Since we know the horizontal projections, and the angles both the strut and the retentor cable form with the vertical we can derive the vertical projection of force they stand when the radial force is 1 tonf

$f_{spv}(\alpha) := \frac{f_{sp}(\alpha)}{\tan(\gamma_s(\alpha))}$ $f_{cpv}(\alpha) := \frac{f_{cp}(\alpha)}{\tan(\gamma_c(\alpha))}$

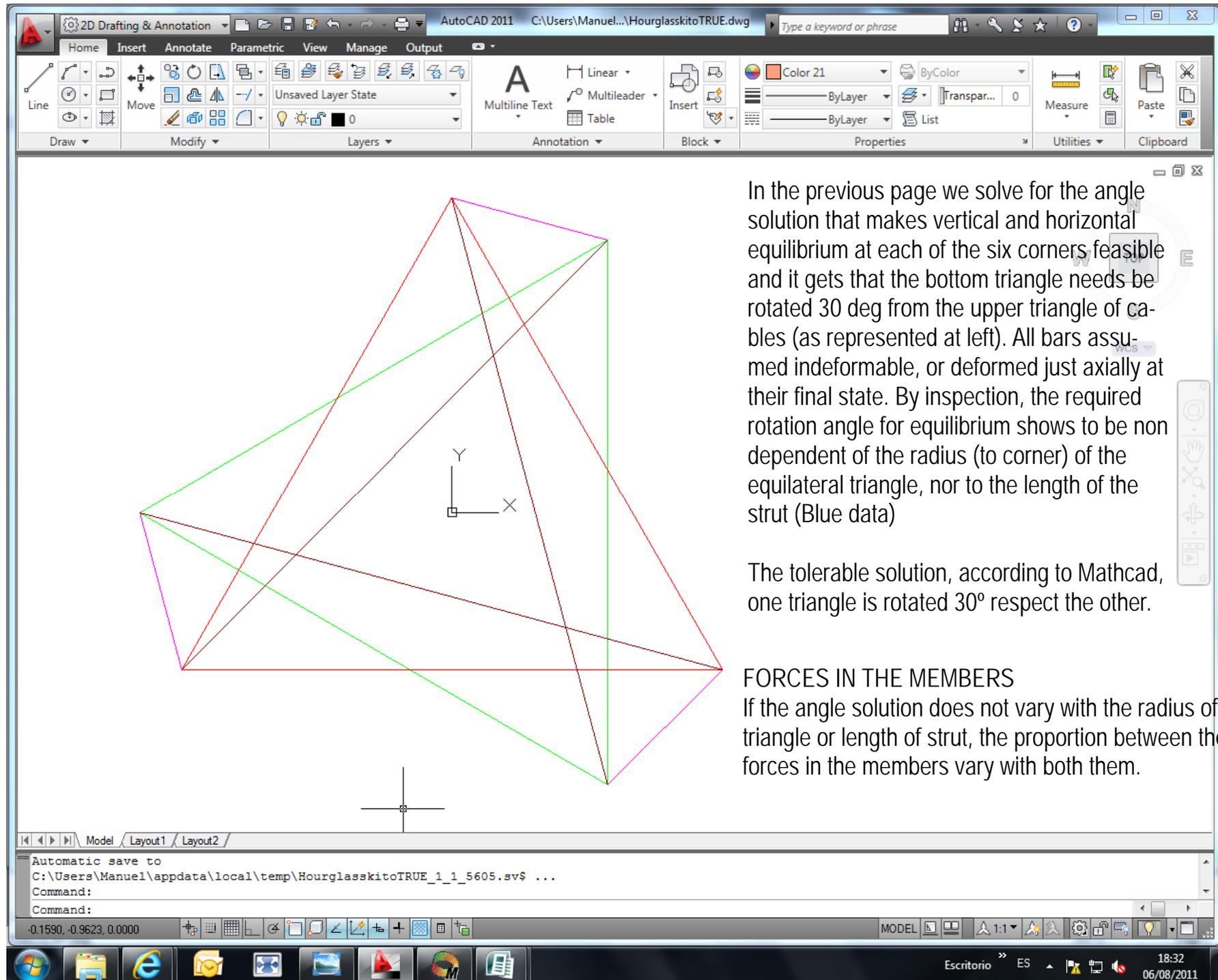
$\alpha := 20\text{-deg}$ unwarranted guess for the angle for which vertical and horizontal equilibrium is feasible

Given

$f_{spv}(\alpha) = f_{cpv}(\alpha)$

$\text{True}_\alpha := \text{find}(\alpha)$ **True_α = 30 deg** $f_{spv}(\text{True}_\alpha) = 2.022\text{ tonf}$ $f_{cpv}(\text{True}_\alpha) = 2.022\text{ tonf}$ OK +

$f_{\text{cable_triangle}} := \frac{1\text{-tonf}}{\cos(30\text{-deg})}$ **f_cable_triangle = 0.577 tonf** $f_{\text{strut}} := \frac{f_{sp}(\text{True}_\alpha)}{\sin(\gamma_s(\text{True}_\alpha))}$ **f_strut = 2.309 tonf** $f_{\text{retentor_cable}} := \frac{f_{cp}(\text{True}_\alpha)}{\sin(\gamma_c(\text{True}_\alpha))}$ **f_retentor_cable = 2.044 tonf**



In the previous page we solve for the angle solution that makes vertical and horizontal equilibrium at each of the six corners feasible and it gets that the bottom triangle needs be rotated 30 deg from the upper triangle of cables (as represented at left). All bars assumed indeformable, or deformed just axially at their final state. By inspection, the required rotation angle for equilibrium shows to be non dependent of the radius (to corner) of the equilateral triangle, nor to the length of the strut (Blue data)

The tolerable solution, according to Mathcad, one triangle is rotated 30° respect the other.

FORCES IN THE MEMBERS

If the angle solution does not vary with the radius of triangle or length of strut, the proportion between the forces in the members vary with both them.