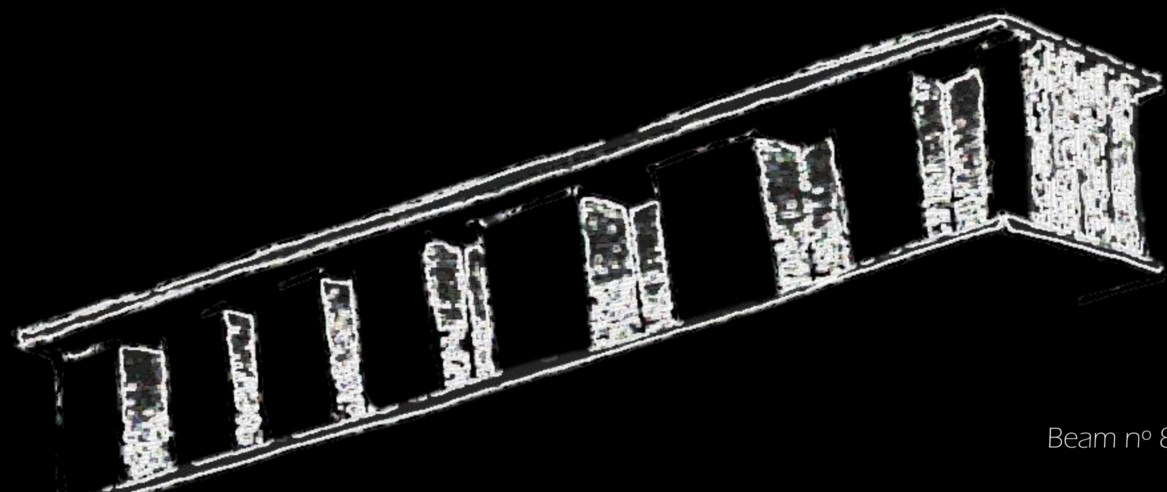
Estruturas III

# REPORT



Beam nº 8

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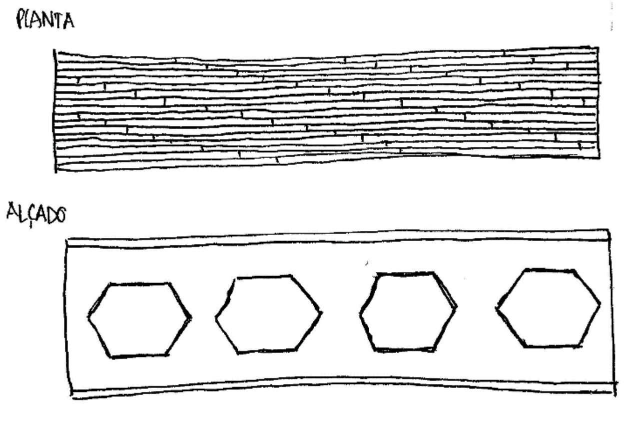
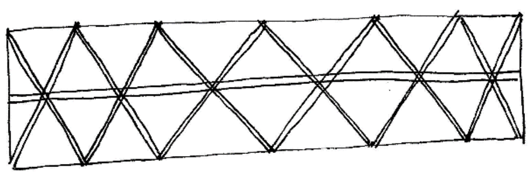
# Introduction

The goal of this practical exercise was to build a beam with a 2 meter free spam as light and with as little deflection as possible.

With the weight and the resistance factors in mind, we started planning what could be called a nerve structure. The construction resembles the longitudinal cells of a plant's branch with its openings and connections between the different cells. We argued that if we orientated 30 – 40 cm cardboard pieces vertically in the length of the bridge, it would make our bridge very resilient to vertical loads being applied on the structure, thus leaving us with almost no deflection. After drawing the idea in scale we realised that this technique would make our bridge extremely heavy and we would be using a lot of material. This is why we decided to put this idea aside and come up with something better.



After some research was done, we studied the bridge design based on the Warren Truss. The Warren Truss uses equilateral triangles to spread out the loads on the bridge. The equilateral triangles reduce the forces to mainly compression and tension. This would be ideal for what we were trying to accomplish since this type of structure would make the bridge very light. However, due to the mechanical characteristics of the cardboard, working considerably better at traction then at compression, we weren't sure that we could use it as vertical beams. If we would built the bridge following the Warren Truss logic, the beams making up the triangles might not be able to sustain the load, and it would just fold onto itself. Therefore, we opted for a structure with full vertical elements to limit the risk on folding and ensuring the transmission of the vertical load.



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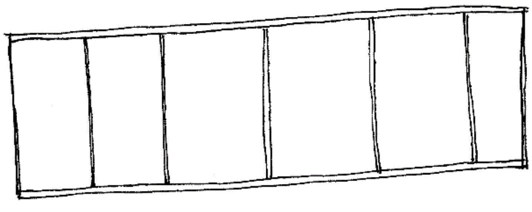

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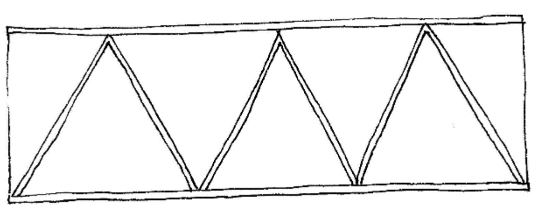
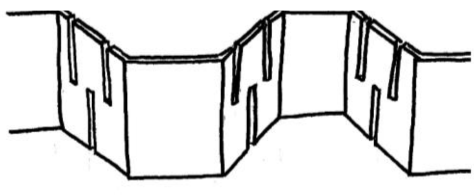
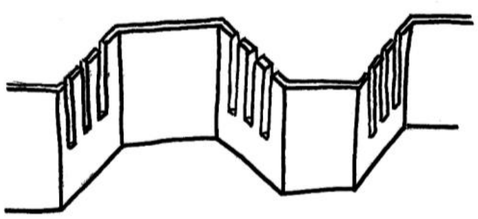


After studying the Warren truss and considering the limitation of working with cardboard, we decided to look at the design of the bridge from a plan view. Now we focused more on how we could create a strong middle piece which we would then place in between an upper and lower beam. This is how we came up with a hexagonal structure as core of the bridge. The hexagonal structure is still experiencing mainly the tension and compression forces from before in the Warren truss, but it also gives more strength to the cardboard since it supports the neighbouring pieces in the chain. Besides that, the verticality of the structure already helped to limit the deflection of the bridge.

From a full board of cardboard we cut a 30cm stripe, did half cuts on it so we could bend them and make the shape of half hexagons, and we cut the cardboard in a way that it would fit another stripe of cardboard, shaped the same way, making whole hexagons. With the half cuts and the fittings system we were able to accomplish a 2.5m piece that didn't need to be glued and worked as whole piece, having barely any weak points.



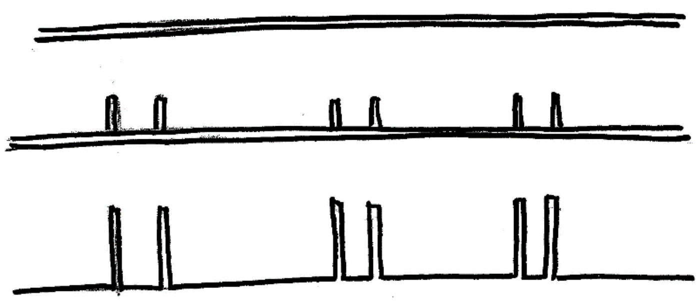


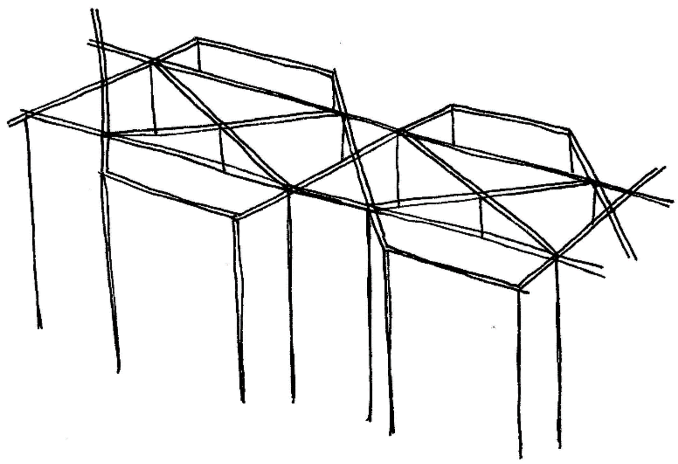
So, we already had a pretty solid core structure but we still needed to break the bending stress of the whole beam even more and the shear force within the hexagons. To minimize the bending stress we built two equal straight pieces to carry the vertical load. Those go all along the beam, with cuts on their upper half to fit in the hexagons. Consequently, the lower half of those straight pieces is stronger and more resilient to the traction forces in the lower part of the beam - it works like the reinforcement bars in a (hollow core) concrete slab.

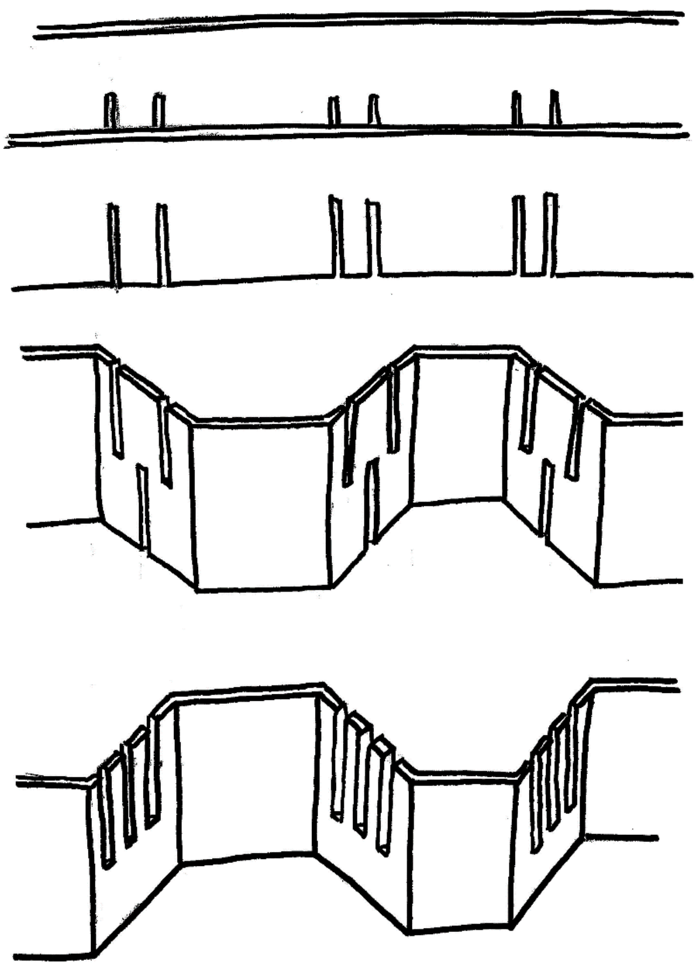
After this our bridge was working very well for the vertical forces and the hexagon structure already took away some of the horizontal – and shear forces. But the bridge remained to shaky in the horizontal plane. That's why we applied an X structure to break the horizontal - and the shear forces within the hexagons, using the same fitting system as we did with the hexagons and the straight piece.

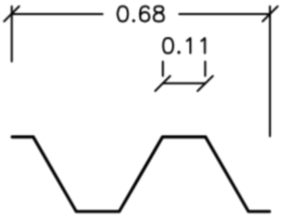
Since we already determined that the lower side of our construction should be more resilient to deal with traction forces than the upper half, we made the lower board out of 4mm cardboard pieces and the top one with 3mm cardboard. We made the upper and lower boards wider than the hexagons to create a bigger walkway, because no efficiency would be lost and it would barely impact the weight of the construction.

We, finally, reinforced and fixated the top and bottom pieces to the whole structure using hot glue.

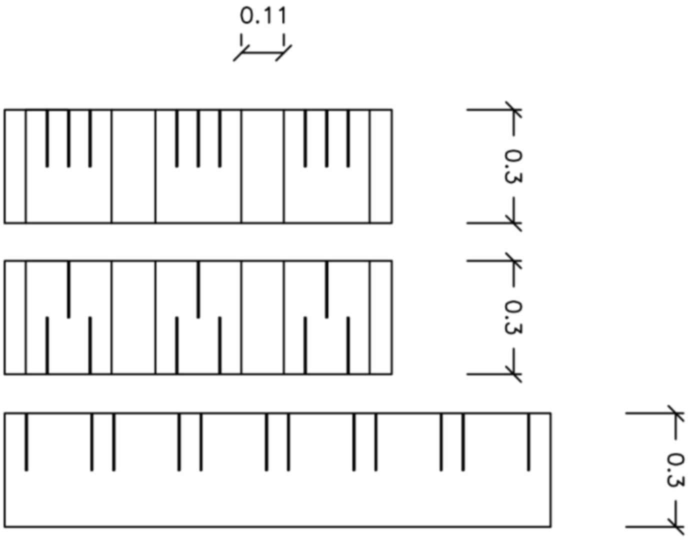




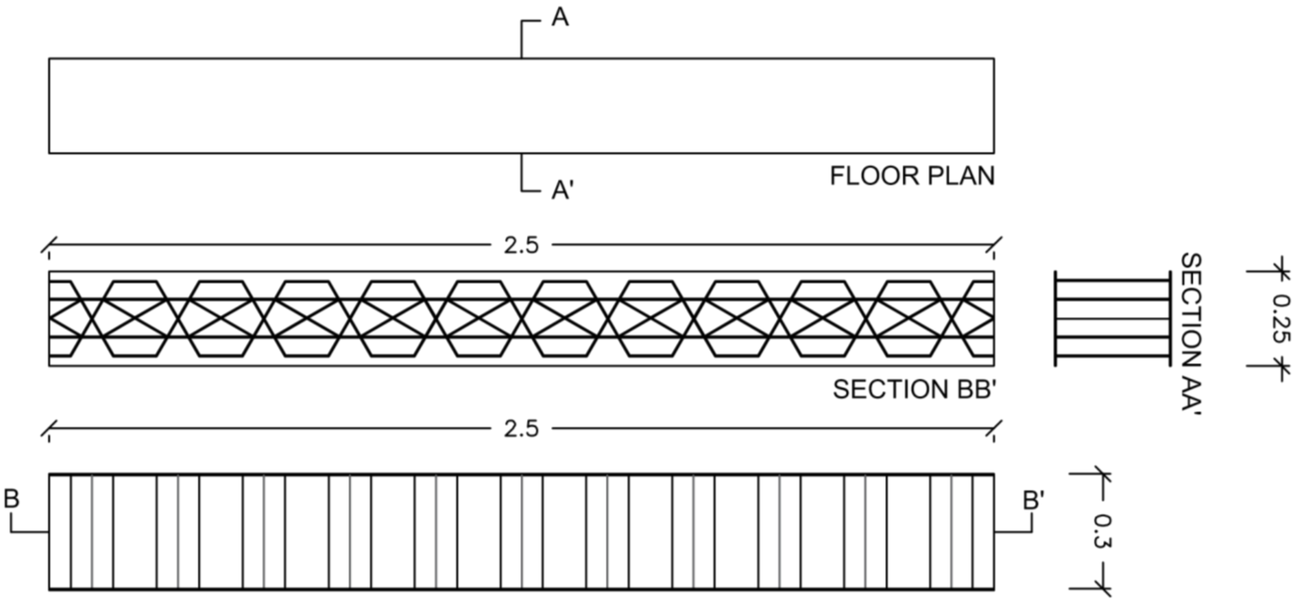





FLOOR PLAN

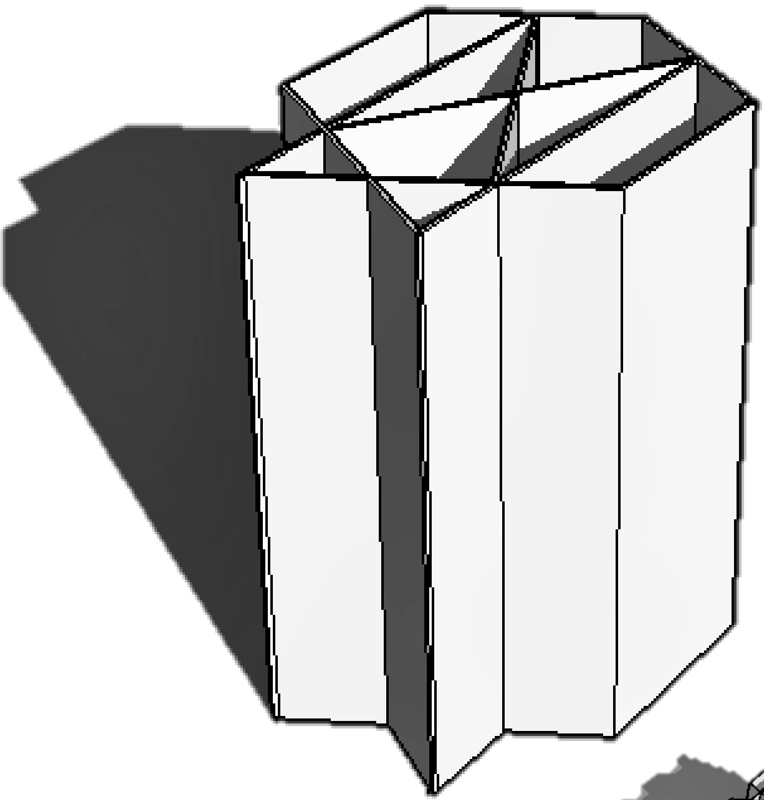


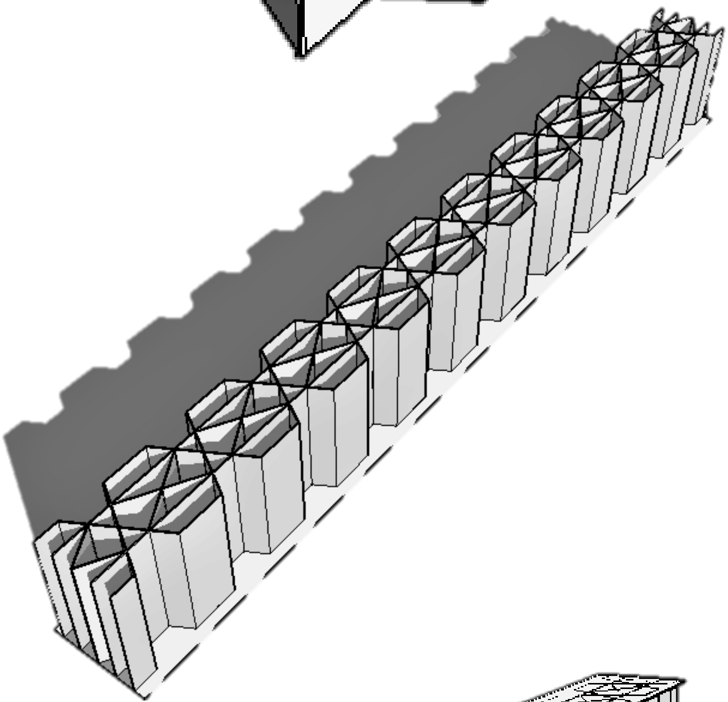

BEAM COMPONENTS

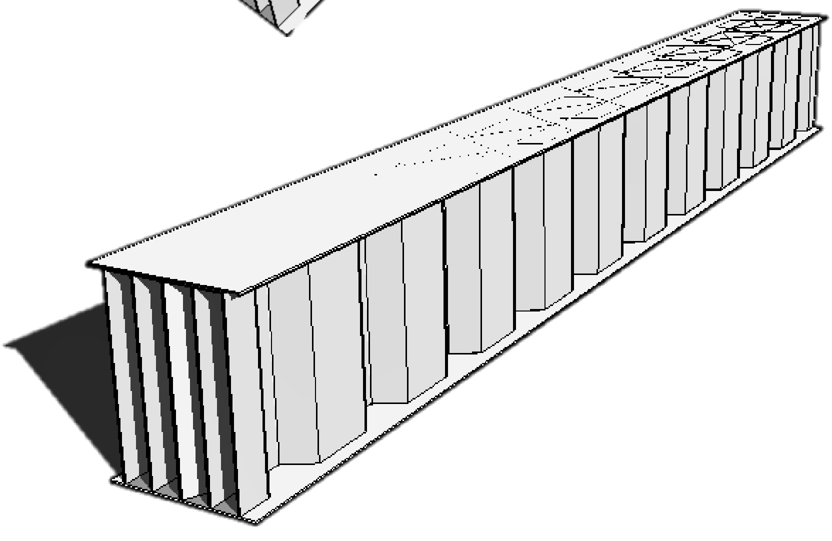


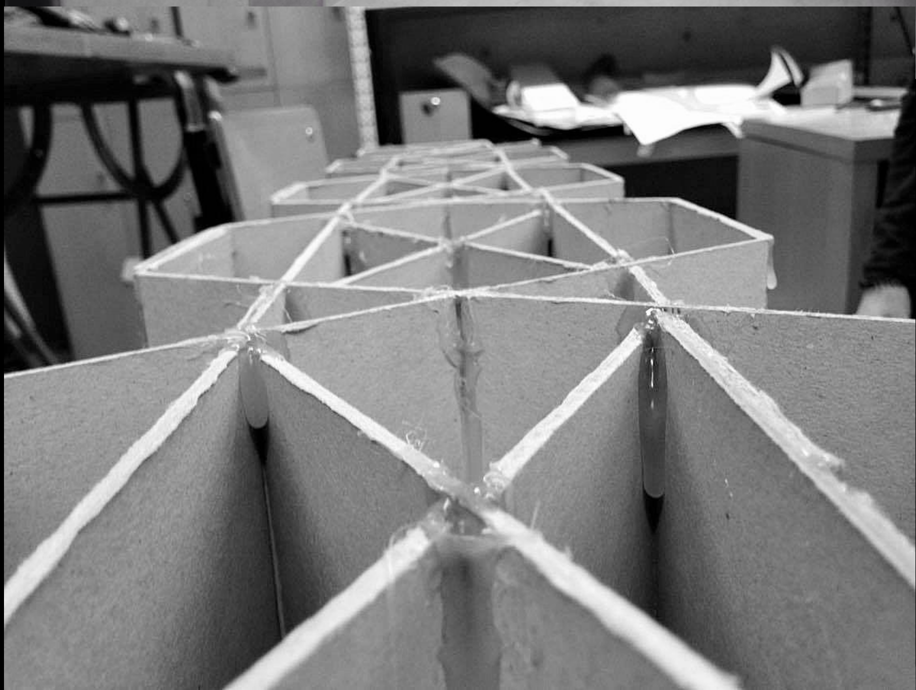

SIDE VIEW

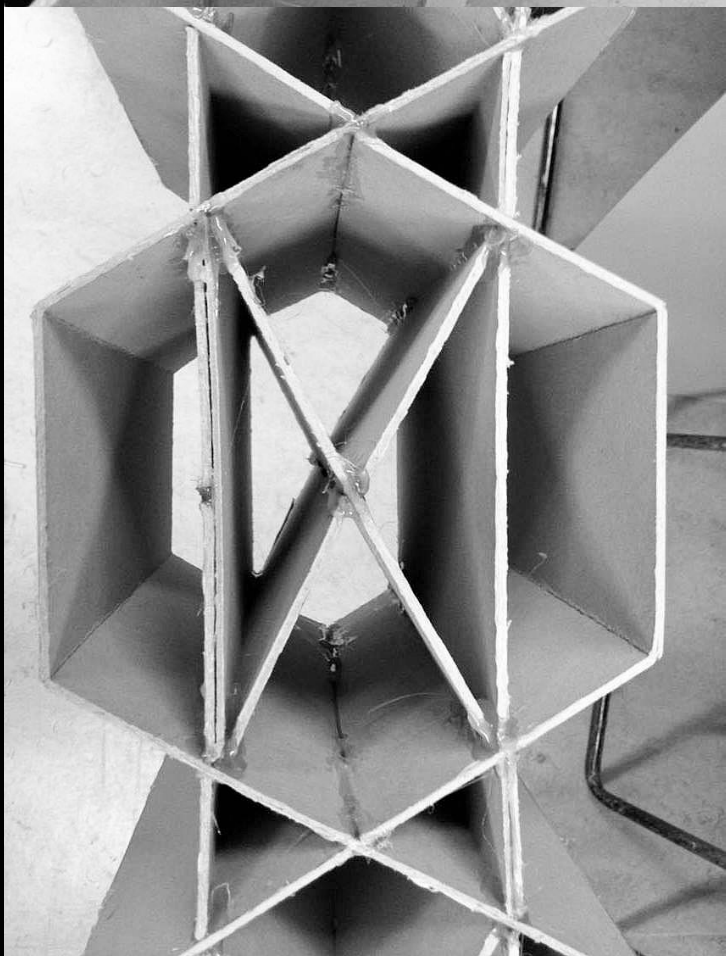
SCALE 1:20











# Conclusion

We believe that the beam would have been more efficient if the straight boards that go all along the construction would've been reinforced, meaning that they should have been thicker than the 3mm cardboard we built them in, or maybe even double layered, making them 6mm boards. Overall, mindind the relation weight/deflection, we are satisfied with the result, since we manage to build a 2.5m structure using less than 15 boards of cardboard (1.0x0.70m per board)

In conclusion, throughout all the steps of this project- the planning, the building, the addings to the initial plan and the final deflection test, it became clear the importance of the subjects lectured on this semester, to guarantee the beam's proper and successful conception.