Topic 5: Scaffolding

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1. Introduction

Our topic is named scaffolding. Scaffolding, also called scaffold or staging, is a temporary structure used to support a work crew and materials to aid the construction, to maintain and repair buildings, bridges and all other human-made structures. We have to study a 2D structure in a grid of size m*n, as you can see in the Figure 1, which is composed of rhombuses made of merged bars which may be distorted. Our goal was to strengthen the rhombuses by adding the minimum number of diagonal bars in order to form a stable structure.

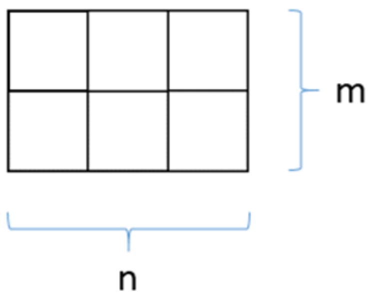

Figure 1: The model

2. Our research

2.1 Experimental approach

At the beginning we wanted to approach our problem in a practical way. We knew that we needed something flexible and easy to move so we made the bars from cardboard pieces, like the ones in Figure 2. After that we searched for something to connect the cardboard bars and we found some pieces in the store that work very well.

Figure 2: Materials

Furthermore, we started our experiments in order to solve the problem and discover new things based on the subject.

2.2 Analytical approach

2.2.1 Develop our findings

As we tested the cardboard pieces in order to find the minimum number of diagonals required to stabilise any kind of structure, we started to think of a possible rule. By trial and error, we decided to direct our approach to the easiest figure: a 3*3 squares, and develops our finding based on it. Firstly, we placed the diagonals on the smaller squares that formed the diagonals of our square just like in the following image.

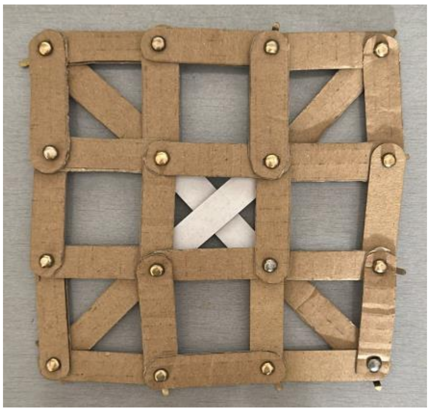

Figure 3: First trial

Thus, the structure was rigid and as we counted the number of squares on the length (m) and those on the width (n), we reached a conjecture which stated that the sought number of diagonals was m+n. But after all, our goal was to determine the minimum number, so another challenge occurred. It seemed quite unusual that the middle square was held by 2 diagonals forming an x, while other squares contained no diagonals at all. Therefore, we tried to take 1 diagonal out from the middle and the structure still remained stable, creating another rule.

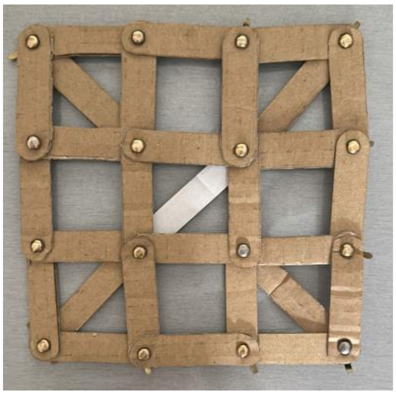

Figure 4: The structure that led to the conjecture

The discovered conjecture regarding the minimum number of diagonals became m+n-1, guiding our research towards a new perspective. Furthermore, by testing on more complex cardboard pieces, we established that 5the rule applied to rectangles as well. Taking everything into consideration, the final conjecture: m+n-1 determined the minimum number of diagonal bars needed for a figure to be stable. Then, we directed our attention to the way we place the diagonals.

2.2.2 The way we place the diagonals

After we found the number of diagonals that are required to make the scaffolding stable, we tried to think of the best way in which we can place them. In the first place, we positioned them from the corner and from there we put the diagonals in a parallel order as you can see in Figure 5.

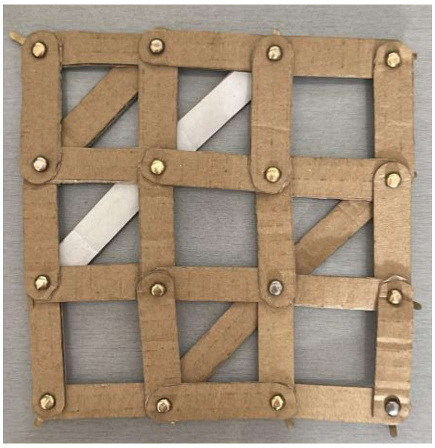

Figure 5: The initial pattern

As we tested further this arrangement, we discovered that for some bigger figures the diagonals necessary to make the structure rigid were not the number that the formula states.
Moreover, we thought that if we stabilise each line and each column the structure will be stable. The easiest way to do this is if we put the diagonals in a L form.

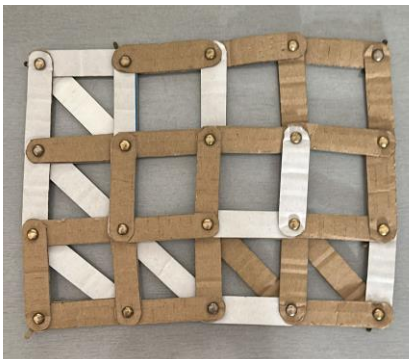

Figure 6: The pattern

2.2.3 Particular case

Throughout our research we discovered a particular case when the number of squares on the length or on the width is 1. As we created cardboard pieces following the rule, we noticed that in order for the structure to be stable we must place the diagonals in every single square. Thus, each square is held adamant by one diagonal and the number of them equals the total number of squares in the figure and also the rule that we discovered is respected . This case can be better visualised in the following figures:

Figure 7: Particular case example 1

Figure 8: Particular case example 2

3. Conclusion

Taking everything into consideration, as we studied this topic, we managed to determinate a conjecture and a pattern to help us stabilise the figures. It was a very interesting theme and we learnt to work together in order to discover new things. In the future we would like to study more the applications of scaffolding in different fields just as construction and architecture.