The structural model spring as a tool in the teaching of structures through qualitative analysis

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1 INTRODUCTION

In engineering and architecture courses, the disciplines in the area of structures value results from mathematical calculations and theorems, which is of paramount importance; however, the complexity of the themes taught in an analytical-theoretical way makes it difficult to understanding the behavior of the structures to the students, resulting in low learning or disincentive to a portion of students to follow this area and may even question their ability to continue on course.

According to Oliveira (2008, p. 9) ministering disciplines of structures exclusively by analytical means is insufficient, because it does not develop intuitive skills at the time of learning, thus disregarding the structure as a phenomenon. Therefore, the numbers should not act as trainers, but mainly as verifers valuing the qualitative sensesand the development of intuition.

Oliveira (2008 apud HILSON, 1972) recognizes the importance of professionals and students having the ability to visualize and understand how structures behave in different situations, which should improve their perception through trials (OLIVEIRA, 2008, p. 11).

According to Rebello (1992, p. 3), "it is very common for a newly graduated civil engineer not to know where to start a structural project [...]"; in this sense, the presentation of active concepts to the behavior of structures in a visual way, through models or prototypes used as a teaching tool for a pre-evaluation of structural behavior results in a greater learning by students.

In this context, this article aims to present, through the Structural Model1 the concepts related to the behavior of spatial structures in order to facilitate learning. Thus stimulating the interest of students for the tema, by participating more actively in the teaching process.

2 METHODOLOGY

This work adopts the basic research methodology, in which a teaching method is presented that can be used to minimize learning problems; and as a procedure the bibliographic research as a way to defend the use of Structural Model as a didactic-experimental prototype developed to provide students of disciplinestriggered the theory of structures and mechanics of solids, among others, the understanding of the behavior of structures evidencing the absorption capacity about structural concepts.

The Structural Model, created by the architect Márcio Serqueira became known as Mola2 , an interactive physical model that simulates the behavior of structures.

According to Marina (2010, p. 7) the concepts addressed in the classroom are realized through experimentation and visualization using the models. The use of the Structural Model is based on methods and philosophies of learning that stimulate "learning bydoing" (OLIVEIRA, 2008, p. 44).

Pinheiro (2000, p. 1) reinforces the importance of the "learn by doing" method by quoting Confucius3 : "I listened and forgot; I saw it and I remembered; I did and then I understood!"; According to Oliveira (2008, p. 48), the same method is used by american professor Paul G. Hewitt to teach the concepts of physics, by defending that it is necessary to improve the way of observing phenomena; the aforementioned author published in 1997 the book "Conceptual Physics" in which he applies several experiments that help in the understanding of physical concepts.

The direct contact with prototypes, like Mola, is that in addition to enriching learning, it promotes a more active participation of students (OLIVEIRA, 2008, p. 44). The practice of this exercise of assembling a structure and testing the effects that will be provoked is an innovative experience. Users can create their own solutions to structural problems and that way they will have the feeling of true learning.

> In cooperative learning, the student seeks the solution of his problems and, in doing so, builds at the same time, physically and mentally his own knowledge. [...] the development of prototypes from the initial disciplines of the mechanical engineering course, allows the student to know from an early age the methodology of engineering project development, allows the creation that of a global and interdisciplinary view of the course, stimulates scientific curiosity and becomes a powerful incentive to the student [...] (PINHEIRO, 2000, p. 7)

Through qualitative models , the study of structures becomes intuitive, since everything is done manually, from the assembly to the application of loads, and can be characterized by a simple touch. Thus, students can visualize the application of their calculations in practice, observing the deformations, displacements, resistance and all the behavior of the structure.

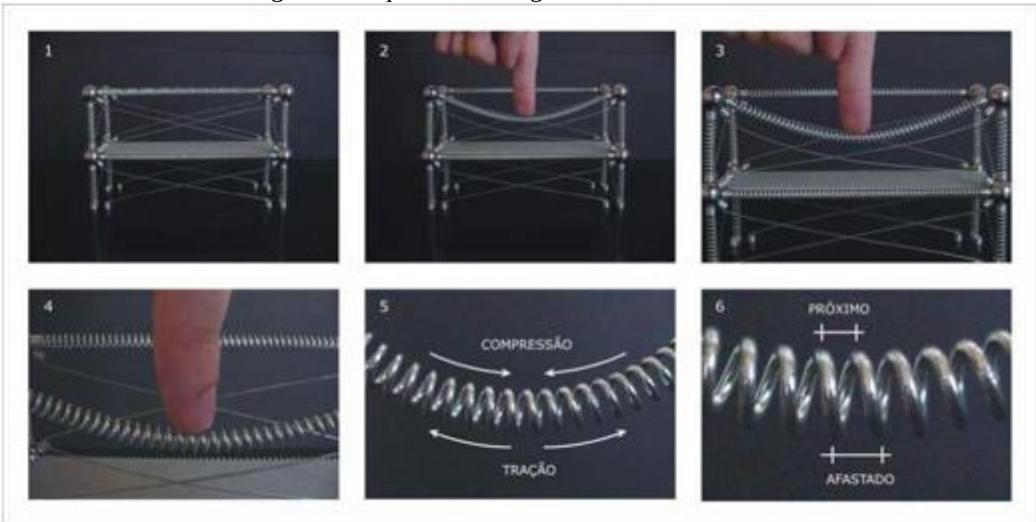
3 CONCLUSION

This section presents some applications performed with Mola in order to evidence the effects of loading on the structure, from structural systems that can be analyzed.

Example 1: Acting of an external force and the stresses generated on a beam: Bending, Traction and Compression

When a beam supported at extremities is subjected to the application of a load perpendicular to its axis it undergoes normal bending, traction and compression stresses; flexion is visually presented in a curved parabola shape, resulting in the deformation of the part. With the use of mola, it is possible to observe the effects of the active external force, as shown in Figure 1, both bending and traction, which is characterized by forces applied in directions opposite, increasing the size of the part and the compression, which is the opposite of traction, that is, the part decreases by forces applied to its axis.

Figure 1: Sequence of images of a beam's behavior

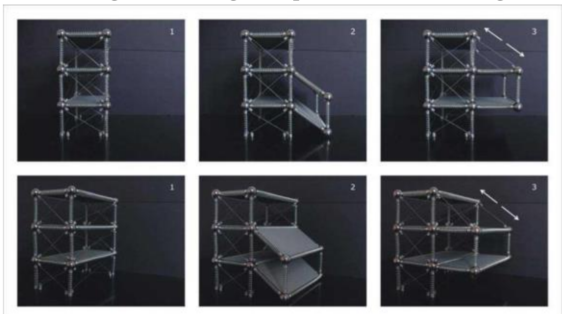


SOURCE: (OLIVEIRA, 2006, p. 6)

Example 2: Use of Lifter as a way to transmit tensile stresses

The lifter is a slender piece that has little resistance to bending and compression stresses. This part is used to support suspended covers and floors. Figure 2 shows how the lifter transmits all the loads from the pillars to the foundation. The use of Mola in this case showed how the application of the lifter could be understood in a practical way. In frame 2 there is a fallen floor that through the lifter could be erected, where this piece suffered traction because of the forces that are onthe floor act down and the forces in the connection with the kneecap of the upper floor that act upwards.

Figure 2 - Images showing the path of loads through tirantes.

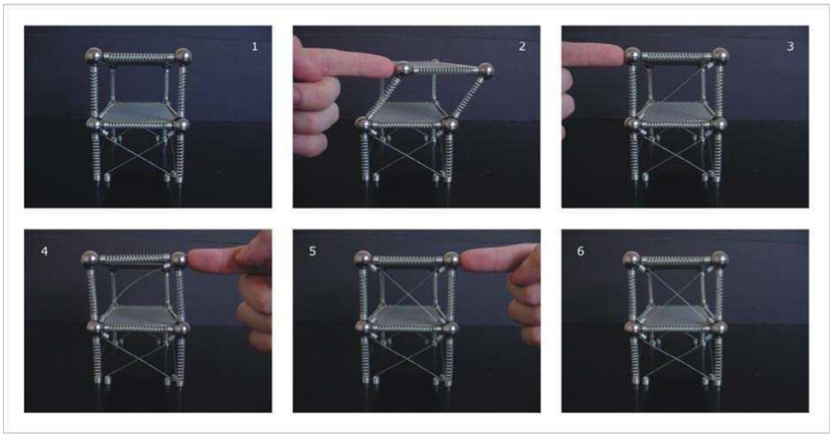


SOURCE: (OLIVEIRA, 2006, p. 6)

Example 3 : Use of Braces to Stabilize Structures

In order to resist lateral stresses such as winds for example, braces are used. This structural part provides stability to a system, avoiding displacement. Through Mola, it is possible to observe that the use of braces on the diagonals of the structure is able to make it undisplaceable. Figure 3 shows the compression effect in frame 4, because there is only one diagonal locked, while the next one is visually clear the X-shaped locking, a more stable shape.

Figure 3 - Operation of the Brace

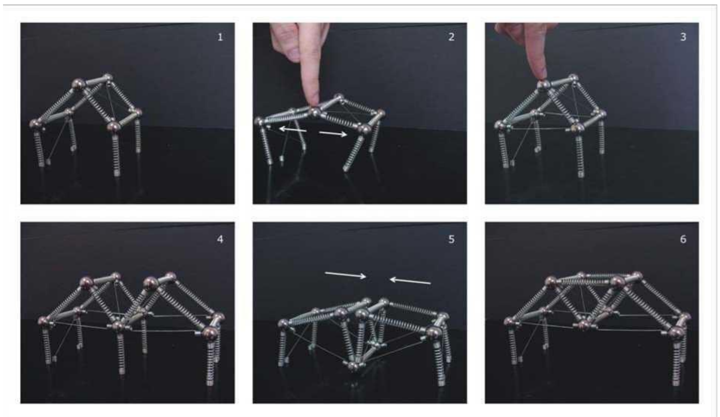


SOURCE: (OLIVEIRA, 2006, p. 7)

Example 4 : Use of Trusses for Structural Solutions

Truss is a structural system of bars joined by meio of nodes (connections) in triangular format. It is generally used in bridges, roofs and towers with the function of overcoming large spans. In General Mechanics and Structure Theory we work the efforts that act axially on the bars, that is, normal stresses, which can manifest as traction or compression. In the experiment using Mola, it is observed in table 2 of Figure 4, that when applying a vertical load on the structure the bars compress away the pillars of the original axis. However this problem is corrected by placing a bar between the pillars, this bar is traction and stabilizes the structure. Similarly, tables 5 and 6 are the solution to a problem when placing a bar to form a triangle, it is compressed in order to balance the structure.

Figure 4 - Behavior of a Truss



SOURCE: (OLIVEIRA, 2006, p. 8)

The use of the Mola Structural Model brought structural phenomena closer to the perception of human senses, because the influence of touch proved to be very important in understanding the behavior of the tested structures (OLIVEIRA, 2008, p. 155). For Pinheiro (2000, p.7) this form of education provides greater receptivity on the part ofthe al unos, encouraging them to interact between the various disciplines of the course and leading them to be interested in the area.

Thus, through these and other examples, Mola proved to be efficient for the qualitative evaluation of the deformations and displacements of the structures. The prototype is easy to assemble, which facilitates understanding of the functioning of the interaction of its elements (OLIVEIRA, 2008, p. 155). According to Oliveira (2008, p. 156) "the deformity of the springs used in the construction of the model parts proved to be decisive in the presentation of the behavior of the analyzed structures". In suma, oliveira agrees with Oliveira (2008, p. 157) by stating that Structural Model used to simulate the behavior of structural systems, presents practicality, versatility, reliability and applicability.

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