Learning Physics by Computer in an Architectural School

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ABSTRACT

A method is proposed for computerised problem-solving related to beam bending, using a programme of symbolic calculus. This approach permits easy posing of the equations to be solved.

The algebraic logicial enables the problem posed to be solved easily. The fact that the data can be entered in symbol form, not necessarily in numerical form, enables the student, when analysing the solution, to become familiar with the system behaviour, which is an essential aspect for support of the project task.

INTRODUCTION

Problems related to strength of materials have traditionally be tackled in different ways. In order to solve a good number of practical cases, the physical basis of the behaviour of materials involve a conceptually simple formulation as regards their mathematical content, but a cumbersome one from the calculus point of view.

Last century, complex methods to resolve the latter problem were devised. These were based on powerful results of physics, and make it possible to have profound understanding of the behaviour of systems. Because of their considerable educational and projectural interest, they have been brought into most teaching programmes on these subjects.

The arrival of computers made it possible to collect the original simple formulation so that complicated problems could be solved fast and surely.

The aim of this project is to present an educational approach, which by using modern programs of operational (algebraic) calculus for computers, will enable us to retrieve the simple approach to the problem, from the point of view of conceptual tools, belonging to numerical computation methods, without losing the projectural capacity of the former.

We shall show what this method of procedure consists of by implementing a proposal relating to training in the subject of bending. To do this, we shall start from the basic approach to the problem of beam bending, and then we shall show how by following the theoretical steps of reasoning and formulation, we can succeed in programming in a simple way the resolution to practically any problem. This will free the student from time and effort in solving particular examples, while he will he obliged to consider problems within the conceptual scheme of theory.

For problem-solving the program "Mathematica" will be used, because of the possibilities of operational calculus it offers, it being possible to combine them with those of numerical computation and graphic display. These possibilities make it possible to perform a followup of the conceptual lines in the approach to problems to be solved. Knowledge of programming and use of "Mathematica" required are minimal; on the other hand, of course, the programmes created by the inexperienced student in solving his problems will not be optimised.

GENERAL PROCEDURE

Let us consider the problem of a single beam, of constant cross section and a single material. Any type of support and any type of transverse load will be accepted.

We shall assume that in any section are fullfilled the suitable conditions for the equation

$$Y'' = \frac{M}{EI}$$

holds, where M is the bending moment on the section and y" the reverse of the curve radius of the neutral line in it, EI is the product of Young's modulus of the material times the moment of inertia of the section about the neutral axis.

The general procedure to he followed will he

1.- Choice of the sign convention to be followed, taking into account that vector calculus should strictly be used for equation formulation, and representation of quantities involved in the problem.

2.- Free body diagram for the whole system. Choice of unknown quantities representing the reactions. Equilibrium equations for the set. If the problem is statically undeterminated, the equations form an undetermined system.

3.- Free body diagram for a beam span in which a section is considered. Equations of shear force and bending moment. The different spans considered depend on the loads applied.

4.- From the expressions of the bending moment for the various beam spans, formulation of the integration relationships for the slope y' and for the neutral line y. Also enter the appropriate integration constants that are, for the present, unknown.

5.- Set up the boundary conditions relating to external ties.

6.- Set up the conditions of continuity between the different beam spans, that is, y' and y must be continuous functions of x.

7.- Resolution of the system made up by the equations written in 2, 5 and 6, by means of the program "Mathematica". The result will give us the value of the reactions and the integration constants. With this, the various functions involved in the problem (bending moments, y', y, ...) will be fully determined.

8.- Graph, if desired, of the results, using the program's graphic option. According to what has been said so far, it is possible to have any function of those involved in the program, and therefore it will also be possible to draw a graph (for example the bending moment in terms of x).

CONCLUSIONS

By applying the procedure described in the above section, it is easy to solve problems related to the bending of beams subject to transverse loads, in cases where approximation of pure bending is relevant.

It is necessary to stress that there is no difference either in approach to or execution of isostatic problems from those that are statically undeterminated. This fact shows one of the method's advantages.

The algebraic logicial enables the data to be entered in symbol form and so the solutions will depend on these parameters. Seeing how the result obtained for several values of these parameters varies makes it possible to obtain an abstract understanding of the problem which is generally difficult to achieve by other methods.

Finally, we equally successfully applied this approach to the study of framework deformation, among others, which assures us of the methods's educational capacity and usefulness.

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