Development of a Computer Program for Column Analysis

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Abstract

The conventional method of carrying out structural analysis of columns is tedious and time consuming, as it is characterized by sourcing for the design data and long processes of manipulation. This therefore necessitates the development of a computer program for structural analysis of columns. Visual Basic development tool was used in the program development. The fundamental principles of strength of materials were used in the program modeling. The program was designed to accept inputs through an assisting wizard. Sample problems were used to test the program and obtained results were analyzed. The obtained results were in agreement with the exact solutions.

Keywords*: Column analysis, buckling, slenderness ratio, Visual Basic.*

Introduction

According to French (1995), columns are structural members that carry their loads axially rather than transversely. Columns may be: short and fat columns (Fig. 1), when loaded to such a point that the load actually crushes the materials; long and slender columns (Fig. 2) which are more likely to buckle under the higher axial loads; or beam columns (Fig. 3).

Program Requirements (Hardware and Software)

For a personal computer (PC) to run a computer program for structural analysis of columns, it is a matter of choice to have Windows operating system installed. Windows is a graphical user system and as such requires a substantial processor speed and memory to operate efficiently. A large hard disk is generally needed for Windows applications to facilitate easy access to needed and stored files. A VGA/SVGA screen display is required to enhance the quality of graphics output.

The program could be developed using application/education-oriented programming languages such as Pascal (Holmes 2000) or Visual Basic (Microsoft Corporation 1997).

A person with basic knowledge of engineering mechanics and basic window environment knowledge should conveniently use such program.

Hopefully, the majority of users are familiar with windows, word processing and graphics packages (e.g., exploring windows using Windows Explorer, Paint Brush, etc.) and would be able to install and use the developed software with minimal efforts.

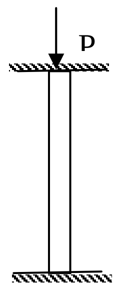

Fig. 1. Short column with fixed ends.

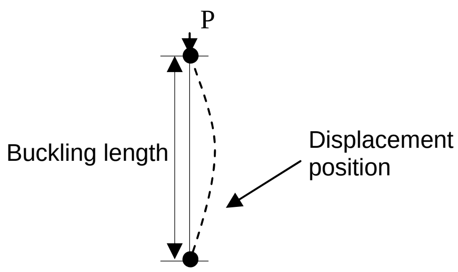

Fig. 2. Long slender column with pinned ends.

Fig.3. Beam column.

Need for the Program

The need for a computer software to assist in solving mechanics problems is obvious for the fact that engineering mechanics problems require long computations and graphical results. These processes are complicated and time consuming. With the attainment of the computer age, there is need for replacement of traditional way of solving engineering problems in a computerized (i.e., more modern) way, so as to reap the benefits accrued in the use of computers (such as time saving, accuracy, versatility, efficiency and reliability).

One of the problems of the traditional problem solving process is the long and complex manipulation process, which is easily and accurately handled by computers.

Theoretical Analysis

The analysis presented here will be based on SI units, but the program will be designed to accept and convert other standard units of measurement.

The analyses presented here are on long slender column with the following end conditions:

- Clamped-free columns;
- Clamped-pinned columns;
- Clamped-clamped column;
- Pin ended column;
- Pin ended beam-column;
- Eccentrically loaded columns;
- Cantilever columns.

Column Buckling Loads

According to Shames (1996), a column carrying an increasing load will reach a time in which the deflection can be considered to be large. At that time the load can be considered critical, i.e., the load which causes the column to attain a condition of neutral equilibrium. The critical load of a column depends on the end condition. Euler's equation (Eq. 1) is used to establish some critical loads shown in Table 1:

$$d^2M/dx^2 + M/EI = 0, \qquad (1)$$

where: M = moment variable of the column; I = moment of inertia of beam; and E = Young modulus of elasticity.

Table 1. Showing column end conditions and formulas.

S/no	Column end condition	Critical load
1	Clamped-Free	$= \pi^2 E I / 4 L^2$
2	Clamped – Pinned	$= 2.05\pi^2 E I / L^2$
3	Clamped – Clamped	$= 4\pi^2 E I / L^2$
4	Pinned ended	$= \pi^2 E I / L^2$

Design Factors

The design of a column requires the determination of the maximum axial load allowable. This depends on the column material and the slenderness ratio of the column. Majorities of columns are designed by reference to tables of permissible stress standards available in engineering design manuals. The critical load for a column depends on its cross-sectional dimensions.

Slenderness Ratio

The slenderness ratio involves not only height or length of the column, but also the size and shape of its cross-section and the end conditions.

The slenderness ratio of a column is the ratio of the effective length of the column to the least width of the column.

Software Development and Environments

Software is what breath life into the computer. It make each hardware to function well and also allow a specific application of computer possible. Without good and efficient software a computer will be good for nothing.

Software Development Steps

Software development process entails converting broad system specification into usable machine instructions that produce desired results. It is a challenging process that does not begin and end with the writing and/or keying of lines of code. A program designer must follow a series of steps before they can use computers to perform useful work. These steps are (French 1996; Rilwan 2004):

- **Defining The Need**
  The particular problem to be solved, or the tasks to be accomplished must be clearly defined (for example "Computer Aided Structural Analysis)". In an ideal situation, the users of the program a professional in that field and data processing specialist work together in defining the need.
- **System Analysis**
  At this stage, data pertaining to the problem is gathered with data acquisition and analyzed.
- **System Design**
  A system (i.e., programming sequence) required to achieve the need through the data gathered and analyzed is designed. The design specification include desired output, input, and the general processing procedures, computation, logical structure, simple sequence structures, selector structures, loop structures, branch structures, etc.
- **Programming Analysis**
  The system specification is further broken down into the input/output (I/O), calculations, logical/comparison and storage/retrieval operations required to satisfy the need. Also, at this stage the desired eutectic designs are conceived, such as form, size and colors, control arrangement of controls on forms, etc.
- **Program Preparation**
  The mathematical modeling (i.e., analysis) in is translated and coded in a form acceptable to the compiler (i.e., high level language). This stage involves testing a translated code by interpreter and each module by a compiler to see that all modules perform their various functions.
- **Testing And Implementation**
  The coded program is checked for errors (e.g., syntax and logical errors) by testing each module and the overall program prior to being compiled and made into a executable file for use on a routine basis. During the testing process, sample data are entered and the output results are compared with other sources.
- **Program Maintenance**
  Maintenance modules for future modifications and improvements are provided. Also, a help module is being provided containing basic guidelines.

Structure of the Program

MDI Form

The program was designed on one Multi Document Interface (MDI) form (Microsoft Corporation 1997), with two MDI child forms interrelated for easy data transfer and efficient setup. The MDI form contains some controls fashioned to ease the problem definition. It contains controls like picture box, labels, frames, command buttons, textboxes, option button, and menu (Fig. 4).

Form 1 (Output Screen)

This is an MDI child with control buttons. On this form, column design parameters are obtained based on the design intended on the screen (Fig. 5).

Program Flowchart

The flow sequence of the program is shown in Fig. 6 starting from selecting the type of the column down to the output results.

Installing, Testing and Discussion of Results

Program Installation

The software was compiled and burned onto compact disks (CD plates).

To successfully install the software, the completion of the following steps is necessary:

- Insert the CD plate containing the installer into the CD-ROM drive.
- If it does not auto run, open the file sleandercollumn.exe from the CD-ROM.
- Follow the installation wizard screens and read carefully the instructions to the end.

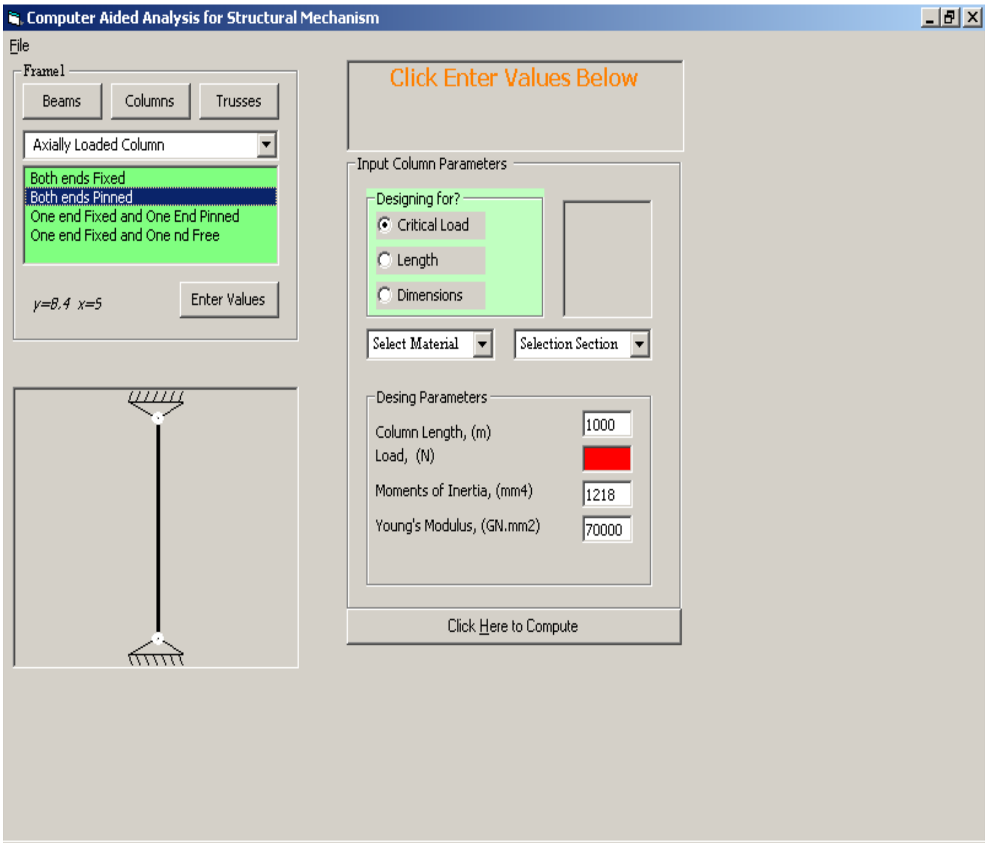

Fig. 4. Main screen.

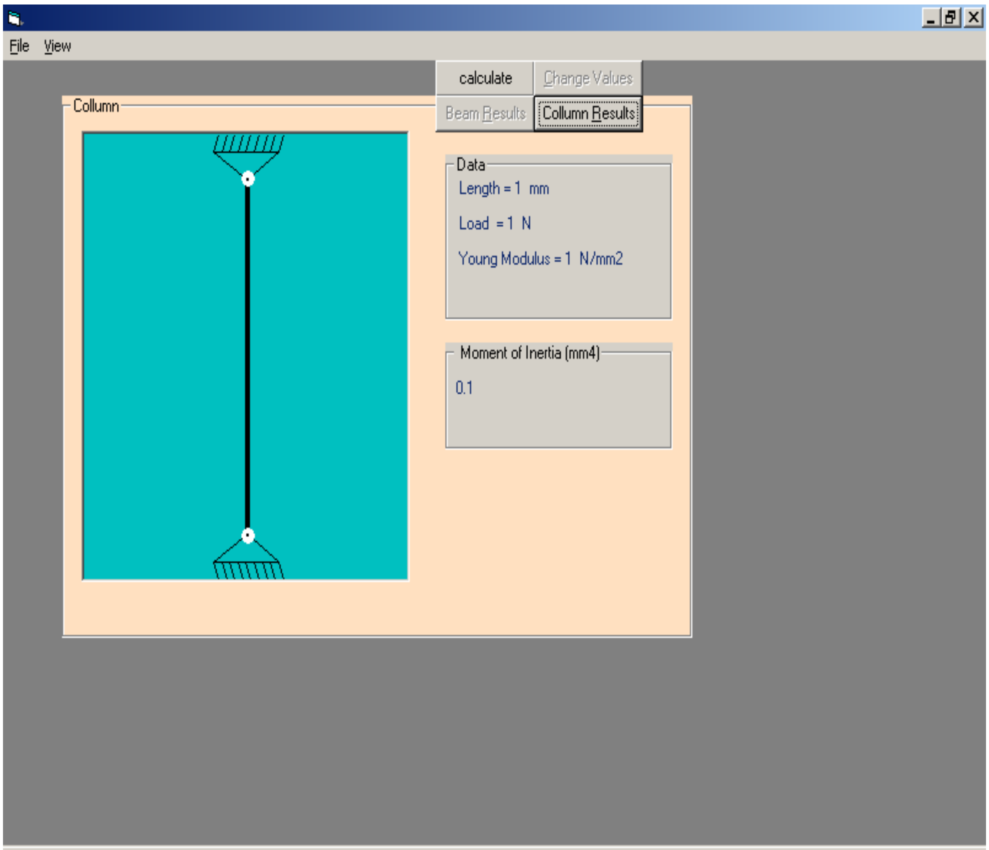

Fig. 5. Output screen.

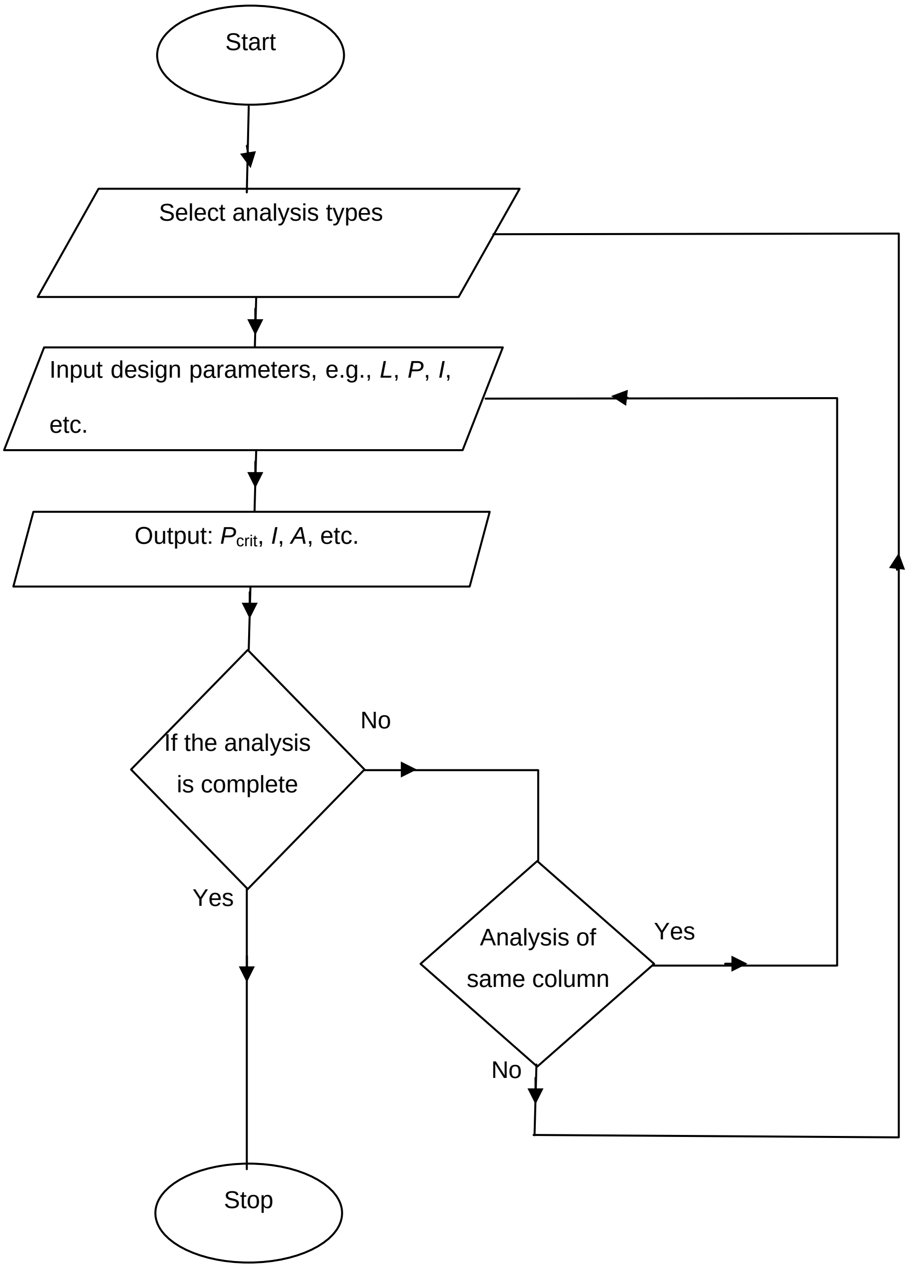

Fig. 6. A flow chart of the computer program.

Program Testing.

The compiled and installed program was tested with several sample data sets obtained from mechanics textbooks (Khurmi 2000; Durka *et al*. 1996; Ryder 1969; Seward 1998).

The testing was done in order to compare the program output with conventional results found in textbooks. If the computational results coincide with known numerical results in a number of selected clear-cut private cases for which exact analytical solutions are known, this is an indication that the program would provide reliable data for arbitrary scenarios.

Results and Discussion

Various input data were fed into the program and the obtained computational results of the tests are identical with the results from the sources, the small differences occur as a result of round-off error. And due to such negligible discrepancies, it can be estimated that the program would function properly with arbitrary input data.

As an illustration, the data used to test the program (column with both ends pinned) result in a solution (Fig. 7) which is equivalent to the one (Fig. 8) given also by Seward (1998).

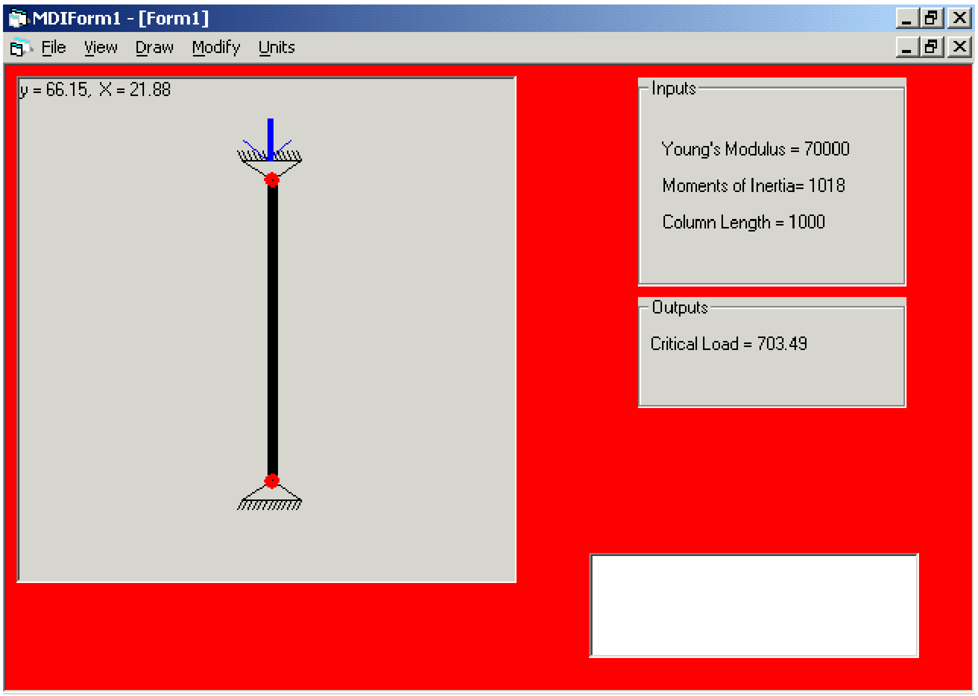

Fig. 7. Sample problem and solution for a column with both ends pinned.

Example 8.2

Determine the critical Euler buckling load of a solid aluminium rod of diameter 12 mm if it has a length of 1.0 m between pin-ended supports.

Solution

From *[8.9]* $P_{crit} = \frac{\pi^2 EI}{L^2}$

From *table 3.4* E = 70 000 N/mm^2

From *figure 7.31* I = $\pi r^4/4 = \pi \text{ x } 6^4/4 = 1018$ mm^4

Therefore $P_{crit} = \frac{\pi^2 \times 70000 \times 1018}{1000^2} = 703 \text{ N}$

Answer Critical Euler buckling load = 0.703 kN

Fig. 8. Sample problem and solution. Source: Seward (1998).

Summary, Conclusion and Recommendations

Summary

A program for structural analysis of columns was successfully developed. The programming development process does not just involve analysis and coding of programs, but also requires tedious piping and debugging process, followed by program compilation.

The most difficult problem encountered in this work was at the modeling stage (that is, trying to adopt standards of analysis from various sources).

Conclusion

In the face of numerous constraints, this work was brought to a practical level, i.e., an operational computer program for column analysis was developed based on fundamental concepts of structural mechanics.

The executable program (SLENDERCOLLUMN.EXE) is 324KB in size, while the compiled program ready for installation is comprised of cabinet files, two setup files and a text file (i.e., SLENDERCOLLUMN.CAB, SC1.CAB, SC2.CAB, SC3.CAB, SETUP.1ST, SETUP.EXE and README.TXT), all amounting to 15.8MB in size. It will take maximum of a few minutes per problem to obtain results when using the program.

This software is in close conformity to other existing application programs, and is fashioned to simplify most aspects of structural mechanics discussed earlier. It is hoped to be of some help to engineering professionals.

Recommendations

The room for further improvements in this program could be in the following areas:

- Interfacing with other graphics software;
- Accommodating more types of column problems;
- Statically indeterminate problems should be accommodated.

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