

Development of Design Spreadsheet Tool for R.C.C. Beam Design using V.B.A.

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Abstract

The design methodology in light of Limit State Method includes various mathematical statements and parameters, which makes the outline handle a confusing and repetitive undertaking. Additionally, outline being a trialing procedure is extremely repetitive and time-consuming in nature. Henceforth utilization of spreadsheets can decrease the time and effort of a planner/build widely. On account of the minimization and compliance, spreadsheets have turned into one of the best choices for a designer, notwithstanding the accessibility of number of standard configuration programming packages. The primary point of this undertaking is to set up a Microsoft Excel Spreadsheet using VBA Programming which will allow user to

- 1) Analyse a beam for Shear Force, Bending Moment, Slope & Deflection for various End Conditions and for different load patterns.
- 2) To analyse a beam for its Safe Load Carrying Capacity
- 3) To Design RCC Beams

The result of this venture will be an outline apparatus, which can be advantageously utilized by a specialist to analyse and design a RCC beam.

Keywords: Spreadsheet Design Tool, V.B.A, R.C.C. Beam, Reinforcement, Design

I. INTRODUCTION

Design of members and structures of reinforced concrete is a problem separate from but closely related to analysis. Strictly speaking, it is almost impossible to precisely analyze a concrete structure, and to design accurately is no less difficult. Luckily, we can make a few fundamental assumptions which make the design of reinforced concrete quite simple, if not easy. A problem sole to the design of reinforced concrete structures is the need to detail each member throughout. Steel structures, in general, require only the detailed design of connections.

For concrete structures, we must determine not only the area of longitudinal and lateral reinforcement required in each member, but also the way to best arrange and connect the reinforcement to insure acceptable structural performance.

The design methodology based on Limit State Method involves a prior assumption over which design of certain member is carried out which involves numerous equations and parameters. After reaching a satisfactory result for Area of Member and Area of Steel, this result which was obtained as use of prior assumption is checked, failing which same design process is repeated using revised assumption. Thus, Design process is a trial and error process and is repetitive in nature.

Since, manual design procedures are very tedious and involves complex calculation steps, various design software's are used to enhance working of as Structure Engineer. But Design Software's have their own advantages and disadvantages. Sometimes for very small problems a design software may not be used due to their limitations and in such cases a Design Spread Sheet may serve as a perfect option as a design tool. Also, use of spreadsheets can reduce the time and effort of a designer/engineer considerably. So, the main aim of this project is to prepare a Microsoft Excel Spreadsheet which will entail a detailed design of RCC Beams.

A. Introduction to Visual Basics for Applications (VBA)

VBA is the acronym for Visual Basic for Applications. It is an incorporation of the Microsoft's event-driven programming language Visual Basic with Microsoft Office applications such as Microsoft Excel, Microsoft Word, Microsoft PowerPoint and more. By running Visual Basic IDE within the Microsoft Office applications, we can build tailored solutions and programs to enhance the capabilities of those applications.

Among the Visual Basic for applications, Microsoft Excel VBA is the most popular. Using Excel VBA, one can build custom made functions to accompaniment the built-in formulas and functions of Microsoft Excel. Although MS Excel has many built-in formulas and functions, they are not enough for certain composite calculations and applications. In simple words by using VBA all together with MS Excel one can develop tailored solutions for many problems.

B. Advantages of Using Excel with VBA

- 1) One can make his own tailored programs which include sets of functions and formulas all bind up with a VBA Programs

- 2) If a VBA program is well created, a person with no information of VBA can operate it without any difficulty
- 3) One can do things in Excel that are otherwise not possible
- 4) Looping or iteration process is possible in Excel Sheets only with use of VBA
- 5) Data Analysis becomes more easy and systematic with use of VBA
- 6) While writing complex calculations, use of VBA program can minimize the chances of accidental changes in cell while working.

C. Importance of Spreadsheet as a Design Tool

Despite the availability of many influential structural design software packages that flawlessly integrate analysis and design, spreadsheet applications are among the most extensively used computational tools in the world of engineering and science. Conventionally, engineers have used spreadsheets to solve special and complex analysis and design problems that are not outfitted in commercial packages or to perform simple and repetitive tasks that would not have been as efficiently accomplished if they were tackled otherwise. Spreadsheets are relatively easy to learn and use, allow adequate flexibility for mixing text, graphics, and charts into the solution document that they produce, and provide a powerful and user-friendly platform for the development of simple to fairly complex analysis and design applications.

D. Advantages of Using Design Spreadsheet over Design Software's

- 1) Unlike design software, spreadsheets can be made for a specific problem.
- 2) The Design Software require proper training to use them, however a spreadsheet is designed properly it can be used without any prior training.
- 3) Design Software are costly and have copyright issues.
- 4) Spreadsheet are totally customizable as per requirement of user.
- 5) Design Spreadsheet can run on any system with running Microsoft Office, hence require no installation prior to use.

II. PROBLEM OVERVIEW

The basic aim behind writing this paper is to develop a spreadsheet tool in MS Excel using Visual Basic Application, which will let user to analyses as well as design RCC Beam. The spreadsheet design is basically based on the various characteristics of MS Excel along with development in Visual Basic Editor Environment. The spreadsheet includes all the numerical functions and mathematical relations and expressions for different design methodologies.

III. OVERVIEW OF DEVELOPED SPREADSHEET

The developed Design Spreadsheet contains four modules excluding Main Menu, which let the user easily toggle between different modules, by just clicking the respected button. (Figure: 1)



Fig. 1: Snapshot of Main Menu of Design Tool

- 1) Module: 1 Analysis of Beam: This module deals with analysis of beam. It let user to find Shear Force, Bending Moment, Slope and Deflection. User can generate Diagrams for same and can also find specific values of Shear Force, Bending Moment, Slope and Deflection at desired span of beam.

These diagrams are important in structural engineering as they show not only the variation of the internal forces along the length of the structural member but also the most critical values that the structural engineer needs to design the relevant structural member. They are the most popular techniques to show the changes in the internal forces of a structural member along its length. These

diagrams are obtained using the relationships between the external loads on the member and the internal forces generated in the member. Then equations of equilibrium are applied to ensure equilibrium is satisfied. The shearing forces and the ending moments obtained are basically the internal stress distribution resultants.

User can also change restraining support conditions and loading patterns.

2) Module: 2 Load Carrying Capacity of Beam: In cases when engineer has to determine load carrying capacity of pre-constructed or existing beam, calculations have to be made to find out the same. This module deals with the same.

In this module user has to enter details like size of beam, Area of Steel, grade of Steel and grade of Concrete. The tool will determine the beam is under reinforced or over reinforced. Also, it will determine what is the moment that beam can easily support depending upon the reinforcement.

The module allows user to select whether the beam is Singly Reinforced or Doubly Reinforced. In case of doubly Reinforced Beam user has to input additional data like Area of Compression Steel and effective cover to compression steel.

User can also find the safe load carrying capacity by entering the length of the beam.

3) Module 3: Beam Design: This spread sheet deals with design of RCC Beams. The user is allowed to enter data like type of Reinforcement Singly or Doubly Reinforced, Type of beam Simply Supported or Cantilever. Width of beam, length, Load, Grade of Concrete and Steel.

The tool upon entering all these fields will incorporate the design for flexure and shear.

4) Module 4: Continuous Beam Design: This spreadsheet aims to design a continuous beam.

The User has to enter effective length of Beam, load, width of support, and Grade of steel and concrete for which spread sheet will calculate the negative as well as positive reinforcement in flexure. Also, the sheet will calculate the shear reinforcement at intermediate and end support.

IV. OPERATING SPREADSHHET DESIGN TOOL

This section particularly deals with the process by use of which spread sheet should be operated.

Since, the design spreadsheet is outcome of use of programming in VB Editor, the spreadsheet contains visual basic programming language and there by saved as Microsoft Excel Binary Worksheet. The user must, therefore check first the “Enable Content” Button located below the ribbon of the spreadsheet. Some programming procedure run upon opening of the workbook, thus the user is suggested to always enable the macros content of this program. Figure

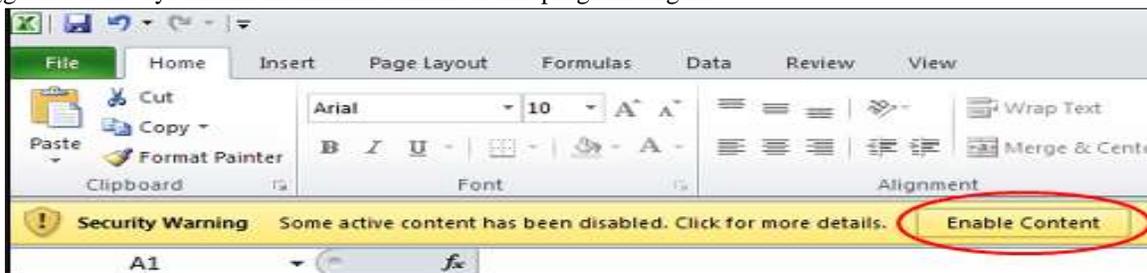


Fig. 2: Enable Content Option

Now, as discussed earlier, the design spreadsheet contains four modules. As we open the design Spreadsheet the Main Menu Page Opens Figure below, shows the appearance of the main menu as it appears once opened.



Fig. 3: Main Menu Page

Click on the respected button to open the desired Tab.

A. Operating Module: 1, Analysis of Beam

As discussed earlier this module deals with analysis of beam.

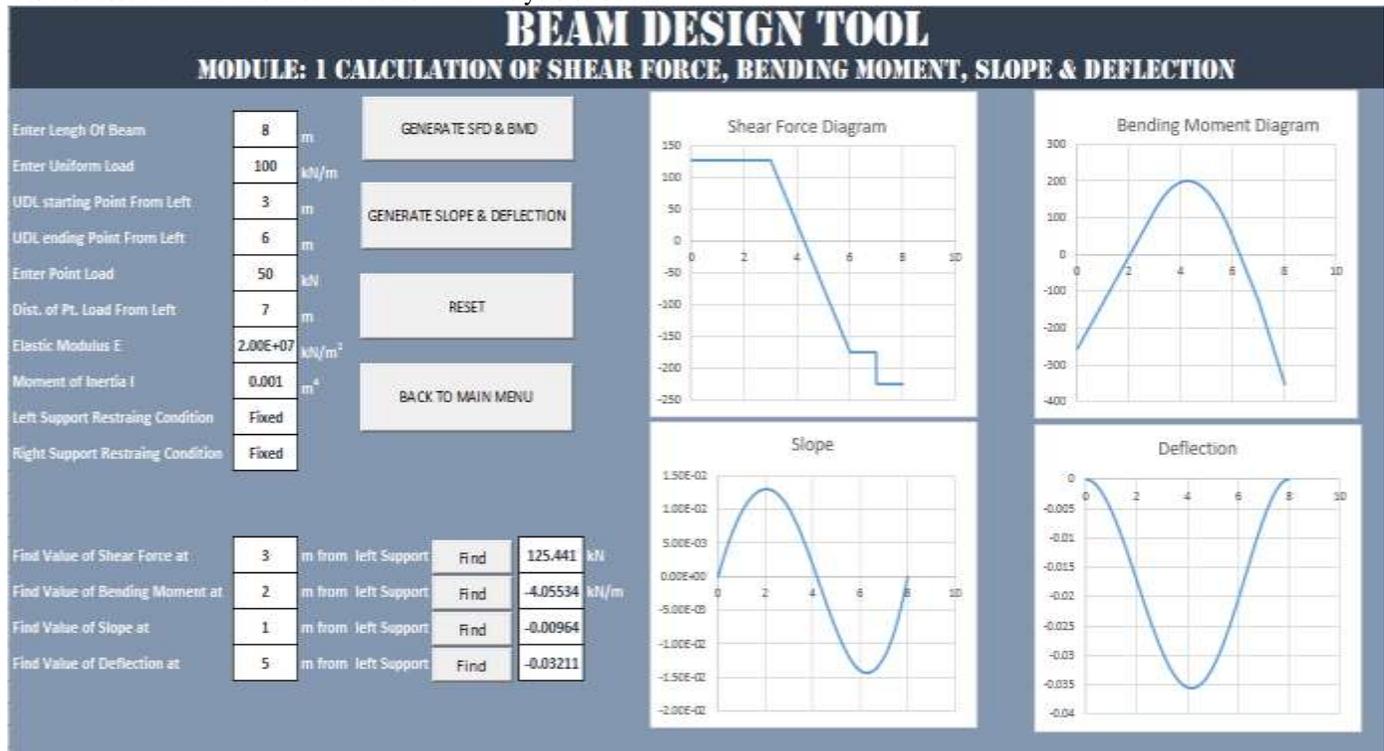


Fig. 4: Snapshot of Analysis of Beam Module

As can be seen from the figure the spreadsheet contains following

- 1) Input Box: To input following data
 - 1) Length of Beam
 - 2) Value of Uniform Load and its Location
 - 3) Intensity of Point Load and its location
 - 4) Elastic Modulus
 - 5) Moment of Inertia
 - 6) Left and Right Support Restraining Condition which allows user to select between Simply Supported Beam, Fixed Beam, Cantilever Beam and Propped Cantilever beam.
- 2) Graphs which shows graphical representation of Shear Force, Bending Moment, Slope and Deflection.
- 3) Scroll Select: User can click over Enter Uniform Distributed Load and select between Uniformly Distributed Load and Uniformly Varying Load. However, in case of Uniformly Varying Load user can not select the span it will act over, i.e. it will act over the whole span. It is one of the limitations of the programme.
- 4) Buttons: Sheet Primarily contains five Buttons, namely
 - 1) Generate SFD & BMD: After entering data in input box, clicking on the button will generate SFD and BMD, the calculation of Shear Force and Bending Moment will occur only on clicking upon the button.
 - 2) Generate Slope & Deflection: After entering data in input box, clicking on the button will generate Slope and Deflection Graphs, the calculation of Slope and Deflection will occur only on clicking upon the button.
 - 3) Reset: Clicking upon this button will reset all the values to zero and will bring the sheet to its original form.
 - 4) Back to Main Menu: Clicking upon this button will close Analysis of Beam Tab and will reopen the Main Menu sheet.
 - 5) Find Button: This button is used to find the value of Shear Force, Bending Moment, Slope and Deflection on desired entered location.

B. Operating Module: 2, Load carrying Capacity of Beam

This Module is used to determine whether the beam is under reinforced or over reinforced. Also, it can find safe load carrying capacity of beam.



Fig. 5: Snap Shot of Module: 2

As can be seen from the figure the spread sheet contains following

- 1) Input Box: To input following data
 - 1) Type of Reinforcement: This allows user to Select between two options Singly Reinforced or Doubly Reinforced.
 - 2) Width of Beam
 - 3) Depth of Beam
 - 4) Grade of Steel: Allows user to select between Fe250, Fe415 and Fe500
 - 5) Grade of Concrete: Allows user to select between M20, M25 and M30.
- 2) Buttons
 - 1) Find Moment of Resistance: Clicking upon this button will find Moment of Resistance.
 - 2) Find load Carrying Capacity: This will calculate the load carrying capacity.
- 3) Input Box: The additional information will be entered through input boxes.

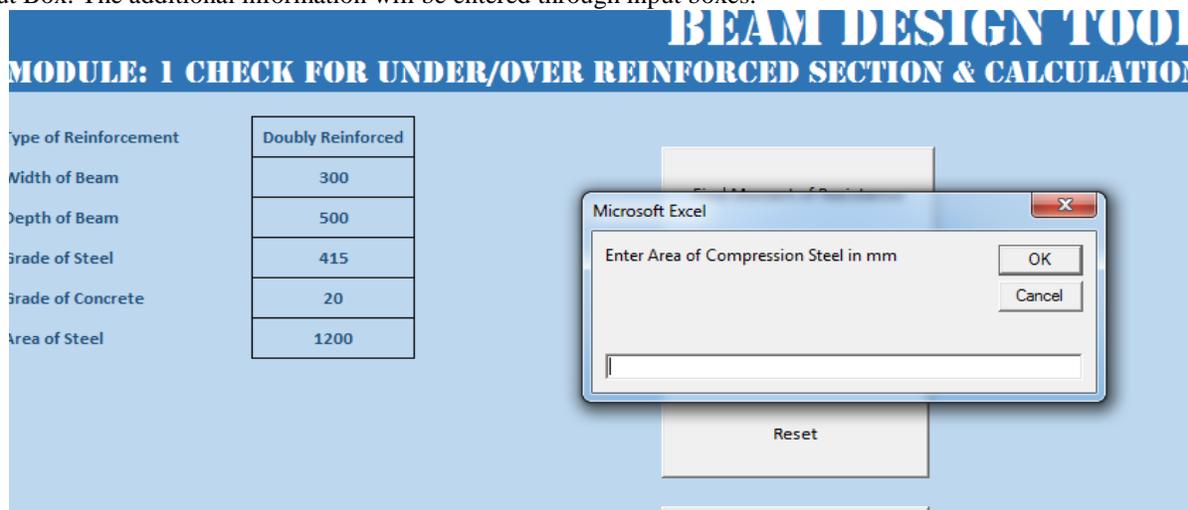


Fig. 6: Input Box for entering additional data

When Doubly Reinforced Beam is selected, additional data like Area of Compression Steel and Effective cover to compression steel is entered through input box.

- 4) Message Box: The Results or Output is displayed through Message Box.

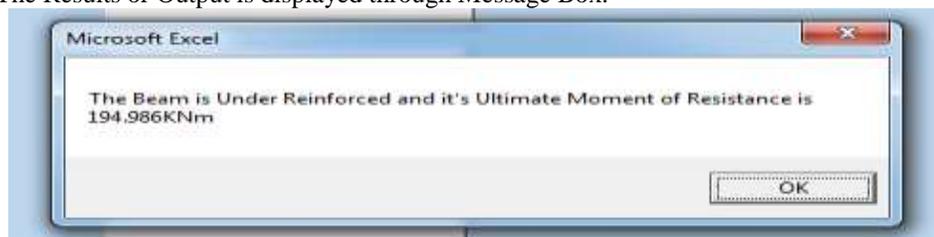


Fig. 7: Message Box for output display

C. Operating Module: 3, Design of Single/Doubly RCC Beam – Simply Supported/ Cantilever Beam

This module deals with the design of Singly/doubly Reinforced- Simply Supported/ Cantilever Beam.

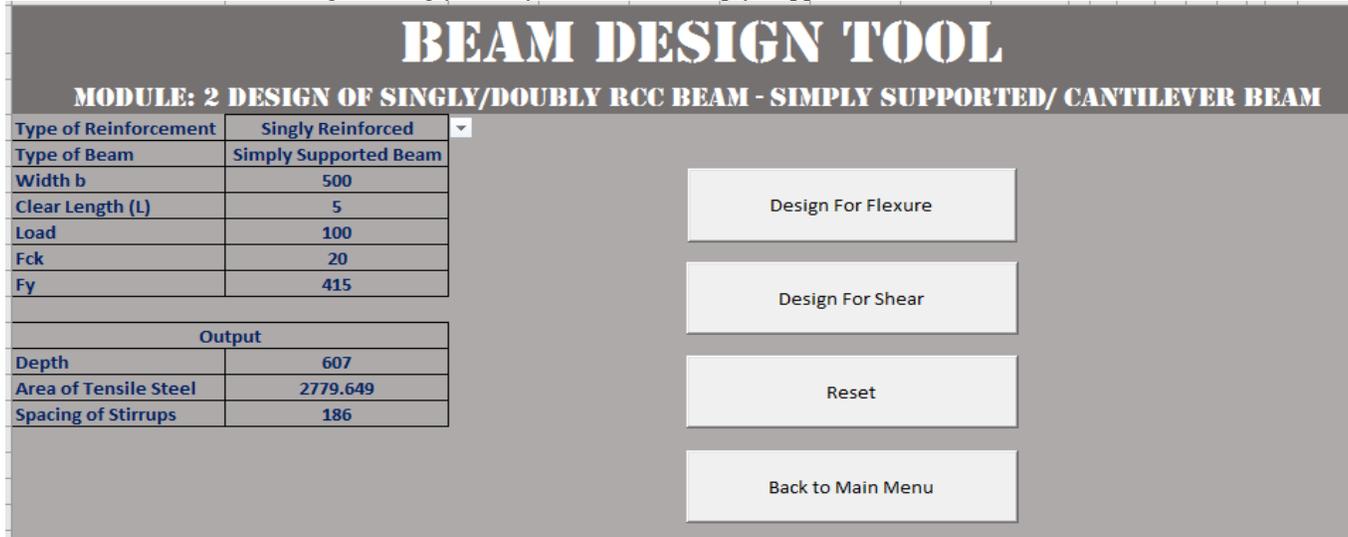


Fig. 8: Snap shot of Module: 3

As can be seen from the figure the spreadsheet contains following

- 1) Input Box: To input following data
 - 1) Type of Reinforcement: This section allows user to select between Singly Reinforced and Doubly Reinforced Beam.
 - 2) Type of Beam: This section allows user to select between Simply Supported and Cantilever Beam.
 - 3) Width
 - 4) Clear Length
 - 5) Load: Live Load is to be entered in this section
 - 6) Grade of Concrete: user must select between M20, M25 and M30
 - 7) Grade of steel: user must select between Fe-250, Fe-415 and Fe-500.
- 2) Buttons
 - 1) Design for Flexure: Clicking upon this button will perform design for flexure and will calculate Depth of the Beam and area of Tensile Steel.
 - 2) Design for Shear: Clicking upon this button will perform design for Shear and will ask for selecting diameter of bars to be used for vertical reinforcement.
- 3) Input Box: The additional information will be entered through input boxes. Like Selection of diameter of bars to be used for vertical reinforcement (Stirrups).

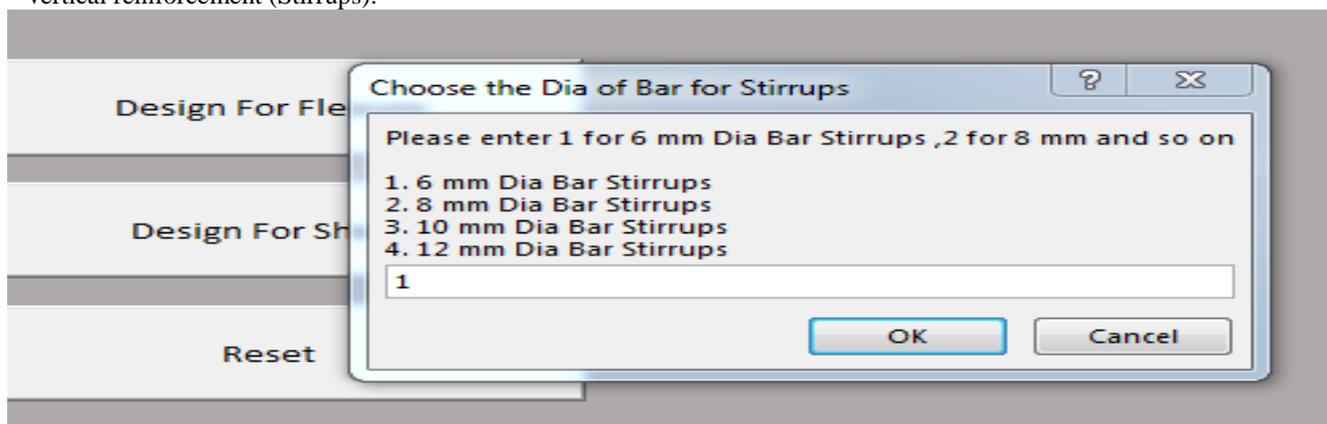


Fig. 9: Snaps shot of Selection of Dia. Of Bars for Stirrups.

- 4) Message Box: Any other additional information is displayed by use of Message Box.

D. Operating Module: 4, Design of RCC Continuous Beam

This module deals with the design of Continuous Beam.

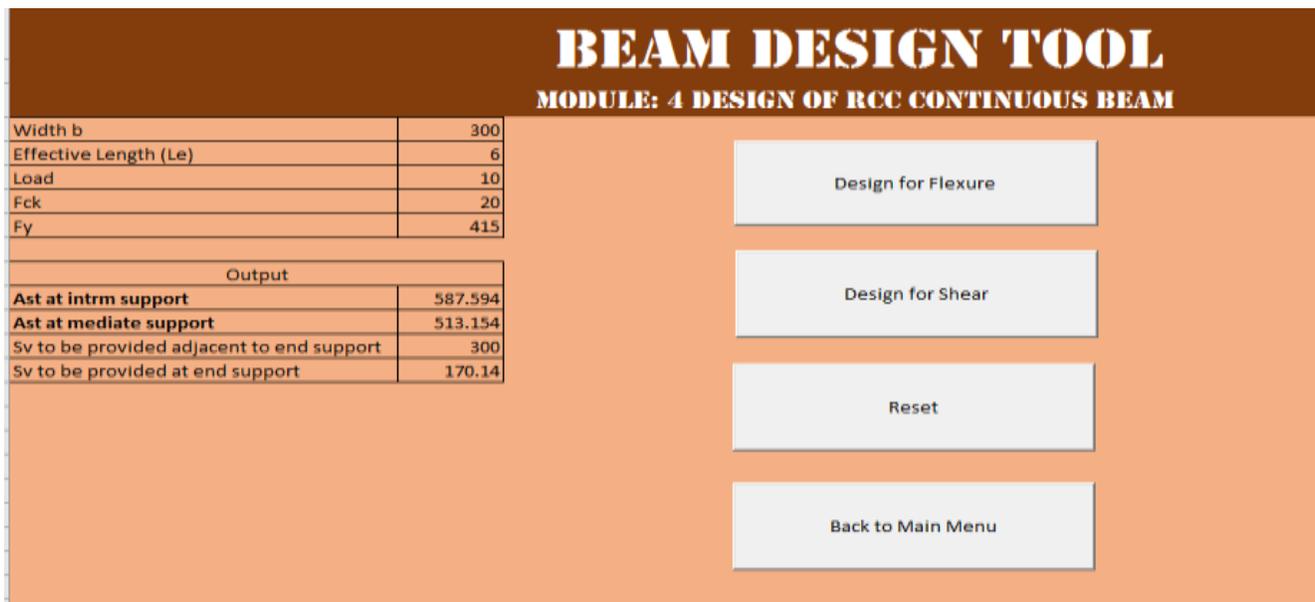


Fig. 10: Snapshot of Module: 4

As can be seen from the figure the spread sheet contains following

- 1) Input Box: To input following data
 - 1) Width
 - 2) Effective Length
 - 3) Load: Live Load is to be entered in this section
 - 4) Grade of Concrete: user must select between M20, M25 and M30
 - 5) Grade of steel: user must select between Fe-250, Fe-415 and Fe-500.
- 2) Buttons
 - 6) Design for Flexure: Clicking upon this button will perform design for flexure and will calculate Depth of the Beam and area of Tensile Steel.
 - 7) Design for Shear: Clicking upon this button will perform design for Shear and will ask for selecting diameter of bars to be used for vertical reinforcement.
- 3) Input Box: The additional information will be entered through input boxes. Like Selection of diameter of bars to be used for vertical reinforcement (Stirrups).
- 4) Message Box: Any other additional information is displayed by use of Message Box.

V. IMPLIMENTATION OF DESIGN (PROGRAMMING CODE) IN VB EDITOR

To prepare design spreadsheet programming was done in VB Editor. This Chapter deals with the same. The programming code is mentioned here:

A. Programming Code for Module: 1

Analysis of Beam. The snapshot of programming code written for developing the spreadsheet is mentioned below:

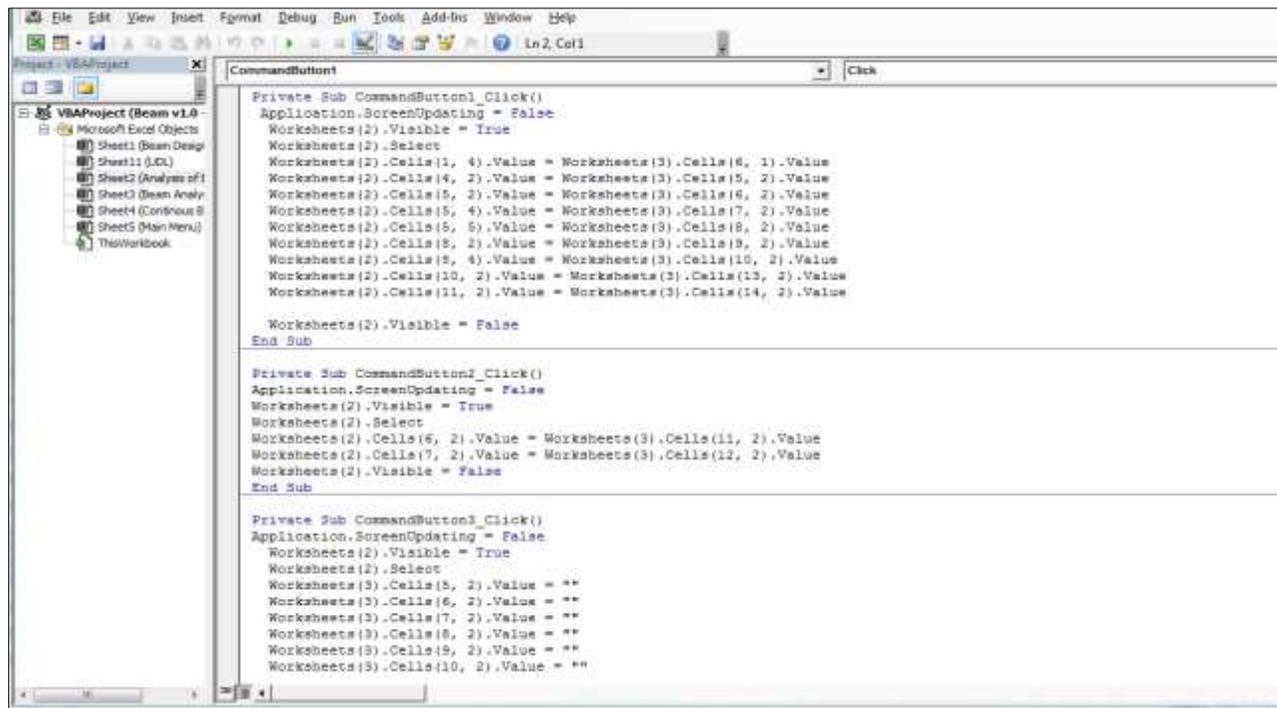


Fig. 11: Snapshot of Code in VB Editor

B. Programming Code for Module: 2

Analysis of RCC Beam. The snapshot of programming code written for developing the spreadsheet is mentioned below:

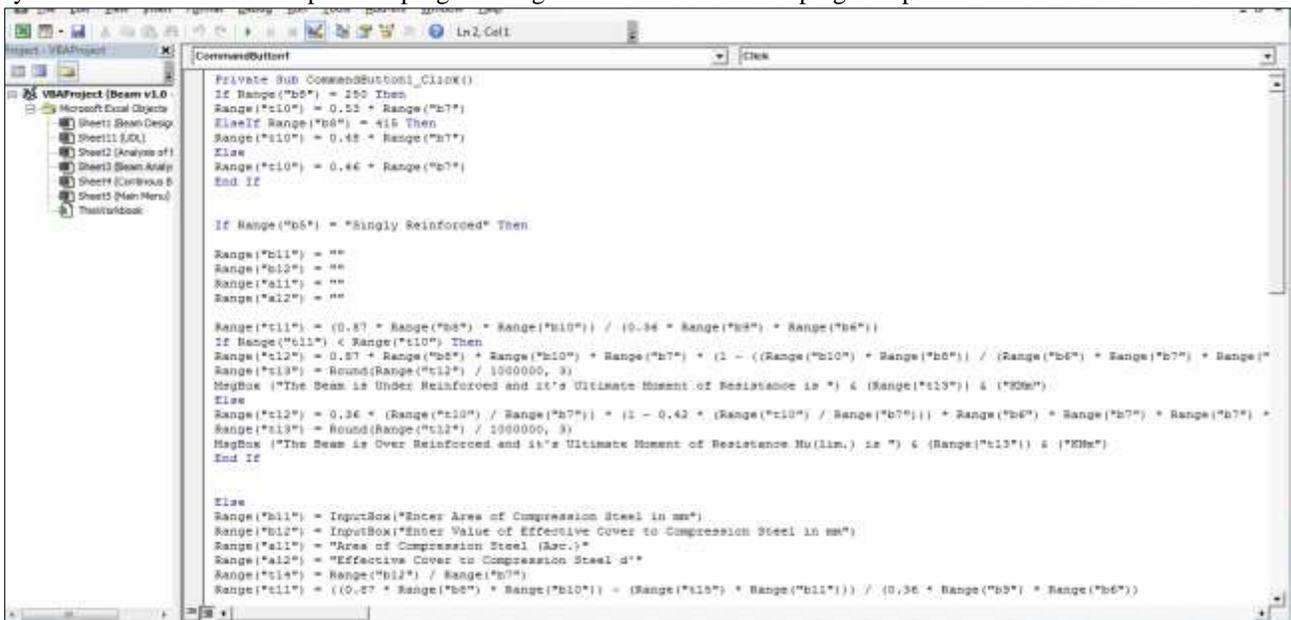


Fig. 12: Snapshot of Code in VB Editor

C. Programming Code for Module: 3

Design of RCC Beam. The snapshot of programming code written for developing the spreadsheet is mentioned below:

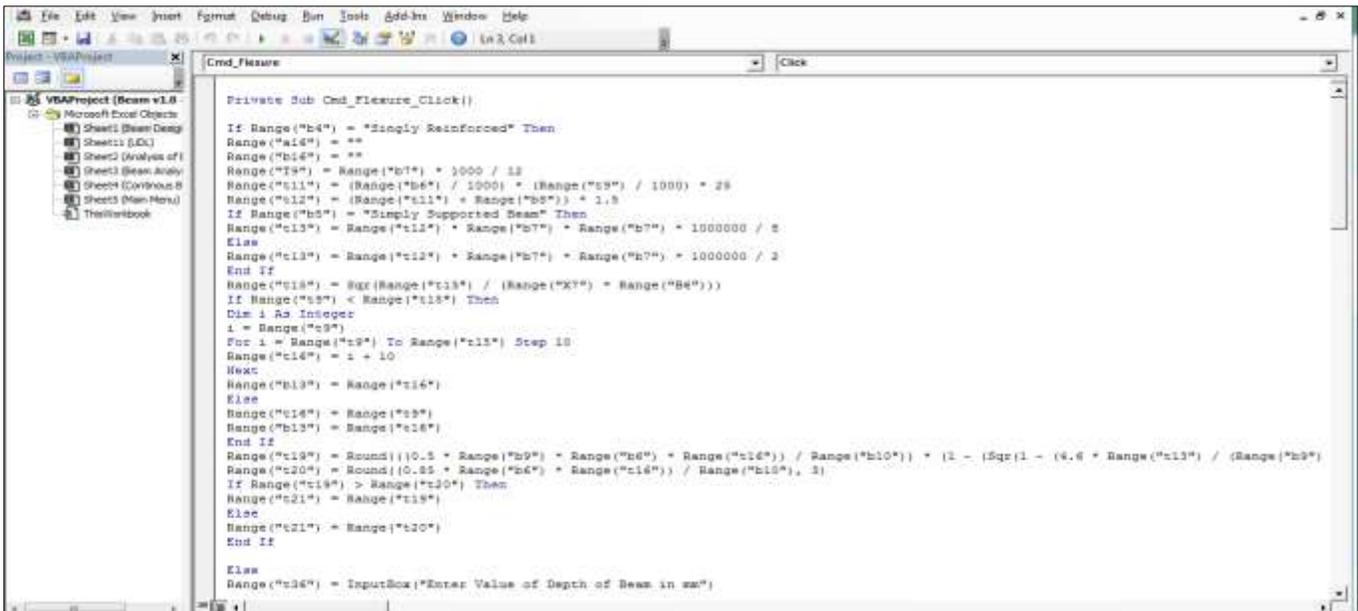


Fig. 13: Snapshot of Code in VB Editor

D. Programming Code for Module: 4

Design of RCC Continuous Beam. The snapshot of programming code written for developing the spreadsheet is mentioned below:



Fig. 14: Snapshot of Code in VB Editor

VI. RESULTS AND DISCUSSIONS

Just like human creation, computer program is less than perfect. A series of sample problems, and some solved examples from different books were tried and results were compared of the Design Tool and that of sample problems. Many other problems were solved using Design Spreadsheet in order to attain satisfactory results and find out source code errors. Transferring files to other computers was also done to detect compatibility issues.

VII. CONCLUSION

The project judgements on the development of a spreadsheet design application for analysis and successful and flexible design of RCC beam sections in accordance with Indian Standard codes of practices for Plain and Reinforced Concrete (IS 456:2000) and the development of such an application is successfully completed with effectively.

The spreadsheet applications support the analysis of beam (both to calculate Shear Force, Bending Moment, Slope and Deflection, as well as analysis of RCC beam) and effective designing of beam (Singly/Doubly Reinforced – Simply

Supported/Cantilever/Continuous) sections maintaining proper balance with economy and safety. As consumption of time in design procedures is a hectic job for a designer such spreadsheet design tools serve greatly with well-furnished and accurate results in limited time which is its greatest advantage and the application of technology in conservative design procedure is getting more and more popular among designers. Around the globe various efforts for its further development is in progress providing the use of Design Spreadsheet applications a bright future standpoint.

REFERENCES

- [1] Development of educational software for beam loading analysis using pen-based user interfaces Yong S. Suh, Journal of Computational Design and Engineering, Vol. 1, No. 1 (2014) 67~77
- [2] Reinforced Concrete Structure Design Assistant Tool for Beginners, Kang Kyu Choi, 2002
- [3] Development of IOS Application for Design of Flat Slabs, Shreelakshmi MJ1, Mr. Manjunatha L2, Miss. Spandana B3, Ritesh L4, International Research Journal of Engineering and Technology (IRJET)
- [4] Developing Civil Engineering Design Software using MS Excel. Varsha S Danavandi1, Shaik Kabeer Ahmed2, INTERNATIONAL JOURNAL OF CURRENT ENGINEERING AND SCIENTIFIC RESEARCH 2017
- [5] Using Spreadsheets a APPLICATIONS and VBA for Teaching Civil Engineering Concepts, Essam Zaneldin
- [6] DESIGN OF POST-TENSIONED PRESTRESSED CONCRETE BEAM USING EXCEL SPREADSHEET WITH VISUAL BASIC , RIMMON S. LABADAN, International Journal of Advances in Mechanical and Civil Engineering, 2016
- [7] Toward Reverse Engineering of VBA Based Excel Spreadsheets Applications, Domenico Amalfitano, Nicola Amatucci, Vincenzo De Simone, Anna Rita Fasolino, Porfirio Tramontana, 2015