

# Computer-Aided Design of Raft Foundation using Excel VBA and FORTRAN

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**Abstract** - In today's modern era software and AI is being used in almost every field, civil engineering is not an exception. Hence to develop a software for a specific purpose to achieve accuracy, minimize the work and reduce the tediousness, has now become the primary requirement. This paper discusses creating a self-developed program for design of Raft Foundation using Excel VBA and FORTRAN and comparing the results obtained from them with already existing software (STAAD.Pro). VBA stands for Visual Basic for Applications. Excel VBA is Microsoft's programming language for Excel. FORTRAN is another programming language which has a significant use in civil engineering for design purposes. STAAD.Pro is a user-friendly software which is used for analysing and designing of structure.

**Key Words:** Excel VBA, FORTRAN, Self-developed program, Computer Aided Design, Raft Foundation.

## 1. INTRODUCTION

For the last few years civil engineering has a shift from its traditional execution processes to the modern way of using Computer Aided Design (CAD) and software tools in construction. With due course of time, as the scale of construction has increased, the range of problems and challenges has also increased. These types of structure need more complex analysis as large investment is involved & safety of people is important. For this CAD is proved to be the most reliable and time effective tool for analysis, designing and systematic generation of design drawings. Various software like Autodesk REVIT, STAAD.PRO, AutoCAD, ETABS, etc. are widely used in this field. All these software supports various code and all necessary design criteria. However, to use such software requires great knowledge & high software operating skills. Also, most of the software does not support direct design of any particular member of structure. Due to interdisciplinary nature of civil engineering stream, wide range of structures are to be designed and this has made the use of software inevitable part of design.

## 2. NEED FOR SELF-DEVELOPED PROGRAM

- Time reduction: Self-developed program helps in reducing the rather tiring task of doing repetitive

trials during manual calculations for designing purpose. The program thus gives rapid results.

- Error Elimination: To increase the accuracy of design CAD is much more needed. The developer can restrict the input values. Also default values for various parameters are so chosen that they are a good choice for the majority of users which makes it user friendly.
- Ease of use: The same design program can be used number of times for several values of input for different conditions of design. While designing if any of the component fails, then designed program can recover and perform redesign.

## 3. LITERATURE REVIEW

Suchita K Hirde and S.S.Kulkarni (2001) reviewed how a self-made user friendly program of software can be developed for design of particular civil engineering structure like water tank and how it can be associated with different readymade software to provide additional detailing of structure and to produce more understandable/workable output. This ensures that all technicalities and standards are included in design since one generalized process is to be used for different inputs.

Alcnia Zita Sampaio (2007) explained Building Information Models (BIM) as a computer aided design methodology in civil engineering, due to their ability to store all the information also the BIM concept aims at improving the work methods used nowadays. The work enabled the knowledge of the subject BIM within an education context but oriented to the real activity. Research on the subject has exposed several objects of study covering BIM, from its origin to its application in the Construction sector.

Zhou Lushui (2016) studied how combinations and application of modern science and technology can be done with computer science in field of civil engineering so as to use computer tools more efficiently. It also explains applications of computer virtual simulation in civil engineering. Use of CAD in civil engineering accelerate the pace of development, the scientific transformation of the overall civil engineering to adapt to dynamic factors,

improve the overall quality level of the engineering industry, and realize the economic value of the reasonable optimization, and finally meet the long-term development of enterprise.

Alexander Kolbasin and Oksana Husu (2018) explained the concept of computer aided engineering and the results of using CAE are also discussed. With the help of CAE-technologies it becomes possible to use inter-industry and interdisciplinary transfer of methodologies and technologies by storing, accumulating and sharing the experience of engineers and designers. Using these advantages of Computer-aided design, especially in combination with power and speed of high-performance computing, the cost and time of each design iteration cycle, and also the overall development process can be significantly reduced.

#### 4. FEATURES OF APPLICATION AND PROGRAMMING LANGUAGE USED

##### A. Excel VBA

Microsoft Excel is a spreadsheet program used for various operations, which contains columns and rows, the intersection of columns and rows is called Cell. The MS Excel has its own programming language called Visual Basics for Application (VBA) as in Fig. 1. VBA is used to automate the operation in Excel. Such programs can also be made using a macro. A macro is a recorded program which creates its own code to perform the recorded function. Such macro-enabled spreadsheet has an extension (.xlsm).

Visual Basic Editor (VBE) is the window where the codes are written as in Fig. 2. Each program in VBA should start with syntax (sub xyz) and end with syntax (End sub xyz).

In VBE user forms are created as per data required to be input by user then another user form is created for output window. These user forms are then programmed to be showed when prompt given by user. Rest of the programming is done in the modules of VBE.

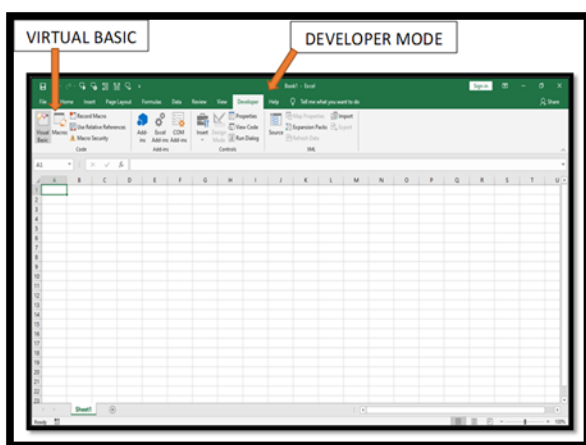


Fig. 1 Excel Interface

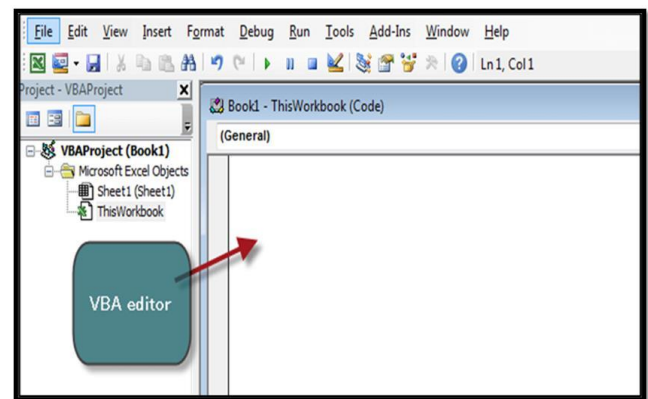


Fig. 2 VBA Editor

##### B. FORTRAN

FORTRAN (acronym for FORMula TRANslation) was developed at IBM, by John Backus and his colleagues, in 1957, to shorten the process of programming, reduce the cost of programming scientific applications and make it more accessible by allowing easy translation of mathematics formulae into code. Soon various incompatible versions were introduced by IBM's competitors. In 1977, 1990, 1995, 2003, 2008 and 2018, revisions of the standard were produced. The next revision FORTRAN 2023 is yet to be released. FORTRAN is a simple to learn machine independent problem oriented language, which allows for easy transportation of a program from one machine to another, with more natural ways to express complex mathematical functions also with efficient execution. Due to its rapid number-crunching ability FORTRAN is recommended for various scientific, mathematical, statistical, and engineering type procedures. Fig. 3 shows FORTRAN interface.



Fig. 3 FORTRAN Interface

C. STAAD.Pro

STAAD.Pro is a structural analysis and design software application originally developed by Research Engineers International in 1997. In late 2005, Research Engineers International was brought by Bentley Systems. STAAD.Pro is one of the most widely used structural analysis and design software products worldwide. It can apply more than 90 international steel, concrete, timber and aluminium design codes.

Some Key Points of STAAD.Pro

- Analytical Model can be created planar using the ribbon-based user interface, by editing the command file or by importing several other file types.
- Physical modelling has been a significant feature included in the program.
- STAAD Building Planner is a module that enables seamless generation of building models that can be analysed and designed thereafter in the program itself.
- The Advanced Concrete Design workflow provides direct access for STAAD.Pro models to leverage the power of the RCDC application.

A4	119.837
B1	249.24
B2	525.322
B3	525.322
B4	249.24
C1	119.837
C2	248.881
C3	248.881
C4	119.837

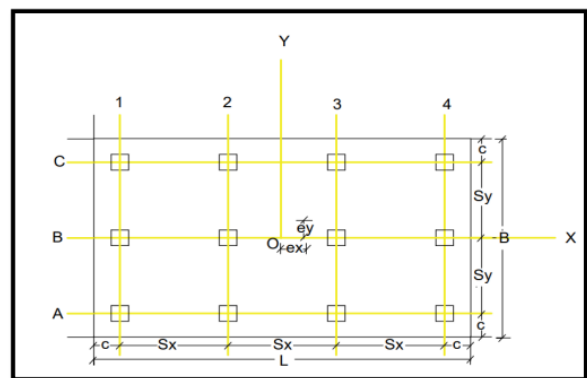


Fig. 4 Foundation Plan

5. PROPOSED DESIGN METHOD

Programs has been developed for the design of footings which included raft footing. The program has been formulated to satisfy all the requirements of relevant IS code. For the design of footings IS 456:200 was used. The program for the design of raft foundation is discussed in detail in the following section.

- Given data: - This data is input by user
- Grade of steel = Fe415
  - Grade of concrete = M35
  - Size of column = 230 mm x 230 mm
  - SBC of soil = 200 kN/m<sup>2</sup>
  - Diameter of Main Bars = 32 mm
  - Diameter of Distribution Bars = 32 mm
  - Spacing along X- direction = 7 m
  - Spacing along Y- direction = 6 m
  - Cantilever length from centre line of column = 0.3m

Table - 1. Column Details

COLUMN NAME	LOAD ( in kN )
A1	119.837
A2	248.881
A3	248.881

Steps require to go through for solution procedure of Raft Foundation Using Excel VBA and FORTRAN:

- Giving Input: First, input values such as the size of the column, load on columns, grade of concrete, grade of steel, soil bearing capacity, etc. are defined. This can be done either by using the user form in excel or by simply putting value in the excel cell. Also, in FORTRAN, input values are entered in command prompt window. Interface is as shown in Fig. 5, Fig. 6 and Fig. 10.
- Determining dimensions of foundation: The dimension of raft slab, eccentricity of columns, maximum moment acting on columns is calculated in Excel VBA and FORTRAN using appropriate formulae Interface is as shown in Fig. 7, Fig. 8, Fig. 9 and Fig. 11.
- Applying Various Checks: Various checks are applied for determined dimensions such as check for two way shear, for limiting moment, for soil pressure, for reinforcement in x and y direction in Excel VBA and FORTRAN. If any of check fails data is again modified in Excel VBA and FORTRAN input window.

D) Determining reinforcement details: After determining that design is safe, reinforcement details calculation is made as per IS Codal provisions in Excel VBA and FORTRAN.

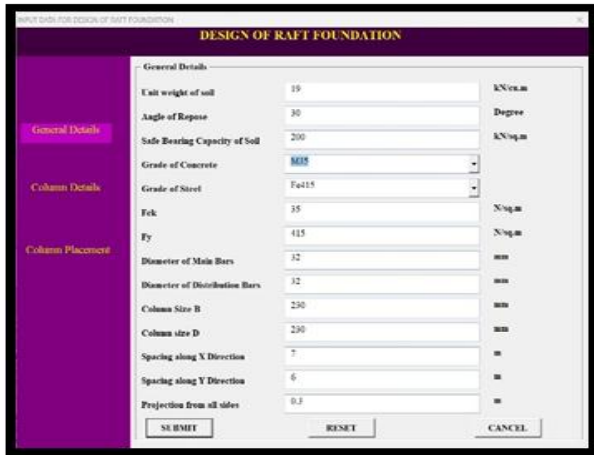


Fig. 5 Input Window-1

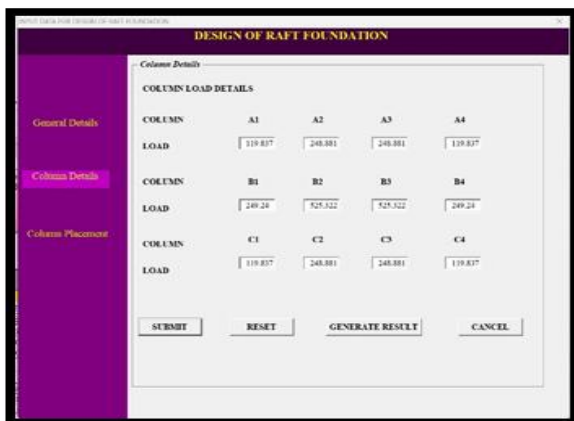


Fig. 6 Input Window-2

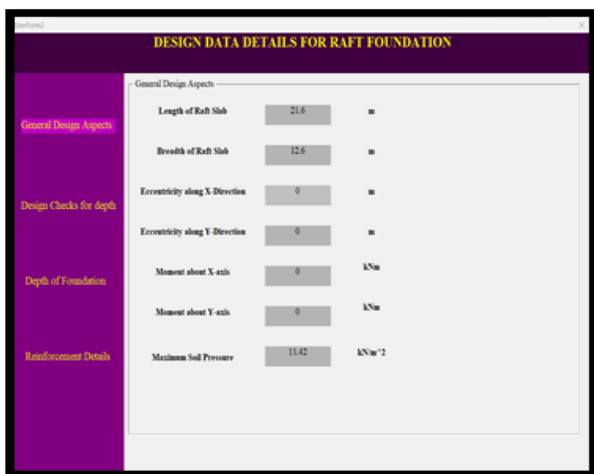


Fig. 7 Output Window-1



Fig. 8 Output Window-2

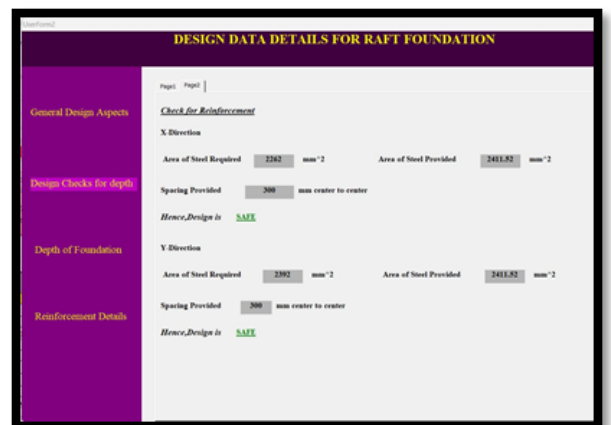


Fig. 9 Output Window-3



Fig. 10 FORTRAN Input window

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Generating Results.....
$$$$$$$$$ DESIGN RESULTS FOR ENTERED DATA $$$$$$$$$$
*****Dimensions of Raft Slab*****
Length of Raft Slab is: 21.6000004 metre
Breadth of Raft Slab is: 12.6000004 metre
*****Eccentricity and Moment Calculation*****
Moment of column Forces about vertical axis is: 10.5000000 kNm
Eccentricity along x direction is: 0.0000000 m
Moment of column forces about horizontal axis is: 6.0000000 kNm
Eccentricity along y direction is: 0.0000000 m
Moment of Inertia about X-axis is: 3600.67749 m^4
Moment of Inertia about Y-axis is: 10581.5830 m^4
Area of Foundation is: 272.160004 m^2
Moment about X-axis is: 0.0000000 m^2
Moment about Y-axis is: 0.0000000 m^2
P/A = 11.1110964 kN/m^2
*****Soil Pressure At Different Points*****
Corner A14 = 11.4110966 kN/m^2
Corner A24 = 11.4110966 kN/m^2
Corner A11 = 11.4110966 kN/m^2
Corner A31 = 11.4110966 kN/m^2
Corner A24 = 11.4110966 kN/m^2
Corner A31 = 11.4110966 kN/m^2
Maximum Soil Pressure is: 11.4110966 kN/m^2
    
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Fig. 11 FORTRAN Output window

E) STAAD.Pro: With the same given data a 3-D model of building is created using STAAD.Pro Connect as shown in Fig. 12 and the reaction acting on the columns are calculated as shown in Fig. 13.

Then raft foundation is designed for the same building using STAAD.Pro Foundation Advanced as shown in below figure. The reports regenerated for reinforcement details and compared with self-developed program.



Fig. 12 Rendered View

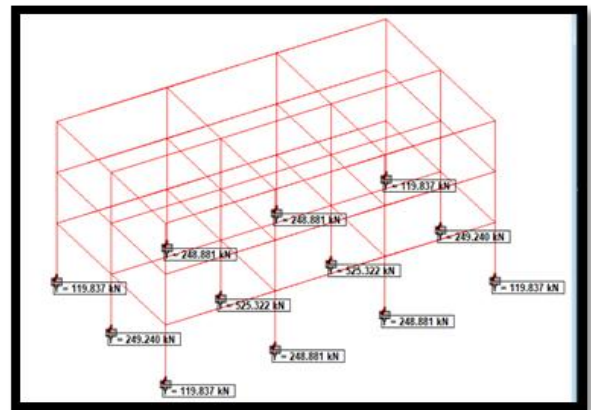


Fig. 13 Column Reactions

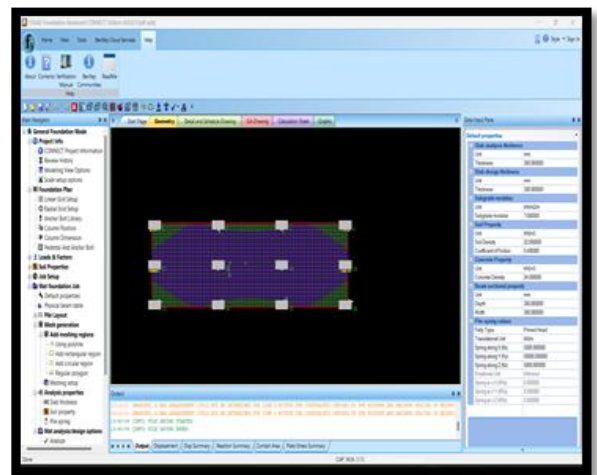


Fig. 14 Raft model in STAAD.Pro

### 6. COMPARISON OF RESULTS

Raft foundation is designed for the given data. The outputs obtained from manual calculation, Excel VBA, FORTRAN are compared with STAAD.PRO as shown in table below.

Table – 2 Comparison of results from Excel VBA, FORTRAN f90 with STAAD.Pro

Outputs	Manual Calculations	Excel-VBA	FORTTRAN	STAAD-PRO
Overall Depth (D) (mm)	260	260	260	260
Main Reinforcement ( mm <sup>2</sup> )	2411.52	2411.52	2411.52	2405.28
Distribution Reinforcement ( mm <sup>2</sup> )	2411.52	2411.52	2411.52	2332.32
Spacing of main bars	32 dia. at 300 mm c/c	32 dia. at 300 mm c/c	32 dia. at 300 mm c/c	25 dia. at 200 mm c/c
Spacing of distribution bar	32 dia. at 300 mm c/c	32 dia. at 300 mm c/c	32 dia. at 300 mm c/c	32 dia. at 350 mm c/c

## 7. FUTURE SCOPE OF STUDY

All R.C.C components such as beams, columns, and slab can be analyzed and design using Excel VBA and FORTRAN. Analysis and design of steel structure and portal frames can be done using these softwares. Also design of other types of foundations can be done. Analysis can also be done with other software like SAP 2000, ETABS, etc. And result can be compared with Excel VBA.

## 8. CONCLUSION

From Table 2, it can be concluded that program developed in Excel VBA & FORTRAN generates similar results. The values obtained from the program for the various parameters of footings are rounded up, which reduces the complexity in the results. Comparing with standard software (STAAD.Pro) it can be deduced that accuracy of self- developed program is about 95%.

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