

Computer-Aided Design of Strap Footing using Excel VBA and FORTRAN

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Abstract - Numerous analysis and design software programs are available for the analysis and design of structural members in the field of civil engineering. It appears that certain abilities were necessary in order to operate this software. It has become vital to create new software that is user-friendly, simple to use, less error within less time, in order to overcome this dexterity. This paper illustrates the use of FORTRAN programming and Excel VBA in civil engineering. The program has been designed to comply with all applicable IS requirements. Knowing how to build software can help you accomplish a number of sophisticated calculations, modeling, drawing, designing, and analytical procedures for civil engineering infrastructure with efficiency.

Key Words: Computer-Aided Design, Excel VBA FORTRAN(f) 90, Strap Footing, and self-developed program.

1. INTRODUCTION

The design of footings is a critical aspect of civil engineering, as these structures form the foundation of most buildings and structures. With the increasing complexity of modern construction projects, it has become essential to use software tools to ensure the accuracy and safety of footing designs. There is a large variety of software, including AUTOCAD, REVIT, STAAD.Pro, AutoCAD, ETABS, Struds, etc. used in this industry. All of this software supports different types of code and all required design requirements. Among the various software tools available, VBA (Visual Basic for Applications) and FORTRAN are widely used in the field of civil engineering for their versatility and power. VBA can be used to automate repetitive tasks and perform complex calculations, making it a valuable tool for footing design. FORTRAN is particularly useful in the field of civil engineering for its ability to perform large-scale calculations and simulations. In order to illustrate how these technologies have been applied in actual civil engineering projects. The employment of VBA and FORTRAN may enhance the precision, effectiveness, and safety of footing designs, making them a vital tool for civil engineers in the modern era.

2. REQUIREMENTS FOR A SELF DEVELOPED PROGRAM

- Efficiency: A well-designed program can automate repetitive or time-consuming calculations, allowing for faster and more efficient design processes.
- Accuracy: A customized program can be designed to accurately calculate the loads and forces acting on the

footing, taking into account various factors such as soil properties, building design, and environmental conditions.

- Flexibility: A self-developed program can be easily updated and modified as needed, allowing you to incorporate new design criteria or standards, or make adjustments based on changing site conditions.
- Learning: Developing your own program can be a valuable learning experience, helping you to deepen your understanding of footing design principles and programming concepts.

3. LITERATURE REVIEW

Suchita K. Hirde 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.

Alcinia 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. CHARACTERISTICS FEATURES OF VBA AND FORTRAN

4.1. EXCEL:

Microsoft Excel is a spreadsheet program that was created by Microsoft for a variety of operating systems. It has columns and rows, and the point where the columns and rows intersect is known as a cell. Visual Basic for Applications is the programming language that MS Excel uses. (VBA). Excel's operation is automated using VBA. A macro can likewise be used to create such programs. A recorded program that generates its own code to carry out the recorded function is known as a macro. This spreadsheet has a macro feature and an extension. (.xlsm). The window where the codes are written is called the Visual Basic Editor (VBE). Every VBA program must begin with syntax (sub xyz) and end with syntax. (End sub xyz). How to activate VBA in Excel is shown in Fig. 1, 2&3

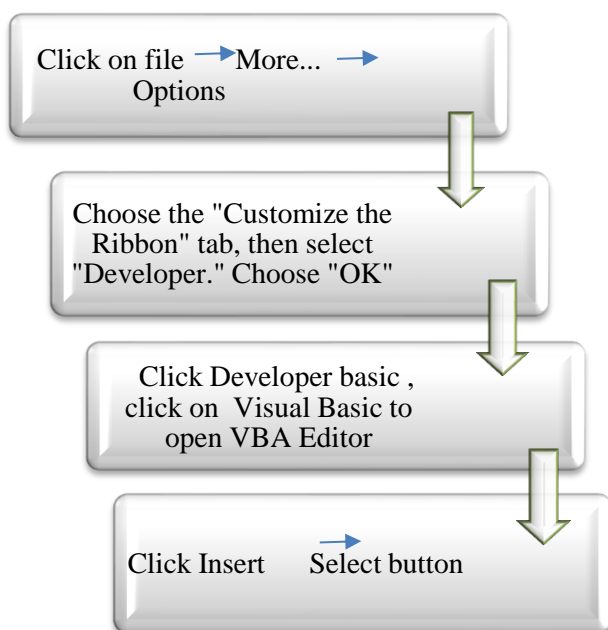


Fig. 1 Steps to activate VBA developer mode in excel

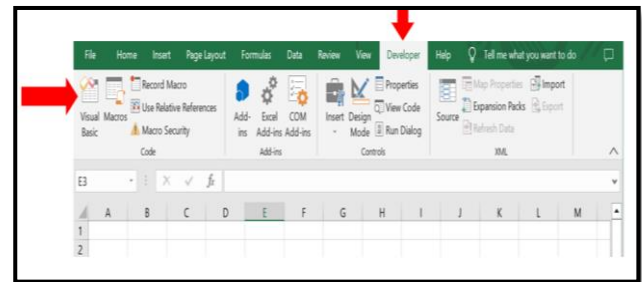


Fig. 2 Showing VBA developer mode in excel

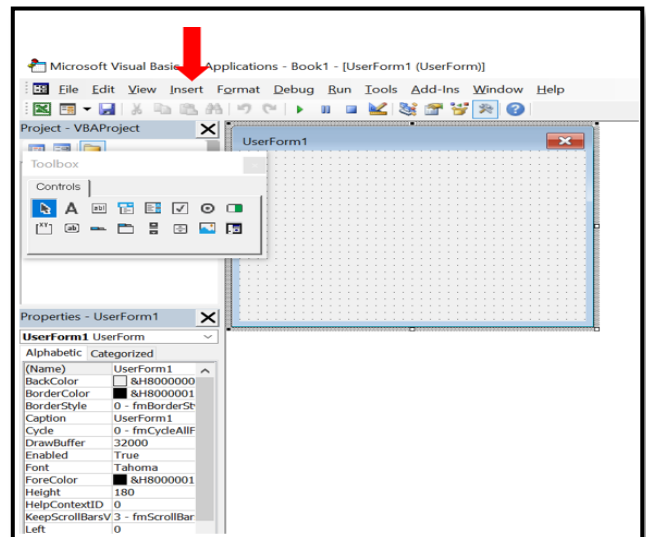


Fig. 3 Showing VBA developer mode in excel

4.2. FORTRAN

Fortran was first created by IBM in the 1950s by John Backus. It has been used for more than 60 years in fields that need extensive computing, including crystallography, finite element analysis, computational fluid dynamics, geophysics, and computational chemistry.

Features of F90: Object-oriented programming (OOP): OOP concepts includes encapsulation, inheritance, and polymorphism. As a result, Fortran were able to create more intricate and complex programs.

- **Dynamic memory allocation:** It allows programs to allocate and deallocate memory as needed. Programs that could handle data of various sizes and structures were therefore simpler to build.
- **Modules:** It allows modular programming and better code organization. The use of modules enables the consolidation of related processes, kinds, and data into a single entity.

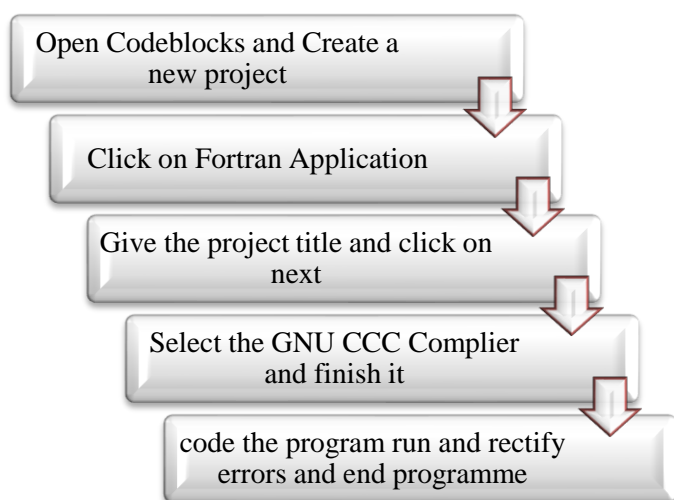
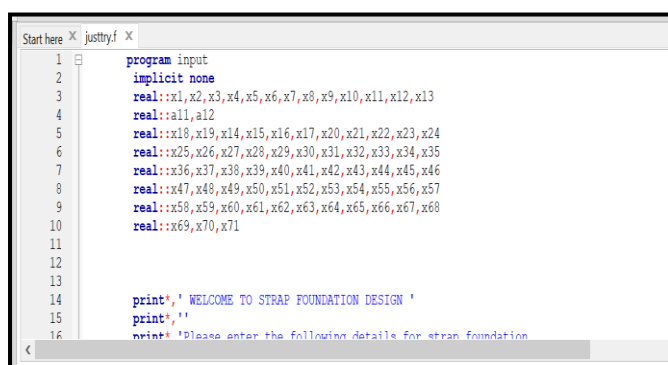


Fig 4 Steps to start the programming in code blocks



```

1  program input
2  implicit none
3  real::x1,x2,x3,x4,x5,x6,x7,x8,x9,x10,x11,x12,x13
4  real::a1,a12
5  real::x18,x19,x14,x15,x16,x17,x20,x21,x22,x23,x24
6  real::x25,x26,x27,x28,x29,x30,x31,x32,x33,x34,x35
7  real::x36,x37,x38,x39,x40,x41,x42,x43,x44,x45,x46
8  real::x47,x48,x49,x50,x51,x52,x53,x54,x55,x56,x57
9  real::x58,x59,x60,x61,x62,x63,x64,x65,x66,x67,x68
10 real::x69,x70,x71
11
12
13
14 print*, ' WELCOME TO STRAP FOUNDATION DESIGN '
15 print*, ''
16 print*, 'Please enter the following details for strap foundation
  
```

Fig. 5 user interface of code block

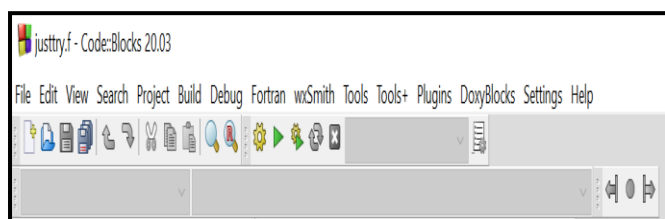


Fig. 6 showing menu bar

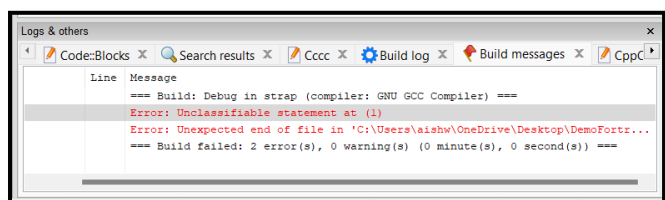


Fig. 7 Indicating errors

5. DESIGN METHODOLOGY

The program has been developed using Excel VBA and FORTRAN for the design of Strap Footing. The design procedure and checks are in competence with IS 456:2000. Design input required for both Excel VBA and FORTRAN are

as follows and the design output are also depicted in this section:

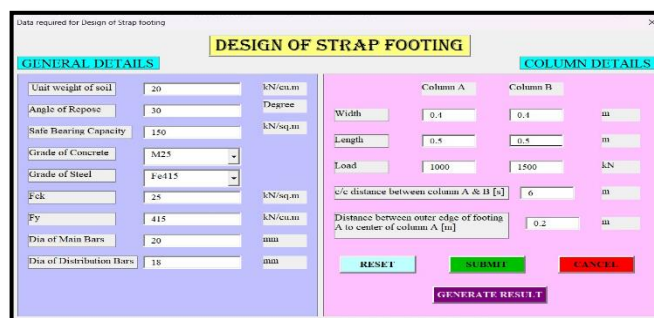
Given Data: To be fill by user

Unit weight of soil: 20kN/m^3 , Angle of repose: 30° , Safe bearing capacity of soil: 150kN/m^2 , Grade of concrete: M25 Grade of steel: Fe415, $F_{ck}: 25\text{ N/mm}^2$, $F_y: 415\text{ N/mm}^2$, Diameter of main bar: 20 mm, Diameter of distribution bar: 18 mm, K:0.138.

Table -1: COLUMN DETAILS

Description	Column A	Column B
Width (m)	0.4	0.5
Length (m)	0.4	0.5
Load (kN)	1000	1500
C/C distance between Column A and B (m)	6	
Distance between outer edge of footing A to center of column A (m)	0.2	

5.1 Input: Unit weight of soil, Angle of repose, Safe. bearing capacity of soi, Grade of concrete, Grade of steel, Diameter of main bar, Diameter of distribution bar, K, column details to be filled by the user first in the output window created in Excel using VBA and command prompt black window in FORTRAN as shown in Fig.8 and Fig. 9



DESIGN OF STRAP FOOTING

GENERAL DETAILS

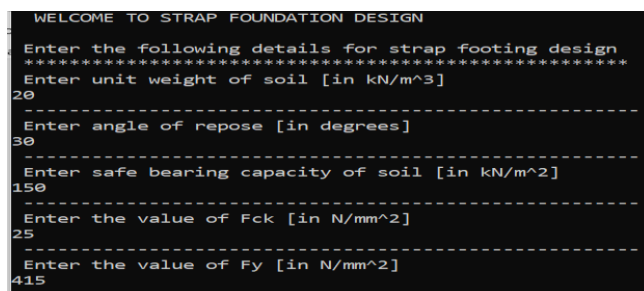
Unit weight of soil: 20 kN/cum
 Angle of Repose: 30 Degree
 Safe Bearing Capacity: 150 kN/sqm
 Grade of Concrete: M25
 Grade of Steel: Fe415
 F_{ck}: 25 kN/sqm
 F_y: 415 kN/cum
 Dia of Main Bars: 20 mm
 Dia of Distribution Bars: 18 mm

COLUMN DETAILS

Column A: Width 0.4 m, Length 0.5 m, Load 1000 kN
 Column B: Width 0.4 m, Length 0.5 m, Load 1500 kN
 C/c distance between column A & B [m]: 6
 Distance between outer edge of footing A to center of column A [m]: 0.2

Buttons: RESET, SUBMIT, CANCEL, GENERATE RESULT

Fig. 8 Input Interface of VBA



```

WELCOME TO STRAP FOUNDATION DESIGN
Enter the following details for strap footing design
*****
Enter unit weight of soil [in kN/m^3]
20
-----
Enter angle of repose [in degrees]
30
-----
Enter safe bearing capacity of soil [in kN/m^2]
150
-----
Enter the value of Fck [in N/mm^2]
25
-----
Enter the value of Fy [in N/mm^2]
415
-----
  
```

Fig. 9 Input interface of FORTRAN

5.2. Calculated dimension: Depth of footing, Width of footing, Area of footing, Length of footing, provided area of footing

is calculated using FORTRAN and Excel VBA using proper coding and Formula.

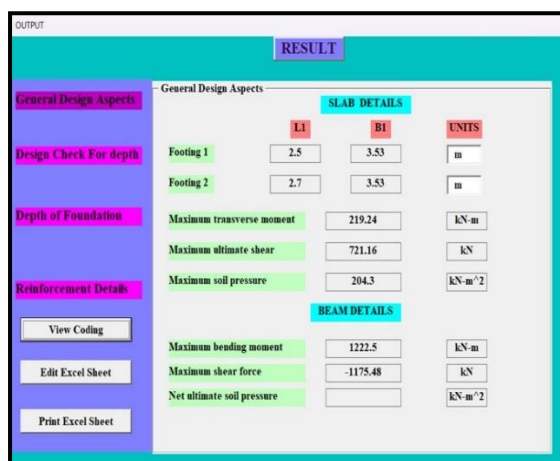
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Length of footing A : 2.500000 meter
-----
Length of footing B : 2.6562498 meter
2.7
-----
width of footing : 3.555558 meter
3.56
-----
Provided area of footing : 18.333334 sq meter
18.33
-----
Check for Area: SAFE
  
```

Fig. 10 Calculated dimension in FORTRAN

5.3. To ensure all safety checks as per codal provision: When we click on generate result of Excel VBA the result is generated as per standard design steps. Design follows IS456:2000 code of practice. User must ensure all the checks are safe or not same in FORTRAN.

5.4. General design aspect: After design input and clicking on generate result in the Excel VBA interface new window will display, clicking on general design aspects we will get footing dimensions, maximum transverse moment, maximum ultimate shear, and maximum soil pressure in slab and maximum bending moment, maximum shear force, net ultimate soil pressure in beam. Same details will appear in FORTRAN black window as shown in Fig. 11

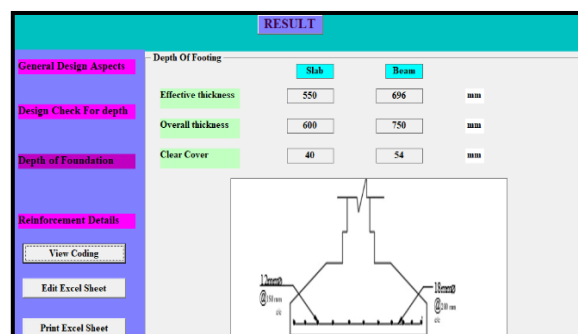


The interface displays a 'RESULT' window with a sidebar containing 'General Design Aspects', 'Design Check For depth', 'Depth of Foundation', and 'Reinforcement Details'. The main area is divided into 'SLAB DETAILS' and 'BEAM DETAILS'.

	L1	B1	UNITS
General Design Aspects			
Design Check For depth	Footing 1: 2.5	3.53	m
	Footing 2: 2.7	3.53	m
Depth of Foundation	Maximum transverse moment	219.24	kN-m
	Maximum ultimate shear	721.16	kN
	Maximum soil pressure	204.3	kN-m ²
Reinforcement Details			
	Maximum bending moment	1222.5	kN-m
	Maximum shear force	-1175.48	kN
	Net ultimate soil pressure		kN-m ²

Fig 11 General design aspects

5.5. Depth of Foundation: Clicking on the interface window of Excel VBA Depth of Foundation can be known such as effective depth of Foundation, overall thickness. Same will be appear in FORTRAN Black Window as shown in Fig. 12



The interface displays a 'RESULT' window with a sidebar containing 'General Design Aspects', 'Design Check For depth', 'Depth of Foundation', and 'Reinforcement Details'. The main area shows 'Depth Of Footing' with 'Slab' and 'Beam' tabs.

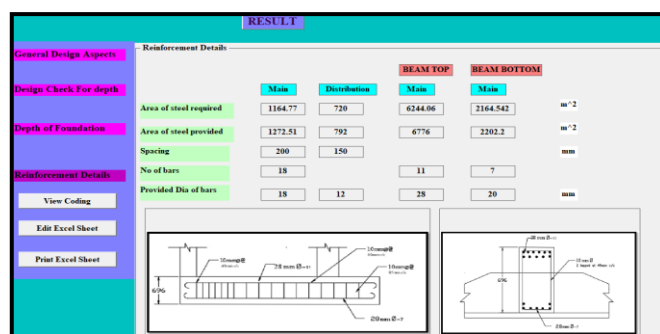
	Slab	Beam	mm
General Design Aspects			
Design Check For depth	Effective thickness	550	696
	Overall thickness	600	750
Depth of Foundation	Clear Cover	40	54

Below the table is a cross-section diagram of a footing and beam.

Fig. 12 Depth of foundation

5.6. Design check for Depth: Design check for depth of strap footing can also be verified whether it is in competence with the codal provision or not.

5.7. Reinforcement Details: Details such as area of steel required, area of steel provided, spacing, number of bars, diameter of main and distribution bar can be generated in Excel VBA interface and FORTRAN as shown in Fig. 13&14.



The interface displays a 'RESULT' window with a sidebar containing 'General Design Aspects', 'Design Check For depth', 'Depth of Foundation', and 'Reinforcement Details'. The main area shows 'Reinforcement Details' with 'Main' and 'Distribution' tabs.

	Main	Distribution	BEAM TOP	BEAM BOTTOM	mm
General Design Aspects					
Design Check For depth	Area of steel required	1104.77	720	6244.06	2104.542
	Area of steel provided	1272.51	792	6776	2202.2
Depth of Foundation	Spacing	200	150		
Reinforcement Details	No of bars	18	11	7	
	Provided Dia of bars	18	12	28	20

Below the table are two diagrams: a longitudinal section of a beam and a cross-section of a beam.

Fig. 13 Reinforcement details in VBA

```

Longitudinal R/F in beam at Top
Ast tension side of beam: 5222.5146 sq mm
Min Ast: 1436.8767 sq mm
Mini Tension R/F IS456:2000 clause26.5.1.1: 2275.9204 sqmm
Considering Section @ D: 6677.3887 sq mm
Reinforcement required: 6677.3887 sq mm
No of bars required: 10.835977 sq mm
No of bars provided: 11.000000
Ast provided: 6776.0000 sq mm
-----
Longitudinal reinforcement provided at bottom
Ast required: 1949.4291 sq mm
Minimum Ast: 540.00000 sq mm
Min Tention R/F IS456:2000 clause26.5.1.1: 855.32538 sq mm
Assumed diameter: 20.000000 mm
No of bars required: 6.1965327
No of bars provided: 7.0000000
Ast provided: 2202.2000 sq mm
Check for Area: SAFE

Area of steel required: 1187.4177 sq meter
provided dia of bar : 18.000000 mm
Area of steel provided : 1272.5100 sq meter
Check for Area: SAFE
  
```

Fig. 14 Reinforcement details in FORTRAN

Table -2: OUTPUT OBTAINED FROM MANUAL CALCULATIONS, EXCEL-VBA, FORTRAN (F) 90

Table -2: OUTPUT OBTAINED FROM MANUAL CALCULATIONS, EXCEL-VBA, FORTRAN (F) 90						
Outputs	Manual Calculations		Excel-VBA		FORTRAN	
Footing dimension's	Footing 1	Footing 2	Footing 1	Footing 2	Footing 1	Footing 2
Length (m)	2.5	2.7	2.5	2.7	2.5	2.7
Breadth (m)	3.53	3.53	3.53	3.53	3.56	3.56
Depth of foundation(mm)	Slab	Beam	Slab	Beam	Slab	Beam
Eff. Thickness	550	696	550	696	550	696
Overall depth	600	750	600	750	600	750
Clear cover	50	54	50	54	50	54
Footing reinforcement						
Main R/f provided (mm ²)	1272.51		1272.51		1272.51	
Distribution R/f provided (mm ²)	792		792		791.78	
Main bar spacing	18mm Ø @ 200mm C/C		18mm Ø @ 200mm C/C		18mm Ø @ 200mm C/C	
Distribution bar spacing	12mm Ø @ 150mm C/C		12mm Ø @ 150mm C/C		12mm Ø @ 150mm C/C	
R/F for beam						
R/f at top (mm ²)	6776		6776		6776	
R/f at bottom (mm ²)	2202.2		2202.2		2202.2	
No of bar at top	11-28Ø		11-28Ø		11-28Ø	
No of bar at bottom	7-20Ø		7-20Ø		7-20Ø	

6. RESULT AND DISCUSSION

The results obtained from Excel VBA, FORTRAN are compared with manual calculations in Table No. 2, shows the values obtained for strap footing from manual calculations, Excel VBA and FORTRAN have similar values.

7. CONCLUSION

The design of strap footing can be greatly improved through the use of programming languages such as VBA and FORTRAN. These tools enable faster and more accurate design and reduce the potential for errors in complex mathematical expressions. With the use of algorithms, the design process can be streamlined, resulting in a more efficient and effective approach.

By incorporating VBA and FORTRAN into the design process of strap footing, civil engineers can create more reliable and durable structures. The use of these programming languages allows for more precise calculations and better analysis, ultimately leading to more accurate and safe designs. Therefore, the integration of technology into the design process is crucial for the advancement of civil engineering and the construction industry as a whole.

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