

# ANALYSIS AND DESIGN OF PAD FOUNDATION USING VISUAL BASIC PROGRAM

K. A. Kau\*, C. E. Osakwe and J. E. Nicholas

Department of Civil Engineering, Modibbo Adama University of Technology, Yola, Nigeria

\*Corresponding Author: [kachallahakau@mautech.edu.ng](mailto:kachallahakau@mautech.edu.ng)

## ABSTRACT

*This paper focuses on the use of Visual Basic (VB) programming language in developing a computer program for the analysis and design of pad foundation (isolated and combined pad footings) to BS8110 code specification. Flow charts were developed to accept design data after which, VB codes were then developed. Using the design data, the program analyses the foundation in terms of; effective depth, base area, shear and moment. The analysis is preceded by the design of the foundation footings. The accuracy and reliability of results obtained using the developed program (application) were comparatively evaluated by manual analysis using the same input design data. It was observed that obtained results using the manual method of analysis as well that obtained using the developed program (application) were found to be same with zero percentage error. Furthermore, it was observed that the analysis done using the developed program was easier and faster thus, enhancing the efficiency of analysis and design of the foundation footings.*

**Keywords:** Pad Foundation, Analysis, Design, Flow Chart, Visual Basic Program

## 1 INTRODUCTION

Computers are said to be devices that perform calculations and logical operations at a great speed, with little or no human intervention through the action of an internally stored program [1]. Among some of the important attributes of computer applications (programs) in engineering are; its ability to handle a very large amount of data accurately as long as the instructions given to it are reliable as well as its ability to perform a task in repetition especially numerous arithmetic operations at a phenomenal speed [2]. Foundation design consists of selecting and proportioning foundations in such a way that limit states are prevented [3]. Foundation design like other structural designs basically requires a good approach in order to achieve reliable results. The use of a manual method of structural design is challenging especially in cases where there are changes in loading configuration implying re-design. Furthermore, it is rigorous, time-consuming and also more prone to errors [4]. In almost all aspects of Civil Engineering, the use of computer programs (applications) cannot be overemphasised. It suffices, however, to note that, in order to undertake a sound and efficient analysis and design of structural elements or components, an engineer has to be diligent and cogent [5]. A number of programs for structural analysis and design have been created with various programming languages as reported in [6], [7], [8] and [9]. VB program was used to simulate numerical iterations as reported by [10]. However, as reported by [11], VB programming language was used in the development of an application for the analysis and design of timber structural elements. Little, however, is reported in the literature on the analysis and design of pad foundation (footings) to BS8110 code specification using VB (2015) programming language hence, the need to develop a program (application) for use in the analysis and design of pad foundation (isolated and combined pad footings). Visual Basic evolved from BASIC (Beginners All-purpose Symbolic Instruction Code). It is a Microsoft window programming language, created in an integrated development environment (IDE). VB is ideal for small to medium scale programs and is suitable for developing graphical and interactive software applications [12].

## 2 METHODOLOGY

The methodology adopted in carrying out this work includes manual analysis and design of pad foundations (isolated pad and combined pad foundations) in accordance with [13], designing of a flow

chart for the pad foundations and developing the program using Visual Basic 2015. The following equations were employed for the analysis of design parameters as outlined in [13].

## 2.1 Analysis and Design Procedure

The process for analysis and design of the footings are as given in equations 1 – 11.

- i. The required area of the foundation base:

$$A_{req} = \frac{1.1W}{P_b} \quad (1)$$

- ii. Net pressure:

$$f_{net} = \frac{1.1W}{A_{prov}} + 1.4h\rho_c \quad (2)$$

- iii. Moment for isolated pad footing:

$$M = \frac{f_{net}l^2}{2} \quad (3)$$

- iv. Design for steel reinforcement:

$$K = \frac{M}{f_{cu}bd^2} \quad (4)$$

$$Z = d \left( 0.5 + \sqrt{0.25 - \frac{K}{0.9}} \right) \quad (5)$$

$$A_s = \frac{M}{0.95Zf_y} \quad (6)$$

- v. Minimum area reinforcement:

$$A_{s_{min}} = 0.24\%bh \quad (7)$$

- vi. The critical perimeter taken as 1.5d from the column face is calculated from:

$$P_{crit} = 2(a_1 + a_2) + 12d \quad (8)$$

- vii. The area within the critical perimeter  $A_{crit}$  is calculated from:

$$A_{crit} = (a_1 + 3d)(a_2 + 3d) \quad (9)$$

- viii. Thus, the load causing punching shear  $V_{punch}$  is calculated from:

$$V_{punch} = f_{net}(A_{prov} - A_{crit}) \quad (10)$$

- ix. And the punching shear stress,  $v_{punch}$  is calculated from:

$$v_{punch} = \frac{V_{punch}}{P_{crit}d} \leq V_c \quad (11)$$

Where:  $A_s$  = Area of reinforcement,  $A_{crit}$  = Area within the critical perimeter,  $A_{s_{min}}$  = Minimum area of reinforcement required,  $A_{req}$  = Base area of footing required,  $A_{prov}$  = Base area of footing provided,  $b$  = Unit width of footing,  $f_{cu}$  = Concrete compressive strength,  $f_{net}$  = Net pressure,  $f_y$  = Steel stress,  $h$  = Depth of footing,  $P_b$  = Soil permissible bearing pressure,  $P_{crit}$  = Critical perimeter,  $v_{punch}$  = Punching shear stress,  $V_{punch}$  = Punching shear force,  $v$  = Shear stress,  $V$  = Shear force,  $v_c$  = Allowable shear stress,  $Z$  = Lever arm,  $W$  = Total load on the base at serviceability limit state,  $\rho_c$  = Concrete density. The program sequence is summarized in the flowcharts in Figures 1 and 2 respectively.

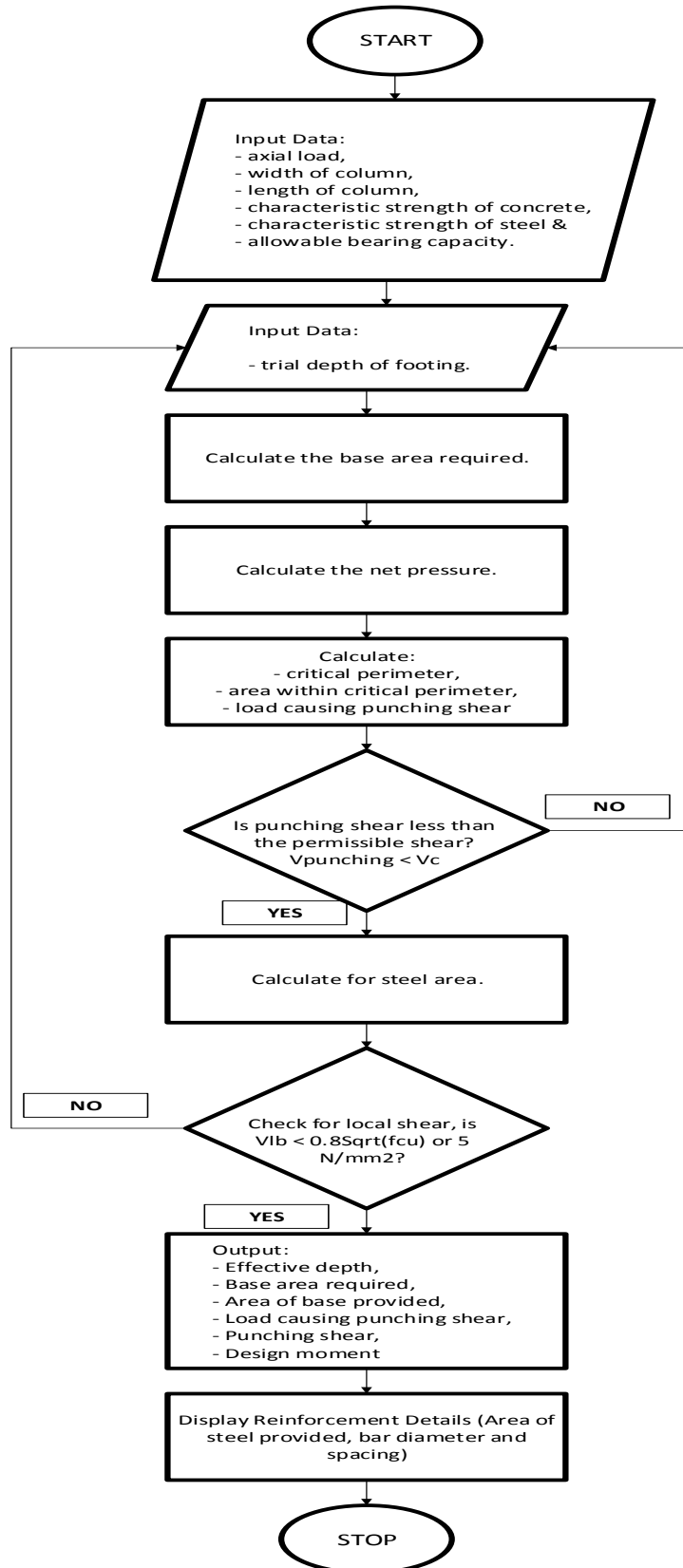


Figure 1. Flow Chart for the Analysis and Design of Isolated Pad Footing

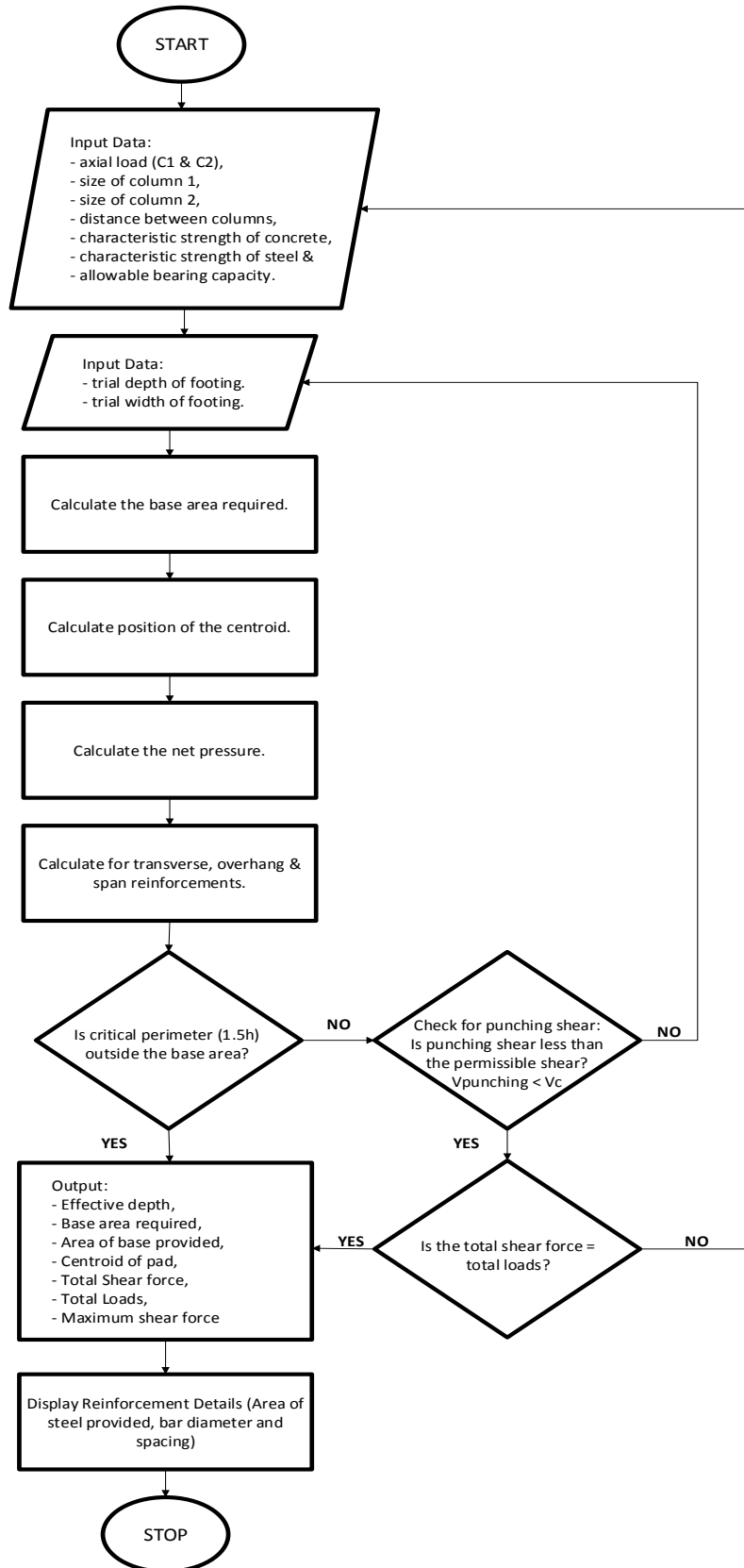


Figure 2. Flow Chart for the analysis and design of combined pad footing

## 2.2 Design Data

Design data were adopted for the analysis and design of isolated and combined footings are given in Tables 1 and 2 respectively.

Table 1. Design Data Adopted for Isolated Pad Footing under the action of 450kN Axial Column Load

Column Size	230mm X 230mm
Column Load at U.L.S	450kN
Soil bearing capacity	150kN/m <sup>2</sup>
Concrete stress	35N/mm <sup>2</sup>
Steel stress	460N/mm <sup>2</sup>

Table 2. Design Data Adopted for Combined Pad Footing Subjected to Columns Loading of 300kN and 400kN

Column Size	230mm X 230mm
Column Load at S.L.S	300kN + 400kN
Soil bearing capacity	150kN/m <sup>2</sup>
Concrete stress	35N/mm <sup>2</sup>
Steel stress	460N/mm <sup>2</sup>

## 3 RESULTS AND DISCUSSION

### 3.1 Results

Tables 3 and 4 are results obtained from manual analysis and design of isolated pad (under the action of 450kN axial column load) and combined pad (Combined Footing subjected under column loads of 300kN and 400kN) footings vis-à-vis program output using the developed application based on adopted design data.

Table 3. Isolated Pad Footing under the action of 450kN Axial Column Load

Design Parameters	Manual	VB Program	% Error
Base Area Required (m <sup>2</sup> )	2.26	2.26	0
Length (mm)	1600	1600	0
Width (mm)	1600	1600	0
Net Pressure (kN/m <sup>2</sup> )	179.92	179.92	0
Critical Perimeter (mm)	4688	4688	0
Area within critical perimeter (m <sup>2</sup> )	1.74	1.74	0
Load causing punching shear (kN)	147.53	147.53	0
Punching shear (N/mm <sup>2</sup> )	0.09	0.09	0
Area of steel required (mm <sup>2</sup> )	960	960	0

Table 4. Combined Pad Footing Subjected to Columns Loading of 300kN and 400kN

Design Parameters	Manual	VB Program	% Error
Base Area Required (m <sup>2</sup> )	5.13	5.13	0
Length (mm)	4300	4300	0
Width (mm)	1200	1200	0
Net Pressure (kN/m <sup>2</sup> )	197.71	197.7	0
Left Overhang Moment (kN m)	18.79	18.79	0
Right Overhang Moment (kN m)	73.79	73.79	0
Span Moment (kN m)	222.42	222.42	0
Maximum shear force (kN)	182.32	182.32	0
Punching shear (N/mm <sup>2</sup> )	0.281	0.281	0

### 3.2 Discussion

Results presented in Tables 1 and 2 are results obtained from the manual method of analysis vis-à-vis the developed VB program (application). It can comparatively be observed that, for all design parameters analyzed using the adopted design data, the percentage error was found to be zero thus, highlighting the accuracy of the program which is of the essence in design. It is worthy of note that, ease of use (of the developed application), speed and accuracy were major considerations in the development of the program. The whole process of the analysis and design (using the developed application) follows the same method and procedure like that done manually. To underscore the essence of the choice of VB programming language, it is worthy to note that because of the program's language ability in presenting a visually interactive and appealing graphical interface as well as an interface to create codes for correct execution of commands, the choice of VB (2015) programming language is justified. Furthermore, it can be observed from the tables that, comparison between the manual results and the results obtained using the developed program (application) shows that both results are essentially the same thus, highlighting the accuracy and reliability of the developed VB program (application).

### 4 CONCLUSION

The program ran successfully with efficient speed and reliability. Furthermore, it was observed that the VB program (developed application) enormously saves time and reduces errors to its barest minimum level as compared with the manual approach which has a limiting point in cases of complex analysis and design. Conclusively, the essence of speed in the analysis and design as a major factor of consideration bearing in mind accuracy was equally justified. It is recommended that further research be fashioned out using VB (2015) programming language for the analysis and design of other foundation types such as raft, strip, and pile.

### REFERENCES

1. Akinyokun, O.C. (1991). Computers and programming using FORTRAN 77. Alagbaka, Akure: New Era Commercial Press,
2. Aggarwal, K. K. and Yogesh, S. (2007). Software Engineering. 3th Ed. New Delhi: New Age International Publishers Limited.
3. Foye, K. C., Abou Jaoude, G., and Salgado, R. (2004). *Limit States Design of Deep Foundations*. Publication FHWA/IN/JTRP-2004/21. Joint Transportation Research Program, Indiana Department of Transportation and Purdue University, West Lafayette, Indiana pp. 91-101. <https://doi.org/10.5703/1288284313262>
4. Mohammed, A., and Ogork, E. N. (2015). Development of JAVA Application Software for Design of Concrete Foundations. *Northwest University Science, Faculty of Science Annual International Conference* pp. 1-7.
5. Sreenivasa, H. J., and Nagaraj S. (n.d). Computer Diligence for Civil Engineers. Jain University Jakkasandra Post, Kanakapura Taluk, Ramanagara District pp. 1-6. Retrieved from <http://engineeringcivil.com/computer-diligence-for-civil-engineers.html>
6. Vasani, P. C. (2001). Development of Packages for Analysis and Design of Civil Engineering Structures which extensively Utilizes MS excel. Ahmedabad (INDIA): L.D. College of Engineering, Gujarat University, pp. 1-9.
7. Wang, J., and Chopra, A.K. (2008). A Computer Program for Three Dimensional Earthquake Analysis of Concrete Dams Considering Spatially-varying Ground Motion. EERC 2008 -04 Berkeley, California: Earthquake Engineering Research Center.
8. Akman, A., Arici, Y., Binici, B., and Kurc, O. (2015). Development of a software suite for the structural analysis and design of concrete gravity dams. Turkish National Sciences Foundation (TUBITAK): 5130011 pp. 1-9.
9. Adu, M. K., and Abe, O. E. (2014). Improving Structural Designs with Computer Programming in Building Construction. *Journal of Computer Engineering (IOSRJCE)*, Vol. 16, pp. 10-16.

10. Hassan, A. B., Abolarin, M. S., and Jimoh, O. H. (2006). The Application of Visual Basic Computer Programming Language to Simulate Numerical Iterations. *Leonardo Journal of Sciences*, ISSN 1583-0233, Issue 9. pp. 125-136.
11. Osakwe, C.E., Mustapha, Z.A., and Garnvwa, S.D., (2017). Application of Visual Basic Program to Analysis and Design of Timber Structural Elements. *Nigerian Journal of Engineering Science and Technology Research*, vol. 3, no.1, pp. 61-69.
12. Babu, J. M. (2015). Software Application for Design of Structural Element Using Visual Basic Coding. *International Journal of Engineering and Computer Science*, vol. 4, Issue 4, pp. 1661-1667.
13. British Standard, BS 8110: (1997). Structural Use of Concrete. Part 1: Code of practice for Design and Construction. pp. 72-74.