Application of Visual Basic in Geotechnical Design (Shallow Foundation)

Shantana Sheikh, A.Z.M Sanaul Haque

Abstract— The research work represents how effectively programming language can be used in geotechnical design work. In this case the design of shallow foundation is done by Visual Basic programming. The lowest and supporting layer of a structure.is called foundation. Soil is an unconsolidated material, composed of solid particles, produced by the disintegration of rocks is not same all the place. Its load bearing capacity varies with its nature. According to soil load bearieng capacity foundation is categorized as shallow foundation.In this researches the design of single column and combined footing is done. Construction of shallow foundation is more economical and easier. But manually it required more time. So, in this case the application of Visual Basic is done for the design. The entire design has been translated into simple functions.

Index Terms— Bearing Capacity, Bending Moment, Dowel bar, Reinforcement, Shallow Foundation, Structural engineering, Visual Basic.

———————————— ◆ ————————————

1 INTRODUCTION

The ultimate load which a foundation can support may be calculated using bearing capacity theory. The ultimate bearing capacity of a foundation is calculated from an equation that incorporates appropriate soil parameters (e.g. shear strength, unit weight) and details about the size, shape and founding depth of the footing.

Footing belongs to the category of shallow foundations and is used when soil of sufficient strength is available within a short depth below the ground level.

With the advent of personal computers, the application of computers has increased tremendously in the analysis/design of civil engineering structures and many other fields. The paper illustrates the application of computer for carrying out the design of combined footings using Microsoft (MS) visual basic software. The problem has been formulated for determination of soil-bearing capacity using Terzaghi's bearing capacity equation and Meyerhof's bearing capacity equation. It also been formulated for rectangular footings without central beam. However, the design of slab type rectangular combined footing has been discussed and presented in detail.

————————————————
- *Shantana Sheikh, Lecturer, Department of Civil Engineering, Stamford University Bangladesh, Dhaka, Bangladesh.E-mail: sheikh_ruet@yahoo.com*
- *A.Z.M Sanaul Haque, Junior Engineer, Institute of water Modelling, Dhaka, Bangladesh. E-mail: azmsanaulhaque@yahoo.com*

1.2 Objective of the Work

Determination of soil bearing capacity and foundation design based on hand calculation is so much time consuming. In this case the development of visual basic programming is very effective. The main objectives of the present study are as follows:

(i) To determine the bearing capacity of soil using hand calculation and visual basic.

(ii) To study how to develop visual basic programming.

(iii) To design single column footing and combined footing by hand calculation and visual basic.

(iv) To investigate the benefit of using visual basic instead of hand calculation.

1.3 Scope of the Work

Civil Engineering is a field of construction work. Varieties of structures are constructed here. Not only construction but also stability of these structures is very important. The factor which governs the stability of structure is the soil-bearing capacity on which the substructure stands. The choice of the type of foundation, shallow or deep largely depends on the soil condition. If the bearing capacity is high it requires shallow foundation which proves to be not only economical but also easy to construct. But manually, determination of bearing capacity and design of combined footing both required hard work and lengthy of time. In this case, computer programming solution can be a great effort. Among many of them Visual Basic is one. Application of Visual Basic in the determination of soil-bearing capacity and design of shallow foundation makes it easier and faster. So, there is no other comparison of computer base solution in the design of structures.

2 RESEARCH BACKGROUND

2.1   General

Building loads are transmitted by columns, bearing walls, or by other bearing member to foundations. The lowest part of a structure is generally referred to as the foundation. It's function is to transfer the load of a structure to the soil on which it is resting. A properly designed foundation transfers the load throughout the soil without overstressing the soil. Overstressing the soil can result in either excessive settlement or shear failure of the soil, both of which cause damage to the structure. Thus, geotechnical and structural engineers who design foundations must evaluate the bearing capacity of soil.

2.2   Soil-Bearing Capacity for Shallow Foundation

To perform satisfactorily, shallow foundations must have two main characteristics:

1. The foundation has to be changed against overall shear failure in the soil that supports it.
2. The foundation cannot undergo excessive displacement, that is, settlement. (The term excessive is relative, because the degree of settlement allowable for a structure depends on several considerations.)

2.3   Bearing Capacity Theories

2.3.1   Terzaghi's Bearing Capacity Theory

Terzaghi (1943) was the first to present a comprehensive theory for the evaluation of the ultimate bearing capacity of rough shallow foundation.

Terzaghi expressed the ultimate bearing capacity in the form

$$q_u = cN_c + qN_q + 0.5\ \gamma BN_\gamma \qquad \text{(strip foundation)} \qquad (1)$$

Where c = cohesion of soil
γ = unit weight of soil

$$q = \gamma D_f$$

N_c, N_q, N_γ = bearing capacity factors that are nondimensional and are only functions of the soil friction angle Φ

For estimating the ultimate bearing capacity of square or circular foundations,

$$q_u = 1.3\ cN_c + qN_q + 0.4\ \gamma BN_\gamma \qquad \text{(square foundation)} \qquad (2)$$

$$q_u = 1.3\ cN_c + qN_q + 0.3\ \gamma BN_\gamma \qquad \text{(circular foundation)} \qquad (3)$$

In equation (2), B equals the dimension of each side of the foundation; in equation (3), B equals the diameter of the foundation.

For foundations that exhibit the local shear failure mode in soils, Terzaghi suggested modifications to equations (1), (2), and (3) as follows:

$$q_u = 0.667cN_c' + qN_q' + 0.5\ \gamma BN_\gamma' \quad \text{(strip foundation)} \qquad (4)$$

$$q_u = 0.867\ cN_c' + qN_q' + 0.4\ \gamma BN_\gamma' \quad \text{(square foundation)} \qquad (5)$$

$$q_u = 0.867cN_c' + qN_q' + 0.3\ \gamma BN_\gamma' \quad \text{(circular foundation)} \qquad (6)$$

N_c', N_q', N_γ' are the modified bearing capacity factors. They can be calculated by using the bearing capacity factors equations by replacing Φ by $\Phi' = \tan^{-1}(2/3\tan\Phi)$

2.3.2   Meyerhof's Bearing Capacity Theory

Meyerhof (1963) suggested the following form of the general bearing capacity equation:

$$q_u = cN_cF_{cs}F_{cd}F_{ci} + qN_qF_{qs}F_{qd}F_{qi} + 0.5\gamma\ BN_\gamma F_{\gamma s}F_{\gamma d}F_{\gamma i}$$

Where
c = cohesion
q = effective stress at the level of the bottom of the foundation.
γ = unit weight of soil
B = width of foundation (= diameter for a circular foundation)
F_{cs}, F_{qs}, $F_{\gamma s}$ = Shape factors
F_{cd}, F_{qd}, $F_{\gamma d}$ = Depth factors
F_{ci}, F_{qi}, $F_{\gamma i}$ = Inclination factors
N_c, N_q, N_γ = bearing capacity factors

The equations for determining the bearing capacity factors are given above by equations (3), (5), (7). Table 2.3, 2.4 shows the value of Meyerhof's bearing capacity factors. B.M.Das(1984)

2.4   Shallow Foundations

According to Terzaghi, a foundation is shallow if the depth, D_f, of the foundation is less than or equal to the width of the foundation. Later investigators, however, have suggested that foundations with D_f equal to 3-4 times the width of the foundation may be defined as shallow foundations.

Footings

Footing foundation is one of the oldest and most popular type of shallow foundations. A footing is an enlargement of the base of a column or wall for the purpose of distributing the load on the supporting soil at a pressure suiting its properties.

2.4.1   Choice of the Type of Foundation

The choice of the appropriate type of foundation is governed by some important factors such as B.C Punmia et al(1970)

1. The nature of the structure
2. The loads exerted by the structure
3. The subsoil characteristics
4. The allotted cost of foundations

Therefore to decide about the type of foundation, subsoil exploration must be carried out.

2.5   Types of Shallow Foundations

The shallow foundations are of the following types:
a) Wall Footing
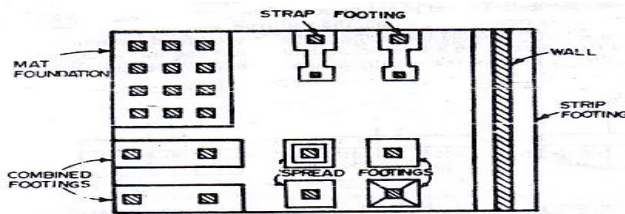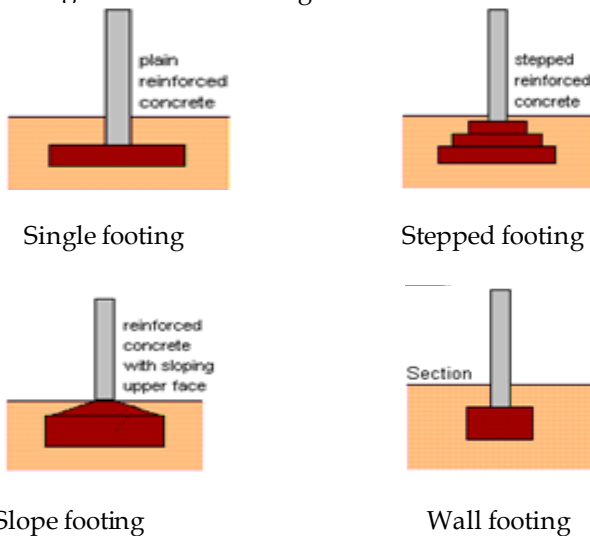b) Spread Footing

c) Combined Footing
d) Mat or Raft Footing

Figure 2.1. Various types of shallow foundation

2.5.1 Spread Footing

A spread footing or simply footing is a type of shallow foundation used to transmit the load of an isolated column, or that of a wall to the subsoil. This is the most common type of foundation. Spread footings can be classified as wall and column footings. The horizontal outlines of the most common types are given in Figure. Single-column footings are usually square, sometimes rectangular, and represent the simplest and most economical type. The single column footings are usually square in plan, Rectangular footings are used if there restriction in one direction or If the supported columns are of too elongated .rectangular cross section. In the simplest form, they consist of a single slab FIg.2.15-a. Fig.2.15-b shows a pedestaled column footing, the pedestal provides depth for a more favorable transfer of load and in many cases is required in order to provide the necessary length for dowels. Sloped footings such as those in Fig.12.15-c B.C Punmia et al(1970)

Single footing   Stepped footing

Slope footing   Wall footing

2.2 Structural design of spread footings

For spread footing the following items should be considered

2.5.1.2 Design Procedure of Single Footing (Square)

In square footings, the reinforcement is uniformly distributed over the width of the footing in each of the two layers; i.e. the spacing of the bars is constant. The moment for which the two layers are designed are the same. However, the effective depth d for the upper layer is less by 1 bar diameter than that of the lower layer. Consequently, the required A_S is larger for the upper layer. Instead of using different spacing or different bar diameters in each of the two layers, it is customary to determine A_S based on average depth and to use the same arrangement of reinforcement for both layers. It's design procedure is described below:

Step # 1. Calculation of bearing pressure to carry the column service load.
Bearing pressure, q_e = allowable soil pressure (q_a) - γD_f
Where, γ = average unit weight of concrete and soil.

Step # 2. For concentrically loaded footings, the required area is determined from
$$A_{req} = DL + LL/ \ q_e$$

Step # 3. Determination of ultimate soil pressure.
$$qu = 1.2 \times DL + 1.6 \times LL/ \ A_{req}$$

Step # 4. Determination of effective depth of footing
Perimeter, $b_0 = 4(l + d)$
Where, d = effective depth of footing
l = column length
Shear force acting on the perimeter, V_{u1} = (qu)[(A_{req})-((l + d)/12)²]
Nominal shear strength, $V_c = 4\Phi\sqrt{(fc')}\times b_0 \times d/1000$

Step # 5. Punching Shear Check
Shear force acting on the perimeter, V_{u1} = (qu) [(A_{req})-((l + d)/12)²]
Nominal shear strength, $V_c = 4\Phi\sqrt{(fc')} \times b_0 \times d/1000$
The check will be ok, if $V_c > V_{u1}$

Step # 6. Beam Shear Check
Shear force, V_{u2} = qu ×length or width of footing (B) × (B/2-l/24-d/12)
Nominal shear strength, $V_c = 2\Phi\sqrt{(fc')} \times B \times d/1000$
The check will be ok, if $V_c > V_{u2}$

Step # 7. Depth Check against Moment
Bending moment, $M_U = ws^2/2$
Where, w = qu ×B

$$s = B/2 – l/2$$

$d= \sqrt{[Mu/\{0.9\times\rho\times f_y\times B(1-0.59\times\rho\times fy/fc')\}]}$
Where $\rho = 0.75\times\beta1\times(fc'/fy)\times(87000/87000+fy)$
Step # 8. Calculation of Steel
Required steel area, $A_S = M_U/0.9 \ f_y(d-a/2)$
Minimum reinforcement, $A_{Smin} = 200/fyBd$
Spacing, S = (L-6)/(No of bars-1)
Step # 9. Calculation of Development Length
$L_d = 0.04\times b_d\times f_y/\sqrt{(f_c')}$
Where, b_d = diameter of the bar used.
L_{dall} = L/2-1l/2-cc
Where, cc = clear cover
Total thickness, h= d + (l/12)×b_d +cc

Step #10. Calculation of Dowel Steel Requirement
Minimum dowel steel requirement = 0.005×column dimension [Nilson(1923)]

2.5.1.3 Design Procedure of Single Footing (Rectangular)

The procedure is the same as square footing. The depth is usually controlled by punching shear except if the ratio of length to width is large, the wide beam shear may control the depth. The critical sections for shear are at distance d from both sides of the column Fig.2.18-a. The bending moment is calculated for both directions, about 1-1 axis and about b-b axis as shown in Fig.2.18.b and c. Nilson(2006)
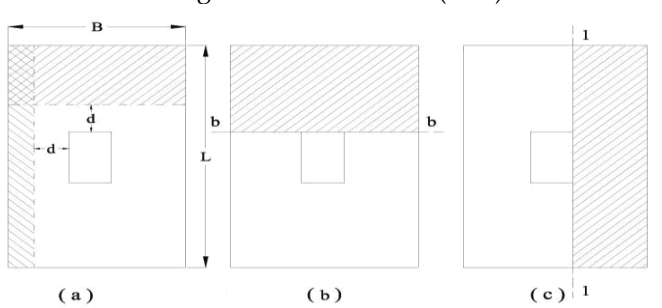

Figure 2.3 Rectangular single column footing

2.5.2   Combined Footing

The preceding section presented elements of the design of spread and wall footings. This section considers some of the more complicated shallow-foundation problems. Among these are footings supporting more than one column in a line (combined footings), which may be rectangular or trapezoidal in shape, or two pads connected by a beam, as for a strap footing. Eccentrically loaded footings and un-symmetrically shaped footings will also be considered.L.Pricto-Portar (2008)
It is assumed that the footing is rigid and rest on a homogeneous soil, so as to give rise to a linear stress distribution on the bottom of the footing. If the resultant of the soil pressure coincides with the resultant of the loads (and centre of gravity of footing), the soil pressure is assumed to be uniformly distributed.Figure2.21 shows Combined footing
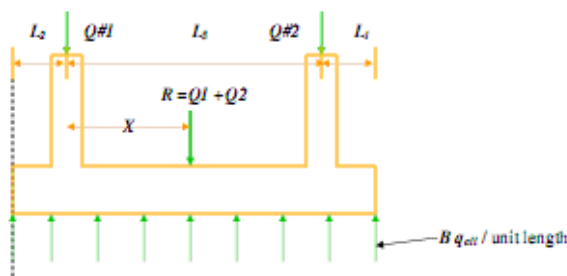

Figure 2.4 Combined footing

Figure 2.5 Construction of a combined footing

2.5.2.1   Types of Combined Footing

Combined footings are classified according to their shape. They are
(a) Rectangular Combined Footing
(b) Trapezoidal Combined Footing
(c) Strap or Cantilever Footing

2.5.2.1.1 Rectangular Combined Footing

If both the columns carry equal loads the combined footing may be rectangular in shape. When property lines, equipment locations, column spacing, or other considerations limit the footing clearance at the column locations, a possible solution is the use of a rectangular-shaped footing. This type of footing may support two columns, as illustrated in Fig2.23.or more than two columns with only slight modification of the design procedure.

Step #1. The required design area A of a footing can be found from,

$$A = \frac{Q_1 + Q_2}{q_{\text{all (net)}}}$$

Where Q_1, Q_2 are the loads in column #1 and #2, and $q_{\text{all (net)}}$ is the net allowable soil bearing capacity.

Step #2. Determination of the location of the resultant of column loads.

$$x = \frac{Q_2 + L_3}{Q_1 + Q_2}$$

For a uniform distribution of soil pressure under the footing, the resultant of the column loads should pass through the centroid of the foundation. Thus,

$$L = 2(L_2 + x) \tag{3}$$

where L= length of the foundation.

Step #4. Once the length L is determined from above, the value of L1 can be obtained from,

$$L_1 = L - L_2 - L_3 \tag{4}$$

The magnitude of L2 will be known and depends on the loca-

tion of the property line.
The width B of the foundation is then found from, L.Pricto-Portar(2008)

$$B= A/L \qquad\qquad (5)$$

3 INTRODUCTIONS TO VISUAL BASIC PROGRAMMING

3.1 Introduction

A programming language is a notation for writing programswhich are specifications of a computation or algorithm.Visual Basic enables a disciplined approach to computer-program design. In this phase, we introduced Visual Basic programming and present examples that illustrate several important features of the language.

3.2 What is a programming language

A Computer cannot understand any person's spoken language. A spoken language such as English, French, is simply too general and ambiguous for computers to understand. Therefore, we must adapt to the machine and learn the computer language so that the computer can understand. This is where visual basic comes into it - when one type visual basic source code into the computer, the computer processes these statements into Visual Basic language. Noah Amolo (2008)

3.3 How to Create a Project in Visual Basic Language

Suppose we want to create a simple project, addition of two values. Although we will create a complete functional Project with controls and code and so on, the purpose of this exercise is to show what can be done. In the following lessons we will be explaining scripts and the use of controls in a lot more detail. First thing to do is to create a Directory where we will store all our Visual Basic Projects. Noah Amolo(2008)
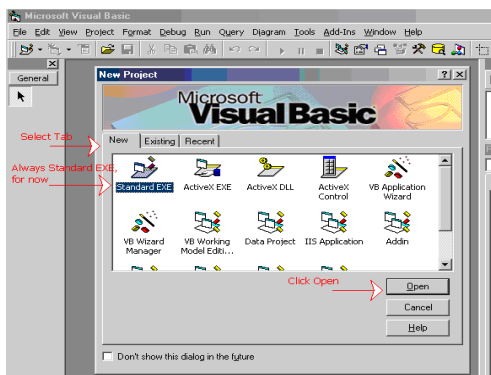

Figure 3.1 Opening form of Visual Basic

3.3.1 The Development Environment

Learning the ins and outs of the Development Environment before one learn visual basic is somewhat like learning for a test one must know where all the functions belong and what their purpose is. First we will start with labelling the development environment.
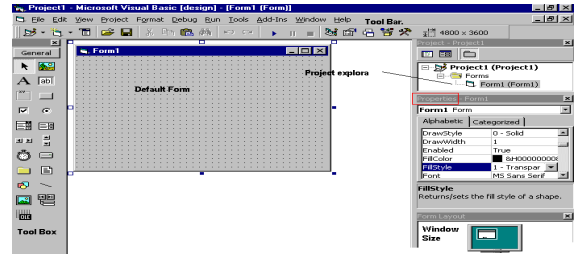

Figure 3.2 Development environment

The above diagram shows the development environment with all the important points labelled. Noah Amolo(2008)
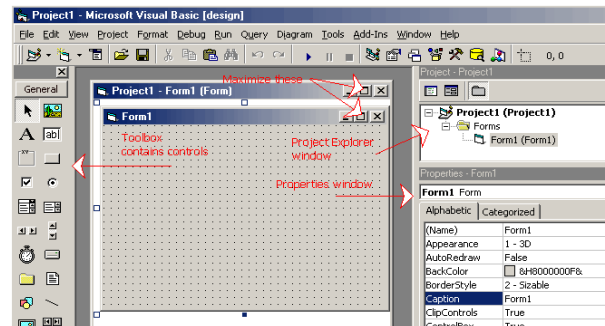

Figure 3.3 Visual Basic project form
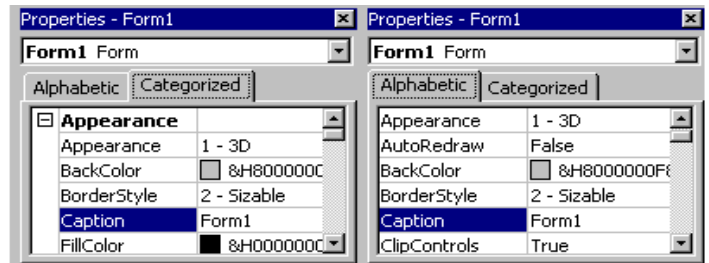
3.3.2 Properties Window

Figure 3.4 Properties window

Some programmers prefer the Categorisized view of the properties window. By defaulting, the properties window displays its properties alphabetically (with the exception of the name value) when you click on the categorized button the window changes to left picture. Noah Amolo (2008)

3.3.3 The Default Layout

On start up, Visual Basic will displays the following windows
- The **Blank Form** window
- The **Project** window
- The **Properties** window

3.3.4   Name of toolbox

It also includes a Toolbox that consists of all the controls essential for developing a VB Application. Controls are tools such as boxes, buttons, labels and other objects draw on a form to get input or display output. They also add visual appeal.
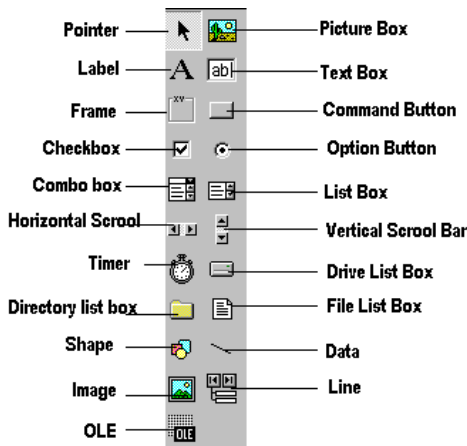

Figure 3.5 Toolbox

About toolbox:

List box: It is used to select a item among various types of items in a box.

Combo box: It is a type of input box which contain list box and text box.

Picture box and Image box: To use graphics in a project Picture box and Image box is used.

Timer: To create infinite looping it is used.

Scrollbar: It is used to verify the size of the window.

Filelist box, Drivelist box and Dirlist: They are used to locate any file from any directory of computer.

Line and Shape: They are used to draw different shapes and line in a project.

Text box: It is used to create input box.

Command box: It is used to see output.

Noah Amolo(2008)

3.3.5   Saving visual basic project

The most important thing while performing a project is to save it frequently. The process is described as, from the form or code window click in File at the top and left side of the window. Then click save project as first and later click save form as. After doing this we can save the project in our desirable place.
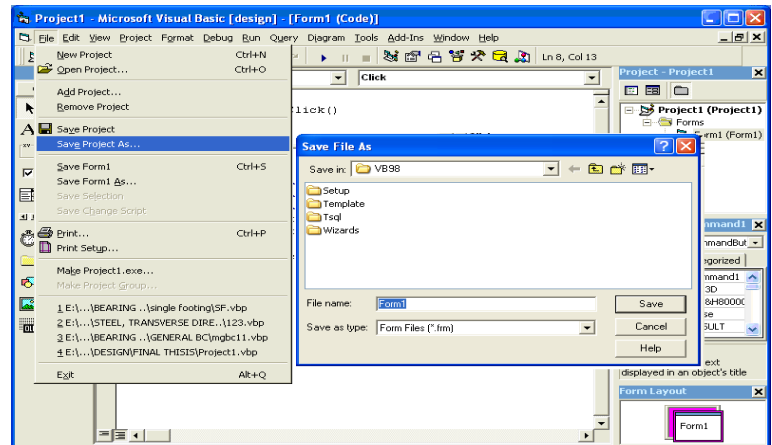

Figure 3.6 Project saving process

Now the main thing is to Run or Compile the project. It can be done in two ways. First, from File option click Make Project1.exe...to compile the project and then from Run option at the top of the window the project can be Run.
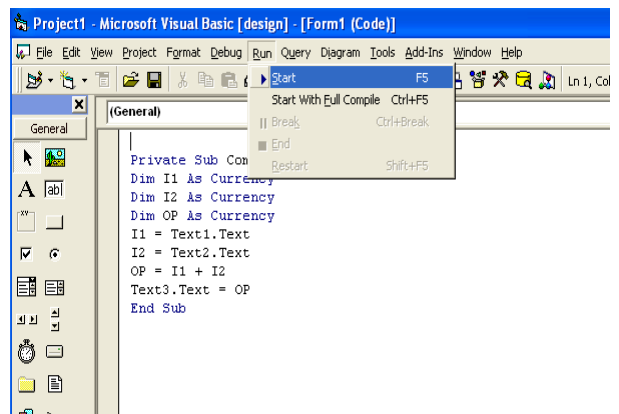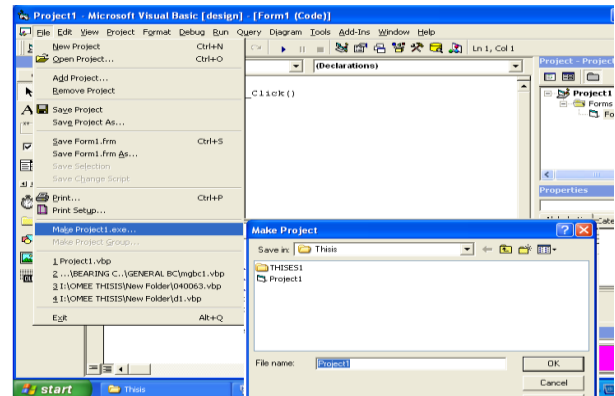

Figure3.7 Project saving process

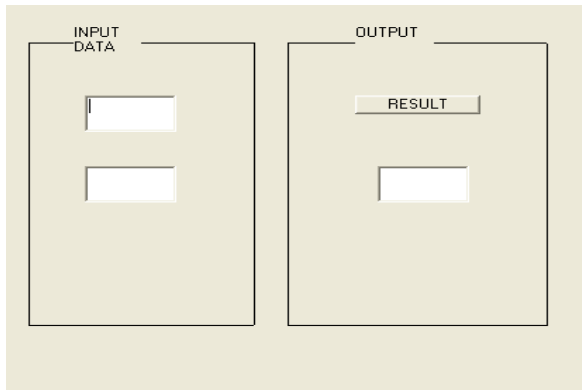After compiling the form will be in the form as given below:

Figure 3.8 Form after compilation of program

3.3.6   Control Arrays

A control array is a list of controls with the same name. Therefore, instead of using five command buttons with separate five names, one can place a command button control array on the form, and that control array holds five command buttons. The control array can have a single name, and one will distinguish the control from each other with a subscript. One of the best reasons to use control array from that first control, all the elements in the control array take on the same property values, Noah Amolo(2008)

3.4   Arithmetic Calculation

Most programs perform arithmetic calculations. The arithmetic operators are summarized in Table. value.Asura (2008)

Table 3.1
Arithmetic operators

Visual Basic operation	Arithmetic operator	Algebraic expression	Visual Basic expression
Addition	+	$f + 7$	f + 7
Subtraction	−	$p - c$	p - c
Multiplication	*	bm	b * m
Division (float)	/	x / y or $\frac{x}{y}$ or $x \div y$	x / y
Division (Integer)	\	none	v \ u
Modulus	%	$r \bmod s$	r Mod s
Exponentiation	^	q^p	q ^ p
Unary Negative	−	$-e$	-e
Unary Positive	+	$+g$	+g

Arithmetic expressions in Visual Basic must be written in straight-line form so that programs can be entered into a computer. Thus expressions such as "a divided by b" must be written as a/b so that all constants variables and operators appear in a straight line. The following algebraic notation generally is not acceptable to compilers:

$$\frac{a}{b}$$

Parentheses are used in Visual Basic expressions in the same manner as in algebraic expressions. For example, to multiply a times the quantity b + c, we write

a * (b + c)

Not all expressions with several pairs of parentheses contain nested parentheses. For example, although the expression

a * (b + c) + c * (d + e)

contains multiple sets of parentheses, none of the parentheses are nested. Rather, these parentheses are referred to as " on the same level."

Let us consider several expressions in light of the rules of operator precedence. Each example lists an algebraic expression and its Visual Basic equivalent.

The following is an example of an arithmetic mean of five terms:

$$\text{Algebra: } m = \frac{a + b + c + d + e}{5}$$

Visual Basic: m = (a + b + c + d + e) / 5

The parentheses are required, because floating-point division has higher precedence than addition. The entire quantity (a + b + c + d + e) is to be divided by 5. If the parentheses are omitted, erroneously, we obtain a + b + c + d + e / 5, which evaluates as

$$a + b + c + d + \frac{e}{5}$$

The following is the equation of a straight line:
Algebra: y = mx + c
Visual Basic: y = m * x + c

No parentheses are required. The multiplication is applied first, because multiplication has higher precedence than does addition. The assignment occurs last because it has a lower precedence than multiplication and addition.

The following example contains modulus, multiplication, division, addition and subtraction.
Algebra: z = pr%q + w/x – y
Visual Basic: z = p * r Mod q + w / x – y

As in algebra, it is acceptable to place unnecessary parentheses in an expression to make the expression easier to read. Unnecessary parentheses are also called redundant parentheses. For example, the preceding assignment statement might be parenthesized as

y = (a * x ^ 2) + (b * x) + c

There are some other expressions used in this project are described below:

Quadratic Equation:
Required equation,
$$ax^2 + bx + c = 0$$
Solve of the equation,

$$\text{Algebra: } x = \frac{-b \pm \sqrt{(b^2 - 4ac)}}{4ac}$$

Visual Basic:
x1 = Round((-b + Sqr(b ^ 2 - 4 * a * c)) / (2 * a), 2)

x2 = Round((-b - Sqr(b ^ 2 - 4 * a * c)) / (2 * a), 2)

Angle:

In Visual Basic angle is always in Radian. Suppose we have to determine the value of tanΦ, where Φ = 30°. As Φ (phi) is a Greek letter the Visual Basic languagr does not read it. So, the expression of tanΦ is,

Value = Tan(phi * 3.1416 / 180)

Other letters which are not a English letter and are used as a symbol are expressed in Visual Basic in the following form: [Asura (2008)]

Table 3.2

Visual Basic Form of Different Symbol

Symbol	Original Name	Visual Basic Form
Φ	Greek capital letter PHI	Phi or p or other English letter
σ	Greek small letter SIGMA	Sigma or s or other English letter
β	Greek small letter BETA	Beta or b or other English letter
γ	Greek small letter GAMMA	Gamma or g or other English letter
α	Greek small letter ALPHA	Alpha or a or other English letter
δ	Greek small letter DELTA	Delta or d or other English letter
η	Greek small letter ETA	Eta or e or other English letter
θ	Greek small letter THETA	Theta or other English letter
λ	Greek small letter LAMDA	Lamda or other English letter
ψ	Greek small letter PSI	Psi or other English letter
e	Cyrillic small letter IE	Eee = 2.718
°	Degree	Degree
ρ	Greek small letter RHO	Rho or other English letter

Inverse function:

Algebra: value = tan⁻¹(D/B)

value = sin⁻¹ (D/B)

Visual Basic: value = Atn (D/B)

value = Asn (D/B)

3.5   Equality and Relational Operators

This section introduces Visual Basic's If/ Then structure, which allows a program to make a decision based on the truth or falsity of some expression. The expression in an If/ Then structure is called the condition. If the condition is met (i.e. the condition is true), the statement in the body of the If/ Then structure executes. If the condition is not met (i.e. the condition is false), the body statement is not executed. Conditions in If/ Then structures can be formed by using the equality operators and relational operators, which are summarized in Table. Asura (2008)

Table 3.3
Equality and Relational Operators

Standard algebraic equality operator or relational operator	Visual Basic equality or relational operator	Example of Visual Basic condition	Meaning of Visual Basic condition
Equality operators			
=	=	x = y	x is equal to y
≠	<>	x <> y	x is not equal to y
Relational operators			
>	>	x > y	x is greater than y
<	<	x < y	x is less than y
≥	>=	x >= y	x is greater than or equal to y
≤	<=	x <= y	x is less than or equal to y

Example of If / Then statement:

```
d1 = Text11.Text
If d1 = 6 Then
dm = 0.75
ElseIf d1 = 7 Then
dm = 0.875
ElseIf d1 = 8 Then
dm = 1
ElseIf d1 = 9 Then
dm = 1.128
ElseIf d1 = 10 Then
dm = 1.27
ElseIf d1 = 11 Then
dm = 1.41
ElseIf d1 = 14 Then
dm = 1.693
End If
n1 = (Asreq * 4) / (3.1416 * (dm) ^ 2)
```

Project1 - Microsoft Visual Basic [design] - [Form1 (Code)]
File Edit View Project Format Debug Run Query Diagram Tools Add-Ins Window

Command1   Click

```
Private Sub Command1_Click()
n1 = (Asreq * 4) / (3.1416 * (dm) ^ 2)
If n1 <= 1 Then
n = 1
ElseIf n1 <= 2 Then
   n = 2
ElseIf n1 <= 3 Then
n = 3
ElseIf n1 <= 4 Then
n = 4
ElseIf n1 <= 5 Then
n = 5
ElseIf n1 <= 6 Then
n = 6
End If
Text12.Text = n
End Sub
```

Figure 3.9 Example of a If/Then statement

4 VISUAL BASIC PROGRAMMING

4.1   General

Availability of user-friendly software has increased the application of computers tremendously in the analysis/design of civil engineering structures and many other fields. Application of MS visual basic software has been illustrated in this paper to carry out the design of combined footings. The entire design has been translated into simple functions and used in the worksheet on the basis of the design steps described earlier. Hence as for exaple the soil-bearing capacity using Terzaghi's bearing capacity equation is given.

4.2   Determination of Bearing Capacity

4.2.1   Bearing Capacity Using Terzaghi's Equation

```
Private Sub Command1_Click()
C = Text1.Text
Df = Text2.Text
gamma = Text3.Text
B = Text4.Text
phi = Text5.Text
L = Text6.Text
FS = Text11.Text
If phi = 0 Then
Nc = 5.7
Nq = 1
Ngamma = 0
......continued upto phi=50.......
End If
If GWT > Df Then
zw2 = GWT - Df
If zw2 > B Then
Rw1 = 1
Rw2 = 1
q = gamma * Df
q1 = (1.3 * (C * Nc)) + ((q * Nq) * Rw1) + ((0.3 * gamma * B *
Ngamma) * Rw2)
Text7.Text = q1
q11 = q1 / FS
Text12.Text = q11
q2 = (1.3 * (C * Nc)) + ((q * Nq) * Rw1) + ((0.4 * gamma * B *
Ngamma) * Rw2)
Text8.Text = q2
q22 = q2 / FS
Text13.Text = q22
q3 = ((1 + 0.3 * (B / L)) * (C * Nc)) + ((q * Nq) * Rw1) + ((0.4 *
gamma * B * Ngamma) * Rw2)
Text9.Text = q3
q33 = q3 / FS
Text14.Text = q33
q4 = (C * Nc) + ((q * Nq) * Rw1) + ((0.5 * gamma * B * Ngam-
ma) * Rw2)
Text10.Text = q4
q44 = q4 / FS
Text15.Text = q44
ElseIf B > zw2 > Df Then
Rw1 = 1
```

```
Rw2 = (0.5 * (1 + (zw2 / Df)))
gamma1 = ((gamma * zw2) + (gammasat * (B - zw2))) / B
q = gamma * Df
q1 = (1.3 * (C * Nc)) + ((q * Nq) * Rw1) + ((0.3 * gamma1 * B *
Ngamma) * Rw2)
Text7.Text = q1
.....same as above......
End If
ElseIf GWT < Df Then
zw2 = o
zw1 = GWT
Rw1 = (0.5 * (1 + (zw1 / Df)))
Rw2 = (0.5 * (1 + (zw2 / Df)))
gamma1 = ((gamma * zw1) + (gammasat * (Df - zw1))) / Df
q = gamma1 * Df
q1 = (1.3 * (C * Nc)) + ((q * Nq) * Rw1) + ((0.3 * gammasat * B *
Ngamma) * Rw2)
Text7.Text = q1
.....same as above......
ElseIf GWT = Df Then
zw2 = o
zw1 = GWT
Rw1 = (0.5 * (1 + (zw1 / Df)))
Rw2 = (0.5 * (1 + (zw2 / Df)))
q = gamma * Df
q1 = (1.3 * (C * Nc)) + ((q * Nq) * Rw1) + ((0.3 * gammasat * B *
Ngamma) * Rw2)
Text7.Text = q1
.....same as above......
End If
End Sub
```

5 RESULTS AND DISCUSSION

5.1 General

In a Visual Basic, hundreds of complex problems can be solved in a very short time, while hand made calculations are time consuming and hard labor is required, not only that sometimes it becomes very complex. But, not only simplicity and speed, accuracy of result is also a vital issue. In this chapter, we will observe that, how much accurate the result in Visual Basic is in comparison with hand calculation.

5.2 Determination of bearing capacity of soil
5.2.1   Bearing Capacity Using Terzaghi's Equation

Table 5.1:

Variation in Bearing Capacity Result for spread footing (Terzaghi)

Types of foundation	Calculation method	Ultimate bearing capacity (psf)	Allowable bearing capacity (psf)
Circular		46154.025	11538.51
Square	Hand calculation	48765.1	12191.275
Rectangular		48765.1	12191.275
Strip footing		45832.175	11458.04
Circular		46154.025	11538.5063
Square	Visual Basic result	48765.1	12191.275
Rectangular		48765.1	12191.275

Strip footing			45832.175	11458.0438

5.2.2   Bearing Capacity Using Meyerhof's Equation

Bearing capaity factors	Bearing capacity (psf)	Result from hand calculation	Visual Basic result
Factors from equation	q_u	17227.73	17185.0599
	q_{all}	4306.93	4296.2649
Factors from chart	q_u	17231.56	17188.67
	q_{all}	4307.89	4297.12

Table 5.2

Variation in Bearing Capacity Result (Meyerhof)

5.3 Verification in Design Results

5.3.1 Design of Single Footing (square)

Reinforcement type	Design	Steel area (in²)	Bar size	No. of bar
Main reinforcement	By hand calculation	7.27	#7	13
	By Visual Basic	7.267	#7	13
Dowel bar	By hand calculation	1.62	#8	4
	By Visual Basic	1.62	#8	4

Table 5.3

Design Result of Single Footing (Square)

5.3.2 Rectangular:

Table 5.4

Design Result of Single Footing (Rectangular)

Moment	Design	Required Steel area (in²)	Steel area (in²)	Bar size	No. of bar
(-ve) moment	By hand calculation	9.22	10.40	#9	11
	By Visual Basic	9.23	10.40	#9	11
(+ve) moment	By hand calculation	2.52	10.40	#9	11
	By Visual Basic	2.52	10.40	#9	11

5.3.3   Design of Rectangular Combined Footing

Reinforcement	Design	Steel area (in²)	Bar size	No. of bar
Longer direction	By hand calculation	7.93	#7	14
	By Visual Basic	7.91	#7	14
Shorter direction	By hand calculation	8.82	#7	16
	By Visual Basic	8.82	#7	16

Table 5.5

Design Result of Rectangular combined Footing

6 CONCLUSIONS

To get a technically feasible and economically sustainable structure selection of suitable types of foundation is very important. For this the determination of bearing capacity of soil is essential. After that, selection of foundation type becomes easier. In the research work we apply Visual Basic both for the determination of soil bearing capacity and design of foundation (single and combined footing). From the analysis of the result obtained from Visual Basic and hand made calculation, we see that they are very much similar. So, the design is very much accurate and it can be done within a short time. Thus the application of Visual Basic in various structural design in civil engineering field proves to be more convenient, easier and safety of time and labor.

REFERENCES

[1]   B. M. Das (1984). "Soil-Bearing Capacity for Shallow Foundation", Principles of Foundation Engineering, Vol.4,pp.152-153.

[2] B. M. Das (1984). "Terzaghi's Bearing Capacity Theory", Principles of Foundation Engineering, Vol.4,pp.156-159.

[3] Dr. B. C. Punmia, Ashok Kumar Jain, Arun Kumar Jain (1970). "Assumptions and Limitations of Terzaghi's Bearing Capacity Theory", Soil Mechanics and Foundations, Vol.13,pp.668-669.

[4] B. M. Das (1984). "Meyerhof's Bearing Capacity Theory", Principles of Geotechnical Engineering, Vol.4,pp.536-539.

[5] B. M. Das (1984). "Effect of Water Table on Bearing Capacity", Principles of Geotechnical Engineering, Vol.4,pp.530-531.

[6] B. M. Das (1984). "Effect of Eccentricity of Loading on Bearing Capacity", Principles of Geotechnical Engineering, Vol.4, pp. 544-546.

[7] Dr. B. C. Punmia, Ashok Kumar Jain, Arun Kumar Jain (1970). "Shallow Foundations", Soil Mechanics and Foundations, Vol.13,pp.727-729.

[8] BS: 8004. "Strip Footing", Vol. 13, pp. 169-170.

[9] American Concrete Institute: "Structural design of spread footings"

[10] Arthur H. Nilson, David Darwin, Charles W. Dolan (1923). "Design Procedure of Single Column Footing", Design of Concrete Structures, Vol. 13. pp. 551-559.

[11] L.Pricto-Portar (2008). "Combined Footing", Journal of the Geotechnical Engineering Division, American Society of Civil Engineers, pp. 1257-1276.

[12] B. M. Das (1984). "Mat Foundation", Principles of Foundation Engineering, Vol.4,pp.293-296.

[13] Noah Amolo, Asura (2008). Introduction to Visual Basic Programming.