

Adoption of Programming Codes in the Design of Earth Retaining Wall in Different Backfill Conditions.

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ABSTRACT: *The earth retaining wall is the most important structure in various construction projects of civil engineering. It involves intricate design work and the manual calculations can sometimes become tedious and time taking. Also the accuracy and precision of the design becomes very important when it comes to big structures such as bridges and dams. Therefore, a lot of companies and construction firms have started using various user friendly software. We, through this paper, want to make an attempt to use programming languages to make calculations of the design of retaining wall much more easy and swift.*

KEYWORDS: *Retaining wall design, Active earth pressure, Software programming.*

I. INTRODUCTION

Retaining walls are used to retain earth or other loose material. These walls are commonly constructed in the places namely construction of building basement, as wing wall or abutment in bridge construction and in the construction of embankment. All these types of construction works require intricate calculations with accuracy and precision. So to make these calculations much easy and appropriate, the use of a programming language known as Python is used here. Python as a coding language is very useful as it gives Learning Ease, it has User-friendly Data Structures: and the Productivity and Speed is very quick. This paper deals with the design of retaining wall with horizontal backfill using Python to get more accurate data.

1.1 Retaining Wall

Retaining walls are used to retain earth or other loose material. These walls are commonly constructed in the following places :

1. In the construction of building basement
2. As wing wall or abutment in bridge construction
3. In the construction of embankment

1.2 Types of Retaining wall

1. Gravity Retaining Wall
2. Cantilever Retaining Wall
3. Counterfort Retaining Wall
4. Buttress Retaining Wall

1.2.1 Cantilever Retaining Wall

It is the most common type of Retaining wall which consists of a vertical wall called as stem, heel slab and toe slab. As all the three components of this wall acts as cantilever, the wall is called as cantilever retaining wall.

The stem, heel and toe all resist the earth pressure by bending. These walls can be L or inverted in shape. The cantilever Retaining wall are used upto height of 6meter.

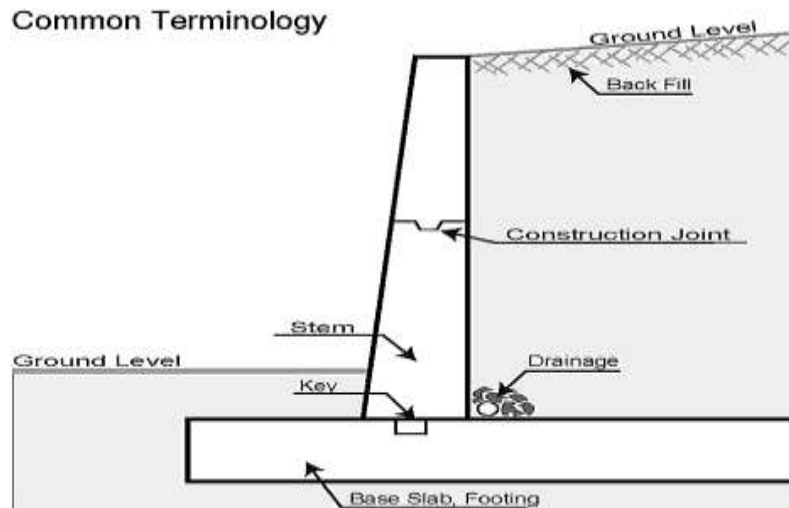


Figure 1: Basic elements of Retaining Wall

(Source: Wikipedia)

1.3 About the programming language: Python

Python is an interpreted high-level programming language for general-purpose programming. Created by Guido van Rossum and first released in 1991, Python has a design philosophy that emphasizes code readability, and a syntax that allows programmers to express concepts in fewer lines of code, notably using significant whitespace. It provides constructs that enable clear programming on both small and large scales.

Python features a dynamic type system and automatic memory management. It supports multiple programming paradigms, including object-oriented, imperative, functional and procedural, and has a large and comprehensive standard library.

Python interpreters are available for many operating systems. CPython, the reference implementation of Python, is source software¹ and has a community-based development model, as do nearly all of its variant implementations. CPython is managed by the non-profit Python Software Foundation.

(Source: Wikipedia)

1.3.1 Advantages of Python Language

1. This language is Open Source and support Community Development.
2. It is easy to learn.
3. The language is User-friendly Data Structures.
4. It is Productivity and Speedy.

II. METHODOLOGY

By using Python programming language we have designed retaining wall in different backfill conditions.

2.1 Case 1: Retaining wall with dry horizontal backfill

Problem 1:

Total height of retaining wall = 4.4m

Width of base slab = 2.5m

Thickness of base slab = 0.4m

Cantilever projection on toe side = 0.8m

Cantilever projection on heel side = 1.4m

Angle of shearing resistance = 30degrees

Unit weight of soil = 18

Soil Bearing Capacity = 150

2.2 Program for design of retaining wall structure

```
import math
print 'Enter the height of retaining wall'
H = input()
print 'Enter width of base slab'
b = input()
```

```
print 'Enter the thickness of base slab'
t = input()
print 'Enter projection on toe side'
b1 = input()
print 'Enter angle of shear resistance'
phi = input()
print 'Enter unit weight of soil(in kN/cumec)'
gama = input()
print 'Enter soil bearing capacity'
q = input()
print 'Enter grade of concrete'
fck = input()
print 'Enter grade of steel'
fy = input()
print 'Enter clear cover'
cc = input()
b2 = b - b1 - 0.1 - 0.2
ka = (1 - math.sin(math.radians(phi)))/(1 + math.sin(math.radians(phi)))
Df = (q/gama) * ka * ka
print 'Depth of foundation is ',Df
h = H - t
Pa = (ka * gama * h * h)/2
Pau = 1.5 * Pa
Mu = Pau * h/3
print 'Bending moment due to active earth pressure on retaining wall in kN-m is',Mu
d = math.sqrt(Mu*1000000/(0.138*fck*1000))
print 'Effective depth is',d
Astem = (0.5*fck*1000*d)/fy*(1 - math.sqrt(1-((4.6*Mu*1000000)/(fck*1000*d*d)))
print 'Area of steel of stem is',Astem
W1 = 0.2*h*25
W2 = 0.5*0.1*h*25
W3 = b*t*25
W4 = (2.5 - b1 - 0.3)*h*18
W = W1 + W2 + W3 + W4
Wu = 1.5*W
Pa1 = 0.5*ka*gama*H*H
Pa1u = 1.5 * Pa1
OM = (Pa1 * H)/3
X1 = b1 + 0.1 + 0.1
X2 = b1 + (2 *0.1)/3
X3 = b/2
X4 = b1 + 0.1 + 0.2 + b2/2
RM = W1*X1 + W2*X2 + W3*X3 + W4*X4
RM1 = RM - OM
x = RM1/W
e = b*0.5 - x
print 'eccentricity is ',e
Smax = (Wu*(1+(6*e)/b))/b
Smin = (Wu*(1-(6*e)/b))/b
print 'Maximum pressure is',Smax
print 'Minimum pressure is',Smin
Px = (((Smax-Smin)*(b-b1))/b)+Smin
Py = (((Smax-Smin)*(b-b2))/b)+Smin
print 'Pressure at the end of toe section',Px
print 'Pressure at the end of toe section',Py
BMtoe = (0.5*(Smax+Px)*b1)*((2*Smax+Px)/(Smax+Px))*(b1/3)-((t*b1*25*1.5)*(b1/2))
BMheel = ((b2*t*25*1.5)*(b2/2))+((W4*1.5)*(b2/2))-0.5*(Smin+Py)*b2*(((2*Py+Smin)/(Py+Smin))*(b2/3))
print 'Bending moment at toe section is',BMtoe
print 'Bending moment at heel section is',BMheel
```

```
d1 = t*1000-cc
Atoe = (0.5*fck*1000*d1)/fy*(1 - math.sqrt(1-((4.6*BMtoe*1000000)/(fck*1000*d1*d1))))
Aheel = (0.5*fck*1000*d1)/fy*(1 - math.sqrt(1-((4.6*BMheel*1000000)/(fck*1000*d1*d1))))
print 'Area of steel at toe section is',Atoe
print 'Area of steel at heel section is',Aheel
```

2.2 Output of Retaining wall with dry horizontal backfill

```
Command Prompt

C:\Users\Rishabh\Desktop>python retainingwall.py
Enter the height of retaining wall
4.4
Enter width of base slab
2.5
Enter the thickness of base slab
0.4
Enter projection on toe side
0.8
Enter angle of shear resistance
30
Enter unit weight of soil(in kN/cumec)
18
Enter soil bearing capacity
150
Enter grade of concrete
20
Enter grade of steel
415
Enter clear cover
40
Depth of foundation is 0.888888888889
Bending moment due to active earth pressure on retaining wall in kN-m is 96.0
Effective depth is 186.500961648
Area of steel of stem is 1778.19545376
eccentricity is 0.243107869142
Maximum pressure is 143.27136
Minimum pressure is 37.68864
Pressure at the end of toe section 109.4848896
Pressure at the end of toe section 84.1450368
Bending moment at toe section is 37.442945024
Bending moment at heel section is 53.253620224
Area of steel at toe section is 293.169404787
Area of steel at heel section is 420.089246213

C:\Users\Rishabh\Desktop>
```

Figure 2:Output of Retaining wall with dry horizontal backfill

Figure 2 shows the required depth of foundation, pressures at various sections of the retaining wall and area of steel required.

III. CASE 2: RETAINING WALL WITH FULLY SUBMERGED CONDITION

Problem 2:

Total height of retaining wall = 4.4m
Width of base slab = 2.5m
Thickness of base slab = 0.4m
Cantilever projection on toe side = 0.8m
Cantilever projection on heel side = 1.4m
Angle of shearing resistance = 30degrees
Unit weight of soil = 18 kN/m³
Soil Bearing Capacity = 150 kN/m²
Unit weight of water = 9.81 kN/m³

3.1 Program for design of retaining wall structure under fully submerged condition

```
import math
print 'Enter the height of retaining wall'
```

```
H = input()
print 'Enter width of base slab'
b = input()
print 'Enter the thickness of base slab'
t = input()
print 'Enter projection on toe side'
b1 = input()
print 'Enter angle of shear resistance'
phi = input()
print 'Enter unit weight of soil(in kN/cumec)'
gama = input()
print 'Enter unit weight of water(in kN/cumec)'
gama1 = input()
print 'Enter soil bearing capacity'
q = input()
print 'Enter grade of concrete'
fck = input()
print 'Enter grade of steel'
fy = input()
print 'Enter clear cover'
cc = input()
gama2 = gama-gama1
b2 = b - b1 - 0.1 - 0.2
ka = (1 - math.sin(math.radians(phi)))/(1 + math.sin(math.radians(phi)))
Df = (q/gama2) * ka * ka
print 'Depth of foundation is ',Df
h = H - t
Pa = 0.5 * (ka*gama2*h+ka*gama1*h)*h
Pau = 1.5 * Pa
Mu = Pau * h/3
print 'Bending moment due to active earth pressure on retaining wall in kN-m is',Mu
d = math.sqrt(Mu*1000000/(0.138*fck*1000))
print 'Effective depth is',d
Astem = (0.5*fck*1000*d)/fy*(1 - math.sqrt(1-((4.6*Mu*1000000)/(fck*1000*d*d))))
print 'Area of steel of stem is',Astem
W1 = 0.2*h*25
W2 = 0.5*0.1*h*25
W3 = b*t*25
W4 = (2.5 - b1 - 0.3)*h*18
W = W1 + W2 + W3 + W4
Wu = 1.5*W
Pa1 = 0.5 * ((ka*gama2*H)+(ka*gama1*H))*H
Pa1u = 1.5 * Pa1
OM = (Pa1 * H)/3
X1 = b1 + 0.1 + 0.1
X2 = b1 + (2 *0.1)/3
X3 = b/2
X4 = b1 + 0.1 + 0.2 + b2/2
RM = W1*X1 + W2*X2 + W3*X3 + W4*X4
RM1 = RM - OM
x = RM1/W
e = b*0.5 - x
print 'eccentricity is ',e
Smax = (Wu*(1+(6*e)/b))/b
Smin = (Wu*(1-(6*e)/b))/b
print 'Maximum pressure is',Smax
print 'Minimum pressure is',Smin
Px = (((Smax-Smin)*(b-b1))/b)+Smin
Py = (((Smax-Smin)*(b-b2))/b)+Smin
```

```
print 'Pressure at the end of toe section',Px
print 'Pressure at the end of toe section',Py
BMtoe = (0.5*(Smax+Px)*b1)*((2*Smax+Px)/(Smax+Px))*(b1/3)-((t*b1*25*1.5)*(b1/2))
BMheel = ((b2*t*25*1.5)*(b2/2))+((W4*1.5)*(b2/2))-(0.5*(Smin+Py)*b2)*(((2*Py+Smin)/(Py+Smin))*(b2/3))
print 'Bending moment at toe section is',BMtoe
print 'Bending moment at heel section is',BMheel
d1 = t*1000-cc
Atoe = (0.5*fck*1000*d1)/fy*(1 - math.sqrt(1-((4.6*BMtoe*1000000)/(fck*1000*d1*d1))))
Aheel = (0.5*fck*1000*d1)/fy*(1 - math.sqrt(1-((4.6*BMheel*1000000)/(fck*1000*d1*d1))))
print 'Area of steel at toe section is',Atoe
print 'Area of steel at heel section is',Aheel
```

3.2 Output of Retaining wall with fully submerged condition

```
Command Prompt

C:\Users\Rishabh\Desktop>python rwwater.py
Enter the height of retaining wall
4.4
Enter width of base slab
2.5
Enter the thickness of base slab
0.4
Enter projection on toe side
0.8
Enter angle of shear resistance
30
Enter unit weight of soil(in kN/cumec)
18
Enter unit weight of water(in kN/cumec)
9.81
Enter soil bearing capacity
150
Enter grade of concrete
20
Enter grade of steel
415
Enter clear cover
40
Depth of foundation is 2.035002035
Bending moment due to active earth pressure on retaining wall in kN-m is 96.0
Effective depth is 186.500961648
Area of steel of stem is 1778.19545376
eccentricity is 0.243107869142
Maximum pressure is 143.27136
Minimum pressure is 37.68864
Pressure at the end of toe section 109.4848896
Pressure at the end of toe section 84.1450368
Bending moment at toe section is 37.442945024
Bending moment at heel section is 53.253620224
Area of steel at toe section is 293.169404787
Area of steel at heel section is 420.089246213
```

Figure 3: Output of Retaining wall with fully submerged condition

Figure 3: shows the required depth of foundation, pressures at various sections of the retaining wall and area of steel required.

IV. CONCLUSION

By adoption of the Python programming language, it is easy to solve complex problems like the design of retaining wall in different conditions with accuracy and precisions. It is a quicker way of solving time taking problem. Also the use of a modern software such as python enables the civil engineer to construct the structure according to the demands of the clients.

REFERENCES

- [1]. Research Paper on Python: A Programming Language for Software Integration & Development by M.F.Sanner (The Scripps Research Institute, La Jolla)
- [2]. Wikipedia.
- [3]. Retaining wall: A building guide and design by Tina Skinner.
- [4]. Basics of Retaining Wall Design by Huge Brooks and John P Nielsen.
- [5]. Learning Python Design by Gennadiy Zlobin.



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