DESIGN OF CANTILEVER REATAINING WALL USING PYTHON PROGRAMMING LANGUAGE

Abhishek Tiwari[*1], Vedant Diwan[*2], Nandini Kar[*3], Sukriti Tiwari[*4], Mrs. Deepa Sahu[*5]

[*1,2,3,4]Student, Department of Civil Engineering, Bhilai Institute of Technology, Durg, India)
[*5]Assistant Professor, Department of Civil Engineering, Bhilai Institute of Technology, Durg, India)

ABSTRACT

The most significant building in a variety of civil engineering construction projects is an earth retaining wall. It requires complex design work, and the human computations can occasionally be laborious and time-consuming. Proper design of retaining wall is very crucial to avoid landslides, the most effective retaining wall to avoid landslides is Cantilever retaining wall. When it comes to large constructions like bridges and dams, the accuracy and precision of the design also become crucial. As a result, many businesses and construction organizations have begun to adopt a variety of user-friendly software, including Python. Python is a high-level programming language with dependable code and a user-friendly Interface. In this study, we seek to leverage Python programming languages to speed up and simplify calculations for retaining wall design.

KEYWORDS- *Earth Retaining Wall, Landslides, Cantilever retaining wall, User friendly software, Python programming language*

I. INTRODUCTION

(1.1) About Landslides:

Landslides are defined as the mass movement of rock, debris or earth down a slope and they include a broad range of motions whereby falling, sliding and flowing under the influence of gravity dislodges earth material. They often take places in conjunction with earthquakes, heavy rainfall resulting into flash floods and cloud bursts. In the hilly terrain of India, landslide is a major and widespread natural disaster which occurs during the monsoon period, i.e., from July to September and after the snow fall, i.e., from January to march. The most common types of landslides are debris slide, rock slide, rock fall, slump, wedge failure and planer failure.

(1.2) About Retaining Wall:

Retaining walls are moderately rigid structures that support soil masses laterally, allowing for the retention of soil at various depths on each side. Buildings called retaining walls are used to hold soil to slopes that it would not naturally follow. They are frequently utilized in terrain with unfavourable slopes or in regions where the environment needs to be drastically changed and constructed for more specialized uses, including hillside farming or traffic overpasses.
There are mainly 5 types of retaining walls which are commonly used:

- Gravity Walls
- Cantilever Retaining Walls
- Sheet Pile Retaining Walls
- Anchored Retaining Walls
- Counterfort Retaining Walls

(Fig 1) Landslide prone area

(Fig 2) Decrepit Retaining Wall

(1.3) About PYTHON PROGRAMMING LANGUAGE:

Python is used by software development organizations due to its flexible capabilities and little number of programming codes. It is used by over 14% of programmers who work with UNIX, Linux, Windows, and Mac OS operating systems. Python is used by programmers at large corporations since it has distinguished itself in the field of software development with traits like-Interactive, Interpreted, Modular, Dynamic, Object-oriented, Portable, High level, Extensible in C++ & C.

(1.4) ADVANTAGES OF PYTHON:

- This improves productivity and lightens the workload, especially for significant building projects like retaining walls.
- It offers flexibility in producing the necessary papers on screen as needed.
- Teaching structural engineering topics using design sheets.
- When using a design sheet, the use of software to improve the idea and effectiveness of structural design.
- It is highly useful for large construction companies when building dams, bridges, etc., which requires complex calculations.

II. RESEARCH AIM

- Study of Existing techniques to avoid land sliding.
- Suggestions of cost-efficient techniques as per site condition.
- Study of Modern Techniques to be adopt in India.
- Analysis of new techniques used over worldwide Introducing effective techniques against landslide.
- Introduce new techniques that will be more convenient.

III. METHODOLOGY

The researchers began by manually calculating the design of a retaining wall in three different conditions: horizontal backfill, inclined backfill, and surcharge. This involved following basic design steps and considerations. They then looked for ways to simplify the process by adopting the Python coding language. To do this, they studied various research papers, algorithms, and flowcharts related to retaining wall design. Ultimately, they decided to use Python to design retaining walls under the three conditions mentioned above.
The outcome appeared, after entering the following data:

Enter the total height of the retaining wall (< 6m)	4.4
Enter width of base slab (upto 6m)	2.5
Enter the thickness of base slab (0-0.6m)	0.4
Enter angle of shear resistance (in degrees)	30
Enter unit weight of soil (kN/m^3)	18

Enter unit weight of concrete (in kN/m^3)	24
Enter soil bearing capacity (in kN/m^3)	150
Enter grade of concrete	20
Enter grade of steel	415
Enter clear cover (in mm)	40
Enter diameter of bar in stem (in mm)	12
Enter diameter of distribution bar in stem (in mm)	8

IV. ANALYSIS

Following are the outputs of each cases using python programming.

CASE 1. PROGRAM OF DESIGN OF CANTILEVER RETAINING WALL WITH HORIZONTAL BACKFILL:

```
C:\Users\HP\AppData\Local\Programs\Python\Python311\python.exe C:\Users\HP\PycharmProjects\pythonProject\main.py
hello..i am CODO..i am here to help you with design of cantilever retaining wall
enter the total height of retaining wall<6m
4.4
enter width of base slab (upto 6m)
2.5
enter the thickness of base slab( upto - 0.6m)
0.4
enter angle of shear resistance(in degree)
30
enter unit weight of soil
18
enter unit weight of concrete
24
enter soil bearing capacity
150
enter grade of concrete
20
enter grade of steel
415
height of toe is 4.0
projection on toe side is= (in m) 0.8333333333333334
depth of foundation= 0.9259259259259258
ultimate active pressure at stem= 72.0
ultimate moment at stem= 96.0
enter clear cover
40
enter diameter of bar in stem
12
total depth of stem=, 282.50096164806274
total depth of stem= 286.50096164806274
Area of steel in Stem =  1001.1149365685162 mm^2
Spacing of bars in stem =  113.01685952335013 mm
Distribution Area of Steel =  339.0011539776753 mm^2
Enter diameter of Distribution bar in stem(in mm)
8
Spacing of Distribution bar in stem =  148.334935429234 mm
Total Ultimate load =  220.22996538066974 kN
Active Earth Pressure at Base Slab =  58.08000000000001 kN
Resulting Moment at Base Slab =  148.01475974825797 kN-m
Location of Resulting Moment =  1.0081377401963416 m
Ecentricity =  0.24186225980365839 m
Maximum Pressure at Base Slab =  139.22669057158012 kN
Minimum Pressure at Base Slab =  36.957281732955664 kN
Bending Moment at toe section =  39.39702184820975 kN-m
Bending Moment at heel section =  52.699016819372176 kN-m
Depth is safe
Area of steel at toe section =  339.0011539776753 mm^2
Area of steel at heel section =  423.01247410086717 mm^2
Spacing of bar at toe section =  300 mm
Safe in no tension at the bar
Safe in overturning
Provide shear key
Enter depth of shear key
0.5
Total Active Earth Pressure 72.03000000000002 kN
Passive Earth Pressure 21.87 kN
Safe in sliding

Process finished with exit code 0
```

CASE 2. DESIGN OF RETAINING WALL HAVING INCLINED BACKFILL:

```
C:\Users\HP\AppData\Local\Programs\Python\Python311\python.exe C:\Users\HP\PycharmProjects\pythonProject\main2.py
Enter the total height of retaining wall (in m)(Upto 6)
4.4
Enter width of base slab (in m)(Upto 3.6m)
2.5
Enter the thickness of base slab(in m)(Upto 0.6m)
0.4
Enter angle of inclination of backfill(in degree)
34
Enter angle of shear resistance(in degree)
30
Enter unit weight of soil(in kN/m^3)(Upto 20)
18
Enter unit weight of concrete(in kN/m^3)(Upto 25)
24
 Enter soil bearing capacity(in kN/m^2)(Upto 200)
150
Enter grade of concrete(in N/mm^2)
20
Enter grade of steel(in N/mm^2)
415
Height of stem is =  4.0 m
Projection on toe side is =  0.8333333333333334 m
Depth of Foundation =  1 m
Ultimate active Earth Pressure at stem =  95.99420623805744 kN
Ultimate Moment at stem =  106.11040495859625 kN-m
 Enter clear cover (in mm)
40
 Enter diameter of bar in stem (in mm)(Upto 32)
12
Total depth of stem =  296.0 mm
Effective depth of stem =  250.0 mm
Area of steel in Stem =  1321.0024693329153 mm^2
Spacing of bars in stem =  85.64923970202149 mm
Distribution Area of Steel =  355.2 mm^2
 Enter diameter of Distribution bar in stem(in mm)
8
Spacing of Distribution bar in stem =  141.57014157014157 mm
Total Ultimate load =  233.92670671923432 kn
value of x5 2.04768
Active Earth Pressure at Base Slab =  77.43532636536634 kN
Resulting Moment at Base Slab =  266.4429457169353 kN-m
Location of Resulting Moment =  1.7085027365220504 m
Ecentricity =  -0.4585027365220504 m
Maximum Pressure at Base Slab =  -9.395111081611933 kN
Minimum Pressure at Base Slab =  196.5364764569994 kN
Bending Moment at toe section =  -0.3172998532367268 kN-m
Bending Moment at heel section =  2.7985270945591196 kN-m
Depth is safe
Area of steel at toe section =  355.2 mm^2
Area of steel at heel section =  355.2 mm^2
Spacing of bar at toe section =  -45517.56395365123 mm
Spacing of bar at heel section =  300 mm
Safe in no tension at the bar
Unsafe in overturning
Provide shear key
Enter depth of shear key
0.5
Total Active Earth Pressure 96.03420382398997 kN
Passive Earth Pressure 16.403489978291265 kN
Safe in sliding
Enter diameter of bar shear key
```

CASE 3. DESIGN OF RETAINING WALL HAVING INCLINED SURCHARGE:

```
C:\Users\HP\AppData\Local\Programs\Python\Python311\python.exe C:\Users\HP\PycharmProjects\pythonProject\main.py
hello..i am CODD..i am here to help you with design of cantilever retaining wall
enter the total height of retaining wall<6m
4.4
enter width of base slab (upto 6m)
2.5
enter the thickness of base slab( upto - 0.6m)
0.4
enter angle of shear resistance(in degree)
30
enter unit weight of soil
18
enter unit weight of concrete
24
enter soil bearing capacity
150
enter grade of concrete
20
enter grade of steel
415
height of toe is 4.0
projection on toe side is= (in m) 0.8333333333333334
depth of foundation= 0.9259259259259258
ultimate active pressure at stem= 72.0
ultimate moment at stem= 96.0
enter clear cover
40
enter diameter of bar in stem
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total depth of stem=, 282.50096164806274
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Distribution Area of Steel =  339.0011539776753 mm^2
Enter diameter of Distribution bar in stem(in mm)
8
Spacing of Distribution bar in stem =  148.334935429234 mm
Total Ultimate load =  220.22996538066974 kN
Active Earth Pressure at Base Slab =  58.08000000000001 kN
Resulting Moment at Base Slab =  148.01475974825797 kN-m
Location of Resulting Moment =  1.0081377401963416 m
Ecentricity =  0.24186225980365839 m
Maximum Pressure at Base Slab =  139.22669057158012 kN
Minimum Pressure at Base Slab =  36.957281732955664 kN
Bending Moment at toe section =  39.39702184820975 kN-m
Bending Moment at heel section =  52.699016819372176 kN-m
Depth is safe
Area of steel at toe section =  339.0011539776753 mm^2
Area of steel at heel section =  423.01247410086717 mm^2
Spacing of bar at toe section =  300 mm
Safe in no tension at the bar
Safe in overturning
Provide shear key
Enter depth of shear key
0.5
Total Active Earth Pressure 72.03000000000002 kN
Passive Earth Pressure 21.87 kN
Safe in sliding

Process finished with exit code 0
```

V. RESULT

Following are the comparison tables of each cases comprising manual calculations and calculations done using python programming.

CASE 1. PROGRAM OF DESIGN OF CANTILEVER RETAINING WALL WITH HORIZONTAL BACKFIL:

PARAMETERS	MANUAL CALCULATIONS	CALCULATIONS USING PYTHON
Depth of Foundation (D_f)	0.9m	1m
Area of steel at stem	1156.63mm^2	1001.11mm^2
Spacing of bars at Stem.	97.78mm	113mm
Distribution area of steel	300mm^2	339mm^2
Spacing of Distribution bars	167.5mm	148.334mm
Area of Steel at toe section	480mm^2	339mm^2
Spacing of bars at toe section	230mm	279.583mm
Area of steel at Heel section	529.14mm^2	423mm^2
Spacing of bars at Heel section	145mm	192.179mm
Area of steel in shear key	452.38mm^2	452.16mm^2
Bending Moment at toe section	38KN-m	39.9 KN-m
Bending Moment at heel section	65.55 KN-m	52.69KN-m
Total Active Earth Pressure	71.3 KN	72.03 KN
Total Passive Earth Pressure	21 KN	21.87 KN

CASE 2. DESIGN OF RETAINING WALL HAVING INCLINED BACKFILL:

PARAMETERS	MANUAL CALCULATIONS	CALCULATIONS USING PYTHON
Depth of Foundation (D_f)	0.9m	1m
Area of steel at stem	1156.63mm^2	1001.11mm^2
Spacing of bars at Stem.	97.78mm	113mm
Distribution area of steel	300mm^2	339mm^2
Spacing of Distribution bars	167.5mm	148.334mm
Area of Steel at toe section	480mm^2	339mm^2
Spacing of bars at toe section	230mm	279.583mm
Area of steel at Heel section	529.14mm^2	423mm^2
Spacing of bars at Heel section	145mm	192.179mm
Area of steel in shear key	452.38mm^2	452.16mm^2
Bending Moment at toe section	38KN-m	39.9 KN-m
Bending Moment at heel section	65.55 KN-m	52.69KN-m
Total Active Earth Pressure	71.3 KN	72.03 KN
Total Passive Earth Pressure	21 KN	21.87 KN

CASE 3. DESIGN OF RETAINING WALL HAVING INCLINED SURCHARGE:

PARAMETERS	MANUAL CALCULATIONS	CALCULATIONS USING PYTHON
Depth of Foundation (D_f)	0.92m	1m
Area of steel at	1727.52mm^2	1574.86mm^2

stem		
Spacing of bars at Stem.	60mm	71.8mm
Distribution area of steel	300mm^2	318.57mm^2
Spacing of Distribution bars	160mm	131.78mm
Area of Steel at toe section	396.96mm^2	402.12mm^2
Spacing of bars at toe section	230mm	281.34mm
Area of steel at Heel section	766.25mm^2	592.47mm^2
Spacing of bars at Heel section	145mm	190.96mm
Total Active Earth Pressure	75KN	72.03 KN
Total Passive Earth Pressure	27 KN	21.87 KN

VI. CONCLUSION

1. Using the Python computer language, the design of a cantilever retaining wall was accomplished successfully in three situations: retaining wall in horizontal backfill, inclined backfill, and inclined surcharge.
2. The outcomes were contrasted with those attained through calculation by hand.
3. It was noted that the Python language's results were more precise.
4. The errors were significantly diminished.
5. All three of these conditions required less time to create than they did overall.
6. The task grew easier and less tiresome.
7. Python is simple to learn and is a high-level programming language.
8. Use of Python programming language requires less time as compared to manual calculations.
9. If area of steel and dimensions of retaining wall is reduced using python, it can reduce the cost of structure and make it economical.
10. Seismic analysis of cantilever retaining wall by python can be very convenient.

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