Effect of Safe Bearing Capacity & Coefficient of Friction between Soil and Concrete in Stability of Cantilever Type Retaining Wall

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Abstract

To maintain the two different ground level retaining wall are constructed. Retaining wall is basically design for lateral force acting on it due to pressure force exerted by backfill retained by the wall and pressure force due to traffic. In this paper the effect due to reduce in safe bearing capacity and coefficient of friction in the stability of existing retaining wall. Design philosophy is based on Indian standard code IS 456. Safe bearing capacity of soil and coefficient of friction taken as variable to know the effect in stability.  

Keywords: Cantilever type retaining wall, Safe bearing capacity of soil, Coefficient of friction, Stability, Factor of safety (F.O.S.)

I. INTRODUCTION

As we know that design of retaining wall is trial and error process, very laborious and time taking process. So for the analysis purpose we have developed a design tool and tool coded in Visual basic application. Design tool results were compared with manual calculation and found correct. In this paper to know the effect of Safe bearing capacity of soil and Coefficient of friction in the stability analysis of cantilever type retaining wall following input parameter were uses -

1) Height of retaining wall above the ground.  
2) Unit weight of backfill.  
3) Traffic load.  
4) Angle of internal friction.  
5) Safe bearing capacity of soil.  
6) Coefficient of friction between soil and concrete.  

Only Safe bearing capacity of soil and Coefficient of friction consider as a variables. While changed one variable rest of the input parameter were remain constant.

Fig. 1: Showing the Cantilever type retaining wall
Effect of Safe Bearing Capacity & Coefficient of Friction between Soil and Concrete in Stability of Cantilever Type Retaining Wall

**A. Loads on Retaining Wall:**

Cantilever retaining wall subjected to the following forces:

1) **Vertical forces**
   - Weight of the stem AB. \( W_1 \)
   - Weight of the base slab DC \( W_2 \)
   - Weight of the retained material above the heel slab BC \( W_3 \)

2) **Horizontal forces**
   - Earth pressure force due to retained material \( P_a \)
   - Pressure force due to traffic or surcharge load \( P \)

**B. Stability of retaining wall**

Following conditions must be satisfied for stability of cantilever type retaining wall:

1) It should not overturn
2) It should not slide.
3) It should not subside, i.e Max. Pressure at the toe should not exceed the safe bearing capacity of the soil under working condition.

**C. Check for overturning**

Resistance against overturning of retaining wall created by the self-weight of the structure i.e. Weight of the stem \( W_1 \), Weight of the base slab \( W_2 \) and Weight of the retained material above the heel slab \( W_3 \) these entire vertical force create a resisting moment about toe.

\[ M_R = W_1 x_1 + W_2 x_2 + W_3 x_3 \]

\( x_1, x_2 \) and \( x_3 \) as shown in fig 2

Overturning moment created by the horizontal forces i.e. Earth pressure due to retained material \( P_a \) and Pressure force due to traffic or surcharge load \( P \) about toe.

Overturning moment, due to active earth pressure, at toe is

\[ M_o = K_{a} \gamma e H^3 / 6 + K_a H^2 / 2 \]

Hence F.O.S against the overturning given by

\[ F_1 = \frac{M_R}{M_o} \]
D. Check for Sliding

The horizontal force Earth pressure force due to retained material (Pa) and Pressure force due to traffic or surcharge load tends to slide the wall away from the fill. Resistance against sliding achieved by the friction at the base. Magnitude of the resistance force against sliding calculated by:

\[ F = \mu \Sigma W \]

Where
- \( \mu \) is the Frictional coefficient between soil and concrete
- \( \Sigma W \) sum of all the vertical forces acting as shown in Fig 2

The F.O.S against the sliding is the ratio of resistance force against sliding and sum of horizontal force due to retained material (Pa) and Pressure force due to traffic or surcharge load.

\[ \text{F.O.S. against the sliding} = \frac{\mu \Sigma W}{(P_a + P)} \]

Shear key below the base of the retaining wall are provided whenever wall unsafe in the sliding.

E. Soil Pressure Distribution below the Base of Retaining Wall

As shown in Fig 2 various forces acting on the wall and soil pressure distribution below the base of the foundation. Resultant of the all the vertical forces and horizontal forces act at an eccentricity (e) from the midpoint of the base.
Eccentricity $e = \frac{B}{2} - x$

Where

$x$ - Resultant distance from the toe.

Eccentricity should be less than one sixth of the base.

Magnitude of the soil pressure below the base at the toe is calculated by

$$P_1 = \frac{\sum W}{b} \left( 1 + \frac{6e}{b} \right)$$

Magnitude of the soil pressure ($P_1$) below the base at the toe should not more than the safe bearing capacity of the soil.

Magnitude of the soil pressure below the base at the heal is calculated by

$$P_2 = \frac{\sum W}{b} \left( 1 - \frac{6e}{b} \right)$$

Magnitude of the soil pressure below the base at the heal always more than zero

II. PROBLEM OVERVIEW

In this thesis the main is to know the effect in stability of cantilever type retaining wall mainly in three conditions as mentioned in chapter-3 by changing in input parameter. Following input parameter consider as a variable

1) Safe bearing capacity of soil
2) Frictional coefficient between soil and concrete

While changing in one of the above input parameter rest of the input parameter will remain constant. Following value of input parameter is considered in the analysis.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Height of retaining wall above the ground</td>
<td>4.0 m</td>
</tr>
<tr>
<td>2. Unit weight of backfill</td>
<td>18 kN/m²</td>
</tr>
<tr>
<td>3. Internal friction angle</td>
<td>30°</td>
</tr>
<tr>
<td>4. Traffic load or surcharge load</td>
<td>18 kN/m²</td>
</tr>
<tr>
<td>5. Safe bearing capacity of soil</td>
<td>160 to 200 kN/m²</td>
</tr>
<tr>
<td>6. Frictional coefficient between soil and concrete</td>
<td>0.25 to 0.35</td>
</tr>
<tr>
<td>7. Grade of concrete</td>
<td>M 20</td>
</tr>
<tr>
<td>8. Grade of concrete</td>
<td>Fe 415</td>
</tr>
</tbody>
</table>

III. INPUT PARAMETER

A. By reducing the bearing capacity of soil

1) Input-3.1.1

<table>
<thead>
<tr>
<th>Parameter</th>
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</tr>
<tr>
<td>3. Internal friction angle</td>
<td>30°</td>
</tr>
<tr>
<td>4. Traffic load or surcharge load</td>
<td>18 kN/m²</td>
</tr>
<tr>
<td>5. Safe bearing capacity of soil</td>
<td>200 kN/m²</td>
</tr>
<tr>
<td>6. Frictional coefficient between soil and concrete</td>
<td>0.30</td>
</tr>
<tr>
<td>7. Grade of concrete</td>
<td>M 20</td>
</tr>
<tr>
<td>8. Grade of concrete</td>
<td>Fe 415</td>
</tr>
</tbody>
</table>

2) Input-3.1.2

<table>
<thead>
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<th>Parameter</th>
<th>Value</th>
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</thead>
<tbody>
<tr>
<td>1. Height of retaining wall above the ground</td>
<td>4.0 m</td>
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<td>2. Unit weight of backfill</td>
<td>18 kN/m²</td>
</tr>
<tr>
<td>3. Internal friction angle</td>
<td>30°</td>
</tr>
<tr>
<td>4. Traffic load or surcharge load</td>
<td>18 kN/m²</td>
</tr>
<tr>
<td>5. Safe bearing capacity of soil</td>
<td>190 kN/m²</td>
</tr>
<tr>
<td>6. Frictional coefficient between soil and concrete</td>
<td>0.30</td>
</tr>
<tr>
<td>7. Grade of concrete</td>
<td>M 20</td>
</tr>
<tr>
<td>8. Grade of concrete</td>
<td>Fe 415</td>
</tr>
</tbody>
</table>

3) Input-3.1.3

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Height of retaining wall above the ground</td>
<td>4.0 m</td>
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<td>2. Unit weight of backfill</td>
<td>18 kN/m²</td>
</tr>
<tr>
<td>3. Internal friction angle</td>
<td>30°</td>
</tr>
<tr>
<td>4. Traffic load or surcharge load</td>
<td>18 kN/m²</td>
</tr>
<tr>
<td>5. Safe bearing capacity of soil</td>
<td>180 kN/m²</td>
</tr>
<tr>
<td>6. Frictional coefficient between soil and concrete</td>
<td>0.30</td>
</tr>
</tbody>
</table>
7. Grade of concrete M 20
8. Grade of concrete Fe 415

4) Input-3.1.4
1. Height of retaining wall above the ground 4.0 m
2. Unit weight of backfill 18 kN/m²
3. Internal friction angle 30°
4. Traffic load or surcharge load 18 kN/m²
5. Safe bearing capacity of soil 180 kN/m²
6. Frictional coefficient between soil and concrete 0.30
7. Grade of concrete M 20
8. Grade of concrete Fe 415

5) Input-3.1.5
1. Height of retaining wall above the ground 4.0 m
2. Unit weight of backfill 18 kN/m²
3. Internal friction angle 30°
4. Traffic load or surcharge load 18 kN/m²
5. Safe bearing capacity of soil 160 kN/m²
6. Frictional coefficient between soil and concrete 0.30
7. Grade of concrete M 20
8. Grade of concrete Fe 415

B. By reducing the Frictional coefficient between Soil & Concrete
1) Input-5.4.1
1. Height of retaining wall above the ground 4.0 m
2. Unit weight of backfill 18 kN/m²
3. Internal friction angle 30°
4. Traffic load or surcharge load 18 kN/m²
5. Safe bearing capacity of soil 165 kN/m²
6. Frictional coefficient between soil and concrete 0.35
7. Grade of concrete M 20
8. Grade of concrete Fe 415

2) Input-3.2.2
1. Height of retaining wall above the ground 4.0 m
2. Unit weight of backfill 18 kN/m²
3. Internal friction angle 30°
4. Traffic load or surcharge load 18 kN/m²
5. Safe bearing capacity of soil 165 kN/m²
6. Frictional coefficient between soil and concrete 0.33
7. Grade of concrete M 20
8. Grade of concrete Fe 415

3) Input-3.2.3
1. Height of retaining wall above the ground 4.0 m
2. Unit weight of backfill 18 kN/m²
3. Internal friction angle 30°
4. Traffic load or surcharge load 18 kN/m²
5. Safe bearing capacity of soil 165 kN/m²
6. Frictional coefficient between soil and concrete 0.31
7. Grade of concrete M 20
8. Grade of concrete Fe 415

4) Input-3.2.4
1. Height of retaining wall above the ground 4.0 m
2. Unit weight of backfill 18 kN/m²
3. Internal friction angle 30°
4. Traffic load or surcharge load 18 kN/m²
5. Safe bearing capacity of soil 165 kN/m²
6. Frictional coefficient between soil and concrete 0.28
7. Grade of concrete M 20
8. Grade of concrete Fe 415
5) Input-3.2.5

1. Height of retaining wall above the ground 4.0 m
2. Unit weight of backfill 18 kN/m²
3. Internal friction angle 30°
4. Traffic load or surcharge load 18 kN/m²
5. Safe bearing capacity of soil 180 kN/m²
6. Frictional coefficient between soil and concrete 0.28
7. Grade of concrete M 20
8. Grade of concrete Fe 415

IV. RESULTS & DISCUSSION

A. For Overturning of Retaining Wall

Here result is Factor of safety, if the numerical value of factor of safety against overturning increase means stability against overturning of retaining wall increase and vice versa.

B. For Sliding of Retaining Wall

Here result is Factor of safety, if the numerical value of factor of safety against sliding increase means stability against sliding of retaining wall increase and vice versa.

C. For Tension at base of Retaining Wall

Here result is eccentricity (distance from mid of the base where resultant of all the vertical and horizontal forces strike) calculated under the different inputs of each cases. Increase in value of eccentricity indicates compressive stress below the base reduces.

Discussion-From the above graph it is clear that as the decrease in bearing capacity of the soil below the base of retaining wall decrease the stability of retaining wall against the overturning.

Fig. 4.1: Effect of SBC in Overturning

Fig. 4.2: Showing effect of bearing capacity of soil in sliding
Discussion- From the above graph it is clear that as the gradually decrease in bearing capacity of the soil below the base of stability of retaining wall against the sliding decrease.

Discussion- when safe bearing capacity of soil decrease Eccentricity (Distance of resultant from the centre of retaining wall) increase as shown in fig 4.3
From the fig 4.4 it is clear that as the bearing capacity of soil reduce soil pressure exerted below the toe of the existing retaining wall increase.
From the fig 4.5 it is clear that as the bearing capacity of soil reduce soil pressure exerted below the heel of the existing retaining wall reduce.

![Effect of friction in overturning](image)

**Fig. 4.6:** Showing effect of coff. of friction in overturning.

Discussion- It is clear from the above graph Frictional coefficient between soil and concrete does not effect the stability of retaining wall against the overturning.

![Effect of friction in Sliding](image)

**Fig. 4.7:** Showing effect of coff. of friction in sliding.

Discussion- It is clear from graph as the Frictional coefficient between soil and concrete decrease stability of retaining wall against the sliding gradually decrease.

![Effect of friction in base](image)

**Fig. 4.8:** Showing effect of coff. of friction in base.
Discussion- It is clear from the above graph Frictional coefficient between soil and concrete does not affect the stability of retaining wall against the tension below the base of retaining wall.

REFERENCES


