International Journal of Engineering Research

Sirte University
Faculty of Engineering

Journal homepage: Scientific Journals (su.edu.ly)

Calculating the Ultimate Bearing Capacity of a Strong Soil Layer over a Weak Soil Layer

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ARTICLE INFOR

Article history:

Received 8 August 2023
Revised 23 Septemper2023
Accepted 30 Septemper2023

Available online
31 October2023

ABSTRACT

The ultimate bearing capacity UBC calculations for shallow footings in two-layered soil systems hinge on the underlying failure surface pattern. his study examines scenarios observed in nature, where strong soil overlays a weaker layer within layered soils, specifically focusing on square footings and calculation of the UBC value using different theoretical equations according to the approaches of the scientists Terzaghi, Hansen, Meyerhof, and Vesic. an analysis of the values of the results and compared with each other. Presented the results of the study for the UBC of layered [C - Θ] soils are stronger than all studied soils cases and the ultimate bearing capacity of sandy layered soils is times stronger than the UBC of clayey layered soils, As that UBC of clayey layered soils is weaker than all studied soils cases.

Keywords: UBC, Sand Layered, Clayey Layered, Meyerhof Equation two layers (C - ∅) soils, Terzaghi Equation,

1. Introduction

The equation was derived from a continuous foundation with general shear. The supporting material was assumed to be a thick layer of homogenous soil [1]. Theory of the UBC of two-layer soil to the cases of three-layer soils. The analysis compared well with the results of model tests and the strip and circular footing on a two-soil

layer. The same theoretical failure mechanism was assumed by considering a soil mass of the upper two layers is pushed into the lower layer and the same force acting on the failure surface [2]. The UBC of dense sand overlying medium clay increases as increasing in the sand thickness ratio, H/B, and width of footing, B [3]. There was an increase in the UBC of clay overlying sand with an increase in clay thickness ratio H/B While there was a decrease in cases of sand overlying clay with the increase in 2020) [4]. Sand thickness ratio. In this, the paper studied some cases of the UBC of strong soil layer over weak soil layer for square footing as follows:- strong sand layer over weak clay layer [$\emptyset_2 = 0$], Strong sand layer over weak sand layer [$C_1 = C_2 = 0$], Strong clay layer over weak clay layer [$\emptyset_1 = \emptyset_2 = 0$, $C_1 > C_2$], Strong layer over weak layer [two layers (C - $\emptyset$) soils. Operation analysis and compassion results value the UBC for the previously studied cases [5].

2. Equations for Calculation of the UBC of Strong Soil Layer over Weak Soil Layer.

There are special for a strong soil layer over a weak soil layer based on the general equations, some special cases may be developed they are as follows:

2.1 Strong Sand Layer over Weak Clay Layer [$\emptyset_2 = 0$].

Equation of the UBC for a strong sand layer over a weak clay layer for this case [$C_1 = 0$, $C_a = 0$. Also for $\emptyset_2 = 0$, $N_{\gamma 2} = N_{q2} = 0$, $N_{q2} = 1$].

$$q_u = C_2 N_{C2} S_{C2} + \gamma_1 H^2 (1 + \frac{B}{L}) (1 + 2 \frac{D_f}{H}) (K_S \tan \emptyset_1) + \gamma_1 D_f \leq (\gamma_1 D_f) N_{q1} S_{q1} + \frac{1}{2} \gamma_1 B N_{\gamma 1} S_{\gamma 1}). \quad (1)$$

Where B = Width of foundation, H = thickness of the stratum from the base of the footing $K = _S$punching shear coefficient, D_f = the thickness of the foundation embedded in the subsoil [6].

γ = unit weight of soil, N_c ,N_q ,N_γ = bearing capacity factors, S_c ,S_q,S_γ = shape factors

2.2 Strong Sand Layer over Weak Sand Layer [$C_1 = C_2 = 0$].

In this case, [$C_1 = 0$ and $C_a = 0$]. The equation of the UBC can be given as:- $q_u = \gamma_1 (D_f + H) = N_{q2} S_{q2} + \frac{1}{2} \gamma_2 B N_{\gamma 2} S_{\gamma 2} + \gamma_1 H^2 (1 + 2 \frac{D_f}{H}) (\frac{K_S \tan \emptyset_1}{B}) - \gamma_1 H \leq q_t$

$$q_t = (\gamma_1 D_f) N_{q1} S_{q1} + \frac{1}{2} \gamma_1 B N_{\gamma 1} S_{\gamma 1}). \quad (2)$$

2.3 Strong Clay Layer over Weak Clay Layer [$\emptyset_1 = \emptyset_2 = 0$, $C_1 > C_2$].

In this case,N_{q1} and N_{q2} are both equal to one and $N_{\gamma 1}= N_{\gamma 2} = 0$. The equation of the ultimate bearing capacity can be given as:- $q_u= C_2\ N_{C2}\ S_{C2} + (1 + \frac{B}{L}) (\frac{2\ C_a\ H}{B})\ \gamma_1 D_f \leq q_t = (C_1 N_{C1}\ S_{C1})\ +\ \gamma_1 D_f$. (3)

2.4 Strong layer over weak layer [two layers (C - $\emptyset$) soils]. [2]

Using the equation Purushothamaraj et . al (1974) [7] to estimate the UBC for two layers system (C - $\emptyset$) and the bearing capacity factor for Terzaghi, Meyerhof, Hansen, and Vesc, and give many charts for N_c factors and to obtain modified $\emptyset$ C values as follow:-

1- Compute the depth H = 0.5 B tan [45 + $\frac{\emptyset_1}{2}$] using $\emptyset_1$ for the top layer. (4)

2- If H > d compute the modified value $\emptyset$ for use as: $\emptyset' = [\frac{d\emptyset_1 + (H-d)\emptyset_2}{H}]$ $C' = [\frac{d\ C_1 + (H-d)\ C_2}{H}]$ and using the bearing capacity equations. (5)

3. Ultimate Bearing Capacity Calculation for Layered Soils Models

Calculated the UBC of layered soils for square footing using different theoretical by assuming some models for previous cases.

3.1 Strong Sand Layer over Weak Clay Layer Model.

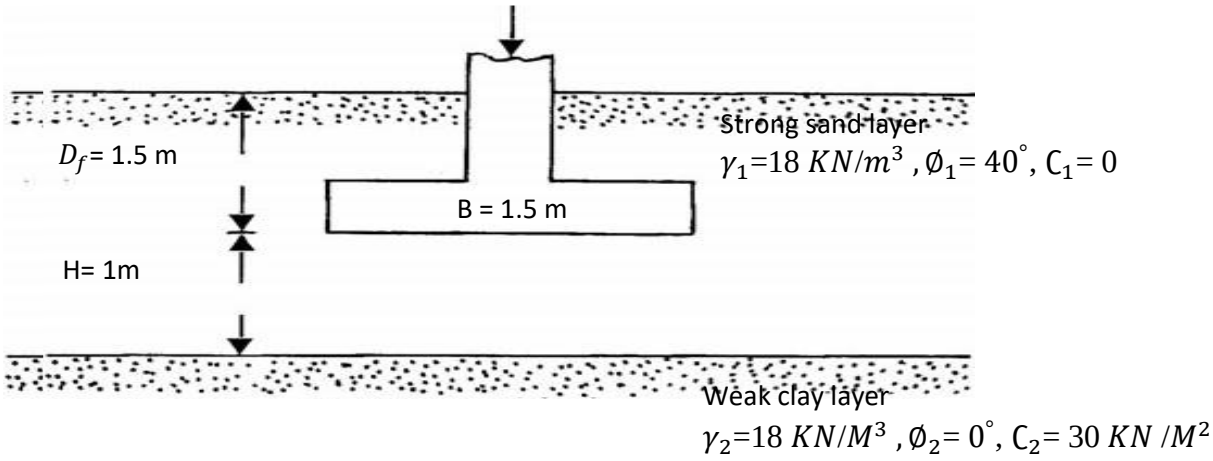

Figure (3.1) Strong sand layer over weak clay layer

Table (3.1) The calculated UBC for a strong sand layer over a weak clay layer

Equation	**The** UBC ($\boldsymbol{KN/M^2}$)
Terzaghi	472.12
Meyerhof	462.39
Hansen	513.293
Vesic.	281.08

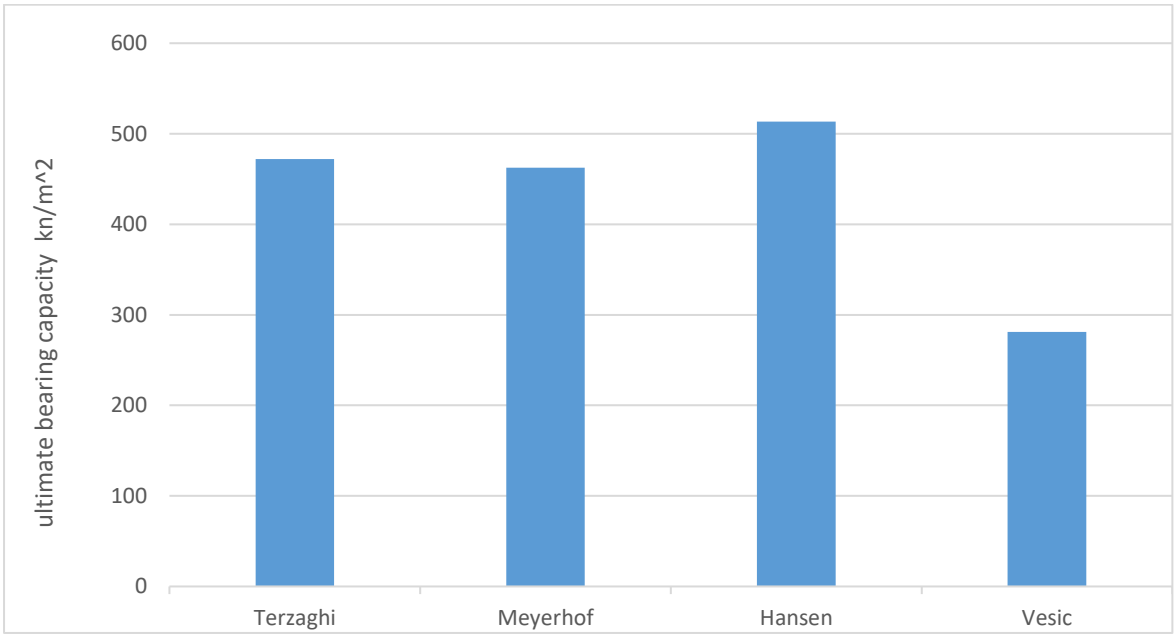

Figure (3. 1) plan shows the values of the UBC for a strong sand layer over a weak clay layer

3.2 Strong Sand Layer over Weak Sand Layer Model [$C_1 = C_2 = 0$, $\gamma_1 > \gamma_2$].

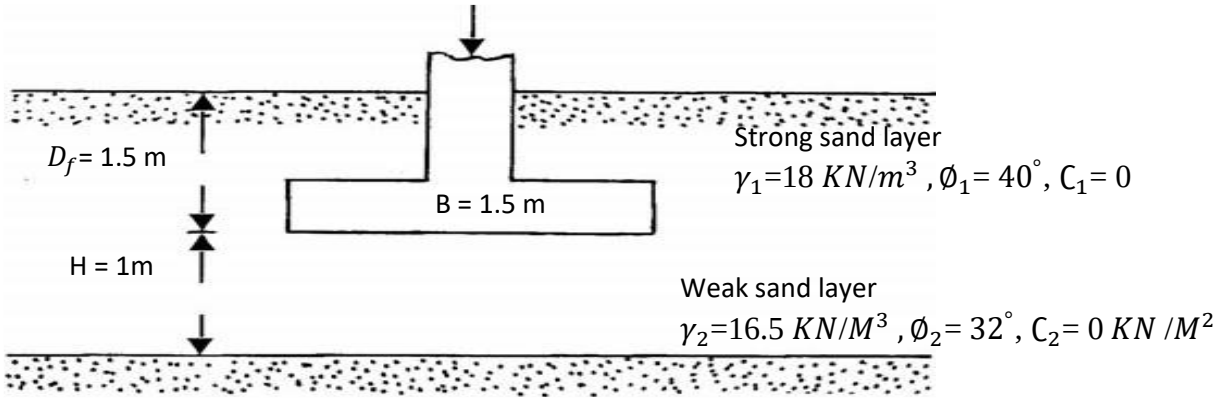

Figure (3.2) strong sand layer over the weak sand layer

Table (3.2) The calculated UBC for a strong sand layer over a weak sand layer

` **Equation**	**The** UBC (KN/M^2)
Terzaghi	2048.9
Meyerhof	2192.7
Hansen	2180.33
Vesic.	2031.4

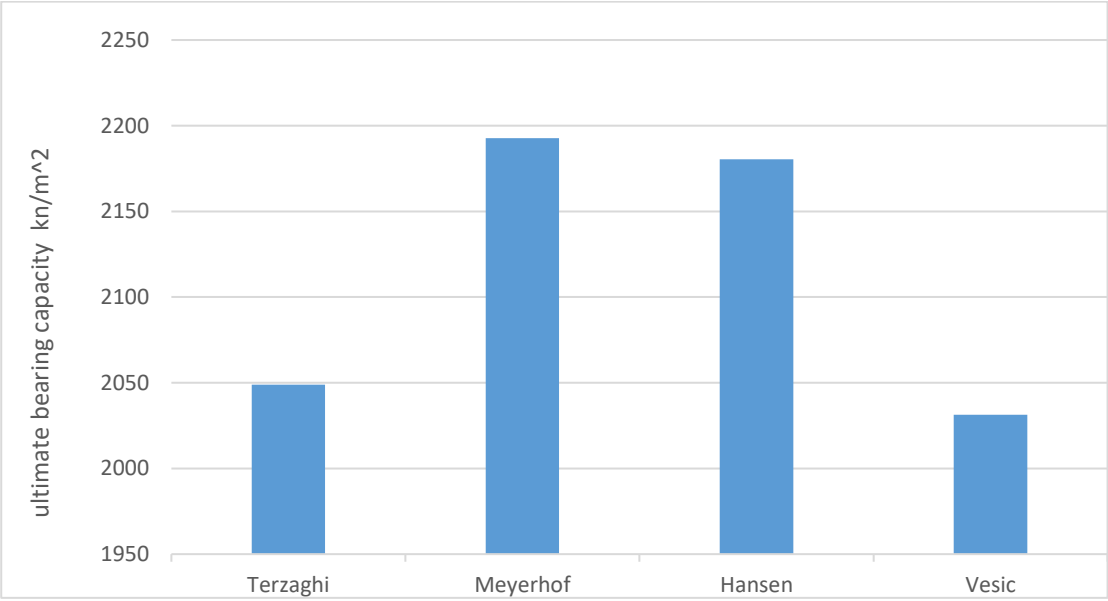

Figure (3.2) plan shows the values of the UBC for a strong sand layer over a weak sand layer.

3.3 Strong Clay Layer over Weak Clay Layer Model[$\emptyset_1=\emptyset_2=0$, $C_1 > C_2$].

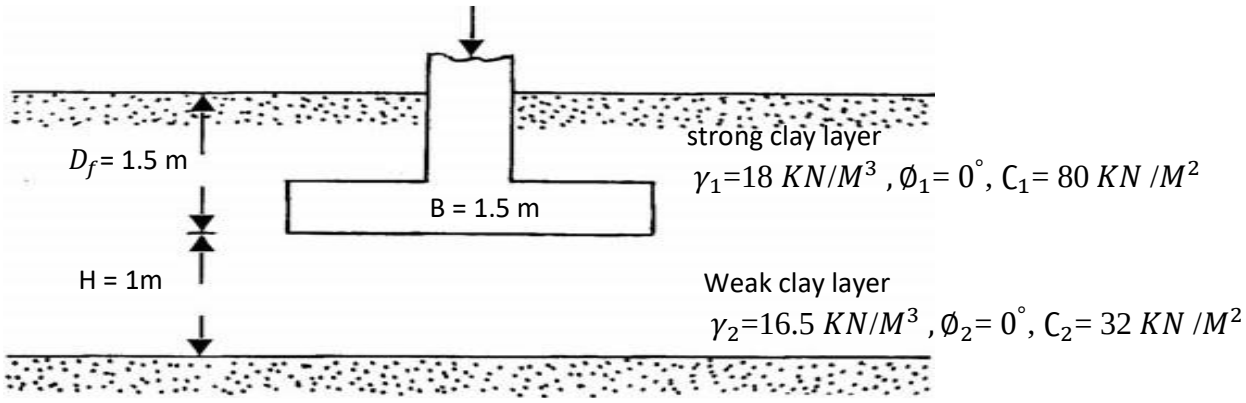

Figure (3. 3) strong clay layer over the weak clay layer

Table (3. 3) the calculated UBC for a strong clay layer over a weak clay layer

Equation `	**The** UBC ($\boldsymbol{KN/M^2}$)
Terzaghi	450
Meyerhof	406.63
Hansen	408.29
Vesic.	408.29

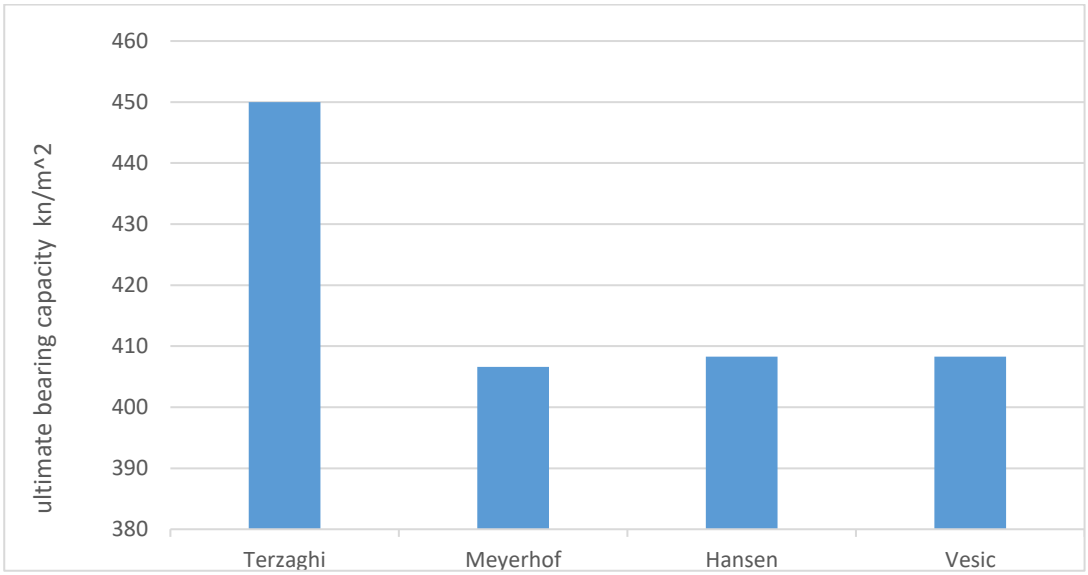

Figure (3.3) plan shows the values of the UBC for

a strong clay layer over a weak clay layer

3.4 Strong layer over weak layer [two layers (C - ∅) soils Model].

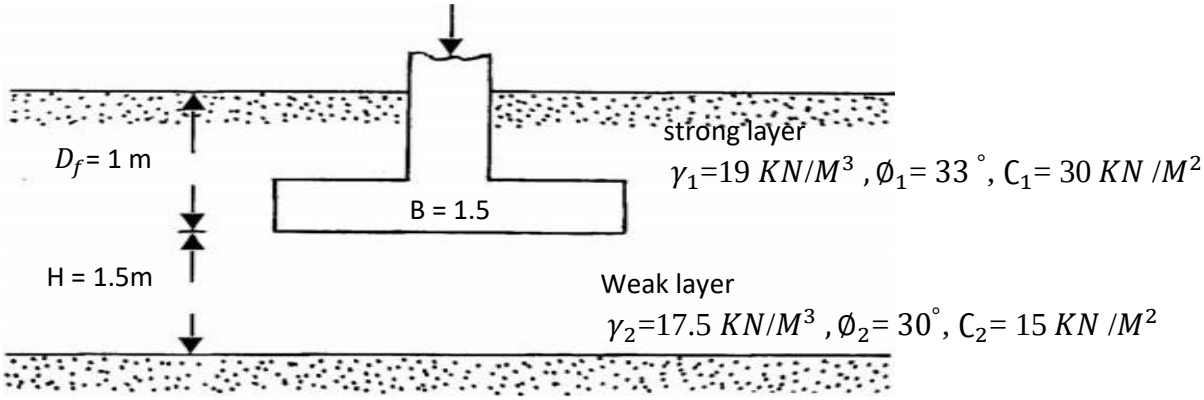

Figure (3.4) Strong layer over weak layer [two layers (C - ∅) soils]

Table (3. 4) the calculated UBC for the Strong layer over the weak layer [two layers (C - Ø) soils]

Equation	The Ultimate Bearing Capacity (KN/M^2)
Terzaghi	2563.88
Meyerhof	3120.36
Hansen	2967.17
Vesic.	3074.33

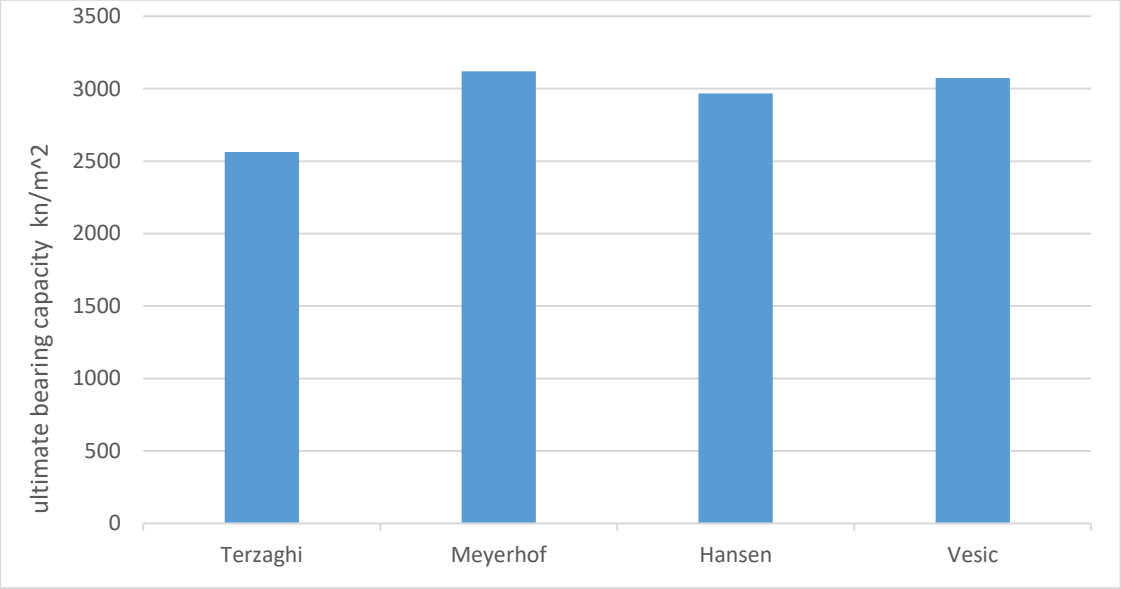

Figure (3. 4) plan shows the values of the UBC for the Strong layer over the weak layer [two layers (C - Ø) soils]

4. Results and Discussion

Analysis and comparison, the values of results of the UBC of a strong soil layer over a weak soil layer for all the cases studied were in the case of a strong sand layer over a weak clay layer for Hansen equation give large value, it is higher 15.7 % than means average and Vesic equation is less 53.8% than the means average. As the results values of the ultimate bearing capacity for a strong sand layer over a weak sand layer, are approximate, the Meyerhof equation value is higher by 3.6% than the means average and the Vesic equation value is less than 4 % than the means average. while the results values of the UBC for a strong clay layer over a weak clay layer, the Terzaghi equation gives a higher value it is higher by 7% than the means average

and the Meyerhof equation value is less than 2.9% than the means average, while the rest of the results are approximate. As for the results values of the UBC of the strong layer over the weak layer [two layers (C - Ø) soils] are generally large. The Meyerhof equation value gives a large value, it is higher than 6% than the means average and the Terzaghi equation value is less than 14.3% than the means average.

5. Conclusion

1- The results achieved from the UBC for layered soil of the same case by using most equations gave approximate values.

2- The results value the UBC of the layered sand is larger than the UBC of both cases layered clay and sand layer over clay layer, they are approximately 80% higher according to the means average.

3- Strong layer over weak layer [two layers (C - Ø) soils] are strongest to bear loads of the square foundation than all other cases according to the results value of the UBC that was greater than all other studied cases, while values of the ultimate bearing capacity of layered clay are the weaker.

4-In the study it is important to use a lab model of layered soils in different cases and calculate the values results of the UBC and compare results with theoretical results of the same cases.

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