Differences Between Embedment Depth and Berm On Stability Of Cellular Cofferdam

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Abstract

In this study the stability of cellular retaining structures is studied by using tests models .Series of laboratory test have been carried out on one (single) diaphragm cells of different width to height ratio (0.75, 0.85 ,1.00). The tests include to know differences between embedment depth and berm ratio (back fill of cell), the embedment depth ratio and berm ratio equal to (0.2, 0.3, 0.4) ,three type of soils are used ,these type subbace ,sand passing sieve No.4 and river sand .The results obtained from this research, embedment depth ratio give resistance for cell greater than berm ratio**.**

الخلاصة

في هذه الدراسة تمت دراسة استقرارية المنشآت الساندة الخلوية باستخدام نموذج مختبري حيث تم إجراء سلسلة من الفحوصات المختبرية على نماذج خلايا حجابيه أحاديه وهذه الخلايا بنسب عرض/ ارتفاع مختلفة (0.75, 0.85, 1.0) تضمنت هذه الفحوصات لمعرفة الفرق بين عمق الدفن تحت سطح الأرض والأملائيات خلف السد, نسب عمق الدفن تحت سطح الأرض والأملائيات خلف السد مساويه الى (0.2, 0.3, 0.40). تم استعمال ثلاث أنواع من الترب وهي السبيس و الرمل المار من غربال رقم 4 و الرمل النهري.ومن خلال هذه الدراسة تم التوصل إن عمق الدفن تحت سطح الأرض ذات مقاومه أكثر من الأملائيات الخلفية.

1. Introduction

Cellular cofferdams are retaining structures consisting of a series of interconnecter earth or rock-filled cells .These cells and the connecting arcs constructed of interlocking steel sheet piling arranged in a variety of geometric shapes . A cellular cofferdam is a gravity retaining structures and used primarily as water-retaining structures. They depend for stability on the interaction of the soil used to fill the cell and the steel sheet piling. The purpose of a cofferdam is to exclude soil and/or water from an area in which it is required to carry out construction work to a depth below the surface**(Saponaro ,et .al (2008))** .Use of cellular bulkhead as permanent retaining structures developed directly from cofferdam construction. bulkhead is primarily intended to retain or prevent sliding of the land, while protecting the upland area against wave action is of secondary importance. Cellular structure had been constructed in a variety of geometric shape ,the three most common shape circular ,diaphragm, and cloverleaf,**[TVA, (2003)]**. The aim of this study is, to find out which one is the best stabilizing influence on cellular retaining structure berm or embedment depth.

2. Testing Apparatus

The testing apparatus used in this research to check the general stability of cellular cofferdam are consist of:

A. The steel frame.
B. The loading system.
C. The pulley system.
D. The soil box.
E. The dial gages.

A. The steel frame

A steel frame was used to carry the soil box and its content, as illustrated in Fig. (1), with dimensions (1400 mm) length, (1050 mm) width, and (800 mm) height. [**Al-Khyatt, (2009)].**

B. The loading system

The load is applied to the cell by a steel cable loop (4 mm) in diameter hold around the cell tightly from one end and connected to the weight holder from the other and after passing over a pulley system, shown in fig .(2).

C. The pulley system

The pulley system consist of a round steel shaft (30 mm) in diameter and (200 mm) length, a pulley (50 mm) in diameter is fixed in the middle of the shaft, and two brackets each one surrounding ballbaring(60 mm) and internal diameter (30 mm), the two brackets provided with two holes that was used to fix the pulley set to the knee-braced frame, shown in fig .(3).

D. The soil box

A wooden container with inner dimensions (1250 mm) length, (1040 mm) width, and (250 mm) height, was used as a container for a foundation to the circular cells of cellular cofferdams, shown in fig .(1).

E. The dial gages

Dial gages were used to monitor the displacements of models throughout the entire testing program, four dial gages of (0.01 mm) accuracy and (25 mm) travel were employed, they are mounted to vertical steel shaft. shown in fig .(4).

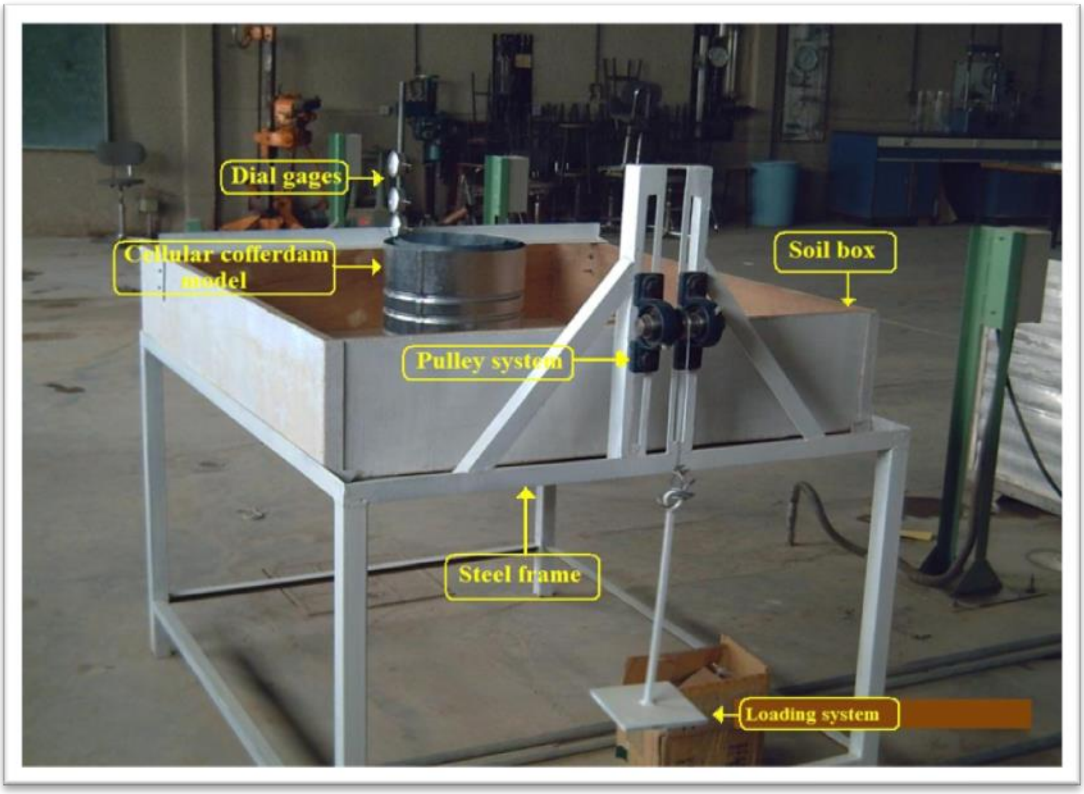


Fig. (1): The steel frame

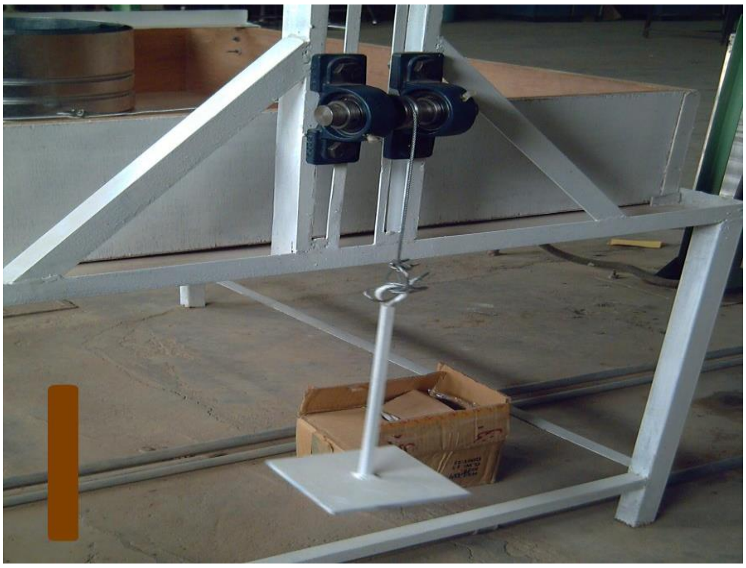


Fig. (2): The loading system

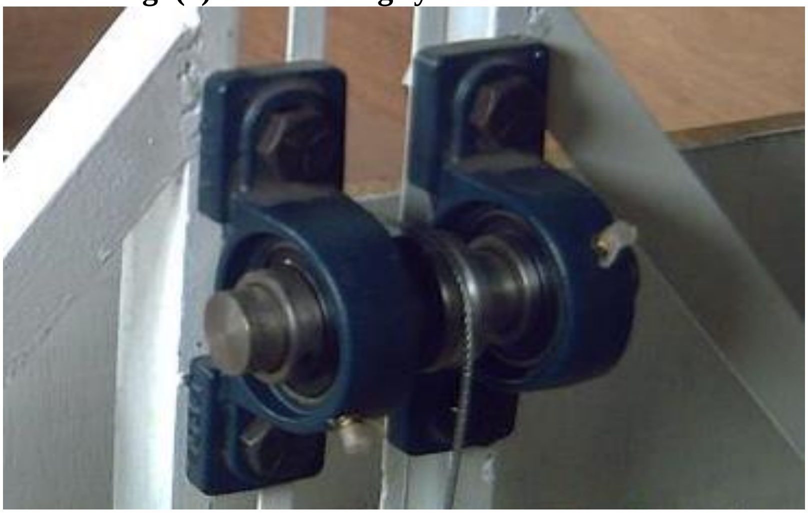


Fig. (3): The pulley system

Fig. (4): Dial gages

3. Type Of Cell Used In Laboratory

3.1 Diaphragm Model Cells

To construct the continuous diaphragm model cell, the cells divided into two groups, the first group the model driven into the soil for three depth to height ratios

(D/H=0.2, 0.3 and 0.4),all these ratios for different width to height ratio (0.75,0.85 and 1.0) are shown in Fig. (5), and the second group used outside berm by slope (3H:1V) in the back side of the cells and have ratio (0.2,0.3,0.4) from height of the cells for different width to height ratio(0.75,0.85,1.00) shown in Fig. (6). The cells shown in Fig. (7), consists of two arcs connected by straight cross walls. Each arc is 20 cm in radius, 30 cm height and 0.09 cm thickness cold-rolled galvanized steel. And width of the straight cross walls equal to 30 cm ,25.5 cm 22.5 cm respectively In order to hold the loading the cable tied to the cell during tests, the channel has been used at 100mm height from the base of the cell.

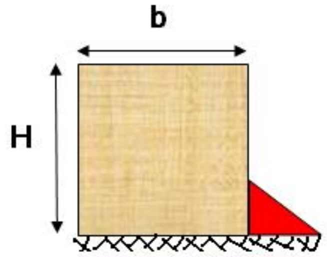
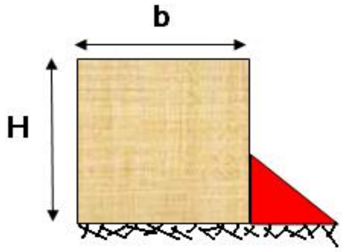
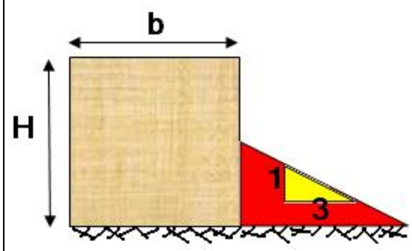
Berm=0.2H	Berm =0.3H	Berm =0.4H
		

Fig .(5): Diaphragm cells at placed berm in the back side of cells for (b/H)=(0.75,0.85,1)

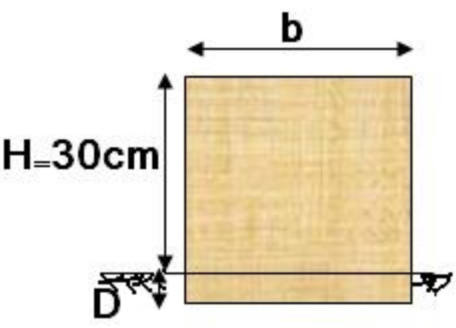
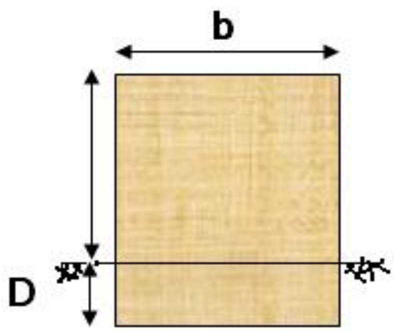
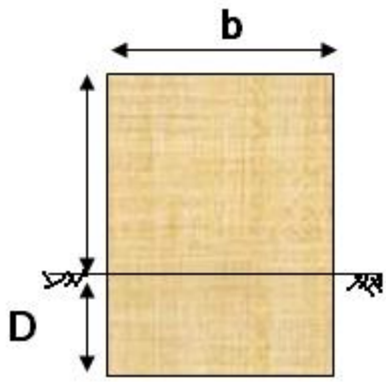
D/H=0.2	D/H=0.3	D/H=0.4
		

Fig. (6): Diaphragm cells driven into the soil for(b/H)=(0.75,0.85,1)

Fig. (7): Diaphragm Cells

3.2 The Properties of Soil

three different types of soil were used in all tests, the dry density and angle of friction for all soils which testing in laboratory are illustrated in table (1):

Table (1): The properties of the soils used in the cells fill.

Type of soil	Dry density (γ) (KN/m^3)	Angle of friction (ø)
Subbace	17.5	38
Sand sieved on No.4	16.5	34
River sand	14.5	32

4. Testing Procedure

In all tests the soil bed on wooden box of (300mm) height, placed by means of raining technique. The cells then placed in the middle width of soil box at (100mm) distance from the support of dial gages. The models are then filled carefully to minimize disturbance.

The raining technique has been used successfully in providing uniformly dense soil bed for model studies, **[Kelly, (1969)].** Basically, the technique involves raining soil through a single or series of sieves with a constant height of the drop and raining intensity, weight of soil raining per unit area; the raining technique could be used to provide a uniform dense soil fill with good density control, angle of internal friction. A height of (500mm) was kept between the sieve that was used in the raining technique and the top surface of the soil. After the cell was filled, the cell level checked by handy level, the loading system and dial gages were adjusted. Then, the load is applied incrementally and continued until a failure in the model was occurred. At the end of each load increment, the dial gages recorded. The displacements of the cell, at each load level and increment can be calculated. In all tests the same soil type was used in the cell fill and foundation. Figure (9)show laboratory the cell at placed berm and figure (10) show cell in case embedment depth .

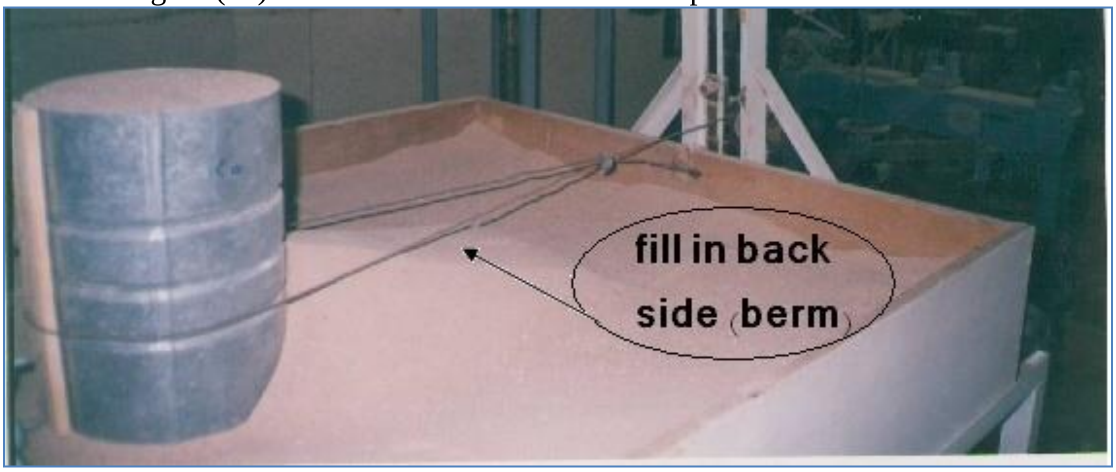


Fig. (9) : **Cellular retaining structure at placed outside berm.**

Fig. (10): Cellular retaining structure in case embedment depth

5. Results and Discussion

5.1 Differences Between Berm and Embedment Depth on Stability of Cofferdams.

To understand differences between berm and embedment depth ,berm gives resistance less than embedment depth because the passive resistance of soil behind the cell in case embedment depth greater than berm . Tables from (2)to (4) shown difference between berm and embedment depth for each ratio ,for each type of soil and for each b/h ratio, resistance of cell (b/h=1.00) when the berm ratio (0.4H) equal to (1.258kN/m) and when embedment depth ratio (0.4H) equal to (1.567kN/m) ,thus differences between two case equal to (19.719%), differences for other ratios shown in tables from (2)to(3).This differences relate to the passive resistance of soil behind the cell in case embedment depth and berm. The figures from (11) to (20) is showed relationship between load failure and displacement for embedment depth and berm.

Table (2) :Differences in resistances between berm and embedment depth in diaphragm cells ,H=300mm,withD/H=0.4 ,berm ratio =0.4

Type of soil	*b/HRatio*	*Resistance KN/m*		*Differences%*
		Berm	*Embedment Depth*	
Subbace	*0.75*	*1.267*	*1.511*	*-16.148%*
Sand passing no .4	*0.75*	*1.222*	*1.422*	*-14.065%*
River sand	*0.75*	*0.982*	*1.156*	*-15.052%*
Subbace	*0.85*	*1.176*	*1.529*	*-23.087%*
Sand passing no .4	*0.85*	*1.167*	*1.451*	*-19.573%*
River sand	*0.85*	*0.980*	*1.127*	*-13.043%*
Subbace	*1.00*	*1.258*	*1.567*	*-19.719%*
Sand passing no .4	*1.00*	*1.192*	*1.533*	*-22.244%*
River sand	*1.00*	*0.967*	*1.342*	*-27.943%*

Table (3) :Differences in resistances between berm and embedment depth in diaphragm cell,H=300mm,withD/H=0.3 ,berm ratio =0.3

Type of soil	*b/HRatio*	*Resistance KN/m*		*Differences %*
		Berm	*Embedment Depth*	
Subbace	0.75	0.933	1.213	-23.083%
Sand passing no .4	0.75	0.849	1.056	-19.602%
River sand	0.75	0.680	0.853	-20.281%
Subbace	0.85	0.992	1.088	-8.824%
Sand passing no .4	0.85	0.871	1.058	-17.675%
River sand	0.85	0.718	0.853	-15.826%
Subbace	1.00	0.993	1.058	-6.144%
Sand passing no .4	1.00	0.933	1.033	-9.681%
River sand	1.00	0.767	0.842	-8.907%

Table (4) :Differences in resistances between berm and embedment depth in diaphragm cell,H=300mm,withD/H=0.2 ,berm ratio =0.2

Type of soil	*b/HRatio*	*Resistance KN/m*		*Differences%*
		Berm	*Embedment Depth*	
Subbace	0.75	0.720	0.769	-6.372%
Sand passing no .4	0.75	0.644	0.700	-8.00%
River sand	0.75	0.600	0.611	-1.800%
Subbace	0.85	0.714	0.804	-11.194%
Sand passing no .4	0.85	0.627	0.686	-8.601%
River sand	0.85	0.553	0.578	-4.325%
Subbace	1.00	0.733	0.920	-20.326%
Sand passing no .4	1.00	0.667	0.892	-25.224%
River sand	1.00	0.508	0.717	-29.149%

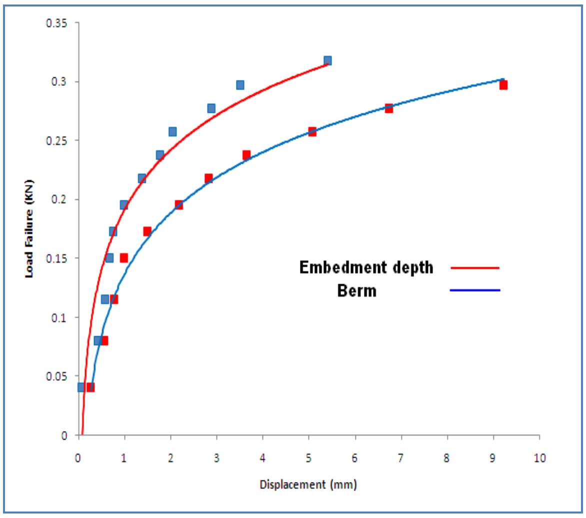


Fig. (12) Displacement vs. lateral load curve , $\frac{b}{H} = 1.00$, berm=0.3H , Embedment depth =0.3H

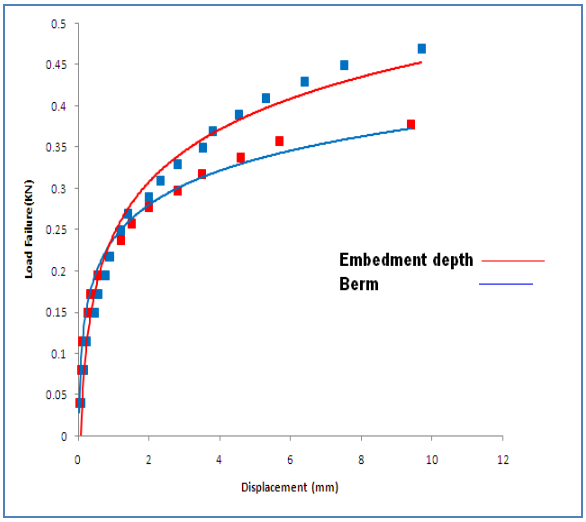


Fig. (11) Displacement vs. lateral load curve , $\frac{b}{H} = 1.00$, berm=0.4H , Embedment depth =0.4H

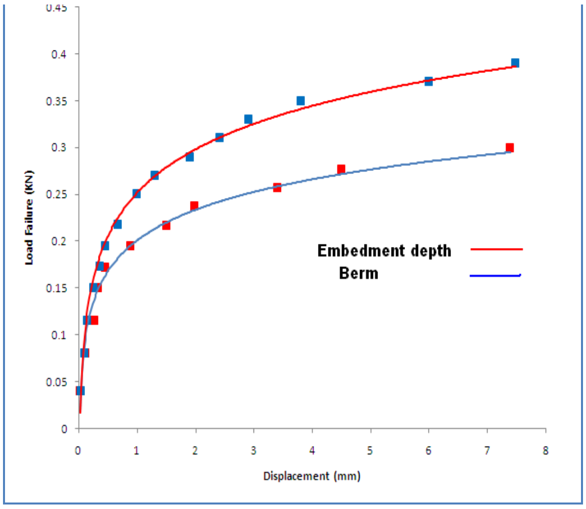


Fig. (14) Displacement vs. lateral load curve , $\frac{b}{H} = 0.85$, berm=0.4H , Embedment depth

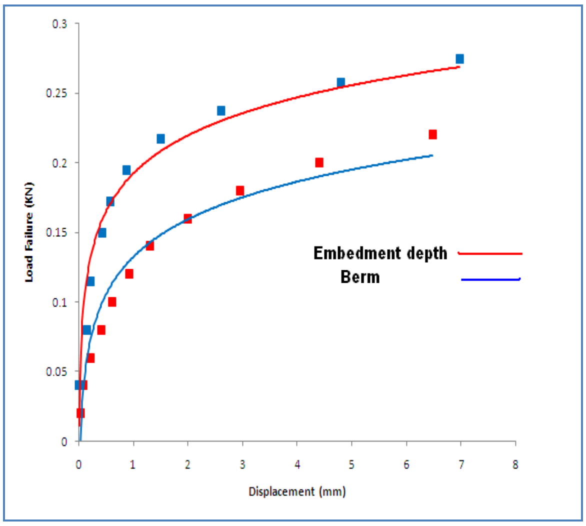


Fig. (13) Displacement vs. lateral load curve , $\frac{b}{H} = 1.00$ [illegible]H

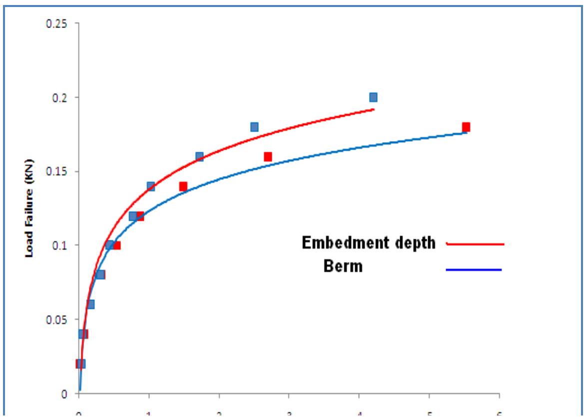


Fig. (16) Displacement vs. lateral load curve , $\frac{b}{H} = 0.85$, berm=0.2H , Embedment depth =0.2H

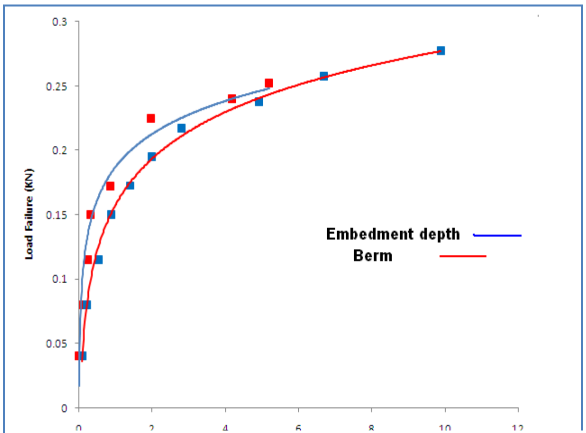


Fig. (15) Displacement vs. lateral load curve , $\frac{b}{H} = 0.85$, berm=0.3H , Embedment depth

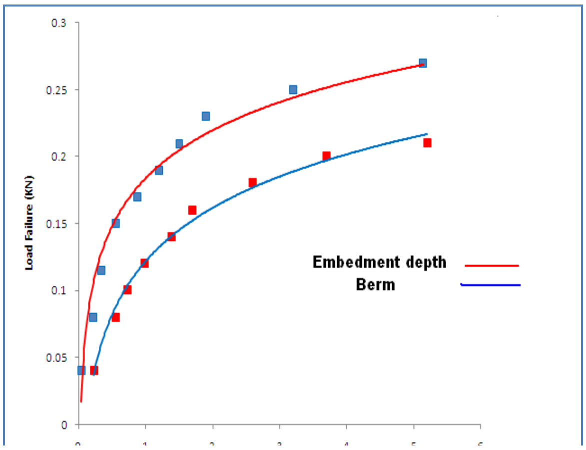


Fig. (18) Displacement vs. lateral load curve , $\frac{b}{H} = 0.75$ **, berm=0.3H , Embedment depth**

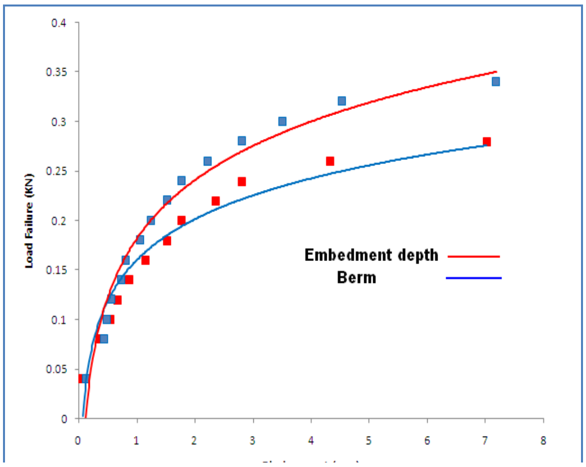


Fig. (17) Displacement vs. lateral load curve , $\frac{b}{H} = 0.75$ **, berm=0.4H , Embedment depth**

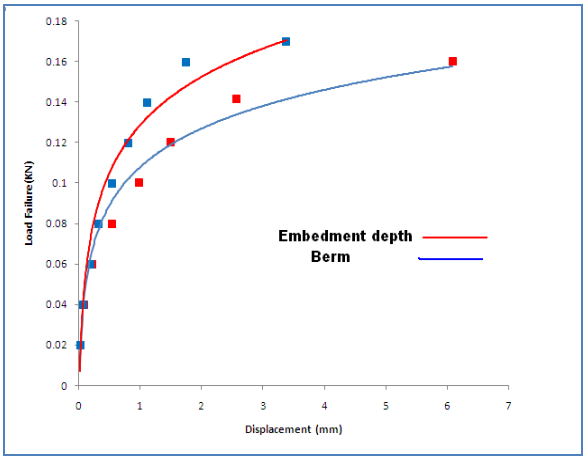


Fig. (19) Displacement vs. lateral load curve , $\frac{b}{H} = 0.75$ **, berm=0.2H , Embedment depth =0.2H**

6. Conclusion

Berm gives resistance less than embedment depth because the passive resistance of soil behind the cell in case embedment depth greater than berm and size of berm less than embedment depth .

7. References:

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