

Relation between Shape of Excavation and Soil Movement in Deep Excavation

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ABSTRACT: Now deep excavations are often carried out for 15-20 m depth and in close vicinity to existing buildings or infrastructures. The structures or buildings are very sensitive to ground movements due to excavations. The ground movement during deep excavation are influence by shape of excavation. It plays an important role in the analysis and design process of excavation. Hence, the present work is focus on understanding the analysis of deep excavation and the lateral ground movement due to various shapes of excavation using finite element MIDAS 3D software. The shapes of excavation considered for the present study were square, circle, pentagon and octagon. The volume of excavations was kept constant for different shapes. The displacement curves were drawn at corners and at the middle of edge of excavation along horizontal plane and vertical plane. The result indicates that the shape of corner of excavation had a significant effect on lateral movement. The lateral movement in ground decreases going away from the edge of excavation. The maximum displacement appeared at the depth 80% of the depth of excavation from surface of ground. The circular shape of excavation had the minimum displacement on ground and in depth among all shapes.

KEYWORDS: ground movement; deep excavation; shape of excavation; MIDAS 3D

I. INTRODUCTION

The constructions of structures like cut & covers, basement, multistorey buildings foundations requires deep excavations having technically challenging problem. The limited available space forced civil engineers to go for deep excavations to accommodate different structures. The enormous constructions and size, shape of plots lead to different shape of excavations. The shape of excavations affects the deformations of ground and excavated face. To understand the influence of shape of excavation, at the corners of an excavation and the middle of the excavation wall along ground and excavated face, 3D finite element software MIDAS 3D was used. The present paper will give the choice for best shape of excavation that will provide minimum ground and face movements during excavation.

II. RELATED WORK

The deep excavation in soft to medium clayey subsoil stratum was studied for the effect of the existence of the corner on the deflection behaviour [1]. The corners can heavily affect the deformation behavior of a "short" primary wall.

The effects of corners on wall deflection and ground movement around multi-strutted deep excavations in Singapore were studied to assess the significance of such effects in a typical-sized excavation, in soft marine clay [2]. The comparative exercise suggests that as length-to-depth ratio decreases the deflection in the ground increases and if the excavation was underlain by stiff soil strata, the maximum wall deflection was likely to be reached above excavation level, and corner effect may be suppressed if sufficiently stiff strutting systems were used.

The potential corner effects of long and narrow multipropped metro station excavations had done by analyzing the field data from nine metro-station pits with aspect ratios (AR) of pit length to width of 6.6–19.4 in Shanghai soft clay [3]. The corner effects of the metro station pits were much less pronounced than the regular rectangular excavations and the

pit length to-depth ratio or the pit length-to-width ratio hardly affect the corner effect development of long and narrow multi- propped pits because of their narrow widths.

An empirical methodology that allows calculation of ground displacements behind corners of retained cut excavations had been proposed [4]. The results presented suggest that the reduction of percentage of ground movements follows a linear relationship with the distance from the point of maximum ground movements along each side of the wall. It was also shown that this percentage reduction in ratio seems to be approximately 33% independently of factors such as different ground conditions, support arrangements, construction sequences, and retained heights, as covered on the verification processes.

From the literature review, it was observed that the ground movement due to supported deep excavation on clayey and sandy soil had been studied by many researchers. The effect of shape of unsupported excavation having large depth surrounded by heavy structures need to be studied. The present paper studied the soil behaviour due to deep excavation for different shapes of excavation using the finite element simulation geotechnical software MIDAS 3D.

III. NUMERICAL MODELLING

The geometry of the finite element soil model in MIDAS 3D was adopted as 10H x 10H x 10H with the different sizes of excavation. The volume of excavation was kept constant throughout the analysis for different shapes of excavation to compare the results. The side boundaries of the mesh were restricted by “roller” fixities to prevent displacement in the perpendicular direction to the boundary and the bottom boundary prevents displacements in both directions horizontally and vertically. The geometry of model is depicted in Fig. 1. The typical layouts of different shapes of excavation studied are shown in Fig 2.

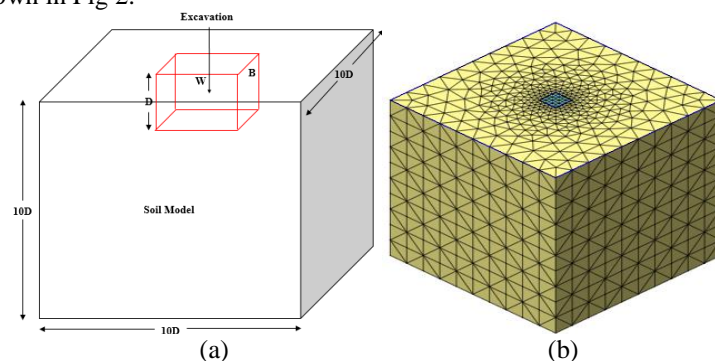


Fig 1: Soil model and excavation (a) Typical Soil model (b) Soil Model in MIDAS 3D

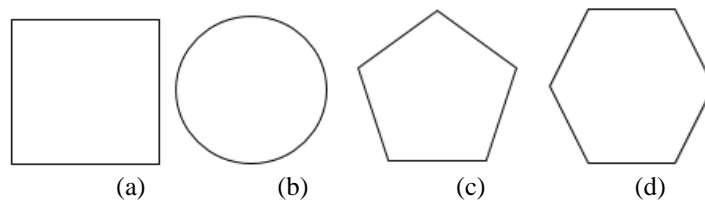


Fig 2: Shapes of Excavation(a) Square (b) Circle (c) Pentagon(d) Octagon

For analyzing the soil model in MIDAS 3D software, the properties of soil used in the analysis are shown in Table1. The type of soil for the present analysis was sandy soil.

Table 1: Material properties for soil

Sr. No	Properties	Soil
1	Dry unit weight (kN/m ³)	25
2	Cohesion c (kN/m ²)	20
3	Poisson's ratio ν	0.3
4	Young's modulus E (kN/m ²)	2000
5	Angle of internal friction (ϕ)	36
6	Material model	Mohr Coulomb
7	Type of material behaviour	Drained

IV. RESULTS AND DISCUSSION

The analysis was carried out using MIDAS 3D for excavation on the surface of ground. The excavation of soil was carried out in different shapes such as square, circular, pentagonal and octagonal. Fig. 3 illustrates the analysis of ground movement with excavation having 5m depth in MIDAS 3D. The depth of excavation was kept constant as 5 m throughout the analysis. Fig. 3 (a) shows the mesh generation, Fig. 3 (b) shows the boundary conditions and Fig. 3 (c) shows the displacement contours for analysis of ground movement after analysis obtained in MIDAS 3D.

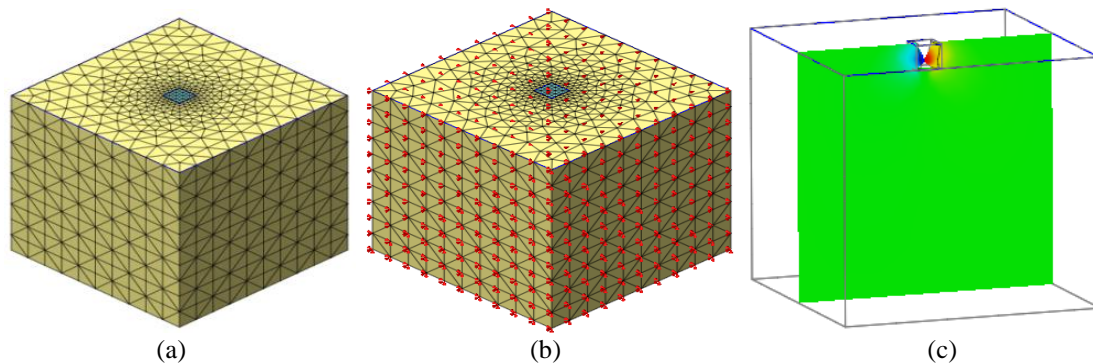


Fig. 3: Modelling in MIDAS 3D (a) Mesh generation (b) Boundary conditions (c) Displacement contours

After analysis in MIDAS 3D, the displacement curves were drawn at different location on vertical plane and horizontal plane. Fig 4 shows the lateral ground movement along depth for different shapes of excavation. The deflection profiles are extracted at different locations such as A, B and C where, A = at corner, B = at one fourth of the width of excavation from corner of excavation and C = middle of the excavation face. Herein, the lateral ground movement means the movement in ground in the direction perpendicular to the edge of excavation. Fig. 4 shows that for circular excavation, the lateral ground movement is minimum among all shapes of excavation. It was also observed that the maximum displacement occurs near the corner of excavation, which decreases as we move towards centre of the excavation for all shapes. In addition, the maximum movement of soil occur at 70% depth of excavation for all cases. The maximum deflection was seen for rectangular shape excavations.

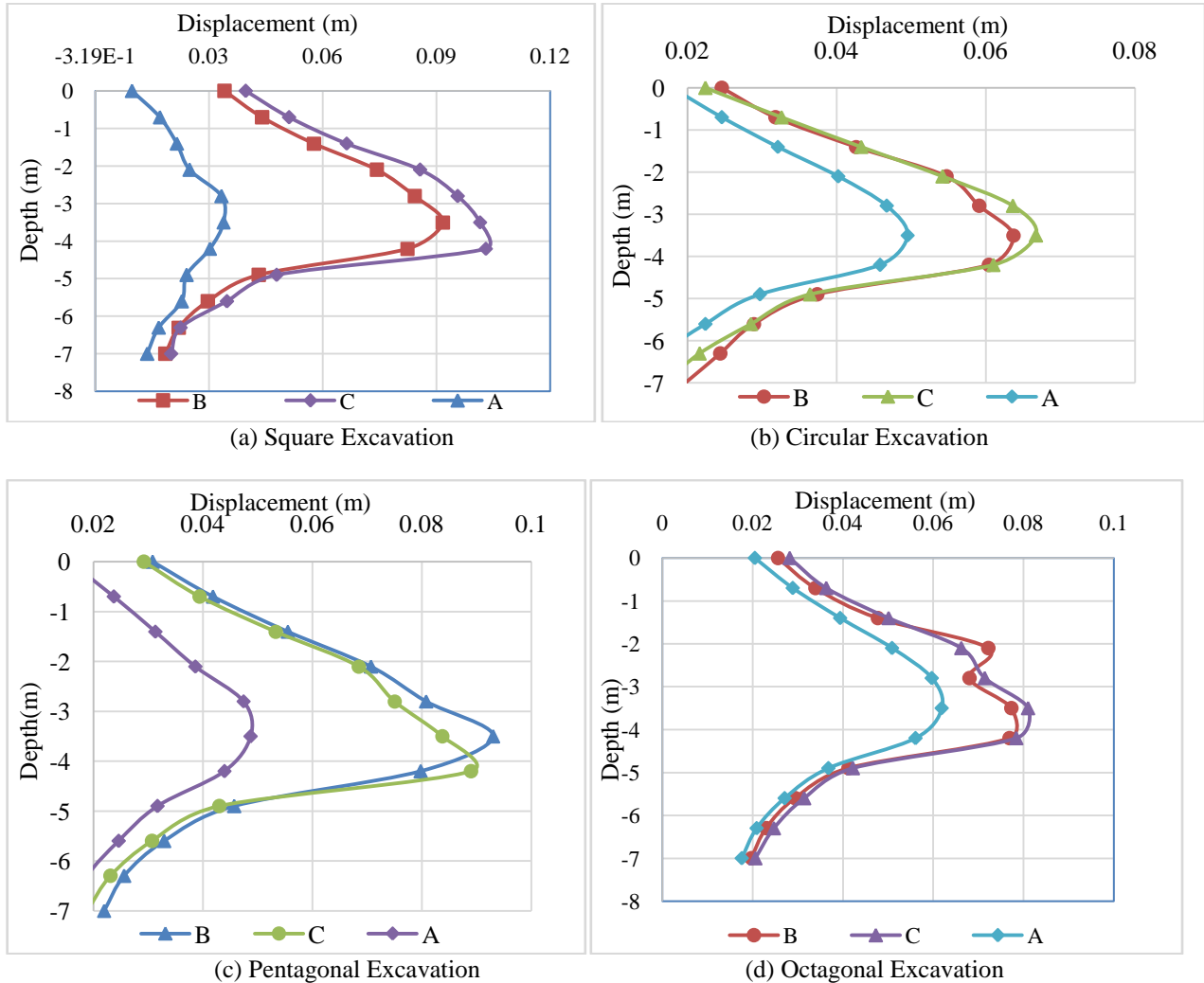


Fig 4: Lateral Ground Displacement along Depth for Different Shapes of Excavation

Fig 5 shows the lateral displacement along ground surface for different shapes of excavation at corner (A), one fourth of width distance (B) and middle (C) of the excavation edge. The lateral displacement along ground surface was observed to be maximum at middle of the excavation edge for all shapes except, circular shape. The lateral displacement along ground surface at the corner is found to be minimum at corner for square excavation while it remain same for all other shapes for which the number of edges of the excavation increases.

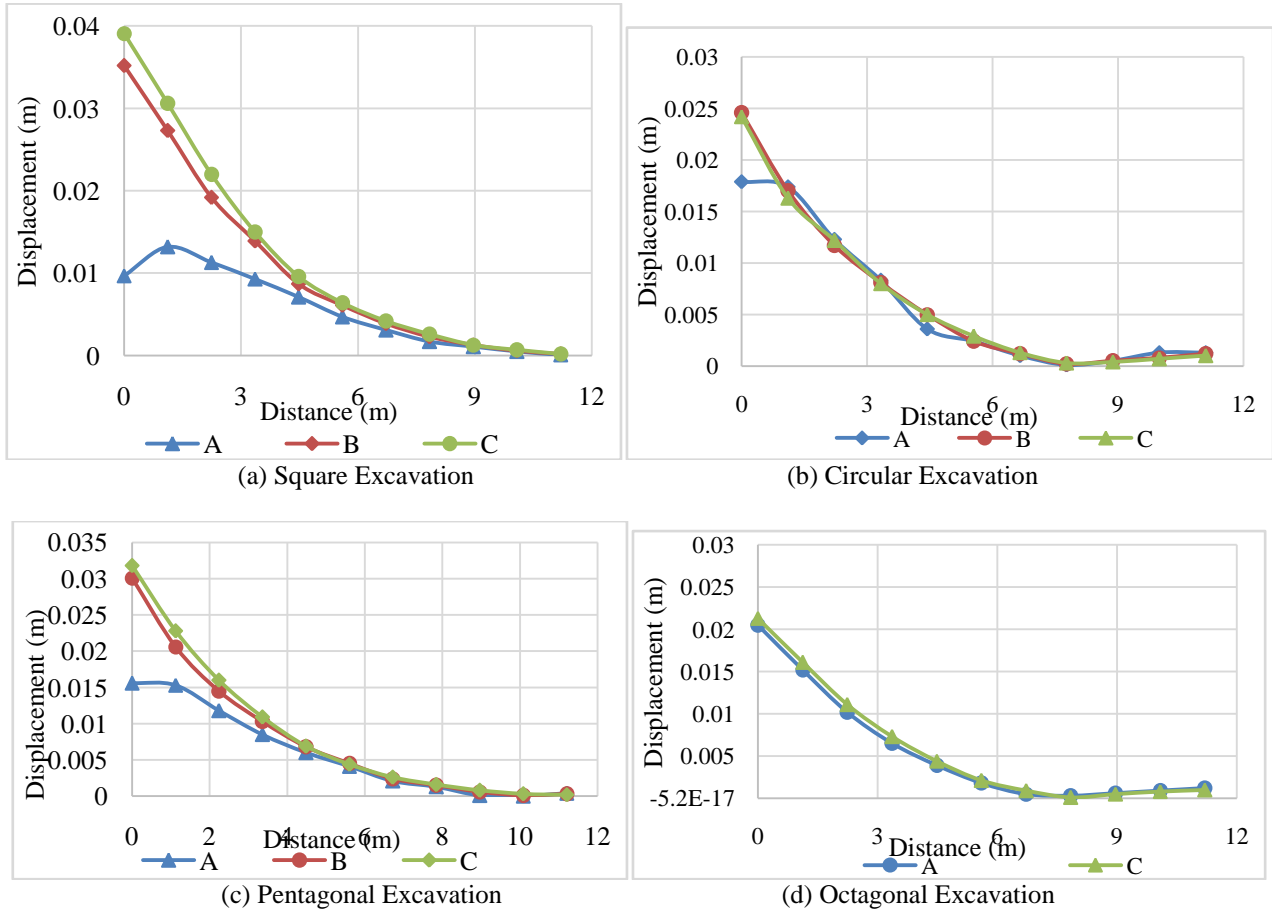
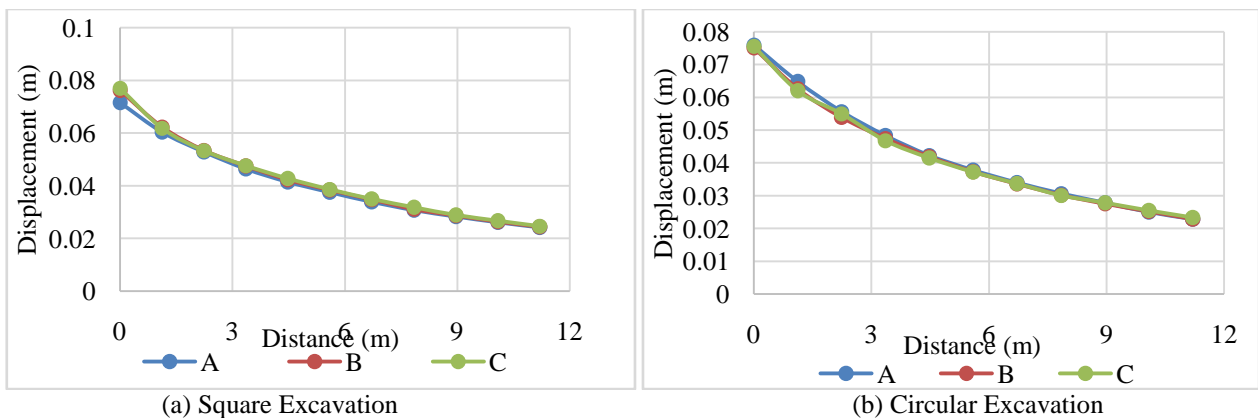


Fig.5: Lateral Ground Displacement along Ground Surface for Different Shapes of Excavation

Fig 6 shows the vertical displacement along ground surface for different shapes of excavation. It can be seen that the vertical displacement is independent of shape of excavation for all point along the edge of excavations.



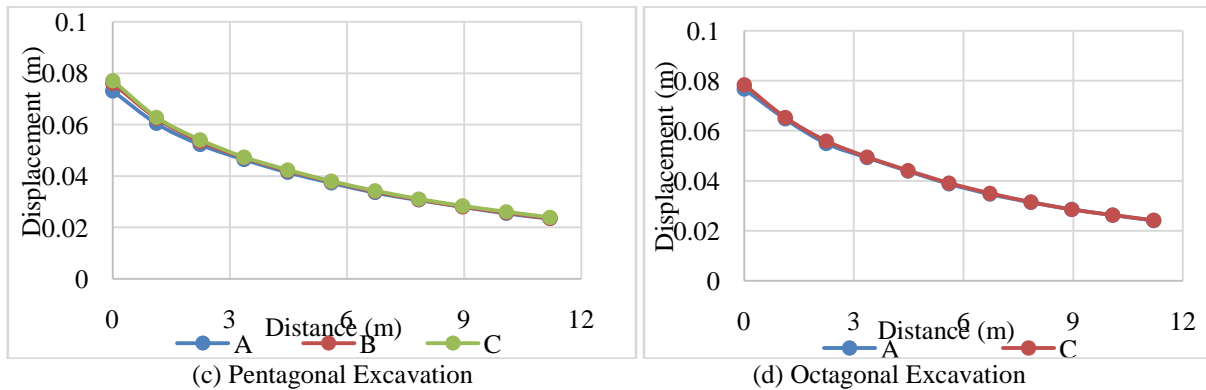


Fig.6: Vertical Displacement along Ground Surface for Different Shapes of Excavation

V. CONCLUSIONS

A series of various numerical model were analysed using MIDAS 3D to evaluate the lateral ground movement during excavation with different shapes of excavation. The shape of excavation plays an important role in reducing the displacement. The study investigated the effect of shape of excavation on lateral ground movement and vertical displacement. From the study, it can be concluded that;

1. The shape of excavation plays an important role in decreasing the ground movement both vertically and horizontally.
2. The lateral displacement near the centre of edge of excavation was found to be minimum, which increases towards the corner of the excavation edge.
3. The maximum lateral displacement occurs at approximately 70% of the depth of excavation along the vertical plane.
4. Maximum movement on the surface of ground arises at the edge of excavation which diminishes gradually away from the edge of excavation.
5. The excavation having circular shape shows least ground movement while square shape excavation shows maximum ground movement during deep excavations.

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