Assessment and Management of Adjacent Excavations near Existing Buildings using PLAXIS 2D

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Abstract: Rapid urbanization and the growing need for underground infrastructure have caused a lot of deep excavation work to occur in areas with large number of buildings. Excavations conducted near existing structures present considerable geotechnical issues owing to soil-structure interaction and the potential for ground movements, which may result in structural distress or failure. This research concentrates on the evaluation and supervision of neighboring excavations through sophisticated numerical modelling methodologies in PLAXIS 2D. The study focuses on making staged construction processes as realistic as possible, including excavation sequences, and how soil behaves under loads. The estimation of ground settlement, and generated stresses in neighboring structures is given special consideration. In addition to this, the research includes persistent evaluation procedures that emphasize the relevance of evaluating numerical models to enhance the accuracy of forecasts. As a result of this research, the gap between theoretical modelling and real-world application is being bridged, which will result in safer construction methods and greater preservation of existing infrastructure.

***Keywords* – Rapid Urbanization; Deep excavation; Soil-Structure Interaction; Structural Distress; Plaxis 2D.**

I] INTRODUCTION

Urbanization and population increase have caused many infrastructures to be built in cities and other highly populated places as there is not enough land available. Due to this scarcity of available land, modern construction projects increasingly require deep and adjacent excavations for basements, underground parking, metro stations, utility corridors, and high-rise foundations. These excavations are often done quite close to buildings and utilities that are already in the ground, which makes planning and carrying out the work very difficult. Excavations that are close to each other change the stress conditions of the soil, which causes ground movements, lateral soil deformations, and settling. These effects can hurt structures that are close by, causing them to crac k, tilt, settle unevenly, or even fail completely in the worst circumstances. So, it's important to carefully evaluate and manage the hazards that come with excavation to make sure that existing buildings are safe and useful.

II] LITERATURE REVIEW

The research by Dr. A. I. Dhatrak, S. D. Kulkarni [1] aimed at investigating the effect of excavation induced movements on the lateral deflection of pile situated near the excavation in multilayered soil. To identify the critical depth and deflection, Divyani P. Sonkusare, Prof. S. W. Thakare [2] used PLAXIS 2D to examine the consequences of excavation close to structures in sandy clay soil by examining factors such as excavation depth, building height, distance, and support systems. The study of Anand. M. Hulagabali, Pankaj Bariker, C. H. Solanki and G. R. Dodagoudar [3] uses PLAXIS 2D finite element analysis to evaluate how deep excavations, supported by contiguous pile walls, affect adjacent structures by analyzing deformation, settlement, and structural response under varying design parameters. The study by J. Jasmine Nisha, M. Muttharam, M. Vinoth, C. R. Eswara Prasad [4] presented the design and analysis of deep excavation systems using PLAXIS 2D, including shoring solutions, failure investigation, and remedial measures to protect adjacent structures in a constrained urban environment. Dinakar K. N. and S. K. Prasad [5] in their study used PLAXIS 2D to analyze the stability and deformation behavior of deep excavations supported by diaphragm walls near adjacent structures, showing they can safely limit ground movement even beyond 25 m depth. Hua-feng Shan, Shao-heng He, Yu-hua Lu and Wei-jian Jiang [6], this research investigated the effects of excavation beneath existing buildings using field monitoring and *Plaxis 2D* modeling to study how different pile cutting sequences influence load transfer and settlement behavior. It concludes that excavation depth and pile cutting sequence significantly affect pile forces and structural settlement, with symmetrical cutting providing better performance. The paper by M. F. Maruf and H. Darjanto [7] intended to describe the analysis of the excavation process and the inferred ground stability. The model simulation by means of Plaxis 2D 2011 recommended the modification of construction stages drastically. Local excavation at the pile cap area was the best method to generate the smallest deformation in the nearby area.

From the literature review, the crucial issue of how new foundations and deep excavations affect the stability of the surrounding soil and adjacent structures. They compare anticipated soil settlements and wall movements with actual field measurements by simulating real-world scenarios, like the Rio de Janeiro Metro project, using computer modelling tools like Plaxis 2D. To map out stress sites and possible soil deformation, they also analyse specific site data, such as drilling results from water delivery projects in India. In the end, they hope to provide engineers more accurate ways to forecast structural hazards and stop harm, such cracks or sinking, to already-existing neighbourhood structures at various phases of construction.

III] METHOD AND MODELLING

Plaxis 2D is a sophisticated and easy-to-use finite element program for analysing deformation and stability in geotechnical engineering and rock mechanics in 2D. Plaxis 2D lets you model a wide range of geotechnical problems from a single, integrated program. In Plaxis 2D Software we firstly create a soil model to which all the respective soil properties are assigned. After that a mesh is generated and loads are applied and analysis is run. After a proper analysis is carried out, we get the output for soil settlement, soil shifting, etc. After obtaining the results conclusions are drawn and remedial measures are provided.

The Finite Element Method using Plaxis 2D Software is used for the numerical calculations of this research. The Mohr-Coulomb constitutive model is selected for the soil. For conducting the analysis for research, a site is selected. The selected site is in Shivshankar Nagar of Nandura City in the Buldhana District of Maharashtra State. The location of the site where the deep excavation is to be carried out has an existing G+2 storey commercial and residential structure adjacent to it. The footing provided to the existing building is a shallow footing provided at a depth of 1.5 m. The footing that will be provided at the proposed building site is also a shallow footing provided at a depth of 1.5 m. The footing used is of trapezoidal and eccentric type of footing.

Fig. 1: Proposed site for excavation adjacent to existing building

Fig. 2: Exposed Eccentric Footing of Existing Building

In this research work, figure 4 illustrates the two-dimensional numerical model developed in PLAXIS 2D for the analysis of isolated footings. The model consists of a layered soil profile with three distinct strata representing different soil properties. Four shallow footings which are considered from the actual site plan are placed at the ground surface level and are subjected to uniformly distributed loads, as indicated by the downward arrows. The analysis is carried out using staged construction, where the initial phase represents the in-situ stress condition, followed by subsequent phases for footing activation and load application. The soil is modeled using appropriate constitutive behavior, and boundary conditions are assigned to simulate realistic field constraints. The mesh is refined around the footing regions to capture stress distribution and settlement behavior more accurately. This model is used to evaluate the interaction between adjacent footings and the resulting deformation and stress patterns in the underlying soil.

PARAMETER	NAME	LAYER 1	LAYER 2	LAYER 3
Type of Soil	Soil	Clay	Stiff Clay	Sand
Material Model	Model	Mohr-Coulomb	Mohr-Coulomb	Mohr-Coulomb
Unit Weight above phreatic level (kN/m³)	γ_{unsat}	16	17	18
Unit Weight below phreatic level (kN/m³)	γ_{sat}	18	19	20
Young's Modulus (kN/m²)	E	10000	20000	30000
Cohesion (kN/m²)	c	29	50	0
Friction Angle (°)	Φ	10.9°	18°	30°
Poisson's Ratio	v	0.35	0.35	0.35

Fig. 3: Soil Properties used for analysis

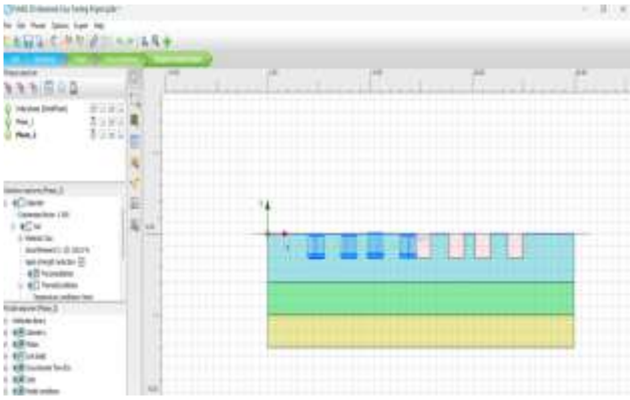
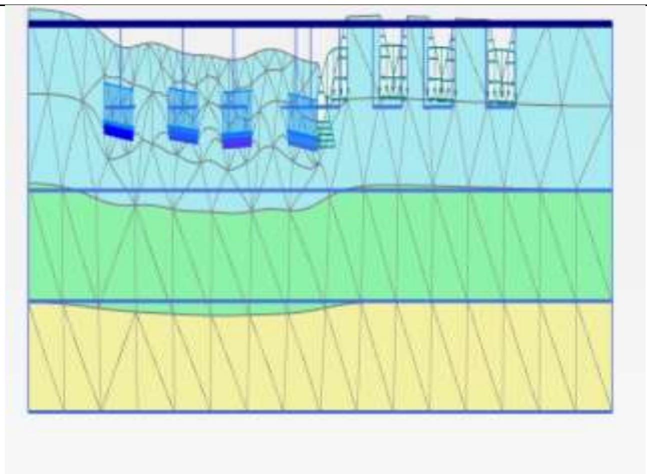
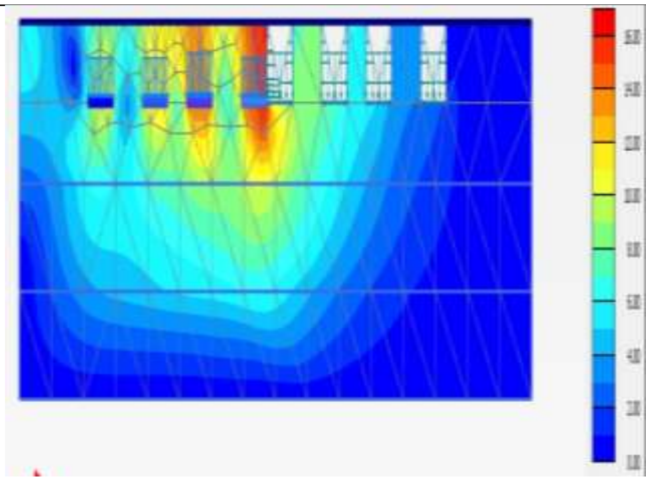


Fig. 4: Soil Model

IV] RESULTS





In the above figure, total displacement represents the combined horizontal and vertical movement of soil. The maximum displacement obtained from the analysis is 0.01616 m (16.16 mm). This value is within the permissible settlement limits (0.025–0.05 m), indicating that the soil–foundation system is stable and safe under the applied loading conditions.

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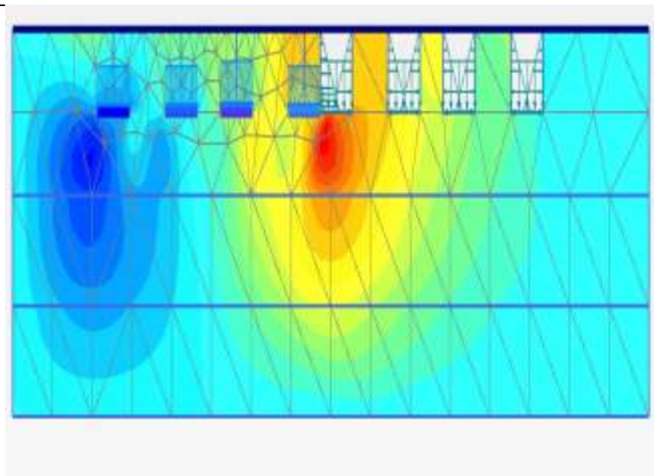
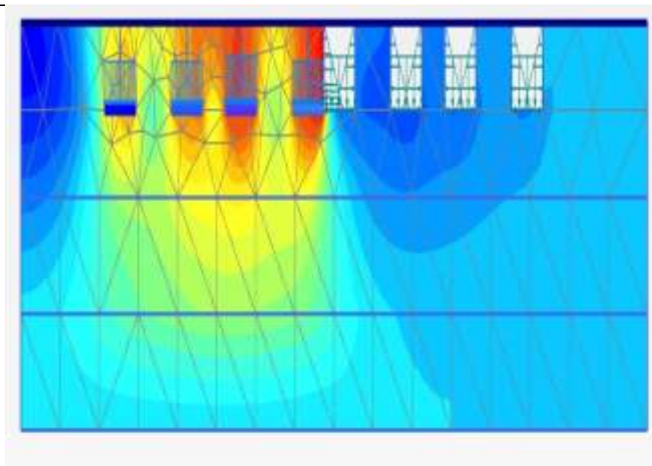
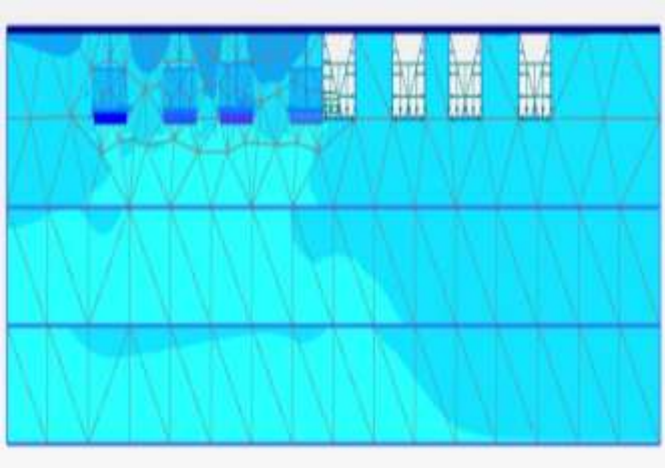
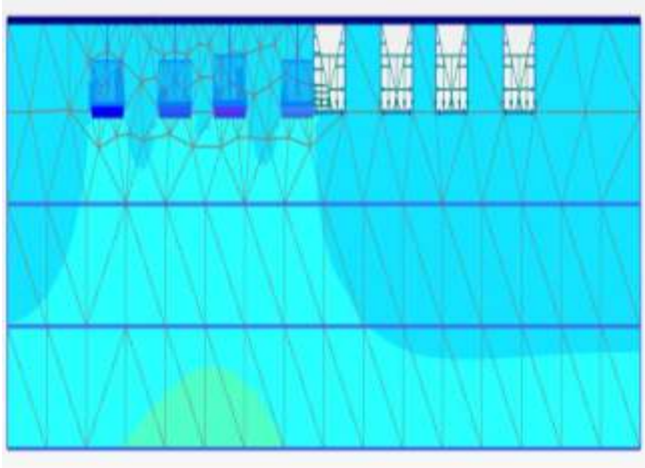




In the above figure, horizontal displacement represents the movement of soil in the X-direction due to applied loading. The maximum horizontal displacement obtained from the analysis is 0.01276 m (12.76 mm), while the minimum displacement is −0.00615 m (−6.15 mm). The positive and negative values indicate that the soil is moving in opposite horizontal directions at different locations, which is expected due to load distribution and interaction between adjacent footings. Higher horizontal displacement is observed near the loaded footing region, while it reduces away from the load showing serious instability and possible failure of the ground supporting the footing.

In the above figure vertical displacement represents the movement of soil in the Y-direction due to applied loading. The maximum vertical displacement obtained from the analysis is 0.005401 m (5.40 mm), while the minimum displacement is −0.01431 m (−14.31 mm). The negative values indicate settlement of the soil beneath the loaded areas, while the positive values show slight (upward movement) in surrounding regions, which is typical due to load transfer and soil interaction effects.





From the above figure the horizontal stress (σ_{xx}) represents the stress acting in the X-direction within the soil due to loading. The maximum stress is 302.4 kN/m², while the minimum stress is −1001 kN/m². Positive values indicate compressive stress, while negative values show tensile stress. This variation occurs due to load distribution and interaction between the footings and surrounding soil.

In the above figure, the vertical stress (σ_{yy}) represents the stress acting in the Y-direction within the soil due to applied loads. The maximum stress is 362.3 kN/m², while the minimum stress is −1045 kN/m². Positive values indicate compression, while negative values indicate tension. This variation is because of loading and soil interaction beneath the footings

V] CONCLUSIONS

i. The numerical study with PLAXIS 2D accurately modelled how the soil and structures interacted in adjacent excavations near existing buildings, giving a realistic picture of how stress and deformation spread.

ii. The highest total displacement measured (16.16 mm) is within acceptable settlement limits, which means that the foundation system is still stable and safe given the current loads and site conditions.

iii. The displacement pattern reveals that the soil deforms the most near the loaded footing and less as you move away from it. This is what we would expect to happen when the soil is loaded in a specific area.

iv. The horizontal displacement figures show that the soil is moving sideways because of the load interaction between footings that are near together. This shows how important it is to think about interference effects when foundations are close together.

v. The findings of the vertical displacement test demonstrate that there is obvious settling under loaded places and slight heaving in the areas around them. This shows how load is often transferred and redistributed in layered soil systems.

vi. Stress analysis shows that both horizontal and vertical strains vary a lot. Compressive stresses are stronger under the footings, and tensile zones emerge in nearby areas because of how the soil interacts with the footings.

vii. The study shows that rigorous numerical modelling and staged construction analysis are good ways to estimate the consequences of excavation and make sure that neighbouring buildings are safe.

VI] FUTURE SCOPE

i. Future research may integrate sophisticated constitutive models such as Hardening Soil or Soft Soil Creep to more precisely depict long-term settlement, stress redistribution, and soil–structure interaction.

ii. Additional parametric assessments that change the depth of the excavation, the distance from existing buildings, and the conditions of the groundwater can assist establish general rules and performance charts for safer excavation procedures.

iii. General recommendations and performance charts for safer excavation procedures can be developed with the aid of additional parametric assessments that alter excavation depth, distance from existing buildings, and groundwater conditions.

iv. Prediction accuracy can be improved and a more realistic evaluation of deformation patterns surrounding nearby excavations can be obtained by expanding the work to 3D numerical models and verifying findings using field monitoring data.

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