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A THEORETICAL STUDY ON THE ANALYSIS OF DIAPHRAGM WALL

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Abstract - *Diaphragm walls are deep retention systems used as a part of foundation. These are generally used in deep basement of building, congested urban spaces, underground structures of metro trains, river fort structures and marine structures. Indian code for design and construction of diaphragm wall, IS 9556-1980 gives recommendations for construction procedure and equipment. For the analysis and design procedure, it refers to the code of practice for reinforcement concrete design IS 456- 2000. The aim of the paper is the theoretical study on the analysis procedure of diaphragm wall.*

Key Words: Diaphragm Wall, IS Codes, Lateral Pressures, Apparent Earth Pressure Diagrams, Strut Systems

1. INTRODUCTION

Diaphragm walls are typically constructed in reinforced concrete to provide the required structural capacity, but they may also be designed as unreinforced plastic cut offs. These are watertight structures it can extend to great distances both horizontally and vertically. The construction of the walls minimizes noise and vibration compared to construction of sheet pile walls. Diaphragm walls are typically 20m to 50m deep, but may extend to considerably greater depth. There are two types of diaphragm walls. Temporary and permanent diaphragm walls based on their usage. Temporary diaphragm walls are used only as retaining walls during construction of other permanent structures. The permanent diaphragm wall on the other hand serve both as a retaining wall and as a part of a permanent load bearing structure. Temporary diaphragm walls often require more space on the construction site than the permanent ones. This is because the final structure needs to be built on the inside of the temporary walls, usually few meters from the walls on each side. Therefore the combination of retaining wall and the final structure with a permanent diaphragm walls become more advantageous in urban areas [1].

Diaphragm wall provide structural support and water tightness. These reinforced concrete diaphragm walls are also called Slurry trench walls. This is because excavation is made by filling and keeping the wall cavity full with bentonite-water mixture to prevent collapse of vertical excavated surfaces. These are also used as a permanent basement wall. Typical wall thickness varies between 0.6 to 1.1m. The wall is constructed panel by panel in full depth. Panel width varies from 2.5m to about 6m. The stability is provided through an embedment of the wall on the ground working as a cantilever structure and eventually a system of anchors, so the wall is subject to shear stresses and bending moments. It is generally a reinforced wall which can be used to transfer lateral loads like earth pressure, hydrostatic pressure and earthquake loads [1]. The diaphragm walls mainly classified into three categories, strutted diaphragm wall, cantilevered and anchored diaphragm wall. The research is mainly focus on strutted diaphragm wall. The figures 1, 2 and 3 showing the strutted diaphragm wall, cantilevered diaphragm wall and anchored diaphragm wall respectively.

Fig -1: Strutted Diaphragm Wall

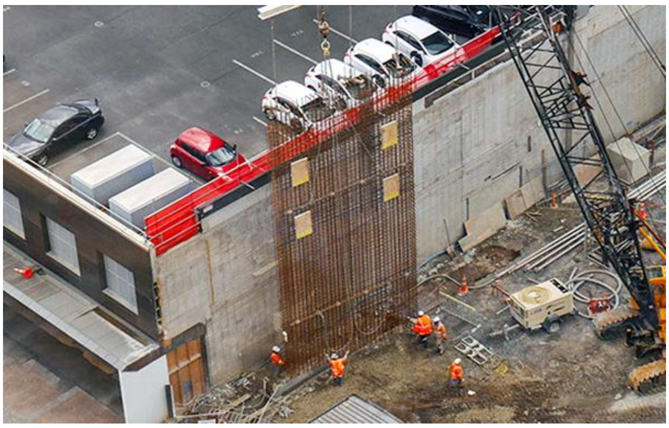

Fig -2: Cantilevered Diaphragm Wall

Fig -3: Anchored Diaphragm Wall

2. LITERATURE REVIEW

Literature review is carried out in five sections, such as Study of design parameters, Effects on adjacent buildings, Effects of earth and water pressure, Seismic effects and Study of Indian standards.

Qualitative and quantitative aspects of physical and functional characteristics of a component is determined through study of design parameters. Subha Sankar Chowdhury et.al [2], this paper discusses the development of a numerical model for a braced excavation to estimate the various design parameters that significantly influence the excavation's behavior. The developed model is used for parametric study to show the influence of different design parameters, such as strut stiffness, wall thickness, strut arrangement and the embedded depth of the wall on strut force, maximum moment developed in the wall, maximum lateral displacement of the wall, and maximum vertical displacement of ground surface. It was found that, among all the combinations studied, a particular type of strut arrangement for a particular ratio of embedded depth and excavation depth produces the best possible result. A design guideline is also provided based on the results of this numerical study. It was observed that, for a particular wall thickness and strut stiffness, different strut arrangements produced different results for maximum strut force, maximum moment, maximum horizontal wall displacement, and maximum vertical ground surface displacement. The moment in the wall increases with an increase in wall thickness, but the behavior is completely opposite for both horizontal displacement of the wall and vertical displacement of the ground. The results presented in this paper will also help in choosing the proper value of the design parameters. The parameters chosen for the validation are excavation to embedment ratio the position of strut system and soil conditions. Nicoleta-Maria Ilies et.al [3], carried out a study to assess the design optimization of diaphragm wall. The purpose of this paper is to demonstrate how different calculation models influence the design. Main result is the comparison between the embedment depths, the values of bending moments, shear forces and the structure displacements for different diaphragm walls. The soil conditions for the validation are selected from this journal. This study is limited to explain about the procedure for analysis.

Depends on the soil profile the diaphragm wall configuration and the close existence of adjacent building with poor foundations may render the effects of diaphragm wall installation. This part of literature study deals with effects on adjacent buildings. Dinakr K N and S K Prasad [4], in this study, 2D Finite element model is developed using PLAXIS to represent the performance of diaphragm wall on the stress distribution and deformation. The analysis is carried out considering non-linear behavior of soil using Mohr-coulomb failure criteria. A typical building load is idealized and its effect on excavation and supporting system is analyzed in terms of bending moment, shear force and displacement of diaphragm wall. Results of the study reveal that diaphragm wall method is stable to limit ground movements under buildings considerably and the excavation can be carried beyond 25m safely. Horizontal and vertical displacements as well as shear stress in ground decreased with increase in distance of the structure from the excavation. The minimum distance of excavation from existing structure can be estimated based on allowable stresses and displacement of ground. The study is limited to explain about the settlement of adjacent structures. Emilios M. et. al [5], in this paper the effects from the installation of diaphragm walls have been investigated using a new method for simulating the excavation and construction of subsequent panels. The results of the numerical analysis confirmed the statement that the panel length is the most affecting factor of ground movements and lateral stress reduction during panel installation. The lateral movements under panel construction, it was found that the effect on settlements depends on the distance from the panel under construction. The application of a micropile curtain is recommended in the case of a building extremely close to the diaphragm wall in conjunction with poor foundations and soil conditions. The study limited to full modelling of structure using soil-structure interaction.

Effective earth pressure and pore water have great influence on the design of diaphragm wall. Robert A. Day [6], this paper investigates the hypothesis that the earth pressure on cantilever walls in their service condition can also be approximated satisfactorily by a rectilinear pressure distribution, which can be predicted. Thus, the service bending moment distribution is obtainable. It provides the missing data that have been needed to verify and justify the CIRIA104 method. This study indicates that for practical cantilever walls with typical factors of safety, the active and passive pressure in the design condition can be assumed to be at the theoretical limiting values. Brian Simpson and William Powrie [7], this paper aims to summarize and extendthis debate, and to suggest future developments which might help to clarify understanding and design procedures. This paper has argued that safety factors can most usefully be applied to soil strength, rather than to passive resistance, rotational moments, or structural load effects such ascending moments and prop forces. Investigations using advanced numerical analysis, physical models are limited to explain in this study.

Diaphragm walls are most deep structures their design and analysis should concern with the effect earthquakes. G. Neelakantan et.al (1992) [8], a balanced seismic design concept for anchored retaining walls is presented in this study. The balanced seismic design enhances the seismic resistance of anchored retaining walls at little additional expense. A typical design example is considered to compare the balanced design procedure with current design practices. It is found that embedment depth ratios arrived at via these static design procedures can retain the stability of anchored retaining walls under an earthquake of moderate intensity. For the seismic stability of structures its need to understand the earth pressure characteristics too. The study limited to explain these condition.

In the construction industry both structural and non-structural elements are designed according to the specifications. Indian standards as well as international standards gives recommendations for design and analysis of structural elements. This part of my study going through the recommendations provided for analysis of diaphragm wall. IS 9556-1980, Code of Practice for Design and Construction of Diaphragm walls [9], gives recommendations for design and construction of diaphragm wall. The code of practice provide information about construction materials, methods and stages of construction. In the design consideration they refer to other Indian standards. As per code provision the depth of the diaphragm wall can be considered up to 65m. Since it is an underground structure we have to consider the seismic effect in design. But the provisions are limited to consider these effect which is unavoidable. IS 456-2000, Plain and Reinforced Concrete Code of Practice [10], gives recommendation for structural analysis. There is no clear cut provision for analysis of diaphragm wall. In the Section 4: Special Requirements for Structural Members and Systems contain the design and analysis part of walls. Clause 32.3.2 Walls Subjected to Combined Horizontal and Vertical Forces state that, walls subjected to horizontal forces perpendicular to the wall and for which the design axial load does not exceed 0.04 fck Ag, shall be designed as slabs in accordance with the appropriate provisions under clause 24 (SOLID SLABS), where Ag is gross area of the section. The reinforced slab with or without drops, supported generally without beams, by columns with or without flared column heads is the flat slab. Hence diaphragm wall analysis can be done similar to as analysis of flat slab.

3. CONCLUSIONS

Literature review carried out by five stages: study of design parameters, effects on adjacent buildings, effects of earth and water pressure, seismic effects and study of Indian standards. Through the study of design parameter study we can understand the suitable parameters, optimum dimensions, grade of concrete, soil conditions and position of anchor rod which can be used for the design. Also these study deals with the effective bending moment, displacement and shear force. In the second part it is found that diaphragm wall have greater influence on the adjacent buildings. There is particular amount of settlement when the buildings are exposed near to diaphragm wall. Water pressure and earth pressure have great importance in diaphragm wall design. Stability of structure based on these factors, the third part is deal with these factors. Diaphragm walls are considered as deep ground structures, hence it should exposed to seismic effect. Final stage of literature review dealing with study of available standards. From the study of Indian standards, there are some uncertainties in the field of analysis. Seismic conditions are not mentioned anywhere in the diaphragm wall code IS 9556-1980 code provision [2]

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