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Effect of Stiffness on Performance of Diaphragm Wall

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Abstract

Diaphragm walls are generally constructed using stiff concrete of same stiffness throughout. Research has shown that as wall flexibility increases, the stress imposed by the soil redistribute and reduces structural forces on wall. Approximately five fold reduction in maximum bending moment occurred when wall stiffness was reduced from that of a 1m concrete section to that of a Frodinghamn1N sheet pile. Unfortunately this beneficial effect is accompanied by greater wall and soil movements (Potts & Day, 1991). So the diaphragm wall cannot be too flexible also. In this paper static analysis of two different diaphragm wall sections of varying stiffness is carried out using PLAXIS software for the load condition existing at deep draft berth of New Mangalore Port, and the performances of these sections are compared with previous study performed by Yajnheswaran et al. (2015). The diaphragm wall sections used in analysis are modeled as single panel. The length of the panel is taken as 5m. Anchors are provided at +2.5m. Soil layer details are obtained from boreholes at NMPT.

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Keywords : Diaphragm wall, Anchor rod, Berthing structure

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1. Introduction

Berthing structures are constructed in ports and harbors to provide facilities for berthing and mooring of vessels, loading and unloading of cargo and for embarking and disembarking of passengers and vehicles. In berthing structures, lateral forces are caused by impact of berthing ships, pull from mooring ropes, pressure of wind, current, wave and floating ice, seismic force, active earth pressure, differential water pressure, in addition to self-weight of the structure and live load.

Diaphragm walls and anchor rods are provided to support open berth structures in marine soils. The diaphragm walls are subjected to loads due to the soil layer on one side of the structure. In case of dredging, additional lateral loads are derived from landside earth pressure. If not properly designed, the structure may fail due to these loads. So a common practice in design of diaphragm wall is to design a thick section of uniform stiffness throughout. In this paper two diaphragm wall sections of non uniform stiffness are analyzed using finite element software PLAXIS 3D and the displacement, shear force and bending moment of the structure subjected to static loads are investigated and the results are compared.

2. Review of Literature

Comprehensive model tests by Tschebotarioff (1948) and Rowe (1952) lead to the first quantitative evaluation of the effect of the wall flexibility on bending moment. Theoretical studies by Baumann (1934), Hansen (1953), Terzaghi (1953), Rowe (1955) and Richart (1957) have demonstrated that the maximum bending moment in anchored sheet pile retaining wall is dependent on the stiffness of the wall. Rowe (1957) performed approximately 900 small scale model tests on anchored sheet pile wall. He conducted two types of tests denoted as pressure test and flexibility test. From the flexibility test, Rowe established a relationship between the degree of sheet pile and reduction in bending moment. Lasebnik (1961) performed large scale model test on anchored sheet pile wall and he concluded sheet pile flexibility has a large effect on bending moment. The total active pressure against a flexible wall is 25-30% smaller than that against a rigid wall. Potts and Day (1991) suggested significant savings can be made if flexible walls are used instead of stiffer diaphragms.

3. Details of Berthing Structure

The cross section of existing deep draft berth is shown in Fig 1. The components of the berth includes diaphragm wall, deck slab, longitudinal and cross beams, pile cap, pile and anchor rod. The diaphragm wall is located at 33 m from left most pile and it is of 1100 mm thickness. The tie rod anchor is inclined at an angle of 45° and it is pre-stressed to a load of 225 Tones. The anchor rods are provided at every 2.5 m interval. The width and depth of the beams are 1200×1200mm. The maximum span of the longitudinal beam is 10m and the minimum is 3m. The slab is simply supported having dimensions of 10m×5m and the thickness of the slab is 600mm. The width of the berthing structure is 33 m. The berth is supported by a diaphragm wall and 4 rows of 1200mm diameter piles. The piles are terminated at a depth of -30 m. The pile spacing is 10m center to center. The dredge depth is -10m near the diaphragm wall and -17 m near the first pile as shown in fig 1. Hard rock is found at a depth of -30 m. The chart datum is at 0 m.

Table 1 Input parameters of structural elements

Materials	Models	Modulus of elasticity	Poisons ratio
Pile	Elastic	4.025E7	0.15
Beam	Elastic	1.233E7	0.15
Anchor rod	Elastic	1.351E8	
Diaphragm wall	Elastic	5.9E8	0.15