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Parametric Study of Diaphragm Wall

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Abstract

Diaphragm wall is very common type of earth retention scheme in deep excavation/foundation, weak/poor soil condition or congested site condition. Diaphragm walls are generally used in deep basement of building, congested urban spaces, underground structures of metro trains, riverfront structures and marine structures. In absence of standard procedure for analysis and design a tool is made with help of Visual Basic.Net, which will take care of soil variation & give quick optimized results, is considered here. Parametric study of diaphragm wall is conducted with different width of wall, grade of concrete, soil property below dredge line and diaphragm wall with secondary wall.
Keywords: Diaphragm Wall, Visual Basic.Net, Retaining Structure, Deep Foundation, Parametric Study

I. INTRODUCTION

Diaphragm walls are classified as flexible retaining structures. The stability is provided through an embedment of the wall on the ground working as a cantilever structure (see Figure 1) and eventually a system of anchors, so the wall is subject to shear stresses and bending moments. One of the main benefits is the minimization of used material, in contrast to the needs of rigid retaining structures.

Thus, there are four main functions that can be carried out by a Diaphragm wall (Jiménez Salas, 1980):

- Resist the thrust generated by the excavation.
- Limit the movements in the back of the wall, in the unexcavated zone.
- Prevent from the water inlet.
- Support vertical loads.

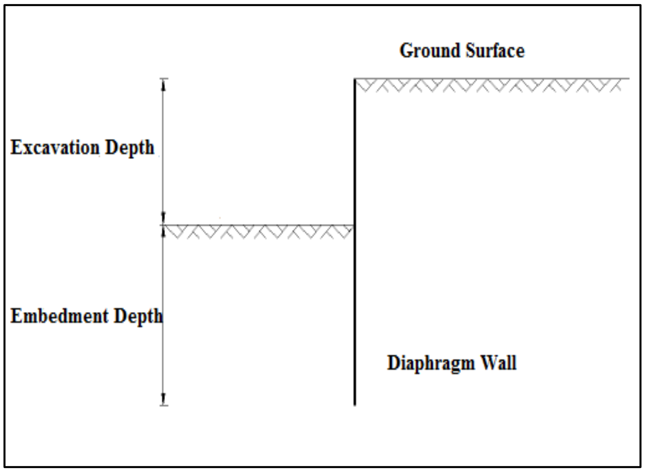

Fig. 1: Cantilever Diaphragm Wall

II. GLOBAL MECHANICAL BEAHAVIOUR

The main feature of an embedded retaining structure is the contribution on stability of the embedded zone. Hence, the main unknown parameter to define is the embedment depth, which depends on the magnitude and distribution of the earth pressures over the wall.

A. Free Earth Support Method:

This method is based on the assumption that movements on the embedded zone of the wall are sufficient to mobilize the active and passive thrust behind and in front of the wall respectively. The passive pressure is assumed to act only in front of the wall through the depth *d* (Figure). The bottom of the wall has therefore free movement, and a minimum reference embedment depth, to satisfy equilibrium, is obtained.

The equilibrium is fulfilled between the passive and active pressures, and the anchor force, for obtaining the embedment depth. The way to proceed is to take moments with respect to the point of application of the anchor (the anchor head) and then equating this expression to zero. This equation provides the minimum embedment depth *d* to provide equilibrium.

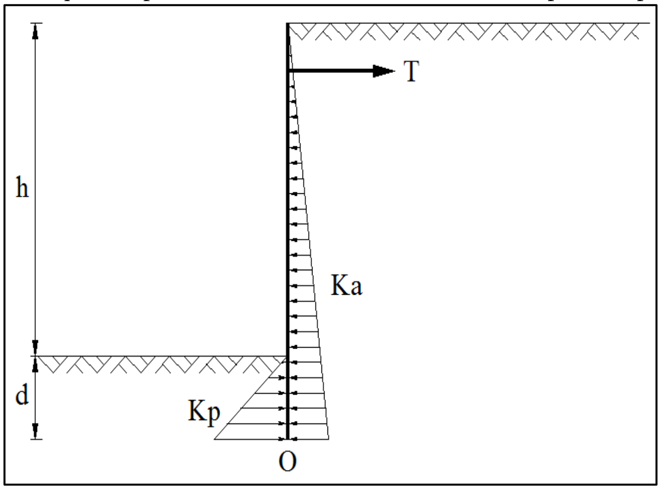

Fig. 2: Free Earth Support Method

III. Important Features of Design Tool

The salient features of the program are following.

1) The tool attempts to create optimum design of Diaphragm Wall which is subjected to
   - Lateral Earth Pressure,
   - Surcharge Load (Dead Load and Live Load including),
   - Different water table on both side of wall and
   - Seismic force which results in dynamic change in earth pressure for retaining structure
1) The program is suitable for
   - 8 conditions of 3 layers of soil

Table – 1
8 Conditions of 3 Layers of Soil

	Case1	*Case2*	*Case3*	*Case4*	*Case5*	*Case6*	*Case7*	*Case8*
Layer1	*φ*	*c- φ*	*φ*	*c- φ*	*c- φ*	*φ*	*c- φ*	*φ*
Layer2	*φ*	*φ*	*c- φ*	*c- φ*	*c- φ*	*c- φ*	*φ*	*φ*
Layer3	*φ*	*φ*	*φ*	*φ*	*c- φ*	*c- φ*	*c- φ*	*c- φ*

   - Surcharge condition (which includes dead load or live load up to distance of 45◦ from dredge line),
   - 6 water table conditions which includes 3 differential water table and 3 same water table on both side and
   - Seismic conditions of 4 different seismic zones.
2) The program considers the thickness of diaphragm wall as 600, 800, 1000 and 1200 mm for 4 grades of concrete viz M25, M30 and M-35, M-40respectively. So design and material cost is calculated for 16 different cases as below.

Table – 2

Width of wall		*(mm)*	*600*	*600*	*600*	*600*	*800*	*800*	*800*	*800*
fck		*N/mm²*	*25*	*30*	*35*	*40*	*25*	*30*	*35*	*40*
Width of wall		*(mm)*	*1000*	*1000*	*1000*	*1000*	*1200*	*1200*	*1200*	*1200*
fck		*N/mm²*	*25*	*30*	*35*	*40*	*25*	*30*	*35*	*40*

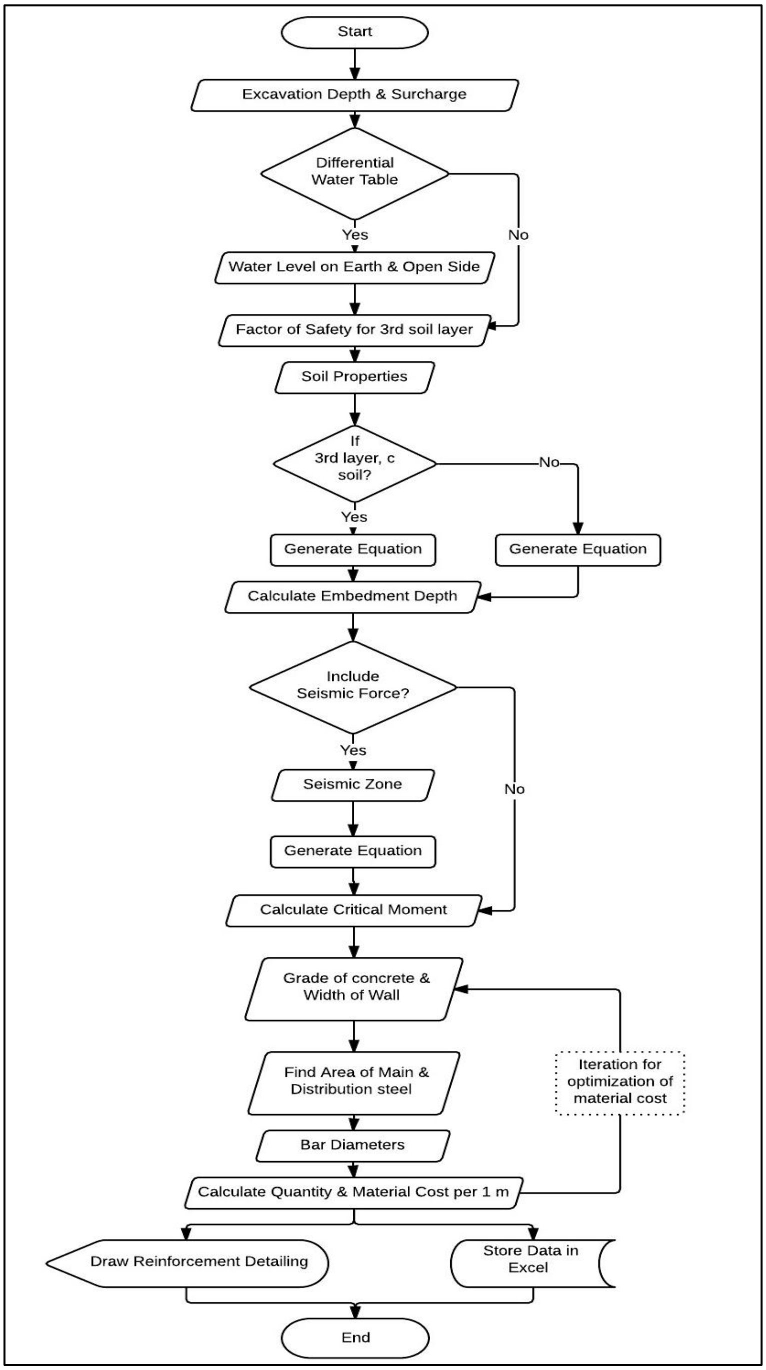

Fig. 3: Flaw Chart of Design Process

3) The program displays the reinforcement detailing of diaphragm wall based on bar diameter
4) Storage of data trails in excel sheets, helps in design optimization process and thus result comparison can be checked for 16 combinations of Concrete Grade and thickness of wall.

IV. RESULTS

A. Case1:

Here, a problem of phi soil below dredge line is taken & 16 combinations of results are compared.

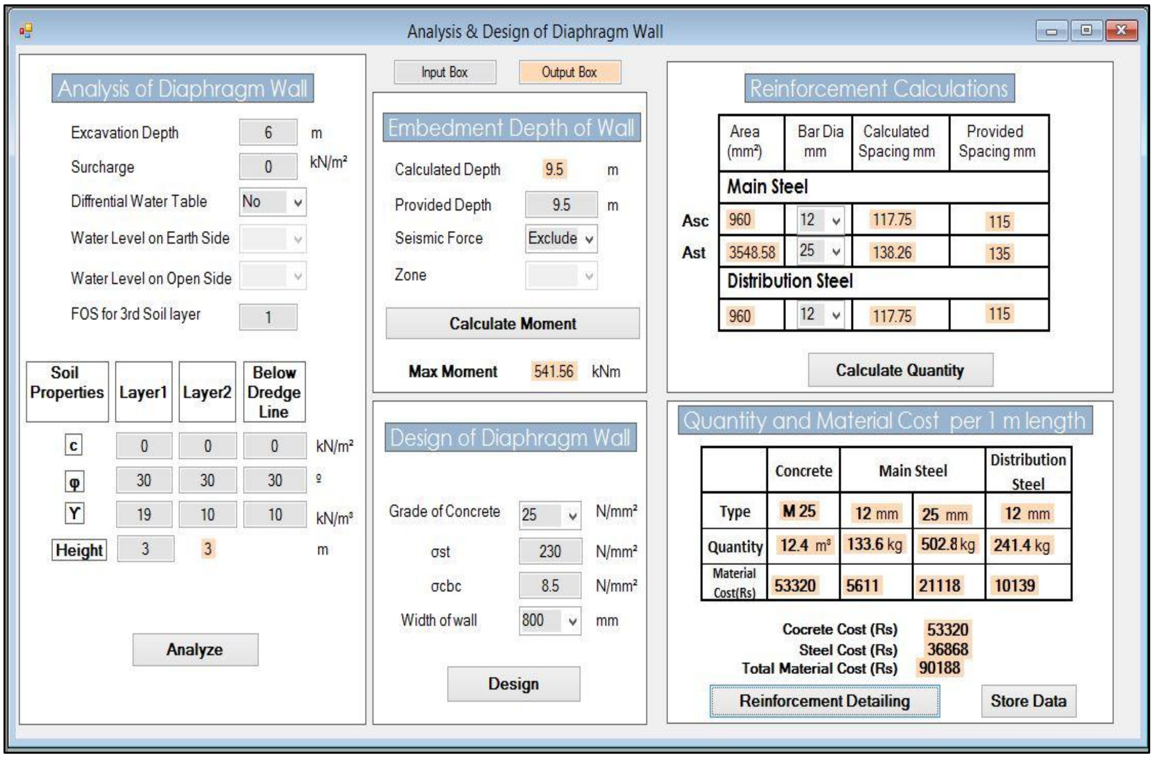

Fig. 4: Program1

Table – 3
Quantity and Material Cost for Program1

Width of wall	*fck*	*Concrete*	*Steel*	*Concrete Cost*	*Steel Cost*	*Material Cost*
(mm)	*(N/mm^2)*	*m^3*	*(kg)*	*(Rs.)*	*(Rs.)*	*(Rs.)*
600	*25*	*9.3*	*1276.1*	*39990*	*53596*	*93586*
600	*30*	*9.3*	*1192.1*	*43989*	*50068*	*94057*
600	*35*	*9.3*	*1089.3*	*51448*	*45751*	*97199*
600	*40*	*9.3*	*995.5*	*58897*	*41811*	*100708*
800	*25*	*12.4*	*877.8*	*53320*	*36868*	*90188*
800	*30*	*12.4*	*877.8*	*58652*	*36868*	*95520*
800	*35*	*12.4*	*877.8*	*68597*	*36868*	*105465*
800	*40*	*12.4*	*877.8*	*78529*	*36868*	*115397*
1000	*25*	*15.5*	*859.2*	*66650*	*36086*	*102736*
1000	*30*	*15.5*	*859.2*	*73315*	*36086*	*109401*
1000	*35*	*15.5*	*859.2*	*85746*	*36086*	*121832*
1000	*40*	*15.5*	*859.2*	*98162*	*36086*	*134248*
1200	*25*	*18.6*	*893.7*	*79980*	*37536*	*117516*
1200	*30*	*18.6*	*893.7*	*87978*	*37536*	*125514*
1200	*35*	*18.6*	*893.7*	*102895*	*37536*	*140431*
1200	*40*	*18.6*	*893.7*	*117794*	*37536*	*155330*

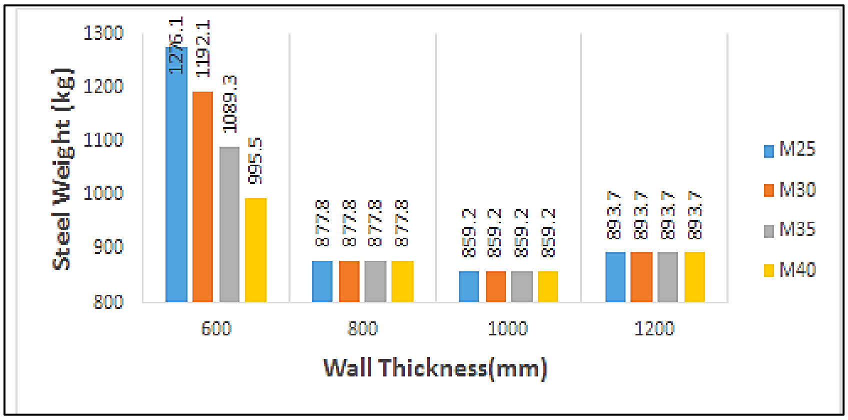

Fig. 5: Graph for Program1: Wall thickness vs. Steel Weight

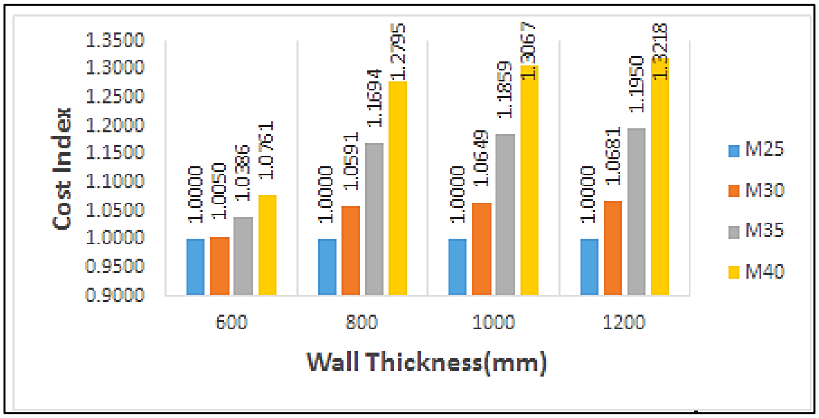

Fig. 6: Graph For Program1: Wall Thickness vs. Cost Index

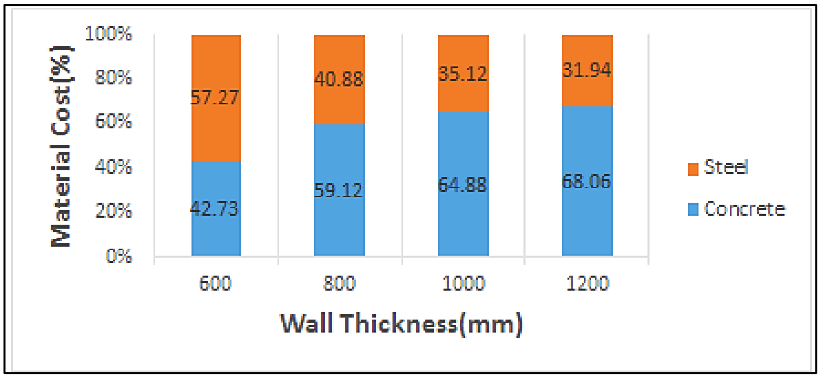

Fig. 7: Graph For Program1: Wall Thickness Vs Contribution of Material Cost (%)

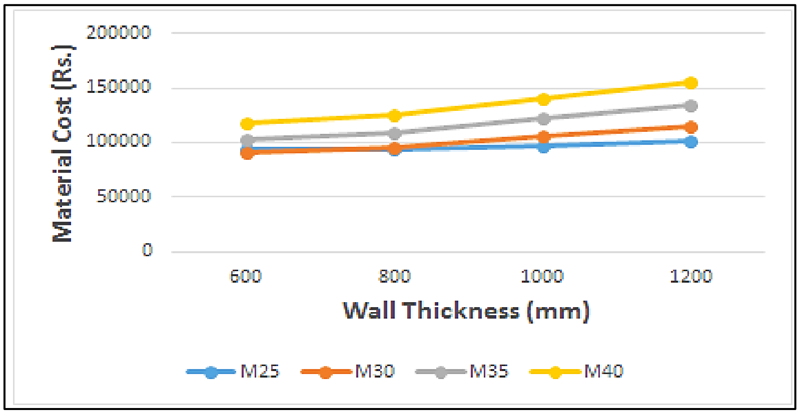

Fig. 8: Graph for Program1: Wall Thickness vs. Material Cost

B. Case2:

Here, a problem of c soil below dredge line is taken & 16 combinations of results are compared

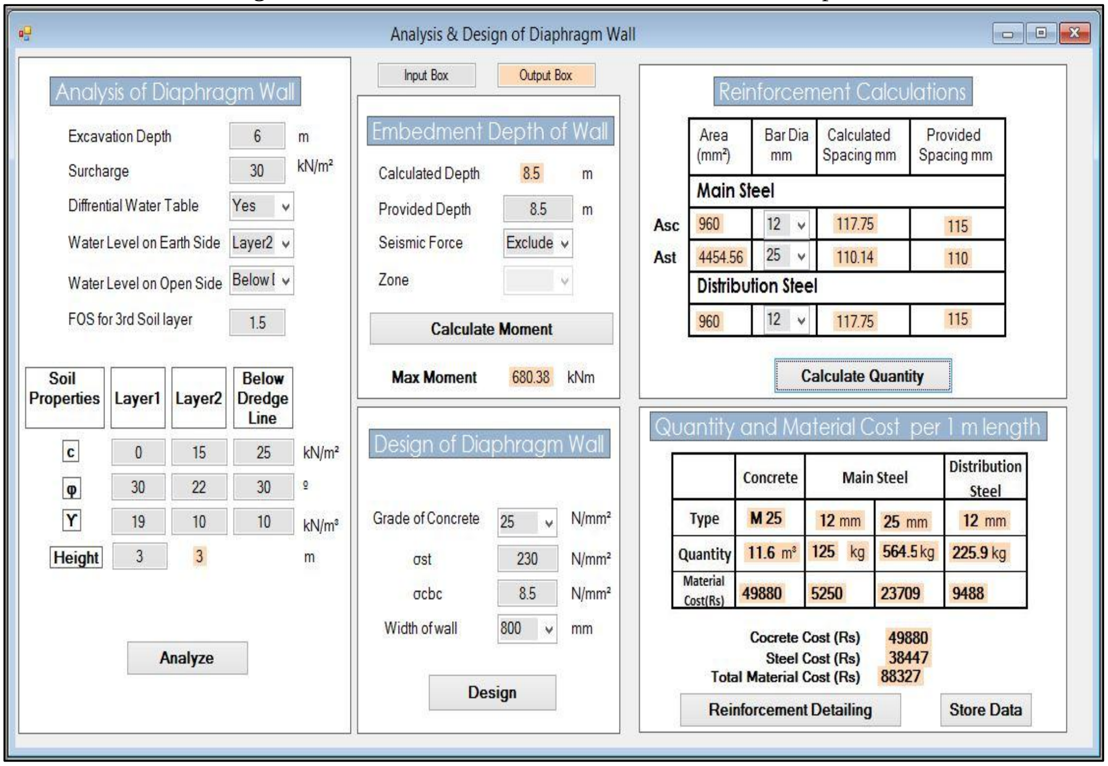

Fig. 9: Program2

Table - 2
Quantity and Material Cost for Program2

Width of wall	*fck*	*Concrete*	*Steel*	*Concrete Cost*	*Steel Cost*	*Material Cost*
(mm)	*N/mm^2*	*m^3*	*(kg)*	*(Rs.)*	*(Rs.)*	*(Rs.)*
600	*25*	*8.7*	*1581.7*	*37410*	*66431*	*103841*
600	*30*	*8.7*	*1496.5*	*41151*	*62853*	*104004*
600	*35*	*8.7*	*1421.9*	*48128*	*59720*	*107848*
600	*40*	*8.7*	*1335.8*	*55097*	*56104*	*111201*
800	*25*	*11.6*	*951.7*	*49880*	*39972*	*89852*
800	*30*	*11.6*	*951.7*	*54868*	*39972*	*94840*
800	*35*	*11.6*	*951.7*	*64171*	*39972*	*104143*
800	*40*	*11.6*	*915.4*	*73463*	*38447*	*111910*
1000	*25*	*14.5*	*898.2*	*62350*	*37725*	*100075*
1000	*30*	*14.5*	*898.2*	*68585*	*37725*	*106310*
1000	*35*	*14.5*	*898.2*	*80214*	*37725*	*117939*
1000	*40*	*14.5*	*898.2*	*91828*	*37725*	*129553*
1200	*25*	*17.4*	*920.2*	*74820*	*38648*	*113468*
1200	*30*	*17.4*	*920.2*	*82302*	*38648*	*120950*
1200	*35*	*17.4*	*920.2*	*96257*	*38648*	*134905*
1200	*40*	*17.4*	*920.2*	*110194*	*38648*	*148842*

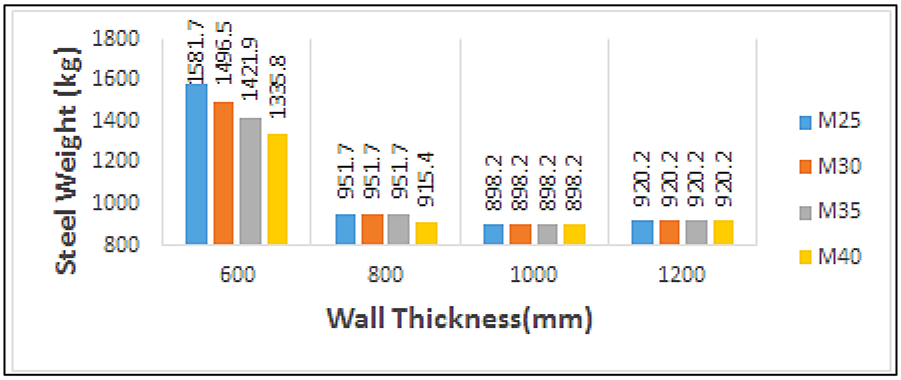

Fig. 10: Graph For Program2: Wall Thickness vs. Steel Weight

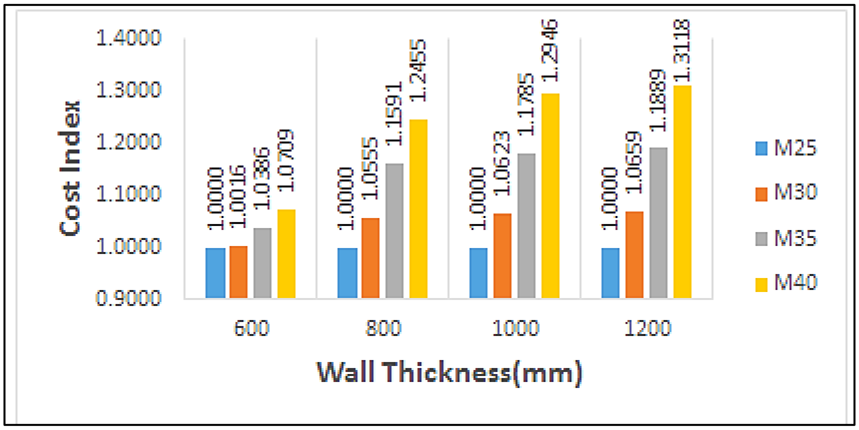

Fig. 11: Graph For Program1: Wall Thickness vs. Cost Index

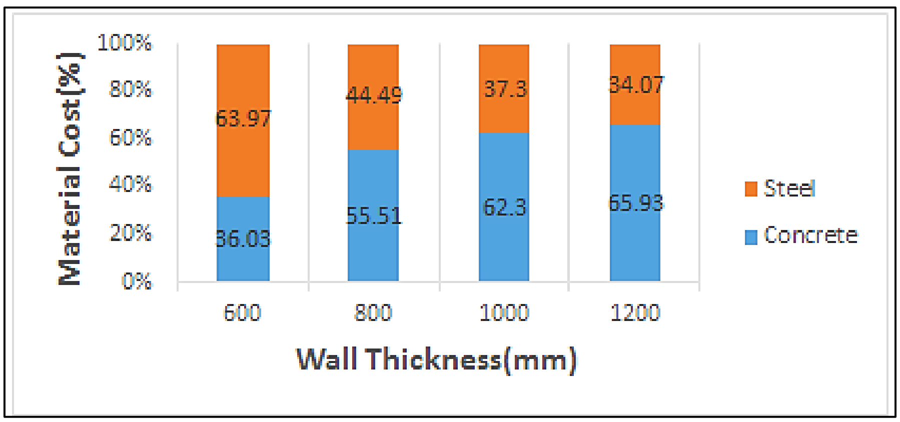

Fig. 12: Graph For Program1: Wall Thickness Vs Contribution of Material Cost (%)

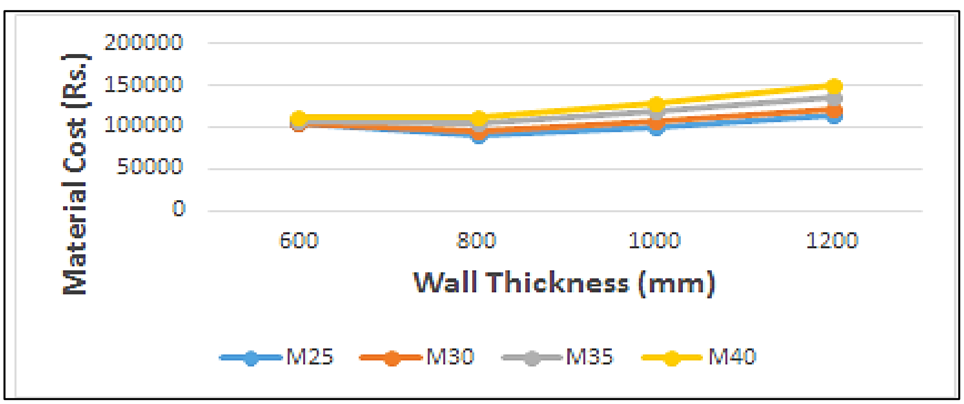

Fig. 13: Graph for Program1: Wall thickness vs. Material Cost

C. Case 3:

Here, change in soil property below dredge line is considered & change in embedment depth of wall is observed.

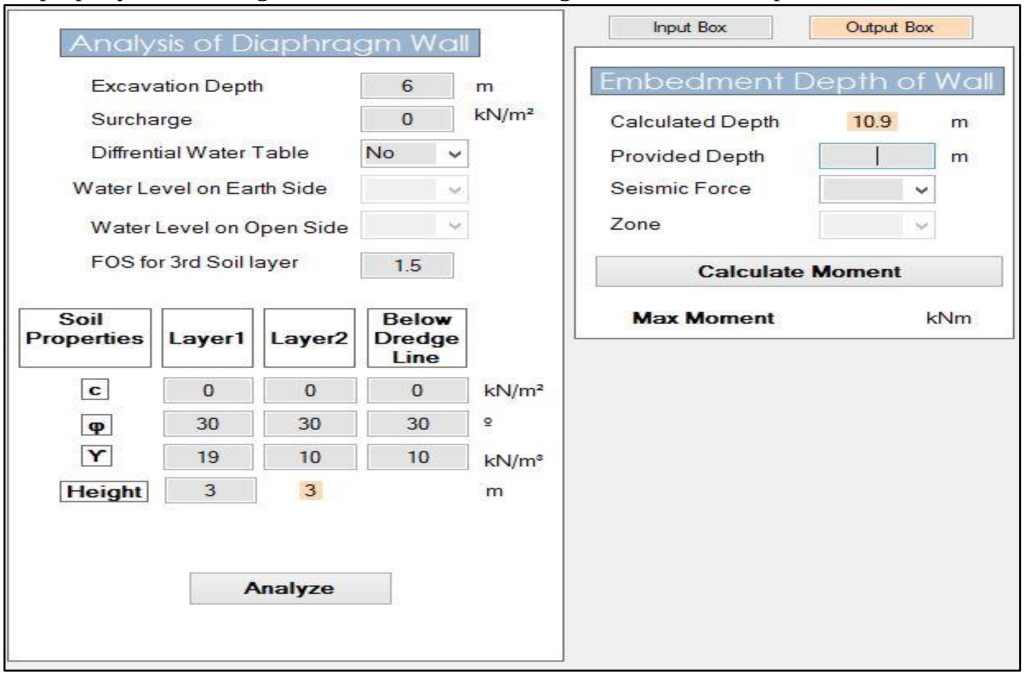

Fig. 14: Phi Soil Problem

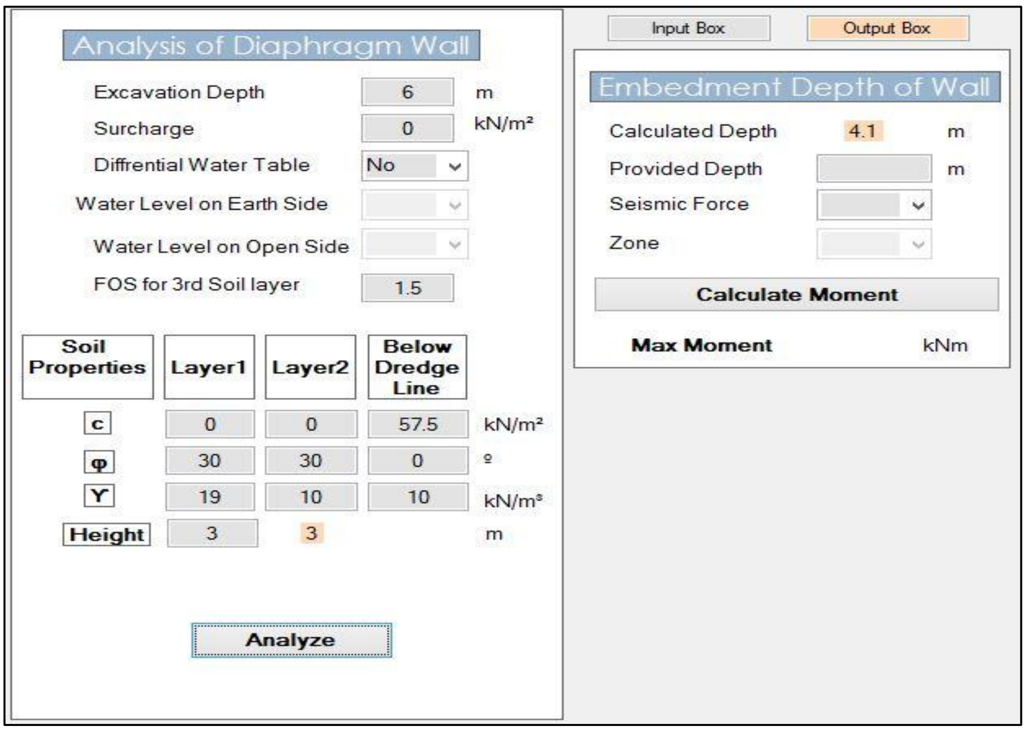

Fig. 15: C Soil Problem

D. Case 4:

Here, simple diaphragm wall and diaphragm wall with secondary wall is taken &change in embedment depth of wall is observed.

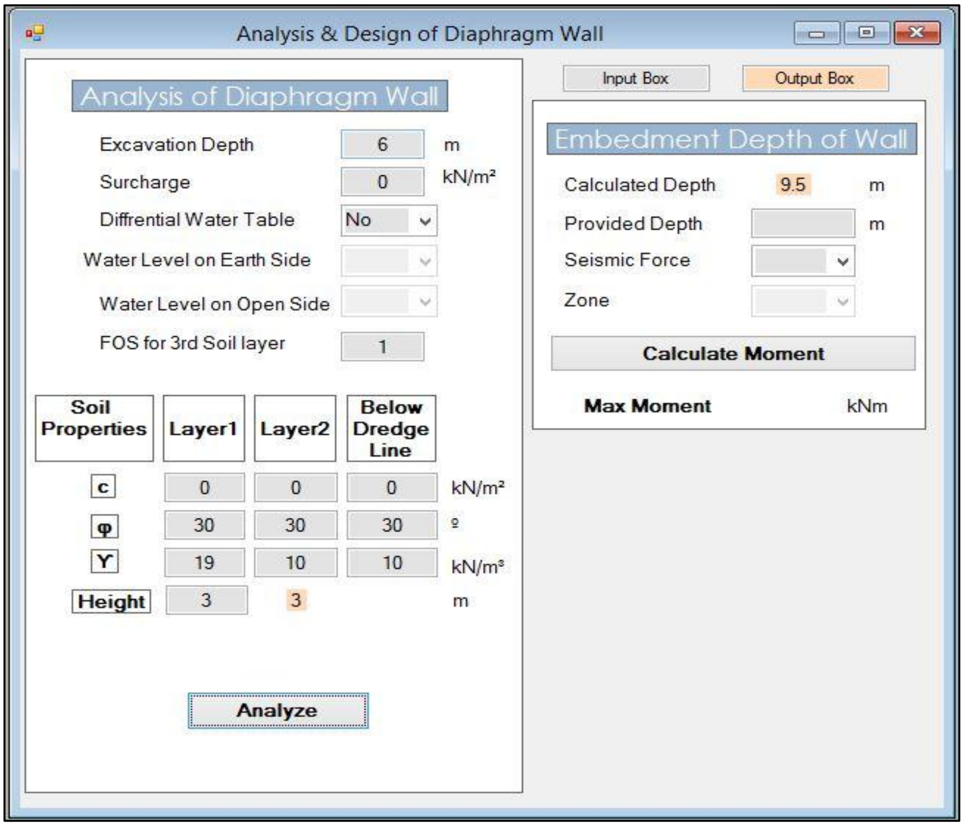

Fig. 16: Diaphragm Wall Problem

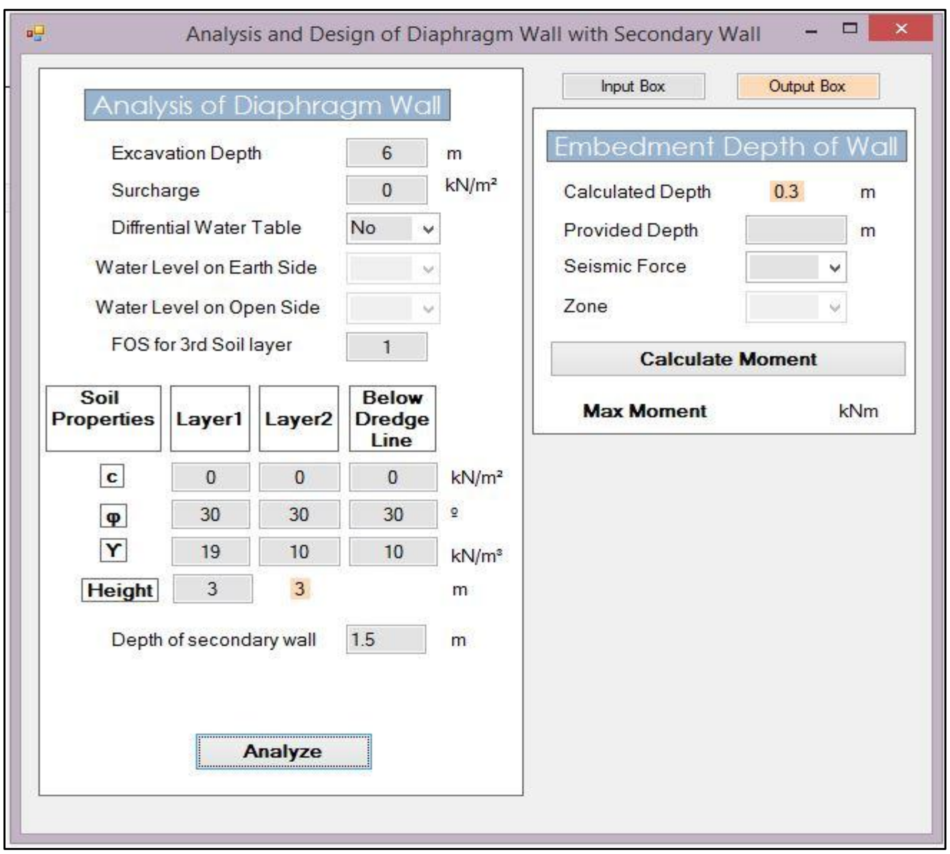

Fig. 17: Diaphragm Wall with Secondary Wall Problem

V. CONCLUSION

- Optimization process in design of diaphragm wall becomes simple and time saving in "DiaphragmWallv1.0". Because in STAAD.Pro or any FEM software, modeling of diaphragm wall will need lots of time and in this program by simply putting data, we can get result on the spot.
- Sometimes placing of heavier steel cages through crane becomes problem on site, so in that case by increasing concrete grade from M25 to M40 weight of steel can be reduced up to 30%.
- Thickness of wall has more influence on ultimate material costing than grade of concrete.
- Cohesive Soil strata below dredge line gives favorable results, it decreases embedment depth of Diaphragm wall.
- In case of diaphragm wall at riverfront or docks, where sufficient space is available, it is preferred that diaphragm wall is built with secondary wall. Because, embedment depth of main diaphragm wall is sufficiently reduced due to secondary wall.

REFERENCES

[1] "Geotechnical Performance Of Embedded Cast-in-situ Diaphragm Walls For Deep Excavations" by A. Rahman, M. Taha, Slovak Journal, Egypt on18 April, 2005
[2] "Effects from diaphragm wall installation to surrounding soil and adjacent buildings",byEmilios Comodromos, Mello Papadopoulou, Georgios Konstantinidis, SciVerse Science Direct on14 June 2013
[3] "Effect of Deep Excavation on Adjacent Buildings By Diaphragm Wall Technique Using PLAXIS" by Dinakar K N and S K Prasad, IOSR-JMCE, in 2014
[4] "Deep Support Systems Using Diaphragm Walls And Contiguous Piles" by Manish Kumar, Indian Geological Society Mumbai Chapter
[5] "A Study of Different Aspects of Diaphragm Wall",by O. M. El Hussieny, Tunnelling and Undergruond Space Technology, Elsevier on Janury 1992
[6] "Seismic Analysis Of Retaining Walls Within Plasticity Framework", by by T. Kalasin and D. Muir Wood, 14^{th} World Conference on Earthquake Engineering on 12-17 October, 2008
[7] Deep Excavations: A Practical Manual by Malcolm Puller, Thomas Telford Publication
[8] Structural and Cut-off Diaphragm Wall by R.G.H. Boyes, Applied Science Publishers Ltd 1975
[9] Foundation Analysis and Design by Joseph E Bowles, McGraw-Hill Book Company Fourth Edition
[10] Basics and Applied Soil Mechanics by Gopal Ranjan and ASR Rao, New Age International Publishers Revised Second Edition
[11] Soil Mechanics and Foundations by B C Punamia, Ashok Kumar Jain, Arun Kumar Jain, Laxmi Publications 16^{th} Edition
[12] IS : 9556-1980, Code Of Practice For Design And Construction Of Diaphragm Walls
[13] IS : 14366-1996, Design and Construction of Diaphragm for under Seepage Control – Code of Practice
[14] IS: 1893-1984, Criteria for Earthquake Resistant Design of Structure.