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Parametric Studies for Concrete Sheet Pile Wall Using GE05FINE

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***Abstract:** Based on the site conditions and lateral earth pressure of soil plays important role in the selection of sheet pile wall. In the present day different types of sheet pile wall present in the market like as steel sheet pile wall , concrete sheet pile wall and timber etc. Concrete sheet pile walls are common in use. Modification in the properties of the concrete sheet piles is easier making it more economical as the utility of the section can be considerably increased according to projects requirement. Sheet pile wall deformation is dependent on the materials properties. Consequently, it is essential to research how different material types and properties affect the deformation and stress distribution of cantilever concrete sheet pile walls. A parametric analysis was carried out numerically using a case study that makes use of a base model to determine how long a sheet pile wall should be at the bottom of an embankment with various material types for ditch with a depth of 3m, 5m and 7m.to safeguard and improve the stability of the embankment , a sheet pile wall was temporarily constructed near the toe of the embankment. Analysing simulation data was completed with the aid of GE05FINE. The analysis findings revealed that when subjected to the same loading situation, bending moment and shear force varies with the material properties. Therefore, it is wise to carefully select the sheet pile wall materials in accordance with the projects requirements.*
***Keywords:** Concrete sheet , Rigid materials , Ductile materials , sheet pile wall , GE05FINE , Bending moment ,Shear force.*

I. INTRODUCTION

Sheet pile walls, a type of retaining walls, are built to hold back - soil, water or other fill materials. As compared to masonry walls they are narrower in section. The following are typical applications for sheet piles walls:

1) Buildings on the water edge, such as wharves, quays, and piers,
2) Constructing cofferdams or other diversion dams,
3) River bank defense,
4) Maintaining the edges of earthen cuttings.

Steel and reinforced concrete can be used for sheet pile walls. The popularity of steel sheet pile structure in cities is due to their advantage over reinforced concrete pile wall. In the present time steel sheet pile wall available in different shape according to strength with easy in driving into the soil.

Steel sheet pile wall gives approximate same value in compressive and tension loading condition. Steel sheet pile wall durable as compare to reinforced concrete wall.

In this study examine the effect of material types on the bending moment and shear force distribution with depth of cantilever sheet pile wall. To clear the selection of pile in design process for economical and sustainable in nature. In this research study involves conditions of soil at sites , total stress and soil behavior for selection of material types of sheet piles can be proposed and accepted.

The sheet pile walls are preferred over retaining wall due to following reasons.

a) Available a wide range of lengths, size and steel options.
b) Can be used for temporary and permanent structures.
c) Can be installed using silent and vibration-free methods.
d) Quicker installation than masonary wall.
e) Cofferdams can be constructed in almost any desired shape
f) Provide a close-fittings joint to form an effective water seal.
g) Light in weight , making lifting and handling easy
h) A little maintenance is needed.

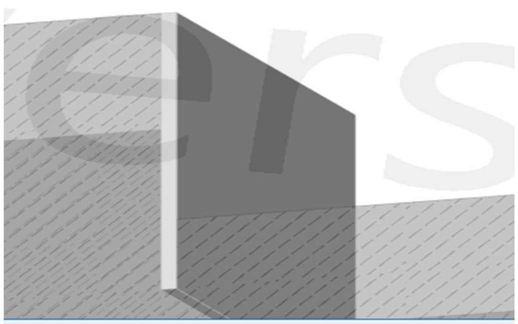
The objective of this work is to study the effect of different parametrs of a concrete sheet pile wall on its behaviour. The analysis is being carried out using software GE05FINE. The study is being carried out to see:-

- Effect of soil layers on behaviuor of concrete shet piles.
- Effect of properties and earth pressure on the sheet pile wall with varing depth of ditch.
- Effect of grade of concrete & steel on behavior of concrete sheet pile wall.
- To understand the behavior of steel sheet pile wall and reinforced sheet pile wall.

II. SHEET PILE WALL

Here we defined used member of reinforced concrete wall component.

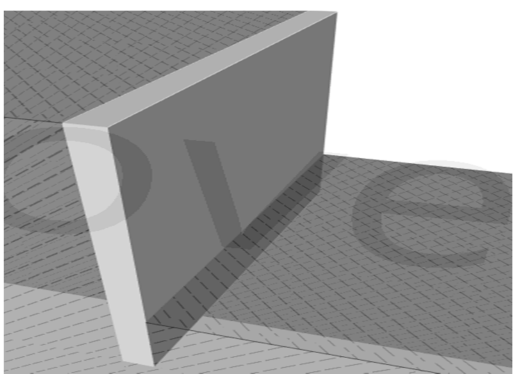
1) Reinforced concrete pile wall



C/S DIMENSION

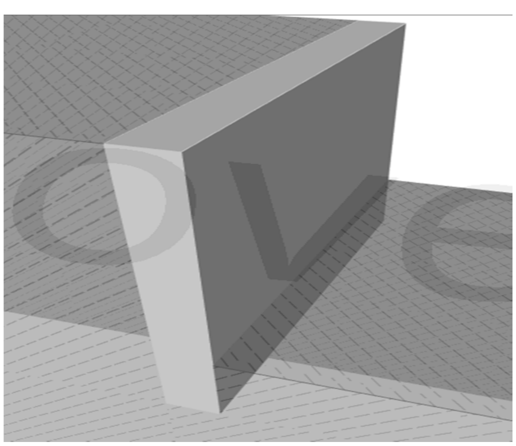
A-1.50E-01m^2/m
I – 2.85E-03m^4/m
Width-0.15m

Figure-2.1- RCC rectangular sheet pile wall



C/S DIMENSION
A – 3.00E-01m^2/m
I – 2.25E-03m^4/m
Width – 0.30m

Figure -2.2- RCC rectangular sheet pile wall



C/S DIMENSION

A – 5.00E-01m^2/m
I – 1.04E-02m^4/m
Width-0.50m

Figure -2.3- RCC rectangular sheet pile wall

III. MODELLING AND ANALYSIS

The concrete sheet pile walls are being modeled, analysed using software GE05FINE. The code for steel and concrete member is consider in design procedure. The calculation of bending moment and shear force on different model is mentioned here.

1) Model 1: RCC rectangular wall for 3m depth of ditch in 1 layer soil
2) Model 2: RCC rectangular wall for 5m depth of ditch in 1 layer soil
3) Model 3: RCC rectangular wall for 7m depth of ditch in 1 layer soil
4) Model 4: RCC rectangular wall for 3m depth of ditch in 2 layer soil
5) Model 5: RCC rectangular wall for 5m depth of ditch in 2 layer soil
6) Model 6: RCC rectangular wall for 7m depth of ditch in 2 layer soil

A. *Optimization*

The process of finding the best economic structural outcomes with maximum benefit at minimum material or cost is called optimization. Due to recent advances in structural design, it is very easy to obtain a safe design, but difficult to find an economical design, so optimization techniques are needed to obtain most economically efficient design. This is beneficial in many ways such as saving materials, reducing concrete usage. Therefore, optimization has gained momentum in structural engineering. In this work, optimized reinforced concrete rectangular sheet pile wall are considered as bench mark for studying the effect of different parameters on behavior of sheet pile walls.

B. *Step of Section Optimization*

1) First define depth of required ditch both for concrete rectangular sheet pile wall
2) Start assigning width of RCC rectangular wall as per needed.
3) After analyses check for design if design check meets the demand capacity ratio, then section is safe for structure.
4) If not then increase the section and repeat the process till design check satisfy the demand capacity ratio
5) After satisfy the demand capacity ratio for section, then shear and bending moment values are obtained.
6) According to shear force and bending moment variation in RCC sheet pile, the section come out by this iterative process is now optimized section for structure.

C. *Material properties*

In analyzing RCC concrete sheet pile walls, three models have been considered with soil to be retained is of only one type. The models have been named as models with 1- layer of soil. Similarly three models have been considered with two layers of soil to be retained and the models have been named as models with 2- layer of soil. The properties of the soil considered in the modeling are given in the following table

Table 3.1: Soil properties used in GE05FINE software

Soil type	Silt	Clay
Unit weight	21 KN/m^3	18 KN/m^3
Stress state	Effective	Effective
Angle of internal friction	30^0	27^0
Cohesion of soil	75 kPa	100kPa
Angle of friction-struc.	20^0	18^0

The grade of concrete and steel being considered in the for modeling RCC concrete sheet pile walls are M20, M25 and Fe500 respectively.

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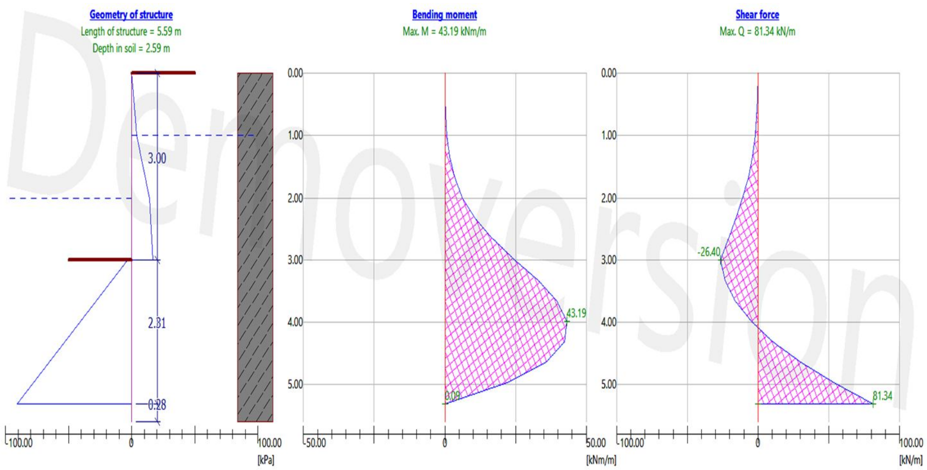
D. Optimized RCC Concrete sheet pile wall section and Moment and pressure distribution

For the six models of concrete sheet pile wall the optimize sections obtained are given in the table Table 3.2.

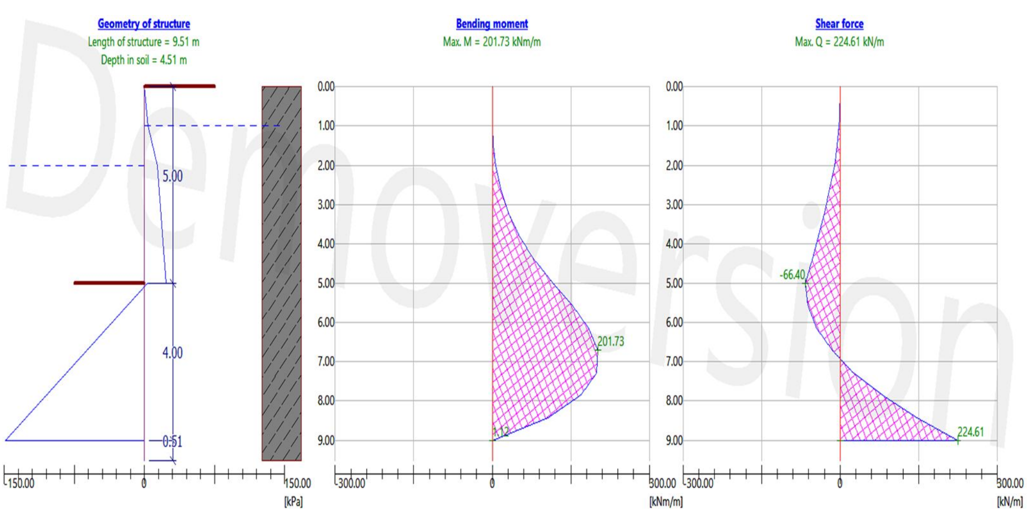
Table 3.2: Optimsed width for RCC Sheet pile walls.

MEMBER	WIDTH	GRADE OF STEEL	GRADE OF CONCRETE	DEPTH	SOIL LAYER
RCC RECT.	0.15M	B500	M20	3M	1 LAYER
RCC RECT.	0.30M	B500	M20	5M	1 LAYER
RCC RECT.	0.50M	B550	M25	7M	1 LAYER
RCC RECT.	0.15M	B500	M20	3M	2 LAYER
RCC RECT.	0.30M	B500	M20	5M	2 LAYER
RCC RECT.	0.50M	B550	M25	7M	2 LAYER



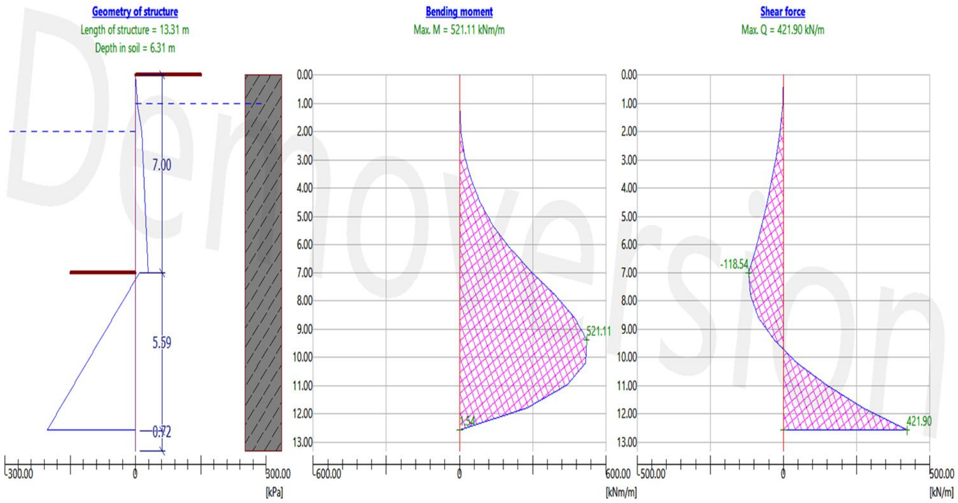
Length of structure-5.31m
Depth in soil-2.31m
Max. moment – kNm/m
Max. shear force- N/m
Section – RCC width 0.15m

Fig. 3.1 Model 1: RCC rectangular wall for 3m depth of ditch in 1 layer soil



Length of structure-9.51m
Depth in soil- 4.51m
Max. Moment- 201.73kNm/m
Max. Shear force-224.61kN/m
Section – RCC width 0.30m

Fig. 3.2 Model 2: RCC rectangular wall for 5m depth of ditch in 1 layer soil



Length of structure-13.31m\
Depth in soil- 6.31m
Max. Moment -521.11kNm/m
Max. Shear force- 421.90kN/m
Section –RCC width 0.50m

Fig. 3.3 Model 3: RCC rectangular wall for 7m depth of ditch in 1 layer soil

IV. RESULT

The Analysis is conducted on three different section using GE05FINE software , several values of model were found out from RCC rectangular wall. The all recommended code is used for the analysis for the all model. After analysing, optimized section is selected for design.

Therefore, total 6 model are used for analysing the response of soil behavior , effective stress and active earth pressure of soil. The impact of grade of steel, grade of concrete, thickness of RCC member, layer of soil and anchor are mentioned here.

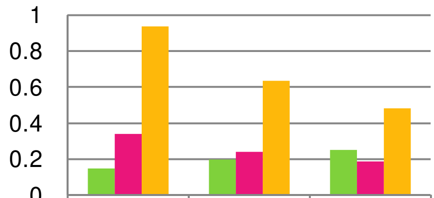
Utility results of member are in form of shear force and bending moment

Table 4.1 shows the sheer force and bending moment utilization of the optimum sections for three different depth of ditches and for two types of backfill considered. From the table it is very clear that embedded length does not depends on the no of layers of the different soils to be retained. With every 2 m increase in depth of ditch; embedded length increases by almost same amount. Shear force utlisation for all the depths of sheet pile walls considered is almost same at optimum section. Bending moment marginally varies with no of layers of soil for optimised section.

Table 4.1: Optimsed width for RCC Sheet pile walls.

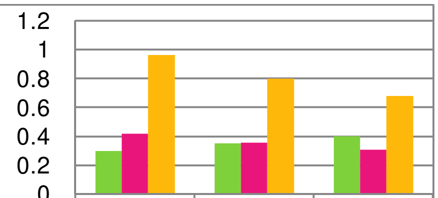
Total Length	Depth of Ditch	Embedded Length	Shear Force Utilsation		Bending Moment Utilisation	
			1 - Layer	2- Layer	1 - Layer	2- Layer
5.31 m	3.0 m	2.31 m	33.90 kN	33.90 kN	80.50 kN-m	80.50 kN-m
9.31 m	5.0 m	4.31 m	42.42 kN	42.90 kN	96.50 kN-m	86.40 kN-m
13.31 m	7.0 m	6.31 m	45.90 kN	45.90 kN	95.50 kN-m	99.10 kN-m

The effect of variation of width of the pile for the three depths' has been studied. Figure 4.1 to 4.3 shows the variation of shear force utilisation and variation of bending moment utilsation of sheet pills for different ditch depths'. For smaller ditch depths, variation with width signifcantly affect the shear force and bending moment utilisation.



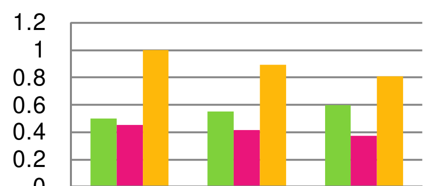
	1	2	3
WIDTH	0.15	0.2	0.25
SHEAR FORCE	33.90%	24.00%	18.60%
BENDING MOMENT	93.60%	63.50%	48.10%

Fig. 4.1 : Effect of width for 3.0m RCC Sheet Pile Wall (M20 & FE500)



	1	2	3
WIDTH	0.3	0.35	0.4
SHEAR FORCE	42%	35.50%	30.70%
BENDING MOMENT	96.50%	79.80%	68%

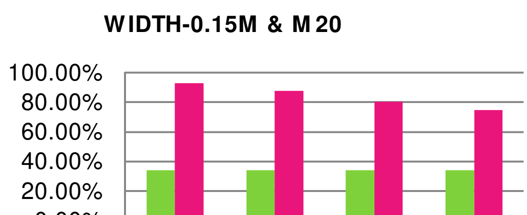
Fig. 4.2 : Effect of width for 5.0m RCC Sheet Pile Wall (M20 & FE500)



	1	2	3
WIDTH	0.5	0.55	0.6
SHEAR FORCE	45.40%	41.40%	37.50%
BENDING MOMENT	99.90%	89.40%	80.90%

Fig. 4.3 : Effect of width for 7.0m RCC Sheet Pile Wall (M20 & FE500)

Effect of variation of Gr. Of steel on shear force utilisation and bending moment utilisation with respect to optimum RCC Concrete Sheet Pile Wall section has been studied. It has been observed that shear force utilizations capacity is independent of grade of steel. However bending moment utilisation with same percentage of reinforcement, reduces with increase in grade of steel.



	FE420	FE450	FE500	FE550
SHEAR FORCE	33.90%	33.90%	33.90%	33.90%
BENDING MOMENT	92.90%	87.70%	80.50%	74.60%

Fig. 4.4 : Effect of Gr of Steel for 3.0m RCC Sheet Pile Wall (M20 & FE500)

	FE420	FE450	FE500	FE550
SHEAR FORCE	42%	42%	42%	42%
BENDING MOMENT	95.80%	90.30%	82.70%	76.40%

Fig. 4.5 : Effect of Gr of Steel for 5.0m RCC Sheet Pile Wall (M20 & FE500)

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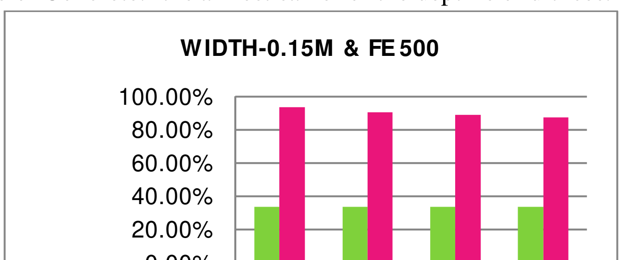
	FE420	FE450	FE500	FE550
SHEAR FORCE	45.40%	45.40%	45.40%	45.40%
BENDING MOMENT	98.20%	92.40%	84.20%	77.60%

Fig. 4.6 : Effect of Gr of Steel for 7.0m RCC Sheet Pile Wall (M20 & FE500)

Effect of variation of Gr. Of Concrete on shear force utilisation and bending moment utilisation with respect to optimum RCC Concrete Sheet Pile Wall section has been studied. It has been observed that shear force utilizations capacity is independent of grade of Concrete like that of steel. However bending moment utilisation with same percentage of reinforcement, reduces with increase in grade of Concrete. It is almost same for the depth's of dithces.

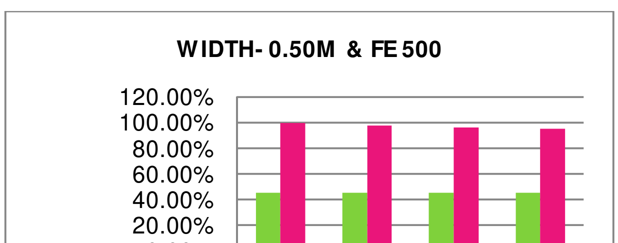


	M 20	M 25	M 30	M 35
SHEAR FORCE	33.90%	33.90%	33.90%	33.90%
BENDING MOMENT	93.60%	90.70%	89%	87.70%

Fig. 4.7 : Effect of Gr of Concrete for 3.0m RCC Sheet Pile Wall (M20 & FE500)

	M 20	M 25	M 30	M 35
SHEAR FORCE	42%	42%	42%	42%
BENDING MOMENT	96.50%	93.90%	92.30%	91.10%

Fig. 4.8 : Effect of Gr of Concrete for 5.0m RCC Sheet Pile Wall (M20 & FE500)



	M 20	M 25	M 30	M 35
SHEAR FORCE	45.40%	45.40%	45.40%	45.40%
BENDING MOMENT	99.90%	97.80%	96.50%	95.50%

Fig. 4.9 : Effect of Gr of Concrete for 7.0m RCC Sheet Pile Wall (M20 & FE500)

In order to study the effect of anchors in sheet pile walls, the three models are provided with anchors at a depth of 1.0 m from top. It is observed that the provision of anchor reduces the bending moment and pressure on the walls. The embedded length also reduces considerably for sheet piles with anchors. Table 4.2 show the embedded length for RCC sheet piles with anchors.

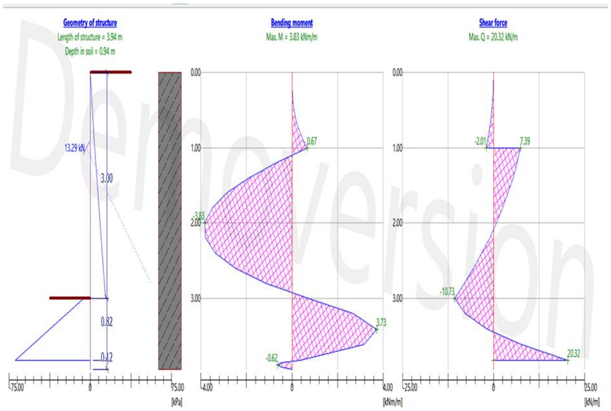


Fig. 4.10 : Effect of Anchor on 3.0m RCC Sheet Pile Wall (M20 & FE500)

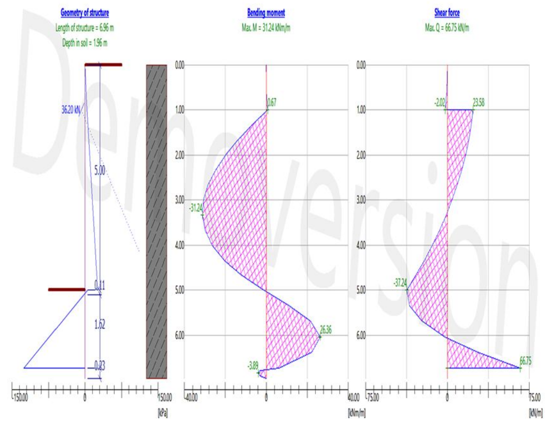


Fig. 4.11 : Effect of Anchor on 5.0m RCC Sheet Pile Wall (M20 & FE500)

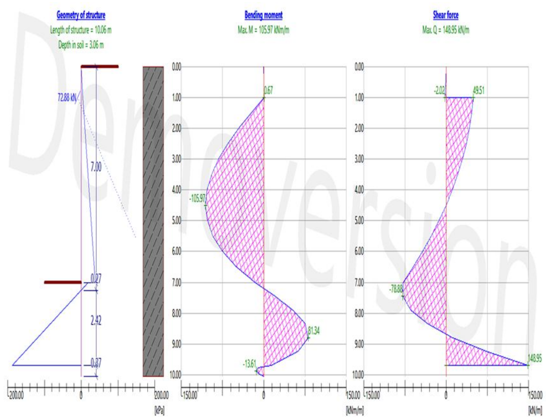


Fig. 4.12 : Effect of Anchor on 7.0m RCC Sheet Pile Wall (M20 & FE500)

Table 4.2: Effect of Anchor on optimise width for RCC Sheet pile walls.

DEPTH OF DITCH	WITH ACHORE		WITHOUT ANCHOR	
	Length of Structure	Embedded Length	Length of Structure	Embedded Length
3m	03.94 m	00.94 m	05.59 m	02.59 m
5m	06.94 m	01.94 m	09.51 m	04.51 m
7m	10.06 m	03.06 m	13.31 m	06.31 m

V. CONCLUSION AND FUTURE SCOPE

In the study concrete sheet pile walls of three different ditch depths have been considered. The concrete sheet piles have been subjected to two types of embankment system. In first only one type of soil mass has been considered where as in other the soil mass considered consist of two layers of different soil mass. Properties pertaining to optimsed sections of the concrete sheet pile wall have been considered as datum for the study. On the basis of study following conclusion have been drawn.

1) Embedded length does not depends on the no of layers of the different soils to be retained.
2) Embedded length increase with depth of ditch by almost same amount as depth of the ditch over 3.0m height.
3) Shear force utlisation for all the depths of sheet pile walls considered is almost same at optimum section.
4) Bending moment utilistion marginally varies with no of layers of soil for optimised section.
5) For smaller ditch depths, variation in width significantly affects the shear force and bending moment utilisation.
6) Shear force utilizations capacity is independent of grade of steel. However bending moment utilisation with same percentage of reinforcement, reduces with increase in grade of steel.

7) Shear force utilizations capacity is independent of grade of Concrete like that of steel. However bending moment utilisation with same percentage of reinforcement, reduces with increase in grade of Concrete.
8) The embedded length reduces considerably for sheet piles with anchors.

Furthers studies could be carried to investigate the effect of anchor on embedded length of the piles.. The location of anchors, inclination of anchors could be studied to have a deep knowledge about effect of anchors on behavior of concrete sheet pile walls.

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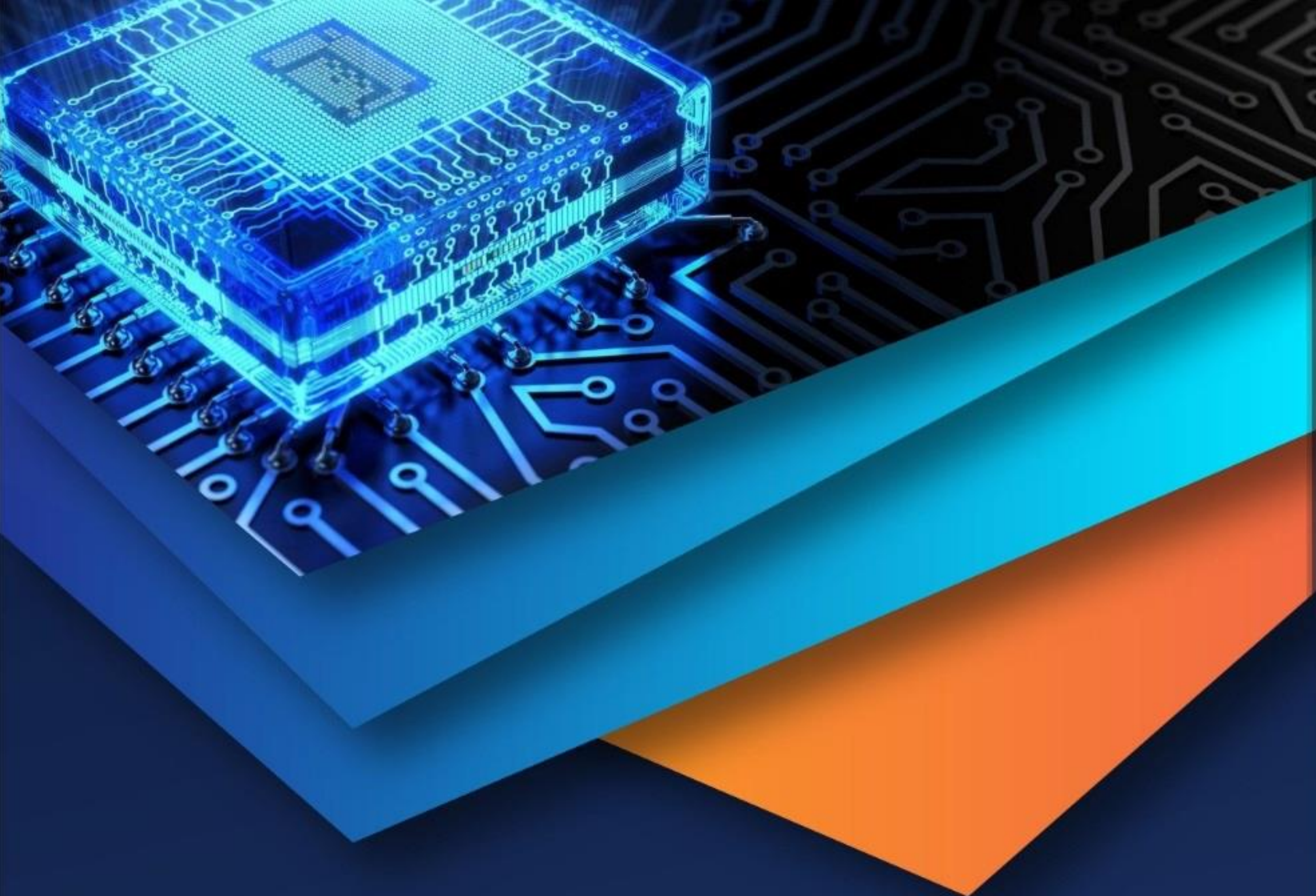

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