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Parametric Studies for Steel 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: 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.

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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 steel shet piles.
- Effect of properties and earth pressure on the sheet pile wall with varing depth of ditch.
- Effect of grade of steel on behavior of steel sheet pile wall.
- To understand the behavior of steel sheet pile wall when provide anchor support.

II. SHEET PILE WALL

Here we defined used member of steel sheet pile wall component.

1) U-section Steel sheet pile wall

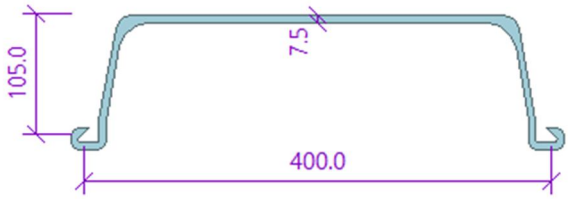

Figure-2.1-U-section(I an) sheet pile wall

C/S DIMENSION
H - 105mm
B - 400m
T - 7.5mm
S - 6mm
R_i - 25m
R_e - 15mm
Wall angle-80^0
A - 1.14E-$2m^2$/m
I - 6.64E-$5m^4$/m
W_{y1}- 6.0E-$4m^3$/m
W_{ply}- 7.20E-$3m^3$/m

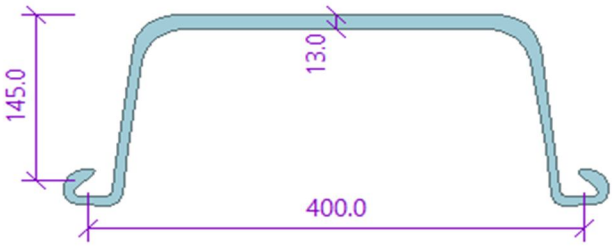

Figure-2.2-U-section(III n) sheet pile wall

C/S DIMENSION
H - 145mm
B - 400mm
T - 13mm
S -9mm
R_i -32mm
R_e-34mm
Wall angle-81.90^0
A- 1.97E-$02m^2$/m
I – 2.32E-$04m^4$/m
Wy_1-1.60E-$02m^3$/m
$W_{pl,y}$-1.756E-$03m^3$/m

2) Z-section steel sheet pile wall

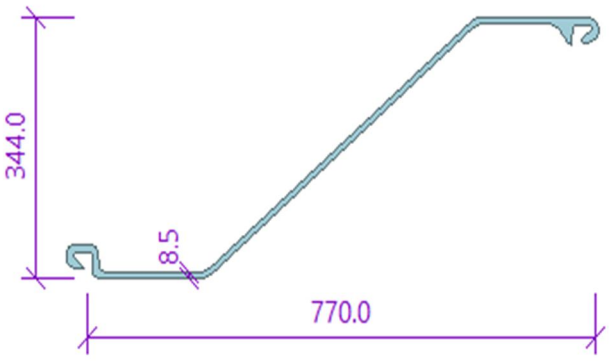

Figure-2.3-Z-section (AZ12-700) sheet pile wall

C/S DIMENSION
H - 344mm
B - 770mm
T - 8.5mm
S - 8.5mm
R_i – 20mm
R_e – 15mm
Wall angle – 39.5^0
A – 1.20E-$02m^2$/m
I – 2.14E-$04m^4$/m
Wy_1 – 1.245E-$03m^3$/m
$W_{pl,y}$- 1.480E-$03m^3$/m

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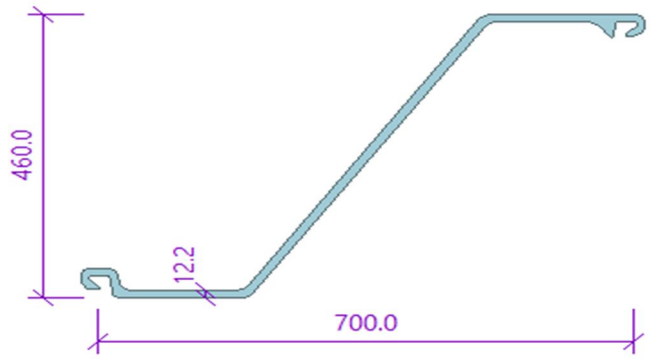

Figure-2.4-Z-section (AZ26-700) sheet pile wall

C/S DIMENSION
H – 460mm
B – 700mm
T – 12.2mm
S – 12.2mm
R_i – 20mm
R_e – 15mm
Wall angle – 55.20^0
A – 1.87E-02m^2/m
I – 5.97E-04m^4/m
Wy_1 – 2.600E-03m^3/m
$W_{pl,y}$ – 3.070E-03m^3/m

III. MODELLING AND ANALYSIS

The steel sheet pile walls are being modeled, analysed using software GE05FINE. The code for steel member is consider in design procedure.

The calculation of bending moment and shear force on different model is mentioned here.

1) Model 1: U-section sheet pile wall for 3m depth of ditch in 1 layer soil
2) Model 2: U-section sheet pile wall for 5m depth of ditch in 1 layer soil
3) Model 3: U-section sheet pile wall for 7m depth of ditch in 1 layer soil
4) Model 4: U-section sheet pile wall for 3m depth of ditch in 2 layer soil
5) Model 5: U-section sheet pile wall for 5m depth of ditch in 2 layer soil
6) Model 6: U-section sheet pile wall for 7m depth of ditch in 2 layer soil
7) Model 7: Z-section sheet pile wall for 3m depth of ditch in 1 layer soil
8) Model 8: Z-section sheet pile wall for 5m depth of ditch in 1 layer soil
9) Model 9: Z-section sheet pile wall for 7m depth of ditch in 1 layer soil
10) Model 10: Z-section sheet pile wall for 3m depth of ditch in 2 layer soil
11) Model 11: Z-section sheet pile wall for 5m depth of ditch in 2 layer soil
12) Model 12: Z-section sheet pile 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 steel usage. Therefore, optimization has gained momentum in structural engineering. In this work, optimized steel 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 for steel sheet pile wall
2) Start assigning steel sheet pile 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 change 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 steel sheet pile, the section come out by this iterative process is now optimized section for structure.

C. Material Properties

In analyzing steel 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

D. Optimized Steel 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 table 3.2:

Table 3.2: steel section used analysis

MEMBER	SECTION	GRADE OF STEEL	DEPTH	SOIL LAYER
U SECTION	I an	FE360	3M	1 LAYER
Z SECTION	AZ12-700	FE360	3M	1 LAYER
U SECTION	I an	FE360	5M	1 LAYER
Z SECTION	AZ12-700	FE360	5M	1 LAYER
U SECTION	III n	FE510	7M	1 LAYER
Z SECTION	AZ26-700	FE510	7M	1 LAYER
U SECTION	I an	FE360	3M	2 LAYER
Z SECTION	AZ12-700	FE360	3M	2 LAYER
U SECTION	I an	FE360	5M	2 LAYER
Z SECTION	AZ12-700	FE360	5M	2 LAYER
U SECTION	III n	FE510	7M	2 LAYER
Z SECTION	AZ26-700	FE510	7M	2 LAYER

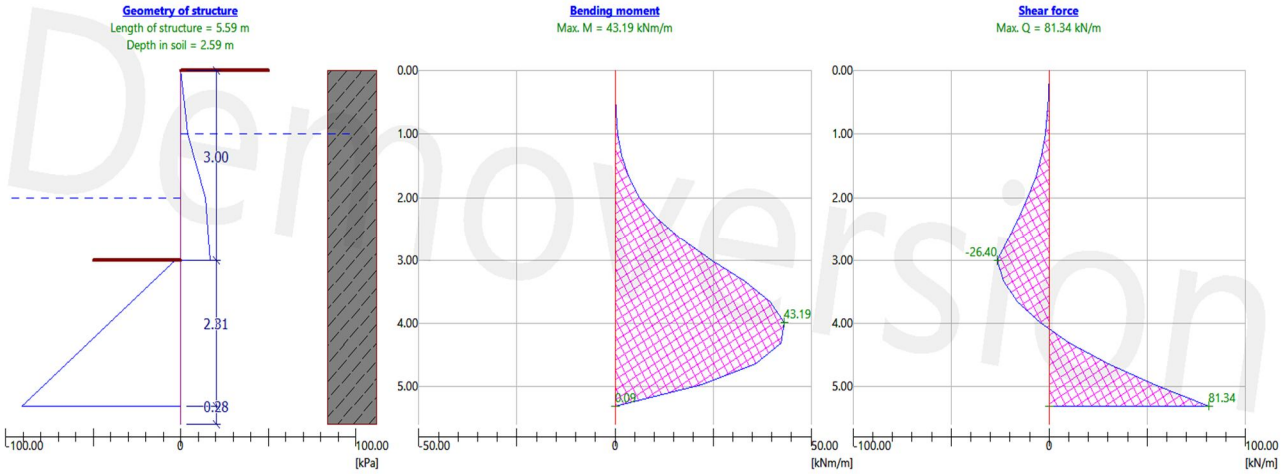

Fig. 3.1 Model 1: U-section sheet pile wall for 3m depth of ditch in 1 layer soil

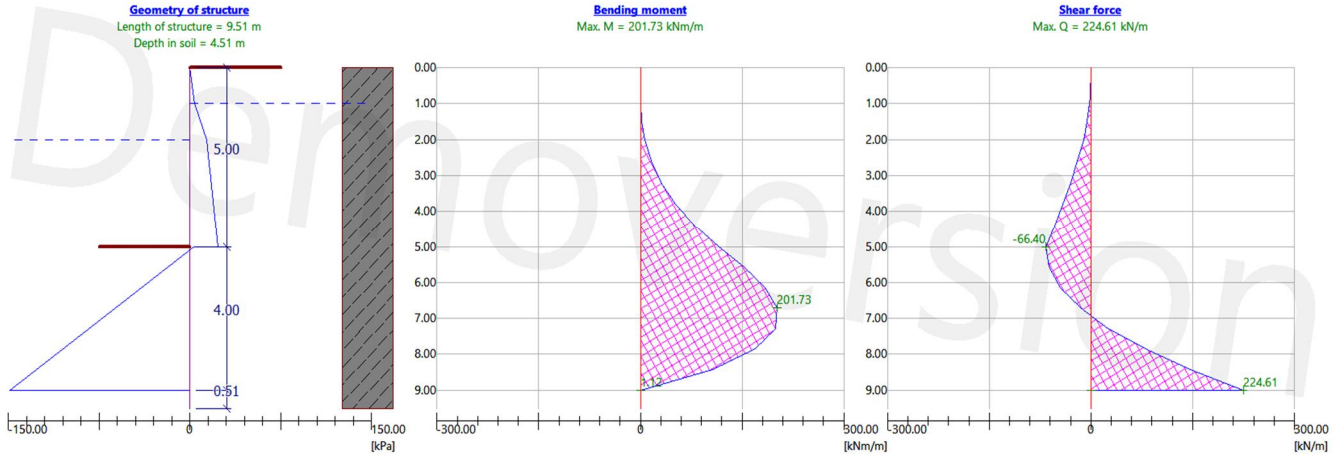

Fig. 3.2 Model 2: U –section sheet pile wall for 5m depth of ditch in 1 layer soil

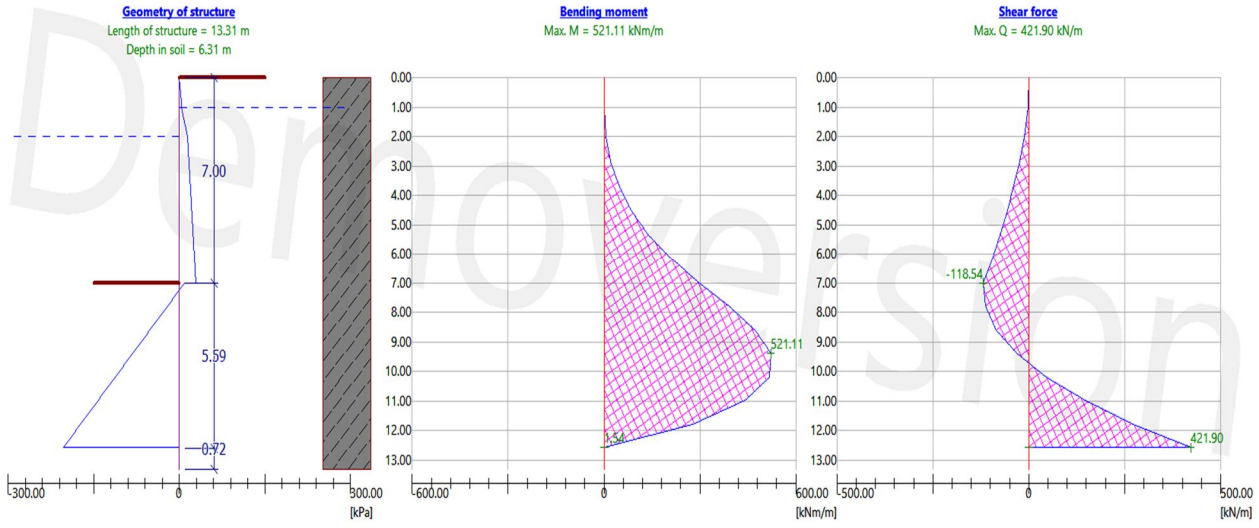

Fig. 3.3 Model 3: U-section sheet pile wall for 7m depth of ditch in 1 layer soil

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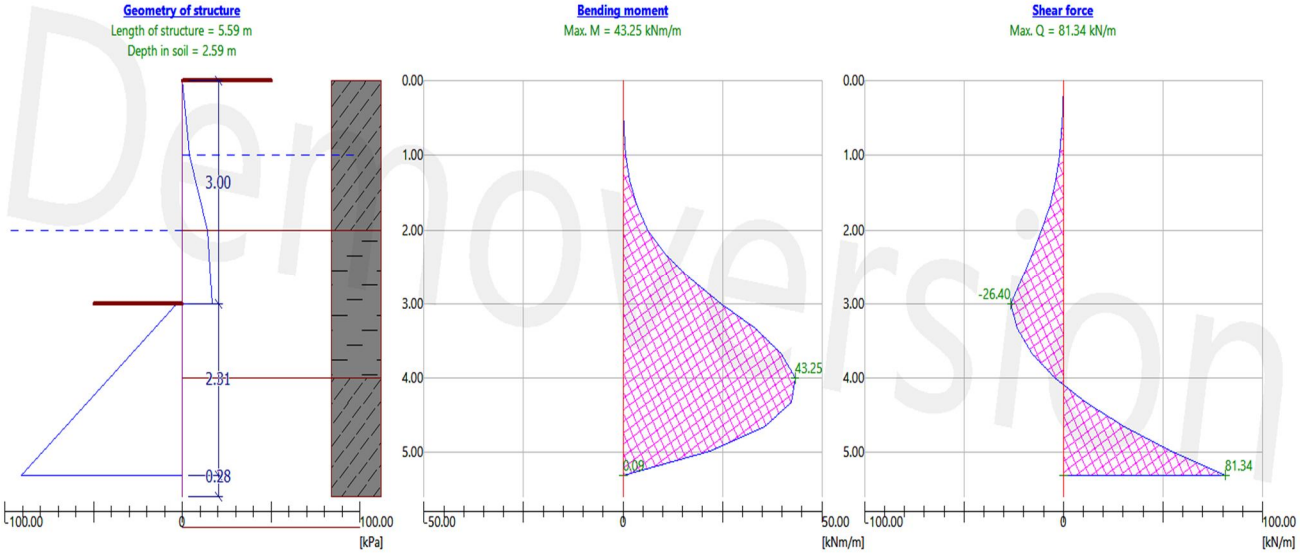

Fig. 3.4 Model 4: U-section sheet pile wall for 3m depth of ditch in 2 layer soil

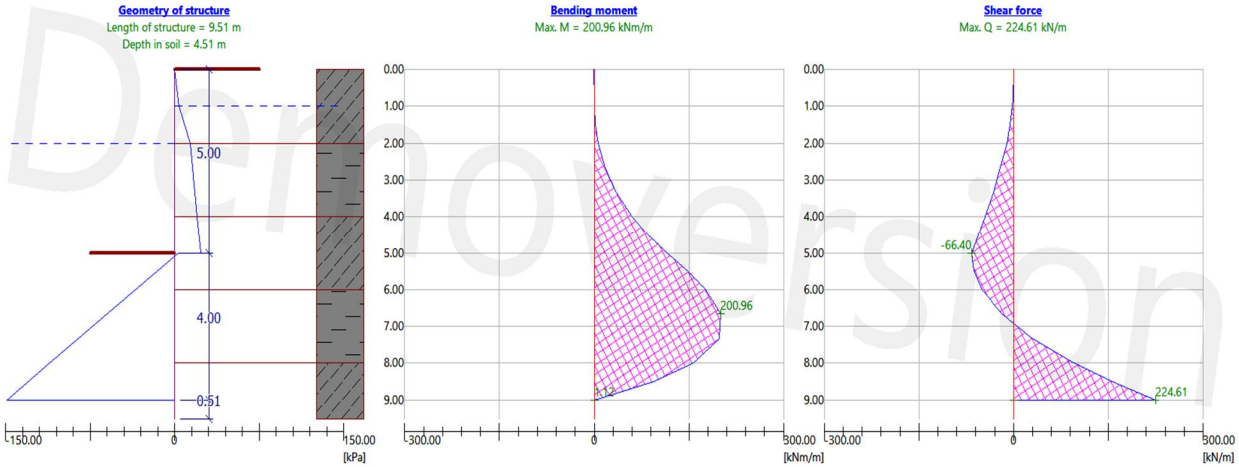

Fig. 3.5 Model 5: U-section sheet pile wall for 5m depth of ditch in 2 layer soil

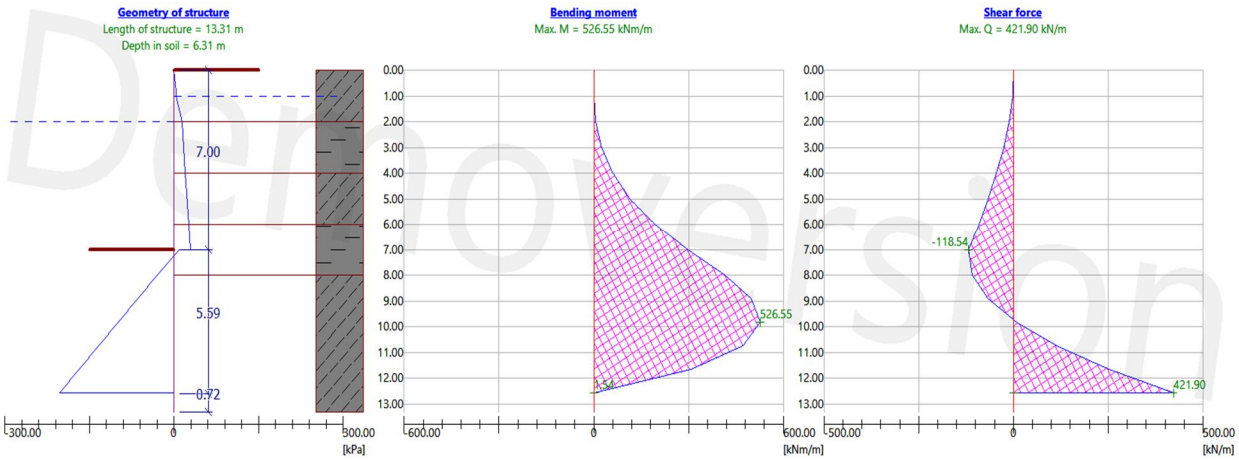

Fig. 3.6 Model 6:U=section sheet pile wall for 7m depth of ditch in 2 layer soil

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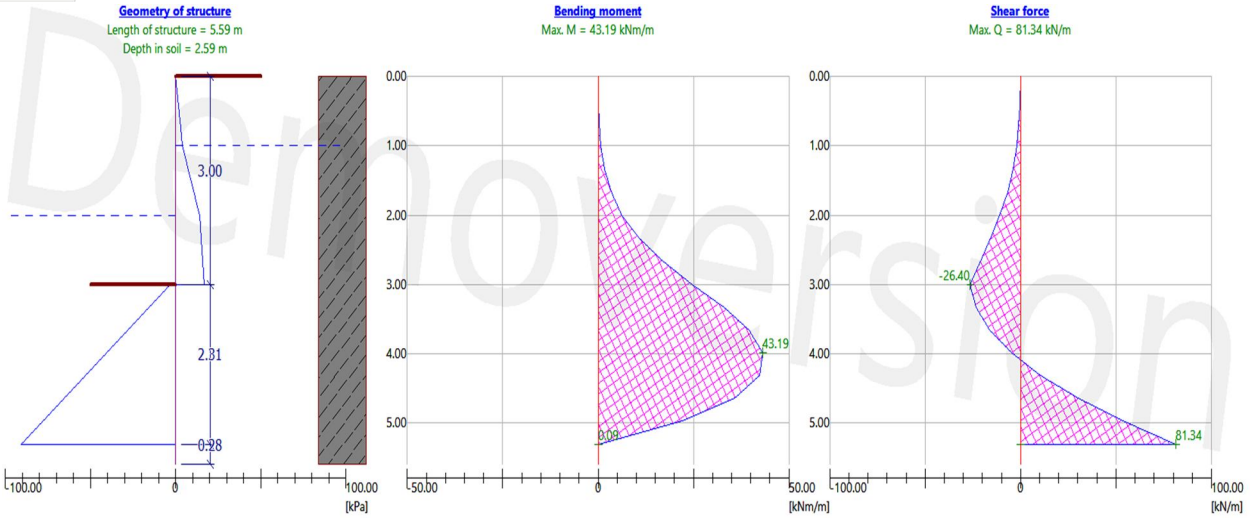

Fig. 3.7: Model 7: Z-section sheet pile wall for 3m depth of ditch in 1 layer soil

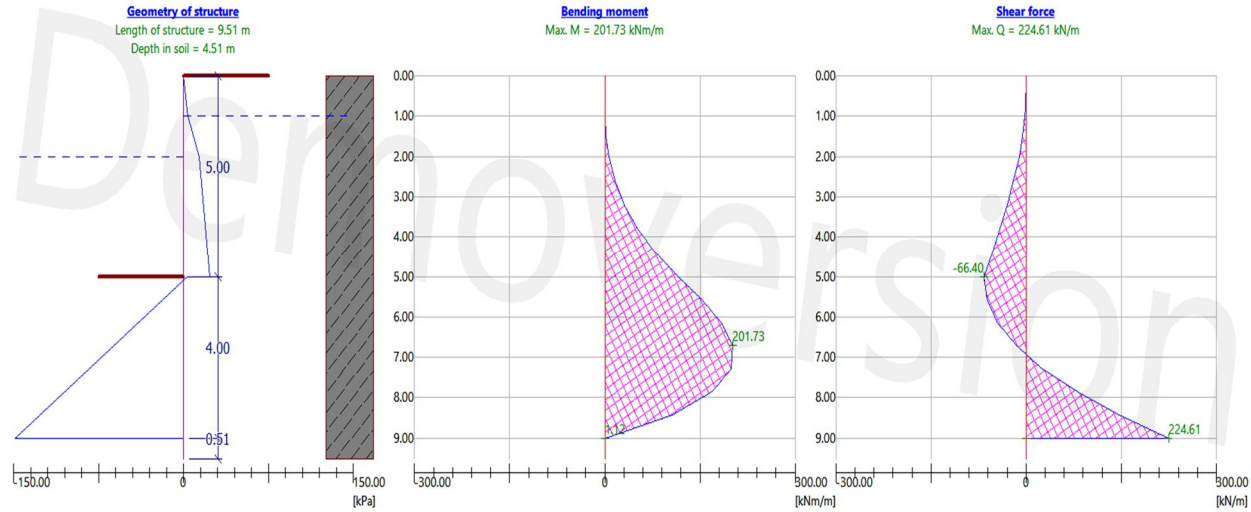

Fig. 3.8: Model 8: Z-section sheet pile wall for 5m depth of ditch in 1 layer soil

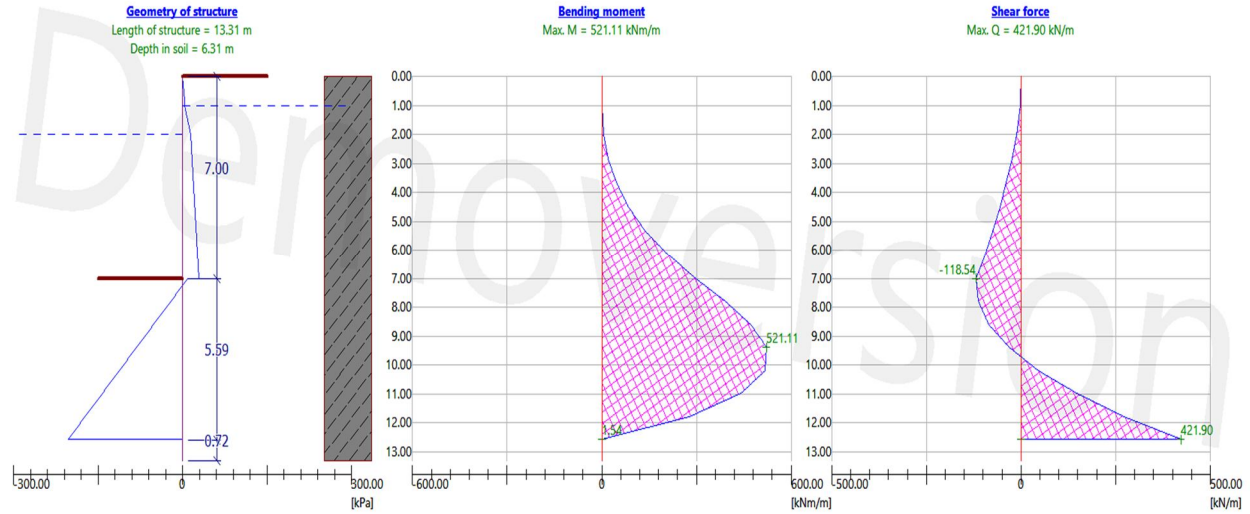

Fig. 3.9: Model 9: Z-section sheet pile wall for 7m depth of ditch in 1 layer soil

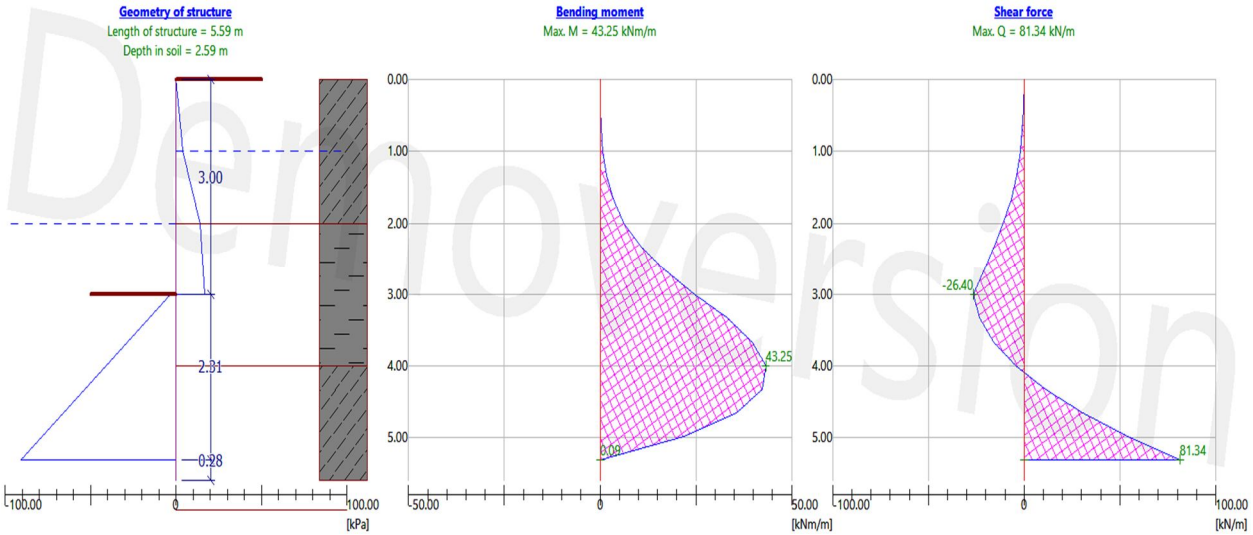

Fig. 3.10: Model 10:Z-section sheet pile wall for 3m depth of ditch in 2 layer soil

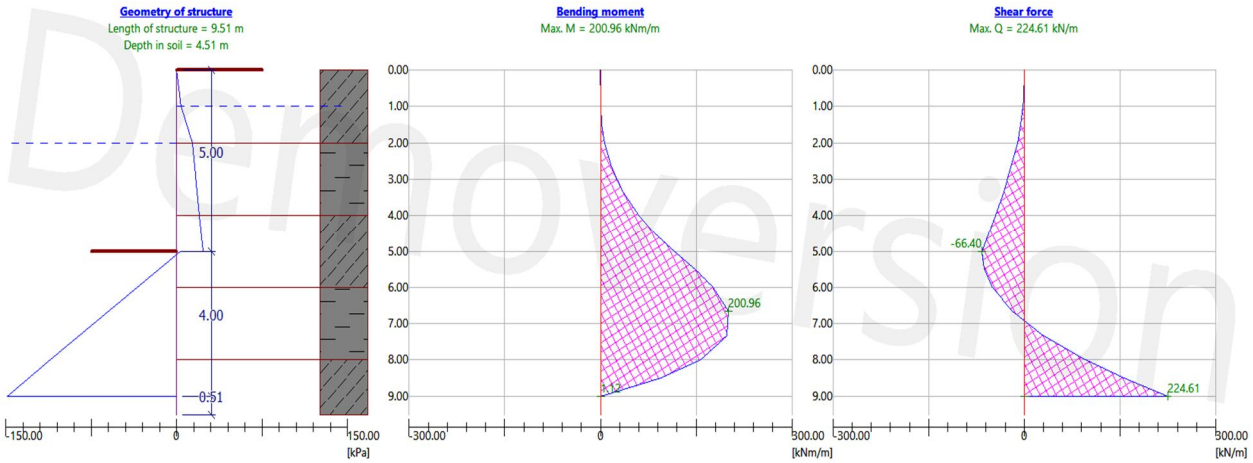

Fig. 3.11: Model 11: Z-section sheet pile wall for 5m depth of ditch in 2 layer soil

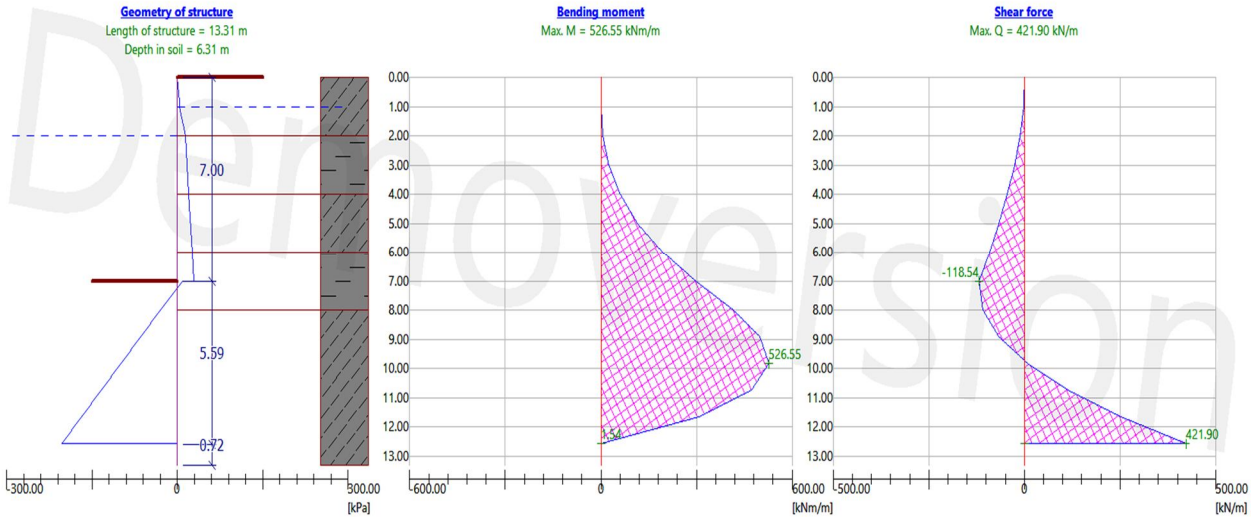

Fig. 3.12 Model 12: Z-section sheet pile wall for 7m depth of ditch in 2 layer soil

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IV. RESULT

The Analysis is conducted on two different section using GE05FINE software , several values of model were found out from steel sheet pile wall. The all recommended code is used for the analysis for the all model. After analysing, optimized section is selected for design. Therefore, total 12 model are used for analyzing the response of soil behavior , effective stress and active earth pressure of soil. The impact of grade of steel, thickness of steel section, 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 steel Sheet pile walls.

B	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 section 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 section significantly affect the shear force and bending moment utilisation.

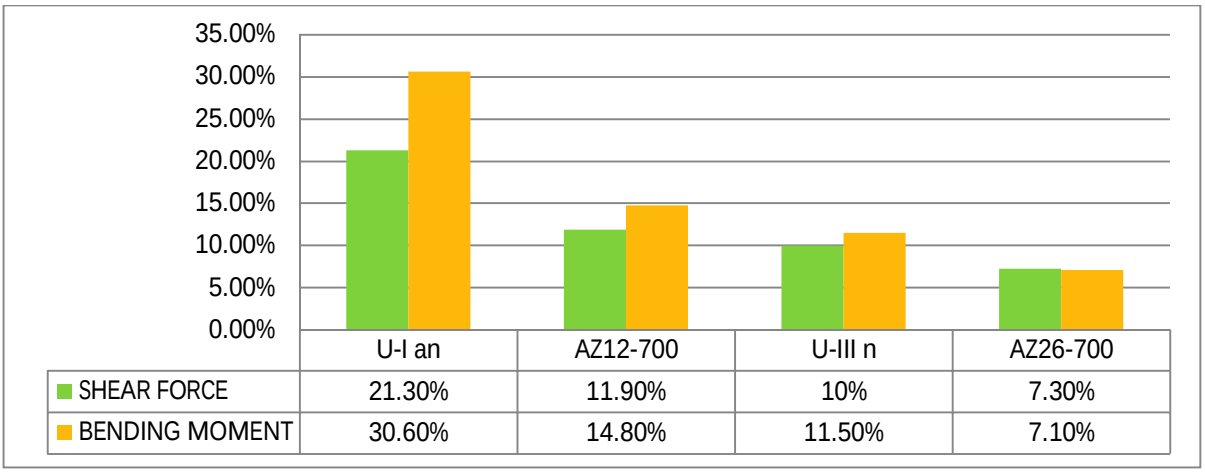


Fig. 4.1. Variation in section for 3m depth of ditch

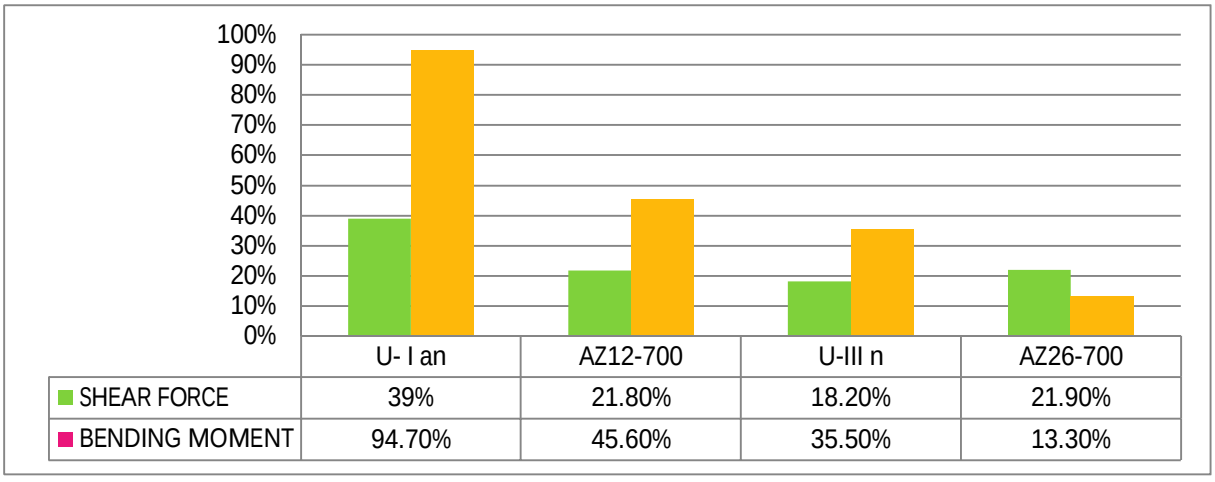
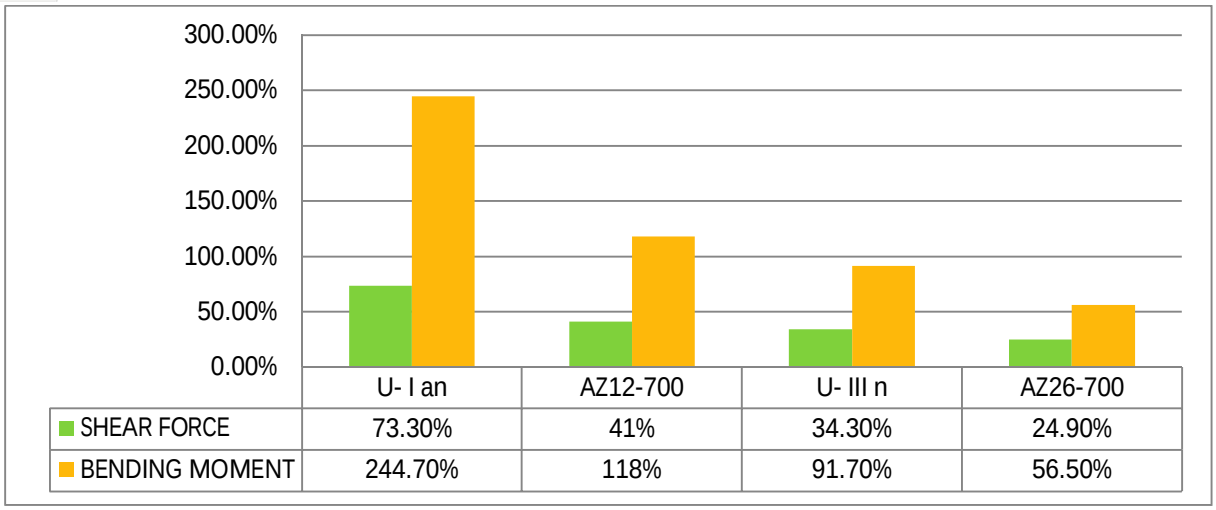


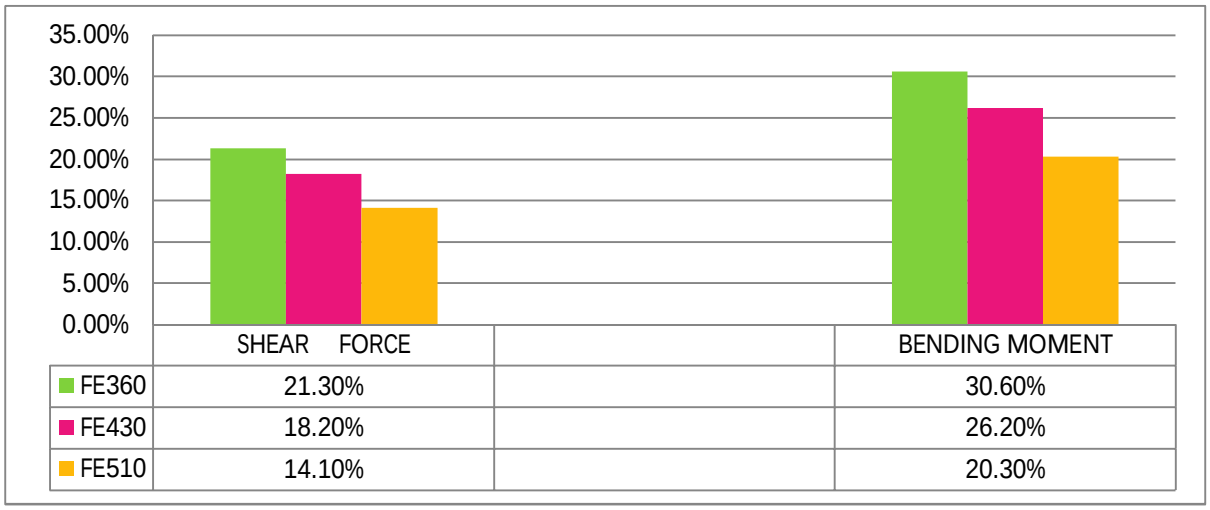
Fig. 4.2. Variation in section for 5m depth of ditch



	U- I an	AZ12-700	U- III n	AZ26-700
SHEAR FORCE	73.30%	41%	34.30%	24.90%
BENDING MOMENT	244.70%	118%	91.70%	56.50%

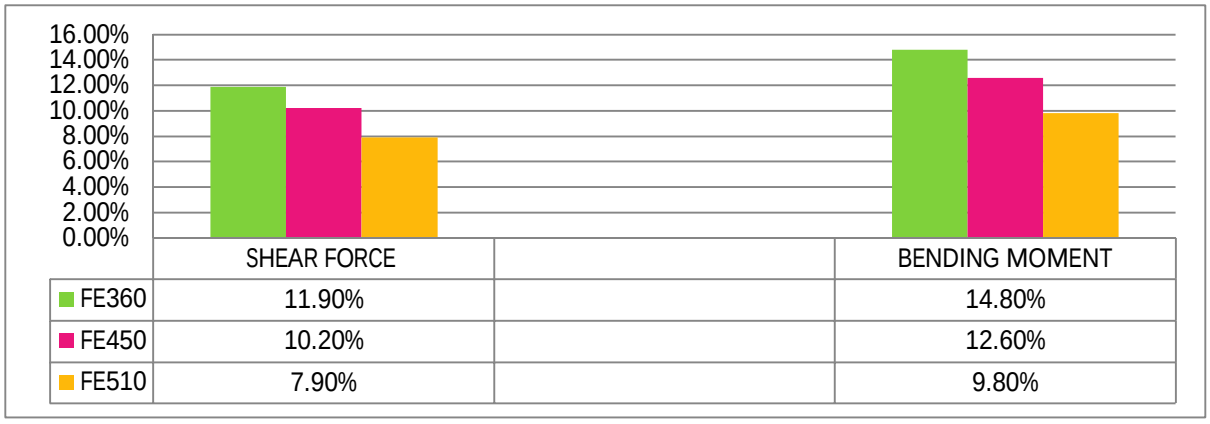
Fig. 4.3. Variation in section for 7m depth of ditch

Effect of variation of Gr. Of steel on shear force utilisation and bending moment utilisation with respect to optimum steel Sheet Pile Wall section has been studied. It has been observed that shear force utilization and bending moment utilization capacity is dependent of grade of steel. However bending moment and shear force utilization reduces with increase in grade of steel.



	SHEAR FORCE		BENDING MOMENT
FE360	21.30%		30.60%
FE430	18.20%		26.20%
FE510	14.10%		20.30%

Fig. 4.4 : Effect of grade of steel in U-section



	SHEAR FORCE		BENDING MOMENT
FE360	11.90%		14.80%
FE450	10.20%		12.60%
FE510	7.90%		9.80%

Fig. 4.5 : Effect of grade of steel in Z-section

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 4.3 show the embbeded length for steel sheet piles with anchors.

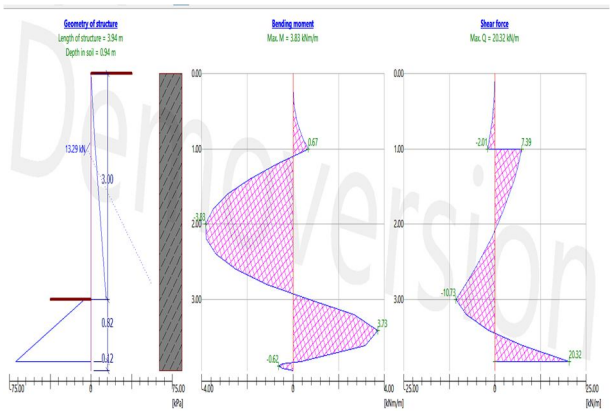


Fig. 4.10 : Effect of Anchor on 3.0m steel Sheet Pile Wall

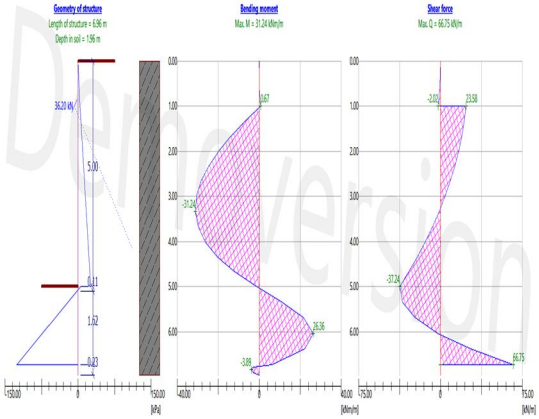


Fig. 4.11 : Effect of Anchor on 5.0m steel Sheet Pile Wall

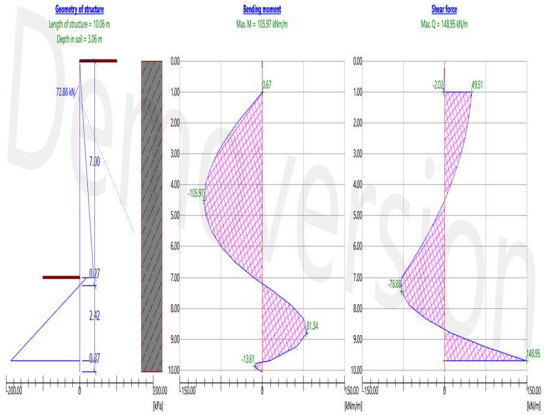


Fig. 4.12 : Effect of Anchor on 7.0m steel Sheet Pile Wall

Table 4.2: Optimsed width for steel 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

Steel sheet pile wall successfully analyze in different layer of soil, variation of section, grade of steel and anchor support. After analysis some conclusion are mentioned here:

1) Embedded length does not depend on layers of soil. For 1 and 2 layer in both cases embedded length same.

2) No. of soil layers does not affect the shear force utilization its almost same for constant ditch depth. But Bending moment optimization varies with 5kN-m to 10kN-m

3) For smaller ditch depth, variation of section affect the utilization of shear force reduces with 8% to 10% and bending moment almost half.

4) For same ditch depth variation in grade of steel (fe360, fe450, fe510), Shear force utilization reduces with 3% to 4% and bending moment utilization reduces with 4% to 6% in U-section.

5) For same ditch depth variation in grade of steel (fe360, fe450, fe510), shear force utilization reduces with 1% to 3% and bending moment utilization reduces with 2% to 3% in Z-section.

6) When we provide anchor support to the steel sheet pile wall almost 2 to 2.5 times reduces the embedded length of sheet pile wall in soil.

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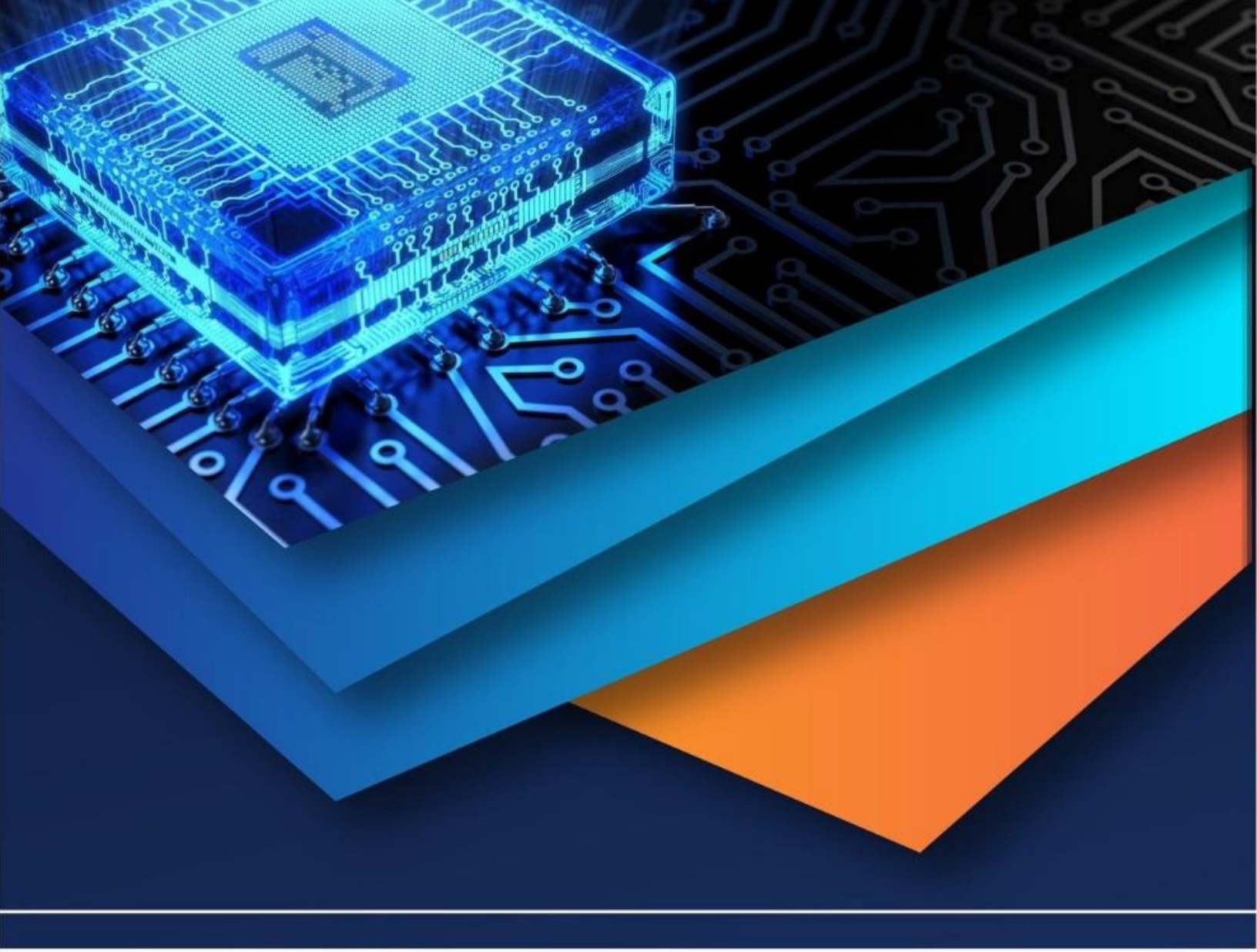

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