

Comparative Study on Shallow and Deep Bin For A Constant Volume at Same Loading Condition using ETAB Software

Rahul Patidar¹, Nitesh Kushwaha²

¹M. Tech. Scholar, ²Professor

Department of Civil Engineering, Millennium Institute of Technology, Bhopal India

Abstract - In this study, we will modelling, analyze & Design the grain storage Silo & Bunker for seismic zone III. Comparative study based on different types of storage structures i.e. silo & bunker with various configurations of radius & height is considered but keeping the volume of grain constant. Food grain has been considered for the storage loadings. All over 6 models (3 models of silo & 3 models of bunker) have been prepared for the consideration of the study. The seismic forces and wind pressure are considered simultaneously as per IS: 1893-2002 and IS: 875 PART 3 respectively. The whole structure is analysis on software ETAB. Comparing the displacement results of silo of height 13.5m & bunker of height 8.64 m, we find that silo shows very close result to bunker i.e. 9.95 mm & 9.32 mm, thus silo can be used for further research & design work. Silo can be preferred over bunkers. More storage capacity of silos structure then bunker in a given land space, bunker is prefer more land space then silo. As per the cost analysis silo is more economical then bunker.

I. INTRODUCTION

Bunkers and silos may be classified as storage structures generally used for storing coal, cement, food grains and other granular materials. Reinforced concrete bunkers and silos have the almost replaced the steel storage structures because of their ease of maintenance and superior architectural qualities. A silo (from the Greek – siros,) is a structure for storing bulk materials. They are supported by frames or reinforced concrete columns. A silo carries normal pressures and axial compressive loads due to stored material together with the load of super structure. It also carries lateral loads due to wind or seismic forces. The silo wall deforms considerably in its cross-section and along the height when subjected to such lateral loads. For circular silo having height of wall to diameter of silo approximately equal to one ($H/D=1$), there is not much effect, in general. But for silo having the same ratio exceeding one ($H/D>1$) is subjected to deformation to greater extent, The failure of a silo structures usually leads to catastrophic collapse of the entire silo. The complete structural failure results in loss of contained material and also loss of life.

II. OBJECTIVES

- The main intention of this study is to know about the behaviour of bunkers and silos in various situations such as during earthquake, during filling & discharge of materials.

III. METHODOLOGY

In this study, we will modeling, analyze & Design the grain storage Silo & Bunker for seismic zone III. Comparative study based on different types of storage structures i.e. silo & bunker with various configurations of radius & height is considered but keeping the volume of grain constant. food grain has been considered for the storage loadings. All over 6 models (3 models of silo & 3 models of bunker) have been prepared for the consideration of the study. The 6 models are:

1. Silo

1.1 Diameter = 6m

Height = 24m

Volume = 678.24 cum.

1.2 Diameter = 7m

Height = 17.6m

Volume = 678.24 cum.

1.3 Diameter = 8m

Height = 13.5m

Volume = 678.24 cum.

2. Bunker

2.1 Diameter = 10m

Height = 8.64m

Volume = 678.24 cum.

2.2 Diameter = 11m

Height = 7.15m

Volume = 678.24 cum.

2.3 Diameter = 12m

Height = 6m

Volume = 678.24 cum.

In this study, I am focusing the analysis using finite element method using analysis tool ETABS, which is capable of applying all conditions and methods with respect to preferred standard code.

4.2 Methodology

Following steps are required in a sequence for proper completion:

Step-1 Preparation of geometry in ETABS

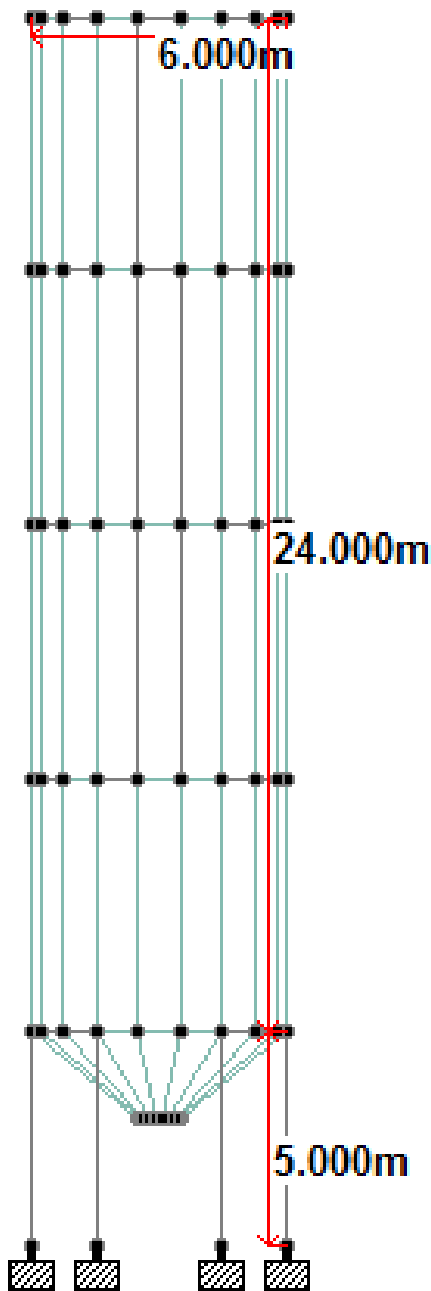


Fig 4.1 Silo (Dia = 6m &Ht = 24m)

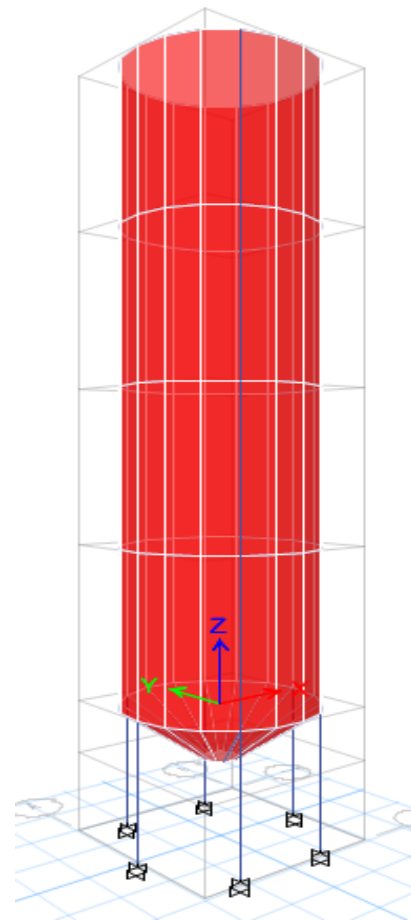


Fig 4.2 Silo (Dia = 6m &Ht = 24m) on ETABS

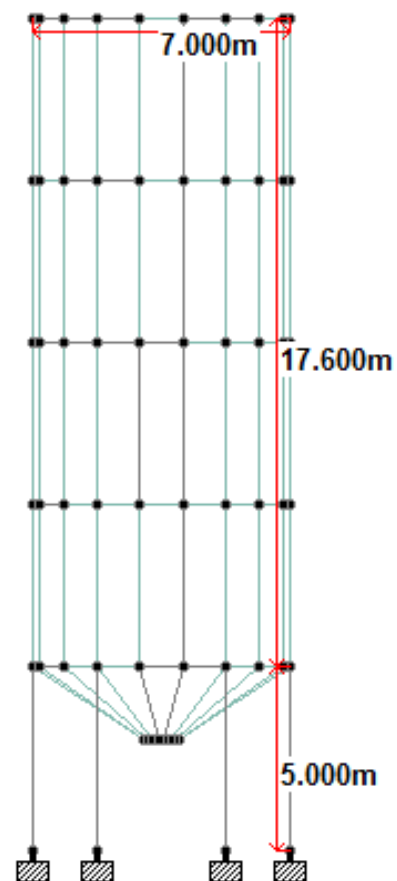


Fig 4.3 Silo (Dia = 7m &Ht = 17.6m)

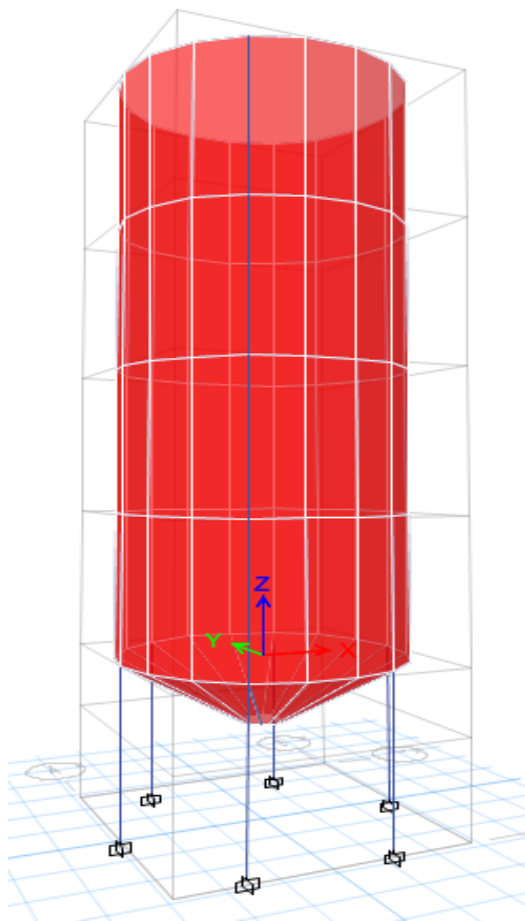


Fig 4.4 Silo (Dia = 7m &Ht = 17.6m) on ETABS

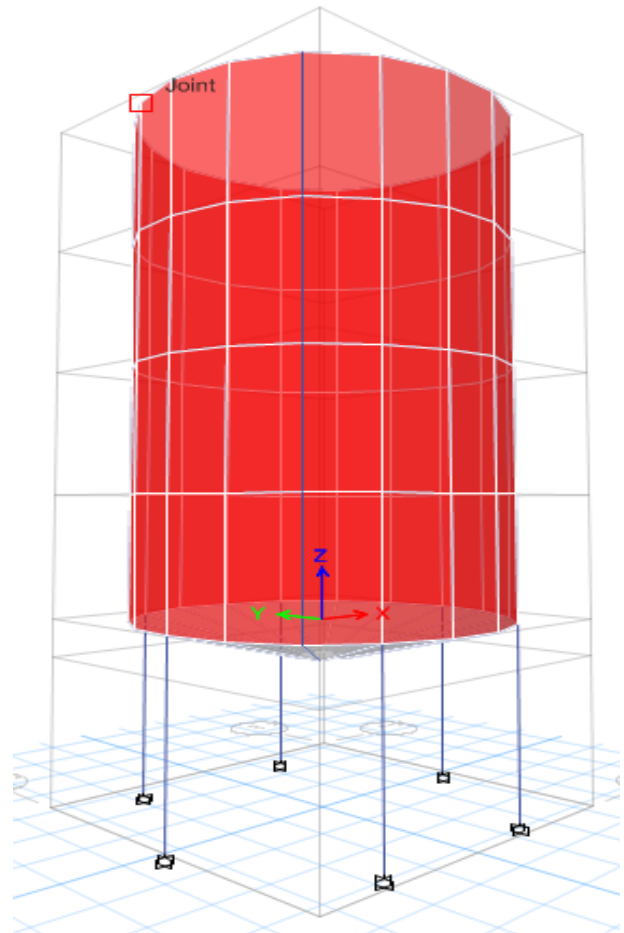


Fig 4.6 Silo (Dia = 8m &Ht = 13.5m) on ETABS

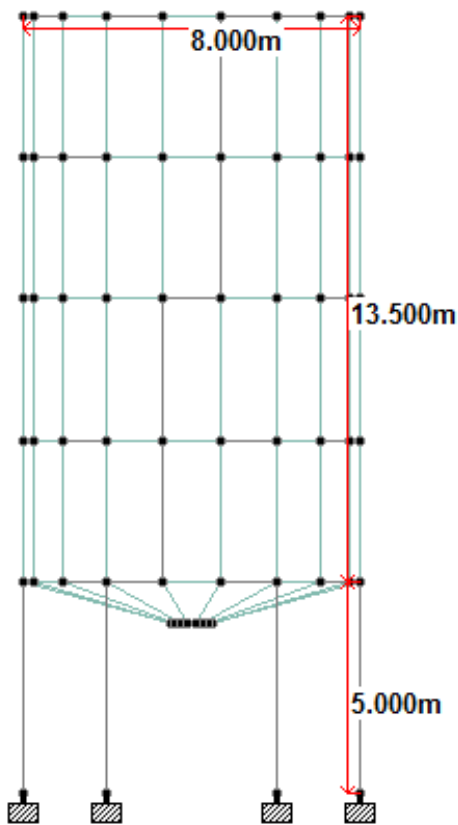


Fig 4.5 Silo (Dia = 8m &Ht = 13.5m)

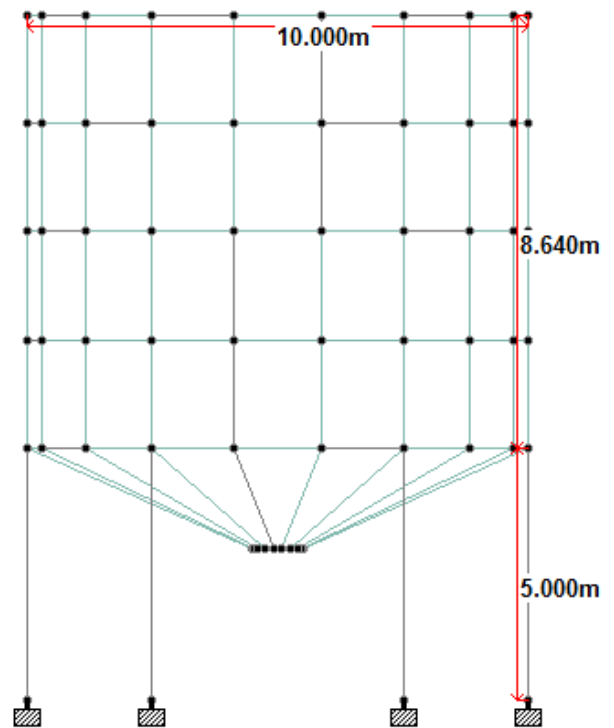


Fig 4.7 Bunker (Dia = 10m &Ht = 8.64m)

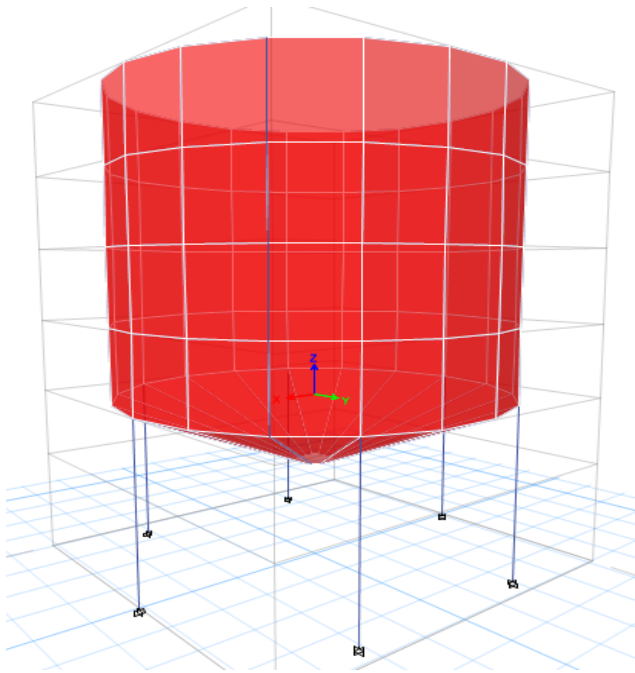


Fig 4.8 Bunker (Dia = 10m &Ht = 8.64m) on ETABS

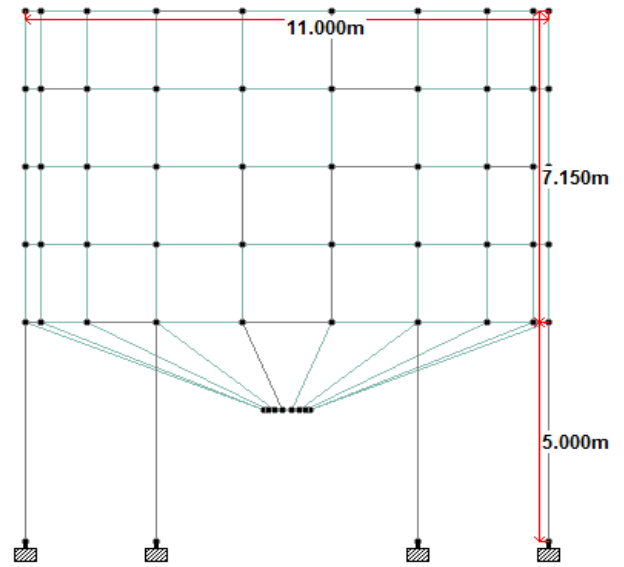


Fig 4.9 Bunker (Dia = 11m &Ht = 7.15m)

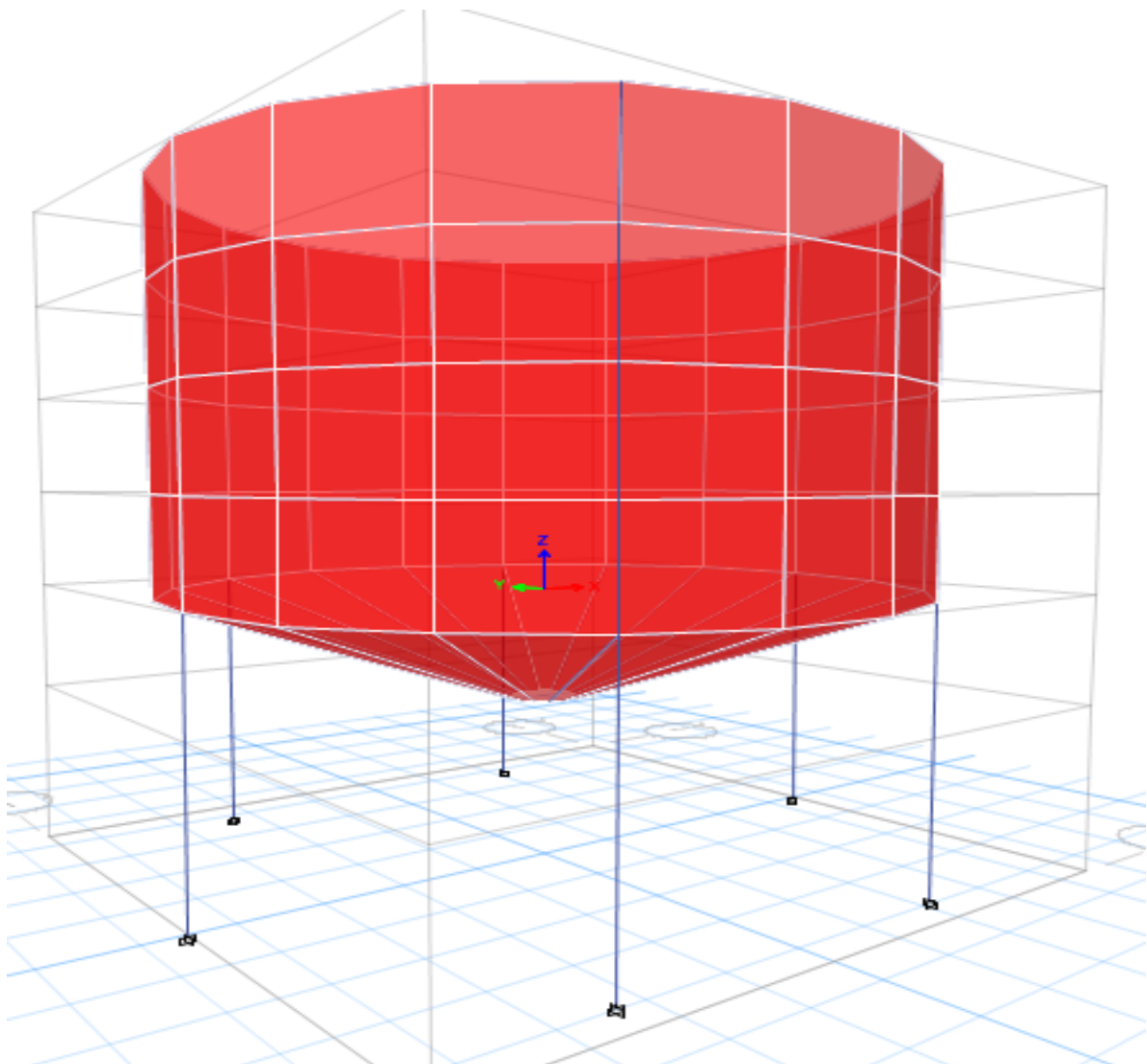


Fig 4.10 Bunker (Dia = 11m &Ht = 7.15m) on ETABS

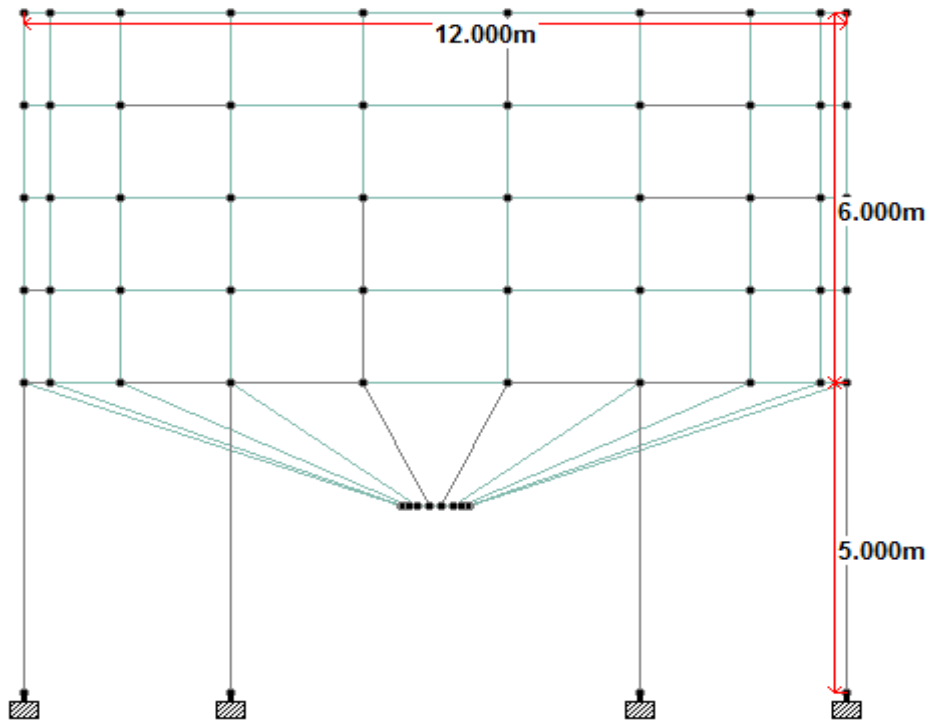


Fig 4.11 Bunker (Dia = 12m &Ht = 6m)

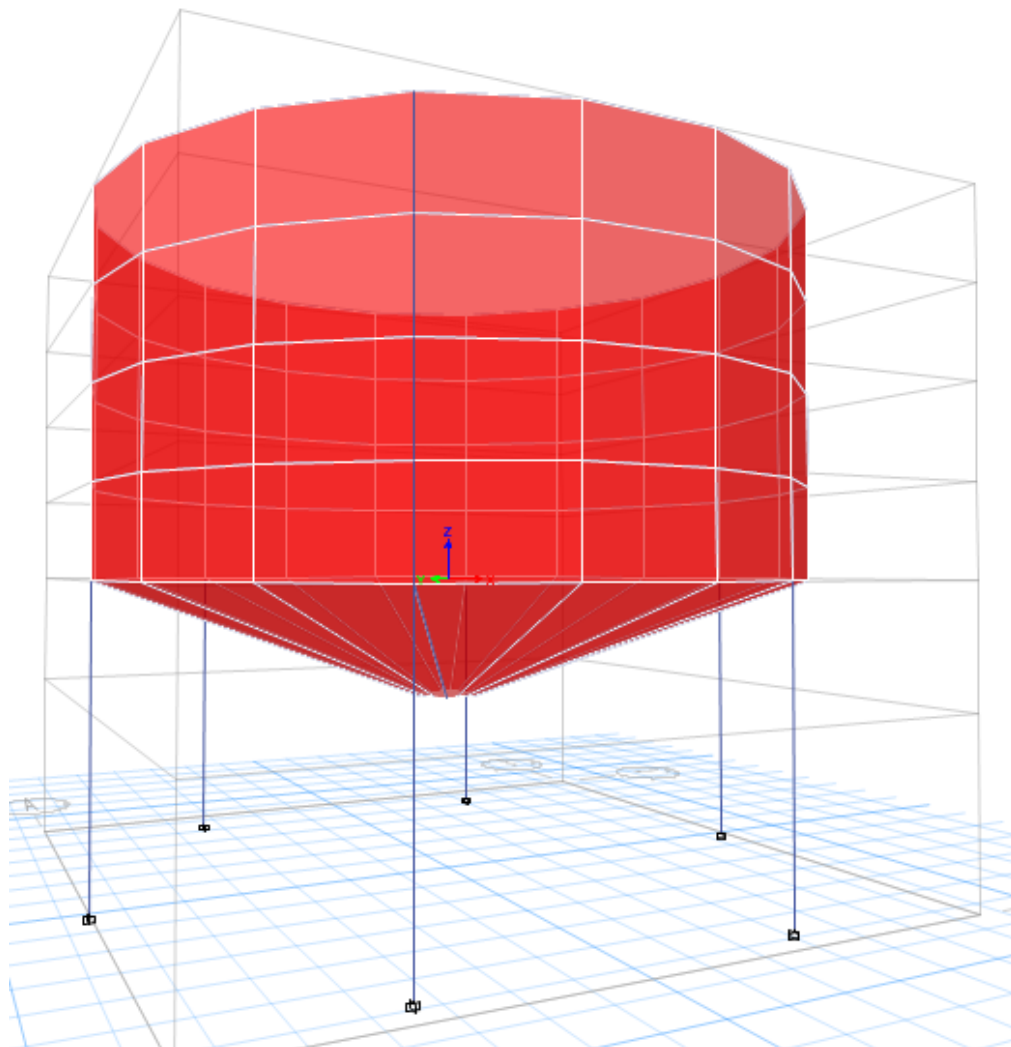


Fig 4.12 Bunker (Dia = 12m &Ht = 6m) on ETABS

IV. RESULTS

After finishing comparative study of the bunker & silos a comparison is made on the basis of following points given below. Then final result is obtained by reading these tables.

5.1.1 MAXIMUM & MINIMUM DISPLACEMENT ON BUNKERS & SILOS

5.1.2 MAXIMUM & MINIMUM FORCE ON BUNKERS & SILOS

5.1.3 MAXIMUM & MINIMUM BENDING MOMENT ON BUNKERS & SILOS

5.1.4 DESIGN DETAILS FOR BUNKERS & SILOS

5.4 Staad Pro Max Forces & Moments Result Graphs

5.2.1 Displacement Comparison Graph Silo & Bunker

Table 5.19 Maximum Displacement of Silo in X Direction

	Silo (Dia = 6m & Ht = 24m)	Silo (Dia = 7m & Ht = 17.6m)	Silo (Dia = 8m & Ht = 13.5m)
Max Displacement (X Dir in mm)	13.25	10.68	9.95

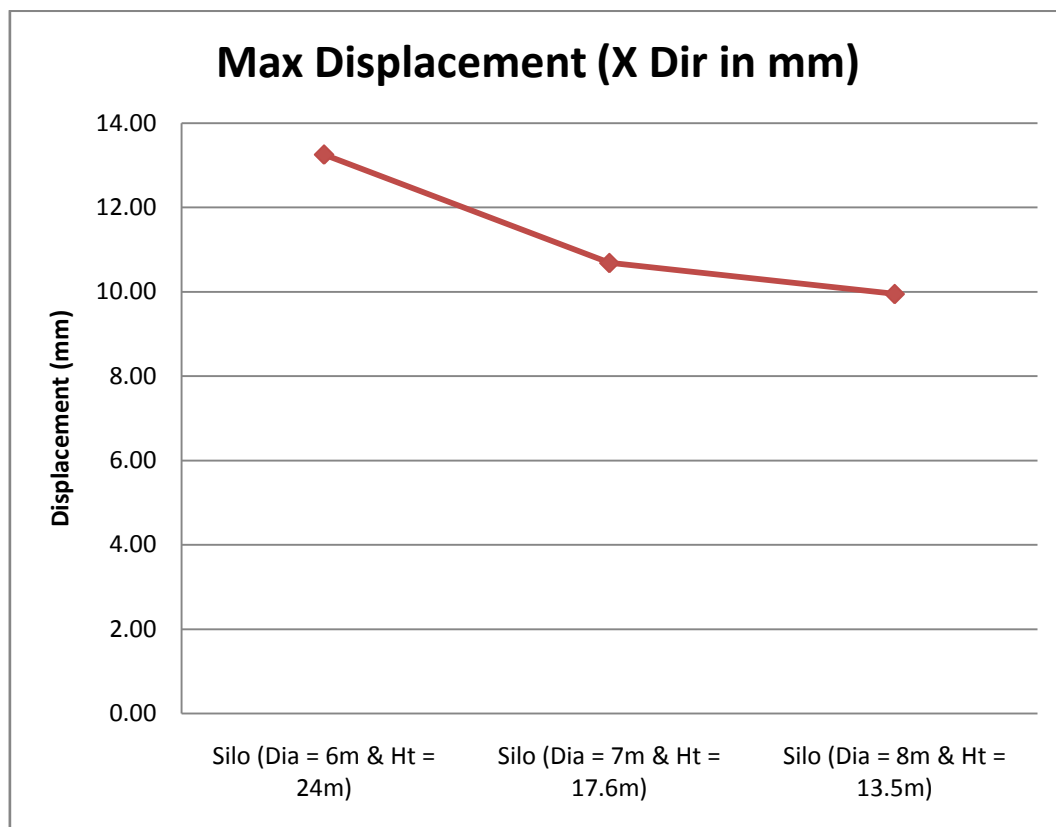


Fig. 5. 1 shows comparison of Maximum Displacement of Silo in X Direction

Table 5.20 Maximum Displacement of Bunker in X Direction

	Bunker (Dia = 10m & Ht = 8.64m)	Bunker (Dia = 11m & Ht = 7.15m)	Bunker (Dia = 12m & Ht = 6m)
Max Displacement (X Dir in mm)	9.32	9.78	10.39

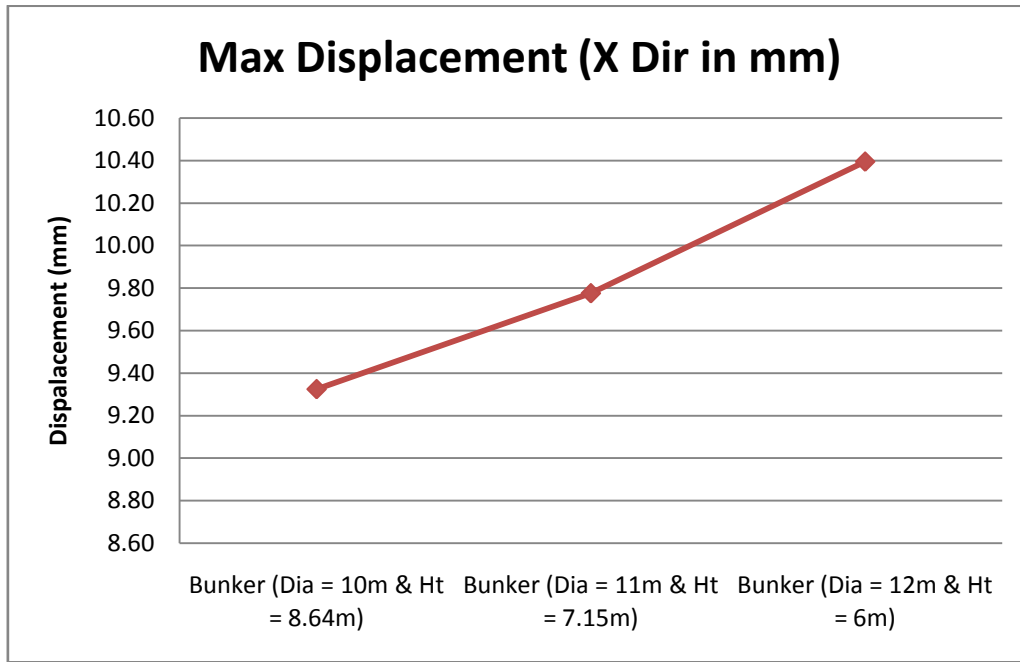


Fig. 5. 2 shows comparison of Maximum Displacement of Bunker in X Direction

Table 5.21 Maximum Displacement of Silo in Y Direction

	Silo (Dia = 6m & Ht = 24m)	Silo (Dia = 7m & Ht = 17.6m)	Silo (Dia = 8m & Ht = 13.5m)
Max Displacement (Y Dir in mm)	8.866	5.903	6.248

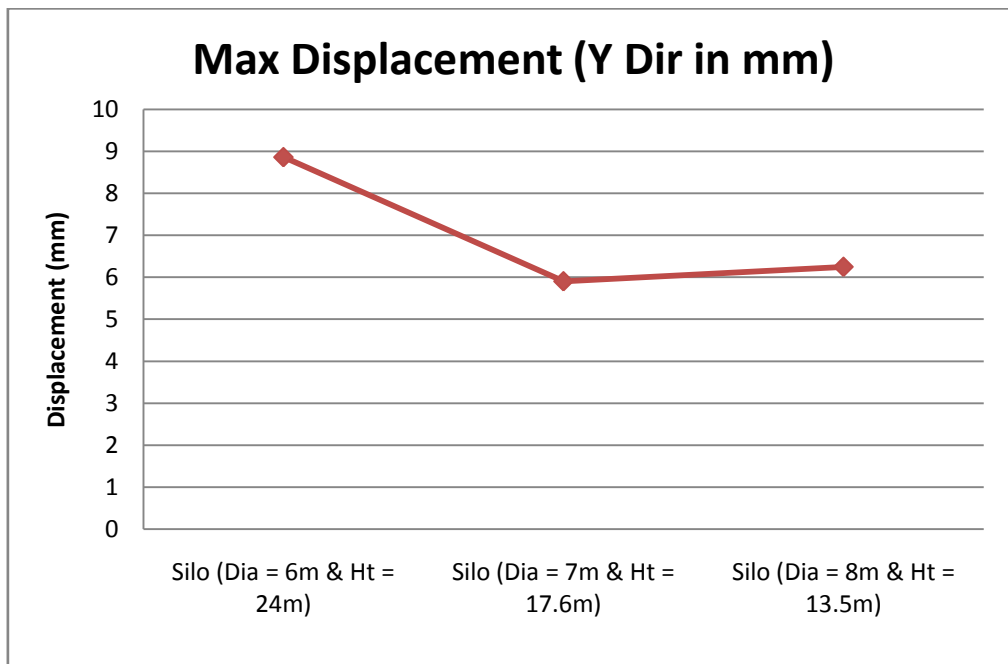


Fig. 5. 3 shows comparison of Maximum Displacement of Silo in Y Direction

Table 5.22 Maximum Displacement of Bunker in X Direction

	Bunker (Dia = 10m & Ht = 8.64m)	Bunker (Dia = 11m & Ht = 7.15m)	Bunker (Dia = 12m & Ht = 6m)
Max Displacement (Y Dir in mm)	2.124	1.926	1.802

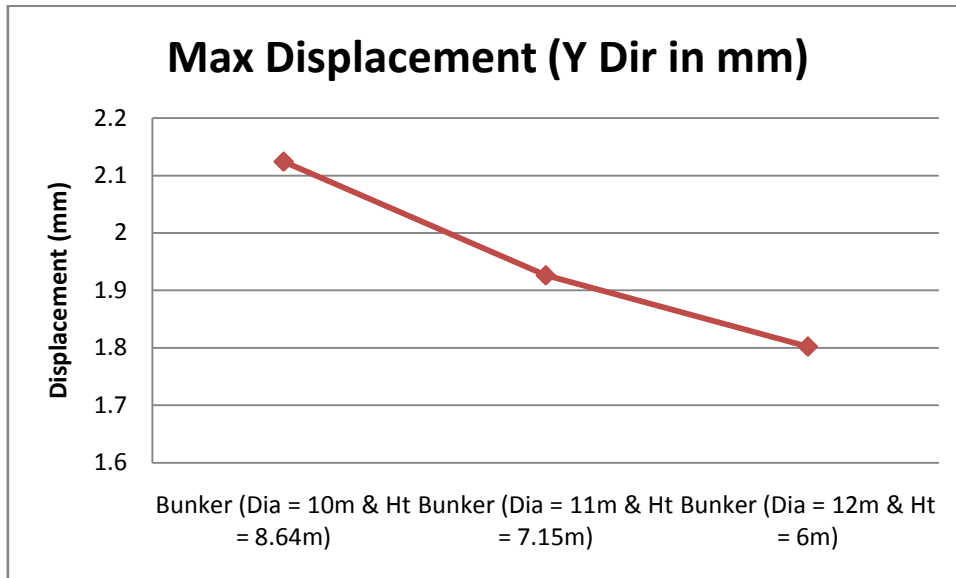


Fig. 5. 4 shows comparison of Maximum Displacement of Bunker in X Direction

Table 5.23 Maximum Displacement of Silo in Z Direction

	Silo (Dia = 6m & Ht = 24m)	Silo (Dia = 7m & Ht = 17.6m)	Silo (Dia = 8m & Ht = 13.5m)
Max Displacement (Z Dir in mm)	13.246	10.719	10.016

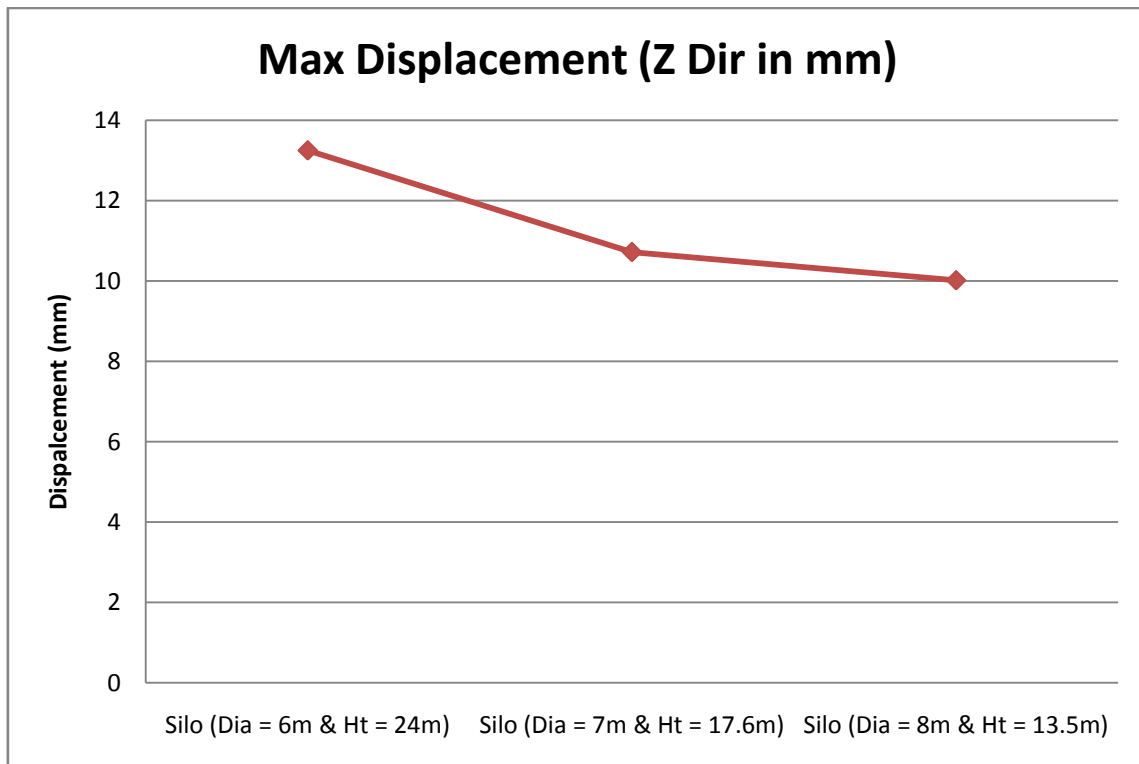


Fig. 5. 5 shows comparison of Maximum Displacement of Silo in Z Direction

Table 5.24 Maximum Displacement of Bunker in Z Direction

	Bunker (Dia = 10m & Ht = 8.64m)	Bunker (Dia = 11m & Ht = 7.15m)	Bunker (Dia = 12m & Ht = 6m)
Max Displacement (Z Dir in mm)	9.444	9.91	10.387

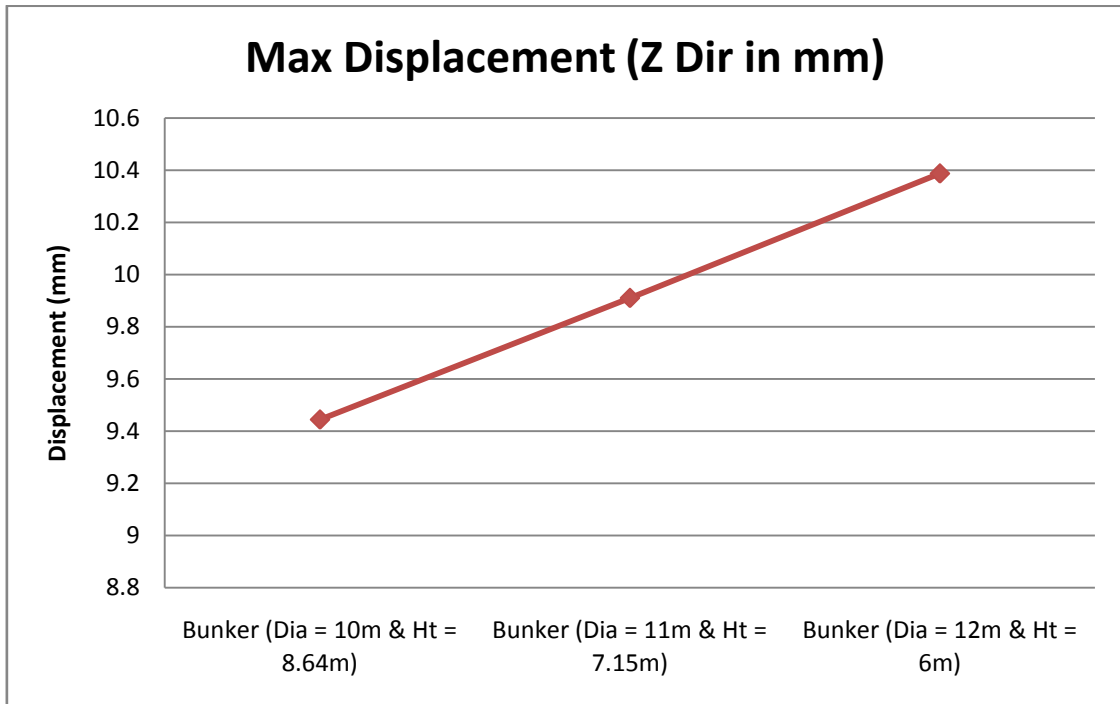


Fig. 5. 6 shows comparison of Maximum Displacement of Bunker in Z Direction

Table 5.25 Maximum Force of Silo in X Direction

	Silo (Dia = 6m & Ht = 24m)	Silo (Dia = 7m & Ht = 17.6m)	Silo (Dia = 8m & Ht = 13.5m)
Max Fx (in KN)	1317.022	738.641	972.402

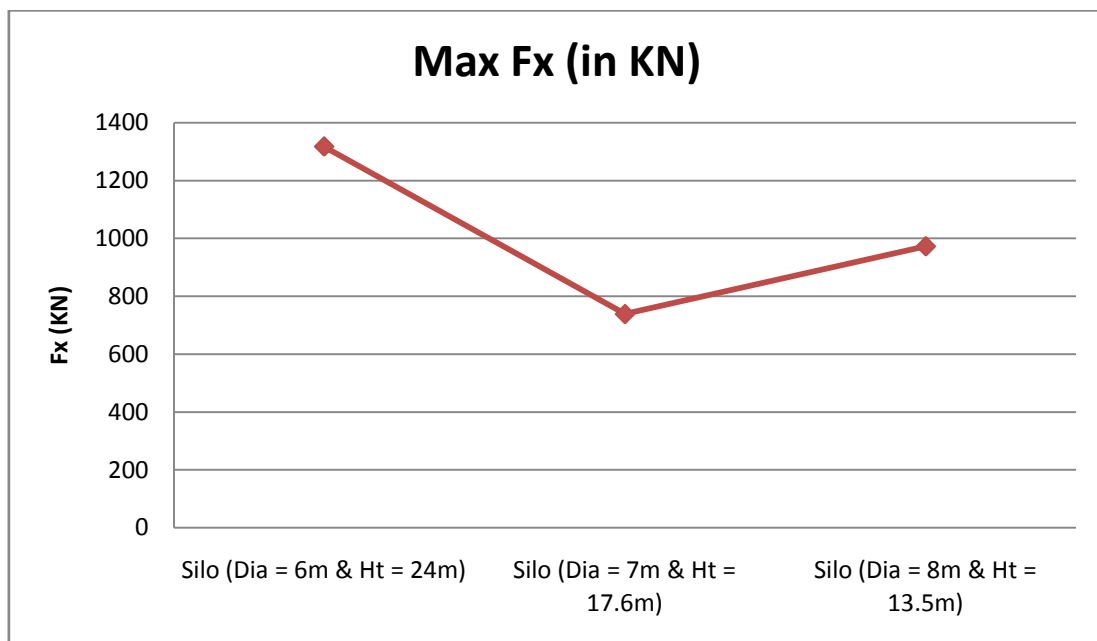


Fig. 5. 7 shows comparison of Maximum Force of Silo in X Direction

Table 5.26 Maximum Force of Bunker in X Direction

	Bunker (Dia = 10m & Ht = 8.64m)	Bunker (Dia = 11m & Ht = 7.15m)	Bunker (Dia = 12m & Ht = 6m)
Max Fx (in KN)	400.186	392.95	392.562

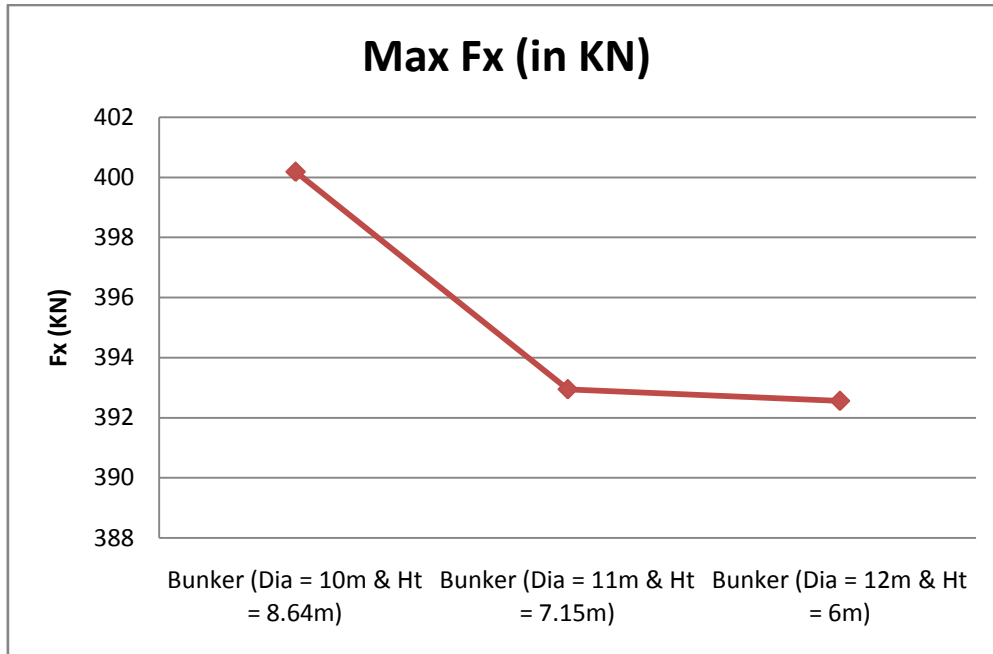


Fig. 5. 8 shows comparison of Maximum Force of Bunker in X Direction

Table 5.27 Maximum Force of Silo in Y Direction

	Silo (Dia = 6m & Ht = 24m)	Silo (Dia = 7m & Ht = 17.6m)	Silo (Dia = 8m & Ht = 13.5m)
Max Fy (in KN)	58.196	33.756	24.965

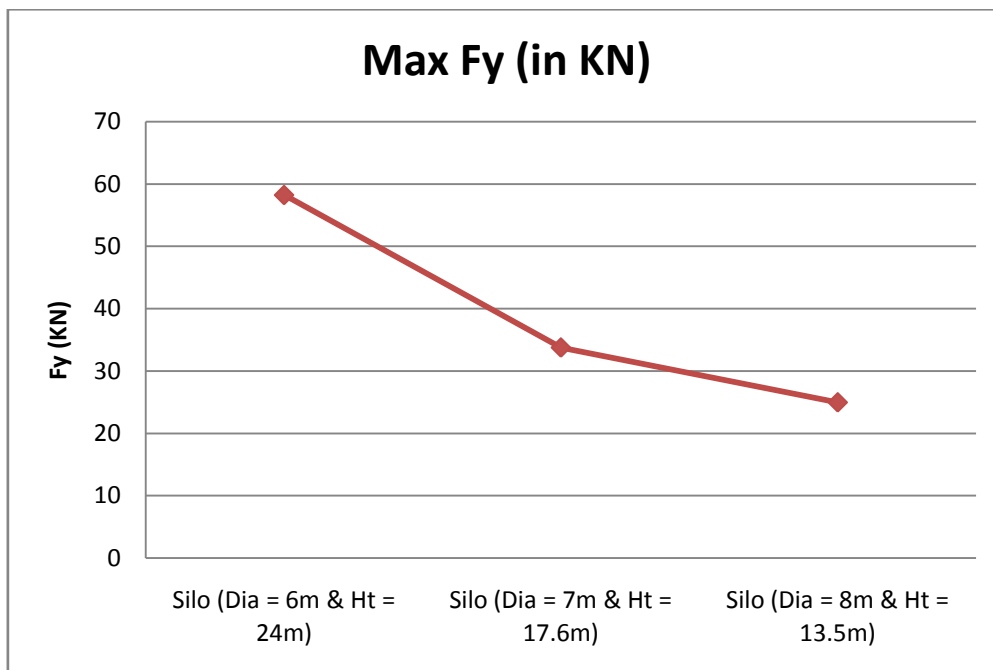


Fig. 5. 9 shows comparison of Maximum Force of Silo in Y Direction

Table 5.28 Maximum Force of Bunker in Y Direction

	Bunker (Dia = 10m & Ht = 8.64m)	Bunker (Dia = 11m & Ht = 7.15m)	Bunker (Dia = 12m & Ht = 6m)
Max Fy (in KN)	11.412	12.511	13.609

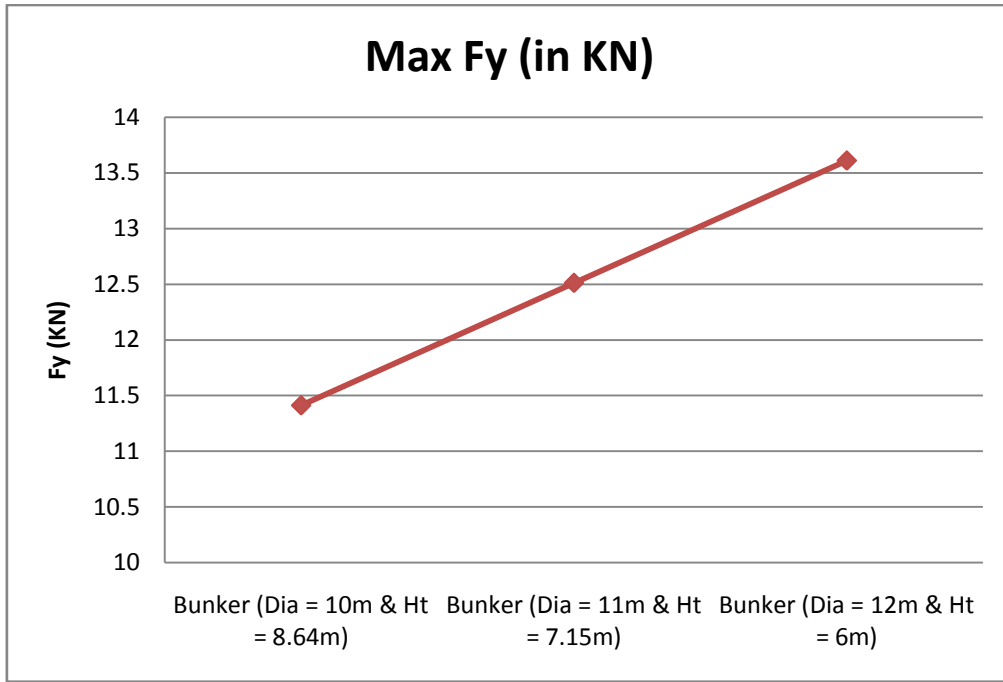


Fig. 5. 10 shows comparison of Maximum Force of Bunker in Y Direction

Table 5.29 Maximum Force of Silo in Z Direction

	Silo (Dia = 6m & Ht = 24m)	Silo (Dia = 7m & Ht = 17.6m)	Silo (Dia = 8m & Ht = 13.5m)
Max Fz (in KN)	50.692	30.233	29.522

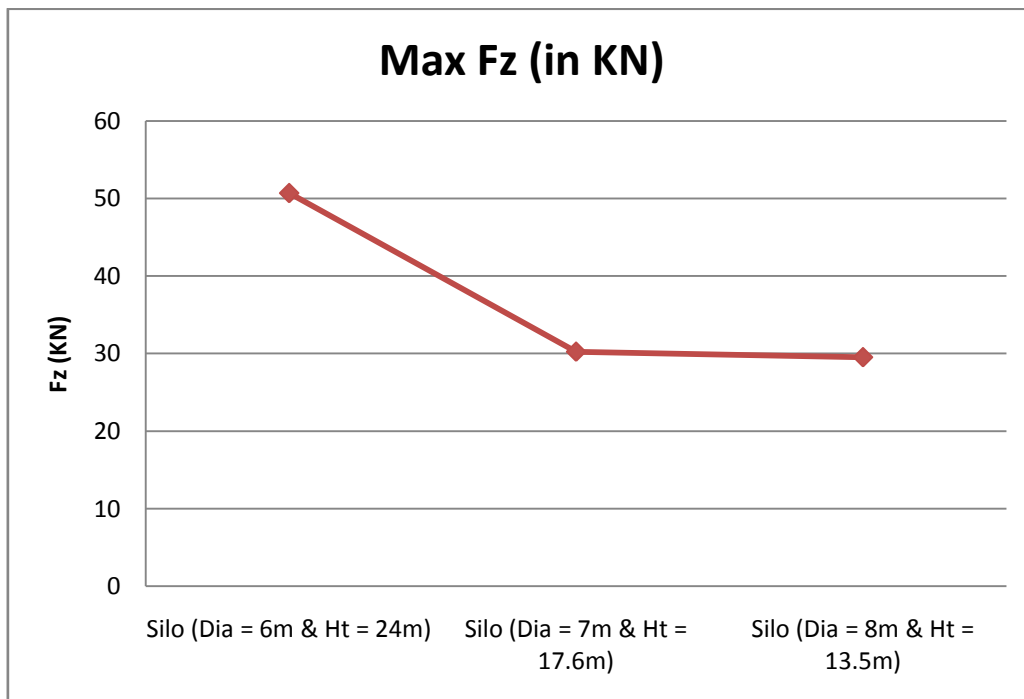


Fig.5.5 Maximum Force of Silo in Z Direction

Table 5.30 Maximum Force of Bunker in Z Direction

	Bunker (Dia = 10m & Ht = 8.64m)	Bunker (Dia = 11m & Ht = 7.15m)	Bunker (Dia = 12m & Ht = 6m)
Max Fz (in KN)	11.376	12.594	13.72

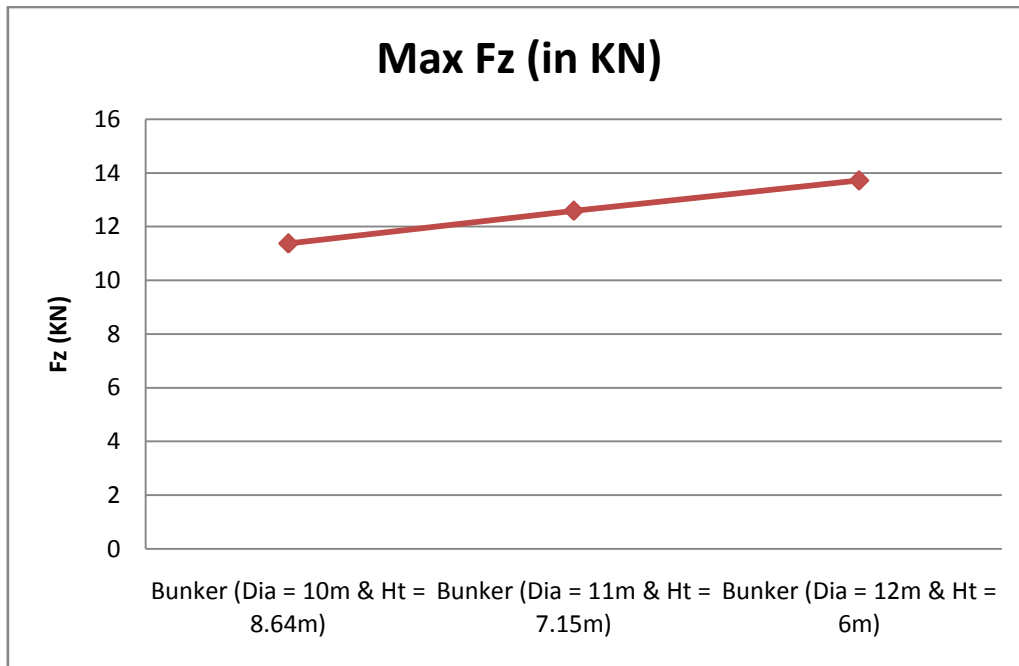


Fig.5.5 Maximum Force of Bunker in Z Direction

Table 5.24 Maximum Moment of Silo in X Direction

	Silo (Dia = 6m & Ht = 24m)	Silo (Dia = 7m & Ht = 17.6m)	Silo (Dia = 8m & Ht = 13.5m)
Max Mx (in KNm)	15.665	10.207	4.777

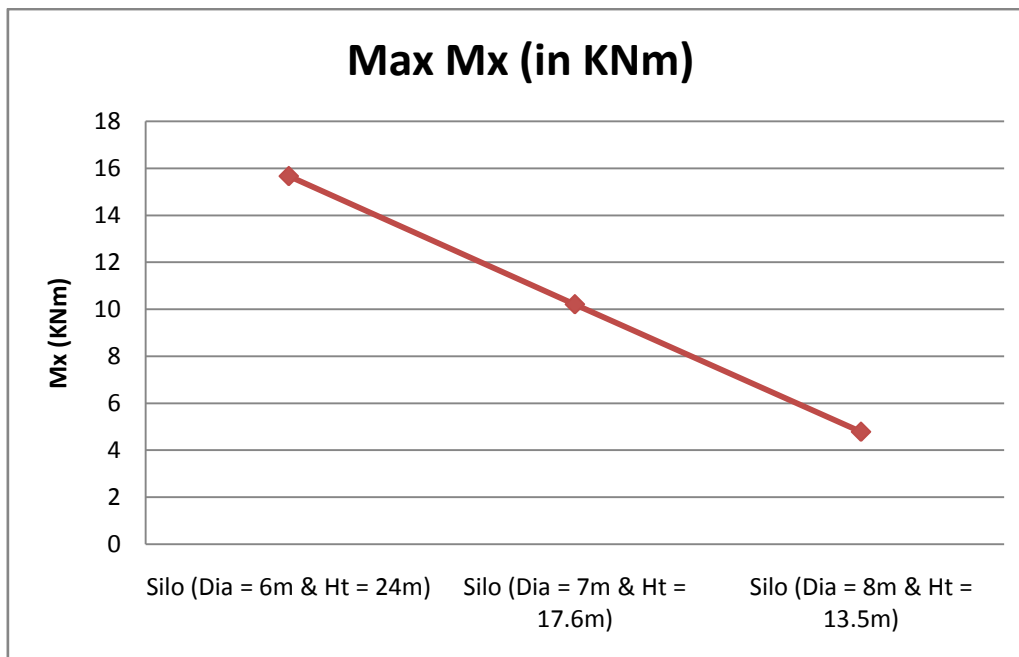


Fig. 5.5 Maximum Moment of Silo in X Direction

Table 5.24 Maximum Moment of Bunker in X Direction

	Bunker (Dia = 10m & Ht = 8.64m)	Bunker (Dia = 11m & Ht = 7.15m)	Bunker (Dia = 12m & Ht = 6m)
Max Mx (in KNm)	2.544	3.712	3.741

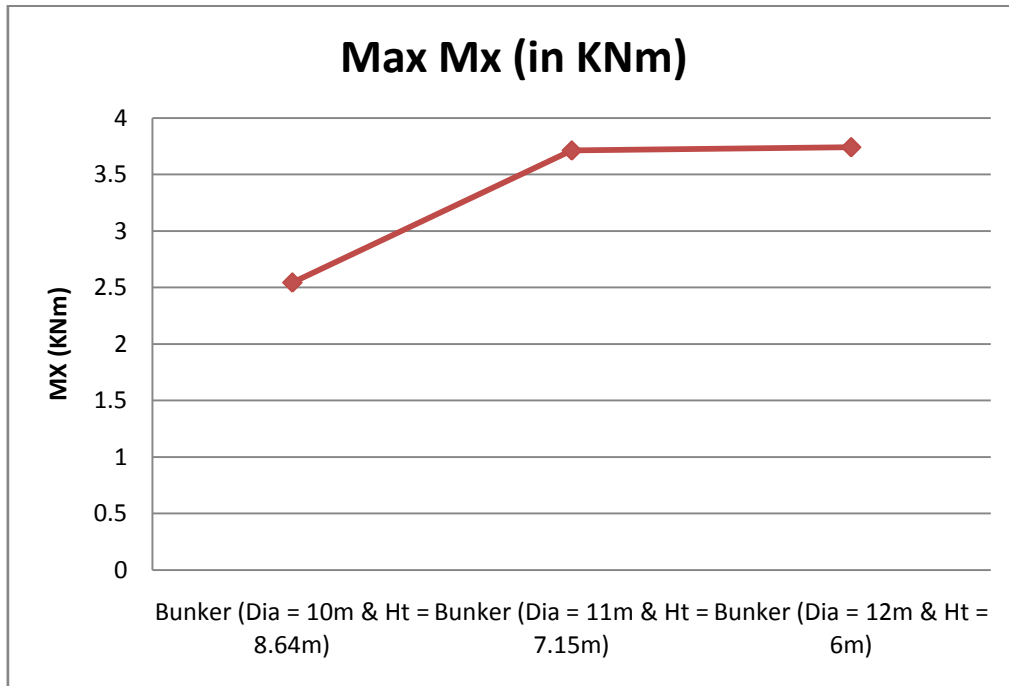


Fig.5 Maximum Moment of Bunker in x Direction

Table 5.24 Maximum Moment of Silo in Y Direction

	Silo (Dia = 6m & Ht = 24m)	Silo (Dia = 7m & Ht = 17.6m)	Silo (Dia = 8m & Ht = 13.5m)
Max My (in KNm)	165.073	95.661	67.888

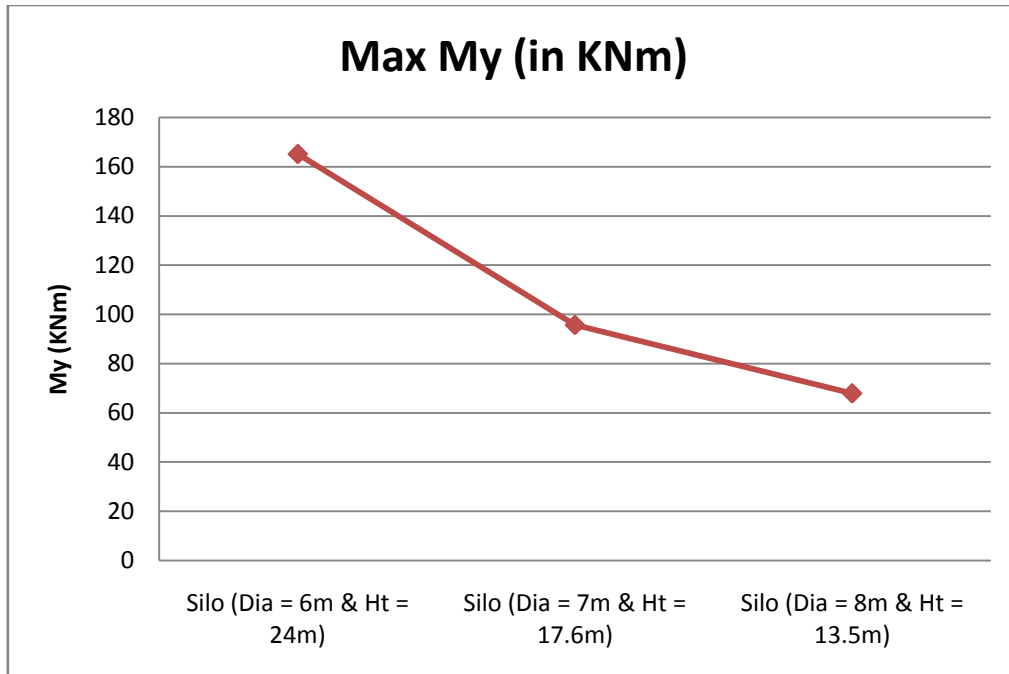


Fig. 5 Maximum Moment of Silo in y Direction

Table 5.24 Maximum Moment of Bunker in Y Direction

	Bunker (Dia = 10m & Ht = 8.64m)	Bunker (Dia = 11m & Ht = 7.15m)	Bunker (Dia = 12m & Ht = 6m)
Max My (in KNm)	28.745	31.829	34.676

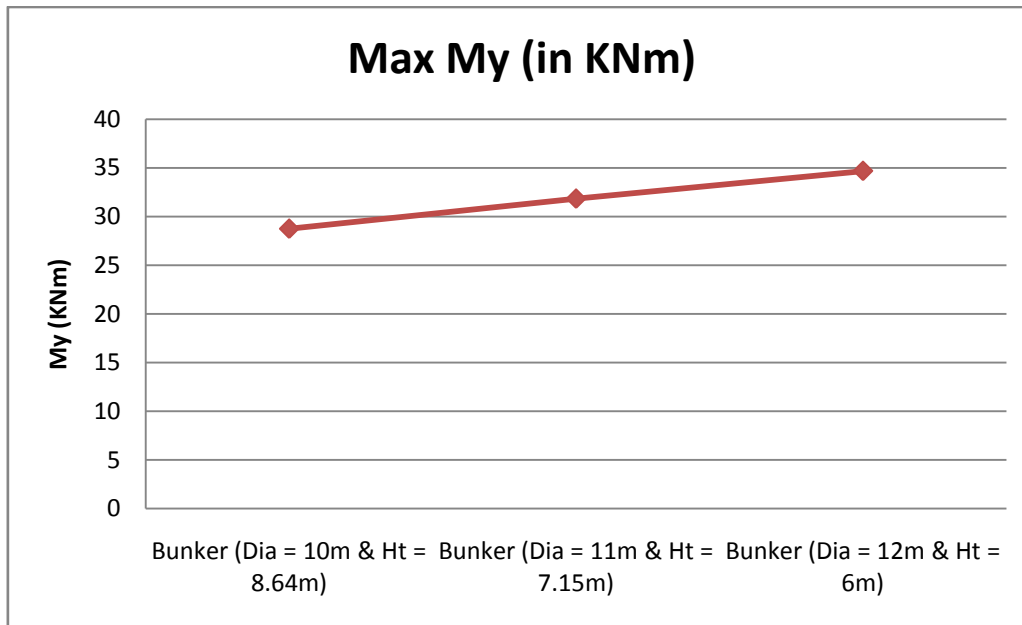


Table 5.24 Maximum Moment of Silo in Z Direction

	Silo (Dia = 6m & Ht = 24m)	Silo (Dia = 7m & Ht = 17.6m)	Silo (Dia = 8m & Ht = 13.5m)
Max Mz (in KNm)	188.938	109.587	75.265

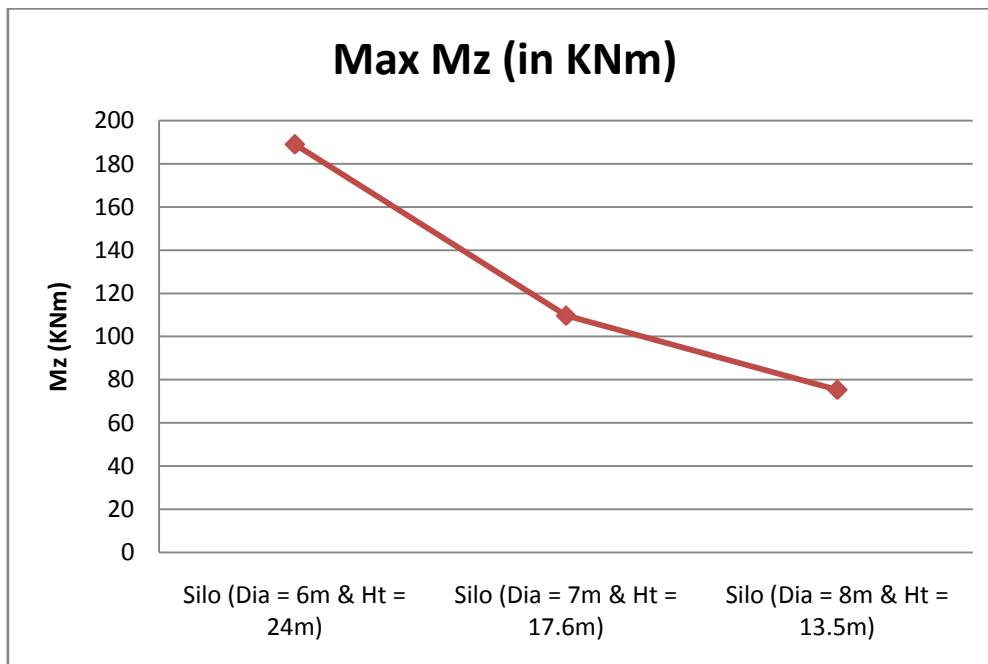


Fig. 55 Maximum Moment of Silo in Z Direction

Table 5.24 Maximum Moment of Bunker in Z Direction

	Bunker (Dia = 10m & Ht = 8.64m)	Bunker (Dia = 11m & Ht = 7.15m)	Bunker (Dia = 12m & Ht = 6m)
Max Mz (in KNm)	28.749	31.549	34.327

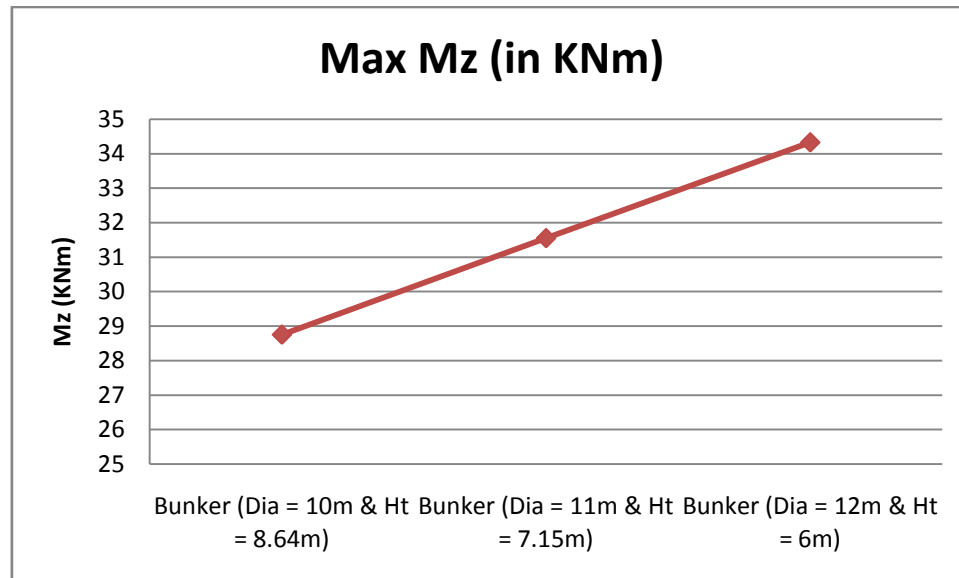


Fig.5 Maximum Moment of Bunker in Z Direction

V. CONCLUSION

- Comparing the displacement results of silo of height 13.5m & bunker of height 8.64 m, we find that silo shows very close result to bunker i.e. 9.95 mm & 9.32 mm, thus silo can be used for further research & design work.
- Silo can be preferred over bunkers.

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