International Journal of Research in Engineering, Science and Management
Volume-3, Issue-1, January-2020
www.ijresm.com | ISSN (Online): 2581-5792

Analysis and Design of Retaining Wall as a Plate with Varying Internal Angle

Shrikrishna Thokal[1], Vikram A. Patil[2], Somanagouda R. Takkalaki[3]
[1]*PG Student, Dept. of Civil Engineering, B. R. Harne College of Engineering and Technology, Mumbai, India*
[2]*Principal, Dept. of Civil Engineering, B. R. Harne College of Engineering and Technology, Mumbai, India*
[3]*Assistant Professor, Dept. of Civil Engg., B. R. Harne College of Engineering and Technology, Mumbai, India*

***Abstract*: Folded plate structures have gained popularity and are used very extensively in Europe and America. Folded plate structures are finding increasing applications in the present day to building practice for covering large column free areas. The economy in covering large column free areas, and consumption of materials, aesthetic views and ease of construction are all in favor of such structures. The behavior of such structures is divided into a transverse slab action and longitudinal plate action. The structural behavior of folded plate is generally 3-dimensional. In this study, Folded plate connected in triangular pattern is used as a retaining wall and the analysis is carried out on the same structures also design of retaining wall by using software is compared with the design by using conventional method by using IS 14458 Part: 2. The thickness and angle of inclination of the plates are taken as 0.15m and 450 respectively. The analysis related to different shapes of retaining wall are carried out the different shapes includes the triangular shape with different internal angle (θ). The angle varies from 300 to 1500 and results of the same are obtained. This study shows that there is 11.8% reduction in the steel when folded plate is used as a retaining wall and also concrete save as 33% more than conventional retaining wall. The thin reinforced-concrete folded plates and shells, as we know today, had its beginnings in Germany in the 1920s. Folded plate structures are now very popular and are used very extensively in many places. The economy in materials, especially where relatively large spans are needed, and the aesthetic advantages are all in favor of such structures. The economy in covering large column free areas, and consumption of materials, aesthetic views and ease of construction are all in favor of such structures. The behavior of such structures is divided into a transverse slab action and longitudinal plate action. The structural behavior of folded plate is generally 3-dimensional.**

***Keywords*: Retaining wall**

1. Introduction

The thin reinforced-concrete folded plates and shells, as we know today, had its beginnings in Germany in the 1920s. Two German engineers, walder and Dischinger were the first to develop a theoretical analysis applicable to reinforced – concrete cylindrical shells around the year 1930 [8]. In this early simplified treatment, the plates were regarded as hinged to each other along their junctions so that longitudinal sliding between them is prevented. The transverse moments at the joints were ignored. Most of the methods developed in Europe were based on the theory of elasticity and led to differential and algebraic equations. Starting from 1947, American engineers have done much to simplify the analysis of folded plates by the development of numerical distribution procedures which are very suitable for use in the design office.

A. Concept of folded plate roof

Folded plate structures are now very popular and are used very extensively in many places. The economy in materials, especially where relatively large spans are needed, and the aesthetic advantages are all in favor of such structures. Other advantages are the ability of hipped plate structures to handle large concentrated loads, or to accommodate openings of appreciable size, and others. Folded plate structures are finding increasing applications in the present day building practice for covering large column free areas. The economy in covering large column free areas, and consumption of materials, aesthetic views and ease of construction are all in favor of such structures. The behavior of such structures is divided into a transverse slab action and longitudinal plate action. The structural behavior of folded plate is generally 3-dimensional.

Fig. 1. Folded plate roof type 1

2. Objectives

First objective of this project is cost comparative study on conventional retaining wall and plate used as a retaining wall which will be very helpful to achieve economy of the structure in case of special architectural features.

- To design retaining wall as a plate with varying internal angle.
- To compare the result, obtain from soil load and water load.

3. Scope

- To understand the behavior retaining wall as a plate with varying angles.
- Comparative study of conventional retaining wall and retaining wall as a plate.
- To understand the behavior of retaining wall as a plate with soil load and water load.

4. Problem statement

This study investigates the effects of triangular shaped retaining wall on the load carrying capacity of the retaining wall. Here, to find the effectiveness of triangular shaped folded plate used as a retaining wall, design is done by using conventional method as per IS 14458 Part:2 and Also by using STAAD pro software.

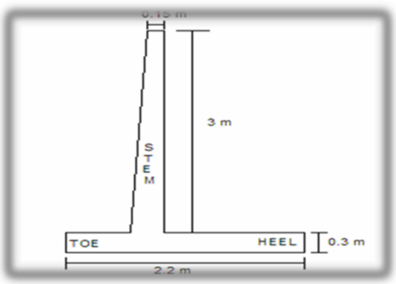

Fig. 2. Diagram of conventional retaining wall

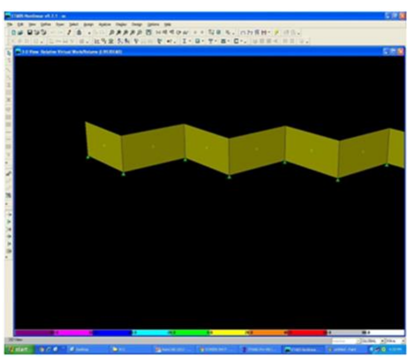

Fig. 3. Diagram of Model of retaining wall in STAAD pro software

5. Methodology

In the present study cantilever type of retaining wall is designed by using conventional method as per IS 14458 Part:2 having height 3 m and subjected to the uniform surcharge of 10 KN/m and check it for overturning, sliding and bearing pressure. Then found the percentage of steel for the various types of steels i.e. main steel as well as distribution steel for Toe, Heel and Stem portions. Then same load is applied on triangular shaped retaining wall and analysis and design of retaining wall was done in STAAD pro software. Details of the design by using conventional method as per IS 14458 Part:2 is as follows

1. Thickness of base slab = 0.3 m
2. Total depth of wall = 3.3 m
3. Base width = 2.2 m
4. Top width = 0.15 m
5. Bottom width = 0.3 m
6. Resisting force and resisting moment

Table 1
Resisting force and resisting moment table

Parts	Area (Sq.m.)	Weight (KN)	PerpendicularDistance (m)	Moment (KN-m)
▲	$\frac{1}{2}\times0.15\times3=0.225$	$0.225\times25=5.625$	$0.6+2\frac{0.15}{3}=0.70$	$5.625\times0.70=3.937$
■	$0.15\times3=0.45$	$0.45\times25=11.25$	$0.6+0.15+\frac{0.15}{2}=0.825$	$11.25\times0.825=9.28$
Base slab	$2.2\times0.3=0.66$	$0.66\times25=16.5$	$\frac{2.2}{2}=1.1$	$16.5\times1.1=18.15$
Back fill	$1.3\times3=3.9$	$3.9\times18.5=72.15$	$0.6+0.15+0.15+\frac{1.3}{2}=1.55$	$72.15\times1.55=111.83$
Surcharge	10KN/m	$10\times1.3=13$	$0.6+0.15+0.15+\frac{1.3}{2}=1.55$	$13\times1.55=20.15$

6. Results

Case - I: Soil load results

In this the reaction load and moment for various internal angles for the different heights of folded plate subjected to soil load are found.

Height = 3m Combined analysis (DL+SL)

ANGLE	MX (KN-m)	MY(KN-m)	MZ(KN-m)
$\theta = 30^0$	-291.23	-66.84	98.70
$\theta = 60^0$	-223.06	-247.19	191.51
$\theta = 90^0$	-240.33	-412.02	255.60
$\theta = 120^0$	-95.85	-494.34	220.36
$\theta = 150^0$	52.45	-613.83	245.29

Height = 3.5 Combined analysis (DL+SL)

ANGLE	MX(KN-m)	MY(KN-m)	MZ(KN-m)
$\theta = 30^0$	-321.73	-90.97	115.15
$\theta = 60^0$	-225.53	-336.42	223.42
$\theta = 90^0$	-227.81	-560.76	298.20
$\theta = 120^0$	-51.72	-672.80	257.09
$\theta = 150^0$	-128.17	-835.42	286.17

Height = 4m Combined analysis (DL+SL)

ANGLE	MX(KN-m)	MY(KN-m)	MZ(KN-m)
$\theta = 30^0$	-343.84	-118.86	131.61
$\theta = 60^0$	-211.91	-439.56	255.34
$\theta = 90^0$	-195.54	-732.68	340.80
$\theta = 120^0$	20.29	-879.07	293.82
$\theta = 150^0$	234.95	-1091.54	327.05

Height = 4.5m Combined analysis (DL+SL)

ANGLE	MX(KN-m)	MY(KN-m)	MZ(KN-m)
$\theta = 30^0$	-356.48	-150.41	148.06
$\theta = 60^0$	-180.05	-556.27	287.26
$\theta = 90^0$	-137.47	-927.21	383.40
$\theta = 120^0$	123.9	-1112.47	330.54
$\theta = 150^0$	376.95	-1381.36	367.93

Combined moments of all angles and heights of folded plate for Soil load

COMBINED MOMENTS (KN-m)				
Angle	H= 3m	H= 3.5m	H= 4m	H= 4.5m
θ = 30⁰	291.23	321.73	343.84	356.48
θ = 60⁰	247.19	336.42	439.56	556.27
θ = 90⁰	412.02	560.76	732.68	927.21
θ = 120⁰	494.34	672.8	879.07	1112.47
θ = 150⁰	613.83	835.42	1091.54	1381.36

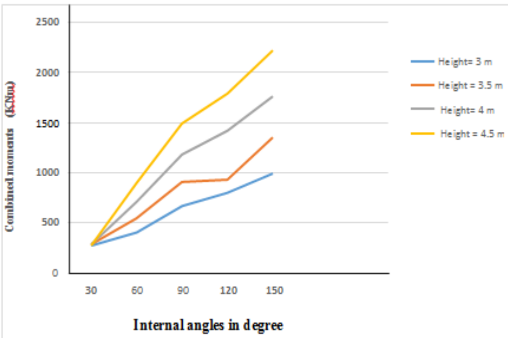

Fig. 4. Graph of combined moment vs. Internal angle

Case- II: Fluid load results

In this the reaction load and moment for various internal angles for the different heights of plate subjected to fluid load are found.

Height = 3m Combined analysis (DL+FL)

ANGLE	MX(KN-m)	MY(KN-m)	MZ(KN-m)
θ = 30⁰	- 265.24	- 107.39	98.70
θ = 60⁰	-173.02	-397.31	191.51
θ = 90⁰	-166.5	-662.24	255.60
θ = 120⁰	-9.81	794.56	220.36
θ = 150⁰	149.03	986.61	245.29

Height = 3.5m Combined analysis (DL+FL)

ANGLE	MX(KN-m)	MY(KN-m)	MZ(KN-m)
θ = 30⁰	-280.42	-146.20	115.15
θ = 60⁰	-146.09	-540.70	223.42
θ = 90⁰	-115.39	-901.25	298.20
θ = 120⁰	33.39	-923.22	221.32
θ = 150⁰	281.49	-1342.70	286.17

Height = 4m Combined analysis (DL+FL)

ANGLE	MX(KN-m)	MY(KN-m)	MZ(KN-m)
θ = 30⁰	-282.19	-190.99	131.61
θ = 60⁰	-93.35	-706.32	255.34
θ = 90⁰	-27.8	-1177.32	340.80
θ = 120⁰	225.64	-1412.56	293.82
θ = 150⁰	463.78	-1753.98	327.05

Height = 4.5m Combined analysis (DL+FL)

ANGLE	MX(KN-m)	MY(KN-m)	MZ(KN-m)
θ = 30⁰	-268.71	-241.69	148.06
θ = 60⁰	-11.26	-893.84	287.26
θ = 90⁰	101.31	-1489.88	383.40
θ = 120⁰	416.23	-1787.57	330.54
θ = 150⁰	702.7	-2219.63	367.93

Combined moments of all angles and heights of folded plate for fluid load

COMBINED MOMENTS (KN-m)				
Angle	H= 3m	H= 3.5m	H= 4m	H= 4.5m
θ = 30⁰	265.21	280.42	282.19	268.71
θ = 60⁰	397.31	540.70	706.32	893.84
θ = 90⁰	662.24	901.25	1177.32	1489.88
θ = 120⁰	794.56	923.22	1412.56	1787.57
θ = 150⁰	986.61	1342.70	1753.98	2219.63

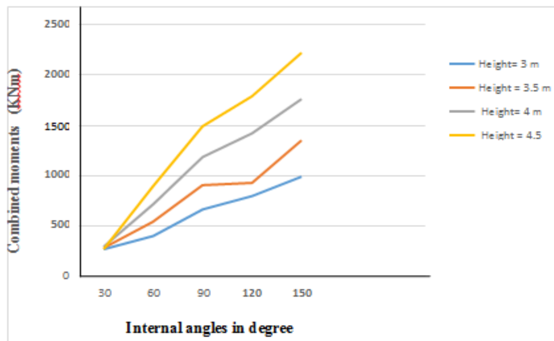

Fig. 5. Graph of Combined Moment vs. Internal Angle

Table 2
Results of designed conventional retaining wall

Part	Main Steel (Kg)	% of Total Qty. required for RW	Distribution Steel (Kg)	% of Total Qty. required for RW	Total %
Stem	436.27 x 2 =872.54	0.38	314.25 x 2 =628.5	0.278	0.658

Table 3
Results of designed plate retaining wall

Part	Main Steel (Kg)	% of Total Qty. required for RW	Distribution Steel (Kg)	% of Total Qty. required for RW	Total %
Stem	399.36x2 =798.72	0.27	399.3x2 =798.72	0.27	0.54

Table 4
Concrete volume reduction

Type	Calculation	Volume of Concrete	Total percentage of reduction
Conventional Retaining Wall	$\frac{0.15+0.30}{2}$x3x1=0.675m³	0.675m³	33.33%
Plate Retaining Wall	0.15x3x1=0.450m³	0.450m³	

7. Conclusion

After the comparison of the design of conventional and plate retaining wall it is found that in plate retaining wall 11.8% reduction in steel quantity is observed which directly helps to achieve economy in the design of retaining wall. Also we can save concrete up to 33% in plate retaining wall. This project helps to use the concept of plate for the construction of retaining wall structure. Analysis of different shapes of plates in retaining wall shows that the internal angle 300 is the optimum angle for soil load and for fluid load.

References

[1] J. A. Puckett and D. L. Wiseman (1991), "compound strip method for folded plates with connecting elements" Vol. 117, No. 1, January, 1991.
[2] Subramani, K. Bharathi Devi, M. S. Saravanan, C. T. Sivakumar, "Cost Comparative Study on Steel Frame Folded Plate Roofing System Vs Conventional Truss Roofing System, Vol. 4, Issue 12(Part 4), December 2014.
[3] Hasmukh Vitlialbhai Trivedi, Sachchidanand Sinha, and Kaveti Seetharamulu (1983) "No prismatic Folded Plates: Tests" This paper is part of the Journal of Structural Engineering, Vol. 109, No. 10, October, 1983.
[4] Tibu Chacko, Ramadass S and Jayasree Ramanujan (2013) "Parametric study on the transverse and longitudinal moments of trough type folded plate roofs using ANSYS".
[5] Mital Desai, Shilpa Kewate, Sneha Hirkane, "Study of fold and folded plate in structural engineering. Volume 5, Issue 12, December 2014.
[6] Martin Trautz, Ralf Herkrath, "The application of folded plate principles on spatial structures with regular, irregular and free-form geometries", October 2009.
[7] ArunTejani, A. A. Parikh (May 2013) "computer aided wind analysis on R.C.C folded plate". Indian journal of research, Volume 3, Issue 4.
[8] S. Muthu keerthana, V. Preetha, "Studies on V-Type R.C.C Folded Plate Roofs". IJIRSET, Volume 5, Issue 3, March 2016.
[9] Bhavin J. Punjani, Kaushik C. Koradia, "Cost optimization of v-type folded plate roof", IJAERD, Volume 2, Issue 3, March 2015.
[10] Albertus Sidharta Muljadinataand A. M. Subakti Darmawan, "Redefining folded plate structure as a form-resistant structure," ARPN journal of Engineering and applied science, April 2016.
[11] IS456:2000
[12] IS2210:1988
[13] https://www.bentley.com/en/products/product-line/structural-analysissoftware/staadpro#sthash.pPo5lk2I.dpuf
[14] https://www.bentley.com/en/products/product-line/structural-analysissoftware/staadpro#sthash.pPo5lk2I.dpuf
[15] https://www.bentley.com/en/products/product-line/structural-analysissoftware