Analysis on Reinforced Soil Retaining Wall To Incorporate The Stability Of Rcc Facia Panels

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Abstract- *There are tremendous increase in the construction of highway and bridges where the height of the approaches are up to certain limits where use of the retaining walls or other rigid retaining structures are uneconomical and most importantly not safe as in view of stability and safety consideration of the structures. So, nowadays the reinforced soil retaining walls are being used by the engineers. These retaining structures are used for maintaining the ground surface at different elevations on either side of it. Reinforced soil retaining wall have gained substantial acceptance as an alternative to conventional masonry and reinforced concrete cantilever retaining wall structures. These walls can be construct for a long height where conventional retaining walls are not suitable in terms of stability, safety, cost and time required for construction. Seismic loading, differential have and settlement requirements make rigid masonry and concrete cantilever walls very difficult to achieve the desired safety factor. Whereas, reinforced soil retaining walls when subjected to seismic loads and differential earth movement has shown exceptional performance due to its flexibility and inherent energy absorption capacity. Even reinforced soil retaining wall is being used widely in India mostly for highways and bridges construction for last more than 20 years.*

I. INTRODUCTION

The reinforced soil retaining structure is used for maintain the ground surface at different elevations on either side of it. These walls are in used for more than 40 years world over and for the last 25 years in India and are increasingly being adopted in highway and bridge construction. Reinforced soil walls technology has almost completely replaced conventional retaining structures with the help of extensible or inextensible reinforcement and facia elements. Over the years these products have helped designers and contracts to solve several types of engineering problems where the use of conventional construction materials would be restricted or considerable more expensive.

Soil is a natural material and its properties are varies with types of soil. Which is mainly depends on its soil parameters i.e. cohesion c and angle of internal friction. During free flow of dry soil, it always makes a slope. It is not in straight vertical face. But in many cases, it is necessary to retain the soil in straight vertical face, like both side of highway, for bridge a but ment, sea walls, submerge walls, wing walls and also for slope stabilization. To This article guides a stepwise walkthrough by Experts for writing a successful journal or a research paper starting from inceptionofideastilltheirpublications.Researchpapersarehighlyr ecognizedinscholarfraternityandform a core part of PhD curriculum. Research scholars publish their research work inleading journals to completetheirgrades.In addition, the published research work also provides a big weight-age to get admissions in reputed varsity. Now, here we enlist the proven steps to publish the research paper in a journal.
retain the soil in vertical face, it is necessary to give a vertical support to the soil and that support is given by Earth Retaining Structure. There are a significant number of geosynthetics types and geosynthetic applications in geotechnical and environmental engineering. Common types of geosynthetic used for soil reinforcement include geotextile (particular oven geotextiles), geogrids and geocells. The mix of improved materials and design methods has made possible engineers to face challenges and to build structures under conditions that would be unthinkable in the past

The development in the theory, design methods and experience of the behavior of these walls gained in laboratories, full scale tests and field applications in India and abroad have brought knowledge from development stage to widespread applications in hands of practicing engineers.

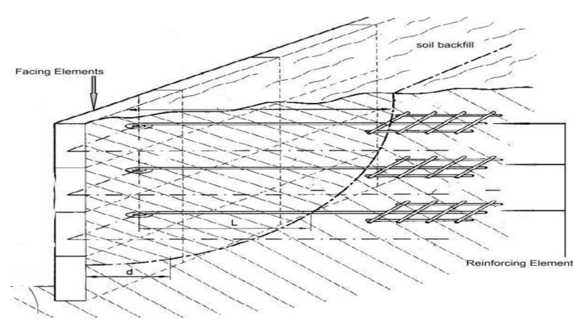

Fig: Facia Panels

Overview

Reinforced soil retaining wall of height 8.00m, 10.00m and 12.00m are considered for thedesign subjected to earthquake loading of zone II has been considered. MS excel programsfor the analysis and designs are used. RCC precast panels of size 1600mm x 1600mm areused of thickness 180mm to retain the backfill soil. Extensible soil reinforcement is assumedfordesignofwall.Henceinthischapterwewilldiscussthee lementsofwall,basicassumptionofgeometryand forces to be

Fig. : Typical cross section of reinforced soil wall

appliedon wall anddesign principles.

3.1 Structural Elements

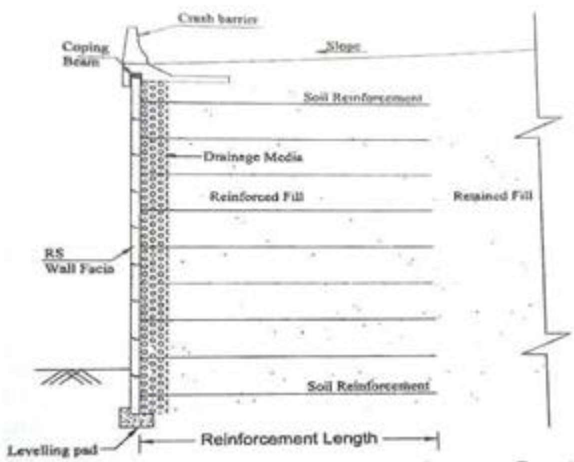

Fig. 3.1 shows the elements of a reinforced soil retaining wall. In addition, following sectiondescribestheelements.

3.1.1 Retained Soil

Retained soil is the layers of earth at a certain height. The main purpose of reinforced soil retraining wall is to hold / retain this soil layer in its position. The retained soil exerts the lateral forces on the wall. The retained soil has angle of internal friction and should be permeable.

3.1.2 Reinforced Fill

Reinforced fill is layers of soil filling which is placed between retained soil and facia of the wall. The reinforced fill of high angle of internal friction must be used. Generally, flash confirming to IRC: SP-58 is used for design and construction of the walls.

3.1.3 Facing Elements

The spacing is provided to prevent the spilling/falling over of fill and also to provide firm anchorage to the reinforcements. Facing should be tough and robust. Facing also provided architectural finishes to the structure.

Facing system shall be one of the following (Refer MORT&H specification – 2013)

- Precast reinforced concrete panels
- Precast concrete blocks and precast concrete hollow blocks
- Gabion facing
- Wrap around facing using geosynthetics
- Metallic facing
- Other proprietary and proven system

3.1.4 Traffic Barriers

Traffic barriers are constructed over the front faces of reinforced soil wall. Commonly a friction slab is used to transfer the lateral loads sue to the impact of vehicles on barriers. Typically, a friction slab varies from 1500 to 2500 mm width and 250 mm thick depending on the types of the crash barrier used. Fig. 3.2 shows a typical section of traffic barrier over a reinforced soil wall.

3.2 DesignParameters

3.2.1 BasicAssumptions

Basicdesignassumptionsaregivenintable3.1asshownbelow:

Table3.1:Basic assumptions

RCC Facia Panel	Size of facia panel – 1600(Length) x 1600(Width) x 180 (Thick.) mm Grade of concrete - M35 Grade of steel – Fe500
Reinforced Soil Retaining Wall	Height of wall – 8.00m, 10,00m, 12,00m Length of reinforcement – 6,50m, 8,50m, 9,50m respectively Embedment depth in soil – 1.00m Batter of wall – 90 Degree
Backfill Soil and Reinforced Fill Property	Unit weight of soil – 18 kN/m3 Angle of internal friction – 32 Degree

FoundationSoilProperty	Unitweight ofsoil–18kN/m3 Angle of internal friction of soil – 30 DegreeCohesion -0
SeismicData	Seismiczone– II Ground peak co-efficient – 0.10 (As per IS1893:2016)Max.hor.Accelerationcoefficient –0.14(Asper IRCSP102:2014, Eq.A3.1)
Reinforcement Type	ExtensibleReinforcement
StripDetails	Width ofstrip– 2.00m DistancefromWallEdge toCentreofStrip Load–1.00m

3.2.1 LoadsAssumptions

Thebasicloads tobeappliedfordesignof reinforcedsoil wallsare as follows:

- Self weight of structure: - Self weight of structure including weight of reinforcement andreinforcedfill is considered.The weight of thefacia panels isnotconsidered.
- Strip load :- Strip load due to weight of crash barrier, friction slab and road crust isconsideredas**40.00 kN/m^2**.
- Live load :- Live load on the reinforced soil wall as per IRC:78-2014 provision isconsideredas**24.00 kN/m^2**.
- Earth pressure behind facia panel :- Active earth pressure for overall height of wall isconsidered.Earth pressureexert alateral forceonwall.
- Surcharge load :- When the live load is applied above the wall it exert a lateral force atsomeintensityin lateraldirection whichis term as surchargeload.
- Earthquake load :- When the earthquake become active it cause the vibration among thestructural elements andalso retained soil which exert an certainamount of forces onwall for which the reinforced soil wall is also to be check and designed. The earth load iscalculated in terms of horizontal inertia force (P_{IR}) and seismic thrust (P_{AE}) which arecalculated as pertheIRC: SP: 102-2014 guidelines.

Internal Stability:

- Rupture of reinforcement :- The rupture of reinforcement due to the tension force acting on the wall and reinforcement should satisfy the rupture failure criteria. The rupture of reinforcement for static load cases can be calculated by two methods, i.e. “Tie Back Wedge Method” and “Coherent Gravity Method”. As per IRC: SP: 102-2014 and BS 8006-1:2010 guidelines, tie back wedge method is suitable for extensible reinforcement and coherent gravity method is suitable for inextensible reinforcement. As the present work is using the extensible reinforcement as soil reinforcement, “Tie Back Wedge Method” is used in the design of reinforcement soil retaining wall. For seismic cases clauses of IRC:SP:102-2014, annexure A3, clause A3.1.2 and A3.1.4 is used.

- Pull-out failure of reinforcement :- The pull out is adherence property check for the reinforcement. For static load cases IRC:SP:102-2014, annexure A2 is being used. The pull out resistant factor for this case is 1.3 as per load factor table. For seismic cases clauses of IRC:SP:102-2014, annexure A3, clause A3.1.3 is used where factor of safety against pull out should be ≥ 1.5.

If the criteria of rupture failure is not satisfied for all reinforcement layers, the reinforcement length has to be increased and/or reinforcement with greater pullout resistance per unit width must be used or vertical spacing must be reduce to reduce maximum tension forces occurring on reinforcement.

IV. DESIGN OF REINFROCED SOIL RETAINING WALL

Design of ReinforcedSoilWallof 8.00mHeight

Design Input

ReinforcedFillData

Angleofinternalfriction	ϕ=	32	o
Unitweightofsoil	γ_1=	18	kN/m^3

RetainedBackfillSoilData

Angleofinternalfriction	ϕ=	32	o

Unitweightofsoil	□$_2$=	18	kN/m^3

FoundationSoilData

Cohesion	C =	0	
Angleofinternalfriction	ϕ=	30	o
Unitweightofsoil	□$_3$=	18	kN/m^3

SIDLoad			kN/m^2
Verticalstriploadduetocrashbarrierandroad crust	=	40	

StripLoadDetail

Width of thestrip load	b =	2.00	m
DistancefromWallEdgetoCentreofStrip Load	d =	1.00	m

Check for Sliding along the Base

For long term stability where there is soil to soil contact at base of the structure $f_s R_h \leq R_v(\tan Ø'_p / f_{ms})+(C'*L / f_{ms})$

Where, R_h is the horizontal factored distribution R_v is vertical factored resultant force
$Ø'_p$ is the peak angle of shearing resistance under effective stress condition
f_{ms} is the partial materials factor applied to tan Ø'p, C', Cu f_s is the partial safety factor against base sliding
L is the effective base width for sliding
Sliding force $(R_h) = (P_1 + P_2)\, f_{fs}$ Resisting force $= R_v.f_{fs}(\tan Ø'_p / f_{ms})$ Sliding force $(f_s. R_h)$

Table: Check for sliding of wall at reinforcement layers (Case A)

Case A									
Layer	**Depth**	**Length**	**Svi**	**Rvi**	**Rvi. Tanϕ**	**Rhi**	**Rvi / Rhi**	**FOS**	**Check**
	m	**m**	**m**	**kN**	**kN**	**kN**			
1	0.40	6.50	0.80	1629.30	1018.10	401.91	2.53	1.3	**OK**
2	1.20	6.50	0.80	1559.10	974.23	369.61	2.64	1.3	**OK**
3	2.00	6.50	0.80	1418.70	886.50	309.00	2.87	1.3	**OK**
4	2.80	6.50	0.80	1278.30	798.77	253.69	3.15	1.3	**OK**
5	3.60	6.50	0.80	1137.90	711.04	203.69	3.49	1.3	**OK**
6	4.40	6.50	0.80	997.50	623.31	159.01	3.92	1.3	**OK**
7	5.20	6.50	0.80	857.10	535.58	119.63	4.48	1.3	**OK**
8	6.00	6.50	0.80	716.70	447.84	85.56	5.23	1.3	**OK**
9	6.80	6.50	0.80	576.30	360.11	56.80	6.34	1.3	**OK**
10	7.60	6.50	0.80	435.90	272.38	33.35	8.17	1.3	**OK**

Rhi	**Rvi / Rhi**	**FOS**	**Check**
kN			
401.91	2.53	1.3	**OK**
369.61	2.64	1.3	**OK**
309.00	2.87	1.3	**OK**
253.69	3.15	1.3	**OK**
203.69	3.49	1.3	**OK**
159.01	3.92	1.3	**OK**
119.63	4.48	1.3	**OK**
85.56	5.23	1.3	**OK**
56.80	6.34	1.3	**OK**
33.35	8.17	1.3	**OK**

Design of Reinforced Soil Wall 10.00 m Height
Design Input Parameters
Reinforced Fill Data

Angle of internal friction	ϕ_1 =	32	o
Unit weight of soil	□$_1$ =	18	kN/m^3

Retained Backfill Soil Data

Angle of internal friction	ϕ_2 =	32	o
Unit weight of soil	ϕ_2 =	18	kN/m^3

Foundation Soil Data

Cohesion	C =	0	
Angle of internal friction	ϕ_3 =	30	o

Unit weight of soil ϕ_3 = 18 kN/m^3

SID Load

Vertical strip load due to crash barrier and road crust = 40.0 kN/m^2

Strip Load Detail

Width of the strip load b = 2.00 m

Distance from Wall Edge to Centre of Strip Load d = 1.00 m

Live load

Live load surcharge = 24.0 kN/m^2

Live load is considered as per provision of IRC:78-2014

Seismic Data

Seismic Zone = II

Ground peak co-efficient A = 0.10 *(...As per IS 1893:2016) (...As per IRC SP 102:2014,*

Max. hor. acceleration Coefficient A_m = 0.14 *eqn.A3.1)*

V. RESULTS

Thecomputationofresultsofdesignof reinforcedsoilretainingwallispresentedbelow:

ExternalStability

Following tables representthecomputedvaluesofforcesofslidingandresistingforwallsofheight 8.00m, 10.00mand 12.00m forload cases A,Band C.

Table: Sliding and resisting forces for load case A

Sr. No.	Forces (Case A)	Height of wall		
		8.00 m	**10.00 m**	**12.00 m**
1	Sliding force (kN/m)	424.75	630.49	876.06
2	Resisting force (kN/m)	1098.52	1700.27	2212.04

Table: Sliding and resisting forces for load Case B

Sr. No.	Forces (Case B)	Height of wall		
		8.00 m	**10.00 m**	**12.00 m**
1	Sliding force (kN/m)	424.75	630.49	876.06
2	Resisting force (kN/m)	781.09	1197.25	1545.93

Table: Sliding and resisting forces for load case C

Sr. No.	Forces (Case C)	Height of wall		
		8.00 m	**10.00 m**	**12.00 m**
1	Sliding force (kN/m)	365.30	554.20	782.12
2	Resisting force (kN/m)	634.87	1006.04	1332.22

Above Table represent the computed values of overturning and resisting moments for walls of height 8.00m, 10.00m and 12.00m for load cases A, B and C.

VI. CONCLUSION

The conclusion base on analysis and design ofreinforced soil wall for 8.00m, 10.00m and12.00m is presented in thischapter. The conclusion base on the work done and observationthroughfield experiencearepresented here.Thewall failurecan occur mainlyon ofthefollowingways,

A) Sliding of wall from the base
B) Sliding of soil in reinforcement
C) Ruptureofreinforcementduetotensionforces
D) Pulloutfailureofreinforcement

from the paper it is concluded that reinforced soil retaining wall have better stability and can beconstructed for a large height of wall as compared to the rigid retaining walls. It has ability toM perform better in seismic condition a sitis flexible innature.Increaseinlengthofthereinforcement improves the stability of the wall by increasing the resisting forces acting on wall.With increase in reinforcement length the base pressure is also distributed over a large area.Rupture and pull out failure of reinforcement cause due to forces acting on wall and the frictionbetweenthe soil andreinforcement layers whichgeneratetension forces.

If a reinforcement layer fails in rupture then reinforcement of higher tension carrying capacitymustbeused.Ifthecriteriaofpulloutfailurearenotsatisfied thenlengthofreinforcementhasto be increased and/or reinforcement with a greater pull out resistance per unit width must beused or vertical spacing of reinforcement must be reduce which would reduce the tension forcesactingonwall.

The internal friction angle of soil is also most important parameter as the basic principle ofmechanically stabilization of earth depends on it. If soil is weak choose backfill soil of highinternal angle of friction. Strata of foundation soil do not affect that much on safety of reinforcedsoilwallintermsofbearingpressure.Asreinforcedsoilwallhaslargerareaforthedistribution of pressure coming from wall to transfer to the base. If soil has low bearing capacity then, length of reinforcement needs to be increase which will also increase contact area of pressure with the foundation soil or other soil improvement techniques should be adopted.

Facia panels play important role in stability of wall. It perform action of retaining the soil in reinforcement layers, used as anchoring media for reinforcement layers and resist the earth pressure and tension forces coming on it. So, facia panels of higher grade of concrete must be used and must be design to resist the earth pressure, surcharge loads and tension forces coming from reinforcement layers. Generally, IRC and MORT&H guidelines suggested to use minimum M35 grade of concrete with minimum 140 mm thickness as per IRC:SP:102-2014 and 180 mm thick as per MORT&H 2013 guideline. Design of precast RCC facia panels do not required heavy reinforcement as per design.

SuggestedFurtherWork

In India reinforced soil wall is being use mostly for highway and bridges construction to retain the earth of for larger heights and extensible reinforcement are being used by the designer and contractors. Reinforcement of reinforced soil wall is of two types which is extensible and inextensible. It is suggested that a design and practical comparison between reinforced soil wall with extensible and inextensible reinforcement must be carried out to understand the structural behavior due to both types of reinforcement and best suitable.

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