ISSN No:-2456-2165

Design and Construction of Bridge Embankment using R.E. Wall Panels

S.Sandana Socrates[1], Dr. S. Lavanya Prabha[2], & S.Raja[3]
[1]PG Scholars, Department of Civil Engineering, Easwari Engineering College, India
[2]Professor& Head, Department of Civil Engineering, Easwari Engineering College, India

Abstract:- In this paper the analyses and design for the bridge embankment have been made and the study of its construction techniques is also explained. Excel and Plaxis 2D software are used for analysis of stabilities and response of the structure. The bridge embankment consists of skin, fill and soil reinforcement. The stability of embankment depends on surcharge load, soil fill and soil reinforcement. Para-web technology is a modern method for soil reinforcement in embankment to replace Geo-grid. Mechanically Stabilized Earth method is adopted for construction of artificial embankment and Precast RE wall panels are used as skin. Different types of filling materials can be used of which fly ash is found to have higher strength than other alternative materials. This paper can help the future to construct artificial bridge embankment in a simple and faster ways where less skilled labours are required.

***Keywords**:- Embankment, Mechanically Stabilized Earth, Soil reinforcement, Geo-grid.*

I. INTRODUCTION

A. General

Bridge embankment is a combination of earth fill, linear reinforcing strips and facing panels that are capable of bearing highway load and large tensile stresses. In earlier method, granular materials and soil were used as fill. The soil reinforcements used in earlier method were steel bars and geo-synthetic materials. The reinforcement provided by these strips enable the soil mass to resist the tension in a way which the soil alone could not resist. The source of this resistance to tension is the internal friction of soil, because the stresses that are created within the mass are transferred from soil to the reinforcement strips by friction.CIP Cantilever/ Counterfort Retaining walls, Gravity Blocks Retaining wall and Sheet-pile/Anchored walls were used as skin of the structure.

There is necessary for modernisation of bridge embankment using the results from the above construction method. The factors considered for modernisation are faster construction, pore water pressure, corrosion of soil reinforcement, differential settlement, construction cost and economical usage of land.

B. Objectives

- To analyse and design the bridge embankment using the design principle of reinforced earth structure.
- To study on effective alternate components used for embankment to replace the materials used in existing method.
- To study about the stability of embankment such as External stability, Internal stability and Seismic stability.
- To find out the forces and stresses produced in soil reinforcement.

C. Advantages

- Alternate construction materials (fly ash, polymeric strap and pre-cast wall panels) used are light, easy to transport and quick to construct.
- The only machinery required is excavator and compactor.
- Differential settlement is eliminated & bearing capacity is increased.
- Rapid construction is expected.
- This technique can result in saving the area of land.

D. Important materials for embankment

1. Fly ash
2. Skin
3. Reinforcement

E. Fly ash

Soil or fly ash is the important component for embankment to carry highway loads. It may be natural or artificial material which depends on the location of construction. It should be granular, cohesion less material and for the case of silt or clay the particle size should not more than 125 mm. The earth reinforcement coefficient of friction to be either higher than or equal to 0.4 and Plasticity Index should be less than 6. The soil must have moisture content suitable for compaction. Fly ash (Class F) to be used as fills in this method.

Fig 1:- Fly ash fill

ISSN No:-2456-2165

F. Facing elements (skin)

Skin is the facing element of the reinforced soil wall. This element keeps the reinforcement at a desired elevation in the reinforced soil wall and also protects the granular material at the edge of the soil mass from falling off. These are made of either metal units or pre-cast concrete panels. It should be able to deform without distortion.

Fig 2:- Precast RE wall panels

Fig 3:- Panel placement for initial course

G. Reinforcement for fill

A variety of materials can be used as reinforcing materials such as Steel, Concrete, Glass fibre, Wood, Rubber and Aluminium. Reinforcement may take the form of strips, grids, anchors & sheet material, chains, planks, rope, vegetation and combinations of these or other material forms. The main aim of providing reinforcement in soil is to bear large tensile stresses and to carry the facing elements from falling off. For developing countries, polymeric strap is used as soil reinforcement.

Fig 4:- Polymeric Strap as reinforcement

II. CONSTRUCTION METHODOLOGY

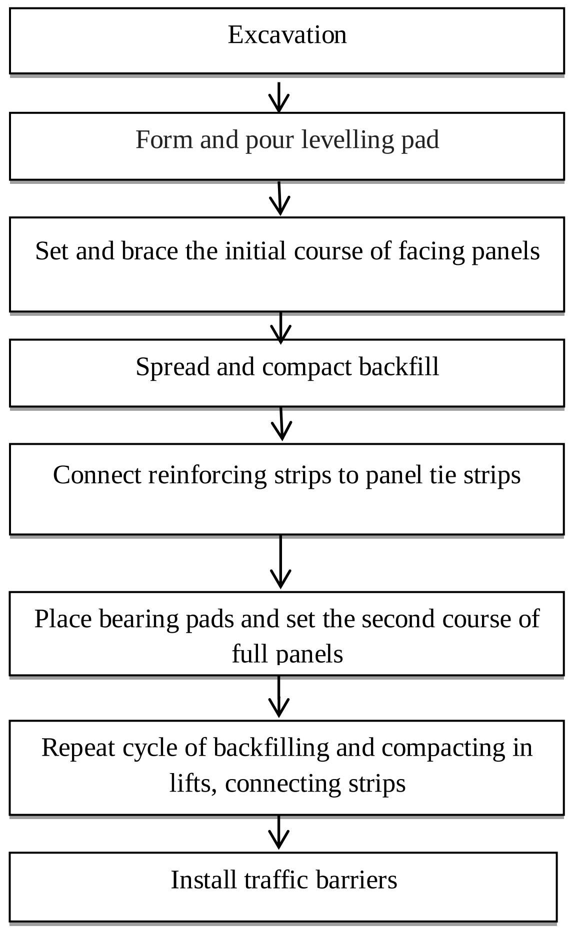

Fig 5:- Construction Procedure

Existing method	Modern method
Payments laid on natural earth for transportation purpose.	Embankment can be raised artificially using filler materials similar to mechanically stabilised earth.
Steel rods/meshes were used as soil reinforcement.	Geo-grid/polymeric strap can be used as soil reinforcement.
Clay/silty soil or granular materials were used as fill for reinforced earth structure.	Fly ash can be used as filler material inside the structure.
For facing of the structure, gravity retaining walls/cantilever retaining walls were used.	Pre-cast wall panels can be used as skin of the structure and these are interconnected to soil reinforcement.
It needs large equipments and construction area for filling and compaction purposes.	It needs only simple equipments for panel lifting, backfilling and compaction processes.
Require high skilled person.	Since it is a simple technique, the structure can be completed with less-skilled person.

Table 1. Comparison of methodology

A. Equipments

- *Panel lifting* – A hydraulic crane, boom truck or similar equipment is required.
- *Backfilling* – Dump trucks, scrapers, dozers, graders, front-end loaders, water trucks, etc, are used for hauling dumping and spreading backfill. (Specific equipment selection will depend on backfill, lift thickness, compaction specifications, etc).
- *Compaction* – Large smooth-drum vibratory rollers are used for mass compaction of most backfills. Fine uniform fills are compacted using a smooth-drum static roller.

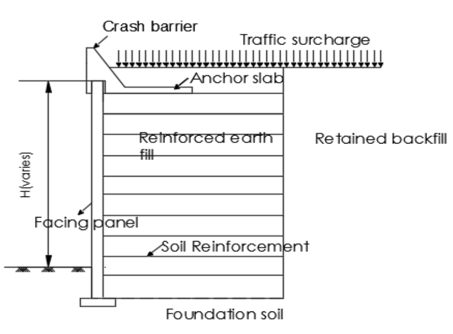

Fig 6:- Sample c/s of Reinforced earth structure

III. STEPS INVOLVED IN DESIGN PROCESS

- Load calculation
- Design of reinforced earth structure

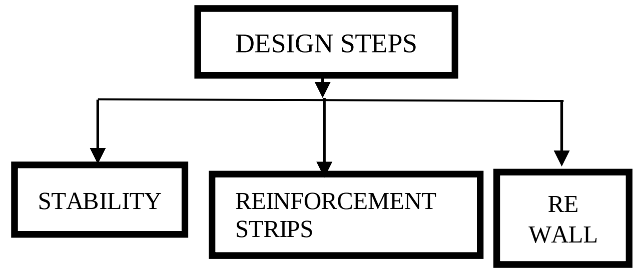

Fig 7:- Design steps

IV. ANALYSIS AND DESIGN

Design of reinforced earth structure consists of three phases – 1.Stability, 2.Reinforcement strips & 3.RE wall.

A. Load

For 4-lane highway road (i) Class A & (ii) Class 70 R are used (IRC: 6-2014 'STANDARD SPECIFICATIONS AND CODE OF PRACTICE FOR ROAD BRIDGES')

DEAD LOAD	12 kN/m^2
LIVE LOAD (CLASS A)	23.23 kN/m^2
LIVE LOAD (CLASS 70 R)	20.46 kN/m^2

Table 2. Load comparison

Effects	Load combination		
	A	B	C
Earth pressure behind the structure	1.5	1.5	1.0
Traffic load behind reinforced soil block	1.5	1.5	0.0

Table 3. Partial Load Factors

B. Stability analysis

The stability analyses (External, Internal and Seismic) are made using BS 8006: 1995- 'CODE OF PRACTICE FOR STRENGTHENED REINFORCED SOIL AND OTHER FILLS'.

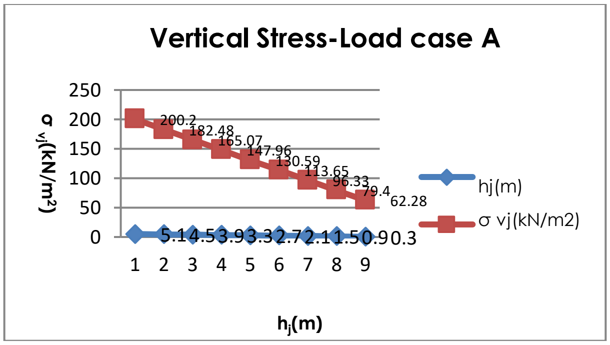

Fig 8:- Vertical stress vs. Height

C. Tension capacity of embankment

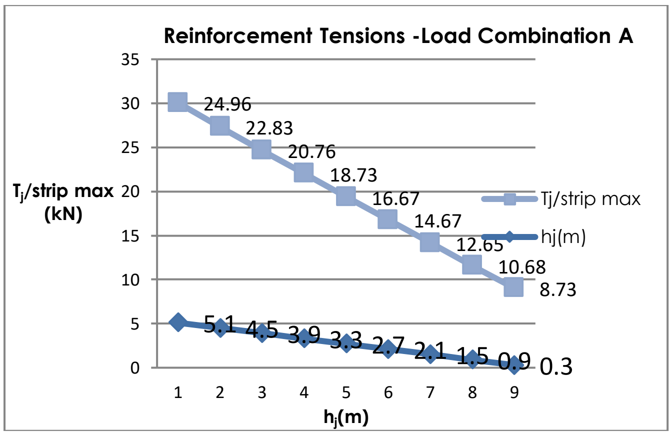

Fig 9:- Reinforcement tension vs. Height

Reinforcement types	T_{ult} (kN)	T_D (kN)
KO 20	20	10.565
KO 30	30	15.848
KO 50	50	26.413
KO 70	70	36.978
KO 100	100	52.826
KO 120	120	63.391
KO 150	150	79.329

Table 4. Types of reinforcement strips

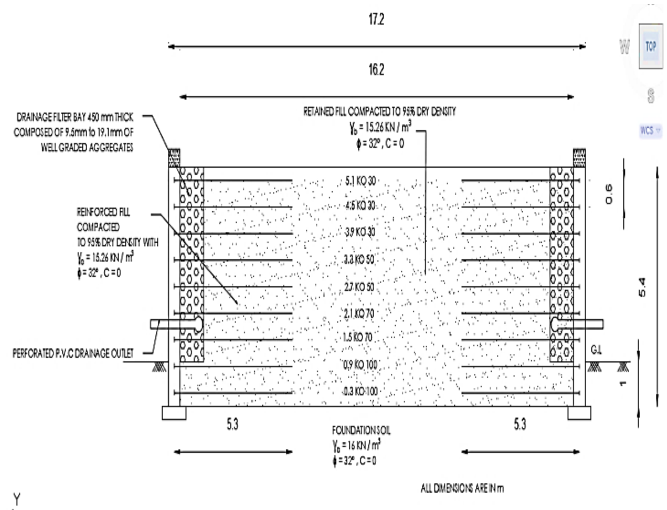

Fig 10:- C/s of Bridge Embankment at 5.4m height

D. Precast wall panels

The different available types of wall panels in developing countries are shown in Figure 11. The shape of the wall used in construction is cruciform.

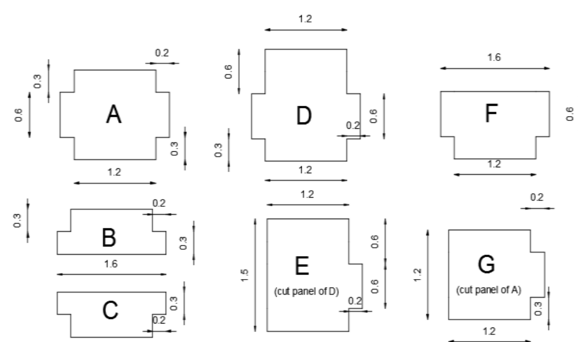

Fig 11:- C/s of Bridge Embankment at 5.4m height

E. Lateral Earth Pressure on wall

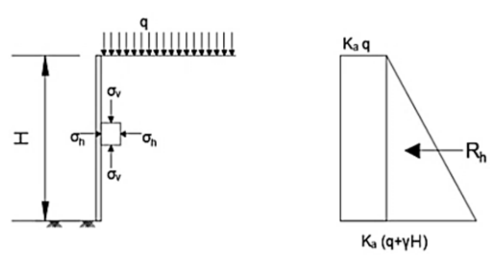

Fig 12:- Lateral earth pressure on wall

The wall panel-A is preferred for most cases in urban areas. The reinforcement detail for such panel is shown below.

ISSN No:-2456-2165

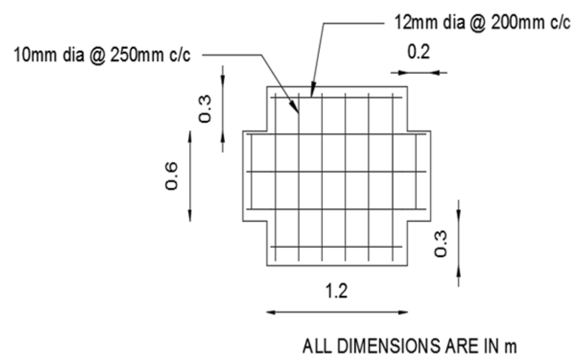

Fig 13:- Reinforcement details of RE wall

V. ANALYSIS USING PLAXIS 2D

Plaxis is a special purpose two-dimensional finite element computer program used to perform deformation and stability analyses for types of Geo-technical applications. Typical PLAXIS applications include stability analysis of embankments, displacements around an excavation pit, and dam stability during different water levels. The applicability of PLAXIS has been extended to solve problems dealing with excavations in soft soils, piled-raft foundations, embankments or dams with creep behaviour and its interaction with consolidation and large deformation analysis. The challenges that remain are the stability of embankments under conditions of drawdown, designing embankments on soft compressible soils with low permeability of the underlying deposit together with low undrained shear strength, dynamic movements of embankments that determine the train speed, and migration of finer materials during the long-term operation of an embankment or a dam.

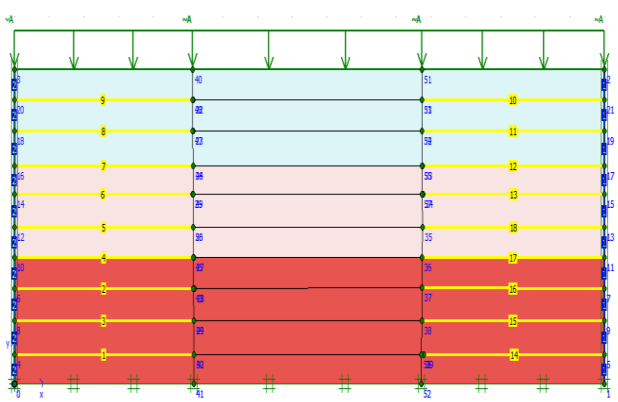

Fig 14:- Input data

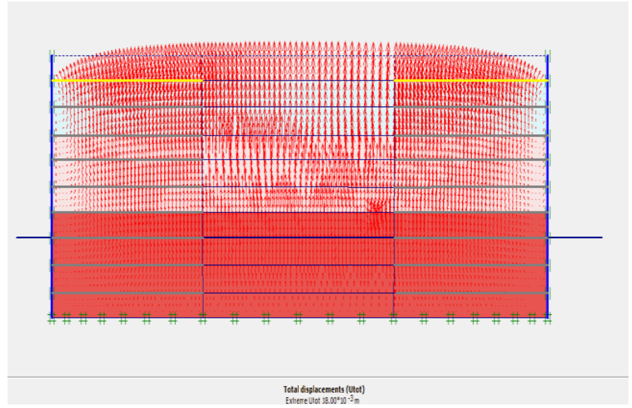

Fig 15:- Total displacement of structure

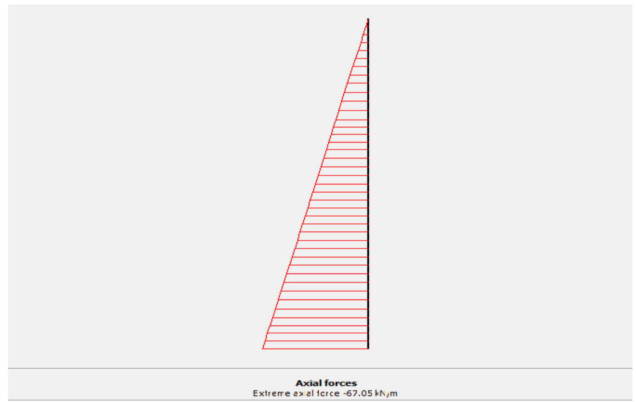

Fig 16:- Distribution of axial forces on wall

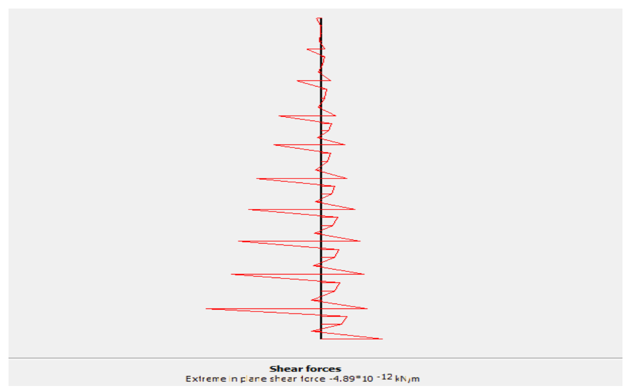

Fig 17:- Shear force diagram

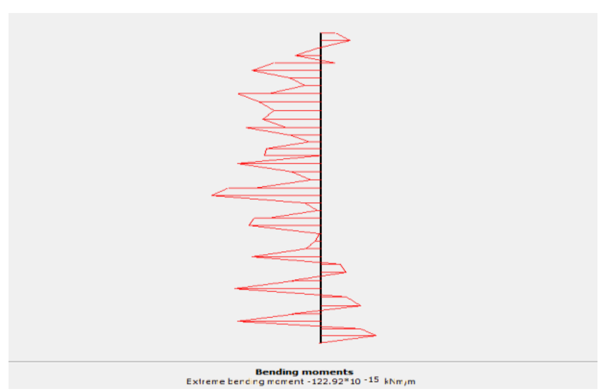

Fig 18:- Bending moment diagram

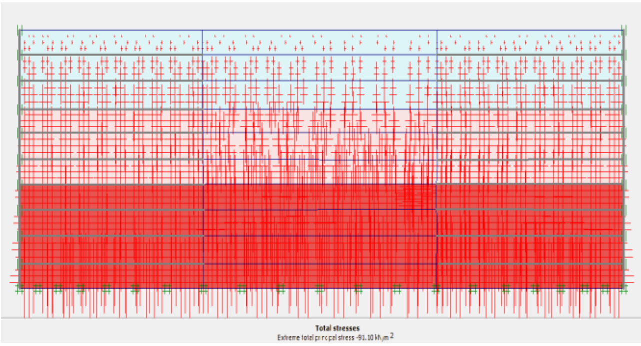

Fig 19:- Total stresses

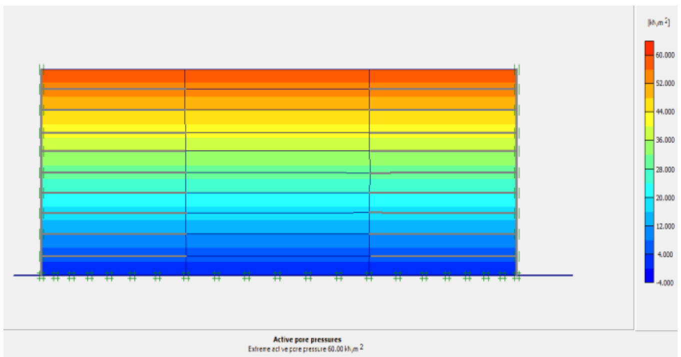

Fig 20:- Pore Pressures

VI. RESULTS & DISCUSSION

- Analysis and design of embankment is done with the help of Excel and Plaxis 2D.
- The stabilities of structures are safe with safety factor calculation.
- The shape of Pre-cast wall panel used- cruciform.
- The maximum tension capacity of reinforcement strips – 52.86kN.
- The maximum stress produced in structure- 200kN/m^2.
- Plaxis 2D output- Extreme active pore pressure=60kN/m^2, Extreme total principal stress= 91kN/m^2, Total displacement = 18x10^{-3}mm.

VII. CONCLUSIONS

- The most common application of reinforced earth is in Mechanical Stabilized Earth Wall (MSEW) and Reinforced soil slope (RSS).
- Reinforced earth walls have evolved as viable technique and contributed to infrastructure in terms of speed, ease of construction, economy, aesthetics, etc.
- It need little space in front of the structure for construction operations.
- Do not need rigid, unyielding foundation support, because reinforced or multi anchored structures are tolerant to deformations.
- A cast-in-place or precast unreinforced concrete levelling pad serves as a smooth, level surface for placing panels.
- The construction of reinforced earth structure has become wide spread in Geotechnical engineering practice in the last two decades owing to their ease of construction and economy compared to those of conventional methods.
- Corrosion of steel reinforcing elements and deterioration of reinforcement rods inside the fill will be unexpected to occur due to the usage of polymeric strap.
- The usage of Pre-cast wall panels aids in faster construction and avoids the failure of wall in terms of cracks and drainage.
- Fly ash fill can overcome the deficiency of soil stability with the influence of pore water pressure. It tends to give higher compressive strength than soil.
- The durability of Reinforced earth structure can be expected up to more than 100 years than conventional method.

VIII. ACKNOWLEDGEMENT

The author would like to thank the staffs Dr.S.Lavanya Prabha and S.Raja for their continuous determination in assisting the author to gather research materials for this paper work and for those who had contributed to the cause of this project. It is of great respect to all staffs who have also contributed directly and indirectly to this paper and the whole research work.

REFERENCES

[1] Harangad Singh, Dr. Saleem Akhtar, Study of Cost Economics of Retaining Wall over Reinforced Earth Wall. International Journal of Emerging Technology and Advanced Engineering Website: (ISSN 2250-2459, ISO 9001:2008 Certified Journal, Volume 5, Issue 11, November 2015).

[2] Hj. Mohd Idrus, Overview and Preliminary Study of Approach - Slab Design Concept for Bridges, 2nd International Conference on Rehabilitation and Maintenance in Civil Engineering, Procedia Engineering 54 (2013) 774 – 784.

[3] D. Kishan, Analysis & design of 44 meter M.S.E. (mechanically stabilized earth) wall by using plaxis 8.2. International Journal of Advanced Engineering Technology E-ISSN 0976- 3945, 2010.

[4] Edward J. Hoppe, Ph.D, Guidelines for the use, design and construction of bridge approach slabs. P.E.Senior Research Scientist, Charlottesville, Virginia, VTRC 00-R4, November 1999.

[5] Carmo Cardoso, Design and Analysis of Approach Embankment Bridges over SoftSoils. Department of Civil Engineering, Institute Superior Técnico, Universidade Técnica de Lisboa, Portugal, 2006.

[6] Ioannis Zevgolis, Philippe Bourdeau, Mechanically stabilized earth wall abutments for bridge support, PublicationNo. FHWA/IN/JTRP-2006/38, SPR-285, April 2007.

ISSN No:-2456-2165

[7] Harangad Singh, A Review on Economic Analysis of Reinforced Earth Wall with Different Types of Reinforcing Materials. Department of Civil Engineering, UIT RGPV-Bhopal, Volume IV, Issue XII, IJLTEMAS ISSN 2278 – 2540, December 2015.

[8] Construction and Quality Control Procedures Manual. Corporate Headquarters, The Reinforced Earth Company 12001 Sunrise Valley Drive, Ste 400 Reston, VA 2019 (February 25, 2014).