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Design construction and monitoring of reinforced soil wall

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ABSTRACT: A Reinforced soil wall was constructed at Okhla fly over, New Delhi. Design methodology adopted, construction techniques and the materials used for the construction are discussed in detail in this paper. The benefits of using Fly-ash as backfill material are clearly brought out. Lateral movement of the wall was monitored using three inclinometers installed at three locations along the wall length. The lateral movement of the wall was found to be less and within the permissible limits.

1 INTRODUCTION

A reinforced soil retaining wall was constructed on one of the ramps forming at Visweswarahia setu on National highway No:2, in New Delhi. The wall was 59m long and its height varied ranged from 5.9m to 7.3m. The construction of reinforced soil wall has eliminated the problem of land acquisition which is a critical problem at the site. Salient features of the wall are given in Table No.1. The reinforced soil wall was built on a reinforced soil foundation of 2m thickness, which will act as reinforced soil foundation for the wall.

Table.1 Salient features of reinforced soil wall

Length	59m
Height	7.3m to 5.3m
Allowable bearing capacity of sub soil	125kN/Sqm.
Fill material	Flyash
Substructure	Bottom ash
Superstructure	Pond ash
Reinforcement	Geogrid
Substructure	Bi-oriented geogrid
Superstructure	Mono-oriented geogrid
Facing panel	150mm thick precast RCC panel

2 DESIGN METHODOLOGY

Design of the reinforced soil wall was carried out in accordance with the 'Department of Transport, Highways and Traffic of UK, Technical Memorandum, BE 3/78 (revised in 1987). Since the height of the wall varies from 5.9m to 7.3m, the 59m long wall was divided into four sections and for each section external or global stability viz. sliding, overturning, tilting and slip failure and internal stability viz.tension failure, adequacy of anchorage length and stability of wedges were checked. Based on the above mentioned factors, spacing of geogrids, type of geogrids, anchorage length were arrived at for Tenax Geogrids. A typical cross section is shown in figure 1, gives the various details.

3 MATERIAL PROPERTIES

3.1 Fill materials

Utilisation and disposal of flyash which has been causing concern for environment has assumed importance on account of the accumulation of Flyash in large quantities. Accordingly with the help of Flyash Mission and Department of Science and Technology (DST) pond ash was used as fill material in this project. The prime objective was to examine and demonstrate the viability of flyash as fill material. For the present project two types of Flyash were collected from Badarpur Thermal Power Station located at 8 km from the project site, they are (a) Bottom ash for the reinforced soil foundation and (b) Pond ash for the backfill. (here onwards pond ash is referred as fly ash). Physical properties of the flyash are given in table.2. From the table it can be seen that flyash fulfills all the requirements

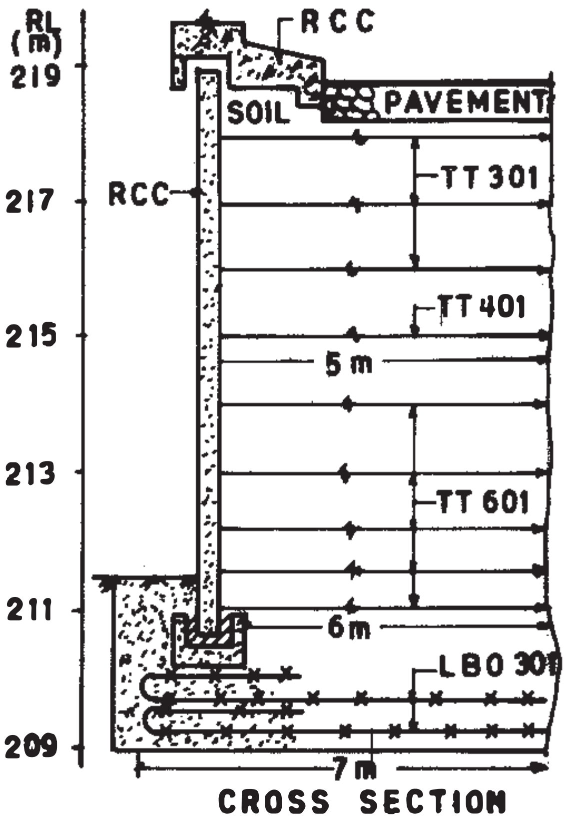

Fig. 1 Typical cross-section

and specifications as a fill material specified by IRC-75 or IS 2720(Part II) and BE 3/78 (revised 1987).

Table 2. Properties of materials

	Bottom ash	Pond ash	Backfill soil
Liquid limit (%)	NP	NP	26
Plasticity index (%)	NP	NP	NP
Sieve analysis Gravel (%) Sand (%) Silt & Clay (%)	 0 86 14	 0 22 78	 0 50 50
Max.dry density kN/m^3	10.3	10.6	20.0
OMC (%)	37	35	10
Specific gravity	2.09	2.05	2.6
Cohesion, c (kN/m^2)	5	5	10
ϕ' (Degree)	37	31	32
ϕ_μ (with geogrid)	31	30	30

3.2 Geogrids

Two types of geogrids were used for the reinforcement. Bi-orientated geogrids in the reinforced soil foundation for distribution of load and mono-orientated geogrids for reinforcement in the backfill. The geogrids were procured from Tenax, SPA, Italy. Various properties of the geogrids are listed in table 3. The safety of the design is further ensured since the requisite tensile strength is mobilised at a strain of 3% .

Table 3a. Properties of Bi-orientated geogrids (LBO-301)

Property	MD	TD
Aperture size (mm)	30	40
Unit weight (g/sq m)	350	
Roll width (m)	4	
Roll length (m)	51 to 53	
Color	Black	
Polymer type	Polypropylene	
Peak tensile strength (kN/m)	19.5	31.6
Yield point elongation (%)	16	11
Tensile strength at 2% strain	6	10
Tensile strength at 5% strain	12	20

Note: MD = machine direction (along roll length)
TD = Transverse direction (across roll width)

Table 3b.Properties of mono-orientated geogrids

Property	TT 301	TT 401	TT 601
Aperture size MD (mm)	120	120	120
Aperture size TD (mm)	13	13	13
Unit weight (g/sq m)	620	770	860
Roll width (m)	1.0	1.0	1.0
Roll length (m)	30.	30.	30.
Color	Black		
Polymer type	H D P E		
Peak tensile strength (kN/m)	65	80	100
Yield point elongation (%)	13	13	13
Tensile strength at 2% strain	21	26	31
Tensile strength at 5% strain	40	48	56
Characteristic strength (kN/m)	23.5	30.6	36.0

Note: MD = machine direction (along roll length)
TD = Transverse direction (across roll width)

3.3 Facing panels

Precast RCC panels made of M20 concrete having a thickness of 150mm and sizes varying from 0.98m X 2.0m to 0.98mX2.8m (width X Depth) were used as facing panels. The size was arrived at by considering the weight of the panels, total height to be covered ,ease of handling and that at least two geogrid units shall be provided in each unit. These panels were designed for handling stresses. The reinforcement consisted of 10 0 bars placed at 200mm c/c in both ways and in both faces. One lifting hook of 16 0 was placed as shattering for weep holes at appropriate positions to have 1.0m spacing in either direction above the ground level. Mono orientated geogrid of 0.45m long was embedded at specified locations as per the design while casting the panels. Tongue and groove arrangement was provided for connection between panels. Figure 2 shows details of facing panels.

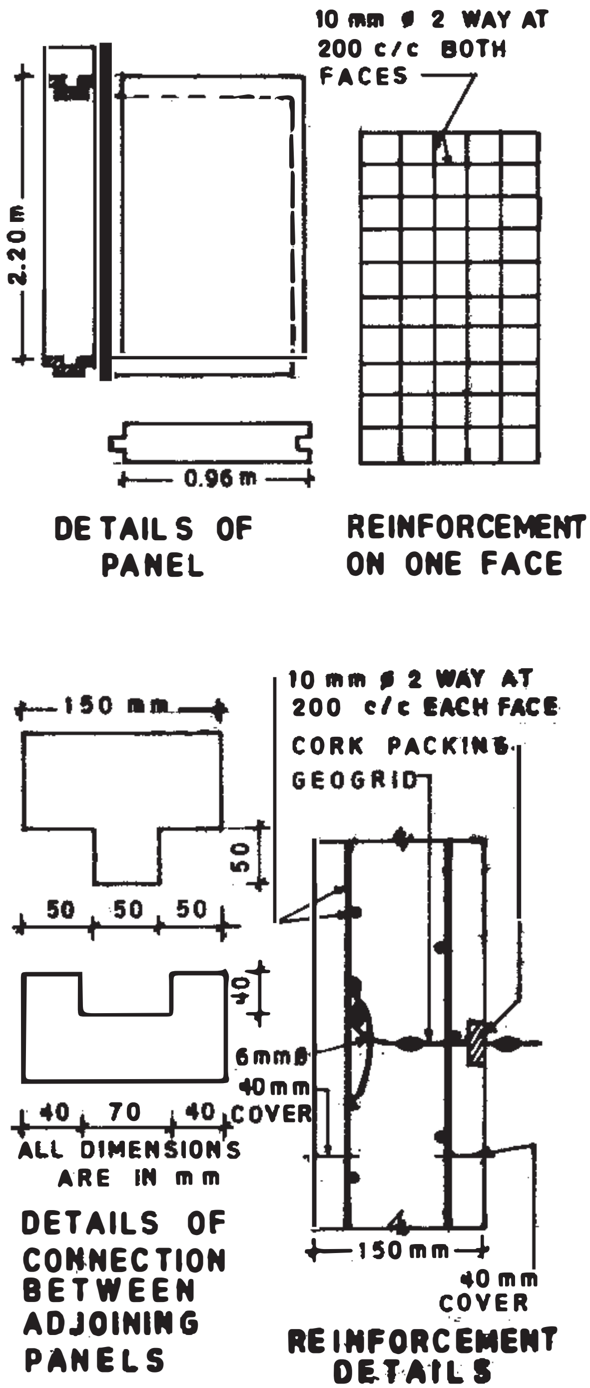

Fig. 2 Details of facing panels

4 CONSTRUCTION

4.1 Reinforced soil foundation

Excavation was made upto the original ground level of RL 209.0 for a width of 7.8m. Bearing capacity of the insitu soil was determined to be 125 kPa. Bottom ash was spread and compacted in layers of 0.20m compacted thickness to achieve 95% of Proctor density. Bi-orientated geogrid was spread at required depths without undulations and stretched after being placed in position to achieve an elongation of 0.5%. This elongation ensures a proper contact between flyash and geogrid. Filling with bottom ash was carried upto RL 210.5

4.2 Foundation block for facing panels

A trench of 500mm X 500mm was excavated in the filled up soil, with a 80mm leveling course of cement concrete 1:3:6. The sides were protected by polyethylene sheets and a formwork was placed at the center. Thereafter M20 concrete wall was placed making the trough.

4.3 Erection of facing panels

Facing panels were placed over the foundation block at a batter of 1 in 40 as recommended by BE 3/78. In the second lift a batter of 1 in 30 was used to take care of the likely outward movement of facing panels. These facing panels were erected in position with the help of a mobile crane, while erecting care was taken to see that edges of adjacent facing panels fit into each other. All joints were filled with bitumastic filler prepared by heating a mixture of 80 kg bitumen and 0.25 m3 of coarse sand and 1 kg of cement to provide flexibility to the wall.

4.4 Placing of geogrid and compaction of backfill

The fill material was brought by trucks from the ashpond of thermal power station. The ash was spread uniformly and water was added with the help of a sprayer in required quantities to maintain a water content of 30 to 35%. Flyash was compacted in layers of 20cm thick compacted thickness using 8-10t static roller (Figure 3). Compaction was done in the wet state. Near the facing panels compaction was done using plate compactors in lesser thickness layers to ensure proper compaction and to achieve 95% of Proctor density. After reaching the levels at which geogrid has to be laid, mono-orientated geogrid was connected to the geogrid strips embedded in the facing panels. The connection was made with the help of HDPE bodkin pins of 1.0m length, 40mm wide and 5mm thick. Before laying geogrids it was ensured that the compacted flyash surface was leveled. The geogrids used for reinforcement having lengths of 5.0m to 6.0m are stretched after being placed in position to achieve an elongation of 0.5%. This elongation was required to have a proper contact between flyash and reinforcement and also to mobilise the required friction between flyash and reinforcement.

A vertical graded filter drain of 1.0m width was provided adjacent to the panel wall throughout the length of the wall. Drain pipes were also provided to collect surface water and for discharging it.

Fig. 3 Compaction of flyash

Lateral displacements of the walls are within the permissible limits.

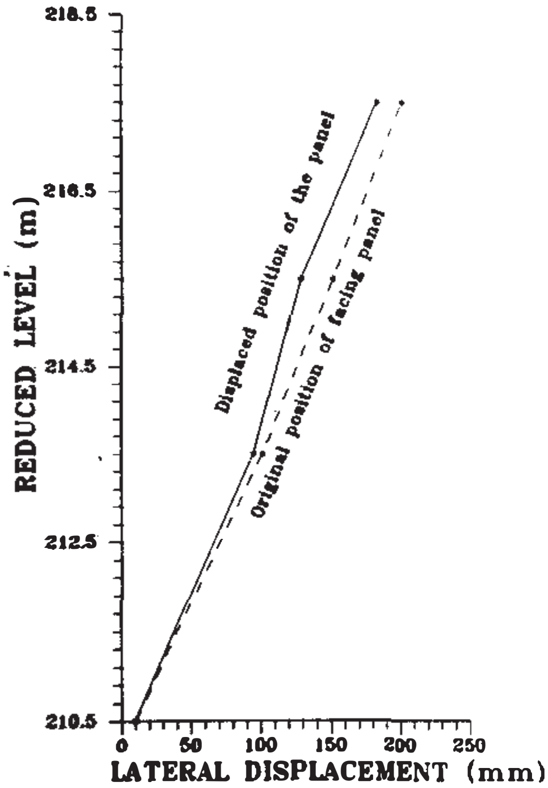

Fig.4. Lateral displacement of the reinforced soil wall

5 FIELD MONITORING

For observing the lateral displacement of the wall it is essential to monitor it. For this purpose three inclinometers are installed at the beginning, center and end of the wall. Inclinometer measurements were taken during construction as well as subsequently. The final displacements obtained till now are plotted and are presented in figure 4.

6 CONCLUSIONS

Reinforced soil wall is a simple technique and it doesn't require any special construction skills than that of RCC retaining wall.

Economically also Reinforced soil wall was found to be marginally less expensive compared to RCC wall.

Flyash was found to be a better back fill material compared to the soil backfill.

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