GABION GRS WALL FOR RAISING SOLID WASTE DUMP SITE AT SURAT - CASE STUDY

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ABSTRACT: For a site having land constrain and relatively soft soil foundations at Jiav village Surat. Option like strengthening compound wall such as diaphragm wall was economically nonviable. Geosynthetic Reinforced Soil (GRS) structural design was option which required architectural planning of using gabion walls in phase-I to take earth pressures keeping compound wall safe. The gabions have Geofabric tie back to minimize stress and settlement of Phase-I then Phase-II is earth fill over old dyke subjected to stresses of proposed 4 m fill hump over original dump pit for heavy metal waste of industry. The empirical design taking poor compaction as site constrain was proposed as Geofabric reinforced slope to take loads of raised backfill. The geotextile woven, cohesive backfill, heavy rainfall area was considered to evolve geometry (Fig. 5). Phase-II was planned for the flexible unpaved road on reinforced embankment expansive cohesive soils. The function of drainage of rain water, pore water pressures are taken care. The design of spacing of reinforcement and specification for Geofabric and gabions has been incorporated by checking forces by stiffness method (Bathurst et al., 2008[1]). The alternative in absence of extra land in part of area was workable, economical and feasible by parts in phase form.

INTRODUCTION
The used of gabion reinforced soil retaining wall which was built in the summer of 2011 to meet stable and environmentally safe project for a Solid Waste disposal site at Jiav Village of Surat District (Gujarat). This paper described the architectural planning and construction phase of the Reinforced Earth Gabion Wall. Reinforced Earth Gabion Wall was used to protect the Masonry wall around the periphery of the site (Fig. 1- a to d). The paper describes a unique set of project constrain that lead to the final construction phase to ensure a stable and environmentally safe project.

As lot of assumption are involved, design was evolved empirical and conservative for cost aspect. In long run cheaper alternative may prove disastrous and investigation could take time.

The standard pile foundation or deep diaphragms was rejected as not feasible or practicable in time cost and availability of agency for small work.

The section based on data provided is shown in Fig. 2. Approx data provided indicate maximum of 4 m surcharge of solid waste over final height of raised embankment to 5.28 m above G.L. This had a horizontal thrust on the proposed raising of embankment & existing compound wall.

Special design of RCC Wall of height 6.28 m is requiring feasibility & economic assessment for site particularly. This vertical and horizontal load passed on to the untreated un-compacted soil fill of random cohesive soil as foundation. So drainage for complete structures requires special structure feasible for available land and minimum disturbance to existing site condition.
The typical section of earth dyke for raising the solid waste fill to maximum 4 m above present fill level is shown in Fig. 2. Problem is for part of dyke which destabilized the compound wall near village road.

**PROPOSED DESIGN FOR PROBLEM SECTOR**

The proposed design structure was done in 3 phase.

**Phase - I:** Dressing existing soil filling (1.1 to 2.96 m) to level platform about top 2.96 m elevation as shown in Fig. 3. The job involves stripping 0.3 to 0.5 m filling to design profile after wetting to 15% moisture and compacting by light roller up to 7 m along x-axis. 7 to 10 m will be proving a 1 m x 0.5 m x 2 m wide gabion with a geo-filter specified. The geo-filter will be extended for 10 m width as shown in Fig. 3. A toe gabion wall with toe drain of RCC box without fail will be designed by structural engineer. Earth fill platform with toe gabion will restrict lateral movement disturbing existing compound wall.

**Phase - II:** A reinforced earth fills of cohesive soil having PI < 25 at w.c < 20% compacted to MDD say 1.45 g/cc, C_u > 30 kPa, \( \Phi \) > 15°. The placement of PET woven geofabric 100/50 (Garware Ropes Ltd) having tensile strength of 100 kN/m & permeability 30 L/m²/s in 6 layers as shown in Figs. 4 & 5. The wrap over section will be planned with sand fill polyester bags or 2 mm wire mesh 0.5 x 0.5 m x 3 m stoned filled gabions/tubes. The slope will be protected by mattress 0.3 m thick of wire-mess with gunniting, if need be on exposed surface.

**Phase - III:** Protection on waste dump pit side as per standard raised up to height gradually over 5 years or so. The design take 4 m fill thrust on the gabion protected fill sub-base & road surfacing Fig. 5. For protection of slope, 0.15 m thick R.C.C drain channel provided with proper disposal of water. The preliminary pilot design gives adequate safety and durability of 10 to 15 years if drains slopes maintained annually.
The design of spacing of reinforcement and specification for Geofabric and gabions has been incorporated by checking forces by stiffness method (Bathurst et al., 2008[1]). In most cases these walls have performed well. Miyata and Bathurst (2007)[3] reviewed the literature and found a total of nine new case studies – six from Japan and three from the USA – with enough high-quality data to investigate the influence of lower quality backfill soils on wall reinforcement loads for vertical face walls within the context of the current AASHTO Simplified Method and K-stiffness Method.

The modified K-stiffness Method equation is expressed as:

\[
T_{\text{max}} = \frac{1}{2} K \gamma (H + S) S_v D_{\text{max}} \theta_g \theta_{\text{local}} \theta_f \theta_b \theta_c
\]  

Where \( K \) is the lateral earth pressure coefficient; \( \gamma \) is the unit weight of the soil; \( H \) is the height of the wall; \( S \) is the equivalent height of uniform surcharge pressure \( q \) (i.e. \( S = \frac{q}{\gamma} \)); \( S_v \) is the tributary area (equivalent to the vertical spacing of the reinforcement in the vicinity of each layer when analyses are carried out per unit length of wall);

### Table 1: Calculation for horizontal pressure at various depths for design of gabion wall

<table>
<thead>
<tr>
<th>Depth ( z ) (m)</th>
<th>( \alpha )</th>
<th>( \beta )</th>
<th>( \beta \text{ rad (}\pi/180)</th>
<th>( \cos^2 \alpha )</th>
<th>( \sin^2 \alpha )</th>
<th>( P_q ) (kN/m²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>81</td>
<td>5</td>
<td>0.098</td>
<td>0.02</td>
<td>0.97</td>
<td>3.98</td>
</tr>
<tr>
<td>2</td>
<td>74</td>
<td>9</td>
<td>0.16</td>
<td>0.07</td>
<td>0.92</td>
<td>8.19</td>
</tr>
<tr>
<td>3</td>
<td>66</td>
<td>12</td>
<td>0.20</td>
<td>0.16</td>
<td>0.83</td>
<td>10.20</td>
</tr>
<tr>
<td>4</td>
<td>60</td>
<td>14</td>
<td>0.24</td>
<td>0.25</td>
<td>0.75</td>
<td>18.34</td>
</tr>
<tr>
<td>5</td>
<td>54</td>
<td>15</td>
<td>0.27</td>
<td>0.34</td>
<td>0.65</td>
<td>17.88</td>
</tr>
</tbody>
</table>

*Horizontal Pressure at depth \( z = P_q = \frac{2q}{\pi} (\beta + \sin \beta) \sin^2 \alpha + \frac{2q}{\pi} (\beta - \sin \beta) \cos^2 \alpha \) [2] \n
\( q \) = strip load in kN/m², \( \beta \) is in radian
is the load distribution factor that modifies the reinforcement load based on layer location. The remaining terms, $\secant\phi$, $\phi_{local}$, $\phi_{fs}$, and $\phi_{f}$ are influence factors that account for the effects of global and local reinforcement stiffness, facing stiffness and face batter, respectively. The coefficient of lateral earth pressure is calculated as $K = 1 - \sin \phi$ with $\phi = \phi_{ps}$ secant peak plane strain friction angle of the soil. However, it should be noted that parameter $K$ is used as an index value and does not imply that at-rest soil conditions exist in the reinforced soil backfill according to classical earth pressure theory. The value of $T_{max}$ comes less than 1kN/m, for vertical spacing of reinforcement was calculated is 0.4 m and provided 0.3 m for safety. Length of reinforcement was also calculated and provided 6.0 m with overlap of 1.0 m from warp around. Calculation for horizontal pressures at various depths is shown in Table 1. Keeping this in view PET geotextile 100/50 of Garware was adopted.

A primary objective of this paper was to check the K-stiffness Method formulation expressed by Eq. 1 against an extended database that included a case study found in Surat Municipal Landfill site. The modified K-stiffness Method gives better statistics base and hence more accurate predictions of reinforcement loads under typical operational conditions. As the proposed design is a special solution, field instrumentation to observe some displacement, pullout resistance test insitu during construction have been proposed.

CONCLUSIONS
The planning of constructed dyke for extended land fill site illustrates the use of gabions to retain lower earth mass (Fig. 5). Geofabric reinforced slope to counter stress of gradually increasing waste fill upto maximum height of 4 m. The design considers site constrains and construction eases for the extended dumping solid waste above original design. The use of geosynthetics judiciously used provided economical and feasible alternative with land & time constraints.

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REFERENCES