PARAMESH WALL FOR WADI SHOMER BRIDGE  
AL ZARQA, JORDAN

REINFORCED SOIL RETAINING WALLS
Product: Terramesh System, ParaGrid, Geotextile, Gabion Mattress.

Project Background:
The proposed Wadi Shomer Bridge is located in Al Zarqa, Jordan which is part of the ongoing Al Zarqa - Al Sukhneh Road Project. The geographical area and the project is separated by deep wadi (wadi shomer) which gets flooded with high water flow when it rains in the area.

The proposed shomer bridge (240m long) thus intend to connect the two area with 4 lanes (2+2) at the top and with a carriageway width of 20m. The critical factor in the design of the bridge is the high discharge - high velocity flood that occurs in the wadi every year, during the rain and the presence of silty clay soil in the foundation depths. Thus the main bridge piers were constructed on pile foundations.

Problem & Solution:
As per the project tender documents the proposed bridge to built as an RCC structure with pile foundation and two approach roads to be constructed on the MSE Retaining Walls. As per the tender documents MSE Retaining wall shall be carried out by MSE Concrete Panel Walls.

Maccaferri was invited for submitting the MSE Concrete Panel Retaining Walls. However, Maccaferri’s advise to the main contractor was to adopt MSE ParaMesh Wall system, as the concrete panel wall can have distresses & washing out during the high discharge flood and due to the presence silty clay soil layers in the foundation bed.

Maccaferri’s concerns of wadi floods and presence of weak soil was thus brought to the attention of the client and the consultant and after several meetings, the client and the consultant agreed to change to Terramesh Wall system, understanding the risk involved in Concrete Panel Retaining Walls on the project.

Subsequently a full design of MSE ParaMesh Wall was submitted by Maccaferri which was reviewed and approved by the consultant and the client.

Client: The Ministry of Public Works and Housing
Main contractor: Abu Shreikh Contracting Co.
Consultant: Dar Al Omran Infrastructure
Designer: Maccaferri Middle East LLC
Products used TMS (8x10), ParaGrid, Gabion, Reno Mattress, Jumbo Gabions
ParaMesh Wall Construction: Start Date: Oct-2016 Completion Date: Ongoing

Typically, ParaMesh Wall is a composite soil reinforcement system with different types of soil reinforcement used with the following Maccaferri products:

- **Terramesh System® (TMS)**, a double twisted hexagonal steel wire mesh unit which forms the facia, with the aesthetics of gabion and with the reassurance of a secondary soil reinforcement to prevent sloughing failure of wall face.
- **ParaGrid® (PG)**, a high strength polyester geogrid (Primary Reinforcement) with polyethylene coating.
- **Geotextile (Non Woven)**, is used as separator between the inside face of the Terramesh system (gabion fascia) and the structural fill soil in order to prevent escape of the fine particles from backfill into the gabion fascia voids.
Design Sections:

Based on the wadi bed level and the proposed road level, maximum design height of the proposed MSE ParaMesh wall was 14m, which is near to the bridge abutment (A1 & A2) and the minimum design height was 2m. Hence several sections with different wall heights were analysed by our design engineers as per BS 8006:2010, using MacStars-W Software.

Two analytical cases were carried out for each design section, STATIC and SEISMIC with a seismic horizontal coefficient of 1.47m/s². The primary reinforcement considered in the designs were PG80, PG100, PG150 & PG200 which varied for different wall heights.

Different soil layers modeled in the design analyses and the loads considered are given below:

### Soil Layers Considered in the Design

<table>
<thead>
<tr>
<th>Soil Properties</th>
<th>Foundation Soil</th>
<th>Reinforced Soil</th>
<th>Retained Backfill</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unit Wt. (kN/m³)</td>
<td>18</td>
<td>19</td>
<td>19</td>
</tr>
<tr>
<td>Friction Angle (deg)</td>
<td>30</td>
<td>34</td>
<td>34</td>
</tr>
<tr>
<td>Cohesion (kN/m²)</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Poisson’s ratio</td>
<td>0.3</td>
<td>0.3</td>
<td>0.3</td>
</tr>
</tbody>
</table>

### Design Loads

<table>
<thead>
<tr>
<th>Traffic Live Load (kPa)</th>
<th>Pavement Dead Load (kPa)</th>
<th>Crash Barrier &amp; Friction Slab Dead Load (kPa)</th>
<th>Earthquake Coefficient (PGA)</th>
</tr>
</thead>
<tbody>
<tr>
<td>22</td>
<td>14</td>
<td>20</td>
<td>0.15g (A)</td>
</tr>
</tbody>
</table>

### Foundation Ground:

The foundation ground exhibited presence of silty clay layer and hence ground improvement by replacement with rock filling was recommended. The depth of ground improvement was decided based on the net allowable bearing capacity of existing soil (reported by soil testing agency) and the contact pressure from the proposed retaining wall structure. The depth of ground improvement by rock filling was decided based on the pressure distribution values as given in the below table:

### Calculated Ground Improvement Depth

<table>
<thead>
<tr>
<th>Loads Applied</th>
<th>Wall Height (m)</th>
<th>Base Width (m)</th>
<th>Required allowable soil bearing capacity (Kpa)</th>
<th>Required Depth of Ground Improvement</th>
</tr>
</thead>
<tbody>
<tr>
<td>DD+LL = 36 Kpa</td>
<td>9</td>
<td>11</td>
<td>161</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>10</td>
<td>11</td>
<td>178</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>11</td>
<td>11</td>
<td>194</td>
<td>0.5</td>
</tr>
<tr>
<td></td>
<td>12</td>
<td>11</td>
<td>212</td>
<td>1</td>
</tr>
<tr>
<td>2m Barrier Load LHS = 20 Kpa</td>
<td>13</td>
<td>11</td>
<td>229</td>
<td>1.5</td>
</tr>
<tr>
<td>2m Barrier Road RHS = 20 Kpa</td>
<td>14</td>
<td>11</td>
<td>246</td>
<td>2</td>
</tr>
</tbody>
</table>

Recommendation from GEOTEST Laboratory

- Minimum Soil SBC at 1m depth: 182 Kpa
- Minimum Soil SBC at 2m depth: 190 Kpa
Hydraulic Design:
The hydraulic study data, revealed that the flash flood with a discharge of 360 m$^3$/s & with water height 5m can occur in the wadi every year with a large volume of debris flow. Hence the following have been considered in our ParaMesh Wall designs:
1. Flood Extreme Event (5m High Flood Water in the analysis)
2. Scour Protection for the wall in the Wadi Area

Scour Protection:
Based on the hydraulic data provided by the consultant, scour depth calculations were made using Lacey’s formula given below.

\[
\text{Scour Depth} = 0.473 \times \left( \frac{Q}{f} \right)^{1/6}
\]

Where,
- \( Q \) = Discharge (m$^3$/s) = 360 m$^3$/s (see the hydrograph)
- \( f \) = Silt Factor = 2.5 (based on avg. particle size)

Based on the above equations and data (provided by the consultant), maximum scour depth was calculated as 2.44m and accordingly a launching apron Reno Mattress of width equal to 1.5-times the calculated scour depth is considered as the scour protection. Reno Mattress (0.3m thick) of 4m length was provided around the ParaMesh wall, within the wadi bed area.

Wadi Bed Lining & Abutment Wall Protection:
In addition to the scour protection apron gabion mattress at the bottom of the ParaMesh Wall in the wadi area, additional hydraulic protections were also considered in the project, as the flash flood in the wadi during the rain is extremely vigorous with boulder size debris flow which can cause impacts on the retaining walls.

As per the hydraulic data, the height of flash flood within the wadi can rise up to a level of 5m. Hence, for both the abutment wall locations (A1 & A2), an additional gabions units were also installed around the abutment wall for a height of 3m.

Also, the wadi bed between the two abutment wall was also lined with Gabion Mattress (0.5m thick) in order to avoid erosion from the bridge location. A general plan view and relevant photographs are presented here:

Current Status of the Project:
Upon final approval of the shop drawings by the consultant, construction of the ParaMesh Wall at the site was started on 10-Oct-2016 and is expected to finish by April-2017. As of now, ~3m height of the retaining wall have been completed on both the abutments location.
ParaGrid Installation (Primary Reinforcement)

ParaMesh Wall (A2-Side) - Under Construction