Ghazieh Public Garden Project
REINFORCED SOIL WALLS SPECIFICATION

1. GENERAL

This work shall consist of constructing retaining walls using a proprietary reinforced soil wall system, constructed in accordance with the supplier's drawings and specifications and in conformity with the alignment, grades and dimensions shown on the contract documents or as established by the Engineer. Any particular requirements of approved detailed specifications for the approved proprietary system shall override any conflicting or incompatible requirement contained within this section.

The wall system as a whole shall have a current British Board of Agrèment (BBA) certificate for Roads and Bridges, demonstrating suitability for use in highways walls and abutments with 120-year design life.

2. DESIGN

The design shall address the climatic and soil conditions existing in Lebanon and provide a design life of 120 years. The specifications as presented to the Engineer shall state any requirements for or limitations on the backfill used in the structure to ensure the design life. The tender submission shall be accompanied by:

A. A copy of the current BBA certificate
B. Sample design calculations for the proposed walls in compliance with BS8006 or similar internationally recognized standard
C. Soils test information of the proposed reinforced soil fill
D. Method statement for construction

3. STANDARDS

The following standards and codes in their latest edition shall be particularly applied to work covered by this specification where applicable; together with any further standards or codes as described within the approved Specification for the approved reinforced soil wall system.

3.1 Segmental Retaining Wall Units

ASTM C 140 - Sampling and Testing Concrete Masonry Units

3.2 Geogrid Reinforcement

A	**ISO 2602: 1980**	Statistical Interpretation of Test Results
B	**BS EN ISO 9001: 2000**	Quality Systems – Model for Quality Assurance in Production, design and development Installation & Servicing

C	**BS 2782: Part 4**	Methods of Testing Plastics. Part 4: Chemical Properties
D	**GRI GG2 - 87**	Geogrid Junction Strength
E	**BS EN ISO 10321: 1996**	Geotextiles – Tensile Test for Joints-Seams by Wide-Width Method
F	**BS EN ISO 10319: 1996**	Wide-Width Tensile Test
G	**BS 6906: Part 5**	Methods of Test for Geotextiles. Part 5: Determination of Creep

3.3 Soils

A. **BS 1377** - Moisture Density Relationship for Soils, Standard Method
B. **BS 1377** - Gradation of Soils
C. **BS 1377** - Atterberg Limits of Soil
D. **BS 1377** - Shear Box Test

4. MATERIALS

The wall system will comprise interlocking concrete block facing units, uniaxially orientated high density polyethylene geogrids and connectors designed to ensure a high strength, positive connection between wall face and geogrid. The independent approval certificate will have assessed this connection efficiency.

4.1 Modular Block Facing Units

A. The blocks shall be machine manufactured from Portland cement concrete specifically designed for use in a reinforced soil retaining wall system.

B. Colour of the facing units shall be as specified by the engineer/client.

C. The blocks shall have a finish as specified by the client.

D. Block height should be 200mm

E. Block units shall be solid through the full depth of the unit

F. Blocks when installed shall have gap not greater than 4mm between adjacent units

G. Block units shall be sound and free of cracks or other defects that would interfere with the proper placing of the unit or significantly impair the strength or permanence of the structure. Cracking or excessive chipping may be grounds for rejection. Units showing cracks longer than 13mm shall not be used within the wall. Units showing chips visible at a distance of 10 metres from the wall shall not be used within the wall

H. Concrete used to manufacture block units shall have a minimum 28 days' compressive strength of 30N/mm2 and a maximum moisture absorption rate, by weight, of 8% as determined in accordance with ASTM C 140. Compressive strength test specimens shall conform to the saw-cut coupon provisions of Section 5.2.4 of ASTM C140 with the following exception: Coupon shall be taken from the least dimension of the unit of a size and shape representing the geometry of the unit as a whole. By Block Manufacturer

I. Block units' moulded dimensions shall not differ more than + 3mm from that specified, except height which shall be + 1/16 inch as measured in accordance with ASTM C140.

4.2 Geogrid Reinforcement

A. The reinforcing element shall be a geogrid manufactured in accordance with the Quality Assurance requirements BS EN ISO 9001. The Contractor shall provide evidence that the manufacturer's Quality Assurance System has been certified to conform to BS EN ISO 9001 by an external authenticating authority approved by the owner or his engineer.

B. The reinforcing element shall be a geogrid manufactured from high density polyethylene sheet, oriented in one direction so that the resulting ribs shall have a high degree of molecular orientation, which is continued through the integral transverse bar.

C. Real time creep tests on the geogrid, or earlier versions using the same base polymer and manufacturing method, shall have been carried out for a period of not less than 10% of the design life. If creep testing has been carried out for shorter periods, then the strength should be factored in accordance with Annex A.3.3.3 of BS8006.

D. The geogrid shall have an appropriate partial factor for site installation and construction damage, determined by the particle size distribution of the reinforced fill and in accordance with the values used in the design. This factor shall be based on full scale tests carried out in accordance with BS8006 Annex D and witnessed by an independent Approval Authority. If required by the Engineer, the Contractor shall provide supporting documented evidence of testing for this and any other partial factors assumed in the design.

E. The strength of the junctions between the longitudinal ribs and transverse bars, as determined by the Geosynthetics Research Institute, Drexel University, USA, Test Method GG2-87, shall be not less than 100% of the Quality Control Strength.

F. Any site joints in the reinforcement roll length shall be capable of carrying in excess of 100% of the geogrid Quality Control Strength when tested in accordance with ISO 10321.

G. The geogrid shall be inert to all chemicals naturally found in soils and shall have no solvents at ambient temperature. It shall not be susceptible to hydrolysis, shall be resistant to aqueous solutions of salts, acids and alkalis, shall be non-biodegradable and shall have a minimum of 2% finely divided carbon black, as determined by BS 2782 Part 4, Method 452B 1993, to inhibit attack by ultraviolet light.

4.3 Face to geogrid connection

A. The connection between the modular block facing unit and the geogrid shall be a mechanical continuous connection manufactured using an approved High Density Polyethylene. The allowable connection strength at the face (T_{conn}) to be used in the design shall have been tested and independently assessed for each grade of geogrid reinforcement used in the design and published in the relevant BBA Roads and Bridges certificate. Pin or frictional connections shall not be allowed.

4.4 Levelling Pad

A. Material for levelling pad shall consist of 30N/mm2 strength mass concrete and shall be a minimum of 150mm in depth. Lean concrete with strength of 30 N/mm2 and 150mm thick may also be used as a levelling pad material. The levelling pad should extend laterally at least a distance of 100mm from the toe and heel of the lowermost SRW unit.

4.5 Drainage Aggregate

A. Drainage aggregate shall be angular, clean stone or granular fill meeting the following gradation as determined in accordance with BS 1377

Sieve Size	Percent Passing
37.5mm	100
20mm	85-100
10mm	50-100
5mm	35-90
1.18mm	15-50
0.06μm	5-35
0.015μm	0-5

4.6 Reinforced (Infill) Soil

The reinforced soil material should be well graded crushed and granular not sub-rounded, and should conform to the following:

A. Maximum particle size 75mm
B. Uniformity coefficient greater than or equal to 10
C. Maximum 15% by mass passing the 75μm sieve
D. Well graded material not gap graded
E. Inorganic with no plastic material content
F. Minimum angle of friction (ø') of 36 degrees
G. The contractor should provide the Wall System supplier and the Engineer/Client with Effective Stress Parameters soil test information including soil density to allow completion and checking of the final design.

5. CONSTRUCTION

5.1 Excavation

H. Contractor shall excavate to the lines and grades shown on the project grading plans. Contractor shall take precautions to minimize over-excavation. Over-excavation shall be filled with compacted infill material, or as directed by the Engineer/Architect.
I. Contractor shall verify location of existing structures and utilities prior to excavation. Contractor shall ensure all surrounding structures are protected from the effects of wall excavation. Excavation support, if required, is the responsibility of the Contractor.

5.2 Foundation Preparation

A. Following the excavation, the foundation soil shall be examined by the Owner's Engineer to assure actual foundation soil strength meets or exceeds the design bearing strength. Soils not meeting the required strength shall be removed and replaced with infill soils, as directed by the Owner's Engineer.
B. Foundation soil shall be proof rolled and compacted to 95% standard Proctor density and inspected by the Clients Engineer prior to placement of leveling pad materials.

5.3 Levelling Pad Construction

A. Levelling pad shall be placed as shown on the construction drawings with a minimum thickness of 150mm. The levelling pad should extend laterally at least a distance of 100mm min from the toe and heel of the lower most SRW Unit.

5.4 SRW Unit, coping and Geogrid Installation

A. All SRW units shall be installed at the proper elevation and orientation as shown on the wall profiles and details on the construction plans or as directed by the Engineer. The SRW units shall be installed in general accordance with the manufacturer's recommendations. The specifications and drawings shall govern in any conflict between the two requirements.

B. A single course of base units should be bedded on mortar to the correct line & level on the levelling pad. The units shall be levelled side-to-side, front-to-rear and with adjacent units, and aligned to ensure intimate contact with the levelling pad. The first course is the most important to ensure accurate and acceptable results. No gaps shall be left between the front of adjacent units. Alignment may be done by means of a string line or offset from base line to the back of the units.

C. The wall units are designed to allow construction down to a minimum radius of 3m in plan. Preparation of the foundation strip and laying of the base units to the necessary alignment will be as in steps A & B. Depending on the radius it may be necessary to reduce the width of the grid by cutting on site, so as to ensure an efficient fit when the connector & grid are positioned in to the rebate.

D. Place and compact approved fill up to the top of the course. Use a vibrating plate compactor or vibrating roller with a mass per meter width less than 1300kg and a total mass less than 1000kg within 2m of the face. Install a minimum 150mm thickness of Type A drainage material immediately behind the face.

E. Cut the grid from the roll to the required design length. At one end ensure that a row of ribs is trimmed to a length of 50mm (across the full width of the roll). Do not cut them back to the transverse bar.

F. Clean all excess debris from top of units using a brush.

G. Place the prepared end of the grid over the rebate in the block & locate the moulded connectors around the transverse bar. Ensure that each aperture of the geogrid is covered by a connector. The connectors should be split where necessary.

H. Position the assembly neatly into the rebate with the trimmed ribs towards the face.

I. Repeat this procedure for the whole course ensuring that adjacent lengths of grid are abutted at the wall face.

J. Once again, ensuring all debris is brushed away, place the next course (standard units are now used right up to the coping course). They should be placed & arranged so that the down stand is pushed up against the front of the rebate in the lower unit.

K. Pull the grid so that the moulded grid connectors are up against the rear of the rebate.

L. Place three further courses ensuring they are fully forward & square with the previous course.

M. Apply tension at the free end of the grid with a load sufficient to remove any slack.

N. Whilst maintaining tension, place a layer to fill on the gird which is sufficient to retain it in position when the load is released. Release the tension.

O. A 150mm thick cover of fill must be maintained between the grid & the tracks of any plant to avoid damage. Fill should be placed by plant such as an excavator bucket or dozer with an opening bucket, which causes the fill to cascade onto the grids.

P. Plant used to place fill should be kept at least 2m away from the face.

Q. Place and compact fill (as described in step 3), keeping units a minimum of three courses above the fill until the top of the structure. Compaction should always commence nearest the facing units, working away toward the free end of the grid. Any lengths of grid fitted into the wall face above the level of fill should be temporarily folded over the top of the wall to provide a free working area.

R. Repeat steps D-Q to construct the wall to the required height. The top course of units should be bonded to the course below using the adhesive supplied. Extrude a bead of adhesive either side of the rebate of the lower units & place the top course, pressing firmly to locate.

S. In order to achieve good line & level, the coping units should be bedded on mortar. When alignment of the wall is curved or angled, the coping units require cutting on site to achieve best fit.

T. The Contractor must fully assess the safety risk associated with working at height and where appropriate install any necessary temporary edge protection.

5.5 Drainage Materials

Drainage aggregate shall be installed to the line, grades, and sections shown on the final plans. Drainage fill shall be placed to the minimum thickness shown on the construction plans between and behind units.

5.6 Construction Adjacent to Completed Wall

The contractor is responsible for ensuring that construction adjacent to the wall by others does not disturb the wall or place temporary construction loads on the wall that exceed design loads, including loads such as water pressure, temporary grades, or equipment loading. Heavy paving or grading equipment shall be kept a minimum of 1m behind the back of the wall face. Equipment with wheel loads in excess of $15kN/m^2$ live load shall not be operated with 3m of the face of the retaining wall during construction adjacent to the wall. Care should be taken by the General Contractor to ensure water runoff is directed away from the wall structure until final grading and surface drainage collection systems and erosion protection measures are completed.

END OF SECTION