ASHGHAL

Interim Advice Note No. 024

Specification for Mechanically Stabilised Earth Structures

Revision No. A1

EXW-GENL-0000-PE-KBR-IP-00024

Summary

This Interim Advice Note (IAN) provides information and guidance on the specification to be adopted for mechanically stabilised earth structures. This IAN takes immediate effect. The following shall be noted:

- This IAN does not make any amendments to the existing Qatar Construction Specifications (QCS) 2010.
- This IAN adds a new Section and new Part to QCS 2010, namely Section 101, Part 4, Mechanically Stabilised Earth Structures.

This document supersedes IAN 024 Rev 0 dated February 2013. Third parties not working on Ashghal projects make use of this document at their own risk. Paper copies of this document are uncontrolled. Refer to Ashghal's website for the most recent version.

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0	Feb. 2013	For issue to EXW Consultants & Contractors	IF	EDF	MG
Rev	**Date**	**Reason For Issue**	**Auth**	**Chk**	**App**

Contents

1. Foreword

1.1 Interim Advice Notes (IANs) may be issued by Ashghal from time to time. They define specific requirements for works on Ashghal projects only, subject to any specific implementation instructions contained within each IAN.

1.2 Whilst IANs shall be read in conjunction with the Qatar Highway Design Manual (QHDM), the Qatar Traffic Manual (QTM) and the Qatar Construction Specifications (QCS), and may incorporate amendments or additions to these documents, they are not official updates to the QHDM, QTM, QCS or any other standards.

1.3 Ashghal directs which IANs shall be applied to its projects on a case by case basis. Where it is agreed that the guidance contained within a particular IAN is not to be incorporated on a particular project (e.g. physical constraints make implementation prohibitive in terms of land use, cost impact or time delay), a departure from standard shall be applied for by the relevant Consultant / Contractor.

1.4 IANs are generally based on international standards and industry best practice and may include modifications to such standards in order to suit Qatar conditions. Their purpose is to fill gaps in existing Qatar standards where relevant guidance is missing and/or provide higher standards in line with current, international best practice.

1.5 The IANs specify Ashghal's requirements in the interim until such time as the current Qatar standards (such as QHDM, QTM, etc.) are updated. These requirements may be incorporated into future updates of the QHDM, QTM or QCS, however this cannot be guaranteed. Therefore, third parties who are not engaged on Ashghal projects make use of Ashghal IANs at their own risk.

1.6 All IANs are owned, controlled and updated as necessary by Ashghal. All technical queries relating to IANs should be directed to Ashghal's Manager of the Design Department, Infrastructure Affairs.

Signed on behalf of Design Department:

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2. Ashghal Interim Advice Note (IAN) – Feedback Form

Ashghal IANs represent the product of consideration of international standards and best practice against what would work most appropriately for Qatar. However, it is possible that not all issues have been considered, or that there are errors or inconsistencies in an IAN.

If you identify any such issues, it would be appreciated if you could let us know so that amendments can be incorporated into the next revision. Similarly, we would be pleased to receive any general comments you may wish to make. Please use the form below for noting any items that you wish to raise.

Please complete all fields necessary to identify the relevant item			
IAN title:			
IAN number:		Appendix letter:	
Page number:		Table number:	
Paragraph number:		Figure number:	
Description comment: Please continue on a separate sheet if required:			
Your name and contact details (optional):			
Name:		Telephone:	
Organisation:		Email:	
Position:		Address:	

Please email the completed form to:

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We cannot acknowledge every response, but we thank you for contributions. Those contributions which bring new issues to our attention will ensure that the IANs will continue to assist in improving quality on Ashghal's infrastructure projects.

3. Introduction

3.1 This Interim Advice Note (IAN), which takes immediate effect, provides information and guidance on the Specification to be used for Mechanically Stabilised Earth Structures. This IAN will provide interim guidance prior to issue of a revision to the Qatar Construction Specifications (QCS).

3.2 The specification is applicable to all mechanically stabilised earth structures.

4. Additional Standard

4.1 For application to mechanically stabilised earth structures and to be added to the next revision of the Qatar Construction Specifications (QCS).

5. Implementation

5.1 This IAN is to be used with immediate effect on projects as follows:

- All Ashghal projects in Design Stage
- All Ashghal projects in Tender Stage

5.2 Ashghal projects in Construction Stage shall be reviewed by the Project Consultant / Contractor and the implications of adoption of this Interim Advice Note discussed with the respective Ashghal Project Manager.

5.3 The only exceptions are:

- Projects already in Construction, where a significantly high proportion of mechanically stabilised earth structures have been designed or procured, where this would result in significant additional cost or delay.

5.4 If in doubt, Consultants / Contractors should seek guidance from the respective Ashghal Project Manager or designated Programme Management Consultant (PMC) on a scheme specific basis.

Appendix A – QATAR CONSTRUCTION SPECIFICATIONS (QCS) 2010 Additional Section 101, Part 4, Specification for Mechanically Stabilised Earth Structures

Appendix A

QATAR CONSTRUCTION SPECIFICATIONS (QCS) 2010

Additional Section 101, Part 4, Mechanically Stabilised Earth Structures

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4 MECHANICALLY STABILISED EARTH STRUCTURES

4.1 GENERAL

4.1.1 Summary

1. This Section specifies the design and construction of retaining walls using a proprietary reinforced soil wall system using either Precast Concrete Facing Panels or Modular Concrete Block Facing Units (Segmental Concrete Facing Units), as specified in the Bill of Quantities or contract drawings, constructed in accordance with the supplier's drawings and specifications and in conformity with the alignment, grades and dimensions shown on the Contract Drawings or as established by the Engineer.
2. It shall be read together with the QCS.

4.1.2 Related Sections

- Section 1 - General
- Section 3 - Ground Investigation
- Section 5 - Concrete Works
- Section 6 - Road Works

4.1.3 References

1. All work shall conform to the latest edition of all applicable standards and codes. The following is a representative list of applicable codes and standards however is not an all-inclusive list:

Mandatory Standard	
Highways Agency (UK)	Design Manual for Roads and Bridges (Volumes 1 & 2 (DMRB)
BS 8006-1:2010	Code of Practice for Strengthened/Reinforced Soils & Other Fills
BS EN 14475:2006	Execution of Special Geotechnical Works – Reinforced Fill
BS EN 1997-1:2004	Eurocode 7: Geotechnical Design - Part 1: General Rules
BS EN 1992-2:2005	Eurocode 2: Design of Concrete Structures – Part 2: Concrete Bridges – Design and Detailing Rules
BS EN 1990:2002	Basis of Structural Design
BD 70/03	Strengthened Reinforced Soils and Other Fills for Retaining Walls and Bridge Abutments
ASTM D6638-07	Standard Test Method for Determining Connection Strength Between Geosynthetic Reinforcement and Modular Concrete Block Facing Units
AASHTO LRFD & FHWA-NHI-10-024 & 025	For the application of Seismic Loads only

4.1.4 Definitions

1. The following definitions shall pertain to words or phrases as utilized in this section:

   MSE Walls - Mechanically Stabilised Earth Walls.

4.1.5 General Requirements

1. The Contractor shall provide a complete set of drawings issued for construction and complete specifications of the proposed wall system for the approval of the Engineer prior to ordering materials.
2. The Contractor must demonstrate that the proposed reinforced soil wall system has had a successful track record of use of at least 10 years in the Middle East.
3. The allowed alternates are Owner approved MSE and/or modular proprietary wall systems,
4. All of the components of the wall system shall have a current British Board of Agreement (BBA) certificate or equivalent European Technical Approval (ETA) certificate, demonstrating suitability for use in highway walls and abutments with a minimum 120 year design life. This requirement is applicable for bridge super structures which are supported on their own foundation structures and do not rely on the strength of the MSE walls for support.
5. The scope of work of the contractor shall include the following:
   (i) Relevant geotechnical investigation of existing soils for the design of the wall system, if the geotechnical investigation provided with the contract documents is insufficient.
   (ii) Full responsibility for the design of the Reinforced soil volume of fill and facing panels based on site and structure geometries, loadings, the contractor's geotechnical investigation and backfill properties as specified by the supplier of the propriety wall.
   (iii) Geotechnical review of bearing pressures applied to the foundation soils, overall stability, excavation, installation, supply, placement and compaction of the Reinforced Soil volume of fill.
   (iv) Replacement of the existing soils with a compacted backfill to meet the requirements of the wall system if required.
   (v) Design and construction of the concrete barrier/coping above the reinforced fill wall together with its counterbalancing slab all as indicated on the Drawings. All exposed faces of the concrete barrier and coping above the reinforced fill wall shall be precast.
6. A Representative of the reinforced fill retaining wall manufacturer shall be present on site during the casting and erection phases to ensure that the quality of the works performed by the Contractor is in accordance to the Specification. Furthermore the Engineer/Client reserves the right to ask for the Manufacturer's Representative whenever they deem necessary. All expenses relative to his presence on site shall be borne by the Contractor.

7. The design shall address the climatic conditions existing in Qatar and soil conditions at the site. The design must be performed by the supplier of the wall system, who shall submit proof of professional indemnity insurance coverage. 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.

4.1.6 Submittals

4.1.6.1 Design Calculations

1. The design of Mechanically Stabilised Earth (MSE) retaining walls shall be based on the most recent version of BS 8006-1, BS EN 14475 and BD 70/03.

2. The following design criteria shall also be considered:

   (i) The design life of the reinforcing elements shall be taken as equal to the service life of the structure.

   (ii) All MSE walls shall be considered as Category 3 structures.

   (iii) The design Temperature shall be ≥35°C.

   (iv) The angle of friction shall be taken as:

   - ≥35° for selected fill material
   - ≥34° for general backfill material

   (v) The unit weight of all backfill material shall be ≥19kN/m3

   (vi) For MSE walls using concrete facing panels, the vertical distance between soil reinforcement layers shall not exceed 800mm.

   (vii) For MSE walls using modular concrete block facing units, the following shall apply:

   - The horizontal distance between soil reinforcement sections or strips shall be not more than one block width.
   - The vertical distance between soil reinforcement layers shall be not more than two block heights apart.

   (viii) Seismic load shall be applied as per the AASHTO-LRFD Extreme Event Limit State I, with A = 0.09g.

   (ix) A vehicle impact horizontal static load of 45 kN/m on the traffic barriers shall be transferred to the top of the wall in the design.

   (x) No vertical live load shall be allowed when considering the resistance to overturning of the concrete barrier/counterbalance slab when subjected to vehicle impact load.

   (xi) The live load surcharge shall be 22.4kN/m^2.

   (xii) The length of the soil reinforcement shall not be less than the greater of 50% of the design wall height or 3 meters.

3. The design of MSE panels or units should be based on the following:

   (i) Basic section geometry, backfill tests results, permeability and grading information provided by the main Contractor. The backfill properties shall be regularly monitored by the Contractor during construction to ensure compliance with the approved property limits.

   (ii) The difference between specified backfill and embankment backfill elevations shall not to be more than 600mm at any time during backfilling.

4.1.6.2 Information submittals

1. The system submission shall be accompanied by:

   (i) A copy of the current BBA certificate or equivalent European Technical Approval (ETA) certificate.

   (ii) Detailed design calculations for the proposed wall system, coping, concrete barrier/counterbalance slab.

   (iii) Soils test information of the proposed reinforced soil fill.

   (iv) Method statement for construction.

   (v) Copy of a current 10 year “Design and Product Liability” insurance to be issued in the name of the Wall System Supplier. The Insured amount shall not be less than the Wall System Supplier sub-contract value.

   (vi) At least 10 year proven track record that the proposed system and type of reinforcement have been used previously and successfully in the Middle East for similar heights as walls of this project.

   (vii) Complete test results required in “4.2 MATERIALS” along with a comparison table.

4.1.6.3 Shop Drawings

1. The Contractor shall submit details and drawings of the wall system, coping and concrete barrier/counterbalance slab. Any particular requirements of the approved detailed specifications for the approved proprietary system shall govern over any conflicting or incompatible requirement contained within this section of the specification. The Contractor shall also provide a detailed method statement.

4.1.7 Quality Control

1. Quality Assurance shall be as per BS EN ISO 9001:2008; "Quality Systems-Model for Quality Assurance in Production, Design and Development Installation and Servicing".

4.1.8 Delivery, Storage and Handling

1. All precast facing panels or units shall be protected as far as practicable from mechanical damage or surface deterioration, from handling and storage or other causes, from time of shipment until it is placed.

2. All materials susceptible to degradation from exposure to the sun shall be kept under protected and covered areas.

4.2 MATERIALS

4.2.1 General

1. The MSE retaining walls shall conform to the Supplier's standards as previously approved by the Engineer and to the above mentioned mandatory standards.
2. The wall system design shall ensure a high strength, durable, non-corrosive, positive connection between wall face and reinforcement. Only non-metallic soil reinforcement and fixings shall be utilized

4.2.2 Drainage

1. Drainage systems consisting of a drainage layer with drainage pipe of not less than 150mm diameter wrapped in geotextile shall be installed where specified on the drawings or by the Engineer. They shall be perforated or slotted PVC, or corrugated HDPE, shall be detailed to be accessible for future maintenance. The pipes shall be manufactured in accordance with ASTM D3034 and/or ASTM D124B
2. All drainage material shall be designed to avoid loss of reinforced fill or adjacent soil into the drain.
3. Where applicable open channel drains shall be provided along the top edge of the wall on the top of each terrace and taken down at intervals
4. Sketches of drainage details may be found in BS 8006-1.

4.2.3 Precast Concrete Facing Panels

1. Concrete Class C50/20 shall be used for precast panels, coping, and for barriers and concrete balance footing.
2. The minimum panel thickness shall be as required by design but should not be less than 150mm nominal thickness (excluding texture finish) and 160mm nominal thickness for panels below the ground level.
3. The maximum standard panel area should not exceed $4m^2$.
4. All faces of the panel that have the possibility of coming in contact with earth shall receive three coats of bituminous paint, including exposed recesses or cavities made in the panels and shall comply with BS 8500-1: 2006 to suit the proposed location and level of exposure of the proposed structure.
5. Concrete quality for the panels shall conform to EN 206.
6. All steel reinforcement used in panels shall conform to BS EN 10080 and BS 4449 (Grade B500B or B500C).
7. The minimum reinforcement bar cover should be:
   (i) 60mm for any part of the concrete panel that has the possibility of coming in contact with earth and which is protected by the bituminous paint
   (ii) 50mm for the external exposed face of the wall
   (iii) 40mm for non-corrodible reinforcement

8. The cover to the embedded reinforcement of 60mm shall be maintained in all cavities or indentations formed in the back of the panels to accommodate the embed/connection device.

9. There shall be no direct contact between the panel embed/connection devices and the embedded steel reinforcement.

10. All exposed reinforcement forming part of the embed/connection device shall be of either Stainless Steel Grade 316L reinforcement or of approved non-corrodible material.

11. Where exposed non-corrodible elements are used as a connection device, it shall not come in direct contact with the panel embedded steel reinforcement. The minimum gap between such elements and the panel reinforcement shall be 50mm.

12. The panels should have a ship lap or tongue and groove system of overlapping joints between panels designed to conceal joints and bearing pads.

13. All dimension deviations should be within 5mm.

14. Angular distortion with regard to the height of the panel should not exceed 5mm in 1.5m.

15. Surface defects on formed surfaces measured on a length of 1.5m should not be more than 2.5mm.

16. The panel embeds/connection devices should be cast into the facing panels with a tolerance not to exceed 25mm from the locations specified on the approved shop drawings.

17. The back face of the panel should be roughly screeded to eliminate open pockets of aggregate and surface distortions in excess of 6mm.

4.2.4 Modular Concrete Block Facing Units

1. The blocks shall be machine manufactured from Sulphate Resistant Cement specifically designed for use in mechanically stabilised earth retaining wall systems.

2. The minimum concrete strength shall be 40N/mm^2 at 28 days. The concrete mix specification comprises a minimum cement content of 340 kg/m^3 and a maximum water/cement ration of 0.55 and satisfies the requirements of exposure class XF2 to BS 8500-1.

3. Blocks shall conform to BS EN 771-3:2003+A1. Concrete used to manufacture blocks shall have a maximum moisture absorption rate, by weight of 5%, when tested in accordance with the method of BS 7263-1:2001, Annex C.

4. Pigments/Colourr of the blocks shall be as specified by the Engineer/Client and shall conform to BS EN 12878.

5. The blocks shall have a straight split/textured face finish.

6. Block height shall not exceed 200mm.

7. Blocks shall be solid through the full depth.

8. Blocks when Installed shall have gaps not greater than 4mm between adjacent units.

9. Blocks 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 meters from the wall shall not be used within the wall.

10. All modular concrete block facing units will be manufactured by a block manufacturer approved by the Engineer.

11. Only block systems that provide full face without any "voids" when constructed will be accepted. The blocks should be interlocking from one level to the next by means of an integrated mechanical key built into their shape. Blocks must achieve connectivity by a continuous mechanical connection built into the shape, and/or by a mechanical key formed as part of the connection device.

12. The shear strength between blocks, and the connection strength between block and geosynthetic reinforcement must be demonstrated in accordance with the procedures of ASTM D6916, ASTM D6638, NCMA SRWU·1, Determination of Connection Strength between Geosysthetics and Segmental Retaining Wall (SRW) units and SRWU-2, Determination of Shear Strength between Concrete SRW units or other recognized test standard.

13. All units shall be manufactured within the following tolerances:

    (i) the height of the blocks are to be ±3mm.

    (ii) the length of the block to be ±3mm

    (iii) the squareness of the blocks to be ±2mm

14. Particular care shall be taken during storage to avoid staining the front face of the blocks.

15. Blocks will be subject to rejection because of failure to meet any of the requirements of the Specifications. In addition, any or all of the following defects shall be sufficient cause for rejection:

    (i) Defects that indicate imperfect moulding.

    (ii) Defects indicating honeycombed or open textured concrete.

    (iii) A block with a damaged surface finish or staining or is otherwise chipped or cracked on the front face such that in the opinion of the Engineer is visibly different from other blocks. Such a block may however be used in positions where it is below final ground level, subject to the Engineer's approval.

16. All faces of the blocks that have the possibility of coming in contact with earth shall receive two coats of bituminous paint.

4.2.5 Polymeric (GeoSynthetic Friction) Reinforcement

1. The proposed geosynthetic friction reinforcement shall have a CE certificate (EC certificate of Factory Production Control (FPC)).
2. The wall shall be designed to be safe under the climatic conditions existing in the Middle East.
3. The design life of the friction reinforcement shall be 120 years
4. The geosynthetic material used in the MSE wall system shall be tested for a design mean temperature of 35°C.
5. Geosynthetic friction reinforcement utilized with the precast concrete facing panel wall system shall comply with the following:
   (i) They shall be strips of polymeric high tenacity polyester fibers concentrated in a series of separated bundles and encased in a durable low density polyethylene sheath. Polyester fibers shall have a minimum Number Average Molecular Weight of 27,000 as per ASTM D4603 and GGI-GR8 method, and Maximum of Carboxyl End Group Content of 30 as per GRI-GG7 method. All polymeric components shall contain no recycled materials.
   (ii) They shall never be cast directly into the concrete and shall never be skewed more than 15º from a position normal to the wall panel. Where obstructions such as manholes, piles, foundations, etc. cannot be avoided and result in skews exceeding this limit the wall designer shall ensure that he accounts for this in his design.
6. GeoSynthetic friction reinforcement utilized with the modular concrete block wall system shall be in accordance with the suppliers' wall system BBA Certificate and specifications and shall be subject to the approval of the engineer.
7. All product specific durability testing reports, documented evidence of third party participating, and any relevant information shall be provided to the Engineer to examine the short-term and long-term effects of environmental factors. The reports, documents and information shall include, but shall not be limited to the following:
   (i) Short-term Tensile Strength, Elongation Tests results and load/strain characteristics as per EN ISO 10319:2008
   (ii) Real time Long Term and Short Term Creep tests results as per ASTM D5262 and FHWA-NHI-00-043 and FHWA-NHI-00-044. [The manufacturer should have at least continuous 10,000hrs of data) or as per ISO TR 20432 "Guidelines for the Long Term Strength of GeoSynthetics for Soil Reinforcement" along with RS K 0023 "Lifetime Prediction Test Method for Accelerated Tensile Creep of GeoSynthetics (B) - SIM
   (iii) Hydrolysis Resistance Tests as per ASTM D5322/92 (or EN ISO 12447) at 35 °C design mean temperature and 120 year service life.
   (iv) Chemical Resistance Tests ISO TR 12960 (Alkali, Acid) and Weathering (EN 12224)
   (v) Resistance to microbiological attack shall be to BS EN 12225:2000

(vi) Installations Damage Resistance Tests in a soil similar in gradation and texture to the material that will be used for backfill in the reinforced zone as per ASTM D5818.

(vii) Pull-out tests to establish the coefficient of friction between the geosynthetic reinforcement and a soil similar in compaction, moisture content, gradation, and texture to the material that will be used for backfill in the reinforced zone shall be to BS EN 13738:2004.

8. The manufacturer shall provide appropriate factors for installation damage.

9. Where concrete facing panels or modular concrete block units are to be embedded in potentially aggressive soils, the guidance in BRE Special Digest 1:2005 – Concrete in Aggressive Ground, shall be followed.

4.2.6 Connection

1. External components being part of the connection between the facing and the soil reinforcement and having a mechanical role, such as loops, dowels, bodkins, dented hooks shall be tested for long term effect on creep, hydrolysis, chemical resistance for the specified design mean temperature of 35°C and 120 year service life. The same test methods listed in "4.2.5 Polymeric (Geosynthetic Friction) Reinforcement" shall apply.

2. Polymeric connectors utilized in the modular concrete block wall system are propriety products which shall be manufactured strictly in accordance with the suppliers' wall system BBA Certificate and specifications and will be subject to the approval of the engineer and tested for the specified design mean temperature of 50ºC and 120 year design service life.

4.2.7 Pervious Backfill

1. Pervious backfill shall be angular, clean stone or granular fill meeting the following gradation as determined in accordance with BS 1377, BS EN 1997-1 and 2:

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

4.2.8 Reinforced (Infill) Soil

1. Soil test report for any source of selected fill should be approved by the Wall System supplier and presented to the Engineer or Client for approval. The reinforced soil material should be well graded crushed and granular not Sub-rounded, and should conform to the following:

   (i) Maximum particle size 75mm

   (ii) Uniformity coefficient greater than or equal to 4

   (iii) Maximum 10% by mass passing the 75µm sieve

   (iv) Well graded material not gap graded

   (v) Inorganic with no plastic material content

   (vi) Minimum angle of friction of 356° measured through direct shear test under drained condition

   (vii) Plasticity index 6 maximum

4.2.9 Joint Filler

1. All joints between concrete facing panels shall be filled with a continuous filler, flexible open cell polyethylene foam strips, and further protected by a strip of geofabric, thermally bonded non-woven needle punch polypropylene of weight 150g/m^2 minimum, installed on the inside face of the panels along all of the joints, horizontal and vertical, so as to prevent any leakage of the fine particles of the fill material at the back of the facing but allowing the passage of water from behind the panels. The jointing material shall be pervious unless otherwise required by the specification for the works.

2. The bearing pads supporting panels along horizontal joints shall be to the wall manufacturers requirements and specifications or shall consist of resin bonded cork conforming to ASTM D1752 (Type II) or elastomeric pads with shore A hardness 80±5 or HDPE pads with minimum density of 1g/cm3 in accordance with ASTM D1505. The compressibility of the bearing pads shall be consistent with the compressibility of the retained fill.

4.3 EXECUTION

4.3.1 Excavation

1. The Contractor shall excavate to the lines and grades shown on the project grading plans. The Contractor shall take precautions to minimize over excavation. Over-excavation shall be filled with compacted infill material, or as directed by the Engineer.

2. To prevent the possibility of differential settlements occurring immediately behind the bridge abutments (at least 15m), it is recommended that at least 1m of existing soil below the future embankment is removed and replaced with sub-base material compacted in layers of 200mm to 98% Modified Proctor density.

3. The Contractor shall verify location of existing structures and utilities prior to excavation. The Contractor shall ensure all surrounding structures are protected from the effects of wall excavation. Excavation support, if required, is the responsibility of the Contractor.

4. The Contractor shall report immediately to the Engineer any sub-soil conditions which he encounters during excavation which are likely to result in the bearing capacity required as shown on the Drawings not being achieved. The foundation of the structure shall be graded level for a width equal to or exceeding the width of the strip footing plus a working space.

5. Prior to wall construction, except where constructed on rock, the sub-soil shall be compacted with a smooth wheel vibratory roller.

4.3.2 Foundation Preparation

1. Following the excavation, the foundation soil shall be examined by the 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 Engineer.

2. Foundation soil shall be proof rolled and compacted to 98% Modified Proctor density and inspected by the Engineer prior to placement of levelling pad materials.

3. The foundation soils supporting the structure should be graded for a width equal to or exceeding the length of the soil geosynthetic reinforcement. Prior to wall construction, the foundation should be compacted with a smooth wheel vibratory roller to 98% of Modified Proctor density. Any foundation soils found to be unsuitable should be removed and replaced, as directed by the Engineer.

4. The strip footing shall be Grade 20/20 concrete, to the dimensions indicated in the Drawings or in the suppliers' specifications and manuals.

5. Embedment of the panels at the base of the wall shall be at least 800mm

4.3.3 Delivery, Site Handling and Storage

1. The facing panels or units shall be delivered, handled and stored on site strictly in accordance with the suppliers' recommendations.

2. They shall be clearly marked with the manufacturer's label or marking identifying the product type and batch code.

4.3.4 Erection of Panels and Modular Blocks

1. During the specified backfill placement to install the concrete facing panels, the Contractor shall keep the backfill at just above the geosynthetic reinforcement connection to panel, prior to making the connection.

2. Fill material is placed and compacted up to the top of the block facing units allowing a minimum of 150 mm of free draining, granular material behind the face where necessary.

3. The Contractor shall remove and replace any facing panel or modular block that does not meet the construction tolerances.

4. It is required to use the geotextile filter cloth across all panel joints (refer to 4.2.9). It should be a thermally bonded non-woven needle punch polypropylene of weight 150g/m^2 minimum and with a minimum width of 300mm and a minimum non-sewn lap of 150mm where necessary.

5. For aesthetic considerations and differential settlement concerns, the panels should be erected in such a pattern that the horizontal panel joint line is discontinuous at every other panel. This should be accomplished by alternating standard height and half height panel placement along the levelling pad. Panels above the lowest level should be standard size except as required to satisfy the top of exposed panel line shown on the contract drawings.

6. This is however not required for the modular block facing units which are usually laid along horizontal level lines with blocks being out of step (discontinuous) in the vertical direction only.

7. At locations where the plans specify a change of panel alignment creating an included angle of 150° or less, precast corner joint elements will be required. This element should separate the adjacent panels by creating a vertical joint secured by means of separate soil geosynthetic reinforcement.

8. Isolation or slip joints, which are similar to corner joints in design and function, may be required to assist in differential settlements at locations indicated on the plans or as recommended by the wall supplier. As select fill material is placed behind a panel or block, the panel or block should be maintained in its proper inclined position or with a nominal setback according to the supplier specifications and as approved by the Engineer.

9. Vertical tolerances and horizontal alignment tolerances should not exceed 20mm when measured along a 3.0m straight edge. The maximum allowable offset in any panel joint should be 20mm. The overall vertical tolerance of the wall, (plumbness from top to bottom) should not exceed 15mm per 3.0m of wall height and 50 mm overall. The precast face panels or modular blocks should be erected to ensure that they are located within 25mm from the contract plan offset at any location to ensure proper wall location at the top of the wall. Failure to meet this tolerance may cause the Engineer to require the Contractor to disassemble and re-erect the affected portions of the wall. A 20mm joint separation should be provided between all adjacent face panels to prevent direct concrete to concrete contact.

10. The select fill and embankment placement should closely follow the erection of each lift of panels. At each soil geosynthetic reinforcement level, the fill material should be roughly levelled and compacted before placing and attaching the soil reinforcing system. The soil geosynthetic reinforcement and the maximum lift thickness should be placed according to the supplier's recommended procedures except, the lifts should not exceed 250mm loose measurement or as approved by the Engineer.

11. At the end of each day's operations, the Contractor should shape the last level of select fill to permit runoff of rainwater away from the wall face. Select fill should be compacted according to the General Specifications for embankment. Select fill compaction should be accomplished without disturbance or distortion of soil geosynthetic reinforcing system and panels. Compaction in a strip 2.0m wide adjacent to the backside of the panels should be achieved using a minimum of 3 passes of a light weight mechanical tamper, roller or vibratory system.

4.3.5 Construction of Precast Concrete Barrier and Counterbalancing Slab

1. Care shall be taken to ensure that the expansion joints in the precast concrete barriers coincide with the expansion or construction joints in the cast in place counterbalancing slab.

4.3.6 Construction of the Wearing Surface

1. Every effort shall be made to limit cracking in the wearing surface resulting from the settlement or outward movement of the MSE walls. Sufficient time should be allowed for the MSE wall to settle into its final position prior to the construction of the roadway surface. The contractor will be responsible for the making good, to the satisfaction of the engineer, of any defects in the wearing surface resulting from the construction of the MSE wall and its components (backfill, counterbalancing slab, traffic barrier, etc.) prior to handover.

4.4 WARRANTEE

1. The contractor and the supplier of the MSE wall panels and segmental block wall facing shall submit letters of warrantee that the system has been designed for the specified service life and for the specified design mean temperature encountered in the country.