4.10 **ASSEMBLY OF METAL ARCH FORM:** THE DESIGN ENGINEER WILL ENSURE THAT THE ASSEMBLY DETAIL FOR THE METAL ARCH FORM (PROVIDED BY THE MANUFACTURER) WILL BE SUPPLIED WITH THE MATERIALS AND/OR THE DESIGN DRAWINGS. THE BOTTOM EDGES OF THE METAL ARCH FORM MUST BE FITTED WITH EITHER A METAL CHANNEL OR ANGLE TO PREVENT CONCENTRATED STRESSES ALONG THE THIN METAL EDGE OF THE FORM.

4.11 **DEADMAN ANCHORS:** THE DEADMAN ANCHORS ARE PRIMARILY DESIGNED TO SECURE THE METAL ARCH FORM TO THE GRS COMPOSITE MASS AND TO RESIST CONSTRUCTION LOADING. ALTHOUGH THE NEEDED TENSILE CAPACITY OF THE ANCHORS IS NOMINAL, THEY MUST BE DESIGNED TO FUNCTION FOR THE DESIGN SERVICE LIFE OF THE STRUCTURE AS THEY ARE A SECONDARY LOAD CARRYING ELEMENT. THE DESIGN DRAWINGS MUST INCLUDE ANCHOR DETAILS AND MATERIAL SPECIFICATIONS INCLUDING REQUIREMENTS FOR CORROSION PROTECTION. ANCHOR LAYOUT AND INSTALLATION DETAILS WILL BE SHOWN ON THE DESIGN DRAWINGS.

4.12 **CONSTRUCTION LOAD:** THE DESIGN ENGINEER MUST CONSIDER THE WEIGHT OF MATERIALS, WORK CREWS AND EQUIPMENT SUPPORTED DURING CONSTRUCTION WHEN DESIGNING THE STRUCTURE. THE DESIGN ENGINEER MUST SPECIFY MAXIMUM PERMISSIBLE CONSTRUCTION EQUIPMENT LOADS AND CONSTRUCTION SEQUENCE ON THE DETAILED DESIGN AND CONSTRUCTION DRAWINGS, AS REQUIRED TO ADDRESS WORKER SAFETY DURING CONSTRUCTION.

5. FIELD REVIEWS DURING CONSTRUCTION

5.1 **FIELD REVIEWS:** THE PROFESSIONAL OF RECORD **(POR)**, OR THE **POR'S** DESIGNATE ACTING UNDER THE DIRECT SUPERVISION OF THE **POR**, WILL CONDUCT THE NECESSARY CONSTRUCTION FIELD REVIEWS REQUIRED TO PROVIDE ASSURANCE THAT THE STRUCTURE IS CONSTRUCTED IN GENERAL CONFORMANCE WITH THE DESIGN DRAWINGS.

THE **POR**, OR THE **POR'S** DESIGNATE ACTING UNDER THE DIRECT SUPERVISION OF THE **POR**, MUST BE ON-SITE FOR REVIEW AND APPROVAL OF CONSTRUCTION PROCEDURES, VERIFICATION OF MATERIALS USED IN CONSTRUCTION, AND FOUNDATION PREPARATION.

NOTE: PERMITS FROM OTHER REGULATORY AGENCIES MAY BE REQUIRED AS DETERMINED BY THE COORDINATING REGISTERED PROFESSIONAL (CRP).

THE **POR** WILL BE RESPONSIBLE FOR THE FOLLOWING TASKS:

- DOCUMENT ALL FIELD PRESCRIBED MEASURES OR VARIATIONS FROM THE DESIGN DRAWINGS IN THE *PROFESSIONAL OF RECORD CROSSING ASSURANCE STATEMENT* .
- APPROVE AND DOCUMENT ALL SOURCES OF SOIL MATERIALS USED TO BUILD THE GRS COMPOSITE MASS, AND ALL SOURCES OF ROCK MATERIALS FOR RIPRAP, FOUNDATION PREPARATION AND CHANNEL RECONSTRUCTION, PRIOR TO SOURCE DEVELOPMENT.
- DOCUMENT THE TYPES OF SOIL MATERIALS USED TO BUILD THE GRS COMPOSITE MASS, AND THE SIZE AND TYPE OF ALL ROCK PLACED FOR RIPRAP, THE FOUNDATION PREPARATION AND CHANNEL RECONSTRUCTION.
- OBTAIN ALL MILL TEST CERTIFICATES FOR THE GEOTEXTILE FABRIC, METAL ARCH FORM, (DEADMAN ANCHORS IF AVAILABLE), AND WELDED WIRE MESH FORMS, INCORPORATED INTO THE STRUCTURE.
- DOCUMENT THE TYPE, SIZE, GRADE OF STEEL, AND MANUFACTURER OF DEADMAN ANCHORS USED.

5.2 CONSTRUCTION DOCUMENTATION SHOULD INCLUDE ASSEMBLED SHAPE MEASUREMENTS (CORDS) AND POST CONSTRUCTION CORD MEASUREMENTS AT A MINIMUM OF THREE LOCATIONS ALONG THE LENGTH OF THE STRUCTURE. A MINIMUM OF THREE CORD MEASUREMENTS (INCLUDING THE SPAN) SHOULD BE RECORDED AT EACH LOCATION. IN ADDITION, AT BOTH THE INLET AND OUTLET ENDS, THE ELEVATIONS OF THE BOTTOM EDGES AND CROWN OF THE METAL ARCH FORM SHOULD BE RECORDED AND REFERENCED TO PERMANENT SITE BENCHMARKS.

6. INLET AND OUTLET DETAILS

6.1 **CONSIDERATIONS IN SELECTION OF INLET AND OUTLET DETAILS:** THE CONFIGURATION OF THE INLET AND OUTLET ENDS OF THE STRUCTURE MAY INCLUDE RETAINED WALLS OR REINFORCED SOIL SLOPES, OR A COMBINATION OF THESE TWO OPTIONS. THE SELECTION OF INLET AND OUTLET DETAILS (I.E., CONFIGURATION OF THE INLET AND OUTLET ENDS OF THE STRUCTURE AND ASSOCIATED FACING OPTIONS) MUST CONSIDER VARIOUS FACTORS TO ADDRESS DURABILITY, SERVICEABILITY AND OTHER DESIGN OBJECTIVES, INCLUDING BUT NOT LIMITED TO THE FOLLOWING:

- DESIGN SERVICE LIFE
- ECONOMIC IMPLICATIONS OF THE STRUCTURE LENGTH AND POTENTIAL ENVIRONMENTAL IMPACT
- ROAD SAFETY CONSIDERATIONS AND TRAFFIC BARRICADE REQUIREMENTS
- LIFE CYCLE COST CONSIDERATIONS, FUTURE MAINTENANCE AND SERVICEABILITY
- DRAINAGE REQUIREMENTS FOR THE GRS COMPOSITE MASS
- DURABILITY FOR GIVEN EXPOSURE
- TOLERANCES TO MOVEMENT DURING AND AFTER CONSTRUCTION SETTLEMENT, DEFLECTION, AND ROTATION
- EXPOSURE OF UNCOVERED GEOTEXTILE MATERIALS TO POTENTIALLY DELETERIOUS ENVIRONMENTAL FACTORS SUCH AS THE LONG-TERM EFFECTS OF ULTRAVIOLET (UV) LIGHT
- LIKELIHOOD OF POSSIBLE DAMAGE TO FACING ELEMENTS FROM STREAM ABRASION AND SCOUR HAZARDS
- LIKELIHOOD OF POSSIBLE DAMAGE FROM GRADING AND SNOW REMOVAL OPERATIONS AND VANDALISM
- AESTHETICS
- ANTICIPATED POTENTIAL FUTURE TRANSFER OF THE FSR TO OTHER AGENCIES POSSIBLY NECESSITATING THE INSTALLATION OF SPECIFIC MATERIALS FOR FACING ELEMENTS
- AVAILABILITY OF MATERIALS
- HORIZONTAL ALIGNMENT RESTRICTIONS AND SPACE LIMITATIONS.

6.2 **MINISTRY APPROVAL:** THE MINISTRY ENGINEER MUST APPROVE THE FACING ELEMENT TYPE FOR THE INLET AND OUTLET ENDS OF THE ARCH PRIOR TO FINAL DESIGN AND CONSTRUCTION.

6.3 **RETAINED HEADWALLS AND WINGWALLS FOR INLET AND OUTLET ENDS:**

- **CONFIGURATION OF WALLS:** THE INLET AND OUTLET ENDS OF THE STRUCTURE MAY BE CONSTRUCTED AS RETAINED HEADWALLS AND WINGWALLS WITH SLOPE GRADIENTS EQUAL TO OR STEEPER THAN 2 VERTICAL TO 1 HORIZONTAL (63 DEGREES) BY UTILIZING THE BIAXIAL NATURE AND STABILITY OF THE LAYERED GEOTEXTILE SOIL REINFORCEMENT THAT IS USED TO CONSTRUCT THE ARCH. THIS CONFIGURATION MAY BE SUITABLE FOR STRUCTURES INSTALLED ON EITHER TEMPORARY TERM OR PERMANENT TERM FSRS WITH APPROPRIATE RIPRAP SCOUR PROTECTION WHERE REQUIRED AT THE BASE OF THE WALL. THE WALLS ARE CONSTRUCTED USING A FACING ELEMENT THAT SERVES AS A CONSTRUCTION AID, AND PROTECTS THE GRANULAR FILL OF THE GRS COMPOSITE MASS FROM OUTSIDE WEATHERING, EROSION AND RAVELLING. THE WALL FACING ELEMENT IS NOT A STRUCTURAL MEMBER OF THE STRUCTURE.

- **DURABLE MATERIALS AT THE FACE:** UNLESS OTHERWISE SPECIFIED OR APPROVED BY THE MINISTRY ENGINEER, THE FACING ELEMENTS FOR RETAINED HEADWALLS AND WINGWALLS WILL BE COMPRISED OF DURABLE MATERIALS SUCH AS ROCK FILL (COBBLES, OR BROKEN ROCK), OR GALVANIZED STEEL SHEETS, INCORPORATED WITH GALVANIZED WELDED WIRE MESH FORMS. FOR ROCK FILL FACING, THE DESIGN WILL SPECIFY ADEQUATELY SIZED ROCK TO PREVENT THE LOSS OF COBBLES OR BROKEN ROCK THROUGH THE GRID OPENINGS IN THE WELDED WIRE MESH FORMS. THE USE OF DURABLE FACING MATERIALS IS REQUIRED FOR RETAINED HEADWALLS AND WINGWALLS FOR STRUCTURES INSTALLED ON PERMANENT TERM FSRS.

- **DOUBLE LAYERED GEOTEXTILE FABRIC AT THE FACE:** SUBJECT TO APPROVAL BY THE MINISTRY ENGINEER, THE FACING ELEMENT OF RETAINED HEADWALLS AND WINGWALLS MAY CONSIST OF A DOUBLE LAYER OF GEOTEXTILE FABRIC AT THE FRONT OF GALVANIZED WELDED WIRE MESH FORMS PROVIDED THE DESIGN ENGINEER HAS DETERMINED (AFTER CONSIDERATION OF THE SITE SPECIFIC UV POTENTIAL) THAT THIS DOUBLE LAYER SYSTEM OF GEOTEXTILE FABRIC WILL PROVIDE SUITABLE UV PROTECTION TO MEET PROJECT DURABILITY AND SERVICEABILITY REQUIREMENTS OVER THE DESIGN SERVICE LIFE. THE GEOTEXTILE FABRIC MUST BE UV STABILIZED USING CARBON BLACK MEETING THE FOLLOWING MINIMUM SPECIFICATION: MINIMUM 70 PERCENT STRENGTH RETAINED AFTER 500 HRS OF UV EXPOSURE ACCORDING TO ASTM D4355 - "STANDARD TEST METHOD FOR DETERIORATION OF GEOTEXTILES BY EXPOSURE TO LIGHT, MOISTURE AND HEAT IN A XENON ARC TYPE APPARATUS." THE POSSIBLE USE OF DOUBLE LAYERED GEOTEXTILE FABRIC SHOULD ONLY BE CONSIDERED FOR RETAINED HEADWALLS AND WINGWALLS ON STRUCTURES INSTALLED ON TEMPORARY TERM FSRS AFTER CONSIDERATION OF THE FACTORS LISTED IN SECTION 6.1 AND CONSULTATION WITH THE MINISTRY ENGINEER.

6.4 **REINFORCED SOIL SLOPES FOR INLET AND OUTLET ENDS:**

- **CONFIGURATION OF REINFORCED SOIL SLOPES:** THE INLET AND OUTLET ENDS OF THE STRUCTURE MAY ALSO BE CONSTRUCTED AS AN EMBANKMENT OR OVERSTEEPENED SLOPE WITH SLOPE GRADIENTS LESS THAN 2 VERTICAL TO 1 HORIZONTAL (63 DEGREES) UTILIZING THE BIAXIAL NATURE AND STABILITY OF THE LAYERED GEOTEXTILE SOIL REINFORCEMENT THAT IS USED TO CONSTRUCT THE ARCH. A FACING ELEMENT COMBINING (1) GALVANIZED WELDED WIRE MESH FORMS, GEOTEXTILE AND VEGETATION; OR (2) STACKED ROCK WITH GEOTEXTILE SEPARATION, IS USED FOR THIS CONFIGURATION. THIS CONFIGURATION MAY BE SUITABLE FOR STRUCTURES INSTALLED ON EITHER TEMPORARY TERM OR PERMANENT TERM FSRS WITH APPROPRIATE RIPRAP SCOUR PROTECTION WHERE REQUIRED AT THE BASE OF THE SLOPE.

- **VEGETATION AT THE FACE:** SUBJECT TO APPROVAL BY THE MINISTRY ENGINEER, AND FOR REINFORCED SOIL SLOPES OF HEADWALLS AND WINGWALLS WITH SLOPES OF LESS THAN 2 VERTICAL TO 1 HORIZONTAL (63 DEGREES), THE FACING ELEMENT MAY CONSIST OF A VEGETATED WALL FACE, UTILIZING GALVANIZED WELDED WIRE MESH FORMS AND A SINGLE LAYER OF GEOTEXTLE FABRIC AT THE FACE. TO ACHIEVE THE VEGETATED FACE, GRASS SEEDING AND/OR LIVE STAKING WILL BE INCORPORATED INTO THE DESIGN. THE PROCEDURES AND MATERIALS FOR SEEDING AND LIVE STAKING WILL BE SPECIFIED ON THE DESIGN DRAWINGS, BASED ON CONSIDERATIONS OF CLIMATE, EXPOSURE ASPECT, ROAD GEOMETRY AND OTHER SITE CONDITIONS.

- **STACKED ROCK AT THE FACE:** SUBJECT TO APPROVAL BY THE MINISTRY ENGINEER, STACKED ROCK FOR REINFORCED SOIL SLOPES OF HEADWALLS AND WINGWALLS WITH GEOTEXTILE SEPARATION MAY BE USED FOR EMBANKMENT HEIGHTS OF LESS THAN 4m HIGH AND SLOPING AT LESS THAN 2 VERTICAL TO 1 HORIZONTAL (63 DEGREES). THE DESIGN WILL SPECIFY THAT ONLY DURABLE ROCK OF SUITABLE SIZE AND SHAPE TO ACHIEVE A STABLE FACE WILL BE USED.

7. MATERIALS

7.1 **WOVEN GEOTEXTILE FABRIC FOR SOIL REINFORCEMENT:** WOVEN GEOTEXTILE FABRICS USED TO CONSTRUCT THE GRS COMPOSITE MASS WILL MEET THE FOLLOWING MINIMUM DESIGN CRITERIA:

- MINIMUM WIDE-WIDTH TENSILE STRENGTH OF 30kN/m (ASTM D4595 - "STANDARD TEST METHOD FOR TENSILE PROPERTIES OF GEOTEXTILES BY THE WIDE-WIDTH STRIP METHOD").

7.2 **NON-WOVEN GEOTEXTILE FABRIC (IF SPECIFIED):** NON-WOVEN GEOTEXTILE FABRICS, WHERE PERMITTED, WILL MEET THE FOLLOWING MINIMUM DESIGN CRITERIA:

- GRAB TENSILE STRENGTH OF 890N (ASTM D4632 - "STANDARD TEST METHOD FOR GRAB BREAKING LOAD AND ELONGATION OF GEOTEXTILES")

- PUNCTURE STRENGTH 580N (ASTM D4833 - "STANDARD TEST METHOD FOR INDEX PUNCTURE RESISTANCE OF GEOMEMBRANES AND RELATED PRODUCTS").

7.3 **METAL ARCH FORM, CHANNEL OR ANGLE, AND STRUCTURAL BOLTS FOR CONNECTIONS:** THE METAL ARCH FORM, AND CHANNEL OR ANGLE AFFIXED ALONG BOTTOM EDGES OF THE METAL ARCH FORM, USED TO CONSTRUCT THE GRS ARCH™ WILL CONSIST OF COMPONENTS MANUFACTURED IN ACCORDANCE TO CAN/CSA-G401 - "CORRUGATED STEEL PIPE PRODUCTS." SMALL LOCALIZED SCRATCHES GREATER THAN 3mm WIDE, OR BURNS CAUSED BY WELDING, NOT INCLUDING CUT EDGES, WHERE THE GALVANIZED COATING HAS BEEN DAMAGED WILL BE REPAIRED BY CLEANING AND THE APPLICATION OF A ZINC-RICH COATING IN ACCORDANCE WITH CAN/CGSB-1.181 - "READY-MIXED ORGANIC ZINC-RICH COATING."

7.4 **DEADMAN ANCHORS AND ASSOCIATED HARDWARE:** THE DEADMAN ANCHORS AND ALL ASSOCIATED HARDWARE MUST BE PROVIDED WITH CORROSION PROTECTION. THIS CAN BE ADDRESSED BY THE METHOD OF APPLYING A SUITABLE HOT DIPPED GALVANIZED COATING TO THE ENTIRE ANCHOR ASSEMBLY TO CSA-G164 - "HOT DIP GALVANIZING OF IRREGULARLY SHAPED ARTICLES" (ASTM 123 - "STANDARD SPECIFICATION FOR ZINC (HOT-DIP GALVANIZED) COATINGS ON IRON AND STEEL PRODUCTS"). THE DESIGN DRAWINGS MUST SPECIFY THE METHOD OF CORROSION PROTECTION USED AND ALL REQUIRED COATINGS IF APPLICABLE.

7.5 **WELDED WIRE MESH FORMS AND ASSOCIATED STEEL STRUTS AND HARDWARE:**

- WELDED WIRE MESH TO BE FABRICATED USING MINIMUM 4 GAUGE WIRE MANUFACTURED IN ACCORDANCE WITH ASTM A1064 - "STANDARD SPECIFICATION FOR CARBON-STEEL WIRE AND WELDED WIRE REINFORCEMENT, PLAIN AND DEFORMED, FOR CONCRETE"

- WELDED WIRE MESH TO BE FABRICATED IN ACCORDANCE WITH ASTM A1064 AND GALVANIZED TO ASTM A123"

- STEEL STRUTS TO BE FABRICATED WITH A MINIMUM 4 GAUGE WIRE MANUFACTURED IN ACCORDANCE WITH ASTM A1064 AND ZINC COATED IN ACCORDANCE WITH ASTM A641 - "STANDARD SPECIFICATION FOR ZINC-COATED (GALVANIZED) CARBON STEEL WIRE"

7.6 **MATERIAL SUPPLY LIST:** THE DESIGN DRAWINGS WILL INCLUDE A COMPLETE MATERIALS SUPPLY LIST, PROVIDING MATERIAL SPECIFICATIONS FOR ALL COMPONENTS. SOME CONTINGENCY IN MATERIAL QUANTITY SHOULD BE INCLUDED TO ACCOUNT FOR POTENTIAL CHANGES IN THE SUBSURFACE CONDITIONS AT THE SITE. THIS WILL HELP TO REDUCE THE POTENTIAL FOR CONSTRUCTION DELAYS AND INCREASED COSTS DUE TO MATERIAL SHORTAGES.

CONCEPT DRAWINGS ONLY - NOT FOR CONSTRUCTION

ASSUME NOT TO SCALE

SCALE AS SHOWN

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REVISIONS

BRITISH COLUMBIA

Province of British Columbia
MINISTRY OF FOREST, LANDS AND NATURAL RESOURCE OPERATIONS
ENGINEERING BRANCH

STANDARD BRIDGE DRAWING

Terraspan® GRS Arch™ Structure–Conceptual Only

General Notes – Sheet 2

ORIGINAL SIGNED and SEALED BY: Calvin VanBuskirk, P.Eng., P.Geo.
APPROVED BY:
DESIGN ENGINEER Calvin VanBuskirk, P.Eng., P.Geo.
FLNR ENGINEER
DATE June 2015
DATE
FILE No.
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