IR 18-2

SEGMENTAL RETAINING WALL SYSTEMS OF PRECAST CONCRETE UNITS: 2022 CBC

Disciplines: Structural

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Division of the State Architect (DSA) documents referenced within this publication are available on the DSA Forms or DSA Publications webpages.

PURPOSE

This Interpretation of Regulations (IR) clarifies design, construction, and quality assurance requirements for segmental retaining wall (SRW) systems used on projects under DSA jurisdiction.

SCOPE

This IR is applicable to gravity type retaining walls assembled of precast concrete units, referred to as SRW systems, which are an alternative to conventional retaining systems. Approval of SRW systems requires compliance with the conditions of this IR and acceptance by DSA. Only soil-reinforced SRW systems are permitted on projects under DSA jurisdiction. The reinforced soil mass may consist of cohesive or cohesionless soil, subject to the recommendations of a geotechnical report.

Retaining walls less than 4-feet above the top of the foundation and not supporting a surcharge may be designated as exempt from DSA review and approval in accordance with *IR A-22: Construction Projects and Items Exempt from DSA Review*. However, such walls shall meet the manufacturer's specifications and the applicable design and wall system requirements described below.

BACKGROUND

SRW systems consist of facing units anchored to a reinforced soil mass that provides gravity load for resistance to overturning and lateral sliding. California Building Code (CBC) Section 1807A.2.4 requires the concrete units used in SRW systems comply with American Society for Testing and Materials (ASTM) Standard C1372: Standard Specification for Dry-Cast Segmental Retaining Wall Units. Geosynthetic grid materials (i.e., geogrid) are used to anchor the facing units and to reinforce the soil mass. For further information on SRW systems refer to the National Concrete Masonry Association (NCMA) Design Manual for Segmental Retaining Walls, 3rd Edition (DMSRW), Section 2.

1. GEOTECHNICAL REQUIREMENTS

A California licensed geotechnical engineer, in accordance with CBC Section 1803A, shall prepare a soil investigation report for the project site. Recommendations for the preparation of reinforced soil mass and slope stability above and below the retaining wall (if necessary) shall be addressed in the report.

The design of SRW systems shall include lateral pressure due to earthquake motion as defined in the geotechnical report, per CBC Section 1803A.5.12, Item #1 and Section 1807A.2.2. The additional seismic lateral earth pressure shall be reviewed and accepted by the California Geological Survey (CGS). Refer to CGS Note 48, Item #11A.

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2. DESIGN REQUIREMENTS

Design of the SRW systems shall comply with the CBC, NCMA DMSRW, American Association of State Highway and Transportation Officials (AASHTO) LRFD Bridge Design Specifications (BDS), 9th Edition, and this section.

2.1 General

2.1.1 SRW system shall be qualified by an evaluation report complying with *IR A-5: Acceptance of Products, Materials, and Evaluation Reports.*

Exception: SRW systems without a complying evaluation report may be used up to a maximum height of 10’-0" above the top of the foundation when submitted and approved by DSA as an alternate method of construction per California Administrative Code (CAC) Section 4-304. Refer to *Procedure (PR) 18-01: Request for Alternate Design, Materials and Methods of Construction* and form *DSA 1-AMM: Request for Alternate Design, Materials and Methods of Construction*.

2.1.2 SRW systems shall not be constructed in a location that will cause the wall to receive loads from any existing or new building foundation. Structures shall not be supported by SRW systems. The minimum setback shall be a 1 horizontal to 1 vertical projection from the tail of the lowest geogrid.

2.1.3 SRW precast concrete units shall comply with ASTM C1372.

2.2 Design Criteria

The design shall include the effect of all surcharge loads, potential settlement, and sloping soil conditions for both gravity and seismic analyses.

2.2.1 Seismic analysis will be required for walls in accordance with CBC Section 1807A.2. The seismic design criteria shall be determined by the geotechnical engineer per Section 1 above in consideration of the properties of the SRW system.

2.2.2 Where structures or fire access lanes adjacent to the SRW would be impacted by wall movement, the horizontal acceleration coefficient per NCMA DMSRW Section 9.4 shall be based on no lateral wall deflection (i.e., $d_{seismic} = 0$) during the design basis seismic event, unless a detailed analysis acceptable to DSA is performed which evaluates the impact of soil movement on the affected elements and justifies their adequacy.

2.2.3 Design factors of safety for systems and design criteria shall be based on and comply with NCMA DMSRW Table 5-2, including minimum width of reinforced zone, minimum wall embedment, minimum anchorage length of geogrid in wall blocks, and maximum wall batter.

2.2.4 The vertical spacing of the geogrid shall not exceed 32-inches nor twice the depth of the block unit, whichever is less. An additional layer of geogrid shall be provided in the top 12-inches of all SRW; this top geogrid layer may be sloped down to avoid and pass below the aggregate base at driveways and parking lots.

2.3 Design Documentation

The wall design shall be prepared by a California registered structural engineer. Complete design calculations of the SRW system shall be provided for DSA review with the project submission. SRW are not permitted to be designed and approved as deferred submittals. Construction drawings shall provide complete plans, sections, and details of the SRW system, including the following information:

2.3.1 Locations and elevations of the top and bottom of all wall sections including the foundations, minimum wall embedment, and water table.

2.3.2 Geogrid type, location, and embedment lengths behind the interior face of the block units. A plan view shall show the interaction of geogrid layouts at wall corners, curves, or bends in accordance with Section 3.2.2 below.

2.3.3 Soil gradation requirements, assumed soil design properties (such as density, soil friction angle, etc.) for reinforced and retained fills, and placement/compaction specifications for all backfill materials and block unit fill material, including any special compaction or construction equipment considerations based upon proximity to wall face.

2.3.4 Location and size of all holes or openings to be cut into the geogrid. Such penetrations may be required for fence posts, light poles, and other components. Any additional geogrid reinforcement and details required to accommodate penetrations shall be included on the drawings.

2.4 Global Stability Analysis

A global stability analysis, per NCMA DMSRW Section 12.4, shall be prepared, stamped, and signed by a California registered geotechnical or civil engineer. The global stability analysis shall be submitted to DSA for review with the project submission. Where the analysis indicates soil displacement, any structure or fire access lane in front or behind the wall shall be able to withstand this displacement; otherwise, soil strengthening shall be provided to limit the displacement to a tolerable level or relocate these elements beyond the critical slip plane.

3. WALL SYSTEM REQUIREMENTS

All SRW block units shall have a mechanical interlocking mechanism between adjacent units, such as formed lips, pins, or keys that will resist horizontal movement normal to the wall. The geogrid shall be mechanically anchored to the block units through aggregate interlock, pins, pipes, etc. Formed lips in block units will not provide adequate anchorage unless configured to mechanically engage the geogrid.

Adequacy of the mechanical interlock must be maintained if block courses separate due to settlement of the lower course, uplift of the upper course, or bulging of the surface between geogrid layers. The design performance objective of SRW systems is to limit course separations to 1/4-inch maximum for the life of the wall.

3.1 Installation

3.1.1 Installation of SRW systems shall be in conformance with the manufacturer's instructions, product evaluation report, NCMA DMSRW, and AASHTO BDS. ←

3.1.2 The backfill materials for reinforced soil mass, retained soil, and foundation soil shall be placed and compacted as required by the DSA-approved construction documents and the geotechnical report. Drainage systems as described in Section 3.3 below shall be placed in accordance with the DSA-approved construction documents.

3.1.3 Regardless of the geogrid spacing, compaction of the reinforced backfill and retained soil shall not exceed eight inches in thickness per NCMA DMSRW Section 5.10.1.

3.2 Geogrid

3.2.1 Acceptable geogrid suppliers and grid types shall be specified on the construction documents. The allowable long-term design strength and pullout capacity of grid-to-block connections shall be defined and justified.

3.2.2 In retaining wall systems with corners, the geogrid layers shall be staggered at adjacent walls to avoid overlap of grids and permit planar installation at each level. Geogrid layers in different plan orientations need not be staggered vertically when explicitly permitted by the

evaluation report, and the design complies with any capacity reductions, geometry limitations, or other requirements given in the report.

3.2.3 Penetrations in the geogrid reinforcement are not permitted except as shown on the DSA-approved construction drawings per Section 2.3.4 above. Proposed penetrations not shown on the DSA-approved construction drawings shall be submitted to and approved by DSA in accordance with *IR A-6: Construction Change Document Submittal and Approval Process* prior to cutting geogrid.

3.2.4 Geogrid layout shall comply with Section 2.2.4 above.

3.3 Drainage

3.3.1 Drainage pipes and granular drainage backfill shall be provided between the facing units and the reinforced soil mass. The granular drainage backfill shall be composed of clean free-draining gravel materials, extending full height and length of the wall at a minimum thickness of 1'-0" and shall meet the compaction requirements specified by the manufacturer. Surface drainage at the top and bottom of the wall shall be directed away from the wall.

3.3.2 If the reinforced soil mass is not constructed of free-draining material and has not been designed for the reduced internal shear strength of the saturated condition, an additional drainage system shall be provided to prevent saturation of the reinforced soil mass. The additional drainage system shall extend the full height and length of the wall and be located at the rear of the geogrid reinforced soil mass. It shall consist of granular material in accordance with Section 3.3.1 above or a manufactured composite drainage product. Drainage shall be collected at the base of the granular or composite drain and transmitted by tight-line pipe to the face of the wall or other appropriate drainage disposal location. To further mitigate the potential for soil saturation resulting from surface infiltration, hardscape or low permeable material may be placed above the reinforced soil mass.

4. TESTING AND INSPECTION

Testing and inspection shall be performed by the geotechnical engineer or his/her qualified representative per CBC Section 1705A.6.1 and as described in Appendix A below. The design professional shall add the applicable items listed in Appendix A below to the form *DSA 103: List of Required Structural Tests and Special Inspections* in the user defined “S6. Other Soils” category.

4.1 Material Certification

4.1.1 The precast units used in SRW systems shall comply with CBC Section 1807A.2.4, CBC Chapter 19A, and ASTM C1372. A letter of certification shall be provided with the units indicating the manufacturer's name and address, name of product, and unit type. The certification shall include applicable laboratory compressive strength and absorption test results.

4.1.2 A letter of certification shall be provided for the supplied geogrid, indicating the manufacturer’s name and address, name of product, and the product designation meeting the specified requirements of the project design. The letter of certification shall include the roll numbers, identification procedures, sampling procedures, and the results of the quality control tests. Quality control tests include flexural rigidity, tensile strength, tensile modulus, and junction strength for each batch of resin and each shift’s production.

4.1.3 Certification letters required by Sections 4.1.1 and 4.1.2 above shall be submitted to the design professional in responsible charge, the project inspector, the laboratory of record (LOR), and the school district.

4.2 Soil Testing

Soil properties, such as soil type, soil classification, moisture content, density, compaction, shear strength, and gradation, for all backfill materials shall be tested for compliance with the specified requirements. The geotechnical engineer shall determine the appropriate frequency for these tests, not less than the following:

4.2.1 Moisture, density, and compaction test per ASTM D1557: Test every 2-feet vertical and 100-feet horizontal, or fraction thereof, in reinforced fill, retained soil, and foundation zones.

4.2.2 Shear strength test per ASTM D3080: One test for every backfill type and source, minimum two tests. Perform tests prior to start of backfill operation. Perform gradation tests on these samples to be used as a baseline described below.

4.2.3 Gradation test per ASTM D422 or ASTM C136: One test for every 4,000 square feet of wall facing area, or fraction thereof, per each backfill type and source. The gradation results shall be correlated with the baseline gradation tests from the shear strength tests. The geotechnical engineer shall establish an acceptance range for these gradation tests based on the baseline tests. If a gradation test falls out of the acceptance range, a shear strength test shall be performed on the subject backfill.

4.3 Reporting Requirements

4.3.1 Progress Reports

Detailed daily reports are required for all material testing and special inspection activities that occur at the project site. Reports shall be forwarded to the project inspector within one day of the test or inspection. Reports of all material tests performed by the LOR shall be distributed in accordance with CAC requirements.

4.3.2 Verified Reports

At the conclusion of earthwork-related material testing and special inspection activities, the geotechnical engineer shall submit verified report form *DSA 293: Geotechnical Verified Report* to the design professional in responsible charge, DSA, the project inspector, and the school district.

REFERENCES:

California Code of Regulations Title 24
Part 1: California Administrative Code (CAC), Section 304.
Part 2: California Building Code (CBC), Sections 1803A, 1803A.5, 1807A.2.

Appendix A: Example Form DSA 103

	S6. OTHER SOILS:			
	Test or Special Inspection	**Type**	**Performed By**	**Code References and Notes**
☑	c. Segmental retaining wall (SRW) excavations and subgrade preparation.	Periodic	GE	Refer to Section S1.a. Verify excavations are extended to proper depth. Prior to placement of drainage fill and compacted fill, observe subgrade and verify that site has been prepared properly.
☑	d. SRW material classification and gradation.	Test	GE	Refer to Section S2.a. Classify and gradation test per ASTM D422 or ASTM C136 of the following: reinforced fill material, retained fill material, foundation fill material, and drainage fill material. See *[drawings/specifications]* for frequency.
☑	e. SRW fill material placement.	Continuous	GE	Refer to Section S2.b. Verify placement and proper material, density, and lift thicknesses of the following: reinforced fill material, retained fill material, foundation fill material, and drainage fill materials.
☑	f. SRW fill material compaction.	Periodic	GE	Refer to Section S2.b. Verify compaction of the following: reinforced fill, retained fill, foundation fill, and drainage fill.
☑	g. SRW leveling pad.	Continuous	GE	Verify placement, flatness, and levelness of pad to ensure intimate contact between units and aggregate.
☑	h. SRW block material.	Periodic	GE	**1807A.2.4**. Verify block dimensions, identification, and manufacturer's certification.
☑	i. SRW block placement.	Continuous	GE	Verify block placement, alignment, and inclination.
☑	j. SRW geogrid reinforcement material.	Periodic	GE	Verify type, proper material identification, and manufacturer's certification.
☑	k. SRW geogrid reinforcement placement.	Continuous	GE	Verify placement including elevation, length, and orientation (i.e., strong direction as specified).

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	S6. OTHER SOILS:			
	Test or Special Inspection	**Type**	**Performed By**	**Code References and Notes**
☑	l. SRW geogrid connection to block.	Continuous	GE	Verify connection including mechanical device and overlap length.
☑	m. SRW block fill and wall embedment.	Continuous	GE	Verify placement.
☑	n. SRW final construction.	Periodic	GE	Verify wall elevations, front and back slope conditions.