EVERGREEN®

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# Specifications for:

# Evergreen Macro Retaining Walls

A Prefabricated Concrete Retaining Wall System.

**Content:**



## Section 1: SCOPE

1.1 This specification sets up requirements for the design, materials, manufacture, and construction of precast, reinforced concrete retaining Evergreen Macro Wall System.

1.2 Contract work consists of furnishing materials and installing retaining Wall in accordance with details shown on project plans.

1.2 This specification applies for EVERGREEN MACRO Retaining Wall Units.

## Section 2: DESIGN OF WALL SYSTEM

2.1 **Evergreen Macro Units:**

- The wall consists of precast concrete units with a battered face at 3 to 5 vertical to one horizontal, typically 4:1. Sound walls are normally built with no wall batter, yet with horizontal resets, typically after every second or third unit.
- Wall components are all monolithic and do not consist of individual units.
- Such monolithic type units are of variable width: wider units are used at the bottom, and narrower units at the top.

2.2 **Resets:**

- Using smaller units on top of wider units produces offsets, which will be either on the front side or on the rear, depending on specific wall design.
- This configuration contributes to improve structural integrity and safety at each joint.
- Resets further provide for horizontal resets at the outer surface for plants to catch rainwater and improve plant growth. Resets further allow for using small brushes for landscape sculpturing.

2.3 **Topsoil:**

- Fill resets at the front of the wall with 8 to 10 inches, 0.2 to 0.25m of high quality topsoil.
- This topsoil must be rich in nutrients, for expediting plant growth, or else use container plants.

2.4 **Design of Units:**

- Evergreen Macro wall components require specifically designed units, manufactured for each individual application.
- Consider site-specific soil parameters for determining the size and the specific steel reinforcement of Evergreen Macro.
- Licensees have an in-depth Evergreen Macro computer design software and staff of engineers available to assist with the design of specific walls.

2.5 **Specific Location of Units:**

- The various types of units are designed for loads in a specific location in the wall, as identified. Heavier steel reinforcement may be necessary for high walls and in case of resets on the back.
- These units are to be clearly numbered on wall front drawings and marked at the time of manufacture indicating the location of use.

2.6 **Fill and Backfill Requirements:**

- Units are designed to withstand pressures created by a certain type of backfill within the wall.

- Wall fill and backfill materials are defined in section 4.7 and 4.8 of this specification.
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2.7 **Engineering Review and Stamp:**
- These specifications are designed to be utilized together with the Evergreen Macro computer software design program.
- These instruments DO NOT purport a full engineering analysis; a qualified and especially Evergreen trained engineer for each project must perform such analysis.
- All shop drawings shall bear the seal of a professional engineer registered in the State of Application. Such local stamp is not included in standard Evergreen designs.

2.8 **Drainage:** See 4.9 of this specification.

**Section 3: MATERIALS**

3.1 **Unit Materials:** Materials shall meet the requirements specified in the following subsections:
3.2 **Fill:** Fill materials shall conform to the material requirements as specified in 4.7
3.3. **Backfill:** Backfill material shall conform to the material requirements as specified in 4.8
3.4 **Concrete Units:** Concrete units shall be Evergreen Macro monolithic type fabricated according to standard concrete specifications with the following exceptions and additions:

(1) **The Concrete** shall have a compressive strength of **5000 psi**, 35 MN/m2 at 28 days.
(2) The units shall be fully supported until the concrete reaches a minimum compressive strength of **1500 psi**, 10 MN/m2. The units may be shipped and installed after reaching a compressive strength of 4000 psi, 28 MN/m2.
(3) **Concrete Surface at the Front** of the units shall be smooth as resulting from steel forms. For rear and inner faces, no special requirements are requested. Front faces of units shall be screened to eliminate open pockets of aggregate and surface distortions in excess of ¼ in. The units shall be cast in steel forms.
(4) **Concrete Should Cover Steel Reinforcing** by 1 ½ inch, 32mm from center or 1 ¼ inch from reinforced surface. Concrete cover of reinforcement shall be maintained by positive mechanical control.
(5) **Marking:** The date of manufacture and piece mark shall be clearly scribed on an unexposed face of each unit. Individual stickers are acceptable as well.
(6) **Handling, Storage and Shipping:**
All units shall be handled, stored, and shipped carefully for minimizing the danger of chipping, discoloration, cracks, fractures, and excessive bending stresses. All units in storage or transported shall be supported on **three** blocks for preventing distortion and for protecting the exposed exterior finish.
(7) **Tolerances:** All units shall be manufactured within the following tolerances:
a) General dimensions, position of suspending devices within 1 inch, 0.025m; all other dimensions within 3/16 inch, 5mm.
b) Element dimensions: Dimensions as determined by length and transverse width near the legs shall not exceed ½ inch, 12mm.
c) Element surface finish: Surface defects on smooth formed surface measured over a length of 5 ft., 1.50m shall not exceed ¼ inch, 6mm.
(8) **Compressive Strength:** Acceptance of concrete units with respect to compressive strength will be determined on the bases of production lots. A production lot is defined us a group of units represented by a single compressive strength sample and consist of a single day production.
During the production of the concrete units, the manufacturer will randomly sample the concrete in accordance with AASHTO T-141.
A single compressive strength sample consists of a minimum of 4 cylinders randomly selected for every production lot of every 20 cu yards, 15m3.
Compression tests shall be made using standard 6"x12" or 4"x8", 150x300mm or 100x200mm test specimen prepared in accordance with AASHTO T-23.
Compressive strength testing shall he conducted in accordance with AASHTO T-22.
If air entrained concrete is required, air content testing will be performed in accordance with AASHTO-T-196. Air content samples will be taken at the beginning of each day's production and at the same time as compressive samples are taken to ensure compliance.

The slump test will be performed in accordance with AASHTO T-119. The slump will be determined at the beginning of each day's production and at the same time as the compressive samples are taken.

For every compressive strength sample o minimum of two cylinders shall be cured in accordance with AASHTO T-23 and tested after 28 days.

The average compressive strength of these cylinders, when tested in accordance with AASHTO T-22, will provide a compressive strength test result, which will determine the compressive strength of the production lot.

The average compressive strength of these cylinders when tested in accordance with AASHTO T-22 will determine whether the units can be stripped from or the units may be shipped.

Acceptance of a production lot will be made if the compressive strength test result is in accordance to AASHTO T-20, and then the acceptance of the production lot will be based on its meeting the following acceptance criteria in its entirety:

a) Ninety percent (90%) of the compressive strength test results for the overall production shall exceed 5200 pounds per square inch, 36 MN/m2.

b) The average of any six consecutive compressive strength test results shall exceed 5300 pounds per square inch, 37 MN/m2.

c) No individual compressive strength test result shall fall below 4500 pounds per square inch, 31 MN/m2.

d) Units shall be considered acceptable for placement in the wall when 7-day strength exceeds 65 percent of 28-day requirements.

Rejection: Units may be rejected for replacement or repair because of failure to meet any of the requirements specified above.

(9) **Corrosion Protection:** Special consideration shall be given where the wall will be exposed to seawater or maritime atmosphere.

(10) **Curing:**

a) All units will be covered with a moisture barrier membrane covering immediately after pouring to hold in heat and moisture, and will remain covered until a stripping strength of 1500 psi, 10 MN/m2 has been attained.

b) All units shall be protected from frost and from direct rays of the sun and from drying for 72 hours or until the units reach 90% of their design strength (5000 psi, 35 MN/m2). This protection shall be either by a totally enclosed building or by the use of insulated heavy plastic covering adequately secure to avoid movement created by wind and severe loss of temperature or freezing.

c) **Steam curing** is used; at least two hours elapse after casting until the steam is applied. Thereafter, the rate of temperature rise temperature shall not exceed 20 degrees Fahrenheit, 11°C per hour. The temperature of the steam enclosure shall not exceed 165 degrees F, 74°C. In temperatures below 50 degrees F, 10°C, allow four hours cool down inside to prevent thermo cracks.

## Section 4: CONSTRUCTION

4.1 **Acceptance of Units on Site:**

- All units shall be subject to final acceptance on site. It shall be the contractor's responsibility to ensure that all units are erected in an undamaged condition.
- The Project Engineer's representative may carry out such tests or measurements us he thinks fit to satisfy himself that the units delivered to the site are equal in quality to the units specified and are in accordance with the approved design.
- Where these tests are of a destructive nature arid units prove acceptable, the cost of the units us delivered to the site of testing will be a Charge to the contract.
- Units that do not satisfy the material requirements, dimensions, or tolerances of this specification will be liable to rejection.
- Units with structural cracks arc unacceptable shall not be placed in the wall.
- Rejected units shall immediately be removed from the site and shall be replaced with acceptable units at no extra cost to the contract.

4.2 **Wall Layout:**

- Crib wall construction shall be in reasonably close conformity to the lines, grades, design arid dimensions shown on the Plans and us established by the Project Engineer by means of surveyed staking.
- The Contractor shall obtain the Engineer's approval of alignment before casting any concrete or placing any Evergreen Macro units.

4.3 **Excavation and Foundation Preparation**

- A bench excavation to sound material shall be made for the base of the retaining wall.
- Unless shown otherwise on the project plans, the benches shall be horizontal in the line of the wall and have a fall of 1 in 4 (or as specified for the wall batter), from the front to the back of the excavation.
- The depth of the excavation shall be a minimum of 1.0 foot below the proposed finished ground level at the front face of the Wall, or us shown on the project plans.
- Contractor shall call for and obtain the Engineer's inspection and approval of the excavated foundation prior to casting any concrete or placing any Evergreen Macro units.
- Any soft, wet, organic, or other deleterious material evident at the footing area shall be sub-excavated a minimum of 2 ft. and backfilled with clean sand or gravel and compacted in lifts of 1 ft., 0.3 m maximum.
- Bulk excavation to bring grade within 0.5 feet, 0.15m of base excavation is not a part of the retaining wall contract.
- Finish base excavation to within 0.5 inches, 12mm of foundation drawings.
- Prior to wall construction, except where constructed on the rock, the foundation shall be compacted with mechanical compaction equipment.
- Minimum requirement of foundation material beneath foundation must be as shown on drawings.

4.4 **Base Slab for Individual Footing**

- The footing designs vary according to the specific job site conditions.
- They are to be constructed as per the detail on the approved construction plans.

4.5 **Wall Erection**

- A field representative of the proprietary Evergreen wall system shall be available from time to time during the erection on the wall site no additional cast to the project.
- The specific observations of the field representative must be closely followed by the construction crew.
- Precast concrete units shall be handled and placed in such a manner that they are not severely cracked or chipped and so that no damage is caused at seating areas.
- Precast concrete units shall be placed in such a way that final position is vertical or battered, as shown on the plans. For erection, units are handled by means of lifting devices or excavator connected to the element supporting devices. Special care shall be taken for avoiding damages to the units during transport and installation.
- Units shall be placed on mortar beds except for upper four units.
- All Evergreen units are fabricated in steel molds, i.e. contact surfaces formed by steel.
- First layer of units shall be adjusted by means of temporary wooden wedges and the use of a wooden triangle to check for the wall batter along the top of the legs.
- Wooden wedges are preferable, because they may deteriorate after months or years and therefore transfer contact pressures from wood to mortar.
- Steel or plastic wedges or shims are absolutely not allowed, because they are more slippery than mortar beds and they keep contact pressures for ever and thus initiate cracking and spalling.
- After positioning of the units, the mortar bed shall be completed using dry pack as necessary.
- An engineer's level is to be used to adjust the first layer of units precisely.
- Wooden triangles are to be used to check proper batter along top of each element.
- As determined by the engineer, projects lowest units shall be secured against sliding by a stirrup or reinforcing steel dowels min. #5 bars placed in the foundation concrete directly in front of the Evergreen leg, and then covered with concrete or mortar.
- Similarly, in certain cases upper units shall be secured against sliding using concrete shear blocks erected into the special slots.
- Use a piece of wood ½ inch, 12mm thick inserted between the arms of the units to prevent damages of units while lowering the neighboring unit.

- This piece of wood eases and controls spacing of units as specified. Remove this piece of wood immediately after setting the unit.
- Use a min. 3 ft, 1m long piece of wood to check longitudinal alignment of units while setting the units.

4.6 **Geosynthetic Reinforcing**

- For high walls MSE, Mechanically Stabilized Earth methods are used by placing geogrids or geotextile reinforcing into the fill behind the Evergreen Macro units.
- The design of the geosynthetic reinforcing follows the approved codes and guidelines.
- The geogrids are placed directly into the Evergreen Macro units, with the remaining portion for the next layer of reinforcing flipped over the front edge of the Evergreen Macro unit.
- Then a layer of fill and backfill is placed and well compacted.
- Then the geosynthetic is flipped and pulled back for minimum tension in the geoysnthetic prior to fill and compact.
- Avoid wrinkling the geosynthetics.
- Note that compaction must begin inside the units, and then continue in passes parallel the back of the wall, slowly moving toward the mountainside, that way slightly stretching the geosynthetics by the compaction operation.
- Note that Polyester geogrids and geotextiles are susceptible to high pH-values of concrete and therefore should not directly contact concrete surfaces.
- For avoiding Polyester long term strength loss from direct contact with concrete use a minimum distance of 4 inches, 0.10m of fill material or Polyester coating.

4.7 **Fill Materials :** ( inside the Evergreen units )

- The Evergreen Macro units are filled in two layers, directly after erection of each unit.
- Never stack more than one unit before filling (except for adjusting neighboring units across vertical foundation steps, see above).
- Fill material within precast concrete units to be ordinary borrow material, provided friction angle after compaction is phi' = min. 32° for not exceeding design silo pressures.
- Such fill must be at a moisture content max. $\pm$ 2% off optimum.
- Fill material shall have max. 10 to 25% fines passing sieve # 200 = 0.074 mm;
- If fill contains 15 to 25% fines, then PL plastic limit must be below 6 and fraction below 15 microns = 0.015 mm shall not exceed 15%.
- This means: eliminate clay and clayey materials; preferably use material with less than 15% fines, clay and silt).
- Impervious material, such as loam, clay, and peat cannot be used for fill inside of units and is not desirable for backfill of retaining walls anyway.
- Big blocks must be eliminated separately;
- Maximum size of fill materials is 5" =125 mm and weight of stones of 3" = 75 mm should not exceed 15% for reasons of acceptable compaction.
- Maximum cohesion within compacted fill material should not exceed 0.04 to 0.17 ksf = 2 to 7 kN/m2, which again excludes organic material, loam, and clay.
- Filling of voids behind legs and under trays is essential to achieve the required design weight of the gravity retaining wall.
- Fill front pockets of L-shape trays with min. of 10" = 0.25 m plantable topsoil for better plant growth with min. or 1 inch = 25 mm freeboard.
- Fill topsoil and finish final grade on each tray as wall goes up, seed for erosion protection.
- Fill compaction must reach minimum moist density of 118 pcf = 19 kN/m3.
- This minimum average moist density including possible voids and it is crucial to ensure the weight for the gravity wall effect.
- This requires quality fill of all voids and quality compaction using Wacker jumpers or Rammax vibratory rollers or equivalent proven tools.
- Compaction must reach minimum 92% relative density (Proctor density) and not more than 95% to avoid over-stress, measured on top of compacted layer, within center or along the mountainside of cells.
- Note that minimum moist density is the specified requirement and relative density of compacted fill is for rough comparison only.

- Do not over-compact to avoid deformations and over-stress and damages to units.
- Maximum thickness of compacted layers should not exceed 15" = 0.4 m. Thus filling operation proceeds in two layers per unit in any case.
- The internal friction angle of fill material after compaction must be phi' = min. 32° to limit silo pressures to design values.

4.8 **Backfill Material :** ( behind wall )

- Provide drainage before backfilling:
- Provide sand drains, French drains or a geotextile on the excavation face to intercept mountainside seepage.
- Provide a drainage pipe min. schedule 80 = dia. 100 mm at the heal of the wall using min. grade of 0.5%.
- Provide free draining fill material within 8" = 0.2 m of the first Evergreen unit.
- Collect and divert runoff water on the back slope to prevent water from running over the wall face.
- Backfill a layer of fine material along the top of the wall to prevent excessive percolation of surface water runoff to penetrate into the backfill and to allowing collection and diversion of runoff water along the top of the wall.
- Fill and backfill shall follow erection of each course of units with a berm behind the wall of minimum 10 ft. = 3 m wide and adjacent slope of max 2:1 if fill goes up faster or if wall goes up faster than backfill.
- Remove debris and topsoil before backfilling.
- Backfill behind the wall follows filling of units to avoid shifting of empty units. This backfill and compaction is made in lifts not exceeding 12" = 0.3 m
- Backfill must be compacted to min. 95% relative density (= standard Proctor density) at optimum water content $\pm$ 2% to min. 125 pcf = 20 kN/m3 at maximum lifts of 16" = 0.4 m
- Heavy compaction equipment is not allowed within 3 ft. = 1.0 m of back of wall, to avoid excessive compaction pressures and deformations within fill and subsequent wall deformations and possible shifting of units.
- Friction angle of fill material must reach at least values as used for design of wall, see typical section, and notes.

4.9 **Drainage -** Any retaining wall requires adequate drainage provisions such as:

- Provide drainage along the excavation face to intercept any seepage water from the mountainside.
- provide a drainage pipe along the heal of the wall with a perforated pipe dia. min. 4 in., 100mm installed at a min. grade of 0.5 to 1%.
- Preferably, use PE Polyethylene pipe instead of PVC, because it is much less vulnerable to crushing and cracking.
- Cover the drainage pipe with min. 8 in. of free draining material and
- Cover the gravel with non-woven geotextile, min. 18 in. wide.
- Provide a min. 2% grade at the top of fill away from the edge of the wall.
- Or else provide a ditch along the top of the wall to intercept any surface water and direct it away.
- Provide an underground drainage outlet at low spots.
- Do not provide 'weep holes' or drainage pipe outlets to the air in areas with winter frost, because of freezing and clogging of such outlets.

## 5. Payment

5. 1 Evergreen Macro walls are paid on the base of the area of the wall facing measured from top of foundation to top of rim of top unit along the battered face line and the length measured for each for each stack standard length.

5.2 Evergreen foundations are paid per m3 resp. cf of foundation concrete.

5.3 Drainage pipe and system is paid for by linear m or ft. installed.

5.4 Planting of wall is paid for on the base of a detailed planting scheme and as survived after the first year and including maintenance and watering of plants for that period.