EVERGREEN®

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Minimum EVERWALL Requirements

1. **Design**
2. **Plans, Specifications and Notes**
3. **Fabrication**
4. **Site Preparation**
5. **Excavations and Foundations**
6. **Transportation, Unloading, and Stockpiling**
7. **Wall Erection**
8. **Material Specifications**

These **Everwall Minimum Requirements** address the various activities separately, so separate sheets of it are **ready for distributing to the designer, the manufacturer, the transportation crew, and to the erection crew**.

The typical sections sometimes refer to this paper as **'Everwall Erection Instructions'.**

Minimum DESIGN Requirements

The following design instructions must be fulfilled for Everwall retaining wall projects:

MINIMUM SAFETY FACTORS for permanent loads SF minimums are:

	Code minimum	**Everwall min.**	**Some DOT min.**
SF sliding	= min. **1.5 - 1.6**	**min. 1.5**	min. 1.5
SF overturning	= min. **1.5 - 1.8**	**min. 1.7**	min. 2.0
SF bearing capacity	(full) = min. **2.0**	**min. 2.0**	(min. 3.0*)

Everwall requests formally to increase minimum safety factors to levels set.
Experience shows, that the extra safety margin is of negligible additional cost.
* 3.0 is minimum for the (outdated) simple bearing capacity formula. The new AASHTO code uses set coefficients for additional issues. For this conservative approach min. is 2.0.

For **exceptional surcharges** including **seismic loading** the safety factors are:

SF sliding	= min. **1.2** (DIN = German code)
SF overturning	= min. **1.3**
SF bearing capacity	= min. **1.3** (DIN)

Wall friction angle delta at the back of the wall - Normally delta is 2/3 of phi for contact of soil against concrete. Since the back of an Everwall retaining wall is 53% concrete to soil and the remainder is soil against soil, the average wall friction theoretically is delta = 0.842 phi. For this reason the standard wall friction used is delta = 0.75 phi'**.**

Watch for rare cases - If the subsoil is deep clay, prone to long term consolidation under the load of the heavy gravity wall, the subsequent settlement of the wall itself may cause sliding of the wall along its back downward. Of course this effect reverses the standard wall friction and it may mean zero delta or even a negative delta value, up to delta = minus phi. It is easy to design for, the wall will be much heavier and costlier.

EQP - equivalent fluid pressure is an American design method as found in the Navy Design Manual. There it is specifically pointed out that this method is for short walls only. Experience shows that too many designers are using that method and then use it even for seismic design, which ends up with extremely heavy gravity walls. EQP-method should therefore be abandoned and replaced by more rational methods such as Coulomb.

No cohesion for backfill - Professional rules and experience show that the development of cohesion in an artificial fill is not possible, except for a minimum cohesion of 0 - 0.08 ksf = 0 - 4 kN/m2. Thus using cohesion in a backfill is not quite appropriate. The exceptions are cuts in rock or firm clay, provided the gap between the back of the wall and the cut is less than 18 inches = 0.45 m. Otherwise the silo pressure build up in the gap is bigger than active earth pressure.

Minimum Requirements for PLANS, SPECIFICATIONS and NOTES

These are minimum requirements for plans, specifications, and notes for Everwall retaining wall projects:

Typical Section - Each offer, bid or wall design including set of drawings for final projects must include a typical section showing the main features of an Everwall retaining wall and notes explaining specifications and erection instructions. (That is what they look at).

Soil Parameters - Final drawings must show soil parameters used for design calculations, for backfill, and for subsoil. Then only the site supervisor can evaluate whether the materials seen on site are within design or worse. If he is not familiar with evaluating soils for friction angle he must call the soil engineer. That is a professional approach, which is encouraged by giving full design information to the site engineer.

Geology - A note on the drawings should say: 'Soil properties as found on site must be conveyed to design engineer for checking final design calculations.'

Wall designs based on assumed soil parameters use the following sticker or stamp: **'For preliminary use, not for construction, pending confirmation of soil properties'.**

This note clearly indicates that natural variations of soil properties are not within the risk of the engineer. It also means that in case of subsoil changes the wall design has to be revised and a change order entitles for extra payment.

Drainage: Remember the three most important issues in retaining walls are drainage and drainage and drainage, i.e.

- Drainage of runoff water on the backslope,
- Drainage on the excavation face and
- Drainage pipe at the heal of the wall.

Drawings have to show such drainage facilities, such as water diversion at the top of the wall, geotextile cover over the excavation face, a drainage pipe at the heal of the wall and free draining material within one foot of the first unit.

Drawings:

- Prepare Everwall retaining wall elevation and plan view showing # of stacks
- Prepare typical section and various wall sections showing each unit
- Each stack must be numbered and each unit must be specified by a letter
- Specialty units are to be numbered: stack #, unit type and layer #
- Arrow to indicate 'starts erection here' for lowest foundation or corner
- Prepare foundation plan view with dimensioning for layout
- Prepare foundation reinforcing drawing.

Minimum FABRICATION Requirements

These are minimum requirements for fabrication of Everwall units

CONCRETE QUALITY - Concrete quality requirement for Everwall retaining walls is **5000 psi = 35 MN/m2** compressive strength of concrete after 28 days. Walls along highways where road salts are used must be made using **air entrainment** for salt resistant concrete.

SPACERS - A very large number of spacers are necessary to ensure proper concrete cover of steel reinforcing, **minimum 1"1/4 = 30 mm.** Walls erected a long time ago indicate that on certain products this requirement was not observed carefully showing bad corrosion. Thus concrete cover is a crucial point for long term quality performance of Everwall retaining walls. Some states require even more concrete cover.

STRIPPING OF UNITS FROM MOULDS - Stripping of the units is the hardest moment in the lifetime of Everwall units. Special care must be taken to avoid any torsion stresses on the unit by having one corner still sticking.

STOCKPILING - The green units should be cured by keeping them away from cold temperature, from wind, and from direct sunshine for at least one day by keeping them inside the fabrication hall or covered with plastic covers. Units must be stored on a solid yard, leveled and firm, using shims to adjust support within $\pm$ 1/16" = 1.5 mm using an engineers level. A newer and very efficient method is to stack units on 3 points using wood pieces: Two under one leg, one at the center of the other leg preventing twist and distorted units during curing.

MAXIMUM NUMBER OF CRACKS - The Everwall license agreement allows for a maximum of 5 fissures on 100 units installed on site. Many precasters demonstrated that this requirement is fulfilled regularly.

ERECTION INSTRUCTIONS - Each offer, bid, set of final drawings and each first delivery of units to site must also include **Everwall erection instructions**. This requirement is to reduce product liability and to help the others involved to understand the special requirements from the beginning.

SITE INSTRUCTIONS AND SUPERVISION - The Everwall representative must visit the site at the day of first delivery of units for bringing an extra set of erection instructions as a legal requirement and for teaching the crew the handling of Everwall units for stockpiling, erection, adjusting, filling and backfiring. This is to have the field crew know about Everwall, learn about the tricks and hints and feel comfortable working with the big units and produce a lot at quality standards.

PREFABRICATORS RESPONSIBILITY - Many of these activities seem outside of the standard duties of the prefabricator. However the correct handling of the units in all phases brings the precaster and the Everwall retaining wall system the success needed. The clients do not order concrete units, **they order a 'system' and with that they mean help to make sure all goes well.** .

Minimum SITE PREPARATION Requirements

The following **site preparations** are necessary before shipping Everwall units to site:

1 - Confirm soil properties to design engineer for final checking of safety factors.

2 - Have final erection drawings approved by authority as appropriate.

3 - Have engineer confirm adequate safety factors for sliding, overturning and bearing capacity.

4 - Possibly have engineer provide slip circle analysis.

5 - Check foundation drawing for layout and space available.

6 - Determine excavation sequence and drainage with soil engineer.

7 - Erect foundations and drainage.

8 - Discuss tentative site schedule and Everwall transportation plan with precaster and transport.

9 - Have large enough excavator machine on site capable for handling of heavy units and for reach required.

10 - Order Everwall units as needed on site, preferably 2 or 3 days in advance.

11 - Prepare tools and materials as listed in erection instructions below.

Minimum EXCAVATIONS AND FOUNDATIONS Requirements

The following minimum requirement applies for excavations and foundations:

Excavation:

- **The excavation slope and the size of excavation is to be determined by or together with the soil engineer depending on the geology and local soil conditions, the size of the excavation needed and the year's season.**

- In case of unstable soil conditions the excavation can be limited to a minimum of 20 to 40 feet for just one or two stacks of Everwall units. Thus excavation, foundation and wall erection takes only a few days during which the excavation must be able to remain open.

- Prepare necessary precautions to prevent slope failures, such as drain surface water away from the top of the wall area, drain foundation water away

- Have the soil engineer approve the foundation subsoil.

Foundations

- Check foundation subsoil and backslope material for accordance with design parameters. If conditions are worse than anticipated new design calculations and changes of certain foundations and wall sections are needed.

- Prepare formwork and reinforcing for concrete foundations

- Concrete foundations using a wooden triangle for measuring slant of foundation.

- Tolerance for top of foundation is **plus zero, minus 1/2" to 1"**= 10 to 30 mm.

- Place stirrup in front of leg before concrete has hardened to provide sliding resistance.

Minimum Requirements for
TRANSPORTATION, UNLOADING, and STOCKPILING

The following are the minimum transportation requirements for Everwall units:

- Everwall units are delivered on truck accessible sites by tractor - trailer

- Wood pieces nailed onto the trailer avoid shifting of load during transport.

- Units must put on pieces of wood and be tied down firmly to avoid bouncing and damaging. Three points loading is good for avoiding twist in units, yet possible over-topping must be kept in mind.

- Before unloading units must be checked for fabrication and or transportation damages.

- Any units not fit for erection must be reported immediately for shipping back. Later claims are not acceptable. Even minor fissures must be reported.

- For unloading a hydraulic excavator is used, the same used for earthwork and erection of wall. A truck waiting time of two hours is included in the delivery price. Additional waiting is charged on the standard hourly fee.

- Normally the units are unloaded directly onto foundations or onto the wall without intermediate stockpiling. To do that truck and excavator advance one stack at the time.

- The Everwall units are handled using long slings or using a beam with chains and pins to be inserted into the side of the Everwall legs or cables and threaded loops to be screwed into the threaded sockets on top of the units. The manufacturer rents out slings or other appropriate hanging equipment. The slings have reinforced sections for reducing damage to the units and to the slings.

- Intermediate stockpiling and on site is to be eliminated as much as possible for reducing cost and for avoiding damages to the units.

- If such stockpiling should be necessary special care is needed to avoid twisting of units. Thus units cannot be placed on soft soil; they must always be placed on wooden beams. The new alternative is to stockpile units on three pieces of wood, one of the pieces being placed exactly at center of units to avoid twist.

- Any stockpiling must be on level and firm ground.
- Maximum height of stockpiling is 5 units in any case.

Minimum WALL ERECTION Requirements

The following minimum requirements apply for Everwall retaining wall erection:

Preparation and Tolerances:

- Wall erection cannot start without having Everwall retaining wall erection instructions on site and having oral instructions by the Everwall representative, except for contractors AND crew with prior experience with Everwall retaining walls.
- Before unloading and or starting erection all units must be checked for possible fabrication or transportation damages.
- Any units not fit for erection must be reported immediately for shipping back. Later claims are not acceptable. Even minor fissures must be reported.
- For unloading a hydraulic excavator is used, the same used for earthwork and erection of wall. A truck waiting time of two hours is included in the delivery price. Additional waiting is charged on the standard hourly fee.
- Before starting erection foundations must be totally completed including stirrups placed in front of the units and including marks placed on top of foundations to indicate 'toe' of wall.
- Tolerances for accepting foundations are plus zero and minus 10 to 30 mm = 1/2" to 1", thus ample tolerance, yet foundations should never be too high.
- Tolerance for placing Everwall units is $\pm$ 1/8" = 3 mm for the first range of units and $\pm$ 1/4" to 1/2" = 5 to 10 mm for upper units.

Erection procedures:

- The first layer of Everwall units is placed onto foundations, and then shimmed using small wooden wedges placed on the side of the legs. Simultaneously the units are adjusted with each other for straight alignment.
- Wedges must be made of wood to rot away after some time, passing the load over to the mortar gradually. Shims made of plastic or steel do not have that ability and are not allowed.
- Check proper wall batter using a plywood triangle with side length 4 ft. and 1 ft. for 4:1
- Then dry pack (fast set, non shrinkage mortar) is pushed under the legs using a piece of wood. Additional mortar is placed in front of the lowest leg to cover the stirrup placed into the foundation to ensure additional sliding resistance.
- For walls with foundation at differing levels, erection must start at lowest foundation level. This allows for adjustment of neighboring stacks. For walls with corners erection must start at the corner for adjusting.
- For walls with several such constraints ALL FIRST UNITS must be placed and shimmed and at foundation steps a second unit must be placed. Then all units are adjusted to wall batter to alignment and to each other, and then

underpinned with mortar. The second units (temporarily erected in corners with foundation steps) must then be removed for filling and backfilling of first units.
- All joints between Everwall stacks are covered using a piece of geotextile, about 6" wide for erosion protection.

- Certain projects call for shear blocks, for earth beams or for extension beams. Such pieces must be erected before continuing erection of Everwall units.
- Before stacking next Everwall unit a continuos layer of rather liquid mortar is placed on top of each leg. This eliminates load concentrations and subsequent spalling.
- Such mortar beds on contact surfaces between Everwall units are not necessary in case of Everwall units cast face down, i.e. contact surfaces were formed by steel mold and contact surfaces are perfectly smooth.
- For keeping the liquid mortar rather up front than in the back, the units are suspended using a longer hanger on one side for a slanted position slightly more than the wall batter.

Earth Fill materials:

- Remove debris and topsoil before backfilling.
- The Everwall units are filled and backfilled layer by layer, directly after erection of each unit. Never stack more than one unit before filling (except for temporarily erected units for adjusting neighboring units across vertical foundation steps, see above).
- Backfill behind the wall follows after filling of units to avoid shifting of empty units. This backfill and compaction is made is made in lifts not exceeding 12" = 0.3 m
- Fill and backfill shall follow erection of each course of elements with a berme 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.
- Fill material within precast Everwall units to be ordinary excavation material, provided the fill INSIDE the Everwall units is well compacted with a minimum average moist density of 112 pcf = 18 kN/m3.
- In projects with EXTENSION AND CROSS BEAMS: Fill and backfill material within the units and behind the units until the cross beam must be engineered fill fit to transfer lateral earth pressure loads from the back down into the foundation. Thus, this fill functions as part of the structural system and requires a shear resistant material, use select fill of a quality similar to MSE with steel reinforcement: High friction (phi' = min. 36°), low plasticity (less than 15° fines, below 0.06mm), and high compaction (min. 95% relative density) and material on the dry side (w* = w opt + 1%, -2%).
- In other projects ordinary borrow material is acceptable for fill inside and backfill, provided such material is not overly wet and well compactable and provided the individual project design does not specify otherwise. Thus friction angle after compaction is phi' = min. 32° 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 eliminates clay and clayey materials).
- Impermeable material, such as loam, clay, and peat cannot be used. Big blocks must be eliminated separately; maximum size of fill materials is 5" =125 mm for limiting damage to precast concrete by dropping stones.
- Amount of stones of 3" = 75 mm and larger 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. (This excludes organic material, loam, and clay).

Compaction requirements:

- Compaction of fill INSIDE the units must reach minimum density of 122 pcf = 18 kN/m3. This minimum average density including possible voids 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 INSIDE of units and within a zone 4 ft. = 1.2m behind the back of units must be minimum of 90% relative density (=Proctor density) and not more than 95% to avoid over-stress, measured on top of compacted layer, within center and mountain side of cells. Use trench compactor such as Wacker and minimum 6 passes.
- Heavy compaction equipment is not allowed within 4 ft. = 1.20 m of back of wall, to avoid excessive compaction pressures and deformations within fill and subsequent wall deformations and possible shifting of units.
- Compaction for BACKFILL BEHIND THE wall in the zone beyond 4 ft. = 1.2m behind the wall must be minimum 95%, maximum 100% relative density (formerly named Proctor standard)
- Maximum thickness of compacted layers should not exceed 15" = 0.4 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. preferably use Rammax self propelled sheep foot vibratory roller, min. weight 1000 lbs = 450 kg, minimum 6 passes.
- In any case friction angle of fill material must reach at least values as used for design of wall, see typical section and notes.

Drainage requirement:

- provide drainage before backfilling:
  - provide sand drains, French drains or a geotextile directly on the excavation face to intercept mountain side seepage,
  - provide a drainage pipe min. schedule 80 = dia. 100 mm at the back of the wall using min. grade of 0.5% with extension to the surface for flushing.
  - cover drainage pipe with a min. of 8” of free draining material and cover this with a non-woven geotextile for separating fines.
  - provide free draining fill material within 8" = 0.2 m of the first Everwall unit.
  - collect and divert runoff water on the backslope,

MATERIAL SPECIFICATIONS

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 Ennetbaden, 22. November 2013