Retaining Walls

ReCon retaining walls are classified as Precast Modular Block Walls or PMBWs. When designing a PMBW, it is critical that all of the appropriate information be gathered so that a proper design can be completed. At a minimum, the following information needs to be obtained:

- Wall Geometry – Including length, height, corners, curves, etc.
- Site Geometry – Wall surcharges, toeslopes, and backslopes and whether the wall is a cut or fill application.
- Soils Information – Retained soils, foundation soils, reinforced soils, etc.
- Project Specification – Design and project information and requirements.

Once this information has been collected, the designer can begin the design process. ReCon walls can be designed as either gravity retaining walls, which use the mass of the block to retain the soil, or as geogrid reinforced walls. The ability to construct tall gravity walls is one of the key advantages of the ReCon retaining wall system. Geogrid reinforced walls, also referred to as mechanically stabilized earth (MSE) walls, utilize layers of soil reinforcement between the block and in the area directly behind the retaining wall.

ReCon has several design tools to assist engineers in the analysis process. ReConWall, which is ReCon’s proprietary analysis software, is a fully comprehensive retaining wall analysis tool available to industry engineers. In addition, ReCon has Wall Charts for both gravity and geogrid reinforced walls that demonstrate the general capabilities of the system. More information can be found on these and other tools later in this manual.

Finally, in many cases, special design considerations will arise that a designer will need to account for. Some of these considerations include, but are not limited to:

- Increased Wall Setback Options
- Retaining Walls in Water Applications
- Retaining Wall Drainage and Water Management
- Terraced Walls
- Global Stability

Each of these special design cases will be discussed in further detail within this manual.
**Wall Geometry**

For each ReCon retaining wall, the geometry will be dictated by the specifics of the project site and topography. Geometry for each wall generally consists of: wall length, wall height and the location of corners and curves. For most projects this information is found on the site-grading plan. A site-grading plan provides a tremendous amount of the information necessary to properly design a ReCon retaining wall.

For projects that don’t have a formal site-grading plan, wall geometry is still required, even if perhaps obtained in a less formal way. Regardless of the source, this information is critical to proper design, determination of unit types, and the formulation of accurate unit quantities.

**Site Geometry**

In addition to wall heights, lengths, and layout, site-plans (grading plans) offer additional information about adjacent structures, surcharges, site access, property lines, utility locations and site drainage. All of these factors influence the final design and construction of a ReCon retaining wall.

**Surcharges**

When a retaining wall is exposed to additional loads, whether permanent or temporary, the overall wall design is affected and the loads will need to be accounted for. This is generally the case when the source of the load (building, roadway, sidewalk, etc.) is located within a distance from the face of the wall, that is less than twice the height of the wall. This is only a general rule based on the most common soil types. Wall design engineers must consider many other factors which may adjust this proximity formula.

Surcharges are usually classified as either temporary (live load) or permanent (dead load) and may stabilize or destabilize a wall, depending on their type and / or relative location with respect to the wall. An example of a live load might be a fully loaded semi-truck traveling along a roadway within close proximity to the top of the finished wall. Because this type of load is temporary, it only contributes to destabilizing forces and any stabilizing contribution of a live load is usually ignored.
A dead load, by contrast, is intended to be permanent. Although it will increase stresses on the wall, depending on its type and location, it can also contribute to certain aspects of wall stability. An example of a dead load may be a building constructed behind the wall which exerts additional weight through its foundation or footing.

**Backslopes**
A backslope is defined as an upward sloping grade at the top of a retaining wall. Backslopes are technically considered a soil dead load. Determining backslopes is completed during a review of the site-grading plan and inclusion of the backslope during the analysis process is critical.

**Toeslopes**
A toeslope is defined as a downward sloping grade at the face (or toe) of a retaining wall. Toeslopes are determined by examining the site-grading plan but in general do not increase or decrease the driving forces acting on the wall. They can, however, impact the overall Global Stability of the wall. Refer to the Global Stability section of this manual for additional information.

**Cut or Fill Application**
One of the final things determined regarding site geometry is whether the wall is a cut or fill application. Typically speaking, a cut wall is constructed to maximize the useable space at the bottom of the wall by cutting into an existing slope. By contrast, a fill wall maximizes the useable space at the top of the wall. Normally, a ReCon gravity wall will be best suited for cut wall applications and a ReCon geogrid reinforced wall will be best suited for fill wall applications. However, the use of wall type, gravity or geogrid reinforced, may vary depending on site conditions.

**Soils Information**
PMBWs, by definition, are a soil retention structures with a modular and mortar-less aesthetic facing. Since soil is one of the main components of the structure, it is necessary to know and understand the properties of these soils since they come in numerous types and compositions. For most projects, information regarding soil properties is obtained from a Geotechnical Report or Soil Boring Log. This information is then used in the wall analysis as well as to predict a wall’s overall performance.

In the absence of detailed soils information, assumptions must be made about the soil properties in order to proceed. It is recommended that when assumptions are necessary, that they be generally conservative to preserve safety factors and wall integrity.

There are some soils that should never be used in the construction of a ReCon retaining wall. A detailed discussion of all soil types and properties is beyond the scope of this manual. The determination of a particular soil’s suitability for use rightfully belongs within the realm of a trained and experienced civil or geotechnical engineer.
The soils that are of critical interest to a wall designer are categorized into five basic zones with respect to their location in and around the finished wall.

The **leveling pad** is not technically a soil zone, but is an integral part of a well-designed, well-built retaining wall. The leveling pad, located directly beneath the base block, should consist of well-graded granular material that allows for drainage but has enough fines to allow for proper compaction. Some examples of leveling pad material (by regional name) include: road base, class 5, ¾-inch minus, and crush-and-run. The dimensions for the leveling pad vary and are discussed elsewhere in this manual.

The **drainage zone**, located within the voids between blocks and to a minimum depth of 1-foot behind the back of the units, is typically an imported, free-draining crushed rock material. This zone helps facilitate water flow to drainage collection pipes or dispersal areas. It is recommended that a generally self-compacting material, such as ¾-inch crushed stone, be used as it eliminates the need to operate compaction equipment directly behind the wall facing.

The **foundation soil zone** is the area located beneath the ReCon blocks and drainage zone. This soil zone is responsible for providing adequate support for the weight of the retained wall above. In the case of a geogrid reinforced wall, the foundation soil zone extends beneath and behind the wall to a distance roughly equal to the depth of the embedded soil reinforcement.

The **reinforced soil zone** only applies to MSE walls and extends from the back of the drainage zone to the furthest extent of the geogrid soil reinforcement (tails of the grids). In some cases, this soil could be an on-site material. If this material is not suitable, then an imported, select fill material should be used. The properties of this material strongly influence the performance characteristics of the reinforced soil mass and, as such, have a significant effect on the strength, length and quantity of soil reinforcement in the design of the finished wall.

The **retained soil zone** is the material located behind the reinforced soil zone, in an MSE wall, or behind the drainage zone in a gravity retaining wall. Soil characteristics within this zone also have a significant effect on the design of the finished wall in the same way that the reinforced soil zone does.
Project Specification
The purpose of a project specification is to outline specific requirements regarding materials, products, installation procedures, design guidelines and quality aspects. As a wall designer, this document should be used to determine required design methodologies, submittals, and other project specific requirements. For wall specifiers, an example of a project specification for ReCon is located at the end of this manual and is available for use. Visit www.reconwalls.com to obtain a copy.

ReConWall Analysis Software
ReConWall is ReCon’s proprietary retaining wall analysis software that is available to industry professionals and wall design engineers. This powerful and easy to use software allows the user to analyze both gravity and geogrid reinforced wall sections. Here are just a few of the software’s enhanced and comprehensive features:

- NCMA, AASHTO and CSA Design Methodologies
- Water Analysis – Buoyancy and Rapid Drawdown
- Global Stability Analysis
- Seismic Analysis
- Inputs for multiple soil zones
- Inputs for surcharge loading, backslopes and toeslopes
- Full calculation print-out
- Extensive User Help Manual

To obtain a copy of ReConWall, please visit www.reconwalls.com.
### Multiple Setback Options

The ability to design a gravity wall to heights reaching 20-feet and beyond can help solve even the most complex site challenges and add significant value. This is especially true in cut wall applications when the objective is to maximize the usable space at the base of the wall. ReCon gravity walls can be designed using a smaller footprint than geogrid reinforced walls, which require grids to be at least 60% of the height of the wall. Therefore, gravity walls maximize usable space and save on excavation and construction costs.

In design, the achievable height of a gravity wall can be increased by (a) increasing the depth of the blocks, or (b) increasing the batter / setback of the wall. ReCon’s retaining wall block lineup has a standard, industry leading, EIGHT block depths. Each of the blocks is produced with an integrated block-to-block tongue and groove system that creates 1-inch of setback per course. In addition, ReCon offers two options for increasing the batter of the wall by modifying the setback between the individual blocks. These options include:

1. **Adding a 1-inch fiberglass spacer bar** (available from ReCon) along the back of the tongue, effectively doubling the batter of the wall from 3.6 to 7.2-degrees. This quick modification is completed by the contractor in the field. Use of the spacer bar is recommended for walls 13-feet 4-inches in height or less.

2. **Using ReCon Channel Block**, which increases the setback between courses from 1-inch to 8-inches, resulting 26-degrees of wall batter. ReCon Channel Block achieves this additional batter through an alternate tongue and groove system that is integrated into the form during the production process.

*Check with the local ReCon Licensed Producer for availability of the Channel Block in each particular market since it is not generally stocked as an inventory item.*
**Water Applications**

ReCon blocks have quickly become the product choice for retaining wall water applications because of their proven durability and ease of installation. By using wet-cast, air-entrained concrete, ReCon blocks can perform in numerous harsh environments, including exposure to chlorides, exposure to repeated freeze thaw cycles, and water submerged applications. Since ReCon blocks do not require steel reinforcement, they are not susceptible to the effects of corrosion. In addition, ReCon blocks allow for rapid installation and reduce the footprint when constructed as a gravity wall.

Special consideration should be taken when designing a retaining wall for a water application. Water has a significant impact on the bearing capacity of soils, the magnitude of driving forces and the calculation of resisting weights. It is recommended that wall designers utilize ReCon’s wall analysis software, ReConWall, when completing the design of a water application retaining wall. The figure below shows some of the specific construction requirements for water application walls. Additionally, designers should refer to ReCon’s Typical Construction Details regarding water application for specific construction recommendations and requirements. Visit [www.reconwalls.com](http://www.reconwalls.com) for additional information.
**Drainage and Water Management**

Most performance issues associated with PMBWs can be traced back, directly or indirectly, to water. The presence of water behind a retaining wall, whether it is anticipated or not, affects soil mechanics and increases wall stress. Additionally, a high-water table can weaken foundation soils to the point where they can no longer support the wall. Moving water over the top or along the bottom of a finished wall can erode the soil at the toe causing the wall to become unstable and needing to be rebuilt. For these reasons, it is critical that drainage and water management be considered prior to, during, and after a wall is constructed. In construction, the project site is continually changing. Consequently, drainage and water management techniques may change or need to be modified during the construction process.

Proper drainage and water management considers water from all directions. Where the water originates from will dictate the best method for moving or removing the water from the areas that may adversely affect wall performance. This may be completed through drainage columns, pipes, blankets or specifying a specific backfill material. A number of these features can be seen in the figure shown below. For more information please refer to ReCon’s Typical Construction Details regarding drainage and water management which can be found at [www.reconwalls.com](http://www.reconwalls.com).
**Terraced Walls**

Terraced walls are a common feature in retaining wall applications. From an engineering standpoint, these walls must be treated as a single composite structure if their proximity, in conjunction with other site and soil parameters, is such that an upper wall places additional load or stress on the wall (or walls) below.

Most terraced walls may be considered independent of each other if they meet the requirements of the following general rule:

**Terraced Wall “2:1” General Rule**

“Terraced walls are generally considered independent of each other if... 1) the height of the upper wall is less than or equal to the height of the lower wall and ... 2) the distance between the two walls is at least twice the height of the lower wall.”

This general rule may not apply if soils are very poor, if toeslopes or backslopes are involved, or if there are additional surcharges present. Terraced walls that do not meet the “2:1” rule usually require additional mass and / or soil reinforcement incorporated into the lower wall design to resist the additional stress applied by the upper wall.

Regardless of whether terraced walls are determined to be independent, based upon the rule above, it is recommended that an overall global stability calculation be completed for the system of walls as this may control some of the design aspects.
**Global Stability**

Global stability is defined as rotational, general mass movement of a retaining wall and the adjacent soils. Over the years, several analysis methods and tools have been developed for analyzing global stability. ReConWall, which is ReCon’s proprietary wall analysis software, is just one tool that designers have access to that can aid in the analysis process. In analysis, numerous soil failure planes, passing behind and beneath the wall, are considered to determine the most critical path. Based upon this critical path, a factor of safety is determined. To learn more about ReCon-Wall’s approach to global stability analysis, refer to the software’s User Help Manual.

Global stability is an important component in retaining wall design and should always be considered during the analysis process. It becomes increasingly important in the presence of any of the following site conditions:

- Walls with toeslopes and/or backslopes
- Walls with significant surcharge loading
- Walls subjected to seismic loading
- Water application walls
- Walls constructed in poor soil conditions (soft soils, organics, high plasticity clays, etc.)
- Terraced walls
- Or any combination of the above

As previously mentioned, ReConWall is a powerful tool for analyzing global stability for simple wall geometries, which includes many of the conditions noted above. For complex geometries though, such as terraced walls or multiple toe and back slopes, it is recommended that a third-party software be used that is capable of modeling these conditions.