DESIGN CONSIDERATIONS FOR NSWS® NATURAL STONE RETAINING AND FREESTANDING WALL SYSTEMS
**Concept and Applications**

NSWS® uses a patent pending new process of construction, delivery and seamless installation of natural stone retaining and freestanding walls. This new process guarantees beauty, quality, efficiency and project savings.

NSWS® natural stone retaining wall system is a prefabricated modular retaining or freestanding wall system that uses bulk natural field or quarry stone containing structural and aesthetic elements such as zig zag interlocking joints and field-set bridge stones for a structurally engineered retaining wall that has a completely seamless, “built on site” appearance. NSWS® retaining walls are designed for a minimum service life of 100 years (lifetime guarantee).

Applications for NSWS® natural stone walls are:

<table>
<thead>
<tr>
<th>Structural</th>
<th>Decorative</th>
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<tbody>
<tr>
<td>Retaining (one-sided) walls</td>
<td>Freestanding (two-sided) walls</td>
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</table>

**Features**

NSWS® natural stone walls:

- Offer the beauty, history and exceptional quality of natural stone that cannot be replicated even with materials such as decorative concrete made to look like stone.
- Are structurally engineered to outlast any traditionally built stone wall and come with a lifetime guarantee.
- Process efficiency allows project schedules to be cut from weeks or months to just days.
- Cost significantly less than traditionally built stone walls and even some of the pre-cast block systems that mimic real stone.

**Benefits**

The timeless beauty and durability of natural stone is a perfect complement to almost any architectural style.

Engineering and construction designs can specify any type of natural stone, mortar style or finish. NSWS® walls can be designed for straight lines or any radius vertical or horizontal curves. Tops of walls can be straight, sloping or stepped with a natural finish or capped. Additional architectural features such as fence, columns, posts and lighting are easily incorporated into wall engineering.

The Architect/Designer has multiple opportunities for inspection and oversight both in construction and installation of NSWS® walls. Full size samples of the walls are available upon request prior to project start.
Green Building Certification

Natural stone has many innate attributes that make it a green building product: it is natural, low-maintenance, and exceptionally durable. Designs using natural stone can contribute to LEED credits in various categories such as Sustainable Sites (SS), Energy and Atmosphere (EA), Materials and Resources (MR), and Innovation and Design (ID).

Design Factors

The methodology used in the design of NSWS® natural stone retaining or freestanding walls is the same as that used for the design of any traditional stone wall. The designer can assess all the factors that impact the wall structure.

Standard factors such as the surrounding environment, ground water conditions, soil characteristics, earth and water pressures, sliding, overturning and bearing stability should be considered in the design of any permanent gravity retaining walls. As the complexity of a project increases, the information on each factor should contain more detail.

All structural engineering requirements such as footings, drainage and retaining capacity are always addressed and met prior to wall construction.

Materials Used in Wall Construction

<table>
<thead>
<tr>
<th>Material</th>
<th>Description</th>
<th>Compliance*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stone</td>
<td>Natural quarry dimension stone such as granite and untreated bulk architectural aged or quarried fieldstone.</td>
<td>ASTM C1528</td>
</tr>
<tr>
<td>Concrete</td>
<td>Concrete mix with minimum compressive strength 3000 PSI.</td>
<td>ASTM C33, ACI 301-10</td>
</tr>
<tr>
<td>Rebar</td>
<td>Epoxy coated #4 reinforcing steel.</td>
<td>ASTM A934</td>
</tr>
<tr>
<td>Geogrid</td>
<td>Geogrid reinforcement manufactured for soil reinforcement composed of high molecular weight, high tenacity polyester multifilament yarns which are woven in tension and finished with a PVC coating such as Miragrid 3XT or equal.</td>
<td>ASTM D6637</td>
</tr>
<tr>
<td>Drainage</td>
<td>4&quot; diameter flexible perforated drain pipe, full length of wall connected to pre installed PVC 2” schedule 40 weep holes at 15’ o.c. or as required.</td>
<td>ASTM D2665</td>
</tr>
</tbody>
</table>
Structural Design of NSWS® Retaining Walls

Structural Capacity and Aesthetic Requirements

NSWS® walls are built in sections or segments designed to interlock seamlessly when installed on site. All NSWS® walls are designed to provide adequate structural capacity with acceptable movements from differential settling. Wall segments have structural zig-zag interlocking joints and negative voids for on-site bridge stone placement to meet structural capacity and aesthetic requirements (Figure 1). End segments have exposed stone only and no interlocking joint.

- **Structural**: Zig-zag interlocking joint systems prevent vertical and lateral deformation.
- **Aesthetic**: The zig-zag connections and the negative voids for placement of bridge stones eliminate any appearance of a vertical joint. Styrofoam or other similar impenetrable material is placed in the joint forms according to design where a bridge stone will be placed.

All NSWS® walls are built with a reinforced concrete backing and a minimum 5% batter (1:20).

As any retaining wall relies on self weight to resist overturning and sliding due to the lateral stresses of the retained soil, NSWS® retaining walls weigh approximately 200 lbs per square face foot. Typical wall sections are 35 square face feet and weigh up to 7,000 lbs.

**Figure 1: Wall sections before and after installation**
Drainage and Reinforcement

Wall segments are built with pre-installed drainage systems and geogrid reinforcement. (Figure 2).

The development of hydrostatic water pressure on walls is eliminated through use of perforated perimeter drains and crushed stone backfill behind all NSWS® walls. 4" diameter flexible perforated drain pipe, full length of wall connected to pre-installed PVC 2” schedule 40 weep holes at 15’ o.c. or as required.

Geogrid reinforcement manufactured for soil reinforcement composed of high molecular weight, high tenacity polyester multifilament yarns which are woven in tension and finished with a PVC coating such as Miragrid 3XT or equal is pre-installed in all wall sections and cut to required lengths. Anchoring the geogrid into the concrete develops its full tensile strength.

Figure 2: Drainage and Reinforcement
Footings and Structural Backfill

The methodology used in site preparation of NSWS® natural stone retaining or freestanding walls is the same as that used for site preparation requirements of any traditional stone wall.

Site contractor excavates footing or base and prepares leveling pad in accordance with area building codes and requirements.

<table>
<thead>
<tr>
<th>Height of Wall (Feet)</th>
<th>Recommended type of footing</th>
<th>Recommended Width of Footing (Inches)</th>
<th>Recommended Depth of Footing (Inches)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Under 4’</td>
<td>Crushed gravel</td>
<td>24”</td>
<td>24”</td>
</tr>
<tr>
<td>4’</td>
<td>Crushed gravel</td>
<td>24”</td>
<td>24”</td>
</tr>
<tr>
<td>5’</td>
<td>Concrete on gravel</td>
<td>30”</td>
<td>12” on 24”</td>
</tr>
<tr>
<td>6’</td>
<td>Concrete on gravel</td>
<td>36”</td>
<td>12” on 24”</td>
</tr>
</tbody>
</table>

Base leveling pad material should consist of crushed gravel base compacted to 95% standard proctor density and non-reinforced concrete as required based on height.

Structural backfill and drainage aggregate placed immediately behind all retaining walls should be free draining, non-expansive, noncorrosive material such as crushed stone or gravel meeting the following gradation as determined in accordance with ASTM D448:

<table>
<thead>
<tr>
<th>Sieve Size</th>
<th>Percent Passing</th>
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<tbody>
<tr>
<td>1 inch</td>
<td>100</td>
</tr>
<tr>
<td>¾ inch</td>
<td>75 – 100</td>
</tr>
<tr>
<td>No. 4</td>
<td>0 – 10</td>
</tr>
<tr>
<td>No. 50</td>
<td>0 – 5</td>
</tr>
</tbody>
</table>

Maximum aggregate size should be limited to 2”. Unsuitable soil for backfill (high plastic clays or organic materials) should not be used in reinforced soil mass.
Reference Standards

ASTM C33: Standard Specification for Concrete Aggregates
ACI 301-10: Specifications for Structural Concrete
ASTM A934: Standard Specification for Epoxy-Coated Prefabricated Steel Reinforcing Bars
ASTM D698: Moisture Density Relationship for Soils, Standard Method
ASTM C1232: Terminology of Masonry
ASTM C1528: Geotechnical Engineering Standards
ASTM D422: Gradation of Soils

Notes

Third party structural engineer approval for retaining walls up to 6’.

All drawings are available in AutoCad format upon request. Please contact info@naturalstonewallsolutions.com.
NSWS® Freestanding (Two-Sided) Wall

FIELD SET TOP STONE
FACE STONE
CONCRETE FILL
FACE STONE
UPPER DRAIN
STRUCTURAL CONCRETE
#4 RE-BAR
WEEN HOLE
GRADE
STONE DUST SETTING BED
STONE FOOTING
LOWER DRAIN