SECTION 4: Raised and Multi-level Patios

Part A. Considerations

Raised patios create functional and attractive outdoor living areas. Traditionally, a raised patio allows movement from house to front or back yard without a change in elevation. In many cases, raised patios include multiple, well-defined areas using differing elevations.

Raised patios are constructed using three basic components: walls, flatwork and steps. An effective and appealing project has all three components working in harmony with one another. Visualizing the levels and steps and then developing solutions for the site and customer will help make the installation profitable.

A building permit may be necessary for a project for several different reasons, including exceeding a maximum vertical grade change or providing access to and from a building. The requirements for a building permit are typically different for construction on private and public projects. Check with the local building authority for permit requirements.

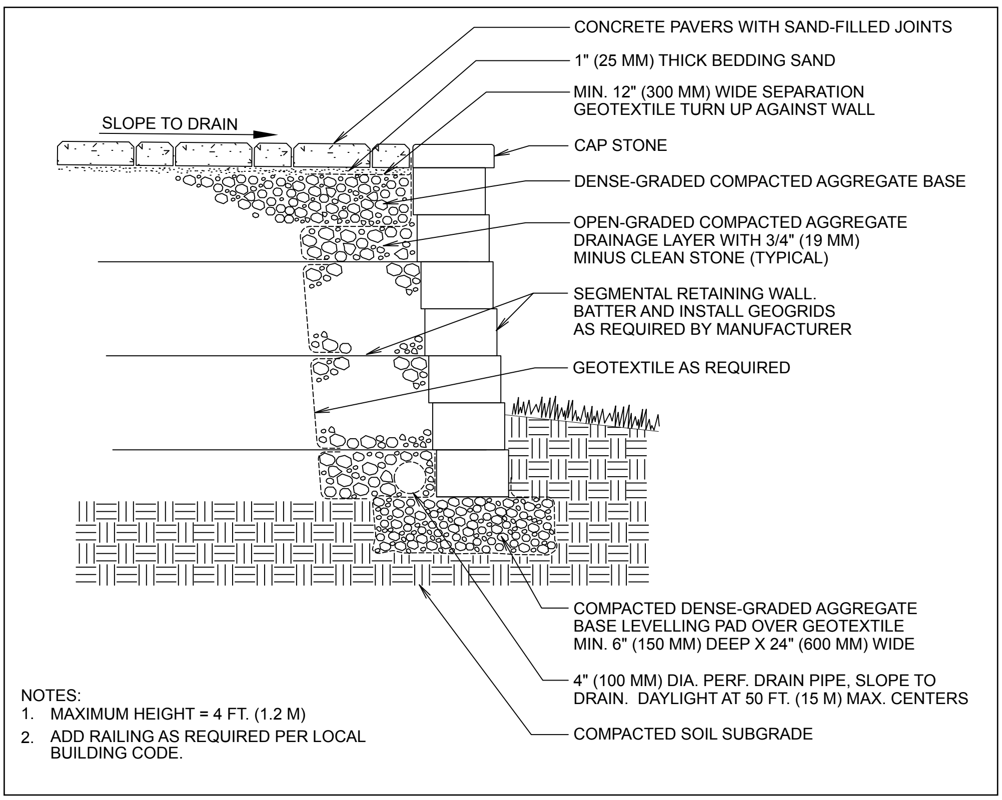

Figure 4-1: A typical raised patio cross section.

4. Raised and Multi-level Patios

Differing elevations require steps to be constructed. Section 4 Part B provides more details regarding the design and construction of steps. Depending on the building codes for the project and the measured vertical difference in elevation between patio areas, it may be necessary to install railings or other types of guards. Building codes vary, so it is important to check local requirements.

For patio elevations greater than 24 in. (600 mm), most building codes require some form of guard. Building codes typically dictate the minimum height and maximum size of openings for these guards. Section 4 Part C provides specific details about including railings in a raised patio project.

Figure 4-2: This raised patio used a seat wall as a guard. This is not acceptable according to some building codes.

Retaining walls incorporated into a raised patio must be stable structures. Some building codes require walls over 48 in. (1.2 m) in height (measured from finished grade to top of wall) to be engineered. Moreover, some areas have implemented regulations that require engineering to a wall height as low as 24 in. (600mm). Check local building code requirements for engineered walls prior to designing the project.

A Segmental Retaining Wall (SRW) can be constructed to a limited height as a conventional SRW, which does not incorporate geogrid reinforcement. A very conservative rule of thumb is that the maximum height of the wall should be approximately twice the depth of the SRW unit. When the height of the wall reaches three times the depth of the SRW unit, it is prudent to include geogrid to help stabilize the wall. Segmental retaining wall (SRW) systems can use geogrid reinforcement to create taller, more stable walls.

Figure 4-3: A raised patio of this height would require some engineering design.

Determining the type, length and elevation of the geogrid layers needed to stabilize the wall and optimize the construction typically require engineering skills. However, a conservative design can be used in the initial stages of a project. At a later stage in the design phase, an engineer can review the initial design and adjust the plan as needed. A conservative initial design could use a low strength geogrid, placed in continuous layers every 12 to 16 in. (300 to 400 mm) vertically with a length equal to the height of the wall and not less than 3 ft. (1 m). This conservative design would only be usable for typical installations: backfilled with dense graded aggregate, pedestrian-only loading above with no slope, constructed on a stable undisturbed subgrade to a maximum total height of 8 ft.

(2.4 m). If these typical conditions do not exist on the site, an engineer should be consulted to develop the initial design. Contact the National Concrete Masonry Association (www.ncma.org) for guidelines on the design and construction of segmental retaining wall (SRW) systems.

When building a raised patio, it is important to address water and moisture at the beginning of the project. It is important to ensure that rainfall landing on the patio surface is directed away from the house. Typically, a minimum grade of 2% is ideal to ensure that water flows across the surface. If the slope is lower than this, the water won't move rapidly off of the patio. Slopes can be increased up to 4% to help speed the movement of water, but the pavement surface will be pitched. Tables and chairs will be on a noticeable slant, and the area can become a slipping hazard if ice forms on the patio surface. For larger patio areas, surface drains may be constructed to remove water from the surface. For smaller patios, it may be appropriate to have surface water flow across the patio, over the top of the retaining wall, and onto the garden or patio below. The use of stabilized joint sand may be appropriate to ensure that it is not removed by falling or flowing water.

Raised patio construction will likely affect the house. In most cases, there are two types of exterior walls: 1) below grade foundation walls, and 2) above grade exterior walls. During construction, the compaction of fill places large dynamic loads on the adjacent walls. Placement of fill next to a building wall also increases the lateral load applied to the walls. The fill material used to construct the patio has moisture in it that can affect the building if the fill is contacts the exterior walls. Below-grade foundation walls are typically constructed using concrete or concrete masonry units (CMU) waterproofed on the exterior with a drainage system incorporated at the base. Foundation walls are designed to withstand moisture against them continuously.

Figure 4-4: Excessive slope on a patio will create a noticeable lean on chairs and tables.

An above-grade exterior wall of a house can be constructed from materials such as wood, vinyl or aluminum siding, cement board, stucco, mortared clay, concrete brick, mortared stone or mortared veneers. These exterior wall materials are designed to support the load of the building above, and to resist the penetration of water. Placing compacted soil next to these types of siding can trap moisture in and against the them, which leads to deterioration and eventually failure. Deterioration is accelerated when freeze-thaw conditions also exist. For raised patios with compacted fill material against the exterior wall, it is best to construct a stress relief wall leaving an air gap between the raised patio and the exterior wall. The stress relief wall can be constructed like any other segmental retaining wall on a raised patio project, but the face of the wall faces the exterior wall of the building. The air gap created needs to have drainage so any water that finds its way into the gap can drain out. It is also appropriate to allow air circulation in the space to minimize condensation and allow the space to thoroughly dry out.

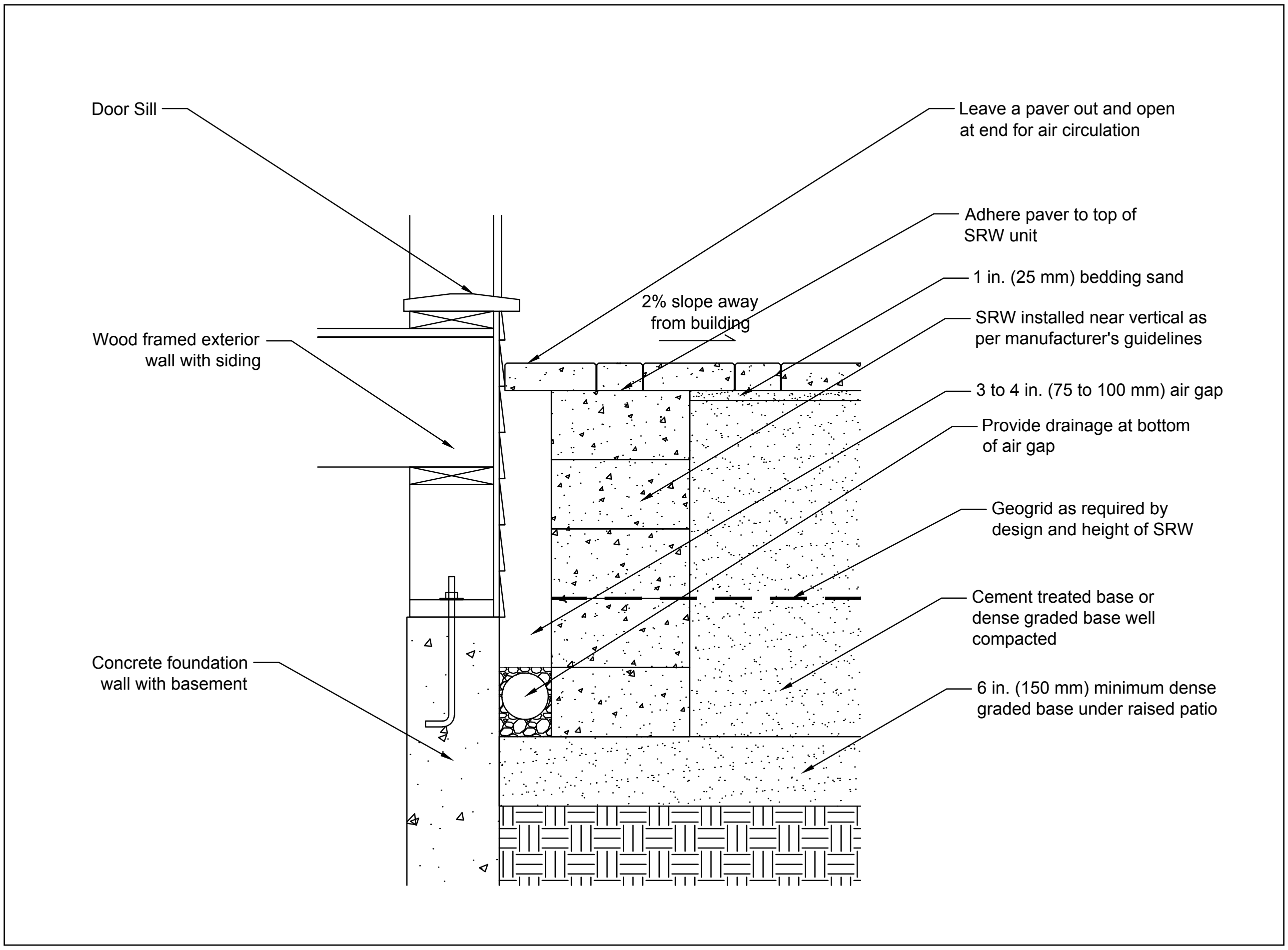

Figure 4-5: A stress relief wall is design to keep lateral soil pressure off an exterior wall.

When constructing a raised patio, additional fill is placed, that increases the lateral load applied to the foundation wall. This is true even when a stress relief wall is used. For buildings with below grade living spaces, like a basement, the weight of the additional fill can exceed the lateral capacity of the foundation wall and can cause the wall to bulge and eventually blow out in to the basement area, potentially causing a collapse of the structure. This is called to as an unbalanced fill condition. Extra load is applied from the raised patio fill, but no extra resistance is provided by the foundation wall. Care should be taken when taking on an unbalanced fill project, and an engineer should be consulted to ensure the stability of the project.

Before constructing a raised patio, it is important to inspect the foundation walls in the vicinity of the construction work. Inspect for cracks and water staining, and take photographs. Being held accountable for damage to a foundation wall, especially for damage not created by the raised patio construction, will definitely make a project unprofitable.

For some projects, it might be advantageous to use flowable fill instead of dense graded, compacted aggregate to construct the raised patio areas. Flowable fill can be lighter than aggregate, and it is not compacted. However, flowable fill may be more expensive to install and there will be down time when waiting for the material to cure and develop sufficient strength to continue building on it.

Using Permeable Interlocking Concrete Pavement (PICP) may be desirable for the construction of a raised patio; however, ICPI recommends that PICP systems are installed at least 9 ft. (3 m) away from foundation walls to reduce the amount of water leaving the PICP system and flowing directly into the foundation drainage system. If a PICP system is to be used near or next to a foundation wall, use a geomembrane to keep water away from the foundation wall.

Figure 4-6: Take pictures of the exterior and interior of the foundation walls to document their condition before you move equipment or materials on site.

On the nex page is an extensive checklist that can be reviewed for guidance during the four phases of a raised patio project:

- Appraisal
- Design
- On-Site, and
- Close Out

This checklist does not contain every detail that should be considered. Additional details might need to be addressed. While the list is presented in chronological order, some steps might be better addressed at another point during the project. This checklist covers many of the details to help ensure a successful raised patio project.

Raised Patio Checklist

1. Appraisal (phone call and first site meeting)
   A. Prequalify owner (Business practices?)
      - ❑ Initial contact
      - ❑ Identify wants and needs
      - ❑ Likes and dislikes
      - ❑ Identify budget – estimate

   B. Pre-bid Exterior Inspection/Documentation:
      - ❑ Photos
      - ❑ Existing topography/shoot grades
      - ❑ Drainage (downspouts, flow on site, leech field)
      - ❑ Locate utilities
      - ❑ Obstructions (above grade—sheds, trees, existing slabs, subgraded—irrigation, invisible fence, lines to out buildings)
      - ❑ House structure (crack—horizontal, vertical, stepped crack), foundation wall (excavated basement, shallow footer—crawl space, slab on grade)
      - ❑ Finished floor elevations
      - ❑ Check soil density near foundation—soil probe
      - ❑ Accessibility from road to project site
      - ❑ Access to utilities (gas, potable water/waste water, electric)
      - ❑ Waterproofing?
      - ❑ Basement bulkhead doors/ basement access

   C. Pre-bid Interior Inspection/Documentation:
      - ❑ Photos
      - ❑ Water in basement (look in corners, closets, lift corner of carpet)
      - ❑ Finished/unfinished
      - ❑ Cracked foundation walls
      - ❑ Basement windows/vents
      - ❑ Utility meter locations
      - ❑ Salt lines, stains, mold, water
      - ❑ Structural concerns
      - ❑ What does the owner want to create (business practices?)
      - ❑ Look at portfolio, marketing materials
      - ❑ Refine wants and needs
      - ❑ Prequalify owner—educate them to the price of options (i.e.,wrought iron rails will cost approximately $_____)

2. Design
   A. Initial Considerations
      - ❑ Identify applicable codes – engineering requirements
      - ❑ Steps
      - ❑ Railings
      - ❑ Drainage – impervious coverage (allowance)
      - ❑ ADA compliance or Accessibility
      - ❑ Structural
      - ❑ Trenching
      - ❑ Plumbing
      - ❑ Electrical
      - ❑ Cost of permits
      - ❑ Design not provided to owner until paid for or contract signed
      - ❑ Be able to estimate range of project cost

   B. Bid/Proposal/Quotation
      - ❑ Unforeseen conditions clause
      - ❑ Identify construction activity - disruption
      - ❑ Detail construction schedule
      - ❑ Payment schedule
      - ❑ Signed proposal

   C. Final Design
      - ❑ Engineered drawings
      - ❑ Apply for permits
      - ❑ Specific details
      - ❑ Materials selection – availability
      - ❑ Pavers
      - ❑ Caps
      - ❑ SRW
      - ❑ Treads
      - ❑ Railings
      - ❑ Piers/columns/pillars

- ❑ Seat walls
- ❑ Lighting
- ❑ Drains
- ❑ Natural stone
- ❑ Plantings
- ❑ Outdoor living amenities (grill, sink, refrigerator, fire pit)
- ❑ Signed contract and drawings – allowances for change orders

3. On-Site

   A. Site Prep
   - ❑ Verify site access and staging area
   - ❑ Receive final permits and drawings
   - ❑ Identify slopes and drainage issues
   - ❑ Install erosion control and containment measures
   - ❑ Provide protection for trees, plantings, and other structures

   B. Project Layout
   - ❑ Verify location of utilities – and non-utilities
   - ❑ Confirm design is applicable to site
   - ❑ Elevations and offset layout stakes
   - ❑ Owner approval – in writing

   C. Staging
   - ❑ Stockpile, bulk material location
   - ❑ Excavated materials stockpile/removal
   - ❑ Local codes for traffic details
   - ❑ Local codes for construction hours
   - ❑ Material delivery method – part/full loads, Boom, Moffett
   - ❑ Owners/neighbors access
   - ❑ Vehicle parking

   D. Excavation
   - ❑ Subcontractor to coordinate?
   - ❑ Equipment to be used
   - ❑ Haul off (removal and disposal) or stockpile
   - ❑ Soil stabilization/shoring/dewatering
   - ❑ Subsoil to mirror final surface

   E. Construction
   - ❑ Understand that each task takes time and consumes materials
   - ❑ Document time and materials (pictures, timesheets, bill of lading, material labeling, load tickets)
   - ❑ For future work and accurate estimates
   - ❑ Comparison estimated versus actual
   - ❑ Compliance with design
   - ❑ Change orders – pre-negotiated price, signed by both parties

4. Close out
   - ❑ Equipment removal
   - ❑ Clean up
   - ❑ Punch list items
   - ❑ Final inspection
   - ❑ Certificate of occupancy
   - ❑ Restoration
   - ❑ Final payment
   - ❑ Care package – pavers, sand, cleaner
   - ❑ Thank you note for a high-dollar project

Figure 4-7: Banding and different materials guide visitors through this area.

Figure 4-8: Step lighting provides an attractive safety feature.

Figure 4-9: Lighting to the sides of the steps is functional and attractive.

Figure 4-10: The raised patio provides a comfortable lookout over the back yard.

Figure 4-11: The different raised patio section defines areas for different activities.

Figure 4-12: The terracing provides plenty of opportunities for gardens.

Part B. Steps

The purpose of steps in a raised patio is to allow people to pass from one elevation to another, with as little difficulty or inconvenience as possible. Local codes should be reviewed prior to designing a raised patio. Depending on the elevation change from the top to the bottom of the steps and their configuration, the building code may require a hand rail along the sides of the steps. Section 4 Part C provides details for constructing railings.

1. Treads and Risers

Every building code has several requirements for steps including obvious details like riser height, tread depth and pitch. The typical pitch for stairs is $7^{1}/_{4}$: 12. For outdoor applications, it is common to use something slightly lower, such as 6 : 12, using a 6 in. (150 mm) riser and a tread depth of 12 in. (300 mm). Building codes will typically require a consistent tread depth and riser height for a set of steps. Variations in these dimensions could create a tripping hazard.

Figure 4-13: Steps with side lighting.

Lighting around steps is important if the raised patio area is used at night. Lighting should illuminate the tread surface, making it easy to identify each step. Diffusing lighting from the side that lights the entire tread surface is preferable. Highly concentrated light or light that shines on the tread and directly at the person using the steps is not as effective.

Figure 4-14: Steps constructed with SRW units.

Full compaction of the base material is extremely important. Any settlement, however minor, is easily spotted as sagging treads and opening joints and corners. It may be prudent to use flowable fill or a cement treated base to minimize the potential for settlement.

Steps are routinely constructed using SRW units and pavers. Each type of material has advantages and drawbacks.

a. Using SRWs

When using SRW units to construct steps, it is important to check the manufacturer's documentation. Many systems have specialized units such as corners and caps that can make construction easier. Another source of information is the National Concrete Masonry Association (www.ncma.org). They can provide additional information about constructing steps using SRW units.

When selecting an SRW system, make sure it can be constructed to achieve the riser height and tread depth required by the building code. It is also important that the

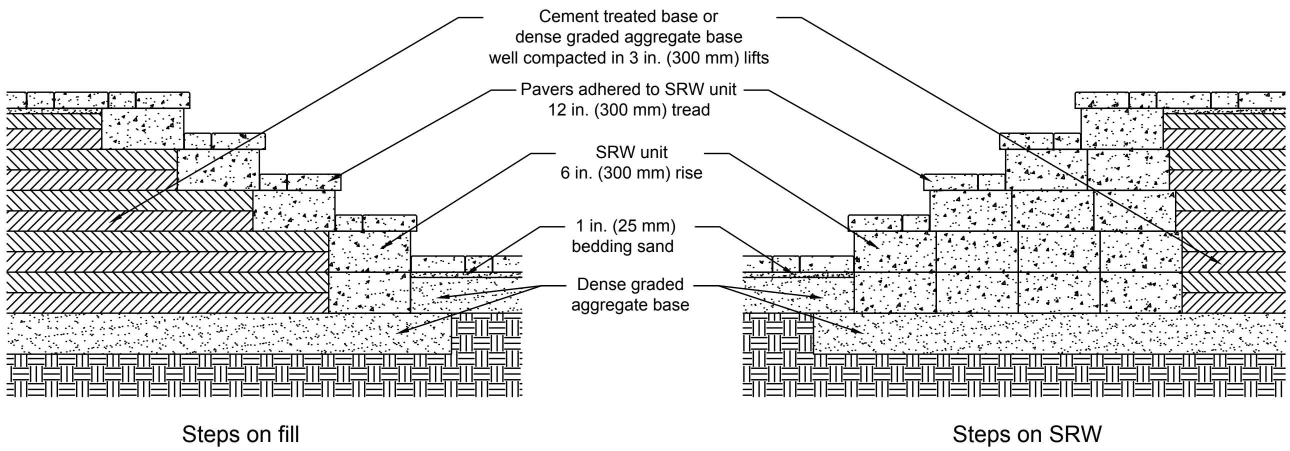

Figure 4-15: Cross section of SRW steps.

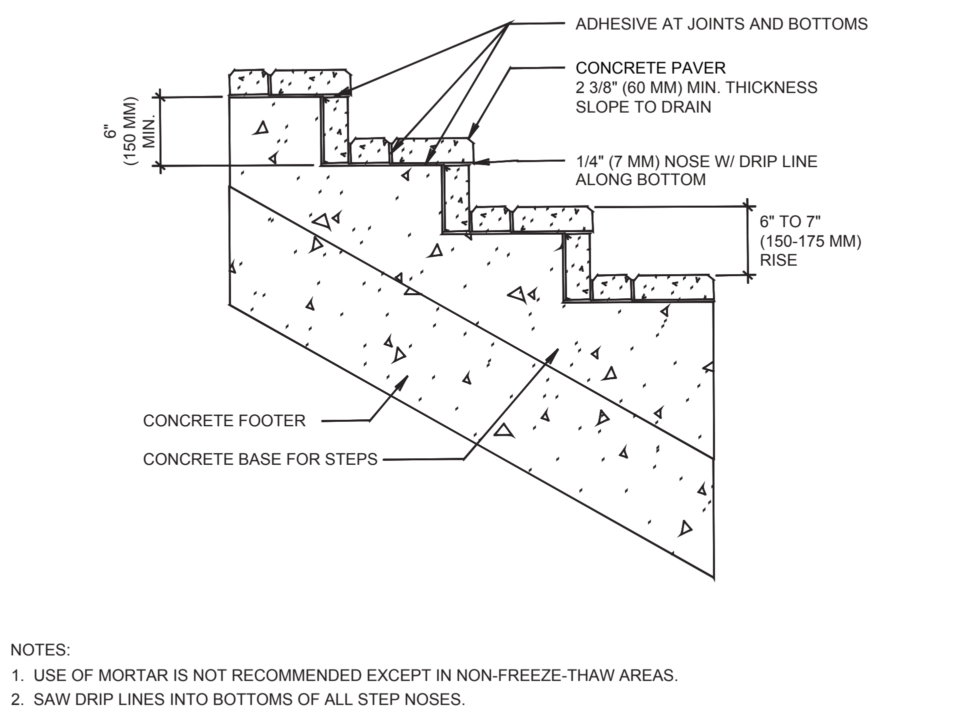

Figure 4-16: Steps constructed using concrete pavers.

selected material has freeze-thaw durability. Steps are typically scraped clean of snow and ice and are heavily salted. De-icing materials are very aggressive and can destroy concrete materials not manufactured with a high level of freeze-thaw resistance. Some SRW systems, due to their geometry, are not designed for steps. Select an SRW system that can be used to easily construct steps. Some SRW systems have cap units that are not meant to support regular pedestrian traffic. Treads can be constructed using a number of different materials like SRW cap units, pavers or natural stone. It is important to select a tread material that works with the SRW units. Use SRW units that can be easily placed and adhered to the tread with a minimum of cutting and modification to the SRW unit. The typical overhang of the tread at the front of the step is between 3/8 in. and 1 in. (10 and 25 mm).

Figure 4-17: Steps constructed using pavers.

Published guidelines from manufacturers typically show one full SRW unit buried at the base of the steps.

b. Using Pavers to Construct Steps

If the design calls for the risers to be constructed out of pavers, it is necessary to use concrete to build the base for the steps. If pavers are stood on edge, they tend to "roll over" if they are not properly supported. This type of application might be considered more of an overlay.

Figure 4-18: Bullnose pavers used for treads.

2. Parallel Inset, Parallel Outset or Perpendicular Steps

It is important to use common terminology when referring to the different styles of steps.

Styles of Steps

Parallel Steps – The front edge of the step is parallel to the line of the retaining wall. Each course is constructed using an inside and outside corner on each side. Parallel steps require the use of a side wall to retain fill.

Perpendicular Steps – The front edge of the step is parallel to the line of the retaining wall. Each step is created using an inside corner on one side and an outside corner on the other. The side wall for the steps is created by the wall leading to the steps.

Inset Steps – The steps are set in from the line of the retaining wall. The side walls are above the steps and face each other creating a stair well effect.

Outset Steps – The steps extend out from the line of the retaining wall. The side walls are below the steps and face away from each other.

Types of Corners

Inside Corner – The location where two retaining walls meet and face each other.

Outside Corner – The location where two retaining walls meet and face away from each other.

Side Wall – A retaining wall of limited length used to support fill near the steps.

Alignment

Convex or Outside Curve – The face of the retaining wall faces away from the center of the circle.

Concave or Inside Curve – The face of the retaining wall faces towards the center of the circle.

Linear or Straight – The wall follows a straight horizontal line, but the base may move forward or back as the grade changes because of the batter or lean built into the wall.

Typically, inset and outset steps can only be constructed parallel to the line of the wall. Steps can also be curved or straight. A single set of steps may be constructed using a combination of different styles. Steps at the top may be inset and may be outset at the bottom. Steps built in a corner may be perpendicular on one side and parallel on the other. Vertical transitions between the different alignments requires a landing between them. Lateral transitions in alignments can be seamless.

Figure 4-19: Straight parallel inset steps using pavers as treads with a lower outside curved landing.

Figure 4-20: Double set of parallel inset steps.

Figure 4-21: Straight parallel outset steps.

Figure 4-22: Round outset steps using bullnose treads.

Figure 4-23: Outside curve parallel inset steps.

Figure 4-24: Straight parallel outset steps.

Figure 4-25: A raised patio with only one riser.

Figure 4-26: A raised patio with 3 risers and a landing.

Figure 4-27: A raised patio with several risers and landings.

Part C. Railings

Building codes often refer to railings as handrails and guards. Building codes typically define them as providing support for people climbing or descending stairs. Guards are similar to fences and are used to prevent falls from raised platform areas. It is common for a handrail to be incorporated into a guard.

Building codes typically specify the maximum size of openings, the minimum and maximum height and the lateral load railings must be able to support. As an example the International Residential Code (IRC) states "Guards shall be located along open-sided walking surfaces, including stairs, ramps, and landings, that are located more than 30 inches (750 mm) measured vertically to the floor or grade below…" (IRC 2009, Section R312.1), "guards at open-sided walking surfaces, including stairs, porches, balconies or landings, shall be not less than 36 inches (900 mm) high…" (IRC 2009, Section R312.2), and for one- and two-family dwellings, the IRC requires guards be designed to resist a single concentrated load of 200 lbs. (0.9 kN) applied in any direction at any point (IRC 2009, Table R301.5). Additionally, all guards must be designed and constructed in accordance with the governing building code, including guards that are not required. Falls resulting from guard failures can cause serious injury, regardless of the fall height.

Resistance to a 200 lb. (0.9 kN) load applied laterally at the top of the guard requires secure connections between the guard and its foundation. For raised patio construction, there are generally four types of post connections used to connect the post to the stabilizing foundation. Each type of connection has varying stabilizing capacities. In all cases, the connection should withstand the loads applied. More importantly, the foundatin to which the post is attached must also resist the applied load.

1. Surface Mount

Surface mount is a very common type of connection. Surface mounting a guard can assist in stabilizing and stiffening the guard system, but should not be relied upon as the only means of securing the guard. A plate is welded or connected to the base of the post and the plate is connected to the top of the retaining wall using either lag bolts or self-tapping concrete screws. Epoxy is also used in some areas. As noted above, this type of connection should be able to withstand the applied load. However, if the wall is a 12 in. (300mm) deep SRW system, the mass attached to the plate is not wide enough to counter act the specified applied load. Some installers have suggested that gluing the top courses together will resolve this. However, 20 sq. ft. (1.9 sq. m) or more of wall would need to be glued together to resist the applied load.

Figure 4-28: Surface mount connection

2. Core Mount

A preferred method used to secure a guard is drilling into the retaining wall down 18 to 24 in. (450 to 600 mm) and grouting or epoxying the post from the guard directly into the retaining wall. Core drilling has some disadvantages. Core drilling can be time consuming and costly. The sediment created during the drilling process can get on the face of the wall or pavers and if allowed to dry can discolor them. Core drilling SRW units can split the block open under certain conditions in freezing environments, similar to freezing water in a glass bottle. To help prevent this:

Figure 4-29: Core mount connection

Figure 4-30: Direct mount connection

1. Only grout round posts into core drilled holes. If the guard uses square posts sleeve them over the round post sent into the SRW unit.

2. The core hole should be no more than 1 to 1.5 in. (25 to 37 mm) larger diameter than the post inserted into the hole.

3. Fill the core hole with grout or epoxy first then set the post in it. Make sure the mortar "mushrooms" above the surface of the unit, or use a control joint sealing compound to seal the top of the hole. This keeps water draining away from the post.

Just like surface mounting, core drilled guards only mobilize a fraction of the mass necessary to resist the applied load. Core drilled guards are potentially more stable than surface mount guards and can assist in stabilizing and stiffening the guard system, but should not be relied upon as the only means of securing the guard.

3. Side Mount

Side mounting is used to attach handrails to the face of a side wall for perpendicular or inset steps. When handrails and guard systems are combined, they may provide an opportunity to help stiffen and contribute to the stability of the entire guard assembly.

4. Direct Mount

Direct mount is the most effective way to secure a guard system. This method can use surface mount, core mount or cast-in-place mounting, but the attachment is made to a solid fixed object like a building or caisson.

For a given project, several of these methods are used to create the stability required by the prevailing building code.

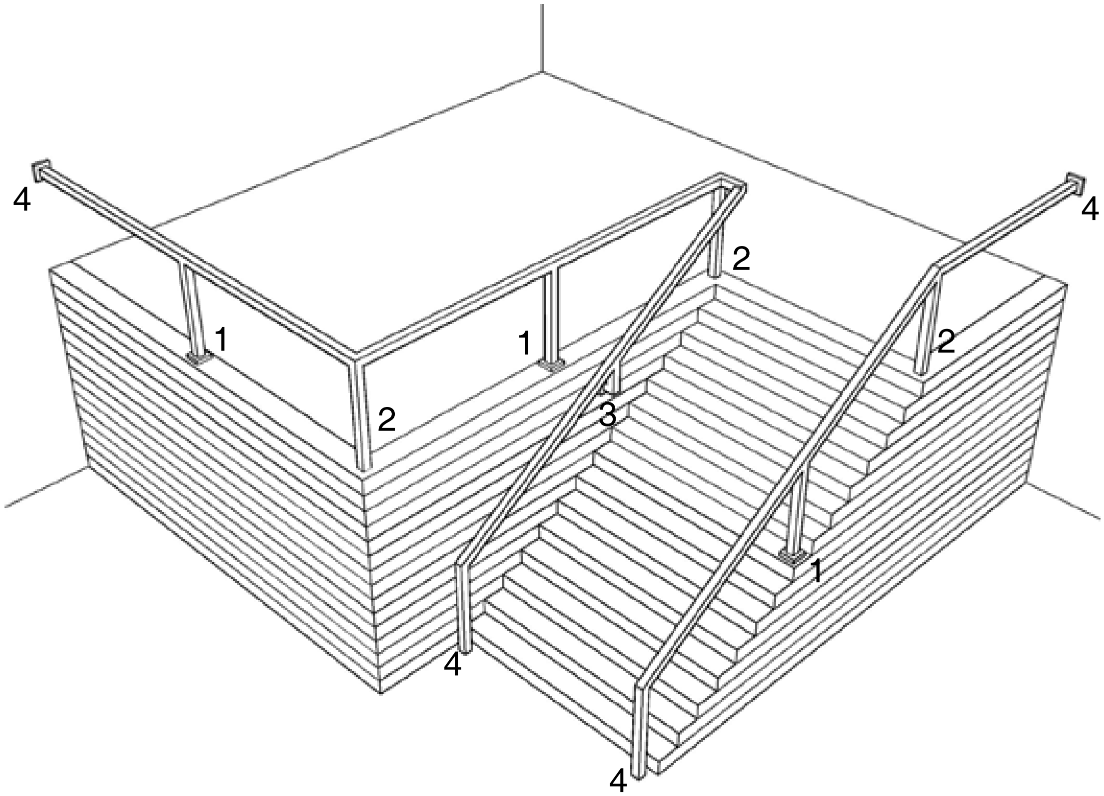

Figure 4-31: Different connections used for handrails and supporting posts. 1. Surface Mount 2. Core Mount 3. Side Mount 4. Direct Mount

Part D. On-Site

As noted on the Raised Patio Check List presented in Section 4 Part A, the actual construction takes place only after numerous other details have been completed. Before the On-Site phase can begin, the Appraisal and Design phases of the project must be completed.

The first detail is site preparation. Before materials and equipment move to the site, it is important to ensure that the site is prepared. Details include: verify site access and staging areas, receive final permits and drawings, identify slopes and drainage issues,install erosion control and containment measures and provide protection for trees, plantings and structures.

Figure 4-32: Make sure all utility lines are clearly mark during the project layout phase.

Project Layout is more than just spray painting a line on the grass to show where the end of the patio goes. The location of all utilities and buried lines should be verified and marked. These locates should have been done in the Appraisal phase, but now that you are on-site it is important to reconfirm their location. The main task in job layout is transferring the final design from a sheet of paper to the job site. This is done by marking the extent of the excavation and patio, noting important features like corners, curves and steps, installing offset stakes and string lines, and marking the finished elevation with stakes and marks on adjacent structures. The last step in the Project Layout is to obtain the owner’s approval in writing.

Figure 4-33: Staging materials and equipment will help keep a work site productive

Now the project is at a point where it is possible to start Staging. Ensure that transport complies with local code requirements and that stockpiled material is out of the way of the owner, the neighbors and construction activities. Make sure equipment and materials are being delivered as planned. Most project plans call for materials to be delivered as needed. If all material was delivered at the beginning of the project the site would be overcrowded and productivity would plummet. Make provisions for the storage of equipment and the parking of vehicles. Maintaining a clean, organized site makes a favorable impression for a company and helps to earn future business.

Figure 4-34: Another successful project.

1. Course Elevations

When defining the elevations of a project, identify the critical or benchmark elevations on existing structures such as the elevation of a door sill or the coping around a pool. In most cases, the critical elevation defines the finished elevation, so it is necessary to calculate backward from the finished elevation down to the starting elevation. Repeat this calculation in several locations on the site and double check them. It is important to determine the total elevation change, consider the slope of the pavement, the incremental height of the retaining wall and cap units and step risers. This should have all been considered in the design. At this stage, confirm that the design fits the site conditions.

2. Compaction

When constructing a raised patio, settlement after construction can cause significant problems when the patio surface no longer meets the fixed elevations of adjacent structures. The potential for settlement can be minimized by ensuring that the base can support the additional load from the raised patio and by fully compacting the soil used in the construction. When constructing a SRW, the first course of units is placed on a dense-graded aggregate base compacted to a minimum of 98% standard proctor density. Care must be taken when compacting adjacent to a foundation wall. Excessive force may crack the foundation wall, incur unexpected costs and delay the project. Less force can be used to achieve the necessary compaction by placing the soil in thinner lifts. When placing fill behind the retaining walls, industry guidelines recommend that 95% SPD should be achieved. However, ICPI recommends that the subbase and base aggregates placed under pavers should be compacted to 98% SPD. When applying this extra compactive effort, it is important to watch the alignment of the SRW units to ensure they are not pushed out of alignment or rotated forward. If there is movement, stop compacting the soil, correct the unit position of the SRW, and continue compacting the soil in thinner lifts.

3. Alternative/Improved Bases and Fill

Sometimes the subgrade soil on a site is too weak to support the load applied by the raised patio. In such cases, a stiffer base may be needed. Options to improve the base could include removal and replacement with suitable material, reinforcement using a woven geotextile or geogrid, or the use of flowable fill, cement treated base (CTB), and asphalt treated base (ATB). Selection of the appropriate alternative depends on several factors, including experience. Installers who have limited experience with these materials and methods should receive technical support before selecting one of these

Figure 4-35: Even though flowable fill may be more expense than aggregate, it may require less labor on some projects.

options. A geotechnical engineer's input might also be necessary to determine the strength of the subsoil and the extent of remediation required.

4. Adhesives

When constructing raised patios, it is necessary to adhere retaining wall caps, treads and other materials. Adhesive must be applied to clean, dust free, dry concrete at above freezing temperatures for them to achieve their maximum bond strength. Once cured, the adhesive needs to remain slightly flexible, given the non-rigid nature of interlocking concrete pavement and segmental retaining walls. Mortar can be a less expensive option and creates a more rigid connection between the concrete pieces. Consequently, the use of mortar in area where freeze-thaw conditions exists is not recommended. The mortar is typically more porous than the concrete, and will hold water that will freeze. In addition, when frost heave moves the concrete elements slightly, the additional stress may cause the bond to fail or the concrete elements to break. Either condition is undesirable. Section 7D provides a more thorough discussion on the use of adhesives and mortar to adhere concrete materials.

Figure 4-36: Which building code and city bylaws may be applicable to these projects?

Part E. Building Codes

Some U.S. states and some federal agencies have adopted the International Code Council's building codes, such as the International Building Code (IBC) and the International Residential Code (IRC). Municipalities may supplement these codes with building ordinances that are more restrictive or may include topics not specifically covered in the state adopted code. In Canada, at the federal level, there is the National Building Code. Some provinces have developed their own provincial building codes, like the Ontario Building Code (OBC), which affirm requirements of the National Building Code, while applying more restrictions and adding requirements for topics not specifically covered in the national code. To ensure a project's compliance with building codes the state/provincial adopted building code and the local municipal/city ordinances should be reviewed.

Additionally, the city has additional bylaws or ordinances that may affect construction. There may be specific time periods when construction activities are not permitted. Parking on the street and stock piling of materials on the road may be restricted. The local building authority should be able to provide details on these types of restrictions.

As noted throughout this section, many aspects and details of raised patio construction are regulated by building codes. Consequently, it may be necessary to obtain a building permit, so the local building authority can ensure code compliance. A building permit requires proper scaled drawings detailing the construction. These drawings may need to be reviewed and sealed by a professional engineer.

HOMEWORK ASSIGNMENT

Discuss with your local building department the specific details they look for when approving a construction drawing and inspecting a project. Specific details may include:

- Maximum height of terrace before railing or guard is required: __________
- Minimum tread depth: __________
- Maximum tread depth: __________
- Restrictions of tread width: __________
- Minimum riser height: __________
- Maximum riser height: __________
- Minimum landing dimensions: __________ x __________
- Maximum height of wall not requiring engineered drawings: __________
- Minimum offset between terraced walls: __________