CONCRETE SKATEPARKS

Design and construction of a skateboarding recreational facility

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Bachelor's thesis

Degree Programme in Construction Engineering

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ABSTRACT

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ABSTRACT

This Bachelor's thesis was commissioned by Windmill Skate Company. The purpose of the thesis was to thoroughly research and describe the setup, planning, design, and construction of an efficient concrete skatepark by focusing on the execution of the building process and the engineering aspects and requirements.

One aim was to provide better understanding on the whole concept behind building a skatepark and point out and analyze different challenges in its construction.

Another aim was to show the importance of skateboarding and of having such a facility in any municipality for the well-being of the young community and of youth in general.

All research information was both gathered from various internet resources and presented by Windmill Skate Company.

The result of this thesis was the creation of a skatepark construction guide for familiarizing oneself with the basics of design, planning and building of such an athletic reinforced concrete facility. It can serve as a reference for getting better acquainted with this particular branch of construction and its different aspects and details.

Keywords skatepark, concrete, design, construction, Windmill Skate Co.

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1 INTRODUCTION

For the past 40 years skateboarding has undergone major development and expansion - from an unknown urban activity into an everyday recreational sport around the world. The way man-made skating environments are built, have changed and developed accordingly.

The first part of this thesis revolves around several main research questions and describes what a skatepark is, what the basic design principles are, how quality skateparks are built, and indicates the standard skatepark obstacles in this purpose-built recreational environment.

The second part provides an introduction into the methods and technology one needs to be well acquainted with, in order to successfully build a skatepark. Its purpose is to thoroughly explain the basic principles of forming, jigging and construction of such a modern facility. In this section, advantages, disadvantages, and specifications of concrete are also brought to the reader's attention.

The third part of this thesis is about a skatepark in Pornainen, Finland, that was built by Windmill Skate Company. It describes the development of planning, design, and building of this type of a construction project, showing how theories in the field are applied into practice by the local professionals.

The first appendix presents drawings and photos of several skatepark projects in Finland built by Windmill Skate Company. The second appendix represents an example set of documents typically created for a skatepark project.

2 SKATEPARKS

2.1 Overview

A skatepark is a recreational and athletic environment that is engineered and constructed to be used specifically by skateboarders, as well as scooter and BMX riders and in-line (rollerblade) skaters. The main purposes of such a facility are to offer a safe place for its users to congregate, relax, practice and perform their extreme sports. A skatepark may consist of any number of various elements and obstacles designed for the riders to overcome as they cruise around the terrain. Due to skateboarding's popularity, ideally, there is a fence for the protection of the ever present spectators and passers-by, as well as efficient lighting for night time use. Figure 1 below is a typical example of a modern skatepark facility. (Gembeck, What is a skatepark?)

Figure 1 Pedlow Skatepark, San Fernando Valley, California (https://en.wikipedia.org/wiki/File:Pedlow_Field_Skate_Park.JPG)

2.2 Benefits and advantages of a skatepark

According to a report from 2009, skateboarding, with its rapid growth and expansion worldwide, is estimated to have 4.8 billion dollars in annual revenue with 11.08 million participants around the world which are an essential part of urban culture and communities. (Montgomery, 2009)

If engineered to do so, a skatepark can attract skateboarding tourists from all around the world. It is a social space that attracts people from different ages and parts of the community, promotes the need of a healthy amount of exercise, and with the low cost of participation, it is easily accessible to everyone interested. Skateboarding is a unique activity that has major mental and physical health benefits. While skaters practice their movements repeatedly, in the pursuit of satisfaction from successfully landing tricks, they improve their brain function significantly. During exercise, skaters develop eye-foot coordination, stamina and balance, whilst simultaneously teaching themselves self-discipline and gaining confidence. The culture behind skateboarding is based upon mutual respect among participants, social interaction, and appreciation of environment. A skatepark stimulates the desire for channelling potential in the young generation. It provides a more caring community for the skaters thus bringing people closer together. A properly designed and executed skatepark requires very little maintenance and can provide a safe place for skateboarding, while at the same time reduces damage to public and private property in the municipality. In an extreme sport, where safety is the most important issue, it is only logical to encourage the construction and further development of such facilities, where users can have the opportunity to develop from beginners to professionals. (The top 6 benefits of skateparks, 2015; Whitley, 2011; Why a skatepark is a good idea…)

2.3 Types of skateparks

There exist two types of skatepark typologies. One organizes them by size, the other – by type of the terrain. Should it be necessary, the two can be combined to generate a specific notion of the skatepark type. This minimizes confusion when talking to a person well acquainted with the subject. (Whitley, 2010)

2.3.1 Skateparks by size

2.3.1.1. Skate dot

This is the smallest possible skateable area. Usually a single structure already existing in a municipal area e.g. a sidewalk or a single ledge. It can support from three to five users, one at a time. A typical example is visible in Figure 2 below. Skaters wax the edge to minimize friction and then ride on top of it – a motion in skateboarding that is called a grind (Figure 11) or a slide, depending on the trick performed. (Whitley, 2010)

Figure 2 Waxed ledge of a flower stand (https://skatermoms.files.wordpress.com/2011/03/dscf0209.jpg)

2.3.1.2. Skate spot

Skate spots are relatively larger than skate dots, with areas from around 230m^2 to about 460m^2. Typically found around city streets, they feature a small amount of elements and structures that the skater uses in sequence, riding from one to the other in a single run. On average, a skate spot can support five to eight users, one at a time. (Figure 3) (Whitley, 2010)

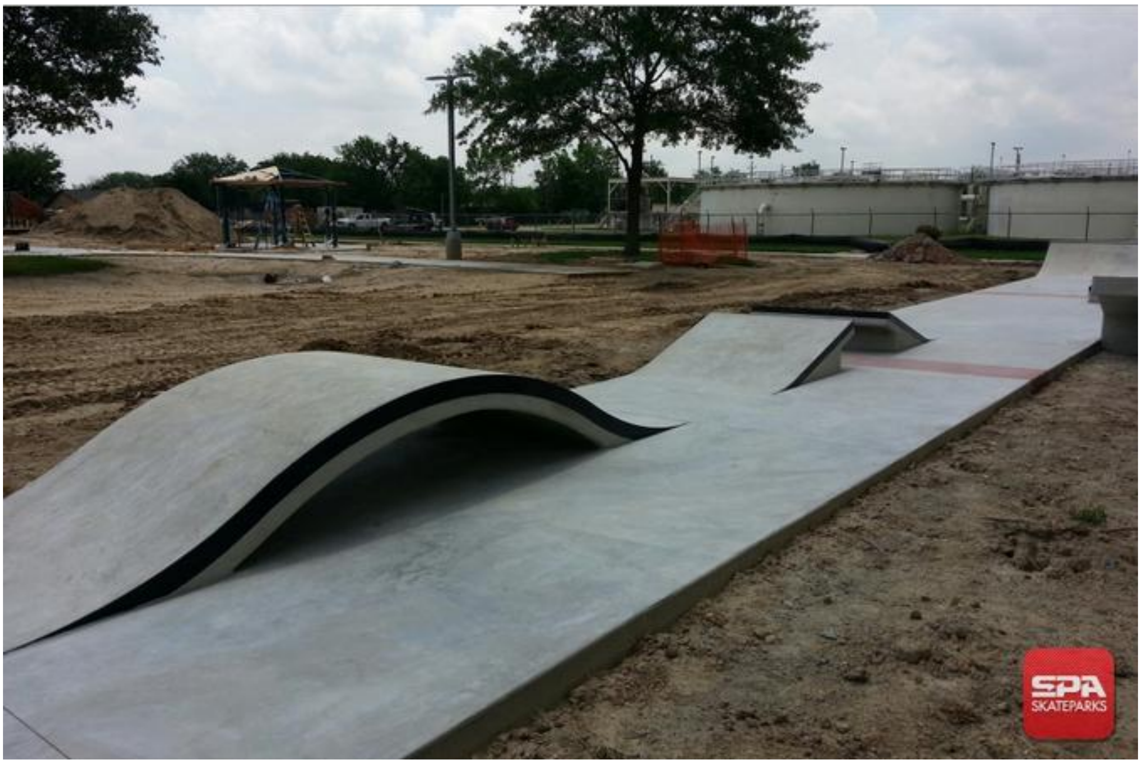

Figure 3 Vogel Creek skate spot, Houston, Texas (http://www.spaskateparks.com/images/made/uploads/projects/Vogel_Creek_-_SPA_Skateparks_-_Houston_Skate_Spot_11_900_600_assetsimgspaskateparks_water-mark_square.png_90_90_80_r_b_-10_-10_c1.jpg)

2.3.1.3. Neighbourhood skatepark

The majority of skateparks can be considered as neighbourhood type of parks. Their size varies from $500m^2$ to $1000m^2$ and they include a wide range of skatable elements (Figure 4). The edges are outlined so that it is clear where the skatepark begins. In addition to trash cans, fresh water supply and seating space, a neighbourhood park usually benefits from nearby parking lots for users' cars. This type of skatepark can support dozens of users and up to six riding simultaneously, depending on the design and size. (Whitley, 2010)

Figure 4 Weston Lions neighbourhood skatepark, Ontario, Canada (http://www.torontoskateboarding.com/uploads_managed/Location/39/weston_lions_skatepark_2.jpg)

2.3.1.4. Regional skatepark

Regional parks are the largest ones. Their size can be around 2300m^2 or more and a wide variety of obstacles is at disposal to the users (Figure 5). Different portions of the area can be dedicated to different types of skatable terrain like stairs or bowls. A park of this type is appropriate for special skateboarding events and is typically designed by a credible company with sufficient experience in skatepark construction. (Whitley, 2010)

Figure 5 Lake Cunningham regional skatepark, San Jose, California (http://www.goskate.com/go/wp-content/uploads/2012/01/Lake-Cunningham-Regional-Skate-Park.jpg)

2.3.2 Skateparks by style

Unlike other organized sports, such as football or basketball, skateboarding does not have a set of rules and limitations. Every single skatepark created is designed to have exceptional shapes and curves that provide different challenges to its users. However, there exist three main types of skateparks, i.e. bowl parks, street plaza parks and flow parks which will be discussed below. (Skatepark)

2.3.2.1. Bowl park

A bowl park (otherwise known as a transition park) mainly consists of pools where skaters can ride around freely without taking their feet off the board to push themselves (Figure 6). The curved walls of those obstacles allow for the back and forth skating motion typical for a traditional half pipe. Bowls and bowl parks come in an endless variety of sizes and shapes but most of the bowls are between one and three and a half meters deep. (Skatepark; Whitley, 2010)

Figure 6 Bowl skatepark in the city of Kortrijk, Belgium (http://img.archiexpo.com/images_ae/photo-g/skatepark-bowl-63496-4757615.jpg)

2.3.2.2. Street plaza park

For the vast majority of skateboarders, street plaza parks are the most favourite choice. They are designed to mimic the raw urban skating experience and to make it better. The elements are made similar to the ones naturally existing in the streets, such as rails, ledges, stairs, banks and benches. Modern street plazas aim to create a place that does not resemble the "traditional" skatepark. They adopt structural and cosmetic enhancements in the skate space, such as dyed concrete or materials like brick, stone, and even small green patches of land. Due to the rather flat nature of the plaza park, skateboarders push off their feet to gain speed and momentum. Figure 7 below is a typical example of a modern street plaza skatepark. (Skatepark; Whitley, 2010)

Figure 7 Skatepark – 2011 SLS (Street League Skateboarding) competition, LA, CA (http://californiaskateparks.com/wp-content/uploads/2010/10/SLS.jpg)

2.3.2.3. Flow park

Flow parks, also known as hybrid parks, combine features from both bowl and street parks. In a well thought design, the skaters can pump around the park, using the curved walls of quarter pipes and bowl corners, without taking their feet off the board to push. They can later use that momentum to ride the different obstacles such as ledges, transfers, stairs and rails. This can be clearly seen in Figure 8, which serves as an example. These types of parks have become more popular as skateboarders are pushing their limits in the sport. (Skatepark; Whitley, 2010)

Figure 8 Hybrid park (http://d1wlqxr6fzatvd.cloudfront.net/wordpress/wp-content/gallery/hybrid/saugerties_-ny1.jpg?9859d6)

2.4 Ownership

Skateparks are either public or private. Generally, publicly owned skateparks are free, whereas privately owned skateparks have submission fees. A lot of the private parks are built indoors, usually in places like former factory buildings with high roofs, unusable warehouses, or ever old roller rinks (Figure 9). This is done especially in Nordic regions where winters are heavily snowy. On the contrary, public skateparks are mostly outdoors. (Skatepark)

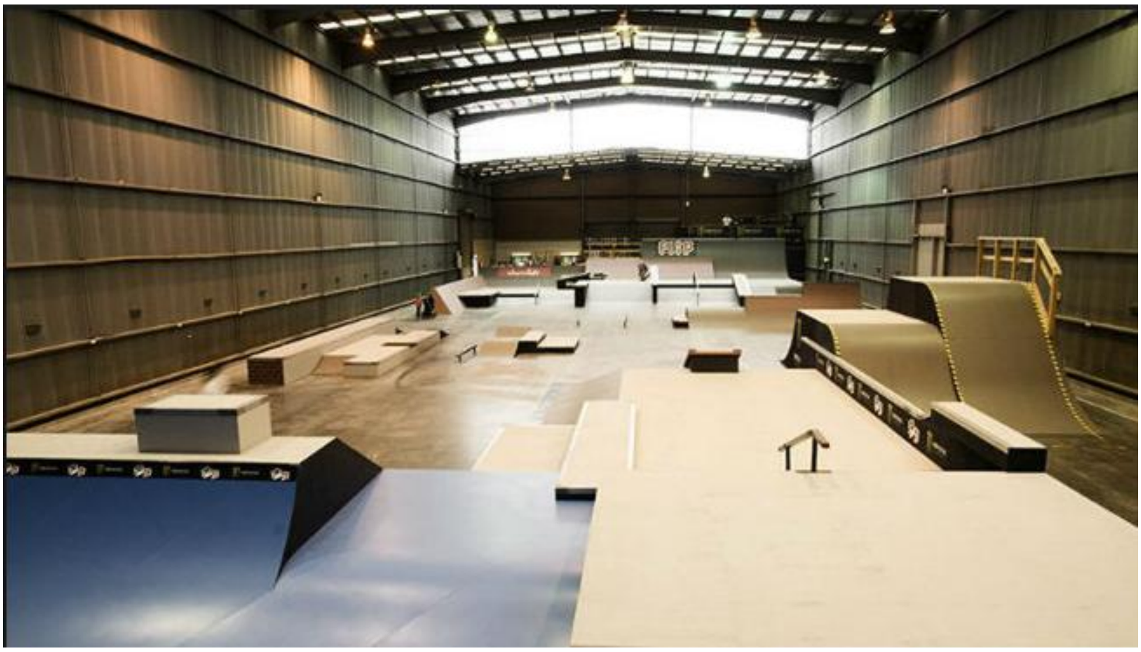

Figure 9 Rampit Indoor Skatepark, Melbourne, Australia (http://images0.aystatic.com/places/160820/82214_home_hero.jpg?1387521752)

2.5 Construction

2.5.1 Prefabricated vs. custom built concrete

A skatepark put together from prefabricated elements is referred to as a ramp park. Whether the structures are made from timber, steel or other materials they should be considered only if there is an available unused basketball court or parking lot in the municipality. This type of ramps are usually recommended for short term use, because they require a lot of maintenance, are less environmentally friendly, and cost more. When building a modern skatepark, concrete is the preferable choice. A concrete park provides a permanent and nearly maintenance-free solution to a community's skating needs. Nowadays these parks are considered the industry's standard. (see Advantages of concrete) (Gembeck, What is a skatepark?; Porstner, 2007)

2.6 Costs

A concrete skatepark costs from around 215 to 250 euros per square meter to build. This price generally includes all the design fees and services, materials necessary for construction, as well as the labour, but only for the skating surface. It does not include conveniences like getting power and water to the building site, putting up fences, lighting and on-site bathrooms. A big skatepark that is worth designing and building costs around 200 000 – 300 000 euros, but it can be accomplished for a lot less, depending on the size, and with the help of skateboarding communities, donations, and volunteers. In comparison with other athletic facilities, this price is quite reasonable. A poorly designed skatepark is considered expensive and can be seen as a bad investment when it does not reach the desired popularity and visitor numbers constantly remain low. (Gembeck, What is a skatepark?)

2.7 Setup

All skateparks should be designed so that they meet the skill levels of all its users – from rookies to professionals. However, the separate zones for beginner, intermediate, and advanced skaters should not be directly combined as this is an unsafe approach which leads to more collisions. Successful designs include separate riding areas, with various elements and features corresponding to the different skill levels, which would be connected by buffer/transition sections. A beginner zone is a must. It is a portion of the park where users with little to no experience can safely and comfortably practice their skills in a controlled environment. Usually this is a flat space between 450m^2 and 750m^2 with slow sloping areas, little hips and small curves. Skateparks are about efficient use and performance, not about looks. Thus said, a practical and realistic approach would make the park a safe and enjoyable place for its users at all times. (Gembeck, Skatepark design – Listen to the skaters!)

2.7.1 Design basics

Figure 10 below presents ten quick rules for skatepark design.

Ten Quick Rules for Design

1. Simplicity
2. Smoothness of Surface
3. No Kinks
4. Flatbottom
5. No Overcrowding
6. Pushing Room
7. No Ledges Over Your Bellybutton
8. Edges that Grind
9. Pump-able Hips
10. Lights

Figure 10 Ten quick rules for skatepark design (http://www.skateparkguide.com/design_basics.html)

When creating a skatepark, the community has to be involved and have a key role in the design the professionals create. Ultimately, the park is being built for the skaters and it has to be custom fitted for them and to reflect their interests, ideas, and suggestions, which come from experience in the sport. This gives a sense of ownership as well as provides for a perfected and optimized design of the skatepark. (Gembeck, Skatepark design – Listen to the skaters!)

2.7.1.1. Flat bottom

Any skatepark must have at least three meters of flat ground in between obstacles. Skateboarders move and get momentum by “pumping” (kneeling slightly at the right time) up and down curves and transitions, thus carrying their speed for good distances across smooth concrete. The more flat bottom there is the more skaters can ride simultaneously while avoiding collisions. It is also crucial for the recovery from a performed trick and the set-up for a next one. After successfully doing a stunt, a skater regains their balance on the board and, with enough flat space in front of them, adjusts their stance for the next line of tricks. In addition, no design should include two walls opposite of each other where a skater can fall from one and crash into the other. It is very dangerous if one does not have enough space to roll out of a failed trick. This could be the difference between scraped knees or elbows and a broken limb. (Gembeck, Skatepark design – Listen to the skaters!)

2.7.1.2. Transition

The transitions between flat ground and inclined surfaces should be accomplished by one of two possibilities. First one is by a pool-like radius curve that is perfectly round. A small and round transition wall, that is not higher than 1.2 meters, would call for a radius between 1.5 and 2.1 meters, whereas a taller transitional wall would require a radius between 1.8 and 2.7 meters. The second one is a banked slope with a tight transition curve to a flat bevel, similar to a modified ditch used for draining. The height of the wall touching the lip (edge) of the transition determines its measures, but the angle should not be more than 50 degrees. (Gembeck, Skatepark design – Listen to the skaters!)

2.7.1.3. Lips, edges, and coping

All edges of any ledge, bank, or wall should be made hard and grindable. The skateboarders are always looking for places to grind and slide on when they are over a wall or a ramp. The edges should be sticking out slightly in order to protect the concrete from wear. At the same time, this allows the skaters to feel the grind and know exactly where they are during the trick. A good example of edge coping is a round metal steel pipe at the lip of a pool (Figure 11). On the picture, the skater is performing a grind trick and it is clearly visible that the pipe is slightly protruding, so that it is not embedded into the edge, but rather on top of it. (Gembeck, Skatepark design – Listen to the skaters!)

Figure 11 Frontside smith grind (http://www.coastalbc.com/skate/photos2009/90630miller09.jpg)

2.7.1.4. Curbs, blocks, steps and walls

Everyday street elements, such as curbs, blocks, steps and walls can and should be used in a contemporary skatepark design. Blocks, steps, and curbs are best suited when combined wisely with each other and with other objects and structures. Such examples are a bank with a curb on top of it, an isolated street area, with stairs and rails that are far from pools and banks, or simply ledges and blocks which skaters can ride or sit on. (Gembeck, Skatepark design – Listen to the skaters!)

2.7.2 Elements and obstacles

Table 1 below contains a list of skateboarding obstacles, as well as a corresponding short descriptions. (Skatepark)

Table 1 Skateboarding elements and obstacles

ELEMENT / OBSTACLE	DESCRIPTION
Quarter pipe	Literal quarter of a pipe. There is usually a narrow metal rod running the length of the top edge; this is called the coping. There may also be a flat platform connected to it at the top; this is called the deck
Half-pipe	Two quarter pipes facing each other (half of a pipe). A smaller half-pipe that is less than 2.4 to 3 meters can be referred to as a "mini ramp"
Bowl	A completely enclosed area of quarter pipes that curve in corners. The curve placement and opposing quarter pipe placement can manifest in any fashion
Deck	The flat elevated area used as a staging area above ramps and bowls
Spine transfer	Two quarter pipes or similar curves placed back to back, that do not contain a deck. Spines may exist in bowls and half-pipes
Extension	Extensions in quarter pipe or half-pipe ramps
Escalator	Sloping increases or decreases in quarter pipe or half-pipe ramp
Flatground	The flat lower areas between transitions, usually at grade
Vert wall	A vertical wall above, and sometimes slightly behind, a quarter pipe
Bank	These can vary in angle but are simply wedge ramps for traversing obstacles, i.e. elevated flats. They may contain curvature at the tops or on sides
Hip	Essentially two quarter pipes (or banks) put side to side forming a 90 degree angle
Funbox	A combination of banks, flats, rails, kickers, etc. connected to each other to form mini gaps
Pyramid	Funbox-type ramp made from four banks put in a square pyramid shape with flat space on the top

Kicker / Launcher	A curved bank a rider uses to launch into the air
Roll-in	A long sloping ramp used to gain speed
Step-up / Eurobox	A funbox type ramp consisting of a bank with a flat at the top and a second, higher flat after it; in other words a bank-to-flat setup with a section removed from the bank part
Wall-box	In an indoor skatepark, this is a funbox built against the wall of the park; in an outdoor skatepark, it is a funbox with a wall splitting it down the middle
Bowl	A circular pool
Pool	Usually an actual swimming pool that has been drained out for skateboarding.
Foam pit	A pile of foam pads to land safely into while learning tricks, usually found after a launch ramp
Flat rail	A rail set level with the ground (Figure4)
Sloped rail	A rail set at an angle
Kinked rail	A rail with two flat sections, one higher than the other, and a sloped section in the middle connecting them
Hand rail	A rail going with a staircase, either extended from the staircase or off an adjacent wall (Figure 7)
Stairs	A simple staircase
Kidney bowl	A bowl roughly in the shape of a human kidney
Egg bowl	a bowl shaped like an egg
Cradle	Spherical bowl turned on its side, typically connected with a bowl. Enables inverted and oververted carving
Jersey barrier	Often used as center dividers of roads. Skaters can wallride up them and grind if coping is emplaced along the top. Sometimes DIY skaters will pour cement on the sides to create a smoother transition, or even turn the barrier into a low spine

(Skatepark)

3 CONCRETE SKATEPARK CONSTRUCTION

The following section will provide a step-by-step introduction into the methods and technology one needs to be well acquainted with, in order to successfully construct a skatepark. Its purpose is to thoroughly explain the basic principles of forming, jigging and construction of such a modern facility. Concrete skatepark design and technical implementation require experience and attention to detail as well as a thorough understanding of skateboarding. The designer must have previous experience in planning and a long term experience in the sport as well as a very good general comprehension of skateparks. Builders must be monitored for a proper technical implementation and work quality of each one of the construction phases. Site supervision is an important part of a successful construction project. The methodology discussed is not the fastest nor the most technologically advanced. However, these are efficient, simple, and easy to understand methods that have proved to be beneficial and highly stable, thus allowing for a longer construction time without deterioration of the building site. (Concrete skatepark construction)

3.1 Choosing a site

Typically, organizations and communities approach their city council for donating a piece of land on which they can build and maintain a skatepark. They can pick several possible locations in the municipality and come to a consensus with the authorities, in order to be granted permission for building. They might also present to the people responsible a petition signed by locals who agree to the construction of such a facility, for example on an old basketball court that is no longer used. When choosing the location, it should be noted that it has to be easily reachable, for example near the centre of the city/town. However, it should not be at immediate proximity of buildings and structures. The soil in the area must have sufficient load-bearing capacity and must not be too fine. The best option is sandy soil, which is rowdy and does not require expensive ground works. Thus, the total budget can be utilized mainly in the construction of the concrete surface. (How to pick a suitable site)

3.2 Site evaluation

Once there is a place that has been agreed upon, the very first thing that should be done is site surveying. This is a crucial step in the process, as it will establish all elevations from which later on construction and design can begin. After completion, a map of the site will be provided with all contours and elevations. The information, provided by the people doing the survey, together with a design plan and advice from a structural engineer, is essential for the creation of the skatepark’s blueprints. Example documents and drawings can be found in Appendix 2. (How to pick a suitable site)

3.3 Site preparation

Before construction can begin, the whole site has to be carefully cleaned of all possible organic matter including vegetation like bushes and trees. When whole trees have to be cut down, it has to be made sure that all of the roots are removed. With time, organic material decomposes and can do a severe damage by leaving hollow parts in the soil, thus causing the concrete above to sink, forming breaks and cracks.

After a careful removal of the organic debris, the entire place should be covered by evenly spreading gravel all over the site. It is very unwise to pour the concrete directly on top of the earth itself, even if compacted. Concrete is heavy, so the earth underneath will settle. An improperly compacted base layer will almost always result in concrete cracking.

A recommendation when beginning construction of a skatepark is to start with a minimum 10 centimetres of crushed gravel (pebbles of 2cm. or smaller), which is then wet and compacted. A small machine that compacts the soil, usually referred to as a compactor or a whacker, is typically available from equipment rental companies (Figure 12). It ensures that the gravel is well compacted for a proper base under the concrete. (Concrete skatepark construction)

Figure 12 Worker using a compactor. (http://www.skateparkguide.com/images/articles/19.jpg)

3.4 Specifications

3.4.1 Concrete

For skateparks, concrete as a material provides a more self-sustainable option with an easily maintained and smooth surface that skateboarders find very attractive. In the construction, a concrete class of C 28/35 or higher should be used (strength 28 N/mm^2) to a minimum depth of 10 centimeters. This is poured over the previously compacted layer of gravel. Unless highly experienced in skatepark construction, one should not use curing accelerators in the concrete. They speed up curing of the concrete, and it can set up before trowel finishing can be properly completed. Other requirements include aggregate of maximum 2.5 centimeters, a minimum of 310 kilograms of cement per cubic meter, a maximum 5 centimeters of slumping (settling), and air content from three to six percent. For a big project like building a skatepark, the best way to place the readymade concrete on site is by using a pump truck. It is a vehicle that can pump concrete through a pipe to distances of more than 45 meters. The last 3 meters are a flexible rubber tube, which can be guided in the desired direction while the concrete is being pumped (Figure 17). (Concrete skatepark construction)

3.4.1.1. Advantages of concrete

Concrete has many advantages for skatepark construction. Users are really attracted to the hard-wearing and ideal riding surface which is much quieter, than riding on wood or steel. Because skateboarding is by nature an urban activity, it is often practiced close to residential areas. A concrete park offers near-silent skating conditions. The traction between smooth concrete and polyurethane wheels is excellent and it gives skaters the best feel of their board out of all other materials. It is the least slippery when wet and also dries the quickest. Because of its easy formability the concrete allows for the design of limitless shapes for elements and obstacles. This way the typical wooden skatepark's sharp and distracting corners are avoided and thus better aesthetics are achieved. Even though a skatepark is done in sections, when the entire park is constructed from concrete, wearing of the joints and connections does not occur, which is a typical problem for asphalt joints for example. Concrete provides something that is far more durable than any other skatepark material. It is practically vandal-proof even in severe circumstances and stays just as new after years of usage and weather influences. For comparison, when exposed to moisture, plywood which is an alternative material for skateparks, becomes soft, tends to crumble forming holes in the surface, and only after a couple of years is in need of new boards. (Concrete skatepark construction)

3.4.1.2. Estimating concrete volume

When beginning a project, one should always have an idea of the quantity of concrete that will be needed for building even before the design is completed. A simple multiplication of the length and width of the site together with the desired thickness of the slab would give a rough estimation of the concrete volume needed. (Concrete skatepark construction)

3.4.2 Cold weather concreting

3.4.2.1. Cold weather definition

Cold weather is a period of time when the daily average temperature falls below 4 degrees Celsius for three days in a row or more. These conditions demand special precautions when pouring, finishing, curing and protecting concrete against cold weather impacts. Since Finland's weather conditions can dramatically change during the winter months, and the country definitely falls into the cold weather category, proper planning is crucial for good concrete constructions. (CIP 27 – Cold weather concreting)

3.4.2.2. Effects of temperature, air-entrainment, and cement hydration

Effective concreting in cold-weather conditions demands for a profound understanding of the different factors affecting the properties of the material. When in plastic state, concrete will freeze if its temperature drops further below than -4°C. If it does, potential strength would be reduced by more than 50% and durability will be detrimentally affected. The curing concrete has to be protected from freezing while it attains a minimum compressive strength of 3.5 MPa, which generally happens about 48 hours after placing, if maintained at around 10 °C. The low temperature of concrete has a significant impact on the cement hydration rate, which in turn results in slower setting and slower rate of strength increase. A reduction in the concrete temperature by 10° will double the setting time. This slower pace of curing has to be accounted for when planning various construction works, such as removing of formwork for example. (CIP 27 – Cold weather concreting)

Concrete that comes in contact with water and is exposed to cycles of freezing and thawing, even if only during the construction phase, should be air-entrained. Air entrainment is when tiny air bubbles are intentionally created during mixing of the concrete, using entraining agents. The aim of this process is to increase durability and resistance of concrete against freeze-thaw cycles, as well as to improve workability in plastic state. The excess water in the concrete mixture, which is not absorbed for the hydration of cement, evaporates and leaves pores in the concrete. Water from the environment gets in those voids and when frozen it expands, increasing its size by up to 9%. At temperatures of -22°C, this ice growth generates enormous pressures of up to 207 MPa, which can fracture any rock or concrete. The air bubbles entrained in the concrete are very tiny – typically from 10 to 500 micrometers (0.01 to 0.5 millimeters). They can be compressed a little bit, thus absorbing the pressure generated from frozen water and reducing the stress rendered on the concrete. As a whole, the freshly poured concrete is saturated with water. For optimal results, it should be protected from all freezing and thawing until it reaches a compressive strength of at least 24 MPa. The air bubbles also contribute to a better workability of the concrete by acting as a sort of lubricant for the large particles and aggregates in the concrete mix. (Air entrainment; CIP 27 – Cold weather concreting; Frost weathering)

Cement hydration is the main chemical process which generates heat. The fresh concrete has to be well insulated to conserve that heat and therefore maintain favorable curing conditions. Great differences in between ambient and surface temperatures have to be prevented as this could cause cracking when the difference is more than 20°. Gradually, the insulation and protective means should be progressively removed to prevent thermal shock to the concrete. Figure 13 below shows the effect of temperature on the setting time and the strength of concrete. (CIP 27 – Cold weather concreting)

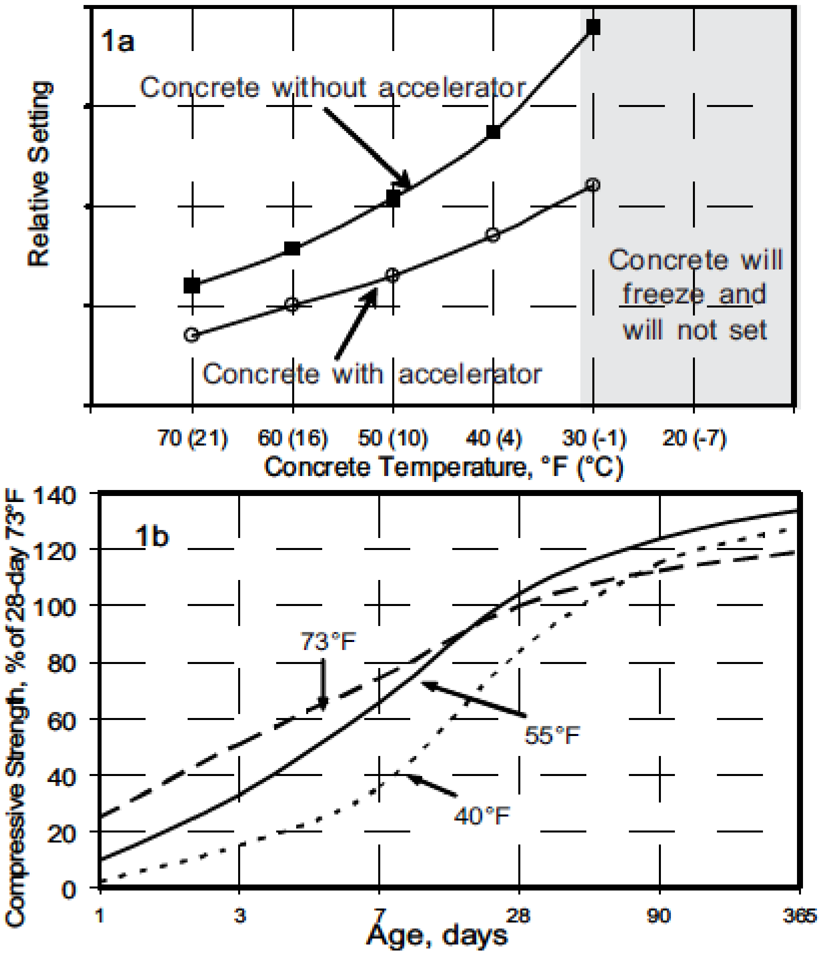

Figure 13 Effect of temperature on set time (1a) and strength (1b) of concrete (http://builderssupply.net/cip/27%20-%20Cold%20Weather%20Concreting.pdf)

3.4.2.3. Cold weather concrete pouring

At a higher temperature concrete demands more mixing water, is more susceptible to cracking, and has a higher rate of slump loss. When concrete is placed in cold conditions, a chance for a better quality is provided, as lower initial temperatures will result in higher ultimate strength. Unfortunately, slower setting time and strength gain during cold weather delays the finishing and formwork removal. In order to accelerate the process, chemical admixtures and other compounds can be added to the concrete mixture.

A common accelerator is calcium chloride ($CaCl_2$). However, accelerators do not protect the concrete against freezing and thawing and do not help to conserve the necessary temperature for proper curing. The rate of setting and strength gain can also be sped up by increasing the amount of Portland cement or by using a high early strength type of cement. Before placing concrete in cold weather appropriate preparations should be made. All frost, snow, and ice has to be removed and the contact surface temperature of the soil has to be above freezing. This may demand for insulation or special heating subgrade. All equipment and materials have to be properly placed to protect the concrete from early freezing and to sustain the temperature both during and after the pour. Specifically edges and corners lose heat the quickest and need additional attention. The concrete surface must not dry out too quickly while still plastic because this will cause plastic cracks from shrinkage. Afterwards, it must be cured adequately. (CIP 27 – Cold weather concreting)

3.4.3 Reinforced concrete

Reinforced concrete is a composite material with high strength, relatively low cost and versatility. It has allowed for the creation and erection of various structures that would have otherwise been impossible or impractical to design and construct. Its two components work excellent in combination – steel is strong in compression and has a high toleration of tensile strain, while concrete has a high relative compressive strength. Naturally, the calcium hydroxide [$Ca(OH)_2$] in concrete creates and alkaline environment ($12 < pH < 13$) which is favorable for the rebars inside. A thin oxidized layer is formed around the reinforcement and thus it is protected from corrosion through passivation of the metal. This layer is also known as a passivating layer. (Figure 14) (Brown, 2013)

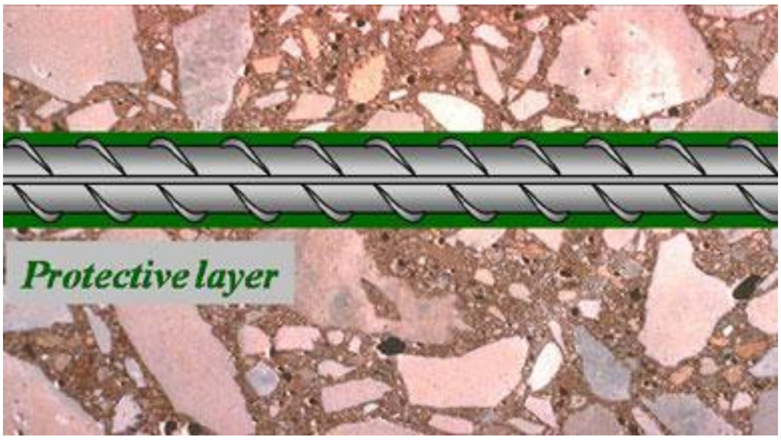

Figure 14 Passivating layer of a steel rebar (http://www.cement.org/images/default-source/contech/corrosion_graphic2.jpg?sfvrsn=2)

In concrete design and construction, it is extremely important to understand the processes that can threaten and compromise the structural integrity. Besides mechanical damage or fire, the corrosion of steel reinforcement is the most common cause of reinforced concrete failure. Due to the presence of moisture and most notably the effect of carbon dioxide (CO_2), concrete carbonation occurs and leads to a structural failure. (Brown, 2013)

3.4.3.1. Concrete carbonation

Since a skatepark is a reinforced concrete structure, carbonation has to be taken into account during design and construction. It is a process that is almost impossible to avoid in untreated concrete exposed to the environment, as it begins straight away after the concrete is exposed to open air. The carbon dioxide (CO_2), impregnates the surface where it reacts with moisture in the concrete's pores and the calcium hydroxide [$Ca(OH)_2$], and forms calcium carbonate ($CaCO_3$) and water (Figure 15). When the carbon dioxide meets the pore water it forms a diluted carbolic acid (C_6H_5OH), also known as phenol, which reduces the alkaline environment of the concrete. (Brown, 2013)

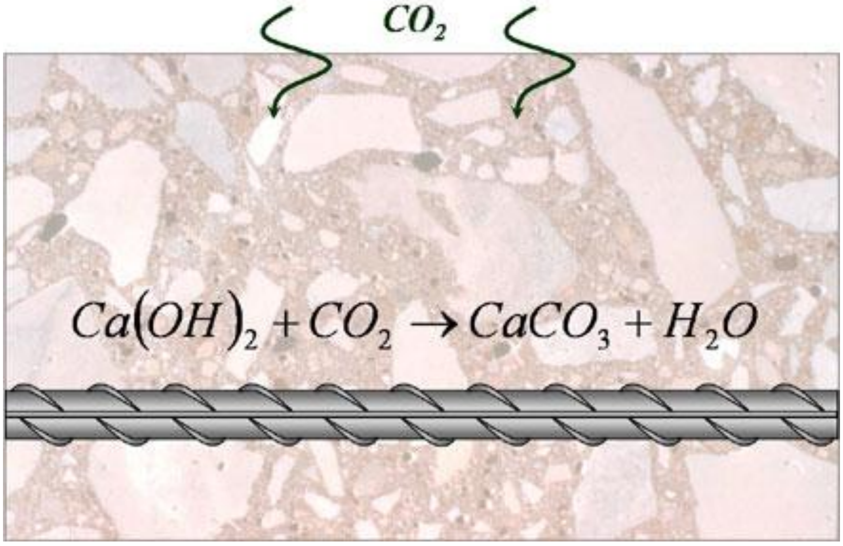

Figure 15 Carbonation process in concrete (http://www.cement.org/images/default-source/contech/corrosion_graphic3.jpg?sfvrsn=2)

The speed with which carbonation advances in the concrete depends on its porosity and permeability. The rate can be from around 1 to 5 millimeters per year. Although initially this hardens the concrete and increases its compressive strength, the carbonation process reduces the alkalinity from 13 to around 8. This drastic change in the chemical surroundings of the reinforced concrete compromises its structural integrity. When the carbon dioxide goes deep enough and reaches the reinforcement, the passivating layer around the rebars is broken down by carbonation. This exposes the steel to the corrosive impact of air and moisture. It rusts and expands thus creating pressure in the concrete, cracking it and significantly decreasing the strength in the surrounding areas. (Figure 16) (Brown, 2013)

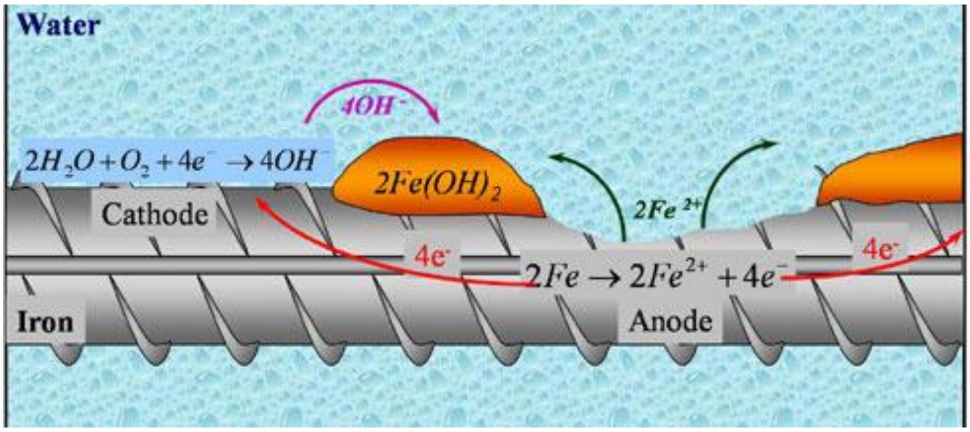

Figure 16 Corrosion process on a steel rebar (http://www.cement.org/images/default-source/contech/corrosion_water_graphic.jpg?sfvrsn=2)

The corrosion of the embedded steel reinforcement can be largely reduced by using crack-free concrete that has a low permeability, by providing adequately thick concrete cover, and by using membranes and sealers on the concrete surface. (Brown, 2013)

3.4.3.2. Chloride attack

Another aspect that has to be taken into account during designing and planning are chloride attacks. Although they are more frequently manifested in reinforced concrete in marine environments, they can also cause problems when the concrete is cast in soils with a high concentration of salts. A chloride attack acts in a similar way to carbonation. The moisture in the soil and air carries salts and corrosive substances into the concrete through its pores and reduces the pH value of the environment inside. The passivating oxidized layer of the reinforcement is eliminated and corrosion takes place as the chloride ions meet with the steel surface and the surrounding oxidized material. This chemical process forms hydrochloric acid (HCl) which slowly but effectively erodes the metal of the rebars. Just like with carbonation, the physical characteristics of the concrete are the most major factors contributing to the rate with which chloride attacks can occur. In general, concrete is a porous material and its durability and strength are governed by water to cement ratio, compaction, and curing. When taking a chloride attack into consideration, the density of the concrete becomes an important factor which determines the speed of deterioration. The smaller the concrete pores the lower the connectivity in between them and the less vapor and moisture absorption, which in turn slows down the intake of chlorides and salts into the structure and prolongs the life of the concrete. (Brown, 2012)

Another important factor in the rate of deterioration is the surface condition of the concrete. If there are damages on the surface in the form of cavities, abrasions, and other mechanical or impact damages they will magnify the speed of corrosion. From there, exposure to freeze-thaw cycles will furthermore amplify it. An inspection of exposed reinforcement attacked by chloride shows black colored rust and pitted rebar surface due to the aggressive hydrochloric acid “eating” the material. (Brown, 2012)

3.4.4 Reinforcement

The structural support of the concrete comes from rebars (Figure 17). The ones that are most commonly used in skatepark construction are 10 millimeters in diameter and are 300 millimeters apart from center to center in a reinforcement mesh. With this configuration, the slab becomes stronger and tougher than a normal driveway. It is obvious that through normal use by skaters it will never endure stresses of similar magnitude. However, this strength not only guarantees the structural integrity, but also keeps even the slightest future hairline cracks on the surface to a minimum. (Concrete skateprk construction)

Figure 17 Reinforcement of a quarter pipe. (http://www.skateparkguide.com/images/articles/32.jpg)

3.4.5 Drainage

How drainage will be taken care of, depends entirely on the specific design of the skatepark and the elevations of the building area. There are two types – above drainage and below drainage, which will be discussed below. (Concrete skateprk construction)

3.4.5.1. Above grade drainage

Below grade drainage does not use pipes. Instead, it uses a slope together with gravity to lead the water across and away from the surface of the park. This is the least expensive of possible solutions, but it will limit the design of the skatepark, because the water has to be able to exit the slab along clear outside edges. What this means is, there cannot be any bowls, pools and other types of widespread obstacles. However, if this becomes the preferred drainage option, the slope should be kept to the standard 20 millimetres downward pitch for every meter. The slab can either be crowned in the centre, or pitched in any chosen direction. (Concrete skateprk construction)

3.4.5.2. Below grade drainage

With this solution, drainage relies on the slope of the skatepark to lead the water into drain boxes and then into underground pipes, from where it will go straight into the municipality's drain system. The pipes used should be made out of PVC (as well as all the couplers for joints) with a minimum diameter of 10 centimetres. The slope should be the standard 20 millimetres pitch per meter. One may think a greater slope would be more efficient, as it would drain the water quicker. However, it will drain away too rapidly and it will not carry along debris and other material with it, which will lead to clogging of the pipes. A drain box is a space with a filter where the water runs to before going in the drain pipes and into the main drain system. For skatepark construction, standard and commercial drain boxes are not preferable as their grates are dangerous to skate on and are difficult to fit with the concrete. The box should stretch another 20 to 25 centimetres below the lower edge of the drain pipes. This extra space is the debris trap where dirt and leaves can accumulate instead of going into the drainpipes. This way, the drain box has to be cleaned only about once per year. Another very important step is to ensure that the top of the drain box follows precisely the bottom slope of the bowl or slab (Figure 18). It should in no case be levelled with the surrounding ground, because this will lead to one side of the box being higher than the finished concrete surface. (Concrete skateprk construction)

Figure 18 Drain box at the bottom of a pool. (http://media.fromthegrapevine.com/assets/images/2014/7/Venice%20California%20Skate%20Park.jpg.824x0_q85.jpg)

3.4.6 Expansion joints

Expansion joints are a series of purposefully created cracks that allow the concrete to expand without forming new cracks. In a typical driveway they can be placed at every 2.5 meters or so. This is really inconvenient for a skatepark surface. However, as expansion joints are large enough to disrupt the skateboard's wheels by "embracing" them, and prevent skaters from having a smooth ride. When designing a park, these joints should be kept to a minimum and placed only at 90 degree angles between ledges and slabs, as this is one of the most frequent places for cracks to appear. Using high strength concrete class like C 28/35 will result, in the worst case, in random hairline cracking, also known as concrete crazing, which is not felt through the wheels of the skateboard and is thus definitely the preferred option. A structural engineer's recommendation would be to include those joints at all costs, as this is the standard procedure for general concrete constructions like sidewalks (Figure 19) or parking lots. However, the design and form of a large concrete facility, which is specifically engineered for the sport of skateboarding, has to follow its function. As described above, random surface hairline cracking does not disrupt the ride of users and is rarely more than 3 millimetres deep. Therefore, this approach is better for the construction of concrete skateparks than other familiar methods known by engineers. If the engineer strongly insists that there should be some expansion joints, there is a solution. Expansion steel can be incorporated into the design of the skatepark. It is a type of galvanized steel sheet that is designed to serve as formwork, but at the same time it remains inside the concrete and creates a really thin expansion joint. It is primarily used for flat surfaces like slabs and different angular elements like banks and pyramids. (Concrete skatepark construction)

Figure 19 Expansion joints in a sidewalk (http://www.customconcrete.biz/Portals/119041/images/)

3.5 Concrete construction

3.5.1 Formwork

After all the preparations on the site, the first step into building the skate-park is fabricating and placing the formwork, in which concrete will be poured. (Figure 20) The strength of the formwork is crucial. If the walls cannot withstand the amount of pressure the concrete creates, there might be a breakage which is something that has to be avoided at all costs. The insides of the formwork are sprayed with diesel fuel to ease a clean removal of the forms from the dried concrete. After that, all faces have to be smoothened out and all edges or junctions rounded. (Concrete skatepark construction)

Figure 20 Formwork of a funbox (http://www.skateparkguide.com/images/articles/5.jpg)

3.5.2 Filling

The concrete should not be poured in a hot and dry weather, because if the moisture from the surface is evaporating too quickly, this will hinder the finishing of the concrete. However, if it cannot be prevented, temporary tent-like shelters can be built over the curing concrete, to block direct sunlight from the surface. Also, the ground should be kept moist when the concrete is placed, or otherwise dry soil will absorb moisture from the concrete and will hamper the curing. Once the concrete starts filling the forms, they have to be overfilled slightly and the material pushed into the corners and spread with a shovel and a muck rake. This must be done quickly while at the same time avoiding overworking the concrete and trapping air bubbles inside. Overworking can lead to excess concrete rising to the surface, which in its turn can lead to scaling. Scaling is when concrete's surface starts to flake and peel away. The concrete has to be worked around until the forms are completely filled to the top so that screeding can begin. (Concrete skatepark construction)

Figure 21 Pouring of concrete at Pornainen skatepark, Finland (http://www.ebaka.fi/skeittiparkki/sp05.jpg)

3.5.3 Screeding

Once the concrete is in the forms and is spread evenly, it is ready for screeding. This is the process of shaping and truing the surface of the concrete by using so-called screeds – purpose-made timber boards or aluminium tools, and guiding them along the formwork which acts as screed rails (Figure 22). The screeds are used to apportion the extra concrete and remove low spots. Normally, they are flat, but when building a skatepark one needs a variety of shapes and sizes. Screeding should be done a meter to a meter and a half at a time and sections should be rescreeded as necessary. (Concrete skatepark construction)

Figure 22 Workers screeding concrete on a bank. (https://s-media-cache-ak0.pinimg.com/736x/f5/6e/a7/f56ea79252b81eb1f713652a04815d60.jpg)

3.5.4 Floating

The next step is floating the concrete. Floating is the process of smoothening out the surface of the concrete and working some of the water to the top. Typically for big flat surfaces, a magnesium bull float is used. It has a large blade with a rectangular shape attached to a long metal rod. The bull float evens the high and fills the low spots while at the same time forces the aggregate a little below the concrete surface. For curved surfaces, like quarter pipes for example, floating should be done with floats that have an equal radial transition (Figure 23) (Concrete skatepark construction)

Figure 23 Worker using a bull float on a curve. (http://www.siuntio.fi/Liitetiedostot/Tarjouspyynnot/Skeittiparkki/betonipark kiopas.pdf)

3.5.5 Finishing

3.5.5.1. Re-floating

After the concrete has been curing for some time, the first step to finishing it is to re-float the surface by hand (Figure 24). This is a very precise process because in practice the whole area has to be done manually section by section. Magnesium floats are light and easily pass over the surface of the concrete. In order for workers to reach every part, without blundering the concrete beneath them, they need to use knee boards. These are rectangular boards made from plastic that distribute the weight of the worker over a bigger area thus minimizing the disturbance of the concrete underneath. (Concrete skatepark construction)

Figure 24 Workers floating a curve by hand. (Windmill Skate Co.)

3.5.5.2. Rounding

The next step is to round all the outside edges of the concrete. This prevents damage from chipping when removing the formwork or from impact, after the concrete has cured. Rounding is done with an edging tool. (Figure 25) (Concrete skatepark construction)

Figure 25 Worker using an edging tool. (https://www.icreatables.com/images/exteriorhomeimgs/concrete/concrete-edger.jpg)

3.5.5.3. Troweling

A high quality skatepark requires hard trowelling in order to really bring out a glossy polished concrete surface. It is the last step of the finishing process. Hand trowels are tools similar to the hand floats – flat in shape with a rectangular blade. Pool trowels are round in the corners and are specifically used for working curved transitions of swimming pools or, in case when building a skatepark, for quarter pipes, bowls, transitions, etc (Figure 26). Sometime after the first trowelling, there has to be some additional trowelling done, which is referred to as “burning”, if the surface is to be really smoothened out and made durable. For big flat surfaces, engine-driven power trowels can be used (Figure 27). Often referred to as “helicopters” or “power floats”, these light construction machines can be rented from equipment stores to apply the final smooth finish to the concrete. The last step is to add liquid post-treatment curing agent, which closes the pores of the surface and prevents the penetration of moisture into the concrete. The end result is a glassy and hard surface that can be compared to the concrete of shopping centre parking lots, the only difference being that it is even smoother. (Concrete skatepark construction)

Figure 26 Hand trowels

(http://www.siuntio.fi/Liitetiedostot/Tarjouspyynnot/Skeittiparkki/betonipark kiopas.pdf)

Figure 27 Worker using a power trowel. (http://www.bluestone1.co.nz/files/cache/cec866d03b71f5a94d8439c185419 df3.JPG)

3.5.6 Stripping formwork

The formwork has to be removed by exercising great care in the disassembly, keeping in mind that the concrete is still fresh and more or less fragile. Usually, all the wooden boards and beams can be thoroughly cleaned and used again in a future project. There must not be any organic material left on the concrete because its decomposing will inevitably damage the concrete by causing lumps and cracks. Excess welds from coping as well as sticking bolts can be removed by using an angle grinder with a steel grinding wheel. Any concrete residue on metal parts can be removed with a die grinder or a wire brush. (Concrete skatepark construction)

3.5.7 Curing

The concrete will gain most of its strength during the first week of the curing. However, in order to achieve the best possible result and keep cracking to a minimum, it is recommended that the concrete is kept moist, by daily saturating the whole area, and free of traffic for at least four full weeks (28 days). The anticipation of the public behind the completion of the skatepark and trespassing has to be suppressed, as patience is crucial at this final stage of construction. (Concrete skatepark construction)

4 PORNAINEN SKATEPARK PROJECT

4.1 Introduction and timetable

Pornainen is a municipality in Finland with a population of 5000 inhabitants, located around 50 kilometres north-east from the capital Helsinki. The town's recreational committee invested 20 000 euros in 2013 and 2014 for the construction of a skatepark. It was ordered by the main contractor Ebaka Ltd. and is being built by Windmill Skate Company. It is a diversified company with decades of experience and has been involved in dozens of skatepark projects (see Appendix 1). Windmill is part of the "Hämeenlinna Skateboard Association" (Hämeenlinna Rullalautaliitto Ry.) which in its turn is a part of "Finnish Skateboard Association" (Suomen Rullalautaliitto Ry.)

According to a user survey and consultations with experts at the beginning of 2014, it was concluded that the pre-fabricated elements will not be a long term investment and not the best decision. Even though the costs for building fixed concrete elements were estimated to be over 20 000 euros, it was found to be sensible, and construction was scheduled for the year 2015. The target for the year 2014 was plan making and purchasing of the land where the skatepark was to be constructed. Therefore, the 2014 investment in the share accumulated savings. This project plan aims to point out and clarify the different points that were considered in the construction process. The Pornainen skatepark's project schedule is shown in the table below. The construction phase was planned to start in April 2015 the earliest, due to necessary time for law regulations and construction approval, and to continue for about two months.

Table 2 Pornainen's skatepark project schedule

Competitive bidding plan	Purchase plan	Approval for construction	Construction
Spring 2014	Autumn 2014	January-March 2015	April - August 2015

4.2 Skatepark plan 2014

Before dispatching invitations to contractors for bidding (tendering), various skatepark designers and builders were contacted by telephone for comments and suggestions on the project. Through consultations and discussions with young people the plan was roughly shaped. It was concluded that the elements should be made out of concrete instead of plywood because it is a more meaningful and cost-efficient alternative. After that, calls for bidding were made and the layout and skatepark design with asphalt surface were sent to five different parties. Biddings were received from two of them. One of the main criteria was that the plan must take account of local enthusiasts' and young people's aspirations, as well as to use the input of the local youth organization. The Finnish Skateboard Association was selected to be the main designer. The association was founded in 2003. It aims to promote skateboarding recreational activities in Finland and to act as a skate club central organization. It is responsible for consultations during the skateprk construction.

4.3 Participatory planning

Pornainen skatepark's plan was created together with local young people and enthusiasts. The design project implemented Pornainen's youth committee. It organized a skatepark planning "competition" in the spring of 2014. Young people participating drew their layouts for the desired number of elements. The base drawings were given to the local youth club, young people from the local church, as well as to people from the local comprehensive school. With the corresponding input from everyone, the plans were returned and the final design included 10 obstacles. (Figure 28)

In the first meeting Skateboard Association representatives inspected and tested the existing asphalt area for its general condition, drainage slots and asphalt slope of the plane. Designers handed over to the same event the works from the skatepark planning competition and the best suggestions were used in the plan. In addition, the young people had the opportunity to express their desires through social media websites and youth centre counsellors. A list of requests had been brought to the attention of the designers on two occasions. In addition, the designers were in telephone contact with two local skaters, who interacted with Pornainen young people and skateboarding enthusiasts. The representatives provided comments on the skatepark plan, so a few changes were made based on those comments. The locals were very pleased with the plan. The finished design was presented to the youth on the skatepark's Facebook page, so that people could leave their last comments before the official adoption of the plan.

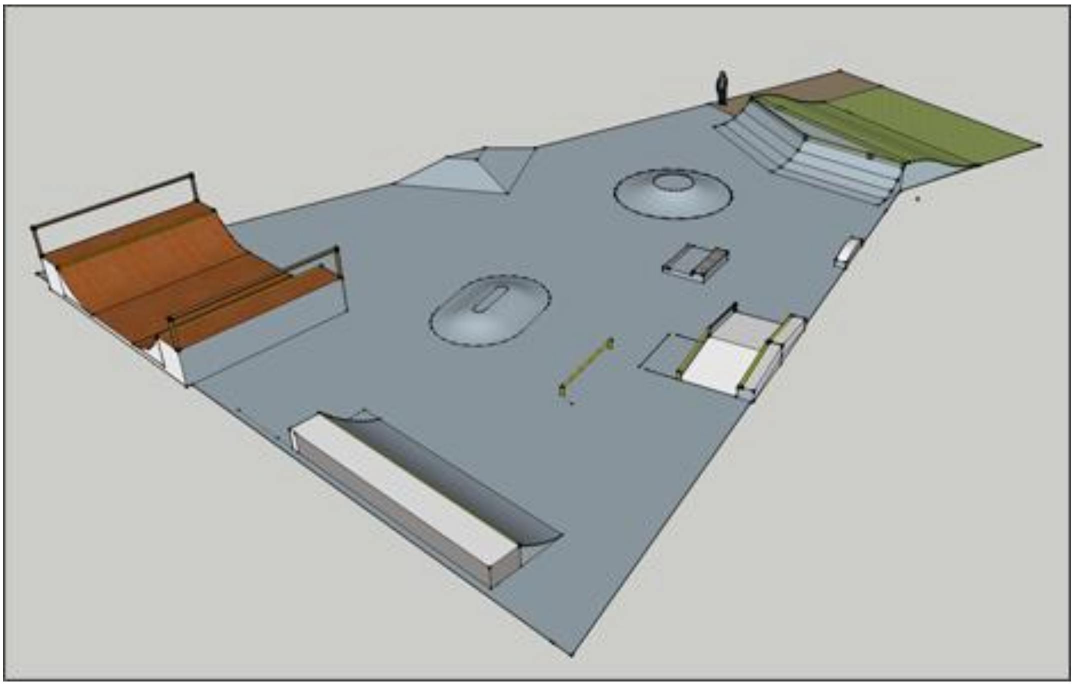

Figure 28 Pornainen's skatepark design arrangement

4.4 Pre-cast concrete and asphalt surface

From the existing pre-fabricated elements on the site, only the pyramid obstacle was skatable. The biggest ramp had been severely damaged, so it was to be serviced thoroughly and the boards and plates changed, if it is was still desired to be used as a part of the skatepark. If not, it could possibly be moved away from the asphalt area.

The biggest problem with the existing prefabricated elements had been vandalism, so the main point of the design was not only to make the park practical and weather-proof, but also stronger and more resistant to vandalism. Concrete elements are much harder to damage than plywood material. Based on the project budget, a user survey and feedback, and input from builders and designers, a decision was made to build the obstacles from concrete. There were different concrete alternatives researched as well, but the costs were estimated to be higher.

Planners estimated that the current skatepark area is suitable due to the very good condition of the asphalt surface. The major problem when casting concrete on top of asphalt is quick deterioration. Asphalt is not a good sealing material due to its fairly rough surface. Because of this, pre-fabricated concrete elements cannot simply be placed and connected on top of the asphalt's coarse-grained surface because it is a brittle material. Small amount of wear creates deep holes fast. When skateboarder's wheels get stuck in them they crash, often with severe consequences.

The Finnish Skateboard Association suggested that the best solution when connecting reinforced concrete and asphalt is to cut the asphalt (Figure 29) and then cast the concrete obstacle into the slot (Figure 30). The jointing consists of rebars inserted into the asphalt's flat surface, which are connected to the rebars of the concrete obstacles. This is the method applied in the construction of Pornainen skatpeark. Representatives from the Finnish Skateboard Organization provide constant site supervision to ensure that the construction work is carried out properly.

Figure 29 Excavator cutting slots in the asphalt for concrete obstacles (http://www.ebaka.fi/)

Figure 30 Rebars and connections in place, ready for concreting (http://www.ebaka.fi/)

4.5 Pornainen’s skatepark design

In the following Figures 31- 34 the general arrangement drawings of Pornainen’s skatepark can be seen

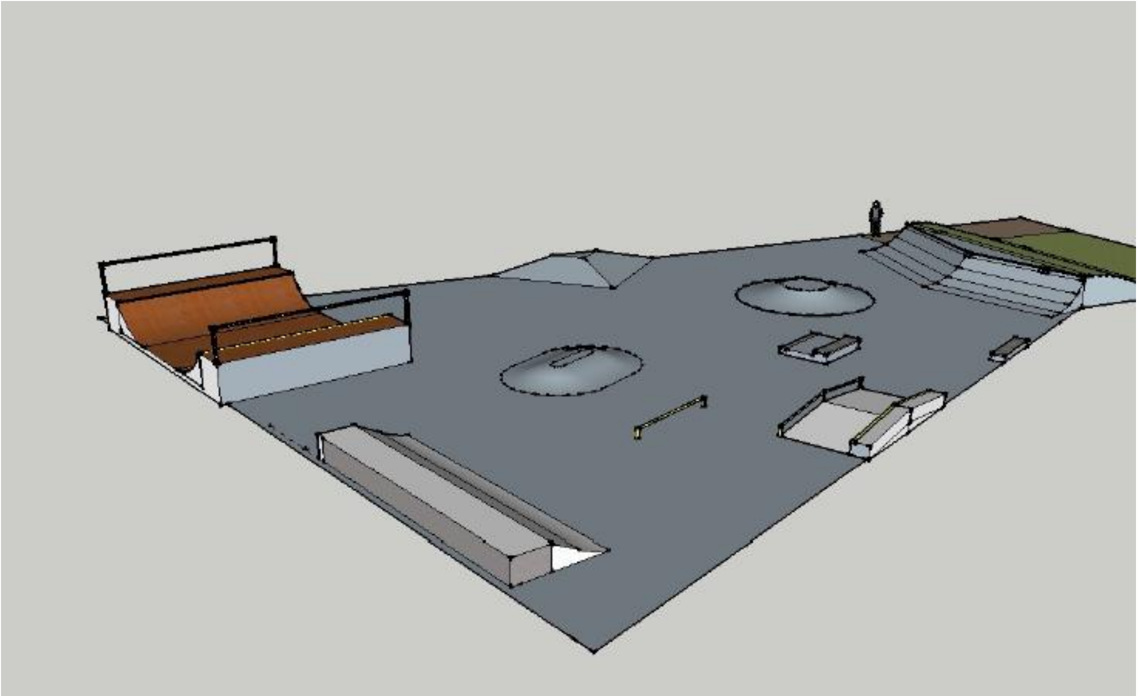

Figure 31 3D perspective #1

Figure 32 3D perspective #2

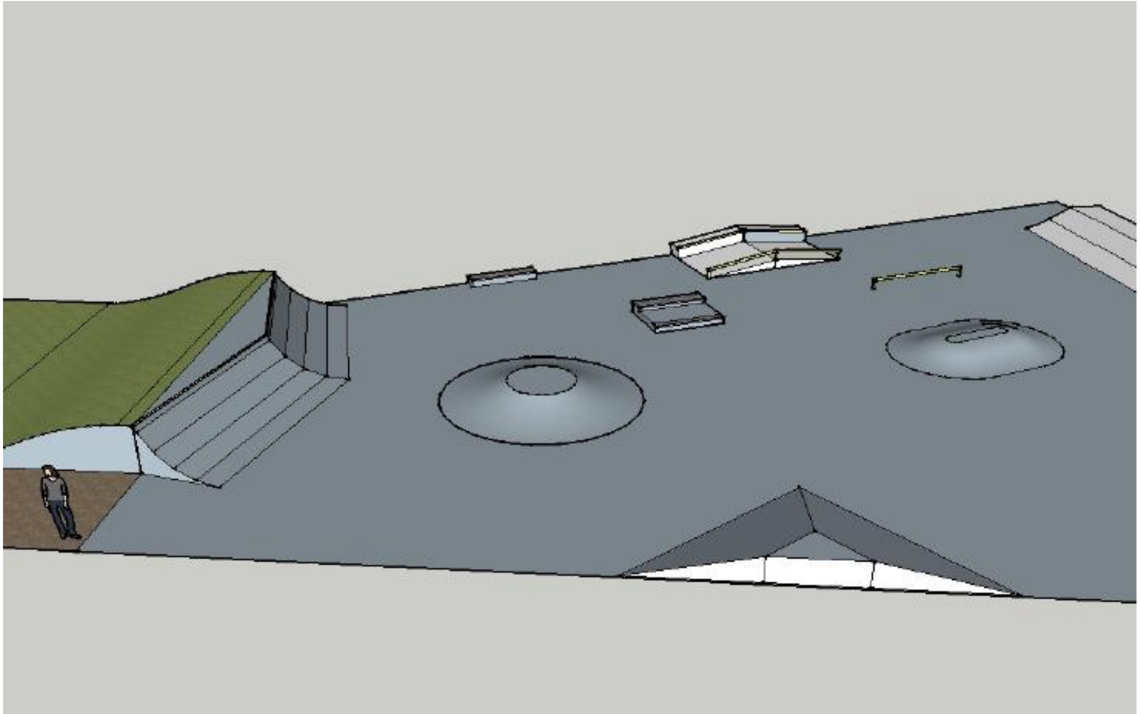

Figure 33 3D perspective #3

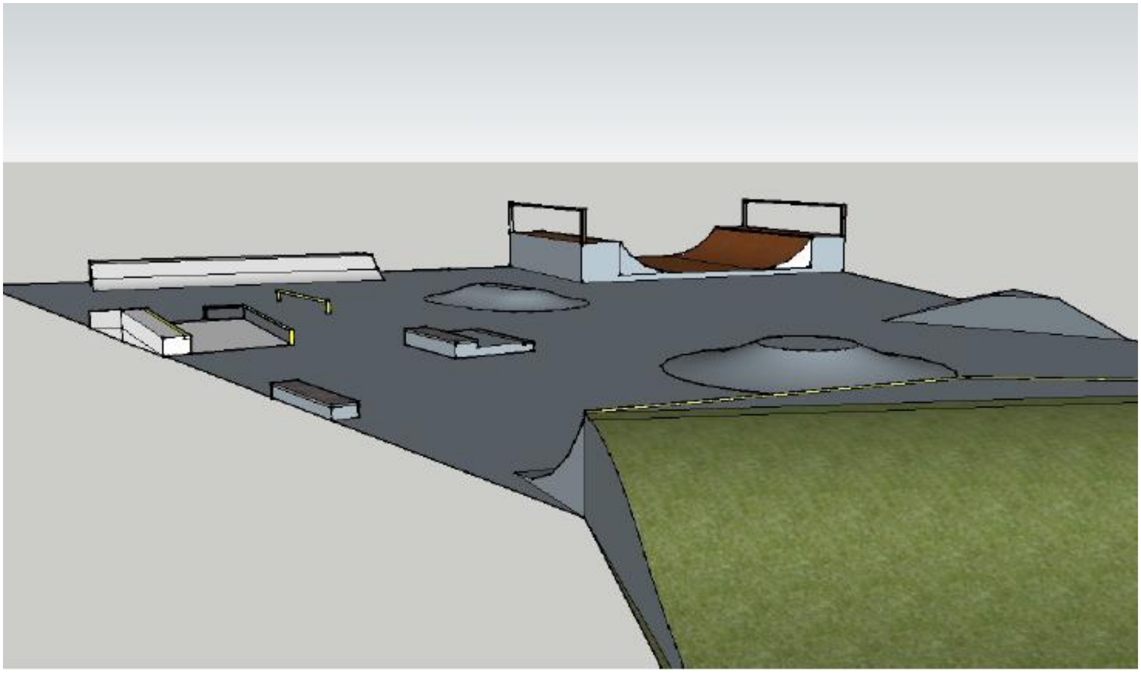

Figure 34 3D perspective #4

4.5.1 Elements and positioning

Pornainen's skatepark asphalt surface has an area of 600 square meters. The area dimensions are 27.5 by 25.2 by 31.5 by 12.4 meters. By definition it is somewhere between a small and a medium-sized area. The plan takes into account the asphalt slope level and the general condition of the surface for the drainage location. The design uses the existing asphalt area in such a way that the different skating lanes are taken into consideration. This way all the structures are possible to use and to approach without interference. The entire area is barrier-free and is designed so that the absence of even one of the elements affects the whole park and disrupts tricks continuity. Safety is also accounted for in the design. The skating lanes are planned in a specific way so as to minimize them crossing one another. It was possible that the mini-ramp could be excluded from the design or possibly bought later, that is why it was deliberately positioned in the corner of the area. (Figure 35)

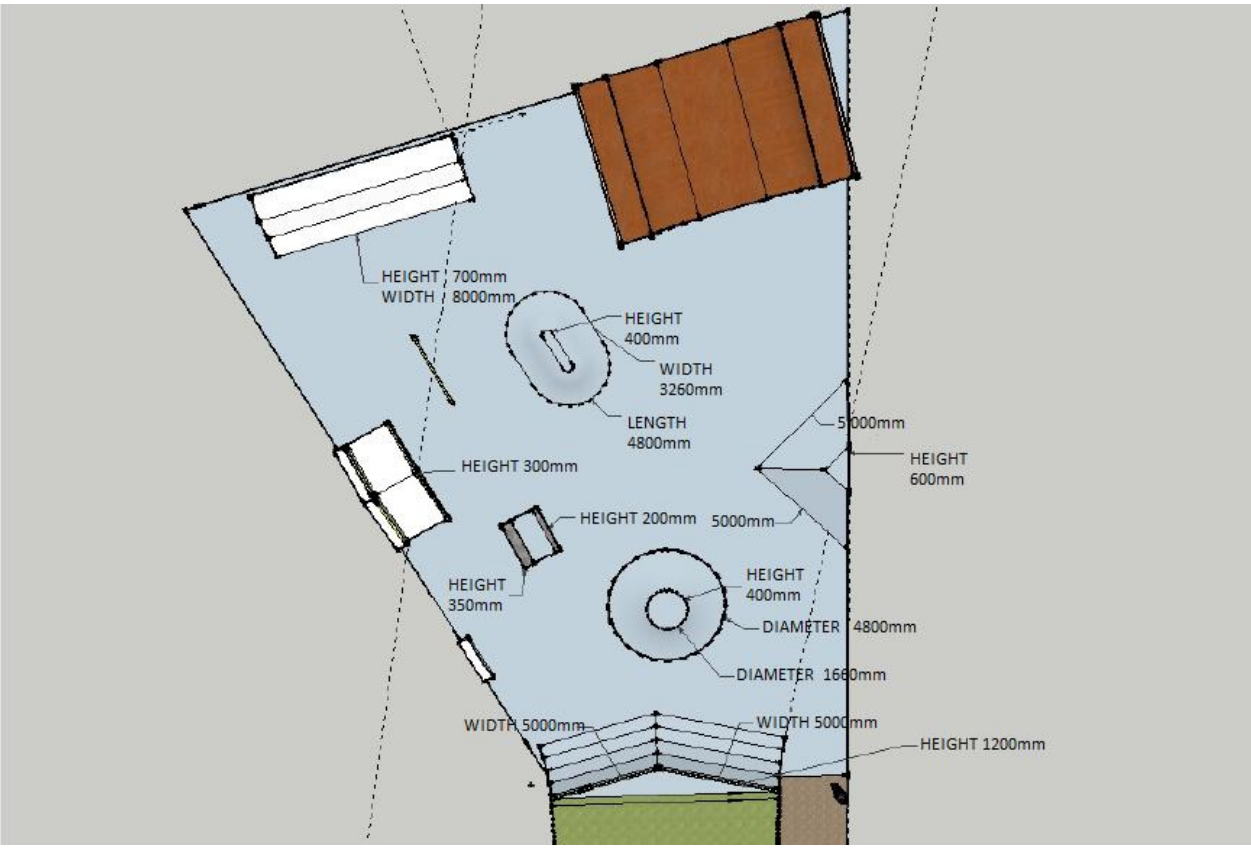

Figure 35 Pornainen's skatepark plan view (http://www.pornainen.fi/)

– Bank

• A bank is good in its simplicity and is a classic basic obstacle for learning a variety of tricks.
• The designed bank is 8 meters wide and 0.7 meters high with a mellow slope (the height does not require a top deck platform).

– Rail

• Seamless single steel tube. The metal thickness should be 3mm or more so that the tube will be durable and able to withstand grinding and sliding.
• An obstacle for learning basic grind and slide tricks that is both easy and cheap to build.
• The supports must be firmly embedded into the asphalt to the supporting structure.

– Ledge / Curb (2x)

• The coping is made of steel (granite flat stone is also an option).
• The metal thickness should be 3mm or more so that the tube will be durable and able to withstand grinding and sliding.
• Steel pipe ends must be welded up and sharp edges rounded.
• The granite stone does not necessarily need steel around the ledges.

– Hummocks

• Both obstacles are 0.4 meters high.
• A mound-type of obstacle that gives an extra dimension to the skatepark, enables speed pumping, changing direction, and a variety of tricks.

– Manual pad

• This element can be cast in-situ or pre-fabricated.
• The edges have metal coping installed.

– Peakless pyramid corner

• Height of 0.6 meters and a side width of 5 meters.

– Quarter pipe + graffiti wall

• Acts as a skating obstacle and an art piece.
• All fences are removed. There is piled embankment on the back side of the quarter pipe.
• The quarter pipe is facing the skatepark and serves as a graffiti wall, an idea proposed by the youth council.
• The graffiti is part of the skatepark, so the urban art drawings do not disturb pedestrians and drivers passing by.
• Height is 1.2 meters. The upper deck of the rear is a solid top flat. The coping on the upper edge of the quarter pipe is a steel pipe, which runs all the way and gives the required sliding and grinding properties.

– Mini Ramp

• Weather-resistant surface plates
• Made out of coated plywood.
• Can be obtained later, if necessary.
Safety distance between all the obstacles must be at least 2 meters.

4.5.2 Costs

The following Table 3 summarizes the costs of Pornainen's skatepark.

Table 3 Pornainen's skatepark costs

Skatepark Plan	**Finnish Skateboard Association; 3 000 €**
Construction supervision	**Finnish Skateboard Association** (skatepark plan included in price)
Materials • Granite stone blocks 30x300mm • Steel tube 60mm • Steel 100 x 40mm • Leca concrete blocks 200 (Wall) • Plywood 15mm • Brush Steel 6mm • Mesh 6mm	**8 000 € (VAT 0.00%)**
Mini-ramp	**Rhino Ramps; 8 000 € (VAT 0.00%)**
Construction • Gravel • 6mm steel mesh and 6mm rebar • Sections are bound together with steel ties • Asphalt edge is cut off so that the concrete overlaps the asphalt surface at least a 100mm before the curved part of the formwork. • Concrete casting of the elements	**approx. 35 000 € (VAT 0.00%)** (bidding based on January 2015)
YEAR 2014 SHARE	**3 000 €** incl. plans/ **13 000 €** incl. plans + mini-ramp
YEAR 2015 SHARE	**approx. 43 000 €** (construction incl. materials, labor, cleaning)
TOTAL	**46 000 €** without mini-ramp / with mini ramp **54 000 €**

4.5.3 Construction 2015

It was initially planned that the skatepark will be finished by the autumn of 2015. Due to the fact that Windmill Skate Company is occupied with other projects parallel to this one, the construction of Pornainen’s skatepark will be completed in the spring of 2016.

5 CONCLUSION

Proper skatepark design and construction requires profound knowledge and understanding of skateboarding and skateparks in general. Information related to this particular topic was found to be scattered across various unlinked resources, was unstructured, and at times was not thorough and comprehensive. Therefore, this demands writing in an organized way and easily accessible information that is suitable for a wide range of readers.

The main result of this thesis was the creation of a detailed skatepark construction guide that familiarizes oneself with the basics of design, planning and building of such an athletic reinforced concrete facility. It can serve as a reference for getting better acquainted with this particular branch of construction and its different aspects and details.

This research provides detailed information on a broad range of related subtopics such as skatepark topology, financial costs, concrete advantages and disadvantages, consecutive construction procedures, weather influences, and others. Figures and tables are introduced along the way, and referenced in the body of the thesis, for a better visual presentation and understanding.

This thesis also presented a skatepark project developed and built in Pornainen, Finland, by Windmill Skate Company. Appendix 1 shows illustrations of several other skatepark projects of the company.

SOURCES

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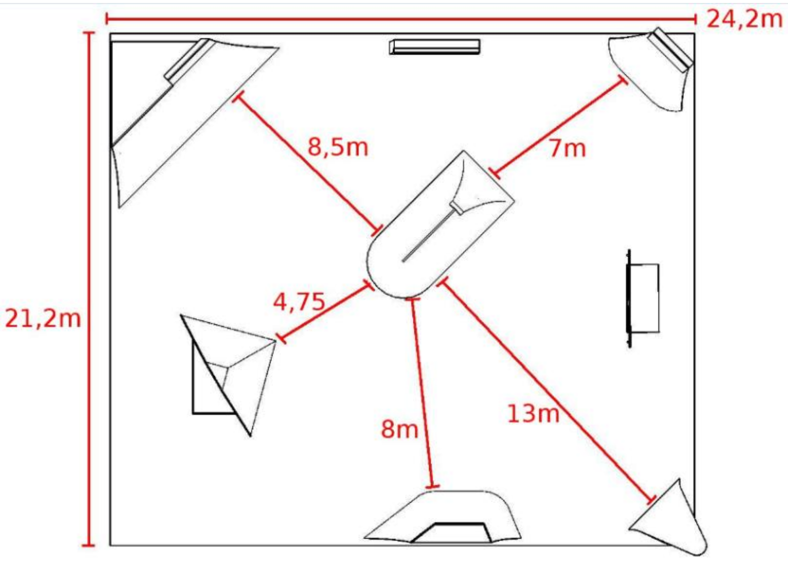
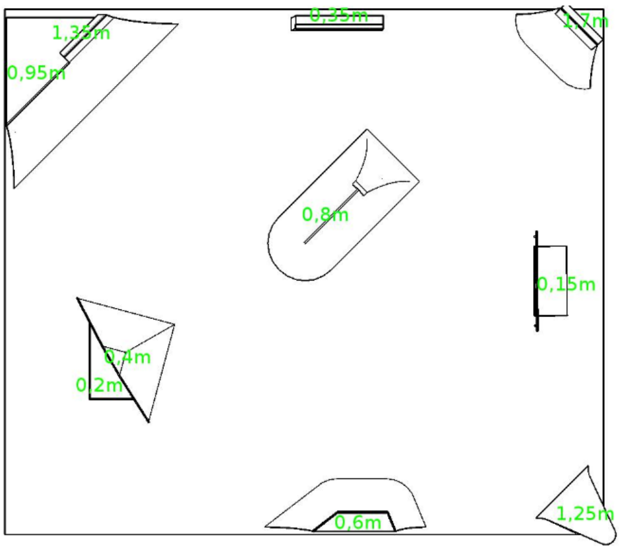
Appendix 1

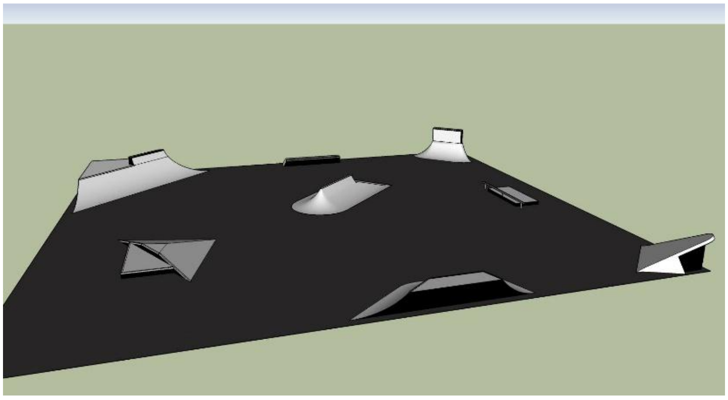
WINDMILL SKATE COMPANY PROJECTS

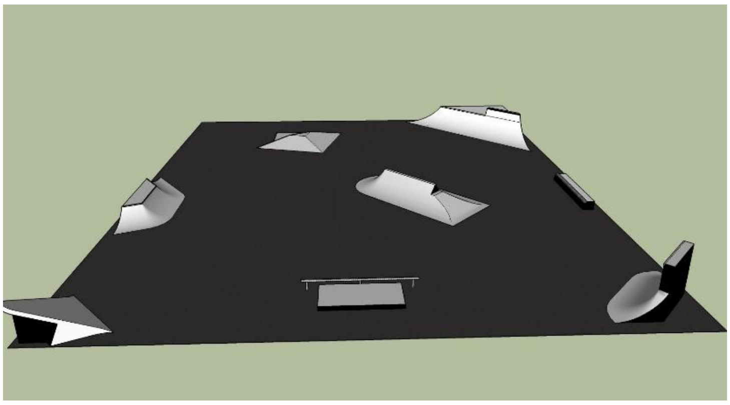
The following appendix presents drawings and photos of several out of many other skatepark projects in Finland built by Windmill Skate Company.

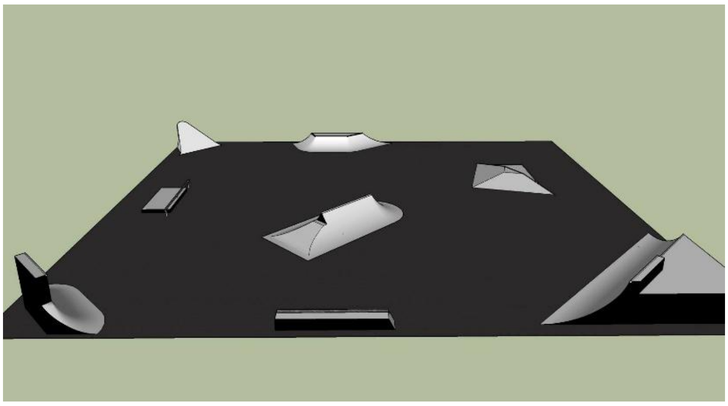
– HÄMEENKOSKI SKATEPARK

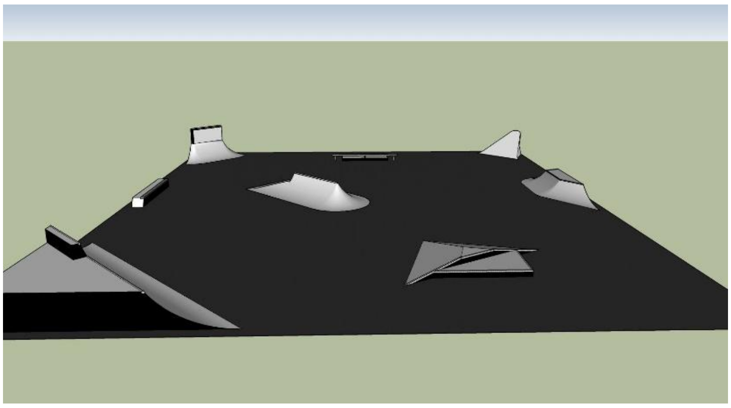












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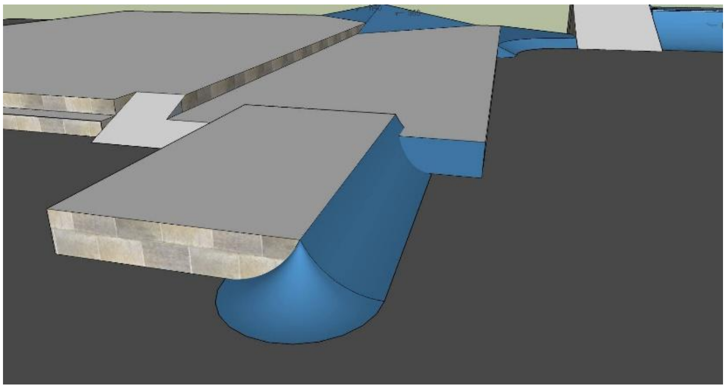
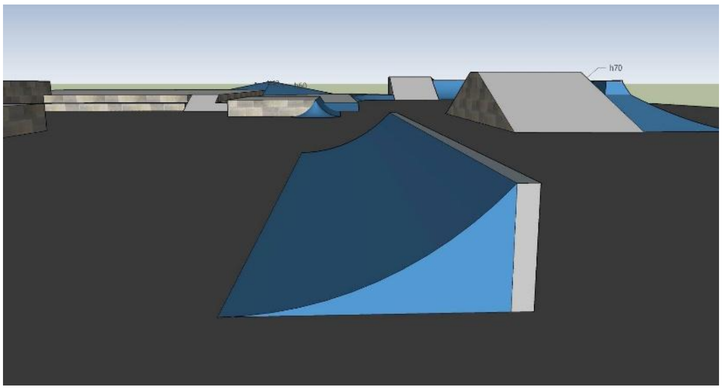
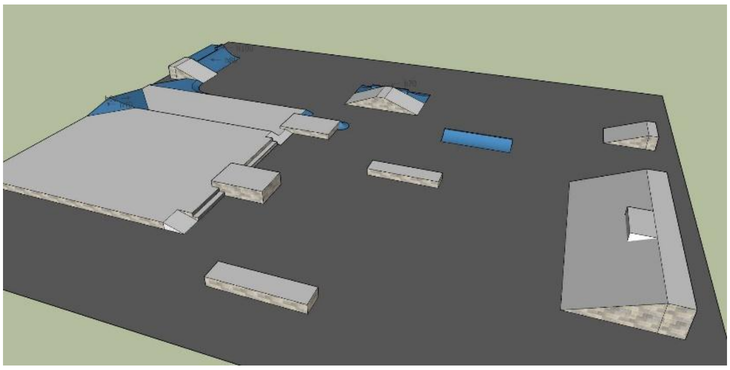
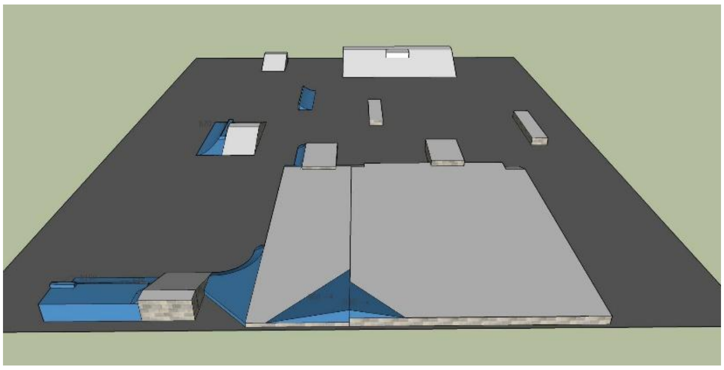
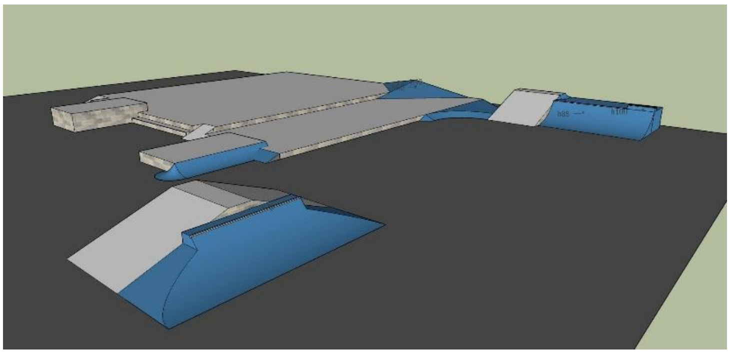
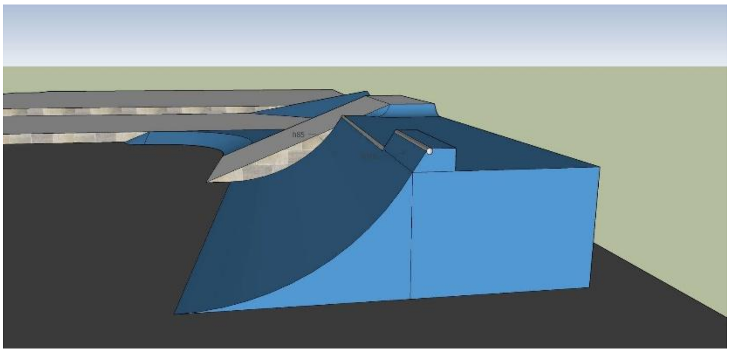


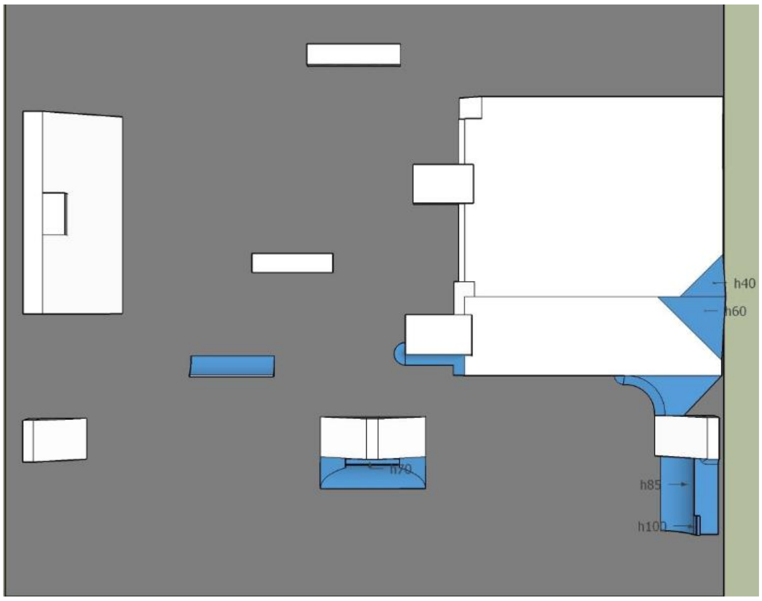




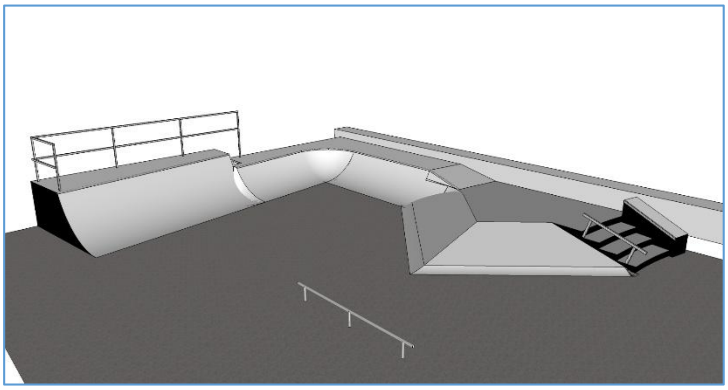
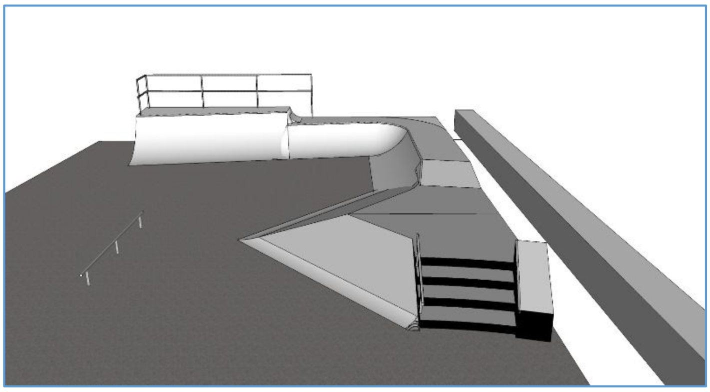
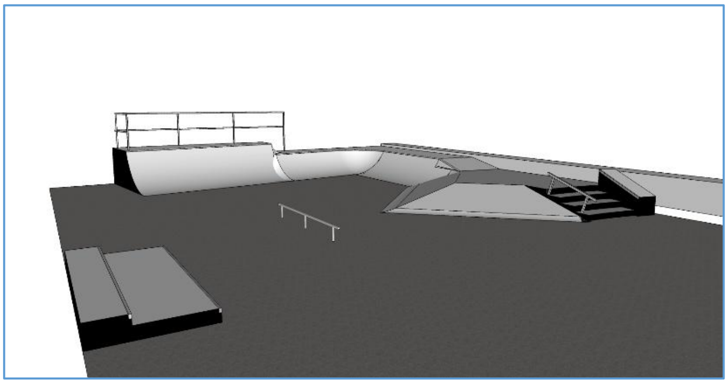
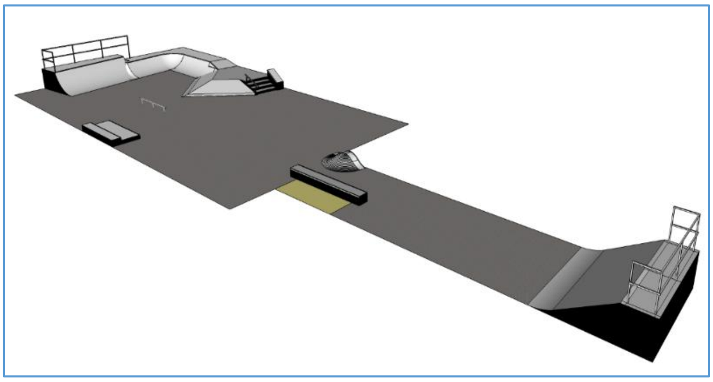








– **SIUNTIO SKATEPARK**



Appendix 2

SKATEPARK DOCUMENTS AND DRAWINGS

The following appendix represents an example set of information and documents that are created for a skatepark project. It includes excerpts of structural and construction notes, as well as different types of architectural and engineering drawings from a skatepark project located in Kearns, Utah, USA.

general construction notes

1. GENERAL

1.1 CONSIDER GENERAL NOTES AS APPLYING TO ALL DRAWINGS.

1.2 NOTIFY SKATE PARK DESIGNER OF ANY DISCREPANCIES TO THESE PLANS.

1.3 PERFORM ALL WORK IN ACCORDANCE WITH ALL APPLICABLE NATIONAL, STATE AND/OR LOCAL BUILDING CODES.

1.4 THE SKATE PARK DESIGNER SHALL HAVE NO CONTROL OR CHARGE OF, NOR BE RESPONSIBLE FOR THE CONSTRUCTION MEANS, METHODS, TECHNIQUES, SEQUENCES, OR PROCEDURES, SAFETY PRECAUTIONS, AND PROGRAMS IN CONNECTION WITH THE WORK, THE ACTS OR OMISSIONS OF THE CONTRACTOR, SUBCONTRACTOR, OR ANY PERSONS PERFORMING ANY OF THE WORK OR FOR THE FAILURE OF ANY OF THEM TO CARRY OUT THE WORK IN CONFORMANCE WITH THE CONTRACT DOCUMENTS.

1.5 PROVIDE SPECIAL INSPECTION AS REQUIRED BY BUILDING CODES FOR THE FOLLOWING ITEMS:

1.5.1 PLACEMENT OF REINFORCING STEEL.

1.5.2 TAKING OF TEST SPECIMENS AND PLACING OF ALL CONCRETE.

1.5.3 BOLTS IN CONCRETE.

1.5.4 TAKING OF TEST SPECIMENS AND PLACING OF ALL SHOTCRETE.

1.6 THE CONTRACTOR SHALL WARRANTY ALL OF THEIR WORK DURING CONSTRUCTION AND A MINIMUM OF TWO YEARS AFTER THE PROJECT IS COMPLETED.

1.7 THE METRIC EQUIVALENT "[ ]" DIMENSIONS ARE SHOWN FOR REFERENCE ONLY. THE CONTRACTOR SHALL BE RESPONSIBLE TO VERIFY THERE ACCURACY.

2. CONCRETE WORK

2.1 CONCRETE MIXES SHALL BE DESIGNED BY A TESTING LABORATORY AND APPROVED BY THE SKATE PARK DESIGNER. MIXES SHALL CONFORM TO APPLICABLE BUILDING CODE REQUIREMENTS, REGARDLESS OF OTHER MINIMUM REQUIREMENTS SPECIFIED HEREIN OR ON THE DRAWINGS. MIX DESIGNS SHALL BE SUBMITTED TO THE SKATE PARK DESIGNER FOR APPROVAL BEFORE USE. DESIGNS SHALL SHOW PROPORTIONS OF CEMENT, FINE AND COARSE AGGREGATES AND WATER, AND GRADATION OF COMBINED AGGREGATES.

2.2 CEMENT: ASTM C150. CEMENT SHALL BE OF SAME BRAND, TYPE AND SOURCE THROUGHOUT PROJECT. WHERE AGGREGATES ARE POTENTIALLY REACTIVE, USE LOW ALKALI CEMENT.

2.3 AGGREGATES SHALL CONFORM TO ASTM C33.

2.4 NO ADMIXTURES WITHOUT APPROVAL. ADMIXTURES CONTAINING CHLORIDES SHALL NOT BE USED. CONCRETE SHALL NOT BE IN CONTACT WITH ALUMINUM.

2.5 CONCRETE MIX DESIGN:

2.5.1 PROVIDE MIX DESIGNS THAT WILL MEET THE MINIMUM REQUIREMENTS LISTED BELOW. INCREASE CEMENT CONTENT OVER THAT SHOWN, IF REQUIRED TO OBTAIN THE COMPRESSIVE STRENGTH:

MIN. 28-DAY COMPRESSIVE STRENGTH (PSI)	MIN. CEMENT CONTENT (POUNDS)	MAX. SLUMP (INCHES)	MAX. AGGREGATE SIZE (INCHES)	MAX. AIR ENTRAINING (PERCENT)
4000 [27.56MPa]	480 [217.72kg]	4" [10.16cm]	1" [2.54cm]	1.5 - 3

2.6 SHOTCRETE MIX DESIGN:

2.6.1 ACI STANDARD 506, LATEST EDITION, "SPECIFICATION FOR MATERIALS, PROPORTIONING AND APPLICATION OF SHOTCRETE" AND ACI 506.2, LATEST EDITION, "RECOMMENDED PRACTICES FOR SHOTCRETING" SHALL BE FOLLOWED.

2.6.2 MIX DESIGNS FOR SHOTCRETE CONTAINING FLY ASH SHALL BE BY AN INDEPENDENT TESTING LABORATORY. ONLY ASTM C618 CLASS F FLY ASH SHALL BE USED. THE AMOUNT OF FLY ASH USED SHALL NOT EXCEED 20 PERCENT BY WEIGHT OF THE COMBINED WEIGHT OF FLY ASH PLUS CEMENT.

2.6.3 PROVIDE MIX DESIGNS THAT WILL MEET THE MINIMUM REQUIREMENTS LISTED BELOW. INCREASE CEMENT CONTENT OVER THAT SHOWN, IF REQUIRED TO OBTAIN THE COMPRESSIVE STRENGTH:

MIN. 28-DAY COMPRESSIVE STRENGTH (PSI)	MIN. CEMENT CONTENT (POUNDS)	MAX. SLUMP (INCHES)	MAX. AGGREGATE SIZE (INCHES)	MAX. AIR ENTRAINING (PERCENT)
4000 [27.56MPa]	600 [272.16kg]	2" [5.08cm]	3/8" [0.95cm]	1.5 - 3

2.6.4 SURFACE PREPARATION: EXPOSED EXISTING CONCRETE SHALL BE SANDBLASTED CLEAN. SURFACES SHALL BE FOLLOWED BY WETTING AND DAMP DRYING JUST PRIOR TO SHOTCRETE APPLICATION.

2.6.5 ANY REBOUND OR ACCUMULATED LOOSE AGGREGATE SHALL BE REMOVED FROM THE SURFACES TO BE COVERED PRIOR TO PLACING THE INITIAL OR ANY SUCCEEDING LAYERS OF SHOTCRETE. REBOUND SHALL NOT BE REUSED AS AGGREGATE.

2.6.6 JOINTS IN WALL POURS ARE PERMISSIBLE. AT JOINTS, SHOTCRETE SHALL BE SLOPED TO A THIN EDGE. BEFORE PLACING ADDITIONAL MATERIAL, ALL SURFACES SHALL BE THOROUGHLY CLEANED AND WETTED AND ALL REINFORCING STEEL SHALL BE BRUSHED FREE OF LATENT SHOTCRETE MATERIAL.

2.6.7 ANY IN-PLACE SHOTCRETE MATERIAL WHICH EXHIBITS SAGS OR SLOUGHS, SEGREGATION, HONEYCOMBING, SAND POCKETS OR OTHER OBVIOUS DEFECTS SHALL BE REMOVED AND REPLACED.

2.6.8 TESTING AND INSPECTION OF INPLACE SHOTCRETE SHALL BE IN ACCORDANCE WITH 2003 IBC.

2.7 CONCRETE SHALL BE PLACED WITHIN 90 MINUTES OF BATCHING AND SHALL NOT EXCEED A TEMPERATURE OF 90°F [32°C] UNLESS PREAPPROVED BY THE SKATE PARK DESIGNER.

2.8 CONCRETE CYLINDERS SHALL BE TAKEN AND TESTED PER THE CODE BY AN INDEPENDENT TESTING LABORATORY FOR STRUCTURAL POURS OVER 50 CUBIC YARDS [38m³] OF CONCRETE. HISTORICAL DATA SHALL BE SUBMITTED AND APPROVED PRIOR TO THE POUR IF NO TEST SAMPLES ARE TAKEN FOR POURS LESS THAN 50 CUBIC YARDS [38m³].

2.9 DURING THE CURING PERIOD, CONCRETE SHALL BE MAINTAINED AT A TEMPERATURE ABOVE 40°F [4°C] AND IN MOIST CONDITION. FOR INITIAL CURING, CONCRETE SHALL BE KEPT CONTINUOUSLY MOIST FOR 24 HOURS AFTER PLACEMENT IS COMPLETE. FINAL CURING SHALL CONTINUE FOR SEVEN DAYS AFTER PLACEMENT AND SHALL CONSIST OF APPLICATION OF CURING COMPOUND PER ASTM C309. APPLY AT A RATE SUFFICIENT TO RETAIN MOISTURE, BUT NOT LESS THAN 1 GALLON [4.55l] PER 200 SQUARE FEET [18.58m²]. COVER CONCRETE WITH POLYETHYLENE PLASTIC TO MAINTAIN TEMPERATURE IF NECESSARY. LAP SEAMS IN THE PLASTIC 6" [15.24cm] AND TAPE, WEIGHT DOWN THE PLASTIC AS NEEDED.

2.10 THE CONTRACTOR SHALL FIX ALL CRACKS AND DISPLACEMENTS LARGER THAN 1/16" [1.59mm].

2.11 ALL CONCRETE WHICH DURING THE LIFE OF THE STRUCTURE WILL BE SUBJECTED TO FREEZING TEMPERATURES WHILE WET, SHALL HAVE A WATER CEMENT RATIO NOT EXCEEDING 0.53 BY WEIGHT AND SHALL CONTAIN ENTRAINED AIR AS PER ACI 301. SUCH CONCRETE SHALL INCLUDE EXTERIOR SLABS, PERIMETER FOUNDATIONS, EXTERIOR CURBS AND GUTTERS, ETC.

2.12 CONDUITS, PIPES, AND SLEEVES EMBEDDED IN CONCRETE SHALL CONFORM TO THE REQUIREMENTS OF UBC SECTION 1906.

2.13 USE INTERMEDIATE GRADE ASTM A615, GRADE 60 FOR ALL REINFORCING. USE ASTM A706, GRADE 60 FOR ALL REINFORCING THAT IS TO BE WELDED. USE A108, GRADE 60, FOR ALL WELDED ANCHORS REFER TO AWS SPEC FOR WELDING WITHOUT PREHEAT. WELDING OF REINFORCING BARS TO BE IN ACCORDANCE WITH ALL BUILDING CODES.

2.14 ALL WELDED WIRE FABRIC REINFORCING SHALL BE ASTM A185 GRADE 65. LAP OF AT LEAST TWO CROSS WIRES.

2.15 OBSERVE FOLLOWING REINFORCEMENT CLEARANCES:
3" [7.62cm] AT SURFACES POURED AGAINST EARTH
2" [5.08cm] AT FORMED SURFACES EXPOSED TO EARTH OR WEATHER
1-1/2" [3.81cm] AT OTHER SURFACES, EXCEPT WHERE SHOWN OTHERWISE.

2.16 SECURE REINFORCING, ANCHOR BOLTS, INSERTS, ETC. RIGIDLY IN PLACE PRIOR TO POURING CONCRETE.

2.17 SUPPORT HORIZONTAL REINFORCING ON GALVANIZED CHAIRS OR OTHER APPROVED METHOD (MORTAR BLOCKS ARE UNACCEPTABLE) OF SUPPORT FOR FOOTINGS AND SLABS ON GRADE.

2.18 REMOVE FORMS AT FOLLOWING MINIMUM TIMES AFTER POURING: AT SLAB EDGES - 24 HOURS; AT WALLS LESS THAN 4'-0' [1.22m] HIGH - 36 HOURS.

2.19 MAKE HOOKS ACI 318-99 STANDARD HOOKS UNLESS OTHERWISE NOTED. PROVIDE 135 DEGREE MINIMUM TURN, PLUS 4" [10.16cm] EXTENSION AT FREE ENDS OF COLUMN PILASTER TIES.

2.20 MAKE LAPS CONTACT SPLICES, DEVELOPMENT LENGTHS, HOOK EMBEDMENTS PER ACI 318-99, UNLESS OTHERWISE NOTED. STAGGER LAP SPLICES WHERE POSSIBLE.

2.21 ALL REBAR SHALL BE COLD BENT.

2.22 WHERE REINFORCING IS SHOWN CONTINUOUS THRU CONSTRUCTION JOINTS, LENTON FORM SAVERS DOWEL BAR SPLICE DEVICES AS MANUFACTURED BY ERICO PRODUCTS, INC. (ICBO #3967) OR EQUIVALENT MAY BE USED. SIZES AND TYPES SHALL BE SELECTED TO DEVELOP THE FULL TENSION STRENGTH OF THE BAR PER ICBO RESEARCH REPORT.

2.23 MINIMUM CLEARANCE BETWEEN PARALLEL REINFORCEMENT BARS SHALL BE 2-1/2" [6.35cm]. LAP SPLICES IN REINFORCING BARS SHALL BE BY THE NONCONTACT LAP SPLICE METHOD WITH AT LEAST 2" [5.08cm] CLEARANCE BETWEEN BARS.

2.24 AGGREGATE BASE COURSE TO BE 4" [10.16cm] OF COMPACTED 1" [2.54cm] CRUSHED LIMESTONE AND SUBGRADE TO BE 95% COMPACTED NATIVE SOIL AND/OR ENGINEERED FILL. IF THESE GUIDELINES CONFLICT WITH THE GEO-TECHNICAL REPORT, THE CONTRACTOR TO FOLLOW THE MORE STRINGENT OF THE TWO GUIDELINES.

design criteria

THESE GENERAL STRUCTURAL NOTES APPLY UNLESS OTHERWISE NOTED.

CODE:
COMPLY WITH 2006 INTERNATIONAL BUILDING CODE, AS AMENDED BY THE CITY.

SEISMIC:
SEISMIC USE GROUP
SPECTRAL RESPONSE: Sds = 25.2
Sd1 = 10.9
SITE CLASS "D"

WIND:
3-SECOND GUST WIND SPEED 90 M.P.H. [144.84 K.P.H.]
IMPORTANCE FACTOR I = 1.0
WIND EXPOSURE "C"

structural notes

1. SPECIAL STRUCTURAL INSPECTION

1.1 PROVIDE SPECIAL STRUCTURAL INSPECTION AS REQUIRED BY BUILDING CODES FOR THE FOLLOWING ITEMS:

1.1.1 CONCRETE: DURING THE TAKING OF TEST SPECIMENS & PLACING OF REINFORCED CONCRETE WHERE F'C > 2,500 PSI [17.23MPa], EXCEPT SLABS ON GRADE.

1.1.2 BOLTS INSTALLED IN CONCRETE: DURING INSTALLATION OF EMBEDDED BOLTS IN CONCRETE AND DURING INSTALLATION OF EXPANSION BOLTS & EPOXY BOLTS / REBAR INTO EXISTING CONCRETE.

1.1.3 REINFORCING STEEL: DURING PLACING OF REINFORCING STEEL, FOR ALL CONCRETE REQUIRED TO HAVE SPECIAL INSPECTION BY THE CONCRETE SECTION ABOVE AND PLACING REINFORCING STEEL IN EPOXIED HOLES PER ABOVE.

1.1.4 SHOTCRETE: DURING THE TAKING OF TEST SPECIMENS AND PLACING OF ALL SHOTCRETE.

1.2 SCHEDULING OF SPECIAL STRUCTURAL INSPECTIONS:

1.2.1 THE CONTRACTOR SHALL ALLOW A MINIMUM OF 24 HOURS NOTIFICATION FOR THE SCHEDULING OF SPECIAL STRUCTURAL INSPECTIONS.

2. FOUNDATIONS

2.1 IF THERE IS NO SOIL REPORT AVAILABLE FOR THIS PROJECT, THE CONTRACTOR SHALL RETAIN A SOIL ENGINEER TO VERIFY EXCAVATIONS FOR ASSUMED ALLOWABLE SOIL BEARING, LOW SETTLEMENT AND SWELL POTENTIAL, AND TO MAKE ANY ADDITIONAL RECOMMENDATIONS. FOOTINGS SHALL BEAR ON FIRM UNDISTURBED SOIL AT 3'-6" [45.72cm] MINIMUM BELOW LOWEST ADJACENT NATURAL OR FINISH GRADE, ALLOWABLE SOIL BEARING 2,000 P.S.F. PER IBC TABLE 1804.2. IN THE PRESENCE OF SITE FILLS, THE CONTRACTOR SHALL VERIFY THESE DEPTHS TO FURNISH MINIMUM DEPTH OF 3'-6" [45.72cm] BELOW NATURAL GRADE AND DEEPEN FOOTINGS WHERE NECESSARY. UNDER NO CIRCUMSTANCES ARE FOOTINGS ALLOWED TO BEAR ON SITE FILLS WITHOUT A SOIL REPORT.

3. REINFORCING

3.1 SECURELY TIE ALL REBAR, INCLUDING DOWELS, IN LOCATION BEFORE PLACING CONCRETE OR GROUT.

3.2 WHERE REINFORCING IS SHOWN CONTINUOUS THRU CONSTRUCTION JOINTS, LENTON FORM SAVERS DOWEL BAR SPLICE DEVICES AS MANUFACTURED BY ERICO PRODUCTS, INC. (ICBO #3967) OR EQUIVALENT MAY BE USED. SIZES AND TYPES SHALL BE SELECTED TO DEVELOP THE FULL TENSION STRENGTH OF THE BAR PER ICBO RESEARCH REPORT.

4. STRUCTURAL STEEL

4.1 ASTM A-36 FOR C, MC, ANGLES, AND PLATES.

4.2 ASTM A-53 GRADE B OR A-501 FOR STEEL PIPES

4.3 ASTM A-500 GRADE B, FY=46 KSI FOR TS/HSS TUBE STEEL FOR SIZES UP TO 5/8" [15.88mm] THICK.

4.4 ASTM A-307 OR A-36 PLAIN ANCHOR BOLTS.

5. STRUCTURAL STEEL & REINFORCEMENT WELDING

5.1 ALL CONSTRUCTION AND TESTING PER AMERICAN WELDING SOCIETY CODES AND RECOMMENDATIONS. ALL WELDING SHALL BE BY WELDERS HOLDING CURRENT CERTIFICATES VALIDATED BY AN INDEPENDENT LAB & HAVING CURRENT EXPERIENCE IN TYPE OF WELD CALLED FOR. THE CONTRACTOR SHALL SUBMIT WELDING CERTIFICATES FOR EACH WELDER PRIOR TO COMMENCING THE WORK.

5.2 WELDING RODS TO BE LOW HYDROGEN TYPE, E70 SERIES, PER AWS D1.1 TYPICALLY EXCEPT E-6010 SERIES FOR STEEL SHEET METAL PER AWS D1.3 AND REINFORCING WELDMENTS PER AWS D1.4. USE E80 SERIES WELDING RODS FOR A706 REBAR.

5.3 FIELD INDICATED WELDS MAY BE DONE IN SHOP & SHOP INDICATED WELDS MAY BE DONE IN FIELD ONLY IF SUBMITTED AND APPROVED PRIOR TO CONSTRUCTION.

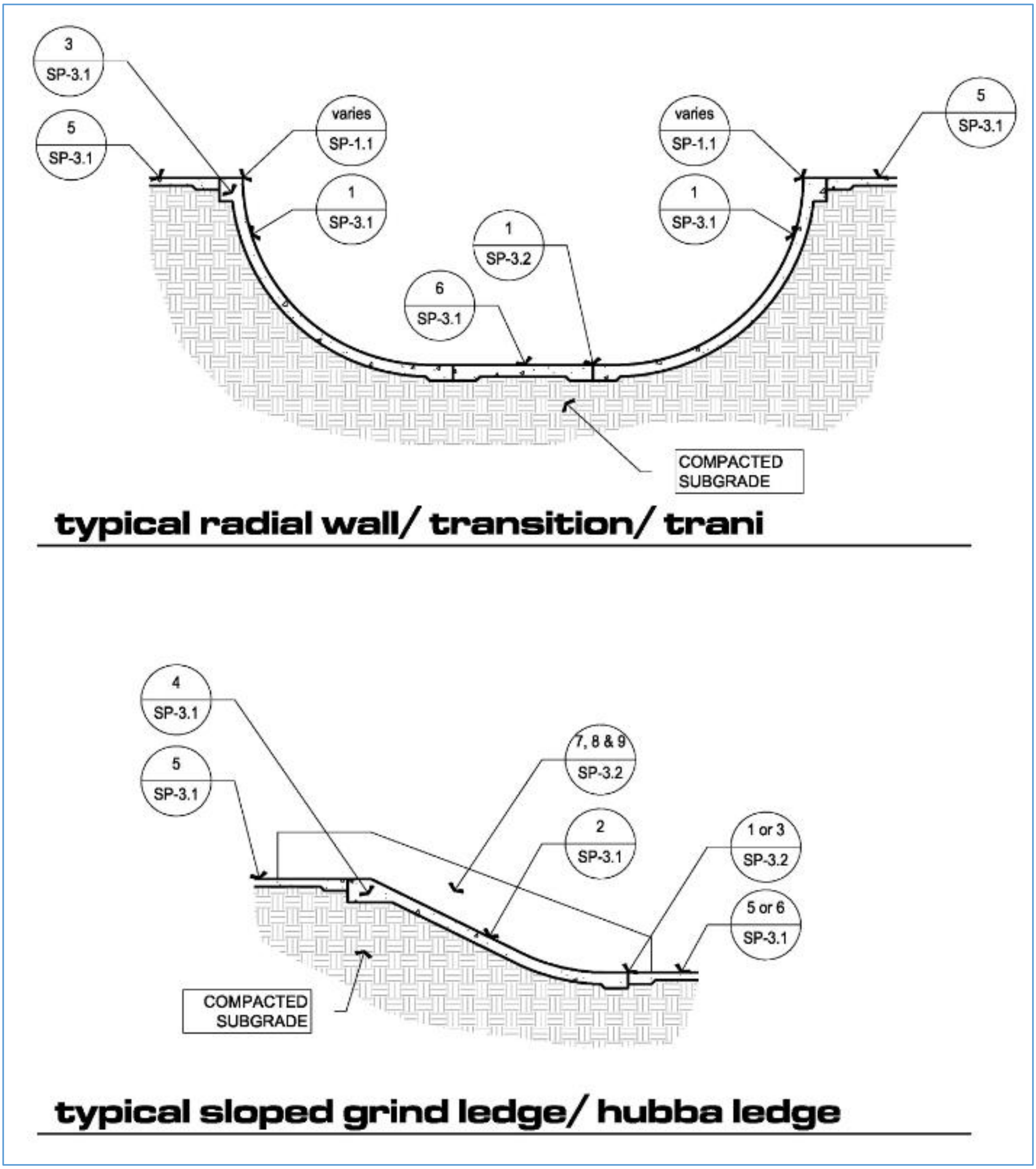


Figure 36 Typical section views

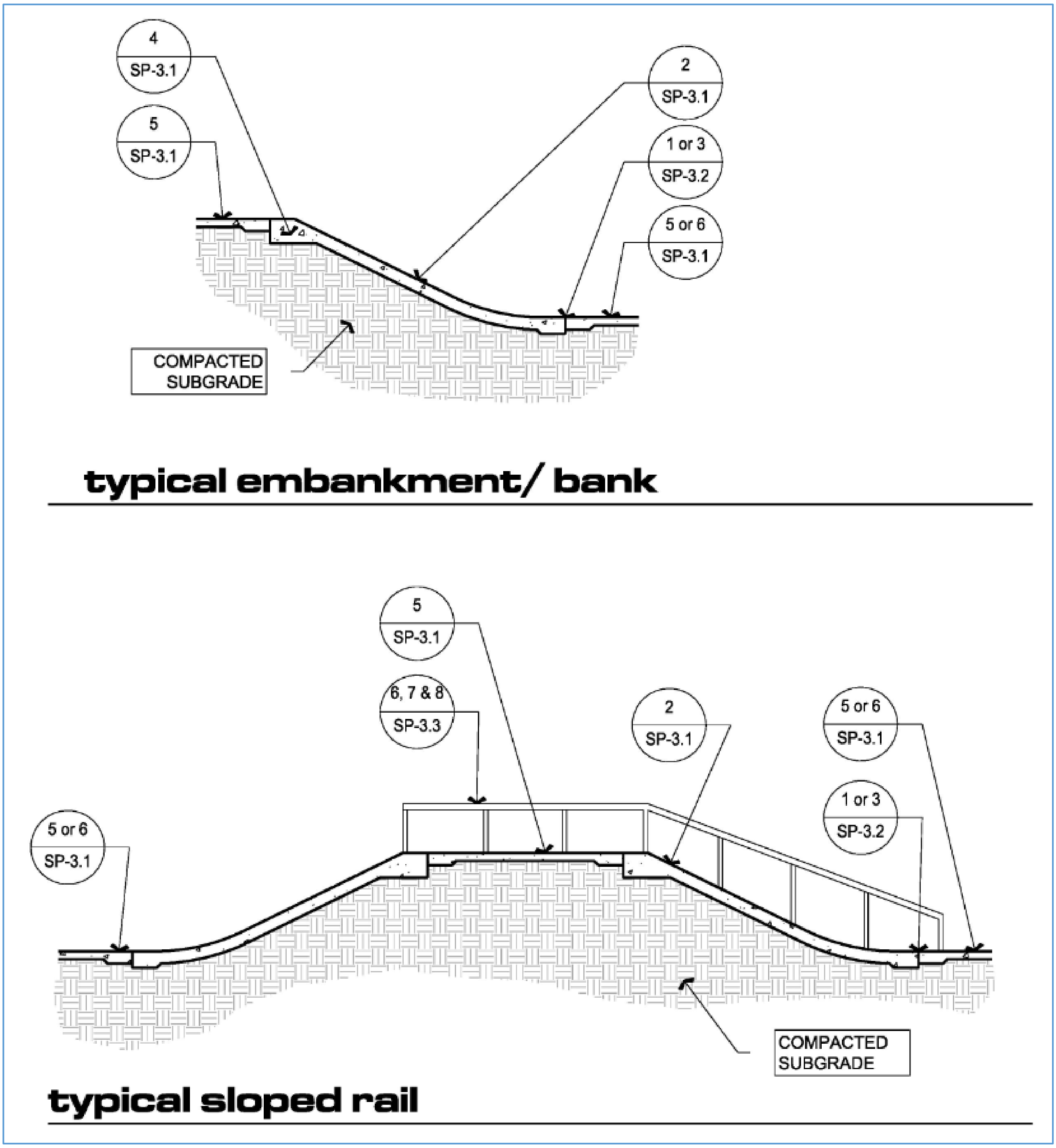


Figure 37 Typical section views

steel shapes chart

NOTE: ALL HOLLOW STRUCTURAL SECTIONS (HSS) TO BE ASTM A-500 GRADE B STEEL.

Round		Square		Rectangular	
Nominal Size	Actual Size	Nominal Size	Actual Size	Nominal Size	Actual Size
2"	6.03cm x 4.76mm	2" X 2"	5.08cm x 5.08cm x 4.76mm	2" X 3"	5.08cm x 7.62cm x 4.76mm
2-1/2"	7.30cm x 4.76mm	3" X 3"	7.62cm x 7.62cm x 4.76mm	2" X 6"	5.08cm x 15.24cm x 4.76mm
3"	8.89cm x 4.76mm	3-1/2" X 3-1/2"	8.89cm x 8.89cm x 4.76mm	2" X 8"	5.08cm x 20.32cm x 4.76mm
3-1/2"	10.16cm x 4.76mm	4" X 4"	10.16cm x 10.16cm x 4.76mm	2-1/2" X 4"	6.35cm x 10.16cm x 4.76mm
4"	11.43cm x 4.76mm			3" X 5"	7.62cm x 12.70cm x 4.76mm

Figure 38 Steel profiles table

rebar development lengths

NW Concrete							
Rebar Size		3000psi			4000psi		
English	Metric	Top Bars ld	Bot. Bars ld	ldh	Top Bars ld	Bot. Bars ld	ldh
#3	#10	21" [53.34cm]	16" [40.64cm]	8" [20.32cm]	18" [45.72cm]	14" [35.56cm]	7" [17.78cm]
#4	#13	28" [71.12cm]	22" [55.88cm]	11" [27.94cm]	25" [63.50cm]	19" [48.26cm]	9" [22.86cm]
#5	#16	36" [91.44cm]	27" [68.58cm]	14" [35.56cm]	31" [78.74cm]	24" [60.96cm]	12" [30.48cm]
#6	#19	43" [109.22cm]	33" [83.82cm]	16" [40.64cm]	37" [93.98cm]	28" [71.12cm]	14" [35.56cm]
#7	#22	62" [157.48cm]	48" [121.92cm]	19" [48.26cm]	54" [137.16cm]	42" [106.68cm]	17" [43.18cm]
#8	#25	71" [180.34cm]	55" [139.70cm]	22" [55.88cm]	62" [157.48cm]	47" [119.38cm]	19" [48.26cm]
#9	#29	80" [203.20cm]	62" [157.48cm]	25" [63.50cm]	69" [175.26cm]	53" [134.62cm]	21" [53.34cm]
#10	#32	89" [226.06cm]	68" [172.72cm]	27" [68.58cm]	77" [195.58cm]	59" [149.86cm]	24" [60.96cm]
#11	#36	98" [248.92cm]	75" [190.50cm]	30" [76.20cm]	85" [215.90cm]	65" [165.10cm]	26" [66.04cm]

NOTES:
THESE LENGTHS APPLY TYPICALLY UNLESS NOTED OTHERWISE ON PLANS AND/OR DETAILS.

CLEAR SPACING BETWEEN PARALLEL BARS MUST BE AT LEAST ONE BAR DIAMETER BUT NOT LESS THAN 1" [2.54cm].

TOP BARS: HORIZONTAL BARS PLACED SO THAT MORE THAN 12" OF FRESH CONCRETE IS CAST IN THE MEMBER BELOW.

LIGHTWEIGHT CONCRETE: MULTIPLY VALUES IN TABLE BY 1.3.

CLASS B SPLICE: ld x 1.3 LAP LENGTH. STAGGER SPLICES MIN. OF 24" [60.96cm].

Figure 39 Rebars measurement table

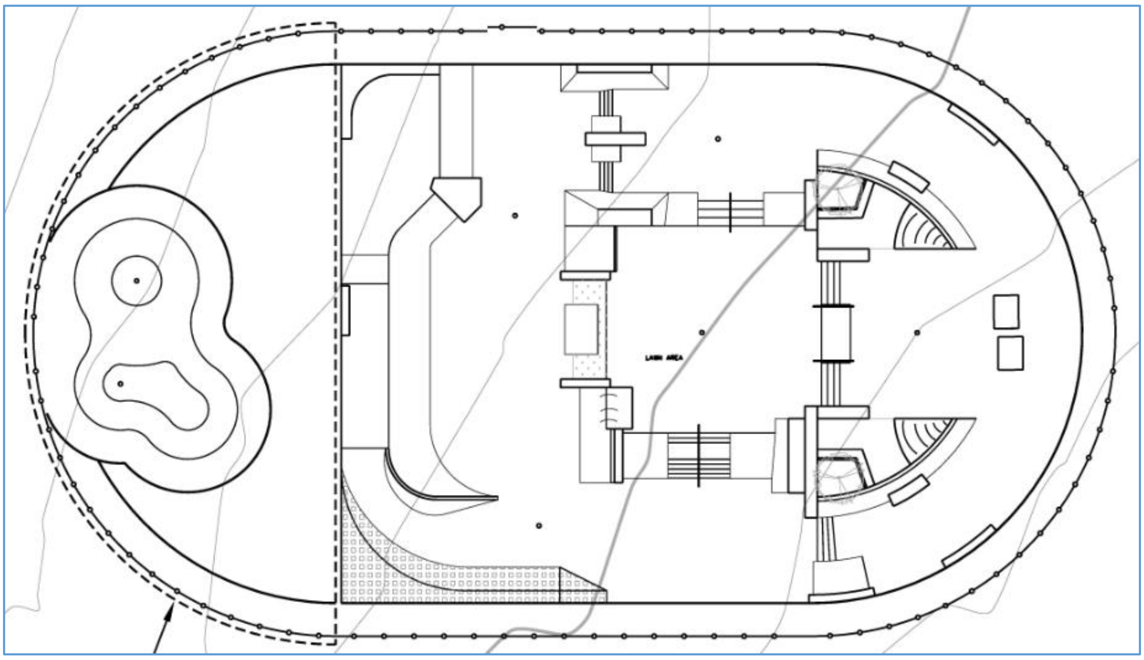


Figure 40 Site plan

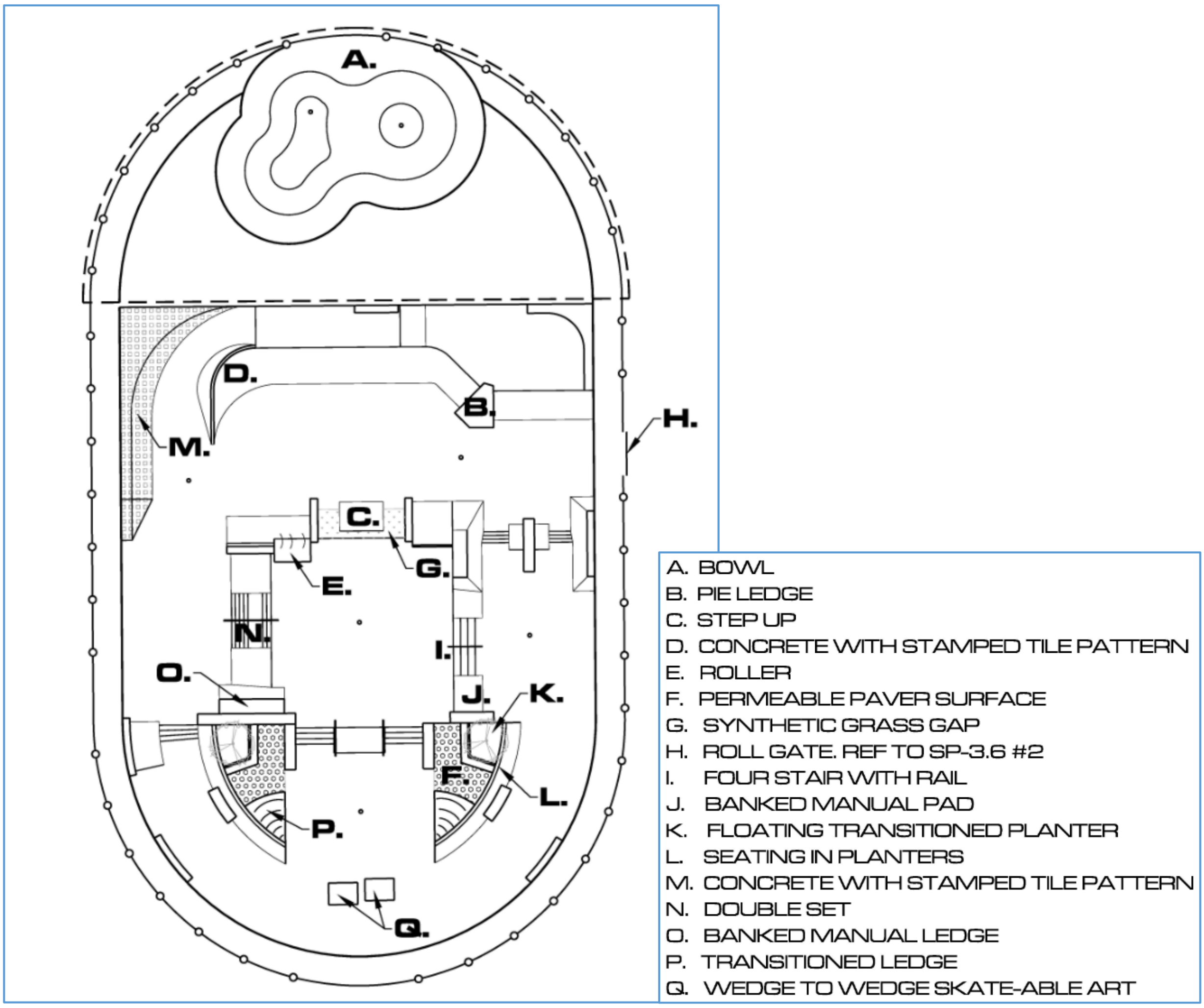


Figure 41 Features plan

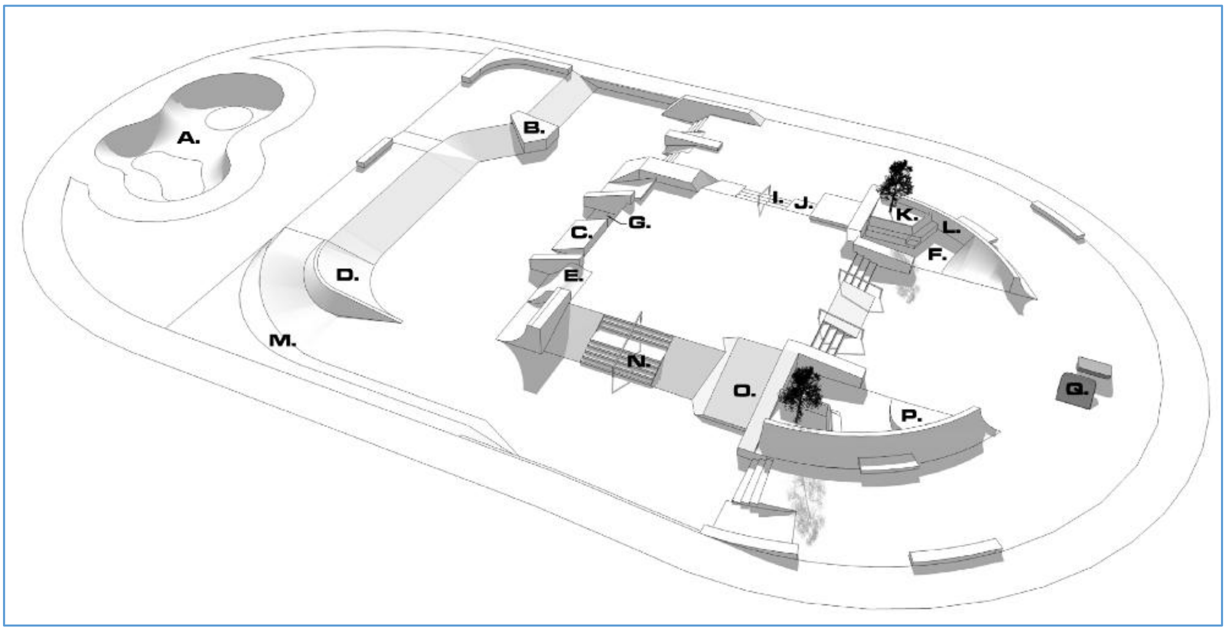


Figure 42 3D perspective

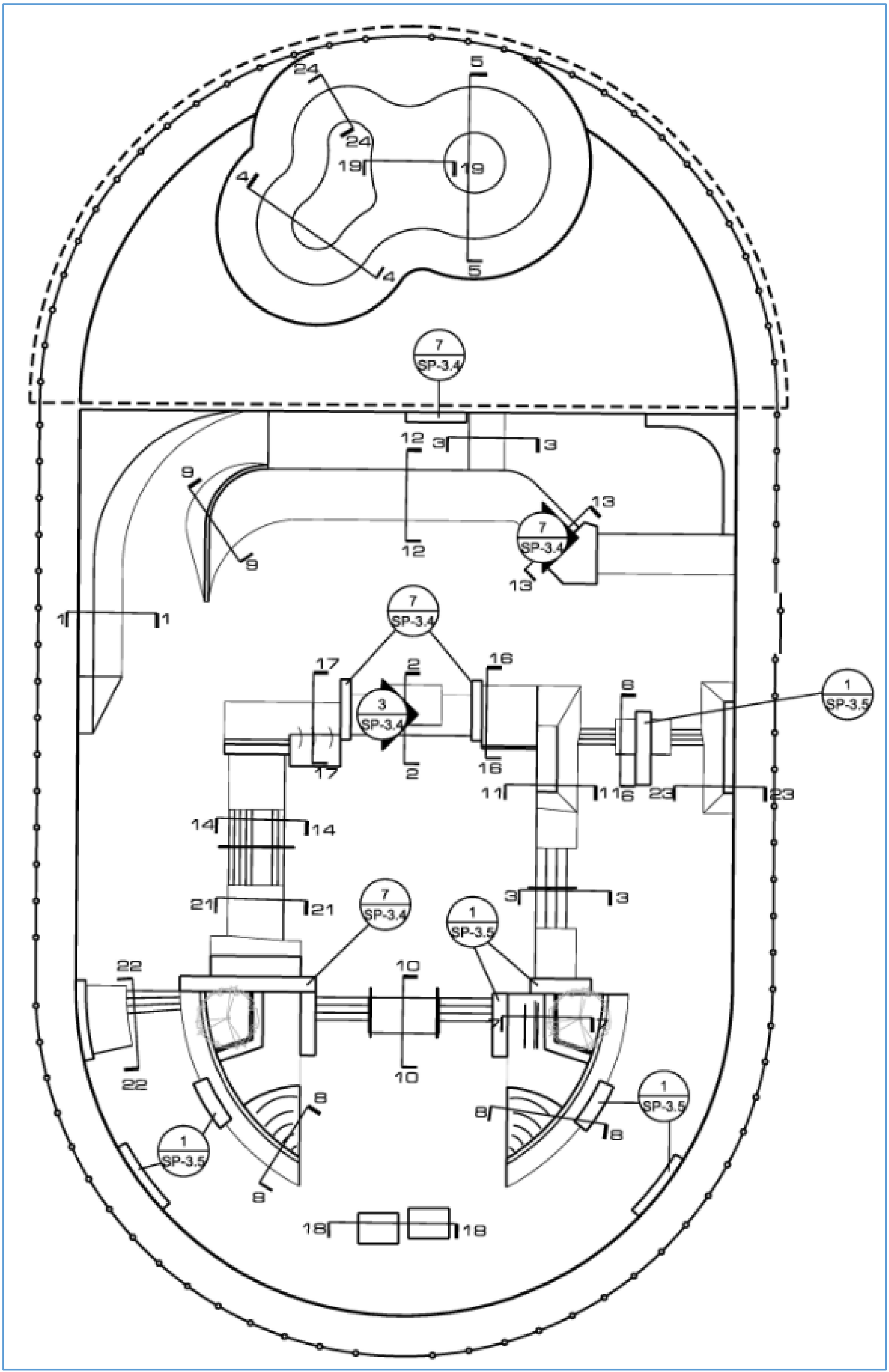
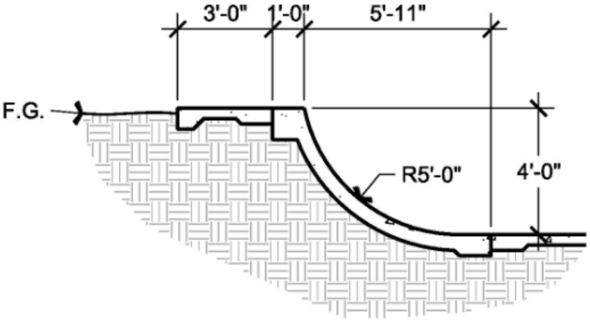
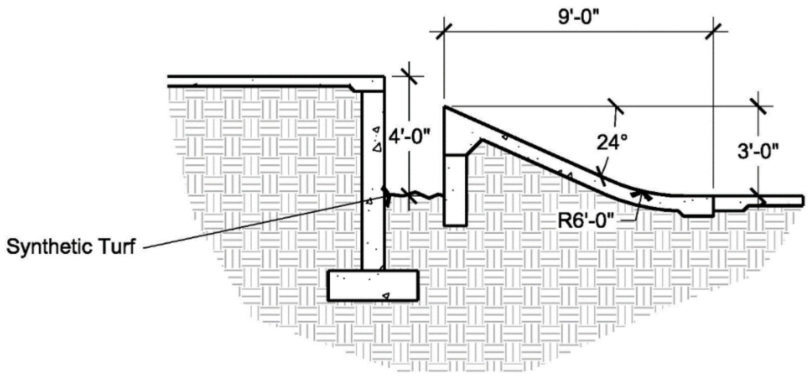


Figure 43 Sections plan

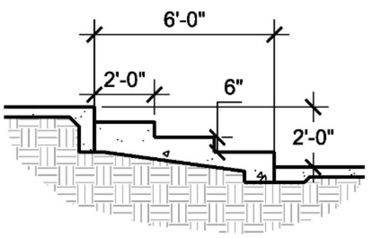
– LIST OF SECTIONS



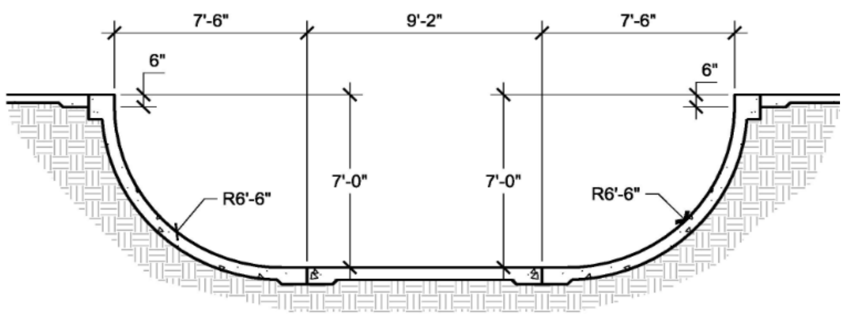
section 1



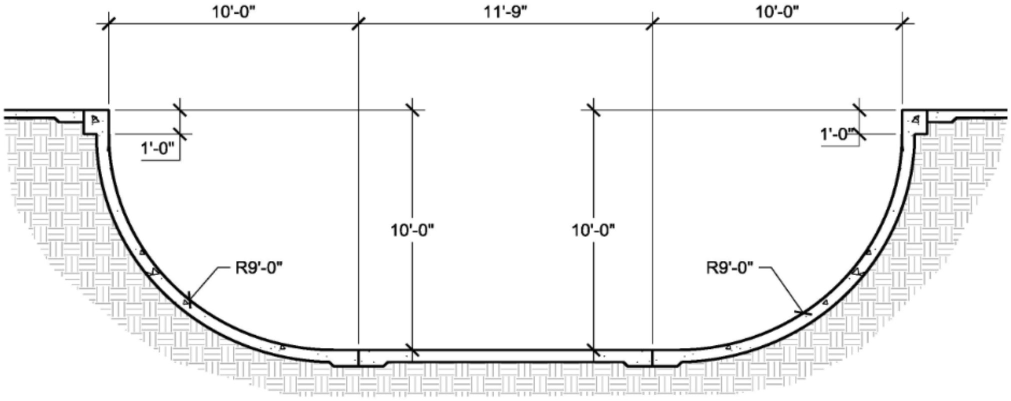
section 2



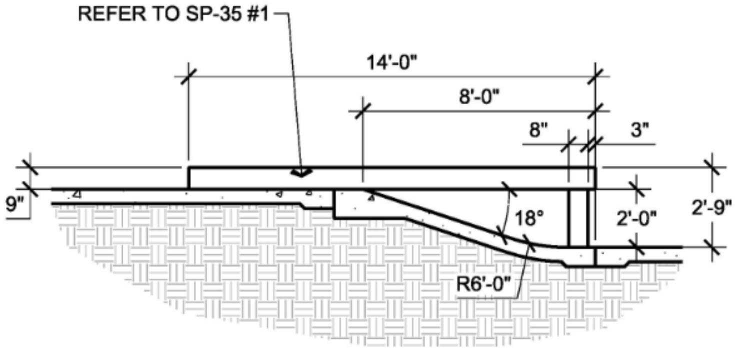
section 3



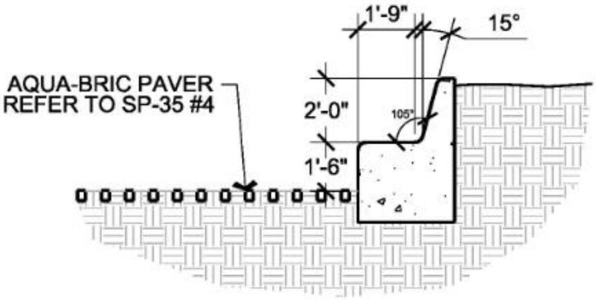
section 4



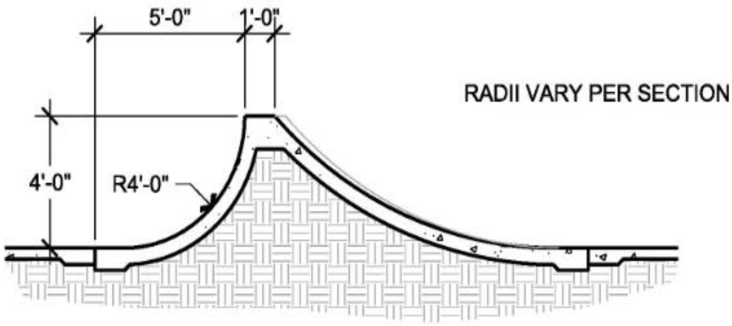
section 5



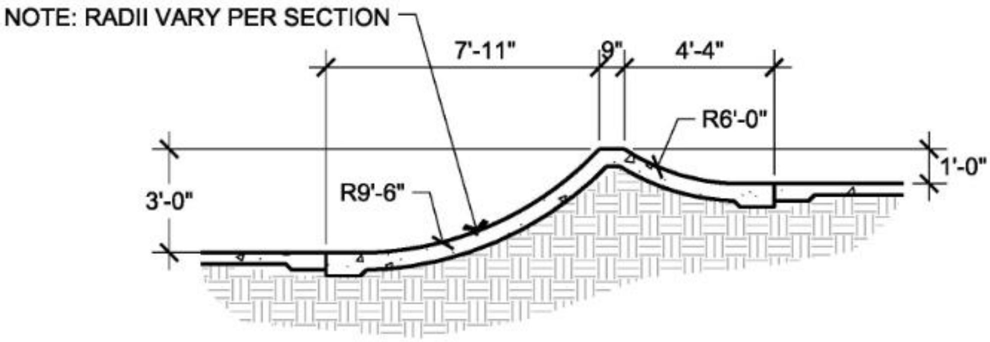
section 6



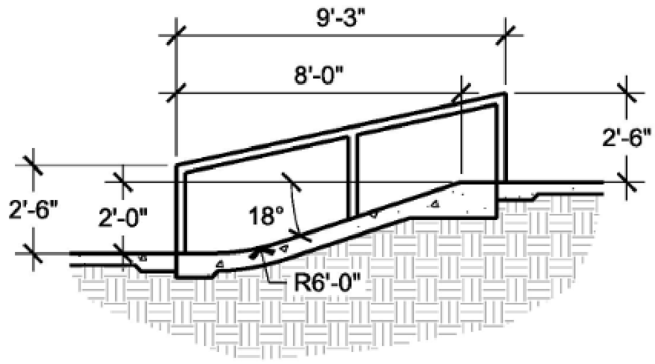
section 7



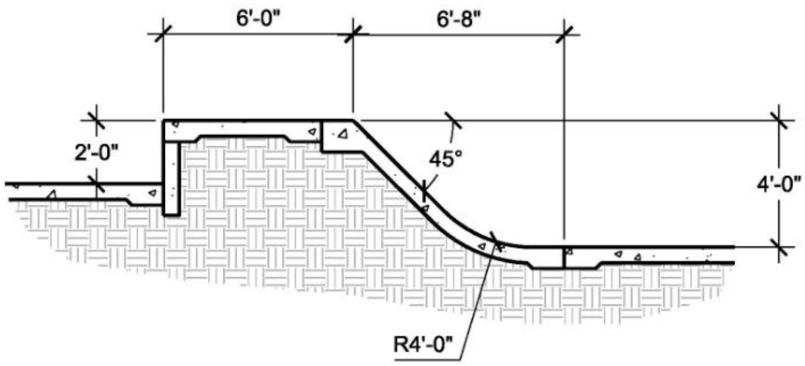
section 8



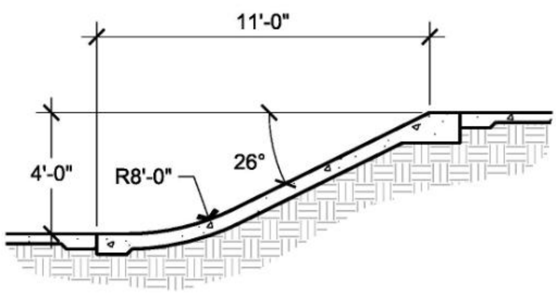
section 9



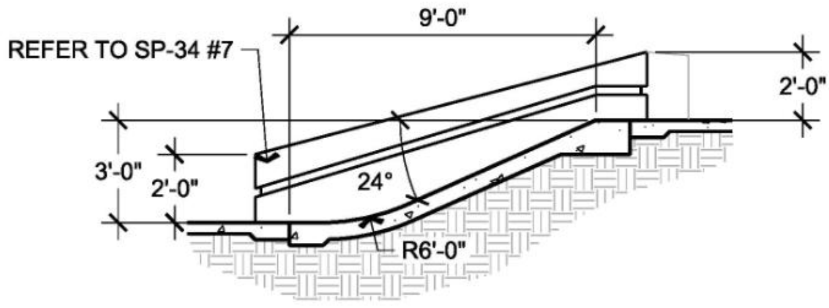
section 10



section 11



section 12



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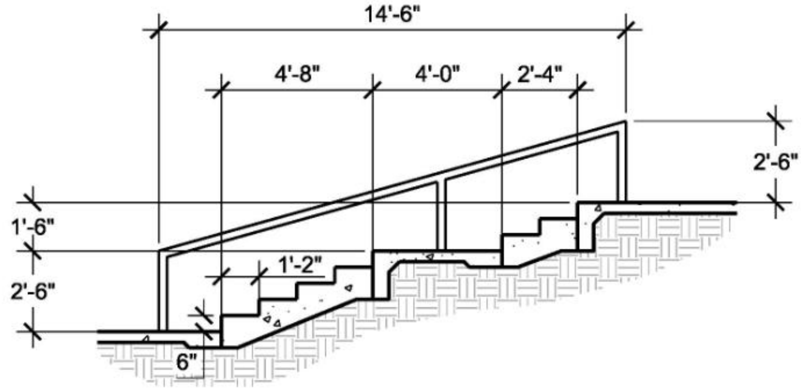

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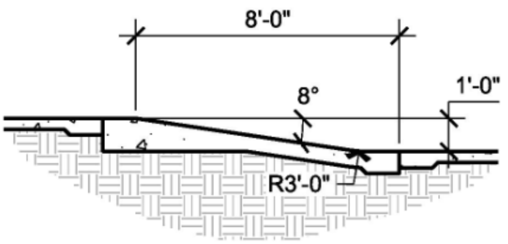

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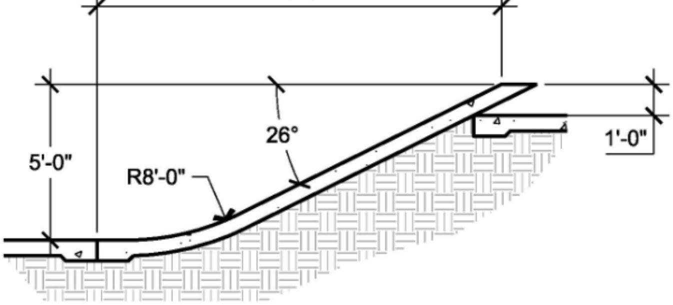

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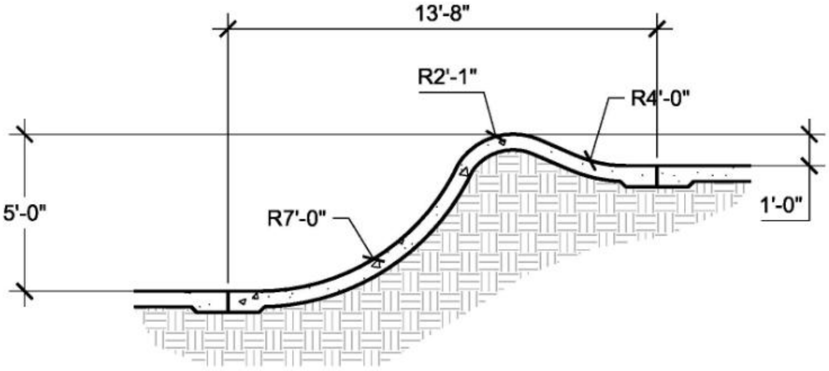

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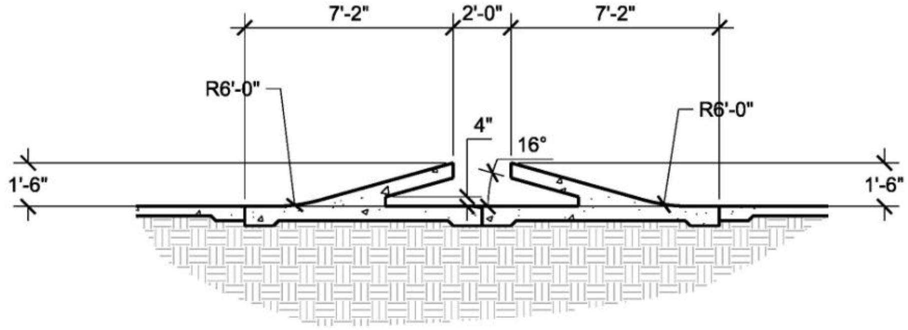

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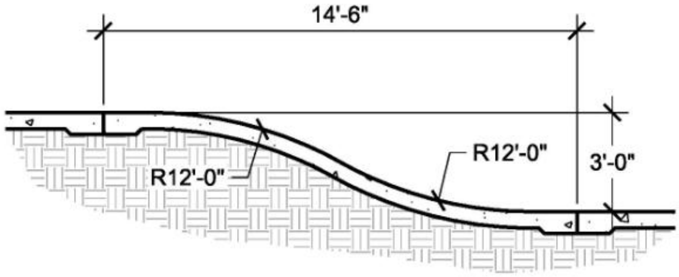

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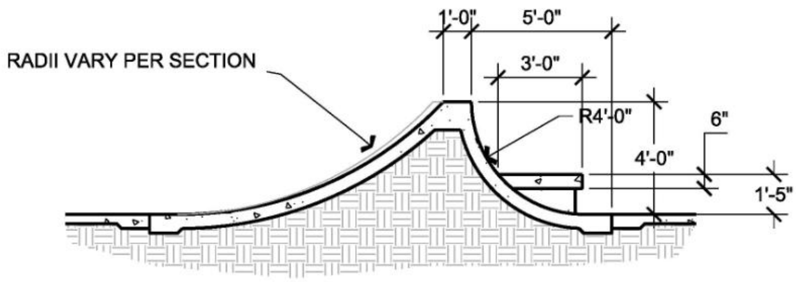
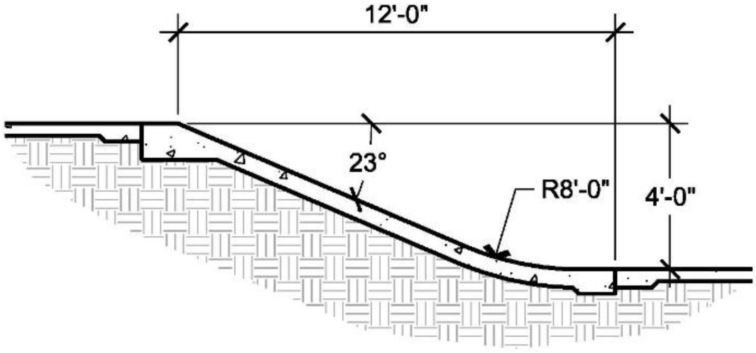
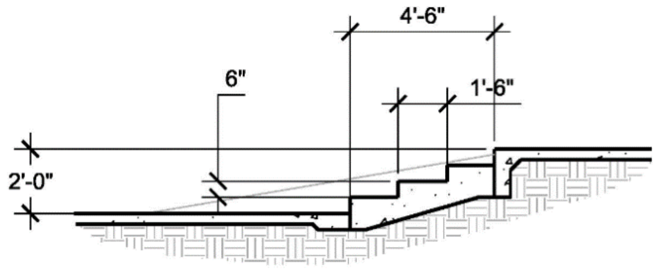


section 20



section 21



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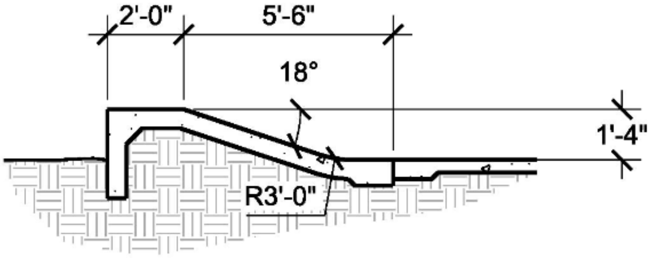


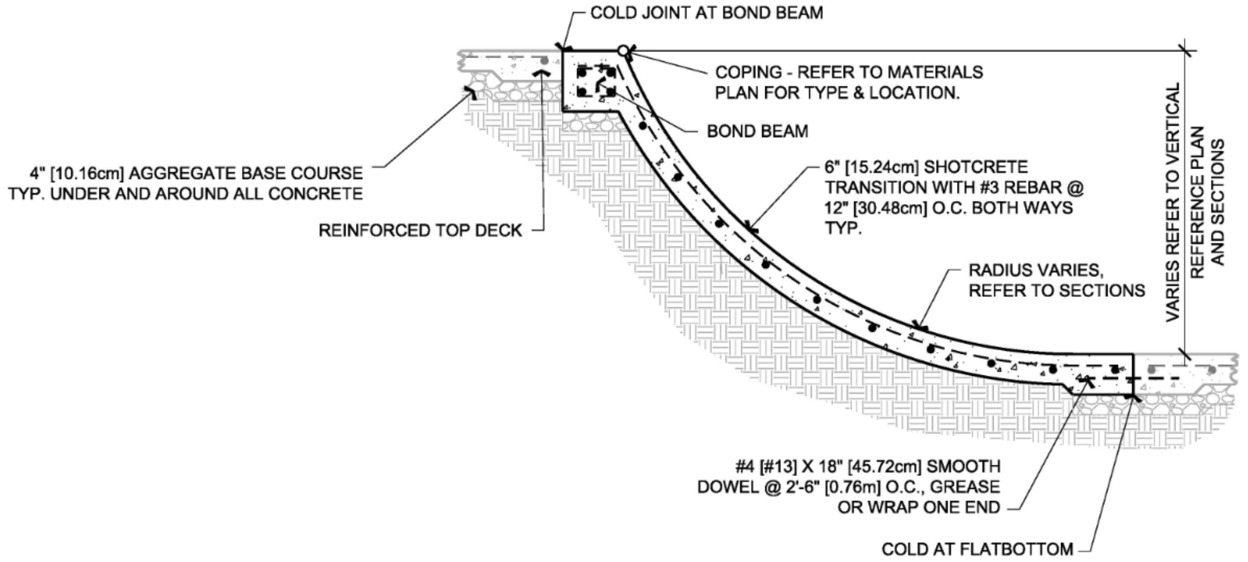
section 23

– DETAIL SECTION DRAWINGS

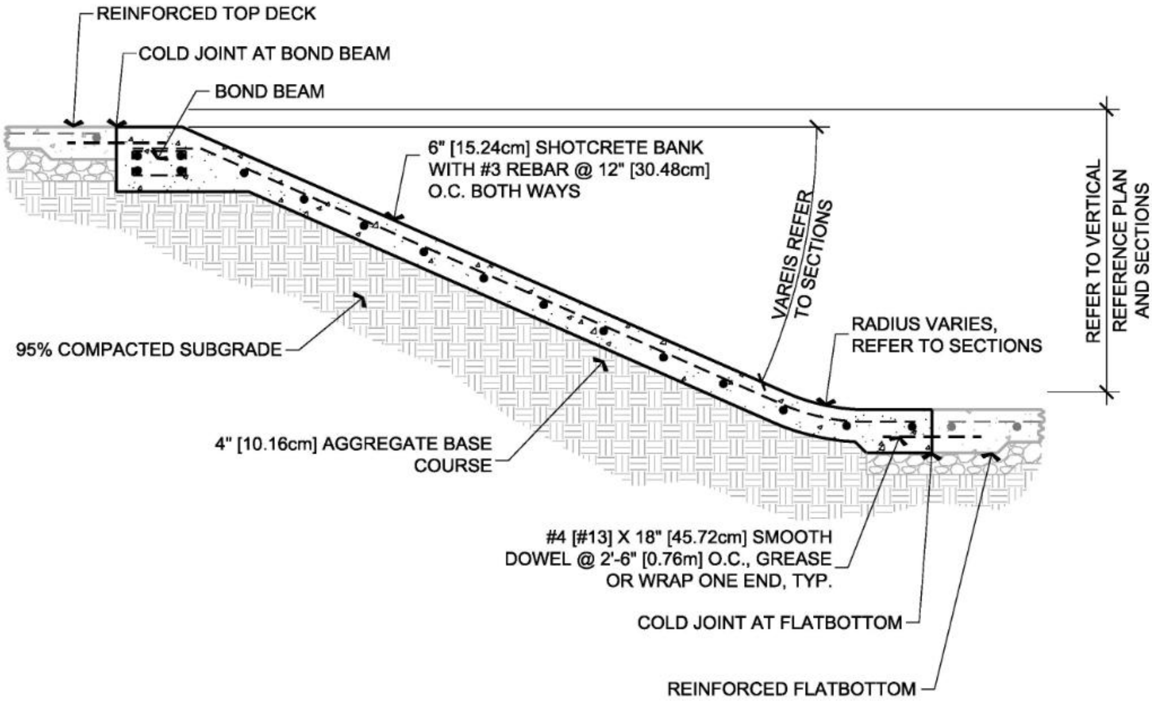
special note:

ALL TRANSITIONS (RADIAL WALLS) AND BANKS (EMBANKMENT WALLS) SHALL BE CUT, SCREEDED AND INSPECTED WITH TEMPLATES CUT TO THE SPECIFIED RADIUS/ ANGLE. CONTRACTOR IS TO SUBMIT SHOP DRAWINGS FOR TEMPLATE SIZE, MATERIAL AND LOCATION TO BE USED FOR APPROVAL BY PROJECT MANAGER AND SKATE PARK DESIGNER.

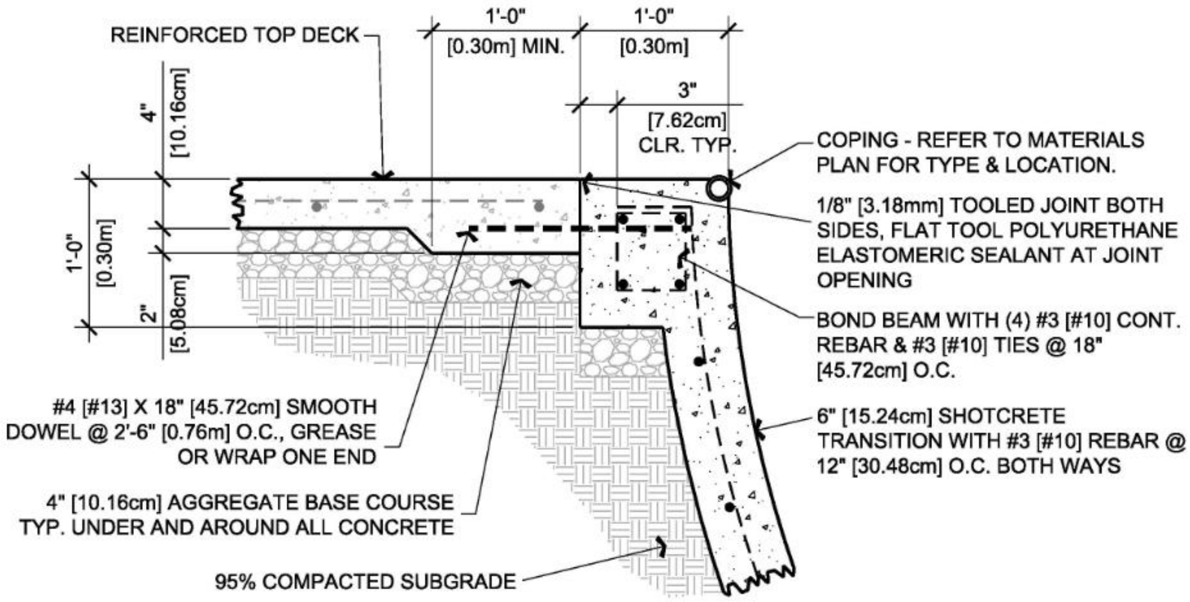
ALL SHOTCRETE TRANSITIONS AND BANKS TO BE POURED AND INSPECTED PRIOR TO ALL CONCRETE FLATWORK. CONTRACTOR IS TO SUBMIT POUR SCHEDULE BY LOCATION AND SEQUENCE FOR REVIEW BY PROJECT MANAGER AND SKATE PARK DESIGNER.



1 **typical concrete bowl - section**
scale: 1/2" = 1'-0"

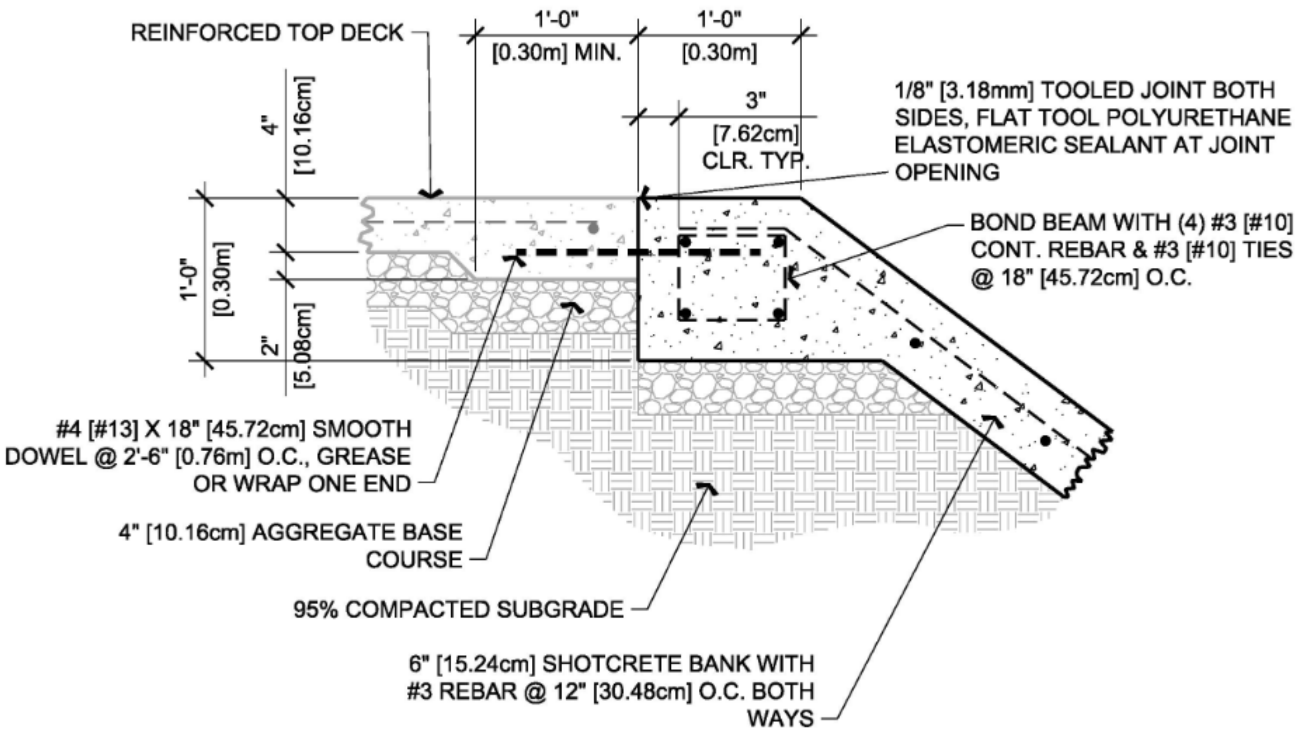


2 **typical concrete bank - section**
scale: 1/2" = 1'-0"



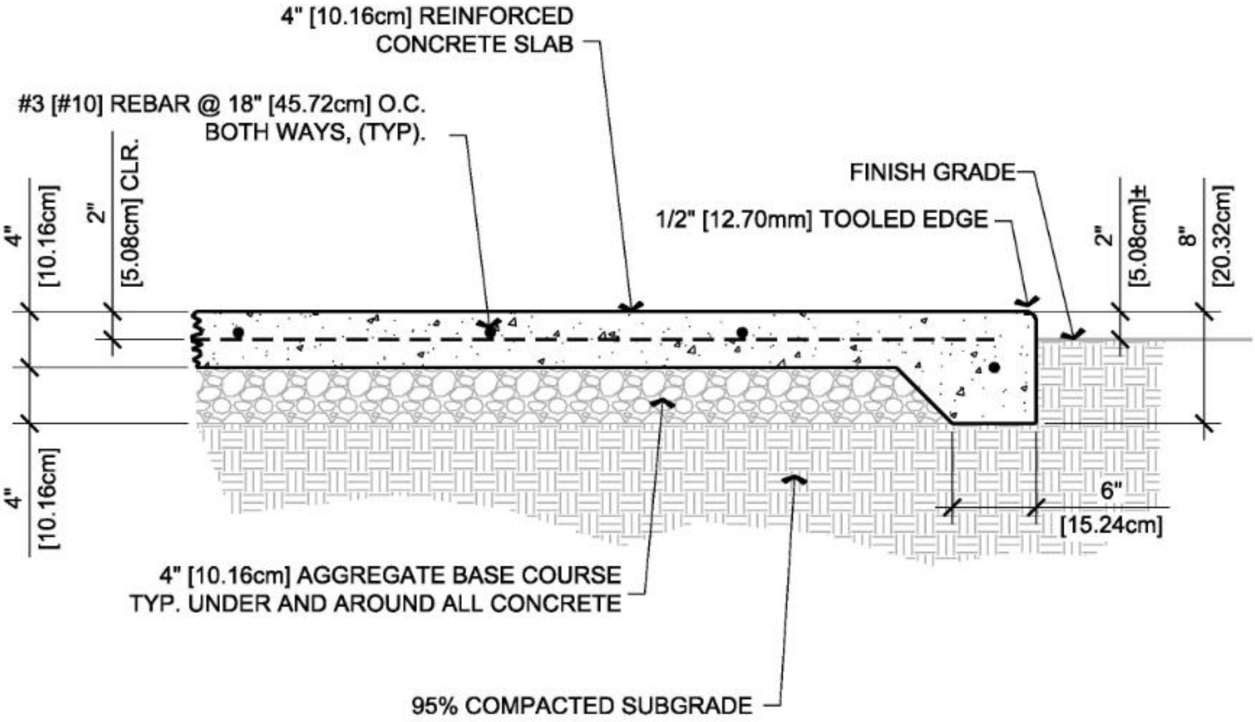
3 **typical transition bond beam**

scale: 1" = 1'-0"



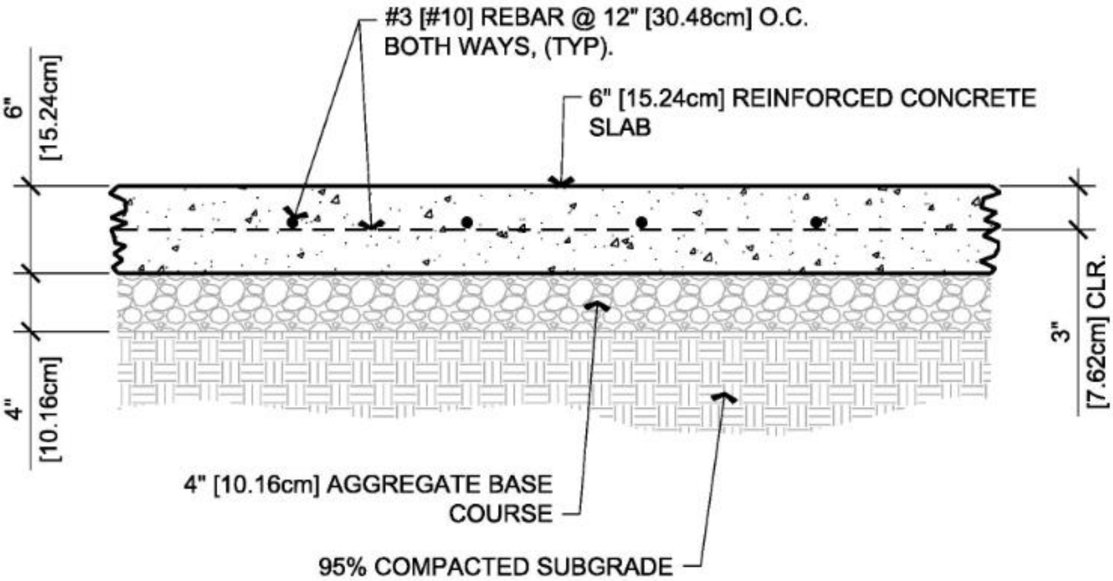
4 **typical bank bond beam**

scale: 1" = 1'-0"



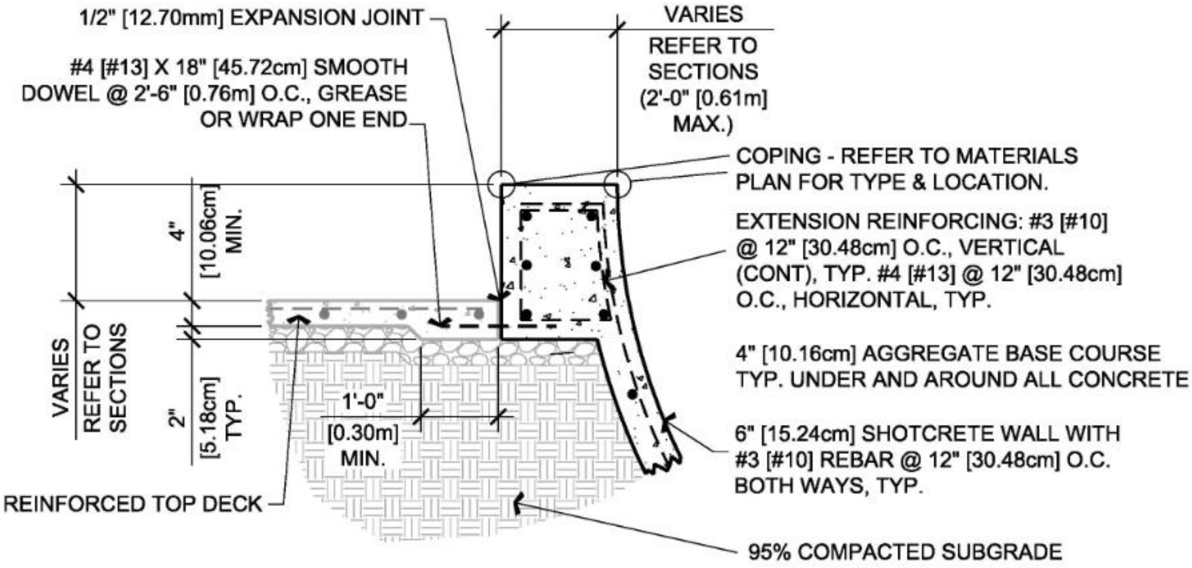
5 **reinforced top deck slab**

scale: 1" = 1'-0"



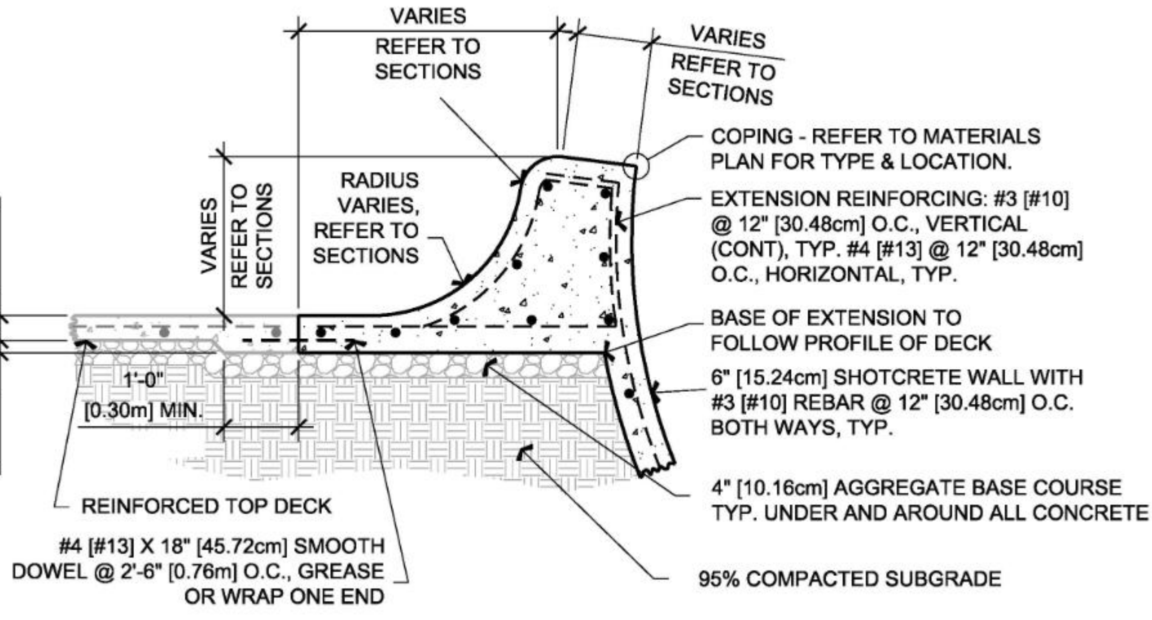
6 **reinforced flatbottom slab**

scale: 1" = 1'-0"



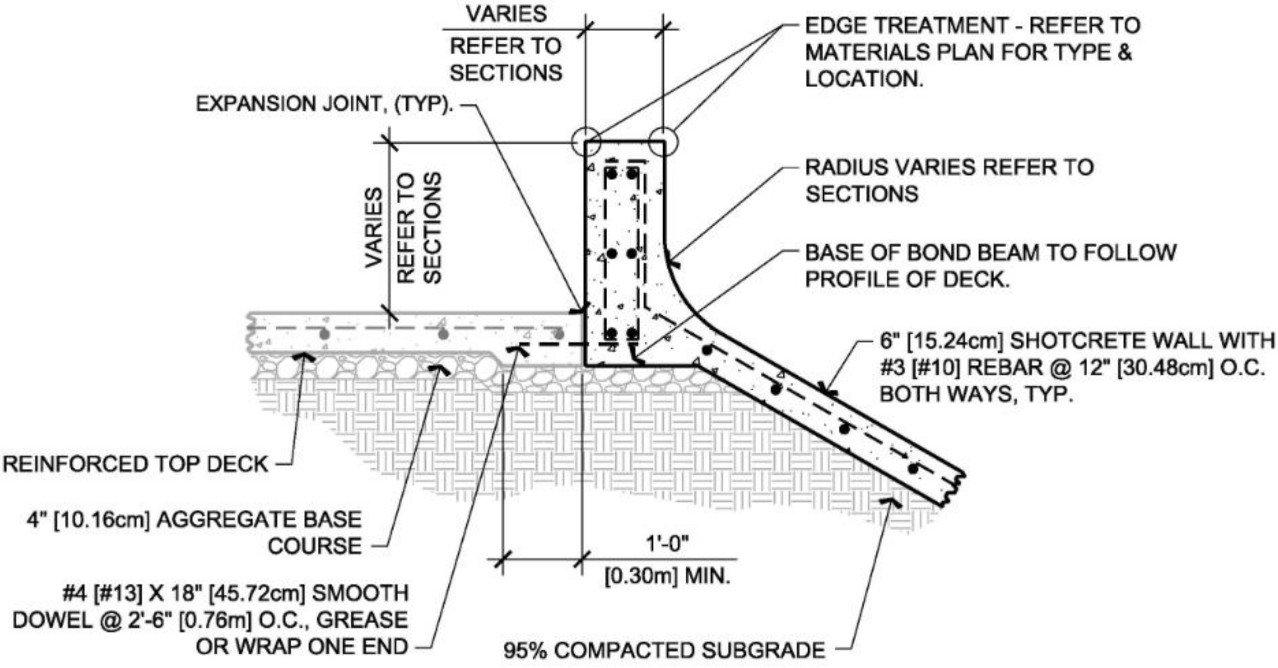
7 typical narrow extension section

scale: 1/2" = 1'-0"



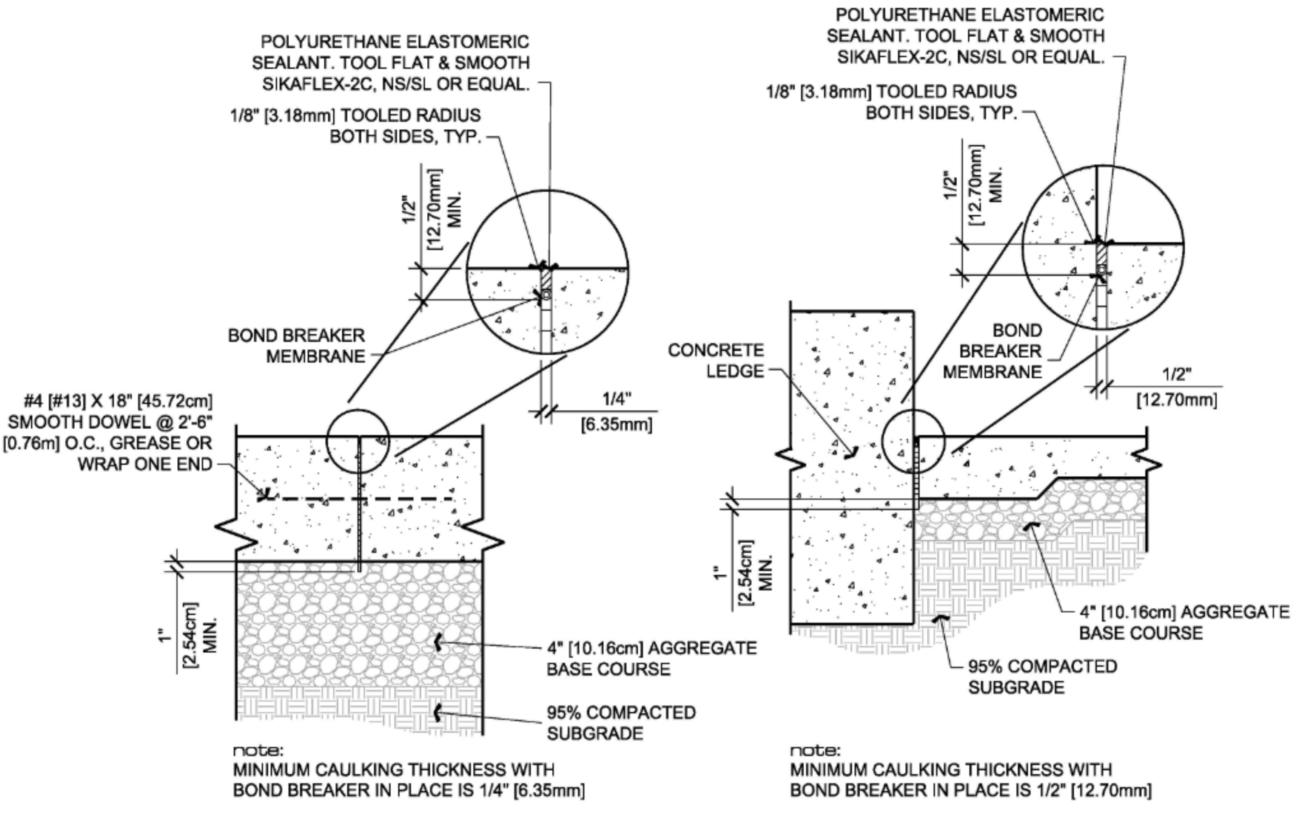
8 typical over vert to transition section

scale: 1/2" = 1'-0"



9 typical bank to ledge section

scale: 1/2" = 1'-0"

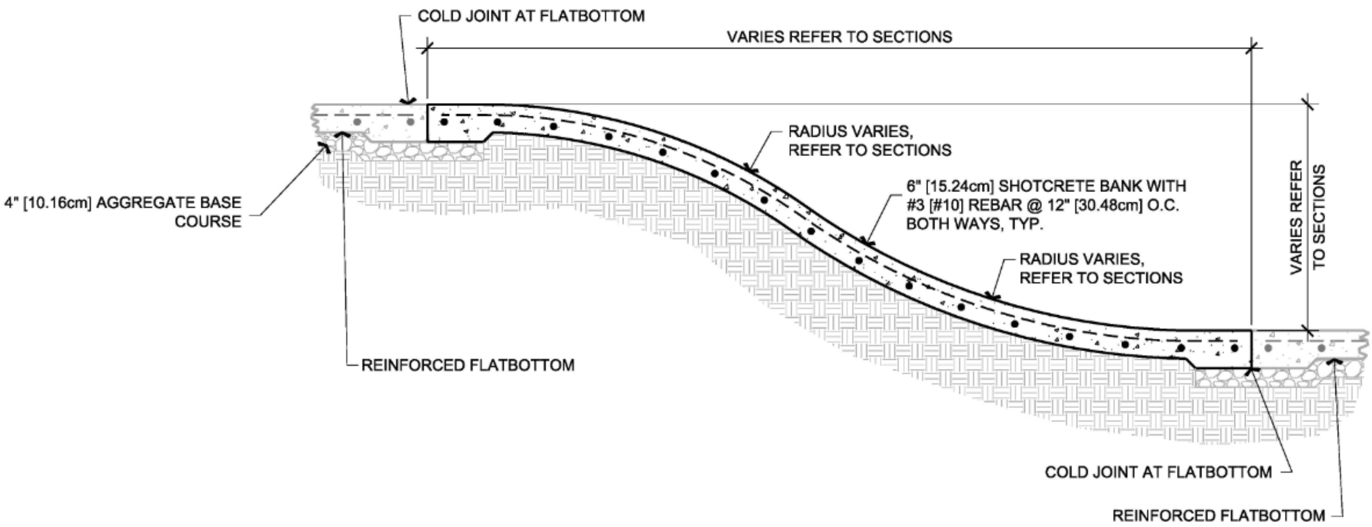


1/4" expansion joint at flatwork

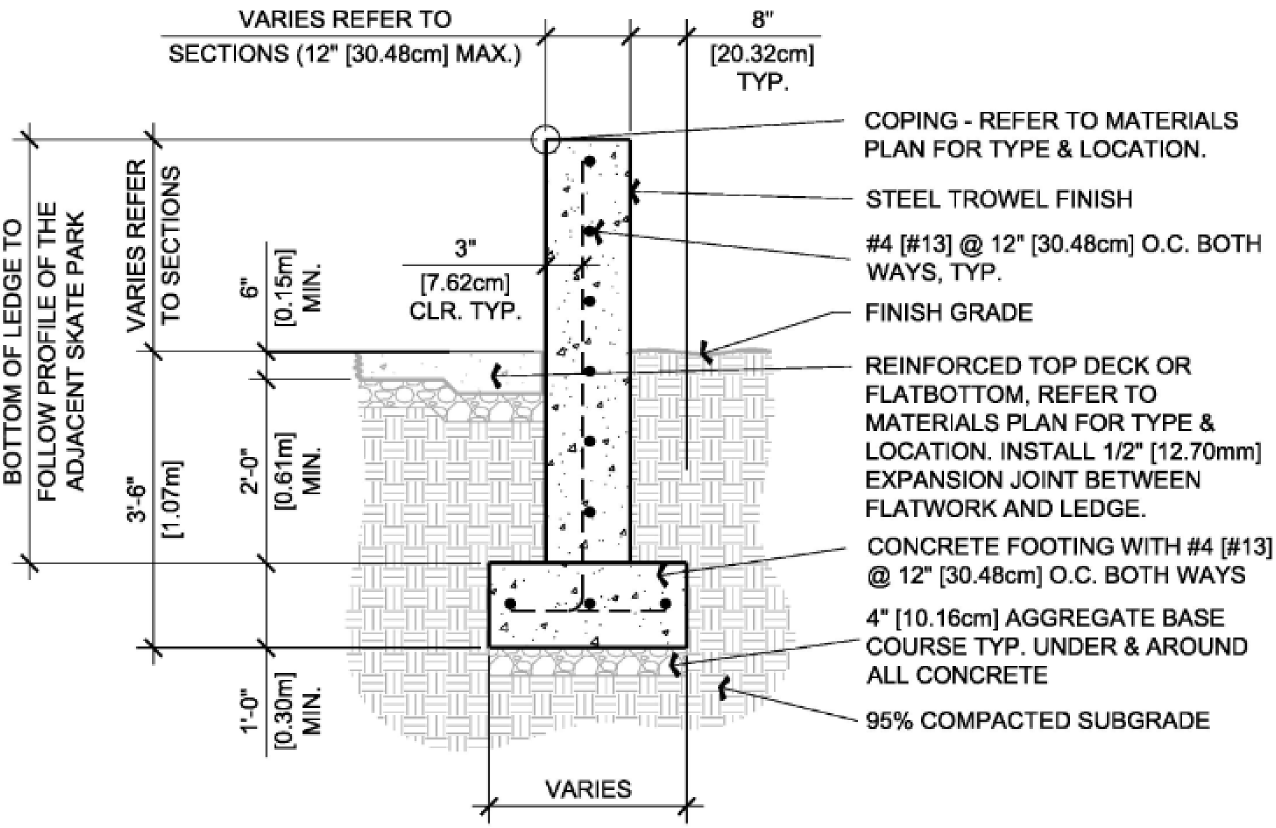
1/2" expansion joint at concrete ledge

5 expansion joint

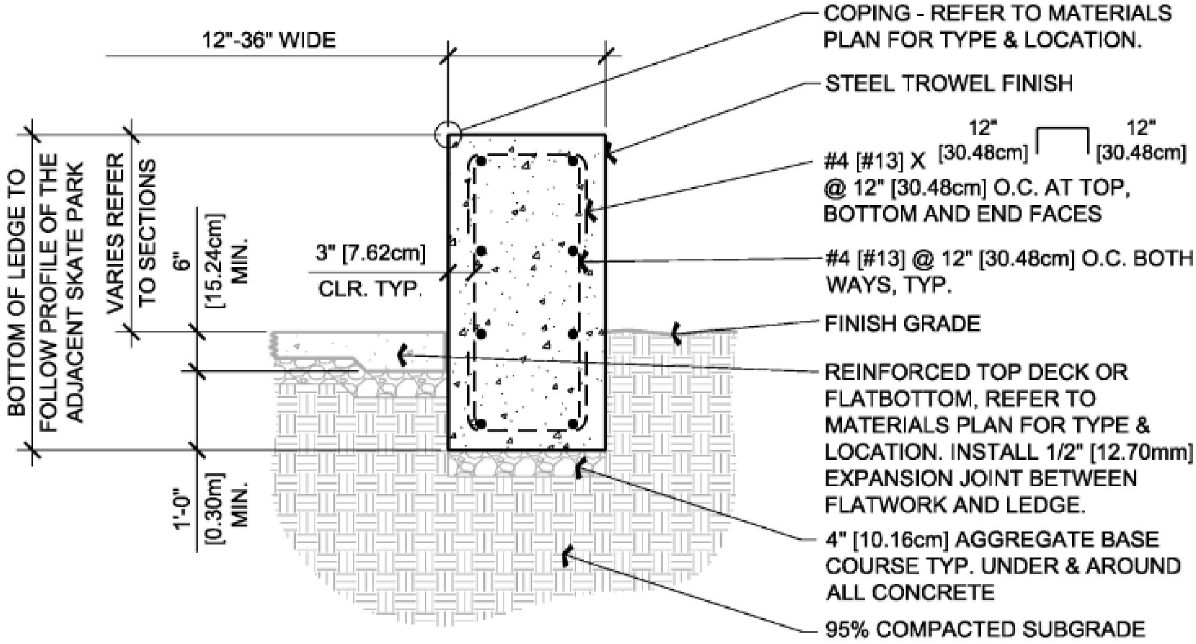
scale: 1" = 1'-0"



6 **typical waterfall section**
scale: 1/2" = 1'-0"

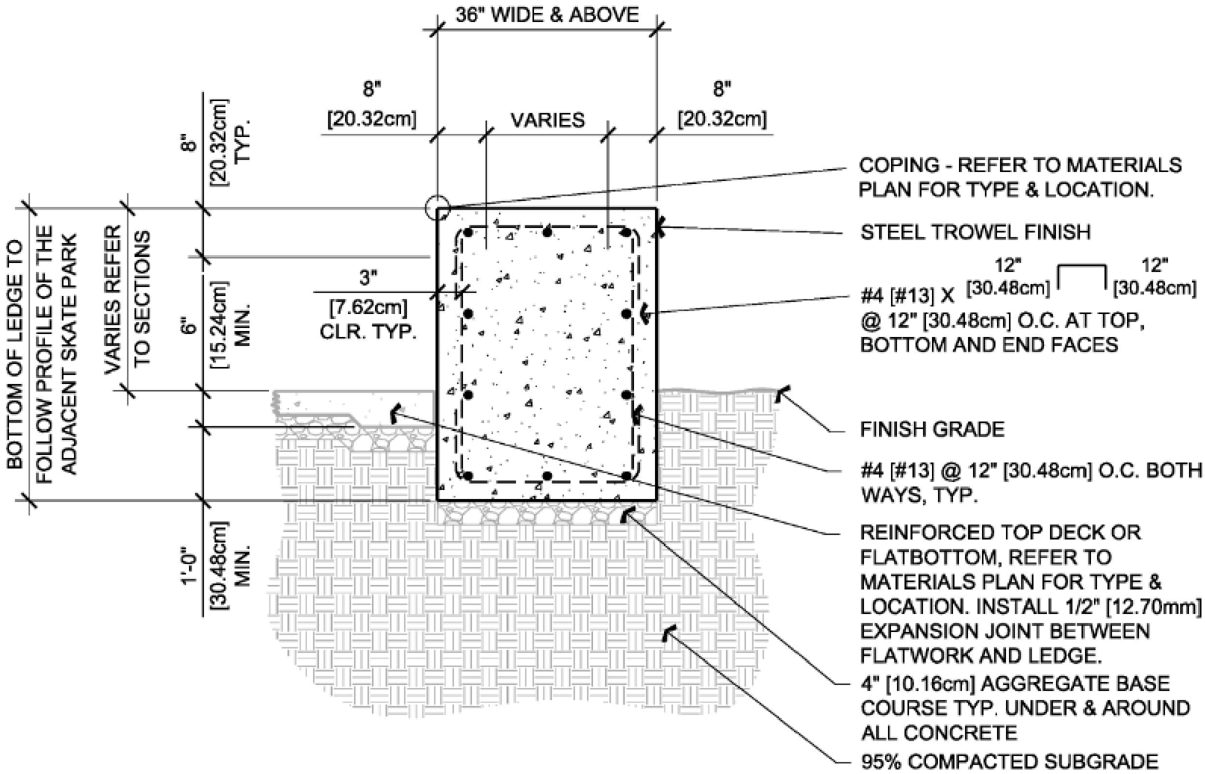


7 **small grind ledge**
scale: 1/2" = 1'-0"



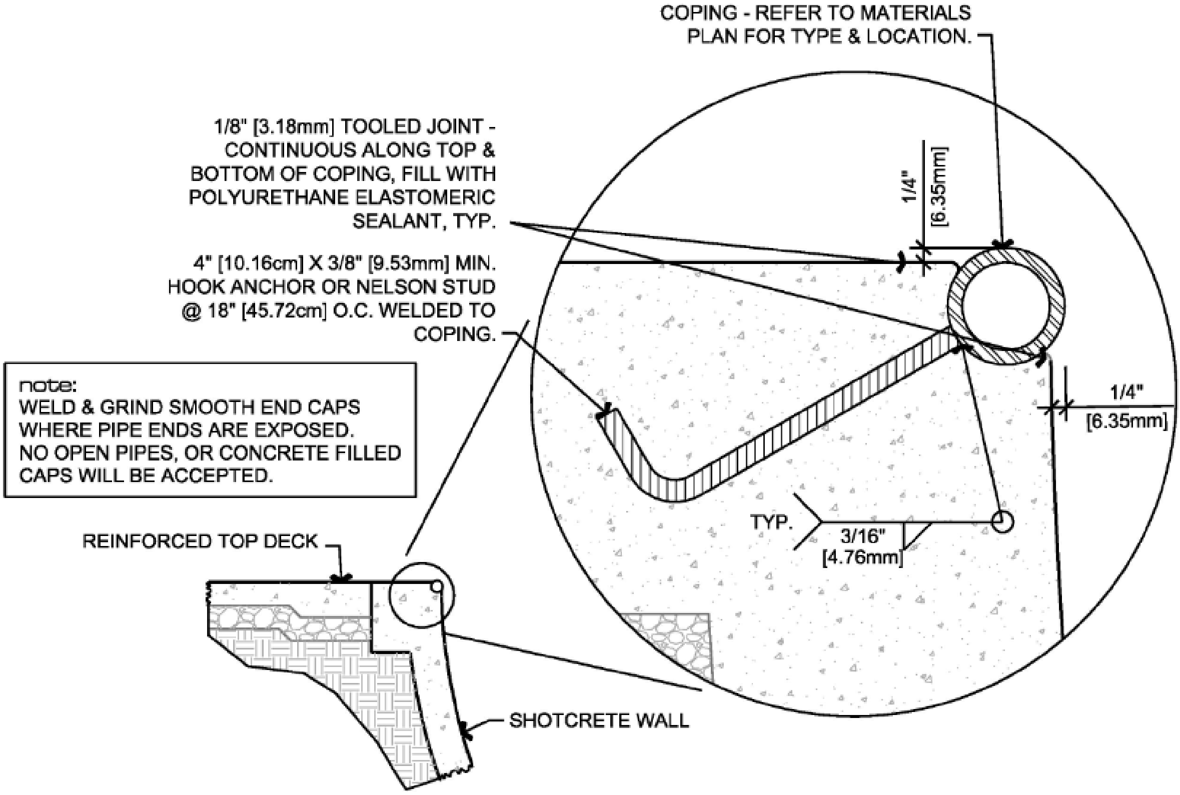
8 **medium grind ledge**

scale: 1/2" = 1'-0"



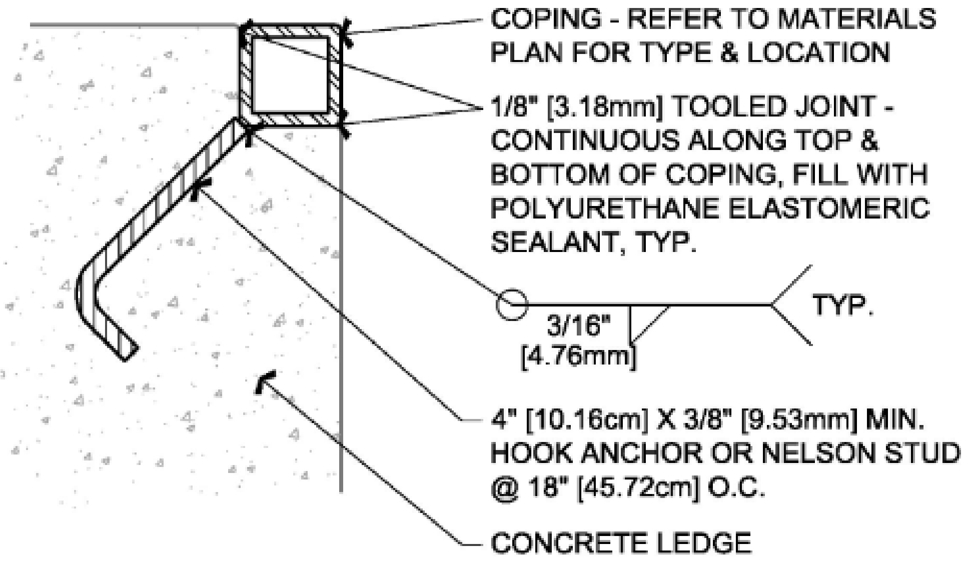
9 **large grind ledge**

scale: 1/2" = 1'-0"



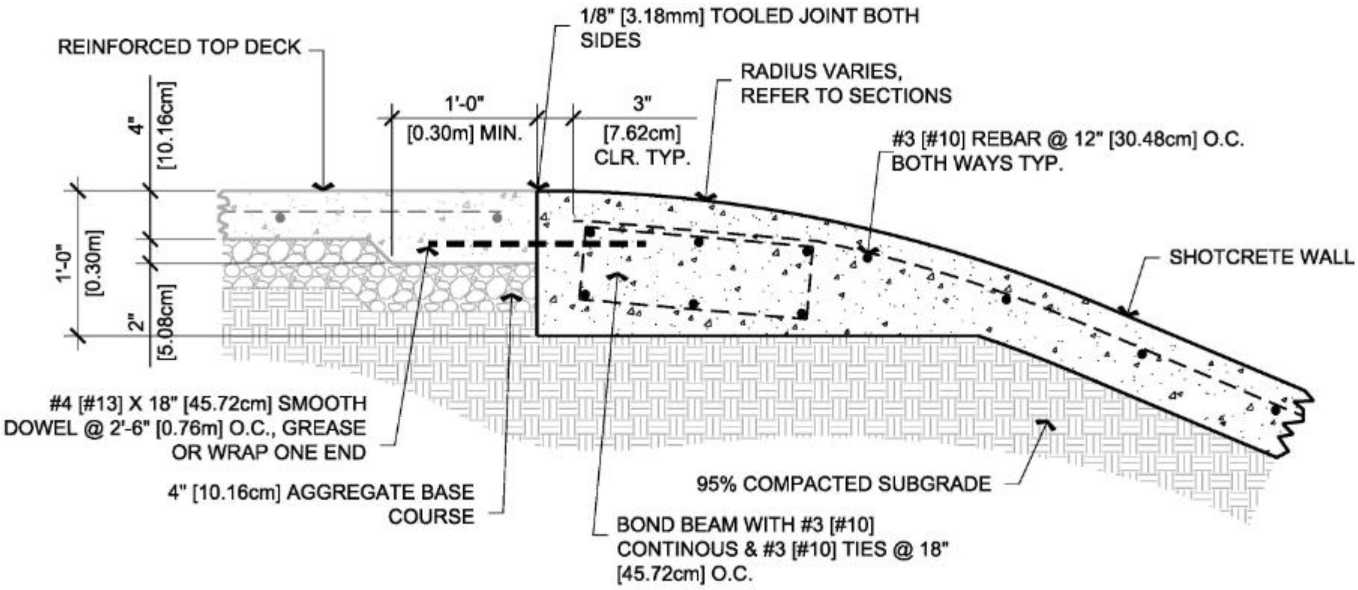
1 **round coping detail**

scale: 1/2" = 1'-0"

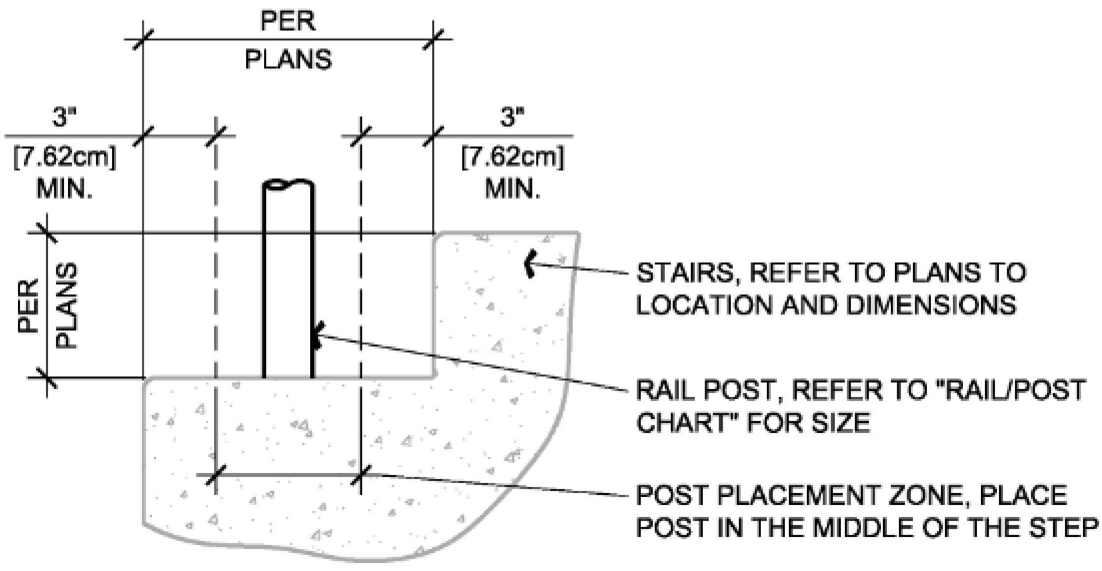


2 **square coping detail**

scale: not to scale

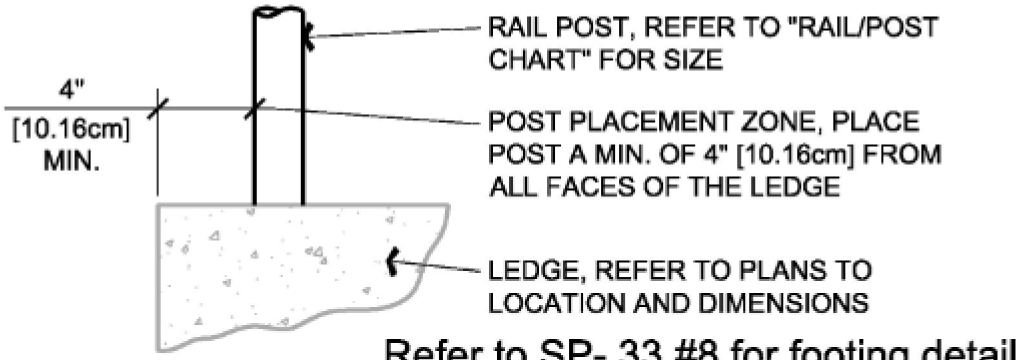


3 **bond beam with radius edge**
scale: 1" = 1'-0"



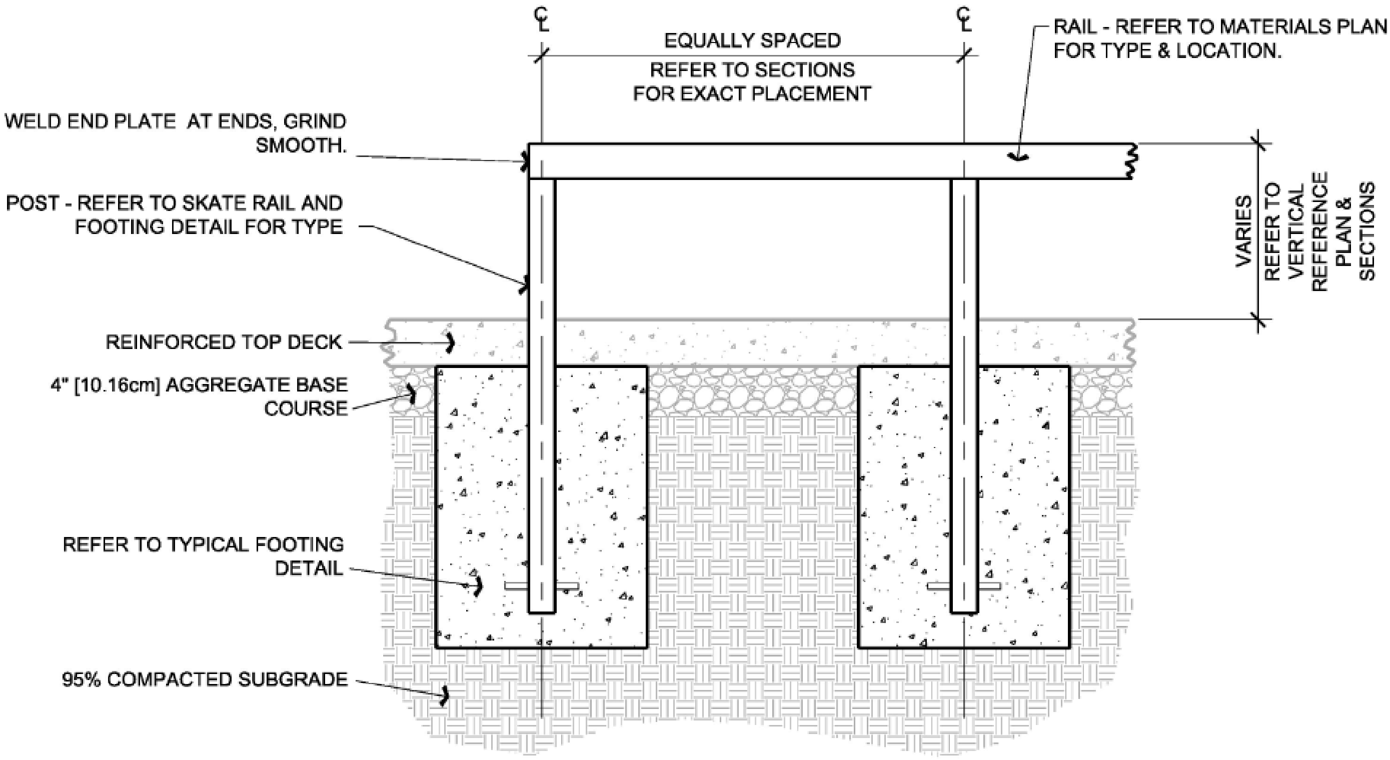
Refer to SP- 33 #8 for footing detail

4 **post in step detail**
scale: 1-1/2" = 1'-0"

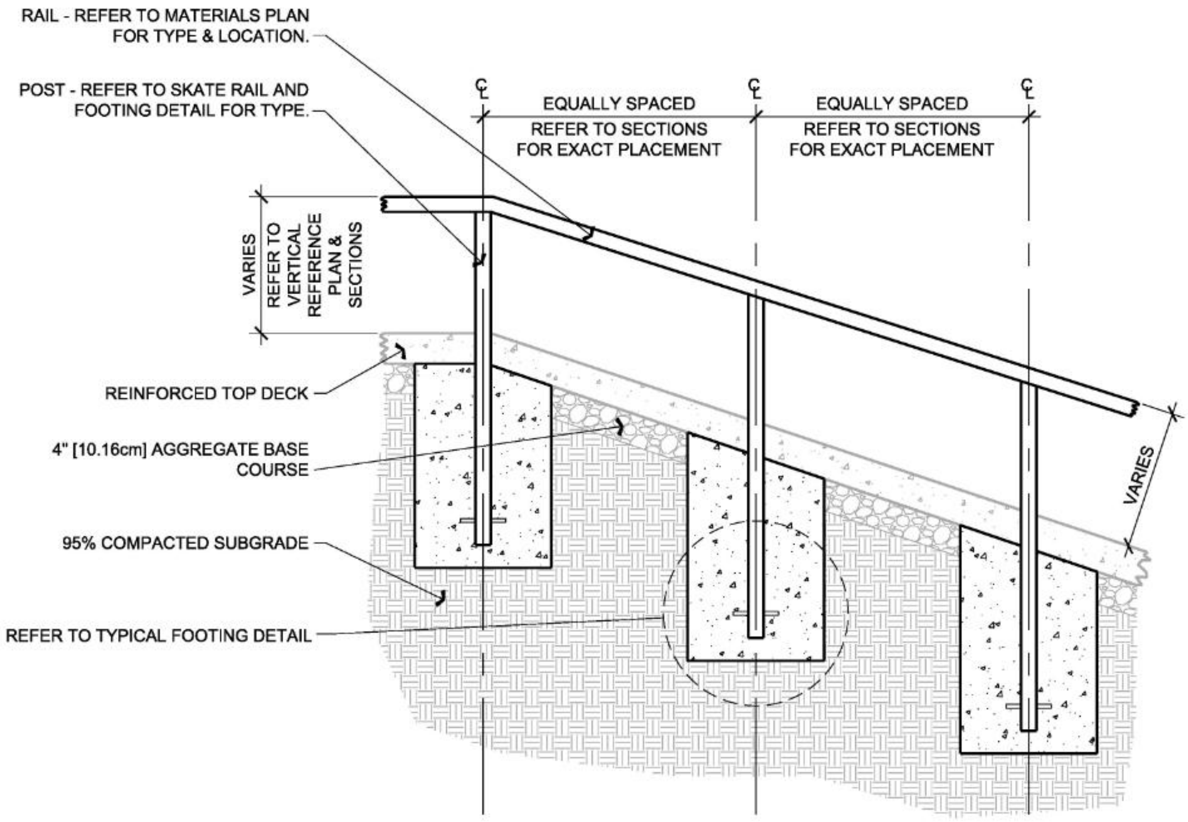


Refer to SP- 33 #8 for footing detail

5 post in ledge detail
scale: 1-1/2" = 1'-0"



6 flat steel rail section
scale: 1" = 1'-0"



7 sloped steel rail section

scale: 3/4" = 1'-0"

rail/post chart

ROUND PIPE

RAIL	POST
3" ROUND	2-1/2" ROUND
3-1/2" ROUND	2-1/2" ROUND
4" ROUND	2-1/2" ROUND

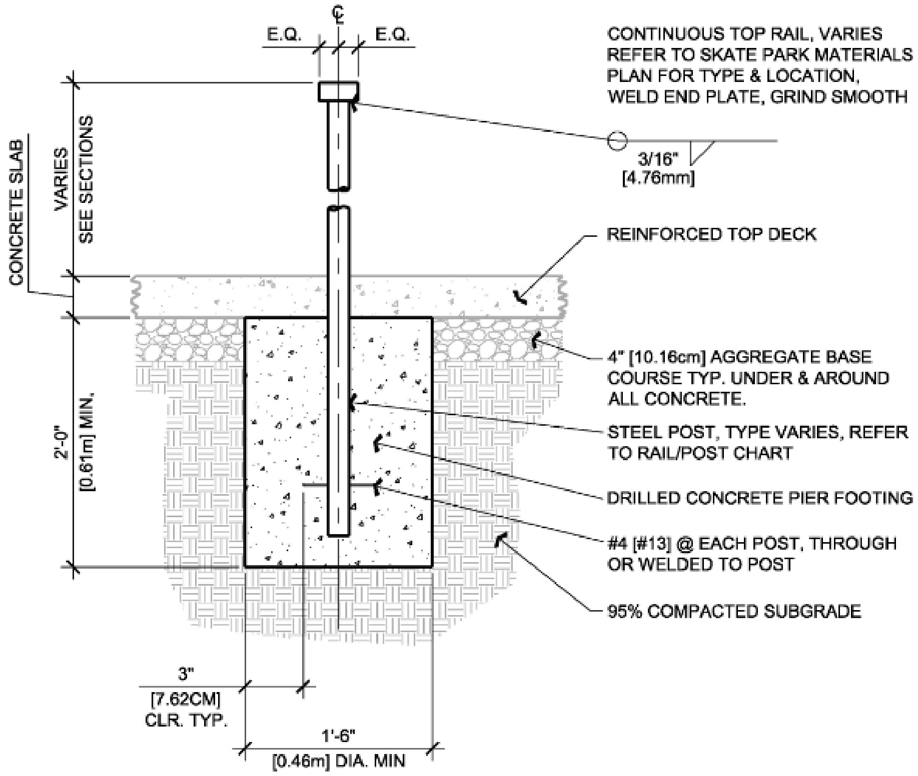
HORIZONTAL FLAT BAR

RAIL	POST
2" X 3" SQUARE	2" ROUND
2" X 6" SQUARE	2" X 2" SQUARE
2" X 8" SQUARE	2" X 2" SQUARE
3" X 3" SQUARE	2-1/2" ROUND
4" X 4" SQUARE	3" ROUND

VERTICAL FLAT BAR

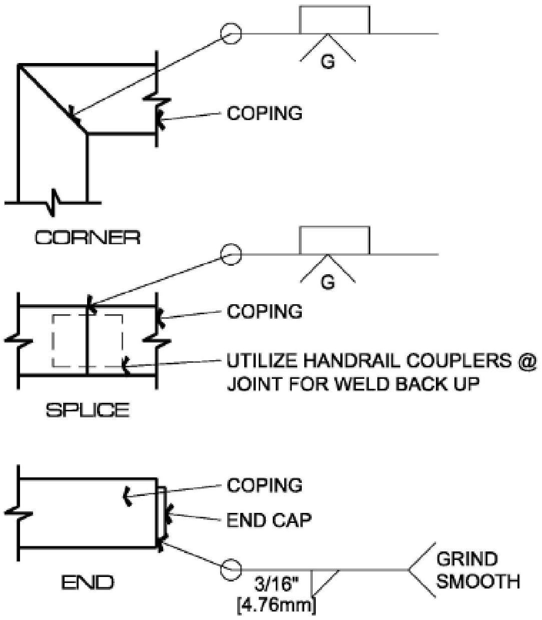
RAIL	POST
2-1/2" X 4" SQUARE	2" X 2" SQUARE
3" X 5" SQUARE	2-1/2" ROUND
4" X 6" SQUARE	3" ROUND

USE THESE RAIL/POST COMBINATIONS UNLESS OTHERWISE NOTED.

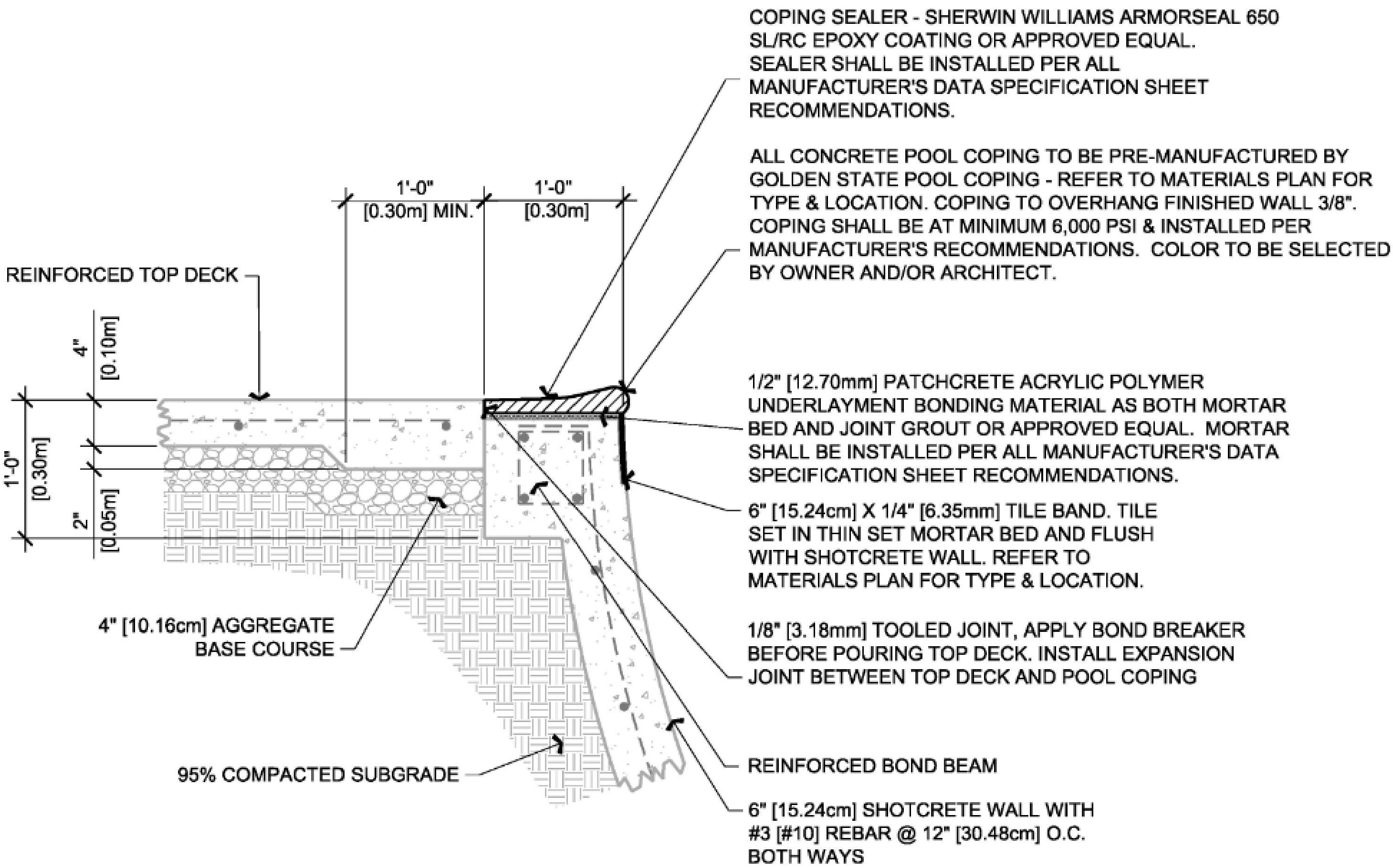


8 typical rail and footing detail

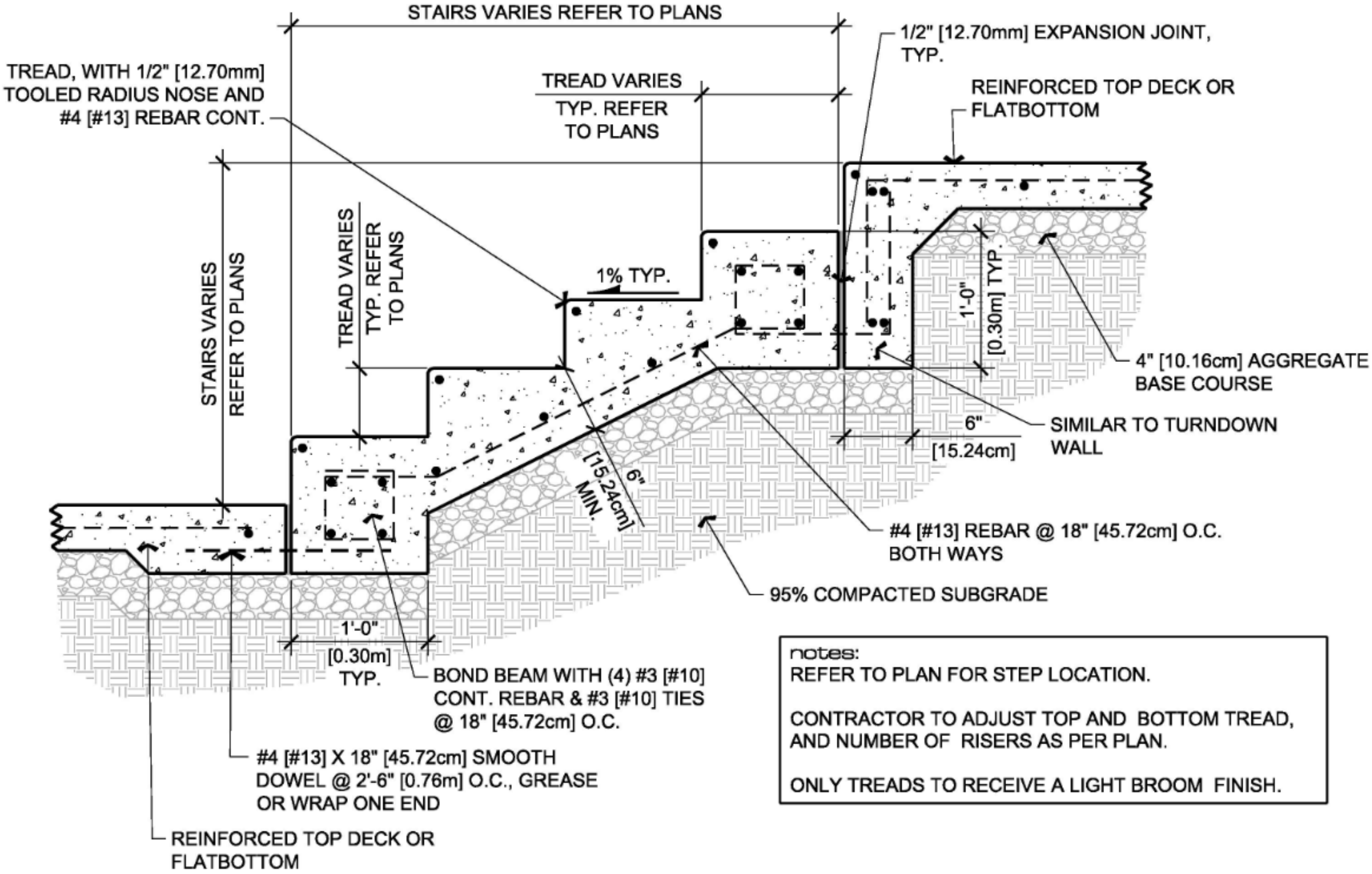
scale: 1" = 1'-0"



9 **coping/rail joint welds**
scale: 3" = 1'-0"

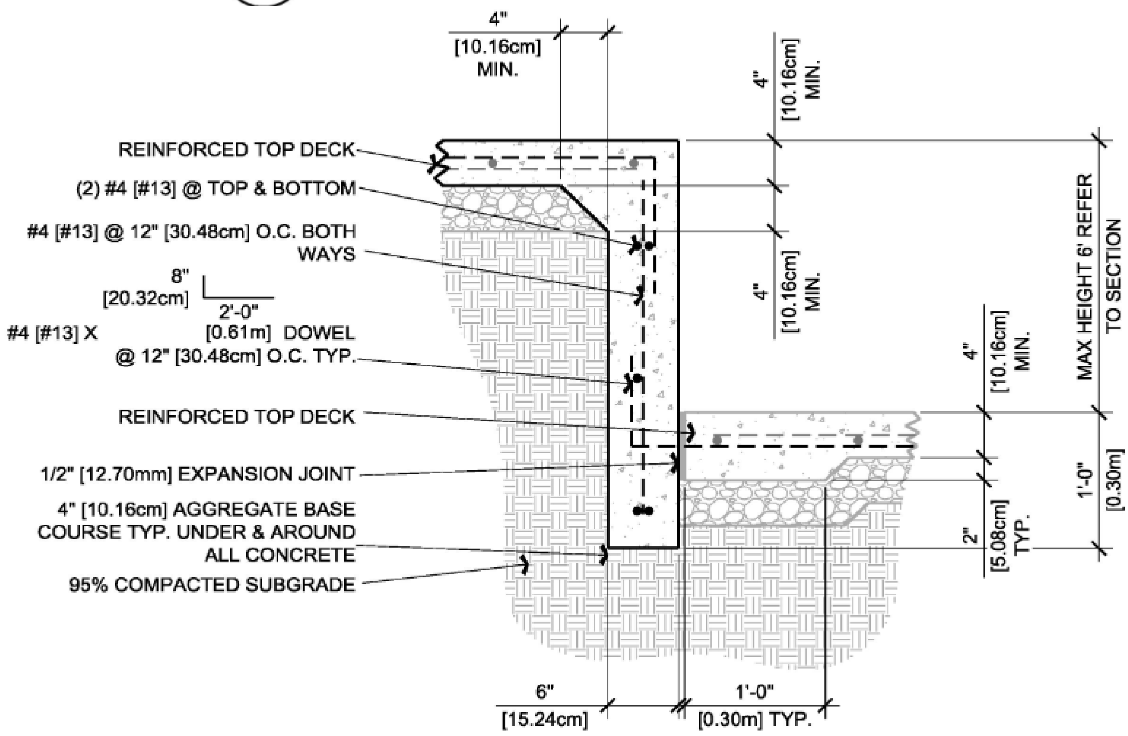


10 **pool coping detail**
scale: 1" = 1'-0"



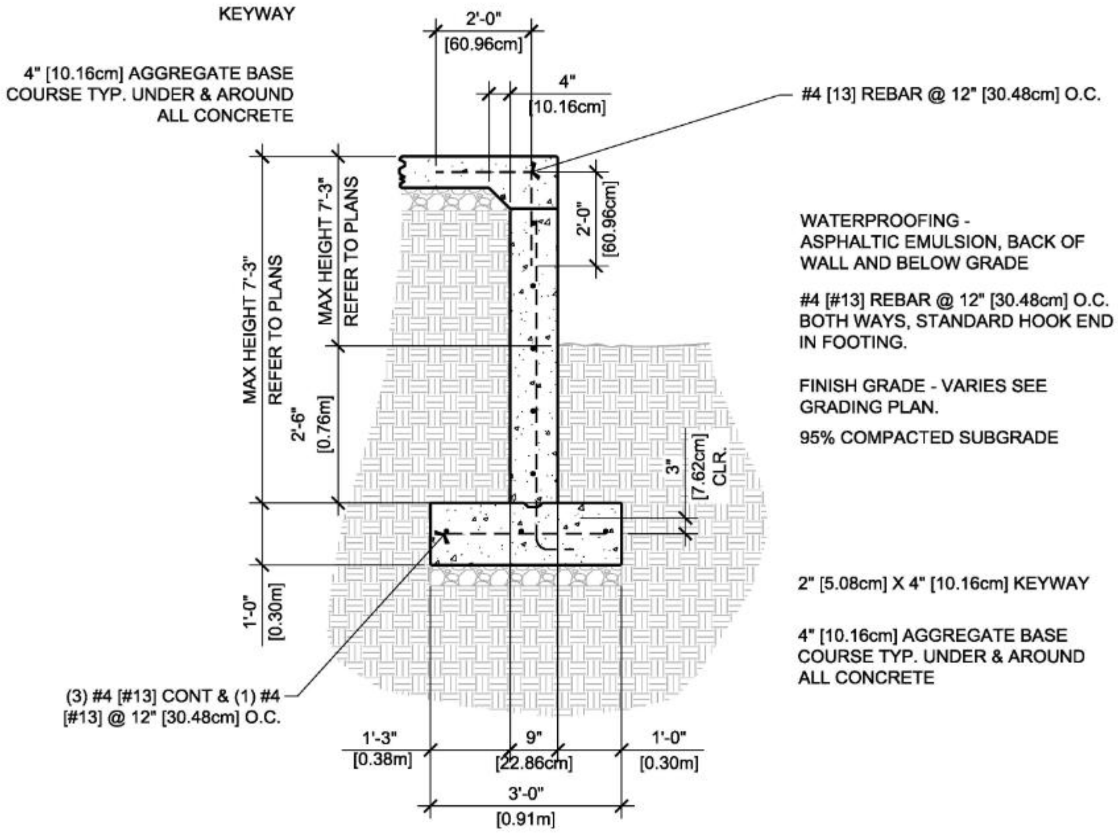
2 concrete stairs detail

scale: 1" = 1'-0"



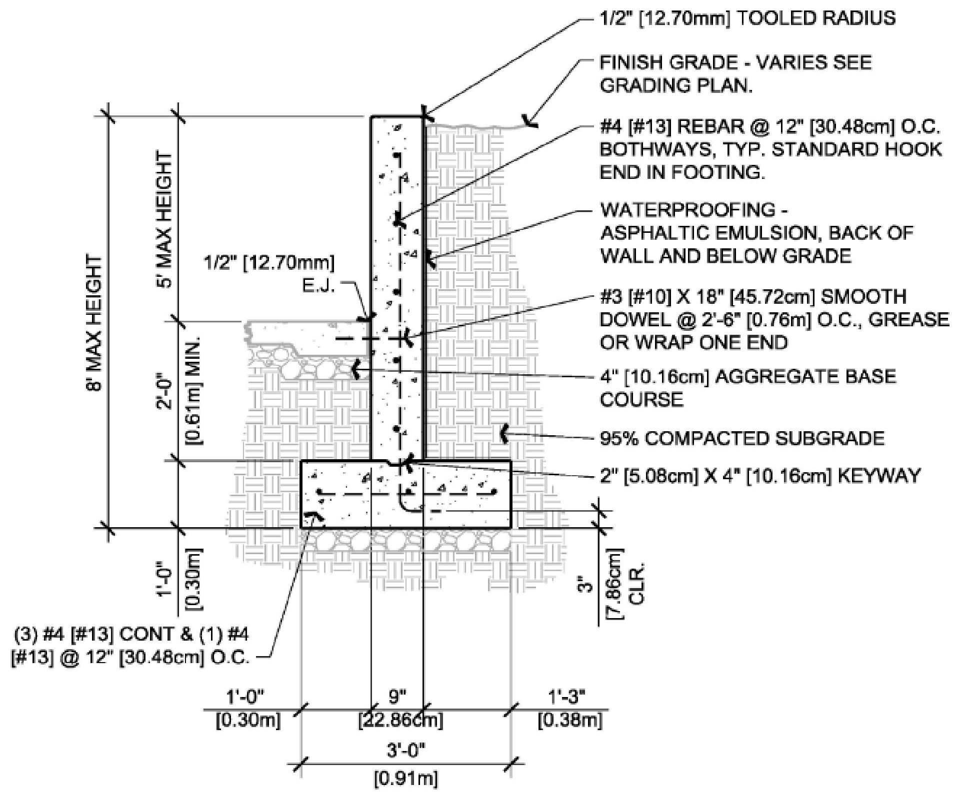
3 typical turndown wall

scale: 1" = 1'-0"



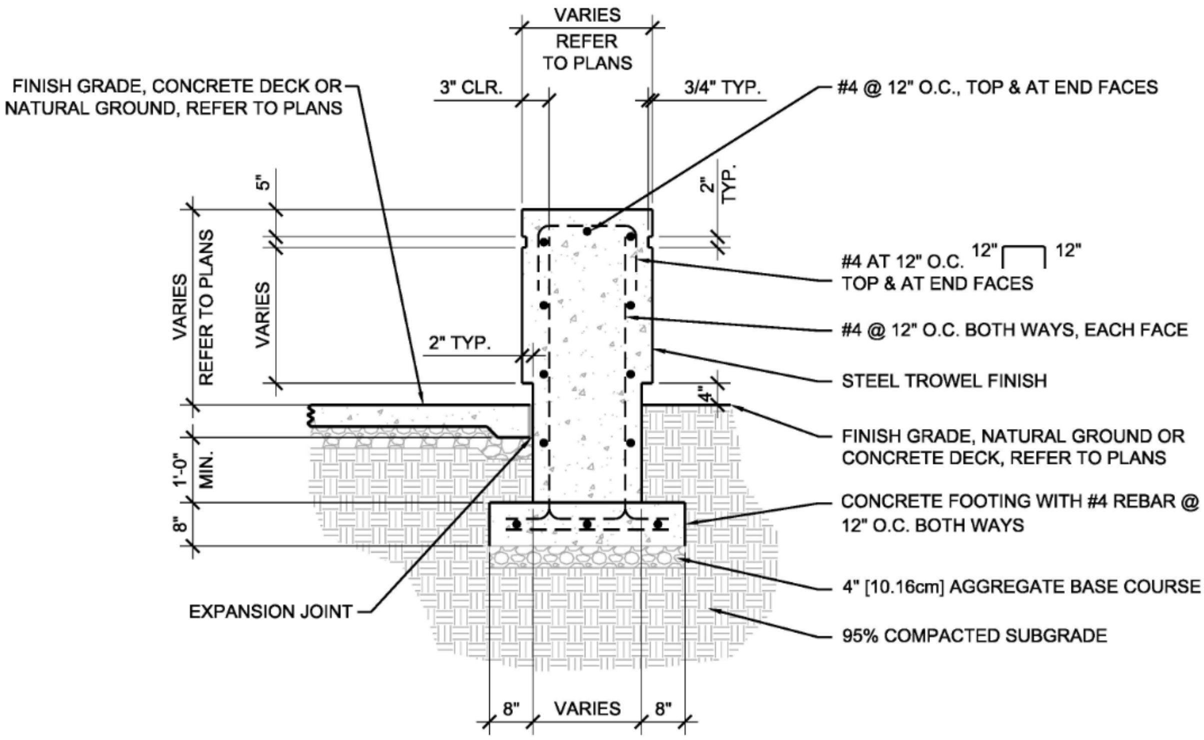
4 retaining wall under deck

scale: 1/2" = 1'-0"



5 retaining wall adjacent to deck

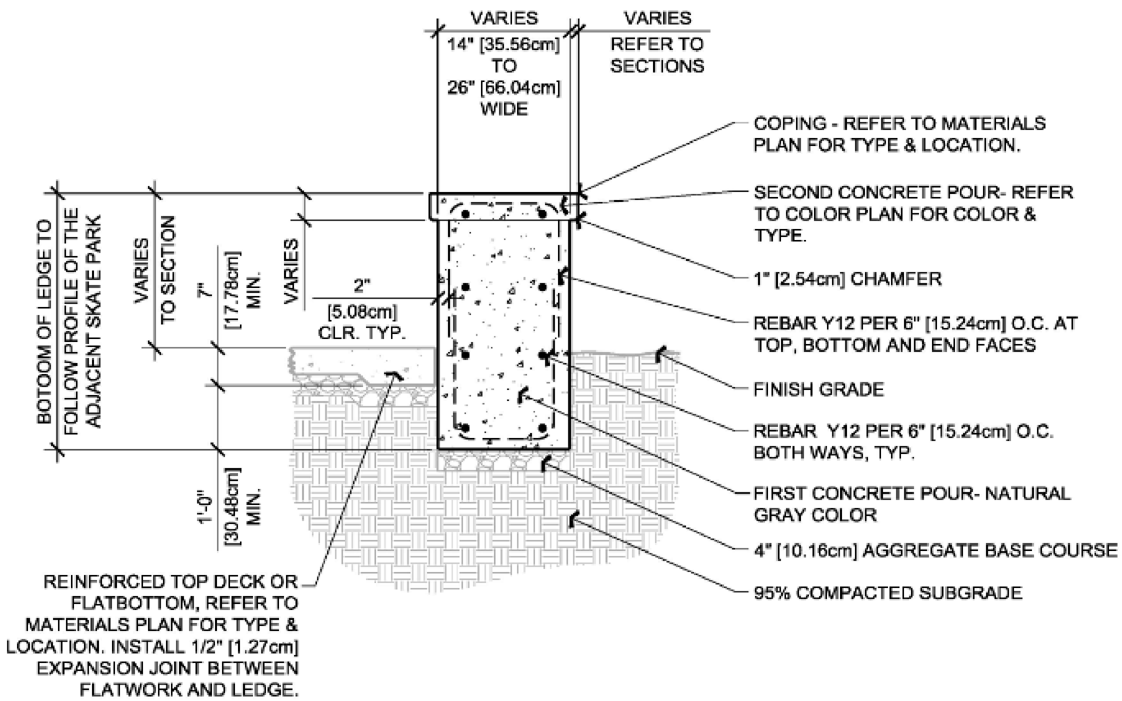
scale: 1/2" = 1'-0"



ledge section

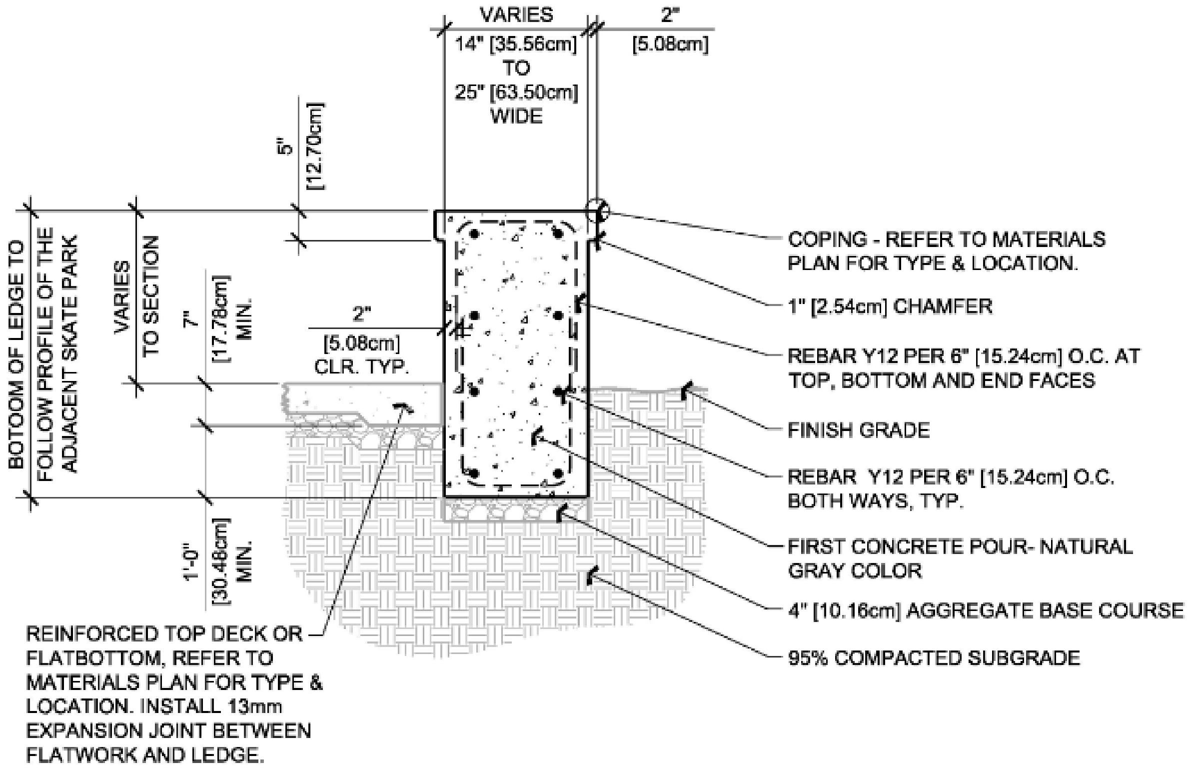
7 notched grind ledge

scale: 1/2" = 1'-0"



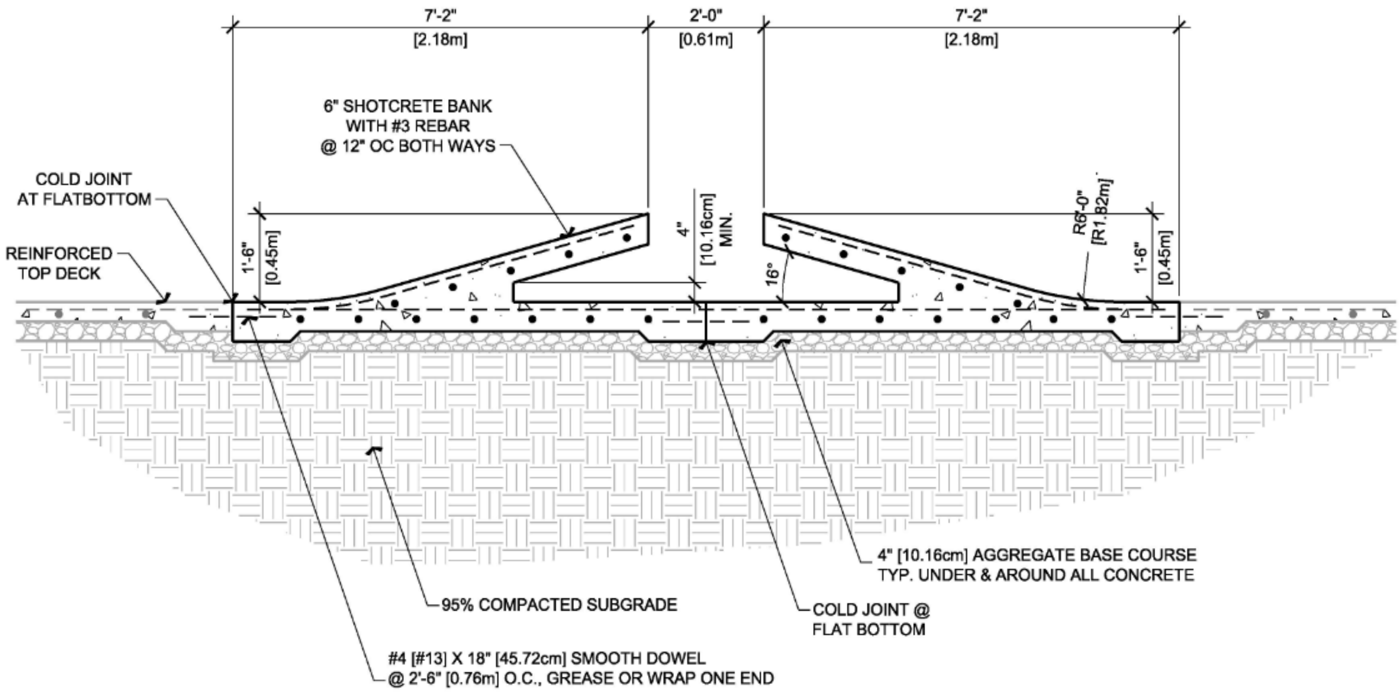
1 capped ledge

scale: 1/2" = 1'-0"



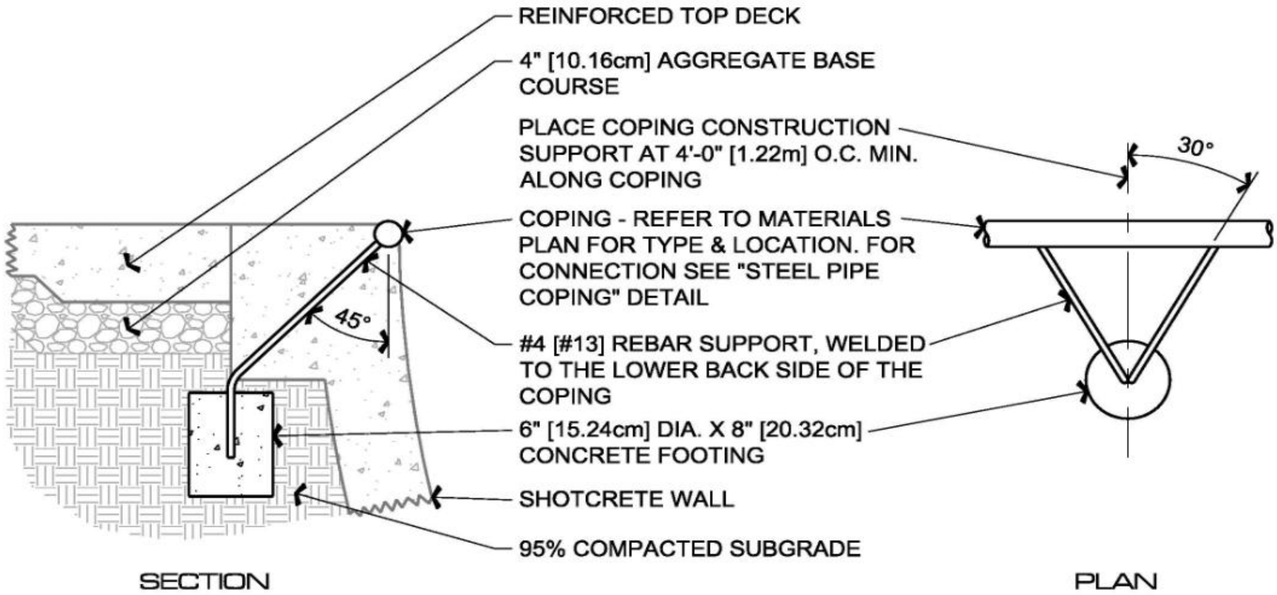
2 cantilever ledge

scale: 1/2" = 1'-0"



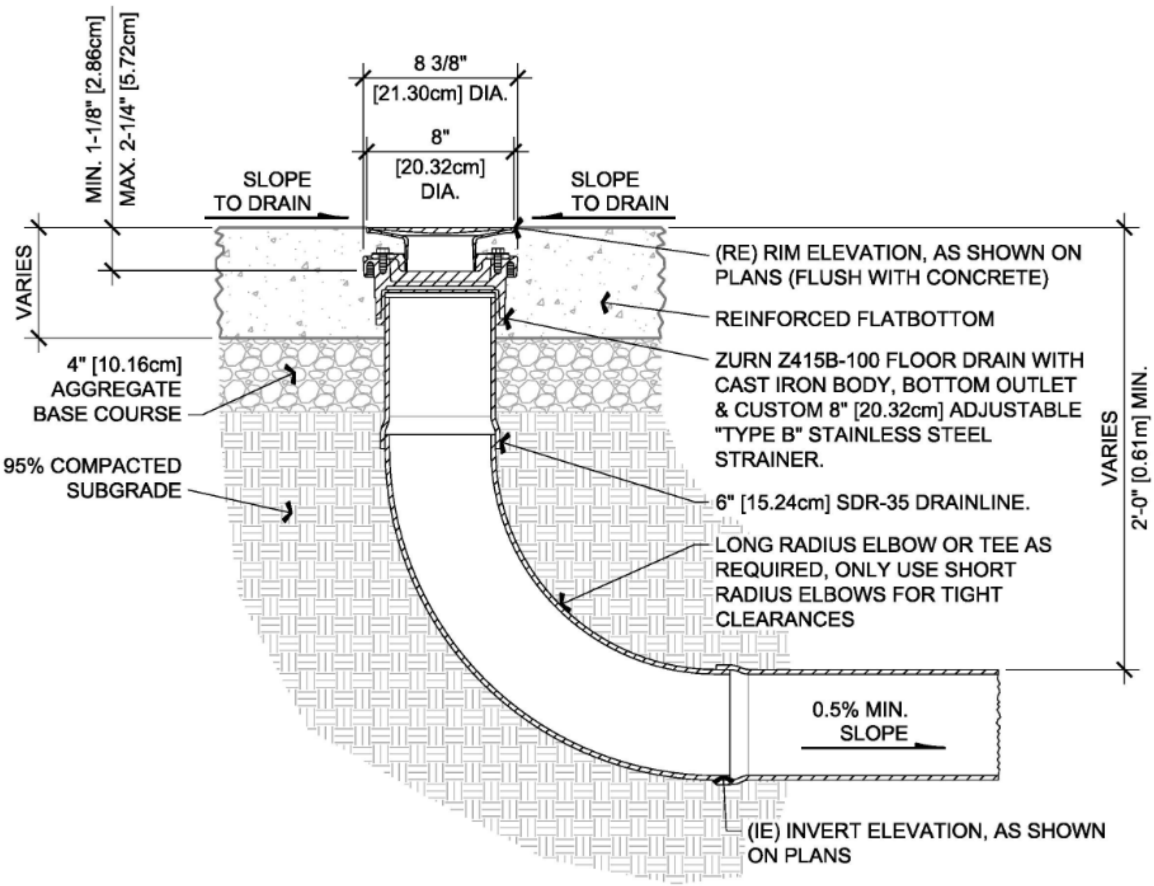
3 floating bank ramp

scale: 1/2" = 1'-0"



4 coping construction support

scale: 1" = 1'-0"



1 drain inlet detail

scale: 1 1/2" = 1'-0"