

Cable Railing Systems

Designing for Building Code Compliance, Maximum Aesthetic Effect, and Sustainability



Guardrail systems that use horizontal stainless steel cables as part of a fully coordinated and engineered system provide safety, security, and a wide range of visual styles

PROVIDED BY: ATLANTIS RAIL SYSTEMS

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Whenver an interior or exterior guard rail is needed, say along a raised deck, floor, or stairway, that guard rail needs to meet some specific structural requirements dictated by building codes and standards to protect the safety of people standing or walking along that guard rail. Guard rails can also be a strong, visual, element of the design of the space where they are used. On one hand, they can be intended to look heavy, bold, and traditional or conversely can be designed with a minimized appearance so as not to detract from the surroundings.

Materials used can run the full gamut from wood, metals, glass, concrete, and others. Recently, a popular choice has been to use steel cables run horizontally instead of vertically which often achieves two design objectives. First, the horizontal lines often complement the surrounding design and introduce a feeling of movement along the guard rail. Second, the comparatively small diameter of cables compared to other materials means there is a reduced visual interruption when looking through the guardrails out to the area beyond. That preserves views



or simply allows better visual access between separate areas. For these, and perhaps other reasons, architects have turned to cable rail systems for interior and exterior installations on all types of buildings, in all climate areas, and with all manner of design vocabularies.

With the above in mind, this course provides information related to the best practices for horizontal stainless steel cable railing systems used in commercial and residential applications. It includes a brief overview of cable railing as well as the current general and specific code, safety, and engineering requirements and best practices to create functional, appealing indoor and outdoor railing systems. It also includes an in-depth explanation of stainless steel materials, their elemental makeup, and treatments for increased sustainability. Of significance, it points out the need to select manufacturers of a cable railing system that can demonstrate independently tested and engineered solutions that meet or exceed code and safety requirements. By demonstrating how to identify key design criteria in specifying stainless steel cable railings, it is intended to encourage the development of ideas for creatively integrating cable railing into design projects.

Preface:

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Cable Railing Systems Overview

The use of steel cables in construction is hardly new. They have been used to support bridges, pull trolley cars, and carry building loads since steel was first used in the late 1800s. It was recognized early on that even thin cables created from clusters of steel wire can carry very high tensile loads while adding relatively small dead loads from the weight of the cables. As a flexible material when not stressed, it is also fairly easy to work with. This combination of attributes has made steel cable an attractive choice for many nautical, industrial, and construction applications which sought lightweight, durable, and strong solutions for structures and personnel protection.

The process of connecting the cables to building structures, posts, top rails, etc. is also not new. Many standard and customized hardware solutions have been in use for decades based on proven engineering and performance in the field. Of course, with an industrial and nautical approach to their use, the hardware carried a similarly utilitarian appearance. Over time, as architectural applications were being sought out, connection hardware has become available that is more consistent with architectural design aesthetics. (Of course industrial looking products remain available too.) The variety of finishes on the hardware have also become more available allowing more choices at reasonable cost points.

Currently, manufacturers offer complete railing systems with standard cable types, parts, pieces, and options that can be selected and specified to suit a specific building design. The standard material of choice for the cables and the connection hardware is stainless steel, which requires no other finish, blends well with virtually all design aesthetics, and creates a minimal visual impact. Standard offerings are also available for vertical metal posts and horizontal metal top rails that are all specifically designed to work with cabling and connection hardware to create a fully coordinated, engineered guard rail system. When the use of wood is desired, there are systems that are designed to work with solid wood or composite products provided by others. Any of these systems can typically be used along a horizontal deck or floor as well as be configured for use

along runs of stairs and landings. Some manufacturers also offer optional items such as solid bottom rails and integrated LED lighting that can be incorporated.

Available cable railing systems fall into two basic categories:

Surface Mount Systems

In this case, the hardware that holds the cable is, as the name implies, literally mounted to the surface of posts and other components of the system. This means that everything is visible making the installation of the cabling and connector hardware easy and predictable. These systems also offer greater flexibility in design both for guardrails and for stairs where the required angles are self-adjusting based on using point connected hardware. They also make it easier to adjust the tensioning on the cables to the proper levels. In regards to the impact on the vertical posts, surface mount systems do not require holes drilled all the way through them so the inside of the posts are not exposed to the elements at the point of tension. Since the posts are stressed on the front face, there is typically less overall loading stress on the post. Surface mount hardware is the recommended choice for installing cable on composite railing systems. While all of these advantages are good, there are a few disadvantages to be aware of. The obvious one is that the hardware is all visible which may or may not be consistent with the design intent of the railing. Since all of that visible hardware is likely high polished finished and mechanical, surface mount systems are usually higher in price compared to other options. Generally, cable railing hardware is only installed at the termination of run, end and corner post, and in some cases can transcend corners. All mid posts, regardless of material are usually drilled to allow cable to pass through.

Through-Post Systems

In this type of cable railing system, the end and corner posts (regardless of material) are drilled through so the cable and mounting hardware can pass from the front to rear side allowing for fastening and tensioning on the rear

side of the post. This is a fundamentally simpler design with the hardware mostly hidden from sight. It also usually carries a lower price than surface mount systems. There are, however, some significant points to be aware of related to through-post systems. First is the limited choices of hardware that are appropriate to this installation which may or may not be an issue with the overall design. More significantly is the impact on the posts which will be exposed to the elements at the point of tensioning and will need to be considered in the design. Like surface mount, the mid posts should all drilled for cable to pass through, but tension will be applied to end and corner posts from behind where the elements can have access to the inside of the post. Material choice is critical for this reason when using wood for posts. Corners will require either double posts (one for each direction of cabling) or the cable heights will need to be staggered in a single post. The tensioning of the cables is a bit more labor intensive due to the concealed nature of the system. Since the post will be loaded from behind, not the front, it will impose different stresses on the post and is not advised for posts made of composite materials. If this type of system is used for stairs or other angled installations, then some very precise drilling will be required.

The decision on which type of system to use will be based on project requirements, the overall building design, and other relevant design considerations. Both are common and ultimately, it is the choice of the architect to specify the preferred version and design accordingly.

Building Code and Engineering Considerations

Regardless of the type of system used or materials selected for the non-cable components, all cable railing systems must meet some stringent requirements as discussed further as follows.

Guardrail Code Basics

The International Building Code (IBC) and the International Residential Code (IRC) have some long-held standards related to guard rails in general. That said, local and state



code requirements may differ and must be complied with. Both codes require guard rail protection any time there is a walking surface that is 30 inches or more above the adjacent walking surface (grade or floor surface below) as a basic standard for fall protection (IBC 1015.2/ R312.1.1). It may be acceptable to omit such a guardrail only if the height difference between walking surfaces is less than 30 inches. If placing a guard rail where not required the design and installation should be consistent with the manufacturers engineered design, and not altered by reasoning that a guard rail is not required. The height of the guard itself is viewed as a significant aspect for safety, although there are some variations in the minimum acceptable height. The IRC states that 36 inches is the minimum height for residential guards (R312.1.2) while the IBC requires a minimum of 42 inches for commercial guards (1015.3). There are some local variations such as the state of California which requires a minimum height of 42 inches everywhere. There are also some specific exceptions called out in the IBC for special conditions such as assembly occupancies and certain multifamily buildings.

The codes recognize that most guardrails are not solid materials, but rather, are made up of spindles, rails, cables, or some similar linear materials. Therefore it becomes the spacing between those components that is critical for safety. Here, all of the codes state that a 4 inch sphere cannot pass through any part of the railing (IBC 1015.4/ R312.1.3), which often prompts most railing systems to space components 4 inches apart. There are exceptions for the area directly above a stair tread, where a 6 inch sphere cannot pass through.

It is important to recognize that there are separate code requirements related to hand rails on stairs which are defined as the place where a person grips a railing (with its own set of requirements) and are separate from the requirements for a guard rail along the stairs. The height of guardrails along stairs must be between 34 and 36 inches in height above the front face of stair treads and have other detailed requirements (IBC 1014/ R311.7.8). In cases where the stairs are open (i.e. no wall to enclose them), then the requirements for both handrails and guard rails need to be coordinated.

Cable Railing Specific Code Compliance

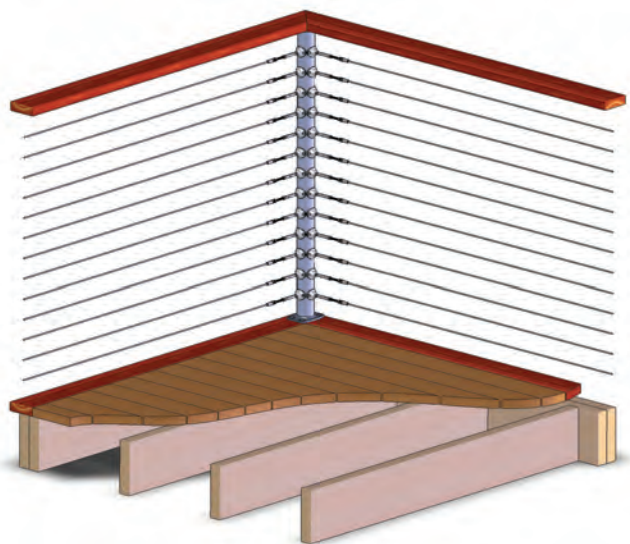
When designing a code compliant cable railing system, there are some specific things to be aware of. The first point is to recognize that even a taut cable will deflect when pressure is placed on it. Therefore, managing that deflection is the key to code compliance for the spacing of the cables. Commonly, in order to insure that the horizontal cables will not exceed the maximum 4 inch spacing when deflected, the installed cables should never be spaced more than 3 inches apart.

The vertical posts in a cable railing system play a significant role in safety and code compliance of a guard rail system too. In addition to providing the means to resist the horizontal force from people along the guard rail, they help restrict the amount of deflection in the cables by virtue of their spacing and rigidity. The general recommendation is to never space posts more than 4 feet apart when cable is spaced at 3". However, if spacing posts more than 4 feet apart is preferred, then a "cable stabilizer" can be used which will act to restrict cable deflection when the post spacing is up to 7 feet between them. Cable stabilizers are not structural and only one cable stabilizer can be used per section. Regardless of the post spacing, a solid material top rail must always be used that runs horizontally between the posts and above the cables. Such a top rail needs to be capable of handling both tension and lateral forces along the top.

There is one aspect of cable railing code compliance that occasionally comes up, but is usually mistaken. Before the IBC and IRC became the dominant building codes, some earlier requirements restricted the use of any horizontal exterior building elements since they created a "ladder effect" which was thought to compromise safety. This provision was removed long ago primarily because there were too many disagreements over what constitutes a ladder compared to other horizontal building elements. Therefore, horizontal cable railing systems are fully code compliant under the IRC and IBC with any reference to any such "ladder effect" by a reviewer being woefully outdated.

Engineering Criteria and Best Practices

Beyond code requirements, cable railing systems are based on some known engineering criteria with a variety of common best practices. First, these systems rely on



Code requirements specific to cable railing systems include attention to height, cable spacing and post spacing

sustained high tension in the cables to safely serve their purpose as a guard rail. Thus, all components, especially post and rails, must be designed to account for the imposed tensile stresses. Proper tensioning exerts about 200 to 240 lbs. of tension per cable strand. That means a 36" high guardrail with up to 11 cables will yield 2,640 lbs. of tension on an end post. It is important that both the post structure and the fastening system used will support that load with very little or no deflection.

Top rails must comply with the building code for load, but they must also be structured to keep the posts from moving or buckling under tension. Commonly, that means resisting on the order of 2,000 pounds of force. This may be easy to accomplish in some metal systems, but wood or composite systems typically require a braced rail to assist in load resistance.

Of course, since all systems are engineered and manufactured by different companies, it is always advisable to consult the manufacturer's engineering data, testing information and installation instructions. Manufacturers will commonly provide this information as well as recommendations for the best ways to design and install their specific systems consistent with independent testing reports.

Stainless Steel as the Material of Choice

Stainless steel is a relatively common and proven material in construction which is readily available. In order to better understand why it is the material of choice for cable railing systems, we look closer at its makeup and traits as follows.

What is Stainless Steel?

Stainless steel is defined as a corrosion resistant Iron alloy containing a minimum of 11 percent Chromium. Changing the amount of Chromium and adding other elements such as Nickel, and Molybdenum creates different types and grades of stainless steel. These elements are described as follows:

- **Iron (Fe):** Typically stainless steel contains between 74 and 64 percent Iron as the base material.
- **Chromium (Cr):** Chromium is the significant added element in stainless steel. This is the element that provides the bright finish, similar to chrome on an automobile in many ways. When in contact with Oxygen, it forms a natural barrier of Chromium Oxide called a "passive film" that is only about one ten thousandth of the thickness of a human hair. This is the protective layer which is impenetrable to water and air, helping the metal to resist corrosion.
- **Nickel (Ni):** The advantage of Nickel is that it is less susceptible to highly corrosive compounds than Chromium. It also has a cathodic property that neutralizes the protective layer so it doesn't break down.



Stainless steel is a corrosion resistant iron alloy that contains chromium and other elements making it particularly well suited for salt water and other environments

- **Molybdenum (Mo):** Harder and more heat resistant than Chromium and Nickel, Molybdenum it is more resistant to pitting and crevice corrosion in chloride-contaminated media and sea water. It also has the 6th highest melting point of any element (4,753 degrees F).

All of these elements are "transitional metals" which means their ability to connect and interact with other elements exists in different atomic shells and are changeable – i.e. transitional. It also means they can develop an oxide layer when adapting to changes in the atmosphere and they can be combined with other transitional elements to create metals with certain desired properties. For example, Iron develops a protective oxide layer we call rust (dark and flaky). By comparison, Chromium develops a protective oxide layer called Chromium Oxide (shiny and smooth) that protects the Iron.

Stainless Steel History

Stainless steel is a relatively new material. The alloys needed to make stainless steel were not discovered until the 1700's; Nickel in 1751, Molybdenum in 1778, and Chromium in 1797. By comparison Copper was discovered more than 10,000 years ago and Iron was first used by humans around 2000 BC. The first US patent for stainless steel was granted to Elwood Haynes in 1919.

Stainless Steel Types

Currently, there are 5 types of stainless steel commonly used; Ferritic, Austenitic, Martensitic, Duplex and Precipitation Hardened (PH). Within these types, there are 29 commonly used grades available for hundreds of different applications. The most popular type is Austenitic

accounting for as much as 70 percent of the stainless steel manufactured. The most common grade of stainless steel produced is classified by the number 304 which accounts for approximately 50 percent of world production. It is used in some cases for architectural applications, but since it lacks the corrosion resistance required for many architectural uses, Austenitic 316 stainless is usually recommended for cable railing.

Austenitic 316, which has a minimum Chromium content of 16 percent, is manufactured by adding Molybdenum (Mo, or moly) to a 304 mix and adjusting the percentages of Chromium and Nickel to achieve the additional corrosion and heat resistance. Austenitic 304 contains 8-10.5 percent Nickel, 18-20 percent Chromium, .08 percent Carbon and approximately 72- 68 percent Iron. By contrast, 316 Stainless has more Nickel at 10-14 percent, a little less Chromium at 16-18 percent, introduces 2-3 percent Molybdenum, has about the same .08 percent of Carbon and slightly less Iron at 71 to 64 percent. There is also a low carbon version (316L) which contains a maximum of .03 percent Carbon and is optimal for cable railing. Either way, the resulting Austenitic 316 is characterized by enhanced surface quality, formability, increased corrosion resistance and heavy wear resistance compared to 304.

Corrosion Resistance

One of the things to keep in mind about these products is that they are “stain-less”, not “stain-proof.” There can still be some things in the environment that can stain or discolor the metal, particularly if the wrong type or grade of stainless steel is used. The best defense against corrosion is based on selecting the best material, finish and treatment. For best results on cable railings and guards, using only Austenitic 316L is recommended. Further, during installation, the cables should be immediately cleaned to remove oils or free ions that may be present. Cleaning should only be done using mild detergent, car wash soap is recommended, and avoiding commercially available “Stainless Steel Cleaners” as most contain harsh chemicals.

Another common concern is galvanic corrosion, which is caused by using dissimilar metals in a corrosive environment without proper insulation or separation between those materials. Generally speaking, the most common galvanic corrosion on railings occurs between aluminum and stainless steel or steel in salt water environments. Metals that are finished with anodic properties, such as anodized aluminum, tend to be sacrificed or even dissolve in these conditions when in contact with cathodic materials such as stainless steel. Hence, proper separation of any other materials needs to be detailed and installed correctly.

Metal Finishing

Stainless steel is often finished during manufacturing to create a superior Chromium Oxide layer and remove

Myth Busted – is 316 Stainless Steel Magnetic?

The degree of magnetism of a material is called out as magnetic permeability. A permeability of 1 is non-magnetic. Two elements of stainless steel, Chromium and Molybdenum have a permeability of 1 and are therefore not magnetic. However,

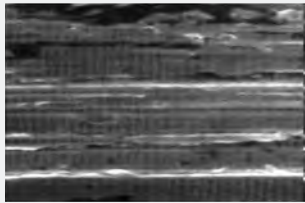
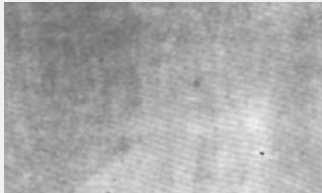
Iron and Nickel are both magnetic materials and collectively make up approximately 80 percent of 316 stainless steel. Iron has an initial magnetic permeability of 1150 and Nickel has an initial magnetic permeability of 110.

Interestingly, when these basic elements are combined to make 316 stainless steel the transitional nature of the product creates a radical change in the grain structure that renders 316 stainless “nearly” non-magnetic in its original state despite the high content of magnetic material.

That said, when 316 stainless steel is taken from its original state as formed into ingots, plate or raw wire, and made into products such as cable by performing work (casting, forging, drilling, forming, welding or drawing), the grain structure changes and the stainless steel most always becomes magnetic to some extent. Cold working causes the biggest change because there is no relaxing of the grain structure. Wire rope (cable) manufacturing is an example of extreme cold working. Hence, depending on the degree of cold working, the ultimate magnetism of 316 stainless steel can vary between very little and a lot of magnetic permeability.

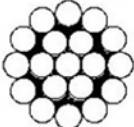
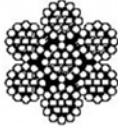
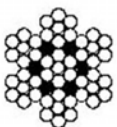
impurities (iron) from the metal surface. There are two ways to carry out this finishing:

- **Passivation:** This is the application of citric acid or nitric acid to the metal, followed by a complete water rinse. It is usually done in a tank within a specific temperature range. Welders often field passivate their work using a citric acid paste. These welds are a potential place for future corrosion
- **Electro-polishing (Super Passivation):** This process adds an electrical current in a tank environment to further smooth the metal surface while achieving passivation. It is the ultimate metal treatment for corrosion resistance since the current and the acid work together to clean and smooth the metal surface thus developing a superior and uniform Chromium Oxide layer. This is an excellent choice for any exterior condition but in a salt-water environment in particular, electro-polished materials should always be used.

Before: Electro-Polish**After: Electro-Polish**

In electro-polishing, electrical current and acid work together to clean and smooth the surface of stainless steel thus developing a superior and uniform Chromium Oxide layer

Working Load & Cost Comparison

				
		1 x 19	7 x 19	7 x 7
	Cost	+ 29% \$	+ 9% \$	Lowest \$
	WLL	WLL	WLL	WLL
Size				
1/8"	Lowest \$	1,800	1,600	1,360
5/32"	+ 30% \$	2,900	2,300	2,200
3/16"	+ 45% \$	4,200	3,400	3,100

Cables used in railing systems will vary in cost and working load capacity based on the type of clustering of wires used in the cable and the overall size of the cable

Components of Cable Railing Systems

With a good understanding of the code, safety, and material aspects of cable guard rail systems, we can now take a closer look at the individual component parts that make up a full system.

Cables

A cable is simply the combination of multiple strands of wires. The strength and characteristics are therefore directly influenced by the thickness of the wires and the number of wires or clusters of wires that make up any given cable. Hence, cables are referred to by the number of wires in a cluster and the number of clusters in a cable. They are then classified by their overall thickness. Accordingly a 1x19 cable is made up of one cluster of 19 single wires while a 7x19 cable is composed of 7 clusters but with 19 smaller wires in each cluster. Similarly, a 7x7 cable will have 7 clusters of wire bound in sets of 7 in each cluster. Any one of these options could be a total of 1/8", 5/32", 3/16", or 1/4" thick

based on the thickness of the individual wires used. The working load (WLL) and the cost of each type of cable are, of course, directly affected by the type of cable used and the size.

Based on the above, the design question quickly becomes, what is the best cable to use? The common safe working load is 2 times the work load (WLL) load of a cable, taking into account the number of cables used. For most residential and commercial guard rail situations, it is highly recommend to use only 1 X 19 cable and generally 5/32" diameter is appropriate – 2 times its working load will be 5,800 lbs. and satisfy most guardrail loading conditions. 1/8" is the minimum diameter that may be used safely, but it has a working load 38% less than 5/32" which is usually acceptable for residential use. Nonetheless, the cable will be the strongest part of the system. That is not usually the case for other types of guard rail systems, particularly if they use vertical, composite balusters which will often break under as little as 250 pounds of applied pressure.

Step 1



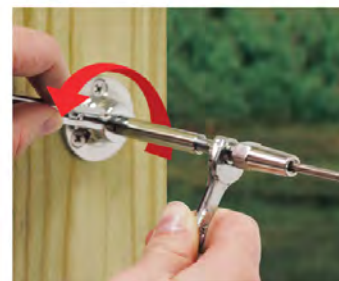
Fully seat wire rope.

Step 2



Tighten cone onto receiver.

Step 3



Rotate body to tension.

Mechanical connection of cables to posts relies on specialty hardware and common hand tools and is often used for surface-mount systems



Swaging is the practice of forming a metal receiver around a cable using a hand tool or machine, such that the two components become virtually one

Cable Attachment Hardware

The cables need to be attached to vertical posts in some manner in order to be anchored and tensioned. There are two basic ways to do that. The first is with hardware that is designed to receive the cable and be mechanically attached and tensioned using specific hardware and common hand tools. This hardware is typically made of the same stainless steel that the cable is and is sized to match the size of the cables used. Mechanical attachment of the cables is most common for surface mount systems, particularly since hardware is available that is intended to be screw attached to wood or metal posts. The connection to the cable is done by tightening nuts or specialty hardware around the cable and tensioning as required.

The second means of attachment is to use different specialty hardware that is attached to the cable using a swage tool. Swaging is the practice of forming a metal receiver around wire cable in such a way that the two components become virtually one. Essentially, the swage hardware is hollow to receive the cable and a swaging hand tool or machine can be used to compress the hardware around the cable. Swaging is the highest strength cable connection available when done properly. Swaging is most commonly used for through-post cable attachment but can be used for surface-mount systems in some cases too. Tensioning of the cable is done on the rear side of the post commonly using a nut or similar hardware tightened down on a stud that is swaged to the cable.

Vertical Posts

The posts in a guard rail system receive and support the wire cables and are the ultimate receivers of most loads imposed on the guard system. To that point, it is appropriate to consider the load limitations of any posts selected. There is little wisdom in specifying a very heavy duty cable (say 1/4" thick) capable of carrying up to 7,100 pounds each if the posts in the system can only carry a fraction of that load. Coordination of the cable and post loading is thus worth addressing. Note that this loading is typically transferred to end posts or corner posts. Mid span posts are simpler and generally simply support the tensioned cable, allowing it to pass through the post. In order to limit cable deflection, however, the mid span posts should be spaced no more than 4 feet apart unless a cable stabilizer is used allowing spans up to 7 feet.

When deciding on post design, the first decision is which material to use, typically wood, composites, stainless steel, or aluminum to match or complement the rest of the building design. Each material carries its own characteristics and considerations based on the size of the post. For example, a 4x4 wood post can be the least costly and most flexible design choice, but if an 8x8 wood post is selected, the cost escalates and it can become difficult to work with. Wood also carries the highest maintenance compared to stainless steel or aluminum, often making the metals a more attractive choice in many cases. Aluminum is not as strong as stainless steel, however, and often requires some manufactured reinforcement, not to mention separation from stainless steel cables to prevent galvanic corrosion.

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Post Material Selection								
Materials	Wood			Stainless Steel			Aluminum	
Factors	4 x 4	6 x 6	8 x 8	1.5 x 1.5	2 x 2	3 x 3	3 x 3	4 x 4
Cost	Least	Average	Above Average	Average	Above Average	Most	Average	Above Average
Design Flexibility	Wood is the most flexible and least expensive option available. Wood can be combined with other materials and is easily worked for customization.			Stainless Steel is still flexible due to superior strength on smaller profiles. Stand alone post available for combination with wood.			Aluminum is least flexible and usually requires a full system, no stand alone post. Aluminum usually requires extrusion to render it strong enough.	
Strength	Good	Best	Overboard	Good	Excellent	Overboard	Must be integrated	Must be integrated
Workability	High	Average	Difficult	Must be fabricated	Must be fabricated	Must be fabricated	Must be fabricated	Must be fabricated
Fabrication required	no	no	Possibly	Yes	Yes	Yes	Yes	Yes
Maintenance	High	High	High	Low	Low	Low	Average	Average
Labor Cost	Low	Low	Mid	Low	Low	Low	Mid	Mid

Chart summarizes some of the factors that influence the selection of post materials

Top Rails

Top rails are a very significant part of a cable railing system since they provide some compression support between the posts and contribute to the overall functioning of the system. Typically, these railings must withstand a 50lb. distributed load and a 200 lb. load in any direction. When using a completely fabricated system, manufacturers' recommendations and specifications should be followed to be sure that the top rail works in concert with the rest of the railing system. This is particularly true if a wood or composite top rail is used since it may require reinforcement of some type. Care must also be taken that the railing installation and fastening is adequate to withstand the pressure applied by the cable tensioning without buckling or deflection of the top rail.

Green Building Characteristics Of Cable Railing Systems

All building products are routinely reviewed by architects and others for sustainability traits and quite often for how they can help contribute to certification under the LEED® green building program or others. The U.S. Green Building Council has developed the well-known LEED® rating system to recognize and certify buildings that can be considered to be green or sustainable. Cable railing systems can be used to help contribute to earning LEED credits for LEED for New Construction, LEED for Homes, or other versions of this popular program. They have also contributed to other green building standards including National Green Building Standard (ICC-700), and Earth Craft. Hence it is worth recognizing the following green building attributes of cable railing systems.

Materials and Resources (MR)

A prerequisite for any LEED building is to reduce the impact of construction materials. Along this line, the average stainless steel building component contains 60% recycled content, at least 25 percent of which is post-consumer, post-industrial. Looking more broadly, LEED recognizes efforts to address the environmental impacts of materials over their full life cycle. Towards that end, a Life Cycle Assessment (LCA) protocol is used to support certification points for this MR credit. Typically stainless steel has a very long life cycle, outlasting galvanized steel by a factor of 10. It is also 100 percent recyclable when it has completed its service life and provides no environmental toxicity in the process. By using this information, the environmental impacts can be determined of stainless steel and the railing systems made from them.

Indoor Environmental Quality (EQ)

Healthy indoor environments are paramount among many green building rating systems including LEED®, the WELL building standard, and The Living Building Challenge. In particular, the use of building materials inside of buildings that do not contain or emit substances that are harmful to human health has been a major motivation behind the creation of these standards and criteria. Their refinement and sophistication have helped define a good quality, healthy indoor environment. In that light, stainless steel railing systems are very favorable since they require no site-applied finishing over their lifetime, thus helping to avoid the introduction of VOCs or other harmful substances.

Specifying Cable Railing Systems

When specifying cable railing systems, we have seen that there are clearly a range of choices and options to select from. Coordination with manufacturers during the design phases of a project will help gain insight for project specific details, cost drivers, installation nuances, and the latest options. In a standard CSI or MasterFormat, the usual location to include this specification is in Section 05 73 00 “Ornamental Railings”. Some of the relevant items to address in a standard 3-part specification format are highlighted as follows.

Part 1 - General

The scope of specification work can include all preparation work, structural system review, product choices, and final installation. In terms of specifying performance, the appropriate ASTM and other testing standards should be referenced including:

- o ASTM A554 – Standard Specification for Welded Stainless Steel Mechanical Tubing
- o ASTM A492 – Standard Specification for Stainless Steel Rope Wire
- o ASTM E985 - Standard Specification for Permanent Metal Railing Systems and Rails for Buildings
- o ASTM E935 - Standard Test Methods for Performance of Permanent Metal Railing Systems and Rails for Buildings

Submittals should demonstrate compliance with code requirements including submission of certified third-party test reports for verification of all code, engineering, and performance criteria of the system. For custom systems shop drawings prepared by a qualified manufacturer should be submitted indicating verification of the proper material choices and attachment systems. For standard systems a qualified manufacturer should provide sample design drawings, third-party test reports and installation instructions. Where the appearance or assembly are a particular concern, then samples and/or mock-ups should be provided either by the manufacturer (low cost or free) or by the contractor (cost).

Quality assurance is clearly an important part of any field installed system and the same is true here. Manufacturer qualifications should include references, certifications such as ISO 9001-2015: Quality Management Systems (QMS), and the ability to provide assistance with design and code compliance for their products. That may include the availability of an experienced engineer to assist as needed. Installers should have qualifications acceptable to the manufacturer although it is reasonable to request a list of completed projects in the previous 2 years and recommendations for a distributor or local source.

Part 2 - Products

All of the different cable railing products used in the building should be called out and specified. If multiple products are used, then they should be identified by type in the specifications and the locations of each type needs to be clearly called out in either the drawings or specifications. The details of the specified products can include:

- Specify 1 x 19 Austenitic 316L stainless steel construction cable in a minimum diameter of 1/8”, with 5/32” recommended for full strength capabilities.
- Specify all 316L (low carbon) stainless steel if the railing is near the ocean.
- Specify the type of fastening and the nature of the fastening components needed.
- If posts and railings are part of the system, the particular size, profile, and type need to be called out.
- For coastal areas specify electro-polished railing and components.
- Always require compliance with ASTM materials standards wherever possible
- Use caution in combining aluminum or steel with stainless steel cable and fittings
- When specifying a wood frame system select appropriate wood materials suited to the environmental needs of the project.

In addition, all fasteners, any trim or accessories need to be identified in the specifications all as part of a complete, coordinated system.

Part 3 - Execution

As with any site installed product, the installation requires multiple steps which need to be clearly articulated in the specification in order to achieve the best results.

- Examination and Preparation: The importance of this step should always be stressed. In addition to the architect, the installer should review and examine the area to receive the railing to be sure it is complete, structurally sound, and able to support the imposed railing loads.
- Installation: The cable railing system should be installed according to the layout shown on the drawings and the specific installations instructions presented by the manufacturer. If there is any doubt, then the default spacing is 3” maximum for cable spacing and 4 feet maximum for post spacing.
- Cleaning: Upon completion, the cable and hardware should be cleaned to remove any miscellaneous oil, dirt, impurities, etc.

When specified and installed correctly, the cable railing system should provide the desired look and provide the long-term performance characteristics that are sought.

Case Study: Hospital



Health Center

Location: Monroeville, AL

Architect: Paul Carpenter Davis Architecture, PC

Design Challenge: This busy health care center needed to provide a safe guardrail system to protect patients/visitors from the adjacent roadway. Matching the existing color scheme was also particular design criteria.

Solution: A complete, coordinated cable railing system was selected and specified using 3" x 3" powder coated square aluminum posts in bronze color formed the basis of the guard railing. Horizontal cables using 1/8" 1 x 19 316L stainless steel cable were connected using 316L hardware.

Result: A low maintenance, easy to install product was provided quickly since it was readily available from the manufacturer.

Solution: Surface mounted hardware was secured to the existing posts and with cable stabilizers used in post spans between 4'-7' (on both level and stair runs) thus minimizing the amount of cable and hardware needed. The railing was 5/32", 1 x 19 316L stainless steel cable with the same type of stainless steel tensioning and non-tensioning hardware and cable stabilizers.

Result: The solution avoided having to replace the existing posts while also giving the buildings a more modern, revitalized look.

Case Study: Restaurant and Beer Garden

Location: Cincinnati Zoo & Botanical Garden - Roo Valley

Architect: Gregory Gates Architect

Design Challenge: The project needed to accommodate a variety of conditions including level rails, angled stair rails, gates, and an ADA compliant ramp with grab-rails.

Solution: In order to maintain a consistent look based on the design, the manufacturer customized the system to accommodate the ADA handrail requirement with angled post bases for the sloped surface of ramp. Similar customization occurred for the stairs and custom gates. The posts are 1 1/2" square heavy gauge stainless steel surface mount posts, powder coated black, with 2 x 4 hardwood top rail. The stainless steel cable and attachment components are 1 x 19, 316L stainless steel.

Result: A code compliant solution for all of the project's custom needs were met while achieving a low-profile modern look. The stainless steel materials provide strength, durability and low maintenance.

Case Study: Lake Front Cabins




Lake Front Cabins

Location: Lake Walker- Camp Shelby, MS

Architect: JBHM Architecture

Design Challenge: Existing wood posts in the cabins needed to be retained but the guard rail infill needed to maintain code compliance, achieve maximum aesthetics, and control costs.

Conclusion

When it comes to selecting a guard rail system for interior or exterior locations on buildings, there are some specific considerations to take into account related to safety, performance, and overall design. While some traditional choices have been used for years, stainless steel cable railing systems have emerged as a clear choice with many advantages due to their inherent traits for performance, appearance and sustainability. Specifying and designing such systems in a variety of buildings and settings is a proven, long lasting, durable, and easy to maintain solution, provided the architect understands the choices and options available from manufacturers. 

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Images: Courtesy of Atlantis Rail Systems

Test Questions

Cable Railing Systems

1. The standard material of choice for cables and the connection hardware is stainless steel because it:
 - a. Requires no other finish
 - b. Blends well with virtually all design aesthetics
 - c. Creates a minimal visual impact
 - d. All of the above
2. What aspect of cable attachment is the same for both surface mount and through-post systems?
 - a. The cable attachment is only on the front face of all posts
 - b. The mid posts are all drilled for cable to pass through
 - c. The loading on the posts is the same for both systems
 - d. It doesn't matter what the post material is for either system
3. The IRC states that 36 inches is the minimum height for residential guards while the IBC requires a minimum of what height for commercial guards?
 - a. 42 inches
 - b. 36 inches
 - c. Between 34-36 inches
 - d. 32 inches
4. For horizontal cable railing systems to be fully code compliant under the IRC and IBC which factor is outdated and no longer applicable?
 - a. Accounting for cable deflection in cable spacing
 - b. The "ladder effect"
 - c. Allowing for designated sphere sizes not to pass through cabling
 - d. The proper spacing and strength of vertical posts
5. Austenitic 316 has a minimum Chromium content of?
 - a. 20 percent
 - b. 18 percent
 - c. 16 percent
 - d. 10 percent
6. For best results against staining and corrosion on cable railings and guards, using only what type and grade stainless steel is recommended?
 - a. Austenitic 316L
 - b. Austenitic 304
 - c. Any type with more than 10 percent Chromium
 - d. Any grade as long as it is Ferritic type
7. A 1x19 cable is made up of:
 - a. 19 clusters of 19 single wires
 - b. One cluster of 1/8 inch diameter wire
 - c. One cluster of 19 single wires
 - d. None of the above
8. The highest strength cable connection available, when done properly, is:
 - a. Mechanical connections
 - b. Swaging
 - c. Surface mount only
 - d. Through-post only
9. The average stainless steel building component contains up to what percentage of recycled content?
 - a. 30 percent
 - b. 40 percent
 - c. 50 percent
 - d. 60 percent
10. When specifying stainless steel cable railing products, all of the following are recommended EXCEPT:
 - a. Specify 1 x 19 Austenitic 316L stainless steel in a diameter of 1/8", with 5/32" never needed
 - b. Specify all 316L (low carbon) stainless steel if the railing is near the ocean
 - c. Specify the type of fastening and the nature of the fastening components needed
 - d. For coastal areas specify electro-polished railing and components

This article has been submitted to ALA and AIA for 1 LU/HSW and is pending approval. Please email ala@alatoday.org for status.

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