

LICENSED ARCHITECT



Association of
Licensed Architects

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Fall 2023



Solar for Architects Pt II

Cable Railing Systems

Wood Framing Connections

CONTENTS

Articles

- 8 Solar for Architects Pt II:
A Building Electrification
Trend that's Here to Stay



- 12 Continuing Education:
Cable Railing Systems



- 24 Wood Framing:
Connection Considerations for Uniquely
Framed Wood Designs



04

Featured Firms



06

Departments

| | |
|--|----|
| President's Message | 3 |
| AI - Friend or Foe? | 28 |
| Continuing Education Providers/ ALA New Members | 31 |
| Index of Advertisers | 31 |

Cover Photo:
Chicago Lakefront Condo (Lenore Weiss Studios)
Photo by: Norman Sizemore



Fall is a time of thanksgiving, and we are thankful for the support of our members. We're also proud of our association, which fosters continual learning, valuable relationship building and a warm, collegial atmosphere. I would also like to thank our board members for their service and introduce you to two new board members: Jay Cox, ALA, RA, NCARB, SAME, serving as Director, and Tamsan Mora, serving as Associate Advisor. Both are with COBU Architecture Studio. Welcome, Jay and Tamsan.

On October 20, we announced and celebrated the winners of the 2023 ALA Design Awards, held at Medinah Country Club. A total of 20 awards were presented for design excellence in commercial/industrial, institutional, mixed use, single-family, multi-family, interior and unbuilt categories.

This year's winning projects were exceptional and showcased lightness, innovative use of materials and incredible attention to detail. The world's tallest timber structure, a mixed-use development in a busy urban location, an energy company training center, a Mississippi River loft, and an Iowa career center are among the projects winning top honors.

Giving Thanks This Fall

The highest honor, the Don Erickson Presidential Award, went to the world's tallest timber structure, Ascent, Milwaukee, WI, designed by Korb and Associates Architects, Milwaukee, WI. The project also received a Gold Award in the Mixed-Use category. Judges praised the project, remarking on its well-detailed elements and beautiful execution, inside and out.

We also announced the winners of our napkin sketch contest. Participants sketched their interpretations of architectural ornamentation...the art of the detail. Top honors went to Michael Henning, with Pappageorge Haymes Partners, Chicago.

Check out all of the design award and napkin sketch winners on the ALA website. Just click on the Awards tab.

Membership renewal is in process and you can pay easily from your profile once you log in. Our Fall Conference will be covered in the Winter Issue, so stay tuned. Until next time, best wishes to all of you for a healthy and happy holiday season.



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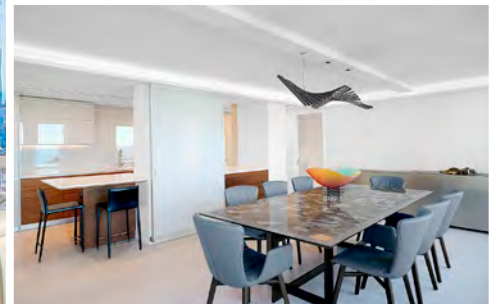
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Lenore Weiss Studios is an architecture and interior design practice headquartered in heart of Chicago’s design district. Their process is founded on the belief that architecture must be inspirational, eminently functional, and delightful to all the senses. The unique team of talented design professionals integrates environmental consciousness into every facet of their work. This includes incorporating evidence-based-design and empathic practices into their design approach to elevate their design solutions to a deeper level.

The Studio’s award-winning projects reflect customized design solutions that elegantly support clients’ unique lifestyle requirements while bolstering their clients’ wellness and ability to flourish. 

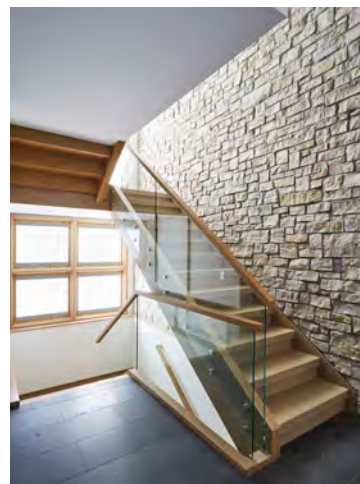
CREDITS: PHOTOS BY NORMAN SZEMORE



Chicago Lakefront Condo, Chicago, IL

A combination of three units on the 56th floor of a building near Lake Michigan that offered magnificent east, west, and southern vistas of the city and lake. With the views being “the thing” from sunrise to sunset, the condo offers a warm, cozy frame to the surrounding urban landscape and seascape.

CREDITS: PHOTOS BY MIKE KASKEL



Ravine Residence, Chicago, IL

This contemporary single family home experienced a rebirth with new owners bringing a fresh, young perspective and lifestyle needs. The home maintains a clear orientation to the surrounding wooded ravine and lake view beyond but in a current, casually elegant way. LWS teamed together with the home’s original architect, Stuart Shayman to transform the original iteration into a home better suited for its current occupants.

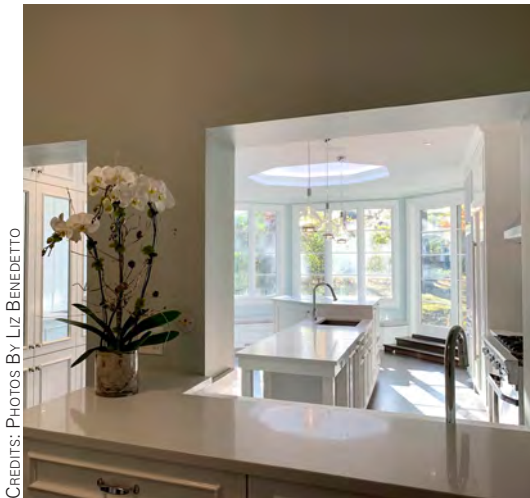


CREDITS: PHOTOS BY MIKE KASKEL

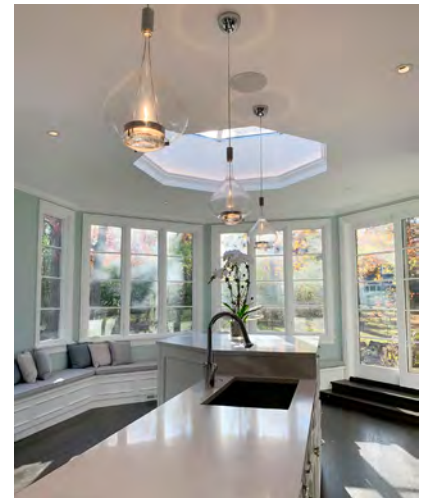


Home Addition, Chicago, IL

A classic colonial required additional entertainment space for large crowds of family and friends. Preserving the beauty and integrity of the existing house while adding on new space for contemporary entertaining and optimizing exterior views and natural daylighting were clear directives for this project.

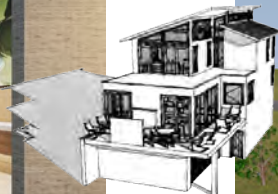


CREDITS: PHOTOS BY LIZ BENEDETTO



Kitchen Remodel, Chicago, IL

A classic home with traditional details throughout included a discordant 1980's multilevel addition in need of an update. LWS designed a makeover to align the new spaces stylistically with the remainder of the house while modernizing its functionality.



PROJECT STUDIES:

Lenore Weiss Studios uses BIM software to develop project designs.




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ARCHITECTS, LLP



Scott Kramer,
Managing Partner

With a history dating back to 1935 and roots reaching to 1890, Plunkett Raysich Architects, LLP is a 90-person national innovative architecture and interior design firm. We are professionals skilled in providing a variety of services including strategic planning, architectural design, interior design, and construction administration.

Our goal is to transform learning environments, bring order to complex healthcare facilities, re-envision ways of working, create places for people to call home, and provide safe and inclusive worship spaces for our clients. Our portfolio spans across the nation with four offices located in Milwaukee, Wisconsin, Madison, Wisconsin, Sarasota, Florida, and Buda, Texas. 

CREDITS: PHOTOS BY TRICIA SHAY PHOTOGRAPHY



Large Employer, Central Wisconsin

A three-story new headquarters was designed in the heart of Wisconsin to foster employee engagement and enhance collaboration. The combined vision of “feels like home” and “up north lodge feel” led the design effort across all spaces.

CREDITS: PHOTOS BY TRICIA SHAY PHOTOGRAPHY



Lincoln High School, Wisconsin Rapids, WI

Designed to empower and create a better, more flexible future for students and their community, this addition and renovation brought this learning environment into the 21st century. Purposeful branding throughout revitalizes spaces, reinforces culture, and shares school pride.

CREDITS: PHOTOS BY TRICIA SHAY PHOTOGRAPHY



Duluth Trading Company, Mount Horeb, WI

Tucked in an urban site, this new office headquarters provides support for evolving workstyles and promoting collaboration by housing teams in a flexible environment. A stunning mix of materials is seen throughout, with each space defined by wood armatures.

CREDITS: PHOTOS BY TRICIA SHAY PHOTOGRAPHY



Orthopaedic Associates of Wausau, Wausau, WI

Positioned to take advantage of the views of the nearby Granite Peak Mountains, this new facility allows both providers to be independent but connected with ease. Each wing boasts state-of-the-art equipment for exceptional patient care.

CREDITS: PHOTOS BY RYAN GAMMA PHOTOGRAPHY



Suncoast Orthopaedic Surgery & Sports Medicine, Venice, FL

By combining two facilities under one roof, this new clinic provides ease of access for providers and patients. A collaborative working model allows the care team to easily interact with patients through a pod cluster layout and centralized staff work station.

Solar: A Building Electrification Trend That's Here to Stay



PART II



BY: DAVE WILMS, AND THE TEAM AT SUNPEAK

Solar is one of the fastest growing sectors in energy production today. Beyond being environmentally sustainable, solar is an approachable technology that can provide clients with significant and long-term energy cost savings.

In the first segment of this two-part series (*Licensed Architect, Summer 2023 pp 10-14*), we covered the benefits of solar, the factors that have contributed to making it a cost-effective energy source, and some of the different mechanical and structural provisions that must be considered when designing a system. In this edition, we will look more closely at common applications for solar, including roof-mounted and ground-mounted arrays and solar carports, key equipment and maintenance considerations, and the long-term economic and environmental impacts of these projects.

Roof-Mounted Solar Options

Many high-quality mounting systems are available to safely and attractively secure solar panels to a variety of different types of roof structures. These systems, which are made of aluminum or stainless steel, are incredibly durable and designed to withstand decades of weather and climate exposure.

For flat or very low-pitched roof applications, the mounting apparatus is commonly attached to the roof using ballast

weight, which minimizes or eliminates penetration of the roof membrane. Specialized clamps are then used to attach solar panels to the mounting structure. Beyond the typical south-facing system, panels can be mounted in an east-west orientation to optimize available roof space, lower the ballast quantity required to hold down the system, and capture solar energy over a longer portion of the day. Finally, while the typical flat roof system is ballasted, anchoring is still possible. Anchoring may even be required or desired, depending on seismic loading of the array or insufficiency in the structural capacity of the existing building.

A range of modular PV mounting options also exist for buildings with pitched roofs. For these applications, racking systems can utilize either an affixed rail or hook system. The racking system is affixed to the roof either by a direct attachment to the roof support or a clamp to the roof material. Clamps are again used to attach the solar panels to the mounting apparatus and a clean, low-profile design can easily be achieved.

Systems on pitched and flat roofs will have different load impact to the supporting building due to the different schemes used to attach the solar racking to the building. In the case of non-penetrating, ballasted racking, the additional dead load from the solar array is typically



South and EastWest-facing rooftop systems

around 5 psf. In the case of dispersed arrays with atypical geometry, the added dead load could be as high as 10 psf; this makes it important that adequate space is made available for the solar array that is free of rooftop units, vent pipes, and other obstacles.

For systems that are mechanically fastened to a pitched roof, the added dead load is much less compared to a ballasted system. A client can expect that a mechanically fastened solar array will add only 2 to 4 psf of dead load to the roof.

For any type of roof-mounted application, an experienced solar installation company can provide intelligent design schemes and also calculate the expected utility offset and savings potential for any system. When an initial design concept is chosen by the client, a solar developer will then work closely with other professionals, including the building's architect and the solar racking manufacturer, throughout the system's engineering process. Final system plans and equipment selections will incorporate local building codes, regional weather considerations such as wind and snow loading and seismic analyses, as well as

the building's structural capacity. The resulting system will be engineered for long-term performance and will also be supported by a long-term warranty.

Ground-Mounted Options for Solar Installations

When there is available land near a building, a ground-mounted solar installation can also be considered. Ground systems can be desirable for customers who want to visually highlight their solar investment. They are also an excellent option when a system's size would be constrained by available roof space, or if the roof's condition or structural capacity cannot support solar.

Ideally, a ground-mounted solar installation is installed close to the building's electrical equipment, allowing the solar system to be interconnected efficiently with the building's existing electrical infrastructure.

Like rooftop systems, a number of durable and attractive racking support options exist. These are commonly



Clients looking for an ultra-sleek design for their roof may be interested in monochromatic or black-framed panels



Ground mounted East West ballasted system



Rooftop systems are incredibly durable withstanding decades of weather exposure



A large carport system in construction atop a parking garage

attached to the ground using driven piles, ground screws, or ballast. The selection of which type of foundation to use will depend on soil conditions and the topography of the area. The soil conditions will also dictate the size and specifications of the foundation supports.

Some customers use the area around a ground-mounted installation to highlight other sustainability projects, such as native or wildflower beds or beehives.

Solar Carport and Vehicle Canopy Options

Beyond generating usable solar energy for a business, solar carports can be an attractive way to offer vehicle protection from the weather. On a sunny day, for example, finding a parking spot in the shade is a bonus, and customers with large parking lots can use these areas to offer this benefit while visually highlighting their sustainability investment and reducing their utility dependence.



An efficient ground-mounted solar system will be installed close to a building's electrical equipment

Solar carports tend to be more expensive to install than standard roof or ground-mounted systems because they often have unique design considerations that can affect project feasibility and financials. Critically, the lofted design of a carport can increase the weather loads experienced by the system, which increases the quantity of materials needed for the carport substructure compared to a regular ground mount array.

Unlike rooftop and ground-mounted solar PV systems, solar carports and vehicle shade structures are frequently accessible by the public, so some additional cost can be expected to accommodate necessary safety protocols for solar carport projects. With demand growing for electric vehicle technology, it can also be a good time to plan for the immediate or future installation of EV charging stations, which can be supported by the solar installation.

Solar carport installation projects fare best financially when vacant land is being developed for a new building and parking area, and allowances for carports can be included in the architectural process and civil design plan. This is another time when involving an experienced solar PV developer early can help a client get the results they want while ultimately saving money and frustration down the road.

Solar Inverters

Beyond the mounting apparatus and the panels themselves, the inverter is the other key piece of equipment in a solar PV system.



Solar carports can support EV charging stations



A solar inverter is a key piece of equipment in a solar PV system

Depending on the size of a solar system, one or more electric power inverters convert the DC power produced by the solar panels into AC current, which is matched to the frequency of the grid and therefore provides usable electricity for the building. Specialized cables transfer the electricity generated by the panels down to the inverter and then into the building's electrical system. This wiring is durable and designed to be utilized for the entire life of the system. Likewise, inverters are solid state equipment, designed to last decades and operate with very little supervision or maintenance required.

Whenever needed or desired, a solar PV system can easily be turned off. DC current can be stopped with a disconnect switch at the inverter. The entire PV system can be disabled with the utility disconnect located at the meter.

Solar Maintenance Considerations

Once installed, solar systems generally require minimal routine maintenance, though having an operations and maintenance contract with an established solar company relieves this responsibility and gives customers peace of



Some solar providers offer web-based performance monitoring

mind the system is performing as expected over its useful life. Typical routine maintenance activities that are simple to do for any person include visual inspections of cables, ensuring all nuts and bolts are tight, and inspecting ballast for any shifts. Any intensive maintenance activities, such as inverter troubleshooting or panel replacement, should always be handled by trained professionals.


Some solar providers offer web-based performance monitoring. This tool has myriad benefits for customers. First, it gives their solar technicians an alert if a potential system issue is present. Secondly, it gives the technician a way to remotely access, troubleshoot, and sometimes repair the problem, which is more efficient and cost-effective to the customer than a physical site visit. Monitoring platforms also capture solar production data from the inverter to provide customers with interesting, useful, and visual dashboards to showcase their solar investment and validate their ROI.

The Long-term Economic and Environmental Benefits of Solar

In our work with commercial customers at SunPeak, even moderately sized systems located in the Midwest will reduce a customer's environmental impact by millions of pounds of carbon dioxide and save the building owner hundreds of thousands of dollars in energy costs. When you combine these savings with accessible federal tax credits and other financial incentives for solar, the decision to invest becomes an obvious choice for many customers.

Key Takeaways

Regardless of which type of system a customer may prefer, solar provides decades of safe, sustainable, hassle-free, and cost-effective electricity. By involving an experienced solar provider early in the building design process, architects can consider all of the factors necessary to help their clients implement solar successfully. This not only benefits the environment but also adds value to the property and reduces long-term operating costs for the customer.

For more information on the benefits of solar installations, read part one of this series (*Licensed Architect, Summer 2023 pp10-14*). Images: Courtesy of SunPeak 

About the Author: Dave Wilms

(d.wilms@SunPeakPower.com) is a retired Adlai Stevenson High School AP Environmental Science teacher in Illinois who now uses his interest in solving environmental problems by developing solar energy projects that help reduce climate change and pollution issues associated with fossil fuels. He works with SunPeak, which is a leading, full-service solar photovoltaic developer specializing in commercial and industrial applications. For more information, please visit www.sunpeakpower.com.

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

WRITTEN BY: PETER J. ARSENAULT, FAIA, NCARB, LEED-AP

Whenever 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:

Whenever 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.

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Architects have turned to cable rail systems for interior and exterior installations.

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.

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

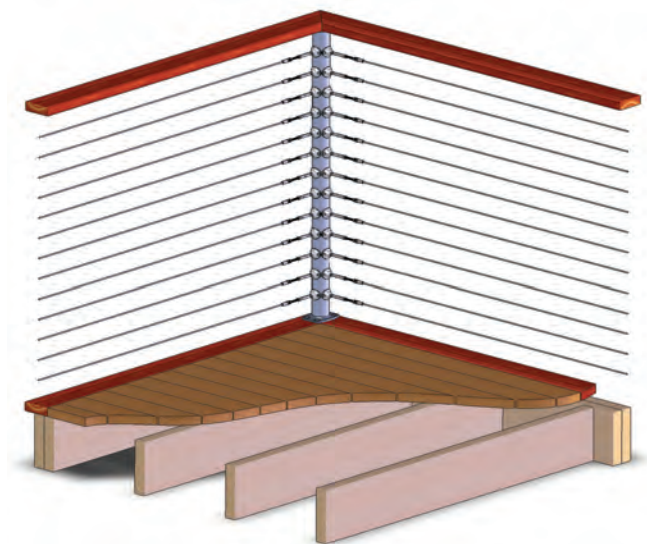
When designing a code compliant cable railing system, there are some specific things to be aware of. The first point is to recognize that even a taut cable will deflect when pressure is placed on it. Therefore, managing that deflection is the key to code compliance for the spacing of the cables. Commonly, 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,

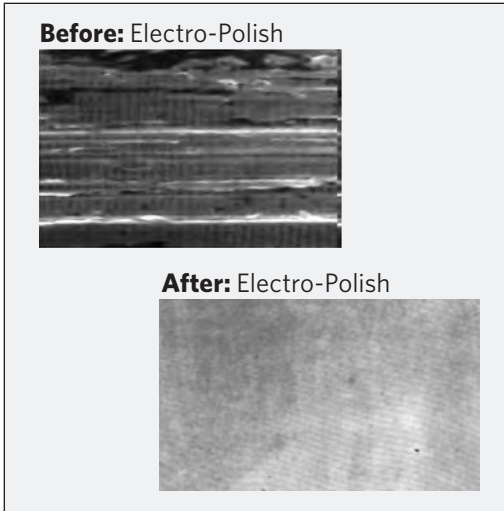
Iron and Nickel are both magnetic materials and collectively make up approximately 80 percent of 316 stainless steel. Iron has an initial magnetic permeability of 1150 and Nickel has an initial magnetic permeability of 110.

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.


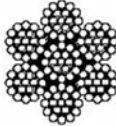
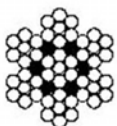
impurities (iron) from the metal surface. There are two ways to carry out this finishing:

- **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.



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.



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

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

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Connection Considerations for Uniquely Framed Wood Designs

BY: BECKY HAVEL, S.E., SIMPSON, GUMPERTZ & HEGER

As architects and engineers continue to push the limits of wood-framed residential construction, traditional sawn lumber is not always the most appropriate material to fulfill the designer's vision. Today, many residential projects include reinforced concrete, structural steel, and a variety of engineered wood products designed to meet the unique needs of residential construction. To successfully execute a project with various materials, trades, and specialty products, designers must possess a sound understanding of the systems and their interfaces or connections. This article reviews the most common engineered wood products in residential construction, their advantages and disadvantages, and the typical connection considerations associated with each.

Engineered Wood Products

Engineered wood products include: structural composite lumber such as laminated veneer lumber (LVL), metal plate connected wood trusses (MPCWT), I-joists, or parallel strand lumber (PSL), glue-laminated timber (glulam), and cross-laminated timber (CLT).

Structural Composite Lumber

Laminated veneer lumber (LVL), parallel strand lumber (PSL), laminated strand lumber (LSL), and oriented strand lumber (OSL) are all examples of the family of engineered wood products known as structural composite lumber (SCL). The most common applications for SCL are in headers, girders, posts, and long span beams.

Structural composite lumber is created by layering wood pieces with resin adhesive to form blocks called billets. The billets are then sawn to the sizes published by the manufacturer. Layering wood and resin creates elements that have higher strength properties and are more dimensionally stable than sawn lumber. The downside to SCL is that the resin used in the manufacturing process is susceptible to prolonged and permanent exposure to moisture. Care must be taken during construction to keep SCL dry.

Metal Plate Connected Wood Trusses

Metal plate connected wood trusses (MPCWT) are commonly used as floor joists and roof trusses. They are constructed from sawn lumber or LVL pieces connected by punched sheet metal plates, pressed into each face of the jointed connection. MPCWT offer many upsides compared to sawn lumber including a high strength to weight ratio, spans that can exceed 25 feet, and flexibility to meet unique roof profiles. The potential downside to

a MPCWT system include more susceptibility to floor bounce and vibration than traditional sawn lumber systems. Manufacturers have also developed prefabricated connector products specific to metal plate connected wood trusses.

Structural Engineers of Record (SEOR) typically delegate the design of MPCWT to Specialty Structural Engineers (SSE). The SEOR provides performance requirements, geometry, permanent connections, and required loads, and the SSE designs trusses to the specifications. Permanent bracing can be designed by either the SEOR or SSE; however, the author typically prefers the SSE to design the bracing.



Figure 1 - Metal plate connected wood trusses and punched sheet metal plate connectors



Figure 2 - I-joists

I-Joists

Prefabricated wood I-joists are an engineered wood product comprised of two laminated veneer lumber (LVL) or sawn lumber flanges and a continuous plywood or oriented strand board (OSB) web. I-joists are available in a variety of depths up to 16 inches. I-joists are lighter, stronger, and stiffer for equivalent depths compared to sawn lumber. They are also easy to install as manufacturers have developed prefabricated connector products specific to I-joists.

Glue-Laminated Timber (Glulam)

Glue-Laminated Timber, or Glulam, is created by stacking individual parallel pieces of lumber (“lams”) on the flat face and combining with adhesive to create the final cross section. To optimize cost and strength, typically, the outer laminations are stronger than the inner laminations near the neutral axis.

These shapes offer higher strengths and more dimensional stability than sawn lumber and can be used in striking applications, like vaulted ceilings or curved elements. Glulam can also be used for headers and long-span beams. Similar to SCL, some adhesives used may not be appropriate for prolonged and permanent exposure to moisture.

Cross-Laminated Timber

While increasing in popularity and functionality, Cross-Laminated Timber (CLT) is not discussed in this article.

Connection Types And Best Practices

Wood-to-Wood Connections

Many types of wood products are used in modern wood-framed construction. It is common to see sawn lumber,

I-joists, or metal-plate-connected wood trusses comprising a building’s primary floor framing system, while glulam or structural composite lumber beams often function as headers and transfer girders. Manufacturers have developed prefabricated light gauge metal connector products to efficiently facilitate connections for a variety of sawn and engineered wood elements and conditions. Connectors accommodate sloped, skewed, or offset members as well as provide options to conceal the hanger flanges where required.

These prefabricated, light gauge connectors are often the cheapest option for wood-to-wood connections. The connectors do not use much material and are easy for engineers to specify. In addition, contractors can efficiently install them due to their template holes for nails, screws, and bolts. The downside to these connectors is that they can only be specified within the bounds of the manufacturer’s pre-tested and reported conditions. For truly unique conditions, these connectors may not meet the desired strength or aesthetics.

Figure 3 shows an example connection at the roof line with an integral gutter. The gutter is hidden from sight by notching into the roof trusses, which takes away material from a high-stress area and creates a unique condition at the bearing point. Due to the geometry and loads, a prefabricated truss was not an option. A custom wood truss and wood-to-wood steel connector solved the structural issues and allowed the architectural features to shine.

Wood-to-Steel Connections

For floor plans with large open areas, depth-restricted areas, or discontinuous loads from floors above, localized steel members can efficiently fulfill the design intent. Typically, steel beams are supported on steel columns and/or reinforced concrete foundations.



Figure 3 – Custom wood to wood connector

Steel beams introduced locally should integrate seamlessly with the wood framing systems used in the rest of the project. Steel tends to be more dimensionally stable than wood, as it is less sensitive to changes in relative humidity. Steel-to-wood connections not detailed specifically to accommodate seasonal expansion or contraction in the wood can result in cracked finishes, splits in the wood, or connection failures.

Wood-to-Steel Beam Connections

Three types of wood-to-steel beam connections include: (1) top flange mounted hangers welded to the top flange of the steel beam (2) top flange mounted hangers connected to wood nailers affixed to the beam top flange, and (3) face mount hangers connected to the side face of wood blocking attached to the web of the steel beam.

Manufacturers have designed top flange mounted hangers that can be welded directly to steel beams. Welded top flange joist hangers eliminate the need for a wood nailer and reduce the associated floor-to-floor height or ceiling depth. The downside to these hangers is that the required welds are small and can require additional contractor labor. Architects should consider specifying weld certifications which may also add costs depending on availability of skilled welding labor in the project area.

Top flange hangers can also be used in applications with a wood nailer, though this results in a slight increase in floor-to-floor height. The wood nailer, typically 2x sawn lumber laid flat atop the steel beam, allows the plywood floor sheathing to be attached with ease. In situations where the steel beam is a transfer beam for a wall above, the nailer also facilitates structural connections between the wall and the beam. Top flange hangers do not typically require

wood blocking between the beam flanges, which reduces contractor's labor requirements compared to other wood-to-steel beam connections.

Face mounted hangers can eliminate the need for a wood nailer, and can increase construction speed, depending on the contractor's preference. These joist hangers require continuous wood blocking installed inside the beam flanges using through bolts. Multiple layers may be required. Joist hanger manufacturers do not qualify the wood blocking so additional engineering effort is required to design these elements.

Wood-to-Steel Column Connections

While common to have wood-to-steel beam connections, wood-to-steel column connections present their own unique challenges. Custom steel connectors are often designed for locations where architectural requirements, connection geometry, or load demand prevent the use of typical prefabricated joist hangers. These custom connections offer greater design flexibility but incur higher engineering and material cost relative to prefabricated hangers.

Figure 5 shows an example connection where a large LVL header beam is connected to a full height steel column. The LVL beam supports long-span I-joist framing at the level shown and provides additional stiffness for exterior glazing. In this example, because the LVL beam is wider than the column, a steel plate is welded between the beam hanger and the column.

Welding joist hangers requires skilled and qualified welders to prevent burn through of the light-gauge material, and not all hangers can be welded. Specifying an American



Figure 4 - Wood joist connection at steel beam



Figure 5 – LVL Connection to Steel Column



Figure 6 – Custom steel connector to column

Welding Society (AWS) certified welder to perform these welds can improve the quality. Figure 5 also shows the reaction between weld material and steel paint. Blemishes can occur if the base steel surface is not appropriately prepared. For connections to be exposed in their final condition or for other critical welds on a project, consider requiring weld-specific inspections by qualified inspectors.

Another unique connection is shown in Figure 6. It is a custom steel hanger used above an open concept floor framing area adjacent to an exterior wall of full height glazing. The slender steel columns support the glazing elements. Continuous diffusers at the base of the glazing cut into the plywood flooring that acts as a structural diaphragm and removes potential connection locations. Switching the joist direction and installing transfer beams solved the structural concerns. Because the width of the steel column, load, and weldability requirements precluded many prefabricated connectors, the custom steel connector was an effective solution.

Wood-to-Concrete Connections

Typical wood-to-concrete connections occur where the wood floor joists bear on top of a wood sill plate. Where wood and concrete come into contact, there is a potential for moisture migration from the concrete to the wood. Over time, this moisture can cause wood to rot and may necessitate wood replacement, especially for engineered lumber. Typically, wood in contact with concrete (sill plates and rim boards) is pressure treated to protect against this effect.


Other wood-to-concrete connections can also occur when you have window or door openings in lower levels, partially below grade. Figure 7 shows a multi-ply LVL beam



Figure 7 - Custom wood connection at concrete wall

where the beam elevation is below grade and needs to be supported by the concrete foundation wall. In this custom connection, the wood beam hanger is welded to a steel plate, which is anchored to the concrete wall. With multiple materials, this connection requires coordination between the concrete, steel, and wood subcontractors. The steel plate can be cast into the wall to create a flush look or post-installed. Cast-in anchors allow for a more finished surface but require more coordination by the designer and contractor.

Summary

Architects can utilize prefabricated and custom connectors to create ever-more complex and exciting structures. There are multiple ways, typical and unique, to connect wood elements, structural steel, and concrete. Successful implementation of residential projects with multiple systems requires an understanding of the advantageous and disadvantages of each system systems and the connections between them. 

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AI – Friend or Foe of Architects & Engineering Firms?



CONSTRUCTION
BUILD MOMENTUM

BY: ARCHITECT & ENGINEERS TEAM, HOLMES MURPHY & ASSOCIATES

In the middle of 2023, another new topic has emerged; it is being touted as a potential threat to the very way that professional services are provided. Artificial Intelligence (AI). We are still very much in the infancy stages of the AI movement. There are many questions arising that need to be considered, as the practice of AI in the professional services world evolves. What is AI? What can be done with AI? What is the standard of care when using AI? Who owns what AI produces? What are other firms doing with AI?

In this article we hope to share, to the best of our professional opinion, knowledge, and belief, what some of these answers may be. We aim to highlight potential pitfalls which may arise with the use of AI. While many are fearing the potential threat AI presents to the livelihoods of all design professionals, others view AI as a robust tool boosting productivity and increasing the quality of client deliverables.

What Is It And What Is It Not?

Let's start at the surface and define AI. Artificial Intelligence is "the ability of a computer, or a robot controlled by a computer, to perform tasks that usually require human intelligence and discernment." There are three "stages" of AI and how it may develop over time. Those stages are:

- **Artificial Narrow Intelligence (ANI) or Weak AI:** the stage of AI where machines can only perform a narrowly defined set of specific tools. There is no thinking ability.
- **Artificial General Intelligence (AGI) or Strong AI:** the stage of AI where machines can think and make decisions like humans. Currently, this does not yet exist.
- **Artificial Super Intelligence (ASI):** the stage of AI where computers surpass the capabilities of human intelligence. Currently, this does not yet exist.

Where we stand in the three stages outlined above may come as a surprise. The media, and other news outlets, lead us to believe that we are already in the AGI stage; however, AI is not currently capable of thinking or making decisions like a human. In the current form, AI is providing information based on a narrowly defined set of specifications. This data is pulled from many sources, and there is not a generation of new ideas or innovations. Most do not realize AI already is, and has been, part of our everyday lives for quite some time. For example, Siri, automatic vehicle shifting, social media algorithms, and other website chat bots are providing similar ANI outcomes. Even when writing this paper, Microsoft Word is attempting to predict what word or phrase will be typed next, to create a more efficient process.

What Are The Known Concerns?

There are already many questions this debate has sparked, and we will shed light on a few that we find most pertinent today:

• AI Impact on the Standard of Care

One big question is: "How will AI affect the Standard of Care?" Well, who better to ask about Standard of Care than ChatGPT? The following question was asked of ChatGPT 3.5:

"What is the Standard of Care for a design professional using artificial intelligence?"

The standard of care for a design professional using artificial intelligence (AI) involves several aspects that focus on ensuring ethical, legal, and efficient use of AI. Depending on the context and jurisdiction, these might include:

1. ****Professional Knowledge**:** Design professionals must fully understand AI technology they are using. They should stay updated on technology developments and familiarize themselves with the operations, limitations, and potential risks of the AI.
2. ****Transparency**:** The use of AI should be clear and transparent to all concerned stakeholders. Design professionals must fully clarify how AI is influencing any decisions, especially when these systems are being used to automate design processes or augment capabilities.
3. ****Quality and Accuracy**:** Designers must ensure that the AI tools they use are reliable and accurate. Any tool's output should be carefully reviewed and validated to avoid mis-design due to AI errors or bias free.

4. ****Data Privacy and Protection****: Design professionals should understand data protection laws and ensure the AI systems they use comply with them. Users' personal and sensitive information must be protected and not shared without informed consent.
5. ****Ethics****: The use of AI should follow ethical guidelines. For instance, AI should not be used to create deceptive or misleading designs. Any design decisions influenced by AI should be unbiased and free from discrimination.
6. ****Inclusivity****: AI-powered design should respect diversity and inclusivity. It should not just serve a small, specific group of users but consider the wide range of human experiences and needs.
7. ****Ongoing Monitoring and Maintenance****: The performance of AI systems should be regularly monitored. Any anomalies, failures, or concerns raised by users should be promptly addressed.
8. ****Collaboration with Experts****: Particularly complex uses of AI might require collaboration with data science or AI ethics experts. Recognizing when outside expertise is necessary is a crucial professional responsibility.

Just like in the use of any professional tool, using AI requires judgment, responsibility, and in-depth understanding of one's professional obligations to clients and the wider society. This extends to using AI and technology for design purposes and more widely.

As we can see, even AI struggles to provide an exact answer regarding the Standard of Care when using AI. Note that AI itself offers a disclaimer on what it believes to be the Standard of Care. The current Standard of Care for a design professional typically accepted is:

"Performing services in a manner consistent with that degree of care and skill ordinarily exercised by members of the same profession, under similar circumstances, at the same time, and in the same or similar locality." (AXA XL Contract Guide - Standard of Care).

The more design professionals use AI on projects, the more data will become available, as to what the Standard of Care will be. Until then, as AI in design evolves, so will the Standard of Care.

• Copyright Concerns

One issue that has become clear, as we explore the leveraging of AI and who owns the content, is the improper use of copyrighted material. AI is not currently thinking and making insights, but rather pulling from previously published work found during a broad internet search. This would likely violate laws governing intellectual property and create unanticipated risks to Architects and Engineers.

What is AI? What can be done with AI?

The fine print with many of the AI tools or software programs declares the content generated to be now owned by the company who developed the AI software. In essence, once we put in the prompts, the output is now owned by someone else. This creates a great deal of confusion, and insurability concern related to the ownership of instruments of services.

Additionally, there is the issue of validating content and advice that a chatbot may offer when queried on a subject. When we use AI, we must still verify the accuracy of the output or response. This is true for all data-providing technology, even a calculator. When we type an equation into a calculator, we have already figured a rough estimation of the expected response in our head. When we press the equals sign, we will automatically compare that answer with the estimation we formulated. We have all seen what happens when we hit the multiplication symbol, instead of addition. Would this error be the calculator's fault or the user? In the same way, a design professional will have an obligation to act with caution and confirm accuracy, even when applying an advanced technology, like AI.

Further concerns include ethical dilemmas, safety concerns, and unique AI biases; however, the topics outlined above are believed to have the greatest impact on insurability.

When coverage may or may not respond?

Finally, the question everyone is asking: is the usage of AI by design professionals, in providing professional services, insured? Like any good insurance question, the answer is: it depends, and no one knows yet. While many "what if" scenarios can be considered, highlighted below are some helpful insights found in most Professional Liability policies, where questions may be asked or answered:

• Applicable Language

o **Professional Services definition**: This definition establishes the professional services provided and whether coverage will be triggered by a specific service being offered. Currently, most language will include something like the following: *The preparation of reports, opinions, recommendations, permit applications, maps, drawings, designs, models, Building Information Modeling, specifications (including the use of 3-D printing or other computer-assisted design technology to prepare such maps, drawings, designs and specifications), manuals, instructions, change orders or computer programs for designed systems.* Will this definition expand to the usage of AI technology? The early feedback in the marketplace would lean toward 'yes,' but this is subject to change.

The media, and other news outlets, lead us to believe that we are already in the AGI stage; however, AI is not currently capable of thinking or making decisions like a human.

o **Personal Injury definition:** Many professional liability policies will include exclusionary language for copyright or patent infringement for intentional acts in the definition of personal injury in a policy, and intentional acts exclusion which could be triggered if the copyright issues are not previously addressed. The language will typically read something like:

“PERSONAL INJURY means injury arising out of false arrest, detention, or imprisonment; wrongful entry, eviction, or other invasion of a right of occupancy; any libel, slander, utterance, electronic distribution, or other publication in violation of a right of privacy; malicious prosecution; or the unintentional infringement of copyright or patent.” (Per AXA XL LDD 050 1116)

• Non-Applicable Coverages

o **Network Security Liability Insuring Agreement:** While most Professional Liability policies have a Network Security Liability insuring agreement, not everything relating to computers applies. This portion of the policy has a different intent, and future policies will narrow this coverage to fit its true intentions.

• Exclusions to be mindful of

o **Products Liability Exclusion:** As the development of documents leverage the technology more, cases will establish the output of an AI program and how it differs from that of human work. If AI output is considered a product, and not a service, this could create some concerns with potentially triggering the products liability exclusion in a Professional Liability policy.

o **Contractual Liability Exclusion:** While the requirement to use AI may not appear in a contract, utilization could lead to a heightened standard of care. This could trigger the contractual liability exclusion in a Professional Liability policy. This would also be triggered in the event of a copyright infringement battle or intellectual property dispute.

Holmes Murphy will continue to gather information and data from our carrier partners, as coverage is expected to evolve with increased use of Artificial Intelligence.

What Are Other Firms Doing?


We have solicited feedback from several design firms to shed light on how others are approaching the application of AI in their everyday services. The most common

response we have received is, “Nothing yet! What do you recommend?” Whether we spoke with industry firms, carrier partners, or other brokers, everyone reflects this same sentiment. Currently, no one appears to be ahead or behind. Here are some pathways to consider on the AI journey:

- ✓ **Take a stance.** It is important that leadership of a firm discusses this important topic and determines how to address the use of this type of technology.
- ✓ **Communicate to employees.** This can be done via companywide memo and updating the employee handbook or manual. AI should be treated similar to a social media policy. All staff should understand what can and cannot be done in leveraging this resource.
- ✓ **Control usage.** If utilization of AI is prohibited, clearly communicate the reason. Speak with the firm’s IT service provider about blocking known websites (ChatGPT, OpenAI, etc.) on staff computers. If usage of AI is allowed, outline the parameters.
- ✓ **List the approved resources.** Firms allowing the usage of AI are going to the granular step of outlining which current technologies and specific resources are allowed to be used. As this technology evolves, the permitted list will need to be updated.
- ✓ **Provide clients with transparency.** Communicate what is and what is not being produced using AI systems. Learn the comfort level of each client with this practice.
- ✓ **Seek fairness.** Avoid any biases these technologies may create. Implement human oversight checking accuracy and equality.

As seen above, the steps some firms are taking center around communication and flexibility. These policies should be more like guideposts, rather than hard and fast rules, until the technology and users evolve to their final form. Company policies regarding AI should be monitored and updated with regulatory to capture the true exposure for firms.

In Conclusion

While there are many more questions than answers, as it relates to this complicated topic, we are still too early in the advent of this technology to speak definitively. Artificial Intelligence, like many past technology iterations before (BIM, E-Mail, Drones, etc.), may revolutionize how business is conducted, but it is yet to be answered whether there will be the doomsday impact that has been making headlines. 

About the Author: Holmes Murphy & Associates provides in-depth risk management strategies for architectural and engineering firms of all sizes. Partner with Holmes Murphy’s Architects and Engineers Specialization Team to manage risk and insurance needs. www.holmesmurphy.com

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