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Barrier Cable Constructors
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✧ About Barrier Systems

All parking structures are required to have some type of barrier system provided at the open edges of the ramps and at the perimeter of the structure. The barrier systems serves a dual purpose. They are utilized as a safeguard for pedestrians and/or as a vehicular restraint mechanism.

There are criteria that the system must meet and these typically include:

- State and local building codes
- PTI "Specification For Seven Wire Steel Strand Barrier Cable Applications"
- These requirements are covered later in the presentation.

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- Deterioration is a Threat to Life Safety

Many building owners and property managers overlook the significance of barrier cable deterioration:

• The barrier system is often the primary (or only means) of providing vehicular and pedestrian restraint and is a critical component in maintaining the safety of those using the garage.
• Barrier cable corrosion is usually not a localized problem and is often representative of a systemic breakdown of the barrier installation.
• Some barrier cable systems have an unusually short life span.

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- Deterioration is Threat to Life Safety

  Damage to the barrier system can pose a significant threat to the the safety of vehicles and persons using the garage.

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- Deterioration is a Threat to Life Safety

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- Deterioration is a Threat to Life Safety

Barrier cable corrosion is usually not a localized problem and is often representative of a systemic breakdown of the barrier installation.

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✧ Cable Corrosion : Required Corrosion Protection

PTI Barrier Cable Specifications call for the use of at least one form of corrosion coating on the strand. The most common types of strand coatings include:

a. Zinc Galvanized Coating: Requires hot-dip, hot-dip & post-drawing, or electro-plating to ensure complete coating around each wire. Bezinal is a proprietary coating (Bekaert) that is 95% zinc and 5% aluminum for improved corrosion resistance and coating adhesion.

b. Polyethylene Coating: Requires continuous seamless extrusion coating not less than 60 mils thick with antioxidants and UV stabilizer. High Density Polyethylene (HDPE) is most common.

c. Epoxy Coated Strand: Requires minimum 30 mil coating over crowns of wire. Special anchors and installation procedures are required.

When a polyethylene or epoxy coating is not used in conjunction with galvanized strand, it makes the cable extremely vulnerable to aggressive corrosion.

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- Cable Corrosion – Coating Failures

Zinc galvanized coatings have proven to be the most durable means of protecting the barrier cables.

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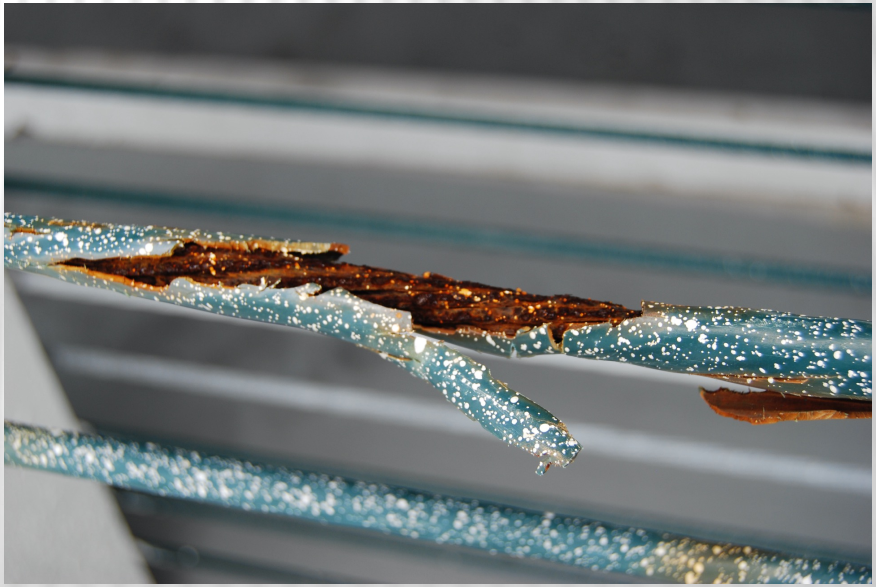
- Cable Corrosion – Coating Failures

High Density Polyethylene (HDPE) coatings are supposed to provide a continuous seamless extrusion and contain a UV stabilizer in order to withstand prolonged exposure to sunlight. However, these coatings often become brittle and will ultimately lead to cable failure, unless the coating was applied over galvanized strand.



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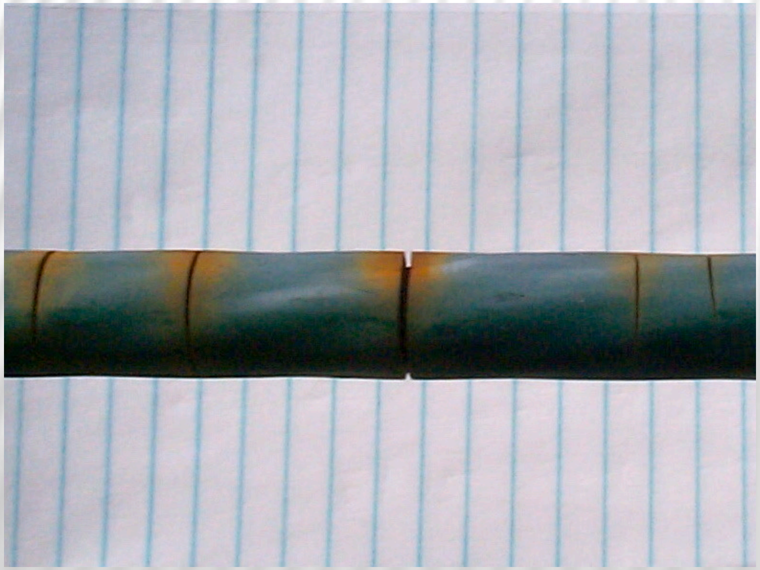
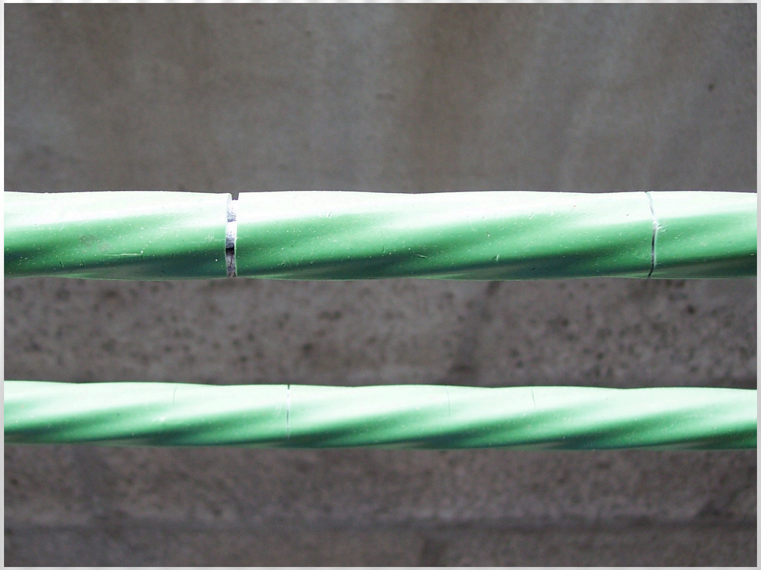
- Cable Corrosion – Coating Failures

Epoxy coatings can become brittle with prolonged exposure to sunlight. Micro corrosion is created at cracks in the coating and will ultimately lead to cable failure unless the epoxy coating was applied to galvanized strand.





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✧ Cable Corrosion – Coating Failures

Not all coatings provide equal levels of long term protection of the strand.

- Zinc galvanized coatings have proven to be the most effective long term corrosion inhibiting coating.
- Polyethylene coatings have been problematic in two areas:
  a. Even with UV inhibiting materials in the polyethylene, this material is subject to fading, cracking, and splitting when exposed to direct sunlight.
  b. The coating is not continuous and water is assured to enter the coating (even water through humidity). Unless applied over galvanized strand, this coating causes an accelerated corrosion of the cables.
- Epoxy coated strand is subject to the same problems as polyethylene coated strand.
- Corrosion in polyethylene or epoxy coatings over non-galvanized strand should be considered a systemic problem and ultimately replaced with galvanized cable.

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- Hardware Corrosion

Barrier cable is the same ½” seven wire material used in bonded and unbonded post-tension (and prestress) construction, so many of the anchors and splice coupling devices can be used for barrier cable construction and repair. However, barrier cable hardware must be plated for use in exterior (corrosive) environments, while most structural hardware is not.

In some instances, the designer specifies the use of a polyethylene covering rather than plated hardware.

In either case, the durability of the installation or repair is ultimately compromised due to corrosion of the hardware.

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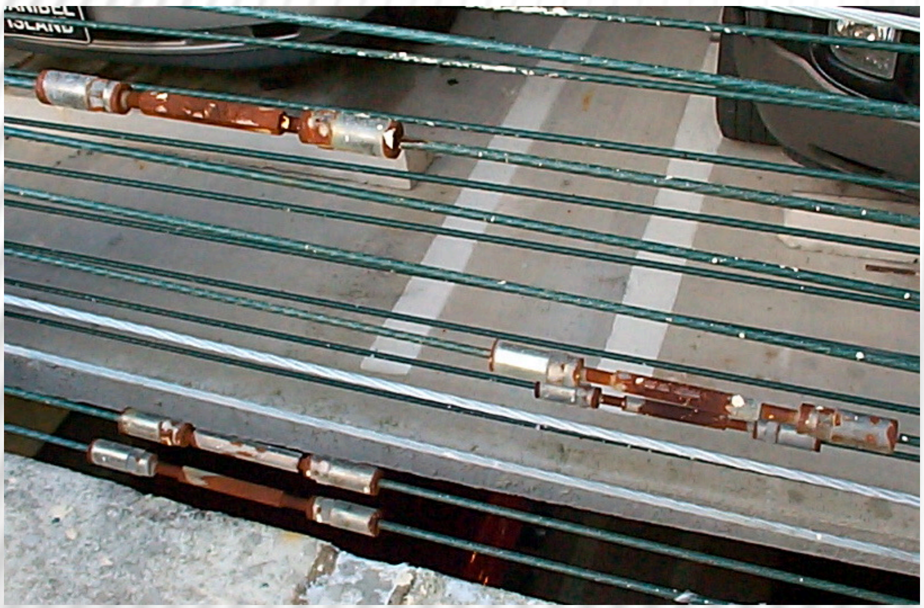
- Hardware Corrosion



Examples of corroded structural cable splices.

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- Hardware Corrosion

Examples of corroded structural cable anchor and splice.

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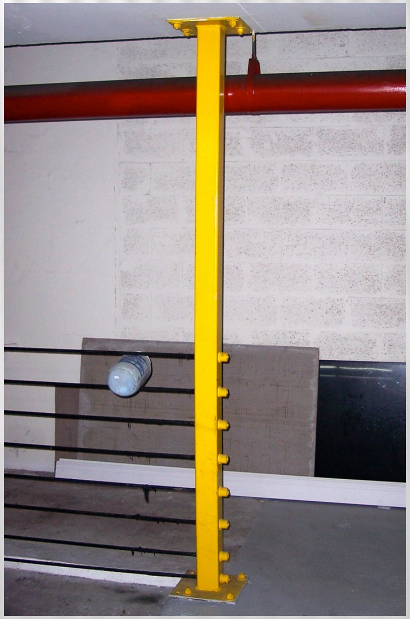
✧ Miscellaneous Problems – Structural Steel Corrosion

Corrosion or damage to structural steel components used as anchor end terminations or intermediate cable supports can compromise the integrity of the barrier system.



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- Miscellaneous Problems – Eye Bolt Damage

Eyebolts are often used as an intermediate support for the profile of the cable span. Failure of the eyebolts will render the cable spacing non-compliant with the building code.

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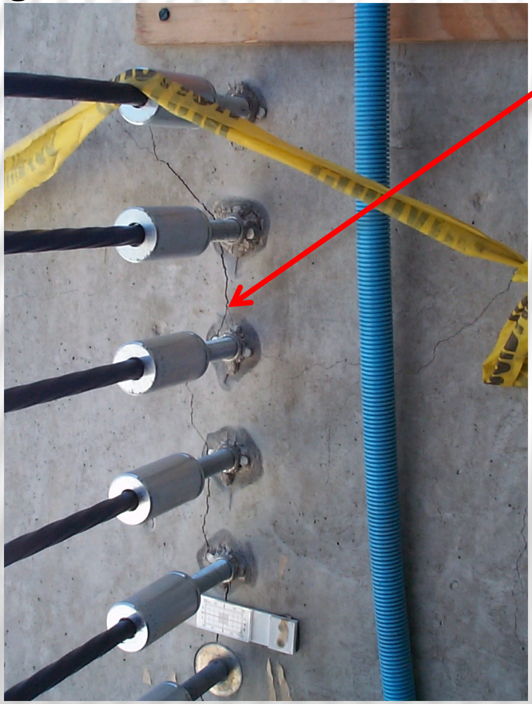
- Miscellaneous Problems – Structural Failure

This issue rarely arises, but can occur during the replacement and stressing of an entire group of cables in a single span. It can result when the calculated cable stressing load exceeds the limits of the design or construction of an existing column at the end of the cable span. The results can be catastrophic, so it is important that an engineer review the existing structural capacity in conjunction with the barrier cable design.



Stress cracks developing in column due to stress load on embedded anchors.

Stress failure due to inadequate column reinforcement.

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- Miscellaneous Problems – Structural Failure

Column rebar from slab was cut during original construction.

New column rebar was not doweled into slab.

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✧ Improper Repairs

There are several acceptable ways of repairing broken cables, but there are an unlimited number of ways that people have used to create their own means of repair in the field. The following pages illustrate examples in several areas:

- Replacement Cables
- Cables Splice
- Alternative Cable Anchors

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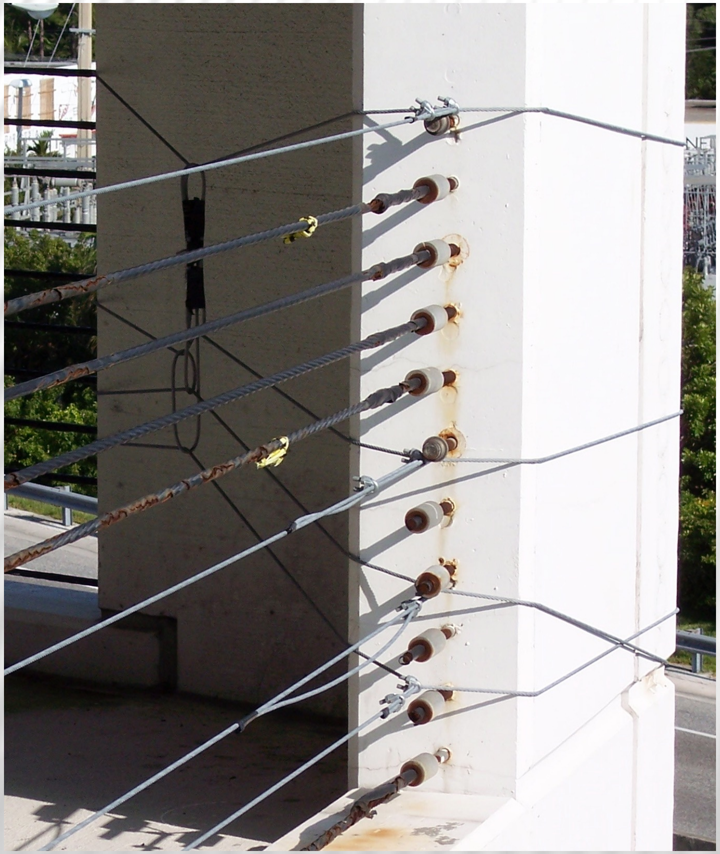
- Improper Repairs – Replacement Cables



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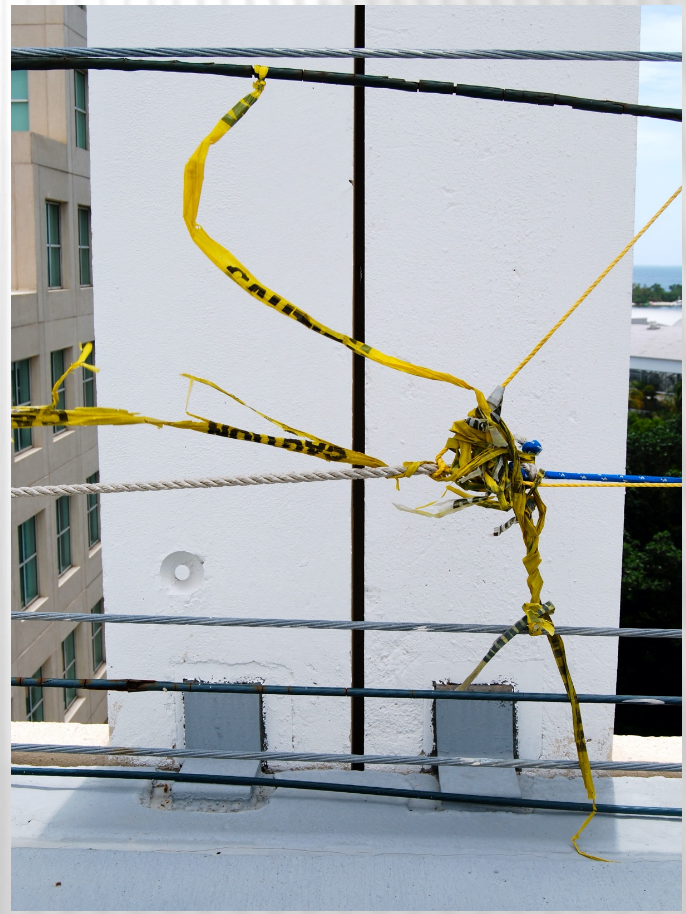
- Improper Repairs – Replacement Cables



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- Improper Repairs – Replacement Cables

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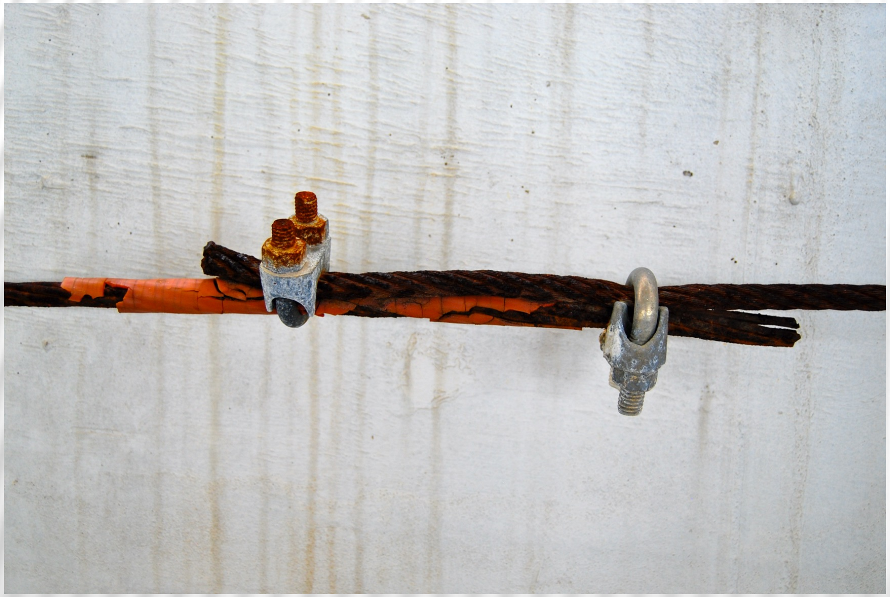
- Improper Repairs – Cable Splices



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- Improper Repairs – Alternative Cable Anchors

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- Improper Repairs – Alternative Cable Anchors

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✧ Compliance with Building Code Requirements

One of the most common problems encountered with an older parking garage, is that the existing barrier system does not meet the current building codes. When the entire existing is replaced, it must be brought up to the most recent applicable building code requirements.

This can create challenges for the building owner and structural engineer. Some of the issues that must be addressed are:

• What type of system should be used (barrier cable, framed or fabricated fence, fence on cable, reinforced concrete, etc.). Some considerations that enter into this decision are the architectural characteristics of the existing system and the replacement system, as well as, the cost of each possible alternative.
• Will the existing structure support the load requirements imposed by the new system. If not, will another barrier system work, or will the structure require modification/reinforcement.

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✧ Building Code Requirements

As a pedestrian safeguard, the (Florida & International Building Code) requirements are as follows:

a) Required where level differences exceed 30”.
b) Height of the restraint shall not be less than 42”.
c) Bottom of the restraint shall not be more than 2” from the surface.
d) Intermediate surface of restraint shall reject a 4” diameter object.
e) Shall be designed to resist a load of 50 pounds per lineal foot (applied to a 1 sf area) and a concentrated load of 200 pounds at the top of the barrier.
f) The PTI Guideline states that “This requirement is to prevent an adult from falling over the system, or a small child from falling through an opening.”

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- Building Code Requirements

  As a vehicle safeguard, the (Florida & International Building Code) requirements are as follows:

  a) Required where elevation differences exceed 12”.
  b) Must be capable of resisting a minimum horizontal load of 10,000 pounds applied 18” above the floor at any point in the barrier. This is based on a 5,000 vehicle traveling at 5 mph. The PTI Guideline states that “The equivalent static load is 6,000 lbs. for allowable stress design and 10,000 lbs. for strength design.”
  c) The horizontal deflection under design load shall not exceed 18”.
  d) The design load shall be resisted by not more than 2 cables in the 2007 Florida Building Code. Other Codes may allow 3 cables.
  e) The system (including anchors) shall be protected against corrosion.
  f) Cable tension under design load shall not exceed 90% yield strength of the cable.

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- Building Code Requirements – Examples of Non-Compliant Systems

Concrete parapet wall likely meets the vehicular restraint requirements, but the cables fail to satisfy pedestrian code requirements

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- Building Code Requirements – Examples of Non-Compliant Systems

Aside from the corroded condition of the existing cables, the cable spacing is insufficient to meet the vehicular restraint requirements and fails to satisfy pedestrian code requirements.

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- Building Code Requirements – Examples of Non-Compliant Systems

The steel guardrail likely meets the vehicular restraint requirements, but fails to satisfy pedestrian code requirements. As a multi-story structure, this is a significant life safety concern

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- Replacement Alternatives

Replacement of a barrier system is usually required when it has been determined that the existing system has sustained extensive damage (corrosion) or is grossly out of compliance with building codes.

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- Replacement Alternatives

There are numerous design alternatives when it is necessary to provide a new replacement barrier system in order to meet building code pedestrian and vehicular safety requirements. This presentation is limited to the following types of systems:

a) Framed fence pedestrian barriers.
b) Fence on cable pedestrian & vehicle barriers.
c) Cable pedestrian & vehicle barriers.

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- Types of Systems: Framed Fence System

Framed fence systems are utilized exclusively as a pedestrian barrier on those structures that incorporate other means of providing a vehicle barrier.

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- Types of Systems: Fence on Cable

This system utilizes fence for the pedestrian barrier. It is installed without the use of pipe frames, with steel cables providing the fence support. When additional steel cables are incorporated, it can function as a vehicle barrier and pedestrian barrier.

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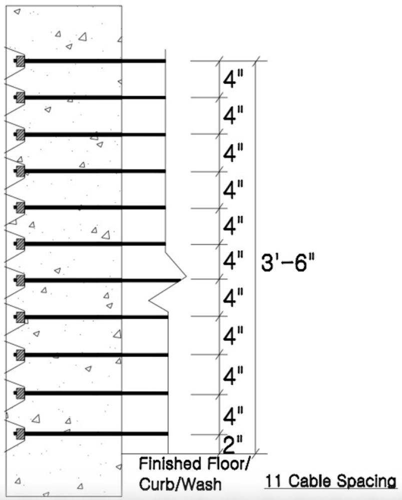
- Types of Systems: Steel Cable

This system utilizes either 3/8" or 1/2" 230k to 270k seven wire galvanized strand. The cable spacing, anchoring hardware, and cable supports must be designed to comply with applicable pedestrian and vehicular restraint codes.



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- Types of Systems:

The following are some considerations that must be addressed when determining which type of system is best suited for the unique conditions related to each project:

- The new system should satisfy the Owner's architectural requirements.
- Will the existing structure require modification in order to install the new system (column reinforcement, extensive drilling through columns, etc.)
- How cost effective is the desired system when utilized on a given structure.
- Can the structural components (particularly the columns) withstand the loads imposed on them by the new barrier system.

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- Barrier Cable Design Limitations & Issues

Installing a barrier system on a new structure presents challenges for the building designer. The structure must be designed to accommodate the desired system and comply with all applicable Building Code requirements and limitations. Most issues are related to steel cable systems and primarily involve the following areas:

- Cable span lengths
- Column stress loads
- Cable deflection limitations
- Adequate anchor development

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- Structural Design Limitations & Issues

Cable span lengths – The are two critical cable span lengths. One is the total length of the cable from anchor end to anchor end. The second, is the distance between the intermediate columns that will be utilized to support the cables along their length. Both can create obstacles for the structural designer.

If the distance between intermediate columns is too great (absolute maximum is 36'), it may result in excessive cable deflection. The excessive deflection may cause the cable to come in contact with a either a structural / architectural element, warranting the use of an intermediate column or high cable stressing loads.

The greater the total cable length from anchor end to anchor end, the higher total stressing load on the end columns. This will factor into the design of the column size/reinforcement and cable anchor hardware selection.

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✧ Structural Design Limitations & Issues

Column stress loads – The columns at the end of each cable run can typically expect a total combined stressing force load of between 33k and as high 75/80k for an 11 cable system. Insufficient design of the column can result in deflection, cracking, or catastrophic failure of the column.

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- Structural Design Limitations & Issues

Cable deflection limitations (Issue 1)
In those cases where the cables do not run through intermediate concrete or steel columns, eyebolts or brackets can be used to maintain the required 4" spacing between the cables. Otherwise, the stressing load needed to maintain cable separation and performance on long spans may result in excessively high cable tensioning loads.

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- Structural Design Limitations & Issues

<u>Cable deflection limitations (Issue 2)</u>
In those instances where the architect has designed the structure with exterior covering (i.e.: aluminum screens, brick facade, precast panels, etc.), the covering must not be within the 18" zone of maximum horizontal deflection of the cables allowed by code.

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- Structural Design Limitations & Issues

<u>Adequate anchor development</u>
The contractor and structural engineer must ensure that the columns are adequately designed and constructed in order to handle the development of the cable loads into anchor systems embedded into the columns.

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- Repair Alternatives

In most cases, damaged cables are either replaced from anchor to anchor, or they are partially replaced using a mechanical splice coupler and a short length of new cable. The decision to repair or replace the cable is based on the overall condition of the entire length of cable, and the location and condition of the end anchors.

If access to an anchor is difficult or impossible (but the end of the cable and anchor are in otherwise sound condition) then the cable would be spliced.

Otherwise, the damaged cable would have to be removed and replaced from end to end (regardless of the difficulty and expense related to accessing the anchor) or a new type of anchor system may be utilized.

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- Repair Alternatives – Cable Replacement

BEFORE: Badly corroded and missing cables.

AFTER: New anchors installed and cables replaced.

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- Repair Alternatives – Cable Replacement

Embedded anchors failing due to inadequate development of threaded rods into the column.

Existing anchors Abandoned. New cables run through holes drilled into the column and fastened to barrel anchors on the back of column.

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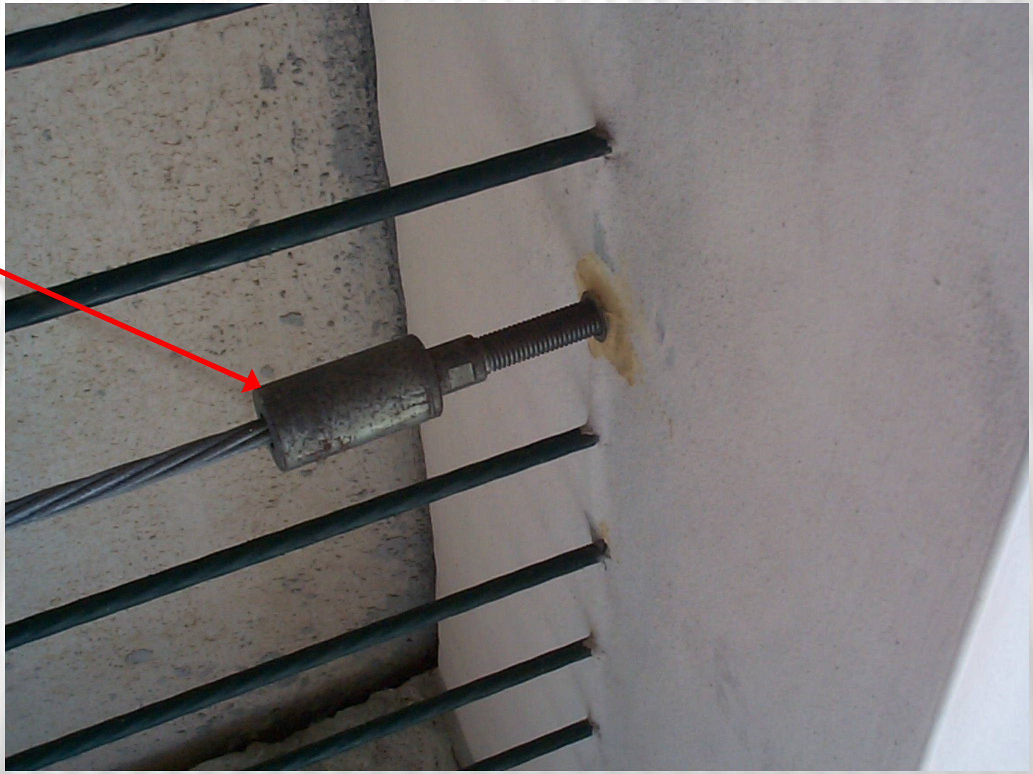
- Repair Alternatives – Cable Replacement

Due to the inability to access the stressing anchor ends, this cable was replaced using a non-adjustable anchor drilled and set with epoxy into the column.



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