PARKING GARAGE BARRIER SYSTEMS

New Construction Design, Limitations, and Problems

Barrier Cable Constructors

Barrier Cable Constructors
(800) 330-7883

NEW CONSTRUCTION

- Building Code Requirements
- Types of Systems
- Design Limitations & Issues
- Installation Issues

NEW CONSTRUCTION

Building Code Requirements

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 several sources of design criteria that the system must meet and these typically include:

- State and local building codes
- International Building Code
- PTI “Specification For Seven Wire Steel Strand Barrier Cable Applications”

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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 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) In the 2007 Florida Building Code, the design load of 6,000 lbs. shall be resisted by not more than 3 cables.
e) In Dade & Broward Counties, the design load of 5,000 lbs. shall be resisted by not more than 2 cables.
f) The system (including anchors) shall be protected against corrosion.
g) 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 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 fail to satisfy pedestrian code requirements.

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- Types of Barrier Systems

There are many ways of designing a structure to meet building code pedestrian and vehicular safety requirements. However, 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

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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- Framed Fence System – Other Uses

Another use of the framed fence system is to create secured storage areas within the structure or for use in limiting ground floor access.

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Framed Fence System- Materials

The materials typically utilized in this system are composed of:

- Extruded and adhered 2” x 9 gauge galvanized chain link fence with a PVC coating.
- Galvanized metal tubing with a thickness of .065” for framing with a powder coating.
- Galvanized hardware (bolts, clips, corner brackets, etc.) with a powder coating.

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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 galvanized steel cables providing the fence support (and vehicular restraint if necessary).

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- Fence on Cable System - Uses

Similar to fence on pipe systems, it can be used exclusively as a pedestrian barrier on those structures that incorporate other means of providing a vehicle barrier. The galvanized steel cables provide only a means support the fence fabric.

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- Fence on Cable System - Uses

When additional steel cables are incorporated, it can function as a vehicle barrier and pedestrian barrier.

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Fence on Cable System - Materials

The materials typically utilized in this system are composed of:

- Extruded and adhered 2” x 9 gauge galvanized chain link fence with a PVC coating.
- Galvanized metal tubing with a thickness of .065” for framing with a powder coating.
- Galvanized hardware (bolts, clips, corner brackets, etc.) with a powder coating.
- 1/2” 230k to 270k galvanized seven wire strand and hardware.

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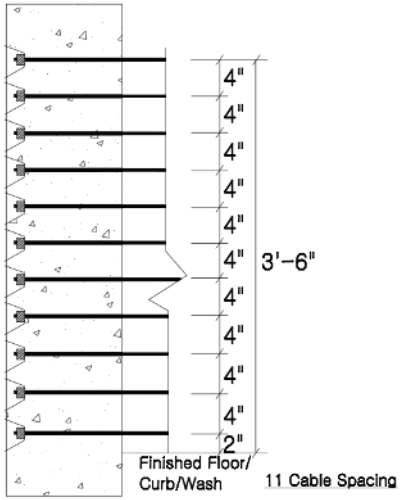
- Types of Systems: Steel Cable

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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✧ Steel Cable System – Cable Materials

• 3/8” or 1/2” - 230k to 270k seven wire strand is most commonly used cable.

• 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.

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✧ Steel Cable System – Cable Materials

Not all coatings provide equal levels of corrosion protection of the strand.

• Zinc galvanized coatings have proven to be the most effective long term corrosion inhibiting coating.

• Polyethylene coatings have shown to be been problematic in two areas:

a. Even with UV inhibitors 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 will enter the coating (even in the form of humidity). Unless used in conjunction with galvanized strand, it makes the strand extremely vulnerable to aggressive corrosion.

• Epoxy coated strand is subject to the same problems as polyethylene coated strand.

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Steel Cable System – Cast Anchors

• Ductile iron anchors are designed to be used as cast in place anchors. They are not intended to be used as surface mounted anchors. They are less common than the barrel anchor.

• Requires access to both sides of the column for stressing and back-stressing as necessary to seat the wedges.

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Steel Cable System – Barrel Anchors

• Commonly used as an end anchor and is typically recessed into a cast in place pocket in the column. Requires the use of a pocket former during construction in order to create the recessed pocket.

• Requires access to both sides of the column for stressing and back-stressing as necessary to seat the wedges.

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Steel Cable System – Adjustable Anchors

- Utilized as an end anchor termination where there are access limitations that do not allow for a through column anchor.
- The threaded sleeve allows the anchor to be backed down into the threaded rod in order to shorten the span and create tension on the cable.
- Can not be used for vehicular cables, as the embedment is limited to 7,500 lb load.

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Steel Cable System – Non-Adjustable Anchors

- Utilized as an end anchor termination where there are access limitations that do not allow for a through column anchor.
- As a fixed anchor, it can not be used to introduce tension.

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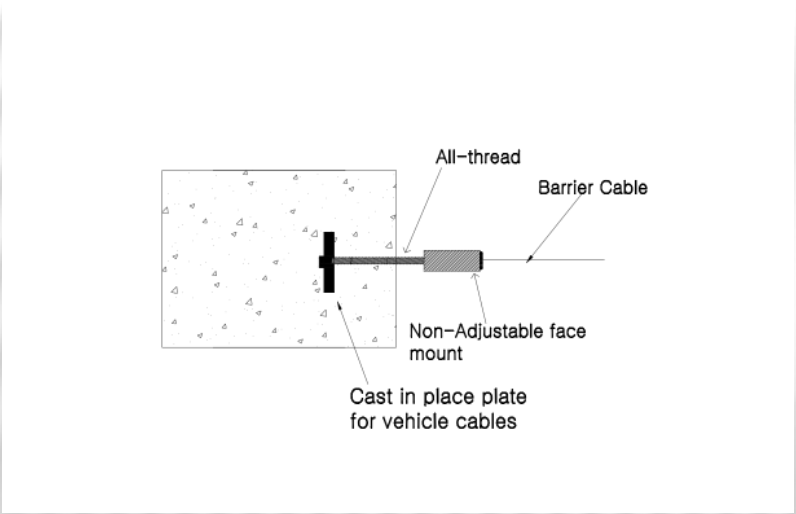
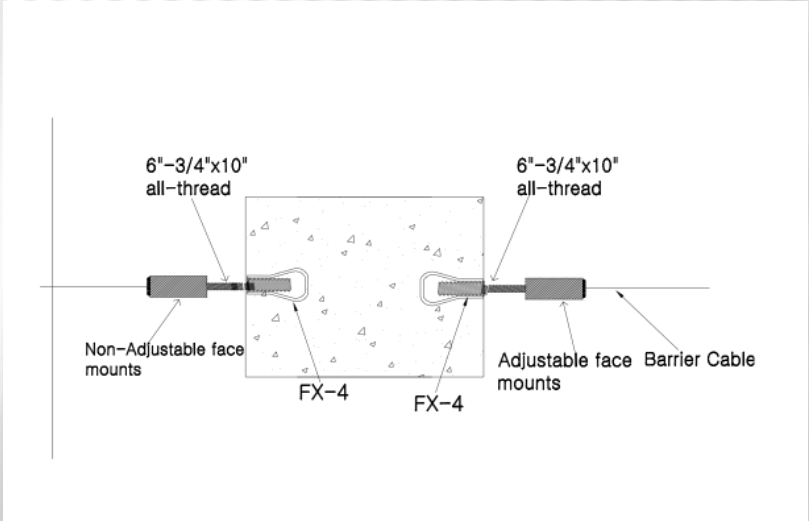
- Steel Cable System – Structural Steel Connections

  - Cast-in-place anchor connections: FX-4 connection is limited to 7,500 lbs. A cast in place plate can be used when loads exceed FX-4 capacity.





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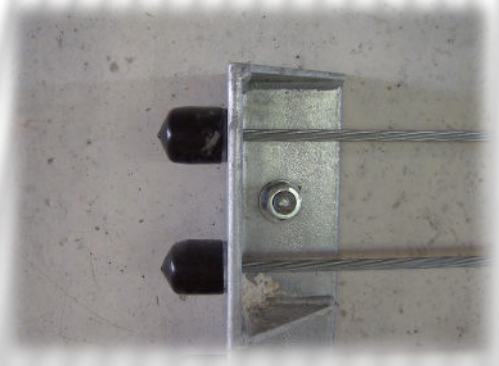
- Steel Cable System – Structural Steel Connections

• Surface mounted anchor brackets:
  An alternative to cast in place anchors and through column cable installations.
• May be used when the end columns are out of alignment with the intermediate columns/walls, or when the through column form tubes/pocket forms were left out.



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Steel Cable System – Intermediate Supports

In longer spans, the cables require support along their length in order to reduce cable sag and to keep the cable stressing loads down. This can be accomplished in several different ways.

- Through structural columns
- Eyebolts or brackets on column face
- Tube steel supports

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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 – There 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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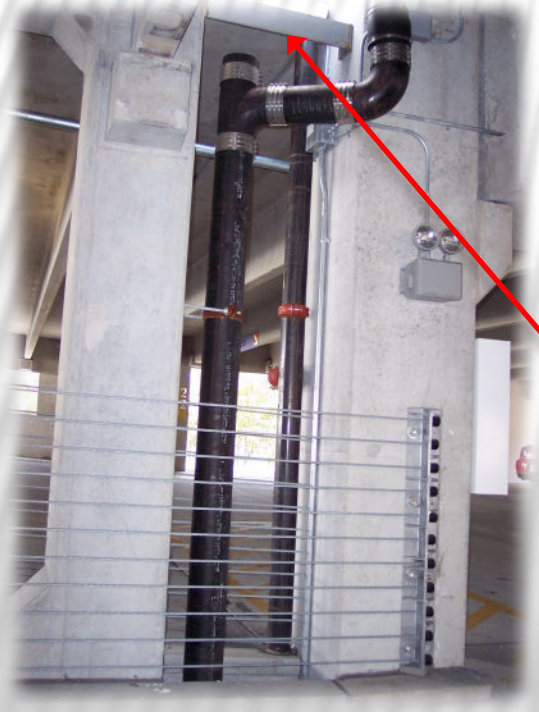
Structural Design Limitations & Issues

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.



Structural steel brace installed to support column bending due to cable load.

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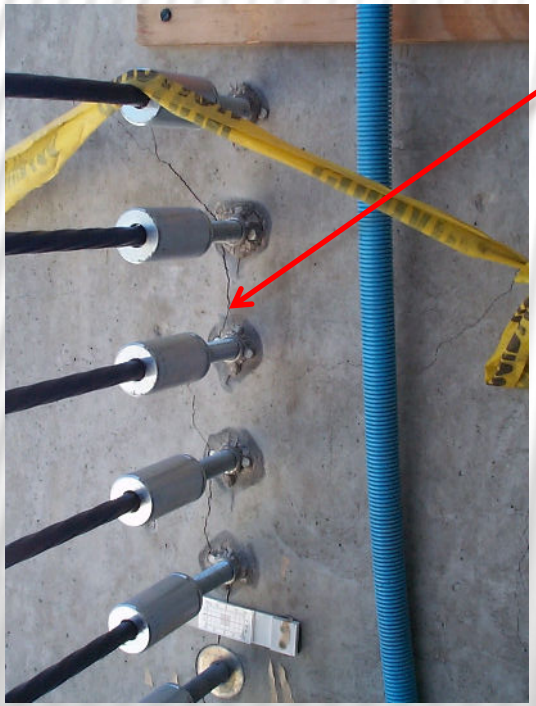
Structural Design Limitations & Issues

Column stress loads – 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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- Structural Design Limitations & Issues

<u>Cable deflection limitations (Issue 1)</u>
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

Cable deflection limitations (Issue 2)
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

Adequate anchor development

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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- Installation Issues

  There are many issues that arise during the installation of new pedestrian / vehicular restraint systems. Most problems that are encountered are either design related or construction related issues.

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- Installation Issues – Design Problems

Many design problems were previously addressed:
- Cable span lengths – Excessive cable spans
- Column stress loads – Inadequately designed columns
- Cable deflection limitations – Architectural elements too close to cables
- Adequate anchor development - Inadequately designed columns

In addition to these issues, some of the most common types of design related problems are:
- Structural or architectural elements conflict with cable end anchors and do not provide enough room to stress the cables. Usually require approximately 2’ 6” clearance for installation of the stressing jack and cable pull.

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- Installation Issues – Construction Problems

The most common types of problems that arise during a barrier cable installation are some form of construction related issue. These problems generally fall under one or more categories:

- Failure to properly sequence related work.
- Conflict with an structural, architectural, or mechanical obstruction.
- Failure to adhere to plans and provide necessary inserts and sleeves.
- Project not ready for barrier installation.

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- Installation Issues – Construction Problems

Failure to properly sequence related work:
In the rush to complete a project, improper sequencing of the work can create problems during and after the barrier cable installation. Some common sequencing mistakes are:

• Cast in place curbs / washes have not been poured and/or waterproofing (expansion joints, etc.) have not been installed. Once the cables are in place, these trades may not have adequate access to the work areas.

• CMU walls at stairs are constructed and may prevent access to cable anchor access in columns.

• Exterior architectural panels (aluminum, precast, etc.) are installed and may prevent access to cable anchor access in columns, or limit room to utilize stressing jack.

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- Installation Issues – Construction Problems

Failure to properly sequence related work:
Installation of the cables prematurely can inhibit the access of other trades to work areas beyond the barrier.

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- Installation Issues – Construction Problems

Conflict with an structural, architectural, or mechanical obstruction.
This problem can be the result of either a design error or a construction sequencing issue. Some of the most common conflicts are the result of:

• Plumbing or drain lines located in line with the cable span, or cover the anchor locations, or are too close to the anchor ends and the conflict won't allow the stressing jack to fit.

• Architectural elements are installed prior to cable installation and conflict with cable end anchors. This may not provide enough room to stress the cables. Usually require approximately 2' 6" clearance for installation of the stressing jack and cable pull.

NEW CONSTRUCTION

- Installation Issues – Construction Problems

Failure to provide the necessary column inserts and sleeves:
This error can result in a major issue, sometimes requiring the redesign of the barrier system. Some of the most common problems are:

• Anchor pocket formers were not installed. This is usually not a problem if the structure will accommodate the use of surface mounted barrel anchors.

• PVC sleeves through the concrete columns were not installed. This can be a significant problem. Correcting this usually requires drilling holes through the columns or revising the system to a surface mounted design.

• PVC sleeves and/or anchor pocket formers are not installed at the correct elevation. The location of the cables must comply with the building code, so variations in the cable spacing must be corrected.

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- Installation Issues – Construction Problems

Project not ready for barrier installation:
These problems are the result of poor project management. Some of the most common problems are:

• Construction of the structure is not complete.
• Access to the garage is blocked due to other construction activities on the site (excavation, concrete placement, paving, etc.).
• The form contractor has not removed the anchor pocket formers or trimmed the thru column PVC sleeves.
• Other trades are scheduled to work in the barrier areas during installation (waterproofing, stucco, mechanical, etc.).
• Materials stored on the site are too close to the work areas and interfere with the barrier installation.

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