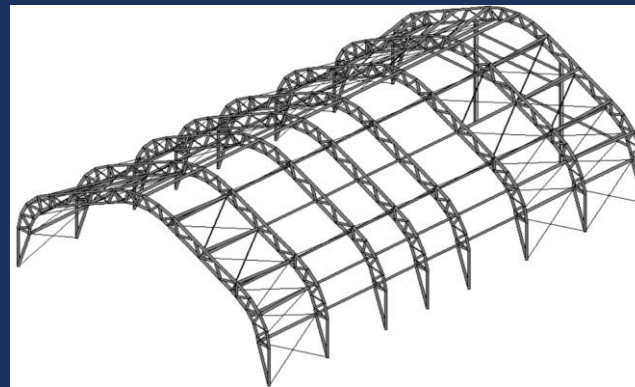


# PERFORMANCE OF STEEL SALT STORAGE FACILITIES

NEW YORK STATE COUNTY HIGHWAY SUPERINTENDENTS ASSOCIATION – WINTER CONFERENCE

JANUARY 2017

Presented by:



# INTRODUCTION

Three things we know about salt...

# INTRODUCTION

Great on fries!



# INTRODUCTION

Deicing agent of choice for most transportation agencies



# INTRODUCTION

Doesn't mix well with steel!



# INTRODUCTION

Presentation will cover the following:

- Inspections and common problems found
- Retrofits
- Replacements
- Required analysis
- Learning assessment



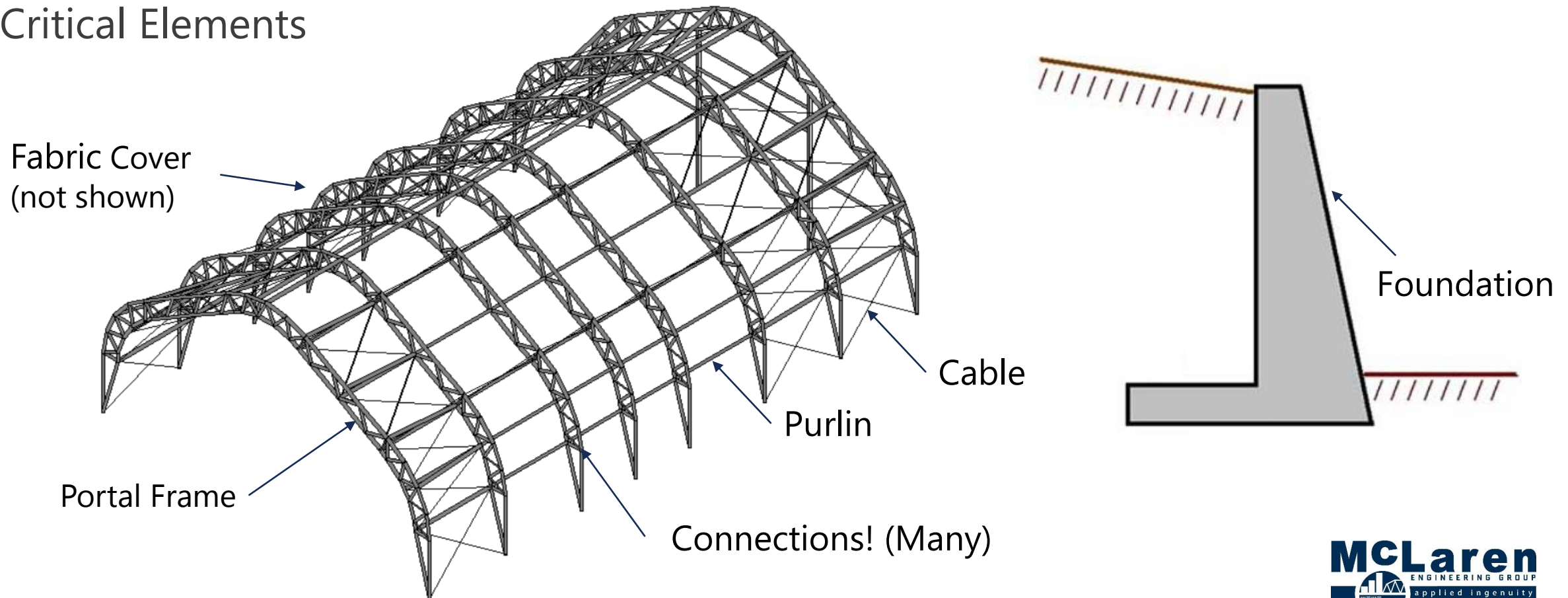


# INSPECTIONS AND COMMON PROBLEMS FOUND



# INSPECTIONS AND COMMON PROBLEMS

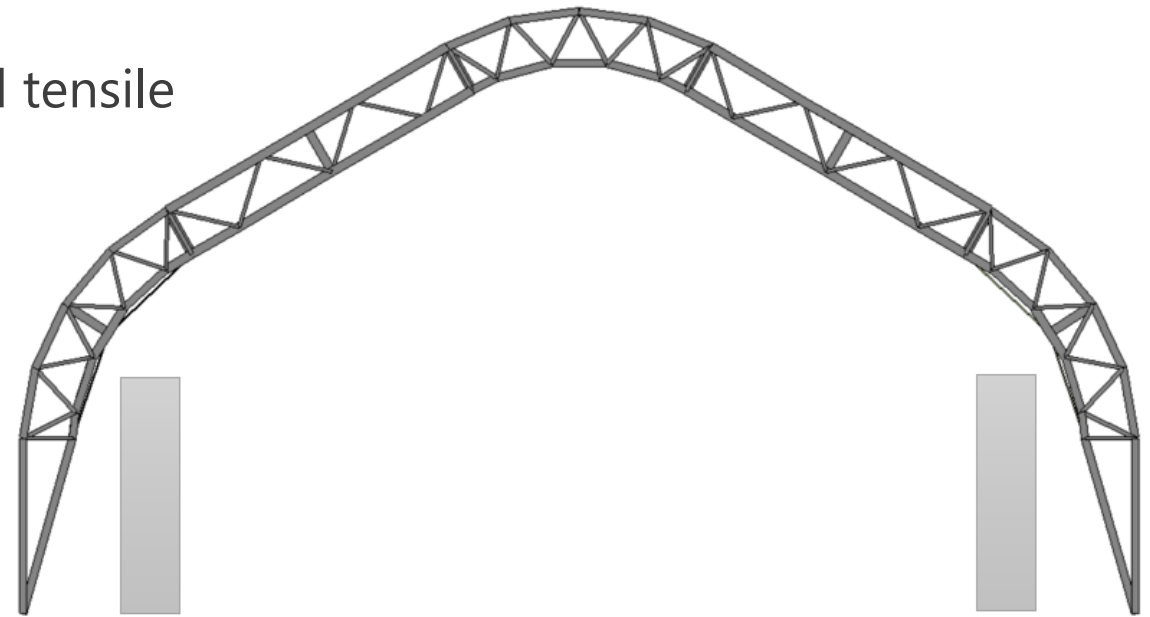
## Critical Elements





# INSPECTIONS AND COMMON PROBLEMS

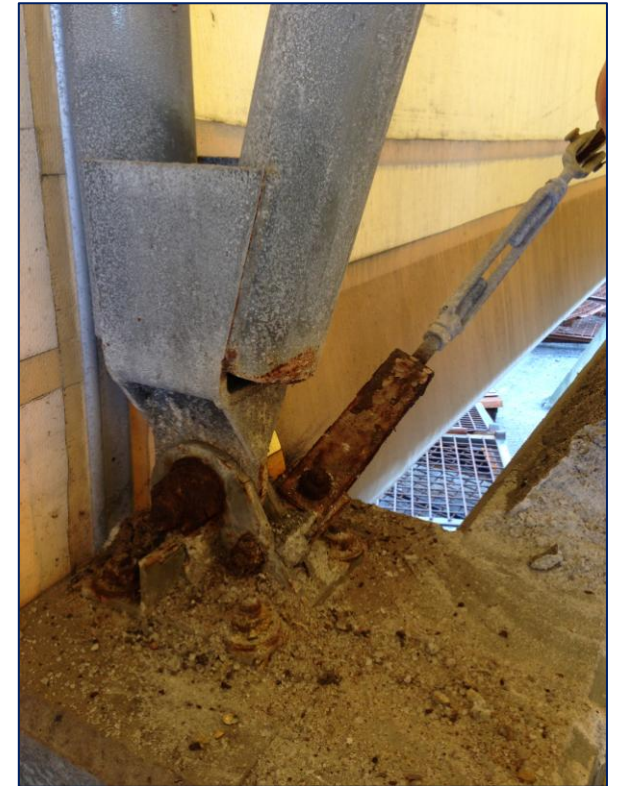
- Impact damage from equipment
- Any member can be in tension or compression depending on loading.
- Beware of buckling in compression members and tensile rupture in tension members.



# INSPECTIONS AND COMMON PROBLEMS

## Connections

- Complex details
- Accelerated corrosion when covered with salt
- Keep the salt away from the steel components!



# INSPECTIONS AND COMMON PROBLEMS

## Cables

- Porous
- Gaps between strands can collect salt and moisture which leads to corrosion
- Subject to sudden failure



# INSPECTIONS AND COMMON PROBLEMS

## Cable Connections

- Many Components
  - Turnbuckles
  - Wire rope, turn buckle
- Trap salt and moisture
- Subject to severe corrosion



# INSPECTIONS AND COMMON PROBLEMS

- Quality Control on Welds



# INSPECTIONS AND COMMON PROBLEMS

## Wall Issues

- Prefabricated foundations
- Look for spalling, cracking, and separation
- Check for proper backfill on the outside of the wall



# INSPECTIONS AND COMMON PROBLEMS

## Salt overloading

- Too much salt can pour over the top of the retaining wall
- Can lead to corrosion or fabric failure
- Note that the fabric is an integral part of the structure – provides bracing to the top chord



# INSPECTIONS AND COMMON PROBLEMS

- Corrosion Overall





# INSPECTIONS AND COMMON PROBLEMS FOUND

## ■ Connections

- Welds/cables are tough to inspect once initially affected
- Bolts and ratchet straps (used to tension fabric) may need replacement





# REPAIRS AND REPLACEMENT



# REPAIR OR REPLACE?

## Why Repair?

- Address design inadequacies
- Moderate corrosion
- No major manufacturing flaws
- Would need new foundation
- Lower Cost (\$10-\$100k), depending on condition



# REPAIR OR REPLACE?

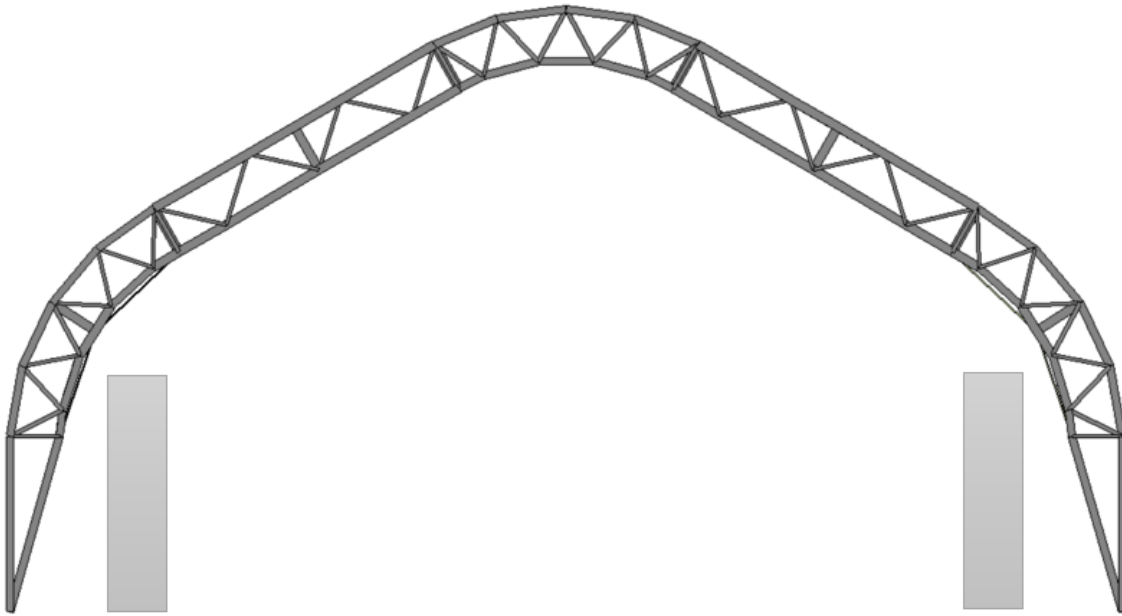
## Why Replace?

- Acquire larger/different structure
- Heavy corrosion
- Suspect manufacturing (i.e. welds)
- Fabric needs replaced
  - \$45-\$75k alone
- Higher Cost (\$250k-\$500k)



# REPLACEMENT STRUCTURES

Keep Foundation

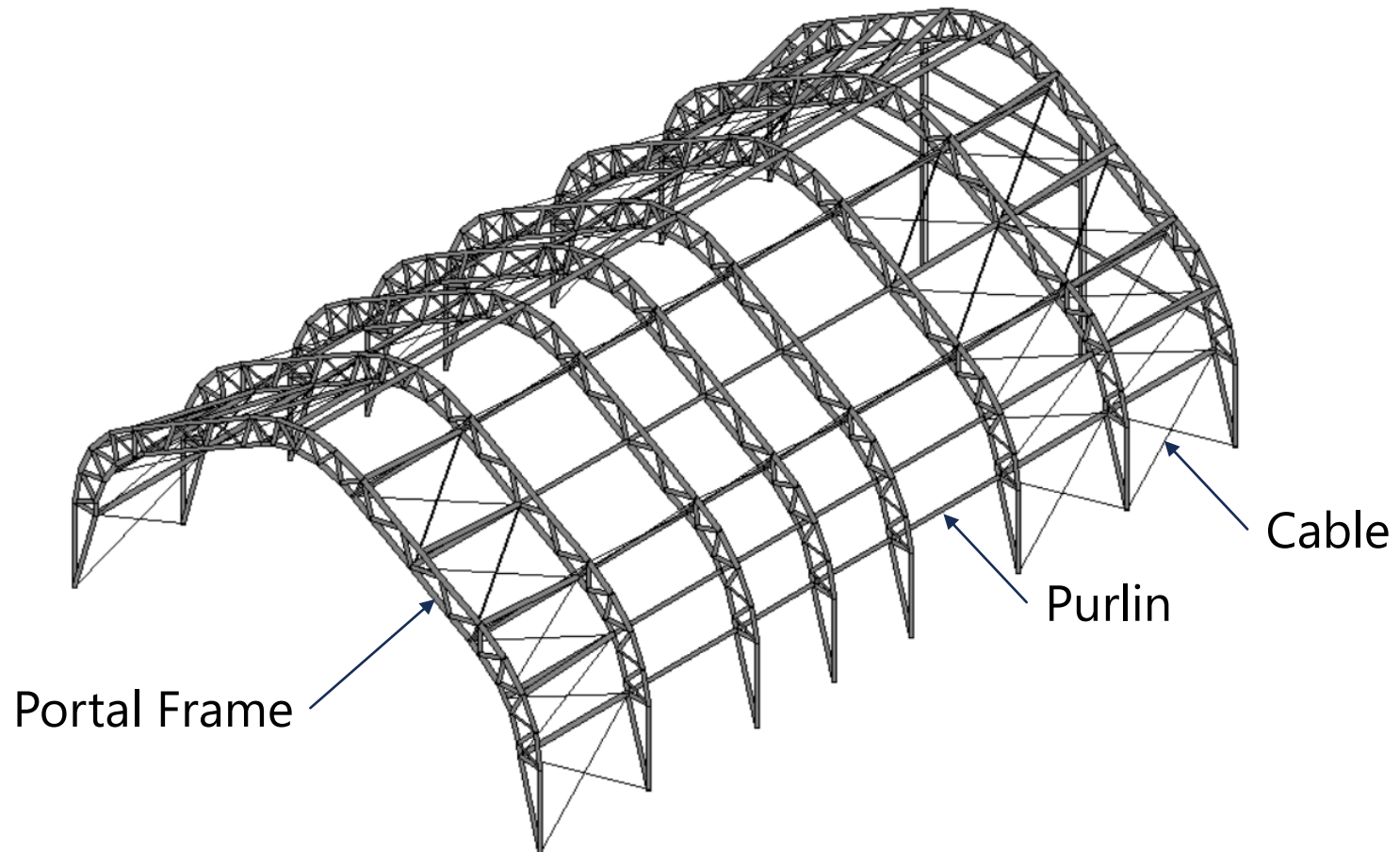


Complete Change



# REQUIRED ANALYSIS AND METHOD

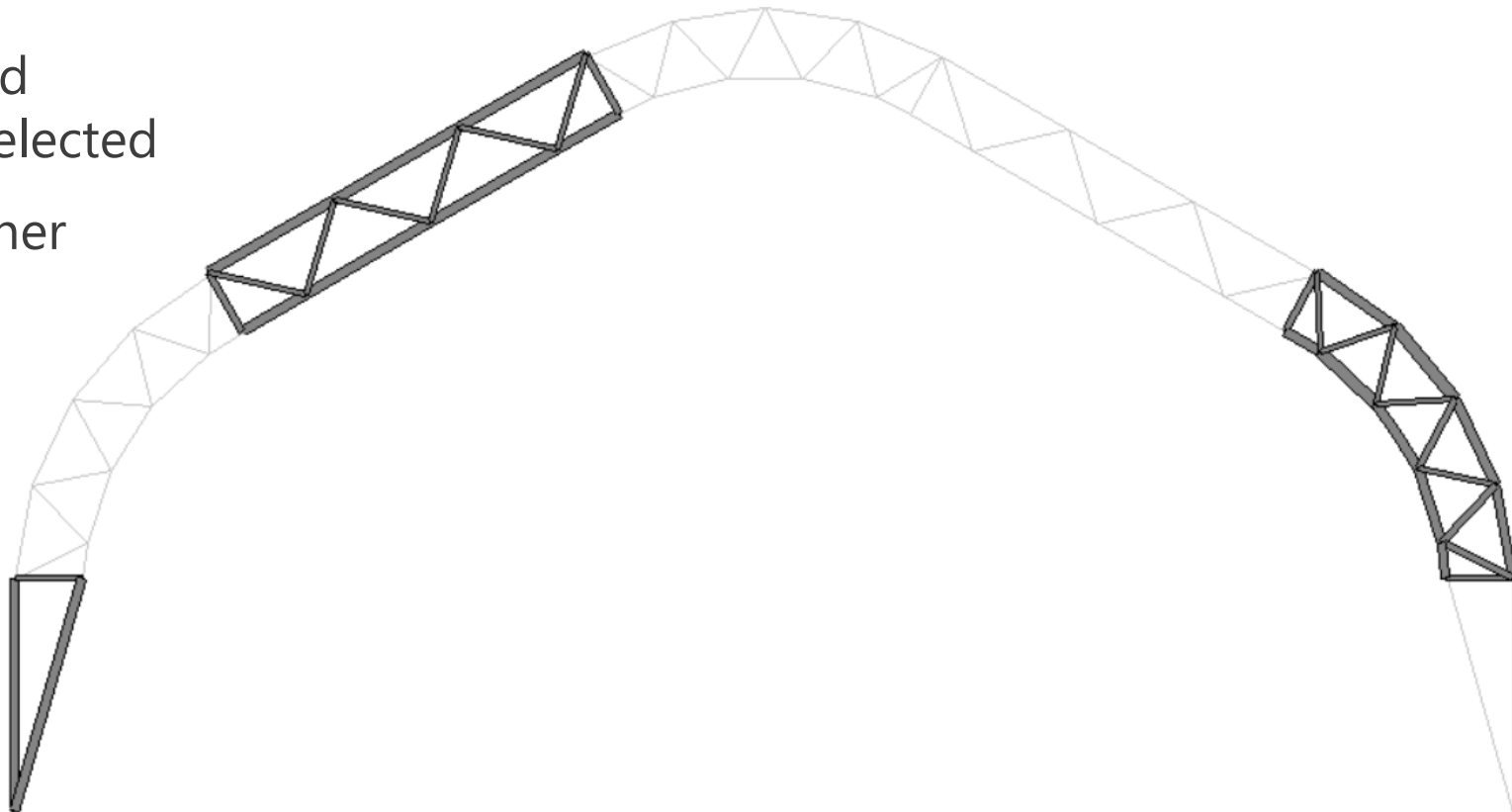
## System Overview



# REQUIRED ANALYSIS AND METHOD

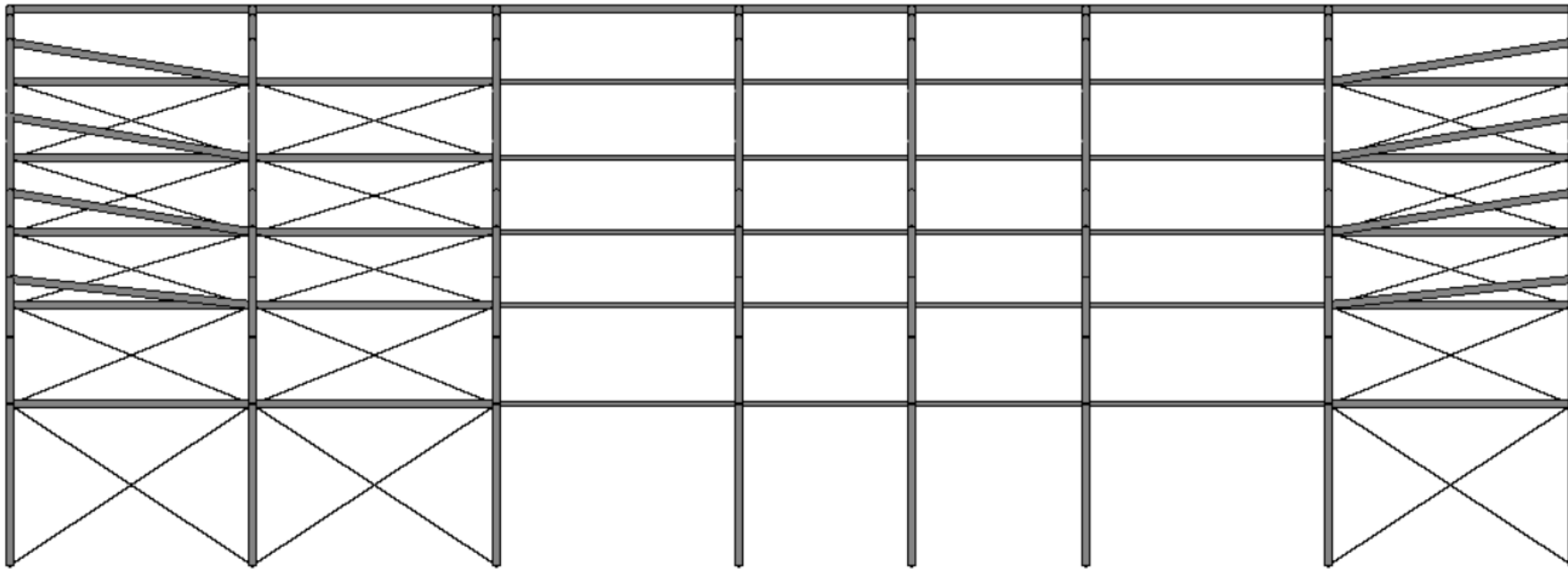
## Portal Frame

- Pre-fabricated weldments selected
- Bolted together



# REQUIRED ANALYSIS AND METHOD

## Longitudinal System





# REQUIRED ANALYSIS AND METHOD

## Fabric

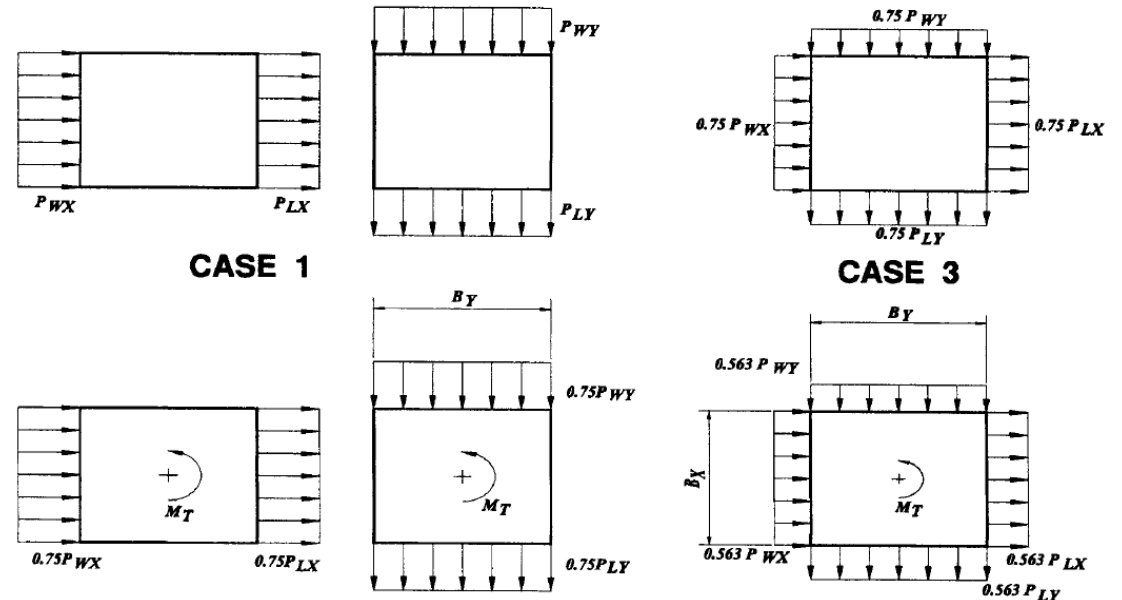
- Braces members
- Tensioning effect
- Dictates load direction



# REQUIRED ANALYSIS AND METHOD

## Wind Load

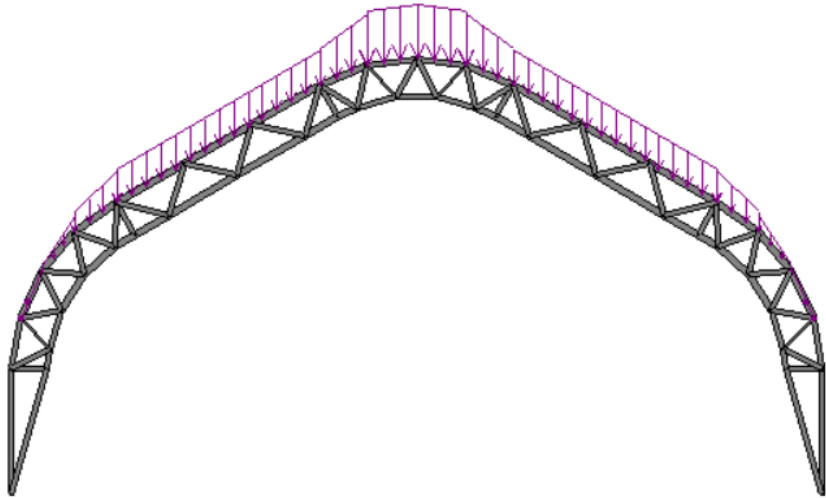
- Design wind speeds vary locally
  - Special wind region
  - Exposure category
- Enclosed/Partially enclosed
- Many load cases
  - Torsional
  - Uplift/downforce



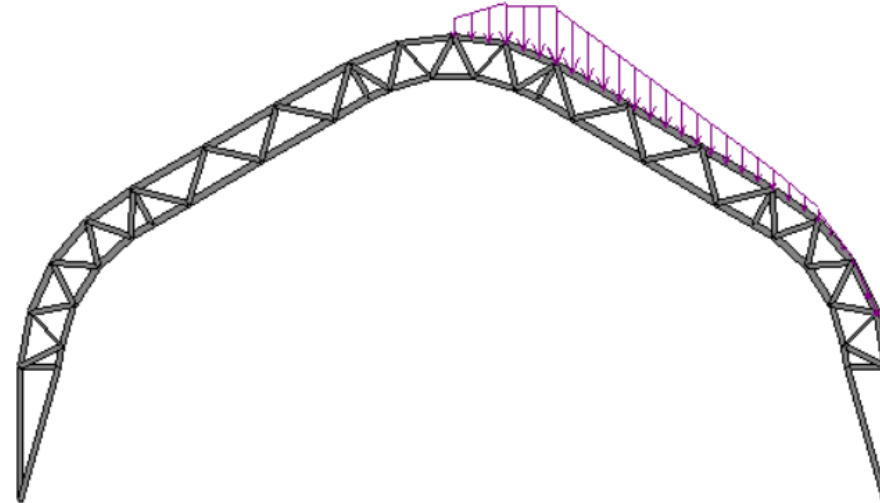
# REQUIRED ANALYSIS AND METHOD

## Snow Load

- Design snow loads vary locally
- Non-heated structure



- Slippery surface
- Snow creates additional fabric tension
- Balanced and unbalanced loading



# REQUIRED ANALYSIS AND METHOD

## Dead Load

- Light if fabric, heavy if wood
- Is being light good or bad?
  - Seismic
  - Snow
  - Wind
  - Foundation



# REQUIRED ANALYSIS AND METHOD

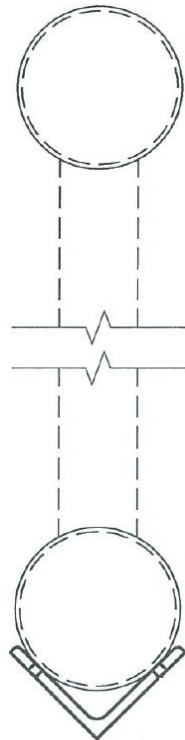
## Analysis Results

- Tube-to-tube connections/weld often fail
- Gross member overstress
- What happens when the analysis considers the effect of corrosion?

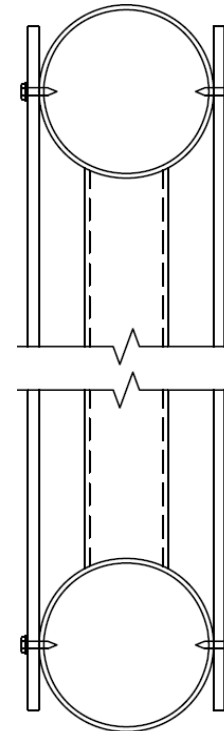


# REPAIRS AND RETROFITS

Repair Example 1

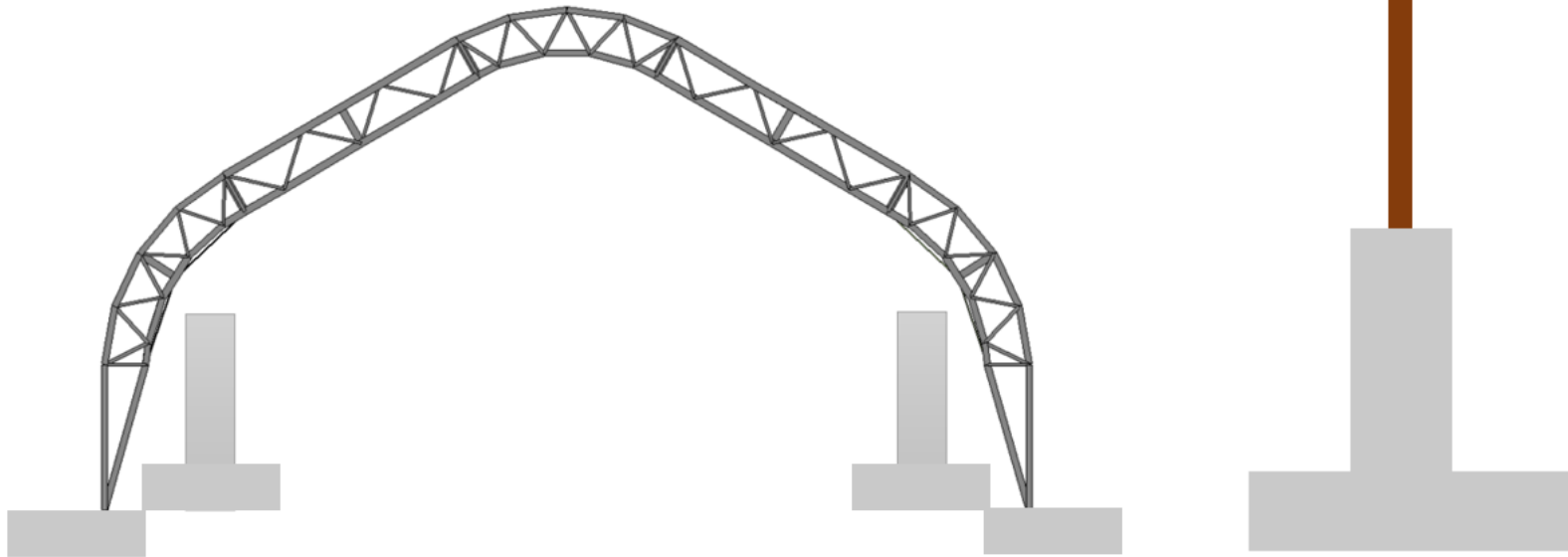


Repair Example 2



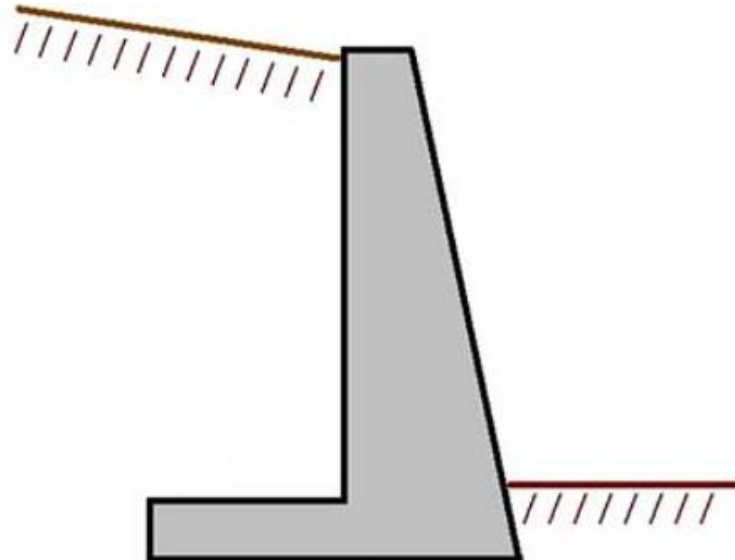
# REPLACEMENT STRUCTURES

- Foundation concerns
  - Capacity of existing wall
  - Undermining of existing structures
  - Soil bearing capacity



# CONSIDERATIONS FOR EXISTING STRUCTURES

- Foundation
  - Concrete failures
  - Review design and construction

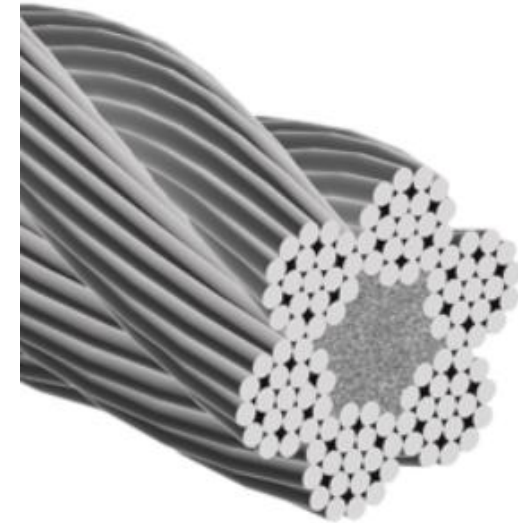
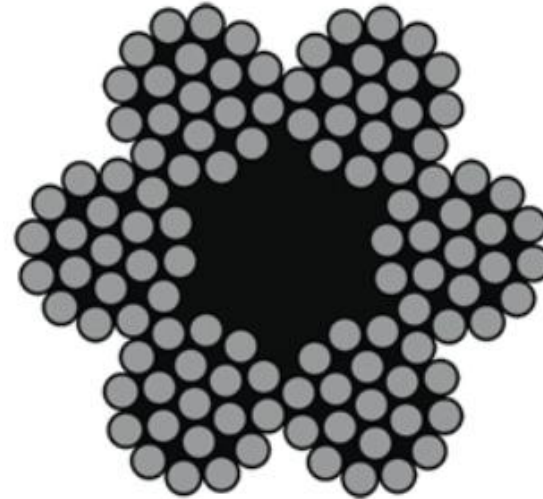




# CONSIDERATIONS FOR EXISTING STRUCTURES

## ■ Connections

- Difficult to tell degree of corrosion on cables once initially affected



# CONSIDERATIONS FOR EXISTING STRUCTURES

- Connections
  - Welds may be inadequately designed, improperly placed, or failed



# CONSIDERATIONS FOR EXISTING STRUCTURES

- Connections
  - Bolts and ratchet strap brackets may need replacement, or must be considered to be less effective – especially over time



# CONSIDERATIONS FOR EXISTING STRUCTURES

- Different areas of members are more/less perceptible to corrosion
  - Environmental factors
  - Quality of construction



# DESIGN SUGGESTIONS

## Hot Dip Galvanization

- Member must fit in galvanization tanks
- High bond strength
  - Durability
- Superior Protection
  - Barrier protection
  - Cathodic protection
  - Zinc forms patina
- Provides coating on inside of HSS
  - Important if pipe ends are not closed



# DESIGN SUGGESTIONS

## Cold Galvanization (Zinc-Rich Paints)

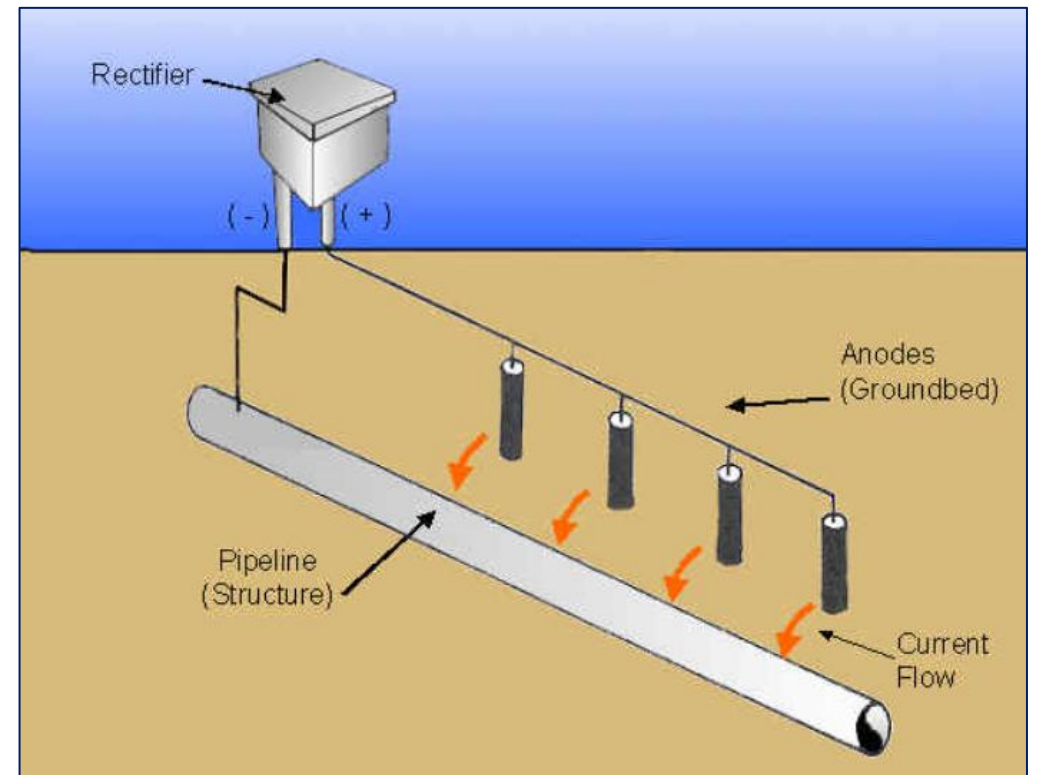
- Greater versatility
  - Can accommodate all member lengths
- Inferior Protection
  - Barrier protection
  - No cathodic protection due to bonding agents
  - Protective patina does not form
- Applied in-field
  - Applied over welds
  - Can be used to touch-up holes, cut ends, etc.



# DESIGN SUGGESTIONS

## Active Cathodic Protection

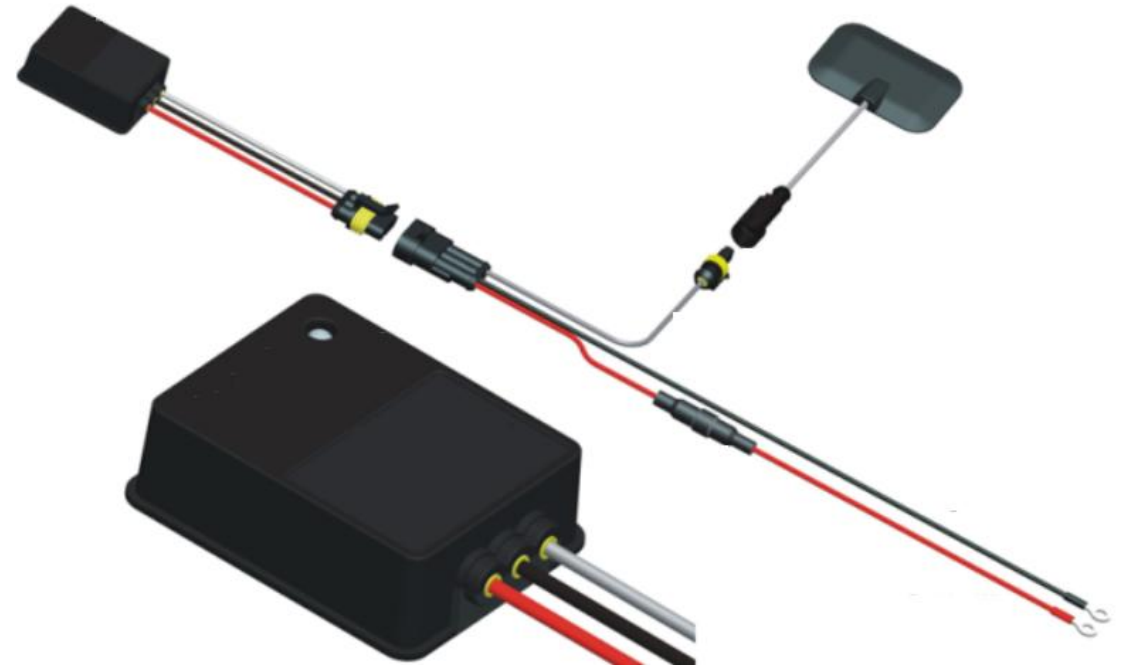
- Uses sacrificial anode to electronically supply electrons as they are lost to the environment
- Only protects steel if it is:
  - Submerged or filled with water
  - Buried in the ground
  - Encased in concrete



# DESIGN SUGGESTIONS

## Electronic Rust Prevention System

- Interferes with chemical bond between iron and oxygen
- Operates on a “closed loop” electrical circuit
- Can be used in open air
- Popular on vehicles
  - Building is a larger-than-typical application





# DESIGN SUGGESTIONS

Prevent Overloading of Salt





# LEARNING ASSESSMENT



# LEARNING ASSESSMENT

Which of the following is not a critical elements of a fabric structure?

- a) Portal Frame
- b) Cables
- c) Connections
- d) Purell
- e) Fabric

# LEARNING ASSESSMENT

Cold Galvanization is usually just as effective as Hot Dip Galvanization.

- a) True
- b) False

# LEARNING ASSESSMENT

Fabric tears can be ignored as long as they don't allow excessive snow/rain from entering the structure.

- a) True
- b) False

# LEARNING ASSESSMENT

Which of the following corrosion systems is not applicable to a salt structures?

- a) Hot Dip Galvanization
- b) Electronic Rust Prevention System
- c) Active Cathodic Protection
- d) Cold Galvanization

# LEARNING ASSESSMENT

Precast wall units can be placed on grade without backing material.

- a) True
- b) False

# LEARNING ASSESSMENT

Which of the following members can be in tension depending on loading?

- a) Top Chord
- b) Bottom Chord
- c) Cables
- d) Fabric
- e) All of the above



# LEARNING ASSESSMENT

Which of the following is not usually a concern for the integrity of the structure?

- a) Impact damage
- b) Fabric tearing
- c) Cable deterioration
- d) Snow accumulation

# LEARNING ASSESSMENT

Hand computations are usually the most efficient way to check the adequacy of the design.

- a) True
- b) False

# LEARNING ASSESSMENT

Which of the following conditions is evaluated during design?

- a) Balanced snow load
- b) Imbalanced snow load
- c) Wind direction
- d) Wind zone
- e) All of the above

# LEARNING ASSESSMENT

Salt Overloading:

- a) Can lead to corrosion
- b) Can lead to fabric failure
- c) OK on fries
- d) All of the above

# QUESTIONS

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