

# NEW HAVEN MAINLINE CATENARY & BRIDGE REPLACEMENT PROGRAM



## Presentations by:

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(Construction)**

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## PRESENTATION OVERVIEW

- **Historical**
- **Selected Catenary & Bridge Replacement**
- **Track Outages Required**
- **Challenges Moving Forward**

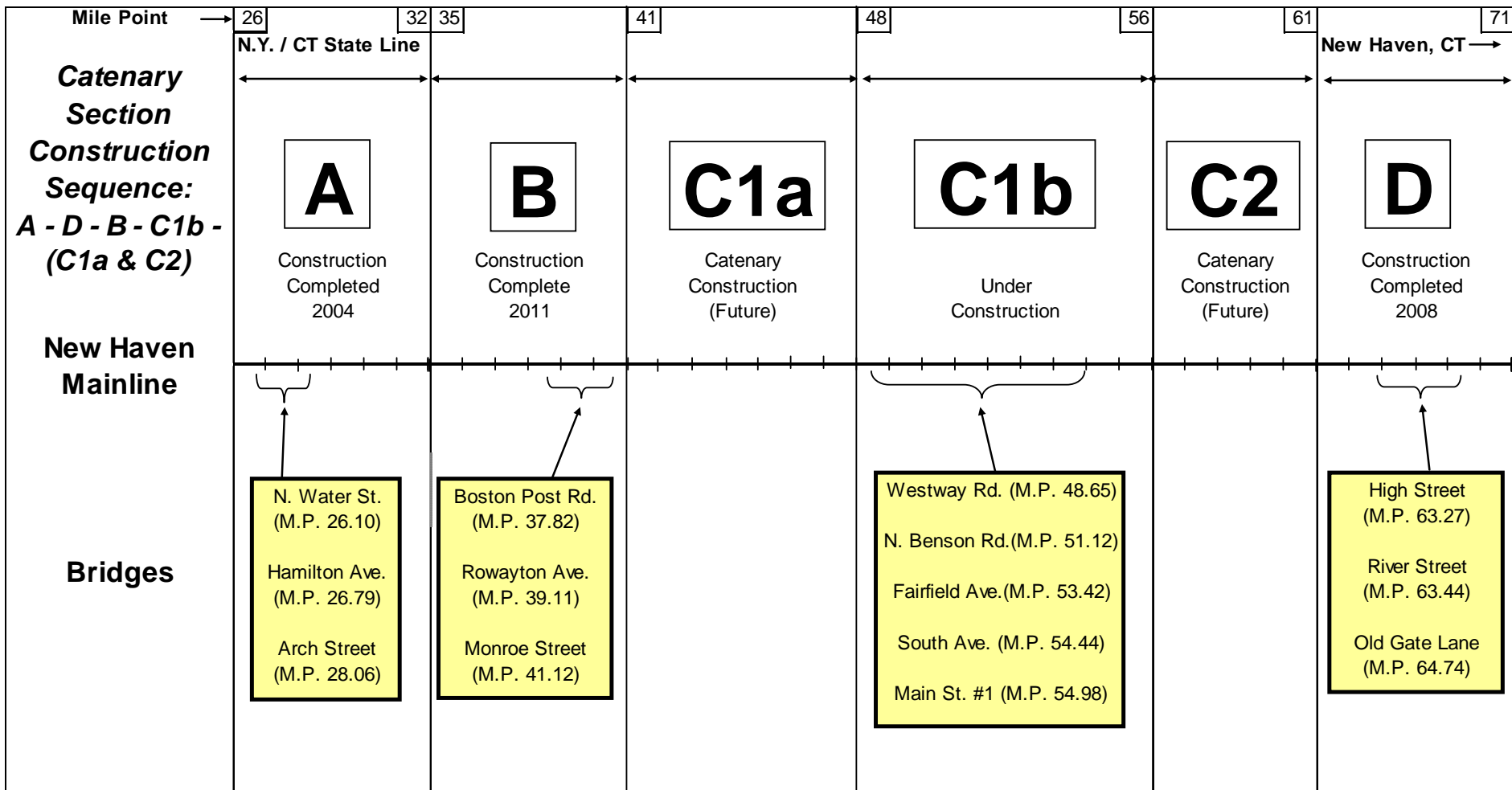
# NEW HAVEN MAINLINE CATENARY & BRIDGE REPLACEMENT PROGRAM



In Connecticut, there are approximately 200 track miles of mainline overhead catenary powering our trains.

For 20+ years, the Office of Rail has undertaken the monumental task of complete replacement while still operating the nations busiest commuter rail service.

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## Catenary Section Assignments

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- The existing traction power system on the New Haven Line is referred to as a variable fixed tension catenary system.
- The selected replacement catenary system is referred to as a simple two wire auto-tension (AT) system.

The AT system allows the conductors to remain at a constant tension while experiencing extreme expansion and contraction due to ambient temperature fluctuations.

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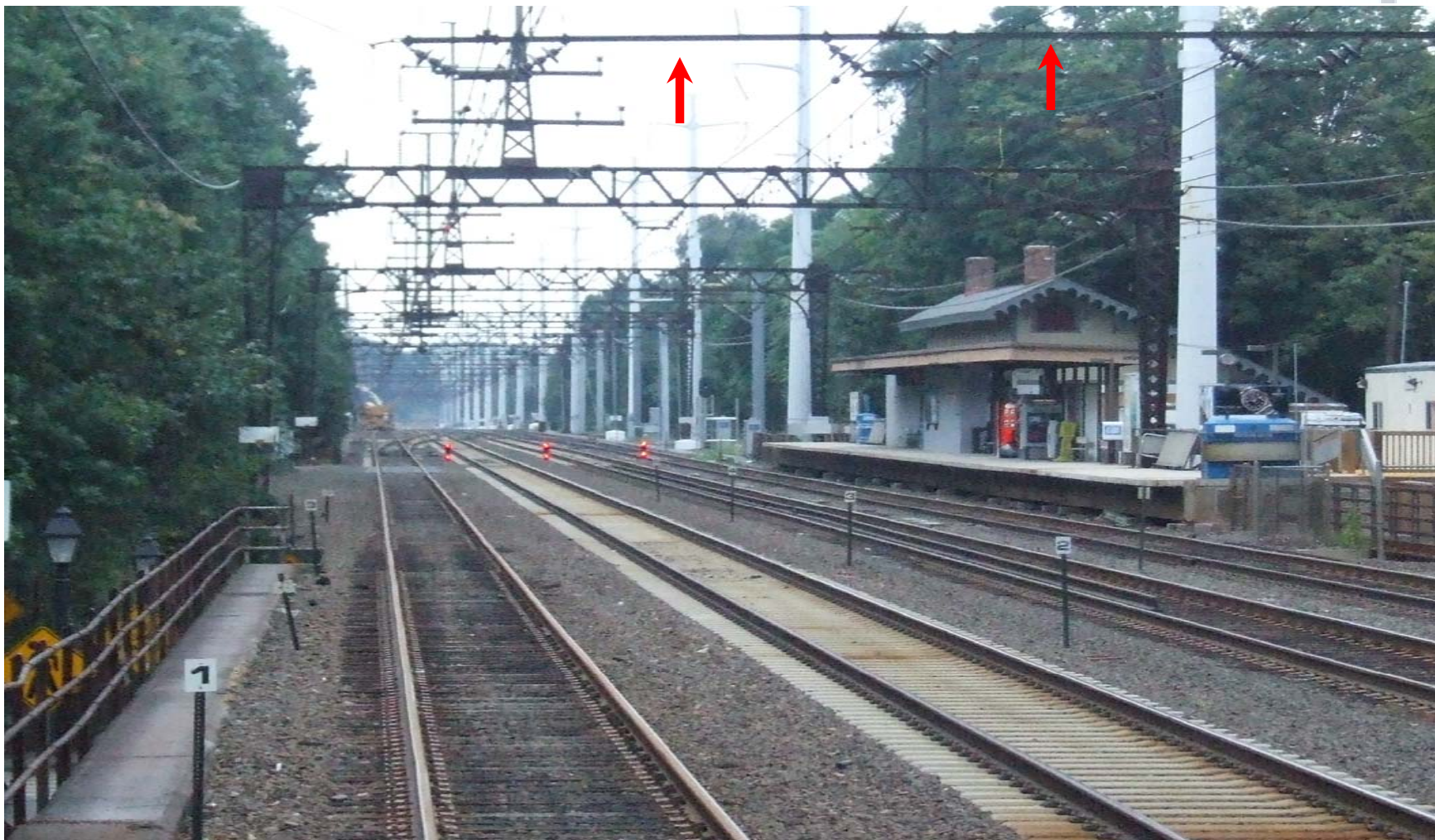
**Traction power to propel trains is delivered from overhead wires known as Catenary and transferred through the Pantograph.**

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**Triangular Catenary**

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Floating-Beam Catenary



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Experimental Arch Catenary

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Underside view of "Experimental" type

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**ERECTOR SET** Fascinating facts about the invention of Erector Sets by A.C. Gilbert in 1913. Born in Salem, Oregon in 1884. A. C. Gilbert (1884-1962), boyhood love was magic tricks: he became so proficient that he once matched a traveling professional magician trick for trick, and earned the prescient praise, Gilbert was also a brilliant student, and soon went on to Yale Medical School. He helped pay his tuition by performing as a magician, and founded a company, Mysto Manufacturing, which sold magic kits for kids. In 1909, Gilbert finished medical school, but decided to expand his budding toy business rather than practice as a doctor.

Like many residents of New Haven, Connecticut, he often took the train to New York City; and on one trip in 1911 he was inspired with what would be the most popular of his dozens of inventions.

**Watching out the train window as some workmen positioned and riveted the steel beams of an electrical power-line tower, Gilbert decided to create a children's construction kit: not just a toy, but an assemblage of metal beams with evenly spaced holes for bolts to pass through, screws, bolts, pulleys, gears and eventually even engines. A British toy company called Meccano Company was then selling a similar kit, but Gilbert's Erector set was more realistic and had a number of technical advantages --- most notably, steel beams that were not flat but bent lengthwise at a 90-degree angle, so that four of them nested side-to-side formed a very sturdy, square, hollow support beam.**

Gilbert began selling the "Mysto Erector Structural Steel Builder" in 1913, backed by the first major American ad campaign for a toy. The Erector set quickly became one of the most popular toys of all time: living rooms across the country were transformed into miniature metropolises, filled with skyscrapers, bridges and railways. Those kids who already owned a set would beg Santa annually for an upgrade, aiming for the elusive "No. 12 1/2" deluxe kit that came with blueprints for the "Mysterious Walking Giant" robot. It is difficult for anyone under the age of 35 today to appreciate just how popular the Erector set was for over half a century.

A. C. Gilbert was one of the most multi-talented inventors of all time. With many fields open to his ingenuity, he chose to educate and entertain children through toys.

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## CATENARY REPLACEMENT PROGRAM PHILOSOPHY

- While the track is out-of-service for catenary replacement accomplish as much bridge replacement and scheduled maintenance as possible.
- Utilize existing catenary structures as much as possible.

However....

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- The catenary wires (bare conductors) and the structures supporting them are, in general, over 100 years old.
- From the ground up, the catenary structures are severely deteriorated and require extensive repairs.

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Left – view of deterioration of steel in catenary portal bridge before repair.

Right – view of catenary portal bridge after repair.

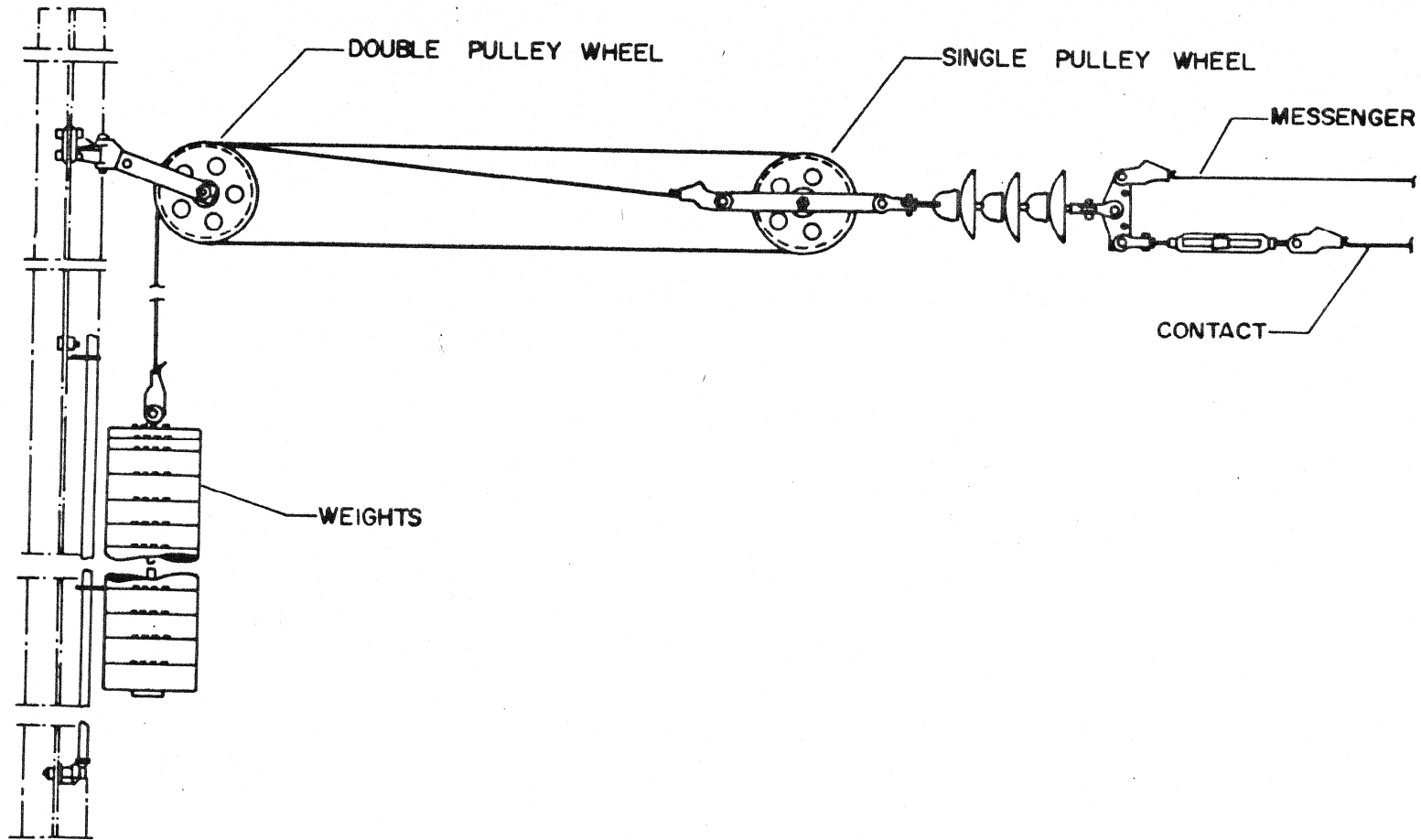


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Existing catenary portal retrofitted to accept the new constant tension catenary wires and the counterweight assembly.

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3:1 RATIO BALANCE WEIGHT ASSEMBLY



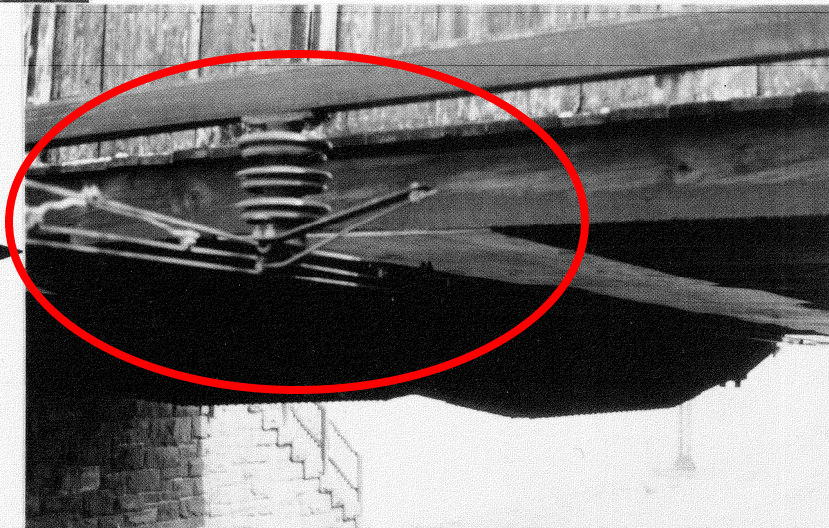
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Many wooden deck bridges cause severe problems to the system during the winter months. Power outages occur as a result of icicle formation caused by water leakage through the bridge decking.

← This photograph is a good example of the maintenance forces ingenuity. Utilizing this warning sign as a drip shield they have attempted to divert the water leakage from the deck of the wooden bridge away from the catenary.

A drip shield constructed of plywood to protect the catenaries from water run-off from the bridge deck and corrosive de-icing salts during the winter months. The use of this type of material is not satisfactory for long term protection of the catenary beneath the bridge.



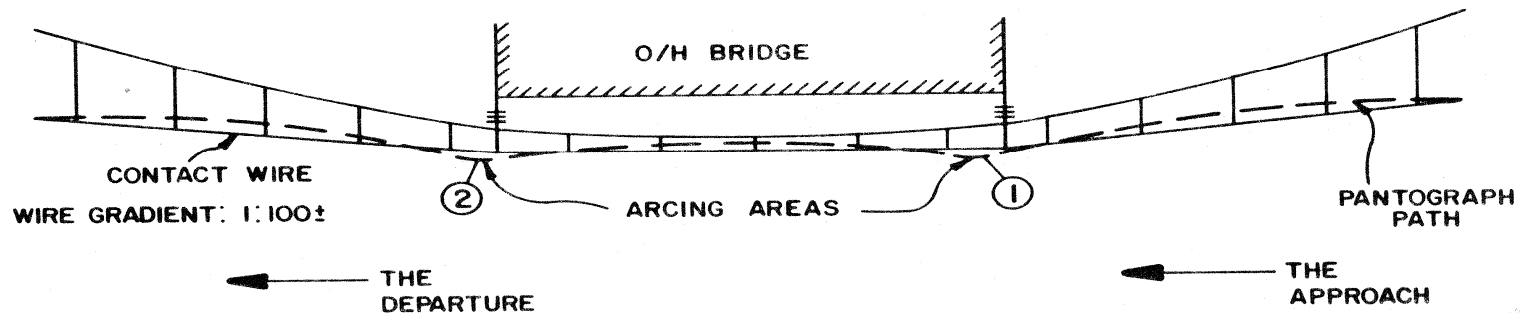
Low overhead structure (i.e. bridges) compress the system creating hard spots (see lower right photo).

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## TYPICAL PANTOGRAPH TRACKING AT OVERHEAD BRIDGES

- AT LOCATION ① THE PANTOGRAPHS DOWNWARD INERTIA FORCES IT TO LEAVE THE CONTACT WIRE.
- AT LOCATION ② THE PANTOGRAPH CANNOT RESPOND FAST ENOUGH TO THE SHARP CHANGE IN WIRE GRADIENT.



### Contact Wire Gradient

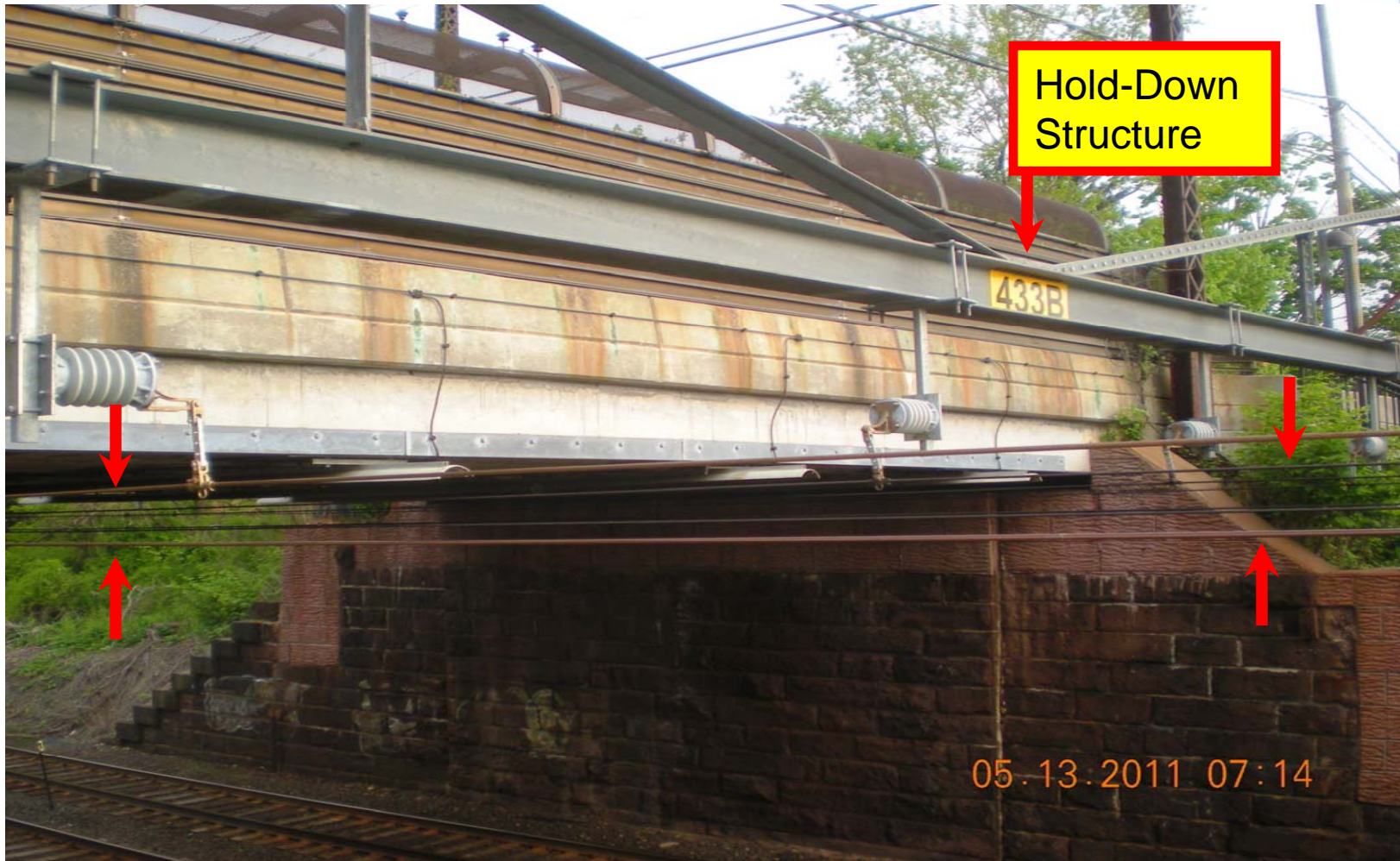
The majority of the overhead bridges have contact wire gradients of  $1:100_{\pm}$  relative to track.

These gradients are excessive and result in the pantographs being forced down sharply on the approach side of the bridge.

On the departure side of the bridge, the tendency is for the pantograph to lose contact with the contact wire as the wire is rising at a faster rate than the dynamic trajectory of the pantograph.

The net result is severe arcing, contact wire pitting and rapid wear of the contact wire in the vicinity of the overhead bridge.

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Fixed overhead structures are cause for great concern when designing the catenary system (shows system wire compression approaching bridge).

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**Blending old with new - Existing portal close-up, showing new drop tube assemblies retrofitted to the trusses of existing portals.**

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**Night work required for demolition of “Experimental” portal –  
Four Track outages are necessary to undertake such work.**

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Preparing to lift new catenary truss.

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New catenary truss is lifted vertically to clear existing catenary.

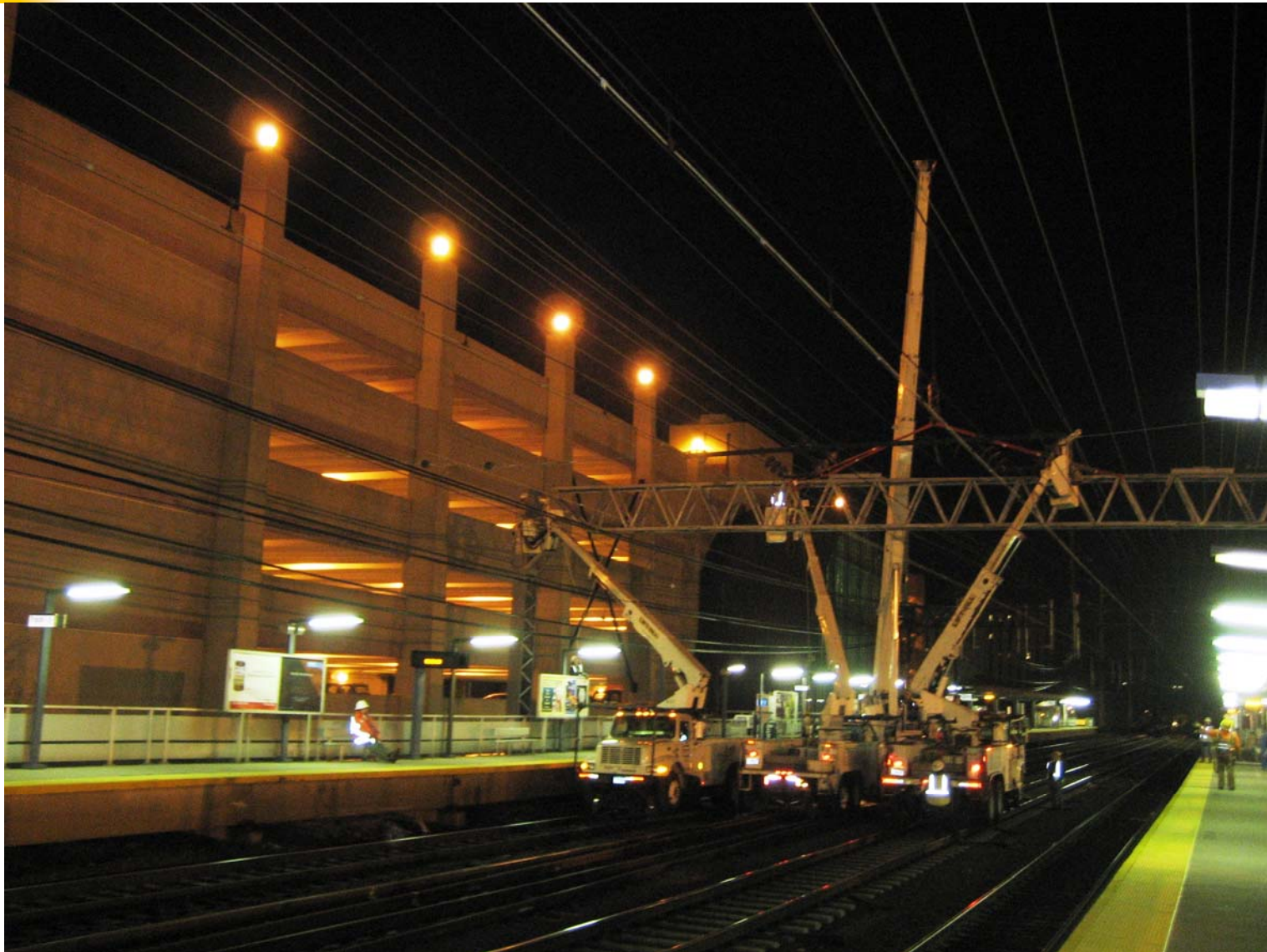
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**Spinning new portal truss over to its vertical columns.**



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**New catenary truss set in final location on support columns.**

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New catenary Truss type portal

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**New catenary portal close-up, showing catenary hanger drop tube assemblies used to replace the old antiquated triangular system.**

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**Complex and diverse array of catenary structures, utility overbuild and utility monopoles.**

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The work to upgrade the catenary must be conducted in a dangerous environment. Trains pass through workzone at up to 70 mph.

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**Contractors must possess specialized equipment of their own. The installation of new catenary wire is shown above.**

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Workers install and adjust new catenary wire.

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## FOUNDATIONS

- Existing foundations exhibit severe concrete spalling, efflorescence and exposed reinforcing bars.
- Repairs involve removal of unsound concrete, drilling and grouting of new steel reinforcement, forming and pouring concrete, and final sealing of new concrete.



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**Catenary foundation under repair - unsound concrete has been removed, new rebar installed. Foundation is now ready to be formed and poured.**

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Catenary foundation base with severe deterioration of structural steel.

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Foundation repairs – formed and ready for concrete.

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**Completed foundation repair.**

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**New catenary caisson foundation excavation.**

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Completed catenary foundation in foreground, innovative use of machinery to get to tight and often difficult work locations.

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Specialized equipment required to work in tough locations and with limited headroom, notice the overhead wires.

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**Catenary foundation atop a 20 foot retaining wall, formed and ready to receive concrete.**



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Continuous track outages require the deployment of station “Bridge Plates”, shown here, that allow passengers to board train on inside tracks.<sup>41</sup>

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Continuous "Double Track" outages require the use of full length temporary platforms to be installed over inside track with use of bridge plates seen on left.



## BRIDGES – History

- Most Bridges on the New Haven Line were originally built between the late 1800s and early 1900s by the New York-New Haven-Hartford Railroad.
- Originally built to carry heavy loads from steam engines and coal cars. This combination represented some of the heaviest loads these bridges have ever seen.
- Today's commuter railcars, such as the new M-8's, are much lighter and incur fewer stress cycles that induce structural fatigue. Today, our heaviest loads come from the freight cars.

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## SELECTION OF BRIDGES FOR REPLACEMENT

Some items that are considered:

- **Load and Condition Rating – indicators of the bridge's ability to carry the design and operational loads.**

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BRIDGE NO. 04132R – ROWAYTON AVE. MP 39.11, NORWALK



**CONDITION** - shows up as cracks often when a bridge has experienced stress cycles beyond its design life.

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BRIDGE NO. 03691R – EAST AVE. MP 42.14, NORWALK



**LOAD RATING** - Section loss (rust) is a steel structures biggest enemy and reduces its load carrying capacity.

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## SELECTION OF BRIDGES FOR REPLACEMENT

Some items that are considered:

- **Load and Condition Rating** – indicators of the bridge's ability to carry the design and operational loads.
- **Bridge type (open deck-thru girder)** are more difficult to replace due to the need for double track outages and for installation of temporary bridges if working only with single track outages.

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## OPEN-DECK THRU GIRDER BRIDGE



**OUT WITH THE OLD** – existing bridge at Fairfield Avenue showing one track with deck removed, adjacent to track that still has the open deck timber structure. Of note is the common girder (red arrow) that supports both tracks and is non-redundant.



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BRIDGE NO. 03943R – N. WATER ST. M.P. 26.1, GREENWICH



**NEW BRIDGE** – multi-beam deck girder construction, ballasted deck, built in redundancy against bridge failure. Easy to inspect and perform maintenance. COMPLETED 2004.

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## SELECTION OF BRIDGES FOR REPLACEMENT

Some items that are considered:

- **Load and Condition Rating** – indicators of the bridge's ability to carry the design and operational loads.
- **Bridge type (open deck-thru girder)** are more difficult to replace due to the need for double track outages and for installation of temporary bridges if working only with single track outages.
- **Low Roadway vertical clearance**

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BRIDGE NO. 03635R – FAIRFIELD AVE. M.P. 53.42, BRIDGEPORT



**VERTICAL CLEARANCE IS IMPORTANT**

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**BRIDGE NO. 00316R – BOSTON POST RD. (US RTE 1) MP 37.82, DARIEN**



**NEW BRIDGE UNDER CONSTRUCTION REQUIRING ROADWAY UNDERCUTTING DUE TO LOW VEHICLE UNDERCLEARANCE DURING CONSTRUCTION. ROADWAY WAS ALSO WIDENED.**



## **BRIDGE DESIGN & CONSTRUCTION**

- **Incorporate latest products and construction methods into the design. (Modern steels allow for stronger more efficient bridge types)**
- **Traffic impacts – Roadway vs. Railway (Balancing the needs to allow vehicles to pass through the project while trains operate on the in-service portions of the bridge above.)**
- **Is there a better way to build it? (Foundation technology, Cranes vs. Bridge Movers vs. Girder launching, Staged Construction, Excavation Shoring Methods, etc...)**

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BRIDGE NO. 08039R – WESTWAY ROAD, M.P. 48.65, FAIRFIELD



View before removal of first two tracks.

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## BRIDGE REMOVAL



Setting up of the four hydraulic jacks leading up to the removal of first of two tracks.

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**BRIDGE NO. 08039R – WESTWAY ROAD, M.P. 48.65, FAIRFIELD**



**The four bridge jacks are linked by the command station allowing them to work together to raise the bridge off its abutments and walk it up the street.**



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## BRIDGE REMOVAL



View of the removal of first two tracks.

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## BRIDGE REMOVAL



Final stage of bridge removal, now that there is overhead clearance the crane can be used to load the old bridge on a trailer to be hauled of site.

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## BRIDGE NO. 03945R – HAMILTON AVENUE MP 26.79, GREENWICH



- ❖ **ORIGINALLY BUILT: 1893**
- ❖ **BRIDGE TYPE: STEEL THROUGH GIRDER**
- ❖ **TYPICAL ABUTMENT CONFIGURATION**
- ❖ **NEW CONCRETE BRIDGE SEAT**

### NEW BRIDGE

- ❖ **CONSTRUCTION COMPLETED: 2004**
- ❖ **BRIDGE TYPE: MULTI BEAM DECK GIRDER**

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## BRIDGE NO. 08027R – MONROE STREET MP 41.12, NORWALK



**BEFORE CONSTRUCTION – 3 SPAN, OPEN DECK BRIDGE.**

- ❖ **ORIGINALLY BUILT: 1895**
- ❖ **BRIDGE TYPE: STEEL THROUGH GIRDER**



**NEW BRIDGE UNDER CONSTRUCTION FEATURES ELIMINATION OF BOTH PIERS AND CONSTRUCTION OF NEW ABUTMENTS IN FRONT OF EXISTING. SINGLE SPAN – BALLASTED DECK.**

- ❖ **BRIDGE TYPE: STEEL THROUGH GIRDER**

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## FAIRFIELD AVENUE, BRIDGEPORT



**Use of a Crane-Concrete Pumper Truck to place concrete for the new abutment foundations.**

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## BRIDGE NO. 08058R – MAIN STREET #1 MP 54.98, BRIDGEPORT



**OLD STRUCTURE ORIGINALLY BUILT 1900.**

**Above is the view of half of it removed and filled in.**

**At right are simulated brownstone faced precast retaining wall units to be stained brown to match the look of the adjacent walls.**

**Below is a view from the former roadway abandoned by the City, that made the elimination of this bridge possible. It's removal now allows the railroad the ability to make improvements to the geometry of Jenkin's curve, shown at right.**



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## SETTING NEW BRIDGE STEEL



At Monroe Street, new bridge girder is delivered by semi-trailer, with a complete road closure, the crane lifts the new girder up onto the new abutments.

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## APPROACH SLABS



Over time, the constant impact from passing trains would force the abutment backwalls forward and pinch the girders inhibiting normal expansion. The idea to incorporate approach slabs at railroad bridges was taken from highway bridge design.

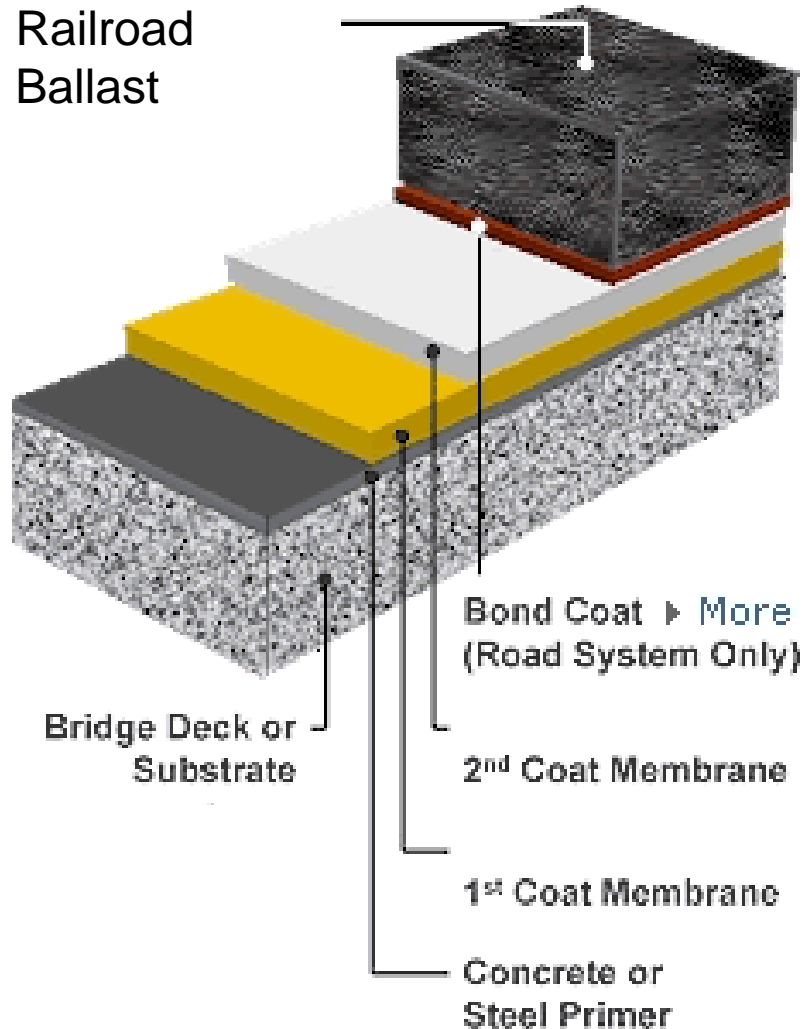


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## BRIDGE DECK WATERPROOFING

Railroad  
Ballast



Another item updated with the times and taken from highway construction to meet the needs of the railroads.

Some of our earlier bridge projects, used woven glass fabric and liquid asphalt, however, that combination required the use of a protection board to keep the stone ballast from puncturing it.

Prior to either of these products, railroads used coal tar to coat their bridge decks, and a lot of it.

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## FOUNDATION TECHNOLOGY



Left: Photo of micropile drilling rig showing limited overhead clearance available to allow installation of the piles.

Right: Photo of typical micropile pipe fitted with drilling teeth. Pipe comes in short lengths to allow installation with low overhead clearance.



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## CHALLENGES MOVING FORWARD



NORWALK (WALK) MOVABLE SWING BRIDGE



SAGAUTUCK (SAGA) MOVABLE LIFT BRIDGE

- Rehabilitation/Replacement of movable bridges while maintaining marine and railroad traffic.
- Working on these movable bridges will necessitate two track outages that will negatively impact railroad operational flexibility.

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## CHALLENGES MOVING FORWARD

- High Tower Structures and wire replacement.
- Non-Catenary Bridge Replacements:
  - Section C1a Bridges – additional to movables – East Avenue and Osborne Avenue
  - Section C-2 Bridges – Devon Movable, E. Main St., Bruce Avenue, Bishop Avenue, Union Avenue
  - Sound Beach Avenue and Tomac Avenue

**The above will result in approximately 20 more years of continuous track outages.**