

# PRESERVING SUSPENSION BRIDGE MAIN CABLES



NATIONAL BRIDGE PRESERVATION PARTNERSHIP CONFERENCE 2018

PRACTICES WE CAN NOT AFFORD TO DEFER

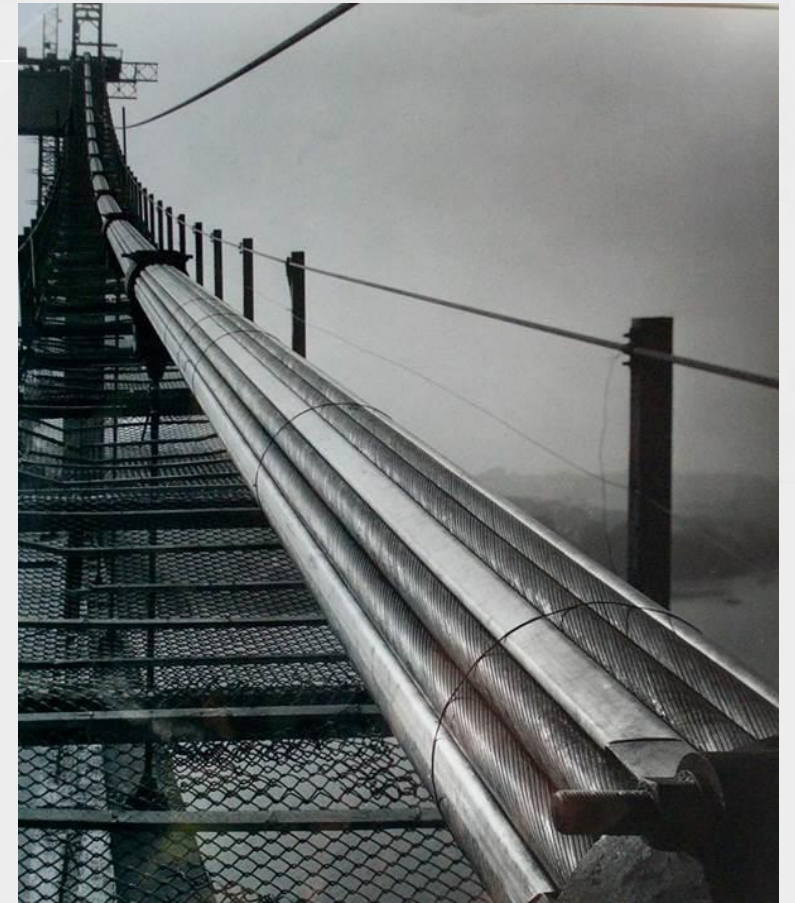
# SUSPENSION BRIDGE CABLE CONSTRUCTION



Aerially Spun (AS)

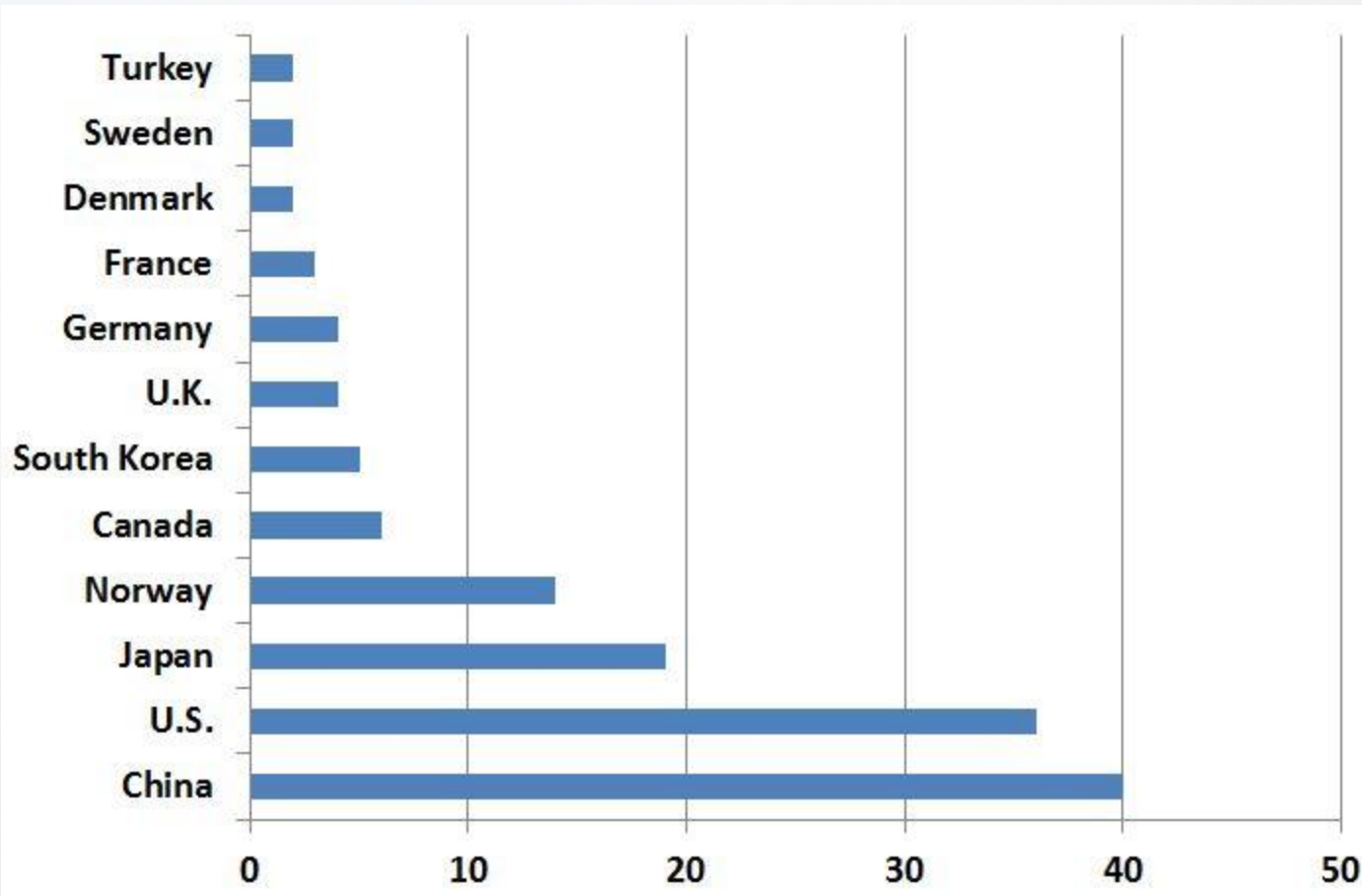


Prefabricated Parallel Wire  
Strand (PPWS)



Helical Strand (HS)

# GLOBAL SUSPENSION BRIDGE INVENTORY



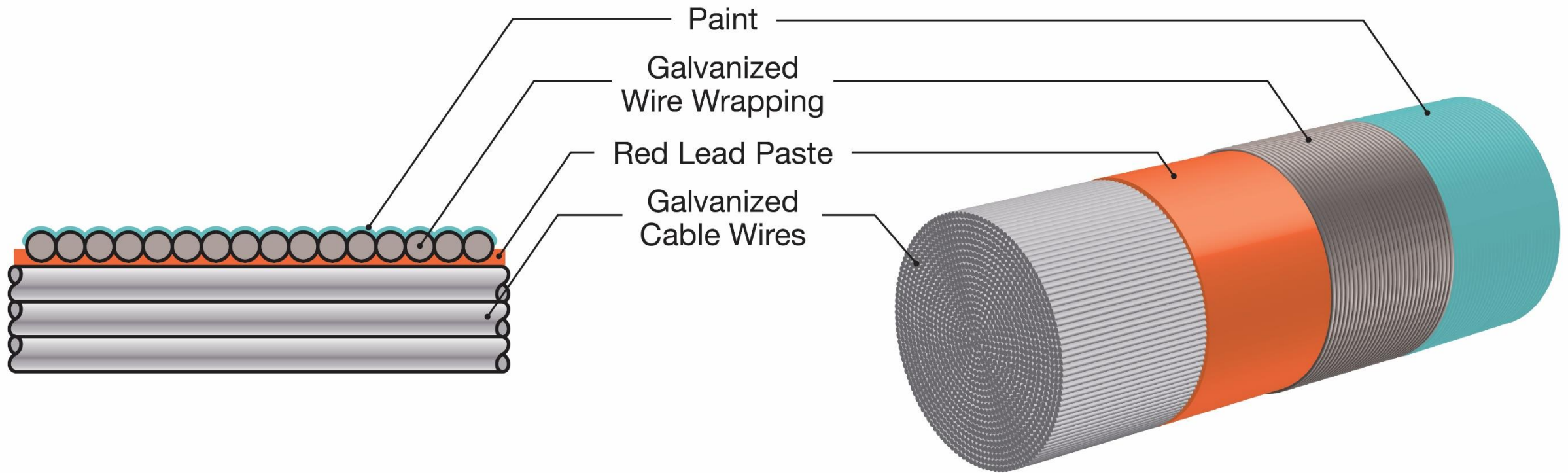
- Twelve (12) countries share over 90% of the inventory
- China surpassed the US in the last two decades
- China and US have the most
- Followed by Japan, Norway & Canada

# NORTH AMERICA SUSPENSION BRIDGE INVENTORY



- N.A. has combined total of nearly 30% of the inventory
- Notable US Bridges
  - Verrazano-Narrows
  - Golden Gate
  - Mackinac
  - George Washington
- Notable Canadian Bridges
  - Lions Gate
  - Angus L. MacDonald
  - A. Murray McKay

# CONVENTIONAL CABLE PROTECTION



# CONVENTIONAL CABLE PROTECTION



# MAIN CABLE INSPECTIONS

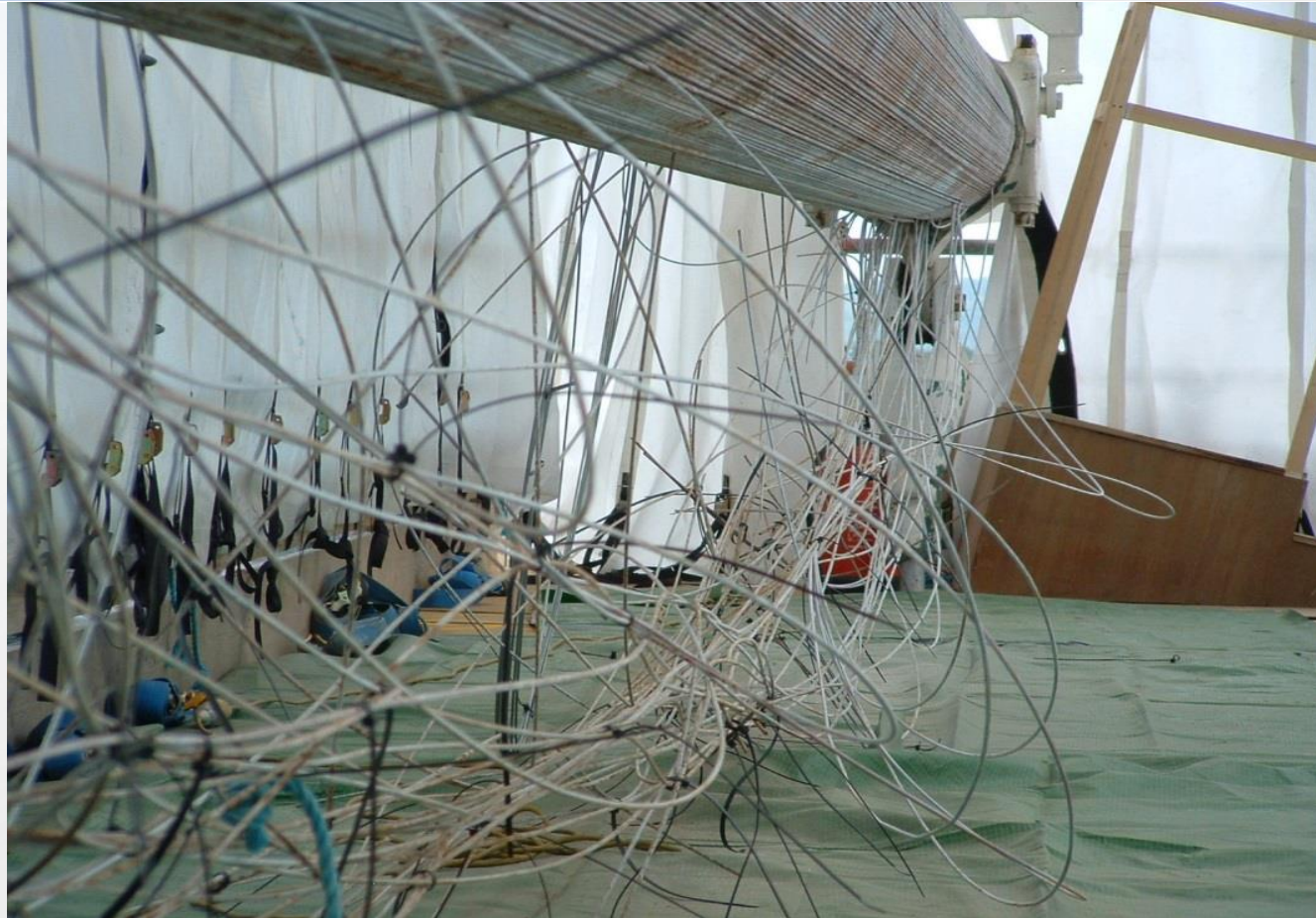


# MAIN CABLE INSPECTIONS

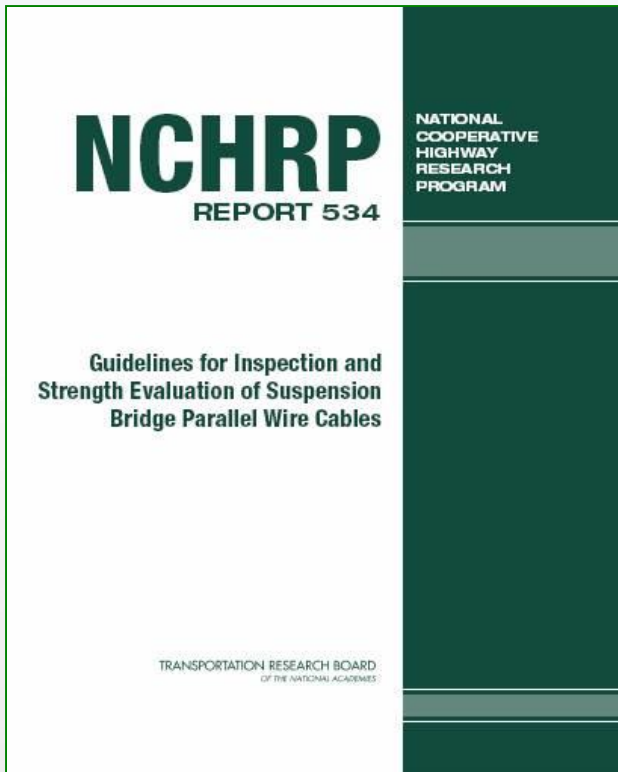




# BROKEN WIRES



# CALCULATING STRENGTH LOSS



Stage 1

Stage 2

Stage 3

Stage 4

It is broken and cracked wires that cause strength loss not corrosion.

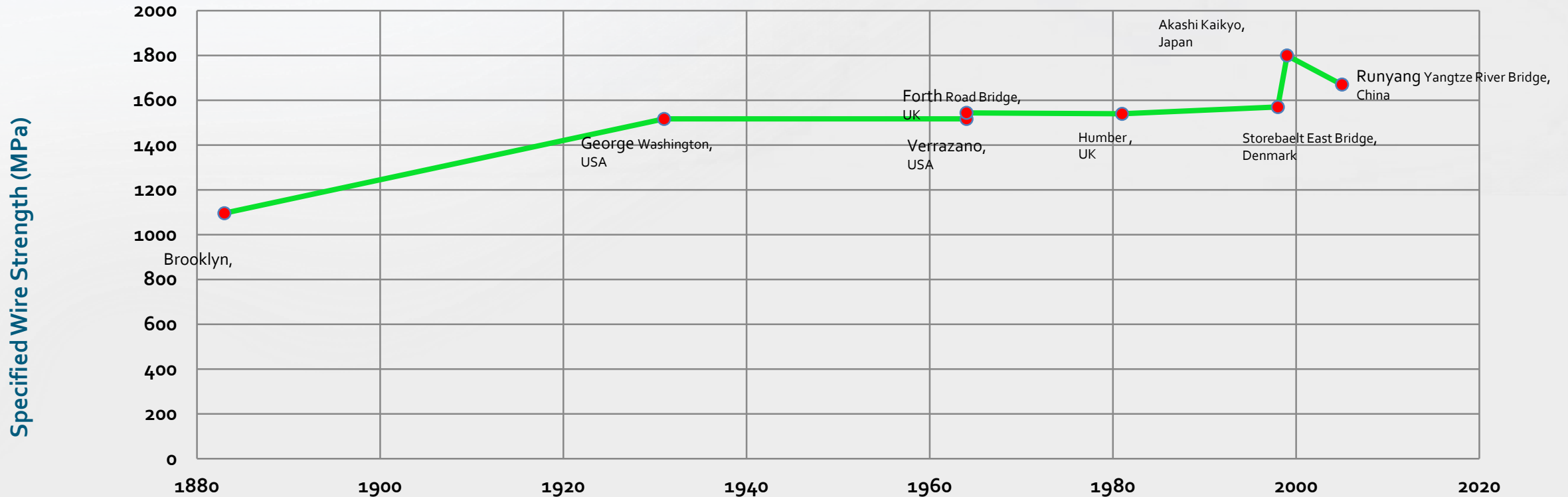
# SAMPLING AND TESTING WIRES



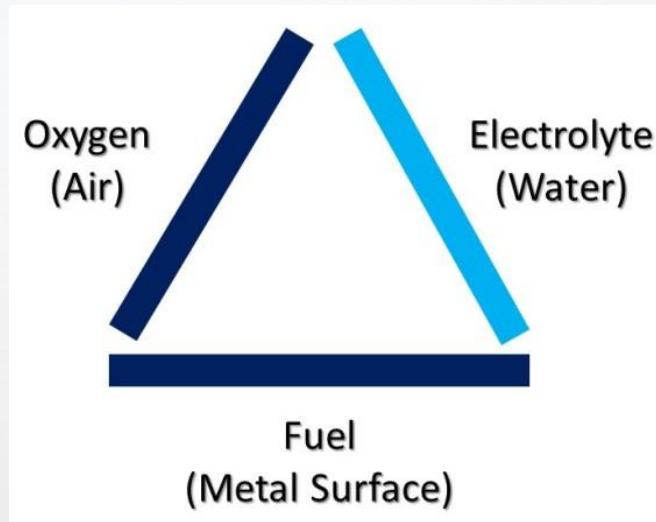
# NEED TO RE-COMPACT AND RE-WRAP CABLE



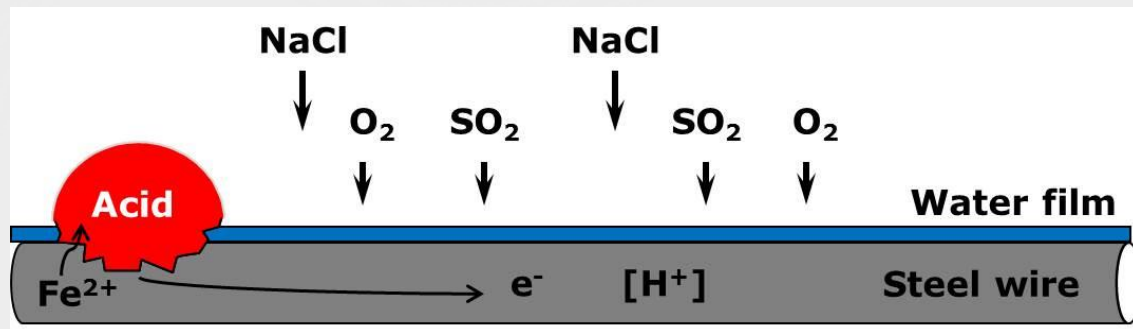
# CABLE WIRE STRENGTH - INCREASE WITH TIME



# CABLE STRENGTH DETERIORATION



- **Water** is primary cause for atmospheric corrosion
- Leads to **zinc depletion, wire corrosion,** and **hydrogen embrittlement**
- By removing water, one of three components necessary for corrosion & hydrogen embrittlement to occur is **eliminated**



# PAINTING DOESN'T KEEP WATER OUT

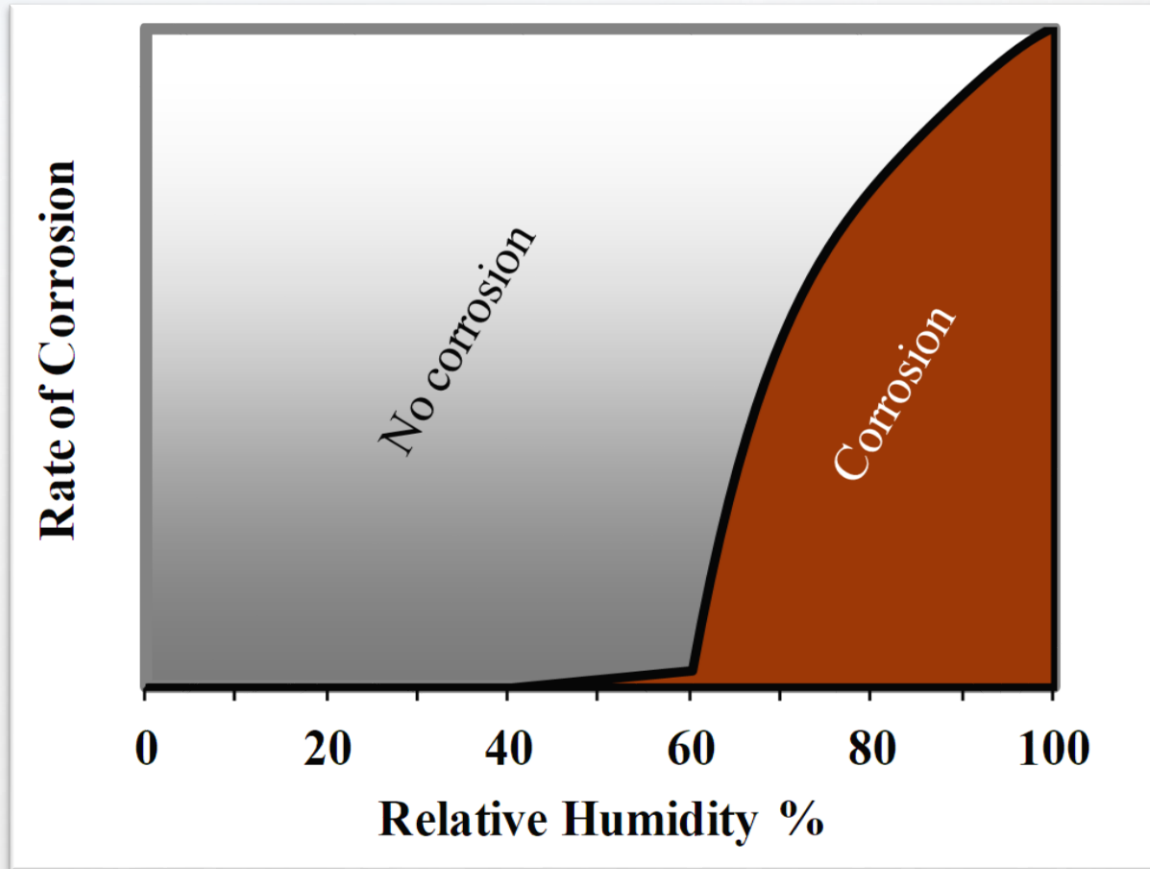


Oiling



Wrapping

# CABLE DEHUMIDIFICATION PRINCIPLES



- Protection of steel through control of RH dates back to research in the early 20<sup>th</sup> Century
- Discovery of critical RH below which corrosion of steel did not take place (Vernon 1935)
- RH below 60%, substantial reduction in corrosion
- RH below 40%, corrosion practically ceases



# APPLICATION OF DEHUMIDIFICATION - BRIDGES

## Dehumidification used on **bridges**

- Steel upper box girder on Humber Bridge, UK and Yeongjong Grand Bridge, Korea
- New & Existing Suspension Bridge Anchorages, Global

### **New Suspension bridge anchorages**

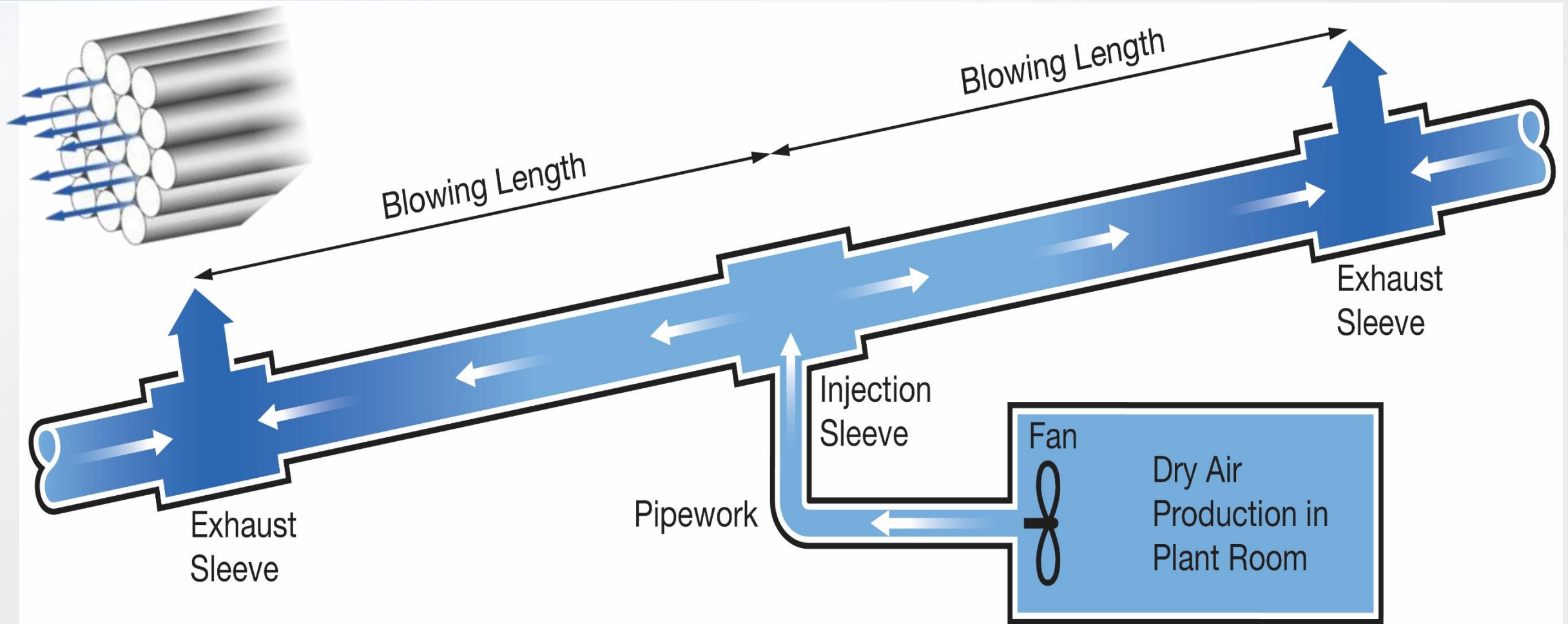
- Askoy Bridge (1992)
- Great Belt East Bridge (1998)
- Akashi Kaikyo Bridge(1998)
- Tsing Ma Bridge (1997)

- **Anchorage Dehumidification** on Humber Bridge dates back to the 1980's – **35 years ago**
- **Main Cable Dehumidification** on Akashi-Kaikyo Bridge in 1997 – **20 years ago**

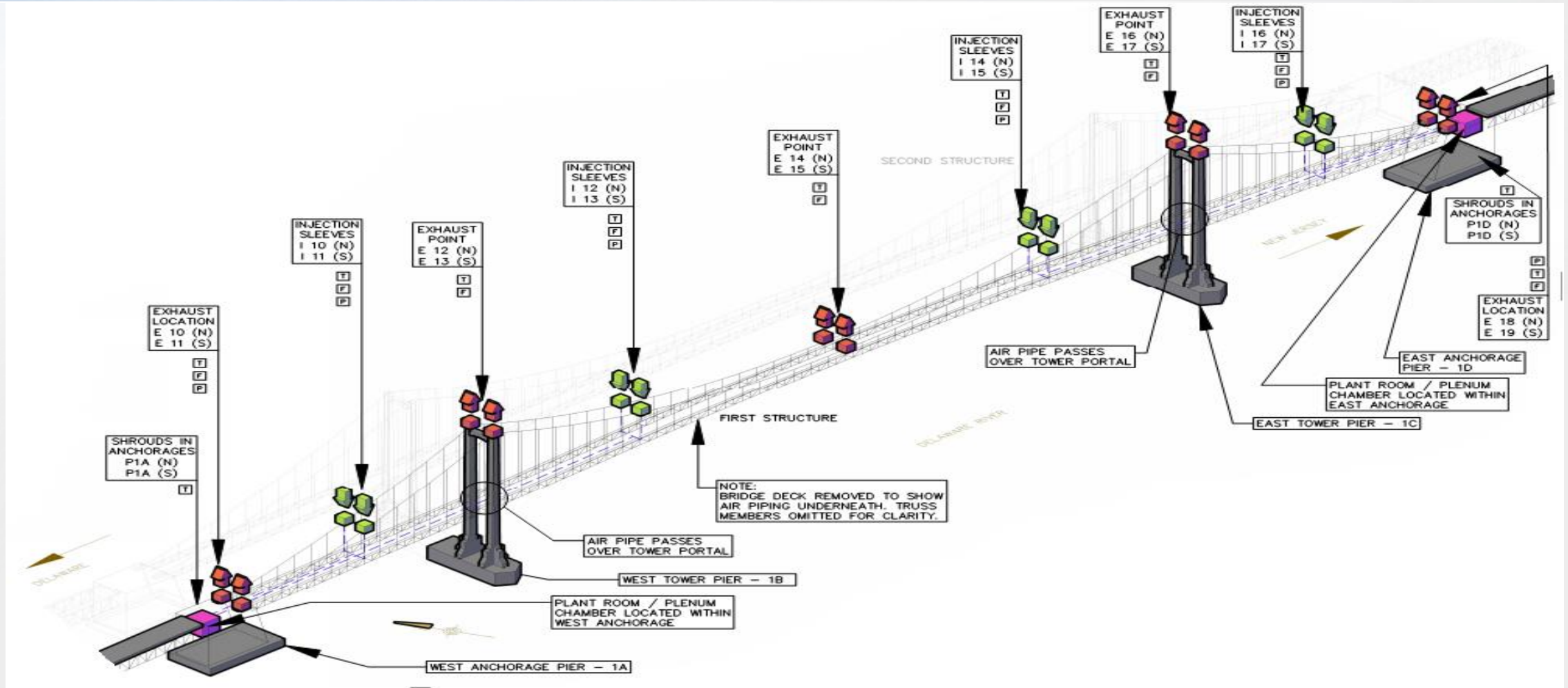
### **Existing Suspension bridge anchorages**

- Forth Road Bridge
- Humber Bridge
- Severn Bridge
- Ben Franklin Bridge
- Verrazano-Narrows Bridge

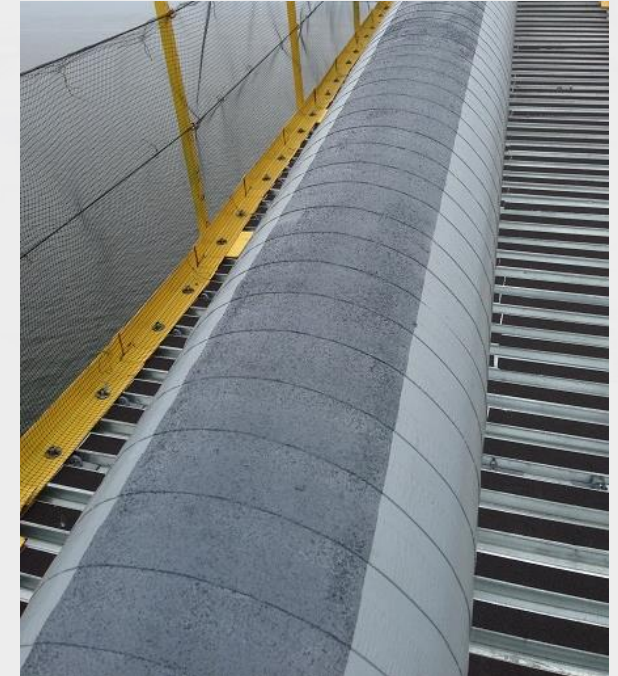
# CABLE DEHUMIDIFICATION SYSTEM



# CABLE DEHUMIDIFICATION SYSTEM - LAYOUT



# CABLE DEHUMIDIFICATION SYSTEM - WRAPPING



# CABLE DEHUMIDIFICATION SYSTEM - SEALING



# CABLE DEHUMIDIFICATION SYSTEM – INJECTION / EXHAUST



# CABLE DEHUMIDIFICATION SYSTEM – INJECTION / EXHAUST



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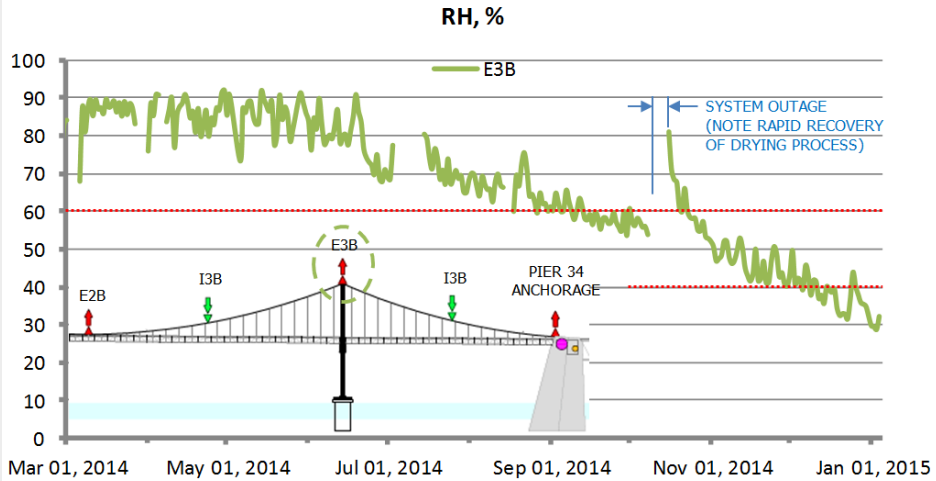
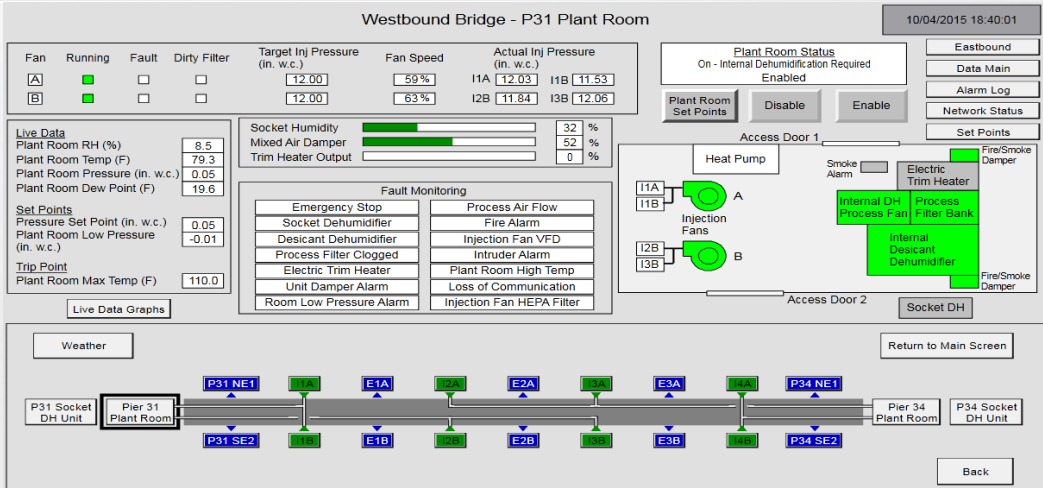
PRACTICES WE CAN NOT AFFORD TO DEFER

# CABLE DEHUMIDIFICATION SYSTEM – PLANT ROOM

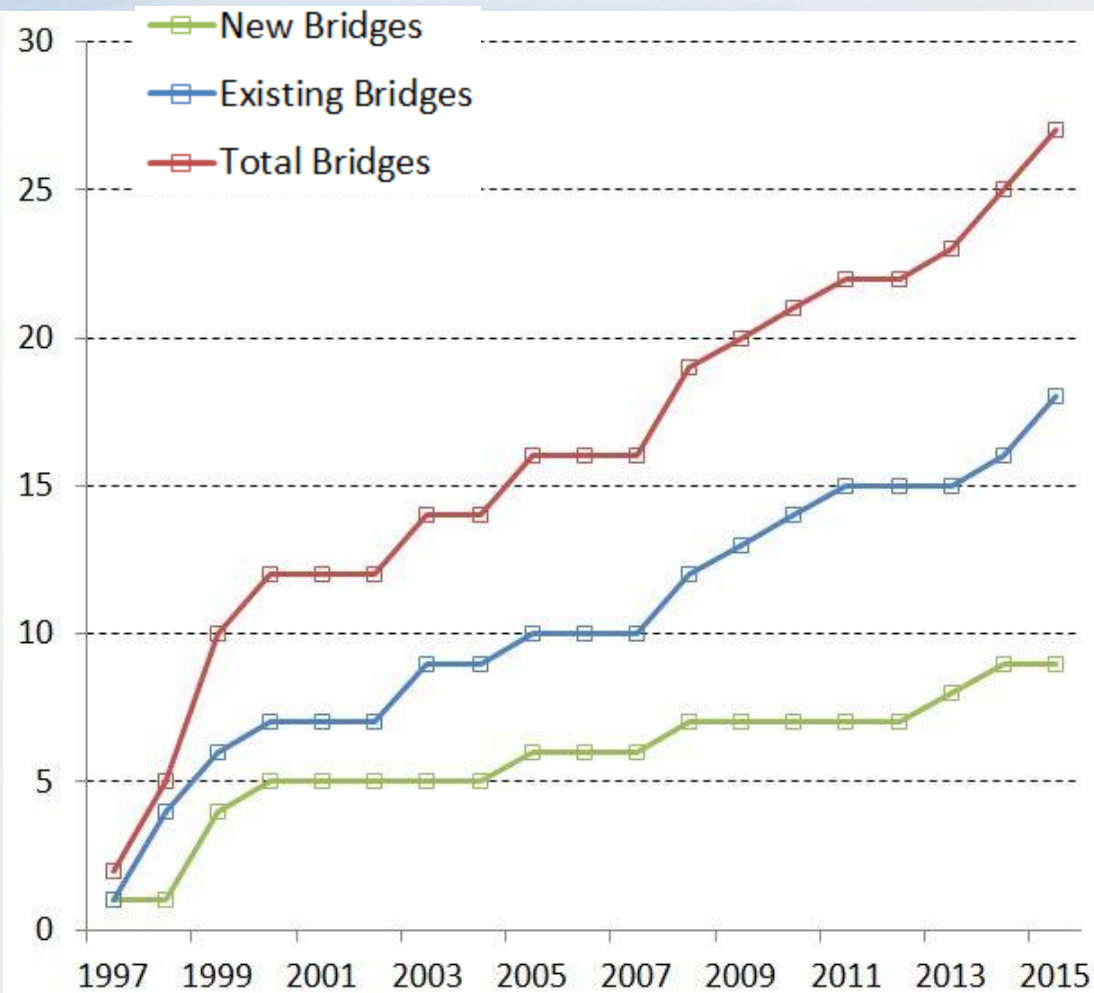




# CABLE DEHUMIDIFICATION SYSTEM – CONTROLS & MONITORING



# MAIN CABLE DEHUMIDIFICATION



## – Akashi-Kaikyo Bridge

- New Bridge
- Japan, 1997

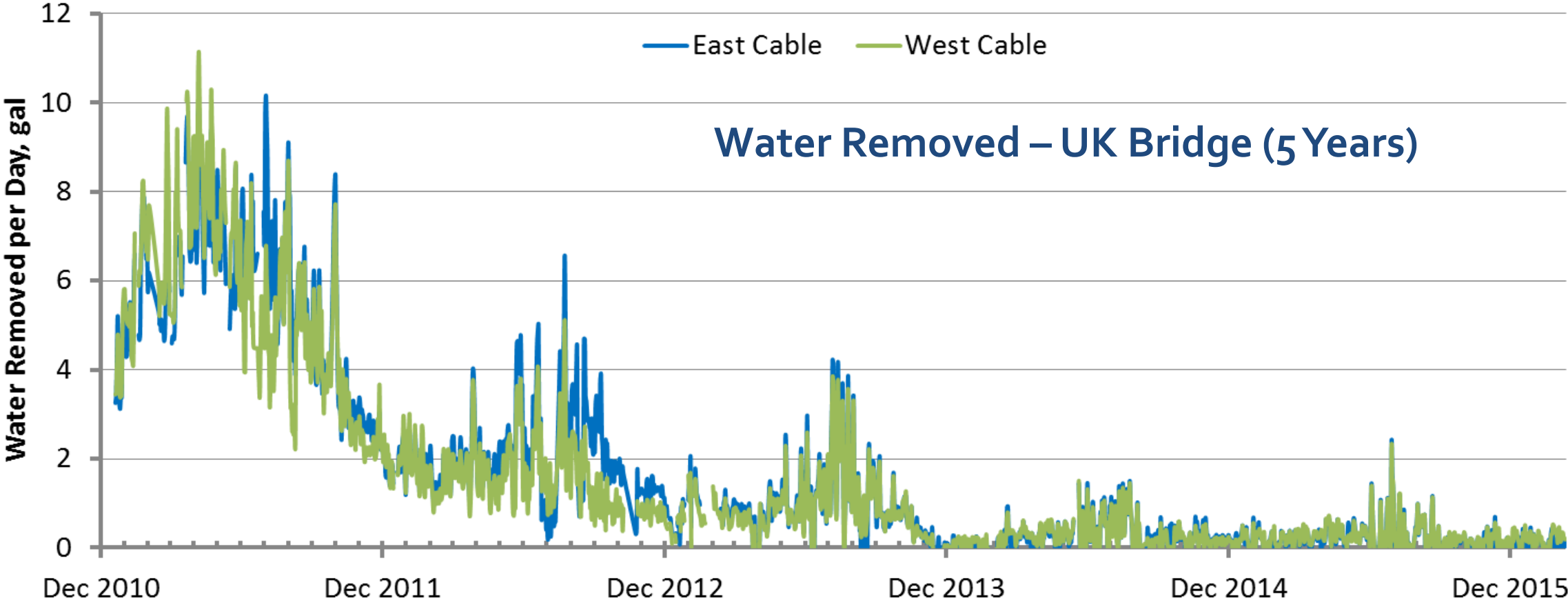
## – Honshu-Shikoku Bridges

- Existing Bridges
- Japan, 1997

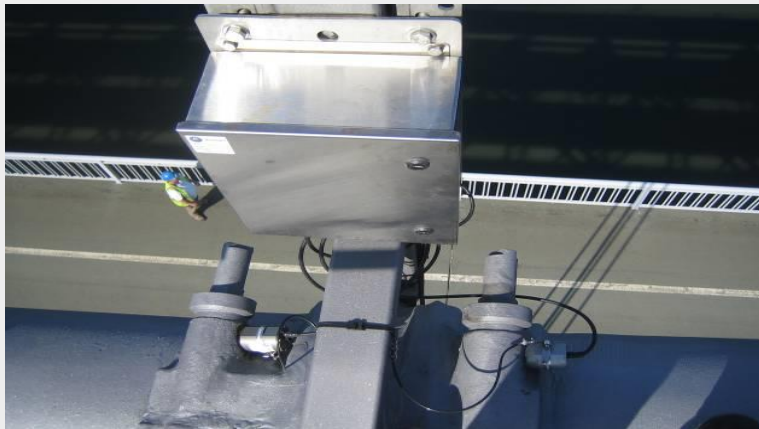
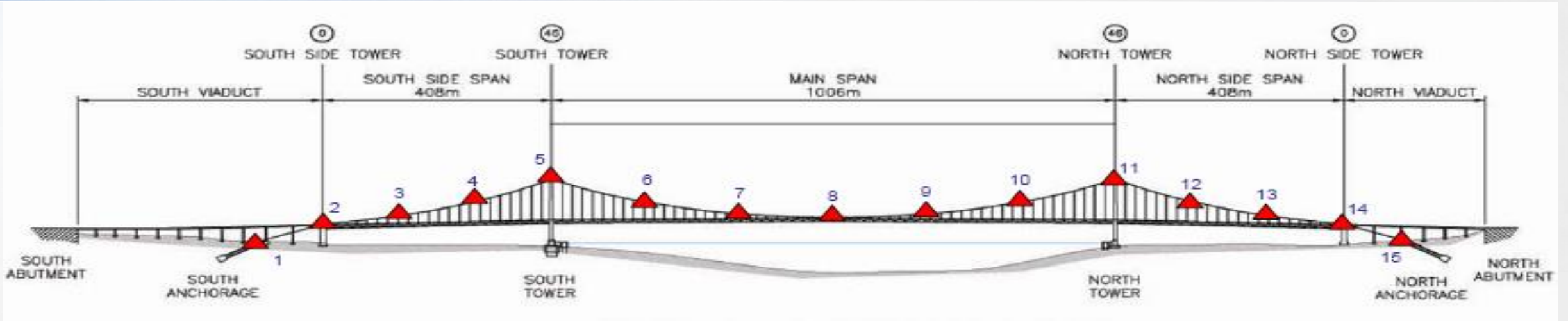
– Over **25 New & Existing Suspension Bridges** Dehumidified

– Nearly **20% Global Inventory**

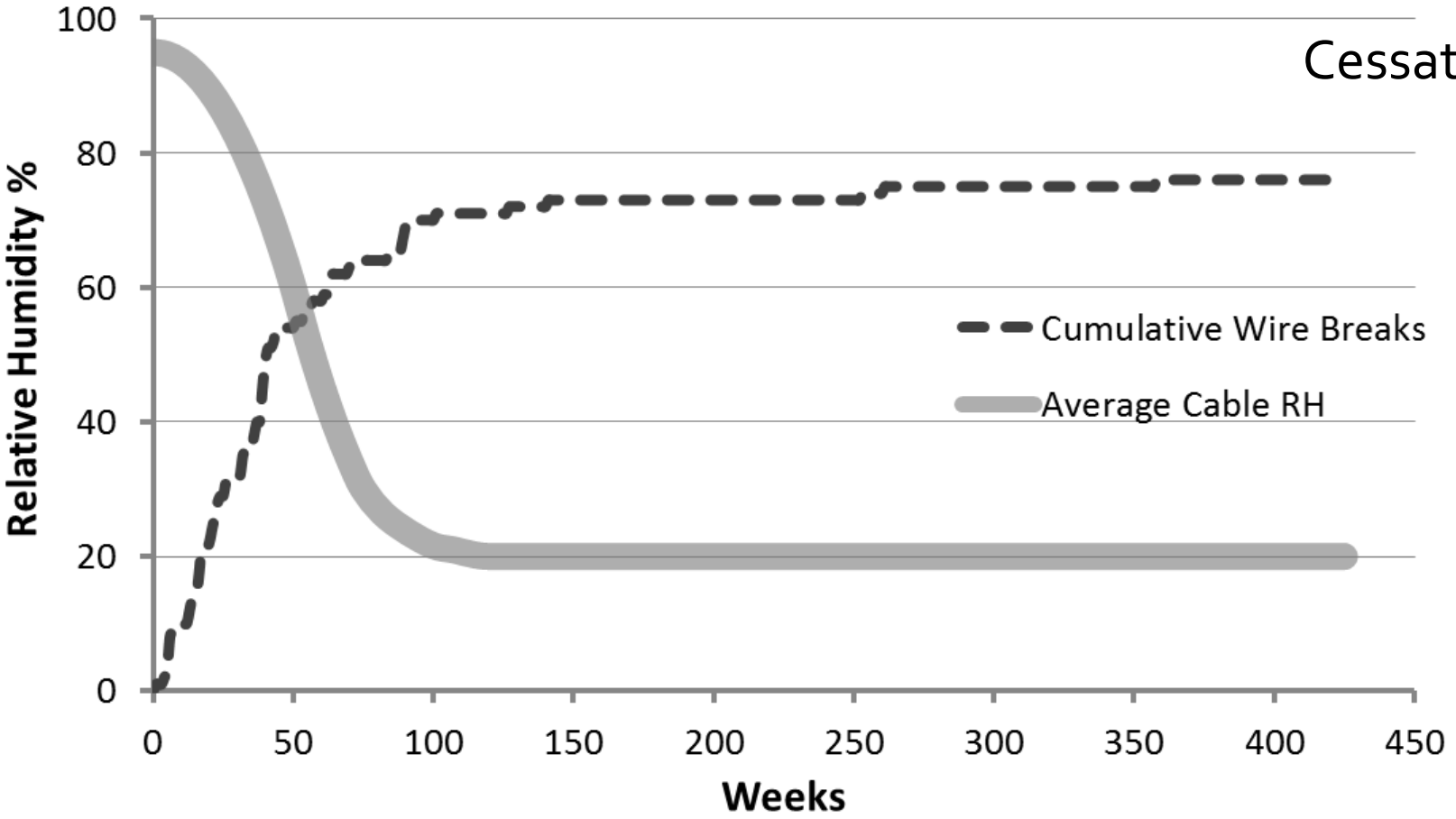
# MAIN CABLE DEHUMIDIFICATION - EFFECTIVENESS



# Acoustic Monitoring

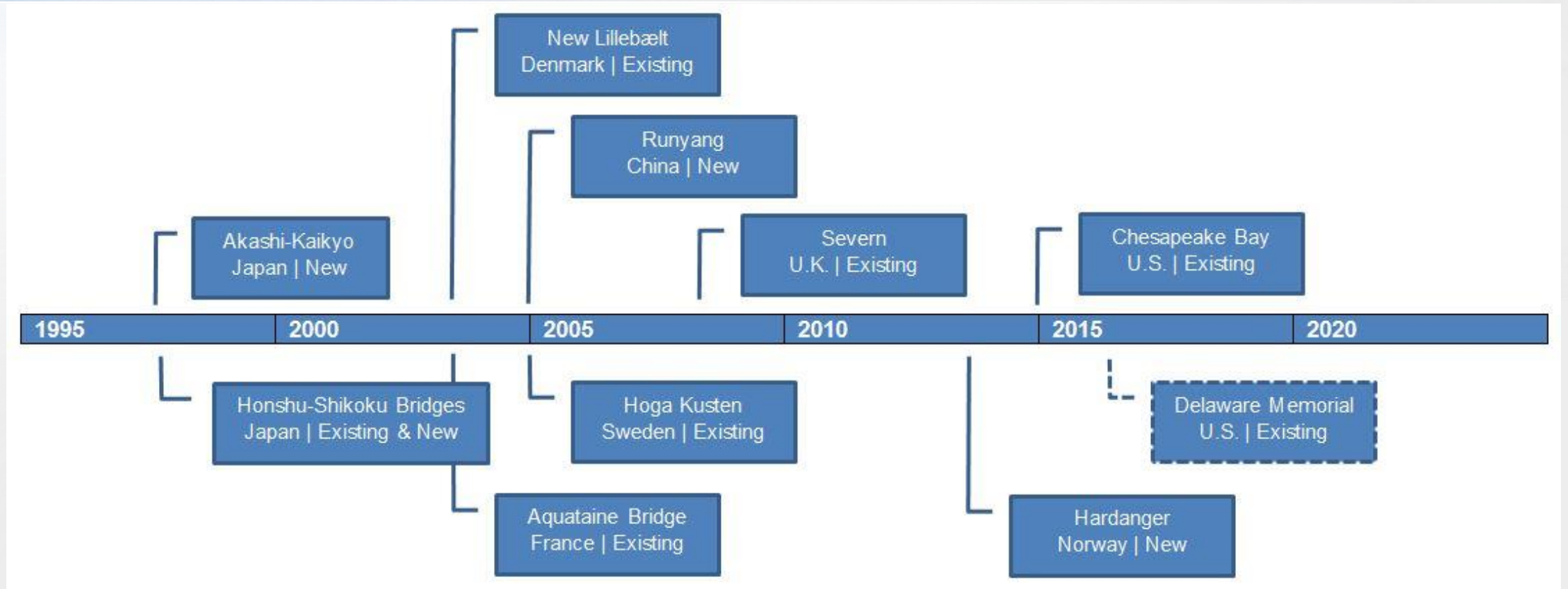


# MAIN CABLE DEHUMIDIFICATION - EFFECTIVENESS



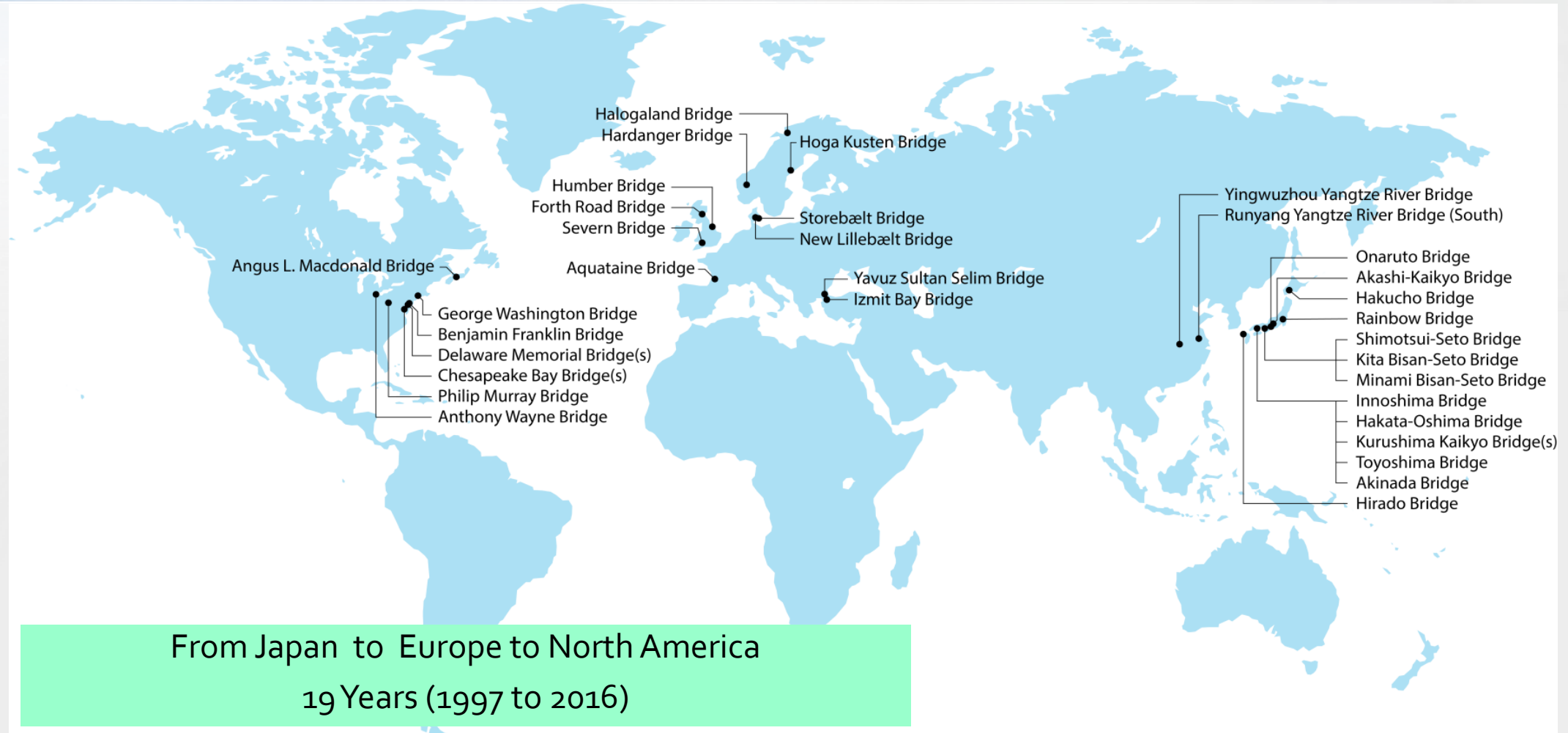
Cessation of Wire Breaks

# MAIN CABLE DEHUMIDIFICATION



Chesapeake Bay Bridge (Maryland) first full-length main cable dehumidification in North America

# MAIN CABLE DEHUMIDIFICATION



# CONCLUSIONS

- Conventional means of cable protection not effective
- Water is the main cause of deterioration (corrosion, wire breaks & hydrogen embrittlement)
- Cable Dehumidification demonstrates sustained reduction in RH and wire breaks
- Cable Dehumidification installed on new and existing bridges
- Over 25 bridges dehumidified representing nearly 20% of the global inventory; more in the planning stages
- Slow but now more rapid change in thinking regarding cable protection



# Thank You

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