



37<sup>TH</sup> INTERNATIONAL  
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FLORENCE 2019

Fortezza da Basso • FLORENCE (Italy)

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# SUCCESSFUL INSTALLATION OF CFRP AND GFRP ON PIPE BRIDGES IN SCOTLAND, UK

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# OUTLINE



**Project  
Background**



**Introduction to  
FRP**



**Engineered  
Solution**



**Installation**



**Inspection**



**Conclusion**



# PROJECT BACKGROUND - ROUNDKNOWE

**Client:** Scottish Water

**Alliance Partner:** Amey Black & Veatch

**Contractor:** Environmental Techniques

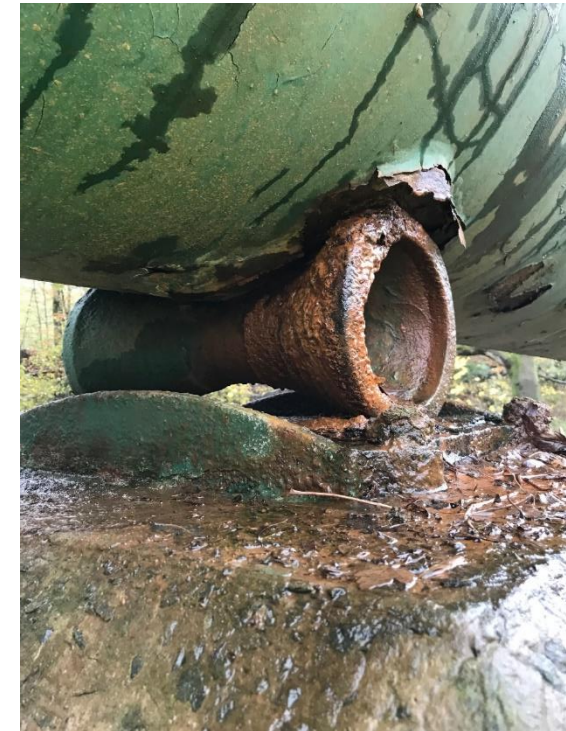
The site is located within Calderbraes Golf Club, located just off Roundknowe Road, 2km northwest of Uddingston, South Lanarkshire.

- 900mm OD Steel Pipe
- 235m overall length
- 4 Nr. Manholes
- 11 Nr. Piers
- 2Nr. River crossings
- Signs of corrosion
- Alongside a golf course



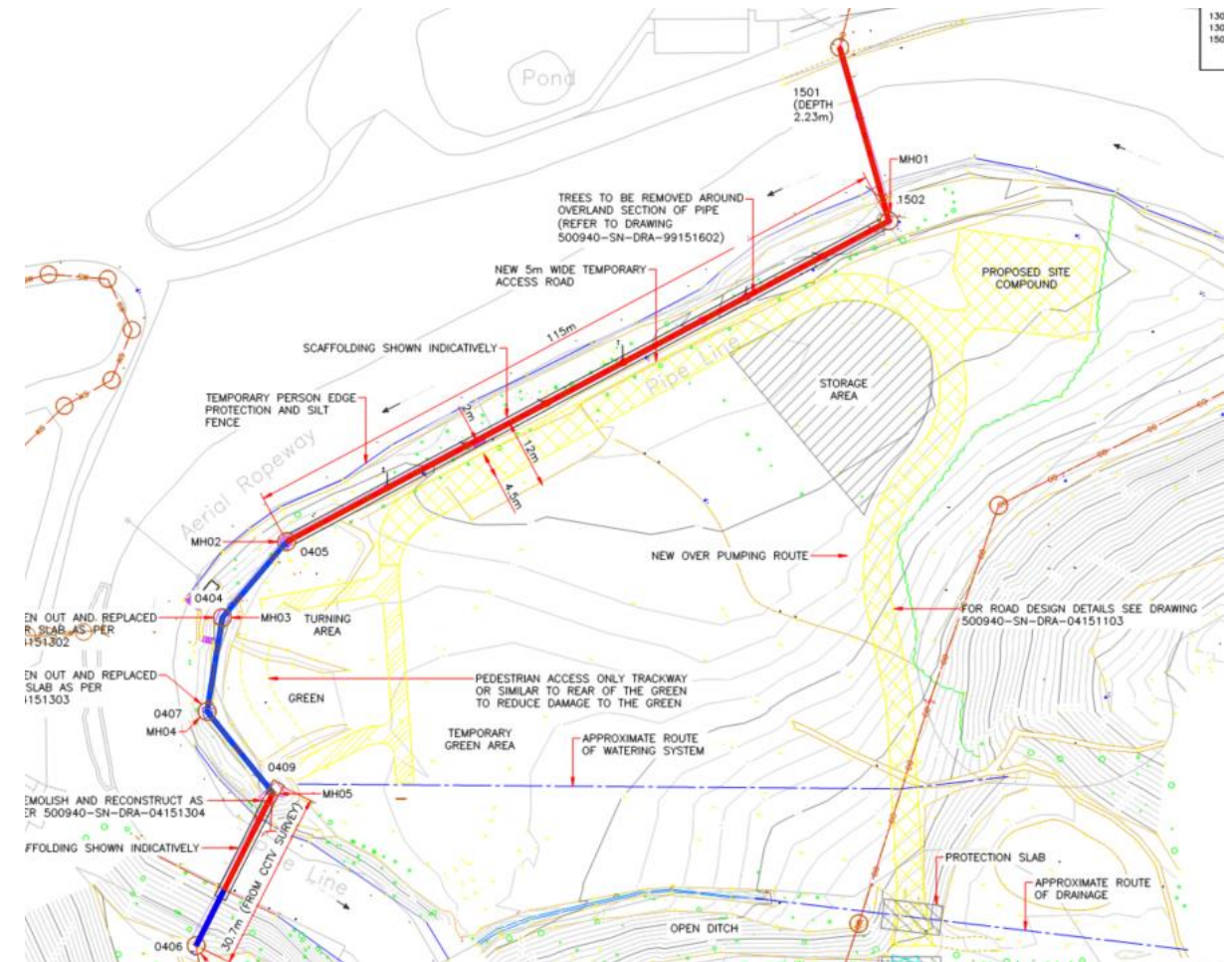
## Reasons for Strengthening

- Corrosion
- Structural Failure
- Leaks
- Pollution
- Environmental Issues
- Poor image



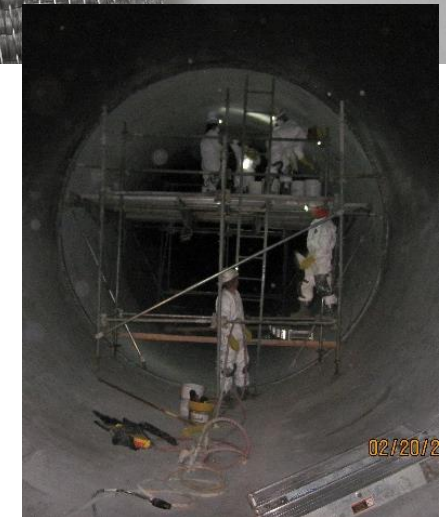


- Flows of 850l/s
- 20 Weeks of Overpumping
- 500m of hoses
- £500k for temporary pumping station
- High Risk of Environmental incident occurring

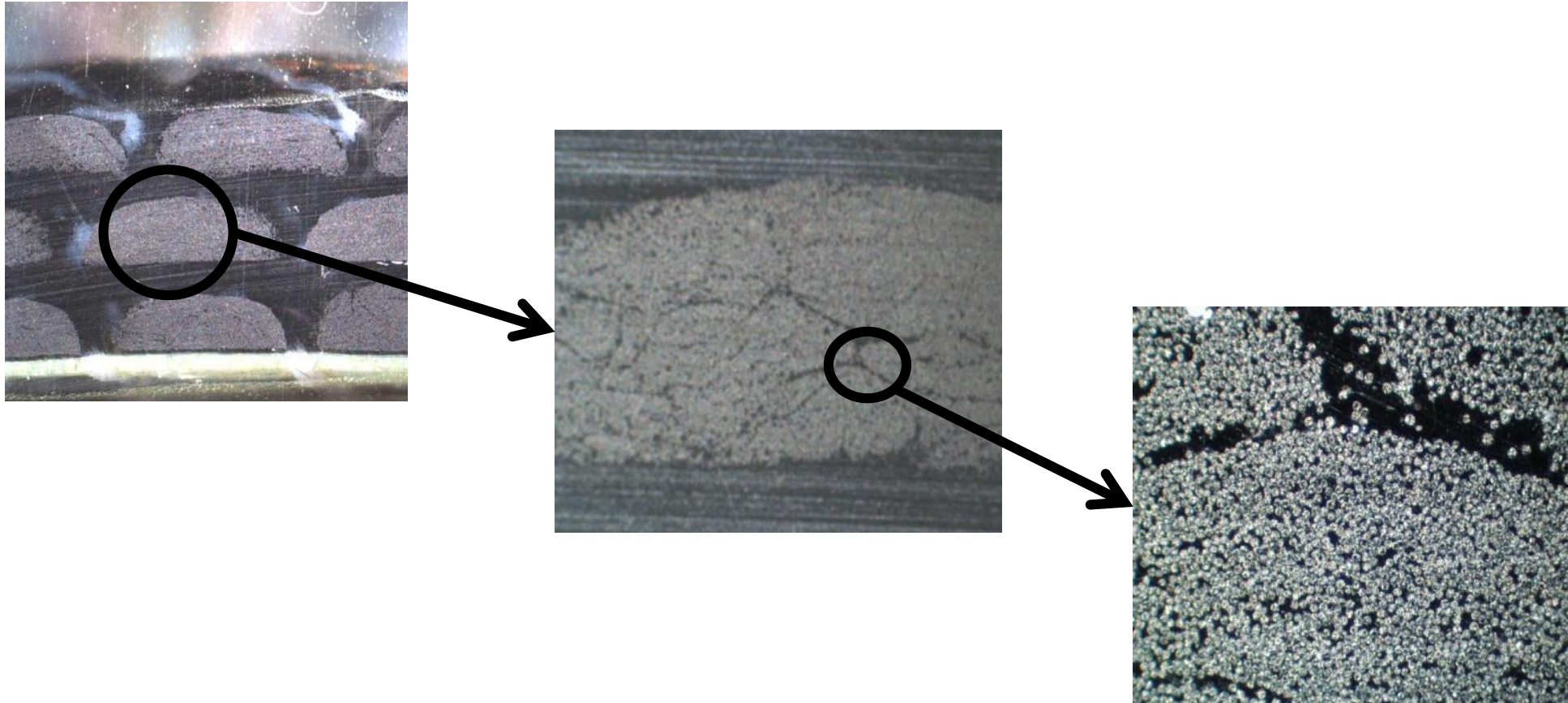


# INTRODUCTION TO FRP SYSTEMS

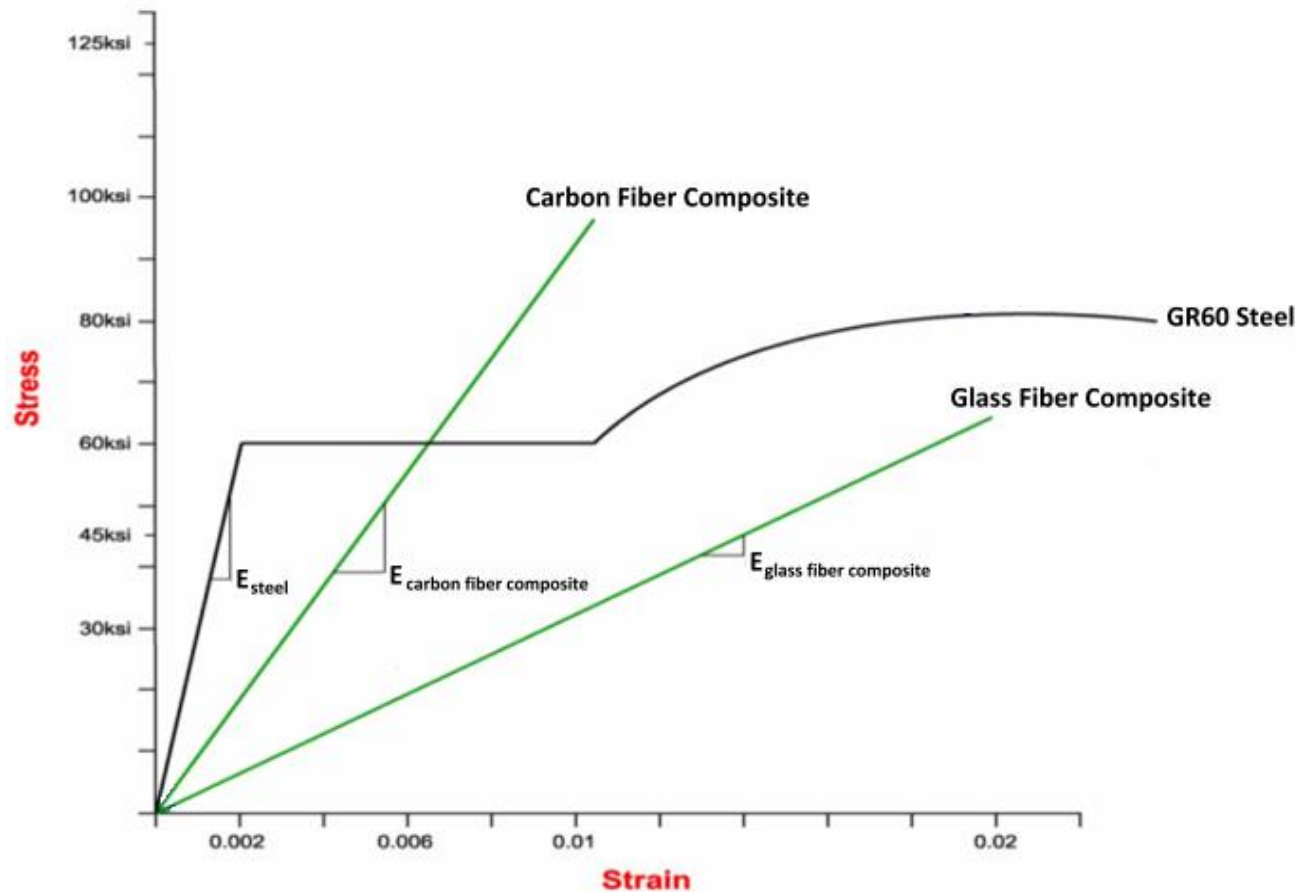
- **Fiber Reinforced Polymers (FRP)**
  - Reinforced fiber (carbon or glass)
  - Epoxy Resin
- **FRP Rehabilitation**
  - Pipes
  - Buildings
  - Bridges



## CFRP: Close Up



## Comparison of Mechanical Properties



## Advantages of an External Repair

1. Pipe diameter is not an issue
2. Pipeline can remain in service during installation
3. Design can be a fully structural solution
4. No impact to flow
5. Emergency repairs can be accommodated
6. Repair length can be varied based on requirements (local or continuous repairs)
7. Installation time is typically 25 percent less

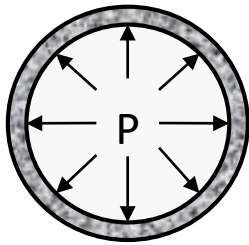


# ENGINEERED SOLUTION – DESIGN PHILOSOPHY

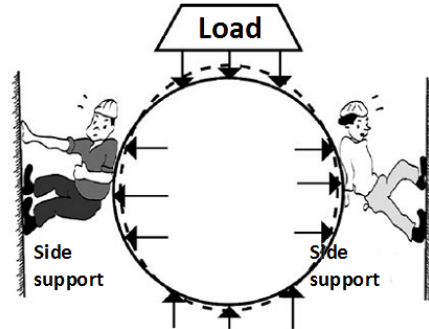


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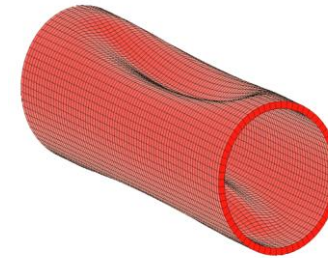
- Hoop Direction



*Burst Pressure*

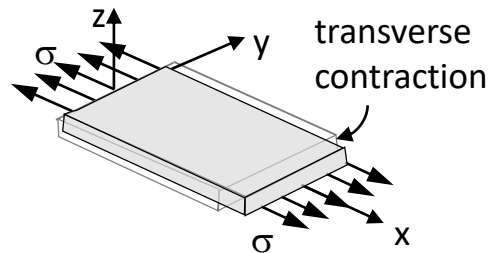


*Pipe Deflection*

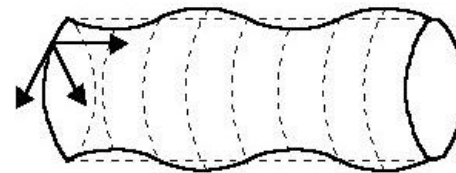


*Constrained Buckling*

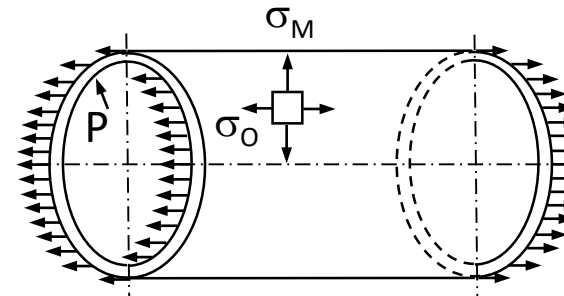
- Longitudinal Direction



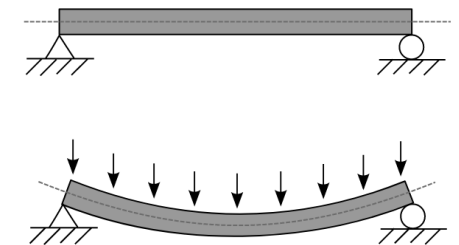
*Poisson's Effect*



*Temperature Change*



*Thrust Loading*

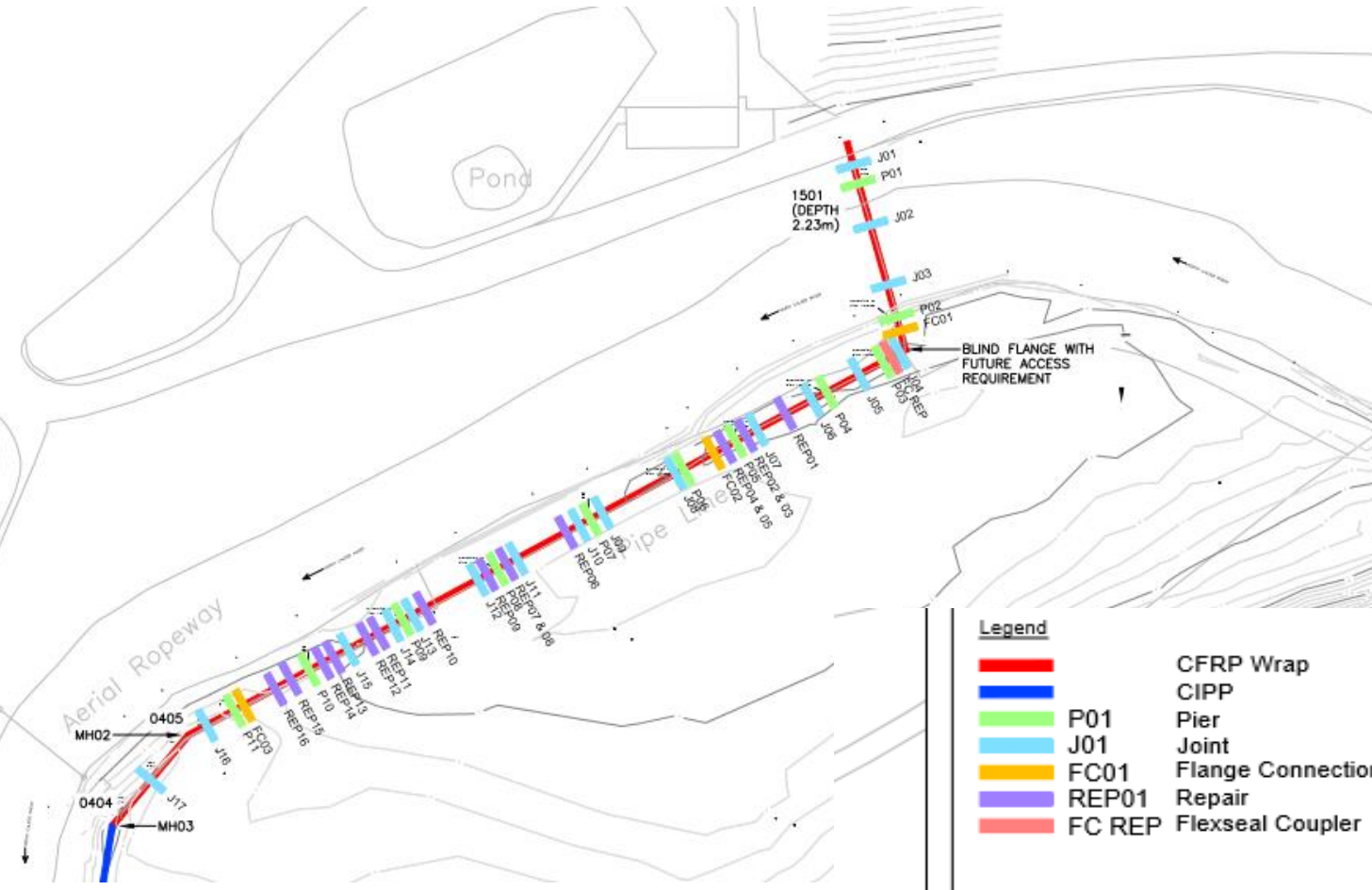


*Beam Bending*

# ENGINEERED SOLUTION – SPECIAL DETAILING



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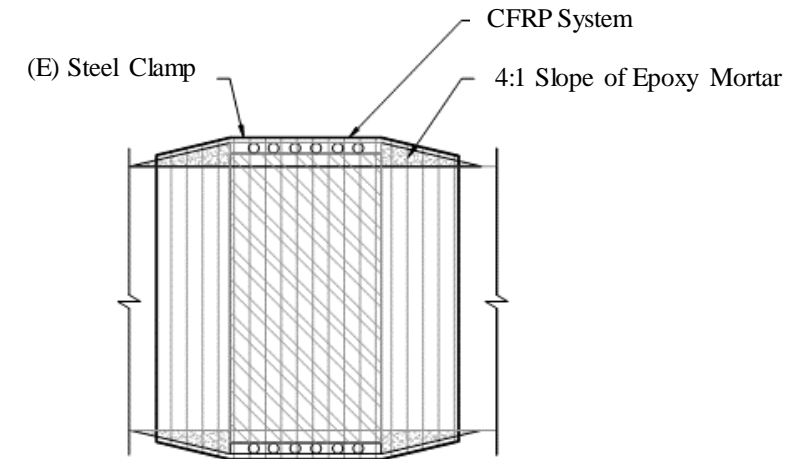
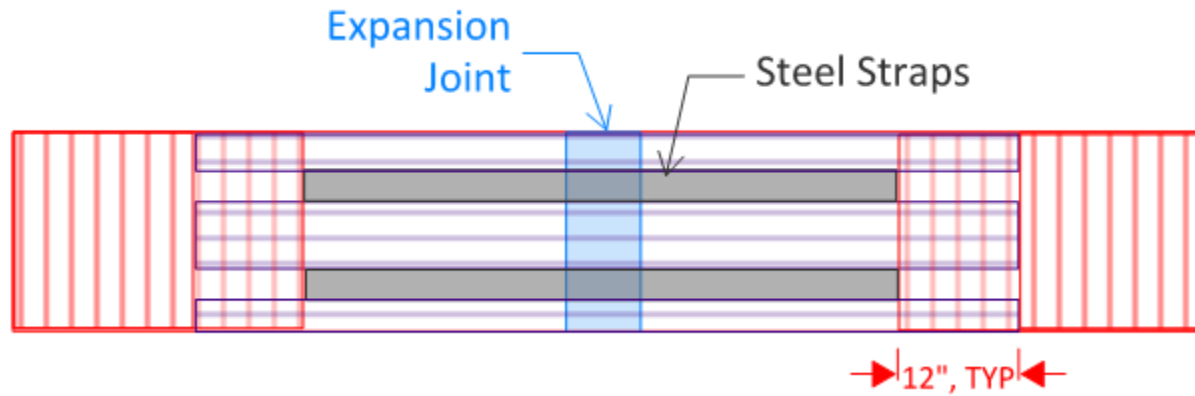
Piers



Flange Connections



## Flange Connections



# INSTALLATION - CHALLENGES

- Requirement to maintain golfers access to the 7<sup>th</sup> green – throughout the installation
- Due to remote location of the pipeline, safe access needed to be created whilst minimizing the environmental impact



# INSTALLATION - CHALLENGES

- Set-up of external scaffolding
- Encapsulation of the pipe during the installation
  - Due to lead in the existing paint coating
  - Ensure proper cure of CFRP
  - Environmental protection during the installation



# INSTALLATION – GFRP/CFRP SYSTEM



**Step 1:** Surface Preparation

**Step 2:** Installation of  
GFRP/CFRP System



**Step 3:**  
Finish System  
applied



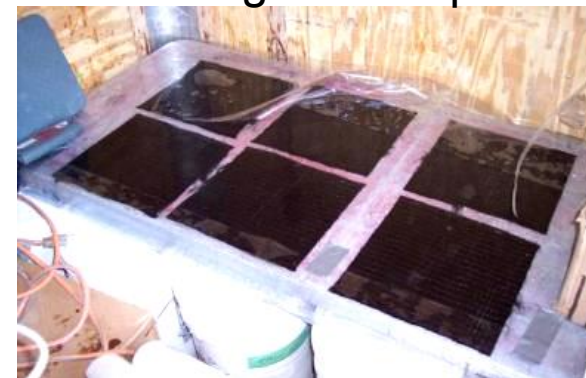
## Shore D Hardness Testing

- Measures Cure of FRP System



## Witness Panels

- One layer of the GFRP and CFRP System
- Preparation of panels spread throughout construction
- Testing per ASTM D3039
- Confirms design assumptions



# CONCLUSIONS



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235 meters of  
pipe rehabbed



25% less time  
compared to  
traditional



Extended Life  
by 60 years



10% Cheaper



QA/QC  
Program



# QUESTIONS



amey-BLACK & VEATCH



## WINNER – 2019 SALTIRE CIVIL ENGINEERING