
THE MILLENNIUM LINK
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Project Manager The Falkirk Wheel
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[Operations Director, Galliford Try]
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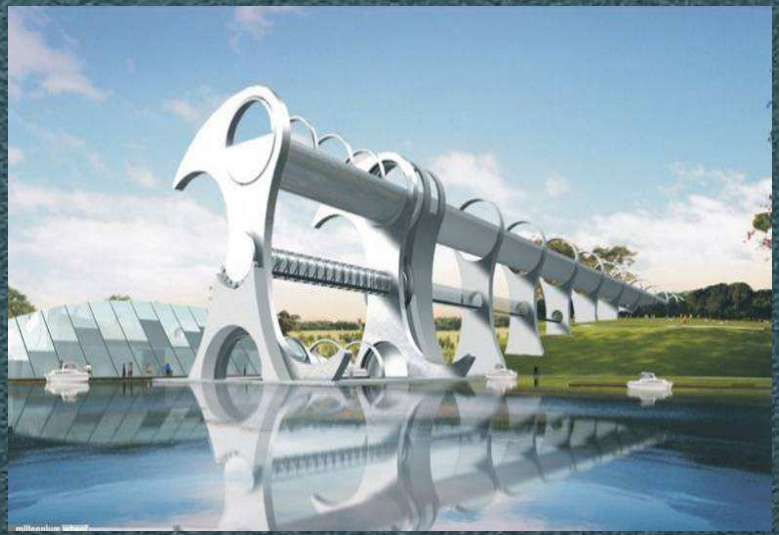
Contents

- Forth & Clyde/Union Canals
  - Millennium Link
- The Falkirk Interchange
  - Canal extension
  - Tunnel
  - The Falkirk Wheel
- Construction
  - Basin
  - Tunnel
  - Aqueduct
  - Wheel



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- **Forth & Clyde/Union Canals**
  - History
  - Millennium Link

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THE LOWLAND CANALS

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HISTORY – Forth & Clyde

- Forth & Clyde Canal
  - First coast-to-coast ship canal
    - Connecting Grangemouth (Forth) to Bowling (Clyde)
    - 35 miles long
  - 40 Locks
    - Also 25 aqueducts, 32 opening/swing bridges
  - Constructed 1768 – 1773 (fully open 1790)
    - John Smeaton
  - Closed to navigation 1963

HISTORY – Union

- Union Canal
  - Single level canal
    - Connecting Edinburgh and Falkirk
    - 31 miles long
  - 11 locks
    - All at end, to connect to the Forth & Clyde
  - Constructed 1818 – 1822
    - Hugh Baird
  - Closed to navigation 1965

HISTORY – City link

- Major transport link
  - 200,000 passengers/yr
  - 80km distance
  - Horse-drawn swift boats
  - 7 hour journey

HISTORY – Falkirk Interchange

- 11 lock staircase
  - **35m height difference**
  - **3500 tonnes water per "run"**
    - **Took most of a day**

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HISTORY – Millennium Link

- Reopening project
  - 5 year project
    - But funding 1999 tied to completion 2001!
  - 30 major obstructions had to be removed
  - Replacement/rebuild of 120 structures
  - Twenty-five £3M “design and build” packages let
  - Required careful water management!
  - World’s first “drop lock” at one road bridge

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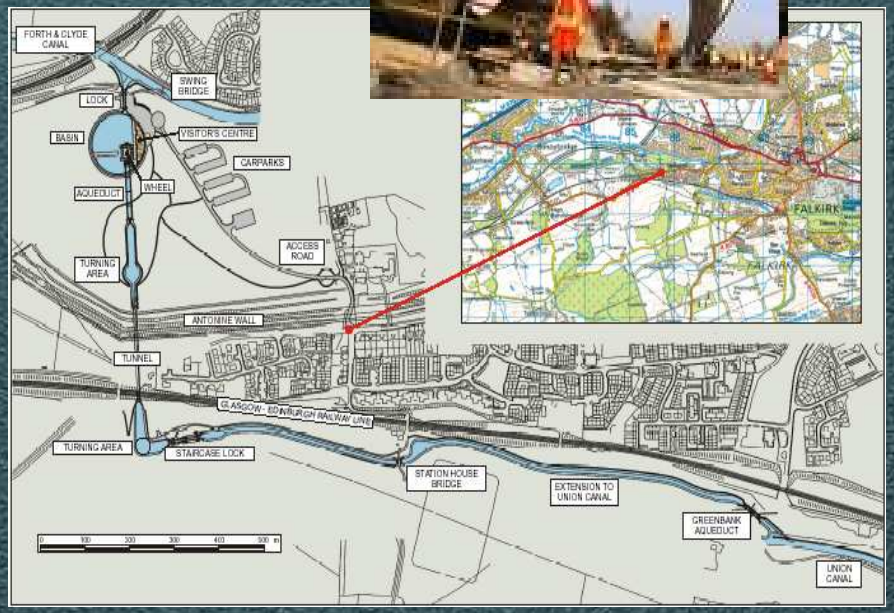
- **The new Falkirk Interchange**
  - Canal extension
  - Tunnel
  - The Falkirk Wheel



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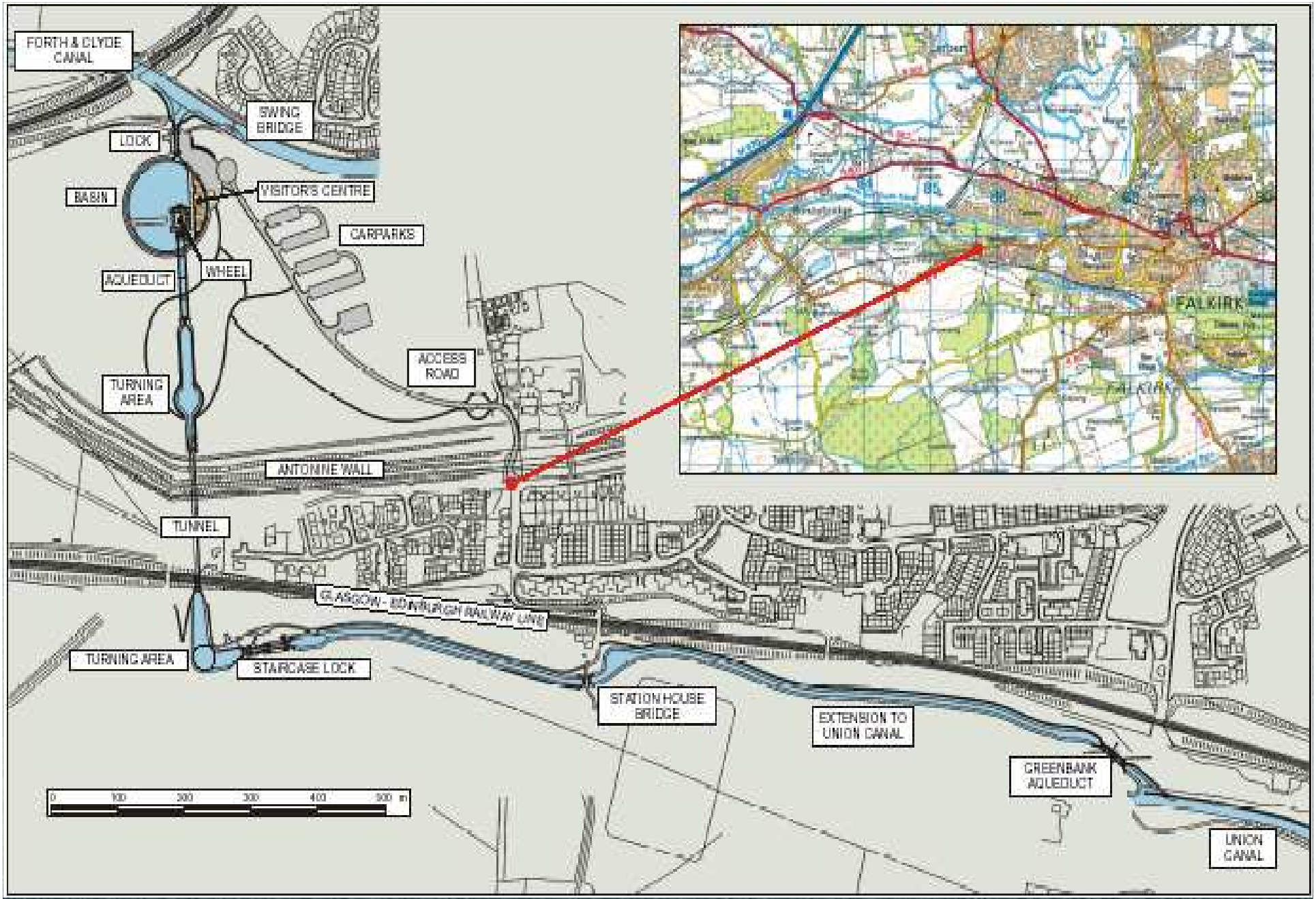

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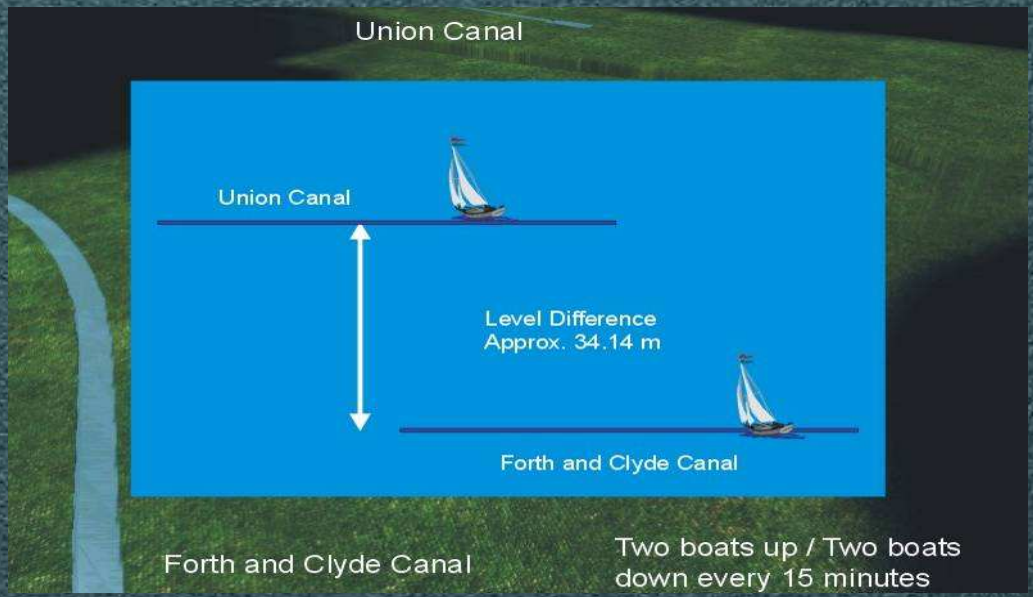
The Problem – The Falkirk Interchange

- **Historically**
  - **11 lock staircase**
  - **34m height difference**
  - **3500 tons water per run**
  - **Full day**
- **Start again**
  - Novel solution?



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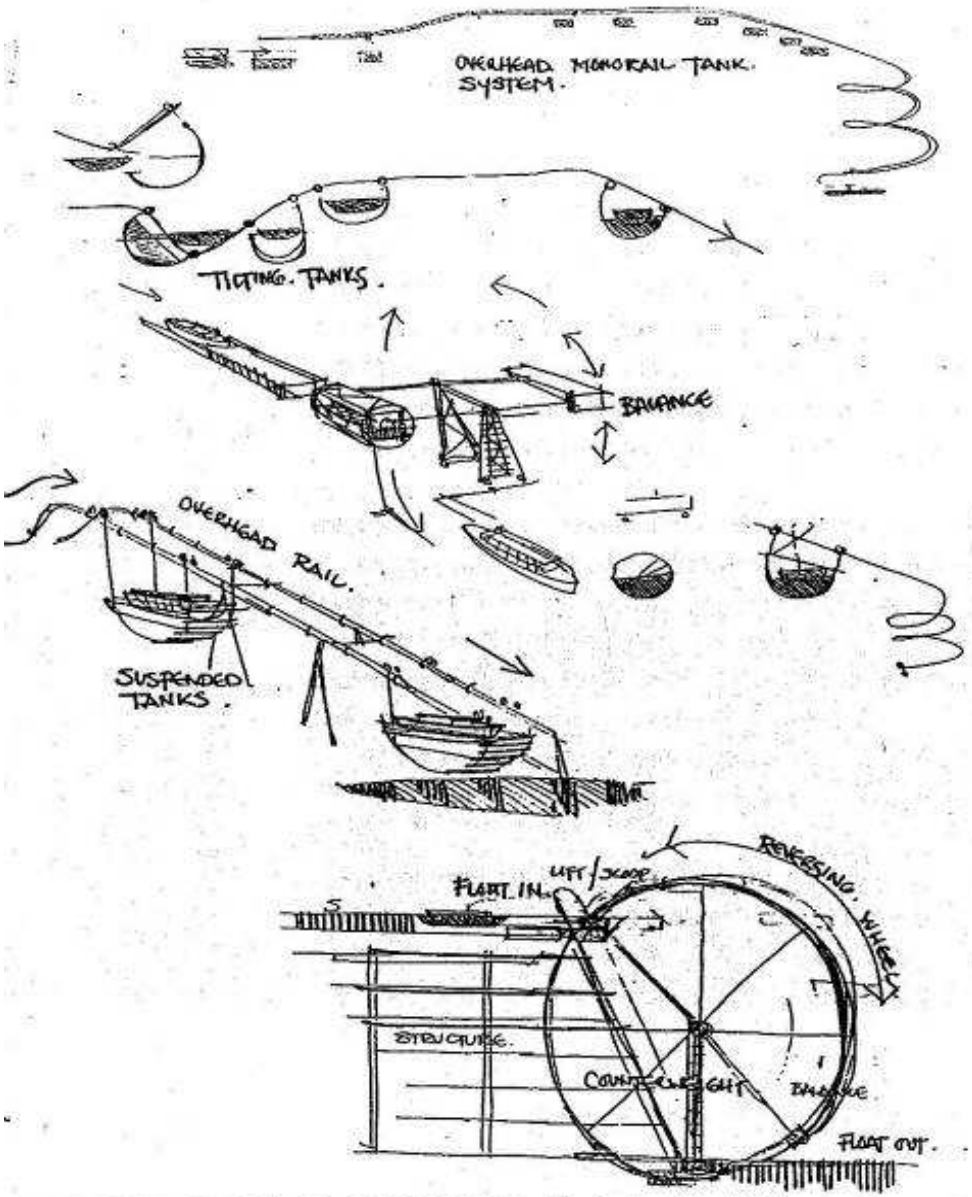

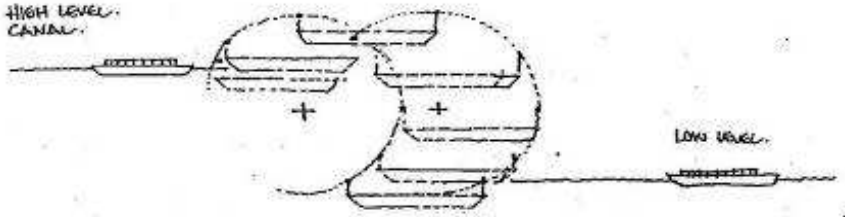

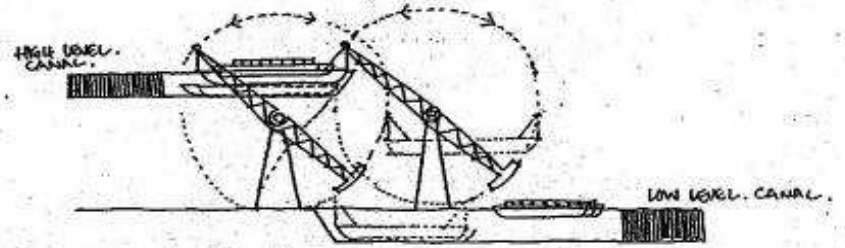

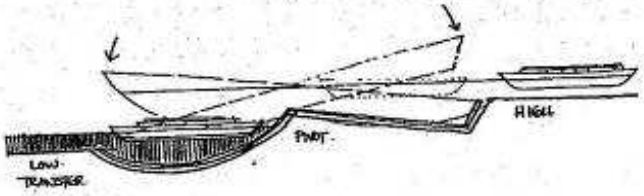

SEESAW TRANSFER DEVICE.

AVOIDING GATES.

THE MILLENNIUM LINK

Examples of Conceptual Development of Transfer Mechanisms

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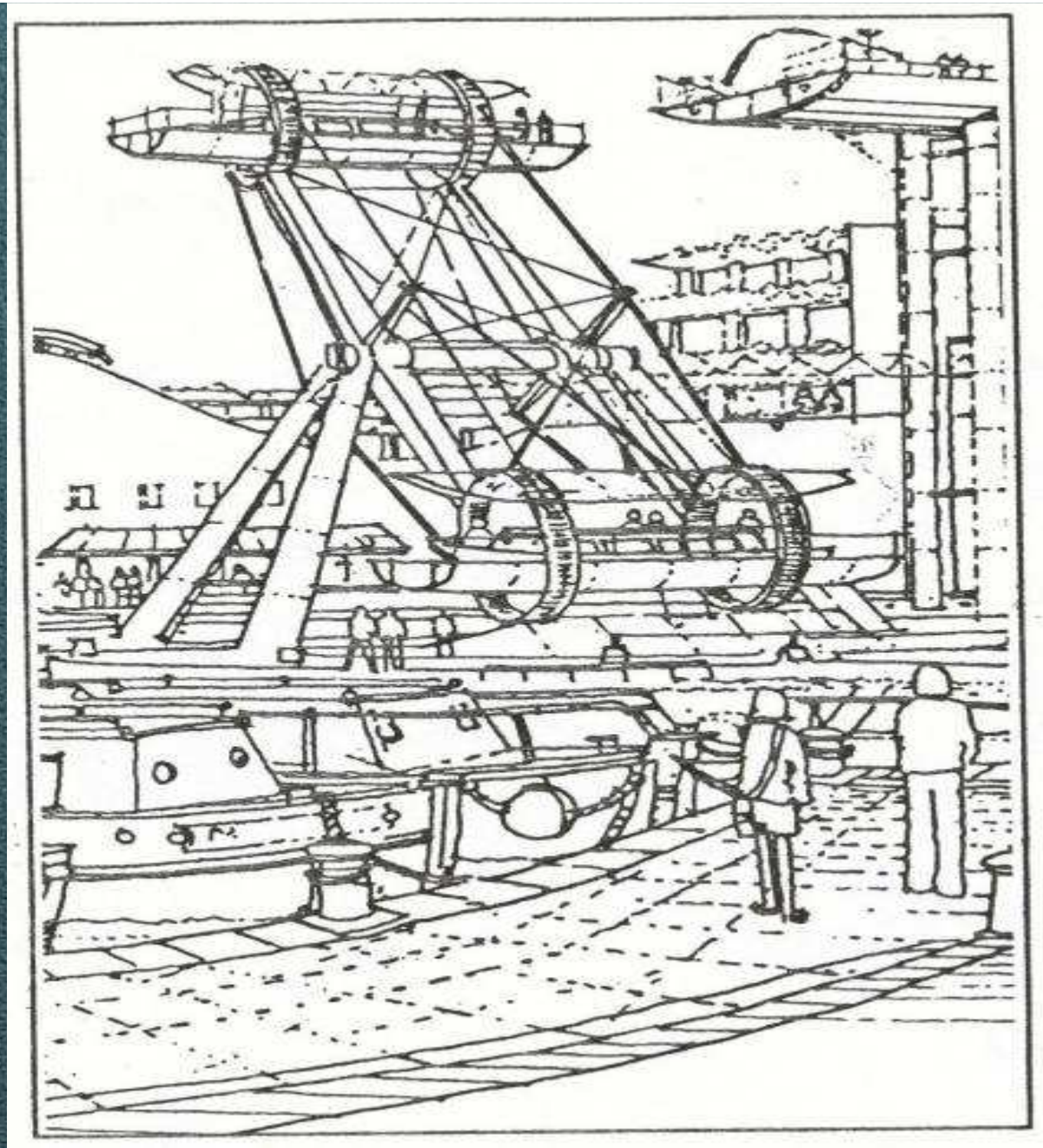

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Winning bid
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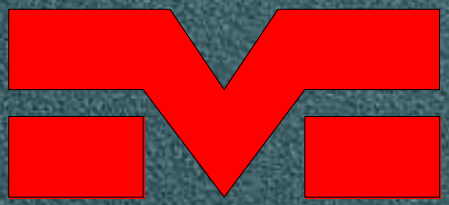
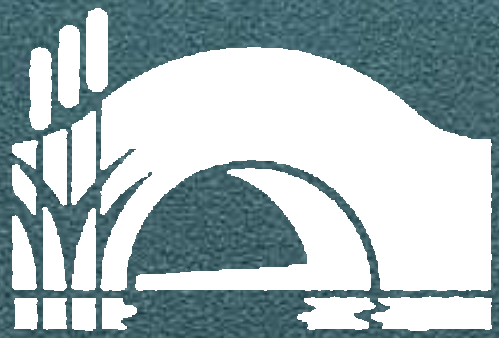
The Team





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The Wheel – revised design

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The Wheel – revised design

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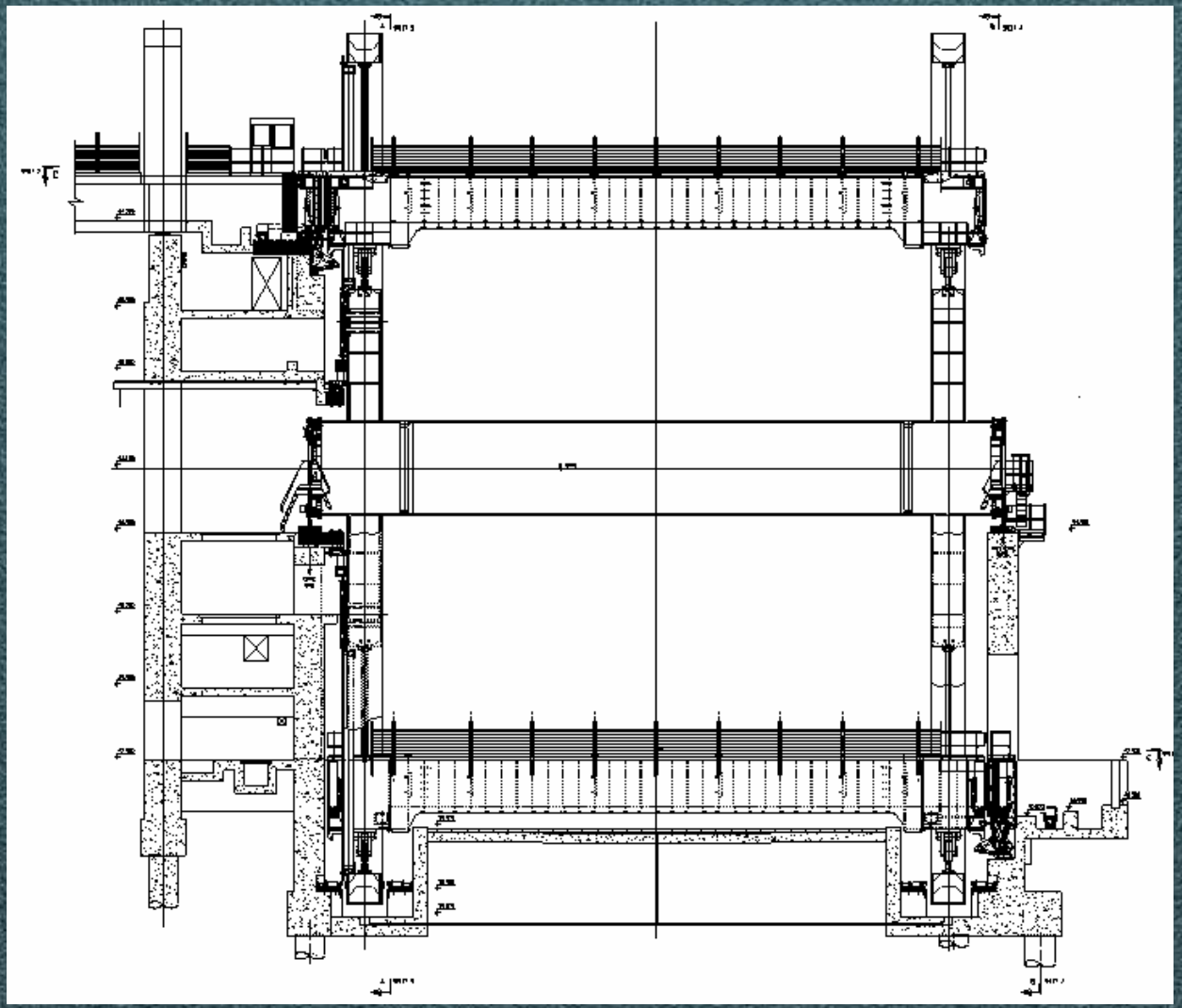
The Wheel – Concept



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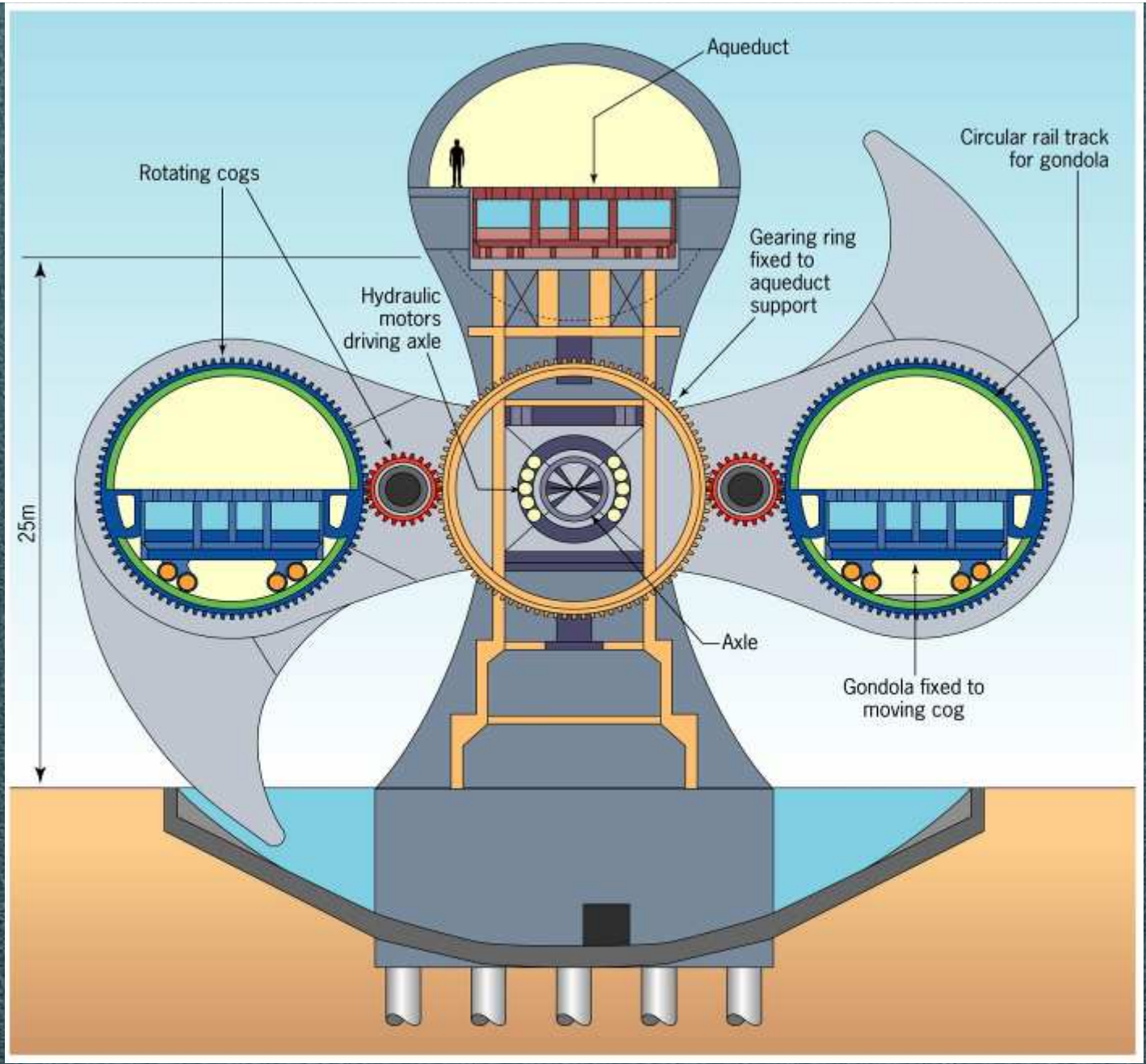
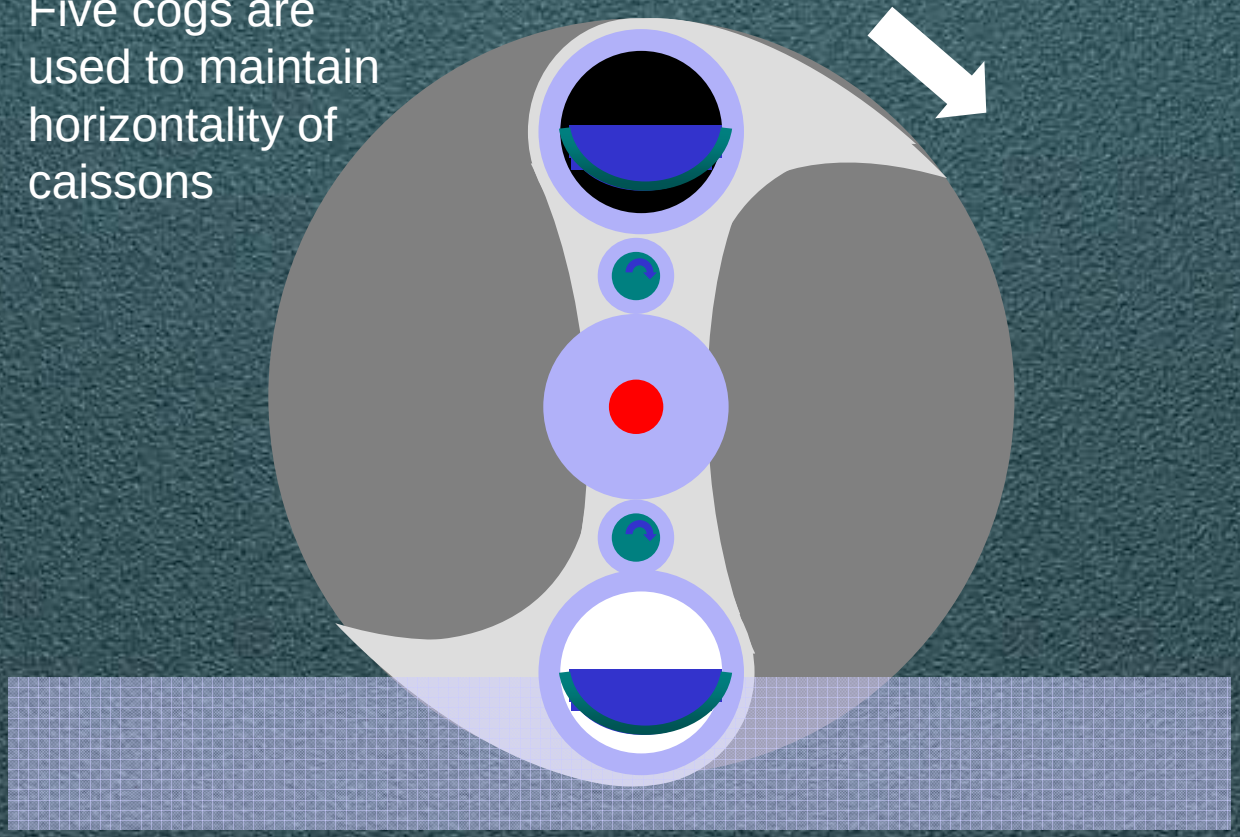


Wheel Operation

- 5 Gear Wheels are incorporated into arms

Five cogs are used to maintain horizontality of caissons



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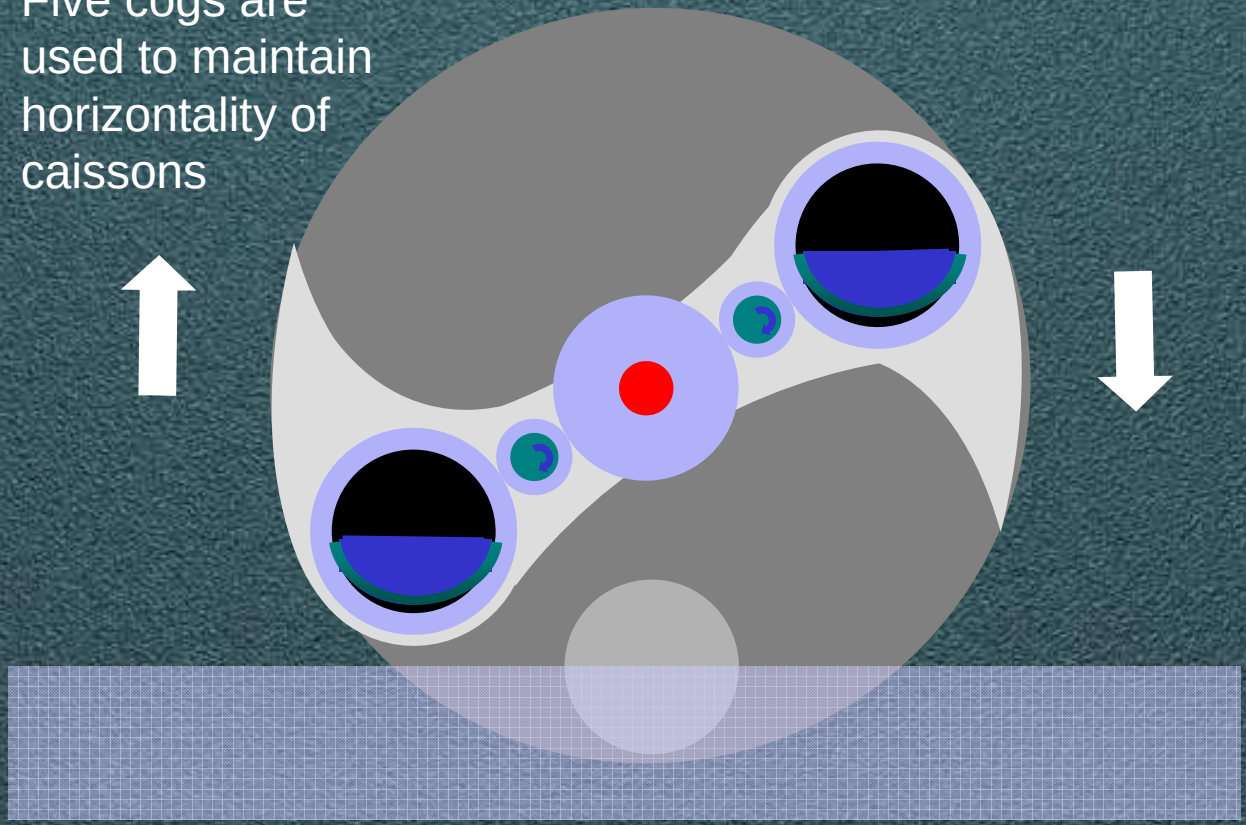
Wheel Operation

- Mechanism maintains horizontality of caisson

Five cogs are used to maintain horizontality of caissons



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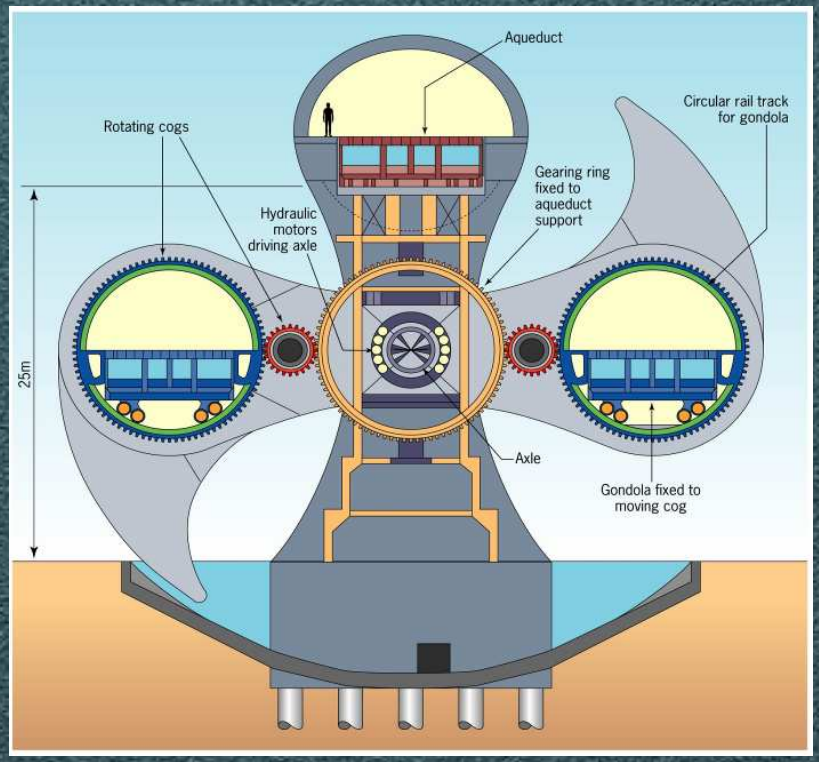
Wheel Operation

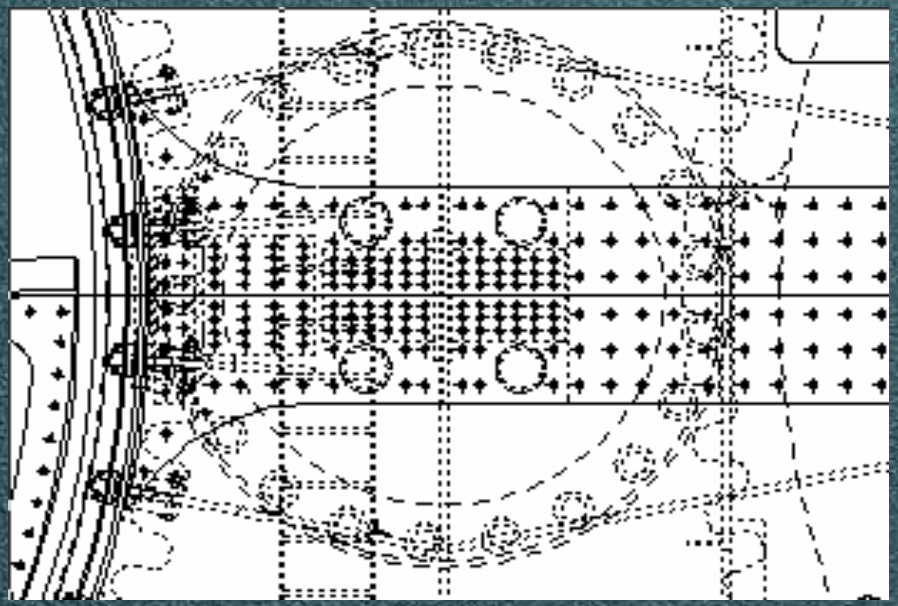
- **Power consumption**
  - 10 x 7kW geared motors
  - Consume 1.5 kW-hrs in 4 mins
    - Equivalent to boiling 8 kettles!
  - Trick is Archimedes
    - Water displaced by boat exactly equal to boat weight

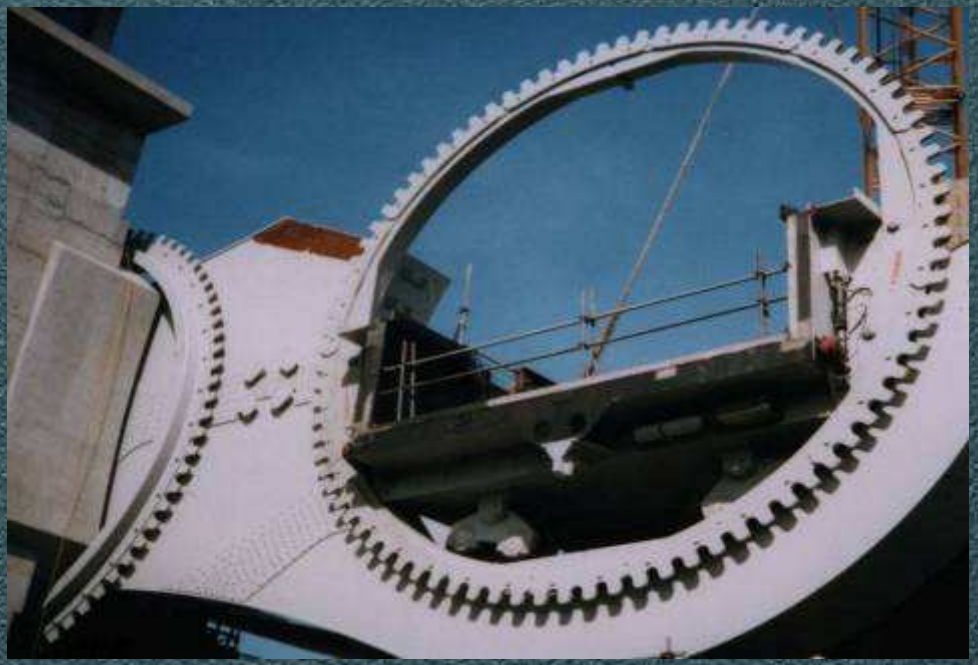
Wheel Engineering

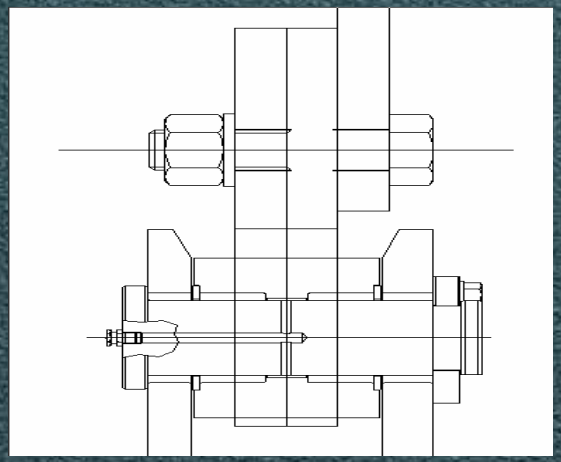
- **Mechanical performance**
  - 100% stress reversals
  - 1kN/mm^2 on rims
  - FEM analysis
- **Accommodate**
  - Thermal movements
  - Solar effects
  - Boat impacts
  - Freezing



Timing Gears







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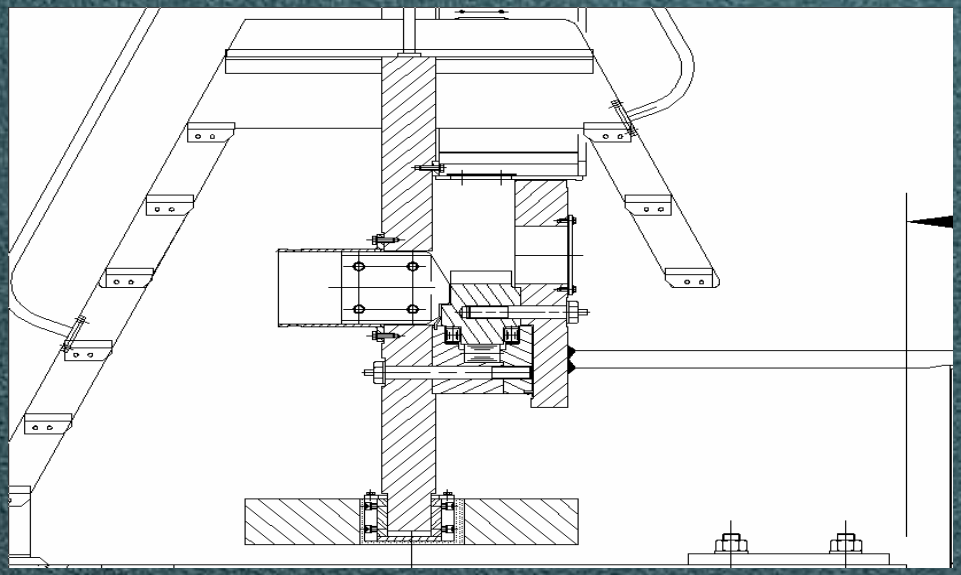
Support Bearings and Drive



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- **Construction**
  - Basin
  - Tunnel
  - Aqueduct
  - Wheel

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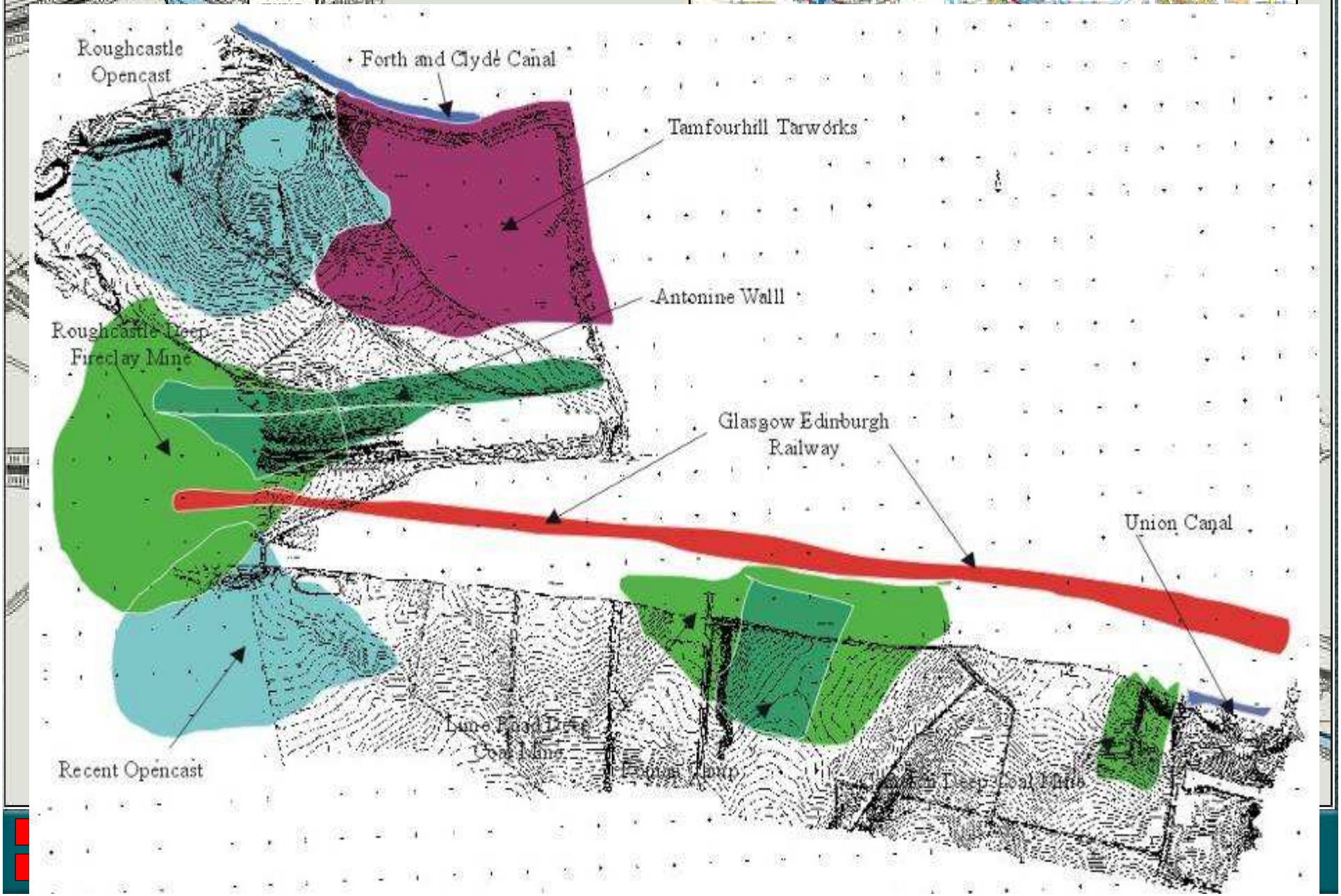
Site Constraints



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CONSTRUCTION

- **2km of New Canal**
  - 250,000m^3 Excavation/Fill
  - 160m tunnel (8m diameter, sprayed concrete)
  - 20m + 120m aqueducts
  - 3 sets of locks (7.4m + 3.0m)
  - Bridges over Forth & Clyde and Union Canal
  - 600m access roads
- **Boat Lift**
  - Unique in the world
  - 23.7m long gondolas
- **Visitor Centre**

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Falkirk Interchange – Construction

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Falkirk Interchange – Construction

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Tunnel – Construction

- **180m Roughcastle Tunnel**
  - Under Antonine Wall!
- **8m wide, driven in 3 stages**
  - 2 upper quarters, lower half
  - Adapted road planer took out 100mm milled layers
  - Excavated rock recycled


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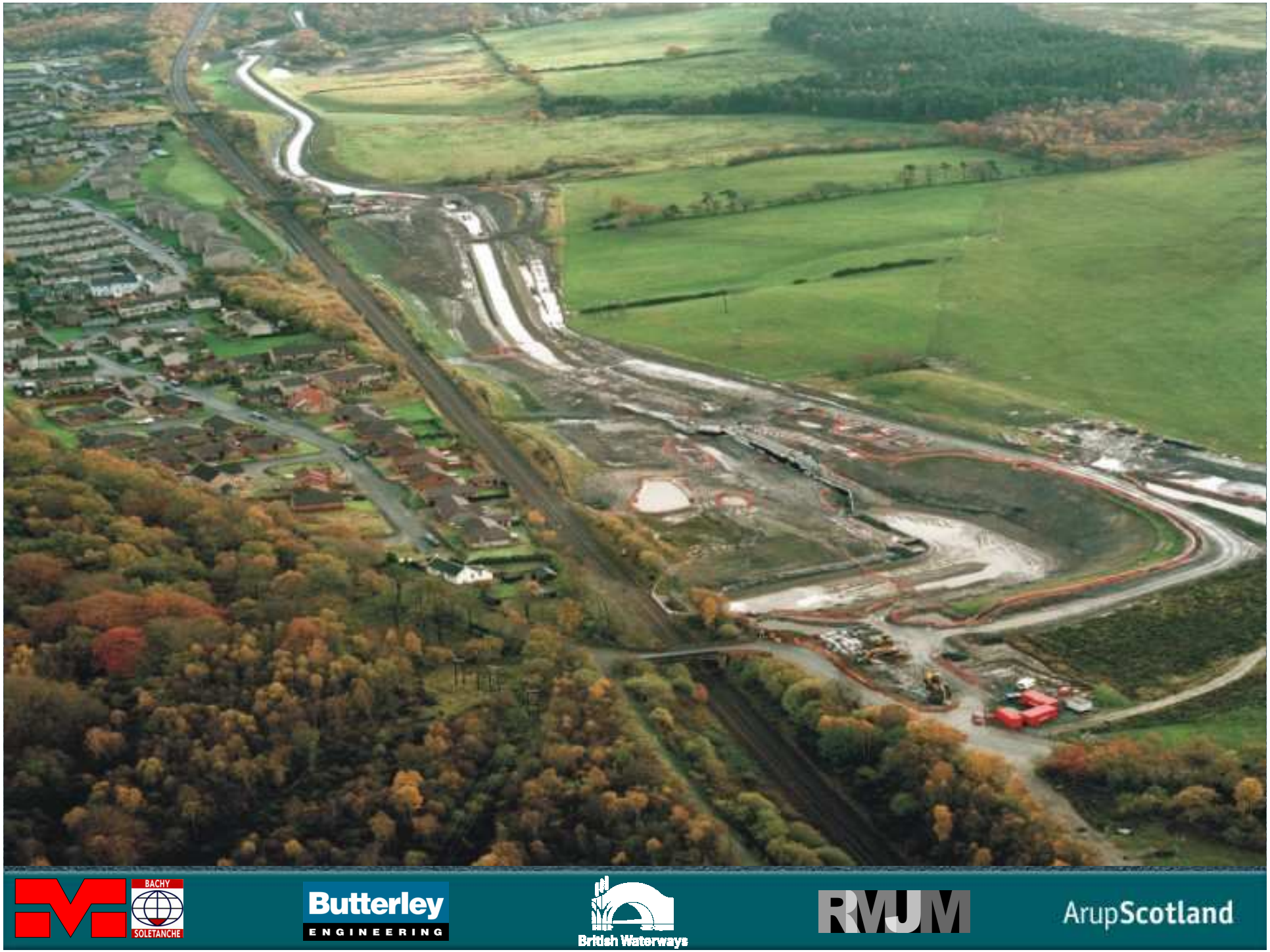
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Aqueduct – Construction

- **104m long**
  - On 24m high curved concrete columns
  - Matches profile of Wheel
  - Aesthetics required floating canal
    - “Unbuildable”
    - Lots of steel (40mm rebar)

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Falkirk Interchange – Construction

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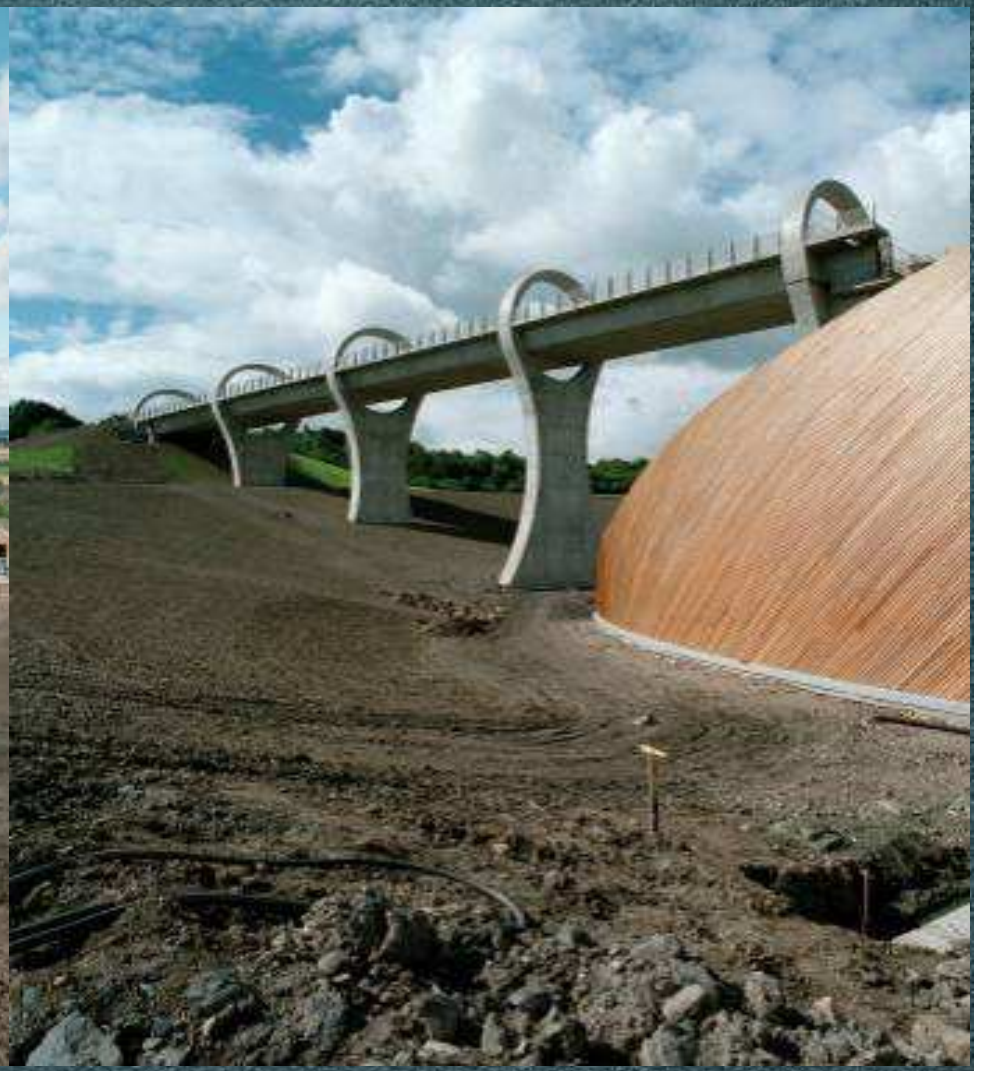

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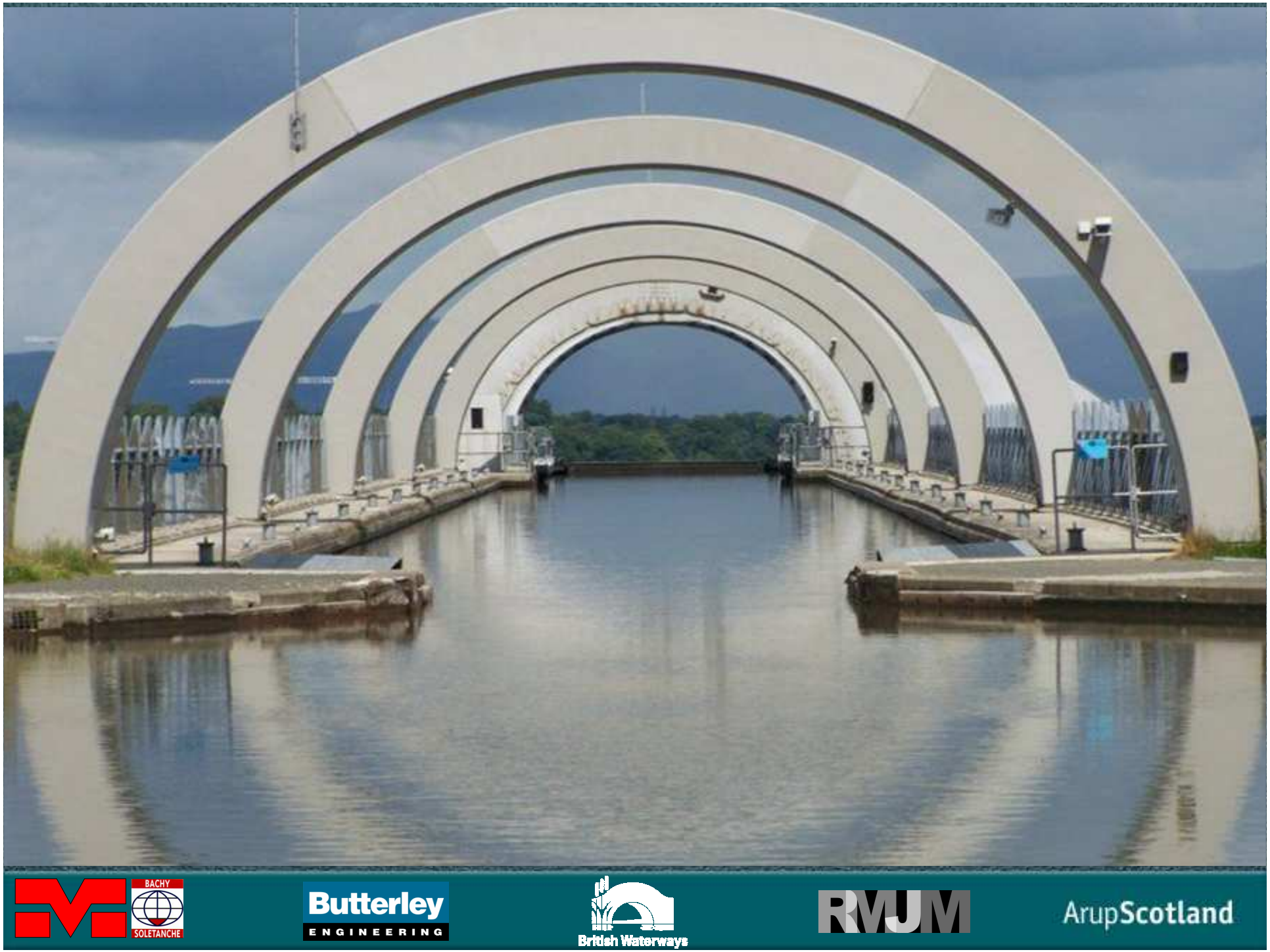
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Falkirk Wheel – Construction

- **Uses 1200 tonnes of steel**
  - 2 x 50 tonne gondolas
  - Assembly to within 10mm
  - 25m axle aligned to within 1mm
- **Fabrication**
  - Steel sections bolted, not welded
    - Robustness to fatigue loading
    - 600 tonne fully reversed load cycle
    - 15,000 bolts
  - All pre-assembled offsite to test fits
  - Broken down and transported in 35 lorry loads
    - Averaging 34 tonnes


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Lower canal (Forth & Cylde)

Lock connecting basin to lower canal

View towards tunnel from boat on aqueduct


welcome to


Two boats in gondola

Boats in both gondolas

Rotation


BarrettWells
British Waterways Scotland
welcome to
The Falkirk Wheel


welcome to


Marcelo

Project success?

- **Total cost £84.5M**
  - Wheel complex c. £20M
  - Wheel itself c. £5M
- **Opened on time**
  - HM The Queen
    - 24 May 2002
- **Generated development**
  - Aim
    - 4500 new jobs
    - £400M private investment
  - www.thefalkirkwheel.co.uk/

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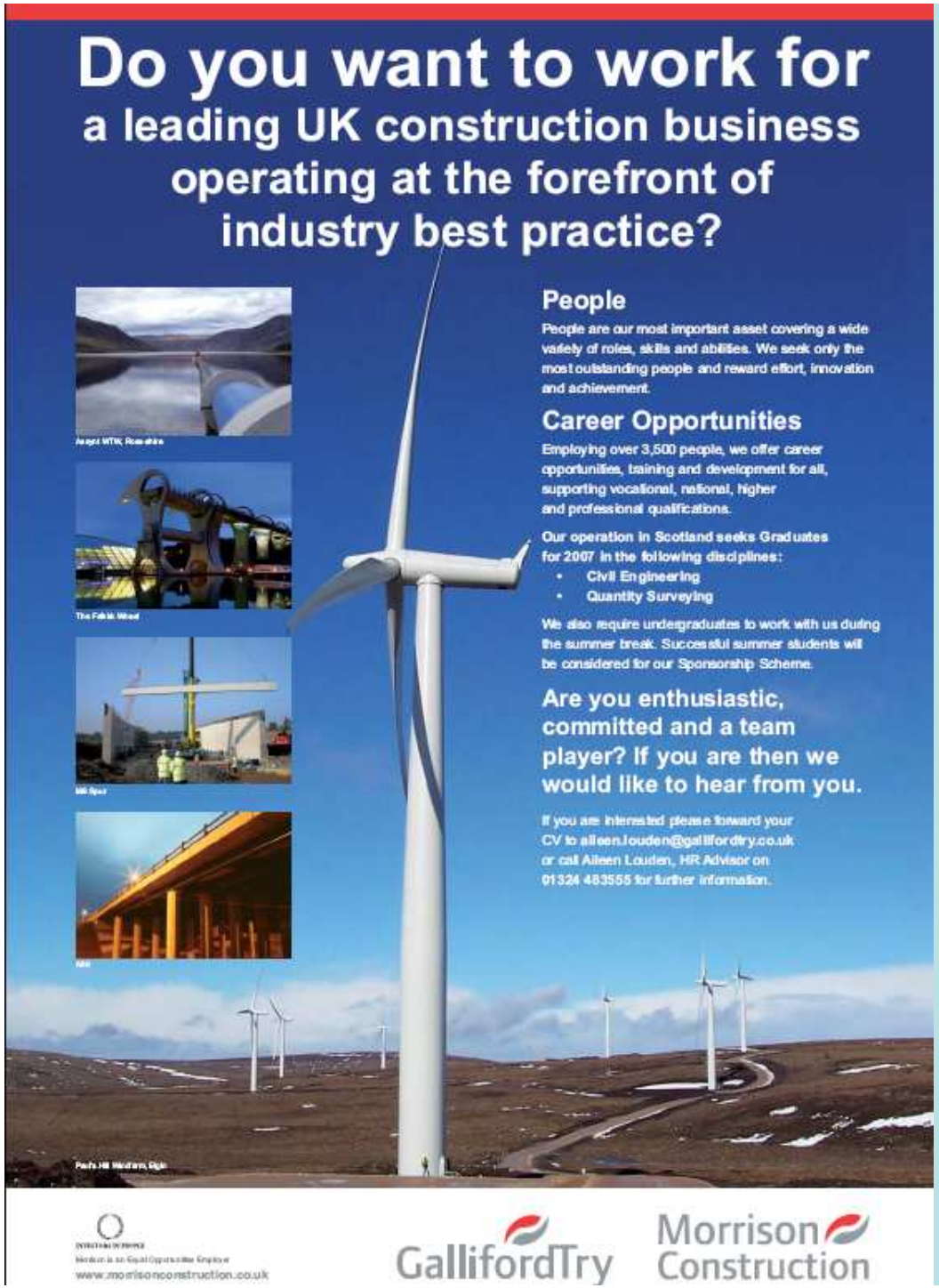

- Civil Engineering Graduates
- Civil Engineering Undergraduates
  - Sponsorship Scheme
- ICE Approved Training Scheme
- Opportunities in
  - Construction
  - Engineering
  - Planning
  - Cost Management
- Scotland or UK