DESIGN FOR EARTHQUAKE INDUCED MOVEMENT ON LIFELINES

THE FERRYMEAD BRIDGE EXPERIENCE

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TECHNICAL PRINCIPAL – PIPELINE MATERIALS
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ROAD (AND RAIL) BRIDGES

- Are convenient crossings for Lifelines

But:

- Permanent Ground Deformation (PGD) events cause damage
- Some bridges inherently unsafe

LIFELINE DESIGN - BRIDGE CROSSINGS

- Is all about minimising risk
- A structure that survived an event may not be safe
- Note – you can't out-Engineer the earth mother
- Christchurch experience -"Build it flexible and fixable"

THE FERRYMEAD BRIDGE

- Connects Christchurch to the suburbs of Mount Pleasant, Moncks Spur, Redcliffs, Sumner and Scarborough
- Carries >30,000 motor vehicles per day
- Also water supply, sewage, tele-communications and electric power lifelines
- Its vulnerability identified in 1997 lifelines study

FERRYMEAD BRIDGE STRENGTHENING

- Strengthening work started 1 week before September 2010 earthquake
- Only minor damage
- February 2011 earthquake caused substantial damage
- Only realistic option, demolish, and build a new, resilient bridge

PGD DESIGN REQUIREMENTS

2010 (Pre-earthquakes)

- Allow for 200mm in any direction
- PE Pipes chosen for flexibility
- "Snaking", bending and stretching of PE could take-up 200mm movement

2011

- 2011 earthquakes showed 1.5m towards the river and 0.5m vertical PGD possible

PIPE MATERIALS SELECTION

- Possible pipe material options
  - PVC-U, –M or -O
  - GRP
  - Ductile Iron
  - Stainless steel
  - Concrete lined steel
  - Epoxy coated and lined steel
  - Butt welded PE 100
- Only a PE pipe solution did not require "earthquake" joints

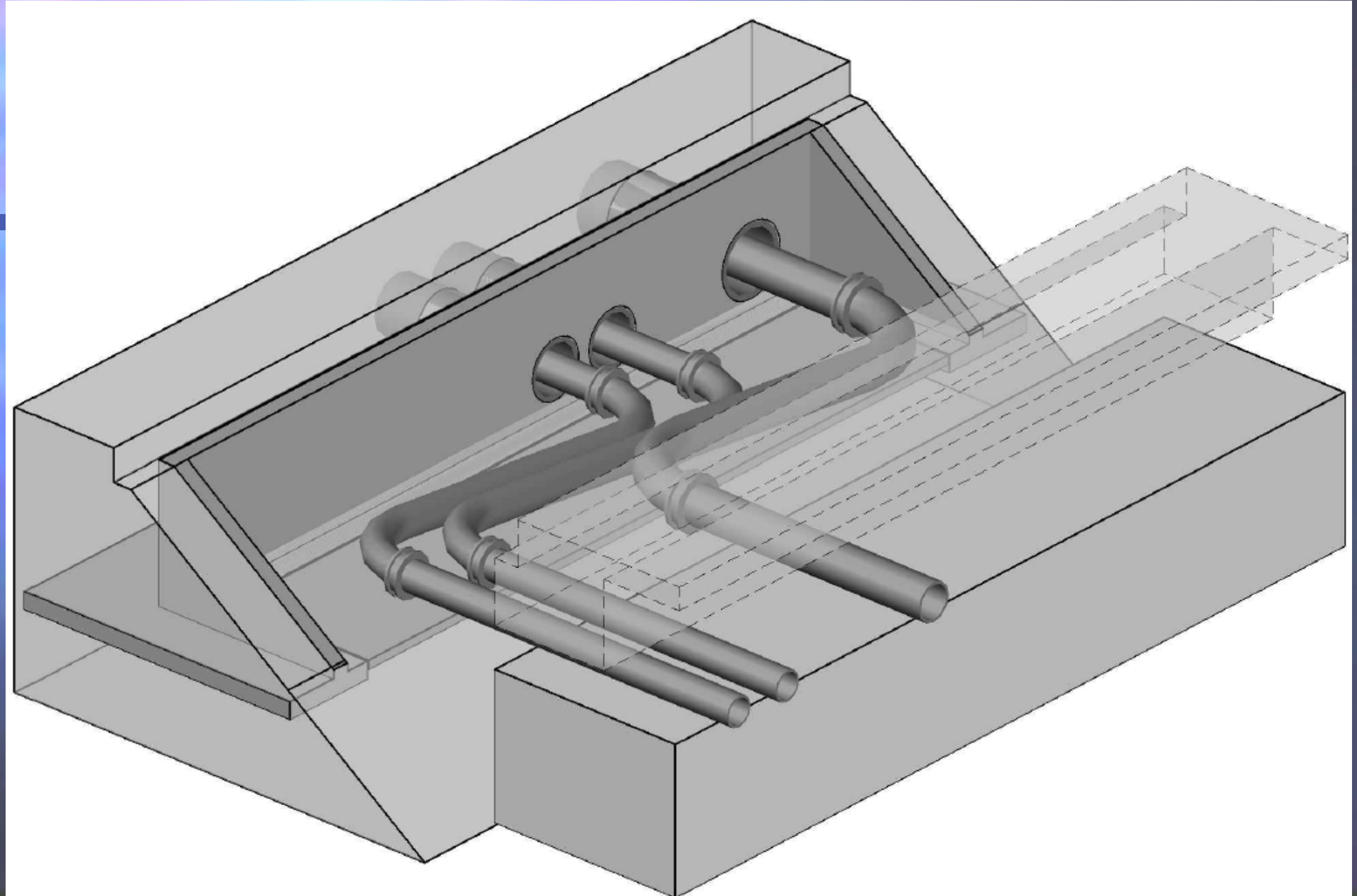
PE PIPE FOR FLEXIBLE DESIGN

- PE 100 can stretch by more than 300% before rupture occurs
- Short term bending radius 20 x OD for SDR 11 pipe
- Even a "kinked" pipe is unlikely to leak (short-term)
- Special "S" bends would work

Now to convince CCC

DEMO PHYSICAL MODEL

- A model was used to demonstrate flexibility
- SDR 11 DN 32 and DN 25 PE pipes used
- Hand butt welded mitred "S" bends ex PE pipe easily met scaled PGD
- And, withstood repetitive movement
- But >25% more than design caused a weld fracture
- Formed bends would minimise risk



THE "S" BEND

- The PENTAIR 90 degree fo
  DN 355 pipe) The 2 DN 45
  shown)

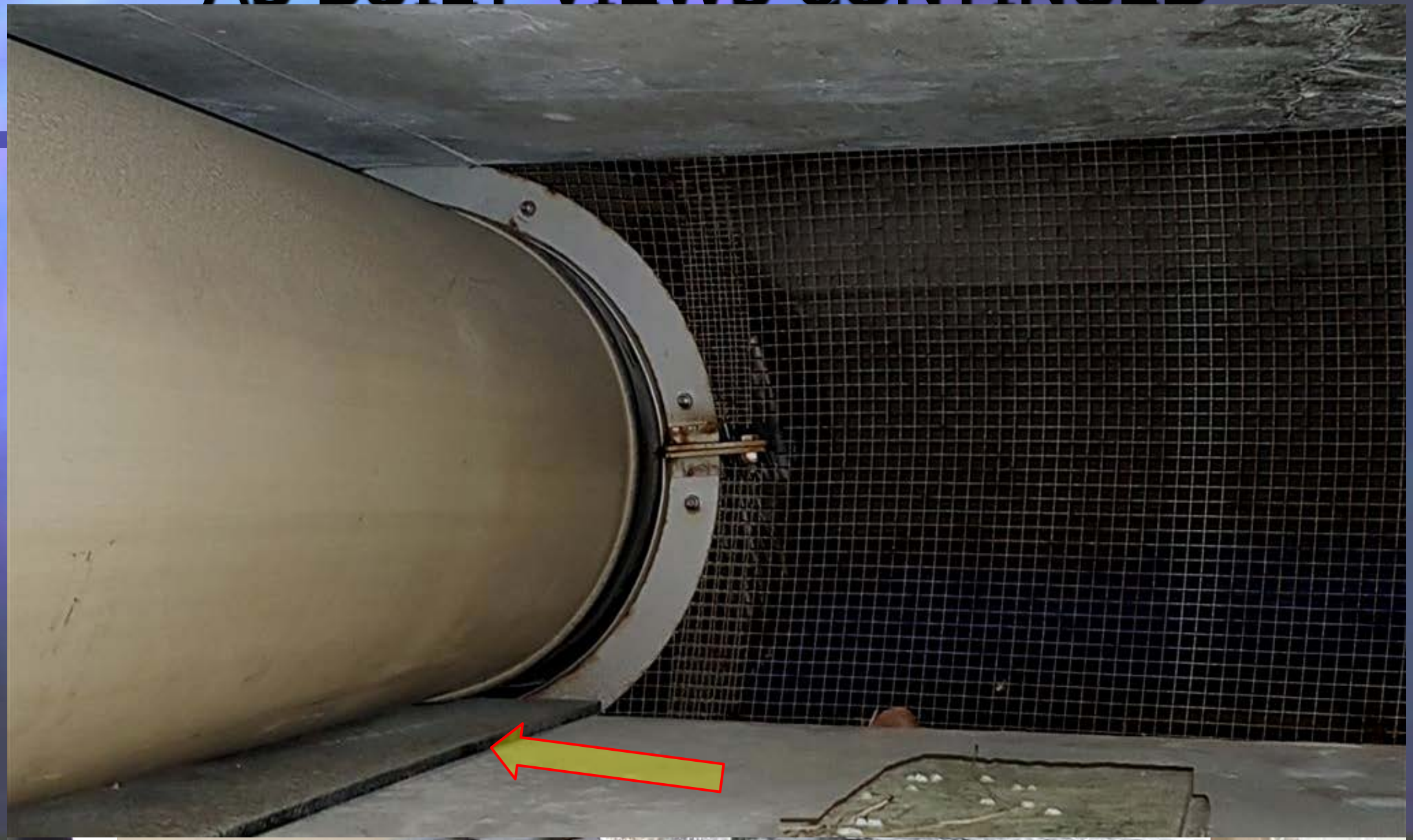
THE ENCLOSED CAVITY

AS BUILT VIEWS

AS BUILT VIEWS CONTINUED

- Air valves
- "S" bend

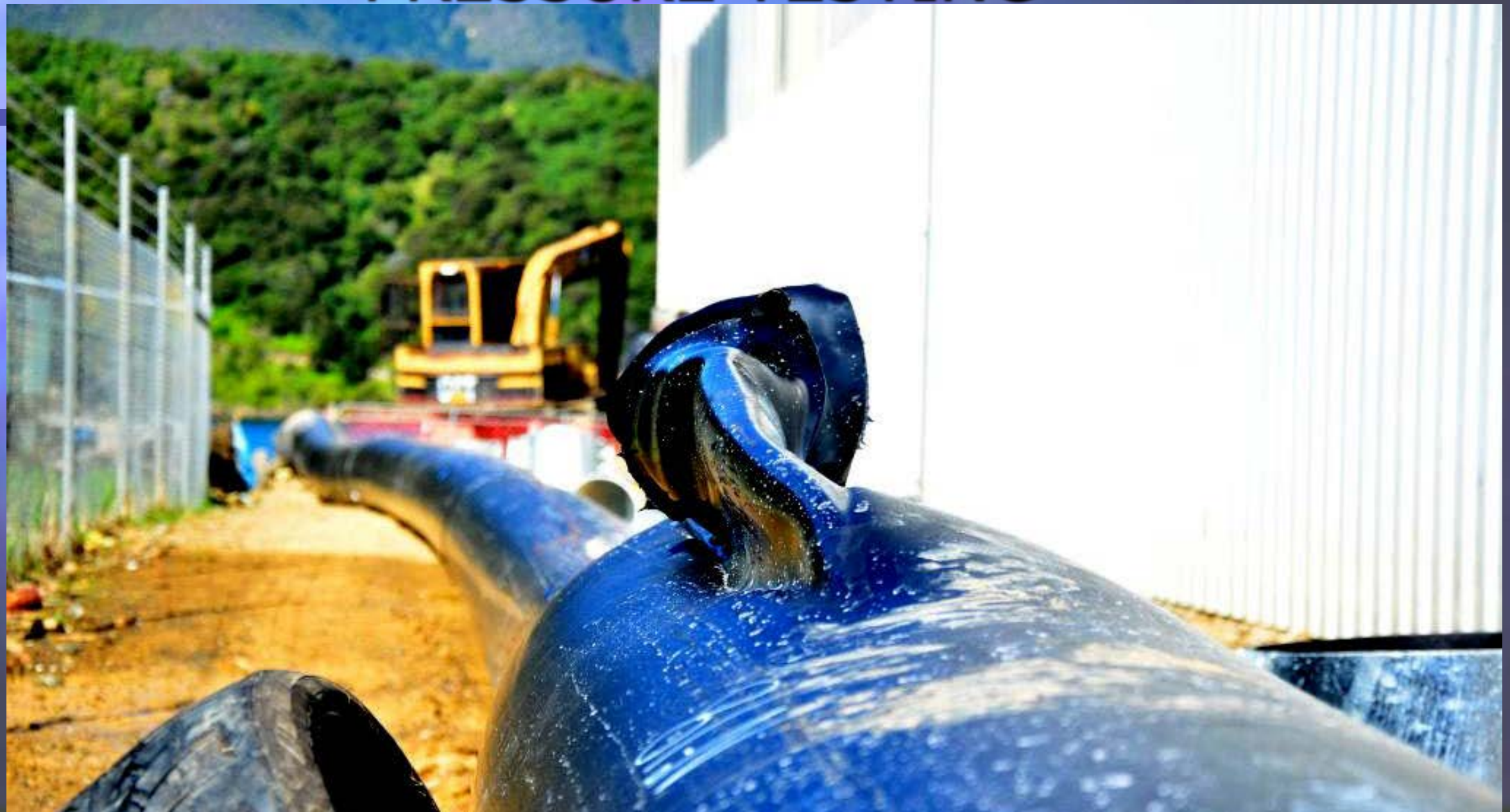
AS BUILT VIEWS CONTINUED



QUALITY ASSURANCE

- All construction aspects observed, reviewed & recorded
  - Pipe Manufacturers records
  - Weld logs & machine print-outs including EF records
  - "S" bend manufacturer's records
  - Pressure acceptance testing

PRESSURE TESTING



COMMENTS AND CONCLUSIONS

- Pipelines attached to bridges may need to accommodate significant movement
- PE "specials" with "S" bends can provide for significant movement
- The Ferrymead Bridge design concept can be adapted and used for any bridge crossing
- Identify the risks
- Ensure materials and installation are the best possible
- Keep it simple

THANK YOU

- Any questions?