Increasing the use of PE pipe for large diameter water mains

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PE Pressure Pipes

- Modern polyethylene is a highly engineered, high performance pipe material

- PE80 has now been in use since the mid 80s and PE100 since 1990

- PE pipeline systems are now the UK Water Industry standard for distribution size mains

- PE jointing systems obviate the need for anchorage, minimise leakage and make PE the ideal material for cost saving and environmentally friendly trenchless installation methods

- But what about large diameter use?
The Large Diameter Pipe Market

Water Pipe in UK 2001

- Data in km per annum for pipes of 300mm & larger
- Total length 646 km of which 138 km PE (21%)
- This means a potential growth of over 18,000 tonnes of PE pipe
- So what are the obstacles?

Source: AMI 2003
What are the factors affecting increased use of large diameter PE?

- Cost
- Conservatism
- Lack of knowledge/experience
- Confused/conservative design rules and guidance
- “Complicated” jointing methods – some thought poor
- “Complicated” and lengthy pressure test methods
- Poor product range
Cost

- Generally PE will lose out on materials cost
- Can improve comparison by using installed cost and correct hydraulic sizing and choice of pressure rating
- Really need a true ‘whole life costing’ model
- Need to correct the common fallacy that the life of PE pipe systems is 50 years whereas competing materials last longer
Conservatism

- PE has a limited track record compared with most of the other materials – and engineers therefore have limited experience

- Large diameter mains are treated as ‘one off’ engineering projects
  - Designers are not necessarily pipeline engineers
  - Designers lack operational experience

- DI and steel are familiar materials

- PE regarded as “plastic”, therefore not an engineering material
Guidance Documents

- Pipe Materials Selection Manual – 2 editions
- PE Pipelines Manual – 3 editions
- CP 312 / BS 8010
- PErseus software – structural and hydraulic design
- IGN 4-37-02 – design for surge and fatigue
- IGN 4-32-18 – design guidance for PE pipe systems
- IGN 4-?-? – guidance on the WIS/EN differences
Confused Guidance/Design Rules

- Guidance documents available are not widely promoted
- Guidance has improved rapidly but old, outdated versions still in circulation
- Structural design methods still very conservative
- Confusion between WIS, CEN and ISO standards – many engineers don’t know the differences!
- Few technical courses/training on the “new” materials
Hydraulic Design

Existing 30” (760mm) CI versus PE 710mm SDR17
Surge and Fatigue

- PE slipline - 630mm into 720mm, 3km long
- Working pressure: 2.5 bar
- 'Surge' envelope: 0 - 5 bar
- PMSM/CP 312: \(dp < 0.5 \times \) static rating
- WIS 4-37-02: \(dp = \) static rating if surge less than \(2 \times \) PN
- 10 bar rating versus 4 bar rating
- Material cost difference: £115,000
EN 1295 - 12 national annexes! - None are appropriate for plastic pipes

Overall modulus of soil reaction $E' = E_2 C_L$

Note that if $b > 4.3 d_e$, then $E' = E_2$

Soil modulus adjustment factor $C_L = \frac{0.985 + 0.544 \frac{b}{d_e}}{1.985 - 0.465 \frac{b}{d_e} \left( \frac{E_2}{E_3} - 1 - \frac{b}{d_e} \right)}$

Short-term critical pressure $P_{crs} = 0.5 \left( \frac{E_3}{d_m^3} \right)^{0.33} \left( \frac{E_2}{E_3} \right)^{0.67}$

Long-term critical pressure $P_{crl} = 0.6 \left( \frac{E_3}{d_m^3} \right)^{0.33} \left( \frac{E_2}{E_3} \right)^{0.67}$

Rerouting of pressure pipes $\left( \frac{\Delta}{d_m} \right)_R = \left( 1 - \frac{P}{40} \right) \left( \frac{\Delta}{d_m} \right)$
Consult online at BPF or WRc websites

Free from websites
“Complicated” Jointing

- Needs special, expensive, hard to get equipment
- Takes much longer than DI etc – over 1 hour to make a 630mm SDR11 joint
- “Dual pressure” method seems complicated and difficult to achieve control of
- Different parameters for water and gas
- Large Diameter EF couplings expensive
- Large diameter EF couplings too prone to failure
- Need special trained staff
PE Jointing Machine
Single purpose

DI/GRP Jointing Machine
Multi-purpose
“Complicated” Pressure Testing

- Not straightforward for viscoelastic materials because:
  - Creep behaviour
  - Material dependent
  - Temperature dependent
  - Embedment condition dependent
  - Time dependent
- DI etc are only time dependent
EN 805 Method – Modified ‘Rebound’

- Preliminary Test
  - After filling, reduce pressure to atmospheric and allow to stand for at least 60 minutes
  - Raise to test pressure in less than 10 minutes
  - Maintain test pressure for a further period of 30 minutes
  - Shut off and allow main to stand for 60 minutes without pumping
  - If pressure is > 70% of test pressure continue to next phase
  - If drop is greater consider if test conditions have changed, temp etc
  - If test repeated allow a minimum 60 minutes relaxation period

- Two further stages if this is successful!
Limited Product Range

- 16 bar rated pipe only available up to 630mm
- 10 bar rated pipe only available up to 1000mm
- EF couplings only available up to 710mm
- Many large diameter fittings are fabricated – concerns about mitred joints
- DI has a full product range of pressure ratings and fittings up to 1000mm and GRP/steel go above this.
But on a more positive note…

- PE is the material for “Trenchless” Techniques

- These should be promoted by all for the refurbishment of trunk mains, especially in urban areas

- Cost savings should be available over conventional open cut

- Experience with PE in this field of application should promote wider use in new lay applications

- Engineers need to be given a better understanding of PE material properties and TT design
Conventional Sliplining
‘Rolldown’: Up to 500mm; SDR 11 to 33
‘Subline’: up to 1400mm; SDR26 to 80
Thank You