PIPE STIFFNESS EXPLAINED: PVC AND DUCTILE IRON

Pipe stiffness is the measure of a flexible pipe's resistance to deflection (ovalization) under load. A flexible pipe is any pipe that can deflect 2% without suffering damage. Both Ductile Iron (DI) and PVC meet this requirement and are considered flexible pipes. Some specifications require DI pipe due to its "strength" in resisting external loads. While this was true in the era of thick-walled DI Class pipe, the thinner walls of DI Pressure Class pipe have made PVC the stronger option.

DEFLECTION LIMITS – ADVANTAGE PVC

PVC pipe is able to deflect 30% before experiencing failure (by reverse curvature). AWWA C605 (pressure pipe) and ASTM D3034/F679 (gravity pipe) limit PVC pipe deflection to 7½%, providing a 4:1 safety factor.

On the other hand, DI pipe deflections are significantly limited by the linings used:

- Cement-mortar (gravity sewer and pressure water pipe) – maximum allowable deflection is 3% due to potential cracking of the lining. Safety factor is 2:1.
- Flexible lining (gravity sewer and forcemain sewer pipe) – maximum allowable deflection is 5% due to potential damage to the lining. Safety factor is 2:1.

Conclusion: DI pipe fails at a lower deflection than PVC pipe and DI has a lower safety factor against failure.

COMPARISON OF PIPE STIFFNESS – ADVANTAGE PVC

Pipe stiffness (PS) is calculated using the equation: $PS = 6.7\ EI / r^3$

where:

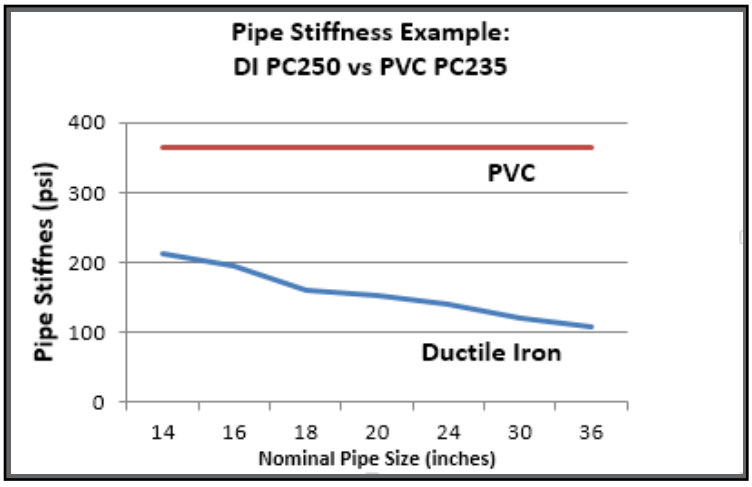
E = modulus of elasticity (psi)
I = moment of inertia (in^4/in)
r = mean diameter (in)

Pipe geometry is used to calculate I and r. Modulus values are E = 400,000 psi for PVC and 24,000,000 psi for DI.

The chart to the right compares pipes of about the same pressure class (PC): DI PC 250 pipe and PVC PC 235 pipe.

A picture is worth a thousand words, but engineers like numbers too:

- For the 14" size, PVC has 1.7 times DI's pipe stiffness
- For 24" pipe, PVC has 2.6 times the stiffness
- For the 36" size, PVC is 3.4 times as stiff



As shown, PVC pipe has higher pipe stiffness throughout the size range and PVC's advantage grows as pipe size increases.

CONVENTIONAL WISDOM – NOT ALWAYS CORRECT

Facts:

1. PVC PC235 pipe has more pipe stiffness (and therefore will deflect less) than DI PC250 pipe.
2. PVC pipe can safely withstand about five times as much deflection as cement-mortar lined DI pipe.

Conclusion: For this example, PVC pipe is the "stronger" pipe.

References: *Buried Pipe Design*, Moser; "Ductile Iron Pipe for Wastewater Applications," DIPRA; *Handbook of PVC Pipe,* Uni-Bell

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