

A decorative vertical border on the left side of the slide, composed of a grid of hexagons in various shades of blue and green. Some hexagons contain white icons: a calendar, a magnifying glass, a hard hat, a lightbulb, a leaf, a road with a tree, and a cylindrical container.

PNWS AWWA Spring Conference

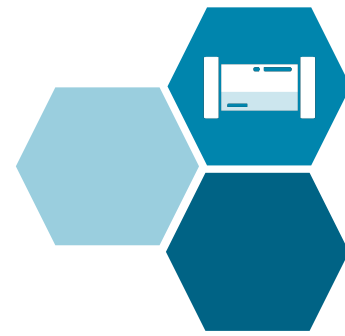
April 29<sup>th</sup>, 2022

# Thrust Restraint for Buried Water Systems

Doug Schlepp, PE



# Forces Causing Thrust

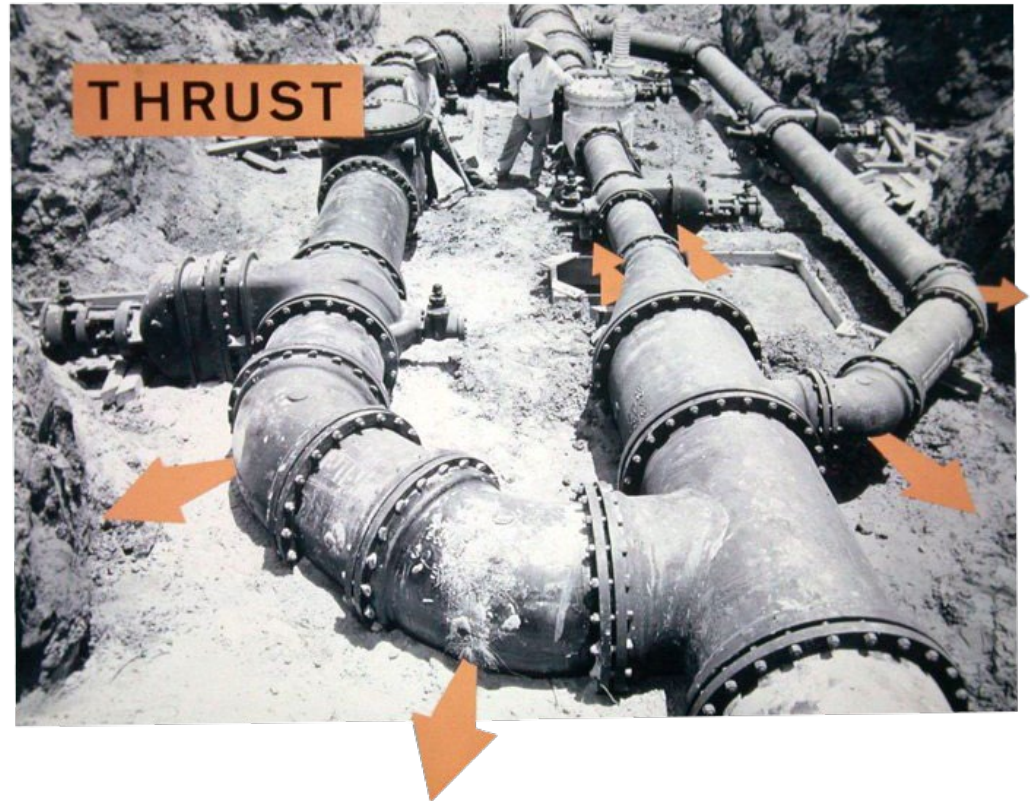


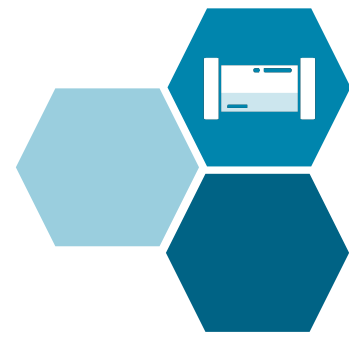
## Static Forces

- Internal Pressures

## Dynamic Forces

- Water Hammer





# Restraining Techniques

## Blocks

- Bearing (Thrust Block)
- Gravity
- Deadman

## Restrained Joint Systems

- Flange
- Glands
- Gaskets
- RJ Pipe

## Tie Rods

## Combined Systems

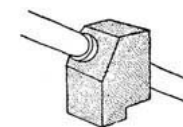
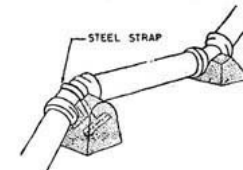
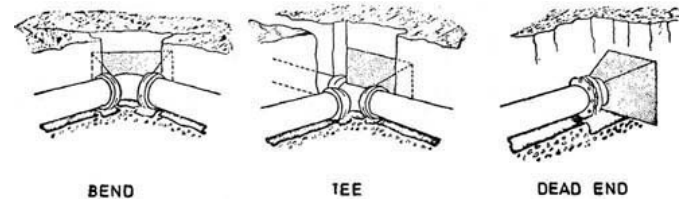
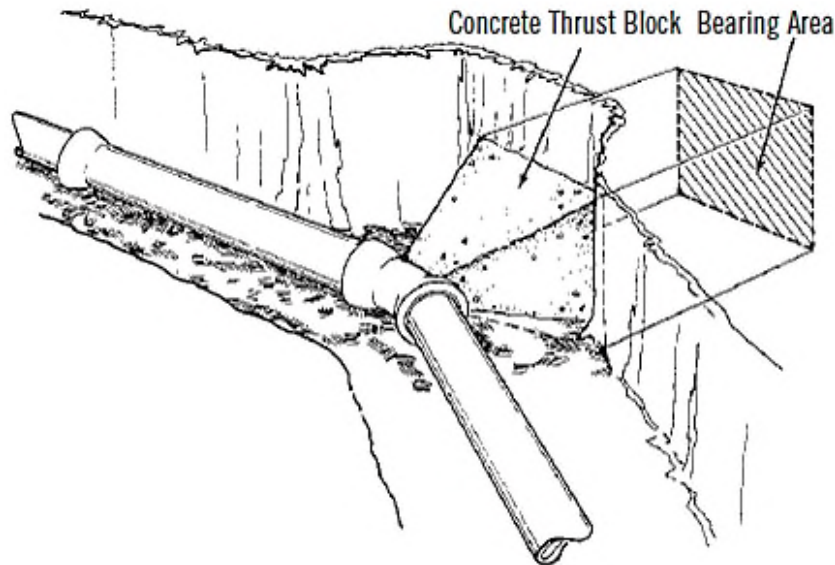
# Thrust Block – Bearing



## Design

- Size varies with pipe size, soil and pressure
- Transfers thrust to bearing area

Soil	Bearing Strength $S_b$ (lb./ft <sup>2</sup> )
Muck	0
Soft Clay	1,000
Silt	1,500
Silty Sand	3,000
Sandy Silt	4,000
Sandy Clay	6,000
Hard Clay	9,000



# Thrust Block – Bearing

## Construction

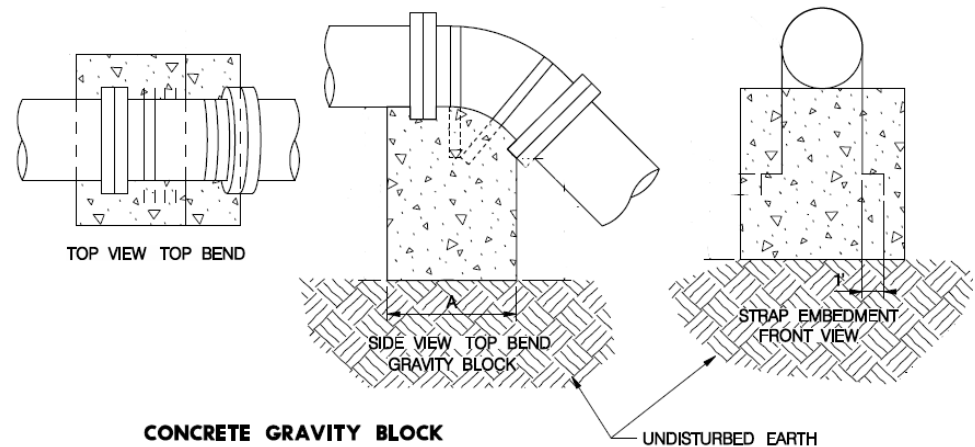
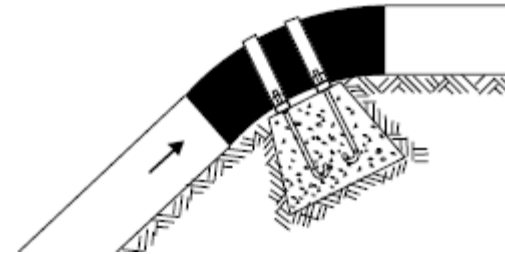
- Distribute load uniformly to bearing soils
- Align bearing face with pipe
- Preserve access to fitting and connections
- Use correct concrete mix design



# Gravity Block

## Design and Construction

- Formwork
- Secure connection between block and pipe
- Proper concrete embedment
- Transfers thrust from pipe to strap to block

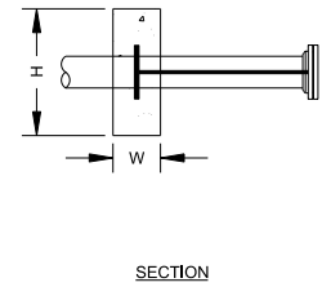
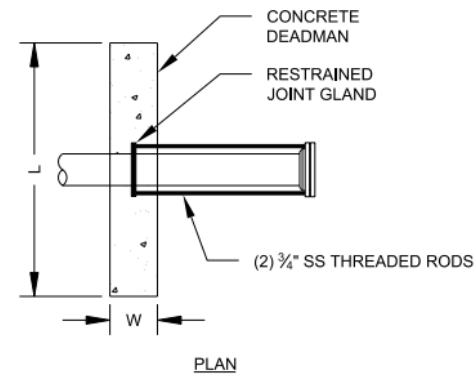
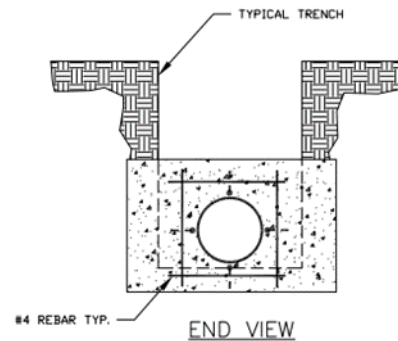
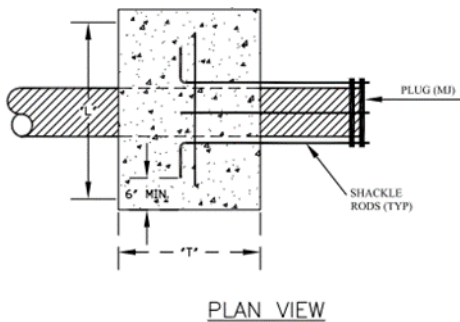
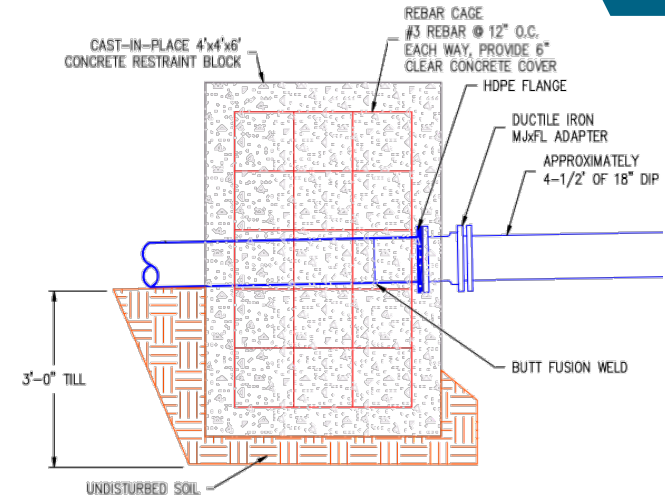
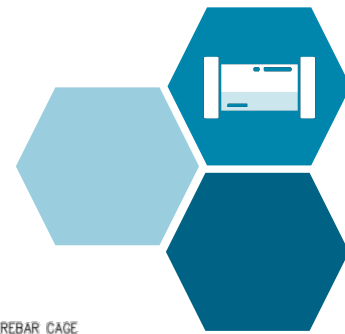




# Dead Man Block

## Dead Man

- Dead weight restraint – skin friction
- Keyway thrust to soil
- Pipe/fitting and block connection
- Transfers thrust from fitting to block



# Flanged Joints

## Flanged Assemblies

- Valves to fittings
- Fitting to pipe
- Flange coupling adapter
- Rigid





# Restraint Glands

## Restraint Glands

- Set screw or wedge
- Mechanical joints
- Transfers thrust from fitting to pipe
- Field installation



# Restraint Gaskets

## Gasket Systems

- Push-on and Mechanical
- Locking teeth in gasket
- Field installation
- Push-on requires cut to remove
- Transfers thrust to pipe



# Restrained Joint Pipe

## RJ Systems

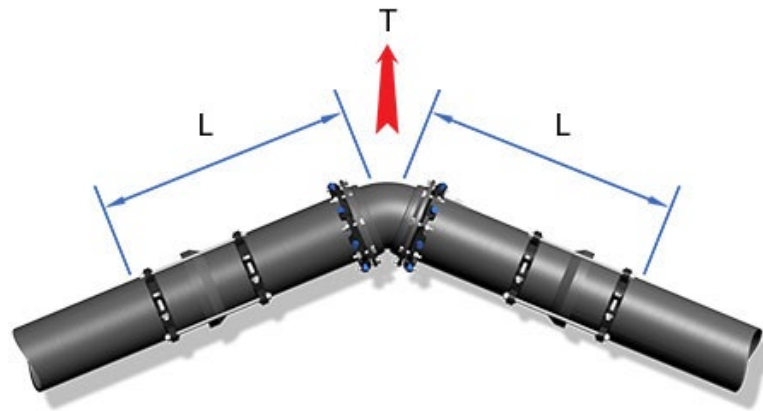
- Push-on and Mechanical
- Welded bead on male end with restraining gland
- Specific design lengths
- Transfers thrust to pipe



# Restrained Joint Systems

## Development Length

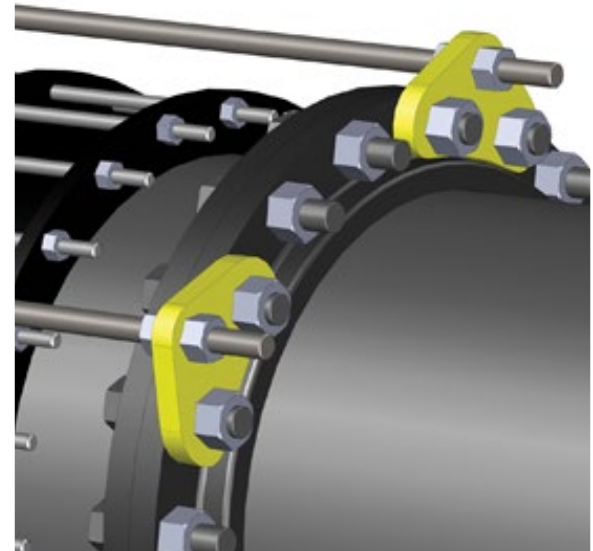
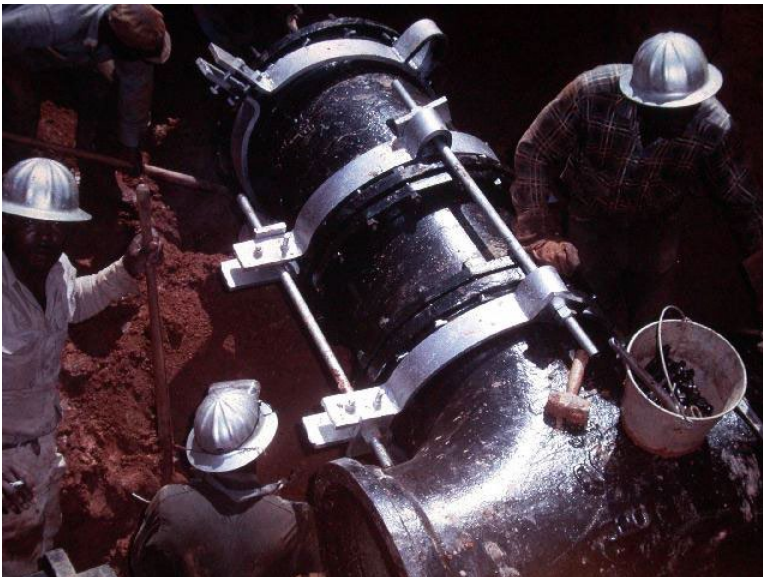
- Transfer of thrust to pipe
- Relies on skin friction between pipe and soil
- Function of pressure, pipe size, bedding, and soil type



# Tie Rods

## Rod Restraint Systems

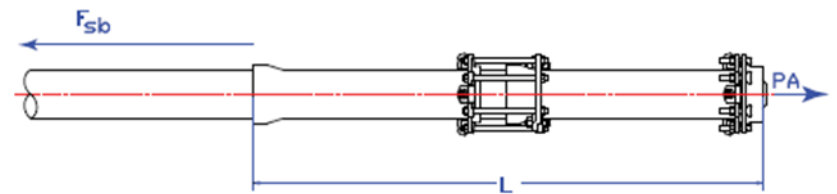
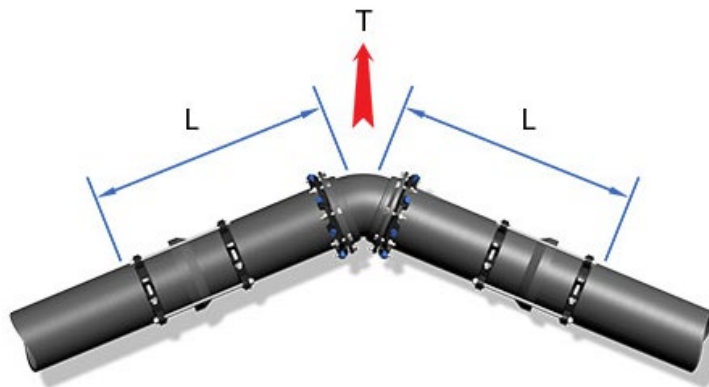
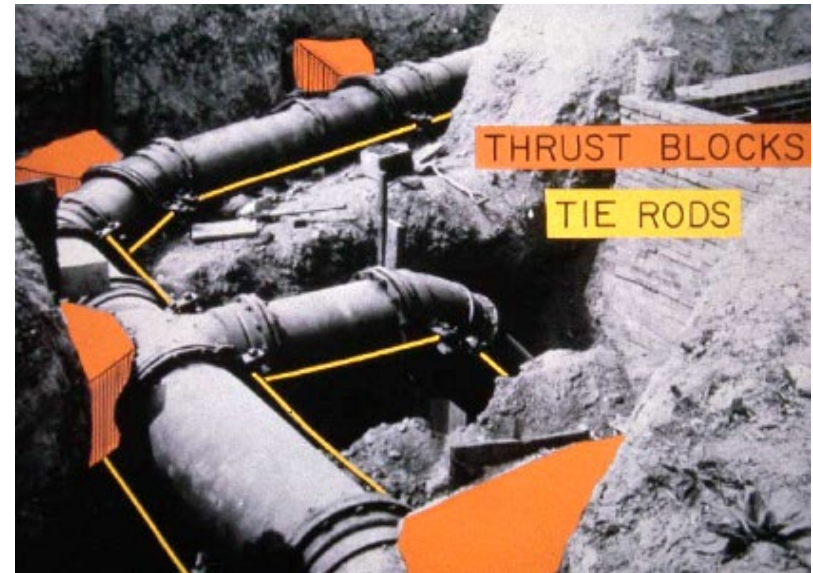
- Hydrants, dead man, RJ pipe systems
- Transfers thrust through rods to point of connection
- Number of rods and size designed



# Combination Systems

## Combined Restraint Systems

- Inadequate space
- Economics
- Redundancy



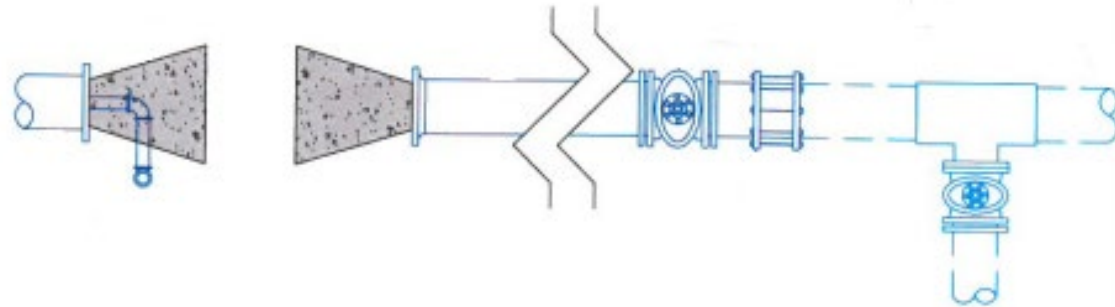
$$L = S_f \cdot P \cdot A / F_{sb}$$



# Temporary Restraints

## Dead End

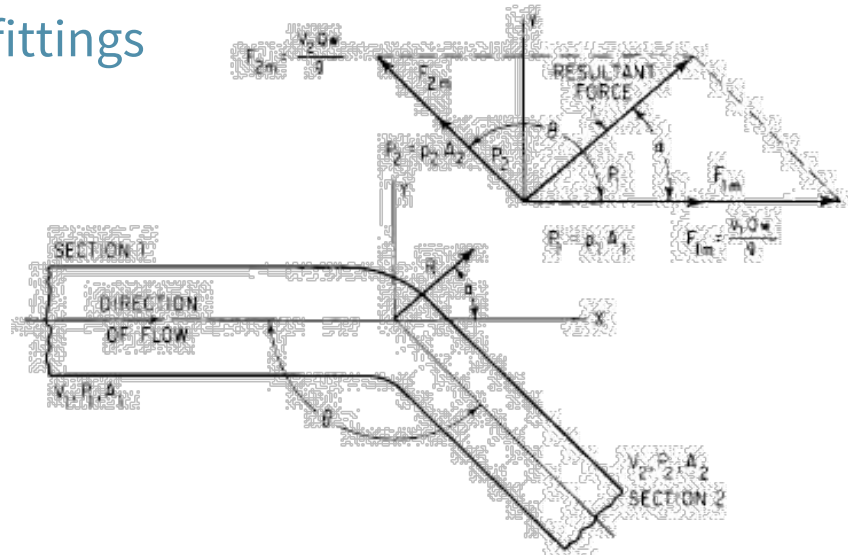
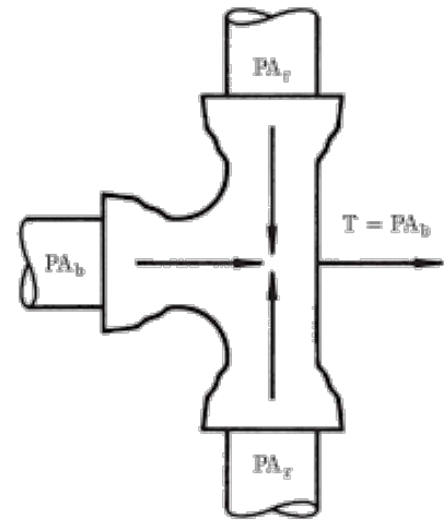
- Timbers
- Ecology or Thrust Blocks
- RJ Pipe and Fittings



# Free Body Diagram

## Resultant Force

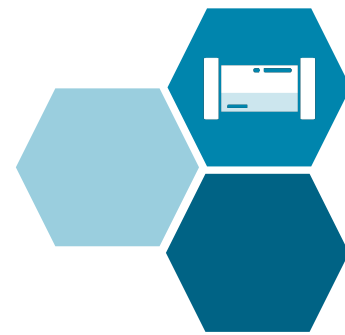
- Pressure and area
- Opposing forces
- Methods to resist resultant force
  - Thrust, gravity or dead man blocks
  - Shackle rods
  - RJ pipe and fittings



# System Failure

## Design and Construct to Avoid System Failure

- Know the conditions
- Understand the design
- Factor of safety



# Questions?

