INSITU STABILIZATION of SOILS by INJECTION of HIGH-DENSITY POLYURETHANE: PRINCIPLES AND APPLICATIONS

aka Insitu Soil Stabilization by Injecting Polyurethane or ISSBIP

Randall W. Brown, PhD, PE

Vice President for Engineering

URETEK

AGENDA

- GOAL
- ISSBIP DEFINITION
- ISSBIP TENETS
- ISSBIP: SOIL / POLYMER INTERACTION
- ISSBIP ADVANTAGES
- ISSBIP APPLICATIONS
- SUMMARY

GOAL

Provide essential information on ISSBIP to engineering professionals involved in evaluating insitu soil stabilization alternatives

ISSBIP DEFINITION

The ISSBIP process is a technique for stabilizing weak and/or poorly compacted foundation soils insitu and leveling structures (including pavements) by injecting a specially-formulated polyurethane into the foundation soils

ISSBIP DEFINITION

- ISSBIP Polyurethane Description
  - Low viscosity when introduced into the soil
  - 2-component: Resin & Hardener
  - 1:1 mixing ratio by volume
  - Exothermic chemical reaction generates CO2 gas
  - CO2 gas causes expansion of the polymer and creates pressure on the surrounding environment
  - Fast reaction – complete in < 1 minute
  - Rigid Structural Polyurethane created as the material cures

ISSBIP DEFINITION

- ISSBIP Polyurethane Description
  - Rapid Cure – Can support traffic after 20 minutes; full strength after 24 hours
  - Lightweight – 3 to 20 pcf (installed density)
  - E Modulus, Compressive Strength, Tensile Strength directly proportional to Density

ISSBIP DEFINITION

- ISSBIP Polyurethane Description
  - Spread is primarily limited due to speed of reaction
  - Water resistant (Hydro-insensitive)
    - Contains water insoluble diluents - can be injected into wet soils and even standing or flowing water
    - Resists water intrusion into the chemical reaction that forms polyurethane; water can compromise the integrity of the polyurethane if it enters the reaction

ISSBIP DEFINITION

- ISSBIP Process Description
  - The heated components are introduced in the impingement gun and forced down the injection tube by air pressure
  - The low viscosity polymer flows easily into the voids and weak zones in the soil mass
  - As the reaction occurs, the expanding polymer compacts the surrounding soils
  - The resistance necessary for compaction to occur is achieved by 1) the soil overburden and 2) creation of a stablized mass in the upper elevations by employing a top-down injection pattern

ISSBIP DEFINITION

- IN SUM
  - A CHEMICAL COMPACTION GROUTING TECHNIQUE
  - USES A LOW-VISCOSITY POLYMER THAT ALSO INFILTRATES CERTAIN SOILS
  - FORMULATED TO RESIST THE INTRUSION OF WATER
  - POLYMER FORMS RIGID STRUCTURAL POLYURETHANE DURING ITS RAPID CURE PROCESS

ISSBIP TENETS

- Polymer is placed via an injection tube; “surgically” placed in the strata where stabilization is needed
- Multiple injection tubes are used to promote full coverage throughout the area being stabilized
- Injected substance is a two-component, high-density polyurethane characterized by rapid expansion and large volume increase created by chemical reaction between the components
- Movement is monitored at the surface during the injection process

ISSBIP SOIL / POLYMER INTERACTION

- Complex Issue
  - Governed by both soil and polymer properties
  - Can be further impacted by adjusting operational parameters

- Soil Properties – density, grain size, porosity, degree of saturation

- Polymer Properties – chemical composition and viscosity

- Operational Parameters – injection temperature, injection pressure, shot duration, and shot sequencing

ISSBIP SOIL / POLYMER INTERACTION – TRENDS

- Aggregate Bases/Subbases and Coarse Sand
  - Polymer Infiltration (binding)
  - Polymer Expansion (compacting)

- Saturated Fine Sands
  - Polymer expansion displaces the water and flowable soils
  - Polyurethane encapsulates the remaining soil and begins to “set up”

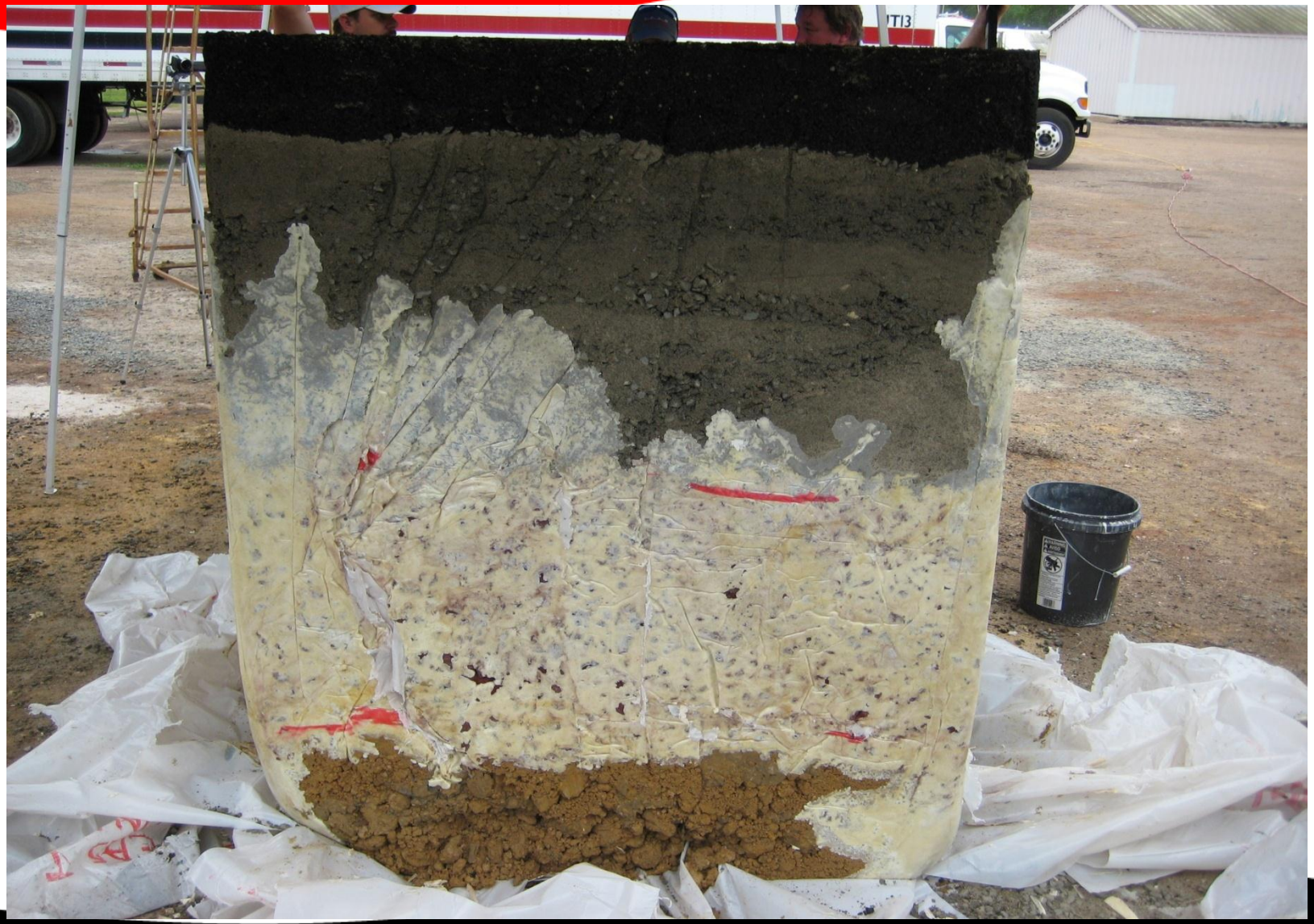
ISSBIP SOIL / POLYMER INTERACTION – TRENDS

- Layers with Silts and Clay Size Particles
  - Polymer infiltrates the weak lenses in these layers
  - Polymer begins to expand – encapsulating and compacting the surrounding soils
- Organic Soils
  - When operating in soft soils, the polymer reaction time is accelerated so the polymer spends little time moving laterally
  - The rapid reaction time causes the polyurethane to form a vertical shear wall within the soft soil mass
  - By designing the injection pattern, these walls can be shaped into an interconnected series of confinement cells capable of supporting loads

ISSBIP SOIL / POLYMER INTERACTION – TRENDS

PHOTOGRAPHS

Stabilization of Aggregate Subbase



Excavation Revealing ISSBIP-Stabilized Sand

Excavating Native Soil to Expose Crater Repair – Note Polymer Veins

Intact Extraction of Stabilized Crater Repair

Forensic Excavation of ISSBIP-Stabilized Peat Deposit

The constructed structure was removed to expose the injected foam

ISSBIP ADVANTAGES

- Comparison of High-Density Polyurethane Grouts to Cementitious Grouts
  - Both are useful tools when applied correctly
  - High-density polyurethane grouts have an advantage in key applications (particularly transportation) because
    - No shrinkage during curing (dimensionally stable)
    - Environmentally benign
    - Provide strength with minimal additional weight
    - Resist disintegration when subjected to vibration
    - Lower viscosity promotes more infiltration into the soil matrix
    - Possess tensile strength

ISSBIP ADVANTAGES

- Fast: can withstand traffic in 20 minutes; achieves 90% strength in less than 1 hour
- Reduced Disruption: Minimally Invasive Process
- Safe: Job Site & Environmental Safety
- Predictable: Highly Controlled Expansion, Every Time
- Accuracy: 1/10” Alignment Precision
- Lightweight: Provides strength (with minimal weight) to the already distressed soil
- High utility: a single process which can solve multiple problems
- Permanent: Impervious to Water and Most Chemicals
- Eco-Friendly: Environmentally Benign Material

ISSBIP APPLICATIONS

- Transportation Assets or Structures Settled Due to:
  - Voids
  - Poor Soil Conditions
  - Inadequate Pavement Structure for Current Mission
  - Leaking Underground Drainage System Causing Loss of Soil Support

ISSBIP – Insitu Stablization by Injecting Polyurethane

- Fixes the problem by stabilizing the soils and increasing the stiffness of the weak layers in order to better support the load
- Fixes the symptom of the problem by lifting the settled pavement or structure to the desired grade
- Completed with minimal downtime

THANK YOU

FOR

YOUR TIME