CUTOFF WALL CONSTRUCTION TECHNIQUES
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Levee State-of-the-Practice Symposium
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• Over 6,000 miles of levees in Sacramento

• During Floods – If serious seepage develops, then boils may develop and failure may occur

• Since 1990, the Corps, DWR SAFCA and other local agencies have launched a levee strengthening program
SACRAMENTO AREA SLURRY WALL
HISTORY – 1990 To Present

- 1990 Test Section / 4 Methods
- Sacramento Urban Area Program
- Marysville / Yuba City Projects (Including Three Rivers Levee Improvement Authority and Sutter Butte Flood Control Agency)
- American River Common Features
- Natomas Levee Improvement Program
- Marysville Ring Levee
- West Sacramento
- Pocket
- Delta
REASON FOR THE LEVEE REPAIRS
TO PREVENT THIS: LEVEE FAILURE
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Cutoff Wall Construction Technologies

- Trench Re-mixing and Cutting Deep Wall Method (TRD)
- Cutter Soil Mix Method (CSM)
- Deep Soil Mix Method (DSM/DMM)
- Conventional Excavation Method (CEM)
  - Long Stick Excavator
  - Clamshell Excavation Method
Cutoff Wall Types and Quality Control

- Soil-Bentonite (SB)
- Soil-Cement-Bentonite (SCB)
- Cement-Bentonite (CB)
  - Self Hardening
- Alternative Methods
  - Slag Cement-Bentonite
  - Soil-Attapulgite
  - Cement-Attapulgite
  - Other
- Slurry trench excavation involving excavation utilizing conventional and specialized long stick excavators

- Capable of excavation up to 95 feet

- Deeper excavations performed utilizing clamshell buckets (over 95 feet)

- Excavation performed under an engineered fluid (bentonite slurry) for trench support

- Requires separate ex-situ backfilling mixing operation performed using track dozers and small excavators

- Backfill is placed at lead-in trench or tremie placed and progressively displaces trench slurry
CONVENTIONAL EXCAVATION EQUIPMENT
TYPES OF CUTOFF WALLS

- Soil-Bentonite
- Soil-Cement-Bentonite
- Cement-Bentonite
- Others
SOIL-BENTONITE (SB)

- Constructed utilizing all cutoff wall construction technologies
- Permeability of $1 \times 10^{-6}$ cm/sec or less
- Soil can be remixed (if clean and suitable) and used in backfill material
- Approximately 20% spoil disposal required
- No structural strength
- Requires capping to support loading above the trench
- Constructed utilizing all cutoff wall construction technologies
- Permeability of $1 \times 10^{-6}$ cm/sec or less
- Soil can be remixed (if clean and suitable) and used in backfill material
- Approximately 20% spoil disposal required
- Provides minimal strength (30 – 300 psi)
- Capping required for curing and protection of cutoff wall
- Constructed utilizing conventional excavation technology
- Permeability of $1 \times 10^{-6}$ cm/sec or less
- Self hardening slurry; requires no separate backfilling operations; suitable in areas with limited equipment access; depth limitations
- 100% trench spoil disposal required
- Provides minimal strength (30 – 300 psi)
- Capping required for curing and protection of cutoff wall
SLURRY CUTOFF WALLS

DEFINITION:
SUBSURFACE WALLS THAT ACT AS BARRIERS TO LATERAL FLOW OF GROUNDWATER AND WATERBORNE CONTAMINANTS
SLURRY TRENCHING TECHNIQUE
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HYDRAULIC BARRIERS
SLURRY CUTOFF WALLS
HYDRAULIC BARRIERS SLURRY CUTOFF WALLS

- Soil-Bentonite
- Soil-Cement-Bentonite
- Cement Bentonite
- Composite walls
- Plastic Concrete
CASE STUDY
Cement/Slag Cement Bentonite Cutoff Wall
American River Common Features
Project Sites L8 and R8
BATCH PLANT / STAGING AREA
BATCH PLANT / STAGING AREA
CB SLURRY MIX DESIGN

- 28 DAY HYDRAULIC CONDUCTIVITY OF $1 \times 10^{-6}$ cm/s
- 28 DAY UNCONFINED COMPRESSIVE STRENGTH OF 50 – 300 PSI
- LEVEE RESTORATION - AFTER 15 PSI WAS ACHIEVED
- 10 DIFFERENT MIX DESIGNS WERE EVALUATED
SITE L8 – BATCHING OPERATION
CEMENT BENTONITE CUTOFF WALL PANEL CONSTRUCTION
OVER 5,500 MAN HOURS WITH ZERO LOSS TIME ACCIDENTS

CB WALL EXCEEDED SPECIFICATION REQUIREMENTS

PROJECT COMPLETED ON TIME

PROJECT COMPLETED UNDER BUDGET
US ARMY CORPS OF ENGINEERS – SACRAMENTO DISTRICT

HDR

SACRAMENTO AREA FLOOD CONTROL AGENCY (SAFCA)

DEPARTMENT OF WATER RESOURCES (DWR)

ASCE – SACRAMENTO SECTION
The trench remixing and deep wall (TRD) method is a process for excavation and in situ mixing.

The TRD method has been widely employed in Japan.

Utilizes a large revolving chain and cutter bar, which is lowered down to design depth of the cutoff wall and then moved in horizontal direction.

TRD equipment simultaneously excavates and mixes in situ soils and added slurry resulting in a continuous soil mixed wall.
TRD OVERVIEW (CONTINUED)

- TRD wall installation can consist of two steps
  - Pre-trenching using bentonite slurry to stabilize the trench
  - Wall production by adding cement grout to the soil-bentonite mixture in the pre-trenched zone.

- TRD equipment, in general, requires a very high maintenance cost due to the need for frequent repair of cutter
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Cutter soil mixing (CSM) provides for the construction of retaining and cut-off walls by mixing soil in-situ with a cement/bentonite grout.

- The CSM wall consists of adjacent primary and secondary panels.
- The CSM wall is constructed using equipment derived from diaphragm wall cutter technology.
- Consists of cutting and mixing drums mounted on compact hydraulic motors.
- The positioning and verticality of the wall is achieved using a kelly bar.
Deep Soil Mix Method (DSM/DMM) has been utilized in United States since 1986

Process involves in-situ mixing utilizing multiple augers (3 to 6)

Depth capabilities in excess of 200 feet

Applications include excavation support, under seepage cutoff, liquefaction mitigation and other ground improvement
DSM/DMM METHOD
DSM/DMM METHOD
DSM/DMM METHOD
CASE HISTORY
CALPERS Headquarters Expansion
3rd and Q Streets
Sacramento, CA
- 12 miles of slurry walls (3.6 million sf)
- Maximum depth to 80 feet
- Permeability Requirements: $5 \times 10^{-7}$ cm/sec
- Strength Requirement: 30 psi
- Residential and commercial areas
CASE HISTORY
CDSM BATCH PLANT
SLURRY PREPARATION
SLURRY PREPARATION
DSM CORE SAMPLES
TEST SPECIMENS PREPARED FROM CORE SAMPLES
CDSM Panel, Berths 55/56, Port of Oakland
Raito, Inc
SINGLE PASS TRENCHING METHOD
SHEET PILE WALLS
Focused Applications:

- Temporary Excavation Support/Seepage Control For Environmental Applications
- Permanent Seepage Barrier For Environmental Applications
- Used In Conjunction With Other Systems:
  - Jet Grouted Bottom Seal
  - Rock Grout Curtains
  - Funnel And Gate Treatment Systems
Conventional Hot and Cold rolled sections with interlock sealants

Waterloo™ Barrier

HDPE and Vinyl Sheets
DISCUSSION POINTS
DISCUSSION POINTS

- Design Intent
- Applicable Construction Method/Site Condition
- Risk Analysis/Cost
- Uniform Specifications
- Lessons Learned
- Experience/Qualifications
- Permits
- Water
- Community Involvement