July 29, 1983

Mr. Larry Chako
City of St. Petersburg
Pollution Control
Post Office Box 2842
St. Petersburg, Florida 33731

Dear Mr. Chako:

RE: Pinellas County Resource Recovery Project - Phase II
Power Plant Site Certification Application

The Department received the above referenced application on July 26, 1983. We are soliciting your agency's comments on the proposed project, in particular regarding those plans or issues which may impact those areas under your agency's purview. Please have the appropriate sections of your agency review the application. We would appreciate a response by September 26.

If your agency feels that insufficient information has been provided in the application and its appendices to permit a satisfactory analysis, please call this to our attention as soon as possible but no later than August 22, 1983, so that we can request additional information from the applicant.

The Power Plant Siting Section will be happy to answer any questions you may have regarding the application processing procedures or other concerns and may be reached at telephone number 904/488-0130. Ask for myself or Ms. Karen Anthony. Please find attached a partial copy of the original application.

Sincerely,

Hamilton S. Oven, Jr.
Administrator
Power Plant Siting Section

HSO/sb

Attachment

July 29, 1983

Mr. Ed McNeely
Department of Transportation
Haydon Burns Building
605 Suwannee Street
Tallahassee, Florida 32301

Dear Mr. McNeely:

RE: Pinellas County Resource Recovery Project - Phase II
Power Plant Site Certification Application

The Department received the above referenced application on July 26, 1983. We are soliciting your agency's comments on the proposed project, in particular regarding those plans or issues which may impact those areas under your agency's purview. Please have the appropriate sections of your agency review the application. We would appreciate a response by September 26.

If your agency feels that insufficient information has been provided in the application and its appendices to permit a satisfactory analysis, please call this to our attention as soon as possible but no later than August 22, 1983, so that we can request additional information from the applicant.

The Power Plant Siting Section will be happy to answer any questions you may have regarding the application processing procedures or other concerns and may be reached at telephone number 904/488-0130. Ask for myself or Ms. Karen Anthony. Please find attached a partial copy of the original application.

Sincerely,

Hamilton S. Oven, Jr.
Administrator
Power Plant Siting Section

HSO/sb

Attachment

July 29, 1983

Mr. Jacob Stowers, III
Pinellas County Pollution Control
Pinellas County Courthouse
315 Court Street
Clearwater, Florida 33516

Dear Mr. Stowers:

RE: Pinellas County Resource Recovery Project - Phase II
Power Plant Site Certification Application

The Department received the above referenced application on July 26, 1983. We are soliciting your agency's comments on the proposed project, in particular regarding those plans or issues which may impact those areas under your agency's purview. Please have the appropriate sections of your agency review the application. We would appreciate a response by September 26.

If your agency feels that insufficient information has been provided in the application and its appendices to permit a satisfactory analysis, please call this to our attention as soon as possible but no later than August 22, 1983, so that we can request additional information from the applicant.

The Power Plant Siting Section will be happy to answer any questions you may have regarding the application processing procedures or other concerns and may be reached at telephone number 904/488-0130. Ask for myself or Ms. Karen Anthony. Please find attached a partial copy of the original application.

Sincerely,

Hamilton S. Oven, Jr.
Administrator
Power Plant Siting Section

HSO/sb

Attachment

July 29, 1983

Mr. William A. Ockuzzi
Director of Planning
Tampa Bay Regional Planning Council
9455 Koger Boulevard
St. Petersburg, Florida 33702

Dear Mr. Ockuzzi:

RE: Pinellas County Resource Recovery Project - Phase II
Power Plant Site Certification Application

The Department received the above referenced application on July 26, 1983. We are soliciting your agency's comments on the proposed project, in particular regarding those plans or issues which may impact those areas under your agency's purview. Please have the appropriate sections of your agency review the application. We would appreciate a response by September 26.

If your agency feels that insufficient information has been provided in the application and its appendices to permit a satisfactory analysis, please call this to our attention as soon as possible but no later than August 22, 1983, so that we can request additional information from the applicant.

The Power Plant Siting Section will be happy to answer any questions you may have regarding the application processing procedures or other concerns and may be reached at telephone number 904/488-0130. Ask for myself or Ms. Karen Anthony. Please find attached a partial copy of the original application.

Sincerely,

Hamilton S. Oven, Jr.
Administrator
Power Plant Siting Section

HSO/sb

Attachment

July 29, 1983

Lt. Governor Wayne Mixon, Secretary
Florida Dept. of Commerce
Collins Building
Tallahassee, Florida 32304

Dear Lt. Governor:

RE: Pinellas County Resource Recovery Project - Phase II
Power Plant Site Certification Application

The Department received the above referenced application on July 26, 1983. We are soliciting your agency's comments on the proposed project, in particular regarding those plans or issues which may impact those areas under your agency's purview. Please have the appropriate sections of your agency review the application. We would appreciate a response by September 26.

If your agency feels that insufficient information has been provided in the application and its appendices to permit a satisfactory analysis, please call this to our attention as soon as possible but no later than August 22, 1983, so that we can request additional information from the applicant.

The Power Plant Siting Section will be happy to answer any questions you may have regarding the application processing procedures or other concerns and may be reached at telephone number 904/488-0130. Ask for myself or Ms. Karen Anthony. Please find attached a partial copy of the original application.

Sincerely,

Hamilton S. Oven, Jr.
Administrator
Power Plant Siting Section

HSO/sb

Attachment

July 29, 1983

Mr. L. Ross Morrell
Department of State
Division of Archives, History
and Records Management
The Capitol
Tallahassee, Florida 32304

Dear Mr. Morrell:

RE: Pinellas County Resource Recovery Project - Phase II
Power Plant Site Certification Application

The Department received the above referenced application on July 26, 1983. We are soliciting your agency's comments on the proposed project, in particular regarding those plans or issues which may impact those areas under your agency's purview. Please have the appropriate sections of your agency review the application. We would appreciate a response by September 26.

If your agency feels that insufficient information has been provided in the application and its appendices to permit a satisfactory analysis, please call this to our attention as soon as possible but no later than August 22, 1983, so that we can request additional information from the applicant.

The Power Plant Siting Section will be happy to answer any questions you may have regarding the application processing procedures or other concerns and may be reached at telephone number 904/488-0130. Ask for myself or Ms. Karen Anthony. Please find attached a partial copy of the original application.

Sincerely,

Hamilton S. Oven, Jr.
Administrator
Power Plant Siting Section

HSO/sb

Attachment

July 28, 1983

Mrs. Liz Cloud
Bureau of Administrative Code
Department of State
The Capitol
Tallahassee, Florida 32301

Dear Mrs. Cloud:

I would appreciate your publication of the enclosed Notice of a Receipt of an Application for Power Plant Site Certification An the next issue of the Florida Administrative Weekly.

If you have any questions, please let me know. I appreciate your assistance and cooperation.

Sincerely,

Geneva M. Hartsfield
Administrative Assistant
Office of the Chairman
Environmental Regulation Commission

GMH/HSO/sb

Enclosures: Origiaal and one copy of a Public Notice of Hearing

The Florida Department of Environmental Regulation announces receipt of an Application for Construction and Operation of an Addition to the Resource Recovery Power Plant Facility Located Near St. Petersburg, Florida. Pinellas County has filed application No. 83-18 for Phase II of the Pinellas County Resource Recovery Project located south of the St. Petersburg-Clearwater Airport.

The department expects to hold a public hearing on the effects of the construction and operation of this resource recovery boiler in approximately 180 days. All persons wishing to become parties to the proceedings should file with the department a notice of intent to become a party by November 1, 1983.

DEPARTMENT OF ENVIRONMENTAL REGULATION

DISTRIBUTION LIST

POWER PLANT SITE CERTIFICATION APPLICATION

NAME	LOCATION	DATE RECEIVED	APPL#
Pinellas County Resource Recovery Project	Pinellas	7/26/83	PA 83-18

AGENCY Pinellas County	REPORT NO.	DATE SENT	COMMENTS RECEIVED	REMARKS
STATE				
PSC	~~7/27~~ ~~9/6~~	9/7		
~~DOA/DSP~~ DCA	~~7/27~~ 9/6	9/7		
DOA/DIV HEARING EXM.	~~7/27~~	9/7		
WTR MGT DIST	7/27	9/7	9/22/83	
AGR & CONSUMER SERVICES	7/27	~~7/27~~ 9/7	8/5/83	o.k.
COMMUNITY AFFAIRS	7/27	9/7	8/12/83	o.k.
COMMERCE				
DOT				
DNR	7/27			
HRS	7/27		9/27/83	
REGIONAL PLAN. COUNCIL				
STATE-ARCHEOLOGY			8/15/83	o.k.
GAME & FISH	7/27		8/10/83	o.k.
FEDERAL				
EPA				
DEPARTMENT PPSR COMMITTEE				
GENERAL COUNSEL - Deane		~~7/27~~ 9/7		
AIR QUALITY Fancy Rogers Palagyi		7/27 9/7	8/5	
WATER ANALYSIS - Olsen		7/27 9/7	8/2	
WATER RESOURCES				
COASTAL ZONE MGT. Dehan-Kell		7/27 9/7	8/2	
DRINKING WTR & SPECIAL PROG.				
PERMITTING -STD PERMIT				
WASTEWATER MGT - IND W. Smith		7/27 9/7	8/5	
DISTRICT/SUBDISTRICT Hennessy		7/27 9/7	8/4	
LIBRARY Lewis		7/27 9/7		
STAFF Oven		7/26 9/7		
Anthony		7/27 9/7		
INTERVENORS Sierra		7/28 9/7		

HDR

Henningson, Durham & Richardson

P.O. Box 12744
101 West Garden Street
Pensacola, FL 32575
(904) 432-2481

LETTER OF TRANSMITTAL

DATE 7/27/83 JOB NO. 1617-39-63

ATTENTION Mr. Hamilton Oven

RE:

TO:

State of Florida
Department of Environmental Regulation
Twin Towers Office Building
2600 Blair Stone Road
Tallahassee, FL 32301

WE ARE SENDING YOU: [x] Attached [ ] Under separate cover via ______ the following items

[ ] Shop drawings [ ] Prints [ ] Plans [ ] Samples [ ] Specifications

[ ] Copy of letter [ ] Change order [ ] ______

COPIES	DATE	NO.	DESCRIPTION
1			Copy of Air Modeling requested.
			Received DER
			JUL 28 1983
			P. P. S

THESE ARE TRANSMITTED as checked below:

[ ] For approval [ ] Approved as submitted [ ] Resubmit ______ copies for approval

[ ] For your use [ ] Approved as noted [ ] Submit ______ copies for distribution

[x] As requested [ ] Returned for corrections [ ] Return ______ corrected prints

[ ] For review and comment [ ] ______

[ ] FOR BIDS DUE ______ 19 ______ [ ] PRINTS RETURNED AFTER LOAN TO US

REMARKS ______

COPY TO ______ SIGNED James C. Andrews

If enclosures are not as noted please notify us at once

JCA:jr

July 27, 1983

Mr. John DeGrove
Department of Community Affairs
2571 Executive Center Circle, East
Tallahassee, Florida 32304

Dear Mr. DeGrove:

RE: Pinellas County Resource Recovery Project - Phase II
Power Plant Site Certification Application

The Department received the above referenced application on July 26, 1983. We are soliciting your agency's comments on the proposed project, pursuant to Section 403.507, F.S., in particular those regarding those plans or issues which may impact those areas under your agency's purview. Please have the appropriate sections of your agency, such as Power Plant Siting and Flood Hazard Protection, review the application. We would appreciate a response by September 26.

If your agency feels that insufficient information has been provided in the application and its appendices to permit a satisfactory analysis, please call this to our attention as soon as possible but no later than August 22, 1983, so that we can request additional information from the applicant.

The Power Plant Siting Section will be happy to answer any questions you may have regarding the application processing procedures or other concerns and may be reached at telephone number 904/488-0130. Ask for myself or Ms. Karen Anthony. Please find attached a partial copy of the original application.

Sincerely,

Hamilton S. Oven, Jr., P.E.
Administrator
Power Plant Siting Section

HSO/sb

Attachment

TO: Power Plant Siting Review Committee

FROM: Hamilton S. Oven, Jr.

DATE: July 27, 1983

SUBJECT: Power Plant Siting Application
Pinellas County Resource Recovery
Project - PA 83-18 - Module 8188

The department received the attached application from Pinellas County for Phase II of their Resource Recovery Project on July 26, 1983. Please review the application for completeness and submit your comments by August 5, 1983. There will be a meeting on August 1, 1983, at 3:00 p.m. in the Dredge and Fill conference room to discuss the application. For your assistance I am attaching a copy of Pinellas' application for Phase I.

cc: Frank Andrews
Clair Fancy
Bill Deane
Rodney Dehan
Bob McVety
Larry Olsen
Karen Anthony
Bill Hennessey
Pat Lewis
Dick Smith

July 27, 1983

Mr. David Pingree, Secretary
Department of Health and
Rehabilitative Services
1323 Winewood Boulevard
Tallahassee, Florida 32301

Dear Secretary Pingree:

RE: Pinellas County Resource Recovery Project - Phase II
Power Plant Site Certification Application

The Department received the above referenced application on July 26, 1983. We are soliciting your agency's comments on the proposed project, in particular regarding those plans or issues which may impact those areas under your agency's purview. In particular, the proposal is a garbage-fired power plant and may raise questions such as public health impacts. Please have the appropriate sections of your agency, such as Environmental Health, review the application. We would appreciate a response by September 26.

If your agency feels that insufficient information has been provided in the application and its appendices to permit a satisfactory analysis, please call this to our attention as soon as possible but no later than August 22, 1983 so that we can request additional information from the applicant.

The Power Plant Siting Section will be happy to answer any questions you may have regarding the application processing procedures or other concerns, and may be reached at telephone number 904/488-0130. Ask for myself or Ms. Karen Anthony. Please find attached a partial copy of the original application for Phase I.

Sincerely,

Hamilton S. Oven, Jr., P.E.
Administrator
Power Plant Siting Section

HSO/sb
Attachment

July 27, 1983

Mr. Doyle Connor
Department of Agriculture
and Consumer Services
The Capitol
Tallahassee, Florida 32301

Dear Mr. Connor:

RE: Pinellas County Resource Recovery Project - Phase II
Power Plant Site Certification Application

The Department received the above referenced application on July 26, 1983. We are soliciting your agency's comments on the proposed project, in particular regarding those plans or issues which may impact those areas under your agency's purview, such as impact on agriculture, forestry, or endangered plants. We would appreciate a response by September 26.

If your agency feels that insufficient information has been provided in the application and its appendices to permit a satisfactory analysis, please call this to our attention as soon as possible but no later than August 22, 1983, so that we can request additional information from the applicant.

The Power Plant Siting Section will be happy to answer any questions you may have regarding the application processing procedures or other concerns and may be reached at telephone number 904/488-0130. Ask for myself or Ms. Karen Anthony. Please find attached a partial copy of the original application.

Sincerely,

Hamilton S. Oven, Jr., P.E.
Administrator
Power Plant Siting Section

HSO/sb

Attachment

July 27, 1983

Colonel Robert Brantley
Game & Fresh Water Fish Commission
Bryant Building
Tallahassee, Florida 32304

Dear Colonel Brantley:

RE: Pinellas County Resource Recovery Project - Phase II
Power Plant Site Certification Application

The Department received the above referenced application on July 26, 1983. We are soliciting your agency's comments on the proposed project, in particular regarding those plans or issues which may impact those areas under your agency's purview. Please have the appropriate sections of your agency, such as Environmental Programs, review the application. We would appreciate a response by September 26, 1983.

If your agency feels that insufficient information has been provided in the application and its appendices to permit a satisfactory analysis, please call this to our attention as soon as possible but no later than August 22 so that we can request additional informatio from the applicant.

The Power Plant Siting Section will be happy to answer any questions you may have regarding the application processing procedures or other concerns and may be reached at telephone number 904/488-0130. Ask for myself or Ms. Karen Anthony. Please find attached a partial copy of the original application.

Sincerely,

Hamilton S. Oven, Jr., P.E.
Administrator
Power Plant Siting Section

HSO/sb

Attachment

July 27, 1983

Mr. William Tatum, Executive Director
Southwest Florida Water Management District
5060 US 41 South
Brooksville, Florida 33512

Dear Mr. Tatum:

RE: Pinellas County Resource Recovery Project - Phase II
Power Plant Site Certification Application

The Department received the above referenced application on July 26, 1983. We are soliciting your agency's comments on the proposed project, pursuant to 17-17.04(5) FAC, in particular regarding those plans or issues which may impact those areas under your agency's purview. Please have the appropriate sections of your agency review the application. Please provide your final comments by September 26, 1983.

If your agency feels that insufficient information has been provided in the application and its appendices to permit a satisfactory analysis, please call this to our attention as soon as possible but no later than August 22, 1983, so that we can request additional information from the applicant.

The Power Plant Siting Section will be happy to answer any questions you may have regarding the application processing procedures or other concerns and may be reached at telephone number 904/488-0130. Ask for myself or Ms. Karen Anthony. Please find attached a partial copy of the original application.

Sincerely,

Hamilton S. Oven, Jr., P.E.
Administrator
Power Plant Siting Section

HSO/sb

Attachment

July 27, 1983

Dr. Elton Gissendanner
Department of Natural Resources
3300 Commonwealth Building
Tallahassee, Florida

Dear Dr. Gissendanner:

RE: Pinellas County Resource Recovery Project - Phase II
Power Plant Site Certification Application

The Department received the above referenced application on July 26, 1983. We are soliciting your agency's comments on the proposed project, in particular regarding those plans or issues which may impact those areas under your agency's purview. Please have the appropriate sections of your agency review the application. We would appreciate a response by September 26.

If your agency feels that insufficient information has been provided in the application and its appendices to permit a satisfactory analysis, please call this to our attention as soon as possible but no later than August 22, 1983, so that we can request additional information from the applicant.

The Power Plant Siting Section will be happy to answer any questions you may have regarding the application processing procedures or other concerns and may be reached at telephone number 904/488-0130. Ask for myself of Ms. Karen Anthony. Please find attached a partial copy of the original application.

Sincerely,

Hamilton S. Oven, Jr., P.E.
Administrator
Power Plant Siting Section

HSO/sb

Attachment

TO: William Hennessey, District Manager

FROM: Hamilton S. Oven, Jr.

DATE: July 27, 1983

SUBJECT: Pinellas County Resource Recovery Project - Phase II Power Plant Site Certification Application - PA 83-18

Attached is a power plant siting application submitted by Pinellas County Resource Recovery. Please have your staff review and comment on the completeness of the application by August 4, 1983 and for sufficiency by August 30, 1983. If possible, please submit recommendations concerning whether or not the application should be permitted and, if so, appropriate permit provisos by December 1, 1983.

Please designate a contact person to coordinate the review of the application by the various sections of your office. If the contact person has any questions, I can be reached at Suncom 278-0130.

Also attached is a copy of the application for Phase I.

July 27, 1983

Mr. Chris H. Bentley, Director
Division of Administrative Hearings
Oakland Office Building
2009 Apalachee Parkway
Tallahassee, Florida 32310

Dear Mr. Bentley:

RE: Pinellas County Resource Recovery Project - Phase II
Power Plant Site Certification Application - PA 83-18

A Power plant site certification application for Pinellas County Resource Recovery Project - Phase II was received by this department on July 26, 1983. A copy of the application is attached. Pursuant to Section 403.5065, Florida Statutes, please designate a Hearing Officer. Mr. William Williams was the hearing officer during Phase I, DOAH Case No. 78-2041.

The Department is now reviewing the application for completeness. A formal response on completeness will be prepared by August 8, 1983.

As this is an expansion of capacity at an existing certified site with no change in boundaries, it is anticipated that no land use-zoning hearing will be needed. Pinellas County may modify their boundaries during the proceedings. At that time a land use hearing would be required.

Sincerely,

Hamilton S. Oven, Jr., P.E.
Administrator
Power Plant Siting Section

HSO/sb

cc: Bill Deane, DER
Art Shell, PSC
Larry Keesey, DCA
Tom Cone, SWFWMD
Bob Trapp, PSC
William D. Courser, SWFWMD

State of Florida
DEPARTMENT OF ENVIRONMENTAL REGULATION

INTEROFFICE MEMORANDUM

For Routing To District Offices And/Or To Other Than The Addressee		
To: Suzanne Walker	Loctn.:	
To:	Loctn.:	
To:	Loctn.:	
From:	Date:	
Reply Optional [ ]	Reply Required [ ]	Info. Only [ ]
Date Due:	Date Due:	

RECEIVED
JUL 28 1983
DIV. ENVIRONMENTAL PERMITTING

TO: Power Plant Siting Review Committee

FROM: Hamilton S. Oven, Jr. HSO

DATE: July 27, 1983

SUBJECT: Power Plant Siting Application
Pinellas County Resource Recovery
Project - PA 83-18 - Module 8188

The department received the attached application from Pinellas County for Phase II of their Resource Recovery Project on July 26, 1983. Please review the application for completeness and submit your comments by August 5, 1983. There will be a meeting on August 1, 1983, at 3:00 p.m. in the Dredge and Fill conference room to discuss the application. For your assistance I am attaching a copy of Pinellas' application for Phase I.

cc: Frank Andrews
Clair Fancy
Bill Deane
Rodney Dehan
Bob McVety
Larry Olsen
Karen Anthony
Bill Hennessey
Pat Lewis
Dick Smith

STATE OF FLORIDA

DEPARTMENT OF ENVIRONMENTAL REGULATION

SOUTHWEST DISTRICT

7601 HIGHWAY 301 NORTH
TAMPA, FLORIDA 33610-9544

July 15, 1983

7-515
6/13/83
NO 83 405 406

Mr. Robert Becker
Department of Solid Waste Management
Pinellas County
P.O. Box 21623
St. Petersburg, FL 33742-1623

Re: Sample Analyses - Pinellas County Resource Recovery Facility
ESE Sample No. 246900 and 246901

UNOFFICIAL

Dear Mr. Becker:

Attached for your attention and corresponding action is a memorandum from our Groundwater Section concerning the above referenced subject. No disposal of the ash material below the natural water table should be allowed until this matter is resolved.

Concerning our telecon of July 13, 1983, this office has no objection to the proposal for using ash material for weekly cover at the Class III facility, provided that it can be done in an environmentally safe manner. It is recommended that the county implement a month try-out period to determine its feasibility, then submit a written report to our office for review and approval. The report should provide details of how the proposal will be implemented and details of any problems encountered and how they were corrected. (i.e. fugitive dust, rain, etc.)

If you have any questions, don't hesitate to contact me at telephone number 813/985-7402.

Sincerely,

Patrick W. Lewis

Patrick W. Lewis
Environmental Specialist II

PWL/bc
cc: John Reese
Hamilton S. Oven

RECEIVED
JUL 27 1983
HDR

58973
RECEIVED
JUL 18 1983
PINELLAS COUNTY
SOLID WASTE SYSTEM

To: Bill Hennessey Tampa
For Routing To District Offices
And/Or To Other Than The Addressee
To: Pat Lewis Loctn.: Tampa
To: Loctn.:
To: Loctn.:
From: J. J. Crane Date:
Reply Optional [ ] Reply Required [ ] Info. Only [ ]
Date Due: Date Due:

State of Florida
DEPARTMENT OF ENVIRONMENTAL REGULATION

INTEROFFICE MEMORANDUM

TO: Pat Lewis, Environmental Specialist
Southwest District - Tampa

THROUGH: Bill Hennessey, Manager
Southwest District - Tampa

Rodney DeHan, Administrator
Groundwater Section

FROM: James J. Crane, Hydrogeologist
Groundwater Section

DATE: July 7, 1983

SUBJECT: Sample Analyses - Pinellas Co. Resource Recovery Facility

I have reviewed the analyses and found most parameters to be below drinking water standards. The detection limits for two parameters, mercury and selenium, are too high to determine whether these parameters exceed drinking water standards. The standard for mercury is 2 ug/l, but the detection limit was <9 ug/l. The standard for selenium is 10 ug/l, but the detection limit was <25 ug/l. These parameters should be re-done using detection limits below the drinking water standard.

If these two parameters also prove to be below the standards, the waters can be deposed of as requested.

JJC/cs

D.E.R.
JUL 11 1983
SOUTHWEST DISTRICT
TAMPA

RECEIVED
JUL 22 1983
PINELLAS COUNTY
SOLID WASTE SYSTEM

To: Buck Oven

State of Florida
DEPARTMENT OF ENVIRONMENTAL REGULATION

INTEROFFICE MEMORANDUM

SPW 7/13

For Routing To District Offices And/Or To Other Than The Addressee		
To:	Loctn.:	
To:	Loctn.:	
To:	Loctn.:	
From:	Date:	
Reply Optional [ ]	Reply Required [ ]	Info. Only [ ]
Date Due:	Date Due:	

RECEIVED
JUL 13 1983
DIV. ENVIRONMENTAL PERMITTING

TO: Cost Center Administrators

THROUGH: Dan McCall, Chief DM
Bureau of Accounting and Budgeting

FROM: John McDermott JGM

DATE: July 12, 1983

SUBJECT: Addendum to the October 1982 Program Module Accounting System Handbook

Attached is Addendum Number 34 to the October 1982 PMAS Handbook. Please insure that all personnel in your cost center receive a copy of this addendum.

JM/kbr

Attachment

State of Florida
DEPARTMENT OF ENVIRONMENTAL REGULATION

INTEROFFICE MEMORANDUM

For Routing To District Offices
And/Or To Other Than The Addressee

To: ________ Loctn.: ________
To: ________ Loctn.: ________
To: ________ Loctn.: ________
From: ________ Date: ________

Reply Optional [ ] Reply Required [ ] Info. Only [ ]
Date Due: ________ Date Due: ________

TO: Buck Oven

FROM: John A. Reese JR

DATE: July 8, 1983

SUBJECT: Proposal for Pinellas County Refuse to Energy Facility

Initial comments on the installation of a slurry wall to surround this facility and adjacent landfills were made April 13, 1983, copy enclosed. The concerns about continuity of the underlying confining clay layer and maintenance of 10^{-7} cm/s permeability of the slurry wall seem to have been addressed in the proposal. Although bore holes on 300' grid centers is a close investigation, it is recognized that absolute certainty of the clay layer continuity may not be verifiable. A responsible soil scientist should be required to evaluate the bore hole information to provide reasonable assurances that the layer is continuous.

The concept of making the slurry walled area a zone of discharge seems reasonable with consideration for the groundwater monitoring plan that may be devised to monitor inside and outside of the wall.

A review of some additional literature on slurry walls indicates that groundwater levels are a major concern with regard to the stability of these walls. One recommendation suggests that the wall be maintained no less than 5 ft. above the water table in granular soils; 3 ft. in cohesive soils. The hydrostatic pressure of the slurry is also a stability factor as is backfill with clay materials. See pages 157 and 159 of, Applications of Slurry Walls in Civil Engineering, copy attached.

A review of two other papers, Current USA Practice; Slurry Wall Specifications and Slurry Cut-Off Walls Methods and Applications, indicate that the slurry wall proposed for this project should be installed under the supervision of an engineer experienced in this practice, perhaps with a certification or guarantee of wall performance, subject to a performance bond or other surety.

JAR/dt

Attachment: As noted
cc: Gregory L. Parker
Robert McVety
Ed Snipes

Received DER

JUL 8 1983

PPS

State of Florida
DEPARTMENT OF ENVIRONMENTAL REGULATION

INTEROFFICE MEMORANDUM

For Routing To District Offices And/Or To Other Than The Addressee	
To: Hamilton Oven	Loctn.: Permitting
To:	Loctn.:
To:	Loctn.:
From: Kell, D	Date: 7/8/83
Reply Optional [ ]	Reply Required [ ] Info. Only [ ]
Date Due:	Date Due:

TO: Mr. Hamilton Oven, Jr., Professional Engineer
Bureau of Permitting

THROUGH: Dr. Rodney S. DeHan, Administrator RSD
Groundwater Section

FROM: Don Kell, Engineer DJK
Groundwater Section

DATE: July 7, 1983

SUBJECT: Pinellas County: Resource Recovery Facility

Conceptually the proposal appears to be acceptable. However, no new information has been presented since our last meeting. Pending completion of ongoing studies, therefore, please review our concerns (especially points 1,2, and 5, pg 2) expressed in our memorandum to you of April 12, 1983.

DK/ek

GEO·CON INC.
Geotechnical Contracting

PITTSBURGH

"Experience and Expertise"

GEO-TEC '80
Chicago, Illinois - March 18, 1980

SLURRY CUT-OFF WALLS
METHODS AND APPLICATIONS

Christopher R. Ryan[1]

ABSTRACT

Slurry cut-off walls are non-structural walls constructed underground to act as barriers to the lateral flow of water and other fluids. Principal applications are site dewatering, pollution control, and seepage barriers in the foundations of water retaining structures. In this paper, the two basic types of trench -- soil bentonite (SB), and cement-bentonite (CB), and the principal kinds of slurry trenching equipment are discussed. There are examples of several recent projects with emphasis on the reasons behind the selection of the particular method.

Slurry cut-off walls normally have a permeability in the range of 10^{-6} to 10^{-7} cm/sec. Recent advances in methods of analysis of slurry cut-off walls for the key factors of permeability and durability have provided much-needed assistance in the design process. The primary purposes of quality control are to check the continuity and depth of the wall, and to ensure a slurry and backfill which fall within workable limits while satisfying design criteria.

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INTRODUCTION

The past five years have seen a veritable explosion in the number of applications of slurry cut-off walls. They are increasingly being used on all types of projects where a positive groundwater cut-off is required. Recent advances in the capacity of excavating equipment and refinements in technique have brought the cost of slurry walls down and they now easily compete economically on projects where well-points or sheeting would have previously been used. The types of walls discussed herein are non-structural; they are relatively impervious but are not capable of supporting bending moments or significant shear stress. Normally, their strength is of the same order as the surrounding ground.

The techniques all involve excavating a trench which is kept filled with slurry, whose primary ingredients are bentonite clay and water, and whose function is to maintain the trench open with vertical sides, even below the water table. The excavation is carried out through the slurry from the ground surface using any equipment capable of the trench widths and depths required. Once the trench is excavated to its final depth, a mixture of soil and bentonite is placed in the trench, displacing the bentonite slurry. This type of construction is called a Soil-Bentonite (SB) slurry cut-off wall.

With a variation on the above technique called a Cement-Bentonite (CB) slurry trench, cement is added to the bentonite slurry just before it is introduced into the trench. The resultant slurry has properties substantially similar to normal bentonite slurry with respect to maintaining the sides of the trench. However, once excavation is complete, the CB slurry remains in the trench, sets up and forms the permanent watertight wall.

The extent and type of quality control on slurry wall projects has varied widely. In some recent cases, specifications have been too brief or incomplete to protect the owner's interests; in others, overly conservative design and excessively rigid specifications on aspects of construction not pertinent to overall performance have led to higher than necessary project costs and sometimes to unnecessary burdens on the contractor. In a later section, design parameters and quality control are discussed and optimal ranges for key indicators are recommended.

CONSTRUCTION METHODS

Trench Backfill

The Soil-Bentonite slurry trench technique has been in use in the United States for about thirty years. Figure 1 shows the excavation for a SB cut-off. On projects where the material excavated from the trench is suitable for use as backfill, the SB system can be economical because of the minumum amount of materials required. After the trench has been excavated under a bentonite slurry, more slurry is mixed with the soil adjacent to the trench (Figure 2). A bulldozer is used to work the material to a smooth consistency and it is then pushed into the trench so that the backfill slope displaces the bentonite slurry forward (Figure 3). Excavation and backfilling are phased to make the operation continuous with relatively small quantities of new slurry required to keep the trench full and to mix backfill.

Cement-Bentonite slurry trenches have been in use in Europe for at least ten years and in the United States for about six years. Figure 4 shows a small CB batch plant. Since the entire trench must be filled with slurry materials and a significant amount of slurry is wasted due to the excavation process and seepage losses through the sides of the trench, the backfill is considerably more expensive than under the SB method. This increased cost is partially offset by the elimination of the backfill mixing operation. However, the CB method can provide the following technical and construction advantages over the SB method.

- The technique is not dependent on the availability or the quality of soil for backfill.

- The CB system is more suitable in trenching through areas with difficult access or not enough room for backfill mixing.

- Because of the cement content, the backfill sets up quickly to a stiff consistency. Trenches may be cut through the wall without sloughing of the backfill. Construction traffic can cross the trench after a few days. There is no significant consolidation with time.

- Since the trench can be constructed in sections with later sections keyed-in by reexcavating a short section, the construction sequence is more flexible to meet site constraints. The long slope of the backfill under the SB system normally requires trenching continuously in one direction.

The major disadvantage of CB compared to SB is in situations where even tiny amounts of seepage are critical, due to its relatively higher permeability. A CB wall is also less resistant to chemical attack of many pollutants. These topics are treated in more detail in a later section.

Given the relative advantages between the two systems, the project requirements should be evaluated to determine the best method to be selected. Where possible, it may be most economical to specify both methods and allow the contractor to bid with the least expensive system.

Excavating Equipment

The primary requirement for the excavating equipment is the capability to excavate a trench of the design width to the required depths within permissible verticality tolerances. A variety of equipment has, in fact, been used. In the following paragraphs, the principal types are discussed, along with their relative advantages.

The hydraulic excavator, or backhoe, has been used on many slurry cut-off wall projects in the United States (Figure 5). The depth limitation of the largest hoes is presently about 18m but new advances in equipment technology will undoubtedly extend this range. The backhoe, because of its fast cycle time, is the most economical means of excavation. Minimum trench widths are controlled by the thickness of the boom. For large hoes, this can mean 80cm or more. The thickness of the wall is an important cost factor for CB slurry cut-offs.

Draglines have been used on projects to depths of about thirty meters. Specially weighted buckets are used to get the power required at depth. Draglines are sometimes the most economical means of excavating below the range of the backhoe; minimum bucket widths are in the range of 2m, ruling out using draglines with CB slurry due to high material costs. To reach the deeper depths, very large draglines are required and mobilization can be expensive.

The clamshell bucket rigs which were originally developed for cast-in-place concrete slurry walls have been applied to slurry cut-off trenching. These buckets may be cable-mounted or attached to a rigid sliding kelly bar (Figure 6). They may be powered by mechanical means (cables) or by hydraulic cylinders operated by a remote power supply. These rigs have a maximum range up to 80m and can be used with buckets as thin as 40cm. Their production is much lower than other methods, so unit costs for excavation are higher.

Another technique more recently introduced into the United States from Europe involves driving a beam into the ground with a vibrating pile-hammer while simultaneously jetting with CB slurry to form a "thin wall cut-off". The beam is withdrawn while more slurry is injected under pressure. The beam is driven in overlapping imprints to form a continuous wall. The result is a curtain about five centimeters thick with the additional protection of grouting coarse-grained strata with CB slurry. Given the right soil conditions, production is rapid and the thin wall cut-off uses far less CB slurry than conventional slurry trenching. However, the same narrow width mandates more careful quality control since each square meter of the wall is subjected to one pass of the beam which does not mix the slurry as in the case of slurry trenching. The principal problem of the vibrated beam has been assuring continuity between adjacent passes at depth. Its range is approximately 10-15m, but even within these depths slight deviations may leave "windows" in the wall. Soil profiles with cobbles or boulders are a particular problem and keying into underlying weathered rock or hardpan may not be possible to the extent feasible with excavated slurry trenches. The narrow width of wall makes this type of cut-off less suitable for applications in soil where movements due to settlement, subsidence, etc. can be expected later. Design parameters and quality control for thin-wall cut-offs are specialized topics, not treated in this paper.

APPLICATIONS

There have been several hundred slurry cut-off walls constructed in the U.S. Applications have included dewatering walls for excavations, seepage cut-offs under dikes and dams, and cut-off walls to contain outflow of various liquid pollutants. In general, this type of construction enjoys a number of advantages over competitive systems such as grouting or continuous pumping: The cut-off wall is more positive; it requires no maintenance; it elimates system risks due to strikes, pump breakdowns, power failures, etc.; it elimates headers and other obstructions around the perimeter of the excavation.

In the following sections, three recently completed jobs which represent the main types of applications of slurry cut-off walls are described. To illustrate the fact that cut-off walls are not necessarily always jobs of major scope and cost, two of the selected examples involve walls where total costs were under $30,000.

Seepage Cut-off under a Dike

In 1979, the city of Jackson, Mississippi gained national attention as the "Easter Flood" of the Pearl River devastated large areas of the city and its suburbs. The Pearl was partially contained by a system of levees. Along a long section on the east side of the river, the levees had held but had been substantially weakened by underseepage which had created numerous boils on the landward side. The levees themselves were constructed of relatively impervious material so the Corps of Engineers decided to improve them by installing a slurry cut-off wall on the river side of the levees (Figure 7) and keying it into the levees with an impervious cap. Figure 8 shows a typical section through the work site.

For this job, the Corps rightly decided on a soil-bentonite trench, since there was adequate room for a mixing area. Most of the material excavated from the trench was suitable as backfill, but it had to have some coarse aggregrate added to meet the standard Corps backfill gradation specification. The corps uses a good average backfill mix that incorporated a specified range of fine particles to minimize permeability. They perhaps do not vary their ranges sufficiently to always suit design constraints and locally found soils. For example, on this project, there were to be no loads superimposed on the wall. The addition of imported coarse gradation material to the in situ silty sands may not have been necessary.

The wall was installed to a maximum depth of forty feet and keyed into an underlying silty sand formation. The section treated was about one mile long, the weather was favorable and the work completed in about one month's working time.

Excavation Dewatering

Figures 9 and 10 illustrate the problem that a large southern industrial plant faced with its new addition. The soil profile consisted of about eight feet of rubble fill overlying eight feet of sand over clay. Previous construction had left massive concrete foundations underlying a major portion of the site. The owner wished to use the old foundations to the maximum extent possible while at the same time being able to excavate for new foundations. The groundwater was heavily polluted with caustic wastes and lowering the water table too far would cause the existing wood piles on and near the site to deteriorate. Any water pumped from the ground had to be treated before release. The problem was further complicated by extremely tight access conditions on most of the site and by the owner's need to maintain access across the site.

A soil-bentonite wall was essentially infeasible due to access. Also, the material excavated from the trench consisted of rubble, wood, and organics and was unsuitable as backfill. Fortunately, cement-bentonite was chemically compatible with the high pH caustic groundwater, so a CB cut-off was the obvious choice. There was still the problem of how to penetrate the old foundations at several points which was necessary to completely isolate the site. This was accomplished eventually (Figure 11) by open-cutting along the alignment, breaking out the old slabs with a hydraulic ram, and then backfilling the cut and subsequently installing the slurry trench to the full depth.

Figure 12 show the trench excavation in progress. Figure 13 shows the hardened slurry. The trench was about seventeen feet deep and, once site preparation work was complete, required ten days to install.

Pollution Control

There have been many applications of the use of slurry cut-off walls for pollution control. All types of municipal, industrial and chemical wastes have been contained. The following example illustrates one of the neatest applications, to oily wastes on top of the groundwater table. Most slurry wall cut-offs built for containment purposes require the presence of a clay or rock layer underlying the site to provide an impervious stratum that the cut-off wall can key into. In the case of most petroleum pollutants, they do not mix with water and are borne on the top of the groundwater table and flow laterally until they exit in a stream or wall. It is necessary for the cut-off wall to merely intersect the groundwater table to skim off the oil and contain it. There have been numerous applications of this technique, as idealized in Figure 14, particularly in the State of Michigan where numerous tank farms lie along the shores of the lakes and streams. The selected example shows how one refinery attempted to use steel sheets inserted into a stream to try to contain the pollution (Figure 15). This was mostly ineffectual and required frequent maintenance by vacuum trucks. The slurry cut-off wall was installed along a 1,000 ft. section (Figure 16) in five working days.

Cement-bentonite was used because of limited working room and the time of the year in which the work was done. Mixing soil-bentonite backfill would have been essentially impossible in the sub-freezing weather which prevailed.

DESIGN AND QUALITY CONTROL

Design Parameters

The primary design parameters, in their usual order of importance, are permeability, strength, and compressibility. In the following paragraphs, each is briefly discussed. A fourth parameter, durability, has implicit importance in permanent installation and is discussed in the next section.

Permeability has been the best studied of the design parameters. Laboratory and field studies have repeatedly yielded measured permeabilities in the range of 10^{-6} for CB cut-offs and in the range of 10^{-6} to 10^{-8} for SB cut-off walls. There has been some speculation about the role of the filter cake and how it differs between the two types of trench. The filter cake is the buildup of solids due to water seeping out of the slurry through the walls of the trench. After a certain point, the filter cake is thick enough to preclude further seepage losses. The higher concentration of bentonite in the filter cake is an important factor in bulk permeability or SB cut-off walls (Figure 17). In the case of the CB slurry, the filtrate loss increases dramatically upon the addition of the cement. Some penetration of the cement-bentonite mixture into the more pervious zones may be possible.

With respect to the backfill, research has shown that in the case of an SB wall, the permeability is dependent on the percentage and character of the fines content of the soil blended with the bentonite slurry. The higher percentage of minus 200 sieve particles and the more plastic the fines, the less pervious the wall will be (Figure 18). Twenty to forty percent fines seems to be an ideal range. Permeability may also be decreased by adding additional bentonite to the backfill mix (Figure 19). The permeability of the CB slurry cannot be controlled as easily since addition of bentonite would affect the working properties.

Under most conditions, the only strength requirements for slurry cut-off walls is to attain the approximate strength of the surrounding ground. Either SB or CB walls will satisfy this criterion. The top of the trench is usually covered to prevent the application of wheel loadings or other concentrated loads.

The compressibility of slurry cut-off walls is high in most situations to allow for deformations without cracking. In the case of CB slurry backfill, a normal mix can withstand compressive strains of several

percent under in situ stress conditions without cracking. Slight changes in the mix can increase compressibility. The walls can also be designed for maximum flexibility under seismic conditions.

With the SB backfill, the percentage of coarse grained particles has the greatest effect on both strength and compressibility. As the percentage of coarse-grained particles increases, strength increases and compressibility (plasticity) decreases.

Durability

In any permanent installation of a slurry cut-off wall, the ability of the wall to remain impervious in the underground environment is always an important question. The materials involved are bentonite clay, and soil or cement. In situations which involve clean water, these materials are indefinitely stable and no reduction in permeability is experienced. However, cement is known to be a poor performer in situations where acids or sulphates are present. Soil particles are stable in all but the most extreme acid or basic environments, where they may actually become soluble.

The greatest concern lies with the bentonite, since soil-bentonite walls are usually used in harsh chemical situations because of their lower permeability and better resistance to attack. The pore fluid substitution may lead to a smaller double layer of the partially bound water surrounding the hydrated bentonite or other clay particles, reducing the effective size of the clay particles that clog the pore space between soil grains, and thereby increasing the size of the effective flow channels in the soil skeleton and the permeability.

The permeation time required for the changes associated with pore fluid substitution to be completed is relatively short. Once a sample has been permeated by a volume of pollutant equal to about twice the volume of the pore fluid in the sample, the initial pore fluid has been, for the most part, leached out and the new pore fluid is essentially the pollutant. Sodium readily exchanges with multivalent cations such as calcium, magnesium and heavy metals, and the exchange is typically complete once an equivalent number of ions are supplied by the permeant to satisfy the total cation exchange capacity of the bentonite. Once both the pore fluid is substituted and the cation exchange occurs, steady state conditions prevail and the permeability remains constant at a higher value associated with the new pore fluid and the new cation montmorillonite. These points are illustrated by Figure 20 which plots permeability for both bentonite filter cakes and SB backfill as a function of permeation time with a calcium carbonate.

The best approach from a design standpoint where durability is in question is to conduct a test using the materials from the site and the actual leachate. The best test is to mix a sample of soil-bentonite backfill, consolidate it in a tri-axial cell and run a continuous permeability test. The same kind of test can be run on the cake in a filter-press cell. Behavior such as that shown in Figure 20 where a relatively small increase in permeability is experienced followed by a constant reading is indicative of a stable mix.

While every pollutant should be checked, in general, a mix with well-graded SB materials and about one percent bentonite will exhibit small increases in permeability for most pollutants. Where this mix is not sufficient, the addition of more fines, particulary clay fines, or more bentonite will provide a satisfactory solution for practically all cases.

Quality Control

The primary functions of quality control during construction are to:

- Assure continuity of the completed trench to the widths and depths required.
- Control the composition and placement of the backfill to achieve the required design parameters.
- Control the quality of the slurry during construction to minimize the risk of trench failure (in most cases where trench failures threaten adjacent structures).

The continuity of the trench with respect to the required dimensions is relatively easy to control. The excavating equipment should have a minimum width equal to or greater than the width of trench required. Depth is controlled by direct measurement and by observation of materials excavated from the trench. When the wall is excavated by a backhoe, the motions of the machine ensure longitudinal continuity. In the case of a clamshell which digs vertically, primary panels should first be dug and then overlapped by secondary panels. Once this process is completed, a slight sideways movement of the bucket in both directions is used as a final check on continuity before the machine is moved and a new primary panel is dug.

The most important requirement for the slurry during the excavation of the trench can be summarized as workability. If the slurry is too thin, the trench may collapse. If the slurry is too thick, excavation may become difficult and large lumps of soil may become suspended in the slurry. In the case of the SB trench, a very thick slurry may interfere with the backfill process. Experience has shown that an optimal slurry can be attained by controlling a few essential factors: hydration of the bentonite, viscosity, and specific gravity.

Viscosity is the primary test to control the workability of the slurry. The standard test, the Marsh Funnel, consists of measuring the time required for a known volume of slurry to run out of a standard funnel. The ideal range for both SB and CB slurries is in the range of 40-45 seconds. Typical values measured in the trench may range as low as 35 seconds or as high as 80 seconds without causing problems. In the case of CB slurry, the slurry may become so thick as not to pass through the cone, but still be acceptable. The fluctuations may be caused by variations in the slurry being added or changes in the underground environment, or simply setting time. Any specification on workability should recognize and allow for these variations and permit the contractor to add new slurry with the properties required to bring the slurry in the trench back to an optimum value. The continued action of digging will tend to mix the slurry to a homogenous mass.

Specific gravity provides an additional control on workability. The principal application of a specific gravity criterion is to SB slurry cut-off walls. If the mud becomes too heavy, it is difficult to assure good placement of the backfill because the backfill may fold over the heavy slurry, rather than displace it. Experience has shown that as long as unit weights are maintained at least 15 pcf below the unit weight of the backfill mix, the slurry will be easily displaced.

The composition and placement of the slurry trench backfill is a different problem for the SB and CB techniques. In both cases, the amount of bentonite in the original slurry is as required to achieve correct slurry properties. In the case of the CB wall, cement is weighed and added in the correct proportions to the slurry as it is placed into the trench. The SB backfill is composed of suitable soil material mixed with additional slurry to attain a smooth consistency with a slump of 4 to 6 inches; the resultant mix is bladed into the trench. Care is taken to assure that the backfill moves continuously forward in the trench, displacing the slurry and not folding over it.

SUMMARY

Slurry cut-off walls have achieved wide recognition in a variety of applications as seepage barriers for dewatering and pollution control. The two principal techniques, soil-bentonite and cement-bentonite, have different relative advantages, but under some conditions are technically interchangeable. Typical projects involve the prevention of water inflow into excavations, seepage cut-offs under or through dikes, and dams, and underground barriers to prevent lateral flow of polluted water or other fluids.

A design for a slurry cut-off wall should take into consideration whether the wall is for permanent or temporary use, the loadings anticipated, and other construction constraints in selecting the technique to be used and the extent to which the work should be controlled by the engineer. Specifications should take account of the built-in safety factors in slurry cut-offs (e.g. more thickness than required in most cases) and allow the variability in slurry properties normally experienced during this type of work and give maximum flexibility to the contractor in selecting materials, equipment and technique. The economy, convenience and positive control of seepage afforded by slurry cut-off walls wil bring them acceptance and application on an increasing number of construction projects in the United States.

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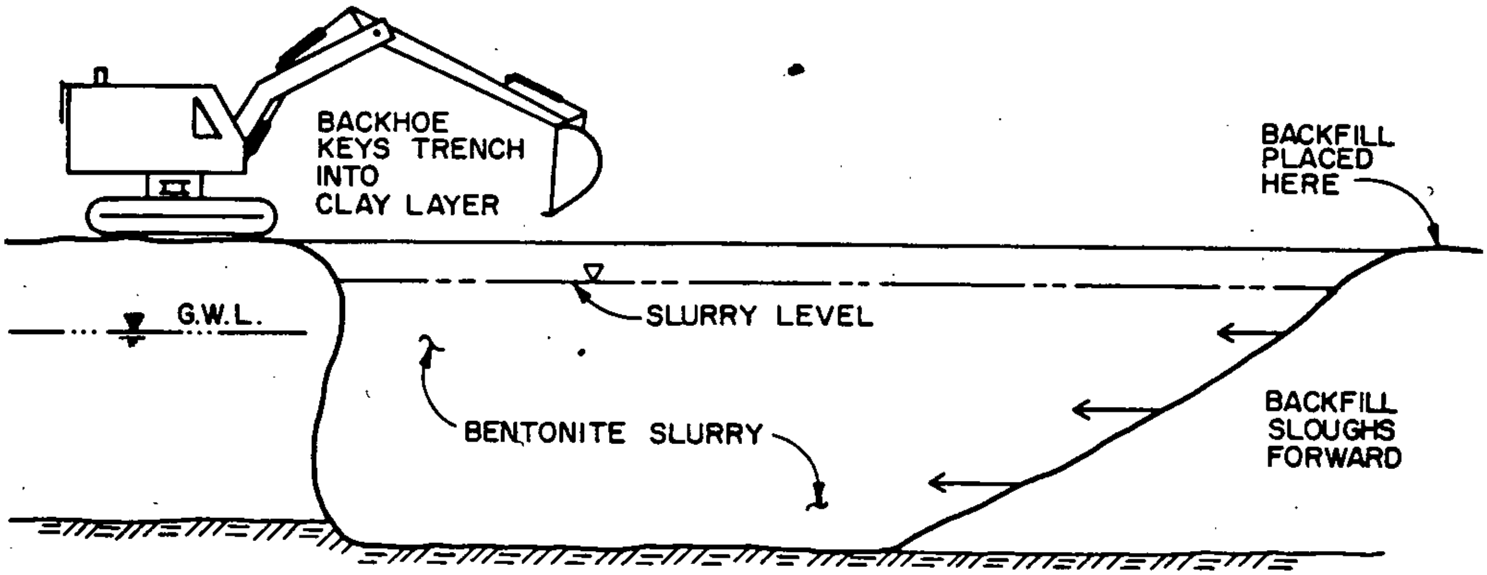


FIG. 3 SCHEMATIC SECTION THROUGH SB SLURRY CUT-OFF

FIG. 1
S-B CUT-OFF WALL
EXCAVATION

FIG. 2
MIXING S-B
BACKFILL

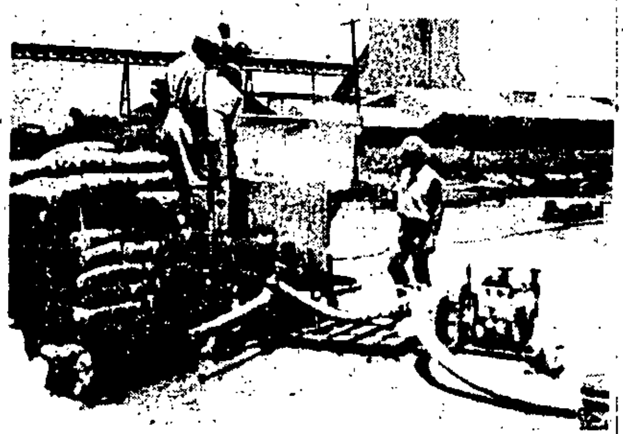


FIG. 4
SMALL C-B
MIX PLANT

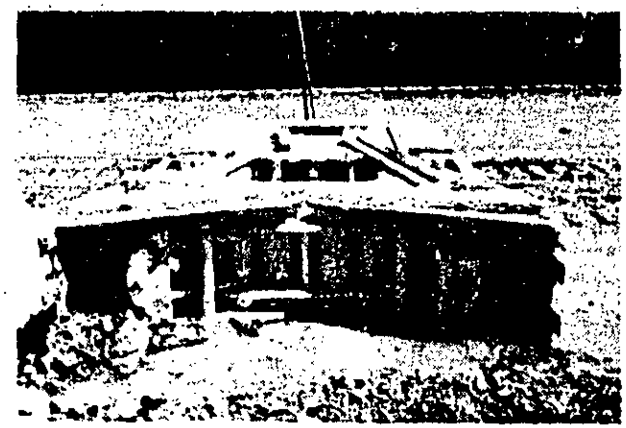


FIG. 6
SLURRY TRENCH
CLAMSHELL

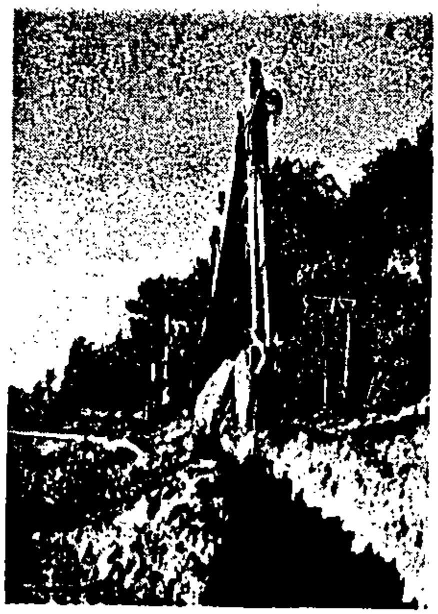


FIG. 5
BACKHOE EXCAVATING
SLURRY TRENCH

FIG. 7
JACKSON PROJECT
WORK IN PROGRESS

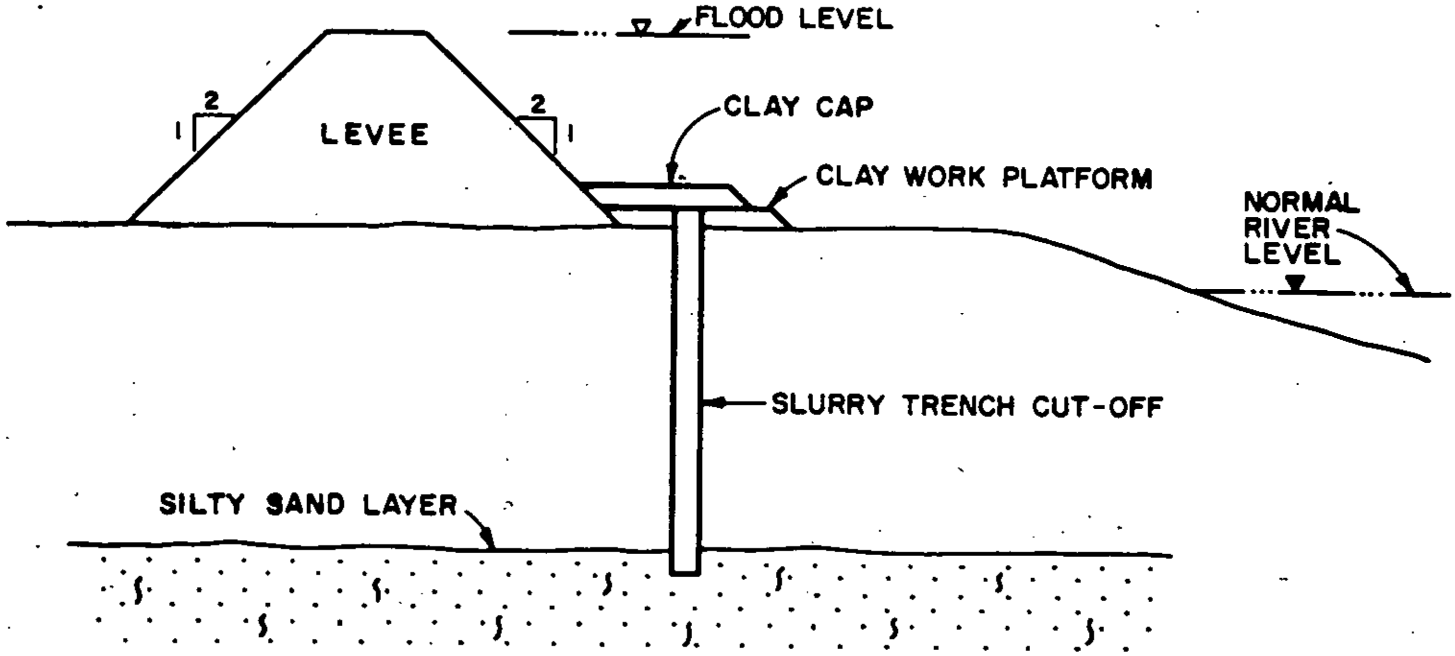


FIG. 8 SECTION - SEEPAGE CUT-OFF UNDER LEVEE
JACKSON, MISSISSIPPI

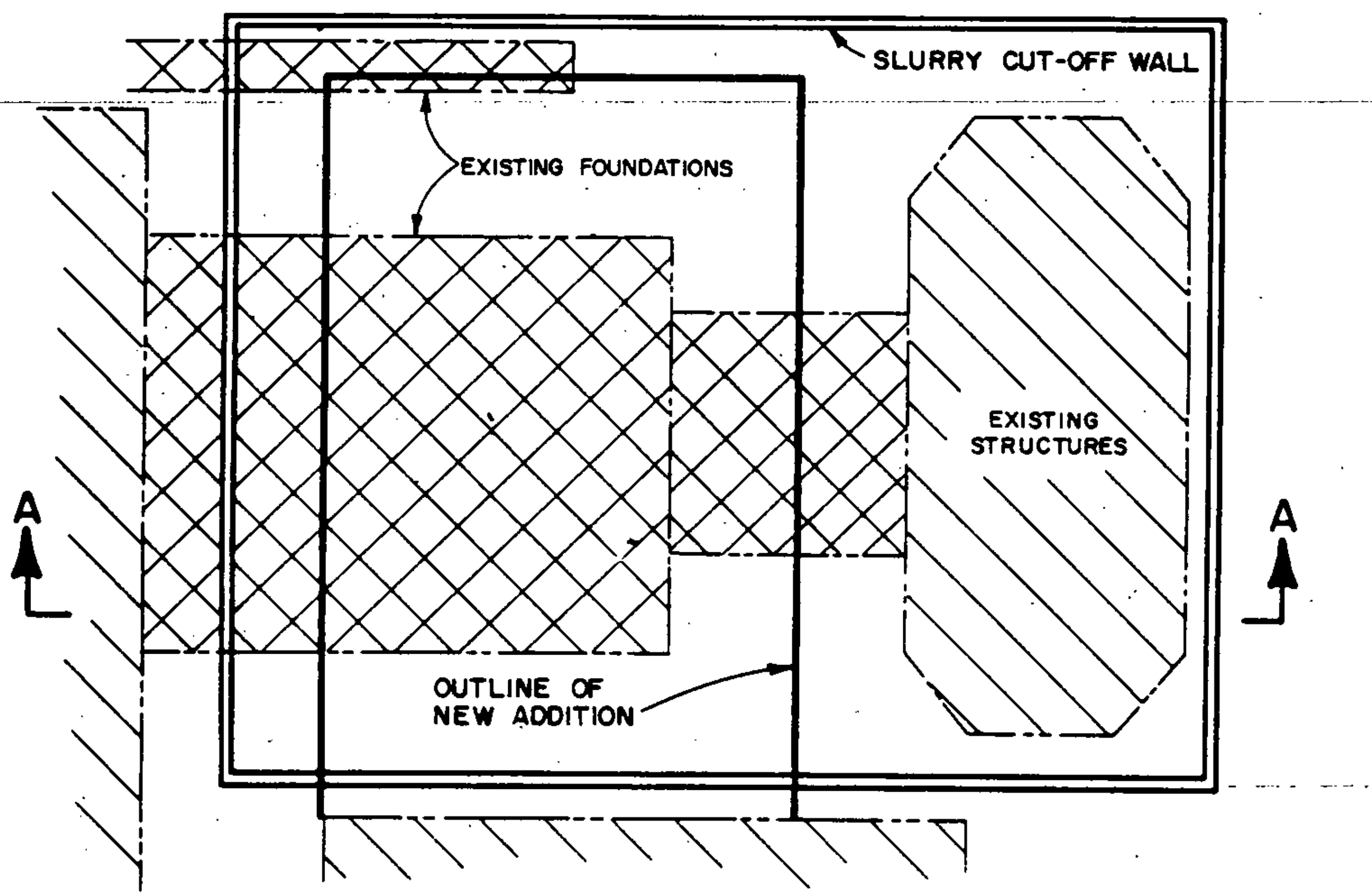


FIG. 9 PLAN OF SITE TO BE DEWATERED

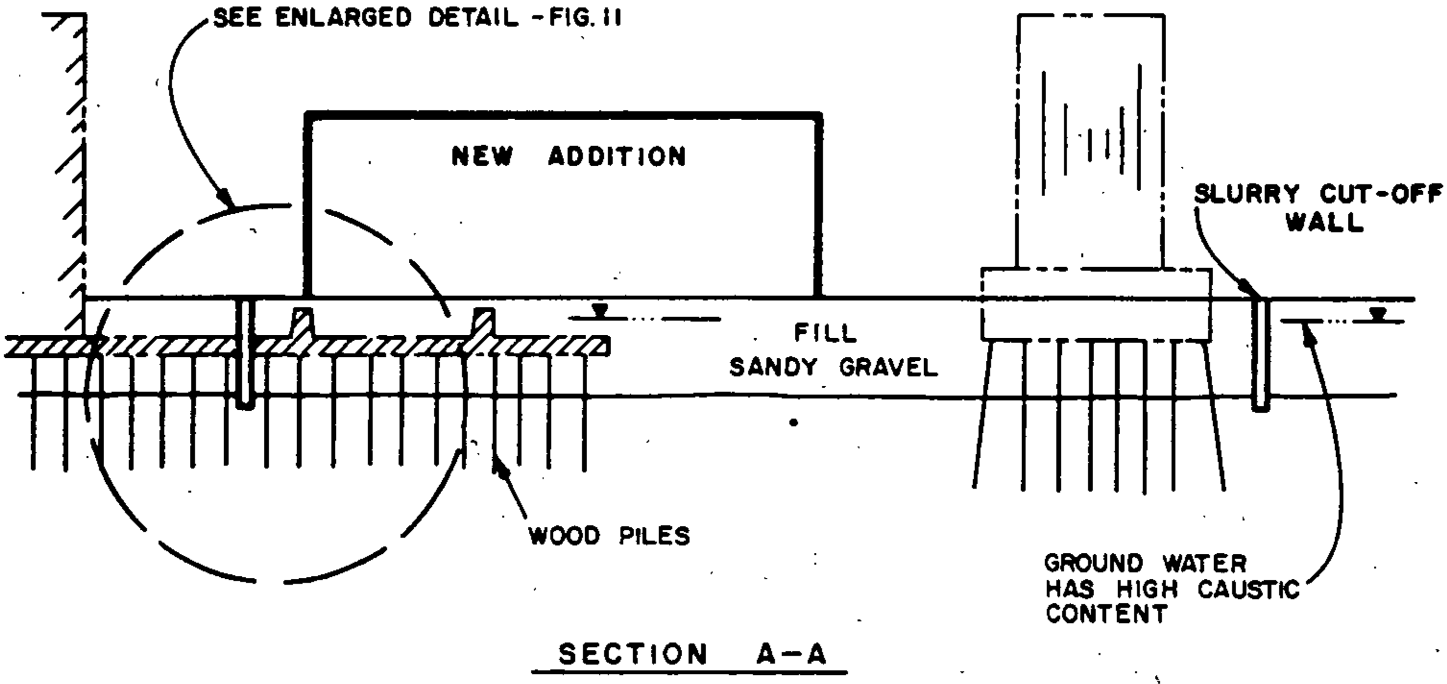


FIG. 10 SECTION THROUGH SITE TO BE DEWATERED

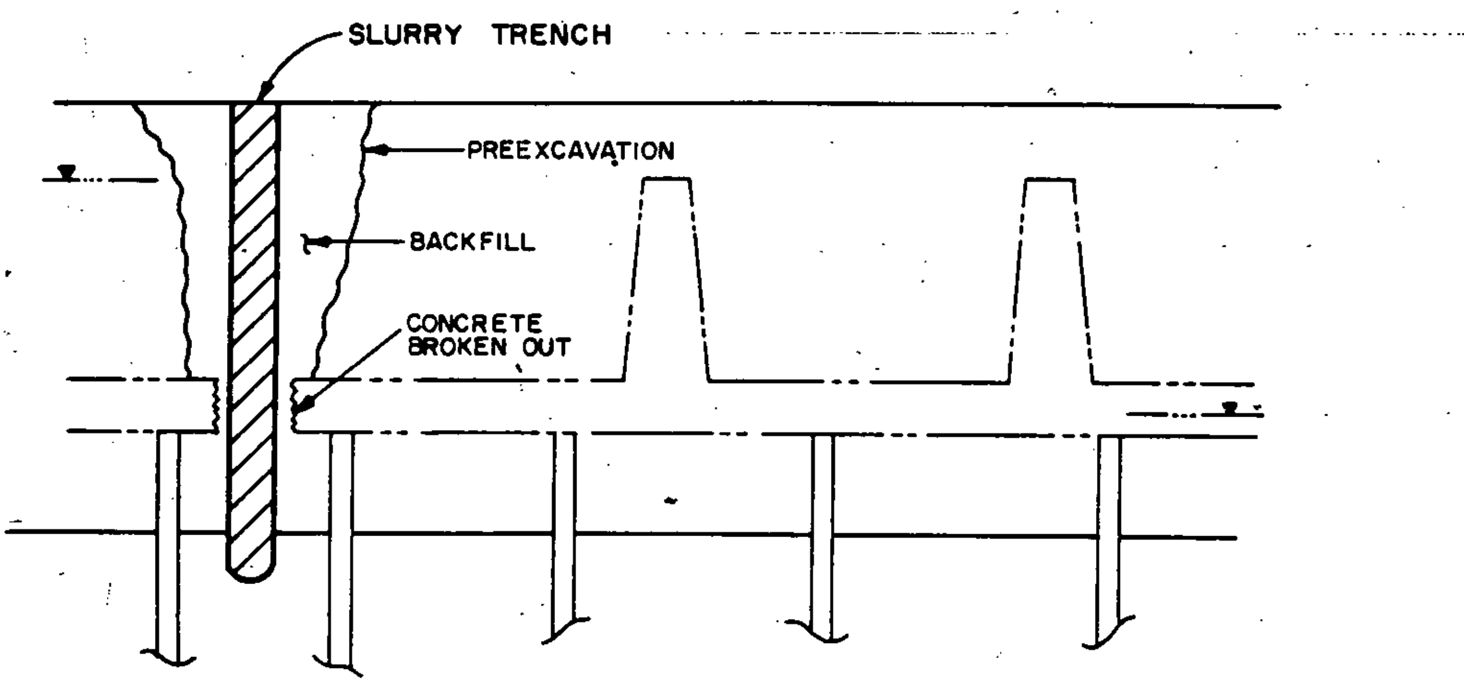
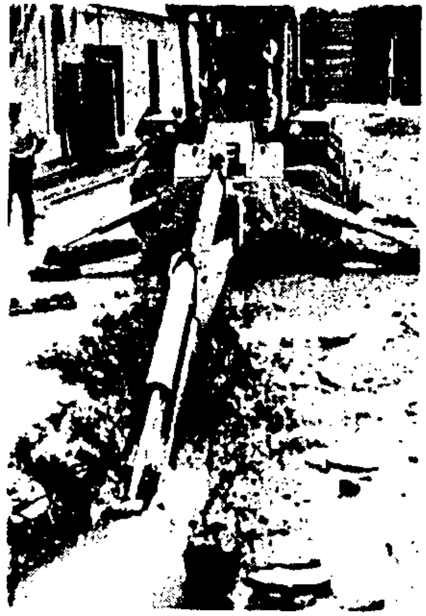


FIG. 11 DETAIL OF SLURRY CUT-OFF SOLUTION

FIG. 12
TRENCHING UNDER
CEMENT-BENTONITE



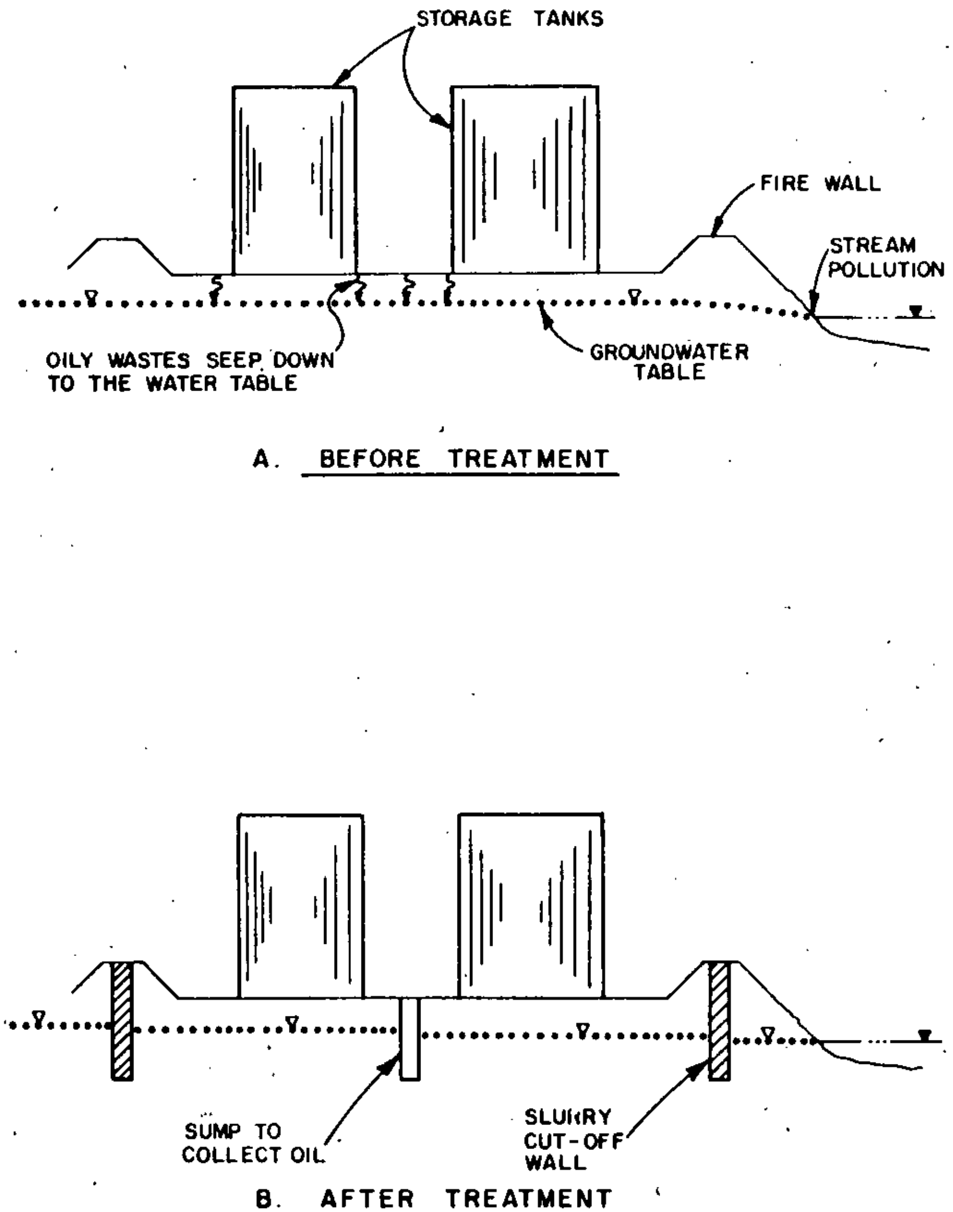


FIG. 14 SCHEMATIC OF TYPICAL APPLICATION
OIL-POLLUTED GROUNDWATER

FIG. 13
HARDENED
C-B SLURRY

FIG. 15
OWNER'S PREVIOUS ATTEMPT TO CONTAIN OIL POLLUTION

FIG. 16
SLURRY CUT-OFF WALL ALONG RIVERBANK

$$k = \frac{l_b}{\left(\frac{l_b}{k_b} + \frac{2l_c}{k_c}\right)}$$

k = WALL PERMEABILITY
k_c = CAKE PERMEABILITY
k_b = BACKFILL PERMEABILITY
l_b = BACKFILL THICKNESS
l_c = CAKE THICKNESS

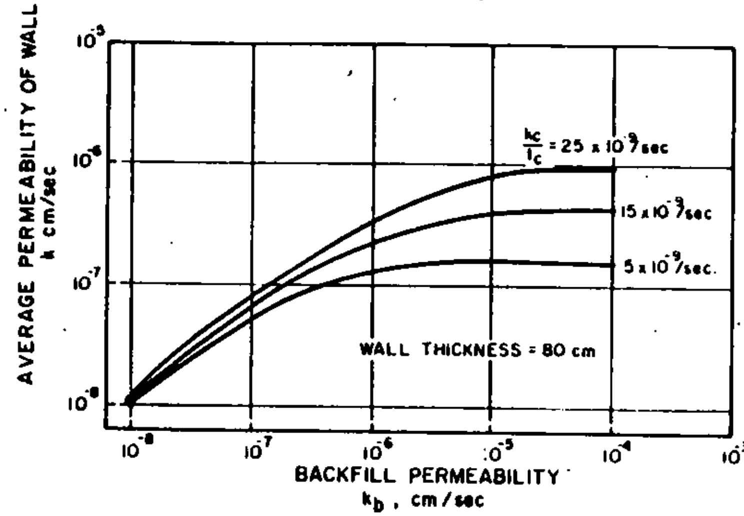


FIG. 17 THEORETICAL RELATIONSHIP BETWEEN WALL PERMEABILITY AND PERMEABILITY OF THE FILTER CAKE AND BACKFILL

(AFTER D'APPOLONIA AND RYAN 1979)

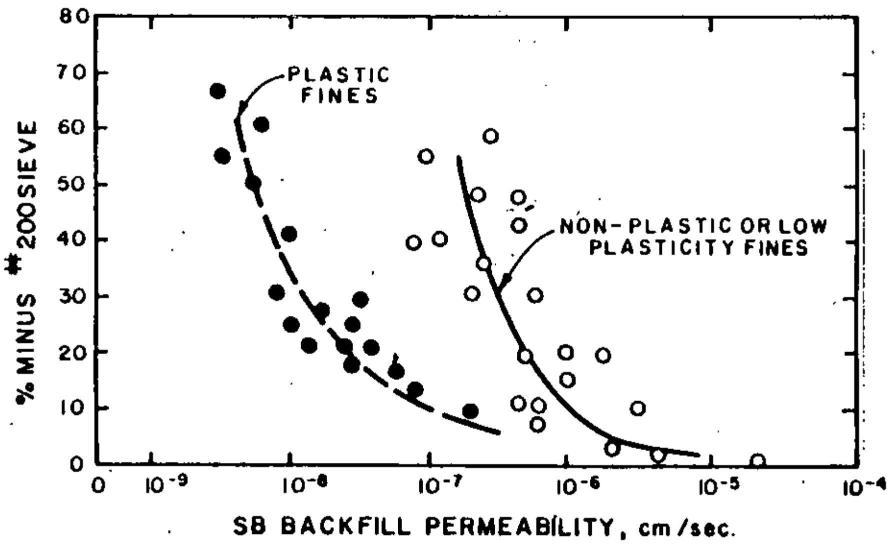


FIG. 18 PERMEABILITY OF SOIL-BENTONITE BACKFILL RELATED TO FINES CONTENT

(AFTER D'APPOLONIA AND RYAN 1979)

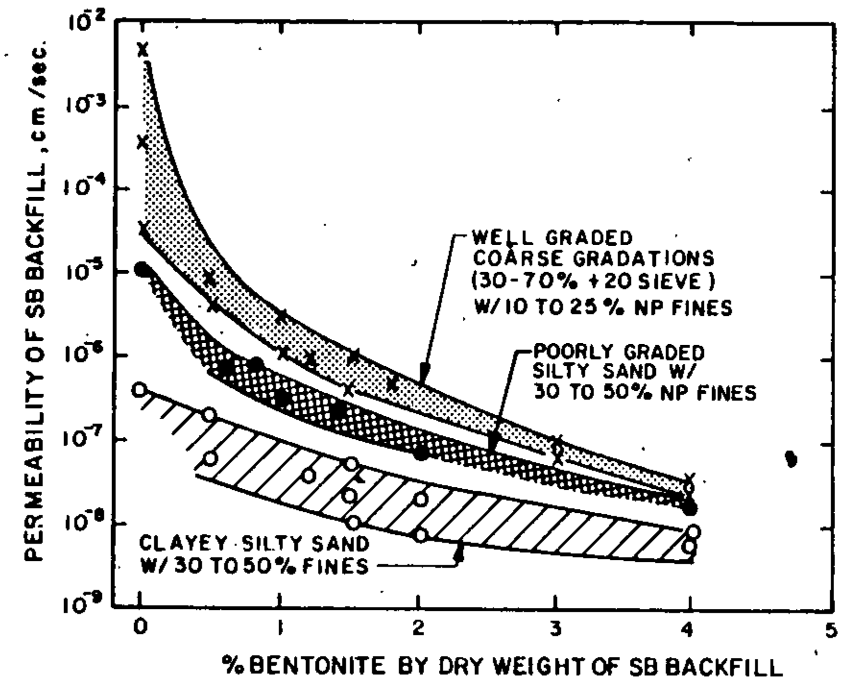
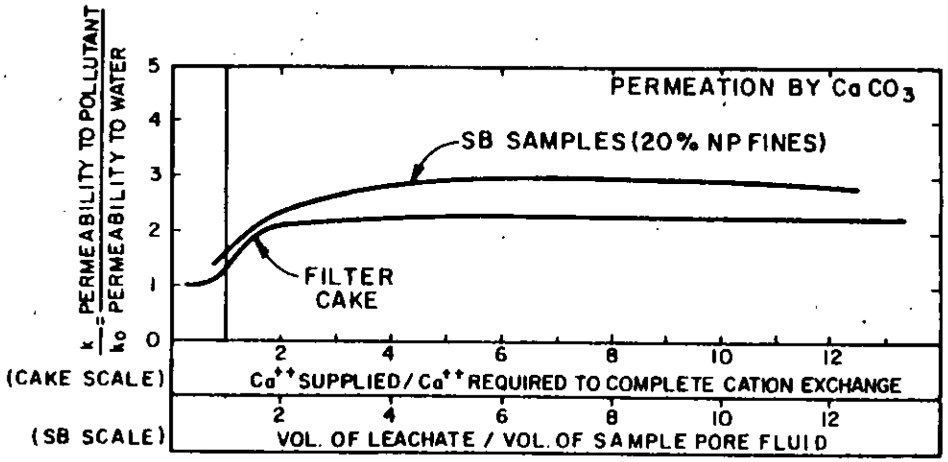


FIG. 19 RELATIONSHIP BETWEEN PERMEABILITY AND QUANTITY OF BENTONITE ADDED TO SB BACKFILL

(AFTER D'APPOLONIA AND RYAN 1979)



EXCHANGE CAPACITY OF CAKE ($meq\ Ca^{++}/100g$ BENTONITE)	
BEFORE PERMEATION	AFTER PERMEATION
94	12

FIG. 20 EFFECT OF POLLUTANT PERMEATION ON PERMEABILITY OF FILTER CAKE AND SB BACKFILL

(AFTER D'APPOLONIA AND RYAN 1979)

Current USA Practice: Slurry Wall Specifications

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Introduction

To establish diaphragm and cutoff slurry wall design criteria and, thus, specifications, the designer must clearly establish the objectives or end results that are to be obtained. This paper considers the critical design criteria and the resulting specifications for both slurry trench diaphragm walls and cutoff walls.

Diaphragm and cutoff walls are initiated with a common process. This process is the excavation of a narrow trench without the use of significant lateral support other than that provided by a bentonite-water slurry which is pumped into the trench so that the slurry level is maintained at or near the top of the trench throughout the excavation process.

In the diaphragm wall process, after completion of a segment of excavated trench, either cast-in-place concrete (tremie process) or precast panels are used to displace the stabilizing mud and construct a load-bearing wall (vertical and lateral).

There are two types of slurry cutoff walls: (1) Soil-bentonite; and (2) cement-bentonite. In the soil-bentonite cutoff process, the bentonite slurry is displaced by a soil-bentonite mixture similar in consistency to high slump concrete. The soil backfill forms a low permeability highly plastic cutoff wall. In the cement-bentonite cutoff process, cement is added to a fully hydrated bentonite-water slurry. The cement-bentonite-water slurry is then used to both stabilize the slurry wall during excavation, and upon setting of the cement, for the permanent cutoff wall itself.

The critical design criteria for the two types of slurry walls are

1. Diaphragm walls: (1) Structural strength and integrity; (2) permanence; and (3) permeability.

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2. Cutoff walls: (1) Permeability; (2) deformability; and (3) permanence.

These critical criteria can be subdivided and the corresponding building blocks of a specification developed. It is important to realize that specifications should be no more restrictive than is necessary to achieve the desired end product. To make specifications more complex and restrictive than necessary only results in raising the bid prices, delaying the progress of the work, and increasing the potential of contract litigation. Restrictive specifications may also tend to stunt the specialty contractor from trying new ideas in difficult situations in this still developing field.

End-result (performance-guaranteed) specifications are acceptable if (and this is an important if) the owner, engineer, and contractor truly understand and can agree on what end results are to be obtained. Until owners and engineers become more familiar with slurry trench techniques, applications, and limitations, some method specification will be continued to be used. However, these specifications should be tailored to the true needs of the owner. With this philosophy, we shall examine in more detail the basic criteria for slurry wall construction.

Diaphragm Wall

Structural Strength and Integrity.—Eight main criterion are recommended for consideration: (1) Continuity and stability of excavation; (2) steel reinforcement or precast panel placement, or both; (3) concrete placement (tremie process); (4) concrete fluidity (slump test); (5) concrete strength (water-cement ratio); (6) panel connections; (7) support systems (struts, rakers, tiebacks, etc); and (8) internal excavation procedures (control of soil and ground-water pressures).

Continuity and Stability of Excavation

Critical Excavation Tolerances.—Specifications normally will indicate the minimum width and depth of the wall. In addition, it is normal to specify a maximum deviation from plumbness for the wall. With respect to depth and width, these criteria are usually established by the structural requirements of the diaphragm wall, the excavating equipment thought most appropriate for the site conditions, and with regard to depth, the geologic formations into which the diaphragm wall is to be founded. In general, the excavation tolerances, and particularly, the alignment of the diaphragm wall, can be better controlled when adequate guide walls are constructed ahead of the trenching operations.

With regard to plumbness, structural or potential architectural considerations are important. The state of the art is such that walls have been built to depths of over 400 ft (122 m) with less than 6 in. (152 mm) deviation from the vertical, i.e., 1:800. However, one should specify such severe limitations on verticality only in cases where this is deemed to be a necessary requirement for the intended purpose of the wall. On most projects, tolerances of 1:80–1:100 have been used and found to be satisfactory.

Slurry Properties.—The properties of the trench stabilizing slurry are important in that they control to a great extent the stability of the trench, the removal of excavated material, and the adequacy of concrete placement. Primary slurry properties thought to be important and typically specified are viscosity, density, unit weight or specific gravity, filtrate loss, and pH.

[redacted] Viscosity is a measure of the ability of a fluid to resist shearing; [redacted] viscosity of approximately forty Marsh seconds is appropriate for slurry wall construction. This value of viscosity has been found to give consistently reasonable results in ensuring the satisfactory excavation, stability, and concreting of the trench.

Minimum density of slurry has typically been set slightly over that of ground water. Some specifications have set minimum densities so high that, if prepared with bentonite alone, the mixture would not even flow. Such high densities can only be obtained if fine sands or other excavated material are mixed in with the slurry. Because it is important in a diaphragm wall to minimize the sand content of the slurry so that the eventual tremie concreting operations are not impeded, it is important that a minimum density for a diaphragm wall should not be made a severe limitation (actually, it is probably more appropriate to rely on control of the viscosity). Specified maximum [redacted], and is limited to ensure the tremie processes are not impeded.

Another factor considered in slurry trench specifications is the maximum allowable sand content prior to concrete placement. This parameter can be measured directly by screen tests or, more commonly, indirectly by the density of the slurry. Prior to tremie concreting of the diaphragm wall, it is typically specified that [redacted].

Filtrate loss for a bentonite slurry is determined by a standard filter press test [American Petroleum Institute (API) Test PP131B]. The filter press test is used to simulate the formation of filter cake that is built up on the excavated surfaces by the electrokinetic forces and seepage forces pushing the slurry through the sides of the trench. [redacted] is indeed a measurement of the stability of the slurry. A polluted [redacted] such as salts or acids, will [redacted]

To ensure a slurry of adequate quality, the engineer should specify a reasonable upper limit for the standard filtrate loss [redacted] Actually, in this application, it is preferred to measure the filtrate loss of the fully-hydrated bentonite slurry before the addition of cement. That filtrate loss should be maintained below 30 cm³.

The last important control item on slurry properties is pH, especially in an area where the chemistry of the soil excavated or of the groundwater could dramatically change the pH of the bentonite slurry mixture. The most desirable range for the slurry pH is in the order of 6.5–10 [redacted] At this point it may be necessary to require the addition of a deflocculating agent to ensure continued effectiveness of the

Groundwater Conditions.—It is extremely important that ground-water conditions in the area of the trench and excavation be thoroughly understood. This will include a sound understanding of the seasonal variations, as well as the potential for dramatic changes in ground-water levels due to anomalous weather conditions. Conditions such as artesian pressures and other geologic anomalies; such as springs and man-made sources of water (such as broken sewers) also should be thoroughly understood in order to avoid difficulties with the stability of the trench excavation. Once ground-water conditions are defined, specifications should require that the slurry in the excavation be kept a minimum of 3 ft (1 m)–5 ft (1.5 m) above the maximum ground-water level. The ability to set the minimum distance that the slurry should be above highest ground-water level is directly related to the ability one has in establishing that ground-water level, i.e., the less certainty, the greater the distance one should stay above the estimated ground-water table.

Subsurface Conditions.—As with ground water, it is important to thoroughly understand the subsurface soil or bedrock conditions in the area of the proposed excavation, or both. Areas of problem excavation, such as boulders, cemented layers, broken rock, extremely pervious horizons, impervious layer boundaries, foundation levels, etc., must be thoroughly understood and presented to the contractor if the diaphragm wall is to be properly excavated and constructed.

Steel Reinforcement Placement

The steel reinforcement requirements for a concrete diaphragm wall follow standard America Iron and Steel specifications or other appropriate steel specifications. In addition to these basic reinforcing specifications, it is important to recognize that the steel should be such that tremie concrete can be easily and thoroughly placed around the steel without honeycombs and slurry-filled voids. Consequently, it is important that steel reinforcement not be so dense and tightly placed as to present problems in concreting. Spacers on the external reinforcing bars on the reinforcing cage must be installed to ensure proper placement of the reinforcing cage in the slurry wall and ensure proper concrete coverage of the steel on the external faces of the wall. To facilitate future construction, sleeves and trumpets for future tiebacks, bearing plates for future struts and structural members, knockout panels, and shear keys can be included in the reinforcing cage. It is important to remember that because the reinforcing cage is placed in sections panel by panel, it must be checked to ensure the integrity of the cage while and prior to its placement into the excavation. Techniques to connect reinforcing cages across panel joints are available.

The adherence of slurry to the reinforcing bars does affect the concrete-to-steel bond, but not sufficiently to control design. Reduction factors of 0.8–0.6 have been used.

Placement of precast panels into a cement-bentonite slurry trench is a relatively new advancement of diaphragm walls. As with any diaphragm wall, the most difficult part of the precast panel operation is to ensure panel connections are intact and properly aligned. Proper spacers must again be used and vertical and horizontal alignment of the panels must be monitored, during and after installation. Existing proprietary precast panel techniques usually include a special surface treatment of the excavation side of the panels to facilitate removal of the hardened cement-bentonite slurry.

Concrete Placement (Tremie Process)

The standard tremie concreting processes are applicable in the placement of concrete in bentonite slurry diaphragm wall construction. [redacted]. When concreting wide panels, e.g., panels wider than 30 ft (9.2 m), it is recommended that more than one tremie pipe be specified. A rule of thumb is to use one tremie per 15 ft (4.6 m) of panel. The design of the concrete mix must ensure that the maximum size of aggregate is appropriate to the tremie process as regards the spacing of steel reinforcement. The tremie process also is affected by the slurry viscosity, density, and consequently, sand content. It is important that in the tremie process, sufficient concrete be on hand to adequately backfill a panel section without interruption so as not to cause a formation of horizontal cold joints and, thus, slurry seams during the concreting process.

Concrete Fluidity (Slump Test)

It is normally considered good practice to specify concrete fluidity (as measured by the standard concrete slump test) in the range of 7 in.–9 in. (180 mm–230 mm). This will ensure adequate flow of the concrete in the tremie system and the displacement of the slurry in the wall panels. Stiffer mixes usually lead to voids and open honeycombs in the panels, particularly where the reinforcing cage is dense.

Concrete Strength (Water-Cement Ratio)

The strength of the concrete in the backfilled diaphragm wall is directly related to the water-cement ratio of the concrete mix. Consequently, normal American Concrete Institute (ACI) specifications and practice can be followed in specifying the required structural strength of the concrete.

Panel Connections

There are various positive panel construction connection techniques that can be specified to ensure that there is a structural tie between adjacent panel sections and that these sections have adequate strength and integrity to support the design loads imposed upon them. Some of these connections are proprietary, others have become standard practice. In many cases, this is a good place to require an end-result specification, i.e., require that the strength, integrity, and continuity of the joints is maintained and allow the contractor to use his ingenuity to develop an appropriate scheme.

Support Systems (Struts, Rakers, Tiebacks, Etc.)

The support system needed to provide the temporary or permanent support for concrete diaphragm walls after excavation inside the wall enclosure is very similar to that for any retaining wall. Consequently, struts, rakers, and earth and rock tiebacks are appropriate and have been used successfully with diaphragm walls.

In addition, cantilever design by internal stiffening with vertical still members, and by post-tensioning, are recent developments.

Internal Excavation Procedures (Control of Soil and Ground-Water Pressures)

Many times, structural support of diaphragm walls has been determined by the design engineer only in a final excavated condition, whereas internal support systems described previously and ground water and soil conditions inside the excavation area, are left totally up to the contractor. This can cause difficulties in that there may be certain combinations of construction conditions, i.e., ground water, excavated soil and rock conditions, and installation procedure of retention system, which can lead to higher stresses during excavation than considered for the permanent conditions.

If the engineer feels this may be the case, it may be necessary to either work out a compatible system with the eventual contractor or place limits in the specification on the procedures that must be followed in installing the support system for the concrete diaphragm wall, and on the sequence of excavation.

A simple example of a possible problem would be permitting total dewatering of the interior of the excavation and removal of a large lift thickness of excavated material without the placement of the first interior support, e.g., tieback, raker, etc. These conditions must be examined in close detail on a job-by-job basis and then the engineer must decide what are the maximum limits he can permit the contractor to develop, and where he must specify control to ensure the structural strength and integrity of the wall.

Permanence.—Permanence of a concrete diaphragm wall is of eminent importance. In most cases, the concrete diaphragm wall has become a permanent part of the structure and, thus, must endure for the life of the structure. There are four areas of general concern and interest: (1) Active role in foundation; (2) reinforced concrete permanence; (3) tieback permanence; and (4) architectural considerations.

Active Role in Foundation

As previously identified, many typical concrete diaphragm walls become an integral part of the foundation of the proposed structure, either as a permanent retaining wall or vertical load-bearing member, or both. In this regard, all considerations that are involved in any permanent foundation unit must be reviewed and evaluated in controlling and specifying the desired end result.

Reinforced Concrete Permanence

As for any other subsurface structures, time-dependent corrosion must be taken into account for diaphragm slurry walls. The quality of the concrete may be altered with time by aggressive ground water. In some cases, sulfate resistant cement may have to be specified. In other cases, the concrete may have to be designed to withstand the long-term corrosive action of saline or acidic waters. Because the concrete in a diaphragm slurry wall is actually cured under rather ideal humidity and temperature conditions, shrinkage cracks are not usually of concern.

Tieback Permanence

A recent practice that has been developed in Europe concerns the use of permanent earth tiebacks to support permanent concrete diaphragm walls. This practice consists of providing access to the jacking head of earth anchors; this permits the rejacking of the anchors over the life of the structure.

Corrosion is also a concern for permanent stressed tiebacks. The designer should be aware of the corrosion potential of the soil and rock mass surrounding the tiebacks. The specifications should include measures, such as protective coatings and grouting, cathodic protection, etc.

Architectural Considerations

In many applications, the interior portions of concrete diaphragm walls can be left exposed, i.e., subway excavations, basements of parking garages in buildings, etc. Where this is the case, certain limitations on concrete projections into the excavation may be appropriate. There have been many case histories where the interior of the diaphragm walls, when exposed upon excavation, have been found to be quite satisfactory for use without any additional cosmetic applications.

Permeability.—With regard to the permeability of the concrete diaphragm wall, it is typical to specify that there be no free-water leakage through the wall, but depending upon the architectural and social use of the interior part of the exposed slurry wall, dampness of the wall may be permitted. It is of course possible that in certain applications even dampness needs to be limited. If this is the case, the engineer will have to recognize that the more restrictive the specifications, the greater the likely bid costs.

For permeability, five primary criteria are recommended for consideration: (1) Continuity and stability of excavation; (2) concrete placement; (3) concrete fluidity (slump); (4) panel connections; and (5) sleeves and other wall inserts.

Continuity and Stability of Excavation

Considerations are identical to those listed under structural strength and integrity of diaphragm walls, i.e., critical excavation techniques, slurry properties, ground-water conditions, and subsurface conditions. If the wall is not continuous and stable, then excess seepage, leakage, or dampness is certain. Of particular concern are two items: (1) The contact conditions at the bottom of the wall ensuring a watertight cutoff; and (2) the tolerances in the wall to ensure that corners and panels are closed.

Concrete Placement

Again, the same consideration consistent with structural strength and integrity applies; the tremie process must follow the same good practices as required for any tremie process.

Concrete Fluidity (Slump)

To ensure low permeability of the wall, a fluid concrete mix is needed to prevent bad concrete joints and honeycombs.

Panel Connections

There are proprietary and generally sound practices available in the profession to handle panel connections. However, most leakage through diaphragm walls occurs at the panel joints. An end-result specification may be applicable and thus permit the contractor to use his ingenuity in avoidance of leakage or dampness problems at these panel connection joints.

Sleeves and Other Wall Inserts

As mentioned previously, for future construction ease, various sleeves and inserts, e.g., for tiebacks, can be installed in the reinforcing cage prior to concreting. Often these inserts constitute a preferential seepage path for outside ground water. To avoid unacceptable water inflow, grouting behind the sleeves and inserts may have to be specified.

Cutoff Wall

The use of concrete diaphragm walls has had much exposure in the technical and construction literature; however, the use of the so-called plastic slurry cutoff

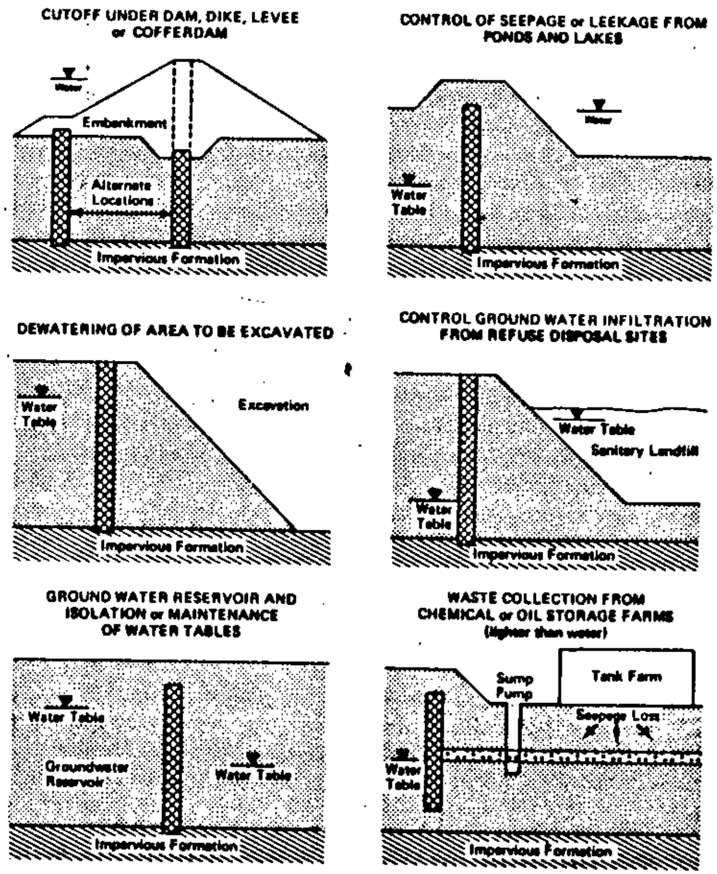


FIG. 1.—Typical Applications of Slurry Trench Cutoff Wall

wall has not had such wide-spread exposure. Fig. 1 presents typical applications of the cutoff wall as constructed with the slurry method. As can be seen from Fig. 1, applications can range from forming an impervious cutoff for a dam or dike empoundment to the containment of subsurface oil and chemical pollutants.

At the present state of the practice, two types of plastic cutoff walls are

used: (1) Walls excavated with a bentonite-water slurry and backfilled with a soil-bentonite mixture; and (2) walls excavated with a cement-bentonite-water slurry which does not need to be backfilled as cement causes the slurry to harden to strengths comparable to that of a stiff clay. With the aforementioned applications and types of cutoff walls in mind, there are three prinicpal design criteria which we believe to be important considerations in the preparation specifications for construction of plastic cutoff walls. These criteria are permeability, deformability, and permanence.

Permeability.—Permeability is, of course, the most important characteristic of the cutoff wall in that the major reason this type of slurry trench/wall is constructed is to minimize the passage of fluid. Cutoffs can prevent infiltration into an excavation, retain water in a reservoir, or prevent a leakage of polluted chemicals, oils, gasoline, etc., out of a containment area. The following five factors are important to the eventual permeability of a slurry trench cutoff wall: (1) Continuity and integrity; (2) thickness of wall (hydrostatic head); (3) cutoff backfill properties; (4) backfill placement for soil-bentonite cutoff; and (5) connection detail with surface structures.

Continuity and Integrity

It is quite important that the slurry trench excavation be continuous so as not to permit seepage zones or zones of pervious material to breach the cutoff. In this regard, the following factors must be considered.

Critical Excavation Tolerances (Width, Depth, and Vertical Inclination).—The same factors considered in the diaphragm wall section are applicable here. The depth will be controlled in many cases by the subsurface conditions, i.e., the depth to an aquiclude and the type of containment or permeability barrier that is to be constructed. The width will be dependent upon the required permeability of the cutoff wall, the materials that make up the wall, the waterhead across the wall, and the size of available excavation equipment. These latter items will be considered subsequently. The inclination and deviation from verticality will only be important as they affect the continuity and integrity of the wall and should be specified accordingly.

Slurry Properties.—The slurry properties important to ensuring stability of the wall during excavation and backfilling are identical to those specified for diaphragm walls, i.e., viscosity, density, filtrate loss, pH, and to a lesser extent for the cement-bentonite slurry sand content.

Ground-water Conditions.—Ground-water conditions must be thoroughly understood along the entire length of the cutoff wall in order to prevent difficulties with regard to caving of the trench due to high hydrostatic pressures encountered during the excavation. As was considered for diaphragm walls, it is important that a minimum of 3 ft–5 ft (1 m–1.5 m) of slurry head be maintained in the excavation above the level of the maximum anticipated ground-water conditions. Seasonal fluctuation of ground-water levels must be established in this regard.

Subsurface Conditions.—Potential anomalous subsurface conditions that will impede either the continuity of the cutoff wall as it is being excavated or the tie-in with the subsurface aquiclude must be understood. Solutions for closures of windows in the walls must be evaluated. The minimum penetration into an aquiclude at the base of the wall must be thoroughly examined before it is specified. If the aquiclude is a competent impervious bedrock, a very minor penetration may be satisfactory. A considerable cost penalty would be imposed on the project by requiring a 2-ft (0.6-m) penetration into a competent bedrock if it is not truly required. If, however, the excavation is to be carried into a clay aquiclude, then it might be reasonable to specify a 2-ft or 3-ft (0.5 m or 1 m) penetration into the aquiclude. Such penetration may avoid problems with regard to cleaning the bottom of the excavation, as essentially a sump has now been provided in which soil which has settled out of the slurry may collect without causing a seepage path through the wall.

Thickness of Wall (Hydrostatic Head)

In setting minimum thickness of the cutoff wall, hydrostatic head and permeability of the backfill materials must be evaluated. A typical relationship that has been developed for the use of soil-bentonite backfill slurry walls is that the wall should have a thickness of 5 ft–7.5 ft (1.5 m–2.3 m).

For a cement-bentonite slurry trench cutoff wall, the increased shear strength of the backfilled wall has typically permitted the wall thickness to be set at a minimum physical excavation thickness, i.e., somewhere between 24 in. and 36 in. (610 mm–910 mm). This width is satisfactory up to a depth of at least 100 ft (30 m) of hydrostatic head. Beyond that point, more detailed and sophisticated engineering evaluations should be carried out to evaluate the ability of cement-bentonite cutoff walls to resist hydrofracturing.

Cutoff Backfill Properties

Soil-Bentonite Backfill.—In many cases, specifications have established a gradation of soil-bentonite backfill that compares to that of a glacial clay till, i.e., a wide range of particle sizes from coarse to fine with the resultant bentonite content somewhere in the range of 2%–4% by weight and on the order of 10%–20% fines (soil particles finer than the openings of a No. 200 standard U.S. sieve). Permeabilities of such mixtures have been measured to be on the order of 10^{-6} mm/s. It must be pointed out that other gradations have been used satisfactorily for soil-bentonite backfill, including fine sands and clays.

The second factor with respect to specification of the backfill concerns its consistency. Typically, the consistency of soil-bentonite backfill is controlled by a concrete slump test. To control the slope of the backfill and to ensure that liquid slurry is not trapped in the backfill, it has been found that a slump in the range of 4 in.–6 in. (100 m–150 mm) is appropriate. If the slump is greater than this, then a very flat backfill slope is obtained which can pose problems with regard to efficiency of excavation. If the slump is less, honeycombs, voids, and entrapment of pervious materials may result which can cause breaches in the cutoff wall.

Cement-Bentonite (Self-Hardening Slurry).—The principal factors affecting the permeability of the cement-bentonite slurry (which is also the slurry used during the excavation process) are cement-water ratio, bentonite-water ratio, and, of course, mechanical procedure in making eventual panel connections between the fresh cement-bentonite slurry and the set cement-bentonite. It is important to recognize that the cutoff wall is formed by the cement-bentonite mixture which is the same material that is used to stabilize the trench during excavation. Typical permeability of cement-bentonite slurry cutoff wall is also on the order of 10^{-6} mm/s.

It is important to specify in the cement-bentonite process that the bentonite be fully hydrated with water prior to the addition of any cement. When this procedure is followed, the cement-water ratio typically will be the controlling factor in the eventual strength, deformability, and permeability of the backfill.

It is important, when panel connections are made between two excavation units, that a thorough overlapping is obtained to ensure that no windows or cold joints are created. Experience has indicated that connections may be made as long as one week later into set cement-bentonite and adequate continuity has been obtained. In some cases, retarder can be added to the cement-bentonite slurry to prevent flash set and cracking and, therefore, permit plastic contact between adjacent panel units. In many cases, the cement-bentonite slurry trench process has been used in a continuous fashion, with connections made along the wall on a daily basis.

Backfill Placement for Soil-Bentonite Cutoff

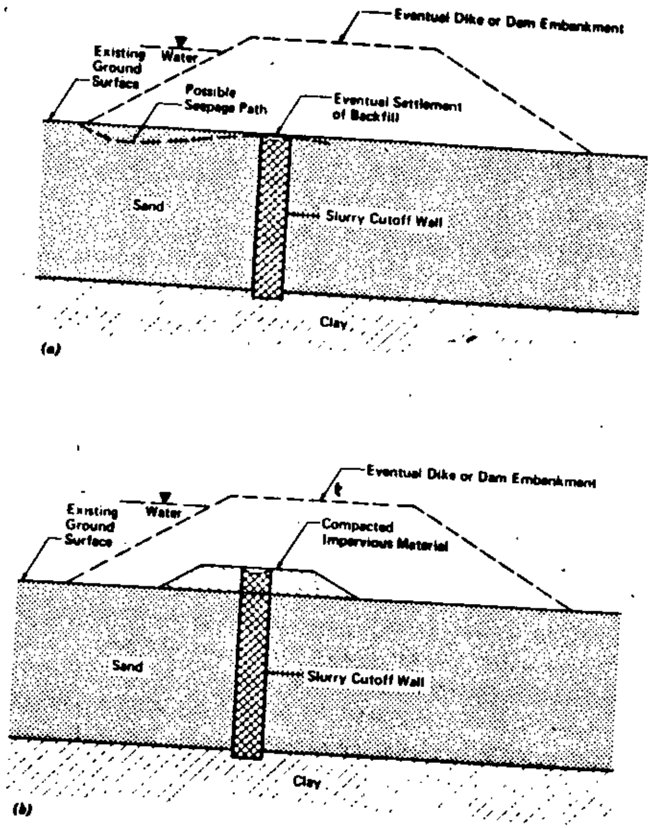
The initial backfilling procedure for a soil-bentonite cutoff wall requires that the soil-bentonite mixture be placed by a tremie process in the slurry-stabilized cutoff trench. The initial process continues until sufficient material has been placed in the excavation to permit the backfill material to become exposed at the top of the trench. Standard practices with regard to tremie should be maintained. Backfill also has been successfully tremied with a clamshell bucket.

After exposure of the backfill material at the top of the trench, the remainder of the backfill is pushed with a dozer onto the exposed backfill at the top of the slurry wall. Free fall through slurry is not permitted. Pushing the backfill forces the material to slide down into the trench under its own weight. This process is continued until the entire excavation has been backfilled. Typical slopes of the backfill surface during the backfilling process range from 5:1–10:1; the slope depends upon the slump of the backfill material and the gradation of the material involved. The higher the slump and the more uniform the gradation, the greater or flatter the slope of the backfill surface will be. A low slump and a coarse grade of material reversely will have the steepest slopes. Of course, the steeper the slope and the lower the slump, the greater the possibility of trapping sediment, partially excavated material, or fluid slurry in the cutoff wall.

Connection Detail with Surface Structures

Fig. 2 demonstrates the application of a soil-bentonite cutoff wall beneath a dam or dike embankment. It is important to recognize in the engineering application of cutoff walls that there will be some settlement and consolidation of a soil-bentonite cutoff wall. Fig. 2(*a*) presents a typical application of a slurry wall in such a circumstance. Note that if proper connection details are not carried out, there is potential for a seepage path to develop, due to consolidation of the backfill material, at the top of the soil-bentonite cutoff wall. However, a simple construction detail of forming an impervious dike, which probably would be needed to provide a working platform for the construction of the slurry wall anyway [see Fig. 2(*b*)], reduces the potential risk for such a seepage path to develop. Considerations such as this connection detail are a fundamental part of proper application of slurry wall cutoffs.

Deformability.—It is important to recognize that under major dam embankments up to 10% foundation strain may occur and that slurry cutoff walls must be capable of sustaining such high levels of deformation without cracking or failing. This is significantly different than conditions typically faced by diaphragm walls. A major factor which controls the deformability of the cutoff wall is the cutoff material properties. The following consideration is thus separated into the two types of basic material, i.e., soil-bentonite and cement-bentonite.



IG. 2.—Connection Detail for Soil-Bentonite Slurry Trench Cutoff Under Embankment

Soil-Bentonite.—As considered briefly with regard to backfill slope and ermeability, backfill strength is effected by gradation and slump of the backfill aterial. The coarser the gradation of the backfill, the more rigid and firm e eventual performance of the wall. Conversely, the greater the slump, the ore flexible the wall will be with respect to potential deformations. With regard soil-bentonite walls, however, it is suggested that when specifying a reasonable idation of coarse to fine material and a slump of 4 in.–6 in. (100 mm–150 n), there is little problem with deformation or cracking. Consequently, in ieral, it can be said that soil-bentonite walls are quite deformable and typically not have problems with regard to cracking.

Cement-Bentonite.—The factors which effect the deformability of cement-bentonite slurry trench cutoff walls are the cement-water ratio and the bentonite-water ratio. Significant laboratory testing has been carried out to relate the cement-water ratio and, to a lesser degree, bentonite-water ratio to the deformability (without cracking) of various cement-bentonite mixtures. It has been determined that the higher the strength, i.e., the higher the cement-water ratio, the stiffer, more

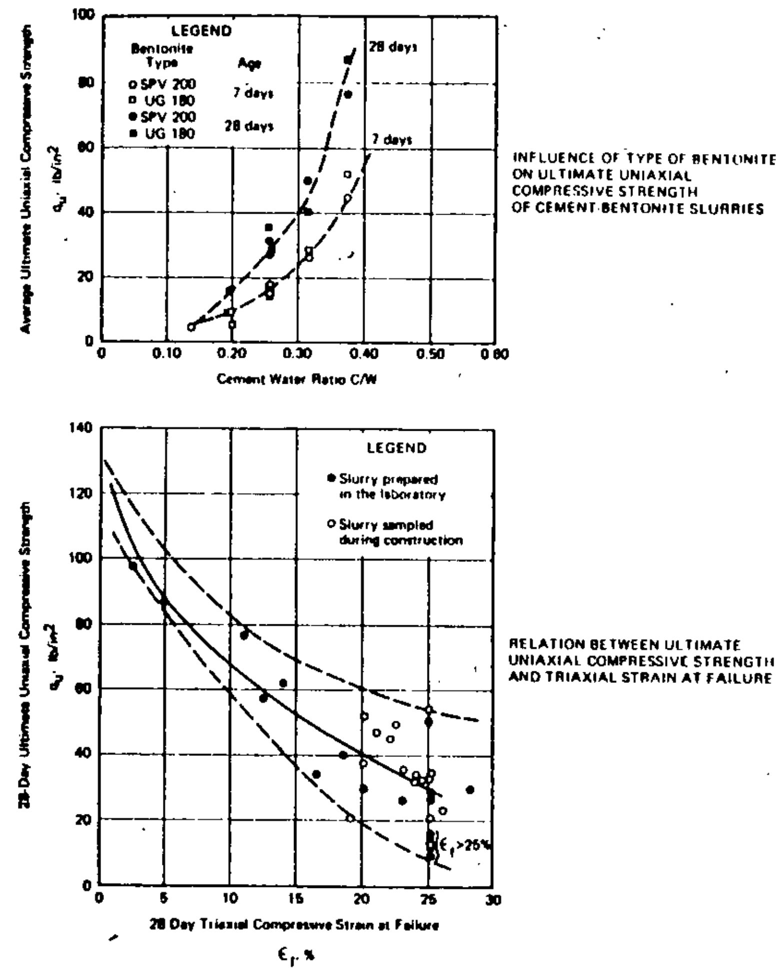


FIG. 3.—Typical Strength Deformability Tests for Cement-Bentonite Slurries

rigid, and thus, less deformable, the eventual cement-bentonite wall. Correspondingly, investigation of the bentonite-water ratio indicates that the higher the bentonite-water ratio, the more flexible, the more deformable the wall may be. Fig. 3 presents a summary of typical test results for a particular application of a cement-bentonite wall. It can be seen from this plot that the cement-water ratio has a dramatic effect on deformability of the cement-bentonite backfill.

In this particular case, a 10% deformation was required. Because of the more complex relationships that must be evaluated in the application of a cement-bentonite slurry trench cutoff wall, more sophisticated testing may be required on a specific project basis to ensure the desired end result will be obtained.

Permanence.—The use of slurry trench cutoff walls may or may not have a permanent application. If a slurry cutoff wall is used around an excavation to provide a temporary dewatering expedient, then the life of the wall may be only on the order of 1 yr–2 yr. If, on the other hand, the slurry wall cutoff has been applied as a cutoff or seepage barrier beneath a dam or pollutant containment pond, then of course the slurry wall must last for the life of the structure.

Under normal environmental and geotechnical conditions, properly constructed soil-bentonite and cement-bentonite backfilled slurry walls can be considered permanent structures.

Continued research is being carried on by the bentonite producers to develop bentonites that may be used in corrosive environments and, thus, provide permanence even under severe environmental conditions. For specific applications of bentonites for anomalous or corrosive ground water, soil conditions, or containments, it is important that the correct type of bentonite be specified. In this regard, it is recommended that advice and consultation be obtained from bentonite producers.

Construction Quality Control/Quality Assurance

It is often required, in specifications, that the contractor be made responsible for running basic quality control tests on the various specified control points, i.e., viscosity of the slurry, density of the slurry, slump of the backfill material, etc. This testing is usually reported on a periodic basis, typically daily. Depending upon the size, volume, and scope of the project, the number of tests should be delineated.

In addition to the contractor's quality control, it is strongly recommended that the owner and engineer provide, through a geotechnical organization, construction quality assurance. This is especially true if the engineer/owner are not familiar with slurry walls and their applications. Such geotechnical quality assurance services would include spot testing of the appropriate specified criteria, i.e., again, slurry viscosity, slurry density, slump of backfill, concrete slump, depth of trench, proper tie-in with aquiclude or bearing stratum, verticality, cleaning of trench bottom, etc. The frequency of the spot checks and spot testing would be dependent upon, again, the volume and production of work and the discrepancy, if any, between spot checks and the contractor's quality-control testing. Such an independent quality assurance organization provides the owner with the necessary controls over the desired products and criteria that had been established in the specifications. It should be emphasized that there should not be items in the specifications that require quality control if these items are not, in fact, important to the end results or desired objective of the construction. In other words, quality control and quality assurance should be specified only for those items that truly have an effect on the desired end product.

Conclusions

There are many and varied applications for the use of slurry diaphragm and slurry cutoff walls. Their full application and exposure has not yet been developed in the United States. Because of this fact, the specialty contractors who have engaged in slurry wall construction efforts overseas and to a limited extent in the United States have developed a degree of expertise above that of owners and architect/engineer firms. Consequently, owners and architect/engineers are faced with a process in which they must establish specifications for work in which the specialty contractor is the expert. This can lead to rather awkward contract specifications and relationships, and can often result in specifications that require unnecessary controls and limitations which only generate additional cost and add nothing to the technical superiority of the wall or cutoff. It is important, therefore, that in preparing specifications for a slurry wall, a thorough understanding of the desired end result is maintained and only those specific criteria that effect the end result be addressed and controlled by the specifications.

It is important to recognize that there are many portions or applications of slurry wall work where truly an end-result specification may be appropriate. However, the application of end-result specifications in the present practice is a long way off until the owners and engineers gain a more thorough understanding and knowledge of the technical and construction procedures involved in slurry trench work.

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16458 SLURRY WALL SPECIFICATIONS

KEY WORDS: **Design criteria; Objectives; Permeability; Quality control; Slurry excavation; Slurry trenches; Specifications; Subsurface structures**

ABSTRACT: The critical design criteria and the resulting specifications for slurry trench diaphragm walls and cutoff walls are discussed. To establish diaphragm and cutoff slurry wall design criteria and specifications, the designer must clearly establish the objectives or end results that are to be obtained, and shape his specifications accordingly. There are many portions or applications of slurry wall work where truly an end-result specification may be appropriate. However, the application of end-result specifications in the present practice is a long way off until the owners and engineers gain a more thorough understanding and knowledge of the technical and construction procedures involved in slurry trench work.

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JOURNAL OF THE CONSTRUCTION DIVISION

Applications of Slurry Walls in Civil Engineering

By Safdar A. Gill,[1] F. ASCE

Introduction

The use of slurry walls (also called diaphragm walls) for civil engineering projects has increased tremendously during the last two decades. The technique was developed in the post-war years in Europe and has spread steadily all over the world since then. Less than two decades ago, there were just a few specialist contractors in slurry wall construction. They still dominate the field but experience is spreading among the foundation contractors many of whom are listing slurry wall construction as one of their specialties. Popularity of slurry walls can also be judged from the number of conferences held on the subject in the past few years devoted to techniques (1,8,25,26.) Conferences have also been held by the dealers of slurry wall equipment to familiarize contractors with the different types of products, and the engineering community about the applications of slurry walls. Each of the recent International Conferences on Soil Mechanics and Foundation Engineering contains several papers on slurry walls and slurry trenches. Certainly the slurry wall technique fits into the category of an outstanding innovation in below-ground construction.

The slurry wall technique is still relatively new and remains a mystery to many engineers and contractors. This paper covers some of the applications of the slurry wall system for a variety of projects. The examples will show the immense versatility of the system for good ground conditions as well as for difficult subsoils. A brief description of construction procedures and design principles is also given. The purpose of the paper is to examine the use of slurry walls for underground construction, for situations where no other system would have been feasible or economically competitive.

Note.—Discussion open until November 1, 1980. To extend the closing date one month, a written request must be filed with the Manager of Technical and Professional Publications, ASCE. This paper is part of the copyrighted Journal of the Construction Division, ASCE. This paper is part of the copyrighted Journal of the Construction Division, Proceedings of the American Society of Civil Engineers, Vol. 106, No. CO2, June, 1980. Manuscript was submitted for review for possible publication on December 13, 1978.

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The concrete for the slurry wall is usually
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tremieing could also create pockets and void

Design Principles

The design of a slurry wall must conside
and the final requirement for the complete
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which will have one side exposed will be subj
Besides soil conditions (4,16), lateral press
upon the bracing system, sequence of exca
of the bracing. Walls have been designed for
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modified by experience of the designers (12)
walls in a variety of soils have shown soi
and Peck empirical diagram for braced cuts
is most commonly used. The contract docume
Area Transit Authority Subway System, and
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slurry wall support system. Water pressures
even in the case of cohesive soils since, c
that full hydrostatic pressures would act b
of a circular shaft where no yielding of the
be based on at-rest pressures. There are no
for such walls to suggest using a different pr
Stability of the slurry trench during excava
consideration. Ground-water level has the gr
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formation of a filter cake on the walls of
in stabilizing the trench. For this, the just m
Using conventional stability analyses, the
as the Rankine active pressures. The main
the hydrostatic pressure of the slurry. A mere
with the inside pressures would in most cas
In spite of research study as well as field obs
are still not fully understood. The panel lengt

arching effects and reduce outside pressures. The effect of arching can be considered by using the method suggested by Piakowski and Kowalski (20) and by Huder (14).

A review of the stability investigations by several authors suggest that a slurry trench remains stable if the computed hydrostatic pressure of the slurry inside the trench is greater than 65%–80% of the outside pressures (2). It is believed that the remaining stability is imparted by such incalculable forces such as gel strength, resistance of the filter cake, electric potential between the slurry and the soil, dynamic gradient of slurry flowing into the soil, rigidity imparted to the slurry by the bentonite as well as by the suspended cuttings, the effect of permeating slurry on the soil strength, etc. Several theories of trench stability have been proposed by different authors in an attempt to theoretically verify observed stability of slurry trenches (2). However, with the present state of knowledge, these methods can only be used as guides. Slurry trenches have been found to be stable even in situations where these theories would predict instability. On the other hand, collapse of the trenches has been observed where most conservative computations would show stable conditions.

In actual practice, sophisticated analyses are rarely done and reliance is placed on experience in similar soil and ground-water conditions. When faced with unstable conditions, adjustments are made in the construction procedures, level and density of the slurry, length of the panels, and in the shape and type of cutting tools. The presence of artesian water pressure, large gravel and boulders, very loose soils, soft clays, recently placed hydraulic fill with undissipated pore pressures, and sudden changes in the soil strata are potential conditions of instability and require careful consideration prior to deciding upon the construction procedures. For conditions of high ground-water table and for artesian pressures, the remedial measures include lowering of the water table by deep wells or well points or increasing the working platform level to maintain a higher level of slurry.

Surcharge loads become more important when the slurry wall is located close to existing footings; the settlement of the structure supported thereon is also important. Such a case occurred recently at one of the station excavations for the Baltimore Subway System. The slurry wall was placed so close to the existing structures that some of the footings will require to be cut off by as much as 23%. Analysis of the slurry wall stability during the excavation was performed by considering the effect of soil arching as suggested by Piakowski and Kowalski (20). In spite of the minimum practical length for slurry wall panels, it was necessary to improve the soils by grouting to a depth of about 15 ft (4.6 m) below the footings to get adequate safety factor against caving of the trench walls.

Applications of Slurry Walls

Slurry walls have been used for a variety of civil engineering projects and their potential use is routinely investigated in underground construction projects when: (1) There is likely to be a ground-water problem; (2) adjacent structures have to be protected against settlement; (3) noise from sheetpile driving is not acceptable; and (4) the excavation has to extend through difficult soils. The following examples consider some of the applications of slurry walls.

Cutoff for Controlling Seepage

Slurry wall and trench cutoff walls have been used extensively for controlling seepage from under dams, navigation locks, and excavation for pumping stations and power plants. Such walls have been constructed to depths of over 200 ft (61 m) through a variety of soil conditions, in granular soils, rocky formations, through cavernous formations (5), through soils containing very large boulders, etc. For the construction of the second powerhouse at Bonneville Dam on the Columbia River near Portland, Oreg., the Portland District of the U.S. Army Corps of Engineers designed a 2-ft (61-cm) thick concrete slurry wall for control of ground water into the power station excavation (23). This slurry wall extends through formations of old landslides that contain extremely large rock chunks, gravel, and sands. No other method of seepage control would have been economically practical at the site. The wall has been very effective in preventing seepage into the power station excavation.

Wolf Creek Dam on the Cumberland River in Kentucky presented a very difficult situation where the slurry wall method was used to install a cutoff to arrest seepage from under the dam (6). Excessive seepage through the limestone foundation of the 200-ft (61-m) high rolled earthfill embankment threatened its safety. A detailed subsurface investigation revealed large caverns in the foundation limestone. Test grouting showed installation of a grout curtain to be impractical. The slurry wall method was the only feasible method for constructing a cutoff and a very ingenious system consisting of circular elements and intermediate panels was utilized. This was the first time that a slurry wall was installed through 200 ft (61 m) of earth embankment and extending 80 ft (24 m) into the foundation rock (full of caverns and solution channels) while maintaining a high reservoir pool. Similar systems of circular elements and intermediate panels were used for cutoff at Manicougan Dam in Northern Quebec, Canada.

In the case of slurry trench cutoffs, which has been used extensively by the U.S. Army Corps of Engineers in the Mississippi Delta, the excavated soil blended with granular materials or imported granular materials impregnated with bentonite slurry is backfilled into the trench. The cutoff function is provided by this backfill and by the filter cake formed on the sides of the trench. Slurry trenches more than 5 ft (152 cm) thick and as much as 10 ft (305 cm) are not uncommon for deep excavations. Tests conducted in conjunction with the slurry trench under Wanapum Dam showed a gradient of 34.6 caused rupture of the filter cake (17). In the actual design a safety factor of approx 4 was provided. For proper functioning of the slurry trench cutoff, the gradation of the backfill material is important. Backfill of clay materials causes segregation with consequent future settlement at which time the filter cake could be damaged and render the slurry trench defective.

Backfill for cutoff trenches may consist of cement-bentonite mixture which solidifies to attain a low strength (comparable to soil strength) plastic backfill. Cement solution may be introduced into the bentonite slurry after the excavation or the mixture may be used as the slurry during the excavation. A special patented method for constructing shallow cutoffs to about 50 ft (15 m) is the so-called "vibrating beam" method. This method results in a thin cutoff approx 4 in. (10 cm) thick made of cement-bentonite mixture.

Construction Shafts

Slurry walls have been used for the construction of deep shafts in conjunction with mine shafts, pumping stations, and deep tunnels. Two of the construction shafts for the Metropolitan Sanitary District of Greater Chicago Deep Tunnel Project were constructed utilizing slurry walls. In the latest construction completed in 1978, the round shaft 34-ft (10.4-m) clear inside diam, 73 ft (22.3 m) deep,

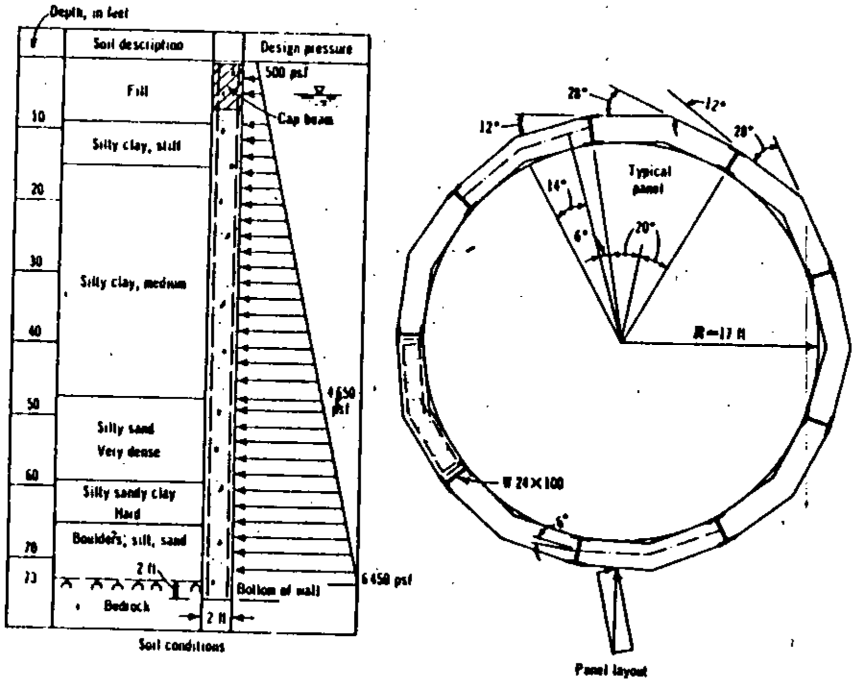

FIG. 1.—Construction Shaft Slurry Wall

was replaced with a polygon of 18 sides. Each panel consisted of two sides of the polygon. As previously mentioned, such walls are not likely to yield to mobilize active pressure and thus, the walls were designed for the at-rest pressure conditions as shown on Fig. 1. The joint between the panels consisted of wide flange sections. Complicated joints with continuous reinforcement through the panel junctions were not considered necessary as the compressive thrust from the outside pressures would keep the joints tight. Excavation inside the shaft proceeded rapidly and no seepage occurred through the joints, even though the shaft was located within 35 ft (10.7 m) of a river (see Fig. 2).

Although an equivalent circle through the 25-in. (63-cm) thick concrete walls would show that the thickness provided is adequate to resist the compressive

thrust considering a circular ring, horizontal reinforcement in the panels was designed for a simple beam supported at the junctions. Since hydrostatic pressure acts at right angles to the face of the wall, it is desirable to keep the panel length small to reduce the bending moment. In order to further reduce the bending moment in the panels, different angles were provided in the panels as shown in Fig. 1. The possibility of unequal surcharge loadings on the surface as well as the possibility of failure of the adjoining dock wall, was also investigated by considering the shaft as a tube cantilevering from the base. A reinforced concrete ring beam at the top was designed to prevent slippage of the joints from bending due to the unequal pressures.

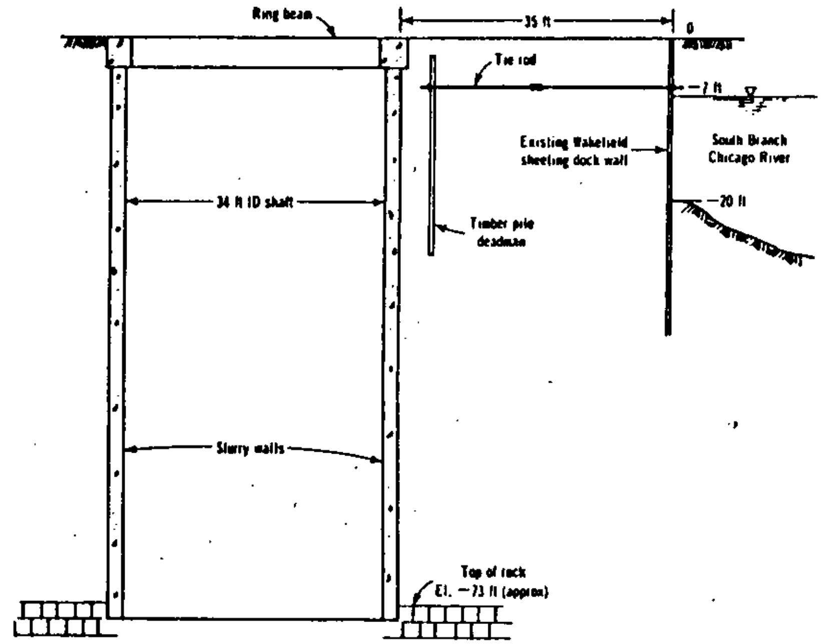

FIG. 2.—Location of Construction Shaft

The slurry wall will serve as the permanent lining for the shaft and it proves economically attractive when taking into account the elimination of temporary support of excavation, the difficult ground-water control, and delays in the construction of permanent lining.

Foundation Pits

A slurry wall, 62 ft (18.9 m) deep, was utilized for the construction of a 44-ft (13.4-m) deep foundation for a large press in Memphis, Tenn. The structure was located within an existing plant in wet, sandy soils. The use of slurry walls permitted relatively large spacing between the bracing levels to suit the machinery to be installed within. The top level of bracing consisted of a cap beam 2.5 ft (76 cm) thick and 6 ft (183 cm) deep which also served to connect all of the panels. Slurry walls, 25 ft (7.6 m)–54 ft (16.5 m) deep, 32 in. (81 cm) thick, were used for the walls of an access tunnel and hopper at a steel mill complex in El Hadjar, Algeria. The wall extended through an artesian formation into underlying clays and permitted excavation of the tunnel without water seepage problems.

The use of slurry wall for a deep sewage pump station near Portsmouth, N.H. in difficult ground conditions is described in Ref. 24. In this case also, the top level bracing consisted of a reinforced concrete ring beam at the top. The bottom slab was constructed by utilizing a system of dewatering from

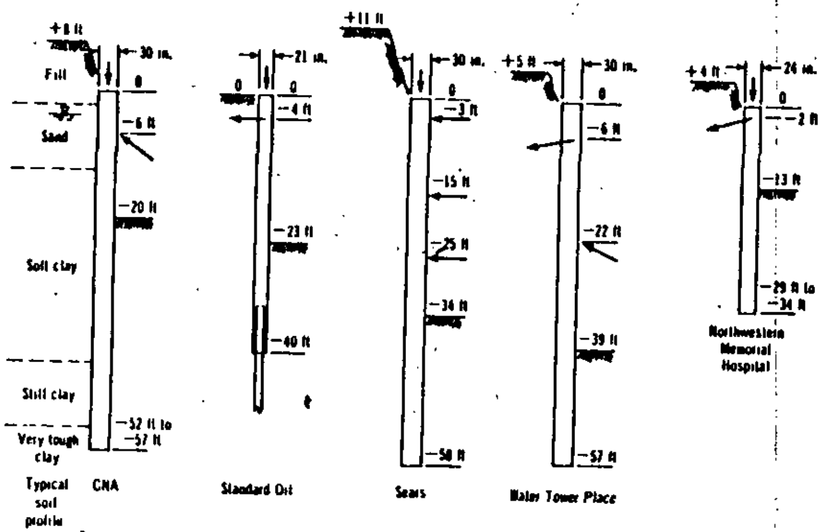

FIG. 3.—Slurry Walls for Buildings in Chicago

a gravel layer placed beneath a 4-ft (122-cm) thick tremie seal. Multisided slurry walls have been used in replacement for circular shafts at many locations.

Bridge Foundations

A slurry wall system was utilized for the Barton anchorage of the Humber Bridge in England (15). Cellular blocks were created by the slurry walls and it permitted excavation in each cell and construction of the structure within, without allowing for the heave expected in the underlying Kimmeridge clay.

Basement Walls

Slurry walls have been extensively used for basement walls both as load bearing elements and as the perimeter wall for earth retention and ground-water control. In the Chicago area, slurry walls have been used for the Sears Tower, the Water Tower Place, the Standard Oil Building, the CNA Building, the

Northwestern Memorial Hospital Addition, (Fig. 3) and recently for the Provident Hospital Addition and for the Westinghouse School.

In the case of the Standard Oil Building, only a 21-in. (53-cm) thick wall, *40 ft (12.2 m) deep, was used and it was supported on steel H Piles of 150-ton* capacity driven into hardpan soils. The piles were driven through the trench full of slurry and no detrimental effects were observed on trench stability from the pile vibrations. It was the first time that a slurry wall was utilized to serve as a pile cap (22). The slurry wall was laterally supported by a deadman anchor outside the excavation at the top. Although the bottom of the wall stopped in soft clay with a shear strength of about 700 psf (33.5 kN/m^2) and according to the classical theory, passive pressure was less than the active pressures for the entire embedded section of the wall, reliance for stability of the wall was placed on the resistance to lateral movement of the piles embedded in the wall. Inclinometer observations showed inward movements of the walls by about 1 in. (25 mm) below the excavation which extended to 23 ft (7 m) in a width of 50 ft (15.2 m) from the wall and to 34 ft (10.4 m) in the interior (7). Similar application of a slurry wall supported on piles was utilized for the basement wall at the First Wisconsin Center in Milwaukee, Wisc. Here again, piles driven through the slurry did not cause any instability of the trench walls.

For the Water Tower Place project, the slurry wall was constructed between the perimeter caisson foundations for the building. The connection of the slurry wall with a caisson was made through a sheetpile for which the female portion was welded to the steel shell around the caisson. Considerable difficulty was encountered to keep the interlock hole clean to permit placement of the male sheetpile section from the slurry wall. A greased cable was inserted in the interlocking hole to prevent contamination from the slurry as the panel was being excavated and the cable was then removed prior to inserting the sheeting section (13).

All of the previously mentioned slurry walls served as the permanent wall of the building basements and required little surface treatment. There have been no complaints of seepage through the joints or from elsewhere through the walls. Ground movements adjoining these excavations were insignificant compared with the settlements and displacements that would be common for excavations of similar depth utilizing the conventional sheeting and bracing.

Underpinning Alternative

Slurry walls have served effectively as an alternative to underpinning structure foundations adjacent to excavations (21). Ground movements during a bentonite supported excavation were measured for a test excavation in London clay as described by Farmer (10). These movements are quite small and less than the movements expected during the underpinning operation. Of course, the movements can be reduced by limiting the size of the panels opposite the foundations.

The movements in the ground adjoining an excavation supported by a slurry wall depend upon the bracing levels, the strut prestressing loads, and the depth of excavation below a strut level before the bracing system at that level is installed. The slurry walls are usually so stiff that elastic deformations between the levels of support are negligible. The major portion of the deformation occurs while the ground is excavated and prior to the installation of the bracing system.

With an internal bracing consisting of cross struts, the post installation elastic deformations of the strut would induce the corresponding movement in the wall. However, such deformations are also quite small. In the case of tie-back supported walls, observations of instrumented excavations have shown movements related to the prestressing and relaxation of the anchors (4,8,26). In any event, by proper construction sequence and good workmanship, ground movement adjacent to slurry walls can be minimized to limits tolerable by the structures. Composite slurry walls consisting of soldier piles and tremie concrete have been very effective in minimizing ground movements as shown by the application of this system during the Bay Area Rapid Transit Subway construction in the San Francisco area. The spacing of soldier piles reduces the panel length and thus, helps in the soil arching with consequently lesser ground movement.

The use of slurry walls in lieu of underpinning has recently been accepted by the authorities for large buildings as high as 23 stories and supported on footings with bearing pressures as high as 12,000 psf (57.5 N/mm^2), adjacent to a subway station in Baltimore, Md. The subway excavation will extend 30 ft-50 ft (9.1 m-15.2 m) below the base of the footings. It is proposed to use a composite slurry wall 24 in. (61 cm) thick, consisting of 24-in. (61-cm) wide flange beams at 3.5 ft (1.07 m) on centers with concrete in between. The wall will be built in 7-ft (2.13-m) panels. The most important consideration is the stability during excavation of the panels. To safeguard against undermining of the footings by excavating equipment or by a slip failure of the subgrade soils, chemical grouting was used to make the existing granular soils cohesive and stronger. The zone of grouting extended at least 15 ft (4.6 m) below the bottom of the footings and covered at least half the footing along the excavation. Stability analysis utilizing the conventional method has shown that the trench should be stable during the panel excavation. Additional precautionary measures such as predrilling for alternate soldier piles and supporting the heavily loaded footings from these soldier piles by brackets, is also contemplated.

Cut and Cover Tunnelling for Subways

Jobling (26) describes the use of slurry walls for the Heathrow Extension Subway in London, England. In this case, the slurry wall serves as part of the permanent structure. In this country, slurry walls have been used for excavation support on stations and deep excavations for the subway, but have not been utilized as part of the permanent structure.

Precast panels were used for several subway projects. Examples include A13 Motorway Extension in Paris (8), Paris Metro Extension and covered trench at Sevran, Paris, Stuttgart Subway, Moscow Metro and a transportation tunnel in Kyushi, Japan (18). The resulting wall has a smooth finish with tight joints. Any surface texture can be incorporated in the precast panels. The general use of prefabricated structural members for cut-and-cover tunnelling is described in detail by Martin, et al. (18). The advantages of utilizing slurry walls for cut-and-cover tunnels would equally be applicable to the cast-in-place concrete system. Same principles apply for highway underpass construction.

Quays and Dock Walls

The use of slurry walls for three large docks is described by Fisher (8).

Slurry walls were constructed in the form of cells and T shapes to resist pressures from a fairly deep dredge depth of 50 ft-92 ft (15.2 m-28.0 m). Post-tensioned ties were also utilized.

Slope Stabilization

A slurry wall system for stabilization of a slope along a street in Washington, D.C. was investigated utilizing the slurry wall system. Tight space conditions, and the fear of precipitating a slide from vibrations due to pile driving or from excavation for a retaining wall, favored the use of the slurry wall system.

Sewage Projects

Slurry walls can easily be adapted for large box culverts for the conveyance of waste water. The City of San Francisco, Channel Outfalls Consolidation project was designed to allow the use of slurry walls for the walls of a box culvert. The soil and ground-water conditions favored the use of slurry walls as the best choice.

Load Bearing Elements

Slurry walls in a variety of shapes can be used to serve as load-bearing elements for structures. Foundations for the United Nations city in Vienna utilized slurry walls in different shapes (8). Piles and caissons installed utilizing a slurry method are very common. Field observations and research studies have been conducted to determine the effect of bentonite on skin friction. Published information shows that skin friction is not reduced (3). However, in the case of sands, a reduction of 10%-30% is suggested.

During construction of the slurry walls for the Northwestern Memorial Hospital in Chicago, a 24-in. (61-cm) diam test pile was installed by the slurry method to determine skin friction in a 13-ft (4-m) layer of medium dense to dense sand. Loose hay was placed at the base of the pile to eliminate end bearing resistance. It was then load-tested to failure. Analysis of the data from this test showed average skin friction at failure of approx 2,200 psf (105.4 kN/m^2). A most liberal static analysis yielded average friction of 1,500 psf (17.9 kN/m^2). The test indicated practically no reduction of the skin friction value of the slurry constructed pile or caisson through sandy soils.

Miscellaneous Use

Slurry walls can be used to protect a structure from vibrations. An example of such a use was the slurry trench installed between a subway and a printing factory in Berlin (25). Slurry trench cutoffs are now increasingly used for containment of seepage from waste water ponds and leachate from landfills.

Conclusions

In this paper, some basic principles for the design and construction of slurry walls have been described. Versatility of slurry wall as a construction technique

TO: Sylvia Holloway

FROM: Hamilton S. Oven, Jr.

DATE: July 1, 1983

SUBJECT: Power Plant Siting Module

Pinellas County is going to be submitting an application for Power Plant Siting in the next two weeks. Please set up a new module. I believe the next available number will be 8188 for PPS-PA 83-18.