Corps of Engineers, Bureau of Reclamation, and
Tennessee Valley Authority



# RESUMÉ

# OF

# CONFERENCE ON RESEARCH ACTIVITIES

Denver, Colorado
August 1-3, 1961

Resume of Conference on Research Activities of Corps of Engineers, Bureau of Reclamation, and Tennessee Valley Authority

August 3, 1961

1. Introduction

The Corps of Engineers, the Bureau of Reclamation, and the Tennessee Valley Authority are concerned with the design, construction, and operation of dams and hydraulic works. Each agency is performing research investigations for the purpose of solving problems relating to this work. For many years there has been a free interchange of reports and technical information among these agencies. Nevertheless, it was felt that additional benefits would be derived from formal meetings, the first of which was held at the Waterways Experiment Station during the period May 9-12, 1960. The second meeting was held at the Laboratory of the Bureau of Reclamation during the period August 1-3, 1961.

2. Purpose

These meetings were held for the purpose of reviewing in detail the engineering research programs of each of the agencies, determining areas of mutual interest, and discussing and exchanging detailed information on these projects.

3. Agenda and attendance

Concurrent sessions were held over a period of 3 days in which projects on concrete, soil mechanics, hydraulics, and a variety of other subjects were reviewed and discussed. Attached is a copy of the agenda outlining the subjects and a list of those attending the meeting.

4. Accomplishments

Through these formally arranged discussions a more complete understanding of the research projects underway was gained by each organization. The meetings demonstrated that some improvement can be made in the interchange of information and it was emphasized that it would be desirable to have more frequent meetings of those involved in the details of individual research projects. The results of these meetings and the further contacts which are expected will be of benefit to each agency in planning and prosecuting future work.

5. Report of the meeting

This covering statement and the group summary reports which were presented at the last general session are the formal report of the meeting. Copies of this report will be made available to each participating organization.

6. Future meetings

Due to the nature of the research performed by the three interested agencies, it was the consensus of the group that better coordination of the research work would be attained by more frequent meetings of those involved in the details of the particular subject areas and that general meetings concerning all items of research for surveying the entire program can be profitably held at 2-year intervals. The TVA has invited the Corps and the USBR to meet with them in Knoxville, Tennessee, during October 1963, and it was the consensus of the meeting that the three agencies should meet then and accept the invitation of the TVA.

Appendices

1. Agenda for coordination meeting
2. List of conferees
3. Report of Hydraulics group
4. Report of Soil Mechanics group
5. Report of Concrete group
6. Report of General group

# AGENDA FOR COORDINATION MEETING
# CORPS OF ENGINEERS, TENNESSEE VALLEY AUTHORITY AND U.S. BUREAU OF RECLAMATION

Bureau of Reclamation, Denver Federal Center
Denver 25, Colorado
August 1-3, 1961

## Tuesday, August 1

**Session No. 1, Room 16, North Mezzanine, Building 56 (all attendants)**

| | |
|---|---|
| 8:00-8:30 | Registration and introductions |
| 8:30-8:40 | Welcome by Assistant Commissioner and Chief Engineer |
| 8:40-8:50 | Remarks by representative of Tennessee Valley Authority |
| 8:50-9:00 | Remarks by Director, Waterways Experiment Station |
| 9:00-9:10 | Review of total research activities of Bureau of Reclamation--nonreimbursable program; contracts with other institutions; design studies; computer services; technical library (Mr. Price) |
| 9:10-9:35 | Break |

**Session No. 2A (Hydraulics) Room 13**

| | |
|---|---|
| 9:35-11:45 | Introduction to program, and description of mission, functions, and organization of the Hydraulic Laboratory; detailed tour of the Hydraulic Laboratory, USBR (Mr. Martin) |
| 11:45-12:30 | Lunch |
| 12:30-3:00 | Group discussion on research projects, USBR, to determine the items of common interest |

a. Vertical stilling wells
b. Hydraulic jump and energy dissipators
c. Hydraulic characteristics of pipeline distribution systems and related structures
d. Air demand of gates and valves in outlets
e. Instrumentation for acquiring and recording hydraulic data
f. Specifications finishes and tolerances for irregularities and misalinements in concrete surfaces subjected to high-velocity flow
g. Crest and transition section for morning-glory spillways
h. Radial gate studies
i. Canal capacity studies

j. Development of small canal structures
k. Sediment studies
l. Water measurement studies
m. Lower-cost canal lining hydraulic studies

3:00-4:00 Tour of Automatic Data Processing Branch; Technical Library; Network Analyzer

Session No. 2B (Soils) Room 14

9:35-11:45 Introduction to program, and description of mission, functions, and organization of the Earth Laboratory; detailed tour of the Earth Laboratory, USBR (Mr. Holtz)

11:45-12:30 Lunch

12:30-3:00 Group discussion on research projects, USBR, to determine items of common interest

a. Field sampling and in-place testing
b. Properties of gravelly soils
c. Shear, consolidation, and pore pressure of cohesive soils
d. Field performance of structures
e. Buried pipes and conduits
f. Petrographic characteristics of soils
g. Erosion and tractive forces studies
h. Subsidence of soils upon initial wetting
i. Characteristics of fills carrying canals and problems related to canals
(continued in 3B)

3:00-4:00 Tour of Automatic Data Processing Branch; Technical Library; Network Analyzer

Session No. 2C (Concrete) Room 16

9:35-11:45 Introduction to program, and description of mission, functions, and organization of the Concrete Laboratory; detailed tour of the Concrete Laboratory, USBR (Mr. Higginson)

11:45-12:30 Lunch

12:30-3:00 Group discussion on research projects, USBR, to determine items of common interest

a. Concrete research
b. Cement and pozzolan research

c. Structural research
d. Prototype analysis--structural behavior of concrete structures

3:00-4:00 Tour of Automatic Data Processing Branch; Technical Library; Network Analyzer

Session No. 2D (General) Room 15

9:35-11:45 Introduction to program, and description of mission, functions, and organization of the Chemical Engineering Laboratories; detailed tour of the Chemical Engineering Laboratories (Mr. Ellsperman)

11:45-12:30 Lunch

12:30-3:00 Group discussions on research projects, USBR, to determine items of common interest

a. Hydrology
b. Limnological studies
c. Bituminous materials
d. Plastic materials
e. Joint and crack sealers
f. Protective coatings used on masonry, concrete, metals and wood
g. Steel pipe lining
h. Corrosivity of soils and waters
i. Cathodic protection
j. Evaporation reduction
k. Chemical soil sealants
l. Engineering applications of radioisotopes

3:00-4:00 Tour of Automatic Data Processing Branch; Technical Library; Network Analyzer

Wednesday, August 2

Session No. 3A (Hydraulics) Room 13

8:00-10:30 Group discussion on research projects of Corps of Engineers to determine items of common interest

a. Review of progress on Hydraulic projects of mutual interest since last meeting
b. Energy loss of flow over spillways
c. Wave forces on crest gates
d. Detroit large scale tests



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e. Criteria for riprap protection
f. Channel stabilization problems
g. Channel deterioration downstream of reservoirs
h. Analysis of vortex formation
i. Garrison power plant transient tests
j. Design of low navigation dams
k. Lock design and associate problems
l. Design criteria for inland waterways
m. Wave action problems pertaining to harbor and breakwater design
n. Tidal estuaries

10:30-11:45 Group discussion on research projects of Tennessee Valley Authority to determine items of common interest

a. Turbulence
b. Development of lock filling and emptying systems
c. Simplification of locks for tributary streams
d. Measurement of turbine discharge for turbine settings with very short penstocks
e. Density currents

11:45-12:30 Lunch

12:45-1:15 Continuation of group discussions on research projects, TVA, to determine items of common interest

f. Hydraulic downpull on turbine emergency closure gates
g. Metering of large air flows
h. Strain gage measurements of strut pulls on emptying and filling valves of locks and lower miter gate to supply data for computing horsepower requirement for future locks

1:15-4:00 Preparation of Hydraulics Group Report

Session No. 3B (Soils) Room 14

8:00-9:00 Continuation of group discussion on research projects, USBR, to determine items of common interest

i. Performance studies of earth canals
j. Soil stabilization

k. Riprap studies
l. Improvements in soils laboratory testing procedures and equipment

9:00-11:45 Group discussion on research projects, Corps of Engineers, to determine items of common interest

a. Review of progress on Soils projects of mutual interest since last meeting
b. Evaluation of Soil Mechanics Laboratory Equipment (CW 520)
c. Laboratory Test Manual (CW 520)
d. Three-dimensional Electrical Analogy Seepage Model Study

11:45-12:30 Lunch

12:30-1:15 Group discussion on research projects, Tennessee Valley Authority, to determine items of common interest

a. Shear and friction test in place on horizontally bedded limestone with weak bedding planes and shale seams.
b. Prototype measurements of uplift and pore pressures in locks
c. Evaluation of measured foundation drainage and uplift pressures in dams as it affects maintenance of these structures

1:15-4:00 Preparation of Soils Group Report

Session No. 3C (Concrete) Room 16

8:00-9:00 Continuation of group discussion on research projects, USBR, to determine items of common interest

e. Rock foundations
f. Miscellaneous

9:00-11:45 Group discussion on research projects, Corps of Engineers, to determine items of common interest

a. Review of progress on Concrete projects of mutual interest since last meeting
b. Correlation between behavior in service in concrete and laboratory evaluation of aggregates (CW 602)



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c. Normal variation in test results between different laboratories
d. Testing similar samples of aggregates (CW 602)
e. Study of mechanisms involved in sand-gravel concrete deteriorations (CW 603)
f. Affect of variation of grading of coarse aggregate on properties of concrete (CW 617)
g. Affect on temperatures gradients in concrete from use of bulkhead insulation (CW 620)
h. Capping of high strength concrete cylinders (CW 622)

11:45-12:30 Lunch

12:30-1:15 Group discussion on research projects, Tennessee Valley Authority, to determine items of common interest

a. Exploratory investigation of portland-pozzolan cement using TVA fly ash
b. Treatment of horizontal construction joints in mass concrete
c. Use of high-strength reinforcing steel
d. Investigation of composite design of superstructure floor slabs using metal decking in place of precast slabs
e. Investigation of the ultimate-strength method of design of concrete structures

1:15-4:00 Preparation of Concrete Group Report

Session No. 3D (General) Room 15

8:00-9:00 Continuation of group discussion on research projects, USBR, to determine items of common interest

m. Reservoir area clearing
n. Power
o. Weed control in floodways, waterways, canals and reservoirs
p. Saline water demineralization

9:00-11:45 Group discussion on research projects, Corps of Engineers, to determine items of common interest

a. Review of progress on General items of mutual interest since last meeting

11:45-12:30 Lunch

12:30-1:15 Group discussion on research projects, Tennessee Valley Authority, to determine items of common interest

a. Remote control of hydro plants
b. Corrosion mitigation
c. Development of computer programs for engineering analysis and operating studies
d. Development of specification tests for greases

Power

e. Determination of minimum cable stock for generating plants
f. Field drying of transformers
g. Analysis of gases in power transformers as an indicator of transformer condition
h. Corona effects on insulation
i. Transmission line construction using a helicopter

1:15-4:00 Preparation of General Group Report

Thursday, August 3

Session No. 4 (all attendants) Room 16

8:00-9:00 Presentation of Group Reports

Hydraulics
Soils
Concrete
General

9:00 Closing Session

Critique
Plans for report of meeting
Plans for interim exchange of information
Plans for next meeting



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9:45 Closing Remarks

Representative, Corps of Engineers
Representative, Tennessee Valley Authority
Representative, Bureau of Reclamation

10:00 Adjourn

LIST OF CONFEREES
RESEARCH COORDINATION MEETING, BUREAU OF RECLAMATION,
CORPS OF ENGINEERS, TENNESSEE VALLEY AUTHORITY
DENVER FEDERAL CENTER
AUGUST 1-3, 1961

U.S. Bureau of Reclamation

From Washington, D.C.

W. D. Denit, Assistant Commissioner, Administration
T. W. Mermel, Chief, Division of General Engineering

From Denver, Colorado

Grant Bloodgood, Assistant Commissioner and Chief Engineer
Walter H. Price, Chief Research Engineer
M. E. Trenam, Chief Construction Engineer
Graydon E. Burnett, Assistant Chief Research Engineer
E. V. Lindseth, Assistant Chief Designing Engineer
H. S. Riesbol, Chief, Hydrology Branch
M. H. Kight, Chief, Electrical Branch
E. C. Higginson, Chief, Concrete Laboratory Branch
D. S. Campbell, Chief, Maintenance Engineering Branch
H. M. Martin, Chief, Hydraulic Laboratory Branch
J. Parmakian, Chief, Technical Engineering Analysis Branch
W. G. Holtz, Chief, Earth Laboratory Branch
L. M. Ellsperman, Acting Chief, Chemical Engineering Laboratory Branch
L. P. Witte, Assistant Chief, Concrete Laboratory Branch
J. E. Backstrom, Head, Properties of Concrete Section
G. B. Wallace, Head, Concrete Materials and Structural Section
L. J. Mitchell, Concrete Laboratory
L. C. Porter, Concrete Laboratory
R. J. Elfert, Concrete Laboratory
O. J. Olsen, Concrete Laboratory
H. F. Avery, Concrete Laboratory
P. W. Lewis, Head, Protective Coatings Laboratory Section
P. R. Tramutt, Acting Head, Analytical Laboratory Section
H. J. Cohan, Head, Saline Water Demineralization Laboratory Section
L. O. Timblin, Head, Physical Investigations Laboratory Section
M. E. Hickey, Acting Head, Bituminous Laboratory Section
T. R. Bartley, Head, Weed Control Laboratory Section
E. J. Benton, Petrographic Laboratory Section
W. Y. Holland, Head, Petrographic Laboratory Section
C. E. Selander, Protective Coatings Laboratory Section
S. Rubenstein, Petrographic Laboratory Section

H. J. Gibbs, Head, Special Investigations and Research Section, Earth Laboratory
A. A. Wagner, Head, Physical Properties Testing Section
C. W. Jones, Earth Laboratory
J. Merriman, Earth Laboratory
W. Ellis, Earth Laboratory
A. J. Peterka, Head, Hydraulic Investigations Section
J. W. Ball, Head, Hydraulic Structures and Equipment Section
W. E. Wagner, Hydraulic Laboratory
J. C. Schuster, Hydraulic Laboratory
E. J. Carlson, Hydraulic Laboratory
S. M. Denton, Head, Power and Pumping Plant Section
D. C. Millard, Head, Transmission Plant Section
F. R. Schleif, Power Operations

## Corps of Engineers

From Washington, D.C.

Wendell E. Johnson, Chief, Engineering Division, Civil Works
J. A. Douma, Chief, Hydraulics Branch
R. A. Barron, Assistant Chief, Soils Branch
W. R. Waugh, Chief, Concrete Branch

From Waterways Experiment Station

Colonel E. H. Lang, Director, Waterways Experiment Station
J. B. Tiffany, Technical Director
F. R. Brown, Hydraulics Division
J. R. Compton, Soils Division
T. B. Kennedy, Chief, Concrete Division
Bryant Mather, Concrete Division

## Tennessee Valley Authority

J. R. Barnwell, Assistant Chief, Electrical Laboratory and Test Branch, Division of Power System Operations
W. E. Dean, Chief, Research Staff, Office of Power
Rex A. Elder, Head, Hydraulic Operations and Tests Section, Division of Water Control Planning
Nathan E. Way, Assistant to the Chief Engineer

Appendix 3

# REPORT OF HYDRAULIC GROUP

August 3, 1961

## INTRODUCTION

The Hydraulic Group met on August 1-2 at the times prescribed on the agenda for the coordination meeting. The following attended all sessions:

Mr. J. H. Douma, OCE

Mr. F. R. Brown, WES

Mr. R. A. Elder, TVA

Mr. H. M. Martin, USBR

Mr. J. W. Ball, USBR

Mr. E. J. Carlson, USBR

Mr. J. C. Schuster, USBR

Mr. W. E. Wagner, USBR

Mr. J. B. Tiffany, WES, J. Parmakian, USBR, and O. J. Olsen, USBR, attended part of the sessions.

To determine items of common interest, and to prevent duplication of effort by Corps, TVA, and USBR, group discussions were held on all research subjects listed in the agenda. As a result of these discussions, it was determined that certain items of research are being actively pursued by all three organizations, whereas other subjects are being investigated by one or two agencies. Following the procedure established at the 1960 meeting in Vicksburg, the subjects were placed in the following categories:

1. Subjects pursued by two or more organizations
2. Subjects pursued by USBR only
3. Subjects pursued by Corps only
4. Subjects pursued by TVA only

The basis for separating the subjects in this manner was active participation by an organization in the current year. Because of the complexity of fluid flow and the continual search for practical solutions to hydraulic design problems, most of the subjects are of mutual interest to two or more of the organizations, even though an organization is not actively working on a specific item. Each of the four categories is discussed separately below.

## SUBJECTS PURSUED BY TWO OR MORE ORGANIZATIONS

### 1. Hydraulic Characteristics of Vertical Stilling Wells

The Corps is investigating the vertical placement of a standard pipe for use as an energy dissipator at storm drainage outfalls under comparatively low heads. Incoming pipes are on slopes from 1 on 1 to 1 on 4. The USBR is conducting tests on vertical stilling wells, rectangular and circular in cross section, with the incoming pipe placed vertically and operating under heads up to 225 feet. The TVA has no current program in this subject.

### 2. Hydraulic Jump and Energy Dissipators

The USBR is conducting a general study to develop energy dissipator design criteria for high-head flows controlled by slide gates. Dynamic pressures on baffle piers and training walls are also being investigated. The Corps is concerned with specific structures and collection of data on low navigation dams. Wind tunnel tests to determine drag of stilling basin elements are proposed. The TVA has no current plans for energy-dissipator tests. Because each structure is unique and requires special design considerations, energy-dissipator tests should be continued by each organization as required.

### 3. Instrumentation for Model and Field Use

None of the organizations is engaged in basic instrumentation research. Each organization develops instrumentation from commercially available components to meet the needs of its particular work. The Corps has an Instrumentation Branch which is available to all WES divisions, and the TVA and USBR have special units within their hydraulic laboratories for instrument development. An active exchange of instrumentation information between the Corps, TVA, and USBR is considered to be essential.

### 4. Cavitation Studies

The Corps and USBR are both engaged in various phases of cavitation research. Because cavitation is a broad field in which both basic and design criteria are lacking, it is concluded that these efforts complement each other and that both agencies should continue this research in connection with their respective problems. Although TVA

has no active cavitation research, it is interested in results obtained by the other two agencies.

5. Radial Gate Studies

The USBR plans to conduct a general study to determine general equations for discharge coefficients of radial gates. The Corps is doing no research on this subject but is making use of existing data to develop design criteria. The TVA has accumulated considerable model and prototype data on tainter gates over the years, but it has not evaluated or analyzed these data. Because of the common interest in this subject, it is concluded that representatives from the three organizations should meet to study and evaluate the TVA and other available data.

6. Prototype Testing

All three agencies are actively engaged in prototype testing of spillways, outlet works, locks, etc. A full exchange of information between the agencies should be continued.

7. Navigation Locks and Dams

The Corps and TVA are actively engaged in testing navigation locks and dams. The particular aim is to develop satisfactory operation of the navigation structures. TVA is also interested in development of low-cost navigation structures for justification of navigation on small channels. Although the USBR is not actively engaged in projects of this nature, it is interested in the results of certain aspects.

8. Sedimentation

The USBR is actively engaged in both project and research studies directed toward sedimentation control at diversions, design of stable channels, and channel stabilization. The Corps is primarily concerned with channel stabilization from the viewpoint of flood control and is performing both project and research tests.

9. Spillways

The Corps is conducting project and research studies on spillways. These studies involve the improvement of low spillway crests to obtain higher discharge coefficients and better pressure conditions. The USBR is conducting both project and research tests on tunnel spillways and stilling basins.

10. Vortex Formation

All three agencies are interested in research involving the vortex phenomena. The Corps and TVA are particularly interested from the viewpoint of vortex formation at lock intakes. All three agencies are interested in vortex formation at turbine and flood control intakes, and at large spillway gates. The USBR is particularly interested in vortex formation at morning-glory spillways and submerged water measurement devices.

11. Riprap Protection

Both the Corps and USBR are vitally interested in riprap protection for flood channels. The Corps is also interested in riprap protection downstream of stilling basins and miscellaneous control structures. The USBR is concerned with riprap protection in irrigation distribution systems and in the vicinity of stilling basins. The Corps is currently making a survey of all field failures which have occurred in riprap protection, with the view to developing design criteria.

12. Turbine Discharge Measurements

All three agencies are interested in developing methods for measurement of turbine discharge, especially for turbine settings in which there are essentially no penstocks. The TVA and Corps are presently developing and constructing test facilities, and field tests will be initiated within the year.

## SUBJECTS PURSUED BY USBR

Because the USBR is engaged in water resources development with emphasis on irrigation and power, certain fields of hydraulic research are being pursued only by this organization. The group determined that these subjects include:

1. Hydraulic characteristics of pipeline distribution systems and related structures
2. Crest and transition section for morning-glory spillways
3. Canal capacity studies
4. Development of small canal structures
5. Water measurement studies for irrigation purposes
6. Hydraulic studies relating to lower-cost canal lining

7. Hydraulic characteristics of gates and valves

8. Radioactive tracer techniques related to water measurement and tracing seepage from canals

## SUBJECTS PURSUED BY CORPS

The Corps' responsibility for flood control and navigation also involves fields of hydraulics common only to this organization. Subjects being actively pursued by the Corps include:

1. Tidal estuaries and associated problems, including estuarine sedimentation and tidal pollution

2. Wave action problems pertaining to harbor and break water design

3. Specific river flood-control problems

4. Radioactive tracer techniques for shoaling in waterways

5. Friction factors for multiple-plate pipe

6. Garrison Powerplant transient tests

7. Beach erosion studies

8. Wave forces on crest gates

## SUBJECTS PURSUED BY TVA

Since the system of dams (except for small tributary dams) in the TVA area is essentially completed, subjects in fluid mechanics pursued by this organization are primarily those concerned with lock design, maintenance and operational problems in connection with existing structures, and fluid dynamics problems in design and operation of equipment for steam powerplants. Subjects actively pursued by TVA include:

1. Turbulence and vibration problems in air and gas duct systems of steam powerplants and in high-head lock culverts

2. Density currents in deep and shallow reservoirs

3. Metering of large air flows

4. Hydraulic downpull on turbine emergency closure gates

5. Strain gage measurements of strut pulls on emptying and filling valves of locks and lower meter gates to supply data for computing horsepower requirements for future locks

## CONCLUSIONS

The consensus of the group is that the hydraulic research activities of the Corps, TVA, and USBR are concerned with the unique requirements of the respective organizations, that the results produced by each are complementary to the development of sound hydraulic design procedures, and that the activities of the three agencies have no significant areas of duplication. Although a formal exchange of technical reports and basic data through correspondence and informal visits has been in effect for many years, it is the feeling that there is further need for visitations between the laboratories to enhance a fuller understanding of programs and techniques. This should be accomplished by a continuation of the conferences on hydraulic techniques initiated 5 years ago by the Corps and by formal conferences and correspondence between key personnel of each laboratory.

In spite of the large amount of hydraulic investigation which has been conducted in the past, there is a general lack of hydraulic data and design criteria. Therefore, it is considered necessary that each agency continue to collect prototype data and to expand on its program of general research studies.

REPORT OF SOIL MECHANICS GROUP
August 1-3, 1961

Representatives of the USBR, CE, and TVA met to discuss the progress of Soil Mechanics Research Studies, which were made during the past year. The representatives were:

CE--R. A. Barron and J. R. Compton

TVA--N. E. Way

USBR--W. G. Holtz, H. J. Gibbs, C. W. Jones, and part time A. A. Wagner, W. Ellis, J. Merriman, and S. Rubenstein

The TVA is not actively engaged in soils research, but is interested in the soils research findings of the other two organizations. During the meeting, 26 major programs of research were discussed. A working agenda listing these subjects is attached to this report.

These research programs can be divided into three categories: (1) those in specific areas of interest to the CE, (2) those in specific areas of interest to the USBR, and (3) those in common areas of interest to both organizations.

The comments that were made in last year's report regarding subjects of mutual interest remain valid for this year because the research efforts have been concentrated in the same fields of interest. These are briefly discussed in the following paragraphs.

1. Field Sampling and In-place Testing

Both the USBR and CE are attempting to develop or improve methods of determining the relative density of sands in situ; the USBR by split spoon penetration resistance and the CE by cone sounding. Each of the two methods is believed peculiarly adapted to the needs and objectives of the respective organizations; in addition, much more field correlation needs to be done to solve this problem. The USBR is investigating a new double tube (pitcher) sampler for securing undisturbed samples of firm soils, while the CE is investigating the Swedish foil sampler for securing undisturbed samples of soft soils. A vane shear apparatus for testing cohesive soils in situ has been developed and is in use by the USBR; the CE is drawing on the experience of USBR and others in devising a vane shear device and in developing techniques for the use of the apparatus by CE offices. Nuclear moisture and density meter studies are being continued by both organizations. The approach in each case is essentially the same and information is exchanged at frequent intervals. These devices are relatively new and all obtainable information is needed to prove or disprove their reliability and

applicability; thus, parallel efforts by several groups are considered highly desirable at this stage of development. The mutual exchange of test results at frequent intervals reduces the test requirements of each agency for the proper evaluation of the devices.

2. Engineering Properties of Gravelly Soils

Both the USBR and CE continued research on compaction and strength characteristics of these important construction materials. The two organizations are using different material gradations. In the measurement of strength properties, the USBR is testing unsaturated materials for the most part; whereas, the CE is testing saturated materials. In compaction studies on cohesionless soils the end product is a test procedure; the USBR is developing a relative density test procedure, whereas the CE is developing a test that will duplicate acceptable field placement density. It is considered that the work of the USBR and CE in this particular area is complementary and each will benefit from the work of the other.

3. Shear, Consolidation, and Pore Pressure in Cohesive Soils

The CE effort in this field is primarily a continuation of studies over many years to obtain fundamental information on the mechanisms by which cohesive soils develop resistance to deformation during shear tests. The major part of the CE program is devoted to studies on remolded, saturated, and unsaturated soils, and some comparisons of laboratory compacted soils with undisturbed samples of compacted embankment materials over 20 years old. The USBR program is also a fundamental study and includes shear tests on unsaturated soils, limited data on saturated soils, and comparison of remolded and undisturbed compacted embankment soils immediately after placement. The USBR also is working on fundamental pore pressure studies and measurements and on the consolidation characteristics of soils. The programs of the two organizations do not overlap and are complementary. A great number of private and public organizations are working in this area at the present time. As noted at the June 1960 ASCE Research Conference on the Shear Strength of Cohesive Soils, the subject is so complex that data from many sources and on many soils are needed before satisfactory explanations of the behavior of cohesive soils can be made.

4. Field Performance of Structures

The USBR and CE continued the gathering of data on the behavior of engineering structures and earth dams during the following construction for the purpose of checking design assumptions and to aid in the design of similar future projects. These studies are in connection with particular projects, each having its own special materials and

design conditions; thus, no overlap of effort exists. Through mutual exchange of technical reports the work may be considered complementary and, thus, adds to the design knowledge of both organizations.

5. Pipes and Conduits

The CE program is directed toward the establishment of pipe cover requirements beneath airfield pavements; whereas, the USBR interest is to study the behavior of conduits under high fills and deep backfills. Fundamental knowledge of pipe stresses and deflections and behavior of surrounding fill and backfill are common to both studies. However, the objectives are different, in that the CE is interested in the behavior of pipes and conduits under heavy moving wheel loads; whereas, the USBR interest is in the behavior under static loads.

During the meeting, an important observation was made that there are many examples where research findings of these organizations are utilized for mutual benefit. For example, the USBR is now making use of the two CE samplers and sampling procedures, adapting them to fit their particular soils problems. CE experiences with earth pressure determinations for lock and other structures are being utilized in USBR research studies of earth pressures on buried conduits. Similarly, the CE is interested in the research studies of the USBR for the utilization of soil-cement for dam facings in lieu of riprap in locations where stone riprap is expensive. The CE is also making use of USBR development and design of piezometers to measure pore pressures in earth dams.

A good mechanism is now in effect for exchanging research reports between the organizations. In addition, another valuable means of exchange of current ideas and findings exist through personal contacts of the organizations' engineers at meetings of professional societies and conferences such as this.

The consensus of the representatives attending this meeting is that no duplication of effort exists in their soils research activities. In areas of mutual interest, the activities are complementary and will be beneficial in accelerating the progress of these research programs.



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USBR, CE, and TVA RESEARCH COORDINATION MEETING

August 1 to 3, 1961

Agenda of the Group Session on Soil Mechanics

Subjects in Areas of Common Interest

a. Field Sampling and in-place testing

(1) Exploration and sampling (USBR)

(2) Penetration resistance studies of sands and cohesive soils (USBR)

(3) Cone penetrometer study (CE)

(4) In-place vane shear tests (USBR)

(5) Vane shear tests and Swedish foil sampling (CE)

(6) Nuclear soil moisture-density meters (USBR and CE)

b. Properties of gravelly soils

(1) Compaction and strength characteristics of gravelly cohesive soils (USBR and CE - Proj. CW521A)

(2) Compaction and strength characteristics of gravelly cohesionless soils (CE - Proj. CW521-B)

(3) Compaction test procedures for cohesionless soils (CE - Project CW-522 and USBR)

(4) Permeability of gravelly soils (USBR)

c. Shear, consolidation, and pore pressure of cohesive soils

(1) Determination of pore pressure in compacted soils (CE - Project CW-518)

(2) Stress deformation and strength characteristics of undisturbed and remolded soils (CE - Project CW-523)

(3) Pore pressure studies (USBR)

(4) Comparison of shear characteristics of laboratory-compacted specimens to field-compacted specimens (USBR)

(5) New developments in equipment and procedures (USBR)

d. Field performance of structures

(1) Instrumentation of Port Allen and Old River Locks (CE - Project CW-030)

(2) Compilation of Earth Dam Criteria (CE - Project CW-519)

(3) Prototype reports -- Enid, Grenada, Ferrells Bridge, Texarkana Projects (CE)

(4) Data on performance of engineering structures (USBR)

e. Buried pipes and conduits

(1) Pipe cover requirements (CE)

(2) Earth pressure measurements and installation of a test pipe for evaluation of earth pressure effects (USBR)

f. Improvements in soil laboratory procedures and equipment (USBR and CE) for specific individual work

Subjects in Specific Areas of Interest to the CE

a. Project CW-516 --Evaluation of Soil Mechanics laboratory equipment

b. Project CW-520 --Preparation of Laboratory Test Manual

c. Three-dimensional Electrical Analogy Seepage Model

d. Statements on Miscellaneous Military Studies

(1) Gyratory compaction of soils

(2) Moisture studies under pavements

(3) Improved quality of base course material

(4) Dynamic foundation studies

(5) Dynamic bearing capacity

(6) Response of soil to dynamic loads

Subjects in Specific Areas of Interest to USBR

a. Petrographic characteristics of soils

b. Erosion and tractive force studies

c. Subsidence of soils upon initial wetting

d. Characteristics of earthfills carrying canals

e. Performance studies of earth canals and granular cover material

f, Chemical stabilization of soils (canal sealants)

g. Riprap studies of substitutes and evaluation

h. Canal seepage and ultrasonic effects on compaction of canal soil in-place

Problems of Specific Interest to the TVA

a. Shear and friction tests in situ on horizontally bedded limestone with weak bedding planes and shale seams

b. Prototype measurements of uplift and pore pressures in locks

c. Evaluation of measured foundation drainage and uplift pressures in dams as it affects the maintenance of these structures

APPENDIX 5

AUGUST 1-3, 1961

# REPORT OF CONCRETE GROUP

## INTRODUCTION

The Concrete Group convened for the following sessions:

1. Tuesday, August 1, 1961, 9:35 a.m.-3:00 p.m.
2. Wednesday, August 2, 8:00 a.m.-4:00 p.m.

Present at the sessions of the Concrete Group were:

| | | | |
|---|---|---|---|
| Elmo C. Higginson | USBR | Chairman | All Sessions |
| Thomas B. Kennedy | WES | | All Sessions |
| W. R. Waugh | OCE | | All Sessions |
| J. B. Tiffany | WES | | In Part |
| W. E. Dean | TVA | | All Sessions |
| J. Parmakian | USBR | | In Part |
| W. Y. Holland | USBR | | All Sessions |
| L. P. Witte | USBR | | In Part |
| J. E. Backstrom | USBR | | All Sessions |
| G. B. Wallace | USBR | | All Sessions |
| L. J. Mitchell | USBR | | All Sessions |
| L. C. Porter | USBR | Recorder | In Part |
| R. J. Elfert | USBR | | All Sessions |
| O. J. Olsen | USBR | | In Part |
| H. F. Avery | USBR | Recorder | All Sessions |

The Concrete Group discussions were conducted according to the schedule outlined in the agenda. Representatives of each agency concerned were equipped with written descriptions of research areas in which the respective agencies were engaged. Descriptions were distributed to all participants. Discussion commenced with a presentation and coordinate review of research items currently underway by the USBR.

Inasmuch as the concrete and structural research program of USBR encompassed 36 major items, the Corps and TVA representatives were polled to determine items of particular interest, and discussion thereafter was centered on items which elicited the mutual interest of the conferees. The USBR presentation was followed by those of the Corps and TVA, respectively. In addition to reviewing investigational programs, status, and objectives, a valuable informal interchange of specific findings and technical questions took place, as suggested by the items of research discussed.

A complete tour of the laboratories was conducted.

Considerable time was saved in the discussions by virtue of the fact that many of the items had been discussed in the 1960 meeting, and the conferees were generally informed. It was evident in the meetings that each agency

has research items in progress and in prospect that are related to economic aspects of its own work, but do not have any counterpart in either of the other agencies. The discussions this year were much more profitable to the USBR than in 1960, because of the greater number of USBR representatives participating.

## ITEMS OF COMMON INTEREST

The nine areas of common interest on the agenda are discussed and the findings in each case summarized in the following subparagraphs.

### Chemical Admixtures for Concrete

The Corps has prepared a report on 13 water-reducing admixtures, some of which were tested with pastes and mortars, others with concrete. The work of the USBR in this field has predominantly involved use of admixtures in concrete. The Glen Canyon contractor is now using a water-reducing agent in the mass concrete for the dam. This is such a large field of research with so many commercial admixtures on the market that the work of the two laboratories is complementary.

### Alkali-Aggregate Reaction

The amount of work performed by each agency in this field since the previous meeting is very small. The specific items of research within the general subject area are different in each organization.

### False Set of Cements and Concretes

Both agencies are observing cases where false-set in cement causes difficulty in concrete construction. There is mutual interchange of experience and a minimum amount of laboratory work, which are considered essential.

### Creep and Volume Change

The Corps is studying the creep characteristics of chert gravel concrete for Port Allen Lock. Check tests are being made at the University of California. The USBR is starting a program to determine the creep characteristics of concrete containing 6-inch maximum-size aggregate.

### Sulfate Attack on Concrete

The Corps is planning a program to study the mechanism of sulfate attack by forcing various sulfate solutions into several qualities of concrete made with different cements. Work has continued in developing X-ray diffraction techniques for distinguishing between sulfate-resistant and sulfate-susceptible cements.

The USBR is conducting a program to determine how absorption of concrete pipe is related to its sulfate resistance.

Freezing and Thawing Methods

The Corps is attempting to develop methods for physically testing 3- to 6-inch aggregate, and is overhauling its methods for evaluating riprap. The USBR continues to experiment in the field of freezing large concrete specimens containing 6-inch maximum-size aggregate.

Petrographic Methods for Aggregates

The Corps has developed a method of impregnating NX cores of fractured materials with epoxy resins, to facilitate the preparation of thin sections. In addition to petrographic examinations of particular aggregates encountered on projects, the USBR has emphasized development of a new method of investigating the proportions of sand, gravel, and cement paste in concrete. Interchange of information revealed no instances of overlapping between agencies in this research area.

Preparation of Construction Joints

The Corps is actively studying methods for preparation of horizontal construction joints in mass concrete. Joint conditions to be studied in the tests are: (1) wet with water; (2) dry, with and without stiff grout, and (3) with wet grout. Ten-inch-diameter cores will be taken to determine the flexural, tensile, and shear strengths of these joints. The USBR does not have an active program in this area, but is very interested in obtaining test information. The USBR proposed that the Corps expand this investigation to include the effects of wet sand blasting versus water jets in joint preparation methods. The TVA would also like to obtain information on methods of treatment of horizontal construction joints in mass concrete. These factors suggest the possibility of a joint research venture in this area.

Pozzolans and other Mineral Admixtures

Both the Corps and the USBR are actively engaged in this area, but there is no indication of overlapping efforts. The Corps has emphasized extremely lean mass concrete containing pozzolan. Their tests have been made on mass concrete containing as little as 1 sack of cement per cubic yard, and a large amount of pozzolan. The USBR has just completed a program testing the durability of concrete containing pozzolans. Since the TVA produces about 1 million tons of fly ash each year, and is attempting to find more uses for this pozzolanic material, the TVA representative was very interested in these research programs. The TVA has worked with the Corps in tests to determine the value of fly ash in project concrete. This is the primary concern of TVA in the field of concrete research, and is a likely field for coordinated research activity.

## CONCLUSIONS

With respect to the research work relative to concrete and concrete materials now being conducted by TVA, the Corps, and the USBR, the group arrived at the following conclusions:

1. Each agency is pursuing a research program aimed particularly at solving problems peculiar to the work of its own agency. Where research in the same general field is performed by more than one agency, the approaches and techniques employed are such that the work is complementary rather than duplicative.

2. Active participation of representatives of each agency in technical and professional societies and in developing Federal specifications for cement is particularly useful to all concerned and saves a great deal of time and money.

3. It was suggested that an additional copy of concrete reports from the Corps be furnished to the USBR in the future for use in the Concrete Laboratory.

Appendix 6

USBR, CE, AND TVA RESEARCH COORDINATION MEETING
August 1-3, 1961

Report of General Group

After the opening session and a tour of the facilities of the Chemical Engineering Laboratory Branch, the following attended the group discussion sessions:

Corps of Engineers

Colonel E. H. Lang, Director, WES
Bryant Mather, Chief, Special Investigations Branch, WES

Tennessee Valley Authority

W. E. Dean, Chief, Research Staff, Office of Power
J. R. Barnwell, Assistant Chief, Electrical Laboratory and Test Branch, Division of Power System Operations

U.S. Bureau of Reclamation

Denver, Colorado

L. M. Ellsperman (Chairman), Acting Chief, Chemical Engineering Laboratory Branch
G. W. DePuy (Recorder), Petrographic Laboratory Section

Part-time attendance:

Graydon E. Burnett, Assistant Chief Research Engineer
M. E. Trenam, Chief Construction Engineer
D. S. Campbell, Chief Maintenance Engineering Branch
M. H. Kight, Chief, Electrical Branch
H. S. Riesbol, Chief, Hydrology Branch
F. R. Schleif, Power Operations
P. W. Lewis, Head, Protective Coatings Laboratory Section
L. O. Timblin, Jr., Head, Physical Investigations Laboratory Section
T. R. Bartley, Head, Weed Control Laboratory Section
H. J. Cohan, Head, Saline Water Demineralization Laboratory Section
P. R. Tramutt, Acting Head, Analytical Laboratory Section
M. E. Hickey, Acting Head, Bituminous Laboratory Section
S. M. Denton, Head, Power and Pumping Plant Section
D. C. Millard, Head, Transmission Plant Section
E. J. Benton, Petrographic Laboratory Section
C. E. Selander, Protective Coatings Laboratory Section

During the group discussions on research items of a general nature, the accomplishments on items discussed during the last coordination meeting, May 1960, were reported upon and the planned or proposed research programs for the next fiscal year were discussed. Necessarily, the list appearing upon the agenda of the General Group is long and covers a wide range of activities within the three agencies. Items which were discussed in brief detail during this coordination meeting are reported below and, for clarity, all items considered are listed following the discussions report.

Representatives of the USBR, Corps, and TVA agreed that this meeting presented another opportunity to discuss in some detail the activities of each agency where there exists a mutual interest. The opportunity for representatives of each of the agencies to examine the facilities and discuss in person, research investigations, is extremely beneficial in planning investigations or phases of research not under study by other agencies.

Agreement was expressed with the general conclusions reported at the termination of the last meeting held in 1960, particularly that certain phases of the work are being pursued by the different agencies; however, the work is being conducted on different projects involving different sources of materials, for different climatic and working conditions, all of which require specific solutions to meet particular service requirements. Therefore, it is considered that the work on the items is complementary. The combination of findings result in attaining broader knowledge which is of mutual benefit to all agencies and to the engineering profession.

## SUMMARY OF GROUP DISCUSSIONS--GENERAL SESSIONS

### Hydrology

The individual studies under the heading of hydrology and the related fields of hydrometeorology and weather are, for the most part, continuing studies. The individual studies were discussed in some detail in the first meeting and reference may be made to Appendix 3, "Report of Miscellaneous Discussion Group" of the report on the May 1960 meeting in Vicksburg for specific details regarding a particular topic. Each topic on the agenda was discussed, and it was found, as was the case for the Vicksburg meeting, that these studies are complementary, and while similarities do exist, these are not considered as duplication of effort. The hydrologic studies being conducted are in specific areas, and are of a continuous nature. Adequate data must be collected before reliable statistical analyses can be made.

All three organizations have an interest in hydrology, for the planning, design, and operation of engineering projects utilizing our water

resources are dependent upon the extend of knowledge of the water supply. The immediate hydrologic needs lay in the areas of data gathering and analytical techniques.

The Corps is engaged in extensive data gathering and analytical programs in low flow and flood volumes, wind and wave and freeboard, snowmelt and snowmelt runoff, reservoir and lake hydrology (Great Lakes), and other related studies. The Corps is also working on the use of electronic computers for reservoir operations. Programs such as this are, of course, naturally dependent upon the availability of basic hydrologic data obtained over the years and upon knowledge of basic physical processes.

During the discussion of the Corps' hydrologic activities, Colonel Lang, Director, Waterways Experiment Station, took the opportunity to mention the activities of the U.S. Army Cold Research and Engineering Laboratories (formerly the Snow, Ice, and Permafrost Research Establishment). This is a military establishment and not a part of the Corps' Civil Works Program. They are primarily interested in the military properties of snow and ice; however, during the course of their technical studies, a great deal of information has been obtained. An extensive bibliography of their work has been published and has been obtained by the Bureaus' Technical Library. This basic information may be of interest to other agencies and may have application to other fields. Colonel Lang stressed the point that this information is available upon request.

The USBR hydrologic activities include studies relating to water resources and utilization, flood hydrology, evaporation, water requirements, water salvage, sedimentation, reservoir and river operations, and economic studies of water requirements. These studies are of a continuing nature for specific localities and, as in the case of the irrigation water versus crop yield studies, pertain to specific problems of the USBR.

All three agencies have an interest in hydrometeorology and weather forecasting. These studies require close coordination with the Weather Bureau. The TVA has a program on weather forecasting for prediction of demand for electric power. The Corps has contributed greatly to hydrometeorological studies. The USBR has likewise engaged in similar studies in its particular areas of interest.

There has been an extensive exchange of data between these and other organizations.

Limnological Studies

Construction of reservoirs reduces the length and effective turbulence of streams and channels between reservoirs, which affects the temperature and oxygen content of the water. This, in turn, may affect the quality and biological environment of the water. The problems studied by the three agencies are directly related to the different geographical and climatic localities in their respective areas of operation, and secondly to the techniques involved, which are of mutual interest.

Plastics

The field of plastics is growing at a tremendous pace. There are thousands of plastic products on the market today and the number is constantly increasing. The use of plastic products is a subject of interest to all three agencies, although, in most cases different applications may be in mind. The use of plastics as protective coatings is mentioned in another part of this report.

The uses being studied are for adhesives, membranes, plastic pipe and tubing, protective coatings, and for miscellaneous uses, such as admixtures in asphalt and joint sealers.

The TVA reported on an epoxy varnish for electric windings of various motors and control coils. The advantage of this material is that it has a hard, slick surface which reduces the accumulation of fly ash and helps in cleaning. Also, use of vinyl tape as aircraft warning markers on poles and towers was mentioned. This tape is more durable than the previously used paint.

The USBR is interested in the use of plastic membranes for canal linings, plastic additions to asphalts, plastic tubing in specialized application, electrical insulation, and in the patching and repair of portland cement concrete. Several new studies are underway on the use of plastics for roofing and decorative floors.

The Corps' activities are largely in the field of protective coatings. Both the Corps and the USBR have experimented in the use of plastic coatings to reduce cavitation damage. Synthetic rubber and epoxy resins have been found to be effective in mild exposure. This work is complementary and of mutual interest.

Protective Coatings

The Corps' protective coating laboratory at Rock Island, Illinois, and laboratory of the USBR in Denver are engaged in similar activities in acceptance testing, performance evaluation and methods of surface preparation and application. The TVA has a laboratory

which does acceptance testing. It should be pointed out that the service conditions for the use may be considerably different. Evaluation of a specific product and recommendations for its application can only be made by specialized personnel familiar with the material and the conditions which it will be required to meet. As there is an ever-increasing number of products appearing on the market, and as each agency has its own particular problems and application, screening and acceptance testing can best be done by each agency performing its own required tests. The interested personnel of both laboratories are familiar with each others activities and their efforts are considered to be of mutual interest.

The TVA is primarily interested in protective coatings subject to high temperatures and/or abrasion, as is found in smokestacks and other parts of their stream powerplants. The TVA's program essentially consists of obtaining information from manufacturers running screening tests on the manufacturers' products, and selecting the proper product for a particular job. The TVA is very interested in the programs of the Corps and the USBR and have obtained information from these agencies.

Steel Pipe Linings

All three agencies use steel pipe. The USBR uses more steel pipe than the other two organizations and is the most active in the field. Steel pipe linings are used for protection from corrosion, protection from cavitation damage, and protection from erosion. The protective coating work done on steel pipe is of mutual interest.

Corrosion Mitigation

The TVA corrosion problems are largely connected with their steam powerplants; problems which the Corps and the USBR do not have.

The Corps' corrosion studies reported are on the corrosion of steel sheet piling and its control by cathodic protection. The USBR's corrosion mitigation investigations are similar, but are directed towards steel pipe, penstocks, and gates, and therefore, are complementary. There is still much to be learned of cathodic protection and the use of the Corrosometer. All three organizations are using the Corrosometer. Because of the effect of the local environment and exposure conditions, these studies must be conducted on the specific structures by the interested agency.

The Corps has a cathodic protection school at Rock Island. The TVA sent one engineer to this school last year and plans to send several designing engineers to the school in the near future.

Reservoir Area Clearing and Brush Control

Reservoir area clearing is of interest to all three agencies. The general nature of the considerations involved is: (1) whether to clear the reservoir before or after filling; (2) whether to clear out the entire reservoir area or just along the shore lines, and; (3) methods of clearing after filling which include mechanical cutters and the use of herbicides.

The USBR reported that the methods for clearing are generally left to the contractor's discretion. The TVA reported that generally for new reservoirs, the practice is to cut all trees before reservoir filling. Along the reservoir edges, cut and fill techniques are sometimes used for removal of vegetation. The TVA recognizes the problem and is studying it, but has no reports at this time. The TVA also added that herbicides have been investigated, but that for one of their particular problems, that of willow and button ball growths, the only solution so far is mechanical cutting.

The Corps reported the final reports on two studies, "The Death and Decay of Trees from Flooding," and a report on floating equipment for reservoir clearing. The Corps generally clears the edges of reservoirs, but leaves the trees standing in deep reservoirs. The Corps is the only agency developing heavy equipment for cutting, although the subject is of interest to the other two agencies.

The USBR further reported an item concerning the allocation of cost for debris control and removal. The costs for this service are now prorated with the downstream water users at Grand Coulee Dam.

The TVA is using mechanical and chemical methods for brush control on transmission line rights of way. In most areas they have found that chemical methods are more economical. A special problem is the control of black locust.

Power Investigations

The area encompassed under the heading of Power Investigations is extremely broad and merges into other areas. The topics discussed ranged from specific details on particular items, such as excitor commutator brushes, to matters relating to the overall concept of power and resource management, which goes beyond the scope of the present meeting. All three organizations have a general interest in this broad area. The TVA is the most active of the three agencies but is working generally on specific problems rather than long-range programs. The USBR does not have a formal major research program, but rather is investigating specific matters as they arise. The

Corps, although they are not primarily interested in power, has an interest as many resources projects are now developed on a multipurpose basis of which hydroelectric power is a major consideration.

The subject of power operations is vast and extremely complex, both from the technical and administrative considerations. This is a fundamental part of reservoir and river management, which in its grosser aspects is integrally related to the optimum use and development of our vital natural resources. The supplementary studies in hydrology, hydrometeorology, and weather forecasting play an essential related part in development and in increasing operations efficiency. The technological developments under study include automation and remote control, and the ever increasing use of electronic computers and automatic data processing equipment.

Power system operations and automation.--All three agencies are interested in integrated systems of power operations which involve studies of load prediction, plant regulation, automation and computor studies, and reservoir regulation. The immediate application of these studies is for specific areas which have numerous unique and local considerations making it necessary for specific studies by the particular agency involved. However, the progress being made is of general interest to the other agencies, as well as other groups.

The Corps has made studies on the use of electronic computers for reservoir operation, in particular on computations of seasonal hydrosystem power. Other items under Engineering Applications of Electronic Data are a contract with the Massachusetts Institute of Technology for a study of optimum powerplant operation and a contract with Harvard University in the development of optimum river utilization.

The TVA is studying multiunit high-speed load control of hydrounits, multiplant regulation with hydroplants, multiplex telemetering system, probability calculations for system generating and reserve capacity, power supply planning, and study of power system automation and control.

The USBR reported on remote control of hydropowerplants. Remote-controlled plants now in operation are performing satisfactorily and some of the future powerplants will also be remote controlled.

Electric power distribution.--The TVA has constructed a 7-mile, 500,000-volt experimental transmission line. The USBR is beginning a study of ultra-high voltage lines of 345-500 kv as, in the future, it may be required to build these lines. The TVA's experiences will be extremely beneficial. The Corps is not conducting investigations in this area.

The TVA has under study a number of computer programs on various topics which are actually problems in devising better and more efficient engineering methods in application to specific problems confronting the TVA. These include transmission line sag, equivalent circuit studies, powerline carrier frequencies, load duration curves, and distribution system voltage profiles. Other studies include the development and patent for a carrier frequency impedence meter, relaying of 13-kv rural-type distribution circuits, broad band coupling for powerline carrier, and insulated ground wire for communication on high-voltage transmission lines.

Transmission line construction by helicopters.--The USBR is not using this method, although it is felt that some contractors may consider this method on isolated parts of the Colorado River Storage Project. The TVA has made some preliminary tests of placing poles by helicopters and intends to use helicopters for conductor stringing.

Powerplant operations.--The USBR and TVA reported on field drying of transformers and on the detection of combustible gases in transformers. These investigations tend to be complementary as there are several approaches to these problems and the experiences of one agency are useful to the other. The TVA mentioned that in the presence of high-frequency sonic waves, the transformer oil will pick up more water.

The TVA reported on multiplane balancing of rotating machinery using their IBM 704 digital computer, which may have possible application to other equipment than generators. Other miscellaneous items discussed included specification tests for greases in generator plants, use of nitrogen gas for transformers, and it was mentioned that they have found that the best source of excitor commutator brushes are brush manufacturers rather than manufacturers of electrical machinery. The TVA has an investigation on weather forecasting for the prediction of power requirements.

The USBR reported a need for large hydroelectric generators in the range of 250,000-350,000 kv. Other miscellaneous items mentioned were tests of epoxy resins for generator insulation binder, light sources in remote areas for transmission lines, aging of generator coil insulation, survey of the below-ground condition of wood poles, debugging of equipment and operations, study of cooling water tube failures, and the determination of cable stock for generator plants. These are minor items and do not represent a major research effort.

Steam powerplants.--TVA is the only organization of the three directly concerned with steam powerplants. Their studies are of interest to the Corps and the Bureau since some results may be applicable to other problems.

The TVA studies include topics in the fields of protective coatings and corrosion at high temperatures, boiler water analysis, demineralization studies, and scaling of condensers.

Weed and Clam Control

All three organizations are involved in weed control, but are concerned with different weeds and different conditions. The USBR is primarily interested in water weeds in canals, where herbicides must have low toxicity and short contact periods. The Corps is concerned with water-hyacinth and alligator weed. The Corps reported that water hyacinths are effectively controlled by 2,4-D herbicides, but that alligator weed has become a more serious problem with the elimination of water hyacinth. 2,4-D is not effective on alligator weed and new herbicides are being investigated. As mentioned under "Reservoir Area Clearing," the Corps has prepared reports on floating mechanical cutters and on the death and decay of trees by flooding. The TVA is faced with the problem of removal of willow and button ball on their reservoirs, but these apparently are not controlled by the herbicides and mechanical cuttings remains the best method for their control. The TVA is also concerned with brush control on transmission line rights-of-way which include both mechanical and chemical methods. By the use of herbicides using truck and helicopter spraying, the cost per acre in the last 10 years has been reduced from $60 to $15. Black locust is a special problem in the TVA area.

The TVA and USBR are also interested in the control of fresh water clams in water lines. The clams are resistant to high concentrations of chlorine and no effective molluscacides have been developed. Studies in this area would be of mutual benefit to both organizations, as well as other organizations faced with this nuisance. As yet there is no good way to solve this problem. The best solution is to close the system and physically remove the clams. However, in some cases it is not possible to shut down the system.

Design, Prototype Analysis of Structures, and Rock Foundations

All three agencies have programs under this topic, but these are oriented toward particular needs and types of structures.

Under prototype analysis, the Corps reported on temperatures in mass concrete structures and the measurement, comparison, and analysis



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of stresses, deflections, and movements of two full-sized U-type navigation locks. The latter subject is partly concerned with creep in concrete, which is a major problem area in concrete design. The Corps' study on cracking in reinforced concrete flood control channels is nearing completion.

The TVA reported a new idea under consideration on the simplification of locks for tributary streams, studies of composite design of superstructure floor slabs using metal decking, and the use of the ultimate strength method for design of concrete structures instead of the elastic theory.

Developments in these areas are of wide interest.

The shear strength of rock is an important and somewhat unknown factor in the design of concrete dams. The Corps has planned a program to evaluate the actual shear strength of rock foundations from laboratory and field tests; testing is planned to commence in FY62. The USBR has a continuing program of laboratory triaxial testing. Plans are being made for more extensive field testing at Flaming Gorge and Glen Canyon Dams and several other field locations. There is a great need for more laboratory and field testing. This work is of mutual interest and benefit to all interested in rock foundations.

Engineering Applications of Computers and Automatic Data Processing Equipment

These studies are on specific problems encountered by the various agencies and upon the application of the particular equipment used by the individual agency. The studies are on the development of programs for existing machines, or, in special instances in the design of a machine to handle a specific job. These studies are of mutual interest, as this is a new and rapidly growing field and it is important to learn what applications are being made by others. Facilities are in existence for the free exchange of information between the organizations.

The TVA's program centers on the application of an IBM 704 digital computer, which has found use in studies of power operation and power system design as previously mentioned under the headings. The TVA also has used this machine for other programs on vehicular use for accounting and statistical purposes, and personal injury statistics.

The Corps reported on the use of electronic computers for seasonal power computation for reservoir operation, the computation of thermal gradients in mass concrete structures, and have contracted with MIT for the study of optimum powerplant operation. New items

for the Corps are work on the digital terrain model system for obtaining engineering quantity estimates of many alternate damsites, elevations, and orientations, and a contract with Harvard University in the development of optimum river utilization plans and programs. The Corps' studies have been with the IBM 650.

The USBR is working with the General Electric powerline network electric analog analyzer, and also an IBM 650 for various computations such as the determination of total sediment loads by the Modified Einstein Procedure. As a part of the coordination conference, a tour was conducted for representatives of the Corps and TVA through the USBR's Automatic Data Processing Section and Network Analyzer Unit.

Bituminous Materials

The Corps and the USBR are both engaged in testing and evaluation of bituminous materials. The Corps' Waterways Experiment Station is primarily interested in the use of bituminous materials for flexible pavements, particularly for paving airfield runways where the considerations are resistance to dissolution from jet and piston aircraft fuels and landing impact resistance. The Corps is also interested in asphalt pavements for protection of sidebanks and levees.

The USBR is primarily interested in the use of bituminous materials in hydraulic construction for canal linings, dam facings, and to a lesser extent, for roofing and other applications. The USBR's work with pavements is very small and is limited to a few access roads. The USBR's investigation of bituminous products include sprayed membranes, prefabricated membranes, asphalt emulsions and cutbacks, asphaltic concrete, and other specialized products.

The USBR is primarily interested in water-impervious bituminous materials, while the Corps is primarily interested in the strength characteristics of bituminous materials. As the USBR and the Corps have different application and uses of the materials, exposed to somewhat different conditions, the work of the Corps and the USBR is not a duplication of effort. However, information of the properties of bituminous materials and specific applications are of mutual interest. The TVA is doing no work in this field, but is interested in the work of the Corps and the USBR.

The USBR and the Corps activities were discussed in some detail in the 1960 meeting (see Appendix 3, Report of Miscellaneous Discussion Group). In the present meeting, the USBR's program was covered, including a new item on Aging Characteristics of Asphalt Material.



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Joint and Crack Sealers

The TVA, Corps, and USBR are interested in material for sealing joints and cracks in structures. The USBR work centers on sealing grooved joints in concrete canal linings and construction joints in power and pumping plants. The Corps is interested in sealing pavements against weather and runways against the heat and blast from jet aircraft. This is not a large item, but development would be of interest to all three organizations.

Engineering Applications of Radioisotopes

As covered in the 1960 report, all three agencies are involved with uses of radioisotopes. Through the Subcommittee on Sedimentation of the Committee on Hydrology of the various Federal Interagency Basin Coordination Committees, all three agencies have coordinated their efforts in developing a nuclear gage for making rapid measurements of in-place density of reservoir sediment deposits and tidal wasteway shoals. The Corps is interested in a nuclear moisture meter for concrete aggregates and has developed an automatic radio-reporting snow gage using cobalt 60. The Corps reported that they are especially interested in a nuclear moisture meter for concrete aggregates for use in automatic batch plants. The commercial devices presently available do not operate fast enough for this application, and the Corps is awaiting further developments by industry. The TVA is interested in the application of radioisotopes in investigation of power reactor development. The USBR is performing laboratory and field tests on measuring soil density and moisture with commercial gamma ray and neutron scattering equipment, is studying the use of radioisotopes for flow measurement, has collaborated with the University of California at Berkeley on tracers for water seepage, and is using radioactive carbon and iodine for cooperative aquatic weed research in collaboration with the Agricultural Research Service.

Miscellaneous Research Studies--TVA

The TVA has studies on the coal reserves in Tennessee and Kentucky, thin-seam coal mining methods, interest rates, and the operation of a battery-powered car. The Corps and the USBR do not have similar studies.

The TVA reported that it has been using cyclones for the collection of fly ash, but is now turning to electrostatic collectors as these are more efficient and are becoming lower priced. The TVA's Steam Powerplant Studies are summarized under Power Investigations.

Miscellaneous Research Studies by the Corps

The Corps has completed their model study for Hopper Dredge Pumps. There are several other programs conducted by the Corps only, such as the development of floating equipment for reservoir clearing which have been mentioned under other research headings.

Miscellaneous Research Studies by the USBR

The USBR reported on lower-cost canal linings, chemical soil sealants, and saline water demineralization.

The USBR is actively engaged in studying low-cost methods of canal and reservoir seepage loss reduction. The Corps and TVA are not active in this field. The Bureau reported on encouraging laboratory tests of a proprietary wax emulsion soil sealant.

The USBR saline water demineralization program does not properly fit into this report, as this work is done under contract for the Office of Saline Water and the Government's activities in this field are coordinated by OSW. However, the subject was reported as it may be of interest to the other agencies. The USBR's work has been mainly on the demineralization of inland brackish waters by electrodialysis. The TVA demineralizer studies are somewhat different as they are using an ion-exchange process on their steam powerplant water.

The USBR items under Special Techniques are for special USBR problems which require special study. The developments in these areas may be of interest to others.

The other agencies have similar programs included with the specific problems.

More detailed information on the items considered may be obtained from supplements to this report listed below which are available upon request to the designated agency.

Supplement No. 1

USBR--Chemical Engineering Laboratories Presentation

- Bituminous Research
- Plastics
- Protective Coatings and Corrosion
- Weed Control
- Evaporation Reduction
- Oxygen Content of Streams and Reservoirs
- Special Techniques
- Saline Water Demineralization

Supplement No. 2

USBR--Lower-cost Canal Lining Program

- Asphalt Lining and Lining Materials
- Cover Materials
- Plastic Film Lining
- Joint and Crack Sealants for Concrete Lining
- Spray Application of Plastic Materials
- Canal Sealants
- Detection of Seepage with Radioisotopes

Supplement No. 3

USBR--Hydrology Branch Presentation

- Hydrometeorological Investigations
- Stream Hydrograph Analysis
- Sediment Analysis Procedure Development
- Sediment Surveys of Existing Reservoirs
- Plans for Development of Reservoir and River Operations
- Forecast Method Development for River Operations
- Water Requirements for Irrigation
- Operation, Maintenance, and Rehabilitation Cost Estimate Improvement
- Economic Analysis of Resource Areas
- Cooperative Water Yield Procedures
- Water Salvage Study
- Irrigation Water Shortage Study

Supplement No. 4

USBR--Presentation of Power Operations Division and Design Division, Electrical Branch

Remote Control of Pole Hill Powerplant
Remote Control of Hydropowerplants
Determination of Cable Stock for Generating Plants
Corona Effects in Insulation
Analysis of Gases in Transformers
Field Drying of Transformers

Supplement No. 5

Corps' Presentation

Developments Since Last Meeting

Weed Control

Progress on CWI Projects Since May 1960 Meeting

CWI 005 Paint Tests
CWI 024 Experimental Control Studies for Reservoir Clearing
CWI 028 Floating Equipment for Reservoir Clearing
CWI 030 Prototype Analysis--Structural Behavior of Concrete Structures
CWI 032 Cracking in Reinforced Concrete Flood Control Channels
CWI 034 Shear Evaluation of Rock Foundations
CWI 151 Flood Volumes (West Coast)
CWI 152 Flood Volumes (East Coast)
CWI 154 Low Flow Frequency Analysis
CWI 166 Waves and Tides in Inland Waters
CWI 171 Runoff From Snowmelt
CWI 172 Reproduction of Hydrologic References
CWI 173 Development of Hydrologic Equipment
CWI 177 Electronic Computers for Reservoir Operation
CWI 179 Reservoir Water Level Recorder
CWI 180 Study of Runoff from Bottomland and Hillside Terrain
CWI 181 Lake Hydrology Studies
CWI 311 Corrosion Mitigation
CWI 314 Model Study for Hopper Dredge Pumps
CWI 906 Engineering Applications of Electronic Data

Supplement No. 6

Tennessee Valley Authority Presentation

Simplification of Locks for Tributary Streams
Investigation of Composite Design of Superstructure Floor Slabs
Investigation of the Ultimate Strength Method of Design of Concrete Structures
Study of Power System Automation and Control
Corrosion Mitigation
Computer Programs--IBM 704
Specifications Tests for Generating Plant Greases
Field Drying of Transformers
Transmission Line Construction
Boiler Water Analysis
Measurement of Oxygen in Boiler Feedwater
Demineralizer Studies
Fly Ash Collector Tube Fouling
Air Preheater Cleaning Methods
Scaling of Condensers
Control of Fresh Water Clams
Excitor Commutator Brushes
Detection of Combustible Gases in Transformers
Nitrogen Gas for Transformers
Vinyl Tape for Aircraft Waving on Piles and Towers
Use of Epoxy Varnishes
Brush Control on Transmission Line Rights of Way
Multiunit High-speed Load Control of Hydrounits
Multiplant Regulation with Hydroplants
Multiplex Telemetering System
Carrier Frequency Impedance Meter
Relaying of 13-kv Rural Type Distribution Circuits
Broad Band Coupling for Powerline Carrier
Insulated Ground Wire for Communications on High Voltage Transmission Line
Short Circuit Comparison Study
Weather Forecasts on Load Prediction
Coal Reserve Studies
Studies of Mining Methods
Study of Interest Rates
Initial Operation of an Electric Car