A part of PROCEEDINGS OF THE AMERICAN CONCRETE INSTITUTE Vol. 39

JOURNAL
of the
AMERICAN CONCRETE INSTITUTE

Vol. 14 No. 1 7400 SECOND BOULEVARD, DETROIT, MICHIGAN September 1942

Methods of Handling and Placing Concrete at Shasta Dam*

By C. S. RIPPON†
Member American Concrete Institute

SYNOPSIS

Describes briefly equipment and methods employed by contractors in handling and placing 6,500,000 cubic yards of concrete in construction of Shasta dam and power plant.

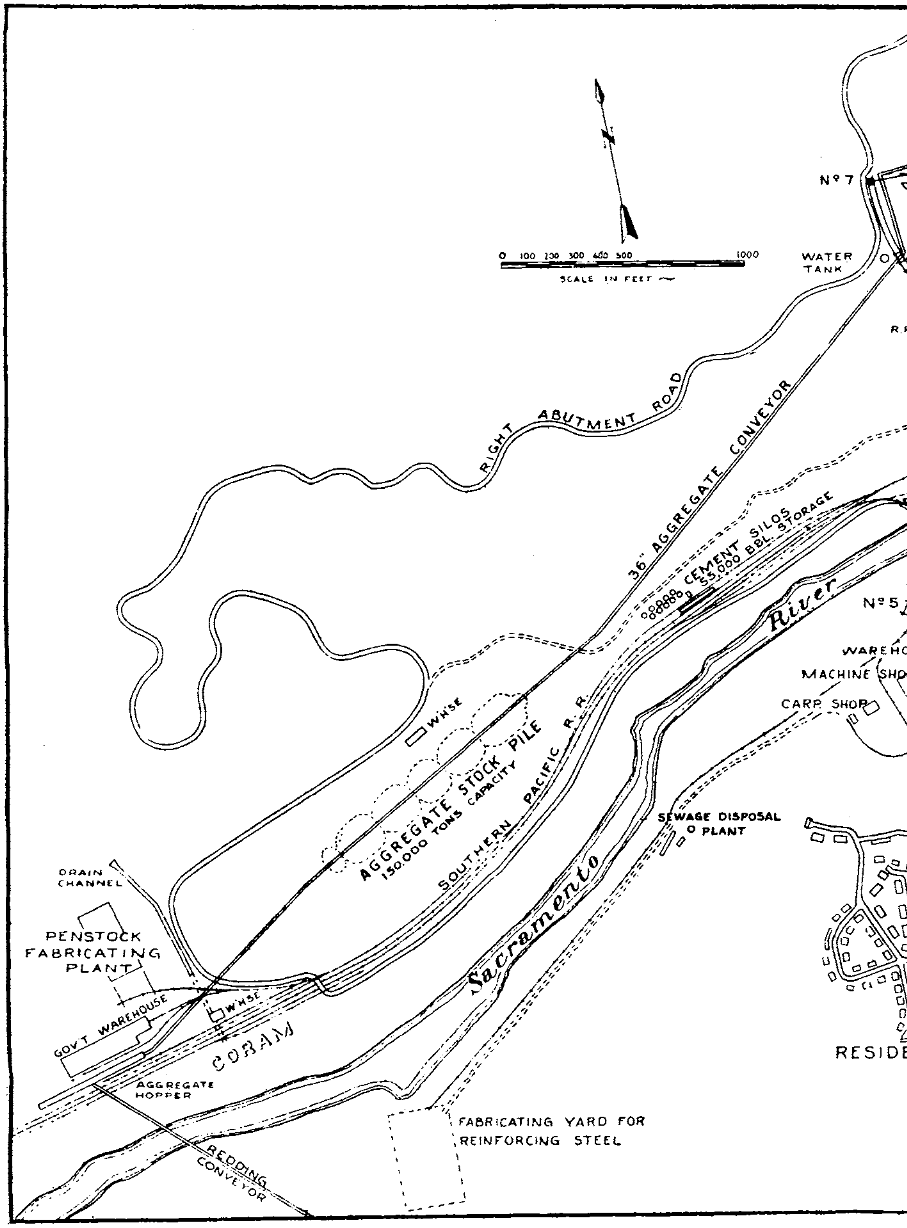
INTRODUCTION

Shasta dam and power plant are being constructed under the direction of the Bureau of Reclamation by Pacific Constructors, Inc. The dam, of concrete gravity type, 3500 ft. long at the crest and 602 ft. high, consists of a straight overflow spillway section and slightly curved abutment sections. Flow of water over the spillway will be regulated by three 110 x 28-ft. drum gates mounted on the crest between piers which will also serve as supports for a bridge connecting roadways of the abutment sections. Variable height training walls 6 ft. thick extending from the spillway crest to the spillway apron will confine overflow water to the spillway section. A stilling pool 40 ft. deep at normal flow, is provided by excavation below the river bed for the spillway apron.

The power plant, a reinforced concrete structure, is on the right bank of the river approximately 800 ft. downstream from the dam. It will house five 75,000-KVA generators driven by five 103,000-horsepower turbines and two 2300-KVA station service units.

The most interesting and unique feature of the contractor's construction layout (Fig. 1) is the distribution of concrete over the job by a system of seven radial cableways, all operated from a single stationary structural steel head tower 460-ft. high.‡ Traveling tail towers on both abutments operate on radial tracks and provide complete coverage of the dam, spillway apron and power house.

*Received by the Institute May 4, 1942.
†Engineer, U. S. Bureau of Reclamation, Shasta Dam, California.
‡*Engineering News-Record*, July 4, 1940.


0 100 200 300 400 500 1000
SCALE IN FEET
Nº 7
WATER TANK
RIGHT ABUTMENT ROAD
36" AGGREGATE CONVEYOR
CEMENT SILOS
55,000 BBL. STORAGE
River
Nº 5
MACHINE SHOP
CARP. SHOP
WHSE
AGGREGATE STOCK PILE
150,000 TONS CAPACITY
SOUTHERN PACIFIC R.R.
SEWAGE DISPOSAL PLANT
DRAIN CHANNEL
PENSTOCK FABRICATING PLANT
GOV'T WAREHOUSE
WHSE
CORAM
Sacramento
AGGREGATE HOPPER
REDDING CONVEYOR
FABRICATING YARD FOR REINFORCING STEEL
RESIDE

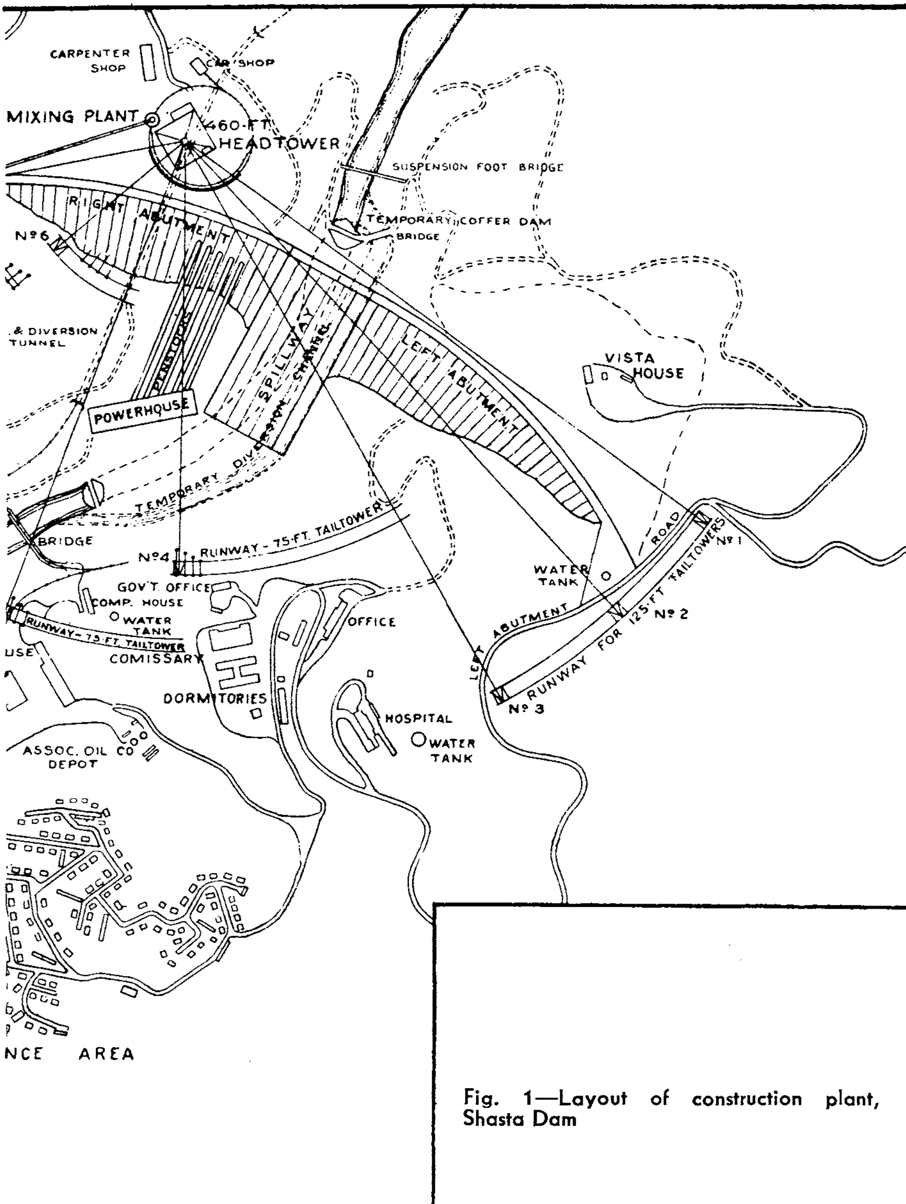


Fig. 1—Layout of construction plant, Shasta Dam

MATERIALS

Aggregates are obtained from a natural river deposit approximately ten miles downstream from the dam. Excavation and processing are done under contract between the Bureau of Reclamation and Columbia Construction Co., Inc. Aggregate is separated into sand and five sizes of gravel; namely, 6 to 3 in., 3 to 1½ in., 1½ to ¾ in. and ¾-in. to No. 4.

Eleven hundred tons of aggregate per hour are transported from the processing plant to hoppers near the dam, a distance of 9.6 miles, by 26 flights of a 36-in. belt conveyor.* Another system of 14 belt conveyors transports aggregate an additional 1.2 miles from hoppers to stockpiles and thence around the right abutment to the mixing plant. (Fig. 1).

Cement, a low heat type, is manufactured by the Permanente Cement Corp., San Jose, Calif., and transported by railroad to the dam. Two Fuller-Kenyon cement pumps capable of unloading 900 bbl. of cement per hour are used to unload cement from railroad cars and blow it into silos of 55,000-bbl. capacity. Cement is pumped or blown from the storage silos to the mixing plant through a 10-in. pipe line. This cement pumping line is 3300 ft. long and includes a 280-ft. net lift.

PRODUCTION

The mixing plant, a steel structure, designed for a capacity of 10,000 cu. yd. per day, has automatic batching equipment and five 4-cu. yd. mixers. Aggregate and cement storage is provided in the upper sections for eight hours of operation.

Batching equipment was designed by C. S. Johnson Co. and is similar to that in other modern concrete plants with push button and interlocking controls making the operations almost automatic. All materials are measured by weight and weights recorded on a combined graph recorder. Concrete consistency is controlled by consistency meters and slump tests. Consistency meters are based on the principle that the center of gravity of the mixers changes with changes in concrete consistency and by means of a system of levers and knife edges attached to the supports of the mixer, these changes are measured and recorded. Meters are calibrated and continuously checked by slump tests.

Mass concrete placed in the dam has the following mix proportions:

Mix—1:2.5:7.1
W/c—.60 by weight.
Slump—2″.
Cement content—1.00 bbl. per yd.
Sand fineness modulus—2.9

*ACI Journal, Feb. 1942; *Proceedings* Vol. 38, p. 329: "The Effect of Belt Transportation on Concrete Aggregate Grading," by Gordon L. Williams.

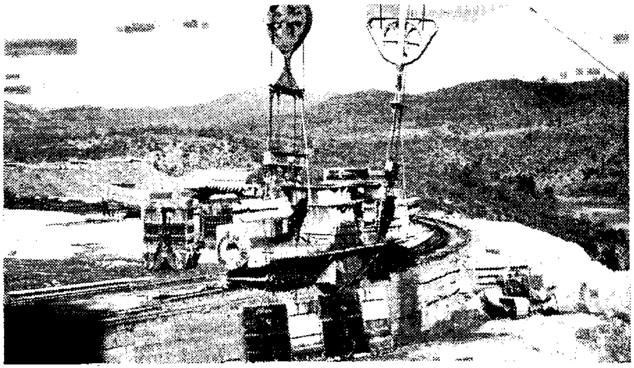


Fig. 2—Discharge of concrete from hopper cars to cableway bucket

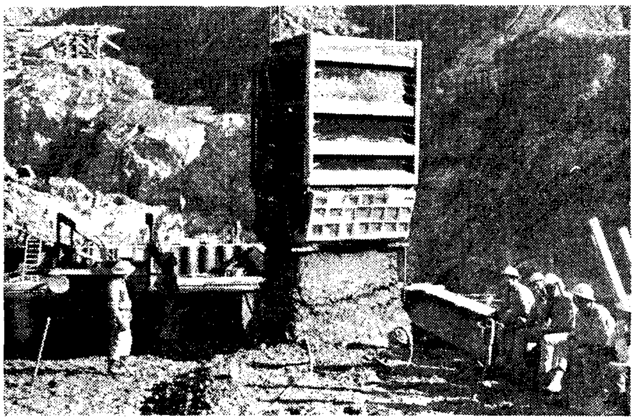


Fig. 3—Discharge of 8-cu.yd. concrete bucket

Operation of the two hoist lines used to open and close gates can be seen at the end of the bucket

Compressive strength of 6 x 12-in. control cylinders after 28 days' standard curing is 3000 psi. and after 90 days it is 5000 psi.

TRANSPORTATION

Mixers are around, and discharge into, a circular cone-type hopper capable of storing 16 cu. yd. of concrete. The hopper discharges into special cars that operate on a circular track, 210-ft. radius, which extends under the plant and around the base of the head tower. These cars were job assembled, all steel, electric driven, and carry two 8-cu. yd. hoppers with large quick opening discharge gates in the bottom.

A landing is provided for cableway buckets directly below the hopper car tracks. Buckets are spotted on the landing by the cableway operator who, from his position in the head tower, can observe all operations below. Hopper cars discharge concrete directly into the bucket, the bucket remaining attached to the cableway. Fig. 2 shows the transfer of 8 cu. yd. of concrete from the hopper cars to the cableway bucket.

Concrete buckets are hoisted from the bucket landing and transported *via the* highline to the point of placement. They are spotted at the point of placement by a bell boy located on the forms who is in telephone communication with the cableway operator at all times. The bucket is rectangular with two side-hinged gates forming the bottom. Opening and closing of the gates is controlled by manipulation of two hoist lines, one attached to the top of the bucket and one to the gates in the bottom. By close control of these two lines, it is possible to regulate the discharge as desired. Safety latches on the sides have to be unfastened by workmen on the block before the bucket can be dumped. Fig. 3 shows the cableway bucket discharging 8 cu. yd. of concrete in a 50 x 50-ft. block on the dam. The bucket was designed for this job by contractor's engineers.

For placing concrete in the power house and in confined areas of the dam where wetter concrete containing smaller size aggregate is desired, a circular cone-type bucket is used with a hand-operated gate in the bottom. In large, massive, reinforced sections, concrete is discharged from the bucket directly into the forms. In more restricted areas a staging is constructed above reinforcement bars. Hoppers and elephant trunks are then located at approximately 10-foot intervals over the entire area of the section and concrete dropped from the bucket through the hoppers and trunks into the forms.

PLACING

Preceding the placement of concrete, all approximately horizontal rock surfaces and construction joints are covered with a one-half inch layer of mortar, which is worked into all irregularities with stiff wire brooms. Mortar has the same proportions of sand and cement and slightly lower W/C ratio as the concrete.

Concrete in the dam is placed in four horizontal layers per 5-ft. lift. Entire contents of the cableway bucket (8 cu. yd.) are deposited in one place and compacted with three large electric internal vibrators manufactured by the Chicago Pneumatic Vibrator Co. (Fig. 3, 4 and 5.) Occasionally it is necessary to deposit smaller quantities at a time in corners and in confined areas around reinforcement. Large cobbles that become separated from the mass are distributed by shovels over the pile as the concrete is being vibrated. Placing crews consist of a foreman, one laborer, and six vibrator men. The top surface of each 5-ft. lift is left relatively smooth by the vibrator and no attempt is made to puddle rocks into the surface.

Numerous delays are caused by heavy rains in winter months. However, there are many days in which rainfall is light and concrete place-

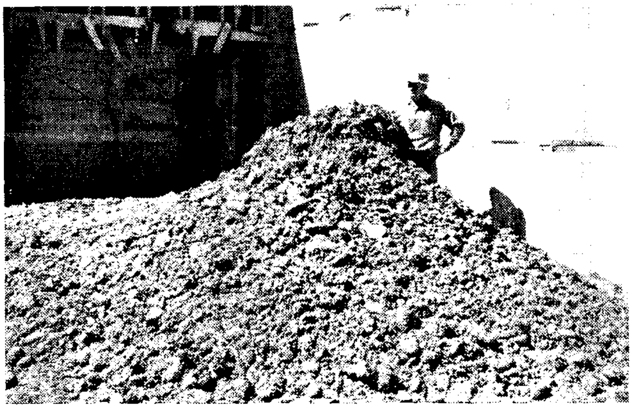


Fig. 4 — Eight cubic yards of concrete immediately after dumping from cableway bucket and before vibration

Fig. 5—The same concrete shown in Figure 4 as the vibration nears completion

ment can progress satisfactorily. (A light rain may be described as one in which the precipitation is not in excess of .05 inch per hour). When concrete is placed under these conditions, the mortar layer is spread in small quantities and covered with concrete as soon as possible. Mortar is mixed somewhat drier than that ordinarily used to compensate for water mixed in at the block. Instead of placing concrete in horizontal layers as outlined above, it is placed on a flat slope, from downstream to upstream. Each bucket of concrete when placed is vibrated to a smooth surface to facilitate drainage of water down the slope. Free water is blown off the surface immediately prior to the dumping of each bucket of concrete and is collected in a sump maintained near the upstream end of the block. Water is removed from the sump by means of siphons, pumps, shovels, sponges, etc. Some cement is washed from the surface and is pumped out of the block along with free water. The actual quantity of cement lost is unknown, but the effect is not considered detrimental. When placing concrete during rainfall special care is taken to weld succeeding layers together by deep penetration of the vibrators.

CONSTRUCTION JOINT CLEAN-UP METHODS

Methods used in curing and cleaning construction joints will be treated in detail by a later article when more data are available. Specifications called for the placement of 2 in. of wet sand on all horizontal construction joints as soon as concrete had hardened sufficiently to withstand traffic in placing. Immediately before the next lift of concrete was placed, sand was removed and the surface thoroughly washed with air and water jets. This procedure was followed from the beginning of concrete placement until March 1941 with apparent satisfactory results. Cost of sand in this vicinity, together with high cost of handling sand, caused this method of joint treatment to be very costly. The contractor, since March 1941 has been sandblasting all joints in lieu of the sand cure method. Water sprays provide curing of all surfaces.

The construction of Shasta Dam is being supervised for the Bureau of Reclamation by Ralph Lowry, Construction Engineer; Grant Bloodgood, Field Engineer; and W. A. Dexheimer, Chief Inspector. Frank T. Crowe is General Superintendent for Pacific Constructors, Inc.

Discussion of this paper should reach the ACI Secretary in triplicate by March 1, 1943 for publication in the JOURNAL for June, 1943

A part of PROCEEDINGS OF THE AMERICAN CONCRETE INSTITUTE Vol. 39

JOURNAL
of the
AMERICAN CONCRETE INSTITUTE

Vol. 14 No. 1 7400 SECOND BOULEVARD, DETROIT, MICHIGAN September 1942

Effect of Grinding in the Large Mixers on Aggregate Grading at Hiwassee Dam*

By W. R. WAUGH†
Member American Concrete Institute

SYNOPSIS

Preliminary investigations revealed that changes in grading due to grinding in the mixers would be a major consideration in the concrete control. Crushing tests gave the first indication of the instability of "graywacke" and laboratory mixing tests were made to determine the relative grinding characteristics of "graywacke" and dolomite.

Preliminary tests served only to confirm the existence of the problem, and field investigations were begun concurrently with concrete placing to determine amount and character of grinding taking place in the large field mixers. "Grab" samples were analyzed periodically as a basis for adjusting "ingoing" grading to compensate for changes in grading due to grinding in order to get a desired aggregate grading in the mixed concrete. Later full batches were analyzed as an additional check on changes in grading due to grinding. "Split batch" charging of the "face" concrete was adopted after job trials indicated that the amount of grinding could be reduced by withholding coarse rock and cobbles from the mixers until one half the mixing time had elapsed.

Variable grinding during mixing made production of concrete of uniform quality more difficult. Several conclusions in regard to grinding are given at the end of the paper.

Hiwassee Dam is the second large tributary dam constructed by the TVA in the unified program of the Tennessee Valley development. It is in Western North Carolina on the Hiwassee River. The dam is a straight-gravity concrete structure approximately 300 feet high with an overflow spillway section in the natural river channel. The dam and powerhouse contain approximately 800,000 cubic yards of concrete.

The dam is in a region where practically no natural concrete aggregate materials exist, and the isolated location made transportation rates from the nearby natural deposits prohibitive. This led to the consider-

*Received by the Institute Apr. 1, 1942.
†Materials Engineer, Hiwassee projects, TVA.

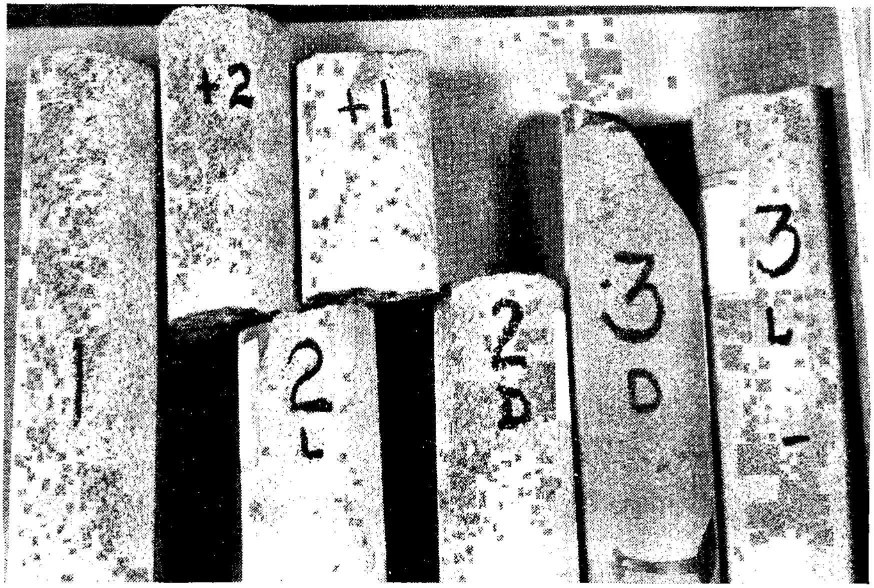


Fig. 1

ation and subsequent adoption for use of a crushed aggregate which could be produced at the job by quarrying, crushing, and processing the material available at the site, commonly known as "graywacke." The "graywacke," more correctly classified according to the geologist as "quartz mica gneiss," is characterized by its high silica content (average about 75 per cent), its relatively high density, (s.g. 2.74), and its variation in physical appearance. In physical appearance it varies from a fine-grained dark-colored rock to a coarse-grained light-colored rock with innumerable intermediate combinations of grain size and color (Fig. 1). Generally speaking the material was roughly placed in three classifications according to grain size only. This was not a precise classification since even the so-called coarse-grained material had a mixture of particles ranging down to very fine material. A preliminary estimate of the quarry selected, indicated that about 10 per cent of the material was fine grained, about 70 per cent medium grained and about 20 per cent coarse grained.

The location of a source of suitable concrete aggregate for any large hydraulic structure is a major problem. A problem which is usually neglected in preliminary concrete investigations is that of the effect of grinding action in the mixing process on the grading of the aggregate in the mixed concrete. Depending on the material under consideration, the importance of the problem of "grinding" is directly related to the amount