ITEMS OF WORK AND CONSTRUCTION DETAILS

Items of work to be performed in conformance with this specification and the construction details are:

a. Subsidiary Item, Loose Rock Riprap, Filter Blanket

(1) This item shall consist of furnishing and placing all filter blanket material that is required to complete repairs to the existing rock riprap as shown on Figure No. 1 and as directed by the Engineer.

(2) Filter blanket material in the existing rock riprap may be used with approval of the Engineer.

(3) The filter blanket material shall be a well-graded pit run sand (4" maximum diameter) and gravel (3" maximum diameter) mixture with less than 3% fines passing the No. 200 sieve if the source is other than item (2) above.

(4) All filter material shall have prior approval from the Engineer before delivery to the structure site.

(5) No separate payment will be made for loose rock riprap, filter blanket. Compensation will be included in Bid Item No. 1.
b. Bid Item 1, Loose Rock Riprap, Repair

(1) This item shall consist of furnishing and placing the rock riprap required for the repair of the existing rock riprap as shown on Figure No. 1 and as directed by the Engineer.

(2) Loose rock riprap shall be equipment placed.

(3) The rock riprap may vary in size as follows:

60 percent to 100 percent shall be greater than (12-inch) 160 pounds. 0 to 40 percent shall be between (6-inch) 20 pounds and (12-inch) 160 pounds. 0 to 5 percent shall be between 0 pounds and (6-inch) 20 pounds.

(4) The rock riprap shall be a minimum of 12 inches thick.

(5) All rock riprap shall have prior approval from the Engineer before delivery to the structure site.

(6) In Section 7, Measurement and Payment, Method 3 shall be reworded (for Bid Item 1 and 2 only) as follows:

For items of work for which specific unit prices are established in the contract, the quantity of each type of riprap placed within the specified limits will be measured to the nearest square yard.

Payment for each type of riprap will be made at the contract unit price for that type of riprap. Such payment will be considered full compensation for all labor, materials, equipment and all other items necessary and incidental to the completion of the riprap, filter layers and bedding.

Lon Hagler Dam
Riprap repair
Home Supply WS
Colorado

(61-6) 8-25-70
c. **Bid Item 2, Loose Rock Riprap, Improvement**

(1) This item shall consist of furnishing and placing the rock riprap required for the improvement of the existing rock riprap as shown on Figure No. 1 and as directed by the Engineer.

(2) Loose rock riprap shall be equipment placed.

(3) The rock riprap may vary in size as follows:

- 60 percent to 100 percent shall be greater than (12-inch) 160 pounds.
- 0 to 40 percent shall be between (6-inch) 20 pounds and (12-inch) 160 pounds.
- 0 to 5 percent shall be between 0 pounds and (6-inch) 20 pounds.

(4) The rock riprap shall be a minimum of 12 inches thick.

(5) All rock riprap shall have prior approval from the Engineer before delivery to the structure site.

(6) In Section 7, Measurement and Payment, Method 3 shall be reworded (for Bid Item 1 and 2 only) as follows:

For items of work for which specific unit prices are established in the contract, the quantity of each type of riprap placed within the specified limits will be measured to the nearest square yard.

Payment for each type of riprap will be made at the contract unit price for that type of riprap. Such payment will be considered full compensation for all labor, materials, equipment and all other items necessary and incidental to the completion of the riprap, filter layers and bedding.

Lon Hagler Dam
Riprap repair
Home Supply W. S.
Colorado
(61-7) 8-25-70
PRELIMINARY RECONNAISSANCE

On 23 January 1970 three members of the Board of Directors of The Consolidated Home Supply Ditch and Reservoir Company - e.g. Mr. John H. Sloan, President, Mr. W. R. Keirnes, Secretary-Manager, and Mr. Neil Hamilton, Treasurer met with the writer and made a field trip to the Lon Hagler Detention and Irrigation Reservoir Dam. The dam is situated in Larimer County, Colorado in the S 1/2 Sec. 29, SE 1/4 Sec. 30, NE 1/4 Sec. 31, and NW 1/4 Sec. 32, R69W, T5N. The quarry site where the riprap for the upstream face of the dam was obtained was the first point of observation. The quarry excavation was shallow and the exposed faces showed seamed and fractured rock with a shear zone evident in the south one third of the quarry. The weathered overburden was not removed to a sufficient depth to expose material not affected by weathering.

From conversation with the board members no devices for screening the fines from the quarried rock were used. And the trucks were loaded with the materials quarried without classification with front loaders. The quarry spoil was wasted in a dry water course on the northeast side and immediately adjacent to the quarry. The dry wash would have been the most logical point to have opened the quarry where a minimum of excavation would have been required to open a vertical face into rock that was unaltered by weathering rather than the flatter slopes of the hillside. The quarry is situated approximately 3/4 mile southeast
of and in the same formation as the quarry that supplied the riprap for the United States Bureau of Reclamation - Flatiron Dam and appurtenances. The construction report on the construction of the Flatiron dam states that only 44 percent of the materials quarried from that source were acceptable for use as riprap on the dam and appurtenances. The riprap as placed on the Flatiron Dam shows no displacement by wave action and no apparent spalling from weathered condition of the rock after 17 years of operation. On the other hand, the riprap placed on the upstream face of the Lon Hagler Dam shows extensive displacement, more than is allowable spalling of the rock and in some observed cases complete disintergration of rock.

LABORATORY TESTS

The sodium sulphate soundness test for coarse aggregate with 5 cycles (Identification No. E 1369) of soaking shows that the weighted loss percent was acceptable in the 1-1/2 inch, 1-inch; 1-inch, 3/4-inch. The 3/8-inch, #4; #4 showed weighted loss percent of 0.42 and would not be acceptable. The sodium sulphate tests for rock used for riprap are those acceptable for coarse aggregates for use in concrete (Designation 19, United States Bureau of Reclamation 6th Edition), and a weighted loss percent of greater than 10 percent is not acceptable. The specifications in the case of Lon Hagler Dam had allowed a 20 percent weighted loss, and this is considered to be unacceptable by The American Society of Testing Materials. The board members of the Consolidated Home Supply Ditch and Reservoir Company find that this requirement has been changed to meet the ASTM manual on Quality of Materials.

The Los Angeles Rattler abrasion test of coarse aggregates - Grading A -
indicates that resistance to abrasion is well within the allowable percent weight loss after 500 revolutions. (United States Bureau of Reclamation Manual on Small Dams, Pg. 571; and United States Bureau of Reclamation Concrete Manual 6th Edition).

The specific gravity of the rock tested was 2.66 and the Los Angeles Rattler Abrasion was 17.1 percent weight loss. These test indicate that both the specific gravity and percent weight loss are well within acceptable limits. The USBR Manual on Small Dams will accept rock with a specific gravity of 2.60 and an abrasion percent weight loss of 0.40.

The only test results available would indicate that the rock would be suitable for use of riprap on the upstream face of the dam; however in the opinion of engineers, the results of only one test of materials for the quantity of rock required would not be conclusive.

The size and soundness of the rock used on the Lon Hagler Dam does not meet those specified on Pg. 127-1 of the specifications. The requirements of the specifications can only be obtained by excavating the quarry to depths beyond alteration by weathering.

The quarry face exposed at the quarry site ranged from 3 to 10 feet and all exposed material was observed to be seamy and broken indicating that the rock was altered by weathering action. A few pieces of rock were observed in the quarry that were dense and hard with no indication of seams. These few pieces were from the north side of the quarry where the exposed face was approximately 10 feet in height and below the broken seamy overburden material at this point approximately 8 - feet thick, and indicated that if the quarry had been properly worked, it could have produced good quality rock of sizes and soundness specified.
OBSERVATIONS OF THE RIPRAP ON THE LON HAGLER DAM.

Approximately 15 feet of the riprap was exposed above the water surface at the time of the field trip. The riprap along the upstream face of the left wing section of the dam extending from approximately station 8 + 40 to station 20 + 22 appeared to be in fairly good condition, however the presence of spalling is evident and slope protection appeared to be adequate now, but future protection is doubtful. From station 20 + 22 to station 41 + 90 the riprap was inadequate for slope protection. It did not have sufficient percentages of rock (24-inch) 1000 pounds, and (16-inch) 300 pounds to protect the upstream face from wave damage. The percentages of (5-inch) 10 pound and less than 5-inch appeared to be far too high. These smaller rock should be just sufficient to fill the voids between closely placed 24-inch, and 16-inch rock to insure proper slope protection against heavy wave action that is present on the upstream face of the Lon Hagler Dam.

The placing of the riprap that was not of sufficient weight as required by specification would indicate that the inspection was inadequate or non-existent. If reasonable doubt existed that improper sized rock was being furnished then the supplier of the material should have been required to screen the rock at the quarry and an inspector that was experienced in the production of rock from a quarry should have been present in the quarry at all times while the material was being produced. Since the riprap shows definite break-down by cracking and spalling in place on the upstream face of the dam the contracting officer should have required that weathered and altered material should have been removed before acceptance at the quarry as riprap material.

Placement of the riprap was not done according to best practices to insure a
dense protective armor against wave action. The filter blanket of 6-inches is below the normal half thickness of the riprap and a minimum thickness of 12-inches, and during placement of the riprap the Board of Directors reported it was so badly disturbed by the equipment working on it that it is now ineffective. The placement of riprap was done with front loaders from rock dumped at the bottom of the upstream slope. The front loaders hauled the rock up the slope and placed it from the top to the bottom of the slope. Placement by this method would make it impossible to acquire an effective density of the rock for riprap. The rock would tend to roll down the slope and prevent a tight closely placed riprap as required by specification. Experience dictates that the riprap can be most efficiently placed by use of a dragline working from the Earth fill of the dam as the dam is built. The riprap should be dumped in sufficient quantity to insure the required thickness on the upstream slope so that the difference in elevation between the top of the Earth fill and the top of the riprap is never greater than the working radius of the dragline. The large rocks are placed with a drag bucket and tamped into place by dropping the bucket on the rock, and then the fines (5-inch) 10 pound and 5 percent fines should be dumped into the voids. Any good dragline operator can do an excellent job if he is apprised of the requirement, and then watched to prevent laxness. If the riprap material is properly classified at the quarry site, placement is not an expensive operation, and sorting on the upstream slope by the dragline is held to a minimum.

The undersized and loosely placed riprap on the upstream face of the dam has been displaced by the heavy wave action. The upstream face of the dam is almost perpendicular to the direction of the strong prevailing westerly winds (often from
40 to 80 miles per hour) and dangerous "beaching" is occurring. In some areas these beaches have eroded into the upstream face of the Earth fill material and are a threat to the safety of the structure.

RECOMMENDATIONS

1. To provide concrete and conclusive evidence that the riprap on the upstream face of Lon Hagler Dam does not afford adequate protection against wave action it is recommended that after the reservoir is drawn down to the minimum elevation at least three test areas be designated on the upstream slope of the dam to determine the gradation of the riprap material. These test areas should be at least ten feet squares taken normal to the slope of the upstream face and the materials within the test areas accurately measured and screened to determine the percentages of the sizes actually present in the as placed riprap. These tests should be conducted by an independent commercial testing laboratory on the site and an evaluation of the test results compared to those size classifications specified in the design specifications.

2. If the tests called for in paragraph 1 of "Recommendations" conclusively show that the riprap does not meet the standards set forth in the specifications then the riprap will be replaced by suitable material as determined by the Board of Directors and their advisor.

Before the riprap can be replaced it will be necessary to excavate a trapezoidal shaped trench into the Earth fill material above the minimum drawdown elevation and to extend horizontally on that elevation until it contacts the original ground on either side. The bottom should be four feet in width and side slopes, should be 1:1. The trench should have selected angular rock of 1 cubic yard carefully and
closely placed into it and the rock should extend to a minimum of 18-inches above the 3-1/2:1 slope of the upstream face of the dam projected transversely across the trench. The voids between the 1-cubic yard rock should be carefully filled with rock 1/2-cubic yard to 1 cubic foot, and then the riprap should be placed on the upstream face of the dam from the bottom of the slope to the top to insure dense 18-inch minimum thickness of riprap rock sizes as specified in the design of the dam.

3. If the quarry initially used to obtain the riprap is to be used to produce supplemental riprap then it should be thoroughly investigated. Quote from p. 130 pp. d USBR Manual on Small Dams, "The competency and quality of riprap are judged by physical properties tests, petrographic examination, and service record of the materials. Since the riprap requirements include obtaining proper sizes of rock fragments, quality tests made in the laboratory must be supplemented by data obtained by field examination and the results of blasting tests in proposed quarry sites. The importance of obtaining representative samples of each type of material in a proposed riprap source must be emphasized. If there is more than one type material in a source, separate samples should be obtained representing each material proposed for use. Intervening layers of soil, shale, or other soft rock obviously unsuitable for riprap need not be sampled, but full descriptions of these materials should appear on the drill logs and in report of the investigation". Unquote.

If the investigations indicate that the material from the initial quarry are not satisfactory for use as riprap, then permission to use the quarry that the USBR used to obtain riprap for the Flatiron Dam should be negotiated.
Regardless of the quarry that will be used to obtain the supplementary riprap, the quarrying techniques set forth in all blasting data should be used to produce rock of the maximum sizes specified.

4. The resurfacing of the upstream slope of the dam with riprap should be done as soon after the water surface is drawn down to the minimum allowable water surface elevation, and as soon thereafter as equipment can satisfactorily work on the upstream surface. The work will require cutting working berms on the surface of the dam and to facilitate movement of equipment on these they can be surfaced with quarry fines.

5. It is imperative that the resurfacing of the upstream slope of the dam with suitable riprap is done before the reservoir is refilled after the next irrigation season.

The report by the Board of Directors of The Consolidated Home Supply Ditch and Reservoir Company to the Annual Meeting of stockholders indicates that conditions on the entire upstream slope of the dam shows that rock used for riprap was not as specified in the design of the dam, with resulting serious beaching conditions along the entire slope, and of the spalling and disintegration of the riprap.
REFERENCES


United States Department of the Interior - Bureau of Reclamation. First Edition Revised


Civil Engineering Handbook - Urquart Third Edition

Handbook of Applied Hydraulics - Davis Second Edition

Handbook of Heavy Construction - Stubbs.


Transcript of pp. 8, 9, and 10 in minutes of the Annual Meeting of Stockholder of - The Consolidated Home Supply Ditch and Reservoir Company, held at Loveland, Colorado, December 8, 1969.

Specifications for the Construction of the Lon Hagler Detention and Reservoir Dam - C-1202

Design Drawings for Lon Hagler Dam.

Specifications for the Construction of Button Rock Dam
City of Longmont, Colorado - By McCall-Ellingson Consulting Engineers. 1721 High Street, Denver, Colorado 80218 - 1967


L. T. Irwin
Registered Professional Engineer
State of Colorado 7149
Following is a synopsis of the engineering career of Mr. L. T. Irwin, registered professional engineer who resides at 1619 So. Iris Way - Lakewood, Colorado.

From 1936 to 1955 including four years with the U. S. Army during WW II, Mr. Irwin was a career irrigation engineer with the U. S. Bureau of Reclamation and worked on design and construction of many major projects including Alcova, Seminole and Hart Mountain in Wyoming and the Shasta Dam in California.

Following this field experience he was a member of the Chief Engineers staff with the Bureau of Reclamation in Denver, where he was assigned specifically to the design and construction section of the Dams Division.

In 1955 Mr. Irwin resigned from the Bureau and entered into service with the U.S. Dept. of State as Project and Construction Engineer on many major irrigation projects in Africa. His twelve years work with the State Dept. took him into Egypt, Libya, Somalia and Nigeria. In each of these countries Mr. Irwin served as construction engineer for various irrigation dams and projects.

In 1966 Mr. Irwin retired from Federal service, but has remained very active in his chosen field of endeavor. His most recent project in this capacity was as resident engineer in charge of construction of the Button Rock Dam for the City of Longmont, Colo. Button Rock Reservoir has a capacity of 15,000 A.F. and is a vital part of the expanded domestic water supply system for the city of Longmont.

Button Rock provided a great bonus value during the floods of 1969 when it saved the town of Lyons, Colo. from severe damage. Farms and homes east of Lyons also suffered much less loss from the cloudburst than would have been the case had not the new dam been in existence. Mr. Irwin states that the Button Rock Reservoir filled in five days, which placed terrific stress on the new structure, but no weakness in the riprap or in the dam itself has resulted.
September 25, 1967

Soil Conservation Service
1312 East 14th Street
Loveland, Colorado 80537

Gentlemen:

Presented in this letter are the results of tests performed on a sample of quarried rock for use as rip-rap. The sample was submitted on September 13, 1967.

After the rock had been crushed to pass a 1-1/2 inch sieve, the specific gravity was determined. The sample was tested for soundness and resistance to abrasion in accordance with Federal Specification S5-R-406. Following are the test results:

**SODIUM SULFATE SOUNDNESS TESTS — COARSE AGGREGATE (5 CYCLES)**

<table>
<thead>
<tr>
<th>Sieve Size</th>
<th>Grading</th>
<th>Avg C-33</th>
<th>Weight of Test Fractions</th>
<th>Weighted Loss</th>
</tr>
</thead>
<tbody>
<tr>
<td>Passing</td>
<td>Retained</td>
<td>of Sample</td>
<td>Before Test (gm)</td>
<td>Per Cent</td>
</tr>
<tr>
<td>1-1/2 in</td>
<td>1 in</td>
<td>48</td>
<td>1500</td>
<td>0.20</td>
</tr>
<tr>
<td>1</td>
<td>3/4</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3/4</td>
<td>1/2</td>
<td>32</td>
<td>1000</td>
<td>0.60</td>
</tr>
<tr>
<td>1/2</td>
<td>3/8</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3/8</td>
<td># 4</td>
<td>18</td>
<td>300</td>
<td>2.33</td>
</tr>
<tr>
<td># 4</td>
<td></td>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TOTAL</td>
<td></td>
<td>100</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

REMARKS: 61 pieces — very slight sanding.
Soil Conservation Service

September 25, 1967

Specific Gravity

2.66

LOS ANGELES ABRASION
Grading A

500 Revolutions

Percentage of Wear

17.1%

Very truly yours,

COMMERCIAL TESTING LABORATORIES

D. W. Fleming, P. E.
8. **ITEMS OF WORK AND CONSTRUCTION DETAILS**

Items of work to be performed in conformance with this specification and the construction details are:

**Bid item:** 29,689 cu. yds.

**In place:** 29,578 cu. yds.

*a. Bid Item 19, Loose Rock Riprap.*

(1) This item shall consist of furnishing and placing the rock riprap and filter blanket on the upstream face of the dam as shown on the drawings.

(2) Loose rock riprap shall be equipment placed.

(3) Gradation of the filter material shall conform to the following:

<table>
<thead>
<tr>
<th>Sieve Size</th>
<th>Percent Passing (by weight)</th>
</tr>
</thead>
<tbody>
<tr>
<td>3&quot;</td>
<td>100</td>
</tr>
<tr>
<td>1-1/2&quot;</td>
<td>65-100</td>
</tr>
<tr>
<td>1&quot;</td>
<td>58-100</td>
</tr>
<tr>
<td>3/4&quot;</td>
<td>51-100</td>
</tr>
<tr>
<td>1/2&quot;</td>
<td>46-100</td>
</tr>
<tr>
<td>3/8&quot;</td>
<td>42-100</td>
</tr>
<tr>
<td>#4</td>
<td>30-100</td>
</tr>
<tr>
<td>#8</td>
<td>18-70</td>
</tr>
<tr>
<td>#16</td>
<td>16-54</td>
</tr>
<tr>
<td>#30</td>
<td>9-36</td>
</tr>
<tr>
<td>#60</td>
<td>0-24</td>
</tr>
<tr>
<td>#100</td>
<td>0-5</td>
</tr>
<tr>
<td>#200</td>
<td>0-5</td>
</tr>
</tbody>
</table>

(4) The rock riprap may vary in size as follows: The maximum size shall be (24-inch) 1000 pounds; 25 percent shall be greater than (16-inch) 300 pounds; 45 to 75 percent shall be between (5-inch) 10 pounds and (16-inch) 300 pounds; 25 percent shall be less than (5-inch) 10 pounds, with sand and rock dust less than 5 percent.

(5) All rock riprap and filter material shall have prior approval from the Engineer before delivery to the structure site.

(6) Measurement and payment shall be by Method 1.

(17-3)
MATERIAL SPECIFICATION

127. ROCK FOR PERMANENT CONSTRUCTION

1. SCOPE

This specification covers the quality of rock to be used in the construction of permanent works.

2. GENERAL REQUIREMENTS

Individual rock fragments shall be dense, sound and free from cracks, seams and other defects conducive to accelerated weathering. The rock fragments shall be angular to subrounded in shape. The least dimension of an individual rock fragment shall be not less than one-third the greatest dimension of the fragment.

Representative samples of the rock shall conform to the requirements specified herein for the designated type of rock construction when tested by the methods specified in Section 5 of this specification.

3. ADDITIONAL REQUIREMENTS FOR RIPRAP

Rock for riprap shall also conform to the following requirements:

a. The bulk specific gravity (in the saturated, surface dry condition) shall be not less than 2.5.

b. The soundness shall be such that the weight loss shall be not more than 10 percent after 5 cycles when tested by the sodium sulphate soundness test method.

c. The resistance to abrasion shall be such that the weight loss shall be not more than 35 percent when tested in the Los Angeles abrasion machine.

4. ADDITIONAL REQUIREMENTS FOR ROCK FILL

Rock for embankment or blankets for slope protection shall also conform to the following requirements:

a. The bulk specific gravity (in the saturated, surface dry condition) shall be not less than 2.4.

(127-1)
b. The soundness shall be such that the weight loss shall be no more than 20 percent after 5 cycles when tested by the sodium sulphate soundness test method.

5. **SAMPLING AND TESTING**

Methods of sampling and testing shall conform to the standard methods contained in Federal Specification SS-R-406, as follows:

<table>
<thead>
<tr>
<th>Method No.</th>
<th>Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sampling</td>
<td>101.01</td>
</tr>
<tr>
<td>Soundness</td>
<td>203.01</td>
</tr>
<tr>
<td>Abrasion (Los Angeles)</td>
<td>208.11</td>
</tr>
<tr>
<td>Specific gravity</td>
<td>209.0</td>
</tr>
</tbody>
</table>
Collection title: Records of the Consolidated Home Supply Ditch and Reservoir Company

Collection code: WCHS

Description of item(s) separated:

9 color photographs of riprap

Old location:
Subseries 6.2
Folder: Lon Hagler: deterioration of riprap, 1967, undated

New location:
Photograph series

Name of processor: [Signature]
Date: 6/3/19
1. Showing severe erosion on upstream face of dam. Wave action has removed fine material and is now working on the dirt fill of the dam itself. A few large rock can be seen. This entire surface would be covered with the large riprap material had specifications been followed and had inspectors insisted that specification be adhered to. This is but one of many areas which are showing the same type of damage.

2. Showing a serious lack of large riprap material on the dam. Many of the large riprap rock have disintegrated and broken up into small "walnut-sized" stones, which afford little protection to the face of the dam.

3. Note large rock in the center. It is in the process of disintegrating. One corner has broken off with the fallen piece visible immediately below. Note the grass area. Little protection is afforded this area. There are few large rocks of specification size over that large area.
4. Showing inadequately protected area. There is evidence of disintegration of the riprap material. This has happened in a period of only two years.

5. More unprotected areas, showing a tendency to "bench out". These areas are at present high-water line and the benching is caused by wave action beating against face of dam. Use of properly selected and graded materials in accordance with S.C.S. specification would have prevented this type of riprap failure.

6. Large rock disintegrated completely. This rock has never been under water - exposed only to sun, air and weather changes; an indication that much unstable material was permitted to be used.
7. Showing the "benching out" or "shelving" which is taking place. As the reservoir was drained down during the 1969 irrigation season, these same "benching" effects were noted at many different levels.


9. Note the extensive areas without adequate protection. In the clear water one is able to discern this lack of protection far down the face of the dam. Benching out is also discernible below present water level.