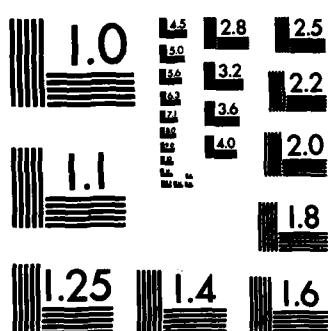




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MISCELLANEOUS PAPER SL-82-14

EVALUATION OF CONCRETE CORES FROM WATERBURY DAM, WATERBURY, VT.

by

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September 1982

Final Report

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number) Concrete cores were obtained from Waterbury Dam, Waterbury, Vt., for examination and analysis. The cores had an average compressive strength of 5790 psi which reflects that the strength of the interior concrete of the dam is excellent. The dam has more surface concrete deterioration than is indicated by the cores and core logs. The major cause of surface concrete deterioration is freezing and thawing. (Continued)		

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20. ABSTRACT (Continued)

There are no signs of monolith misalignment or structural damage; therefore, after the surface concrete has been repaired, the concrete dam will be in excellent condition.

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PREFACE

An evaluation of concrete cores from Waterbury Dam, Waterbury, Vt., was conducted for the U. S. Army Engineer District, New York, by the Structures Laboratory (SL) of the U. S. Army Engineer Waterways Experiment Station (WES). Authorization for this investigation was given in Intra-Army Order for Reimbursable Services No. NYD 81-115(c), dated 26 May 1981.

The contract was monitored by the New York District with assistance from Mr. Tony Barbero. His cooperation and assistance are greatly appreciated.

The study was performed under the direction of Messrs. Bryant Mather, W. J. Flathau, and J. M. Scanlon, Jr., SL. The evaluation was performed by Dr. Carl E. Pace and Messrs. Richard L. Stowe and G. Sam Wong. The core logging was performed and the petrographic report was written by Messrs. Wong and Jerry P. Burkes under the technical supervision of Mr. Alan D. Buck. The concrete core tests were performed by Mr. Michael K. Lloyd. Dr. Pace and Messrs. Stowe and Wong prepared the report.

Funds for publication of this report were provided from those made available for operation of the Concrete Technology Information Analysis Center (CTIAC). This is CTIAC Report No. 53.

Commander and Director of WES during the conduct of the program was COL Tilford C. Creel, CE. Mr. F. R. Brown was Technical Director.



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CONVERSION FACTORS, NON-SI TO SI (METRIC)
UNITS OF MEASUREMENT

Non-SI units of measurement used in this report can be converted to
SI (metric) units as follows:

<u>Multiply</u>	<u>By</u>	<u>To Obtain</u>
feet	0.3048	metres
inches	0.0254	metres
miles (U. S. statute)	1609.344	metres
pounds (force)	4.448222	newtons
pounds (mass)	0.4535924	kilograms
pounds (force) per square inch	0.006894757	megapascals

EVALUATION OF CONCRETE CORES FROM
WATERBURY DAM, WATERBURY, VT.

PART I: INTRODUCTION

Background

1. Waterbury Dam is located on the Waterbury River, 3 miles* north of Waterbury, Vt. It was completed in 1938 as one of the units in the comprehensive plan for flood control in the Winooski River Basin. Besides the steel gates and the concrete spillway and outlet works (Figure 1), the dam is of rolled-earthfill construction, 155 ft high and 1800 ft long.

2. A modification completed in November 1959 raised the earth-fill dam 3 ft, added one 35-ft flood gate, and included other incidental work to increase the spillway capacity of the dam in the interest of safety of the structure. No additional flood storage was provided.

3. The project provides protection for Waterbury and, in conjunction with other units in the comprehensive plan for flood control in the Winooski River Basin, provides protection for other downstream damage centers. In addition to this flood protection, the Waterbury reservoir is used for power storage by a 5500-kw power plant constructed immediately below the dam in 1953 by the Green Mountain Power Corporation and provides a regulated flow which results in considerable benefits to downstream hydroelectric plants of the Green Mountain Power Corporation on the Winooski River.

Objective

4. The objective of this study was to make an onsite inspection

* A table of factors for converting non-SI units of measurement to SI (metric) units is presented on page 3.

of Waterbury Dam, evaluate concrete cores recovered from the dam, correlate information obtained from the observations of the dam with the condition of concrete cores from the dam, and recommend repair/rehabilitation materials and procedures if necessary.

Scope

5. This study was limited to a general inspection and evaluation of the concrete spillway and outlet works of Waterbury Dam. Concrete cores were examined, tested, and evaluated. Repair materials and procedures are suggested.

PART II: PETROGRAPHIC EXAMINATION AND CORE LOGS

Samples

6. Twenty-six concrete cores taken from Waterbury Dam were received during April 1981 from the U. S. Army Engineer District, New York. The cores from the different parts of the structure were assigned Structures Laboratory (SL) serial numbers as presented in Table 1.

Test Procedure

7. All of the cores were examined visually, logged, and photographed. The portions of core of sufficient length were identified for physical tests, while cores representing various conditions of the concrete were selected for more detailed petrographic examination.

8. The portions of cores or the entire core representing 10 locations were examined in more detail. Some of these cores were sawed longitudinally, and the sawed surfaces were ground smooth. These smoothed surfaces were examined using a stereomicroscope.

9. Some core pieces were broken to allow examination of fresh fracture surfaces. Materials that are subject to erosion during sawing, grinding, or coring can be examined by this procedure. It was necessary at times to isolate particles and examine the material by X-ray diffraction or by using a polarizing microscope in the identification of particles.

10. All X-ray patterns were made with an X-ray diffractometer using nickel-filtered copper radiation.

11. Samples examined using a polarizing microscope were first crushed to a powder and then examined as oil immersion mounts.

Results

12. The physical condition of the concrete varied from good sound intact concrete illustrated by cores NY-8 CON-1, 6A, 6B, 6C, 7, 8, 9A,

12, 3, 16, 18, 19, 21, and 23 to fractured and fragmented concrete illustrated by cores NY-8 CON-2, 5, 11, 14, and 15 (Figure 2). Other cores showed areas of poor consolidation and loose contact of new concrete with old concrete. The core logs (Figures 3-28) describe the nature of the cores received for examination. Maximum depth of deterioration was 1.4 ft as shown by core NY-8 CON-5.

13. Microscopic examination of cores indicated that all mortar overlays were air entrained while all original concrete did not contain entrained air. Cracking parallel or subparallel to the formed surfaces was evident in some of the original concrete. No such cracking was observed in the air-entrained mortar. Longitudinal cracks containing white exudation were present in some cores with and without a mortar topping. Cracks traversed aggregate particles as well as the paste.

14. Much of the mortar overlay material separated along the mortar to concrete interface; this was the case in cores NY-8 CON-3, 4, 8, and 17, as indicated in Figure 29. In core NY-8 CON-10, the mortar and about 0.10 ft of concrete separated from the remainder of the core. The mortar and concrete of core NY-8 CON-18 remained intact and with good bond, as shown in Figure 30.

15. The aggregate was a natural siliceous gravel and sand of mixed composition. Both the fine and coarse aggregates were composed of schist, gneiss, quartz, weathered granite, quartzite, and sandstone as rock types.

16. Old fractured surfaces were often coated with white reaction product. Some of this material was needle-like crystals of ettringite and calcite which was probably due to calcium hydroxide leached from the portland cement paste and carbonated when exposed to carbon dioxide from the atmosphere. Alkali-silica gel was found filling voids (Figure 31) and at times saturated the fractured surfaces.

17. Alkali-silica gel appeared as a clear to translucent material coating the fractured surfaces. Drying shrinkage cracks were often observed as the samples are allowed to dry in the atmosphere.

18. X-ray examination of the gel indicated crystalline material

similar to that described by Buck and Mather.*

19. The alkali-silica gel was of a salt and pepper texture when examined with a polarizing microscope. The gel had an index of refraction of 1.478.

Conclusions

20. Some of the concrete was intact and in good condition, but frost action on critically saturated concrete had caused some incipient cracks to develop in the nonair-entrained concrete. The crack development was exacerbated by deleterious alkali-silica reaction which accelerated the deterioration of some near-surface concrete.

21. Previous repairs made to the concrete may not be adequate to prevent continued deterioration since frost action continues to attack the near-surface underlying susceptible concrete. One evidence of this was the lack of bond generally observed at the mortar contact with original concrete.

* A. D. Buck and K. Mather. 1978. "Alkali-Silica Reaction Products from Several Concretes: Optical, Chemical, and X-Ray Diffraction Data," Proceedings of the Fourth International Conference of the Effects of Alkalies in Cement and Concrete, Purdue University, pp 73-79.

PART III: CONCRETE INTEGRITY AND REPAIR RECOMMENDATIONS

22. A general plan view of Waterbury Dam is presented in Figure 32. Concrete cores were taken from locations as presented in Figure 33 and Table 1. A list of the cores which were examined is presented in Table 1.

23. The spillway openings from east to west are designated as A-1, A-2, A-3, and A-4. The spillway sections from the crest downstream at openings A-4 and A-3 on the overflow portion are severely deteriorated. Pattern cracking on the order of about 3 to 4 ft apart covers a greater portion of the spillway area in openings A-4 and A-3. An example is presented in Figure 34. There are some horizontal cracks greater than 2 mm in width, as can be noted in Figure 35. The cracks have efflorescence and exudation associated with them. Spillway sections A-1 and A-2 are not quite as deteriorated as sections A-3 and A-4 but have similar surface deterioration. Pattern cracking exists in sections A-1 and A-2. Some cracks are open while some are closed and exudation products are present.

24. The upstream vertical faces of the four spillway sections have pattern cracking every 3 to 4 ft on centers. Some of the cracks are open and white exudation products are present. Views of these surfaces are presented in Figures 36 and 37.

25. The bridge decking across spillway sections A-1 through A-4 is in relatively good condition. Light pattern cracking is seen on the top surface (Figure 38). There is light deterioration on the bridge decking where it comes in contact with the spillway piers No. 6, 7, and 8. The piers are numbered from east to west. A slight offset of about 1 in. on the upstream edge of one of the bridge deck sections is presented in Figure 39. The offset appears to be due to construction and not an indication of a structural deficiency.

26. In general, piers No. 1 through 8 are in good condition (Figures 37 and 40). They have small local areas of deterioration due to freezing and thawing action. Pattern cracking is present, but it is nowhere so prominent as it is in the spillway section. Few cracks or exudation products are present.

27. The concrete in the right retaining wall on the upstream side is in good condition. Several local areas of deterioration are present; white exudation is also present. Looking downstream on the right retaining wall there are a number of areas of deteriorated concrete; these areas show scaling for approximately 5 or 6 cm. Exudation is also present. The downstream retaining wall has severe surface concrete deterioration as can be seen in Figure 41.

28. The left abutment wall is a concrete retaining wall that has its upstream portion abutted into the rock slope (Figure 42) and the downstream section offset from the rock slope (Figure 43). The back side of that retaining wall is in good condition.

29. The majority of drilled core was recovered from areas that contained very small amounts of deteriorated concrete. Four of the pieces of core that were examined showed evidence of damage due to freezing and thawing. About 10 separate locations were observed where the contractor had drilled core. In all 10 cases, coring was done where the concrete was not damaged. The depth of deteriorated concrete, for the various sections of the concrete dam, cannot be determined from the cores presently in the SL laboratory. The depth of deteriorated concrete is at least a maximum of 1.4 ft as determined by petrographic examination. Some of the severely deteriorated areas in the dam were not cored. The concrete dam can in all probability be repaired by removing the deteriorated concrete and replacing it with a durable overlay.

30. There was no evidence of settlement or misalignment of the concrete structural elements in the spillway section or the gated tainter gate section. Alignment of the concrete appears to be very good. The concrete section of the dam is founded on rock which is exposed both upstream and downstream of the tainter gate sections. No undercutting was observed between the base of the concrete and the foundation rock.

31. Significant structural cracks were not seen in the concrete section of the dam. Cracking of the concrete from a structural standpoint does not appear to be a problem. The concrete at Waterbury Dam is relatively sound except in the spillway sections where areas of severely damaged concrete exist. Freeze-thaw action caused most of the damage.

32. The concrete core strengths (Table 2) indicate that the interior concrete is in good condition. If the deteriorated concrete is removed and replaced with a frost-resistant overlay, the dam should be in excellent condition for future service.

33. It is suggested that the dam be repaired by removing the deteriorated concrete and replacing it with a frost-resistant concrete overlay. The overlay should be doweled into the existing concrete and reinforced. Adequately frost-resistant concrete to withstand the most severe natural weathering can be produced if three criteria are met: (a) adequate air-void system, (b) sound aggregate, and (c) adequate maturity prior to being allowed to freeze and thaw in a critically saturated condition. The latter is met if concrete develops a compressive strength of 3500 psi prior to freezing. Some thin layers of overlay concrete may have a low modulus of elasticity to have more strain capacity to resist cracking. The use of organic additives ("latexes") including products such as so-called "acrylic polymers" has been advertised for this objective and may merit consideration when the overlay is less than 2 in. thick.

PART IV: CONCLUSIONS AND RECOMMENDATIONS

34. The interior concrete at Waterbury Dam is of excellent strength and quality. There are no signs of stability or structural problems.

35. The main problem at Waterbury Dam is surface concrete deterioration which has mainly been caused by freezing and thawing action.

36. It is recommended that Waterbury Dam be repaired by removing the deteriorated concrete and replacing it with a doweled and reinforced overlay of frost-resistant, wear-resistant concrete. The original concrete should be surface dry and no special bonding used other than concrete to concrete bond. After this repair has been accomplished, the dam will not experience accelerated deterioration due to water entering cracks and freezing and thawing.

37. After the deteriorated surface concrete has been removed and replaced, the dam should give economical service for many more years.

Table 1
Concrete Core Designations

SL Serial No. NY-8	Field Identification No.	Location
CON-1	Core No. 1	Downstream face of the spillway section (C) Location: 25 ft west of tainter gate abutment Depth: 24 in. Recovery: 23.6 in.
CON-2	Core No. 2	Downstream face of the spillway section (C) Location: 83.5 ft west of tainter gate abutment Depth: 18 in. Recovery: In 2 parts, 9 in. + 6.5 in. = 15.5 in.
CON-3	Core No. 3	Downstream face of the spillway section (B) Location: 39.8 ft east of spillway retain- ing wall. 11.5 ft north of spill- way face Depth: 20 in. Recovery: In 2 parts, 3.3 in. + 15.5 in. = 18.8 in.
CON-4	Core No. 4	Downstream face of the spillway section (A) Location: 11.2 ft east of spillway retain- ing wall. 12 ft north of spill- way face Depth: 21 in. Recovery: In 2 parts, 3.4 in. + 16.7 in. = 20.1 in.
CON-5	Core No. 5	Downstream face of spillway wall Location: 24.1 ft east of spillway retain- ing wall. 3.3 ft from top of spillway face Depth: 20 in. Recovery: In 3 parts, 2.5 in. + 11.2 in. + approximately 3.5 in. (fragments) = 17.2 in.
CON-6A	Core No. 6	Catwalk Location: 1st Attempt: 70.1 ft east of spillway retaining wall. 4.7 ft north of downstream cat- walk edge*

*Note 1: Due to thickness of catwalk (18 in.)
24-in. core was not possible.

(Continued)

(Sheet 1 of 5)

Table 1 (Continued)

SL Serial No. NY-8	Field Identification No.	Location
CON-6B		2nd Attempt: 69.2 ft east of spillway retaining wall. 4.0 ft north of downstream catwalk edge*
CON-6C		3rd Attempt: 67.3 ft east of spillway retaining wall. 2.1 ft north of downstream edge of catwalk Depth: 1st: 1.9 in. - 2nd: 2.0 in. - 3rd: 13.0 in. Recovery: 1.9 in. + 2.0 in. + 13.0 in. = 16.9 in. *Note 2: 1st and 2nd attempt: Steel refusal
CON-7	Core No. 7	Bridge pier I - west face Location: 2.3 ft from top of spillway. 2.7 ft north of downstream edge of pier Depth: 20 in. Recovery: 19.5 in.
CON-8	Core No. 8	Spillway retaining wall abutment - east face Location: 2.0 ft from top of dam. 6.1 ft south of construction joint Depth: 18 in. Recovery: 16 in.
CON-9A	Core No. 9	6-in. diamond bit core and single tube NX Location: 19.7 ft west of tainter gate abutment wall - 1st attempt. 0.5 ft north of spillway face Depth: 1.1 ft Recovery: 1.1 ft Note: Concrete core broke at 1.1 ft. Slight seepage of water noted at bottom of core hole. Core was moved west due to misalignment of core barrel and existing hole.
CON-9B		Location: 20.2 ft west of tainter gate abutment wall - 2nd attempt. 0.5 ft north of spillway face Depth: 1.8 ft Recovery: 1.8 ft Note: NX core advanced to 4.6 ft. Recovery = 1.5 ft concrete, 1.3 ft rock

(Continued)

(Sheet 2 of 5)

Table 1 (Continued)

SL Serial No. NY-8	Field Identification No.	Location
CON-10	Core No. 10	6-in. diamond bit core and single tube NX Location: 84 ft east of spillway abutment wall. 1.6 ft north of spillway face Depth: 2.2 ft Recovery: 2.2 ft Note: NX core advanced to 3.9 ft Recovery = 0.6 ft concrete 1.1 ft rock
CON-11	Core No. 11	Downstream face of spillway wall Location: 64 ft east of spillway abutment wall. 4 ft from top of spillway face Depth: 18 in. Recovery: 15 in.
CON-12	Core No. 12	Tainter gate abutment wall - west face Location: 3.8 ft north of downstream edge of pier. 3.3 ft up from top of spillway Depth: 21 in. Recovery: In 2 parts, 12.5 in. + 8.5 in. = 21 in.
CON-13	Core No. 13	Bridge pier III - east face Location: 1.6 ft north of downstream edge of pier. 1.7 ft from top of dam Depth: 22.5 in. Recovery: In 2 parts, 9.5 in. + 11.5 in. = 21 in.
CON-14	Core No. 14	Bridge pier II - east face Location: 0.8 ft north of downstream edge of pier. 1.8 ft up from top of dam Depth: 21 in. Recovery: In 2 parts, 6 in. + 12.5 in. = 18.5 in.
CON-15	Core No. 15	Downstream face of spillway wall Location: 2.1 ft west of tainter gate abutment. 1.5 ft from spillway edge Depth: 17 in. Recovery: In 3 parts, 6 in. + 7.5 in. + approximately 2.0 in. (fragments) = 15.5 in.

(Continued)

(Sheet 3 of 5)

Table 1 (Continued)

SL Serial No. NY-8	Field Identification No.	Location
CON-16	Core No. 16	Reservoir face of spillway Location: 10.5 ft east of pier III. 7.6 ft from ground level Depth: 21.0 in. Recovery: In 2 parts, 8 in. + 13 in. = 21 in.
CON-17	Core No. 17	Reservoir face of spillway Location: 7.3 ft east of pier I. 2.9 ft from ground level Depth: 20 in. Recovery: In 3 parts, 4.5 in. + 3.5 in. + 8.5 in. = 16.5 in.
CON-18	Core No. 18	Reservoir face of spillway Location: 12.8 ft east of spillway retain- ing wall. 2.3 ft from ground level Depth: 16 in. Recovery: 7 in.
CON-19	Core No. 19	Spillway retaining wall abutment - east face Location: 4.8 ft north of reservoir face of spillway. 4.1 ft from ground level Depth: 18 in. Recovery: In 2 parts, 9 in. + 9 in. = 18 in.
CON-20	Core No. 20	Spillway retaining wall - east face Location: 70.1 ft north of reservoir face of spillway. 4.0 ft from ground level Depth: 21 in. Recovery: In 2 parts, 7 in. + 12.5 in. = 19.5 in.
CON-21	Core No. 21	Spillway retaining wall - east face Location: 49.5 ft north of downstream end of wall. 3.5 ft from ground level Depth: 21 in. Recovery: In 2 parts, 8.5 in. + 12.0 in. = 20.5 in.
CON-22	Core No. 22	Spillway retaining wall - west face Location: 52.8 ft north of downstream edge of wall. 3.2 ft from ground level Depth: 20 in. Recovery: In 2 parts, 6.5 in. + 12.0 in. = 18.5 in.

(Continued)

(Sheet 4 of 5)

Table 1 (Concluded)

SL Serial No. NY-8	Field Identification No.	Location
CON-23	Core No. 23	Turbine house - north wall Location: 20.2 ft west of east wall. 3.3 ft from platform level Depth: 9 in. Recovery: 9 in.

Table 2
Six-Inch Concrete Core Strengths

<u>Specimens</u>	<u>Unconfined Compressive Strength</u>
1	7510
4B	5720
8	6730
9A	6480
9B	6550
10	6900
13B	5440
14B	3280
16B	5730
20	5580
21	5150
22	4450

Average $\approx$ 5790 psi



Figure 1. Spillway and outlet works, Waterbury Dam

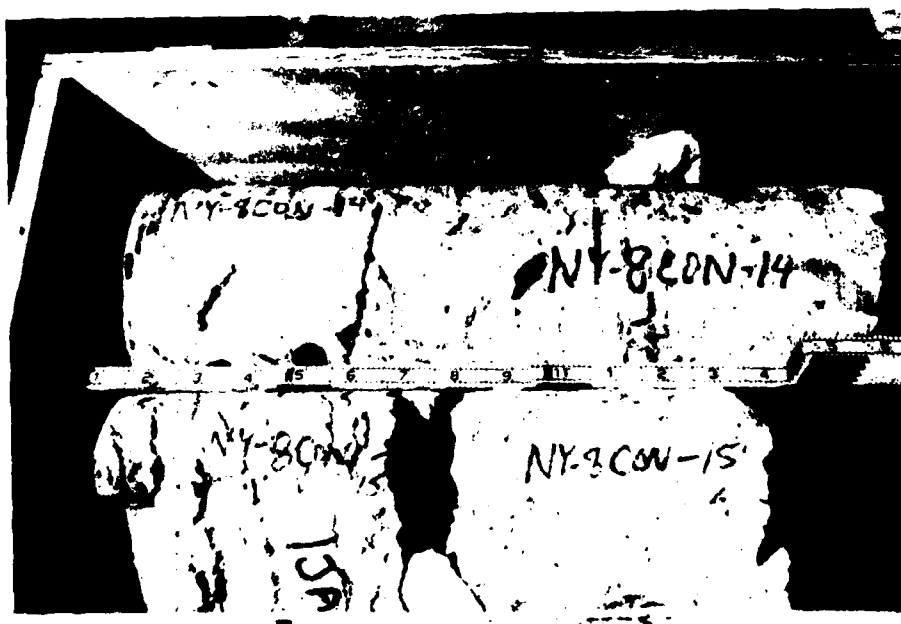


Figure 2. Samples NY-8 CON-14 and 15 showing near-surface incipient cracks

Depth
ft

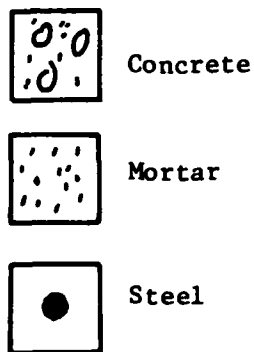
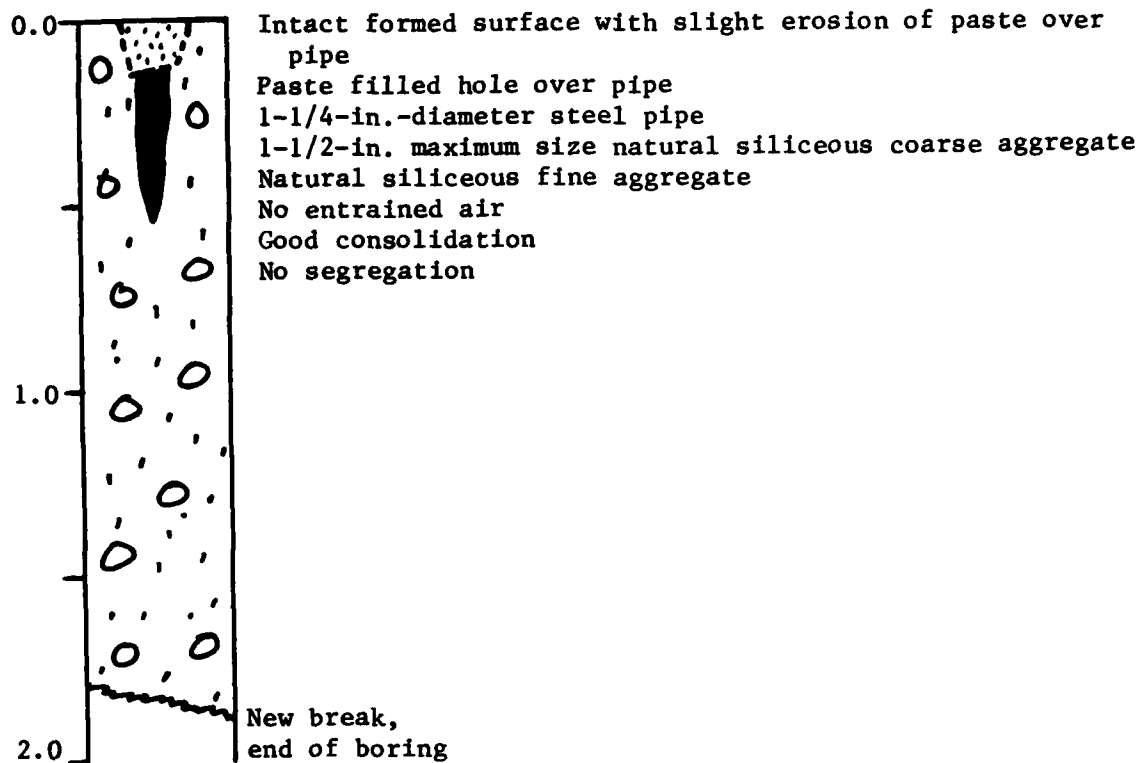


Figure 3. Waterbury Dam, New York District, 6-in.-Diameter Concrete Core NY-8 CON-1 from Spillway Section C

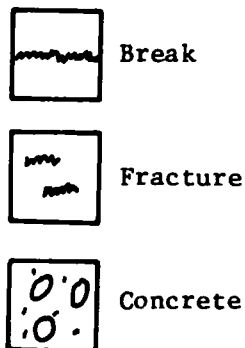
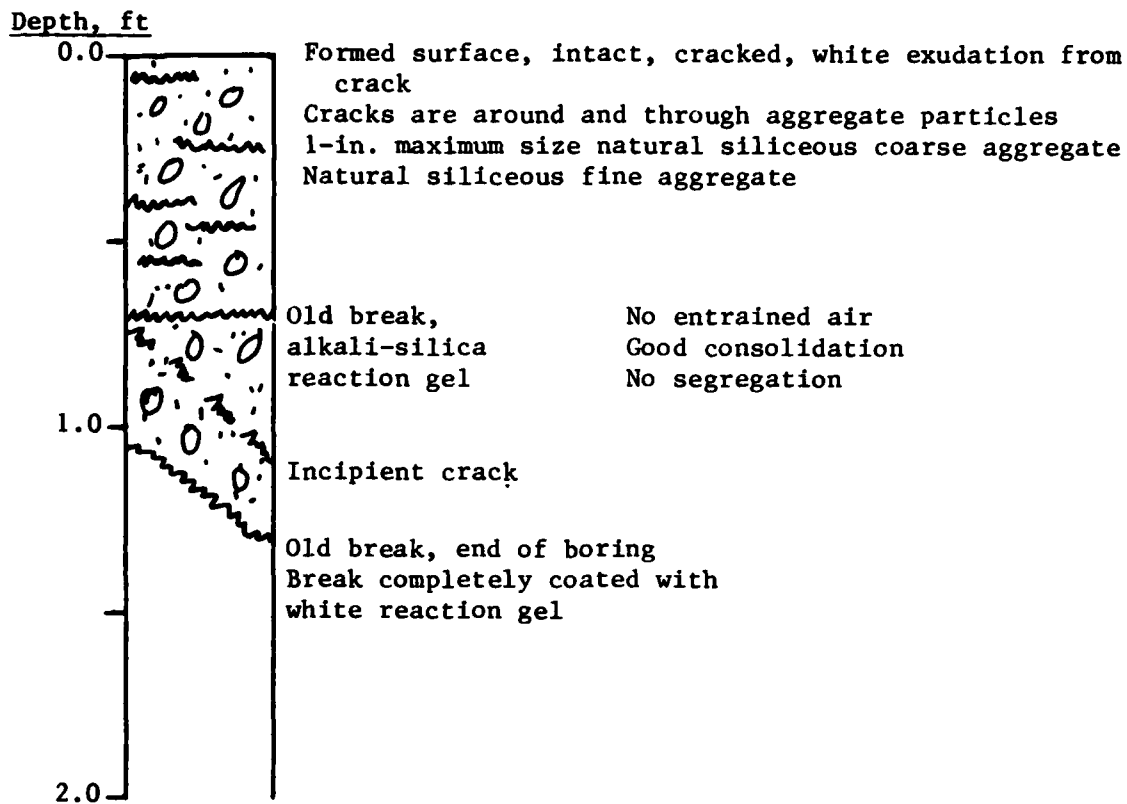


Figure 4. Waterbury Dam, New York District, 6-in.-Diameter Concrete Core NY-8 CON-2 from Spillway Section C

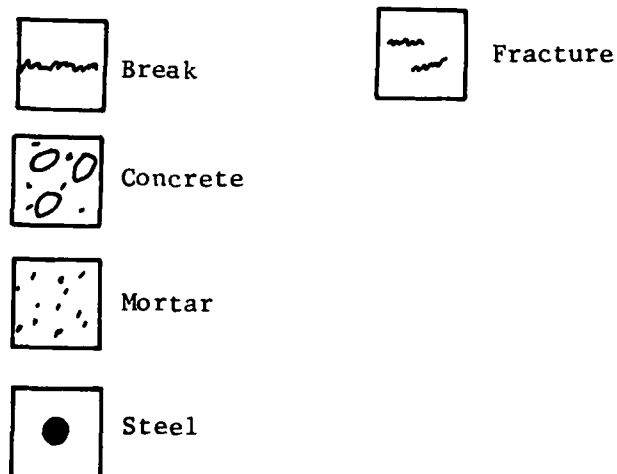
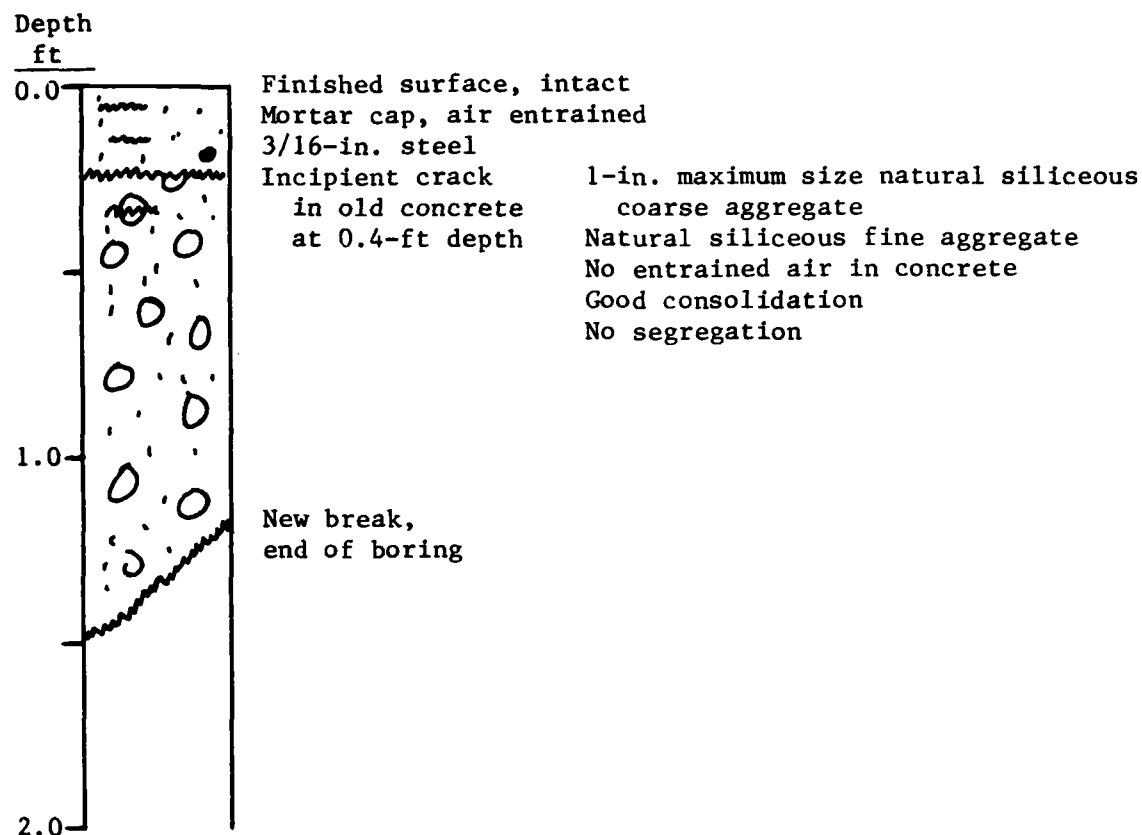
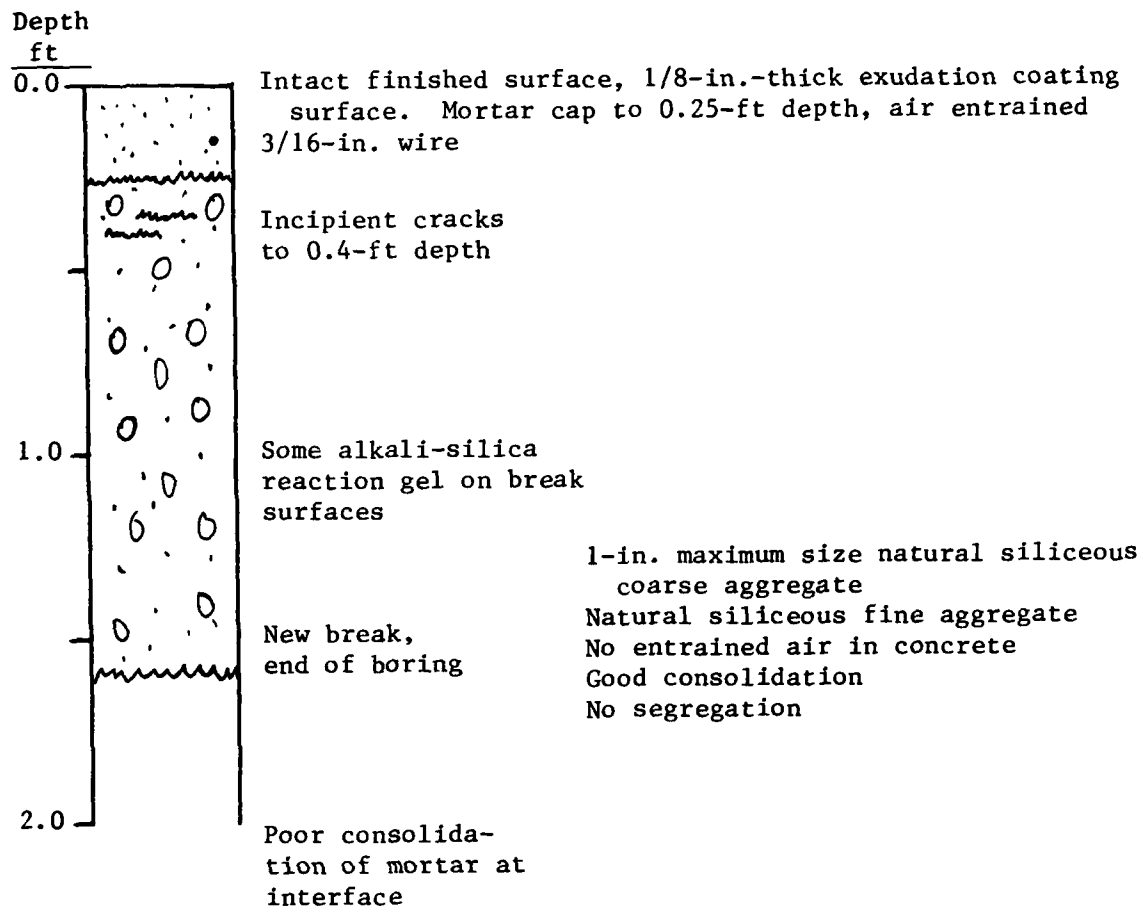


Figure 5. Waterbury Dam, New York District, 6-in.-Diameter Concrete Core NY-8 CON-3 from Spillway Section C



Break



Fracture



Concrete



Mortar



Steel

Figure 6. Waterbury Dam, New York District, 6-in.-Diameter Concrete Core NY-8 CON-4 from Spillway Section 4

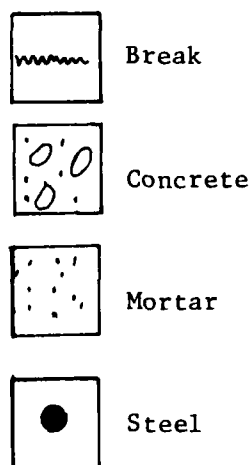
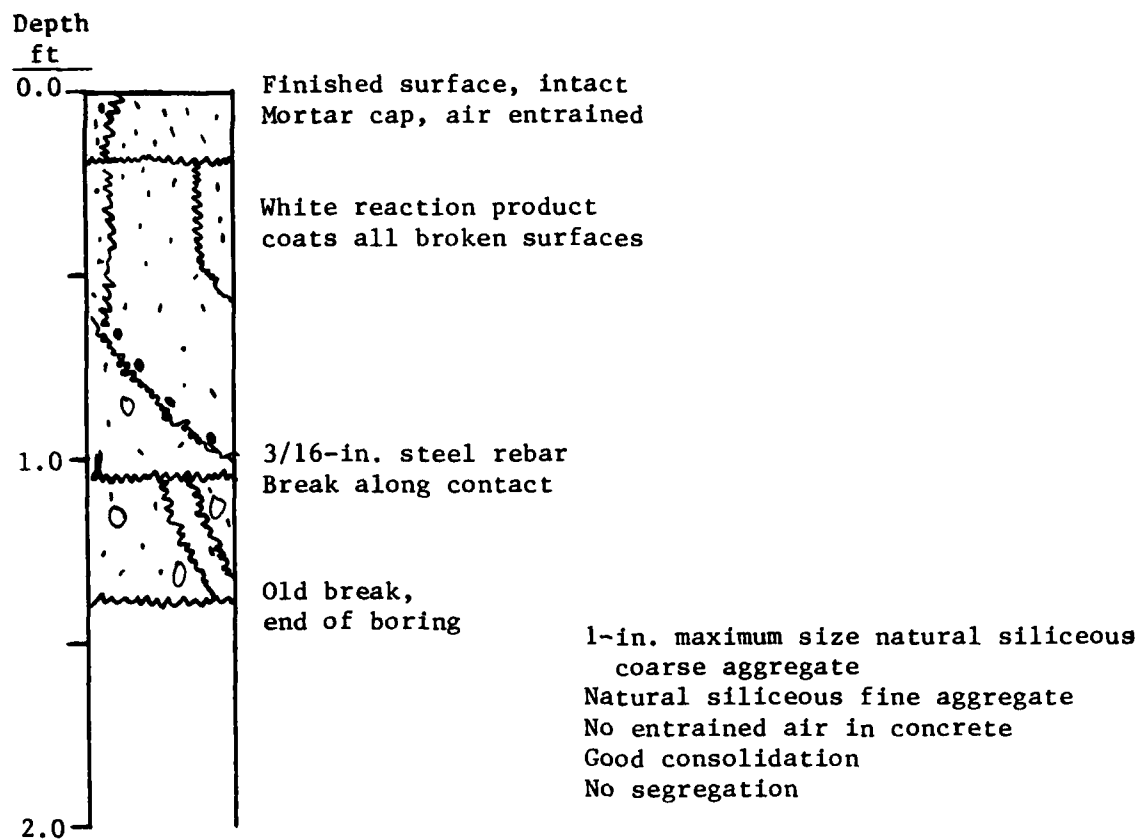


Figure 7. Waterbury Dam, New York District, 6-in.-Diameter Concrete
Core NY-8 CON-5 from Spillway Wall

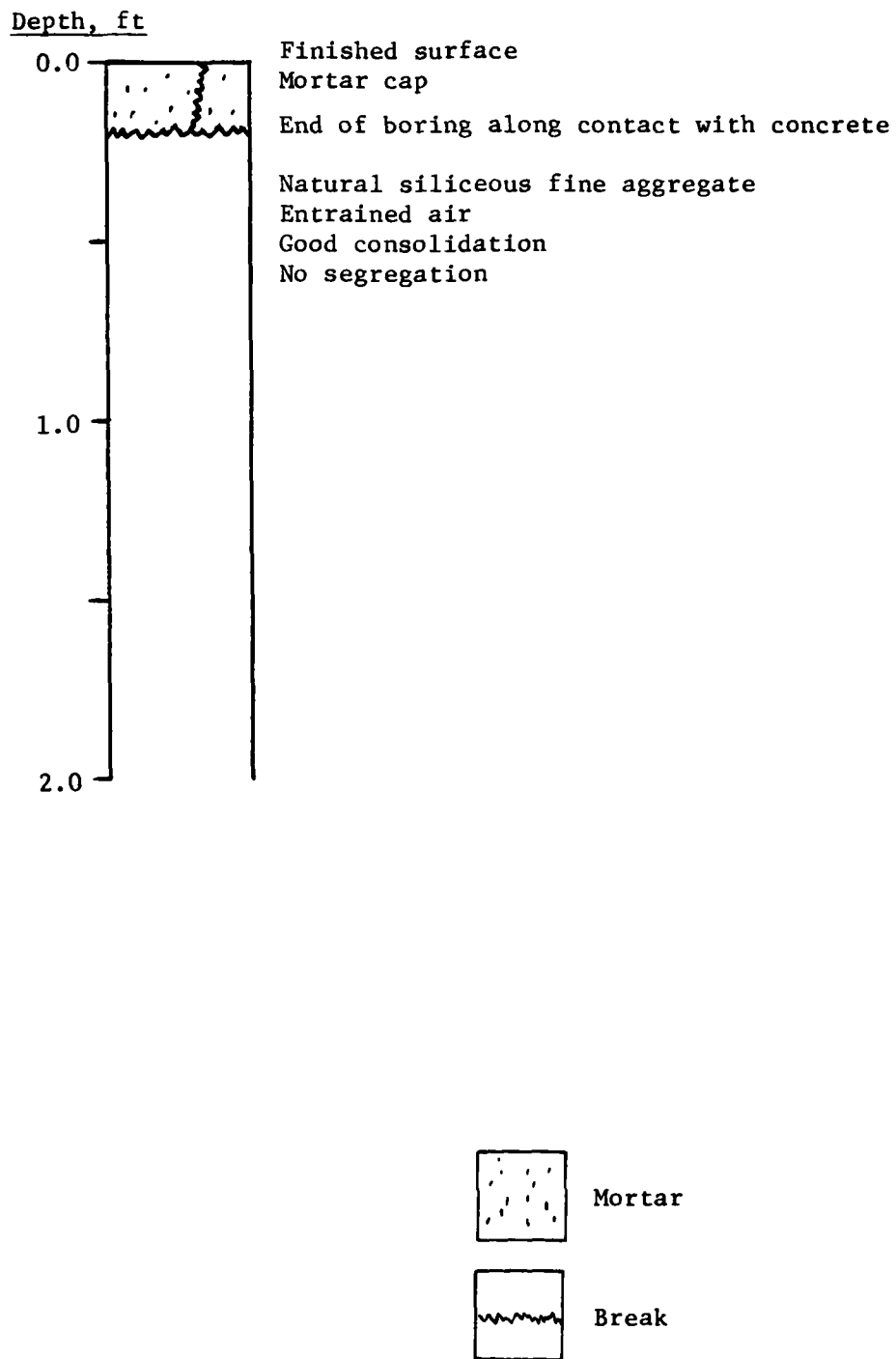


Figure 8. Waterbury Dam, New York District, 6-in.-Diameter Concrete Core NY-8 CON-6A from Cat Walk

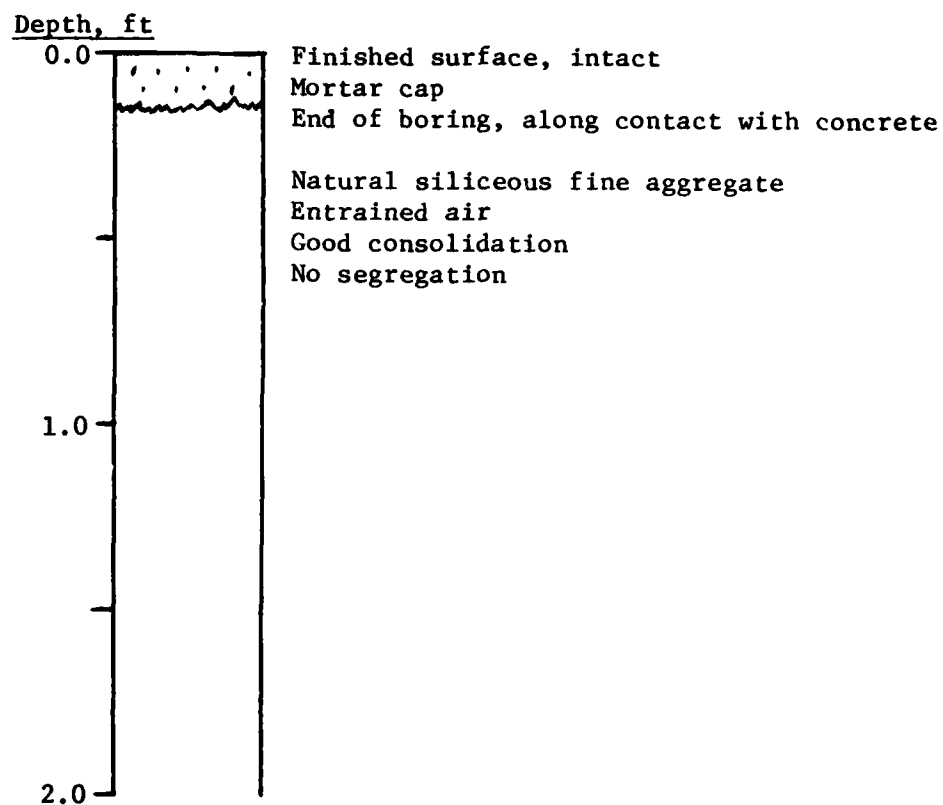


Figure 9. Waterbury Dam, New York District, 6-in.-Diameter Concrete
Core NY-8 CON-6B from Cat Walk

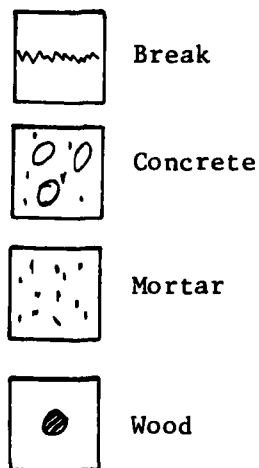
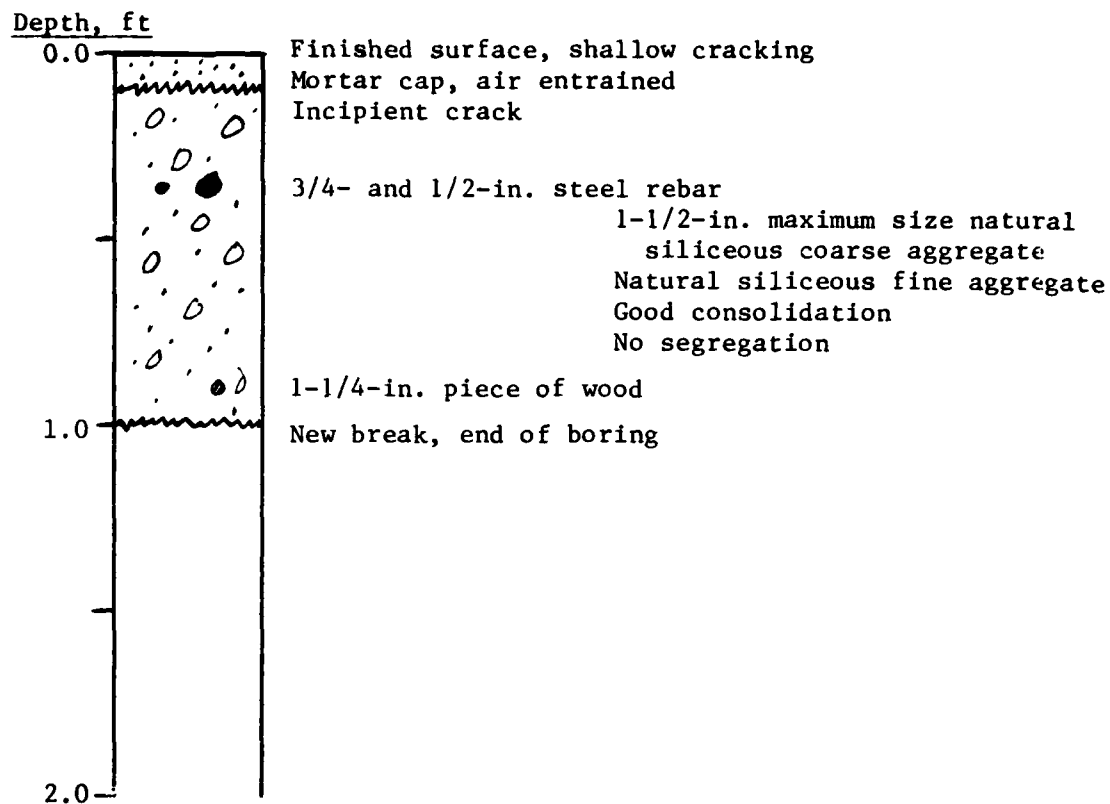


Figure 10. Waterbury Dam, New York District, 6-in.-Diameter Concrete Core NY-8 CON-6 from Cat Walk

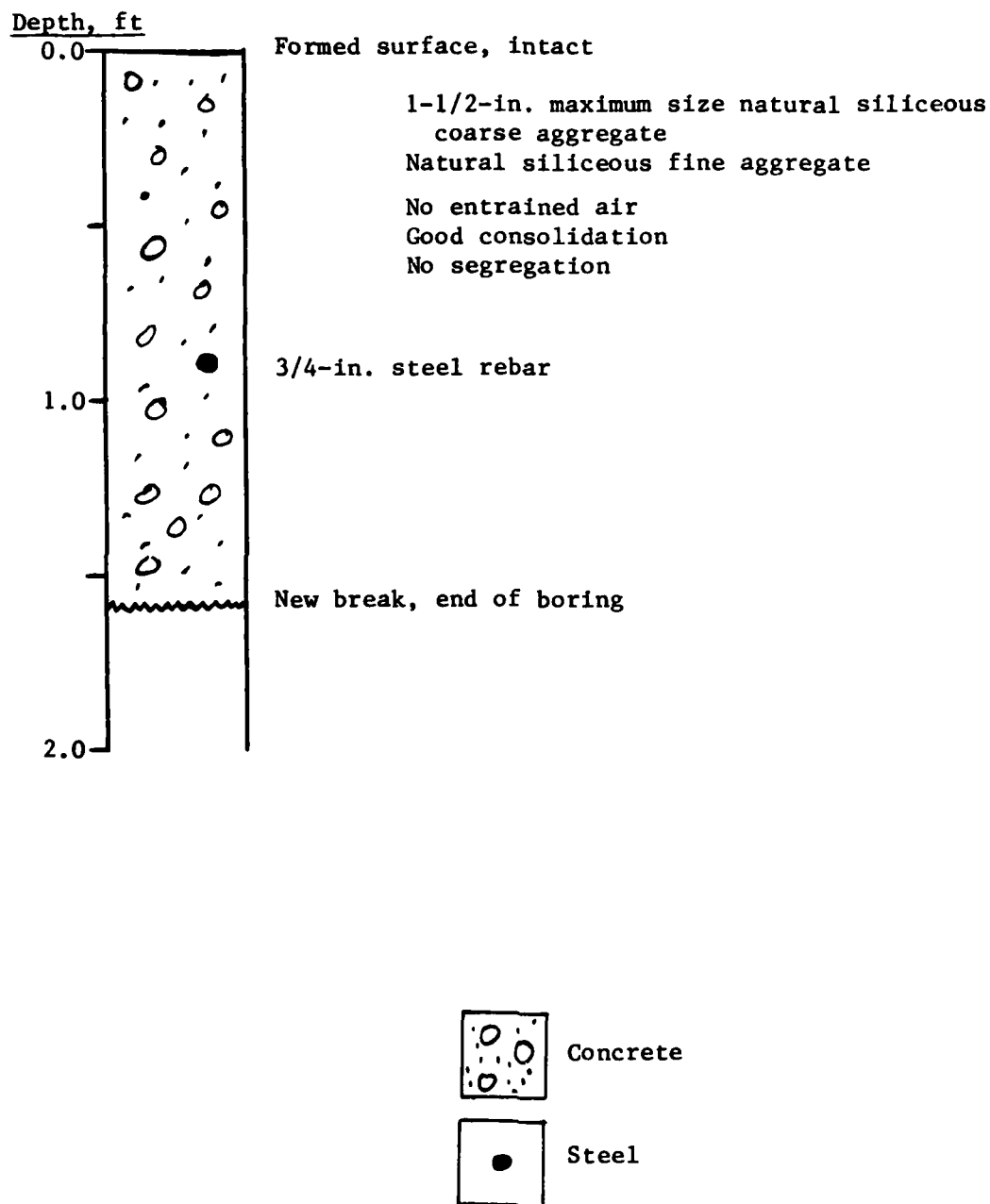


Figure 11. Waterbury Dam, New York District, 6-in.-Diameter Concrete Core NY-8 CON-7 from Bridge Pier I

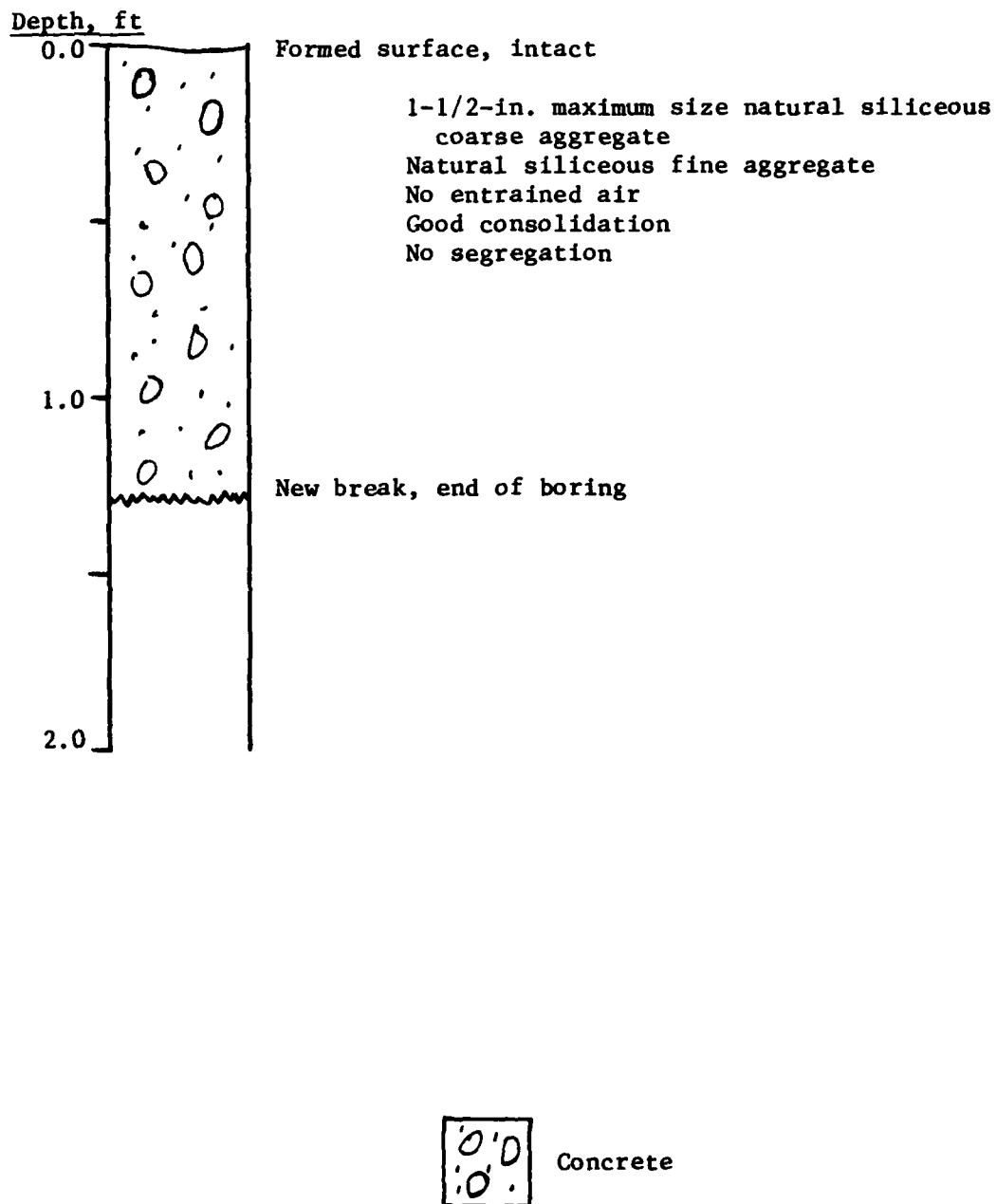


Figure 12. Waterbury Dam, New York District, 6-in.-Diameter Concrete Core NY-8 CON-8 from Spillway Retaining Wall Abutment

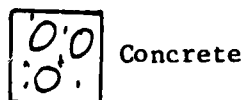
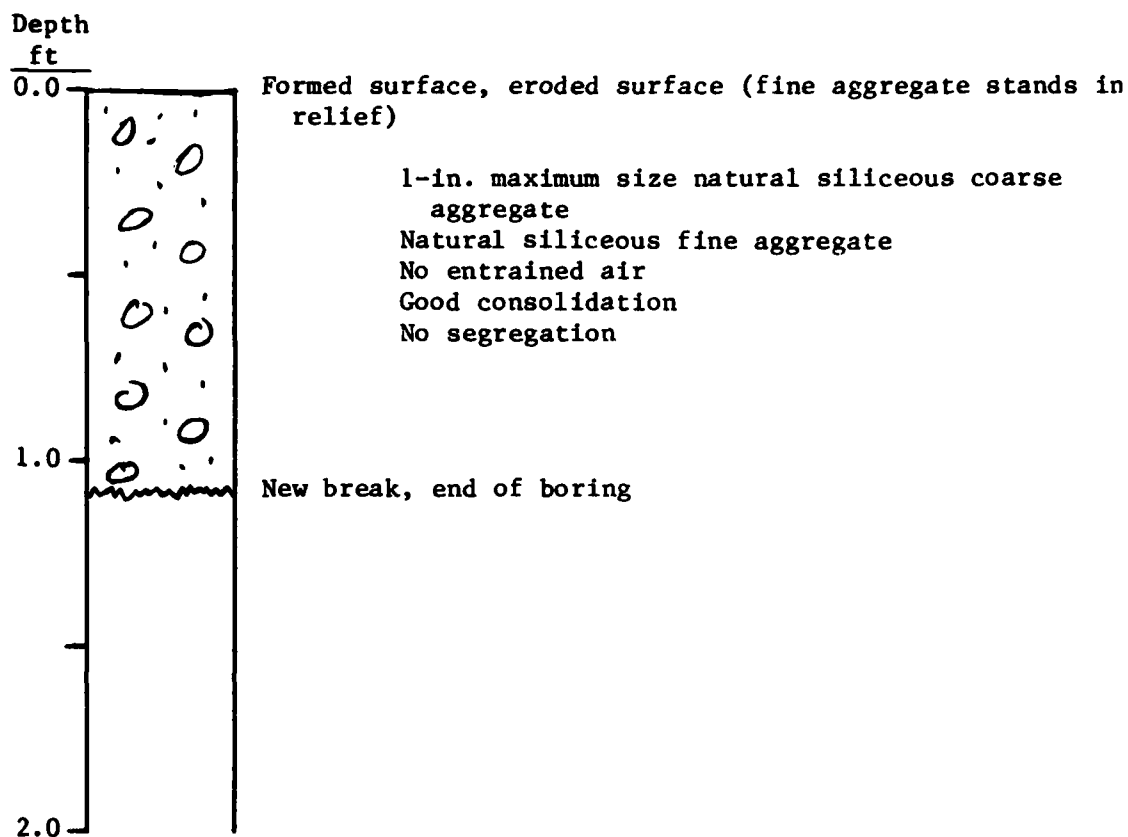


Figure 13. Waterbury Dam, New York District, 6-in.-Diameter Concrete Core NY-8 CON-9A from North of Spillway Face

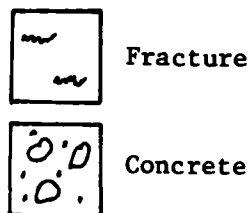
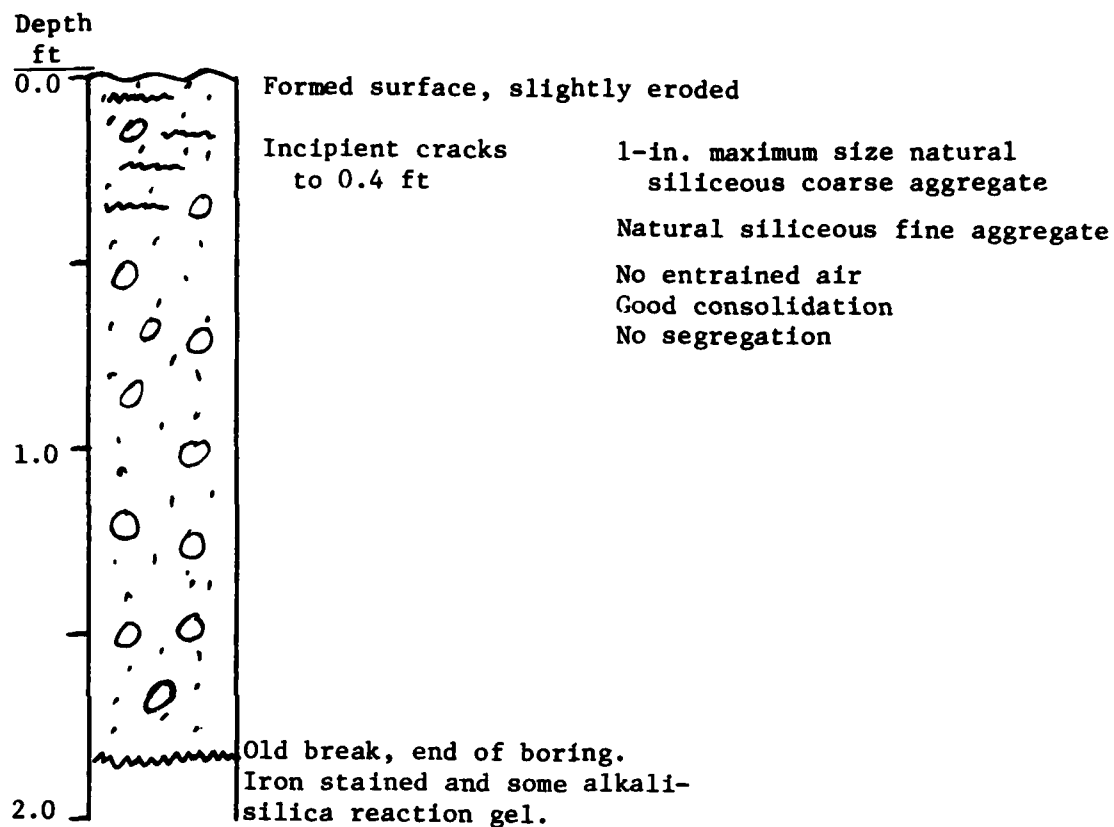


Figure 14. Waterbury Dam, New York District, 6-in.-Diameter Concrete Core NY-8 CON-9B from North of Spillway Face

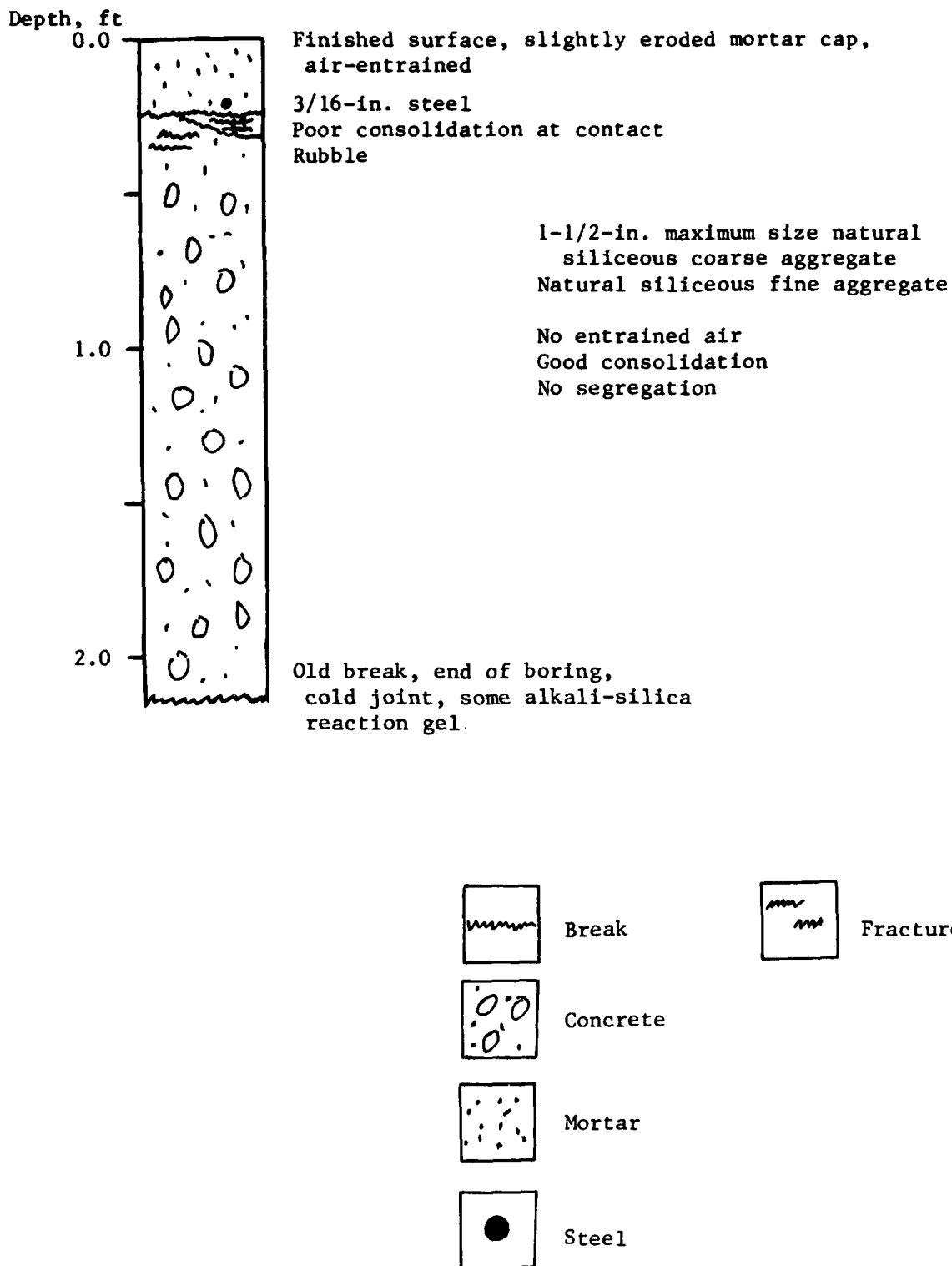


Figure 15. Waterbury Dam, New York District, 6-in.-Diameter Concrete Core NY-8 CON-10 from East of Spillway Abutment Wall

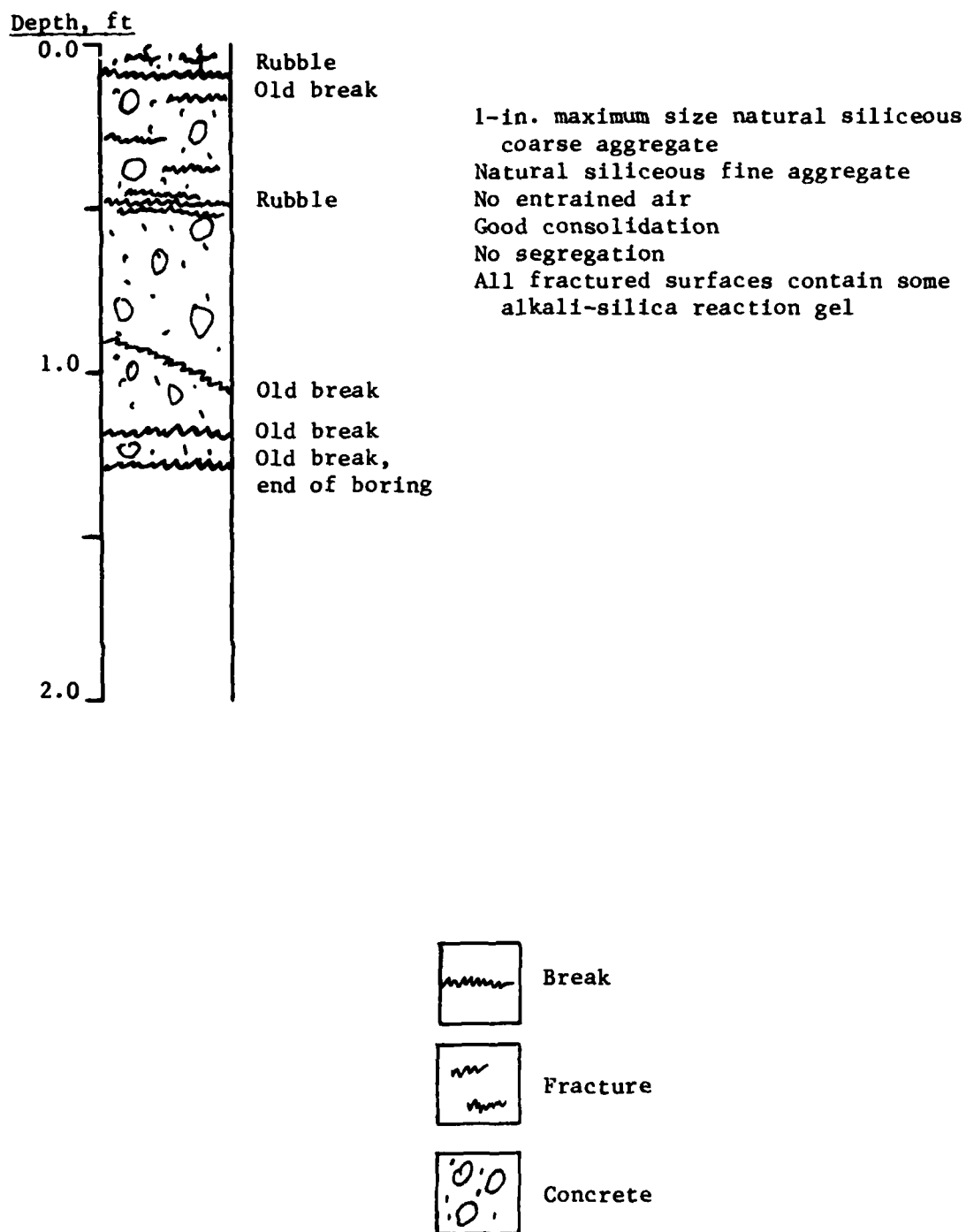


Figure 16. Waterbury Dam, New York District, 6-in.-Diameter Concrete Core NY-8 CON-11 from Downstream Face of Spillway Wall

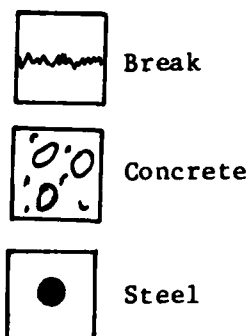
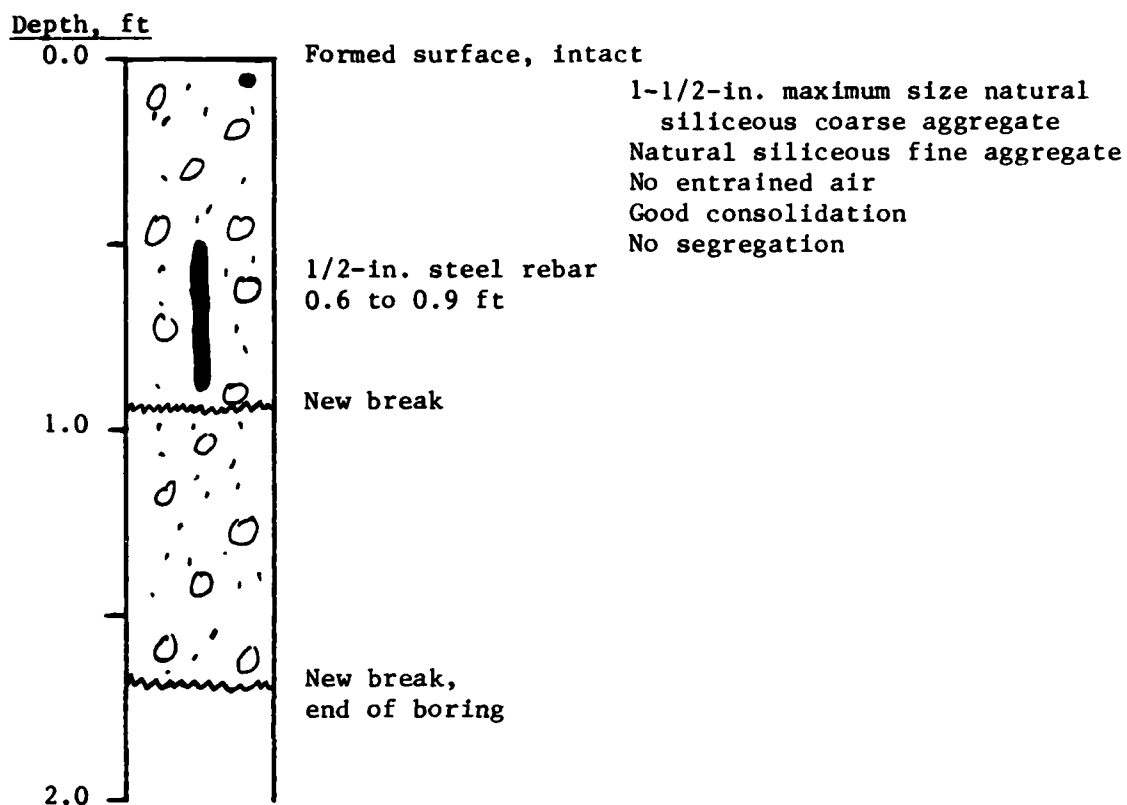


Figure 17. Waterbury Dam, New York District, 6-in.-Diameter Concrete Core NY-8 CON-12 from Tainter Gate Abutment Wall

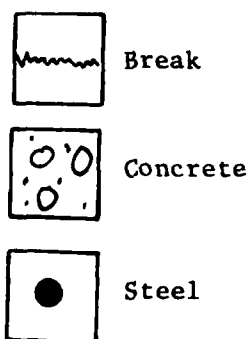
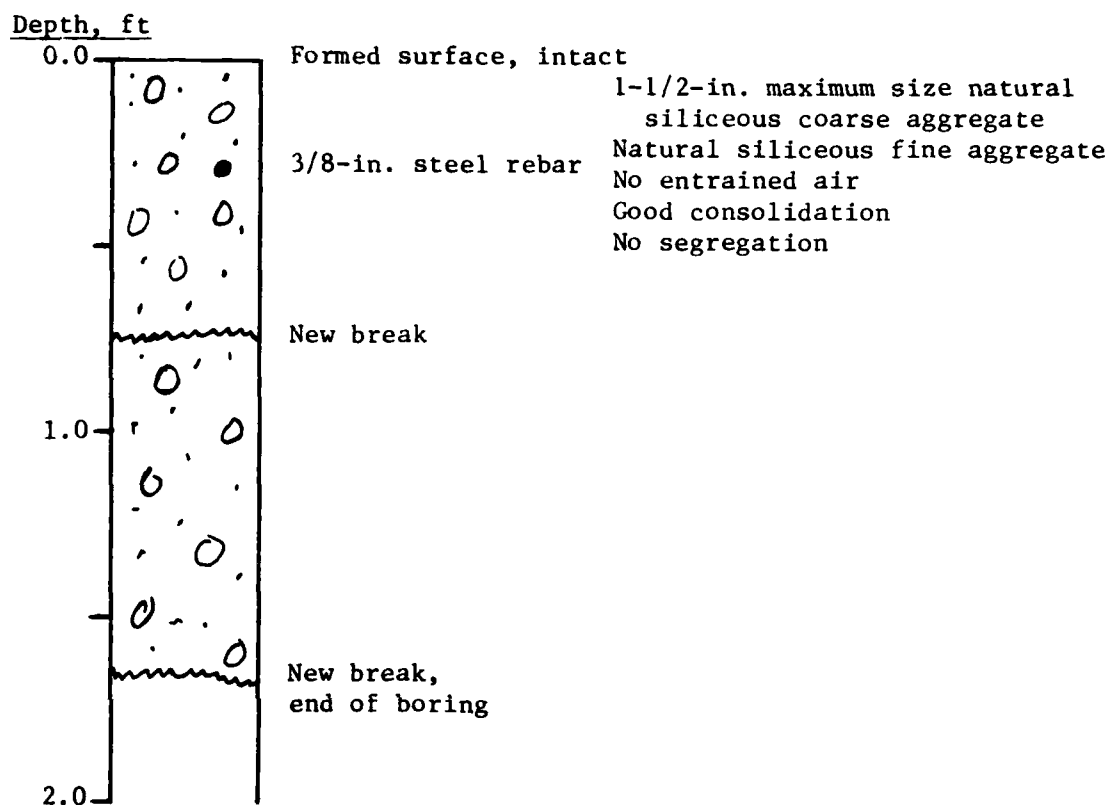


Figure 18. Waterbury Dam, New York District, 6-in.-Diameter Concrete Core NY-8 CON-13 from Bridge Pier III

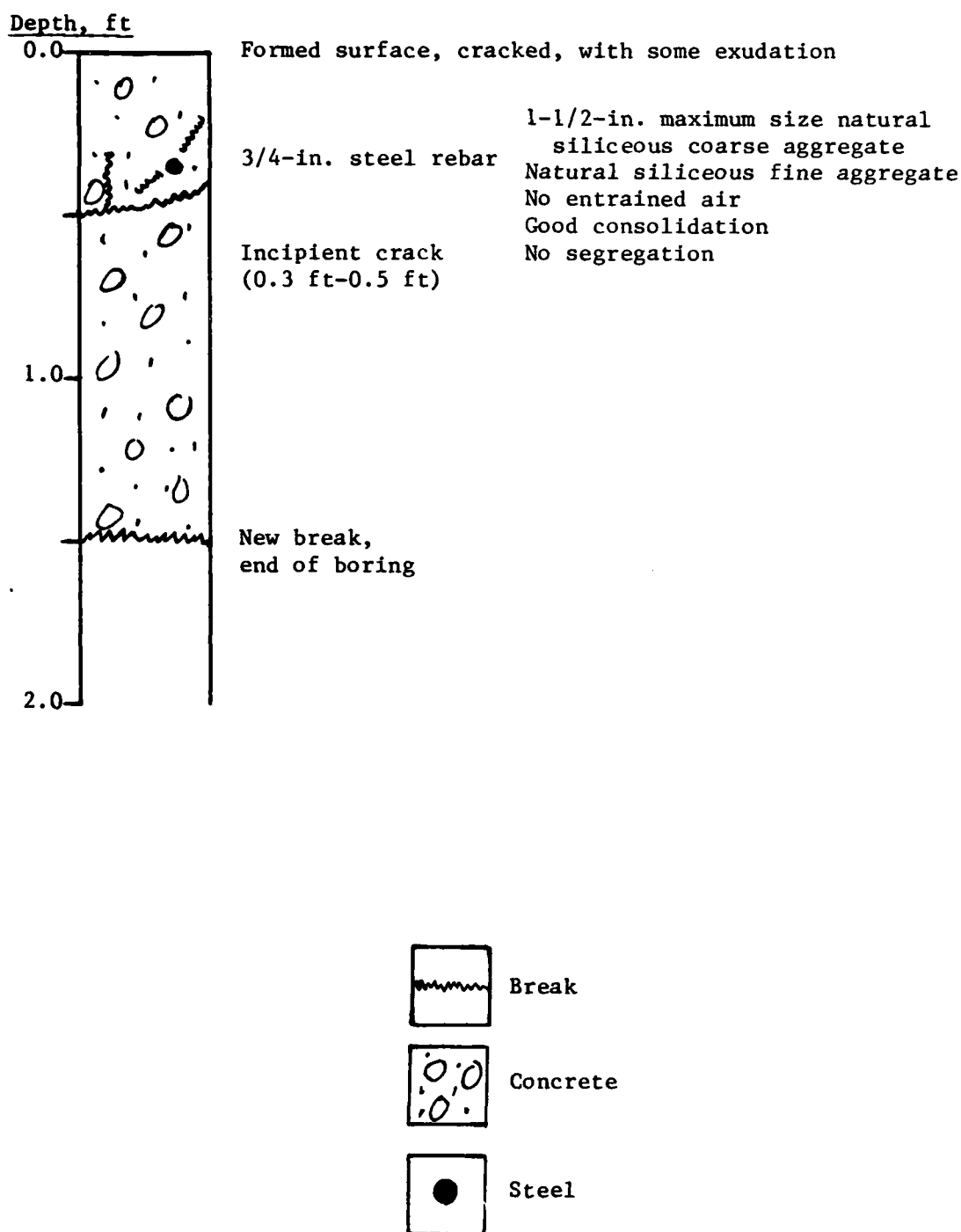


Figure 19. Waterbury Dam, New York District, 6-in.-Diameter Concrete Core NY-8 CON-14 from Bridge Pier II

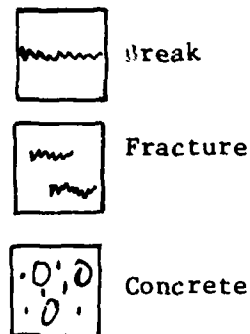
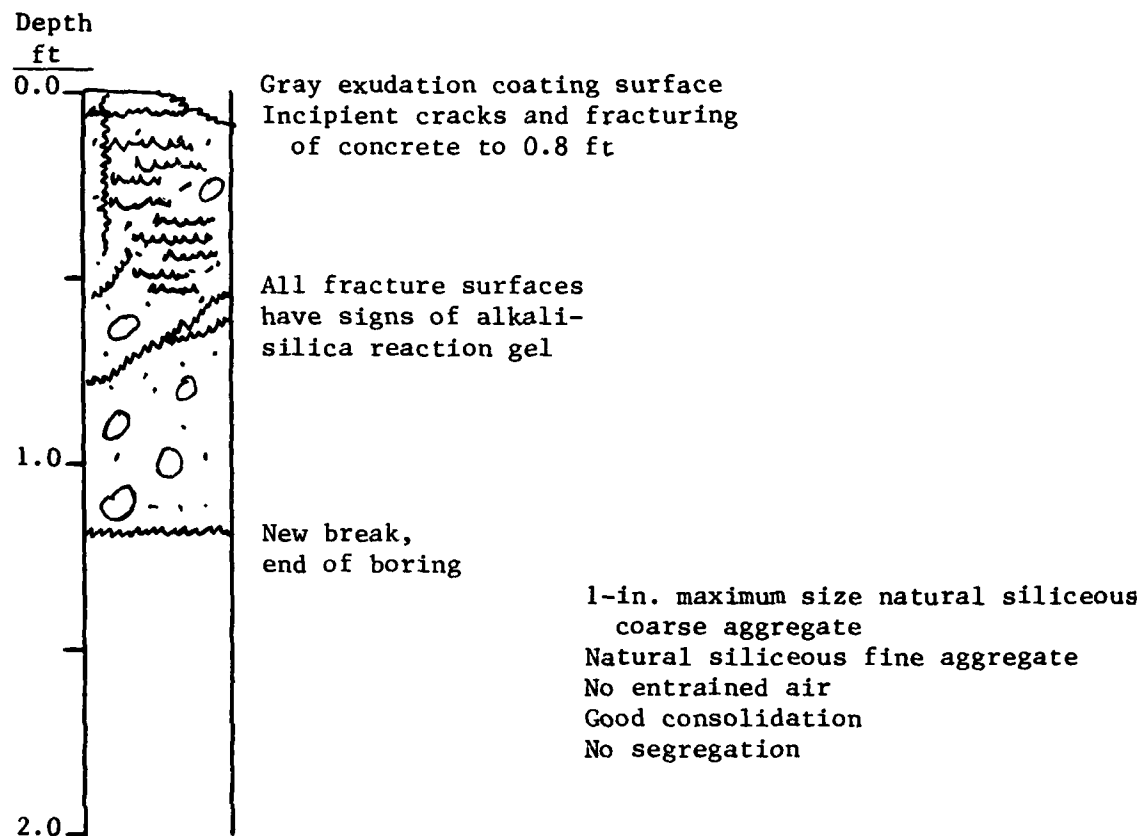


Figure 20. Waterbury Dam, New York District, 6-in.-Diameter Concrete
Core NY-8 CON-15 from Downstream Face of Spillway Wall

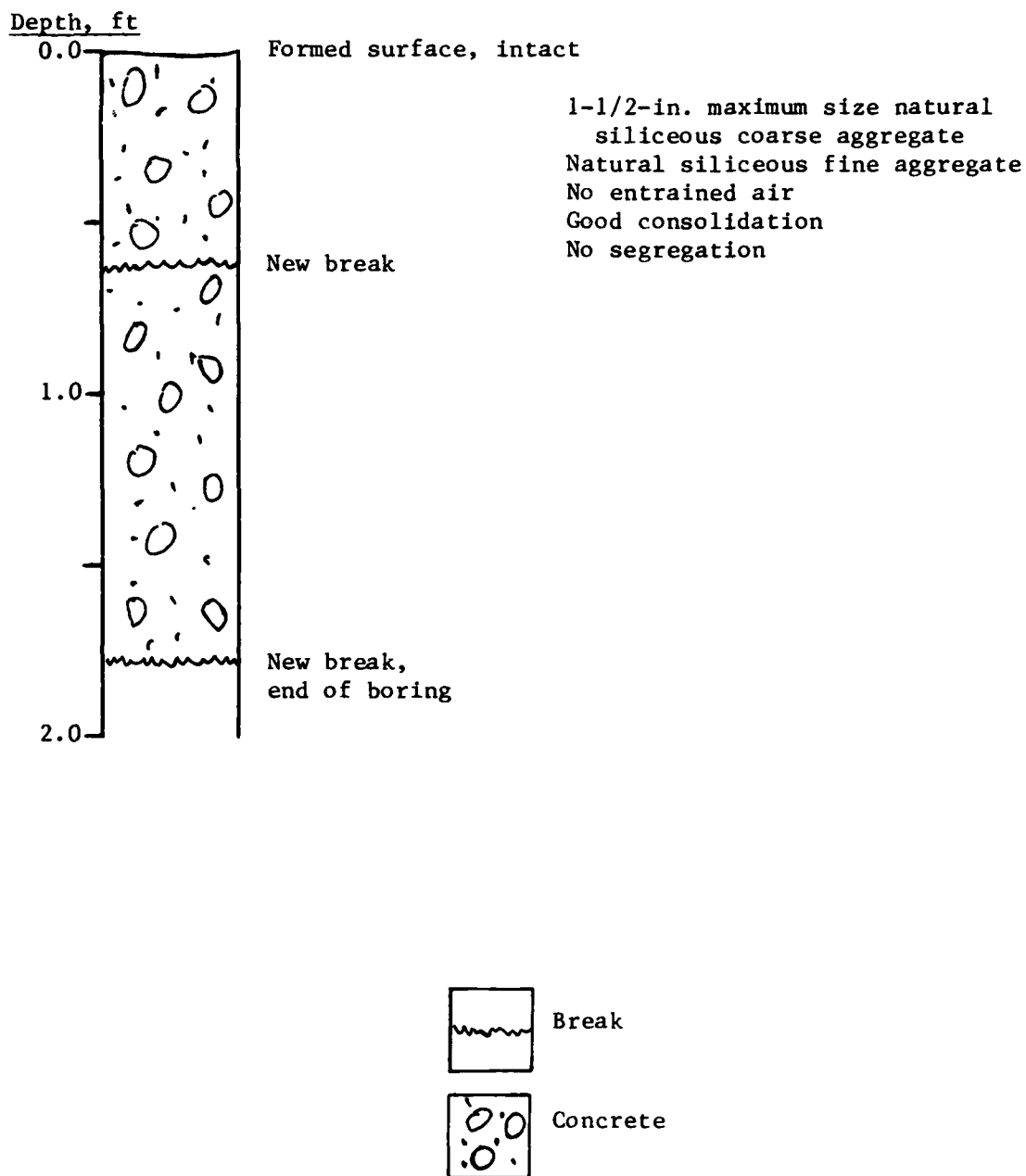


Figure 21. Waterbury Dam, New York District, 6-in.-Diameter Concrete Core NY-8 CON-16 from Face of Spillway

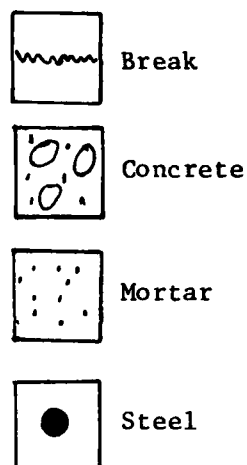
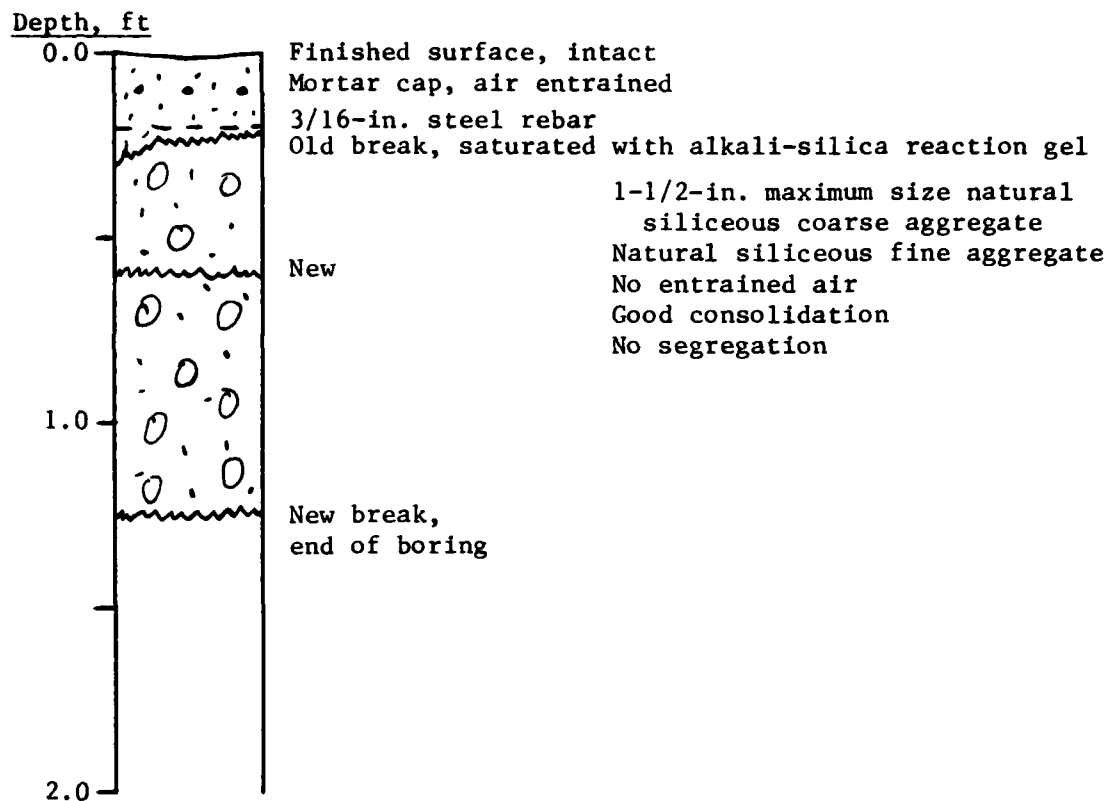


Figure 22. Waterbury Dam, New York District, 6-in.-Diameter Concrete
Core NY-8 CON-17 from Reservoir Face of Spillway

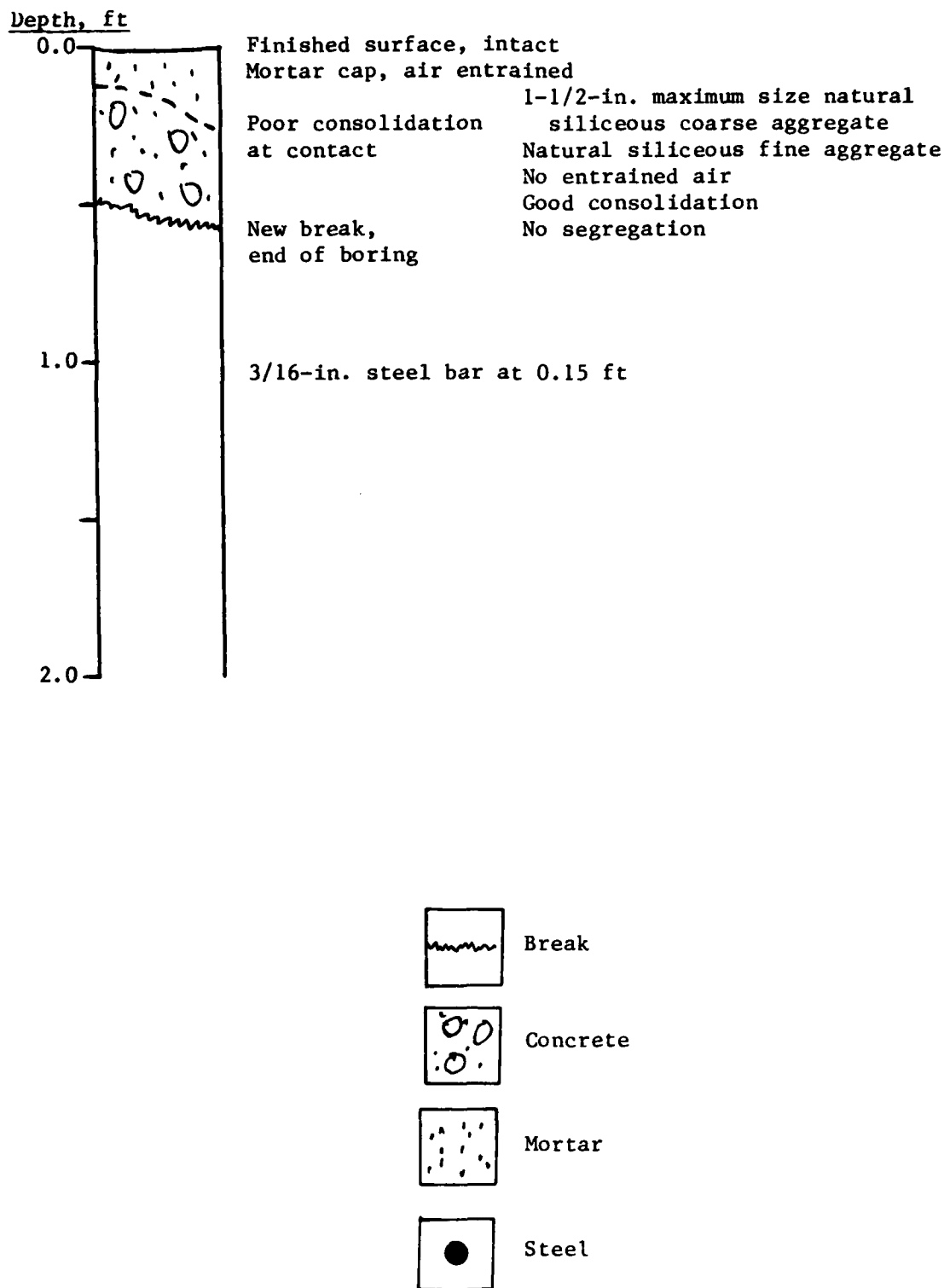


Figure 23. Waterbury Dam, New York District, 6-in.-Diameter Concrete Core NY-8 CON-18 from Reservoir Face of Spillway

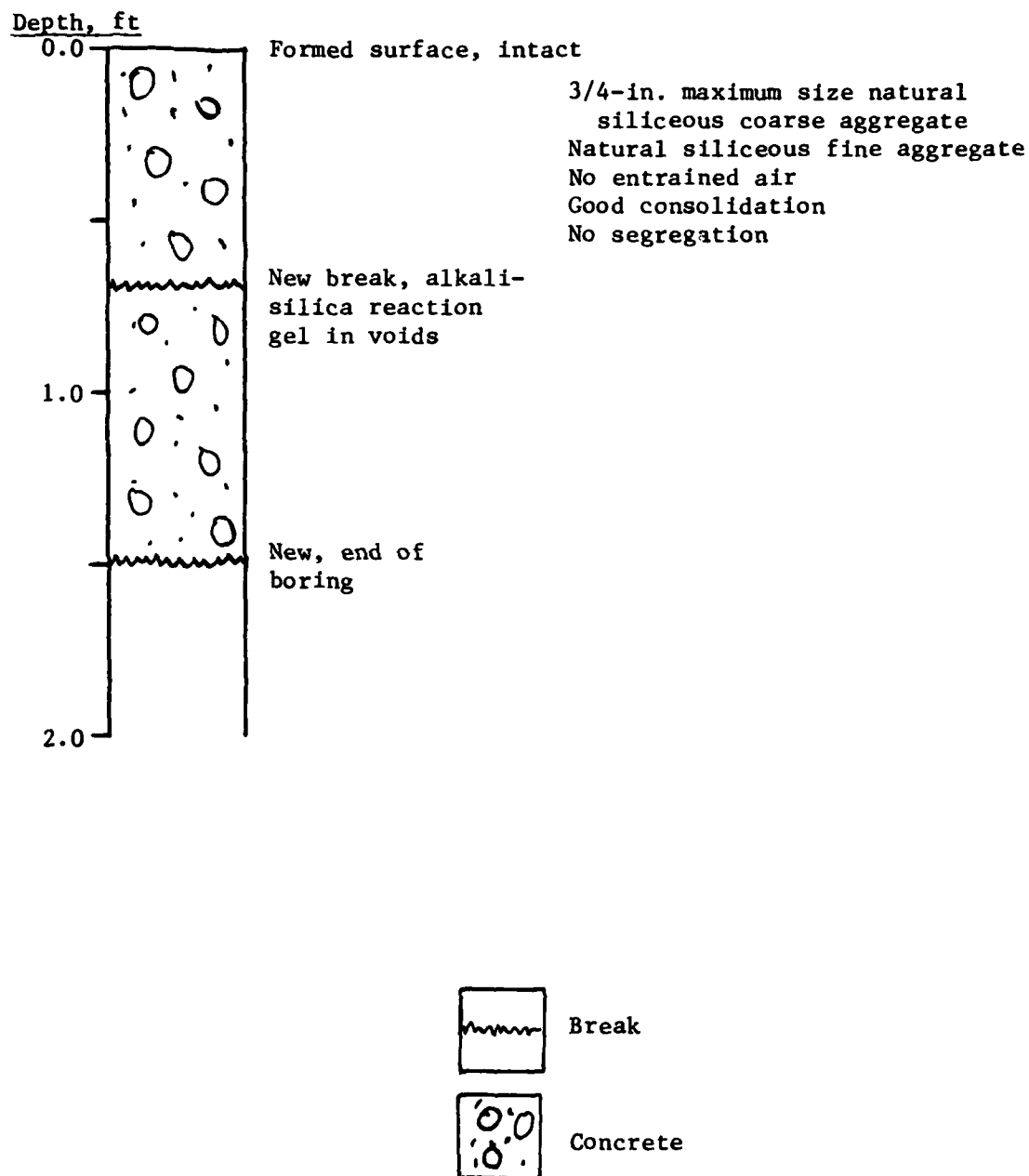


Figure 24. Waterbury Dam, New York District, 6-in.-Diameter Concrete Core NY-8 CON-19 from Spillway Retaining Wall Abutment

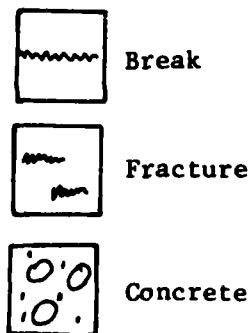
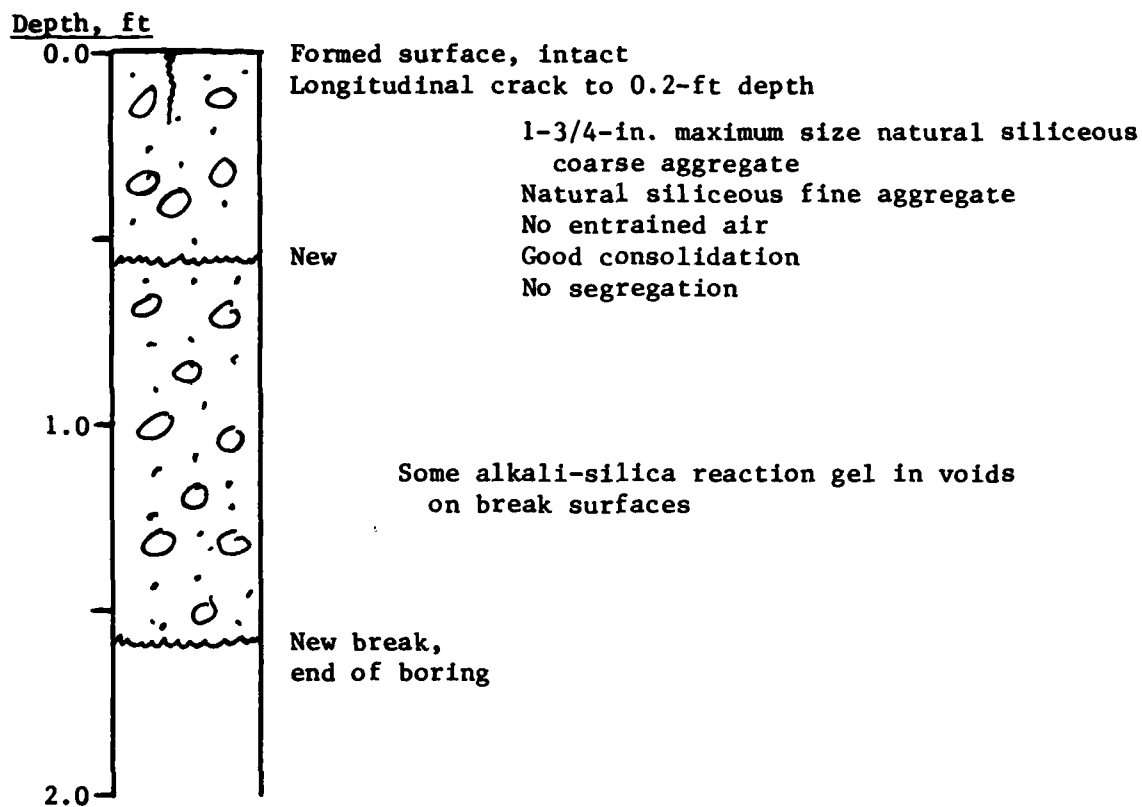


Figure 25. Waterbury Dam, New York District, 6-in.-Diameter Concrete Core NY-8 CON-20 from Spillway Retaining Wall, East Face

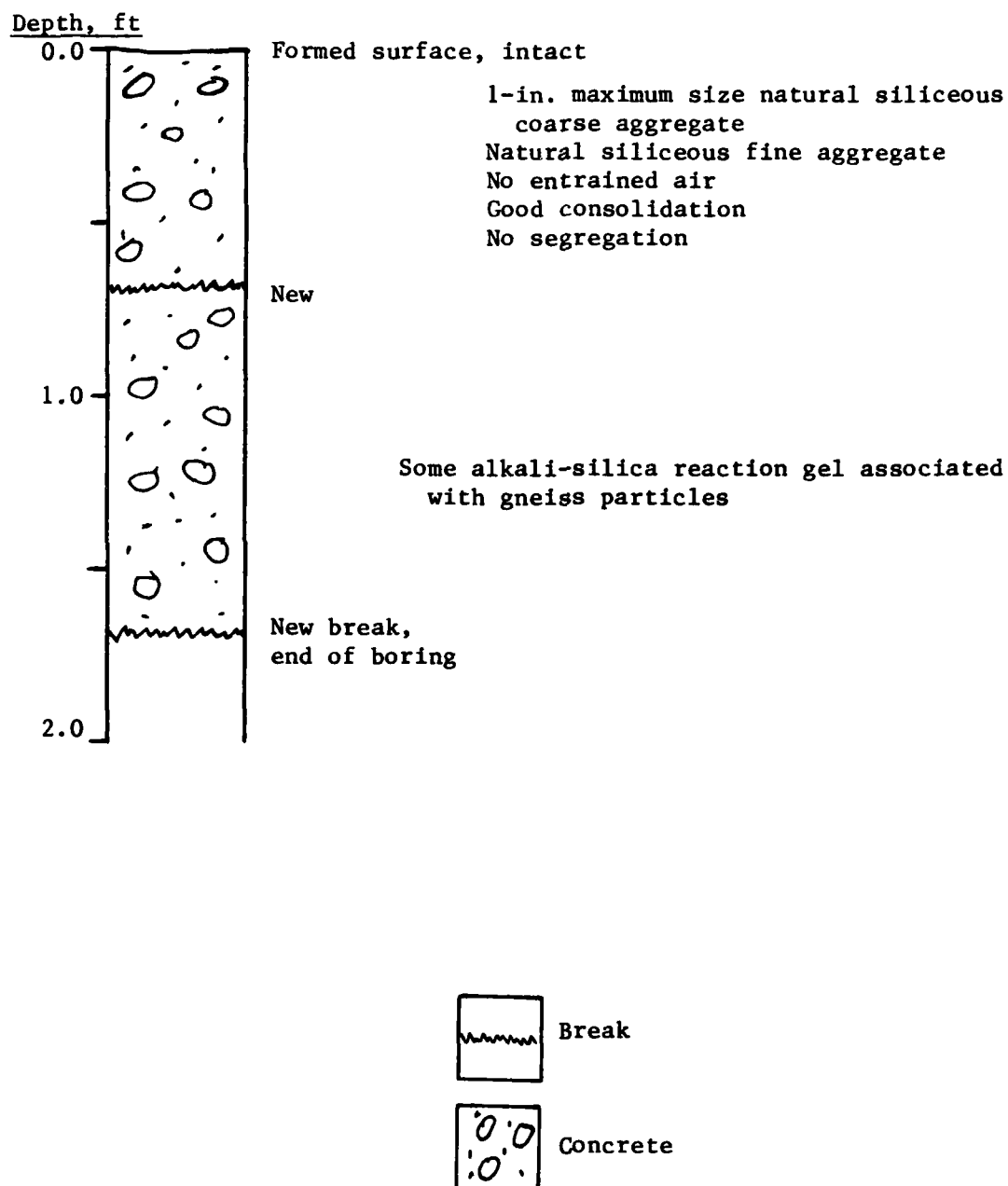


Figure 26. Waterbury Dam, New York District, 6-in.-Diameter Concrete Core NY-8 CON-21 from Spillway Retaining Wall, East Face

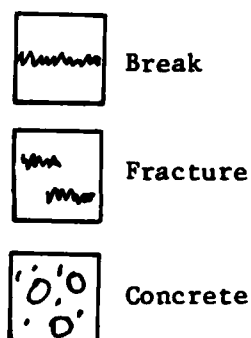
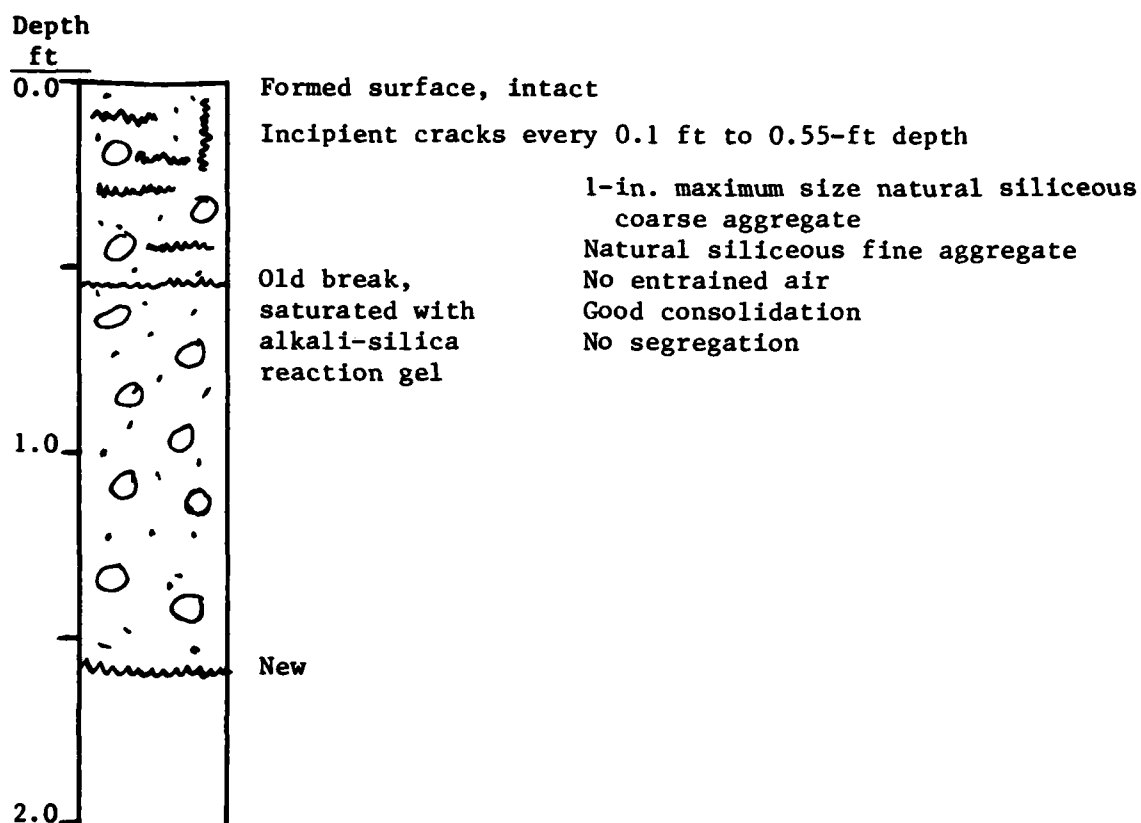


Figure 27. Waterbury Dam, New York District, 6-in.-Diameter Concrete Core NY-8 CON-22 from Spillway Retaining Wall, West Face

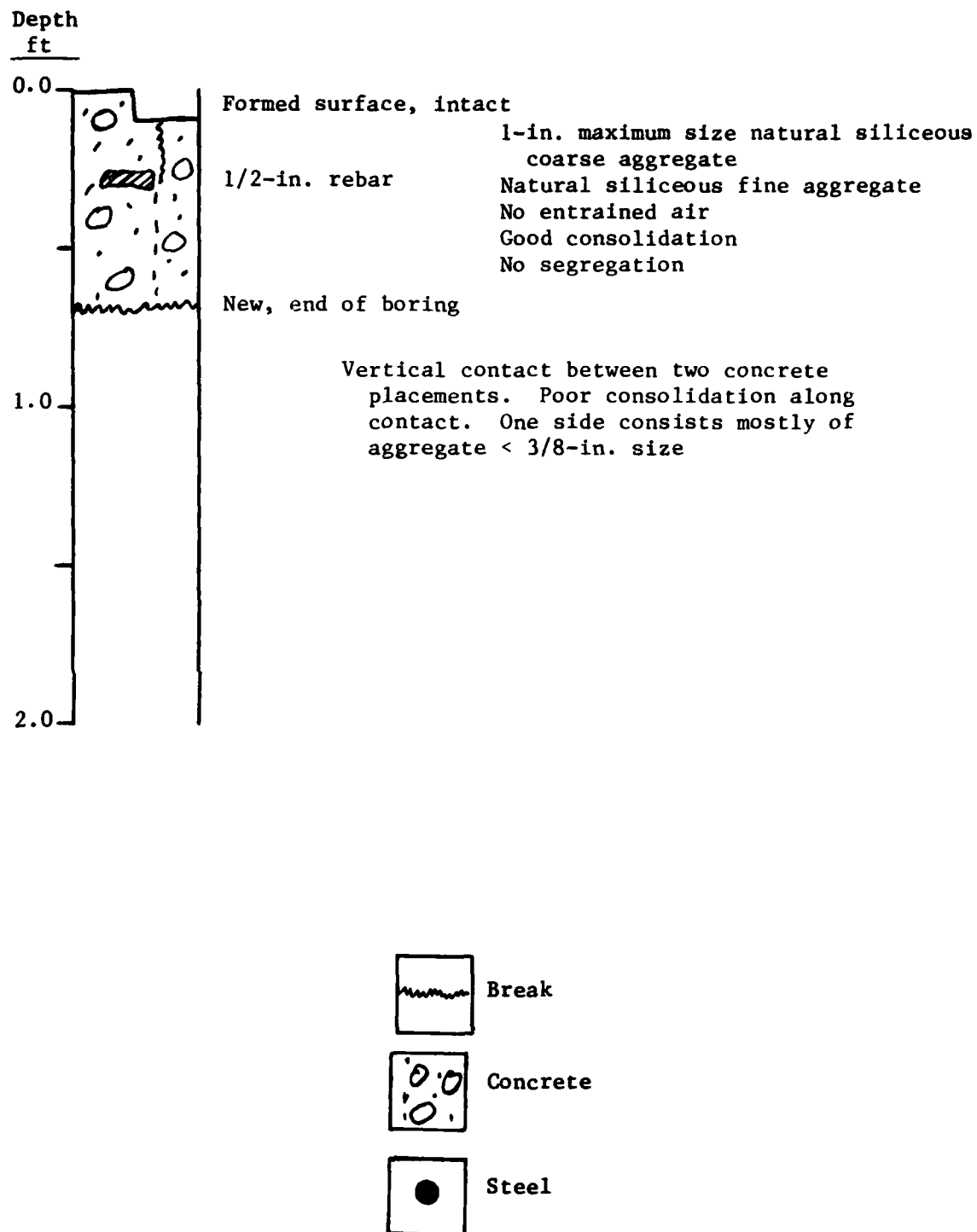


Figure 28. Waterbury Dam, New York District, 6-in.-Diameter Concrete Core NY-8 CON-23 from Turbine House

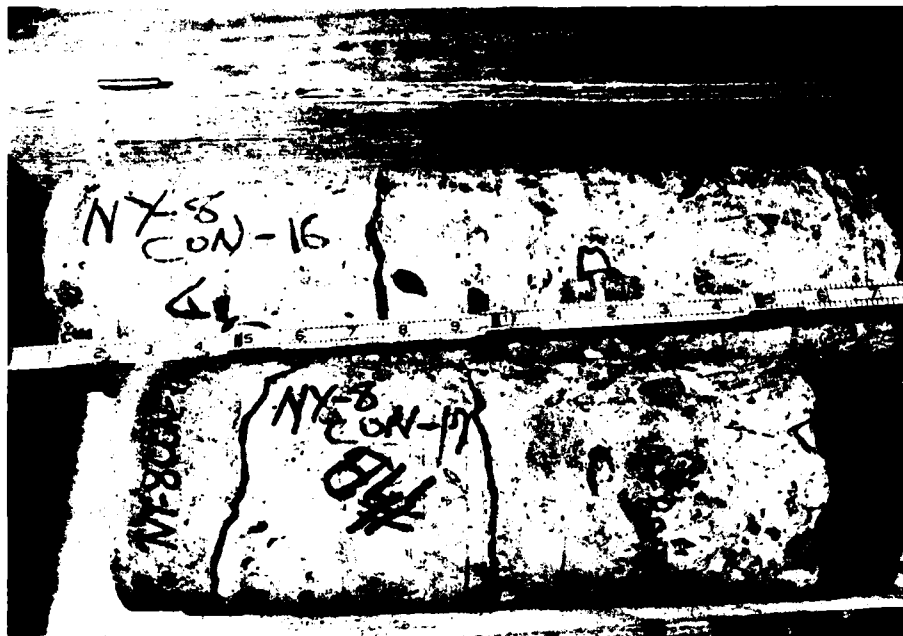


Figure 29. The mortar cap separated along the contact zone of sample NY-8 CON-17. This was common in many of the cores with a mortar cap

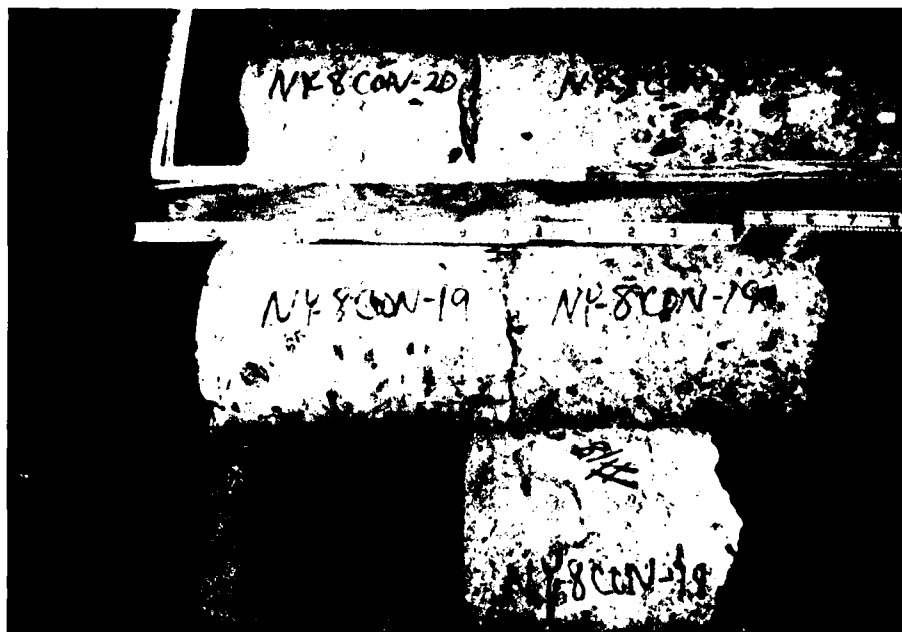


Figure 30. Sample NY-8 CON-18 shows good contact of old and new concrete. Bond at the interface continues to be strong

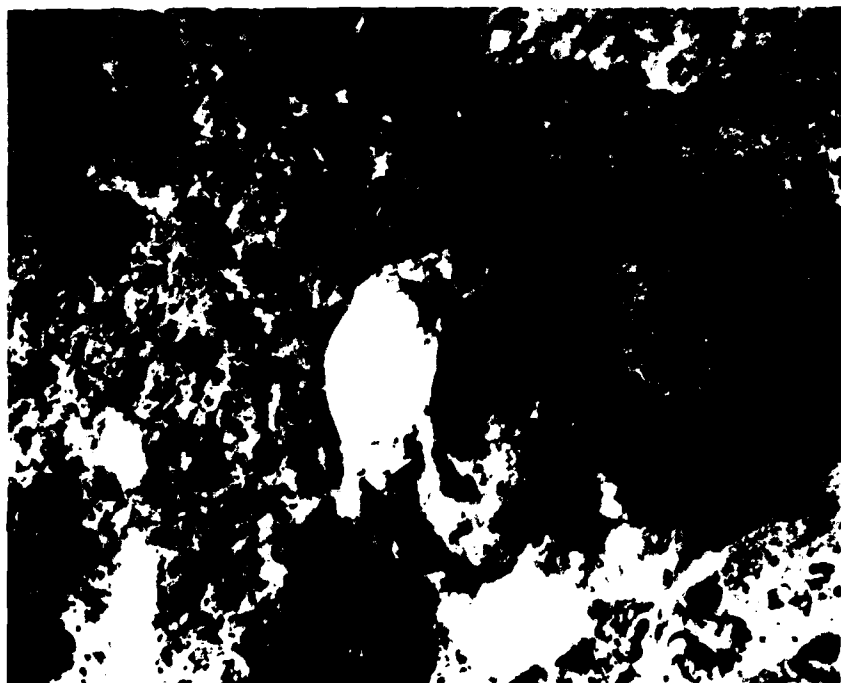
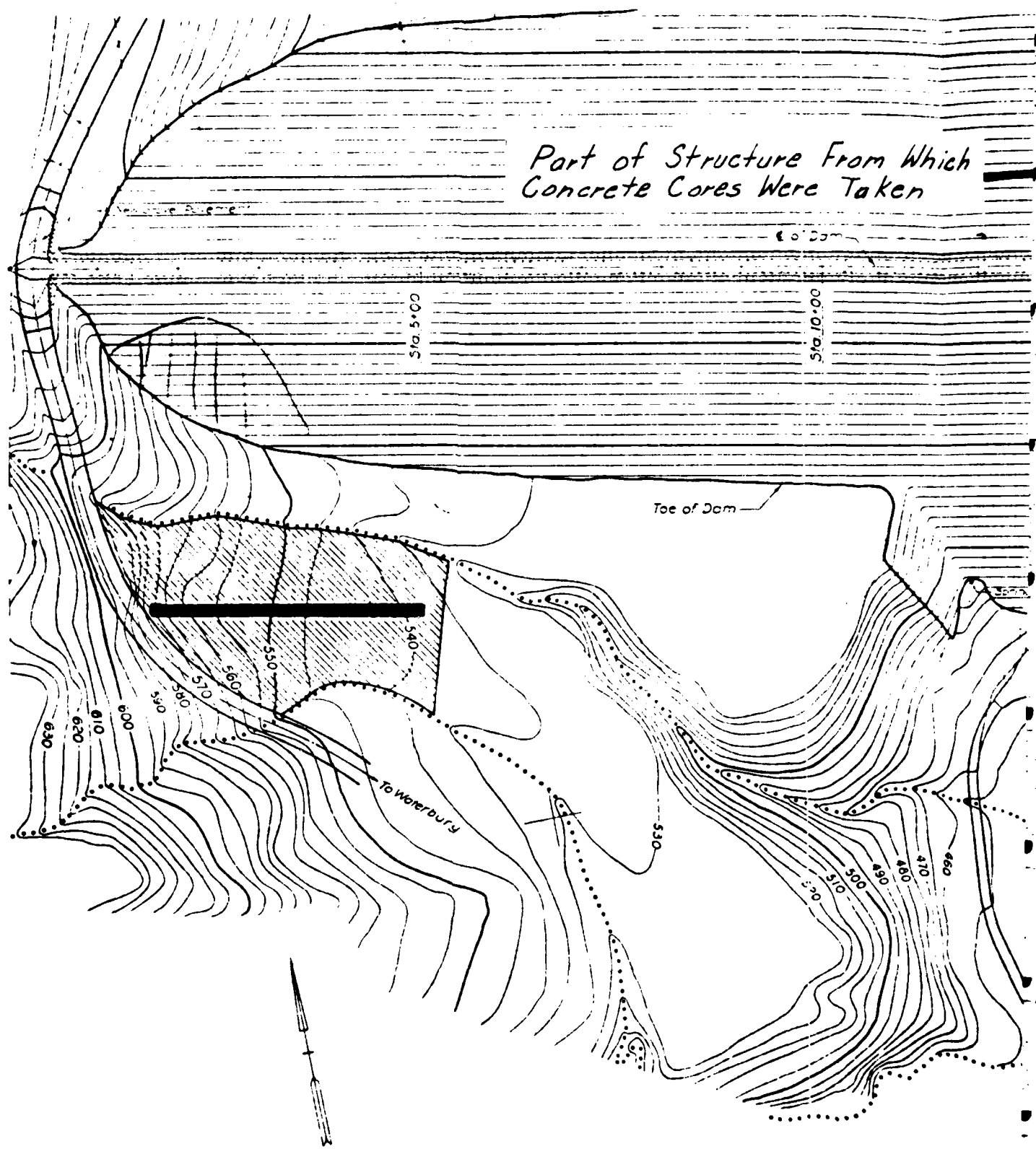
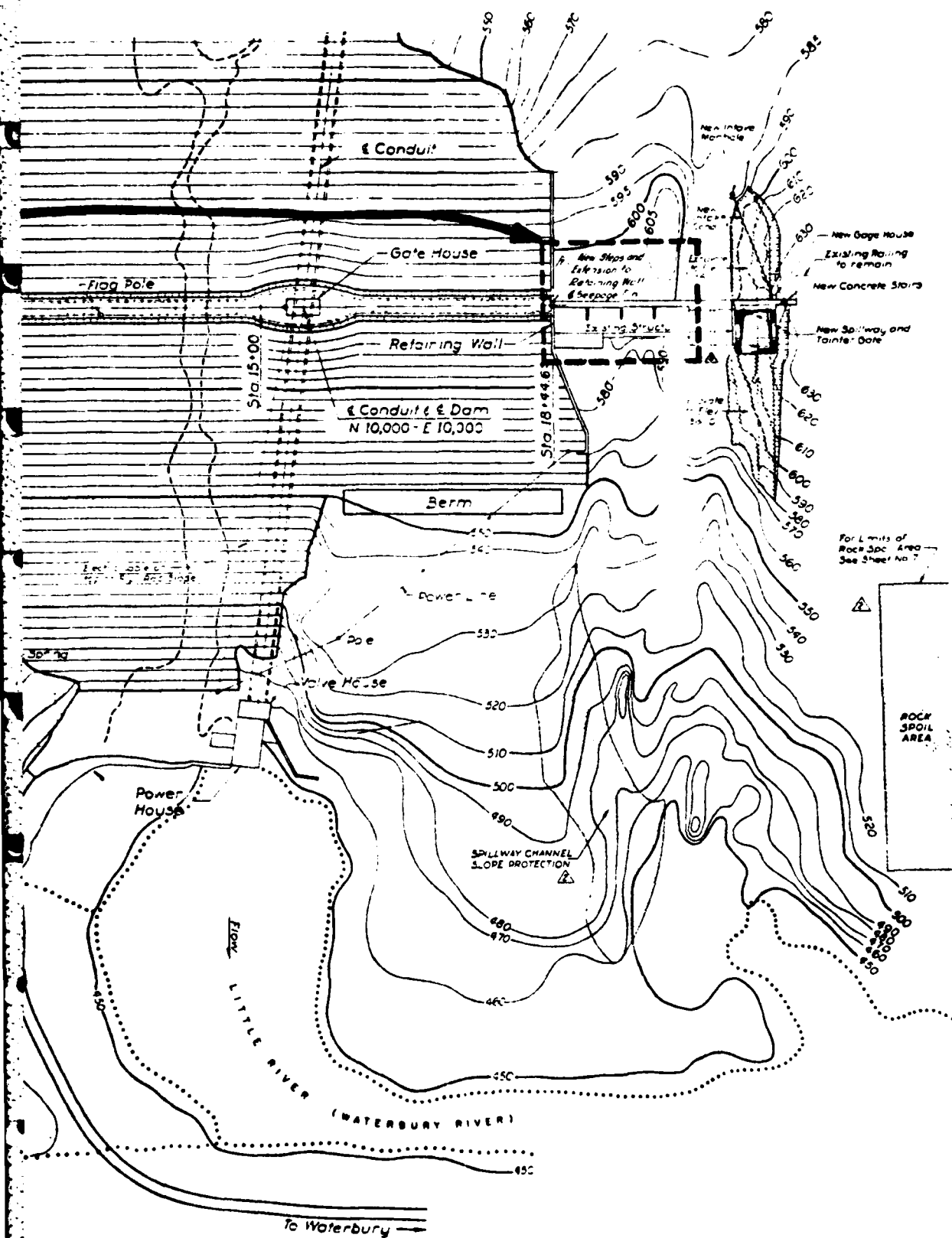


Figure 31. Void filled with alkali-silica gel from sample NY-8 CON-20. The white granular appearing gel is encapsulated by a translucent outer shell. The gel was in contact with quartzite and gneiss particles as well as portland cement paste



PLAN

Figure 32. General plan view of



W of Waterbury Dam

CONCRETE CORES AT VARYING
HEIGHTS ON THE SPILLWAY
ABUTMENT WALL

CONCRETE CORE ON THE
DOWNSTREAM FACE OF THE
SPILLWAY SECTION

CONCRETE CORE ON THE
DOWNSTREAM FACE OF THE
SPILLWAY SECTION

CONCRETE CORES TAKEN
HORIZONTALLY IN THE
DOWNSTREAM FACE OF THE
SPILLWAY WALL

CONCRETE CORE ON THE
DOWNSTREAM FACE OF THE
SPILLWAY SECTION

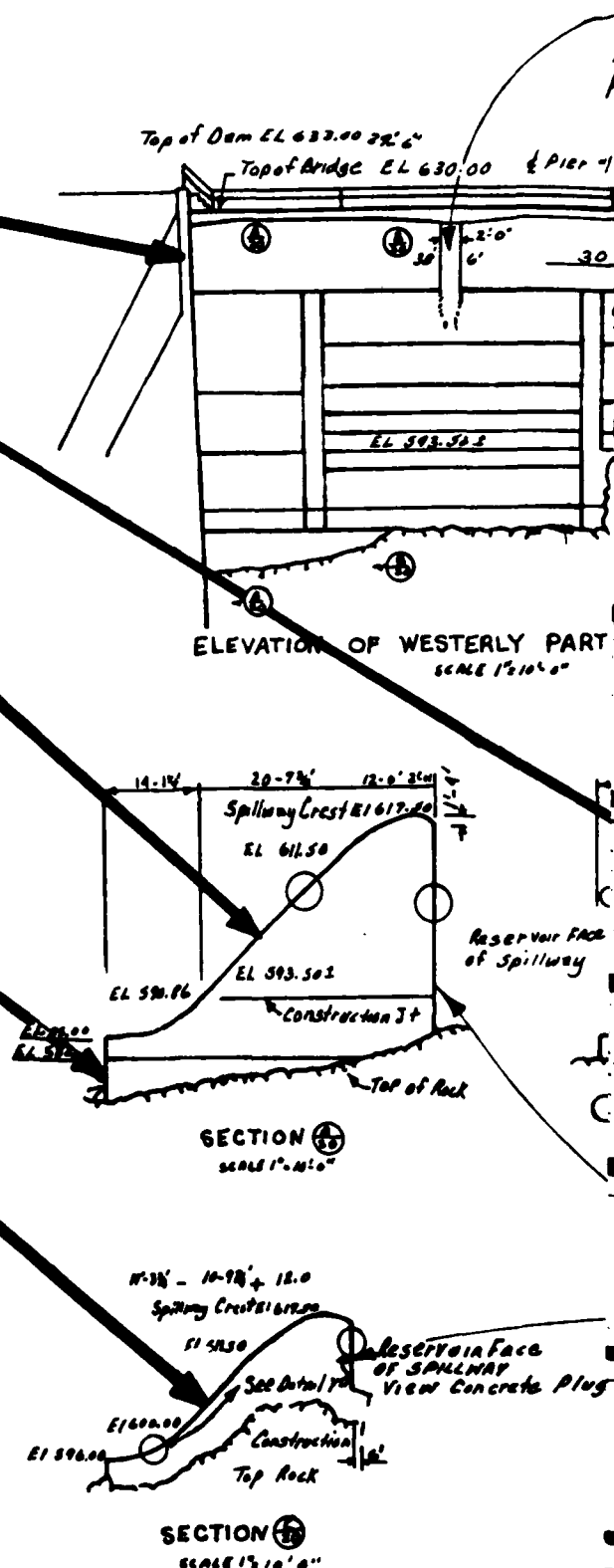
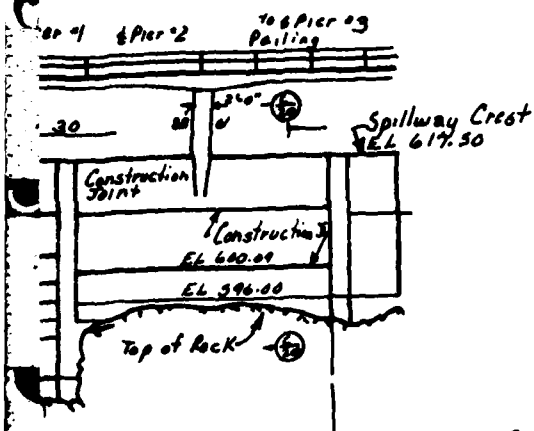


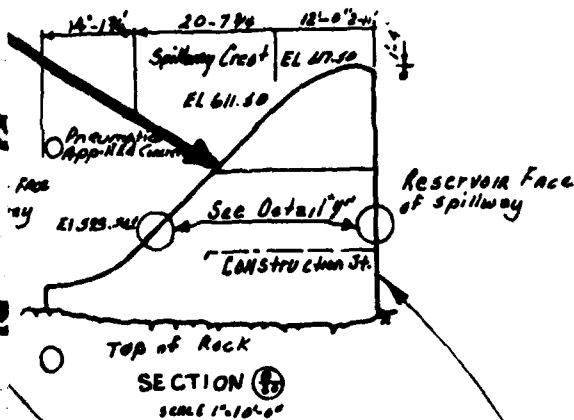
Figure 33. Locations where conc

CONCRETE CORE TAKEN
FROM EACH OF THE BRIDGE
PIERS OVER THE SPILLWAY



ART OF SPILLWAY

CONCRETE CORES ALSO TAKEN
FROM CATWALK, TAINTER
GATE ABUTMENT WALL, AND
NORTH WALL OF TURBINE HOUSE



CONCRETE CORE TAKEN
ON THE RESERVOIR FACE
OF THE SPILLWAY AS SHOWN
IN (A/20) (B/20) (C/20)

concrete cores were taken

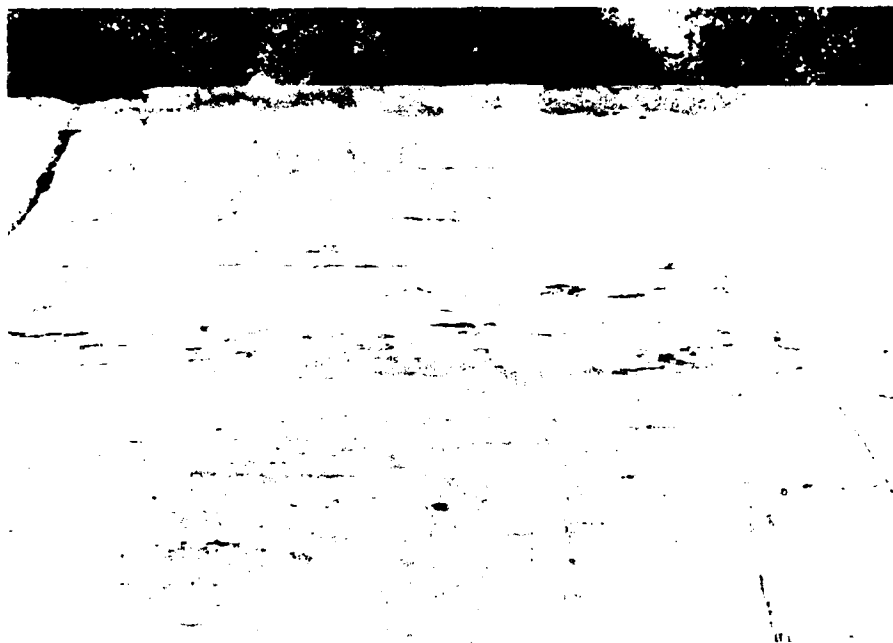


Figure 34. Pattern cracking and concrete deterioration on the downstream surface of spillway section A-4



Figure 35. Horizontal cracks on downstream surface of spillway section A-4



Figure 36. From right to left, spillway sections A-4, A-3, A-2, and A-1 and a partial view of the tainter gate sections

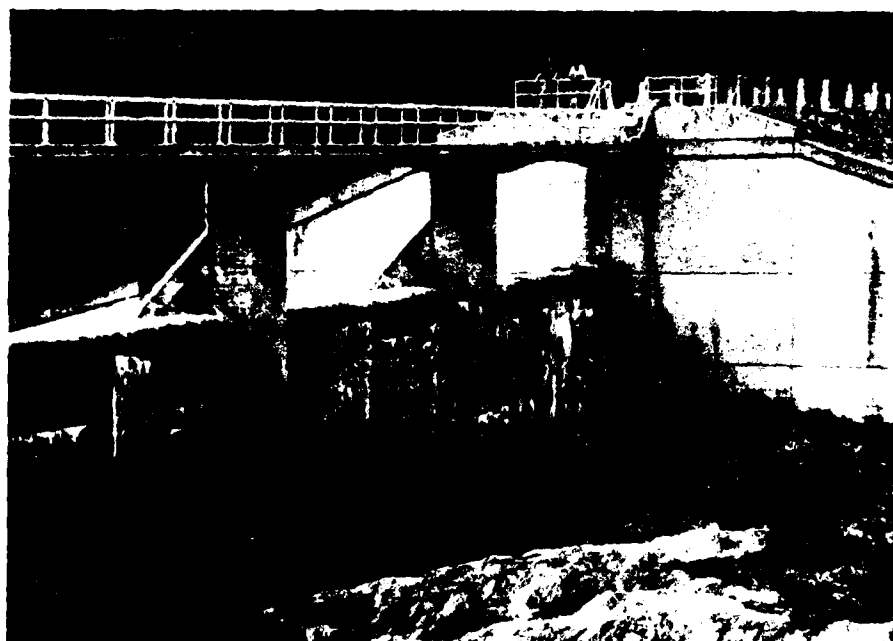


Figure 37. Spillway section openings A-4, A-3, and A-2 from right to left

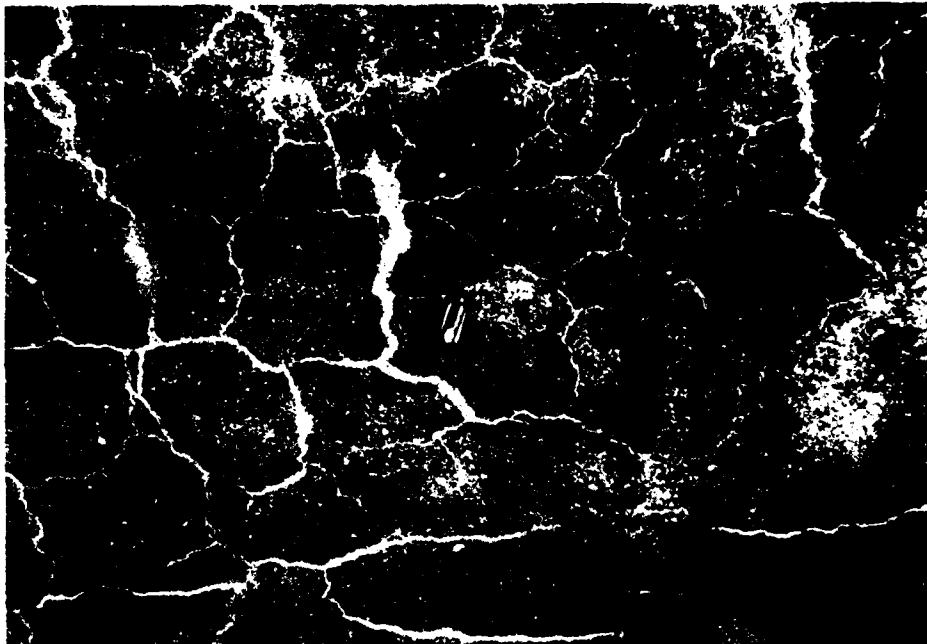


Figure 38. Pattern cracking on the top surface of the bridge deck



Figure 39. One-inch offset at upstream edge of bridge deck section



Figure 40. Typical view of tainter gate pier



Figure 41. Downstream concrete surface of
right retaining wall

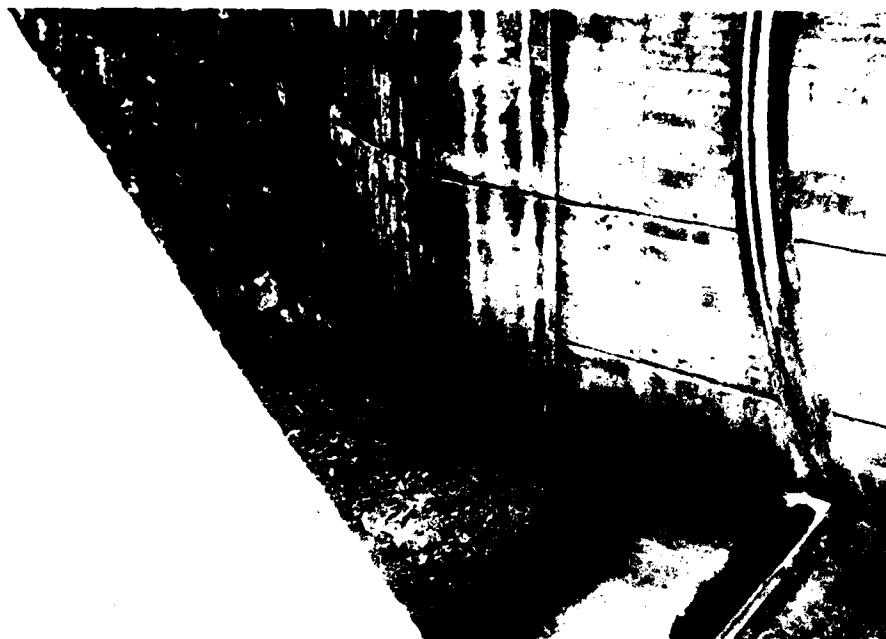


Figure 42. Upstream portion of left abutment wall



Figure 43. Downstream section of left abutment wall

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Pace, Carl E.

Evaluation of concrete cores from Waterbury Dam, Waterbury, Vt. / by Carl E. Pace, Richard L. Stowe, G. Sam Wong (Structures Laboratory, U.S. Army Engineer Waterways Experiment Station). -- Vicksburg, Miss. : The Station ; Springfield, Va. ; available from NTIS, 1982.

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(Miscellaneous paper ; SL-82-14)

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"September 1982."

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"Prepared for U.S. Army Engineer District, New York."

1. Concrete--Deterioration. 2. Concrete--Testing.
3. Concrete dams. 4. Waterbury Dam (Vt.) I. Stowe,
Richard L. II. Wong, G. Sam. III. United States. Army.
Corps of Engineers. New York District. III. U.S. Army
Engineer Waterways Experiment Station. Structures

Pace, Carl E.

Evaluation of concrete cores from Waterbury : ... 1982.
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