Dam Construction
Quality Control and Quality Assurance

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It is necessary to properly specify, inspect and assure that the actual construction process translates the dam design into a satisfactory as-built structure

"The safety factors in design seem to be quite adequate; those in quality control are certainly not. For earth dams, where the slightest lapse in quality can be fatal, I have long recommended that the cheapest form of quality assurance is a professional engineer on the site, on the job, every hour of the working day."

Commonly, the owner/designer organizes a field team to perform the tasks of quality control and quality assurance to enforce the specifications and to provide surveillance during construction. The field staff must maintain close contact with the designers for decisions related to the design intent. In addition, the design team makes frequent trips to the site to provide additional input as needed and for routine inspection. The combined effort of these activities is to increase the success rate of translating the design intent to the actual constructed product.

Changed Conditions

- Engineer is responsible for ensuring that the design intent and technical specifications are met and that the design, if required, is adjusted to suit actual conditions in the field
- Any design changes must be approved and signed off by the Engineer of Record
- Inform Regulator of significant changes

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QC/QA Reports

- Daily Reports
- Weekly/Monthly Reports
- Materials Testing Reports
- Photograph Record
- Construction Summary Report

- These reports are valuable for future dam safety reviews

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Quality Control and Quality Assurance

- Remaining slides gives examples* of construction materials and procedures that need to be observed and documented along with typical tests to check conformance with design specifications
  - Site preparation
  - Fill placement and compaction
  - Granular filter
  - Riprap

*The examples are not intended to be recommendations or best practices. These were taken from a handful of actual dam construction documents.

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Site Preparation

- Remove all vegetation and strip organic topsoil
- Remove debris, snow, ice, and water
- Extract and remove visible boulders
- Surface must be “smooth” and not contain any sharp or angular sections
- Topsoil should be kept separate from subsoil, and stockpiled

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Key Trench

- Excavate down at least 0.6 m into impervious material
- Minimum of 2 m wide
- Remove all water, mud, loose soil and rock before backfill commences
- Sidewalls no steeper than 1:1

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Fill Material

- Fine fraction of the soil (< 0.075 mm) >25% and <50%
- Fine components with low to medium plasticity
- Maximum particle size <100 to 150 mm
- Well-graded particle size distribution
- Moisture content within -1% to +2% of optimum moisture

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Fill Placement

- Place fill after the engineer inspects and approves the surface
- Winter construction – remove frozen soils and do not place/compact frozen soil
- Spread in layers with uniform thickness < 150 to 300 mm
- Fill moisture content within -1% to +2% of the optimum moisture
- Crown the fill surface 3% to 5%

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Fill Placement

- Where material has dried out, it must be scarified and watered before the next layer is placed
- Material that is too wet shall be dried by scarification and aeration or removed and replaced
- Each soil layer should be bonded to the previous layer by light scarifying in the longitudinal direction

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Fill Compaction

- Compact to min. 98% standard Proctor max. dry density
- Overlap successive compactor passages by 1⁄4 of the compactor width
- Compact the entire length of the area on each pass
- Compact in the direction parallel to the longitudinal axis of the embankment
- Completely compact a layer before starting the next layer

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Photo provided by City of Dawson Creek


Photo provided by City of Dawson Creek

Fill QC/QA Testing

- Measure the gradation, moisture content and density of materials in place
- Conduct tests across the full length, width and depth of the fill
- Reference test results to date, fill type, location, borrow source, and elevation
- Report test results within 24 hours of completion
- Remove and replace fill that does not meet the specified requirements

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Recommended Tests and Frequency - Fill

Test	Frequency	Acceptable results
Sieve analysis	3/week or maximum 200 m^3	Within designated boundary and 25 to 50% fines content
Hydrometer	1/week or maximum 500 m^3	20 to 40% fines content
Moisture content	3/day or maximum 75 m^3	-1% to +2% optimum
Standard Proctor	2/week or maximum 200 m^3	Follow standard procedures
Dry density	1/day or maximum 100 m^3	Min. 98% Standard Proctor

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Typical Report

***PROJECT** Name: _____ Project No.: 1667*
Location: _____ Date: October 11, 2019
Engineer: _____ Technician: _____

***Soil Prop.** Soil i) Zone 1A-Sheet pile Exc. South Max Density: 2055kg/m^3 Opt. Moisture: 12.9%*
***Soil Prop.** Soil ii) Zone 1A-Sheet pile Exc. North Max Density: 2017kg/m^3 Opt. Moisture: 13.0%*

***Gauge Type**: InstroTek Xplorer – 3500 G-2 Std. Counts Oct 8th/9th/10th/11th: D-2213/2234/2205/2205 M -740/695/736/736*

***Contractor** _____ Comp. Equipment: Sheepsfoot Roller/Jumping Jack*

Test No.	Station/Test Location	Probe Depth	Date	Soil Prop.	Dry Density	Moisture (%)	Compaction (%)
1	U/S Sheet pile trench ~ On ℄ ~ 893.90 metres	6"	Oct 8	i) 98%	2038	12.8	99.2
2	U/S Sheet pile trench ~ 6 metres north ℄ ~ 893.90 metres	6"	Oct 8	i) 98%	1991	13.0	96.9
3	D/S Sheet pile trench ~ 5 metres north ℄ ~ 893.90 metres	6"	Oct 8	i) 98%	1934	10.5	94.1#
4	D/S Sheet pile trench ~ 1 metres south ℄ ~ 893.90 metres	6"	Oct 8	i) 98%	1981	12.7	96.4@3
5	D/S Sheet pile trench ~ 5 metres north ℄ ~ 893.90 metres	6"	Oct 8	i) 98%	2063	11.9	100.4
6	D/S Sheet pile trench ~ 3 metres south ℄ ~ 894.25 metres	12"	Oct 8	i) 98%	2082.3	11.4	101.3
7	D/S Sheet pile trench ~ 2 metres north ℄ ~ 894.25 metres	12"	Oct 8	i) 98%	2077.5	11.5	101.1
8	U/S Sheet pile trench ~ 3 metres south ℄ ~ 894.25 metres	12"	Oct 8	i) 98%	2008.1	11.9	97.7
9	U/S Sheet pile trench ~ 3 metres north ℄ ~ 894.25 metres	12"	Oct 8	i) 98%	2015.9	11.9	98.1

***NOTES:** 98% of Standard Proctor Density, (ASTM D-698) compaction required. Specification 3.4.2 for Zone 1 and 1A Material in 3.4.2.1 that "The average dry density of compacted material as determined by any 10 consecutive tests shall be at least equal to 98% of standard proctor maximum dry density as defined by ASTM D698. No single test result shall be less than 95%.*

 # _____ told to recompact material.

***@"TestNo."** Result of recompaction at Test No. site noted after material recompacted.*

** Tests 1-5 completed with _____ Test 5 is a retest of 3 after repacking.*

** Test 20 is a retest of 18 after repacking of material.*

** Test 27 is a retest of 25 after repacking of material.*

** Test 28 is a retest of 26 after repacking of material.*

** Test 57 is a retest of 54 after repacking of material.*

** Test 58 is a retest of 56 after repacking of material.*

** Test 59-69 completed by _____*

** Test 67 is a retest of 66 after repacking of material.*

Filter Material

- Silt and clay (< 0.075 mm) less than 4%
- Uniformly graded with max. size of 20 mm

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Filter Placement

- Spread in layers of uniform thickness <300 to 350 mm
- Compacted to min. 98% Standard Proctor maximum dry density at -2% to +2% of optimum moisture content
- Avoid segregation and accumulation of cobbles

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Recommended Tests and Frequency - Filter

Test	Frequency	Acceptable results
Sieve analysis	3/week or max. 200 m^3	Within designated boundary and max 19 mm
Moisture content	2/week or max. 200 m^3	-2% to +2% optimum
Standard Proctor	2/week or max. 200 m^3	Standard lab procedures
Dry density	1/day or max. 100 m^3	Min. 98% Standard Proctor

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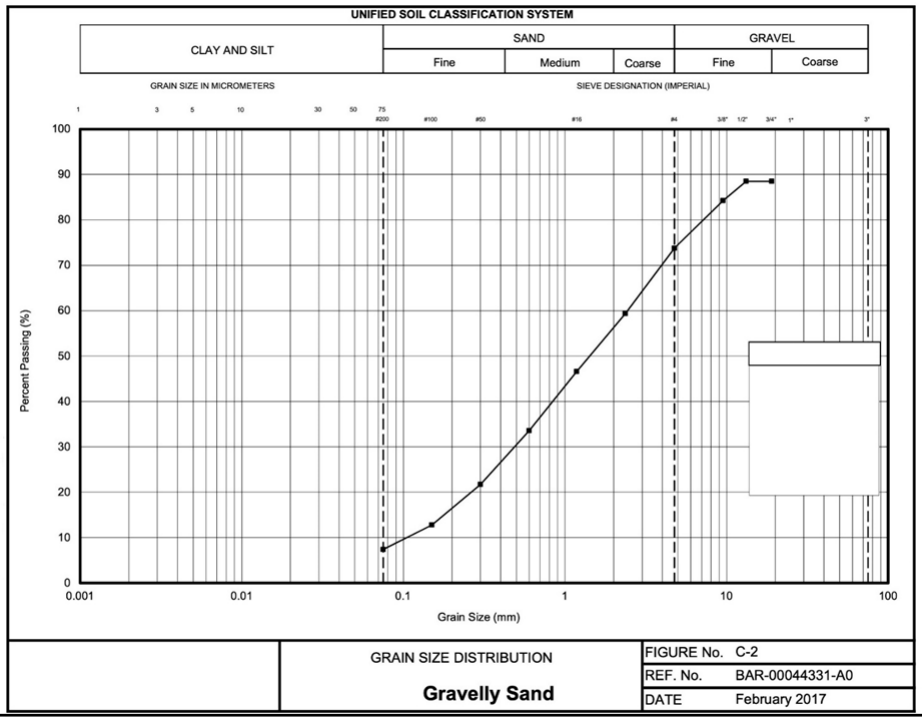

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Spillway Riprap Bedding

- Combination of cobbles and gravel and very little sand
- Fine components less than 3%
- Max. particle size of 150 mm
- Placed in a lift less than 400 mm thick
- Compacted with > 5 passes of a 10-ton roller compactor

- Geotextile alternatives

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Riprap Size for Spillway

- Riprap for spillway
  - D_{min} of 150 mm, D_{50} of 500 mm and D_{max} of 650mm

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Riprap Placement

- Unload rocks onto a horizontal surface for sorting before placing them on the embankment
- Place in uniform layer at least two stones thick
- Tightly pack one rock at a time into an interlocked stable configuration
- Press/compact final surface using a backhoe bucket

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Recommended Tests and Frequency

Test	Frequency	Acceptable results
Sieve analysis (bedding)	3/week or max. 200 m^3	Within specifications
Riprap size	Visual only - daily	Within specifications

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