RECLAMATION

Managing Water in the West

Reclamation Research Updates

Presented by:

Katie Bartojay, PE

Bureau of Reclamation

Materials Engineering and Research Laboratory

Denver, Colorado

U.S. Department of the Interior

Bureau of Reclamation

RECLAMATION

Managing Water in the West

U.S. Department of the Interior
Bureau of Reclamation

RECLAMATION

Bureau of Reclamation

Time-line for Major Improvements of Durable Concrete

Problem	Improvement
Aging Concrete Deterioration	***Concrete Repair Methods Polymers – Silica Fume***
Freezing-Thawing Disintegration	***Air-Entrained Concrete***
Alkali-Aggregate Expansion Swelling - Cracking	***Low – Alkali Cement - Pozzolans***
Sulfate Attack /Cracking	***Sulfate Resisting Cement - Pozzolans***
Poor/Variable Quality	***Hoover Dam – Improved Construction Practices - Process Quality Control***
Low-Strength	***Low Water-Cement Ratio increases quality***

Pioneers--- Abrams--- Hoover---Post War------ “Modern Concrete”

1902	1920	1940	1960	1980	2000

Bureau of Reclamation

Developing durable concrete

Poor Quality	*Better Quality*	*Best Quality*	*“Modern Concrete”*
“Pioneers” Hand mixing Low output (cold joints) Poor quality materials ***Sulfate attack*** ***Alkali-aggregate reaction*** ***Freeze-thaw attack*** Recipe mix design Reinforced concrete “Add more water!”	**“Abrams”** W/C ratio Quality materials Mix design Volumetric batching ***Sulfate attack*** ***Alkali-aggregate reaction*** ***Freeze-thaw attack*** “Chuting” “Add more water!”	**“Hoover”** Weigh batching Internal vibration (less water) Block construction Low-heat cement Use of pozzolans Type II,V cement Low-alkali cement Air-entrained concrete Process quality control Concrete Laboratory Concrete Manual “Add more water!”	**“Post War”** Pozzolans (fly ash) Automated Construction (tunnels, canals) Admixtures Concrete Repair Superplasticizers Silica Fume RCC
1902	**1918**	**1928**	**1948**

Bureau of Reclamation

Steps to Achieving Durable Concrete

Poor Quality

Poor durability
Cold joints
Low output
Inconsistent Materials

Better Quality

Low W/C ratio
Type II / V cement
LA cement
Petrographic examination
Air-entrainment
QC testing

Best Quality

Automated batching
Pozzolan/fly ash
Chemical admixtures

1975 - Fly Ash

1945 - Freeze-thaw Durability

1942 - Alkali-aggregate reaction

1936 - Sulfate Attack

1918 - Quality Materials and Mix Design

1902 to 2001 - Improved Construction Practices

1900	1920	1940	1960	1980	2000

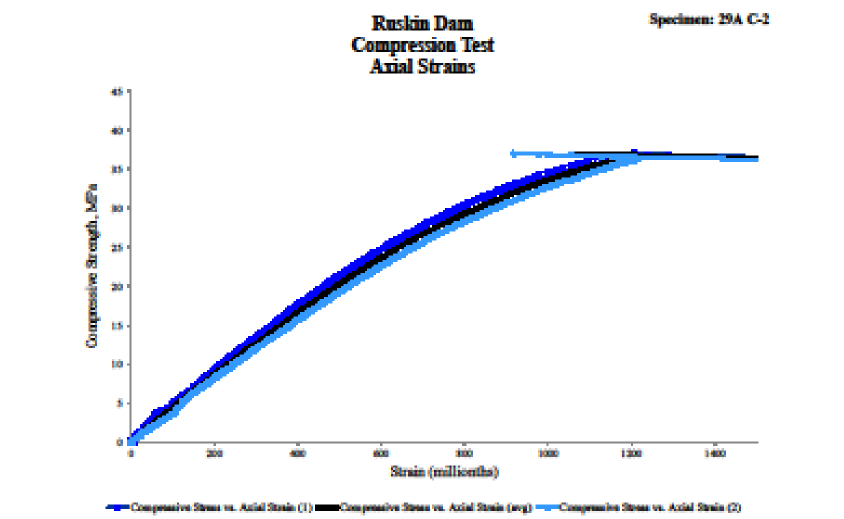
RECLAMATION

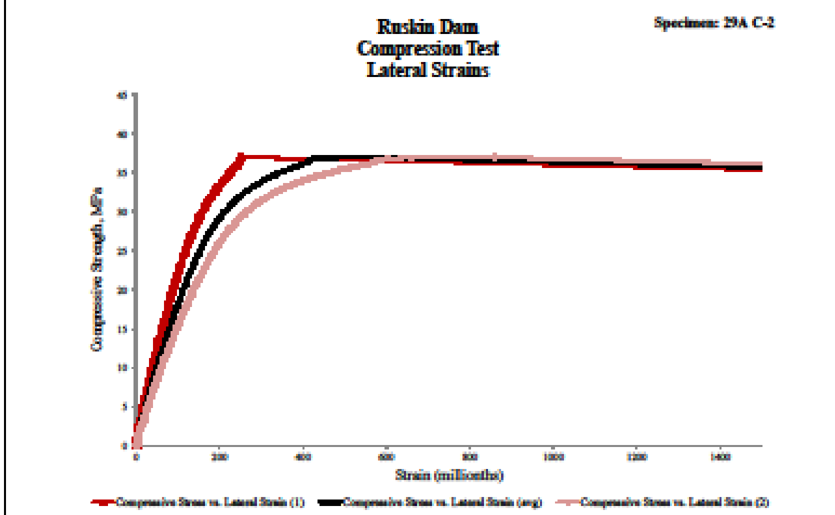
Concrete Technology - Folsom Dam Modifications

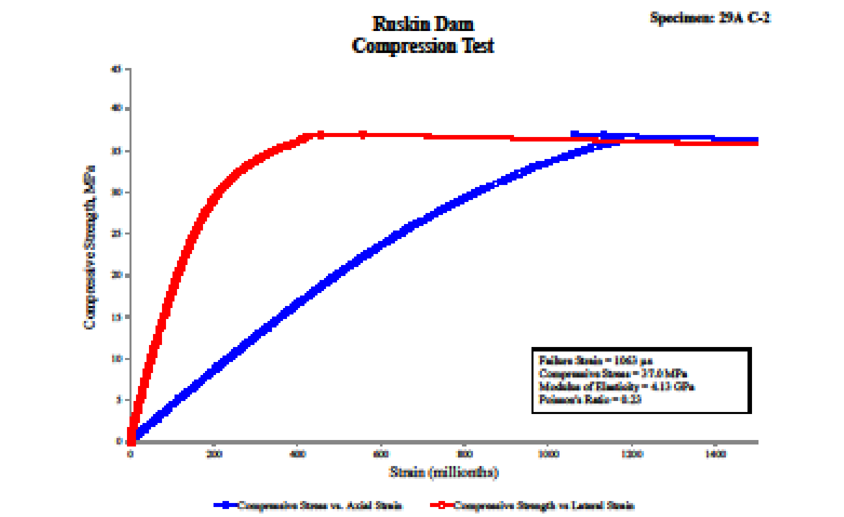
Flexural Strength and Tensile Strain

RECLAMATION

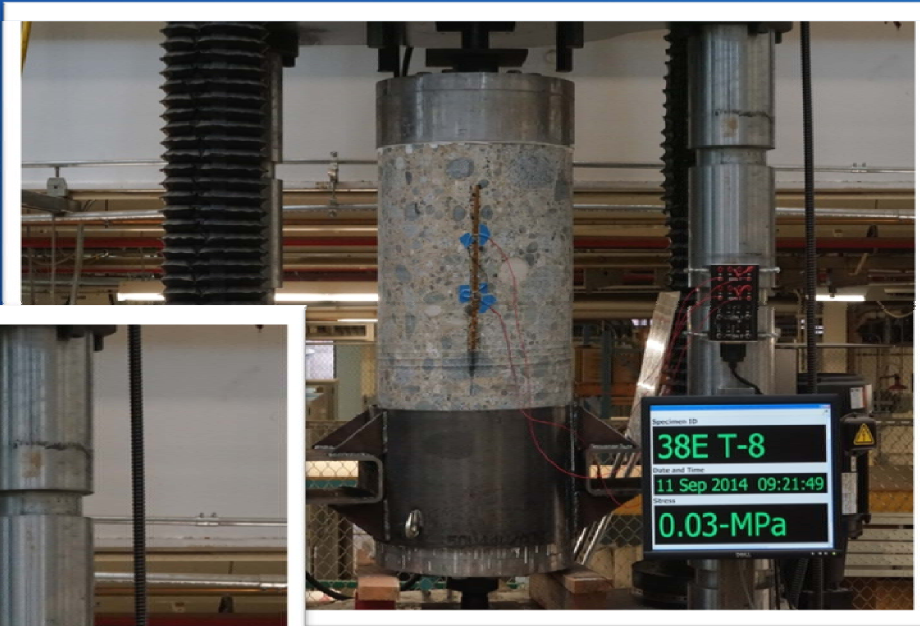
RECLAMATION



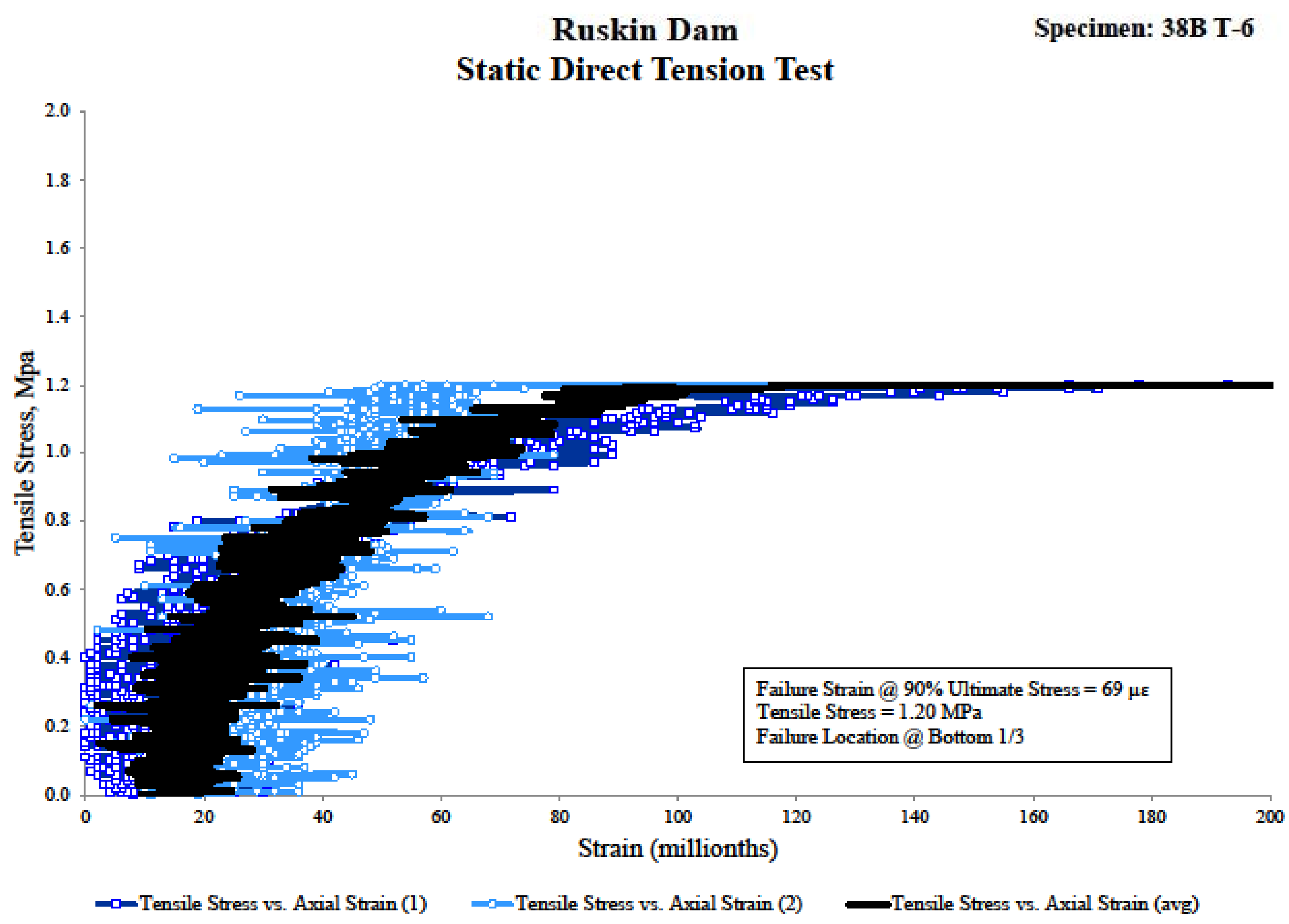




RECLAMATION



RECLAMATION



RECLAMATION

Earthquake Lab
Thin Arch Test

Water Load Behind Arch

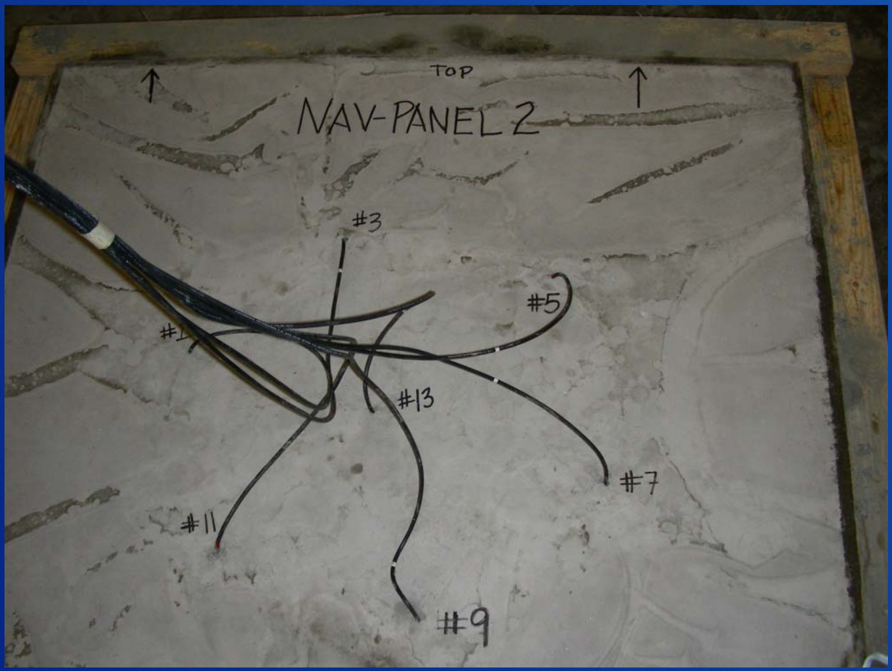
1:100 Scale
75:7500 psi

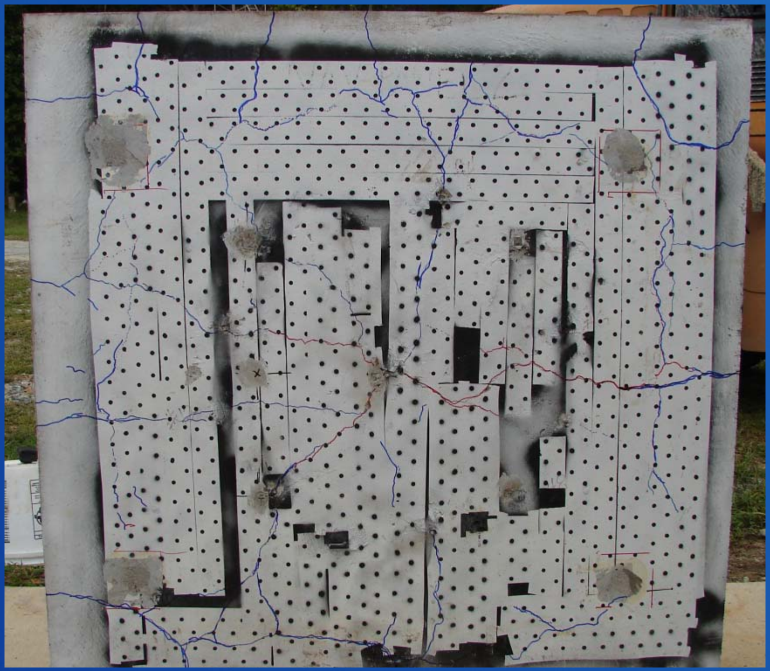
RECLAMATION

Shake Table

RECLAMATION

Mass Concrete Panels, 4.5” NSMA

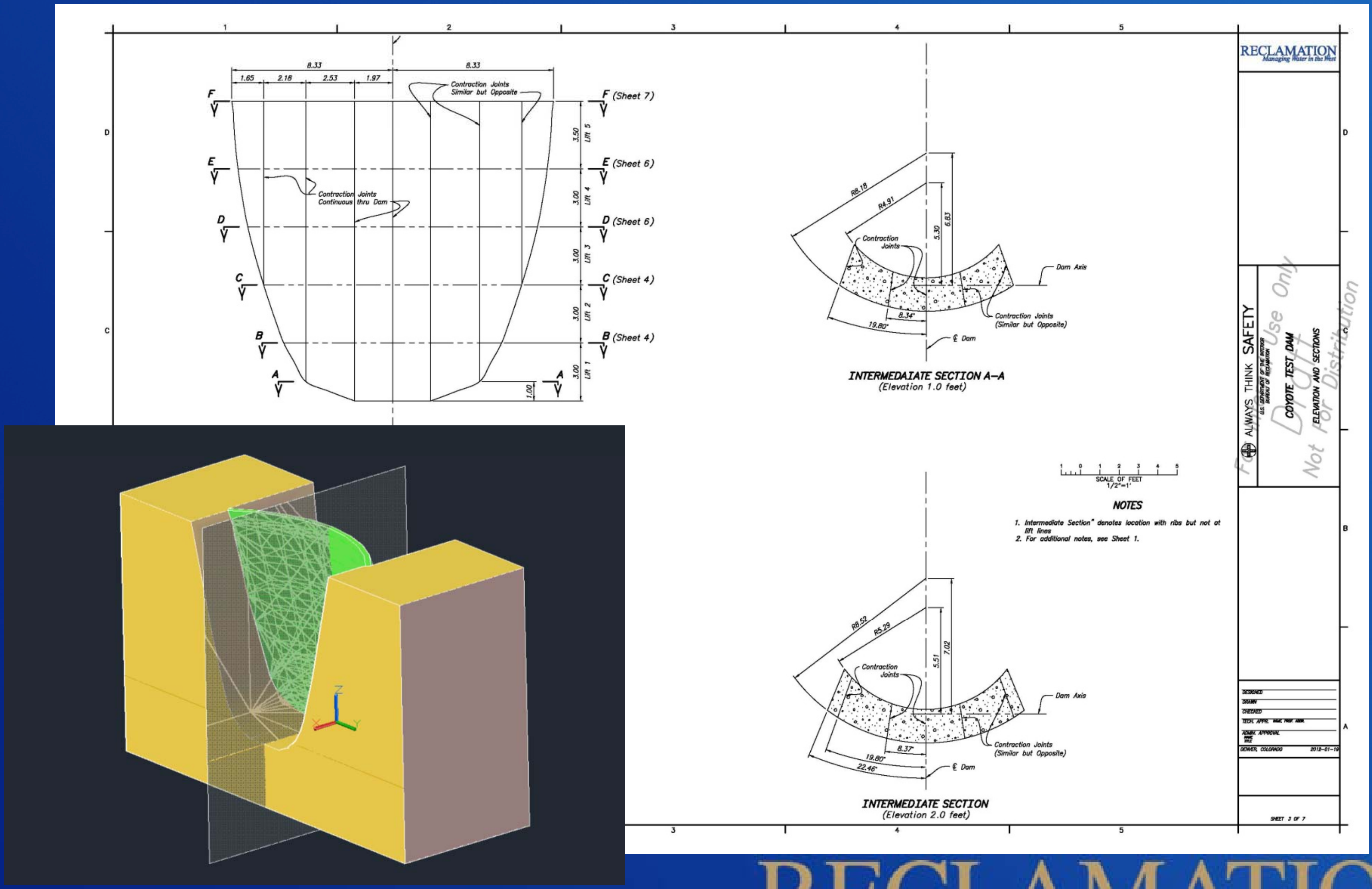




- Bureau of Reclamation
  - Security, Safety and Law Enforcement
  - Materials Engineering and Research Laboratory
- Navy, Indian Head Division, Naval Surface Warfare Center

RECLAMATION

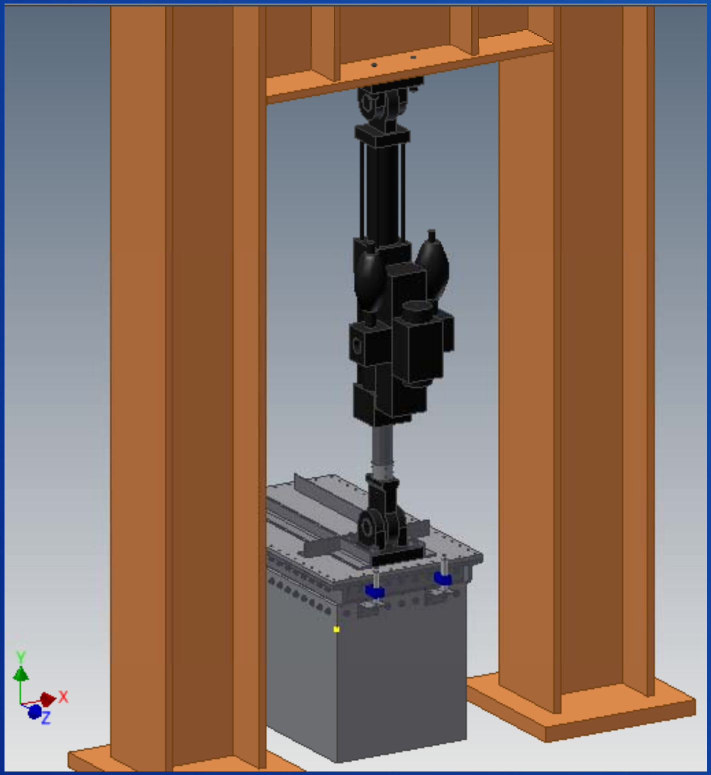
Scaled Testing of a Thin Arch Dam



Sliding Friction of 1:100 Scale Dam

RECLAMATION

Dynamic Uplift Research



Modeling Water Behavior in a Cracked Dam During a Seismic Event

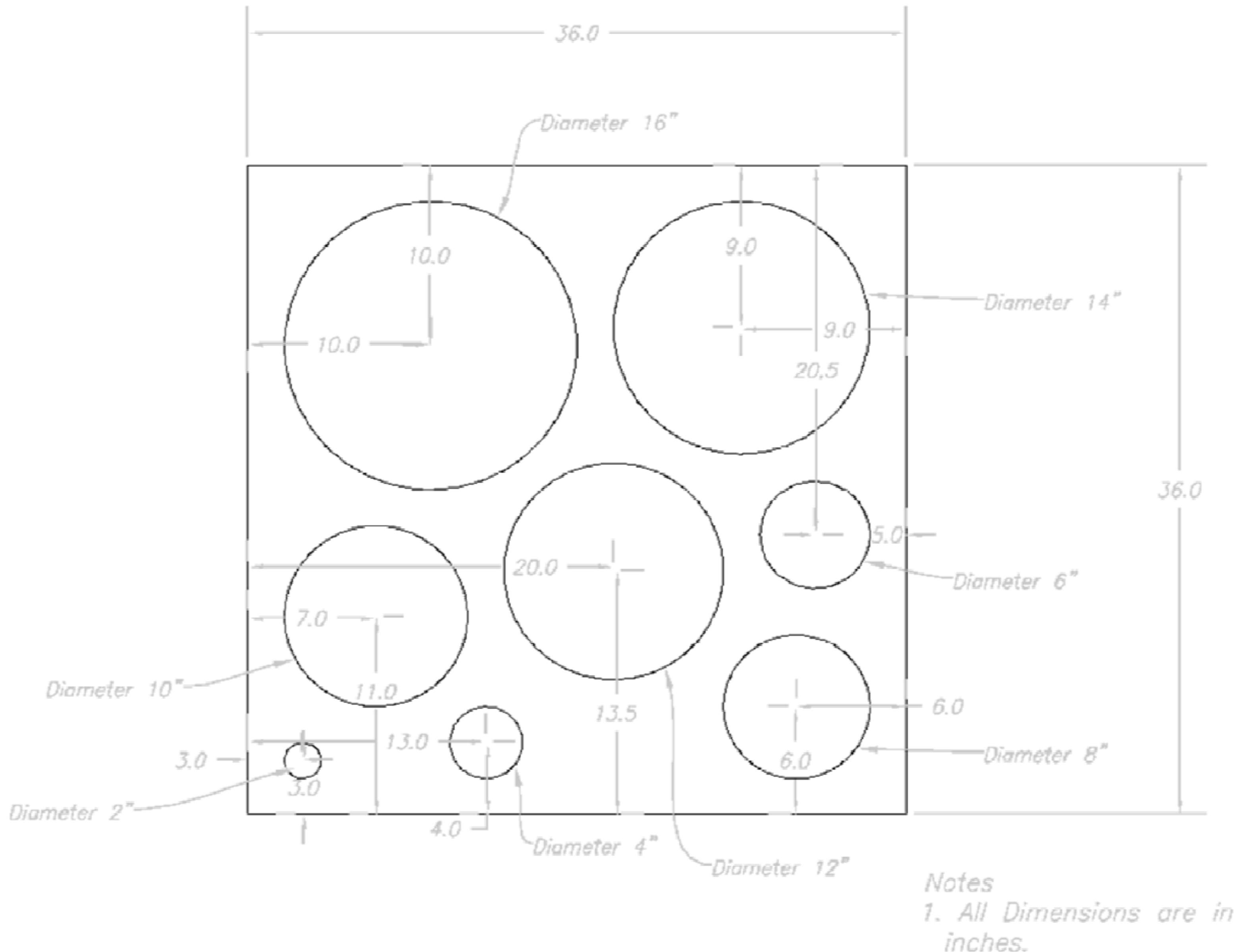
RECLAMATION

Specimen Size Effects


DENVER, CO

Mass Concrete

RECLAMATION



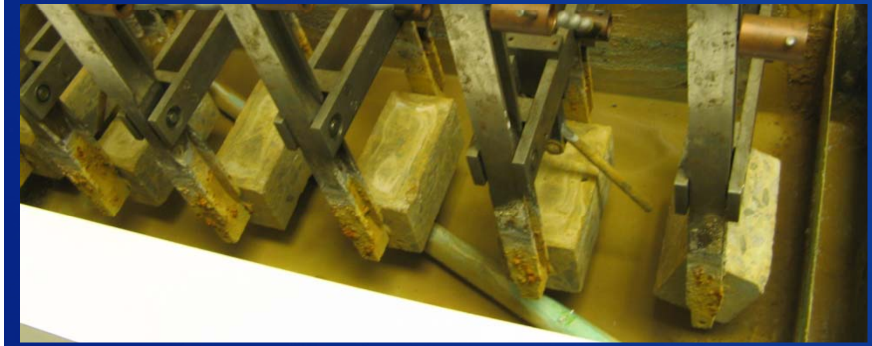
RECLAMATION

Thermal Properties Study

Katie Bartojay, PE

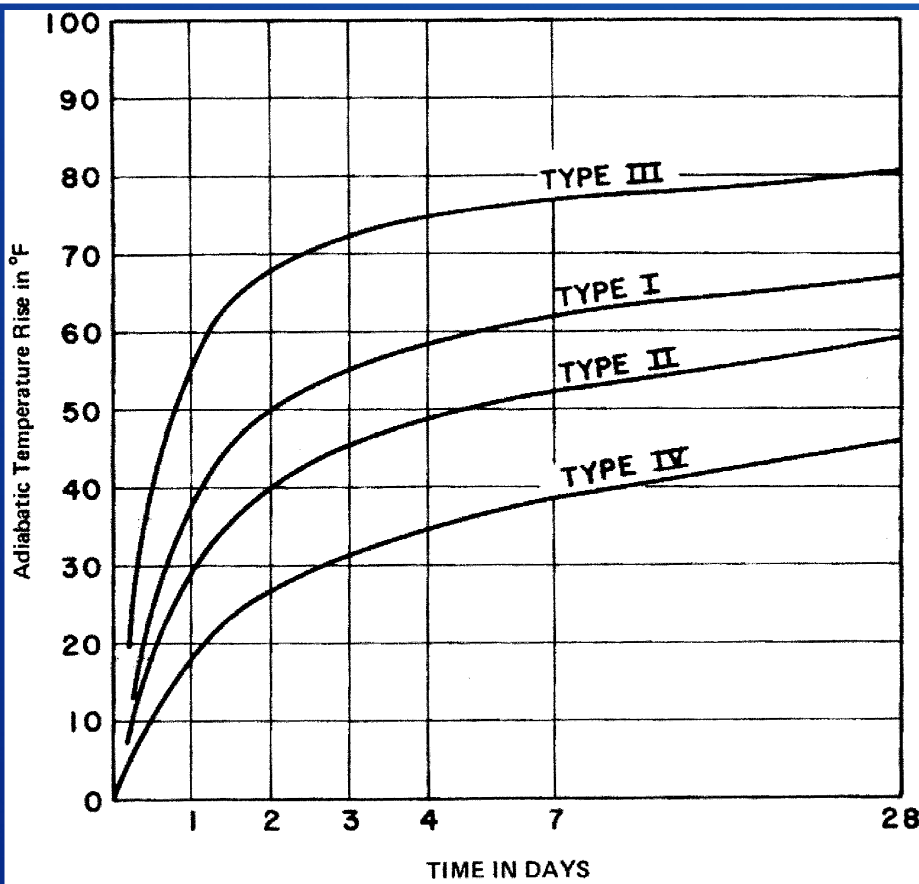
RECLAMATION

Thermal Properties Testing



Full Adiabatic Heat Rise – 6 Calorimeter Chambers (-X to X oF)
Thermal Expansion'
Specific Heat
Diffusivity

RECLAMATION



Cement Type	Fineness ASTM C 115 cm^2/gm	28-Day Heat of Hydration Calories per gm
I	1790	87
II	1890	76
III	2030	105
IV	1910	60

ACI 207.2R Fig. 2.1—
Temperature rise of mass concrete containing 376 lb of various types of cement per cubic yard of concrete

These curves are typical
of cements produced prior to 1960.

Reference point to Reclamation EM
EM point to Boulder Canyon Studies
4-1/2” NMSA Mix

1930-1940 era cements

RECLAMATION

2014 – 2015 USBR Dam Safety Technology Development Program Funding

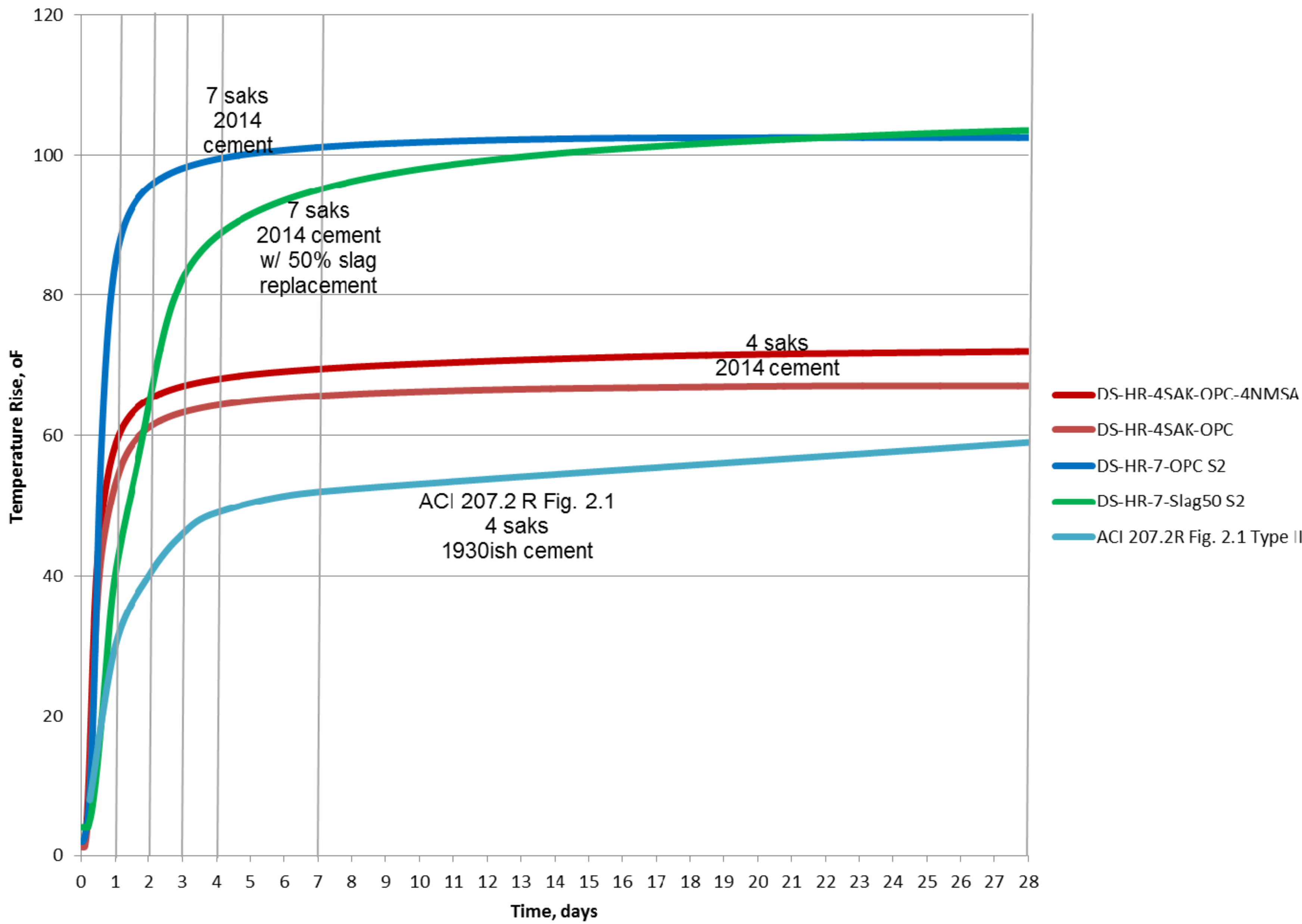
Funding for 8-9

Full Adiabatic Heat Rise Test, USBR Method

Total Saks of Cementitious	Total Cementitious, lbs/cy	Pozzolan Replacement	Aggregate Size
4*	376	0 %	4.5” NMSA
4*	376	0 %	No. 57/67 (1” minus)
7*	658	0 %	No. 57/67
7*	658	50 % Slag	No. 57/67
7	658	70% Slag	No. 57/67
7	658	25 % Fly Ash	No. 57/67
7	658	50 % Fly Ash	No. 57/67
7	658	75 % Fly Ash	No. 57/67

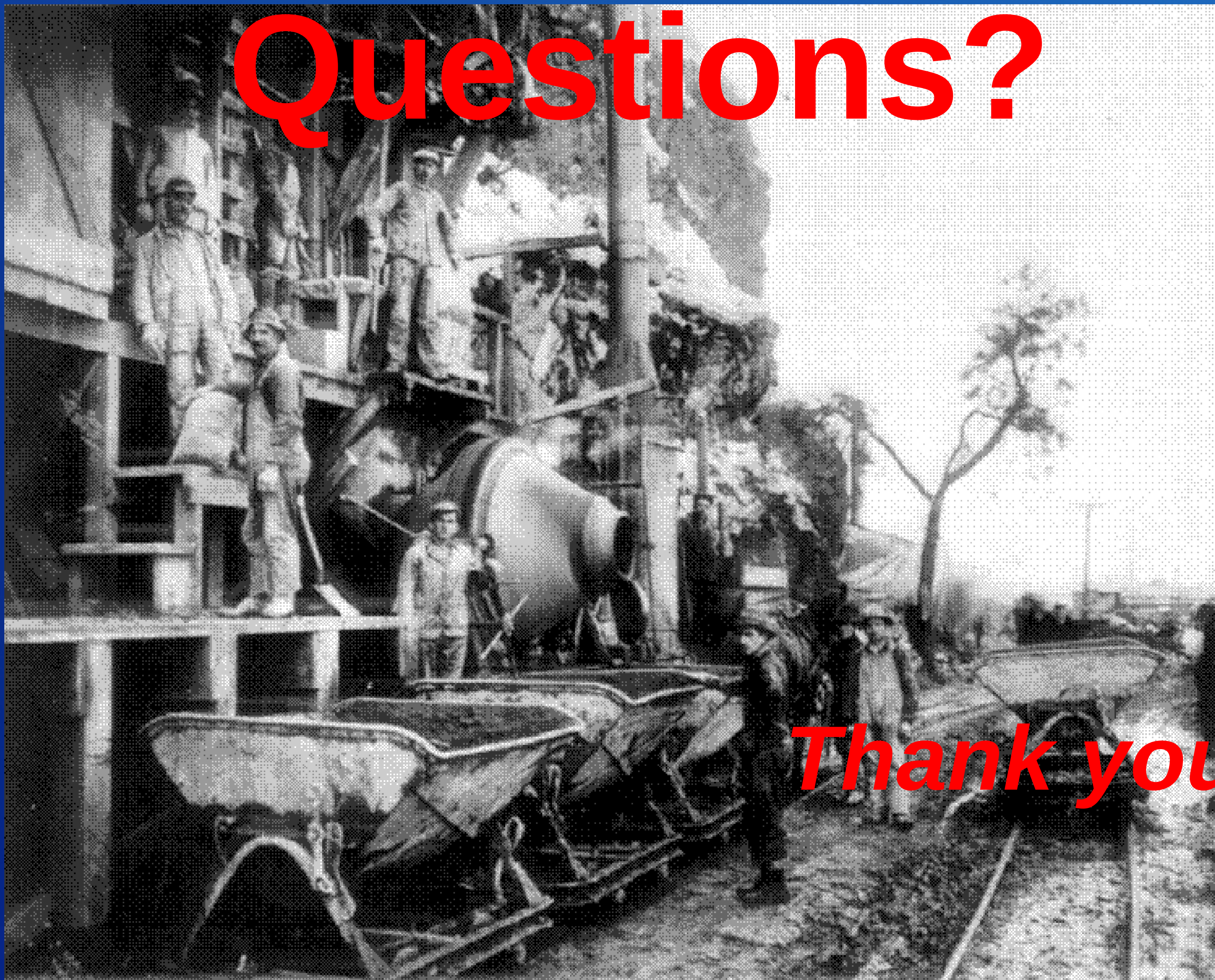
* Completed

RECLAMATION



RECLAMATION

Questions?



Thank you

RECLAMATION