THE CHANGUINOLA DAM
&
HYDRO ELECTRICAL POWER PLANT

A large construction project with its own cement and fly ash import operation

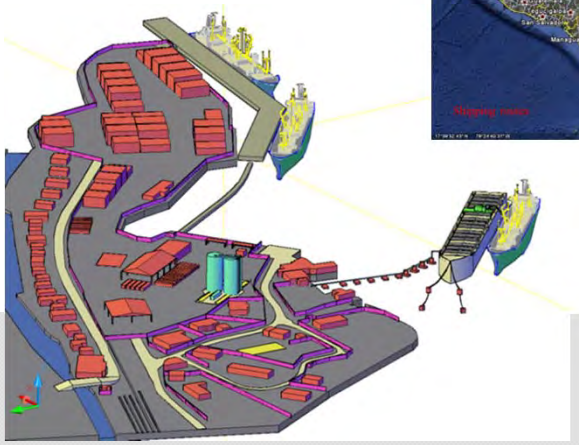
Ad Ligthart

CEMENT DISTRIBUTION CONSULTANTS

12-12-2012

2c2i Club des Carriers Industriels Indépendants

CONTENTS OF PRESENTATION



- The construction project
  - Location
  - Scope of supply
  - The dam
    - Design
    - Roller compacted concrete
  - The tunnel
    - Design
    - Method of construction
- The powerhouse and mini hydro
  - Design
  - Construction
  - Bridges and roads
- Temporary facilities
  - RCC batching plant
  - RCC delivery system
  - Aggregate mining area
  - Crushing plant
  - Aggregate storage area
  - Power plant
  - Workshop
  - Small concrete plant
  - Housing camps

CEMENT DISTRIBUTION CONSULTANTS

CONTENTS OF PRESENTATION

The cement and fly ash import operation

- Key factors
- Sourcing cement and fly ash
- Logistics
- Setting up the supply chain
  - Shipping routes
  - Planning the terminal facility
  - Building a floating terminal
  - Shipping
  - Final preparations
- Operations

CEMENT DISTRIBUTION CONSULTANTS

PROJECT INFORMATION

LOCATION

CEMENT DISTRIBUTION CONSULTANTS

Bocas del Toro Province

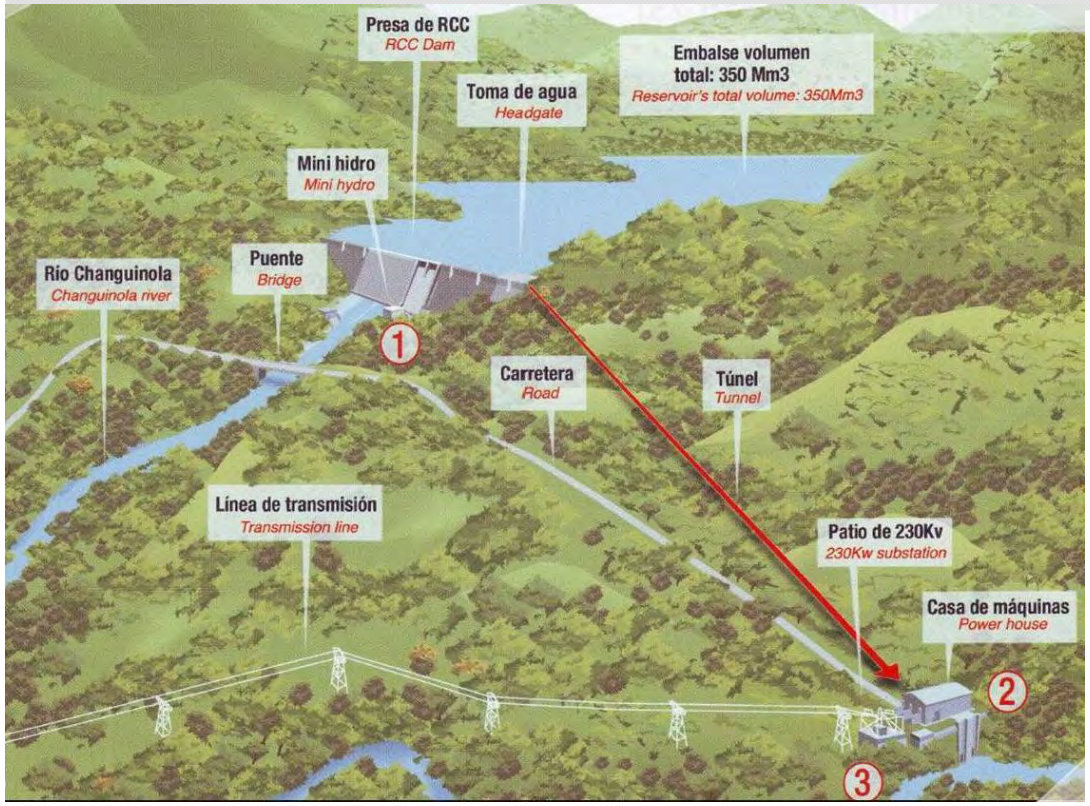
- Very poor province
- Over 60% Indigenous (Indian) population
- 50% of houses without water sanitation and electricity
- Life expectancy 57 years!
- "Banana" Economy

CEMENT DISTRIBUTION CONSULTANTS

BOCAS DEL TORO PROVINCE

PROJECT SITE

CEMENT DISTRIBUTION CONSULTANTS

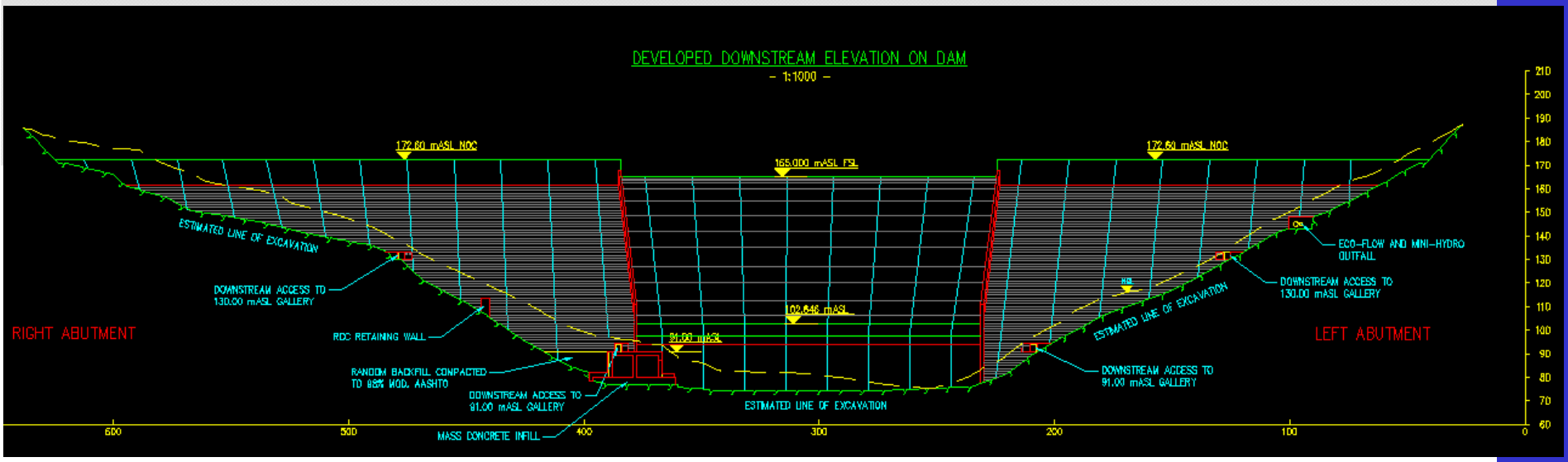


1. A large dam of mass concrete (1 million cubic meter)
   - Height 100 meters
   - Width at top 600 meters
2. Tunnel
   - Length 4 km
   - Diameter 10 meters
3. Powerhouse
   - 2 Turbines
   - Total 210 MW
4. "Mini" powerhouse at dam
   - 9 MW with Eco flow
5. 25 km of permanent road
   - 10 km of temporary road incl. bridges, drainage systems, hill improvements, etc.

Total project value USD 400 million

SCOPE OF SUPPLY

CEMENT DISTRIBUTION CONSULTANTS



Dam Design

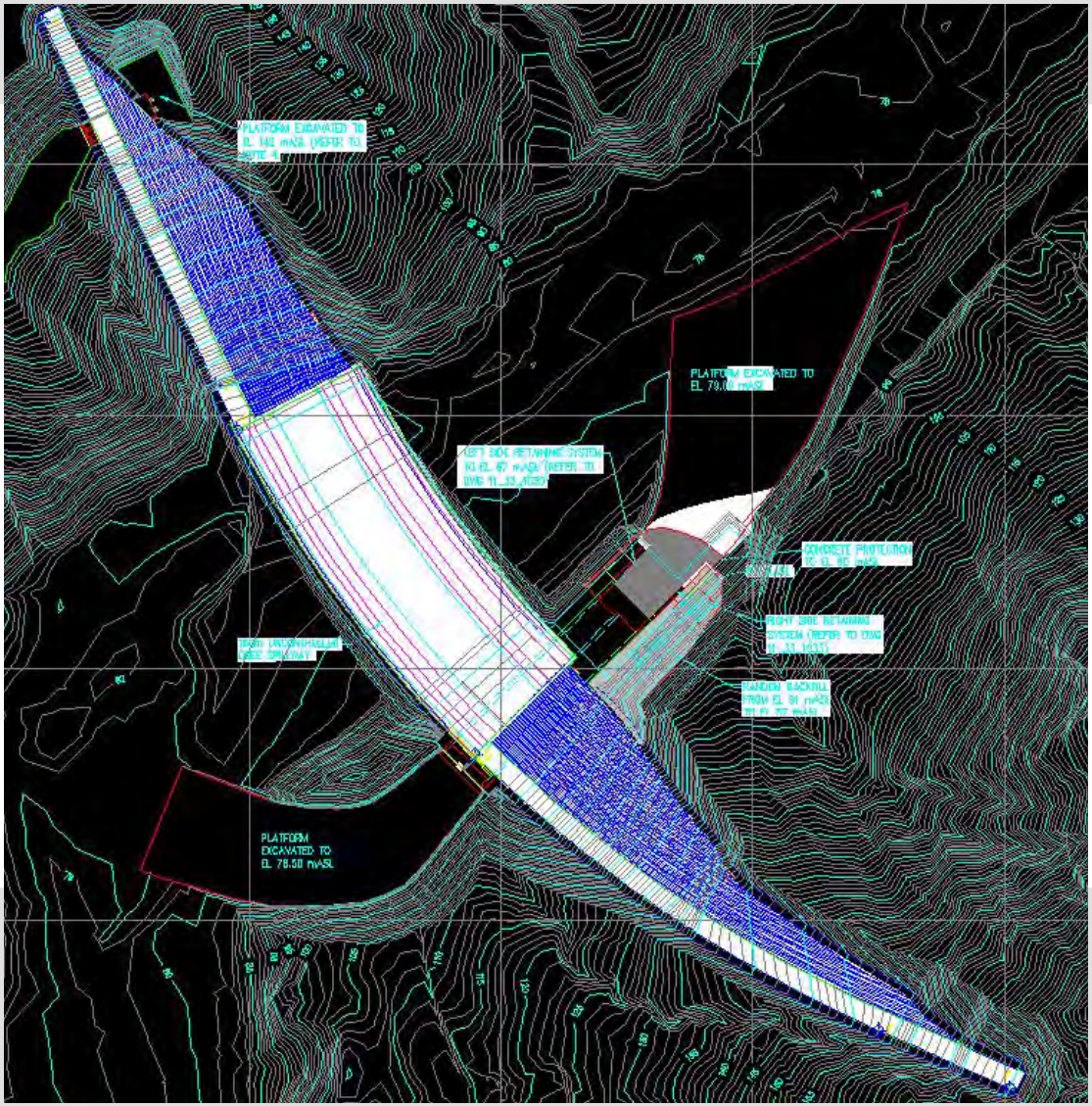
Height of dam 102 m
Width of dam (top) 615 m
Concrete quantity 860,000 m^3

A mass concrete design was chosen over a rock and earth filled dam as this would shorten the construction period with one year.

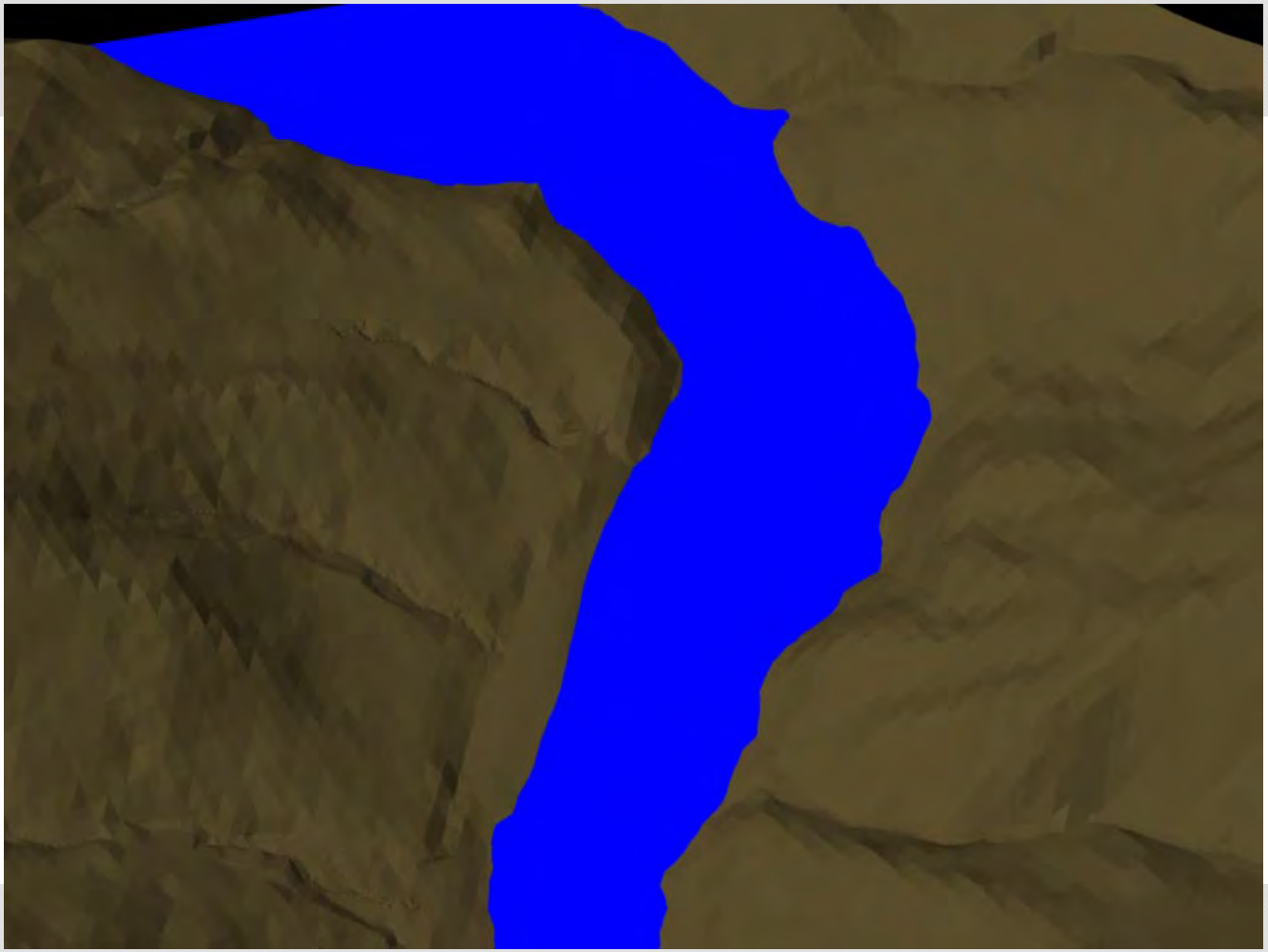
CEMENT DISTRIBUTION CONSULTANTS

Dam Design

A curved dam design was chosen over a "gravity type" design as this saved about 15% of concrete. The concrete mix design and quality of construction had to be a significant higher levels because of this.

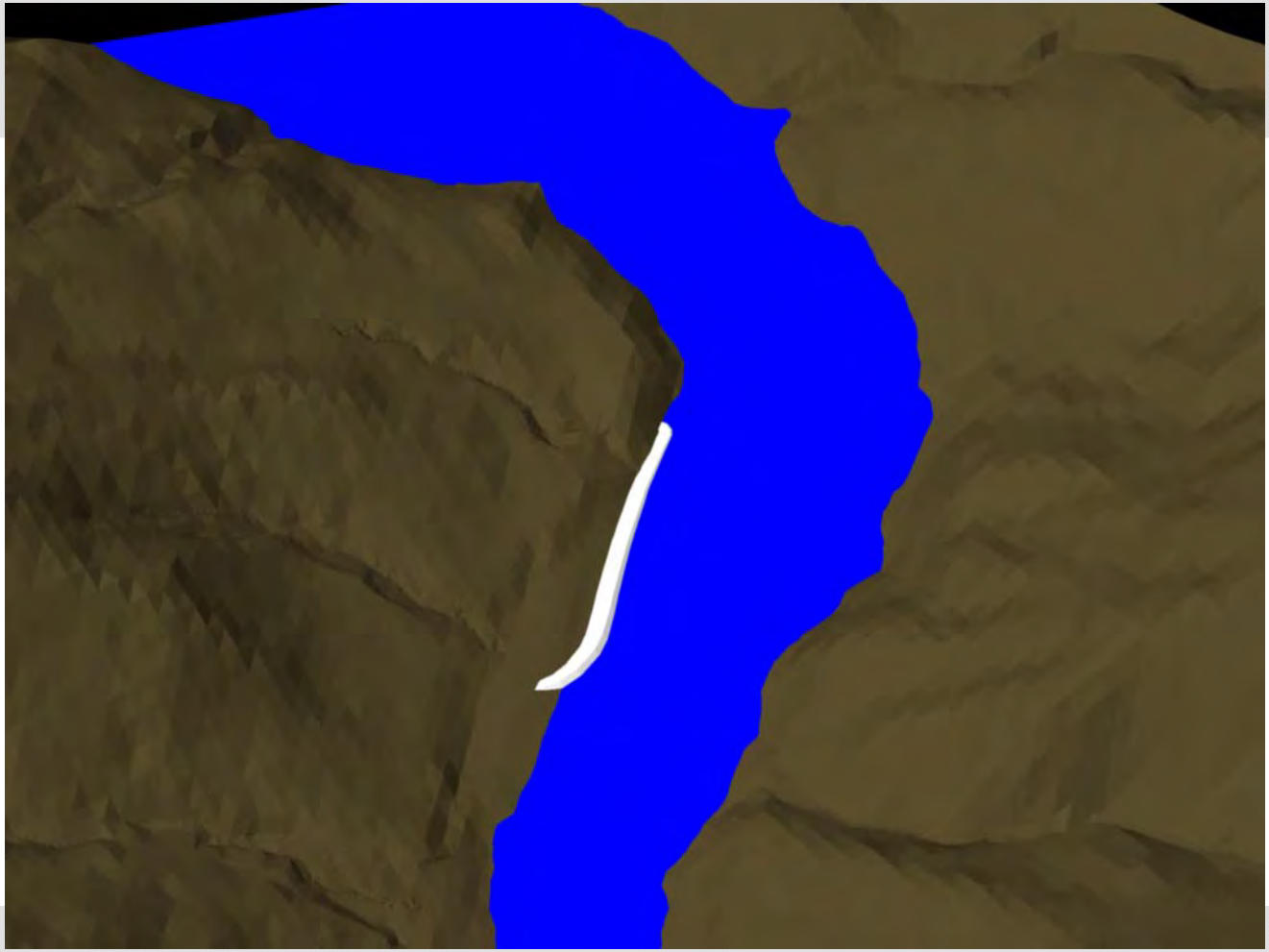


CEMENT DISTRIBUTION CONSULTANTS



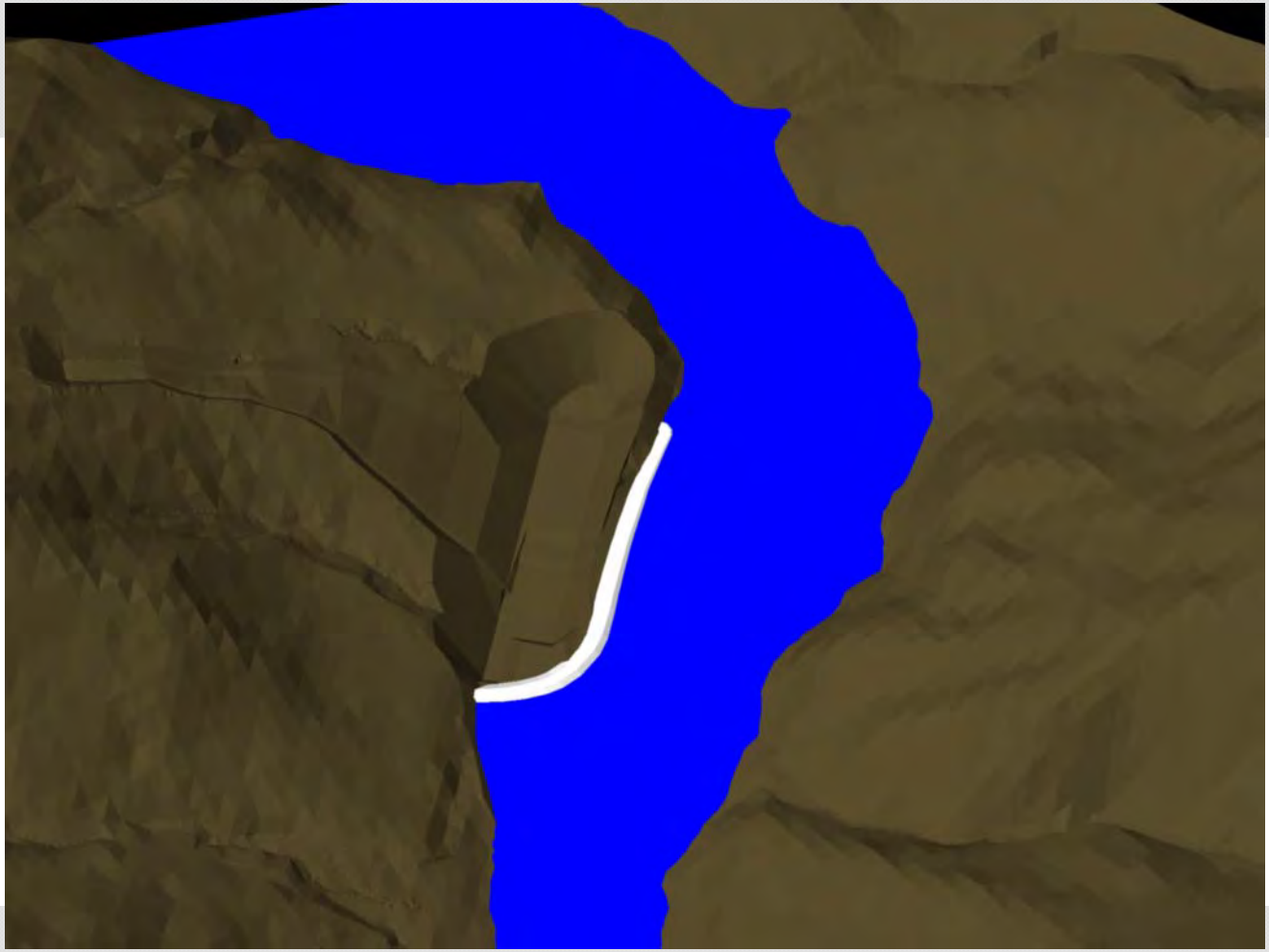
DAM CONSTRUCTION

CEMENT DISTRIBUTION CONSULTANTS



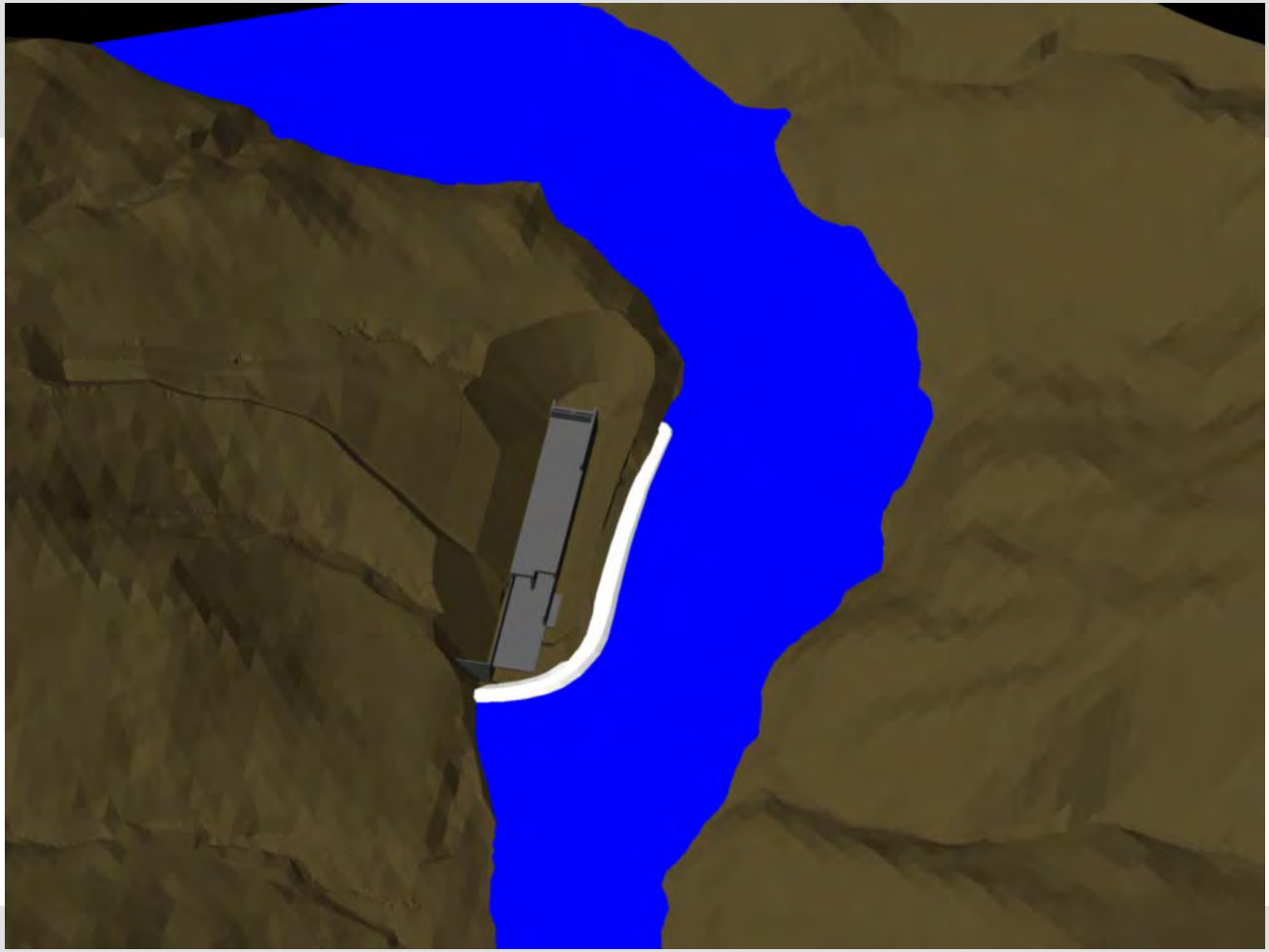
DAM CONSTRUCTION

CEMENT DISTRIBUTION CONSULTANTS



DAM CONSTRUCTION

CEMENT DISTRIBUTION CONSULTANTS

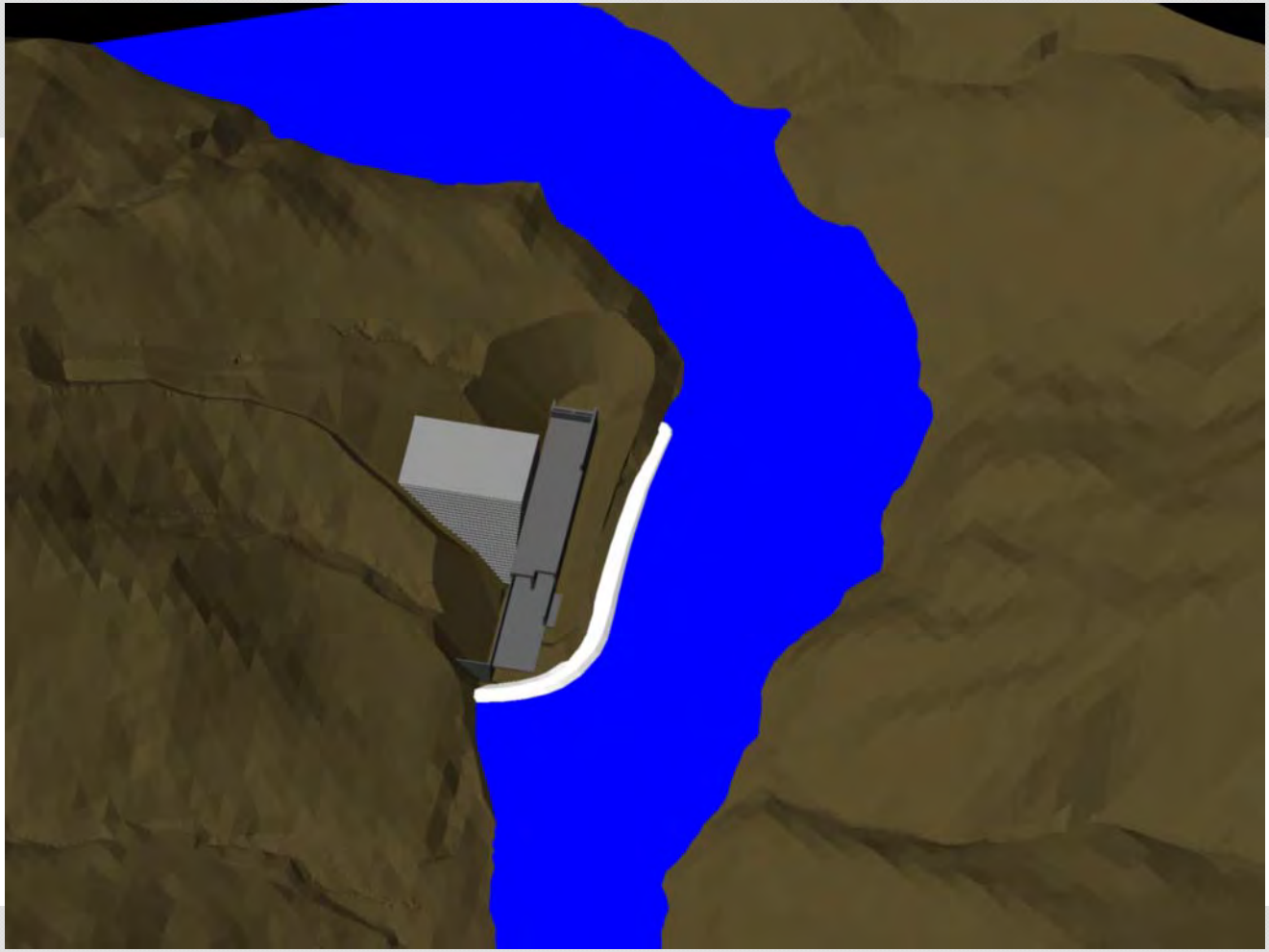


DAM CONSTRUCTION

CEMENT DISTRIBUTION CONSULTANTS

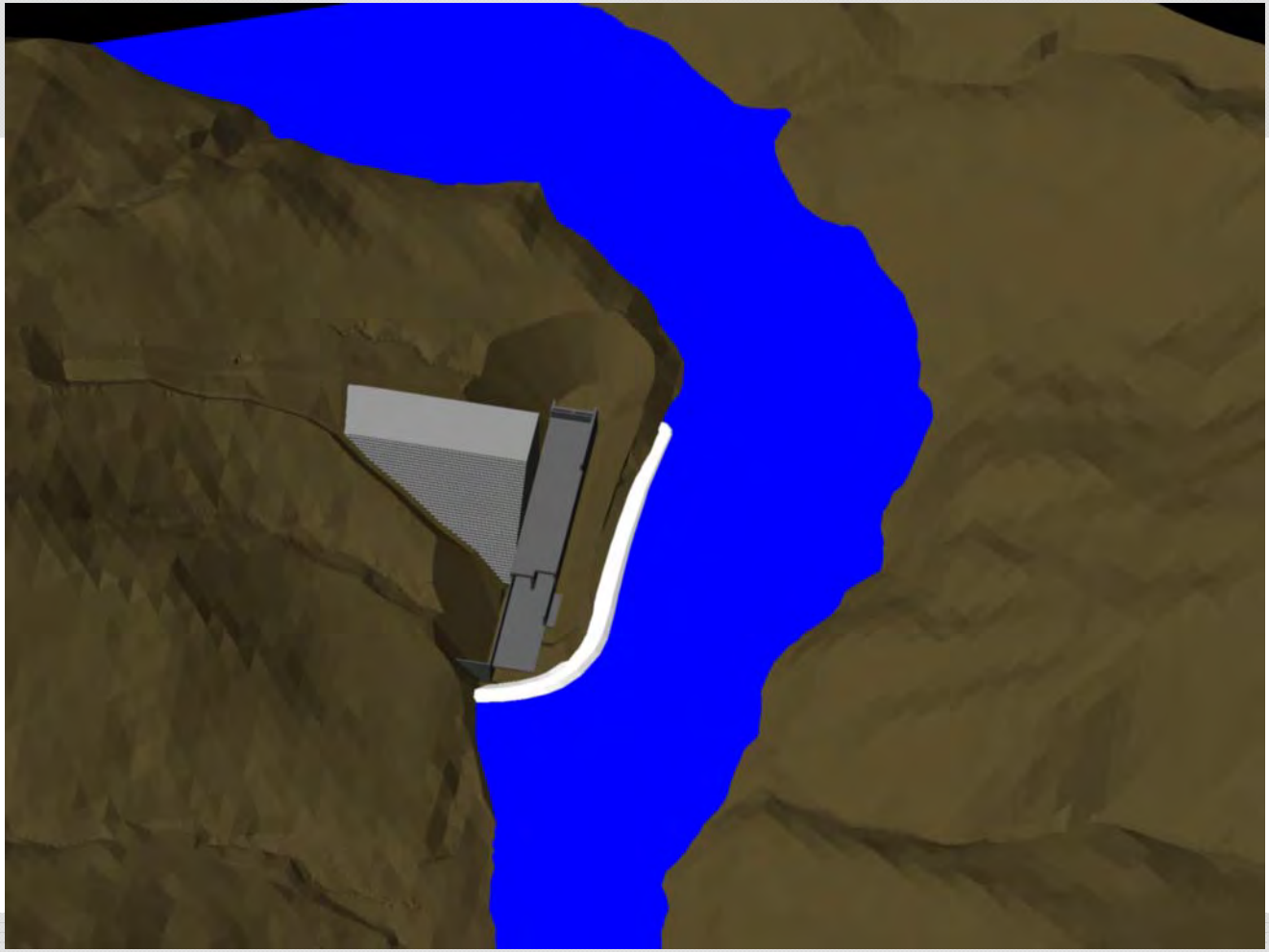
DAM CONSTRUCTION

CEMENT DISTRIBUTION CONSULTANTS



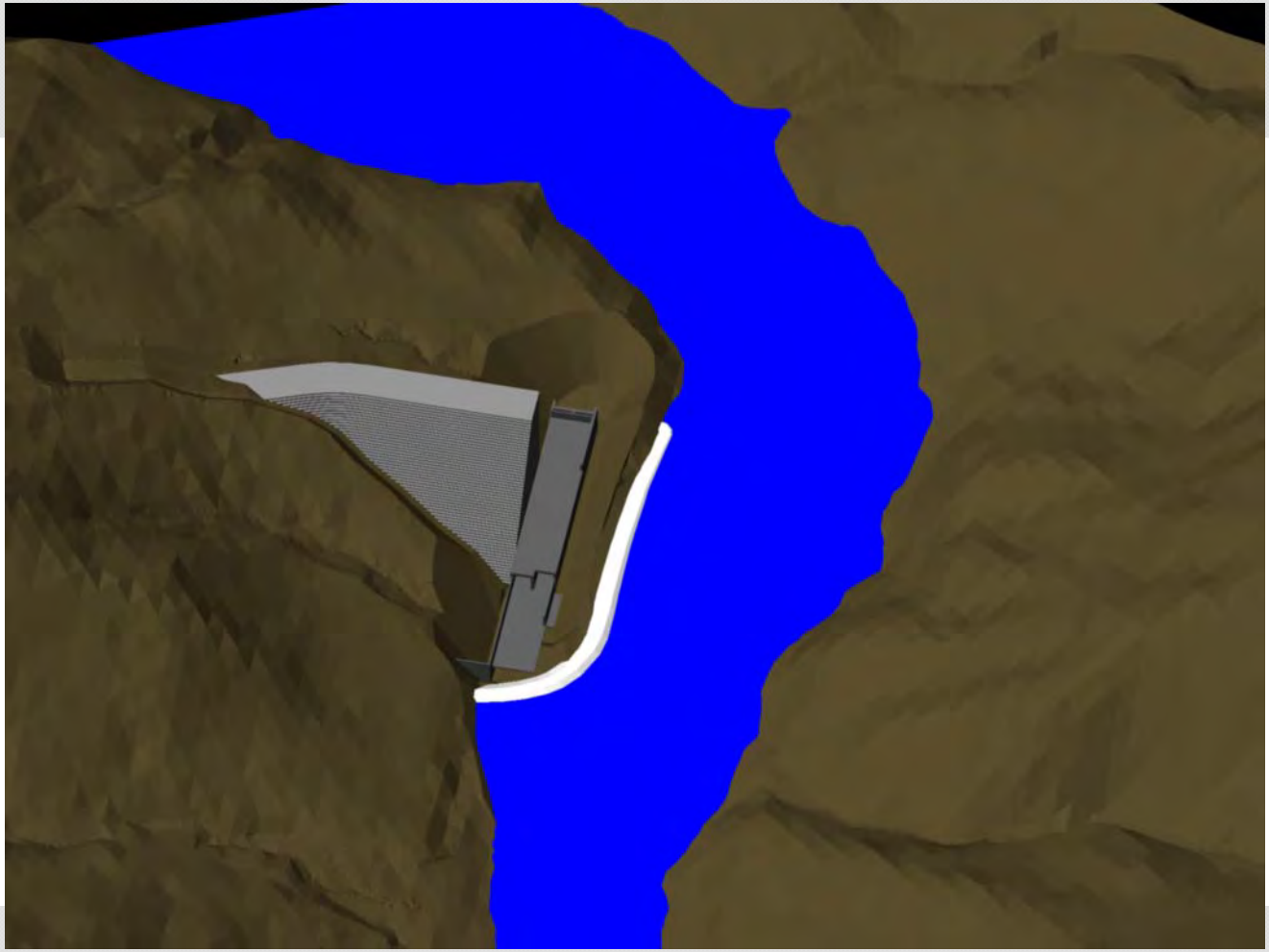
DAM CONSTRUCTION

CEMENT DISTRIBUTION CONSULTANTS



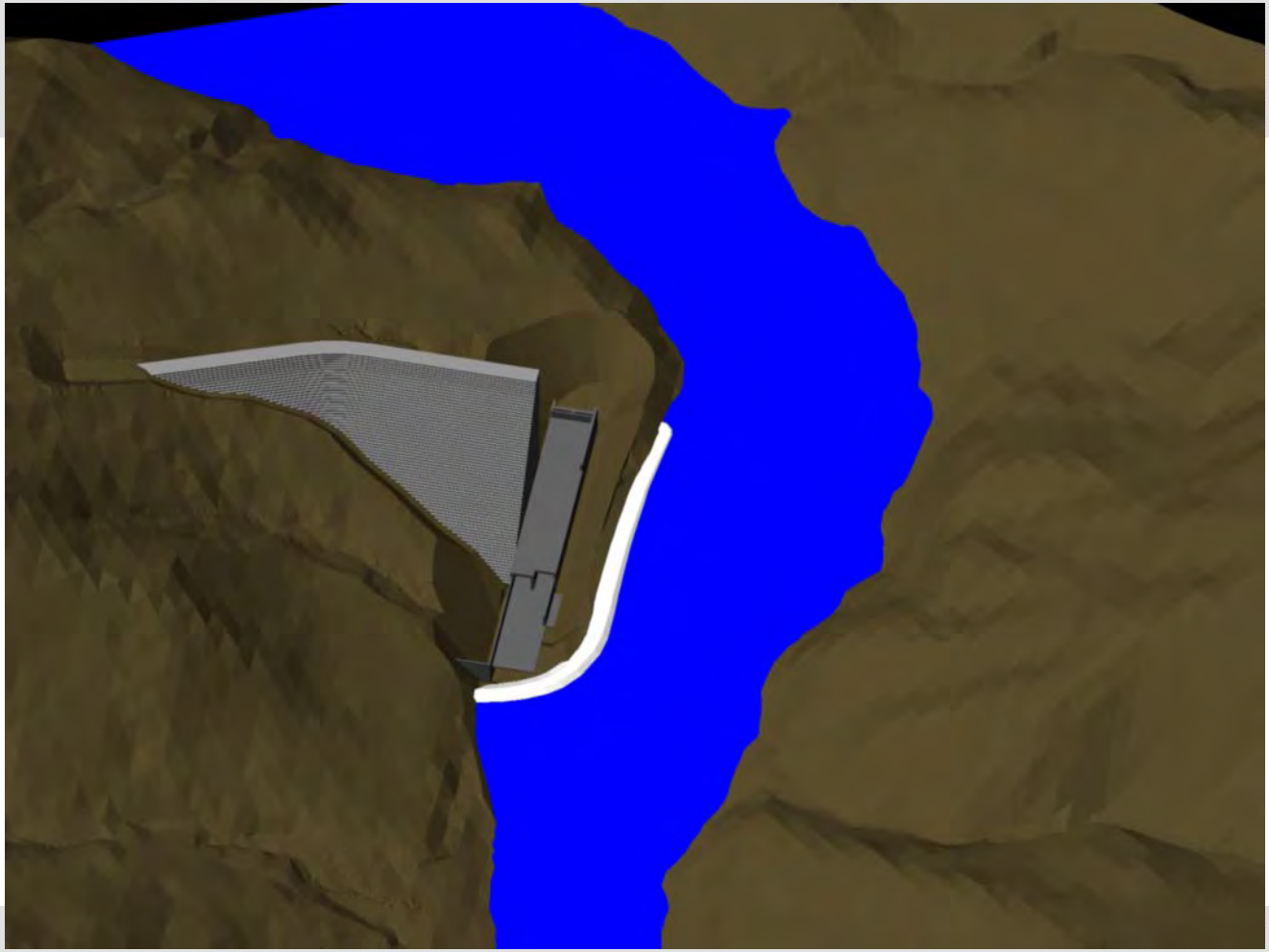
DAM CONSTRUCTION

CEMENT DISTRIBUTION CONSULTANTS



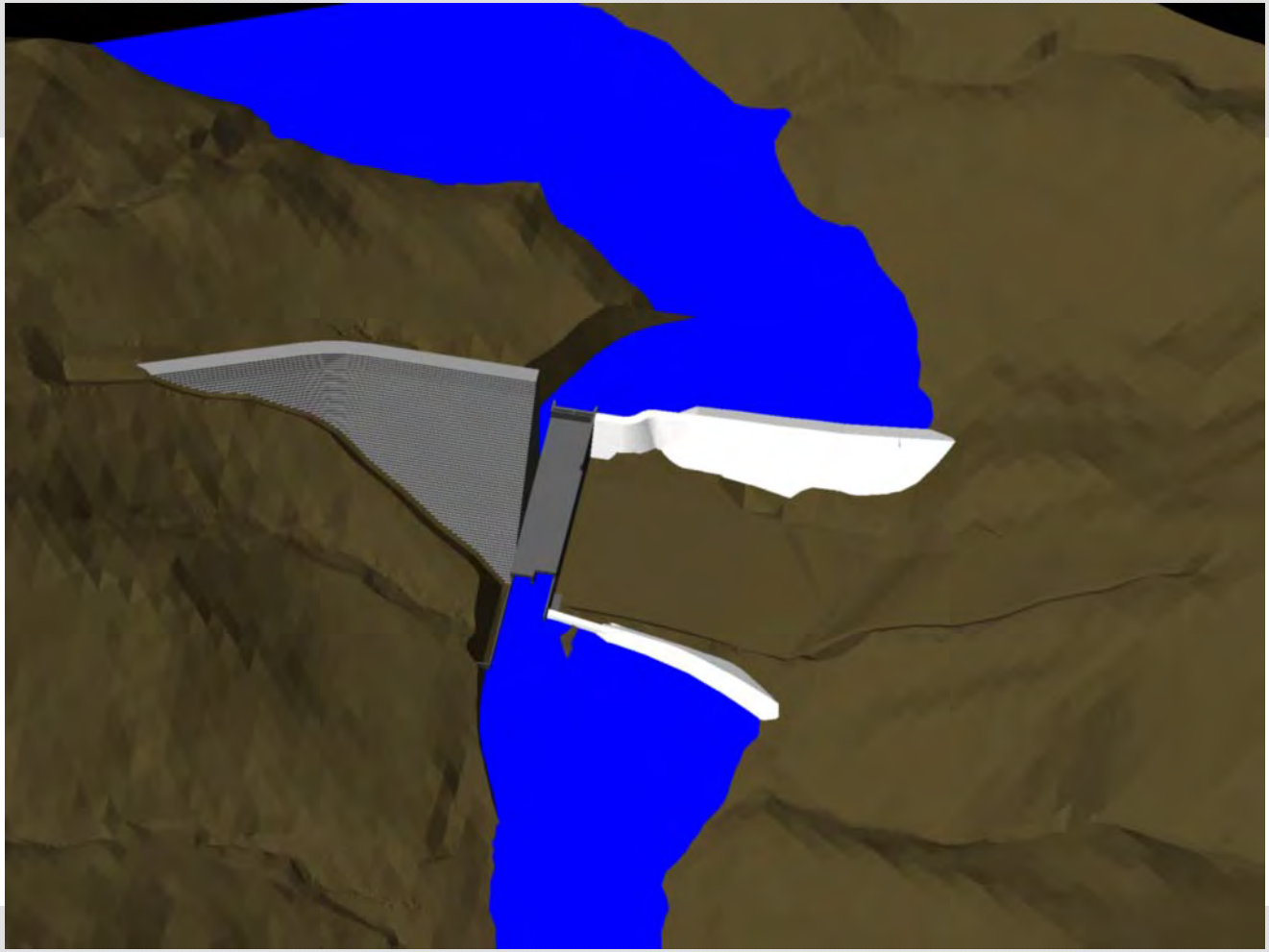
DAM CONSTRUCTION

CEMENT DISTRIBUTION CONSULTANTS



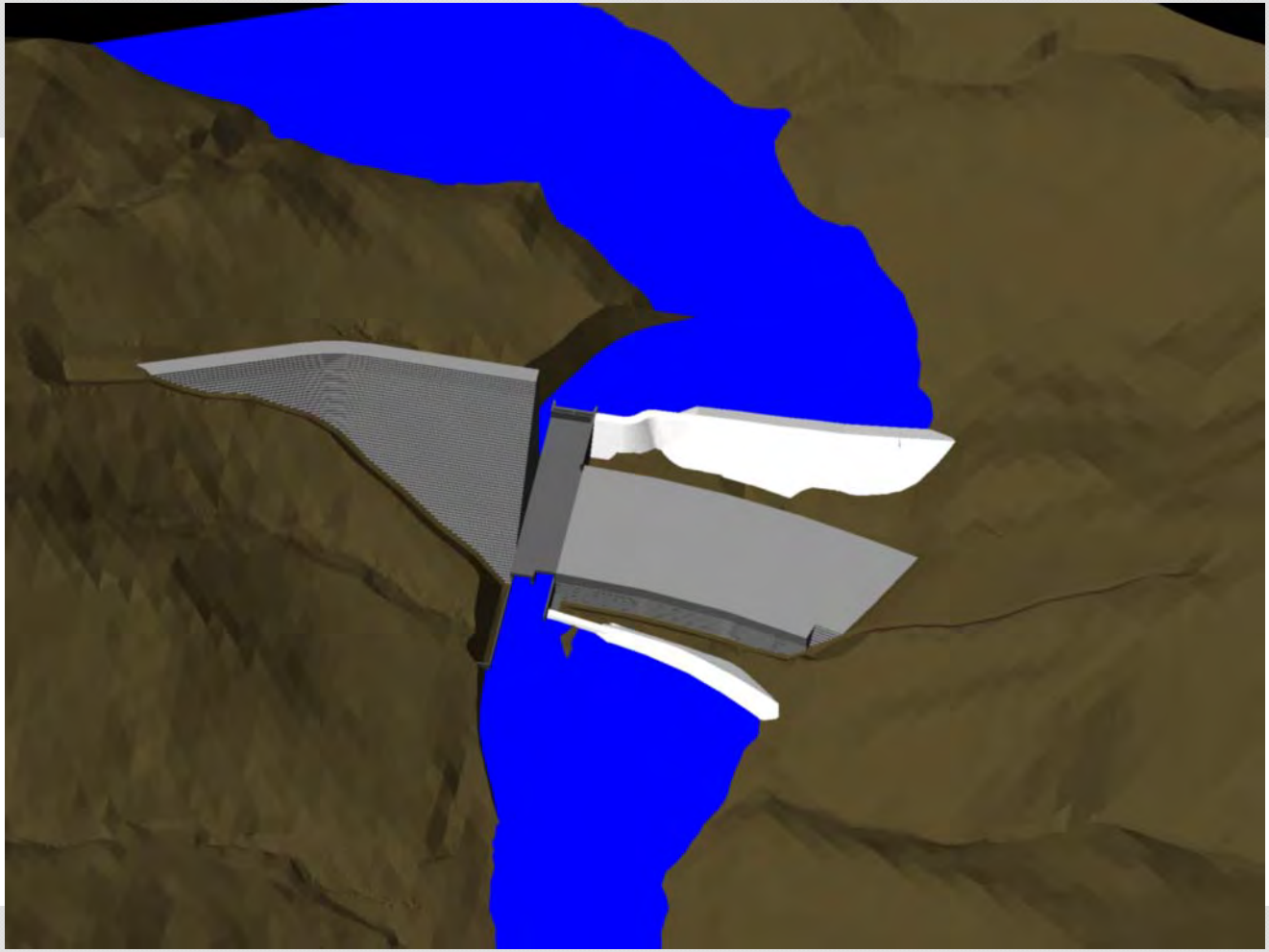
DAM CONSTRUCTION

CEMENT DISTRIBUTION CONSULTANTS



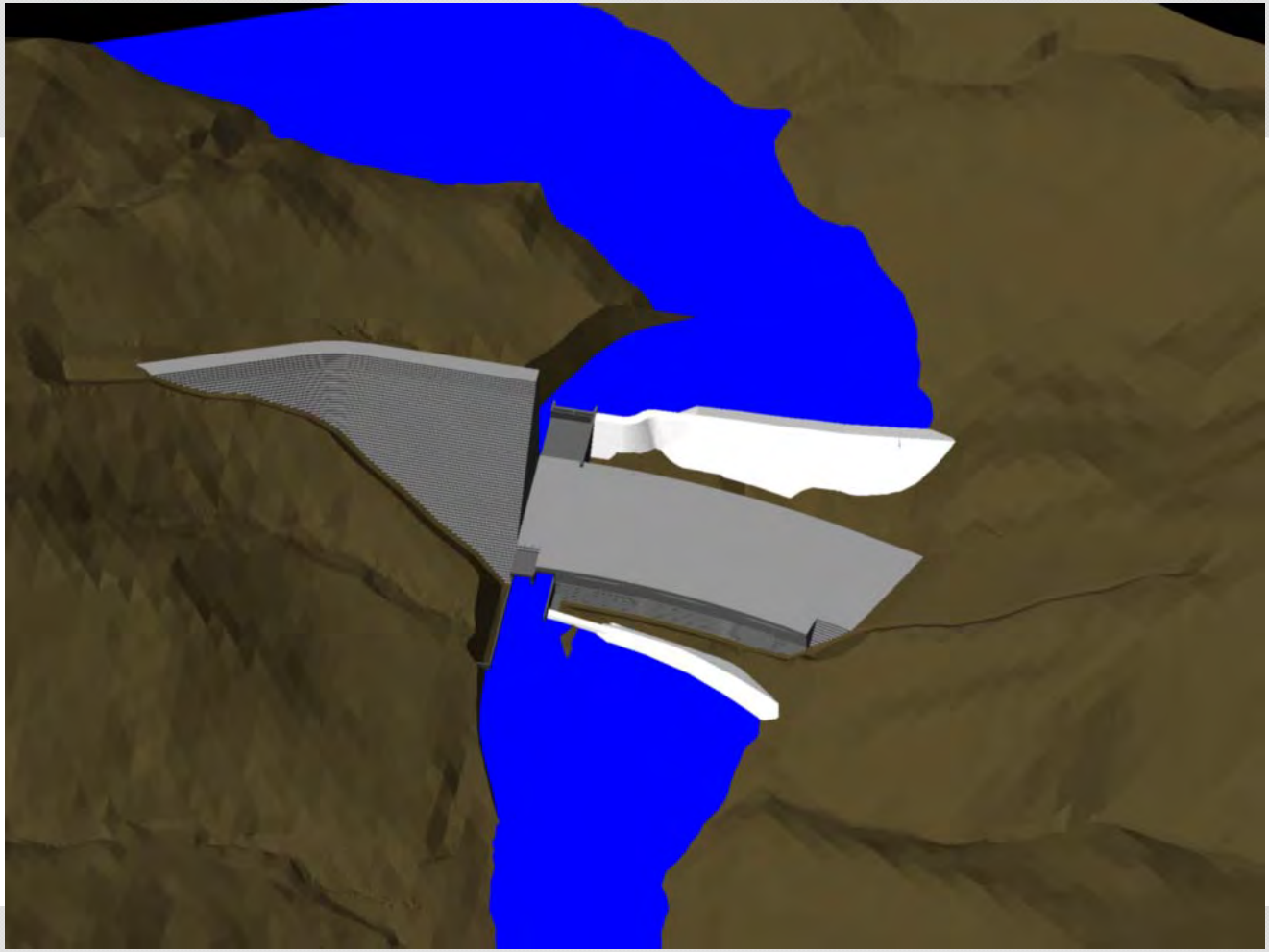
DAM CONSTRUCTION

CEMENT DISTRIBUTION CONSULTANTS



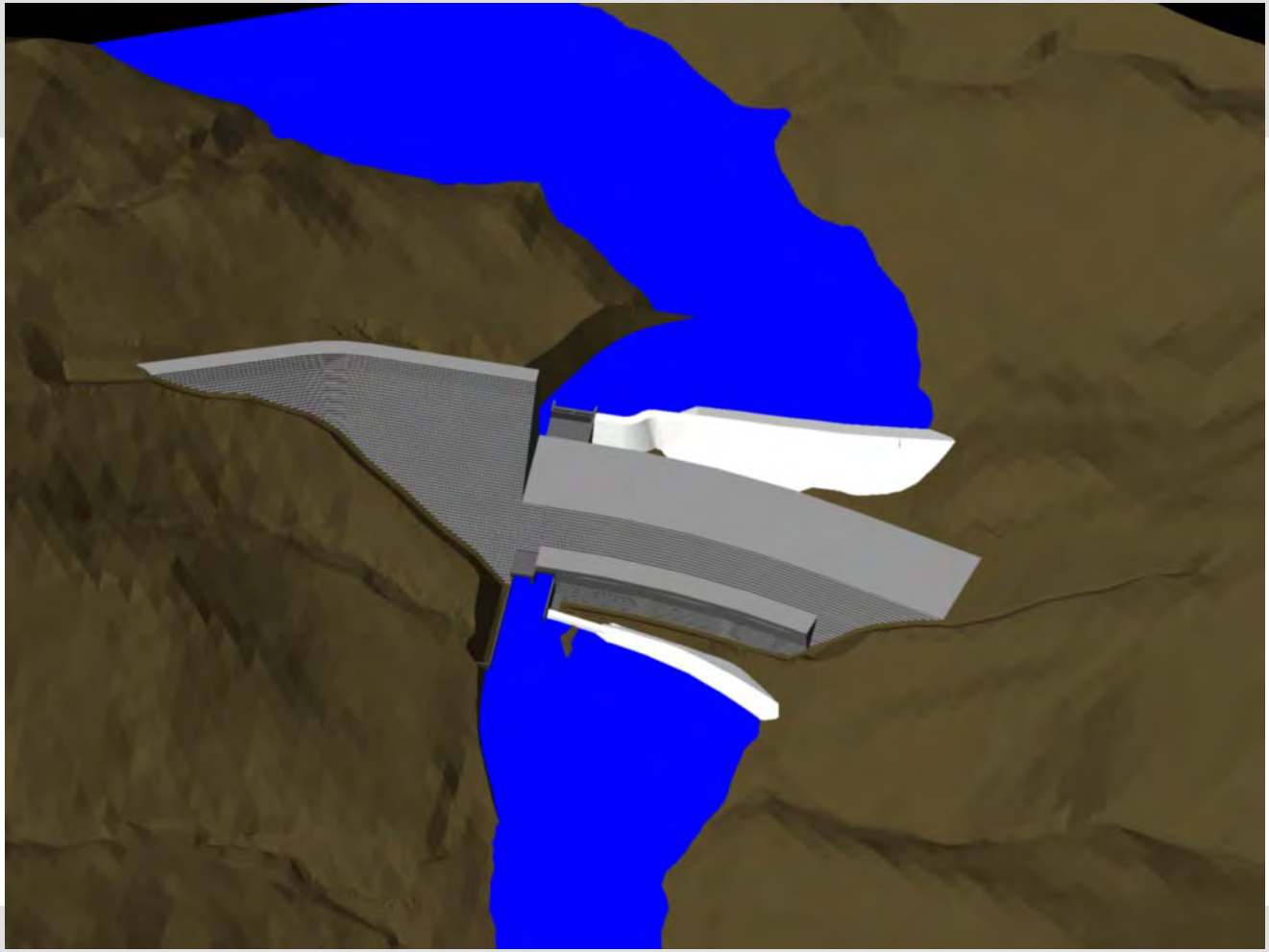
DAM CONSTRUCTION

CEMENT DISTRIBUTION CONSULTANTS



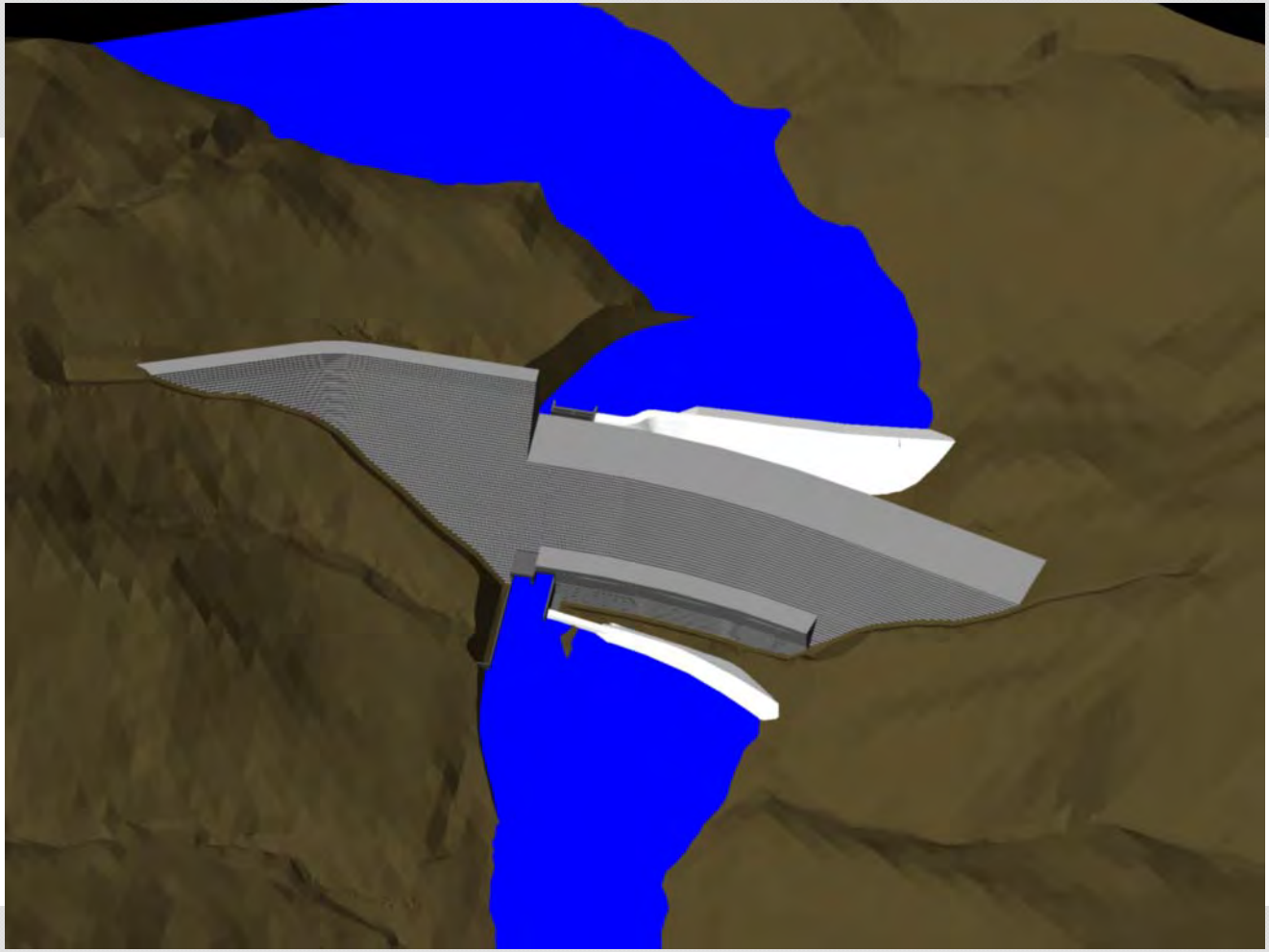
DAM CONSTRUCTION

CEMENT DISTRIBUTION CONSULTANTS



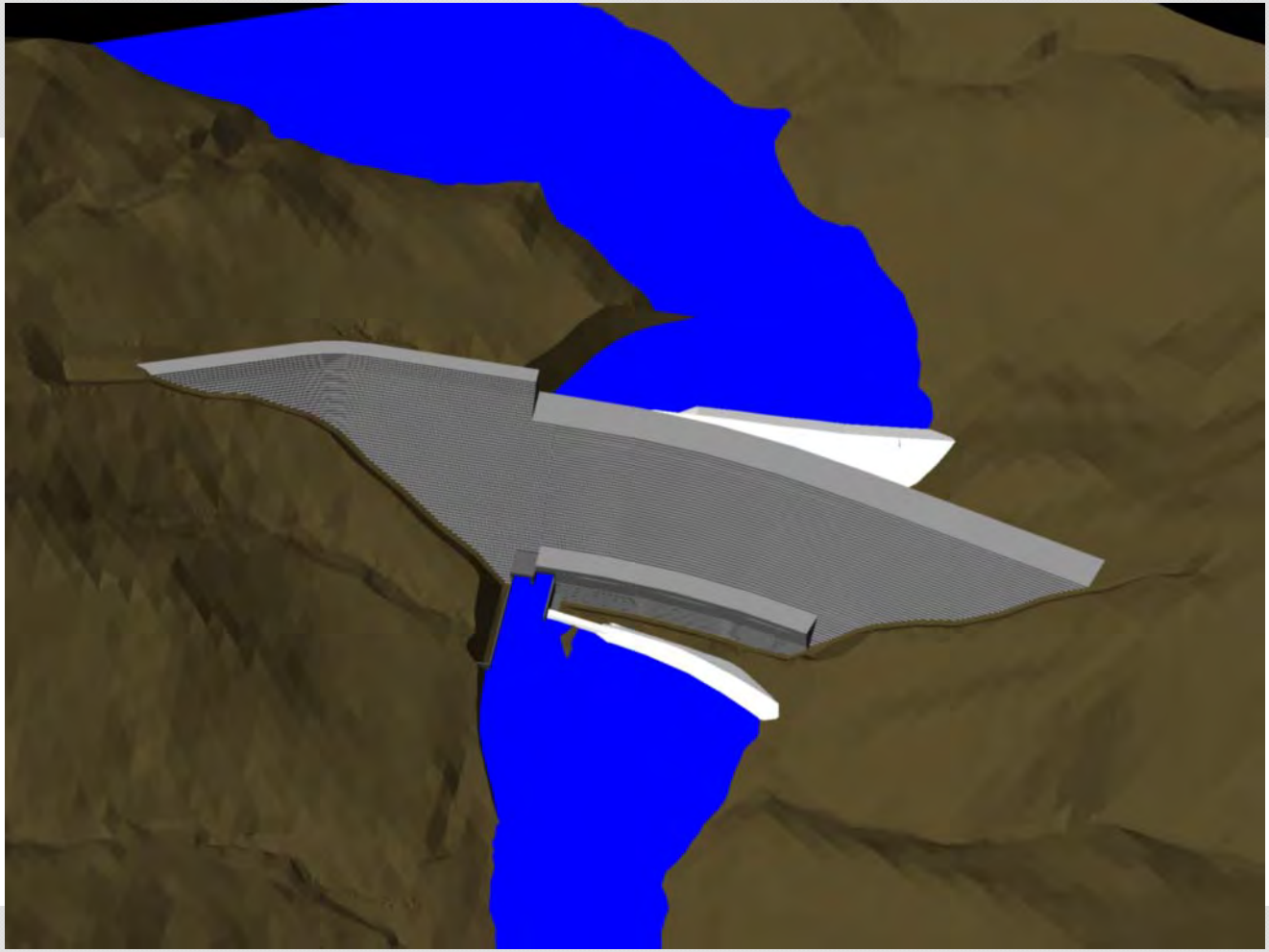
DAM CONSTRUCTION

CEMENT DISTRIBUTION CONSULTANTS



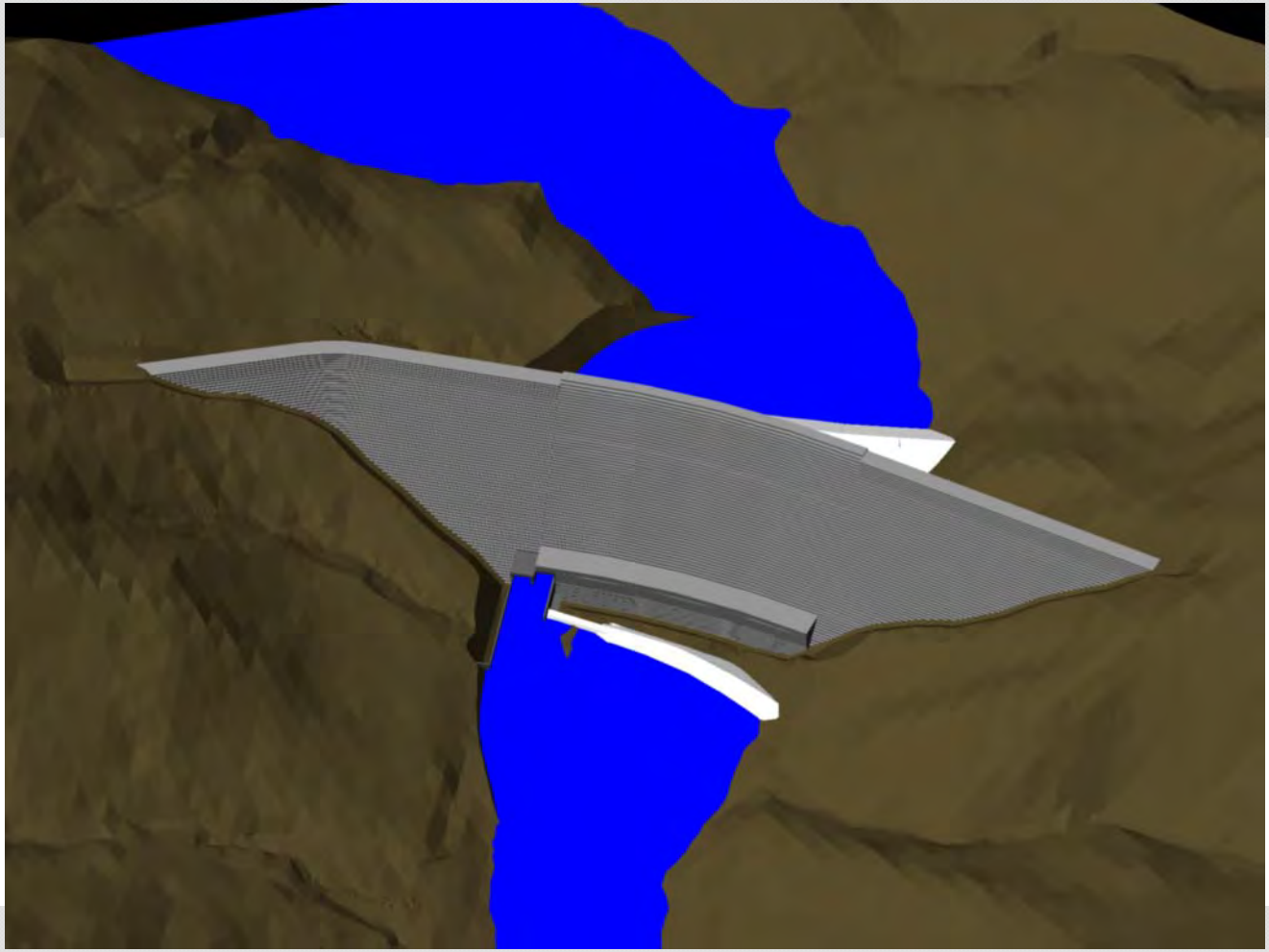
DAM CONSTRUCTION

CEMENT DISTRIBUTION CONSULTANTS



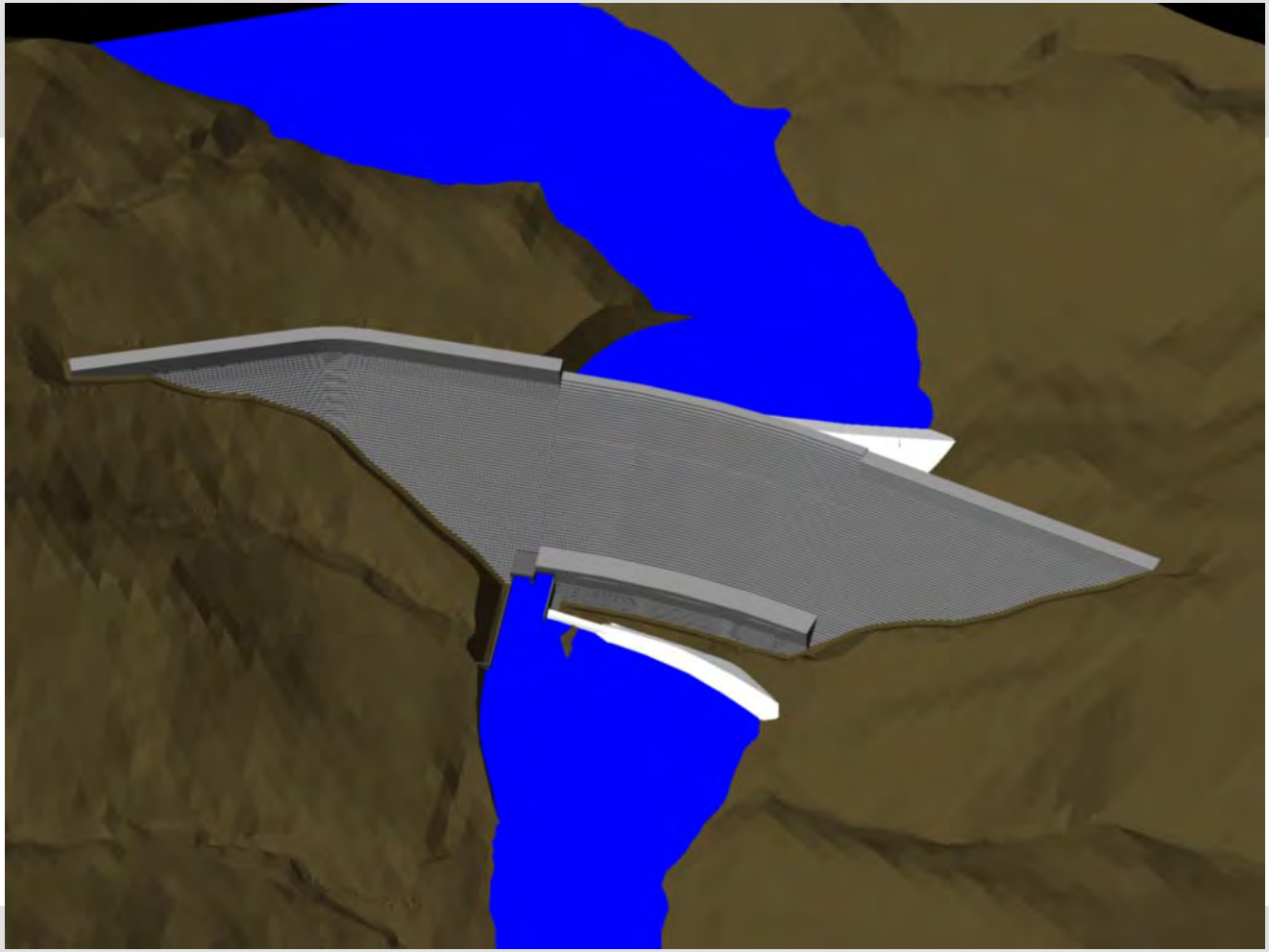
DAM CONSTRUCTION

CEMENT DISTRIBUTION CONSULTANTS



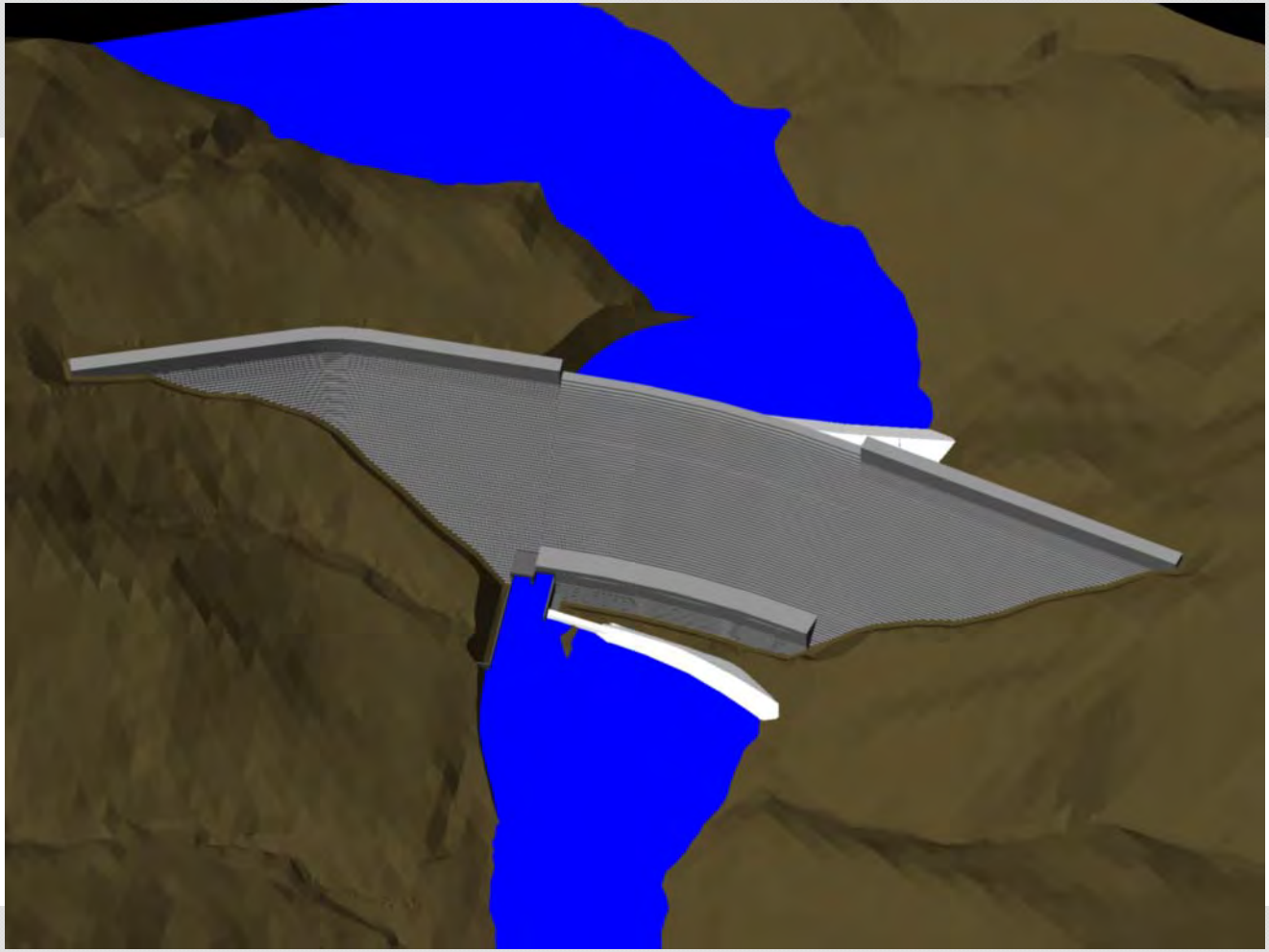
DAM CONSTRUCTION

CEMENT DISTRIBUTION CONSULTANTS



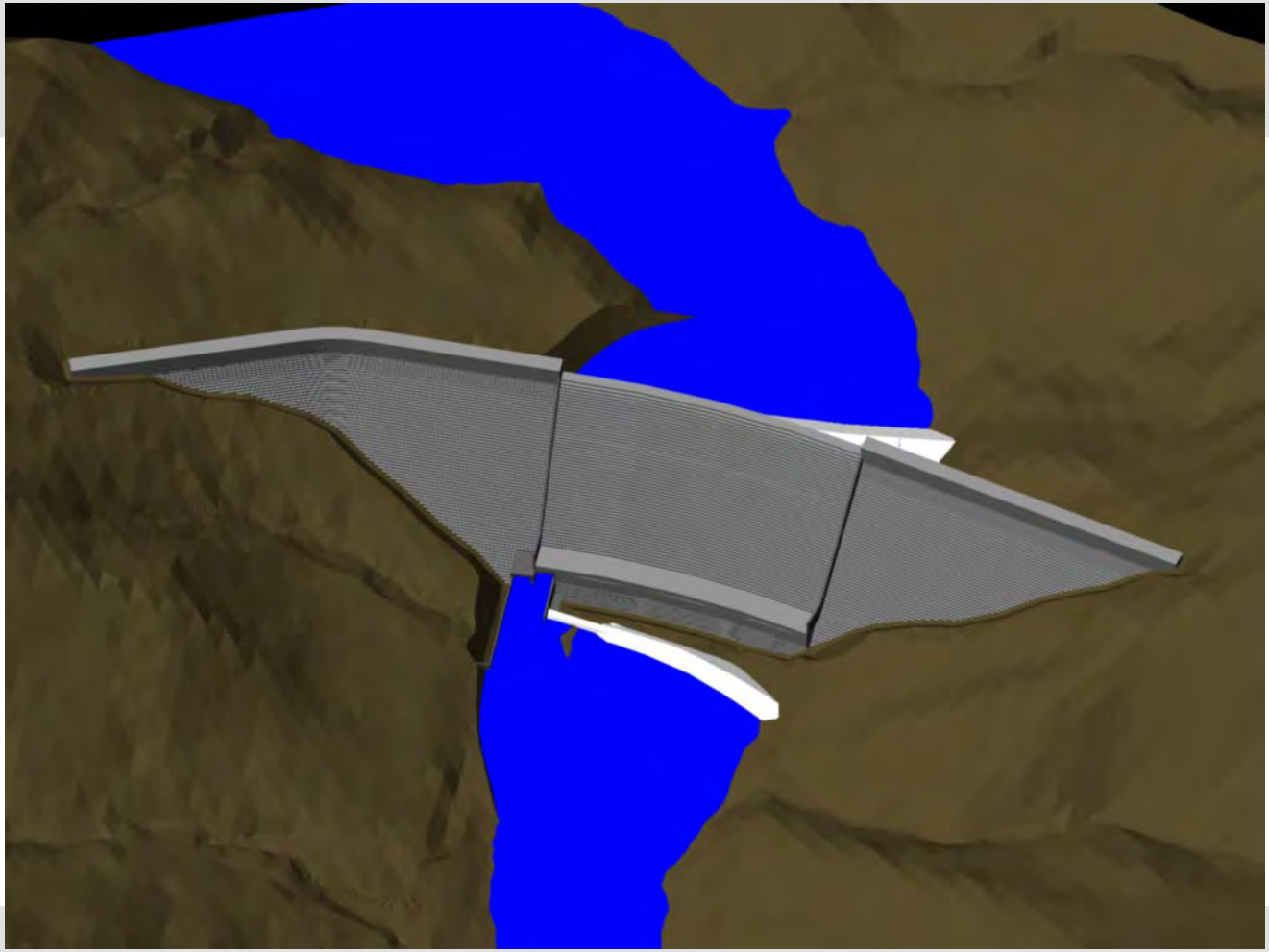
DAM CONSTRUCTION

CEMENT DISTRIBUTION CONSULTANTS



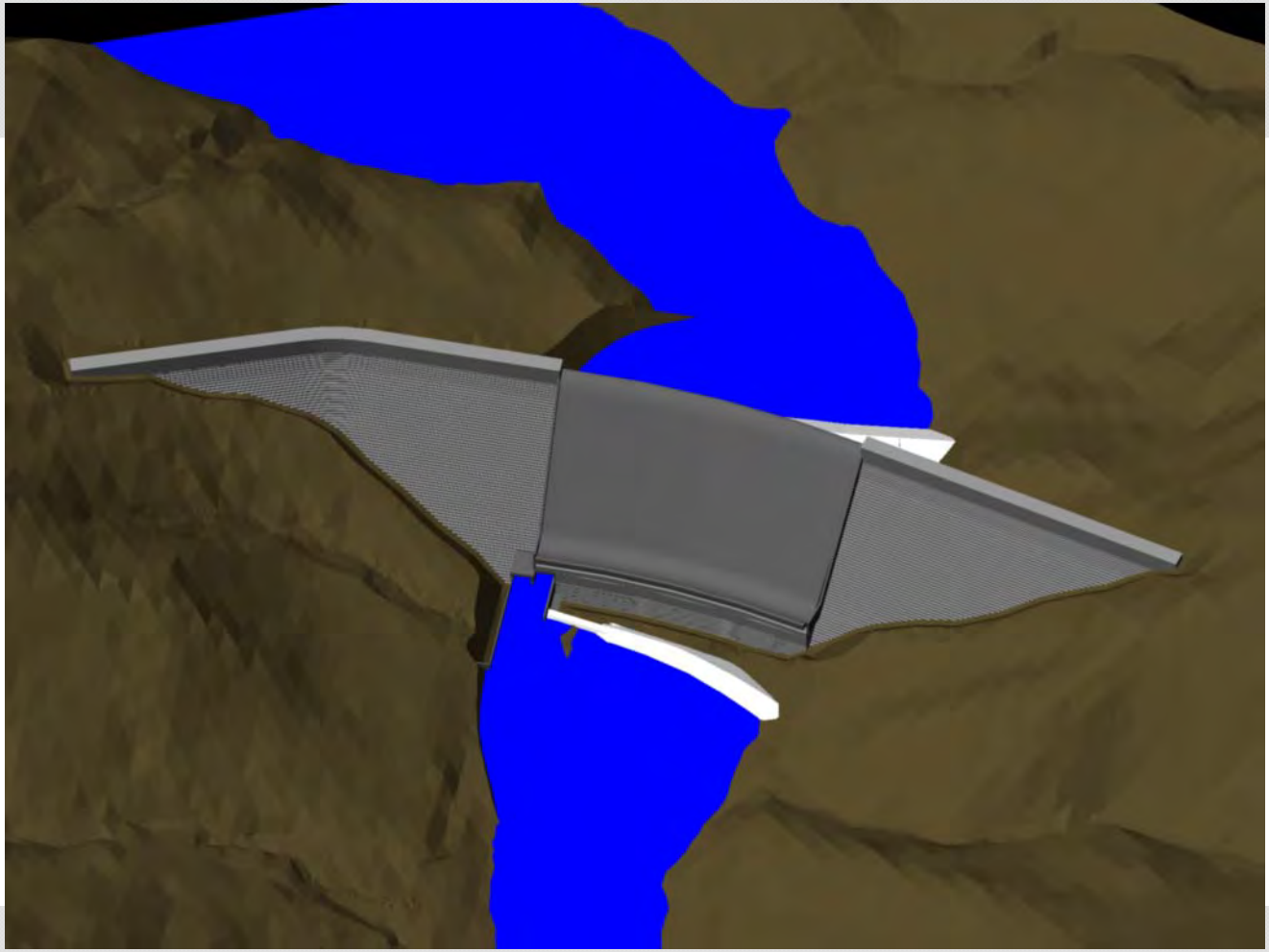
DAM CONSTRUCTION

CEMENT DISTRIBUTION CONSULTANTS



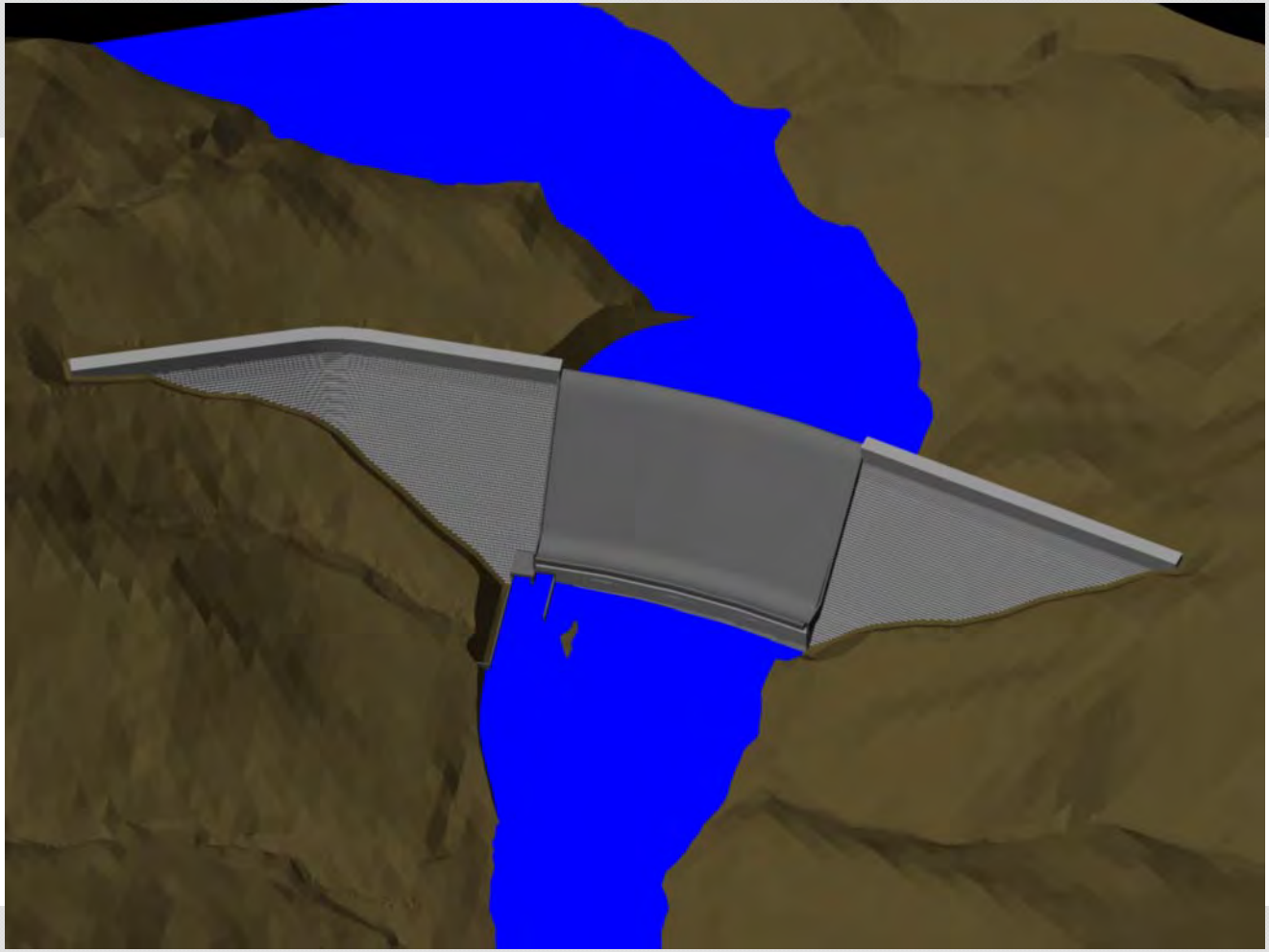
DAM CONSTRUCTION

CEMENT DISTRIBUTION CONSULTANTS



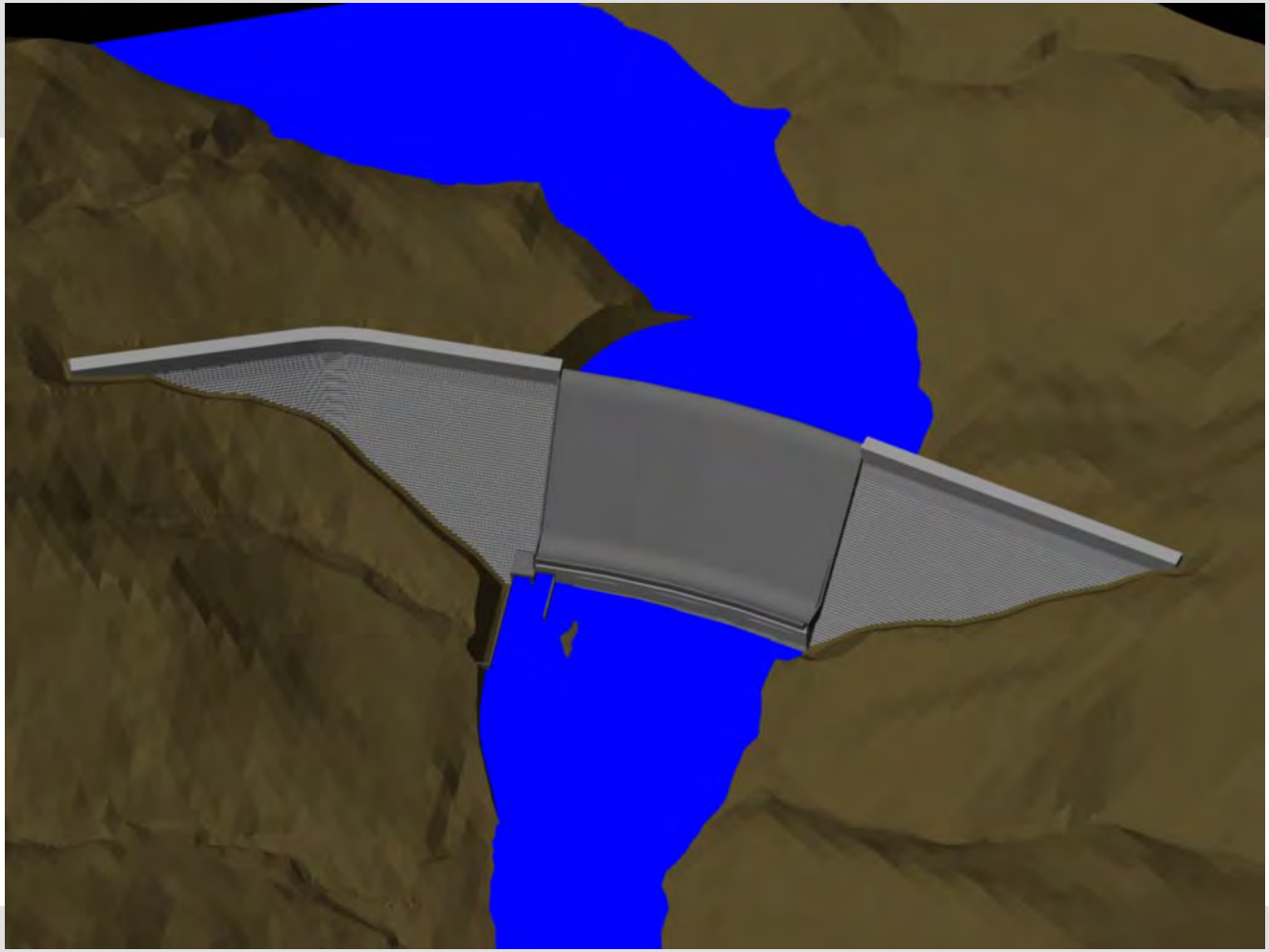
DAM CONSTRUCTION

CEMENT DISTRIBUTION CONSULTANTS



DAM CONSTRUCTION

CEMENT DISTRIBUTION CONSULTANTS



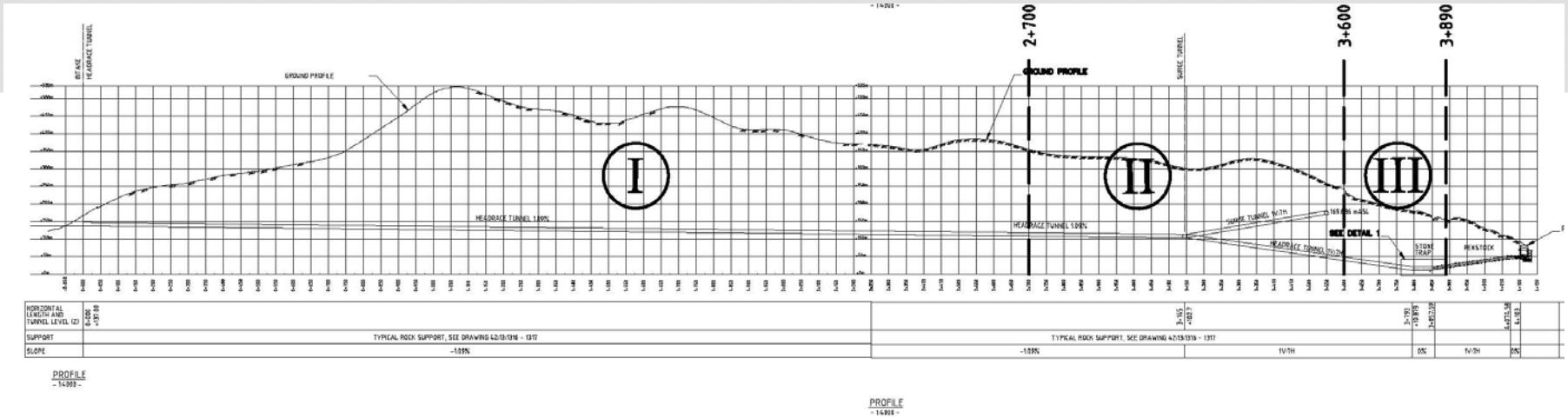
DAM CONSTRUCTION

CEMENT DISTRIBUTION CONSULTANTS

- Mass concrete without rebar
- 14 months of "24/7" placing operations
- Heat of hydration key issue
  - ⇨ High fly ash ratio
- Substantial amounts of retarder used to extend workability during interruptions
- Delivery by 2.000 tph delivery system
- Transported over dam with articulated dump trucks
- Spread out by bull dozers
- Compacted by vibrating rollers

ROLLER COMPACTED CONCRETE

CEMENT DISTRIBUTION CONSULTANTS



- Total tunnel length 4100 meters
- Diameter 10 meters
- At the end of the tunnel it had to go deeper to keep sufficient rock strength
- Extra adit (or surge) outlet

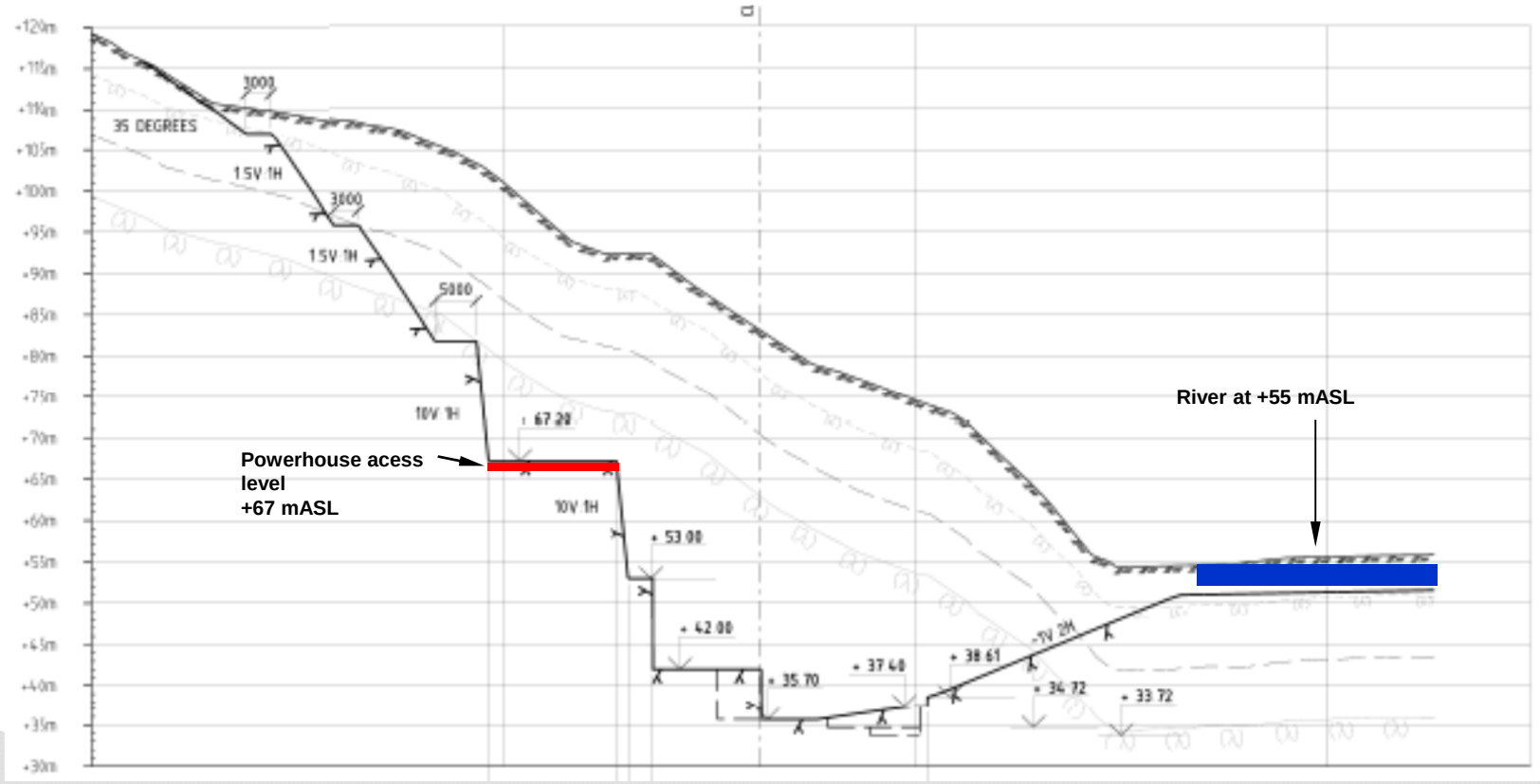
TUNNEL DESIGN

CEMENT DISTRIBUTION CONSULTANTS

- Tunnel is blasted through the rock
- Tunnel is stiffened with rock dowels and shotcrete. This also prevents water leakage from the tunnel

TUNNEL CONSTRUCTION

CEMENT DISTRIBUTION CONSULTANTS

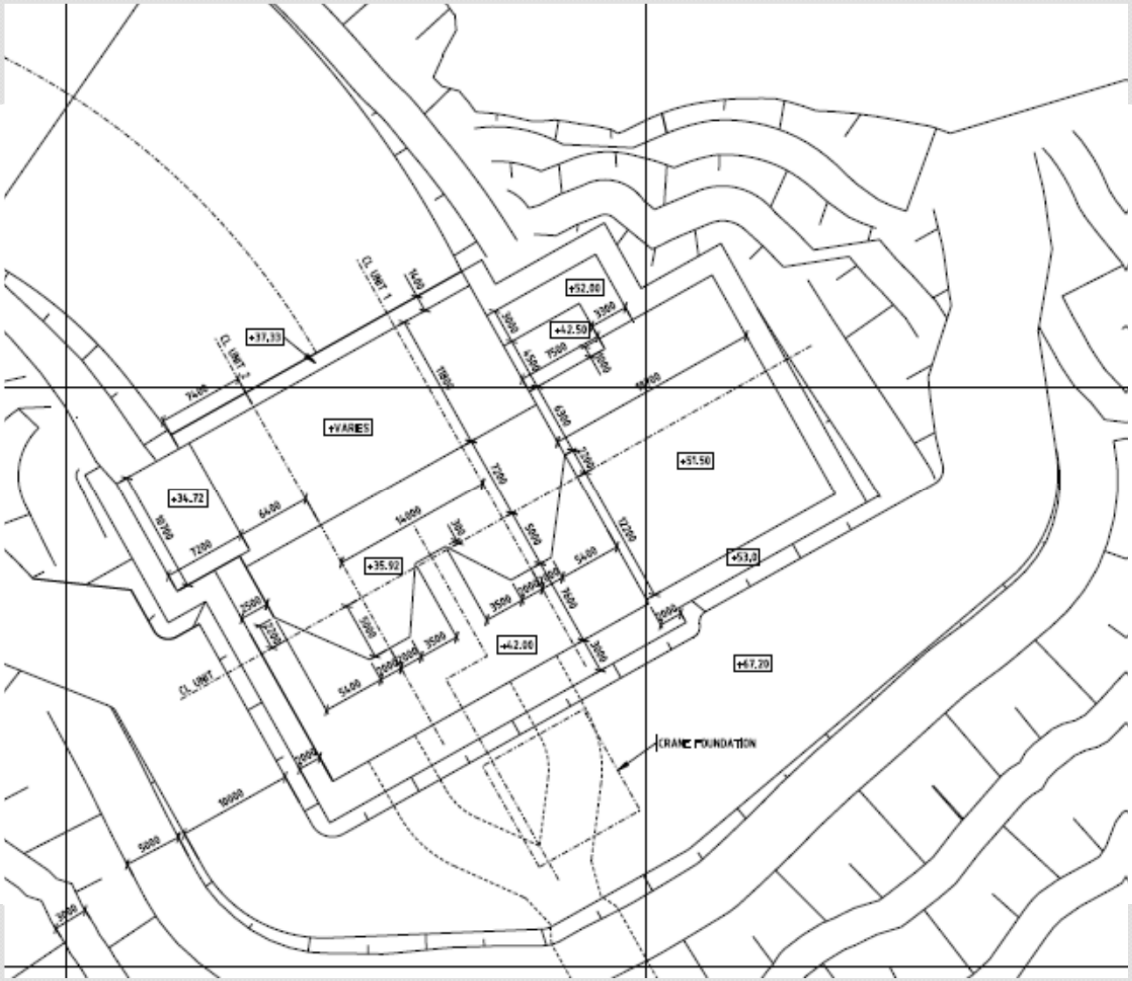


POWERHOUSE DESIGN

CEMENT DISTRIBUTION CONSULTANTS

Powerhouse

- Total output 205 mW
- 2 Turbines
- Total height of building 28 m
- Turbine height 16 m
- Largest part of building is located into the rock



POWERHOUSE DESIGN

CEMENT DISTRIBUTION CONSULTANTS

POWERHOUSE CONSTRUCTION

CEMENT
DISTRIBUTION
CONSULTANTS

Powerhouse construction site

- …

Powerhouse construction site

- …

No bridge yet

Temporary bridge

Culvert construction

Permanent bridge

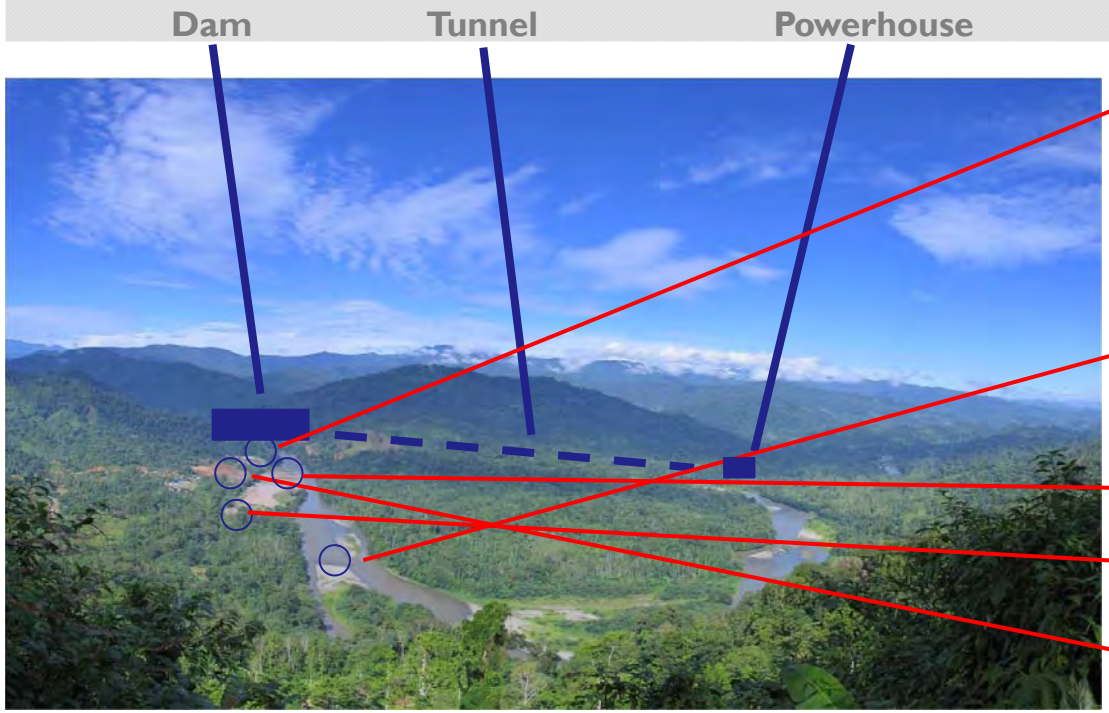
ROADS AND BRIDGES

CEMENT DISTRIBUTION CONSULTANTS

- Permanent roads 25 km
- Temporary roads 10 km
- 4 Bridges
- 8 Large culverts
- Substantial work on hillside stabilisation

ROADS AND BRIDGES

CEMENT DISTRIBUTION CONSULTANTS



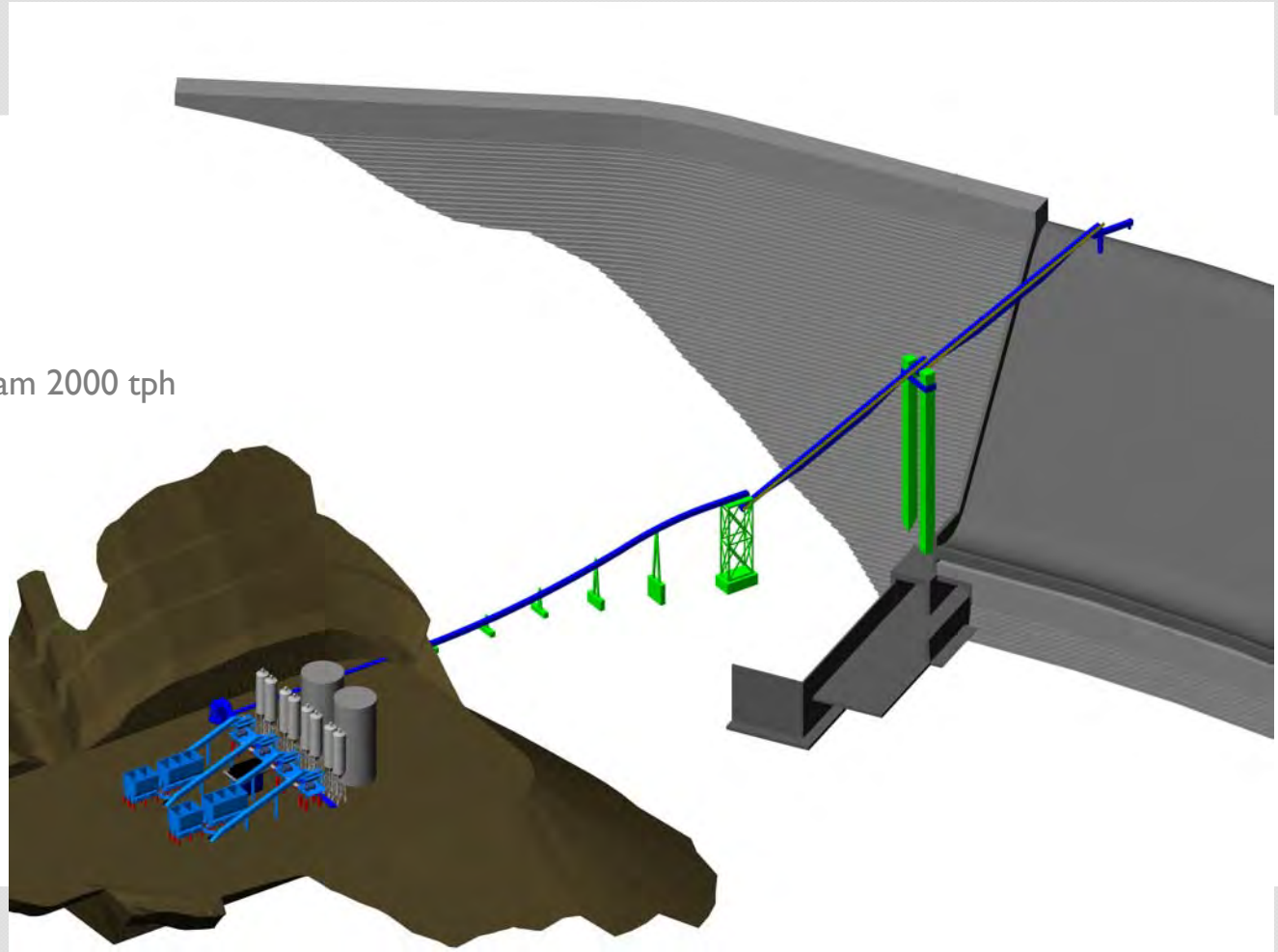
- Concrete plant (RCC)
  - Capacity 650 m^3/h
  - 2.000 tph delivery system
  - 80.000 tons of sand/aggregate storage
  - 3.000 tons of cement and fly-ash storage
- Aggregate mining area
  - 3 km long along river
  - 2,5 m tons required
- Crushing plant
  - 50.000 tons per week
  - 5 qualities
- Aggregate storage area
  - 1 million tons storage
- 8,000 kW power plant, diesel driven
- Large workshop
- Batching plant regular concrete
- Laboratories
- Safety organisation facilities
- Housing camps

TEMPORARY FACILITIES

CEMENT DISTRIBUTION CONSULTANTS

RCC plant

- 650 m^3/hour capacity
- 4 Mixers
- Delivery system to dam 2000 tph



RCC PLANT AND DELIVERY SYSTEM

CEMENT DISTRIBUTION CONSULTANTS

A platform for the RCC plant was blasted out of the hill close to the dam

RCC PLANT AND DELIVERY SYSTEM

CEMENT DISTRIBUTION CONSULTANTS

A platform for the RCC plant was blasted out of the hill close to the dam

RCC PLANT AND DELIVERY SYSTEM

CEMENT DISTRIBUTION CONSULTANTS

RCC PLANT AND DELIVERY SYSTEM

CEMENT DISTRIBUTION CONSULTANTS

Aggregate mining

- Total two million tons of sand and aggregates required
- All taken from riverbed
- Sizes 40-20 mm, 20-10 mm, 10-5 mm, fines, natural sand
- Storage area of one million tons

AGGREGATE MINING AREA

CEMENT DISTRIBUTION CONSULTANTS

AGGREGATE MINING AREA

CEMENT DISTRIBUTION CONSULTANTS

AGGREGATE STORAGE

CEMENT DISTRIBUTION CONSULTANTS

- Power Station 8000 kW
- Rebar workshop
- Wood workshop
- Health and safety offices

- Workshop
- Logistical warehouse

OTHER TEMPORARY FACILITIES

CEMENT DISTRIBUTION CONSULTANTS

HOUSING CAMPS

CEMENT DISTRIBUTION CONSULTANTS

HOUSING CAMPS

CEMENT DISTRIBUTION CONSULTANTS

Project

April – October 2007	Preparations
October 2007 to mid 2009	Earth moving, road construction, surface preparation, plant construction
Mid 2009 to end 2010	Construction of tunnel, powerhouse
December 2009 – March 2011	Construction of dam
May 2011	Closing diversion tunnels
June 2011	Lake full
July – September 2011	Start-up
September 2011 – April 2012	Demobilisation

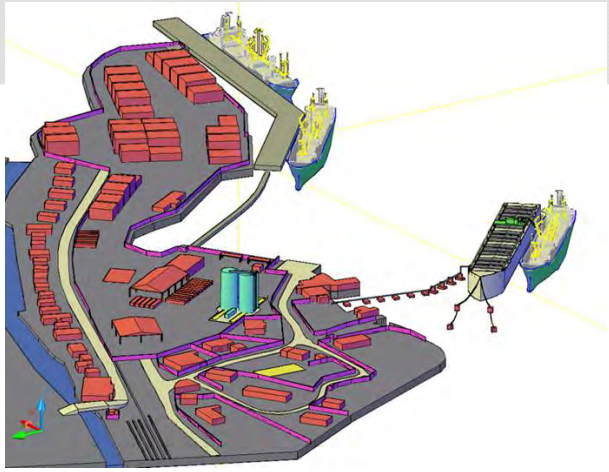
Cement and fly ash supply

October – November 2007	Feasibility study
January – March 2008	Concept terminal design and permit application
March – August 2008	Purchasing barge, terminal equipment, trucks, etc.
March – October 2008	Sourcing cement and fly ash
September 2008 – September 2009	Conversion floating terminal
July 2009 – October 2009	Construction shore silos and facilities
January 2009 – October 2009	Big Bag operations
November 2009 – February 2011	Bulk operations
March 2011 – July 2011	Demobilisation

CEMENT DISTRIBUTION CONSULTANTS

TIME FRAME

ARRANGING THE CEMENT AND FLY ASH SUPPLY



FACTORS

- Quantities
  - Overall quantity 240.000 – 260.000 tons
  - Ratio between cement and fly ash not yet known early in the project
  - Cement type I/type II issue
- Usage fluctuations
  - Project schedule still "subject to change" early in the project
  - Regular concrete use spread unevenly over project
  - RCC use during 16 months with fluctuations between 5.000 tpm and 30.000 tpm
  - Maximum daily peak 2.000 tons
- Infrastructure limitations
  - Poor roads
  - Small banana port without sufficient dock availability or storage area
- Supply sources and shipping routes not known early in project

LOGISTICS

CEMENT DISTRIBUTION CONSULTANTS

Fly ash supply

- No fly ash available in Central America
- Best possible supply from USA

Cement supply

- Issues with suppliers in Panama
  - Shortage situation
  - Both companies in plant expansion situation
  - Quality issues
- Cement supply situation in Caribbean not easy
- But…. Economical crisis in USA ➔ cement available for export

AVAILABILITY

CEMENT DISTRIBUTION CONSULTANTS

Fly ash

Separation Technologies (Titan America Group)
Production unit 20.000 tons per month
at Big Bend Power plant, Apollo Beach
10.000 tons product silo at plant
Additional 14.000 ton silo at Titan terminal in Tampa

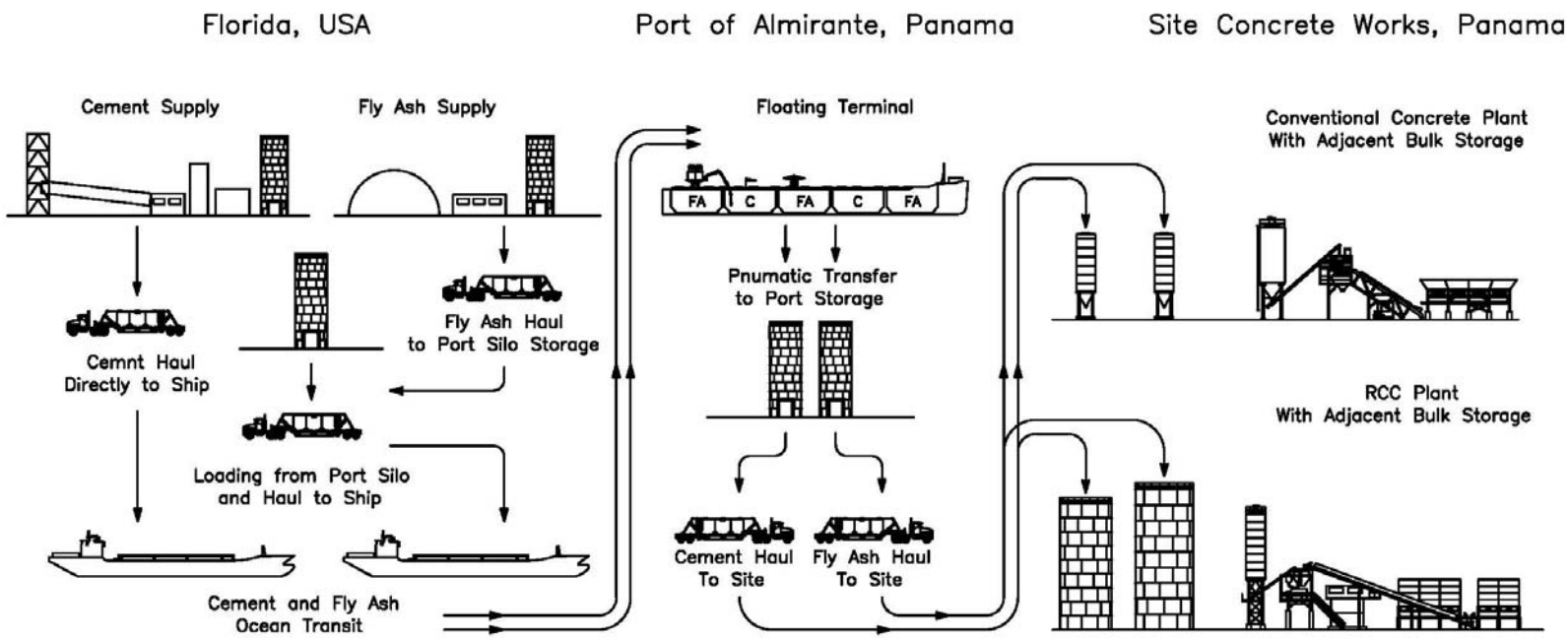
Cement

Titan America
Pennsuco plant (North of Miami)
2,7 mtpa capacity
70.000 tons of finished product silos
Type I – II cement!!
Shiploading in Port Everglades directly by bulk trucks from plant

AVAILABILITY

CEMENT DISTRIBUTION CONSULTANTS

FLOW SHEET SEABORNE CEMENT AND FLY ASH SUPPLY SYSTEM



- Key factor is shipping distance
- Shipping distance determines ship size
- Ship size determines required storage facilities in loading and discharge port and required loading and discharge capacities.

Spreadsheet business model of complete supply system calculating full logistics and economics

- Basis is concrete placement schedule and from there the whole system is calculated backwards to cement and fly ash suppliers
- Calculates all logistical factors as well as operating and capital costs
- Calculation of many scenarios possible as well as different storage and equipment options

CEMENT DISTRIBUTION CONSULTANTS

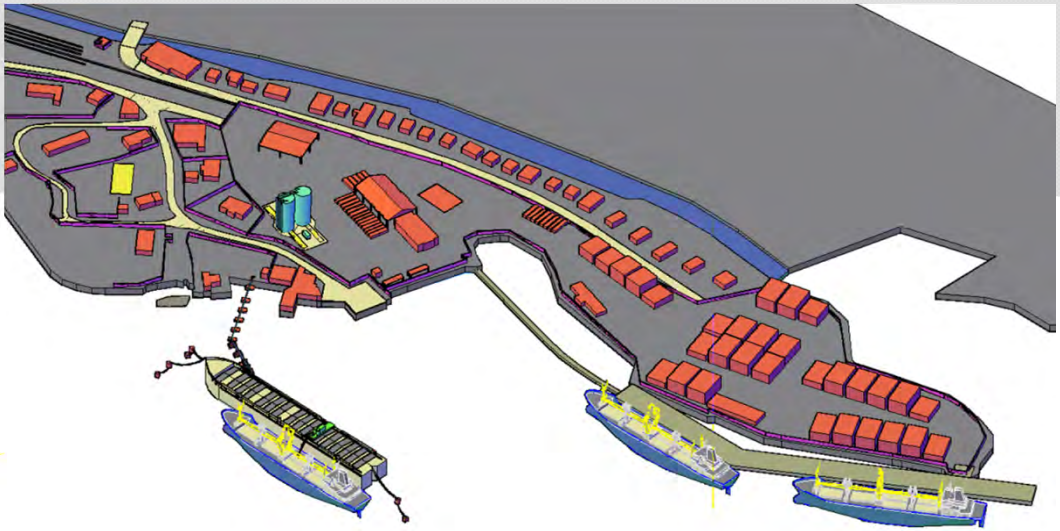
SETTING UP THE SUPPLY CHAIN

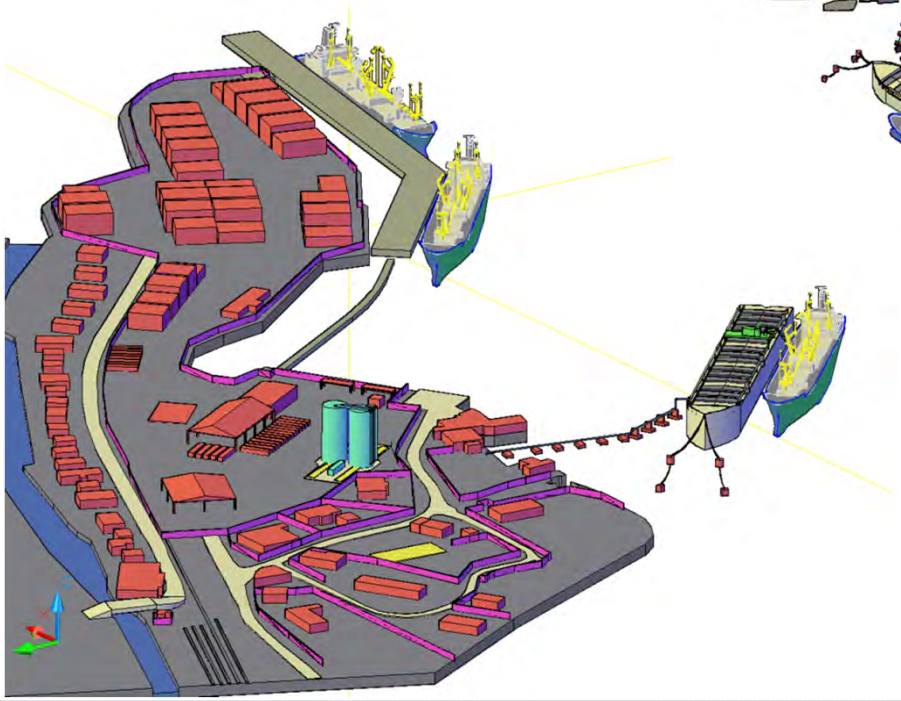
SHIPPING ROUTES

CEMENT DISTRIBUTION CONSULTANTS

SHIPPING ROUTES

CEMENT DISTRIBUTION CONSULTANTS





PLANNING THE TERMINAL FACILITY

CEMENT DISTRIBUTION CONSULTANTS

Floating terminal Lavioletta
Storage capacity 23.000 tons
5 Holds
Length 151,3 m
Width 22,9 m
Depth 11,0 m
Draft 8,6 m

By means of two spudpoles the floating terminal can be fixed in position but move up and down with tide and cargo condition

BUILDING A FLOATING TERMINAL

CEMENT DISTRIBUTION CONSULTANTS

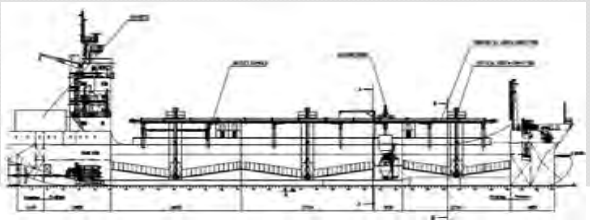
Conversion Work

- Barge purchased in Canada and towed to Limon in Costa Rica
- Repairs and modifications to hold structure
- Product conveying pipelines, fuel, water and waste water pipelines
- Refurbishment ballast system
- New gantry for ship unloader
- Installation of ship unloader
- Installation of generator set
- Installation of spud poles!
- Electrical installation

BUILDING A FLOATING TERMINAL

CEMENT DISTRIBUTION CONSULTANTS

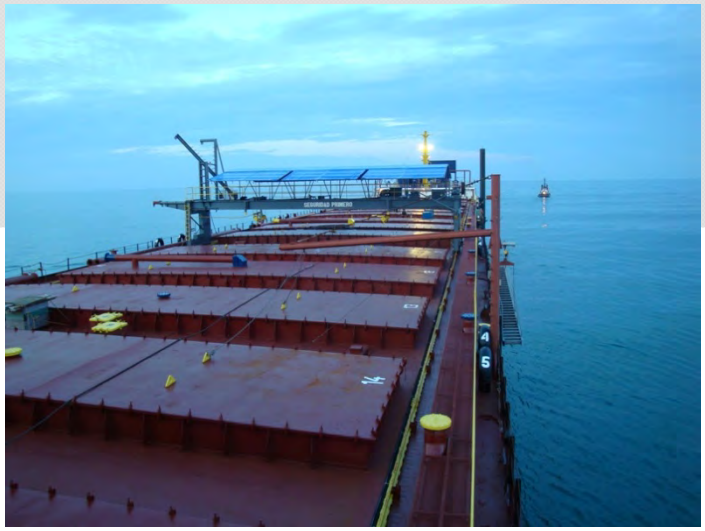
SHIPPING



- 2 Self discharging vessels taken in time charter
  - One for the full concrete placement period (16 months)
  - One for the peak placement period (9 months)
- Vessel characteristics
  - Cargo capacity approx. 7.500 tons
  - Loading time 48 hours
  - Discharge time 30 hours
- Roundtrip time to Florida is 14 days (at reduced speed)
- Charter party agreement
  - Based on BIMCO uniform time charter
  - Additional conditions
    - ❖ Loading and discharge conditions (must match with supplier and receiver agreements and capabilities)
    - ❖ Vessel to comply with US regulations!
    - ❖ Various issues regarding trading in Caribbean

CEMENT DISTRIBUTION CONSULTANTS

SETTING UP THE SUPPLY CHAIN



FINAL PREPARATIONS

CEMENT DISTRIBUTION CONSULTANTS

OPERATIONS

CEMENT DISTRIBUTION CONSULTANTS

LOADING FLY ASH IN TAMPA

CEMENT DISTRIBUTION CONSULTANTS

LOADING CEMENT IN PORT EVERGLADES

LEAVING TAMPA

CEMENT DISTRIBUTION CONSULTANTS

CEMENT DISTRIBUTION CONSULTANTS

SEAVOYAGE TO ALMIRANTE

ARRIVAL ALMIRANTE

CEMENT DISTRIBUTION CONSULTANTS

ARRIVAL IN ALMIRANTE

CEMENT DISTRIBUTION CONSULTANTS

CEMENT DISTRIBUTION CONSULTANTS

TERMINAL OPERATIONS

TERMINAL OPERATIONS

CEMENT DISTRIBUTION CONSULTANTS

CEMENT DISTRIBUTION CONSULTANTS

PUMPING CEMENT AND FLY ASH TO SHORE

CEMENT DISTRIBUTION CONSULTANTS

FLOATING PIPELINE TO SILOS

TRUCK LOADING SILOS

CEMENT DISTRIBUTION CONSULTANTS

CEMENT DISTRIBUTION CONSULTANTS

TRUCKING TO PROJECT SITE

CEMENT DISTRIBUTION CONSULTANTS

SILOS AT RCC PLANT

CEMENT DISTRIBUTION CONSULTANTS

AND THE DAM GROWS

CEMENT DISTRIBUTION CONSULTANTS

AND THE DAM GROWS

CEMENT DISTRIBUTION CONSULTANTS

AND THE DAM GROWS

CEMENT DISTRIBUTION CONSULTANTS

AND THE DAM GROWS

CEMENT DISTRIBUTION CONSULTANTS

AND THE DAM GROWS

CEMENT DISTRIBUTION CONSULTANTS

AND THE DAM GROWS

CEMENT DISTRIBUTION CONSULTANTS

AND THE DAM GROWS

CEMENT DISTRIBUTION CONSULTANTS

AND THE DAM IS READY

CEMENT DISTRIBUTION CONSULTANTS

PROJECT COMPLETED

CEMENT DISTRIBUTION CONSULTANTS

PROJECT COMPLETED

THANK YOU

adligthart@cementdistribution.com

www.cementdistribution.com

CEMENT DISTRIBUTION CONSULTANTS