THE CHANGUINOLA DAM & HYDRO ELECTRICAL POWER PLANT

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

Ad Ligthart

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
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
PROJECT INFORMATION

Changuinola
HEP PROJECT
Location

LOCATION
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
SCOPE OF SUPPLY

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
Dam Design

Height of dam 102 m  
Width of dam (top) 615 m  
Concrete quantity 860,000 m³

A mass concrete design was chosen over a rock and earth filled dam as this would shorten the construction period with one year.
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.
DAM CONSTRUCTION
DAM CONSTRUCTION
DAM CONSTRUCTION
DAM CONSTRUCTION
DAM CONSTRUCTION
DAM CONSTRUCTION
DAM CONSTRUCTION
DAM CONSTRUCTION
DAM CONSTRUCTION
DAM CONSTRUCTION
DAM CONSTRUCTION
DAM CONSTRUCTION
DAM CONSTRUCTION
DAM CONSTRUCTION
• 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
- 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 is blasted through the rock
Tunnel is stiffened with rock dowels and shotcrete. This also prevents water leakage from the tunnel.
POWERHOUSE DESIGN

River at +55 mASL

Powerhouse access level
+67 mASL
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 CONSTRUCTION
Powerhouse construction site

...
Powerhouse construction site

...
ROADS AND BRIDGES

No bridge yet

Temporary bridge

Culvert construction

Permanent bridge
ROADS AND BRIDGES

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

- Concrete plant (RCC)
  - Capacity 650 m³/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

[Caption: Dam, Tunnel, Powerhouse]
RCC plant

- 650 m³/hour capacity
- 4 Mixers
- Delivery system to dam 2000 tph
A platform for the RCC plant was blasted out of the hill close to the dam
A platform for the RCC plant was blasted out of the hill close to the dam

RCC PLANT AND DELIVERY SYSTEM
RCC PLANT AND DELIVERY SYSTEM
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
AGGREGATE MINING AREA
OTHER TEMPORARY FACILITIES

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

- Workshop
- Logistical warehouse
HOUSING CAMPS
HOUSING CAMPS
<table>
<thead>
<tr>
<th>Project</th>
<th>Cement and fly ash supply</th>
</tr>
</thead>
<tbody>
<tr>
<td>April – October 2007 Preparations</td>
<td>October – November 2007 Feasibility study</td>
</tr>
<tr>
<td>October 2007 to mid 2009</td>
<td></td>
</tr>
<tr>
<td>October 2007 to mid 2009</td>
<td></td>
</tr>
<tr>
<td>Earth moving, road construction, surface</td>
<td>Concept terminal design and permit application</td>
</tr>
<tr>
<td>preparation, plant construction</td>
<td></td>
</tr>
<tr>
<td>Construction of tunnel, powerhouse</td>
<td>January – March 2008</td>
</tr>
<tr>
<td>Construction of dam</td>
<td>March – August 2008</td>
</tr>
<tr>
<td>Construction of dam</td>
<td>Purchasing barge, terminal equipment, trucks,</td>
</tr>
<tr>
<td></td>
<td>etc.</td>
</tr>
<tr>
<td>Mid 2009 to end 2010</td>
<td>March – October 2008</td>
</tr>
<tr>
<td></td>
<td>Sourcing cement and fly ash</td>
</tr>
<tr>
<td></td>
<td>September 2008 – September 2009</td>
</tr>
<tr>
<td></td>
<td>Conversion floating terminal</td>
</tr>
<tr>
<td></td>
<td>July 2009 – October 2009</td>
</tr>
<tr>
<td></td>
<td>Construction shore silos and facilities</td>
</tr>
<tr>
<td></td>
<td>January 2009 – October 2009</td>
</tr>
<tr>
<td></td>
<td>Big Bag operations</td>
</tr>
<tr>
<td>Construction of dam</td>
<td>Bulk operations</td>
</tr>
<tr>
<td></td>
<td>March 2011 – July 2011</td>
</tr>
<tr>
<td></td>
<td>Demobilisation</td>
</tr>
<tr>
<td>May 2011 Closing diversion tunnels</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>June 2011 Lake full</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>June 2011 Lake full</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>July – September 2011 Start-up</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>September 2011 – April 2012 Demobilisation</td>
<td></td>
</tr>
</tbody>
</table>
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
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
**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**
• 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
SETTING UP THE SUPPLY CHAIN

SHIPPING ROUTES
SHIPPING ROUTES

Project site

Shipping route

Trucking route (18 km)

Project site
PLANNING THE TERMINAL FACILITY
Building a Floating Terminal

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

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
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
SETTING UP THE SUPPLY CHAIN

FINAL PREPARATIONS
LOADING FLY ASH IN TAMPA
LOADING CEMENT IN PORT EVERGLADES
LEAVING TAMPA
SEAVOYAGE TO ALMIRANTE
TERMINAL OPERATIONS
PUMPING CEMENT AND FLY ASH TO SHORE
FLOATING PIPELINE TO SILOS
TRUCK LOADING SILOS
TRUCKING TO PROJECT SITE
SILOS AT RCC PLANT
AND THE DAM GROWS
AND THE DAM GROWS
AND THE DAM GROWS
AND THE DAM GROWS
AND THE DAM GROWS
AND THE DAM GROWS
AND THE DAM IS READY
PROJECT COMPLETED
PROJECT COMPLETED
THANK YOU

adligthart@cementdistribution.com
www.cementdistribution.com