HIGH-PRESSURE FISSURE GROUTING FOR DRILL AND BLAST TUNNELLING AMBUKLAO, PHILIPPINES
Presentation Outline

Project History / Background

Project Scope

Geology

Grout Mix and Design

Grouting Materials and Equipment

Shaft Grouting

Tunnel Grouting
Project Background

Built in 1956 – The first hydro electric plant in the Philippines.

**Original installed –**
3 x 25Mw Horizontal Turbines
75 Mw @ 155m Head

**After Rehabilitation -**
3 x 35Mw turbines
105Mw @ 155m Head

**Project Award** – 27th August 2008

**Practical Completion** – 2nd June 2011
Project Background

• Damage to the existing Underwater Intake Structure

• Due to 1990 earthquake 7.8Ms
  - Unable to close intake gate

• Valves – Leaking collectively up too 5,000l/s

• Siltation – Major Problem

• Poor Management of Catchment
  - Deforestation

• High Rainfall >3000mm of Rainfall

• Topography - Mountainous
Ambuklao Dam - Project Scope

- New Intake Structure – 24m high
- Intake Shaft - 124m x 6.2m diameter
- Dam Wall Rehabilitation
- Transformer Yard
• New Access Tunnel  
  (120m long x 6m high x 5m wide)

• New Headrace Tunnel  
  (6.8m Horsehoe)

• New Connection to Valve Chamber  
  (2.6m diameter steel penstock)

• Tailrace Outlet Structure and Jette
- Gabbro (Hard and Highly fractured)

- Rock Quality Designation (RQD)
  - 47% Fair
  - 37% Poor
  - 16% Really Poor

- Rock Charged with Water from the Dam
Grout Design, Equipment and Materials

**Equipment**
- Atlas Copco Unigrout
- Logac Unit
- Hydraulic and Mechanical Packers

**Materials**
- OPC
- Microfine 20 – (MF20)
- Ultrafin® 12 – (UF12)
- GroutAid®
- SP40

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![Image of grout design equipment and materials](image-url)
Grouting - Flow Chart

Grout Type – MF20
Pressure – 55 to 60 bar
Max. cement = 1200kg/hole

- Select hole to be grouted
- Start mix W/B 1.5
  - 1 batch approx 169 litre 60kg cement
  - 1 batch approx 171 litre 100kg cement
  - 6 batches approx 1026 litre 600kg cement
- Mix W/B 1.2
- Pump at flow rate 15 – 25 l/min
- Pump at flow rate 15 – 25 l/min
- Is pressure at max. & flow <3/ min?
  - NO
    - Continue pumping at 15 – 25 l/min
  - YES
    - Stop – hole complete. Go to A
- Is pressure increasing?
  - NO
    - Is pumped volume 1100 - 1200 litres?
      - NO
        - Is pressure close to maximum?
          - NO
            - Change to Mix W/B 1.0
          - YES
            - 1 batch approx 175 litre 120kg cement
              - 4 batches approx 700 litre 480kg cement
Tunnel Grouting

- Drilling Jumbo – AMV
- Clients objective <10 L/s into the powerhouse
- Systematic Grouting Approach
- Probe Drilling
- Challenges – Water (300L/min from one probe hole)
- Ambuklao Tunnels - 508m
- 100T of Grout Injected around the Adit Gate
Tunnel Grouting

- 51mm – 54mm Drill Bits
- 2m Pipe Sleeves – Due to Bad Ground
- 5m – 6m Overlap Between Grouting Rounds
- Spacing 2-3m Between Holes
Major Objectives - Tunnel
Manifold
Shaft Grouting

- 124m deep shaft
- Hand Sunk
- Drill and Blast
- Challenges – Water
- Cactus Grab - Mucking System
- Systematic Grouting Approach
- Pipe Sleeving
Shaft and Cofferdam Grouting

- 5 to 7m Overlap
# Grouting Summary

<table>
<thead>
<tr>
<th>Location</th>
<th>Drilling (lin.m)</th>
<th>Type A * (kg)</th>
<th>Type B ** (kg)</th>
<th>Total Grout (kg)</th>
<th>Average kg/m</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ambuklao - Intake Cofferdam</td>
<td>4,501</td>
<td>136,640</td>
<td>53,020</td>
<td>189,660</td>
<td>42.1</td>
</tr>
<tr>
<td>Ambuklao Waterways – (Shaft, Headrace tunnels and Penstocks)</td>
<td>25,226</td>
<td>18,520</td>
<td>503,340</td>
<td>521,860</td>
<td>20.7</td>
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<tr>
<td>Ambuklao - Access Tunnel</td>
<td>14,130</td>
<td>45,520</td>
<td>266,260</td>
<td>308,780</td>
<td>21.9</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>43,857</strong></td>
<td><strong>197,680</strong></td>
<td><strong>822,620</strong></td>
<td><strong>1,020,300</strong></td>
<td></td>
</tr>
</tbody>
</table>

* Type A – OPC  
**Type B – Microfine(20) and Ultrafin® (12)
Conclusion

• Successful in achieving the client’s objective of <10 L/s of seepage into the powerhouse

• Observational approach method to respond to the variable ground conditions

• Grouting was results driven

• High collaboration with employer, engineer and contractor
DRIVING PROGRESS
THROUGH SAFE, SMART & EFFICIENT INFRASTRUCTURE

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