The Jinping II Hydroelectric Project in China

John A Hudson
(and with some slides from Prof Xia-Ting Feng)
Location of the hydroelectric project on the Yalong River in China
One of many hydroelectric projects on the river
Hydroelectric project on the Yalongs River
‘Short circuit’ via tunnels to provide hydroelectric power
Typical in this mountainous country is core discing as a result of high stress.
The hydroelectric scheme

- Water intake
- Access tunnel
- Power tunnels
- Surge chamber
- Drainage tunnel
- Penstock
- Tailrace gatehouse
- Power house
- Main transformer chamber

Distance: 16.67 km
Headrace tunnels

- Seven tunnels: two auxiliary tunnels, one water drainage tunnel and four high pressure headrace tunnels
- Maximum overburden of 2525 m and maximum principal stress of 70MPa
- Average length of 16.7km
- Excavated mainly in marble by TBM and D&B
Rock spalling and rockbursts
Asymmetry of the overburden loading

Asymmetry of overburden loading
Water inflows 2-3 m$^3$/s with maximum 5 m$^3$/s
Robbins
12.4 m
diameter
TBM
Rock spalling and rockbursts
Top heading, drill and blast
In addition to solving the construction problems, there is an underground research laboratory.

- **Testing tunnels**

  - **Auxiliary tunnel A**
  - **Tunnel B and F, 7.5 x 8.0m**
  - **Tunnel C, 3 x 3.2m**
  - **Headrace tunnel no.1, D=12.4m**
  - **Headrace tunnel no.2, D=13.0m**

  K5+186 to K6+198

  K7+374 to K9+100
Testing apparatus and contents

- Acoustic wave (single or cross-hole method)
- Sliding Micrometer
- Digital borehole camera
- Microseismic
- Acoustic emission

Evolution of surrounding rock induced by TBM or D&B
- Structure
- Elastic wave
- Deformation
- Fractures
- Rockburst/Rock spalling
Evolution of excavation damaged zone

- Excavation Damaged Zone (EDZ): new fractures observed by digital borehole camera, >0.2mm

- Excavation disturbed Zone (EdZ): deformation obvious and micro fractures concentrated, measured by acoustic emission and sliding micrometer

Image of borehole wall and fractures
Deformation of surrounding rock mass in test tunnel F

Acoustic emission of headrace tunnel No.3

EDZ formation and evolution observed by digital borehole camera in a borehole wall of test tunnel C
Results for EdZ/EDZ

EDZ and EdZ at test tunnel C

EDZ and EdZ at test tunnel F

EDZ and EdZ at test tunnel B

EDZ and EdZ at No.3 headrace tunnel
Rock spalling process

- *In situ* observation on tunnel sidewall
- Digital borehole camera for rock mass fractures

![Flattened image of borehole wall](image)

Fractures

Borehole depth (m)

31.8
32.2

No.3 headrace tunnel

Broken rocks

①
②
③
④
⑤
**Blasting**

**Test tunnel C**

Intersection angle between crack strike and tunnel axis: 1° - 5°

Observed new cracks by digital borehole camera

**Test tunnel B**

Intersection angle between crack strike and tunnel axis: 16° - 40°

Observed new cracks by digital borehole camera
New cracks

**Blasting**

**Test tunnel F**

No.3 headrace tunnel

Intersection angle between crack strike and tunnel axis:

- Northern sidewall: 1° - 20°
- Southern sidewall: 3° - 40°
**In situ observation of rockburst evolution process**

**Mechanism**

- **Rockburst types**
  - Strain
  - Strain-structure slip

- **Spatial and temporal characteristics**
  - Immediate
  - Time delayed

**Dominated by**

- High geostress
- High stress and rigid structure slip

**During excavation unloading**

- Occurred sometime after excavation unloading

**NWW structural plane**

**“V” notch**

**Up shell hollow grouting anchor prestressed, T=80kN**
Description of immediate rockburst

Rockburst occurred on January 09, 2010, with volume about 6.3 m³
Deformation evolution

Three stages before rockburst

I. Accelerating stage of deformation
II. Relative quiet period
III. Re-accelerating stage of deformation

Excavation progress of the tunnel upper layer
Excavation progress of the tunnel bottom layer
Point P01
Point P02

Test tunnel F
Borehole M2-SM01
Auxiliary tunnel A

Displacement (mm)

Date (yy-mm-dd)
Microseismic emission and rockbursts

Micro seismic events
- Slight rockburst
- Moderate rockburst
- Intensive rockburst

Time (mm/dd, 2010)
Intensive rockburst occurred at southern sidewall to spandrel of 3# TBM headrace tunnel at K11+045-054, June 11, 2010, notch depth: 1-1.2m
Time delay of rock failure occurred after excavation during high stress

Water tunnel 2# (2)13+225: rock spalling at the south sidewall about 74m from working face, 12 days later, depth 1800 m, T2y5 marble
Water tunnel 2# (2)13+370- 13+470: rock spalling at the south sidewall about 130-230m from working face,
30 days later, depth 1800 m,
T2y5 marble
Complimenting the Chinese personnel on their heroic and successful efforts…
End of Lecture 11