Overview of Baleh HEP in Malaysia
&
Dam Foundation Optimization Design

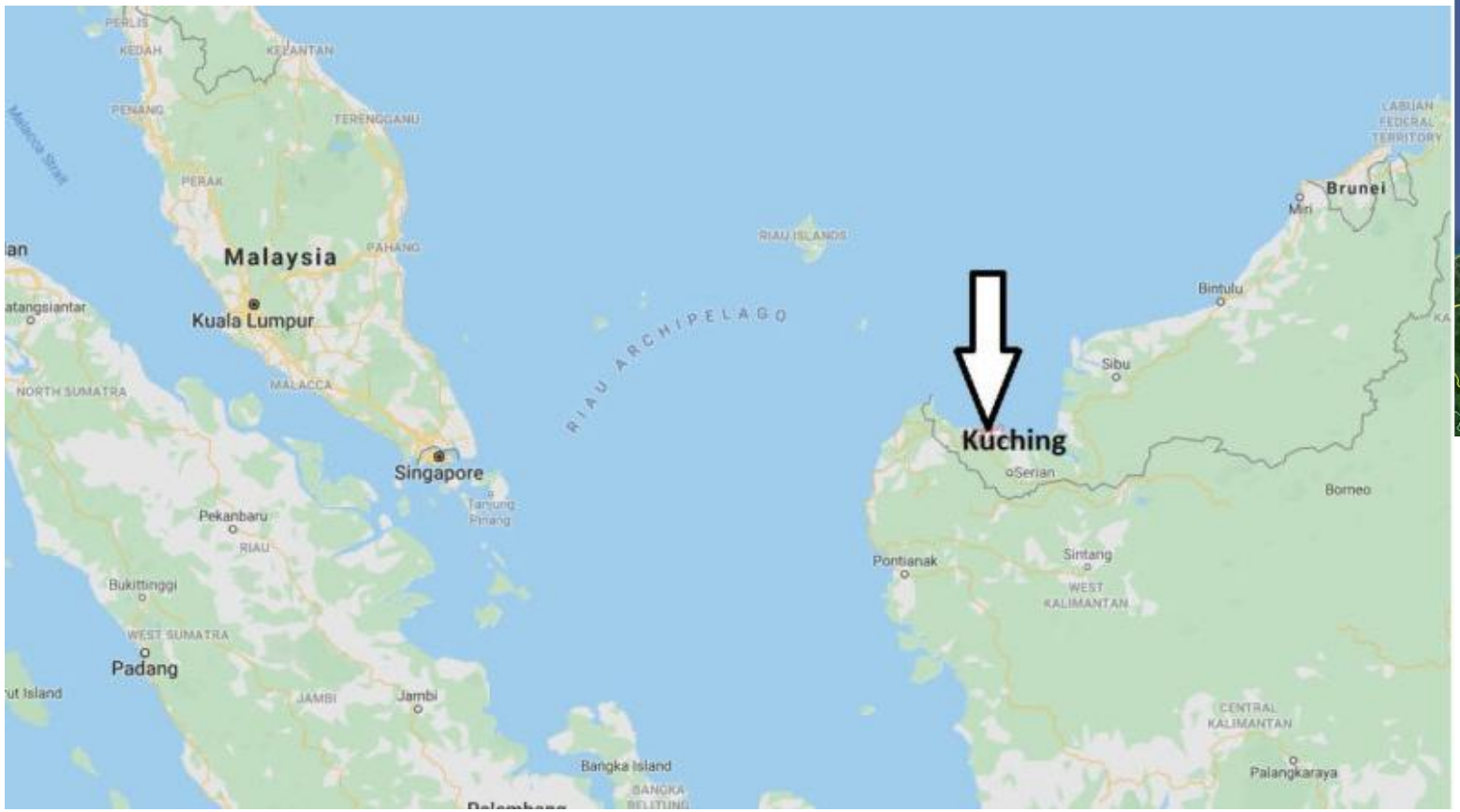
Yellow River Engineering Consulting Co., Ltd.
November, 2021

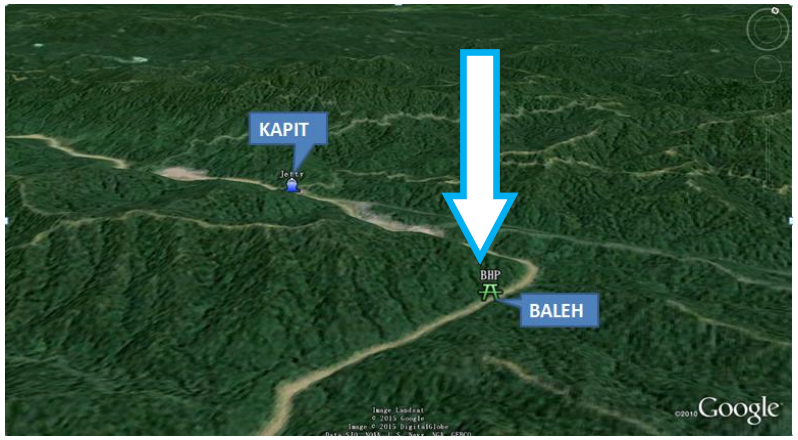
I. Project Overview

II. Main Structures

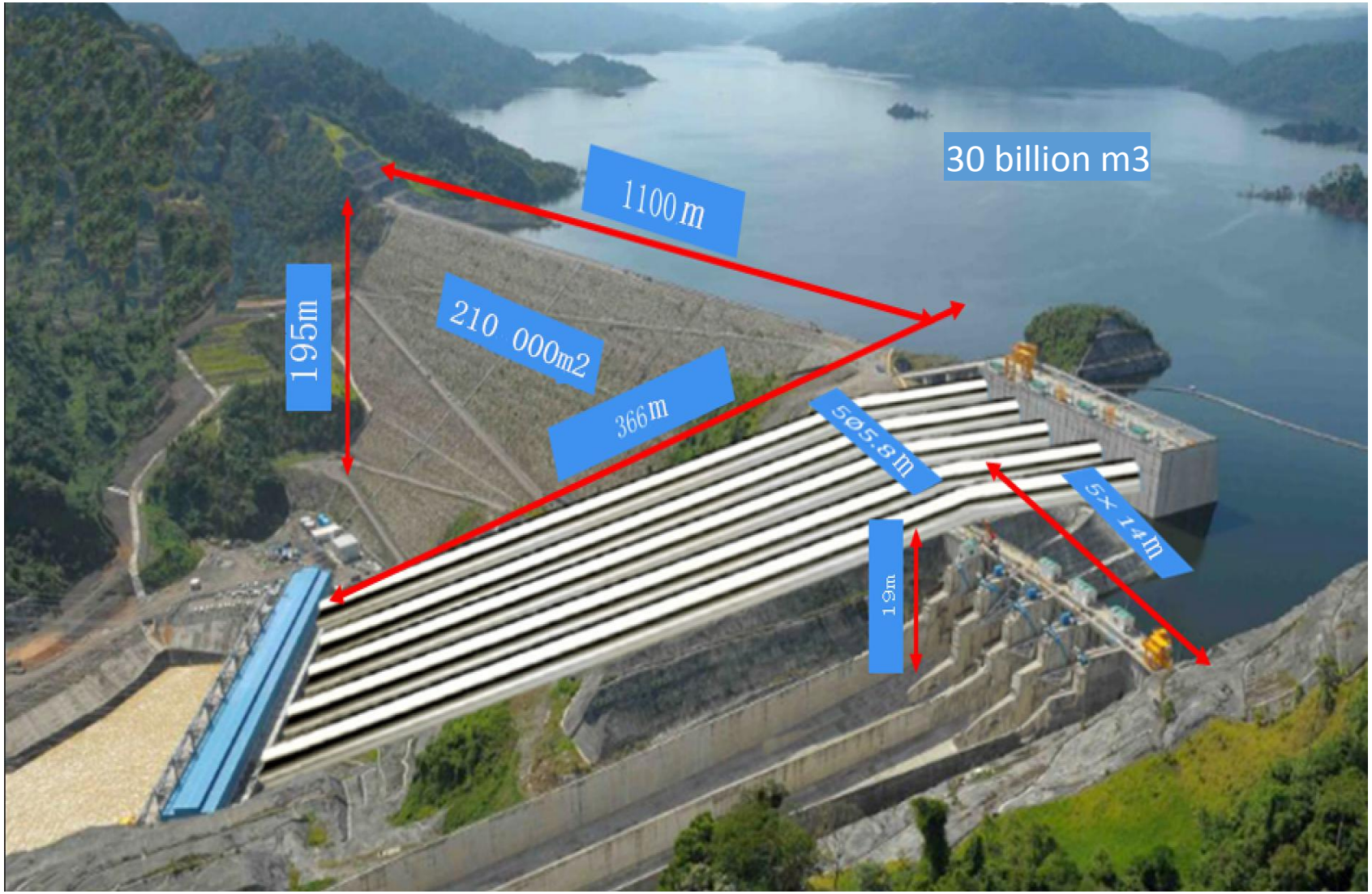
III. Dam Foundation Optimization Design

I. Project Overview



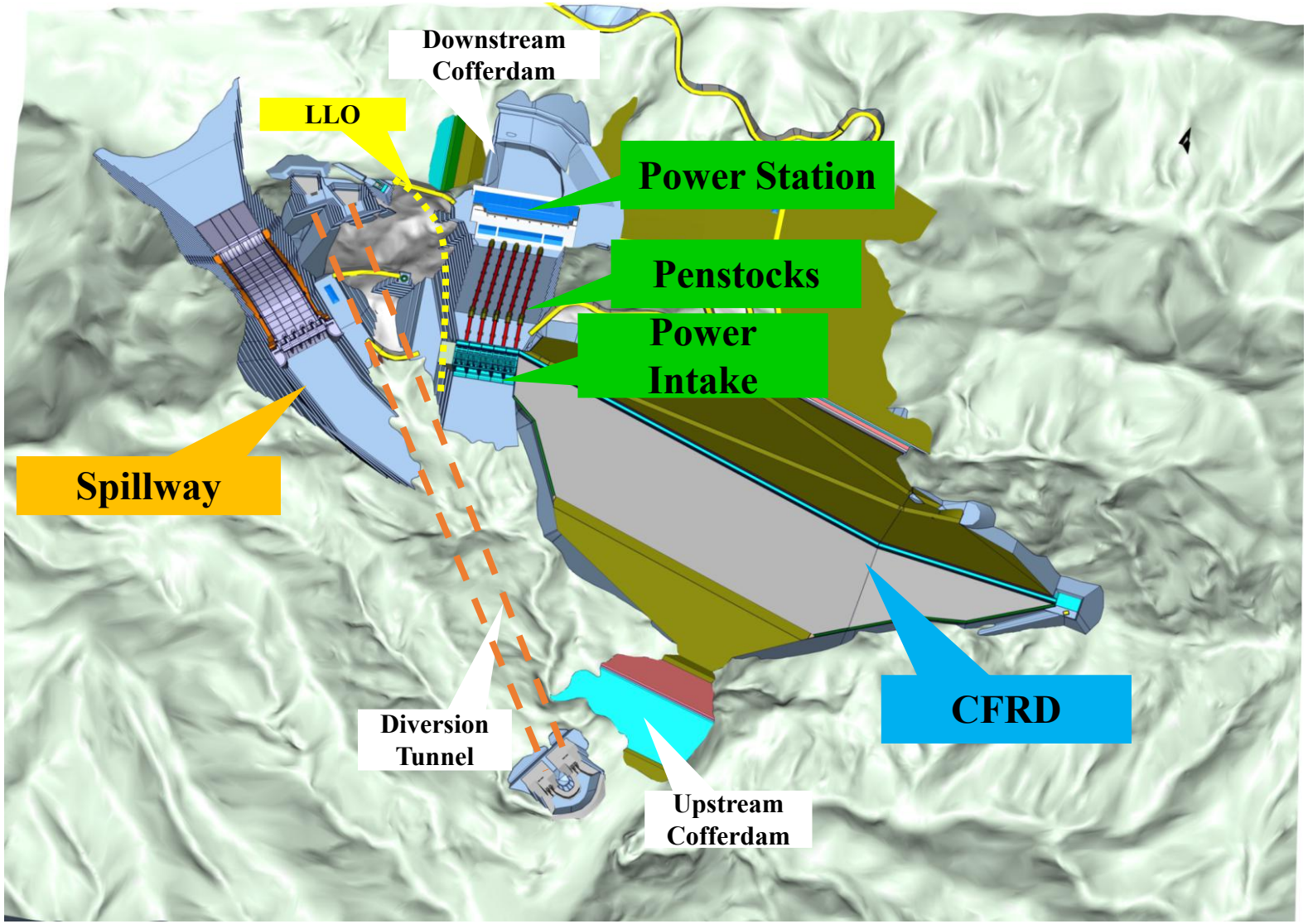


Project location: on the BALEH river in Sarawak of East Malaysia



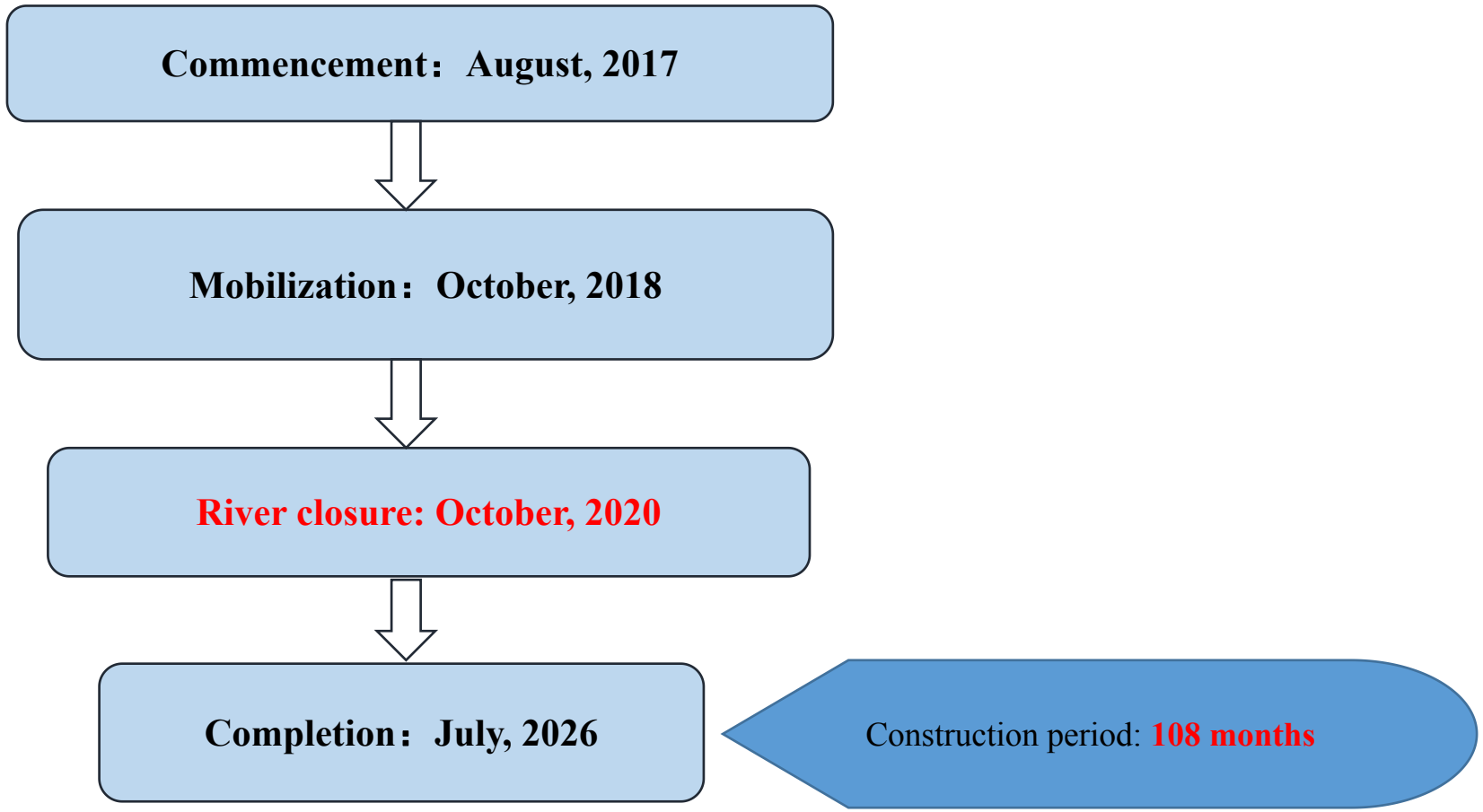
- Baleh HEP is built mainly for power generation with a dam site control catchment area of 5,625km² and a total reservoir capacity of 30 billion m³.
- Five Francis turbine units are provided with an installed capacity of 1,285MW.
- The project is expected to be completed in 2026. After completion, 1,285 MW of renewable energy will be added to Malaysia, further promoting Sarawak to achieve the goal of high income through industrialization in 2030.

Baleh HEP Design Sketch



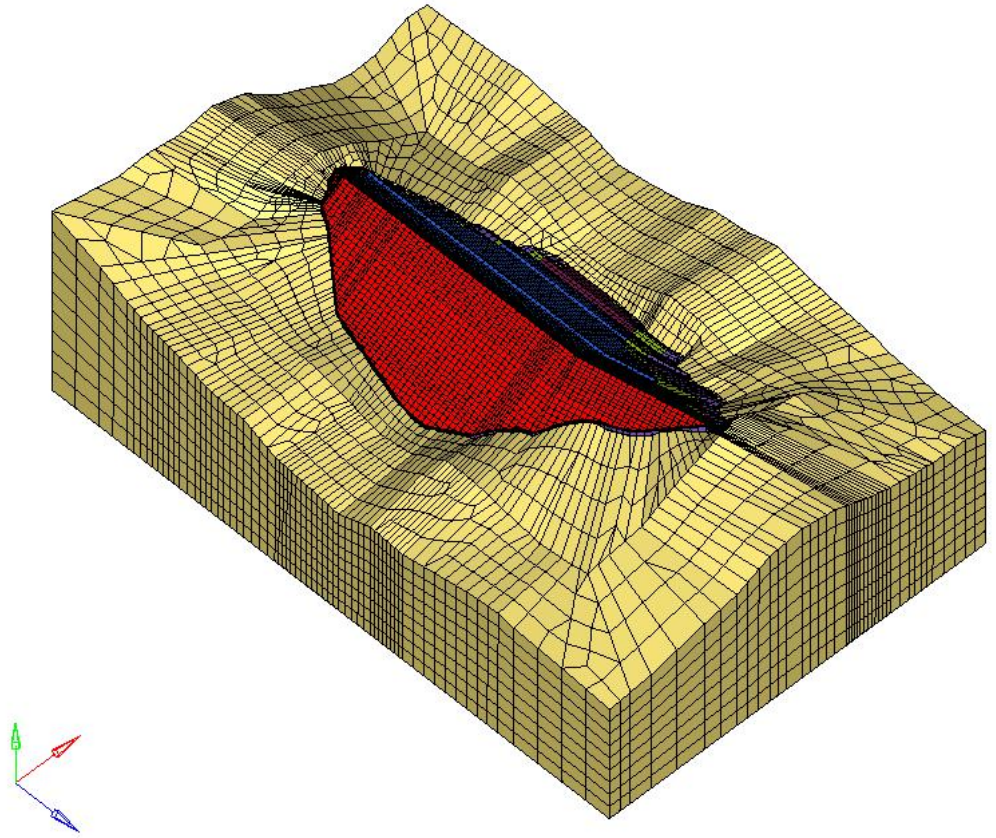
- Water retaining structure: **CFRD;**
- Water diversion and power generation system: **power intake, penstocks and river-side surface power station;**
- Water discharge structure: **spillway(and Low level Outlet);**
- Temporary structures: **diversion tunnel, upstream cofferdam, downstream cofferdam, etc.**

Layout Plan of Baleh HEP


Commencement：August, 2017
Mobilization：October, 2018
River closure: October, 2020
Completion：July, 2026
Construction period: 108 months

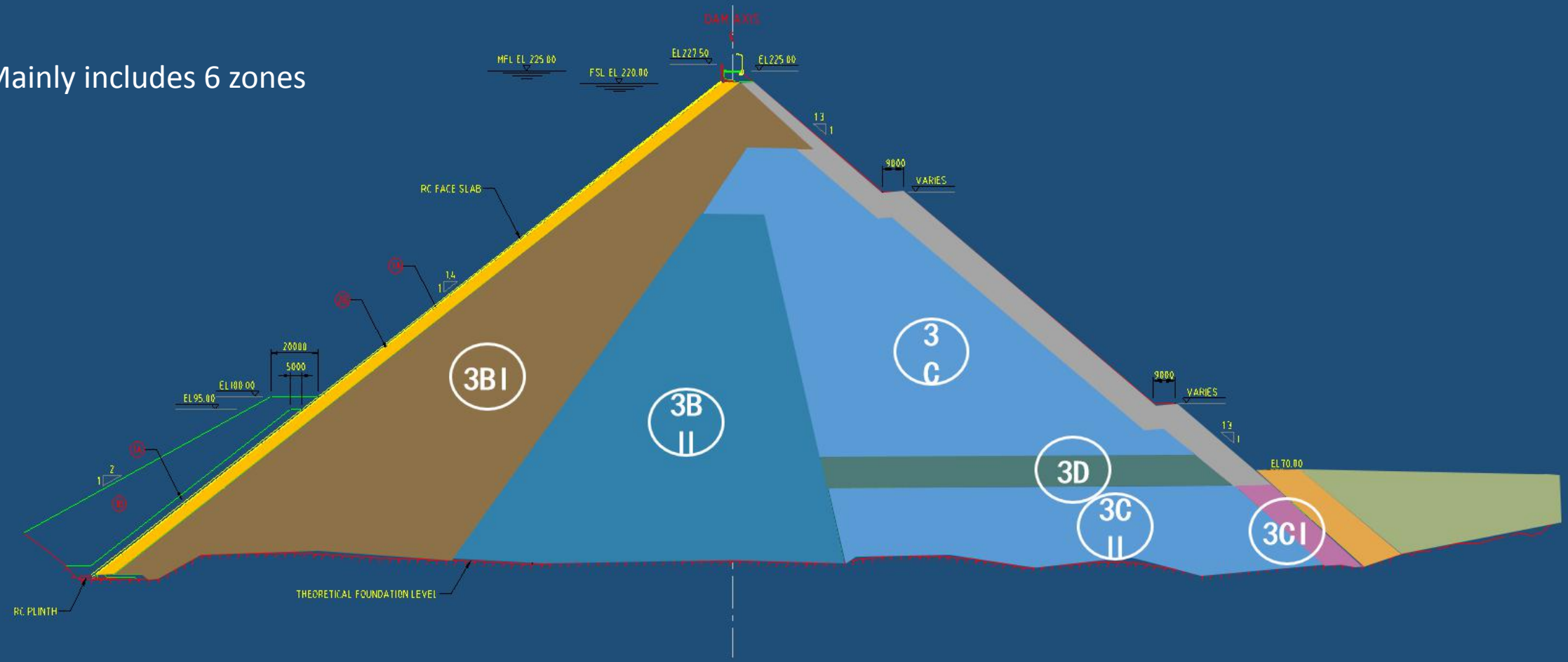
Key Project Parameters of Baleh HEP - Dam

Concrete Faced Rockfill Dam (CFRD)	
Dam crest elevation	EL 225 m
Riverbed elevation at dam site	about EL 37 m
Dam height	**195m**
Dam crest length	1,100m
Dam crest width	9 m
Top of parapet wall	EL 226.5 m
Top of parapet wall including camber	EL 228 m (Additional 1.5m for camber)
Upstream slope	1V:1.4H
Downstream slope	1V:1.3H, with 9m berm road
Embankment volume	**25,765,000 m^3**
Face slab area	213,000 m^3



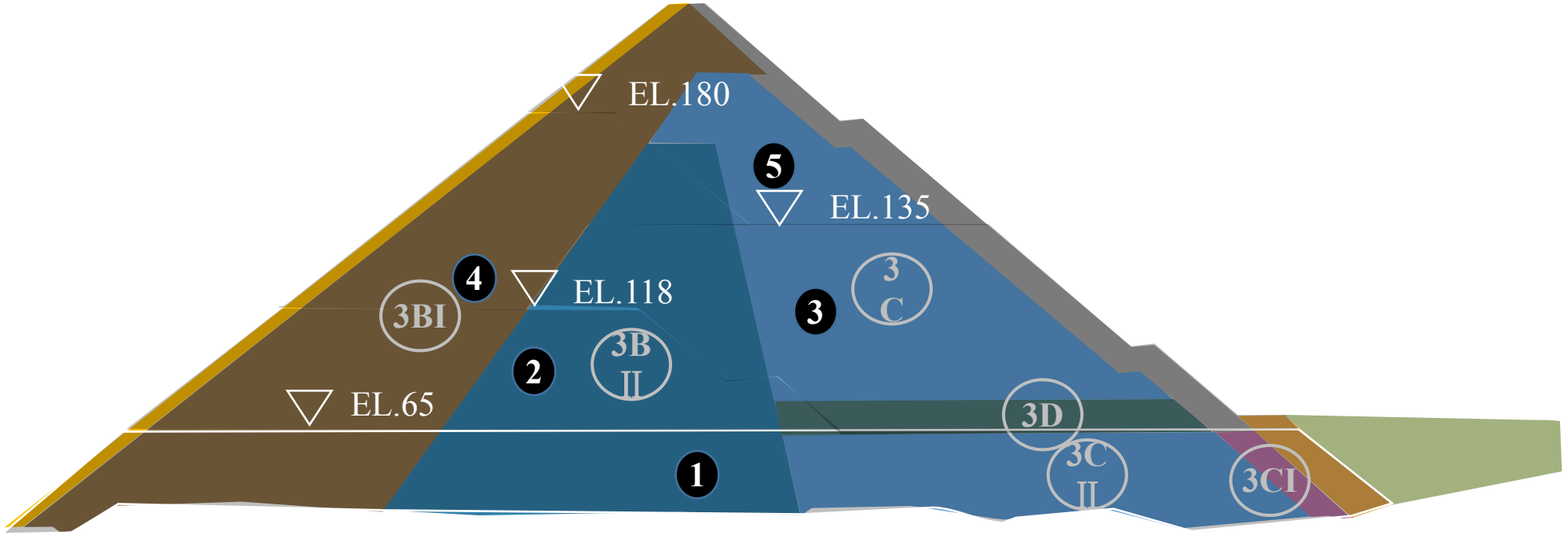
3D Grid Pattern of CFRD Overall Model

Mainly includes 6 zones



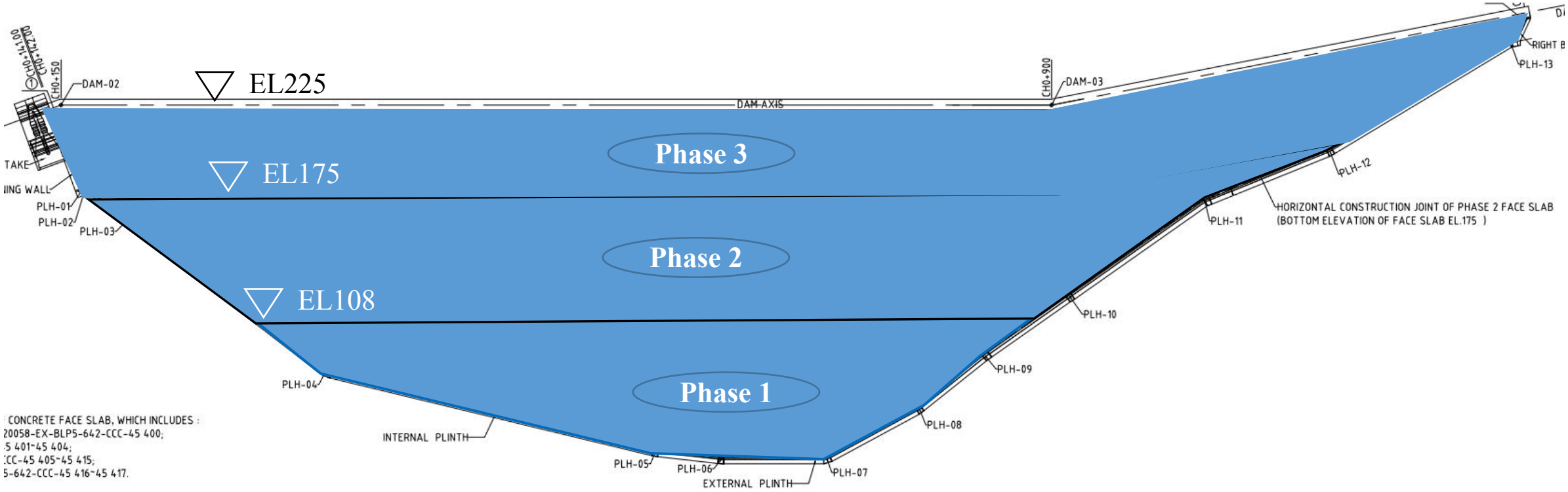
Typical Cross Section of Dam Filling

The dam filling works are divided into five stages.



Processes of Phased Dam Filling

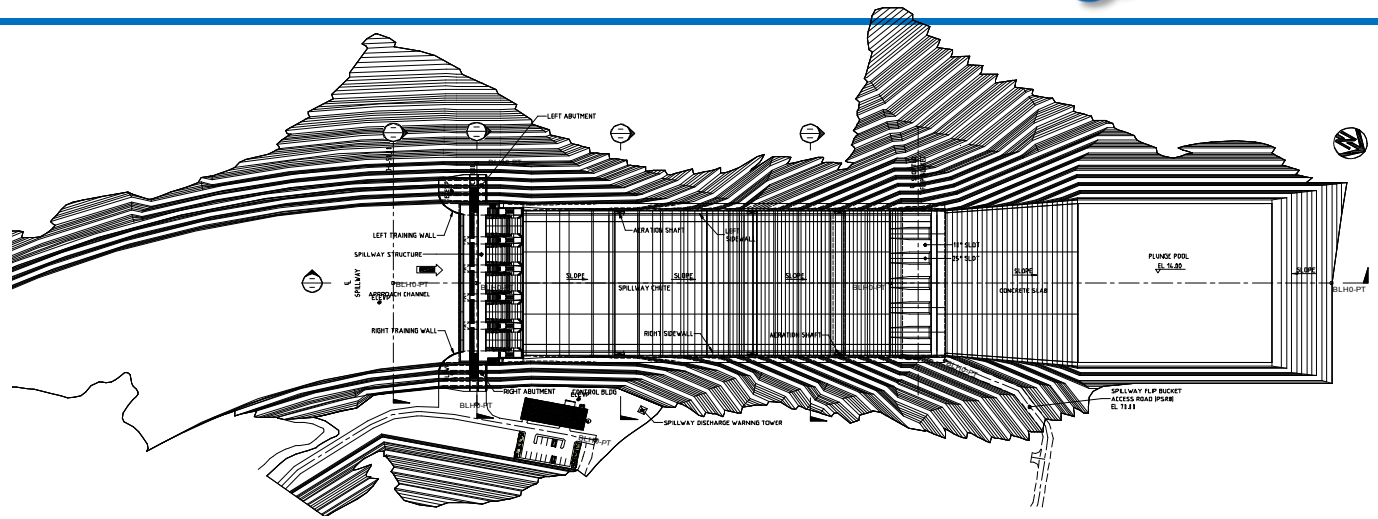
The casting works for face slab are divided into three phases.



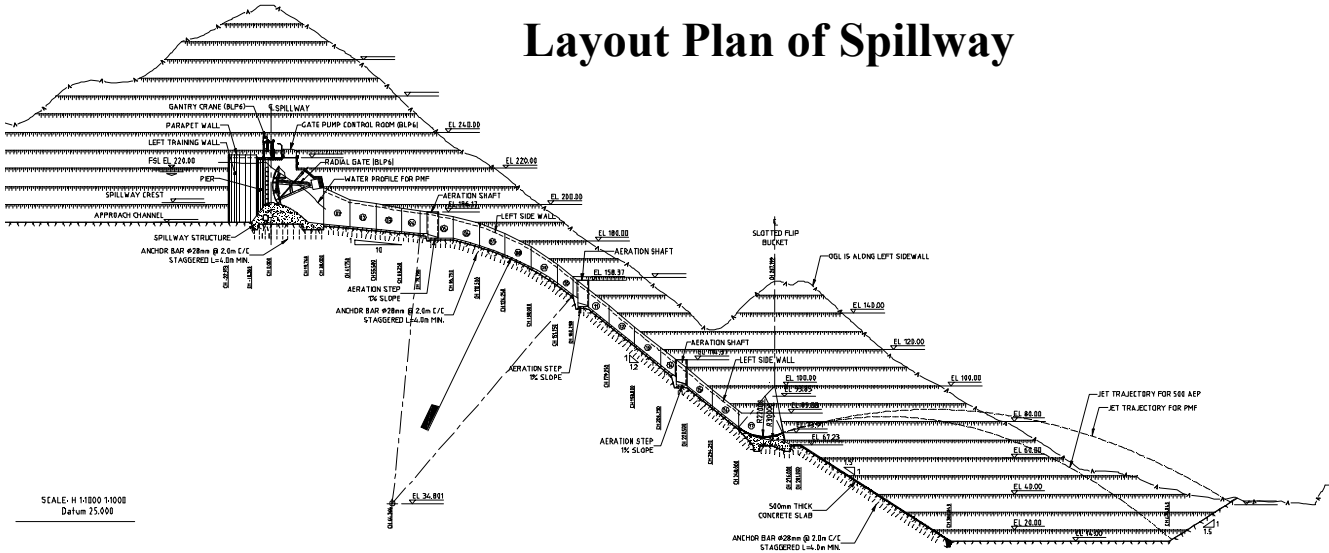
Processes of Face Slab Casting Works

Key Project Parameters of Baleh HEP - Spillway

Spillway	
Weir type	Radial gate, ogee
Number of bays	**5**
Crest elevation (gate sill)	EL 201 m
Bay width	14 m
Pier width	4.5 m
Radial gate dimension (W x H)	14 m×19 m
Gate structure and chute width	88m
Number of aeration slots	3
Maximum discharge	**16,500 m³/s**
Maximum water level	EL 224.93 m
Energy dissipater	Flip bucket and plunge pool

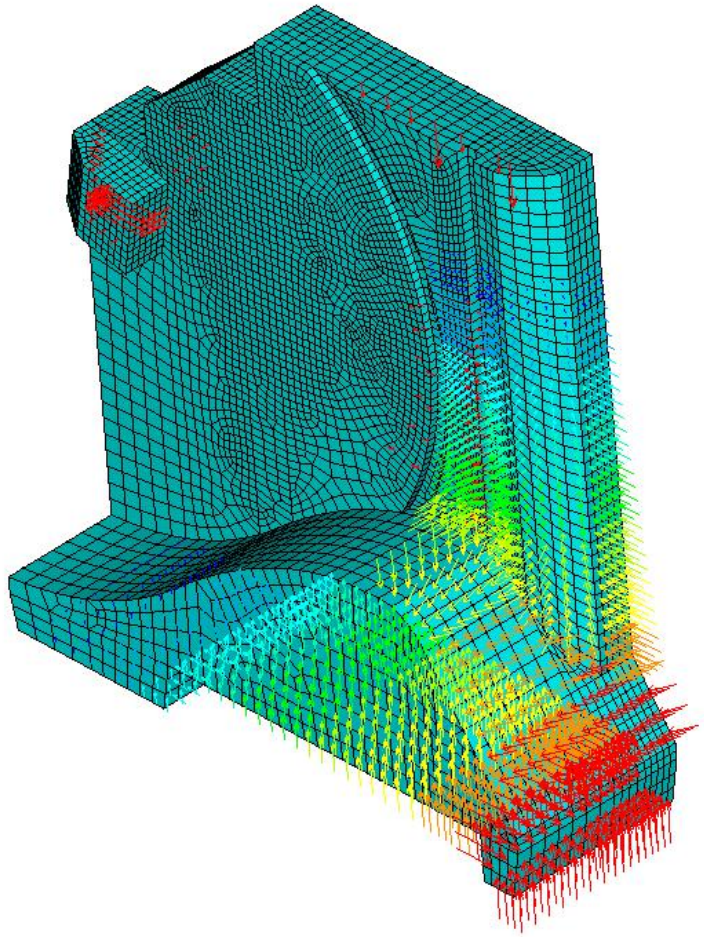


Layout Plan of Spillway



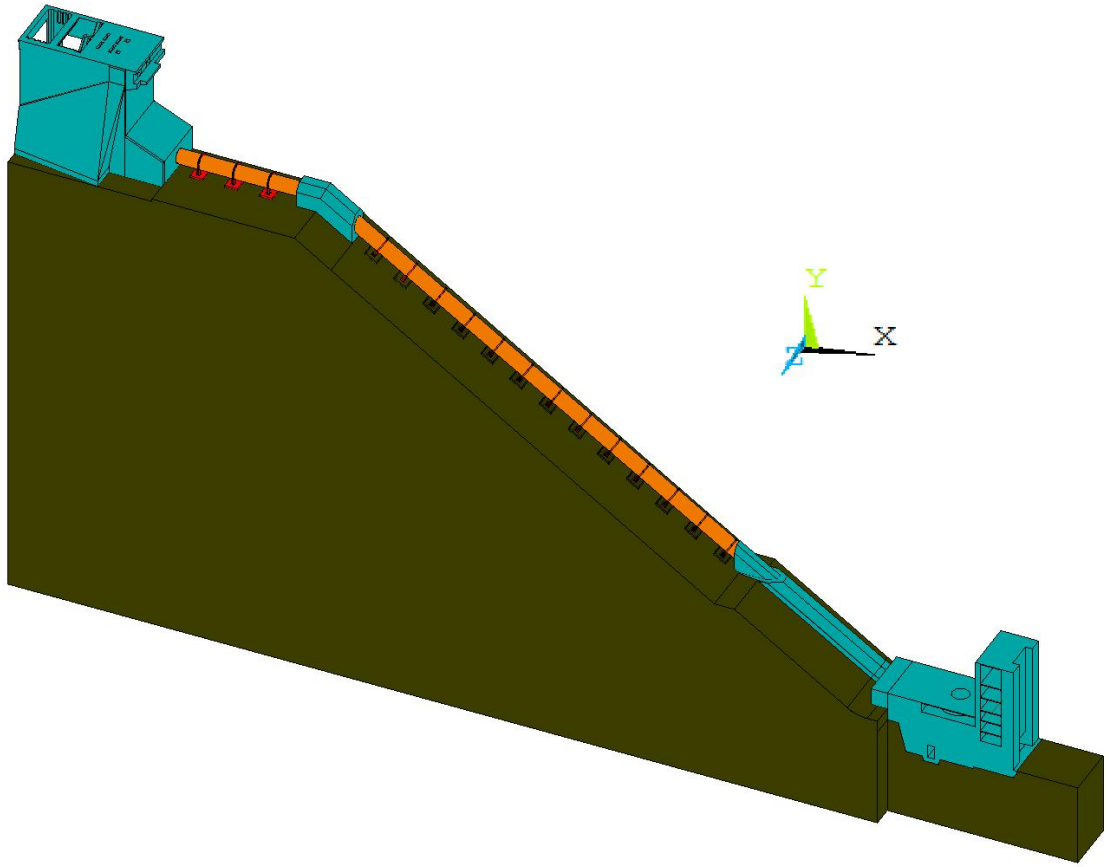
Longitudinal Section of Spillway

Hydraulic Model Test (in ZhengZhou city,2019)



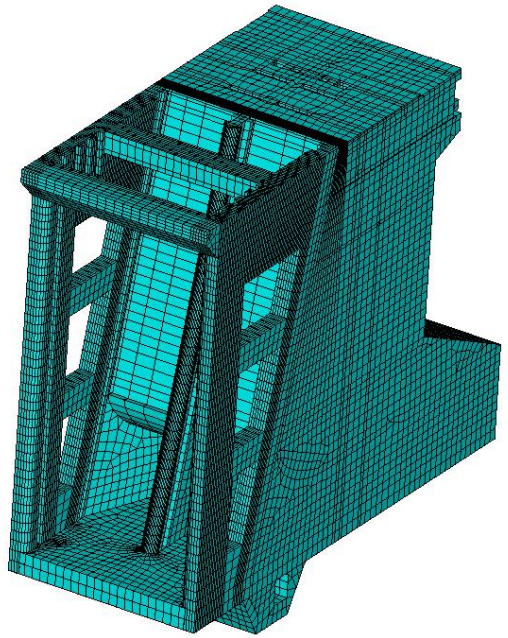
Gate Chamber Stress and Deformation Calculation

Water diversion and power generation system consists of Power Intake, Penstocks and Power Station

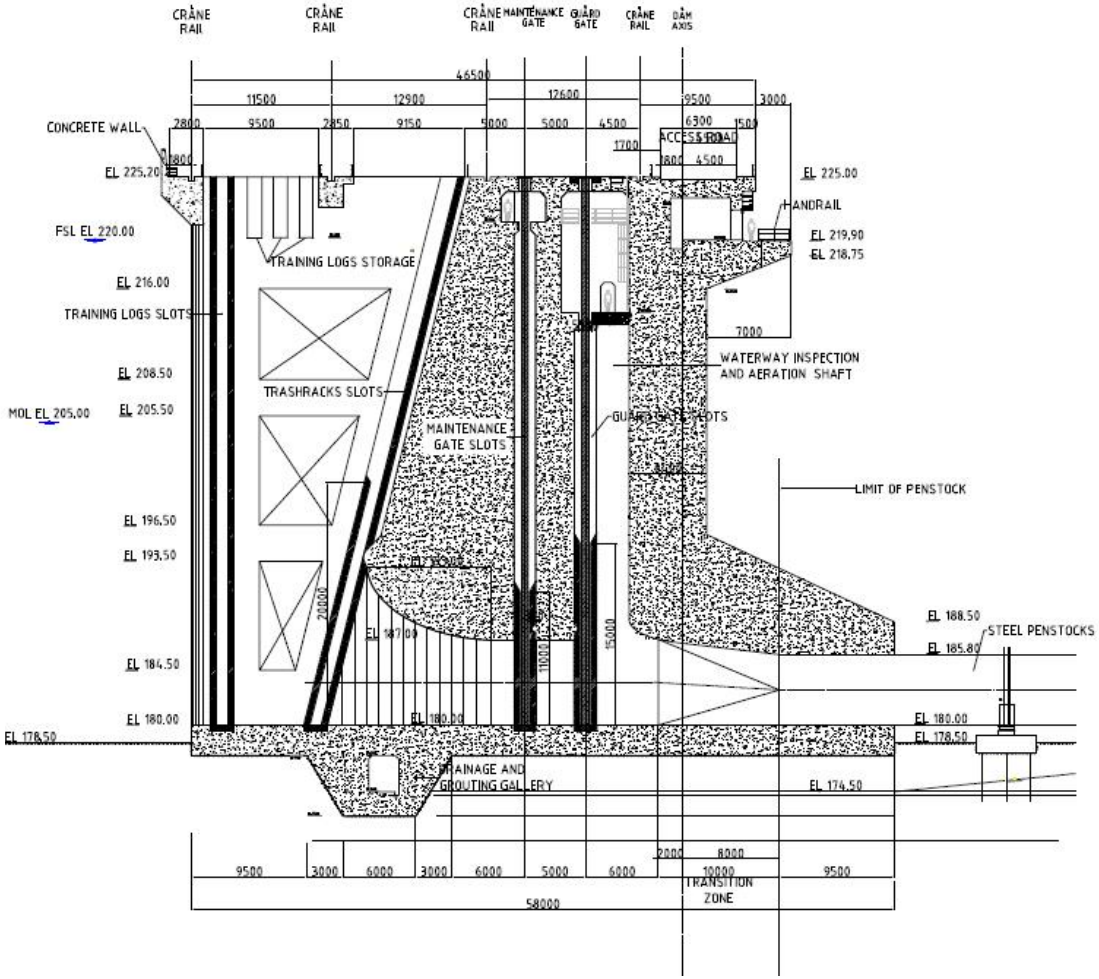


Overall Solid Model (Middle part)

Power Intake	
Number of intakes	5
Sill elevation	EL 180 m
Operating deck level	EL 225 m
Trash rack dimension (W x H)	8.5 m x 13 m
Intake gate dimension (W x H)	**3.4 m x 7 m**

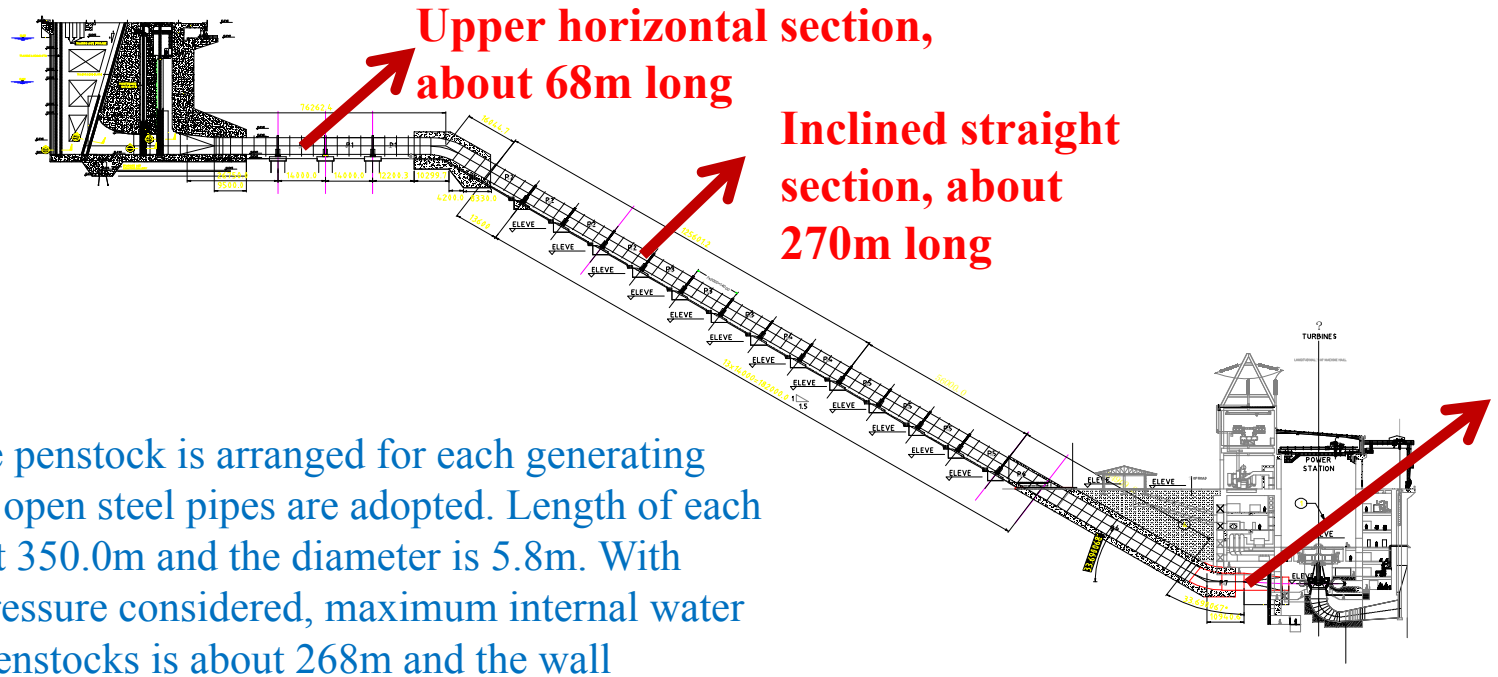


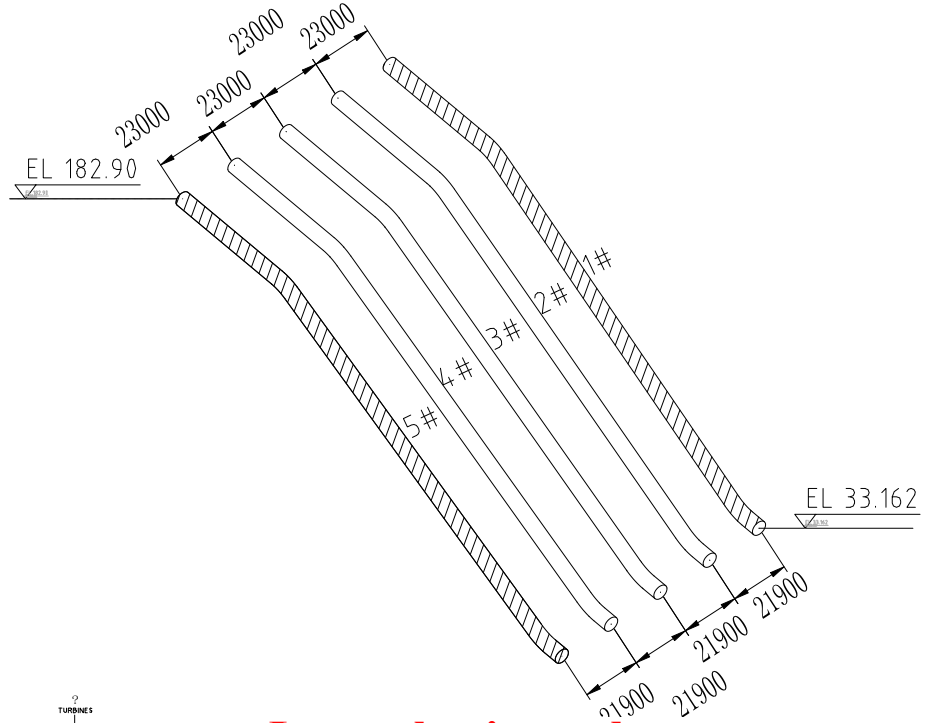
Grid Pattern of Power Intake Concrete Structure in Middle Intake Dam Section



Typical Cross Section of Power Intake

Penstocks	
Number of Penstocks	5
Length	350 m each
Diameter	5.8 m

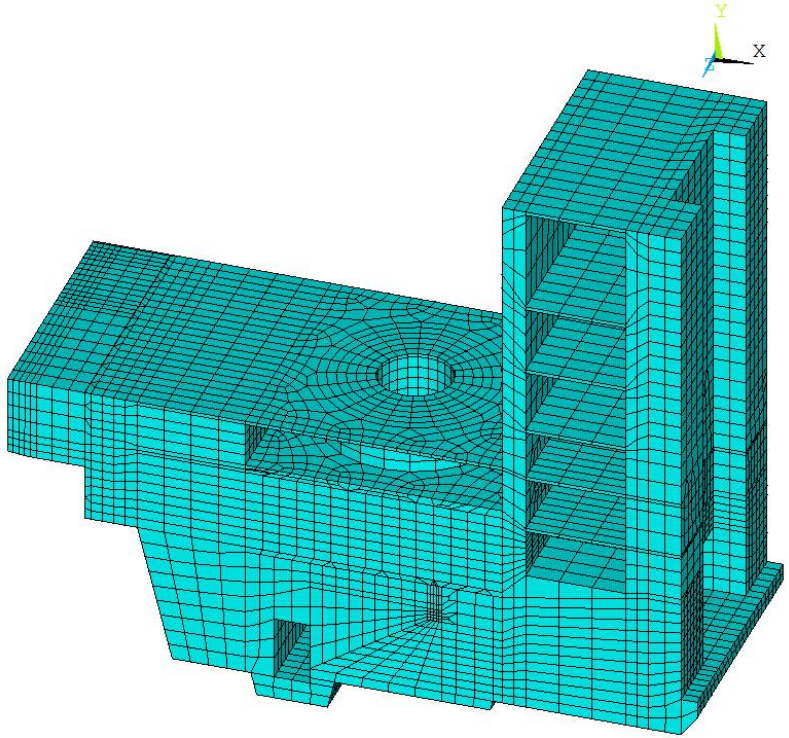




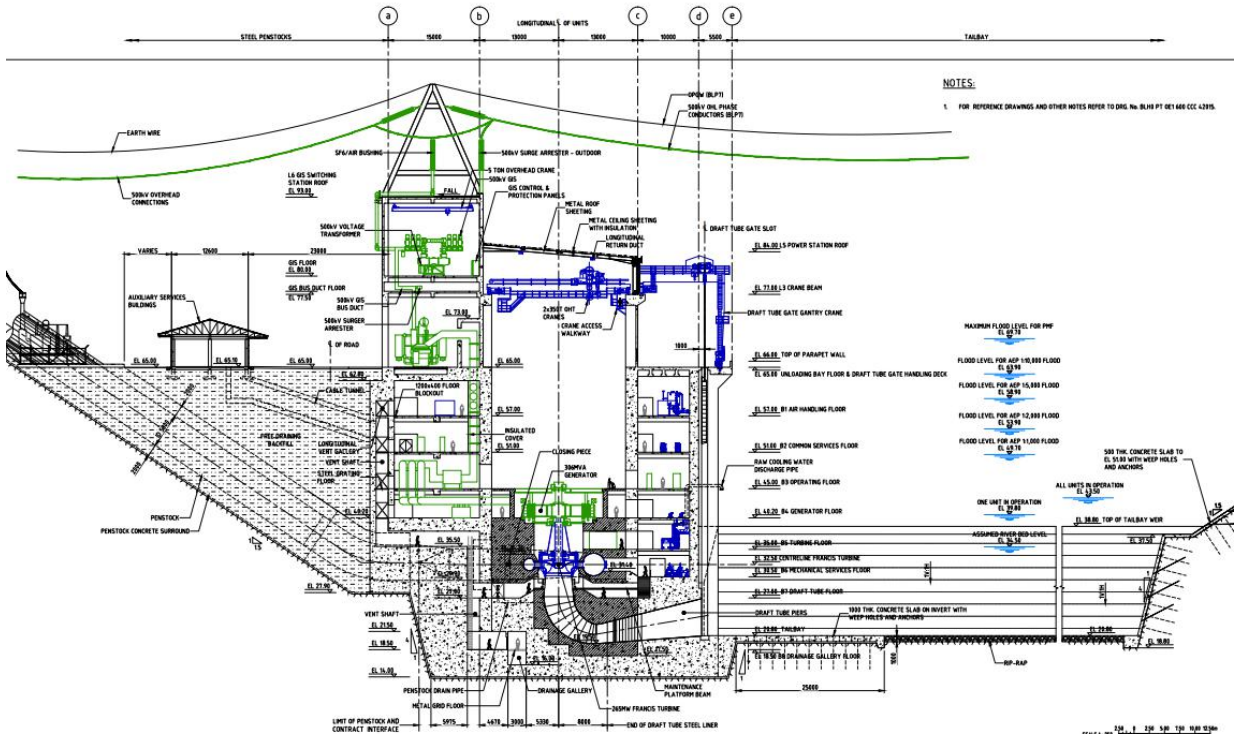
Penstocks: One penstock is arranged for each generating unit, and surface open steel pipes are adopted. Length of each penstcok is about 350.0m and the diameter is 5.8m. With water hammer pressure considered, maximum internal water pressure of the penstocks is about 268m and the wall thickness is 16~40mm.

Longitudinal Profile of Penstoks

Powerhouse	
Number of units	5
Unit type	Francis turbine unit
Installed capacity	1,285MW



Grid Axonometric Projection of Power Station



Typical Cross Section of Power Station

According to previous investigation data, the rock in the dam site area has **thick highly weathered layer**, particularly at the abutments on both banks with a maximum thickness of above 30m.

Whether to excavate **the highly weathered layer** off or not can significantly affect the quantities of excavation works and filling works at the dam.

Figure 6-1 Topography and Geomorphy of the Left Bank of the Dam

Figure 6-2 Topography and Geomorphy of the Right Bank of the Dam

In order to make full use of the highly and moderately weathered rock masses, to reduce dam foundation excavation, YREC has conducted special study on CFRD foundation, which mainly includes:

Phase 1: special test on dam foundation.

Phase 2: special stability and stress analysis of CFRD.



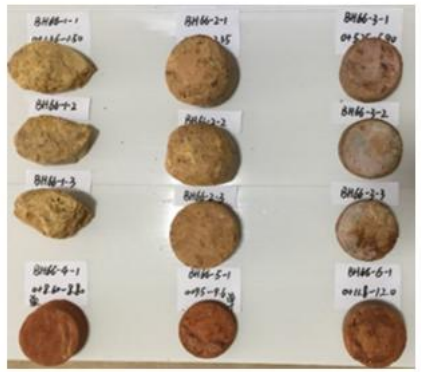




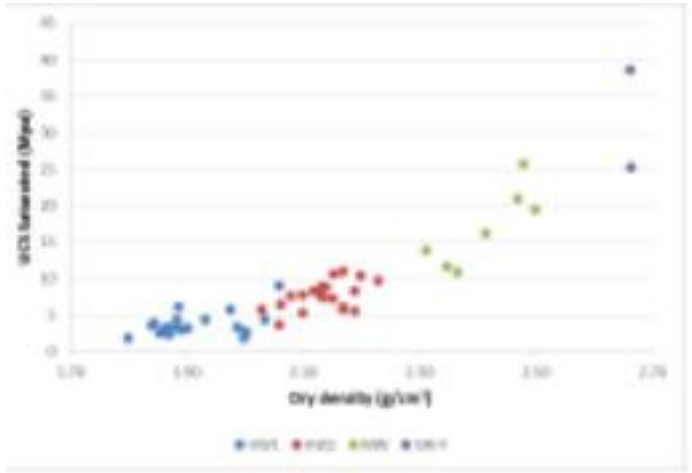


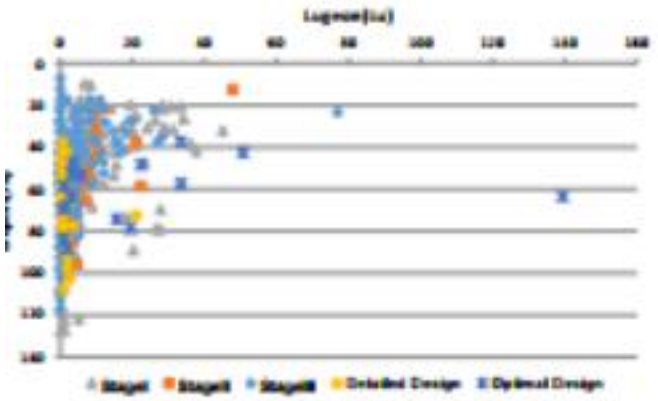


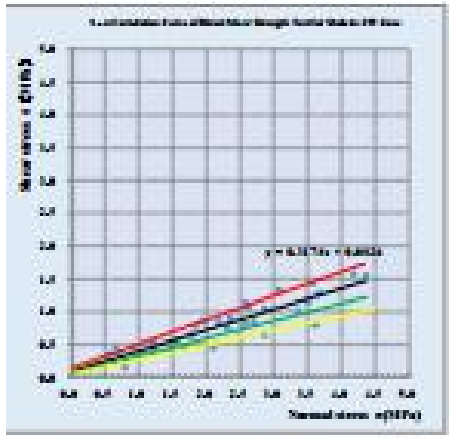
Study Arrangement on site

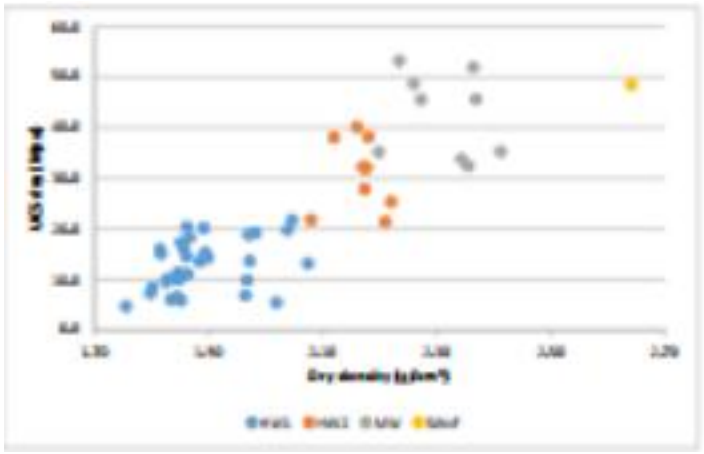


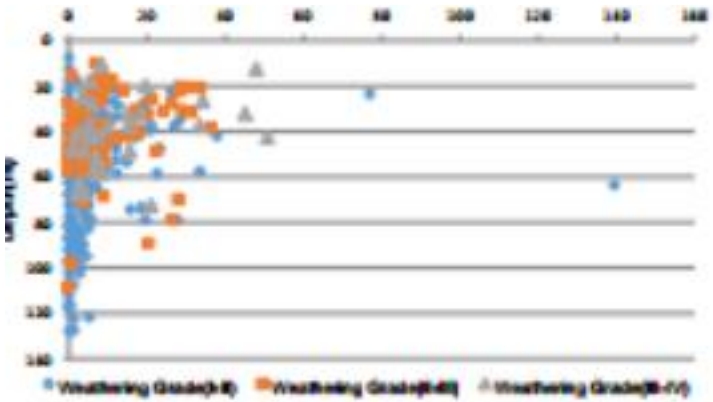
Samples and Test Pieces

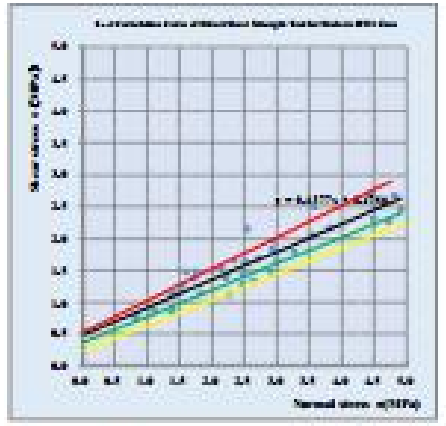












Some of the study results

Test conclusions:

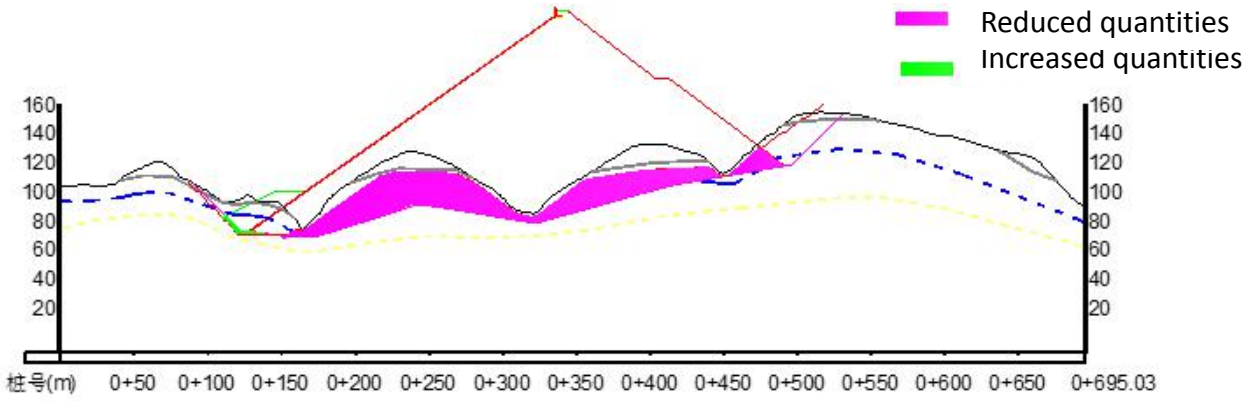
1. For the highly weathered rock, although the deformation test shows that its deformation modulus is generally higher than that of rockfill materials, its shear strength is generally lower than that of dam rockfill.

2. Under the action of higher loads, the dam foundation may cause sliding failure, especially shear expansion damage at the toe of upstream and downstream slopes, so the stability of dam foundation has to be checked.

In the check calculation, two foundation surface schemes are adopted:

Scheme 1 : higher foundation surface, keeping the highly weathered layer of dam foundation, and building the dam foundation at 2m below the interface between CW rock and HW rock ;

Scheme 2: lower foundation surface, removing the highly weathered layer of dam foundation, and building the dam foundation at 2m below the interface between HW rock and MW rock.



Comparison of excavation and filling quantities of typical sections

Study conclusions:

Dam stress & deformation behaviors and distribution laws in the two foundation surface schemes are the same, and that such behavior and safety of the dam can meet the requirements. so being high or low, the dam foundation surface exerts no substantive influence on dam stress deformation behaviors and dam safety.

While, higher foundation surface is of **less work quantities** and it can be taken as the **recommended scheme** .

The dam foundation optimization design is obviously more cost saving and it will shorten the construction period, and it has been **approved** by employer's consulting engineer from SMEC (Australia).

Thanks

Thanks for your time !

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