

## Diversion Tunnel Concrete Plug Implementation Aspects Associated with Reservoir Impounding of NN2 Hydro Electric Project, Laos

Lekhak, B.M., Ch. Karnchang Public Company Limited, Thailand,

lekha@rocketmail.com

Shakya, U., Ch. Karnchang Public Company Limited, Thailand

Nishimura, Y. Previously Ch. Karnchang Public Company Limited, Thailand

Shiraishi, N., Ch. Karnchang Public Company Limited, Thailand

Kitiyodom, P., Geotechnical & Foundation Engineering Co. Ltd., Thailand

### 1 INTRODUCTION

Nam Ngum 2 Hydroelectric Power Project with 181 m high concrete faced rock fill dam (CFRD) and 615 MW installed capacity located about 90 Km from the Vientiane has been fully commissioned since March 2011 (see the general site layout of the project in Figure 1). There are two 11.7 m diameter horse shoe shaped diversion tunnels on the left abutment named as DT1 and DT2 with respective length of 1,141 m and 1,262 m. These diversion tunnels with concrete plug system have been the core components of river diversion and impounding scheme of the project. This paper discusses the shear key provision in Diversion Tunnel to meet rigorous planning and implementation aspects associated with demanding concrete plug construction completion requirement against the quick rise of impounding/ flash flood related water head of 8 bar in 1 month and 10 bar in 1.5 month.

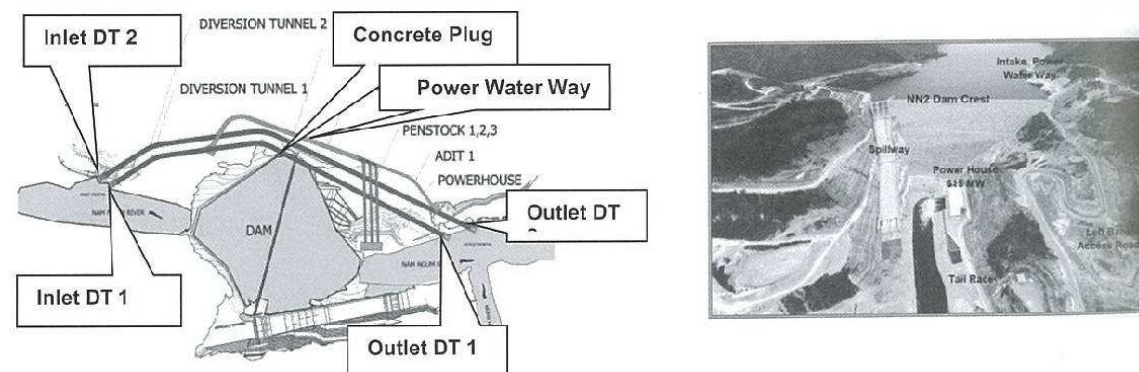


Figure 1 Nam Ngum 2 general site layout

### 2 PLUG CONSTRUCTION GENERAL PHILOSOPHY

The installation of the plug in the left diversion tunnel (No.2) could only be started once all the works for the permanent outlet works have been entirely completed. Last tunnel inlet would be closed by employing the roller gates recovered from the other inlet structure. This being one of the most critical stage in the whole operation, it was planned to be performed in a period of low flows. If this is not possible, two separate sets of stop logs would have to be provided, one for each inlet DT gates – which was too late at that point of time in the project.

The plugging work inside of the tunnel required construction of a heavily reinforced pre-plug, placing the grout and cooling water piping within the main plug body, placing the plug concrete, and grouting the gap created between the plug and the lining after the plug concrete has cooled off. Grouting campaign was planned to be followed after a period of at least one month after the plug concreting.

During the plugging operation in the left tunnel (DT No.2), impounding of the reservoir will have already made a quick rise of water level in V shaped valley. The outline design plan of above elevation 290 masl controlled impounding as necessary using the bottom outlet gates in order to prevent rapid rise in water level was not possible later due to detail design stage change.

### 3 IMPOUNDING COMMENCEMENT AND CONCRETE PLUG

Following issues involving construction constraints and time constraints related to reservoir impounding and plug construction were reviewed and adjusted to achieve successful completion in time:

- Dam Face Slab 2nd phase progress was ensured to start timely impounding and plug construction in March 2010 without any risk of losing 1 year with 2 times increased resources.
- Planning was implemented to work with only 1 set of Diversion Tunnel (DT) Inlet gate available to manage 2 DT inlet gates closure taking advantage of dry season low flows with cofferdam.
- DT1 partial plug construction was implemented first to establish and verify time cycle associated with designed plug concrete lift heights, reinforcement fixing, grouting pipe fixing, cooling pipe fixing arrangement in tight work area including temperature, shrinkage monitoring. In this regard, a special pump mix with significant higher amount of fly ash with controlled placement rate, heat of hydration and shrinkage crack concern with tailored cooling was worked out.
- Rate of uncertain rise in water level with impounding and flash flood was reviewed in depth for dry, wet and normal year rainfall case. In addition to that impounding water rise related to early flash flood was reviewed (see Figure 2 below).
- Carefully planned regrout valve placement, air release valve and back up grouting lines were installed to cover all Cavity grouting /re-grouting exercise 4 to 5 times since concrete placement.
- Achievable firm plug construction schedule of 4-6 weeks was established and followed up closely to meet 8 to 10 bar requirement in time and plug was completed successfully without any problem.

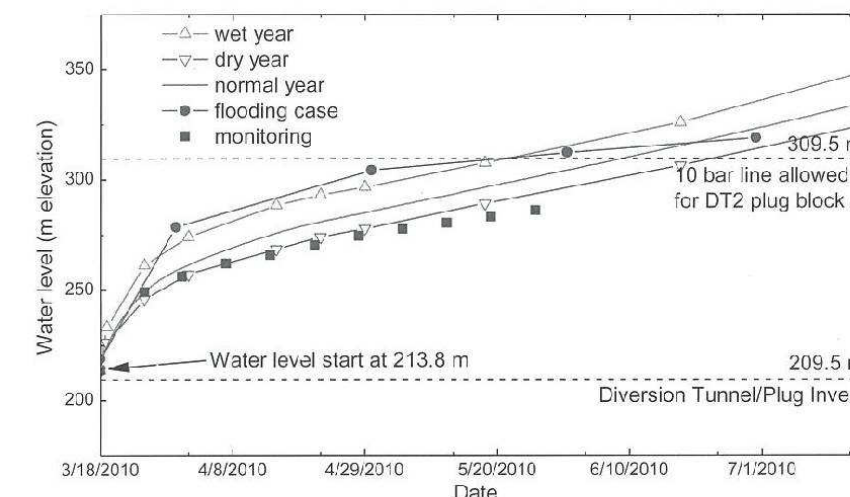


Figure 2 Reservoir Impounding Forecast Trend and Actual Water Rise Monitoring