
Annex 5:

Safety of Dams

Part A: Formation and Scope of a Dam Safety Review Panel (DSRP)

The MRC Preliminary Design Guidance for mainstream dams approved by the MRC Joint Committee in September 2009 calls for the establishment of an independent panel of experts for the investigation, design and construction of the dam and start of operations.

Lao PDR has established dam safety review panels for project that are supported by international financing institutions such as the World Bank and also non-World Bank projects, although under different names and a scope of work that is often limited to design reviews. A Dam Safety Review Panel (DSRP) was established for the Nam Theun II project. The NT2 Panel was given the authority to scrutinise and comment on the design, construction, commissioning, operation and maintenance of the Project to ensure that the Project conformed with requirements of the World Bank's Dam Safety Policy, including design, hydrology, engineering and downstream impacts. Members of the Panel regularly inspected project sites and facilities since the beginning of construction.

As noted in the MRC PDG, the proposed mainstream dams in the Lower Mekong Basin offer a range of new challenges for the safe design and operation of the proposed facilities and have transboundary implications. Broader guidance on establishing a DSRP that reflects the PDG and Lao PDR experience noted in the following;

Typical Composition of the Panel:

The Panel may have any name. Typically there may be at least three permanent members with wide and specialized experience which collectively covers the following fields:

- Engineering Geology
- Concrete Dam Design
- Embankment Dam Design
- Hydraulic Structures Design Layout and Operation
- Rock Mechanics and Design of Underground Works
- Concrete Technology
- Construction of Dams and Hydropower Facilities

When necessary, the Panel can be enlarged on a temporary basis by adding specialists with expertise in areas deemed important for a particular project such as: flood hydrology, sedimentology, seismology, seismic-related analysis and design, operation, monitoring or emergency preparedness planning, etc.

Functions:

The primary purpose of the Panel is to review and advise the project owner on matters related to dam safety and other critical aspects of the dam, its appurtenant structures, the catchment area, the area surrounding the reservoir, and downstream areas. The DSRP may also comment on any other matter which it perceives to be important to the successful design, construction and operation of the projects and to the long-term safety of the dams and appurtenances.

Scope of Concern:

The scope of the Dam Safety Review Panel reflects all aspects of dam safety. The Nam Theun 2 DSRP scope of activity offered as an illustration, is summarised as follows:¹

- **Flood Hydrology:** extent and sufficiency of data, methodology for derivation of extreme and design floods, procedures for routing floods throughout the reservoir and impact of floods downstream of the power plant;
- **Seismology:** identification of sources of seismic activity, assignment of earthquake magnitudes to each source, and methodology for derivation of vibration parameters at the site for maximum credible and design basis earthquakes;
- **Engineering Geology:** quality and sufficiency of the geological investigations and the interpretation thereof; correctness of the geological and hydrological models of the region, reservoir area and dam site; engineering implications with respect to foundation design, stability of natural and excavated slopes; and support of surface and underground excavations;
- **Rock Mechanics/Underground Excavations:** design of surface and underground excavations, including selection of stable slopes; appropriate shapes and orientations for underground excavations; and design of temporary and permanent support systems and linings;
- **Sedimentology:** estimates of sediment load that will enter the reservoir; method of operation of the reservoir to provide sediment storage in the short term and systematic scouring of the downstream channel over the long term, and likelihood of achieving desired effect;
- **Dam Design:** adequacy of field and laboratory investigations in relation to materials for construction of the dam and cofferdams, appropriateness of materials selected, proportioning and composition of the various zones, static and dynamic analyses of the dam section; selection of foundation levels, proposed measures of forming cutoffs in and drainage of the foundations and abutments; construction procedures specified in relation to the dam and its foundations, instrumentation of the dam and proposed monitoring programme;
- **Hydraulic Design:** hydraulic design and specifications of the spillway and energy dissipation facilities, diversion, power conduit and drawdown facilities, regulating pond and tailrace facilities;
- **Planning and Design of Dams and Hydropower Facilities:** overall layout of the Project; design criteria; specifications; design of hydraulic structures; diversion scheme and sizing of its various components; capacity of the spillway and drawdown and tailrace facilities; procedures for routine inspection of the dam and checking safety of structures, including the organisation and staffing of the inspection agency;
- **Construction of Dams and Hydropower Facilities:** Construction planning studies, temporary facilities, access to the site, master schedule for implementation, conditions of contract; contractors proposals in relation to construction procedures, schedule, river diversion; organisation, staffing and procedures for managing the construction of the Project, methodology and organisation for quality control of the construction;

¹ Annex N: Environmental & Social Panel of Experts, Dam Safety Review Panel & International Advisory Group, NT2 Project in Lao PDR

- **Concrete Technology:** Adequacy of testing of concrete materials, and their suitability for use in the works, specifications for concrete, mix design and quality control procedures; and
- **Specifications and manufacturers' proposals:** for turbines, generators and mechanical and electrical equipment in the PowerStation and switchyard, with particular emphasis on design provisions for turbines operating in sediment laden water, and state of the art design of generators, switchgear and control systems.

The DSRP will also review the various detailed plans required to be prepared in accordance with the plan for construction supervision and quality assurance, the instrumentation plan, the operation and maintenance plan, and an emergency preparedness plan.

Part B: Elaboration on Codes and standards in the Project Design.

The Design Report (Annex II shared with MRCS) provides the main engineering calculations and names the various codes and standards applied. The Design Report comprehensively presents and elaborates technical criteria relevant to dam safety in a number of sections as noted in the main PC Review report.

Each of the criteria has an element of dam safety and performance embodied in them. The Design Report notes that the Lao Electric Power Technical Standards are the primary general design code met. In addition, the Design Report explained that the Lao standards require internationally recognized design codes, design manuals and specifications, which have been taken into account in establishing the specific design criteria.²

To illustrate this further, Section B4.2 of the Design Report notes that design of geotechnical works which includes earthquake design standards is made in accordance with the following international codes and standards:

- **United State Army Corps of Engineers (USACE)**
 - EM 1110-1-2908: Rock Foundations
 - EM 1110-2-3506: Grouting Technology
 - EM 1110-2-1605: Hydraulic Design of Navigation Dams
 - EM 1110-2-1902: Slope Stability
 - EM 1110-2-2006: Roller-Compacted Concrete
 - EM 1110-2-2200: Gravity Dam Design
 - EM 1110-2-2300: General Design and Construction Considerations for Earth / Rock-Fill Dams
 - EM 1110-2-2502: Retaining and Flood Walls

² The Design Report notes in North American and Western European practice there are no codes or standards strictly regulating design of hydropower projects. There are various guidelines developed by different entities for their own use and adopted by others, commonly with modifications for specific project requirements. The Design Report state the most commonly referenced guidelines (which implies also they rely upon them) include those published by (i) the US Army Corps of Engineers (USACE): Engineering Manuals, Engineering Pamphlets, Regulations, Engineering Technical Letters (ii) US Bureau of Reclamation (USBR): Design of Gravity Dams, other publications, and (iii) Federal Energy Regulatory Commission (FERC): Engineering Guidelines for the Evaluation of Hydropower Projects, other publications (iv) Canadian Dam Association: Dam Safety Guidelines (v) American Concrete Institute (ACI): Standard Specifications and Recommended Practices (vi) American Society for Testing and Materials (ASTM): testing specifications and (v) International Committee on Large Dams (ICOLD): guidelines and recommendations.

- EM 1110-2-2503: Design of Sheet Pile Cellular Structures Cofferdams and Retaining Structures
- **Federal Energy Regulatory Commission (USA-FERC):**
 - Engineering Guidelines for Evaluation of Hydroelectric Projects
- **Federal Emergency Management Agency (USA - FEMA):**
 - Federal Guidelines for Dam Safety: Earthquake Analyses and Design of Dams
 - The National Dam Safety Program Research Needs Workshop: Seepage Through Embankment Dams
- **International Commission on Large Dams (ICOLD):**
 - The Specification and Quality Control of Concrete for Dams
 - A Review of Earthquake Resistant Design of Dams
 - Finite Element Methods in Analysis and Design of Dams
 - Seismicity and Dam Design
 - Earthquake Analysis Procedures for Dams
 - Static Analysis of Embankment Dams
 - Selecting Seismic Parameters for Large Dams
- For major structural components, such as the spillway and powerhouse sections, the design parameters and various safety factors are detailed.

The Design Report similarly describes the various international codes and design standards applied to the major hydraulic and civil engineering works, including results of the stability analysis, loadings and factors of safety (for permanent and temporary structures), as well as performance standards applied for electrical, hydro-mechanical equipment (including navigation lock and spillway gates, stop logs, and control systems). Specifications are provided for all project components normally considered at EPC design stages including the electro-mechanical equipment in the plant, hoist equipment and cranes, etc., and other equipment connected with the safe operation of the critical dam structures in flood situations.

The Design Report notes the dam facilities, including spillway controls would be back up by an emergency diesel generator to ensure operation in event of outages at critical times. The instrumentation scheme to monitor the integrity of the various dam structures in operation is set out, such as to measure deflections and stresses in structures for navigation locks, spillways, the intermediate block, powerhouse, as well as abutments, etc. The stated aim of the instrumentation is (i) to compare the behaviour of the structures with design assumptions, and (ii) to detect any unusual behaviour at an early stages. The Design Report notes that, apart from the instrumentation readings, visual inspections of all structures needs to be carried out at regular intervals.

Within the scope of the PC Review, it is mentioned that no attempt is made to provide any engineering or risk assessment of how the various technical codes and standards may translate to the safe design of the project components, or performance and safe operating modes.

It is only stated that the Design Report demonstrates the extensive use of a wide range of internationally accepted technical standards and the Lao PDR Guidelines for technical standards and Safety Rules consistent with the PDG approach. For the purpose of the PC Review, the main observation on the technical design and standards is the PDG calls for an independent panel of experts to review the design and all provisions with regard to dam safety, from early stages.

Moreover, responsibility is placed on the owner / operators to adopt safe design standards and operating practices consistent with Lao PDR requirements and accepted international practice. The PDG states the general principle where, for the life of any dam, the owner is responsible for ensuring that all appropriate measures are taken and sufficient resources are provided for the safety of the dam, irrespective of its funding sources or construction status.