ICS 27.140
CCS P 59

NB

ENERGY INDUSTRY STANDARD OF THE PEOPLE'S REPUBLIC OF CHINA

NB/T 11559.2-2024

Guidelines for finite element analysis of hydropower projects - Part 2: Embankment dams

水电工程有限元数值分析导则 第2部分：土石坝

Issued on: May 24, 2024 **Implemented on: November 24, 2024**

Issued by: National Energy Administration of the PRC

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Foreword

This document was issued on 24 May 2024 by the National Energy Administration of the PRC and takes effect on 24 November 2024.

It is a NB/T standard: recommended rather than compulsory, but it is the text a Chinese reviewer applies when assessing a submission.

It is classified under ICS 27.140, Chinese classification P 59.

This document was drafted in accordance with the rules given in GB/T 1.1-2020 Directives for standardization - Part 1: Rules for the structure and drafting of standardizing documents.

This document is Part 2 of NB/T 11559 Guidelines for finite element analysis of hydropower projects.

Please note that some of the content of this document may be the subject of patent rights. The issuing body of this document assumes no responsibility for identifying patents.

This document is administered by the National Energy Administration and was proposed by the General Institute of Hydropower and Water Resources Planning and Design.

1 Scope

NB/T 11559.2-2024 is the Chinese guideline for finite element analysis of embankment dams, the second part of the NB/T 11559 series. It exists because the safety case for a modern rockfill dam rests on a computer model, and a computer model is only as trustworthy as the choices made in building it. Two competent engineers analysing the same dam can reach materially different answers by choosing different constitutive models, different meshes or different boundary conditions, and each can defend the result; the regulator is then left comparing incomparable numbers. This document narrows that freedom. It fixes the analysis workflow as a defined sequence - data collection, geometry model and meshing, constitutive models and parameters, initial and boundary conditions and loads, analysis settings, computation, then presentation and evaluation - with an explicit loop back to recomputation whenever the results fail a reasonableness check. It enumerates the analyses an embankment dam may require and how they subdivide:

seepage analysis into steady and unsteady, stress and deformation analysis into static and dynamic, with static further covering wetting analysis for the collapse settlement that occurs when rockfill is first saturated and creep analysis for the deformation that continues for decades after construction, and sliding stability analysis into static and dynamic. It specifies the data that must be collected at each project stage in a detailed table covering hydrology and sediment, topography and geology, seismic parameters, in situ and laboratory test data, hydraulic engineering data and construction records down to the rolling parameters and compaction indicators. It then sets requirements for geometry modelling and meshing, for the seepage and stress-deformation constitutive models and the determination of their parameters, for the calculation cases and methods, for verification of results, and for the analytical and safety evaluation and the report. Two informative annexes give the constitutive models themselves: the static models, including Duncan-Chang E-v, Duncan E-B, the Tsinghua decoupled K-G, the HHU K-G and the Shen Zhujiang double yield surface model; and the unified static and dynamic models, including generalised plasticity, proportional memory elastoplastic, cyclic elastoplastic and concrete plastic damage. It also requires that models, parameters and results be kept in a managed database so that they can be reused for whole life cycle tracking of the dam. It was issued on 24 May 2024 by the National Energy Administration and took effect on 24 November 2024.

This document specifies the basic content and the requirements of finite element numerical analysis of embankment dams.

This document applies to finite element numerical analysis of embankment dams.

2 Normative references

The contents of the following documents constitute indispensable provisions of this document through normative reference in the text. For dated references, only the edition corresponding to that date applies to this document. For undated references, the latest edition, including all amendments, applies to this document.

GB/T 51394 Standard for loads on hydraulic structures

NB 35047 Code for seismic design of hydraulic structures of hydropower projects

3 Terms and definitions

The following terms and definitions apply to this document.

3.1 finite element method, FEM

The numerical analysis method in which the solution domain is discretised into a finite number of elements and meshed into a computational model, so as to solve approximately for the physical and mechanical state or behaviour of the object analysed.

3.2 geometry model

The model formed by the basic geometric entities of points, lines, surfaces and volumes, which reflects the configuration, the dimensions and the other geometric characteristics of the object studied.

3.3 contact element, joint element

The element that simulates the contact interaction between interfaces.

3.4 constitutive model

The mathematical expression that reflects the mechanical behaviour of a material, generally in the form of a stress-strain relationship.

4 Overall requirements

4.1 The finite element analysis of an embankment dam may comprise seepage analysis, stress and deformation analysis and sliding stability analysis, carried out in accordance with the requirements of the relevant codes. Seepage analysis may comprise steady seepage analysis and unsteady seepage analysis. Stress and deformation analysis may comprise static analysis and dynamic analysis, and static analysis may further comprise wetting analysis taking account of the wetting effect and creep analysis taking account of the creep effect. Sliding stability analysis may be divided into static sliding stability analysis and dynamic sliding stability analysis.

4.2 The determination of the type of finite element analysis of an embankment dam and of the method of analysis shall take comprehensive account of the importance of the project and of the characteristics, the purpose and the requirements of the stage the embankment dam project has reached, whether design, construction, impounding or operation. Parameter sensitivity analysis may be carried out where necessary.

4.3 Where an overburden layer is present in the dam foundation, the initial stress field of the overburden shall be determined, and may generally be taken as the self-weight stress field.

4.4 A database or file management system should be established for the finite element analysis, so that the geometry model, the mesh model, the calculation parameters, the analysis results and the analysis report are managed in a unified way, so that models and parameters can be reused, and so that the needs of whole life cycle state tracking analysis and safety evaluation of the embankment dam project are met.

5 Analysis workflow

5.1 The finite element analysis of an embankment dam should be carried out in the following steps: data collection; creation of the geometry model and meshing; determination of the constitutive models and parameters; initial conditions, boundary conditions and application of loads; analysis settings; computational analysis; and presentation of results and analytical evaluation.