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Original research article

Deformation features of a super-high arch dam structural system

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ABSTRACT

The interaction among the dam body, dam foundation and dam basin under the collaborative effect of multiple complicated external factors can significantly influence dam deformation. Based on the analysis of the super-high arch dam structural system characteristics, a model for calculating and analysing the dam-body foundation basin was established. The deformation modulus of the dam basin and the comprehensive deformation modulus were inversely calculated. By extensively considering the effect of a complicated load on the super-high arch dam structural system, the distribution features and variation law of dam deformation under different overloading conditions were studied with the overloading approach. Moreover, the actual deformation features of the super-high arch dam structure were analysed based on a super-high arch dam engineering project.

1. Introduction

As an overall compressed structure, the super-high arch dam body has complicated mechanical features, which are influenced by several unknown factors, as compared with common arch dam deformation [1,2]. Given the high elevation and thin structures of super-high arch dams, the dam body suffers from high-stress levels while the overall structure rigidity is relatively small. The different properties of dam materials have been completely explored. Any local failure will lead to changes in the final failure development. Several analyses have shown that when the dam body, dam foundation and dam basin are used as the overall structural system, the interaction among these components under the collaborative effect of multiple complicated external factors will significantly influence the dam deformation [3].

Existing simulation results are mostly based on the dam body-foundation system analysis model [4]. However, these simulations neglect the effect of dam basin deformation on the dam. The results are not the actual overall model of the super-high arch dam structural system. Therefore, model simulation analysis of the overall arch dam deformation based on existing research results is necessary. In addition, a super-high arch dam often suffers various non-conventional loads and impact from the unique factors during the service period, with the exception of conventional loads. The exploration of the distribution law of deformations under the collaborative effect of possible accidental and unfavourable loads, as well as the evolutionary process of the dam deformation state, are necessary to comprehend the deformation features of the arch dam during the service period.

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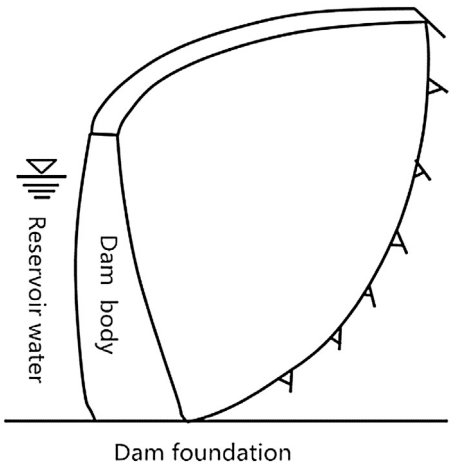

Fig. 1. Sketch of the dam system.

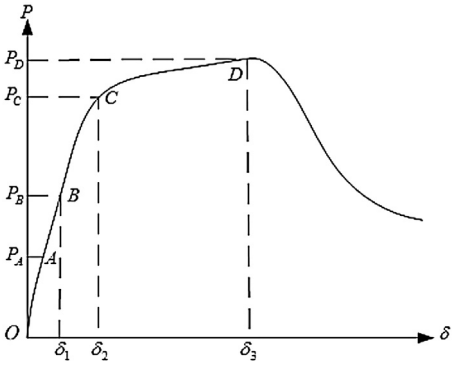

Fig. 2. Progressive process of arch dam deformation.

2. Numerical simulation of the deformation of a super-high arch dam

2.1. System characteristics of the dam structure

The super-high arch dam system is composed of the dam body, dam foundation and dam basin, as well as the load and surrounding environmental influence [5] (Fig. 1). A dam is an open and complicated vast engineering system, which is comprised of a variety of subsystems [6]. During its service period, the dam has "open" exchanges with the surrounding substances and energies, as mainly manifested by the following aspects:

2.1.1. Coupling properties of the system

The dam system involves the coupling of micro-/meso-/macro-sized multi-scales and multi-level subsystems. The overall progressive process of the super-high arch dam structure is a collaborative effect of the self-evolution of complicated microstructures with different scales and regions. The evolution of different dam positions is not independent. The regional state is restricted by the integral behaviour, which is the collaborative consequence of numerous regional states.

2.1.2. Progressive process of the arch dam structure

In practical engineering, the progressive process of a super-high arch dam structure can be divided into four general stages (Fig. 2): the linear elasticity working stage (OA), the quasi-linear elasticity working stage (AB), the local yield deformation stage (BC) and the deformation failure stage (CD) [7].

2.1.3. Adaptive adjustment features

The super-high arch dam is an indeterminate thin-shell compressed structure. During the progressive process of the arch dam system, the dam body has distinctive adaptive adjustment features. Macro-mechanical properties of the dam structure refer to adaptive responses of internal parts to various effects based on cooperation. During the service period of the dam, the internal structure will adaptively adjust with the changes of external environment and loads. The stress states of different

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