产品类成果
高混凝土坝数值仿真及优化软件

【创新性】

　　仿真软件完整模拟基岩开挖、回填支护、浇筑硬化、温度控制、封拱灌浆、时效变形、分级蓄水、长期运行和边界环境变化等 9 个过程，具备渗流 − 温度 − 应力多场耦合、弹塑性和损伤、缝的开合迭代分析功能，全面实现了高混凝土坝全生命期仿真和安全评估；计算规模大，网格规模超过亿级自由度，并行能力达到数百核；计算效率高，单机可实现千万自由度规模计算；提出并实现了复杂地质构造的网格切割建模，极大提高了建模效率。优化软件提出了合理实用的数学模型与高效计算方法，国际上首次将拱坝优化完全实用化；在相同安全度下提出的优化设计方案与原方案相比节省坝体投资 5%~30%。

【影响力】

　　仿真软件 saptis 在国内 100 余座高混凝土坝中得到应用，国内全部 14 座 200m 以上已建在建混凝土坝 13 座应用该软件，小湾、锦屏、溪洛渡、乌东德、白鹤滩等特高拱坝和向家坝、黄登、丰满等重力坝在施工及运行初期全程跟踪仿真；除坝工领域外，在升船机、渡槽、水闸等复杂水工结构中得到广泛应用，如三峡、向家坝、龙滩等大型升船机，南水北调中线、黔中调水系列渡槽等。软件在水工结构领域备受认可，影响广泛，以该软件为基础，成功获批国家十三五重点研发专项"高性能计算"−复杂工程力学高性能应用软件系统研制项目。优化软件 ADASO 在小湾、拉西瓦、QBT、东庄等 100 余座拱坝体型设计分析中得到应用，获 1988 年国家科技进步二等奖。仿真及优化软件已纳入《水工设计手册》中。

主要完成人：张国新、贾金生、朱伯芳、邱永荣、刘　毅、
　　　　　　周秋景、张　磊、杨　波、程　恒、刘有志
受奖单位：水电中心／结构材料所

NUMERICAL SIMULATION AND OPTIMIZATION SOFTWARE FOR HIGH CONCRETE DAMS

【 Innovation 】

　　The simulation software can fully simulate the nine processes, including base rock excavation, backfill support, casting hardening, temperature control, closure grouting, time-dependent deformation, hierarchical water storage, long-term operation and boundary environment change, and possesses functions of seepage−temperature−stress field coupling, elastoplasticity and damage, seam opening and closing iteration analysis, thus comprehensively achieving the full life cycle simulation and safety evaluation for high concrete dams. The computing scale is large, with the grid scale exceeding a hundred million degrees of freedom and the parallel capacity reaching several hundred cores. The computing efficiency is high, with a single unit able to achieve the computing scale of ten million degrees of freedom. It has put forward and realized the mesh cutting modeling for complicated geological structures, which has significantly improved the modeling efficiency. The optimization software has proposed rational and practical mathematical models and high-efficient calculation methods, and achieved the fully practical optimization of arch dams for the first time in the world. Under the same degree of safety, optimal design plans can save dam investment by 5%−30% over common design plans.

【 Influence 】

　　The simulation software saptis has been applied in nearly 100 high concrete dams of China. 13 out of the total 14 concrete dams of over 200 meters in China that have been constructed or are under construction have used this software; ultrahigh arch dams, such as Xiaowan, Jinping, Xiluodu, Wudongde and Baihetan, and gravity dams like Xiangjiaba, Huangdeng and Fengman have adopted the tracking simulation during construction and in the early days of operation. Except the dam engineering sector, the software has been widely applied in complicated hydraulic structures, such as ship elevator, aqueduct and floodgate, such as large ship elevators for the Three Gorges, Xiangjiaba and Longtan dams and aqueducts for the middle route of South-to-North Water Transfer Project, and water transfer project in central Guizhou. The software is highly recognized in the hydraulic structure sector and brings about profound influence. Based on this software, the research center was approved to establish a research project of high-performance application software and systems for complicated engineering mechanics under a national key "high-performance computation" R&D program during the 13th Five-Year Plan period. The optimization software ADASO has been applied in the shape design analysis of nearly 100 arch dams, such as Xiaowan, Laxiwa, QBT and Dongzhuang, and won the second prize of the National Science and Technology Progress Award in 1988. The simulation and optimization software have already been included in the Hydraulic Design Manual.

Main Contributor : Zhang Guoxin, Jia Jinsheng, Zhu Bofang, Qiu Yongrong,Liu Yi
Zhou Qiujing, Zhang Lei, Yang Bo, Cheng Heng, Liu Youzhi
Award-winning Unit : Research Center for Sustainable Hydropower/Department of Structures and Materials