UDC

SL

Standard of Ministry of Water Resources of the People's Republic of China

P

SL 282—2003

Design Specification for Concrete Arch Dams

Issued on March 9, 2003

Implemented on June 1, 2003

Issued by Ministry of Water Resources of the People's Republic of China

SL

Standard of Ministry of Water Resources of
the People's Republic of China

SL 282—2003

Design Specification for Concrete Arch Dams

Drafted by:

Shanghai Investigation, Design & Research Institute

Changjiang Institute of Survey, Planning, Design and Research of Changjiang Water Resources Commission

Translated by:

Shanghai Investigation, Design & Research Institute

Beijing 2015

中国水利水电出版社
www.waterpub.com.cn

图书在版编目（CIP）数据

混凝土拱坝设计规范 = Design Specification for Concrete Arch Dams SL282-2003 : 英文 / 中华人民共和国水利部发布. -- 北京 : 中国水利水电出版社, 2015.1
ISBN 978-7-5170-2957-1

Ⅰ. ①混… Ⅱ. ①中… Ⅲ. ①混凝土坝－拱坝－设计规范－中国－英文 Ⅳ. ①TV642.4-65

中国版本图书馆CIP数据核字(2015)第035228号

书　　名	**Design Specification for Concrete Arch Dams** **SL 282—2003**
作　　者	中华人民共和国水利部　发布
出版发行	中国水利水电出版社 （北京市海淀区玉渊潭南路 1 号 D 座　100038） 网址：www.waterpub.com.cn E-mail：sales@waterpub.com.cn 电话：（010）68367658（发行部）
经　　售	北京科水图书销售中心（零售） 电话：（010）88383994、63202643、68545874 全国各地新华书店和相关出版物销售网点
排　　版	中国水利水电出版社微机排版中心
印　　刷	北京瑞斯通印务发展有限公司
规　　格	140mm×203mm　32 开本　4.75 印张　166 千字
版　　次	2015 年 1 月第 1 版　2015 年 1 月第 1 次印刷
定　　价	**278.00** 元

Introduction to English Version

Department of International Cooperation, Science and Technology of Ministry of Water Resources, P. R. China has the mandate of managing the formulation and revision of water technology standards in China.

Translation of the specification from Chinese into English was organized by Department of International Cooperation, Science and Technology of Ministry of Water Resources, P. R. China in accordance with due procedures and regulations applicable in the country.

This English version of specification is identical to its Chinese original SL 282—2003 *Design Specification for Concrete Arch Dams*, which was formulated and revised under the auspices of Department of International Cooperation, Science and Technology of Ministry of Water Resources, P. R. China.

Translation of this specification is undertaken by Shanghai Investigation, Design & Research Institute.

Translation task force includes Lu Zhongmin, Liang Hongli, Xuan Chuan, Gao Ying, Xiao Gongyuan, Wu Xiaomei, Yang Shuiqin and Bai Baozhong.

This specification is reviewed by Xu Zeping, Qiao Shishan, Meng Zhimin, Jin Hai, Hao Zhao, Wang Yichen, Sun Feng, Zhu Dangsheng and Zhang Guoxin.

Department of International Cooperation, Science and Technology

Ministry of Water Resources, P. R. China

Foreword

According to the plan to formulate and amend the technical standards issued by Ministry of Water Resources in 1997, *Document No. 7 (1997) —Notice on Distribution of Relevant Documents Concluded in the Work Meeting for Technical Standards of Investigation and Design of Water Resources and Hydroelectric Power* issued afterwards by the Water Resources and Hydroelectric Power Planning & Design Administration, and SL 01—97 *Specification for the Drafting of Technical Standards of Water Resources*, we have amended the SD 145—85 *Design Specification for Concrete Arch Dams*.

The major contents of SL 282—2003 *Design Specification for Concrete Arch Dams* revised in this version include:

—Selection of dam shape, type of flood release structures and layout of arch dam.

—Hydraulic design for flood release, energy dissipation and scour prevention.

—Loads on arch dams and load combinations.

—Contents and methods for stress analysis of arch dams and stress control criteria.

—Stability against sliding and deformation stability of abutments and corresponding safety criteria.

—Excavation, grouting, seepage control and drainage of a dam foundation, treatment of the foundation with faults and weak rock zones.

—Design of appurtenances on dam crest, joints, galleries, water seals, drainage, etc.

—Concrete material, temperature control criteria and measures.

—Design principle of safety monitoring, monitoring items and layout of monitoring facilities.

The major revision and complement to the specification SD 145—85 are as follows:

—Adding a chapter of terms and symbols and deleting of Annex 5 to the original specification.

—Adding that the flood release structures attached to dam should be the first choice for the layout of flood release structures of arch dams, and the influence of engineering geological factors is emphasized in the layout of arch dams.

—Adding a few arch types with variation in thickness and curvature in the shape design, and adding the description of the relationship between the design of crown cantilever cross-section and the layout of surface spillway.

—Deleting Note 5 for flood release arrangement in the text of the original specification, while the other notes are incorporated into the commentary of articles, adding that adverse impact caused by flood release atomization shall be highly concerned.

—Presenting the flood control criteria and the discharge capacity separately in the chapter of Hydraulic Design, adding the requirements of the layout consisting of several water release structures and that of the combined energy dissipation by the outlets through dam.

—Adding the design requirement of the plunge pool for energy dissipation and scour prevention; emphasizing the protection and scour prevention of the river channel subject to scouring downstream of the energy dissipator.

—Adding two usual load combinations and two unusual load combinations where designed normal temperature rise has been included.

—Emphasizing that calculated results by finite element method (FEM) shall also be used as the main criteria to evaluate the strength and safety of an arch dam, and adding the stress control criteria for the calculation by FEM.

—Confirming the fact that there is no risk of sliding along the foundation plane of an arch dam under normal conditions, therefore, the requirement for which to be a control index for design is deemphasized.

—Adding the principle of dam foundation treatment and the requirement of grouting curtain in karst region; relaxing the requirement for weathering depth of bedrock during foundation excavation; adding the content that the dam should be studied together with the bedrock for the treatment of fractured zones of fault and weak intercalated layers; and adding the high-pressure cement grouting, high-pressure jet grouting, etc. as the measures to treat the fractured zones of fault.

—Emphasizing the requirement for the lowest elevation of dam crest; relaxing the spacing for transverse and longitudinal joints; proposing the curved key groove for transverse joints and the construction method of plastic drawn tube; adding the requirements of fire control and supplementing the requirements for water seals of dam and foundation.

—Deleting the general requirements of dam concrete, confirming that the strength shall be the main control index for concrete zoning by grades; utilizing the new calculation method of temperature control; adding the basis on which temperature control criteria and measures are formulated; confirming the factors to determine the thickness of placement lift; supplementing the specific measures to control temperature.

—Renaming the original chapter of "Observation Design" to "Safety Monitoring Design"; deleting the original Annex 4; correcting the classification of observation tasks by their features; specifying clearly the scope of safety monitoring; adding the principles for safety monitoring design; adjusting the special monitoring items and adding the installation requirements of major monitoring devices.

The provisions printed in boldface are compulsory and must be enforced strictly, including Article 6. 3. 1, Article 6. 3. 2, Article 6. 3. 3, Article 7. 2. 7, Article 8. 4. 6, Article 8. 6. 6, and Article 9. 1. 1.

This specification is interpreted by General Institute of Water Resources and Hydropower Planning and Design, Ministry of Water Resources.

This specification is chiefly drafted by Shanghai Investigation, Design & Research Institute and Changjiang Institute of Survey, Planning, Design and Research of Changjiang Water Resources Commission.

Chief drafters of this specification are Zhong Yuanqing, Zhang Liangqian, Liu Shikang, Liao Renqiang, Miao Qinsheng, Bai Baozhong, Cao Quxiu, Zhang Zhiqi, Chen Zaimin, Fan Wuyi, Zhang Zhiyong, Tang Shuming, Hu Zhongping, and Wan Xuejun.

Contents

1 General Provisions

1.0.1 To keep pace with the development of concrete arch dams construction and standardize the design requirements for concrete arch dams, this Specification is prepared on the basis of amendment to SD 145—85 *Design Specification for Concrete Arch Dams*, so that the engineering design could be safe and applicable, feasible in economy, advanced in technology, and reliable in quality.

1.0.2 The classification of concrete arch dams shall conform to SL 252—2000 Standard for Classification and Flood Control of Water Resources and Hydroelectric Projects.

1.0.3 This Specification is applicable to the design of Class 1, Class 2 and Class 3 concrete arch dams of hydroprojects, and may also be applied as a reference for the design of Class 4 and Class 5 concrete arch dams. For concrete arch dams of over 200 m in height or those with particular conditions, special studies shall be conducted.

1.0.4 Concrete arch dams classified with respect to their height are low ones below 30m, medium-high ones between 30m and 70m, and high ones over 70m respectively.

1.0.5 Based on the ratio of base thickness to height, concrete arch dams are classified as thin ones less than 0.2, medium-thick ones from 0.2 to 0.35 and thick ones (or referred to as gravity arch dams) over 0.35 respectively.

1.0.6 In the design of concrete arch dams, great attention shall be paid to the issues below:

1 The basic data on dam site and its vicinity concerning meteorology, hydrology, sediment, topography, geology, earthquake, construction materials, ecology, environmental protection, industrial hygiene, planning for rivers, construction, operation, etc. especially the engineering geological and hydro-geological conditions in relation to the abutments.

2 The analysis on stability and stresses of the dam, and the selection of a proper dam shape.

3 The safety design of flood control for dams and the design of flood release structures, energy dissipation and scour protection; the structural problems caused by using dam body as flood release structures of thin arch dam.

4 The facilities for emptying reservoir or lowing reservoir water level; and the aseismic design of arch dams in earthquake zones.

5 The construction conditions concerning the facilities of river diversion, flood control, concrete placement, access, transportation, etc. the requirements for quality and temperature control of concrete; and the sequence of dam concrete placement and joint grouting, stability and stresses of the dam during the construction and reservoir impoundment, and the safety in flood season.

6 The monitoring system and monitoring design.

1.0.7 In addition to this specification, the design of concrete arch dams shall also conform to other relevant national and industrial standards.

2 Terms and Symbols

2.1 Terms

2.1.1 Arch dam

A curved dam that curves upstream in plane and transfers loads mainly to abutments.

2.1.2 Ratio of thickness to height

The ratio of dam thickness at the base of crown cantilever to dam height.

2.1.3 Arch dam shape

The type, shape and dimensions that an arch dam adopts, including vertical section shape of crown cantilever and horizontal section shape of arch. They are referred to as "type of cantilever" and "type of arch" respectively.

2.1.4 Single-curvature arch dam

Arch dams curved in horizontal section only.

2.1.5 Double-curvature arch dam

Arch dams curved in both horizontal section and vertical section.

2.1.6 Variable-curvature arch dam

Arch dams with its horizontal arch shape of parabola, ellipse, hyperbola, multi-centered circle, logarithmic spiral, unified quadratic curve or other variable curvatures.

2.1.7 Central angle of arch

Sum of the right and left half central angles, of which each is formed by the central line of a dam and the radial line of an arch axis at a spot where they are intersecting with the abutments.

2.1.8 Mean concrete temperature of section

The mean concrete temperature through the thickness of a horizontal arch.

2.1.9 Equivalent linear temperature difference

Temperature difference between upstream and downstream faces described by the linear temperature distribution which is converted from the measured temperature distribution under the principle of area moments of distribution graph being equal through the thickness of a horizontal arch.

2.1.10 Normal design temperature drop/temperature rise

Temperature difference between minimum/maximum average monthly temperature of the year at a guarantee rate of 50% and long-term average monthly temperature. The annual variable amplitude of long-term average temperature can also be adopted.

2.1.11 Trial load method

An analysis method to define the load distribution on arch and cantilever by dividing an arch dam into the horizontal arch system and the cantilever system in accordance with the condition of equal displacement of the two systems at their intersections.

2.1.12 Finite element method (FEM)

A computer-based numerical analysis technique by using a discretization model that composes the elements connected at points of junction to approximate a continuum formed by infinite micro-cells.

2.1.13 Equivalent stress of finite element method

The stress components gained by FEM are converted into the corresponding section's internal forces by integration through the thickness of dam. The stress then calculated by material mechanics method is the equivalent stress of finite element.

2.1.14 Limit equilibrium method

An analysis method to calculate safety factor of stability against sliding along slip surface by taking the possible sliding rock mass as a rigid body and adopting limit equilibrium principle.

2.1.15 Abutments

Rock mass of two banks where an arch dam is located, covering the parts where a dam directly placed and the certain upstream and downstream portions nearby.

2.1.16 Stability of abutments

The abutments' stability against sliding, deformation stability and stability against seepage.

2.1.17 Thrust block

A structure locating between dam and bedrock used for transferring thrust of arch abutment to bedrock, which is applied to the site with unfavorable topography or geological defects.

2.1.18 Pad

A concrete structure laid between dam and bedrock which is wider than the thickness of arch dam.

2.1.19 Peripheral joint

A joint placed at interface between arch dam and riverbed as well as concrete pads on bank side.

2.2 Symbols

2.2.1 Loads

$\sum N$—resultant force perpendicular to slip surface;

$\sum T$—resultant force along slip surface;

P_x—horizontal component of resultant centrifugal force at a bucket of overflow dam;

P_y— vertical component of resultant centrifugal force at a bucket of overflow dam;

P_{sk}—silt pressure;

P_{wk}—wave pressure;

F_{bk}—dynamic pressure by ice striking on dam face;

P_m—intensity of fluctuating pressure;

P_d—impact force acting on baffle blocks.

2.2.2 Material properties

f_1—frictional coefficient of shearing rupture on slip surface;

c_1—cohesion of shearing rupture on slip surface;

f_2—frictional coefficient of shear on slip surface;

λ_c—thermal conductivity of concrete;

C_c—specific heat of concrete;

a_c—temperature diffusivity of concrete;

β_c—heat emission coefficient of concrete surface;

E_C—elastic modulus of concrete;

E_R—deformation modulus of bedrock;

γ_c—unit weight of concrete;

ρ_c—concrete density;

μ—Poisson's ratio of concrete;

α—linear expansion coefficient of concrete;

ε_p—extensibility of concrete;

γ_w—unit weight of water;

ρ_w—water density;

C_w—specific heat of water;

γ_{sb}—submerged unit weight of sediment;

γ_{sd}—dry unit weight of sediment;

φ_s—internal friction angle of sediment.

2.2.3 Geometric features

A—area of calculating slip surface;

A_k—area of exit of outlet;

B—net width of overflow crest;

L_c—length of apron stilling basin.

2.2.4 Calculation indices

K_1—safety factor of stability against sliding calculated by shearing rupture strength;

K_2—safety factor of stability against sliding calculated by shear strength;

k_f—safety factor of crack resistant of concrete.

2.2.5 Calculation parameters

Δh—height difference between wave wall crest and static water level of reservoir;

h_b—wave height;

h_z—height difference between central line of wave and water level of reservoir;

h_c—freeboard;

L_m—average wave length;

H_{cr}—critical water depth where wave breaks;

Q—flow rate;

H_s—design head for determining shape of spillway crest;

Q_o—final hydration heat of cementing material;

θ_o—final adiabatic temperature rise of concrete;

Q_τ—cumulative hydration heat of cementing material at τ age;

T_p—placement temperature of concrete;

T_f—steady temperature of a dam;

T_r—maximum temperature rise of concrete due to hydration heat and other causes.

2.2.6 Calculation coefficients