

## **ICOLD Bulletiner – Sammanfattningar m.m.**

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### **Bulletin 15. Frost resistance of concrete - Comparison of results obtained in different laboratories (1960).**

This paper reports on a series of tests, tending to show the superiority of concrete made with slag cements over concrete made with Portland cement when subjected to alternating cycles of freezing and thawing.

### **Bulletin 20. Surface-active admixtures for concrete for large dams (1968).**

These recommendations refer to surface-active admixtures added to normal ingredients of concrete (aggregates, cement and water) immediately before or during its mixing and which, because of their plasticizing and/or air-entraining action, aim at reducing the quantity of mixing water or at improving the qualities of concrete, including its resistance to frost. The recommendations particularly refer to the use of admixtures in the construction of concrete dams and other large hydraulic works.

### **Bulletin 21. General considerations applicable to instrumentation for earth and rockfill dams (1969).**

This report deals with:

- > Purpose of instrumentation
- > Planning instrumentation systems
- > Types of instruments
- > Factors influencing accuracy of measurements
- > Reliability of measurements
- > Representative dams containing instrumentation

### **Bulletin 22. Pozzolanas and slags for concrete for large dams (1972).**

These recommendations deal with pozzolanas and slags used to form part of the cementitious binder in concrete for large dams. The recommendations are intended to form a general guide. The recommendations cover the basic requirements but each country may complete, enlarge or change these requirements to suit local conditions. The recommendations indicate general methods of testing. Tests should be in accordance with national specifications where such exist.

### **Bulletin 23. Reports of the Committee on Observation on Dams and Models (1972).**

General considerations on instrumentation for concrete dams. Note on the application of geodetic methods to the determination of the movements of dams.

### **Bulletin 24. Accelerating and retarding admixtures (1973).**

This report deals with recommendation based in the data contained in the existing specifications of various countries and give general recommendations, which may be taken into consideration by each country when preparing its own national specifications concerning the use of accelerators and retarders in concrete for large dams. The recommendations indicate what is to be taken into account when selecting and testing accelerating and retarding admixtures for use in concrete for large dams in the light of modern established and accepted practice.



### **Bulletin 25. Extensibility of concrete for large dams (1976).**

The extensibility of concrete is defined as “tensile strain capacity to failure”. The property has a particular application for concrete dams in that there has been considerable interest in changes in strain, such as those due to temperature, creep, or shrinkage, and measurements of strains are far easier than measurements of stresses. There are thus considerable attractions in studying the possibility of cracking in terms of extensibility rather than in terms of tensile strength.

### **Bulletin 26. Methods of determining effects of shrinkage, creep and temperature on concrete for large dams (1976).**

This report presents a review of methods in use of determining the effects of shrinkage, creep and temperature on concrete for large dams. The review has been made principally by a search of the literature and reference to certain specialists.

### **Bulletin 27. A review of earthquake resistant design of dams (1975).**

This report deals with:

- > The present trend if earthquake resistant design of dams and construction work.
- > Considerations on the earthquake resistant design of dams.
- > Recommendations and complementary observations.

### **Bulletin 28. Compendium of dams symbols (1977).**

Member countries expressed opposing views in respect of the number of symbols in the World register of dams. It was suggested by some member countries that the number of symbols be reduced to indicate only groups of symbols. A search of literature and standards in use indicated a need for the symbols listed and referred to in this Compendium. Expansion or limitation of the number of symbols could be considered with future revisions of the Compendium.

### **Bulletin 29. Report from the committee on risks to third parties from large dams (1982).**

This report deals with:

- > Indications on dam failure
- > Procedures currently adopted for minimizing risks from dams
- > Identification of main risk areas associated with dams
- > Levels of supervision and control to be adopted during construction and operation to maximize safety of dams
- > Legal aspects
- > Insurance of dams

Identification of levels of risk beyond which Government may assume liability for damage

### **Bulletin 30. Finite elements methods in analysis and design of dams (1987).**

This report deals with:

- > The finite element method as the general analysis procedure

- > Static analysis - Methods, assumption and criteria
- > Dynamic analysis – Methods, problems, criteria
- > Some recommendations for future attention

### **Bulletin 31. A glossary of words and phrases related to dams (1982).**

This bulletin includes list of words, glossary, regarding dams. This glossary supplements the ICOLD dictionary. Besides the glossary, the bulletin also includes drawings and definition of components in the drawings.

### **Bulletin 32. Bituminous concrete facings for earth and rockfill dams (1982).**

Bituminous facings are used to waterproof the upstream face of dams or embankments. This report deals with:

- > Evolution of facing types
- > Investigation of available information
- > Information on bituminous mix
- > Construction methods
- > Test methods
- > Remarks and performance evaluation

### **Bulletin 33. Compendium for dam symbols (1979).**

Updated symbols for drawings, maps and dam register.

### **Bulletin 34. ICOLD Guide for the International System of Units (IS) (1979).**

This bulletin contains notes and conversions between metric and imperial system in the dam context.

### **Bulletin 35. Dams and the environments (1981).**

This report consists in four parts:

- > Instruction for use of the matrix
- > Matrix of environmental impacts
- > List of types of dams and examples
- > General synthesis

The matrix has been tested with the use of the proposed symbols by 16 countries on 31 dams. This first attempt is encouraging and shows that it is worth pursuing the effort, particularly in improving the means of analyzing the feedback loops between causes and consequences of impacts and in developing the possibilities of computer treatment.

### **Bulletin 36. Cements for concrete for large dams (1982).**

This bulletin deals with:

- > Classification of cements with regard to composition
- > Main properties of concrete as influenced by type of cement

- > Influence of cement type on durability of concrete
- > Notes on fields of use different types of cement

### **Bulletin 37. Dam projects and environmental success (1981).**

This bulletin deals with:

- > Planning the project environmental problems and remedies
- > Health problems in tropical and sub-tropical areas
- > Beneficial side effects
- > Later monitoring and control
- > The environment and management of water resources

### **Bulletin 38. Use of thin membranes on fill dams (1981).**

This bulletin deals with:

- > Watertight facing construction and stresses
- > Recommendations for the use of diaphragms on fill dams

### **Bulletin 39. Upstream facing interface with foundations and abutments (1981).**

This bulletin deals with bituminous concrete facings for earth and rockfill dams. It extend the scope of the bulletin 32 to the bonding arrangements between bituminous concrete facings and the upstream toe of the dam (valley bottom and abutments), the crest and the concrete structures.

### **Bulletin 40. Fiber reinforced concrete (1989).**

The purpose of this paper is to provide state-of-art background concerning the development of fiber-reinforced concrete (FRC), to show where it can be and has been used to advantage in dam construction and repairs, to provide some guidance for design, to discuss fresh and hardened material properties, to discuss proportioning, and to cover the particularities of batching, mixing, placing and finishing it in the field.

### **Bulletin 41. Automated observation for the safety control of dams (1982).**

The bulletin describes theoretical concepts, and practical examples of automated observations of dam behavior for safety control.

### **Bulletin 42. Bituminous cores for earth and rockfill Dams (1982).**

This bulletin deals with

- > Construction methods
- > Dams with bituminous cores
- > Principles for the design and construction of bituminous cores
- > Some typical cross sections of dams with bituminous cores

### **Bulletin 43. Synthetic resins for facings of dams (1982).**

The report reviews the extent to which synthetic resins have been used as facings of dams and associated hydraulic structures, the types of resin employed and their characteristics, the design considerations, methods

of use on site, testing procedures, reported experience in service and where possible draws conclusions in this field of rapidly developing technology.

### **Bulletin 44. Bibliography- Mine and industrial tailings dams and dumps (1989).**

This edition differs from the earlier one in respect of the following:

- > It is now very much larger, reflecting the increase in mining activity and interest in tailings disposal throughout the world.
- > It is in a new format; comprising a comprehensive subject classification, and incorporating duplications of entry where projects fall under more than one of the subject classifications.

### **Bulletin 45. Manual on tailings dams and dumps (1982).**

Tailings dams are dams constructed of: 1) mill tailings, 2) mine wastes, or 3) earth or rock fill; for the retention of tailings slurry or slurry water for reclamation.

Tailings dumps are tailings disposal structures constructed by dry or hydraulic fill means but which do not impound significant quantities of water. Both types of structures have long been designed by empirical means with less than satisfactory performance.

This bulletin deals with:

- > Location of dams
- > Site investigation
- > Design
- > Construction and operation
- > Closure and abandonment

### **Bulletin 46. Seismicity and dam design (1983).**

This bulletin deals with:

- > The assessment of seismicity at a dam site
- > Site investigations for possible induced seismicity at reservoirs
- > Site investigations with small earthquakes
- > Earthquake loading parameters for design – factor of safety
- > Instrumentation
- > Observation and inspection of dams in earthquake zones
- > Material behavior under earthquake
- > Seismic aspects in dam design and analysis

### **Bulletin 47. Quality control of concrete (1983).**

This report presents a general review of systems, practices, methods of testing, and other considerations that underlie the quality control of concrete production during the construction of large dams. The main purpose

of this report is to assemble available information and experience into a concise guide for the preparation of a quality control program for the construction of a concrete dam and its appurtenant works.

The emphasis of this report is the quality control of mass concrete produced for placement in massive blocks in the body of a dam. However, most of the practices and methods are also valid for quality control of concrete production for related structures such as spillways, aprons, powerhouses, piers, etc. detailed quality control practices for placing, compacting, and curing of concrete during dam construction are not considered within the scope of this report.

### **Bulletin 48. River control during dam construction (1986).**

Controlling the river during dam construction means providing one or more working areas free water and safe from river floods where the permanent works can be built in the dry.

Design and implementation of relevant works are critical operations of the whole construction program, especially on medium or high discharge rivers or rivers subject to sudden and important floods.

River control works must form part of an overall project design, as the choice of the solution will have a major impact not only on the cost of the temporary works, but also on the design, construction program and cost of the permanent works.

### **Bulletin 49. Operation of hydraulic structures of dams (1986).**

Some hazards relating to dams are frequent subjects of discussion, while others, which nevertheless may cause serious accidents, are ignored in the literature. Such is the case of operation of hydraulic appurtenances of dams.

This bulletin deals more specifically with the following:

- > Importance of outlet works for dams and features the operator requires
- > Part of operating personnel
- > Inspection and testing of hydraulic appurtenances
- > Operation in flood seasons
- > Latest trends in operating practices

### **Bulletin 50. Dams and the environment - Notes on regional influences (1985).**

It has been thought useful to record and distil the experiences of engineers involved with dam projects located in broadly defined climatic regions of world. The regions chosen have been designated as:

- > Temperate
- > Tropical, sub-tropical and arid
- > Severe winter

As the regions themselves vary, so to a certain extent do the approaches of the sub-committees. The mini reports therefore perhaps reflect the wide diversity of the regions. None is intended as a definitive technical paper or even as a comprehensive aide memoire. Nevertheless, it is hoped that the relevant one will be useful reading for an engineer, or owner, contemplating involvement in a new dam or reservoir project is one of the

regions. The benefit may be greater for someone moving from operations in one region, with which he is fully familiar, to another with its new challenge for environmental protection.

### **Bulletin 51. Filling materials for watertight cut off walls (1985).**

Because a dam is rarely founded on a perfectly watertight ground mass, there is nearly always underground water flow. The discharge of this seepage affects the profitability of the dam; its pressure and exit gradient can endanger the permanence of the structure itself. Numerous techniques have been employed to resolve these problems: impervious blankets, drains, waterproof curtains.

### **Bulletin 52. Earthquake analysis for dams (1986).**

In this report, the authors concentrate on a more fundamental treatment of the subject, which may be somewhat difficult for an average dam design engineer to understand; we try to minimize such difficulties by a reasonable explanation process and apologize in advance for any shortcomings in the description.

It deals with:

- > Basic formulation and analysis procedures
- > Earth dams – earthquake analysis and design

### **Bulletin 53. Static analysis of embankment dams (1986).**

This report deals with problems of the analysis of embankment dams only. This includes both earth and rockfill dams with internal cores but excludes the problems of foundation analysis except in so far as the strength and deformation properties of foundation can be included in an analysis of the embankment.

The report intention is to outline the analytical techniques available and monitoring subsequent performance. The analytical sophistication now available, particularly from the finite element method, makes this a formidable task for the practitioner. The danger is that his judgment may be impaired rather than improved by the sheer quantity of analysis which he can carry out. To further this purpose, the writers have omitted mathematical formulations from this report and have concentrated instead on applications.

### **Bulletin 54. Soil-cement for embankment dams (1986).**

Soil-cement is a mixture of soil, Portland cement, and water. Through compaction and cement hydration, the mixture hardens with the soil particles bonding together to form a dense, durable, relatively impermeable, erosion resistant material.

This report considers the data relating to the use of compacted soil-cement on 136 dams or embankments constructed since 1962.

### **Bulletin 55. Geotextiles as filters and transitions in fill dams (1986).**

The aims of the report are to review considerations for the use of geotextiles as filters in fill dams, to present relevant data gained from other uses, and to record data from dams where geotextile filters are known to have been installed.

### **Bulletin 56. Quality control for fill dams (1986).**

The first draft took inspiration from nuclear power plant quality control procedures, since construction of either a nuclear plant or dam project both require a high degree of safety. However, regulations pertaining to

the nuclear industry differ in that the Contractor and Manufacturers of equipment have primary responsibility for quality control.

### **Bulletin 57. Materials for joints in concrete dams (1986).**

Joints are a necessary part of any large construction where dimensional changes within the structure are likely to occur. This is particularly true for concrete dams where as a result of the nature and behavior of material of their construction, they may suffer cracking to a greater or lesser degree unless joints are provided to control these problems.

This bulletin deals with:

- > Types of joints
- > Selection of type and material
- > Specifications for joint sealing materials
- > Preparation and installation
- > Practical test of waterstop

### **Bulletin 58. Spillways for dams (1987).**

The basic design of spillways involves a variety of complex problems and, without pretending to be a comprehensive state-of-art review, this report does summarize the main considerations arising from modern dam projects.

Wherever possible, each chapter has examples of typical dams currently in operation throughout the world where sufficient information is available from the enquiry or other sources.

### **Bulletin 59. Dam safety – Guidelines (1987).**

Several dam incidents with severe consequences during recent years had given rise to general concern about the safety of dams, and indicated the necessity for a formal safety approach.

The height of new dams and the volume of new reservoirs is increasing, while many older dams are approaching an age at which material deterioration and decreasing operational reliability may dictate some repair and upgrading.

An ever-increasing number of dams is being built in countries with little or no tradition and experience in dam engineering. The formalization of safety considerations and the issuance of summarized safety requirement would be part of the necessary transfer of technological know-how to these countries.

### **Bulletin 60. Dam monitoring - General considerations (1988).**

One of this bulletin's tasks was to bring bulletins n° 21 and 23 up to date and merge them into a single ICOLD bulletin. The whole committee agreed that:

The underlying principles and basic philosophy were clearly and cogently stated in these earlier bulletins and provided a good foundation for those needing to involve themselves in dam monitoring

Some details needed revision (only minor points, considering they were first published twenty years ago)

The sections on optical survey methods could be cut down, both bulletins giving them much space with overabundant details. Topographic survey is now losing favor for dam monitoring purposes and it would seem sufficient simply to remind readers of a few basic ideas and refer to the abundant literature on the subject.

### **Bulletin 61. Dam design criteria - Philosophy of choice (1988).**

The initial approach was to conduct a survey of member countries of ICOLD and to ascertain the currently available practice. This report attempts to present our findings and is the result of much debate and controversy.

Attempts of including quantitative stochastic and probabilistic reliability approaches were made but the available data did not seem to warrant such an approach.

### **Bulletin 62. Inspection of dams after earthquakes - Guidelines (1988).**

An earthquake may cause failure of a dam or cause severe damage to the dam and its appurtenant structures. In the event of damage, immediate action may be necessary to prevent further weakening of the structure. Accordingly, all dam operators should be carefully instructed in the procedures to be followed if an earthquake should occur that produces motions of intensity sufficient to possibly cause damage.

The inspections are most meaningful if the procedures are prepared for individual dams. The general procedures described herein may be used by professional persons conversant with the design and operation of the dam in the preparation of a set of inspection procedures for a specific dam. The procedures should list all of the features to be inspected, in an order believed to be the most important and efficient. Communication checkpoints to designed offices regarding the inspection should be a part of the plan. Aspects of the inspections are discussed below, and inspection checklists are given in the appendix to aid in preparing instructions.

### **Bulletin 63. New construction methods - State of the art (1988).**

The objective of this report is not to carry a general review of all «New Construction Methods», but to select construction techniques, which could be included in the category of new construction methods and to study the essential points of these techniques, based on actual cases.

In recent years, the progress of technology has become more rapid and diverse, but, in simplest terms, it can be recognized that the influence of modern technology in dam construction lies in the rationalization of the use of new construction equipment, computers, synthetic materials, etc.

### **Bulletin 64. Register of dam heightenings (1988).**

Dam heightening is a major task in dam engineering. Several reasons may make it necessary: increased freeboard, spillway capacity, reservoir volume, etc. In every case, the engineer must consider different kinds of problems.

### **Bulletin 65. Dams and environment - Cases histories (1988).**

This bulletin presents a number of case histories. They are dams and reservoirs generally of a significant age. Thus a realistic picture is now available of the performance of each scheme related both to achievement of the main project purpose and to the various environmental impacts involved. It is intended that the reader should be able, through these descriptions, to assess the overall impact of each project in its totality on the communities and countries involved.



### **Bulletin 66. Dams and environment - The Zuiderzee damming (1988).**

The present bulletin describes in considerable detail the experience with the Zuiderzee project in the Netherland on which there has been much effort on the environmental front, with many lessons learned.

### **Bulletin 67. Sedimentation control of reservoirs - Guidelines (1988).**

The terms of Reference of the Committee were as follow:

- > Methods of predicting alluvial deposits as regards quality and quantity.
- > Observation methods and comparison with reductions.
- > Means of protection to extend the life of reservoirs: intake and scouring structures, operation of reservoirs, dredging, sediment trapping.

### **Bulletin 68. Monitoring of dams and their foundations - State of the art (1988).**

The member countries of the Committee were asked to submit state-of-the-art reports on dam and foundation monitoring in their own countries, and ten reports were finally forthcoming. Canada, not a member of the Committee, also furnished a report.

Understandably, each contribution has highlighted those activities that are considered to be either the most important in the country or technically the most advanced. From the different situations, the reader may therefore choose the one that best meets his own situations, the reader may therefore choose the one that best meets his own situation and draw useful guidance from it, knowing that what is described represents actual situations developed by technical experts in this field.

### **Bulletin 69. Moraine as embankment and foundation material - State of the art (1989).**

If sufficiently impervious, moraine is a good foundation material with few settlement problems; it can also provide satisfactory constructional material for dam cores and homogeneous earth dams.

The bulletin describes and discusses moraine properties, in situ exploration problems, design, construction and performance during first filling and long-term operation. It is a comprehensive review of current knowledge and experience of moraine as a dam foundation and fill material. Case histories from various countries illustrate the ways it can be used.

### **Bulletin 70. Rockfill dams with concrete facing - State of the art (1989).**

The bulletin describes design, construction and monitoring practice with practical recommendations on construction of the dam body, concrete facing and ancillary works, and foundation treatment. A full chapter is devoted to earthquake design. Clear illustrations, references and list of existing dams are included.

### **Bulletin 71. Exposure of dam concrete to special aggressive waters - Guidelines (1989).**

This bulletin reviews the extent to which environmental attack on dam concrete has taken place together with the nature of such attacks. It reviews what preventive measures are available against such attacks together with investigative techniques and remedial actions available once attack has occurred.

## **Bulletin 72. Selecting seismic parameters for large dams - Guidelines (1989).**

This bulletin was made:

- > To provide a guide for the selection of parameters to be used in the seismic design, analysis and safety evaluation of new or existing dams and their appurtenant structures.
- > To promote consistency in handling the earthquake aspects of dam performance evaluation among owners, designers and various organizations involved in the planning, design, construction, operation, maintenance and regulation of dams.

## **Bulletin 73. Savings in dam construction - Comments and proposals (1989).**

This bulletin reviews the opportunities for cost savings arising from appropriate dam design and construction factor.

No two dams are the same, and it is difficult to compare their cost and assess potential savings, which are often under-estimated; many dam engineers feel that they are close to the optimum. Judgements on this bulletin may thus be diverse, but it is hoped that all readers will find a few ideas towards a more cost-conscious approach, and may be stimulated to consider what may be done in the future.

Every party involved in the design and construction of a dam usually considers that needless costs are the fault of the others, but major savings are often possible in all areas, either through the direct action of each party or through a clearer definition of contract relationship, duties and powers.

## **Bulletin 74. Tailings dams safety - Guidelines (1989).**

This guideline is essential because of the increasing numbers of large tailings dams that were being constructed around the world and the severe consequences that would result from failure. The need for such guidelines was dramatically emphasized by the failure, in 1985, near Stava in Italy, of two small tailings dams, which resulted in a large loss of life and extensive property damage.

This bulletin is intended primarily for the use of the Regulatory Agencies responsible for the safety of tailings dams, both structurally and environmentally. However, it is also intended to assist the mine operator in understanding the measures that must be adopted to ensure that his tailings dam is safe, both during operation and after rehabilitation. Finally, it should also benefit those individuals or organizations involved in the design, construction, operation, and rehabilitation of tailings dams.

## **Bulletin 75. Roller compacted concrete for gravity dams - State of the art (1989).**

Roller compacted concrete is a new technique characterized principally by its use of rollers for compaction. The resulting material is denser with a lower percentage of water than the usual dam concrete. The mix is spread in thin layers over the whole length of the dam, enabling concreting to proceed very quickly

This bulletin summarizes the information now available for a technique still in the evolutionary phase. It would therefore be wrong to attempt to force it into rigid schemes of prearranged recommendations.

It deals with roller compacted concrete for dams of the gravity type only.

### **Bulletin 76. Conventional methods in construction - Review (1990).**

This Bulletin is intended to review construction practice in dam engineering up to the appearance, in the last decade, of the new developments as described in Bulletin 63 “New construction methods”.

This Bulletin will provide a useful background to students and a comprehensive overview for practicing engineers who are not specialists in all the aspects of dam construction.

### **Bulletin 77. Dispersive soils in embankment dams - Review (1990).**

Dispersive clays are generally poorly understood by engineers and other specialists who work on embankment dam construction. These clays may cause serious problems if they are used without adequate knowledge, and if the precautions required are not taken. It is important that dam engineers and specialists learn about the properties of these clays, especially those that require special attention during the design and construction of embankment dams.

This bulletin reviews these properties and appropriate measures to be taken, and gives valuable information for all engineers concerned with this material present in many countries.

### **Bulletin 78. Watertight geomembranes for dams - State of the art (1991).**

Since that time, new and improved materials became available and the experience gained has resulted in a better understanding of their use and in advanced engineering skills in this field so that they have been used in higher dams than before.

The application of geomembranes was extended to new areas such as enhancing the water-retaining performance of other facings, repairing old gravity dams and the deteriorated upstream concrete facings of fill dams. Lastly, new ideas have been developed regarding drainage, supporting layer and protective covering and geomembranes are being considered for the upstream facings to roller compacted concrete dams.

### **Bulletin 79. Alkali-aggregate reaction in concrete dams - Review and recommendations (1991).**

Interest in the Alkali-Aggregate (AAR) in concrete structures has increased in recent times because of the risk for dam safety and the high cost of repairs and replacements. Though this reaction does not concern dam concrete only, one of the first structures identified as affected by AAR was the Parker Dam (USA) in 1941 and an ICOLD survey in 1985 has shown the worldwide distribution of damaged dams because of AAR

The purpose of this Bulletin is to make aware those responsible for dam safety of the AAR risk and to give recommendations for minimizing this risk at the design and construction stages and adequately treating old dams, which may be affected.

### **Bulletin 80. Dam construction sites. Accident prevention - Review and recommendations (1992).**

Many efforts all over the world to emphasize labor safety and health have resulted in more awareness from public opinion in occupational accidents and disease. So that it is timely to deal with these problems for dam construction sites where they are especially major issues since statistics show that risks of death are far higher during construction from occupational accidents than in operation from dam failures;

The report starts with an evaluation of accident-related losses and goes on with suggestions on methods and procedures to prevent them. It addresses more especially the Engineer, site management and contractors and all those responsible for work organization on dam construction sites.

### **Bulletin 81. Spillways. Shockwaves and air entrainment - Review and recommendations (1992).**

Spillways and bottom outlets constitute a significant percent of the total cost of major dams. Their proper design is, thus, very important from the standpoint of economy as well as safety. This bulletin, which considers the hydraulic concepts of design for high-velocity flow, aeration, cavitation and shock waves, has been prepared as a general design guideline for use of engineers engaged in the design of bottom outlets and steep spillway chutes.

### **Bulletin 82. Selection of design flood- Current methods (1992).**

The problem of the evaluation of the design flood has been passionately debated for years: the subject is one of important and fraught with difficulty. Many failures are due to insufficient spillway capacity. In addition, the diversity and complexity of factors governing flood formation and size have resulted in a variety of evaluation method.

Many of these methods are reviewed in this bulletin and, what is rather new; the limits of their applicability are discussed. The bulletin is addressed more specifically to hydrologists and engineers ultimately responsible for the calculation of project design floods.

### **Bulletin 83. Cost impact on future dam design - Analysis and proposals (1992).**

This bulletin reviews possible changes in dam construction needed to optimize construction cost. It aims at questioning conventional wisdom and at stimulating enquiry into alternatives rather than introducing new rules or ready-made solutions for any situation.

Implementation of innovations in technology depends on reflection and cooperation between several parties. In dam engineering, these include owners, regulatory agencies, consulting engineers and contractors.

### **Bulletin 84. Bituminous cores for fill dams - State of the art (1992).**

This bulletin is dealing with the development of this technique during the past decade, the experience gained and progress made in the design, the construction and the knowledge of bituminous core behavior. It offers a comprehensive synthesis of present knowledge on this type of watertight component.

### **Bulletin 85. Owners, consultants and contractors - How to improve relationships (1992).**

Heavy construction projects such as dam construction many times have delays and increased costs, which can be directly attributed to the relationship between the various parties, i.e., the owner, consultant/designer, construction manager and contractor.

This bulletin reviews each party's responsibilities and provides beneficial ideas on contract documents, contracting considerations, and problem avoidance and resolution, all in an effort to reduce the overall project cost and time. It addresses all the parties involved in dam projects and is intended for a very large readership.

### **Bulletin 86. Dams and environment -Socio-economic impacts (1992).**

The present bulletin gives an overview of social and economic problems, which may arise before, during or after the construction of a large dam. The relevant reports are listed in the references at the end of the bulletin and may be accessed for specific instances of problems and solutions, as the text of the bulletin is general in nature.

### **Bulletin 87. Improvement of existing dam monitoring - Recommendations and case histories (1992).**

This bulletin provides recommendations for the improvement of the monitoring of existing dams where either a monitoring system does not exist, or it is wholly or partially obsolete, incomplete or insufficient.

Even though the basic principles remain the same, improving existing dam monitoring is a somewhat different problem from monitoring new dams, because specific problems such as logistic difficulties can arise and information on the actual past behavior of the dam is available.

### **Bulletin 88. Rock foundations for dams (1993).**

Significant progress has been made over the last twenty years in this field, and it has become necessary to include for these new developments in rock mechanics and discuss a few typical applications.

The subject is vast and many of the problems associated cannot yet be given a definitive answer, since there are many parameters whose values are scattered and constitutive laws for in situ rock are complex. However, engineers now have the benefit of science and technology offering them a truer insight into the physical and mechanical properties of in situ rock, and enabling them to better predict its performance as a dam foundation and treat it accordingly, and monitor it more comprehensively and accurately. The end result is greater safety for the dam/foundation complex.

### **Bulletin 89. Reinforced rockfill and reinforced fill for dams - State of the art (1993).**

This bulletin deals with a technique, which, although not new and of such great interest, has not been extensively used in dam construction: the reinforcement of fill materials.

The bulletin describes the methods used to reinforce the natural materials of a fill dam, which have to be resistant to various conditions, but especially to overtopping. Principles are the same for fine or coarse materials, but the ways they are reinforced and react may be very different.

### **Bulletin 90. Dams and Environment - Geophysical impacts (1993).**

This bulletin gives an overview of geophysical problems, which may arise before, during or after the construction of a large dam. Among its sources, it draws on a number of reports. The relevant reports and other listed references may be accessed for specific instances of problems and solutions, as the text of the bulletin is general in nature.

### **Bulletin 91. Embankment dams: Upstream slope protection - Review and recommendations (1993).**

This bulletin is a comprehensive review of the various methods used to protect the upstream slope of fill dams, with abundant examples of applications. The description is more complete in the case of materials used more frequently so reflecting the day-to-day reality. Embankment dams represent 70% of all dams now under construction, which amply reflects the importance of this bulletin.

The content should be of the greatest interest for all dam designers, contractors and owners.

### **Bulletin 92. Embankment dams: Upstream slope protection - Review and recommendations (1993).**

This bulletin reviews the physico-mechanical properties of rockfill, specifications requirements, dam design, construction methods, settlement and deformation prediction, and performance monitoring.

This bulletin is addressed to all those involved in research on, assessment of properties, and use of rock materials for construction of rockfill dams.

### **Bulletin 93. Ageing of dams and appurtenant works (1994).**

This bulletin contributes to a better understanding of the major ageing phenomena, to indicate appropriate methods for their detection, investigation and evaluation, and to suggest simple remedial measures. The aim is to improve the prevention, control and mitigation of ageing.

The dams used as illustrations for the various ageing phenomena were selected because the documentation of the problems was thorough and the data available were particularly relevant, or because the contributing author's familiarity with the dams.

### **Bulletin 94. Computer software for dams - Validation (1994).**

The description of computational methods, or state-of-the-art review, would only be of temporary value, given the fast pace of new developments. On the contrary, ideas and criteria for effective « validation » of computational tools were deemed to be of more permanent value, while at the same time covering important aspects, although of primary importance, are far from obvious or simple, and moreover they are frequently given insufficient critical attention.

### **Bulletin 95. Embankment dams - Granular filters and drains (1995).**

The importance of filters and drains within the body of an earth, earth-rock, or rockfill dams must be uppermost in the mind of the embankment dam designer. Indeed, many incidents of failure or near failure can be attributed to the absence of filters and/or drains or to filter/drain protection, which was not appropriate to the application. The literature within the various ICOLD Congress proceedings and other sources provides ample case histories of such incidents. Depending on the data cited, 30 to 50 percent of accidents to embankment dams have involved piping or inadequate drainage: the safety of embankment dams depends to a large degree on the proper design and construction of filter and filter/drain systems.

This bulletin is not meant to be a design manual but rather a summary of the current state of the practice.

### **Bulletin 96. Dams and environment - Water quality and climate (1994).**

This Bulletin gives an overview of effects of reservoirs on water quality and climate. Among its sources it draws on a number of reports submitted to the 16th ICOLD Congress in San Francisco, in 1988, in response to Question 60: Reservoirs and the Environment-Experience in management and monitoring, and to further such reports submitted to the 17th ICOLD Congress in Vienna, 199, in response to Question 64: Environmental Issues in Dam Projects. The relevant reports and other listed references may be accessed for specific instances of problems and solutions, as the text of the Bulletin is general in nature.

### **Bulletin 97. Tailings Dams - Design of drainage (1994).**

This bulletin comments various recommended drainage methods for tailings dams.

The research and studies made on tailings dams behavior led to design improved method of drainage for these dams. So successful have these methods been that even dams built upstream construction need no longer be regarded as a type that traditionally has a low factor of safety.

This new approach to starter dam avoids the formation during early deposit of tailings of a zone of low strength slimes, normally found just upstream of that dam and greatly improves stability of a potential slip surface passing through the toe of tailings dam as it approaches full height.

### **Bulletin 98. Tailings Dams and Seismicity - Review and Recommendations (1995).**

A recent USCOLD compilation of tailings dam incidents has listed 185 incidents collected worldwide, covering tailings from a wide variety of materials. This has shown that tailings dams are very susceptible to earthquake damage and those built by the upstream method have failed mainly due to slope instability and earthquake.

There is clearly a need for advice on seismic design for tailings dams and this bulletin has been prepared to show the current state-of-the-art for the design of new dams to resist earthquake forces. Of equal importance is the question of treating existing dams to make them better able to withstand earthquake shaking and this bulletin gives remedial measures for improving the safety of existing impoundments. It also gives a very comprehensive collection of references so that the reader can go back to original sources and study various methods in greater detail.

### **Bulletin 99. Dam Failures - Statistical Analysis (1995).**

Accidents in industry have always been a spur to human progress and, for many years, was even the main driving force. This is especially true in dam engineering and, for this reason, ICOLD has on three occasions instigated worldwide surveys, to collect the largest amount of information on dam accidents and/or incidents. The nineteen-seventies saw the appearance of Lessons from Dams Accidents, the eighties produced Deterioration of Dams and reservoirs, and now we have Statistical Analysis of Dam Failures.

This third effort strives to avoid duplications with earlier work, but to find responses to questions than have hitherto found no objective answer: are some dam types, or some dam heights, more prone to failure than others?

### **Bulletin 100. Dam and environment – Ridracoli: A model achievement (1995).**

This bulletin offers technical information on, and examples of impacts, and engineers' and scientists' suggest means for mitigating them. It describes concrete cases of projects designed and build with a view to make the dam and reservoir blend into their environment.

This bulletin continues this collection of case histories in which the combined effort of engineers, politicians and the public at large have made it possible to develop a natural resource –water- to meet a basic need, while at the same time stimulating the area's economic and social development, and protecting and improving the natural and man-made environment.

### **Bulletin 101. Tailings Dams. Transport. Placement and decantation - Review and recommendations (1995).**

This bulletin gives advice on tailings transportation as a slurry in pipes and open flumes as well as consideration of the "dry" condition. The bulletin describes a method for assessing the overall water balance if impoundment and the way the requirements for a safe discharge can be calculated. It also gives advice on the design of various types of system.

### **Bulletin 102. Vibrations of hydraulic equipment for dams - Review and recommendations (1996).**

Few problems are more difficult to cope with than vibrations of hydraulic equipment. Because of the danger they impose to hydraulic equipment and the associated structures, vibrations have been the subject of extensive research for many decades and research has accelerated in recent times with the result that much more is now known about the occurrence and characteristics of dangerous vibrations. This bulletin attempts to provide the designer with understanding as well as tools that will aid in developing safe designs.

### **Bulletin 103. Tailings dams and environment (1996).**

This bulletin addresses this aspect in relation to tailings dams and their retained lagoons. It considers the environmental impact assessment that must be made at the planning stage and environmental stability to be achieved during the long years of construction and the longer period after completion and rehabilitation.

### **Bulletin 104. Monitoring of tailings dams – Review and recommendations (1996).**

This bulletin concentrates on the difference of approach necessary when considering the instrumentation for tailing dams. Sound advice is given about the importance of seepage measurements and the need for automation to provide continuous records, methods for measuring the position of the phreatic surface, showing the difference of approach from that with embankment dams in this, for tailing dams, vital measurement.

### **Bulletin 105. Dams and related structures in cold climate - Design guidelines and case studies (1996).**

In areas with cold climate, formation of ice and permafrost may cause damage or operational problems to dams, related structures or equipment. These problems must be considered during planning, design, construction and operation of hydraulic projects in cold climate. The purpose of this bulletin is to review these problems and to present preventive or remedial measures against ice and permafrost action.

### **Bulletin 106. A guide to tailings dams and impoundments – Design, construction, use and rehabilitation (1996).**

This bulletin discusses common problems in the disposal of tailings at mines, quarries and other industries, and identifies safe methods of designing and operating dams and impoundments.

The problems encountered at the end of operations when it becomes desirable to end tailings dam construction and it is necessary to rehabilitate the dam and its impoundment to make it permanently safe and environmentally acceptable are discussed and a final chapter describes some of the governmental regulations controlling tailings dams in some countries.

### **Bulletin 107. Concrete dams - Control and treatment of cracks. Review and case histories (1997).**

This bulletin addresses the causes and control of cracking in concrete, techniques for monitoring such cracks, and actions available for accommodating and repairing cracks. Guidance also is provided on how to avoid cracking in concrete dams. A series of case histories from around the world on the care and rehabilitation of dams affected by serious cracking is also included.



### **Bulletin 108. Cost of flood control in dams - Review and recommendations (1998).**

Larger floods now considered lessons from operation and failures since 30 years, wider range of possible solutions have a great impact on design of new spillways: the Bulletin is proposing relevant cost effective dispositions to guarantee safety of new dams and improve safety of existing dams; methods for river control during construction are also reviewed.

### **Bulletin 109. Dams less than thirty meters high - Cost savings and safety improvements (1997).**

This bulletin is devoted to the 150 000 large or small dams 10 to 30m high; capacity of most of their reservoirs is in the range of 1 hm<sup>3</sup> but several thousand reach dozens of hm<sup>3</sup>. Design criteria and typical designs are generally different from those of high dams. Construction methods, often focus upon economy, may increase risks and corresponding accidents have globally caused more victims than for high dams.

Based upon experience from many industrialized or non-industrialized countries, the Bulletin suggests practical solution in order to:

- > Reduce the cost of new dams with due respect to required safety
- > Identify existing dams subject to serious risks and possibilities to lower those risks cheaply and quickly,
- > Optimize use of reservoirs.

### **Bulletin 110. Cost impact of rules, criteria and specifications - Review and recommendations (1997).**

This bulletin deals with the cost impacts of rules, criteria, specifications and contractual conditions on dams.

### **Bulletin 111. Dam break flood analysis - Review and recommendations (1998).**

Concern about the possible failure of dams, with a flood wave routing in the valley, peaked in this century as a result of failures of several important dams such as Vajont, Malpasset, Teton and Macchu II.

The Bulletin reviews parameters and define the state of art of predicting downstream depths, extent of flooding, and velocities which would occur as a result of a failed dam and to catalog and to make recommendations for the use of such programs.

A unique review for all those involved in the assessment of dam safety and the protection of population downstream of dams.

### **Bulletin 112. Neotectonic and dams - Recommendations and case histories (1998).**

Exposure of dams to active tectonic phenomena constitutes a severe hazard which might affect the structural safety of dams.

The Bulletin deals specifically with:

- > Rupturing and creeping tectonic events which might affect dams and storages.
- > The related investigation methodology.
- > Evaluating the effects of fault breaks and crustal mobility on dams.

- > Effects of active tectonic features on selection of sites and types of dams.
- > Defining the engineering strategy, when facing the active tectonic rupturing and creeping movements.

This Bulletin is recommended to all those involved in the design, construction and operation of dams.

### **Bulletin 113. Seismic observation of dams - Guidelines and case studies (1999).**

The Bulletin deals with the basic aspects of seismic observation of dams, and gives criteria and recommendations for the design, installation, operation and maintenance of monitoring systems, including the processing and utilization of the obtained records. It is supported by presentation of forced vibration tests performed on dams and by representative case studies.

This Bulletin will be of particular interest to all dam engineers and all those involved in dam safety.

### **Bulletin 114. Embankment dams with bituminous concrete facing (1999).**

This Bulletin is a revised and unified edition of Bulletins 32 and 39. It introduces the present state of the art in the field of bituminous concrete facings and their interface with other elements of the dam.

It includes a review of the design principles and typical solutions used, a description of the construction materials, the construction methods and quality control, and finally discussions and descriptions of performance, inspection and maintenance for long-term operation.

### **Bulletin 115. Dealing with reservoir sedimentation – Guidelines and case studies (1999).**

As the dams in operation throughout the world age, their reservoirs accumulate sediment deposits to some degree; with that aging, these sediment deposits become more and more of a problem towards meeting the intended purposes of those dams. Therefore, it behooves the owners and engineers of these projects to become more innovative in preventing and resolving these sedimentation related problems.

Aspects of sediment yield determination have been adequately dealt with in Bulletin 67 (1989) and are therefore not repeated in the new Bulletin.

### **Bulletin 116. Dams and fishes - Review and recommendations (1999).**

The maintenance and development of fish life are important aspects to be considered by dam builders. In this area, the aim of the dam builder should be threefold:

- > Conserve the diversity of living species,
- > Enable riverside populations to fish for food,
- > Provide for the development of water-based recreational activities.
- > Three areas are examined in the bulletin:
  - > The reservoir: conditions necessary for fish life (food and reproduction),
  - > The dam: fish pass techniques,
  - > The river downstream of the dam: flow conditions required to maintain fish life.

This Bulletin will be an important source of information for all those involved in the design, construction and operation of dams. However, it is restricted to river dams and does not include those in estuaries.

### **Bulletin 117. The gravity dam. A dam for the future - Review and recommendations (2000).**

It is obvious that new technical developments, particularly RCC technology, are going to promote construction of gravity dams in the world. This Bulletin discusses the possible ways and means for further reducing the cost of gravity dams, without impairing the safety of dams.

This bulletin is based upon dam history and accidents, theoretical analysis and review of practical construction methods.

### **Bulletin 118. Automated dam monitoring systems - Guidelines and case histories (2000).**

The continuing rapid advances in electronics and computer technology have spurred considerable interest in automation of monitoring systems for dams and their foundations.

The Bulletin is intended to serve as a guide and provides comprehensive and practical state of the art information and guidelines to all those interested in the subject of automated dam monitoring.

### **Bulletin 119. Rehabilitation of dams and appurtenant works (2000).**

There are now at least 20 000 dams in the world more than 50 years old. This is the challenge we face in dealing with rehabilitation of dams and appurtenant works, and the problem is growing. The Bulletin contains case histories to illustrate modern and innovative means of rehabilitating dams.

This Bulletin is addressed to all those involved in the design, construction and maintenance of dams and their related structures

### **Bulletin 120. Design features of dams to resist seismic ground motion – Guidelines and case studies (2001).**

The purpose of the Bulletin is to describe the actual seismic behavior of existing dams and, from these case histories, to outline the numerous technical features to be considered for dams to resist seismic ground motion.

Such seismic considerations should essentially reflect the special investigations, design and constructions techniques that are necessary for dams in a seismically active area.

This Bulletin is addressed to all those involved in the design, construction and operation of dams.

### **Bulletin 121. Tailings dams - Risk of dangerous occurrences. Lessons learnt from practical experiences (2001).**

Guidelines for the design, construction, operation and closure of tailings dams have been given by many ICOLD publications (45, 74, 97, 98, 101, 103, 104 and 106). If these guidelines were to be closely followed, the risk of failure or dangerous occurrence with tailings dam and impoundment would be greatly reduced.

Unfortunately, the number of major incidents continues at an average of more than one a year.

With the intention of trying to determine the causes of these incidents, 221 case records have been collected. They are given both in a brief detail and discussed in general terms.

This Bulletin is addressed to all those involved in the design, construction, operation and closure of tailings dams.

### **Bulletin 122. Computational procedures for dam engineering - Reliability and applicability (2001).**

The Bulletin deals essentially with two main subjects. The first one consists of a critical, analytical review of what can be the role and the effectiveness of mathematical models to analyze the different phenomena related to safety of dams during the different stages in their life. The second subject is aimed to illustrate some of the reference solutions.

This Bulletin is addressed to all dam engineers involved in computational problems and related areas.

### **Bulletin 123. Seismic design and evaluation of structures appurtenant to dams – Guidelines (2002).**

This Bulletin, which follows up the Bulletin 120 "Design features of dams to resist seismic ground motion", deals with the earthquake design, analysis and safety evaluation of structures appurtenant to new or existing dams : spillways, water conduits, intake towers and other appurtenant structures.

The Bulletin will be an important source of information for all those involved in the design, construction and operation of dams.

### **Bulletin 124. Reservoir landslides: Investigation and management - Guidelines and case histories (2000).**

This Bulletin examines the interaction between reservoir slopes and impounded water, and the direct and indirect effects of unstable slopes on reservoirs and their operation. The Bulletin introduces guidelines for the identification and investigation on reservoir landslide risks.

Concepts presented here are particularly important to reservoir projects in the planning stage and to the safety evaluation of existing dams and their reservoirs.

The Bulletin is addressed to all those involved in the design, construction and operation of dams and their reservoirs.

### **Bulletin 125. Dams and floods - Guidelines and case histories (2003).**

During the last decades of the 20th century, natural disasters, and particularly those caused by floods, have significantly affected human life by producing grave social impact and economic damages. The principal aim of this Bulletin is to demonstrate the role played by dams in flood mitigation by describing real case.

The Bulletin is addressed to all those involved in the design, construction and operation of dams and their reservoirs.

### **Bulletin 126. Roller-compacted concrete dams - State of the art and case histories (2003).**

This Bulletin deals with the state of the art of roller-compacted concrete dams and follows more than two decades of notable advances in the technology, with the principal objectives of reducing the costs of construction of concrete dams and shortening the construction time.

The purpose of this bulletin is to make available a synopsis of current practice in the use of roller-compacted concrete for dams.

The Bulletin is addressed to all those involved in the design, construction and operation of dams and their reservoirs.

### **Bulletin 127. Remote sensing for reservoir water quality management - Examples of initiatives (2004).**

The purpose of the Bulletin is to present the major results of a three-year study carried out in Japan to evaluate the use of remote sensing as a combined tool for managing the water quality in reservoirs and releases, and the water-shed of the impoundment.

### **Bulletin 128. Management of reservoir water quality - Introduction and recommendations (2004).**

This Bulletin covers the important subject of management of reservoirs to achieve the best possible water quality in the reservoir and downstream releases. It gives an overview of the major physical and biochemical factors influencing the reservoir water quality.

Just after this overview, the setting of attainable environmental goal will be discussed as a precursor to the evaluation and selection of appropriate water quality management methodologies.

### **Bulletin 129. Dam foundations - Geologic considerations. Investigation Methods. Treatment. Monitoring (2005).**

The foundation of a dam is the most complex part of a water storage facility, moreover, it is also one of the most important components governing the safety of the structure. The main objectives of this Bulletin are to present the state of current practice. The Bulletin is intended as a guide to dam Owners, Designers, and Contractors and is relevant to dams under design as well as those under operation. The subject of dam foundation is very broad; a comprehensive bibliography directs the reader to the relevant literature.

This Bulletin is not a manual with ready-made instructions. Its message is to point out the tools and methods available today in dam foundation engineering and analysis, to make the reader aware of problems and pitfalls, and to emphasize the importance of geology and of a systematic approach to engineering geological investigations.

### **Bulletin 130. Risk assessment in dam safety management - A reconnaissance of benefits, methods and current applications (2005).**

The terms risk analysis and risk assessment are associated with estimation of the likelihood of unwanted events, associated consequences that would be realized should the event occur, consideration of the uncertainties involved and consideration of the tolerability of the estimated risks.

The purpose of the bulletin is to introduce the principles and terminology of risk assessment. It can provide a platform for informed discussion by the profession on the place of risk assessment in the wider field of dam safety management.

### **Bulletin 131. Role of Dams in Flood Mitigation - A review (2006).**

The main purpose of this Bulletin is to highlight the role that dams can play in flood mitigation, as one of the options to be taken into consideration within the framework of Integrated Flood Management (IFM). Dams and reservoirs constitute a very effective structural measure, since they are able to store large flood volumes, modify flood routing, and significantly reduce peak floods. This Bulletin contains relevant experiences and real

cases of benefits that dams and reservoirs have brought where flood mitigation is concerned, in China, USA, Japan, South Korea, Spain and Honduras.

The Bulletin aims to demonstrate and put across the essential facts with respect to the role of dams and reservoirs in flood mitigation, and is aimed at a wider and more general audience than just dam experts. It will serve to objectively show the benefits and risks associated with dams and reservoirs as part of Integrated Flood Management.

### **Bulletin 132. Shared rivers: Principles and practices (2007).**

Shared rivers and their drainage basins cover an area of almost half of the total land area of the earth. International considerations are thus vital aspects in the planning, implementation and management of water resources.

The approach taken in this Bulletin was to compile a document (over 3600 treaties relating to international water resources) which will provide the reader with a distillation of principles and practices relating to the subject. Examples of successes and problem cases are included for illustrative purposes. The development of electronic information exchange over the last decade has opened up new approaches towards accessing current information.

### **Bulletin 133. Embankment dams on permafrost - A review of the Russian experience (2007).**

Zones where permafrost is found (cryolitic zones) are characterized by a rigorous climate and complicated topographic, geological and hydrogeological conditions. Therefore, it is reasonable to give an insight into the structural features and the engineering characterizing the operation and repair of dams built in cryolitic zones, on the basis of exploration, design, construction and operation experience

The Bulletin is intended for geological engineers, designers and builders of hydraulic engineering structures.

### **Bulletin 134. Weak rocks and shales in dams (2008).**

There are many potential dam sites on shale or other weak rocks. This bulletin aims to assist dam engineers to develop such sites effectively in future. It advises on the means of using these materials by developing an understanding of their properties and by learning from the experiences of others in their successful use.

It provides a technical background to the behavior of shale and weak rocks as fill in dams.

### **Bulletin 135. Geomembrane sealing's systems for dams (2010).**

This new edition in 2010 cites 280 dams and updates the data and recommendations of the first two 38 and 78 Bulletins. It reviews the new information and practices that have appeared in the meantime, which include application of geomembrane as the only watertight element in fill dams, in RCC dams as external joints, as underwater repair on gravity dams.

This new Bulletin also deals with application of geomembranes for dams affected by AAR. The Bulletin reports about sealing of defective joints and cracks in the upstream face of CFRDs by strips of geomembranes mechanically fastened.

### **Bulletin 136. The specification and quality control of concrete for dams (2009).**

This bulletin follows more than two decades of advances in the construction of concrete dams. The purpose is to make available a summary of current practice in the specification and quality control of concrete for dams.

This Bulletin addresses all aspects of the relationship between the specification of concrete, construction procedures, the properties of the hardened concrete and how quality control is used. The development of concrete for dams from the conceptual stage to finished product is described.

### **Bulletin 137. Reservoirs and seismicity - State of knowledge (2011).**

Reservoir triggered seismic phenomena are affecting a small fraction of the dam population as significant triggered earthquakes. On micro seismic level such phenomena are probably much wider as a number of them have gone unobserved

ICOLD has considered this problem and special attention was paid since 1969.

The main conclusion in this Bulletin is that RTS possibility should be considered for each large dam within the frame of prevailing seismotectonic conditions.

This Bulletin is intended to be of help in understanding the nature of and evaluating the likelihood of facing the RTS phenomena.

### **Bulletin 138. Surveillance: Basic elements in "dam safety" process (2009).**

A "General Approach to Dam Surveillance" is presented here, for owners, managers and other non-specialists.

Dam Surveillance is a basic element in Dam Safety processes within the current legal frameworks. It covers a series of complementary and redundant activities, made of visual inspections, dam documentation management, monitoring, equipment checking and testing, and assessment of dam condition and behavior.

### **Bulletin 139. Improving tailings dam safety - Critical aspects of management, design, operation and closure (2011).**

In considering the critical aspects required to improve tailings dam safety, the following subjects are addressed in this Bulletin:

- > Corporate and Management Commitment
- > Education and training of company staff
- > Critical aspects relating to the design of a tailings dam
- > Critical aspects to be considered when designing for and implementing the final closure of a tailings dam
- > Risk management
- > The essential need for regular external audits
- > Some notes on the positive role that is played by industry regulators.

The conclusion reached in the document is that diligent attention to these critical aspects will result in improved awareness and a lowering of safety incidences for tailings dams.

### **Bulletin 140. Mathematical modeling of sediment transport and deposition in reservoirs (2007).**

As reservoir sedimentation has proven, to be a serious problem in South Africa, research in this field has been ongoing for more than 70 years. This publication emanates from extensive research, which has been over the

past 30 years. A great deal of information has fortunately also been obtained from China, which has the most extensive experience in this field.

Given the universal nature of hydraulic formulae, Chinese and South African data generally conform to the same mathematical relationship. This indicates that these relationships should be applicable in other countries as well.

This guideline on mathematical modeling can be used during the planning and design of new dams, and management of existing dams.

### **Bulletin 141. Concrete face rockfill dams: Concepts for design and construction (2010).**

Updated version of the Bulletin on "Rockfill Dams with Concrete Facing" (Bull 70).

During the decade of the 1990s, the concrete face rockfill dam has become common. A cursory review of the listing of CFRDs in the appendix indicates the widespread use and popularity of this type of dam.

The updated Bulletin is devoted to design concepts, analysis, foundation treatment, instrumentation, construction, and performance.

### **Bulletin 142. Bulletin on safe passage of extreme floods (2012).**

Subjects explored in this bulletin are:

- > The severe direct and indirect consequences of potential dam failure on human life, environment and economy.
- > Planned implementation of dam projects including new projects; the need for the rehabilitation and up rating of ageing dams; the need to cope with increasingly difficult conditions and constraints for the implementation of dams.
- > The intense implementation of small dams with limited use of engineering resources, resulting in increased risks, as evidence by the statistics of failures.
- > The relevant role of hydrological/hydraulic safety, namely its dependence on uncertainties, limitation of available information and limited predictability of intervening phenomena.
- > The specific characteristics of hydrological/hydraulic safety, namely its dependence on uncertainties, limitation of available information.

### **Bulletin 143. Historical review on ancient dams (2013).**

This bulletin treats about ancient dams constructed by the Man, the first one about 5 000 years ago. As varied as their origins, were the structural characteristics of ancient dams, for which no regional preference are discernible. They had one aspect in common however, to resist the water pressure only the weight of the construction material was used, but not its strength itself.

Various countries contributed to the bulletin of the small dams ICOLD committee, in which it is possible to follow up the construction of several ancient dams in different places and time along the world.

### **Bulletin 144. Cost savings in dams (2010).**

The present Bulletin reviews Bulletins 73 and 83, using lessons from Question 84 (Technical solutions to reduce time and cost in dams design and construction) and also takes into account the six other specific



bulletins on Cost Savings. It applies to various dams apart from tailing dams where the problems and solutions are very different.

This present bulletin is devoted to:

- > Identifying and mitigating existing non-technical factors detrimental to cost savings.
- > Technical opportunities for innovation and cost savings in the design of both high and low dams.

It is based upon a preliminary analysis of:

- > Existing dams.
- > Present trends in dam construction.

### **Bulletin 145. The physical properties of hardened conventional concrete in dams (2009).**

The purpose of this bulletin is to provide a comprehensive treatise on the physical properties of hardened conventional concrete for dams.

This bulletin addresses also the physical properties of the mass concrete used most frequently in design and analyses of concrete dams and appurtenant structures.

The scope of the bulletin is, to each property considered, to show typical behavior, factors influencing it, methods for experimental determination, and methods to introduce the properties in mathematical models to be utilized for both design and observation.

### **Bulletin 146. Dams and resettlement - Lessons learnt and recommendations (2016).**

The report is intended to be an informational source for policy makers as well as implementers. It should highlight the latest policies, criteria and resettlement measures adopted, their implementation aspects and the performance or effectiveness of the mitigation measures taken to improve the living standards and quality of the life of the relocation.

This bulletin deal with issues implied by resettlement, it explains history cases and the lesson learnt, it recommends strategies.

### **Bulletin 147. Sedimentation and sustainable use of reservoirs and river systems (2009).**

This Bulletin discusses the upstream and downstream fluvial morphological impacts of reservoir sedimentation and possible mitigation measures.

The current state and possible future sediment deposition in reservoirs have been investigated globally with the aid of the ICOLD Register on Dams.

This Bulletin also investigates the impacts of dams on the ecology related to fluvial morphological changes, and guidelines are proposed to try and mitigate the impacts on the downstream river morphology. Finally, an economical model is presented which considers a life cycle approach and reservoir conservation.

## **Bulletin 148. Selecting seismic parameters for large dams – Guidelines (2016).**

There have been significant advances in the seismic design of dams and a revised Bulletin is considered necessary which takes into account current practice in a number of countries with the following ends in view:

- > To provide a guide for the selection of parameters to be used in the seismic design, analysis and safety evaluation of new or existing dams and their appurtenant structures.
- > To promote consistency in handling the earthquake aspects of dam performance evaluation among owners, designers and various organizations involved in the planning, design, construction, operation, maintenance and regulation of dams.

This bulletin revision comes after several years of work by the Committee on Seismic Aspects of Dam Design and has, in particular, addressed the following aspects:

- > A new section on Seismic Input parameters.
- > Reference to liquefaction.
- > Introduction of Safety Evaluation Earthquake (SEE).
- > Improved references to problems posed when constructing dams across active faults.
- > Improved references to Reservoir-Triggered Earthquakes (RTE).
- > Additional material on Peak Vertical Accelerations and Earthquake Durations.
- > Updated references to attenuation formulae and updated list of references.

## **Bulletin 149. Role of dams on the development and management of rivers basins. A general review (2014).**

The aim of this report is to explain the role of dams in the development of river basins. We have stated that dams are simply tools for the management of water resources in rivers basins.

This bulletin focuses on the process of integrated river basin planning and management that has become an extremely diverse process involving a wide range of economic, and, as the major source of freshwater, is vital to humankind. Good management for sustainable development is the goal with all of its social, environmental and economic dimensions.

This bulletin analyze the role of dams in river basins and their contribution satisfying people needs. Then it deals with the integration of rivers basins as planning units for the development and management of water resources, finally it discuss the decision taking processes and stakeholder participation in different stage.

## **Bulletin 150. Cutoffs for dams (2018).**

Cutoffs for Dams, discusses foundation treatment methods using cutoff-type barriers. High emphasis is given to alluvial deposits throughout this document; however, different materials may require cutoff. The construction of cutoffs has made significant advances mainly through the development of more powerful machinery for drilling and excavation, but also through the introduction of new concepts and techniques, such as jet grouting and deep soil mixing. The following types of cutoffs are presented in this Bulletin:

- > Diaphragm walls
- > Vib walls

- > Pile walls
- > Superimposed concreted galleries
- > Jet grouting
- > Deep mixing

These methods are described, and the practical application of each method is illustrated by selected case histories. These case histories also demonstrate how certain difficulties specific to a particular dam site have been dealt with. The performance of cutoffs should be monitored so that their efficiency in reducing flow and piezometric head can be evaluated. Piezometers installed in the foundation upstream and downstream of the cutoff are needed to meet this objective.

### **Bulletin 151. Tropical residual soils as dam foundation and fill material (2017).**

Dam construction across the world has recently acquired an accelerated pace as needs for water supply and renewable energy sources have increased in many countries. Many of these countries are located in areas where tropical residual soils are abundant.

The main difficulty in dealing with these soils for engineering purposes is that their characteristics are very different from those of transported soils.

The purpose of this bulletin is to illustrate how these materials have been accepted and used in dam projects without imposing selection of better known materials that could jeopardize the economic viability of a project.

### **Bulletin 152. Cost savings in specific dams (2014).**

This bulletin has been devoted to cost savings in Dams, including two parts:

- > Identifying and mitigating existing factors detrimental to Cost Savings such as procedures, set ideas and not adapted specifications.
- > Technical opportunities for innovation and cost savings in the design of high and low dams built in usual conditions.

The present bulletin refers to such technical opportunities for innovation and cost savings when they apply to special dams for which the specific conditions may require or favor unusual criteria or designs and / or construction methods. They may be required by environmental problems, climatic changes or local physical or economic conditions. Such specific dams may in the future require over half of all dam investments.

### **Bulletin 153. Sustainable design and post-closure performance of tailings dams (2013).**

This bulletin provides guidance for the designers, owners, operators and regulators of tailing dams on closure considerations for design at all stages of the tailings dam.

The bulletin contains three main sections with a discussion on the following topics:

- > Sustainable Closure Principles, covering current international practice, regulations, objectives, design life and phases, financial and risk management practices as they relate to closure.
- > Sustainable Design Considerations, covering the main aspects of physical, chemical, ecological and social stability associated with tailing dam closure.

- > Monitoring, covering post closure and long term monitoring requirements.
- > The document presents a range of international approaches to the subject of sustainable tailings dam closure.

### **Bulletin 154. Dam safety management. Operational phase of the dam life cycle (2017).**

This Bulletin is devoted to the development and the implementation of a dam safety management system for dams in the operational phase of their life cycle. It outlines the general structure of a systems approach to safety management, and strives to develop a system that can address all the interdependencies, and encompass all the arrangements necessary to ensure proper dam safety management.

In conclusion, the authors and the entire Committee on Dam Safety sincerely hope that the Bulletin will be helpful in developing, implementing, reviewing and improving the management of dam safety at all organizational levels.

### **Bulletin 155. Guidelines for use of numerical models in dam engineering (2013).**

This bulletin is made to help engineers in establishing a sound computation strategy based on a careful analysis of the problem to be solved, selecting the adequate software options needed, then carrying out the analysis in a progressive way with frequent checks, and finally using adequate outputs to make rational interpretation of the results achieved, so as to translate them into engineering decisions.

This will be done through recommendations, and also examples in different contexts.

The present bulletin provides only few developments on the selection of input data, distributed among the different chapters. Moreover, it voluntarily omits providing recommendations on performance criteria and solicitation combinations, since these aspects are generally widely covered by standards or codes in force in most countries. It does not cover computational fluid mechanics applications.

### **Bulletin 156. Integrated flood risk management (2014).**

The purpose of the present bulletin is to give guidance in integrated flood risk management to people assigned technically or managerially with the task of flood management and control. Without giving preference for any method, the bulletin aims to describe the fundamental knowledge needed for flood management according to the current state-of-the art and to provide help in selecting the most appropriate design and implementation strategy, based on basin-specific characteristics and the framework of integrated flood risk management.

The prerequisites for all flood management are the understanding of flood characteristics and how to calculate both the magnitude and frequency of floods. Equally essential are the understanding of the impacts of floods, both negative and positive, and how to quantitatively and qualitatively evaluate these. The knowledge of flood characteristics and impacts is a fundamental input to the risk analysis, which forms the basis for integrated flood management.

### **Bulletin 157. Small dams: Design, surveillance and rehabilitation (2016).**

This bulletin was prepared as a guide for small dam owners, engineering, Government agencies, developers and contractors who are in charge with the design, construction, operation, maintenance and safety of small dams.

Design criteria and typical features for small dams are generally different from those for high dams, because the construction methods focus upon economy. So the risk may increase and corresponding accidents may cause significant victims. The basic principle of design is to produce a satisfactory functional structure at a minimum total cost. At the “Peculiar Features about the Design of Earthfill Dams” are presented the important contributions from China, United States, France South Africa, Australia and Japan, related to the recommended embankment slopes for small dams based on the experience with the construction of a large number of those small structures.

“Guidelines on Surveillance of Small Dams” presents the main recommendations in order to assure that the dams will behave appropriately and with a minimum cost. The construction of a dam can involve a significant investment and dam owners need to ensure that their money is well spent and that their dam becomes an asset.

### **Bulletin 158. Dam surveillance guide (2018).**

Prepare guidelines for the optimal organization of all components required for dam surveillance and monitoring (independently of the automated monitoring, already covered by Bulletin 118) with the purpose of dissemination in the fields of:

- > Visual inspection methods and procedures for improving their efficiency;
- > Continued availability and maintenance of technical data (documentation management for storage of engineering data and all information needed for periodical appraisal of the dam condition and support of engineering judgment as well as knowledge transfer from one generation to the next);
- > Optimization of instrumentation and monitoring (depending on the dam type and condition) and upgrading of instrumentation (on old dams);
- > Efficient management of monitoring data (acquisition, processing, conservation) and interpretation (of processed readings and observed data) to assess the present dam condition.

### **Bulletin 159. Supplement to the position paper on dams and the environment (2012).**

The global GHG emissions have increased markedly as a result of human activities since 1750; the population are growing and are expecting to increase until 2050. Global warming have impacts on dam safety and dams can therefore be both affected and provide solutions to global warming.

This bulletin is a supplementary paper that summarize the global environmental changes such as global warming and the role of dams in the future.

### **Bulletin 160. ICOLD Dam decommissioning – Guidelines (2018).**

Dam decommissioning or dam removal has been increasingly common since the past decade. The reason for considering dam removal may have to do with the safety of dams, high repair costs, high operating and maintenance costs, or effects on fish passage and water quality. However, the decision to remove a dam must be based on careful evaluation of the alternatives to address the specific problem at each dam.

The ICOLD Committee for decommissioning dams was established in 2005 to develop information that can be used by ICOLD members to respond to questions about the dismantling of dams and to provide a forum for the exchange of information. This ICOLD Bulletin is not intended as a design guide, but as a guide to the decision-making process, consultation and regulatory approvals, design and construction issues, sediment management and performance monitoring.

The primary aim of these Dam decommissioning guidelines is to provide dam owners, dam engineers and other professionals with the information needed to guide decision making when considering dam dismantling as a project alternative. They are not meant to be used as a design guide, but as a guide to highlighting the points of interest. The guidelines in this ICOLD Bulletin apply only to flood defense structures and not to fall dams.

### **Bulletin 161. Dams and water transfers - An overview (2013).**

This bulletin addresses the following subjects:

- > Collection of information on present status of intra-inter basin, and inter sub-basin transfer of water resources.
- > Guidelines for examination of the need and potential for inter-basin developments.
- > Limits of water transfers from surplus to deficit basins.
- > Benefits and costs analysis.
- > Collaboration with the Committee on the Environment to define the specificities of the environmental impacts of water transfers.
- > Guidelines for study of options for inter-basin transfers.

### **Bulletin 162. The Interaction of hydraulic processes and reservoirs (2010).**

Dams provides energy and water along with other things that meet human needs. There are however significant concerns about the environmental impacts of dams. Each dam has their own characteristic depending on the purpose and location of it, which makes it difficult to generalize the impacts of dams on ecosystems.

The bulletin offers different effects on the water quality, environmental impacts and hydraulic processes along with case histories. Downstream impacts of large dams are also discussed.

### **Bulletin 163. Dams for hydroelectric energy.**

The growth of electricity has been faster than any end-source of energy. Hydropower accounts for about 16% of the world's electricity generation and the largest source of production from renewable sources.

The bulletin offers an overview of the main topics related to hydropower and makes particular reference to dams as part of hydropower developments. Current extent of hydropower development and hydropower production are discussed as well as environmental and social impacts.

### **Bulletin 164. Internal erosion of existing dams, levees and dikes, and their foundations (2017).**

Internal erosion is one of the major causes of embankment dam failure.

When constructing new dams, protection against internal erosion is provided by zoning and by providing filters. However, many existing dams are not adequately zoned and do not have filters and may therefore be vulnerable to internal erosion. Others have filters not designed and/or constructed to modern standards, they too may be vulnerable to internal erosion.

The Bulletin are in two volumes. Volume 1 deals predominantly with internal erosion processes and the engineering assessment of the vulnerability of a dam to failure or damage by internal erosion, with a brief oversight of monitoring for and detection of internal erosion and remediation to protect dams against internal erosion. It includes a comprehensive listing of the Terminology used in internal erosion. Many references are also given, including links to many from an ICOLD internal erosion webpage.

Volume 2 gives more details of internal erosion investigations, and appropriate testing, monitoring and detection, and remediation, and gives case histories.

### **Bulletin 165. Selection of materials for concrete in dams (2013).**

Concrete for dams is in some important respects different from concrete used for other purposes. For economic reasons, aggregate is normally derived from new sources local to the dam rather than established quarries.

The bulletin provides guidelines for selection of materials for concrete dams and includes chapters on aggregate, cementitious materials, mineral additions, chemical admixtures and mixing water.

### **Bulletin 166. Inspection of dams - Following earthquake guidelines (2016).**

Large dams should be able to resist the effects of the strongest ground shaking to be expected at the dam site. However, major damage is accepted as long as there is no catastrophic release of water from the reservoir.

Accordingly, the inspection of dams following earthquakes is an important aspect in the integral safety concept of dams.

The bulletin was first published in 1988. Since then a few earthquakes have occurred, which have also caused damage to dams.

### **Bulletin 167. Regulation of dam safety: An overview of current practice worldwide (20xx).**

Dam safety is a dynamic, evolving concept and should be treated accordingly. Countries have different dam safety legislation, dam supervision and dam classification.

The bulletin contains a worldwide overview from 44 countries of main arrangements for dam safety frameworks. The goal of the bulletin is to make basic information available about existing practices in dam safety management.

### **Bulletin 168. Recommendations for operation, maintenance and rehabilitation (2017).**

The need for proper operation and maintenance is of crucial importance for developing countries' organizations which may have, at present, limited experience. The aim of this bulletin is to offer the possibility to benefit from the experience of other organization or countries.

It is also a fact that our dams are aging and one day, or another, Owners will have to face the issue of rehabilitation or adapting to new operating conditions.

Twenty-eight (28) countries participated at different levels to this Bulletin.

The purpose of this Bulletin is not to define the proper organization or procedures, but to open the eyes of newcomers either to plan for the future of their newborn dam or to assist them to solve problems they may experience with their existing dams today.

### **Bulletin 169. Global climate change, dams, reservoirs and related water resources (2016).**

The purpose of this bulletin is to determine the threat and potential opportunities by the global climate change for dams and reservoirs.

### **Bulletin 170. Flood evaluation and dam safety (2018).**

Hydrology and dams are two fields that are obviously closely related. Four bulletins have so far been published by the Committee: Selection of Design Flood – Current methods, Dams and Floods – Guidelines and cases histories, Role of Dams in Flood Mitigation – A review and Integrated Flood Management. These bulletins have essentially addressed floods, the risks they represent and their significance for the concerned populations.

The present Bulletin deviates slightly from this path, adopting a somewhat more technical perspective. The text consists of three chapters, conceived to be accessible to the practitioners.

### **Bulletin 171. Multipurpose water storage - Essential elements and emerging trends (2016).**

The bulletin is describing the local and the global role of water storage and presents the basis of multipurpose developments in the context of the hydrological cycle, environmental assessments, stakeholder engagement and the water energy nexus. It also explores economic and financial perspectives of multipurpose projects.

### **Bulletin 172. Technical advancements in spillway design - Progress and innovations from 1985 to 2015 (2016).**

This bulletin provides technical features of different types of spillways that has been developed during the last four decades and some hydraulic features associated with the structures. Specific types of structures like stepped spillway, PKW and tunnel spillway are included. Analysis of conventional structures that are operating in different conditions such as very large flows, very high head and very cold climate

### **Bulletin 173. Integrated operation of hydropower stations and reservoirs (2016).**

Storage may serve to raise the water level in a river over a particular section to facilitate navigation or to create head for hydropower generation. Storage may also be used to collect surplus flow during floods for later use in supplies for domestic, industrial, agricultural, ecological or hydropower generation needs.

This bulletin gives an overview of main functional aspects relating to cascade hydropower stations and typical case studies.



### **Bulletin 174. Action plan on capacity building (2016).**

The document presented here is the result of the works of the committee which conduct several training programs in parallel with the preparation of the Action Plan.

The aim of this work is to enable ICOLD to have a systematic and comprehensive vision and integrated actions to strengthen ICOLD and its members country committees and in general to enhance the capacity of professional members of ICOLD to handle the process of Dam engineering, construction operation and safety management.

### **Bulletin 175. Dam safety management: Pre-operational phases of the dam life cycle (20xx).**

Dams are a potential hazard in case of uncontrolled release of water due to overtopping by flood or by sliding earth mass in the reservoir. Structural failure of the dam body, its foundation or malfunctioning releasing structures are also potential hazards. Identifying the risk factors and trying to minimize them are essential.

This bulletin address topics including dam development phases and role of the various actors, various risks in design and construction, the need of improve knowledge of prevailing conditions by investigation, minimizing risk in the development of dam projects and safety management system.

### **Bulletin 176. Blockage of spillways and outlet works (20xx).**

Flood debris can be classified in two types: sedimentation and floating debris. Debris are a potential dam safety hazard and can clog the spillway openings, reduce reservoir storage and exert additional load on the dam structure.

This bulletin address issues related to floating debris on dam safety including potential impact on floating debris on dam safety, quantification on floating debris and mitigation methods to reduce the potential impact of floating debris on dams. The bulletin is also reporting on a series of case studies of sediment blockage.

### **Bulletin 177. Roller-compacted concrete dams (2018).**

The purpose of the bulletin is to present current practice and the state-of-the-art roller-compacted concrete (RCC) technology for dams.

This bulletin supersedes bulletin 126 and 75 and addresses all aspects of the planning, design, construction and performance of RCC in dams. Discussed topics are mixture proportioning and quality control.

### **Bulletin 178. Operation of hydraulic structures of dams (2017).**

The bulletin is a revision from first and second edition from 1984 and 1986. This bulletin deals more specifically with importance of outlet works and features the operator requires, operating personnel, inspection and testing of hydraulic appurtenances, operation in flood seasons and the latest trends in operating practices.

### **Bulletin 179. Asphalt concrete cores for embankment dams (2018).**

The first modern asphalt concrete dam was built in Germany in 1962 and has expanded since then. Approximately 200 asphalt concrete embankment dams have been built all over the world. Its popularity follows the excellent recorded field performance and behavior for this type of dam.

This bulletin covers the state-of-the-art of important development in design and construction during the last 25 years. The bulletin addresses all aspects of the design, construction, performance and operation. Topics that are discussed are:

- > Characteristics of asphalt concrete cores
- > Requirements for the mix design
- > Laboratory testing and quality control.

A few case histories are also given in Appendices.

### **Bulletin 180. Dam surveillance - Lessons learnt from case histories (2017).**

This bulletin attempts to show experiences from the field of dam surveillance from the past six decades by case histories and it contains:

- > Methods for the improvement of the quality and reliability of information;
- > Data processing and representation techniques;
- > Effective Diagnostic analyses to determine behavior patterns;
- > Dedicated surveillance systems for the optimization of maintenance-, rehabilitation- and other life cycle costs; and
- > Impact of surveillance (preventing dam incidents and dam failure by means of selected case histories).

### **Bulletin 181. Tailings dam design - Technology update (2019).**

An understanding of the strength of tailings continues to improve with new technologies, and improved sampling and laboratory techniques, and case histories from dam incidents and failures improves our knowledge of tailings behavior.

This Bulletin provides a framework for classifying different types of tailings, ranging from ultra-fine to coarse, based on their geotechnical properties and provides typical geotechnical parameters for the different tailings types.

### **Bulletin 182. Sediment management in reservoirs: National regulations and case studies (2019).**

Sediment management in reservoirs is of great and growing importance in the water storage field. The construction of a dam across a river inevitably triggers a change in the flow regime and a modification of the sediment transport balance.

This bulletin provides a concise summary of environmental regulations associated with sediment management activities in reservoirs (as of 2017) followed by a series of case studies which compare sediment management techniques from various projects around the world.

### **Bulletin 183. Selection of dam type (2019).**

The choice of dam type for any one particular site should be based on the evaluation of a range of dam types with selection of the optimal dam type based on risk factors, costs and environmental impacts. The risk factors may include hydrological risk (uncertainties in the spillway design flood estimate), geological risks (imperfect

knowledge of conditions at the time of dam type selection) and cost risks (unusually large uncertainties in expected tender prices).

The Bulletin contains a section on information required to develop dam designs of a dam such as topography, climate, hydrology, geology and materials availability.

### **Bulletin 184. Management of expansive chemical reactions in concrete dams and hydroelectric projects (2019).**

This Bulletin is to update understanding of expansion phenomena in concrete dams and hydroelectric projects presented in the ICOLD Bulletin 79 published in 1991. Since that time, many new cases of expansion instances involving expansive chemical reactions in dam materials affecting dam safety.

The bulletin presents a review of the methods and effectiveness of recent practices in the management of expansion effects in concrete dams and spillways. It will consider all kinds of chemical expansion phenomena, including that due to alkali aggregate reactions (ASR and ACR), such as reactions due to sulphur compounds and those in which free lime or magnesia has a role.

### **Bulletin 185. Challenges and needs for dams in the 21st century (2019).**

The subject of this bulletin comprises the following four major categories of emerging challenges.

- > The great need, in many parts of the world, for additional fresh water resources and for additional electrical production
- > The mix of energy sources needed to deal with the expanding energy needs world-wide; and the need for pumped storage hydro or other more expensive energy storage as the world develops more renewable and uncontrolled intermittent energy sources such as wind and solar power
- > Climate change that has an impacts to on water supply, flood control, and energy production as the world progresses into the 21st century; and how dams and reservoirs might help mitigating or adapting to climate change and
- > The need to deal with constraints to development and responses to climate change such as financing, environmental needs, and social responsibility.

### **Bulletin 186. Integrated Optimal Operation of Cascade Hydropower Stations and Reservoirs (2020)**

This bulletin serves as a reference for the readers in hydropower and related fields. It gives an overview of the main benefits brought by cascade hydropower stations and typical case studies in the member countries. It was formed by reviewing all the proposals and typical cases provided by the committee members.

Four major conclusions are drawn:

- > More and more reservoirs are built in the same river basin, resulting in a need for integrated operation of cascade reservoirs.
- > Increased water demands, more factors needs to be taken under consideration in reservoir operations
- > The application of new technologies provides a means for integrated operation of cascade reservoirs and makes multi-objective optimal operation feasible.

- > Smart operation of cascade reservoirs is indispensable, and the integrated operation of reservoirs and hydropower stations will be the main development trend.

## **Bulletin 187. Flood evaluation, hazard determination and risk management (2020)**

The Bulletin consists of three main chapters following the introductory chapter.

- > Chapter Two discusses the main aspects related to the volume of floods. In general, a flood is often associated with the consequences due to its peak flow. However the volume of floods is also an important aspect to consider.
- > Chapter Three is a follow-up to the previous bulletin, addressing in more detail the stochastic approaches to flood risk assessment. These analyses include factors that are independent of floods but may have an impact on the safety of the dam(s) in the system under study.
- > Finally, the last chapter deals with the forecast aspects related to the proactive management of floods. Case studies to illustrate short-, medium- or long-term management challenges are presented in Appendix A of this document.

## **Bulletin 188. Statistical analysis of dam failures - ICOLD Incident database Bulletin 99 update (2020)**

The Bulletin is an update of Bulletin 99 which presented mainly statistical analysis based on the sizes of dams, their types and temporal aspects such as year of construction, age at failure, etc. For this update other important attributes have been added, such as the context of failures (normal operation, flood, earthquakes, etc.), the failure mode, and the failure causes. Although Bulletin 99 presented an analysis of the failure causes, in the 1990's there was still a lack of complete clarity about the understanding and interpretation of differences between failure modes and failure causes.

## **Bulletin 189. Current state-of-practice in risk-informed decision-making for the safety of dams and levees (2020)**

The content of this Bulletin focuses on gathering and compiling the information on the state of practice in the countries represented in CODS that agreed to provide information. The unedited information that Committee members participating in two surveys sent to the Working Group is reproduced in the Bulletin without any analysis or commentary, as requested by some members of the Working Group and by some participants at the discussions during the Committee meetings between 2014 and 2017.

A separate Bulletin will provide a critical review of currently used methods and approaches. This is a necessary step in advancing our state of knowledge and planning how to leverage this knowledge in continuing improving of our approach to the use of information about risk in managing safety of dams.

## **Bulletin 190. Cemented Material Dam – Design and Practice – Rock-Filled Concrete Dam. (2020)**

This Bulletin introduces the design of rock-filled concrete (RFC) dams. RFC remains a new technology and this bulletin will serve to inform dam engineers about technology applicable to RFC dams and will assist in the selection of appropriate design and construction parameters and processes. The Bulletin includes information about the preparation of raw material, selection of mixture proportions of high performance self-compacting concrete (HSCC) used in RFC and the construction of rocks and HSCC. This Bulletin also includes information about the quality control of foundation excavation and treatment, installation of formwork, reinforcement and

monitor instruments, and curing and protection of RFC dams. Some test data of the performance of RFC are listed in the bulletin to help understand the performance of RFC. Other dams similar to rock filled concrete dam is presented.

This bulletin is one of the first three planned bulletins prepared by ICOLC Technical Committee on Cemented Material Dams.

### **Bulletin 191. Dam safety guidance – dam safety concepts, principles and framework. (2021)**

This Bulletin is the first in a series of three documents with the goal of addressing all aspects of dam safety assurance for water-retaining dams during all life phases, beginning with the planning and ending with the decommissioning and possibly removal. The content of the first focuses on the general framing of the modern dam safety concepts and principle. Elements of dam safety management, process for dam safety management and dam safety assurance is included. The Bulletin also consists of information about the role of the government and legal arrangements as regulatory, operational and administrative control considerations. Administrative controls during dam development and dam operation and owner's dam safety policy, organization and activities to achieve dam safety goals. Competence, safety culture and capacity building.

### **Bulletin 192. Dam safety guidance – dam safety governance considerations. (2021)**

This is the second Bulletin in a series of three documents with the goal of addressing all aspects of dam safety assurance for water-retaining dams during all life phases, beginning with the planning and ending with the decommissioning and possibly removal. The second Bulletin begins with the brief characterization of different legal systems developed along different legal principles. Its focus is on explaining how to build an effective and efficient dam safety regulatory framework which not only fits the country/jurisdiction legal system but is also appropriate for the country/jurisdiction social and economic circumstances, cultural traditions and societal expectations.

### **Bulletin 193. Sediment Bypassing and Transfer. (2023)**

The focus in this Bulletin is on design and implementation of two sediment management practices: sediment bypass system and sediment transfer system. Hoping that the bulletin will be a resource for practitioners seeking guidance for design and implementation of these methods for either existing projects or those still in design. The chapters contain the following:

- > Chapter 1 outlines the general problem of reservoir sedimentation and provides overview of the structure of the bulletin.
- > Chapter 2 provides a brief review of sediment yield, including production, transport and estimation methods.
- > Chapter 3 focuses on sediment connectivity, defined as the connected transfer of sediment from upstream to downstream within a watershed.
- > Chapter 4 contains a significant part of the overall bulletin, presenting sediment bypass design, particularly design of channels and tunnels.

### **Bulletin 194. Tailings dam safety. (2022)**

Complements Bulletin 139, 153 and 181 and consolidates the key aspects related to good design and good governance of tailings facilities and is a valuable guide for designers of tailings facilities, as well as operators, managers, and regulatory personnel. The bulletin includes information about tailings storage facility governance, closure of tailings dams, different tailing dam consequence classifications methods and site characterization to establish conditions and parameters that impact and/or would be impacted by the TSF (tailings storage facilities). Life phases and design stages of a tailings dam and risk management is also represented. Finally the bulletin includes information about dam failure/breach analysis, emergency preparedness, response planning, construction and operations for tailing dams.

### **Bulletin 195. Cemented material Dams: Design and Practice. Cemented soil dams. (2022)**

The scope of the Bulletin is to provide adequate recommendations to design, construct and repair dams and levees with cemented soils. This Bulletin introduces material properties as binders and soils, properties of cemented soils and the structural design of cemented soil dams. It also includes investigations such as geological and geotechnical, treatment studies, criteria for the selection of the binder and the dosage, construction and quality control.

The second Bulletin of a series of planned bulletins. The first one, Bulletin 190, is about rock-filled concrete dams.

### **Bulletin 196. Levees around the world. Characteristics, Risks and Governance. (20XX)**

This Bulletin gives a first approximate overview of levees, levee-related issues and levee-related data. The first part of the report consists of three concise chapters: Introduction; Main results; Data Gaps and Recommendation, which highlights the main findings of this report. In the main results some overarching findings and a bullet-wise summary of key facts and figures per country is presented. Data Gaps and recommendation presents the most critical data gaps and research needs as identified by the participating countries. The second part consists of a set of over 20 country appendices containing a large amount of levee-related information.

### **Bulletin 197. Dam Breach flood consequence assessment. (2022)**

This Bulletin provides suggested principles and information on the contemporary applications and methods used for dam breach flood consequence assessment. The purpose is to provide guidance for dam safety managers on the principles, contemporary applications and methods used for the analysis and evaluation of the consequences of dam failures. It consists of the following chapters:

- > Chapter 1 - General characteristics and consequence assessment.
- > Chapter 2 - Fundamentals of consequence analysis.
- > Chapter 3 - Consequence evaluation.
- > Chapter 4 - Available procedures used in different countries.

### **Bulletin 198. Ageing of concrete dams. (2023)**

An important objective of this Bulletin is to illustrate the developed and current knowledge on the efficient management of ageing concrete dams and hydropower concrete structures. A focus of the Bulletin is on the nature of the most important concrete deterioration phenomena that affect different concrete properties. The

development of concrete technology from the late 1800's towards contemporary concrete is reviewed and a general system of management of existing ageing concrete dams and hydraulic structures are presented. The important process of condition assessment and analysis is addressed and the presentation of two real world cases demonstrates the possible application of this Bulletin.

This Bulletin is to update and augment the information of the Bulletin 93.

## Special publications

### **Position Paper on Dams and Environment. (1997)**

Dams provide a range of important services to society, but they imply a transformation of the surrounding environment and its people. The impact of dams and reservoirs on this environment is inevitable and undeniable. Due to the complexity of dam engineering the paper lists 10 aspects that should be considered as well as the role of ICOLD in this matter.

### **ICOLD 80 Years – Dams for Human Sustainable Development. (2008)**

A summary of the world's water resources and the role of dams and reservoirs followed by the history of ICOLD, their vision, mission, goals and strategic priorities

### **Position Paper on an Improved Planning Process for Water Resource Infrastructure. (2010)**

The purpose of this paper is to summarize the existing planning process for water resources projects and to highlight the areas that need improvement for the future. It addresses the value of integrated water resources management in the planning for water resources projects. Finally, it recommends a new planning process as the best way forward for new and future water resources projects

### **World Declaration on Water Storage and Sustainable Development. (2012)**

Water is life and water storage infrastructure is an indispensable tool for society. Investment in water storage infrastructure is investment in the green economy. The services they provide will be crucial in the mitigation of, and adaptation to, climate change. To meet growing demands for water, food and energy, it is time to develop solutions for better use of water resources, especially for developing countries, and to match political commitments with action. A balanced approach, combining large, medium and small reservoirs, is required; one that takes into account sustainable development, with full commitment to minimize negative impact. The organizations signing this declaration commit to collaborate with all partners and stakeholders that share this common vision.

### **Position paper on Dams Safety and Earthquakes. (2013)**

Dam failure due to earthquakes with deadly outcomes are rare. However, earthquakes pose a risk to the safety of dams. The paper aims to discuss how earthquakes affect dam safety, the potential hazards and how can they be mitigated. Followed by the role of ICOLD in this.

### **World Declaration on Dam Safety. (2019)**

With the aspirational goal of working towards continuous reduction of dam safety incidents, ICOLD, as the leading international organization committed to dam safety, calls upon all involved professionals and companies to make a firm commitment safety improvements and risk reductions at all dams. Furthermore,

Governments, Financial Institutions and other Developers, in their contribution to the development and regulation of dam infrastructure, are called upon to make a similar political and financial commitment so that the all-important safety recommendations for dams outlined in ICOLD Bulletins, will be disseminated to the relevant entities and followed to completion. This common effort will contribute immeasurably to the overarching ICOLD vision: Better dams for a better world.

### **Position paper on Dam safety and earthquakes. (2021)**

Earthquakes have always been a significant aspect of the design and safety of dams. This position paper deals with the seismic safety of large dams, based on experiences with large earthquakes in Japan, in China and in Chile. It presents ways to prevent key aspects of large dam failure under severe seismic conditions with a focus on design instead of on earthquake prediction. This is done by considering the prevention of uncontrolled rapid release of water of a storage dam under full reservoir conditions in relation to expected seismic conditions. This position paper is composed by the Committee on Seismic Aspects of Dam Design of The International Committee of Large Dams.