World Declaration on Dam Safety

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As of 2019, the World population is nearing 8 billion people and it is expected that this number will **overcome the 9 billion mark by the year 2050**. In our fragile world, this growing population is causing a steady increase in demand for food, energy and water to meet basic needs as wells as increasing standards of living. While there are alternative ways of generating energy and effective means to keep increasing food production, at the present **there is no practical and effective substitute for freshwater for irrigation and drinking**.

The world's water resources available for humankind are distributed unevenly over space and time with water resources infrastructure, including dams and reservoirs becoming more and more indispensable to ensure that water is available where and when it is needed. This is not a new condition. Dams have been providing reliable water supplies for thousands of years. It is now widely recognized that **water storage infrastructures will be needed more than ever in a time of climate change** corresponding to increased hydrological variability. Dams provide storage reservoir to mitigate changing weather patterns and seasonal variations of precipitation.

Throughout history the construction, operation and maintenance of dams and their storage reservoirs have provided **significant benefits to humankind**. Storage of water behind dams has long provided an effective means to regulate natural streamflow allowing benefits resulting from increased water availability and reduction of adverse impacts caused by natural extremes of flooding and drought.

Dams and reservoir have long provided services to human populations in a renewable use of our natural resources. At the same time, however, every dam creates **new hazards**, including risks to downstream life and property caused by the possibility that the dam may fail resulting in an uncontrolled or catastrophic release of stored water.

Levees have also provided protective services for many generations. Within this document, any references to Dam Safety should also be considered as applicable to Large Dams, Small Dams and Levees.

The Dams Engineering profession has a double duty and sacred responsibility; building the necessary dams in the most effective and sustainable way, while also ensuring that they are safe. Dam Safety is a core value to the International Commission on Large Dams (ICOLD). Hence this World Declaration issued by ICOLD to reaffirm our commitment and dedication.

ICOLD and Dam Safety

For almost a century, ICOLD has been committed to dam safety. It is therefore a legitimate institution to voice its concern on the subject.

Safety of dams, as an important part of societal concerns has always been of the highest dedication of ICOLD with a Constitution that states:

> "*The objectives of the Commission are to encourage improvement in the planning, design, construction, operation and maintenance of large dams and reservoirs and associated civil engineering works by bringing together relevant information and studying related questions including technical, economic, financial, environmental and social aspects. The Commission shall support socially and environmentally sustainable development*".

This position is reinforced by the ICOLD Mission statement:

> ***ICOLD** leads the profession in **setting standards and guidelines** to ensure that dams are built and operated **safely**, efficiently, economically, and are environmentally sustainable and socially equitable.*

Founded in 1928, the first ICOLD recommendations were published in 1930, observing:

- Before ICOLD creation, the knowledge on dam safety was disparate while the need for building water storage infrastructures was very high. It was therefore urgent to organize the return on operating experience in the profession of dam engineering.

- ICOLD played a key role in this **very strong improvement of dam safety**, through its work on collecting and analysing information on the failures from the past. Since this glorious beginning, ICOLD and its thousands of individual members have constantly worked to improve dam safety through its gathering at Congress meetings; work of its Technical Committees; and publishing of technical bulletins.
    - 700 large gravity dams built before 1930: 20 failed (5 percent);
        - in contrast, 4.000 were built after 1930: 2 failed (0,05 percent)
    - 2.000 large embankment dams were built before 1930: 100 failed (5 percent),
        - in contrast, 25.000 (outside of China) were built after 1930: 100 failed (0,4 percent)
    - Most of these late failures of embankment dams were caused by extreme floods.

Constant vigilance is required for dam safety as evidenced by occasional dam failures, especially evident in recent events in 2017 through 2019. Although the likelihood of dam failure is small, any dam failure is still a matter of the gravest concern to the dam engineering community. Potential effects of a dam breach can be catastrophic, resulting in multiple deaths and injuries, and widespread damage to the property and the environment.

Changing Conditions of Dam Safety

The total number of dams worldwide continues to grow as the rate of failure is constantly diminishing. The professional knowledge grows as lessons learned from around the world are brought together and distributed by ICOLD professionals. Modern design approaches are applied to new dams around the world at the same time as these approaches are also used to evaluate the safety of our older dams. These provide challenges to our professional of seasoned and younger engineers:

- The **ageing of existing infrastructure** is creating new concerns.

- More and more **new countries are now building dams** which means there are more and more engineers to educate.

- The **increasing influence of the private sector** in the dam business creates new governance conditions on dam safety.

- Currently ongoing **climate change** means there are new purposes for dams and therefore new risks.

As a recognized international collection of experts in dam engineering, ICOLD calls upon governmental authorities and financing institutions to devote a **particular awareness to the subject of Dams Safety**. The goal of this World Declaration is to restate the fundamentals of Dam Safety that have been learned throughout the ages and to remind those institutions of the need for ensuring, through their decisions, that those principles are respected in order to reduce risks to humankind as a result of dam structures.

Pillars of Dam Safety

With more than 90 years of commitment to dam safety, ICOLD recognizes the following pillars of our profession:

- **ICOLD Bulletins:** A body of scientific and technical knowledge (geology, geotechnics, hydrology, hydraulics, civil engineering, material science etc.) has been largely documented by the ICOLD bulletins. In the past 20 years ICOLD Technical Committees prepared 65 new Bulletins describing state-of-the-art methods and new, improved methodologies and approaches in designing, constructing and operating dams. Since 2010, ICOLD provides all Bulletins, free of charge, to dam engineering community through its National Committees.
- **Sharing Lessons from Dam Failure:** It is obligatory to develop and document experiential feedback in particular on dam failures to facilitate a wide sharing of knowledge on the causes and consequences of failures or accidents of the past. The international gatherings at ICOLD Congresses are the privileged place for this feedback, where experts from around the world discuss issues that are at the heart of the profession's concerns;
- **Need for National Regulations:** Those members and non-members of ICOLD - are also benefiting from the sharing of experience collected and documented by ICOLD. ICOLD encourages a specific role of National Committees to support regulatory administrations to ensure coordination between the accumulated knowledge and recommendations of ICOLD and those charged with regulatory authority for dam safety in order to fully account for the history and culture of each nation;
- **Risk Informed Decision Making:** A comprehensive approach to dam safety, based on risk reduction through a range of measures (national organizations to support dam

safety; structural measures to strengthen the structure's resistance; non-structural measures to minimize the consequences of failures; and education / awareness around dams); and

- **Lifecycle Planning of Risk:** Inclusion of formal information about safety risks into decision-making at all phases of dam lifecycle.
- **Owner Responsibility:** The safety and security of all dams is the primary responsibility and liability of the Owner.
- **National Government Responsibility:** Government organizations should take responsibility for regulating the security of the dam to protect those who might be threatened by the dam, especially those living downstream. Government oversight should provide regulatory provisions for minimum design standards, quality construction and operational compliance within accepted industry guidelines and standards.

Government regulatory oversight should include regular assessment of the safety conditions of the dam, including detailed review of dam performance as compared to the design intentions and assumptions. Government personnel should not be responsible for direct inspections and assessments of the dams. Rather, the responsibility of government is to confirm that such periodic inspections and assessments are done by qualified engineers on behalf of the Owner and that those assessments are done considering the current state of the practice for dam safety.

Therefore, Government officials who review dam safety compliance by Owners should include educated and licensed engineers with good experiences with dams. The international organizations such as ICOLD that provide guidelines based on worldwide experiences can provide important guidance to both Owners and Government Regulators to understand the current state of the practice for design and safety.

Approaches to Dam Safety Management

Management of dam safety during the lifetime of a project must be a constant and dedicated commitment by individuals and organizations. In the experience of ICOLD, there are several approaches to dam safety management that may be applied by Owners and Government regulators:

- **Traditional approach**, sometimes qualified as deterministic, based on recognized good practices (state of the art, recommendation, regulation, etc.), conservative safety margins (safety factor and loads taking into account uncertainty), safe design of projects, approaches sanctioned by experience, the use of project supervision by panels of independent experts, etc.;
- **Emerging approach** based on the direct and formal assessment of risk (**risk-informed dam safety management**), first developed in Anglo-Saxon countries and now gaining acceptance in national regulations, especially in Western countries;
- **National-level approach** to dam safety fundamental. It is the State in the form of government regulations under this approach which sets the principles of design and safety factors required in the traditional deterministic approach or the tolerable level of risk when the probabilistic approach and risk analysis is included in considerations;

- **Financing Agencies approach** to dam safety sometimes require the client countries to follow their dam safety policies, such as independent review, design / construction qualifications, dam safety plans, etc. including those recommendations historically provided by major financing agencies - first and foremost the World Bank (OP. 4.37 and Environmental & Social Framework) or by other international development banks;
- **Professional Approach** includes recommendations provided by recognized international experts, with ICOLD as a top organization.

Major Issues Associated with Dam Safety

A first step to recognize the major issues associated with dam safety is important to the development of a comprehensive assessment of a **Dam Safety Programme**, from planning through retirement. Such a programme includes the following considerations:

1. **Safety of existing dams**: It is the ultimate goal that existing dams must maintain the same level of safety as new dams throughout their operational life.
2. **Safety of tailings and mining dams:** These structures have unique considerations for design and operation, so that it is a very critical and specific problem that should be fully addressed.
3. **Safety of a dam throughout its entire life cycle** should be considered:
   a. during procurement phase (increased role of the private sector, lack of or inadequate regulation in developing countries, EPC contracts etc.);
   b. during design (geological and geotechnical survey and foundation treatment, extreme floods and design of spillways, structural risks, internal flow control etc.;)
   c. during construction phase: construction flood and design of the temporary diversion, construction quality, design of cofferdams, and overtopping;
   d. during commissioning: certain mechanisms of rupture are experienced at the first impoundment (settlement, internal erosion of the foundation, etc.), monitoring system is still not fully operational, the emergency plan is not in place;
   e. during operation: aging of the dam and its foundation, strong and extreme flood management, earthquake and post-earthquake stability, long-term dam monitoring; and
   f. during decommissioning: beyond their period of economic activity, provide means for the safe keeping or decommissioning of the structure.
4. **Safety aspects related to specific hazards;**
   - Earthquake safety (unexpectedly good behavior of the dams during the events but post-earthquake stability issues);
   - Landslides into river valleys caused by earthquakes or torrential rains (creation of natural dams and their failures);
   - Landslides into reservoirs;
   - Geotechnical aspects of safety (internal erosion, piping and slope stability of embankments, foundation issues)

- Floods safety (risks from completely gated spillways, risks related to operation during flood);
- Impact of human errors in dam operation.

5. **System safety aspects for Systems of Dams:** Safety impacts should be considered for the critical relationships, interactions and feedbacks between the components of a single dams and between dams in a multiple-dam cascading river system, including safety of dams in a transboundary rivers.
6. **Reservoir Sedimentation Management.** As part of long term operations, the active storage behand a dam should be considered. The per-capita storage volume is reducing because of combination of two factors: (1) the world population has been increasing at a rate greater than the rate at which we have built new storage (2) the loss of active storage due to sedimentation. It is important to develop and secure sufficient reservoir storage to meet the increasing demands for water supply, hydropower generation, flood control, etc. and adopt practices for sustainable sediment management.

7. **Climate Change Impacts:** Climate change is an important element to be considered for hydrological safety and reflected in resilient infrastructure design.

8. **Regular Operation and Maintenance:** Regular surveillance, periodic inspection/ safety review, proper documents archiving, and operation & maintenance works are critical considerations for dam safety assessments.

Summary Declaration

With a high goal of an industry working towards elimination of future failures of dams and levees, ICOLD as the leading international organization committed to Dam Safety calls upon all individuals and corporations associated with dams from planning through retirement to take a personal commitment and dedication to safety.

Further, Governments and Financial Institutions in their development and regulation of dam infrastructure are called upon to make a similar commitment that important Safety Recommendations are disseminated in a responsible manner to the relevant authorities and services.