ICOLD EUROPEAN CLUB

Working group on

SAFETY OF EXISTING DAMS

REPORT

2012

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ANNEX I I - SURVEY ANSWERS

FOREWORD

The informal working group of the European Club on "Safety of Existing Dams" had a first working phase[1], that was followed by a 2nd phase launched at the European Club meeting in Canterbury 2004, where a discussion on the chosen work themes took place. This reformulated group was accepted in 2005, with both new terms of reference and new coordinator.

The adopted terms of reference were the following:

- Study of criteria for the classification of dams according with their potential risk in case of failure;
- Procedures to review and evaluate the safely of existing dams;
- Emergency planning: criteria and content. Coordination with authorities in charge of the Civil Protection.

At the Barcelona Club meeting, in 2006, the Board approved the proposal of the new coordinator to include a small group of colleagues from the Portuguese Committee in the development of the work, alongside the other country elected members, and all interested, so that a report could be presented.

Thus, at the September 2007 Freising meeting, two sub-reports entitled "Damage potential (hazard) and risk classifications of dams" and "Emergency planning" were presented, as well as two surveys, aiming at generating input from the group members and other interested colleagues from Club countries.

The draft reports and the surveys received several important contributions which were merged into the present report, including the survey answers.

Thanks are due to all participants in the work, and also in particular to the colleagues from the Dam Safety European Authority Network (EAN) that, in 2008, kindly contributed by filling the survey at an individual basis.

The names of the working group **nominated members** and of the Portuguese group in charge of specific tasks are as follows:

[1] Coordination by J.Yague, from Spain, that proposed the theme at European level, due to its significance, developed the first terms of reference and devised the need for a general survey. A progress report was issued in 2001.

Portugal	José Rocha Afonso ……	Coordinator
Italy	Rosella Caruana	
Norway	Grethe Holm Midttømme	
Slovenia	Mojca Ravnikar-Turk	
Spain	Juan Carlos de Cea	
Sweden	Marcus Bergman Fredrik Persson	
Portuguese Group	José Oliveira Pedro …… Teresa Viseu …… Eduardo Ribeiro da Silva ……	1st draft of Chapter 2 1st draft of Chapter 3 Survey questions Survey questions

Colleagues from the **Dam Safety European Authority Network (EAN)** who have provided answers to the survey: Rudolf Mueller (Ch), Ian Hope (Uk), Maria Bartsch, Olle Mill (Sw), Grethe Holm Midttømme(No), Risto Kuusiniemi, Mikko Sulkakoski (Fi).

As mentioned above, the initial survey answers are from 2008, so this is the reference year, even though more recent contributions were included whenever available.

The initial drafts of the chapters 2 and 3 were initially written in 2007, but were further amended and updated by new contributions and comments from the members. In particular, use was made of the 2011 updated "Dam Legislation" European Club report.[2]

The remaining parts and overall revision were completed for the present final report.

[2] In this last version of the "Dam Legislation" report, data from some of the member countries was updated in 2007 and 2011, whilst some data for other countries remains still from the initial report of 2001.

1. Introduction

A major concern about existing dams, notwithstanding its fundamental role for society, is the safety of these works. In fact, the risk of an accident, however small, resulting in the development of a large flood wave and the emptying of the reservoir, should always be considered. Besides the overall effects that would arise from the unavailability of water in such an event, the concern about safety is particularly important for people in the dam downstream valley.

The safety of dams has been much increased in the last half century by better knowledge and higher engineering quality, but a full non-risk guarantee is not possible. Therefore, in modern societies the information concerning dams and the participation of the population in decisions has also been increasing, as well as the consideration of tolerability of risk.

Dam safety management programs and legislation were developed in many countries in the last decades, which much influenced the significant improvements experienced in the safety of these structures and in the extension of their lifetime.

Present safety legislation and technical guidelines also impose the consideration of dam failure scenarios, valley inundation maps, zoning and civil protection measures, namely on emergency plans, including warning, alert and recue systems.

In order to evaluate the criteria and the procedures concerning the safety of dams and their downstream valleys, the ICOLD European Club working group on "Safety of Existing Dams" focussed the work on the following three main topics:

- Study of the criteria of classification of dams according to their potential risk;
- Procedures to review and evaluate the safety of existing dams;
- Emergency planning: criteria and contents.

The analysis of the safety procedures adopted by several European countries was also supported by a survey conducted among the working group members, and other contributors. The results of this survey are included in the present report, namely:

- Answers concerning several countries;
- Analysis of the gathered information, in order to obtain the main conclusions and to select some specific topics requiring further discussion.

2. Hazard, risk and classification of dams

2.1. Introduction

Classification of dams, adopted with different formulations in several countries, often act as a basis for selecting appropriate safety requirements to the various categories of dams[3].

Dams are usually classified in existing regulations according to size (dimensions of the dam body, reservoir capacity and discharge capacity of the spillways), type and main characteristics (dam shape and materials used in the construction)[4], reservoir volume and consequences of failure (hazard)[5], or to a combination of these factors.

The size and type of the dam provide indications on the flood wave that would be originated by a dam failure, a scenario that cannot be disregarded, in spite of its extremely low probability of occurrence. To estimate the risk[6] of damage of such a scenario, the human lives, the property and the environmental values that could be affected by the flood wave need to be evaluated.

In the case of a dam failure, a flood wave that can affect human lives and property is very likely to occur. Therefore, the most dangerous flood wave scenario is generally associated with dam-break, although large floods may be also due to other causes, such as to failures in the reservoir slopes, falls of large volumes of rock or ice in the reservoir, failures in the spillways, war or sabotage, etc.

The classification of dams, however simplified, is thus based on the underlying assumption that grading may be helpful in effectively minimizing the risk of damage due to dam failure, and that the associated provisions in the regulations should take into account the several involved factors, namely concerning:

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[3] A typical example is the selection of design flood according to dam hazard class, where design floods for low hazard dams may typically vary from Q100 to Q200, whereas design floods for high hazard dams may typically vary from Q1000 to the probable maximum flood (PMF).

[4] According to ICOLD 2011 Constitution[51], large dam is "*a dam with a height of 15 meters or greater from lowest foundation to crest or a dam between 5 meters and 15 meters impounding more than 3million cubic meters, and defined in greater detail in the World Register of Dams*". According to ICOLD previous definition, which was the same for the main factor of height of 15 meters, additional factors were a bit different and included dams with height between 10 m and 15 m and complying at least with one of the following conditions: the length of crest not less than 500 m; the capacity of the reservoir not less than 10^6 m^3; the maximum flood discharge not less than 2 000 m^3/s; the dam has specially difficult foundations or is of unusual design[1]. These definitions are however still used in several countries. The ICOLD considers also masonry and concrete dams of gravity, arch, buttress or multiple arch types, and embankment dams of earthfill or rockfill types [1].

[5] Technical terminology varies and, for instance, meanings in dam engineering differ from those in risk assessment [2]. In this report "hazard" is used as relating to the potential losses in the area downstream of the dam in event of release of a flood wave, the same as "consequences".

[6] Risk considered as the product of the probability of occurrence of an adverse event and the related consequences (hazard).

- Dam behavior, such as the occurrence of exceptional actions (floods, earthquakes, landslides, etc.), the dam vulnerability (related to the design, construction, operation and maintenance conditions), and the efficacy of the dam safety control program (inspections, testing, and monitoring);

- Consequences (hazard) due to the flood wave, in relation to the generation and propagation of the wave (dam and valley characteristics), the occupation of the valley in the area where the height and velocity of the wave is dangerous for human life, property and environment, and the efficacy of the civil protection program in emergency situations (warning, alert and rescue systems).

2.2. Safety criteria and risk

Safety criteria enforced by dam Regulations aim at specifying minimum safety requirements for the design, construction, operation, surveillance and inspection that will make the probability of dam failure to be very low, during the dam lifetime. On the other hand, provisions concerning civil protection essentially aim at protecting human lives and mitigating the consequences of an accident that is possible to occur, in spite of its very low probability. These combined provisions for dam safety and civil protection make it possible for the risk of damage for human lives, property and environment to be extremely low.

The current safety criteria incorporate the experience of many years derived from the construction and operation of a very large number of dams, in several countries with its own specific development, traditions and culture. These criteria have been expressed in terms of safety coefficients, embodying the several sources of incertitude involved[7].

The risk of damage for people and property depends on the damage potential (hazard). Therefore the probability of dam failure must be reduced in the cases of "high" hazard, but may be allowed to increase in cases of "low" hazard, providing that in both cases the risk remain within the very low accepted limit. From this follows that the safety control requirements (concerning design, construction, operation, and inspection and monitoring) may be graded according to the hazard classification.

[7] However, it should be mentioned that probabilistic approaches are currently used in the evaluation of the incertitude associated to floods and earthquakes, and that the utilization of partial safety coefficients, considering separately the incertitude associated to the actions and to the structural properties, have been proposed for dam design [6].

Similarly, the civil defense measures may also be graded according to the hazard classification. In fact, elaborated civil defense measures should be required in cases of "high" hazard dams and may be avoided in cases of "low" hazard dams.

Hazard classifications are therefore appropriate to grade the level of the safety control requirements and to define the civil protection measures to be enforced by the dam safety Regulations. This gradation keeps the essential objective of ensuring a very low risk of damage for people and property but avoids unjustified safety requirements and civil protection measures for "low" hazard dams.

It should be pointed out that hazard classifications of dams are independent of the probability of dam failure and of the efficacy of civil protection measures, and are supported by objective data concerning the occupation of the valley.

2.3. Risk Assessment

The use of risk informed approaches to dam safety has been increasing in recent years [2], [3]. Risk assessment methodologies can be used as an alternative to size and hazard classifications and graded safety requirements. Both the probability of failure of a given scenario (or several scenarios) and the corresponding consequences need to be assessed.

Risk analysis methodologies may help in the identification of the main scenarios of failure specific of each dam, and the probabilistic evaluation of these scenarios would allow an evaluation of the probability of dam failure [2], [4].

However, the evaluation of the dam failure probability is a difficult task, and reliable statistical data is often not available. The evaluation of the consequences (hazard) due to the flood wave is also difficult, owing to difficulties in the evaluation of the human lives, and even property and environmental values that may be affected. As a result, simplified qualitative and quantitative methodologies have also been adopted for risk analysis and applied for different uses, including to portfolio safety analysis of dams [8], [10], [11].

The quantification of the safety criteria in terms of probability would allow a comparison of the risk involved in dam engineering with the risk accepted in other activities[8]. Studies have been made comparing the FN curves (F being the frequency of N or more fatalities per year, and N being the number of fatalities), for accidents with dams and in other activities [3], [12].

[8] The risk acceptable by society in the construction and operation of dams may be different from country to country and its definition is a complex problem. Values of 10^{-6} (one in one million per year) have been referred to the probability of accident in the United Kingdom [12], studies of risk analyses for dams developed in Norway computed probabilities of occurrence for the different dam failure scenarios ranging from 10^{-6} to 2.10^{-8} [5], and estimations of the frequency of failures occurred with the different types of dams built in Western countries indicate values in the range 10^{-4} to 5.10^{-6} per year[13].

2.4. Hazard Classification of Dams

Hazard classifications based on the evaluation of consequences due to dam failure, without assessing the probability of failure, are used in the regulations of several countries. Different hazard classifications of dams have been developed which, besides specific aspects, include some general common features, such as:

- The delimitation of the downstream valley area affected by the flood wave, according to the arrival time, duration, maximum height and velocity of the flood wave;

- Factors related to the impacted valley, which are the human occupation (urban/rural settlements, etc.), public health (related with water supply, electricity, etc.), property (homes as well as industrial, commercial, touristy, agricultural and recreational facilities), transport infrastructures and environmental resources.

The area affected by the flood wave should cover the river sections where the depth and velocities of the flow may damage people, houses and vehicles[9]. The delimitation of this area is, usually, based on studies using dam-break flood models, but the use of approximate models or the simple prescription of a fixed area in the case of small dams have also been proposed [15]. This area is generally divided in different zones, with different procedures and responsibilities in case of accident, as indicated in the next section [15], [17], [18].

The major factor in the damage potential (hazard) classification of dams is human occupation. This occupation is characterized by direct estimations of the number of people that may be affected, or by indirect estimations based on the land use and occupation by homes, facilities (industrial, commercial, touristy, agricultural and recreational) and transport infrastructures (roads, airports, railroads).

In general, costs are not attributed to human lives, and approximate evaluations are carried out to both property (considering its own value and services) and environmental assets (considering their value, the difficult in recovering and the possible existence of hazardous products).

A three-degree classification of dams is the one most currently used, with "high", "significant", and "low" hazard grades, but classifications adopting two, four or more classes have also been adopted. Criteria adopted for attributing these grades are

[9] The USBR flood danger curves [14], relate the flood depth as a function of the velocity of the water, making it possible to define limit zones of "high" and "lower" danger, as well as an intermediate zone where a "judgement" is required. It is recommended in the USBR procedures, to extend the danger reach limit downstream until the increased flood levels be less than 0.33 m. However, it is also currently assumed that zones will be dangerous for people when the product of the depth by the velocity of the water is over 1 m^2/sec.

specific of each country, reflecting the different characteristics, experiences and cultures.

2.5. Dam Legislation and Classifications in European Countries

In general, classifications based on the size of dams are used to define the scope of the legislation enforcing the safety control provisions and the civil protection measures of most countries and states. For many countries and states this type of classification is complemented by classifications based on the damage potential (hazard) [24], [25].

In the USA, about 80 per cent of the states complement size with a damage potential (hazard) classification in the respective dam legislation [21]. For most of the states (more than 60 per cent) a three-degree classification is adopted, according to the recommendation of the Federal Emergency Management Agency (FEMA). However a few states adopt hazard classifications considering two, four and five degrees.

Hazard potential classifications are also adopted in the legislation of other countries and states, such as of Canada and South Africa [24], [25], [26].

The legislation of several countries in Europe is also supported by classifications based on the size of dams, whilst some countries have, however, developed their classification system towards hazard classification[10]. The current situation for the countries represented in the ICOLD European Club is summarized in Table 2.1 [20] to [23], [27] to [43].

Civil protection measures to mitigate the consequences of floods are generally adopted in the European countries, and the elaboration of emergency action plans specific for dams, supported by dam-break analysis, is also practice (and enforced by law) in several countries [20], [44] to [50].

The civil protection measures may be implemented for all dams under the scope of the Regulations or only for a class of these dams, which is selected by the size (e.g. France, Switzerland) or by the hazard classification (e.g. Norway, Portugal).

Damage potential (hazard) classifications of dams are adopted in the Regulations of several European countries, often considering the 3-degrees (e.g. "high", "significant" and "low" hazard dams[11]). These classifications have been used to

[10] As also shown in the survey table, in Annex II.

[11] The classification adopted in Sweden has 4-degrees: the 1st degree considering the risk for human lives (divided in two different levels); and the 2nd, 3rd and 4th degrees concerning the damage for property and environment (the

grade the civil defense measures, and also (sometimes combined with classifications based on the size and purpose of dams) some safety control measures, such as:

- The selection of the return period for the design flood;
- Safety requirements for spillways and bottom outlets, such as the number of outlets, independent sources of energy available, etc.;
- The equipment and the procedures to be adopted in the inspection and monitoring of dams and the requirements concerning the methods for gathering and analyzing data;
- The systematic intervention in the inspections and monitoring of specialists (individual experts or specialized entities);
- Other aspects related with the time allowed for the dams in operation to comply with the provisions of the Regulations, the qualifications of the technicians, etc.

2nd degree being also divided into two different levels) [50]. Norway has from 2010 extended the classification to 5 classes (0-4), where 0 reflects "minor consequences" and class 4 reflects "very high consequences" with more than 150 houses affected.

Table 2.1

REGULATIONS FOR DAM SAFETY IN SOME EUROPEAN COUNTRIES [12]

Country	Dams subject to Regulations[13]		Emergency planning	Authority[14]
	Size	Nº of Classes (Type of classification)		
Austria	H > 30 or V > 5 [15]**Erro! Marcador não definido.**	--	Largest dams - EAP	*Federal Ministry of Agriculture, Forestry, Environment & Water Management Water Law Authorities*
Finland	Classes 1 to 3	3 (C)	Class 1 - EAP Classes 1 and 2 - warning and alert systems	*Ministry of Agriculture and Forestry*
France	H ≥ 2	4 (H, V)	H ≥ 20 and V ≥ 15 - EAP	*Ministry of Ecology, Energy, sustainable Development and Sea*
Germany (example NRW)[16]	H > 5 and V >1	6 (Dam type)	Civil defense services	*NRW Ministry for Environment and Nature Protection, Agriculture and Consumer Protection*
Italy	H > 15 or V >1	–	Largest dams - EAP	*Ministry of Infrastructure and Transport Direzione Generale per le Dighe e le infrastrutture idriche ed elettriche*
Netherlands	H = 3 to 13 (Dykes)	2 (H)	Local Water Boards - EAP	*Ministry of infrastructure and Environment. Directorate General of Public Works and Water Management*
Norway[17]	H>2 and V>0.01 Classes 0 to 4	5 (C)	Classes 2, 3 and 4 - EAP	*Ministry of Petroleum and Energy and Norwegian Water Resources and Energy Directorate*
Portugal	H ≥ 15 or V ≥ 0.1	3 (C)	Class 1 - EAP	*Ministry for Agriculture, Sea, Environment and Spatial Planning Portuguese Environment Agency*
Romania	Classes 1 to 4	4 (H, v)	Classes 1,2, 3 and V >10 - EAP	*Ministry of Environment and Forest*
Slovenia	H ≥ 15 or H ≥ 10 m and V ≥1 000 000 m^3 (1)	3 (C)	Class 1 – Dam break analysis	*Ministries of Agriculture and the Environment, of Economic Development and Technology and of Defense*
Spain	H ≥ 15 m H ≥ 10 and V ≥ 1	3 (C)	Classes A, B - EAP	*Ministry of Agriculture, Food and Environment Dirección General del Agua*
Sweden	H ≥ 5 or V ≥ 0.05 (inventory)	4 (C)	Civil defense services	*Water Rights Court* *County Councils*
Switzerland	H ≥ 10 H ≥ 5 and V ≥ 5 or "important danger"	4 (H, V)	V ≥ 2 000 000 m3 Special water alarm systems	*Federal Office of Water Management* *Cantons*
Un. Kingdom	V ≥ 0.25	–	Civil defense services	Environment Agency

H - Dam height (m)
V - Reservoir capacity (10^6 m^3)

C – Potential hazard (consequences)
EAP – Emergency Plan

[12] Regulations applying mainly for the "larger dams". Some European countries have specific regulations for the "smaller dams".
[13] Main criteria, other criteria may apply.
[14] Notwithstanding frequent changes, this column is to portray an overall view of European governance choices that concern dam safety.
[15] Smaller dams under Regional Authorities.
[16] Regulations for the State North Rhine-Westphalia, as an example (each State has a specific "Law of Water").
[17] Only few rules (no technical rules) relevant for class 0 (minor consequences).

3 Emergency planning

3.1 Introduction

Most of the European countries have a long story on dam safety programs and have specific legislation and regulations in the area of dam safety, as showed in Section 2. In fact, dam engineering has primarily been concerned with the prevention of failure, by means of appropriate measures on design, construction, operation, monitoring and inspection of dams.

Emergency planning for dams is, compared to dam safety, a more recent issue. Nevertheless, countries like USA, Switzerland, France and Canada have already an established experience in emergency planning for dams, and guidelines are available which include requirements, minimum standards and criteria for the development of emergency preparedness plans for dams and downstream valleys. For some countries, like Portugal and Spain, emergency planning for dams has only given its first steps in the past ten years [1], [2], whilst in some other countries an intermediate situation between those two described arises.

Each country can have a different approach on dam emergency planning, defining different responsibilities or different ways of sharing responsibilities for the general actors (the most important being the dam owner, the dam safety authority and the civil defence authorities). Nevertheless, the development and the implementation of an Emergency Plan is generally considered the key issue to mitigate losses, in the downstream valley.

An Emergency Action Plan is a formal document that identifies the procedures and processes that dam operators would follow in the event of an accident at a dam. It is a common practice to divide the Emergency Plan into five components [3], [4]:

- Detection: identification and evaluation of potential emergencies at the dam;
- Decision making: implementation of actions to respond to the event;
- Notification to the local officials;
- Warning to the population at risk;
- Evacuation of the population at risk.

In general the first tree components are the dam owner's responsibility and should be considered in the Emergency Action Plan for the dam (Internal Emergency Action Plan). The warning and evacuation components are generally under the responsibility of civil defence authorities (at local, provincial or governmental levels). Therefore, emergency action plans developed for those specific levels should

contain appropriate information regarding warning and evacuation of population at risk living in dam-break flood prone areas downstream of the dam.

3.2 To which dams should emergency planning apply?

As public safety expectations are increasing all over the world, the dam safety legislation of several countries requires the development of dam-break analyses, in order to get information about dam failure consequences (in some cases, even for small dams). Rescue action preparedness and emergency planning are also generally a mandatory requirement, unless dam failure consequences are low.

Conversely, the existence of an emergency plan or/and an early warning system can be a mandatory requirement even without the existence of dam-break studies, for those dams being identified as high hazard dams. For example, such is the case of large dams, storing large volumes of water and having significant populated areas at the downstream valleys. Nevertheless the minimum requirement for having an emergency plan can be different for different countries, for instance:

- In France, an Emergency Plan is required for dams higher than 20 m or for reservoirs larger than 15×10^6 m^3;
- In Romania, an Emergency Plan is required for dams higher than 20 m or for reservoirs larger than 10×10^6 m^3;
- In Switzerland, early warning systems are mandatory for reservoirs larger than 2×10^6 m^3 and also, in an easier way, for any dam representing some particular hazard for the downstream population.

3.3 Current practices

3.3.1 Dam-break flood simulation

Concerns about dam failure peaked in the second half of the last century as a result of accidents with important dams, such as Malpasset (France) or Teton(USA) and a few other cases. *In fact, the history of routing dam-break floods is as old as hydraulic engineering modelling.*

A typical Emergency Plan is based on an inundation map, most often carried out using numerical dam-break flood analysis. In general the legislation does not set technical requirements for this analysis, however in some cases specific guidelines are available (e.g. Norway).

The most commonly used programs for calculation of dam-break flood propagation in the downstream valleys are based on the Saint-Venant equations. For low hazard dams, or for preliminary risk assessments, simplified analysis can be considered in some countries (e.g. Portugal, Spain, Norway and Canada).

Results of dam-break numerical models, and the dimension of the inundation map, can be very different depending on the input data and calculation assumptions. Important differences may arise in the results, particularly in the water levels and the time of flood arrival in downstream sections, owing to factors such as the breach opening, the failure time, the initial water level in the reservoir when the failure occurs, the roughness along the river and the scale of topography data for the downstream valley. Normally a sensitivity analysis between two failure scenarios is undertaken: the extreme failure and the most probable failure.

Mapping of a natural flood with high return period, particularly the design flood for the spillway, is also a common approach in some countries. The damages associated with this major event may not be considered in the total amount of dam-break damages and losses, in an incremental damage approach.

3.3.2 Downstream valley risk zoning

In the inundation area different danger zones can be identified depending on some of the flood characteristics, particularly the water levels, the velocities and the time of the flood wave arrival. In France three risk zones are identified, depending on the time of flood wave arrival [5]:

- 15 minutes zone (generally located 5 to 10 km from the dam) which is defined as the self rescue zone, where public warning by audible sirens must be envisaged;

- Alarm Zone I, where it is mandatory to have an emergency plan for rescue actions;

- Alarm zone II, where flood damages are low (no loss of life is expected to occur).

In Switzerland only two risk zones are envisaged [6]:

- "Near" zone, concerning the distance reached by the front of the wave in two hours and where public warnings through audible water alarm sirens must be assured;

- "Far" zone, covered by general alarm sirens.

In Portugal, the zone of major danger is delimited by the distance of the front wave propagation in 30 minutes (with a minimum of 5 km) [7]. In this zone, the responsibility to warn the population can be attributed to the dam owner. Some countries adopt for this most vulnerable zone a population warning co-responsibility, shared between the dam owner and the civil defence authority.

3.4 Warning systems

Early warning systems are non-structural means intended to minimise flood impacts in populations and welfare, which can also play an important role in crisis management, and be a competitive alternative to structural modification projects, in order to reduce risk in dam-break flood prone areas.

Warning systems can be generally divided in the following types [8]:

- Public warning using audible systems (notification via sirens and fixed or mobile loudspeakers) as well as adopting visible systems;
- Personal direct notification via telephone or cell phones also including the door-to-door warning;
- Television or radio station news broadcasts.

Many of the European countries have warning systems being used not only for a specific type of risk but also to face multi potential dangers, such as: nuclear, chemical, earthquake, floods and war (Table 3.1) [9].

Table 3.1

WARNING SYSTEMS IN SEVERAL EUROPEAN COUNTRIES

Country	Type of warning system
Austria	National alert system composed by 700 sirens, specific radiation alert system
Denmark	System of 1100 outdoor electromechanical sirens allowing to warn 80% of the total population and the other 20% by media means
Finland	1500 outdoor sirens covering urban zones. In regions with low population density, vehicles with loudspeakers are used
Netherlands	45 regional control stations and about 3500 outdoor sirens, to warn the total country population. Further recommendations through television or radio broadcast

Norway	Surveillance and Alarm System based on pneumatic sirens for first warning. Warning system operated by Civil Defence Authorities. Further recommendations through television or radio broadcast
Sweden	Exterior alarm constituted by 4800 outdoor sirens in 250 municipalities, concentrated in urban sites with more than 1000 in habitants, for first warning. Further recommendations through television or radio broadcast

Warnings can be issued directly, by the dam owner, to inhabitants in areas immediately downstream of the dam, due to the short time before the anticipated arrival of flood wave. For example, in Italy it is a mandatory procedure to issue an audible wail whenever spillway gates are operated. Some other countries consider warning to the population at risk as a main responsibility for the civil defence authority, and recommend for those most vulnerable areas a shared responsibility, between the dam owner and the civil defence authority.

Another important aspect of the warning systems is the way they are triggered.

Some countries only allow manually triggered warning. In Switzerland, for example, automatic warning is not allowed; warning is issued by an operator at the dam site. Civil protection services advice the use of sirens in localities and the use of mobile loudspeakers (from the municipalities) outside localities. In this country, when the inundation area is small (including a maximum of 3 localities) the use of mobile warning is considered a better solution than the use of sirens; when the inundation area is significant (i.e., for reservoirs with a capacity of more than 2 million of m^3) special sirens must exist in the near zone ("water alarm") [10].

Other countries have automatic issued warnings in case of failure. In Norway, there are two valleys where failure of a specific dam automatically triggers warning by sirens, but for all other dams there are no such automatic warning with sirens at present. However, automatic warning by telephone is possible in many cases. In France, in the "15 minutes zone", warning is completely automatic and directly issued by the emergency system of the dam; individuals can be warned by sirens wail but personal notification via automated telephone service with computer control also exists.

Also as shown in Table 3.1, there are similarities between the warning systems of some countries, for example in the Netherlands, Norway and Sweden.

3.5 Training

Besides the three main actors involved in the emergency planning - dam owner, dam safety authority and civil defence authorities - a fourth one exists, which is the most critical, and concerns the population at risk. These concerned people may be

involved in the Emergency Action Plan development, but commonly only show up at the implementing and training phases of the developed Emergency Plan.

Very important issues for the success in saving lives and diminishing damages are acquaint through public participation, education and information of the population at risk in the downstream valley. Risk communication is the key issue in this matter.

Exercises are important, especially for emergency planning validation and for training of personnel. In many countries table top exercises, where participants meet and discuss a defined event, are done annually. Likewise, drills which are in practice testing of single emergency procedures (for example validity of important telephone numbers), are usually done regularly. Exercises can also be so-called "functional exercises" where different events are simulated. These exercises are performed as role-play with participants seated in separated rooms to simulate their operation centre. The most comprehensive form of exercises are "full scale" exercises where participants play their role "at site" in a most realistic environment [11]

Participants in exercises are always the dam owner and dam personnel, and sometimes also civil defence authorities, or other rescue authorities. Exercises involving the population are rather rare[18].

4 Survey

4.1 Introduction

As a complement of the report, a survey was prepared by the working group, based on the terms of reference, aiming to get an overall picture of the current situation in the European countries (EU + Norway) as regards the themes under analysis.

Due to the fact that the Working Group life span extended for some years, it was not always easy to guarantee that answers for the survey were given by the initially appointed members.

On the other hand, synergies were established with the informal group of Dam Safety Authorities in Europe, and some of its members gracefully supported the fulfilment of the survey in respect to their countries. In this way, some countries not belonging to the appointed group provided data.

The survey questions are presented in Annex I.

The answers from 9 European Countries is presented in Annex II, in table format.

[18] But have been performed, for example in Finland.

The initial survey answers are from 2008, so this is the reference year, but more recent contributions were included whenever available.

Some comments on the reported answers to the survey are presented in the following numbers.

4.2 Conclusions based on the answers to the survey

4.2.1 General trends and harmonization of the European dam safety legislation

There is always a relevant interest in comparing dam safety practices - in this particular case limited to the chosen three issues of the Terms of Reference - in order to try to understand the broad picture of similarities and differences in practice, and then try to ascertain future trends. This kind of survey is informative and a tool for further developments, notwithstanding the limited number of surveyed countries, and the particular set of chosen questions.

Several surveys and comparisons of ICOLD member countries practices have been performed throughout the years, for specific purposes[19].

The European Club also provides in its site, through its competent Working Group, the report on "Dam Legislation", that is to be permanently updated by its members.

Owing to the perceived risks arising from the occurrence of important failures, national dam safety regulations were developed over the years[20] , but they are different in many ways.

The present survey shows that in the majority of European Countries there is a main bulk of legislation that is of mandatory compliance. In several cases, and in different layouts, technical guidelines complement the superior laws and regulations.

In the last 5 years[21], at least 5 of the surveyed European Countries issued new legislation on dam safety, a fact that clearly demonstrates the current efforts and concerns on this subject.

One of the aspects that should be questioned at European level is whether harmonization in the field of dam safety is foreseeable or desirable.

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[19] Such is the case of some of the ICOLD past and on-going technical work and bulletins. Also, a special mention is due to the 2002 World Bank comparative study on "Regulatory Frameworks for Dam Safety"

[20] As referred to in the ICOLD site, "Since the late sixties, focus was put on subjects of current concern such as dam safety, …."

21 Survey answers relate to 2008

It is well known that, concerning policies that are defined as European policies by existing treaties, the EU has issued to this day many Directives, which have to be transposed into the national laws of the member states.

On the more technical side, also the question of Eurocodes arises. Significantly, in May 2011 Prof C. B. Abadjiev, mentioning the Eurocodes, proposed that the European Club should "develop commune European safety norms for dams".

On the other hand, one feels that, should a major unforeseen event or accident concerning dams arise in Europe, the question would probably be raised with a sense of urgency.

The last question of the survey specifically covers this theme: "what kind of issues, amongst those described in this inquiry, do you think should be or not harmonized at European level?"

Few answers to this question were obtained, although additional answers were presented in the specific inquiry about emergency planning. Anyway, there seems to be an agreement that dam safety is a particular field where harmonization is difficult in many aspects, whilst there is also scope to the development of some consistent approaches.

Italy (IT) points out that "*it is simpler to harmonize technical issues (calculation methods, hydrological studies) than administrative/political issues (which are specific for each country). It is possible to implement something similar that has been done to the Eurocodes*". UK answer refers that dam safety legislation for Great Britain is significantly different from the rest of Europe. A full harmonization would be difficult. However, "*there is interest in developing a consistent approach to standards and guidelines*".

So, harmonizing technical issues seem to be a possibility. Some aspects of dam classification, which are different in several countries (dimensions, hazard), or frequencies related to surveillance and revisions of safety, for instance, could be discussed. Also overall dam safety management and organizational principles, presently discussed in ICOLD, should be possible to analyse. There seems to be room for a discussion on the possibility of European harmonization, concerning overarching questions and principles.

4.2.2 Dam incidents and accidents

A specific register of incidents and accidents that have occurred with European dams in is another important aspect of the survey answers.

The development of such register seems not to be a common practice among the European countries. The answers provided indicate that most of the existent data is contained in general databases or embodied into technical reports.

The compilation of this information would be however very relevant, in particular for technical and statistical purposes, notwithstanding the fact that it also may raise problems of confidentiality. This is a subject that has been the frequent subject of discussion at ICOLD Committees.

Regarding the question about accidents in the last 5 years, the only provided answers are the failure of a Portuguese fill dam about 10 m high; and the failure, following heavy rains and floods, of the 12,6 m high "Ulley Reservoir" (United Kingdom), built in 1872.

Italy also refers to an accident that occurred in 1985, as the most recent important accident, causing about 350 fatalities. This however happened with a tailings dam for fluorite. The regulations of several countries do not apply to tailing dams, due to its particular characteristics. ICOLD has dealt with the subject in specific bulletins.

It is worth noticing that when speaking of dams, regulations and surveys, a significant percentage of dams involved are dams of modest dimensions. Such dams have in many instances specific associated problems, regarding the dam itself and the often more simplified methods employed in design, construction, operation, as well as the level of control of these activities, the safety management procedures, the owner's ability and resources to cope with regulations and so on.

In fact, even though damage potential is generally lower for the smaller dams, those are often the dams which present greater risks of failure. The reasons for this are discussed at several ICOLD publications[22].

One other issue of concern is that of floods in smaller dams.

Norway points out the question of public safety at dams, as being the cause of accidents and fatalities. This is a subject that recently has risen as a work topic both at the European Club[23] and ICOLD.

When it comes to what were the main causes of significant incidents in the last five years, there are only few answers, and these relate to gates malfunction, corroded pipes, and lack of maintenance. This subject would deserve further analysis.

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[22] e.g. ICOLD Bulletin 109 (*"Dams less than 30 m high - Cost savings and safety improvements"*) and draft ICOLD Bulletin on Small Dams (*"Small Dams - Design, Surveillance and Rehabilitation").*

[23] *European Club of ICOLD, Working Group on "Public safety at Dams", Final Report, 2012*

4.2.3 Safety control management

Several questions of the survey and the respective answers concern the practices adopted in the European countries for the safety control management of dams. Some relevant aspects of these practices are discussed below.

All the ECs have a regulator(s) ("Authority") on dam safety, which is a public agency (national, or regional, or both). These regulators might have a role of administrative control and technical supervision, but layouts are specific for the different European Countries. In the majority of cases, measures to comply with dam safety must be submitted by the owner to the Authority´s approval, and the Authority can in all cases impose measures to the owners if they fail to comply.

Answers tend to show that, in general, dam "owners" have to guarantee safety according to the legislation and, thus, be able to pay for the costs of these activities. Different provisions in national legislations may, on the other hand, mean that there are significantly different costs associated to the safety management of similar dams in different countries (types, dimensions, risks)[24].

In countries like Portugal, among others, there are significant differences between dam owners and its ability to cope with safety issues, depending on the types of dams and entities. For large dams, safety conditions are in general better assured for dams of hydropower companies, as these owners incorporate within the business the safety practices and respective costs. The same may apply to other owners, such as large water supply companies, but the situation is however less favourable for some large irrigation dams. For the smaller dams compliance proves to be difficult for some owners, even with simpler rules, in particular for small fill dams built for irrigation purposes, often owned by individuals or farmers.

Concerning the use of insurance policies to cover the risk linked with dam failures, the picture seems to be mixed, but this is also a subject that deserves a detailed scrutiny.

The use of hazard or consequence categories for dams is discussed in the more complete analysis in Chapter 2 of this report.

Classifications based on the size of dams are generally used in European Countries to define the scope of the dam safety provisions and the civil protection measures, but in some countries they are complemented or even replaced with the use of hazard or consequence categories/classes (following the practice of many States of USA, and countries like Canada and South Africa).

[24] Some aspects are discussed at ICOLD Bulletin 110 ("Cost Impacts of Rules, Criteria and Specifications")

Size categories, which were used from the outset of dam safety regulations, are well established, with good results, in some countries with a large experience in its application. Arguably, dimensions have some indirect relation with the damage potential, at least for broad classes of dams, and are easier to use, particularly for smaller dams, simplifying both the regulations ant the adoption of measures.

As for the developments arising in the more complex risk analysis and risk-based approaches, the recent work of ICOLD Committee on Dam Safety[25] gives a detailed insight of some foreseen trends, as in the quoted paragraph: *"The traditional approach to dam safety assessment (often called standards based) begins with the establishment of safety requirements and criteria associated with a predetermined classification system reflecting either the hazard potential or the consequences of dam failure. The uncertainty is not addressed directly…… Most of these deficiencies on the process of assessing the safety of dams can, in principle, be eliminated by an appropriate application of either the risk-based or risk-informed approach …….. Taking into account that risk based analyses not only cost more, both in term of financial input, but also that they demand a different set of skills and knowledge than traditional dam engineering, the necessity for a gradual approach should not be surprising"*.

Be as it may, the answers to the survey point to the fact that, besides all ECs having standard based regulations, some countries accept/encourage the use of risk assessment, which is consistent with the referred trends and the development of the related methods.

Some countries use simplified methods to pre-evaluate dam safety, for instance through some kind of risk indexes.

Periodic dam safety evaluations (e.g. standard, in-depth) are required, but periodicity, which may differ with the dams characteristics, is not the same for the different countries.

After special extraordinary events (e.g. floods, seismic activity) special inspections are legally required by all.

In general there are defined checklists for conducting inspections or reassessing safety, but they might be established in technical guidelines or otherwise by internal owner procedures.

[25] "Dam Safety Management: Operational Phase of the Dam Life Cycle"

4.2.4 Emergency planning

Emergency planning is analysed in Chapter 3, which already includes comparisons between countries practices. More specifically about the survey answers, some additional remarks are outlined below.

All the answers show that the development of emergency plans is a mandatory procedure, for specific classes of dams.

The dams to which emergency planning applies are defined in different ways. The majority of countries use consequences criteria, but some also use size (e.g. ICOLD "large dams", other dimensions) to define/complement the bulk of concerned dams.

Some countries answer that they clearly adopt the division of the emergency plan into two different plans – the "Internal Emergency Plan", mainly regarding the dam related procedures, and the "External Emergency Plan", mainly concerned with the downstream valley warning and rescuing procedures.

The dam owner and the civil protection authorities (e.g. local authorities) are always responsible for the development of such plans (typically dam owner for the internal and civil authorities for the external). In a significant number of answers the dam owner is responsible for the warning of concerned people in the highest hazard zone near the dam.

Responsibility for approval of the plans is shared by the dam safety authority and the civil protection authorities.

Criteria for defining the downstream limit for the dam-break flood studies varies: they might be related to some form of comparison with the natural floods, or to the hazard conditions, or to a case to case consideration with no fixed definition. The inundated area scenarios considered for emergency planning varies also. Extreme failure scenarios are defined in all cases, but in different ways and combinations. Also other intermediate scenarios might be considered (e.g. complete opening of gated outlets).

Almost all the answers point to the need of some form of periodical table top exercises between dam safety and civil protection staffs, but only a few countries answer to the question about exercises with the population at risk.

The majority of answers point to manually activated warning systems. These systems vary in type and combination of chosen items, typically sirens, telephones, loudspeakers, door to door, radio or television broadcasts.

Concerning emergency planning, some answers and comments about the need of harmonization are presented and, as previously mentioned, a mixed picture also surfaces.

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ANNEX I - LIST OF SURVEY QUESTIONS

1. General information

2. Classification of dams and potential risk

3. Safety Analysis

4. Surveillance and monitoring

5. Organization of the Safety

6. Emergency Plans

7. Final

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1. General information

1. Total number of dams in the country:
   1.1. large dams (ICOLD definition, more than 15m high, ..)
   1.2. dams under safety regulations
   1.3. smaller dams

2. Types of dams (%):
   2.1. Gravity dams;
   2.2. Arch dams;
   2.3. Embankment or fill dams;

3. Percentage of dams constructed in the last decade:

4. Mean age of all the large dams:

5. Percentage of the dams total with instrumentation:
   5.1. Hydraulic
   5.2. Structural

6. Ownership
   - ☐ Public
   - ☐ Private
   - ☐ Other

7. Is there a legislation concerning dam safety?
   - ☐ Yes
   - ☐ No
   - Specify _____

8. In the affirmative case, to what type of dams does it apply (dimensions, etc.)?
   - Specify _____

9.Was there new safety legislation published in the last 5 years?

- ☐ Yes
- ☐ No
- Specify _____

10. Is there a register of dams with problems?
    - ☐ Yes
    - ☐ No
    - Specify _____

11. Has there been any important accident in the last 5 years?
    - ☐ Yes
    - ☐ No

12. If yes, give a short description (dam main features, accident)
    - Specify _____

12 a What were the major causes of significant incidents in large dams, in the last 5 years? Specify:

12 a1 Earthfill dams
12a2 Rockfill dams
12a3 Concrete dams
12a4 Apurtenant hydraulic structures
12a5 Other

13. Are there incentives for the private owners to invest in the improvement of the safety of their dams?
    - ☐ Yes
    - ☐ No
    - Specify _____

14. Are there insurance policies to cover the risk linked to possible failures of the dams?
    - ☐ Yes
    - ☐ No

15. Is there independent legislation for the dams of mine tailings?
    - ☐ Yes
    - ☐ No

16. Is there any normative which limits or regulates the land uses of the areas close to the riverbeds downstream of the dams?
    - ☐ Yes
    - ☐ No

16 a. Are there specific courses on dam safety and operation for actors concerned?
    - Yes
    - No
    - Specify _____

2. Classification of dams and potential risk

17. Is there a mandatory classification of dams by classes (e.g. high/significant/low or similar) according to the associated downstream consequences (e.g. potential risk/potential damage/hazard)?
    - ☐ Yes
    - ☐ No
    - Specify _____

18. If yes, which criteria is used to classify?

- Specify _____

18 a. Are there instructions or guidelines to help determine the classification for each dam?

- ☐ Legislation
- ☐ Guidelines
- ☐ Other
- Specify _____

3. Safety Analysis

19. Are minimum safety requirements to be observed in each dam established by law or regulations?

- ☐ Yes
- ☐ No

20. If the answer to the previous question is yes, is it the same for all dams?

- ☐ Yes
- ☐ No

21. If there is a regulation, is it mandatory?

- ☐ Yes
- ☐ No

22. Are there periodical evaluations of dam safety carried out?

- ☐ Yes
- ☐ No

23. Of all the dams?

- ☐ Yes
- ☐ No

24. Is that evaluation mandatory by law?

- ☐ Yes
- ☐ No

25. Are there periodical revues of the design of the dams (structural, hydrological, hydraulic, operational and environmental studies)?

- ☐ Yes
- ☐ No

26. What is the periodicity for these revues?

- Specify _____

27. Do the conclusions reached in these revues and the measures to comply with them have an informative value only?

- ☐ Yes
- ☐ No

28. Are revisions carried out in special occasions and events (e.g. floods, seismic activity)?

- ☐ Yes
- ☐ No
- Specify _____

29. In the affirmative case, describe which causes them, what they consist of, who carries them out and who controls the measures to adopt.

- Specify_____
  _____

30. The timetables established for the adoption of corrective measures are they consequent with these revisions (see 27 and 29)?

- ☐ Yes
- ☐ No
- Specify _____

31. Is there any kind of normalised procedure or a technical guide, or a checklist that can be used to tell if a dam needs to be improved regarding safety, in a comprehensive or particular way?

- ☐ Yes
- ☐ No

32. If there is, which of the following features are used in it?

- ☐ Property (public or private)
- ☐ Age of the dam
- ☐ Type of dam
- ☐ Classification of the dam according to the potential risk downstream
- ☐ Type of foundation (rock or soil)
- ☐ In the case of embankment dams, state of slopes
- ☐ Type of spillway (uncontrolled or with gates)
- ☐ Analysis of design criteria
- ☐ Periodical revues of the design criteria
- ☐ Existence of the original design and other related documentation
- ☐ Quality control of the construction
- ☐ Existence of a first filling plan
- ☐ Existence of rules of exploitation
- ☐ Existence of structural, hydraulic or meteorological monitoring
- ☐ Existence of a contingency plan
- ☐ Existence of historical records (technical file)
- ☐ Existence of preventive maintenance
- ☐ Existence of periodic revisions of the design criteria (ordinary or extraordinary)
- ☐ Existence of personnel nearby or on the site of the dam
- ☐ Existence of a team in charge of the safety control
- ☐ Professional knowledge of the personnel of the dam
- ☐ The frequency that the personnel goes to the dam
- ☐ Others
- Specify _____

33. Is there a simplified method (e.g. risk index) to pre-evaluate dam safety?

- ☐ Yes
- ☐ No

34. In case there is, is it of a:

- ☐ Quantitative nature
- ☐ Qualitative nature
- ☐ Others
- Specify _____

35. In case of groups of dams does the previous method allow for prioritizing safety measures?

- ☐ Yes
- ☐ No
- Specify _____

36. Is risk analysis accepted/encouraged?

- ☐ Yes
- ☐ No

37. Is there any research going on about dam safety issues?

- ☐ Yes
- ☐ No
- Specify _____

4. Surveillance and monitoring

38. Is there any kind of periodical on site inspection of dams?

- ☐ Yes
- ☐ No

39. If yes, what is the periodicity?

- Specify _____

40. Does it apply to all dams?

- ☐ Yes
- ☐ No

41. Who carries them out?

- ☐ The owner
- ☐ Independent engineers
- ☐ Other
- Specify _____

42. Are these inspections mandatory by law?

- ☐ Yes
- ☐ No

43. Is their any regulation or guidelines to establish the features that should be examined in each dam?

- ☐ Yes
- ☐ No
- ☐ Other
- Specify _____

5. Safety organization

44. Is there any institution responsible for looking after the safety of the dams (hereafter named Authority)?

- ☐ Yes
- ☐ No

45. In the affirmative case, is it:

- ☐ A public office
- ☐ A public company
- ☐ A private company
- ☐ A partnership between public and private institutions
- ☐ Other
- Specify _____

46 On whom does it depend?

- Specify _____

47. What is its role?

- ☐ ▪ Administrative control
- ☐ ▪ Supervision
- ☐ ▪ Both

48. Is it a centralized institution?

- ☐ ▪ Yes
- ☐ ▪ No
- ▪ Specify _____

49. The measures that have to be implemented in order to comply with dam safety regulations must they be submitted to approval before being implemented?

- ☐ ▪ Yes
- ☐ ▪ No
- ▪ Specify _____

50. Can the Authority determine measures to be implemented by the owners if the dams fail to comply with the safety norms?

- ☐ ▪ Yes
- ☐ ▪ No

51. Are the owners of the dams fined for failing to implement those measures?

- ☐ ▪ Yes
- ☐ ▪ No

51 a. Is there a specific legislation for that matter, concerning penalties?

- Yes
- No
- Specify _____

52. If the owners are fined, who is in charge of it?

- ☐ ▪ Authority
- ☐ ▪ Others
- ▪ Specify _____

53. Is there any tax being paid by the dam owners related to dam safety?

- ☐ ▪ Yes
- ☐ ▪ No
- ▪ Specify _____

54. How does the Authority establish its priorities for checking owner's compliance?

- ▪ Specify _____

6. Emergency planning Inquiry

6.1. The development of the emergency plan is it a mandatory procedure in your country?

- ☐ ▪ Yes
- ☐ ▪ No

6.2. If the answer to the previous question is affirmative. To which dams is the development of the emergency plan a mandatory procedure?

- ☐ ▪ Large dams (ICOLD classification)
- ☐ ▪ Based on special "dam dimension" criteria (dam high and/or reservoir volume)

Specify dam height _____m reservoir volume_____m^3

☐ ▪ Based on "potential damage" criteria

Please, specify criteria (population at risk, material damage, environmental damage, essential services disruption etc..)

6.3. Is it a common practice in your country to divide the Emergency Plan in two? An Internal Emergency Plan (to the dam) and an External Emergency Plan (to the downstream valley)

☐ ▪ Yes
☐ ▪ No

6.4. If the answer to question 1) is affirmative. Who is the responsible for the emergency plan development?

☐ ▪ The dam owner
☐ ▪ The local authorities (communities, mayor, civil protection services)
☐ ▪ Both the previous
☐ ▪ Other
▪ Specify _____

6.5. If the answer to question 1) is affirmative. Who is the responsible for the emergency plan approval?

☐ ▪ The National Dam Safety Authority
☐ ▪ The Civil protection authorities
☐ ▪ Both the previous
☐ ▪ Other
▪ Specify _____

6.6. Which are the current practices in your country in what concerns dam valley risk assessment?

☐ ▪ Dam-break flood simulations

Please, specify to which dams:
Dam height _____m ; reservoir volume_____m^3 or
Dams with potential damage: ☐ High
☐ Medium
☐ Low

☐ ▪ How is the downstream limit for the dam-break flood defined?

Please specify. The study is undertaken until the river cross section where:
☐ the dam-break water level is inferior to the one of the spillway design
☐ the dam-break water level is inferior to the one the 100 year flood return period
☐ Other_____

☐ ▪ Which dam failure scenario is used to define the inundated area in the downstream valley for emergency purposes?

Please specify:

- ☐ Extreme failure scenario
- ☐ Most probable failure scenario
- ☐ Maximum spillway discharge scenario
- ☐ Other_____

☐ ▪ Which is the map scale normally used for dam-break flood simulations?

Please specify:

- ☐ 1/10 000
- ☐ 1/25 000
- ☐ 1/50 000
- ☐ Other_____

☐ ▪ Is the downstream valley risk zonning undertaken?

☐ ▪ Yes
☐ ▪ No

If yes, specify some criteria adopted for its definition.
How many risk zones?

☐ ▪ two
☐ ▪ three

Which flood aspect defines the limits of the risk zoning?

☐ ▪ time of flood arrival
☐ ▪ distance from the dam
☐ ▪ Other _____

Please, if possible, specify the criteria:

risk zone 1 distance = ____km or time of flood arrival = ___ minutes
risk zone 2 distance = ____km or time of flood arrival = ___ minutes
risk zone 3 distance = ____km or time of flood arrival = ___ minutes

6.7. Are the damages in the downstream valley estimated according to a risk incremental approach, not considering in total amount of the dam failure damages the ones due to the flood without the dam?

☐ ▪ Yes
☐ ▪ No

6.8. Emergency training

Please, specify if in your country the following aspects of training are normal procedures:

☐ ▪ Emergency plan revision periodically;
☐ ▪ Table top exercises between dam personnel and agency involved in dam safety and in protection of the population;
☐ ▪ Exercises with the population at risk (general simulacrum).

6.9. Warning system

Who is responsible to warn the population in most risky zone

☐ ▪ Dam owner

- ☐ Civil protection authorities
- ☐ Other

In the last case please specify _____

How are the warning systems activated?

- ☐ Manually
- ☐ Automatically

6.10. Warning system type

How is the population in most risky zone warned?

- ☐ Public warning via sirens
- ☐ Public warning via mobile loundspeakers in vehicles
- ☐ Personnal notification via automated telephone service
- ☐ Personnal door to door notification
- ☐ Televion or radio broadcast notification
- ☐ Other

In the last case please specify _____

6.11. Do you think that some emergency planning aspects should be harmonized on an European scale basis?

- ☐ Yes
- ☐ No

If the answer to the previous question is yes, please specify which aspects do you consider more important to harmonise?

- ☐ Dam failure scenarios used for Emergency Planning
- ☐ Risk zoning criteria downstream the dam
- ☐ Type of warning system
- ☐ Meaning of the siren wails
- ☐ Others_____
- ☐ _____
- ☐ _____
- ☐ _____

7. Final

What kind of issues, amongst those described in this inquiry, do you think should be (or not) harmonized at European level?

- Specify

_____
_____
_____
_____

ANNEX I I - SURVEY ANSWERS

	Italy	Portugal	Spain	Finland	Norway	Switzerland	England	Sweden	Slovenia
1. General information									
1. Total number of dams in the country:				500 dams (including 70 waste dams and small dams)	More than 3200	218 under federal supervision of totally 1'000	2091		40
1.1 Large Dams (ICOLD definition, more than 15m high, ..)	541	269			335				34
1.2 dams under safety regulations (including 1.1)		717			3150 (dams registered by Sept.2010)				34
1.3 smaller dams	more than 8000	unknown - few thousands			unknown - probably more than 2000				6
2. Types of dams (%):					(numbers are uncertain)				
2.1. Gravity dams;	42% are gravity dams	41% / 17%	65	20	gravity + arch: 68%	38	2,7	19	22
2.2. Arch dams;	18 % are arch dams		3,5		(see above)	25	0	1	16
2.3. Embankment or fill dams;	38% are embankment (earthfill and rockfill dam)	57% / 82%	31	80	25% (of all dams, but most of the largest dams are rockfill dams)	37	56,3 (others 40,9)	~80	2
		Note: %1.1 / %1.2							
3. Percentage of dams constructed in the last decade:	The dams constructed in the last decade are : 3%		1,5	2 a 3	1,50%	5	8	0	7,5% (3 dams)
4. Mean age of all the dams:	66		43,5	40 -50 years	approx. 60 - 70 years, maybe more (many dams with unknown construction year are probably quite old)	56 years	108 years	~40 years	52 years
5. Percentage of the dams total with instrumentation:	All italian large dams have a monitoring system, small or large according to the importance of the dam.It is estimated that about half of the italian dams are provided with full or partial automatic data acquisition. The FCEM (Foglio di Condizioni per l'Esercizio e la Maniutenzione) is the document which contains: number,type and precisions of the measures, the frequency of reading and frequency and extent of the visual inspections. The main measured quantities are: reservoir level, ambient temperatures, rainfall, snow thickness, displacements,rotations,deformations, leakage,uplift pressures,pore pressures.		unknown		unknown				
5.1. Hydraulic						95			65%
5.2. Structural						95			65%
6. Ownership									
Public ☐	The.40% of the italian large dams are owned by many small "Consortiums" , Municipalities, and other forms of public entities.	X	30%	X	X	X	X (24 %)	X	38 (95%)
Private ☐	About 60% % of the Italian Large Dams are owned by private owners (including Enel the main Italian dam owner)	X	70%	X	X	X	X (76 %)	X	2 (5%)
Other ☐									
7. Is there a legislation concerning dam safety?									

	Italy	Portugal	Spain	Finland	Norway	Switzerland	England	Sweden	Slovenia
Yes ☐	In Italy the use of the surface and underground water is regulated by :'Water and hydroelectric powerplants Act R.D. n° 1775.(1933).The design,construction,operation and safety of the large dams are regulated by the 'Dam Regulation'. It is composed of two sections : Part I, issued in 1959, ("Regulation for the Design, Construction and Operation of Dams – Part I", DPR n° 1363) defining general and administrative rules; Part II, "Technical Rules", issued in 1982 (updating the Part II of the 1959 Regulation), for the design and construction of new dams (DM n° 44). Moreover there are laws which: a)specify the obligation for the owner to appoint, for each dam, an engineer who is responsible of the safety of the dam and of its regular operation - Law n° 584/1994 "Urgent Measures concerning Dams" .b) update the definition of the role of the National authority for dams (Registro Italiano Dighe RID) - DPR n° 136/2003 "Organisation, duties and activities of the Italian Dam Authority".	x	x	x	x	x	x		x
No ☐								Not specifically	
Specify	In adddition, there are the following specific legal Directions: 1) - "Warning and Alarm Systems for Dams", Ministry of Public Works, Circular n° 1125 /1986; 2) "Directions concerning the application of the Regulation about Dams n° 1363/1959", Ministry of Public Works, Circular n° 352/1987; 3)"Circular", by the President of Government, 13 December 1995, n.DSTN/2/22806 which defines rules to be followed in several subjects related to dam safety; 4) "Circular", by the President of Government, 19 march 1996 n. DSTN/2/7019,gives instructions about civil protection activities. 5) the Directive by the President of Government, 27/02/04, concerning the operational directions for the alert systems for the hydro-geological and hydraulic risk, for Civil Protection purposes. 6) 2005 (Hydraulic Assessment), Circular n. 3199 of the Dam Autority, this regards the evaluation of the maximum floods (up to 1000 years return period) and the corresponding assessment of the hydraulic safety of the dams.				Water Resources Act of 2001 + New Dam Safety Regulation issued Dec. 2009, made valid from January 2010 (replaces four previous regulations). 11 technical guidelines, 2 guidelines under work.	Federal Dam Safety Regulation	Reservoirs Act 1975		Regulations on technical monitoring of large dams (1966)
8. In the affirmative case, to what type of dams does it apply (dimensions, etc.)?	Dam Regulation applies to dams higher than 10m or forming reservoirs larger than 100.000 m3.The Large Dams (dam height ≥ 15 m, reservoir volume ≥ 1 Mm3) are subjected to the Authority and supervision of the State. ☐ Small dams (dam height < 15 m, reservoir volume < 1 Mm3) refer to Regional Regulation (Italy is subdivided in 21 Regions). Some Regions have defined technical rules for such smaller dams.				All dams, but a limited number of requirements apply to dams in the lowest consequence class (class 0, insignificant consequences) ; i.e. chapter 1, § 2-2, chapter 4, § 7-6, § 7-11 and chapters 8, 9 and 10.				
Specify		Dams over 15 m high or more than 100.000 m^3 in the reservoir or smaller dams classified as Class 1 dams	Large dams and dams classified in categories A (high potencial damages downstream) and B (intermediate potencial damages	The height of a dam not less than 3 metres, high risk dam also lower than 3 metres.		a) Impounding head > 10 m; b) Impounding head > 5 m and storage volume > 50'000 m3; c) smaller dams if particular danger exist.	Above 25,000m^3		a) Dams over 15 m high or b) more than 100.000 m^3 in the reservoir or c) dams over 10m high with crest length more than 500m long or d) if Q>2000m3/sec

	Italy	Portugal	Spain	Finland	Norway	Switzerland	England	Sweden	Slovenia
9.Was there new safety legislation published in the last 5 years?									
Yes ☐	Yes in the last years were issued the following regulatory instructions:1)the Directive by the President of Government, 27/02/04, concerning the operational directions for the alert systems for the hydro-geological and hydraulic risk, for Civil Protection purposes. 2) 2005 (Hydraulic Assessment), Circular n. 3199 of the Dam Autority, regarding the evaluation of the maximum floods (up to 1000 years return period) and the corresponding assessment of the hydraulic safety of the dams. A complete revision of the Dam Regulation (General rules and Technical Rules) is currently in progress.	X	X		X		X		
No ☐				X		X		X	X
Specify		New dam safety regulation			New Dam Safety Regulation 2010	Last revision 1998	Water Act 2003 amends the Reservoirs Act 1975		
10. Is there a register of dams with problems?									
Yes						X		X	
No	X	X	X	X	X	X	X		X
Specify		We do have a register of accidents on dams but it's not complete			Dam register for all dams also contains possibility to register damages, but few "damage-data" are registered	The supervision Authority is informed of the cases	Not specifically, but we have data where safety works have been identified	Sort of	these data are only stated in Yearly reports on technical monitoring
11. Has there been any important accident in the last 5 years?									
Yes		X					X		
No	No accident happened in the last 5 years. The most recent important accident occurred on 19 July 1985 (Stava, tailing dam for a fluorite mine). The tailing dam collapsed suddenly, due to the pressures exerted by the tailing deposit.The collapse caused about 350 fatalities		X	X	No, only accidents related to traffic on and around dam sites (persons drowned at intakes/spillways)	X			X
12. If yes, give a short description (dam main features, accident)									
Specify		The failure of a earthfill dam 10 m high with a reservoir of about 700.000 m3					Ulley Reservoir – failure of spillway channel leading to erosion of the dam	Failure of tailings dam in Aitik: year 2000	an irrigation pipe (that goes thru an earthfill dam) broke downstream of the dam (no serious damage to the dam)
12 a) What were the major causes of significant incidents in large dams, in the last 5 years? Specify									
12 a1 Earthfill dams		lack of maintenance; floods in smaller dams							corroded material (pipe)
12a2 Rockfill dams									X
12a3 Concrete dams									gates malfunction
12a4 Apurtenant hydraulic structures		lack of maintenance; gates malfunction							X
12a5 Other									X
13. Are there incentives for the private owners to invest in the improvement of the safety of their dams?									
Yes			X		? (dam owners are responsible for the safety of their dams, given as requirements in the legislations)		X	X	

	Italy	Portugal	Spain	Finland	Norway	Switzerland	England	Sweden	Slovenia
No	Dam safety must be guaranteed by the owner and there are no incentives for this duty. In Italy there are incentives named " green certificates " to promote the renovation of the hydropower plants and to add capacity for extra generation.	X		only dam safety legislation		X			not really
14. Are there insurance policies to cover the risk linked to possible failures of the dams?									
Yes ☐	Yes, the owners can stipulate insurance policies to cover the risk linked to their industrial activities, and damages from dam operation and incidents can be included.				X	X (in some Cantons, but not in the whole Country)	X	X	
No ☐		X	X	X					X
15. Is there independent legislation for the dams of mine tailings?	In Italy the tailing dams refer to the Corps of Mines, belonging to the Ministry of Industry. Technical instructions were issued, after the Stava collapse, for the surveillance of these dams. However, they have never been subjected to a detailed and complete "Dam Regulation", as the "normal dams" did since 1920.								
Yes ☐			X				X		
No ☐		X		only mining law and also dam safety legislation has been applied	X	X			X
16. Is there any normative which limits or regulates the land uses of the areas close to the riverbeds downstream of the dams?									
Yes ☐			X		(only with respect to natural flood hazard)		X	X	
No ☐	In Italy the zones close to the river beds are property of the State, who can give concessions for their use; limits and possible uses of these zones are defined in the territorial development plants.	X		X	X (public guidelines recommend to avoid such areas for critical infrastructure, i.e. hospitals etc.)	X			X
16 a. Are there specific courses on dam safety and operation for actors concerned?									
Yes ☐		X			X				X
No ☐	X								
Specify		2 weeks dam safety course for technical staff (graduates) from dam owner, authorities, consultants, companies			Dam Safety Courses at 3 levels: for dam operators/attendants (practical supervision), for chartered engineers (university level course), for managers (brief overview of dam safety responsibility)				Public enterpises that operate the public large dams have courses for dam operators (internal rules and exams)
2. Classification of dams and potential risk									
17. Is there a mandatory classification of dams by classes (e.g. high/significant/low or similar) according to the associated downstream consequences (e.g. potential risk/potential damage/hazard)?									
Yes ☐		X	X	X	X			X	
No ☐	X					X			X
Specify		Classification in classes 1 to 3 according to the seriousness of the consequence of failure			5 classes (0-4), where class 4 is for dams with highest consequences in case of failure		Classification comes from guidance, but only applies to impounding reservoirs (71% of stock)		
18. If yes, which criteria is used to classify?									

	Italy	Portugal	Spain	Finland	Norway	Switzerland	England	Sweden	Slovenia
Specify		Danger to life, property and the environment	Potential damages downstream	Human life or health, environment or property	Danger to life, property and the environment		Dam category / Potential effect of a dam breach A — Where a breach could put lives at risk B — Where a breach could endanger lives not in a community or could result in extensive damage C — Where a breach could pose little risk to life and limited damage D — Special cases where no loss of life can be foreseen as a result of a breach and very limited additional flood damage could be caused U — Unknown		
3. Safety Analysis									
19. Are minimum safety requirements to be observed in each dam established by law or regulations?									
Yes ☐	Minimum safety requirements are established in the technical Dam Regulation, dated 24 March 1982.	X	X	X	X	X	X		X (yearly inpections and monitoring)
No ☐								X	
20. If the answer to the previous question is yes, is it the same for all dams?									
Yes ☐	X	X	X			X			large dams only (the scope of work is defined by designer of an individual dam)
No ☐				X	X (different requirements for different consequence classes)		X		
21. If there is a regulation, is it mandatory?									
Yes ☐	X	X	X	X , legislation	X	X	X		X
No ☐				X , Dam Safety Code of Practice				X	
22. Are there periodical evaluations of dam safety carried out?									
Yes ☐		X	X	X	X	X	X		X - based on the measured parameters - no additional stability analyses are made
No ☐	X								
23. Of all the dams?									
Yes ☐		X	X	X	X (for classes 1-4)	X	X	X	over 15m public (no data on private dams)
No ☐					X (not class 0)				
24. Is that evaluation mandatory by law?									
Yes ☐	X	X	X	X	X	X	X		
No ☐								X	X - just yearly monitoring
25. Are there periodical revues of the design of the dams (structural, hydrological, hydraulic, operational and environmental studies)?									
Yes ☐	In Italy the design of the dams (and the safety assessment) have to be reviewed when the actual loads (flood, earthquake, sediments..) are recognised to be larger than the original design evaluation. This is for example the case of the updated hydrological analyses for the evaluation of the maximum floods witha return period up to 1000 years.	X	X		X	X	X	X	
No ☐				X					X
26. What is the periodicity for these revues?									
Specify	There is not any predefined periodicity	It is not the same for all dams	5-10 years, depending of the category in which the dam is classified		15 years (class 2-4) and 20 years (class 1)	5-yearly safety assessments for larger dams; or on request of the Authority for the smaller dams	Varies 10-15 years		No revisions

	Italy	Portugal	Spain	Finland	Norway	Switzerland	England	Sweden	Slovenia
27. Do the conclusions reached in these revues and the measures to comply with them have an informative value only?									
Yes ☐							X		
No ☐	The conclusions of the safety re-assessments are utilized to evaluate the necessary structural improvements	X	X		X (deviations from dam safety regulations must be followed by a plan for improvement/measures)	X (They are mandatory)			No revisions
				X					
28. Are revisions carried out after special occasions and events (e.g. floods, seismic activity)?									
Yes ☐	X	X	X	X	X	X	X	X	
No ☐									
Specify	After extraordinary events such as seismic activity of high intensity , floods.	according to Dam Safety Code of Practice should carry out inspectionS after special events	After extraordinarily events	according to Dam Safety Code of Practice should carry out extra inspection after special occasions and events	After extreme floods or other extraordinary events, dams must be inspected by experts. If sudden damage occur, or in case of a dam being registered and the condition of the dam is poor, a full safety reassessmen must be done.			Dependent on the dam owner	No revisions
29. In the affirmative case, describe which causes them, what they consist of, who carries them out and who controls the measures to adopt.									
Specify	Natural events of extraordinary intensity; they consist in a careful inspection of the dam structure and the reading of the more significant measures, to check the actual situation. The dam owner carries them out and the Authority(National Dam Service) toghether with the Civil Protection Department supervise the protective measures to adopt.		Extraordinarily events; deep inspection of dam and appurtenant structures; independent engineers; Dam safety department.		Extraordinary loading situation, e.g. flood, GLOF etc => inspections must be carried out by dam owner and expert. If damages are discovered or dam condition is poor, dam safety expert does inspection and reassessment of flood calculations, stability analyses etc. The dam safety authority (NVE) controls the measures.	Review of the design, the hydrology, the capacity of the outlet works, etc. The owner may them carry out (if capable) or the experts of the dam.	Promoted as Research and Development generally promoted by the industry peer review of outputs implemented by panel engineers		No revisions
30. The timetables established for the adoption of corrective measures are they consequent with these revisions (see 27 and 29)?					?				
Yes ☐	X			X		X	X		in yearly reports are stated necessary actions (mostly repair of reservoir slopes)
No ☐		X	X						
Specify									
31. Is there any kind of normalised procedure or a technical guide, or a checklist that can be used to tell if a dam needs to be improved regarding safety, in a comprehensive or particular way?									
Yes ☐	The "Surveillance and Inspection Standards" establish the need for approval of an "Observation Plan" for each concerned dam	X	X	X	X (technical guidelines on inspections and safety reassessments, governmental audits of the dam owners internal control systems (performed by NVE))	X	X	X	
No ☐									X (EN 1997-1: Eurocode 7:General rules is mandatory form January 2008 but it does not cover large dams)
32. If there is, which of the following features are used in it?									N/A
Property (public or private)									
Age of the dam					(X)				
Type of dam					(X)		X		

	Italy	Portugal	Spain	Finland	Norway	Switzerland	England	Sweden	Slovenia
Classification of the dam according to the potential risk downstream		X	X	X	X		X		
Type of foundation (rock or soil)							X		
In the case of embankment dams, state of slopes				X	X		X		
Type of spillway (uncontrolled or with gates)							X		
Analysis of design criteria				X	X	X			
Periodical revues of the design criteria		X			X (design flood)	X			
Existence of the original design and other related documentation				X	X				
Quality control of the construction				X	X		X		
Existence of a first filling plan							X		
Existence of rules of exploitation		X					X		
Existence of structural, hydraulic or meteorological monitoring		X		X	X		X		
Existence of a contingency plan		X		X	X		X		
Existence of historical records (technical file)				X	X		X		
Existence of preventive maintenance				X	X		X		
Existence of periodic revisions of the design criteria (ordinary or extraordinary)		X		X	X				
Existence of personnel nearby or on the site of the dam				X					
Existence of a team in charge of the safety control				X	X				
Professional knowledge of the personnel of the dam				X	X				
The frequency that the personnel goes to the dam				X	X		X		
Others						X			
Specify						To know if a dam has to be improved the following features are needed: Analysis of the design of the dam, Analysis of the dam behaviour (measurements), Analysis of the state of the dam (regular inspections), 5-yearly safety assessments by experts (The void boxes are no criteria to tell, if a dam needs to be improved)			
33. Is there a simplified method (e.g. risk index) to pre-evaluate dam safety?									
Yes ☐		X					X		
No ☐	X		X	X		X			X
					X				
34. In case there is, is it of a:									N/A
Quantitative nature		X					X		
Qualitative nature							X		
Others									
Specify									
35. In case of groups of dams does the previous method allow for prioritizing safety measures?									N/A
Yes ☐		X							
No ☐						X	X		
Specify									
36. Is risk analysis accepted/encouraged?									N/A
Yes ☐			X		X (for emergency planning and for analysis of public safety around dams)		X		
No ☐	X	X		X, but it is possible to use it		X			
37. Is there any research going on about dam safety issues?									
Yes ☐	No		X		X	X	X	X	
No ☐		X		X					

	Italy	Portugal	Spain	Finland	Norway	Switzerland	England	Sweden	Slovenia
Specify			Related with Risk assessment		No major research program, but several projects concerning climate change/design flood, landslide-generated waves, concrete technology etc	hydrology research and material technology (i.e. AAR	Complete strategy under development. Current projects include guides to: Extreme rainfall, Internal Erosion, Reservoir Act 1975 and Quantitative Guide to Risk Assessment		No major research projects (SLOCOLD organises seminars to improve dam safety public awarness and is also trying to initiate actions)
4. Surveillance and monitoring									
38. Is there any kind of periodical on site inspection of dams?									
Yes ☐	x	X	X	X	X	X	X	X	X
No ☐									
39. If yes, what is the periodicity?									
Specify	Yes, during normal operation phase there are two types of periodic inspections: 1.Periodic technical inspections are in the duties of the owner 2.Technical inspections are also carried out twice a year by the Authority (National Dam Service) representatives.	Depending on the observation plan of the dam	Depending on the particular case analyzed	Monitoring is the continuous surveillance of the dam at regular intervals. Annual inspections are once a year and regular inspections are made at least once every five years.	Periodic inspection every year by dam owner personnel, main inspection every 5 year by dam owner/expert/the authority (NVE)	a) dam warden (weekly to monthly, in special cases daily), b) experienced engineers (yearly), c) experts (5-Yearly) for larger dams	Inspections every 10 years, Safety statements every year		Every year (Depending on the observation plan of the dam)
40. Does it apply to all dams?									
Yes ☐	x	X	X	X	X (class 1-4)	X	X	X	over 15m high
No ☐									
41. Who carries them out?									
The owner	They are carried out by technical personnel and/or the "Responsible Engineer" that must be appointed by the owner for each dam.	X	X	X	X	a)			X (visual inspections)
Independent engineers			X	X	(main inspection)	b)	X		X
Others		X			(main inspection)	c)			
Specify		The authority			independent engineer (expert) or chartered engineer from other dam owner organization must be present at main inspection, NVE can choose to take part	c) the experts are civil engineers and geologists			
42. Are these inspections mandatory by law?									
Yes ☐	X		X	X	X	X	X		
No ☐								X	No, monitoring plan is mandatory
43. Is there any regulation or guidelines to establish the features that should be examined in each dam?									
Yes ☐	X	X		X. Dam Safety Code of Practice	X	X	X		
No ☐			X						X
Others ☐								Each owner has its checklist	
Specify	Yes. The surveillance activities (inspections, monitoring, ….) for the structures (dam, foundation, reservoir slopes, appurtenant works, …) are detailed in a document, named "Foglio di condizioni per l'esercizio e la manutenzione della diga", ("Condition Sheet for the Operation and Maintenance"- FCEM), issued for each dam by the Authority and subscribed by the owner. The type, extension, frequency, .. of each surveillance activity is defined in the FCEM.				Guideline on inspection and reassessment + requirements given in the dam safety regulation chapter 7	1. state of the dam, 2. behaviour of the dam, 3. monitoring instrumentation and monitoring program, 4. Other features on request or necessity			the scope of monitored parameters is defined by designer for individual dam
5. Safety organization									
44. Is there any institution responsible for looking after the safety of the dams (hereafter named Authority)?									

	Italy	Portugal	Spain	Finland	Norway	Switzerland	England	Sweden	Slovenia
Yes ☐	X	X	X	X	X	X	X	X	
No ☐									X
45. In the affirmative case, is it:									
A public office		X	X	X	X	X	X	X	
A public company									
A private company									
A partnership between public and private institutions									
Other									
Specify	For the "large" dams" a national Authority is responsible of the technical evaluation and approval of new projects, and supervise the activities of the owner for the safety of the dams in operation. From 2003 to 2006 the Dam Authority was as an autonomous organisation (named "Registro Italiano Dighe - RID"); in 2006 it returned to be part of the Ministry of the Infrastructures (Public Works), as it was in the past. The "small" dams" refer to the Regional Authorities. Moreover, for each new dams, there is a "Commission of acceptance" which during and at the end of dam construction has the following functions: verification of the compliance of the construction with the approved design; examination of the dam behaviour during each stage of the first filling, issue of the final "Acceptance Act" enabling the starting of the normal operation	National Authority role is commited to the Water Institute (INAG), from the Ministry of Environment. According to the Regulations, INAG is supported by the National Laboratory of Civil Engineering (LNEC), concerning dams of the highests class I (consequences)			The dam safety authority in Norway is "The Norwegian Water Resources and Energy Directorate" (NVE), responsible for governmental supervision of all dams and dam owner organizations	Dam Safety Section in the Federal Office for Energy [d], Cantonal Authorities for smaller dams [e]			most of the public dams are monitored by National Civil Engineering Institute (public company) but it is engaged on terms of bids
46 On whom does it depend?									
Specify	The National Authority depends on Ministry of Infrastructures (Public Works).	Ministry of Environment	Ministry of Environment/department of water affairs		The Ministry of Petroleum and Energy	the Confederation [d] / the Cantons [e	Government Agency		The National Insitute was founded by the Ministry of the Economy and Ministry of Higher Education, Science and Technology
47. What is its role?									
Administrative control						X	X		
Supervision	X					X			X
Both		X	X	X	X	X			
	It has a role of technical supervision.The most important functions are:1) Evaluation and technical approval of dam projects (new dams; rehabilitation of existing dams). 2) Supervision during the construction of the dam and first filling of the reservoir, till the final acceptance (formal phase requested to start with the normal operation). 3)Supervision of the surveillance and control activities carried out by the owner.								
48. Is it a centralized institution?									
Yes ☐	X	X	X		X (but with regional offices)	X (for the larger dams and some of the smaller: [d]	X		X (but it does not cover all lagre dams)
No ☐				X		X (for smaller dams: the cantonal Authorities [e]			
Specify	The National Authority has one Central Section (co-ordination and specialistic Units) and nineTerritorial Sections.			In Finland we have 5 regional dam safety authorities	One main office and 5 regional offices, all officers have equal responsibilities				
49. The measures that have to be implemented in order to comply with dam safety regulations must they be submitted to approval before being implemented?									
Yes ☐	X	X	X		X	X			
No ☐				X			X	X	
Specify									There must be a structural design made before any construction.

	Italy	Portugal	Spain	Finland	Norway	Switzerland	England	Sweden	Slovenia
50. Can the Authority determine measures to be implemented by the owners if the dams fail to comply with the safety norms?									
Yes ☐	X	X	X	X	X	X		X	
No ☐							X		X
	The Dam Authority can impose to the owner repair or rehabilitation works necessary for the safety of the dams, both to remove problems related to deterioration processes or to increase the safety margins according to the results of safety reassessment.								just suggest measures (the public dam operators maintaine dams properly)
51. Are the owners of the dams fined for failing to implement those measures?									
Yes ☐	x	X, it is possible		X, it is possible	X	X	X		
No ☐			X					X	X (it was not the case yet) - no accidents happened
51 a. Is there a specific legislation for that matter, concerning penalties?									
Yes ☐					X				
No ☐	X								X
Specify					There are rules about penalties both in the Water Resources Act and in the Dam Safety Regulation				
52. If the owners are fined, who is in charge of it?									
Authority			X		X	X	X		N/A
Others				X					
Specify	Local Authority named Prefetture (territorial Provincial Offices of the Ministry of the Interior)			Local court of justice	Depends on severity; NVE or court of law				
53. Is there any tax being paid by the dam owners related to dam safety?									
Yes ☐	x				X	X			
No ☐		X	X	X			X	X	X
Specify	Economical contribution must be paid by dam owners. The amount of contribution for each dam is determined on the basis of dam purpose, dam height and reservoir volume	But this is under review			Tax to cover the expenses of the public supervision	there is a decree concerning the tax	But this is under review		
54. How does the Authority establish its priorities for checking owner's compliance?									
Specify			We don't have rules to do it in this moment	Regular inspection once every 5 years	By dam class (highest priority to class 3 and 4)	inspection, conviction, correspondence, order (decree)	Risk based approach dictated by consequence of failure		No rules
6. Emergency planning									
1. The development of the emergency plan is a mandatory procedure in your country?									
Yes ☐	Yes, the Italian legislation of Civil Protection prescribes the elaboration of Emergency Plans.	X	X	X	X (for class 2-4)	X		X	X (not specifically for dams) 'protection and rescue plan' is mandatory for 'large infrastructure systems' including dams
No ☐							X (It is under development and will become a requirement from Spring 2009)		
2. If the answer to the previous question is affirmative. To which dams is the development of the emergency plan a mandatory procedure?									
Large dams (ICOLD classification)	X					X			

	Italy	Portugal	Spain	Finland	Norway	Switzerland	England	Sweden	Slovenia
Based on special "dam dimension" criteria (dam high and/or reservoir volume) Specify dam height _____m reservoir volume____m3	The directives of the Ministry of Public Works n. 11257/1986 e n.352/1987 require that dam break studies must be carried out for all the dams higher than 10 m or forming reservoirs larger than 100.000m3. Subsequent Directive DSTN/2/22806/1995 gives detailed technical directions for the execution of the studies.					X			X
Based on "potential damage" criteria		X	X	X	X (dam classes)	X		3 consequences classes: 1A and 1B loss of lives 2 economic values 3 no/minor consequences	
Please, specify criteria (population at risk, material damage, environmental damage, essential services disruption etc..)	Emergency Action Plans (EAP) have to be set up for various types of risk (hydro-geological, seismic, volcanic, industrial, fire). The risk related to the presence of dams is included in the hydro-geological risk.For the preparation of the EAP, flood propagation studies have been carried out by the dam owners, to determine the affected downstream areas. The following conditions have been examined: 1) - the dam collapse; 2) - the full opening of the dam outlets. The studies were reviewed by the National Dam Authority; when approved, they were transmitted to the involved Prefectures for the preparation of the EAP.Currently the EAP involving some tens of dams have been completed.	All dams in the Class I, that is If there are at least 25 residents In the area that may be affected by the flood wave caused by the failure of the dam		population at risk, material risk, environmental damage, etc.	Potential damage criteria covers all keywords given by you. The development of emergency plan is mandatory for all dams in class 2, 3 and 4	All dams subject to the regulations need an emergency plan			'if the accident may threaten population, animals, material property, cultural heritage etc'
3. Is it a common practice in your country to divide the Emergency Plan in two? An Internal Emergency Plan (to the dam) and an External Emergency Plan (to the downstream valley)									
Yes ☐		X			X (The dam owner is responsible for the first one, the local authorities are responsible for the latter (but with input from the dam owner))		X	X	X (The dam owner is responsible for the first one, the local authorities approve or prepare the latter (sometimes the dam operator prepares the latter),
No ☐	X		X	X		X			
4. If the answer to question 1) is affirmative. Who is the responsible for the emergency plan development?									
The dam owner									
The local authorities (communities, mayor, civil protection services)	Emergency Action Plans (EAP) have to be set up by local Civil Protection Authorities coordinated by the Prefecture								
Both the previous		X (The dam owner is responsible for the Internal one, the local authorities are responsible for the External)		X	X	X	X	X	X (The dam owner is in general responsible for the Internal one, the local authorities are responsible for the External)
Other								X	
Specify								The county administrations have coordinating and supporting assignments and shall have plans for taking over the leadership of rescue operations if appropriate	on state level is prepared a general 'plan for protection and rescue' for floods (not including dam failure)
5. If the answer to question 1) is affirmative. Who is the responsible for the emergency plan approval?									
The National Dam Safety Authority		X	X			X	X		
The Civil protection authorities	X					X		X	X (or the dam owner- manager)
Both the previous					X				
Other				X					

	Italy	Portugal	Spain	Finland	Norway	Switzerland	England	Sweden	Slovenia
Specify				Rescue (emergency) authorities	The dam safety regulations state that the dam owners should have plans. NVE controls the presence of the plan and the contents during audits at the dam owner organization. The requirements for the local authorities are given by another ministry			There is no formal approval. County Administrative Boards supervise dam safety	
6. Which are the current practices in your country in what concerns dam valley risk assessment?									
Dam-break flood simulations. Please, specify to which dams:						X (all dams under the regulation)		X	
Dam height _____m ; reservoir volume_____m^3 or	The national legislation prescribes that flood propagation studies must be carried out for the dams, to determine the downstream areas affected, in case of : dam collapse and outlets opening.. The results of these studies (the submerged areas) are used to set up the Emergency Action Plans by the Civil Protection Authority (the Prefectures).	Dam height equal or taller than 15 m ; reservoir volume equal or larger than 100.000 m^3							
Dams with potential damage:								X	
High			X	X	X (class 3 and 4)			X (Class 1A and 1B)	
Medium			X		X (class 2)			X (Class 2)	
Low									
How is the downstream limit for the dam-break flood defined? Please specify. The study is undertaken until the river cross section where:									
the dam-break water level is inferior to the one of the spillway design									
the dam-break water level is inferior to the one the 100 year flood return period						X			
Other	The technical directions for the studies are defined in the "Circular" by the President of Government dated 13 december 1995 (n.DSTN/2/22806). A sunny day dam collapse is assumed,mono-dimensional analyses are usually applied, the reservoir level is assumed at max. operation level, the calculations are carried out for the downstream areas until the flood effects are comparable to those related to natural floods having a return period (Tr) of 500 years, unless different Tr have been specified by the local river authority.	X	the dam-break water level is inferior to the one of the stream channel	The advance of a flood shall be followed to the extent necessary for assessing the hazard.	To outlet in large river/lake or sea, or to cross-section where the waterlevel rises less than 1 m (in long rivers)			No specific criteria; in practice where the river meets the sea or a major lake or reservoir with the possibility to stop the propagation of the flood wave	No specific criteria - according to the design
Which dam failure scenario is used to define the inundated area in the downstream valley for emergency purposes? Please specify:									
Extreme failure scenario	For arch dams the sudden and total collapse of the whole dm body is usually assumed. For gravity dams the collapse of the central part of the dam (highest blocks), however larger than 30% of the total crest length, is usually assumed. Fo embankment dams the progressive formation of the dam breach (due to overtopping) is usually assumed.	X	X	X		X		Yes but not only	
Most probable failure scenario					Failure scenario specified for each dam type				
Maximum spillway discharge scenario									

	Italy	Portugal	Spain	Finland	Norway	Switzerland	England	Sweden	Slovenia
Other	In addition to dam failure, the scenario of the discharge due to the voluntary complete opening of the gated outlets is also examined				Two scenarios based on different initial flood situations: 1) Design flood + dam failure, 2) Mean annual flood in the river system + dam failure			dam failure and no dam failure during 3 different flow scenarios are calculated; 1.mean annual flow – "sunny day failure", 2.flow with 100 year return period + dam failure, 3. design flow for class 1 dams (return period 10.000 year or more) + dam failure	stated in the design (depends on a dam)
Which is the map scale normally used for dam-break flood simulations? Please specify:									
1/10 000	Regional scale topographic maps (1; 10000 or less)					X		X	
1/25 000		X				X			
1/50 000								X	
Other			depending on the water's depth	1/20 000	Depends on local conditions, from 1/1 000 to 1/50 000			X	not specified - Depends on local conditions
Is the downstream valley risk zonning undertaken?									
Yes ☐	X		X	X					
No ☐		X			X	X		X	X (attention boards showing the maximum water level are placed in the downstream valley risk zones)
If yes, specify some criteria adopted for its definition.									
How many risk zones?									
two ☐			X						
three ☐	The risk area is differenced in three zones.								
Which flood aspect defines the limits of the risk zoning?									
time of flood arrival	x		X	X					
distance from the dam	x								
Other	There are three risk zones: 1) A zone where there is sure risk for people life. 2) A zone where there is risk for territorial damage. 3) A zone where attention is necessary.			Depth of water					
Please, if possible, specify the criteria:									
risk zone 1 distance = ____km or time of flood arrival = ___ minutes			time of flood arrival = 30 minutes						
risk zone 2 distance = ____km or time of flood arrival = ____ minutes			time of flood arrival > 30 minutes						
risk zone 3 distance = ____km or time of flood arrival = ____ minutes									
7. Are the damages in the downstream valley estimated according to a risk incremental approach, not considering in total amount of the dam failure damages the ones due to the flood without the dam?					?				
Yes ☐				X	X			X	
No ☐	X	X	X			X			
8. Emergency training. Please, specify if in your country the following aspects of training are normal procedures:									
Emergency plan revision periodically;	Most of the Emergency Action Plans are under preparation. The periodic revision is surely to be taken into account in the future	X	X	X, when needed	X	X			X
Table top exercises between dam personnel and agency involved in dam safety and in protection of the population;	NO		X	X, sometimes	X	X	X		X, sometimes
Exercises with the population at risk (general simulacrum).	NO	X		X, sometimes					NO
9. Warning system									
Who is responsible to warn the population in most risky zone									

	Italy	Portugal	Spain	Finland	Norway	Switzerland	England	Sweden	Slovenia
Dam owner		X	X	X	X - New requirement in New Dam Safety Regulation about direct warning in high hazard zones (close to dam)	X (in the near zone by special water alarm sirens)		X	
Civil protection authorities	X				X	X (in the far zone by general alarm devices)		X	usually (it is defined in the 'plan for protection and rescue')
Other									
In the last case please specify									
How are the warning systems activated?									
Manually		X	X		X (except in two river valleys where warning systems/sirens are started automatically)	X ((in situ and by teletransmission)		X	X
Automatically				X					
10. Warning system type									
How is the population in most risky zone warned?									
Public warning via sirens		X	X	X	X (in two river valleys)	X		X	X
Public warning via mobile loundspeakers in vehicles				X		X		X	
Personnal notification via automated telephone service		X	X		X (under development)				
Personnal door to door notification				X	X			X	
Television or radio broadcast notification	x	X	X	X	X	X		X	X
Other									
In the last case please specify									
11. Do you think that some emergency planning aspects should be harmonized on an European scale basis?	Yes, at least for those countries with similar territorial situations (density of population, morphology, etc.)								
Yes ☐		X	X		X		X	X	X (when international rivers are involved)
No ☐				X		X		X	
If the answer to the previous question is affirmative, please specify which aspects do you consider more important to harmonise?	All							Not easy to answer yes or no... On the one hand it would be positive if a European standard could stimulate the development and make the understanding among the population easier. On the other hand Sweden does not have "international rivers" where dam failure in one country could affect another country. Below we have not marked which areas which we consider to be most important to harminize since we think this has to be carefully considered first.	
Dam failure scenarios used for Emergency Planning		X					X		NO (difficult)
Risk zoning criteria downstream the dam							X		NO (difficult)

	Italy	Portugal	Spain	Finland	Norway	Switzerland	England	Sweden	Slovenia
Type of warning system	The following installations have to be carried out by the dam owner, at each dam site: • a siren that can be heard 1000 m downstream, to be activated before voluntary opening of the gates • alert signs along the river, for ten kilometres downstream the dam, alerting about the possibility of sudden floods due to water discharge from the dam. • water level recorder immediately downstream the dam.	X	X		X (in some type of rivers)		X		X
Meaning of the siren wails		X	X		X		X		X
Others	.								
	.								
7. Final									
What kind of issues, amongst those described in this inquiry, do you think should be (or not) harmonized at European level?	It is simpler to harmonize technical issues (calculation methods, hydrologic studies) than administrative / political issues /(which are specific for each country). It is possible to implement something similar to the work that has been done for the Eurocodes	Harmonization should be discussed, including issues such as risk criteria, classes of dams, safety evaluations, emmergency planning, techical criteria, and so on. However, there are aspects of safety practice that were developed in different ways throughout the years for different countries, from technical to governance choices, and so full harmonization would no be the aim.					The dam safety legislation for Great Britain is significantly different from the rest of Europe. It would be difficult to harmonise in its entirety. However, there is scope to develop a consistent approach to standards and guides		