



SWEDISH DAMS, DAM SAFETY AND PUBLIC SAFETY AROUND DAMS

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ABSTRACT

This paper is giving very brief information on Swedish dams, dam safety and safety for the public around dams.

There are an estimated 10 000 dams in Sweden, of varying size, type and age. Of these, 190 are hydropower dams classified internationally as large dams. Some of the hydropower dams are very old but most of them were built later than 1950. Earth- and Rock fill dams are in majority.

The Swedish hydropower dams have in general performed well, but some problems have arise linked to internal erosion in embankment dam moraine cores due to too coarse filters and other to deterioration in older concrete dams due to concrete construction methods in earlier days.

Swedish dams are under upgrading to meet now industry safety guidelines RIDAS including new guidelines on design floods. An extensive program of upgrading the dams to implement the guidelines is going on.

In later years mutual actions from the state, power industry and universities have been taken to provide necessary competence for the future in the dam and dam safety field. Besides the technical issues a system view is applied including risk analyses involving not just technology but also personal and organizational aspects. This effort is successful and involving many doctor students and researchers.

Sweden has no specific law on dam safety for the time being. There are regulations on dam safety in several regulatory frameworks, the most central of which are the Environmental Code and the Civil Protection Act. Under these regulations, the operator is required to obtain the necessary knowledge, investigate and assess the risks involved in the operations from environmental and health perspectives, draw up and follow routines for self-regulation and otherwise take requisite measures and be prepared to prevent damage.

The Swedish regulatory system is under revision and a governmental inquiry is proposing a stronger grip from the state for the future.

Public Safety around dams is of growing interest in Europe and around the world today. New Swedish industry guideline is under implementation, including risk analyses, warning and hindering activities and installations.

1. Dams in Sweden

There are an estimated 10 000 dams in Sweden, of varying size, type and age. Of these, 190 are hydropower dams classified internationally as large dams, which means they are more than 15 m high. Apart from the 190 large hydropower dams, about 15 tailings dams are more than 15 m high. The hydropower dams are largely located on regulated rivers.

Examples of older dams are, as indicated in the nice book “Dams in Europe” edited by ITCOLD and presented in the European Club Symposium in Venice this spring, the damming work for waterwheels that was realized in the middle of the 16th century in the Sala mining district not far from Stockholm. See www.sciencedistrict.com

The Swedish large scale hydro power started in the beginning of 20th century with the purpose to provide electricity to the railway system being under development at that time. Most of the dams were constructed in the years 1950-1980.

The major part of the total 190 large hydropower dams are earth- and rock fill dams. A minor part consist of concrete dams and among them very few arch dams. Design, construction and operation of the dams have developed significantly over the years.

In Sweden Embankment dam with moraine core was first used in about 1950. Several Swedish embankment dam have experienced internal erosion in the moraine core mainly due to the use of too coarse filters. To be sure of that such internal erosion will not develop to a dam failure many dams have been strengthened with an extra stabilizing support toe of material coarse enough to be able to safely convey all credible leakage.

Some older concrete dam has deteriorated enough to call for strengthening and in some cases even replacements.



Picture 1 One of the Suorva rockfill dam in northern Sweden exemplifies a Swedish hydropower dam

2. Dam Safety

Dam Safety has of course always been of importance for dam designers and operators. Successively a more and more systematic and coordinated approach has been taken. In recent years Swedenergy has established new Dam Safety Guidelines RIDAS including specification on new design floods. The requirements are linked to four different classes in a classification system based on consequences in case of a dam failure.

An extensive upgrading program is being carried out to meet the new requirements. For some dams the spillway capacity is increased, while some are being strengthened and heightened to allow for higher water levels. The monitoring systems are under upgrading and the surveillance, operation and emergency preparedness will be further systemized.

The guidelines are also proposing the dam owners to carry out the dam safety works in accordance with an established safety management system where the division of safety responsibilities and roles are clearly defined.

Sweden has no specific law on dam safety. There are regulations on dam safety in several regulatory frameworks, the most central of which are the Environmental Code and the Civil Protection Act. Under these regulations, the operator is required to obtain the necessary knowledge, investigate and assess the risks involved in the operations from environmental and health perspectives, draw up and follow routines for self-regulation and otherwise take requisite measures and be prepared to prevent damage.

Dam safety is a part of the 'water activities' supervisory area in the Environmental Code, for which the county administrative board is the supervisory authority. The county administrative boards have exercised limited supervision of dam safety, with very little or no time for self-initiated supervision. There are 21 counties in Sweden.

Since 1998, the public agency Svenska Kraftnät (The Swedish National Grid) has been responsible for promoting dam safety in Sweden, which includes providing supervisory guidance to the county administrative boards.

The Swedish regulatory system is under revision and a governmental inquiry is proposing a stronger grip from the society for the future.

In 2010 Svenska Kraftnät, in the position as central Swedish unit for dam safety, presented a review of the Swedish regulatory system for dam safety to the government. The review was carried on behalf of the Ministry of Enterprise.

Svenska Kraftnät is of the opinion that dam safety needs development and that the present dam safety system does not correspond to the safety requirements that society today must make. Reinforced national efforts are primarily motivated by the existence of dams that could in case of a dam failure, apart from endangering the life and health of many people, also cause serious disturbances in many sectors vital to society. It is particularly important that society has an expert insight in and control of the safety at these dams.

A dam failure in a dam holding a large reservoir volume can have very grave consequences. Many lives may be at risk and critical infrastructure as roads, railways, power stations and electricity grids, telecommunications, water and waste water systems can be destroyed with resulting serious disruption of public services

In the classification system proposed the dams with the largest consequences in case of a dam failure will be specially identified. The operators of these dams must have and work in accordance with a safety management system and must carry out safety reviews of dam facilities regularly.

Svenska Kraftnät as well as Swedenergy guidelines put special requirements on those dams with the most extreme consequences in case of failure.

Two important questions have come more and more in focus in later years.

The first one is that the majority of our dams were constructed about 40 years ago and that all people involved in that process are retired today. That has triggered a strengthening of the cooperation in between the state, the power industry and the universities. A special organization was created and money allocated for research and development about hydropower in general also involving dams and dam safety. That is one reason why there is a renewed interest in this field with many doctor students and researcher today.

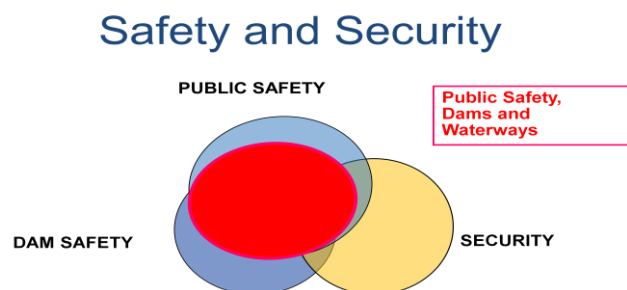
The second one is a growing understanding that we need a system view to get a full grip on the function of dams and the risks involved. That has triggered a lot of activities for risk management and analyses. It also involves studying the full system not just Technology but also People and Organization (PTO) like what is done in many other hazardous industries. That has been an eye opener for many people involved.

3. Public Safety around Dams

Safety of the public engaged in various waterways activities at an around dam sites in the areas potentially affected by the ordinary operation of dams is of increasing concern in many countries. One reason for these concerns is the fact that the number of injuries and fatalities caused by these activities exceeds in many countries the similar outcomes caused by dam failures.

There are obvious links between Dam Safety and Public Safety but there are also significant differences. Safety for the public is of course one of the main reasons to keep the dam safe and to prevent dam failures but there are also other hazards to the public which are not related directly to structural dam safety. It is more about safety for people being around dams under ordinary operations like for instance releasing water through spilling.

Like what is illustrated in the figure below, dam safety, security, public safety in a broader context and public safety around dams and waterways are all linked and integrated.



Picture 2 Illustrated relationship in between Public Safety, Dam Safety and Security

With this background the European Club of ICOLD decided to form a working group on the subject, EWG on Public Safety with the aim to learn from each other, to foster cooperation and experience exchange in between member countries and individuals about safety for the public being in the vicinity of our dam and waterways and to compare different legal and management concepts.

Potential risks associated with dams and hydro facilities, such as sudden opening of spillways and bottom outlets also in sunny days, are often not obvious and unexpected and therefore underestimated by the public. This calls for special information to the public.

3.1 General Hazards

The main public safety hazards linked to the existence and ordinary operation of dams can be described as:

Structural and operational condition:

- Sudden changes of water level due to power plant operation,
- Opening of weirs, especially in cases where the downstream river section is attractive for recreation and leisure activities,
- Operation of dam outlets, especially in cases where downstream river sections are utilized for activities like fishing, canoeing, ice climbing, etc.,
- Intake structures for rivers/brooks, which are equipped with sand traps and a system for (automatic) flushing,
- Open channels with steep slopes and/or high velocity flow.

Hazardous activities:

- Fishing, sport activities and the risk of falling into the water upstream and in the head pond including stretch of water immediately upstream of dam spillway and generating facilities with high velocity and turbulent flow,
- Jumping or falling from dam,
- Fishing, swimming and boating in the tailrace and spillway area downstream of dam and power facility, with high velocity and turbulent flow, and areas further downstream affected by water level and flow changes due to dam operation.

Some plants have been more vulnerable to public safety incidents than others due to long spillway river beds, the ever increasing outdoor adventure activities upstream and downstream, including the use of personal watercraft. At the same time safety expectations by society as a whole have increased. The picture below illustrates people unaware of risks.



Picture 3 Attractive but dangerous location downstream in a spillway canal

3.2 Legal framework and responsibility

Like Finland Sweden has a type of legal concept of Everyman's right giving everyone access to private land and the right to enjoy outdoor activities in the nature. This forms special ground for public safety requirements. The Swedish Environmental Code and the Prevention of Accidents Act provide the legal framework for a dam owner's social responsibility towards the general public. In some installations permits have been issued containing specific requirements intended to protect the general public, such as warning signs and the need to issue audible or visual signals when discharges occur.

3.3 Swedish hydropower industry approach

In general the approach to public safety responsibility differs between the countries. In Sweden we are considering this responsibility as shared between owner/operator and people visiting the area. Owners are responsible for risk management and risk mitigation by

appropriate structural and operational adjustment, information, warning and appropriate barriers. People in the public are responsible take warnings and respect barriers.

Vattenfall was the first Swedish hydropower utility to formulate a Public Safety Guideline (2007). Following this in 2008 Swedenergy developed “Guidelines for the Safety of the General Public at Dam Facilities and Associated Water Courses” for all Swedish hydro power companies operating within the association.

The Swedish guidelines are based on the underlying principle that the main responsibility for safety rests on the individual. Each person has a basic responsibility to be aware of the dangers and to take appropriate precautions. On the other hand, it is in line with Swedish power companies’ responsibility policy for life and safety to, as far as reasonably practicable; prevent accidents involving the public from occurring around dam and hydropower installations.

Given this background, Vattenfall issued the following policy and strategy, fully in line with its values and moral responsibility. In addition to protecting the public, it also serves to protect the company brand and enhance the competitiveness.

Policy

Electricity production at will take place in a responsible and cost-effective manner, without compromising safety.

- It is our endeavour to use systematic safety work in order to protect the life and health of people who are near our dam installations, as far as is reasonably practicable. Each person has an important responsibility to ensure that they are aware of the dangers and to observe warnings.
- Our goal is that if a person has observed the care mentioned above, it should not be more dangerous to be close to one of our installations than to similar undeveloped waterway.

Strategy

Our safety goals are achieved by:

- informing and warning,
- preventing inadvertent risk-taking,
- hindering conscious risk-taking,
- facilitating rescue wherever possible,
- collaborating with representatives from local society (county council, emergency services, schools, voluntary organizations etc).

These preventive measures will be adapted to suit local conditions and requirements, and will be prioritized on the basis of risk, in order to achieve the greatest possible social benefit.

Public safety is a component of total safety, and forms an integrated part of our safety management system.

Progress

All the Power companies in Sweden within the Swedenergy association are in the process of implementing the general guidelines issued in 2008. This includes risk analyses, information activities, new signage, new booms and buoys.

As a first step, a common set of warning signs were developed to avoid confusion with different signs for different companies. The efficiency of the signs has been scientifically validated through a series of focus group tests with members of the public. The picture below shows examples of two of the signs. The first one showing the opening of gates and the second one is warning for the subsequent flood wave.



Picture 4 Attractive but dangerous location downstream in a spillway canal

3.4 A Swedish case story

A case story from Stornorrfors, Ume River, Sweden



Picture 5 Pictures showing the area of the Stornorrfors dam and the dam and spillway from downstream.

Over the years about 10 people have lost their lives in the spillway area downstream of Stornorrfors hydropower plant, a several kilometer long old riverbed. A minimum release of water, stipulated in the permit, is creating a very attractive area for recreation like swimming,

fishing and sometimes canoeing. The area is well equipped with warning equipment like signs (about 200), fences and sirens.

In early 2007 it was an unexpected release of water to this old river bad due to a sudden stop in the power station. This is a very unusual situation in wintertime. A person living downstream was aware that a group of snowmobilers had passed over an ice road and may not be able to hear the sirens. So he placed himself on an island in the river to be able to warn the group should they return at the arrival of the water. The water arrived, broke the ice that stacked up the water then surrounding the island. He was trapped there for six hours when the rescue people were able to lift him out with helicopter. This event was investigated in co-operation with other stakeholders, resulting in the following recommendation and action plan:

- a) Public Safety will be an integrated part of the Hydro Power Dam Safety and Safety Management System
- b) Review of operating procedures.
- c) Investigate the real need of “patrolling”
- d) Communication Guides
- e) Installation of more:
 - Audible and visible alerts/alarms
 - Buoys
 - Fencing
 - Signs
 - TV –monitors

Although this event did not trigger the public safety efforts in Sweden it certainly emphasised the need of further actions.

4. Summary

Of the about 10 000 dams in Sweden, of varying size, type and age 190 are hydropower dams classified internationally as large dams.

The Swedish large scale hydro power started in the beginning of 20th century and most of the dams were constructed 1950-1980.

The major part of the total 190 large hydropower dams consists of earth- and rockfill dams. A minority is concrete dams and among them there are a few arch dams. Design, construction and operation of the dams have developed significantly over the years.

Internal erosion in moraine cores has caused problem in some dams due to too coarse filters. To be sure of that such internal erosion will not develop to a dam failure many dams have been strengthened with an extra stabilizing support toe of material coarse enough to safely convey all credible leakage.

Sweden has so far no specific law on dam safety. That situation will probably change after a governmental inquiry proposing a stronger society grip on dam safety. Dam safety has high priority in Sweden and until now dam safety requirements has been formulated guidelines established by Swedenergy. These guidelines have been of great importance for dam safety development in Sweden.

Important efforts are made to provide know necessary competence for the future. Actions are also taken towards a more systematic view on dams and dam safety involving technical as well as people and organization aspects.

Public safety around dams is dealing with safety for the public being around the dam facilities during ordinary operation. It is of growing interest in Sweden like in many other countries. In Sweden a Swedenergy guideline is established and is under implementation.

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