RESERVOIR SAFETY IN THE UK – PROPOSALS FOR CHANGE – LEGISLATION

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KEY WORDS
Dams, Safety, Legislation, Risk Based Approach, Historic Failure

ABSTRACT
This paper seeks to trace the progress of UK legislation relating to dam safety and to provide information on how the legislation is likely to change in the future. The paper describes the Reservoirs (Safety Provisions) Act 1930, the Reservoirs Act 1975, and the proposals for a new Bill in 2010/2011.

RESUME

1. INTRODUCTION
The UK has been going through a period of change in reservoir safety and will continue to do so over the next few years. A number of severe storms and floods in recent years has led to concerns about our legislative process and to the dams to which the Act applies. The proposals are associated with a move towards a risk or perhaps consequence based approach.

In addition the UK has decided to embark on a managed and structured approach to reservoir related research.

2. HISTORICAL PERSPECTIVE
The first reference to reservoir safety in the UK appeared in the Waterworks Clauses Act of 1863, where someone who was concerned about reservoir safety could complain to two Justices of the Peace who would then investigate the issue and organize repairs/action.

In 1925 there were three failures in the UK which caused loss of life. On Monday 20th April 1925 the reservoir at Skelmorlie ‘burst’ killing a woman and four children. Heavy rain caused the dam to overtop. At the time the Lord Advocate stated that the ‘accident to the reservoir was materially contributed to by the absence of any regular skilled supervision and inspection of the reservoir’.

The reservoir has a capacity of 5 million gallons (22700m³).
In North Wales a cascade failure caused 16 persons to lose their lives in the village of Dalgarrog when two dams failed. The upper dam Llyn Eigeau, a concrete gravity structure released more than 8Mm³ on the 2nd November 1925. The dam was 11 metres high and more than 1 kilometer in length and was built in 1911. The construction was fraught with problems with the original contractor pulling out of the work half way through allegedly corning cutting and bad work. It was possible to see honey combed concrete in the works after the failure. The dam failed by the foundation below the dam blowing out under pressure.

The flood flowed down to Coedty Reservoir, an earthfill embankment with a concrete core wall some 11 metres high and containing some 300,000 cubic metres of water, built in 1924. This dam overtopped and failed with the water going onto Dalgarrog where the life loss would have been much larger had not most of the villagers been in the Church Hall watching a film! Both dams were for hydroelectric generation for power to the aluminum smelting works in Dalgarrog.

Figure 1 : Breach at Eigeau Dam

Figure 2 : Plan and Cross Section of Eigeau Dam
After these failures there was a degree of public concern in the UK and a prominent engineer of the time wrote to The Times newspaper to suggest we needed legislation. On the 1st January 1931 the Reservoirs (Safety Provisions) Act 1930 became law. This Act applied to all reservoirs which contained more than 5 million gallons above the level of the natural ground. These reservoirs were the subject to inspection by an independent engineer but there were no powers to enforce the Act or compel the owner to carry out works required in the interests of safety. At this time there was no guidance on how to deal with assessing the risk of a seismic event, and floods were assessed through the 1930’s and 1940’s until 1975, by plotting extreme floods which had occurred against catchment areas to give a ‘normal maximum flood’ (NMF) on which Panel Engineers would apply a multiplier to get a design flood ie 2 x NMF or 3 x NMF.

As a result of concerns after failures overseas (Malpasset, Vajont, etc) the UK undertook a review of our legislation in 1966. Eventually, after a failure which did not result in loss of life in the early 70’s in Northern England, a new Act was drafted – the Reservoirs Act 1975. This is the legislation which is currently applied and it brought in several new provisions including:
• The formation of an Enforcement Authority – to enforce the provisions of the Act – nested in more than 136 different authorities
• The provision of a Supervising Engineer for each dam – an Engineer to visit the dam usually twice a year to watch for change.
• The formation of a register - the UK didn’t actually know how many dams were subject to legislation!

Again the Act, which now attracted criminal liability, applied to reservoirs with a capacity of 25000m³ (a rounding up of the 5 million gallons – 22700m³).

In 1975 the Flood Studies Report was published which gave us a methodology (rainfall runoff method) to calculate extreme floods, and guidance was written to cover a number of ‘design events’. The Guides are offered as guidance only and are not mandatory ie a different standard can be adopted if the engineer considers it appropriate.

A guide on floods entitled Floods and Reservoir Safety: An Engineering Guide was first published in 1978, was updated in 1989 and again in 1996.

The Guide suggests standards and categorises dams in terms of the potential hazard to life and property downstream. These standards seek to resolve acceptably the conflicting dams of safety and economy by giving guidance on the risk associated with these hazards.

The main factors considered in the Guide when considering flood protection is the combination of circumstances that may arise in progressively rarer events. Three main factors considered are:

• Initial reservoir level
• Design flood inflow
• Concurrent wind speed

The standards set seek to assess the consequence of failure are shown in Table 1 below.

Category A dams are those where a community (defined as 10 or more people) are at risk.

Category B dams are those where inhabitants of isolated houses are at risk or where extensive damage would be caused (ie erosion of soils, severing a main road or rail communications.

Category C dams are situations where there is negligible risk to human life and so included flood threatened areas that are ‘inhabited’ only spasmodically e.g. footpaths etc and loss of livestock and crops.

Category D dams are dams, usually small dams where the additional damage caused by the release of water may well be insignificant if the lake is small – where the stored water would add no more than 10% to the volume or peak of the flood.

<table>
<thead>
<tr>
<th>Dam Category</th>
<th>Potential effect of Breach</th>
<th>Reservoir Design Flood</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Endangers lives in a community</td>
<td>PMF yr</td>
</tr>
<tr>
<td>B</td>
<td>Endangers lives not in a community cause extensive damage</td>
<td>10,000 yr</td>
</tr>
<tr>
<td>C</td>
<td>Negligible risk to life and limited damage</td>
<td>1000 yr</td>
</tr>
<tr>
<td>D</td>
<td>No loss of life foreseen</td>
<td>150 yr</td>
</tr>
</tbody>
</table>

**Table 1 : Flood Standards**

In this Guide Classification Factors are assigned to dams according to the following table:

<table>
<thead>
<tr>
<th>Classification Factor</th>
<th>Capacity 10m³</th>
<th>Height (m)</th>
<th>Evacuation Requirements (people)</th>
<th>Potential damage downstream</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>&gt;120 (6)</td>
<td>&gt;45 (6)</td>
<td>&gt;1000 (12)</td>
<td>High (12)</td>
</tr>
<tr>
<td></td>
<td>120 – 1 (4)</td>
<td>45 – 30 (4)</td>
<td>1000 – 100 (8)</td>
<td>Moderate (8)</td>
</tr>
<tr>
<td></td>
<td>1 – 0.1 (2)</td>
<td>30 – 15 (2)</td>
<td>100 – 1 (4)</td>
<td>Low (4)</td>
</tr>
<tr>
<td></td>
<td>&lt;0.1 (0)</td>
<td>&lt;15 (0)</td>
<td>None</td>
<td>None (0)</td>
</tr>
</tbody>
</table>

**Table 2: Seismic Classification Factor**

Depending on the aggregated score the Guide points the reader to a particular level of analysis appropriate to the type of dam etc.

The ‘Act’ and its associated Guides have served the UK very well for many years. However, after floods in 2002 the profession prompted a change. The Water Bill of 2003 introduced a number of changes, the main ones of which were:-

- Removal of the 136 different enforcement authorities and replacement with a single enforcement authority – the Environment Agency
- Removal of Crown immunity
- And a provision for the Secretary of State to order Flood Plans to be written for dams – flood plans consist of an ‘on-site’ plan, a dam breach and inundation model, and an ‘off-site’ plan

The production of simple inundation plans for all reservoirs to which the Act applies is currently being undertaken by Government and will be given to owners. Owners will then be able to use the Digital Terrain Model (DTM) to carry out more sophisticated modeling for reservoir categorization uses (in terms of identifying potential loss of life) and spatial planning if they so wish.

3. **THE FUTURE**

Once again the floods of 2007 has promoted a desire and opportunity for change. In the floods of July 2007 which caused a significant amount of damage to critical infrastructure in the UK (roads, railways, motorways, electrical sub-stations, water treatment works). There were a number of dam incidents and emergencies both for dams subject to the Act but also smaller structures not subject to the Act. People were evacuated, motorways were closed and significant damage was done, mainly as a result of high intensity but very localized storms.

Since 2007 there have been a number of incidents, again with dams below the 25000 cubic metre threshold and therefore not subject to the reservoir safety legislation, and in fact probably no legislation, to ensure safety.

In their last biennial report to Government the Environment Agency, who having been enforcing the Act for some four years as Regulator, published changes that they would like to see to the legislation.

Government commissioned a report after the 2007 floods known as the ‘Pitt Review’ or the ‘Pitt Report’. In this report Sir Michael Pitt states:-
“the Government should implement the legislative changes proposed in the Environment Agency’s biennial report on dam and reservoir safety through the forthcoming flooding legislation”.

This recommendation has given the political and legislative opportunity to make changes to the Act, and indeed there are so many proposed changes that there may indeed be a completely new Act.

4. PROPOSED CHANGES

The key change proposed to the introduction of a risk-based approach that would determine which reservoirs should come under the Act, replacing the current 25000 cubic metre threshold. This change seeks to recognize that many small reservoirs pose significant risk to life, property and critical infrastructure – the current Act does not do that and all ‘large raised reservoirs’ defined by the current act are subject to the same level of supervision, whether or not they pose a risk to life.

The definition of a large raised reservoir takes no account of the likelihood of failure or the consequence of failure on a downstream community.

Reviews of intentional reservoir safety legislation shows that the UK is unusual in using reservoir volume alone to define which reservoirs are subject to legislation with no consideration of the likelihood or consequence of failure.

The form of the definition is still in consultation phase but it is very likely that all reservoirs in the UK, in theory of any volume (but more likely to be subject to a minimum volume perhaps 10,000 cubic metres) will be assessed according to the ‘risk’ or again more like to the consequence of failure that they pose.

Reservoirs will be given a risk score and categorised as high, significant or low risk. The risk score will be based on factors that indicate the likelihood of failure and the consequence of failure (e.g. type, age, height, potential loss of life).

Based on the risk category the requirements of the Act are likely to be as follows:

<table>
<thead>
<tr>
<th>Risk Category</th>
<th>Inspection</th>
<th>Supervision</th>
</tr>
</thead>
<tbody>
<tr>
<td>High</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Significant</td>
<td>Called for if required</td>
<td>✓</td>
</tr>
<tr>
<td>Low</td>
<td>None</td>
<td>None</td>
</tr>
</tbody>
</table>

Table 3: Possible Risk Categorisation for Dams in the UK

The Supervising Engineer for a significant risk reservoir will retain the ability to call for an inspection if they feel necessary and there will be no requirement for the reservoir to be inspected every 10 years.

The changes are likely to see a huge number of ‘new’ reservoirs being registered, mainly small dams above communities never regulated before, – perhaps as many as 8000 dams and a phased introduction will be required.

Training Succession Planning, Knowledge Transfer - A problem of concern in the UK is the number of engineers ‘qualified’ to inspect reservoirs. The table below shows the declining number of engineers over a relatively short period of time.
Table 4: Age Profile of Dam Engineers in the UK

<table>
<thead>
<tr>
<th></th>
<th>2000</th>
<th>2006</th>
<th>2008</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inspecting Engineers</td>
<td>90</td>
<td>57</td>
<td>53</td>
</tr>
<tr>
<td>Ave Age</td>
<td>53</td>
<td>59</td>
<td></td>
</tr>
<tr>
<td>Supervising Engineers</td>
<td>256</td>
<td>159</td>
<td>152</td>
</tr>
<tr>
<td>Ave Age</td>
<td>52</td>
<td>54</td>
<td></td>
</tr>
</tbody>
</table>

This is becoming a bigger and bigger problem for the UK with time, although some enlightened firms are starting to deal with the problem – but it needs training, time and investment.

5. CONCLUSION

The Floods and Water Bill is currently being drafted, and then it will enter a period of consultation in the Spring of 2009 with the New Act potentially becoming law in 2010 or 2011.

The recent floods have provided an opportunity and catalyst to ‘update’ reservoir legislation in England and Wales to ensure that all reservoirs that pose risk to life are subject to an appropriate level of legislation and regulation to reduce and manage these risks.

REFERENCES

[1] HMSO Reservoirs Act 1975