Dam safety risk treatments

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Introduction

One of the noticeable outcomes of the community emergency risk management process in many areas has been the scrutiny of dam safety by the general community and emergency managers undertaking the risk analysis process. At the same time some dam safety engineers have been utilising risk management principles to assess the risks to their dams. Dams that are categorised as a high hazard should have an emergency action plan that outlines procedures for the safe operation of the dam during an emergency. However, many of these emergency action plans do not interface with or use the terminology that is consistent with local emergency arrangements. Current emergency management principles and practices are now fairly stable but the terminology in use by the community is changing all the time as they become more aware of the risks around them and the prevention strategies that are being implemented.

Dam Safety awareness

There are also many risk treatment options within the engineering field that will change the likelihood or consequences of a flood affected by a dam or a dam failure. Some of these options may save the dam structure but also cause an increase of the consequences within the community. Emergency managers and the community need to actively communicate with the dam owner or operator to ensure that they gain an understanding of these changes to the risks associated with dam operation. This liaison needs to be increased when a dam is undergoing repairs or alterations as these activities change the risk exposure for the community, dam owner/operator and the contractor undertaking the repair work.

Some of the risk treatment options for dam safety involve strategies to change the capacity of the spillway to handle revised maximum floods. An increase in spillway capacity can help save the dam from overtopping, however, these options often have an affect on the downstream community. Emergency managers need to be aware of these options as many create other associated risks while they are saving the dam.

A spillway fuseplug is a strategy used in many countries for increasing the capacity of a dam to cope with the probable maximum flood (PMF) whilst retaining a degree of security. The fuseplug is usually built in an emergency spillway of the dam and is constructed of material that will erode easily when water overtops the fuseplug. When a flood enters the dam, the normal spillway is used until the inflow exceeds its capacity and the water overtops the first level of the fuseplug. This causes the fuseplug to erode before the dam wall is overtopped and thus saves the dam. The fuseplugs are often designed to erode at different water heights so there is an increasing fuse effect. The risk downstream is an increase to the extreme flooding levels, but hopefully the dam will be saved.

Spillway design is very important so that the PMF will pass through the dam and not over the top of the dam. On dams that have limited spillway capacity, a labyrinth design could be used to increase the capacity of the spillway without increasing the spillway width. The labyrinth spillway will allow greater spillway flow to save the dam. However, the use of a spillway fusegate that is designed to topple over when the water exiting the spillway reaches a certain height is a different matter. Once toppled, the fusegate allows increased water to suddenly exit via the spillway. The risk to the downstream community is a sudden increase in the quantity of spillway discharge as the toppled fusegate does not return to its original position after the initial flood peak.

Other innovations in spillway design include the use of pneumatic assisted gates to raise or lower the spillway height. These gates allow a structure such as a weir or spillway to increase it's holding capacity to prevent excessive flooding downstream. The risk is the sudden deflation of part or all of the airbags that will cause a wave of water to flood downstream. These gates are often used to increase the capacity of the dam to hold more water during flood events. The failure to inflate the gate would also increase the affect of the flood event.

There are many differing strategies used to make a dam safer which have a possibility of changing the risks to downstream communities. The liaison between the dam owner/operator, community and emergency management planner is vital to ensure ongoing community safety.

Risk treatment

The risk treatment process starts with the extreme and high risks from the analytical stage and after these are formed into some priority, the group undertaking the risk management process then discusses the various options.

Vulnerable community

The vulnerable elements of the community are again considered at this point in the risk management process for each risk. Much of the information on community vulnerability has been gathered earlier in the risk management process but it is now consolidated for each risk before the options are considered so that a direct comparison of the affects or secondary risks can be made with each option. Vulnerability of the community with regard to dam safety could include access or egress, warning times, risk acceptance or disbelief, communication systems, monitoring systems and demographics of the area downstream or isolation by the dam operation.

Options

Of course, the first option is to accept the risk. In many cases this is not possible in the community safety context. If this option is taken, the risk would only analysed again during subsequent reviews or when factors affecting the likelihood or consequence are changed.

The second option is to avoid the risk. One example of how this can be achieved is the total removal of the dam. Overseas examples show that this is occurring when the repair costs are too great for the dam owner to make the dam safe, or when there are other reasons such as the need for environment flows and enhancing fish migration. The actual removal of a dam may avoid some risks but there could be many other implications due to a change in the flood peak without the dam.

The third option is to transfer the risk. This is usually achieved through contracting out the operation of a dam and/or insurance to cover any possible litigation from consequences of dam operation or

failure. In most cases of risk transfer, there is still a component of the risk or a new risk that remains with the owner or operator regardless of the contract or insurance policy. These risks may range from a change in the public's perception of the owner through to the legal issues of adequate contract management.

To treat the risk through a reduction in likelihood or consequences is the fourth option.

A reduction in **likelihood** can be achieved by:

- river level telemetry
- rainfall telemetry
- operational procedures
- training
- backup systems
- dam design & spillway operation
- maintenance

Reducing **consequences** can be achieved by:

- evacuation plans
- warning systems
- dam design features

Residual risk

Residual risk will always be there, it is the risk of not undertaking the risk treatment options in a timely manner due to funding or other restraints and also any risk that is left over after risk treatments are implemented. In fact, emergency management plans and arrangements are designed to treat residual risk and this is their place within the process. In the ideal world the risk treatment options would eliminate the need for emergency management plans.

Action plans

When the treatment options have been agreed upon, then action plans are completed to ensure that the strategies are undertaken, resources are allocated, responsibilities are clear, timing is agreed upon and a process of reporting and monitoring is included to complete the tasks.

Monitor & review

The entire risk treatment system is then reviewed as part of the normal cycle or as changes occur to either the likelihood or consequences.

Conclusion

It is clearly evident that the dam owner/operator, regulators, community and emergency management planners need to establish clear communication and an understanding of each other's roles and responsibilities within the community and dam safety fields. Dam safety is only one of many specialist areas where the facilitation skills of the emergency management planner are required to ensure an improvement in overall community safety.

Top: Fuseplug emergency spillway. Above: Fusegate spillway using the labyrinth design.

References

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Author

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