Formulation of an Integrated Community Based Disaster Management for Hydroelectric facilities: The Malaysia Case

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Abstract. Dams, however significant their contributions are to the society, are not immune to failures and diminishing lifespan not unlike other structural elements in our infrastructure. Despite continuing efforts on design, construction, operation, and maintenance of dams to improve the safety of the dams, the possibility of unforeseen events of dam failures is still possible. Seeing that dams are usually integrated into close approximities with the community, dam failures may consequent in tremendous loss of lives and properties. The aims of formulation of Integrated Community Based Disaster Management (ICBDM) is to simulate evacuation modelling and emergency planning in order to minimize loss of life and property damages in the event of a dam-related disaster. To achieve the aim above, five main pillars have been identified for the formulation of ICBDM. A series of well-defined program inclusive of hydrological 2-D modelling, life safety modelling, community based EWS and CBTAP will be conducted. Finally, multiple parties’ engagement is to be carried out in the form of table top exercise to measure the readiness of emergency plans and response capabilities of key players during the state of a crisis.

1. Introduction

Dams have provided tremendous benefit to the development of civilization, and continue to cater for our improving standard of living. The earliest known dams were primarily used for irrigation and water supply and thereafter expanded to be used for other significant purposes such as flood control, hydropower and recreation. Throughout history, dams have apparently performed well overall. However, dams have periodically failed or suffered incidents throughout history as they are not expected to last forever. This has necessitated for dams to have regular inspections as they hold a potential risk of failure due to many technical and safety problems. Dam failures are regarded as one of the major “small probability, large consequence” events. The floods resulting from dam failures can lead to devastating disasters with tremendous loss of life and property, especially in densely populated areas. Loss of human life is generally accepted as the most important consequence; therefore it often dominates dam safety decisions (McClelland & Bowles, 2002).

In Malaysia, there are almost 51 recorded dams (60% of the dams are of earthfill type) under different ownerships (Othman, 2006). To-date we have not had the experience of any dam-related failures. However, the occurrence of a deadly tragedy on the 23rd October 2013 at Bertam Valley, Cameron Highlands has been treated as a wakeup call for all parties that prior to any dam failure (see Figure 1), there could be other possible scenarios which could claim lives in the vicinity of any dams (e.g. normal riverine flooding).
Figure 1: Aftermath of Bertam Valley incident

It should be realized that there is a dynamic interaction between people, vehicles, buildings and flood wave. Therefore, flooding from dam related disasters usually cause huge loss of lives and destructions of properties and environment. For example, the 1963 failure of Vajont dam in Italy caused 2600 deaths, the 1976 failure of Teton dam in America caused hundred deaths and economic loss about 1 billion dollars, and the 1993 failure of Gouhou dam in China caused 300 deaths (You, Li, Min, & Xiaolei, 2012). The statistical analysis of 534 dam failures from 43 countries before 1974 indicated that earth-rock dam failures accounted for the largest proportion of all failures and included 49% caused by overtopping, 28% seepage in dam body and 29% seepage in foundation (ICOLD, 1998). Dam failures may cause tremendous loss of life and property, and hence professionals experienced in the field of dam engineering have paid continuing efforts on design, construction, operation, and maintenance of dams to improve the safety of dams. However, many existing dams still pose increasing hazards to the downstream areas due to structural deterioration, inadequate design, faulty construction, and poor operation and maintenance. These dams are referred to as distressed dams. Looking from the stand-point of Malaysia, 20% of its dams are in the range which problems often begin to manifest (Othman, 2006). Othman (2006) also highlighted that it is also worth noting that the safety review of the oldest dam, Bukit Merah Dam (1906) was conducted in 1998 and the review for Sungai Perak Hydroelectric Scheme comprising the Temengor (1978) and Chenderoh (1930) dams was carried out in May 2003. Tenaga Nasional Berhad (TNB) as the major key player in the Malaysia Electricity Supply Industry has conducted its latest review on Kenyir Hydroelectric Scheme in 2006.

2. The Current State of Emergency Preparedness in Malaysia

The Chief Government Security Office (CGSO) Malaysia which is an important arm under Prime Minister’s Office of Malaysia, has asserted that dams are considered as one of the 15 national strategic targets (sasaran penting negara) (CGSO, 2013). Therefore, it is essential to strengthen national preparedness, timely response, and rapid recovery of this critical infrastructure in the event of an attack, natural disaster, or other emergency. Potential risks associated with the failure or disruption of these assets could be considerable and potentially result in significant destruction, including loss of life (LOL), massive property damage, and severe long-term consequences. Therefore, consistent consequence estimation approaches must be achieved to identify those assets within this critical infrastructure sector whose failure or disruption could potentially lead to the most severe impacts. At a minimum, consequence assessment should focus on the most fundamental impact; those corresponding to human consequences. The exposure of people to the physical effects of a dam failure can result in loss of life. Consistent estimation of consequence variables constitutes a problem of paramount importance. Common definitions, scenarios, assumptions, and metrics are needed to ensure human risk assessment
efforts can effectively contribute to a shared understanding of the dam risk profile among key stakeholders associated to dam operations in Malaysia. With this information in-hand, authorities could best plan the evacuation related procedures and logistics.

The failure of Banqiao and Shimantan Dam in Henan in China in 1975 was evaluated as the world’s most catastrophic dam failures, the number of deaths directly caused by the dam-break flood was 26,000; 5.4 million people were impacted (Graham, 1999). Loss of life due to dam break failure is highly influenced by three factors: (1) population occupying the flood plain downstream the dam; (2) the amount of warning time given to the people; and (3) the severity and magnitude of the flooding (Graham, 1999). In addition, nearly 100 quantitative or categorical variables can be considered to affect the number of flood fatalities due to a dam break (McClelland & Bowles, 2002). Loss of life resulting from dam failure, as measured by fatality rates or total number of fatalities, has generally been higher for populations near the dam than for those located further downstream. The recent incident at Sultan Abu Bakar (SAB) Dam has proven that loss of life could also be contributed by dam associated flash floods (riverine flooding) which are obviously not rare compared to dam failure flooding. Dam failures and associated flash floods can result in high fatality rates, especially when flooding overwhelms an unsuspecting group of people. However, dam failures that produce slowly rising floods tend to result in lower fatality rates. The need for mitigation of human risks due to dam related disasters raises questions about the proper estimation of potential loss of lives. We need to engage with the people who live in areas below dams and who would be affected by dam-related flooding. Dam owner must be able to attain the ability of making decisions during the time of crisis in the aspects of warning and assisting evacuation in relation to dam related flooding. The time available to evacuate is an important mediating factor in the dam-failure context, the techniques to be used to educate and warn community is a major component to be addressed.

Evacuation is the process between the start of leaving the risky area and the arrival at a safe place. Evacuation is not solely about ordering people to move from one place to another. It is imperative to persuade people to move, which relates to warning processes, actual movement process and its management. A vital element in-lieu to this effort would be effective utilization of time. Careful consideration of the time variable is necessary to ensure that the evacuation of all those at risk can actually be affected. Notwithstanding, prior community engagement is fundamental to the success of any warning and evacuation strategy. This is reflected by the nature of warning and evacuating people were never simple and would be of least difficult if the people have a sound prior understanding of the threat which requires them to evacuate. Hence, community must be educated about the threat, about its management by dam owners and emergency responders, and about the actions which people can take to respond in their own interests. Apart from that, it remains vital that the efforts of dam owners and emergency responders are properly integrated so that the two sides of the management of potential dam related disasters are fully incorporated.

Prior to this, there have been several studies being undertaken by TNB on dam break of its major hydroelectric schemes. For instance, in 2003, Sungai Perak hydroelectric scheme has been undertaken whereby the emergency action plan (EAP) was derived using USBR format. However, beginning from 2008, there has been a change in adopting HTC format for formulating EAPs. In 2008, Kenyir hydroelectric scheme has been studied and followed by integration of HTC and USBR format for ERP formulation specifically for Sg. Perak and Kenyir facilities in 2011. This chronology continued with dam break study for Cameron Highlands hydroelectric scheme in 2012. The recent study was conducted in the first quarter of 2014 for Pergau Dam. The nature of these studies was more focused towards the types of dam breaches and characteristics of flooding, such as flood arrival time (FAT), depth and flood velocity. However, loss of lives, establishment of safe haven, and engagement with the public was not looked into with a greater emphasis. The perspective towards these elements has changed after the Bertam Valley incident.
3. The Way Forward: Enhancing Community Ownership Towards Disaster Management

Five essential criteria have been identified for formulation of ICBDM. The formulation of ICBDM stands upon five main pillars which support the overarching aim of this study (see figure 2). A 2-D flood modelling will be conducted in the initial phase of this project to determine the impact of dam releases on riverine flooding as an input for the Life Safety Simulator (LSS) under various failure modes. Detailed knowledge on the characteristics of the flooding is then used as an input parameter to conduct a numerical analysis for loss of life using the Life Safety Simulator (LSS), which should be able to model the casualties that may occur due to the flooding. This Life Safety and Evacuation Model is capable of allowing dynamic interaction between people, vehicles, and buildings with the flood wave. Based on the findings from the analysis, a Community Based Early Warning System (CBEWS) can be constructed. From there, a feasibility study will be conducted on the early warning system in terms of efficiency in generating and disseminating timely and meaningful warning information to community members, communities, and organizations so that necessary preparedness measures and action could be taken in sufficient time to reduce the possibility of harms or losses. With the information gathered from the feasibility study, a Community Based Training and Awareness Program (CBTAP), which is a community awareness program, will be designed to educate people about the threat and about its management by dam owners and emergency responders, and about the actions which people could take to respond in their own interests. Finally, a Multi-Stakeholders Engagement Program (MSEP) will be carried out which will include multiple parties’ engagement in the form of table-top exercise to measure the readiness of emergency plans and response capabilities of key players during the state of a crisis. Once all these procedures have been implemented, all the stakeholders, including the public, should be well educated and prepared with the dam disaster evacuation response system.

![Figure 2: Proposed Integrated Community Based Disaster Management (ICBDM) Scopes](image)

4. Conclusion

In line with current global awareness of water security, the aspect of dam safety has drawn increasing attention from the public as it constitutes the element of a country’s national security. This is because the aftermath floods resulting from breaching of dams can lead to devastating disasters with tremendous loss of life and property, especially in densely populated areas. Previous disasters exhibited that the repercussions of dam failures are directly related to the evacuation time available should failures occur. It is therefore very important to study dam failures and their corresponding breaching characteristics, and if possible, to estimate the possible fatalities (loss of life).
References
[1] McClelland, D., & Bowles, D. (2002). Estimating life loss for dam safety risk assessment—a review and new approach. Institute for Water Resources, US Army Corps of Engineers, Alexandria, VA.

[2] Othman, Z. A. (2006). Overview of dam safety in Malaysia.

[3] You, L., Li, C., Min, X., & Xiaolei, T. (2012). Review of dam-break research of earth-rock dam combining with dam safety management. Procedia Engineering, 28, 382-388.

[4] ICOLD. (1998). Dam-break flood analysis. Bulletin 111.

[5] CGSO, Chief Government Security Officer (2013). Background. Retrieved 30 January, 2013, from http://www.cgso.gov.my/~cgso/portal/index.php/en/faq.html

[6] Graham, W. J. (1999). A procedure for estimating loss of life caused by dam failure: US Department of the Interior, Bureau of Reclamation, Dam Safety Office.