

Safe Havens and Evacuation Routes due to Dam Disaster

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ABSTRACT---The aim of the paper is to review the important framework and understanding for the safe havens and evacuation routes due to dam disaster. There is estimated amount of 33,000 dams around the world today in the category of large dams. From the year of 1800, there are about 300 major dam failure occurred, causing thousands of casualties. Although dam owners have taken all the possible precautions, the possibility of incidents to occur remains there due to controlled and uncontrolled situations. In Malaysia, there are more than 20 large dams available, built for different purpose ranging from hydro power generation, water supply, crop irrigation and also for flood mitigation. The first large dam constructed in Malaysia is Bukit Merah Dam in Kerian, Perak in the year of 1906 and the construction continues until the most recent dam, Susu Dam in Jelai, Pahang, completed in the year of 2016. TNB being the dam owner of large dams for hydro power generation in Malaysia for example, has 14 large dams with the largest being the Kenyir Dam in Terengganu, having the capacity of 13,600 million cubic meters of water and dam high of 150 meters. The paper reviews the aspect of safe havens and evacuation routes in order to secure the surrounding communities. It also covers on how the community evacuate safely from the disaster. Based on this framework, it is hoped that the paper will be a useful addition to the body of knowledge and understanding for the safe havens and evacuation routes and also a safety and awareness community during the disaster.

Index Terms: safe havens, evacuation routes, disaster, community awareness

I. INTRODUCTION

There is estimated amount of 33,000 dams around the world today in the category of large dams [1]. From the year of 1800, there are about 300 major dam failure occurred, causing thousands of casualties (International Commission on Large Dams ICOLD). Although dam owners have taken all the possible precautions, the possibility of incidents to occur remains there due to controlled and uncontrolled situations.

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generation, water supply, crop irrigation and also for flood mitigation [2]. The first large dam constructed in Malaysia is Bukit Merah Dam in Kerian, Perak in the year of 1906 and the construction continues until the most recent dam, Susu Dam in Jelai, Pahang, completed in the year of 2016. TNB being the dam owner of large dams for hydro power generation in Malaysia for example, has 14 large dams with the largest being the Kenyir Dam in Terengganu, having the capacity of 13,600 million cubic meters of water and dam high of 150 meters [3].

Up to this day, Malaysia has never experienced a dam failure. The closest event involving a dam was the major water release from the spillway occurred in Sultan Abu Bakar Dam in Ringlet, Cameron Highlands in the year of 2013 and 2014, causing the casualty of 4 and 2 respectively [4]. Although it was not a dam failure and rather a controlled spilling, the chronology of the event has setup a dam failure scenario which gives a very valuable lesson to the dam owners, local community, local authority and the rest of parties involved with dam operation and dam disaster in Malaysia.

The lack of effective evacuation route and safe haven for the community are some of the missing element in the dam disaster event. Although the community is aware of the incoming catastrophe, the improper information for evacuation could be disastrous. Although currently one major safe haven has been assigned by the local authority for such event in Bertam Valley, the suitability and effectiveness of the area will be accessed specifically in relation to dam disaster related event

In this paper, the factors for selection of safe havens and the factor for identification of evacuation routes shall be looked into, and in the end, the acceptance of the community for the proposed safe havens and routes shall be investigated.

II. DEFINITION AND CONTEXT

Dams are water storage, control or diversion structures that impound water upstream in reservoirs. It provides tremendous benefits to human such as providing water supplies for drinking, irrigation, flood control, water navigation, and hydroelectric power. However, in the same time, dams also impose great risk to human in the event of dam failure [5].

Reservoirs created by dams not only suppress floods but also provide water for activities such as irrigation, human consumption, industrial use, aquaculture, and navigability. Hydropower is often used in conjunction with dams to generate electricity. A dam can also be used to collect water or for storage of water which can be evenly distributed between locations. Dams generally serve the primary purpose of retaining water, while other structures such as floodgates or levees are used to manage or prevent water flow into specific land regions. The main purposes of dam construction are for power generation, water supply, stabilizing water flow for irrigation purposes, flood prevention, land reclamation, water diversion, and navigation.

In overall, based on structure and material used, dams are classified as easily created without materials, arch-gravity dams, embankment dams or masonry dams, with several subtypes. Concrete arch dam, concrete gravity dam, concrete arch-gravity dam, barrage dam, rock fill embankment dam, concrete face-rockfill dam, earth fill embankment dam. In Malaysia, the most common type of dams is from the type of rock-fill embankment dam, and concrete gravity dam. Although dam has given human being a lot of benefit, it also carries a similar amount of risk in the event of failure. Historically, dam failures have been among major contributor to catastrophe due to man-made structures.

Dam failure

A dam failure is a catastrophic type of failure characterized by the sudden, rapid, and uncontrolled release of impounded water or the likelihood of such an uncontrolled release. Dam failure can be in many forms, but mainly they are in the form of breach in the structure. Small dams with small volumes might impose less risk due to failure, however dams storing large amount of water can cause significant and catastrophic flooding along its path downstream Dam failures can occur due to the following reasons:

- a. Prolonged rainfall and flooding
- b. Insufficient spillway capacity, causing overtopping of dam embankment
- c. Piping, which is the internal erosion of embankment due to leakage
- d. Poor maintenance, which includes failure to remove trash, failure to repair internal seepage, failure to keep up with the scheduled maintenance of dam mechanical such as gates, valves, and other operational components
- e. Reservoir slope failure, causing landslides into reservoirs, creating waves that overtop dam
- f. Destructive acts of terrorism
- g. Dam structural failure due to earthquakes

Dam failure also becomes catastrophic due to the sudden large amount of water being released in short period of time, sweeping everything in its path [6].

Vulnerable community

Vulnerable community can be defined as a community who are exposed to the possibility of being harmed, either

physically or mentally. The communities experiencing various forms of social exclusion and disadvantage will disproportionately bear the brunt of climate change, including rises in the cost of living (e.g. water and food), increased exposure to extreme weather (because of low quality public and private rental housing) and associated threats to health. This is because adaptive capacity and resilience is dependent on access to financial, material and social resources – climate change will discriminate between communities on the basis of their socio-economic status.

In Malaysia, most of the communities downstream of large dams are in the category of vulnerable community due to the insufficient information on Emergency Action Plan for dam disaster, inclusive of indefinite evacuation route and evacuation shelter. Although there has not been an actual event of a dam failure in Malaysia, one catastrophic event in Cameron Highlands in 2013 was the closest example and precaution for impact of a dam failure. The event was caused by sudden rise of dam water level, causing the dam owner to release some of the reservoir water through the gates to avoid a more serious consequence. Four lives were lost with hundreds of other downstream of the dam in Bertam Valley were badly affected due to major flooding due to the dam spill.

III. SAFE HAVEN/ EVACUATION SHELTER

An evacuation shelter is a structure or an area that serves the targeted population in an existing facility such as residential area, school or buildings, as a shelter for disaster survivors. Evacuation shelter is important as a point where all survivors of an emergency event are gathered for medical assistance, emotional support, safety precautions and head count for possibility of emergency response team to be sent to the disaster area for search and rescue [7].

Different type of disaster require for a different type of evacuation shelter. An evacuation shelter for tsunami requires for it to be at certain distance from the immediate beach, with certain safe height above the largest potential tsunami, while an evacuation shelter for a hurricane might require for it to be underground, away from the potential impact of flying debris from the storm.

An evacuation shelter for a dam failure is similar in nature to the evacuation shelter for flood. However, dam failure characteristics that differ from normal flood have to be taken into consideration. Water released from a dam failure has the characteristics of being gradual but sudden, large in capacity depending on the size of reservoir, and could last for less than a flood if the reservoir is small.

IV. FACTORS AFFECTING EVACUATION SHELTER FOR DAM DISASTER

With the knowledge of the characteristics of dam failure water release, a proper evacuation shelter for a dam disaster can be determined. This characteristic is more properly defined after a simulation modeling being done and validated with past historical event. This simulation will produce time of flood arrival, maximum water depth,



duration of flood, speed of overflowing water and ultimately the flood coverage area or also known as flood hazard map. This information will be crucial for the selection of evacuation shelter specific for this type of disaster.

Location and Accessibility

The location of an evacuation shelter has to be beyond the flood coverage area, but not too far from the intended targeted population. This is for the purpose of optimized duration to reach the evacuation shelter. At the same time, the location has to be convenient for emergency aids to reach. A location close to the main road is some of the best options available.

Height

The height of the evacuation shelter plays a vital role. Should there be a need for the evacuation shelter to be built within the flood coverage area; the height has to be sufficient to cover for the maximum depth of flood water level. However, if the location is away from the flood coverage area, a single storey structure, or even a flat space area could be a good location for the evacuation area.

Building Material

Some of the evacuation shelter requires for it to be built in the flood area due to the reason such as the limited duration the targeted population to reach the shelter, or perhaps the available location out of flood zone are not appropriate for an evacuation shelter. This is the case where the material must consider the incoming impact from the flood water.

Quantity of Evacuation Shelter against Targeted Population

The quantity of evacuation shelters has to be decided against the targeted population. One evacuation shelter might not be sufficient to cover for a large number of targeted populations. A small quantity of evacuation shelter but large in capacity in a less crowded targeted population will mean that people at the farthest point will take longer time to reach the evacuation shelter. Therefore, an optimized quantity of evacuation shelter against targeted population, taking into consideration of duration it takes to reach evacuation shelter, the ease of management of victims in larger number, and the route it would take for the population to reach the evacuation shelter has to be considered.

V. EVACUATION ROUTE

Evacuation route can be defined as an escape route which leads the population at risk from the area of risk to a safe haven. Evacuation route are identified based on many factors or combination of a few factors. During an emergency, the response time is extremely crucial [8]. A good selection of evacuation routes ensures that population at risk could evacuate risky area in a safe condition, as quickly as possible, to a safer place known as safe haven

Evacuation routes are normally available for disaster such as tsunami, fire in building, emergency door in an airplane, and flood. Evacuation route are normally easier to determine from disaster that is known and expected in capacity, direction and capacity. In a dam failure event, the evacuation routes are determined by destination area of

evacuation shelter, flood arrival time, flood path, flood depth and also flood velocity. Some of the factors affecting the evacuation routes are:

Mode of Evacuation

The mode of evacuation can be in the form of walking, in vehicle or assisted by the local authority. Each mode of evacuation will contribute to the overall duration to reach the evacuation shelter. A shelter in close proximity to the disaster area might just require walking to be the main mode of evacuation. The use of vehicle in such situation by the majority will only increase the duration for evacuation. Vehicle should be limited to disabilities and local authorities for the purpose of evacuation.

Familiarity of Route among Targeted Population

Since the ultimate purpose for evacuation is reach the shelter, targeted population who are the local community are more familiar with alternative roads that could lead to the shelter in shortest time possible. Population might prefer for alternative roads since the main road will be crowded during emergency evacuation.

Consideration of flood path

In an area with large population, several evacuation shelters could be prepared. The selection of evacuation shelter to cater for certain population is very important. In the evacuation process, risky move such as crossing the river, long duration beyond the flood arrival and selection of building other than evacuation shelter should be avoided.

Duration to Reach Evacuation Shelter

One of the most important factors for selection of evacuation route is the duration to reach the evacuation shelter. In order to determine the optimized time to reach the shelter, information such as flood arrival time, the route selection, road condition, mode of evacuation, and the health of population.

VI. CONCLUSION

The paper presents the theoretical reviews regarding the understanding of the safe havens and evacuation routes due to dam disaster to secure the surrounding communities. It also covers on how community will evacuate safely from the disaster. The paper reviews the aspect of safe havens and evacuation routes in order to secure the surrounding communities. It also covers on how the community evacuate safely from the disaster.

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