MALAYSIA

Amphibious Housing Structures for Flood-Prone Areas: A Viable Way of Minimizing Evacuation and Displacement

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By definition, a floodplain is a low-lying landscape in the proximity of a flowing (river, stream, canal) or stagnating (lakes, ponds, irrigation reservoirs) water mass that could be subjected to elongated periods of water accumulation due to the overflowing of the water mass. Historically, floodplains are extensively used for agriculture due to rich alluvium, deposited by floodwaters, that makes the soil very fertile. However, with the rapid growth of human population, many such floodplains have been converted into human settlements for the last many decades. The inevitable outcome of such activities is the risk of human disaster due to floods.

It may not always be viable to impose legal constraints to discourage people from developing housing structures in floodplains due to the ever-dwindling land area suitable for human settlements. On the other hand, in the event of floods, evacuation of occupants of such settlements, caretaking of their well-being for extended periods and relocating/re-settling them is a significant burden for the government of any country. In this, backdrop, we propose a sustainable amphibious housing structure for low-income people who live in floodplains, which will be suitable for most Asian countries.

The recent research shows that the urban flooding is mostly contributed by the blockade of flow, egress and absorption of precipitating and runaway water by built-up area. Basically, flood water may cause damage to housing structures due to submerging and lateral forces (in the event of rapids water flow). Both these factors could cause instant damage or material deterioration that result in visible damage after sometime. The extent of damage depends on the water level, duration of submerging and the material of the structure. Economic losses of such an event are due to structural damage, damage and deterioration

of household items, loss of earning time etc. Human losses and injuries may place on top of all the above.

The proposed amphibious housing structure has been designed considering all the above impacts of a flood event. Basically, an amphibious house is a structure that can be used as an ordinary house under normal circumstances (no-flood or dry periods) and the occupation can be continued as it is or after some quick modifications, during a flood event. In this sense, it is different from floating houses used in many parts of the world.

The design and costing have been done for a housing structure which can be occupied by 5 people on average, in a low-income society. The area of the structure will be about 100-120 m^2. The floor material of the structure is treated light wood painted with waterproof coating. The floor structure rests on 9 concrete pillars of which the height could be determined by analyzing regular floodwater levels. Typically, in most floodplains, 100 cm height is sufficient to avoid water invasion from a majority of flood events. The floor structure is fixed to the concrete pillars by anchor bolts and nuts which could be removed (inside the house) within 2-3 min using a purpose made spanner. Apart from preventing flood water entering the house, the elevated structure will also facilitate the runaway and absorption of water, which prevents any undue water accumulation at a given location. In regions where water level occasionally rises to above 1 m, the houses are provided with 6 stainless steel vertical bars which are fixed equidistant on the floor edge lines (inside the house). If the water level is predicted to rise above the concrete pillar height, the occupants can detach the structure from the concrete pillars by removing the nuts. Then by a ship-helm like wheel which can be fixed to the middle part of the house the whole housing structure could slowly be lifted up along the steel bars. The steering wheel could be detached after the operation and kept at a secured place to be used in need.

The wall and roof materials are selected according to the availability, durability, material density and cost. They may most probably be pre-treated to withstand harsh atmospheric conditions of tropics. Bamboo is one of the best contenders for wall materials whereas several polymeric cloths on a bamboo frame are under consideration for roofing. The housing structure is equipped with an inflatable toilet and an inflatable 1 m^3 water tank that will float on rising water (attached to the structure), without adding weight to the

housing structure. In the event of predicted flooding, the tank could be filled and as the water level rises the external water supply will be manually detached from the house (or provided with self-elongating flexible tubes).

Approximately 40% of the population in the State of Florida lost national grid power supply after the Hurricane Irma. A significant fraction of the houses that lost power supply was installed with solar PV panels, however, they could not use the generated solar electricity due to the state power company, Florida Power and Light (FPL) regulations. The company demands the compulsory shutdown of the solar PV electricity as the national grid fails. This is to prevent back feeding which may put the neighbors or repair crew being electrocuted as they may unsuspectingly be in contact with the apparently de-energized lines. Lessons learnt from this experience, lead us to develop the proposed amphibious housing structure with standalone PV system which contains a battery bank and inverter-circuit. Under normal circumstances, the house owner could do usual energy trading by feeding the national grid. However, in the event of grid failure, an automatic changeover switch completely dislocates the grid power and the solar PV energy system is integrated into the house wiring structure.

The costing done on the construction of the above described amphibious reveals that in most South and South East Asian countries shows that the no-profit budget of a complete structure is approximately USD 6500. Adding a profit of USD 500 (approximately 8%), the final cost (turn-key cost) becomes approximately USD 7000. In the aftermath of 2017 mid-year floods in Sri Lanka, the government-appointed Humanitarian Country Team (HCT) requested USD 22.7 million, to provide shelter, food, medicine and sanitary facilities to 374,000 displaced people in seven districts of the country. This may only be a fraction of the total cost of the losses and expenses by a single flooding incident in a small country. Even with the above amount of money, approximately 3250 amphibious houses could be made, which may shelter over 16,000 people on average. Considering the cost of human life and property losses, various indirect losses and secondary catastrophes due to displacement of people (eg. Spreading of infectious diseases in displacement camps; suspension of school activities due to the conversion of school buildings to displacement camps etc.), one can clearly justify the government spending on these amphibious housing schemes for people live in floodplains of frequent flood-risk.