CYCLONE SHELTER AND ITS MULTIPURPOSE USE

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INTRODUCTION

Cyclones and storm surges are among the most destructive of all natural disasters. The regions of the world which are vulnerable to such disasters include the islands in the South–West Pacific, South–East Asia (e.g., the Philippines, Viet Nam), countries adjoining the Bay of Bengal (viz., India, Bangladesh and Myanmar), South–East Africa, the Caribbean and parts of the USA and Latin America around the Gulf of Mexico and Atlantic Ocean.

Bangladesh is among the countries most vulnerable to devastating storm surges which accompany cyclones. About 10 per cent of the global total of cyclones originate in the Bay of Bengal and about one–sixth of these have landfall in the Bangladesh coast. The funnel shaped coastline in the northern bay, coupled with a gently sloping continental shelf (the 10 m depth contour ranges from 20 to 200 km from the coastline), results in surge heights upto 7.5 m. These may move up the flat deltaic land or along the numerous rivers and creeks in the coastal zone and affect places as far as 40 km from the coastline.

Cyclones and storm surges are not new phenomena in Bangladesh –– there are records dating back to 1584, when 200,000 people are reported to have been killed in one southern district due to storm surge. During the last 100 years, a total of sixty–six cyclonic storms have hit the Bangladesh coast, out of which thirty–six have been classified as severe cyclonic storm (i.e., with sustained wind speed greater than 119 km/hr).

The most devastating, in terms of human fatalities, was the 12 November 1970 cyclone, which killed around 500,000 people. The official death toll in the recent 29 April 1991 cyclone was around 140,000. More than 98 per cent of these deaths are due to drowning in the surge water. The average human death toll during the last thirty years has been around 25,000 per year, which is the highest in the world.

The details of the thirty–five cyclones which have affected Bangladesh since 1960 are given in table 1. A review of the tracks of the cyclones (figure 1) shows that these may have landfall on any location in the 700 km long coastline of Bangladesh.

A comprehensive analysis of all available data reveals that there are around 5.2 million people (approx. 4.5 per cent of Bangladesh total) living in an area of 9,182 km^2 (6.4 per cent of Bangladesh total), where the surge height may be 1 m or more. This area has been classified as a high risk area where people are likely to be killed if they do not move to shelter (BUET–BIDS, 1993).

POSSIBLE MITIGATORY MEASURES

Embankments along the coastline and around the off-shore islands can prevent the movement of storm surges inland. However, the cost of construction and maintenance of these embankments, along with the drainage structures, is so high that these may be economically justified only if there are large investments (e.g., infrastructure, industries) to be protected.

The ideal solution for protecting human lives is to build the houses above the surge level and make them strong enough to resist the lateral forces due to high wind and the accompanying surge. Since construction of an entire house fulfilling the above requirement would be very expensive, only one room of every house, capable of accommodating the entire family during the few hours of emergency may be designed to resist the wind and surge. However, under the prevailing economic conditions, construction of such an elevated room would require around US$2,500 per family, which on an average, is equivalent to around three years' income for the entire family. Therefore, for most families, it is almost impossible to construct the houses out of their own resources.

The next option is evacuation to high ground above the surge level. On receiving warning of an imminent storm surge, people can move away from the coastal areas to places above the highest surge level. However, this appears to be a feasible option only in case of a small strip of land along the southeastern coast. Even in these areas the poor communication system is a severe handicap. The required logistic support and mobilization appear to be formidable obstacles.

Construction of community shelters capable of providing refuge to the population likely to be affected appears to be a feasible option. The concept of building cyclone shelter in the coastal belt of Bangladesh dates back to the early sixties. After the devastating cyclones of 1960–61, the Government decided to build a number of two–storey buildings in areas close to the coast, the upper floor of which could be used as shelter during cyclones. These were proposed to be used as offices of the Union Council (the lowest level of local government) and community centres during normal times. A total of 132 of these buildings were built, but lack of maintenance has resulted in rapid deterioration and many of these have been abandoned.

Construction of *killas* (earthen mounds) with the top level raised above the maximum height of surges is a possible solution for sheltering livestock. About 190 of these exist in Bangladesh now. These are usually rectangular in plan, varying in size from 24.4 m x 18.3 m to 61.5 m x 30.5 m at most; a circular plan shape has also been tried. Experience during the recent cyclones shows that stand–alone *killas* have very rarely been used for sheltering livestock. The major reason is that the *killas* are located away from human settlement and people are reluctant to walk a long distance to take their cows, buffaloes, sheep or goat there. Moreover, lack of normal time use and maintenance leads to erosion of slopes and unwieldly growth of grass and shrubs, which make them unusable during emergency.

The frequency of cyclones and surges is such that the shelters are likely to be used only once in four to five years. Since the shelter buildings are quite expensive structures, it would not be economically justifiable unless some normal time use can be ensured. Experience shows that unless these buildings are used regularly, it is very difficult to maintain the facilities.

The normal time use of shelters may include the following:

- Educational Institutions
  - Primary school
  - Secondary school
  - Vocational training institutions

- Colleges

- Health and Family Welfare Centres
- Community Centres
- Offices
- Passenger Terminals

Based on a recommendation of the Task Force of the Institution of Engineers, Bangladesh (IEB, 1991) the Government has decided that all its office buildings in the surge-prone areas will be at least two-storeyed, so that the upper floors can be used as shelter during surge.

PLANNING

The primary consideration in locating a shelter is to ensure that it is easily accessible to potential refuge-seekers. Experience shows that people tend to move to the shelters only a few hours before the water starts rising, by which time the wind speed may be quite high. Under such circumstances, most people are reluctant to walk more than around 1.5 km from their houses. The catchment area for a typical shelter would therefore include the people who live in an area with a radius of around 1.5 km from the shelter. People who move to the shelter carry their valuable assets (which can be hand-carried) to the shelter; some storage space for these must be provided in the shelter.

Experience shows that people who own livestock do not like to take them to a *killa* which is far away from a human shelter. Based on extensive discussions with the local people, it seems that the preferred solution is an integrated shelter-*cum-killa* which can be used by livestock as well as human beings. During the April 1991 cyclone, the use of the existing shelters on *killa* was at a maximum (SDR, 1993).

In order to reduce the wind force on structures, various plan forms approximating a circle have been used. These have included hexagons, octagons and twelve-sided polygons (IEB, 1991). However, it is found that these plan forms lead to difficulties in accommodating normal time activities. Moreover, the wind force in these low-rise structures do not influence the structural design significantly.

Till recently, the common practice was to design the building as a cyclone shelter and then try to find out what activities could be carried out during normal times. Experience has shown that this leads to less than optimum use of the facilities. A better methodology would be to design the building for normal time use (e.g., school, community centre) and then investigate whether any changes would be necessary to make it function as a shelter during emergencies. This iterative process can be continued till an optimum solution is arrived at. The rationale for the above approach is that for more than 99 per cent of the total usage time of the facility, it would have to be suitable for fulfilling the functional requirement of normal time use. Therefore, the design should be based primarily on this consideration. Of course, to satisfy the functional requirements of a shelter, additional elements may have to be introduced; e.g. additional space for storing the belongings of refuge-seekers and storage of food and medicine would be needed. Immediately after the cyclone, the shelters have to operate as relief distribution centres and this must be considered in the design.

The cost of construction of a primary school designed to function as a shelter is relatively more than a normal primary school. Therefore, efforts should be made to utilize these facilities for other purposes as well. Under the prevailing education system in Bangladesh, primary education covers the first five years of schooling for children of the age group six to ten years. The average enrollment for school is 250 students, i.e. fifty students per class. However, most rural primary schools operate on a two-shift basis, i.e. the younger children attend school from 8 am to 10:30 am, followed by the older age group (11 am to 2:30 pm). Thus during afternoons and evenings, the building may be used for other purposes.

The catchment areas (CA) for a typical primary school would have a total population of around 2,000 persons. Community development activities particularly focused towards women, could be undertaken for the people within the CA. The following are among the activities which have been proposed (BUET–BIDS, 1993): training for income generating activities (e.g. quilt making, tailoring); vaccination for livestock/poultry. A family welfare centre/health clinic cannot be justified for 2,000 persons, but the shelter may house a roving centre which provides the facilities in the afternoon on a particular day of the week. A large proportion of the coastal population is engaged in fishing and fish processing. The cyclone shelter could be used for training classes for fishermen, and could also be used for net–making. Some of the shelters could house post offices and public telephone facilities, which would also help during emergencies.

While planning a multipurpose shelter, compatibility of the various activities which may be undertaken simultaneously must be ensured. For example, it would be difficult to combine a place for religious prayer (e.g. mosque) which requires a noise–free environment with a school.

A major deficiency of the existing shelters is their lack of water supply and sanitary facilities. Provisions must be made for drinking water and toilet facilities for the large number of people who would occupy the shelter for periods up to eight to ten hours.

The vast majority of the rural population do not have access to recreation facilities. The shelter could be used as a community centre and provided with a television set. A review of the available technologies has shown that for meeting the lighting needs (a beacon light at top and room lights) a solar photo–voltaic system is the most appropriate (BUET–BIDS, 1993). The rural population, most of whom do not have electricity in their homes, would be attracted to this community facility at night and the television may be used not only for entertainment but also for educational purposes.

METHODOLOGY

The methodology followed in determining the normal time use is outlined below:

- Carry out population projections for each union in the high risk area in five–year intervals up to the year 2017.
- Determine the capacity of shelters, as well as public and private buildings which may be used as shelter. (Consider existing, and under construction buildings, as well as those already proposed for construction)
- Compute the number of people for whom additional shelter space would be necessary (in the year 2002).
- Find the number of children for whom primary and secondary schools would be necessary.
- On the basis of a field survey, locate the existing schools and determine whether these can function as shelter during cyclones.

- Calculate the maximum number of existing primary schools that may be considered for rebuilding as shelter.
- Check whether the capacity provided by these would be adequate to meet the shelter needs. If additional shelters are necessary, estimate the maximum number of primary schools which would be necessary.
- Determine the settlement pattern using available census data (*Small Area Atlas* published by the Government) and satellite imagery.
- Determine the number of schools to be constructed on existing and new locations.
- If additional shelter capacity is needed, review the conditions of existing secondary schools, *madrasas* (educational institution with emphasis on Muslim religious education) and determine which of these may be used as shelters. For additional shelter space, check whether a new secondary school is necessary.
- If after provision of primary schools, *madrasas* and secondary schools, additional shelter is required, try office buildings or family welfare centres.
- Plot the tentative locations on a map.
- Consult the local people; show the map and find out whether the proposed locations are suitable.
- Check whether extensions would be necessary in the year 2017.

Following the above methodology for the high risk area in Bangladesh, it has been found that around 2,500 new shelters, each with a capacity of around 1,750 persons, would be necessary in the year 2002 (BUET-BIDS, 1993). These are in addition to the 500 community shelters which are either existing or under various stages of construction. Around 60 per cent of these new shelters would be located at existing primary school sites, around 23 per cent at new primary schools, 10 per cent at *madrasas* and 6 per cent at secondary schools. Only in some special locations, where there is a seasonal migration of adult workers (e.g. fishermen, agricultural labour), the shelters would have other normal time uses like adult education centre/community centre. The shelters could also be used for social functions like weddings.

Activities related to developing public awareness about cyclones and storm surges may be carried out with the shelter as the nucleus. A particular day of the year may be declared as 'cyclone preparedness day' and a drill for evacuation to the shelter may be carried out.

CONCLUDING REMARKS

In order to maximize the returns from the relatively high investment necessary for shelters, multifarious use of the facilities during normal times would have to be ensured. Besides, experience shows that unless these shelters are used round the year, it would be difficult to maintain them. A comprehensive study leading to a Master Plan for Cyclone Shelters has been carried out in Bangladesh (BUET-BIDS, 1993). Most of the 2,500 shelters necessary would be used as schools. In addition, other uses of these facilities for vocational training, community activities and income-generating activities have been suggested. An integrated solution where a shelter is located on elevated earthen platform (*killa*) which can be used for sheltering livestock, appears to be the preferred solution (figure 2).

Construction of the network of shelters, proposed for completion by the year 2002, would prevent the loss of human lives and livestocks during future cyclones and storm surges. Moreover, the normal time use of the facilities as educational institutions and other community development and income-generating activities can play a very important role in the socioeconomic development of the region.

ACKNOWLEDGMENT

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TABLE 1. LIST OF SEVERE CYCLONES SINCE 1960

Date (d/m/y)	Maximum wind speed (km/hr)	Storm surge height (m)
9-10-60	162	-
30-10-60	210	4.5-6.0
9-5-61	146	2.5-3 0
30-5-61	146	6.0-9.0
28-5-63	203	4.0-5.0
11-4-64	-	-
11-5-65	162	3.5
31-5-65	-	6.0-7.5
14-12-65	210	4.5-6.0
1-10-66	146	4.5-9 0
11-10-67	-	2.0-8.5
24-10-67	-	1.5-7.5
10-5-68	-	2.5-4.5
17-4-69	-	-
10-10-69	-	2.5-7.0
7-5-70	-	3.0-5.0
23-10-70	-	-
12-11-70	223	6.0-9 0
3-5-71	-	2.5-4 0
30-9-71	-	2.5-4.0
6-11-71	-	2 5-5.5
18-11-73	-	2.5-4.0
9-12-73	122	1.5-7.5
15-8-74	97	1.5-6.5
28-11-74	162	2.0-5.0
21-10-76	105	2.0-5.0
13-5-77	122	-
10-12-81	97	2.0
15-10-83	97	-
9-11-83	122	-
3-6-84	89	-
25-5-85	154	3.0-4.5
29-11-88	162	1.5-3.0
29-4-91	225	6.0-7.5
2-6-91	100	2.0
-	-	-

Source: Haider *et al.*, 1991

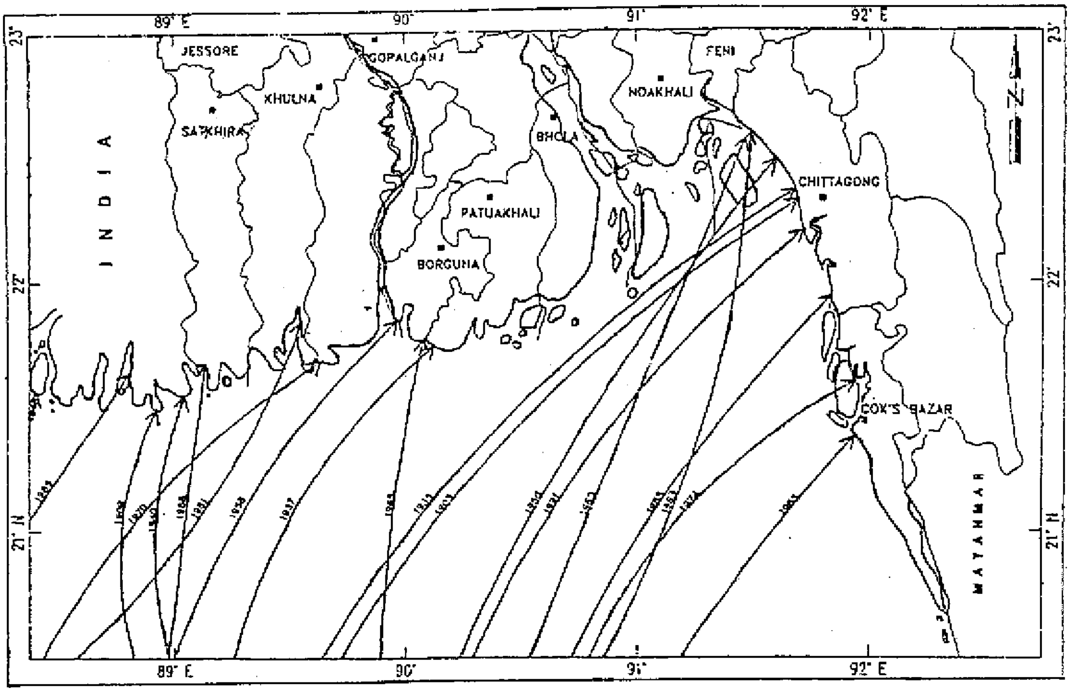

Figure 1. Tracks of Severe Cyclonic Storms Affecting Bangladesh (1905–1991)

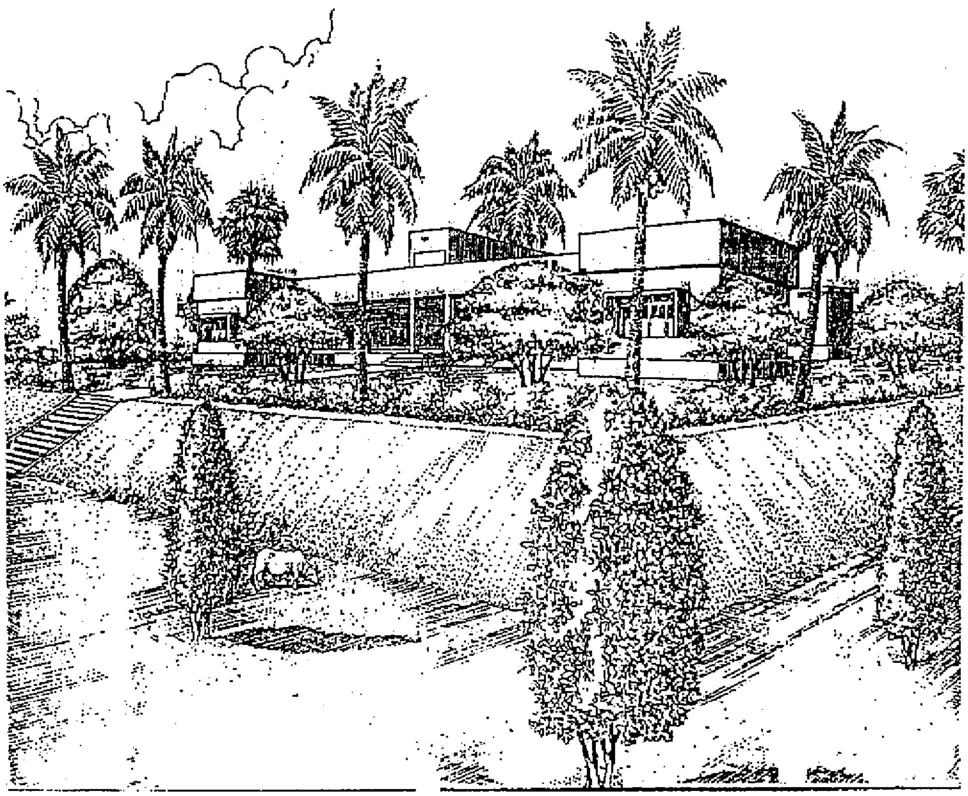

Figure 2. Typical Multipurpose Cyclone Shelter on a *Killa*