CHAPTER 17 DISASTER PREVENTION AND PREPAREDNESS

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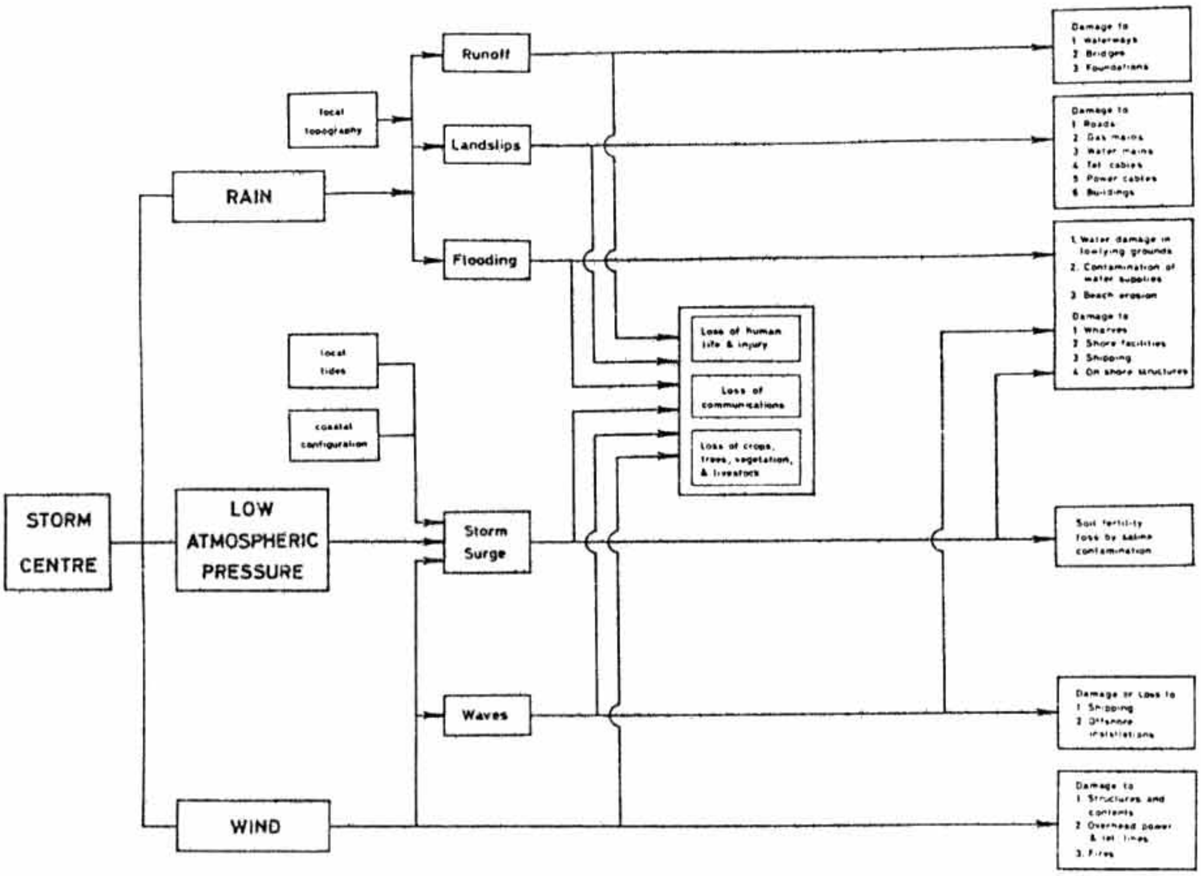

Fig. 17. Diagram showing how the characteristic of tropical cyclones conbine with each other and with local features to produce various geophysical phenomena and their usual accompanying damage.

17.2.3 Design for typhoon-resistant construction

Structures which are liable to be in the path of tropical cyclones should be capable of withstanding the effects due to the associated:-

1) Wind forces
2) Rain
3) Landslides
4) Flooding
5) Battering by waves and floating debris
6) Scouring of foundations by flood or storm surge.

The meteorological information necessary for the rational design of structures to withstand these hazards has been given in earlier sections. Storm surge and the associated scouring and wave effects decrease rapidly in severity with distance inland. The degree of protection against these effects which should be designed into any structure should depend on its location with respect to coast, rivers, slopes and the frequency and intensity of tropical cyclones in the area. In low-lying coastal areas subject to tropical cyclones, high-rise buildings are often designated as shelters it is therefore particularly important that they be made resistant to flooding, scouring and battering.

Saffir (1971) has studied the effects on structures of many hurricanes and he has written extensively on the nature of the damage they cause. His experience relates primarily to the low-lying coastal areas of Florida and the Gulf of Mexico but, apart from landslide damage which does not occur in low-lying areas, his findings are applicable to other areas affected by tropical cyclones. In 1971 he and Simpson proposed a grading scale for tropical cyclones in all part of the world in terms of their effects (Saffir 1971). This scale - with the addition of central pressure equivalents - was adopted in 1974 by the U.S. National Weather Service as a scale for describing the disaster potential of individual hurricanes. There are disadvantages in the use of such arbritrary categories or scales (cf. Beaufort's Scale Section 5.   ) for phenomena that occur in a continuous spectrum of intensities. Furthermore, the gradings cannot have global applicability because damage to structures depends on building style, building codes and their degree of enforcement. A cyclone with causes catastrophic damage in one area (e.g. cyclone Tracy at Darwin 1974) would cause minimal damage in another area (e.g. Hong Kong) where a typhoon resistant building code is strictly enforced. Nevertheless, the

Saffir-Simpson scale is reproduced below because it gives a good indication of damage associated with hurricanes of given intensities in an area on the Gulf of Mexico in which there is no vigorously enforced hurricane building code and because the reader may come across the gradings elsewhere. The wind speeds used in this grading system refer to the maximum gust speeds as measured at 10 m elevation above the ground.

<u>Scale No. 1 (> 980 mbar)</u>

Wind gust speeds of 33-42 m/s. Some damage to shrubbery, trees, foliage. No real damage to building structures. Some damage to poorly constructed signs.

Depending on hurricane direction, may result in

Storm Surge-1.2 to 1.5 m above normal, at and near coastline. Low lying coastal roads inundated, minor pier damage, some small craft in exposed anchorages break moorings.

<u>Scale No. 2 (965-979 mbar)</u>

Wind gust speeds of 43-49 m/s. Considerable damage to shrubbery and tree foliage. Some trees blown down. Extensive damage to poorly constructed signs. Some roofing material damage to buildings; some window and door damage; no major damage to building structures.

Depending on hurricane direction, may result in

Storm surge-1.8 to 2.4 m above normal at and near coastline. Coastal roads and low lying escape routes inland cut by rising water 2-4 hours before arrival of center. Considerable pier damage, marinas flooded. Small craft in unprotected anchorages break moorings. Evacuation of some shoreline residences and on low-lying island areas required.

<u>Scale No. 3 (945-964 mbar)</u>

Wind gusts speeds of 50-58 m/s. Extensive damage to shrubbery and trees. Foliage off trees, large trees blown down. Practically all poorly constructed signs brown down, some roofing material damage, some window and door damage, some structural damage to small residences and utility buildings. Minor amount of curtainwall failures.

Depending on hurricane direction, may result in

Storm surges-2.7 to 3.7 m above normal at and near coastline. Serious flooding at coast with many smaller structures near coast destroyed. Larger structures damaged by battering of floating debris. Low lying escape routes inland cut 3-5 hours before center arrived. Terrain continuously lower than 1.5 m elevation may be flooded inland 13 km or more. Evacuation of low-lying residences within several blocks of the shoreline required.

Scale No. 4. (920-944 mbar)

Wind gust speeds of 59-67 m/s. Shrubs and trees down. All signs down. Extensive roofing material damage, extensive window and door damage, complete failure of roof structures on many small residences. Some curtainwall failures.

Depending on hurricane direction, may result in

Storm surge - 4.0 to 5.5 m above normal at and near coast-line. Terrain lower than 3.0 m elevation may be flooded inland as far as 10 km. Major damage to lower floors of structures near the shore may occur due to flooding and battering action. Low-lying escape routes inland cut 3-5 hours before center arrives. Major erosion of beach areas. Massive evacuation of all residences within 450 m of the shoreline, and of single-story residences on low ground within 3 km of the shoreline.

Scale No. 5 ($<$ 920 mbar)

Wind gust speeds of 68 m/s or higher. Shrubs and trees down. Roofing damage considerable. All signs down. Very severe and extensive window and door damage. Complete failure of roof structures on many small residences and industrial buildings. Extensive curtainwall failure and sidewall failure on industrial buildings. Extensive glass failure. Some complete building failures; small buildings overturned and blown over or away.

Depending on hurricane direction, may result in

(b) Storm surge - heights greater than 5.5 m above normal at and near coast-line. Major damage may occur to lower floors of all structures located less than 4.6 m elevation above sea level and within 450 m of the shoreline. Low-lying escape routes inland cut 3-5 hours before center arrives. Massive evacuations of residential areas situated on low ground within 3 km of the shoreline.

Saffir (1977) has described the proposed building code for the coastal areas of the State of Texas. It has unique features for preventing wind and water damage from hurricanes. The new concept recognises four zones along the coastal areas with different design criteria. The most severe criteria are required in the first 100 m inland from the beach. The requirements for resistence against scouring battering and flooding decrease and eventually disappear with distance from the coast.

The basis for the criteria is the Texas Design Hurricane which is the 100 year storm having a minimum central pressure of 903 mbar approaching the coast at right angles at 6 m/s with sustained winds (10 m) of 63 m/s. Velocity is taken as increasing with height according to the 1/7 (0.14) exponential relationship.

17.3.3 Dissemination of warnings

Two later changes were made to the Hong Kong warning system to meet the changing needs there. In 19   provision was made to warn local strong winds - sustained speeds of 11-17 m/s - due to tropical cyclones, by introducing the Strong Wind Signal (No. 3) to follow the Alert [,] or Stand-by Signal (No. 1). As Hong Kong became more populated and industrialised the proportion of the population having dealings with shipping or the port decreased. Increasing numbers of people had less interest in the information on the direction of expected gales which is contained in the international signals numbered 5, 6,7 and 8. Indeed, i~~ncreasing~~ [when a] signal number~~s~~ [was increased] to ~~indicate~~ [warn of a] change~~s~~ in wind direction ~~were~~ [this warning was] often misread as ~~warning changes in~~ [referring to an increase in] wind force. Accordingly, in 197   , the use of the numbers 5, 6 and 7 were discontinued; No.8 was used as the single gale or storm signal whilst information on wind direction was given in spoken and written warnings and also by the international visual signals which were retained to meet the needs of the port and fishermen.

N.B. Use of numbers, less highly educated people prefer – action geared to number. Sophisticated can be more flexible.