CHAPTER 6

# LAND USE AND ZONING

It can be assumed that the general range of land-use control measures applied for normal environmental, social and economic aims may equally well be applied to disaster prevention in tropical cyclone areas. Some of these measures may be summarized under three main headings:

(*a*) Legal measures for the enforcement of zoning and other regulations for controlling function (type of activity) and density and pace of development;

(*b*) Taxation measures to steer development away from hazard areas;

(*c*) Government action to acquire land by compulsory purchase and to alter existing land use.

It is important to realize that land-use legislation and regulation control not only the type of development defined by hazard risk evaluation but also the rhythm or pace of development. A technical detail of considerable importance should be emphasized, namely that risk mapping (especially risk-micro-zoning) is an essential input to land-use zoning in flood-prone areas or storm-surge-prone areas. It should also be emphasized that land-use control should be supported by vigorous land-development policies and that land-use control for disaster prevention constitutes one of the variables in the comprehensive framework of land-development policies and plans.

Protective engineering works alone cannot guarantee that catastrophic flooding has been banished for all time. Embankment, dams, sea walls and breakwaters (see Chapter 8) may be relied upon to reduce flooding in the flood plains alongside rivers or to present a barrier to the advance of storm-driven seas. Such structures thereby play a major role in the mitigation of flood hazards and the resulting losses but there are always limitations to the effectiveness of devices of this nature. Moreover, flood-control structures which are regarded as adequate on completion may gradually be seen to be insufficient if new development is allowed to encroach into flood-prone areas. It is essential, therefore, that whenever approval is given to new development in areas of significant hazard potential, a review of the installations for flood control should be carried out so that any additional requirements may be recognized and approved for implementation.

The rapid growth of urban areas in developing countries raises important problems with regard to disaster prevention. A consequence of this growth is that a number of paddy fields, ponds and swamps in the flood plains, which formerly served as natural reservoirs for flood water, are converted into impervious paved areas for residential, commercial and industrial buildings together with their associated facilities such as roads, shopping centres and car parks. It should be kept in mind therefore that increased urbanization in flood-prone areas must enhance the vulnerability, possibly increasing it from a moderate to a highly dangerous level.

Inquiries have shown that urbanization is proceeding at a faster rate than the scale of protection provided by flood control and drainage works. If this process is subjected to only limited vulnerability analysis, it could be found that new development raises insurmountable problems of flood prevention. In Hong Kong, concern has recently been expressed about the possible encroachment of development into places adjacent to high or mountainous terrain. Such development would itself increase the potential hazard. Then, if high-intensity rainfall occurred of a duration and magnitude near the recorded maxima, there would very likely be peak flash floods in short periods which would cause landslides with unavoidable loss of life. (See *Rainstorm disasters*, 1972, Hong Kong Government publication.)

The pumping of groundwater can become an additional factor increasing vulnerability in flood plains and low-lying coastal areas. If water is extracted to an excessive extent, subsidence may occur and the locality would experience a greater incidence of flooding.

**Flood-plain management**

There are many varieties of land use in flood plains and coastal areas. The land may be left in its original unoccupied and unused state or it may be put to agricultural and recreational purposes, or it may be developed to suit housing and industrial requirements. Where land is not used or encroached upon by human activities, any damage from tropical cyclones or other natural phenomena would probably be of little consequence. The hazard potential begins to be significant where land is used for agriculture and recreation and reaches a maximum where land is used for urban and industrial purposes. Land-use regulations should clearly define the activities which for social, economic and other reasons may be located within the flood-plain boundaries.

The object of flood-plain management is to supplement flood-control measures which can provide a high degree of protection but normally not complete protection. Flood-plain management can play its part by ensuring that whenever the flood-control measures prove to be inadequate, through the unusual severity of a tropical cyclone or for other reasons, the resulting damage will be small and, economically, not too crippling. The different types of regulation for flood-plain management include zoning ordinances, subdivision regulations and building codes. In addition, development policies with statutory backing can be highly effective by such methods as the purchase of land by the government and by the subsidized relocation of the population from flood-prone areas to relatively flood-free areas.

This supplementary approach to the reduction of flood losses is a desirable part of comprehensive land development planning to obtain the maximum benefit from the land in meeting broad social and economic goals. The extent to which flood-plain management techniques are employed in a country is usually directly proportional to the degree of awareness of government agencies of public safety and welfare questions, and to the level of co-ordination between these agencies and the general public. It is very necessary that the public should understand the general flood problem, the risks that exist and the methods that can be employed to control land use.

The land-use planning process consists of a series of surveys, analyses and policy decisions, beginning with those of a general nature and ending with specific regulations controlling the construction, use and function of a building or other structure on a particular piece of land. The process therefore extends from risk analysis to policy making, through planning and finally implementation and so covers the complete spectrum of action taken by a government in disaster prevention and mitigation. As described in Chapter 5, risk (or vulnerability) analysis is an essential analytical and planning tool for disaster-prevention purposes. Land-use policies and controls in disaster-prone areas should largely be determined by means of vulnerability analyses and risk-micro-zoning maps, particularly with regard to establishing zoning and locational criteria for new development.

Effective flood-plain management must be based upon full information on the areas subject to flooding, including hydrological data on past floods, detailed topographic maps, and aerial photographs. Adequate information would make it possible to identify the flood plain and to determine the expected frequency of future flooding. Such flood-delineation studies (see Chapter 5) permit government agencies to formulate and enact the regulatory measures needed for land-use control in flood plains.

Mapping of the flood plain, the collection and analysis of data on floods, and the institution of standardized technical methods for determining flood frequency must all be effected prior to the adoption of a regulatory approach to flood-plain management. Only in this way can the risk in flood plains be correctly evaluated so that the regulations will appear reasonable and hence be accepted by the general public.

**Land-development policies**

The most efficient way of using flood plains is to formulate a firm planning policy covering existing usage and future development. If there is absence of planning and lack of control a host of problems arise, many of them concerned with the protection of users who would not be in occupation if wise planning had been enforced.

Local authorities should have adequate powers to purchase flood-prone land so that its use and development can be controlled, mainly in the direction of open spaces such as parks, recreation grounds and wild-life preserves. When the vulnerability analysis has spotlighted developed areas of high risk, local authorities should give serious consideration to the purchase of the land and its conversion to open spaces. Governments can persuade private landowners to exchange their flood-prone property for less vulnerable sites at a higher altitude.

Permanent evacuation, urban renewal and redevelopment of flood-threatened areas are also suitable steps for the purpose of flood-damage prevention.

Over the years, forests have grown and been preserved along rivers, coastal-hazard areas and natural levees in the deltaic area. Such green belts reduce the impact of flooding and protect human lives to some extent. Vegetation in flood-hazard areas that is beneficial should be preserved not only from the flood-control point of view, but also for environmental reasons.

Already a number of countries have taken over large areas of floodway and have converted them so as to provide attractive amenities for millions of people living in the vicinity. By preserving the natural environment and providing roads, promenades and recreation facilities, much is accomplished towards adding to the happiness of the population.

Rapid and concentrated urbanization sometimes contributes to the occurrence of landslides in steep development areas and consequently to the collapse of buildings and houses. There must then be restrictions on operations involving excavation, cutting and embankment associated with urban development. Once the collapse of buildings and housing has occurred to a significant extent, no reconstruction should be allowed and relocation to new housing land should be encouraged by a development policy providing some subsidy or financial assistance. Where a village is threatened by floods or landslides, and the villagers wish to move out, the government can give support by providing low-interest loans and subsidies for the purchase of land and new houses in non-hazardous areas.

**Flood-plain zoning**

Flood-plain zoning is the legal tool which is used to implement and enforce the detailed provisions of the land-use planning programme. It is a tool used by countries and their towns and cities and also by government agencies in order to control and direct the use and development of land and property within their jurisdiction. The division of communities into various zones should be the result of a comprehensive programme for the entire area.

Flood-plain zoning may be included in a general system of laws covering, besides zoning, building construction, the subdivision of land and rules for the use of the stream channel and its surrounds which have been laid down for the purposes of regulating any flood that may occur. Provided planning is carried out carefully, making full use of vulnerability analyses and showing concern for the long-term and day-to-day interests of the people, it should be found that economic and social activities are not unreasonably restricted. Where homes and industrial buildings are banned, other activities can normally be permitted provided they would suffer small and acceptable damage if a flood should occur.

Flood-plain regulations have for the most part a twofold purpose: to determine the use and development of land and to specify the flood-control measures that are required. The natural resources of a river, e.g. detention basins, must be preserved and this need must be taken into account when considering whether to approve or reject any projects for land reclamation, land-fill or drainage.

Zoning ordinances should ensure that in flood-risk areas it should be possible to evacuate people in good time. In other words, the efficiency of the warning system and the provision of assembly points and roads should be a first priority in order to safeguard the lives of the people. Moreover, in flood-risk areas installations should be either extremely well protected or of such a nature that they would not incur severe damage in a flood.

**Designated floodway and encroachment lines**

Legislation in support of land-use management with the primary objective of helping to reduce flood damage should, for the information of the general public, be illustrated on maps or diagrams showing the limits of permitted encroachment and the floodway zones. Similarly, high-hazard coastal areas could be outlined in order to indicate localities where restrictions have been placed on various types of development. As shown in Figure 6, a designated floodway comprises the river channel itself and those portions of the adjoining flood plain which must be regarded as available to carry flood waters. Encroachment lines, one on each side of the river, are the lateral boundaries of the floodway.

It is noteworthy that a number of countries in the region of the Economic and Social Commission for Asia and the Pacific have adopted national regulations to control land use within floodways. In Japan and the Republic of Korea, where there is considerable development of dikes and levees, floodways are designated in the national laws. Similar measures apply in New Zealand through the Soil Conservation and Rivers Control Act.

In Japan the River Law (1964) designates a river administrator and grants him powers to:

(*a*) Erect flood-control structures such as dams, weirs, sluice gates, levees, revetments, groundsills or other facilities intended to increase the public benefit from the water of a river, or to decrease public loss caused by flood or high tide;

(*b*) Regulate the occupancy of land, removal of soil and stone, erection of structures and works incidental thereto, land excavation and the cutting down of trees and bamboo;

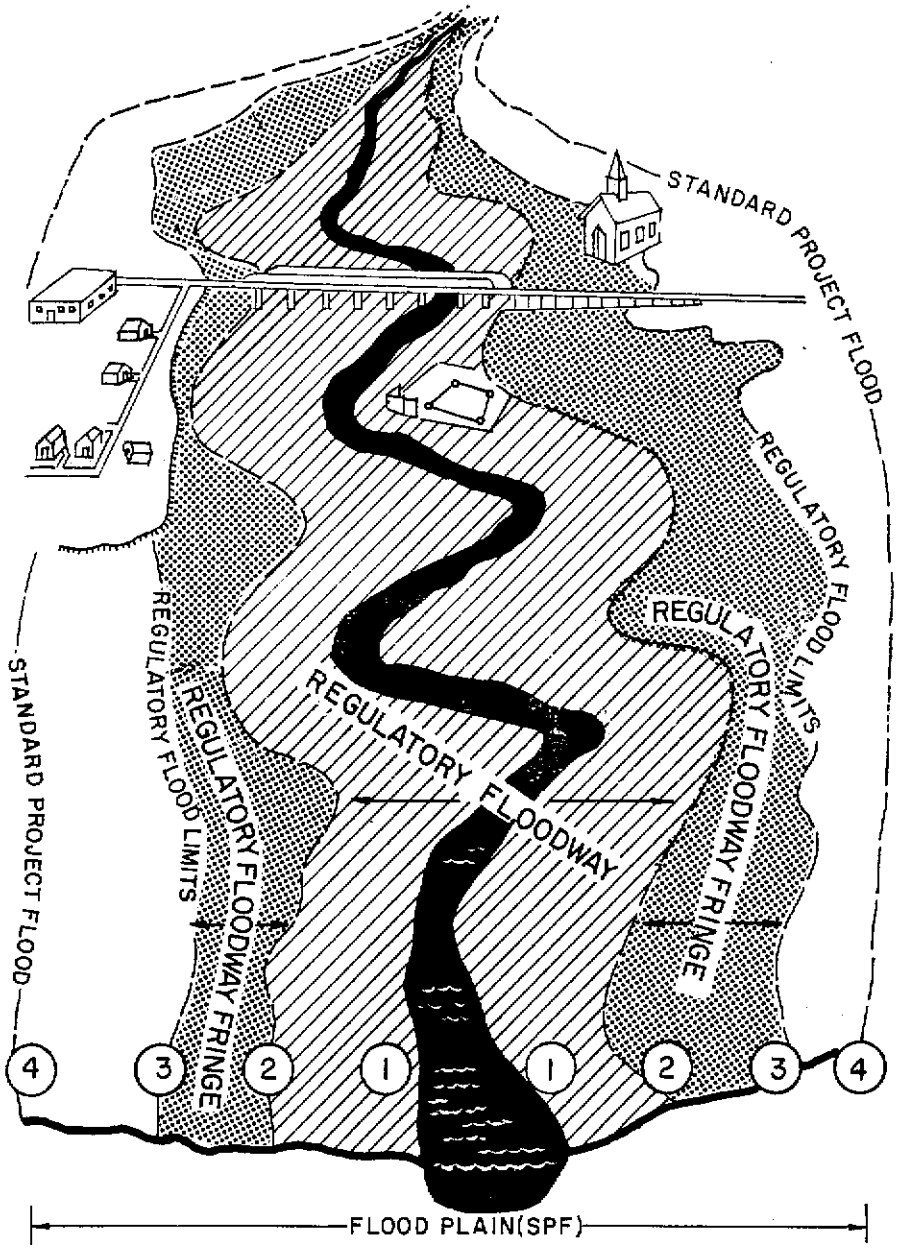
(*c*) Take emergency measures in times of flood.

In accordance with this authority the river administrator is able to designate river areas, floodways, conservancy areas and any river areas earmarked for future flood-control works. When such designations have been made, no development or structural changes can be made within the areas without the permission of the river administrator.

Vulnerable coastal areas are divided into low-hazard localities which are subject to inundation and high-hazard areas which are, in addition, exposed to the effects of strong winds and storm surges. In the Coast Law of Japan, a coast administrator is appointed with powers to designate areas which are to be protected. Within these so-called coastal conservancy areas, the coast administrator regulates use and development, dredging and filling and also the upkeep of embankments.

A prime objective of both the River Law and the Coastal Law in Japan is to promote comprehensive flood control as well as protection from winds, waves and storm surge. In recent years the administrators have had to face the pressures arising from rapid urbanization and have been concerned to ensure that designated floodways are utilized as public parks, recreation grounds, golf courses or simply open spaces, all of which can be regarded as held in reserve for emergencies.

Designated floodways are zoned for the purpose of carrying and permitting the flow of floodwaters and for other limited uses that do not conflict with this primary purpose. The zoning ordinance should also establish regulations for flood-plain areas outside the floodway. These include fixing elevations below which certain types of building cannot be constructed. The diagram (Figure 6) illustrates how a flood plain can be properly regulated (*Regulation of flood-hazard areas to reduce flood losses*, U.S. Water Resources Council, 1971). The standard project flood in this figure is the flood that may be expected from the most severe combination of meteorological and hydrological conditions considered reasonably characteristic of the geographical area in which the site is located but excluding extremely rare combinations. The selected flood limit shows the outer limit of the floodway fringe, and is determined by computing the magnitude of certain selected floods.




1. REGULATORY FLOODWAY — Kept open to carry floodwater — no building or fill.
2. REGULATORY FLOODWAY FRINGE — Use permitted if protected by fill, flood proofed or otherwise protected.
3. REGULATORY FLOOD LIMIT — Based on technical study — outer limit of the floodway fringe.
4. STANDARD PROJECT FLOOD (SPF) LIMIT — Area subject to possible flooding by very large floods.

Figure 6 – Flood-plain regulations

**Subdivision regulations**

A subdivision can be defined in a broad sense as a tract of land divided into lots for the purpose of sale or building development. Subdivision regulations in the United States are used by local governments to specify the manner in which land may be divided. These regulations may state the required width of streets, requirements for curbs and gutters, size of lots, elevation of land, degree of freedom from flooding, size of floodways, and other points pertinent to the welfare of the community. Subdivision regulations also provide an efficient means of controlling construction in flood-plain areas that are at present undeveloped.

The following are some typical examples of the aspects which are covered in subdivision regulations:

(*a*) Extent of flood plain, also shown on subdivision maps;

(*b*) Floodway limits or encroachment lines;

(*c*) Prohibition of any filling-in of channel and floodway that would restrict flow;

(*d*) Specification of minimum elevation of subdivision roads to ensure that they are above selected flood level.

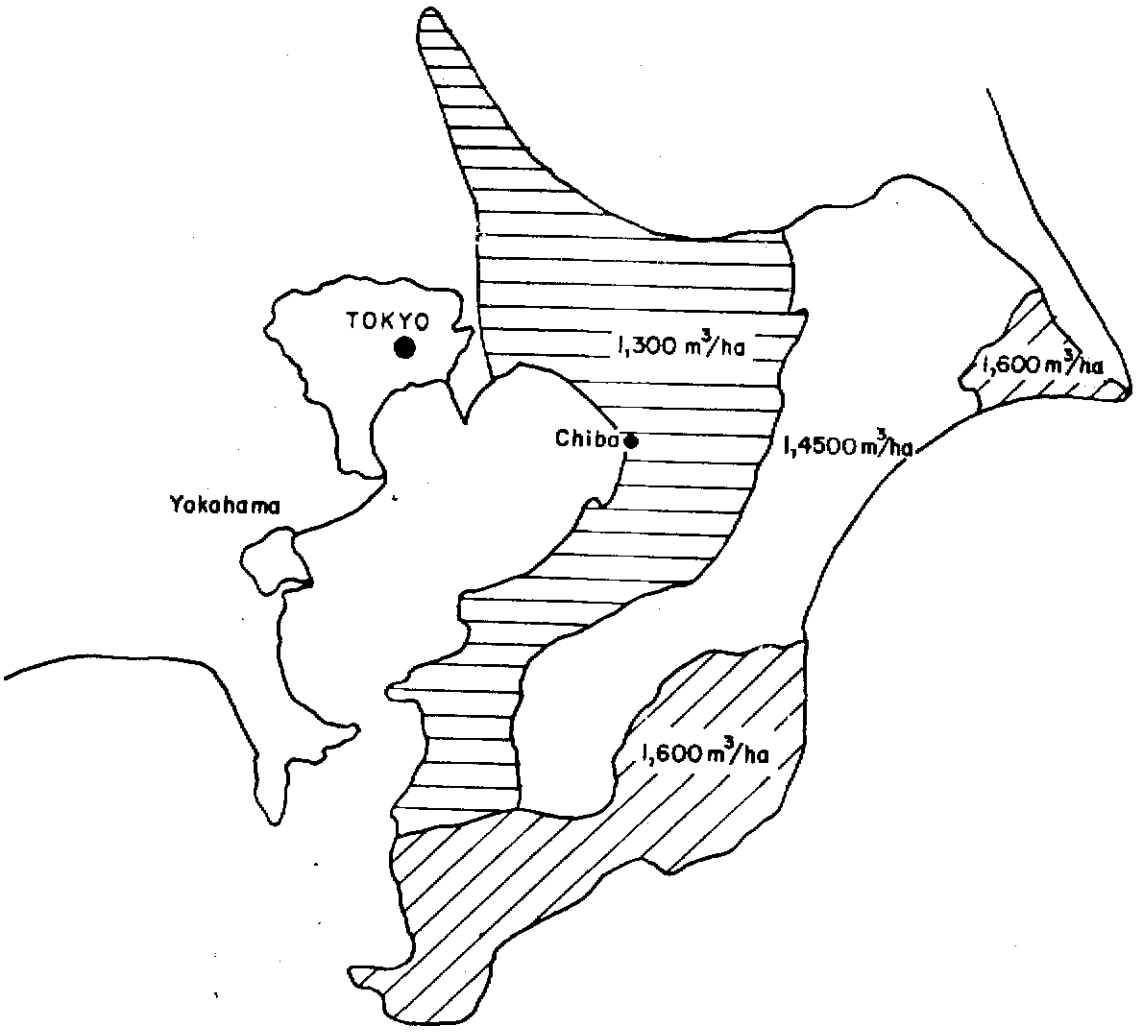



Figure 7 – Flood-detention capacity specified by the Chiba Prefecture's ordinance for housing land development

## Flood-detention ponds

As explained in Chapter 6 on land-use control, rapid urbanization is likely to increase the damage suffered in flood-prone areas. Local government regulations can oblige developers of housing lots to provide, at their own expense, the flood-control works required along streams and rivers to prevent flooding and damage in downstream areas. If these flood-control works are likely to be very costly and to take too long to implement, as for example river-channel improvements, measures such as those prescribed in the ordinance for the development of housing land by the Chiba Prefecture in Japan may be applied. These measures are a supplement or corollary of the zoning regulations.

This ordinance specifies that when housing land over one hectare (ha) in area is being developed, a flood-detention pond should be provided within the development area to store temporarily the inflow of floodwater. A minimum storage capacity is laid-down, as shown in Figure 7, and provision must also be made for a sediment load of at least 150 $m^3$ $ha^{-1}$.

Flood-detention ponds usually inundate one to two hectares of land during the flood season. At other times they may be used as parks or for other recreational purposes. Dams for flood-detention ponds are generally constructed of concrete or earth and will normally be less than 15 metres high.

# CHAPTER 7

# BUILDING CODES

On the basis of vulnerability analyses, land use and zoning (Chapter 6), provided they are rigorously observed, can go far to reduce the loss of life and the material damage that natural phenomena are capable of inflicting upon a country and its people. However, these measures cannot entirely eliminate the effects of such phenomena as tropical cyclones. Additional measures, mainly of a structural nature, are therefore well worth taking because they can form a valuable supplement to the objectives which are served by land-use controls and zoning. Building codes should be regarded as an essential component of disaster prevention. Such codes, covering buildings and other structures, give specifications for design, construction, operation and maintenance, all related to the lifetime for which the building is required.

Well-conceived building codes can have the effect of lessening property losses in tropical cyclones and, even if damage is incurred, the buildings may not collapse and thus the toll of human suffering is less than it might be. A useful by-product is that buildings which are not severely damaged or destroyed can normally continue to perform the functions for which they were constructed, thereby facilitating their utilization in emergency conditions and contributing to a more rapid return to normal economic and social conditions.

## Building-code provisions

The provisions of building codes should take full account of all the substantial risks likely to materialize, for example, from earthquakes, tropical cyclones, landslides, high winds, floods and storm surges. In general, building codes will deal with such aspects as the following:

(*a*) The purposes for which the building is to be constructed and utilized;

(*b*) The criteria to be followed to give the structure the required strength;

(*c*) Specifications and performance standards for materials used;

(*d*) Fire resistance, light, ventilation, etc.

The legislation which enables building codes to be enforced should preferably be integrated with the other legal and administrative procedures which operate in the area concerned.

## Application to low-cost housing

In developing countries subject to tropical cyclones, design and construction criteria should be developed for low-cost, low-rise housing as a guide to public and private organizations involved in the construction of houses. The application of building codes to low-cost, low-rise housing, in particular to low-income housing, is a subject which requires a flexible attitude. Building standards cost money. In addition to the administrative costs, a structure becomes all the more expensive as it is provided with greater and greater resistance to physical damage. Low-income groups can ill afford the extra costs required to give houses the structural strength to prevent them collapsing in the face of wind, water or seismic shock. For this reason, building codes established for low-income housing should rely on basic principles. Such codes should give priority to resistance to disaster damage in key areas of the structure – foundations, floors, walls and roof – in progressive stages according to the risks involved. Estimates should also be made of the probable structural damage in various contingencies. These estimates, used as prediction factors for loss

of life, injury and material damage, would lead to the adoption of additional safety measures such as provision for escape to open spaces. Damage estimates would also be helpful in the organization of salvage.

In areas exposed to tropical cyclones, building codes for low-cost houses should require the application of minimal design criteria, particularly as regards the shuttering of windows and the fitting of wall and roof ties. These remarks on low-cost housing apply to the generality of one-storey dwellings. Multi-storey reinforced concrete or load-bearing structures used for residential purposes should, of course, be subject to very stringent building codes.

### Codes for protection against wind

In a tropical cyclone the winds are very strong and unusually gusty and may persist as such for periods up to two or three days. If a weak point in a building once gives way, the wind damage must be expected to increase rapidly. It is therefore most important to tie the roof, walls and foundations all together and to cover the windows with strong shutters. The structure itself should also be anchored firmly to its foundations. It is also recommended that windows be opened on the lee side in order to permit the equalization of air pressures, a helpful procedure since the suction or pull of the wind is often greater than its direct force. If these measures are taken, the roof will resist uplifting forces and the structure will be prevented from overturning and disintegrating.

In determining the appropriate building codes, engineering designers should be provided with the available statistics for a locality on wind velocity, gustiness and the variation of wind with height. As a general rule any structure in an area where tropical cyclones may make their landfall should be capable of withstanding the loads generated by winds of at least 120 km per hour. It is emphasized, however, that this is a general guide since another factor to be considered is the length of time over which the structure would be in use. For an important building, such as a hospital, a school, etc., the design strength should be such that the critical wind load would have only a very small probability of occurrence during the lifetime of the structure. In this way a good margin of safety is provided; for less important buildings a lower margin may be used, as with the general rule suggested above.

In coastal areas, where the possibility of storm surges must be recognized, it is necessary to provide protection against the surge. This can be done by confining building to higher elevations or by building on concrete pillars embedded in the ground so that the "ground floor" of the structure is above the highest water levels to be expected. The latter type of structure increases substantially the risk of wind damage unless additional strengthening is provided.

### Codes for protection against flood

It has been noted in the ESCAP region that some countries have introduced building codes which are directed primarily at ensuring protection against fire, wind and earthquake. These codes seem to lack the special design and construction requirements that should be applied in flood-prone areas. In these areas the first stage of protection against flood is by means of dikes, embankments, temporary reservoirs, etc. Additional requirements which should be incorporated in building codes in order to combat the effects of floods include the following:

(*a*) Proper anchorage to prevent buildings floating away from their foundations;

(*b*) Adequate elevation of basement and first floor of buildings;

(*c*) Sufficient strength to withstand water pressure and water moving at high speed;

(*d*) Elimination of use of materials which deteriorate when exposed to water;

(*e*) Prohibition of the installation of equipment, e.g. electrical equipment, chemical materials, boilers, at levels which might create a hazard if the items became submerged.

In the United States of America engineers have prepared draft regulations for flood-proofing. These proposals cover such aspects as floodwater loadings and waterproofing for river, coastal and tidal flooding situations and could

readily be included in building codes. Flood-proofing designs are based on studies of hydrological and associated meteorological data and take into account such factors as speed of water flow, rate of rise and fall of flood water, flood depth and duration, debris load and wave action.

In a general study of the protection of buildings against flood, data on the factors mentioned above would be supplemented by statistics on rainfall duration and intensity for the area concerned and also by information on local topography and on the soil's capacity to hold water. This study should enable responsible authorities at national, regional or local level to determine a regulatory flood, that is, the flood expressed as a height of water level above mean sea-level which would have a probable frequency of once every 50 or 100 years. The concept of a so-called Regulatory Flood Datum is then applied, consisting of the regulatory flood plus an arbitrary safety factor which may differ from one area to another according to local conditions. This regulatory flood datum would be delineated on maps of suitable scale which would show:

(*a*) The primary hazard area – the land which would be inundated whenever the regulatory flood occurs;

(*b*) A secondary hazard area – the area adjoining the primary hazard area which could be affected by a flood of greater severity than the regulatory flood and could be subject to various effects whenever the primary hazard area is flooded.

### A practical example

It is sometimes accepted that it is a practical impossibility to impose a total ban on construction of any type in a flood plain. The purposes of disaster prevention, including building codes, are therefore to reduce losses of lives and material damage to the minimum possible consistent with the tolerance of a certain amount of building.

In Japan, the Building Standards Act (1974) grants wide powers to provincial governors for designating disaster areas and for controlling new building within these and adjacent areas. In these areas public buildings such as schools, government offices or public halls with the capacity to accommodate a large number of people must conform to certain standards so that they may be used for emergency evacuation when disaster threatens. Thus they must be raised above expected flood heights, or the floor level should be above this height, and they should be constructed of reinforced concrete and made fireproof.

The city of Nagoya in Japan has applied the Building Standards Act (1974) in a manner which illustrates the value of both building codes and zoning measures which were discussed in Chapter 7. Nagoya has restricted new housing and building on the basis of the risks associated with a particular typhoon which caused the deaths of 5000 people by drowning. Using the basis adopted by Nagoya, the area of the city that is vulnerable to flooding is classified in five zones as follows:

1st zone: Reclaimed land developed for industry, vulnerable to storm surge;

2nd zone: Low-lying land currently being developed for housing and industry, vulnerable to flood;

3rd zone: Developed low-lying land, seriously vulnerable to flood;

4th zone: Lower-level city area, vulnerable to flood;

5th zone: Lower-level rural area, vulnerable to flood.

No residential housing or buildings are permitted within 50 metres of the seashore or a river in the first zone. Ground heights of buildings in the first zone must be at least 4 m above mean low tide Nagoya Port (NP), 2 m in the second and fifth zones, and 1 m in the third and fourth zones. No wooden buildings may be constructed in the first zone and the floor height of residential buildings in the second, third and fifth zones must be more than 3.5 m above NP. All public buildings such as schools, hospitals, government offices, etc., and public facilities such as power stations and pumping stations should be waterproofed structures of concrete or steel. Except in the first zone, these public buildings should have a ground height of more than 2 m higher than NP.

The Building Standard Law also gives prefectural governors the power to declare land where the gradient exceeds 30° as hazardous areas if a landslide or the collapse of the surface is likely to endanger the lives of residents. Furthermore, activities such as the storage of water, cutting, digging and embankment of surface soil can be limited and controlled. The removal to safer areas of existing buildings that constitute a danger in areas of steep gradient can be carried out with the aid of a government subsidy.

**Flood control**

This chapter, concerned with building codes, contains information and discussion on, *inter alia*, the wind and flood-protection measures for houses, buildings and major structures. Other aspects of flood protection come within the scope of engineering works for flood control, a subject which is dealt with in the next chapter.