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REVIEW OF GUIDELINES FOR FLOOD RESILIENT ARCHITECTURE BY NDMA

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Abstract : For over centuries humans has been relying on land for various activities including their living industries, agriculture, recreation and commercial purpose. Out of which living is the most important one in their everyday life. But this living of humans has to deal with the day to day disasters occurring occasionally or frequently. One of the form of this disaster is flooding. India is a peninsular country with its three sides covered with water. It faces heavy monsoon rains and storms that causes large-scale destruction throughout the country. Perennial rivers such as Ganga, Brahmaputra, Sutlej always causes flooding during cyclones and heavy monsoon. The net result of this destruction is the migration of people from affected areas. This study is to explore the ways of creating sustainable living environment for the areas that suffers flooding continuously every year. This report will cover the techniques and ways to provide flood residents a housing that will perform great in both land and water.

I. INTRODUCTION

"Floods cause loss of life, damage and destruction, as many urban communities are located near coasts and rivers. In terms of victims, floods are responsible for more than half the deaths caused by natural catastrophes. As flood events appear to be rapidly increasing world-wide, an advanced and universal approach to urban flooding and how to manage will help reduce flood impact."
- Stephen Garvin

About 180,000 people move to urban areas every day. Around 18% of all urban housing is non-permanent which are particularly vulnerable to the impact of extreme natural events. Flood hazard depends on flood magnitudes such as flood depth, velocity and duration. Vulnerability may be defined as the conditions determined by physical, social, economic, and environmental factors which increase the susceptibility of a community to the impact of hazards.

To develop as a flood Resilient community infrastructure Protection, Upgrading (Invest in and maintain critical infrastructure that reduces risk, such as flood drainage, adjusted where needed to cope with climate change), protect Vital Facilities: Education and Health (Assess the safety of all schools and health facilities and upgrade these as necessary), building Regulations and Land Use Planning (Apply and enforce realistic, risk compliant building regulations and land use planning principles.)

1.1 Aim of the study

The Aim is to probe into the utilization of the fluctuating dimensions in the architecture of urban dwellings to evolve measures to minimize the risk and damages caused due to incidences of flooding through strategies interventions by analyzing the Guidelines.

1.2 Objectives

The objective of the study includes:

- To attain an understanding on the character of the area and identify the critical Flood based zones.
- To gain knowledge on the different types of Flood proofing along with its causes.
- To identify the issues and potential damages in the Urban area.
- To understand the construction techniques to be followed in urban spaces based on Building level, Site level and Policy level.
- To suggest suitable measures for minimizing risks and damages at Policy level and Building level by a comparative analysis of the NDMA guidelines of different states.

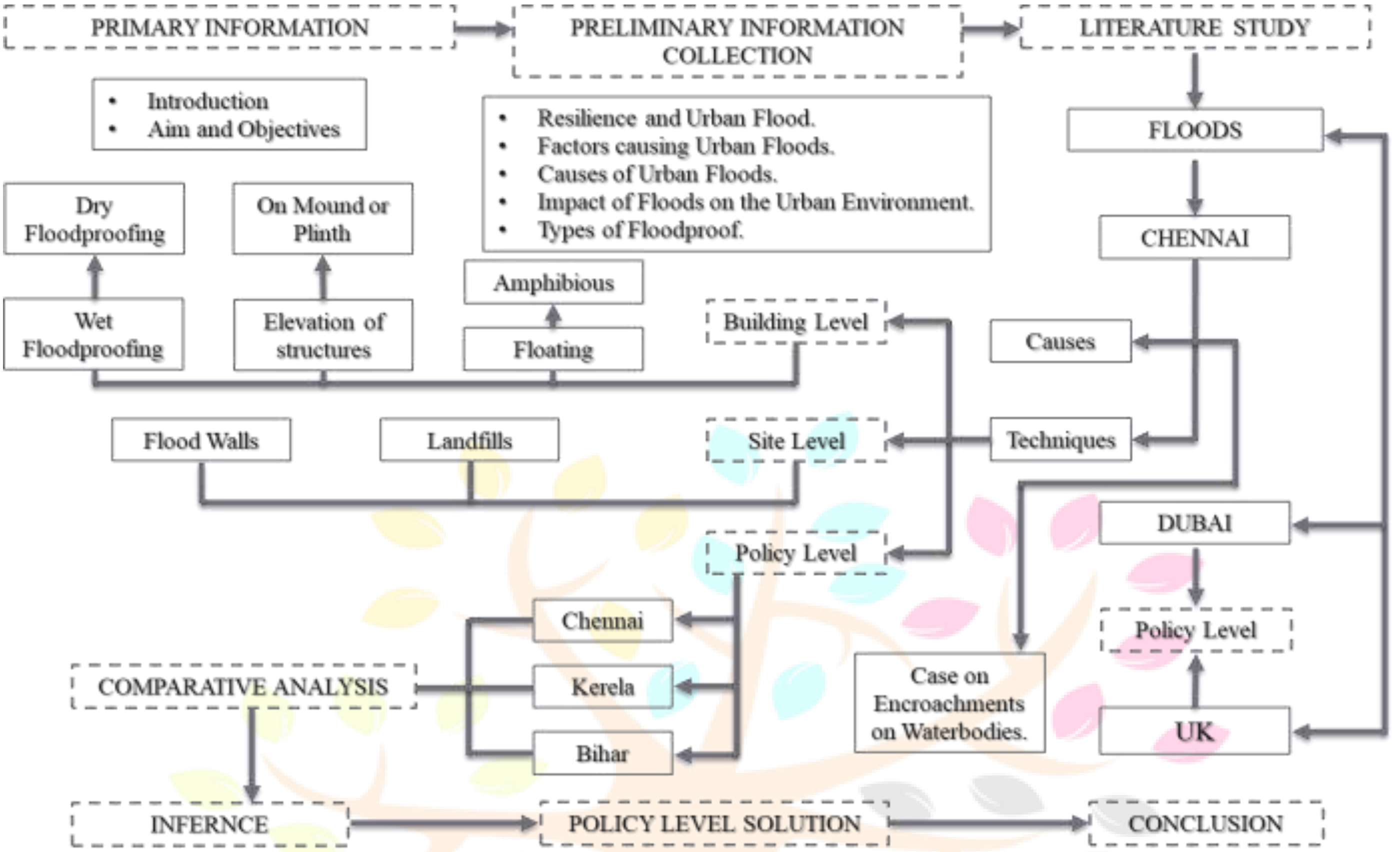
1.3 Scope

The research helps in suggesting solutions for the damages and risk caused by Floods in Urban areas in India at Policy level and Building level which ultimately reduces the loss of life and livelihood.

1.4 Limitation

This study revolves around the damages caused and construction techniques to be implemented at Building level, Site level and Policy level in India with comparison to foreign context.

1.5 Methodology



II. LITERATURE STUDY

2.1 Introduction

Floods are the most common natural disaster in India. The floods can kill thousands and displace millions. Almost all the parts of India are flood-prone and have become increasingly common in central India over the past several decades. 80% of natural disaster is due to climate related events. The scale of disasters has expanded, owing to increased rates of Urbanization.

Figure 2.1 Ranking of Natural Disasters

2.2 Definition of Resilience

The term "Resilience" originates from ecology and can be defined as the ability of a system to resist the perturbation, or it is the speed the system recovers after being disturbed. Flood Resilience generally refers to a capability to anticipate, prepare for, respond to and recover from significant multi-hazard threats with minimum damage to social well-being, the economy, and the environment. This section focuses specifically on resilience to flooding, including a community's capacity to plan for, respond to, and recover from floods. Floodplain areas can be subjected to hydrostatic (standing water) and hydrodynamic (flowing water) pressures during floods. For buildings, these pressures can result in displaced foundation, wall, collapsed structures and other damages.

Figure 2.2 Average Annual Damage due to Flood (1953-2018)

2.3 Urban Floods

Urban flooding is not just " Flooding that happens in an urban area or when a river overflows its banks or when a hurricane drives a storm surge across a coastal neighborhood".

Instead, it's caused by excessive runoff in developed areas where the water doesn't have anywhere to go which leads to flooding on the surface. Poor solid waste management, along with an overburden of plastic, is the major problem for urban flooding.

2.4 Causes of Urban Floods

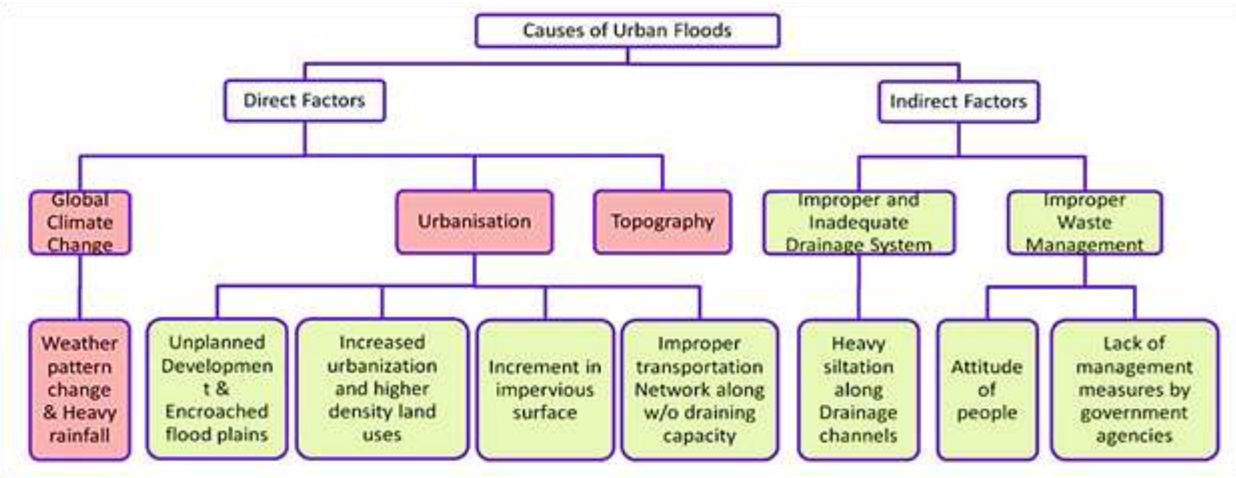


Figure 2.3 Causes of Urban Flood

2.5 Reasons for damage to houses during Urban Floods

The impact of floods to housing units are due to several reasons:

- Flood depth
- Flood duration
- Uplift due to soil saturation
- Horizontal force created by flood waves or currents.

Direct flood hazard is associated with other types of secondary hazards such as high winds or storms, lightning, slope instability and ground settlement. Floodwater can submerge buildings and cause various degrees of damage from staining of walls to structural collapse depending on flood depth or duration and type of building.

2.6 Factors causing Urban Floods

Meteorological Factors	Hydrological Factors	Human Factors
Unprecedented Rainfall	Change in course of rivers	Surface sealing due to urbanization and deforestation
Cyclones and Hurricanes	Type of soil and water retention capacity	Building design without regard to flood risk
Heavy Thunderstorms	Infiltration rate and Ground water level prior to floods	Encroachment of floodplains and lowlying areas
Global warming (Snowfall, snowmelt and sea level rise)	Synchronization of runoffs from various parts of the watershed	Lack of maintenance of infrastructure and drainage channels
Influence of Urban microclimate	Very efficient drainage of upstream areas in comparison to downstream areas	Siltation and improper solid waste disposal in Drainage channels
	Presence / Absence of over bank flow and High tide impeding drainage	Unplanned release of water from dams / lakes located upstream of cities and towns
	Channelled storm water network. cross-sectional shape and roughness	Absence of administrative framework
	Landslides and soil erosion	Lack of preparedness

Figure 2.4 Factors Causing of Urban Flood

2.7 Types of Flood Proofing

Floodproofing is the process of making a building resistant to flood damage, either by taking the built out of contact with floodwaters or by making the building resistant to any potential damage resulting from contact with floodwaters.
Floodproofing can be subdivided into several categories.

2.7.1 Dry Flood Proofing

Dry flooding requires use of special sealants, coatings, components and equipment to render the lower portion of building watertight and substantially impermeable to the passage of water.

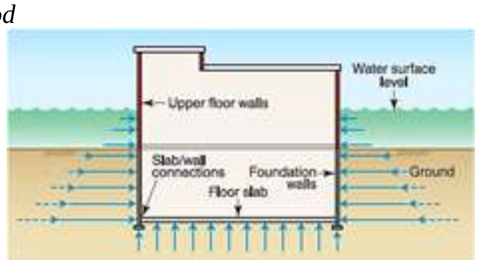


Figure 2.5 Dry Floodproofing Technique

2.7.2 Wet Flood Proofing

Wet floodproofing allows the uninhabited lower portion of building to flood, but uses materials that will not be damaged by flooding.

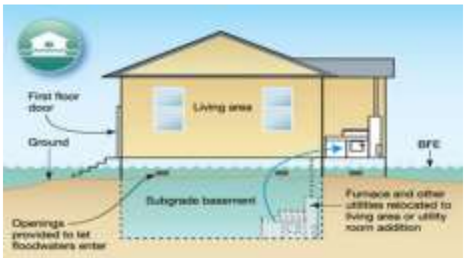


Figure 2.6 Wet Floodproofing Technique

2.7.3 Active Flood Proofing

Active flood proofing sometimes known as contingent (partial) or emergency (temporary) floodproofing, requires human intervention to implement actions that will protect a building and its contingent actions that will protect a building and its contents from flooding. Successful use of this technique requires ample warning time to mobilize people and flooding proofing equipment's and materials.

2.7.4 Passive Flood Proofing

Passive flood proofing, sometimes referred to as permanent flood proofing, requires no human intervention. The building or its immediate surroundings is designed and constructed to be flood proofing without human intervention.

III. LITERATURE STUDY (CHENNAI)

3.1 Reasons for Flood in Chennai

Chennai, the capital City of Tamil Nadu is the fourth largest Metropolitan City in India. The CMA falls in three Districts of the Tamil Nadu State, Chennai District, part of Tiruvallur District and Kancheepuram District.

Figure 3.1 Unplanned Development

3.1.1 The Urban Infrastructure

The area doesn't have proper drainage facilities with inadequate quantities of storm water drains. One of reasons being the terrain condition while the other main reason for this is the unplanned developments and the illegal settlements encroachments. There are many major urban infrastructures works that had been develop ed on waterways.

Figure 3.2 Choking of Waterways

3.1.2 Choking of the waterways

The sedimentation and intensive solid waste disposal are happening in many parts on the major two rivers that are flowing through the city. High quantum of sewage generation and its disposal on these waterways are restricting the flow of water and reducing the width of the river/drain to convey floods.

Figure 3.3 Migration of People

3.1.3 Migration

Many people are shifting towards the city for a better chance of livelihood and employment. This in migration is increasing the already high population density to a higher level. Number of slums and illegal encroachments are increasing due to this factor.

3.1.4 Deteriorating Ecosystem

As a result of increasing urbanization most of the Eco sensitive areas and water bodies are now almost extinct in the region. The number of such areas have reduced drastically over the century.

Figure 3.4 Deteriorating Ecosystem

3.2 Site Level Flood Resilient Techniques

3.2.1 Wet Flood Proofing

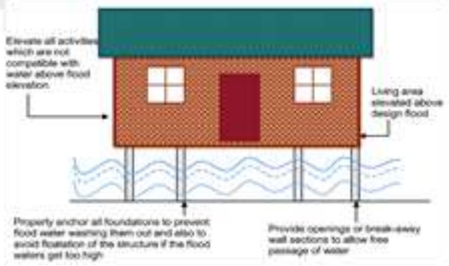
Wet flood-proofing reduces damage from flooding in three ways:

- Allowing flood waters to easily enter and exit a structure to minimize structural damage.
- Use of flood damage resistant materials.
- Elevating important utilities.

It is the practice of making a building watertight or substantially impermeable to floodwaters up to the expected flood height.

3.2.2 Dry Flood Proofing

Structure is made watertight below the expected flood level in order to prevent floodwaters from entering in the first place. Making the structure watertight requires sealing the walls with waterproof coatings, impermeable membranes, or a supplemental layer of masonry or concrete, installing watertight shields on openings and fitting measures to prevent sewer backup.



3.2.3 Elevation of Structures

Elevation is the preferred method of protecting non-residential buildings from flood damage. In non-coastal flood plains, this requires location of the lowest floor or

Figure 3.6 Dry Floodproofing

above the flood protection level, a basement that is below grade on all sides is prohibited. An unfinished, flood-resistant, enclosed area below the lowest floor can be permitted if it is usable solely for vehicle parking, building access or limited storage. Non-residential structures are permitted to have lowest floor below designed flood if they meet requirements of dry flood proofing. The dry flood proofing is a combination of measures that makes structures waterproofing. Elevation on properly compacted fill elevation on piles, posts, piers, or column elevation on walls or a crawl space.

Figure 3.6 Dry Floodproofing

3.2.4 On Mound Or Plinth

Constructing the building on a higher surface or on raised plinth would reduce the impact of flood on the building.

3.2.5 Floating

Floating houses can be defined those houses which are constructed on water in a way that the load of the structure is equal or less than the uplift force of the water which helps in floating the house on water.

Figure 3.7 Houses on Stilts

3.2.6 Amphibious

Amphibious houses are flexible: they adapt to the level of water without disturbing their functionality. They are ordinary houses with floating foundation on the ground on normal condition and float when the water level rises.

3.2.7 Orientation of the Building

Floodwater travels faster through smaller passages between tall buildings. This rapid rush of water has the potential to destroy homes in its path. It would be appropriate for the shorter side of the buildings to be oriented towards the flow of water to minimize the damage caused by a flood. This damage can be intensified further by floating objects such as logs or vegetation striking against the walls of the building.

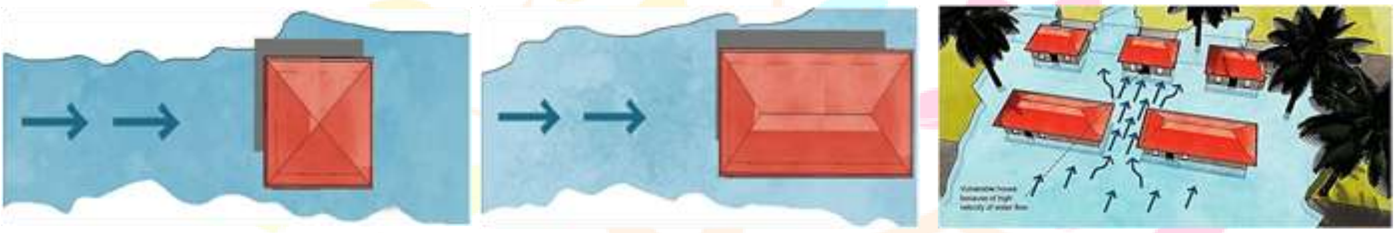


Figure 3.8 Square shaped houses are preferred as they are generally stronger in flood prone areas.

3.3 Building Level Flood Resilient Techniques

3.3.1 Flood Walls

Floodwalls are barriers constructed away from a building as a means of preventing floodwaters from reaching the building. Permanent barriers are typically constructed of earth, concrete, or metal. Temporary barriers are typically installed using sandbags or water-filled tubes.

Figure 3.9 Flood Walls

Figure 3.10 Landfill

Figure 3.11 Raised Plinth Level

3.3.2 Landfill

Inappropriate filling of land will reduce the rate of receding of floodwater and increase stagnation. Filling along the riverside to gain elevation or to create an elevated floor level causes increased flood levels because of a reduction in the cross-section of the river.

3.3.3 Elevating the Plinth Level

The ground floor level is at least 60 cm (2 feet) above the maximum flood level. Such minor differences in elevation can drastically improve the safety of a building during the time of flooding.

IV. LITERATURE STUDY (POLICIES)

4.1 Policies undertaken by NDMA in Chennai

The main thrust of the flood protection programs undertaken in India so far has been on structural measures.

4.1.1 Embankments / Banks, Flood Walls, Flood Levees

The embankment system in the river restricts the river to its existing course and prevents it from overflowing the banks. Embankments are constructed generally with earth easily available from nearby areas. In developed areas where adequate space is not available or land is very expensive, concrete or masonry floodwalls are constructed. Embankments (including ring bunds and town-protection works) are the most popular method of flood protection and have been constructed extensively in the past. Embankments are designed and constructed to afford a degree of protection against floods of a certain frequency and intensity or against the maximum recorded flood depending upon the location protected and their economic justification.

Figure 4.1 Embankment

Figure 4.2 Dams

Figure 4.3 Channel

4.1.2 Dams, Reservoirs and Other Water Storages

Lakes, low lying depressions, tanks, dams, and reservoirs store significant proportions of flood water and the stored water can be released subsequently when the flood has receded. The stored water can also be used subsequently for irrigation, power generation, and meeting industrial and drinking water needs. In the case of large multipurpose reservoirs, a proper reservoir regulation schedule can be worked out for optimum benefit from the project.

4.1.3 Channel Improvement

A channel can be made to carry flood discharge at levels lower than its prevailing high flood level by improving its discharge carrying capacity. Channel improvement aims at increasing the area of flow or the velocity of flow (or both) to increase its carrying capacity. Channel improvement has not been resorted to widely in India mainly because of the high costs involved and topographical constraints. However, it is of advantage to take up such work for local reaches.

4.1.4 Desilting/Dredging Of Rivers

The studies carried out so far indicate aggradation/degradation of riverbeds in certain reaches, but they do not confirm the common belief of a general rise in riverbeds. Silting at places where the rivers emerge from the hills into the plains, at convex bends and near their outfall into another river or lake or sea, is a natural phenomenon. Accordingly, rivers exhibit a tendency to braid/meander/form deltas. Various committees / experts appointed to investigate this problem have not recommended desilting/dredging of the rivers as a remedial measure. Selective desilting/dredging at outfalls/confluences or local reaches can, however, be adopted as a measure to tackle the problem locally.

4.1.5 Drainage Improvement

Surface water drainage congestion due to inadequacy of natural or manmade drainage channels results in flooding in many areas. In such cases constructing new channels and improving the capacity of existing channels constitute an effective means of flood control. However, the possibility of drainage congestion and flooding in the downstream area is to be kept in mind while formulating such schemes. The system of 'Dhar's' or 'old channels', efficiently serve the function of draining away the spillage and surface flows generated by local rains. The blocking of these natural drainage channels, which is normally done in the name of 'reclamation for development, may result in drainage congestion / water- logging.

Figure 4.4 Rivers

Figure 4.5 Drainage

Figure 4.6 Diversion of Water

4.1.6 Diversion of Flood Water

Diverting all or a part of the discharge into a natural or artificially constructed channel, lying within or in some cases outside the flood plains is a useful means of lowering water levels in the river. The diverted water may be taken away from the river without returning it further downstream or it may be returned to the river some distance downstream or to a lake or to the sea. This measure can be used successfully to prevent flooding around cities.

4.2 Policies undertaken by NDMA in Kerala

4.2.1 Dams and Reservoirs

Dam design has ecological aspects for flood regulation and are built to supply water to communities as well as to reduce flood events. To reduce the risk of flooding, the design of the dam should consider the consequences of climate change. The design capacity of the dam is affected by future hydrological events because of climate change. Dam safety includes structural, operative, and emergency strategies. Most dam failures and associated fatalities result from flood events.

4.2.2 Channel Improvement

Channel improvement refers to changes made to the river channel or canal to increase its capacity to hold back water or to enable the water to flow quickly. River channels and canals can be widened and deepened so that they can carry more storm water away. They can also be straightened so that water can be carried away quickly. This will help to prevent water in the river channel and canals from overflowing.

4.2.3 Watershed Management

They can also be straightened so that water can be carried away quickly. This will help to prevent water in the river channel and canals from overflowing. Watershed Management practices Vegetative measure / Agronomical measure, Strip cropping, Pasture cropping, Grass land cropping, Woodlands Engineering measure/structural practices, Contour budding, Terracing, Construction of check dames, Construction of farm ponds, Gull controlling structure.

Figure 4.7 Dams

Figure 4.8 Channel

4.2.4 Highways And Roads

Embankments are the oldest known forms of flood protection works and have been used extensively for this purpose. These serve to prevent inundation, when the stream spills over its natural section, and safeguard lands, villages, and other properties against damages. Design of bank revetment River passing through populated / agricultural areas necessitates protection of adjacent lands and properties threatened by the erosion. The protection of riverbank from the threat of erosion comes under Anti Erosion works. The purpose of bank protection may be training of river, protection of adjacent land and properties, protection of nearby hydraulic structures like embankments.

4.2.5 Floodproofing

4.2.5.1 Wet Flood Proofing

Wet floodproofing means modifying a building so that floodwaters will cause only minimal damage to the building and contents. Building materials below the flood protection level are replaced with materials that are resistant to water.

4.2.5.2 Dry Flood Proofing

Dry floodproofing means sealing a building to keep floodwaters out. All areas below the flood protection level are made watertight. Walls are coated with plastic or rubberized sheeting or special waterproofing compounds. Openings such as doors, windows, sewer lines, and vents are closed permanently or can be temporarily sealed with removable shields or sandbags.

4.2.5.3 Landfill Practices

The Landfill at wrong locations can cause damage to properties that were never flooded before. Inappropriate filling of land will reduce the rate of receding of floodwater and increase stagnation. Making use of the natural contours of the site and using the low-lying areas will reduce the flood impact on buildings.

4.3 Policies undertaken by NDMA in Bihar

4.3.1 Construction of Dams/Hydroelectricity Projects

Floods in Bihar plains are caused primarily from the generation of high flows in upper catchments of rivers on account of extremely high rains and steep gradients. The natural and long-term solution to the problem, therefore, lies in controlling and regulating the flow of rivers by providing several reservoirs in the upper reaches of the main rivers and their tributaries. There is potential of generation of huge amounts of hydroelectricity at very low costs which will go a long way towards meeting the energy requirements of Bihar which form one of the most power-starved regions of the world.

4.3.2 Construction of Embankments

Under the National flood management programs launched in 1954, a total length of 3430 kilometers of embankments had been constructed in the State. A total area of 29.16 lakh hectares has been provided with a reasonable degree of flood protection benefits in the State. Though, embankments are good to channelize the flow of rivers in normal times, embankments also effect the natural drainage pattern of rivers, and this leads to water logging in the other side of the embankments. This is a major problem and needs solution with the active participation of people. Each waterlogged area is unique and requires local solution.

4.3.3 Drainage

A good part of flood prone areas in Bihar also suffers from the problem of surface water congestion and water logging. According to one estimate about 10 lakh hectares of land suffer from the problem of water logging in perpetuity.

4.3.4 Highways and Roads

Any construction of Highways & roads should consider the drainage pattern and natural flow of water. Highways & Roads should not obstruct the natural drainage pattern and pose threat to flooding. Further, proper maintenance of roads and commutation routes must be ensured timely before flood season starts. Highways & roads should provide connectivity in floods situations rather than contribute to flooding. Any development of highways and roads should therefore mainstream disaster risk reduction and in the high seismic zone reconstruction of deserves priority. Similarly, the reconstruction of roads in many areas need to be raised and strengthened with improved design also some other infrastructure both for acting as storage for food-grains as well as designated buildings on High Land or suitably raised which can act as flood/earthquake shelter.

4.3.5 Desiltation Strategies & Dredging Operation

In the case of Bihar, siltation is a major and prominent cause of flooding of most of the rivers. Since many major river systems in Bihar are clogged up and over silted, an efficient de-siltation strategy must be adopted. A massive dredging operation needs to be undertaken.

4.3.6 Afforestation

There has been loss of forest cover over the years in the catchment's areas. Concerted action is required to be taken to restore the eroded green cover of the catchments areas of rivers to regulate water flows. In addition, soil conservation and works in catchment areas should be undertaken to help in reducing run off rainwater and the silt content in flood waters.

4.3.7 Innovative Flood and Seismic-Resistant Housing

The State government works for bringing an innovative housing project specially for the poor, whose Kucha houses encounter repetitive destruction by the floods year after year, to ensure that those are replaced by flood and seismic- proof durable homes. It is seen that floods and earthquakes are major disasters in the State. Some of the districts may get affected by flood and earthquake simultaneously also.

4.3.8 Planning of Human Settlements with due consideration of likely Future Hazards

The State should consider amendment in the Town & Country Planning Act to include consideration of Natural Disasters, amendment and enforcement of Master Plan & Development Area Rules & Regulations to take into account the Hazard Proneness in Land Use Zoning, enacting Land use Zoning Regulations for use in new settlement planning or in the development of existing settlements, marking of high flood level (HFL) in each flood prone settlement using suitable permanent buildings or structures, or through a permanent masonry pillar to guide the population against flood hazard in the settlement, taking action for flood protection and fixing plinth level of new constructions.

Figure 4.9 Seismic Housing

Figure 4.10 Planned Development

Figure 4.11 Development of Houses

4.3.9 Reconstruction of Houses and other Infrastructure

The reconstruction of fully damaged dwelling units in the flood affected districts has been undertaken to be effective against floods. Since many of the districts are both floods affected.

4.4 Flood Resilience Policies Followed in UK

4.4.1 Design Approaches and Flood Resilient Design and Construction

- Flood Avoidance : Constructing a building and its surrounds (at site level) in such a way to avoid it being flooded (e.g., by raising it above flood level, re-siting outside flood risk area).
- Flood Resistance : Constructing a building in such a way to prevent floodwater entering the building and damaging its fabric.
- Flood Resilience : Constructing a building in such a way that although flood water may enter the building its impact is reduced (i.e., no permanent damage is caused, structural integrity is maintained and drying, and cleaning are facilitated).
- Flood Repairable : Constructing a building in such a way that although flood water enters a building, elements that are damaged by flood water can be easily repaired or replaced. This is also a form of flood resilience.
- Design water depth should be based on assessment of all flood types that can impact on the building. Resistance/resilience measures can be used in conjunction with Avoidance measures to minimize overall flood risk. In all cases the 'Water Exclusion Strategy' can be followed for flood water depths up to 0.3m.
- Water Entry Strategy : Emphasis is placed on allowing water into the building, facilitating draining and consequent drying. Standard masonry buildings are at significant risk of structural damage if there is a water level difference between outside and inside of about 0.6m or more. This strategy is therefore favoured when high flood water depths are involved (greater than 0.6m).
- Water Exclusion Strategy : Emphasis is placed on minimizing water entry whilst maintaining structural integrity, and on using materials and construction techniques to facilitate drying and cleaning. This strategy is favored when low flood water depths are involved (up to a possible maximum of 0.6m). According to the definitions adopted in this Guidance, this strategy can be considered as a resistance measure, but it is part of the aim to achieve overall building resilience.

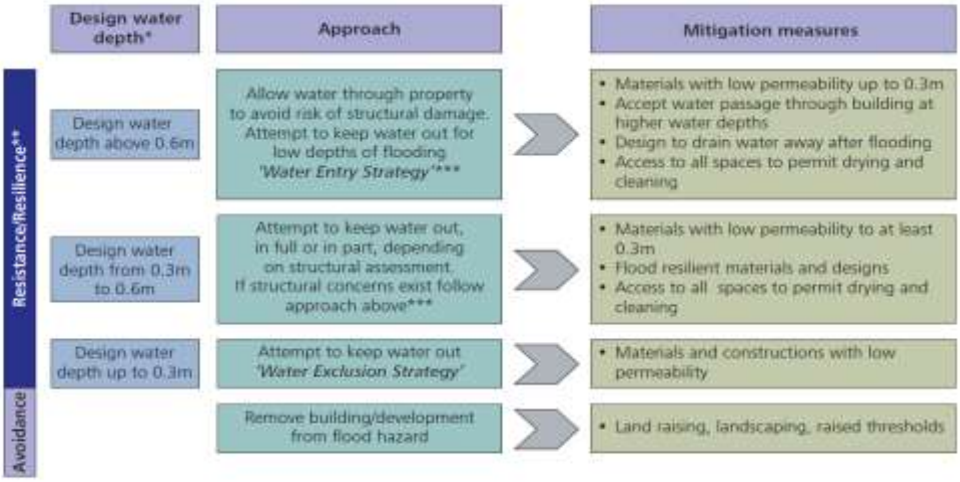


Figure 4.12 Resistance / Resilience / Avoidance

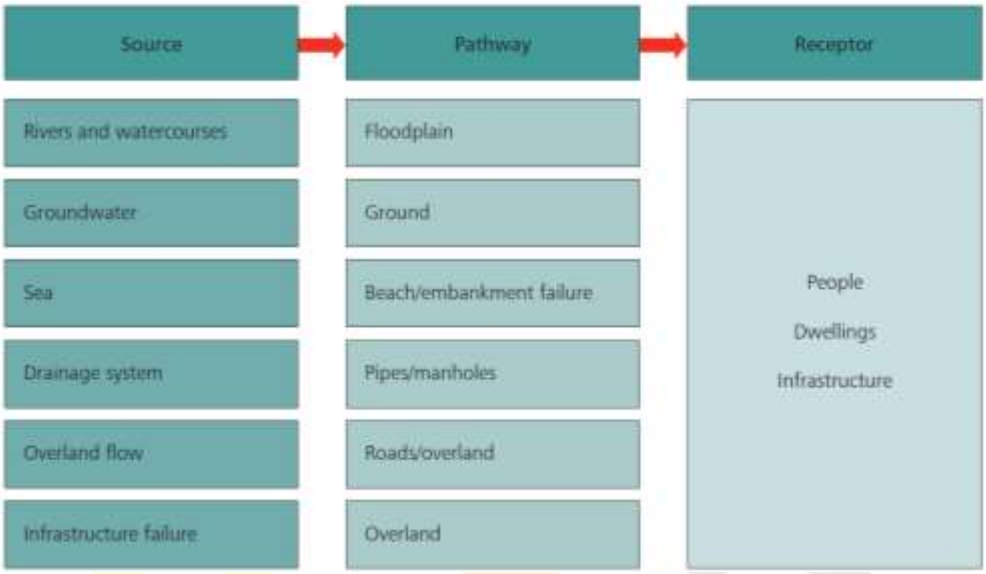


Figure 4.13 Flood Risk Management – The concept of source-pathway-receptor

Although flooding can result from a single event, it more commonly occurs through a combination of events.

- Rainfall fills rivers, streams, and ditches beyond their capacity.
- Floodwater overflows riverbanks and flood defenses.

Figure 4.14 Typical Flood Durations

Coastal storms can lead to overtopping and breaching of coastal flood defenses.

- Properties built behind these defenses are therefore still at risk from flooding, although the 'residual' risk is lower.
- However, the consequences of this type of flood could be high.

Blocked or overloaded drainage ditches drains, and sewers may overflow across roads, gardens and into property. Overloaded sewers can sometimes back up into properties when they become blocked or too full.

Rainfall can be so intense that it is unable to soak into the ground or enter drainage systems.

- Instead, the water flows overland, down hills and slopes.
- Property at the bottom of hills or in low spots may be vulnerable.
- In urban areas floodwater may become contaminated with domestic sewage.

Prolonged, heavy rainfall soaks into the ground and can cause the ground to saturate.

- This results in rising groundwater levels which leads to flooding above the ground.

- Floodwater may enter properties through basements or at ground floor level.
- Groundwater flooding may take weeks or months to dissipate.

A reservoir or canal may cause flooding either from overtopping or bank failure.

- This type of flooding (infrastructure failure) can result in rapidly flowing, deep water that can cause significant damage or loss of life.

4.4.2 Flood Risk Management

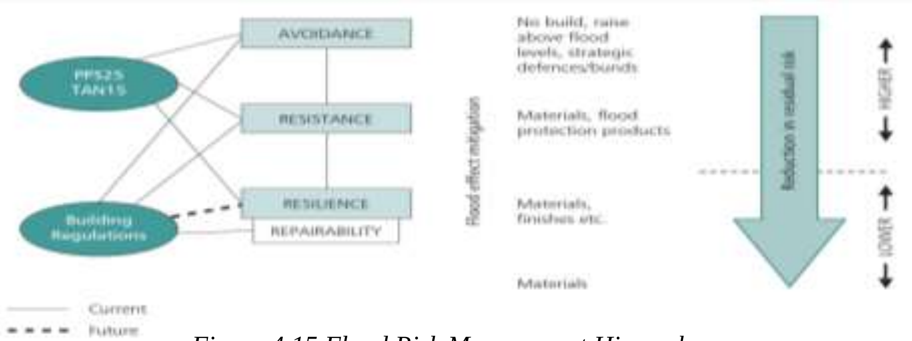


Figure 4.15 Flood Risk Management Hierarchy

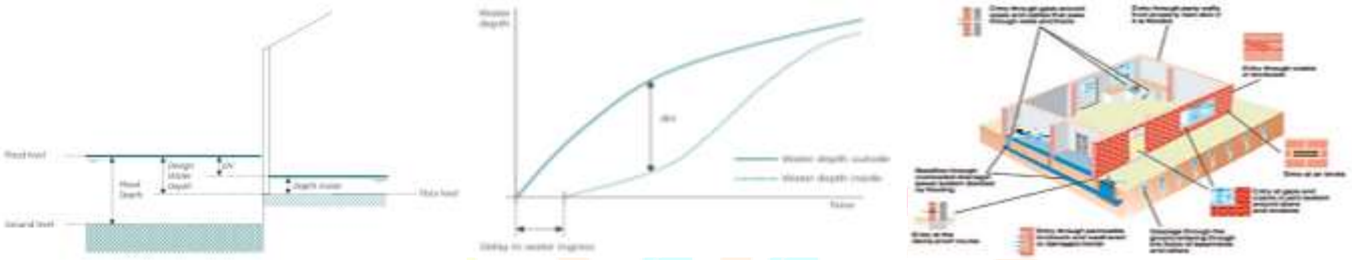


Figure 4.16 Conceptual Illustrations of Flood Water Depths outside and inside the Building

4.4.3 Damage caused by Flood

Depth of floodwater	Damage to the building	Damage to services and fittings
Below ground floor level	Possible erosion beneath foundations, causing instability and settlement Possible corrosion in metal components (e.g. joist hangers) Excessive moisture absorption in timber, causing warping Cracking of ground floor due to uplift pressures Accumulation of contaminated silt Structural and material weaknesses from inappropriate drying Rot and mould	Damage to electrical sockets and other services in basements and cellars. Damage to fittings in basements and cellars
Ground level to half a metre above floor level	Build-up of water and silt in cavity walls, with potential reduction in insulating properties, for some materials Immersed floor insulation may tend to float and cause screeds to debond Damage to internal finishes, such as wall coverings and plaster linings Floors and walls may be affected to varying degrees (e.g. swelling) and may require cleaning and drying out Timber-based materials likely to require replacement Damage to internal and external doors and skirting boards Corrosion of metal fixings Rot and mould	Damage to water, electricity and gas meters Damage to low-level boilers and some underfloor heating systems Damage to communication wiring and services Carpets and floor coverings may need to be replaced Timber-based kitchen units are likely to require replacement Electrical appliances may need to be replaced Insulation on pipework may need replacing
Half a metre and above	Increased damage to walls (as above) Differential heads of greater than 0.6m across walls could cause structural damage, although this will vary depending on the structure of the building. Damage to windows can be caused by much smaller differential pressures High speed flow around the building perimeter can lead to erosion of the ground surface; there is also the potential risk of damage to the structure from large items of floating debris, e.g. tree trunks	Damage to higher units, electrical services and appliances

Figure 4.17 Possible Flood Damage for a Typical Residential Property

4.4.4 Design Strategies and Building Control

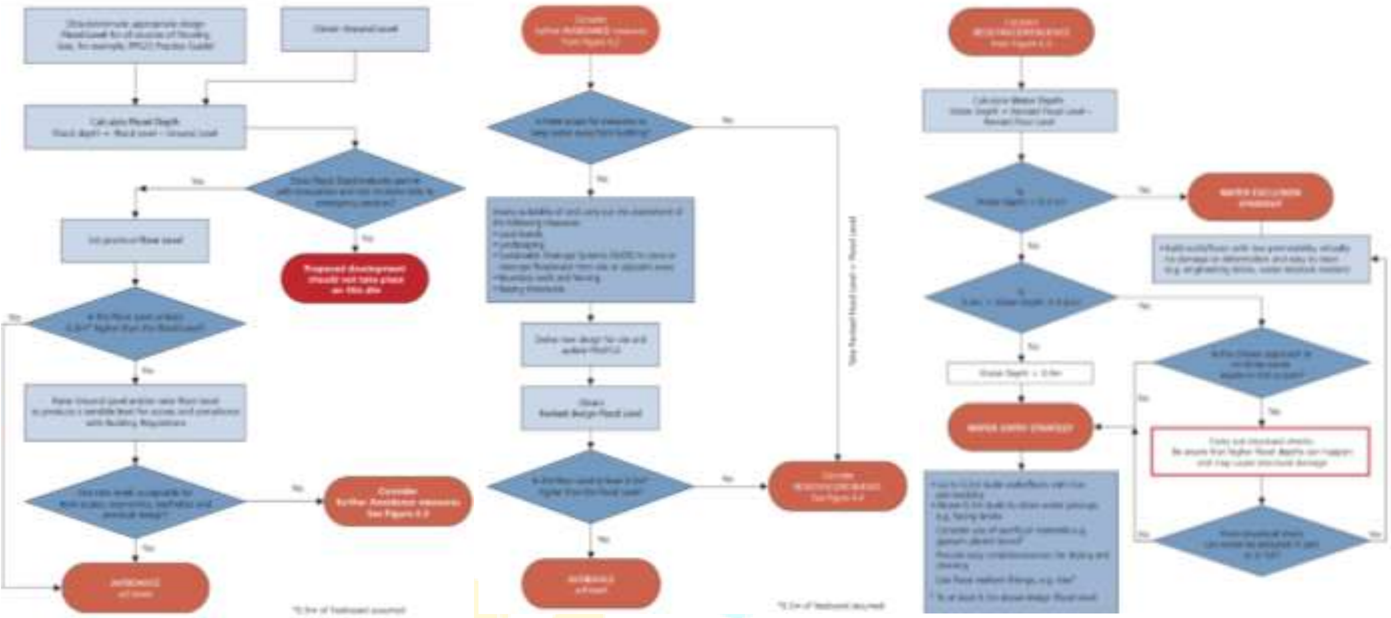


Figure 4.18 Design strategies; decision flowchart – Avoidance

4.4.5 Avoidance and Resistance Design Options

Figure 4.19 Flood Management System

The openings in the property wall and road on the new estate, which is in a known area of flood risk, were specifically designed to convey flood flows away from the property and into temporary underground storage.

- Sustainable Drainage Systems : A sequence of management practices and control structures used to attenuate run-off from development sites and to treat runoff to remove pollutants, thus reducing the negative impact on receiving water bodies. A swale used to deal with surface water drainage in a housing development in England.

4.4.6 Boundary Walls and Fencing

A residential development next to an existing watercourse utilizes raised floor levels and channels underneath the house to convey excess water in times of flood. Design of the above drainage solutions needs to consider the full range of flood water flow, depth, duration and frequency at the site, to optimize their performance. Boundary walls and fencing can be designed to create flood resistant barriers. Options include solid gates with discreet waterproof seals and where possible, integral drains, or fencing where the lower elements are constructed to be more resistant to flooding.

Figure 4.20 Property Boundary Wall and Lower Sealed Gate

Figure 4.21 Protection of Fence Base with Impermeable material.

Figure 4.22 Sealed Gate

4.4.7 Building Materials

Material	Resilience characteristics*		
	Water penetration	Drying ability	Retention of pre-flood dimensions, integrity
Bricks			
Engineering bricks (Classes A and B)	Good	Good	Good
Facing bricks (pressed)	Medium	Medium	Good
Facing bricks (handmade)	Poor	Poor	Poor
Blocks			
Concrete (3.5N, 7N)	Poor	Medium	Good
Aircrete	Medium	Poor	Good
Timber board			
OSB2, 11mm thick	Medium	Poor	Poor
OSB3, 18mm thick	Medium	Poor	Poor
Gypsum plasterboard			
Gypsum Plasterboard, 9mm thick	Poor	Not assessed	Poor
Mortars			
Below d.p.c. 1:3(cement:sand)	Good	Good	Good
Above d.p.c. 1:6(cement:sand)	Good	Good	Good

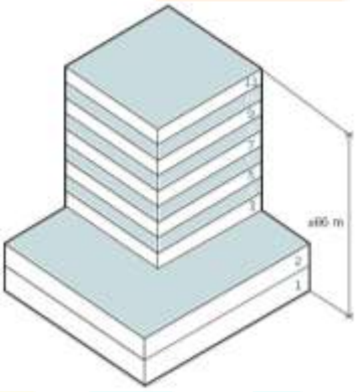
* Resilience characteristics are related to the testing carried out and exclude aspects such as ability to withstand freeze/thaw cycles, cleanability and mould growth

Figure 4.23 Flood Resilience Characteristics of Building Materials

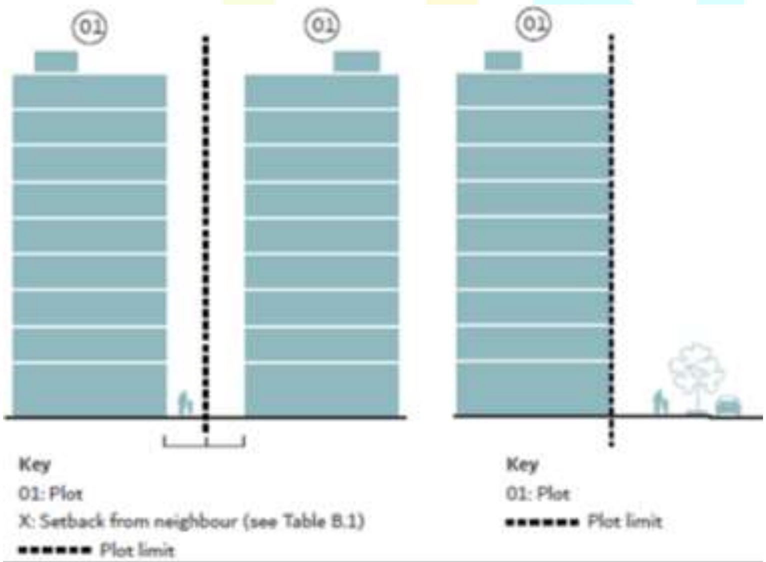
4.5 Flood Resilience Policies Followed in Dubai

4.5.1 Building Height

Buildings plots located in areas requiring Dubai Civil Aviation Authority (DCAA) approval (as noted in the affection plan, DCR or DCAA map) shall meet the Authority's requirements and the height limitation imposed. Building height shall be calculated from the approved road edge level at the main plot access to the average finished floor level (FFL) of the roof. The total building height is the vertical distance measured from the approved road edge level at the main plot access to the highest roof surface or element. Building ground should be elevated from adjacent roads to protect from flooding. Elevated access points shall also meet the requirements.



Building height by number of floors	Setback from neighbour (X) (see Figure B.8) (m)	Setback from road (see Figure B.9) (m)
Basement	0	0
Ground (G)	3	0
G+1 to G+3	3	0
G+4	3.75	0
G+5	4.50	0
G+6	5.25	0
G+7	6	0
G+8	6.75	0
G+9	7.50	0
G+10 and above	7.50	0



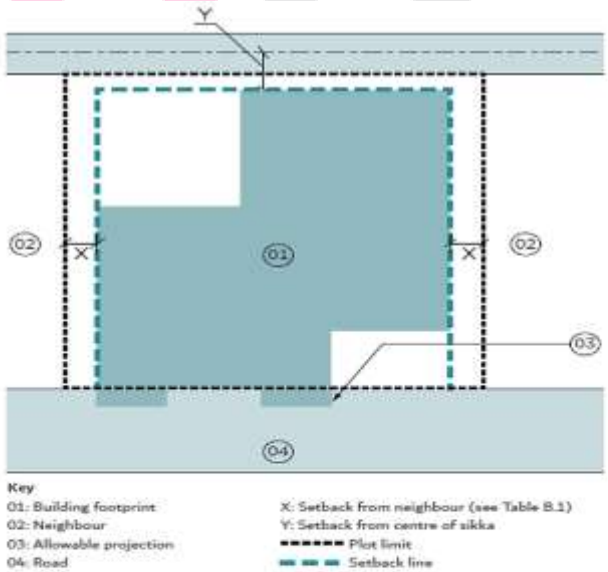


Figure 4.24 Setbacks

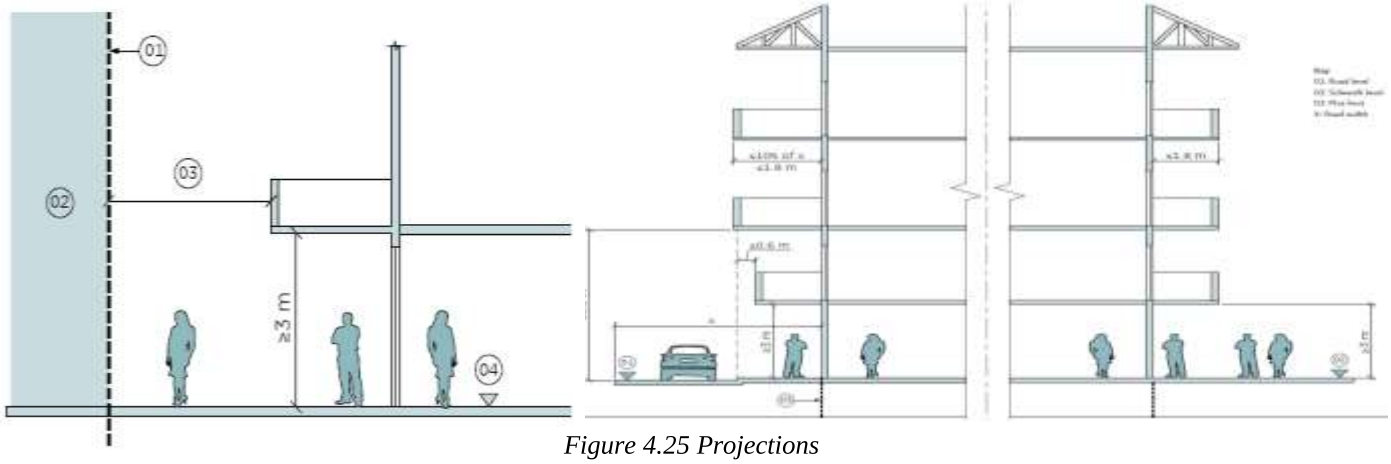


Figure 4.25 Projections

V. JUSTIFICATION

5.1 Case on Encroachment of Water Bodies

C. Govindarajan on 27 April, 2007 had petitioned a case on Encroachment of Water sources by constructing building on it. Chennai has lost its character and has become non-existent. The effect of such illegal encroachments is that during rainy season several areas become inundated with floods as excess water cannot get discharged to the sea. He wanted justice for Flood control, water pollution, water quality, water resource management and water right.

VI. CONCLUSION

6.1 Policies to be followed in India

- Policies followed in developed countries like UK and Dubai can be adapted in India as well.
- These Building level solutions when incorporated will reduce the risk and damage caused by the flooding in Urban Area.
- Appropriate Rainwater Treatment must be incorporated for a proper flow of water during Floods.
- When a separate Channel is created for the water to pass to the water bodies, it will lead to a prevention of Flood in the Urban Areas like Chennai, Kerala and Bihar.
- Proper Soil Condition has to be maintained along with considering the depth and height of the foundation and the building.
- Methods like Water Entry Strategy and Water Exclusion Strategy can be followed for a better Flood mitigation process.
- These solutions when followed will improve the preventive measures taken for Urban Flood.

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