



STRUCTURAL AND NON-STRUCTURAL MITIGATION MEASURES TO COMBAT CYCLONES IN INDIA.

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Abstract

India- the land of geographical diversities has a coastal line of 7516.6 kms and is most vulnerable to tropical cyclones in the basin. On an average 2-3 cyclones make landfall in India every year. Hydrological and meteorological factors are responsible for most of the cyclones in India. Thus, to mitigate the effects on lives and livelihood, structural and non-structural measures are required.

The National Disaster Management Act (2005) lays down policies, plans and guidelines for disaster management and coordinates their enforcement and implementation for ensuring timely and effective response to disasters. The guidelines assist the Central Ministries, Departments and States to formulate their respective disaster management plans on cyclones and floods giving out vulnerable areas, mitigation projects and forecasting and warning.

This article lists the structural and non-structural measure to mitigate the effects of a cyclone on the coastal belt of India. Mitigation measures aim at reducing the effect of cyclones on life and livelihood and cannot control the process of inundation.

Keywords: cyclones in India, disaster management, mitigation measures

1. Introduction

India- the land of geographical diversities has a coastal line of 7516.6 kms, with 5422.6 km of mainland coastline and 2094 km of island territories [1]. Nine states make the coastline of India -- Gujarat, Maharashtra, Goa, Karnataka, Kerala, Tamil Nadu, Andhra Pradesh, Odisha, West Bengal and two union territories-- Daman and Diu and Puducherry. More than 75% of the Indian coastline is prone to cyclones and tsunamis [3].

2. Tropical cyclones

Based on the data collected from INDIA METEOROLOGICAL DEPARTMENT MINISTRY OF EARTH SCIENCES GOVERNMENT OF INDIA

MARCH 2021- Tropical Cyclones are circular storms accompanied by high winds and heavy rainfall. They

are formed when the winds and ocean surfaces come together, mostly over warm areas.

The almost 7500 km-long Indian coastline is exposed to about 10% of the world's tropical cyclones. Most of the cyclones originate over the Bay of Bengal and strike the eastern coast of India. The cyclones bring heavy rains into the coastal regions. The major destruction is caused by that wind that comes along with the cyclones. The intensity of the damage is directly proportional to the speed of the wind. States affected by tropical cyclones in India are Gujarat, AP,

Karnataka, Kerala, Maharashtra, Odisha, and Tamil Nadu [4].

Fig 1. shows the districts of indian states on the coastal belt with the range of 100 kms.

2.1 WHAT CAUSES CYCLONES?

Topography, the temperature on the surface of the sea, the depth of the water, pressure in the sea as well as on the sea surface play an important role in deciding the course and intensity of the cyclone.

The air becomes lighter because of the temperature difference between the warm and the cool climates. the air then becomes lighter and start moving upwards.

Thus, the high-pressure areas fill up cool air into the low-pressure areas. And this cycle continues

Clouds are formed with warm air rising and cooling the water in the air. The formation of clouds and wind increases as the heat on the sea surface and water combines with it. Atmospheric pressure is also an important factor responsible for formation of storm surge. [5]

2.2 DISASTER MANAGEMENT IN INDIA

India is more prone to natural disasters because of its geographical diversities. Every year between 2000 to 2009, 65 million people on average in India were affected by natural disasters.[7]

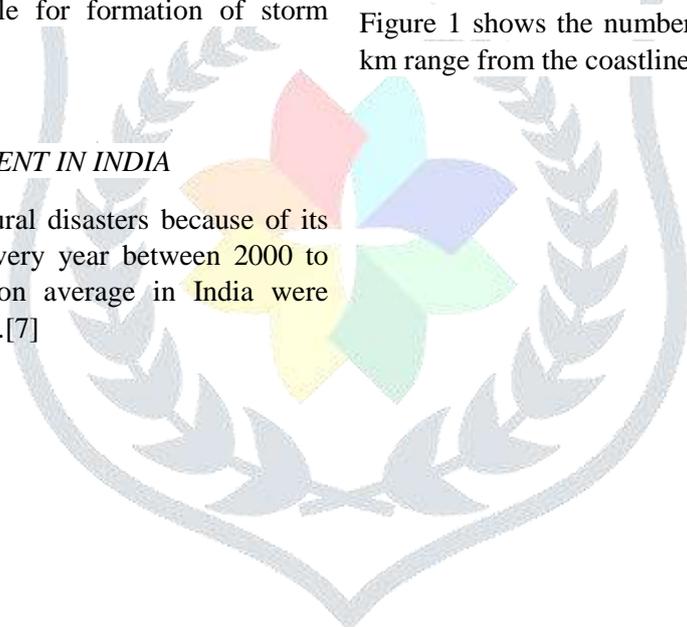
Thus, to reduce the damage caused by disasters, The National Disaster Management Act was passed in 2005.

The National Disaster Management Act (2005) formulates policies, plans and guidelines for better management of disasters, ensuring their enforcement and timely implementation. The guidelines assist the Central Ministries, Departments and States to formulate their respective disaster management plans on cyclones and floods identifying the vulnerable areas, mitigation projects and forecasting and warning systems.

The four main aims of any disaster management system should be a) preparedness, b) response, c) recovery, d) mitigation. In disasters like cyclones, preparedness, and mitigation play an important role in reducing the intensity of the damage caused due to the disaster.

This paper focuses on the structural and non-structural measures that would contribute to the preparedness and mitigation of disaster management.

Figure 1 shows the number of districts within the 100 km range from the coastline of the Indian states.



3. STRUCTURAL AND NON-STRUCTURAL MITIGATION MEASURES.

Mitigation measures aim at reducing the effect of cyclones on life and livelihood and cannot control the process of inundation.

| | |
|----------------------------|--|
| Types of disturbance | Associated wind speed in the circulation |
| Low pressure area | Less than 31kmph |
| Depression | 31 to 49kmph |
| Deep depression | 50 to 61kmph |
| Cyclonic storm | 62 to 88kmph |
| Severe cyclonic storm | 89 to 118kmph |
| Very severe cyclonic storm | 119 to 221kmph |
| Super cyclonic storm | 221kmph and above |

3.1 NON-STRUCTURAL MEASURES

3.1.1 Hazard mapping and zoning

Tropical cyclonic wind hazard is often measured by the statistical distribution of storm intensity and frequency

and a wind speed map of the return period is developed, the frequency of wind speeds is analysed, based on historical ground meteorological observations. [9]

The main aim for mapping and zoning is to form and regulate the communication systems to help the early warning system.

Fig. 2. Criteria followed by meteorological department of India to classify the low-pressure systems in the Bay of Bengal and the Arabian Sea as

| | | | | | |
|----------------------------|--------------------------|--------------------------|----------------------------|------------------------|-------------------------|
| West Bengal | 1. South 24-Pargana(STP) | Tamil Nadu (TN) | 33.Chennai(CNI) | Goa | 65.North Goa |
| | 2. North 24-Pargana | | 34.Kanchipuram(KCP) | | 66.South Goa |
| | 3. Medinipur(MDP) | | 35.Viluppuram(VPM) | | 67.Thane(TNE) |
| | 4.Hoogly(HGL) | | 36.Cuddalore(CDL) | | 68.Mumbai(MMB) |
| | 5.Howrah(HWR) | | 37.Nagappattinam(NPT) | | 69.Ratnagiri(RTN) |
| | 6.Kolkata(CAL) | | 38.Tiruvarur(TVR) | | 70.Raigarh(RGD) |
| | 7.Bardhaman(BDN) | | 39.Pudukkottai(PDK) | | 71.Sindhudurg(SDG) |
| Odisha | 8.Balasore(BLS) | Kerala | 40.Ramanathapuram(RMN) | Gujarat | 72.Junagadh(JGH) |
| | 9.Bhadrak(BDK) | | 41.Toothukudi(TTK) | | 73.Kachchh(HCH) |
| | 10.Kendrapara(KDP) | | 42.Tirunelveli(TNV) | | 74.Bhavnagar(BHV) |
| | 11.Jagatsinghpur(JSP) | | 43.Kanyakumari(KYK) | | 75.Jamnagar(JMN) |
| | 12.Ganjam(GJM) | | 44.Thanjavur(TJR) | | 76.Porbandar(PBD) |
| | 13.Puri(PRI) | | 45.Tiruvannamalai | | 77.Amreli(AML) |
| | 14.Khordha(KRD) | | 46.Ariyalur | | 78.Ahmedabad(AHM) |
| | 15.Mayurbhanj(MYB) | | 47.Sivaganga | | 79.Anand(AND) |
| | 16. Jajpur(JJP) | | 48.Kasargod (KGD) | | 80. Surat (SRT) |
| | 17.Keonjhar(KNJ) | | 49.Kannur(KNN) | | 81.Navsari(NVS) |
| | 18.Dhenkanal(DKL) | | 50.Kozhikode(KZK) | | 82.Valsad(VSD) |
| | 19.Cuttack(CTK) | | 51.Malappuram(MLP) | | 83.Bharuch(BRC) |
| | 20.Nayagarh(NYG) | | 52.Thrissur(TRS) | | 84.Rajkot(RJK) |
| 21.Gajapati (GJP) | 53.Ernakulam(ERM) | 85.Vadodara(VDD) | | | |
| 22.Srikakulam(SKM) | 54.Alappuzha (ALP) | 86.Surendra Nagar | | | |
| Andhra Pradesh (AP) | 23.Vizianagaram(VJM) | Karnataka | 55.Kollam(KLM) | Daman & Diu | 87.Kheda (KDA) |
| | 24.Visakhapatnam(VSK) | | 56.Thiruvananthapuram(TRV) | | 88.Daman |
| | 25.East Godavari(EDG) | | 57.Wayanad(WND) | | 89.Diu |
| | 26.West Godavari(WDG) | | 58.Palakkad(PKD) | | 90.Dadra & Nagar Haveli |
| | 27.Krishna(KSN) | | 59.Kottayam(KTM) | | 91.Puducherry(PDC) |
| | 28.Guntur(GNT) | | 60.Idukki(IDK) | | 92.Karaikal(KRK) |
| | 29.Prakasam(PKM) | | 61.Pathanamthita(PMT) | | 93.Yanam(YNM) |
| 30.Nellore (NLR) | 62.Uttar Kannada(UKD) | 94.Mahe | | | |
| 31.Chittor(CHR) | 63.Udupi (UDP) | A & N Islands | 95.A & N Islands | | |
| Tamil Nadu | 32.Tiruvallur(TVL) | 64.Dakshin Kannada(DKD) | Lakshadweep | 96.Lakshadweep | |

Figure 1. Coastal districts of India within the range of 100 km from the coastline [13]

adopted by World Meteorological Department (WMO2013)

Fig. 2. Criteria followed by meteorological department of India to classify the low-pressure zones

Based on the wind speeds during cyclones, the zoning is done, and areas are identified based on their proneness to different intensities of cyclones.

After zoning, the land use pattern is regulated to restrict the damages. Zoning helps in determining the location and extent of areas for developmental activities to minimise the damage. For example, the public spaces like parks, playgrounds etc and that of the residential colonies and industries are planned to avoid the damages and reduce the risks.

3.1.2 Early Warning systems

Early warning systems help in providing information and warning about the disasters so that evacuation and relocation of the population to safer zones can be done.

High Power Cyclone Detection Radars (HPCDRs) installed along the coastal belt of India is a very useful and important tool in creating early warnings. HPCDRs are now functioning in Calcutta, Pradeed, Vishakhapatnam, Machilipatnam, Chennai, Karaikal, Goa, Mumbai, Bhuj, And Cochin. These radars can track and locate approaching cyclones within a range of 400kms.

Satellite images received from various weather satellites are used in locating the development and the movement direction of the cyclones over the oceans especially when the cyclones are outside the radar range. Advanced Very High Resolution Radiometer (ADVHRR) facilities are also available at delhi and Chennai to observe high resolution images from polar orbiting satellites. India has launched its first geostationary Indian National Satellite in 1980 that receives the cloud imagery round the clock at the INSAT Meteorological Data Processing System (IMDPS) at New Delhi.

MAUSAM App

The ministry of earth sciences has also launched a mobile phone application called 'MAUSAM' for India Meteorological Department through which the users get regular weather updates and it helps to enhance the forecast system as well as the warning systems. The users can also access the radar images and they can get warnings of any approaching cyclones.

3.1.3 Spreading awareness and education

The most effective measure to mitigate the effects of any disaster is spreading awareness and educating the people. The more the people are guided and educated about the dos and don'ts before and after a disaster, the

easier it becomes to manage and mitigate during and after the disasters. Educating the masses is the biggest weapon to fight disasters.

Organising seminars and workshops, street plays, and the use of social media can ensure the information reached the masses.

3.1.4 Quick response teams

Quick response teams (QRTs) are the quickest and the most important step in disaster management. The immediate action contributes majorly towards handling a crisis. Their role before a cyclone makes landfall is very crucial. Moving all living beings to safer zones and moving the necessary valuables along. Bringing aid to those affected and taking them to hospitals and disaster relief camps. QRTs can be a small group of 2 people, or a large group of people and different vehicles loaded with food, medical supply, and necessities. These groups work in a coordinated fashion and try to reach maximum people.

In the coastal belts, QRTs use boats to help rescue the stranded fishermen in the sea. These boats carry basic supply of food, medicine, and other necessities. They use satellite phones to contact other members of their groups and call for help whenever required. Passing information like various safe zones, way to disaster relief camps, way to nearest hospitals, is also done using the satellite phones. Thus, the QRTs play an important part in preparedness and mitigation in managing a disaster.

As a part of the National Disaster Management Act 2005, National Disaster Response Force was formed for better response and handling the situation of a disaster. There are 13 battalions of NDRF deployed in different states of India. [17]

3.2 STRUCTURAL MEASURES

The structural measures mentioned in this section of the paper include the guidelines to all the structures coming up in the cyclone prone zones and how small changes in the already existing structures can make them stronger and help reduce the impact of cyclones.

3.2.1 Retrofitting of the already existing buildings

Since the coastal best of India is not very developed, the construction techniques are also very ancient and not very much capable of withholding the structure during cyclones. The already existing buildings can be retrofitted to make them stronger and more resistant to cyclones. In this section, various structural components of a building are mentioned and how retrofitting them can benefit the building.

3.2.1.1 Roofs

Use of light roofing structures as temporary shade is very common, it being economic. These kinds of roofs are more prone to damage and can be strengthened using simple mechanisms.

- Using different types of bolts near the edges and connections to strengthen the roof sheets.
- Use of U bolts to strengthen the connections near the edges in case of light roofs (Asbestos Cement or Corrugated Galvanized Iron sheeting).
- Use of mild Steel flat ties to hold down the roof. Replacing J-bolts with U-bolts.
- Checking all the projections for strength against uplift and to be tied down if necessary.
- Use of non-corrosive or galvanized metallic connectors or its components. Checking them before each cyclone season and galvanized and painted if required.

3.2.1.2 Openings

Openings such as doors and windows allow the wind to enter any structure and damage the building. Replacing them won't be possible in every existing structure, thus

simple additions and modifications can ensure they withstand high speed winds and can contribute to reducing the impact damage.

- To prevent breakage, the doors and windows can be strengthened by adding an extra layer of mesh or iron grill
- Adding battens at appropriate spacing to strengthen the large glass panels in windows.
- By fixing adhesive tapes, along and parallel to diagonals, glass panels can be strengthened.
- Using thin plastic film on both surface on glass panels to prevent shattering.

Other important factors to be considered are:

- Ensuring there is no water logging in and around the buildings, to prevent the situation of flooding after a cyclone.

- Adding a cover of vegetation to reduce the flow of high-speed winds and check the soil erosion is a very effective method.

3.2.2 Planning and development of new construction requirements of buildings

Building guidelines for any new construction in high-risk zones can include considering a set of rules for the plan forms, openings, and the roof structures. These parts of a building, if planned meticulously, can ensure limited damage.

3.2.2.1 Plan Forms

For a new building, we can control the shape, form, and orientation. For individual buildings, a circular or polygonal plan shape is preferable over rectangular or square plans, but because of functional efficiency, the rectangular plan is commonly used. A symmetrical building gives more stability compared to an asymmetrical building with a zig-zag plan and empty pockets as there is more scope of damage due to the winds.

In case of rectangular house plans, the length not more than 3 times the width should be considered.

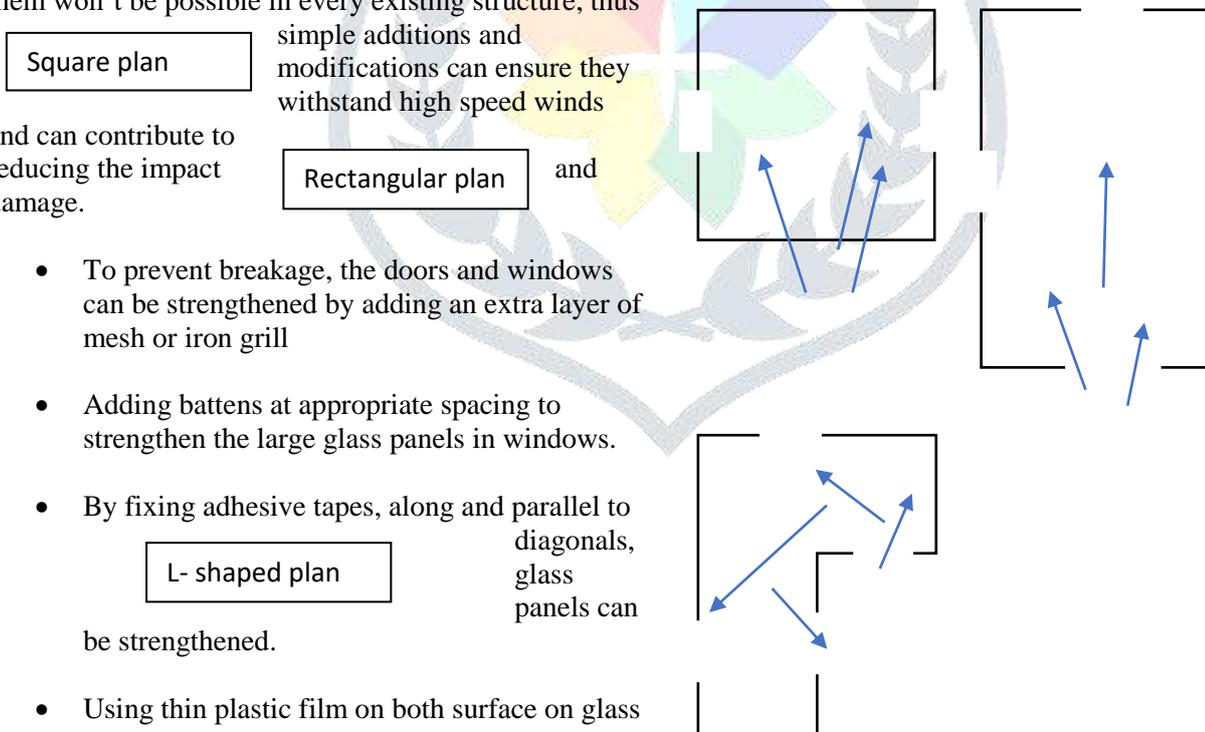


Fig.3. The greater number of pockets and complex plan, the damage caused by the winds will be more. Thus, a square shape is ideal.

3.2.2.2 Cluster Forms

The clusters when placed symmetrically, and at equal distance, the intensity of damage can be more as tunnel

is formed in between the units.

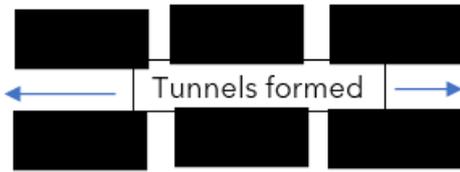


Fig.4a shows the symmetrical placement of clusters leading to formation of a wind tunnel.

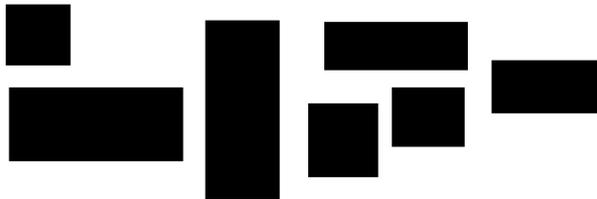


Fig 4b. showing the zig zag placement to avoid the formation of wind tunnels.

3.2.2.3 The Openings.

The elements of any building that requires the most attention are the openings - windows and doors. These are often neglected even when buildings are formally designed.

As there are many flying objects in a cyclone, glass windows and doors are very vulnerable. The solution to this problem is to provide well designed thicker glass panes.

Further, the single panes can be divided into parts and be strengthened by providing batons. Adding sliding membrane that can withstand high speed winds and stop the wind from the entering the building.

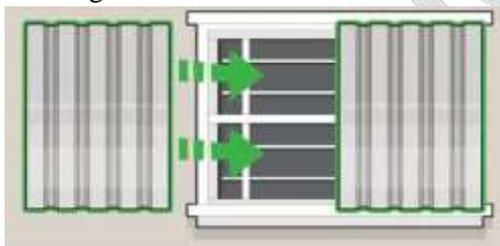


Fig. 5a

Adding sliding horizontal panels to cover the windows as shown in above picture.

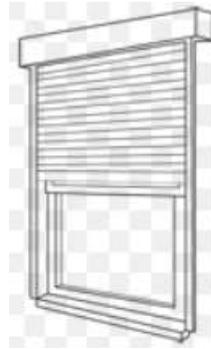


Fig 5b. showing how adding a layer of vertical panel that can slide open/ close.

Adding these sliding members alone can ensure the windows are strengthened.

3.2.3 Building cyclone relief shelters

Building cyclone shelters to aid those affected by the cyclones. The cyclone shelters can be built considering the structural and non-structural measures mentioned above. The cyclone shelters should be at a safe distance from the high-risk zone, the location should be easily accessible. The shelters should cater to the food and medical need of the population of the area.

4. CONCLUSIONS

The natural disasters are inevitable, but our preparedness and the mitigation measure can help in reducing the intensity of the damages they cause. Indian Disaster Management Act has laid down policies for risk reduction. Addition and modifications in the building guidelines can also help strengthening the structures.

With such a great geographical diversity, India remains vulnerable to the disasters like cyclones. The structural and non-structural measures mentioned in this article gives an overview of the aspects we can focus to reduce the loss of lives and livelihood.

THE LIMITATIONS

The aspects mentioned in the article are applicable only to Indian states. The data referred to for this article is also limited to the Indian context. The structural measures mentioned gives and overview of the basic aspects of planning and a there is a scope for a more in-depth study.

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