Behaviour of Buildings to withstand Cyclonic Winds - An Experience of Gujarat and Andhra Pradesh

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Abstract
India due to its geographical location, has 5,700 kms long coastal line in the southern hemisphere of the earth. It faces four to five cyclones every year. Out of which one or two are very severe Cyclones impact 50 per cent of population of the country Due to complexities of cyclonic winds and their dynamic nature, behaviour of buildings and their response can not be predicted on theoratical analysis only. Infact, this needs to be studied historically to improve design of buildings SERC, Chennai has pioneered in the same and have arrived at specific guidelines and findings for structural improvements in residential as well as other buildings preventing devastating impacts. Some extracts of such findings and guidelines have been brought out in this paper.

Introduction

Natural disasters such as cyclones, earthquakes, floods and landslides have become regular features, in different ports of the world, every year These disasters cause extensive damage to property leading to disruption of livelihood to the population besides killing people in these affected areas. Such disasters stand as an impediment against regional, national and global development. Out of different natural disasters, cyclone disaster assumes higher importance because of its frequency, severity and the large area affected by the fury of the cyclone. India faces four to five cyclones every year, out of which atleast one or two may be very severe. These cyclones cause extensive damage to buildings and structures, residential dwellings, communication systems, transport facilities and agricultural land and crops. The efforts by the governmental agencies to give relief and to rehabilitate the community affected by the cyclone are a regular feature of every year.

We have now 970 million people in our country and in the year 2001, it is expected to cross 1000 million. Out of this more than half the population depend on agriculture and live in non-engineered houses (Thatched roof with mud wall) or semi-engineered houses (Tiled or A.C. Sheet roof with brick masonry wall). These non-engineered houses are very much vulnerable to damage due to cyclonic wind forces. It is also noted that most of the loss of life during cyclones is mainly due to the collapse of such buildings.

Such problems are occurring in many of the developing countries such as Bangladesh, Philippines and also in developed countries such as U S A. and Australia. Hence Cyclone Disaster Mitigation assumes high importance not only in India, but it is of international importance. This also has more relevance in the context of the present decade being designated as the "International Decade for Natural Disaster Reduction" by United Nations.

Even though the whole of Peninsular India is affected by cyclones, in the East Coast, the frequency of cyclone occurring in the state of Andhra Pradesh is very high. During the past 10 years, regions of Andhra Pradesh have faced very severe cyclones during the year 1989, 1990, 1996. Similarly out of 65 cyclones on the Western coast, during the past 100 years 46 cyclones have crossed Gujarat coast During the past 25 years, 6 severe cyclones have crossed the Gujarat coast.

The recent cyclone of 1996 in the East Coast, which crossed near Kakinada in Andhra Pradesh and the cyclone of 1998 in the West Coast, which crossed near Porbandar in Gujarat are very severe in nature, which may be termed as category 4 of Saffir Simpson scale[1] These cyclones have caused heavy damage to buildings and structures in addition to killing nearly 1000 people in each cyclone which are illustrated through some of the pictures.

Damage Survey to Buildings and Structures due to Cyclones

Due to the complexities of cyclonic winds and their dynamic nature of wind loading on buildings and structures, the prediction of structural response of buildings and responses of structures can not be studied only based on theoretical or mathematical models alone. Hence the lessons from the damages to buildings due to past cyclones, provide invaluable information for more rational design and detailing of components and structures.

SERC has pioneered activities of cyclone disaster mitigation to buildings and structures since 1997. As a continuing effort on this the damage survey due to cyclones in 1996 and 1998, in Andhra Pradesh and Gujarat States of India respectively were also carried out by documenting and analysing the failed structures.

It is very difficult to predict the exact place and intensity of the cyclone that would strike the coast. However, once the cyclone crossed the shore, it would create innumerable damage in the region as discussed earlier, depending upon the wind speed and height of storm surge. The tracks of 1996 and 1998 cyclones are given in Fig. 1. The 1996 cyclone crossed the coast on 6th November near Kakinada, Andhra Pradesh, with a wind speed of about 220 kmph and accompanied by storm surge of height upto 5m. Similarly, the 1998 cyclone crossed the coast near Porbander, Gujarat on 9th June 1998 with a wind speed between 170 to 200 kmph gusting upto a peak value of 250 kmph and with a storm surge of 5 to 8m. The loss due to the 1996 cyclone was estimated as Rs. 5,375 crores, whereas the loss due to 1998 cyclone was Rs. 1,200 crores.[2&3]

Even though these cyclones have caused extensive damage to different types of buildings and structures, this paper discusses the major damage caused to low-rise buildings such as residential dwellings, storage godowns, school buildings and low-rise industrial structures.

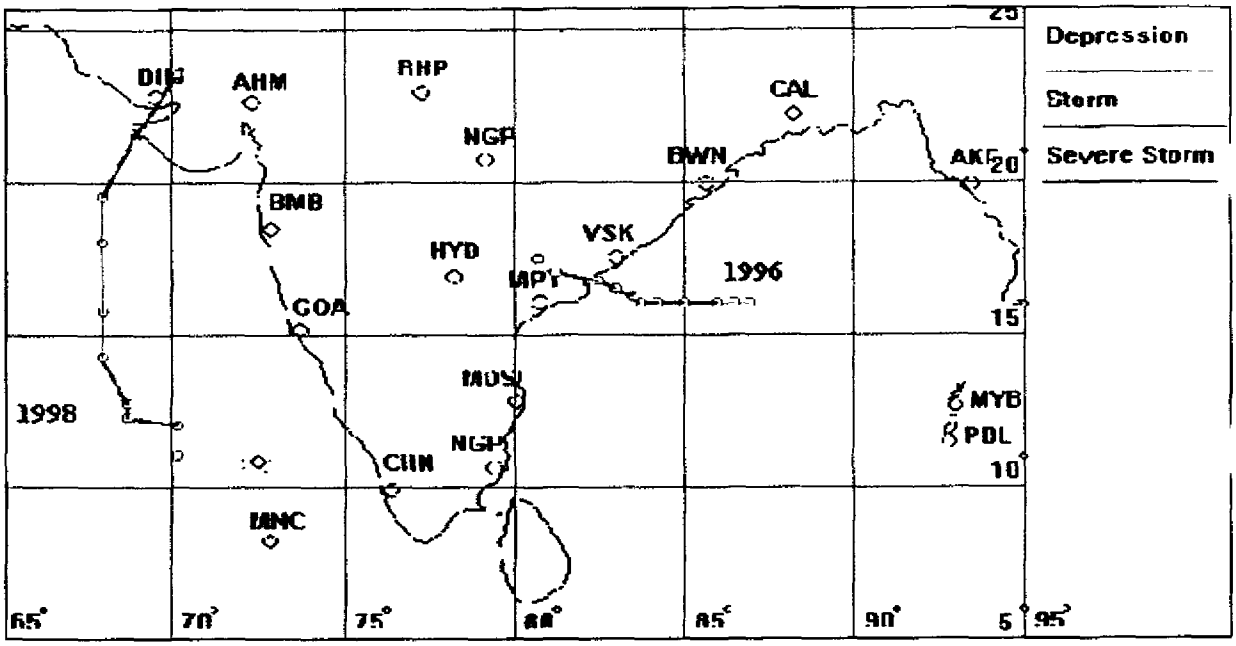

Fig. 1 · The tracks of 1996 and 1998 cyclones

Andhra Pradesh Cyclone

Damage to Residential Dwellings

The residential dwellings in this region were of non-engineered with thatch roof and mud walls, or semi-engineered with tiled/A.C roof and masonry walls or fully engineered with R.C C. roof and masonry walls There were wide spread damage to thatched, tiled and A.C sheet buildings. The roof claddings have been blown away due to the large suction forces or damaged due to debris impact like coconut falling on the thatch/A C. sheet roof cladding. It is reported that more than 6 lakhs thatch houses have been damaged partially or fully In many places the thatch roof houses have been swayed due to lateral wind in addition to damage to some of their cladding In some places, the roof cladding have been blown away, but the truss members are intact, exhibiting the inadequacy of the strength of the cladding material to resist the cyclonic wind pressure. However, as expected and also based on our earlier surveys, the fully engineered houses with R.C.C. roof in the cyclone affected region have not suffered notable damage.

Tiled roof houses using either country or Mangalore tiles are very common in many village hamlets. Mostly Mangalore tiles were used instead of country tiles This failure may be due to blowing off roof cladding alone (Fig 2) or total failure of roof system including roof truss and cladding (Fig. 3).It is obvious, that design and

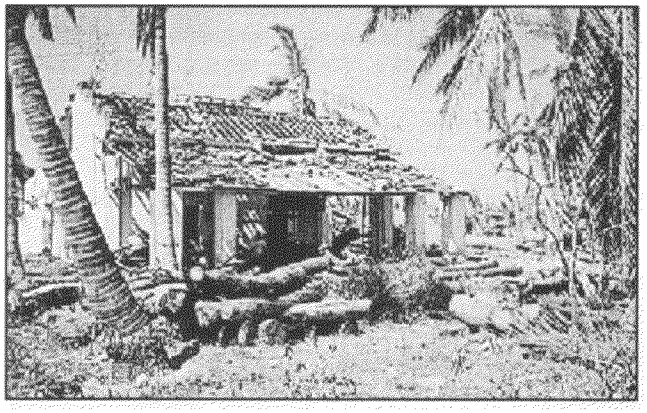

Fig 2 . Failure of tiled roof cladding alones

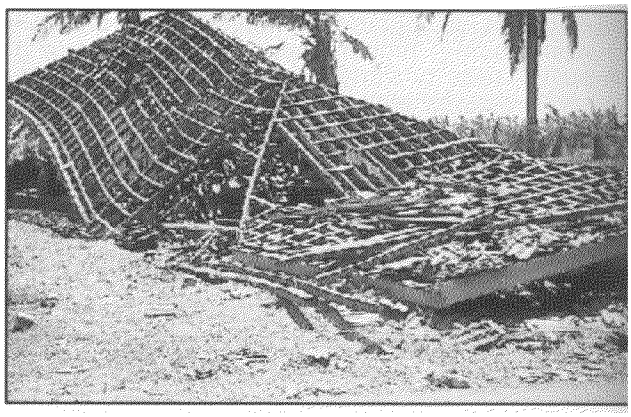

Fig 3· Failure of roof cladding along with roof truss system

construction of these low-cost structures to survive cyclonic winds is practically and economically not viable. Prior evacuation of movable property and population only can reduce serious damage due to cyclones. However, mitigation of structural damage to a great extent to thatch and tiled roofing are illustrated in the design guidelines prepared by SERC.[4]

Storage Godowns/School Buildings

The use of A C Sheet roof to dwellings are comparatively very much less when compared to tiled roofing. However A.C. sheet roofs are very common for storage godowns, industrial structures, poultry sheds, school buildings and auditoriums.

A.C. sheet roofing has the specific advantage of fast erection, and re-usage. The failure of such A C. sheet roofs are very common during cyclones. Complete failure of A.C. sheet roof of a school building with timber truss is shown in Fig. 4. It is seen from the figure that most of the connectors (nails and bolts) are still intact with the truss, indicating the dynamic action of wind has caused brittle failures of A C. sheets

Severe damage was caused to storage godown at Gopalapuram which is around 60 km away from sea. It has been reported that some of the ventilators and window-shutters were damaged in a previous extreme wind. The gusty cyclonic wind which entered through