

Recommended Practices for Improving Cyclonic Resistance of Dwellings/Low-rise Buildings



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Prepared by



CSIR – Structural Engineering Research Centre
(Council of Scientific and Industrial Research)
CSIR Campus, Taramani
Chennai 600 113

National Disaster Management Authority
NDMA Bhawan
A-1 Safdarjung Enclave
New Delhi 110 029

RECOMMENDED PRACTICES FOR IMPROVING CYCLONIC RESISTANCE OF DWELLINGS/LOW-RISE BUILDINGS

PREAMBLE

Cyclones are the most devastating among the natural hazards when viewed in terms of their severity, frequency of occurrence and areas of destruction. The coastal regions of India both in the east and west coasts are severely battered almost every year, causing heavy loss to both life and property. Poor man's dwellings and low rise buildings are seen to be the most commonly affected during a cyclone. The materials and methods of construction practices significantly go a long way in contributing to the cyclonic resistance of these low-rise buildings. Depending on the availability of the local materials and the local economy of the region, thatch, Mangalore or country tiles, asbestos or metal GI sheets and reinforced concrete are generally used as roof cladding materials. Similarly, mud, clay, stone and bricks are generally used as wall cladding materials. **Recognising the fact that a low-rise building is an assemblage of various structural elements such as walls, purlins, rafters, cladding, etc., it is essential to ensure a safe load path from the roof to the foundation.** This requires proper understanding of the aerodynamics of wind flow pattern on and around the building, and on the principles of anchorage, bracing and connections for the safe performance of the building. In this booklet, some of the recommended practices for improving the cyclonic

resistance of dwellings/low-rise buildings along the coastal regions are highlighted in this document with illustrations. These recommendations are primarily based on the continued R&D efforts carried out at CSIR-Structural Engineering Research Centre (CSIR-SERC), one of the premier research institutions in our country working in the area of cyclone disaster mitigation since 1977. Some of these recommendations are also available in the Indian Standard IS 15498 : 2004. In this context, the whole hearted cooperation and the technical assistance extended by Dr. Nagesh R. Iyer, Director, CSIR-SERC, Chennai, in general and that by Dr. S. Arunachalam, Chief Scientist, Advisor (Management), & Head, Wind Engineering Laboratory, CSIR-SERC, Chennai and his team members in particular in preparing this document are being thankfully acknowledged by NDMA.

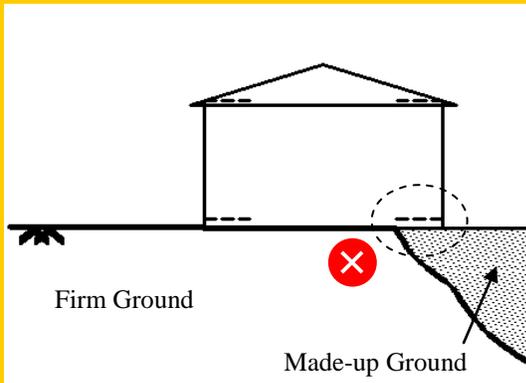
It is sincerely hoped that these recommended practices would go a long way to assist the community living in the cyclone prone areas in the country to enhance the resistance of their dwellings to cyclone hazard.

Issued by the Secretariat of Shri B. Bhattacharjee, Member, NDMA

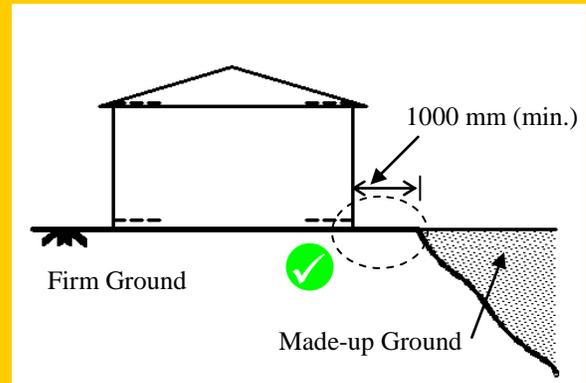
Dated 22nd August, 2012

- ❖ The entire foundation of a house should be constructed on the same soil and not on made-up-soil.

Undesirable ❌

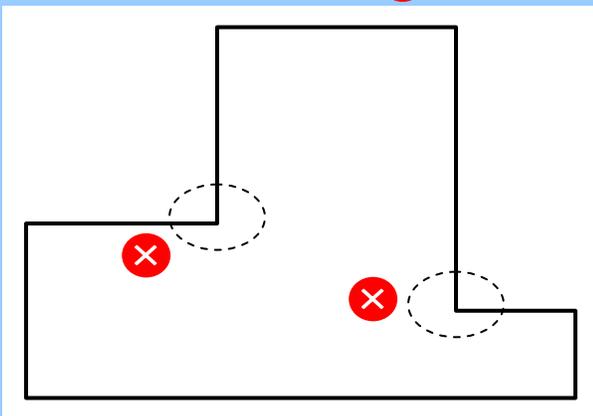


Preferred ✅

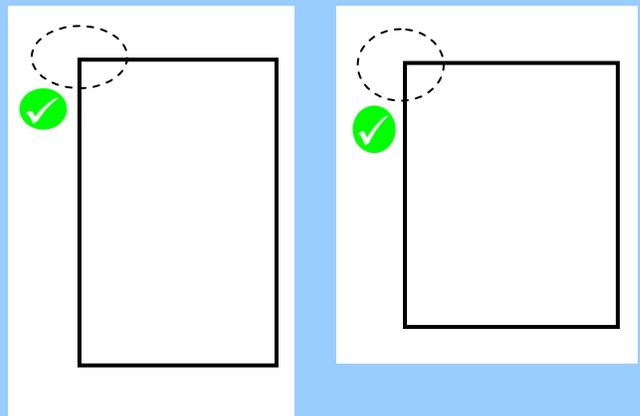


- ❖ Projections resulting in reentrant corners should be avoided to the extent possible
- ❖ Closed configuration, viz. square/ rectangle, is preferred for house plans.

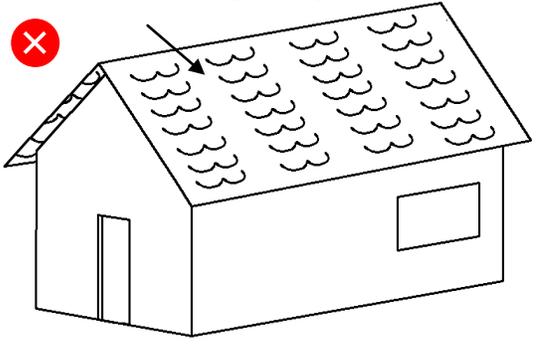
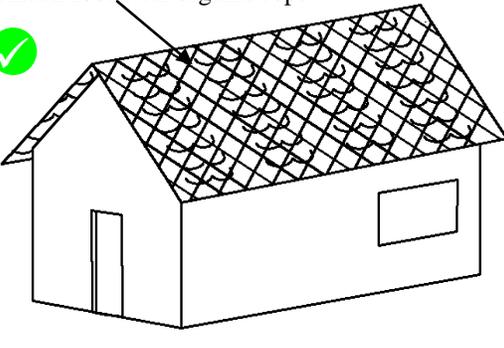
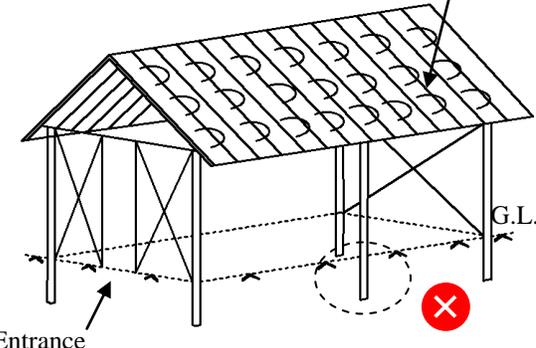
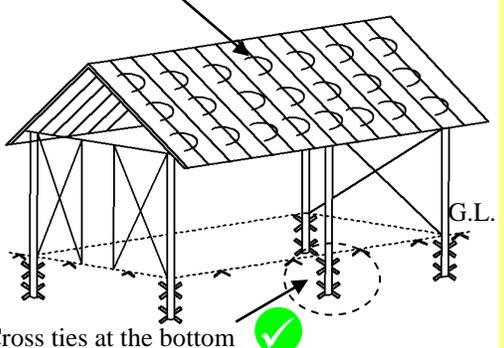
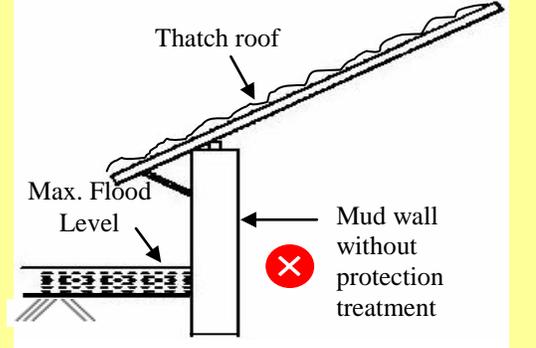
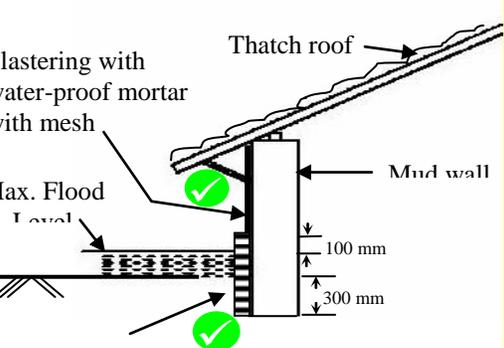
Undesirable ❌



Preferred ✅

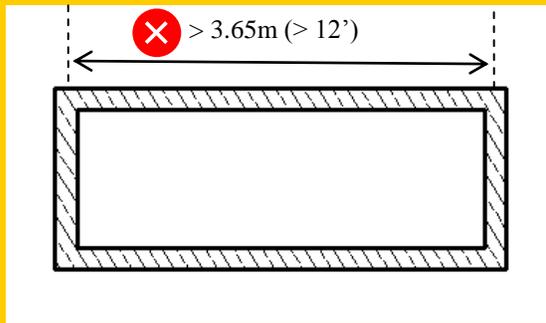


❖ Improvement for thatch roofs and mud walls to reduce damages due to cyclones

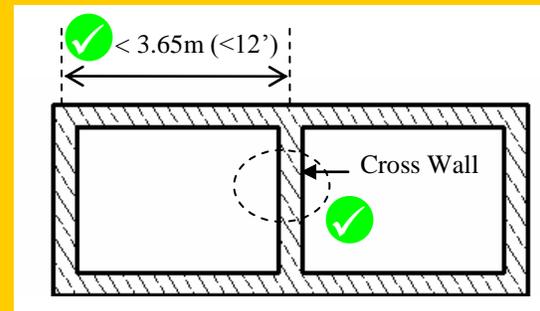
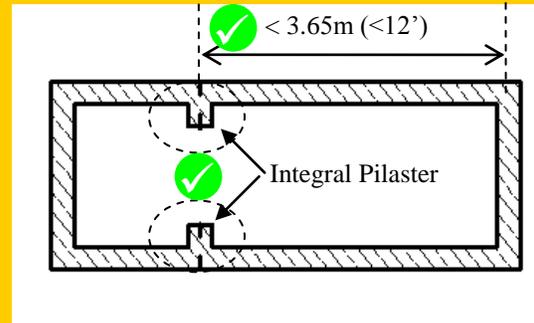
Undesirable ❌	Preferred ✅
<p>Thatch roof without organic rope</p> 	<p>Thatch roof with organic rope</p> 
<p>Thatch roof</p>  <p>Entrance</p> <p>G.L.</p>	<p>Thatch roof</p>  <p>Cross ties at the bottom</p> <p>G.L.</p>
<p>Thatch roof</p>  <p>Max. Flood Level</p> <p>Mud wall without protection treatment</p>	<p>Thatch roof</p>  <p>Plastering with water-proof mortar with mesh</p> <p>Max. Flood Level</p> <p>Mud wall</p> <p>100 mm</p> <p>300 mm</p> <p>Protective barrier or revetment built with stone or brick</p> <p>Not to scale</p>

- ❖ In case of rectangular plan, the length of an individual wall should be kept less than 3.65 m (12') which can be achieved by provision of intervening cross walls or pilasters.

Undesirable ❌

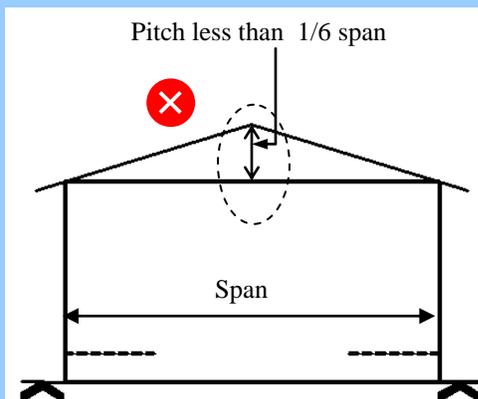


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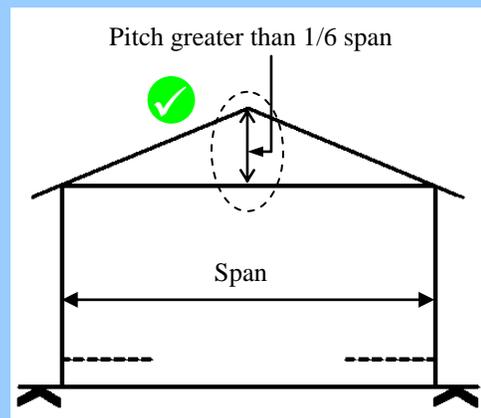


- ❖ Low pitches for roofs should be avoided

Undesirable ❌

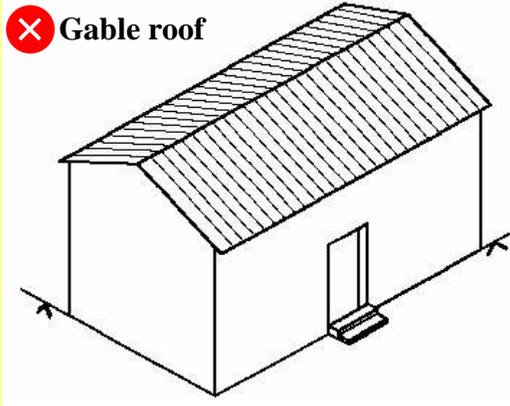


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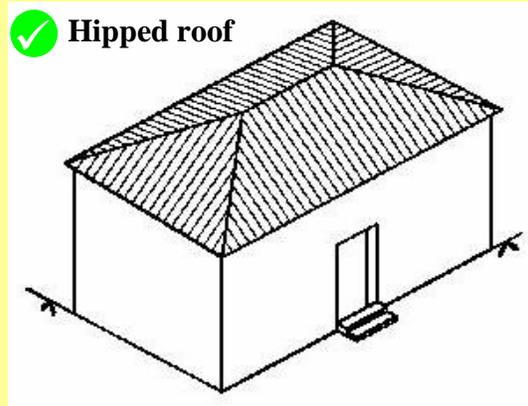


❖ Hipped roofs are preferable to gable roofs.

Undesirable ❌



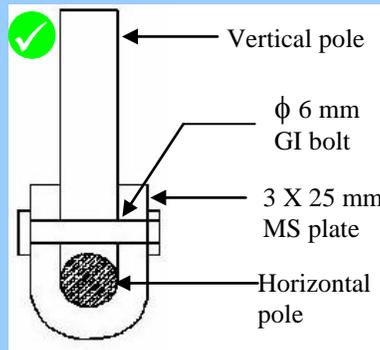
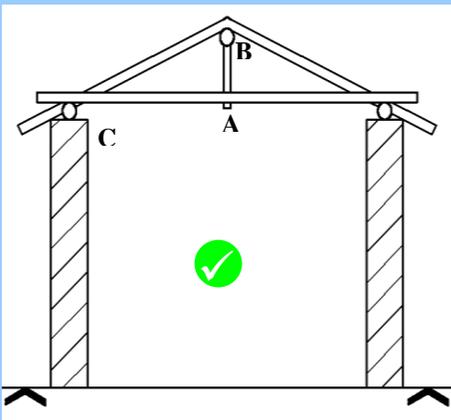
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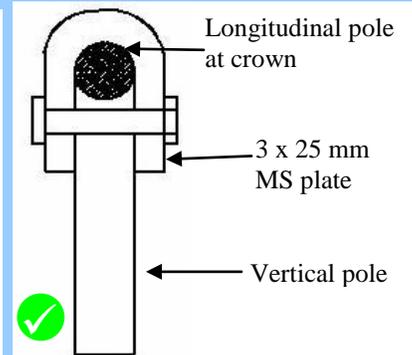
‘ABC’ OF CYCLONIC RESISTANCE FOR DWELLINGS/LOW-RISE BUILDINGS

- ❖ Anchorage
- ❖ Bracing
- ❖ Connections

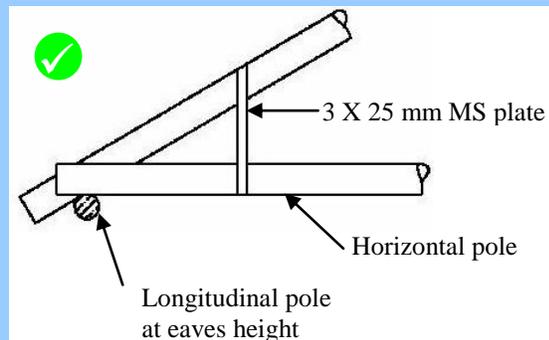
❖ Joints with retrofitting measures (for use in thatch roof dwellings)



JOINT - A (side view)

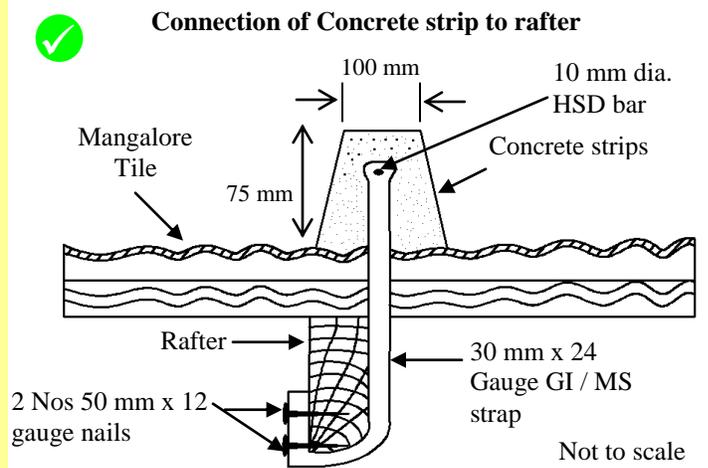
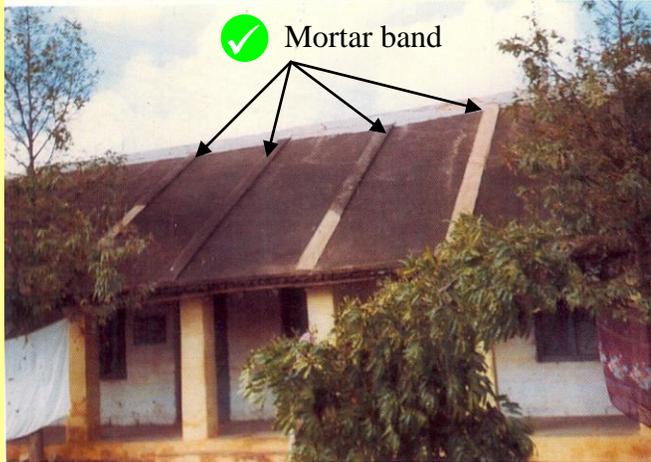


JOINT - B



JOINT - C

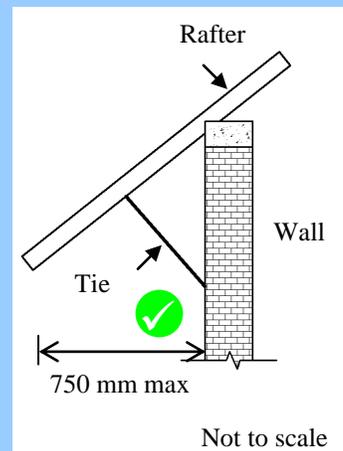
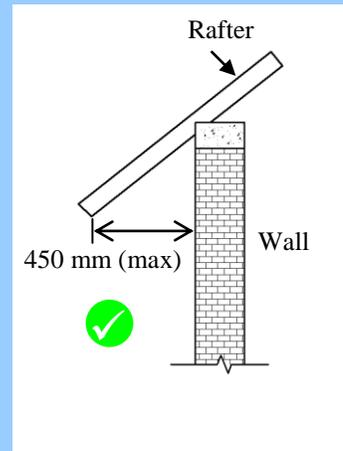
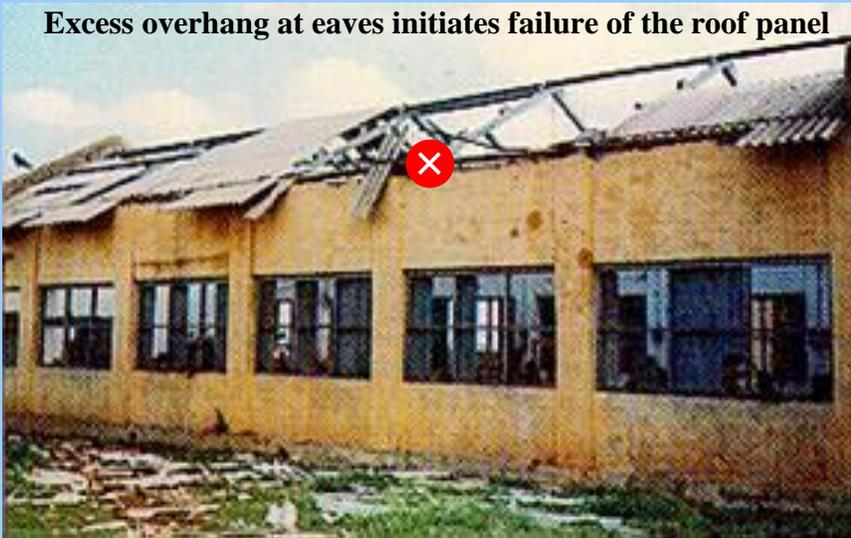
- ❖ Remedial measure by providing mortar bands / concrete strips for tiled roofs



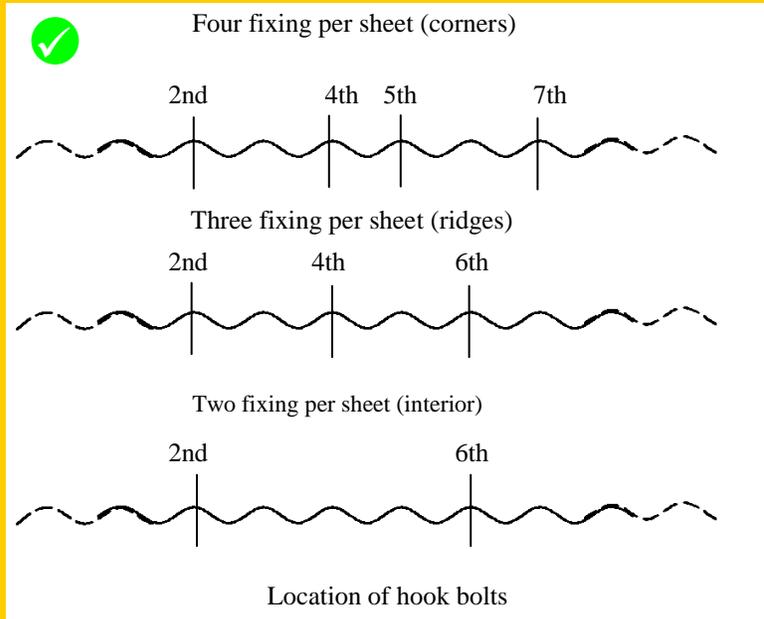
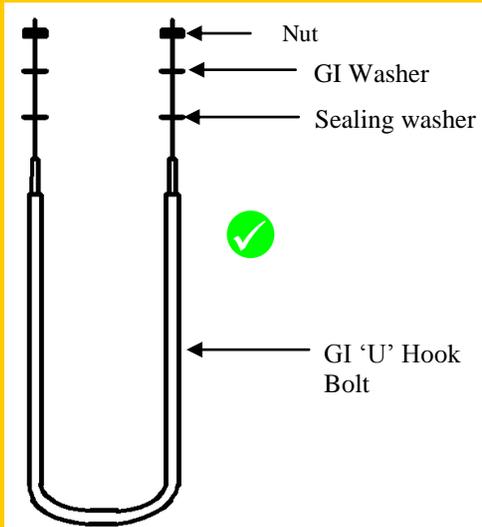
Improvement to tiled roofs to reduce damage to roof due to cyclones

- ❖ The overhang at eaves shall not exceed 450 mm. In case it exceeds this value, the projected portion of the roof may be properly tied back to the wall frame work

Excess overhang at eaves initiates failure of the roof panel

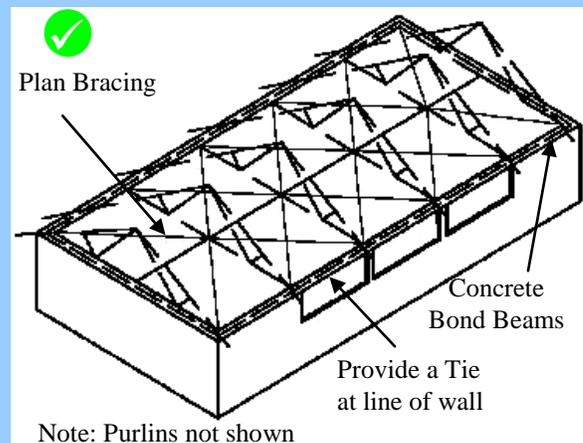


- ❖ Use “U”-bolt and washer assembly in place of conventional ‘J’-bolt connections between cladding and the purlins. Provide additional numbers of ‘U’-bolts at ridges and eaves compared to interior region



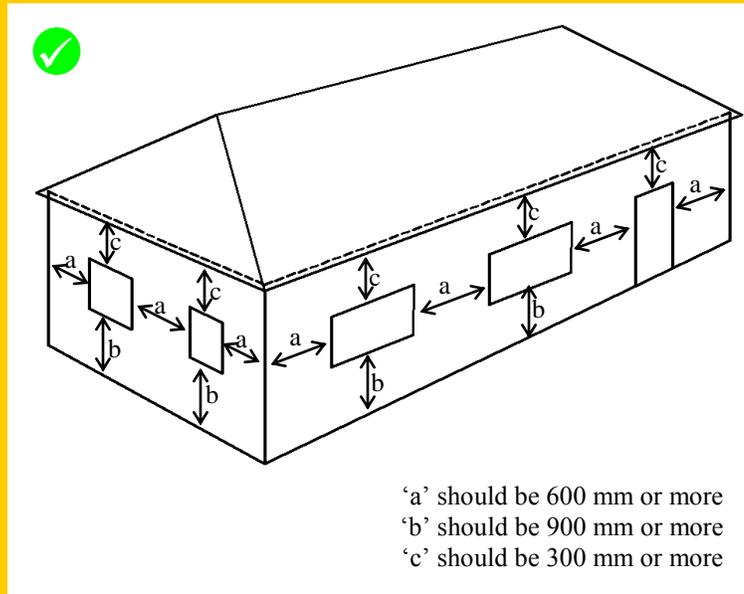
Detailing of U-bolts for roof cladding sheets

- ❖ Provide Plan bracing at the bottom chord level of trusses to avoid bottom chord buckling due to uplift force as well as to distribute the horizontal loading from gable ends
- ❖ Upper chord bracing is also to be provided (not shown in figure) near gable end walls
- ❖ Provide a continuous R.C.C bond beam over the walls to improve the lateral resistance of the supporting brick walls



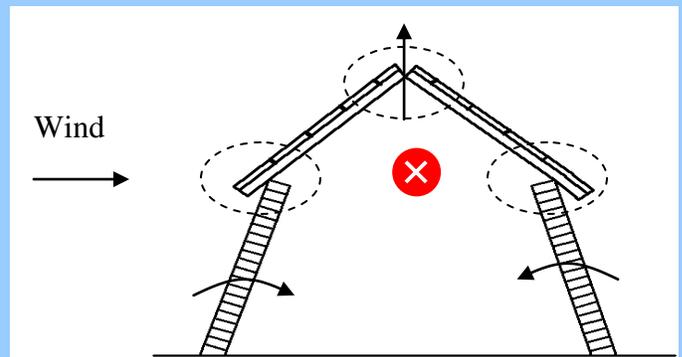
Provision of Wind bracing for Roof Trusses to improve Strength and Stability

- ❖ The opening near to the edge of a wall should be positioned with a minimum distance as shown



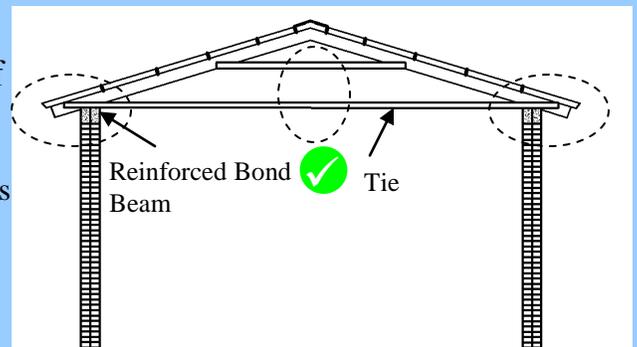
Minimum Distances between Openings in the Wall

- ❖ Many low-rise industrial buildings collapse due to failure of brick masonry walls. In order to improve their resistance to wind loading, the masonry walls may be strengthened by embedding reinforcement with sufficient rich mortar cover to prevent corrosion. The figures below show complete collapse of the masonry walls.



Suggested remedial measure – provision of

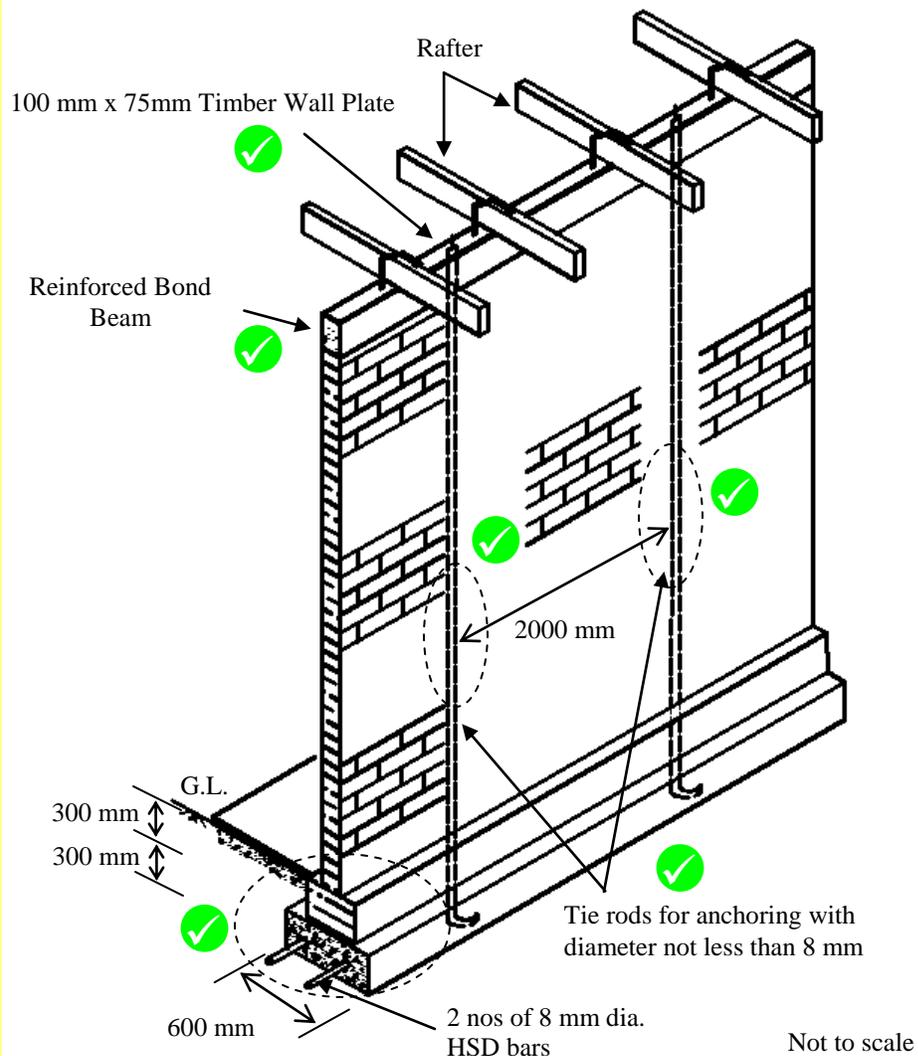
- (i) reinforcement in the wall,
- (ii) proper connection between roof and side walls
- (iii) ties in the roof truss



❖ Continuity of the Load Path

The main reason for the failure of masonry walls due to cyclonic winds is due to the lack of adequate lateral restraint. The masonry must be capable of resisting the lateral load acting both in-plane and out-of-plane in addition to carrying the vertical loads. The masonry must also be capable of resisting impact loads from wind-borne debris.

The continuity of the load path from the roof to the foundation in case of hollow concrete block masonry as shown below is essential.



**Connecting roof to the foundation using Tie-down bolts
(typical for a dwelling with plinth area of 15 sq. m (approx))**

For further details, please contact:

Director,
CSIR-Structural Engineering Research Centre,
CSIR Road, Taramani, Chennai – 600 113

Phone : +91-44-2254 2139

+91-44-2254 9201

Fax : +91-44-2254 1508

E-mail : director@serc.res.in

Website : www.serc.res.in