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How Houses Can Better Resist High Wind

Abstract

This guide presents to designers, builders, government and private building authorities, and building owners and occupants a series of effective methods for improving the resistance of new and existing buildings against high winds. The methods described may be applied to improving the construction of new buildings as well as to increase the wind resistance of existing buildings. This material offers guidelines for selecting the location and orientation of buildings and the building shapes, for suggesting methods of construction, for recommended building details, and for local production of connectors and fasteners. It covers two common types of construction—masonry and timber—as well as selected details based on local materials such as bamboo and adobe.

Key Words: Architecture; buildings; connectors; design criteria; fasteners; wind.

Introduction

These guidelines and illustrations are offered to help local government housing authorities including builders, designers, owners and occupants of low-rise buildings in developing countries subject to extreme winds to improve the resistance of their buildings to high winds.

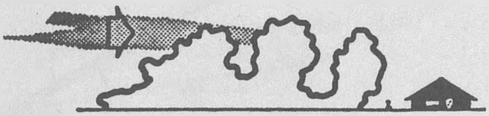
Government and private building officials are encouraged to use this information as a basis to stimulating awareness of bases for improved local building practices, and to translate the text of the report into the local language as needed.

A poster also has been developed that illustrates several critical principles of wind-resistant design and construction practice and identifies a local country point of contact for additional information. The purpose of this poster is to inform the general public of the importance of better building design, need for improved construction practices and identifies where such information may be found.

These findings stem from a project that produced design criteria that would lead to improved performance of low-rise buildings especially in developing countries subjected to extreme winds. The project was sponsored by the Agency for International Development and carried through by the National Bureau of Standards, Center for Building Technology, in the belief that additional research on wind was needed to reduce loss of life and property, human suffering, disruption of productive capacity and costs of disaster relief.

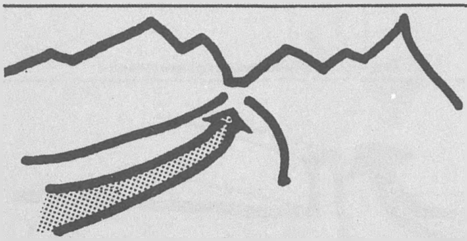
This report is based in part on the technical results contained in the National Bureau of Standards Building Science Series 100: *Building to Resist the Effect of Wind,* Volume 3, "A Guide for Improved Masonry and Timber Connections in Buildings." All five volumes of BSS 100 together or separately are available from the U.S. Government Printing Office, Washington, D.C. 20402 or from AID Missions.

Site

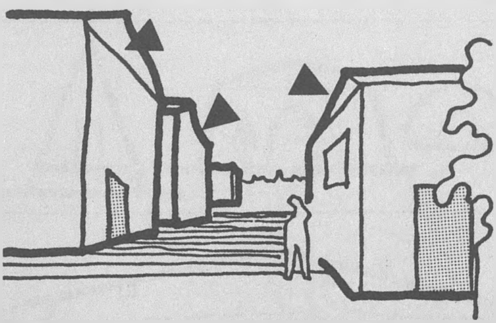


1. In locating a house take advantage of natural windbreaks such as stands of trees, small hills or hedges to reduce the impact of prevailing winds.

2. Be especially careful of sites on or near tall hills. These can increase wind speeds by as much as 50 percent.



3. Valleys funnel winds; they can create abnormally high wind speeds. Consult an engineer or weather station official before building on such a site.

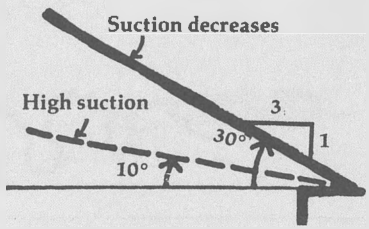


4. Buildings placed near one another can affect wind speeds. Intense suction can develop on the gable ends of pitched roofs. If the building is in the wake of another, expect turbulence and some high local loading on small elements such as cladding. Be sure these elements are securely fastened.

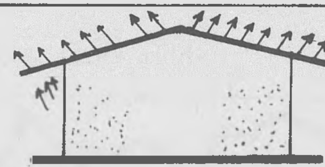
5. When building a windbreak or shield, such as a row of trees or a wall, include small gaps to stabilize the flow on the lee side.

Shape of the Building

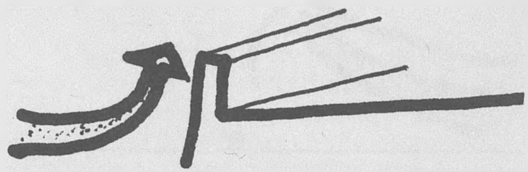
6. Aim for roof pitches that approach 30 degrees (or about 1 m in 3). Wind loads are severe when roofs are pitched around five to ten degrees.



7. Avoid outside overhangs of more than 0.5 m, even if supported at the edge by columns. If unavoidable, consider vents or louvers to relieve the upward pressure.

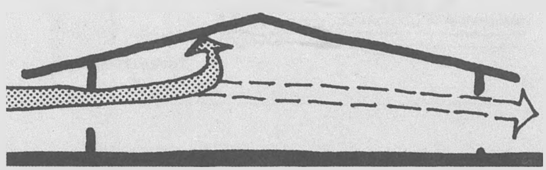


8. A parapet around a roof can reduce high suction along roof edges, but don't expect it to significantly reduce overall roof uplift.



9. Consider round or polygonal shapes as these often reduce wind pressures. Similarly, certain structural systems, such as the A-frame, provide great stiffness.

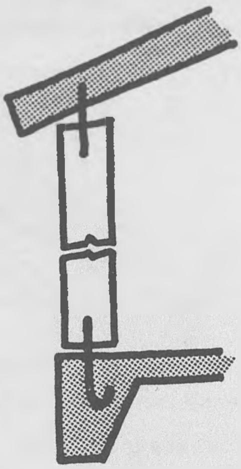
10. Avoid openings that cannot be closed off during hurricanes. High winds penetrate the building and create high outward pressures on walls and roof. If a broken window admits high wind, arrange for openings on opposite walls to relieve pressure build up.



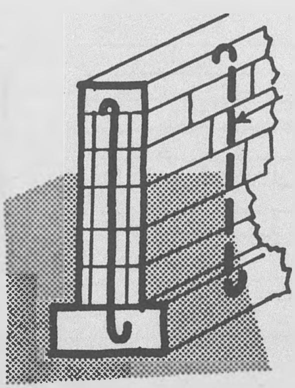
11. Avoid large wall openings near the roof-line as this will weaken the ability of roof to distribute loads to the rest of the structure.

12. Recessed building sections and courtyards may aggravate the effects of high winds. Consult an engineer if possible.

Construction



13. Make sure that all elements of the house are securely tied together, from foundation to roof.

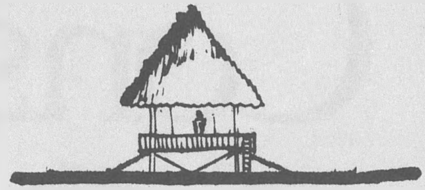


14. Place masonry blocks on a continuous concrete footing in a trench. Avoid placing masonry blocks directly on the ground, as this will make your building settle unevenly, causing wall cracks and openings for wind to penetrate. In extreme cases uneven settlement may bring about building collapse.

15. Whatever the structural materials, be sure to anchor them solidly to the foundation, using dowels, reinforcing bars, tie-rods or other connectors suited to the material. Embed anchors at least 25 cm into the footing.

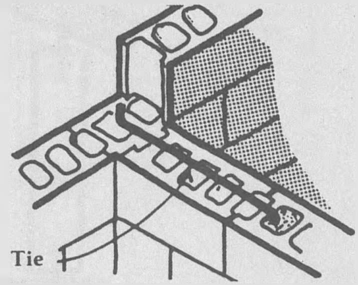
16. Anchor masonry walls and piers to the foundation with 15 mm rods spaced (in case of walls) not more than 2 m apart.

17. If a floor is raised off the ground and supported on posts, piers, or pilings, anchor the corners to the ground using galvanized steel anchor pipe.



18. Tie corner columns or posts securely to adjacent walls, using tiebars and/or horizontal reinforcement.

19. Make intersecting walls continuous by means of tiebars and/or horizontal reinforcement that extends into neighboring walls and partitions.

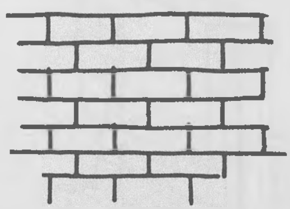


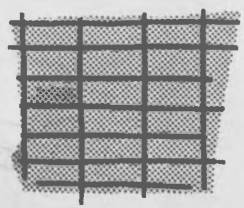
20. Keep wall openings small at corners so as not to weaken the structure.

21. Protect glass with louvers or other means to avoid breakage by flying debris.

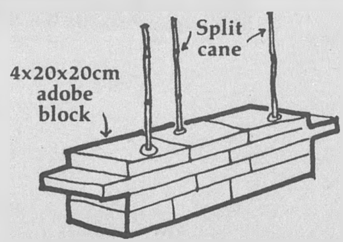
22. When using infill wall construction, be sure to tie vertical and horizontal reinforcement securely into the adjacent structure and foundation. Use 8 mm bars with end hooks.

23. Use running rather than stacked bond when building with masonry.


Running bond

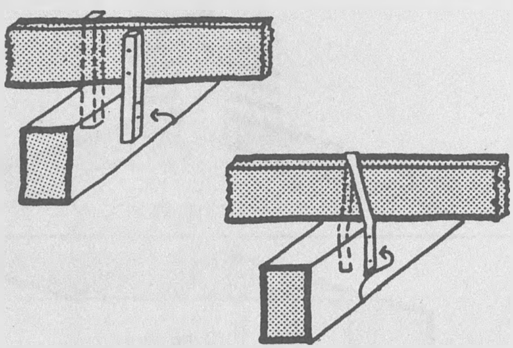

Stacked bond

24. To control cracking, reinforce brick, concrete block, adobe or other masonry block construction internally using metal rods, split cane, bamboo or other ties embedded in grout. Be sure to maintain a tight bond between the reinforcement and the surrounding material.



25. Ensure positive connections between door and window sills, posts and lintels and the walls in which they are placed.

26. Near the ocean or other corrosive atmospheres, protect metal reinforcing bars, ties and other connectors from corrosion by covering over with a waterproof material.

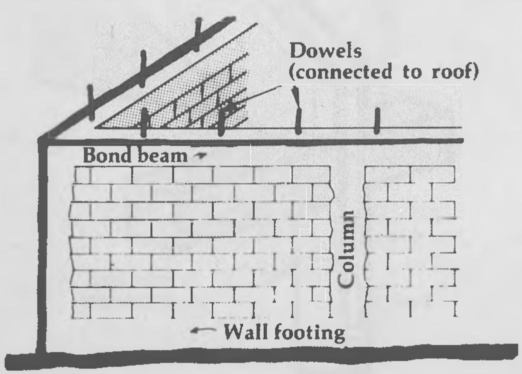


27. To resist twisting of timber joints, use connectors in pairs, one on either side of the members being joined or tie with a metal strap.

28. Avoid flexible joints as they are subject to large displacements under lateral or uplift loads.

29. Avoid using mortar alone to fill small uneven wall openings. It is better to cut masonry units to fit these openings.

30. Insist on high quality masonry. For example, adobe may be made to better resist abrasion, heat and water by stabilizing it with rapid curing road-oil or an asphalt emulsion.



31. When building with masonry, use bond beams to connect all load bearing elements.

Roof

32. Be sure to tie the roof securely to its supporting walls or posts. Ignoring this caution is the single greatest cause of destruction due to high winds.

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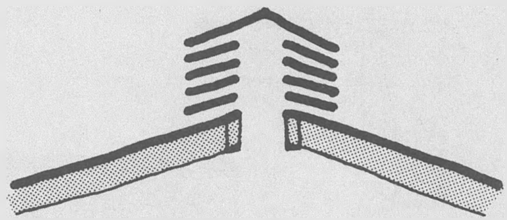
33. Consider ventilation slots placed at the ridge. These are very effective in reducing the internal pressure and thus decreasing total uplift on the roof.



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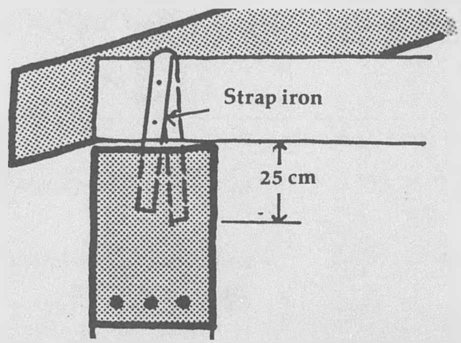
34. When connecting a timber roof to a masonry wall, extend the fastener strap over and around the roof joist. Nail it to the joist and embed the ends in the concrete or masonry to a depth of 25 cm.



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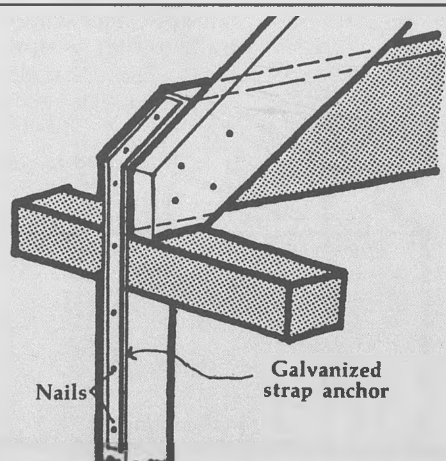
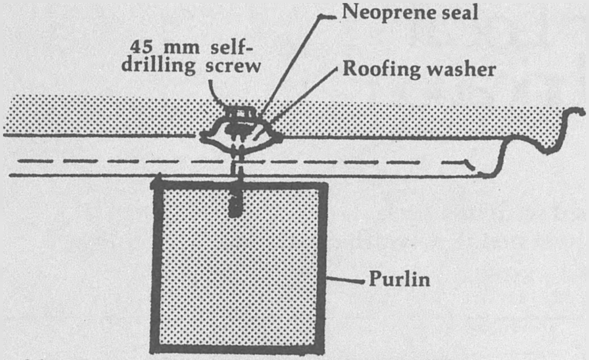
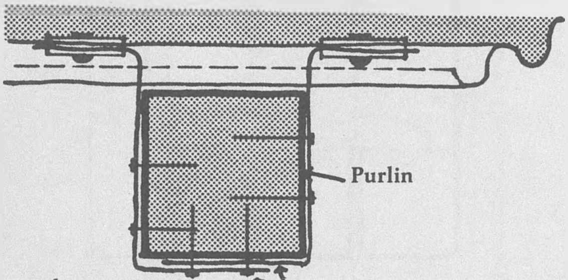
35. Tie roof-framing to timber walls with sheet metal straps or brackets or wood cleats. Nail straps to members, being sure to drive nails laterally, not in direct pull.



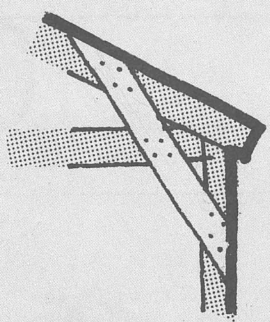


36a.



36b.

36. When using screws to attach a corrugated iron roof to wood purlins, use self-drilling screws if possible, spaced no more than three corrugations apart, with a screw head or washer of at least 20 mm in diameter. For regions of intense uplift pressure, the screws should be placed no more than two corrugations apart. If sheet metal straps and rivets are used, wrap the straps completely around the purlins.



37. For extra bracing against racking and uplift of a wood frame wall and roof, consider a continuous diagonal timber brace nailed to wall studs, joist and rafter.

38. Choose and attach the roof cladding with great care. Cladding dislodged by wind can set off a chain reaction that will quickly destroy the roof's stabilizing function. Protect perishable cladding such as thatch, and replace damaged portions.

Hints for Local Fabrication

39. Sheet metal straps may be easily fabricated with few tools. Use a minimum thickness (20-gauge) galvanized sheet metal. A width of 30 mm and a length of .5m suits many applications.

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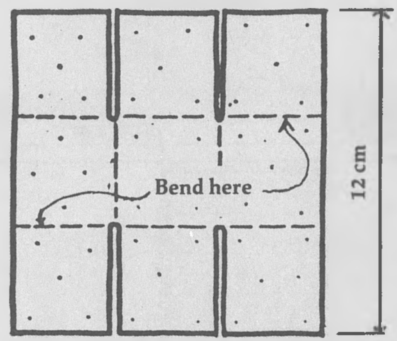
40. A multipurpose bracket can be fabricated from 20-gauge galvanized steel sheet. Dimensions can vary. Slits cut in the sheet metal permit forming the bracket for a variety of uses.



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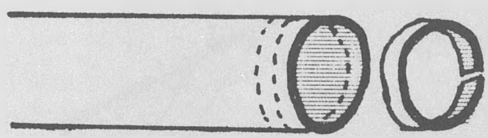
41. Split-ring connectors for roof trusses may be fabricated by cutting 20 mm wide sections from 75 mm diameter steel pipe, and then cutting the ring at an angle.



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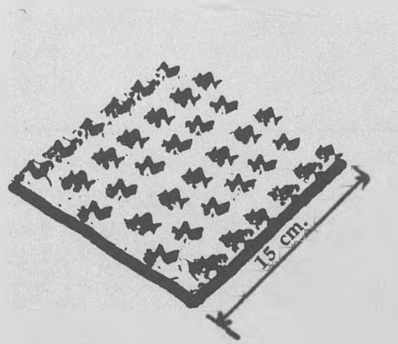
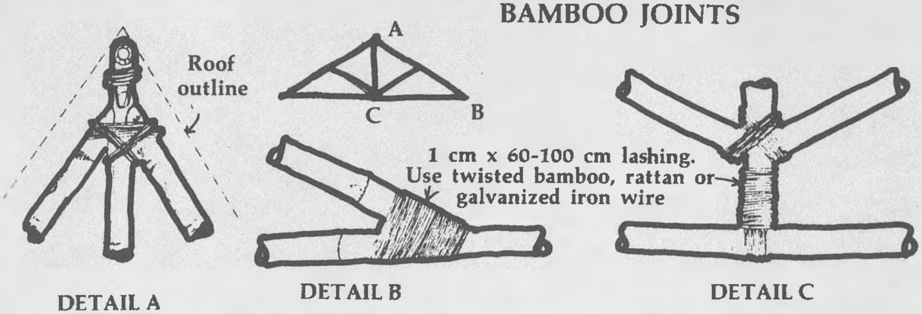
42. Metal plate connectors for truss joints may be fabricated locally, usually from 20-gauge galvanized sheet metal. The sheet metal is punched in a way that produces barbs or teeth at right angles to the plate.

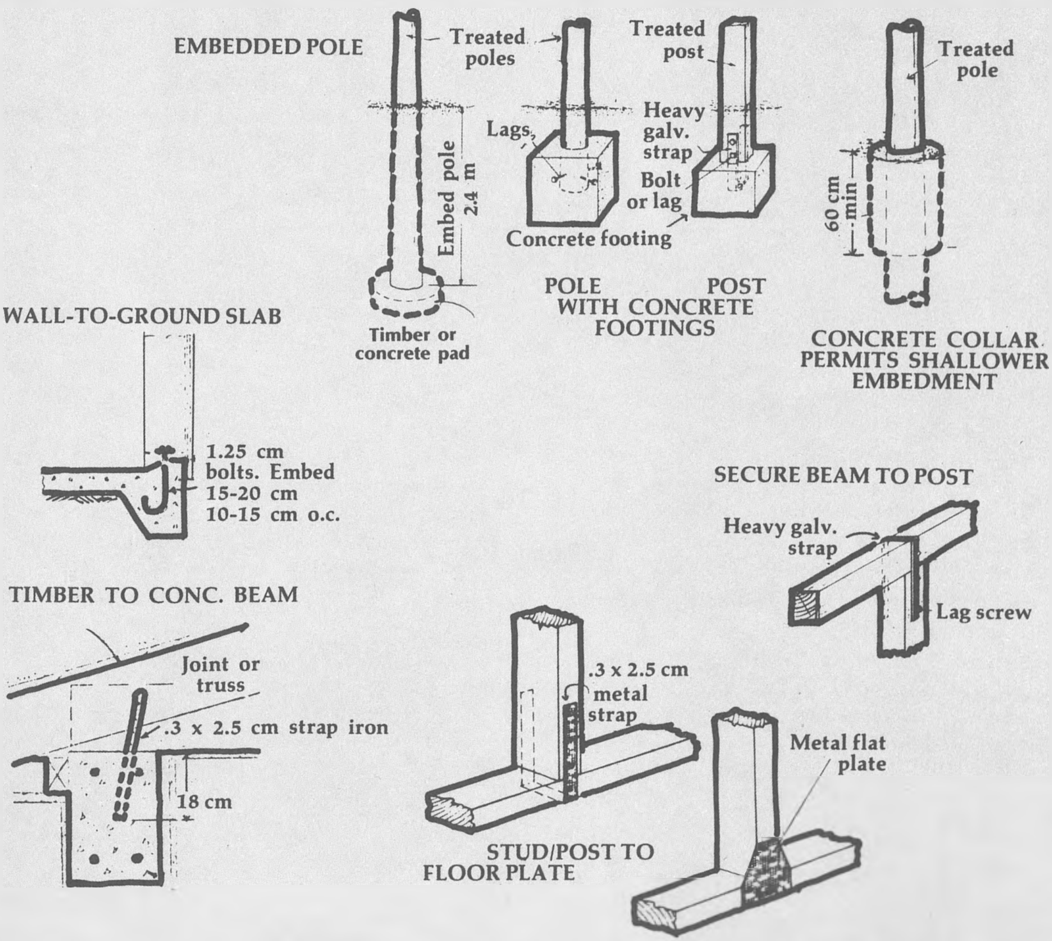


43. These additional connection details may be used with variations as needed for the requirements of each case.

Bamboo details drawn from the free publication "The Use of Bamboo and Reeds in Building Construction," Department of Economic and Social Affairs, United Nations, New York, NY, Catalogue No. ST/SOA/113.

BAMBOO JOINTS





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