CYCLONE RESISTANCE CONSTRUCTION

BY

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A. THE EASY SOLUTIONS

As soon as a cyclone strikes a community and the subsequent damage reports are published we are faced with a litany of what we should not do in future development.

Some of the quick and easy solutions offered are:-

Avoid roof overhangs	-	Lose your shade.
Avoid flat roofs	-	Pitch all roofs at 30°
Avoid large windows	-	Sweat all summer and buy paintings to look at.
Avoid wave surges	-	Build in the hills.
Avoid exposed sites	-	Don't build in the hills.
Don't use Aluminium, Fibre cement or galvanized iron	-	Build everything in Concrete.
Don't use nails or glue	-	Bolt everything to the floor.
Don't build near the sea	-	Live on a farm.
Don't build near trees	-	Cut them down.
Don't have roof penetrations	-	Have invisible vent pipes.
Don't have fancy roof shapes	-	Live in a box.

AVOID CYCLONES - LIVE IN A CAVE AND DESIGN FOR ROCK SLIDES.

and so it goes on.

If we react in the easiest management-orientated way in trying to find quick solutions to all of these problems, we shall all end up living in a concrete box 4m x 4m x 3m with a 1m x 1m window.

In adding professional involvement, a significant improvement can be achieved and a 5m x 3m x 2.5m box with a 3m x 1.5m window and patio provided to improve the living conditions.

Proper, well considered solutions must be developed to all of the problems confronting us so that the future population has an economical choice of solutions to allow the flexibility that is so necessary to maintain some individuality and comfort.

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We must develop a number of solutions to each problem.

The solutions must be economical and practical.

The results must be acceptable and attractive additions to our environment.

B.1 PRACTICAL SOLUTION

In the development of a Cyclonic Resistant design theory, the designer must of course continue to service the desirable aesthetic and comfort motives in order to provide a satisfactory design solution to living in the Tropics.

However he must also provide himself with a list of security items to avoid the consequences of improper detailing and inadequate construction.

The following is a set of "Cyclone Resistant Design" guidelines for use by a designer in the course of designing Cyclone Resistant buildings. Before commencing the drafting of working drawings, reference should be made back to these guidelines to confirm all considerations have been taken into account.

B.2 SITE SELECTION

- identify site, location proximity to sea
- study future developments, viz, growth patterns
- establish terrain category
- is this likely to change in the life of the building?
- establish flood heights and possible surge levels
- is site a flood plain?
- is evacuation possible immediately prior to cyclone?
- study neighbours' proximity to proposed building construction and proximity to proposed building
- study extent and size and rate of growth of trees in immediate vicinity
- advise of possible effects of damage by debris from both trees and neighbours' properties
- where near rivers and open spaces, estimate effects of micro-turbulence and effects of wind patterns

B.3 LANDSCAPING

- study topography in immediate vicinity
- can advantage be taken of mounds etc. to give protection or reduction in wind loads?
- can trees be planted that are more resistant to fracture and collapse?
- can tree foliage be easily pruned to reduce wind effects?
- well located screen walls can break-up wind patterns and act as debris barriers

B.4 FLOOR LEVELS

- study topography and drainage in storm rains to determine flood-free floor levels
- evaluate implications of number of floor levels needed; one, two or split levels
- rises in height introduce higher wind loads

B.5 WINDOWS AND DOORS

- check size and loads to be carried
- design frames and their connections to walls to transfer loads
- consider implications of broken windows
- are openings on opposite walls able to tunnel wind without affecting other areas
- should shutters be used
- evaluate economy of storm screens
- louvre blades leak under pressure and may reduce design wind load
- resolve conflict of wider windows for views and smaller windows for safety

B.6 STRUCTURE

- design for structural integrity
- consider a structural grid system of posts and beams to provide stiffness
- keep structural systems simple
- consider extent of vertical supports internally and in large open areas
- examine large spans and cantilevers
- make decisions on purlin/rafter spacings

B.7 SHAPE

- consider shapes to be adopted
- can roof profile be designed to transfer wind loads more evenly over whole roof?
- advise where roof projections and shapes cause local turbulence - e.g. vent pipes, sharp direction changes, out-riggings etc.

B.8 GENERAL PLANNING

- consider posted verandas to catch or deflect debris
- check interior half-height walls and their stiffness
- good interior cross ventilation can be an advantage
- consider permanent sheltered exterior vents in walls
- stiffen structure around most secure rooms
- disposition and planning of internal spacings should fit into the structural system or vice versa

B.9 COSTS AND ESTIMATES

- evaluate costs of alternative solutions
- are bolts cheaper than metal connectors?
- if post and beam structure is used, are timber studs able to be reduced in size to develop matching economy?
- are grilles on windows cheaper than shutters, and do they give adequate protection?

B.10 SELECTION OF FINISHES

- are wall and ceiling linings suspect when wet and if they lose stiffness, can the remaining structure maintain its stiffness?
- is it wise to place carpets throughout and up to windows where water leaks can damage carpets?
- are external walls debris resistant?
- is there adequate bracing in wall planes, ceiling and roof planes and in internal partitions?
- select type of wall cladding

B.10 SELECTION OF FINISHES

- check higher pressure areas at walls and roofs near corners and profile changes
- check spans of roof cladding with manufacturers
- check type of sheeting, thickness and fixing
- are secret fixings to roof sheetings adequate or are screw fixings needed in addition?
- check that manufacturers instructions match terrain category of site
- check windows selected and glass size and thickness to match pressures to be resisted

B.11 DETAILS

- check door and window frames and their fixings into walls
- check weak joints such as half-height wall with windows above where joint of vertical cantilevered wall and window needs stiffness to resist breaking or overturning
- check door stops and fixings to frames
- check strength of window catches
- check flashings to roofs and ensure adequate fixings are provided
- loss of flashings often leads to degradation of adjacent material
- parapets should be reinforced
- tying-down of roof members should extend down into foundations in a single element or at least in a straight line
- there are technical details available to fix windows into frames but the actual fixings are seldom made correctly
- details of fixings of structure and claddings at edges and corners is very important

B.12 CLADDINGS

- when selecting claddings for walls and roofs examine thickness of material for the proposed use
- examine manufacturer's instructions and verify that they are suitable for the job
- check method of fixing
- check type of fixings used: Nails, screws, etc.
- check number of fixings required
- verify that the material selected is suitable for the job
- does the material have any debris resistance?
- what happens to the material when it breaks?
- does the material add stiffness to the frame?
- does the material still have strength after breaking?

B.13 CODES

- designers should maintain a continuing subscription to relevant code suppliers and other trade publications
- office libraries should be kept up to date with current codes relating to work done by office
- note performance of code requirements in practise so that better alternative solutions may be fed back to the code authorities

C. DESIGN CONSIDERATIONS

General problems to be considered in the construction of roof claddings, especially in cyclone areas, are:-

(a) The designer should understand the actual performance characteristics of each material.

(b) The designer should understand the code requirements in relation to design loads.

(c) The designer should specify clearly and concisely what fixing details and workmanship are required of the contractor.

(d) The contractor should be familiar with and supervise the installation. He should also keep his codes up-to-date.

(e) Specialist subcontractors should act similarly.

(f) The designer should inspect works under construction to ensure that performance matches specification.

D. CAUSES OF FAILURE

While the comments appear to cover relatively simple points, it is surprising how often they are not carried out.

Non performance can be caused by:-

(a) Lack of design and instruction and loose specifications caused by pressure of work, lack of in-service training and use of out-of-date code information.

(b) Transport difficulties due to distance and incorrect ordering, cause compromising decisions to be taken with or without reference to manufacturers or designers.

(c) Trimming of cladding to suit roof dimension. This often causes weakness in fixings at roof edges where uplift forces are greatest.

Lack of manufacturers' instructions for these edge conditions which occur in a large percentage of projects. In particular, I refer to fixing instructions along barges of roof areas.

(d) Lack of performance by some fixing contractors, often caused by volume of work, type of contract with head contractor where head contractor issues specific instructions which may not be in accordance with codes, use of incorrect fixing screws or clips, or insufficient use of fixing screws or clips.

(e) Deterioration of roofing timbers holding fixings.

(f) Damage to the sheeting by flying debris.

(g) Screws failing due to torsion where screws are not driven plumb. This type of failure is more likely with high rib profile sheeting (35mm or more) where screws selected may also be too short.

CAUSES OF FAILURE (Cont'd)

(h) Shifting of the cladding along the roof. Often called "creeping" this defect can occur during installation of sheet roofing, resulting in clips and fastenings having to transfer eccentric loads to the supporting frames.

(i) Difficulty of providing adequate fixings in awkward locations, such as projections through roofs for manholes, changes in structure, roof timber bracing etc.

(j) Difficulties in combining heat insulation foils on the tops of the framing members with the fixings required in cyclone areas. This problem occurs with some pan type sheets and with tiled roofs.

It also prevents inspectors and roof fixers from viewing the roof from the underside, and prevents positive inspections that are needed to ensure that underclips are correctly fastened.

(k) Screw fixings being over-driven to cause fracture of neoprene sealing gaskets. Further investigation of the long-term life of sealing gaskets, especially in hot climates, is also required to ensure that these sealing units are effective in preventing water entry.

(l) Deflection in purlins and battens.
Undersized supporting timbers cause problems when live loads are applied during maintenance. The excessive deflection so caused loosens nail and screw fixings, allowing water entry and weakening fasteners.

These problems will affect corrugated asbestos cement and galvanized iron roofs and weakens the fixings.

(m) Lack of restraint between fixing clips and pan type roof sheets. Insufficient clips or nailing.

(n) Lack of attention to fixing of flashings at ridges and sides of roofs.

Often these flashings are left by the fixer after the roof is fixed and completed at a later date, and there is a tendancy to "rush" the completion.

The flashings are often only pop rivetted to the sheeting and "pinned" to the bargeboards, which is totally inadequate.

Medium wind loads may remove poorly fixed flashings and expose the open ended roof. Once this occurs, roof sheeting is more liable to fail.

Nailing or screwing of flashings at close centres is essential, and these fixings may be required on both the vertical and horizontal plane, where flashings are carried across roof sheeting and turned down over bargeboards.

CAUSES OF FAILURE (Cont'd)

(o) Debris attack: Debris can fracture brittle cladding materials and window glazing leading to internal pressurisation of buildings. This can double uplift forces on roofs and outward forces on walls. Debris attack can also destroy the capability of some cladding materials to act as shear walls.

E. SUMMARY

The majority of homes in Fiji are designed by draughtsmen and building consultants. In many cases where structural engineers have become involved it has only been to check certain components such as slabs, columns or beams, and not the overall structural integrity of the completed building. Cyclones Eric and Nigel have drawn our attention to the fact that the structural performance of small buildings is as important, perhaps more important than the performance of large buildings. The socio-economic cost of large scale damage to a whole community of small buildings in a single event justifies a high priority on building safety.

The present trend in homes being designed by non-professional people will continue in Fiji. It is therefore essential that these designers be provided with appropriate Deemed to Comply drawings which will enable them to improve the quality of plans produced by them. It would be wrong to assume that because buildings are small they are unimportant and therefore lower standards of engineering and safety can be used.