Rachel Coninx
Conference Executive
IDNDR Conference
Institution of Civil Engineers
George Street
London SW1P 3AA
Angleterre

22nd March 1993

your ref: 190/SAW/DISASTER/0074

Dear Ms. Coninx

IDNDR Conference - Natural Disasters Protecting Vulnerable Communities, 13-15 October 1993

Further to your letter of 15th March 1993, I have pleasure in enclosing two copies as requested of the paper I hope to present at the above conference.

Yours sincerely,

John Norton,
Director.

PROMOTING PRINCIPLES FOR BETTER TYPHOON-RESISTANCE IN BUILDINGS. A CASE STUDY IN VIETNAM.

John Norton, Development Workshop, and Guillaume Chantry, GRET

Summary

There is no one solution to safe housing, but there are strong basic rules one can follow for making one's building safer. Making people aware of how they can achieve this - more easily and more cheaply than many think - takes time, and motivation is as much a factor as money. But the process is slow, and projects need time to achieve results that can be sustained and repeated.

1. BACKGROUND

1.1. The problem and context

Almost without fail each year typhoons sweep across the coastal plains of the central and northern areas of Vietnam, leaving behind them a trail of loss of life, massive destruction to property and infrastructure, and wastage of crops. In the aftermath of each typhoon, the population and the authorities mobilize to rehabilitate their region. Scarce resources of materials and money are consumed in the effort of reconstruction and relief: the same resources that could be far better used for the development of the region, where at present many subsist on rice and fishing. In effect the rehabilitation effort acts as a major break on the region's development efforts and capacities. Reducing the damage to buildings would thus make a major contribution to an overall improvement and development of living conditions, as well as allowing people to return as quickly as possible to normal living conditions. Damage prevention is thus an essential part of development action.

In the case of houses and public buildings of these coastal regions, much of the damage could be reduced, and in the case of minor typhoons even avoided, if only preventive steps were taken to make the buildings stronger and less at risk from typhoon damage. To do so, far less effort and money is required than gets used up in the annual reconstruction effort. Sadly, action to safeguard the home is often only done at the very last minute, or once the storm is already there.

In October 1985 two very strong typhoons struck Binh Tri Thien Zone, (which was divided into the three provinces of Quang Binh, Quang Tri and Thua Thien-Hué in July 1989), in central Vietnam. Local authorities reported quite severe damage: 875 persons dead, 49,000 houses destroyed, 230,000 houses damaged, 2,600 classrooms destroyed or damaged, 6 hospitals and 250 health centres damaged. A UNCHS mission in March 1986 highlighted the fact that the most affected buildings - in terms of damage, loss of materials and difficulty in reconstruction - were the 'transition' houses - those neither

traditional nor totally modern, but using a mixture of whatever materials and techniques people can afford - and small communal buildings. The mission also noted that what engineering know-how existed at national and provincial levels was not available to the builders most directly concerned with all types of building.

A UNDP proposal was made to provide funds for a three-project 'package' of assistance, with the Vietnamese Government, aimed at reducing damage in the future: improvement of flood/typhoon warning in Binh Tri Thien Zone; telecommunication facilities for flood forecasting and warning in the Zone; and demonstration of storm resistant building techniques the Zone. It is the third of these which this case-study describes (ref. 1).

1.2. Initial objectives

The overall objectives of the 'demonstration of storm-resistant building techniques' project were defined as attempting to address the situation identified in the UNCHS mission, through the organization of housing and small building vulnerability workshops. These workshops were to initiate activities to inform the local authorities and the public about measures that can be taken to reduce the impact of natural disaster on physical structures. A parallel objective was to assess the feasibility of replication of the programme and the techniques proposed at provincial and national level.

The outputs originally called for a series of training workshops for builders on how to build more disaster resistant houses and small buildings, linked to the construction of several demonstration prototypes. Simplified, illustrated building manuals for the use of local builders were to be produced. Results were to include local builders better trained in typhoon resistant building techniques, greater awareness amongst government institutions and departments on housing disaster preparedness, and provincial and national action plans for the establishment of a permanent capacity to implement a housing and small building vulnerability reduction programme.

In the event, considerably more was achieved, with a perspective to a more long-term sustainable programme.

2. TYPHOON-RESISTANCE OF EXISTING BUILDINGS

2.1. Overview

The majority of buildings in Binh Tri Thien Zone are small Development Workshopellings with adjoining buildings for kitchens, selling, workshops and animal sheds. Apart from a few contemporary major public buildings (notably in Hué) many of the public buildings use forms and methods similar to those used in the smaller domestic building, and, from the point of

view of storm resistance, present similar strengths and weakness. Most buildings, whether modern or old, can be considered primarily in terms of a supporting framework holding up the roof. The walls are in most cases light-weight, and often contribute little to the structure. From the viewpoint of typhoon resistance one can identify three main "families" of construction: the traditional buildings; buildings with a mixture of materials and techniques - the 'transition' house evolving towards the 'modern' dwelling; and the local public buildings in the districts of each province. The latter two are today jointly characterized by poor detailing and frequent poor quality, and since they increasingly represent the contemporary building stock of the areas, they are a major preoccupation for typhoon resistant construction.

Traditional buildings typically survive typhoons much better, and some contemporary larger public facilities survive well too. The frail thatched houses of the poor are rapidly destroyed, and although these are the people it is hardest to help with protection, their homes are nevertheless in general quite quickly repaired.

2.2. Traditional buildings

Traditional buildings, whether on the scale of the palace and the tombs and temples in the area or that of the house, exhibit quite consistent characteristics: a framed structure formed by many substantial heavy wooden posts and short span beams, the whole held together by finely executed mortise and tenon joints. The roof, often with hipped ends, is an integral part of this vertical and horizontal framing. Between the structural elements the walls are filled in with a variety of materials, ranging from wattle and daub through to fired brick or timber shutters. On older tiled roof buildings it is common to see exposed masonry ribs which help hold down the roof covering.

The combination of good jointing, small structural units and large timber sections give the traditional building structural integrity and stiffness, and these make traditional buildings very able to resist typhoons.

Today increasing scarcity of timber has pushed costs up, making the construction of a traditional house very expensive: nevertheless, one still finds the traditional beautifully executed timber frame used in new houses, where it is regarded as a fine status symbol. Sadly, the quality of wall cladding and roof covering are not always of similar standard, and this is but one example of the second category of houses and public building in the area: the transition building.

2.3. Contemporary habitat: the 'transition' building

Today, a much wider variety of materials and techniques of building are employed than in the past, some of which are the

hybrid forms of traditional building, others attempts to apply new techniques or to use new materials such as reinforced concrete, often without the necessary skill to do it well or the money to get things right. Others depend on using locally available grasses and bamboos. The construction of most houses is an ongoing process: with the difficulties of acquiring materials the various parts and elements that make up the building are often linked together in a haphazard manner, more influenced by what is available at the time than by what might best protect and secure the investment that is being made. These buildings are characterized by the weakness of the joints between elements, which thus easily fail; and by the increasing lightness and lack of rigidity in the structure and cladding, offering less resistance to high wind pressures. One sees 10cm thick masonry walls held by lime mortar with nothing to give them stability; or tiled roofs supported on flimsy structures where there is little to inhibit the tiles being blown off the roof. Everyone would like to achieve a local version of the 'modern house', epitomized by the use of a reinforced concrete frame and a flat concrete terraced roof: but in the meantime the step by step investment that is made in materials such as tiles, bricks and cement is at high risk from the frequent typhoons. Moreover, the execution of buildings even with good quality materials is becoming so bad that little resistance is provided against the effect of high winds. This is just as much a problem with small and medium sized public buildings as with domestic 'modern' construction.

2.4. Public buildings

Public buildings, although designed by technicians, are just as much at risk to storms. The weakness in detailing and execution are compounded by the design of the buildings: a trend towards high unframed structures, the use of gable end walls with little rigidity, large verandahs where the roof is greatly exposed to uplift. The effect of Typhoon Irving in 1989 typified this problem, with the major collapse of hospitals and schools in the Thanh Hoa province.

3. COSTS AND PRIORITIES

3.1. Costs

Even buildings little able to resist the effect of cyclones, are far from cheap. At 1989 prices, a thatch and bamboo frame structure cost 50,000 Dong/m2; a bricks and tile roof structure 200,000 Dong/m2, and a reinforced concrete structure with a concrete flat roof some 300,000 Dong/m2. Put these prices against the monthly wage of a local engineer, in the order of 45,000 Dong/month, and one has an idea of the magnitude of the investment. The affordability of housing appears even worse for village farmers and fishermen. When one considers that this investment is scarcely protected against the damage caused by a typhoon, it is easier to understand the impact of the cost of recovery after a typhoon to families and the state alike; and to understand the necessity of investing

a bit more to make buildings and materials more secure.

3.2. Prevention or recovery?

Typhoons of varying intensity hit the Vietnam coast: small intensity 'yearly' typhoons, where damage should be small; medium '10 year' typhoons causing far more major damage: lighter buildings, notably those of thatch and bamboo walls, resist badly, and more solid buildings should resist better but invariably do not; and massive '100 year' typhoons which cause major devastation. The effect of typhoon winds for all but the frailest structures is progressive: in a medium typhoon, bamboo and thatch shelters frequently collapse rapidly under the initial buffeting of the wind. Damage to more substantial buildings comes in a sequences of events, where elements are weakened or loosened by pressure and suction: the tiles begin to lift on the eaves and ridges, the complete roof blows away, followed by the collapse of the roof frame. Walls are either flattened or carried off, depending on the structure. Rapidly, 70 or 80% of the building can be razed to the ground or blown away and 40 to 50% of the materials lost beyond recovery.

Against this cost and loss, comprehensive surveys carried out by project participants during 1989 and 1990 showed that an extra construction investment of 10% (on more solid buildings) to 30% (on thatch and bamboo shelters) would make most buildings able to resist small and medium scale typhoons. A major task of the programme was therefore to persuade people to spend time and money on preventive action in order to secure their investment.

3.3. Who builds and how?

Houses in the Binh Tri Thien Zone are built for the most part by local semi-skilled builders, employed in some capacity even in the simplest construction. The family invariably helps with the work too. Local materials are used for the most part. Little or no attention is paid to typhoon resistant construction details, and there are no applied regulations. When a typhoon arrives, last minute measures are taken to stop the tiles blowing off, or the walls collapsing, by which time it is often too late. Public buildings, designed by local technicians at provincial and district level, who carefully follow the rules for reinforced concrete design, have had habitually little attention paid to typhoon resistant detailing and form. The local building brigades and contractors who do the construction have often little contact with the designer, and pay even less attention to quality control: this sad state of affairs has become too often the accepted norm.

After a typhoon, the population and the province mobilizes in a major effort to reconstruct, but the quality of work that contributed to the collapse of the building beforehand is repeated: at the next typhoon the building will be just as

much at risk. Thus the cost of recovery is compounded by its repetitive nature.

4. DEVELOPMENT WORKSHOP/GRET'S APPROACH AND OUTPUTS

4.1 Overall approach

As well as workshops for local builders, Development Workshop and GRET chose to implement a programme which also integrated workshops and seminars for provincial decision-makers and construction technicians and those involved in information dissemination. All of these are concerned with improving the understanding about cyclone resistant construction methods, with their dissemination to the general public, and their application in public and domestic building and have a part to play in an Action Plan for promoting typhoon resistant construction.

As such, the aim of the programme was not to build houses for people, or (in the main) to train builders, but rather to promote the building of safer houses and public buildings by families and the local authorities alike, and bearing in mind the considerable diversity in the ways in which people actually build and can afford to build. (See sections 2 and 3 above.) The programme had to reflect this diversity, and propose ideas which would enable the widest range of the population to have access to them.

In practice, the programme developed around three main seminar/workshop sessions, culminating in an Action Plan in each of Binh Tri Thien Zone's three newly-formed provinces.

4.2 Demonstration buildings

In response to the call for demonstration buildings, each workshop was accompanied by the design and construction of a modest public building (a primary school, a health centre and library). Builders were trained both through the practical work on these and through their participation in workshops. (In total 42 technicians and 36 builders were trained.)

But in practice, although the demonstration buildings provided good ground for showing ideas and for raising the profile of the programme, they were far from considered to be the central element of the programme.

4.3 Learning through surveys and participatory work

The programme focused in a sense much more on developing amongst the participants an appreciation of that which exists already in local building practice, and going on to establish a link for the participants between the theory of engineered design and standards - rarely applied in local practice - and the realities of building construction in Binh Tri Thien Zone. Thus, each set of workshop participants themselves surveyed the local building characteristics to identify weakness and

potential strengths. These surveys were based on ten key points of typhoon resistant construction (see Illustration 1) put forward by Development Workshop/GRET and refined during the workshops. The surveys confirmed there were ample examples of good typhoon resistant design and construction techniques within existing building practices, on which to base recommendations for each individual province for domestic and small public building.

4.4 Technical dossiers

From these surveys in each workshop session for each province the participants produced illustrated dossiers serving as reference guides. Interestingly, the participants in the workshops rejected the idea of a technical building manual for wide dissemination, on the grounds that it would need to be very varied and complex unless it related to the specifics of a particular district or sub region, and thus difficult to use. Instaed they produced a short, clear document explaining the ten key points of typhoon-resistant construction, i.e. design principles rather than detailed building practices (ref. 2).

It should be noted here that once practical work on the sub-contract started, it became clear that technical knowledge about the realities of typhoon resistant building techniques was, at least at provincial level, much lower amongst technicians, with a few exceptions, than had perhaps been perceived at the time of the UNCHS mission, and that what knowledge there was had been highly theoretical, with little application on the ground. One important aspect was to draw attention to the cost of construction, for the average thatched house, for a transition building, and for local modern construction, and to estimate the extra cost incurred in making each type of building typhoon resistant. (See Illustration 2.) There had been little notion of what it would cost to make buildings safer.

4.5 Communication materials

The project was increasingly concerned with the exchange of information between technicians and builders, and the communication of techniques to the people in the province most directly involved with domestic building. Many locally applicable ways to communicate information about typhoon resistant construction techniques were explored, including using existing popular mobile video shows, and a variety of media were used aimed at various target groups: posters, videos, games, radio announcements, and a film, 'Our house resists the storm', starring a famous Vietnamese actress.

4.6 Public education campaigns

These materials were then used in two public education campaigns, which proved even more dynamic than might have been hoped, and which undoubtedly helped to raise the awareness

both of the general public, and of decision-makers and technicians amongst government departments and institutions.

In the first prototype campaign, held in a District (i.e. at sub-provincial level), local institutions mobilized included the People's Committee, the Technical Services, the school 'Red Cross' brigades; the Disaster Preparedness Committee, District mobile videos and the local radio service were also used. In two weeks over 5000 people saw the video, numerous posters were distributed and commented on - and the programme participants gained ideas about how to improve on this already encouraging first campaign.

In the second campaign - a full-scale Provincial Public Education Programme - activities were multiple and rich. In Hué, the newspapers ran full page articles and press releases. The project team toured the province and appeared on local TV with provincial leaders to carry the message further. Provincial and district radio announced the programme and the time of showings for the film 'Our house resists the Storm', watched each time by several hundreds of people before the showing of main feature films. Photo and drawing exhibitions showing activities against natural calamities were organized, and in schools competitions were held for poetry and drawing about the Campaign for Typhoon Resistance Building. Finally, throughout the province the Women's Union, The Youth Union and the Farmer's Union organized public gatherings on the same theme. All over the province over 2,500 large posters were shown in the main places of gathering, the markets, bus stations and cafés. On an officially-declared 'Provincial Day of Disaster Preparedness', youth brigades paraded in the streets of each District with special banners, and radio and TV ran special programmes. This campaign met with great enthusiasm and several Districts prolonged activities into a second month.

4.7 Implementing a provincial Action Plan

Overall, the framework for such activities has been the application of a provincial Action Plan which in the future will draw for its implementation in part on existing provincial funds but also on external funds as and when the latter are available for training new support teams. The Action Plan was defined to create the structure, expertise and supporting material necessary for providing practical assistance in cyclone resistant construction to the people of the region. It was based on the use of existing local technicians and local builders, the former to train and provide advice, the latter to provide practical advice through their involvement with most building activities on the private and public market. The Action Plan was developed collectively during the first seminar held for decision-makers and in their subsequent participation in the technicians' and builders' workshop which followed on directly from the seminar.

4.8. The 'Cyclone Resistant Construction' unit: a local capacity to operate the programme

Central to the Action Plan has been the development of a core team - the 'Cyclone Resistant Construction Unit' - first within the Institute of Building Design in Hué, and progressively in other provinces. The role of the core team was to provide in the future the coordination of the provincial programme for typhoon resistant construction, and to assure the design and production of documents and graphic materials needed to do so. They also undertake the training of provincial and district staff, and that of local builders. The core team has an ongoing role of programme evaluation and improvement of products and processes.

The constitution of the IBD core team, all of whose members participated in the workshops and seminars, has strongly influenced the ongoing activities of the project. Development Workshop and GRET staff felt that it was important that this team, who played a leading role in the project, should go through the experience of running training programmes in two of the three provinces, and running the prototype Public Education Campaign, on their own without the presence of foreign experts. To facilitate this, materials and guide-lines for running both activities were supplied by DEVELOPMENT WORKSHOP/GRET, and they also had the communication and technical dossiers that the participants themselves had prepared in the first of the three provinces. After a joint review, these were then translated into Vietnamese and prepared as individual handouts to participants. The core team rose admirably to the challenge and successfully ran both types of activity, with evaluation and review jointly undertaken between the second and third provinces.

One measure of the success over a relatively short period - 14 months in all - of such activities, was the public announcement by the President of the 'third' Province (Thua Thien-Hué) that he was pledging not only material but also financial support to the campaign, a gesture of support and confidence of considerable significance. At the start of the project such public official recognition would have been hard to envisage.

5. THE ACHIEVEMENT OF DEVELOPMENT OBJECTIVES

5.1 Impact

The impact of the project and the achievement of genuine development objectives can in the long run only be assessed in terms of less damage occurring in future typhoons. It is still premature to make a real assessment of this sort, although in areas where the programme has been run, damage levels are down in subsequent typhoons which have hit the region in 1992, albeit neighbouring areas still suffer.

The programme can realistically be seen to have achieved its

immediate objectives: a provincial institutional capacity, embodied in the Core Team, has been developed with a working methodology and Action Plan, to enable information to be communicated to local authorities, local builders and the general public about measures that can be taken to reduce the impact of natural disaster on physical structures. At the same time, the feasibility of replication of this approach on a provincial and a national basis has not only been assessed but also tested: the Core team from IBD have run programmes in the Provinces of Quang Binh and Quang Tri. There is wider interest at national level to see the spread of such programmes in this decade of Disaster Preparedness.

On the ground, a large number of technicians and builders were trained and several demonstration buildings were completed, including some independently of the project itself using a small surplus budget. There was a much greater level of awareness of what can be done amongst the authorities of the three provinces, thanks to the seminars and Public Education Campaigns.

In terms of overall impact the project can be seen as positive: the constitution of specially trained teams, a process of training technicians and builders which has been tried and tested, and the development of an excellent local knowledge of 'what is possible'. Linked to the experience of the public information campaigns, this represents a real capacity to identify applicable techniques, evaluate them, and undertake their diffusion. There have also been specific achievements, such as the re-introduction in one demonstration building of small holes on the underside of roofing tiles to allow one to tie them down with wire to the battens - this once common practice had disappeared.

5.2. Limitations

Nevertheless, after almost two years of sustained action, the programme (as distinct from the project) must still confront some major issues. It is clear that for the many families who live in the thatch, branch and bamboo structures, there is still very little chance that their home will resist more than a strong storm: a major typhoon will cause damage and loss. The extra cost of strengthening these buildings, small though it is, is still very high to families whose income is negligible. What money there is goes towards more immediate day to day needs. It is realistic on the other hand to envisage the improvement of transition buildings, to resist at least a medium 'ten year' typhoon; but still there is insufficient protection against the massive '100' year typhoons, in reality much more frequent in recent years along this coast, which destroy essential public infrastructure as much as private homes. The economic situation of the country and the people imposes severe limitations on what can in reality be achieved.

For the individual family, the notion of spending extra scarce

resources on protection against a typhoon that may not hit your home remains hard to accept: child vaccination has taken time to become accepted; 'vaccinating' your home against typhoon damage has much further to go before the idea of such investment is popularized. There still needs much more promotion and active demonstration in each commune and village of the benefits that such strengthening brings. These remain tasks for the years ahead.

6. TOWARDS SOME CONCLUSIONS

6.1. Long-term contacts

Efforts have been made to continue informal ongoing contacts between the Vietnamese counterparts and the project contractors. Development Workshop and GRET staff have continued whenever possible to visit the Binh Tri Thien Zone, and to have meetings in Hanoi with the local project staff. This has been important. Nevertheless, for the long term insertion of the programme into the annual round of activities in typhoon effected regions, ongoing support inputs are necessary. In short, a programme of 14 months would seem to us to be too short to have a sustainable impact, despite local commitment and skills.

6.2. Local level support

In the Action Plan's application, the experience of 1990 showed the very important role that the local institutions for information dissemination, for education, and for political decision have to play in mobilizing resources - of people and money - and in complementing the skills of the more centralized institutions. In effect, it is important that future actions concentrate on mobilizing organizations and people at the village level, which represents the real local social unit, as well as developing the provincial institutional support and organizational capacity.

6.3. Meeting the 'on-cost'

It is also clear that, although the extra cost of strengthening buildings against typhoons is proportionately not great, it is still an extra cost, whether public or domestic, which is difficult or even impossible to afford. A programme of demonstration of typhoon resistant building techniques would have much greater impact if it could at the same time address the economic issue of how people can afford to make this short term investment in order to obtain the benefits of having much less to repair or replace after the next typhoon. Whilst ideas such as housing credits to the rural poor were almost impossible to consider in early 1989 in the region, much has changed since then, and lessons should be drawn from the examples of housing loan programmes linked successfully to disaster mitigation, as in Bangladesh. (Ref. 3).

6.4. The role of demonstration buildings

The project originally required demonstration buildings - new structures which show a variety of techniques, and give opportunities for training. Such buildings can play a significant symbolic role, provided that the purpose of the demonstration remains highly visible: that people can see the techniques - rather than have them, for example, covered with plaster. Demonstration should be an ongoing action. However, there is a much greater potential impact to be achieved through demonstrating how to 'retrofit' or rehabilitate existing domestic buildings so that people can see how their own existing buildings can be made stronger. This approach is both cheaper and closer to the reality of needs in many villages and communes. The lower cost of working with existing structures offers the opportunity of working in far more villages than is possible with a programme involving three or four new buildings.

6.5 The need for core-funding

The financial implication for Vietnamese counterparts of operating the programme with, in reality, very scarce resources, has posed a major potential threat to the efficient functioning of the programme. Each government institution has, since 1989, needed to progressively assure its own income and financial autonomy. This means that there are great pressures on an institute to sign contracts which are income generating, and which thus potentially conflict with a development project. Core funding both for ongoing operation of the information programme and to develop a suitable and accessible housing loan programme are necessities for the future, and show some signs of being achieved.

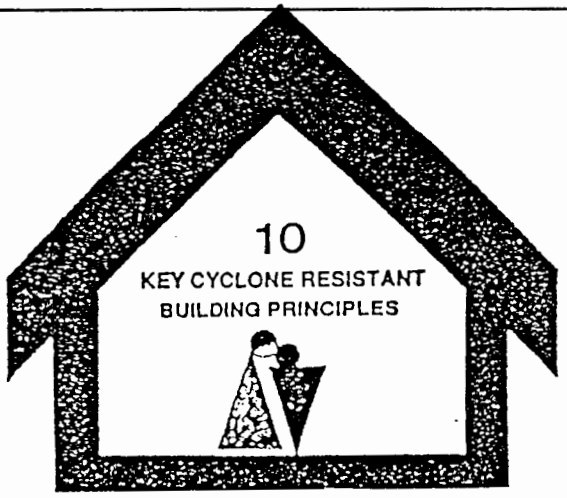
REFERENCES

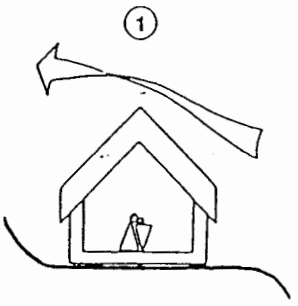
1. The UNCHS/UNDP "demonstration of storm-resistant building" sub-project was implemented by a consortium of non-profit organisations, Development Workshop and GRET (B.P. 13, 82110 Lauzerte, France), in collaboration with two Vietnamese counterpart organizations: the Institute of Public Building (IPB), Hué - the principle partner - and the Institute for Housing and Public Building Design (IHPBD), Hanoi.

2. INSTITUTE OF PUBLIC BUILDING, Ghiai thich va huong dan 10 xay dung chong bao (Manual on the ten key principles of typhoon resistant construction), IBD with Development Workshop/GRET, Hué, 1990.

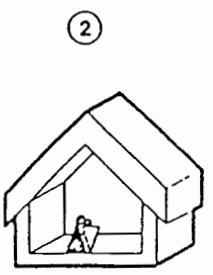
3. The examples of the Grameen Bank and of BRAC in providing housing loan assistance to the very poor amongst the landless rural population of Bangladesh provide models of action directed at resolving specific problems encountered by floods and typhoons. With extremely high repayment rates, the success of such programmes in terms of the scale of their impact and 'spin-off' socio-cultural benefits has been notable.

Illustration 1: Ten Key Points of Typhoon Resistant Building



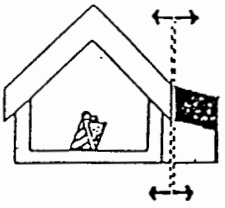


use landscape and topography to minimise flood risk and modify wind speed and direction



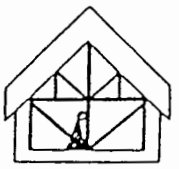
give the building an uniform shape presenting minimum obstruction to the wind

keep the roof pitch between 30o and 45o to minimize suction caused by negative pressure



avoid large roof overhangs; separate verandah covering and frame from main roof

make sure of strong fixings and joints between all elements: foundations - walls - cladding walls - roof frame - covering

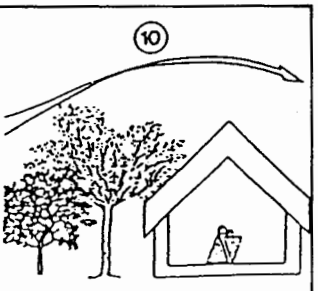


reinforce vertical and horizontal triangulation (diagonal bracing)

make sure roof covering elements cannot be lifted off by wind

balance the size of openings in opposing walls

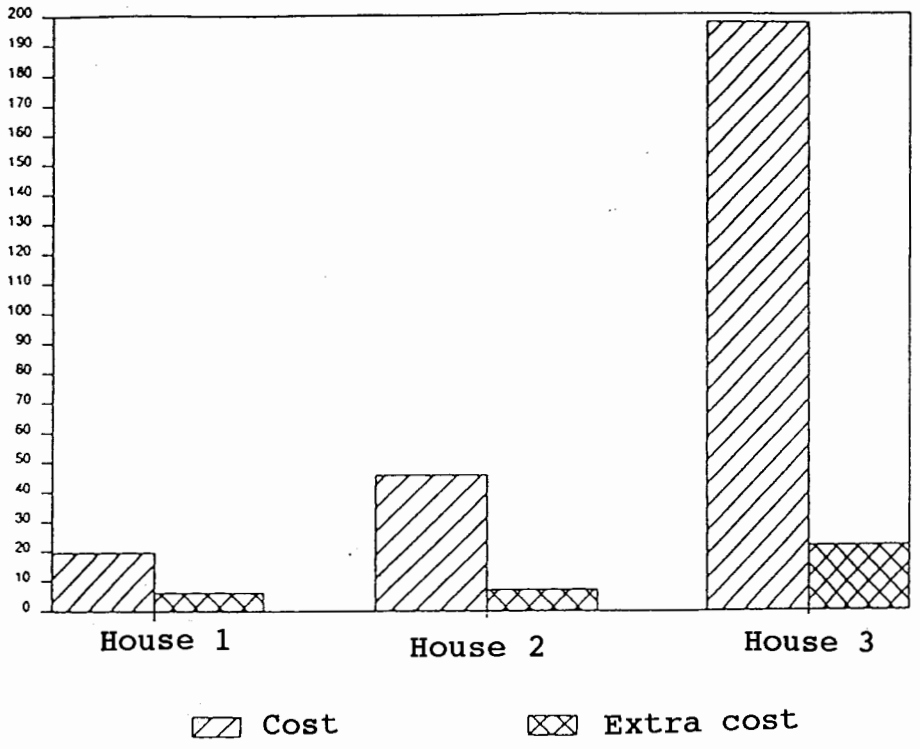
make sure all openings can be closed



use planting of trees and shrubs to reduce wind speed

Illustration 2: Construction costs and extra cost of typhoon resistant measures for various building types.

Construction costs and extra cost of typhoon resistance per m2 in 000s dong



House 1. Thatched roof, bamboo wattle, timber frame, earth floor, area built = 58m2

construction cost:	20,000 dong
extra cost for typhoon resistance:	6,200 dong (+ 31%)
family income:	40,000 dong/month)

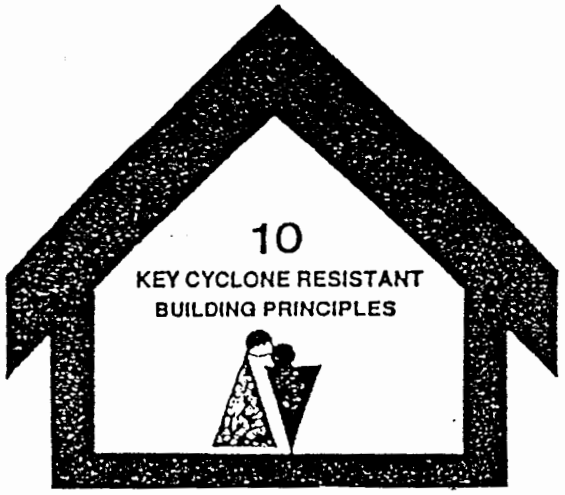
House 2. Tiled roof, timber walls, earth floor, area built = 48 m2

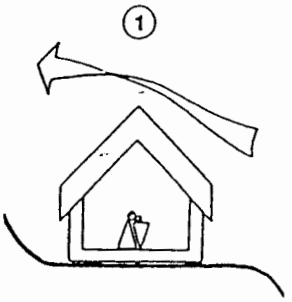
construction cost:	45,000 dong
extra cost for typhoon resistance:	6,750 dong (+ 15%)
family income:	60,000 dong/month)

House 3. Tiled roof, cement block walls, cement floor, concrete verandah, area built = 70m2

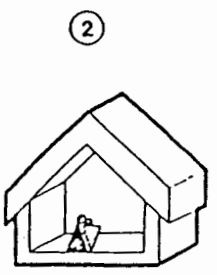
construction cost:	198,000 dong
extra cost for typhoon resistance:	21,800 dong (+11%)
family income:	100,000 dong/month)

Illustration 1: Ten Key Points of Typhoon Resistant Building

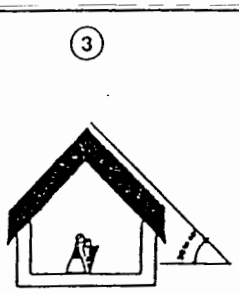




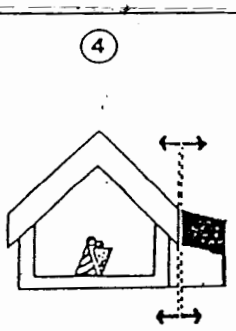
use landscape and topography to minimise flood risk and modify wind speed and direction



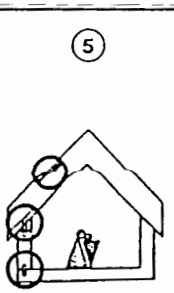
give the building an uniform shape presenting minimum obstruction to the wind



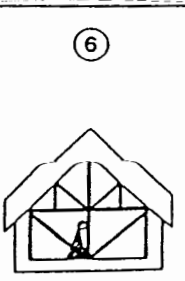
keep the roof pitch between 30o and 45o to minimize suction caused by negative pressure



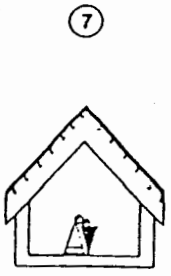
avoid large roof overhangs; separate verandah covering and frame from main roof



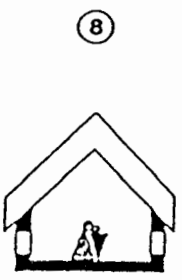
make sure of strong fixings and joints between all elements: foundations - walls - cladding walls - roof frame - covering



reinforce vertical and horizontal triangulation (diagonal bracing)

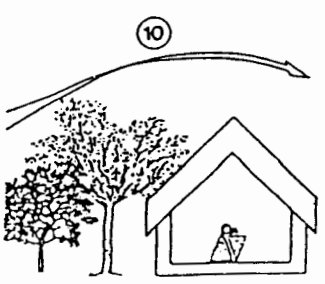


make sure roof covering elements cannot be lifted off by wind



balance the size of openings in opposing walls

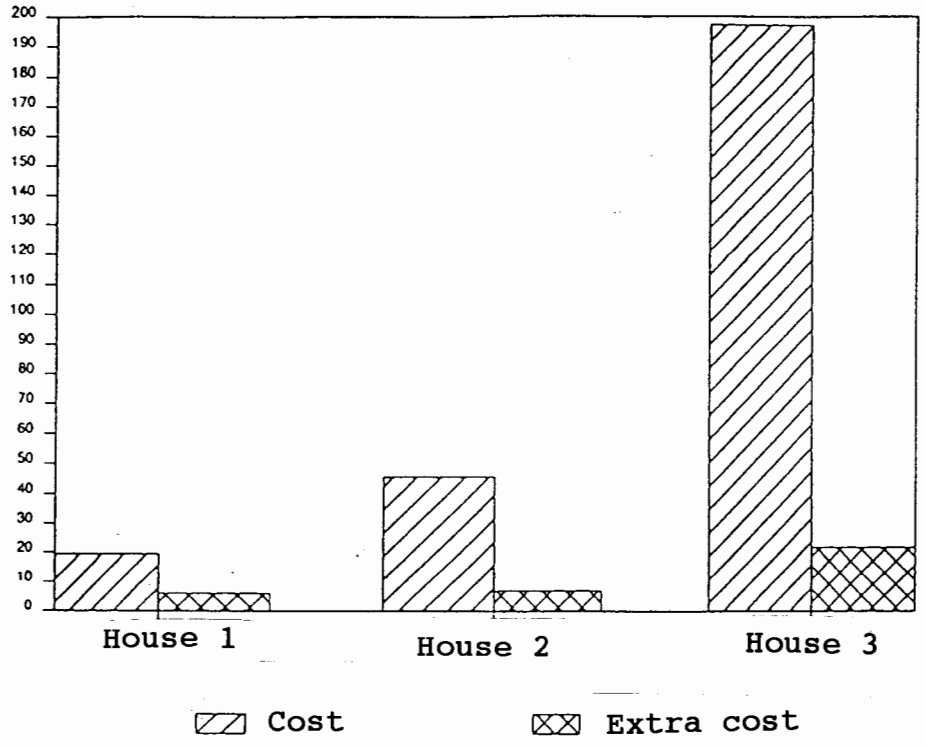
make sure all openings can be closed



use planting of trees and shrubs to reduce wind speed

Illustration 2: Construction costs and extra cost of typhoon resistant measures for various building types.

Construction costs and extra cost of typhoon resistance per m2 in 000s dong



House 1. Thatched roof, bamboo wattle, timber frame, earth floor, area built = 58m2

construction cost:	20,000 dong
extra cost for typhoon resistance:	6,200 dong (+ 31%)
family income:	40,000 dong/month)

House 2. Tiled roof, timber walls, earth floor, area built = 48 m2

construction cost:	45,000 dong
extra cost for typhoon resistance:	6,750 dong (+ 15%)
family income:	60,000 dong/month)

House 3. Tiled roof, cement block walls, cement floor, concrete verandah, area built = 70m2

construction cost:	198,000 dong
extra cost for typhoon resistance:	21,800 dong (+11%)
family income:	100,000 dong/month)