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APPLICATIONS OF WIND ENGINEERING RESEARCH IN THE DEVELOPING COUNTRIES: LESSONS FROM THE CARIBBEAN AND INDIA

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The reduction of the vulnerability of large numbers of people living in areas threatened by cyclonic storms is a major problem confronting developing countries. Throughout the Caribbean Basin, the Mexican Gulf Coast, along the coastal zones of the Indian subcontinent, and in vast areas of the Pacific, large portions of the population live under an annual threat of wind-induced disaster. The typical coastal dweller in developing countries is usually from the poorest sector of the community. In Andhra Pradesh, India, for example, in the areas stricken by the November 1977 cyclone, the average annual income for a family in fishing villages in Guntur District was less than $100 per year. On Dominica, devastated by Hurricane David in 1979, the average annual income was less than $300 per year. Not only do large segments of this population live in high risk areas, but the majority live in non-engineered buildings often built of low-quality materials by craftsmen with limited construction skills and knowledge. Thus the people at most risk from cyclonic storms are often doubly vulnerable to the effects of high winds.

The implications of these population characteristics are such that it is difficult to implement structural improvements to housing in order to reduce vulnerability by means of the usual methods utilized in the industrialized countries. Because the people are poor, they are unable to afford the modifications required by building standards and the architectural inputs necessary to build a safe dwelling. Thus building codes, standards and zoning controls are not only unenforceable but also, given the nature of the construction systems involved, they are totally impractical and do not provide a meaningful tool for local housing or planning authorities.

An additional problem is that most of this high risk population do not, or cannot, give the threat a high priority. Most live in the vulnerable areas not so much as a matter of choice but as a matter of economic survival. In these circumstances, housing is not a high priority in relation to other life needs. Therefore, suggestions that houses be modified (even at a low cost) to make them more wind resistant are likely to be rejected.

For these reasons, most opportunities to improve the housing stock occur <u>after</u>, rather than before, a disaster. Not only is there then a demand for safer housing, but the money and materials available for reconstruction provide a portion of the required resources. Yet, despite the

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demand for change and the resources available, little real change has resulted. Recent studies of housing built after cyclonic storms show little change or improvement in wind resistance over the types of housing that existed before the disaster.

Reconstruction Approaches and How They Affect Vulnerability Reduction

In order to understand why so little change has occurred as a result of reconstruction efforts, it is important to examine the approaches that are used to provide safe housing during reconstruction. In general, there are six approaches used by reconstruction agencies in the developing countries:

1. Conventional Housing Projects. These projects may offer the best means of ensuring that the homeowner receives a safe, well-engineered wind resistant house. An architect and/or engineer designs the house, which is then constructed by a building team under the supervision of a trained building tradesman. Only when the structure is complete is the building turned over to the occupant.

The advantages of this approach are that complete control can be maintained over the quality of the building and that, so long as quality control is maintained, safety can be ensured. However, the disadvantages may often outweigh the advantages; for example:

- Cost: this type of program is the most expensive and thus the number of people served is relatively minimal;
- Time: conventional projects take a relatively long period of time to plan and execute;
- Low Owner-Involvement: because of the nature of the design process, owner/occupant input is usually fairly low. Due to the cost of preparing a design, variations are relatively few.
- Site: this type of program does not lend itself easily to construction on scattered sites. Therefore, conventional housing projects are normally built in clusters. This adds the extra task of land acquisition.

A conventional housing project has one major disadvantage in terms of vulnerability reduction: because the housing is planned and built by an agency, there is little spin-off knowledge about wind resistant construction left within the community. In all, only a small percentage of the people will have a safer house, and no long-term capability for dealing with further vulnerability reduction has been left.

2. Prefab Housing. During the 1960's and early 1970's, a number of reconstruction programs chose to provide prefabricated housing for disaster victims. In most cases, the prefab units were of panel construction with corrugated metal or cement roofing sheets. The success of these programs varied considerably, often depending upon the sophistication of the design, size, and suitability to the particular community and its environment. However, in many cases the housing units were not popular and occupants considered the houses to be only a temporary

measure. Researchers have pointed out that the advantages (including speed of construction, reduced costs, and speed of delivery) accrued to the reconstruction agency and not to the disaster victims. When surveyed, disaster victims were almost uniformly dissatisfied with the prefabs.*

In terms of vulnerability reduction, prefabs presented two problems. First, the ease of construction sometimes translated into ease of destruction. Attempts to mass produce low-cost housing resulted in poor detailing, inadequate joining, and basic design problems (e.g., low roof pitch, excessive openings, etc.) that actually increased susceptibility to wind damage. Second, even if the houses were well-built, there again was little spin-off knowledge about how to build wind resistant housing left within the community.

3. Materials Distribution. Many agencies choose to provide materials for construction rather than build complete housing units. In this way, a large number of people can be assisted at relatively low cost. Distribution is somewhat easier than the provision of prefabs, as materials can be delivered faster than prefab units.

Materials distribution programs can be a method to effect a degree of safer construction. For example, in areas where roofing is particularly vulnerable to uplift during high winds, fasteners and anchors can be provided. However, few reconstruction agencies now possess the technical capability or capacity to ensure that the materials being provided will be used in a safe manner. Without this assistance, the houses that are rebuilt offer no increased protection and, in cases where new materials are introduced that have not been used previously, housing is sometimes even more vulnerable than before.

4. Housing Education Programs. The term "housing education" refers to the provision of technical assistance to homeowners and building tradesment on ways to improve traditional housing to make it more disaster resistant. Housing education may simply be a teaching/training effort or may be a component of one of the other types of programs mentioned here. Most often, it is offered in conjunction with materials distribution programs.

Housing education programs can be difficult to initiate and conduct as the training staff must be familiar not only with the technical aspects of construction but also with the means of conveying the information to different groups of people. Attention must be given to the development of appropriate media for presenting the information and the structuring of sessions where people can receive "hands on" as well as theoretical training. As difficult as this type of program may be, without some effort in this field, long-term acceptance of disaster resistant construction methods is not likely to occur.

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*Tarja Cronberg, "Social Factors Which Influence the Advance of Housing Technology", Design, Siting and Construction of Low-Cost Housing and Community Buildings to Better Withstand Earthquakes and Windstorms, National Bureau of Standards, BSS 48, 1974.

The advantages of housing education programs include the fact that long-term change in construction techniques can be effected and, if properly designed, the program can benefit large numbers of people at a relatively low cost. * Also, these programs place the responsibility of decision-making about the style, shape and materials of the house on the homebuilder and occupant, thus ensuring a high degree of citizen participation and involvement in the program. Most importantly, the knowledge and skills imparted are left within the community.

The disadvantages of this approach include the considerable time required to plan and initiate a program, and the fact that the impact may be negligible in areas where tradition or resistance to change is strong. The ability to change housing according to the techniques being taught also may depend upon the availability of materials or components needed. Housing education programs often require many years of program inputs before the methods being imparted "catch on" and become incorporated into the traditional building process. Thus, an agency initiating this type of program must plan to stay on-site for a number of years or until reconstruction is well underway.

5. Core Housing. This approach is increasingly being used by reconstruction agencies. Here, an agency provides a simple structural frame that can be used as an emergency shelter or temporary structure. The frame and roof are designed to be disaster resistant and permanent. The occupants are intended to fill in the walls with whatever material is available and to progressively upgrade the structure. Initially, the walls may be filled in with materials salvaged from the rubble, then this would later be replaced with more suitable or aesthetic materials as the structures evolve into more formal houses.

There are several advantages to this approach. These programs are relatively low-cost and allow the agency to provide incremental assistance; for example, the frame and roof can be provided during the emergency, with wall and interior materials added at a later time. The components necessary to build the frame and roof can be provided quickly (relatively faster than a complete housing unit). Because the frame is designed to be disaster resistant, a degree of control over the end product is possible. The approach can work on a scattered site basis and can be used immediately following a disaster to provide emergency shelter, thus maximizing expenditures. And the homeowner/occupant can make a significant input in the final product.

However, two major disadvantages are that, without continuing technical assistance or a housing education component, people may infill the walls in an unsafe manner, and the program will only work where people own the land or have long-term tenure rights.

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*Initial costs may be rather high in terms of the development of training aids, exploration of teaching methods, and training of initial staff. However, longer-term operational costs are relatively minor.

6. In-House Shelters. Establishment of an in-house shelter as a safety measure is receiving new emphasis in countries where the cost of building a safe house is comparatively high. One approach is to install a disaster resistant shelter in a house. The second approach is to reinforce an existing room or closet. During a cyclone threat, occupants would seek safety in the designated "shelter" area.

This method reduces the costs of disaster resistant construction, and extensive modification of traditional designs is not necessary. The primary disadvantage to this approach is that in-house shelters have little overall effect on reducing the vulnerability of the houses.

Recent Applications of Wind Engineering Research

Extensive wind engineering research is being conducted although, to date, most of these efforts have concentrated on the types of housing and commercial buildings found in the industrialized nations. While not directly applicable to the developing countries, the resulting information has been used as a starting point for Third World-related research.

In the early 1970's, a major international research project was initiated under the direction of the U.S. National Bureau of Standards with input from numerous organizations in the developing countries and Europe. Part of this effort was focused on construction found in the developing countries, paving the way for further international cooperation, studies and projects. Unfortunately, when the project ended, additional funding was not provided. Other recent projects include field studies by the U.K. Building Research Establishment in the Caribbean; the development of training aids for wind resistant housing by UNNAYAN in India; a long-term research program in wind engineering at the Institute for Disaster Research/Texas Tech University; and a number of research and field study projects being conducted in Australia under the auspices of the government and universities such as the James Cook University of North Queensland.

Most of the information being produced, however, is still of a technical nature, and only a few efforts have been made to reduce this information to simple construction techniques for local builders and reconstruction planners.

Several programs have made significant progress in the application of wind engineering research in Third World regions. As examples, one was undertaken by the Appropriate Reconstruction Training & Information Centre (ARTIC), established to provide information exchange and technical assistance to relief agencies following the 1977 Andhra Pradesh cyclone. A second was initiated by Catholic Relief Services, with support from OXFAM, in the Dominican Republic following Hurricanes David and Frederic in 1979.

In Andhra Pradesh, over 100 agencies offered reconstruction assistance; yet, with only a few exceptions, none of the agencies had staff with prior housing experience and only one had any technical expertise relating to wind resistant construction. This agency, OXFAM, offered to share their information and resources with other agencies, resulting in the establishment of ARTIC to provide assistance to agencies and the Andhra Pradesh government. After several months, many agencies completed their programs and withdrew, yet only a small percentage of the people had received assistance. So ARTIC extended its services to local builders and tradesmen so that they could receive on-the-job training while constructing new houses for disaster victims.

When the program emphasis shifted from assisting agencies to training local building tradesmen, it became necessary to develop methods of transfering technical information. Initially, a series of pamphlets, posters and other printed materials were prepared. Informal classes were set up to provide theoretical training to complement the practical training received on the job. However, the effectiveness of the visual aids was limited. Many builders had not had prior experience with written materials and found the drawings difficult to comprehend or could not relate the words and pictures. Even extremely simplified drawings and those produced in color proved to have only limited success in transferring the concepts. While the practical training was effective in conveying to students an understanding of <u>how</u> to build in a safer manner, without a thorough foundation as to the reasons <u>why</u> the techniques were necessary, the builders were reluctant to use them.

Alternative methods for presenting theory (e.g. motion pictures) were explored. A number of films were obtained but they were too technical for the local tradesmen to comprehend. The production of a special film was proposed but never produced due to cost. Despite these shortcomings, the housing education process has continued and ARTIC is still active.

In the Dominican Republic, Catholic Relief Services entered reconstruction activities with some hesitation. The local staff had no prior experience in housing and no technical personnel available in the office. CRS wanted to support counterpart agencies and not become directly involved in reconstruction but, due to pressure from donors and local organizations with whom CRS had a long-standing relationship, they finally decided to conduct a limited housing reconstruction program.

CRS chose to work with one main traditional building process that offered a viable alternative to the wooden buildings which, while more popular, were no longer feasible due to the depletion of Dominican forests. This process is a method of slip-form concrete construction. Normally the concrete is low quality, and houses built in this manner suffered a high degree of damage in the hurricanes. With the assistance of technical consultants from INTERTECT (a Dallas firm specializing in disaster relief/reconstruction), the structures and building processes were reviewed for deficiencies and modifications were developed utilizing local materials and techniques.

Next a training component was established. It too emphasized both theoretical and extensive on-the-job practical training. Pamphlets and posters were also developed as training aids. The scope of this project was not as broad as the work of ARTIC; the primary emphasis was on construction of a limited number of houses and demonstration of techniques.

Observations and Lessons Learned

Experience with these two programs has provided many lessons for future reconstruction and vulnerability reduction efforts.

1. The receptivity of disaster victims to new ideas and technologies in the immediate aftermath of a disaster was fairly high. At that time, people indicated a willingness to take the steps necessary to rebuild safer homes as long as they were reasonably priced. This attitude prevailed for approximately 6 months to one year, then waned rapidly. The implications are that technical assistance must be instigated immediately following a disaster in order to be successful, and that the cost of any modifications must be kept at an absolute minimum for long-term implementation.

2. Most organizations involved in implementing housing reconstruction programs lack technical capacity and a clear understanding of local housing, as well as the ability to adapt wind resistant techniques to local styles and situations. In some cases, agencies relied on consultants for technical input, but often agencies initiated these projects without adequate technical expertise. Current research efforts are not reaching the implementing agencies; in many cases, agencies were unaware of previous research and existing technical resources/data. Wind engineering skills are not generally found within private reconstruction agencies, nor within the governmental agencies involved.

3. The majority of the technical information that was provided was based on the NBS high wind study. When materials were available from other projects in developing countries, reconstruction agencies often attempted to utilize the ideas cross-culturally. In one case, when a training manual from one country was provided for use as an example, the agencies receiving it tried to use it without adapting it for local use or taking into consideration the differences in materials, lifestyle, etc. There was a limited degree of sophistication among the agencies regarding what was culturally acceptable in housing in the society where they were operating.

4. This lack of immediately available site-specific information, coupled with the influx of many so-called "experts" offering an endless number of housing "solutions", frustrated the agencies. The result was that programs lacked direction and went through many changes in goals and objectives before they were completed.

The implications are clear. If agencies are to make logical choices about housing reconstruction, they must have the information prior to initiation of disaster response. Both the agencies and the technical community must seek out each other to establish a working relationship so that adequate technical services can be provided when required. More advance information should be developed on a site-specific basis. It is not difficult to identify threatened and vulnerable regions, and preparation of materials such as these as a part of routine preparedness activities can significantly improve disaster response.

5. In the cases cited earlier, the organizations chose to concentrate on building tradesmen rather than on direct assistance to families. In

both cases this appears to have positive benefits to the overall program. It has been observed that in almost every society there are persons who are considered to be local building experts. Whether they are masons, carpenters, roofers, etc., these are the people to whom the community will turn for advice or assistance. It is important that these people be involved in the reconstruction process for, if they accept the new ideas, there is a greater likelihood that the methods will continue long after the program is completed.

6. From the experience of the ARTIC and CRS programs, it is evident that further efforts are required to develop teaching techniques and appropriate training aids. While the practical training is of utmost importance, there still must be a basic understanding conveyed of the reasons why a house should be built in a certain manner. Especially needed is a film depicting wind forces on a house -- one that can be easily translated into local languages. Animation and computer graphics offer two possibilities.

Requirements for Vulnerability Reduction in the Third World

Review of the experiences in India and the Caribbean reveals the following needs:

1. Better linkages between program implementers and the wind research community;

2. Increased efforts to reduce available technology to useful formats for non-technical program implementers;

3. Increased emphasis on the development of building components that can be installed at relatively low cost to improve the performance of traditional buildings;

4. Increased emphasis on studying traditional housing in the Third World in order to provide a basis for understanding the overall aspects of housing vulnerability;

5. Increased emphasis on the placement of knowledge, expertise and skills with potential project implementers, i.e. the relief agencies that carry out the majority of reconstruction and vulnerability reduction activities;

6. Upgrading of the skills of local craftsmen within vulnerable communities;

7. Establishment of closer links between researchers and policy-makers at all levels of the reconstruction system so that a basic orientation of wind resistant construction opportunities can precede the formulation of reconstruction programs.

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