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Fiscal Year 1973 Project Status Report

DESIGN CRITERIA AND METHODOLOGY FOR CONSTRUCTION OF LOW-COST HOUSING TO RESIST TYPHOONS AND HURRICANES

July 2, 1973

Prepared for

The Office of Science and Technology

Agency for International Development

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SUMMARY

This report highlights the major accomplishments of the initial phase of a three fiscal year project to provide engineering technical assistance to the Agency for International Development (AID) for the development of design criteria for low-rise buildings to better withstand extreme winds. This phase represents approximately a 3 month level of effort. During this period CBT project staff members commenced five introductory tasks. These tasks will set the pace for the second fiscal year level of effort. The tasks included:

- initiate dialogue with local organizations and institutes in developing countries,
- establish a local Philippine advisory committee,
- conduct on-site visits to developing countries to identity local professional candidates for short term consulting; and visits to developed countries to collect information from research centers,
- purchase initial wind tunnel and full-scale field test instrumentation, and
- commence library search of related subject documents.

As a result of performing these tasks it is expected that the initiation of wind tunnel modeling and field testing will be implemented during the beginning of FY74. In addition, as a result of the site visits an informal relationship and support has been developed between the CBT staff and individuals in private and government agencies and organizations.

INTRODUCTION

Statistics show that the northern Philippine Islands experience the highest annual frequency of extreme winds in the world. It is interesting to note that approximately 70 percent of the Philippine population live within this area. History suggests that the high wind trend is expected to continue, and with it the frequency and variety of problems encountered by the rapidly spiraling population (36.7 million people estimated by the 1970 census with an annual growth rate of 3.0 percent)[1] is expected to increase and with it bring more disasterous after effects. Of the sixty eight major typhoons reported by the Philippine Weather Bureau during 1965-1971, ten had wind speeds in excess of 140 mph.[2] Post disaster reports indicate that on an annual basis millions of dollars of property are damaged and hundreds of lives are lost due to these typhoons. For example, in 1970 the Philippines experienced four typhoons causing over 1000 deaths and over $15 million damage to property, including damage to approximately 9000 public school classrooms. It is estimated that over 300,000 school children were

[1] Research Study of the Socio-Economic Aspects of Low-Cost Housing in the Philippines, Progress Report. Sycip, Gones, Valayo and Co., March 1972.
[2] Ibid.

affected by the storms.

In addition to the Philippine Islands other world wide areas experience extreme winds; they include the Indian Ocean countries; the northern Caribbean Islands and the southeastern United States. A frequency[1] of extreme winds for these geographic areas is presented for illustration purposes. The first geographic area (northern Philippines) experiences a mean annual crossing frequency (per 5° square) of 5 tropical cyclones (wind speeds greater than 34 knots), the second geographical area experiences an annual frequency of 1.2 while the third and fourth experience 1.0 and 1.5 respectively.

While wind research has been conducted on tall buildings in developed countries, very little research has been conducted on low-rise buildings in these developed countries and practically no research performed on low-rise buildings in developing countries. The developing countries are at a particular disadvantage since their economy and residents per capita income usually does not permit a continued rebuilding of damaged structures after each storm. It is estimated that 85 percent of some developing country residents live in temporary houses made out of material found along the roadside or discarded by another person.

With this background in mind, AID requested assistance from NBS to help develop design criteria for low-rise, low-cost structures in developing countries to better withstand extreme winds. And secondly, AID requested that such assistance be structured to improve the local technical expertise

[1] "Distribution of Extreme Winds Over Oceans", Journal of the Waterways, Harbors and Coastal Engineering Division, By Herbert C. S. Thom, February 1973.

and research capabilities and establish indigenous wind research capability in the participating countries, organizations and institutes.

As a preliminary step to this study, an almost completed AID/NBS research effort entitled, "The Design, Siting and Construction of Low-Cost Housing and Community Buildings to Better Withstand Earthquakes and Windstorms" clearly pointed out that improvements in the collection and analysis of climatological design data, strength of structural elements, building siting and its geometry, and information regarding structural connection details is needed. Such information gaps are seriously affecting building designs in many of the developing countries. The results and recommendations of the above study were considered in the planning of this study.

In the course of this fiscal year level of effort, approximately 60 different individuals collectively, were contacted in person to discuss this research (see Appendix A for listing of individuals), to collect information relevant to the project, to help organize a Philippine advisory committee and to identify appropriate short-term consultants.

The next section of this report presents a summary of progress during fiscal year 1973. This is followed by a discussion of the projected progress for fiscal year 1974.

Two appendices are included at the end of the report. These are:

- Appendix A: List of organizations and facilities contacted during FY'73 field visits, and
- Appendix B: A bibliography of data relevant to specific

building problems of concern.

A. SUMMARY OF PROGRESS FOR FISCAL YEAR 1973

Field Trip

Several developing countries (Philippines, Bangladesh and Jamaica) were selected by USAID and NBS for participation in this study. These countries were selected based upon their need for assistance and their potential for implementing and transferring the research results to their respective geographic areas. Three developed countries (Japan, Australia and England) were selected to collect information from research institutes about their experiences with similar research projects.

The first subsection below identifies activities conducted during a field trip to the above countries with the exception of Jamaica. A trip to Jamaica is scheduled for the second week of July 1973. The events associated with the FY'73 trip may be viewed as 3 separate aspects. The first was concerned with introducing the study to appropriate local individuals. These individuals were encouraged to interact with the NBS personnel so to better delineate the purpose of the research, to assess their capabilities and to answer their questions.

On the surface, it might appear that the above developing countries do not possess the capabilities or expertise to perform this type of research. However, it became clear that they have the capability and expertise to successfully perform such research. They are, however, lacking in appropriate technical guidance and funding for necessary

equipment and facilities. Thus, the second of three aspects.

The third was concerned with collecting methodologies and conclusions of similar high wind research projects from other research establishments, organizations and universities.

A summary of the activities performed in each country and specifically at the local organizational level is discussed below:

1. Tokyo, Japan

   a. U.S. Embassy

      A visit was scheduled with Mr. Richard H. Zorn II, Assistant to Dr. Robert W. Hiatt, Scientific Counselor at the American Embassy. Mr. Zorn was interested in our project and offered to act as liaison to identify, if necessary, Japanese researchers with appropriate credentials for participation in this research. He asked that we forward to his office a copy of all relevant correspondence so he would be informed of the project status.

   b. Ministry of Construction, Public Works Research Institute

      This institute is involved with several wind research activities. The individuals listed under Appendix A part 1.b were briefed in detail on the objectives of our research. This meeting provided the opportunity to discuss the wind research project with other qualified individuals, and to identify a future potential source with which to share information. The general discussions with the Public Works officials centered around collecting similar information and a discussion of their experiences in Manila.

It would be desirable to interact with the Institute. If such is agreeable with NBS and AID/W a formal invitation should be addressed to the Institute identifying one individual for his participation under a service-in-kind arrangement. Logically his participation in the forthcoming organizational meeting/ workshop would be desirable.

2. Manila, Philippines

a. USAID Mission

The Assistant and Deputy Assistant Directors for Capital Development (see Appendix A part 2.a) were visited on several occasions to discuss the joint research involvement and areas of responsibility. Mr. Larson believed that the University is the most logical organizational group to serve as the focal point in interacting between NBS and the local Philippine agencies and organizations. This judgment is based upon the University's expertise and capabilities including their sensitivity to administrative aspects associated with this project. While AID Manila has no funding for local Philippine activities, Mr. Larson felt the newly formed Philippine Advisory Committee has potential for raising the necessary funds for their level of activities. The AID Mission, would serve in a consultan capacity to this project and provide assistance to this committee as the need arises.

b. University of the Philippines

A meeting was scheduled with individuals from the College of Architecture and Engineering (see Appendix A, part 2.b) to review the research project, to discuss their participation and assess their laboratory capability and equipment inventory. A list of equipment for wind tunnel tests and field instrumentation was developed during discussions with the Civil Engineering Department and the Computer Center staffs.

The University of Philippines (UP) wind tunnel facility and associated instrumentation were evaluated for conducting building aerodynamic studies. The tunnel is a closed return system with a drive motor located directly above the test section. The test section is 4 feet square and 12 feet long. The fan diameter is 5 feet and produces a maximum wind flow of 100 fps. Corner fillets in the tunnel are removable and provide a means for adjusting the pressure gradient. While the tunnel is quite small (by current standards) for modeling atmospheric flows, it is probably sufficient if the growth rate of the boundary layer is stimulated or augmented. The tunnel is housed in a building having a large uncommitted floor area and the facility is used only on rare occasions. With the exception of some general-purpose equipment in the Department of Electrical Engineering, instrumentation necessary for wind tunnel studies is nonexistent.

The University operates an IBM 360, Model 40 Computer with a memory capacity of 64,000 words. Mass storage is provided by two

2311 disk drives. Four tape drives are available, one is a 7-track and the others are 9-track. No plotting facilities or A-D conversion are available. Two line printers are used each with a capability of printing 1200 lines per minute. CPU rates are approximately $70 per hour for commercial work and $35 per hour for academic work.

c. Philippine Weather Bureau

With the Weather Bureau Officials, (see Appendix A part 2.c) the research projects scope of work was reviewed and questions answered. It was learned that the Bureau presently records winds at about 200 weather stations (50 synoptic stations, 150 climatological stations; 4 are a combination radar/synoptic station). The Weather Bureau suggested that Catanduanes Island (an island east of Luzon) is a promising candidate site for one of the full-scale building tests since this island has a very high mean annual tropical frequency (discussed in more detail later).

d. National Housing Corporation

NHC was organized in 1968 with funding [illegible] private banks to mass produce building components. To date several hundred single family houses have been built, most constructed of porous concrete panels (40" x 96") and galvanized iron roofing (see Figure 1). General Tobias, Executive Vice President of NHC, is very interested in the project since it could directly affect his plans for providing several thousand future homes. He offered NBS the use of his facilities to observe material

Figure 1. This site is located about 25 miles northeast of Manila. The National Housing Corporation designs and fabricates housing structures using 40 by 96 inch porous concrete panels. The panels are joined to the foundation at 40 inches on center by vertical rods.

fabrication processes and a home for NBS staff living while on site and as a test structure.

e. People Homesite and Housing Corporation

This Corporation is directly oriented toward providing housing for the low-income citizen. Its funding is almost solely from the Government which ultimately reduces the selling price of developed lots. Lieutenant Colonel Rebuena, representing PHHC, stated he would follow any decisions made by the advisory committee and would adopt improved design criteria for housing to better withstand high winds.

f. Economic Commission for Asia and the Far East

Dr. Senn, Chief, Typhoon Research Committee Secretariat, is interested in this subject because of his aim and objectives as Secretariat of the Typhoon Research Committee. ECAFE is interested in the improvement of communications, flood and typhoon warning and the transfer of information to the other countries engaged in Typhoon research (Japan, Korea, Hong Kong, Philippines, Laos, Thailand and Cambodia). His area of participation would be to transfer results of our research activities to the Typhoon committee as they develop. In this manner NBS/AID would have the benefit of additional comments and criticisms. If his assistance is requested it should be done on an informal basis. In this respect Dr. Senn would be more flexible in his interaction with the wind project.

g. Land and Housing Development Corporation

LHDC is a privately financed housing development organization

providing homes primarily to low-middle and middle income individuals. A visit was made to one of their sites, near Manila, where this corporation is constructing homes (see Figures 2 and 3) using convential building construction techniques and materials (concrete block and galvanized iron roofing). Colonel Sanchez offered NBS one of his houses to instrument.

h-o. Other Philippine Organizations (Refer to Appendix A parts 2.h-o)

These organizations were invited by the University to attend an organizational meeting on April 27, 1973 at the Weather Bureau. At this time the research project was presented by the NBS team in detail to all the attendees. A question and answer period followed. After the presentation an advisory committee was formed for the coordination of all Philippine activities associated with this research. The committee consisted of the groups listed in Appendix A parts 2.a-o. Dr. Tabujara was elected Chairman and General Tobias as Vice Chairman. In addition, a subcommittee was formed consisting of 5 committee members. The subcommittee's objectives are to schedule activities and establish estimates of the human and financial resources required for the Advisory Committees' recommended level of activity in this project. Dr. Juguilon, Dean College of Architecture, was elected Chairman of the subcommittee. There was a general feeling at the end of this meeting that there is deep Philippine interest in the

Figure 3. This photograph illustrates a typical finished concrete block house. Note roof overhang common to both houses.

project.

3. Dacca, Bangladesh

a-b. USAID Mission and U.S. Embassy

The persons listed in Appendix A, parts 3.a and b were visited on several separate occasions to describe the research project. The Mission and Embassy look forward to receiving results from the project.

Almost daily, stories from the field reported high wind damage in which homes and personal belongings have been swept away and people have been killed by flying debris. In Bangladesh the situation is almost beyond belief. This desperately poor and hungry country of 80 million people living in an area the size of Wisconsin have no method to seek government emergency housing relief (such as provided by our Office of Emergency Preparedness, HUD). Thus, as one might expect USAID's major concern is to provide assistance today to help reduce today's problems. Their activities are not geared to long range assistance. However, the AID Mission in Bangladesh agreed that this research project is certainly an important step toward the development of a much needed housing plan.

The AID office offered any assistance we may need for future contacts or coordination of activities. They can provide effective indigenous advice from their professional staff should such be necessary.

c. CARE, Incorporated

In Bangladesh, CARE is concerned with developing low-cost wind resistant structures. In this respect their involvement in Bangladesh currently centers around providing three different building concepts; a dome shaped house, a quonset shaped structure and a soil stabilized block house. The former design approach (see Figure 4) has not been put into production due to the local cultural nonacceptance of dome shaped buildings. At its present site it is used as a community health station. This structure is composed of 5 separate pieces. When joined together they form a decahedron shaped structure. The second design concept and latest design approach involves a precast on site building using three layers of polyester resin reinforced with jute (see Figure 5). This structure may be designed in incremental lengths of three feet. This house also may be constructed with a veranda at one or both ends. The house shown in the figure is 18 feet long (6 - 3 foot sections per side) with an enclosed length of 15 feet. The windows and doors are formed while in the mold. As evident from the photographs, this design is based upon joining 3-foot half arch sections together at the top to form an arch and then to the ground or a low brick wall by thin metal rods (see Figure 6). The soil stabilized block house concept (cinva-ram) uses about 6 percent of cement for soil stabilization. One hundred fourty eight houses were recently constructed using the cinva-ram method in a village 43 miles west of Dacca (see Figure 7). Since these

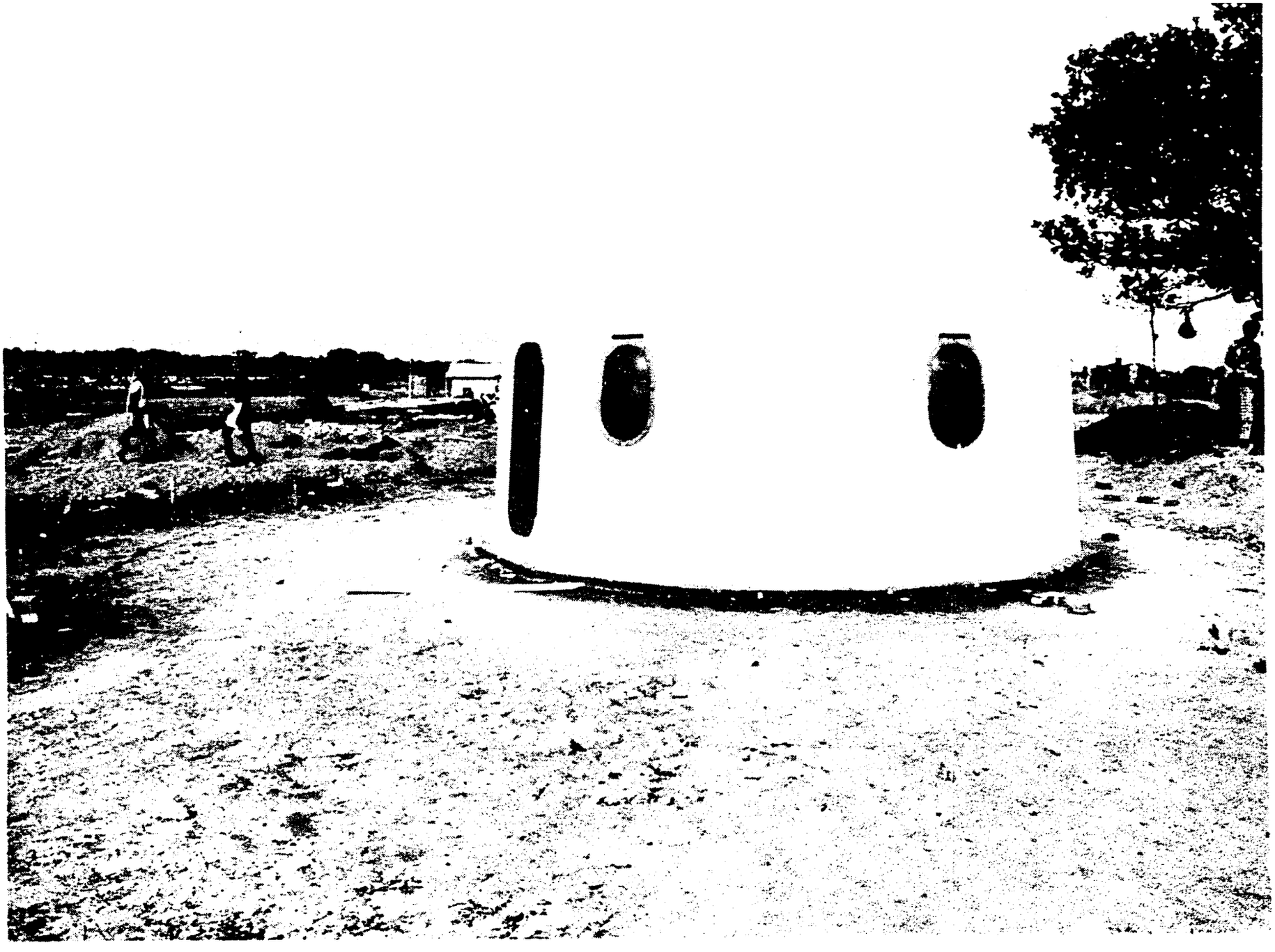

Figure 4. This is a prototype house design by CARE, Inc. The house has not been accepted by the local populace due to its geometric shape.

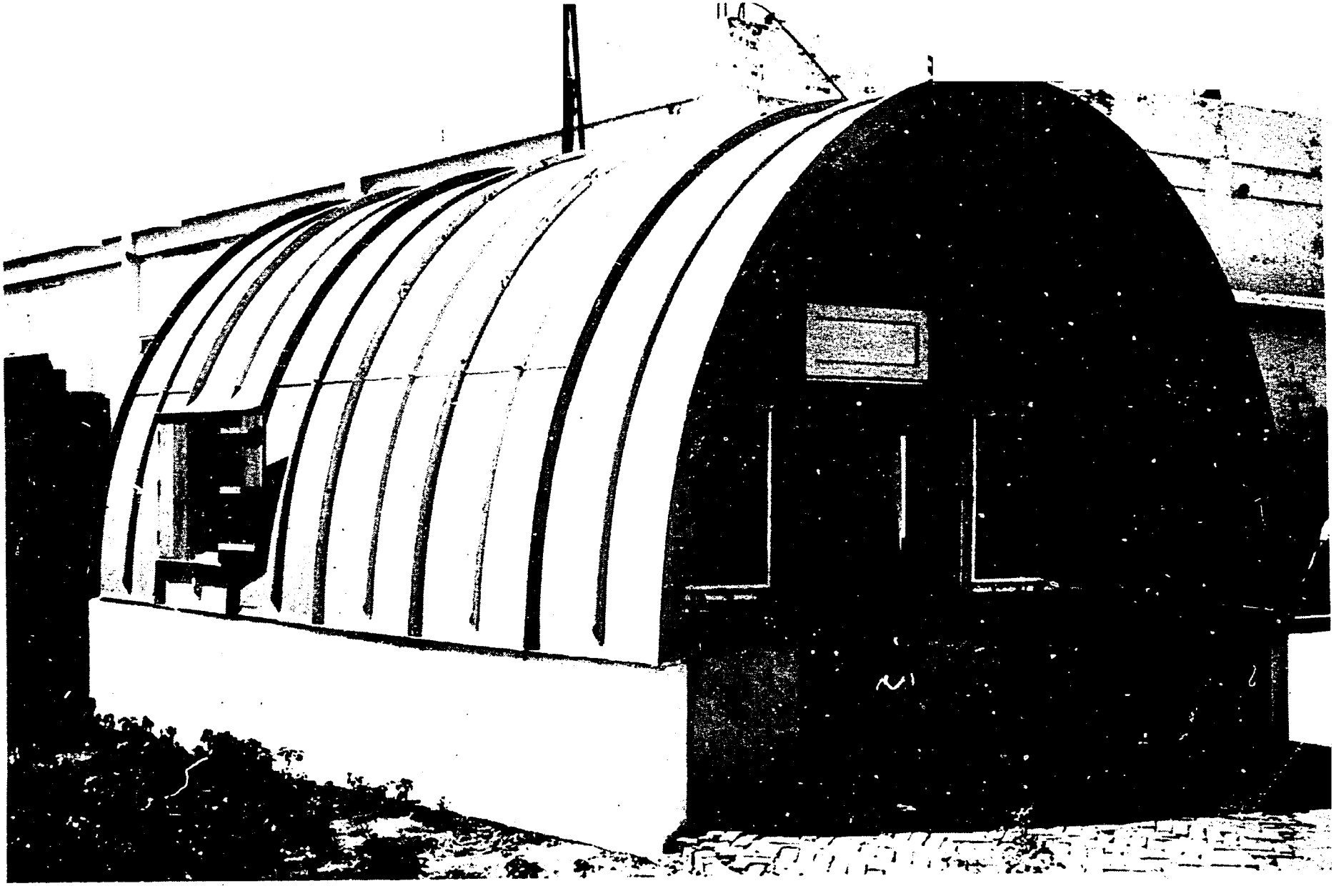

Figure 5. This building is located at the CARE, Inc. fabrication plant about seven miles southeast of Dacca. The photograph shows a typical quonset shape house tied to a low brick wall.

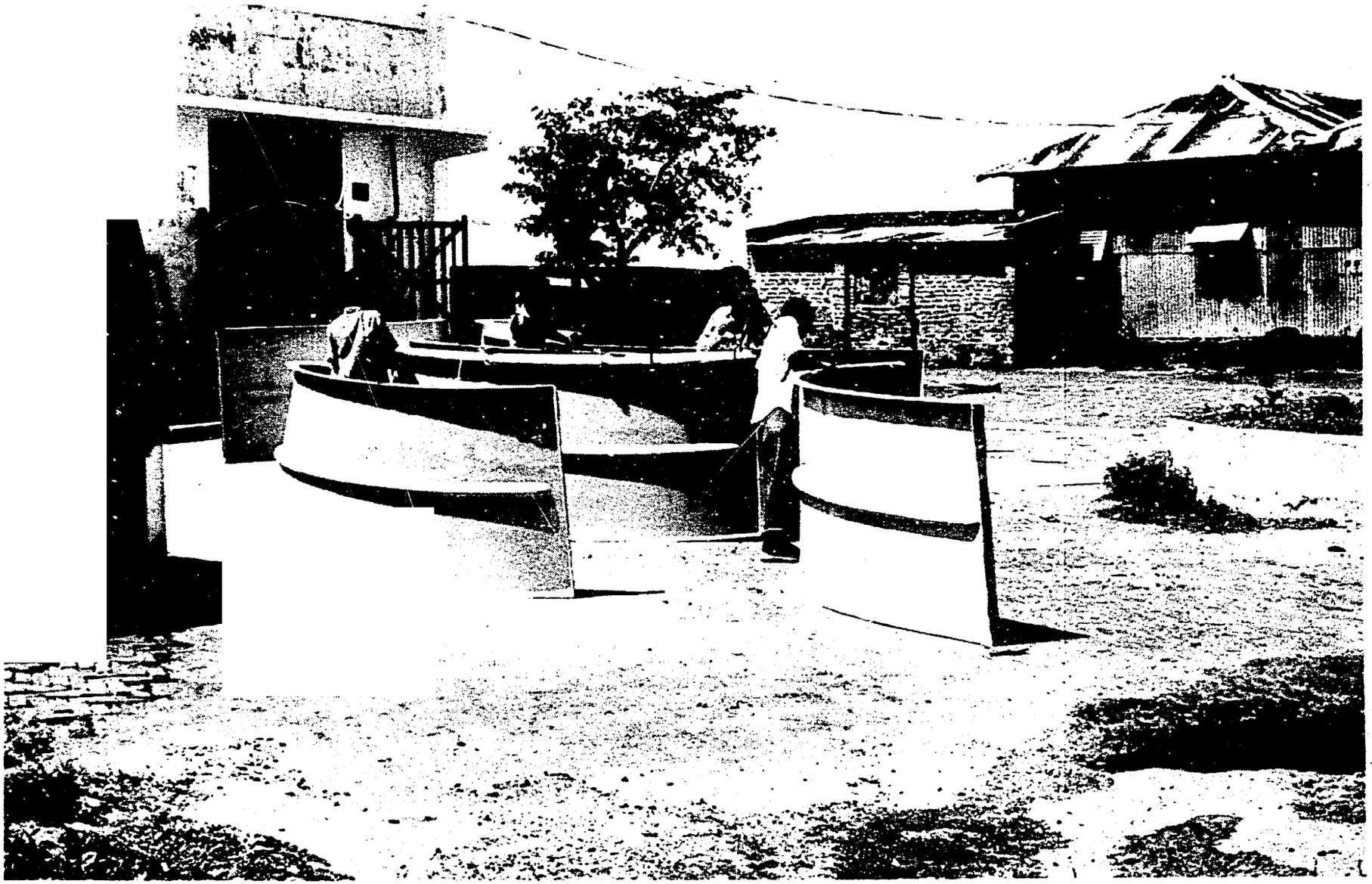

Figure 6. This photograph illustrates the structure's modular component system. Each three foot arch consists of two modules joined at the top. Note the lip running around the perimeter of the module. When butted to another module each are bolted and covered with a layer of jute and resin for waterproofing.

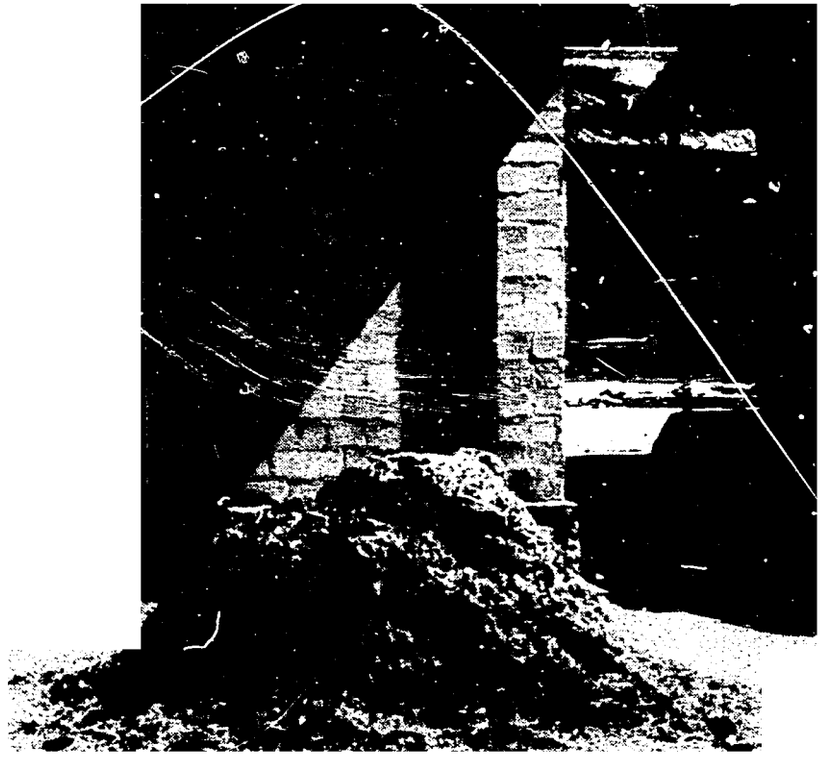

Figure 7. This village is located about 43 miles west of Dacca. A sample of the houses within this village were constructed using cinva-ram cement-stabilized soil block masonry. Note, the galvanized iron roof (used on all cinva-ram houses) and its frequent use on the thatch houses (shown at right of photograph).

houses are relatively new, little data is available as to their success in resisting high winds.

Of the three building designs the quonset type building appears to offer the greatest potential for providing low cost locally acceptable housing to the Bangalees.

d. Bangladesh University of Engineering and Technology

Dr. Fazlur Khan, partner in Skidmore, Owings and Merrill, Architects (SOM), Chicago, and a renown structural engineer identified Dr. Jamilur Choudhury as a candidate with whom to contract on a short term basis to provide a "transfer of knowledge" link between activities in the Philippines and the Indian Ocean countries. A meeting was scheduled with Dr. Choudhury and the project was discussed in detail. Dr. Choudhury then scheduled a briefing with Dr. Islam who is in charge of the University's wind tunnel activities.

The wind tunnel in the Mechanical Engineering Department is an open return type with a test section of 12 inches square and 2 feet long. The maximum wind speed is 100 mph. A new test section is scheduled to be constructed in the near future with dimensions of 18 inches square and 4 feet long with a maximum wind speed of 150 mph. This tunnel will be a closed return system with the drive motor located on the same plane as the test section. The University has a very minimal computer capability.

Both Drs. Choudhury and Islam are very interested in this project because they are performing similar, but less sophicated

research.

A proposal was received from Dr. Choudhury and it is currently being reviewed by NBS.

e. Shaheedulla and Associates

A meeting was scheduled with Mr. Shaheedulla (also referred by Dr. Fazlur Khan), who was presented a description of the project and was requested to indicate his degree of interest. He forwarded to NBS some ideas for reducing wind loads on buildings through use of barriers and tie-downs and a history of high winds in Bangladesh. Mr. Shaheedulla is a consulting engineer with experience in medium rise structures. His information is also being reviewed for a short term contract award.

f. Building Research Institute

This Institute consists of a 3 man staff, 1 draftsman and 2 engineers. Mr. Hossian, Chief Engineer, was briefed and showed an interest in this study. To date, no information has been received from Mr. Hossian. BRI's capabilities are limited both in funding and human resources. Since the war of liberation the country has placed emphasis, at least for the time being, in areas other than improving building practices.

4. Watford, England

a. Building Research Establishment

Meetings were conducted with personnel noted in Appendix A, part 4.a. Each individual was briefed about the project and their

assistance was requested in furnishing NBS with any related "lessons learned" information, e.g.

- o how to design, install and use wind tunnel equipment from 1:250 model scale to perform 1:50 scale modeling,
- o what simulation methods are the most reliable,
- o what would be done differently if BRE had to perform similar tests over,
- o what are BRE recommendations for this study, and
- o provide NBS with related research reports, etc.,

Dr. Eaton, Senior Research Officer, BRE, has performed little research using the 1:50 scale. Most of their test work is performed at Bristol University using a 1:250 scale. The tunnel most used for this type modeling at BRE is about 2 meters wide by 1 meter high by 6.5 meters in length. The wind speed in this tunnel ranges from 0.75 to 5.0 meters per second. Their second tunnel, an environmental tunnel, is an open return system with dimensions of 8 feet by 6 feet by 16 feet long and produces a maximum wind speed of 30 feet per second. The environmental tunnel however, has no room for development of a boundary layer such as is required in our scale modeling activities.

5. Sydney, Australia

a. <u>University of Sydney, Department of Civil Engineering</u>

Wind-tunnel modeling techniques were discussed with Dr. B. J. Vickery. The tunnel used for wind studies at the University of

Sydney is an open-return type with the fan installed at the intake. The working section is 6 ft high, 8 ft wide and 48 ft long. The ceiling is nonadjustable and consists of perforated hardboard. This, coupled with the upstream fan position, results in a negligible pressure gradient and eliminates the problem of flow distortion caused by tunnel leakage. The cost of the tunnel, excluding the propellor and drive motor, was less than $3,500 (Australian). Instrumentation consists of hot-wire anemometers, a digital correlator-probability analyzer, a sampling multimeter and dynamic mounts for aeroelastic studies.

The problem of establishing a suitable boundary layer in the UP tunnel was discussed. It was Dr. Vickery's opinion that, while the existing tunnel in the Philippines would probably be satisfactory for the studies envisioned for the next three years, serious consideration should be given to the construction of a larger facility patterned after his tunnel. It was also his opinion that special purpose analyzers offer a cheaper means of processing random data then can be accomplished with digital computers.

6. Melbourne, Australia.

a. <u>Monash University, Department of Mechanical Engineering</u>

The Department of Mechanical Engineering operates a closed-return tunnel with a 2-meter square test section. This tunnel is rather unique in that two tests are usually carried out simultaneously, one model being placed in the pre-contraction section and one in

the normal test section. Support equipment is quite similar to that used at the University of Sydney with the exception that random data are recorded and converted to digital form for computer processing. However, they intend to make more use of special-purpose analyzers in the future.

The facility is under the direction of Dr. W. H. Melbourne who also conducted several studies on full-scale structures. A number of useful suggestions were offered by Dr. Melbourne concerning wind tunnel and full-scale instrumentation. Of particular note were his comments concerning the training of personnel to conduct wind tunnel studies. He feels that training of one or two UP staff members could best be accomplished by having them visit an operating facility for two or three weeks and take an active part in testing and data analysis.

b. <u>Division of Building Research, Commonwealth Scientific and Industrial Research Organization (CSIRO)</u>

The scope and objectives of the AID/NBS Philippine project were :ussed with senior staff members of DBR. While no wind-load ɜarch programs are currently contemplated by DBR, they expressed ı interest in the project and offered a number of suggestions on the structural aspects of the study.

The Light Timber Framing Code has recently been revised and new recommendations for structural connections have been made on the basis of tropical storm damage at Townsville, Queensland this past year. Several documents were obtained from DBR, including a copy

of a report by Mr. Ian Langlands concerning the establishment of the Building Research Service at the University of the Philippines. Unfortunately it was not possible to meet with Mr. Langlands during this visit.

NBS Fiscal Year 1973 Equipment Purchases

Equipment required to conduct the research program can be conveniently divided into three categories as follows:

1. Equipment for the instrumentation of full-scale buildings
2. Wind tunnel test equipment
3. Data reduction and analysis equipment

Equipment under category (1) is essentially a duplication of field test equipment purchased by NBS for remote and unattended acquisition of wind load data at remote field sites. Some equipment are required for operation in tropical climates and typhoon winds accompanied with intense rainfall. It is anticipated that up to three separate systems will be in operation during FY74 and that one of these systems will be deployed before the end of the current typhoon season. The basic components of a typical system are as follows:

- Anemometer and direction vane,
- Pressure transducers (10),
- Logic and signal conditioning unit,
- Time code generator,
- Analog tape recorder,
- Power supply,

- Equipment enclosure, and
- Meteorological tower.

With the exception of the time code generator and analog tape recorder, the above items, sufficient for one system, were purchased or otherwise made available during FY73.

Equipment under category (2) will be used in conjunction with the wind tunnel facility at the University of the Philippines. The primary components are as follows:

- Hot wire anemometers (2),
- Pressure transducers (10),
- Manometer,
- Digital voltmeter,
- Oscilloscope,
- Pitot probes, and
- Test chamber.

These items, excluding the manometer and digital voltmeter, were purchased in FY73. While these equipment items are primarily intended for wind tunnel testing, the digital voltmeter, oscilloscope and test chamber will also be used to service and calibrate equipment listed under categories (1) and (3).

Equipment under category (3) will be used to analyze both full-scale and wind tunnel data and consists of the following major items.

- Signal correlator and probability analyzer,
- Stripchart recorder,
- X-Y plotter,

- Time code generator/reader, and
- Analog tape recorder.

Only the first of these items was purchased during FY73, the remaining items having a lower priority on the time schedule are proposed for FY74.

As previously mentioned, to avoid duplication and to better integrate new equipment with that already available at the University of the Philippines, procurement of equipment was not initiated until after completion of a site visit in April. Delivery of most of the items purchased in FY73 is anticipated in July.

Identification of Related Documents

The collection of related documents addressing the effects of extreme winds on low rise structures serve two main purposes. First, they offer the opportunity to study the current state-of-the-art of extreme winds. And secondly, these documents serve as a basis to transfer information to local Philippine agencies and organizations. In other words, the collection of wind related documents will be disseminated to the participating Philippine agencies and organizations as additions to their libraries. In addition, a bibliography of the Philippine documents will be sent to the other participating developing countries.

As a background to this task item, a short narrative of related activities is presented below. Shortly after award of contract, a meeting was conducted with NBS staff members to identify in-house related documents. These NBS staff members, in turn, gathered together a series of manuscripts,

technical notes, and documents from various sources. For example; data collection activities have been initiated with the Department of State and in particular the United States Agency for International Developments' library. In addition, the library at the National Oceanic and Atmospheric Administration, the Forest Products Laboratory, Portland Cement Association, the National Technical Information Service and universities are currently being requested to furnish wind related data. Additional documents are being received from the Building Research Establishment in Watford, England through a joint complementary research program on wind loads on buildings.

B. PROJECTED ACTIVITIES FOR FISCAL YEAR 1974

The following section presents activities anticipated to be conducted during fiscal year 1974.

Transfer of Information

To ensure effective transfer of research results to other developing countries, short-term contracts will be awarded to local individuals in Bangladesh, a northern Caribbean country and with other groups as required. The individuals selected will have a working knowledge of their countries' housing problems and climatological conditions. It is expected that the consultants will collect and analyze information leading to the preparatic of two reports dealing with the resistance of low-cost housing and other low-rise buildings exposed to extreme winds. These reports should address a broad range of low-rise, non-tourist type buildings, (e.g. housing,

schools, community centers, etc.).

The first series of reports will be presented by the consultants at an organizational workshop meeting in Manila during the fall of 1973. The topics will include items such as:

1. Discuss extreme wind related problems as found in their respective geographic area.
2. Present an outline of each country's and their respective geographic area's low-cost housing and low-rise building related problems and data gaps, both in the design (e.g. structural systems, connection details, design loads, etc.) and construction phases.
3. Discuss the related socio-economic considerations as they affect the design of structures.

In addition to the results arising from the above information exchange, NBS will assess the effectiveness of the project to date in accomplishing its goals; evaluate the effectiveness and direction of the Philippine advisory committee; and redirect individuals as needed. This opportunity will permit NBS to alter activities and reschedule tasks as required.

The second series of reports will be prepared shortly after the consultants return from the Manila meeting. These reports will address the series of topics discussed during the meeting and will elaborate on problems associated with extreme wind loading on low-cost/low-rise buildings for the consultants geographic area. An example of topics

to be included are the following:

1. Identify housing trends and their design problems.
2. Discuss the influence of socio-economic considerations on housing patterns.
3. Perform a survey and analysis of housing needs for the next ten years.
4. Collect and tabulate available climatological data on extreme winds.
5. Collect and tabulate wind damage statistics.
6. Study the applicability of alternative solutions for mitigating losses from high winds.
7. Define possible low-cost building design problem areas unique to each consultant's geographic area.

NBS received correspondence from Dr. Choudhury and Mr. Shaheedulla expressing an interest in providing consulting services. These individuals are currently under review for a contract award. It is expected that a consultant will be selected in July 1973.

Visit to Northern Caribbean Islands

A meeting on July 9 and 10 is scheduled with the Bureau of Standards, Society of Architects, Ministry of Public Works, the Ministry of Housing and the University of the West Indies in Kingston, Jamaica. In order to maximize the transfer of information to Caribbean developing countries, it is planned that individuals and organizations in Haiti and the Dominican Republic with

the appropriate qualifications be invited to attend the meeting in the Philippines.

Purchase of Equipment for Fiscal Year 1974

Typical components of instrumentation systems required for the research project have been itemized in an earlier section of this report. Components to be purchased and assembled in FY74 will satisfy requirements for wind tunnel testing and data analysis and will provide for three complete field instrumentation systems. It is possible that more than one full-scale structure can be served by a single data acquisition system.

Identification of Field Test Sites

The Philippine Advisory Committee, with the concurrence of NBS, will select 3 or 4 field sites for instrumenting full scale buildings. It is expected that several sites will be discussed for consideration during the international meeting before narrowing the selection down to 3 or 4.

The identification of suitable field test sites depends upon a number of factors including the frequency of tropical storms and typhoons, the type of terrain (wind exposure), the structure's availability, and its accessibility. In addition, commercial power must be available (other than during storm conditions when power outages must be expected to occur) and the sites should be reasonably secure from flooding due to runoff or storm surge.

Obviously, some economy can be realized by instrumenting existing structures that satisfy the above requirements and that are geometrically

and structurally similar to those housing systems which merit detailed study. On the other hand, structures erected specifically for this research program and located on Philippine Weather Bureau sites would allow for supplementary wind data, regular equipment maintenance and equipment security.

As a result of the field visit to the Philippines in April 1973, the NBS study team was able to assess the National Housing Corporation Plant, north of Manila, as a candidate test site. The reasons for considering this site are as follows:

1. Several innovative housing systems have been erected on the plant grounds and have been offered for use as test structures.
2. The site substantially satisfies the requirements or factors for site selection as listed above.
3. The site is reasonably close to the University of the Philippines which will allow for periodic monitoring and maintenance by university personnel.
4. A field trip to the site to observe actual wind monitoring and testing could easily be arranged during the course of the international meeting scheduled in Manila later this year.

Based on discussions with Philippine Weather Bureau personnel, a second candidate site has been identified near Virac, Catanduances (about 240 miles east of Manila). The mean annual crossing frequency of tropical storms in the Catanduances area is relatively high. This island is also the site of a well-equipped weather station. If this site is selected, a housing system will have to be erected at the weather bureau site near the

municipality of Virac.

It is hoped that selection of other sites can be made within the next six months after a more thorough analysis of climatological data has been completed. The choice of housing systems to be erected and instrumented will probably be deferred until after the fall meeting.

Climatological Data

As discussed in the previous subsection, final selection of test sites must be based, in part, upon the probability of extreme winds occurring at the site. Also, the development of maps showing distributions of extreme winds over the Philippines is one of the goals of the research program.

Basically, this involves the tabulation of annual peak winds for a number of selected weather stations and the fitting of the resulting series with appropriate extreme value probability distributions. Fortunately, considerable work has already been done on this problem by the Philippine Weather Bureau and distributions for various mean recurrence intervals are available. While subsequent studies may show that distributions other than the commonly termed Type I, extreme value distribution provide a better fit, existing information is certainly suitable for site selection. Computer programs for establishing parameters of annual extreme winds and mean speeds corresponding to given mean recurrence intervals have been developed at NBS and will be used in the project. The Philippine Weather Bureau is now in the process of digitizing annual extreme wind speeds for all stations and it is anticipated that work on

new distributions will be well under way in FY74. In general, these documents represent approximately 20 years of records which is generally considered adequate for the degree of statistical confidence required.

Wind Tunnel Studies

So that instrumentation can be properly positioned on full-scale structures to yield the most useful test data, it is advantageous to conduct preliminary wind tunnel studies on models of the test sites.

It is recommended that model studies be conducted at a scale of 1:75 or 1:100 in the University of the Philippines (UP) wind tunnel facility. The simulation of the atmospheric boundary layer will be the most critical and most difficult part of this task, requiring a trial and error procedure by persons having extensive experience in this type of work. This can best be accomplished by using a wind tunnel in the United States having dimensions and geometry similar to the UP facility. Once the technique is established to model the mean velocity profile and the scale and intensity of turbulence, it should be relatively simple to establish a similar flow in the UP tunnel. A survey of research centers indicates that Colorado State University is well qualified to carry out, under the technical supervision of NBS, this preliminary phase of wind tunnel testing.

The UP tunnel has a 4 x 4 ft test section with a useable length of 12 feet. While this is satisfactory for most model tests anticipated during the program, serious thought may be required to evaluate the need to construct a new facility specifically designed for building research

problems. This could contribute substantially to the establishment of a regional center for wind research in the Philippines. On the basis of a visit to the new wind tunnel now operating at the University of Sydney, it is believed that a tunnel could be constructed at the University of Philippine's for approximately $8,000. This investment, at least in part, could probably be recovered during the course of the current program due to the simplification of modeling techniques and would allow future investigations into more complex areas such as aeroelastic response problems.

C. PRELIMINARY FISCAL YEAR 1974 PROJECT SCHEDULE

The following table presents a summary of the major activities scheduled for FY74. These items are presented for illustration purposes and should not be considered as complete or inflexible. As activities are initiated the table may be adjusted to reflect appropriate changes.

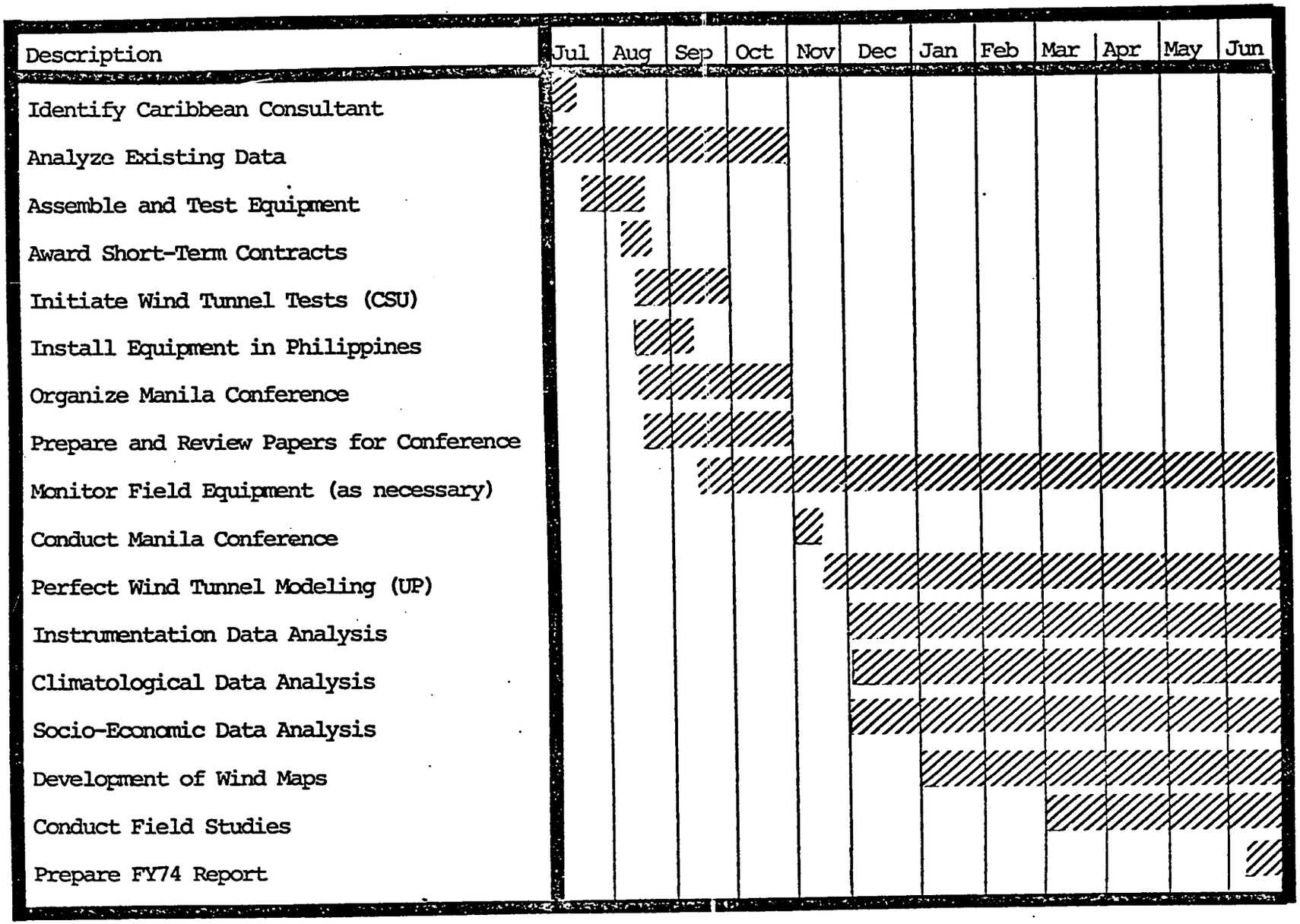

Table 1. FY74 Project Schedule

APPENDIX A

ORGANIZATIONS AND FACILITIES VISITED DURING THE APRIL 1973 FIELD TRIP

APPENDIX A

ORGANIZATIONS AND FACILITIES VISITED DURING THE APRIL 1973 FIELD TRIP

During the initial field trip to Japan, Philippines, Bangladesh, England and Australia contacts were made with many individuals. Among those contacted were the following:

1. Tokyo, Japan

   a. U.S. Embassy
      Mr. Richard H. Zorn II, Second Secretary, Deputy Scientific Counselor

   b. Ministry of Construction, Public Works Research Institute
      Mr. Mitsutu Nagao, Director
      Dr. Tadayoshi Okubo, Head, Structure and Bridge Section, Chiba Branch
      Mr. Tatsuo Kawagoe, Director Arabane Branch
      Mr. Eiichi Kuribayashi, Chief Earthquake Engineering Section, Chiba Branch
      Mr. Hiroshi Yoshimura, Director Planning Division
      Mr. Saburo Matsuno, Chief of Planning Section
      Mr. Masami Fukuoka, Professor Civil Engineering, University of Tokyo

2. Manila, Republic of the Philippines

   a. USAID Mission
      Mr. William C. Larson, Assistant Director for Capital Deveiopment
      Mr. Thomas E. Johnson, Deputy Assistant Director for Capital Development

   b. University of the Philippines, Quezon City
      Dr. Alfredo L. Juino, Dean College of Engineering
      Dr. Aurelio T. Juguilon, Dean College of Architecture
      Dr. Ernesto G. Tabujara, Associate Professor of Civil Engineering
      Mr. Angel A. Alejandrino, Professor of Engineering
      Mr. Geronimo V. Manahan, Professor of Architecture

   c. Philippine Weather Bureau, Quezon City
      Dr. Roman L. Kintinar, Director
      Mr. Catalino P. Arafiles, Weather Specialist

Mr. Wellington A. Minoza, Weather Specialist
Mr. Hugo dela Cruz, Climatologist
Mr. Manuel Bonjoc, Weather Specialist

d. National Housing Corporation (NHC), Caloocan City
Major General G. V. Tobias, Executive Vice President

e. Peoples Homesite and Housing Corporation (PHHC)
Lt. Col. Manuel Rebuena

f. Economic Commission for Asia and the Far East (ECAFE)
Dr. Sudhindra Nath Senn, Chief, Typhoon Research Committe
Secretariat

g. Land and Housing Development Corporation (LHDC), Quezon C
Col. Alberto R. Sanchez, Vice President (Operations)

h. Government Service Insurance System (GSIS)
Mr. Jose P. Orola, Chief, Engineering Department
Mr. Modesto Soriano, Engineer

i. Social Security Systems (SSS)
Mr. Miguel V. Paala, Chief Real Estate Department

j. A. R. Flores and Associates, Consultants
Mr. Ambrosio R. Flores, Structural Engineer

k. Concio and Associates
Mr. Cesar H. Concio, Architect

l. Association of Structural Engineers of the Philippines
Mr. Andres Hizon, President

m. Philippine Association of Civil Engineers
Mr. Cesar A. Caliwara, President

n. Bureau of Public Works (BPW)
Mr. Rosalio A. Mallonga, Chief Structural Engineer

o. National Science Development Board (NSDB)
Mrs. Magdalena Templa, Director
Mr. Romeo Cardoba

Dacca, Bangladesh

a. USAID Mission
Mr. David Mandel, Chief Capital Development Division
Mr. Dave Wilson, AID Coordinator
Mr. Edward A. Glaeser, AID Coordinator

Mr. Roy Haftorson, Chief Engineer
Mr. S. A. F. Rahman, Engineer

b. U.S. Embassy
Mr. Marvin Brenner, Administrative Officer
Mr. Piere H. Jabbour, Budget and Fiscal Officer

c. CARE, Incorporated
Mr. George Taylor, Director
Mr. William Woudenberg, Civil Engineer

d. Bangladesh University of Engineering and Technology
Dr. Obaidul Islam, Associate Professor Mechanical Engineer
Dr. Jamilur R. Choudhury, Associate Professor Civil Engineering

e. Shaheedulla and Associates
Mr. S. M. Shaheedullah, Consulting Engineer

f. Building Research Institute
Mr. Hossian, Chief Engineer, Housing
Mr. Zahiruddin, Chief, Architect Building Department

4. Watford, England

a. Building Research Establishment, Department of the Environment
Dr. S. Bate, Chief Division of Structural Engineering
Dr. Keith J. Eaton, Senior Research Officer
Dr. John Menjies, Section Head
Dr. Nick Cook, Wind Tunnel Analyst
Mr. John Manyn, Instrumentation

5. Sydney, Australia

a. University of Sydney, Sydney, NSW
Dr. B. J. Vickery, Department of Civil Engineering

6. Melbourne, Australia

a. Monash University, Clayton, Victoria
Dr. W. H. Melbourne, Department of Mechanical Engineering
Dr. R. Barden, Head, Department of Mechanical Engineering

b. Division of Building Research, CSIRO, Highett, Victoria
Dr. R. W. R. Muncey, Chief
Dr. F. A. Blakey, Assistant Chief
Mr. N. H. Cloot, Research Officer
Mr. G. F. Reardon, Research Officer

APPENDIX B

BIBLIOGRAPHY OF DATA RELEVANT TO THE NBS/USAID WIND PROJECT

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BIBLIOGRAPHY OF DATA RELEVANT TO THE NBS/USAID WIND PROJECT

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