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DEPARTMENT OF STATE
U.S. AGENCY FOR INTERNATIONAL DEVELOPMENT
AMERICAN EMBASSY, JAKARTA, INDONESIA

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PROJECT PAPER

APPROPRIATE AND LOW-COST TECHNOLOGY

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USAID/INDONESIA Grant Project 497-0268

Project Paper Approved March 17, 1978 by
Thomas C. Niblock, Director, USAID/Indonesia

Life-of-Project Grant Funds allotted by AID/W
in State 073497, dated 22 March 78.

EHR/Science and Technology Office
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APPROPRIATE AND LOW COST TECHNOLOGY

(Grant Project No. 497-0268)

PROJECT PAPER

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A. Face Sheet

AGENCY FOR INTERNATIONAL DEVELOPMENT

PROJECT PAPER FACESHEET

1. TRANSACTION CODE: A (A ADD, C CHANGE, D DELETE)

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2. DOCUMENT CODE: 3

COUNTRY ENTITY: USAID/Indonesia

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PROJECT NUMBER (7 digits): 497-0268

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7. PROJECT TITLE (Maximum 40 characters): APPROPRIATE AND LOW COST TECH.

ESTIMATED FY OF PROJECT COMPLETION: FY 80

9. ESTIMATED DATE OF OBLIGATION: A. INITIAL FY 78; B. QUARTER 2 (Enter 1, 2, 3, or 4); C. FINAL FY 78

10. ESTIMATED COSTS ($000 OR EQUIVALENT $1 =)

A. FUNDING SOURCE	FIRST FY B. FX	C. L/C	D. TOTAL	LIFE OF PROJECT E. FX	F. L/C	G. TOTAL
D. APPROPRIATED TOTAL						
GRANT:	(500)	( )	(500)	(500)	( )	(500)
LOAN:	( )	( )	( )	( )	( )	( )
HER U.S. 1.						
HER U.S. 2.						
ST COUNTRY		50	50		175	175
HER DONOR(S)						
TOTALS	500	50	550	500	175	675

11. PROPOSED BUDGET APPROPRIATED FUNDS ($000)

A. APPROPRIATION	B. PRIMARY PURPOSE CODE	PRIMARY TECH. CODE C. GRANT	D. LOAN	E. 1ST FY 78 F. GRANT	G. LOAN	H. 2ND FY 79 I. GRANT	J. LOAN	K. 3RD FY ___ L. GRANT	M. LOAN
ST	B750			500					
TOTALS				500					

A. APPROPRIATION	N. 4TH FY ___ O. GRANT	P. LOAN	Q. 5TH FY ___ R. GRANT	S. LOAN	LIFE OF PROJECT T. GRANT	U. LOAN
ST					500	
TOTALS					500	

12. IN-DEPTH EVALUATION SCHEDULED: MM 02 YY 80

DATA CHANGE INDICATOR. WERE CHANGES MADE IN THE PID FACESHEET DATA, BLOCKS 12, 13, 14, OR 15 OR IN PRP FACESHEET DATA, BLOCK 12? IF YES, ATTACH CHANGED PID FACESHEET. (See Annex "A").

2 (1 = NO, 2 = YES)

Restatement of project purpose Block 15 to: "Promote rural development and employment generation through low-cost, labor-intensive technology".

14. ORIGINATING OFFICE CLEARANCE

SIGNATURE: Thomas C. Niblock

TITLE: Director, USAID/Indonesia

DATE SIGNED: MM 03 DD 17 YY 78

15. DATE DOCUMENT RECEIVED IN AID/W, OR FOR AID/W DOCUMENTS, DATE OF DISTRIBUTION: MM DD YY

AID 1330-6 (9-78)

(PART I)

B. Recommendations

It is recommended that a Grant of $500,000 be made available for this Project. The Congress has been notified through the regular FY78 CP. Waivers for non-competitive selection of the Georgia Institute of Technology and the Asian Institute of Technology as contractors for technical assistance will be made based on the justification stated in Annexes C and D. Financing Authority for local currency costs will be issued.

(PART I)

C. Summary Description of the Project

APPROPRIATE AND LOW COST TECHNOLOGY (Grant)-Proj. No. 497-0268

Goal : To improve the quality of life and increase the income of the rural poor.

Purpose: Promote rural development and employment generation through low-cost, labor-intensive technology.

Background

The most widely accepted definition of appropriate technology may be stated as the adaptation of technologies to the environment and conditions of the locality where they will be applied. From an AID viewpoint, we would add that the technology must contribute to the social and economic development of a developing nation, with particular attention to benefits to the poor. In Indonesia, (and in many other developing countries), this means that the technology should require relatively little capital and practically no foreign capital, use common local (or locally-available) resources and materials, maximize use of local semi-skilled and unskilled labor, meet local needs and markets, and generate new employment opportunities, particularly through development of small industry.

The Project

This is a pioneering project that is responsive both to Congressional and AID priorities (Sections 106, 107, and 119, FAA in particular) and a GOI determination that small industry development in rural areas will receive priority attention.

Before introducing a technology there first must be practical research and development to adapt, test and assure the acceptance and cost effectiveness of the technology for the specific situation where it is to be used. This project is concerned with such adaptation, designing, experimentation, lab testing, field testing, acceptability trials, training program formulation, cost effectiveness determinations, and any other activities which should be completed before entering into a program of mass dissemination and utilization throughout rural Indonesia.

In other words, before the mass application of any specific appropriate technology, one should be reasonably sure that the technology has been correctly adapted and tested, and is locally acceptable, economically sound, producible and marketable. Environmental consequences, both positive and negative, should be investigated before proceeding to a follow-on application and dissemination project of mass replication and utilization of products.

This project consists primarily of applying the above guidelines to two appropriate technology approaches which appear eminently suitable for the Indonesian scene. Both are based on older technologies, modernized.

These approaches are:

1. Pyrolytic Conversion of Agricultural Waste to Energy Sources ($250,000)

   This process converts relatively dry, cellulosic agricultural waste, such as sawdust, rice hulls, nut hulls, coconut husks or bagasse, into char, fuel oil and gas, using a simple converter designed for the specific situation. A feasibility study for pyrolytic conversion potentials in Indonesia was done in November, 1976 by the Georgia Institute of Technology (Georgia Tech) and the Development Technology Center of the Institute of Technology at Bandung (DTC/ITB). Very favorable conclusions were reached. A small locally-made converter, costing about $1,000 to $2,500 is predicted to give a financial return of between 15%-20% per year when based upon converting rice hulls, a waste material found at more than 30,000 rural rice mills. This project will support the design, adaptation, testing, demonstration, acceptance trials, training trials, market development, etc., relative to introducing pyrolytic converters at the village level. Georgia Tech, which has predominant capacity in this field, would assist the DTC. The oil and char produced may be sold as an alternative energy source, with obvious benefits in resolving energy problems, in employment generation, and, as a wood substitute, in reducing environmental pressures (i.e. deforestation). The char may also be processed for non-energy purposes such as charcoal filters for water, thus deriving health benefits, or it may be processed further to activated carbon, which has a high market price and demand. The gas may be used for drying purposes (e.g. rice), or to run an engine.

2. Ferrocement Technology for a Variety of Village Needs ($200,000)

   Ferrocement technology is the hand-plastering of concrete, normally onto a wire mesh. It is a labor intensive, low capital technology which basically requires only cement, sand and water, wire mesh or other fibers, and relatively unskilled labor. It is a technology that can be used for such village level needs as the construction of food and water storage containers, small and medium (and large) boats, docks and pontoons, well casings, toilet bowls, components for low cost housing, etc. It will serve as an alternative to imported steel plate or scarce wood, particularly where a curved, strong thin shell is required. It requires little or no maintenance, and the products are especially resistant to tropical problems such as humidity, termites and teredo worms, and are wear resistant and very long-lived. It is particularly appropriate to Indonesia because the country now is self-sufficient in cement, with an annual surplus targeted to start in 1978. The President of the Indonesian Cement Association has given his personal approval and support to the purposes of this activity.

   For this activity, the term "ferrocement" will be interpreted broadly, including non-ferrous indigenous fibers such as bamboo, bagasse, coconut husk fiber (coir), or other natural fibers. In some cases, there will be no reinforcing fiber at all. The selection of the type of fiber reinforcement (i.e. steel mesh, chopped wire, vegetable fiber or no fiber)

will depend upon the structural requirements (i.e. low strength or high strength) and the availability and cost of the materials, for each intended application and site.

The activity will provide training assistance and technical support from the experienced ferrocement technology group at the Asian Institute of Technology (AIT), Bangkok, a non-profit regional educational institution which AID helped to establish. The DTC/ITB will interrelate with provincial universities and local administrative units in at least three rural areas; the Ujung Pandang area in South Sulawesi, Aceh Province in Sumatra, and with the Sukabumi Regency in West Java. These units have all expressed a strong desire to collaborate in this project. The beneficiaries will be the small farmers, fishermen, and villagers who will have cheaper and more serviceable facilities for water and food storage, river transport, fishing boats, etc., and who will gain employment in ferrocement manufacturing and marketing.

The long-term effects of this project and the proposed follow-on dissemination and utilization activity will be measurable in terms of an increase in the net income of the rural poor who are influenced by the project and by those job opportunities that accompany the new technology. Better food and water storage, boats, housing and other improved facilities will also enhance the quality of life in the rural community.

3. Special Applications and Studies of Appropriate Technologies ($50,000)

In addition to the major activities described above, 10% of the $500,000 grant, (i.e. $50,000) will be reserved for funding special applications and studies of appropriate technologies, such as the purchase of a low-cost piece of appropriate technology equipment developed by another institution or country, for purposes of examination and initial testing in the Indonesian context. As the appropriate technology movement spreads, there are often special conferences held on the subject with important benefits to participants, both in describing their projects to others to enhance the spread effect, and in obtaining outside viewpoints and ideas from other experts attending the conferences. New publications on appropriate technology often are discussed at the conferences. These special funds will be used for these purposes. Any unexpended portion of this $50,000 line item will be transferred to expedite the ferrocement activity or the pyrolytic converter activity.

D. Summary Findings

The Mission has determined, based primarily upon the positive results of two feasibility studies, that the Development Technology Center (DTC), Bandung Institute of Technology -- the appropriate technology unit of the Institute of Technology, Bandung (ITB) -- should receive this grant of $500,000 for an appropriate technology project of approximately eighteen months to two years duration. The project will be to thoroughly explore and test in the field various designs and adaptations possible in the technologies of (1) pyrolytic conversion and, (2) hand plastered cement , (unreinforced, or reinforced by wire mesh or fiber). In addition ten percent of the funds

($50,000) will be reserved for special applications and studies of appropriate technologies, provided the Mission concurs with the DTC/ITB on each specific expenditure. Such uses may be, (a) participation in conferences specifically treating appropriate technology, (b) purchase of a prototype "sample" of equipment developed by other institutions and countries, (c) limited purchase of publications on appropriate technology, and (d) other similar purposes agreed on by the DTC/ITB and the USAID.

The implementing institution (DTC/ITB) has been examined and is believed to have the capacity to carry out its responsibilities under the project. Through subcontracts for training and technical assistance, it will draw upon the Georgia Institute of Technology in the field of pyrolytic conversion and the Asian Institute of Technology in the field of ferrocement technology. Other consultancies, on a small scale, may be required.

Provided that the project proves successful in adapting and testing these two appropriate technologies, USAID expects to develop a follow-on project for widespread application and dissemination of the technologies and utilization of their products. However, the planning and development of any follow-on project will be done under this project.

The social soundness analysis has proven positive. This initial R&D project will have no environmental impact. However, the successful introduction of the aforementioned technologies should have a salutory environmental impact through the conversion of waste into energy sources that are non-polluting in character. In a like manner, the adaption of ferrocement applications will have a positive environmental impact by reducing the depletion of Indonesia's natural forestry resources.

E. Project Issues

There are no project issues at this stage nor are any expected. All parties that might be involved in the project were thoroughly briefed by a feasibility study team, and, without exception, they understand and support the project. These include village leaders, village entrepreneurs, local administrators at the Bupati (Regency) and other levels, GOI small industry representatives, the cement manufacturing industry, the regional universities that will be involved (i.e. Hasanuddin University and its Regional Adaptive Technology Center, Ujung Pandang, South Sulawesi; Syiah Kuala University and its new Rural Development Center, Banda Aceh, Sumatra; and the Institute of Technology Bandung and its Development Technology Center, Bandung, Java), the Asian Institute of Technology in Bangkok; the Georgia Institute of Technology; several Indonesian private small industry entrepreneurs ; and a UN ferrocement expert working on boatbuilding in Irian Jaya.

PART II. BACKGROUND AND PROJECT DESCRIPTION

A. Background

Appropriate Technology

Appropriate technology, which is more or less synonymous with other terms such as "intermediate technology", "adaptive technology" or "light capital technology", means adapting technologies to the environment and conditions of the locality where they will be applied.

The definition includes software, hardware, and development of entrepreneurship and markets. Technologies suitable for highly developed countries usually are high in capital cost and relatively low in labor usage, simply because of the ready availability of capital and the high cost of labor usually characteristic of highly industrialized nations. Furthermore, high-capital technologies normally require a high skill level for design, construction, operation, and maintenance, which,in turn, requires a broad and deep educational base. Other factors may enter the equation, such as designing for a temperate zone climate, a widespread transportation system, and a large, sophisticated market.

Developing countries usually do not have the above characteristics. Therefore, picking up a technology designed for and successful in a developed country often fails when transferred unaltered tc the developing country.

There are some cases, however, when technology must be transferred without significant change, such as in satellite communications, air transport, modern defense systems, and computerized data handling and analysis. When this happens, the receiving environment must be adapted rather than adapting the technology transferred. That is, capital must be raised, high-skill labor must be trained, the correct electrical supply must be provided and stabilized and adverse climatic conditions must be overcome (e.g. air conditioning).

However, in addressing the broad needs and livelihood of the large, poor, rural populations found in developing countries, such unaltered "advanced" technologies have little meaning, and some other approach using an "appropriate technology" must be developed to enhance the prosperity and well-being of the people, and to balance the investments in sophisticated technology that may be required for national development.

In recent years there has been a growing awareness of this fact. The World Bank now requires an appropriate technology philosophy and approach in its projects when and wherever feasible. The U.S. Congress, in addressing the role and program of the Agency for International Development, included a charge (Section 107, FAA) to use appropriate technology in its programs.

A House Report (94-442) states:

> "The experience of more than a quarter century of development assistance programs overseas has clearly demonstrated that much of the technology used in the United States and other industrialized countries is not well suited to the economies of developing countries. It is too big, it is too expensive, and it does not create jobs needed to absorb rapidly expanding labor forces in countries which already have an abundance of labor. It is not appropriate for use on the very small farms and in the very small business enterprises that make up so much of the economic activity in the developing world.
>
> If the poor are to participate in development, as envisioned by the reforms enacted in the Foreign Assistance Act of 1973 and by this bill, they must have access....to technology which is neither so primitive that it offers no escape from low production and low income nor so highly sophisticated that it is out of reach for poor people and ultimately uneconomic for poor countries...."

The House Report urges AID to expand "as rapidly as possible" its appropriate technology including an increased effort for the following objectives (underlinings added):

> "(1) <u>To promote the development and dissemination</u> of technologies appropriate for developing countries, particularly in the areas of <u>agriculture</u> and <u>rural development</u>, <u>small business enterprise</u>, and <u>energy</u>;
>
> (2) To <u>identify</u>, <u>design</u> and <u>adapt from existing designs</u> appropriately scaled, labor-intensive technology, and policies and institutions directly related to their use;
>
> (3) To formulate policies and techniques to facilitate the organization of new small businesses;
>
> (4) To engage in <u>field testing of intermediate (appropriate) technology</u>;
>
> (5) To establish and maintain and information center for the collection and dissemination of information on intermediate technology; and

(6) To support expansion and coordination of developing country efforts in this field."

More recently (August 3, 1977), the Congress amended the Foreign Assistance Act by adding Section 119, "Renewable and Unconventional Energy Technologies." The "pyrolytic conversion" half ($250,000) of this Appropriate and Low-Cost Technology Project is directly responsive to the mandate in Section 119 to work in

> "....cooperative programs with developing countries in energy production and conservation, with particular emphasis on programs in research, development, and use of small-scale, decentralized, renewable energy sources for rural areas.... directed toward the earliest practicable development and use of energy technologies which are environmentally acceptable to and affordable by the people using them, are simple and inexpensive to use and maintain, and are transferable from one region of the world to another."

Appropriate Technology and Indonesia

In 1973, Indonesia presented a paper, "Indonesia's Present Setting and Perspective for Technology Transfer," at the International Conference on Technology Transfer in Modernizing Nations, Karachi, Pakistan, November 13-14, 1973. The paper was written by Dr. D.A. Tisna Amidjaja (now Director General of Higher Education, Ministry of Education), and Dr. Filino Harahap (now Director, Development Technology Center (DTC), Institute of Technology Bandung (ITB). It pointed out that ITB, (which is Indonesia's leading engineering school) had been exploring since 1969 ways in which ITB could support Indonesia's development efforts and had concluded in 1970 that the basic ITB philosophy should be oriented and committed to the development of the country. Regarding the role of technology transfer, the paper examined technology transfer and encouraged "more appropriate operations and technologies, especially in the consumer goods sector...." and stated, "the rural sector would obtain more attention." It concluded, "We (ITB) are concerned in making the concepts of appropriate technology .... operational within the context of our development efforts, especially with reference to the crucial issues of employment and rural social technology generation. Within ITB, concern is manifested in an agency (new) called the Development Technology Center (DTC)."

The paper then listed the DTC's objectives, which are essentially those outlined in Annex F. It is this appropriate technology organization, created and administered by Indonesians, which will take the responsibility for this project.

Pyrolytic Conversion

Pyrolysis, or destructive distillation, is the thermal degradation of a lignocellulosic material into simpler compounds, and its basic principals (e.g. charcoal making) have been known for centuries. The useful prdocuts of pyrolysis are a char, an oil, and a mix of gases. In rural areas, a pyrolysis process that predominantly generates a gas, however, is normally of little interest because of the problem of transporting this bulky, low energy product to a potential user, unless there is an on-site use, e.g. drying purposes. The char and oil, on the other hand, represent dense, high energy fuels which are storable and readily and economically transportable. Thus, a pyrolysis process designed to maximize char and oil production is most desirable for converting agricultural wastes to useful energy forms or to other useful products such as charcoal filters, activated carbon, rubber processing additives, carbon elements, etc.

The relative amounts of char, oil and gas produced by any pyrolytic conversion process are primarily controlled by three variables, i.e.:

* The residence time of the feed in the pyrolytic reactor

* The temperature in the pyrolytic reactor

* The pressure in the pyrolytic reactor

Most of the technically successful pyrolysis systems developed to date have involved moderate residence times and ambient pressure. Thus, for practical purposes, the major controlling variable is temperature. Low temperature pyrolysis processes favor char and oil production, while high temperature pyrolysis processes favor oil and gas production.

A low temperature pyrolysis process, because it maximizes char and oil production, is best suited for various kinds of agricultural wastes. Conveniently, low temperature pyrolysis processes typically require readily available materials and relatively simple technology and are thus more rugged and can be more simply maintained than high temperature systems, a special advantage in developing nations.

Because the pyrolytic convertor must operate in areas remote from outside sources of power, the system must also be self-sustaining. One simple, well-understood, technically developed way to accomplish this is to provide the heat necessary to maintain the reaction rates at attractive levels through partial oxidation of a fraction of the char produced. A steady-flow, vertical, porous bed, reactor design is mechanically and technically perhaps the simplest means to achieve this.

Applying Pyrolytic Conversion to Indonesia

Current Indonesian development plans assume an average annual increase of about 7% in energy consumption throughout the last quarter of this century, with the result that by the year 2000 the energy required will have increased almost six times above today's needs. While Indonesia is fortunate to have relatively abundant supplies of oil and coal, it currently depends heavily, and will continue to do so in the future, upon these fossil fuels, especially the oil, to provide it with the foreign exchange required for planned development. Thus, since the needs of the country for energy are increasing and the need for foreign exchange is unabated, the obviously finite limit to Indonesia's fossil fuel reserves is a subject which cannot be ignored. Clearly, a program to develop an alternate energy supply appropriate to certain of Indonesia's energy needs should be of high priority.

Pyrolytic conversion, an attractive means of converting agricultural waste (biomass) into high-energy fuels that can be stored, transported, and used much more efficiently and conveniently than the original agricultural waste, is an appropriate technology suitable within the Indonesian context. Low temperature pyrolysis produces charcoal and oil, fuels than can be used directly by the people and thereby relieve the current heavy burden on Indonesia's forests caused by the need for firewood, particularly on the deforested, highly populated island of Java. It also will relieve pressures on the use of kerosene, now highly subsidized (up to 80%) by the GOI. A preliminary technical and economic feasibility study was made in November 1976 to insure that an adequate supply of wastes were available, that a market existed for the products of pyrolytic conversion, and that the means for producing the necessary equipment were at hand, using locally available materials and labor.(Available from USAID/Indonesia Science and Technology Office).

In order to use energy from wastes, especially in the homes, some changes in habit may be necessary and the development of auxiliary equipment, such as cooking stoves and lamps, that can burn the pryolytic oils must be made. Also, appropriate equipment to convert the char to convenient "charcoal briquettes" may be needed.

The feasibility study also recommended strongly that a programmatic focus be on rice hulls as the waste to be utilized initially. Thirty thousand rural rice mills produce about 5.5 million metric tons of rice hulls per year, nearly all of which are burned behind each mill, adding to air pollution but nothing or little to the economy. The average small rice mill handles about three tons of rice per day, of which two tons are milled rice and bran and one ton waste hulls.

This focus on developing, testing and demonstrating ideal designs for converting waste rice hulls from small rice mills, is not meant to exclude experimentation on other wastes, such as sawdust and related tree waste, and coconut husks.

It is also possible to develop mobile units; that is, a converter which could be dismantled after a relatively small waste resource (such as a sawdust pile from a small sawmill) had been used up, the dismantled units placed on several trucks of a size suitable for Indonesian roads, moved to a new waste site (e.g. another sawdust pile) and reassembled.

The feasibility study also proved the unit could be made from locally obtainable materials such as pipe, copper tubing, and "tin" sheeting, and by using existing local labor skills to cut and fasten tin sheeting, braze tubing, etc. The feasibility study suggests that a unit capable of handling one ton a day of rice hulls waste might be made locally for about $1,500 to $2,000 each, with the capital investment paid off in two or three years and a 15% to 18% return in profit. More precise figures would be developed during the course of the activity.

A thorough discussion of the technical and economic aspects of this activity can be found in the sections and annexes on technical and economic analysis, which have been drawn primarily from the feasibility study, "Pyrolytic Conversion of Agricultural and Forestry Wastes to Alternate Energy Sources in Indonesia; A Feasibility Study," issued by the Economic Development Laboratory of the Engineering Experiment Georgia Institute of Technology, Atlanta, in February 1977.

Background(continued)

Applying Ferrocement (and unreinforced or natural fiber reinforced cement) Technology to Rural Development

Ferrocement is a highly versatile form of reinforced concrete made by plastering a mortar of cement, sand and water onto a wire mesh, giving it not only unique qualities of strength, crack-resistance and serviceability, but also its ability to follow compound curves and lines in free form, thus being adaptable to shapes and sizes to fit the local needs. In this project, the word "ferrocement" is used broadly. That is, its conventional and literal meaning of "plastered concrete with ferrous (steel and iron) content" is used only when considerable strength is needed, (e.g. boats). Where only moderate strength is needed (e.g. roof panels) to serve the purpose, reinforcement with indigenous natural fibers (e.g. bamboo, coir, bagasse, palm tree fiber, etc.) will be stressed. In the cases where no reinforcement is needed (e.g. moderate sized and specially shaped water and food storage containers), the "ferrocement"will be simply cement mortar hand plastered onto a temprary surface acting as a form. These distinctions are clarified further in this project paper.

Background

Historically, "ferrocement" was invented in 1847 by a Frenchman, Joseph Louis Lambot, who in 1848 pressed a cement mortar into and around wire mesh made in the form of a rowboat. The boat can still be seen in the Brignoles Museum in France. Another rowboat, built in Holland in 1887, was still afloat in 1967 in a pond in the Amsterdam Zoo. This demonstrated durability of ferrocement is one of its strong points, particularly for a tropical climate which quickly destroys wooden materials through termites and other insects (and the teredo "worm" in a marine environment), steel materials through corrosion from tropical humidity, and plastic materials through high intensity ultra-violet radiation from the tropical sun.

The next historical developments in the technology of steel reinforced concrete drifted away from "ferrocement" and into "reinforced concrete," that is, the development of the technology of using larger diameter rods in cement and aggregate poured into molds. Attention to ferrocement technology declined for several reasons, including the fact that the hand plastering required a high degree of labor which was costly in highly industrialized societies, and the competition of mass produced thin steel plate. Reinforced concrete is still preferable, of course, for compression uses such as supporting beams and roadways. For other uses, however, such as boat hulls and thin shell domed roofs, ferrocement is superior in technical performance. On occasion, even in developed economies, ferrocement is used without the public being aware of it; for example, the distinctive arched roofs of the Sydney Opera House, Australia, are of ferrocement.

The technology of ferrocement was given a boost in the early 1940's by an Italian engineer, Piere Luigi Nervi, when he noted that reinforcing concrete with layers of wire mesh (i.e. ferrocement) produced a material capable of resisting high impact. Thin (less than 1 inch) slabs of concrete reinforced in this manner proved to be flexible, elastic and exceptionally strong. After WW II, Nervi's firm built a 165-ton motor sailer Irene with a ferrocement hull 1.4 inches thick, weighing 5 percent less than a comparable wood hull, and costing 40 percent less. The Irene proved entirely seaworthy, surviving two serious accident. Other than simple replastering necessitated by the accidents, the hull required little maintenance, pointing up another of the advantages of ferrocement: it is easily repairable and nearly maintenance free. In 1965, an American-owned ferrocement yacht built in New Zealand, the 53 foot Awahnee, circumnavigated the world without serious mishap, although it encountered 70-knot gales, collided with an iceberg, and was rammed by a steel-hulled yacht.

Nervi also applied ferrocement to buildings, constructing a small storehouse in 1947, a 50 foot vaulted ceiling over a swimming pool, and the then famous Turin Exhibition Hall -- a roof system spanning 300 feet made of a combination of ferrocement and reinforced concrete.

In 1973, a U.S. National Academy of Sciences committee, working under a centrally-funded A.I.D. project to seek technologies particularly appropriate and useful to the conditions and needs of developing countries, produced a

study, "Ferrocement" Applications in Developing Countries." The point of the report was that the very thing that retarded the use of ferrocement in highly industrialized economies, its labor-intensivity, made it ideal for those developing countries which were short on capital but had an over-abundance of unskilled and semi-skilled labor, provided they also had cement, sand, water and wire. The historical attention to using ferrocement in boat building often causes the public to equate ferrocement technology only with boat building; however, the Academy report suggested its possibilities for use in food and seed storage, water (or other liquid) storage, water catchments, troughs, vats, leather-processing facilities, grain and copra dryers, engine beds (ferrocement is particularly resistant to vibration) drying pads, cattle dips and feeders, housing components (particularly roofing slabs and shingles), well linings, and for disaster relief and mitigation purposes as well as boats, barges, docks pontoons, The Academy study panel recommended on-site adaptation and experimentation in developing countries, a recommendation to which this activity is directly responsive. The Academy panel also recommended that an "International Ferrocement Information Service" be established, since only sparse and scattered information was available on the subject of ferrocement. That recommendation was followed up 1976 by the establishment, under the sponsorship of the New Zealand Government, the Canadian Government (through CIDA) and the U.S. Government (through AID/Washington), of such a center at the Asian Institute of Technology (AIT), Bangkok. The AIT had been doing research and development concerning ferrocement applications since about 1969, and was the host institution to an AID sponsored regional meeting in late 1974, which produced a report called "Ferrocemet, a Versatile Construction Material: Its increasing use in Asia," in cooperation with the U.S. National Academy of Sciences. Further information on the IFIC (International Ferrocement Information Center) at the AIT in Bangkok can be found in Annex E, which describes AIT, the IFIC, and ferrocement and its applications.

Adapting Ferrocement Technology to Indonesia

In 1977, Indonesia became self-sufficient in the production of cement, and will have a growing surplus of cement production from 1978 on. Thus, cement (and sand and water) are locally available, as well as the unskilled and semi-skilled labor required for the basic plastering operation of shaping concrete by hand over a mold of wire or other material. "Chicken wire mesh" and a variety of wires are produced in Indonesia or are standard imports for other purposes. A variety of natural fibers are also available.

Indonesian rural areas have many of the needs for which ferrocement would seem the ideal solution; that is, containers for water, other liquids and foods, troughs for irrigation, watering or feeding, food dryers and storage bins, well casings, a variety of small boats, water catchment areas, pontoons for simple ferries or floating docks, etc.

To sharpen the focus of the ferrocement technology activity, AID-sponsored in October, 1977, a two-week feasibility study by the leading

ferrocement expert from the Asian Institute of Technology, Professor Ricardo Pama, accompanied by Mr. Opas Phromratanapongse, Head of the Product Development Department, Siam Cement Co., Bangkok, Thailand. This expert team worked closely with the DTC/ITB (Institute of Technology, Bandung/ Development Technology Center) on a program consisting of a technical seminar at DTC/ITB, a visit to the Sukabumi Regency in rural West Java, a visit to Ujung Pandang area and Hasanuddin University in South Sulawesi, a visit to Banda Aceh area and Syiah Kuala University in Aceh Province in North Sumatra and a "wrap up" conference at the University of Singapore with Professor Seng Lip Lee, formerly of AIT Bangkok. All arrangements were made by the DTC/ITB, and the study and field reception proved to be an unqualified success, with great enthusiasm expressed by all participants for the concept and proposed activity. In-depth discussions were held with a variety of local administrators from the village chief level to the Bupati level, with faculty and students from the mentioned universities, with private entrepreneurs, and with three individuals who are already doing limited work with ferrocement in Indonesia. Two of these are private concerns working in the Jakarta area making housing panels and tugboats respectively, and the third, a UN expert from New Zealand, is teaching and working with ferrocement boat building in Jayapura, Irian Jaya. They were not aware of each others' activities prior to the feasibility study, which points up the typical situation of small, individual and isolated efforts in the field to date, and the need for the information center recently established at AIT, Bangkok. These local activities will be correlated with the project in an advisory capacity, so that their experience, although limited, will contribute to the success of this project.

The AIT (Asian Institute of Technology) will also participate in the activity by training about six Indonesian engineers or scientists in the structural engineering properties of ferrocement through a special four-month course and, to a limited extent, by providing consultant services for technical problems and evaluations. Other worldwide experts may also be used on occasion for short-term (1-2 weeks) consultancies.

Mr. Opas Phromratanapongse believes the Siam Cement Company may release him for short periods to assist in training in Thailand at the non-academic level, particularly in a simple technique for making unreinforced water jars, toilet traps and food storage containers. This training would be for about two weeks, at the "foreman" level. The water jar, toilet trap and food bin techniques were devised and developed by Mr. Opas Phromratanapongse, and have been successfully applied at the village level in Thailand. They are described in detail in Annexes I and J of this PP, except the toilet trap.

Given the general lack of ferrocement technology activity in the United States, there is no involvement of an American institution expected for this activity, other than the possibility of a short term consultant for specific technological problems or for evaluation assistance. The U.S. Government, through AID, has been a major contributor to the expansion and development of the Asian Institute of Technology, and AID has a policy to use third-country educational and R&D institutions in developing countries where those institutions are qualified and capable. AIT is uniquely qualified in this respect, as explained in Annex D, which justifies its

predominate capability for ferrocement training, consultancy and information.

The technical results of the DTC/ITB ferrocement technology feasibility study are described in further detail in the sections on technical and economic analyses and the Annexes. In summary, the main recommendations are to:

1. Establish the activity as described;

2. Use the DTC/ITB as the managerial and technical leader for the overall activity and for field operations particularly in the Sukabumi Regency area;

3. Use Syiah Kuala University and its new Rural Development Center as the managerial and technical leader for field operations in the Aceh Province area;

4. Use Hasanuddin and its Regional Adaptative Technology Center as the managerial and technical leader for field operations in South Sulawesi;

5. Concentrate initially on the following potential applications of ferrocement and related materials for rural use in Indonesia

   a. pontoons for river crossings, replacing steel pontoons,

   b. dug-out canoes replacing scarce, prime logs which are expensive and wear out quickly,

   c. fishing and cargo boats replacing wood which has a limited life span,

   d. larger water catchments and containers which are presently unavailable or are costly, causing villagers to walk up to five to six kilometers to wells to obtain and then carry water in small tin or plastic containers, with storage in small clay jars or used oil drums,

   e. toilet bowls with water traps for sanitary and aesthetic reasons,

   f. well casings, replacing thick, friable, heavy casings, which have to be transported,

   g. on-farm grain storage bins to reduce post harvest losses,

   h. building boards with natural fibers as reinforcement, for various uses such as roofs and wall panels, replacing wood and tile, corrugated iron sheets, or thatch;

6. Special training for four months for a nucleus of academically qualified people; and

7. Technical training (two weeks) for a nucelus of technical people for teaching the simpler techniques of the unreinforced cement water jars, food containers and toilet bowls.

B. Project Description

Pyrolytic Conversion

The feasibility study reached positive conclusions on the economic, technical and social aspects of pyrolytic conversion in Indonesia. Before embarking on a widespread application and dissemination project, however, it is necessary to adapt and test the system under Indonesian conditions. The purpose of this pyrolytic conversion subproject is to support activities such as design, adaptation, laboratory and field testing, demonstrations, acceptability, trials, formulation of training and dissemination programs, training of trainers, and market analysis and development. If, during the course of the project, these activities look positive in their outcome, a follow-on application and dissemination project also will be developed as part of this project, in the form of a project paper draft, including an initial environmental assessment.

The primary output of the subproject on pyrolytic conversion will be to arrive at one or more optimized designs and actual constructions of pyrolytic converters suitable for typical Indonesian conditions, and fully tested and demonstrated in the field for performance, construction and operating costs, and acceptability and based on utilizing waste rice hulls. Within the limitations of funds available to this activity, other designs for converters based upon waste sawdust, wood, coconut hulls and husks, or other available wastes, should be developed and tested to the extent possible. Technical assistance in optimizing designs will be given by the Georgia Institute of Technology, which has predominate capability in this particular task, as explained in Annex C. The services of Georgia Tech will include 15 man/months of short term consultancies, including transportation and per diem costs, focused on assisting the DTC/ITB in reaching the optimal and most cost-effective design for Indonesian conditions. The services of Dr. John Tatom will be considered key personnel to the success of this project and be provided through the Georgia Tech contract, unless USAID, DTC/ITB and Georgia Tech agree otherwise. Georgia Tech may also be called upon for evaluation services, and informal, on-site training of trainers, if these services are required, within the 15 man/months of consultancies.

Additional outputs of the pyrolytic conversion activity will be market analyses for pyrolytic products and a suggested program of market development including small industry development based upon pyrolytic products and initial designs and models of rurally used items such as simple stoves and lamps to use pyrolytic char and oil, and charcoal briquette presses.

Other outputs may suggest themselves as the R&D progresses. The general objective is, through laboratory and field research, development, experimentation and testing, to arrive at optimized uses for the pyrolytic process

under Indonesian conditions, for Indonesian rural needs. Presuming success, the aforementioned plan (project paper draft) for a follow-on application and dissemination project will also be considered an expected output. The field testing of various designs may include collaboration with village leadership, and other institutions and organizations involved in the appropriate technology apprach, under small subcontracts or other agreements where necessary.

Suggested Budget (Pyrolytic Conversion Activity)

It is planned that $250,000 will be reserved for this pyrolytic conversion activity and provided to DTC for distribution through subcontracts or other appropriate agreements as follows:

DTC/ITB:

Overall administration, R&D and field work:

- Salaries, overhead and support services	$ 40,000	
- Travel costs (domestic)	10,000	
- Materials and labor (unskilled or semi-skilled) for construction of experimental models and prototypes	95,000	
- Evaluation and report costs, miscellaneous and contingencies	10,000	
- Travel costs (international) to Georgia Tech*	5,000	
DTC/ITB subtotal	$160,000	
Georgia Tech:		
Technology transfer services:		
- Short term consultancies (15 man/months) including salaries, overhead and support services	$ 60,000	
- International and domestic travel costs (incl. per diem)	30,000	
Georgia Tech subtotal	$ 90,000	
Activity Total (Grant funds)		$250,000

The GOI contribution is discussed at the end of this section.

* This item is to enable one or two DTC/ITB project personnel to make a short visit to Georgia Tech for viewing and discussing Georgia Tech's pilot programs on pyrolytic conversion.

Project Description (Continued)

Ferrocement Technology

The principle of appropriate technology requires that adaptation and testing be done, as explained earlier, to assure the economic and market viability and the social acceptance of the technology before it is promoted on a massive scale. The second major activity in this appropriate technology project will be to support the design, adaptation, laboratory and field testing, demonstration, acceptability trials, formulation of training and application/utilization programs, training of trainers, market analyses, and market development programs, for ferrocement technology. These must logically be accomplished, with positive results, before entering into a program of widespread production of ferrocement products in rural Indonesia. Presuming positive results in the adaptation and testing, the activity will also design a broad-based dissemination and utilization project, in the form of a project paper draft, for ferrocement technology application in mass scale, involving other institutions, e.g. BUTSI (the local "Peace Corps"), several GOI agencies, and the cement industry.

The primary output of the subproject on ferrocement will be to arrive at one or more optimized designs and actual constructions of ferrocement (or fiber-reinforced cement, or unreinforced cement) for a variety of products made at the village level, suitable for Indonesian conditions, and fully tested and demonstrated in the field for performance, construction and operating costs, and local acceptability. Within the limitations of funds available to this activity, these designs should be at least for the priority uses identified in the feasibility study, and described in the preceding section on "background".

Outputs will also include five or six university graduate Indonesian engineers trained in the mechanical properties of ferrocement through a special graduate course arranged at the Asian Institute of Technology (AIT) Bangkok, Thailand. Details of AIT's predominate capability to do this training are given in Annex D. In addition, the AIT will provide limited consultancy and evaluation services. The AIT proposal for this training and technical assistance is given in Annex K.

The Universities of Syiah Kuala and Hasanuddin have agreed to collaborate with DTC/ITB, particularly in the field aspects of adaptation, testing, and evaluation, under contractual agreements with DTC/ITB. Other appropriate technology or small entrepreneur institutions or organizations, such as Dian Desa, Yogyakarta or an existing cement product manufacturer (village level), may also be able to assist in field testing, under small subcontracts from DTC/ITB. The purpose of involving these other institutions and organizations is to make the designs, testing and evaluation activities as widespread and realistic as possible. These other organizations may be even more useful in the follow-on application and utilization project, and their early involvement will help in bridging over to the follow-on project.

The marketing analyses and programs should stress not only the primary utility of the products but also employment generation through small industry development. In developing short training programs for the "foreman" level,

consideration will be given to retraining entrepreneurs who may be affected by the new products. Benefits to women will be maximized throughout all activities.

Suggested Budget (Ferrocement Technology)

It is planned that $200,000 will be reserved for this ferrocement technology activity, provided to ITB for distribution through subcontracts or other appropriate agreements as follows:

DTC:

Overall administration and field work in the Sukabumi Regency:

- Salaries, overhead and support services	$45,000	
- Travel (domestic)	5,000	
- Materials (cement, sand, wire, etc.) and unskilled labor	5,000	
- Evaluation and report costs, miscellaneous, contingencies	10,000	
Subtotal		$ 65,000

Hasanuddin University: Field work, South Sulawesi

- Salaries, overhead and support services	$30,000	
- Travel (domestic)	5,000	
- Materials (cement, sand, wire, etc.) and unskilled labor	10,000	
Subtotal		$ 45,000

Syiah Kuala University: Field work, Aceh Province, Sumatra

- Salaries, overhead and support services	$30,000	
- Travel (domestic)	5,000	
- Materials (cement, sand, wire, etc.) and unskilled labor	10,000	
Subtotal		$45,000

Asian Institute of Technology:

- Training programs (including travel and per diem for students) and short term consultancies	$ 45,000
ACTIVITY TOTAL	$200,000

GOI contributions are found at the end of this section.

Special Applications and Studies of Appropriate Technologies

Background and Project Description

Although the project is focused on developing and testing two specific applications of appropriate technology, i.e. pyrolytic conversion and ferrocement, up to 10% of the total project funds may be used for special applications and studies of other appropriate technologies. These may include:

1. The purchase and transportation of appropriate technology devices, developed within or outside of Indonesia, as a sample. (e.g., the Koreans apparently have a hand operated, char compressor to make a specially formed charcoal block which fits into a small, special stove. This should be examined for its potential application in Indonesia).

2. The testing and experimental adaptation of such devices.

3. Observation study tours, or attendance at conferences to learn about appropriate technologies which may have application to Indonesia.

4. The purchases of publications related to appropriate technologies.

Suggested Budget

1.	Purchase and transportation of appropriate technology devices	$20,000
2.	Testing and experimental adaptation of such devices	10,000
3.	Observation and study tours, attendance at special conferences	15,000
4.	Purchase of appropriate technology publications	5,000
	Total	$50,000

Government of Indonesia (GOI) Contributions

The GOI will contribute at least 25% of the total project cost through provision of salaries for professional and non-professional persons concerned with the work, cost of office and other space overhead costs, selected local transportation, costs use of laboratory space and equipment, administrative and bookkeeping costs, and other similar items. The total project is $675,000, i.e. $500,000 (U.S.) and $175,000 (GOI), cash and in-kind.

A suggested budget is:

1.	Salaries, (professional and non-professional)	$ 45,000
2.	Office, conference and experimental space	25,000
3.	Local vehicles transportation; communications	15,000
4.	Laboratory space and equipment, ITB, Syiah Kuala University, Hasanuddin University, etc.	30,000
5.	Administrative and bookkeeping costs	10,000
6.	Overhead	35,000
7.	Miscellaneous	15,000
	Total	$175,000

PART III - PROJECT ANALYSES

In the sections below, specific comments are made on the technical, economic, social and financial aspects of pyrolytic conversion and ferrocement. These comments are based primarily upon feasibility studies completed in November, 1976 (pyrolytic conversion) and in October, 1977 (ferrocement) by technical and economic experts. In the case of ferrocement, the reports of two studies by the U.S. National Academy of Sciences also provided analytical resource material. Details of the technical and economic analyses are appended as Annexes G and H.

A. Technical and Economic Analyses

1. Technical Analysis

(a) Pyrolytic Conversion: In November, 1976 USAID/Indonesia sponsored a feasibility study to analyze the technology, materials, economics, markets and acceptance of "pyrolytic conversion of agricultural and forestry wastes to alternative energy sources in Indonesia." To the best of the Mission's knowledge (later confirmed by a check of the data banks of the National Technical Information Service, U.S. Department of Commerce), the only U.S. (and perhaps worldwide) institution which has recent and considerable practical experience in adapting pyrolytic conversion technology to the conditions found in developing countries is the Georgia Institute of Technology. Therefore, Georgia Tech was asked to join the Development Technology Center at the Institute of Technology, Bandung (DTC/ITB) in performing a feasibility study.

The technical and other analyses of the feasibility study are reported in Pyrolytic Conversion of Agricultural and Forestry Wastes to Alternative Energy Sources in Indonesia -- A Feasibility Study, published by Georgia Tech. Copies are available from the Economic Development Laboratory, EES, Georgia Institute of Technology, Atlanta, Georgia 30332, from DTC/ITB, or from the Science and Technology Office, USAID, American Embassy, Jakarta.

The technical analysis shows there is no technical barrier to the success of this subactivity on pyrolytic conversion, and the challenge will be to adapt, optimize and test to fit local situations. The design work is to be focused initially on using rice hulls in a small, low-temperature, one-ton-a-day converter, matching the average daily output of this waste by each of the 30,000 small rice mills scattered throughout Indonesia. However, the subactivity also includes the exploration of technologies that might utilize other wastes, such as sawdust and wood waste, and coconut huks, particularly if unforeseen technical, economic or cultural difficulties should arise in pursuing the rice hull option.

The details of the technical analysis, attached as Annex G, are drawn largely from the feasibility study report.

(b) Ferrocement Technology

In October, 1977, USAID/Indonesia sponsored a feasibility study to analyze the technology, materials, economics, markets and acceptance level of using ferrocement technology (including unreinforced and fiber-reinforced cement) at the village level in Indonesia. The study was done by DTC/ITB and the Asian Institute of Technology (AIT), Bangkok, Thailand, an institution that has been working on the mechanical properties and the utilization of ferrocement for ten years and which contains a new international center for the collection and dissemination of ferrocement technology information. The AIT is unique in these respects.

The technical analysis by the feasibility study team found that it was technically possible (and economically desirable) to use ferrocement to meet certain village requirements. From a technical and cost viewpoint, the study team felt that the experimental activity should focus on making the following items out of ferrocement;

- pontoons for river ferries
- well casings
- water containers (especially larger sizes)
- grain storage bins
- toilet bowls with water traps
- dug-out canoes
- low-cost housing components

Although ferrocement fishing and cargo boats were also identified as being technically and economically promising, it was recommended that they be excluded from this specific project because of the relatively large capital investment required and the necessity for a high degree of skill and experience in handling ferrocement. Furthermore, several months would be required before the villagers could see the actual results; whereas, with simpler applications the villagers can see the results in a matter of days or weeks.

The study team also recognized the lack of technical skills in Indonesia for making and adapting initial designs and demonstrating and teaching their applications. Therefore,

project formulation includes two training programs: (1) the training of six Indonesian engineers in the mechanical properties of ferrocement will be done at the A.I.T., Bangkok through a special four-month course, and (2) short courses (one or two weeks) of practical, village-level training will be conducted in Thailand as a contribution to the project by the Siam Cement Company, and later within Indonesia according to arrangements to be made by the DTC/ITB. In addition, regular Indonesian graduate students at A.I.T. will be encouraged to do thesis work on ferrocement at no cost to the project.

Further detail on the technical aspects of ferrocement can be found in Annex G and in the Social Soundness Analysis.

2. Economic Analysis

The feasibility studies conducted here on pyrolytic conversion and village applications of ferrocement have shown that both are economically sound in the Indonesian context. Some analytical details follow, supplemented by further detail in Annex H.

(a) Pyrolytic Conversion

Pyrolytic conversion is an alternative energy source with considerable promise, particularly for Indonesia. It's attractiveness from an economic viewpoint stems from the fact that its input is agricultural waste, and its output is in three forms of energy -- oil, gas and char (powdered charcoal).

Much of Indonesia's agricultural wastes are concentrated at process centers where the effort and cost of waste collection is minimal. These process wastes are of a small individual particle size and could be readily used, where required, as fuels for the process plants themselves particularly for drying or for running engines. Thus, such materials as rice hulls, sawdust, coconut shells and husks, and oil palm wastes all offer a ready-made opportunity to produce significant quantities of high-energy fuels from an existing, although previously unusable, source.

The feasibility study examined the economic aspects of the waste itself, the converter location and size, the converter model (design), the markets for the resultant products, and various options regarding intensivity of labor and capital, fixed location vs mobility, etc. The study concluded that the initial concentration should be on rice hulls, using a small converter with a capacity of about one ton per day. One model, working at one shift per day for 150 days per year, should give a projected return on investment of 18.5%.

For three models, the charcoal yield would be about 0.25 ton per day and the oil yield would be 0.15 ton per day with the processing of 1.0 ton of waste material. The complete economic analysis from which this summary was derived can be found in Annex "H".

(b) Ferrocement Technology

Once the design has been optimized for the local conditions, the techniques of using ferrocement (and unreinforced or fiber-reinforced cement) to meet village requirements is dependent primarily upon the availability of unskilled labor directed by a semi-skilled person. Labor costs are relatively low in Indonesia, and a semi-skilled foreman can be trained in one to two weeks. He should be able to teach others in turn. The main skills required are to know the right mixture of materials required for the mortar, to master the techniques of plastering the mortar to avoid air pockets (voids), to be able to keep uniform wall thickness, and generally to be able to maintain a quality control, thereby assuring cost-effective performance according to design. Key to the success of this activity will be the original design, which must be the product of a skilled person, normally a specially trained engineer. Although the design must match the need with respect to shape, size and strength, it must not be over-engineered, which would be wasteful in material and/or labor costs. Fortunately, the higher cost of designing something like a well casing can be spread over thousands of well casings, whereas the actual construction, on a one-by-one basis, is done at the relatively unskilled and inexpensive labor level.

Costs for materials for unreinforced cement products are limited to the purchase of cement, sand and water. As Indonesia is now self-sufficient in cement production, costs shoudl drop somewhat or at least stabilize. Sophisticated additives to enhance flow or other properties may be useful, but these are generally considered unnecessary, particularly for the relatively unsophisticated uses discussed here. For requirements where moderate strength is needed local fibers may be added at an additional, moderate cost. Where even greater strength is needed, as in boat hulls, the cost of wire mesh must be added to the total material cost.

All the basic raw materials needed in ferrocement sontruction are available in Indonesia.

In summary, the feasibility team, Culling upon their experience and knowledge of the material, found there were many cases where ferrocement would provide a good, long-lasting, strong, easily reparable, locally made product at very competitive costs. Further, its use would have a favorable environmental effect by reducing pressures on wood usage. When competing against steel (e.g. ferry pontoons), considerable foreign currency savings and reduced

maintenance costs would result. When competing against poured cement (e.g. well casings), breakage and transportation costs would be drastically reduced, and performance, longevity and maintenance would be improved. The project will further test these claims and determine actual cost-effectiveness. Further analysis of the cost/performance of the use of ferrocement is found in Annex H.

PART III

B. Environmental Assessment Summary

The determination of the Initial Environmental Examination of this Appropriate Technology Project is favorable. (See Annex B). The project is wholly concerned with analysis, research, development, design, experimentation, training, testing, and demonstration.

Among the tasks within the project will be the requirement to develop an environmental assessment for expected follow-on projects which, if this initial project proves successful, will be devoted to application and dissemination on a wide scale.

It is worthwhile noting that in many cases there will be an eventual improvement in the environment through acceptance of ferrocement products which successfully substitute for local wood. The level of deforestation in Indonesia is alarming, particularly in Java and Bali. The widespread substitution of ferrocement canoes and boats for wooden craft relieves one of the pressures on tree cutting, particularly on the larger, older, higher quality trees where logging tolls are greatest. Substitution for wood now used in rice storage and in certain housing components is also feasible. These environmental aspects will be further explored within the project and fully developed within the environmental assessment required for the expected FY80 follow-on project.

The requirements of FAA Section 611(a) have been met by the two feasibility studies, which concluded that such a project will prove beneficial to Indonesia. There are no local legislative requirements that must be met. The remaining subsections of FAA 611 do not apply to the project.

C. Financial Analysis and Plan

Project funds will be administered by the Development Technology Center at the Institute of Technology, Bandung, with $250,000 earmarked for pyrolytic conversion activities, $200,000 for ferrocement technology, and $50,000 for special applications and studies of appropriate technologies. Of the $250,000, an estimated $90,000 will fund a contract with the Georgia Institute of Technology for technical assistance, and the remaining $160,000 will be used by the DTC/ITB for other project costs, including materials and labor for the construction of various design concepts of pyrolytic converters, in the laboratory and at various testing/demonstration sites. Included also

will be some professional salaries and domestic travel. Another $200,000 is earmarked for ferrocement technology, including $45,000 for a special training program at the Asian Institute of Technology, $45,000 to help cover costs of participation by Syiah Kuala University, Aceh Province, Sumatra and $45,000 for similar participation by Hasanudddin University in Ujung Pandang, South Sulawesi. The remaining $65,000 will pay for supporting lab and field activities carried out by DTC/ITB, including field work in the nearby Sukabumi Regency, and for overall project administration. The final $50,000 of the original $500,000 is reserved for special applications and studies of appropriate technologies, particularly the purchase and shipment of samples of appropriate technology equipment developed by others, travel costs to appropriate technology conferences and studies, and purchase of appropriate technology publications for study and reference.

Government of Indonesia contributions will total at least 25% ($175,000) of the total project amount of $675,000, much of which will be in-kind, in the form of contributed salaries, space, transportation, and equipment use. Also included will be budgeted or in-kind contributions by the two Indonesian Universities formally involved (Syiah Kuala and Hasanuddin), contributions by village, regency and provincial governments during field tests and demonstrations, and contributions by other collaborators, such as local entrepreneurs or a cement company. It will be important that DTC/ITB systematically record these various contributions in order to reach the true cost of the project and the total value of GOI contributions.

Summary cost estimates follow:

Summary Cost Estimates

1. AID Grant contribution ($500,000)

Personnel/Technical Assistance Costs

Pyrolytic Conversion:-	Salaries, overhead and support services (DTC/ITB)	$ 40,000
	- Short term consultancies (15 M/M, under Georgia Tech contract)	60,000
Ferrocement Technology:-	Salaries, overhead and support services (DTC/ITB)	105,000
	- Salaries, overhead and support services (AIT)	8,000
Special Applications:	Testing devices, conference attendance, study tours (DTC/ITB)	13,000
	Sub-total	$226,000

Training Costs

Ferrocement Technology:-	Special course, all expenses, 6 persons for 4 months; 24 M/M; AIT contract	$ 37,000
	Sub-total	$37,000

Commodities

Pyrolytic Conversion:-	Local materials for prototypes	$ 50,000
Ferrocement Technology:-	Local materials (cement, sand, wire, etc)	20,000
Special Applications:	Appropriate technology devices and pubs.	25,000
	Sub-total	$ 95,000

Other

Pyrolytic Conversion:	-Local labor for prototypes	$ 45,000
	-Travel (domestic and international) DTC	15,000
	-Travel (domestic and international) Georgia Tech	30,000
	-Report and evaluation costs; contingencies	10,000
Ferrocement Technology:	-Travel (domestic and international)	$ 15,000
	-Report and evaluation costs; contingencies	10,000
	-Local labor for prototypes	5,000
Special Applications:	-Travel for conferences and study tours	$ 12,000
	Sub-total	$142,000
	Grand total for AID contribution	$500,000

2. GOI Contributions (cash and in-kind), estimated:

Salaries, (professional and non-professional)	$ 45,000
Office, conference and experimental space	25,000
Local vehicular transportation and communications	15,000
Laboratory space and equipment usage at ITB, Syiah Kuala University, Hasanuddin University	30,000
Administrative and bookkeeping costs	10,000
Supplemental overhead	35,000
Miscellaneous	15,000
	$175,000

PART III

D. Social Soundness Analysis and Benefits

The general objective of an appropriate technology approach is to focus on those technologies which:

(a) have a wide range of uses in rural areas and villages;

(b) can be effectively adapted to local conditions;

(c) are low in capital costs;

(d) make maximum use of local, relatively unskilled labor;

(e) use local materials, or at least materials easily available locally;

(f) benefit the poor through, among other ways, employment generation.

A full analysis of the social soundness of the project and its benefits for the poor rural Indonesians must lie in the future, as this project's purpose is to design, test, and demonstrate technologies for possible adaptation and application to the development of Indonesia's rural communities. Potential applications could include locally identified energy sources, better water and food storage containers, low-cost and easily fabricated housing components, and longer lasting small boats and pontoons. These and similar applications will also provide new opportunities for local employment and small industries.

The direct beneficiaries of the present project will be the cadre of change or extension agents trained to support a planned, broad dissemination program.

In short, this project seeks to insure that technologies disseminated later, on a mass scale, are first proved to be acceptable, useful, economically-sound and technically feasible in the context of rural Indonesia. A social benefits analysis should therefore address the expected results of the follow-on dissemination projects that logically will be the outgrowth of this experimentation and testing activity. The following paragraphs are based on the expectation of those follow-on activities.

(1) Pyrolytic Conversion

An effective use of the pyrolytic conversion of agricultural and forestry wastes to convenient fuels will have a direct impact on reducing rates of unemployment and underemployment and will enhance equitable income distribution. The local manufacture of the converters will generate employment, and the new energy sources will stimulate new rural industries. The char, oil, and gas from the conversion process will provide alternative fuels for home lighting and cooking needs in rural areas.

The conversion process will thus provide easily available, useable forms of energy that can be substituted for firewood and petroleum products. The demand for firewood is now depleting vital forest resources and creating serious soil erosion problems. Petroleum products for rural energy have been heavily subsidized (up to 80%) by the GOI; however, the increase in world petroleum prices is causing pressure on the GOI to drop the subsidies. The resultant fuel price increase which would place an additional heavy burden on the rural poor, makes the alternative energy sources all the more important.

Since the pyrolytic conversion process is relatively labor intensive, its widespread use will create substantial new direct employment opportunities in Indonesia. Indirectly it should stimulate the growth of new small industries and businesses.

The wastes to be converted are often a continually produced nuisance, and converting the wastes to supplement Indonesia'senergy needs will help to clean the environment. The conversion process does not present hazards to human or the environment, and the fuels that are produced contain little or no sulphur and burn relatively cleanly.

It is also possible that the pyrolytic char produced may find an economic use in water filtration, this providing health benefit to the consumers of the water.

No labor group will be harmed by the use of pyrolytic conversion provided that some retraining is conducted and the few people potentially displaced by the technology participate in the manufacturing or business opportunities. The present kerosene distributors, for example, can become involved in char and oil distribution. Attention to this point will be important in designing a follow-on dissemination project.

The form of pyrolytic conversion planned under this activity will be labor-intensive and widely dispersed among some 30,000 small rice mills. It is thus not easily subject to monopolization. Its capital requirements are low, and its basic technology is not patentable, thus providing little incentive for the involvement of large industrial interests.

(2) Ferrocement Technology

The feasibility study for this project conducted in October, 1977 investigated the possible social benefits to the rural poor through the use of ferrocement technology. The study identified seven potentially beneficial applications as a starting point.

(a) Pontoon Ferries

These ferries, which are used to cross many of the rivers in Indonesia, now use steel or wood pontoons, which are costly or short-lived. Their break-downs result in replacement delay and costs, and a consequent disruption of transportation. This in turn causes prices to rise , which is very detrimental to the poor, rural consumer. Ferrocement pontoons will be longer-lasting, cheaper and easier to repair. It is also important to note that the substitution of ferrocement for

wood will help reduce the depletion of forests and resultant soil erosion problems.

(b) Dug-out Canoes

Small-scale fishermen and small-scale ferries now use wooden dug-out canoes that last only 1-1/2 to 3 years. Ferrocement boats can be made at less expense and last 30 or more years, greatly reducing both the original construction and long range operational expenses. This will benefit boat-owners and at the same time will reduce the cost of water transportation of people and goods. It will also reduce the demand for the prime logs now used for such canoes.

(c) Water Containers

Cement mortar jars with a capacity of up to 1000 gallons can be made cheaply without any metal reinforcement. These can be used to collect water during the rainy season so that farm and village families can have a source of pure water, without the women and children having to toil daily to carry water long distances during the dry season.

(d) Toilet Bowls with Traps

A ferrocement toilet bowl with a sanitary trap, based on a design developed in Thailand, can replace the present unsanitary open facilities that are widely used, thus improving health and sanitation in the rural area.

(e) Well Casings

Presently heavy concrete casings are being used to line rural water wells. These have to be transported by truck from the place of manufacture, are heavy, and break easily during transportation and handling. Ferrocement casings are at least as serviceable, are lighter, and can be built on site with a better fit between rings. The use of ferrocement casings should make possible the widespread use of casings thus giving village wells better protection from contamination.

(f) Grain Storage Bins

Normally grain is stored in structures constructed of woven bamboo or with wooden walls so that the loss to insects and rodents is estimated at 10-15%. A ferrocement structure, though initially more expensive, would be within the price reach of the average Indonesian farmer and would reduce such losses to a small fraction of those presently experienced.

(g) Housing Components

Experiments are proposed to use a mixture of cement and available natural fibers to produce house panels and roofing that would be cheaper and/or more durable than materials currently being used.

The use of ferrocement would cause some small dislocation of employment, however adjustments to offset this circumstance can easily be made. For example, the manufacturers of conventional cement products can be retrained to make or supervise the making of ferrocement products.

In addition to the uses mentioned above, ferrocement applications are so flexible that it is believed that many other socially-beneficial uses will evolve as the technology becomes widely employed. For example, the desired round domes for mosques can easily be fabricated from ferrocement once expertise becomes available its use. Use in a religious context presumably should enhance the general acceptability of the material, but this thesis should be tested.

E. Impact Upon Women

The use of appropriate technologies such as pyrolytic conversion and ferrocement should result in reducing some of the more onerous chores that traditionally fall to rural women. For example, ferrocement water storage containers can reduce the need for carrying heavy loads of water over long distances. Fuels that would substitute for firewood would reduce the back-breaking labor of the women firewood gleaners.

Easily available, new, cheap forms of energy in the rural area can lead to small scale industries which can use the labor of women.

PART IV IMPLEMENTATION PLANNING

A. Administrative Arrangements and Implementation Plans

The GOI institution for administering this program will be the Development Technology Center of the Institute of Technology, Bandung, (DTC/ITB). The Center, which was started in 1973, is a flexible organization consisting of ITB professors and staff members. It conducts research and development programs on problems related to Indonesia's development, with particular focus on the use of appropriate technologies.

The DTC/ITB is headed by a Director (currently Dr. Filino Harahap), under the supervision of a Governing Board. The Board is chaired by the Rector of the Institute of Technology, Bandung (ITB) and its members include not only ITB faculty members but others such as the Director of Academic Affairs, Directorate General of Higher Education, Ministry of Education and Culture, Jakarta. The DTC/ITB Director is assisted by several Deputy Directors and several Project Leaders. It is planned that a Project Leader will be assigned to this project, augmented by an informal

project steering committee which will collectively review project progress about once a month in order to assist the project leader and the DTC/ITB Director in guiding the project. The project leadership will draw upon other expertise and technical facilities as required in the project, particularly from the ITB. Further detail on the DTC organization, objectives, policies and programs can be found in the brochure reproduced as Annex F.

A contract will be made with the Georgia Institute of Technology for technical assistance in pyrolytic conversion and with the Asian Institute of Technology (AIT) for technical assistance in ferrocement technology. Georgia Tech, through its own research and feasibility studies, has established preeminence (see Annex C) in this field. AIT earlier was selected by AID/W to take the lead in studying applications of ferrocement technologies and AID/Indonesia has reconfirmed AIT's predominate capability for this project purpose (see Annex D).

The project agreement will be completed as soon as possible after the project is authorized. Both Georgia Tech and AIT have made project proposals, and a review of these by DTC and USAID shows them to be in accord with project guidelines and within projected cost estimates. The relatively simple contract negotiations will be conducted by a USAID Contract Officer from the AID Area Contract Office, USAID/Philippines.

Project Agreements for this Project will be signed by an authorized representative of the Directorate of Higher Education on behalf of DTC/ITB.

It is important to implement the project quickly to take advantage of an AIT special training course planned for May-August, 1978 (see Annex K). It would be difficult and perhaps impossible to reschedule this course without delaying the entire project.

Primarily because of time limitations, the policy of host country contracting will be waived for the AIT and Georgia Tech contracting.

DTC/ITB will arrange agreements or sub-contracts with Syiah Kuala University, Banda Aceh, and Hasanuddin University, Ujung Pandang to participate in cooperative ferrocement activities. These universities, through their regional appropriate technology type centers, will assist DTC/ITB in field adaptation, testing, demonstration, and evaluation.

Particular attention will be paid to the systematic recording of cash and in-kind project contributions by Indonesian institutions, including DTC and DTC-related contributions, cooperating universities, government institutions and private group contributions, village and local government contributions, and contributions by individual entrepreneurs and private business, such as cement companies or associations. The steering committee will monitor the required accounting procedures. In-kind contributions may include, for example, the value of personnel time, services such as use of institutional laboratories, overhead, rental value of space, vehicular transportation and communications, and similar contributions. Cash contributions will consist of institutionally budgeted contributions, including

cooperating institutions such as Hasanuddin University and Syiah Kuala University.

The project is expected to be completed in 18 months. In anticipation of its success, FY80 projects are being planned to provide for the general application and dissemination of those technologies which this project has proved to be economically, socially, and technically sound. One of the tasks of the present project will be to assist in the design of the follow-on project or projects.

An implementation plan follows;

Implementation Plan

1.	Project Paper Approved	March 15, 1978
2.	Allotment received from AID/W	March 21, 1978
3.	PROAG signed	March 29, 1978
4.	R&D program starts	April 3, 1978
5.	PIO/Ts for Georgia Tech and AIT contracts completed and signed. Host country waivers signed	April 15, 1978
6.	Contracts for Georgia Tech and AIT completed and signed	April 30, 1978
7.	AIT Training Course starts	May , 1978
8.	Georgia Tech consultant arrives	June , 1978
9.	DTC/ITB agreements with Syiah Kuala and Hasanuddin universities completed and signed	June 1, 1978
10.	AIT training course ends	Sept , 1978
11.	First year project review and evaluation	April 1, 1979
12.	Completion of R&D and technical evaluation	Oct 1, 1979
13.	Draft final report	Jan 1, 1980
14.	Final evaluation	Feb 1, 1980
15.	Final report printed. Project completed	April 1, 1980

The USAID Project Manager will be the Science and Technology Advisor.

B. Evaluation Plan

The Director of DTC/ITB and the USAID Project Manager will be responsible for evaluating the progress of the project on an informal but continuing

basis so that potential problems are identified and minimized. This continuing evaluation also will make it possible to lend added emphasis to those components of the project which prove to be most effective.

Each phase of the project is to be evaluated upon its completion. For example, each training program wil be carefully evaluated so as to make improvements in future training projects.

At the end of the first 12 months and at the completion of the project, formal project reviews will be held. These will involve the Indonesian leaders involved in the project, appropriate representatives of GOI entities interested in its findings, Georgia Tech and AIT experts, and USAID officers, including the USAID Evaluation Officer. These reviews will be integral parts of project since they will attract greater interest and give greater impetus to the projects as well as to provide the basis for making changes in project design.

The basic nature of research and development requires that considerable latitude be given in conducting the research and development, and in adapting technology so that it is appropriate to the local conditions, opportunities and constraints. It is inhibiting and unrealistic to predict how many pyrolytic converter designs will be made, constructed and tested before some ideal designs will be developed. Similarly, one should not predetermine how many experimental ferrocement canoes will be made before a satisfactory model, for certain typical conditions, is reached. On the other hand, some outputs are predictable; e.g. five or six engineers will be trained on the structural properties of ferrocement, through completion of the special course at AIT, certain pyrolytic converters and ferrocement products will have been optimized in regard to materials, price, usefulness and acceptability, local training programs will have been designed, and the basis and scope-of-work for a follow-on application and dissemination project(s) will have been formulated. To construct a log-frame matrix useful to project managers and evaluators will take further work particularly in consultation with the DTC/ITB. Therefore, it is planned that such a matrix be constructed within two months of the authorization of this Project Paper, in consultation with the DTC/ITB and the AID/Indonesia Evaluation Officer. The matrix will be attached to this Project Paper as an integral part of the Project Paper.

C. Negotiating Status

The Development Technology Center, ITB, is prepared to expedite the implementation of this project. As mentioned earlier, the two institutions to be involved in technical assistance, Georgia Tech and the Asian Institute of Technology, have already submitted their proposals to the DTC/ITB. Their proposed programs and budgets have been examined by the DTC/ITB and by the USAID Science and Technology Officer and have been found to be reasonable in design and in cost for the services proposed. The Ministry of Education and Culture, and the Rector of ITB have approved the project's

design and its implementation plan. The leaders of the two Indonesian universities to be involved, Syiah Kuala and Hasanuddin, are eager to begin their activities. The President of the Indonesian Cement Association has pledged the cooperation of the cement industry. Others, including local provincial and village officials have expressed a strong wish to participate in the project.

The Area Contracting Office of the USAID/Philippines has been notified of the intent to request their services for the contracts with Georgia Tech and AIT. Presuming approval of the Project Paper by the Mission Director a Project Agreement will be drawn up for signature as soon as possible, targeted for the end of March, 1978. PIO/T's will follow shortly thereafter.

The technical and training aspects of the project should be completed in eighteen months, with final evaluations and reports completed within twenty-four months. Presuming that the project is successful in developing, (1) models of pyrolytic converters and ferrocement products which are optimal for Indonesian conditions, (2) designs for short-term training programs, and (3) the design of a two year program of application and dissemination, there should be a smooth transition to the follow-on utilization program, supported by FY80 funds.

ANNEX A

AGENCY FOR INTERNATIONAL DEVELOPMENT

PROJECT IDENTIFICATION DOCUMENT FACESHEET

TO BE COMPLETED BY ORIGINATING OFFICE

1. TRANSACTION CODE: A (A = ADD, C = CHANGE, D = DELETE)

PID

2. DOCUMENT CODE: 1

3. COUNTRY/ENTITY: INDONESIA

4. DOCUMENT REVISION NUMBER:

5. PROJECT NUMBER (7 DIGITS): 497-0268

6. BUREAU/OFFICE: A. SYMBOL: B. CODE: 08

7. PROJECT TITLE (MAXIMUM 40 CHARACTERS): APPROPRIATE & LOW COST TECHNOLOGY

8. PROPOSED NEXT DOCUMENT: A. 2 (2 = PRP, 3 = PP) B. DATE: MM 11 YY 76

9. ESTIMATED FY OF AUTHORIZATION/OBLIGATION: A. INITIAL FY 78 B. FINAL FY 79

10. ESTIMATED COSTS ($1,000 OR EQUIVALENT, $1 = Rp414.5)

FUNDING SOURCE		DATE OF PRESCOR
A. AID APPROPRIATED		500
B. OTHER U.S.	1.	
	2.	
C. HOST COUNTRY		175
D. OTHER DONOR(S)		
TOTAL		675

11. PROPOSED BUDGET AID APPROPRIATED FUNDS (SCOD)

A. APPROPRIATION	B. PRIMARY PURPOSE CODE	PRIMARY TECH. CODE C. GRANT	PRIMARY TECH. CODE D. LOAN	E. FIRST FY 78 F. GRANT	E. FIRST FY 78 G. LOAN	LIFE OF PROJECT H. GRANT	LIFE OF PROJECT I. LOAN
(1) ST	B750	875		500		500	
(2)							
(3)							
(4)							
			TOTAL	500		500	

12. SECONDARY TECHNICAL CODES (maximum six codes of three positions each)

112	874	333	329		

13. SPECIAL CONCERNS CODES (MAXIMUM SIX CODES OF FOUR POSITIONS EACH)

TECH	BR	BL	BS	NUTR	

14. SECONDARY PURPOSE CODE: 79

15. PROJECT GOAL (MAXIMUM 240 CHARACTERS)

To improve the quality of life and increase the income of the rural poor.

16. PROJECT PURPOSE (MAXIMUM 480 CHARACTERS)

To promote rural development and employment generation through low-cost, labor-intensive technology.

17. PLANNING RESOURCE REQUIREMENTS (staff/funds)

18. ORIGINATING OFFICE CLEARANCE

Signature: [signature]

Title:

Date Signed: MM DD YY

19. DATE DOCUMENT RECEIVED IN AID/W, OR FOR AID/W DOCUMENTS DATE OF DISTRIBUTION

MM DD YY

AID 1330-1 (4-70)

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TAGS:

SUBJECT: PID REVIEWS

1. AID/W HAS REVIEWED ALL PIDS SUBMITTED BY MISSION. IN GENERAL PIDS WELL PREPARED AND COMPRISE BROAD GAUGED PROGRAM.

2. IT UNLIKELY THAT AID/W WILL DETERMINE PROXIMATE COUNTRY LEVELS PRIOR EARLY SEPTEMBER. IN VIEW SHORT TIME-FRAME FOR PREPARATION PRPS DUE AID/W OCT 1, WE HAVE SELECTED CORE PROGRAM PIDS WHICH MISSION AUTHORIZED DEVELOP TO PRP STAGE ASAP. THE APPROVAL OF THESE PIDS DOES NOT NECESSARILY MEAN AID/W CONCURRENCE ON PROPOSED AMOUNTS; INDIVIDUAL CABLES WILL ADDRESS ANY LEVEL ISSUES. (SEE PARA 5 BELOW.) INDIVIDUAL GUIDANCE ON EACH PID WILL BE PROVIDED SEPTEL. PIDS FOR WHICH THERE ARE POLICY OR OTHER PROBLEMS WHICH MAY CAUSE DISAPPROVAL OR WHICH NEED CLARIFICATION PRIOR APPROVAL ARE LISTED BELOW, PARA 6. SEPTELS WILL FOLLOW WITH SPECIFIC PROBLEMS.

3. INFORMATION IN PIDS INSUFFICIENT AS TO TDY ASSISTANCE REQUIRED FOR PRP DEVELOPMENT. PLEASE ADVISE ASAP TDY ASSISTANCE IF ANY REQUIRED FOR PRP DEVELOPMENT PIDS LISTED IN PARA 5.

4. AID/W WOULD APPRECIATE BY AUGUST 15 ANY CHANGES WHICH MISSION MAY WISH TO MAKE IN PRIORITY LISTING FY 78 PROJECTS.

5. APPROVED NEW PIDS - FY 1977.
A) RD/AGR/TA RESEARCH TRAINING - GRANT DOLLARS 2,750; LOAN 5,000.

APPROVED PIDS FOR FY 1978
B) FADP II - LOAN DOLLARS 9,000; GRANT DOLLARS 3,000.
C) OUTER ISLANDS RICE AND UPLAND CROP RESEARCH - LOAN DOLLARS 5,000; GRANT DOLLARS 1,800.
D) HEALTH TA, RESEARCH AND TRAINING (TITLE TO BE CHANGED) GRANT DOLLARS 3,000.
E) FAMILY PLANNING ASSISTANCE - GRANT DOLLARS 9,000 DOLLARS 6,500 SERVICES, DOLLARS 2,500-R AND D).
F) CONTRACEPTIVES - LOAN DOLLARS 10,000.
G) MANPOWER DEVELOPMENT TRAINING - LOAN DOLLARS 5,000. SCOPE OF THIS PROJECT CHANGED TO GENERAL PARTICIPANT TRAINING. NO GRANT FUNDING TO BE PROVIDED AFTER FY 77 FOR GENERAL PARTICIPANT TRAINING.)
H) INTERMEDIATE TECHNOLOGY - GRANT DOLLARS 500.
I) VOLUNTARY ORG. COFINANCING - GRANT DOLLARS 1,000.

6. PROBLEM PIDS - SEPTELS WILL EXPLAIN AID/W CONCERNS.
A) SCIENCE AND TECHNOLOGY - LOAN DOLLARS 5,000; GRANT DOLLARS 900.
B) MARINGGAI FISHERIES - LOAN DOLLARS 4,000; GRANT DOLLARS 1,800. KISSINGER

7035

ANNEX B

Initial Environmental Examination

Project Location: Indonesia

Project Title : Appropriate and Low-Cost Technology (Proj. No. 497-0268)

Funding : 18 to 24 months

IIE Prepared by : Wm. H. Littlewood
Science and Technology Advisor
USAID, Indonesia

Date: 2 March 1978

Environmental Action Recommended: Negative Determination

Concurrence: _____
S.J. Littlefield, Deputy Director

Date: 17 March 1978

Director's Decision:

Approval: _____
T.C. Niblock, Director, USAID/Indonesia

Date: 17 March 1978

Disapproval: _____

Date:

IMPACT IDENTIFICATION AND EVALUATION FORM

Impact Areas and Sub-areas	Impact Identification and Evaluation 1/
A. LAND USE	
1. Changing the character of the land through:	
a. Increasing the population	N
b. Extracting natural resources	N
c. Land clearing	N
d. Changing soil character	N
2. Altering natural defenses	N
3. Foreclosing important uses	N
4. Jeopardizing man or his works	N
5. Other factors	
_____	N
_____	
B. WATER QUALITY	
1. Physical state of water	N
2. Chemical and biological states	N
3. Ecological balance	N
4. Other factors	
_____	N
_____	

1/ "N" = No environmental impact

IMPACT IDENTIFICATION AND EVALUATION FORM

C. ATMOSPHERIC

1. Air additives ---------- N
2. Air pollution ---------- N
3. Noise pollution ---------- N
4. Other factors

_____ N

_____

D. NATURAL RESOURCES

1. Diversion, altered use of water ---------- N
2. Irreversible, inefficient commitments ---------- N
3. Other factors

_____ N

_____

E. CULTURAL

1. Altering physical symbols ---------- N
2. Dilution of cultural traditions ---------- N
3. Other factors

_____ N

_____

F. SOCIO ECONOMIC

1. Changes in economic/employment patterns ---------- N
2. Changes in population ---------- N
3. Changes in cultural patterns ---------- N
4. Other factors

_____ N

_____

IMPACT IDENTIFICATION AND EVALUATION FORM

G. HEALTH

1. Changing a natural environment ---------- N

2. Eliminating an ecosystem element ---------- N

3. Other factors

_____ N

_____

H. GENERAL

1. International impacts ---------- N

2. Controversial impacts ---------- N

3. Larger program impacts ---------- N

4. Other factors

_____ N

_____

I. OTHER POSSIBLE IMPACTS (not listed above)

_____ N

_____

_____

ANNEX C

Justification for non-competitive procurement of services of the Georgia Institute of Technology as contractor for pyrolytic conversion technical assistance

Background

The Engineering Experiment Station (EES) of the Georgia Institute of Technology, Atlanta, Georgia, began research and design work on a continuous pyrolytic convertor to produce char, pyrolytic oils and gases from organic agricultural waste materials about eight years ago. One of the principal motivations behind this initiative was the presence in Georgia of vast amounts of peanut shells,sawdust and cotton gin waste. The Government of Ghana and AID/Washington both heard of this work and have sponsored projects,with non-competitive contracts based on predominate capability, to apply the process and experience to the agricultural wastes and conditions found in Ghana. A feasibility study was made, and Georgia Tech is presently collaborating with the Government of Ghana and USAID/Ghana in the construction and testing of prototype models.

Justification for Employing Georgia Tech

Georgia Tech's work since it began its pyrolytic convertor research program is believed to be unique. There are a number of other American pyrolysis systems, but these are primarily focused on pyrolysis of municipal waste, rather than agricultural waste. These are large systems, such as capital-intensive gasifiers, and operate at high temperatures. Purex, Garrett, Monsanto, and other processes have these characteristics, which are not suited to or economical to utilize in small-scale units.

The proposed Indonesian pyrolytic convertor development under this project is a low-cost, labor-intensive system operating at relatively low temperatures, ideal for agricultural and wood wastes in developing countries. It produces char and oil and is not focused on the gasification products associated with the other systems. While the basic process is not patentable, the know-how to design, construct and optimize the system is believed to reside only at Georgia Tech and at no other institution in the United States at the present time.

Conceivably this capability could be developed elsewhere in the future, but such a process would take years. The Georgia Tech technology and capability results from many years of research and a considerable investment of manpower and resources which no other institution or organization in the U.S. is known to have in any sense duplicated or be capable of duplicating within a reasonable time.

In addition, Georgia Tech and the Development Technology Center, ITB, have a formal agreement for collaboration and cooperation between their institutions, signed in 1976 by the President of Georgia Tech and the Rector of ITB (Institute of Technology Bandung) which is the primary Indonesian Institute conducting the grant project.

Furthermore, Georgia Tech participated in the joint feasibility study held in November, 1976, with ITB, giving them even more insight into the problems of local application of pyrolytic conversion technology. USAID/Indonesia, on behalf of the Government of Indonesia (DTC/ITB), plans to contract directly with Georgia Tech for the services required under this project. We have determined that the non-competitive procurement of Georgia Tech is justified for technical assistance in pyrolytic conversion as described under this project.

ANNEX D

Justification for non-competitive procurement of services of the Asian Institute of Technology as contractor for ferrocement technology training, evaluation and technical assistance

Background

The Asian Institute of Technology (AIT) is an autonomous, international post-graduate technological institute in Bangkok, Thailand, providing advanced education in engineering, science and allied fields. Its students are almost exclusively from the Asian region, and its educational and research programs are focused on applications of technology and engineering principles to the problems of Asian development. For nearly ten years the Structural Engineering Division of AIT has been engaged in research activities to improve and investigate the material properties of ferrocement for structural use, since it has many advantages for use in the region. Ferrocement (and fiber-reinforced cement) uses simple materials (cement, sand, water, and wire or fiber), is resistant to tropical problems such as termites, rot, solar radiation, et al, is adaptable to construction purposes at village and rural levels, requires low skill levels and modest or low capital, and is very labor-intensive. As an old technology, it is not patentable. These characteristics mitigate against its development in technologically advanced countries, where labor costs are high. Therefore, to the best of our knowledge, institutional programs of broad scope and meaningful size for ferrocement technology are non-existent in developed countries.

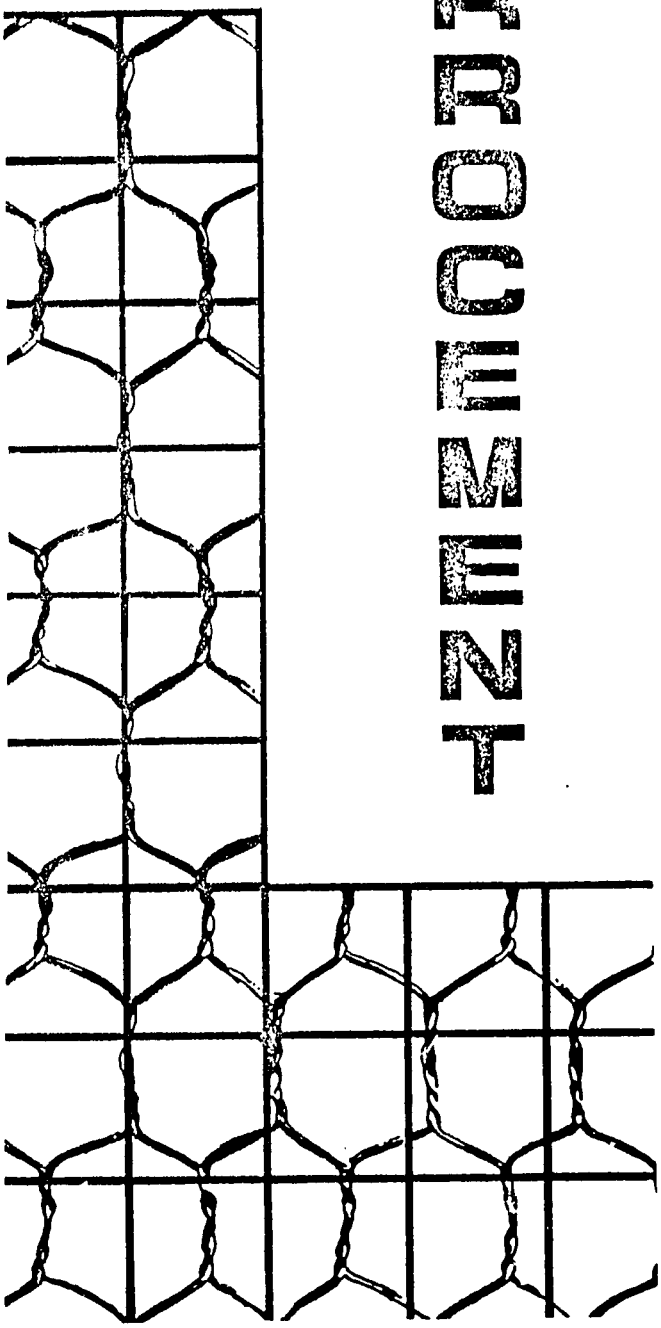
An AID-sponsored study on ferrocement technology for developing countries was done by the U.S. National Academy of Sciences (NAS), culminating in a report in 1973, "Ferrocement Applications in Developing Countries." The study and report featured some of the original work at the AIT. In 1974, AID sponsored a joint AIT/NAS regional workshop on "Ferrocement, A Versatile Construction Material; Its Increasing Use in Asia" held on the AIT campus. The report was published by AIT in 1976. Following recommendations emmanating from both studies, Canada, New Zealand, and the U.S. (AID) jointly contributed funds for an information center on ferrocement, which was established at AIT in 1976 as the "International Ferrocement Information Center." In 1977, the Center's program expandéd considerably, including publication of the "Journal of Ferrocement," the world's only technical journal devoted to ferrocement. Meanwhile, AIT continues with graduate programs, masters and doctoral theses, and sponsorship of conferences, all on ferrocement. Annex E provides further information on the International Ferrocement Information Center at AIT.

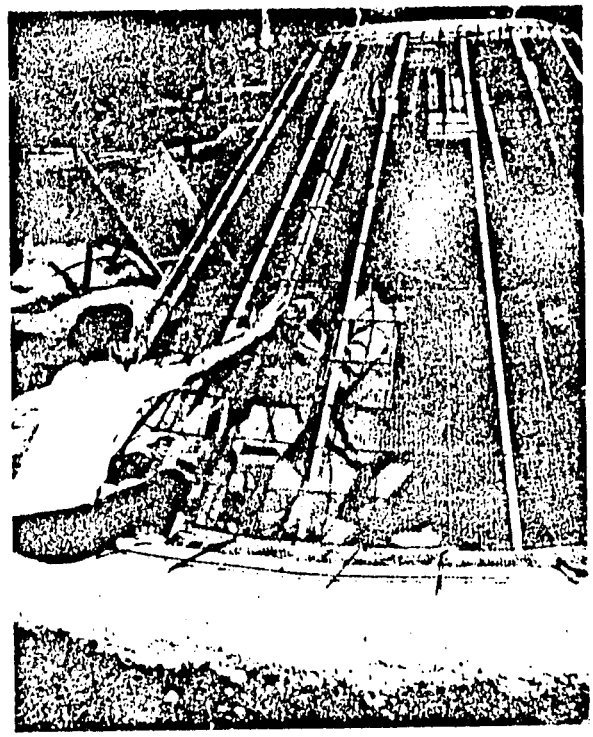
Justification for Contracting with the Asian Institute of Technology

Through the history outlined above, the AIT has become unique in its experience and capability in teaching the structural properties of ferrocement, and for related purposes such as evaluation and advice. Following AID policy of using developing country institutions for contracting purposes when and where qualified, and in view of the fact that there are no U.S. institutions broadly experienced in ferrocement technology. We have determined that the non-competitive procurement of AIT is justified for the training, evaluation and technical assistance required for ferrocement technology activities under this Project.

FOCUS

FERROCEMENT





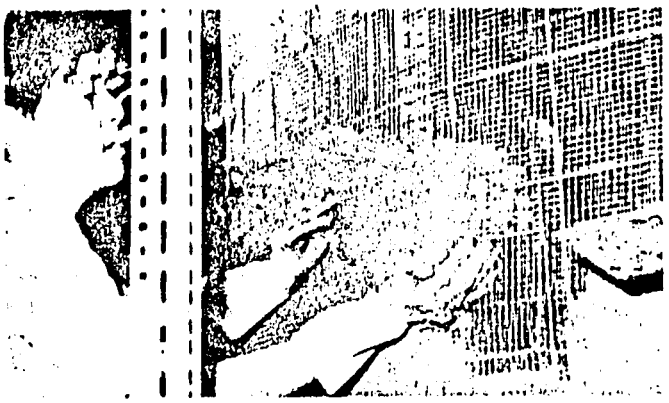
Fabricating wall reinforcement for Thai ferrocement rice bin

SUITABILITY FOR USE IN DEVELOPING COUNTRIES

Ferrocement is particularly suited to developing countries for the following reasons:

- Its basic raw materials—sand, cement and reinforcing mesh—are readily available in most countries.
- It can be fabricated into almost any shape to meet the needs of the user; traditional designs can be reproduced and often improved. Properly fabricated, it is more durable than most woods and cheaper than imported steel, and it can be used as a substitute for these materials in many applications.
- The skills for ferrocement construction are quickly acquired, and include many skills traditional in developing countries. Except for sophisticated and highly stressed designs, as those for deepwater vessels, a trained supervisor can achieve the requisite amount of quality control using fairly unskilled labour for the fabrication.
- Ferrocement construction does not need heavy plant and machinery.
- Ferrocement could be easily and rapidly repaired on site. Only simple tools are needed to repair any damage to the mesh and cement and sand to make a fresh mortar.

Ferrocement is a highly versatile form of reinforced concrete made of wire mesh, sand, water and cement, which possesses unique qualities of strength and serviceability. It can be constructed with a minimum of skilled labour and utilizes readily available materials. Proven suitable for boatbuilding, it has many other tested or potential applications in agriculture, industry and housing.



Plastering of ferrocement tank wall

MATERIALS REQUIRED

- Reinforcing Mesh: Chicken wire or similar small diameter steel mesh
- **Cement:** Ordinary portland cement
- **Sand:** Natural fine sand
- **Water:** Commonly used fresh water

COST

Ferrocement applications are relatively inexpensive:

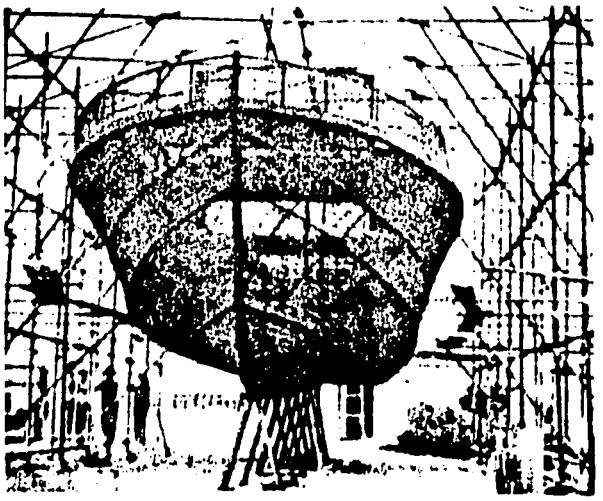
- Low cost of materials
- Major cost goes to unskilled labor which is very cheap in developing countries
- Volume of material required is comparatively small and this reduces the transportation cost

EASE OF CONSTRUCTION

Ferrocement is easy to construct:

- It can be fabricated into any desired shape
- Mixing of mortar could be done even by hand
- Hands and trowels are used for mortar placement in mesh structure
- Hand vibration is good enough for complete mortar penetration of the mesh and proper consolidation
- Fresh water curing has been found to be the most effective
- Any desired surface finish could be obtained in ferrocement

Ferrocement Patrol Boat under construction in Iran



MERITS OF FERROCEMENT AS A STRUCTURAL MATERIAL

The most noteworthy properties are:

- **Strength:** High compressive and tensile strengths
- **Durability:** Ferrocement will last for a long time, as it does not rot, rust, corrode or crack easily. Ferrocement is the only boat-building material that increases in strength with age whereas all other materials deteriorate.
- **Resistance to Mechanical Agents:** Ferrocement, for its great flexibility, is highly resistant to impact, shock and explosion.
- **Resistance to Chemical Agents:** Unlike steel and alloys, ferrocement has a high resistance to most chemical agents. Special surface treatment might be necessary for a very few cases.
- **Sound and Vibration Absorbance:** Due to its relatively high density and mass, ferrocement absorbs sound and, dampens vibration better than any other commonly used hull material.
- **Thermal Conductivity:** The thermal conductivity of ferrocement is extremely low being about 1/6 that of steel.
- **Surface finish:** A very good surface finish could be obtained in ferrocement, equivalent to that of fiberglass.
- **Painting:** Ferrocement structure may be painted to enhance appearance and the surface will take a good paint coating.
- **Crack Arrest:** The dispersed reinforcement of the mesh helps in arresting cracks and limiting their width.
- **Maintenance:** Ferrocement does not require maintenance at all, as the material is highly resistant to rot, rust, heat, cold and other elements that necessitate preventive maintenance.
- **Ease and Economy of Repair:** Damage is localized and the damaged area is cheaply and easily repairable by mortar . If carefully done, the repaired section would be as strong as the original section.

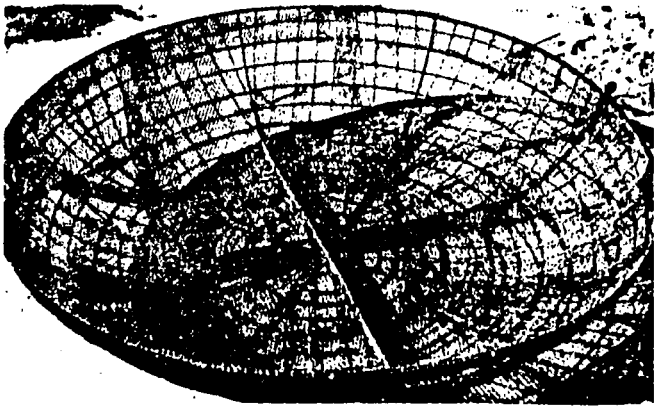
Twenty five bed hospital in the Philippines

FERROCEMENT RESEARCH AND DEVELOPMENT AT AIT

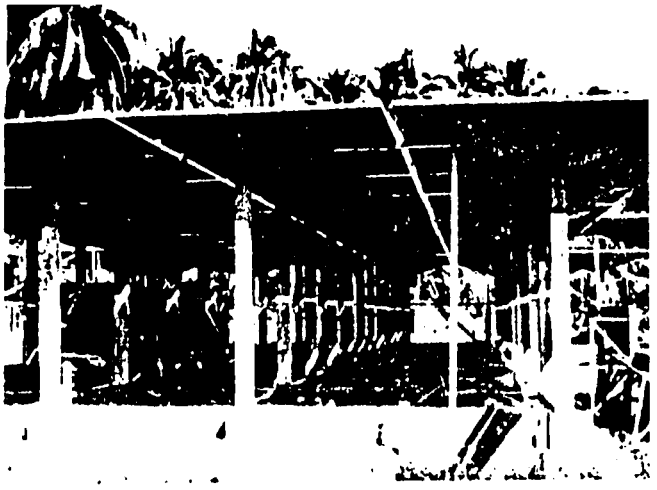
AIT's Structural Engineering Division is actively engaged in research activities to improve and investigate the material properties of ferrocement, and to use these research findings in practice in order to bridge the gap that now exists between research and field applications. All of these studies have been based on simulated field conditions and have used indigenous materials available in developing countries.

During the previous few years graduate students at AIT have investigated the basic mechanical properties of ferrocement, behaviour of ferrocement slabs, concrete canal lining with ferrocement facings, analysis and design of ferrocement pipes, investigation and field performance evaluation of ferrocement rice bin and canal lining, design and construction of a ferrocement water tank and investigation of the dynamic properties of ferrocement slab.

Wire frame for ferrocement coracle



Finished coracle in use



Philippines

APPLICATIONS

- Fishing and cargo boats
- Tugs and barges
- Bridges
- Docks and marinas
- Permanent food-storage dumps
- Seed (vegetables, etc.) storage
- Starch, flour, sugar storage
- Silage storage
- Edible oil storage (olive, peanut, cottonseed, palm, etc.)
- Grain storage (rice, wheat, corn, sorghum, millet, etc.)
- Manioc-soaking vats
- Fermentation tanks for cocoa, coffee, etc.
- Retting tanks for sisal, jute, hemp, etc.
- Gas tanks (for liquid and natural gas)
- Cooling towers
- Sewage troughs, lagoons, septic tanks, and other treatment facilities
- Guttering
- Leather-processing facilities
- Dying vats
- Grain dryers
- Copra dryers
- Greenhouse, packing-house and drying tables
- Pads for drying tea, coffee, cocoa, coconuts, other oilseeds, peppers, spices, etc.
- Cattle feeders and water troughs
- Cattle dips
- Water storage (drinking & irrigation)
- Pipes and irrigation conduits
- Ovens and fireplaces
- Slabs and shingles for roofs
- Decorative panels and tiles
- Wall panelling
- Floors
- Telephone and power poles
- Lining for tunnels & mines
- Stakes for supporting vine crops, tomatoes, beans, etc. (for termite resistance)
- Pothole repairs (squares of ferrocement sized and laid in the hole
- Timber treatment enclosures
- Shutters and formwork for use in standard concrete construction

INTERNATIONAL

INTRODUCTION

The **International Ferrocement Information Center (IFIC)** was founded in October 1976 at the Asian Institute of Technology under the joint sponsorship of the Institute's **Structural Engineering Division** and the **Library & Information Center.** The formation of IFIC is a response to the recommendation made in 1972 by the **U.S. National Academy of Sciences' Advisory Committee on Technological Innovation (ACTI)** which identified ferrocement as an overlooked, labor intensive, intermediate technology material with wide potential especially for application in the rural areas of developing countries.

AIT–IFIC NETWORK

Established within the AIT Library & Regional Documentation Center, IFIC will be guided by an editorial board whose members are internationally renowned specialists – IFIC expects to have correspondents in all countries involved in Ferrocement applications.

(L–R): Water Tank, Gas Cylinder & Grain Silo

FERROCEMENT INFORMATION CENTER

OBJECTIVES

Basically IFIC must serve as a clearing house for information on Ferrocement and related materials. In cooperation with national societies, universities, libraries, information centers, government agencies, research organizations, engineering and consulting firms all over the world, IFIC will attempt to collect information on all forms of Ferrocement applications, published or unpublished. This information will be repackaged and disseminated as widely as possible through the publications and the reference and reprographic services of IFIC.

OPERATIONS

The first issue of the *Journal of Ferrocement*, the main disseminating tool of IFIC, will be published in July 1977 in association with the **New Zealand Ferro Cement Marine Association (NZFCMA)** which has agreed to hand over to IFIC, the responsibility of publishing this Journal.

The *Journal of Ferrocement* will be subsequently upgraded and will cover all fields in which ferrocement is used. The proposed contents include:

- technical papers on Ferrocement;
- technical notes;
- annotated and indexed bibliography, current awareness service, news, etc.

In addition IFIC intends to publish **bibliographies, directories, and state-of-the-art reviews** on Ferrocement applications.

IFIC plans to design a **computer based information storage and retrieval system** for effective handling of information on Ferrocement and related materials. IFIC will also provide on request bibliographic searches and copies of documents through its reference and reprographic services.

FUNDING

IFIC receives financial support from the **United States Agency for International Development (USAID)**, the **Government of New Zealand** and the **International Development Research Center (IDRC) of Canada.**

Report of Workshop on Introduction of Technologies in Asia: Ferrocement, a Case Study

This Volume contains 13 case studies on the 'state-of-the-art' of ferrocement technology and its applications in nine countries in Asia and Australasia:

- **Design Philosophy for Ferrocement**
- **Korean Experience in Ferrocement Boats**
- **Ferrocement Roofing Research in the Philippines**
- **Ferrocement Boat Building in Fiji**
- **Rice Bin for Rural Farmers**
- **Ferrocement Housing in Papua New Guinea**
- **Ferrocement Research & Development in Bangladesh, India, Malaysia, Singapore, and Sri Lanka**

Edited by **Dr Ricardo P. Pama, Dr Seng-Lip Lee** (AIT Faculty) & **Dr Noel D. Vietmeyer** (U.S. National Academy of Sciences).
106 pages, 8½ x 10½ inches.

Available free on request, but a fee of **US$2.00** is required to cover postage cost. Write to:
International Ferrocement Information Center (IFIC), AIT
P.O. Box 2754, Bangkok, Thailand

AIT IN A NUTSHELL

The Asian Institute of Technology is an autonomous, international post-graduate technological institute in Bangkok, Thailand providing advanced education in engineering, science and allied fields through:

- **Academic Programs** leading to the degrees of Master of Engineering, Master of Science, Doctor of Engineering, Doctor of Technical Science, and Diplomas:
- **Research Activities** by faculty and students directed towards the solution of technological problems to improve the quality of life in Asia;
- **Special Programs** comprising conferences, seminars, and short in-service training courses.

Originally established as the SEATO Graduate School of Engineering in 1959, the Institute was chartered in 1967 as an independent, international and non-profit making educational institution by special legislation of the Royal Thai Government. The campus is situated on 400 acres of land 42 kms north of Bangkok.

At the Institute, students from many Asian countries pursue practical academic studies: seeking, defining and testing alternative solutions to urgent problems found in the region.

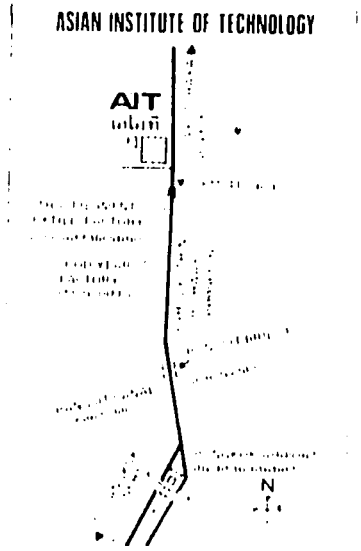
From its inception, the Institute has stressed the problem-oriented nature of its academic programs to the end that appropriate solutions may be found for Asian problems. The Institute offers degree and diploma programs in six Academic Divisions, viz: **Water Resources** Engineering, **Geotechnical** Engineering, **Structural** Engineering, **Environmental** Engineering, **Industrial** Engineering & Management, **Community and Regional Development.** Commencing in July 1978, the Institute will be offering fields of study in three new academic divisions, viz: **Energy Resources** Engineering, **Agricultural & Food** Engineering, and **Information Systems** Engineering.

Support teaching is provided through the Language & Media Center, the Regional Computer Center, and the Mathematics and Statistics Committee.

The present enrollment of over 400 students will increase until a projected peak enrollment of about 800 is achieved by 1985. All students live on campus where, through study and extra-curricula activities they become more aware of a common Asian identity, despite differences of nationality and culture.

Annual Subscription rate for
JOURNAL OF FERROCEMENT
a quarterly publication of IFIC

Subscribers	Individual	Institutional
From developing countries	US$ 15	US$30
From developed countries	US$ 25	US$50
Supporting subscribers	US$100	



The scenic 400-acre AIT campus is located 42 kms north of Bangkok or 17 kms north of Bangkok's Don Maung Airport.

AIT's growing achievements are based on its commitment to the belief that the quest for academic excellence can be creatively combined with the resolve to seek appropriate solutions to Asian problems. AIT's student body and international faculty work towards the fulfilment of such a commitment.

All enquiries on IFIC to:
Director, IFIC–AIT
Asian Institute of Technology
P.O. Box 2754, Bangkok,
THAILAND • Cable: AIT-BANGKOK
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5168331–5

IFIC–AIT Miscellaneous Publication, 77/2
April 1977 • Prepared by AIT Public Relations Office

DEVELOPMENT TECHNOLOGY CENTER
INSTITUTE OF TECHNOLOGY BANDUNG
DTC - ITB

Mailing address	: P.O. BOX 276, BANDUNG
Office address	: JALAN GANESHA 10 BANDUNG
Telephone	: 82051-82055 ext. 246
Telex code	: —
Cable address	: DTC-ITB BANDUNG

PROSPECTIVE PROGRAMS

1. Collaboration with TDI (Technology and Development Institute), East-West Center, Honolulu, Hawaii.
2. Collaboration with BUTSI (Indonesian Volunteers Service), KKN (Work Study Program for Students), and other Indonesian development service programs.

PAST PROJECTS

1. Survey of productivity of metalsmiths in rural and urban-rural transition areas.
2. Consultancy to develop achievement motivation training program for entrepreneur development. UNIDO sponsored.
3. Collaboration with Regional Adaptive Technology Center, University of Hassanuddin, Indonesia.

DTC programs have received support from various sources including Indonesian government offices and banks, international agencies and foundation, local governments and organizations, and institutions of higher learning.

The DTC considers the set of difficult and complex problems relating to development programs in Indonesia in this age of rapidly changing technology as a challenge that will have to be met by solutions which are still buried in a body of unknown science and technology. To the DTC this science and technology possesses academic and scientific values which are equivalent to the conventional academic values. Also, the DTC perceives the mastery of this unknown science and technology as promising significant potential and utility for the development of Indonesia.

STAFF AND ORGANIZATION

DTC-ITB is a flexible, self-supporting organization based at the Institute of Technology Bandung and drawing primary staff inputs from the ITB faculty. Other individuals and institutions, such as the University of Padjadjaran, do provide valuable contributions to DTC activities.

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- Ir. Suryandi Sadeli, Hardware Development Projects.

Administrative and Secretarial Staff (5 persons)

EDP (Entrepreneur Development Program) Staff (3 persons).

DEVELOPMENT TECHNOLOGY CENTER INSTITUTE OF TECHNOLOGY BANDUNG DTC - ITB

The Development Technology Center (DTC), an organization within the Institute of Technology Bandung (ITB), was established in 1973 by a decree of the Rector of ITB. DTC is a flexible organization, consisting of a group of ITB professors and staff members who are interested in conducting research and development programs and problems related to the development of Indonesia.

The focus of DTC activities is the application of a wide range of intermediate technologies to the needs of development including rural development. Priority concerns of DTC are the planning, selection, and development of appropriate technologies and of the specific skills necessary for integrated development.

The character of DTC programs are geared to the development missions of Indonesia and are designed to find and demonstrate new means by which modern science and technology can contribute to national development through new, simpler, and less expensive techniques. The DTC group believes that appropriate technology and strengthened economic agents can contribute significantly to meeting the challenges of unemployment and underemployment in Indonesia.

I. OBJECTIVES AND POLICIES

1. To promote ITB as a center for development technology (ITB Master Plan 1971 - 1981) and facilitate the input of ITB's scientific and technical resources to the generation of appropriate technology and programs to achieve national development goals.
2. To formulate, evaluate, and execute technological projects conforming with the following priority characteristics :
   - directly contributory to the needs of development; involve and strengthen a multidisciplinary approach to activities;
   - oriented toward action research, innovation, and development;
   - contribute to the development of indigenous skills and economic systems.
3. To stimulate the development and transfer of specific technologies needed by the development, and if necessary, manage the application of such new technology.
4. To foster collaboration with similar agencies and institutions both within Indonesia and internationally.

II. PROBLEM AREAS OF INTEREST

1. Linkages between macro planning and micro implementation for rural, regional, and national development.
2. Innovation and transfer of technology appropriate to the needs of national development.
3. Development of entrepreneurial agents and enterprise systems.
4. Productivity and the effective utilization of technology in enterprises.
5. Other topics in science and technology policy for national development.

III. ACTIVITIES

1. **Rural Appropriate Development Technology** : Five year Collaboration with the Netherlands TOOL (Technische Ontwikkeling Ontwikkelings Landen) Foundation. Extensive program will establish :
   - a technical information system;
   - hardware development projects;
   - a system of field stations for realistic testing and demonstration of hardware or software technologies;
   - an inquiry and extension activity complemented by publication, documentation, and training programs.
2. Entrepreneurial development and training programs with project and materials development and evaluation.
3. Development of Local Power Sources :
   solar energy, wind energy, bio-gas, micro-hydro, and integrated systems, mainly for the rural areas in the form of autonomous or decentralized systems.
4. Appropriate Technology Hardware Development and Testing.
   Sample Projects :
   - non electric ice-maker;
   - agricultural product dryer;
   - food processing technologies : *Kemiri* nut shelling mahine, coconut processing;
   - stone cutter for cottage jewelry industry.
5. Technical needs assessment, regional development, and technology transfer studies. Regionalization of technology transfer through Regional Development Technology Centers.
6. Field Station Yayasan Dian Desa. Appropriate Technology development and demonstration in and around Jogjakarta, Central Java.
7. Study with CAMS (Council for Asian Manpower Studies) on relationship between local s[illegible]tries and multinational joint venture emphasizing vehicle assembly.

ANNEX G

Detailed Technical Analysis

Section (1) Pyrolytic Conversion*

Pyrolytic Conversion of Wastes to Higher-Quality Fuels

Pyrolysis, which is the thermal degradation of lignocellulosic materials, is one promising means for converting wastes into higher-value fuels which can be transported, stored, and used more efficiently and economically than the original materials. The products of pyrolysis are a char, an oil, and a combustible gas. The char is a familiar product; however, the oil and gas are not so widely utilized at present. The applications of the char for home cooking or as an industrial or metallurgical fuel are also well known, but the uses of the gas and especially the oil are not generally appreciated.

System Capacity

Examination of the data concerning rice production indicates that the overwhelming majority of the rice in Indonesia is processed in mills having capacities in the range of two to four tons of rice per day. Thus a mill producing about three tons per day appears to be representative. Such a mill would typically produce about one ton of hulls (14% moisture) and about one-third ton of bran each day, additionally. Therefore, a one-ton-per-day pyrolytic conversion system would be an appropriate size. This is a convenient choice since it allows for the use of a single International Rice Research Institute (IRRI) drier (18) operating on a three-shift basis to dry the paddy. Additionally a one-ton-per-day conversion system, if need be, could be readily disassembled and transported to another site during the slack season.

A number of factors govern the relative amounts of char, oil, and gas produced through pyrolytic conversion; among them are the operating pressure, the time required for pyrolysis, and the temperature of the process. In the more commercially successful pyrolytic conversion systems developed to date, carbonization has occurred at near ambient pressure and at a relatively moderate rate. Thus the conversion temperature is, for practical purposes, the most important controlling variable. At higher temperatures, greater amounts of gas and oil are produced and the char yields are small; at lower temperatures, the storable and more easily transported, they are of greater interest than the gas as the products of pyrolytic conversion of agricultural wastes. Thus low-temperature pyrolysis has a definite advantage in rural applications. This is convenient, since the materials problems associated with the higher temperature processes can create serious design difficulties.

Pyrolytic conversion can occur in batch processes, such as those historically used for making charcoal, or in continuous processes. Batch processes are simpler and allow carbonization of relatively large pieces; continuous

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* The text in this Appendix has been extracted directly from the pyrolytic conversion feasibility study report, Pyrolytic Conversion of Agricultural and Forestry Wastes to Alternated Energy Sources in Indonesia, published by the Economic Development Laboratory, EES, Georgia Institute of Technology, Atlanta, Ga. 30332, February, 1977.

processes are generally more mechanized and require the feed to be in smaller sizes, such as the wastes produced at agricultural processing plants. Continuous processes also allow the recovery of the pyrolytic oils, while this is not so easily accomplished with batch processes.

While pyrolysis is actually an exothermic reaction, once the feed reaches a temperature of several hundred degrees, the rate of this reaction without any external heat addition is usually too slow, especially for continuous processes, for commercial utilization. Thus most continuous flow systems require the addition of external heat.1/ This heat can be added in many ways, i.e., directly through the walls of the containing vessel or retort, in a rotary-type kiln where combustion of some fuel is made within the kiln, or perhaps in a vertical shaft furnace where a small part of the charcoal produced is oxidized using controlled air addition and the hot gases generated transfer the necessary heat to the feed. Combinations of these techniques also can be found.

Because of the simplicity and efficiency of the shaft furnace design, because it can be made to be self-sustaining, and because it provides greater flexibility in the type of feed that can be used, it has been developed over the last century in a variety of forms. While there have been some differences in the source of the energy, i.e., either by external combustion of the pyrolysis gas with subsequent introduction into the bed or by the simple addition of air and combustion of the char, almost all the designs have involved the introduction of the feed at the top of the retort, the removal of the char from the bottom, and the passage of the hot gases upward through the downward-moving feed. The gases are subsequently removed at the top of the unit, scrubbed, and passed through a condensing unit, from which the liquid fraction is recovered. Frequently the feed is dried externally, rather than in the bed itself, thereby allowing the utilization of the chemical rather than the sensible energy of the gas for drying. This results in another advantage, which is that less gas need be produced, thus allowing greater char and oil yields -- an important consideration for agricultural wastes.

In these systems involving partial burning of the char, the amount of air introduced can be used to control the reaction temperature, thus allowing variation in the product yields. One important consideration in the operation of these systems is to maintain the off-gas temperature well above the dew point of the mixture and even above the condensation temperature of all but the highest boiling point fraction of the pyrolytic oils. This is usually satisfied if the off-gas temperature is in the range of 350°-400°F.

Several examples of this general type of pyrolytic conversion system, utilizing all or some of the above characteristics, include:

- the basic Stafford retort used widely over the past 50 years in the U.S. and elsewhere for production of charcoal and liquid by-products
- the Mellman retort

1/ An important exception is the Stafford retort, which is designed to utilize the exothermic heat of decomposition in well-insulated kilns. Usually the kilns are very large and, even though the feed residence time is long, the charcoal production is substantial.

- the Lambiotte retort
- the de Bartolomeis design
- the Barneby process
- the Georgia Tech design

Obviously, the technology of low-temperature pyrolysis is well advanced and can be applied to Indonesia's needs with confidence.

While continuous conversion systems are suitable for process wastes, and do allow oil recovery, they generally are more complex and more expensive than simple kilns, which provide charcoal production only, but can readily process logging residues. Likewise, continuous processes are more vulnerable to shutdowns in LDCs because of reduced spare part availability. Thus, since the character of the wastes in Indonesia varies widely, a process that would accept all kinds of materials in various sizes and shapes and still allow oil recovery would be most desirable. However, it is important that such a system should work efficiently using rice hulls, since they represent the predominant waste. In a later section, a preliminary description of a system which has many of these desirable characteristics is presented.

In reviewing the previously mentioned problems of using agricultural wastes for energy production, it is useful to note that low-temperature pyrolysis systems produce dense, dry, high-energy fuels that can be easily stored and transported and used in existing facilities with little or no modification. By making the system transportable, the seasonal nature of these wastes can be dealt with. Thus, the problems characteristic of using these wastes can be materially reduced or resolved through the use of low-temperature pyrolytic conversion.

Design Philosophy

The crucial element in the design philosophy is the requirement that the system be appropriate to the needs of Indonesia. The technology utilized and the level of labor intensity must be chosen to best suit the local Indonesian situation. Ideally, the system should be designed as simply as possible, possess reliable, rugged operating features, have only a few moving parts, require negligible maintenance, have a minimum number of imported components and/or materials, and operate as flexibly as possible. In addition, commonality of motors, bearings, etc., as much as practicable, should be sought. Moreover, while labor-intensive methods generally should be applied, care must be taken not to compromise system performance by replacing critical components by manual operators who can occasionally be distracted from their duties. Additionally, the system design should allow for operator inattention and be designed, where possible, to be fail safe. Finally, the system components should be readily

available in Indonesia, insofar as possible, and be off-the-shelf, where practical.

The results of a survey of a number of large, medium-size, and small metal fabrication shops in Bandung, Surabaya, and Jakarta indicate that in Indonesia the general availability of materials -- including iron, aluminum, copper, steel, stainless steel, sheet metal, and tubing -- is adequate and that the people's ability to work with these materials is excellent. Even in the smallest shops, surprising but simple techniques allow fabrication of relatively complex components. Indonesian ingenuity and the relatively low labor cost make techniques practical that would be out of the question elsewhere; but these methods are effective and economical. Thus there appears to be no difficulty in fabricating and assembling components for any practical pyrolytic conversion system. Moreover, the availability of components such as electric motors, gasoline engines, blowers, and other manufactured items is quite adequate for the needs of any conversion system contemplated.

Alternative Designs

While mechanical drying of the paddy, using heat available from combustion of the pyrolytic gases, is an attractive approach for many rice mills, there likely will be numerous situations where sun drying is still preferred. Moreover, although it is desirable to reduce initial capital requirements and maximize labor needs by full utilization of the conversion system, the difficulty of obtaining crews for three-shift operation and the convenience of processing only during the times when the mill itself is running make necessary the consideration of systems operating on both a single shift and on three shifts. In all cases, because the convertor is assumed to be located at a rice mill, where either electrical or mechanical power is available, there seems to be no need to consider completely manually operated systems (although in unusual circumstances such systems may be required and could readily be devised). Thus there appear to be three general classes of pyrolytic convertors applicable to Indonesian needs:

(1) A relatively mechanized system, operating on three shifts with one-ton-per-day capacity and including a drier. The system probably would be at a rice mill in a locale where three crops of rice are harvested each year.

(2) A more simplified system, without a drier,1/ and operating on three shifts with one-ton-per-day capacity which would probably be located at a rice mill in an area where only two annual crops are harvested and where sun drying is practical.2/

(3) A more capital-intensive system, with one-ton-per-day capacity but requiring only a single-shift operation.

1/ Thus flaring of the off-gas would be necessary. While this would initially be a wasteful practice, it is likely that this gas would be quickly utilized once its potential and presence were recognized since it represents an ideal source of clean energy for other commercial applications.

2/ It appears that the need for drying the first rice crop is reduced because the supplies of stored rice from the previous season have been depleted by the time this rice has been harvested and the rice produced can be quickly sold. Thus only the second crop must be dried for storage; however, this can be done after the monsoon season has ended and the dry season returns.

Obviously a mixture of these cases is possible. However, in all systems, the design of the basic pyrolytic conversion unit or kiln would be the same.

The technical approach to the development of these systems is also an important consideration. One approach might be to use existing practices; another might involve the development of more advanced, inexpensive, and maintenance-free components. The first designs could be made with relative confidence immediately; the latter would require some development. Both approaches have merit and together would provide for both today's and tomorrow's needs. The presence at the Institute of Technology Bandung (ITB) of the Development Technology Center (DTC), together with its skilled and experienced personnel, offers an especially promising opportunity to pursue both paths.

Thus the system for pyrolytic conversion of waste in Indonesia to be described in the next section involves four different design approaches:

(1) A mechanized system, with a drier, using existing practices, and based on a three-shift operation.

(2) A more labor-intensive system, without a drier, using existing practices, and based on a three-shift operation.

(3) A mechanized system, without a drier, using existing practices, and based on a one-shift operation.

(4) A mechanized system, with a drier, using more advanced practices.

System Description

The first three selected system designs are shown schematically in Figures 1, 2, and 3. In the figures, the various components for each system are numbered and a brief description of each is presented in a table insert. In the fourth design (not shown), typical improvements such as the integration of the cyclone (scrubber) and the condenser[1/] and the use of a pumping ejector (rather than a mechanical blower) would be investigated. It is likely that other component simplifications also can be found; however, these two appear presently to offer the most promise since they should result in considerably reduced cost and lower maintenance.

In all the designs presented, a basic characteristic is the use of the same kiln or pyrolytic conversion unit design. The differences all lie in the off-gas systems and in the presence or absence of a drier. For example, designs 1 oand 3 are basically the same except that the convertor in design 3 is larger and no drier is used.

1/ Using a conventional condenser design approach, a recurring problem is blockage of the condenser tubes by particulates not removed by the scrubber. In the proposed approach, the condensation process would not involve a solid boundary, and thus clogging would be much less of a problem. Additionally the particulates could be removed from the oil using a disposable oil filter, perhaps composed of the rice hulls themselves. It would not be expected that the fine fraction of the feed would be a problem since microscopic examination of the hulls indicates only a very minor portion of the waste to be in the fine particle range.

While all the systems are capable to some degree of recovering oil while processing large pieces of wood waste using a batch mode and the sequenced firing technique described in (3), the preferred operating practice is a batch-continuous mode with rice hulls as the feed. This is because the number of conversion units is only two (as opposed to four in (3)), and it is uncertain if truly significant amounts of oil could be recovered in the pure batch mode, sequenced operation. Therefore, only the batch-continuous mode with rice hulls will be discussed further. Moreover, only a description of the more mechanized system, No. 1, will be presented in detail, since an understanding of the other systems should follow from this discussion.

Referring to Figure 1, it is seen that the basic system involves several components:

(1) The cylindrical kilns, including a feed storage plenum at the top, a manually operated shaker-grate char output system, several adjustable air tuyeres, and a char holding container at the bottom.

(2) The off-gas ducting system.

(3) The cyclone scrubber for removing particulates from the off-gas.

(4) The single-pass condenser to separate the high-temperature oily fraction from the off-gas stream.

(5) The draft fan.

(6) The modified IRRI drier for drying the paddy.

In practice, the paddy is introduced into the drier, the dry grain later milled and the dry hulls separated from the remainder. Then, periodically the hulls are introduced into the kiln. After enetering the kiln, the hulls pass down into a hot zone and are there converted to charcoal. The char is removed from the holding container into steel drums for cooling and storage. The air induced by the draft fan into the kiln passes through the tuyeres and combusts a small fraction of the charcoal to produce hot upward-flowing gases which, in turn, supply heat to carbonize the downward-moving feed. The resulting smoke or pyrolytic gas from the feed leaves the kiln, passes through the cyclone to remove the particulates, passes through the condenser where the oily fraction is recovered, and then is incinerated in the drier.

The system operates at several inches of water negative pressure. The pressure is controlled by the speed of the draft fan, the process rate, and the tuyere opening. The combustion air for the modified IRRI drier passes across the condenser tubes to provide the required cooling of the off-gas. To allow ease of maintenance, the off-gas passes through the tubes rather than across the tube bank, as in normal condenser design practice. Easily removable access plates allow the tubes to be cleaned with a minimum of disruption to operation. During this cleaning, the condenser would be bypassed.

Insulation of the kiln walls in the hot zone above the tuyeres may be provided by means of "char shelves," which would use the feed/char itself as a lightweight, expendable insultator.1/ The kilns are basically cylindrical and constructed of two welded 200-liter oil drums with a single 100-liter drum inside at the top for feed storage. The kiln would stand about 10 to 11 feet above the ground and be approximately two feet in diameter. Because of the danger of corrosion, especially in the upper volume, the 100-liter drum should be constructed so that it can be easily removed from the overall kiln.

Blowout ports would be located on the kilns, the cyclone, and the condenser to insure that any over-pressure would be easily vented. The entire system would be located underneath a shed to protect it from the rain and direct sunshine.

The overall system would process, on a three-shift, 24-hour basis, one ton of dry hulls per day. It is estimated that the system would produce about 250 kilograms of charcoal and about 150 kilograms of oil each day.

It should be recognized that the system described is only preliminary. The limitations of time and budget have allowed only a brief span in which to actually consider the design within the constraints previously noted. Thus some oversights have likely occurred and some oversimplifications have no doubt been made. No attempt has been made to optimize the design. However, the system design presented should be useful in making cost estimates. Hopefully, a future program will allow the opportunity for a more detailed investigation of the system.

System Operation

To start up the system, a fire would be built in each kiln at a level slightly below the tuyeres. After the fire has reached a stable condition and the unit heated up, additional feed would be added to cover the combustion zone until the hulls fill the kiln. Then, after a pause to allow a thermally stable condition to be reached, the shaker grates would be manually activated and the system slowly brought up to the operating mode. Depending on the process rate desired and the feed moisture characteristics, the tuyeres could be completely closed or partially open.

To check the char quality, a sample could be taken through one of the tuyeres. If the char contains brown, uncharred material, the process rate is too high; if the char contains much ash, the process rate is too low; if the char is dark black, the process rate is just right.

Periodically the char holding container would need to be emptied. The char level could be monitored by striking the sides of this container at

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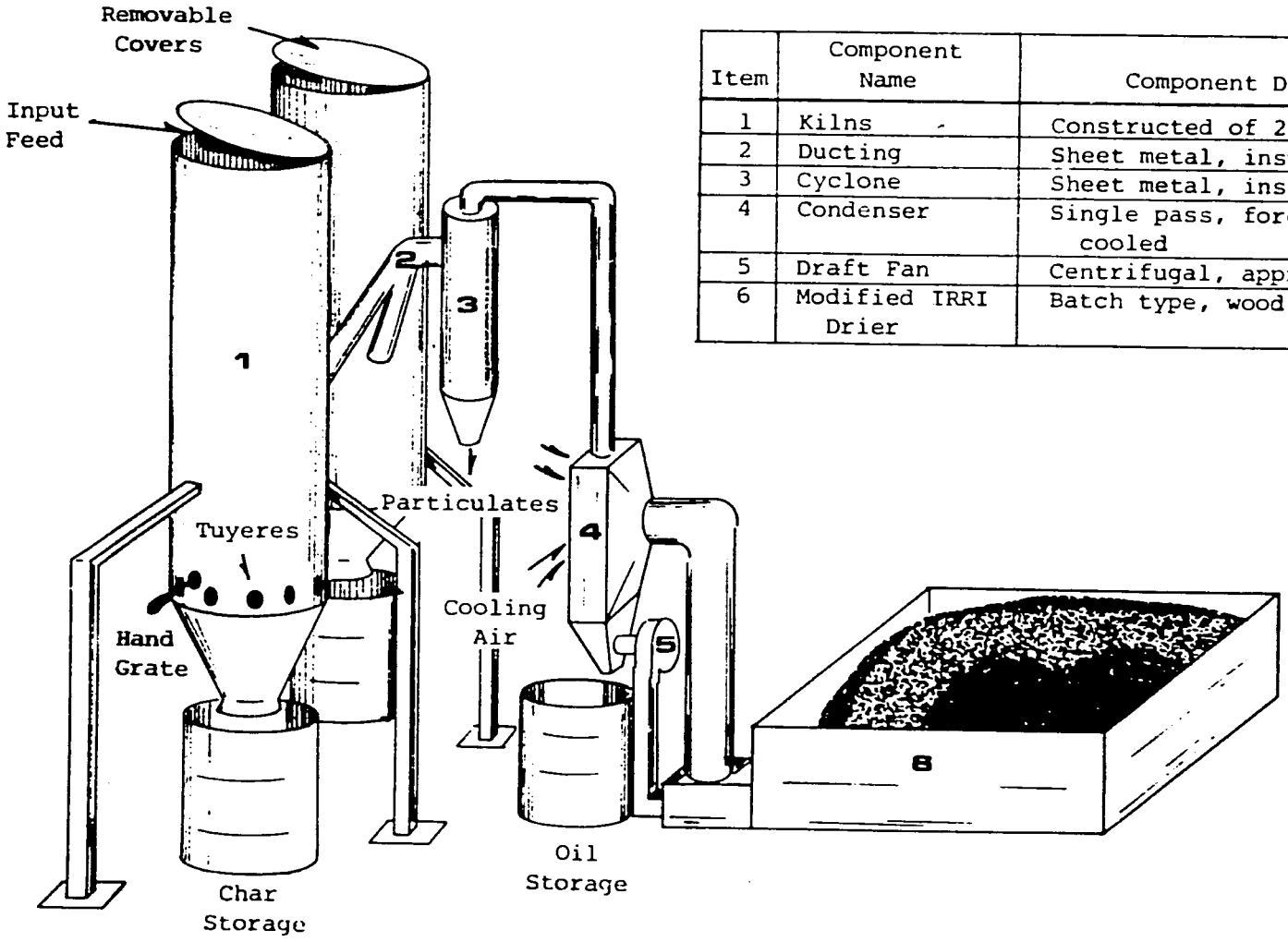
1/ The use of the feed as an insulator is a well-established practice in producer gas technology.

Figure 1

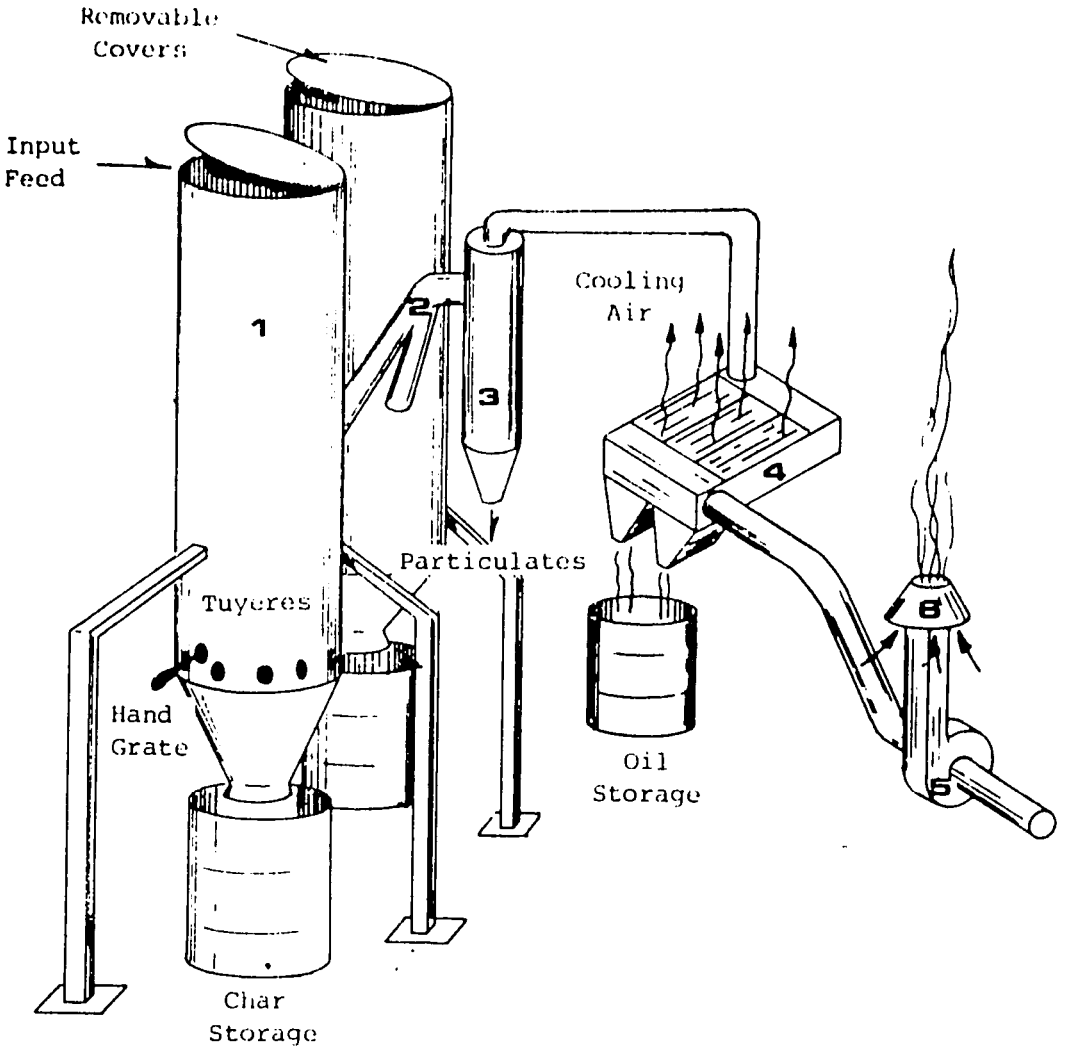
ONE-TON-PER-DAY PYROLYTIC CONVERTOR FOR INDONESIA - MODEL 1



Item	Component Name	Component Description
1	Kilns	Constructed of 200-liter oil drums
2	Ducting	Sheet metal, insulated
3	Cyclone	Sheet metal, insulated
4	Condenser	Single pass, forced convection cooled
5	Draft Fan	Centrifugal, approximately 20 cfm
6	Modified IRRI Drier	Batch type, wood construction

Figure 2

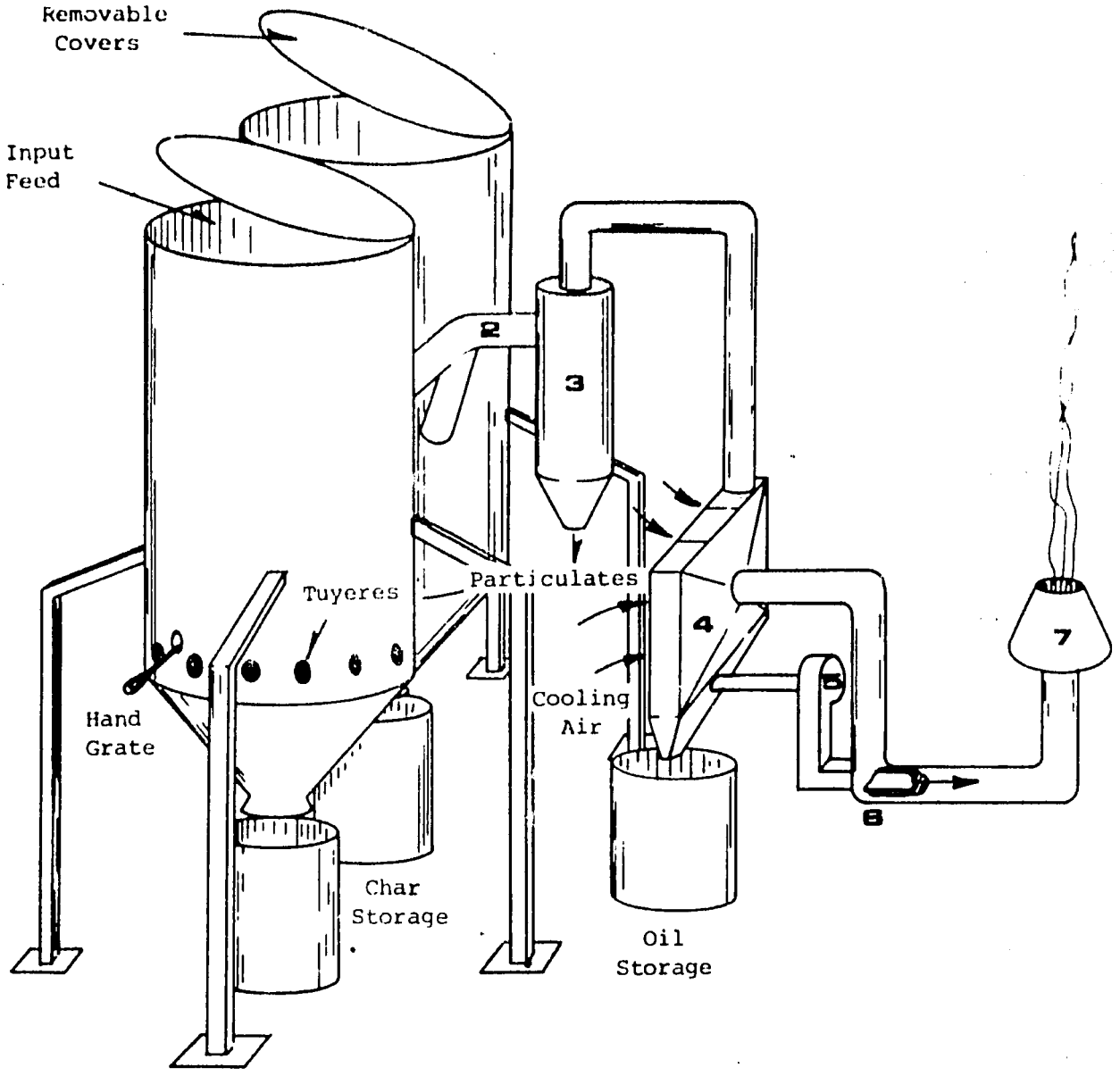
ONE-TON-PER-DAY PYROLYTIC CONVERTOR FOR INDONESIA - MODEL 2



Item	Component Name	Component Description
1	Kilns	Constructed of 200-liter drums
2	Ducting	Sheet metal, insulated
3	Cyclone	Sheet metal, insulated
4	Condenser	3 pass, natural convection cooled
5	Draft Fan	Centrifugal, approximately 30 cfm
6	Burner	Diffusion

Figure 3

ONE-TON-PER-DAY PYROLYTIC CONVERTOR FOR INDONESIA - MODEL 3



Item	Component Name	Component Description
1	Kilns	Sheet metal construction
2	Ducting	Sheet metal, insulated
3	Cyclone	Sheet metal, insulated
4	Condenser	3-pass, forced convection cooled
5	Draft Fan	Centrifugal, approximately 60 cfm
6	Ejector	Pumping - secondary to primary flow ratio ~ 2
7	Burner	Diffusion

different heights with a stick and listening for the difference in the sound below and above the char zone. Typically the charcoal has about 50% of the volume of the hulls; thus, by designing the char storage to be one half the hull storage volume, the need to fill the kiln with hulls would occur at the same time the char storage needs to be emptied.

Also, the oil storage container would need to be emptied periodically and the cyclone checked to be certain that the off-gas particulates were not blocking the flow. Finally, daily inspection of the condenser would need to be made to insure that particulates passing through the cyclone do not foul the tubes.

While the above discussions are not complete, they should provide a reasonable picture of the basic system design and operation.

Section (2) Ferrocement Technology 1/

"A report published in 1972 by the National Academy of Sciences of the United States of America, through its Board on Science and Technology for International Development (BOSTID) and its Advisory Committee on Technological Innovation (ACTI) has identified ferrocement as a labor intensive, appropriate technology material which has potential applications in developing countries. Ferrocement is a highly versatile form of reinforced concrete made of wire mesh, sand, water and cement, which possesses unique qualities of strength and serviceability. It can be constructed with a minimum of skilled labor and utilizes readily available materials. Proven suitable for boat building, it has many other tested or potential applications in agriculture, industry and housing. Ferrocement is particularly suited to developing countries for the following reasons:

- Its basic raw materials are available in most countries.

- It can be fabricated into almost any shape to meet the needs of the user; traditional designs can be reproduced and often improved. If properly fabricated, it is more durable than wood and cheaper than imported steel and it can be used as a substitute for these materials in many applications.

- The skills required for ferrocement construction are quickly acquired, and include many skills traditional in developing countries. Ferrocement construction does not need heavy plant or machinery; it is labor-intensive. Except for sophisticated and highly stressed designs, such as deep water vessels, a trained supervisor can achieve the requisite degree of quality control using fairly unskilled labor for the fabrication.

- The concerns of most developing countries on its rapid rate of deforestation makes ferrocement more attractive as possible replacement for wood in many applications.

"One of the problems in introducing ferrocement technology in Indonesia is the lack of indigeneous talent that can demonstrate and teach the rural people how to build ferrocement structures and related objects for use in their daily lives. Two ferrocement construction facilities exist in Indonesia. One is a small,commercial boat building company in Jakarta which branched off to ferrocement boat building with the help of a New Zealand company. This company, P.T. Kodja, builds ferrocement boats and barges. The other facility is a small boat building company in Jayapura, West Irian. This project was undertaken by the Irian Jaya Joint Development Foundation with financial support from the United Nations Development Program."

The intended response to this problem of lack of people technically skilled in ferrocement is to include in the program two training programs. One, the training of about six Indonesian engineers in the mechanical properties of

1/ Quotations are from an Asian Institute of Technology report to USAID/Indonesia entitled The Potentials of Ferrocement and Related Materials for Rural Indonesia, A Feasibility Study, October, 1977

ferrocement, will be done at the Asian Institute of Technology, Bangkok, through a special course of training for four months, starting in May, 1978 (See Annex K for detail). The other is for short courses (one or two weeks) of practical, village-level training, to be conducted in Thailand as a contribution to the project by the Siam Cement Company, and in various parts of Indonesia, according to arrangements made by the overall project manager. The designing and experimental testing of such courses is part of the technical task of this Project. In addition, regular Indonesian graduate students at A.I.T. will be encouraged to do theses work on ferrocement, at no cost to the project.

"The Development Technology Center (DTC) as a research and development arm of Institut Teknologi Bandung (ITB) has the capabilities to adapt and introduce ferrocement technology in Indonesia. The DTC is multi-disciplinary in approach and has the support of the different faculties in ITB. They have many projects in the rural areas and could easily integrate ferrocement technology in their rural development program.

"In order to accelerate the introduction of ferrocement technology in different areas in Indonesia, national institutions such as Universitas Hasanuddin and Syiah Kuala in South Sulawesi and North Sumatra respectively can be made agents for the experimental transfer of this technology in their respective area. These two Institutions have Rural Development Centers which work with the various faculties in their respective universities on rural development projects. They have staff members who can be trained in ferrocement construction and have laboratory facilities to carry out basic structural testing and conduct field demonstrations."

Other organizations involved in teaching or experimenting in village-level technology may also be included in this experimental training testing and demonstration program. Such organizations can include private voluntary agencies (e.g. CARE), government agencies (e.g. BUTSI), village technology teaching organizations (e.g. Muslim boarding schools such as Pesantren Pabelan, near Yogyakarta, and Pesantren Darul Fallah, near Bogor), private Indonesian appropriate technology groups (e.g. Yayasan Dian Desa, Yogyakarta), et al.

In summary, the technical analysis by the DTC/ITB and AIT feasibility study team found using ferrocement for selected village needs to be technically feasible. Furthermore, the team found that the following applications should be tested in the field, adapted as necessary, and then be evaluated before continuing on with any full-scale application and dissemination project:

- Pontoons
- Dug-out canoes
- Water jars (large sizes)
- Building boards with indigenous fibers as reinforcement.
- Toilet bowls with water traps
- Well casings
- Grain storage

Although fishing and cargo boats have been identified as possible applications of ferrocement in Indonesia, it is recommended that they be excluded in the field testing for the following reasons:

(i) The capital investment required in ferrocement fishing or cargo boat (about Rp 2,000,000) is large in relation to the other applications identified previously.

(ii) The construction of a ferrocement boat requires special expertise and will take several months to complete. Since the project is only of 2-year duration it is felt that only a very limited time will be left to try out other applications if boat building is undertaken. It will take a long time before the villagers can see the actual results whereas, with other simple applications the villagers can see the results in a matter of weeks.

Detailed Economic Analysis

Section (1) Pyrolytic Conversion 1/

Agriculture is the principal economic activity in Indonesia. About 64% of the population is directly employed on farms during the major part of the year. If employment in forestry and in the manufacturing and selling of agricultural and forestry products is included, the percentage may reach over 80%. The quantity of waste materials associated with farming and manufacturing of agricultural and forestry products is enormous. This section, then, presents a discussion of the types of these wastes found in Indonesia along with a description of the quantities involved and the general locations where the wastes are produced, as the first element in the economic analysis.

In any discussion of wastes, there is an immediate difficulty which must be faced regarding the important distinction that should be made between the terms "wastes" and "available wastes." This is because there are many present commercial uses for "wastes", and while it is not too difficult to determine the quantities of wastes produced in most cases, it is often extremely difficult to identify what portion of those wastes is presently being used and what portion is actually "available." Conveniently, the predominant sources of waste in Indonesia, i.e., rice hulls and logging and sawmill residues, are generally used to a relatively minor extent. However, such materials as coconut, oil palm, and rubber tree wastes and bagasse, which are produced in prodigious quantities, are used to a significant but unknown degree. Therefore, some inaccuracies are likely present in the results shown in this study, since estimates of the available fraction of the wastes have been made of necessity.

In addition, there are likely problems of omission -- no doubt some waste types have been ignored due to lack of information regarding their existence and/or amounts. For example, peanut hulls and maize stalks, because of poor knowledge regarding their production rates and uses, are not included. Further, there is a semantic difficulty regarding the definition of what a waste actually is. For example, rice straw, which has historically been burned in the fields and used as a fertilizer -- by and large -- and is therefore not a waste, to a large extent could be replaced by chemical fertilizers and thus become a waste. However, for present purposes this straw has not been considered a waste even though its total dry weight could easily approach an order of magnitude greater than that of the rice hulls; hence, the energy potentially recoverable from this source is enormous.

A summary of the agricultural and forestry wastes in Indonesia which, based on the results of the feasibility study, have a high potential for energy conversion is given below, 2/ along with the estimated available percentages:

1/ The text on the economics of pyrolytic conversion in this Annex was largely extracted from Pyrolytic Conversion of Agricultural and Forestry Wastes to Alternative Energy Sources in Indonesia; A Feasibility Study, Economic Development laboratory, EES, Georgia Institute of Technology, Atlanta, Ga. 30332.

2/ All weights given in this report are metric, except where otherwise indicated.

	Annual Waste Production (in metric tons)	Estimated Percentage Available
Rice hulls	5.7×10^6	90
Logging wastes	1.4×10^6	50
Sawmill wastes	1.1×10^6	70
Coconut wastes	2.4×10^6	30
Oil palm wastes	1.5×10^6	30
Rubber wastes	1.9×10^6	30
Bagasse	3.1×10^6	10
Total	17.1×10^6	

The weight of these materials is in green tons. 1/ If all the estimated available wastes were converted into charcoal and oil, 1.5×10^6 tons of charcoal and 90×10^6 tons of oil would be produced. The market value 2/ of these products would be about 28 billion rupiahs. 3/ To put this number in perspective, Indonesia consumed an amount of energy equivalent to 16 million tons of coal in 1974. Thus, charcoal and oil produced by pyrolytic conversion would be equivalent to about 15% of the total energy consumed in the nation in that year. 4/ If the energy potentially available from rice straw also were included, this percentage might be increased by a factor of three or more. Clearly, the potential impact of agricultural and forestry wastes as an energy source in Indonesia is highly significant.

It should be noted that in the event a pyrolytic convertor, based on a specific waste materials, is to be built, a survey of available wastes to confirm the results of this study should be conducted. More importantly, a long-term supply of material should be assured before actual construction of a pyrolytic conversion plant is begun.

In the following sections the seven major types of waste identified above as potential raw materials for pyrolytic conversion are discussed in terms of production rates and location.

1/ The rice hull moisture content is taken at 14%. The remaining wastes are assumed to have a 50% moisture content.

2/ The producer's price for loose charcoal is taken as 12,000 rupiahs per ton; pyrolytic oil is valued at 10,560 rupiahs per ton.

3/ At current (1978) exchange rates, one U. S. dollar is worth 414 rupiahs.

4/ The energy content of the char and oil is approximately equal to that of coal.

Rice Hulls

The production and marketing of rice constitut the dominant economic pursuit in Indonesia. The varied occupations associated with rice production and marketing include paddy cultivation in the wide tracts of rural land, thousands of rice mills scattered among farms, and numerous wholesalers and retailers of rice in villages and cities. Since rice is the major food staple of the land and 129 million people consume it daily, the importance of rice to Indonesia can only be imagined. About 62% of the rice production is centered in Java, which contains a comparable fraction of the national population.

After the rice is harvested, the separation of stalk and rice grains is typically done at the farm by simple foot-pedaled r hand-operated threshers. Rice stalks, which contain potassium, are presently being left on the farms and are typically burned, thereby returning the potassium to the soil. Only about 10% of the stalk from the local rice variety goes through the rice mills and is used for papermaking or for mushroom cultivation. The stalk of the local rice variety has a value of 15-20 rupiahs per kilogram for these purposes, but the stalk and leaves of the miracle rice currently have no value. In sum, rice stalks in Indonesia cannot currently be considered as waste because they play an important function in maintaining soil fertility. However, in the future, chemical fertilizers could be used to replace the rice stalks if the economics were favorable.

Today, the rice is generally sent for grinding to mills rather than using the older manual methods. However, in the outlying areas, the older methods are still practiced to some extent. Two kinds of wastes are generated in the milling and polishing processes -- rice hulls and fines, or bran. These wastes consitute about one third of the weight of rice grains input. The balance is the output of milled and polished rice. Of the total grain, rice hulls constitute about 25% and fines make up about 8%. Fines, or bran, are considered as a by-product and are sold as feed materials for poultry and animals. Only rice hulls are true wastes. For disposal, rice hulls are generally burned at the sites of rice mills. (A small amount of ash may be used in scouring powder, or the hulls used as land fill.)

Since rice hulls are generated at rice mills, the distribution of rice mills in Indonesia is important to this study. A list of small and large rice mills by province, their milled-rice production, and the hulls generated is given in Table 1. There are 1,144 large rice mills and 28,059 small rice mills in Indonesia. Large mills refer to rice output capacity of one ton per hour or more, while small mills are considered to be under one ton per hour. On the average, the output of large mills is one ton per hour, while the output of small mills is 1.3 ton per hour.

From the table, it is obvious that the three provinces of West, Central, and East Java have the majority of the rice mills in Indonesia, produce the largest volume of rice, and generate the major portion of the rice hulls. In Java, 3,379,242 tons of rice hulls were generated in 1975. This constitutes about 60% of the 5,667,450 tons of rice hulls produced by all the rice mills in Indonesia in that year.

Forestry Wastes and Sawmill Wastes

Major wastes from the forests in Indonesia are of two types, logging wastes and sawmill wastes. Logging wastes are composed of branches, twigs, tops, etc., which together constitute about 30% of the cut-down part of a tree. About 50% of these logging wastes are being processed as wood chips for papermaking. The balance is left in the forests, representing a true waste for purposes of this study.

Approximately 50% of each log that goes through a sawmill is wasted. Sawmill wastes are in the forms of off-cuts, edgings, sawdust, etc. About 30% of these wastes are being processed into wood chips for papermaking or used as the base material for wood particleboard production. The balance is a potential feed material for pyrolytic conversion. Generally off-cuts and edgings are sold as firewood and only sawdust is burned as waste or given away to neighbors. Sawdust constitutes about 40% of all sawmill wastes by weight. However, because of a potential higher recovery value by pyrolytic conversion, sawmill wastes, except the 30% processed into wood chips for paper and particleboard making, are considered as potential waste materials for pyrolytic conversion.

Table 1

THE DISTRIBUTION OF RICE MILLS BY PROVINCE, PRODUCTION, RICE HULLS GENERATED, INDONESIA, 1975

Province	Number of Rice Mills		Milled Rice Production (metric tons)	Hulls Generated (metric tons)
	Large	Small		
West Java	273	5,994	3,675,375	1,357,683
DKI Jakarta	1	26	14,692	5,427
Central Java	145	3,855	2,671,376	986,806
D.I. Yogyakarta	8	872	284,485	105,088
East Java	245	4,022	2,801,172	1,034,753
D.I. Aceh	70	1,071	456,859	168,764
North Sumatra	269	2,044	981,846	362,694
West Sumatra	1	841	479,224	177,025
Riau	2	198	146,903	54,266
Jambi	2	406	212,171	78,376
Bengkulu	-	141	110,503	40,820
South Sumatra	11	2,072	477,433	176,364
Lampung	63	1,080	356,793	131,799
West Kalimantan	3	403	282,567	104,380
Central Kalimantan	-	257	112,933	41,717
South Kalimantan	19	683	322,638	119,182
East Kalimantan	-	209	70,175	25,923
North Sulawesi	-	121	127,467	47,086
Central Sulawesi	-	88	119,993	44,325
South Sulawesi	13	2,761	788,568	291,297
Southeast Sulawesi	-	64	29,238	10,800
Maluku	-	39	5,975	2,207
Irian Jaya	-	19	670	247
Bali	-	705	323,925	119,658
N.T.B.	17	55	359,512	132,804
N.T.T.	2	33	129,829	47,959
Total	1,144	28,059	15,342,322	5,667,450

Note; Large mill = One metric ton or more per hour.
Small mill = Less than one metric ton per hour.

Source: Directorate for Food Crops Promotion, Sub-Directorate for License, Ministry of Agriculture, Jakarta.

Published data giving potential or maximum allowable cut of logs and potential logging and sawmill wastes by province in Indonesia for 1974-1975 are presented in Table 2. Based on the potential production data, estimated logging and sawmill wastes were derived on the basis of actual log and sawmill outputs in 1974. The quantity of logging wastes were estimated at 1,103,897 tons. East Kalimantan, Central Kalimantan, and Riau are the major logging and sawmilling centers of Indonesia.

Coconut Wastes

Indonesia has slightly over 2 million hectares in coconut plantations. Over 99% of this acreage is operated by small holders and only slightly less than 1% is operated by "estates." An "estate" is a government institution organized to own and operate the plantations for the production of various crops.

Coconut production is centered in North Sulawesi, West Java, East Java, and North Sumatra. The nation produced 1,365,000 tons of copra in 1974.

The average weight contents of a coconut are given as follows:

Components	Percent
Husk	40
Copra	33
Shell	17
Water	10
Total	100

Waste volume estimates are as follows:

Husk	1,654,000 tons
Shell	703,000 tons
Total	2,357,000 tons

A portion of the husks and shells is used by farmers for drying the copra. The remainder is burned; however, the amount burned is unknown. These wastes are at the sites of coconut plantations.

Oil Palm Wastes

The nation had 164,300 hectares of oil palm plantations in 1974, nearly all of which are state-run estates. The distribution of oil palm estates is given in Table 3.

Table 2

POTENTIAL LOGGING AND SAWMILL WASTES IN INDONESIA, 1974

Province	Logging Wastes		Sawmill Wastes	
	Potential Volume 1/ (cubic meters)	Estimated Actual Volume (metric tons) 2/	Potential Volume 1/ (cubic meters)	Estimated Actual Volume (metric tons) 2/
West Java	65,957	11,872	51,172	9,211
Central Java and Yogyakarta	63,214	11,379	49,044	7,357
East Java	111,557	20,080	86,450	15,561
Aceh	323,850	58,293	251,253	45,225
North Sumatra	210,600	37,908	156,390	28,150
West Sumatra	135,600	24,408	105,203	18,936
South Sumatra	231,300	41,634	179,450	32,301
Riau	652,350	117,423	506,115	91,101
Jambi	471,450	84,861	365,766	65,721
Bengkulu	117,750	21,195	91,354	16,444
Lampung	45,900	8,262	35,611	6,410
West Kalimantan	422,925	76,126	328,119	59,061
Central Kalimantan	1,671,075	300,794	1,296,476	233,366
South Kalimantan	135,300	24,354	104,854	18,874
East Kalimantan	2,253,600	405,648	1,748,418	314,715
North Sulawesi	77,550	13,959	60,166	10,830
Central Sulawesi	214,500	38,610	166,417	29,955
Southeast Sulawesi	46,650	8,397	36,193	6,515
South Sulawesi	150,300	27,054	116,608	20,989
West Nusa Tenggara	13,050	2,349	10,125	1,823
Maluku	404,730	72,851	314,003	56,521
Irian Jaya	106,200	19,116	82,394	14,831
Total	7,925,408	1,426,573	6,144,581	1,103,897

1/ Derived from published potential volume for logging and sawmilling wastes by province in 1974-1975.

2/ The conversion into actual wastes volume in metric tons is based on the following equation:

MT = PW x .6 : SV x D, where

MT = Metric Tons of estimated actual waste volume

PW = Potential Waste volume given in the table as M^3. Actual Waste volume estimated based on 1974 log production is 60% of PW

SV = Solid Volume, which equals Actual Waste volume divided by 2.

D = Wood Density of .6 ton/M^3 to arrive at metric tons

Source: Evaluation of Forest Utilization for Wood Processing Plants in Indonesia, 1975, Directorate General of Forestry, Ministry of Agriculture, Jakarta, 1976.

Table 3

NUMBER OF OIL PALM ESTATES BY PROVINCE IN 1973

Province	Number of Estates
Aceh	9
North Sumatra	48
Riau	1
West Sumatra	1
Lampung	6
West Java	3
Total	68

Source: Statistical Pocketbook, Indonesia, 1974-1975, Central Bureau of Statistics, Jakarta, 1975.

From the tables, it is obvious that North Sumatra is the oil palm plantation center in Indonesia. The area exported 385,020 tons of palm oil in 1975 and the volume is expected to increase 8.84% per year. According to Asjari Darus, Head of the North Sumatra Trade Service, the export in the area is projected to reach 732,740 tons by 1985. 1/

The average yield of oil palm fruits and bunches is estimated at 9.4 tons per hectare. The weight distribution between the fruit and the bunch of oil palms is given below:

Bunch stem	40%
Fruit	60%
Husk	60% of the fruit
Shell	32% of the fruit
Kernel	8% of the fruit

Waste volume estimates are as follows:

164,300 hectares x 9.4 tons fruits and bunches	= 1,544,420 tons
Bunch stem wastes	= 617,768 tons
Fruits	= 926,652 tons
Husks	= 555,991 tons
Shells	= 296,529 tons
Kernels	= 74,132 tons

1/ Indonesia Times, October 26, 1976

Thus the total waste volume, which includes bunch stems, husks, and shells of the oil palm production, is estimated at 1,470,288 tons in 1974.

It is interesting to note that coconut shell and oil palm shell are two excellent materials for pyrolytic conversion, and these two materials deserve special attention. Dimensionally they are the right size for pyrolytic conversion using continuous processes without additional chopping or hogging. Physically they have high density and are excellent materials for making activated charcoal, which commands a much higher value in the world market than ordinary charcoal. These two sources of shells, based on currently estimated data, have a total weight of 995,500 tons per year in Indonesia. Assuming a yield of 6% activated carbon, this would produce 59,730 tons of activated carbon per year. Assuming the world price of activated carbon is $500 per ton, $29,965,000 worth of commodities would be created out of these shell wastes in Indonesia.

Rubber Wastes

Indonesia had 2,303,400 hectares in rubber plantations in 1974. Of the total acreage, small holders constituted 81%, while estates made up the balance. West Java and North Sumatra are the major provinces for rubber plantations. The distribution of estates of rubber plantations is given in Table 4.

The productivity of a rubber tree depends greatly on cutting practices. In general, after 25 to 30 years' cuttings, a plantation of rubber trees should be removed for replanting because of the declining yields of the trees. It is estimated that 3% to 5% of the total acreage of rubber plantations in Indonesia is being replanted each year. In 1973, 12,628 hectares were replanted; each hectare had an average of 500 trees. However, 300 trees per hectare are used here for waste-volume estimates because of mortalities during the years after planting. It is further estimated that each cut-down tree weighs about one-half ton. The quantity of old rubber trees being cut down for replanting purposes is estimated as given below:

12,628 hectares x 300 trees = 3,788,400 trees

3,788,400 trees x 1/2 ton = 1,894,200 tons

At present, the primary use for old cut-down trees is as a fuel for smoking rubber. Only a small portion is currently being sold as firewood or being

Table 4

NUMBER OF RUBBER ESTATES BY PROVINCE, 1974

Province	Number of Estates
Aceh	35
North Sumatra	160
Riau	53
West Sumatra	4
Jambi	5
South Sumatra	7
Lampung	15
West Java	246
Central Java	49
East Java	85
Bali	1
West Kalimantan	10
South Kalimantan	17
North Sulawesi	2
South Sulawesi	4
Southeast Sulawesi	1
Total	694

Source: Statistical Pocketbook, Indonesia, Central Bureau of Statistics, Jakarta, 1975

converted into charcoal for export. However, the percentage of the total available wood that is actually wasted is uncertain.

Bagasse

Indonesia has 57 sugar processing plants (in 1976). Fifty-five of them are in Java. Sugarcane cultivation and sugar refining are largely done in East Java, and Central Java. The distribution of sugar plants by province, cane processed in 1975, and bagasse generated are presented in Table 5.

Nearly all the bagasse is or soon will be burned as boiler fuel in sugar refining. Only an insignificant amount is used in papermaking or as pressboard material. Because of the high moisture content of bagasse, burning it directly

Table 5

THE DISTRIBUTION OF SUGAR PLANTS BY PROVINCE
CANE PROCESSED, SUGAR PRODUCED, AND BAGASSE GENERATED IN INDONESIA, 1975

Province	Number of Plants	Cane Processed (in tons)	Sugar Produced (in tons)	Bagasse Generated
East Java	33	5,964,242	596,424	1,816,112
Central Java	16	2,891,972	289,197	880,605
West Java	6	1,084,876	108,488	330,345
Outside Java	2	361,627	36,163	110,115
Total	57	10,302,717	1,030,272	3,137,177

Source: Indonesian Sugar Experiment Station, Pasuruan, Indonesia

as a boiler fuel entails a loss in thermal conversion efficiency of about 40%. Through pyrolytic conversion into a char and oil mixture, bagasse would become a higher-quality fuel with a much smaller loss in thermal conversion efficiency when it is used in a properly designed, lower-cost boiler. The replacement of an old boiler with a new one requires the consideration of capital costs. However, when a worn-out boiler in a sugar plant needs a replacement, it would be appropriate to consider pyrolytic conversion of bagasse because of the substantial savings in the boiler cost and significant improvements in conversion efficiency that could be realized.

MARKETS FOR PRODUCTS OF PYROLYTIC CONVERSION IN INDONESIA AND THEIR COMPETING PRODUCTS

Charcoal, oil, and gas are the three end products from pyrolytic conversion. The gas is most practically used on site for such purposes as drying; however, the other two end products, charcoal and oil, must compete in the market with cheaply available kerosene, diesel and fuel oils, and with firewood. In order to understand the situation in which the charcoal and pyrolytic oil have to compete, the current market for the major domestic fuels is described separately.

Kerosene

Kerosene is a petroleum-based derivative. It has clean burning characteristics and is easily handled. In Indonesia, the processing of kerosene is heavily subsidized by the government in order to provide a cheap fuel for domestic uses and to relieve the burden on the forests resulting from firewood cutting. The production cost of a liter of kerosene is estimated at about 26 rupiahs and the net sale price (f.o.b.) of a liter of kerosene is 16 rupiahs; the result is a loss to the government of approximately 10 rupiahs. The consumption of kerosene in Indonesia was reported at 4,868,663,000 liters in 1975, which meant that the government subsidies were at 48,686,630,000 rupiahs for

the kerosene production in that year. By 1977, the domestic consumption of kerosene is projected to reach 6,150,000,000 liters. If the production costs remain the same, the government will have to pay 61,500,000,000 rupiahs for subsidies.

Kerosene is used largely by city dwellers for cooking and lighting purposes. However, in rural areas, kerosene is used more for lighting. Retail prices of kerosene may be 25 to 30 rupiahs per liter because of markups in the various middleman transactions.

Indonesia is one of a few oil exporting countries in the world.1/ However, the known proven oil reserves may be exhausted in 20 years if no new discoveries are made. Further exploration for new oil is likely to depend upon the world price of oil and the costs of exploration.

Diesel Oil and Fuel Oil

Diesel oil and fuel oil are both industrial fuels which would compete directly with the charcoal and the pyrolytic oil. The processing of both oils is subsidized by the government for the same reason as kerosene. The domestic consumption of the oils and government subsidies are given in Table 6.

Table 6

DOMESTIC CONSUMPTION OF DIESEL AND FUEL OILS IN 1975 AND PROJECTED CONSUMPTION IN 1977, WITH GOVERNMENT SUBSIDIES, INDONESIA

	1975		Projected 1977	
Kind	Consumption (kiloliters)	Government Subsidies (rupiahs)	Consumption (kiloliters)	Government Subsidies (rupiahs)
Diesel Oil	708,758	4,252,548,000	1,130,000	6,780,000,000
Fuel Oil	1,085,360	6,512,160,000	1,660,000	9,960,000,000
Total	1,794,118	10,764,708,000	2,790,000	16,740,000,000

Source: Directorate General of Oil and Gas, Department of Mining, Jakarta

The consumption of diesel and fuel oils was reported at 1,794,118 kiloliters in 1975 and was projected to reach 2,790,000 kiloliters by 1977. The government subsidies for the production of these two fuels would increase from 10,764,708,000 rupiahs in 1975 to 16,740,000,000 rupiahs by 1977. The enormous costs to the government to maintain cheap fuels for domestic consumption are obvious.

Firewood

Firewood of various kinds and species is the dominant fuel for domestic cooking despite the low cost of kerosene. The sources of firewood come largely from the forests, mangrove trees on the beaches, cut-down rubber trees, coconut trees, oil palms, logging wastes, sawmill wastes, etc. No reliable statistics are available on the production and consumption of firewood. However, it is estimated that the uses of firewood are equal to twice the commercial energy consumption in Indonesia.1/ The rapid disappearance of trees and forests as a result of the demand for firewood has alarmed many authorities in the world. A recent article in the Indonesia Times aptly described the situation.

> A century ago tropical forests provided an inexhaustible supply of energy in the form of firewood for the poor of the world. Today the forests are disappearing at the rate of 15 hectares a minute. In the developing world the shortage of firewood is becoming critical. The increasing rate of destruction of trees in the developing world shows no sign of abating, as between one and two thirds of the rural population burn up these forest products . . . . Exhortation not to chop down bushes or trees can have little effect, if people have no other means of cooking. The third world's energy crisis could become much worse unless some alternative to firewood as fuel becomes available.2/

To find alternatives to firewood is one of the major objectives in conducting this field study in Indonesia. Pyrolytic conversion of agricultural and forestry wastes into charcoal and oils may make them important alternative sources of fuel energy to the population in the years to come because these wastes are self-generating as long as farming and forestry activities are conducted in Indonesia.

Firewood is sold at about 1,500 rupiahs per cubic meter in rural areas and about 3,000 rupiahs in cities. A large percentage of the firewood consumed in the nation is obtained simply by foraging into nearby forests by the rural population. The loss of trees and bushes causes erosion and depletion of the fertility. How to stop the practice of chopping down trees and bushes in rural areas is a delicate problem. Firewood is used not only for domestic cooking, but also as industrial fuel for drying roof tiles, bricks, etc.

Potential Market Outlets for Pyrolytic Oil

The weight of oils produced by pyrolytic conversion is equal approximately to 75% to 80% of the weight of charcoal produced. Although the oils presently cannot be used directly as fuels for combustion engines, they could be used as fuels for cooking, drying, steam and electrical power generation, and for

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1/ Filino Harahap, "The Prospect of Solar Utilization, the Indonesia Case," paper presented to the Symposium on Energy, Resources and the Environment, February 25 to 28, 1975, Jakarta.

2/ Alastair Matheson, "Third World Faces a Firewood Crisis," Indonesia Times, November 3, 1976.

lamps. Pyrolytic oils could be used as fuel in the place of firewood in thousands of kilns throughout Indonesia used for making roof tile. They also could be used in the same way in making bricks, which is another large industry within Indonesia. A mixture of pyrolytic oils and charcoal could be used as boiler fuel in factories, in steamships, in trains, and in power stations.

Pyrolytic oil, because of its convenient form, should be a suitable fuel for domestic cooking purposes. It would appear that a simple cooking stove based on the oil could be designed and manufactured in Indonesia. The domestic cooking and heating market may well be a good potential outlet for the oil because of its instant generation of heat, because of the cleanliness of its burning, and because of the ease of control in using it. A good cooking stove design is essential to the success of promoting the oil for domestic cooking purposes. In addition, the stove itself would become a manufacturing opportunity in Indonesia. If it is accepted in the market, it could become an export item together with the oil.

Pyrolytic oil also can be used for lamplight.[1/] Kerosene-type lamps are already commonly used in Indonesia. With some modification of the lamp, pyrolytic oil could replace kerosene if it were produced in large quantities. Modified kerosene lamps could become another manufacturing opportunity in Indonesia.

The heating value of pyrolytic oil is approximately equal to two thirds that of kerosene. As a result, the market value of pyrolytic oil is given at two thirds of the current market price of kerosene, which is sold at 16 rupiahs per kilogram (net sale price f.o.b. refinery). Pyrolytic oil should be valued at 10.56 rupiahs per kilogram or 10,560 rupiahs per ton.

It should be noted that the pyrolytic oils, in their initially produced form, have a pungent odor, are mildly corrosive at room temperature, and upon exposure to air do tend to apolymerize. Thus further work to stabilize the oils needs to be done before the applications of lighting and cooking are immediately pursued. There is no reason to expect, however, that the necessary modifications to the oil characteristics cannot be made. Experience with these oil at Georgia Tech's Engineering Experiment Station indicates that the corrosion problem, even with untreated oils, is not excessive, 55-gallon steel drums of these oils having been stored routinely for two or more years without leakage. Furthermore, in LDCs such as Indonesia, wood or ceramic storage containers might be more readily available than metal ones and would have essentially no corrosion problems.

Potential Market Outlets for Charcoal

Because cheap kerosene and firewood are available as domestic fuels, the charcoal production in Indonesia is declining. Unfortunately there are no reliable statistics concerning the production and consumption of charcoal. This is because a large amount of charcoal is produced and sold without being re-

ported by small holders using wood obtained from the forests. Foraging forests for charcoal makes it illegal; however, the practice goes on.

Forest Service published data on charcoal production and exports are given in Table 7. According to the table, exports are increasing and production is declining. However, a contradiction exists because the export volume exceeds the production volume. It is believed that the production refers to domestic consumption excluding the export volume. Generally there is some question about the validity of the data for the reasons previously cited; however, it is the only published source of information available.

Table 7

CHARCOAL PRODUCTION AND EXPORTS IN INDONESIA, 1968 TO 1975
(in tons)

Year	Production	Exports
1968	646,000	-
1969	120,000	-
1970	6,517	-
1971	15,436	18,983
1972	30,992	25,826
1973	38,702	34,345
1974	-	51,686
1975	30,566	47,029

Sources: Production - Statistical Pocketbook, Indonesia, 1974/1975, Central Bureau of Statistics, Jakarta, Indonesia; Exports - Indonesia Forests, 1975, Directorate General of Forestry, Jakarta, Indonesia.

There are three kinds of charcoal producers in Java -- Forest Service (government), estates (semigovernment), and small holders (privates). Based on one estimate, the government supplies about 70% of the charcoal market in Java, estates 20%, and privates 10%. The total volume of charcoal consumed in Java is insignificant compared with the total energy needs for domestic cooking.

The charcoal export business in Indonesia appears to be a growing enterprise. According to one report, a number of charcoal producers in Sumatra export about 1,000 tons of charcoal to Singapore, Hongkong, and Japan daily. (Clearly such amounts of charcoal production are totally inconsistent with the data presented in Table 7 and caution must be advised in the use of these results.)

Charcoal production in Java is accomplished by earth mounds. Mound charcoal is produced by piling pieces of timber or wood together in mounds and setting the pile afire. Then the pile is covered with earth and allowed to smolder

for a week or so. After the fire goes out, the charcoal is removed. The method is primitive and wasteful, producing barely half the quantity of charcoal which might be obtained from the same amount of wood by a more efficient method such as pyrolytic conversion.

The charcoal produced by the Forest Service in legal operations is sold at 14,000 rupiahs per ton to wholesalers. Labor costs constitute the largest single outlay in production, about 9,500 rupiahs per ton. Wholesalers pay about 3.5 rupiahs per kilogram for the charcoal to be shipped to a city about 60 kilometers away. Wholesalers' prices are 45 to 50 rupiahs per kilogram on chunk charcoal and about 33 rupiahs per kilogram for loose charcoal. The retail value of charcoal may reach as high as 75 rupiahs per kilogram, depending upon the quality and distance from the sources of supply.

A wholesaler in Bandung sells only about 200 kilograms of charcoal a day with a profit margin of 15 to 16 rupiahs per kilogram. The sales of a retailer average only about 30 to 50 kilograms a day.

Because of the declining use of charcoal, it appears that the market for pyrolytic-conversion charcoal in Java may be limited. However, successful pilot plants could be introduced to sell a moderate amount of charcoal for domestic uses. If pyrolytic conversion is to be introduced in Indonesia on a large scale, exports to Singapore, Hongkong, and Japan should be explored throughly.

It should be noted that charcoal produced by pyrolytic conversion may be in a loose and pulverized condition, while mound and kiln charcoal are in lump form. Lump charcoal is more suitable for domestic cooking and heating purposes, while loose charcoal, until it is briquetted, is more suitable for industrial applications such as boiler fuels. As an industrial fuel, loose charcoal has to compete with coal and raw-grade oils such as Bunker C. Coal production in Indonesia has suffered the same fate as charcoal, a declining trend, because it cannot compete with the government's subsidized fuel oils.

Problems with Recovering Energy from Wastes

The use of agricultural wastes as an energy source has been considered frequently in the past but has not been widely practiced because of the following factors:

1. Agricultural wastes, even process wastes, are widely scattered, often far from potential energy users.

2. The wastes frequently contain significant amounts of water which, combined with the great distance involved, make transportation costs excessive.

3. The moisture content makes it difficult to efficiently employ conventional energy conversion techniques such as direct burning, and expensive

boilers must be constructed to burn the wastes.

4. The wastes are usually produced seasonally and thus do not offer a steady supply of fuel.

Any successful system to utilize agricultural wastes as fuel must overcome these problems.

PROJECTED COSTS AND RETURNS

The analysis of costs and returns, based on the designs shown in the previous technical analysis Annex G, requires the assumption of several essential working conditions in order to arrive at quantitative results. These conditions, based on past experience and the best knowledge of the local situation, were used as the basis for the cost and return estimates:

a. Plant location: Adjacent to the source of waste material supply; i.e. a rice mill, in this case.

b. Plant sizes and models: Three models are given.

   (1) One ton of dry feed material per day with three shifts and with a drier

   (2) One ton of dry feed material per day with three shifts and without a drier

   (3) One ton of dry feed material per day with one shift and without a drier

c. The system would be in a fixed position, but it is designed to be easily dismantled for moving purposes.

d. The system is designed for labor-intensive purposes. All major components would be manufactured locally.

e. For the first two models, the plants would be operated on a three-shift basis (24 hours per day). For the third model, the plant would be operated on a one-shift basis (eight hours per day). There would be 150 working days a year to allow for a six-month season of rice mill operation in Java.

f. In all the analyses, the assumption is made that the rice hulls are free. (More than likely this will require participation of the rice mill owner in any commercial enterprise involving pyrolytic conversion of these materials.)

Estimated Capital Costs

The three plant models (See "Technical Analysis" Annex G) require different capital inputs. The estimated capital costs for each model are presented in Table 8.

Table 8

ESTIMATED CAPITAL COST REQUIREMENTS FOR DIFFERENT MODELS
(in rupiahs)

	Model 1	Model 2	Model 3
Production Components	800,000	510,000	760,000
Building and Hull Storage	250,000	250,000	250,000
Contingency	100,000	40,000	40,000
Total	1,150,000	800,000	1,050,000
Working Capital	250,000	200,000	200,000
Total Capital Requirements	1,400,000	1,000,000	1,250,000

Note: 1= One ton per day with an IRRI drier (three shifts)
2= One ton per day without a drier (three shifts)
3= One ton per day without a drier (one shift)

Operating Costs

Several elements in the operating cost estimates have to be predetermined. Labor represents the largest cost outlay in the operation. The assumed number of workers needed per shift and costs involved are given in Table 9.

Table 9

ESTIMATED LABOR REQUIREMENTS AND COSTS PER DAY

Shift Number	Model 1		Model 2		Model 3	
	No. of Workers	Wages (rupiahs)	No. of Workers	Wages (rupiahs)	No. of Workers	Wages (rupiahs)
1	2	800	1	400	2	800
2	2	1,000	1	600	-	-
3	2	1,000	1	600	-	-
Total	6	2,800	3	1,600	2	800

Total operating costs based on a 150-day operation per year are given in Table 10. Operating costs include labor, management overhead and maintenance, and debt service on borrowed capital. The debt service includes both interest and principal for the total capital requirements, based on a 10-year loan at 12.5% annual interest rate.

Table 10

ESTIMATED OPERATING COSTS PER YEAR
(in rupiahs)

	Model 1*	Model 2*	Model 3**
Labor	420,000	240,000	120,000
Management Overhead and Maintenance	150,000	110,000	110,000
Debt Service	253,400	181,000	226,250
Total	823,400	531,000	456,250

* Based on three-shift operation per day, 150 days a year.

** Based on one-shift operation per day, 150 days a year.

Projected Returns

Returns would vary according to the quantity of products produced, service performed, and the number of shifts operated per day. Models 1 and 2 are based on three shifts per day and 150 days a year, while Model 3 is based on one shift per day and 150 days a year. Besides the products produced, Model 1, which is equipped with an IRRI drier, would dry the wet paddy brought in by the farmers. For this drying service, a credit of 600 rupiahs per ton of grain is assumed to be received from the mill. The drier would dry four tons of grain per 24 hours and would be operated 150 days a year. The total income from the drying service would be 360,000 rupiahs per year.

For all three models, the charcoal yield would be 0.25 ton per day and the oil yield would be 0.15 ton per day. Loose charcoal is priced at 12,000 rupiahs per ton, while oil is priced at 10,500 rupiahs per ton.

Projected returns for the three models are presented in Table 11. The profit margins vary according to the model. The return on investment is 16.0% for Model 1, 15.7% for Model 2, and 18.5% for Model 3. Payout time would be 6.25 years for Model 1, 6.4 years for Model 2, and 5.4 years for Model 3.

In passing, it is of interest to note that even though Model 3 requires more capital and does not use a drier, its return on investment is higher than for Models 1 and 2. This is largely due to major reductions in labor costs which override the increased capital. Considering the added convenience of

Table 11

PROJECTED RETURNS PER YEAR
(in rupiahs)

	Model 1	Model 2	Model 3
Charcoal	450,000	450,000	450,000
Oils	237,600	237,600	237,600
Drying Service	360,000	-	-
Total	1,047,600	687,600	687,600
Operating Costs	823,400	531,000	456,250
Profit before Taxes	224,200	156,600	231,350

one-shift operation, Model 3 appears to offer the most attractive option of the three considered.

In addition, it might be noted that the income from milling operations alone for rice mills in the size category chosen is typically in the range of 400,000 to 600,000 rupiahs per year and the return on investment is approximately 15% to 20%. Thus the income derivable from pyrolytic conversion of the wastes could substantially augment the present mill revenues and the capital required would be invested at a rate of return compatibe with the mill operation itself. Therefore, such a system should be of considerable interest to the mill operators as a means of increasing their income.

Finally, it must be observed that the above economic analysis is based on prototype models. Further improvements made to the models and a larger scale of operation would naturally lead to the reduction of production cost per unit of product output.

Section (2) Ferrocement Technology

There are now six cement companies in Indonesia, producing 2.8 million tons of cement per year. With three of these companies now undergoing expansion and another one under construction, it is estimated that by the end of 1978 cement production in Indonesia will reach 3.2 million tons with a projected surplus of 200,000 tons for export. In 1979, Indonesia will be exporting approximated 1 million tons of cement. It is expected that by then the cost of cement, which at present is Rp. 35/kg,[1/] will fall considerably.

Sand is readily available in Indonesia, although in certain remote areas the cost of transportation makes the cost exceptionally high, as much as Rp. 8,000/cu. mtr., delivered on site. Therefore costs are not uniform, and the economic analysis and cost-effectiveness will depend upon the local availability of sand to the specific village concerned. Fortunately, Indonesia has extensive river beds and shorelines where sand is available.

Indonesia manufactures a wide range of wire and wire meshes. Like other developing countries in Asia, Indonesia imports steel from abroad, and wire mesh costs from Rp.500 to 1,200/sq. mtr., depending on size, type of the mesh, and delivery costs. It is a simple matter to cut costs by buying wire and weaving the mesh locally, thus creating another village industry. In summary, the economics of wire in the ferrocement will be more a function of site, design requirements, and original wire cost. The ferrocement activity under this project will determine these factors for various tasks and sites. For example, the normal "dug-out" canoe used to ferry people and small cargoes, is made from a prime log which has a high market value. Thus it has a high original cost due to competitive uses, and yet it wears out in as quickly as 18 months in Irian Jaya, and 36 months in Sukabumi Regency, Java. A ferrocement equivalent should last 30 to 60 years, and be more or less impervious to wear, and considerably cheaper in its original cost. This ferrocement activity will test this hypothesis. Similar economic benefits are expected in making large water tanks for village water storage. This project will look to larger sizes particularly to avoid competing with the local makers of ceramic water jars, and thus compete only with imported and expensive steel water tanks, and conventional reinforced concrete water tanks. Another expected relationship is to work through a local small industry already making products of ordinary concrete, converting him to the ferrocement technique. A local, successful, small-scale manufacturer of cement products in Banda Aceh has been briefed on ferrocement, and is ready to start "today" on its manufacture and sale, provided he is given optimized designs and taught the techniques. He undoubtedly will be involved in this project.

1/ $1.00 = Rp 414.50

WATER JARS OF CEMENT MORTAR*

by

O. Phromratanapongse

In many parts of the world, water has to be collected daily over long distances using human labor. This involves a great waste of time and labor, and is often unhygienic.

If a cheap and easy method of making containers for storing rain water could be developed and put into widespread use, a great deal would be gained by improved standards of public health and by turning wasted labor to more productive use.

The traditional water jars of burnt clay and cement mortar are not as widely used as one might expect because their production requires skills which are not popularly known.

The following series of photographs describes a cheap and practical method, of marking a 250 litre jar at the cost of about US$0.50 (the major cost item being the cost of 12 kg. of cements. This method of constructing water jars was developed by the Siam Cement Co., Ltd., in Bangkok.

The cement sand proportion was 1:2 by weight and the water cement ratio was about 0.4.

A piece of wire or wooden stick was used to control the thickness of the wall by piercing it through the fresh mortar.

This method has been taught to a number of people without any previous knowledge in masonry. Most of them learn the technique in one day.

The biggest jar built by this method has a capacity of 3.5 Cu.m., and costs about US$12.00 (Figure 12).

In conclusion, the method described requries a very low level of technology and can easily be adapted by practically anyone. Its low cost is also attractive to people with low income.

This jar described in this Appendix has no reinforcing mesh and is not strictly ferrocement. Nevertheless it is an extension of ferrocement technology and is included here because of its importance.

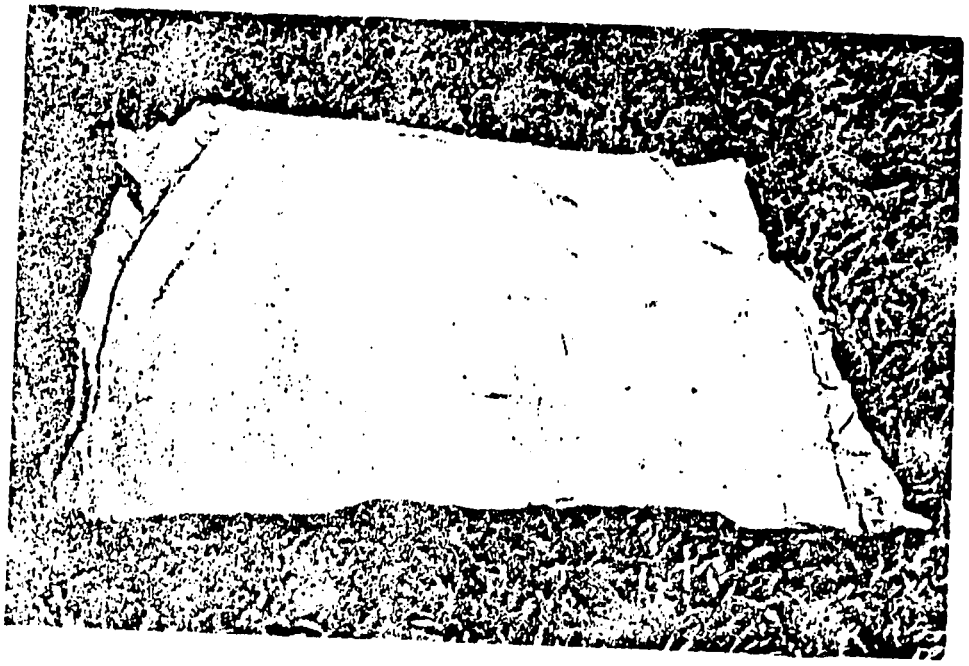


Figure 1: Two pieces of gunny cloth 125 x 112 cm. are used. One piece is laid on top of the other and sewed along the curved lines at the two sides (see Figure K 11) leaving the top and bottom open

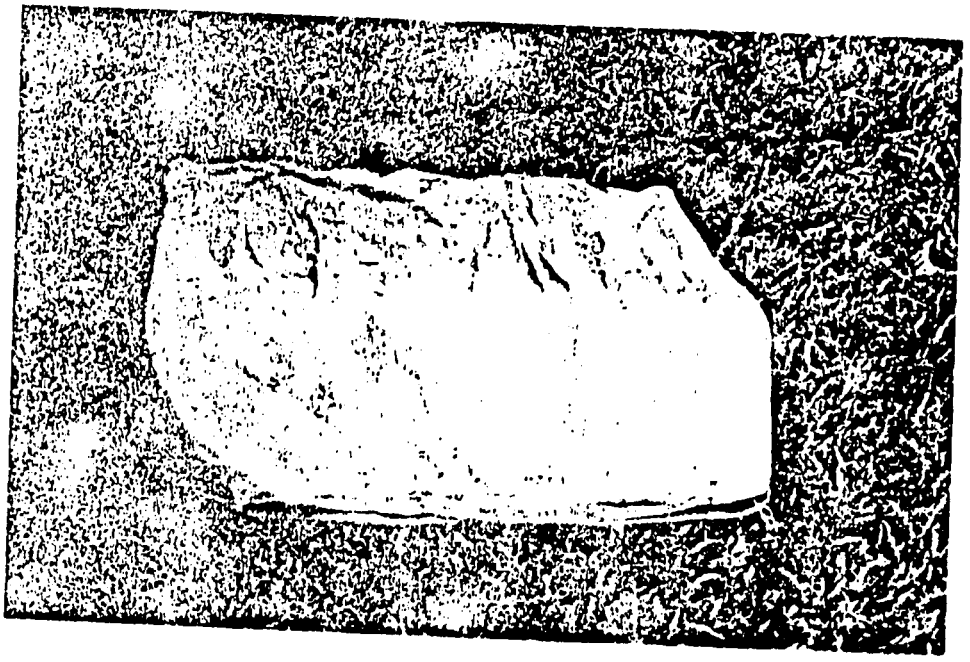


Figure 2: The sacks are turned inside out after sewing

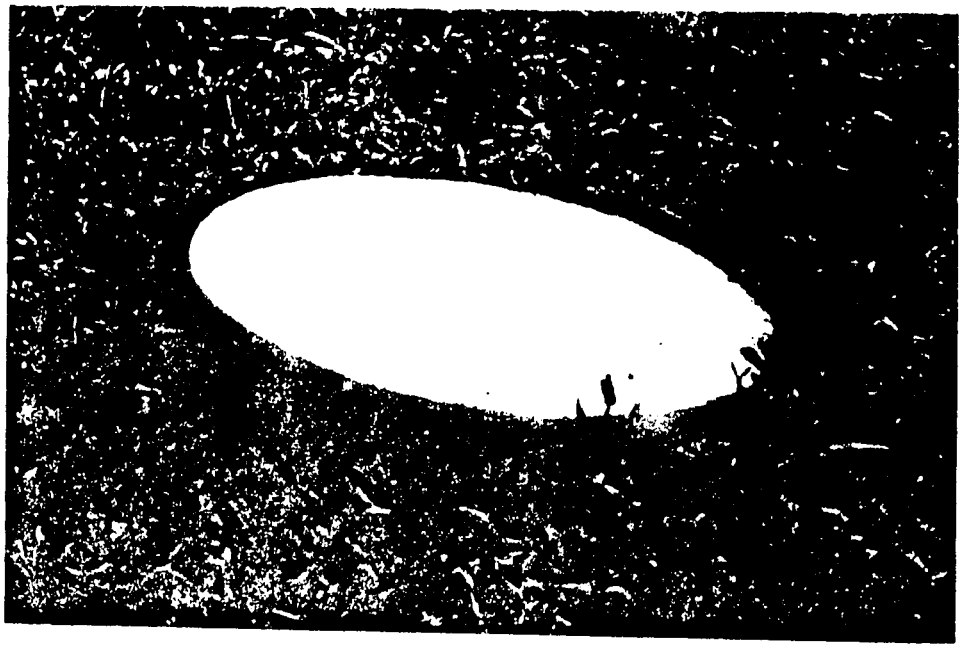


Figure 3: Precast bottom plate 58 cm. in diameter and 1.5 cm. thick

Figure 4: The sack is placed on the bottom plate and the space filled with paddy husk, saw-dust or sand. The weight of the fill will hold the lower edge of the sack firmly on the bottom plate

Figure 5: The upper part of the sack is folded to the shape of the traditional water jar. A piece of wood is used for tapping the mould to obtain a smooth surface

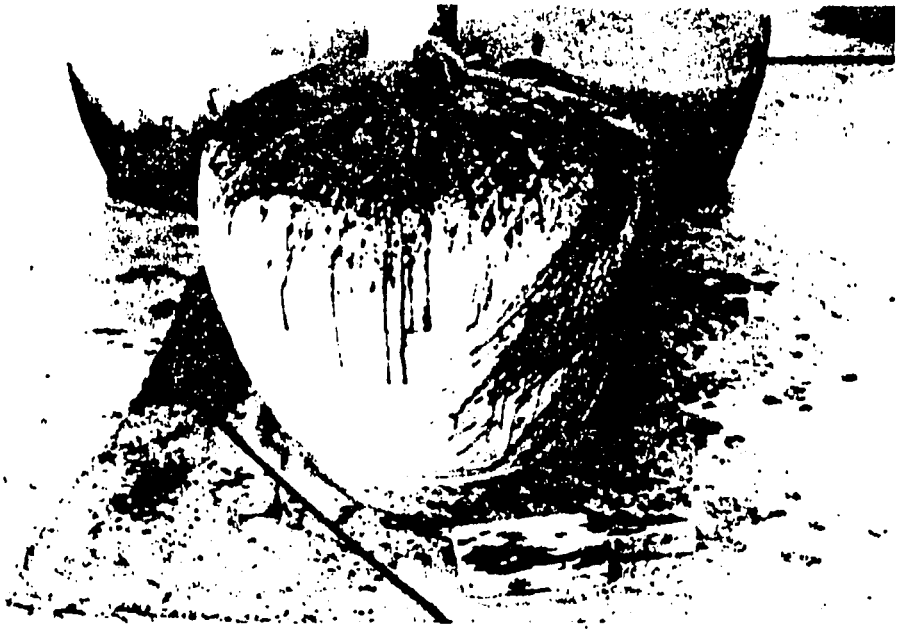


Figure 6: Water is sprayed on tha mould before plastering

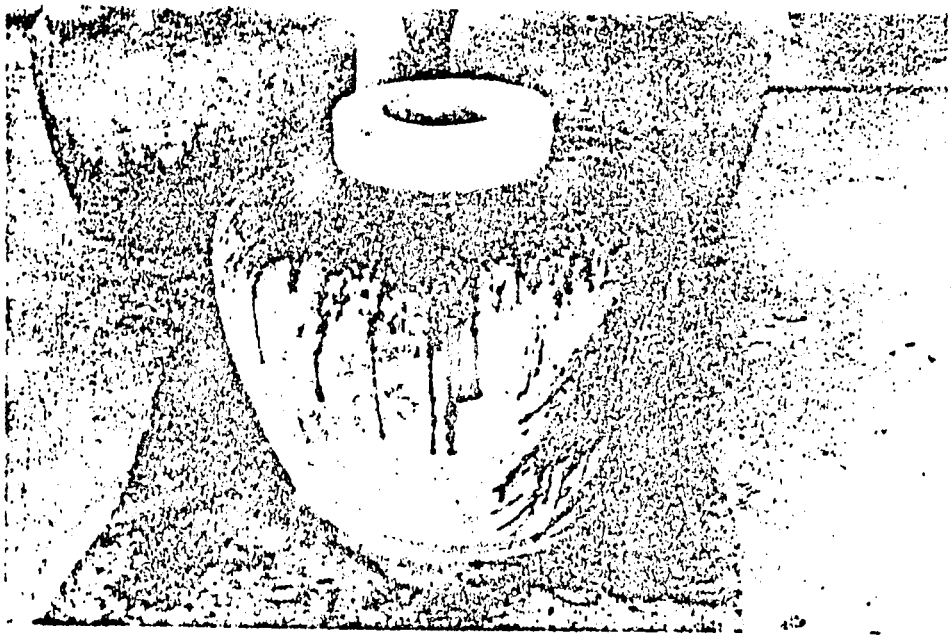


Figure 7: A circular object is placed on the top to act as a mould for the opening

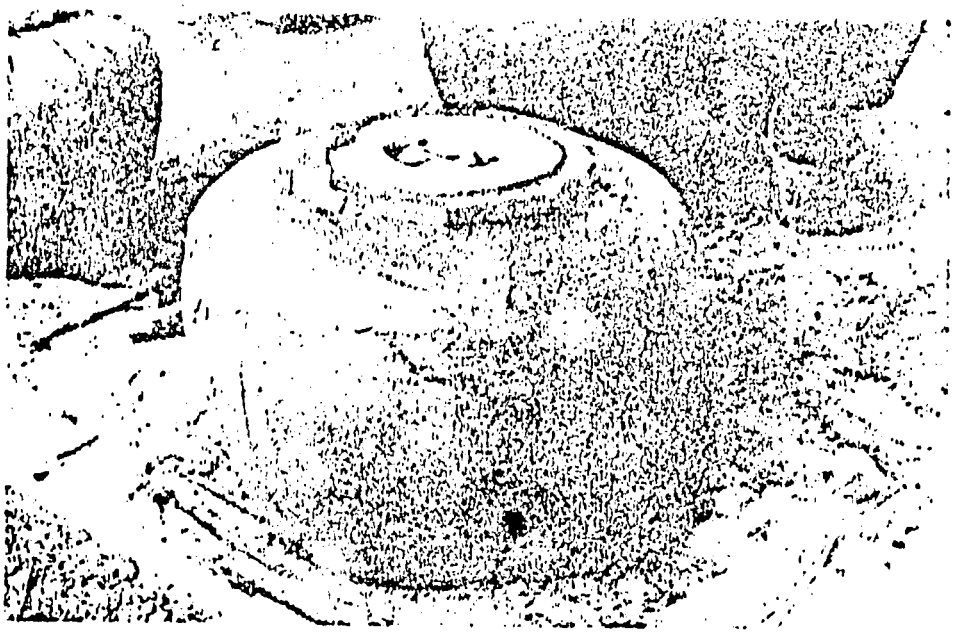


Figure 8: The first layer of cement mortar is applied from the bottom to the top with a thickness of about 0.5 cm.

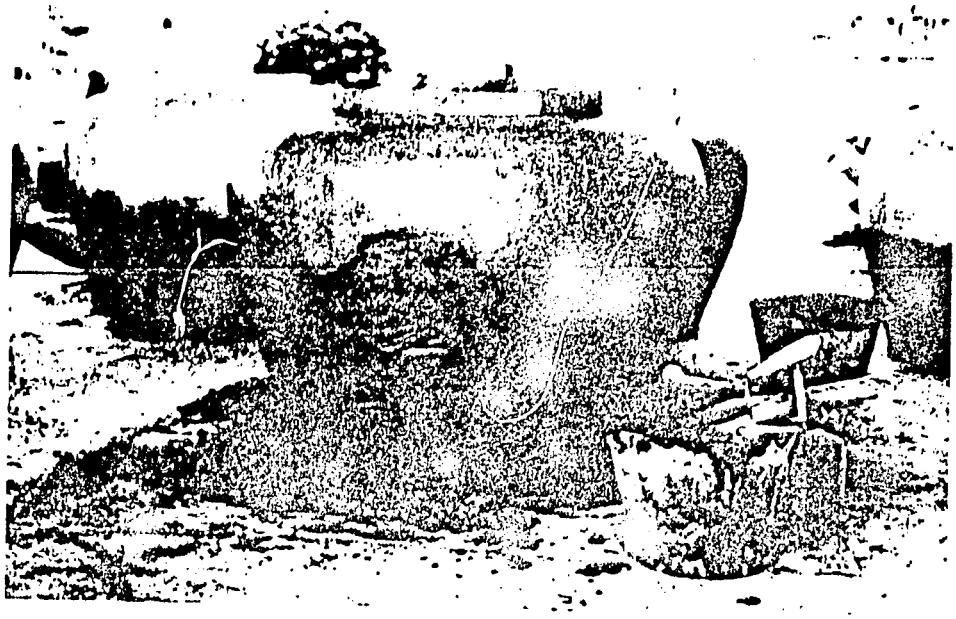


Figure 9: The second layer of cement mortar 0.5 cm. thick is applied

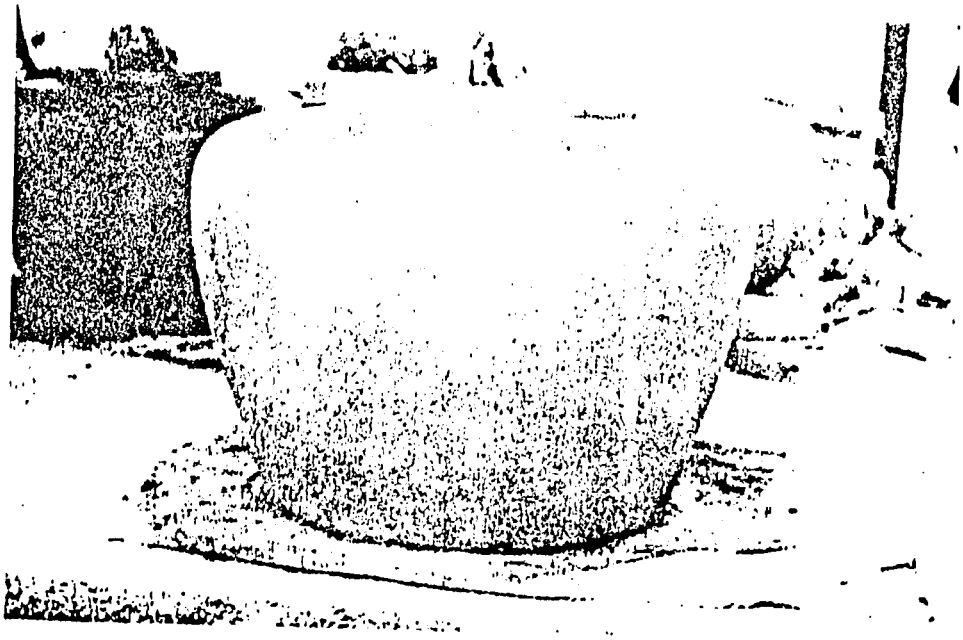
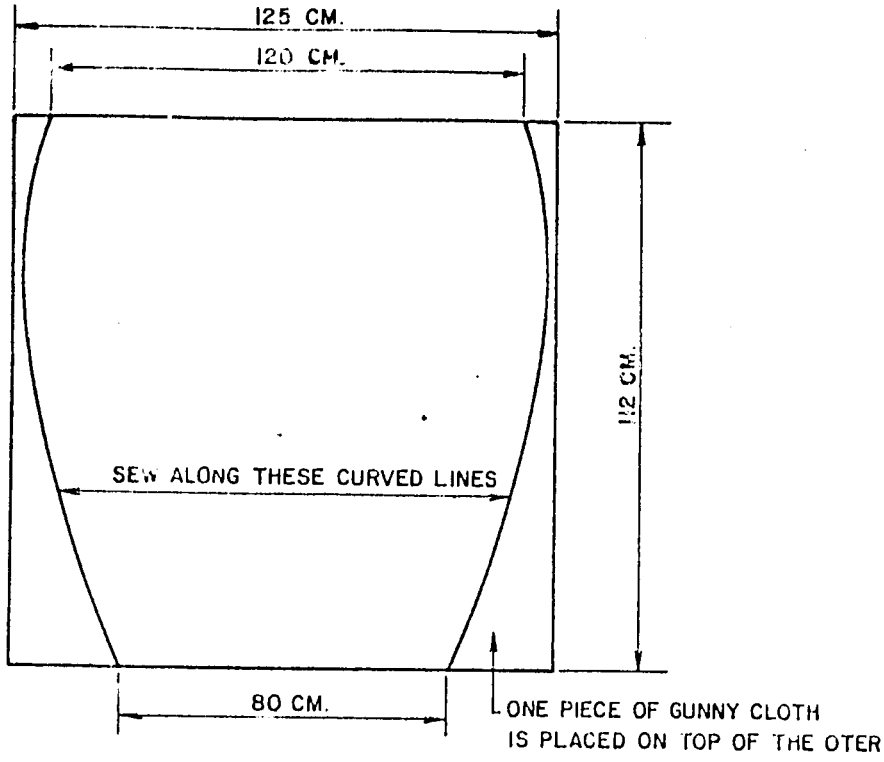


Figure 10: The jar is cured as in ordinary plastering work. The contents of the gunny bag and the bag are removed 24 hours after plastering



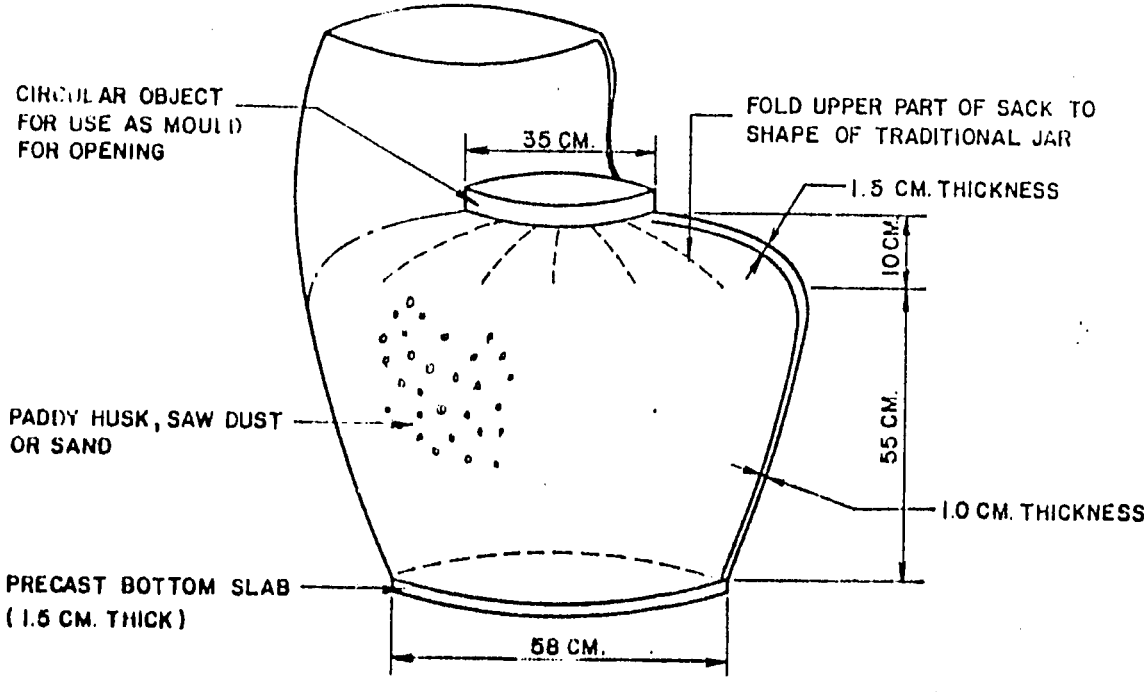


Figure 11: Gunny cloth pattern for use as mould

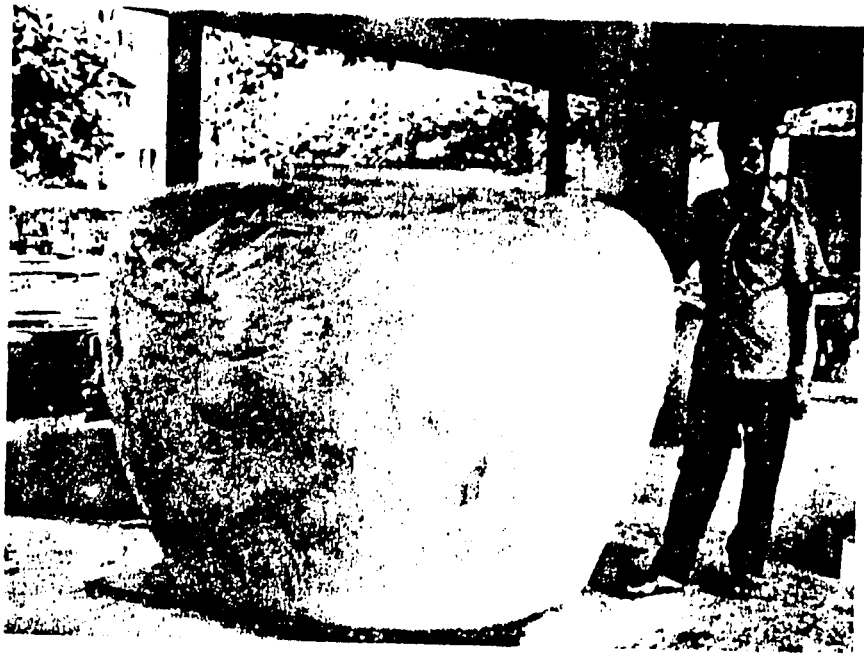


Figure 12: The biggest jar built by this method has a capacity of 3.5 cu.m. and the cost is about US$12.00. (1974)

ANNEX J

RICE BIN FOR RURAL FARMERS*

by

O. Phromratanapongse

It is estimated that the loss of rice paddy due to insects, birds, fungus attack and spillage is as high as 20%. In Thailand where the annual production of the rice crop is 12 million tons, this loss amounts to 2.4 million tons, valued at U.S.$120 million at the current market price. The Asian Institute of Technology and the Applied Scientific Research Corporation of Thailand have developed a ferrocement rice bin with a capacity of 3 tons, and in 1970 the cost of the bin was U.S.$120. The major cost component of this ferrocement bin is that of the reinforcement. It was felt that if the reinforcement could be reduced or completely eliminated it would be possible to design low-cost rice bins which would be within the economic reach of the farmers.

Construction Details

A trial rice bin made of unreinforced cement mortar was built in Bangkok, using paddy husk as the internal mold. The bin can store 2.8 cu.m. of rice paddy. It is conical in shape with a circular base plate, as shown in Figure 1. The diameter of the cone at the base is 2.8 m. and the height is 1.4 m. The wall of the bin is 2 cm. whereas the base is 5 cm. thick. These dimensions were chosen such that a man could reach the top of the bin without having to step on the paddy husk heap during construction. A bigger bin can be built by simply increasing the diameter of the base.

The construction started by building an embankment of compacted earth about 60 cm. above the ground. This height is dictated by local factors such as ground water level, maximum flood elevation and method of loading and unloading rice paddy. A layer of coarse sand 10 cm. above the embankment is added to stop capillary water. The unreinforced base plate is cast using cement mortar, and a ring beam is provided along the circumference of the base, as shown in Figure 2. In the trial bin, the cement-sand proportion was 1:2 by weight and the water-cement ratio was 0.40. The base plate and ring beam were cured by keeping water in the base for 3 days. After the curing period, a pile of paddy husk was placed on the base and a conical mold was formed by wetting and tamping the husk into shape. In the absence of paddy husk, sawdust or sand can be used as mold. The mold is sprayed with water just before plastering. The mortar used for the wall was of the same mix proportion as used in the base. The plastering of the wall is done in two layers, each layer being approximately 1 cm. thick. The plastering operation started from the base to the top. The thickness of the wall is measured by piercing the wet wall with a small piece of wire.

After plastering and before the mortar sets initially, the top of the bin is cut about 15 cm. from the top. The upper lid is used as cover of the bin. A rectangular opening is also made near the base for unloading the rice paddy. A rectangular slab is specially cut to be used as the door for this opening. The bin is cured as in ordinary plastering work, and subsequently the paddy husk is removed. In 1973, the cost of this bin was U.S.$10.

This bin described in this Appendix has no reinforcing mesh and is not strictly ferrocement. Nevertheless it is an extension of ferrocement technology and is included here because of its importance.

Field Tests

The bin was loaded with rice paddy on June 26, 1974 to a height of 107 cm. above the base plate. The lids of all openings were sealed with cement mortar. The test results obtained are as follows:

(a) Temperature

The temperatures inside the bin were recorded at three different levels, i.e., on top of the paddy, at 47 cm. and 17 cm. above the base plate. In general the readings obtained at the two lower levels were fairly constant at 30°C. At the top, the temperature varied from about 22°C in the early morning to 27°C at mid-day. Outside the bin the maximum temperature recorded was about 32°C at mid-day.

(b) Moisture Content

The moisture content of the grain was measured at the time of loading and was 12.11%. After three months of loading, the average moisture content was found to be only marginally higher at 12.66%. This showed that the bin was water tight and is capable of maintaining the moisture content of the rice paddy.

(c) Carbon Dioxide and Oxygen Content

The carbon dioxide content increased from 0 at the time of loading to 3.7%, 10% and 11.70% after 1 month, 2 months and 3 months respectively. The oxygen content decreased from 20.4% at the time of loading to less than 10% after 1 month.

(d) Germination

The germination decreased rapidly and this was probably due to the fact that the rice paddy was stored some 6 months after harvesting.

(e) Insect Attack and Others.

After 2 months, no insect or rodent attacks were observed. In fact insects trapped inside during storage were found dead.

(f) Starch Quality

There was no significant change in the millability, chemical and physical properties of the starch due to storage.

In conclusion, the bin described here requires a very low level of technology to build and it could be easily adapted by farmers. It is low in cost and is well within the means of farmers. The field tests showed that the bin provides adequate grain protection against insects and other environmental hazards.

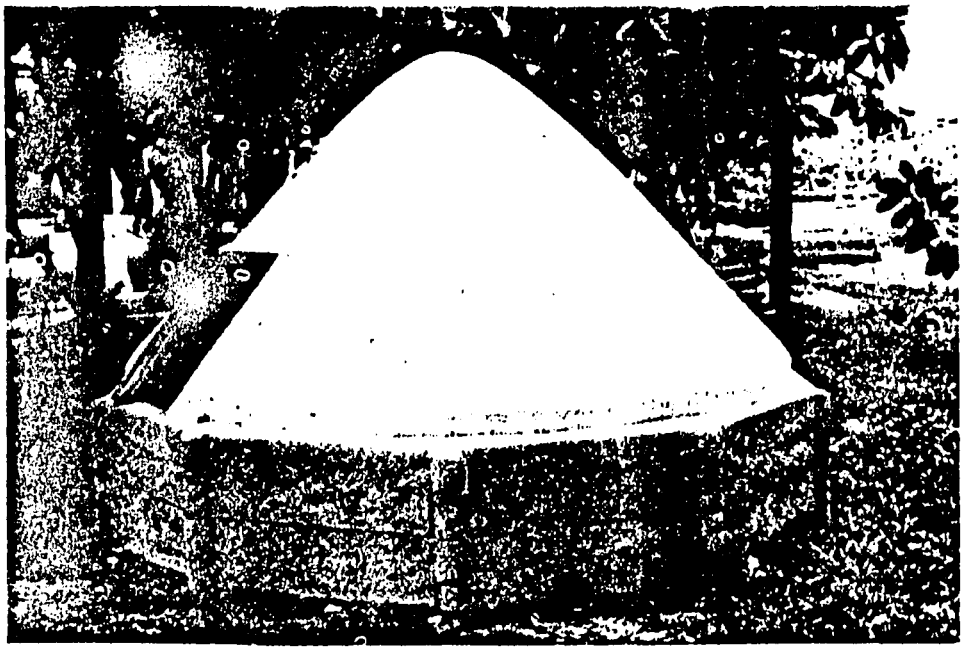


Figure 1: Completed cement mortar bin

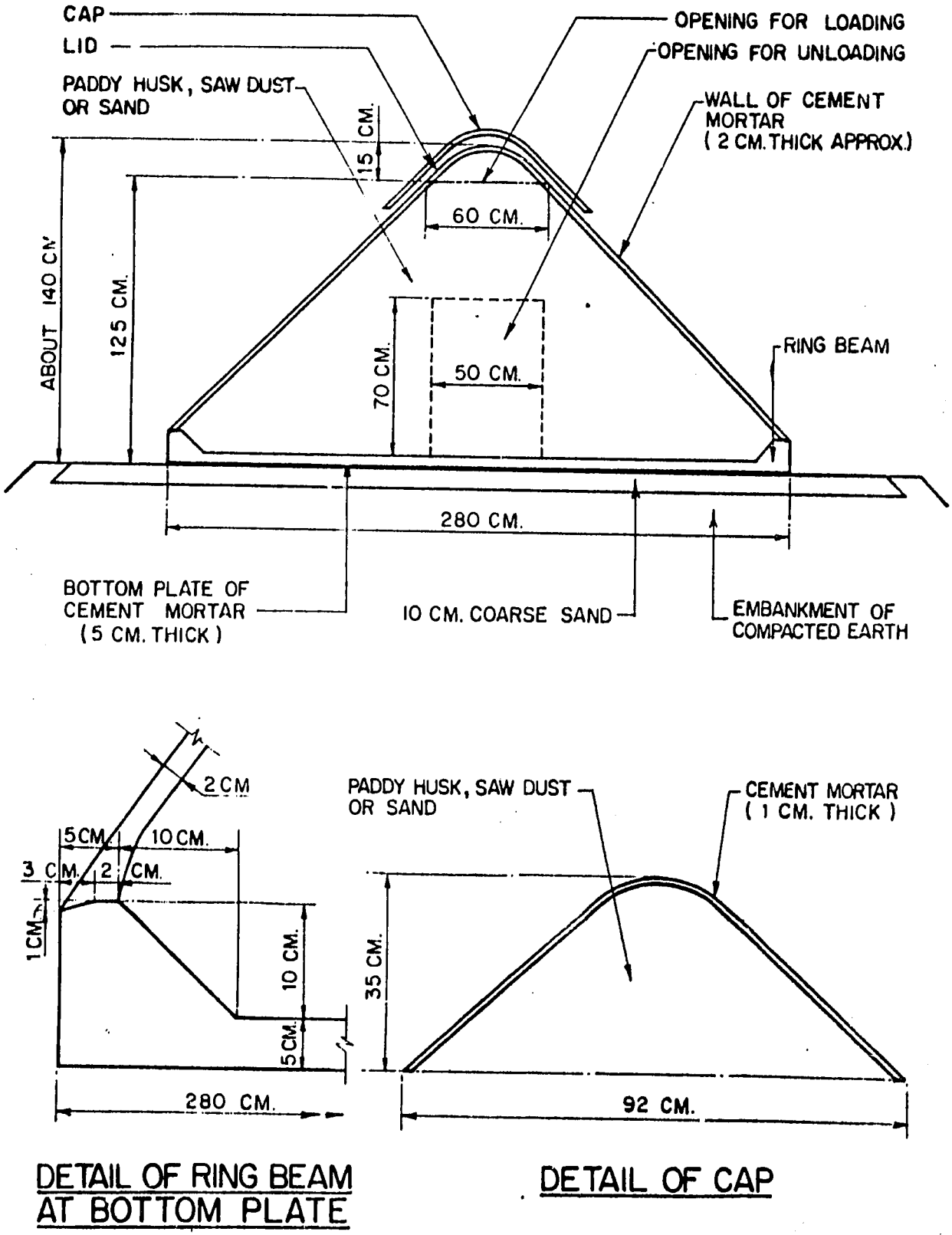


Figure 2: Details of cement mortar bin

A TRAINING PROGRAM ON FERROCEMENT TECHNOLOGY FOR INDONESIA

A PROPOSAL SUBMITTED

TO

DEVELOPMENT TECHNOLOGY CENTER
INSTITUT TEKNOLOGI BANDUNG
BANDUNG, INDONESIA

AND

USAID/INDONESIA

BY

DIVISION OF STRUCTURAL ENGINEERING & CONSTRUCTION
ASIAN INSTITUTE OF TECHNOLOGY
P.O. BOX 2754
BANGKOK, THAILAND

JANUARY 1978

INTRODUCTION

At the invitation of USAID/Indonesia, a team from the Asian Institute of Technology (AIT) in Bangkok, Thailand conducted a field trip to various places in Indonesia to identify potential applications of ferrocement and related materials and to suggest the most practical and effective way to introduce ferrocement technology for the benefit of the people in the rural areas of Indonesia. The team consisting of Professor Ricardo P. Pama of the Division of Structural Engineering and Construction, AIT and Mr. Opas Phromratanapongse of Siam Cement Co. Ltd. visited several villages in West Java, South Indonesia and North Sumatra between October 4-18, 1977. Their findings and recommendations are outlined in a report "The Potentials of Ferrocement and Related Materials for Rural Indonesia - A Feasibility Study" which is attached as Appendix A.

Four (4) major recommendations are made. One of the recommendations calls for an effective transfer of ferrocement technology to three institutions in Indonesia, namely Development Technology Center (DTC) of Institut Teknologi Bandung, Universitas Syiah Kuala and Universitas Hasanuddin. In particular, the recommendation calls for a 4-month training program on ferrocement technology to be undertaken by one or two staff members from each of these three institutions who will later serve as project coordinators in their respective universities. It is envisaged that the training program should have three essential components, namely: (a) fundamental studies on the properties of ferrocement as a construction material, (b) laboratory experimentation and (c) field demonstration on various ferrocement applications. The Asian Institute of Technology was suggested as the institution that could undertake this training program under its Special Student or Certificate Student Program as AIT has done extensive research and development on ferrocement and other related materials since 1968.

This proposal, "A Training Program on Ferrocement Technology for Indonesia" is therefore a follow-up of the feasibility study conducted earlier for the USAID/Jakarta - DTC Project on ferrocement for rural Indonesia.

TRAINING PROGRAM

It is proposed that, where possible two project coordinators be identified from the Development Technology Center, Universitas Syiah Kuala and Universitas Hasanuddin for the 4-month training program at AIT starting in May 1978. To qualify for the Special Student or Certificate Student Program, the project coordinators must have a bachelors' degree in engineering or equivalent and must be fluent in the use of the English language as the medium of instruction at AIT is English.

As mentioned previously, the training program should have three essential components. The first component involves a series of lectures on the properties and behavior of ferrocement and other related materials. The topics to be discussed include the following:

(A) Ferrocement

- Definition of ferrocement
- Difference between ferrocement and reinforced concrete
- Constituent materials
- Mix design
- Casting and curing process
- Properties in tension and compression
- Behavior under impact and repeated loads
- Cracking phenomena in ferrocement
- Design parameters
- Durability considerations
- Studies on creep and shrinkage
- Construction methods
- Potential applications

(a) grain silos
(b) water jars
(c) pontoons
(d) canoes
(e) well casing
(f) canal linings, etc.

(B) Related Materials

- Properties of coir fiber boards
- Properties of bamboo chip boards
- Properties of sugar cane bagasse boards
- Properties of rice husk ash - lime mixture

The second component of the training program calls for laboratory testing to observe the actual behavior of ferrocement under different loading conditions. The following laboratory tests will be conducted:

- Mix design
- Tension test
- Compression test
- Test under repeated loads
- Flexure test
- Anticlastic test
- Impact test

The third and final component of the training program entails field demonstration. The following applications will be demonstrated:

- water jars
- grain silos
- well casings
- toilet bowls
- canal lining
- canoes, etc.

BUDGET

The budget is estimated on the assumption that six (6) project coordinators will participate in the training program. The budget covers the air fare, bursary, accommodation, textbooks and printed materials, local transportation and materials needed in the laboratory work and field demonstration. The budget also covers the fees of the AIT staff members who will be conducting the project. The proposed budget allows for 2 visits to be made by an AIT staff for the evaluation of the field project in Indonesia. The details are as follows:

Training

Tuition & fees:	6 x 1,500	=	US$ 9,000
Accommodation:	6 x 10 x 4 mo.	=	240
Air fare:			
2 from Bandung to Bangkok and return	= 2 x 550	=	1,100
2 from Ujung Pandang to Bangkok and return	= 2 x 750	=	1,500
2 from Banda Aceh to Bangkok and return	= 2 x 800	=	1,600
Textbooks and printed materials	= 6 x 300	=	1,800
Building Materials	= 6 x 300	=	1,800
Local Transportation	= 6 x 50	=	300
Salaries:			
2 Professors at 20%	$= \frac{2 \times 4}{12} \times 20{,}800 \times 0.20$	=	2,775
1 Asst. Professor at 20%	$= \frac{1 \times 4}{12} \times 11{,}375 \times 0.20$	=	760
2 Technicians x 50%	$= \frac{2 \times 4}{12} \times 1{,}200 \times 0.50$	=	400
1 Research Associate	$= \frac{1 \times 4}{12} \times 4{,}800$	=	1,600

Evaluation

Air fare:			
2 trips to Bandung, Ujung Pandang and Banda Aceh from Bangkok for evaluation of the project		=	US$ 2,400
Per diem	= 54 x 14 days x 2	=	1,512
Salary	$= \frac{20{,}800}{12} \times \frac{14 \times 2}{30}$	=	1,617
			US$30,504
Plus 50% AIT overhead			15,252
	Total		US$45,756

CONDITION OF PAYMENT

If the proposal is accepted, the sum of US$45,156 is to be paid to the Asian Institute of Technology by the Development Technology Center in two installments. The first 50% should be paid upon signing of the contract and the remaining 50% at the completion of the training program.

Submitted by:

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AIT

Professor Pisidhi Karasudhi
Project Co-coordinator
AIT

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Engineering & Construction
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Professor Robert B. Banks
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Professor Hiroshi Shi-igai
Vice President & Provost
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