CERAMIC INDUSTRIAL RESEARCH AT THE APPLIED SCIENTIFIC RESEARCH CORPORATION OF THAILAND

A REPORT TO ASRCT AND UNIDO

BY

G.A. KIRKENDALE
U.N. EXPERT IN STRUCTURAL CLAY PRODUCTS

Bangkok, June 1973

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G.A. Kirkendale THA-081-SWF (SF/ID)

INTRODUCTION

The writer was assigned by UNIDO, for fourteen months, to Thailand to conduct a feasibility study for the establishment of structural clay product industries to manufacture common brick, face brick and sewer pipe. The results of this study have been published in two reports(1). The above work was carried out for and with the cooperation of the Applied Scientific Research Corporation of Thailand, Technological Research Institute, Building Materials Group.

There are, at present, two other organizations conducting research and development in ceramics. These are:

Chulalongkorn University, Faculty of Science.

Chulalongkorn University offers a B.Sc. degree in Materials Science. The curriculum concentrates heavily on Ceramics with introductory courses in Industrial Minerals, Polymers, Ore Dressing and Metallurgy. Laboratories are not adequately equipped and space is limited. However new laboratory equipment is being acquired and the question of space can be solved.

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(1) "Preliminary Investigation of Clay Properties for Building Brick and Sewer Pipe." ASRCT Classified Investigation No. 16, Report No. 1, 1973 and

"Feasibility Study for Structural Clay Products Industries in Thailand". ASRCT Classified Investigation No. 16, Report No. 2, 1973.

Research in the Materials Science Department seems to be chiefly student oriented and much of it is based on student theses. Some industrial consultation is being carried out by members of the faculty.

Ministry of Industry, Department of Science.

This is the largest ceramic research center in Thailand. The Department of Science has been conducting ceramic investigations for the past 20 years. They have exceptionally large laboratory and workshop space. There are several expansive buildings devoted to office space, laboratories and pilot plants. Equipment is almost unlimited and ranges in scope from laboratory instruments to commerical manufacturing machines. Most of the equipment is designed for the manufacture of whiteware, particularly dinnerware. Clay washing and refining can be and is being carried out on a pilot plant scale. There are facilities for grinding and screening large amounts of raw materials. De-airing pug mills, automatic jiggers, sagger and roofing tile presses, glazing machines and a mangle dryer are part of the equipment. Six kilns, ranging in size from about 1/8 cu. meter to a round, down-draft kiln approximately 4 meters in diameter, are capable of firing anything from test bars to a commercial production of roofing tile.

The Department of Science acts also as a training center for ceramic factory supervisors and technicians. They presently employ about 80 persons and are operating for 1973 under a budget of 1,634,720 baht[2]. Research is devoted, to a large extent to the development of commercial products and the utilization of indigenous raw materials. They are not well equipped or staffed to do basic research in ceramics but they do have the best equipped laboratories for applied research and pilot plant testing in Bangkok.

(2) Yoshimori Kato. Report No. 1. Oct. 1972, Ministry of Industry, Department of Science.

Applied Scientific Research Corporation of Thailand.

The ceramic research facilities at ASRCT are very small and totally inadequate for carrying out any important industrial research in this field. The ceramic department is part of the Building Materials Research Unit of the Technological Research Institute. The staff consists of one Experimental Officer, one laboratory Technician and one laboratory Assistant. The Experimental Officer is a trained ceramic scientist, the others have little scientific knowledge of ceramics.

Because the Experimental Officer must constantly supervise and direct all laboratory work as well as analyze results and prepare reports she seldom is able to carry on more than one project at a time.

Laboratory space is cramped and inadequate. The Experimental Officer shares a laboratory cum office with two others. There is also a small space in one of the work shops alloted to a few pieces of miscellaneous heavy equipment of not much general value. The present equipment for ceramic research and testing is as follows.

1. Expansion furnace designed by the British Ceramic Research Association. This equipment is somewhat obsolete but is satisfactory for testing fairly large specimens. It is not satisfactory for testing glazes or very small specimens of ceramics. It should be replaced by more accurate equipment in the near future.

2. Modulus of rupture testing machine designed by the British Ceramic Research Association. This is a crude piece of equipment and can only be used for determining the tensile strength of unfired specimens.

3. Small electrical furnace capable of reaching 1200°C. This furnace is in good condition but is limited to firing very small specimens since it has a volume of only 16 cm x 12 cm x 10 cm high.

4. Polarizing microscope.

5. De-airing pug mill. This is a medium size laboratory machine and is too large to conveniently extrude test bars. A rather large amount of clay is required just to fill the machine. Cleaning the machine is difficult and requires that the extrusion section be disassembled completely. Each time the machine is taken down the vacuum seal is broken and it is very difficult to maintain a good seal. The cleaning operation takes about one and a half hours. This machine would not be recommended for making test bars from 100 to 200 samples of clay when testing drill samples from a property survey.

6. Blunger.

7. Bickley revolving hearth P.C.E. furnace.

8. Potter's wheel.

9. Six-point recording potentiometer.

Other equipment not belonging to the ceramic division but available to it includes:

1. Jaw crusher.

2. Muller type wet mixer.

3. Test-screen shaker.

4. X-ray machine.

5. Tensile strength testing machine.

In order to properly carry out industrial research and testing in ceramics the department should obtain the following minimum of new equipment.

One laboratory size roll-crusher.

One laboratory bench-type de-airing extruder.

One Ro-tap sieve testing apparatus.

One Differential Thermal Analysis furnace.

*One Gas-fired test kiln capable of reaching cone 12. This kiln will have an inside firing chamber of 4 cu. ft.

*One optical pyrometer.

*Two Platinum, Platinum-10% Rhodium thermocouples.

*Two Chromel Alumel thermocouples.

*One Portable potentiometer.

Type of ceramic research to be conducted at ASRCT.

Since the two institutions, ASRCT and the Ministry of Industry Department of Science, serve quite different functions in scientific research there is no need for the ceramic research of either institution to duplicate that of the other. The Department of Science is concerned with the utilization and beneficiation of indigenous raw materials as well as the development of new or improved ceramic products. It operates chiefly through government funding and functions as a public institution.

ASRCT, on the other hand, is semi-autonomous and concentrates its efforts on industrially oriented research. ASRCT can fulfil an extremely beneficial function in the development of ceramic industries in Thailand. The existing ceramic industries are individually too small in size to be able to maintain adequate research facilities of their own. Even if they were able to do so there would be a severe shortage of ceramic scientists with which to staff individual

*These items have highest priority.

laboratories. The most obvious solution to ceramic industrial research, at present, would be to have a central laboratory, accessable to all who wish to make use of its services, staffed with capable scientists, and functioning as a consulting body for existing and newly planned ceramic industries. With an addition to its staff and equipment ASRCT is idealy suited for this purpose.

Generating ceramic research.

The success of a ceramic research and consulting laboratory will depend, to a large extent, on the ability of the laboratory director to contact industries and sell services.

Many industry managers are prone to accept manufacturing problems and the resulting high percent of rejects as inevitable and a necessary profit erosion. This is largely because they are not able to recognize the cause and cure of the trouble, they have insufficient knowledge of the chemical and physical properties of their raw materials with which to plan quality control measures, and they are aware that their competitors are experiencing the same difficulties. There should be no lack of ceramic industrial research problems in Thailand.

There are a variety of ceramic industries producing products both for domestic consumption and for export. These include:

Sanitary ware, dinnerware, wall tile, electrical procelain, refractories and structural clay-products.

All of these industries have many production problems, most are technical and often relate to quality control. Such problems could be solved in the laboratories of ASRCT. The scope of consulting work need not be limited to manufacturers of ceramic products. Consumers of these products very often have need of a ceramic consultant also. For example, procedure or a combination of all three. Since only 30% of the tiles are cracking, the manufacturing process is likely to be partially or wholly at fault. The investigator will, therefore, want to determine the uniformity with which manufacturing operations are carried out. He should take a sample of ware from the forming machine every hour for a period of one or two eight-hour shifts and determine the water content. If there are many samples that fall outside the upper and lower limits allowable then the clay-water mixing operation is faulty. Next the investigator will check on the dryer. He will measure and determine the temperature and relative humidity at various points in the drying time-cycle and in different parts of the dryer. He will also measure the velocity with which warm air and other gases flow through the dryer. With this practical operational information from the factory he returns to the laboratory bringing with him a representative sample of the raw material.

Without a practical knowledge of the physical and chemical properties of the raw material it is not advisable to recommend changes in manufacturing practices. In this case the raw material would be tested for plasticity, drying shrinkage with various water contents, dry strength, and drying characteristics. If the material is difficult to dry and requires very close control of water content and/or drying conditions, then experiments should be made with different additives that will tend to simplify drying. Optimum conditions for drying can be established in the laboratory and these conditions then specified for the factory.

To complete the investigation an economic study should be made on this particular problem. Most factory problems can be solved and most product defects can be cured. However sometimes the cost of correcting a defect may be greater than the loss due to ware that must be scrapped. An economic study would indicate the break-even point where the cost of quality control is equal to the cost of non-marketable ware.

Thus it may be economically better to accept a 2% dryer loss than to adjust raw materials and manufacturing procedures to obtain a zero loss.

It is evident from the foregoing example that sound planning is a prerequisite to successful industrial research. The research director must be observant. He can often learn enough during a 2-3 hour visit at the factory to save a week or more of time in the laboratory. He must be able to correctly interpret what he sees and he must have a sound knowledge of the chemistry and physics of ceramic materials. Most manufacturing defects occur during the heat treatment of ceramics, therefore it is important to know how variations of temperature, time and atmospheric conditions in the kiln may affect the finished product.

Carrying out research programs.

As pointed out earlier in this report, the ceramic laboratories of ASRCT are not adequately staffed to carry out meaningful and lucrative industrial research. It has been suggested that a build up of staff be planned concurrently with the goal of steadily increasing industrial research contracts.

The availability of ceramic engineers and technologists in Thailand is limited. The first locally granted degrees in ceramic engineering were awarded by Chulalongkorn University in 1965. Before that time there were only a very few ceramic scientists who had been educated abroad. Consequently the supply of ceramic engineers consists of relatively young and inexperienced people. Many are well grounded in the basic fundamentals of ceramic science but are not yet experienced or mature enough to undertake the kind of research planning and industrial know-how that would be required in the laboratories of ASRCT. Never-the-less, ASRCT must accept and utilize, to the best advantage, the human resources available.

Since the science of ceramics is young in this country, only time can provide the background of experience and maturity necessary for highly successful industrial research. Meanwhile certain adaptations can be employed to fill the trained manpower gaps. There are many scientists in Thailand, in other fields than ceramics, who are both well qualified and highly trained to plan and direct industrial research. The science disciplins closest to ceramics are chemistry or metallurgy. If some one from these fields is not available then an experienced person from any field of science could carry out the function of project director.

The director would be responsible for generating research contracts from industry and for the total planning of the work to be done, the procedure and the time table. He need not be an expert in ceramics but he should consult with ceramic experts who would assist him with the planning. When the director visits various factories to discuss the possible need for industrial research, he should take with him the ceramic scientist from the laboratory. To provide temporary relief and assistance to the one Experimental Officer, it would be advisable to hire, on a part time basis, a member of the faculty of the Materials Science Department of Chulalongkorn University. This measure would permit the operation of the laboratory until opportunity and finances permit the acquisition of a second ceramic experimental officer.

With the director responsible only for generation and planning of the work, he should be able to supervise all ceramics and building materials research and possibly other related fields. The various experimental officers would have the responsibility of carrying out and reporting on the investigations and of directing and supervising the laboratory assistants.

Research reports.

A research organization will often be judged by the quality of its reports. The report is the only concrete material a client receives for his fee. Reports, therefore, should be prepared and submitted to the client immediately following the conclusion of the experimental or test work. If the project is an extended one then interim reports should be submitted regularly. Reports should be complete in detail and the research results discussed fully with carefully thought out conclusions and recommendations. The report should be followed up with a discussion between the research director, the experimental officer and the client for clarification of the report and planning for further work.

It is the writer's opinion that report writing is at present a weak point at ASRCT. Considering the importance of good communication it would be worth while for ASRCT to provide a short course or courses in report writing for its staff. This could be done with the cooperation of the editor and the editorial department.

Recommendations for further work in Structural Clay Products.

The feasibility study in structural clay products has provided strong evidence that there is a need for such industries in Thailand and that they could be operated profitably. Although several excellent clay deposits were located, the study was not extensive enough to estimate the size of the deposits.

As soon as an interested sponsor can be found, one or more clay deposits must be thoroughly tested for reserves. The method of testing is given in ASRCT Classified Investigation No. 16 Report No. 1 1973 Summary and Recommendations page 61. This project could take from two to six months.

Concurrently a continuation of the economic feasibility study might be carried out. Because only very few standard building bricks are now being manufactured and used, and because the market for a relatively untried product such as this is largely speculative, a minimum production of 15 million bricks per year was used in the study. It is the firm belief of the writer that, eventually, there will be a large enough market demand for structural clay products to support from four to ten factories. With this goal as a future objective a concentrated and extensive market study should be undertaken in order to attract further investment and encourage the development of other clay deposits. A study of the markets and economics of clay sewer pipe production alone could occupy the attention of ASRCT for some time to come.

Markets in Thailand for quarry tile and roofing tile should be examined. The manufacture of clay roofing tiles in Thailand constitutes a large sector of the small industry component. Roofing tiles are fired in crude kilns that are not capable of reaching temperatures higher than 700 to 800°C. Because of this limitation it is necessary to use a low melting glaze. The most powerful and successful flux for low temperature glazes is red lead. Raw red lead is also extremely toxic. Without exception, wherever glazed roofing tile are made in Thailand, inadequate or no precautions are taken to protect the workers from lead poisoning.

When red lead is used as a constituent of a glaze in making dishes, cups and bowls, there is danger of poisoning to any one using these articles. Lead glazes are soluble in weak acids and any lead released will enter the body system. In Britain, government regulations require that a glaze must not yield more than 5% of its dry weight of soluble lead when treated with 0.25% of hydrochloric acid at room temperature. Most other countries have similar standards.

The technical problem is to convert raw lead into compounds that are insoluble in gastric juices and to do this as early as possible in the manufacturing process. This can be achieved by melting the raw lead with silica and certain other compounds to form a glass of low solubility. There is also a range of leadless glazes available but they require higher melting temperatures than lead glazes. In order to control the health hazard present when using lead, all lead frits should be produced by one properly supervised factory and sold to the numerous small potteries and roofing tile manufacturers.

Another approach to the problem is to use higher firing temperatures and eliminate lead entirely from the glaze. Since more fuel would be required to reach higher temperatures the firing costs would be greater. To offset part of this additional cost better kilns must be constructed. The small potteries and tile manufacturers would have to be taught better kiln construction and design. In the case of roofing tile two firings are employed. The tile are fired once before the glaze is applied. A second firing is required to harden the glaze. Considerable fuel is needed for two firings and much of the heat generated is used in heating up the brick work in the kiln itself. A leadless glaze could be developed which can be fired at the same time as the body thus eliminating the need for two firings. Although the firing temperature would be higher there would be an overall saving in fuel with only one firing.

Mason training.

Along with the development of clay bricks as a construction material is the equally important necessity of establishing good masonry practice and promoting masonry training centers. High quality face brick can be ruined by poor work on the part of the brick layer. The structural quality of the building walls is no better than the quality of the workmanship that went into their construction. Masonry is a skilled trade and ranks equally with plumbing, electrical wiring and carpentry.

Masonry can be taught in trade schools. To establish courses in masonry some international assistance will be required. Such assistance could be supplied through the U.N. perhaps by I.L.O. ASRCT should press for a mason training program in Thailand as a necessary part of the development of structural clay industries. It should also be recognized that trained masons would command higher wage than that now paid to untrained brick layers.

Accomplishments of SCP program.

Preliminary tests on raw materials and a feasibility study for the manufacture of clay building brick have been completed. In addition to this work a ceramic Experimental Officer has been trained in evaluating clays and in the techniques of brick manufacturing. This Experimental Officer has profited by association with the UNIDO adviser and is capable of carrying out the remaining aspects of the project.

The value of a counterpart association with the adviser, however, has been somewhat short of full potential. A counterpart provided by the host institution should be one who is equal in professional standing and administrative authority to the adviser and who will be expected to carry on the project or similar projects upon the termination of the adviser's appointment. Anyone less qualified is a trainee rather than a counterpart. It is realized that some institutions may have extreme difficulty in providing a counterpart in the full sense of the word and, if this is so, the best that can be done is to provide a counterpart who is able to devote at least fifty percent of his time to the U.N. adviser and the project.

Unfortunately the counterpart selected by ASRCT for this project was a person with multiple responsibilities of which structural clay products was only one. He was physically not able to devote more than approximately twenty-percent of his time to this project. Therefore the value of close contact with the U.N. adviser and the opportunity to become thoroughly conversent with all details of the project was lost. These comments are not made in the spirit of criticism but rather, with a full understanding of the difficulties involved, in hope that future aid programs can be timed or planned with more emphasis on the value of counterpart participation. In the opinion of the writer, the overall value of the program to the industrial development of Thailand far outweighs any discouraging factors brought out in this report.

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