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15624

Dist.
Restricted

UNIDO/IO/R.238
12 June 1986

ENGLISH

UNITED NATIONS
INDUSTRIAL DEVELOPMENT ORGANIZATION

ESTABLISHMENT OF A CERAMIC RESEARCH AND DEVELOPMENT LABORATORY

US/SRL/78/207

SRI LANKA

Technical report: Management of Ceramic Research*

Prepared for the Government
of the Democratic Socialist Republic of Sri Lanka
by the United National Industrial Development Organization

Based on the work of Zdenek A. Englethaler,
Consultant in Ceramic Research Management

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V.86-57342

N.Biering/pe

13 May 1986

SUMMARY

Document:	UNIDO/IO/R.238 V.86-57342 pn
Nature:	Technical Report
Title:	Management of Ceramic Research
Length:	58 pages
Type of Document:	Restricted circulation, original English
Scope:	Advice to the senior staff of the Ceramic Research Laboratory of the Ceylon Ceramic Corporation on ways of more effectively utilizing the capacity of the laboratory to serve the national ceramic and non-metallic mineral based industry.
Contents:	Description of the present situation of the laboratory and the ceramic industry in general. Presentation of a total of 14 case studies showing how production problems can be tackled by the laboratory.
Conclusions:	The Ceramic Research Laboratory can play an important role in the development and strengthening of the industry. There is scope for increasing its level of activity and for establishing close contacts not only to industrial manufacturing plants but also to institutions, organizations etc., in or outside the country.

ACKNOWLEDGEMENT

The UNIDO expert would like to express that the success of the mission was possible due to very well conducted preparatory activities and supports of UNIDO Headquarters in Vienna, namely Mr. N. Biering and Mrs. S. Yalcindag, Industrial Development Officers, Division of Industrial Operations.

Valuable assistance of Mr. Theo Schroll, UNIDO Senior Industrial Development Field Adviser for Sri Lanka, Maldives and Nepal, and Mr. St. Ericcson, UNIDO Junior Programming Officer, was given to the UNIDO expert during the mission. Thanks also belong to Mr. M. Corsi, UNIDO Geological Associate Expert in Ceylon Ceramics Corporation, for his good co-operation.

Furthermore, the Government of the Democratic Socialist Republic of Sri Lanka extended to the UNIDO expert all help in arranging high level meetings, consultations, lectures, visits and in collecting necessary information for the implementation of the mission.

Thanks for the help and assistance belong to

Mrs. Beligammana, Chairman, Ceylon Ceramics Corporation, Colombo

Mr. Dr. C. T. S. B. Perera, General Manager, Ceylon Ceramics Corporation, Colombo

Mr. Dr. J. W. Herath, Director, Ceramic Research Laboratory, Piliyandala

Mr. W. D. Weerasinghe, Deputy General Manager, Ceylon Ceramics Corporation, Piliyandala

Mr. D. T. Mannakkara, Deputy General Manager, Lanka Wall Tiles Ltd., Colombo

Mr. P. Piyasena, Production Manager, Lanka Tiles Ltd., Yaltara, Ranala

Mr. P. Wickramasinghe, Assistant Factory Manager, Lanka Wall Tiles Ltd., Balangoda

Mr. M. Kikushima, Deputy General Manager, Noritake Co. Ltd.

Mr. T. Yayaweera, Factory Manager, Lanka Porcelain Ltd., Matale

Mr. V. G. Dayaratne, Associate Production Manager, Lime-plant, Hungama

and to all other colleagues from the Ceramic Research Laboratory, Piliyandala, and from the Ceylon Ceramics Corporation, Sri Lanka, who participated very actively in reaching the results obtained during this UNIDO mission.

ABSTRACT

The mission realized by UNIDO Vienna according to the scheduled activities of the projet US/SRL/78/207/11 "Establishing of a Ceramic Research and Development Laboratory in Sri Lanka" was related to the Ceramic Research Management.

All duties of the mission were fulfilled. The studies, made in the Ceramic Research Laboratory, showed that the management improved by installing the Director since 1 January 1986 and by recruiting two local experts. Unexhausted capacities in different research laboratories were gradually filled in by iniciating new research duties according to the interest of local industries. Different types of the ceramic industry in Sri Lanka were visited and case research studies reflecting the actual need of the industry were defined, negotiated and some of them iniciated in the Ceramic Research Laboratory. Two less complicated studies were finished during the mission of the UNIDO consultant, the other ones will be incorporated into the research programme of the Ceramic Research Laboratory.

Following the need of the Sri Lanka ceramic industry, some additional equipment will be needed for conducting technological evaluations. Since the industry heavily depends on external markets, more training abroad is needed as well as testing of selected non-metallic raw materials.

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I. INTRODUCTION

Within the framework of the UNIDO Project US/SRL/78/207/11 Ceramic Research Laboratory, Piliyandala, Sri Lanka, Mr. Zdeněk A. Engelthaler was appointed Consultant in Ceramic Research Management with the duration of one month. He was attached to the Ceylon Ceramics Corporation (hereinafter called C.C.C.) to assist in the setting-up of its central quality control and development laboratory and to advise on its effective use within the field of specialization. According to the Job Description US/SRL/78/207/11-60/32.1.B, the duties were specified as follows:

1. To familiarize with the work of the Laboratory and examine how it responds to the needs of C.C.C. and to the industrial and scientific community of the country as a whole.

2. To advise the management of the Laboratory on the most effective utilization of available manpower and equipment with a specific view to achieving full co-operation between the various sections in the execution of the work of the Laboratory.

3. To elaborate proposals for the new areas of research and development work within the capability of the Laboratory and suggest ways and means of establishing closer links to its potential clients.

4. To provide ad-hoc advice to the laboratory staff on technical and administration questions as the time permits.

Apart from the foregoing, the UNIDO backstopping officer stressed the importance of indentifying selected case research studies which might be negotiated and/or started during the mission. The General Manager of C.C.C. as well as the Director of the Ceramic Research Laboratory (hereinafter called C.R.L.)

stressed the importance of periodic lectures and round-table discussions conducted not only in C.R.L. but also in the ceramic industry of Sri Lanka.

The UNIDO expert visited each laboratory of C.R.L. and negotiated the current testing and research works conducted by the laboratories at present. It was obvious that after C.R.L. had started to charge its clients for services,conducted for them, their interest went down in 1985. However, at present the interest grows not only of the plants of C.C.C., but also of other external clients. A free capacity which still exists in different laboratories, amounting from 20 to 60% respectively, starts to be exploited by conducting different research duties. Other duties, covering the needs of C.C.C. plants, need to be specified. Therefore, the UNIDO expert, following the work programme,agreed upon with C.C.C., visited a series of ceramic and raw materials plants in which detailed negotiations on current and development needs were conducted. Jointly, the research duties as case research studies were identified and negotiated as the most important ones for the time being. The results obtained were regularly negotiated with the C.R.L. management and related activities started. Some of the case studies were commenced during the stay of the UNIDO Consultant, 2 of them were even settled.

Since the recent period the management of C.R.L. has improved very much. On 1 January 1986 the Director of C.R.L. was appointed and two more experts were recruited during the stay of the UNIDO Consultant. To develop closer links between C.R.L. and the Sri Lanka ceramic industries it was recommended to establish, under the direct management of the C.R.L. Director, the C.C.C. Scientific and Technical Assistance of 3 - 5 people who will be available any time when the need in the industry occurs because of troubleshooting, testing, standardization, research and development, or because of the need of discussing the actual manufacturing problems.

The intention of the C.C.C. management to establish the Lanka Ceramic Society is very good for closer co-operation between C.R.L. and the ceramic industry as well as for exchange of experience with Technical Universities and other research bodies of Sri Lanka.

C.C.C. has already started editing a Technical Magazin on the yearly basis. Such magazin is a very good means of informing the industry of the newest scientific and technical developments.

From the general point of view, several improvements were negotiated, such as raw materials inventory, calculation of ceramic bodies according to the rational (mineralogical) composition, recalculation of the chemical composition to the rational one, etc. Testing of raw materials is carried out locally in the industry and in C.R.L. However, there is the interest of C.C.C. in testing different non-metallic minerals and rocks abroad to check the results with the locally available ones and for upgrading possibilities of selected raw materials for which the available equipment in the laboratories is not applicable (such as high intensity electromagnetic separation for increasing the whiteness of kaolins and purification methods for up-grading locally available glass sands).

The actual stage of the development of ceramic science and technologies in Sri Lanka is remarkable and it is gradually being improved by collecting necessary experience. The local industry, however, depends not only on the local market, but also on the markets of neighbouring countries. Some of the Sri Lanka factories directly depend on export possibilities, exporting up to 80 - 85% of all their products, such as Lanka Wall Tiles Co. Ltd. Therefore, it can be expected that further training of Sri Lanka nominees will be requested since the need for training exists not only in C.R.L. but also in the Sri Lanka ceramic industry. It was recommended to differentiate

Study Tours for up-grading the knowledge of key personnel from Fellowship Trainings of Sri Lanka's engineers and experts.

The existing equipment of C.R.L. is suitable and applicable for a lot of research duties which are being conducted. However, it is felt that some smaller apparatuses might be required for the evaluation of technological factors. A list of additional equipment required will be elaborated by C.C.C. and submitted to UNIDO SIDFA in Colombo.

The Sri Lanka ceramic industry has developed very well recently. Under the free market conditions, C.C.C. maintained a profit in 1985 and its further growth is expected in 1986. The C.C.C. experts and technicians are conducting their duties and, step by step, they are gaining more experience. The establishment of C.R.L. was a right step to reinforce and accelerate the scientific, technical and technological development of the ceramic industry of Sri Lanka.

II. FINDINGS AND RECOMMENDATIONS

1. C.R.L. in Piliyandala represents well equipped research laboratories for conducting testing and researching activities in the field of ceramics and ceramic raw materials. Only a few additional apparatuses are requested for the completion of technological researching. A list will be specified by C.C.C. and submitted to UNDP Colombo.

2. The Management of C.R.L. has improved very much by installing the Director of C.R.L. since 1 January 1986.

3. During the mission two more local experts were interviewed by the General Management of C.C.C. and recruited for the Energy Management and for Microscopy Laboratories.

4. C.R.L. in Piliyandala is divided into the following research laboratory sections:

   1. X-Ray Laboratory
   2. Mineralogy Laboratory
   3. Pilot Plant
   4. Kiln Laboratory
   5. Material Testing Laboratory
   6. Chemical Laboratory
   7. Design Laboratory
   8. Library and Conference Room

   and the overall management.

5. All the laboratories have shown a free capacity between 20 and 60% although series of routine tests have been made for external customers.

6. A new research programme has been established and introduced into each particular research laboratory respecting the research duties initiated in 1985 and establishing new

research duties according to their priorities and the free capacity of C.R.L.

7. The studies, made by the UNIDO Consultant during his mission, have shown that there is a great interest of the associated ceramic industries in further research activities related directly to the actual manufacturing problems faced in Sri Lanka, such as

a/ glaze crazing and body cracking of sanitary ware products in Piliyandala

b/ water absorption of ceramic wall tiles from Balangoda

c/ pinholes in the earthenware glaze of crockery in Piliyandala

d/ cracking of green porcelain insulators in the Negombo plant

e/ application of fired rejects to ceramic bodies and glazes in ceramic plants, such as in Piliyandala and Negombo

f/ increasing of the whiteness of refined kaolins by high electromagnetic separation for kaolin plants in Boralesgamuwa and in Methiyagoda and increasing of the content of fine particles in the washed kaolin

g/ technology of red floor tile manufacture in Lanka Refractories in Hanwella

h/ graphite crucible manufacture in Lanka Refractories in Hanwella

i/ refractory kiln furniture and cordierite technology in Lanka Refractories in Hanwella

j/ industrial exploitation of red ochres from Tangalle

k/ classification of the main types of ball clays from Dediyawala

l/ preheating of sea shells by exploiting the waste heat before firing in the Lime Plant in Hungama

m/ inventory of locally available ceramic and non-metallic raw materials with their technological evaluation in C.R.L.

n/ testing of locally available glass raw materials and their evaluation for glass tableware and crystal glass manufacture.

The foregoing problems were identified and negotiated with the C.R.L. Management as further case research studies to be incorporated into their research programmes. Some of them were iniciated, 2 case research studies were terminated.

8. In order to maintain direct contacts between C.R.L. and the Sri Lanka ceramic industry, to consider the establishing of a group of 3 - 5 local experts as the Scientific and Technical Assistance of C.C.C. to the industry.

9. In order to reinforce the exchange of technological know-how between the ceramic industry itself and C.R.L., to support the establishment of the Lanka Ceramic Society and develop a link with Technical Universities and other research bodies in the country. To extend the edition of the C.C.C. Technical Magazin in order to enable C.R.L. to publish the most actual research and development findings interesting for the industry.

10. To follow the composition of different ceramic products according to their rational (mineralogical) compositions which is a more accurate method than that based on comparing the inserts of raw materials into the drum mills. To make recalculations of chemical composition of raw materials and products for the rational (mineralogical) ones and strictly follow the standard blends.

11. To put new blends into the production after they have been verified in a semi-industrial test. To keep all records on tests and new body and glaze development in the plant laboratory.

12. To establish a ceramic raw materials inventory with the technological evaluation in C.R.L. Examples of Raw Materials Summary and Working Sheets are attached.

13. Since there are extensive reserves of siliceous glass sands and quartz in Sri Lanka, to consider the possibility of up-grading and refining these raw materials as a possible basis of the establishment of high-grade glass tableware and crystal glass manufacture.

14. The Sri Lanka washed kaolins are applied in the ceramic, paper, paint, chemical and rubber industries. To consider the possibility of increasing their brightness by modern refining methods, such as high intensity electromagnetic separation. In order to meet the requirements of the Sri Lanka Porcelain industry, to rearrange the existing four hydrocyclones into two separate technological steps.

15. The ceramic industry of Sri Lanka depends heavily on export markets. Further training of local ceramic engineers and managers abroad is considered in order to maintain the fast development to be competitive in the international market.

16. The top-management of C.C.C. requires closed long-term co-operation with the UNIDO-Czechoslovakia Joint Programme in Pilsen in the field of training, testing, up-grading and refining of non-metallics, in the field of exchange of know-how and in different technical assistance to the C.C.C. industries in Sri Lanka.

III. CERAMIC RESEARCH LABORATORY IN PILIYANDALA

This Laboratory was established jointly by UNIDO and C.C.C. The agreement to establish the Laboratory was signed between UNIDO and the Government of Sri Lanka on 27 April 1983. The total contribution by UNIDO was 1,005,800 US $ and that of C.C.C. was Rs. 1,848,850. Out of the UNIDO contribution, US $ 610,000 were allocated to purchase the equipment.

The Laboratory was officially opened in September 1984 and it constitutes of the following departments:

1. X-Ray Laboratory
2. Mineralogy Laboratory (XRF, XRD, DTA)
3. Pilot Plant
4. Kiln Laboratory
5. Material Testing Laboratory
6. Chemical Laboratory
7. Designs
8. Library and Conference Room

Dr. J. W. Herath works as the Head of C.R.L. and also as the National Consultant of UNIDO to the Project. Each department has two Research Officers who are trained at overseas in their relevant fields. Laboratory orders are accepted by Administrative Officer who directs these orders to the respective Laboratories.

A Objective of C.R.L.

1. To investigate the exploitation of all local non-metallic raw materials.
2. To develop new products and to improve the present manufacturing processes of products that are manufactured by C.C.C. and other ceramic industries of Sri Lanka. This includes e.g. Tableware, Sanitaryware, Porcelain, Glass and Glazes, heavy clay products and special ceramics.

3. To investigate and develop new technologies by applying local raw materials.

4. To extend scientific and technical services to the industrial and scientific sectors of Sri Lanka.

5. To elaborate and certify quality standards in order to facilitate the exports and to improve the local market supply.

6. To train Sri Lankans in ceramic and allied products technologies and in manufacturing processes.

B Services Provided by C.R.L.

1. X-ray and Thermal Analysis Laboratory

In this Laboratory, a highly advanced X.R.D. and X.R.F. equipment is available imported from Phillips, Holland. Using these machines, the Laboratory detects the mineral structures and mineralogical compositions of ceramic raw materials and minerals. Clays and, in fact, most ceramic materials are used in the form of fine powder consisting of a large number of very small crystals. A specimen is made from a small quantity of the powder and it is loaded into the X-ray equipment. A narrow beam of X-rays of known wavelength, produced by bombardment of a chromium target, is directed on to the specimen. The diffracted beam is detected by a counter and transferred into a diffractometer and printed out in the form of a graph. Using Bragg's law, the distance between the atombearing planes is calculated. The mineral is identified by using these d-spacings which is characteristic of the relevant mineral and may serve to identify it from the A.S.T.M. Card.

Thermal Analysis

Differential thermal analysis depend on the detection of the heat given out or absorbed when a phase change occurs in a substance which is being heated. The apparatus available at C.R.L. is a Netzsch Simultaneous Thermal Analysis Unit. The apparatus used consists of a refractory specimen holder divided into two components, the material under test,in the form of a fine powder, is placed in one of these, and alongside it, in the adjoining compartment an inert material is placed which does not undergo phase changes and which acts as a reference material. The specimen holder is provided with a set of thermocouples for measuring the temperature T of the inert material and also the difference in temperature between it and the specimen (Δ T). This specimen is heated in an electric furnace at a constant rate of 10^{o}C per minute, from the room temperature up to the desired maximum (1000 - 1200^{o}C). The thermocouple reading is automatically recorded.

Where Δ T is plotted against T, a peak will occur whenever the phase change occurs. From the exothermic and endothermic curves and also from the magnitude of the peak the characteristics of the clay mineral could be identified.

A Differential Dilatometer is used to identify the thermal expansion of different ceramic bodies and glazes.

2. Microscopy Laboratory

With the modern SEM equipment from Joel Japan, the facilities are available for the identification of minerals, identification of micro-structure, micro-behaviour of ceramic raw materials, fired bodies and fired glazes and also other allied minerals. A polarizing microscope and a stereo microscope are available for the identification of minerals.

3. Pilot Plant

Equipments are available for crushing, grinding, blunging, de-watering, de-airing, making, forming and drying of ceramic bodies of any shape on a pilot scale.

4. Kiln Laboratory

Facilities are available for firing up to various temperatures from the room temperature to 2000^{o}C. Gas, Electric Kilns and a Gradient Kiln are available to do the firings under oxidation - reduction conditions.Calibration of temperature equipment, gas analysis of flue gases, calorific value measurements could also be obtained in this department.

5. Material Testing Laboratory

Modern and sophisticated instruments such as programmable IR Moisture Balance, Calorimeter, Air Permeability Meter, Visco Meters, such as Brookfield, Torsion, Ferranti, Red Wood Viscometers, Gravitational and Centrifugal particle size analysers, bending strength tester, moisture cabinet, sieve machine and Anderson Pipettes are available in this Laboratory to test the moisture of samples, brightness and whiteness of clay powders, air permeability of clay powders, particle size distribution, viscosity, bending strength of unfired and fired materials and also crazing and moisture expansion tests could be done in this department.

6. Chemical Laboratory

New equipments, such as digital pH meter, calorimeter, flame photometer, automatic centrifuge, crucible furnace are available to carry out the following analysis:

a/ full chemical analysis of all incoming raw materials

b/ glaze raw materials

c/ purity of samples, such as Na_2CO_3, $BaCO_3$, Na_2SiO_3, ZnO, Cr_2O_3, $CoSO_4 7H_2O$, redochres and other chemical samples forwarded by respective units d/ tests for finished products, such as led and cadmium release test

e/ alkali and acid proof test

f/ detergents and boiling test

7. Design Section

This section has a capacity to make new models and designs for different ceramic products.

C Programme of Work for the Year 1986

No industry based on ceramic raw materials can prosper unless the reserves and potentialities of the raw materials are known and fully understood and the problems associated with their behaviour and use are solved. Efficient and continuous research along with quality control in the various stages of production are vital factors in achieving the goal of increased production and higher quality. With this preliminary consideration, the proposed programme for the year 1986 concentrates on the subjects listed below:

1. Studies on ceramic raw material reserves and resources, present raw material production and consumption, near future demands for raw materials and an evaluation of future mineral commodity supplies for the expanding ceramic industry.

2. Investigations on how best waste materials in the various factories and mines could be used in a profitable manner.

3. Formulation of new ceramic bodies, glazes and designs with special reference to the production of ornamental and fancy ware.

4. Studies on the efficient use of local raw materials and the possibilities of replacing imported varieties with local mineral commodities.

5. To make known to the entire ceramic industry of the country and other institutions the facilities available at C.R.L. for raw material testing purposes. Also to provide a reliable and efficient service to all customers both private and public.

C.1 On-going Projects from 1985

The following are the on-going projects which have been assigned to the officers of the various sections:

Laboratory	Project	Officer
X-ray	Composition of Waste Clay from Boralesgamuwa and Meetiyagoda	Mr. H.W.S. Siritunga
	Effects of moisture expansion and thermal expansion on crazing, peeling and spit-out of earthenware bodies (Piliyandala and Negombo)	Mr. C.L. Ranatunga
Mineralogy	Usage of paddy husk as a raw material for ceramics	Mr. N. Karunasinghe
Kiln	Conservation of Energy on the basis of a Thermal Balance Sheet for the Sanitaryware kiln and NGK kiln at the Negombo Plant	Mr. P. Mithraratne
	Effect of heat treatment on different types of alumina based on semi-precious and precious stones	

Laboratory	Project	Officer
Pilot Plant	Development of a hard porcelain body and glaze for laboratory items	Mr. E.C. Alles
	Pfefferkorn plasticity of Sri Lanka Clays	Mr. G.M.A.G.B. Gaspe
Physical Laboratory	Regeneration of Plaster of Paris from used moulds	Mr. A.S. Pannila
	Development of a sagger body for use in industry	Mr. K.P. A. Jayakody
Chemical Laboratory	Study of lead release in ceramics and other tableware	Mr. K.A.N. Dharmasiri
	Cation exchange capacity and its effect on the rheology of local clays	Miss L. Pigera
Designs	Study of current market trends (design-wise) on ornamentalware	Mrs. R.D. Hemalatha
Chief Research Officer	Studies on Pigment Preparation and Application	Mr. B.D.S.R. Silva

c.2 Proposed Projects for 1986

Increasing familiarity with the industrial clays of the Island has brought with it the realization that the clay materials vary widely in character and in their suitability for the manufacture of various products. For these reasons the following projects are listed for the year 1986. Also included in this list are other areas of study which are of interest and value to those concerned with the ceramic industry. These are long-term projects and may continue or run on to the year 1987.

Laboratory	Project	Officer
Chemical	Chemical characteristics of Sri Lanka Ceramic Raw Materials	Mr. K.A.N. Dharmasiri
X-ray	X-ray Diffraction Studies of Sri Lanka Raw Materials	Mr. H.W.S. Siritunga
	Characterization of some Sri Lanka Ceramic Raw Materials by the D.T.A. Method	Mr. C. L. Ranatunga
	An Experimental Study of the Elastic Properties of Clays used in ceramic ware employing the sonic technique (Project partly completed)	Mr. C. L. Ranatunga
Pilot Plant	Building Clays and their behaviour under industrial conditions	Mr. E. C. Alles

Laboratory	Project	Officer
Materials Testing Laboratory	Studies on Sedimentation Techniques in the Refining of China Clays	Mr. K.P.A. Jayakody
Chief Research Officer	Geology, Constitution and Properties of Sri Lanka Ball Clays and China Clays	Mr. B.D.S.R. Silva
Consultant	Sri Lanka Ceramic Raw Material Resources, Production and Consumption	Dr. J. W. Herath

Research Priorities

C.R.L. intends to handle its work load in the order of priorities as listed below:

1. The highest priority would be given to ad-hoc requests made by C.C.C. and other public and private organizations.
2. Every effort will be made to complete the on-going projects which were assigned to research officers of C.R.L. in 1985. A report will be presented on each project completed.
3. Projects listed for 1986 are long-term projects expected to run on to the year 1987. Hopefully, these projects are to be completed by the end of 1987.
4. Case research studies, developed by the UNIDO consultant, will be incorporated into the research programme of 1986 with a high priority.

D Sri Lanka Association for the Advancement of Science (SLAAS)

Every encouragement would be given to all research officers to present research papers at the annual sessions of the SLAAS. Certain on-going projects if completed may merit presentation at the above sessions to be held in December 1986.

Action will also be initiated for research officers of C.R.L. to associate themselves with the SLAAS and also University Departments that focus interest on some aspects of the science of Ceramics. If the C.R.L. officers are properly directed in their research activities, there is also a possibility of getting their names registered at the various universities for obtaining post graduate qualifications. Such a procedure in no way will affect the smooth working of C.R.L.

E Ceramic Society of Sri Lanka

Except for C.R.L., none of the other Research Establishments in Sri Lanka concern thermselves with the totality of ceramic research and development. C.R.L. is gradually developing as the Focal Point for activities concerned with the expanding ceramic industry of the Island. It is therefore considered a responsibility of C.R.L. to initiate action to form a Ceramic Society of Sri Lanka. Steps have already been taken to study the response from the private sector industry to the formation of the above society and their reactions are extremely favourable.

F Brochure for C.R.L.

It is also proposed to prepare a brochure for C.R.L. Such a brochure could highlight the objectives of the laboratory, the present organizational structure, the facilities available and a few of the tangible indicators of progress to date. Its publication however would depend on the funding available for this purpose.

G <u>Status Review Meeting</u>

A Status Review Meeting is held each month to monitor the progress made by each division. Such meetings have tentatively been fixed for the last Friday of each month.

IV. CASE RESEARCH STUDIES

During the mission the UNIDO Consultant was engaged into several research and technological problems which needed to be settled as the support to the management of the ceramic research as well as to the ceramic manufacture. Such problems have arisen in C.C.C. and they have been considered as a real obstacle of the increased sale of goods. In some cases, the increased quality of produced ceramics was believed to be the most important factor to expand the exportation of different products which must, in their quality, correspond to the international Standards in order to be exportable. The following case studies were identified, realized or iniciated during the mission.

A Crazing of Sanitary Ware Products

Glaze crazing of sanitary ware products was considered by C.C.C. as the most important defect of the goods which created such situation that the local market preferred imported sanitary ware being affraid of the local products.

A detailed investigation and studies were made in the Piliyandala Ceramic Research Laboratories and in the Piliyandala Ceramic Plant which produces sanitary ware and earthen tableware. During the past 6 years, the ceramic plant developed a sanitary ware composition as follows:

		1981	1983	1985	1986
siliceous sand	%w.	25	23	21	21
feldspar	%w.	32	34	36	37
washed kaolin	%w.	22	22	22	22
BWS clay +/	%w.	14	14	14	14
BWVA clay+/	%w.	7	7	7	7

+/ Imported raw materials

The foregoing analysis shows that the Company has kept the plastic part of the body composition on the constant basis. In order to reach better vitrification, the content of feldspar was increased from 32% to 37% by decreasing the content of siliceous sand from 25% to 21%. The produced sanitary ware shows low porosity which varies between 0.001 up to 0.79% during last several months.

The manufacture of the sanitary ware body is based on standard operations, open air drying is a slow operation during which no cracks on products occur. Firing of green products is realized in a fully muffle tunnel kiln at the temperature 1250°C. The kiln was installed in 1966, in 1984 a general repair of the kiln was executed. The tunnel kiln is 51.51 metres long with the preheating zone of 19.51 metres, the firing zone of 10.67 metres and cooling zone of 21.34 metres. The firing zone is equipped with 4 burners in each side only. Inside the kiln, there are 26 cars with two floors made from the refractory kiln furniture.

The tunnel kiln represents a small kiln with the projected daily output of 18 cars with the average load of 116 kg. During the presence of a UNIDO expert within the period of September - - October 1985, the kiln was audited and detailed diagnostics on proper kiln installation was done. As a result of that the firing process was intensified and the operation of the kiln was increased by producing 20 cars per day with the good product quality.

However, in December 1985, the kiln output was increased up to 22 cars per day. The fired products were nice, they showed low water absorption mostly below 0.7%. However, laboratory tests indicated low resistance against crazing.

There was a general opinion that the sanitary ware products' glaze crazed and that the products would show moisture expansion after 12 months. Autoclave tests were to show the glaze crazing after 10 hours under the pressure of 3.4 kp/cm^2 (according to the Sri Lanka Standard).

Detailed evaluation of the autoclave tests showed that the test could not be realized during a 1-shift time and therefore each test was carried out twice applying a 2 x 5-hour test under the pressure of 3.4 kp/cm^2. Having finished one 10-hour test, very few cracks occurred in the body and no crazing of the glaze was determined by the ink test.

Therefore, a new series of tests was organized by applying the ink test on

a/ fresh produced products of C.C.C. - firing cycle of 22 cars
b/ C.C.C. products older than 6 months - firing cycle of 18 cars
c/ testing specimens according to the Sri Lanka Standard with the surface bigger than 250 mm^2
d/ imported competitive products
e/ C.C.C. products - firing cycle of 20 cars.

No crazing of glaze had been found on these products before they were put into the autoclave. After the 10-hour autoclave test under the pressure of 3.4 kp/cm^2, the following results were reached:

1. No glaze crazing occurred on the products of C.C.C.
2. No body cracking occurred on the local products produced at the firing cycle of the tunnel kiln 20 cars per day.
3. No difference in cracking or crazing of the sanitary ware was found between large-size products and testing specimens bigger than 250 mm^2.
4. No crazing or cracking occurred on the imported products.

Conclusions related to crazing and/or cracking of the sanitary ware products:

1. To maintain the speed of firing 20 cars per day in order to eliminate cooling cracks of sanitary ware products.
2. To initiate tests on replacing or extending the content of feldspar by fired rejects of sanitary ware.
3. To prefer the continous autoclave tests on specimens of sanitary ware bigger than 250 mm^2 in order to determine the glaze resistance against crazing.
4. To follow the relationship of the coefficients of thermal expansion between the body and the glaze.

B Cracking of Green Porcelain Insulators in the Negombo Plant

Serious troubles occur in the porcelain insulators manufacture of the Negombo Plant. Green semi-products, after the external surface has been cut and shaped, show cracks in the amount of 30% of the total, and rejects, occurring during the firing, amounts to 50% of the total. Cracking of insulators is a great financial loss as the ex-factory price per piece amounts to nearly US $ 1.

An analysis made in the plant shows that the body is composed of

Feldspar	25%
Quartz	23%
Kaolin Boralesgamuwa	26%
Ball clay Dediyawala	26%
Total	100%

The content of non-plastic raw materials of the body is low reaching 48% only. No fired grog is added. The body is prepared by a standard wet grinding technology with filter-pressing and extrusion from a deairing pug mill. The raw material reserve in the factory is low, the recommended stock is for 2 - 3 months' operation. Porcelain insulators are shaped on cutting machines by providing the green clay cylinder by interior shapes and screws. After 24 hours, i. e. the next day, the surface shaping of the semi-product is done when its surface is already hardened. Cleaning of the shaped surface is done by a wet sponge. Then the shaped unglazed green insulators are placed on a drying car for open-air drying the speed of which must differ during the rainy and dry seasons.

The dried insulators are then provided with a raw glaze of the following composition:

Fedlspar	144 kg
Quartz	45 kg
Kaolin washed	6.5 kg
Calcined kaolin	17 kg
Dolomite	25 kg
$ZrSiO_2$ (fine)	35 kg
$CaCO_3$	35 kg
$CoCO_3$	0.05 kg
Na_2CO_3	0.05 kg

Firing is realized in a tunnel kiln at the temperature $1300^{\circ}C$ and the glaze fits to the body well. However, it is recommended to extend the glaze composition by fired rejects.

In order to assist the ceramic plant in Negombo, immediate recommendations were given as well as a case study was suggested and negotiated to be implemented by C.R.L.

a/ Immediate Recommendations

1. Cracking of green products increased when the dry season started. Extruded clay from the deairing pug mill is hot. It is possible that water evaporation from the surface layers of the wet semi-products is higher than the normal one and after products'

shaping the next day the fresh body cracks. Therefore, it is recommended to cover the cars loaded with green semi-products with wet and dry textile covers alternatively.

2. In order to determine the safety interval of predrying of semi-products to conduct experimental cutting and shaping of insulators immediately after semi-products are made and then in each 2-hour interval. To compare the results with the actual situation of the green and fired rejects.
3. Never to put water or a wet sponge on green products to clean the surface. The moistured surface cracks during drying.

b/ Case Studies

1. The porcelain insulators' manufacture is based on the body composition as follows:

Feldspar	.....	25%
Quartz	....	23%
Kaolin B.	.....	26%
Ball Clay D.	...	26%
Total		100%

This composition shows that the non-plastic raw materials in the blend are represented in a low proportion of 48% of the total and no fired reject is used being wasted. To increase the non-plastic material content in the blend, it is recommended to add on the top of 100% additional 3%, 5% and 10% of fired rejects and to evaluate the results. If necessary, the content of feldspar and quartz can be adjusted according to the results obtained.

2. The addition of the porcelain fired rejects into the raw glaze always improves the harmony between the glaze and the porcelain body. Therefore, the addition of 5%, 10% and 20% of the fired glazed rejects into the batch of the glaze is recommended for researching and evaluation. Following the results obtained, the amount of feldspar and/or calcined kaolin can be adjusted accordingly.

Conclusion

After the shaped green products had been dried under the reduced speed of water evaporation being covered with a cover, within a few days the green reject dropped down. The fired reject started to be reduced before the mission was terminated. However, it has to be considered that the porcelain insulators' body is sensitive for cracking and the negotiated case study should be implemented in order to make the porcelain green body more resistant against crazing.

C Lanka Refractories in Hanwella

The plant was established few years ago in order to produce the yearly capacity of 10,000 tonnes of fireclay and insulating products, high alumina, magnesite and chromium-magnesite refractory standard and shaped bricks. The country having opened the free market conditions, the plant lost some of its customers because it was unable to produce competitive quality of bricks with competitive prices. Therefore, the plant management started to diversify the manufacturing programme in order to cover the actual demand for products which can be produced successfully under existing conditions.

Locally available raw materials are as follows:

- kaolin Methiyagoda with its refractoriness 1760°C, used as powdered for fireclay blends or in filterpress-cakes for the production of the refractory grog,
- clay Dediyawala, with its refractoriness 1710°C, used as powdered or in lump pieces similarly as the kaolin Methiyagoda

- grog from the kaolin, produced in the factory
- grog from the clay, produced in the factory
- graphite with big flakes or a powdered grade
- red clay available from a local mine used for red-brick making
- fired rejects from the own manufacture and used cordierite kiln furniture from other associated factories

Imported raw materials are sintered magnesite, chromium ore and calcined high alumina materials, such as cyanite and sillimanite.

The case studies, some of which have already been initiated, are recommended to be oriented to:

1. Comprehensive testing of presently available local raw materials with its technological evaluation
2. Graphite crucibles' manufacture
   Sri Lanka is a rich country with extensive reserves of graphite which is represented in different sizes of graphite flakes. The management conducted already a test on the graphite crucible manufacture with the following body composition:

fine graphite	50%
SiC	13%
fine ball clay grog ..	15%
powdered ball clay ...	22%
Total	100%

The shaping of crucibles was different. The shaped crucibles were fired in a tunnel kiln under the reducing graphite protection. However, after firing, the crucibles showed low mechanical strength.

The situation was analyzed with the following conclusions and recommendations for further experiments to be conducted:

a/ To use big flakes of graphite in the manufacture of graphite crucibles which show better properties and quality for the customer.

b/ The total amount of non-plastic raw materials in the body amounts to 78%, which is too much for plastic shaping of crucibles into the plaster moulds.
To increase gradually the content of the powdered ball clay by replacing the grog. The content of graphite in the composition can also be lowered by 5 to 10%.

c/ If the required mechanical properties of crucibles are still not reached after firing, to insert into the body composition alternatively 5% to 10% of powdered feldspar.

d/ After the plastic body composition is extruded, to let the green body ageing for 2 - 3 weeks under a wet cover.

e/ To shape the crucibles without using water for cleaning their surface.

f/ If any cracking occurs during the open-air drying, to cover the crucibles with a textile to reduce the speed of evaporation.

g/ To fire the crucibles under the protecting atmosphere.

3. Cordierite kiln furniture's manufacture

The plant produces successfully different types of the kiln furniture from fireclays and high alumina blends. The management also started to produce the cordierite kiln furniture from the used imported cordierite kiln furniture from other associated ceramic plants by blending 75% of cordierite grog with 25% of local refractory clay.

A good suggestion was developed for the manufacture of the synthetic cordierite manufacture. In the entdusting equipment there is a mixture of fine magnesite and kaolinite since the plant produces both magnesite and fireclay refractories. This blend, after having the regulated content of magnesite reaching the limit of 13%, shows after firing the content of cordierite.

In order to develop the technology of cordierite kiln furniture, to consider further steps to be undertaken:

a/ The composition of cordierite is defined by the formula $2\ MgO.2Al_2O_3.5SiO_2$ and with its low linear thermal expansion of 0.1×10^{-6}. The pure cordierite composition is difficult to be reached under existing conditions, however, it is possible to say that the higher will be the cordierite content in the kiln furniture, the lower will be its expansion and the higher will be its thermal shock resistance.

b/ Depending on raw materials used, cordierite is usually created in the temperatures above 1200^oC when spinel $MgO.Al_2O_3$ enters into the reaction with cristoballite SiO_2 creating cordierite $2MgO.2Al_2O_3.5SiO_2$. The optimum firing temperature usually fluctuates around 1370^oC. If the cordierite is heated above 1400^oC, it starts to decompose again into mullite $3Al_2O_3.2SiO_2$ and the glass phase.

c/ In order to reach the optimum content of cordierite in the fired product, a higher content than the theoretical one of talcum or magnesite in the body composition is to be represented. In all cases the amount should exceed 13%. Depending on applied raw materials, the content of talcum or magnesite in the composition fluctuates between 16% up to 30% of the total.

d/ The best cordierite products are produced from the grog and from the bond of the same mineralogical composition. Therefore, to try to add some fine magnesium raw materials also into the clay bond.

e/ If, at present, the tests are made by blending the grog in the ratio 13% of $MgCO_3$ and 87% of kaolinite, then to try other ratios by increasing gradually the content of $MgCO_3$ up to 30% and 70% of kaolinite. To evaluate all experimental blends and choose the best one. Then, to try to mix the best grog with the bond of the same composition.

f/ In order to maintain the proper firing temperature of the cordierite grog and products, to load these products on the upper part of the kiln cars which shows a lower firing temperature than the lower part due to the open firing system of the kiln.

4. The manufacture of unglazed red floor tiles of the standard size can be realized in the refractory plant. However, it is recommended to use other red clays than available at the factory site since they do not provide a nice deep red colour.

Any rejects available in Sri Lanka contaning different colouring oxides or metals, such as iron, titanium, chromium, mangan and others, might be mixed into the red clay in order to get a more contrast shade.

On the other hand, the Geological Services of Sri Lanka should be consulted for their reference on the availability of plastic clays with different deep colours after firing.

One of the possible solutions is the application of the so called red ochre pigment into the red floor tile body as it contains over 22% of Fe_2O_3. The red ochre occurs in huge deposits in the South of Sri Lanka, nearby Hungama.

D Ball Clay Factory in Dediyawala

The ball clay deposit at Dediyawala is an extensive one being located as the sedimented deposit in a large valley. The surface of the deposit amounts to several dozens of square kilometers. Under a thin overburden of average 1.5 f there is a layer of 5 f of a white-yellow clay. 10 f of blue-white clay are underlaying the white-yellow clay. The bottom of the deposit is created by a black clay and by a siliceous sand. The total thickness of high-quality clays amounts up to 15 metres.

The UNIDO Consultant was told that the Company mined yearly about 60,000 t of white-yellow and blue-white clays while the black clay had not yet been exploited. The large deposit is mined in several pits on different sites of the valley and the quality of both clays from different pits seems to be equal.

There is an up-grading plant installed in the Ball Clay Factory. Both types of ball clays are dried under sunshine and the white-yellow clay is powdered. The installation, made locally, consists of a fire side fired by wood, drying chamber, desintegrator, bin and a bagging machine. The transport is carried out on belts and by an elevator. The ground clay is well powdered and homogenized.

While the ball clays in lumps are sold ex-factory to the ceramic and refractory industries of Sri Lanka for Rps. 475 per tonne, the up-graded powdered clays are sold for Rps. 1,225 per tonne.

The case study is recommended to be oriented to:

- Integrated evaluation of white-yellow, blue-white and black clays.

The ceramic and other industries of Sri Lanka do not distinguish too much the types of clays from Dediyawala. Therefore, integrated testing is recommended to be conducted separately of white-yellow, blue-white and black clays in order to consider

a/ the substitution for some still-imported ball clays, specially in the casting technology,

b/ the possible exportation of Sri Lanka clays and technologies to neighbouring countries' markets

c/ the preparation of blends from available three clays with the defined quality.

E <u>Lanka Wall Tiles Co. Ltd. Balangoda</u>

The wall tile plant in Balangoda has been operating since 1975. It is a well managed ceramic plant producing 5,000 m^2 of double fired glazed wall tiles daily, with the yearly capacity over 1 million m^2. The wall tiles are produced in 2 main dimensions, i.e. 4"x4" and 6"x6", in white, black and many other colours, a part of the production is decorated on the fired as well as on the raw glaze. 80% to 85% of glazed wall tiles from the total manufacture are exported to the neighbouring countries' markets.

The wall tile body is composed of the following raw materials:

Dediyawala ball clay	.....	34.6%
Balangoda raw kaolin	.....	10.4%
Korean pyrophillite	.....	24.2%
Balangoda limestone	.....	13.3%
siliceous sand	.....	17.5%
Total		100.0%
glazed reject	....	3.0%
bisque reject	....	6.0%

The plastic and non-plastic raw materials are ground separately, then mixed together, spray-dried and pressed. The pressing operation is realized by presses from 2 different suppliers. Presses A press 8 tiles 4"x4" in one line during one stroke. Presses B press 6 tiles 4"x4" in each of three lines during one stroke. The pressed tiles are loaded on the bisque tunnel kiln cars and fired in 1100°C. The bisque after sorting is glazed on different water-fall glazing machines. The glost firing is made in an open-fire tunnel kiln. Therefore, the glazed wall tiles are put in the vertical position into refractory boxes, made locally. The glost firing takes place at the temperature 1060°C. Glazes are made locally from imported frits which amount to 65% of the total glaze composition.

The quality of glazed wall tiles is very good showing the glazed reject of 3% and the bisque reject of 6% only.

There is one factor which needs to be studied in the factory. The water absorption of glazed tiles in some cases exceeds 18% and such wall tiles are not exportable according to A.S.T.M.

The case studies are recommended to be oriented to:

1. Replacing the imported pyrophillite by local raw materials
2. Lowering the water absorption below 18%

1. Wall tile manufacture from domestic raw materials

The standard lime-siliceous body composition of glazed wall tiles is based on

- plastic raw materials - clays and kaolins
- siliceous raw materials - silica sands, quartz, flint, raw kaolin, sandy clays, etc.
- calcareous or even calcareous-magnesium raw materials

- limestone, chalk, shells, spongellite, wollastonite, pyrophillite, marl slate, dolomite and others.

There is no condition that the pyrophillite must be one of the body components. The calcareous raw materials are interchangeably replaceable.

The plastic body components to the non-plastic ones range usually between 40:60 up to 50:50. The content of the main oxides of the lime-siliceous wall tile body fluctuates usually within the following limits

66 to 70% of silica
17 to 20% of alumina
9 to 11% of calcium oxide

Such bodies are usually bisque fired within the temperature range of 1040 - 1060°C and they do not shrink during firing.

According to the rational composition, the wall tile body should contain

35 to 37% of kaolinite
36 to 41% of quartz
13 to 15% of limestone
about 2% of $Fe_2O_3+TiO_2$ for light coloured bodies, if otherwise, even more
6 to 8% of alcaline feldspar from plastic clays
3 to 5% of reject

Two possible examples of the lime-siliceous wall tile body composition are suggested:

Plastic clays	35 - 45%
Raw kaolin with a very high content of quartz	35 - 40%
Calcium carbonate	13 - 16%
Reject	5 - 10%

Plastic clays	40 - 50%
Silica sand	30 - 35%
Calcium carbonate	13 - 16%
Reject	5 - 10%

After recalculation of the chemical composition of local raw materials to the rational - mineralogical one, to calculate different body blends according to the suggested compositions and fire the body to 1040°C and to 1060°C and test the physical properties. It is necessary to check always the coefficient of thermal expansion and control the harmony between the ceramic body and the glaze.

2. Lowering the water absorption of glazed wall tiles

To lower the water absorption of glazed wall tiles without influencing the coefficient of thermal expansion can be a complicated technological problem which always has to be approached from 2 different aspects:

a/ Body composition

always plays an important role. The general recommendations are

- to increase the content of the plastic clay
- to reduce the content of silica in the body
- to increase slightly the content of calcium carbonate in the body.

In case of Lanka Wall Tiles Co. Ltd., there is a specific situation that the Dediawala ball clays vitrify at the temperature above 1300°C. Therefore, other fluxes might be needed in the body than feldspar which will also act as a flux at the bisque firing temperature. It is recommended to

- add 2% and 4% of glazed tile reject to the body and to evaluate the water absorption of the wall tiles
- add 2% and 4% of glass reject to the body and to evaluate the water absorption of the wall tiles.

Note: It is necessary to check always the harmony with the ceramic glaze.

b/ Technological factors

The size of ground raw materials should be checked and the influence on the water absorption of fired glazed wall tiles is to be evaluated.

A very important technological factor is the pressing operation. The influence of the pressing power on the density of pressed green products and on the water absorption of fired glazed wall tiles is to be evaluated. The recommended pressing power is usually between 300 and 350 kp per cm^2. However, the pressing power will always depend on the pressability of locally available clays.

The detailed analysis made in the Lanka Wall Tiles Co. Ltd. shows that wall tiles are pressed in 2 presses. Presses A, showing higher specific pressure and pressing 8 tiles in one line, produce wall tiles the water absorption of which amounts to 17.5%. Presses B, pressing 6 tiles in each of three lines, produce wall tiles with the average water absorption of 18.4%. Therefore, the immediate solution for lowering the wall tile water absorption is to increase the pressing power for pressing green pressed tiles or to reduce the number of pressed tiles during one stroke and to increase the number of strokes during one minute.

F Kaolin Washing Plant in Boralesgamuwa

The Kaolin Washing Plant in Boralesgamuwa was established about 25 years ago with the standard technology based on a Bavaria washing machine, screening of mica, hydrocyclones of 50 mm diameter, round thickener, mixing basin, filterpresses, a three belt drier with preshaped kaolin chips, grinding and filling machines.

The kaolin deposit is close to the plant. Though a part of the deposit was excavated during the past 25 years, the reserves searched by the company show a fair amount for a couple of dozens of forthcoming years. The raw kaolin is very rich showing about 60% of kaolinite and 40% of fine quartz with some mica, ilmenite and other impurities. The sedimented deposit shows different grades of brightness of kaolin in different parts.

At present, the kaolin plant operates at about a yearly capacity of 5,000 tonnes, however, its output might be increased up to about 20,000 tonnes a year if the market exists. The production is directed to the paper, rubber, paint and ceramic industries.

The possible case studies are recommended to be oriented to the following aspects:

1. To try to increase the brightness of washed kaolin by the application of high-intensity electromagnetic separation. Such tests and research should be done abroad as C.R.L. is not equipped with a suitable separator.
2. To supply the filler-grade kaolin to the paper industry with 10% humidity according to the world Standards.
3. To examine the possibility to produce the coating-grade kaolin for the paper industry since the kaolin shows 70% of particles below 2 microns and only 10% of particles bigger than 10 microns. The brightness of the produced kaolin will be the decisive factor.

G Kaolin Washing Plant in Methiyagoda

The washing technology of kaolin used is a standard technology based on a Bavaria washing machine, screening of mica, 4 hydrocyclones of 50 mm diameter, two round thickeners, a mixing basin and 3 filterpresses. No drying is made in the plant, filterpress kaolin cakes are stored for a certain time and predried before they are expedited. No ferro-filter is in the manufacturing flow.

The raw kaolin is mined from several pits of a large deposit. According to the whiteness of the raw kaolin, two grades of washed kaolin are produced:

- upper grade with the whiteness between 80 - 85 grades with the blue filter
- industrial grade with the whiteness around 80 grades with the blue filter.

The upper grade of washed kaolin is supplied to the porcelain tableware manufacture in Sri Lanka, i.e. Lanka Porcelain Ltd., which claims two factors of the washed kaolins:

a/ brightness which should be higher than 85 grades with the blue filter

b/ amount of fine particles below 2 and 8 microns should be increased in the washed kaolin.

The case research studies on the kaolin refining technology of Methiyagoda kaolins are recommended to be directed to:

1. High intensity electromagnetic separation of the kaolin slurry which might increase the brightness of the kaolin by 3 - 5 grades. However, such tests are to be conducted abroad since C.R.L. is not provided with a suitable separator.
2. Separation technology with hydrocyclones which does not correspond to the actual requirements of the Sri Lanka porcelain manufacture.

In order to develop the case research study, the kaolin washing technology was studied in detail.

The present situation of hydrocyclones is given by four hydrocyclones of the diameter 50 mm each. The hydrocyclones are marked A, B, C and D.

The slurry of the kaolin and fine sand is pumped into the hydrocyclones A and B. The overflow goes into the thickener while the underflow is directed into the hydrocyclone C. The overflow of hydrocyclone C joins the overflow from hydrocyclones A and B and this mixture flows into the same thickener. The underflow of hydrocyclone C goes to the hydrocyclone D which represents the final stage of separation because its overflow joins the fresh slurry of kaolin and fine sand which enters hydrocyclones A and B and the fine sand leaves the production as the reject.

C.R.L. conducted different tests on the particle size leaving hydrocyclones as follows:

	Hydrocyclones			
% particles below	A	B	C	D
2 microns	57.0	54.8	48.5	48.2
8 microns	80.5	82.3	75.5	78.0

The tests prove that hydrocyclones A and B separate finer particles of washed kaolin as getting fresh slurry from the washing process. Hydrocyclones C and D represent the second separation process extracting the washed kaolin from the underflown mixture of sand and kaolin from hydrocyclones A and B. Since a bigger amount of finer particles of kaolin was already "extracted" from the kaolin in hydrocyclones A and B,a smaller amount of fine particles in the washed kaolin is created by hydrocyclones C and D. The delamination process of coarser particles into finer ones seems to be expensive for the technology installed in the Methiyagoda kaolin washing plant.

A cheaper solution can be obtained by the rearrangement of the kaolin flow through hydrocyclones.

It is obvious that hydrocyclones A and B are providing the amount of fine particles which corresponds to the requirements of Lanka Porcelain Ltd. Therefore, the washed kaolin overflowing hydrocyclones A and B can be directed separately to the thickener No. 1 and Extra Upper Grade of washed kaolin can thus be produced for the procelain industry.

The washed kaolin with a smaller amount of fine particles leaving hydrocyclone C can be directed to the thickener No. 2. Further analyses will show if the overflow from hydrocyclone D can go directly to the thickener No. 2 or if the present situation is preferrable in which the overflow from hydrocyclone D is returned back into the entry of hydrocyclones A and B. This industrial grade of washed kaolin can be sold to the refractory industry or as a filler to the paper and rubber industries.

The firing test made with sands leaving the washing process has certified the result that the majority of impurities in the kaolin slurry is separated jointly with the fine sands which are not, therefore, applicable in the ceramic manufacture.

H Lime Plant in Hungama

The Lime Plant in Hungama produces daily 18 to 19 tonnes of quick-lime, which is partly converted into the hydrated lime. The technology is based on the washing and calcining of sea shells in a rotary kiln which is 60 f long and 9 f wide. The decomposition of sea shells takes place at the temperature of 1100°C in the contra-current heat flow. Motor Diesel oil is used for heating the rotary kiln.

The case research studies are recommended to be oriented to:

1. Replacing the Motor Diesel oil by the heavy fuel oil to lower the manufacturing costs

2. Energy savings by installing a preheater for preheating sea shells before entering the rotary kiln.

At present, sea shells are still wet when inserted into the rotary kiln as they must be washed before calcining.

The exit temperature between the rotary kiln and the chimney amounts to 720^{O}F and this waste heat is not utilized at all. By installing a simple preheater sea shells will be dried and preheated to the temperature between 200 - 300^{O}C before entering the rotary kiln which will influence not only the heat consumption but also the output of the rotary kiln.

I Evaluation of Ceramic Bodies According to Their Rational Composition

There are several ways of the evaluation of ceramic bodies. The less accurate one is based on the comparison of crude raw materials' inserts into drum mills. A better way is in comparing the blends according to their chemical composition. However, the best method is developed based on the evaluation of the rational (mineralogical) compositions of ceramic raw materials and bodies, comparing the content of minerals, such as kaolinite, feldspar, quartz and limestone, as the activity of each mineral in any ceramic body during firing is well known. Therefore, it is recommended to start with the evaluation of ceramic raw materials and products according to their rational compositions of the fired body. If the rational composition is not known or if it has not yet been conducted by C.R.L., it can be recalculated according to the following procedure.

1. To recalculate the chemical composition for the fired body, i.e. without the loss on ignition.

2. Conversion of the chemical composition of unfired body into the mineralogical composition.

A Principle of the calculation:

1. The content of Na_2O is to be converted to sodium feldspar (albite) $Na_2O.Al_2O_3.6SiO_2$, the content of K_2O is to be converted to potassium feldspar (orthoclase) $K_2O.Al_2O_3.6SiO_2$
2. The content of Al_2O_3 in both the feldspars is to be deducted from the total content of Al_2O_3 and the clay substance (kaolinite) is to be calculated from the remaining Al_2O_3.
3. The content of SiO_2 in the feldspars and in the clay substance is to be deduced from the total content of SiO_2 the rest being free silica.
4. Cao and MgO should be converted to carbonates.

B Calculation

1. The content of Na_2O in terms of % multiplied by 8.450 = the content of sodium feldspar in terms of %

   The content of sodium feldspar in terms of % multiplied by 0.1944 = the content of Al_2O_3 in sodium feldspar

   The content of potassium feldspar in terms of % multiplied by 0.6873 = the content of SiO_2 in sodium feldspar

   The content of K_2O in terms of % multiplied by 5.907 = the content of potassium feldspar in terms of %

   The content of potassium feldspar in terms of %

multiplied by 0.1832 = the content of Al_2O_3 in potassium feldspar

The content of potassium feldspar in terms of % multiplied by 0.6475 = the content of SiO_2 in potassium feldspar

2. Total content of Al_2O_3
   - total of Al_2O_3 from the feldspars
   Al_2O_3 from kaolinite multiplied by 2.531 = the content of clay substance in terms of %

   Clay substance multiplied by 0.4651 = the content of SiO_2 in kaolinite

3. Total content of SiO_2

   - SiO_2 from the feldspar
   - SiO_2 from the clay substance

   SiO_2 - free silica

4. The content of CaO in terms of % multiplied by 1.785
   = the content of $CaCO_3$ in terms of %

   + the content of MgO in terms of % multiplied by 2.091 = the content of $MgCO_3$ in terms of % = the total amount of carbonates

C Checking

Content of sodium feldspar	%
+ Content of potassium feldspar	%
+ Content of clay substance (kaolinite)	%
+ Content of silica	%
+ content of carbonates	%
	100 %

As soon as the rational - mineralogical composition of all entering ceramic raw materials is known, further calculations are conducted according to the enclosed sheet "Body Composition".

UNIDO-Czechoslovakia Joint Programme for International Co-operation in the Field of Ceramics, Building Materials and Non-metallic Minerals Based Industries
Pilsen, Czechoslovakia

Confident

Blend No.

BODY COMPOSITION

19

I.	II.	III.	IV.				V.					VI.	VII.	VIII.	IX.	X.
Raw Material	% (burnt)	No. of Analyses	Rational Composition of Burnt Raw Material %				Rational Composition of Burnt Blend %				Total	% after Igniting	Dried Blend	% after Drying	Crude Blend	Batch of ______ kg
			K	Q	F	L	K	Q	F	L						
Total Batch																

	K	Q	F	L	Grog
New Blend No.					
Standard Blend No.					
Note :					

K .... Kaolinite
Q .... Quartz
F .... Feldspar
L .... Limestone

Calculated by ______________

Checked by ______________

Approved by ______________

V. FINAL NOTE

The UNIDO mission to the Ceramic Research Laboratory was realized in the right time. The new Director of the Laboratory was appointed, senior and research officers trained abroad and the laboratory started a new phase of its activities.

During different visits of the UNIDO consultant to the ceramic and raw materials industries of Sri Lanka, different case research studies were identified, analyzed, negotiated with the management of C.C.C. and Ceramic Research Laboratory, some of them were started and 2 of them finished during the duration of the mission.

In order to assist the C.C.C. Authorities, the UNIDO Consultant also negotiated with the research officers the way of making ceramic raw materials inventory. Suggested forms are attached to the Terminal Report.

The management of C.C.C. was also interested in a paper of main faults of the glazed ceramic products. Following the recommendation of the UNIDO Headquarters, such a publication is of interest of many developing countries and, therefore, it will be edited as a separate publication of the UNIDO-Czechoslovakia Joint Programme for International Co-operation in the Field of Ceramics, Building Materials and Non-metallic Minerals Based Industries in Pilsen and supplied to C.C.C. later on.

The samples of non-metallic raw materials sent by C.C.C. to the UNIDO-Czechoslovakia Joint Programme for testing and technological evaluation will be tested and the respective report sent to C.C.C. within 3 months after their receipt.

The C.C.C. technicians who might be present during the time of testing and evaluating those raw materials, will actively participate in this matter.

VI. ATTACHEMENTS

1. Terms of Reference for Testing of Sri Lanka Raw Materials in the UNIDO-Czechoslovakina Joint Programme in Pilsen

2. Raw Materials Work Sheet

3. Raw Materials Summary Sheet

Annex I Terms of Reference for Testing of Sri Lanka Raw Materials in the UNIDO-Czechoslovakia Joint Programme

A <u>Dediyawala Ball Clays - three samples</u>

Ball clays exist in three varieties according to the visual evaluation, i.e. blue, black and yellow. Testing and technological evaluation of all three clays is required since the local industry does not distinguish both qualities and the black clay is not yet industrially exploited at all.

B <u>Methiyagoda Raw Kaolin</u> - two samples

The raw kaolins are mined from different pits of one large deposit. They occur in two different qualities called as the upper grade and industrial grade. While the upper grade is used for the Sri Lanka porcelain industry only, the industrial grade is sold to other ceramic, paper and chemical industries.

However, the porcelain industry requires a higher whiteness than available at present. Therefore, tests on the increase in the whiteness of the upper as well as industrial grade are required.

C <u>Nattandiya Silica Sands and Matale Quartz</u>

At present, the Sri Lanka glass industry is limited in the manufacture of bottles produced from Nattandiya silica sands without proper refining. Since the Sri Lanka Authorities are interested in the table glass- and crystal glass manufacture, the evaluation of existing silica sands and quartz is requested. Semi-industrial melting tests are required, too.

D <u>Red Ochre Tangalle</u>

Red ochre raw materials occur in Tangalle in huge reserves. The mineralogical, chemical and technological evaluation is requested as the checking of locally available results.

E <u>Feldspar Rattota,Matale District</u>

Chemical analyses and melting tests are required as the checking of locally available results.

UNIDO-CSSR JOINT PROGRAMME

PILSEN

CZECHOSLOVAKIA

CERAMIC RAW MATERIAL WORK SHEET

Date :

Deposit :

Test level :

F-No										
C-No										
Date of Delivery to LD										
1. Natural Humidity %										
2. Particle size % Bigger than 2,000 Mic.										
630 - 2,000 Mic.										
200 - 630 Mic.										
50 - 200 Mic.										
30 - 50 Mic.										
5 - 20 Mic.										
2 - 5 Mic.										
Smaller than 2										
3. Workability Point %										
4. Chemical Analyses % loss of Ignition										
SiO										
Al_2O_3										
TiO_2										
Fe_2O_3										
CaO										
MgO										
K_2O										
Na_2O										
P_2O_5										
CO_2										
SO_3										
5. Rational Analyses % Kaolinite										
Quartz										
Feldspar										
Lime - Stone										
6. Refractoriness SC (°C)										
7. Linear Drying Shrinkage %										
Modulus of Rupture Kg/cm²										
8. Firing Temperature										
Linear Shrinkage %										
Water - absorption %										
Porosity %										
Bulk Density %										
Modulus of Rupture kg/cm²										
Description										
9. Firing Temperature										
Linear Shrinkage %										
Water - absorbtion %										
Porosity %										
Bulk Density %										
Modulus of Rupture Kg/cm²										
Description										
10. Cl [illegible]										

UNIDO-CSSR JOINT PROGRAMME

PILSEN

CZECHOSLOVAKIA

CERAMIC RAW MATERIAL SUMMARY SHEET

No.	Name :	Date :

1. Locality : Mine : Mapping :

2. Geological and Petrographical Characteristic :

3. Reserves Estimate :

4. Natural Humidity % :	Summer				
	Winter				
5. Partical Size %	Bigger than 2.000m				
	630 - 2.000m				
	200 - 630m				
	50 - 200m				
Dispersing Agent :	20 - 50m				
	5 - 20m				
Shaked for :	2 - 5m				
	Smaller than 2m				

6. Workability Point % :

7. Chemical Analysis % :

Loss Ign	SiO_2	Al_2O_3	TiO_2	Fe_2O_3	CaO	MgO	K_2O	Na_2O	P_2O_5	CO_2	SO_3	Note

8. Rational Analysis % :

Kaolinite	Quartz	Feldspar	Limestone	Note

9. Linear Drying Shrinkage %				
Modulus of Rupture kg/cm^2				

10. Deflocculation
The Best Deflocculation Agents :
Optimum of Addition ‰ :
Ceramic Slurry :
Thickness of the Body :
PH of Slurry :
Water Soluble Salts :
Note :

11. Refractoriness SC (°C)

12. Firing Tests : Firing Temperature °C				
Linear Shrinkage %				
Water - absorption %				
Porosity %				
Bulk Density %				
Modulus of Rupture kg/cm^2				
Description				

13. Mineralogical Evaluation :

	%	Type of Mineral	Method Used
Kaolin Group			
Montmorilonite Group			
Mica Minerals			
SiO_2 Minerals			
Feldspar Group			
Limestone Group			

14. Other Factors :

15. Suggested Usage :

Tests Carried out by :

Geological Evaluation Done by:

Processing Evaluation Suggested by :