CSIR NETWORK PROJECTS

Network project on new building construction materials and technologies

Development of glazed brick utilizing locally available raw materials

Bricks were developed with much improved ceramic properties in comparison to commercially available building bricks having water absorption (cold) 4-6%, water absorption (hot) 7-9% and CCS as high as >25 MPa. The saturation coefficient value of the product was between 0.76 and 0.78, thus ensuring better durability. Matching glazes (both opaque white and coloured) were developed. No efflorescence or crazing of glaze were observed with the glazed products. Steps for networking with the nodal laboratory i.e. Central Building Research Institute, Roorkee was initiated for evaluation and commercial exploitation of the glazed bricks with prospective entrepreneurs.

Photographs of glazed building bricks

SEM of pyrophyllite incorporated tile product showing well developed mullite crystals

Fly ash incorporation in place of quartz for floor tile body led to an increase in strength. SEM has shown well developed mullite needles embedded in the matrix that led to strength improvement in fly ash incorporated tiles.

Flexural strength distribution of fly ash incorporated tiles

that variation in mullite proportion (needle shaped secondary mullite) was responsible for difference in flexural strength developed in the final products.

SEM of fly ash incorporated tiles
In addition, firing temperature could be reduced opening up possibilities of producing low cost building materials utilizing several waste materials. **Development of porous tiles from marble dust and other industrial wastes for humidity and temperature control in residential buildings**

Process of hydrothermal treatment for strength development in lime bearing systems is known since long but research on hydrothermal reactions and solidification behavior in the system CaO–SiO₂–H₂O system is of recent origin. Majority of the investigations are based on high purity raw materials. Owing to gradual depletion of good quality earthy minerals and higher cost, the acquisition of pure variety of raw materials is becoming increasingly difficult. As a result, the need for recycling and reuse of various waste materials have become important.

Calcined marble dust can be used as an alternative source of active CaO for hydrothermal solidification of clay - quartz mixtures. Marble dust (200µm size), air and water polluting waste, generated by the marble cutting industries was used as cheap source of lime for hydrothermal solidification of clay - quartz mixtures at different saturated steam pressure (0.525 - 1.225 MPa). Marble dust was calcined at two different temperatures (900°C and 1000°C) and then added to the clay - quartz mixture, with clay/(clay + quartz) ratio 0.9. The hydrothermally solidified samples were characterized by bulk density, apparent porosity, flexural strength, porosimetric study, phase and microstructural analysis and the results were compared against similarly treated chemical grade CaCO₃ containing compositions.

Hydrothermal treatment of clay–quartz mixtures with calcined chemical grade CaCO₃ or calcined marble dust produced tobermorite and hydrogarnet as the major hydrated phases. The SEM of the hydrated sample revealed a network structure of these hydrated phases. These features contributed towards development of higher strength in the samples. Porosimetric data on hydrated samples revealed that chemical grade CaCO₃ containing samples had higher exposed surface area and indicated greater hydrothermal reaction. This is also supported by X-ray diffraction study where higher intensity of hydrated phases was observed than the marble dust containing compositions.

**Scanning electron photomicrograph of the hydrated sample**

Pore size of the samples with marble dust in the compositions was found to be on the higher side. The combined properties of low density, higher porosity and adequate strength obtained in the developed hydrothermally treated CaO–SiO₂–Al₂O₃–H₂O system may be suitable as new building materials where presence of mesopore with inherent micron range pore size distribution are important parameters to control humidity and temperature in buildings.

**EXTERNALLY FUNDED PROJECTS**

**Studies on the rouletted and black pottery from early historic sites of the eastern coast and mid Gangetic plain**

The objective of this project was to utilize the methods and techniques available in order to understand certain aspects of archaeological pottery with respect to (i) possible body composition & firing temperature of the ancient pottery wares and (ii) ancient technology of pottery practice.
A total of 180 specimens were collected and 6 varieties were chosen for study (Red, Grey, Black polished, Black slipped and Northern black polished wares). The chemical analysis of Rouletted & Black ware revealed the following composition:

- Highly siliceous materials – mostly of clay source alone
- (SiO₂: 60 – 70 wt%)
- Ferruginous (Fe₂O₃: 4 – 8 wt%)
- Red clay variety
- Alkali (K₂O + Na₂O: 3 – 6 wt%) – high alkali bearing clay and other sources of alkali added.

The characteristic cellular structure associated with extent of vitrification remained essentially unchanged over a temperature range of about 2000°C (800-1000°C) and thereafter the control of the temperature attained during firing was not particularly critical. Rouletted ware, Arikamedu type 10 and fine grey ware showed both chemical and mineralogical similarities indicating not only a common origin but also a similar paste technology of Chandrakhetugarh.

![Rural folk at work in CCRD, Panchmura, Bankura](image)

Presence of minerals like montmorillonite, illite and quartz as well as clay of different regions have been revealed in the pottery wares.

Comparing the wares of different colours i.e. black and red ware, tan slipped red ware, coarse red slipped ware and coarse grey ware, it may be assumed that the ancient potters were able to use the same paste recipe to make different forms, which demanded different surface treatment and firing and even finally a difference in their physical properties. Chemical analysis of red ware and black ware indicated that the later was fired possibly at a higher temperature as is evident from lower Loss on Ignition (LOI) values. Grey ware can be of the finer or coarse variety, the finer variety usually follows the same shape as other black ware and the coarse variety those of the coarse red ware.

**Manufacture of Bone China products**

With the financial assistance from a Bankura Zilla Parisad and Technology Information, Forecasting & Assessment Council (TIFAC) of the Government of India, CGCRI has implemented a Bone China technology at Ceramic Centre for Rural Development (CCRD), situated at village Panchmura, district of Bankura, West Bengal with the following objectives.

- To set up an economically sustainable manufacturing unit in basically a rural environment utilizing the skill of the local artisans and the technological base available with CGCRI.

To create more rural employment.

To infuse modern technology among rural artisans.

Partial Technical and Managerial Support has been provided by M/s Jaipur Ceramics Pvt. Ltd., Jaipur.

The commercial production started from June 2005. The products (cups, saucers & mugs) were launched in the market in September 2005. The sale proceeds exceeded Rs. 10.00 lakhs in March 2006. Presently, the unit has on the rolls, 30 personnel mostly local rural artisans including 4 (four) women potters. Efforts are being made to increase the productivity to make the plant self-sustainable and generate further employment.
The Khurja Centre is engaged in the development of traditional ceramics in Uttar Pradesh state. Khurja is a pottery town in the Bulandsahar district of the state. It has the largest agglomeration of small and medium scale ceramic industries in India. The major contributions of the centre were the white ware ceramic cluster development, energy efficient kilns, Bone China waste utilization for decorative tiles manufacturing and construction & supply of portable gas fired furnace. The major achievements of the centre are enumerated below:

**EXTERNALLY FUNDED PROJECTS**

**Development of white ware ceramic cluster**

This project has been sponsored by the Development Commissioner (SSI), Ministry of Small Scale Industries, New Delhi. The centre catered to a strong network of small and medium enterprises (SME) along with the financial agencies to provide assistance in the cluster development. Awareness seminars and workshops were conducted in different fields for upgradation. Exposure visits to the developed cluster of Gujarat helped in the mindset change of the entrepreneurs. Twelve units of different disciplines at Naroda, Thangadh and Morvi were visited and in this attempt, twenty-five SMEs of Khurja participated. The SMEs appreciated the step initiated by centre towards cluster development in the state. A new directory with the details of Khurja SMEs were collected for business growth and a Technical Cell for carrying out different technological upgradation work has been formed. The Khurja cluster has been divided into seven sub-clusters for carrying technical work in different areas. Several workshops were organized for enhancement of knowledge in processing, skill development and energy conservation in collaboration with many organizations. Efforts were made to upgrade the quality and productivity of the ceramic units by technical inputs in every step of production. Special emphasis was given to reduce the fuel consumption by modifying the kilns and using low thermal mass kiln furniture. With the CGCRI, Khurja centre as the nodal institution, mutual interaction of the SMEs would help to fill up technological gaps and contribute to overall development of ceramic units, in the region.

**Design and development of energy efficient kiln for ceramic industries with a focus on improvement in the working of existing tunnel at Khurja**

Two local ceramic units were selected for the purpose of design and development of energy efficient kilns. The pre-heating, soaking and cooling systems for different ceramic wares were worked out. The details of different accessories, attachments etc. necessary in a modern kiln, design and material specifications of a light-weight kiln furniture for optimum utilization for different shapes and sizes of ceramic wares commonly used by industry were also provided. Work led to the modifications in the design of the existing tunnel kilns along with some accessories and attachments necessary in a modern kiln in the selected units. The refractory lining was also modified for different zones based on least cost investment. An energy efficient pre-heating, soaking and cooling system for different ceramic wares was worked out. The outcome of the project have showed that the productivity increased by 30-34% and saving of 11-17% fuel could be achieved. The project has been sponsored by RDCIS, SAIL, Ranchi.

**Technology upgradation of ceramic cluster at Khurja**

Twenty-five producers of crockery wares and table wares were selected for finding the problems of processing steps in raw materials, body and glaze and development of standard body composition for lower maturing temperature with a view to energy saving. Representatives from the centre made series of visits to the selected units and deliberations held on the raw materials and their quality specifications, fabrication and process control parameters, firing as well as defects and remedies in bodies and glazes. A suitable body mix of required properties was formulated in order to optimize some processes for crockery ware manufacturing at 1180°C in fast firing system. A training programme was on the offering to disseminate the obtained results.

**Energy savings through the use of roller head jigger in fabricating pottery wares**

The project was taken up to introduce the Roller Head Jigger (RHJ) in ceramic industries which would be of help in the production of quality products previously made by Jiggering method. For this
purpose the required machine was shifted to the centre from M/s Chatwal Ceramics and restored to operational condition. For making flat ware, large amount of body was prepared and passed through de-airing plug mill to achieve desired properties. Using roller head jigger machine and jigger jolly (JJ), flat ware of 9' x 11' was fabricated. The properties obtained by systems were compared. The result revealed that the saving in energy was observed to the amount of 1058 Kcal/day for production of flat ware using roller head jigger compared to the conventional JJ. The product obtained was of improved quality owing to reduction in defects such as warpage, pinholes, breakage etc. Productivity was increased by about 5 times in comparison to conventional process of manufacturing.

**Bone China waste utilization for manufacturing decorative tiles**

The units in U.P. engaged in manufacturing of Bone China wares generate about 15-20% biscuit bone china waste due to warpage, cracks etc. The wastes are usually thrown away by the factory owners around the units and roadsides which pollute the surrounding atmosphere. For the reutilization of the waste material an inhouse project was taken up to develop decorative and designed wall tiles. Different body mixes were formulated with the waste material and their properties were evaluated. The formulations led to encouraging properties with modulus of rupture = 674 kg/cm², water absorption = 0.5%, bulk density = 2.55 at 1220°C with 1 hr soaking. The tiles fired at 1100°C confirmed the properties of wall tile as per BIS specifications. Efforts are now on to develop small designed tiles for the decoration purpose.

**Construction and supply of portable gas fired furnace for making glass beads to artisans at Purdilpur**

The Centre has designed and developed an environment friendly and thermal efficient gas fired kilns. Fifty numbers of kilns of two pots capacity were distributed to the glass beads makers of Purdilpur.

The art of glass beads making is about centuries old in the region. Traditionally the kilns are wood fired. The smoke emission and other polluting gases to the surrounding areas affect the health and efficiency of beads makers. Due to deposition of ash particles from burnt wood, the quality of beads suffers. With CGCRIS’ intervention, the working environment of artisans using these kilns was completely changed. The significance of the work was due to the fact that more than 3000 tonnes of glass beads are produced annually with an estimated turnover of Rs. 400 million. Nearly half of the annually produced glass beads are exported.
NARODA CENTRE

The Naroda Centre is the lead ceramic research centre in the state of Gujarat which has a large number of ceramic industries. The centre caters mainly to the needs of industry in the region in the field of traditional ceramics. The salient achievements of the centre were: the progress in ceramic cluster development programme, attainment of exotic properties for body mix by complete elimination of Ukraine clay for granite floor tiles production, utilization of wallastonite for glaze production and initiation of sol-gel coating research activity on traditional ceramics. The major achievements of the centre are enumerated below:

EXTERNALLY FUNDED PROJECTS

Ceramic cluster development programme in Gujarat state

The centre was actively engaged in the development of ceramic clusters in Gujarat state. The programme sponsored by the Government of Gujarat involved 500 ceramic units producing sanitary wares, crockery and table wares, ceramic tiles refractories etc. The units were located in Thangadh, Morbi-Wankaner, Himmatnagar and Ahmedabad clusters.

The first phase of the programme which comprised of technology upgradation, productivity and skill development, quality improvement was already completed. The second phase consisting of infrastructure development, safety and environmental protection, linkage with service providers etc. were put underway through the industries associations of the clusters. The centre undertook innovative measures in different areas and conducted a series of Training & Demonstration (T&D) programme at cluster level on various topics of importance such as raw materials and their quality specifications, fabrication and process control parameters in production, ceramic firing as well as defects and remedies in bodies and glazes for production of different traditional ceramic products. A large number of supervisor level trainings were also conducted for the first time for all the units including the units covered under the special technology upgradation programme. The centre created history in imparting technological solutions to about 500 ceramic units and achieved various milestones with the enhancement in productivity, quality and export potential of the units.

The centre incorporated singular blended clay developed earlier, for the development of crockery and tableware body and found superior thermo-mechanical properties in comparison to those of standard body. Studies were conducted on blending and beneficiation of raw Than clay and various blends developed for production of crockery and sanitary ware.

Physico-chemical characterization of all the plastic and non-plastic raw materials presently used for production of glazed floor tiles was carried out and properties evaluated. The raw materials were Bikaner clay, Santhal clay, Kutch clay, feldspar, quartz calcite, wallastonite etc. A T&D programme was conducted in Morbi-Wankaner cluster for dissemination of information to floor tile units. One more attractive feature of centre’s activity was networking with support agencies. In this connection a Roster of Business Development Service (BDS) providers was prepared and two articles were published on Morbi cluster in Asian Ceramics Journal. Few more publications on other clusters of Gujarat were under preparation to draw international attention towards Gujarat cluster. The programme is under progress.

Development of an appropriate body mix through part or complete replacement of Ukraine clay in body composition for granito ceramic tile production

Various types of raw materials used and required for the development of alternate body mix were tested through part and complete replacement of Ukraine clay in body composition for granito ceramic tile production. Based on various properties of the raw materials, about 75 body mixes were formulated and tested for their physical and thermo-mechanical properties after firing the sample specimens at 1160°C, 1180°C, 1200°C and 1220°C respectively. After studying about seventy-five trial bodies, two optimized compositions were selected and tried at M/s Decolite Ceramics, Morbi for plant trial. The trials produced satisfactory results and properties were found almost identical and sometimes superior to those of production body.
### Results of initial trial of Granito tile body mixes with replacement of Ukraine clay

<table>
<thead>
<tr>
<th>Property</th>
<th>Production standard</th>
<th>Trial 1</th>
<th>Trial 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Body batch (tons)</td>
<td>30</td>
<td>30</td>
<td>27</td>
</tr>
<tr>
<td>Grinding media (tons)</td>
<td>30</td>
<td>30</td>
<td>40</td>
</tr>
<tr>
<td>Grinding time (hr)</td>
<td>8</td>
<td>8</td>
<td>4.5</td>
</tr>
<tr>
<td>Litre wt</td>
<td>1680</td>
<td>1690</td>
<td>1670</td>
</tr>
<tr>
<td>Flow time (B₄ cup)</td>
<td>30 sec</td>
<td>35 sec</td>
<td>35 sec</td>
</tr>
<tr>
<td>Green MOR (Kg cm⁻²)</td>
<td>6.7</td>
<td>6.1</td>
<td>5.3</td>
</tr>
<tr>
<td>Dry MOR</td>
<td>19-20</td>
<td>21.8</td>
<td>18</td>
</tr>
<tr>
<td>Dry rejection</td>
<td>Nil</td>
<td>Nil</td>
<td>Nil</td>
</tr>
<tr>
<td>Fired MOR</td>
<td>470</td>
<td>400</td>
<td>470</td>
</tr>
<tr>
<td>W.A %</td>
<td>0.1 max</td>
<td>0.6</td>
<td>0.02</td>
</tr>
<tr>
<td>Fired colour</td>
<td>Ivory</td>
<td>Very good</td>
<td>Dull</td>
</tr>
<tr>
<td>Firing cycle (min.)</td>
<td>59</td>
<td>60</td>
<td>59</td>
</tr>
<tr>
<td>Temperature (°C)</td>
<td>1198</td>
<td>1203</td>
<td>1201</td>
</tr>
<tr>
<td>Polishing rejections (%)</td>
<td>2.0</td>
<td>1.7</td>
<td>1.0</td>
</tr>
<tr>
<td>Re-cutting (%)</td>
<td>2.0</td>
<td>2.7</td>
<td>2.0</td>
</tr>
</tbody>
</table>

The know-how and the technology for granito floor tiles through the complete replacement of Ukraine clay have been successfully transferred.

#### Utilization of wallastonite in production of different types of glazes

Utilization of Wallastonite in production of different types of glazes for LT insulators, opaque glazes, HT insulator glaze was undertaken. Physico-chemical characteristics of wallastonite along with other raw materials were carried out. A large number of recipes on molecular formulae basis for each glaze were formulated and then converted into batch compositions. All the glazes were prepared according to standard practice and then fired at their respective maturing temperatures in the range of 1200° to 1230°C. The fired samples were tested for gloss values.

Four samples were optimized on the basis of maximum gloss values. The pilot scale trial for all the four glazes was conducted. The technical know how has been transferred to the sponsors, Wol kem India Pvt. Ltd., Udaipur.

#### Traditional ceramics based on Sol-gel technology—New initiative

With a view toward future, research work in the area sol-gel application in traditional ceramics was initiated by the centre. The objective of this project is to set up a new facility in order to cater to the future needs of ceramic industries. Sol-gel is one of the important research areas in ceramics including the production of specialized ceramic coating. The application of sol-gel coatings on traditional ceramics items is a current field of ceramic technology. The deposition of glass like silica film on vitrified tiles surface by sol-gel route might be a possible solution to improve the stain resistance of vitrified tiles. A project proposal for the necessary financial support to carry out innovative research in this area was submitted to the Industries Commissionerate, Government of Gujarat. In addition, plans were drawn to work in the areas such as hydrophobic cum scratch resistant coatings and low temperature maturing glazes on tiles along with studies on effect of nano additives on the properties of traditional ceramic products.