THE PRESENT MANUFACTURING SITUATION OF CERAMIC TILE IN CHINA AND ITS QUALITY CONTROL

Kang-shi Liu
(China)

Prof. Liu has graduated from Zhong Zheng Univ. with a B.S. in chemical engineering 1948, has taken additional graduate course at Dalian Univ. of Techn. and Tianjin University (1952-1955), served as assistand prof., associate prof. and full prof. in South China University of Technology since 1958, visited to Rutgers University USA as visiting scholar in 1981.

Prof. Liu has authored/coauthored of 20 technical papers in ceramic material science, published 5 textbooks on ceramic technology. Retired from SCUT since 1987.

Now serve as technical advisor in Foshan Ceramic Ind. and Trade Group Company. Member of Chinese Ceramic Society.

ABSTRACT

Under the guidance of the "reform and open" policy, China's ceramic tile industry has been making rapid development. In this paper the present situation of the ceramic tile industry (including annual output, types of products manufactured, distribution of production centers, introduction and manufacture of production equipment etc.) are described. The standardization work in the ceramic tile industry and the product quality control systems that have been implemented are also detailed. The last part of this paper sets out a brief appraisal of the level of ceramic tile quality in China.

1. BRIEF HISTORY OF THE ARCHITECTURAL CERAMIC INDUSTRY

China is a native country to pottery and porcelain. It has a long history in the manufacture of ceramic products.

The production and use of architectural ceramics dates from the Shang dynasty in the 16th century B.C. At that time, vitrified clay pipes were used as underground drainage pipelines. Segmental tile and semi-cylindrical tile were produced as roofing material at that same time as well. In the North Wei dynasty (386-543 AD.), the manufacture of "Liuli" (ceramic building material with coloured lead glaze for palace buildings) was begun. These articles are representative products of ancient traditional architectural ceramics.

The manufacturing technology of architectural and sanitary ceramics used in modern building, was introduced from Europe and North America. Early in the 20th century, several factories were established, which produced floor tile, exterior wall tile, washbasins and water closets in Tangshan city, in the province of Hebei. Glazed wall tile was first produced in Wenzhou city, in the province of Zhejiang, during the forties in this century. The technical basis of the architectural ceramic industry was very weak at that time, and production output was low with a narrow assortment.

After the founding of new China, many architectural ceramic factories of a certain size were established, thus raising the total output of ceramic tile. However, the radical change in the architectural ceramic industry took place after the implementation of the "reform and open" policy. Since the eighties, the product structure of many ceramic enterprises in different districts has been regulated, modern production lines and key facilities have been introduced from Italy, Germany, Japan and Spain. Through assimilation and dissemination, and the imitation of foreign equipment, the level of mechanization and automation has rapidly increased in these factories, yielding a great increase in ceramic tile output. The range of tile models, with different designs and colours has grown sharply. At present, the architectural ceramic industry has become the economic mainstay of many provinces.

2. THE PRESENT SITUATION OF CHINA'S CERAMIC TILE INDUSTRY

In China, we generally define architectural ceramics in the narrow sense as a product for tiling the floors and walls of buildings. Hence, architectural ceramics is a synonym for ceramic tile.

The main characteristics of ceramic tile production are set out in the following.

2.1 Assortment

The following kinds of ceramic tile are produced in large quantities.

2.1.1 Glazed interior wall tile

According to relevant National Standard GB/T4100-92, water absorption of this type of wall tile is less than 21%. It is decorated by silk screen printing, spraying, hand painting, tracing with liquid gold, glaze embossing, etc. The production methods used are: single firing with a fast schedule,

and double firing with a traditional or fast schedule. The body composition involved belongs to the following systems, clay-limestone, clay- talc, clay-wollastonite, clay-diopside, clay-pyrophyllite and clay-tremolite, etc.

2.1.2 Glazed exterior wall tile

The water absorption of this of type wall tile is divided into two classes, less than 6% and less than 3%. Light-coloured glaze is applied to these bodies. They exist as long strips or small square forms.

2.1.3 Ceramic mosaic

Both unglazed and glazed ceramic mosaics are produced in China. Water absorption in both kinds is less than 0.5%. However, the surface area of a glazed mosaic tile is larger than the unglazed product.

2.1.4 Coloured glazed floor and wall tile

This is used usually for paving floors or facing exterior walls. A coloured glaze coating covers the red body, which is decorated by patterned printing. Water absorption is the same as for exterior wall tile.

2.1.5 Porcelain tile

Due to its good abrasion resistance and low water absorption (<0.5%), it is also named abrasion-resistant tile or vitrified tile. It is unglazed or sprayed with a thin glaze layer. The surface of this tile can be polished or penetrated with a soluble colouring agent.

Besides these products, split tile, plaza stone, antislip floor tile and tile for swimming pools are also being manufactured nowadays.

2.2 Total Production

The total output of ceramic tile in China has increased, doubled and then redoubled since the eighties. The change in annual output of architectural ceramics from 1983 to 1993 is plotted in Fig. 1.

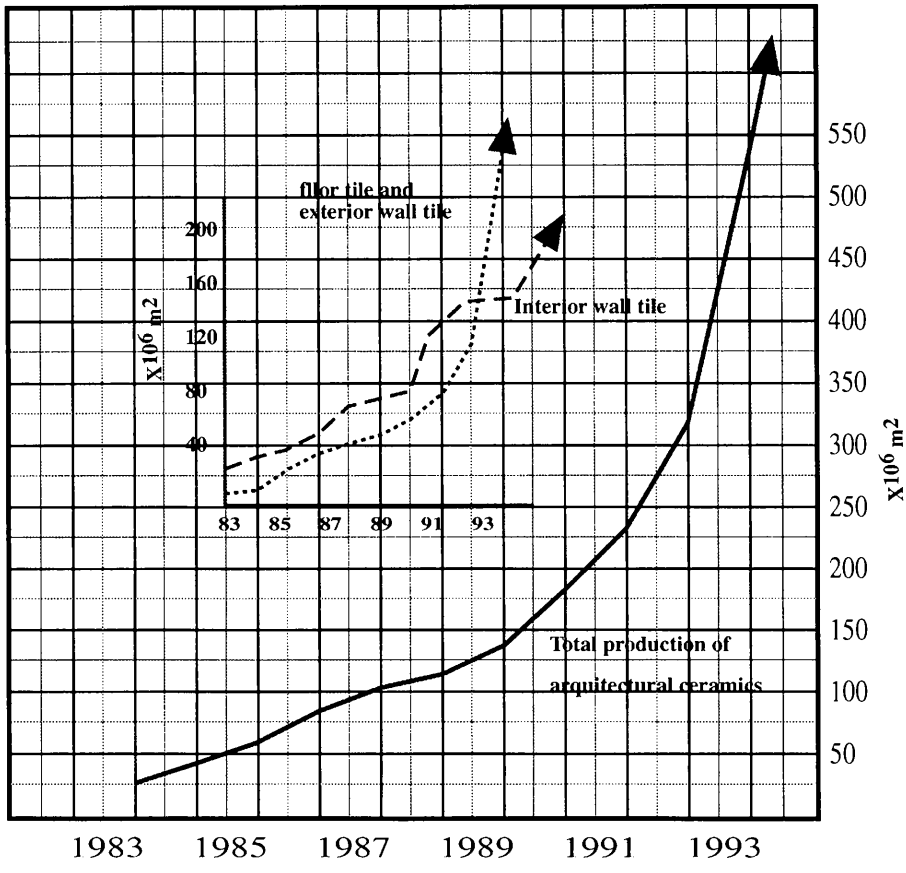

Figure 1. China's Architectural Ceramics Production

It can be observed from this figure, that the total production in 1988 (116.84 million m2) is 4.83 times as much as in 1983 (24.2 million m2), while the total production in 1993 (532.82 million m2) is 22 times as much. Compared with the leading tile producers in the world, China's total production in 1993 exceeded the production of Italy. Thus China's leading position in world production is revealed.

However, as compared to the own rate of ceramic tile production (m2/person, year), the rate value of China (0.44) is equal to about 13.3% of that in Italy (3.33), and 17.7% of the corresponding one in Spain (2.51).

2.3 Number and Location of Factories

In recent ten years, the number of ceramic tile factories has risen very swiftly, indeed they have increased to such an extent that it has become difficult to keep count. According to the data in 1994 of the Technical Information Institute, there are nearly 300 medium-large scale factories and about 4000 town- and village-owned tile enterprises.

These factories are unevenly spread over the country. They are concentrated in the eastern and southern coastal regions. The main production centers are located at the cities of Foshan (Guangdong province), Zhibo (Shandong province) and Tongshan (Hebei province) (see Fig.2). The output of ceramic tile in 1994 in the Guangdong, Shandong and Hebei provinces respectively was: nearly 600 million m2, 77.5 million m2 and 13.1 m2. The Shichuan province has now become another important production base for ceramic tile in south-western China. Its tile output in 1994 amounted to 40 million m2. The distribution of tile production in 1992 is shown in Fig. 3.

Figure 2. Location of Ceramic Tile Production Centers in China

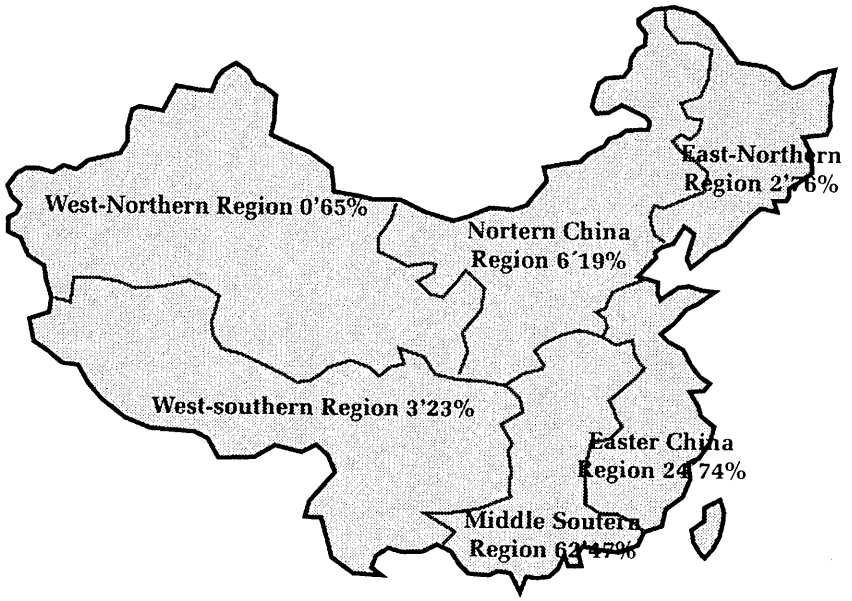

Figure 3. Distribution of China's Architectural Ceramics Production in 1992

2.4 Installed Production Equipment

Since the beginning of the eighties, we have imported about 300 tile production lines, about 1600 hydraulic presses and 300 roller-hearth kilns. Thus all the new factories have been equipped with modern machines and kilns. Their level of mechanization and automation has been raised enormously. But most of the old, small factories still use ball mills with granite lining, heatable brick drying beds, pan mills, friction presses and multi-channel slab kilns). Seen countrywide, the percentage of tile factories which adopted large volume ball mills (loading capacity 8-15T) was only 15%, spray dryers have been installed in only about 25% of the factories, and only 15% of the factories installed automatic hydraulic presses

with a nominal pressure larger than 600T. In about half of the tile factories, coal is used as kiln fuel. Gas fuel is used in about 40% of the factories.

2.5 Fabrication of Production Equipments

With the cooperation of machine building factories, research institutes and universities, different kinds of tile production facilities have been imitated and improved.

At present the following machines and kilns can be made in China:

(1) periodic ball mills with a loading capacity of 8T, 14T, 15T and 20T;

(2) spray dryers with a water evaporation rate of 1000, 1500, 2000 and 3200 kg/h;

(3) hydraulic presses with a nominal pressure of 400T, 500T, 600T, 800T and 1000T;

(4) ceramic plunger pumps for body slip of 110, 120, and 140 psi;

(5) glazing and pattern printing production lines;

(6) vertical and horizontal dryers for raw tile bodies;

(7) liquid and gas fuel fired roller-hearth kilns.

3. QUALITY CONTROL OF CERAMIC TILE

While speeding up the production of ceramic tile, great importance was also attached to product control and supervision work.

3.1 Standardization of the ceramic tile industry

In China, a system of four classes of standards has implemented for a long time, i.e., a system mainly based on National Standards which are complemented by professional standards, local standards and enterprise standards. The code names of National Standards, professional standards of building materials, local standards and enterprise standards are GB, JC, DB and Q respectively. The first three standards (National Standards, professional standards and local standards are also divided into two categories: compulsory standards and recommended standards).

The standardization work in China began in the seventies. Most of the ceramic tile standards prepared before 1988 were drafted on the basis of the actual production situation and the average level of domestic products. There is a big gap with regard to the advanced foreign standards. However, our government states clearly that the adoption of International Standards and advanced overseas standards constitutes an important technical and economic policy, and the

Authorities encourage enterprises to actively adopt International Standards. The adoption of International Standards and advanced overseas standards means that the contents of those standards are converted to different kinds of Chinese standards, with varying degrees of adoption. The degrees of adoption are classified as identity, equivalent and non-equivalent. The indicative abbreviations on degrees of adoption are idt or IDT, eqv or EQV and neq or NEQ respectively. In order to carry out the transition, which is to enable adopting International Standards as soon as possible, so-called enterprise internal control standards that are more demanding than the National Standards have been formulated and implemented in many factories.

At the end of 1994, there were 8 product standards of ceramic tile (including 5 National Standards and 1 professional standard), 17 standard testing methods (including 16 National Standards and 1 professional standard), 4 basic standards (including 2 National Standards and 2 professional standards).

To date, we have not found International Standards of tile products. However, considering the authority of European standards in the world, and the fact that advanced level international tile production can be mirrored by them, the European Norms were consulted during the preparation of the relevant tile standards.

The names of China's tile standards and the relevant foreign standards are listed in the following table.

List of China's Ceramic Tile Standards

Serial Number	Name of Standard	Relevant Foreign Standard
1. Product Standards		
GBn 213-83	Outside Appearance of White Glazed Wall Tile	
GB 8488-87	Acid-resisting Brick and Tile	
GB 9197-86	Building Terra-Cotta	
GB 11947-89	Color-glazed Cer. Tile for Wall and Floor	EN176-178 neq
GB/T4100-92	Glazed Interior Wall Tile	EN159 neq
JC 456-92	Ceramic Mosaic Tile	JISA 5209 neq
JC 457-92	Ceramic Split Tile	EN186 neq
JC 501-93	Unglazed Ceramic Floor Tile	EN177 neq
2. Test Method Standards		
GB 2582-81	Test Method for Bending Strength of Glazed Tiles	

GB 2583-81	Test Method for Compressive Strength of Cer. Floor Tiles	
GB 2584-81	Test Method for Impact Toughness of Cer. Floor Tiles	
GB 3950-83	Test Method for Colouring of Architectural Ceramics	
GB 6954-86	Test Method for Moisture Expansion of Ceramic Floor and Wall Tiles	EN155 neq
GB 6955-86	Test Method for Frost Resistance of Ceramic Floor and Wall Tiles	EN202 neq
GB 8917-88	Test Method for Bending Strength of Ceramic Tiles	EN100 neq
GB 11948-89	Test Method for Surface Flatness, Straightness of Sides and Rectangularity of Ceramic Tiles	EN98 neq
GB 11949-89	Test Method for Crazing Resistance of Glazed Tiles	EN105 neq
GB 11950-89	Test Method for Surface Abrasion Resistance of Glazed Tiles	EN154 neq
GB 2579-89	Test Method for Water Absorption of Architectural and Sanitary Ceramics	EN99 neq
GB/T13478-92	Test Method for Chemical Resistance of Glazed Tiles	EN122 eqv
GB/T13479-92	Test Method for Abrasion Resistance of Unglazed Tiles	EN102 eqv
GB/T18891-92	Test Method for Image Gloss of Building Facing Materials	
GB/T2581-93	Test Method for Thermal Shock Resistance of Ceramic Tiles	EN104 eqv
JC 329-82	Test Method for Abrasion Resistance of Ceramic Mosaic and Floor Tiles	EN102 eqv
GB 5950	General Rule of Test Method for Whiteness of Building Materials and Non-metal Mineral Products	
3. Basic Standards		
GB 3810-83	Sampling Schemes and Methods for Glazed Ceramic Tiles	EN163 neq

GB 9195-88	Terms of Products for Architectural and Sanitary Ceramics	EN87 neq
JBW 06-2-1	Standard Sample of Low and Medium Glossiness Ceramic Plates	
GSBQ30001- 92	Series of Standard Matt Glazed Cer. White Plates	

After the ISO-9000 Standards were published, they have been adopted in different degrees as China's National Standards:
(1) equivalent adopted with code number GB/T10300 (1988)
(2) identity adopted with code number GB/T19000 (1992)
In recent years, the work for the adoption of GB/T19000- ISO9000 standards has been accelerated in the ceramic tile industry.

3.2 Legislation Control in the Field of Standardization and Quality control

Since the beginning of the eighties, the State has issued a series of statutes related with quality control and supervision inspection. The basic laws in this field are: "Law on Standardization of P.R.C.", "Law on Quality of P.R.C", "Law on Metrology of P.R.C."

For the purpose of implementing these basic laws, the following coordinated rules and regulations were prepared and published:

(1) Rules on Implementation of Standardization;
(2) Measures for the Adoption of International Standards and Advanced Overseas Standards;
(3) Regulations on Production Quality Certification;
(4) Trial Measures for Product Quality Supervision;
(5) Rules on Administration of National Standards, Professional Standards, Local Standards and Enterprise Standardization.

In order to strengthen the quality of management and raise product quality, the State Bureau of Building Materials organized the preparation of the following 3 regulations in 1994:

(1) Regulations on Management of Architectural and Sanitary Ceramic Enterprise;
(2) Fundamental Conditions of Inspection Laboratories of Architectural and Sanitary Ceramic Product Quality;
(3) Rules on Contrast Supervision and Inspection of Architectural and Sanitary Ceramic Product Quality.

These rules and regulations provided a legal basis for the administration of Standardization work and quality supervision in China.

3.3 Work of Product Quality Supervision and Inspection of Ceramic Tiles.

Quality supervision and inspection organs at different administrative levels have been established in accordance with the series of regulations on quality control issued by the State. The National Quality Inspection Center of Architectural and Sanitary Ceramics was founded in the Shansi province. Quality inspection institutes were established in various provinces and cities. Specialized quality supervision and inspection stations were also set up. A nationwide product quality supervision and inspection network has begun to take shape.

The main ways to carry out product quality supervision are:

(1) Selective supervisory inspection;
(2) Nationwide centralized inspection;
(3) Periodical daily supervisory inspection;
(4) Inspection for appraisal of new products.

Generally speaking, the National Quality Inspection Center of Architectural and Sanitary Ceramics organizes the work of nationwide centralized inspection, selective supervisory inspection, appraisal and comparison of product quality; quality inspection institutes are responsible for carrying out selective supervisory inspection and daily inspection of local products, as well as quality inspection of new products. Thus quality inspection work protects the interests of the State, users and consumers, while promoting the continuing rise of product quality. It also inspects the implementation of technical Standards in each factory.

4. APPRAISAL OF THE LEVEL OF CERAMIC TILE QUALITY

In the past fifteen years, although China's ceramic tile industry has been developed rapidly, product quality countrywide lies at different levels. There are many products in several factories that were appraised as a "State Superior Product" or "Professional Superior Product", since all the property indexes complied with the requirements of National Standards or advanced overseas standards, the quality in kind being about the same as for imported products. But there are also products with poor quality in various factories. The main problem with tile quality is its instability, as it does not remain uniform. The factors influencing product quality involved the following:

(1) Raw materials are not standardized in China. They are variable in composition and properties;
(2) Coal is used as kiln fuel in most tile factories;
(3) The technical basis of each enterprise is uneven;
(4) Technical regulations are not pursued firmly in some factories;
(5) More importance is attached to quantity than to quality;
(6) The management ways and institutions involved are not suited to the demands of a socialist economic system.

Along with the pursuance of a market economy system, and the deep implementation

of reform and open policy, market competition is gradually becoming serious. The situation "superior will win, inferior will be eliminated" will promote productive factories that pay more attention to product quality. It is believed that the ceramic tile quality will rise rapidly, as fast as their quantity.

REFERENCES

1. "China's Building Material Industry at the Present Age" (manuscript) 1987
2. "Building Material Information" No. 6, No. 11, 1995
3. "Standardization and Quality Control of Building Materials" No. 5, 1987; No. 3 1988; No. 1, No. 4, No. 5, 1990; No. 4, 1994
4. "China Ceramic Industry" June No. 2, 1995
5. "China Standards Yearbook 1994" Standard Press of China