6 THE NEW DEVELOPMENT OF MANUFACTURE AND APPLICATION OF SULPHATE-ALUMINATE CEMENT IN CHINA

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SUMMARY: Sulphate-aluminate cement (SAC) was invented by China Building Materials Academy (CBMA) in the 1970s. It is a low alkali cement with properties of rapid hardening, high strength, low alkalinity etc. In the past 30 years, SAC has been widely and successfully used in civil engineering and building construction. SAC has been used in making GRC products, for example concrete casting in winter, drainage drain pipes etc. Total SAC production in China has reached 1,300,000 tons per year.

SAC is a kind of hydraulic binder with series excellent properties of high strength and rapid hardening. It is made by inter-grinding special clinker with one or more blending materials. The clinker, consisting principally of C_4A_3, C_2S and $C_4AF(C_6AF_2)$, is produced by heating an appropriate raw mixture of limestone, bauxite and $CaSO_4$ at 1300-1350°C.

Tangshan Liujiu Cement Ltd is a private enterprise that belongs to the Tangshan Hongwen group. Its annual output can reach 250,000 tons and it has become the largest SAC manufacture plant in China. Tangshan Liujiu Cement Ltd works in close technical cooperation with CBMA and has established a full set of quality guarantee systems.
KEYWORDS: Alkalinity, cement, GRC, low alkali, SAC, sulphate-aluminate.

BRIEF INTRODUCTION OF MANUFACTURING TECHNOLOGY

At present, there are three kinds of manufacturing technology for SAC in China.

1. Dry process rotary kiln

The manufacturers who use this kind of kiln are the initial SAC enterprises; it is outdated technology in cement manufacturing with low output, high consumption of energy and raw materials, and heavy environmental pollution.

2. Dry process rotary kiln with shaft preheating

The SAC plants that use this kind of kiln were developed mainly in the 1990s, and output comprises around half of the total amount of SAC produced in China. Compared with the dry process rotary kiln, the consumption of energy and raw materials is much lower, but the output of these kilns is still small and unsatisfactory.

3. Dry process kiln with cyclone preheating

The SAC plants that employ this kind of kiln were developed mainly after 2000. The scale of these plants is larger compared with the previous two kinds of kiln, the consumption of energy and raw materials is the lowest, output is the largest among them, and the quality of products is much more stable.

Tangshan Liujiu Cement Ltd is a plant which uses a dry process kiln with cyclone preheating to make SAC clinker. Its output can reach 700 tons daily, and the compressive strength of clinker in 3 days can reach 65MPa.

Figure 1 - Product line of Tangshan Liujiu Cements Ltd

The physical properties of SAC produced by Tangshan Liujiu are shown in Tables 1 and 2.

Table 1 - The properties of rapid-hardening SAC of Tangshan Liujiu

Species situation	Specific surface	Bending strength (MPa)			Compressive strength (MPa)		
	m^2/kg	1 day	3 days	28 days	1 day	3 days	28 days
Standard value of JC933 (grade 42.5)	> 350	6.0	6.5	7.0	33.0	42.5	45.0
SAC produced by Tangshan Liujiu	387	7.0	8.2	9.1	40.5	48.6	51.7
Standard value of JC933 (grade 42.5)	350	6.5	7	7.5	42	52.5	55
SAC produced by Tangshan Liujiu	408	8.6	9.3	9.6	47.8	54.3	58.6

Table 2 - The properties of low-alkali SAC of Tangshan Liujiu

Species situation	Specific surface	Bending strength (MPa)		Compressive strength (MPa)		pH value
	m^2/kg	1 day	7 days	1 day	7 days	
Standard value of JC933 (grade 42.5)	> 400	4.0	5.5	32.0	42.5	< 10.5
Low-alkali SAC produced by Tangshan Liujiu	428	6.7	7.8	36.1	48.9	10.3

From Tables 1 and 2, we can see that all the physical properties of products which are made with dry process kiln with cyclone preheater by Tangshan Liujiu could meet the requirements of national industry standard for building materials. The standard code is JC933-2003 for rapid-hardening SAC and JC/T659-2003 for low-alkali SAC.

ENERGY-SAVING EFFECT

The coal for producing SAC is the high-grade coal from Datong, its calorific value (Q) reaching 25340kJ/kg. According to the statistical data for 3 years, the coal consumption for making SAC clinker with the dry process kiln with cyclone preheater is 158kg for 1-ton clinker. The exchanging value of heat consumption is 4000kJ/kg. The different values of heat consumption for various production technologies for SAC clinker are shown in Table 3.

Table 3 - The different values of heat consumption for various technologies for producing SAC clinker

Production technology	Dry process rotary kiln	Dry process rotary kiln with shaft preheater	Dry process kiln with cyclone preheater
Coal consumption (kJ/kg)	> 6800	4400~4600	4000

From Table 3, we know that the consumption of coal for making SAC with the dry process kiln with cyclone preheater is the lowest, its energy saving effect is clear. By using the dry process kiln with cyclone preheater, heat consumption can be reduced by 70% compared with the dry process rotary kiln, and by 10~15% compared with the dry process rotary kiln with shaft preheater. Saving energy could bring a large economic benefit, especially in the situation of energy shortage and rising energy costs.

PRE-HOMOGENISING – THE DETERMINANT OF STABLE QUALITY

During the process of SAC production, the raw materials must be pre-homogenised completely before input into the production line in order to keep the clinker and cement to a stable quality. The main reason for this is that the characteristics of bauxite mined in nature varies; the useful composition will change and fluctuate over a large range. Formula (1) shows the degree of pre-homogenising of raw materials:

$$\alpha = \sigma_1/\sigma_2 \qquad (1)$$

where
α represents the homogenising coefficient;
σ_1 is the standard deviation of variable raw materials before input to the homogenising equipment;
σ_2 is the standard deviation of variable raw materials after output from the homogenising equipment.

There are several homogenising methods to achieve pre-homogenising for those SAC-producing plants.

1. Strip homogenising silo
By input of raw materials with multi-layers, multi-cutting and feeding, the homogenising coefficient is 3~5. The homogenising capacity is around 2000~3000 tons of bauxite in every batch. This quantity could supply 1–2 weeks' usage for a 100,000-ton annual output for a SAC-producing plant. But it is still too small for a 200,000-ton annual output SAC-producing plant.

2. Silo mate homogenising
Taking three to four raw materials silos as a group, the raw materials are discharged from a group of silos into a mixing silo. The mixed raw materials will be transported to the batch bin for dosage. The homogenising coefficient is 2~3, the quantity of homogenising once is only 300~500 tons; it requires multi-batching and leads to fluctuation.

3. Manual stockpiling
The homogenising coefficient is 1.5~2, the labour requirement is high, and the effect of homogenising is poor.

Tangshan Liujiu Cement Ltd makes a pre-homogenising stockpile by mechanical power: the homogenising coefficient is 6~8, which is much higher than other SAC plants in China. Therefore the good effect of homogenising is the main contributor to stable product quality for Tangshan Liujiu. Based on the raw materials homogenising coefficient, the plant also take a series of technology measurements to maintain a stable product quality, and the percentage of acceptable quality could reach 100%.

Figure 2 - Pre-homogenising stockpile by mechanical power in Tangshan Liujiu Cements Ltd

THE APPLICATION OF SAC

The rapid-hardening SAC and low-alkali SAC produced by Tangshan Liujiu Cement Ltd are used mainly for making GRC decorated products, various wallboards, grid boards, mushroom flooring, ventilation ducts, grain stores etc. It has large markets in Beijing, Tianjin, Tangshan and northeast China, and has received good comment and widespread acceptance.

Glassfibre reinforced composite product combining low-alkali SAC and alkali-resistant glassfibres is widely used in China due to its characteristics of light weight, high strength and good durability. The features of GRC material, such as easy moulding and thixotropy before cement setting, and other good basic properties, such as its light weight and high strength, provide the advantageous conditions for developing various products extensively.

EXTERIOR GRC DECORATED ARCHITECTURAL COMPONENTS

At present, GRC products have been used widely in decorated architectural components and artwork in many areas such as Beijing, Shanghai, Dalian and Tianjin. Beijing Baogui Artificial Rock Art and Technology Ltd is a typical company which makes GRC sculptures and decorates many important places such as the Diao Yu Tai Hotel, the Great Hall of the People and so on. Hundreds of companies such as Shanghai Ningshi Building Materials and Engineering Companyand Dalian Dapengda Decorated Ltd have used GRC products to make various European- or Chinese-styled exterior decorated components. These components are widely used for many top-grade residence blocks and villas. This market is increasing and has developed at a rapid rate because of the low price and excellent durability compared with that of gypsum products and glassfibre reinforced plastic products.

Figure 3 - GRC exterior decorated components made from SAC of Tangshan Liujiu Cements Ltd

INTERIOR GRC WALL PANELS

According to Chinese national policy, since 2000, it has been prohibited to construct buildings using red brick as a wall material in order to protect the ground and environment. Since June 2002, when the Chinese State Department issued the administration order, the use of red brick was completely forbidden in 256 cities. Meanwhile, a tax deduction policy was applied to those enterprises which develop and manufacture new types of wall materials. By June 2005, the action had extended to more than 600 medium- and small-sized cities. This government action has created good development conditions for Chinese wall materials, especially for GRC wall materials. The glassfibre reinforced composite product using low-alkali SAC and alkali-resistant glassfibres is so far the ideal building material, with main products such as interior and exterior wall panels, various kinds of irregularly shaped elements, such as corrugated sheets, square roof slabs, toilet units, ventilation pipes, bathtubs as well as architectural decorative products.

Based on statistical data from the Chinese Association, the output of GRC wall materials has reached 25 million cubic meters annually to the end of 2003, while the use of SAC has reached over 0.8 million tons, twice the amount of 3 years ago. With the step-change of wall innovation, the GRC products industry will use more low-alkali SAC in the future.

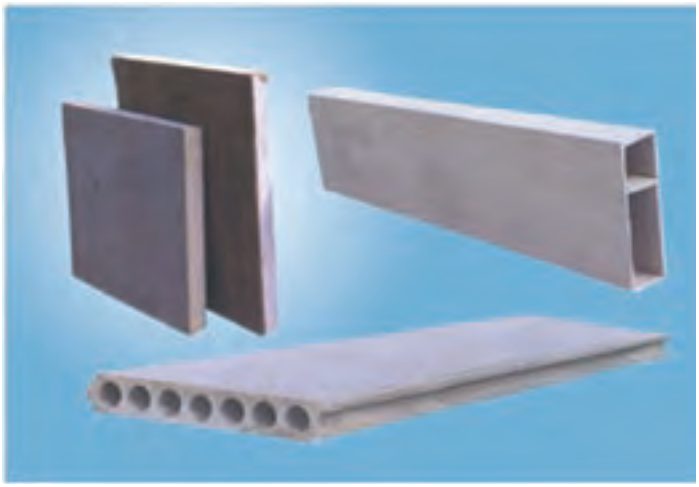

Figure 4 - GRC wall panel made from low-alkali SAC from Tangshan Liujiu Cements Ltd

Figure 5 - The ventilation pipes made from low-alkali SAC from Tangshan Liujiu Cements Ltd

GRC SILO

With the reform of the grain distribution system going further, grain requirements have changed from a shortage to surplus. The GRC product is accepted by the relevant grain administration department for its excellent properties of light weight, high strength and anti-damp characteristics, which is most suitable for making grain silos. The GRC grain silo is widely used in the main producing areas in north China, such as Jilin and Heilongjiang, and it has large application potential in the market.

Figure 6 - GRC grain silo

GRC MUSHROOM FLOOR

It is always a difficult problem to make wide-span roof materials in Chinese construction. The GRC mushroom floor could solve the problem to some extent. Putting small-diameter GRC pipe (diameter 100~200 thickness 5~7mm) together, then pouring fine aggregate concrete to construct the overall structure, it solves the problem of wide-span construction. GRC mushroom floors bring great convenience to the roof construction of large theatres or sports complexes, gymnasiums, restaurants and other entertainment places. It is widely appreciated with the low cost that the market share is going up at present.

Figure 7 - GRC light-wall conduit produced using SAC from Tangshan Liujiu Cements Ltd

GRC TRANSFORMER ROOM

GRC materials could be used to produce transformer rooms in city and country with its properties of light weight and high strength. It is easy to install, and could resist the damage from changeable weather. The service life could be extended as well. In the areas of Beijing, Tianjin and Tangshan, its application is developing very fast. There are more than 20 enterprises producing this kind of product.

Figure 8 - GRC transformer room produced using SAC from Tangshan Liujiu Cements Ltd

Tangshan Liujiu Cement Ltd is producing rapid-hardening and composite cement, which is used for making drainpipes. Products are introduced in large volume in north China due to the features of rapid hardening and high early strength. The main advantages are saving demoulding time, high strength, short curing time, fast turnover of the mould, and increasing the work efficiency. At present, the demand of large-diameter drainpipes is increasing with the growth of a large amount of infrastructure construction. As the yield efficiency is increased to a large degree, and the strength is very high, it wins the good opinion of the customers.

Figure 9 - GRC drainpipe produced using SAC from Tangshan Liujiu Cements Ltd

To sum up all of the above, GRC production is developing very fast in China. It has become the biggest and the most important application market in the SAC industry, and will grow continually.

CONCLUSION

1. Tangshan Liujiu Cement Ltd is the biggest enterprise producing SAC in China. Its advanced manufacturing technology and pre-homogenising equipment can ensure products with stable quality.
2. The SAC produced by Tangshan Liujiu Cement Ltd is used mainly for making GRC products and in the drainpipe industry. Their good service and the stable quality of products have won the good opinion of customers.
3. Tangshan Liujiu Cement Ltd is engaging in close technical cooperation with the CBMA to enhance quality management and develop new types of product. They are endeavouring to be ranked in the first line in the SAC industry in China.