Application of Industrially Produced LC^3 to Pavements, AAC Blocks and Other Products

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Abstract. LC^3 and LC^2 produced in the plants of JK Lakshmi Cement were used in the construction of several pavements, AAC blocks and other practical applications like plaster and mortars. It was found that in most applications, OPC could be easily replaced by the same weight of LC^3 without a negative impact on performance. Plain, reinforced and fibre-reinforced pavements were cast using the cement and the construction could be carried out using usual construction procedures.

LC^3 and LC^2 could also be used in the production of autoclaved aerated concrete (AAC) blocks, without a significant change to the technology or performance. It was found that a better cohesion and flow could be obtained by the use of LC^3 in place of OPC in mortars and plasters.

For most applications, it was found that a direct replacement of OPC by LC^3 was possible without negatively influencing the performance of the product.

1 Introduction

Concrete is the most widely used building material in the construction of infrastructure such as buildings, bridges, highways, dams, and many other facilities. Concrete usage around the world is second only to water. Ordinary Portland cement (OPC) is the main constituent of the concrete and its production contributes about 5 to 7% of total global greenhouse gas emission [1], which possesses a potential problem for global warming. It is estimated that by the year 2020, emissions will rise above the current levels by approximately 50%.

In order to reduce emission from the cement industry, attempts have been made to prepare blended cement using pozzolanic materials. The major drawback of the blended cement is low early strength. Recently we found that if an appropriate amount of calcined clay is mixed with the clinker at the time of grinding, properties to the concrete are enhanced and emission of greenhouse gases is reduced. Combination of calcined clay, limestone and clinker, also known as Limestone Calcined Clay Cement (LC^3) were used. In this paper properties and applications of LC^3 has been discussed.

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2 Industrial Production of LC^3 in India

Indian Government is committed to reduce industrial emission, particularly emission from the cement industries. India is also a partner for signing treaty for climate change. In an attempt JK Lakshmi Cement Ltd., New Delhi, in collaboration with TARA, New Delhi and IIT Delhi developed the process for the industrial manufacture of LC^3 for the first time in India. At the same time, a new environment friendly additive for concrete that makes it easier to produce high performance concrete at a lower cost was produced. Full-scale plant trial production of the cement was conducted at JK Lakshmi Cement Ltd., Jhajjar Unit, Haryana, India on 6^{th} & 7^{th} Oct 2016 under real conditions. Trial applications of the cement have shown that it can reduce as much as 30% CO_2 emissions and 20% energy consumption in cement production. The performance of the concrete produced using this cement exceeds those using cements commercially available today in most aspects.

3 Materials and Experiment

China raw clay (Fig. 1) was purchased from Bhuj, Gujarat mines and the chemical composition is given in Table 1. The calcination of 150 tons of Calcined Clay was done at Shree Ram Minerals in the rotary kiln up to 800° successfully (Fig. 2). Calcined clay is shown in Fig. 3. After the grinding process at JK LAKSHMI CEMENT LTD, a production of 200 MT of LC^3 was obtained. Clinker used was from JK LAKSHMI CEMENT LTD, Sirohi, Rajasthan Plant, mineral gypsum with 80%

Table 1. Chemical composition of Calcined clay and LC^3 (mass%).

Compounds	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	K_2O	SO_3	Na_2O
Calcined Clay	61.95	22.97	3.21	11.73	0.00	0.01	0.02	0.11
LC^3	33.28	14.48	4.30	39.65	2.73	0.49	2.13	0.40

Fig. 1. Raw clay mines

Fig. 2. Calcination in rotary kil

sulphate and low grade limestone from the mines of JK LAKSHMI CEMENT LTD, Shirohi, Rajasthan Plant [1] were used. The Raw material proportions are given in Fig. 4. Physical test results of LC3 are given in Table 2.

Fig. 3. Calcined clay

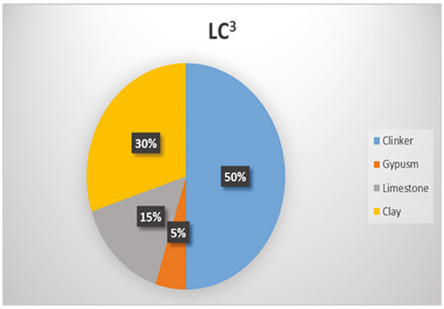

Fig. 4. LC^3 mix proportion

Table 2. Physical test of LC^3

Sl. No	Characteristic	LC^3 Industrial production (JK Lakshmi Plant, Jhajjar)
(i)	Specific gravity	2.88
(ii)	(a) Blaine	637
	(b) Retained on 90μ sieve	6.3%
	(c) Retained on 45μ sieve	22.4
(iii)	Standard Consistency	31.75
(iv)	Initial, min(Setting Time)	115
	Final, min (Setting Time)	155
(v)	1 day, Mpa, Compressive Strength	11.6
	3 days, MPa, Compressive strength	25.40
	7 days, Mpa, Compressive Strength	30.0
	28 Days, MPa, Compressive Strength	39.8
(viii)	Soundness by Le Chatelier Method, MM	0.45 MM
(ix)	Dry shrinkage, Percent of Gauge length	0.01
(x)	Expansion in autoclave	0.02%

4 Industrial Productions of Several Types of Concrete Using LC3 Produced

4.1 Laying of Road Panel at JKLC- Jhajjar with LC3 Cement

To evaluate the performance of LC^3 in concrete, constructing road panels of 64 square meters were cast at JK LAKSHMI CEMENT LTD. plant the data are given in Table 3.

The variation of compressive strength with time in the presence of LC^3 is shown in Fig. 5.

Table 3. Raw materials and Mix design

Used raw material's specifications:

SI. No	Material	Source	Specific gravity
1	LC3	JK Lakshmi LC3 Cement	2.87
2	20 mm aggregate	Kothputli, Rajasthan	2.68
2	10 mm aggregate	Kothputli, Rajasthan	2.66
3	Manufactured sand	Kothputli, Rajasthan	2.56
4	Admixture	PC based (Make: Kunal)	1.08

Mix design for road construction (Per cubic metre):

Grade of concrete	Cement (Kg)	Sand (Kg)	Coarse aggregate 20 mm (Kg)	Coarse aggregate 10 mm (Kg)	Water (Kg)	Chemical admixture (1.1% of Cement)	W/C ratio
M50	547	670	612	408	175	6.56	0.38

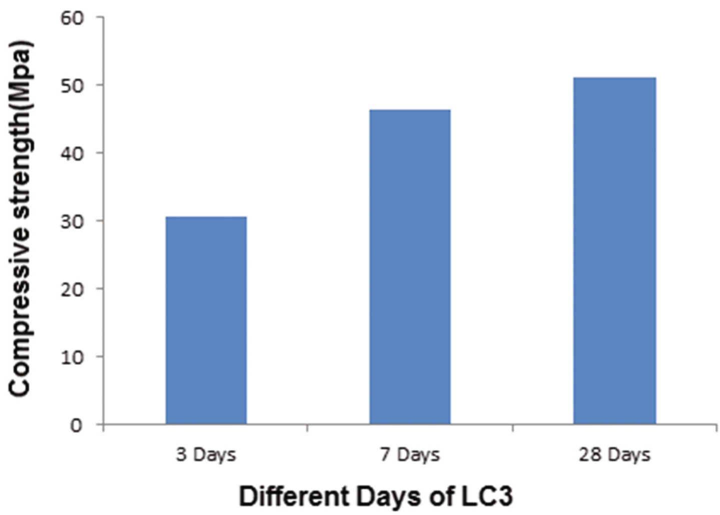

Fig. 5. Compressive strength of LC^3

Fig. 6. Self-compacting concrete with LC^3

Fig. 7. Testing of LC^3 concrete

It was observed that as the LC^3 content increases the slump flow increases. Other features of concrete made from LC^3 are shown in Figs. 6 and 7.

5 AAC BlockProduction at JKLC- Jhajjar with Calcined Clay

Autoclaves aerated concrete (AAC) block production was conducted at JK LAKSHMI CEMENTLTD, Jhajjar Plant with calcined clay with the replacement of OPC grade cement. The composition of the AAC blocks is shown in Fig. 8. The compressive strength is shown in Fig. 9. A 6% increase in the strength of the blocks was observed with the use of calcined clay.

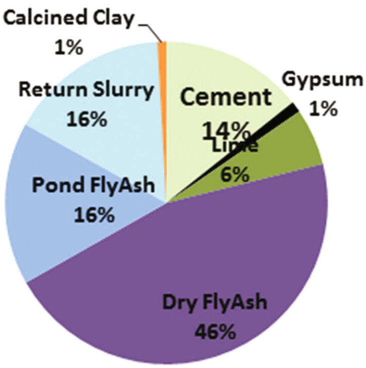

Fig. 8. Composition of AAC blocks

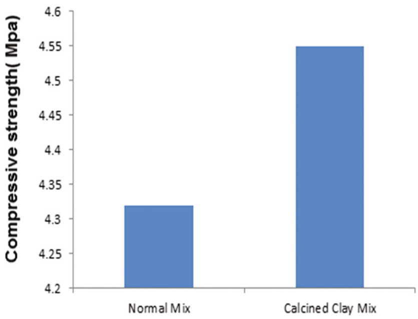

Fig. 9. Compressive strength of AAC blocks

6 Conclusions

This study was carried out to evaluate the fresh and hardened properties of LC^3 containing fiber s and AAC blocks with calcined clay.
The following conclusions can be made from the obtained results:

- It is possible to develop high strength self-compacting LC^3 concretes of strengths ranging from 50–60 MPa,
- The increase in LC^3 content in Concrete Mixes increases the viscosity of the mix.
- Compressive strength increases with adding the 1% of Calcined clay and replacing the OPC cement.

Reference

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