Limestone
Calcined
Clay
Cement

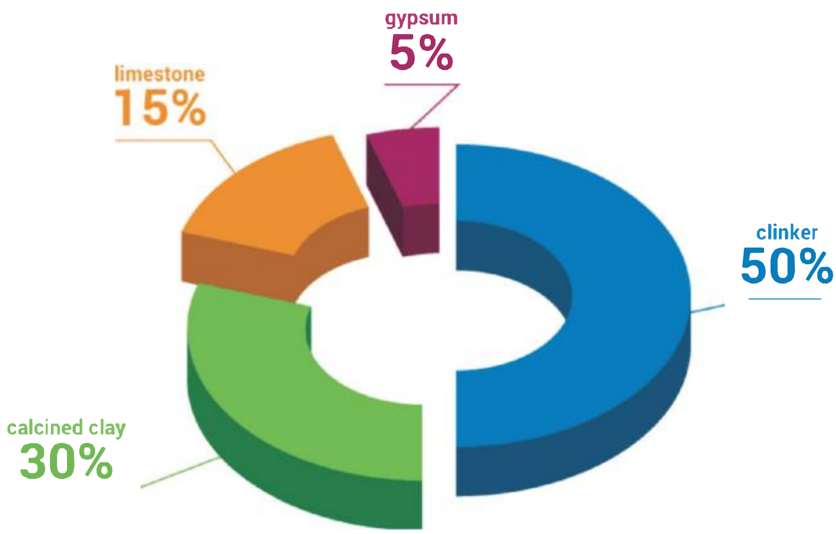
LC3

LOW CARBON LOW COST LOW CAPITAL HIGH PERFORMANCE

www.lc3.ch

What is LC^3?

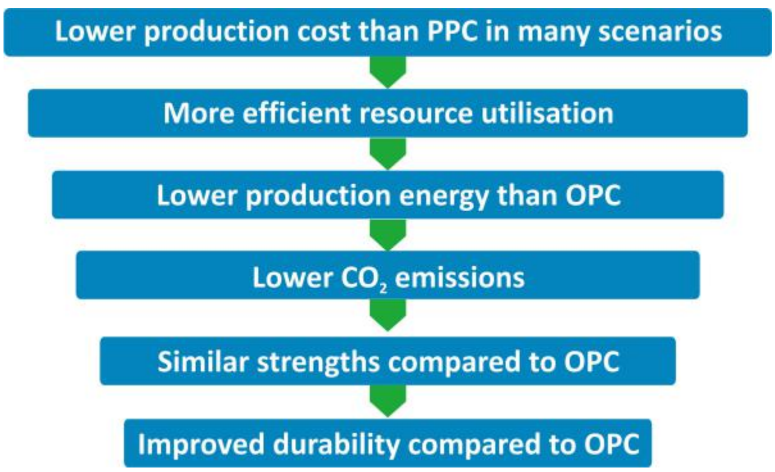
LC^3 cements are a family of composite cements containing portland clinker, calcined clay and limestone. The LC^3 technology promises a sustainable growth of economies around the world by reducing CO_2 emissions by more than 30% compared to plain portland cement at lower production costs. As LC^3 cements use raw materials and technologies that are already commonly used in cements and can be used in the same way as normal cements, they provide a practically viable solution to improve sustainability.



Typical composition of an LC^3 cement

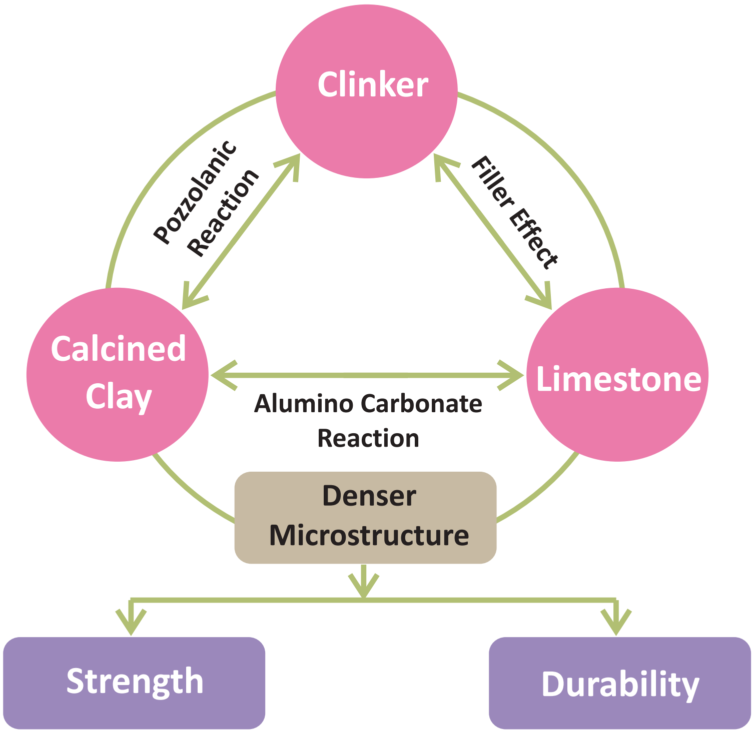
Advantages of LC^3 technology

Due to the lower clinker content, the LC^3 technology has several advantages over ordinary portland cement (OPC) and fly ash based portland pozzolanic cement (PPC). The main advantages will be:



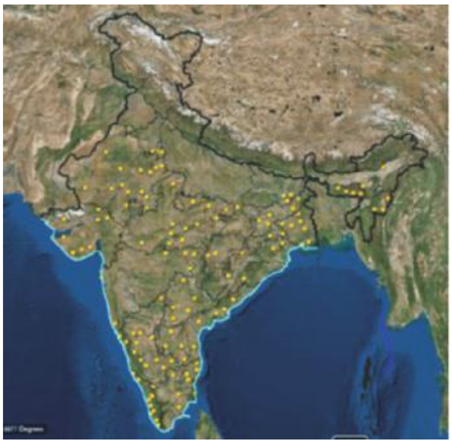
Synergy in LC³ cements

LC³ works on the synergy between clinker, calcined clay and limestone phases. Calcined clay reacts with hydration products of clinker and limestone reacts with calcined clay, giving phases that make the microstructure denser. Calcined clays have been long used as pozzolanic materials in cements and limestone is an established semi-reactive filler in cements. The added synergy from the reaction of calcined clays with limestone producing carboaluminate phases improves the strength and durability of the cement.



Raw materials for LC³

Normal portland clinker is used in the production of LC³. Clinkers and OPCs from all around India have already been tested in LC³ blends. Clays containing 40% to 70% kaolinite are ideal for the production of LC³. Such clays are abundantly available as waste in mines where higher grade clays are used for high value applications. The clays are calcined at 750˚C to 850˚C to make them reactive. Calcination requires less than half the energy required for clinker production. Limestones with as little as 65% carbonate content can be used. Such low grade limestones are often rejected in cement plant mines. Limestones with impurities such as quartz and dolomite can be consumed in LC³. No calcination of the limestone is required. Waste materials from marble and kota stone production can be used in place of limestone.



Locations with availability of suitable clays in India

Composition and production of LC³

Typical LC³ cements contain 40% to 65% clinker by weight. The remaining LC³ cement contains 30% to 38% calcined clay, 15% to 20% of crushed limestone and 3% to 7% of gypsum. The calcination of clays can be carried out using rotary kilns. Due to lower temperatures and lower energy, the capital investment required for these rotary kilns is likely to be less than that of cement kilns of the same capacity. Flash calcination and fluidised bed reactor technologies can also be used for the calcination of clays. Flash calciners are similar to preheaters commonly used in cement plants.

LC³ can be produced in a similar manner as OPC and PPC by intergrinding or blending. The softer nature of the materials reduces grinding energy, although, as is the case with many composite cements, separate grinding may be desirable. Ball mills, vertical roller mills or presses can be used for grinding.

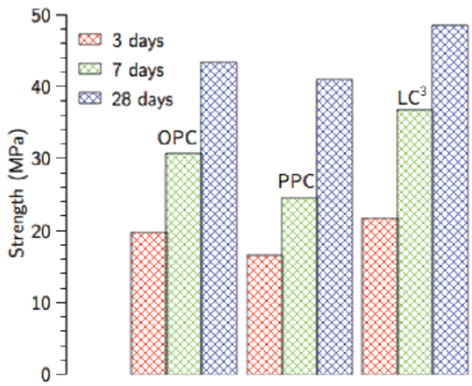
Characterisation of raw materials and LC³ cement

The suitability of clays and limestones required for the production of LC³ can be easily characterised using loss on ignition, thermogravimetric analysis or X-ray diffraction techniques. These techniques are available in most cement plants and are routinely used to characterise other cements. Existing standard test methods can also be used to identify suitable combinations of clays and limestones.

Once produced, quality control of LC³ can be easily carried out by measuring strength and other methods used for OPC and PPC.

Mechanical and other physical properties of LC³

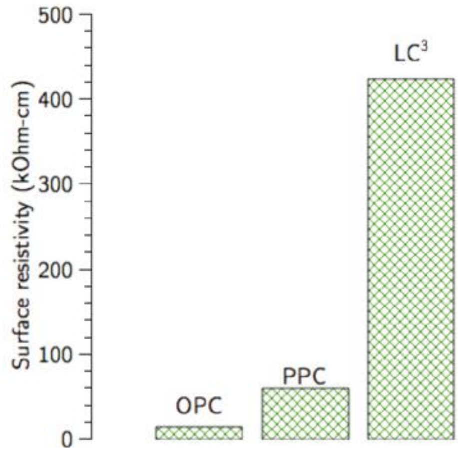
LC³ has been seen to develop ultimate strengths comparable to OPCs produced using the same clinker. Strength development in LC³ has generally been observed to be faster than OPC and PPC. LC³ cements are expected to satisfy all the other requirements of physical characteristics laid down in the Indian standards.



A comparison of OPC, PPC and LC³ produced using the same clinker and the same process

Durability of LC^3

Under most severe conditions, the performance of LC^3 was found to be better than or at par with OPC and PPC. LC^3 has a high chloride penetration resistance and produces a dense microstructure with high resistivity making it ideal for harsh conditions like in marine environment. LC^3 is also highly suitable for use with reactive aggregates.



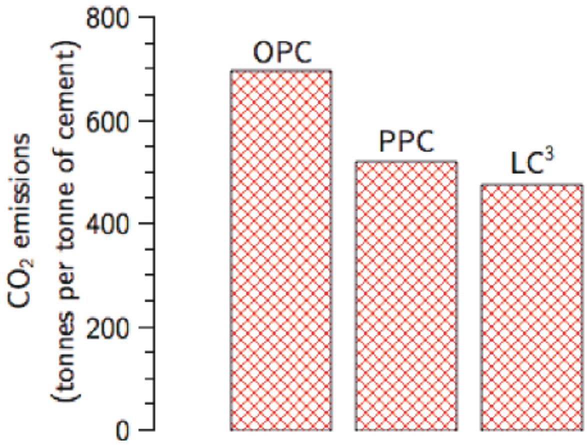
The surface resistivity of LC^3 concretes was found to be an order of magnitude higher than OPC and PPC concretes

Economy of LC^3

Due to the lower calcination requirements, LC^3 is more economical to produce than OPC for similar performance. Especially at locations with shortage of high quality fly ash, LC^3 is more economical to produce than PPC. Due to its lower clinker content and lower capital investment required for calcination of clays, LC^3 allows higher returns on capital investments.

Emissions and resource efficiency from LC^3

The production of LC^3 emits as much as 30% less CO_2 than OPC and 11% less CO_2 than PPC. The energy consumed in producing LC^3 is also significantly lower than OPC and even lower than PPC in many scenarios. LC^3 also offers an interesting solution for the utilisation of low grade mine rejects widely available with the cement industry.



A comparison of CO_2 emissions for production of different cements at one plant in India

Field and laboratory experience with LC^3

Almost 170 tonnes of LC^3 has been produced in India. A detailed research and development programme has been put in place to understand all important aspects of this cement. Pilot construction projects have been executed to obtain field data on the performance of LC^3 as a general use cement.


The LC^3 building in Jhansi built using the first batches of LC^3 produced in Jhansi


The SDC building at the Swiss Embassy in Delhi having AAC blocks made of LC^3


Blocks produced in an automated unit using LC^3 in Ghaziabad


A worker demoulding LC^3 kerb-stones in Jhansi

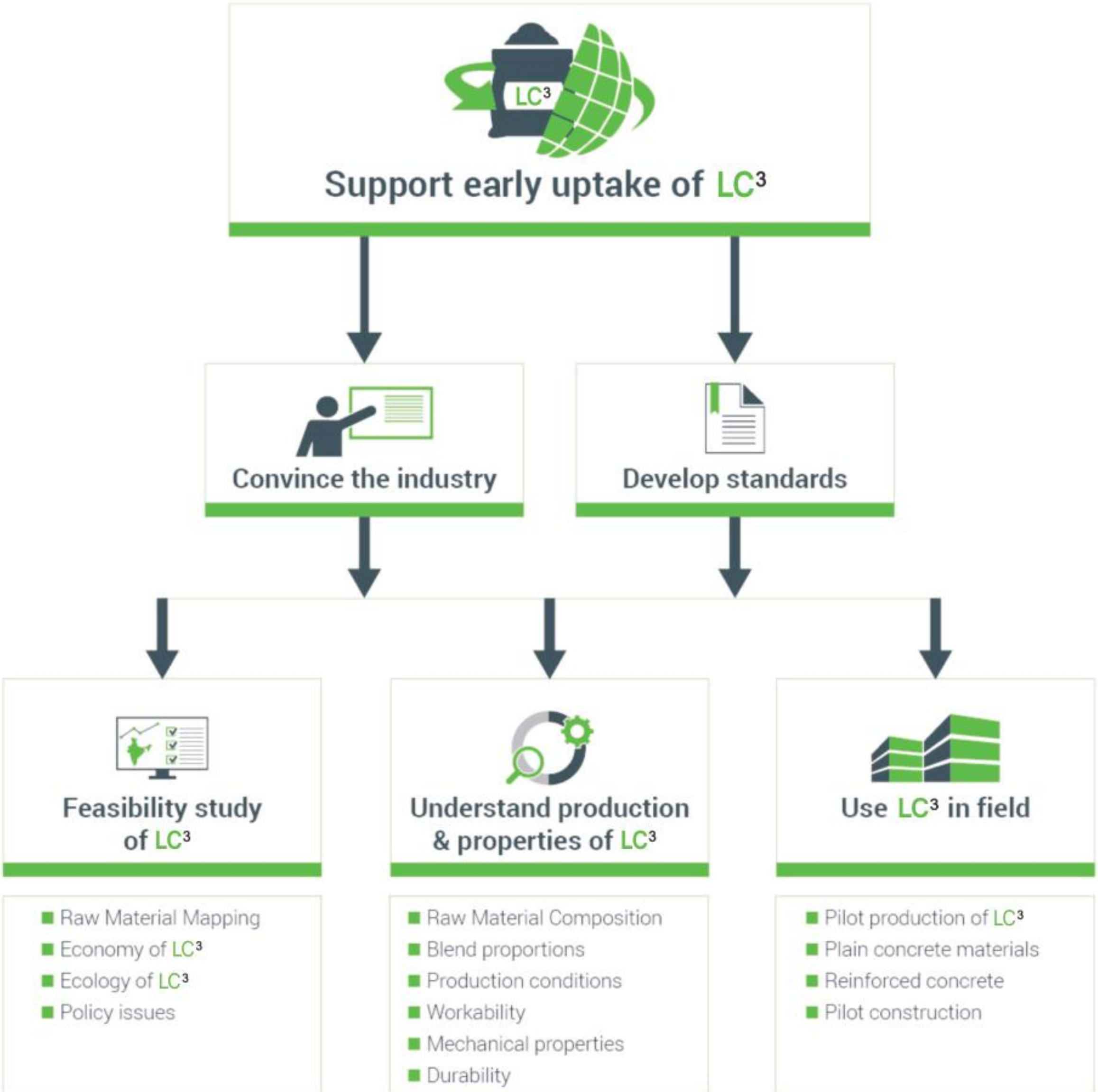

A house made of LC^3 in Cuba


Road segments made using LC^3 in Chennai

Challenges with LC³

Significant effort is needed to establish LC³ as a viable alternative for the cement industry. The mapping of resources, establishment of test methods and performance criteria and the estimation of commercial viability and environmental impact of LC³ in various scenarios is essential. It is most important to develop standards for LC³ that will be accepted by the Bureau of Indian Standards, allowing its commercial production. For this, a vast amount of laboratory and field data, verified by government bodies, the cement industry and the construction industry, has to be generated. This project aims to accelerate the uptake of LC³ through a focused, mission-mode generation of this data.

LC³ is expected to be a general use cement for structural and non-structural applications. Like all cements, it expected to perform well under many conditions. The data generated in this project will allow designers to use LC³ safely and efficiently.



The objectives and the key aspects to be studied in the LC³ project

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