Cement production is a very complex process. Different materials are mixed to form the raw meal, and – after the thermal process in the kiln – different components are ground together to obtain the final cement. However, the material flow within the cement production process is not fully linear and constant. A cement plant contains many bypasses, intermediate stocks and side streams. In addition, the inconsistency of raw materials and the need to produce different cements often lead to material shifts within the plant. The lack of a detailed knowledge and control of the internal material flows can result in quality fluctuations in clinker and cement, and to sub-optimised production, causing ultimately higher production costs.

Once cement leaves the plant, tracking its footprint along the distribution chain is very difficult, if not impossible. This issue is particularly important in cases of litigation related to the use of one specific cement in concrete. In these cases, the cement producer has few means to prove or disprove the origin and dosage of the cement used in the real application. In addition, it is a common opinion that there is currently no reliable method to assess cement content in hardened concrete with the accuracy needed for clarification of construction deficiencies or damages, particularly critical in case of composite cements. As a result, minimum cement limits and cement types specified by concrete standards cannot actually be proven in the field, which could lead not only to reduced cement sales but also to a potentially lower quality of concrete for buildings and infrastructure. To help address these issues, BASF developed within its MasterCem® cement additive range the cement tracer, a product which allows the reliable marking and tracking of cement. This technology, already applied commercially for many years in other industries, is now available to the cement sector.

**The technology**

The technology behind BASF’s cement tracer is a colloidal liquid suspension of acrylic co-polymer particles which are dyed with fluorescent material. After dosing onto cement, the tracer, thanks to its hydrophobic character, sticks to the cement particles and thus follows their path. Marked cement samples, after an extraction phase, are then analysed by flow cytometry, a method usually applied in medical and biology sciences. Exposure to a laser beam excites the particles and leads them to emit a fluorescent light. The count of the number of particles gives information on their concentration and thus on the quantity of the carrying material. The chemical structure of the tracer has a strong resistance towards the alkaline environment of cement as well as the acid extraction phase. It survives the temperatures and sheer forces that occur during the grinding process. In addition, its stability against weathering represents a...
good prerequisite for long-term application in concrete. In contrast to common tracing techniques with fluorescein, where only one of few colours are available, a very large number of marking combinations are possible, allowing for the identification of each individual cement plant, cement type, or batch. The polymer dyes can be coated with one single colour or with more colours, and different particles can be combined. This results in billions of colour combinations, allowing the identification of each cement, producer, or batch with a sort of invisible ‘bar code’. Simple material flow investigations, however, can be carried out with just a few colours.

**Possible applications**
The cement tracer can be used in following applications:

**Material flow investigations within a cement plant**
- flow assessments: retention times, abductions, leakages
- homogenisation performance of equipment for raw meal, fuels and cements
- silo management, purging times
- mill management.

**Cement commercialisation and distribution**
- marketing: differentiation/quality labelling/branding of premium cements
- liability: proving cement supplier and production batch (eg shelf life for Cr reducers)
- tracking cement distribution, import, blending, reselling.
- plagiarism protection.

**Cement application in concrete**
- detecting cement origin and assessing content in hardened concrete, even after years have lapsed
- compliance to concrete standards:
  - minimum cement content and cement types
  - concrete quality assessment for repair works.

**Cement tracer application at cement plant**
The cement tracer is simply dosed in liquid form by a screw pump on cement or other materials, as any common cement additive. To guarantee full homogenisation, the tracer is ideally dosed before grinding stages. According to the project objective, marked cement samples are then collected at defined places and sent to the lab for analysis. In case of hardened concrete, powder material samples are obtained by manual drilling of concrete.

**Case studies**

**Raw meal homogenisation**
A tracing campaign was conducted in April 2014 at the Mergelstetten cement works of Germany-based cement producer Schwenk. The objective was to assess the mixing performance of the raw meal mixing bed and the related variations or raw meal composition before the kiln. Two tracing particles with different colours (pink and yellow) were dosed on the feeding belt of the preblend pile. A total of 290 material samples were then collected for analysis at defined intervals after raw material grinding and after the raw material silo. The outcomes of the investigation delivered important information on the mixing performance of the raw material bed and thus on the potential improvement of the raw meal feed to the precalciner.

**Assessing cement footprint in the distribution chain**
In this project a cement shipment was continuously marked over five days. Some 10,000t of cement were treated with 100kg of cement tracer. Cement samples were then collected at different stages of the distribution chain, down to the final application in concrete. The investigation delivered important information, allowing the mapping of the cement footprints along the value chain. Nevertheless, within the defined project, not all cement flows could be explained and will require further detailed investigations. The methodology also proved the possibility to identify and quantify the use of cements from different suppliers in concrete production.

**Conclusion**
The new cement tracer offers enhanced knowledge of cement and other material flows within the cement plant, and within the cement distribution process. In addition, it enables cement producers to qualitatively and quantitatively track cement use in concrete, after several years. For the cement producer, the benefits are: improved cement quality control, potential for increased production efficiency and lower costs, marketing differentiation, better legal protection in liability cases, and ultimately, the potential for a higher quality of construction. In addition, the observation of a minimum cement content in concrete leads to a direct increment of sales volumes, which may be particularly relevant in countries where concrete standards are systematically overlooked.