RMC
TECH BEAT

Inside

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Concrete Innovations & Trends

Two Innovative Initiatives in Aggregate

PrismSand™

Besides producing ready-mixed concrete, RMC Readymix (India) has also ventured in to Aggregates Quarrying and Processing business. With a modest beginning made in October 2000, the Company has established a total of seven aggregate processing facilities in major locations and is currently producing around 1.8 million tonnes of aggregates annually. The Company has employed hi-tech crushing and processing plants from world-renowned manufactures like Metso Minerals, Sandvik, Puzzolona, Cedrapids, Voltas, Terex Pegson, and Terex Finlay, with the drilling machinery obtained from Atlas Copco and Ingersoll Rand, etc. The quality of aggregate produced is regularly monitored by routine testing conducted in in-house labs of the Company.

In recent years, considering growing scarcity of river sand, arising out of the stricter restrictions imposed by authorities on dredging in different states, RMC Readymix (India) decided on producing manufactured sand with a patented tag PrismSand™.

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Company News

Easycrete™ for Raft Foundations

High-rise buildings require massive foundations to withstand stresses generated by vertical loads and horizontal forces, the latter due to wind and seismic effects. As the building height increases, foundation sizes become larger, making their design and construction more challenging. Generally, provision of rafts resting on hard strata or piles becomes essential. Reinforced concrete has been the obvious choice for rafts. However, two major challenges are faced in the construction of massive rafts. Firstly, it is essential to ensure that concrete fully encapsulates the congested reinforcement and flows easily to all corners of the raft. Secondly, effective measures are needed to mitigate the adverse effects of high heat of hydration generated within the large concrete mass.

With a view to meet these twin challenges in a satisfactory manner, RMC Readymix (India) has developed an innovative special product – Easycrete™. After conducting a large number of laboratory and field trials, the product has been optimized to satisfy the three basic requirements of self compacting concrete, namely, easy flowability, passing ability and adequate segregation resistance.

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NABL Accreditation for Ghatkopar Plant Lab

RMC Readymix (India)'s central laboratory attached to its twin plants at Ghatkopar, Mumbai, has secured the coveted NABL endorsement. It has achieved the distinction of getting the Accreditation under ISO/IEC 17025:2005 in the field of Mechanical Testing of aggregate, cement and concrete.

The company can now proudly boast to be the first ready-mixed concretemanufacturer in Mumbai Region to have acquired the NABL Accreditation for its Laboratory. The Company's incessant quest for technical superiority has helped it to achieve this esteemed landmark.

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Around the World

USA: Growth Expectations in 2015

In the United States, the Bureau of Economic Analysis revised the 4th quarter 2014 economic growth downward to 2.2 percent from the previously reported rate of 2.6 percent. Despite this revision, overall growth is expected to exceed 3 percent in 2015. Strong job growth, pristine corporate balance sheets, low debt burdens, and easing of lending standards reinforce a healthy rate of growth.

Portland Cement Association (PCA), USA, expects net job creation to maintain pace in 2015 following 3.1 million jobs created in 2014. Improved job growth will benefit commercial construction and will eventually assist the public construction sector; however in the short-term, tight fiscal conditions have constrained public growth. In 2015 public construction spending will once again be a growth contributor, after five years of decline.

Another positive indicator is that large state fiscal deficits of the Great Recession have receded and many states continue steady, albeit slow fiscal healing. PCA believes public construction spending will slowly improve in 2015 and start to reflect the improving state fiscal climate.

Source: PCA News

Achieving Sustainable Urban Mobility with Concrete

The recently published a Position Paper on "Sustainable Urban Mobility" by the European Concrete Paving Association (EUPAVE) makes an interesting reading.

The paper begins by stating that most of the transport in the European Union happens in cities which account for 70% of the population and is responsible for a quarter of CO_2 emissions. It argues that for reducing congestion and preventing traffic jams, concrete is the best solution for European roads as their low maintenance requirement translates in to fewer road works and less nuisance to citizens, thus avoiding disruptions in urban mobility.

Further, higher rigidity of concrete pavements enable lower fuel consumption of heavy vehicles, leading to reduction in CO_2 emissions. With the addition of titanium dioxide (TiO_2) to concrete, it is now proved that pollution can be minimized as TiO_2 helps in absorbing harmful compounds such as nitrogen monoxide and nitrogen dioxide from air.

The light grey colour of concrete reflects more heat and light from its surface, thereby contributing a lot in reducing the "heat-island effect". The resulting lower overall temperature in the urban areas will lead to saving electricity consumed in cooling and air conditioning. In addition, the light-coloured surface of concrete pavement requires less energy for night-time illumination, allowing up to 20-30% cost savings.

Concrete pavements also permit the integration of different urban mobility modes. Dedicated bus and tram lanes in concrete offer a practical approach to public transport since they meet the long-term requirements of functionality, comfort, cost-efficiency and aesthetics. As they allow for faster routes into city centres they become a sustainable and efficient solution to congestion with few emissions.

Finally, concrete pavement is an economically attractive solution from public finance point of view. It not only has the life-cycle cost advantage, but increasingly, the lower initial cost advantage too.

Source: EUPAVE (www.eupave.eu)

Taller Wind Turbines with Concrete

Standard wind turbine towers are routinely designed to be 80-m tall because that is about the maximum height that can be achieved with the limits of the highway system for transporting and delivering major parts in the USA. Of course, taller towers would allow the capture of faster, more sustainable wind energy. To this end, some companies are exploring other design options that would enable hub heights of 100 m or higher. Steel would not be the material of choice because the increased base dimensions for taller steel towers would require the bottom section to be transported in multiples pieces and assembled onsite, adding considerable time and cost to the operation.

To overcome this challenge, researchers at Iowa State University USA, have developed a new tower design that uses concrete, not steel, as the construction material.

Concrete towers could reach heights of 100 m and utilize the current transportation system for delivery of parts.

Source: https://www.asme.org

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Forum

Concrete's Ascendancy from Historical Perspective

The development and use of different materials of construction are closely linked with the progress of human civilization. Ancient man started constructing his abode with naturally-occurring materials like wood and stones. The first use of sun-baked bricks belongs to the late Neolithic period. Brick-making was also known to ancient Indians as is evidenced from the archeological excavations at Mohenjodaro and Harappa from the Indus Valley civilization.

The fact that calcination of gypsum and lime results in powders which on cooling and mixing with water achieve binding properties was known to our ancestors. As per Kingery, a noted archaeologist, the use of lime mortar dates back to 12,000 BC; but its applications gained ground later during the Roman era. The credit for the invention and use of gypsum mortar goes to the Egyptians prior to 3000 BC. Here, it is interesting to note that it was possibly the shortage of firewood (most part of Egypt being desert) which must have forced Egyptians to use gypsum mortar as the calcination of gypsum requires only around 130°C as against 800-1000°C required by lime. Many monumental structures were built with lime and gypsum mortars - the famous Pantheon and the Colosseum (lime mortar) and the Pyramid of Cheops (gypsum mortar) - to name only a few. It is noteworthy that these structures constructed more than 2000 years back are still standing today!

Pantheon, Rome, constructed more than 2000 years back is a shining example of ancient concrete

During the medieval period, considerable refinements happened in the brick-making and in the use of stone and wood resulting in the creation of some architecturally-pleasing churches, cathedrals, chapels, residential buildings, etc. in Europe. Renaissance witnessed the use of cast iron, wrought iron and glass.

The modern era in construction commenced during the 19th century. The beginning was made by Joseph Aspdin who obtained the patent for Portland cement in 1824, followed by the one on reinforced concrete by William Wilkinson in 1854.

With these developments the use of concrete gained ground in Europe and North America and later in many other countries. The invention of pre-stressed concrete by Eugene Freyssinet in the early 20th century gave a further boost to the use of concrete.

During the past one-and-a-half century the use of concrete has reached to such an unprecedented level that it has achieved the distinction of being the largest used man-made material on earth, next only to water!

In spite of achieving such a towering feat - which in itself justifies the supremacy of concrete - the hidden competition between concrete and other major structural materials of construction such as steel and timber continues. The case in point is an article appearing in an online industry magazine *Sourceable*[1]. The editor of the magazine requested leading industry bodies from the respective materials industry to argue their case.The pros and cons of different materials make an interesting reading.

Timber has been and is being used mainly for low-rise residential structures in many countries of the western world. Timber is lightweight, can be easily worked and offers immense design flexibility to architects. It is very adaptable to offsite manufacturing, provides healthier environment for occupants and above all, it is a renewable product sourced from "sustainably managed" forests. One of the main disadvantages of timber is its proneness to fire hazards, especially for timber-framed buildings constructed in congested localities. In addition, there is a problem of premature deterioration of timber. It is reported that some timber structures have not been performing in accordance with the design assumptions and that concerns have been raised about the assumed modulus of elasticity and stress capacities of timber, particularly for visually-graded timber[2]. It is also mentioned that the lower-than-expected performance of low-density timber will have an impact on the performance of the bracing elements and nail-holding capacity.

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Forum

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Incidentally, considering the fact that the world has been losing forest cover at an alarming rate, there is a growing resistance to the use of natural timber. In countries like India, the Central PWD has prohibited the use of natural timber in buildings and the Indian Railways has been replacing the timber sleepers with pre-stressed concrete sleepers in a programmed manner.

With structural steel, the main advantages are lower dead weight, smaller foundation sizes, reduced labour requirements, higher quality assurance, higher recycling and reuse potential and higher speed and efficiency of construction, leading to faster completion and payback commencement. However, as the recent reports from Council for Tall Building and Urban Habitat indicates, the use of structural steel witnessed a dramatic decline in its share in the tall building arena and its place is being increasingly occupied by concrete and composites (*see RMC TechBeat issue of July-September 2013*). The main disadvantages of steel are that it requires continuous maintenance and is prone to corrosion. It is also recognized that for resisting disasters like hurricanes, tornados, earthquakes and fire, concrete is much better material than timber or steel. Researchers at the Wind Engineering Centre of Texas Technical University have recently concluded that walls built with wood or steel studs lack the strength and mass to resist the impact of wind-driven debris.

It is the versatility of concrete that has made it a natural choice for architects, builders and contractors. This versatility stems from basic advantages of concrete like the easy availability of ingredients locally, ability of moulding to any shape and size, and its relative cost-effectiveness. In addition, the technology of concrete has evolved to greater heights and allowed this seemingly simple material to adapt to the changing needs of modern society.

Centro Ovale concrete shell, Chiasso, Switzerland, illustrates the versatility of concrete[1]

Today, one can achieve almost any structural property desired by a designer from concrete - be it high compressive strength, high flexural/tensile strength, low level of permeability, high abrasion resistance, aesthetically pleasing texture, finish or colour. Further, the constructability of concrete has vastly improved with the advancements in chemical admixtures and pumping techniques which have enabled placement of concrete over longer distances and greater heights.

Two more properties of concrete, which have helped a great deal in improving the sustainability of this material, need a mention here. First relates to concrete's ability to absorb a vast amount of agro-industrial by-products such as fly ash, granulated slag, rice husk ash, silica fume, etc. The use of these by-products, which improves environmental-friendly profile of concrete, also helps in improving a variety of properties of concrete including its long-term durability, and hence sustainability. Secondly, the thermal mass of concrete can be beneficially used to influence energy savings during the service life of concrete structures. It has been proved that the thermal mass of concrete acts as a battery, storing the heat for use, long after the source of energy has been withdrawn. Concrete has the ability to moderate temperature extremes. Thus, occupants in a concrete house do not experience the extremes of temperature that tend to occur in light-weight structures. All this goes a long way in improving the sustainable image of concrete.

Even in the 21st century, there is no alternative to concrete. It is going to be the material of choice for a long time.

References

1. Timber VS Steel VS Concrete Structures; https://sourceable.net/timber-vs-steel-vs-concrete-structures/
2. Concrete Homes, Concrete – Journal of the Cement & Concrete Association of New Zealand, June 2002, Vol. 46, No. 2, pp. 8-15

Concrete Innovations & Trends

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Considerable efforts were made both on the production front as well as in laboratory evaluation to arrive at the best product mix of PrismSand™. It is produced from a Vertical Shaft Impactor (VSI), wherein three main crushing actions, namely impact, cleavage and attrition take place simultaneously to provide a consistently good quality product having uniform gradation and shape. Typical grading of PrismSand™ included in Table 1 indicates that it's grading lies between the upper and lower limits specified in IS 383 for Zone II sand.

Table 1: A typical grading of PrismSand™

IS Sieve	*PrismSand™ % passing*	*% passing of fine aggregate for Zone II sand as per IS 383*	
		Lower limit	*Upper limit*
4.75 mm	99.8	90	100
2.36 mm	86.3	75	100
1.18 mm	65	55	90
600 μm	48	35	59
300 μm	21	8	30
150 μm	8	0	20

One more advantage of PrismSand™ is that it contains less organic/inorganic impurities, and much lower levels of chlorides and sulphates, when compared with those of river sand. In view of the lower levels of silt, clay and other impurities, there is a reduction in water demand for the concrete mix, thus improving strength and durability of concrete. As the water demand is reduced, cement content can also be reduced to achieve the same levels of workability and strength.The superior shape, consistent gradation, improved surface texture and consistency in production of PrismSand™ go a long way in improving the strength and durability of concrete. Further, there is a reduction in the incidence of shrinkage cracking as the cement and water contents are lowered. Thus, a variety of benefits can be achieved by using PrismSand™.

Finally, there is a substantial environmental benefit. With the increasing use of products like PrismSand™ the dredging of river basins for obtaining natural sand will gradually diminish, thus saving them from environmental degradation and enhancing the river eco-system. PrismSand™ is therefore an eco-friendly product.

Copper Slag as Partial Replacement of Fine Aggregate

With the rapid depletion of good sources of coarse aggregates on the one hand and non-availability of river sand in major cities owing to strict restrictions on dredging on the other, search for alternative sources of aggregates is gathering momentum. Considering that the steel and the copper industries in India are currently facing serious problems of disposal of their industrial waste, some leading central research organizations like National Council for Cement & Building Materials, Delhi; Structural Engineering Research Centre, Chennai; National Metallurgical Laboratory, Chennai, Central Pollution Control Board, etc. have conducted detailed studies on the possible fruitful utilization of these wastes. These organizations have concluded that the wastes from the steel and copper industries are non-hazardous and can be used by cement and concrete industries in building and road construction. It was also observed that such wastes when incorporated in cement, concrete and bitumen become stable and pose no risk of toxicity. As far as use of the slags in concrete is concerned, there is ample evidence from studies conducted by some of the above-mentioned national laboratories that their use as a partial replacement of sand is feasible and advisable.

Huge quantities of steel and copper slags are currently lying unutilized. It is reported that while 22 million tonnes of steel slag is generated annually, the corresponding figure for copper slag is 1.4 million tonnes per annum. Over years, large quantities of these slags have remained unutilized. In fact these should be considered as a good resource by the concrete industry. The lack of interest in the utilization of these wastes can be attributed to two main factors. One pertains to logistics hurdles, in that the major concrete producing centres are located far away from the factories producing slags. Second, the use of slags as aggregates in concrete is not yet authenticated by codal provisions. The good news is that the latter hurdle is being resolved now. It is encouraging to note that the Bureau of Indian Standards recently constituted a "Panel for Aggregates from other than Natural Sources" to evolve guidelines/standard for use of such aggregates and we understand that the first draft is also prepared.

RMC Readymix (India) is possibly the first commercial ready-mixed concrete producer in the country to take the initiative in using copper slag in commercial production. A small beginning was made by the Company in procuring copper slag from Sterlite Industries, Thoothukodi and using the same in the Company's plant located in Trivandrum on a trial basis.

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Concrete with copper slag as partially replaced fine aggregates

Before using the slag in production, proper characterization of the material was carried out through third-party testing involving evaluation of its basic physical and chemical properties. Test results revealed that copper slag contained no harmful organic impurities and the soundness of aggregate is within the limits specified by IS 383. The test on alkali-aggregate reactivity revealed that the slag aggregate is innocuous. Sieve analysis indicated that the copper slag fits into Zone I of IS 383. The specific gravity of aggregate is little higher i.e. 3.66 and colour is black. A number of mix proportioning trials were then conducted in the laboratory to ascertain the optimum proportion of replacement of fine aggregates with copper slag. The results revealed that it is possible to replace around 10 to 15% of fine aggregate by copper slag, with combined specific gravity of the fine aggregates being 3.08. While no difficulties were experienced in obtaining the desired slump and slump retention, the 28-day compressive strength data indicated that there is a slight improvement in the compressive strength of concrete with the use of copper slag. Trial production with partial replacement of fine aggregate with around 10-15% of copper slag has now commenced from Company's plant located at Trivandrum.

The above mentioned two environmental-friendly initiatives of RMC Readymix (India) will go a long way in reducing the Company's carbon footprints.

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NABL Accreditation for Ghatkopar Plant Lab

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National Accreditation Board for Testing and Calibration Laboratories (NABL) is an autonomous body under the aegis of Department of Science & Technology, Government of India. NABL accreditation provides independent third-party recognition of competency in laboratory testing and calibration.

Earlier, RMC Readymix (India)'s laboratory at the Company's Whitefield Plant in Bangalore received the NABL Accreditation in 2013. The NABL Accreditation for the Ghatkopar Plant Laboratory indicates Company's continued commitment to providing quality products to its customers.

The Company believes that NABL Accreditation to the Company's two main laboratories would go a long way in reinforcing customer's confidence.

The Company now intends to open the testing facilities to some of its customers on a commercial basis.

NABL

National Accreditation Board for Testing and Calibration Laboratories

(An Autonomous Body under Department of Science & Technology, Govt. of India)

CERTIFICATE OF ACCREDITATION

RMC READYMIX (INDIA), (A DIVISION OF PRISM CEMENT LIMITED)

has been assessed and accredited in accordance with the standard

ISO/IEC 17025:2005

"General Requirements for the Competence of Testing & Calibration Laboratories"

for its facilities at

L.B.S.Marg, CTS No. 177, Ghatkopar Village (West), Mumbai, Maharashtra

in the discipline of

MECHANICAL TESTING

Certificate Number [illegible]

Issue Date [illegible]

Valid Until [illegible]

Signed for and on behalf of NABL

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Company News

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In addition, with a view to mitigate the adverse effects of temperature rise in the massive foundation, the optimization also involved provision of sufficiently high proportion of a supplementary cementitious material. The latter has been carefully determined in such a manner that client-specified compressive strengths are achieved at different ages. Since incorporation of large proportion of supplementary cementitious material leads to lower compressive strength at early ages including the 28-day value, it is appropriate to specify the 56-day strength criteria.

Fig 1 Close up of congested reinforcement in the raft foundation

Since the foundations need to withstand the total load at a later age, it is usually safe to specify the 56-day compressive strength, instead of the standard 28-day strength. Easycrete™ has been tailored to satisfy all these requirements. The third important advantage Easycrete™ is faster speed of construction, which is very much desired by most of the customers.

Table 1 Salient Properties of Easycrete™

	Tests conducted on Laboratory samples	Tests conducted on Field Samples
Workability (slump-Flow)		
Initial	<700 mm	<700 mm
60 min.	700 mm	650 mm
120 min.	625 mm	600 mm
150 min.	600 mm	525 mm
180 min.	550 mm	500 mm
V-Funnel	11 sec.	13 sec.
L Box	0.83	0.81
U Box	15 mm	18 mm
Compressive strength		
7-day	36.9 MPa	32.1 MPa
28-day	48.9 MPa	45.2 MPa
56-day	61.6 MPa	55.9 MPa
Water penetration Test (DIN 1048-Part 5)	11 mm	13 mm
Rapid Chloride Ion Permeability Test (ASTM C 1202)	1430 Coulomb	1510 Coulomb

One of the leading builders in the country recently utilized Easycrete™ for the construction of a large raft foundation in the central core area of his 60-storey residential tower in Worli, Mumbai. The raft contained very congested reinforcement (Fig 1). A total of 570 m^3 of Easycrete™ was supplied. While carrying out the laboratory optimization of Easycrete™, a variety of tests such as slump flow test, V-funnel, U Box and L box tests were carried out to ensure that Easycrete™ satisfies the filling ability, passing ability and segregation resistance criteria specified in the EFNARC (European) Standard. Further, as against the 56-day compressive strength of 50 MPa specified by the designer, the actual value of strength obtained was 55.9 MPa. Test data on laboratory and field samples are included in Table 1.

Fig 2 Easycrete™ being pumped in the raft foundations

Mail Box

Q. : We are planning to construct a building in soil strata having high sulphate concentrations. When ground water was tested, it revealed the sulphate concentration (expressed as SO_3) to be of the order of around 4000 ppm. In accordance with the requirements of IS 456, our consultant suggested the use of concrete containing sulphate resisting cement (SRC) with the water-cement ratio not exceeding 0.45. When we approached your local business manager, he suggested the use of your special product Foundationcrete™. Can you explain how this product will cater to our requirements? We are ready to give you the concession of following the 56-day compressive strength criteria as the actual loads on foundations will come at later ages.

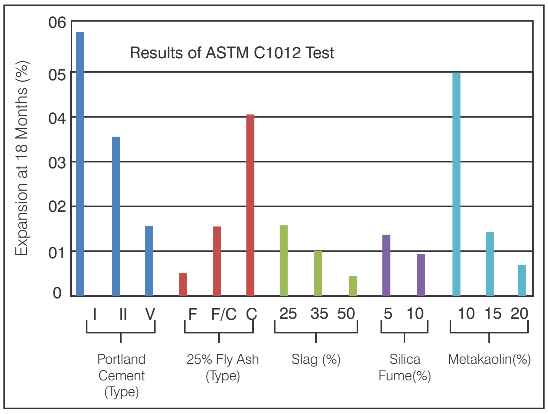
A. Based on the requirements specified by you, we are confident that our Foundationcrete™ is best suited for your application. We will provide you a tailor-made Foundationcrete™ satisfying the IS 456 criteria of the minimum cementitious content and water/binder ratio. However, we can convincingly prove that it is not essential to use SRC to achieve sulphate-resisting property.

Sulphates attack on most hydration products in concrete, including calcium hydroxide (CH), calcium-silicate hydrate (C-H-S), and monosulphate hydrate. The hydrates that form from the tri-calcium aluminate (C_3A) phase of the cement are considered most vulnerable to such attack. Therefore, IS 12330 on SRC specifies that a C_3A content in SRC should not exceed 5%. Further, since there is some evidence that alumina in aluminoferrite phase of Portland cement can participate in sulphate attack, the SRC Standard provides an upper limit on a combination of C_3A and C_4AF in such a way that ($2C_3A + C_4AF$) should not exceed 25%.

Simultaneously, there is ample evidence to show that higher replacement of ordinary Portland cement by supplementary cementitious materials like fly ash and GGBS improve the sulphate resistance of concrete. The improved resistance can be attributed to the partial removal of calcium hydroxide, decreasing the gypsum and ettringite formation and the enhancement of paste-aggregate interface of concrete. As far as the use of fly ash is concerned, it is the low-calcium fly ash (Class F type) which provides better resistance to sulphate attack than the high calcium fly ash (Class C type).

For assessing the sulphate-resistance of mortars, test specified in ASTM C 1012 is being used widely. We have included here a graph showing comparative performance of concrete mixes with different combination of supplementary cementitious materials. This graph very clearly shows that sulphate resistance performance of concrete mixes containing 25% class F fly ash and 50% of granulated slag are superior to the other mix combinations. In addition, the low level of permeability achieved with the use of fly ash and granulated slag provide an additional barrier against the sulphate attack. Such additional barrier may not be available when only SRC is used.

Thus, our Foundationcrete™ offers you the best solution for your application.



Comparative performance of concrete with different cementitous materials content (Source: NRMCA, USA)

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