And Now, Millennium Concrete

Only five months to the Y2K problem; computer engineers are bracing to face the chaos ahead. Are civil engineers ready to deal with the 1:2:4 problem? This was the question asked by Mr. C. M. Dordi, Gujarat Ambuja Cements Ltd, at his recent lecture "Concrete for the Next Millennium" at the Institution of Engineers, Sri Lanka.

Today, concrete is the key construction material in the world. However, things would not remain the same all the time, so it needs preparation to face the challenges looming ahead. New materials, new equipment, should not be completely forgotten; there are lessons to learn from them.

However, change is not coming by that easily. Architects, civil engineers and consultants — all think a hundred times before making a change. All changes may not bear fruit; but progress will come only through change.

Threats to the future of concrete

Neglection of durability aspect

One thousand cubes were tested, but not one failed! is the concrete of good quality? Not necessarily. The strength seems to be all right but what about the durability? Both are important but obsession with the former leads to neglection of the latter. A concrete of high strength but low durability may, after some time (say 15 years), fail to take the design load due to the corrosion of reinforcing steel. Therefore, a structure with a low initial cost can be much costlier due to the repairs required throughout its design life. That's why the life cycle cost deserves attention; it considered the durability aspect. The lowest bid based on the initial cost should no longer get the job all the time.

Inefficient conventional practices

A classic example is volume batching — also known as the 1:2:4 problem. Mixing raw materials to certain proportions may not produce the desired strength — in particular due to variations in quality and graduations of raw materials. Weigh batching on the other hand is more reliable.

Scarcity of natural aggregates

In Mumbai, India, natural sand suitable for concrete is no longer available in abundance. So is the case in Sri Lanka where continued sand mining in the rivers has become an environmental problem.

Problems due to reinforcing steel

Reinforcing steel is expensive but corrodes, leading to durability problems of the concrete. Moreover, introducing more steel to control flexural cracking would cause internal restrainment of concrete. This, in turn, may lead to cracking of concrete.

Increased labour costs

As the quality of education goes up, dedicated labour would not be available in abundance. As a result, the labour cost would go up. This is already a problem in the developed countries; construction equipment, therefore, plays a more important role there.

Aversion to concrete

Concrete invites criticism due to its greyish appearance and the massiveness of concrete structural elements. The label "Concrete Jungle" can only be change by inventing concretes pleasant in appearance.

Speedy but quality construction

The developing world is lagging far behind than the developed world when it comes to infrastructure development. The difference is reflected in the annual per capita cement consumption: 248 kg for the world as a whole, but only 84 kg for India.

by Asitha Jayawardena

To speed up construction work without sacrificing quality, there are two solutions: ready-mixed concrete and precast concrete. In general both are subject to strict quality control, so their performance is superior to site-mixed concrete.

Ready-mixed concrete is easier to handle than massive precast elements. The latter (wall panels, girders etc) bring about problems: for transportation from the factory to the site, wide roads with strong pavements are needed; for handling, large cranes. Moreover, the joints between adjacent precast elements would not be as monolithic and hence as strong as those in ready-mixed concrete.

However, in ready-mixed concrete, the quality of the final product depends on transporting, placing, compacting and curing of concrete. Precast elements on the other hand are compacted and cured at the factory itself and the quality is therefore better.

At a first glance, both types may look more expensive than the site-mixed version; but they offer additional benefits. Firstly achieving such a high quality is practically impossible with site-mixed concrete. Secondly, in the cities in particular, site space is becoming a more and more crucial factor. Therefore, the space saved by doing away with plant, equipment and raw materials for site-mixed concrete is a big gain; it also leads to cleaner hence safer sites.

Of the two types, ready-mixed concrete is more popular in India, where this industry started only in 1997. Now, two years later, seven ready-mixed plants are operating in Mumbai alone — basically catering to the fly-over projects in the region. Moreover, in India, its use is encouraged; for example, the Municipal Corporation of Greater Bombay decided to pay an incentive to the contractors who used ready-mixed concrete.

In a precast concrete factory in Britain, almost the entire process is robotised. There, if a batch of cured precast blocks fails to meet the British Standards, the entire batch is cured and tested again. thus no poor quality block would pass into the hands of the consumer. Such self-imposed quality control is good for the industry in the long run.

For a sewerage project in Mumbai, precast concrete tunnel liners were manufactured with 70% of cement replaced by slag. The mix had been designed to survive extreme conditions with high amounts of sulphates and chlorides as sea water would be used to flush out sewage. As durability was crucial, vacuum pads were used for handling the tunnel liners. Crow bars were not an attractive measure as they would have damaged the edges of the liners, reducing or even eliminating the concrete cover to the reinforcing steel inside. Such careful handling of precast concrete elements is important especially if the environment in which the elements are expected to perform would be aggressive.

New materials, new concretes

Concrete is no longer a combination of cement, aggregates and water only. Now chemicals and additives are used to obtain special properties leading to improvements in performance of concrete. One such additive is microsilica, which can partially replace the cement in concrete. It is an ultra fine silicious material, which is much finer than cement. It improves the bond between the aggregate and the cement paste and is capable of producing concretes of even 90 MPa.

However, there are problems. Microsilica particles tend to flock together, trapping the mixing water and hence reducing the workability of the mix. So it should be used along with good super plasticisers. Moreover, it is dangerous to health; if it goes into breath, lung cancer is possible. therefore, in USA, it comes in celluar bags, which can directly go into the mix; they get dissolved without causing any problem

Off-shore concrete platforms face aggressive marine environments full of sulphates and chlorides. There, tidal fluctuation causes a wetting and drying cycle; in the low tide, concrete would be in contact with oxygen, promoting corrosion of the reinforcing steel. Microsilica can improve durability of concrete facing such conditions.

One such off-shore platform is the Stratford Platform in the North Sea. It is 145 metres deep and has consumed 130,000 cubic

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metres of 60 MPa concrete with a microsilica content of 5%. Another is the Hebura Platform in Newfoundland. With a microsilica content of 8%, its 80 MPa concrete has to bear another burden — the impact of the floating icebergs.

In developed countries highways paved with concrete initially posed a problem: noise due to contact of tyres with the pavement. The solution to this is a two-layer concrete: the bottom layer is normal pavement concrete; the top layer, air entrained concrete. Its success is reflected in its name, Whisper Concrete.

Concrete is greyish; its elements, unlike structural steel ones for example, look massive. Many people, therefore dislike its appearance. To win their hearts back, Imprint Concrete was invented — basically for pavements in gardens and around buildings. Fresh concrete is place and then, using a mould, it is pressed to obtain the desired decoration; colours can also be obtained by adding pigments to the mix. Thus the concrete pavement can be made to look like stone or brick, for example.

Modern batching plants

A ready-mixed company in Britain has all its batching plants connected to a single central cell. As a concrete cube is tested at one of the plants, the quality controller at the central cell immediately receives the test results. Such quick feedback systems help deal with quality problems at an early stage.

Another batching plant in Britain employs cameras all over the place. So that all the components (i.e. the bins, the conveyor, the mixer) are visible to the operator. Meanwhile in Mumbai, a British ready-mixed company uses latest audio equipment to provide a live commentary while the mix is prepared. It keeps the operator on alert; besides he would find it difficult to ignore the sweet female voice.

An asphalt batching plant in Britain is almost entirely automated. A truck comes to the gate; the driver gives the specification of the required mix, along with the money, and obtains a ticket. Then at the bay indicated on the ticket, the mix is delivered into the truck within minutes.

In Portugal the ten-kilometre-long Vascodagama Bridge was completed in just four years — ahead of the Expo Exhibition there. Such speedy construction was possible only because mobile batching plants on pontoons were employed to supply the massive requirements of ready-fixed concrete. Similarly, papers in USA can do fifty-kilometre road stretch a day — again thanks to mobile batching plants.

Modern plant and equipment

Plant and equipment play a major role in producing good quality concrete economically. For example, the water content of a concrete strongly influences not only its strength but also its durability. Now a moisture measuring probe is available to determine the surface moisture content of the aggregate. Thus the amount of water going into the mix along with the aggregate can be determined in order to reduce the amount of mixing water accordingly.

Good quality concrete may show bad results when tested. It may be due to poor sampling or unreliable testing equipment. For the next millennium, more precise but easy-to-operate testing equipment should be developed.

In Canada a computerised transit mixer is in use on trial basis. At the batching plant water is added to the mix a little less and necessary instructions are given to the computer to add the remaining amount of water required to achieve the water-cement ratio of the mix. During the journey to the site, the computer gradually adds water to the mix at a rate dependent on the speed of the truck. If, however, someone else (say the driver) adds water, the computer will reject the mix. Such precise fool-proof control is essential to maintain high standards of quality.

In the rural areas of developed countries, a versatile transit mixer is in use. So that a separate pump car or a crane is not needed for placing concrete. this three-in-one set up consists of a transit mixer, a pump and a placer boom.

In developed countries the popular trend is to relieve the tower crane from the job of placing concrete. So that it can be more wisely used in lifting other materials and equipment. In such instances tower-mounted light-weight placer booms are used for placing concrete.

Over developments may cause problems. For example, in Germany, a gigantic truck-mounted placer boom was manufactured; it could reach 62 metres. So expensive it was that a single contractor could not afford it; a consortium of contractors shared this dinosaur. As a result, it had to be transported to various sites all over the country. The other motorists, however, didn't like to share the highways with a dinosaur for obvious reasons of safety. The result was a ban in Germany. However, it is now in use in Greece.

Concrete on Moon

Honeymooning on Moon with concrete would neither be pleasant nor easy. Firstly, the low gravity would make mixing very difficult. Secondly, without oxygen, hydration would not occur; fresh concrete will fail to gain strength.

These challenges, however, should be met in the next millennium as, in the near future, we would be going there as tourists first and, later on, to settle there permanently.

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