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CRI TECHNOLOGY DIGEST

READYMIX CONCRETE IN INDIA— PROSPECTS AND TECHNOLOGY OPTIONS

CEMENT RESEARCH INSTITUTE OF INDIA

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INTRODUCTION

The foremost step towards rational utilisation of cement is through proper quality control in the choice of materials, proportioning concrete mixes and related workmanship in all aspects of production and use of concrete. It is estimated that by proper quality control, saving of cement of the order of 15 percent or more can be achieved.

In spite of such advantages, controlled concrete is not always adopted in construction. For small construction jobs, the cost of quality control is viewed to be disproportionately high, while for large projects the saving in overall costs by conservation of cement through quality control is sometimes considered to be small in comparison to what is gained by speedier completion of the project.

It is in such situations that Readymix Concrete (RMC) can offer substantial scope for the conservation of cement through proper quality control in production of concrete. Readymix concrete is produced in a centralised batching and mixing plant and delivered in a plastic state to the site of construction in suitable transportation equipment. It also facilitates partial replacement of cement by pozzolana at the site, leading to further conservation of cement because thorough and uniform blending of pozzolana with cement can be satisfactorily accomplished in central batching and mixing plants. More importantly, readymix concrete relieves the consumer of the tasks of procurement of materials, their storage and production of concrete with adequate quality control, which are taken care of by the readymix concrete supplier. Thus, readymix concrete is not only a 'material' but also a 'service'.

This Technology Digest discusses the prospects of readymix concrete in the country and technological options available to make it appropriate to Indian conditions and a saleable and profitable proposition to the entrepreneurs.

APPROPRIATE TECHNOLOGY OF RMC

In spite of the promising potential market for RMC in India with over 120 million tonnes of concrete produced annually and the necessary infrastructure to innovate or develop new technologies available within the country, there is no readymix concrete industry as such set up in

India. The reasons thereof are manifold encompassing various technical, economic and associated parameters. One of the primary reasons is the high capital cost of the transportation fleet of agitators/truck-mixers required by traditional readymix concrete amounting to as much as 60 to 70 percent of the total fixed capital. On this account alone, the cost of concrete from an RMC plant will be more than that of site mixed concrete as indeed has always been the case.

Another consideration is that the capacity at the site to handle and place concrete may not match the size and capacity of the transportation fleet, since in India, the placing of concrete in smaller works is mostly done manually. Placers or pumps are used only in large construction projects which may also be in a position to afford to have a central batching and mixing plant near the site of construction itself. For an average construction job in most of the developing countries, handling even 3 m^3 of concrete delivered by each trip of the truck-mixer/agitator may indeed pose some problems. Environmental conditions will not permit the full truck load of concrete to be kept waiting for long at the site to be used in small batches. Under-utilization of truck's capacity will, of course, add to the cost of transportation of concrete and thereby enhance the total cost.

From the above, the strategy to make readymix concrete an attractive proposition in India, points to two considerations:

a) Unlike in conventional RMC, concrete be transported in ordinary, non-agitating vehicles to reduce the capital cost; of course ensuring quality and other desirable advantages of readymix concrete at the same time; and
b) The size of the readymix concrete plant and the transport fleet be chosen keeping the constraints of placement at the receiving end in view.

R&D IN CRI

As a result of sustained R&D efforts in CRI, an appropriate technology—a total package—of RMC has now become available meeting the above strategic requirements. The cost reduction is achieved by using ordinary, non-agitating vehicles in place of agitators/truck-mixers. The capacities of the vehicles are of the order of 0·66 to 1 m^3, which match the handling capacities generally available at small to medium construction sites in the country, thus making possible the utilization of the transport fleet fully. Overall economy is achieved by choosing appropriate plant capacity and smaller size batching and mixing plants.

Transporting fresh concrete in ordinary, non-agitating vehicles would result in early stiffening of concrete as well as loss of workability in transit and call for technological improvements to alleviate these problems. These were accomplished by deciding to transport fresh concrete from the central batching and mixing plant in a 'semi-dry' consistency. In this process, initially the full mixing water is not added but only such a quantity of water is added which is sufficient to render the concrete into a cohesive mass. The balance of the mixing water is added in the second stage, ie, after transportation and before final placing of concrete. For this purpose, the amount of water is accurately measured and transported in the vehicle along with the concrete. It is the responsibility of the RMC supplier to supply concrete after second stage mixing to the consumer of the agreed quality characteristics. The mixer needed for the second-stage mixing is also a part of the total package.

The amount of initial mixing water was decided by a number of trials, so that the segregation of fresh concrete as well as the loss of water by evaporation during transport were minimum. In general, it was found that as the amount of initial mixing water was less, the segregation was more; conversely, with more water added initially, although the segregation was less, the loss of water by evaporation was higher. A balance was struck by choosing the initial mixing water to be within the range of 50 to 70 percent of the total, with 60 percent as average, at which level the segregation was within the tolerable limits prescribed in IS: 4634-1968, and the evaporation loss was less than 1 percent by weight of concrete.

With the optimum amount of initial mixing water thus decided, further trials were carried out with concrete of different grades, to study the effects on workability and compressive strength. Trials showed that the balance water required to be added during second stage, after transit times upto 2 hours, to restore the desired workability did not exceed the total water as per design, by more than 8 percent. This amount of retempering water is much less than what is usually encountered in conventional readymix concrete. The reason of this is simple; since there is less water to start with, there is less water lost during evaporation and therefore less water required to restore the workability. The trials showed that the workability of the concrete after second stage mixing was close to what was desired and the resultant compressive strength was within ±10 percent of the design control strength (Fig 1). This is considered significant because in conventional RMC such retempering is always accomplished with drop in compressive strength. It is possible that in the technology apart from very little retempering required, the remixing of concrete itself had some beneficial effect on the compressive strength.

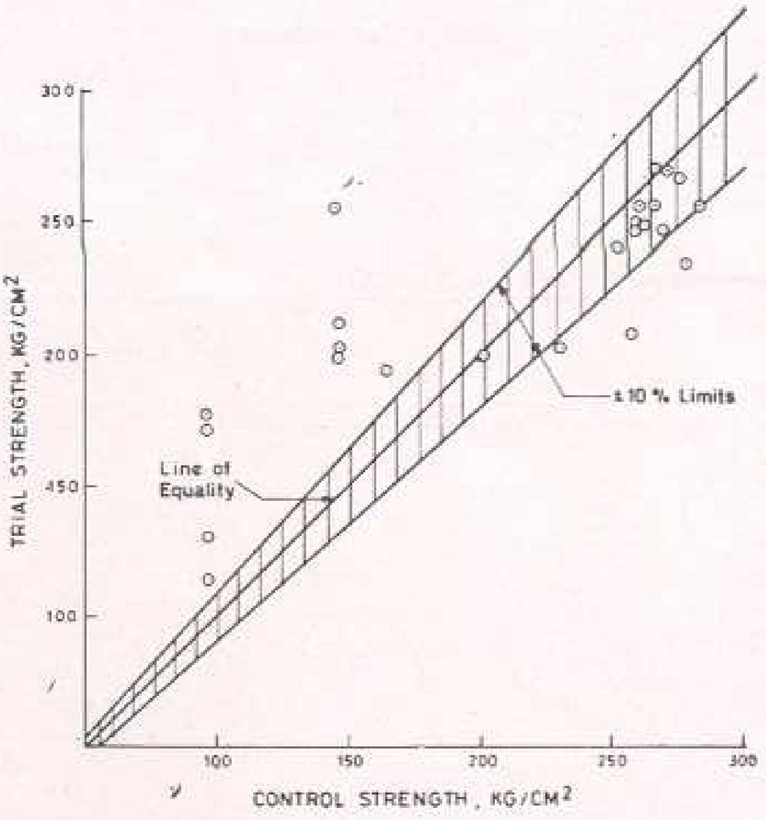

Fig 1 Comparison of 28-Day Compressive Strength for Control and Trial Concretes-CRI Technology

FIELD TRIALS

This technology was adopted to produce and supply controlled concrete of grades M 20 and M 30, used in two of CRI's own construction projects which were being carried out through outside agencies. The projects involved both cast-in-situ and precast concrete constructions, which were spread over both not weather (May), normal tropical conditions (July to September) and favourable weather conditions (October and November). It was seen that concrete of the desired grade and workability, including finishability in some cases as required from architectural considerations, could be achieved on a sustained basis with about 10 to 15 percent saving of cements (Fig 2).

Further trials were carried out in a barrage project where 120 m^3/h capacity fully automatic batching and mixing plant was available. Transport vehicles (both ordinary trucks and dumpers) available at the site were used for transporting the concrete. Trials carried out at the barrage site showed that no retempering water was required to

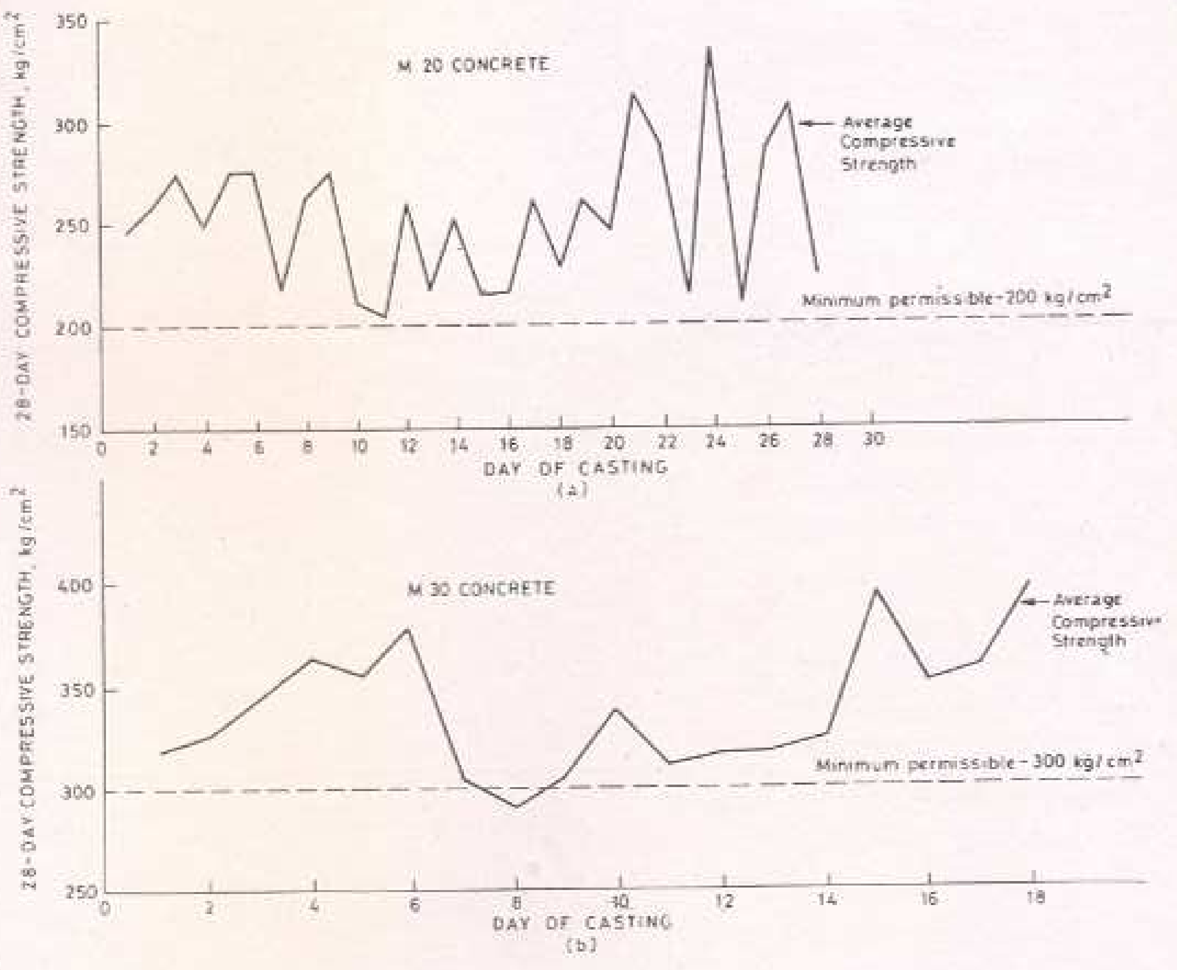

Fig 2 Quality Control Chart for (a) M 20 Concrete and (b) M 30 Concrete, Field (CRI Technology)

maintain the desired workability after transportation for about one hour. The 28-day compressive strength of concrete was within ± 10 percent of the laboratory control.

ADVANTAGES OF CRI TECHNOLOGY

From the above, the advantages of the technology evolved by CRI can be enumerated as under:

* Offers quality assurance; conserves materials, reduces construction time; reduces wastages of materials and guarantees satisfactory performance and service life; and reduces total life-cycle cost.
* Enables 'design mix' concrete to be adopted for small construction jobs also instead of nominal concrete mixes hitherto largely adopted, thereby enabling a saving of 15 percent in consumption of cement.
* Enables conservation of cement achieved through use of pozzolanas like flyash, suitable concrete admixtures, etc, under proper quality control and site operations, and where nominal mixes are used.

* Variability in the characteristics of various materials, such as cement and aggregates, is adequately taken care of by proper testing and mix design, thus ensuring uniform quality of concrete, which is what the user is primarily concerned with.

* Cost of readymixed concrete by CRI technology is comparable to the concrete by traditional site methods and is lower than conventional readymix concrete using large agitating trucks.

* Use of ordinary non-agitating vehicles of smaller sizes and utilisation of the full capacity for transporting concrete will also ensure optimum energy economics which is of paramount importance in today's context. By optimal location of plant and rational movement of raw materials and finished product, the consumption of energy and costs can be further lowered.

* Readymix concrete technology is made accessible to both large and small and scattered construction projects.

* Enables use of ordinary vehicle of small capacity, dispensing with conventional agitating truck-mixers thus reducing the capital cost considerably; transports concrete in such quantities as can be conveniently handled at most of the construction sites. The quality of concrete so produced is comparable to that obtained in conventional readymix concrete at a much lower capital investment, thereby improving economic viability.

* Semi-dry concrete affords longer transportation life than conventional readymix concrete which is advantageous in congested roads and in face of traffic bottlenecks.

* Ordinary transport vehicles, on their return trips, can be used to transport other materials, equipment, etc, which will add to the overall economy of the scheme. Such use of return fleet is not possible in the conventional agitators/truck-mixers.

SIZE AND ECONOMIC CONSIDERATIONS

The economic viability of any readymix concrete plant would depend upon the choice of appropriate plant capacity and matching infrastructure therefor. In an earlier study conducted by CRI, it was found that for conventional RMC, plant capacities of the order of 100 to 220 m^3 per day were more suitable under Indian conditions. In fact, notwithstanding the development of larger sizes of mixers and carriers, this is regarded as the optimum capacity range even in European countries. Such a conventional RMC plant would have used truck-mixers of 3 m^3 capacity which is the smallest size conventionally available. However, as pointed out before, in small and medium construction sites in the country, capacity of a $3 m^3$ truck-mixer would never be fully utilized. The present technology was, therefore, aligned with using ordinary trucks of smaller capacities of 0·66 or 1 m^3. By transporting concrete in such carriers to the full capacity, the unit cost of transportation would eventually be less than when larger vehicles are used (Fig 3).

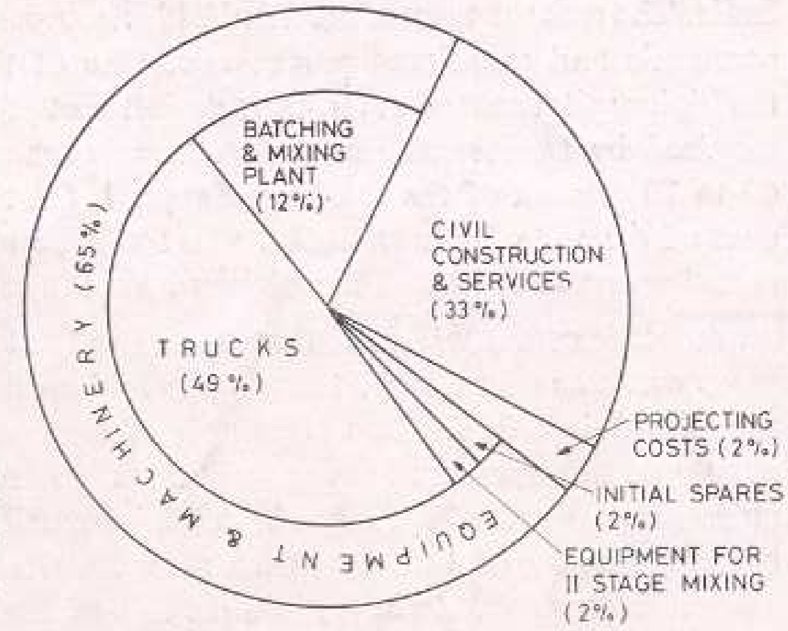

Fig 3 Elements of fixed Capital cost for RMC Plant of capacity $80 m^3$/Day Based on CRI Technology (Batching Plant Cap. $22 m^3$/hr.)

A scraper type batching plant of hourly production rate of 22 to 30 m^3, with mixer capacities of either 0·4 por 0·8 m^3 were considred. From preliminary calculations a plant capacity a of 80 m^3 per day appeared to be optimum. A larger capacity would involve substantially larger capital outlay and transport fleet would become too big to manage, although, selling prices would be marginally lower; for smaller capacity, the selling prices are higher and profits lower.

CRI EXPERTISE

CRI, with the experience it has gained in the development of appropriate RMC technology, is now in a position to help entrepreneurs in setting up of readymix concrete plants by carrying out necessary techno-economic viability studies and providing necessary technical guidance in their operation.

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