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Techno-economic feasibility study for the production of ready-mixed concrete in India

C. L. Verma, S. K. Jain and S. S. Rehsi

The significant features of ready-mixed concrete are described in the paper. Based on investigations carried out, the Central Building Research Institute have drawn up a techno-economic feasibility study for ready-mixed concrete in India, using fly-ash as partial replacement for cement. Operation of the plant and proposed lay-out are given in the paper. It is envisaged that the setting up of ready-mixed concrete plants in the major metropolitan towns will act as fillip to the building industry, leading to significant socio-economic changes.

The production of ready-mixed concrete is an established practice in many metropolitan centres of the industrialised countries. Increased attention is now also being paid in the developing countries who are now also resorting to use of such plants on an enlarged scale. Several government and private organisations are making concerted efforts to set up such plants in the near future. Ready-mixed concrete can also be produced with a part replacement of cement by some pozzolana; *e.g.*, fly-ash with a view to effecting economy in the cost of materials so as to make this process compete with the conventional site-mixed concrete. It is duly manufactured and processed in a centrally located plant, and is supplied to the user at the construction site ready for use in the unhardened state in quantities varying from a few cubic meters to several hundred cubic metres depending on the demand. The general advantages obtained by using ready-mixed concrete are:

(*i*) increased capacity of production due to automatic and continuous operation of the plant

(*ii*) supply of concrete safely upto a radius of 20km from the ready-mix plant eliminates the necessity of setting up a small batching unit at the construction site; this feature is of significant importance for construction work in congested localities for urban building complexes

(*iii*) good quality concrete of uniform consistency is produced under controlled conditions

(*iv*) supervision and labour costs are substantially reduced on account of the automatic controls incorporated in the plant

(*v*) concrete of different mix proportions can be produced from the same plant by incorporating a selector switch ensuring specifications to the customer

(*vi*) proper gradation and accurate weighment of materials guards against segregation of concrete

(*vii*) wastage and pilferage of materials from the plant is reduced.

In spite of the numerous advantages, some limitations of ready-mixed concrete are that of heavy initial investment, and a comparatively higher price, as the exact proportions of ingredients as specified by the design are batched by strict quality control. However, duly motivated consumers would be prepared to pay for the quality they require.

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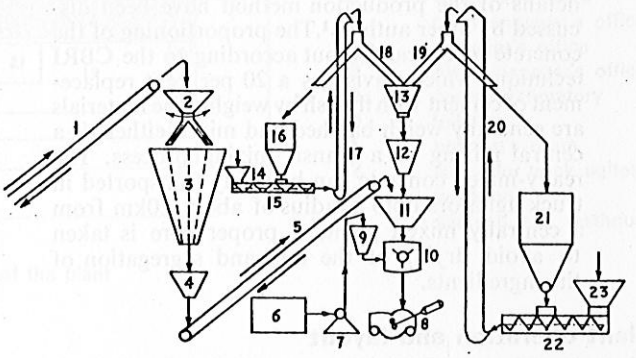


Legend

Serial no	Name of item	Quantity, nos	Remarks
1	Belt conveyor	2	transporting aggregate
2	Rotary chute	2	as a feeder
3	Aggregate storage bin	1	four compartments
4	Weigh batcher	1	aggregate batching
5	Belt conveyor	1	conveying to mixer feed hopper
6	Storage tank	2	water storage
7	Centrifugal pump	1	water pumping
8	Truck agitator	8	transporting ready-mixed concrete
9	Weigh batcher	1	water measurement
10	Mixer	1	concrete mixing
11	Feed hopper	1	conveying to mixer
12	Weigh batcher	1	cement and fly-ash measurement
13	Storage hopper	1	two compartments
14	Feed hopper	1	conveying fly-ash
15	Screw conveyor	1	conveying fly-ash
16	Steel silo	1	storing fly-ash
17	Bucket elevator	1	conveying fly-ash
18	Two-way chute	1	conveying fly-ash
19	Two-way chute	1	conveying cement
20	Bucket elevator	1	conveying cement
21	Steel silo	1	storing cement
22	Screw conveyor	1	conveying cement
23	Feed hopper	1	conveying cement

Fig 1 Schematic process flow diagram for the production of ready-mixed concrete using fly-ash

An investigation was conducted by the Central Building Research Institute, Roorkee on the production of ready-mixed concrete with special emphasis on the process technology and the economic feasibility of a plant. This forms the basis of the paper. Estimates for a plant designed to produce 50,000m³ of ready-mixed concrete per annum have been given.

Production method

The raw materials required for the normal plain ready-mixed concrete are the ordinary Portland-cement, coarse and fine aggregates and water. In fly-ash concrete, the fly-ash is the only additional constituent. The process of producing fly-ash concrete mainly consists of

(*i*) proportioning of the concrete mix, and

(*ii*) batching and mixing of different ingredients. The details of the production method have been discussed by other authors[1].The proportioning of the concrete mix is carried out according to the CBRI technique which envisages a 20 per cent replacement of cement with fly-ash by weight. The materials are generally weigh batched and mixed either by a central mixing or a transit mixing process. The ready-mixed concrete can be safely transported in truck agitators upto a radius of about 20km from a centrally mixed plant, if proper care is taken to avoid drying of the mix and segregation of the ingredients.

Plant operation and layout

The plant layout designed to produce ready-mixed concrete has been schematically outlined in *Fig* 1. The graded aggregates are brought to the plant site in tipping lorries or trucks and are stock piled separately in compartments of the storage yard. Ordinary Portland cement, received in bags, is piled separately in a shed and provision is made to store a part of the cement in a silo. The fly-ash is brought to the plant in trucks and is stored in a separate silo.

The aggregates are transferred to a four-compartment storage bin by means of an inclined belt conveyor discharging through a pivotal distributor which chutes the material from conveyor belt into the compartments of the bin. The bin is installed at the ground level and is designed to provide a storage capacity sufficient for operation for one hour. The remotely controlled gates of the hopper compartments feed the material to a cumulative weigh batcher which discharges the batched material on to another aggregate belt conveyor which leads the material into the hopper feeding into the mixer. The belt conveyors are continuously operated in order to replenish the storage bin.

The batched quantity of water required for the mix is pumped into the mixer through a weigh batcher or a water meter. A reservoir is provided to store water for emergencies.

The fly-ash received in trucks is unloaded directly into a hopper installed at the ground level for a capacity sufficient to accommodate a truck load of the material. From the hopper, the ash is conveyed by a screw conveyor to the boot of the bucket elevator where it is discharged to one compartment of the two-compartment storage hopper, the excess quantity of the fly-ash is transferred to the silo for storage. The bottom of the silo is again connected to the fly-ash screw conveyor for its further conveyance and elevation to the storage hopper, when required.

Cement in bags is emptied into a ground level feed hopper which has an arrangement to convey and elevate the material to its corresponding compartment of the storage hopper or into the storage cement silo similar to one used for fly-ash handling. The cement and fly-ash are batched in a weigh batcher and are discharged into the mixer through the mixer feed-hopper.

The batched ingredients of the concrete are thoroughly mixed in a non-tilting type revolving drum mixer and the material is unloaded into a truck agitator by reversing the rotation of the drum. Depending upon the capacity of the agitator used, usually two, or occasionally three batches are unloaded into the agitator drum and the concrete is transported to the job site in a continuously agitated state. The lay-out of a proposed ready-mixed plant is shown in *Fig* 2.

The entire plant can be operated by a small labour force. An operator at the top of the batching plant selects the gradings of aggregates, inspects the cement and fly-ash in the storage hopper and guides the complete cycle of operations. The second operator stands at a vantage point in front of the controls and starts the push button control operations pressing a series of buttons until the proportion of various aggregates are weighed. The weights are indicated on large dials above the control panel. Smooth operation of the plant requires operators trained in this field. The concrete thus produced is supplied to the customer in the ready-mixed state.

Capital outlays

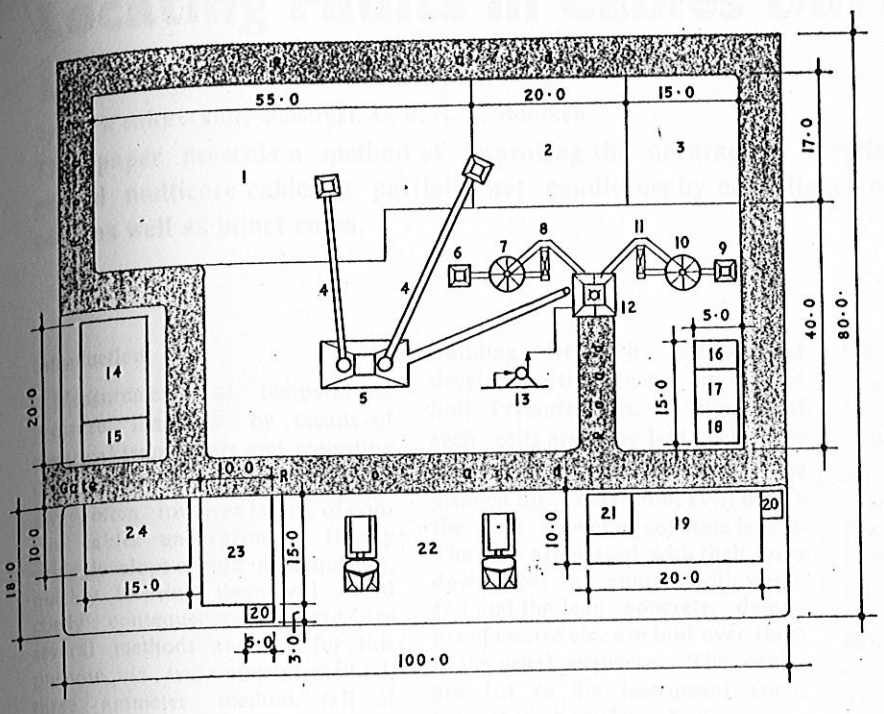
The capital investment required for installing a full-fledged, plant with an average annual production of 50,000m³ of concrete is placed at Rs 40 lakhs which includes a working capital of about Rs 8 lakhs.

The cost of production from a ready-mixed concrete plant producing M-150 concrete and operating in one shift per day for 300 working days in a year has been estimated to be Rs 176.84 per m³ at the prevailing rates. The proposed selling price with a 12 per cent net return on investment capital has been worked out to be Rs 200.84 per m³. The economic estimates outlined herein are of generalised nature and provide a basis for setting up a ready-mixed concrete plant. The real returns on investment can be worked out for different sponsors and specific sites from a knowledge of the exact nature and source of the financing body and locally available materials.

Detailed costs of materials required to produce one cubic metre of fly-ash concrete and the corresponding plain cement concrete were worked out at the Institute[10]. It was inferred that the fly-ash concrete corresponding to M-150, M-200 and M-250 grade of plain cement concrete is cheaper by 13.80, 15.20 and 16.00 per cent per cubic metre respectively, without the use of water reducing admixtures. When water reducing admixture is used the corresponding savings are 11.90, 12.10 and 14.40 per cent, respectively.

Concluding remarks

Utilisation of fly-ash involves the conversion of this waste from thermal power stations into industrial wealth. Fly-ash finds numerous applications in various industries as a building material. Considerable economy and saving in expenditure can thus be visualised if fly-ash is used as a part replacement of cement for producing concrete.



Legend

Serial no	Name of item
1	aggregate piles
2	sand pile
3	storage area for cement
4	belt conveyors
5	aggregate hopper
6	cement hopper
7	cement silo
8	cement elevator
9	fly-ash hopper
10	fly-ash silo
11	fly-ash elevator
12	central mixing unit
13	centrifugal pump
14	office block
15	watch and ward
16	plant engineer's office
17	engineer's office
18	plant manager's office
19	control laboratory
20	toilet
21	chemist's room
22	space for truck agitator
23	workshop
24	canteen and resthouse

Fig 2 Lay-out of the plant

The provision of housing to the masses is the foremost responsibility of the state. The establishment of ready-mixed concrete plants by government and private agencies can make the dream come true by creating a renaissance in the building industry. The continuous production of fly-ash concrete in all the metropolitan cities of India will then have its impact felt and impetus built in the society. The ready-mixed concrete plants will provide all the advantages that a factory provides in terms of increasing employment prospectus, savings in national resources and generating hope for the future.

Acknowledgement

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