

Technology improves efficiency of central mix plants

New machinery and advanced process controls result in faster mixing times

By Rick Yelton

In application, central mix plant production methods have changed little since the early 1960s. But mechanically, today's plants incorporate technology that can offer both increased productivity and mix quality. When facing expansion or replacement decisions, it is important to understand why these changes impact purchasing.

Production rate

Central mix concrete production rates can be a difficult concept for managers and accountants to understand. Rather than a direct function of equipment capacity and time, production must be viewed as a collection of individualized jobs performed in a limited time frame. Each job requires a

similar cycle time even though the size of the job may vary. A plant can run at full capacity, yet sell only half of its rated yardage.

The Concrete Plant Manufacturers Bureau (CPMB) provides standards for production ratings, approved by the Board of Directors of the National Ready Mixed Concrete Association. For comparison between plants, CPMB developed a calculation to determine theoretical plant production:

Theoretical Plant Production

in Cubic Yards/Hour =

$$\begin{aligned} & 3600 \text{ Seconds} \times \text{Load Size (in Cubic Yards)} \\ & \div \text{Production Cycle (in Seconds)} \\ & \times \text{Efficiency Factor} \end{aligned}$$

In publishing ratings of his plant, the manufacturer makes several determinations in the use of the equation. First, the manufacturer expects that a truck is always in position to receive a produced load. Second, the efficiency factor is a best-guess figure. Many manufacturers use a 90% efficiency factor. Others may base the factor on a 50-minute hour. According to *Concrete Plant Production* by Robert Strehlow, retired chief engineer of Rexnord's Concrete Product Division, the efficiency factor is the percentage of the time cycle per batch that can be repeated in the period used as a production rating standard. Third, the production cycle components other than mixing are unique features of each plant design.

Theoretical vs. actual rate

It is rare for a ready mix plant to consistently achieve its theoretical production rate. Several factors create this variation. Customer order size is often less than the optimal batch size. Variability of materials and weather cause increased mixer charging time. Differing slump requirements can increase mixing times. And truck availability can increase discharge time due to waiting.

Plant designers cannot control many of these field variables, but they have made progress in shortening the production cycle. The more cycles per hour a design allows, the more efficient the plant.

In essence, yards produced is a function of sales, while batches completed is a func-



Vince Hagan

Horizontal shaft mixer in its discharge portion of production cycle.

tion of plant management. The production cycle can be the key to overall efficiency.

Production cycle

In his book, Strehlow identified charging time, mixing time, mixer discharge time, and return time as the four components of production cycle time. The table below shows an example of a cycle chart for a central mix plant with a wet or gob hopper. The chart was prepared in 1971 based upon accepted industry standards.

This same chart can be used to plot actual times of today's plants. But, due to improvements, today's plants have shorter production cycles than the example.

Charging time (the time from when the empty mixer is filled with solid materials) has been reduced with a programmable controller and computers with load-cell interfaces. Plant feed conveyors have been automated with controlling logic loops for keep-full systems.

The benefit of automated charging has been more than production speed. "For high-performance applications, properly sized batching and delivery systems, with adequate control of the discharge rate for

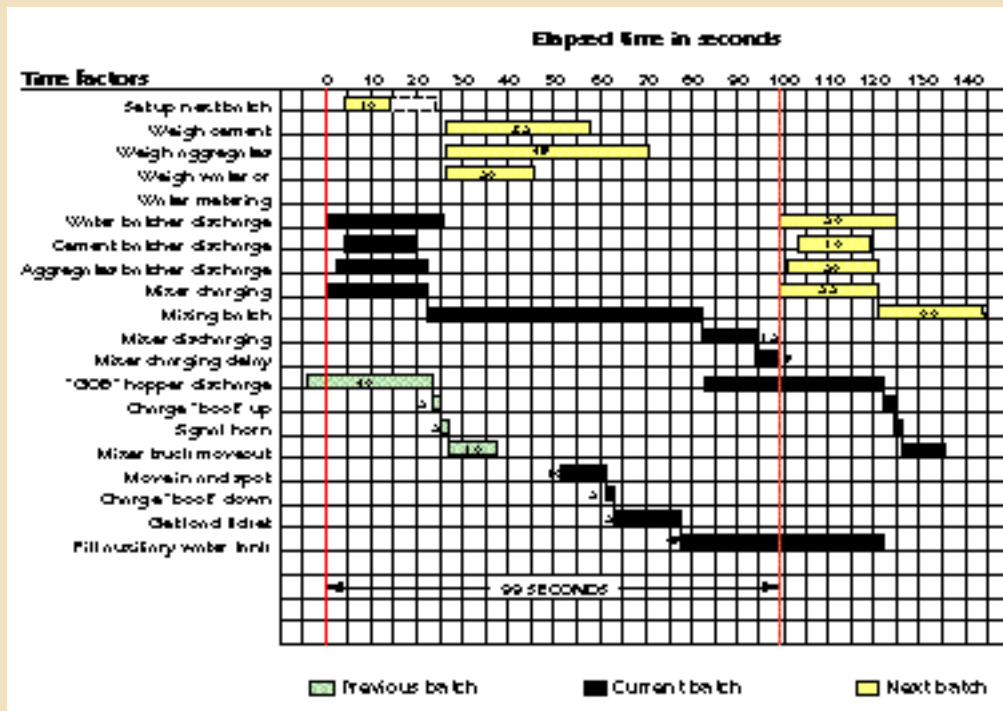
each ingredient, ensure that the ingredients are charged into the mixer at proportionately balanced rates," says Jay Taylor, chief engineer at Ross Co., Brownwood, Texas. By partially preblending the material according to the mix design's specified ratio as it enters the drum, required mixing time can be lowered. With this approach, the performance test results have indicated that a mixing time of 45 seconds provides uniform, high-quality mixes.

Another batching concept that could reduce mixing time is the slurry mixer manufactured by Matrix Master, Costa Mesa, Calif. In a central mix application, the premixed



An example of a compact, high-efficiency central mix plant on a paving job in Illinois.

Typical production cycle chart for central mix plant with dump hopper



The production cycle of 99 seconds is the total of a series of about 25 steps. Mixing time comprises the largest component of the cycle. *Source: Concrete Plant Production by Robert Strehlow.*

slurry of sand, water, and cement are introduced into a drum filled with aggregate. The aggregate can be quickly blended with mortar. The slurry-like mortar quickly coats the coarse aggregate, reducing drum mixing time. In several states, firms are conducting uniformity and performance tests attempting to gain DOT approval for reduced mixing time requirements.

Mixing time has become another area of design and operational emphasis. This segment of the production cycle can be viewed as the period of time required to transform ingredients of aggregates, cements, water, and admixtures into a consistent (uniform) product.

ASTM C 94 "Standard Specifications for Ready Mixed Concrete" suggests that mixing time should start at the point where all solid ingredients are in the mixer. It further specifies that all water must be introduced into the drum by the end of the first one-fourth of the specified mixing period. Mixing ends when the material is first discharged from the drum to a truck or hopper.

Strehlow says plant mixer manufacturers do not guarantee that their equipment will completely mix any formulation in any stated time. Practically, mixing time is deter-



Conveyor belt charges drum mixer with a proportionate mix of aggregates from batchers.

mined by the uniformity of the produced material.

As many regulatory agencies adopt performance specifications, some manufacturers have incorporated new designs to develop ways to reduce the mixing portion of the production cycle. One example is the horizontal spiral blade mixer with rotatable drum developed by the Vince Hagan Co., Dallas. Paving

contractors in Wisconsin have used this machine to produce concrete with a DOT-approved 30-second mixing time.

RexCon of Milwaukee used another approach, the introduction of a new blade design in its tilting mixer. The folding action of the material in the drum replaces the gravity spiral mix of the company's older units. The design has reduced both energy consumption and drum wear by 50%. The system also reduces mixing time. A contractor in Missouri has used this plant to produce uniform DOT-approved concrete in 30 seconds, with further reductions planned.

Mixing time studied in Iowa

Not every state agency is convinced that new technology produces consistent and uniform mixes. A research project in Iowa is evaluating the effect of mixing time on concrete delivered and placed on concrete highway construction projects. James Cable, associate professor of civil engineering at Iowa State University, is in charge of the project. "We believe that mixing time could be a major factor in the consistency of the mix, workability, and the long-term performance of the concrete in the pavement," Cable says.

The research includes field work from two construction projects.

The study will include samples from mixing times of 45, 60, and 90 seconds on three different mix designs. Production samples will be taken at both the plant and the paving site on each project. In addition, hardened concrete samples will be analyzed.

There is a general concern about the effect of mixing time reduction on air entrainment, especially in truck-dump delivered product. Cable's study will evaluate the effects of transportation and placement vibrator on the mix, as measured by the air content of the hardened concrete.

Shrink mixing

Shrink mixing is a commonly used method in central plants to reduce production cycle time. Concrete is mixed to a point where the desired slump is predictable and then finished on the jobsite with the truck mixer.

According to Gary Tuma, vice president of sales for Con-E-Co, Blair, Neb., this method is used widely on commercial applications throughout the country. "Many companies utilize their mixer for

only 20 to 30 seconds to be certain of the proper slump," Tuma says. "The truck drum is used to complete final mixing." ASTM C 94 allows this practice. As with mixing time determination, a test for uniformity should be used to determine the proper duration and speed of transit mixing.

A mixer truck process control system marketed by Compu-Mix Concrete Technologies, Quebec City, Canada, offers another way to reduce mixing time, even when using shrink mixing. The system offers an accurate method for maintaining slump and uniformity with the truck's mixer. Operations with this system reduce the total time in the central mix drum to about 15 to 20 seconds because material can be discharged at lower slumps. With slump developed on the truck rather than at the plant, there are reported reductions in variability in both air content and compressive strength of the delivered product as well.

Each truck is equipped with a controller, a computerized slump meter, and drum rotation control separate from the driver's controls. Using a new generation of artificial

intelligence software, the controller ensures that materials are homogeneously blended without overmixing. The system continuously monitors slump. When measurements indicate that the desired slump is achieved, drum speed is reduced to an agitating action.

During the drive to the jobsite, full aggregate absorption and initial hydration reaction occur in the mix. When near the jobsite, the driver checks the slump with the vehicle's neural slump meter. If a modification is needed, the driver consults an on-board "slump change expert" which suggests any water addition to achieve the desired slump. If the driver needs to add water, the system takes control of drum operation. Material cannot be discharged until it again becomes homogeneous.

The controller retains a historical time-stamped record of the following: mixing turn count, agitation turn count, slump (measured every 1 to 5 minutes), jobsite water added, as well as other truck travel information. The information can be downloaded to the plant computer.

The controlled mixing time, combined with controlled agitation at

low speed, enhances workability by reducing bleeding and segregation caused by adding too much water. Since each truck is identically equipped, the mix's variability, reduced initially at the central mixer, is further controlled and reduced by the truck's controller. Jobsite water addition is also minimized by two factors. First, slump is controlled by an unbiased standard, repeatable in nature. Second, if water is added, proper mixing must occur prior to discharge.

Producers considering purchasing a central mix plant can add the benefit of reduced production cycles to the list of other system advantages such as reduced coefficient of variation on mixes, lower exposures to fugitive dust emissions, and lower truck wear and tear. With this greater design emphasis on reducing production cycles, manufacturers hope to see increased use of central mix plants. ❖

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