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Process Control in Practice

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Our approach to process control is discussed for portland cement as this is the only phase of construction that we encounter. Our process-control system has been in existence since we first started to produce transit mix concrete in the late 1930s. Management took the position from the start that it would provide a quality product—to the point of overdesigning mixes to allow for some error in placement, handling, and testing. This was done and still is being done, to a lesser degree now, at the expense of the company. Changes in the concept of quality assurance introduced by the West Virginia Department of Highways in the mid-1960s, which were accepted by us in the early 1970s, have helped us to achieve and document goals of consistency in our manufactured product. Consistency was achieved by training technicians, setting up our own certified laboratory, maintaining complete control of our aggregates, testing cement from our suppliers, and, probably most important, switching from transit mix to an automated central mix plant. The sharing and use of test data collected by electronic data processing have been invaluable to us in our daily operating procedures. The raising of the iron curtain of communications from the owner to the contractor to us, the supplier, also contributed greatly.

Pfaff and Smith Builders Supply Company has been in business at the same location in Charleston, West Virginia, since 1902. It was founded to produce sand and gravel from the Kanawha and Elk Rivers for construction projects in the local area. Until the late 1930s it continued to produce sand and gravel and to sell wholesale products such as cement, plaster, and lath. Then, Pfaff and Smith entered the transit-mixed concrete market. The business remained basically the same until the early 1960s, when transit-mixed concrete gradually became the predominant product sold.

The first significant change in our operations came about in the early 1960s, when our dredge was modernized in order to produce higher-quality aggregates. We stayed current with the changing times by purchasing new transit mix trucks that allowed us to take on additional and larger jobs. During this period we encountered more stringent concrete specifications. This was also our initial introduction to process control.

QUALITY CONCRETE

During the mid-1960s we believed that we were producing good-quality concrete. Our aggregates were of good quality, cement appeared to be consistent, and the causes of problems in the field could usually be isolated as either the result of inconsistent testing procedures or the result of transit-mixer driver error. We were proud that we were often asked to furnish concrete after competitors had failed to meet specification requirements. We earned a good reputation and were thus able to sell quality concrete and service at a higher price. The reputation for quality and service at a higher price, although successfully sold to many local contractors, proved to be hard to sell to new contractors in our area. At this time we also realized that our gravity-fed transit mix plant was obsolete. It had been in continuous service for more than 30 years. We investigated conversion of the then-existing plant to a semiautomated plant, but this idea was quickly ruled out as too expensive and also this system would only meet the existing needs for plant capacity.

Next, we investigated the installation of a central mix plant. Although we believed that central mix was the way to go, the decision was delayed because it was very expensive, and we were uncertain that we could sell central mix concrete at the higher price needed to justify our investment. However, perhaps the main reason we delayed our decision was that preliminary plans for the Interstate system indicated that our property was in the path of one of the proposed routes.

Quality-Assurance Specifications

The West Virginia Department of Highways introduced their comprehensively rewritten standard specification in 1965. Area producers, already unhappy with the amount of concrete rejected on department of highway projects, viewed the new specifications with much apprehension. Meetings between producers and the department of highways usually ended with the attitude of near antagonism, at least from the producers' side.

During this period of transition, we declined to enter into substantial relations with contractors who were doing jobs under the specification of the West Virginia Department of Highways. For those jobs we did quote, we added up to one additional bag of cement to our cost of materials. In addition, a rule-of-thumb price of up to $4.00/yd^3 was added to the bottom line above the amount quoted to a commercial contractor for a like mix design.

As we neared the end of the 1960s, changing business conditions caused us to take a closer look at department of highways jobs. The Interstate system of roads to be built was coming closer to our area, which could mean more than 200 000 yd^3 of concrete for us. By this time our experience on department of highways jobs had improved and much less concrete was rejected. Test reports indicated good strength; however, we lacked consistency with wide ranges in strength, air, and slump.

Process Control

Good commercial laboratory facilities had not been available in our area, thus concrete test results were unreliable and costly. Therefore, we decided to set up our own laboratory and requested Cement

and Concrete Reference Laboratory (CCRL) approval. This was perhaps the best decision made for our process control program. Within a couple of years we were able to effect a number of procedure changes that improved our process control.

Through our laboratory facilities and joint contractors-department of highways training programs, we have been able to train and hire personnel to handle our operations. We now have six certified concrete technicians who work in most phases of our operations:

1. One heads our dredging operation, where the aggregates are first taken from the river deposit;
2. One heads our laboratory;
3. One heads our sales department;
4. One heads our scheduling and dispatch operations;
5. One heads our equipment-maintenance program; and
6. One operates our central mix plant.

We believe that each of the above personnel has the end result in mind in decision making; therefore, our process-control program is maintained at a high level.

PLANT AUTOMATION

By 1972 the Interstate system had arrived in our area. Management realized two things:

1. If we wanted Interstate business, we had to have automated central mix; and
2. If we had automated central mix, we could meet department of highways specifications.

The decision was made to invest approximately $500 000 in a new, fully automated central mix plant to serve this potential market.

Central mix has enabled us to produce concrete to department of highways specification. In addition, it allowed us to reach a goal that we had thought was unobtainable for a producer such as ourselves (i.e., one who manufactures a diversification of mixes for multiple contractors). The goal was to meet the West Virginia Department of Highways' requirements for level 1 plant process control, which are as follows:

> All plants producing concrete that reasonably conforms to the specification requirements and that satisfies the following additional requirements will be considered to have level 1 process control:
>
> 1. The compressive strength of the concrete produced by the plant shall have a coefficient of variation of 0.15 or less and the average, compressive strength shall be equal to or greater than the specified requirement plus 2.5 standard deviations.
> 2. The air content of the concrete produced by the plant shall have a coefficient of variation of 0.18 or less, and the average air content shall not differ from the specified optimum value by more than one standard deviation.
> 3. The consistencey of the concrete produced by the plant shall have a coefficient of variation of 0.20 or less, and the average consistency shall not differ from the specified optimum value by more than two standard deviations.
> 4. The plant shall maintain an adequate process control program for aggregate gradations.

CONCLUSIONS

Automated central mix has enabled us to realize some cost reduction for good process control. Within one year from opening our central mix plant we had reduced the cement content of 3000 lb/in^2, 6-bag, class B substructure concrete from a penalty content of 6.25 bags of cement to a reward content of 5.5 bags of cement. A three-year analysis of rejected concrete indicated that less than 0.5 percent of the rejections were destined for jobs for the department of highways.

Timely feedback of job information is vital if good process control is to be maintained. Once the communications barrier was overcome, we realized an improvement from most of our contractors in the ordering and scheduling of deliveries, which enables us to make better use of our equipment.

We consider concrete for department of highways' specification as preferred business and quote these jobs at or below rates for comparable commercial jobs.

SUMMARY

We look back at the 1970s as the time that we made great progress in our process-control program. It was an evolutionary rather than a revolutionary process that was guided by management direction. Central mix concrete is the only way we thought that we could maintain consistent process control. Even with central mix, we are not self sufficient. Communications, timely feedback of job conditions, and data furnished to us on a regular basis by the West Virginia Department of Highways enables us to indicate to our personnel how we are doing and the areas in which we need to concentrate. This sharing of information has enabled us to correct problems before they have a chance of getting out of control.