

# Construction Practices for Materials Control and Batching Operations for Rigid Pavement

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● IT HAS BECOME necessary in many areas, due to expanded programs, to spread the work load of available engineering personnel. Because this situation is not likely to change soon, every effort should be made to provide for proper training of new men. This paper outlines the duties of a proportioning plant inspector and provides solutions for some of his problems.

Many states have set up various systems of employee training. The system which seems most workable for men who will supervise work of the type discussed is one in which small groups are trained on a local basis.

Winter schools, of not more than ten or twelve men, make it possible for each man actually to run each test. He will be able to ask as many questions as necessary, and not be lost in a large class. The men brought into such a class generally represent a wide range of education and experience, and require some individual attention. The men available to instruct in such schools, who have had recent practical experience, will ordinarily do better with smaller groups also. Some of the construction divisions in Kansas have followed up these primary schools with more advanced training in following years with good results. Every organization has men who have had years of experience. If confronted with a school teaching task, they will take pride in the job and do it well. Without exception, the instructor will also benefit, almost certainly to a greater degree than any of his pupils.

Many paving specifications need review because of operational speed-up and changed conditions. A recent check of the specifications in Kansas turned up nine clauses which have appeared for years, and which are not applicable to present conditions and practices. Every statement of this kind, which the inspector knows is unworkable or is no longer necessary because of changed equipment or conditions, weakens his position in his relations with the contractor. Many contractors complain, with justification, that they must bid the engineer, or the district in which the work is located, because of different interpretations of vague or outdated specifications.

A large part of the plant inspector's problems are directly or indirectly due to the vastly greater quantities of materials handled now as compared to a few years ago. Many plant sites once considered adequate are now so cramped as to make their operation under existing specifications difficult or impossible. At the same time, greater numbers of projects are handled simultaneously by engineering forces, and available inspectors are often less experienced. Many jobs are operated with too little equipment at the batch plant, though every effort has been made to speed up the work at the pay off or mixer end.

At the start of a project the batch plant inspector should have an understanding with the contractor as to the site, equipment, methods, and materials to be employed. If any of these will lead to failure to meet the specifications, the contractor is entitled to a warning that enforcement will be rigid. If the planning involves not an infraction of the specifications, but inefficient operation, the warning is still in order, and is to the advantage of both contractor and owner. Both have a common goal—a better job.

Fortunately, one way in which the inspector's work has become easier is in the changed attitude of many contractors and their forces. Many contractors now realize that they cannot operate efficiently with cramped facilities and make a practice of setting up 2- and 3-stop plants with ample space. Almost without exception, every paving contractor in business today is making an honest effort to produce work which will re-

flect credit to and further the reputation of his organization. In the past most batch plants were set up in railroad yards. Materials were received almost entirely by rail, and arrangements were made for stockpile room either between or beside the tracks. This was a convenient and workable arrangement for everyone concerned. Paving progressed in a leisurely manner, compared to the present, and volumes of material used could be handled in the space available.

Lack of room to operate properly is never a valid excuse for stockpiles which are not bermed to prevent segregation, or for the intermingling of different sizes, or for uneven moisture due to loading bins directly from cars. It is difficult to prevent a coned-up and segregated stockpile if there is simply not room to build it properly. If sufficient quantities of aggregates of uniform moisture content are to be kept always available, stockpiles properly bermed to prevent segregation must be so large that it is practically impossible to handle two or more sizes of aggregate through one weighing setup, unless a belt-fed plant is installed, and these are not too well adapted to long jobs. Many pavers now follow the practice of setting up, for each size aggregate, a unit consisting of a stockpile, one or more cranes, and a bin with weighing hopper. These units may be separated by a few hundred feet or by a mile or more, but in any case, are so arranged that batch trucks and trucks delivering materials can operate in a smooth-flowing pattern. The first stop, after returning from the mixer can be at the sand bin. If separate cement boxes are not required, the cement stop may be next, and lastly the coarse aggregate. If cement boxes are used, the cement will be loaded last.

The same rule of adequacy applies to equipment. It generally is neither the duty of the inspector nor within the scope of his authority to require that two cranes be used instead of one, or three rather than two, for handling aggregates. It always is his duty and right, however, to see that lack of adequate equipment is not used as an excuse for waiving specifications requiring proper handling of these aggregates. In most cases the specifications are adequate but are not enforced, for the reason that they cannot be enforced, with the amount of equipment, or space, that has long been considered as "standard" for paving work. The inspector must not be influenced by standards of the past. His responsibility is to insure that equipment, space, and methods are adequate for the present.

#### SPECIFIC DUTIES OF THE BATCH PLANT INSPECTOR

There is a logical sequence for the inspector to follow in fulfilling his responsibility. First, he must organize his work, and thinking on an orderly basis. His duties are divided into three phases:

1. Preliminary inspection.
2. Operational control.
3. Reports.

##### Preliminary Inspection

The plant inspector's duties start during the time that materials are being accumulated. Before any concrete is batched, there are four duties to be performed. They are:

1. Approval of plant layout and stockpiling.
2. Inspection of equipment.
3. Inspection of materials.
4. Mix design.

Plant Layout and Stockpiles.—Although the selection and arrangement of the plant site is the contractor's privilege, it has been pointed out that, the inspector has a duty both to the owner and to the contractor to insure the provision of adequate space and working arrangements. He must accomplish this goal by showing its advantages, and necessity, to the contractor.

Even where ample space is provided, the inspector must see that other, more specific requirements are met. Segregation must be prevented, degradation kept to a minimum, and moisture uniformity assured. Segregation of coarse aggregate is

common if it is handled as a single material. The stockpile should be built in lifts of not more than 4 ft, with a distinct berm between lifts to prevent roll and subsequent segregation. Enforcement will not be too difficult at the start of the job but will become increasingly difficult as the job progresses. Moreover, unless the coarse aggregate is divided into two or more "one size" aggregates, stockpiled separately, segregation will undoubtedly occur.

Degradation of aggregate is also a serious deterrent to good concrete production. Most specifications prohibit rough handling, tracked equipment and stockpiling with trucks. The plant inspector should rigidly enforce such specifications. He should also retest aggregates which have been stockpiled through the winter or for long periods. In one instance, -200 mesh material has been known to increase from  $\frac{1}{2}$  to 7 percent during a winter season.

Proper stockpiling for an adequate period of time is the most important means of assuring moisture uniformity. Changes in methods of delivery of aggregates to the site have increased the problem. With the nearly watertight steel cars now in common use, excess water has little chance to drain off, and stockpiling for moisture uniformity is more necessary than ever. The inspector is there to see that moisture is uniform when aggregate goes into the bins, regardless of the circumstances.

Inspection of Equipment.—Although the inspection of equipment will be a continuing duty throughout the operation of the plant, an early and thorough inspection of scales, batching equipment and trucks will minimize later difficulties.

Scales. The scales should be checked after the bins have been allowed to stand loaded for at least 24 hr or until all settlement has taken place. Solid footings must be required under all bins to minimize settlement, and all supporting assemblies must be solidly constructed. The most elaborate and expensive system of hoppers and scales will produce poor results on poor footings.

Wind protection of scales is often slighted, or built in such a way as to fail in its intended purpose. The errors caused by wind may be small, but are of a type which do not tend to balance out. The effect of the wind on a sloped hopper side is well-recognized. However, a wind blowing across a flat horizontal surface will cause equal or greater inaccuracies in weighing. All knife-edge supported parts must be fully protected from wind.

Batching Equipment. In addition to checking the footings and structural stability of the batching equipment, the inspector must be certain that the plant will accommodate the batch trucks which may be used. If the truck beds are all the same height, it is not too difficult to arrange the discharge pipes at the cement batcher so that little cement will be lost as batches are loaded. Because most projects operate with a variety of trucks, it will be necessary to construct the plant so that the discharge pipes can be raised or lowered enough to take care of all the trucks being used without excessive blowing or spillage. Here again, the inspector should remember that he is not directly responsible for shortcomings in the equipment, but that by insisting on proper operation he can control the situation.

Trucks. Batch truck beds should be checked. They must be big enough to handle batches for present day mixers without spillage over the side or from one compartment to another. Compartment doors should be tight and have a positive locking system to prevent multiple dumping at the skip. It does little good to weigh out the components of batches to the pound and then mingle one batch with another in the truck or skip.

Inspection of Materials.—Either all or part of the aggregates are now commonly delivered by truck, and delivery may be continuous throughout the day, and perhaps, night as well. It was once possible to keep a record of railroad car numbers which could be checked against test reports with reasonable assurance that tested and accepted material was being received. It is now difficult even to be sure that aggregate is coming from the right plant, let alone stockpile or bin at that plant. Only by close coordination with the materials inspector at the producing plants can there be assurance that accepted material is being delivered. If there is doubt, retesting must be done.

Foreign material may not be too harmful, generally, but is unsightly. Surveys of year-old and older pavement reveal an astounding variety of included junk—boards, burlap, paper cups, corn stalks, straw, weeds, grasshoppers, mud balls, mud chunks from stockpile cleanup, old hats, and even sledge hammer heads. Most of this assortment originates at the mixer end, but every effort must be made at the plant to eliminate that which gets in there or is present when delivered. The area to be used for stockpiles should be cleaned and smooth, in order that as little aggregate as possible will be lost at the job's end. In addition to inspecting the aggregate the inspector is generally expected to see that all the incidental materials are undamaged and from tested stock. These include wire mesh, load transfer devices, air-entraining agents, joint sealing material, curing compounds, mixing water, and perhaps subbase material, although inspection of this last item can be a full-time job.

Mix Design.—The mix proportions must next be determined. So many methods are used in different areas that no attempt is made to go into this procedure in detail. In any case, however, the specific gravities of the aggregates and cement, the free moisture or absorption of the aggregates, and the unit weights of dry and rodded materials will be needed. Trial batches should be made and cement content should be checked from these trials. If air entraining is required, the approximate amount of agent to be added may be determined by trial batch, but probably with no great accuracy. The first batches through the paving mixers must be checked for air content under actual operating conditions, and these tests must be continued through each day.

#### Operational Control

During batching operations the batch plant inspector is responsible for the delivery of batches to the mixer which are accurately weighed, composed of proper proportions of materials which comply with the specifications, and are accompanied by information as to the water needed to produce concrete of proper slump. In carrying out these functions, he should be guided by the concept that the entire paving project is a line operation, from raw material source to finished slab. As is true of all such operations, the quality and volume of the end product are equally dependent on each step along the line, and no amount of extra effort at one stage can compensate for error or inefficiency at some other. The inspector should also realize that uninterrupted batching, although secondary to accuracy, is an important consideration. High volume, and lowered costs, are eventually passed along to the owner on following jobs. The specific duties of the inspector during batching operations include:

1. Continuous checking and reporting of aggregate moisture.
2. Scale checking and supervision of scale inspectors.
3. Preparation of test specimens, care of molds, curing, testing.
4. Maintenance of proper stockpiles.
5. Daily cement checks.

Supplying Continuous Batch Information to the Mixer Inspector.—Uniformity in the finished product depends on accurate information on water needed at the mixer, to a greater degree, than on any other single factor. Not only the properties of the concrete but the riding qualities of the completed slab are dependent on this information.

Because free moisture in aggregate must be considered a part of the total water in the mixed concrete, a continuous program of moisture testing must be pursued. The aggregate samples should be taken from the aggregate weigh hoppers and tested without delay. Some provision should be made for rapid communication between the inspectors at the mixer and at the batch plant, and these men must keep each other continuously informed of changes of moisture conditions. This information is supplied to the inspector at the mixer by the batch plant inspector in the form of a moisture and proportioning report, often referred to as a batch slip. This report includes the project number, date and time of day, and the mix ratio. It shows the pounds of each material on a saturated and surface dry basis, and the actual weight set on the scales after corrections have been made for free moisture or absorption. It shows either the total gallons or pounds of water in the mix, and the amount of water to be set on the

mixer measuring device. This quantity will vary from total water by that amount that is deducted to compensate for free water in the aggregate, or that is added to allow for absorption. The slip should also show the calculated air free unit weight of concrete and weight of materials in a one-sack batch. The batch slip should be made in triplicate, and the third copy retained in a bound pad.

Two copies should be sent to the mixer inspector at the start of each day's work, and whenever changes of any kind occur during the day. The inspector at the mixer should receive both copies, set the water on the mixers, and record on each copy the time, station and amount of air-entraining agent added. When test specimens are made during the day, the station at which they are made and their identifying numbers should be added to the information on the report. If it is necessary to use a quantity of water that differs from that shown on the slip, the actual amount of water added, the station, and the slump and unit weight of concrete, are recorded and one copy of the report is sent back to the plant inspector. The batch plant inspector can then make the necessary corrections on a new set of slips, and again send two copies to the mixer. At the end of each day, the batch slips should contain an accurate record of most of the pertinent information needed for daily construction reports.

Scale Checking and Supervision of Scale Inspectors.—Scale checking should be an everyday procedure. With a set of 50-lb test weights, cement and aggregate scales should be loaded to the batch weight. In addition, at frequent intervals during the day, spot checks should be made. These can consist of simply returning the beams to zero and checking for balance, or a single 50-lb weight can be added to a loaded hopper and the reading noted. Scale weight lock screws should be kept tight.

Checks should be made for dust. Dust on the beams may cause only small errors but the errors are all in one direction. One pound of dust on the lever system can become several pounds at the weigh hopper, in favor of the owner in a sense, but an error nevertheless, and to be avoided.

The plant inspector should frequently check that no material fails to leave the weigh hopper when it is dumped. He or his scale inspectors should note the disappearance of a truck from the string. Truck breakdowns generally occur on the portion of the trip when they are loaded. Batches spending several hours in a stalled truck with cement and damp aggregate intermingled must be dumped. Even separate cement compartments, which generally have no bottoms, are not capable of protecting the cement overnight if aggregates are other than bone dry.

Test Specimens.—An important part of the control of a paving operation consists of the making, transporting, curing and testing of strength specimens. It is a simple matter to show a new man how to do each test, but unless it is also explained to him why it is necessary to perform each operation in a prescribed manner, he will surely find short-cuts which will reduce the reliability of the test results. He should, for example, be given the reason for a specified rate of loading when breaking a test beam in flexure. He may be told, or discover by accident, that a higher compressive strength may be developed by a period of drying out just prior to delivering cylinders to the laboratory.

Time should be taken to point out to the new man, and some of the old ones, the pertinent AASHO and ASTM sections which prescribe standard procedures for the different tests. It should also be explained that it is strengths obtained by these standard methods that are wanted, not strengths due to an "improved" procedure of his invention.

Daily Cement Checks.—The amount of cement used should be checked constantly. Particularly where air entraining is required, it is easy to get into serious trouble. Neither the theoretical cement content nor the cement content derived from the unit weight of fresh concrete should be considered sufficient evidence that all is well. These methods should be used but at least once a day the total volume of concrete poured should be checked against the actual car load weight, or bulk truck weight, of cement used. This is not easy to do at a predetermined hour of the day, so opportunities must be watched for, such as when the cement bins are allowed to run dry between cars or trucks. The cement scale inspector should be alerted to assist in finding spots for this check.

## Reports

In any kind of construction work uniformity is the goal, so far as materials are concerned. When dealing with concrete, complete uniformity must be recognized as impossible. The list of possible variables is so long, and so many are not controllable on the project, that it is safe to say that no two projects ever built are similar, let alone identical.

If there is no uniformity, then there must be records if concrete paving procedure is to be improved. Most construction people think they are buried in record keeping, and they do spend much of their time writing project reports. However, if a person has ever checked back through the field reports in a search for a reason for either exceptionally good or bad performance of a section of pavement, he knows how incomplete the data can be.

He will find test reports by the hundred, but he will find it difficult to determine where a particular brand of cement or lot of aggregate was used. Someone on the project knew at one time almost every detail of how the work was done, with what materials, and why changes were made. The plant inspector cannot keep complete records of the entire project, but his records should be as complete, and as permanent, as possible.

The proportioning plant inspector should keep, in bound field books, a record of every shipment of material. This record should include the source, the test number, the quantity, and where it was used. It should include the amount of cement used each day, and as nearly as possible, the location of the cement represented by each test number, the actual cement factor based on car weights of cement received, the over or under run, the mix proportions, the air content, the slump, and the source of mixing water. Any changes made during the day in cement brand, water, other materials, and of procedure should be noted.

He should keep a bound book with a record of scale checks, both full scale checks and those of the spot variety. He will, of course, need to record test specimen data which should include date made, from what location, how cured, when tested or sent to the laboratory for test, and the results. Any possibility of damage such as from freezing or handling should be noted.

The control of air entraining is more a matter of record keeping than of computation. Using a given quantity of air-entraining agent the resulting air entraining will be found to vary with changes in temperature, slump, humidity, mix time, percentage of sand and gradation of sand, wind, and manner in which the agent is added. The record should show all of the foregoing factors and the quantity and brand of agent and the resulting air content. Some agents are sold in different concentrations and this should be recorded.

Accidents are seldom found in the job records, yet if improvement is to be made in materials and procedure, the accidents must be recorded. Far more can be learned from a project on which some things went wrong, than from one that was without incident, provided that it is possible to find out just what did happen.

Perhaps at 9 a. m. it is discovered that the sand scale has been set 400 lb light, or heavy, since the start up at seven. The chances are good, that when such a thing occurs the brand of cement has just been changed, and duly recorded. Some years later it will be easy for someone on a condition survey to come to erroneous conclusions as to the effect of the difference in cement.

Two things remain to be impressed on the new inspector, and no amount of training in the mechanics of the operation are of any avail without them. He must be made to realize the importance of his duties, and he must be confident of the backing of his superiors. The rate at which the owner's money is being spent on a high-speed paving job should be used to prove to him the amount of money involved in, for example, a one percent error in cement content. Unless he and the contractor both know that the inspector is truly the representative of the engineer in charge of the project, he cannot hope for complete success.