INSPECTION OF

CONTINUOUSLY REINFORCED CONCRETE PAVEMENT

DISTRICT CONSTRUCTION ENGINEER'S OFFICE

DISTRICT 24

TEXAS HIGHWAY DEPARTMENT

October, 1966

FOREWORD

This Manual was prepared primarily for senior construction inspectors who will presently be in responsible charge of continuously reinforced concrete paving projects in District 24.

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CONTINUOUSLY REINFORCED CONCRETE PAVEMENT

HISTORICAL BACKGROUND

The Bureau of Public Roads in 1921 constructed one of the first continuously reinforced concrete pavements on Columbia Pike in the vicinity of Arlington, Virginia. This was an experimental project in which slabs of 200 feet in length were constructed. Although this project yielded some very practical design data, similar programs were not attempted until autumn of 1938. At that time the Bureau of Public Roads in cooperation with the Indiana Highway Commission built a substantial number of continuously reinforced sections that varied in length from 20 to 1310 feet. The purpose of this joint experimental undertaking was to study and evaluate the results of changing quantities of longitudinal steel in unequal length pavement sections.

Continuously reinforced sections with pavement lengths of more than a mile were built by Illinois and New Jersey in 1947, by California in 1949, and by Texas in 1951. These were still primarily experimental projects. Pavement lengths and depths and amounts of longitudinal steel were varied and studied on these jobs. The design of the Texas job designated the pavement thickness and specified the percentage of reinforcing steel from beginning to end of the project.

Until Cashill and Teske in 1955 published their report on the performance of the Indiana experimental section of continuously reinforced pavement after it had survived 15½ years of service, there was very

little construction of this type being done. Highway engineers since that time have displayed an ever increasing interest in continuously reinforced concrete pavement. These engineers have been most captivated by the vision of mile after mile of enduring concrete pavement constructed without the usual and objectionable transverse joints, except for necessary construction joints caused by the suspension of paving operations between expansion joints at structures or for joints at project ends.

Pennsylvania constructed two experimental jobs of two miles each during 1956 and 1957; and from 1957 to 1961, Mississippi, Maryland, North Dakota, Maine, Michigan, Wisconsin and Texas built continuously reinforced concrete pavements. Many other states are presently contemplating or constructing experimental jobs.

DEFINED

Cashell defines a continuously reinforced concrete pavement as "A concrete pavement in which the continuity of the longitudinal reinforcing steel is interrupted only at structures and at ends of paving projects, and in which no transverse joints, other than construction joints are installed."

CHARACTERISTICS

In a jointless type pavement, continuously reinforced with steel, cracks will happen. But it is a sort of controlled cracking. With the properly designed percentages of longitudinal steel this cracking

will occur at intervals of from 5 to 10 feet. These cracks never open excessively because of the restraining action of the reinforcing steel. A jointless type pavement without reinforcing steel would crack and open excessively without the restraining action of the steel to restrict the cracks once they are open. This excessive cracking would eventually effect the ruin of the pavement by causing extreme pavement fractures and distortions.

Longitudinal changes in a continuously reinforced pavement of a mile or more are restricted primarily to the end portions of the pavement. Observations of experimental sections of a mile or more in length point out that the greater portion of pavement which exists between the ends is practically restrained from longitudinal movement. Experimental studies show that only the 400-to 500-foot end sections of the pavement experience extreme longitudinal changes as a result of moisture and temperature changes. Regardless of a pavement length, terminal movements will not exceed 2 inches.

High strength in concrete for continuously reinforced pavement is neither needed nor desirable. High strength concrete will tend to over stress the reinforcing steel which will tend to lessen its design effectiveness in the pavement.

PROJECT ORGANIZATION

ORGANIZATION MEETING FOR INSPECTION PERSONNEL

Because concrete paving inspection furnishes continuous inspection not only during the placing and finishing operations on the road but also provides for preliminary preparations before road operations begin and makes provisions for controlling batch plant procedures during concreting actions, the Engineer must organize and staff a concrete paving project well in advance of actual paving operations.

On large concrete paving jobs, several inspectors will be required to establish efficient inspection controls over all the many aspects of the paving operations. Each inspection job should be filled by qualified personnel carefully selected by the Engineer. After each inspection assignment has been worked out, the Engineer should call an organization meeting for project inspection personnel for the prime purpose of establishing project organization.

At this meeting, with all project personnel in attendance, the Engineer should define and assign the inspection duties and responsibilities of each man on the job. Every inspector should, after this meeting, know the scope of his work as well as exactly what will be expected of him. There should be a question and answer session conducted by the Engineer during the course of which he should propound project procedures and policies. The "chain of command" should also be outlined at this time. An understanding of who is who on the project should be unequivocally

established at this meeting. The use and mis-use of State vehicles should also be discussed as well as the proper usage of the Department's radio communication system.

THE CONCRETE PAVING PROJECT ORGANIZATION CHART

Figure No. 1 on page 6 gives the Organization Chart for an average concrete paving job. A chart similar to this should be drawn by the Engineer and distributed to project personnel at the Organization Meeting for inspection personnel. Project inspection demands may vary slightly from job to job although in structure the organizational demands of inspection for one project will be quite similar to those demands of another project that is relatively equal in magnitude and scope. A shortage of qualified inspectors may tend to encourage the Engineer to drastically modify his particular Organizational Chart. This "shortage of qualified inspectors" problem is a universal one and it is probably the greatest problem that the Engineer will have to face. Yet the Engineer must fill key inspection positions with qualified personnel. If he does not have them on his staff, then he must hire them. If he cannot hire them, then he must have personnel trained to fill these key positions before they are put in responsible charge of any phase of concrete paving inspection.

The detailed duties of the inspectors as outlined in the Project Organization Chart are as follows.

RESIDENT ENGINEER. The Resident Engineer assigned to a project by the District Engineer will be in full charge and respon-

ORGANIZATION CHART

CONCRETE PAVING PROJECT

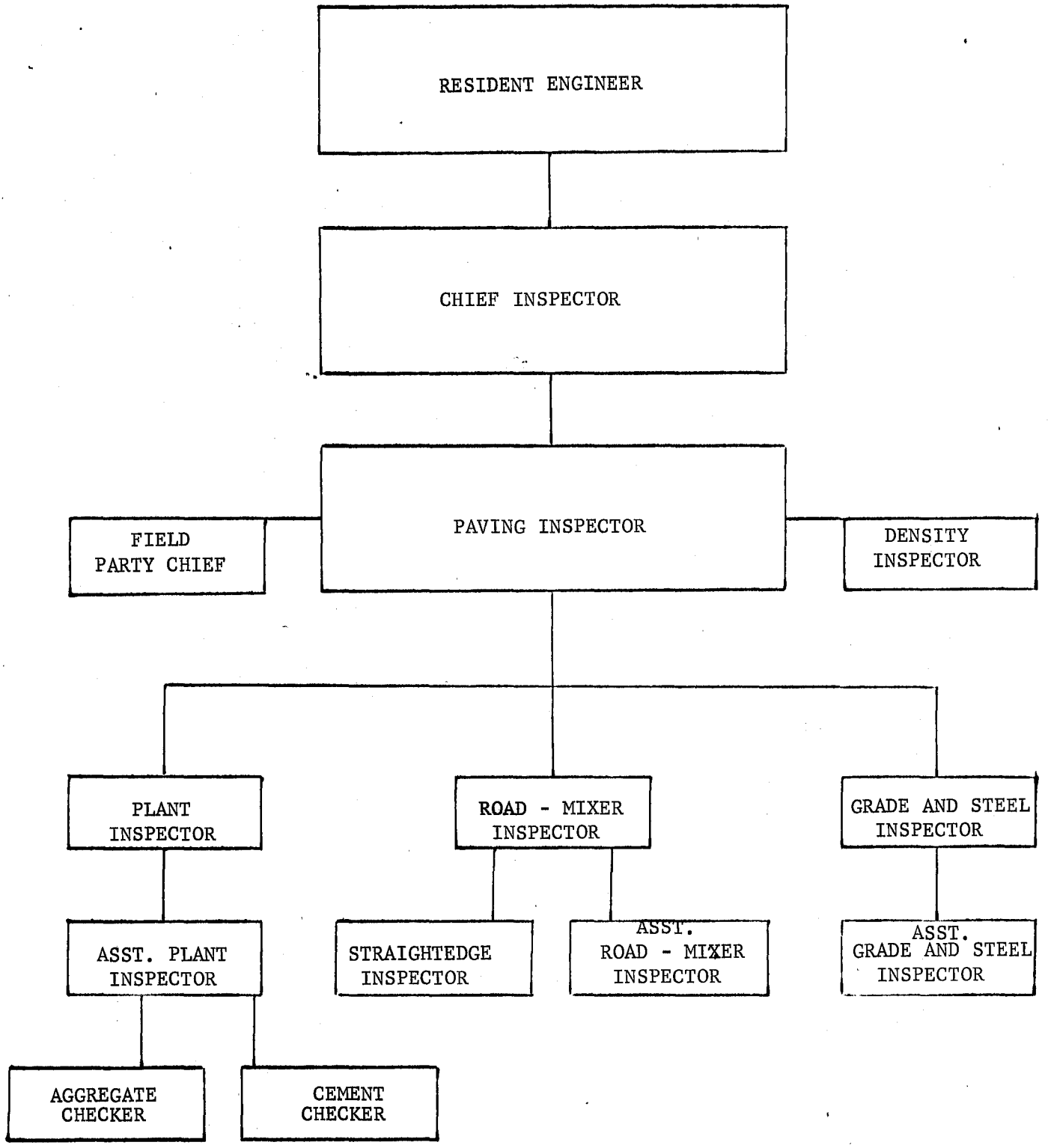


FIGURE 1

sible for all phases of the work.

CHIEF INSPECTOR OR PAVING INSPECTOR. The Paving Inspector operates directly under the Chief Inspector or, in the case of the Chief Inspector functioning as the Paving Inspector, directly under the Resident Engineer. His duties are to carry out the instructions and orders of the Resident Engineer, and to coordinate the work of the plant and road inspection forces. He will be in direct charge of all construction paving operations, and any instructions that may be necessary to be given to the Contractor should be given by this man.

PLANT INSPECTOR. The Plant Inspector will have general supervision of all the operations at the plant site and will have supervision over the assistants stationed at the plant. His principal duties will be to see that all of the various tests required by Bulletin C-11 are made, and that the batch design, the stockpiling of the various aggregates, and the use of the various aggregates meet the requirements of Bulletin C-11 and the governing specifications.

The Plant Inspector should keep his field laboratory report up to date as the work of each day progresses. Bulletin C-11 explains in detail exactly how to fill out Form 312 Rev. The Plant Inspector's attention is directed toward an important requirement regarding Form 312 Rev., the forms are to be submitted at least once a week to the Construction Division, File D-6, Austin Office.

In preparing Form 312 Rev., the Plant Inspector should be careful to show the complete project number, county, highway number, Contractor, and other necessary data. He should keep in a diary records of the weather, daily production records, instructions given to the Contractor, record of breakdowns, shutdowns, and other information of a similar nature. Aggregate sieve analyses should be kept on Form 310, Field Laboratory Aggregate Sieve Analysis Report. Concrete design data should be recorded on Form 309, Concrete Design Work Sheet.

ASSISTANT PLANT INSPECTOR. The Assistant Plant Inspector's principal duties will be to make the various tests required at the field laboratory. All of these tests will be made in accordance with the instructions of Bulletin C-11. He should keep the Plant Inspector advised of the test results, keep the laboratory equipment in good working condition, and keep the laboratory in a clean and neat manner.

AGGREGATE CHECKER. The Aggregate Checker will be stationed at the batching aggregate bins, and will observe the weighing of the various aggregates. He will secure samples of the various aggregates to be tested and deliver them to the field laboratory.

CEMENT CHECKER. The Cement Checker will be stationed at the cement batching bins to see that the proper amount of cement is weighed into each batch of concrete. He will secure the necessary samples of cement to be tested and deliver them to the field laboratory.

THE ROAD-MIXER INSPECTOR. The Road-Mixer Inspector will have general supervision of all the various paving operations on the road and will have supervision over the assistants stationed on the road. The Road-Mixer Inspector's principal duties will be to see that all of the requirements of the plans and specifications are met including making the required number of test beams, slump tests and air determinations of the concrete. He will see that accurate records are kept of all materials delivered to the road, that the proper yield is being obtained, that the joints are smooth and constructed in a workmanlike manner. The Road-Mixer Inspector should assist the subgrade and surfacing inspector. The Road-Mixer Inspector should communicate with the Plant Inspector by notes informing him of the yield and workability of the mix, the temperature and any other information that may help the Plant Inspector secure a uniform paving mixture. This should be noted on Concrete Design Report, Form 356 Rev. A complete record of the paving operations must be kept on Form 311, Daily Road Report - Concrete Pavement.

STRAIGHTEDGE INSPECTOR. The principal duty of the Straightedge Inspector will be to see that the concrete pavement is built with a smooth riding surface. He will be under the direct supervision of the Road-Mixer Inspector and will assist both the Road-Mixer Inspector and the Grade and Steel Inspector during the time that he is not checking the concrete pavement surface.

ASSISTANT ROAD-MIXER INSPECTOR. The assistant Road-Mixer Inspector will be responsible for making the required number of test beams, performing the slump tests, and determining the air content of the concrete. He will be responsible for removing the beams from their forms at the proper time and transporting them to the field laboratory curing tanks. The Assistant Road-Mixer Inspector will maintain a neat and systematic record of all of his activities.

GRADE AND STEEL INSPECTOR. The Grade and Steel Inspector's principal duties will be to see that the subgrade is constructed to the proper section and to the correct depth and to inspect the placement of the reinforcing steel. He will check the form line for irregularities both as to line and grade, and see that the forms are supported on soil that has been compacted to the requirements of the specifications. He will observe and correct form settlement whenever it exists. The Grade and Steel Inspector will make all depth tests and keep a record of the stations where depth tests are made. He will keep an accurate record of all reinforcing steel, dowels, and joint assemblies received on the road.

ASSISTANT GRADE AND STEEL INSPECTOR. The principal duties of the Assistant Grade and Steel Inspector will be to assist the Grade and Steel Inspector in his total operations.

FIELD PARTY CHIEF. The Party Chief will work under the direct supervision of the Chief Inspector or the Paving Inspector.

His party will be responsible for setting all grade and line stakes.

FIELD DENSITY INSPECTOR. The Field Density Inspector will work under the direct supervision of the Chief Inspector or the Paving Inspector. His principal duties will be to determine the density and moisture of the different types of soils (bases, subbases, and subgrade) encountered in the grading and finishing operations.

THE PAVING INSPECTOR

The inspection duties on a paving project of any magnitude are usually grouped into three sections: inspection on the grade, inspection at the paver, and inspection at the plant. Each of these sections is under the control of an inspector who normally will have one or more assistants to aid him in performing his duties. On most paving projects there is usually one senior level inspector who is in direct charge of all three sections of the paving operations. This inspector is in close daily contact with all phases of the paving operations that involve all three paving sections. This inspector is the Paving Inspector and will be referred to throughout the remainder of this Manual as simply the Inspector. This Manual is written primarily from the point of view of this Inspector for it is upon the shoulders of this man that final responsibility for all phases of the concrete paving inspection complex will rest. He is the Inspector who daily must live with all of the multitude of paving details that command the total attention of one man from the beginning of the paving project until its ultimate

completion.

The Paving Inspector may often be the Chief Inspector. There may be occasions when the Resident Engineer himself will function as the Paving Inspector. On large jobs where the concrete paving operation is simply a part of a much greater whole, a Paving Inspector answerable to the Chief Inspector for the total concrete paving operations should be established well in advance of the actual beginning time for paving.

PRECONSTRUCTION CONFERENCE

A Preconstruction Conference between the Resident Engineer and his project inspection staff and the representatives of the Contractor is highly desirable after the Organization Meeting. At such a conference everyone can be briefed in advance as to what is expected and how to cope with anticipated project difficulties. The Contractor's sequence of operations can be discussed, the overall scope of the project reviewed, and the project personnel of both the Residency and the Contractor can be introduced. The assignments and responsibilities of each inspector should be described by the Resident Engineer and the member of the Contractor's force with whom a particular inspector will deal should be determined. The "chain of command" of each party should be made manifest each to the other. Interested parties to the contract, such as utility groups concerned with adjusting or removing lines that are involved in the scope of the project work, may profitably be invited to sit in on the conference. If detours or other changes in established traffic patterns are contemplated, then the police department should be advised to attend also.

Preconstruction conferences by giving advance knowledge and thought to "trouble spot" areas of a project will tend to minimize later misunderstandings and arguments. Brief but accurate minutes of the conference proceedings should be obtained by the Engineer to become a part of the

permanent project file records. All interested parties to the contract who might be affected by the outcome of the conference should be given a copy of the conference minutes.

THE INSPECTOR

A PAIR OF DEFINITIONS

The Inspector is the authorized representative of the Engineer assigned to supervise and inspect any or all parts of the work and the materials to be used therein.

The Superintendent is the representative of the Contractor authorized to receive and fulfill instructions from the Engineer, and who shall supervise and direct the construction.

The Inspector and the Superintendent work together ideally as a team, mutually cooperative, both saddled with the responsibility of building a quality concrete pavement according to the contract documents. An example of this joint responsibility may be seen in the fact that the Contractor's Superintendent should sign the Inspector's preliminary Pilot Strength Curve before paving operations begin thereby signifying that he has checked and approved the work and the results obtained. Similarly, the Superintendent should sign the Inspector's daily Field Laboratory Report For Concrete which is used for recording the design, control, construction progress, and other pertinent data in the placing of concrete pavement during a day or part of a day.

Although a large degree of cooperation is required of the Inspector in his relationship with the Superintendent, the actual directives to the

Contractor's forces for the development of the contract work of the job must come from the Superintendent, not the Inspector.

THE MEASURE OF A MAN

The Inspector and the Superintendent share many joint responsibilities but each has by definition a distinct sphere of operation. The larger responsibility of acquiring a first-rate pavement rests with the Inspector.

The Inspector must be well acquainted with the plans and specifications and he must compel the Superintendent to comply with their requirements. The outstanding Inspector is one who not only knows the facts of the contract documents but is prepared to discuss freely and openly all aspects of them with the inquiring Superintendent.

From a true understanding of the reasons why a requirement is called for in the plans and specifications will come the exercise of good judgement, perhaps the greatest asset that an Inspector can possess. Good judgement may be seen in the Inspector's ability to issue precise and compelling instructions to the Superintendent based on a fair and proper interpretation of the contract documents.

From the start until the very end of the project the Inspector must be resolute and just in his relationships with the Contractor's personnel. He must from the beginning establish an image of trustworthiness and fairness. He must be determined (but not grim) that the specifications

will be enforced and communicate this determination to the Contractor's forces.

Understanding how momentous it is to start a project right and how unsettling it can be to begin wrong, the Inspector will do everything in his power to begin his project properly by proceeding in accordance with the requirements of the plans and specifications. Early mistakes built into a concrete pavement are often very hard, if not impossible, to correct and frequently set a construction pattern that may follow the course of the job to its completion. The Inspector when in doubt about the proper decision to make, particularly during the early stages of the job, should always consult with the Engineer.

Disputes will arise. Since the Engineer acts as a referee in disputes arising between the Superintendent and the Inspector, the Inspector will always submit disputed matters to the Engineer for interpretations. He may find himself occasionally ruled against by the Engineer. He must accept counterdecisions by his superiors with consent and dignity.

The Inspector should always cultivate a friendly, cooperative attitude toward the Contractor's personnel but too much familiarity with them will tend to lessen the effective force of the Inspector's official personality.

Gifts and favors of any sort from the Contractor's people should always be reported to and cleared by the Inspector's superiors before acceptance by him. The Inspector should pick up the tab for coffee his fair share of the times and not let the Superintendent develop the idea

that footing the project coffee bill is a required condition of the contract. The Engineer may have his confidence in his Inspector seriously eroded by the persistent thought that the Inspector's judgement has been impaired or vitiated by the daily indulgence of the Inspector in a ten cent cup of coffee and a two-bit hamburger at the Contractor's "expense".

The final proof of the Inspector's ability will be found in the measure of the quality of the work performed under his direction. If, as a result of his capability as an Inspector, mistakes have been prevented, failures have been reduced, and future maintenance costs have been minimized, and if a pleasing, smooth riding pavement is the immediate result of the Inspector's labors, then you have the measure of a successful Inspector.

RELATIONSHIP WITH THE BUREAU OF PUBLIC ROADS

Federal Aid Projects (including Interstate jobs) are projects where the Federal Government enters into a contract with the State to provide an agreed portion of the necessary finances. The Bureau of Public Roads, through its engineers, follows the progress of these projects from the time they are programmed until the completed projects are accepted and thereafter make periodic maintenance inspections to see that the federal investment is being properly protected.

The objectives of the Bureau of Public Roads coincide very closely with those of the Highway Department. The Engineer should accompany the Bureau of Public Roads' Engineers on their inspection visits, should

inform them of difficulties, as well as good features of the work, and should discuss with them any proposed extra work or changes in design. The Inspector will find that the Bureau of Public Roads' Engineers are competent men, willing and eager to be of service and to help solve any project problems that might exist. The Inspector will do well to extend them all the possible courtesy that he can and to make the best possible use of their engineering knowledge.

RELATIONSHIP WITH THE PUBLIC

The public is the Inspector's employer. If it weren't for the public, there would be no need for a Highway Department and consequently no need for the construction of highways.

Most every major company and corporation in these United States employ Public Relations personnel to promote good will with the public for the betterment of the firm. We are not a company or a corporation, but a state agency which is governed by the people, and the Inspector himself is the Department's Public Relations man. Through him, the public forms its opinion of our organization. The Inspector should always be polite and courteous in all his dealings with the public. He should always be hospitable to visitors and do his level best to answer any and all of their questions.

POSTSCRIPT: RECORD KEEPING

These times may, at a later date, be known as the era of record keeping. The wise Inspector understands and accepts this as simply the way things

are at the moment. He might well wish that things were different from the way are but the facts are that bookkeeping, records, and documentation are being highly emphasized these days. The Inspector must understand the cold fact that, no matter how well the actual pavement is built, no matter how good the road in place may be, without the proper records and documentation to back up the tangible, actual, observable roadway condition, the chances are that to most interested parties to the contract the road will be acceptable to none.

PRELIMINARY SAMPLING AND TESTING - QUALITY TESTS

GENERAL

Preliminary sampling shall be performed according to established Texas Highway Department Testing Procedures, ASTM, AASHO, and as supplemented and implemented by Bulletin C-11 and the Manual of Procedures.

THE SAMPLER

Samples which when tested will form the basis for approval or disapproval of a proposed materials source or stockpile shall always be procured by authorized Texas Highway Department samplers.

REPRESENTATIVE SAMPLES

Within the framework of intrinsic small-size limitations, samples must be secured in such a manner that the small part (the sample) which is to reproduce the larger whole, will always be reasonably representative. Failure to submit representative samples for testing will from the beginning defeat the purpose of any test which is performed on a sample and in fact, result in test values that may be disastrously misdirecting.

QUALITY TESTS AND APPROVED LABORATORY NUMBERS

Preliminary tests performed by the District or Austin Laboratory are

primarily quality determinations. And when previously submitted samples of presently used materials have been tested for quality by these laboratories, it is permissible by cross referencing to extend the use of current laboratory numbers of approved materials. The Austin Laboratory will usually issue "a reference laboratory number" approving these materials for additional or extended use on other projects. When reference laboratory numbers are available, preliminary samples are not necessarily required. Samples of approved aggregates in current usage should be re-submitted for quality determinations every six months at the latest.

MATERIALS SUBJECT TO PRELIMINARY SAMPLING FOR QUALITY TESTS

Representative samples of the coarse aggregates, fine aggregates, mineral filler, cement, and water should be obtained and sent to the District or Austin Laboratory for testing. However, portland cement is usually accepted before being tested on the basis of past performance and water, if potable, will ordinarily not have to be sampled. Normally, project personnel will not have to sample the admixture, joint material, curing compound, reinforcing steel, or elastometric materials. These items, in most instances, are sampled and tested by D-9. Each shipment of D-9 (or other authorized inspecting agency) approved material will be identified by the monogram or other identifying symbol of the inspection laboratory. When a shipment is made to the jobsite, a test report will be issued to the Resident Engineer by D-9 or other inspecting agencies who approved the material shipped.

SAMPLE SIZE AND SHIPPING CONTAINERS

COARSE AGGREGATE. A forty-pound sample of coarse aggregate from each source for screen analysis and L.A. Abrasion is required. Seventy-five pounds of material is required if additional tests are requested. The material should be shipped in standard canvas sample sacks.

FINE AGGREGATE. A twenty-pound sample from each source for screen analysis and mortar briquets should be submitted. Forty pounds of material is required if additional tests are requested. The material should be shipped in standard canvas sample sacks.

MINERAL FILLER. Submit a one-gallon sample from each shipment. The sample may be shipped in one-gallon,friction - top buckets.

CEMENT. A one-gallon sample representing a maximum of five hundred barrels is required. The sample should be contained in a one-gallon,friction-top bucket. This sample may be a composite sample obtained from each of several cars or trucks.

WATER FOR CONCRETE. When it is necessary to sample the water, a one-half gallon sample packaged in a friction-top bucket or glass container properly wrapped to prevent breakage will be satisfactory.

MEMBRANE CURING COMPOUND. A one-gallon sample in a screw-top can is required when the field crews must do the sampling.

ADDITIVES. A one-quart sample in a screw-top can is recommended when field crews must do the sampling.

JOINT MATERIAL. The sample shall be taken from the full width of the material and eighteen inches long. The material should be boxed or properly braced with stiffeners before shipping.

RE-INFORCING STEEL. A sample of every bar size consisting of two bars each thirty inches long shall be obtained. The sample should be wrapped in building or construction paper for shipping purposes. Large shipments may be boxed.

SHIPPING SAMPLES

It is permissible to ship samples to Austin by motor freight, railway express, motor bus, railway freight, or parcel post. When there is no time factor involved, shipments weighing more than one hundred pounds should go via motor freight. Consignments of up to twenty-five pounds can be sent cheaper by bus than by motor freight or railway express. Railway freight should be used only "when the weight of the shipment is excessive and when time is not an important element". Small packages or bags may be sent economically by parcel post.

Samples should be packaged in appropriate shipping containers, snugly wrapped, and securely bound. They should be properly identified using Form 202, Sample Identification slip, which is made out in quadruplicate for each sample. One copy of the Identification Slip is enclosed with the sample, one is placed in the Shipping Tag Envelope, Form 517, another is mailed to the Materials and Tests Laboratory, and the final copy is retained for project records.

Samples that are to be sent to Austin for testing should be addressed: Materials and Tests Laboratory; Camp Hubbard, Austin, Texas. Form 517 has this address printed on it and when shipping samples to Austin, this Form should always be used.

Sample copies of Forms 202 and 517 are given on page 26.

Texas Highway Department
Form 202 81075-262-50m

IDENTIFICATION SLIP FOR MATERIAL SAMPLES

~~Dist. or~~ Res. Engr. A.M. LUCKY
Address DISTRICT 24 - EL PASO
Sampler's Name JAMES BLOW
Sampler's Title ENGR. TECH. III
Contractor J.R. LOVE
Producer ROCKS INC.
Location EL PASO QUARRY #1
(Show name of Pit, Quarry, Refinery, Mill or Plant)
Car No. - Seal No. -
Sampled from STOCKPILE
(Pit, Quarry, Car or Stockpile)

Material CRUSHED STONE

2121 - 31 - 52
Control No. Sec. No. Job No.
I 10-1(99)150 HUDSPETH I-10
Federal Proj. No. County Hwy. No.
24 9-20-66
Dist. No. I.P.E. No. Req. No. Date Sampled
Specification Item No. 421
To be used for COARSE AGGREGATE

Quantity of material represented by sample is 300 ~~Bbls., gals., tons or~~ cu. yds.
This material is from the property of J. "ROCKS" LOVE in
EL PASO County, located 2 MILES WEST of
(Give distance and direction)
EL PASO (Town) on I-10 (Road or Highway) IDENTIFICATION MARKS CA-1
Has material been used in roads, if so, where, in what type and with what results?
YES. STRUCTURAL CONCRETE (TEXAS HWY DEPT) - EL PASO. Good.
(If cement sample, show brand and whether Normal or High Early Strength type)
Remarks: QUALITATIVE ANALYSIS
(Continue remarks on other side)

FORM 202

TEXAS HIGHWAY DEPARTMENT
Form 517 40421-565-64M

IDENTIFICATION SLIP INSIDE THIS TAG

FROM: A.M. LUCKY, RES. ENGR.
DISTRICT 24
EL PASO, TEXAS

TO:

TEXAS HIGHWAY TESTING LABORATORY
CAMP HUBBARD,
AUSTIN, TEXAS

FORM 517

THE GUIDE SCHEDULE OF MINIMUM SAMPLING AND TESTING PER CONTRACT

The Guide Schedule of Minimum Sampling and Testing Per Contract gives a break down of the required job control tests, progress record tests, and final record tests. The Schedule also lists the material or product which is to be sampled or tested, for what a material or product is to be tested, test number or identification, location or time of sampling, and frequency of sampling.

There may be occasions when the plans or specifications will call for a test that is not listed on the Guide Schedule. The Schedule does not waive any test that is called for by the plans and specifications. These tests are in addition to the Schedule requirements and must be performed. Furthermore, in case of conflict between the plans and specifications, the plans and specifications shall govern.

It should be pointed out that the guide schedule is an informational and guidance directive. It should be clearly understood that the number of tests and samples which are listed under the Guide Schedule are minimum requirements only. The Engineer will continue to require as many tests as good engineering judgement may determine necessary in order to construct a project according to the plans, specifications, and special provisions.

The Chief Inspector is reminded that it is still his responsibility

to submit a requisition to the District Laboratory for progress record tests and final record tests. Record data should reflect the quality, quantity, and condition of the actual materials used or in-place on a project.

The Guide Schedule for portland cement concrete pavement is given on page 29. In District 24, the Construction Engineer's Office will extend the Guide Schedule for all projects shortly after they are let. Copies of this "extended" sampling and testing Schedule are then sent to the Resident Engineer, the District Laboratory and to the BPR.

PORTLAND CEMENT CONCRETE PAVEMENTS

GUIDE SCHEDULE OF MINIMUM SAMPLING AND TESTING PER CONTRACT

MATERIAL or PRODUCT		TEST FOR	TEST NUMBER	JOB CONTROL TESTS: LOCATION or TIME of SAMPLING	JOB CONTROL TESTS: FREQUENCY of SAMPLING	PROGRESS RECORD TESTS: LOCATION or TIME of SAMPLING	PROGRESS RECORD TESTS: FREQUENCY of SAMPLING	FINAL RECORD TESTS	REMARKS
MINERAL AGGREGATES	COARSE AGGREGATE	Decantation	Tex-406-A(II)	During Delivery to Plant, from Stockpile, or from Batch Bin	Min. 2 (Each Source)	Same as Job Control	Min. 1 (Each Source)	Final Record Testing Will Consist of Coring For Depth: 1 Core Per 1,000 Linear Feet Per Lane of Pour Where Payment Is by the Square Yard, or 1 Core Per 2,000 Linear Feet Per Lane of Pour Where Payment Is by the Cubic Yard	
		Sieve Analysis	Tex-401-A (Part A)	During Delivery to Plant, from Stockpile, or from Batch Bin	Each 300 C.Y. Min. 1	Same as Job Control	Each 9,000 C.Y. Min. 1		Test Combined Aggregates When Used
	FINE AGGREGATE	Decantation	Tex-406-A(II)	During Delivery to Plant, from Stockpile, or from Batch Bin	Min. 2 (Each Source or Each Combination of Sources)	Same as Job Control	Min. 1 (Each Source or Each Combination of Sources)		Test Combined Aggregates When Used
		Organic Impurities	Tex-408-A	During Delivery to Plant, from Stockpile, or from Batch Bin	Min. 2 (Each Source)	Same as Job Control	Min. 1 (Each Source)		
		Sieve Analysis	Tex-401-A (Part C)	During Delivery to Plant, from Stockpile, or from Batch Bin	Each 300 C.Y. Min. 1	Same as Job Control	Each 4,500 C.Y. Min. 1		Test Combined Aggregates When Used
MINERAL FILLER		Sieve Analysis	Tex-401-A	During Delivery to Plant, from Stockpile, or from Batch Bin	Each 300 C.Y. Min. 1	Same as Job Control	Each 4,500 C.Y. Min. 1		
CEMENT		Compliance With The Std. Specifications & Spl. Provisions	ASTM C-150	Railroad Car, Truck, or Cement Bins	Each 500 Bbls. (May Be A Composite Sample) For Each Type or Brand		Witness Sampling At Least Once		Each Brand and Each Type To Be Sampled and Tested Separately
WATER		Compliance With The Std. Specifications	AASHO T-26	At Source; If Not Potable					
CONCRETE		Flexural Strength	Tex-420-A	At Point of Concrete Placement	1 Test (2 Beams) For Each 1,500 S.Y.		Witness Operation of Fabrication & Testing of 1 Test Every 10 Days' Paving; Min. 1		
		Slump	Tex-415-A	At Time & Location Test Beams Are Made	1 Test Per Set of Test Specimens		Witness 1 Test For Every 10 Days' Paving; Min. 1		
		Entrained Air (A)	Tex-416-A	At Time & Location Test Beams Are Made	1 Test Per Set of Test Specimens		Witness 1 Test For Every 10 Days' Paving; Min. 1		(A) When Entrained Air Is Required by Specifications
ADMIXTURE		Compliance With The Specification Item 437; "Concrete Admixtures"	ASTM C 39 C 192 C 260 C 403	Sampled, Tested, and Approved by D-9 (B)					(B) For Each Shipment, Contractor Shall Furnish Res. Engr. A Certificate That Material Proposed For Use Is Same As Tested by T.H.D.
JOINT MATERIAL		Compliance With The Std. Specifications & Spl. Provisions	Tex-524-C & 525-C	Sampled At Jobsite If Not Sampled At Source by D-9; Tested by D-9	1 Per Batch or Shipment				
CURING COMPOUND		Compliance With The Std. Specifications & Spl. Provisions	Tex-219-F	Sampled At Jobsite If Not Sampled At Source by D-9; Tested by D-9	1 Per Batch or Shipment				
REINF. STEEL		Compliance With The Std. Specifications & Spl. Provisions	As Specified	Sampled, Tested, and Approved by D-9					

TABLE IV

Rev., Oct., 1966

CONCRETE MIX DESIGN FOR CONTINUOUSLY REINFORCED PAVEMENT

GENERAL

There are in our standard specifications two items controlling continuously reinforced concrete pavement: Item 366 and Item 360. These specifications require that concrete for pavement shall be designed by the Absolute Volume Method (Specified Cement Content) in accordance with the procedures outlined in Bulletin C-11.

The intent of that section of Items 360 and 366 pertaining to Mix Design is to develop the most economical mix design possible which will fulfill all requirements of the specifications when using acceptable materials as furnished by the Contractor.

Prior to the beginning of concrete placement, adequate quantities of approved cement, aggregates, and other ingredients proposed for use in the concrete shall be supplied by the Contractor to the Engineer for mix design tests.

After the mix proportions and water-cement ratio required to produce concrete of the specified strength have been determined, placing of the concrete on the road may be started.

DEFINITIONS

ABSOLUTE VOLUME DESIGN CONCRETE is designed to fill a definite space or to produce a definite volume. Actually, fresh concrete without the addition of an agent which will entrain air cannot be perfectly compacted but we assume fresh concrete without admixtures to be a solid containing no air pockets or voids.

The terms 'absolute volume' and 'solid volume' are synonymous and are used interchangeably.

CONCRETE is an intimate mixture of cement, water, coarse aggregate, and fine aggregate. Air may be considered as another ingredient when an air-entraining admixture is used. Even though air is weightless, it occupies space or volume and must be considered in the absolute volume theory of design.

The water used in the mix causes the cement to hydrate and bind the aggregate particles together.

From the point of view of a designer, concrete is composed of two ingredients, coarse aggregate and mortar. The mortar not only fills the voids in the coarse aggregate but separates the aggregate particles. It could also be stated that the mortar lubricates the loose coarse aggregate particles.

MORTAR is an intimate mixture of cement, water, fine aggregate, and air when using an air-entraining admixture. With a given coarse aggregate the quality of the mortar controls both the strength and

workability of the concrete.

Again from the point of view of a designer, mortar is composed of two ingredients, fine aggregate and paste. The paste not only fills the voids in the fine aggregate but separates the fine aggregate particles. The extent of this separation is another factor influencing workability. In other words, the paste lubricates the fine aggregate particles.

PASTE is an intimate mixture of cement, water, and air when using an air-entraining admixture. With given aggregates the proportion of water and cement determines the strength of the concrete and, as paste is the lubricant of the mortar, the consistency of the paste determines the consistency or workability of the mortar.

COARSE AGGREGATE is that portion of the mineral aggregate which is retained on the No. 4 sieve.

FINE AGGREGATE is that portion of the mineral aggregate which passes the No. 4 sieve.

SPECIFIC GRAVITY is the ratio of the weight of a given absolute volume of a material to the weight of an equal volume of water.

It is apparent that specific gravity determines the exact relation of weight to volume and vice versa. This is the most fundamental relation in absolute volume design of concrete.

UNIT WEIGHT of a material is the weight (pounds) of 1.0 cubic foot of the material in a saturated, surface dry, and loose condition.

SOLIDS (Per Cent). Concrete is designed on the basis of absolute or solid volume. Aggregates and cement, however, are not solid masses but are composed of separate particles. Thus, while aggregates and cement are proportioned on the basis of solid volumes, they are actually handled in a loose condition. A given volume of cement or aggregate in a loose condition is composed of two separate and distinct volumes, 'solids' and 'voids.' The term 'solids' signifies that portion of the total loose volume which is occupied by solid particles in a saturated, surface dry condition. When the volume of solids is expressed as a percentage of the total volume of loose cement or aggregate, it is known as 'per cent solids.' It is obtained by dividing the unit weight of the material by 62.5 (weight of 1.0 cubic foot of water) times the specific gravity of the material, and multiplying the quotient by 100. The 'per cent solids' is always the complement of the 'per cent voids.'

THE YIELD (cubic feet of concrete produced with one sack of cement) is obtained by dividing one cubic yard (27 cubic feet) by the required sacks of cement per cubic yard of concrete. This value is called a one sack batch.

DESIGN CONSTANTS are values which are always the same, any where and at any time. Even though these values may actually vary a small amount they are so nearly correct for all cases that deviations

there from have no practical influence on the design or mix. These design constants are as follows.

Weight of one sack of cement equals the weight of one cubic foot of cement (loose)	= 94 pounds
Specific gravity of cement	= 3.10
Absolute volume of one sack of cement	= 0.485 Cu.Ft.
Weight of one cubic foot of water	= 62.5 pounds
Weight of one gallon of water	= 8.33 pounds
Number of gallons in one cubic foot	= 7.50
Specific gravity of water	= 1.00

THE DESIGN FACTORS are four in number when designing ordinary concrete, and consist of the cement factor, water-cement ratio or water factor, the coarse aggregate factor, and the fine aggregate factor.

The fine aggregate factor is not used in the design proper but is calculated. When an air-entraining admixture is used, an additional design factor is introduced and is called the air factor. The primary function of these design factors is to control the proportions of the various ingredients, which in turn controls the strength, workability, and durability of the concrete. Each design factor has a specific function, or the direct control of one ingredient, but all of them are so inter-related that a change in one automatically causes a change in one or more of the others. The specifications place certain limitations on all the design factors with the exception of the fine aggregate factor. Within the framework of specification limitations, then, the designer may arbitrarily

select all design factors but the fine aggregate factor which is always the unknown quantity that is a function of the known values. It follows then, that, under our specifications, the selected factors are given values since no calculation is involved in obtaining them and since the exercise of good judgement based on past experience is the only requirement -- a requirement which, in the final analysis, is considerable.

(1) THE CEMENT FACTOR is the number of sacks of cement used to produce one cubic yard of concrete. The symbol "CF" is used to signify the cement factor. The cement factor is equal to 27/yield or 27/absolute volume of concrete produced by one sack of cement. Our future continuously reinforced concrete paving contracts will probably require that the concrete contain not less than 5 sacks of cement per cubic yard. There is no maximum limitation.

A sack of cement weighs 94 pounds. The specific gravity of cement is 3.10. The absolute volume of a sack of cement is $\frac{94}{62.5 \times 3.10} = 0.485$ of a cubic foot.

(2) THE WATER - CEMENT RATIO is the number of gallons of mixing water used with one sack of cement. It is frequently referred to as 'gallons of water per sack of cement' and might also be termed the 'water factor.' The symbol "W/C" is used to signify the water-cement ratio.

As the water-cement ratio determines the proportion of water

and cement it also establishes the absolute volume of the paste when considering a one-sack batch of concrete.

Effect Upon the Mix: The water-cement ratio exerts a more profound effect upon the mix than any other factor, or factor of mix design. With a given set of aggregates and a given cement the water-cement ratio governs the strength of the concrete, the higher the ratio the lower the strength and vice versa, provided good workability be maintained. As high cement factors produce high strength concrete and as low cement factors produce low strength concrete, it may be thought that the cement factor governs strength, but a closer analysis shows that a change of any magnitude in the cement factor is accompanied by a change in the water-cement ratio, and that a constant water-cement ratio produces constant strengths irrespective of the cement factor, provided good workability be maintained. This is true not only for small variations in cement content but for extreme variations.

As water is the chief lubricating agent for the concrete, it is evident that the total amount of mixing water, which is a function of the water-cement ratio in conjunction with the cement factor, is the greatest single factor in controlling the consistency and workability of the mix.

Continuously reinforced concrete paving specifications require a maximum water-cement ratio of 6.8 gallons. There is no minimum limitation.

If a maximum water factor of 6.8 gallons is selected for use in a concrete mix design, and if there are 7.5 gallons of water to a cubic foot of water, then each one-sack batch of concrete will contain an absolute volume of water of $\frac{6.8}{7.5} = 0.907$ of a cubic foot.

(3) THE COARSE AGGREGATE FACTOR is the loose volume of coarse aggregate in a unit volume of concrete. Expressed another way, the coarse aggregate factor is the per cent of any given volume of concrete which is occupied by the loose volume of the coarse aggregate. The symbol "CAF" is used to signify the coarse aggregate factor.

It is now apparent that the coarse aggregate factor determines the loose volume of coarse aggregate in any given volume of concrete, but this is not all the information available. If we know the per cent solids(orper cent voids) in the coarse aggregate, we can immediately determine the absolute volume of coarse aggregate to be used in any given volume of concrete designed with any given coarse aggregate factor.

The absolute volume of concrete multiplied by the coarse aggregate factor equals the loose volume of the coarse aggregate. The loose volume of the coarse aggregate multiplied by the per cent solids in the loose aggregate equals the absolute volume of the coarse aggregate.

If a 5 sack cement factor is selected, and if there are 27 cubic

feet in a cubic yard, then $\frac{27}{5}$ = yield = 5.400 cubic feet. And if a CAF of .82 is selected, then 5.400 x .82 = 4.428 cubic feet of loose coarse aggregate is used in a one-sack batch. If the per cent solids of the coarse aggregate is 61, then the absolute volume of the coarse aggregate in a a one-sack batch = 4.428 x .61 = 2.701 cubic feet.

From the foregoing it may be seen that the proportion of coarse aggregate to mortar may be varied by varying the coarse aggregate factor. By increasing the coarse aggregate factor the absolute volume of mortar is decreased proportionately, and vice versa.

Effect Upon the Mix: As the mortar not only fills the voids in the coarse aggregate but separates the coarse aggregate particles, it is obvious that some excess mortar is always required in order to produce workable concrete. Experience has shown that a minimum of 15% excess mortar (coarse aggregate factor of 0.85) is required to produce paving concrete which is workable and will not produce honeycomb, but ordinarily the best results are obtained with a coarse aggregate factor of from 0.80 to 0.83. The Specifications limit the coarse aggregate factor to a maximum of 0.85 but do not require a minimum.

(4) THE FINE AGGREGATE FACTOR is the loose volume of fine aggregate in a unit volume of mortar. Expressed in another way, it is the per cent of any given volume of mortar which is occupied

by the loose volume of the fine aggregate. The symbol "FAF" is used to signify the fine aggregate factor.

The fine aggregate factor bears precisely the same relation to mortar as does the coarse aggregate factor to concrete.

It is generally true that a mortar with a constant fine aggregate factor produces constant workability irrespective of the voids in the fine aggregate. Thus, it becomes apparent that it is desirable to reduce the voids in the fine aggregate as low as possible provided such practice is economical. Denser concrete can thus be otained while workability is still maintained.

Specifications do not limit the fine aggregate factor.

(5) THE AIR FACTOR (AF) is expressed as a percentage of the total absolute volume of the mix.

Entrained air is the deliberate introduction of air spaces or voids within a volume of concrete by adding a material to the concrete called 'air-entraining admixture.' These voids are in the form of minute bubbles, and it is estimated that there are many billions of them in a cubic foot of concrete containing between 4 to 5 per cent air.

If a cement factor of 5 sacks is selected for use in a concrete mix design, and if there are 27 cubic feet in a cubic yard, then the absolute volume of concrete produced by a one-sack

batch is $\frac{27}{5}$ = 5.400 cubic feet. If 4 per cent air is to be designed into this quantity of concrete, then the absolute volume occupied by this percentage of air is 5.400 x .04 = 0.216 of a cubic foot.

SPECIFIED CEMENT FACTOR DESIGN

The specified cement factor gives first, the cement factor, second, the water-cement ratio, third, the coarse aggregate factor, and fourth, the air factor. The fine aggregate factor is the fifth and unknown function (X) to be solved. The problem is much the same as the following when thinking in terms of the absolute volumes that design factors represent.

$1 + 2 + 3 + 4 + X = 15.$ Find X.

Assume that the yield is 5.400 and that the per cent solids of the fine aggregate is 0.60. Assume further that the sum of the absolute volumes of all the ingredients but the fine aggregate in a one-sack batch of concrete is as follows.

Cement	= 0.485
Water	= 0.907
Coarse Aggregate	= 2.701
Air	= 0.216
Sum of the Absolute Volumes	= 4.309 Cubic Feet.

Then, the absolute volume of the fine aggregate = 5.400 - 4.309 = 1.091 cubic feet. The absolute volume of the mortar is obtained by adding

the volumes of the cement, water, air, and fine aggregate. Thus,

Cement	= 0.485
Water	= 0.907
Air	= 0.216
Fine Aggregate	= 1.091
Absolute Volume of Mortar	= 2.699

The Fine Aggregate Factor $= \frac{\text{Vol. F.A.}}{\text{FA Solids x Vol. Mortar}} = \frac{1.091}{.60 \times 2.699} =$ .67.

Although the fine aggregate factor (and the absolute volume which this factor represents) is a major problem to be solved in concrete mix design, the ultimate problem of the designer is to determine the actual batch weights or volumes of the different ingredients which are required to produce a definite volume of concrete.

Absolute volumes to weights are determined by multiplying the absolute volume of a material by 62.5 and then multiplying the resulting product by the specific gravity of the material (absolute volume x 62.5 x specific gravity).

All design data should be properly recorded on Construction Form 309, Concrete Design Work Sheet. A sample copy of this Form is given on page 42.

Texas Highway Department
Construction Form 309

County: EL PASO
Project: 2121 - 50 - 30
Date: SEPTEMBER 6, 1966

CONCRETE DESIGN WORK SHEET
(NATURAL AGGREGATES)

Design No: CP - 1
(ITEM 366)

AGGREGATE CHARACTERISTICS:

	SP. GR	SSD Unit Wt. Lbs./Cu. Ft.	% SOLIDS
Fine Aggregate (FA)	2.60	97.5	60.0
Coarse Aggregate (CA)	2.70	102.9	61.0

Water 6.8 - CITY - Sp. Gr. = 1.0

Cement 5.0 - EL TORO - Sp. Gr = 3.1

DESIGN FACTORS:

Cement Factor (CF), 5.0 sacks per cubic yard of concrete
Coarse Aggregate Factor (CAF), .82
Water Factor (WF), 6.8 gal. per sack of cement
Air Factor (AF), 4.0 %

BATCH FACTOR:

Size of Batch (Full Size) / Yield for 1-Sk. Batch = 32.4 / 5.4 = 6

BATCH DESIGN (ONE SACK)	VOLUMES: 1-SK. BATCH (CU. FT.)		VOL. TO WT. (LB.) VOL. X 62.5 X SP. GR	1-SK. BATCH WTS.	FULL SIZE BATCH FACTOR	FULL SIZE BATCH WTS.
1. Concrete Yield = Cu. Ft. per Cu. Yd. / CF	27 / 5 = 5.400					
2. Volume CA = Yield X CAF X Solids	5.400 X .82 X .61 =	2.701	X 62.5 X 2.70 =	455.8	6	*2,735
3. Volume Mortar = Yield — Vol. CA	5.400 — 2.701 = 2.699					(40.8 GALS.)
4. Volume Water = WF / Gal. Water per Cu. Ft.	6.8 / 7.5 =	0.907	X 62.5 X 1.00 =	56.7	6	*340
5. Volume One Sk. Cement	=	0.485	X 62.5 X 3.10 =	94.0	6	564
6. Volume Entrained Air = Yield X AF	5.400 X .04 =	0.216				
7. Volume Paste = Vol. Cem. + Water + Air	0.485 + 0.907 + 0.216 = 1.608					
8. Volume FA = Vol. Mortar — Paste	2.699 — 1.608 =	1.091	X 62.5 X 2.60 =	177.3	6	*1,064
9. Yield (Summation of 2, 4, 5, 6 & 8 to Check No. 1 Above)	=	5.400				
10. Fine Aggregate Factor = Vol. FA / FA Solids X Vol. Mortar	= 1.091 / .60 X 2.699 =	.67				

* Correct For Free Moisture or Absorption.

REMARKS: Volumes in Above Are Absolute Unless Otherwise Noted.
Water Added at Mixer Must Include the Liquid of the Admixtures.

Contractor has 27-E PAVER-MIXER
20% Overload permitted
27 X 1.20 = 32.4 Cu. Ft. Batch
AIR: Aerolith 1 oz./Sk.
1 x 6 = 6 oz./Batch

Eugene Clay
Engr. Tech. IV

PRELIMINARY SAMPLING AND TESTING ON THE PROJECT

TESTS ON CONCRETE AGGREGATES

Bulletin C-11 divides the preliminary tests which project personnel must perform into two parts as follows.

I. Part one tests are performed to establish whether the concrete aggregates meet the controlling specifications. The sieve analyses of the aggregates will be performed according to Test Method Tex-401-A. Both fine and coarse aggregates will be tested for loss by decantation according to Test Method Tex-406-A. The organic impurities in the fine aggregate will be determined by following the procedures of Test Method Tex-408-A.

II. Part two tests are performed on the aggregates to establish definite physical properties which are necessary elements to the absolute volume method of concrete mix design. The specific gravities of fine and coarse aggregates as well as any mineral filler are determined according to Test Method Tex-403-A. An average specific gravity value obtained from at least three tests of each type of material should be used for design purposes. When any aggregate is a composite of two or more materials, the average specific gravity should be derived from tests of the materials in a combined state.

The per cent solids in each of the aggregates shall be

determined according to Test Method Tex-405-A. An average value which has been obtained from a minimum of three tests should be used for design purposes.

TESTS ON THE CONCRETE

According to Bulletin C-11, this aspect of testing may also be split into two groups:

I. Small trial batches are made to determine the water-cement ratio to use with a specified cement factor to produce workable concrete. They are made in the laboratory by the Inspector.

A coarse aggregate factor with a satisfactory past performance record on former projects should be used for the preliminary tests on the concrete. The small trial batches will normally disclose whether the coarse aggregate factor used is satisfactory although the principal reason in devising small trial batches is to ascertain the water-cement ratio which, when used with a specified cement factor, will result in concrete that has both workability and consistency. The designer should keep in mind while selecting a coarse aggregate factor that the specifications limit the factor to a maximum of 0.85.

The maximum water factor permitted in the specifications is normally used, in the sense of a starting point, in the first

small trial batch unless, as in the case of the cement factor, the voice of experience dictates a lower value. In any event, Bulletin C-11 states that, "The exact water factor to use with the minimum cement factor will be determined in the first small trial batch." The maximum water-cement ratio permitted in the specifications is 6.8 gallons.

The concrete shall also be designed "to secure an air content by volume of between 3 percent minimum and 6 percent maximum." Most designers have found 4 percent air to be satisfactory and this percent is used in most mixes for concrete pavement.

The designer should also recall while working with the small trial mixes that according to the specifications, "The mix will be designed with the intention of producing concrete which will have a slump of 1½ inches when tested in accordance with Bulletin C-11. The slump shall not be less than 1 inch nor more than 3 inches."

The information obtained from the small trial mixes should be expressed graphically by plotting the water factor values on the horizontal axis and the cement factor values on the vertical axis. These points are then connected with a smooth curve and the resulting graph is called the Cement Factor Curve. This Curve is used to ascertain the cement factor to use for any water factor value that may occupy an intermediate position between points plotted along a range of water factor values from a minimum to a maximum. A sample copy of the

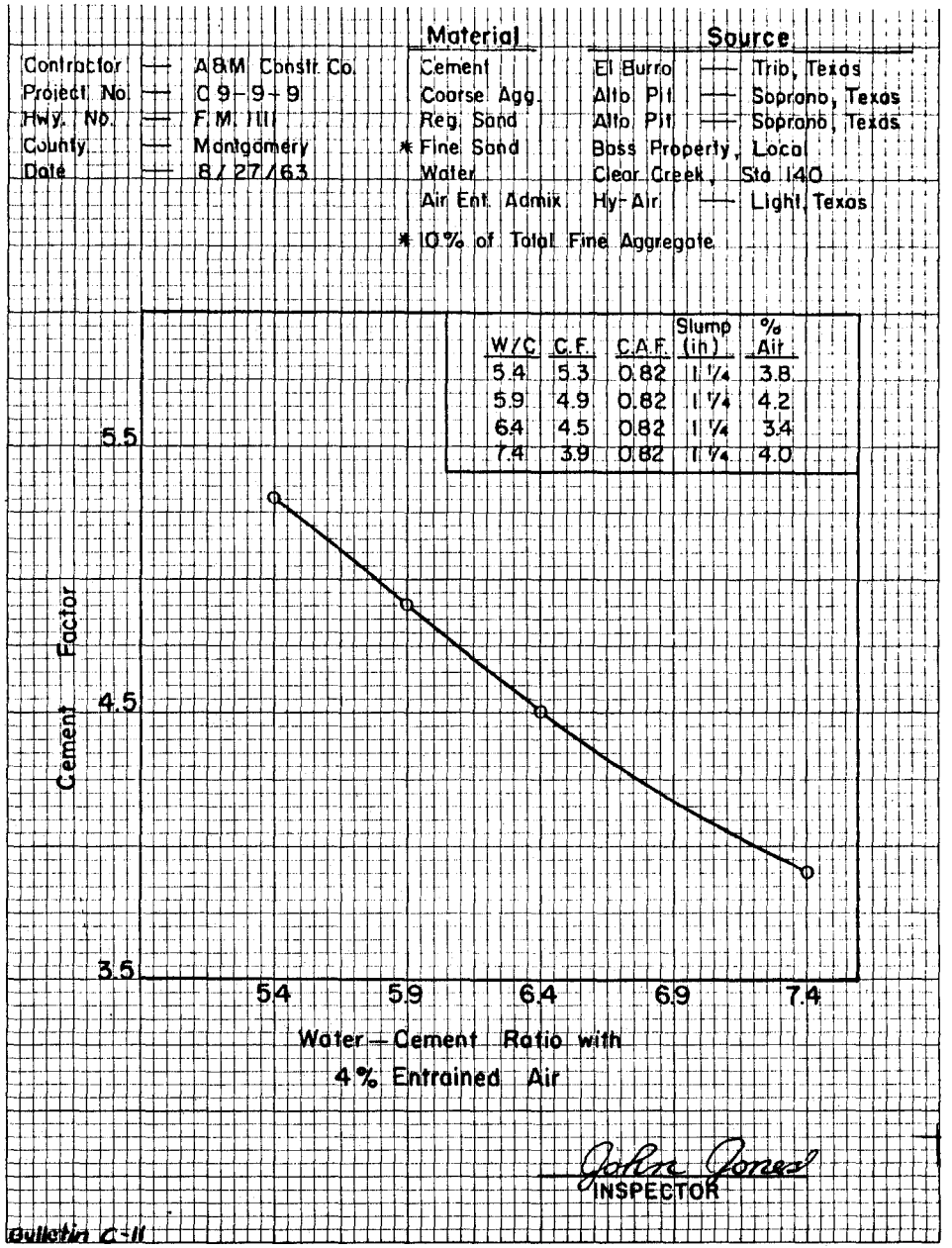
Cement Factor Curve is given on page 47.

Three copies of the Cement Factor Curve must be submitted to the District Construction Engineer's Office before paving operations on the road begin.

II. Bulletin C-11 states that,"For concrete pavement, test batches will be made for pilot beam tests by the inspector in co-operation with the contractor and these batches will be mixed in the mixer furnished by the contractor in accordance with the governing specifications. Unless otherwise provided for in the specifications, the minimum size of the test batch shall not be less than the manufacturer's rated capacity of the mixer used for mixing test batches." This requirement of Bulletin C-11, as well as similar requirements of Specification Item 360.4, Subarticle (5), has been amended by our current special provisions as follows:

> For mixing the concrete to be used in making the preliminary test specimens, the contractor shall furnish and operate the mixer approved for use on the project. A minimum one cubic yard batch shall be mixed or a batch of sufficient size to afford proper mixing, whichever is the greater. In lieu of the above mixer and procedure, the contractor may furnish a portable mixer of sufficient rated capacity to mix a minimum three-sack batch; in which case, the batch mixed for the preliminary tests

CEMENT FACTOR CURVE



shall not be less than the rated capacity of the mixer furnished.

Before a mixer is used to mix the ingredients for concrete which will be used for preliminary test beams, the contractor must first run a coating batch through the mixer as directed by Bulletin C-11.

The Inspector shall make the pilot test beams for strength in accordance with the instructions that are given in Bulletin C-11 on Pilot Tests for Strength (Concrete Pavement) and Test Method Tex-420-A. Four different mixes based on designs that utilize water-cement ratios, cement factors, and entrained air percents taken from the previously plotted Cement Factor Curve shall be used by the Inspector to make the concrete for the pilot test beams. All four designs shall have the same coarse aggregate factor that was used in establishing the Cement Factor Curve.

The Contractor will be required to mix, in the mixer approved for this purpose, a satisfactory batch of concrete for each of the four pilot strength batches. Each batch shall be mixed for at least the specified minimum mixing time of 50 seconds. The inspector should also keep in mind that the water to be added at the mixer shall be introduced during the first 15 seconds of mixing. A slump test shall be performed on material taken from each batch in accordance with Test Method Tex-415-A.

Twenty beams for flexural strength determinations shall be made from each of the four batches that the Contractor is required to mix. A total set of 80 pilot test beams will be required.

Beam forms will be provided by the contractor and should be located appropriately near the mixer. The forms should be in every respect sound and usable. The forms should be cleaned, lightly oiled, and placed in level positions before using.

As soon as permissible after casting, the Inspector should cover the test beams with saturated mats or burlap. They should be kept saturated and well protected until removed from the forms.

The beams may be removed from the forms from 24 to 30 hours after making. Immediately after removal from the forms, they should be immersed in the curing tanks, which are supplied by the Contractor, until they have cured for the required full seven days in accordance with Test Method Tex-420-A. The curing temperature of the water in the tanks shall be constantly maintained at 80° F. plus or minus 10°.

After the beams have been cured for the required seven days, they shall be tested in accordance with Test Method Tex-420-A. The average flexural strength for each group of 20 beams representing each water-cement ratio is then calculated.

Individual beam break values that vary from the average of each group by more than 10 percent should be rejected and an adjusted average value obtained from the remaining flexural strength values. Using these adjusted average values for each water-cement ratio, the Pilot Strength Curve is then plotted.

The Pilot Strength Curve is obtained by plotting the average flexural strength values on the vertical axis and the allied water-cement ratios on the horizontal axis. These coordinates are then connected to a smooth curve which will graphically enable the Engineer to select a flexural strength value that is united to a water-cement ratio value which was not actually run and that occupies an intermediate position between actual points that were plotted along a range of water factor values from a minimum to a maximum. A sample copy of the Pilot Strength Curve is given on page 52.

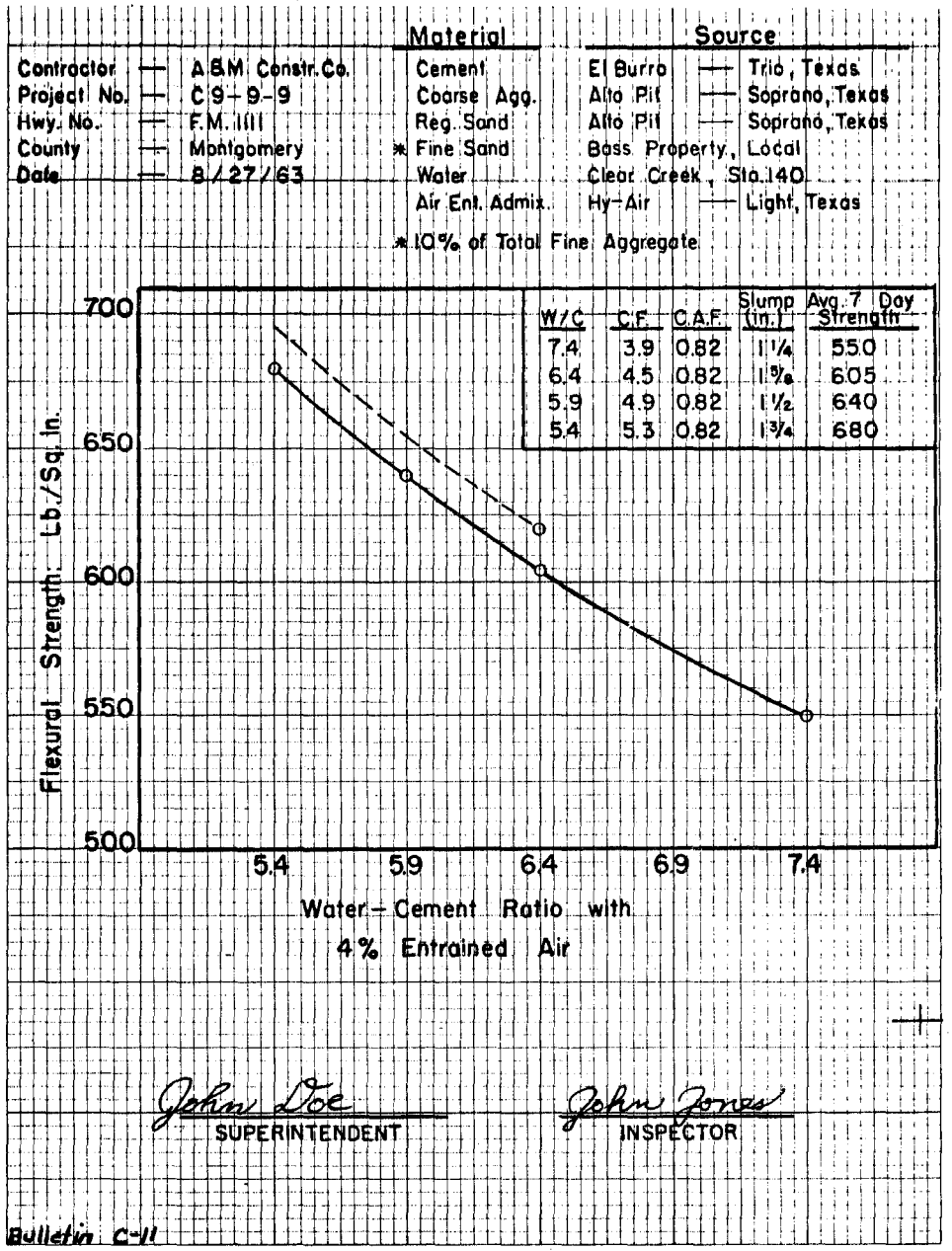
The Contractor's representative, usually his Superintendent, should sign the Pilot Strength Curve. This signature is an attestation that the Contractor has followed the progress of the work that leads ultimately to the production of the Pilot Strength Curve and that he sanctions both the work and the resultant curve.

Three copies of the Cement Factor Curve must be submitted to the District Construction Engineer's Office before paving

operations begin.

Details and procedures for making the pilot tests for strength are to be found in Bulletin C-11. It should be quite evident by now that "The Inspector should read and re-read Bulletin C-11 and become familiar with its entire contents. To be a good concrete Inspector one should know Bulletin C-11 'backwards and forwards.'"

PILOT STRENGTH CURVE



WEIGHING AND MEASURING EQUIPMENT

GENERAL

The weighing and measuring equipment of any contract shall be governed by the requirements of Item 500 when materials are required to be measured or proportioned by weight or volume. It is the Inspector's responsibility to be thoroughly familiar with the total requirements of Item 500.

SCALE AND SCALE INSTALLATION REQUIREMENTS

All scales and scale installations shall meet the requirements of the latest revision of "Specifications, Tolerances and Regulations for Commercial Weighing and Measuring Devices for Use in the State of Texas," published by the Texas Department of Agriculture, Austin, Texas, except that accuracy to within 0.4 percent of the total load being weighed will be satisfactory.

SCALE INSPECTIONS

The Contractor shall provide personnel, facilities and equipment for checking the scales to the satisfaction of the Engineer.

For use of State inspection forces in checking the scales during operation, the Contractor shall furnish four certified 50 pound weights, checked and certified at least once each year. In addition, the

Contractor shall furnish four certified 5 pound weights and four certified 2 pound weights, checked and certified at least once a year, to be used in checking cement and small platform scales and for performing the sensitivity checks on aggregate and cement scales.

All scales shall be checked prior to beginning of project operations, after each move and at such other times as deemed necessary by the Engineer. An accurate record of all scale checks must be kept by the Inspector. This data should be systematically maintained on the project in a permanent - type, hard-backed field book or equivalent, and should contain such essential information as the date of the check, type of check being performed, results or findings of the inspection, scale corrections made or action taken, and the signature of the Inspector conducting the inspection. Other pertinent information which might assist a third party in understanding the Inspector's field scale log should be recorded <u>at the time of the scale inspection</u>.

It is policy in District 24 for the Contractor, at the request of the Highway Department, to have a registered professional scale man inspect all scales prior to the beginning of operations, after each move, and at six-month intervals. The Inspector shall retain in the project files a copy of the scale man's Scale Inspection Report and forward one copy to the District Construction Engineer's office as soon as possible after the inspection is completed. Each scale unit that is approved by the scale man must be stamped or otherwise clearly marked by him, certifying that the approved unit has been left in good operating condition and weighing correctly on the date of certification. A copy

of a recent Scale Inspection Report is given on page 56.

Daily scale inspections are required of our own project personnel. These inspections shall be recorded daily in the project scale book or log.

AGGREGATE BATCHING SCALES

The scales used for weighing aggregate shall be equipped with a quick adjustment at zero to provide for any change in tare. The scales shall be provided with pointers or "tell-tale" indicators of the springless dial type to indicate full load for each aggregate. The dial or "tell-tale" device shall be in full view of the operator while charging the weigh box and he shall have convenient access to all controls.

CEMENT WEIGHING EQUIPMENT

Where bulk cement is used it shall be batched by weight, and scales shall be of rugged construction. Provision shall be made for indicating to the operator that the required load in the weigh box or container is being approached, which device shall indicate at least the last 50 pounds of load. Where a closed type cement weigh box is used, the cement weighing scales shall be provided with a springless dial to indicate when the weigh box is empty. This indicator for the empty condition of the weigh box shall be in continuous operation. The weigh box shall be fitted with an approved vent, a tightly covered inspection opening of not less than 12 inches by 12 inches, and the box and scales shall be maintained in a condition to meet the requirements for accuracy of weight.

SCALE INSPECTION REPORT

HEAVY DUTY SCALES

"SPINKS" INDICATORS

WEST TEX-NEW MEX SCALE CO.
CHAS. G. DENHAM, Mgr.
4417 Manchester
El Paso, Texas
Ph 565-8214

SCALE SERVICE

SCALE INSTALLATIONS

OWNER Vowell Construction Company

ADDRESS 607 N. Mesa, El Paso, Texas

LOCATION OF SCALE Asphalt Plant, 607 N. Mesa

DESCRIPTION OF SCALE Model 3200 V, overhead suspended lever hopper scale, with Detecto dial, graduated 5000# x 5#, Serial No. 549146 - AGGREGATE SCALE

TESTING OF DIAL

MULTIPLE 200 - 1

	WEIGHT APPLIED ON CLAMP	WEIGHT RECORDED
For ¼ capacity dial	6-1/4#	1240# -10#
For ½ " "	12-1/2#	2480# - 10#
For ¾ " "	18-3/4#	3760# * 10#
For full " "	25#	5005# *5 #

Adjustments made Eliminated capacity error with pendulum balls - half capacity with indicator side weights - quarter and three quarter with indicator tail weight

TESTING LEVER SYSTEM TO SYNCHRONIZE WITH DIAL

WEIGHT SUSPENDED FROM SCALE	WEIGHT RECORDED
500#	500#

Adjustments made None required, as scale assembly checked with dial.

(See reverse side of report for procedure)

This is to certify that above scales have been left in good operating condition and weighing correct on this the 18 day of April 1966

Signed Chas. G. Denham Inspector.

Operating in cooperation with the State Department of Agriculture, Division of Weights and Measures, Austin, Texas. Certificate of Registration No. 174 For year 1966

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7-15-66 KC

WATER MEASURING DEVICES

The measuring device for measuring water by volume shall indicate the quantity in gallons and fractions thereof. When a volumetric tank or bucket is used for measuring the water, the supply inlet shall cut off automatically and remain off until the container has emptied completely and the discharge line to the mixer is closed. When water is measured by weight, the weigh bucket shall be properly attached to scales meeting the general requirements of this specification. When a pressure type flow meter for volumetric measurement of the water is used, it shall be so constructed that any setting may be locked and the meter shall be capable of being manually or automatically reset to the locked setting after the addition of water to each batch.

Regardless of the method of water measurement used, the operating mechanism shall regulate the quantity of water required for any given batch to within plus or minus 1.0 percent of the specified quantity of water required for concrete mixes. Provisions of a permanent nature shall be made for checking the accuracy herein specified.

PROCEDURE FOR CHECKING WEIGHING AND MEASURING DEVICES

CHECKING THE AGGREGATE SCALES. When the contractor has completed setting up his plant and the scales are in operating condition, the bins should be loaded to capacity and, after waiting some twenty-four hours to allow for settlement of the plant, the scales should be tested as follows: the lever system knife edges and bearings should be checked to see that they are clean and that the moving parts do not bind against any other part. The scale beam or dial

should be in balance or read zero at No Load and, when touched with the finger, should swing freely. The build-up loading check is made by suspending a platform of known weight below the weigh hopper and then adding the weights as follows: place four 50-pound weights in the center of the platform then record the scale reading as close as it can be read. Then, leaving the scale beam at the reading for the 200-pound load, remove these four 50-pound weights and introduce some form of load, either sand or gravel into the weigh hopper in such an amount that the scale beam will be properly balanced indicating the equivalent of 200 pounds. Note that if the scales are not in balance, this may not actually record 200 pounds on the scale beam or dial. Now add the four test weights, recording the reading on the beam, remove the four test weights and again add sufficient material to bring the beam in balance, and repeat this operation until the total load in the weigh hopper is built up to well above the maximum load which is to be weighed upon the scales. Check this record of actual weight against the scale recordings and if there is a variation in excess of the allowable variation under the specifications, which is 4 pounds per 1000 pounds, the scales should not be used until properly adjusted or repaired and a retest indicates compliance with the specifications.

A test for sensitivity of beam or needle should be made at each 200-pound increment of loading during the build-up test. This is made by placing a 5-pound test weight on the scale and there must be an immediate reaction on the scale beam or scale dial, otherwise it will be necessary to repair the scale by cleaning or possibly

sharpening the knife edges until the scales are sensitive to this 5-pound weight throughout the entire range of use. The sensitivity check should be made at least once a day and at least once a day the four 50-pound test weights should be added to the batching scales after weighing a batch. The weight on the beam should be in balance when increased by 200 pounds.

CHECKING THE CEMENT SCALES. The cement scales should be checked in the same manner outlined above for the aggregate batching scales, but a two-pound test weight should be used in making the sensitivity test on the cement scales.

CHECKING THE WATER MEASURING DEVICE. The contractor's mixer shall be equipped with a water measuring device so constructed that it will measure the water within 1 percent of the total amount required for each batch. Unless the water is to be weighed, the water measuring equipment shall include an auxiliary tank with a capacity greater than that of the measuring tank, and from which the measuring tank will be filled by gravity flow. The measuring tank shall be open to the atmosphere and shall be so placed and constructed that the water for a batch can be discharged into a calibrated tank or weighing device for checking the accuracy of water measurement without seriously delaying the paving operations. The Contractor shall have a calibrated tank or weighing device available at all times at a location satisfactory to the Engineer.

The water measuring device should be calibrated in 5-gallon increments. The calibration should range from the minimum amount of

water to the maximum amount of water that may be required for one batch of concrete. The water gauge is set on the minimum value and the water is then discharged into a container and weighed on platform scales. The platform scales used for checking the water measuring system should be carefully balanced and checked for accuracy. The water gauge setting is then increased by 5 gallons and another charge weighed. This process is repeated throughout the possible water range and all results should check within one percent.

The weight of a quantity of water may be divided by 8.33 to convert pounds of water to gallons of water.

ADMIXTURE DISPENSERS. Refer to the section in this Manual entitled "Admixtures".

ADMIXTURES

GENERAL

The Engineer may specify approved types of admixtures to reduce segregation of materials, increase the workability of the concrete, entrain air, or decrease the required quantity of mixing water.

Under our specifications, admixtures are never used to take the place of cement.

Admixtures, including air entraining agents, must comply with the provisions of Item 437, Concrete Admixtures, including those requirements pertaining to measurement and dispensation.

The specifications for continuously reinforced concrete (Item 366.4) require an air content by volume in the concrete of from 3 percent minimum to 6 percent maximum. The air contents will be determined from tests performed on the concrete directly after it is discharged from the mixer.

DEFINITIONS

I. An air-entraining admixture is defined as a material which, when properly added to a concrete mix, will entrain uniformly dispensed microscopic air.

An air-entraining admixture properly used according to approved dosage rates shall result in compressive strengths at 7 days of not less than 85 percent of the 7 day compressive strengths of the reference, non-air-entrained concrete. The specifications require that a minimum of three cylinders of the reference concrete and three cylinders of the test concrete shall be tested at the age of 7 days. The specifications also require that equal slump shall be maintained within one-half of an inch for the test and reference concrete.

II. A cement dispersing admixture is defined as a material which, when properly added to a concrete mix, will change the physical characteristics of the concrete as follows.

(a) Reduce the required water content of the concrete by a minimum of 10 percent.

(b) Increase the 3 day compressive strength of the concrete by a minimum of 15 percent.

(c) The 28 day compressive strength of the concrete shall be equal to or more than that of the reference concrete.

(d) Retard the initial set of the concrete by a minimum of two hours.

A minimum of three cylinders of reference concrete (without admixture) and three cylinders of test concrete (with admixtures) will be made and tested for 3 day and 28 day compressive strengths. The test concrete and the reference concrete will be identical with regard to cement factor, type of aggregate, and slump.

A cement dispersing admixture should be used according to approved dosage rates.

MEASUREMENT AND DISPENSATION

Specification Item 437.6 states that, "For individual placements of concrete of 25 cubic yards or more and for all Ready-Mix concrete the admixture shall be measured and dispensed by readily adjustable mechanical dispensing equipment capable of being set to deliver the required amount and cut off the flow automatically. The equipment shall be of the type where the amount to be dispensed is visible in the container for ready check by the Inspector. For contract work, where the individual placements of concrete are less than 25 cubic yards and the concrete is batched on the job site, the Engineer may waive the requirements for mechanical dispensing equipment."

Our specifications state further that all admixtures shall be measured and dispensed in the liquid state.

APPROVAL OF ADMIXTURES AND DOSAGE RATES

The Contractor shall submit to the Engineer a notarized certificate that the product proposed for use is the same material as tested and approved by the Department.

The State Highway Engineer maintains an official list of approved admixtures and their dosage rates. This list is periodically reviewed and revised when tests indicate that this is necessary. Only admixtures

which are on this approved list may be accepted for use under Item 437, Concrete Admixtures. A copy of Administrative Circular No. 45-66 with the currently revised list of concrete admixtures is here made a part of this section on admixtures. This list is for the Inspector's information and use. As revisions to this list are made, copies of the adjusted list will be forwarded by the District Construction Engineer's Office to the Inspector for inclusion in his copy of this Manual.

TEXAS HIGHWAY DEPARTMENT

AUSTIN, TEXAS 78703

April 20, 1966

IN REPLY REFER TO
FILE NO. D-9

ADMINISTRATIVE CIRCULAR NO. 45-66

TO: ALL DISTRICT ENGINEERS, ENGINEER-MANAGER AND RESIDENT ENGINEERS

SUBJECT: APPROVAL OF CONCRETE ADMIXTURES

Gentlemen:

Attached hereto is a revised list of concrete admixtures which have been tested and approved for use under Item 437, "Concrete Admixtures." This list supersedes all previous lists of admixtures, either by previous Administrative Circular or individual written approval.

Dosage rates have been included based upon the manufacturer's recommendations and upon laboratory investigations. The dosage rates at 73°F. and 90°F. were shown because at these temperatures carefully controlled laboratory tests were performed at the indicated dosage rate to determine the capability of the admixture. These tests indicated that one admixture now on the approved list requires an increase in dosage when used during hot weather concreting. In using the dosage rate shown, it is intended that for all concrete where the use of a "Cement Dispersing Admixture" is required by the specifications and where the temperature of the air or concrete is above 85°F., the admixture should be added at the rate shown on the list for +85°F. or 90°F. Where the admixture is used for lightweight concrete, prestressed concrete, at the option of the Contractor or any other conditions other than as required by hot weather, it is intended that the admixture be added at the dosage rate shown on the list for 73°F.

The dosage rates for Group I material should be closely adhered to and any recommendation to change these dosages should be cleared through the Materials and Tests Division.

To obtain both cement dispersing and air entrainment, any admixture listed in Group I may be combined with any admixture in Group II so long as the individual admixtures are added separately to the batch and so long as all specification requirements are satisfied by the concrete produced.

It is particularly emphasized that the use of admixtures in concrete requires a thorough and careful design technique. Satisfactory and uniform results can only be achieved by proper control of materials and all phases of mixing and placing operations. Trial mix designs must be made to form a basis for this control.

Attention is called to Item 437.6 "Construction Use of Admixtures." You will note that the contractor is required to furnish the project engineer a notarized certification that the product proposed for use is the same material as previously tested and approved by the Department. This is interpreted to mean that the material producer may elect to furnish this certification directly stenciled or printed on the product container, if he so desires. In any event, the packaged material shall be plainly marked on the outside of the sack or drum.

This is an official Departmental publication intended for use only by employees of the Texas Highway Department. Individuals or organizations who may be in possession of this list are cautioned that it is subject to change or revision without notification to other than Texas Highway Department personnel. Use of this publication for sales or promotional purposes is expressly prohibited.

You will be advised as changes are made in this list to include new products or remove those no longer satisfactory.

Very truly yours,

D. C. Greer
State Highway Engineer

Attachment

Distribution:

District Engineers
Engineer-Manager
Resident Engineers
Austin Office

GROUP I: "CEMENT DISPERSING ADMIXTURES"
ITEM 437.3

	NAME	PRODUCER	DOSAGE RATE
1.	Airsene 311) same Airsene L)	Construction Chemicals, Inc.	6 ozs./sk. @ 73°F & 90°F.
2.	Daratard	Dewey & Almy Chemical Co.	9 ozs./sk. @ 73°F & 90°F.
	Daratard-40 (Concentrate)	Dewey & Almy Chemical Co.	6 ozs./sk. @ 73°F & 90°F.
3.	HPS-R (Powder or Liquid)	Hunt Process Corp.	8 ozs./sk. @ 73°F & 90°F.
4.	Mil-Crete D-RM (Powder)	Milchem Corp.	Mixed 2#/gal. & used 1 pt./sk.
5.	PDA Liquid 25R	Protex Industries	4 ozs./sk. @ 73°F & 90°F.
6.	Plastiment	Sika Chemical Co.	3 ozs./sk. @ 73°F, 4 ozs./sk. @ +85°F.
7.	Pozzolith No. 8 (Powder)	Master Builders	Mixed @ 1#/gal. & used @ 1 qt./sk. @ 73°F & 90°F.
	Pozzolith No. 8 (Powder)	Master Builders	Mixed @ 2#/gal. & used @ 1 pt./sk. @ 73°F & 90°F.
	Pozzolith No. 8 (Liquid)	Master Builders	10 ozs./sk. @ 73°F & 90°F.
8.	Reax-50D (Powder)	West Virginia Pulp & Paper	Mixed @ 3½#/gal. & used @ 8 ozs./sk.
	Reax-50D (Liquid)	West Virginia Pulp & Paper	8 ozs./sk.
9.	Retardwel	Union Carbide Corp.	3 ozs./sk. @ 73°F & 90°F.
10.	Sonotard	Sonneborn Chem. & Ref. Corp.	3 ozs./sk. @ 73°F & 90°F.
11.	Zeecon KRL-40) same Zeecon R-40)	Crown Zellerbach Corp. Crown Zellerbach Corp.	8 ozs./sk. @ 73°F & 90°F. 8 ozs./sk. @ 73°F & 90°F.

"Not to be used for advertising or promotional purposes"

GROUP II: "AIR ENTRAINING ADMIXTURES"
ITEM 437.4

	NAME	PRODUCER	DOSAGE RATE
1.	Aerolith	Sonneborn Chem. & Ref. Co.	1 oz./sk.
2.	Aeromix 219-1507	Lambert Co.	½ oz./sk.
3.	Air-In	Hunt Process Corp.	3/4 oz./sk.
4.	Airecon	Union Carbide	1 oz./sk.
5.	Construction Chemicals NVR	Construction Chemicals Co.	3/4 oz./sk.
6.	Crown Aersoc	Pacific Chemical Co.	½ oz./sk.
7.	Daravair	Dewey & Almy Chemical Co.	1 oz./sk.
8.	Darex	Dewey & Almy Chemical Co.	3/4 oz./sk.
9.	DV's V.R. AEA	Parker Bros. & Co., Inc.	3/4 oz./sk.
10.	En-Train-Air	American Soap & Chemical Co.	3/4 oz./sk.
11.	MB-VR	Master Builders Co.	1 oz./sk.
12.	Protex AEA	Protex Industries	3/4 oz./sk.
13.	Scotch Air	Preston Co.	½ oz./sk.
14.	Shepair	Pacific Chemical Co.	½ oz./sk.
15.	Sika-Aer	Sika Chemical Corp.	½ oz./sk.

Acceptance tests in the laboratory have determined that the above listed materials will yield the required entrained air content at the dosages indicated. Field use, however, may require further adjustment by increasing the dosage rates to give sufficient air entrainment. Trial designs should be made to establish the proper dosage to meet project specifications.

"Not to be used for advertising or promotional purposes"

GROUP III: ITEM 437.3 & 437.4

Any combination of an admixture listed under Group I and an admixture listed under Group II may be used provided care is used to insure they are added to the mixture separately.

In addition, the following admixtures have been found during the initial approval tests to satisfactorily meet the requirements of Group III without the addition of a separate air entraining agent.

1. Daratard

   Daratard-40 (Concentrated Form)

2. HPS-R

3. Pozzolith No. 8 at Regular and Concentrated Dosages

4. Pozzolith No. 8A - Integral Air Entraining Admixture known as "Micro Air" added at the factory to give desired Air Entrainment

5. Zeecon KRL-40

   Zeecon R-40

Any of the combinations or any of the admixtures listed above should be checked by trial designs to be sure the job requirements of the project concrete specifications are met.

OPERATIONS AT THE PLANT

FIELD LABORATORY

The field laboratory should be the first item set up at the plant site. The curing vat for the test beams should be located adjacent to the laboratory. The contractor is required to furnish and operate adequate facilities for curing all test specimens, together with satisfactory curing tanks equipped with heating or cooling devices that will maintain the temperature of the curing water at between 70° F and 90° F. As soon as the contractor begins to receive the mineral aggregates, the Inspector should secure representative samples and perform all the required tests as outlined in Bulletin C-11. The minimum number of control tests which the Plant Inspector should make shall be as determined from the Guide Schedule of Minimum Sampling and Testing. (For details, refer to the section in this Manual on the Guide Schedule.)

ROUTINE TESTS ON MATERIALS - STOCKPILES

The Plant Inspector should make sieve analyses on both the fine and coarse aggregates as delivery is being made and the stockpiles are being formed. Acceptance or rejection of the materials should be made at this point. Each aggregate from a different source or different size must be stored in a separate stockpile. The stockpiles should be so constructed by the Contractor that they will not become contaminated with foreign material such as weeds, trash, dirt or any other substance that would made the aggregates unsuitable for use. These stock-

piles should be constructed so that a minimum amount of segregation will occur. The Contractor should locate his stockpiles so that they do not run into each other. When contamination or overlapping of stockpiles is apparent, the Contractor, as directed by the Engineer, shall remove the unacceptable material from the stockpiles and/or cause the material to become acceptable. Segregated areas in the stockpiles shall be corrected and/or remixed. At the time of use, the aggregates shall be free from frozen material. Coarse aggregates that contain 0.5 percent free moisture by weight shall be stockpiled for at least 24 hours prior to use. All fine aggregate shall be stockpiled for a least 24 hours prior to use.

The loss by decantation of both the coarse and fine aggregates should be determined by Test Method Tex-406-A at least the minimum number of times that are required under the Guide Schedule, and more often if necessary. The presence of an undesirable amount of organic impurities in the fine aggregate should be determined by Test Method Tex-408-A and again the minimum test frequency of the Guide Schedule should be met and more often if necessary. The use of materials not meeting the specification requirements for grading, decantation and organic impurities is prohibited. The maximum loss by decantation for the coarse aggregate is 1%. For the fine aggregate, the maximum loss is 4%. When subjected to the color test for organic impurities, Bulletin C-11, the fine aggregate shall not show a color darker than the standard.

Routine tests data should be recorded on Construction Form 310, Field Laboratory Aggregate Sieve Analysis Report. A copy of this Form is given on page 72.

TEXAS HIGHWAY DEPARTMENT
CONSTRUCTION FORM 310

PAGE CA-1

FIELD LABORATORY
AGGREGATE SIEVE ANALYSIS REPORT

County: EL PASO Project No: 2121-50-30 Hwy.: I-10 Contractor: O. LOVE, INC.

Material Sources: Coarse Aggr.: LOVE QUARRY 2 MI. W. OF EL PASO ON I-10 Fine Aggr.: —

Date	PERCENT RETAINED ON SIEVE: 3"	2½"	1¾"	1½"	1"	¾"	½"	⅜"	¼"	#4	#8	#16	#20	#30	#50	#100	Loss by Decant. CA	FA	Organic Impurities	Fineness Modulus	Remarks
SPECS. →		0	0-20				25-90			95-100							1.0 % MAX.		CLAY - .25 % MAX. SHALE - 1.0 % MAX. LAF - 5.0 % MAX.		TESTS BY
7-1-66		0	10				39			99							0.5		OK		W.E. Clay
7-2-66		0	12				45			98							—		OK		W. E. Clay
"		0	15				50			97							—		OK		W. E. Clay
"		0	13				49			95							—		OK		John Brass
7-3-66		10	25				89			99.5	FIRST LOAD REC. AT 7:00 A.M. SHUT OPERATIONS DOWN. 7:35. SCREEN TROUBLE AT CRUSHER. REPLACED BROKEN SCREEN.							MATL. REJECTED AND REMOVED FROM STOCKPILE. HAULED FROM JOB SITE				W.E. Clay
7-3-66		0	10				49			97	— RECEIVED OK AT 10:30						0.6		OK		John Brass
7-3-66		0	3				45			96							—		OK		John Brass
7-4-66		0	10				55			95							—		OK		John Brass
7-4-66		0	15				65			99							—		OK		John Brass

TESTS FOR CONCRETE DESIGN CONTROL

During paving operations, the specific gravity of the fine and coarse aggregates should be determined in accordance with Test Method Tex-403-A at least twice, and more frequently if necessary. The per cent of solids in both the fine and coarse aggregates, determined by Test Method Tex-405-A, should be ascertained while paving operations are in progress as often as is necessary to control workability. Any change in the per cent of solids of any aggregate does not affect the yield as long as the weights of these materials are not changed; however, it will affect the workability of the concrete mix. As long as the workability of a concrete mix remains the same, the per cent of solids in the aggregates is not changing.

In order to properly control the amount of mixing water, determine the amount of free moisture in the coarse and fine aggregate in accordance with Test Method Tex-409-A approximately once each hour. The moisture content of the first few batches at the beginning of paving each day is critical, particularly if aggregates have been left in the bins over night and moisture has settled to the bottom of the bins. For this reason, materials should not be left in the bins over night.

Special attention must be given to moisture uniformity of the aggregates after each rain. Aggregates should be fed into the bins with as uniform moisture content as possible. Remember, material in the bottom layers of a stockpile usually has a higher free moisture content than material in the top layers of a stockpile.

The absorption in the coarse and fine aggregates should be determined as often as necessary by Test Method Tex-403-A. Usually aggregates containing absorption are in a more uniform condition as compared to aggregates containing free moisture; therefore, it is not necessary to test aggregates for absorption as frequently.

BEGINNING BATCHING OPERATIONS

Assume that now the Contractor is ready to start paving operations; the batch has been designed, the equipment checked and the subgrade and form lines approved.

From the pilot strength curve, select the water-cement ratio required to produce concrete of the specified strength, and from the cement factor curve, select the cement factor to correspond with the selected water-cement ratio. Should this selection result in a cement factor below the minimum required in the specifications (5 sacks on future contracts), select the minimum cement factor provided in the specifications and the corresponding water-cement ratio. Water-cement ratios above the maximum of 6.8 gallons allowed in the specifications cannot be used. Use the same coarse aggregate factor and air factor that were used in making the pilot tests and begin batching operations.

CONTROL OF THE STRENGTH OF THE CONCRETE

Seven days after each set of two beams ("A" and "B") is made, the Plant Inspector should test them in accordance with Test Method Tex-420-A, in each case recording the individual flexural strengths of beams "A" and "B" of the set and the average of these two values on Form 312.

The average strength of each pair of beams constitutes one 'flexural strength value.'

The Plant Inspector should keep a tabulation of all flexural strength values. Where more than one strength is specified, separate tabulations for each strength requirement must be kept. After each day's testing, the last ten consecutive flexural strength values obtained from concrete having the same water-cement ratio, are averaged. Discard any value which varies by more than 10% from the average obtained. Calculate and record a new average, called the 'adjusted average', from the remaining values. If this adjusted average varies from the strength requirement by more than 4%, the batch must be redesigned employing the water-cement ratio, as determined from the pilot strength curve, to produce the required strength, provided the maximum water-cement ratio is not exceeded and the minimum cement factor is met.

Our specifications will, on future contracts, require a flexural strength of 550 pounds per square inch. The situation may arise where the actual flexural strength exceeds the required strength by more than 4%, and the water-cement ratio is less than the maximum allowed yet it isn't possible to redesign the mix becuase the minimum cement factor required is already being used.

Figure 2 from Bulletin C-11 illustrates the proper way to record the flexural strength data. The Plant Inspector should study this sample carefully and pattern his own strength data sheet after it.

FLEXURAL STRENGTH DATA

Beam No.	Beams Made on W/C	C.F.	Date	Date Beams Tested	Flexural Values		Strength Adj. Avg.	W/C Job Running On
1 A & B	.6.4	4.5	5-14-63	5-21-63	573			6.4
2 "	"	"	"	"	604			"
3 "	"	"	"	"	520	*		"
4 "	"	"	"	"	610			"
5 "	"	"	5-15-63	5-22-63	593			"
6 "	"	"	"	"	625			"
7 "	"	"	"	"	640			"
8 "	"	"	"	"	615			"
9 "	"	"	"	"	595			"
10 "	"	"	"	"	680	*		"
11 "	"	"	"	"	630			"
12 "	"	"	"	"	600		614	"
13 "	"	"	5-16-63	5-23-63	635			"
14 "	"	"	"	"	595			"
15 "	"	"	"	"	620		624	"

Since only four flexural values were obtained on 5-21-63, it is impossible to calculate the average of the last ten values. The first adjusted average value of 614 pounds was obtained by averaging the values 3 through 12 and calculating the adjusted average after discarding value numbers 3 and 10, both of which varied more than 10% from the initial average.

Assume the specifications require a flexural strength of 575 pounds per square inch, a minimum cement factor of 4.5 and a maximum water-cement ratio of 6.8. Even though the strength exceeds the required strength by more than 4%, and the water-cement ratio is less than the maximum allowed, it isn't possible to redesign the mix because the minimum cement factor required is already being used.

It may be of interest to note that the adjusted value of 624 pounds was obtained from values 6 through 15; however, Value No. 10 was not discarded this time since its value did not vary from the initial value by as much as 10%. This adjusted average strength exceeds the required strength even more than in the first adjusted average; however, it still isn't possible to redesign the mix with a lower cement factor because the minimum is still being used.

FIGURE 2

CEMENT

The cement furnished for preliminary tests shall have a specific surface area within a range of 1600 to 1900 square centimeters per gram. A change in specific surface of the cement of more than 100 square centimeters per gram from that furnished for preliminary tests will require a new design. The cement shall be sampled and tested in accordance with the Texas Highway Department, Manual of Testing Procedures and the Guide Schedule of Minimum Requirements, and the Contractor shall furnish to the Engineer with each shipment a statement as to the specific surface area of the cement expressed in square centimeters per gram (Wagner Fineness). The Plant Inspector shall be responsible for collecting, verifying, recording, and filing all specific surface area statements that must accompany each shipment of cement to the project. A copy of a Statement of Wagner Fineness is given on page 78.

On all future paving contracts, Type II cement shall be used.

Any cement which has become partially set or which contains hard lumps or cakes, or cement salvaged from discarded or used bags, shall not be used.

Any cement storage shall be a suitable weather-tight building or bin or silo which will protect the cement from dampness, and cement shall be so placed as to provide easy access for proper inspection and identification of each shipment.

SOUTHWESTERN PORTLAND CEMENT COMPANY

SOUTHWEST DIVISION

P. O. BOX 392

EL PASO 43, TEXAS

January 17, 1964

STATEMENT OF WAGNER FINENESS

Type I Cement

Initial Shipment: L. H. Lacy Co.

Bin: 2A

Amount: 300 Bbls.

For: I-10-1(80)022 IH 10

Date Tested: 1-12-64

Wagner Fineness: 1925 sq sm/gm

SOUTHWESTERN PORTLAND CEMENT CO.

K. F. Gibbe

K. F. Gibbe
Chief Chemist

BATCHING EQUIPMENT

All necessary batching equipment shall be approved by the Engineer as to condition before the Contractor will be permitted to begin batching operations.

AGGREGATE WEIGHING EQUIPMENT. Aggregate bins and scales shall conform to the requirements of Item 500. Reference is made to the section in this Manual entitled, "Weighing and Measuring Equipment."

CEMENT WEIGHING EQUIPMENT. Where bulk cement is used, it shall be batched by weight and the scales shall conform to the requirements of Item 500. Reference is made to the section in this Manual entitled, "Weighing and Measuring Equipment."

BATCH WEIGHTS

Assume that the Contractor has a 34-E (34 cu. ft.) Concrete Paver. The specifications permit a 20% overload; therefore, the size of the batch is 34.0 cu. ft. + 20% of 34.0 = 34 + 6.8 = 40.8 cu. ft., the size of the batch. Assume that the CF is 5 sacks and that the yield is 27/5 = 5.40 cu. ft. Then the batch factor = $\frac{40.8}{5.4}$ = 7.556 sacks per batch. To calculate the weights for a 40.8 cu. ft. batch, multiply the weights for a one-sack batch by the batch factor, which in this example is 7.556. The aggregate and cement scales at the batch plant should not be set up on these weights until they have been adjusted to compensate for free water contained in the aggregates or for absorption. Corrections of

batch weights for free and absorbed moisture should always be calculated and recorded on Form 356 Rev., Concrete Design Report. Whenever the design batch weights are changed and/or after each moisture (free or absorption) test is completed, the Plant Inspector must fill out a Concrete Design Report in duplicate. One copy is sent to the Road-Mixer Inspector and the other copy is retained for the field laboratory files. A sample copy of Concrete Design Report, Form 356 Rev. is given on page 81.

Factors for calculation of bin weights corrected for absorption are given on Page 35 of Bulletin C-11. Factors for calculation of bin weights corrected for free moisture are given on page 33 of Bulletin C-11. USE THEM!

Example of a bin weight corrected for absorption. Given 0.4 per cent absorption in the coarse aggregate and a bin weight of 2,500 pounds. From the table on page 35 of Bulletin C-11, opposite "0" and under ".4" select the absorption correction factor .9960. Then, the corrected bin weight = 2,500 x .9960 = 2,490 pounds.

Example of a bin weight corrected for free moisture. Given 2.5 per cent free moisture in the fine aggregate and a batch weight of 1,300 pounds. From the table on page 33 of Bulletin C-11, opposite "2" and under ".5" select the free moisture factor 1.0256. Then, the corrected bin weight = 1,300 x 1.0256 = 1,333 pounds.

Texas Highwny Department
Construction Form 356 Rev.

10249-1263-100m

CONCRETE DESIGN REPORT

Water, Design Total = G.W. 6.8 × Bags/Batch 6 = 40.8 Gals.

Gals. × 8.33 40.8 = 340 Lbs.

Date: 7-4-66

	Free (—) or Absorbed (+) Water
COARSE Agg. + 0.4 %	
D. L. Wt. 2,500 × .9960 = 2,490 Lbs.	+10 Lbs.
FINE Agg. − 2.5 %	
D. L. Wt. 1,300 × 1.0256 = 1,333 Lbs.	− 33 Lbs.
..... Agg. ..... %	
D. L. Wt. ..... × ..... = ... Lbs.	..... Lbs.
..... Agg. ..... %	
D. L. Wt. ..... × ..... = ... Lbs.	..... Lbs.
Total (Free) ~~or Absorbed~~ Water	− 23 Lbs.

Time 9:15 A.M.

C.A.F. = .82

Cem. F. = 5

Water F. = 6.8

Air F. = 4%

Add at Mixer 317 Lbs.

317 Lbs. × .12 = 38 Gals.

Sig. WRC

Received Sta. 514+25 by Mixer Insp.

Time 9:30 A.M.

Mixer Using: 38 Over — Gal.; Under — Gal.

Admix: AEA Aerolith - 6 Ozs.; CDA - Qts. Lbs.

Slump 2 1/2 in.; Air Temp. 75 ° F; Water 70 ° F

Wind No

Weather Sunny & Clear

Sig. J. L.

NOTE: Mixer Inspector will not change water on basis of this report, but will report conditions at mixer and return immediately to plant Inspector with recommendations on mix design under remarks.

Remarks: Mix working good.

Report No. 3

FORM 356 Rev.

OPERATIONS ON THE ROAD:

Workable Concrete
Bleeding and Its Control
Hair Cracking and Its Control
Control of the Strength of Concrete

WORKABLE CONCRETE DEFINED

Concrete shall be uniformly plastic, cohesive and workable. Workable concrete is defined as concrete which can be placed without honeycomb and without voids in the surface of the pavement after the specified finishing machine has been over a given area twice. Workability shall be obtained without producing a condition such that free water appears on the surface of the slab when being finished as specified.

The concrete shall be designed with the intention of producing concrete with a slump of 1½ inches. The slump shall range from 1 inch minimum to 3 inches maximum.

CONTROL OF WORKABILITY OF THE CONCRETE

The Road-Mixer Inspector is directly responsible for the workability of the mix. He should at all times adjust the quantity of mixing water in order to maintain the proper consistency and slump of the mix, but should this amount vary by more than two gallons from the amount shown on Form 356, a new mix design or a new moisture test should be requested immediately.

The Road-Mixer Inspector should at all times observe the concrete closely

to see that it is workable in every respect. He should test the slump of the concrete and determine the air content of the concrete each time a set of beams is made and more frequently if necessary to insure that the slump of the concrete complies with the specifications. Consecutive batches should have the same slump. If they do not, it probably indicates that material with variable free moisture content is being fed into the bins. It must be underlined again that no amount of testing can offset or compensate for charging the bins with material having a non-uniform free moisture content. Likewise, the frequency of tests must be governed by the uniformity of the materials.

At the beginning of paving operations, the Road-Mixer Inspector should observe the mix and determine if the coarse aggregate factor is the proper one to use. From this observation he may decide that CAF should be reduced because the mix is harsh and difficult to finish with the usual finishing operations, or, he may decide that the CAF could be increased without making the mix harsh and hard to finish. In either case, he should advise the Plant Inspector to make those changes in the mix design that his observations indicate should be made.

BLEEDING AND ITS CONTROL

Should free water appear on the slab behind the finishing operations, appropriate changes in the mix design or aggregates must be made. This condition is usually encountered when the humidity is high and the rate of evaporation is low.

All concrete, sooner or later, will lose some of the moisture used as mixing water. When this rate of loss exceeds the rate of evaporation from the pavement surface, it is called bleeding. This bleeding is more likely to occur when using a fine aggregate having a relatively high percentage of voids. Bleeding is objectionable for several reasons. It will leave a thin film or laitance on the pavement surface which will readily wear or scale off under traffic. This produces an unsightly surface as well as an open, weak surface which will deteriorate much faster than a tight, strong, low voidage surface. In addition, bleeding will unduly delay finishing operations, and cause the finishing of joints to become quite difficult.

Where water appears on the surface of the concrete after finishing and this condition cannot be corrected by reasonable adjustment in the batch design, the bleeding will be immediately corrected by one of the following measures or a combination of two or more of the following listed measures.

(a) Redesigning of the batch.

(b) Addition of mineral filler to fine aggregate.

(c) Increase of cement content.

(d) Use of an approved air-entraining agent or other approved admixture.

In the event that the measures taken do not eliminate the bleeding immediately, concrete placement operations will be suspended, as directed by the Engineer, and will remain suspended until such time as additional trial batches demonstrate that a non-bleeding batch design has been achieved. The Contractor may be required to submit samples of different materials for additional trial batches and pilot beams.

HAIR CRACKING AND ITS CONTROL

Hair cracking is just the opposite of bleeding. This condition is due to the rate of evaporation being much greater than the rate of mixing water loss to the surface of the concrete. An increase in the percentage of voids in the fine aggregate will give some relief. Thoroughly wetting the subgrade will afford additional relief; however, the primary remedial action consists of accelerated curing operations.

CONTROL OF THE STRENGTH OF CONCRETE

Two test beams for a flexural strength value shall be taken from the concrete for each 1,500 square yards of pavement placed, or in accordance with the specification requirements. The Road-Mixer Inspector should make these two beams from the same batch of concrete according to Test Method Tex-420-A. Each pair of beams should be numbered consecutively, beginning with "1" and continuing throughout the paving operations. Each beam should be plainly marked with the proper number, followed by "A" on one beam and "B" on the other. The Road-Mixer Inspector should record the number of the beams and the station number at which they were made on Form 311 Rev., Daily Road Report - Concrete Pavement. He should also make a slump test and determine the air content from the same batch from which the beams were made and record this data also on Form 311 Rev. The curing and handling of the test beams shall be in accordance with Test Method Tex-420-A. Before the beams are removed from their molds, the Road-Mixer Inspector will be responsible for transporting them from

the roadway to the field laboratory curing tanks. They should be brought in and placed in the curing tanks from 24 to 30 hours after they are formed.

The Daily Road Report will be prepared in duplicate by the Road-Mixer Inspector and one copy will be furnished to the Plant Inspector for his use in preparing Form Number 312 Rev. Copies of Form Numbers 311 Rev. and 312 Rev. are given on pages 87 and 88 respectively.

Texas Highway Department
Construction Form 311 Rev.

10248-1263-50m

DAILY ROAD REPORT—CONCRETE PAVEMENT

COUNTY EL PASO PROJ. NO. 2121-31-70 DATE 1-19-65

BATCH METER	PROGRESS	TIME
START 34,374	STA. 55+38.5	HRS. RUN 7
STOP 34,750	STA. 46+57.3	HRS. LOST 1 hr. 20 min.
BATCHES 376	LIN. FT. 890.7 *	CAUSE Ran out of
CK. BATCHES 376	YIELD/BATCH .978	Cem. Twice

MATERIALS

CEM. USED 2554.92	CEM. OVER 56.21	STEEL: BARS ** See Below
CEM. REQ. 2498.71	CEM. UNDER —	WIRE MESH —

TEST SPECIMENS

Station	Beam No.	Slump	% Air	Station	Beam No.	Slump	% Air
54+38	4	2"	4.1				
52+50	5	2 1/4"	3.9				
50+63	6	1 3/4"	3.8				
48+76	7	2"	4.3				
46+89	8	2 1/4"	4.2				

PAVEMENT REPORT

Sta. to Sta.	Time to Time	Batches	Wt. Sand	Wt. Grav.	G. Wat.	Depth
55+38.5 - 54+17.8		62	1945	3044	42.5	8 - 8 1/4 - 8 1/8
54+17.8 - 53+47.8		93	"	"	"	8 - 8 1/8 - 8 1/4
53+47.8 - 51+17.3		24	"	"	"	8 - 8 1/8 - 8 1/4
51+17.8 - 50+72.3		25	"	"	42.0	8 1/4 - 8 1/8 - 8
50+72.8 - 49+72.3		107	"	"	"	8 3/8 - 8 1/8 - 8
49+72.8 - 47+49.3		20	"	"	41.6	8 - 8 - 8 1/4
47+49.3 - 46+59.3		45	"	"	42.1	8 - 8 1/4 - 8 1/8
* Measured Length =		890.7	(Includes 90' Terminal Anchor)			
** Terminal Anchor		= 8,360	Lbs.			
Pavement		= 44,006	Lbs.			

INSPECTOR: E. Clay

FORM 311 Rev.

FORM 312 REV.
FIELD LABORATORY REPORT FOR CONCRETE

This form is for recording the design, control, construction progress, and other pertinent data in the placing of concrete pavement during a day or part of a day. It must show the reasons for all mixer shut-downs in brief, but definite notes. Reasons for delays must be given. For example, lack of material, break in machinery, etc.

Texas Highway Department
Construction Form 312 Rev.

FIELD LABORATORY REPORT FOR CONCRETE

County Monroe Project No. C 1-2-3 Hwy. U 25 Contractor Abel Constr. Co. Date 1-3-64

1-SK. DESIGN	DESIGN NO. 4				DESIGN NO. 5				DESIGN NO.				DESIGN NO.			
Material	Sp Gr	D.L Wt. Cu Ft.	% Solids	A.V. Per Sx. Cem.	Sp Gr	D.L Wt. Cu Ft.	% Solids	A.V. Per Sx Cem	Sp Gr	D.L Wt. Cu Ft.	% Solids	A.V. Per Sx Cem	Sp Gr	D.L Wt. Cu Ft.	% Solids	A.V. Per Sx Cem.
Water	1.0			0.497	1.0			0.497								
Cement	3.10	94.0	49.5	0.485	3.10	94.0	49.5	0.485								
*Fine Agg.	2.65	101.8	61.4	1.386	2.65	101.8	61.4	1.426								
*10% Fine Sand																
Coarse Agg.	2.61	98.8	60.6	2.982	2.61	98.8	60.6	2.982								
Air (4%)				0.240				0.240								
Yield				6.000				6.000								

DESIGN FOR 5.80 SACK BATCH= 40.6 CU. FT.

Time Sent	Des. No.	Cement Lbs.	FINE AGGREGATE Wt. D.L.	Moist. Lbs.	FAF	COARSE AGGREGATE Wt. D.L.	Moist. Lbs.	CAF
6:00	4	639	1405	53	.75	3308	13	.82
			156	8				
7:15	4	639	1405	56	.75	3308	10	.82
			156	9				
6:30	4	639	1405	51	.75	3308	7	.82
			156	7				
9:45	4	639	1405	58	.75	3308	10	.82
			156	8				
10:50	4	639	1405	53	.75	3308	13	.82
			156	7				
1:00	4	639	1405	52	.75	3308	10	.82
			156	6				
2:00	4	639	1405	56	.75	3308	10	.82
			156	8				
3:00	4	639	1405	51	.75	3308	7	.82
			156	7				
4:15	4	639	1405	53	.75	3308	10	.82
			156	6				
5:10	5	639	1418	55	.77	3308	13	.82
			159	9				

PAVEMENT REPORT

Time Rec'd	Sta. to Sta.	Length Ft.	Batches	Water Added Gals.	Total Moist. Gals.	Total Water Gals.	Cem. Factor	Water Per Sack	Depth fractions in 1/8 in.
6:20	46+10 — 46+75	65	25	37.3	8.9	46.2	4.5	6.8	8"— 8'— 7'
7:30	49+07	232	92	37.2	9.0	46.2	4.5	6.8	7' 8"— 8'
6:45	51+57	250	100	38.4	7.8	46.2	4.5	6.8	8"— 8"— 8'
10:00	54+12	255	101	37.1	9.1	46.2	4.5	6.8	7'— 6"— 7'
11:05	56+28	216	86	37.4	8.8	46.2	4.5	6.8	8'— 7'— 8'
1:15	58+60	232	92	38.0	8.2	46.2	4.5	6.8	8'— 8"— 8"
2:15	60+65	205	81	37.3	8.9	46.2	4.5	6.8	8"— 7'— 8'
3:20	62+82	217	86	38.4	7.8	46.2	4.5	6.8	8'— 8'— 8'
4:30	65+15	233	91	37.9	8.3	46.2	4.5	6.8	7"— 7'— 8"
5:35	68+18	303	120	35.0	9.2	44.2	4.5	6.5	8"— 8'— 8"

BEAMS MADE / BEAMS BROKEN

Station	Beam No.	Slump	% Air	Beam No.	7 Day
47+00	61	2¼	4.6	1	590
48+87	62	1¾		2	605
50+74	63	1¾		3	570
52+61	64	2	4.0	4	595
54+48	65	2½		5	640
56+35	66	2¼		6	580
58+22	67	2	4.3	7	620
60+09	68	2		8	615
61+96	69	2¼		9	515
63+83	70	2½	3.8	10	600
65+70	71	1¾		11	590
67+57	72	1¾			
				Avg.	592
				Adj. Avg.	601

CEMENT El Toro FROM Tex. Texas

Time	°F. Cem.	°F. Air	Car or Trailer No.	Seal No.	No. Bbls. Sacks
6:00	94	72	4528	325145-50	640
7:05	96	73	4503	325151-56	638
8:20	109	83	2314	325217-22	651
9:30	92	99	4571	325170-75	643
10:40	90	91	2165	325231-36	639
1:00	122	93	2327	325245-49	645
1:45	130	94	2160	325253-58	641
2:35	127	95	4397	325267-72	644
3:20	136	96	2194	325285-90	639
4:45	129	94	2113	325291-96	635

MATERIAL & SOURCE:

Cru. Agg.: Alto Pit, Soprano, Texas
Fine Agg.: Alto Pit, Soprano, Texas
Fine Sand, Local, Bass Property
Water: Clear Creek, Sta 140
Admix: AEA Prolon No. 2, 3.5 Ozs.
CDA Lbs. Gals.

LENGTH: 2208 L.F. 5886 S.Y. % in Place 11.6
CEMENT: Used 5943 Bulk Sacks Req'd 5890 Over under 55
STEEL: Bars Lbs.; Wire Mesh Lbs.
MIXING TIME: 60 Sec. HOURS: 11.5 Run .6 Lost
TIME: Last Batch 6:00 P.M. Slab Finished 7:05 P.M.

REMARKS: 15 Min Delay — Out of water.
20 Min Delay — Realign & Tamp Forms

Superintendent: [signature]
Inspector: [signature]
Report No.: 6

FORM 312 Rev.

OPERATIONS ON THE ROAD:

Construction Surveying
Roughed-in Subgrade
Forms and Form Setting
Fine Grading
Placing Reinforcing Steel

CONSTRUCTION SURVEYING

On those contracts where the concrete pavement has been awarded after the grading and structures have been completed under a prior contract, it will be necessary to take cross-sections of the roadway in order to establish a grade line for the pavement. These cross-sections also will be used to calculate the earthwork involved on the project. The established grade line will be for the top of the pavement at the centerline of the pavement, and any subsidiary grade lines will be calculated from this established grade.

Usually the Contractor will request stakes to assist him in preparing the "roughed-in" subgrade. These stakes are normally set on hundred foot intervals down the center of the roadway, and are driven to where the tops of the stakes coincide with the grade at the bottom of the pavement. The tops of these stakes are then colored blue and are thenceforth referred to as "blue tops."

After the subgrade is "roughed-in," the Contractor will request paving stakes for line and grade. These stakes are off-set from the edge of the pavement at a distance that best suits the Contractor. The tack line stakes are set on one side of the proposed pavement and grade stakes

are set on each side of the pavement. The stakes are usually set on 50 - foot intervals but on vertical and horizontal curves they may be placed as often as 25 - foot intervals. The beginning and end of each horizontal curve must be staked as well as the beginning and end of super-elevations on curves.

ROUGHED-IN SUBGRADE

The roadbed shall be completed to or above the plane of the typical sections shown on plans and the lines and grades established by the Engineer. Drainage of the roadbed shall be maintained at all times and sealed or treated subgrade sections which have been accepted by the Inspector and which have been damaged or cut or in any way caused to become unacceptable in the preparation of the subgrade or setting of pavement forms, shall be resealed or the subgrade restored to the original condition as directed by the Engineer.

The Inspector's subgrade objective is to secure a uniformly compacted foundation that meets all the specification requirements and that will support the projected concrete slab in such a manner that a smooth riding surface can be acquired and retained. If the subgrade is irregular, the odds are favorable that the pavement will reflect these irregularities with a rough riding surface. If the subgrade does not have the proper specified densification, then an immediate, smooth-riding surface may eventually become a maintenance problem.

If a subbase or base is to be placed immediately under the slab, then

the subgrade should be cut to grade. When no subbase is specified, then the subgrade should be cut a bit high so that later it can be shaved to true grade by final fine grading operations. By the same token, subbase material when used should be spread over the subgrade to a width and depth that will yield a compacted depth slightly in excess of the ultimate fine grade elevations.

When proof-rolling is available or specified, sufficient overlapping passes with a properly loaded heavy roller should be made to develop weak spots. Any soft spots or areas that do not meet the specification requirements should be scarified to the proper depth, reprocessed, re-compacted and shaped until the governing provisions of the specifications are satisfied. If permitted on the "roughed-in" subgrade, construction traffic can also be used to detect soft or unstable spots that may not be self-evident otherwise.

Field density test data should be recorded on Form 590. Three copies of Form 590, Weekly Summary of Embankment, Subbase, or Base Materials Tests Results, should be forwarded to the District Construction Engineer's Office as soon as the tests have been completed on samples taken during any calendar week. A sample copy of Form 590 is given on page 92.

FORM SETTING

Forms should always be thoroughly inspected and approved for job usage prior to their being set. The top and sides of the forms should be straight-edged and any defective forms straightened before they are

Texas Highway Department
Construction Form No. 590

WEEKLY SUMMARY OF
EMBANKMENT, SUBBASE, OR BASE MATERIALS TESTS RESULTS

County EL PASO Highway I-10 Project 2121 - 51 - 32 Control I-10-29(89)019

Spec. Item 270 Description CEM. TREAT MATLS IN PLACE Type of Material IN PLACE SUBGRADE

Source of Material ROADWAY MATERIALS Location ROWY. - Subgrade

Sample Identification				Soil Constants			Gradation (Exclusive of gravel or stone retained on 1" and No. 4) (% Retained on / Passing)						Wet Ball Mill Value	Triaxial Data		Density Data			Course	Remarks
Point of Sample or Station	Date Taken	Number	Type	LL	PI									p.s.i. at 0 lat.	p.s.i. at 15 lat.	Desired % C.R. Density	Field Density (%)	% Moist.		
Specification Requirements								1"			N/4					95		X		
					SPECS →			100			80 (MINIMUM)					(MIN.)				
791+00	9/29/66	26														96		6.1		
795+15	9/29/66	24-A														97		7.2		RETAKE AFER SPRINKLING AND ADD. ROLLING.
805+00	9/29/66	22-A														96.5		7.8		" " "
815+00	9/30/66	27						OK			OK					95		8.2		Good PULVERIZATION — NO ROCKS OR GRAVEL

Submit the original to File D-6 as soon as the tests have been completed on samples taken during any calendar week. Prepare a separate series of this form for each different applicable item of work. Write in the specification requirements on each page. Record each sample in chronological order. Identify each sample as "JC" for Job Control or "PR" for Progress Record in the column labeled "Type." Write in the necessary sieve sizes on each page at the top of the unlabeled columns under "Gradation." Indicate in the "Remarks" column any corrective action required due to failing test results. Void failing test results with a single, narrow line when they are replaced with passing test results representing the same material, and reference the passing results to the voided results. The column labeled "Course" applies only to subbase and base work.

Eugene Clay
Inspector

Report No. 2 Week Ending 9/30/66

allowed to be used on the work. Form braces, locks and wedges should be carefully checked for imperfections, excessive wear, and soundness. Twisted, burred, damaged, or warped forms that are defective beyond repair should be condemned and removed from the job site. Form sections shall be not less than 10 feet in length.

Side forms shall be of metal of approved cross-section. The preferred depth of the forms shall be equal to the required edge thickness of the pavement. Forms with depths greater or less than the required edge thickness of the pavement will be permitted provided the difference between the form depth and the edge thickness is not greater than 1 inch, and further provided that forms of a depth less than the pavement edge are brought to the required edge thickness by securely attaching metal strips of approved section to the bottom of the form.

Flexible or curved forms of wood or metal of proper radius are used for curves of 200 - foot radius or less.

Forms are probably the most vital part of a paving Contractor's equipment from the standpoint of securing a good riding surface. Many forms that appear to be in good shape will not attain a satisfactory joint with the adjoining forms. Checking of forms is not a matter to be hurried over. The Inspector should allow himself plenty of time and see that every form which does not comply fully with the specifications is either repaired and made acceptable or is removed from the job site. It is advisable to mark rejected forms plainly so that they can be readily detected and will not be accidently used. The Inspector should

never relax his vigilance in inspecting forms throughout the project.

The form-base grade line should be controlled from string lines which are placed at the required elevation for grading and trimming to final height. In no case shall the form-base be less than 8 inches for a form 8 inches or more in height. When form grading is cut by machine, stringlines must be run twice. The first line is run in as an offset and placed at a height that is convenient for the operation of the mechanical grader. The final string-line for finished form grading is set to run along the face and at the top elevations of the forms. It will thus also function as a control line for later form setting.

The subgrade under the forms must be firm and cut true to grade so that each form section when placed will be firmly in contact for its whole length and base width, and exactly at the established grade. Any subgrade under the forms below established grade shall be corrected, using suitable material, placed, sprinkled and rolled as directed. Forms shall be staked with at least three pins for each 10-foot section. A pin shall be placed at each side of every joint. Form sections should be tightly jointed and keyed to prevent relative displacement. In cases where it is practicable, the plan of staggering form joints should be followed as this greatly increases lateral stability. Forms should be cleaned and oiled each time they are used. Do not permit placement of concrete against forms until they have been thoroughly oiled.

After the forms are in position, the Inspector should check them for alignment by measuring from the line stakes to the form and the distance

between forms. The Inspector, prior to actual form setting, should check the depth of the trench being cut by the form line grader and observe the bearing capacity of the soil in this open trench. Any unstable, wet or mucky soil should be replaced with stable material before the form is set. One method of determining whether the forms are settling after they are placed is to drive a stake into the ground along the side of the form line, then with a carpenter's level, make a mark on the stake, this mark to be level with the top of the form line before the Contractor's machines pass over the form. Repeat this process after the machines have passed over the form. The distances between the marks is the amount of form settlement. If forms settle and/or deflect over 1/8 inch under finishing operations, paving operations will have to be stopped and the forms reset to line and grade. Form settlement should be detected before paving operations begin.

The Inspector should again check the forms for alignment and grade just prior to placing concrete and where any form has been disturbed or any subgrade becomes unstable, the forms should be reset and rechecked. Again it should be emphasized that the area under the forms must be thoroughly compacted to the specified density that will prevail throughout the undisturbed portions of the subgrade that will be under the pavement.

Forms should be set for a sufficient distance in advance of the point where concrete is being placed to permit a finished and approved subgrade length of not less than 300 feet ahead of the mixer.

FINE GRADING

The subgrade planer shall be operated from approved forms immediately ahead of paving operations, and the subgrade shall be finished to the exact section of the bottom of the pavement as shown on the plans. It shall be tested with the approved template resting on the side forms, operated and maintained by the Contractor. The subgrade shall be maintained in a smooth, compacted condition, in conformity with the required section and established grade until the pavement is placed and shall be kept thoroughly wetted down sufficiently in advance of placing any pavement to insure its being in a firm and moist condition for at least 2 inches below the prepared surface. Sufficient subgrade shall always be prepared in advance to insure satisfactory prosecution of the work. No equipment or hauling shall be permitted on the prepared and finished subgrade, except by special permission of the Engineer, which will be granted only in exceptional cases and only where suitable protection in the form of two-ply timber mats or other approved material is provided.

The approved subgrade planer shall be capable of riding on the forms and shall have adjustable cutting blades which can cut the subgrade to the required section. It shall be solidly constructed and shall not deflect more than 1/8 inch when tested by shifting its support from the wheels to the center. Equipment used to tow the planer shall not rut or indent the subgrade.

After the subgrade planer has cut the subgrade or subbase to grade, the resulting disturbed surface should be recompacted and finished with

medium or light weight rollers. Additional water may be required for this surface treatment operation in order that the specified subgrade densification at the surface may be obtained.

A spike (scratch) template properly adjusted to the pavement width and crown is used to detect high spots in the subgrade. A string line and ruler can be used by the Inspector to supplement and confirm the scratching efforts of the Contractor's template. High spots as well as low spots must always be corrected to grade and rechecked with the template.

The template shall rest upon the side forms and shall be of such strength and rigidity that under a test made by changing the support to the center, it shall not show a deflection of more than 1/8 inch. It shall be provided with accurately adjustable rods projecting downward to the subgrade at 1 - foot intervals, and these rods shall be adjusted to the required cross section of the bottom of the slab when the template is resting upon the side forms.

Maintenance of a moist condition of the subgrade in advance of fine grading and concrete placing will not be paid for directly, but shall be considered as subsidiary work.

The final planing of the subgrade should always be done as near the roadway mixer as is considered practical without interferring with other construction operations.

PLACING REINFORCING STEEL

All reinforcing steel shall be accurately spaced and placed and secured in position in accordance with details shown on the plans. Reinforcing bars shall be securely wired together at all intersections and splices. Longitudinal steel shall be so placed that it shall be final positioned to within $\pm$ ½ inch of the vertical position dimensioned on the plans. Longitudinal steel will be vertically positioned normally according to the formula T/2 $\pm$ ½" where T = pavement thickness in inches. Check the plans for horizontal positioning.

At transverse construction joints the regular longitudinal bars shall extend beyond the joint so that the bar splices for the regular longitudinal bars shall be a minimum of four feet from the construction joint. At longitudinal construction joints if the Contractor elects to continue the regular transverse steel through the joint, the #4 tiebars may be deleted. Additional bars will be required at transverse construction joints. Check the plans. Splices shall be a minimum of 24 times the nominal diameter of the bar. Longitudinal bar splicing should be well distributed (staggered) as this greatly increases the lateral stability of the pavement.

In the normal 30" placement for the transverse bars, chairs shall be placed under every transverse bar. The transverse spacing shall be a maximum of 48". Chair placement may be staggered so that the chairs in alternate rows are centered between the chairs in adjacent rows. The chairs used to support the bar mat shall be of sufficient structural quality and number to hold the mat within the placement tolerances, and shall be of a type approved by the Engineer.

Tightly adhered scale or rust which resists removal by vigorous wire brushing need not be removed except that excessive loss of section to the reinforcement due to rust shall be cause for rejection. Excessive loss of section shall be defined as loss of section to the extent that the reinforcement will no longer meet the physical requirements for the size and grade of steel specified.

All shipments of reinforcing steel received on the road must be accompanied by a shipping notice or invoice that clearly identifies the shipment. The notice or invoice must be stamped with the official D-9 monogram and must have a laboratory test number plainly marked on it. High strength bars may be grade marked by either the continuous line system or by the number system. One line in addition to the main ribs indicates 60,000 psi bars. Two additional lines indicate 75,000 psi bars. Under the number system, a grade mark of 60 = 60,000 psi; a mark of 75 = 75,000 psi.

A sample copy of a Shipping Notice for reinforcing steel is given on page 100.

SHIPPING NOTICE

INVOICE NO. 879

BORDER STEEL MILLS, INC.

Plant and Office Site:
INTERSTATE HWY. 10. VINTON. EL PASO COUNTY. TEXAS

Mailing Address:
P. O. BOX 71
EL PASO TEXAS

Phone:
WABASH 6-2105
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DESCRIPTION	NUMBER PIECES	UNIT PRICE	WEIGHT	AMOUNT
Border Hot Rolled Concrete Reinforcing Bars				
☐ ASTM A-15-64 A-305-56T Intermediate Grade				
A ASTM A-432-64 A-305-56T				
LOAD P6D-TT-24P-DSP6D				
#5 x 60' REBAR-LAB #66-1524-A	738		46188	

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TERMINAL ANCHORAGE

PURPOSE OF THE TERMINAL ANCHOR

Major lengthwise changes caused by moisture and temperature variations in a continuously reinforced concrete pavement are confined to the terminal (end) sections. Because these movements take place in sections that are 400 to 500 feet in length, longitudinal expansion may be as much as 2 inches. The conventional expansion joint cannot manage this much movement. That is why the special, terminal-type joints are used with continuously reinforced concrete pavement at pavement ends and at structure approaches.

There are two basic kinds of terminal joints: (1) The free-end types and (2) the fixed or anchor type terminals with lugs. The free-end types control longitudinal movement through an end system of several closely spaced conventional expansion joints or by one super expansion joint. They permit movement. The anchor types with lugs are used primarily when the pavement abuts a structure or structure approach slab. The lugs in the anchor system tend to reduce or repress end movements to such an extent that high abutting pressures at structures will be eliminated. They restrict movement.

PAVEMENT ANCHORS: CONSTRUCTION REQUIREMENTS

Terminal anchorage (concrete pavement) shall consist of the required excavation and construction of lug anchors, anchor slabs, and sleeper

slabs of portland cement concrete and reinforcing steel as shown on the plans.

All concrete and concrete ingredients shall conform to the requirements of the governing specifications for the adjacent concrete pavement or the requirements for Class "A" concrete as specified in the Item "Concrete for Structures (Natural Aggregate)" or in the Item "Concrete Pavement" (Class "A" Concrete).

Reinforcing Steel and all other materials shall conform to the requirements of the governing specifications for the adjacent concrete pavement.

The required excavation for the construction of lug anchors and sleeper slabs shall conform to the requirements of the Item "Structural Excavation", and the pertinent special provisions thereto. Over excavation will be avoided and any excavation for the lug anchors or sleeper slabs beyond the lines required by the plan dimensions shall be backfilled with portland cement concrete of the type used in the lug anchors or sleeper slabs at the Contractor's expense.

Preparation of subgrade and placing, furnishing and curing of concrete shall conform to the requirements of the governing specifications for "Concrete Pavement" or the Item "Concrete for Structures (Natural Aggregate)".

All bending of hard grade bars shall be done in the shops. Bending of

other grades preferably shall be done in the shop. Splices in structural or intermediate grade steel shall be a minimum of 20 times the diameter of the bar. Splices in other grades of steel shall be as noted on the paving detail that permits its use.

Transverse construction joints will not be permitted within the limits of the anchor lugs except in an emergency stoppage of the concrete placement and with the approval of the Engineer.

OPERATIONS ON THE ROAD: EQUIPMENT

General
Mixing
Hauling
Vibrating
Spreading
Finishing

GENERAL

All paving equipment necessary for the construction of the continuously reinforced concrete pavement shall be on the project and shall be approved by the Engineer as to condition before the Contractor will be permitted to begin construction operations on the road.

The manufacturers' manuals that give the detailed adjustments for each unit of the Contractor's equipment which is to be used on the paving work should be kept readily available on the project. The Inspector himself will never make the actual adjustments for the Contractor but will, as a part of his inspection duties, ascertain that the Contractor's forces do make necessary equipment adjustments. The Inspector before paving begins must learn the various adjustments that are possible on all of the paving equipment that the Contractor furnishes for the project. This knowledge will later, during actual paving operations, enable him to give proper instructions to the Superintendent regarding equipment control.

MIXER

The mixer furnished may be either a paving mixer (operated at the site of construction or centrally located) or a stationary mixer (central mixer). The mixer, or mixers, shall conform to the following.

(1) The rated capacity and recommended speed of rotation of each mixer drum shall be shown on a manufacturer's plate attached to the mixer in a prominent place. The mixer shall be capable of operating at a drum speed of from 16 to 22 revolutions per minute. Drum mixing blades shall be replaced when they are worn 3/4" or more.

(2) The minimum size of each mixer shall be not less than a 27-E (27 cubic feet) paver.

(3) The mixer shall be equipped with an automatic timing device that will be capable of locking the discharge mechanism of the mixer until the required mixing time is obtained. The timing device shall operate a sounding horn to signal plainly the completion of the mixing time.

(4) Multiple drum mixers will be permitted when they are properly synchronized. The total mixing time required will not recognize the time involved in transferring concrete from one drum to another.

(5) Water measuring devices. Reference is made to the section in this Manual entitled "Weighing and Measuring Equipment" for details on the specified equipment requirements of the water measuring devices and for the methods of inspection and calibration of these devices.

(6) Devices for measuring and dispensing concrete additives. Reference

is made to the section of this Manual entitled "Additives".

(7) If a paving mixer is furnished and operated at the site of construction, it shall be equipped with a power controlled boom and bucket, so designed as to permit uniform distribution of the concrete for the full width between pavement forms. Alternate equipment for distributing concrete may be substituted when approved by the Engineer in writing, provided uniform distribution is obtained without segregation.

HAULING EQUIPMENT

Batch hauling equipment for the transportation of measured materials from the batching plant to the mixer shall be tight and so covered as to prevent excessive evaporation of moisture or any loss of material. When a central mixer is used, truck agitators of the following types shall be used to transport the concrete from the mixer to the spreading equipment on the road.

(1) Horizontal or inclined axis, revolving drum.

(2) Open top, revolving blade or paddle.

(3) Agitating equipment approved by the Engineer in writing.

The truck agitator drum shall be actuated by an engine mounted as an integral part of the unit for the purpose of rotating the drum or agitation blades. It shall have positive controls for regulating rotation speed and shall be in good operating condition. No separate engine for drum rotation will be required when the truck agitator is equipped with a transmission that will govern the specified rpm of the drum or agitating blades.

Truck agitators shall be equipped with facilities to permit ready access for inspection, cleaning, and repair of blades.

A manufacturer's plate shall be attached to the truck agitator in a prominent place. The plate will give the manufacturer's recommendations on usage, speed of rotation of drum or agitator blades for agitation, and the capacity of the unit.

MECHANICAL VIBRATORY EQUIPMENT

All concrete placed for pavement shall be consolidated by approved mechanical vibrators operated ahead of the transverse finishing machine and designed to vibrate the concrete internally and/or from the surface. Unless otherwise shown on the plans, vibrators of the surface pan type and the internal type shall be furnished. Either type may be used concurrently at the discretion of the Engineer. Vibratory members shall extend across the pavement practically to, but shall not come in contact with the side forms. Mechanically operated vibrators shall be mounted in such manner as not to come in contact with the forms or reinforcement and not to interfere with the transverse or longitudinal joints.

The internal type vibrators shall be equipped with synchronized vibratory units. Separate vibratory units shall be spaced at sufficiently close intervals to provide uniform vibration and consolidation to the entire width of the pavement. The frequency of the internal type vibratory units and the method of operation shall be as determined by the Engineer.

The pan type vibratory units shall apply the vibrating impulses directly to the surface of the concrete. The operating frequency shall be not less than 3500 cycles nor more than 4200 cycles per minute. The Contractor shall have a satisfactory tachometer available for checking the speed of the vibratory elements.

The pavement vibrators shall not be used to level or spread the concrete, but shall be used only for purposes of consolidation. The vibrators will not be operated where the surface of the concrete, as spread, is below the elevation of the finished surface of the pavement and the vibrators shall not be operated for more than 15 seconds while the machine upon which they are installed is standing still.

Hand manipulated mechanical vibrators shall be furnished in the number required for provision of proper consolidation of the concrete along forms, at joints and in areas not covered by mechanically controlled vibrators. These vibrators shall be sufficiently rigid to insure control of the operating position of the vibrating head.

SPREADER

A self-powered concrete spreader of a type approved by the Engineer shall be required when a central mix concrete plant is used. The spreader must be capable of receiving the concrete from the hauling equipment and uniformly distributing the concrete on the subgrade without segregation. Depositing concrete on the subgrade from hauling equipment will not be permitted except for irregular pavement sections when approved by the Engineer.

The basic make-up of spreaders consists of a distribution mechanism (either a screw-type or a plow-type) and a strike-off or leveller. The spreader operator can usually adjust the bottom of the leveller (or the distribution mechanism on some spreaders) to the desired elevations by working from a gage indicator that is "zeroed-in" when the height of the screed is flush with the top of the forms.

FINISHING EQUIPMENT

GENERAL. Finishing machines shall be maintained in a tight and good operating condition, accurately adjusted to the required crown or profile, and free from deflection, wobble, or vibration tending to affect the precision of finish. Machines failing to meet these requirements will be condemned by the Engineer, and the Contractor shall provide approved equipment.

The Contractor shall furnish a canvass or canvass-rubber composition belt for finishing the pavement, to be of two to four ply construction, not less than 6 inches wide, and at least 2 feet longer than the width of the pavement.

The Contractor shall furnish, operate and maintain at least two standard 10-foot steel straightedges.

The Contractor shall furnish a sufficient number of bridges equipped to ride on the forms and span the pavement for finishing operations and for the installation and finishing of joints. All necessary

finishing and edging tools shall be furnished as may be required to complete the pavement in accordance with plans.

THE TRANSVERSE FINISHING MACHINE. The transverse finishing machine shall be provided with two screeds accurately adjusted to the crown of the pavement, shall be power driven and mounted on a substantial frame equipped to ride on the forms, and shall be so designed and operated as to strike off and consolidate the concrete.

In actual practice, the transverse screeds are usually set slightly higher than plan requirements. This overplus of crown is necessary to correct for compaction of the concrete and to provide a small excess for final finishing purposes. Compaction or consolidation can be accomplished with less surface distortion if the leading edge of the forward screed is raised from 1/16" to 1/8" higher than the trailing edge. A flat screed cuts while a tilted screed floats or irons the concrete surface. A tilted screed obtains greater consolidation than a flat screed.

The end plates of screeds suffer the most wear because they slide along the forms. When wear on the end plates exceeds 1/8", the Contractor should either reverse or replace them.

The transverse finishing machine's front screed, moving a uniform 4 to 8 - inch diameter roll of concrete ahead of it for the full width of pavement, should be operated in such a manner that an excess, or roll, of concrete will flow back to the second screed. This screed operates transversely also and is controlled in such

a manner as to compact and finish the pavement to the required section and grade without leaving any surface voids. Its movement is always opposite to the forward screed. The machine shall be operated over each area as many times and at such intervals as directed. At least two trips will be required, and the last trip over a given area shall be a continuous run of not less than 40 feet.

The abrupt loss of the roll of concrete in front of either screed indicates a low spot and corrections should be made.

When concrete begins to swell or "surge" behind the screed, it can usually be corrected by flattening both screeds. This usually happens while paving up a sharp grade. When paving down a sharp grade, the concrete tends to flow ahead of the screed. This condition can be corrected by increasing the tilt of the screed and by increasing the number of passes that are made over the areas.

THE LONGITUDINAL FINISHING MACHINE. The longitudinal finishing machine shall be provided with a longitudinal float not less than 10 feet in length, adjusted to a true plane, shall be power-driven and mounted in a substantial frame equipped to ride on the forms, and shall be so designed and operated as to finish the pavement to the required grade.

There are two widely used forms of crown adjustment for longitudinal floats.

One type machine has a track on either end of the float. These tracks are adjusted to the exact required height above the forms. Then the "straight track" between the end rails is made truly straight by using the end tracks for elevation control points. Through a series of "ordinate" type adjustments, the crown track, in reference to the "straight track", is caused to assume the proper pavement crown elevations.

Another type of machine that has widespread usage permits the shape of the longitudinal float to be adjusted to crown through a number of eccentrics whose extensions are brought in to proportion to a crowned offset line that is described from a straight line reference point. The eccentrics are normally controlled by an adjusting screw or screws that shape the required crown.

The screed should be checked for smoothness of finishing surface as well as straightness. It may be advisable to take the screed off the machine and turn it upside down for this inspection. Screed alignment can be adjusted with bolts provided for that purpose.

The surface of the concrete is finished with a longitudinal finishing machine that has a longitudinal screed of at least ten feet in length. The machine is power driven, rides on the side forms, and should be maintained in a tight operating condition, free of any deflections, vibrations, or wobbles. This machine

moves very slowly forward, and as it moves forward the screed is moving longitudinally as it travels transversely across the surface of the concrete. The proper use of this machine assists in a good riding surface being obtained. This work should never be done in a hurry and should be done very carefully. The longitudinal finishing machine is operated in such a manner that an excess or roll of concrete will be in front of the screed at all times. The abrupt loss of this roll invariably indicates a low spot. The primary purpose of a longitudinal screed is to cut off the high places and fill in the low places which may occur on the pavement surface. Remember, the least amount of work this screed has to do, the better the riding surface will be. Do not over work the longitudinal finishing machine!

The advance along the length of the pavement between successive passes of the float across the surface shall be such that the float shall continuously lap its previous position by not less than one-fourth its length.

STRAIGHTEDGING, BELTING, SMALL TOOLS. The Contractor should have two concrete finishers checking or straightedging the surface with ten foot straightedges. Any discrepancies, however small, should be corrected by these men. Usually slight surface variations will be rectified by the straightedging operations when the total pavement area is given two half-length lapping passes. A standardized straightedge for checking the trueness of the actual straightedges that are used for finishing and checking the concrete

surface should be kept on the project at all times by the Contractor.

After the straightedging operations have been completed, the surface should be finished with a light belt. This belting is done with a light canvass or rubber composition belt that should be not less than six inches nor more than ten inches in width. The belt should be at least two feet longer than the width of the pavement, and should be used with short, rapid, crossmotion strokes which will raise the grain of the sand and leave a uniformly sanded surface texture.

Few small tool manipulations are required when the finishing operations that are done by machines have been properly executed. Some hand edging work will always be required. And some pointing and touching-up will inevitably be needed on any paving job. But these "touch-up" actions are never the order of the day and whenever excessive patching, pointing and touching-up become a daily problem to be reckoned with - the Inspector is being given a sure sign of inferior workmanship.

THE SLIP FORM PAVER

OPTIONAL METHOD AND EQUIPMENT FOR PLACING AND FINISHING CONCRETE PAVEMENT

In lieu of construction methods employing forms, spreading, consolidating, finishing and floating equipment required in the specifications (Items 360 and 366), the contractor, if he so elects, may use a "Traveling Form Paver" (Also known by various other trade names such as "Formless Paver", "Slip Form Paver", etc.). If this method of construction is elected, all requirements of these items in regard to subgrade and pavement tolerances, pavement depths, alignments, workmanship, etc. shall be met in full.

If a "Traveling Form Paver" proves inadequate in the opinion of the Engineer in providing a pavement which meets the plans and specifications in all respects, the use shall be immediately discontinued when so ordered by the Engineer.

GENERAL

With the exception of the mixer, most of the normal equipment of the customary "paving train" is replaced by the slip-form paver. The use of side forms is also eliminated. The paver is actually a composite-type machine that spreads, consolidates, shapes, and finishes the concrete that is placed on the subgrade in front of its spreader. As in

the case with customary paving methods, some hand-finishing associated with touching and point-up may be required. Hand finishing of any kind (straight-edging etc.) must be done within the limits of the traveling forms that trail behind the paver. Some contractors do their edging by fastening edgers to the ends of the trailing forms. It is also permissible for the Contractor to fasten a burlap drag to the last truss of the trailing forms for final finishing.

Excepting the travelway for the tracks of the paver, there are no unusual alignment or grade problems involved in slip-form paving and the customary construction stakes are set as they would be for traditional paving. Off-set grade stakes are usually placed on each side of the road.

The Inspector should give special attention to the establishment of the proper grade for the travelway for the tracks of the slip-form paver in as much as the accuracy of thetravelway elevations will, to a great extent, determine the ultimate riding surface of the slip-form pavement. The travelway achieves the same results as a string of forms and actually decides the smoothness of the pavement riding surface.

The Inspector should also cut sufficient densities in the subgrade near the pavement edges to assure that the travelway for the paver tracks has the specified densification.

The requirements of concrete for slip-form paving are the same as for

conventional paving although the slump should probably not surpass 1½ inches.

The concrete should be unloaded on the subgrade in front of the paver evenly and consistently. Proper quantities of concrete should be meted out uniformly for intake by the paver's spreader at the time of deposition because the slip-form paver has no provision for side flow of the concrete after it is dumped on the subgrade.

The slip-form paver should be operated at a uniform rate of speed and the fewer stops it has to make during the course of a day's operations, the better the final riding surface will be. The paver should seldom if ever have to stop because of a shortage of concrete in front of its spreader.

Because the transverse reciprocating belt and the extrusion plate of the paver do not span the total width between the traveling forms, concrete for an integral curb may be caused to move around them and to issue out through passageways along the forms. Templates or "mules" are usually connected to these passageways to shape the curbs as the concrete flows back along the forms. Additional concrete for curb finishing may be provided by constructing extra-supply hoppers on the "mules."

When jointing one slab with another, logitudinal construction joints may be "keyed" or "deformed" by attaching a grooving tool extension to the end of the traveling form. An angle iron welded to the interior side of the traveling form has been used by many contractors as a grooving tool.

Wood side forms are usually required for hand finishing and edging if the concrete slab edge tends to rise as a result of "keying" or "deforming operations". Edge rising is normally removed when side forms are used with edging and hand-finishing operations.

SPECIAL REQUIREMENTS

The traveling paver shall be equipped with a longitudinal transverse finishing float (Also known by various trade names such as "V-Finisher", "Lewis Transangular Finisher", etc.) attached to the paver and adjustable to crown and grade. The float shall extend across the pavement practically to the side forms.

The concrete pavement shall be cured with a Type II white pigmented curing compound in accordance with the requirements of the Item, "Membrane Curing."

OPERATIONS ON THE ROAD:

Concrete: Batching and Placing
Joints
Depth Tests
Form Removal
Straightedging
Curing
Deficient Pavement Thickness Penalty
Opening Pavement to Traffic

CONCRETE: MIXING AND BATCHING

MIXING TIME. The aggregates, mineral filler if required, cement and water shall be measured separately, introduced into the mixer, and mixed for a period of not less than 50 seconds, measured from the time the last aggregate enters the drum to the time discharge of the concrete begins. The required water shall be introduced into the mixing drum during the first 15 seconds of mixing. The entire contents of the drum shall be discharged before any materials of the succeeding batch are introduced.

BATCH SIZE. The maximum size of the concrete batch, absolute volume, shall not exceed 120 percent of the rated size of the mixer.

Retempering or remixing of concrete will not be permitted.

CONCRETE: PLACING

Any concrete not placed within 30 minutes after mixing shall be rejected and disposed of as directed. If in the opinion of the Engineer, the temperature, wind and/or humidity conditions or such that the quality of the concrete will not be adversely affected, the specified

placing time may be extended to a maximum of 45 minutes. If a central mixer is used, the Contractor shall provide a system satisfactory to the Engineer for determining that concrete delivered to the road meets the specified requirements for mixing and time of placing.

Except by specific written authorization of the Engineer, concrete shall not be placed when the temperature is 40° F. and falling; but may be placed when the temperature is above 35° F. and rising, the temperature being taken in the shade and away from artificial heat. See Item 360.6 for specification requirements of cold weather concreting.

Concrete pavement should never be placed on a frozen subbase or subgrade. Cold weather retards the setting or hardening of concrete. At the freezing point, hardening stops completely. It follows, then, that when temperatures drop below 35°, artificial heat or other approved means of elevating the curing temperature of the concrete must be resorted to by the Contractor in order that proper early curing temperatures may be attained.

Frozen concrete will rarely approach its maximum strength potential. Frozen sections of new or green concrete usually have to be broken out and replaced. Paving in freezing weather should be done only when absolutely necessary.

Concrete shall not be placed before the time of sunrise, and shall not be placed later than will permit the finishing of the pavement during sufficient light.

Concrete shall be deposited on an approved subgrade or subbase in

such manner as to require as little rehandling as possible. Where hand spreading is necessary, concrete shall be distributed to the required depth by use of shovels. The use of rakes will not be permitted. Workmen will not be permitted to walk in the concrete with any earth or foreign material on their boots or shoes. The placing of concrete shall be rapid and continuous.

When the concrete is to be placed in separate lanes, the junction line shall not deviate from the true line more than ½ inch at any point and shall be finished as shown on plans.

The mixer shall not be located on completed pavement except as approved by the Engineer.

Concrete shall be distributed to such depth that when consolidated and finished, the slab thickness required by plans will be obtained at all points and the surface shall not, at any point, be below the established grade. Special care shall be exercised in placing and spading concrete against the forms and at all joints to prevent forming honeycombs and voids.

Concrete for the monolithic curbs shall be the same as for the pavement and if carried back from the paving mixer shall be placed within 20 minutes after being mixed. It may be placed from a separate mixer if desired but in any case must be placed while the pavement concrete is still plastic.

JOINTS

Joints have caused more trouble to concrete pavement than all the other faults combined and, therefore, it is extremely necessary that they be set and maintained perfectly.

Joints should be spaced as near as possible to the planned distance, from one end of the project to the other, and when it is necessary to stop paving operations, for any cause, between joints, a construction header should be put in to form a vertical plane of weakness or a modified warping joint. When paving operations are resumed, this vertical face should be carefully cleaned and paving resumed without placing any foreign substance against the concrete.

While the concrete is still workable, before it has set, joints should be thoughtfully straightedged to assure that the specified surface tolerances are sustained in the joint areas.

A SPECIAL PROVISION FOR TRANSVERSE CONSTRUCTION JOINTS. At the end of each day's run, or at any time that the paving operation is delayed for a prolonged period, a transverse construction joint shall be formed to conform with the details shown on the plans.

> A header board, as detailed on the plans, or of similar design and meeting the approval of the Engineer, providing openings for dowels and reinforcement, and readily disassembled for removal, shall be set and the concrete placed against it. The reinforcing

steel shall extend through the construction joint beyond the header and shall be covered or otherwise protected from any spilled concrete. After the header has been removed, accumulated debris, if any, shall be cleaned out and the portion of the sheet extending beyond the joint shall be supported at the specified elevation by wire chairs or other suitable supports before concreting is resumed (From Design of Continuously Reinforced Concrete Pavements, Manual No. CRP 1, Wire Reinforcement Institute, 1961.)

DEPTH TESTS

In order to be sure that the proper thickness of pavement is being constructed, three depth tests are taken for approximately each 200 feet of pavement during the placing of the concrete. This test is made by placing four plates on the subgrade. These plates should be in a straight line and sufficient notes taken in order that they may be located after they have been covered with concrete. The station numbers where the tests are made should be recorded in a bound field notebook, also the distance to the right and left of the centerline where the depth tests are taken. After the concrete has been placed and the longitudinal finishing machine has passed over, the Inspector works a small rod, which is sometimes called a depth test tool, down through the concrete until it touches the metal plate. The surface of the concrete is marked on this rod and the rod is withdrawn and the depth measured. All measurements should be recorded to the nearest 1/8 inch. Figure No. 3 illustrates this test.

During the course of the job, the Superintendent should be kept

DEPTH TEST

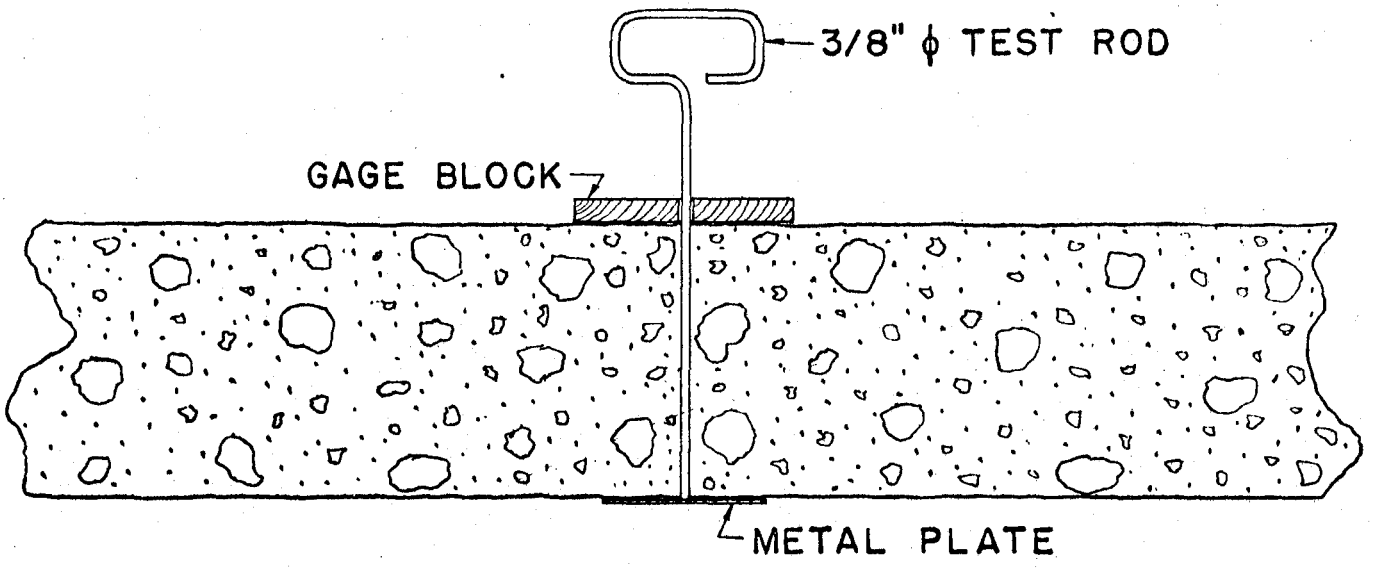


FIGURE 3

constantly advised of the results of the depth tests. He should be advised also that later cores for determination of deficient pavement thicknesses will be taken in those areas where depth measurements indicate a shortage of required pavement thickness.

REMOVING FORMS

Forms shall remain in place for not less than 8 hours after the concrete has been placed. They shall be carefully removed in such a manner that little or no damage will be done to the edge of the pavement. Any damage resulting from this operation shall be immediately repaired. After the forms have been removed, the ends of all joints shall be cleaned, and any honeycombed areas pointed up with approved mortar. Immediately after pointing is complete, the form trench shall be filled with earth from the shoulders in such manner as to shed water from rainfall or curing away from the edge of the pavement. On completion of the required curing, the subgrade or shoulders adjacent to the pavement shall be placed in condition to maintain drainage.

When trapezoidal key joints are used to form the longitudinal construction joints, the shape and tight attachment of the keyways to the forms must be done properly because if the attachments are improperly shaped, keyways or improper form removal will cause edge spalling.

SURFACE TEST - STRAIGHTEDGING

After the concrete has been placed 12 hours or more, the Inspector will

test the surface of the pavement with a 10-foot straightedge placed parallel to the centerline. The surface shall not vary from the straightedge by more than 1/16 inch per foot from the nearest point of contact, and in no case shall the maximum ordinate from a 10-foot straightedge to the pavement be greater than 1/8 inch. Any high spots causing a departure from the straightedge in excess of that specified shall be ground down by the Contractor to meet the surface test requirements.

When membrane curing is used, straightedging can begin immediately after the concrete has been placed for the minimum 12 hours. If other types of curing are used, straightedging is not usually performed until after the curing phase is completed.

All surface areas that do not meet specification tolerances for an acceptable surface without corrective measures should be clearly marked with paint or other marking substances and the Contractor promptly advised of unacceptable surface variations. The Inspector should keep a notebook record of all surface areas which will have to be corrected by the Contractor before the pavement can be accepted.

District 24 has a 16-foot rolling straightedge that can be used to indicate quickly high and low pavement spots. These spots can be marked and later checked accurately with the required 10-foot straightedge.

CURING

All concrete pavement shall be cured by protecting it against loss of moisture for a period of not less than 72 hours from the beginning of curing operations. Immediately after finishing operations have been completed, the entire surface of the newly laid concrete shall be

covered and cured in accordance with the requirements specified for whichever one of the following methods the Contractor may elect.

COTTON MAT CURING. Immediately after the finishing of the surface has been completed, and the concrete has taken its initial set, the surface shall be completely covered with cotton mats, thoroughly saturated before application, in such manner that they will contact the surface of the pavement equally at all points. The cotton mats shall remain on the pavement, including the pavement edges if not covered with moist earth or other moist shoulder materials, for not less than the specified curing period, and shall be kept saturated so that, when lightly compressed, water will drip freely from them (See Item 360.9(2) for additional requirements for cotton mat curing).

WATERPROOFED PAPER CURING. Immediately after the finishing of the surface has been completed, and the concrete has taken its initial set,it shall be wetted with water applied in the form of a fine spray, and covered with waterproofed paper so placed and weighted as to cause it to remain in intimate contact with the surface for not less than the specified curing period. (See Item 360.9(3) for additional requirements for waterproofed paper curing)

POLYETHYLENE FILM CURING. Immediately after the finishing of the surface has been completed, and the concrete has taken its initial set, it shall be wetted with water applied in the form of a fine spray, and covered with the polyethylene film so placed and weighted as

to cause it to remain in intimate contact with the surface for not less than the specified curing period (See Item 360.9(4) for additional requirements for polyethylene film curing).

MEMBRANE CURING. Immediately after the finishing of the pavement has been completed and after the free surface moisture or "water sheen" has disappeared, the pavement shall be sprayed uniformly with a curing compound. Membrane curing shall conform to the requirements of the Item, "Membrane Curing", Type 2 white pigmented. Should the film of compound be damaged from any cause before the expiration of 72 hours after original application, the damaged portions shall be repaired immediately with additional compound.

The curing of concrete pavement actually has a dual purpose: to maintain a uniform curing temperature and to contain moisture in the concrete. In order to do this, membranes must be evenly applied to a thickness that produces an impenetrable film over all exposed concrete surfaces.

White pigmented membranes are used because they tend to reflect light and thus lessen temperature extremes in the green concrete where it is desirable to maintain rather uniform curing temperatures.

Curing compounds should be continuously stirred to prevent the pigment from settling to the bottom of the sprayer tank or barrel.

PENALTY FOR DEFICIENT PAVEMENT THICKNESS

The adjustment in unit prices provided for in this section will apply

only when measurement for payment is by the square yard.

It is the intent of this specification that the pavement be constructed in strict conformity with the thickness and typical sections shown on the plans. Where any pavement is found not so constructed, the following rules relative to adjustment of payment for acceptable pavement and to replacement of faulty pavement shall govern.

(1) The pavement will be core drilled by the Highway Department prior to final acceptance. A minimum of 1 core per 1,000 linear feet per lane of pour will be taken. The thickness of the pavement will be determined by measurement of the cores taken at such points as the Engineer may select. Cores will be drilled from the width of normal thickness of section, and the thickness of individual cores will be determined by averaging at least three measurements.

(2) Pavement of a thickness within ¼ inch of the thickness required by plans will be considered of a satisfactory thickness, and the contract unit price bid shall be used in payment.

(3) Pavement of a thickness less than the thickness shown on plans by more than ¼ inch, but less than ½ inch, will be considered of a deficient thickness, and an adjusted unit price shall be used in payment, which price shall bear the same ratio to the contract unit price as the square of the actual average thickness of the slab bears to the square of the thickness shown on plans. The

length of the area of such deficient thickness shall be determined by additional cores taken at intervals of 10 feet along the length of the pavement in each direction until cores are obtained which are at least plan thickness. The width of such area shall be the entire width of pavement placed in one operation, and within the length thus determined.

(4) Payment will not be made for pavement which is found deficient in thickness ½ inch or more. The length of the area of such unsatisfactory thickness shall be determined by additional cores taken at intervals of 10 feet along the length of the pavement in each direction until cores are obtained which are at least plan thickness less ½ inch. The width of such area shall be the entire width of pavement within the length thus determined. Such pavement shall be removed and replaced by the Contractor with pavement of the specified thickness at his entire expense for removal and replacement. Provided the deficiency in thickness is not more than 3/4 inch, the Contractor, if he so elects, may leave such pavement in place, relinquishing thereby any claim for any compensation incurred in its construction.

(5) No additional payment over the contract unit price will be made for any pavement of a thickness exceeding that required by plans.

OPENING PAVEMENT TO TRAFFIC

The pavement shall be closed to all traffic, including vehicles of the

Contractor, until the concrete is at least 7 days old and has attained a minimum average modulus of rupture as required under the specifications (On future Contracts, 550 psi minimum).

At the end of the 7 day period and as long thereafter as ordered by the Engineer, and if so desired by the Contractor, the pavement may be opened for use by vehicles of the Contractor provided the gross weight (vehicle plus load) of such vehicles does not exceed 14,000 pounds.

After the concrete in any section is 14 days old, or as long thereafter as ordered by the Engineer, such section of pavement may be opened to all traffic as required by plans or when so directed by the Engineer.

The Contractor shall be responsible for protecting the new pavement when moving any equipment not licensed for operation on public highways on or across any pavement opened to traffic.

The Engineer may require the opening of pavement to traffic prior to the minimum time specified above under conditions of emergency. In no case shall the Engineer order opening of the pavement to traffic within less than 72 hours, after the last concrete in the section is placed.

New concrete pavement should normally be opened to traffic only after the specified strength has been attained, the curing cycle is completed, joints have been sealed, the pavement area cleaned, and shoulders formed along the pavement edges (Refer to Items 360.10(2) and 360.10(3) for additional requirements regarding opening pavement to traffic).

MEASUREMENT AND PAYMENT

MEASUREMENT

CONCRETE PAVEMENT. Concrete pavement will be measured by the square yard of surface area of completed and accepted work. The surface area will be construed to include that portion of pavement area extending beneath the curbs.

MONOLITHIC CURB. Monolithic curb measurement will be by the linear foot complete in place.

TERMINAL ANCHORAGE. The quantity of concrete in the anchor lugs, anchor slabs, and sleeper slabs will be measured by the cubic yard to the specified neat line dimensions shown on the plans.

The quantity of bar reinforcement furnished and placed in the anchor lugs, anchor slabs and sleeper slabs will be based on the calculated weights in pounds of the steel actually placed in accordance with the plans and specifications, with no allowance made for added bar lengths for splices requested by the Contractor nor for extra metal used when bars larger than those specified are substituted with the permission of the Engineer. Tie wires and supporting devices will not be included in the calculated weights. The calculated weight for bar reinforcement will be determined, using the theoretical bar weights set forth in Section 440.2 of Item 440, "Reinforcing Steel", and the pertinent

special provisions thereto.

All excavation for lug anchors and sleeper slabs will be measured by the cubic yard to the specified neat line dimensions shown on the plans.

PAYMENT

CONCRETE PAVEMENT AND MONOLITHIC CURB. The work performed and material furnished as prescribed by this item (366) and measured as provided under "Measurement" will be paid for at the unit price bid for "Concrete Pavement (Continuously Reinforced - High Yield Steel), and "Monolithic Curb".

When payment is measured by the square yard, as required, or the adjusted unit price for pavement of deficient thickness as provided under "Penalty for Deficient Pavement Thickness", which price shall be full compensation for shaping and fine-grading the roadbed, including furnishing and applying all water required, for furnishing, loading, and unloading, storing, hauling, and handling all concrete ingredients, including all freight and royalty involved; for mixing, placing, finishing, sawing, cleaning, and sealing joints and curing all concrete; for furnishing and installing all reinforcing steel; for furnishing all materials for sealing joints and placing longitudinal and expansion joints, including all steel dowel caps and load transmission devices required, and wire and devices for placing, holding, and supporting

the steel bars, load transmission devices and joint filler material in proper position; for coating steel bar wires when required by plans and for all manipulation, labor, equipment, applicances, tools, traffic provisions and incidentals necessary to complete the work.

Excavation required by this item (366) in the preparation of the subgrade and for the completion of the shoulders and slopes will be measured and paid for in accordance with the provisions governing the Items of "Roadway Excavation" and "Borrow", respectively, with the provisions that yardage shall be measured and paid for once only, regardless of the manipulation involved; or, where shown on plans, such work will be measured and paid for in accordance with the provisions governing the Item, "Blading". Measurement of subgrade excavation for payment shall be limited to a total width of that of the pavement plus 1 foot on each side. Payment under excavation items will not be allowed within the areas designated for "Blading".

Sprinkling and rolling, required for the compaction of the rough subgrade or subbase in advance of fine-grading, will be measured and paid for as indicated in the governing items of excavation. Maintenance of a moist condition of the subgrade or subbase in advance of fine-grading and concrete placing will not be paid for directly, but shall be considered subsidiary work.

TERMINAL ANCHORAGE. The concrete quantities, measured as provided

above, will be paid for at the unit price bid per cubic yard of "Concrete (Terminal Anchorage)", which prices shall be full compensation for furnishing, hauling and mixing all concrete materials; placing, curing, and furnishing all concrete; all grouting; furnishing and placing all joints, and for all forms and falsework, labor, tools, equipment and incidentals necessary to complete the work except as follows.

Reinforcing steel used in the concrete measured as provided above, will be paid for at the unit price bid per pound of "Reinforcing Steel (Terminal Anchorage)", which price shall be full compensation for furnishing, bending, fabricating, welding and placing for reinforcement, for all clips, blocks, metal spacers, ties, wire or other materials used for fastening reinforcement in place, and for all tools, labor, equipment and incidentals necessary to complete the work.

All excavation performed as required for lug anchors and sleeper slabs and measured as provided above will be paid for at the unit price bid for "Unclassified Excavation (Terminal Anchorage)", which price bid shall be full compensation for furnishing all labor, materials, tools, equipment, all hauling of materials, and incidentals necessary to complete the work. Payment for unauthorized work will not be made.

Excavation required by this item in the preparation of the subgrade for anchor slabs and for the completion of the shoulders and slopes

will be measured and paid for in accordance with the provisions governing the Items of "Roadway Excavation" and "Borrow", respectively, with the provision that yardage shall be measured and paid for once only, regardless of the manipulations involved; or, where shown in plans, such work will be measured and paid for in accordance with the provisions governing the Item, "Blading". Measurement of subgrade excavation for payment shall be limited to a total width of that of the pavement plus 1 foot on each side. Payment under excavation items will not be allowed within the area designated for "Blading".

Sprinkling and rolling, required for the compaction of the rough subgrade or subbase in advance of fine grading for anchor slabs, will be measured and paid for as indicated in the governing items of excavation. Maintenance of a moist condition of the subgrade in advance of fine grading and concrete placing will not be paid for directly, but shall be considered subsidiary work.

CONSTRUCTION RECORDS

FOREWORD

The following data has been assembled to provide a working basis for the determination of a uniform method of recording measurement and calculation data to establish and support final estimate pay quantities.

Reference is made to a portion of the statement relating to final estimate data shown on Page 23 of the AASHO Informational Guide published November 26, 1960:

> "The final estimate should include all field records, any special official instructions, all notebooks, change orders, haul tickets, materials shipping weights, materials test reports, paving records, inspectors records, bar lists, haul records, and all other documents to support the measurements and computations for all quantities involved on the project for which payment is made and to indicate that all materials entering into the construction meet the requirements of the specifications. Supporting computations for all quantities, together with supporting sheets for all force account work, must be submitted. Payment must always be based on the contract unit prices or those prices established by approved Supplemental agreements including any authorized Force Account work."

> "The final estimate files should be complete enough to allow any

subsequent audit and complete check of the project by competent personnel. One of the most important supporting documents of the final estimate is a complete diary, and it is especially important in case the project might be subject to audit or investigation. In such an instance it could be especially valuable to the Project Engineer."

The following data sheets cover only a portion of the items of work performed under contract and are intended only as a guide in the keeping of records for specific items on a project.

GENERAL: The preparation of records and reports to support the final estimate should begin the day the contractor begins work. A considerable amount of planning is required at the beginning of a job in order that all records and reports may be kept in a form that can be used to support the final estimate without revision or modification. It is essential that the Engineer keep in mind at all times the objectives to be accomplished in compiling the records, reports and essential information required. In this way he can reduce the amount of work required thereby promoting uniformity and accuracy, and expediting the preparation of the monthly and final estimates.

Particular attention should be given to the arrangement and space required in the field books containing the final measurements and calculations to the end that the entire records of each individual item of work may be found at one location in the book and not scattered throughout all of the final record books.

All measurements and calculations, other than cross sections, that involve volume computations should be accompanied by a sketch. All computation details should be placed in proper form and labeled as to contents in such a way that an auditor or other person not familiar with the records will have no difficulty in the checking of same.

It is required (News Letter 5-12-60 DCG) that all records relating to measurement and payment of items of work shown on the final estimate be submitted to the District Office for an audit as to content and mathematical accuracy before final payment is made to the contractor. The records required to be submitted prior to or with the final estimate are as follows:

1. Haul Books
2. Field Books
3. Job Diary
4. Final Plans
5. Final Cross Sections
6. All Computation Details
7. Correspondence Files

The final measurements and computations of quantities to support the final estimate should be contained in one or more of the following:

1. Haul Books
2. Final Plans
3. Final Cross Sections
4. Standard Forms in Job Files
5. Final Measurements in Field Books or Standard Size File Folders,

Containing Properly Identified Work Sheets or Field Plan Sheets.

Measurements and computations required to support progress estimates should be recorded in the proper form and location in the records and to such accuracy as required to be used later in support of the final estimate.

An intimate knowledge of and strict adherence to the specification requirements as to the methods of measurement and payment for each contract item of work is essential.

The computations for each item of work included in the final estimate and contained in the above listed field books haul books and other final recrods should be certified as follows:

(1) Measurements by: _____ _____, (2) Computations by_____
Signature Date Signature

_____, and (3) Checked by: _____ _____.
Date Signature Date

The front of field books should be neatly lettered in ink for proper identification. This should include title of book, project no., Hwy. No., name of county in which the project is located, and number assigned to the book.

JOB DIARY: Refer to Construction Manual for details relating to keeping of Job Diaries.

RECORDS OF MATERIALS RECEIVED: A record is to be kept of all materials received by the contractor that is to be incorporated in the work. A level book is usually used for this purpose. This record is used to account for all materials shown on Form 269, "Monthly Record of Materials Received."

When more than one project is included in a single contract a combined record of materials received may be used. Several books are often necessary to record the receipt of all materials and careful selection of the materials to be recorded in each book is required. In general, the record of materials received at an asphalt or concrete plant are kept in a separate book from materials received directly on the roadway. The number of pages required for each material should be carefully estimated to prevent interposition of the records. These books should be clearly identified, labeled, and indexed.

When the contract is complete a recapitulation of each item should be made showing the total quantity of material as follows:

1. Received on the project
2. Used on the project
3. Tested for use on the project
4. Remaining on hands of contractor
5. Wasted
6. Disposed of by contractor (show disposition)

The above information is required for use in preparation of Form 107, "Final Summary of Materials Tested."

Notations covering tests on materials received should be made in "Record of Materials Received" book.

The "Record of Material Used" is usually kept in this book and is used primarily for construction items containing a mixture of materials such as asphaltic concrete pavements, portland cement, concrete pavement, and structural concrete. Other materials used are accounted for by haul tickets, cross sections, standard forms or final measurement records.

Work sheets may be used in lieu of Field Book for keeping a record of materials received on project. Such work sheet data should be clearly identified, labeled, and indexed.

STRUCTURE BOOKS: The record of concrete pours on concrete structures should be kept in a Field Book or on clearly identified work sheets. Data shown in Field Books or on work sheets should be clearly identified, labeled, and indexed.

FIELD BOOK DATA - GENERAL: Field Book and work sheet recording of various items of work have been reproduced for examination and study. All data reflecting work done should be clearly identified, labeled, and indexed. Calculation data should bear date, signature of employee making the calculation, also signature of the one checking the calcualtion.

Partial data relating to many of the items of work can be pre-listed in Field Book prior to construction. This will expedite clerical work on the project and provide uniform Field Book recording.

EQUIPMENT BOOKS: Truck and other vehicle measurement data is to be recorded in a Field Book, Diary Book, or on clearly identified work sheets.

Weight scale tickets obtained to determine capacity of tanks used in sprinkling operations are to be bradded or taped on Field Book or work sheets.

CONSTRUCTION RECORDS AND DATA TO SUPPORT FINAL ESTIMATE

PAY QUANTITIES FOR CONTINUOUSLY REINFORCED CONCRETE PAVEMENT

CONCRETE PAVEMENT (Items 360 and 366)

Square Yard Basis - Pay quantity to be based on calculated square yards of concrete pavement placed. Measurement and calculation data to be recorded in field book, on work sheets, or on field plans.

Measurement and calculation data to be shown on sketches and work sheets for adjustment of unit price on areas having deficient thickness.

MONOLITHIC CURB

Pay quantity to be based on measurements made by the linear foot of curb in place. Measurement and calculation data to be recorded in field book, on work sheet, or on field plans.

TERMINAL ANCHORAGE

Unclassified Excavation and Concrete - Quantity to be plan quantity unless the alignment, grades, etc. are revised by the Engineer during construction. In such event, pay quantities will be the calculated quantities.

For calculated quantities - sketches, measurement and computation date is to be recorded in Field book, on properly identified work sheets or on field plans.

Reinforcing Steel - Pay quantity to be the calculated weight of the steel actually placed in accordance with the plans. No allowance for splicing to be made.

Support for this Item to be field placement records recorded on corrected fabricator's bar lists or in field books or on work sheets. All field control records related to this Item are to be submitted to the District Office to become a part of the completed project records.

Alternate Handling of Reinforcing Steel - Pay quantity to be verified plan quantity if changes in dimensions are ordered in writing by the Engineer. The pay quantity will be verified plan quantity increased or decreased by the quantity changes involved.

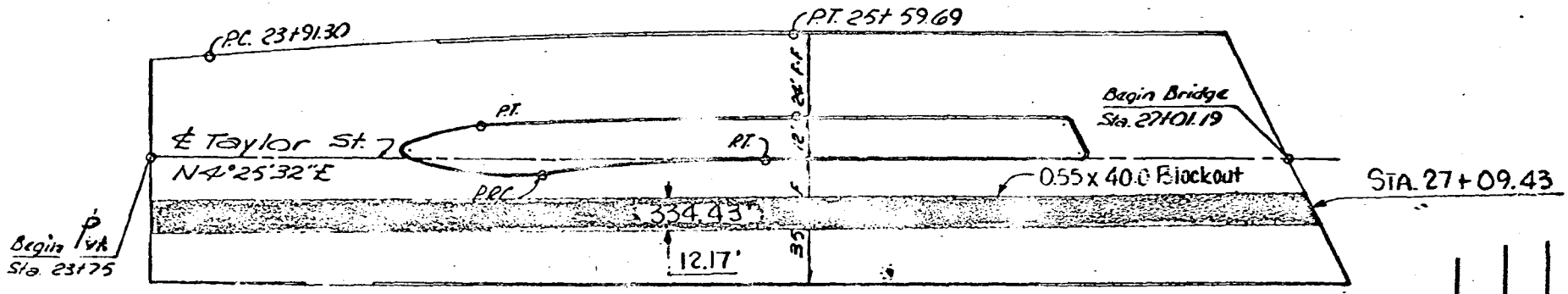
Support for this alternate method to be statement in field book or on work sheet by the Project Engineer or Chief Inspector that steel was placed, substantially, in accordance with the plans and specifications.

Bar lists and other field control records related to this Item are to be submitted to the District Office to become a part of

the completed project records.

SAMPLE MEASUREMENT AND COMPUTATION, AND VERIFICATION AND CERTIFICATION DATA SHEETS

The following four sample data sheets indicate the proper way that measurements, computations, and adjustments should be made and recorded on a continuously reinforced concrete pavement project. They are guidelines for the Inspector to follow in patterning his own measurement and computation data sheets. Two verification and certification sample sheets of pay quantities are also included.



CALCULATIONS:

12.17 x 334.43 = 4,070.01 S.F.

DEDUCTIONS:

0.55 x 40.00 = -22.00

4,048.01 S.F.

REPORT NO. S-1 = 449.78 S.Y.

MEASUREMENTS BY

COMPUTATIONS BY

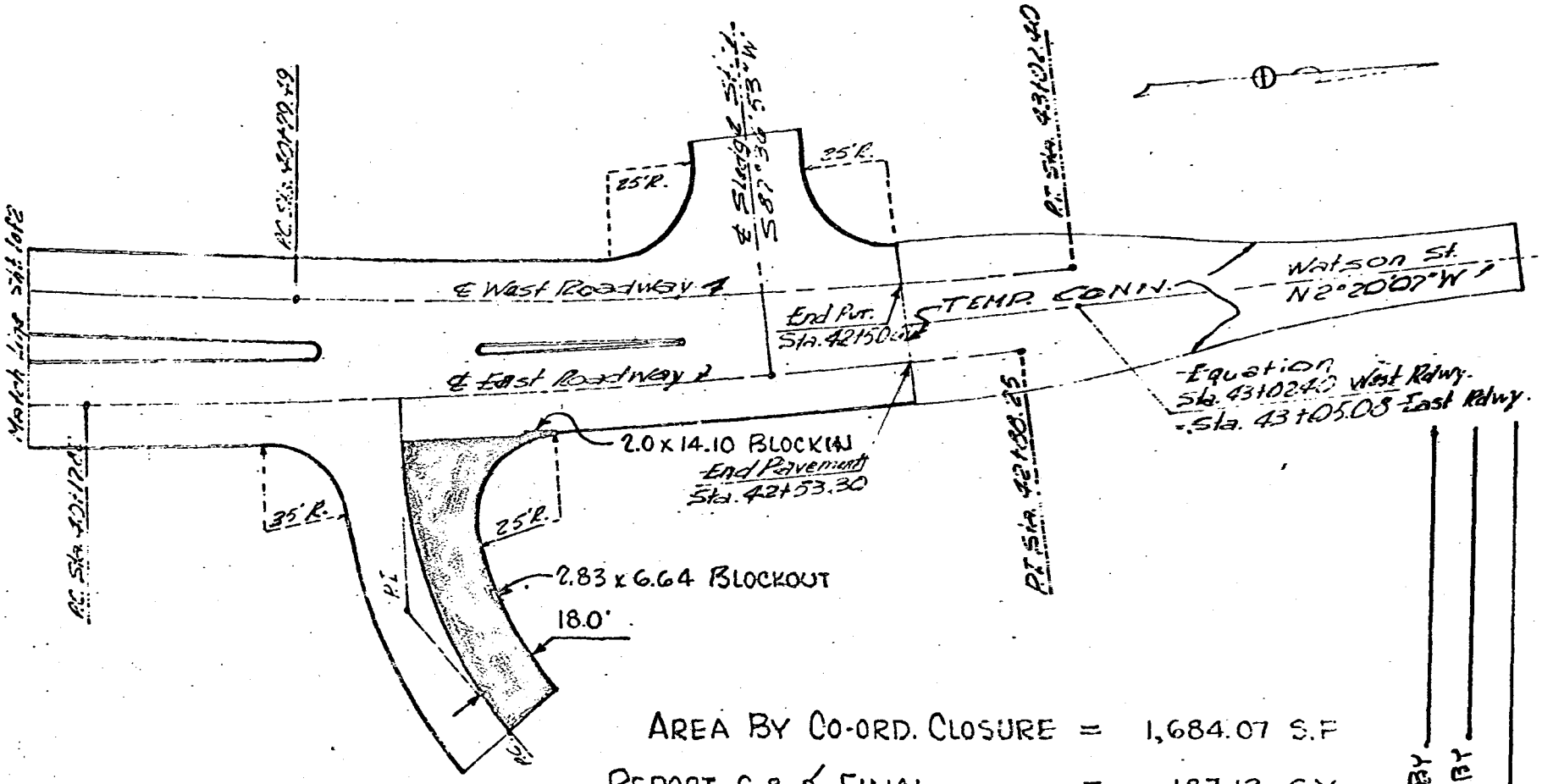
CHECKED BY

Calc. By: WEK.

Ck'd By: EFW.

6" CONCRETE PAVEMENT PAVING REPORT NO. S-1

FED. ROAD DIV. NO.	STATE	FEDERAL AID PROJECT NO.			SHEET NO.
6	TEXAS	I-10-7(105)776			1 of 1
STATE DIST. NO.	COUNTY	CONTROL NO.	SECTION NO.	JOB NO.	HIGHWAY NO.
12	Harris	271	7	48	I-10



AREA BY CO-ORD. CLOSURE = 1,684.07 S.F

REPORT C-8 & FINAL = 187.12 S.Y.

MEASUREMENTS BY

COMPUTATIONS BY

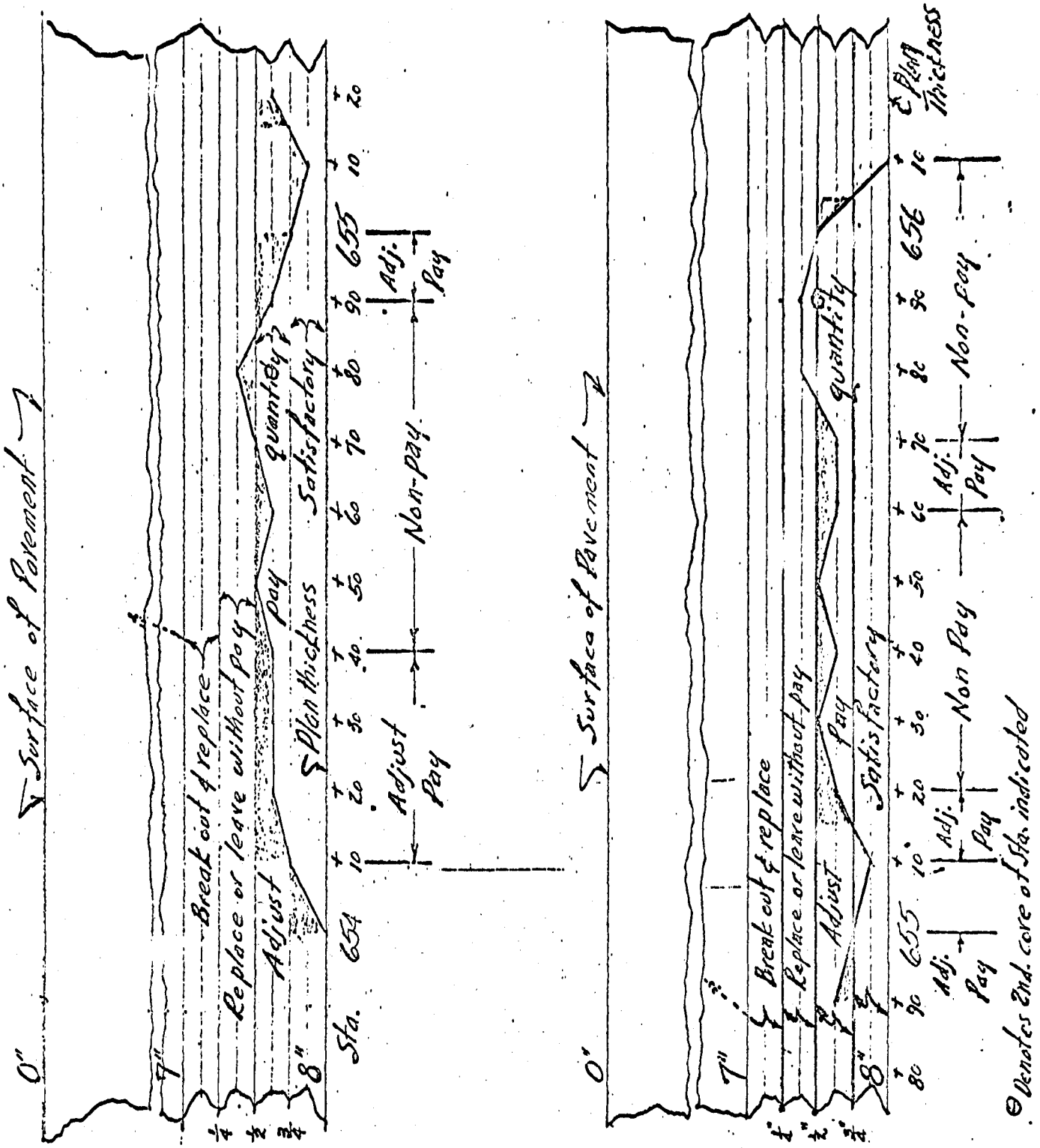
CHECKED BY

Calc. By: WEK

Ck'd. By: EEW

6" CONCRETE PAVEMENT
PAVING REPORT NO C8 & FIN.

FED. ROAD DIV. NO.	STATE	FEDERAL AID PROJECT NO			SHEET NO.
6	TEXAS	I-10-7605)776			1 of 1
STATE DIST. NO.	COUNTY	CONTROL NO.	SECTION NO.	JOB NO.	HIGHWAY NO.
12	Harris	271	7	48	I-10



DEFICIENT PAVEMENT THICKNESS
(left frontage road)

MEASUREMENTS BY Joel Hunter 2-13-64

COMPUTATIONS BY Joel Hunter 2-17-64

CHECKED BY LP Bammell 2-19-64

Texas Highway Department
Form 177

CONSTRUCTION ESTIMATE

Highway No. ..... District No. .....

County ..... No. .....

Project .....

Control No. ..... Sec. ..... Job .....

ESTIMATE NO. .....

Estimate Period

From October 22, 1960 to June 18, 1961

On first estimate and final estimate use actual work dates

FOR J.C. Glass, Inc., Houston, Texas
Contractor

ITEM	Unit of Measure	Project Estimate Quantities	Total Work Done on Contract	Contract Price	AMOUNT
Sta. 421+80.22 to 422+29.78 4-10'x6'x96'		30° Lt. Fwd. Skew		Length 49.56 Ft.	
Struct. Excav. Br.	C.Y.	450.	679.	6.50	4,413.50
Str. Conc., Culverts	C.Y.	325.41	336.11	46.00	15,461.06
Reinforcing Steel	Lb.	43,143.	43,580.	.13	5,665.40
			Sub-Total, Bridge		$25,539.96
*Deficient by more than 1/2 inch No payment.					
**Average Depth = 9.6750 Inches	=	$\frac{(9.6750)2}{(10.000)2}$ x 5.14	= $4.81	Adjusted Price	
***Average Depth = 9.7232 Inches	=	$\frac{(9.7232)2}{(10.000)2}$ x 5.14	= $4.86	Adjusted Price	

APPROVED:

Resident Engineer Date

District Engineer or Engineer-Manager Date

Construction Engineer Date

Bridge Engineer Date

For Res. Engr's Office
Calculations Verified By:
Supporting Papers O. K.
Proof Read By:
For Dist. Engr's Office
Calculations Verified By:
Supporting Papers O. K.
Proof Read By:

Total Amount of Work Done . . . . $.....

Less Retainage . . . . . $.....

Difference . . . . . $.....

Less Special Deductions . . . . . $.....

Less Liquidated Damage . . . . . $.....

Less Previous Payments . . . . . $.....

Amount Due this Estimate . . . . . $.....

PROPOSED DISTRICT REQUIREMENT

CERTIFICATION OF FINAL MEASUREMENT AND DETERMINATION
OF FINAL ESTIMATE PAY QUANTITIES

County_____ Contractor _____

Control_____ Federal Project No. _____Highway No._____

This is to certify that sufficient measurement, computing and checking of quantities was made to insure correctness of final pay quantities on this project. Index for location of properly signed documentary support included with final estimate supporting data furnished to the District Office.

_____
Resident Engineer

VERIFICATION OF FINAL PAY QUANTITIES

This is to certify that an examination of material haul books, haul tabulations, field books and relating work sheets has been made and final estimate quantities verified.

Signed:_____

Title: _____

PROPOSAL

FINAL PLANS TO SHOW CERTIFICATION BY RESIDENT ENGINEER, E. G.

PROJECT WAS BUILT ACCORDING TO THE PLANS AND SPECIFICATIONS. THESE FINAL PLANS REFLECT THE WORK DONE AND THE QUANTITIES SHOWN THEREON AND ON THE FINAL ESTIMATE ARE FINAL QUANTITIES.

_____

Resident Engineer

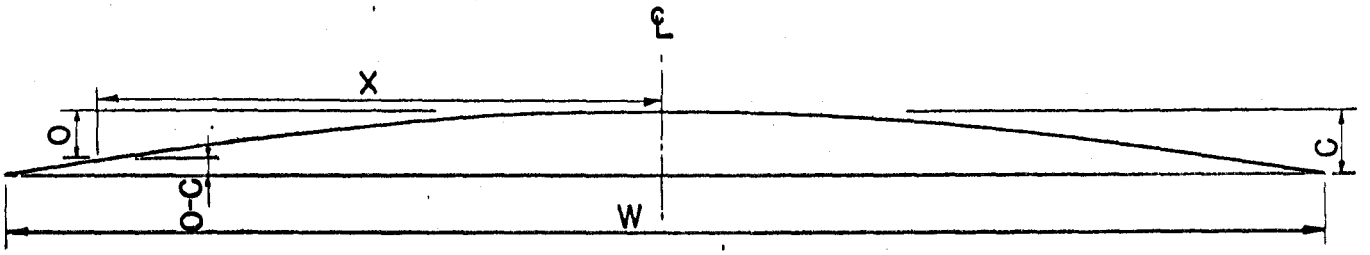
APPENDIX

Crown Formula

Theoretical Bar Weights

Flagging Instructions

CROWN FORMULA



$$O = \frac{4 C X^2}{W^2}$$

Where: O = Ordinate, in inches
X = Distance from ℄, in feet
W = Width of pavement, in feet
C = Crown, in inches

FIGURE 4

CROWN FORMULA: Most of our plans require that the pavement be constructed to a circular crown. The calculations for a circular crown are quite extensive. The difference of ordinates between a circular crown and a parabolic crown are so small for a normal pavement width that the parabolic crown formula is generally used in calculating ordinates for checking screeds, templates, etc. Figure No. 4 illustrates the calculation of ordinates using the parabolic crown formula.

CONCRETE REINFORCING STEEL INSTITUTE

228 NORTH LA SALLE STREET, CHICAGO, ILLINOIS 60601

ASTM STANDARD REINFORCING BARS

BAR SIZE DESIGNATION	WEIGHT POUNDS PER FOOT	NOMINAL DIMENSIONS — ROUND SECTIONS		
		DIAMETER INCHES	CROSS SECTIONAL AREA - SQ. INCHES	PERIMETER INCHES
#2	.167	.250	.05	.786
#3	.376	.375	.11	1.178
#4	.668	.500	.20	1.571
#5	1.043	.625	.31	1.963
#6	1.502	.750	.44	2.356
#7	2.044	.875	.60	2.749
#8	2.670	1.000	.79	3.142
#9	3.400	1.128	1.00	3.544
#10	4.303	1.270	1.27	3.990
#11	5.313	1.410	1.56	4.430

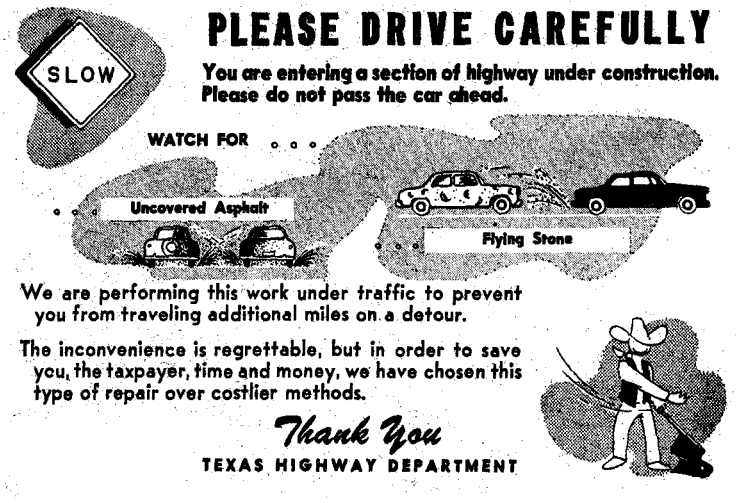
Bar #2 in plain rounds only. These weights have been approved through U. S. Dept. of Commerce Simplified Practice Recommendation 26.

ASTM LARGE REINFORCING BARS

BAR SIZE DESIGNATION	WEIGHT POUNDS PER FOOT	NOMINAL DIMENSIONS — ROUND SECTIONS		
		DIAMETER INCHES	CROSS SECTIONAL AREA - SQ. INCHES	PERIMETER INCHES
#14S	7.65	1.693	2.25	5.32
#18S	13.60	2.257	4.00	7.09

Sizes #14S and #18S are large bars generally not carried in regular stock. These sizes available by arrangement with your supplier.

INSTRUCTIONS TO



The Inspector can obtain these traffic instruction pamphlets from the District Construction Engineer's Office.

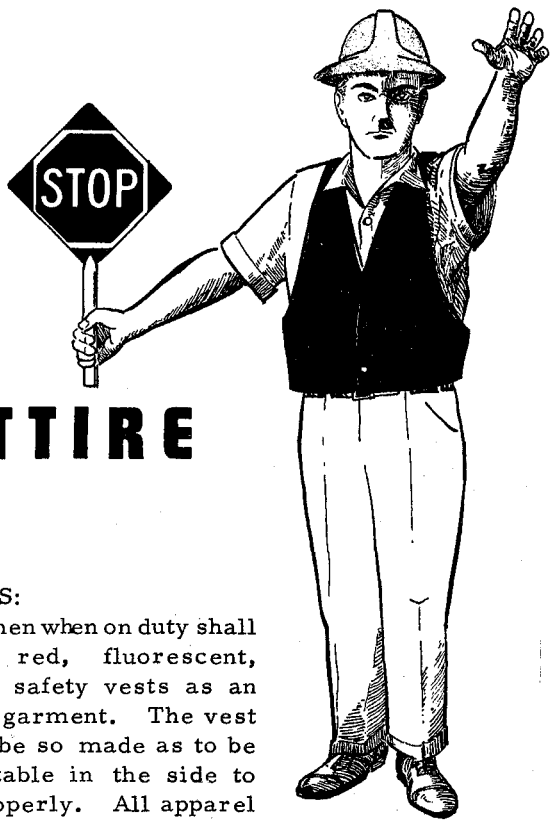
INTRODUCTION

These flagging instructions and procedures govern for employees of the Texas Highway Department engaged in maintenance operations and for contractors performing construction work on the highway systems of the state.

The job of being a flagman is an important one. The lives of workmen and those of the traveling public can be in your hands. This pamphlet has been prepared to help you in understanding your official duties.

It is important that you be courteous in dealing with the traveling public, yet be brief and to the point in your conversation. Do not leave your post unless you are properly relieved.

The hand sign or paddle as illustrated has been adopted as an alternate to the flag and shall be employed in lieu of the flag under conditions as directed by the engineer.



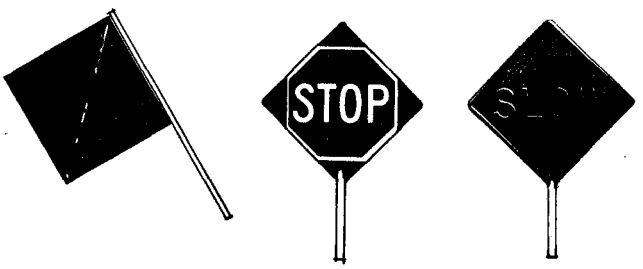
ATTIRE

VESTS:
Flagmen when on duty shall wear red, fluorescent, nylon safety vests as an outer garment. The vest shall be so made as to be adjustable in the side to fit properly. All apparel shall be of a neat appearance. In emergencies and during inclement weather the attire may be altered as approved by the Engineer.

HELMET:
The use of the helmet is optional.

SPECIFICATIONS

Flag - "Stop" and "Slow" Signs

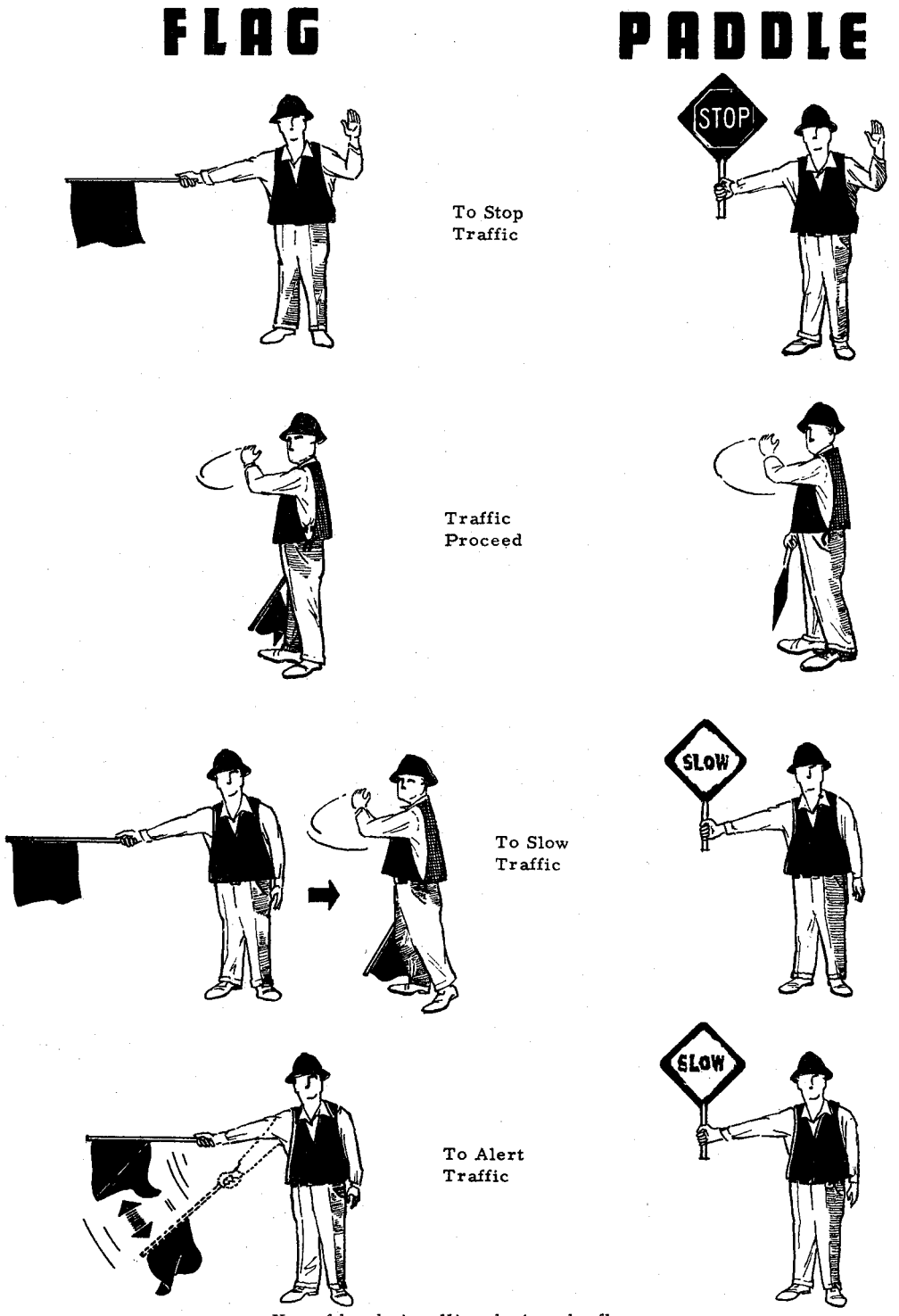


STOP and SLOW, TWO SIDED SIGN

SIZE:	16" x 16"
MATERIAL:	Sign, Aluminum .081 plate, or other comparable light weight material. Staff, 9" min. length thinwall conduit tubing, or other comparable light weight material.
COLOR:	Stop sign, red field, white letters and border; black corners. Slow sign; yellow field, black letters and border.
LETTERS:	5" series C.

FLAG

SIZE:	18" x 18"--32" staff rust proof diagonal stay.
MATERIAL:	Vinyl bonded to nylon fabric material.
COLOR:	Day light fluorescent rocket red.



Use of hand signalling devices by flagman.

Flagging Procedure

GENERAL

You are to remain alert to traffic at all times, and shall not engage in unnecessary conversation with workmen or motorists. In addition, you are forbidden to read magazines, etc., while on duty.

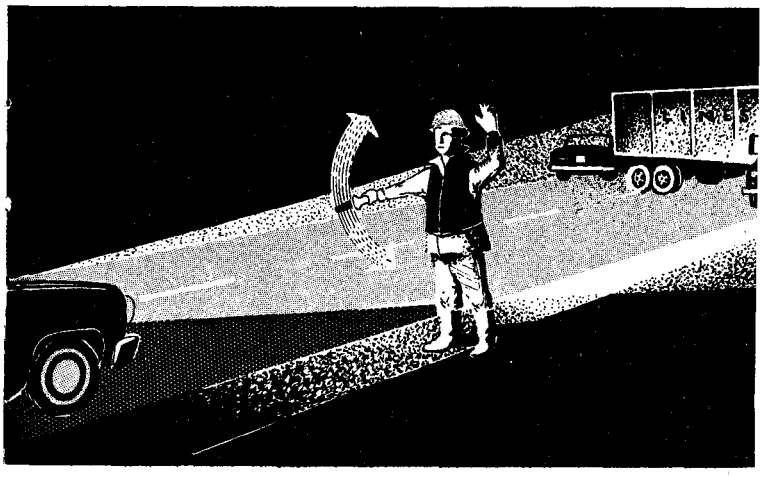
Your are to stand from 200 to 500 feet from the end of the working area where you can see the men working and where you can be seen by oncoming traffic for at least 500 feet.

Stand facing traffic, just outside the lane of traffic so that you are not in danger of being hit. Signals should be definite. Leave no doubt as to the meaning of your instructions. After vehicle stops, inform driver of reason for stop, give instructions to wait or proceed, as the case may be.

Be courteous. Be brief. Information on purpose of stop or delay should be given in as few words as possible, such as "Blasting ahead," "Fresh oil, or whatever it may be.

Never wave your flag either as a signal to stop or proceed.

Night Time Flagging



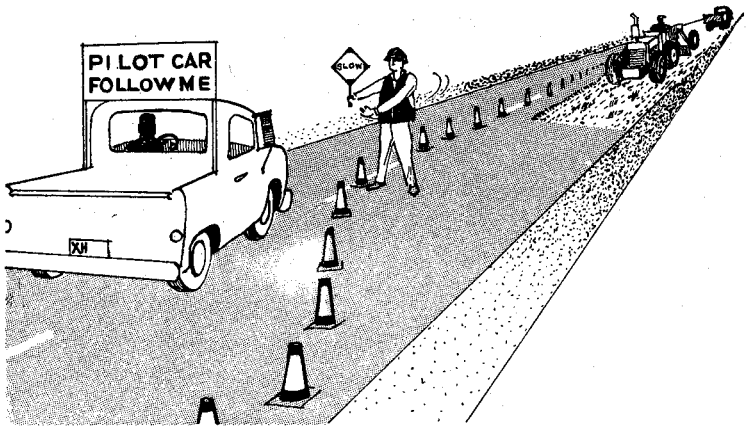
TO STOP A VEHICLE

Stand in position on the shoulder facing traffic at prescribed distance from working area and wave warning light back and forth over the traffic lane. After the first vehicle has been stopped, move to a position near the center line so that your signal may be seen by drivers approaching from the rear. Use minimum of 3 cell flashlight with 8" red traffic wand or other red light of equal visibility.

Give the driver information as to the purpose of the stop or delay in a brief manner.

TO RELEASE STOPPED VEHICLES

The procedure is the same as in daytime. Lower the light and with the free arm, motion the drivers to proceed. Be certain that each driver fully understands the nature of the hazard or emergency ahead.



USE OF PILOT CAR

This procedure for detouring traffic is applicable where the route is unusually hazardous, the flagman at the opposite end of detour is not visible and the route is so involved or frequently altered as to preclude adequate signing.

For contract work its use will be required only when specified in the contract.

The pilot car serves as the lead car in a train of vehicles through the job or detour. The flagman shall stop vehicles in the specified manner as they approach and detain them until the pilot car arrives from the opposite direction; and shall take proper positions to prevent vehicles in the rear from pulling out of line.

CHOICE OF FLAGMEN

Flagmen are responsible for the human safety of travelers as well as for the construction crews and should possess the following qualifications:

Good Physical Condition
Special Emphasis on Sight and Hearing
Average Intelligence
Mental Alertness
Pleasing Personality
Courteous but Firm
Neat Appearance