

Construction Manual for Highway Construction



**American Association of State Highway
and Transportation Officials**

CONSTRUCTION MANUAL For Highway Construction



Developed by the Highway Subcommittee on Construction

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INTRODUCTION TO THE MANUAL

This is the fourth edition of the AASHTO *Construction Manual for Highway Construction*.

This publication was drafted by a Task Force of the Highway Subcommittee on Construction, which has the assistance and cooperation of all of the States. This Manual is designed as a companion to the AASHTO *Guide Specifications for Highway Construction*.

It is the function of highway specifications to set forth those things required of the Contractor, the method of measurement, and the basis of payment, among other things.

On the other hand, the Construction Manual defines the responsibilities of, and instruction to, State highway or transportation department field personnel regarding the proper administration of Contract Provisions.

The publication is intended as a guide and is endorsed to the State highway or transportation departments for their use in preparing their own individual construction manuals. The individual State highway or transportation department may wish to include additional material, directions, or detail to meet their respective needs or requirements. The organizational structure described and the position titles used throughout the text are typical and intended only to simplify the task of writing. Each individual department will make those modifications necessary to accommodate their particular situation.

Terms used in the contract, specifications, and this manual are defined in Section 101 of the AASHTO *Guide Specifications for Highway Construction*.

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DIVISION 100 — ADMINISTRATION, ORGANIZATION AND POLICY

Section 101 — Department Organization

The Department is organized for the purpose of planning, designing, constructing, and maintaining an adequate system of safe highways capable of meeting the traffic needs of the State.

It is organized under the overall supervision of a Chief Administrative Officer who is assisted by various Divisions, each under a responsible administrator.

The Division of Construction is charged with the responsibility for administration of contracts. It assumes responsibility at the time the contract has been awarded in accordance with procedures established by the Department. Its responsibility ceases when the project has been accepted by the Department under established policy.

The District Engineer is the operational representative of the Chief Administrative Officer in each of the various districts of the State. Among the District Engineer's assistants is one assigned to contract administration and designated as District Construction Engineer. The Division of Construction on behalf of the Chief Administrative Officer assists the District Engineer and the assistant in matters of policy, administration, and study of special problems associated with construction.

Operating under the general supervision of the District Construction Engineer is the Project Engineer who is the Department's representative on the project. Personnel will be assigned to the Project Engineer to assist in the staking and inspection of the work.

101.01 — Federal Highway Administration (FHWA)

On a highway project for which all or part of the funding is made available by the Federal Government, the terms of Federal participation are set up in an agreement between the Department and the FHWA. Such an agreement provides that the work is to be done in accordance with predetermined standards embodied in the plans and specifications, in other approved standard drawings, and in any special provisions required by the nature of the project.

Administration of the construction is a function of the Department and its engineers and inspectors. However, engineers from the FHWA will make inspections of these projects at times selected by them.

The relationship between the FHWA and the Department does not directly involve the Contractor. FHWA representatives inspect the project for the purpose of reviewing the Department's procedure requiring the project to be constructed in accordance with the commitments contained in the State-FHWA Agreement. The FHWA's representative is inspecting the State's performance and not the Contractor's. The FHWA has neither responsibility nor authority to deal directly with the Contractor.

Department employees should cooperate with FHWA representatives in their inspections. Their comments should be noted in the diary and matters that require action should be referred promptly to the District Engineer. Their attention should be called to necessary extra work and to any proposed changes. All major changes must be brought to the attention of the FHWA before any of the work is started, and concurrence of the FHWA before the effective date of beginning the work involved in the major change shall be obtained.

101.02 — Project Organization

Each contract is under the direct supervision of a Project Engineer. The Project Engineer is assigned to the project prior to the award of the contract. The assignment is documented by a letter from the District Engineer to the Project Engineer. The Contractor is notified by letter of the name and address of the Project Engineer assigned to the project.

The Project Engineer is responsible for assuring the project is constructed in accordance with the plans, specifications and special provisions, and control of inspection, and proper documentation.

The personnel assigned to assist the Project Engineer will have varying levels of training and experience. The Project Engineer will be responsible for the proper assignment of these personnel.

As the Department's representative, the Project Engineer will have frequent personal contacts with the Contractor, property owners, municipal officers, utility representatives, and the traveling public. The conduct of these associations must be of a character to reflect credit on the Project Engineer and the Department. Further discussion of these contacts will be developed later in this manual.

101.03 — Inter-Department Relations

Harmonious working relations among all employees of the Department are most important. An understanding of the functions and problems of other divisions, as well as the manner in which they fit into the overall organization, will improve the teamwork within the Department. Each employee has a responsibility to promote and foster good relations with fellow employees. An employee is expected to carry out the instructions of the supervisor. Each supervisor's conduct should earn full support and cooperation of all assigned employees. Each employee must know his/her responsibility and must have the authority to handle it.

A major factor in the promotion of good working relations is to keep your supervisor fully informed about all pertinent events that happen on work for which you are responsible. This principle applies equally at all levels of authority.

The Project Engineer should brief the assigned personnel on plans and schedules for the work immediately ahead.

101.04 — Department Equipment

Engineering and Vehicular Equipment

The Project Engineer has the responsibility of requiring personnel to learn and use correct practice for operation of the engineering and vehicular equipment and assuring that the equipment is properly protected and stored when it is not in use.

Section 102 — Bidding Requirements and Conditions

The Specifications establish the conditions under which bids are accepted by the Department and establish the Contractor's personal responsibility for knowledge of job conditions and familiarity with plans and specifications. The Project Engineer should be aware of the contents of this section even though there is no involvement in bidding procedures.

If an inspector or Project Engineer accompanies the contractor during a pre-bid review of the contract limits he must be aware that any statements made regarding conditions, work difficulty or any other comments not included in the Plans and Specifications, have the same effect as contract data and could influence the bid preparation.

Section 103 — Award and Execution of Contract

The Specifications outline the procedures and obligations involved in award of the contract to the successful bidder. The Project Engineer will know that these conditions have been met when an executed copy of the contract or an official notice that the Contractor may proceed with the work is received.

The Project Engineer should not allow work to start prior to receipt of the notice to proceed.

Section 104 — Scope of Work

The Specifications establish conditions under which alterations may be made and establish the Contractor's and the Department's obligations with respect to maintenance of traffic. Be alert to special problems involved in traffic handling and make recommendations to the District Engineer when changes appear justified.

Section 105 — Control of Work

105.01 — Responsibilities of the Project Engineer

Under the direction of the District Engineer and the District Construction Engineer, the Project Engineer shall have immediate charge of one or more

construction projects. The Project Engineer will be held responsible for the activities and efficiency of subordinates and for the satisfactory administration and monitoring of the work.

When it is the Project Engineer's responsibility to stake the projects he must see that the Contractor is informed of the meaning of all stakes. If the Contractor is responsible for all or part of the stakeout, the Project Engineer shall monitor and assure thorough spot checks that lines, grades, and elevations are in conformance with plans and specifications. It is also the Project Engineer's responsibility to know and to document the fact that all materials used meet controlling specifications and that the finished project meets alignment, grade, quality, and quantity requirements of the contract. Authority to alter plans shall be limited to minor field changes. If changes in specifications or major alterations of plans appear necessary, conditions should be investigated and recommendations promptly submitted to the District Construction Engineer.

As the Department's representative, the Project Engineer must assure that the project meets all contract requirements. The Project Engineer should expect to obtain no more than what is specified or accept any less than the contract requirements. The Project Engineer shall in no way attempt to supervise work for the Contractor.

The Project Engineer will be held responsible for the accuracy of all notes and reporting procedures.

Each Project Engineer shall keep a diary for each contract in which matters of importance regarding the project shall be entered daily.

The Project Engineer is not usually expected to function as the sole representative of the State but needs various assistants, inspectors, and others to watch closely the different phases of work for proper compliance and for keeping records in order.

To have an efficient organization, the line of authority must be well-defined. Each employee should be delegated authority in line with administrative responsibilities. The Engineer must check to see that delegated duties are being properly discharged.

It is good policy to delegate the responsibility for inspection supervision on the project to one or more experienced inspectors. As Chief Inspectors, these persons must have the authority to direct and coordinate the activities of all inspection personnel and make day-to-day decisions involving engineering judgments of an immediate nature.

Although the Project Engineer does have a qualified inspector on the project to observe the work, frequent checks should be made of the inspection operations and reports, noting whether plans and specifications are being properly interpreted and applied. The Project Engineer should also be alert to any possible difficulties which could arise either in the construction or in the final function of the project and try to make correction before the situation grows worse.

105.02 — Duties and Authority of Inspectors

Competent inspection is one of the most important elements entering into any construction work.

The Project Engineer may serve as the chief inspector or may delegate this assignment to one or more assistants. If the Project Engineer serves as the chief inspector, a major portion of time shall be spent in the field on the project.

If faulty material or poor workmanship is incorporated into the construction, the work shall be removed or corrected. Proper inspection requires good judgment, diplomacy, common sense, and a thorough knowledge of the work, plans, and specifications.

It shall be the duty and authority of all inspectors on construction projects to enforce the specifications. If differences in interpretation arise with the Contractor, the matter shall be decided by the Project Engineer.

It is not good practice for the Project Engineer to use the same inspectors on successive jobs with the same Contractor. Certain personal relations and precedents can be established which may not be in the public interest.

The Inspector shall check everything carefully to see that it conforms with the specifications. The Inspector shall have the authority to reject materials and to suspend any work which does not conform with the specifications.

When the methods of procedure in any operation are prescribed in the specifications, they shall be rigidly enforced. The Inspector shall always bear in mind that the management of the work is the Contractor's business; however, if any methods are employed which the Inspector has reason to believe will impair the quality of the finished job, the Contractor shall be advised accordingly and the Project Engineer notified immediately. The inspector shall in no way attempt to supervise work for the Contractor.

The Inspector shall not be authorized to revoke, alter, enlarge, relax, or release any requirements of the plans or specifications, nor to approve or accept any portion of the work or to issue any instructions contrary to the plans or specifications. If conditions arise which seem to render it impractical to enforce the specifications, the Inspector should contact the Project Engineer at once.

All Inspectors on construction projects shall work under and report directly to the Project Engineer or to a delegated Chief Inspector.

A set of plans and a copy of the specifications shall always be available for reference.

The Inspectors shall keep a diary in which matters of importance shall be entered daily.

It shall be the duty of all Inspectors to study the plans and specifications of the job to which they have been assigned and they must be fully conversant with all the details of the work to be done. If anything is found which is not fully understood, the Inspector shall consult with the Project Engineer.

105.03 — Preconstruction Conference

A. As soon as possible after the project has been officially awarded, the Project Engineer shall arrange a conference with the Contractor and interested parties for the purpose of reviewing construction details, proposed schedules, etc. Prior to this meeting, the Project Engineer should have studied the Plans and Special Provisions and made a field inspection of the project in order to be well-informed as to the requirements and existing conditions.

B. Among those who should be invited to the conference are the following:

1. A representative of the District Office
2. Principal Assistants of the Project Engineer
3. The Contractor and principal personnel
4. The Representatives of involved utilities
5. Municipal and/or County Engineer, if involved
6. FHWA representative, if involved
7. Any other interested parties involved in the contract

C. Among the subjects to be discussed as applicable on the project are the following:

1. Project Engineer's general overview of the plan concept, specifications, traffic control procedures, and special problem areas.
2. Contractor's proposed operating schedules, computation of work day charges, execution of working day statements, time schedule, and completion date requirements, etc.
3. Work to be sublet, stipulations to be included in the subcontract agreements, Engineer-Contractor relations and responsibility towards subcontractors, authorized representatives, etc.
4. Labor Provisions, necessary posters, Engineer's inspection and investigating procedures with regard to labor requirements. The Contractor and the contracting authority shall be thoroughly familiar with the applicable EEO specifications and both will diligently pursue the requirements as intended.
5. Legal relations and responsibilities; cooperation with utility owners, the public and other Contractors; licenses and permits in connection with execution of the work, local ordinances, etc.
6. Special requirements and unusual conditions, conflicts and problems anticipated, clarification of construction details and specification requirements, procedures for assessment of time, etc.
7. Inspection procedures, notification to the Engineer of material orders, furnishing samples, and the time and place of testing and accepting materials, locating and equipping the field laboratories, storage and use of materials, etc.
8. Thorough discussion of plan concept for traffic control, maintenance thereof, and responsibilities of parties involved.
9. Haul road requirements; location and scheduling of bypass construction, crossroad closures and access facilities; general responsibilities with regard to traffic and public convenience, etc.

10. Employee and public safety, sanitary provisions, etc.
11. Delegation of authority by the Contractor and the Engineer, lines of communication, equipment, and personnel, etc.
12. A list of suppliers should be furnished the Engineer indicating where the Contractor proposes to obtain all materials for the project.

D. The Project Engineer is also responsible for the conference agenda, for conducting the discussions, and for making a written record of the conference discussions. The written record is prepared in letter form to the District Engineer with copies to all participants and to the project file.

E. The preconstruction conference, if properly conducted, can be of material aid in getting the project properly started. Participants should come prepared to make worthwhile contributions to the conference and improvement of general relations. As moderator, the Project Engineer should attempt to keep within the scheduled agenda once the conference has begun and discourage any extraneous or digressive commentary without becoming rude.

Section 106 — Control of Material

The Specifications establish the respective obligations of Contractor and Department concerning materials to be used.

Section 107 — Legal Relations and Responsibility to Public

107.01 — Integrity

Absolute integrity on the part of all Department personnel is essential if public confidence in the Department is to be maintained. Integrity embraces everything that touches a person's ability to do his/her job: resourcefulness, decisiveness, adaptability, stability, forcefulness and moral courage.

Department personnel should not engage in outside work unless the matter is cleared previously by the District Engineer. Project personnel are prohibited from doing engineering work for, and receiving compensation from, the Contractor.

No one in the Department whose job involves negotiating, approving or administering any contract or transaction on behalf of the Department shall have any financial or personal interest, direct or indirect, in the case.

If any Department employee has any interest in real property to be acquired for highway purposes, full documentation of the facts and circumstances of the interest shall be made. The employee shall not participate in acquisition of the property as agent of the State.

No employee shall use Department equipment for personal business or shall seek to acquire Department property which is offered for sale without express written approval of the Chief Administrative Officer.

The solicitation or acceptance of a cash loan by a Department employee from any Contractor doing business with the Department, or from any of the Contractor's representatives, is another example of serious conflict of interest.

Any case of dishonesty or conflict of interest will result in the immediate dismissal of the person or persons involved.

107.02 — Hatch Act

By virtue of the use of Federal-Aid funds for highway construction by the Department, employees are subject to provisions of the Hatch Act, a Federal Law concerning political activity.

TITLE 5, UNITED STATES CODE

CHAPTER 15.—POLITICAL ACTIVITY OF CERTAIN STATE AND LOCAL EMPLOYEES

Section 1501. Definitions. For the purpose of this chapter [§§ 1501-1508 of this title]—

- (1) “State” means a State or territory or possession of the United States;
- (2) “State or local agency” means the executive branch of a State, municipality, or other political subdivision of a State, or an agency or department thereof; and
- (3) “Federal agency” means an executive agency or other agency of the United States, but does not include a member bank of the Federal Reserve System;
- (4) “State or local officer or employee” means any individual employed by a State or local agency whose principal employment is in connection with an activity which is financed in whole or in part by loans or grants made by the United States or Federal agency, but does not include—
 - (A) an individual who exercises no functions in connection with that activity; or
 - (B) an individual employed by an educational or research institution, establishment, agency, or system which is supported in whole or in part by a State or political subdivision thereof, or by a recognized religious, philanthropic, or cultural organization; and

Pub.L. 89-554, Sept. 6, 1966, 80 Stat. 403; Pub.L. 93-443, Title IV, § 401(c), Oct. 15, 1974, 88 Stat. 1290.

Section 1502. Influencing elections—Taking part in political campaigns—Prohibitions—Exceptions.— (a) A State or local officer or employee may not—

- (1) use his official authority or influence for the purpose of interfering with or affecting the result of an election or a nomination for office;
- (2) directly or indirectly coerce, attempt to coerce, command, or advise a State or local officer or employee to pay, lend, or contribute anything of value to a party, committee organization, agency, or person for political purposes; or

- (3) be a candidate for elective office.
- (b) A State or local officer or employee retains the right to vote as he chooses and to express his opinions on political subjects and candidates.
- (c) Subsection (a)(3) of this section does not apply to—
 - (1) the Governor or Lieutenant Governor of a State or an individual authorized by law to act as Governor;
 - (2) the mayor of a city;
 - (3) a duly elected head of an executive department of a State or municipality who is not classified under a State or municipal merit or civil-service system; or
 - (4) an individual holding elective office. (Sept. 6, 1966, Pub.L. 89-554, 80 Stat. 404; Pub.L. 93-443, Title IV, § 401(a), October 15, 1974, 88 Stat. 1290.

Section 1053. Nonpartisan candidacies permitted.—Section 1502.(a)(3) of this title does not prohibit any State or local officer or employee from being a candidate in any election if none of the candidates is to be nominated or elected at that election as representing a party any of whose candidates for presidential elector received votes in the last preceding election at which presidential electors were selected. Pub.L. 89-554, Sept. 6, 1966, 80 Stat. 404; Pub.L. 93-443, Title IV, § 401(b)(1), Oct. 15, 1974, 88 Stat. 1290.

107.03 — Public Relations

A good Department-contractor relationship can be maintained if these suggestions are considered:

- a. Treat the Contractor fairly and impartially
- b. Study the Contractor's viewpoint and be friendly but impersonal. Do not put yourself under any obligations.
- c. Do not discuss with outsiders the Contractor's methods of handling work. Make your suggestions to the Contractor only.
- d. Be ready to advise the Contractor when requested, but do not make snap decisions.
- e. Issue all orders only to the Contractor or authorized representative.
- f. Write and retain copies of specific orders given.
- g. Discuss the Contractor's schedule. Coordinate your staking and inspection with the schedule.
- h. Do not accept gratuities from the Contractor; do not be threatened or intimidated. Notify your supervisor of any trouble.

Courtesy and consideration are necessary in all contacts with the public as the entire Department is judged by the actions of its employees. Although an employee may not obligate the Department to any course of action or any expense without due authorization, it is necessary to always be as tactful and helpful as conditions permit. The media of communication with the public are many: The newspaper, the radio,

television, service clubs, Chambers of Commerce, city and county officials, and direct contact with individuals.

If conditions are observed that might develop into public controversy and misunderstandings, this information should be transmitted through channels so that early news releases can inform the public of the facts. It is important that information given to the public not be slanted or evasive.

In the case of contacts with newspapers, radio, or television, the Project Engineer should furnish information only on matters for which he/she has personal responsibility and in which he/she is well informed. Questions concerning policy or programs should be referred to the District Engineer for consideration.

In dealing with residents along the highway, the Project Engineer must endeavor to maintain friendly relations. Frequently requests will be made on which the Project Engineer will not have the authority to act. In such cases the Project Engineer must make every effort not to offend people making these requests. The Project Engineer should not refer the residents to his/her supervisor. However, the residents should be advised that the matter will be discussed with the supervisor. Subsequently, the Project Engineer should personally inform interested residents of the results of the discussion.

107.04 — Labor Regulations

As part of the contract, it is required that all regulations with regard to labor be properly followed. Requirements of the Contractor and the State regarding the contract labor provisions are well covered in the proposal and the referenced regulations. A working knowledge of these regulations is expected of the State personnel involved to assure compliance by the Contractor.

Also included in the contract provisions are various requirements that relate to equal employment opportunity.

The following subsection will provide further explanation of regulations involving the above.

107.05 — Required Notices and Posters

The proposals for highway construction contracts state that certain information must be displayed in a conspicuous place on the project so that interested persons may be readily aware of their contents. This information is presented on the following:

A. *Fraud Poster.* A "Fraud Poster" required by Section 1020, Title 18, United States Code, must be displayed during the course of the work. It points out the consequences of impropriety on the part of any employee working on the project. For the purpose of advising people where they can report a violation, should any arise, the addresses of the State Highway or Transportation Department and the Federal Highway Administration are shown on the form.

B. Wage Rate Information. The schedule of wage rates, as shown in the proposal and as subsequently modified or amended, shall be posted where all the workers can view it. If more than one wage area is listed, it would be well to clearly define the wage area applicable to the project. For the purpose of advising the employees where they can report a wage violation, should any arise, the name and address of the State Highway or Transportation Department representative is shown on the form.

C. Equal Opportunity Posters. The poster titled "Equal Employment Opportunity is the Law" shall be posted on the project where all the workers can view it. Posters or Notices relative to the Company EEO Officer, etc., should also be posted on the job site.

107.06 — Enforcement of Labor Provisions

In order to properly fulfill the contract, the Contractor must conform to the labor provisions included therein. It is thus the Project Engineer's responsibility to be certain that the requirements regarding labor are properly carried out. Checks and documentation of the labor regulations take a variety of forms as follows:

A. Posters. The required posters and wage rates must be posted on the project when work is in progress.

B. Interviews. The Project Engineer and his/her staff should conduct random on-the-job interviews with several employees of the Contractor at appropriate intervals to determine the actual wages being paid and whether the employee is properly classified in the work being done. This information is reported on proper forms with copies going to the District or Central Offices. Any wage discrepancies should be brought to the attention of the Contractor without delay.

C. Statement of Compliance. The Contractor is required to submit a weekly Statement of Compliance on all Federal-Aid Highway contracts containing a wage rate decision. This affidavit relates to Antikickback regulations and is required throughout the course of the work.

D. Weekly Certified Payrolls. The Contractor must, on all Federal-Aid Highway contracts containing a wage rate decision, furnish each week a statement to the Project Engineer with respect to the wages paid each of its employees (including apprentices and trainees) engaged on the work during the preceding weekly payroll period. The Statement of Compliance as described above must accompany the weekly statement.

Prior to forwarding of the payroll and Statement of Compliance to either the District Office or the Central Office, the Project Engineer or his staff should examine

the payroll(s) for non-conformance with the wage provisions of the contract. A checklist to use in this determination of compliance is as follows:

1. Entries to be checked on every payroll:
 - a. Work classification, title, code number for each employee;
 - b. Hourly wage rates for each employee, including fringe benefits, if applicable;
 - c. Are daily and weekly total hours shown?
 - d. Is the certification signed?
 - e. Are deductions itemized?
 - f. Are all deductions approved?

Approved deductions are shown under Title 29, Subtitle A, Part 3.5 of the Federal Regulations.

2. At least the first two payrolls submitted by each Contractor or Subcontractor on each project should be fully checked with respect to:
 - a. Arithmetical accuracy. In cases where the employer utilizes a computer printout type of payroll, it will not be necessary to check the extensions;
 - b. Overtime computations;
 - c. Wage rates verified with those shown in the applicable contract;
 - d. Employee's full name, address, and social security number being shown on the payroll where the name first appears.

If full compliance is shown on the initial payrolls, the steps listed above can be performed on a sampling basis on subsequent payrolls, at the Project Engineer's discretion.

The project interview forms (refer to No. B above) must be cross-checked against the rates shown on the weekly payrolls.

E. Corrections. If it is found that the payroll has discrepancies and clerical errors, such errors should be called to the attention of the Contractor(s), and corrections should be made promptly. The original submitted payroll should not, under any circumstance, be returned to the Contractor. Corrections are to be made by supplemental payrolls prepared and submitted in the same manner as the original. It is necessary that a completely revised payroll transcript be submitted. The payrolls are to be submitted to the Project Engineer within 7 days following the end of the pay period. The payroll period usually ends on Friday or Saturday, and the Contractor should thus submit payrolls to the Project Engineer not later than the following Friday for checking. The payroll(s) should be transmitted as soon as possible after adequate checking has been done.

Delay in prompt submission of the required payrolls by the Contractor or Subcontractor may cause delay in the payment of monthly estimates to the Contractor.

F. Employment Records. Terms of the contract require that the Contractor's employment records be available during the progress of the work. The Project Engineer should make spotchecks of these records to establish:

1. Whether the wages being paid to the laborers and mechanics are not less than required in the contract;
2. If the work being performed by any specific class of employees, including helpers or apprentices, conforms to the classification set forth in the contract for the wage they are being paid;
3. Whether the age classification is correct if there appears to be a disproportionate number of lower paid help (laborers, helpers, apprentices) indicating avoidance of the minimum wage rules.

G. Violations. The Project Engineer is to investigate any complaints of violation of the Labor Standards. A report of each investigation and action taken is to be prepared and submitted to the District Engineer, and/or appropriate person in the Central Office. The provisions indicate the disposition in case there is substantial evidence that the violations with regard to payrolls are willful or if restitution by the Contractor or Subcontractor is not made. Deliberate violation of the labor requirements regarding wages is a serious matter and cannot be tolerated.

H. Determining Wage Classification. In checking payroll and hearing complaints with regard to wage difficulties, the Project Engineer will be confronted with the problem of determining the actual classification in which an employee is working. Seldom is the solution clear-cut, nor has the Project Engineer authority to determine definitely the classification in which the Contractor's employee fits. The Project Engineer does not have information as to the duties of a Carpenter's helper as against those of a Carpenter, as an example, so that the final analysis in case of wage dispute must be resolved by others.

When a wage dispute arises, the Project Engineer should obtain and assemble all the information available, and consult the District Office, and/or the Central Office concerning the problem.

I. Equal Opportunity Regulations. Executive Orders 11141, 11246, and 11375 prohibit discrimination in employment because of race, color, religion, sex, age, or national origin.

More specifically, the contract provisions address themselves to the FHPM 6-4-1-2. The requirements set forth in this Order constitute the specific affirmative action requirements for project activities under the contract and supplement the equal employment opportunity requirements set forth in the required Contract Provisions (Form PR-1273 or 1316 as appropriate).

In some areas, the Contract Provisions may, in lieu of FHPM 6-4-1-2, carry specific contract provisions that pertain to hometown plans. These type of provisions will contain goals and timetables of minority manpower utilization required of the Contractor and Subcontractors.

J. Training. Depending on certain circumstances, the Contract Provisions may contain the requirements of the FHPM 6-4-1-2. The purpose of this Order is to provide on-the-job training, with emphasis directed toward disadvantaged and minority groups, in the skilled trades used by the highway industry.

There are two types of training programs that may be used to fulfill the training obligation. One type is the Union Apprenticeship Program which has been approved by the Department of Labor, while the second type is referred to as an On-the-Job Training Program. The On-the-Job Training Program is designed by the Contractor and approved by the Department.

107.07 — Safety Precautions

A. Personnel. Many hazards exist on a construction project which require all personnel to be constantly alert if injury is to be avoided. Appropriate safety requirements shall be an emphasis area on all projects. Some special precautions which can be taken to improve safety in hazardous situations are:

1. Wear hard hats around overhead operations such as bridges or batch plants.
2. Wear safety vests while working in traffic.
3. Post signs and flaggers when work must be done on existing highways.
4. Provide adequate illumination for night work.
5. Provide for a shoring of trenches that may be a hazard to workers.

Option:

6. Become familiar with basic requirements of the safety and health regulations for construction as established by the U.S. Department of Labor as they apply to State highway activities. This information can be found in the "Informational Guide on Occupational Safety on Highway Construction Projects."

B. Traveling Public. The traveling public should be protected from danger due to construction operations. Adequate barricades and signs should be placed where they are most effective. This should be done in accordance with Part VI of the Manual on Uniform Traffic Control Devices. If needed, flaggers should be provided. There should be no doubt when roads are completely closed and where detours are located. When signs and barricades have served their purpose, they should be removed. (See Section 618, Traffic Control)

Section 108 — Prosecution and Progress

The Specifications establish the Contractor's responsibility to furnish adequate forces for meeting specified project schedules as well as quality.

Unsatisfactory progress should be directed to the Contractor's attention in writing by the Project Engineer. If the Contractor fails to act in keeping with the intent of this section the matter should be directed immediately to the attention of the District Construction Engineer.

All time assessments must be supported by adequate diary information or other supporting documentation. Review of project history often must rely heavily on diary entries.

Section 109 — Measurement and Payment

109.01 — Force Account

All extra work, to be performed by the Contractor on a Force Account basis, must be approved before starting.

The approval request shall include a brief but complete description of the work to be performed, a definite location by station numbers and an estimate of cost, broken down to show costs for labor, materials, and equipment. The estimate should be as accurate as possible based on available information.

A statement shall set forth the reasons for the extra work. When necessary, a detailed explanation should be included in the letter of transmittal.

Force account work will be paid for in accordance with the contract provisions. The Project Engineer will keep accurate daily records of the work as it is done. This record will be submitted in duplicate to the Contractor's representative each day for signature. The Project Engineer and the Contractor will each receive one signed copy.

All bills for materials used must be properly supported by copies of the invoices for the materials received on the job. Freight costs are considered to be part of the cost of materials used on force account work.

All bills for labor on force account work shall show the name of the employee, the job classification, the rate of pay actually paid by the Contractor, the dates on which the work was performed, and the number of hours worked by each employee each day on force account.

All bills for equipment used on force account shall show the number of hours each piece of equipment worked each day, the dates on which the work was performed, the rate of pay for each piece of equipment, and sufficient description of the equipment so that the rate of pay can be checked. It is suggested that the bill show the manufacturer's name, model number, and size rating (weight, horsepower, or cubic yards) for the equipment. The rate of pay for equipment shall conform to the rates previously established by the Department or agreed upon in writing prior to start of the work.

At the conclusion of the work, the entire force account charge shall be summarized on forms provided for that purpose. The Contractor shall furnish invoices, payrolls, freight bills, etc., to support the charges.

109.02 — Project Diaries

The Project Engineer is required to keep a daily diary on each project or combination of projects. Each Inspector assigned responsibility for a major operations shall prepare a separate daily diary. The Project Engineer's diary need not

repeat the Inspector's detailed entries but may contain only general information about these operations.

Make all entries directly into a bound book. Daily entries must be signed by the person making such entries.

The diary should contain a day-by-day record of all significant items relating to the project. Since it may become important evidence in the decision of claims or the establishment of responsibilities or liabilities, it is essential that the notes be complete.

A partial list of items to be noted in a diary are:

- a. Weather
- b. Orders given the Contractor
- c. Important discussions with Contractor or representative, such as disputes
- d. Official visitors and inspections
- e. Work or materials rejected and reasons
- f. Time of shutting down or resuming work and explanations
- g. Work done by Contractor's forces during day
- h. General purpose of work
- i. Account of any time spent by Contractor's personnel or equipment on disputable items or work
- j. Length and cause of any delay
- k. Arrival and departure of major equipment and work crews
- l. Record of telegrams and telephone calls
- m. Unusual conditions, if any, such as high water, bridge failures, slides, etc.
- n. Progress of stakeouts and surveys made
- o. When appropriate, daily surveillance of traffic control as to effectiveness

At the completion of the project all diaries shall be filed as part of the permanent record.

109.03 — Field Notes

Field notes are the written record of pertinent information, measurements, and observations on the project. They should be kept according to uniform practices and conform as a minimum to the following general requirements.

1. **Neatness.** Use a sharp pencil of at least 3-H hardness. Avoid crowding. Keep the book as clean as possible.
2. **Legibility.** Use standard symbols and abbreviations to keep notes compact. Use plain lettering to avoid confusion.
3. **Clarity.** Plan work ahead so that data can be clearly indicated. Do not make ambiguous statements. Line up descriptions and make sketches for clarity. Record data in a consistent way. Assume that the person who will use your notes has no familiarity with the work.
4. **Completeness.** Show all pertinent measurements and observations. Use a degree of accuracy consistent with the operation. If in doubt about the need for the data, record it. Review data before leaving the field.

All entries must include:

- a. The date
- b. Weather conditions
- c. Names of all persons in the party
- d. Signature of person making the entries

The title page must be completed as the book or project is started. The book must be adequately indexed and cross-referenced as to contents.

- 5. **Permanence.** All entries should be made directly into bound books. At completion of the project they should be filed as part of the permanent record in keeping with Department policy.
- 6. **Honesty.** Record exactly what was done at the time it was done rather than depending on memory at a later time. Never erase. If an item is incorrectly entered, draw a line through the item and insert the corrected value immediately above. When it is necessary to add data to notes previously prepared, the additional item should be dated and initialed. Always enter notes directly into the record.
- 7. **Self-Checking.** Notes should be so kept that the work can be checked without returning to the field. Any person familiar with the project should be able to verify the accuracy of the work from the information contained in the notes. Use positive controls.
- 8. **Pride.** Strive to turn in a set of notes of which you can be proud. These records often create an impression on others concerning your ability and integrity.

109.04 — Other Records

The Project Engineer will require documents to substantiate acceptance of materials and work items for both quality and quantity.

Basis of acceptance for quality, the method of measurement and the basis of payment are established by specifications.

Documentary evidence on which to base payment shall be in accord with policies established by the Department. These must provide evidence of positive control.

A tabulation confining the policies is desirable. Such a tabulation should show as a minimum the Standard Contract Item, how pay quantities are determined, and what documentation is necessary. A typical example is shown herein.

Other records which are the Project Engineer's responsibility include recurring reports such as:

- a. Progress reports
- b. Payment estimates
- c. Personal reports

Payment estimates must be supported by documentary evidence that work items allowed have actually been performed. Such evidence may take the form of scale tickets, diary entries, material receipts, etc.

For example, earthwork quantities might be supported by load count entries in the Inspector's diary or by diary entries which show limiting stations of completed balances.

Weight or volume tickets provide a sound basis on which to allow payment for items measured in this manner. Examples of some documentation requirements for pay items are shown on succeeding pages.

The Project Engineer must be sure that all items allowed for payment have been properly inspected and approved.

Whenever payment is allowed based on an estimate, the basis of the estimate must be well defined to assure that over payment to the contractor is avoided.

Avoid overpayment. Where work remains to be done, such as filling the holes in concrete, the amount allowed for the appropriate pay item should be reduced by the amount estimated as necessary to cover the remaining work. Full allowance should be made for completed items.

All pay estimates must be signed by the Project Engineer as evidence of his approval for payment of the quantities shown.

Computers are increasingly being used for the maintenance of these and other project records and for estimate preparation. In such cases, protected backup files and computer security is extremely important.

109.05 — Retention of Records

At completion of a project all data shall be placed in the district files for possible future reference. Items to be retained shall include:

1. A complete set of final (as built) plans. This will include location sketches, typical sections, tabulation of quantities, plan and profile, bridge plans, special layouts, and a complete set of original contract plans.
2. Project contract, construction correspondence, and payment estimates.
3. All Project Engineer progress reports.
4. Weight or volume delivery tickets for materials. (Such as aggregate base, asphaltic concrete, etc.)
5. Project Engineer and Inspector Diaries.
6. Construction field notebooks such as alignment, original and final cross sections, structure staking, etc.
7. Any other records pertaining to pay quantities.
8. All material test reports.

Five years after completion of the project, the routine correspondence and all except the final estimate and final change order may be discarded provided there is no conflict with Federal regulations. On Federal-Aid projects no records should be discarded, less than three years from the date of the final payment of Federal funds. See Part 17, Title 23, Code of Federal Regulations. At the same time the records mentioned above are discarded, all other records noted under items 3, 4, 7, and 8 above may also be discarded.

Important correspondence and all other records shall be retained indefinitely.

Standard Contract Items	Unit	Documentation	Determination of Pay Quantities
Clearing Swamp Clearing Grubbing Deep Grubbing	Acres or sta.	Stationing—Dimension and computations re- corded in Miscellaneous Removal Book-Inspector's Daily Report or Inspec- tor's Daily Record of Contract Removal Items signed and dated.	Measured in horizontal area bounded by lines 10 feet outside the line of tree trunks of the trees cut or stumps grubbed or measured along the road centerline in stations of 100 feet. Stay within the right-of-way. When clear- ing or grubbing occurs only on one side of the road, it is measured on the basis of one-half the distance along the road centerline.
Earth Excavation Subgrade Undercutting Earth Stripping	Cubic yards	Field books containing the cross section notes, the plotted cross sections, and any notes and com- putations made during the construction opera- tion. All notes to be checked, signed, and dated.	Measured in cyds. of volume in its original position, computed by the method of average end areas, except where this method is not feasible. In the case of hydraulic fills, or other cases where it is not feasible to

Standard Contract Items	Unit	Documentation	Determination of Pay Quantities
Precast Concrete Piles Furnished	Lin. feet	Foundation Piling Record Form signed by Resident Engineer.	measure excavation in its original position, the volume will be measured as compacted embankment computed on the basis of the required section. Will be ordered pile length in lineal feet in accordance with the lengths determined by the Engineer to be furnished.
Pipe Culverts (Concrete or Vitrified Clay)	Lin. feet	Location, number of pieces, commercial length reported on Inspector's Daily Report. Report of shipment from tested stock of size and class need, and sealers for joints. Notice of Acceptance by Office of Testing and Research.	Measured by length in lineal feet, which shall be determined by multiplying the number of units in the structure by their commercial length.

Section 110 — Archeological and Paleontological Salvage

It is in the public interest to preserve for public use historical and prehistoric objects such as Indian ruins, sites, buildings, artifacts, fossils, or other objects of antiquity that may have significance from a historical or scientific standpoint. On a construction project when it appears that significant historic, or prehistoric, objects have been or are about to be encountered, the Project Engineer should immediately take steps to preserve them and should notify the District Engineer.

The District Engineer, in turn, should advise the appropriate authorities within the State of the facts and permit them to inspect the site for the purpose of determining the advisability of salvaging the objects.

Section 150 — Field Work and Staking

150.01 — General

A very important duty of field forces on construction work is proper and accurate staking of the project. Time is important in all contracts; likewise, the staking and handling of related field work is important because the progress of Contractor's forces is dependent upon adequate and proper staking. The contracting authority may require the Contractor to provide the necessary construction staking. This may be incidental or bid as lump sum in the contract.

Cooperation with Contractor. When a project is assigned, the Contractor should be contacted immediately to learn the plan of procedure. This should enable staking to start well in advance of his operations. If the contract provides for the Contractor to furnish the stakes, arrangements should be made for immediate delivery.

It is essential that the Contractor's personnel understand the method used in staking and the markings on the stakes. The work in the field should be discussed with the Contractor's representative, carefully explaining the staking. If there is any doubt of a full understanding, a written explanation should be given the Contractor. A written record leaves little doubt and may prove to be a valuable record in the event the work is not built to proper lines and grades as staked in the field.

Checking Plans. Before staking is started, a preliminary check of the plans for the project should be made in the field for apparent omissions or corrections. A careful check should be made for proper location of drainage structures. Observe drainage areas to make certain structures are adequate.

Entrance locations should be checked and notations made of any additional requirements necessary to serve new properties which are not shown on the plans but which were in existence at the time the right-of-way was secured. No additions, deletions, or revisions should be made to any entrances to condemned property or to

controlled access right-of-way without the approval of the District Construction Engineer.

150.02 — Organizing Staking Parties

A. *General.* The construction staking party has four main purposes:

1. Reestablish sufficient horizontal and vertical control points to assure convenient and accurate staking during construction and verify the existing horizontal and vertical control for accuracy.
2. Provide the Contractor with sufficient stakes of proper alignment and grade so the job can be constructed according to plans.
3. Take necessary measurements so that quantities can be accurately computed for payment.
4. Perpetuate the horizontal and vertical control points after completion of the project.

The Project Engineer should organize the staking party according to conditions and available personnel rather than keeping a set number on each party regardless of the type of work.

B. *Field Notebooks.* All field notes should be recorded in standard field notebooks. Loose-leaf books are not to be used for permanent records or for temporary notes to be copied later into the permanent record. Each notebook should be identified on the front cover as to subject (alignment, cross sections, etc.), project, route, and county. This information should be repeated on the first page of the book along with the Project Engineer's name and address to assure the book's return in case of loss. The next page should carry an index of the book's contents. The date, weather, and party personnel must be recorded in the upper right-hand corner of the first right-hand page of each day's work.

On larger projects, separate notebooks should be used for each operation; such as, alignment, cross sections, structures, etc. On smaller projects, some of the separate operations may be combined in a single notebook. Quite often on supplementary construction, the preconstruction cross sections, bench levels, slope stakes, and final cross sections may be combined in one field notebook. This is not only economical but eliminates filing notebooks at the District Office with only a few pages used.

Notes should be legible and recorded in such a manner that other engineers may readily interpret any part. Erasures should not be made in field books. If it becomes necessary to revise or delete any information, it should be crossed through and an explanation made. Good complete notebooks are valuable project records and should always be kept clean and dry, and stored in a fireproof safe.

C. *Survey Equipment.* When organizing the staking parties, considerable thought should be given to the survey equipment to be supplied to the parties. The equipment may consist of electronic distance and angular measuring instruments,

transits, theodolites and levels. The most important equipment is the transit and level; particularly the transit, for in an emergency it can also be used for leveling work. Three types of tapes are used: the 100-foot steel tape or chain, the 50-foot steel tape generally graduated in inches for use on structure work, and the 50-foot metallic tape graduated in tenths for use in measuring earthwork. Other small tools such as range poles, level rods, plumb bobs, sledge, axe, brush knife, etc., depend on the particular job at hand. The available equipment should be checked to make sure it is accurate and in good condition.

150.03 — Establishing Centerline and Right-of-Way

A. Office Work. Before staking is started, plans should be checked and notebooks prepared. A set of plans should be available for the use of the staking party at all times. Notation of errors which are found in staking should be made on the field plans as well as in the notebooks. All curve and alignment data shown on the plans should be checked before staking starts.

B. Alignment Book. A well-prepared alignment book will permit the party to proceed without delays. Leave plenty of space in the notebook as inadequate information is caused by crowded notes. An accepted method for recording information in the notebook is shown in Figure 150-1.

The station number of the beginning of the project should be obtained from the plans. This station number should be inserted on a line near the bottom of the second or third left-hand page of the field book. List the stations up the page consecutively from the beginning station on every fourth line. Enter the station of all transit points shown on the plans; such as, P.O.T. (point on tangent), P.I. (point of intersection), P.C. (point of curvature), P.T. (point of tangency), at the proper place in the field book according to the station numbers. The reference ties for each point should be entered opposite the corresponding station number on the right-hand page. The station number of each structure shown on the plans should be entered in the field book in order that centerline location of structure points may be established as the line is run.

It is advisable to plot the right-of-way lines showing right-of-way widths on each side of the centerline on the right hand page of the alignment book.

A transcript of each right-of-way deed should be available on the project to enable the checking of right-of-way as shown on the plans or the division of right-of-way should furnish a checked set of plans.

Computer data processing programs are available which can produce alignment stakeout notes. This information is produced from original design data, and can be printed out on convenient perforated paper that can be inserted in hard-bound notebooks. Data produced from these programs includes stationing, tangent bearings, curve deflections, central angle, radius, curve length, semi-tangent distance,

the point of error as possible. An equation refers to a point on the survey that has two station numbers; for example, 185 + 60.3 (back) 185 + 24.7 (ahead). This is a plus equation of 35.6 feet. All equations shown on the plans must be observed.

When transit points are lost, or are not referenced, they should be set from known points that can be located. This can be done by producing tangents from established points or by the intersection of known tangents. All transit points set during the staking of centerline should be referenced to at least 3 objects. It is also well to set tacked hubs at right angles to the transit points along the right-of-way line on each side of the centerline. All ties for these points should be recorded for future use in the alignment book.

D. Simple Curve. Information on the computation of curve data can be found in a number of engineering handbooks; however, a brief explanation and example will be outlined here for the beginner. See Figure 150-2.

The curve data shown has been computed from the arc definition of degree of curve in which the radius varies inversely with the degree of curve. The radius of the 1-degree curve is set at 5,729.58 feet, therefore the radius of a 2-degree curve is 1/2 of 5,729.58 feet, the radius of a 3-degree curve is 1/3 of 5,729.58 feet, etc. For a given central angle the values of the various other functions of the curve also vary inversely with the degree of curve.

The angle of intersection at the P.I., generally shown on the plans as Δ , should be measured in the field as a check. The tangent length is computed by obtaining from tables the tangent length for a 1-degree curve, and dividing this length by the degree of curve. The length of the curve is computed by multiplying the angle of intersection (expressed in degrees and decimals) by 100, and dividing the result by the degree of curve (expressed in degrees and decimals).

Example, Given: P.I. — STA 33 + 70.1

Δ — 30° — 10' Rt.

D — 10° — 00'

From table-tangent of 1° curve for 30° — 10' = 1,544.17 ft.

Tangent — T for 10° — 00' Curve = 1,544.17/10 = 154.42 ft.

Sta. of P.C. = (33 + 70.1) — (1 + 54.42) = 32 + 15.68

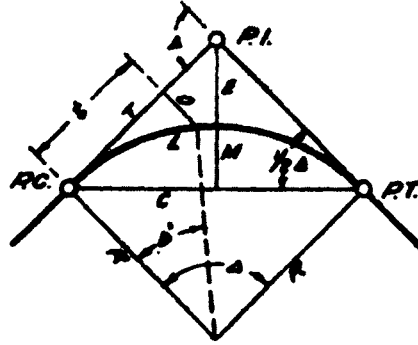
Length of curve — L = 100 Δ /D = 100 $\times$ 30.167/10 = 301.67 ft.

Sta. of P.T. = (32 + 15.68) + (3 + 01.67) = 35 + 17.35

Deflection angle = D/2 for 100', D/4 for 50', D/8 for 25'

Deflection per foot in minutes = 60D/200 = 0.3D = 0.3 $\times$ 10 = 3'

Ordinarily curves are staked for each station, half station, and quarter station. Normally the distance from the P.C. or P.T. to the first station on the curve is an odd distance and requires computation of the deflection for these distances. Chord corrections may be disregarded if 100 ft. chords are used for up to 6° curves, 50 ft.



A 1° Curve is a curve of a radius such that 1° of central angle subtends an arc of 100' in length

Δ	=	Degree of Curve
R	=	Radius
L	=	Length
T	=	Tangent
Δ	=	Central or Deflection Angle
E	=	External
M	=	Mid Ordinate
C	=	Long Chord
O	=	Tangent Offset
t	=	Subtangent
P.I.	=	Point of Intersection
P.C.	=	Point of Curvature
P.T.	=	Point of Tangency
E	=	$R \sec \frac{1}{2} \Delta$
E	=	$T \tan \frac{1}{4} \Delta$
M	=	$R \operatorname{versine} \frac{1}{2} \Delta$
C	=	$2R \sin \frac{1}{2} \Delta$
O	=	$R - \sqrt{R^2 - t^2}$
t	=	$R \sin \Delta'$
R	=	$\frac{50}{\sin \frac{1}{2} D}$
L	=	$100 \frac{\Delta}{D}$
T	=	$R \tan \frac{1}{2} \Delta$
Δ	=	$\frac{DL}{100}$
D	=	$\frac{100\Delta}{L}$
O	=	$R - (R \cos \Delta') = R \operatorname{versine} \Delta' = R(1 - \cos \Delta')$

CIRCULAR CURVE FORMULA

Figure 150-2

chords for up to 12° curves, 25 ft. chords for up to 24° curves, and 10 ft. chords for curves of over 24°. Curve notes should be recorded in the field book similar to sample page shown in Figure 150-1.

Computation of deflections:

Station	Dist.	Def.
32 + 15.68 P.C.		0°00'
32 + 50	34.33	1°43' = $34.32' \times 3'$
		+ 2°30' = $50' \times 3'$
33 + 00	34.32	4°13'
		+ 2°30'
33 + 50	50.00	6°43'
		+ 2°30'
34 + 00	50.00	9°13'
		+ 2°30'
34 + 50	50.00	11°43'
		+ 2°30'
35.00	50.00	14°13'
		+ 0°52' = $17.35' \times 3'$
35 + 17.35 P.T.	17.35	15°05'

Note: Last deflection is $1/2\Delta$

E. Staking Simple Curve. After setting the transit over the P.I., a backsight is taken on a P.O.T. on the back tangent and the tangent distance chained back from the P.I. to set the P.C. A foresight is taken on a P.O.T. on the forward tangent and the tangent distance chained to set the P.T. To establish the curve, with the transit set up over the P.C., sight the P.I. with the verniers of the transit set at zero. Turn off the deflection angle for the first point on the curve and measure the correct distance to this point. This point may be an even station or a station plus 50. After the first even station is reached the rear chainman holds on this station. The remainder of the curve is run in 50-foot increments with all chaining being from the full station points. The last deflection angle and the last measurement should both fall on the P.T. if no error has been made.

The curve may be backed in by using these same deflections. Set the transit on the P.T. with the total deflection set back on the vernier. Take a foresight on the P.I. and run the curve the same as before setting the recorded deflection for each corresponding station, finally tying in at the P.C. with the vernier reading 0 degree.

If the entire curve cannot be seen from the P.C. or P.T., it will be necessary to make an intermediate set-up on the curve. The first set-up will, in most cases, be at the P.C. and the curve will be run forward as far as practicable. The transit is then set up at the last point set and is backsighted on the P.C. with telescope inverted and the

plates reading 0 degree (which is the angular value opposite the P.C. in the notes). After plunging the telescope, the angle opposite each succeeding station in the notes is used to set that station.

If still another set-up is necessary, then the transit is backsighted on the last transit point with the telescope inverted and the plates reading the angular value of the point sighted on, as recorded in the notes. The telescope is then plunged and the angle opposite each succeeding station in the notes is used to locate the stations.

F. Spiral Transition Curves. The purpose of introducing spiral transitions at each end of circular curves is to provide a gradual transition from the tangent to the full superelevated curve. The spiral transition has the property of ever increasing curvature, starting with zero degrees and ending with the same degree as that of the horizontal curve. Information as to spiral and superelevation transitions will be found on the standard drawings of the contract plans. Generally, only those curves of over 2 degrees in curvature and on major and interstate system routes will be spiraled. A complete treatise of spiral curves may be found in "Transition Curves for Highways" by Joseph Barnett of the B.P.R.

G. Staking Right-of-Way. After the centerline has been established, the right-of-way line should be staked on both sides of the roadway. Right-of-way stakes should be set at 50-foot intervals on curves. The staking should conform to the right-of-way as shown on the plans or as modified by executed deeds. Right-of-way lines for drainage easements and borrow pits should likewise be staked. Right-of-way stakes should be set at right angles to the centerline and should have the station number and distance from centerline plainly marked on them. Breaks in the right-of-way should be established by turning off with the transit the designated angle from centerline. It should not be necessary to actually turn 90-degree angles with the transit for other points unless the project requires wide and extensive right-of-way.

150.04 — Levels, Bench Levels, Cross Sections, and Slope Stakes

A. Office Work. Considerable office work should be done before field work starts. The grade line should be checked for errors, and grade elevations computed for each station and necessary plus. Widening, rate of superelevation, and transitions should be checked and listed in the field book for all curves.

B. Level Books. In preparing all level books, leave plenty of space between stations to avoid crowding notes. Except for identification of the field book and a list of benchmarks as taken from the plans, there is little to enter in the cross section book before field work starts. In the slope stake book, however, all of the profile grades and shoulder grades should be entered for each station and each plus. A list of benchmarks should likewise be carried in this book. On paving projects, a level

book should be prepared in advance of setting paving stakes with the edge of pavement elevation shown for even and plus 50 stations.

C. Benchmark Levels. Prior to running any levels or establishing elevations for construction use, a set of benchmark levels should be run to check the elevations of benchmarks shown on the plans and to establish additional benchmarks. When checking bench levels, the length of foresights and backsights should be kept approximately equal and each benchmark should be used for a turning point. It is not advisable to accumulate small variations found in elevations of original benchmarks. In these instances, levels should be corrected before proceeding. See Figure 150-3 for an example of bench level field notes.

					6-21-50 Clear, Warm	5 mi. N - W Brown - Red
B.M.	BS(1)	HI	FS(1)	Elev		
B.M. #1	472	951.44		946.72	USGS B.M. Brass Amp in concrete base	
					125' Rt Sta 1+35	
T.P.	375	944.58	1061	940.83		
T.P.	218	938.05	873	935.85		
B.M. #2	526	935.92	757	930.66	Spike in telephone pole, 45' Rt Sta 11+75	
T.P.	461	932.56	797	927.95		
T.P.	021	921.64	1113	921.43		
B.M. #3	920	920.49	1035	911.29	Spike in root of 14" Oak 65' Lt Sta 20+45	
T.P.	1167	925.87	229	918.20		
T.P.	1201	940.53	135	928.42		
B.M. #3	\		039	940.14	Hub with guard 100' Lt Sta 30+00	
Sum	= 9361	2(1)	6019	946.72		
			-5361	-940.14		
		Diff.	658	658		

BENCH LEVEL NOTES

Figure 150-3

At the completion of a project, additional benchmarks should be established on bridges, concrete box culverts, or other permanent objects. The new elevations and descriptions should be recorded on the final plans. Final benchmarks should not be more than 1,000 feet apart.

D. Preconstruction Cross Sections. Roadway common excavation is usually paid for on the basis of plan quantities; thus, preconstruction cross sections are not

generally required. However, it is suggested that the original plan cross section be checked for accuracy by making a 3-point check while setting slope stakes, i.e., centerline, and right and left limits of excavation. If these points are found to be reasonably accurate, the original section may be used if a recomputation is necessary of the excavation quantities in any balance. If an unsatisfactory average variation is found in the original cross section, new shots should be taken and used in lieu of the plan section for computation of excavation quantities. The level rod should read to the nearest one-tenth of a foot and the distance from the centerline to the nearest one-half foot. The notekeeper, or designated person, should determine where any section is to be taken, and after some training, the rod person may select the individual shots along the section. Sections are to be taken as near right angles to the centerline as practicable. When a revision in excavation quantities is anticipated in a balance, or part of a balance, due to errors found in ground elevations, or change of grade or typical section, the Contractor should be so advised in writing by the Project Engineer during construction progress. See Figure 150-4 for an example of cross section notes.

					6-20-48 Clear, Not	Smith - R Brown - Red Jones - Notes Green - Ch
BM #4	2.20	541.80		539.58	Spike in root of 15' Elm 35' Rt 431+80	
432					1/2 1/2 1/2 1/2 1/2 1/2 1/2 1/2	
+40					1/2 1/2 1/2 1/2 1/2 1/2 1/2 1/2	
433					1/2 1/2 1/2 1/2 1/2 1/2 1/2 1/2	
T.P	3.14	535.46	9.48	532.32		
+55					1/2 1/2 1/2 1/2 1/2 1/2 1/2 1/2	
434					1/2 1/2 1/2 1/2 1/2 1/2 1/2 1/2	
+30					1/2 1/2 1/2 1/2 1/2 1/2 1/2 1/2	
BM #5		10.73	524.73	524.70	0 on NW Cor of W. Howell Cully 10' Rt Sta 435+90	

CROSS-SECTION NOTES

Figure 150-4

When rock is encountered, the rock area should be cross-sectioned as soon as the overburden has been removed. In case of extreme variation of the rock surface, such

as pinnacle formation where a line of demarcation between rock and earth cannot be established, the District Construction Engineer, Project Engineer, and the Contractor's representative should agree as soon as practicable on a percentage factor of rock classification for this area. If sufficient time is available, the Division of Construction should be advised so that a general inspector may be present when determining the percentage factor. This method of classification is not considered good practice and should be used only when it is impossible to establish lines of demarcation. Any decision should be confirmed in writing.

Rock sections should be taken at the stations where original cross sections were taken, plus any additional sections that will be needed to arrive at the correct volume of rock excavation. After the rock has been excavated, and before any backfill is placed, level shots or cross sections must be taken to show the true lower limits of rock excavation. It is not necessary for the rock broken below the limits required for undergrading to be completely removed from the lower portion of the cuts prior to taking the level shots or cross section; however, the broken rock must be moved endways or sideways sufficiently to expose an area of at least one-half the width of the cut so that a true section can be taken. After sectioning this half, the remaining half must be exposed for sectioning in a similar manner.

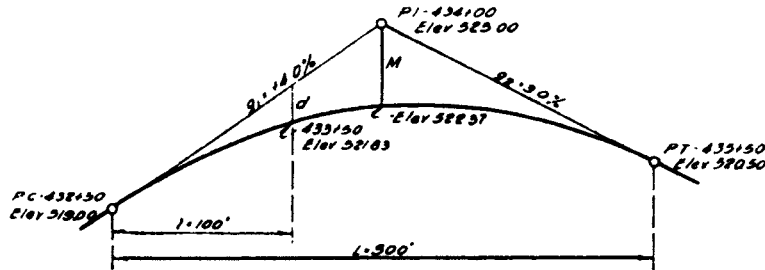
While the above applies specifically to roadway excavation, the principles apply for channel changes and channel cleanouts where quantities have been computed. Where plan quantities are merely estimated, centerlines or base lines must be established and completion preconstruction cross sections taken. Since borrow excavation is not paid for on the basis of plan quantities, borrow areas must be staked and original cross sections taken before the Contractor begins work therein.

E. Final Cross Sections. As soon as practicable after final completion of any part of the work, final cross sections should be taken where they are required for the purpose of computation or recomputation of final pay quantities. These sections must be taken at exactly the same stations where preconstruction sections were taken. Each final cross section should have at least 2 "shots" at each end on the ground beyond construction limits so as to provide a common line between original and final sections. Explanatory notes, made when taking final sections, are often a great aid when plotting the sections later. Low-lying excavation areas which might be materially altered by high water or overflow (channel changes, borrow pits, etc.) should be cross sectioned immediately after excavation is completed.

F. Slope Stakes. Slope stakes are an important part of the staking job as they control the lines and grades to which the grading contractor will work. The grade-line, typical section, and roadway cross sections should be studied in order to be entirely familiar with the section involved before staking starts. A grade to which the road is to be constructed must be computed for each station, and each half station on sharp vertical or horizontal curves and in rock cuts. The grade line is a system of tangent lines with parabolic curves at the intersections. The tangent grade is shown

as a percentage such as 4.50% which means 4.5-ft. rise or fall in each station. Going with the stationing, the ascending grades are marked plus, and the descending grade minus. The vertical curves are shown in lengths, as 200 ft., 300 ft.

Prior to computing vertical curve corrections, the tangent grades are checked by starting at the first intersection of tangent grades near the beginning of the project. Computation of grade elevations on a summit vertical curve with tangents of equal lengths are shown in the following procedure. A vertical sag curve is computed in a similar manner except that the offset is added to the tangent grade instead of being subtracted.



VERTICAL CURVES

Figure 150-5

$$\begin{aligned}
 a &= \text{algebraic difference of tangent grades} = g_1 - g_2 \\
 &= + 4.00 - (-3.00) = 7.00 \\
 M &= aL/800 = 7 \times 300/800 = 2.625' \\
 d &= 4M(1/L)^2 = 4 \times 2.625 \times (100/300)^2 = 1.17'
 \end{aligned}$$

The tangent elevation at Sta. 433 + 50 = 519.00 + 4.00 = 523.00

Curve elevation at Sta. 433 + 50 = 523.00 - 1.17 = 521.83

The centerline, which is usually the profile grade, is computed on tangents where both shoulders are of equal elevation. On curves, the grades of the shoulders are not equal due to the superelevation. The amount of superelevation for the various curves is shown on a standard sheet in the plans. Elevations of each shoulder must be carried in the slope stake book along with any special ditches or variable slopes that may be designated on the roadway cross sections.

See Figure 150-5a for a sample of slope stake notes and Figure 150-6 for the location and marking of the stakes. In setting slope stakes the rod is read to the nearest 0.1 foot and the distances are measured with a metallic tape. All work should be checked for errors by comparing the slope stake distances as computed in the field against the cross sections as plotted in the plans or as shown on computer "Section Data".

Slope stakes should be set on all volume grading sections. They should be set at each station and at any other plus where they may be necessary due to curvature or

				Time Stroke	6-20-51 Cloudy Warm	Smith F. Brown Wd Lopes James Green 1st			
BM 4	228	52680	52452		518 518	518 518	(98)	518 518	518 518
+32				5170	518 518	518 518	5170	5170	518 518
					518 518	518 518	(78)	518 518	518 518
+50				5130	518 518	518 518	5130	5130	518 518
					518 518	518 518	(68)	518 518	518 518
433				5202	518 518	518 518	5202	5202	518 518
TP	614	52646	640	52032					
					518 518	518 518	(49)	518 518	518 518
+50				5218	518 518	518 518	5215	5221	518 518
					518 518	518 518	(47)	518 518	518 518
434				5224	518 518	518 518	5218	5230	518 518
					518 518	518 518	(48)	518 518	518 518
+50				5223	518 518	518 518	5217	5229	518 518
BM 5		1073	51573	51570					
Note. Circled figure is stroke reg									

SLOPE-STAKE NOTES

Figure 150-5a

rough topography. On sections of work that have varying slopes, it is well to indicate the slope on each stake in addition to other markings. Slope stakes should not be set on sections involving linear grading.

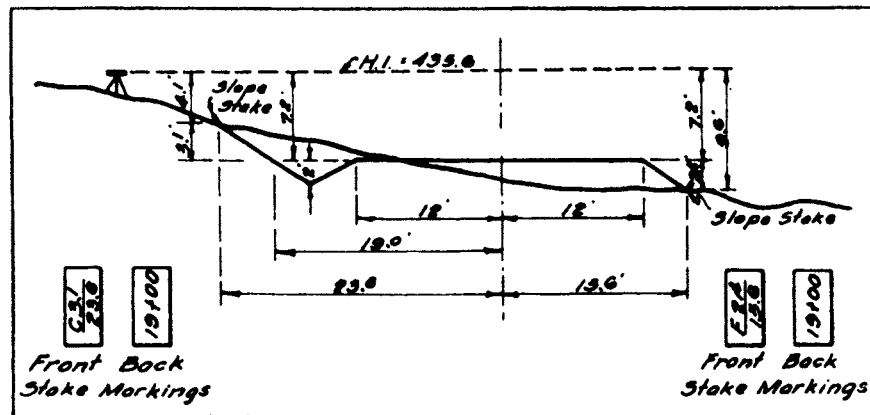
For channel changes and special ditches where there is a grade and typical section, slope stakes should also be set. Slope stakes may be necessary in borrow pits that are to be excavated to certain grades. Slope stakes are not always necessary for road approaches; however, where special grades are designed, they should be set.

Where rock is encountered, new slope stakes should be set on the top of rock for the rock slope as shown on the typical section or for the rock slope as determined by redesign. It is important that these stakes be set, as they will be used in the determination of overbreak quantities. Care should be taken to assure that the same proposed grade as was used for the original staking, except in the case of redesign, is used when setting subsequent lines of slope stakes.

A written order should be issued to the Contractor advising him of the method used in the setting of slope stakes and an interpretation of stake marking.

G. Paving Stakes. Stakes for pavement should be set with extreme care. The centerline must be reproduced to provide alignment for the pavement. Ordinarily a

parallel offset line is run and the form stakes set at one side of the proposed pavement with alignment indicated on the stake with transit tacks. The offset distance should conform to the Contractor's request, if practicable, and is generally 2 or 3 feet from the edge of the pavement. There are several suitable methods of setting grades on paving stakes, however, driving the stakes flush and marking a cut or fill measurement from the top of the stake to the top of the paving form is generally preferable. If sufficient time and staking personnel are available, the driving of the top of the stake to form grade probably results in a more accurate form line. If it is necessary or desirable to give a cut or fill on the stake, it should be driven



SLOPE-STAKING

Figure 150-6

so the grade may be marked to even tenths of a foot. Some engineers prefer to give both grade and tack line on the same stake. Paving stakes should be set at all stations and at each +50.

In some cases, due to abrupt alignment, steep grades, and spiral transition curves, it may be necessary to set them at closer intervals.

H. Finishing Stakes. On projects to be surfaced with a high type of surfacing not requiring the setting of forms, it is necessary that the grade of the roadbed be finished very close to the established grade and to the typical section width. For this reason, the setting of finishing stakes (blue tops) is required not only for the earth subgrade but for finished grade of the aggregate base. Finishing stakes are also needed on the grading work of major system projects where stage construction is being used with the paving to be done on a later project. On concrete paving jobs, most Contractors prefer to do their fine grade finishing after the paving stakes are set and, therefore, do not desire finishing stakes. If the Contractor requests finish stakes, however, they should be set. It is essential to set finishing stakes through rock cuts and to check the rock excavation before it is backfilled.

				Grades Lt Edge Right Post	Grades Right Post	6-30-50 Clear, Worm	Smith & Green Stakes Brown-Red	
BM #4	365	528.17		524.52			Lt Gr	Rt Gr
432				517.50	517.50	10.87 C 0.00	10.87	10.87 C 0.80
+50				519.80	519.50	8.67 C 0.00	8.67	8.67 C 0.70
433				520.71	520.71	7.36 C 0.10	7.46	7.46 C 0.80
TP	764	530.85	528	528.89				
+50				522.96	522.65	6.87 C 1.00	7.57	7.90 C 0.80
434				522.35	523.55	8.80 C 0.70	8.18	6.98 C 0.70
+50				522.21	523.41	8.02 C 0.30	8.52	7.18 C 0.70
TP	406	522.17	1242	518.11				
BM #5			640	515.69	515.70			
						Note Gr = Grade Rod		

PAVING STAKE NOTES

Figure 150-7

Finish stakes should be set at 50-foot intervals on the shoulder line and be driven so the top of the stake is at-grade elevation. It is common practice to blue the top of the stake to indicate that it is set to grade. Stakes or pins should also be set at centerline and on the quarter point where a close tolerance is required. It should not be necessary to set finishing stakes in linear grading sections for volume grading on supplementary construction.

1. Automated Slope Stake and Grade Books. Computer data processing programs are available which can produce slope stake and grade book notes. This information is produced from original design data, and can be printed out on convenient perforated paper that can be inserted in hardbound notebooks. The grade book program can be made to produce grades for subgrade, base material, surface, or any combination of lifts of material placed on the roadway. The slope stake program can be made to provide percent of grade, finished profile grade, vertical curve correction, crown, profile grade, subgrade shoulder, theoretical slope stake, cut or fill, and ditch notes. This information can be sent directly to field crews for immediate use in staking out the project.

J. Plans Prepared by Computer Methods. The earthwork quantities for some projects may be developed by electronic computer methods. In lieu of cross sections, the plans usually include forms showing such information as section data and yardage output data. Details will vary according to the computer and program used. Roadway cross sections will normally not be plotted except for areas requiring special consideration; however, culvert cross sections may be provided.

The computer form provides the same information normally shown in graphical form on the cross-section sheets of projects computed by conventional methods. Elevations for various control points of the section are usually tabulated with the offset distances from the surveyed centerline. The general slope of the existing ground can be determined from the elevation and offset of the slope stake points.

The same section data form may be used for both two-lane highways and divided four-lane roads. Details of the section must be determined from the typical section sheet included in the contract plans.

The outside shoulder points are frequently tabulated by elevation and offset. Inside shoulder points on four-lane divided highways can be established from the typical section. The ditch point offset is usually located at the toe of the slope. If a ditch berm is required, the berm elevation is listed.

The typical rock bench point identifies the elevation of the top of rock and the offset distances from centerline to the intersection of the rock backslope and the top of rock. The rock slope is shown on the typical section sheet.

The Quantity Output Data form provides the earthwork quantity information that is shown on the cross sections of projects computed by conventional methods. This may include end areas, volumes between sections, and accumulated volumes. The backslope may be shown as a number such as $7 = 1 - 1/2:1$, $5 = 1:1$, $3 = 3:1$, and $2 = 4:1$.

The slope stake points noted on the output data form are not to be used for actual setting of slope stakes but may be used as a check for determining if actual ground elevations vary from design elevations. If there is appreciable variation, a new cross section should be taken in the same manner as for plans designed in a conventional manner.

150.05 — Staking Structures

A. General. This section is devoted to the staking of bridges and culverts; however, the staking details of miscellaneous structures will be similar and should be worked out on the project. The staking of structures is an important part of the project work and a detailed study of the plans should be made so as to become thoroughly familiar with each structure before the staking starts. All bridges have separate plans where the dimensions, elevations, etc., necessary in staking the bridge are shown. An error in staking a structure will not occur if the staking procedure is thoroughly checked and some form of triangulation devised.

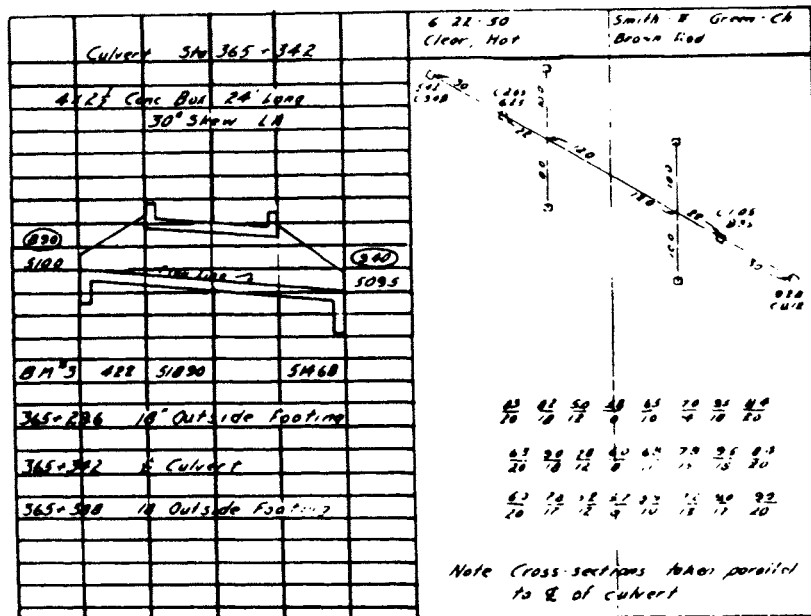
B. Field Notebooks. The field notebooks for structures should be prepared in advance and all necessary data placed in the book so it will be available when staking starts. Sample notebook pages are shown in Figures 150-8 and 150-9.

Culvert books should be prepared by using a separate page for each structure. This sheet should show the station of the structure, the type, size, and length. Staking diagrams, showing all dimensions and staked distances, should be made and a sketch showing the elevations of the flowlines included. This information is taken from the culvert plans which show the station, size, type, length, and the skew angle. Space for sufficient cross sections and elevations should be left to ensure properly computed structure excavation when same is required. The cross sections of the plans indicate the length of the culvert on each side of centerline and flowline elevations. If the culvert is a pipe, the length is to the ends of the pipe. The length of a concrete box culvert is to the inside face of the headwalls. The angle of the culvert is shown as 90 degrees if at right angles to the centerline, or a certain degree skew from right angles if other than 90 degrees. The skew is written RA or LA, meaning right ahead or left ahead.

Bridge field notebooks are prepared in a manner similar to that used for culverts. A separate page is used for each bent of the structure, with the staking diagram showing the required dimensions and staked distances. A sketch showing an elevation of the bent together with the critical elevations should be included. The left-hand page is to be used for recording the required leveling data.

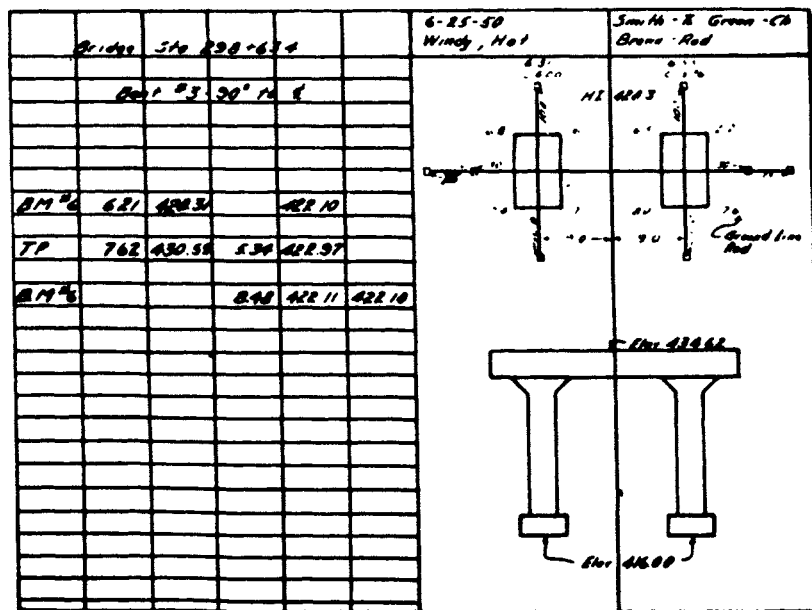
C. Pipe Culvert Staking. With the transit set over a point (tacked hub or nail) on centerline of survey at the station of the centerline of culvert, take a sight on a survey control point (P.I., P.C., P.O.T., etc.) and turn the angle for the centerline of culvert. Generally 2 hubs to establish the centerline are all that are required for a pipe culvert. Set one at each end, offset a definite distance (5 feet minimum) from the ends of the proposed pipe. If there is a break in the flowline, set 2 hubs, right and left of culvert centerline at the break to mark its location. From the nearest benchmark determine the elevation of the top of each hub and compute the cut or fill from it to the respective flowline point. Back of each hub set a guard stake on which has been marked the hub's identity, offset distance, and the cut or fill to flowline elevation.

The culvert as designed should be checked after staking to see that it fits existing conditions. In most cases it will be found that the culvert as planned will function satisfactorily. It is not intended to encourage habitual revision of culvert plans and when occasionally a revision is a necessity, it should be made as early as possible. Take sufficient cross sections for the recomputation of excavation quantities if justified by a change in location or flowline elevation. Usually a single section along the culvert centerline is sufficient, but if additional sections are necessary, they should preferably be taken parallel to the culvert centerline.



CULVERT STAKING NOTES

Figure 150-8



BRIDGE STAKING NOTES

Figure 150-9

D. Concrete Box Culvert Staking. The same method is used to stake concrete box culverts as for pipe, except, in addition, stakes must be set for the inside face of each headwall which are usually parallel with the centerline of the roadway. To set headwall stakes, a point is set along the centerline of the culvert at the inside of headwall distance; the transit set over this point and a sight taken along the centerline of the culvert; and the transit turned the same angle as turned at the centerline. The headwall line should be checked visually to make sure it is parallel to centerline of roadway. Two stakes marked "inside headwall" are set well back from the construction limits, one on each side of the culvert with a tack for line.

Box culverts as designed should be checked against existing conditions, as discussed under "Pipe Culverts," keeping in mind that any change should be avoided if possible. In case a revision of flowline elevation appears warranted, it should be ascertained that no commitment have been made concerning flowline elevations to various agencies or individuals before any changes are made on same. A culvert classed as a bridge should not be changed in any respect without prior approval of the Division of Construction and the Division of Bridges.

1. **General.** The station numbers shown on the plans for a bridge are the stations at the ends of the bridge, usually at the fill face of the end bents. Set the transit on a P.I., or P.O.T., near one end of the bridge, and take a foresight on a P.I. or P.O.T., beyond the bridge. Set at least 2 substantial tacked hubs well past each end of the bridge, preferably on high ground that will not be disturbed. This gives 4 points on the centerline of the bridge. If one is lost or destroyed, the line may still be reproduced. From the station of the bridge, the location of the first bend or abutment can be determined. The work line for the end bents is generally the fill face. Set a tacked hub on centerline at this point. Measure from this point the distance to the centerline of the next pier or bent and set another tacked hub. Continue this until you have tacked hubs at each pier, bent, or abutment. Set the transit over each of these points and stake the working line by turning the angle shown on the plans. At least 2 tacked hubs on each side of the bridge, clear of all construction operations, should be set for each pier, bent, or abutment. With the transit still set over each of the points, measure the distance out of centerline of footing and set a point. Set the transit over this point and turn the centerline of each footing. Set tacked hubs on each side of the footing by turning the angle indicated on the plans, which will usually be 90 degrees. Repeat this operation until each pier, bent and abutment is completely staked.

2. **Triangulation.** Bridges over wide expanses of water will require the use of triangulation to fix the location of river piers and to determine the exact stationing of the substructure units located on the landfall ahead. This triangulation should be accomplished in the manner set forth in any survey handbook.

3. **Benchmarks.** A good benchmark that will not be disturbed should be established at each bridge site. The elevation of this benchmark should be thoroughly checked and it should be used to set all future control elevations at the bridge. After the staking is complete, lay out each footing approximately and obtain