## CHAPTER 9 - CONSTRUCTION DETAILS

## CONTENTS

# SECTION 9-1 - INTRODUCTION

## 9-1 INTRODUCTION

Chapter 9 consists of discussion of construction activities. The chapter is divided into sections for each of the major categories of work. The sections are further subdivided to provide discussion of each individual item or type of work. These subsections each contain instructions, illustrations, suggestions, or references concerning the following:

**1. Preliminary Review and Approval**

**2. Construction Inspection**

**3. Measurement**

**4. Documentation**

**5. Reference Materials (if appropriate)**

The materials should not be considered all-encompassing and, in fact, will not be appropriate in all situations. It does not offer cookbook solutions to problems, but rather suggestions to help try to avoid problems and ideas to aid in the development of solutions.

Much of the material deals with construction processes, procedures and equipment. It is intended that the contractor provide a sufficient level of expertise to properly calibrate and use its equipment. If that is not happening, the problem should be addressed as a management problem on the part of the contractor. It is not intended that this manual provide a level of expertise to the Project Engineer such that he/she can actually intervene to compensate for ineptitude on the part of the contractor. This information can give an indication as to when construction processes and procedures are inconsistent with appropriate quality standards.

## SECTION 9-2 - CLEARING AND EARTHWORK

## 9-2 CLEARING AND EARTHWORK

### 9-2.1 Clearing and Grubbing

#### 1. Preliminary Review and Approval

The vegetation and debris to be cleared, grubbed, removed, and disposed of under this section, includes all surface objects, trees, stumps, roots, and other protruding obstructions within the designated limits except such objects as are designated to remain in place or are to be removed under other contract items.

Before clearing and grubbing operations begin, the Project Engineer should address the following matters:

- Have the limits of all areas in which the Contractor will be required to perform work clearly marked. It should be made clear to the Contractor what access has been provided for the Contractor and for those property owners adjacent to the project.

- Go over the job with the Contractor and discuss the work to be done and any special details. Such details should include trees to be saved, stakes and survey control points to be preserved, and all known utilities that could be damaged during clearing operations. The general clearing procedure and disposal of materials should also be discussed.

- Have all trees, shrubs, survey or historical markers, objects of historical or archeological value, etc., that are to be preserved or remain in place, clearly marked and make the Contractor aware of their location.

- Go over erosion control requirements. See Subsection 9-2.4.

#### 2. Construction Inspection

Inspection is usually a matter of intermittent checks, once the Contractor's supervision and understanding of requirements has been verified. Special circumstances such as a high degree of environmental sensitivity in some National Parks may dictate more frequent reviews. The inspector will usually be concerned with the following:

**A. Equipment and Methods**

The choice of equipment and methods used for this work is usually left to the Contractor, so long as the work is performed in a satisfactory manner. However, there may be limitations to the Contractor's choice as dictated by the specifications or common sense, (i.e., specific control of the use of explosives in congested areas).

**B. Removal of Trees, Undergrowth, Stumps and Roots**

Trees, stumps, and large roots should be removed from excavation areas to a depth sufficient to prevent such objectionable material from becoming mixed with the material being incorporated in the embankment. These areas to be excavated will normally require grubbing to remove small bushes, vegetation, rubbish and other objectionable material.

**C. Removal of Material Outside Clearing Limits**

It may be desirable to remove downed timber, etc., outside the originally established limits for clearing and grubbing. When there is no item for *Individual Removal of Trees*, or when these situations are not covered in the special contract requirements, they should be considered for a contract modification.

**D. Preservation of Objects Designated to Remain**

Precautionary measures must be taken to protect objects designated to remain in place, from damage during clearing and grubbing and other construction operations. These objects may include trees, shrubs, survey or historical markers, objects of historical or archaeological value, and others. Clearly marking such objects and making the Contractor aware of their location will help insure their preservation.

Trees close to the top of high cut slopes should not be designated for preservation as they may become a traffic hazard or threaten the stability of the slopes.

Trees at the bottom of fill slopes should be removed beyond the slope limits, including rounding, unless tree wells or similar provisions for protecting them are included in the contract.

**E. Timber to be Saved**

When merchantable timber is to be saved, it must be trimmed, sawed, and stockpiled ln accordance with the special contract requirements. When there is no suitable place along the highway to stockpile timber to be saved, it may be necessary to clear an additional area for stockpiling. The length of haul of this timber to stockpile areas should be kept to a minimum. The areas of such additional clearing should be included in the measurement for payment, and approved by the Project Engineer in cooperation with land owning agency.

**F. Rehandling**

Contractor is entitled to no additional payment in the event of any rehandling of refuse caused by an order from the Forest Service or other legal authority, to delay burning. Such orders should be requested in writing and should be conveyed to the Contractor in a manner which makes it clear they have not been initiated by Federal Lands as a contractual action.

**G. Hazards**

Clearing and grubbing operations, particularly in dense, tall timber regions, can be very dangerous. Federal Lands personnel should make certain that the Contractor's operation does not endanger them, result in potential hazards to the traveling public, or create damage to existing facilities in or adjacent to the right-of-way.

**3. Measurement**

Methods of measurement must be consistent with Contract. Specifications should be reviewed closely for any exceptions to the general practice of including all area designated for clearing in the measured quantity, whether some parts require physical clearing effort or not. For example, the area of existing roads lying within the area staked for clearing are not deducted from the area otherwise measured unless the contract specifically provides for such deduction.

**4. Documentation**

The Project Engineer is responsible for documentation of the required compliance with specifications, and for the field measurement notes and computations for pay quantities. Compliance is usually documented by IDR or diary entries, and photographs. Original (authorized) quantities are generated with earthwork quantities. Adjustments and additions may be in a field book. Quantities are summarized in the Progress Estimate Book with indications as to when each section is complete or partially complete noted and reflected in the computations. Whether field measurements and/or computations are made by Contractor or Government crews, the Project Engineer must arrange for reasonable verification processes.

## 9-2.2 Removal of Structures and Obstructions

### 1. Preliminary Review and Approval

Before operations begin, the Project Engineer should go over the project with the Contractor and clearly identify any structures and obstructions to be removed. When the bid schedule does not contain a bid item for removal of structures and obstructions, removal within the designated construction limits should be considered a subsidiary obligation of the Contractor. However if the obstruction was not apparent during the bidding, and so unusual that it could not reasonably have been anticipated, the Contractor may make a case that it is compensable as a differing site condition. There may also be instances when it is desirable to remove structures that are not within these limits. In such cases, if the removal of such structures is not covered in the special contract requirements, they should be considered for a contract modification.

### 2. Construction Inspection

As with clearing operations, precautionary measures must be taken to protect objects designated to remain in place from damage during these operations. Clearly marking such objects in the company of the Contractor will help insure their preservation.

### 3. Measurement

The method of measurement must be consistent with the Contract. Usually removal items are measured by *each* or *lump sum*.

### 4. Documentation

The Project Engineer is responsible for documentation of the required compliance with specifications and for the field measurement notes and any computations for pay quantities. A separate field book may be appropriate, especially if the work is extensive. Otherwise, the book used for clearing or for miscellaneous items, can be used. Each structure or obstruction to be removed should be identified by location, measured, if appropriate, date of removal documented as well as place of disposal (if known). The summary book should include reference to the primary record.

## 9-2.3 Excavation and Embankment

### 1. Preliminary Review and Approval

The specifications provide that all suitable excavated material shall be used in the formation of embankment, subgrade, shoulders, slopes, bedding and backfill of structures, and for other purposes shown on the plans or as directed. The specifications also provide authority for making changes in the plans and specifications during the course of construction to adjust them to field conditions. Changes which affect the Contractor's unit costs or time of performance may warrant an equitable adjustment.

If the Contract requires the Contractor to furnish embankment material from sources of its own choosing, and if excavation from the roadway prism is incidental to an embankment pay item, the Project Engineer is usually concerned only with material quality, compaction, and geometrics.

Likewise if the Contract indicates that borrow may be necessary but no pay item for borrow is provided, the Project Engineer should prudently *monitor* quantities and how they are used, but normally is not required to actively *manage* these quantities.

Other contracts will require embankments to be constructed, or constructed in part, from materials to be excavated, and excavation will be a pay item. This is the predominant design scheme in many areas of Federal Lands work, particularly for projects in rugged terrain. The intent (which is also a condition of the Contract) is for the grading work to *balance*. That is, the cuts are to provide adequate material to make the fills. If that is not possible then a borrow item, and often a source for that borrow is provided. The designer must estimate how much the excavated material will shrink, or swell as it is placed and compacted in the embankments. Soil is usually expected to shrink, while shot rock will swell. Usual materials are a mixture. The Project Engineer should attempt to monitor the early grading work for verification of the designer's adjustment factors. This will sometimes provide lead time to correct for errors, perhaps by adjusting slopes in areas not worked, or by adjusting grades or alignment, or by finding waste or borrow areas. Failure to make the earthwork balance when the Contract indicates that it does, may result in a dispute over disposal of excess excavation or the importation of necessary borrow.

It is the responsibility of the Engineer to recommend or make changes found necessary to meet field conditions encountered during the progress of the work. It may be necessary to flatten slopes for stability or revegetation. Where more rock is encountered than anticipated, economy will dictate the steepening of slopes. Changes in grade, alignment, and/or slopes may be necessary to balance quantities, avoid wasting materials, and minimize overruns in excavation quantities. Redesign of the thickness of topping, subbase or base course may be dictated by variations in the quality of subgrade materials. In making or recommending changes, the Project Engineer should be guided by Chapter 3 of this manual and instructions from the Construction Operations Engineer. Insofar as possible, the need for contract modifications should be anticipated and issued before the Contractor starts grading operations in the areas involved. However, it should be kept in mind that changes which increase the Contractor's cost or time of performance can have an additional effect on cost of the remaining work.

Periodic inspection of the construction of side slopes and drainage ditches is necessary. If the Contractor excavates outside the slope stakes, or below subgrade except as required, gouges or undercuts the slopes, or causes significant overbreak, the Project Engineer should immediately advise the Contractor, in writing, that the specifications do not permit payment for such material. Before the work is accepted, the roadway shall be reasonably close to the required alignment, grade, and cross section.

The Project Engineer should discuss with the Contractor, the importance of exercising care in blasting operations to ensure landscape preservation in National Forests and National

Parks, and protection of abutting privately-owned property where such property is involved. The Project Engineer should ensure that the Contractor's Blasting Plan reflects this level of concern prior to approving it.

The Project Engineer should observe the Contractor's methods of drilling, blasting, and other grading operations for compliance with the protection and restoration of property provisions of the Contract. The Standard Specifications provide for restoration (at the expense of the Contractor) of any landscape features damaged by Contractor operations. However, the objective should be, to avoid such damage in the first place.

If blasting causes a scattering of material beyond construction limits, the land owner or agency be consulted, in the presence of the Contractor, to determine an acceptable method of removing the material without further damage to the property. In the event that damage results to privately-owned property, and repairs are not promptly made by the Contractor, the Construction Operations Engineer should be consulted and appropriate action taken.

**2. Construction Inspection**

Inspection at random intervals will usually be adequate, if decisive corrective action is ordered relative to any deficiencies found.

**A. Materials**

Preliminary sampling and testing of excavation, borrow, and subgrade materials normally will have been performed for design purposes prior to award of the contract. The preliminary design data furnished to the Project Engineer may include classification, moisture-density relationship, and color and texture of the soils sampled during the preliminary soil survey.

It is the responsibility of the Project Engineer to see that sufficient supplementary samples are taken and tested during construction, to verify classification, moisture-density relationships and other assumptions made during the design are consistent with the actual constructed conditions.

If the Contract makes specific quality requirements for the subgrade or other portions of the embankment, then verification of those quality requirements is a part of the Project Engineer's responsibility. If there are no specific requirements, then the Project Engineer can request certain better materials be conserved for, say subgrade. But if the Contractor's operations make it uneconomical to do that, the Government may consider a Contract Modification, or it may have to reevaluate its pavement structure design in areas where the below average materials are used. In the latter case, it becomes particularly important to compare the design assumptions with actual conditions.

The Project Engineer should request the soils and/or pavement design report. The report may provide the most significant factors considered in design, including traffic loading, soil support values, and climatic and environmental conditions. It will aid in making an assessment as to whether conditions encountered differ from design assumptions.

Additional information on sampling and testing is contained in Chapter 5 of this manual.

**B. Borrow**

When borrow excavation is included in the bid schedule, the Contractor is required to furnish necessary material from sources designated in the Contract, or from sources the Contractor provides. In either case, the material must meet the gradation and quality requirements of the Contract. The standard specifications provide that borrow used when roadway excavation material would have been available, will be deducted from the borrow volume (not paid for). It is intended that borrow material not be placed until after all reasonably accessible roadway excavation has been used, or will be used. Contractors who, for reasons of efficiency want to bring in borrow before all excavation has been performed, should be advised that they run the risk of having borrow quantities reduced if excavated material is left over.

Another method is often used for projects requiring a significant quantity of material hauled in for embankment construction. This is to simply specify and pay for embankment material from the Contractor's selected sources. The Contractor is paid for the quantity of embankment rather than excavation or borrow. Any excavation required on the project is considered incidental to the embankment pay item, or will be called out as a separate pay item.

Selected borrow for topping is often specified on grading projects where soil conditions are poor. This material is obtained from sources as above, and will usually have more stringent gradation and quality limits specified than borrow for embankment construction.

The selected borrow for topping item may be reduced (or eliminated) if a suitable substitute is found in the excavation or borrow operations. Unless the Contract specifically requires such materials to be identified and used in the subgrade, the change would require a Contract Modification.

Even if better materials are ordered conserved for subgrade use, it is generally not economically practical that such materials be excavated and stockpiled, and later used in the work. Conservation for topping should be accomplished by leaving the material in its original position, whenever practical.

When a source of borrow material proposed by a Contractor for use has not been previously tested and approved, it is the responsibility of the Contractor to submit records of exploration and testing to support a request for approval. If the source is not an open commercial source, environmental and archeological clearances may also be required. Approval of the source should be made to apply only to those portions from which acceptable material can be obtained.

Borrow pits, other than those contemplated in the design, may be required to provide material of the quality and quantity necessary to complete the project. When additional borrow pits are necessary and it is determined the Government will provide them, concurrence of the Construction Operations Engineer should be obtained and approval by the local Forest or Park Service officials secured (where such jurisdictions are involved) before pits are staked. If the pits are on private lands, right-of-way agreements shall be executed and any question of royalty settled before they are staked. It is very unusual for Federal Lands to attempt to negotiate a borrow pit on private land, especially in the midst of an ongoing contract.

If additional right-of-way or an easement is required to expand a designated pit, the Project Engineer should obtain necessary property descriptions and forward them to the Construction Operations Engineer for appropriate action. The Construction Operations Engineer should also be consulted relative to any permits likely to be required. These might relate to State mining laws, laws governing wetlands, etc.

Whenever practicable, borrow pits should be located outside the limits of view of the project. In timbered country they should be located a minimum of 100 meters from the roadway, in open country a minimum of 300 meters.

It is sometimes faster and no more expensive to assign responsibility for the source of any required borrow material to the Contractor, and structure the contract or contract modification on that basis.

**C. Topsoil**

When the plans or specifications provide for removal and storage of suitable topsoil, only soil which can sustain a growth of vegetation should be conserved. Most soil will sustain growth, if given the fertilization. If the Project Engineer has doubts, the Federal land management agency associated with the project may be able to help. That is, the Forest Service or National Park Service may employ specialists locally who can be consulted.

## D. Presplitting Rock Cuts and Blasting Plans

Before starting drilling operations for presplitting rock cuts as specified in the specifications, the Contractor is required to furnish a drilling and blasting plan. The drilling and blasting plan is to document that the Contractor has a plan for accomplishing the work. Its approval or acceptance by Federal Lands does not absolve the Contractor of responsibility for using proper drilling and blasting methods to achieve the required results. The Project Engineer should evaluate the plan, and bring to the attention of the Contractor any apparent weaknesses or proposed procedures which are contrary to the Contract. The Project Engineer should closely inspect initial operations, methods being used and the results obtained. When satisfactory results are not obtained, the Project Engineer should order a revised plan.

Critical factors in successful presplitting are hole diameter and spacing, hole deviation, charge distribution, and confinement. Test blasts, as required by the Standard Specifications, will help to determine the optimum drill pattern for each job. In practice it has been found that the denser, less fractured, and more homogenous the material is, the larger the hole diameter can be, the less explosives will be required, the greater the distance between holes, and the better results will be obtained.

Successful presplitting operations indicate a spacing of 0.4 to 0.75 meters, center to center, and a hole diameter of 50 to 100 millimeters. Charges taped at 0.3 to 1.0 intervals to a down line of detonating cord with heavier loads placed at the bottom of the hole have been used; however, lighter loads are required in weak rock masses. Explosives packaged in long narrow cardboard tubes that can be coupled into a continuous column as they are placed in the hole can be used in place of the taped loads. These have proven to be effective.

Hole depth in presplitting is limited by the difficulty in drilling accurately aligned holes. This is dependent on the quality of the rock mass. Deviation of greater than 150 millimeters from the desired plane of shear will give inferior results. Generally, 15 meters is the maximum depth that can be used without significant deviations of alignment unless unusually large diameter holes are permitted.

Presplitting can be accomplished in conjunction with the primary blast by delaying the primary holes so that the presplitting holes will fire ahead of them. Shooting far in advance of primary excavation can be troublesome if the rock characteristics change and the load causes excessive shatter in weaker areas. By carrying the presplitting only one-half shot in advance of the primary blasting, the knowledge gained from the primary blasts regarding the rock can be applied to subsequent presplitting shots. In this manner, the loads can be modified if necessary, and less risk is involved as compared to presplitting the full length of the neat excavation line before starting the primary blasts.

The above considerations are typical of the issues addressed by the Contractor in the Blasting Plan. It is not Federal Lands' intent to order methods and procedures beyond those in the Contract. Certainly if the Contractor has difficulty achieving required results, these and other issues should be discussed with the Contractor and with trained blasting specialists if the Project Engineers is uncertain of his/her own ability to deal with the technical issues.

Although not normally required, some contracts may, for aesthetic reasons, require the removal or obliteration of remaining drill holes in cut faces.

## E. Prewatering Excavation Areas

In some areas, prewatering of excavation areas by sprinkling, flooding, or irrigation provides more uniform distribution of moisture with less water than truck watering in the embankments. This will also reduce the need for manipulation of the soil on the roadbed. When prewatering is used and water is specified as a pay item, the Project Engineer must closely observe and evaluate the prewatering operations to avoid payment for wasted water. The special contract requirements may limit the pay quantity to the amount required to provide the proper moisture content for compaction to specified densities.

**F. Slope Rounding and Warping**

Slopes are to be rounded as indicated on the plans. The method of measurement and basis for payment is specified in the Contract.

The Project Engineer should encourage the Contractor to perform the slope rounding as a part of rough grading operations, rather than doing it as a special operation after slopes are otherwise finished. This will usually minimize the work involved and improve its overall quality.

In order to obtain reasonably smooth and uniform surfaces required by the specifications, slopes should be warped and adjusted to harmonize with existing landscape features. The Project Engineer can help assure the desired results by carefully reviewing the slope stakes on the ground and ordering appropriate adjustments before grading work begins.

**G. Waterways and Ditches**

Satisfactory drainage often is difficult to secure, particularly in flat country. Except when ponds are specified, waterways should drain quickly and efficiently away from the highway. Cut ditches should be flared out away from the roadbed at the end of the cuts and extended on the natural ground to a point where water will not discharge along the junction of the fill slope and the natural ground. Abrupt changes in these outlet ditch grades should be avoided to prevent erosion or silting. If possible, the flow line slope of waterways should not exceed that which is proper for the material. Where that slope is exceeded on steep grades, the Project Engineer should consult with the Construction Operations Engineer to determine the need for additional cross drains, paving of waterways, or other corrective measures to prevent scour. Extra wide sections require special consideration, especially when super elevation may increase scour or erosion potential.

Where considerable surface drainage over the top of a high cut appears likely, the Project Engineer should consult the Construction Operations Engineer regarding measures to be taken. One method of correction would be the construction of ditches above the cut to intercept and lead the flow to natural drainage courses. Such ditches should be far enough away from the edge of the cut to prevent seepage sufficient to cause sliding, and should not be so steep as to cause erosion. Unless shown on the plans, construction of such ditches in sensitive areas, such as on Park or Parkway projects, should not be undertaken without the agreement of appropriate Park Service officials. Right-of-way for such ditches may be a consideration for some projects.

**H. Subdrainage**

Thorough attention to subdrainage is essential to the life of the road and will result in reduced maintenance costs. Should the Project Engineer suspect the presence of subsurface water in such quantity as to affect the stability of the roadbed, and if corrective measures have not been provided in the plans and specifications, appropriate action should be taken to correct the problem. Stabilization may be accomplished by the simple installation of underdrains under certain conditions. Other conditions may require special investigation and more involved designs using geotextiles. The Project Engineer should consult with the Construction Operations Engineer or FLH specialists when simple underdrains are deemed inadequate for the field conditions.

Section 9-6 of this manual contains information on the construction of underdrains.

**I. Embankment Foundation Preparation**

The quality of embankment construction depends on the proper preparation of the foundation. The presence of subsurface slippage planes, soft or saturated material, and springs or seepage are some of the conditions which may cause embankment failures. These require careful attention.

The plans and/or special contract requirements will usually provide corrective measures for unstable foundation conditions known to the designer. Some may not have been known. Clearing and grubbing may expose them. Before embankment construction begins all embankment areas should be examined to determine any need for corrective treatment. Some areas of questionable support may only require subgrading. Others will require extensive systems of underdrains, filter blankets, rock trenches, or rock embankment.

During the construction of embankments on hillsides, particular attention should be given to obtaining the best possible interlock between sloping original ground surfaces and the new embankment. Sufficient benches should be excavated to assure a firm bearing on solid material. Payment for the benching will depend on how the specifications are written. If not addressed in the specifications, a contract modification may be required.

One of the most frequent points of embankment failure is the area where the roadway changes from excavation to embankment. It is advisable to explore these areas for possible need of underdrains to remove seepage water. The benching operation described above should be very carefully followed in these transition areas.

For any embankment area where the foundation treatment and/or Contract items provided in the Contract seems inadequate for the actual field conditions, advice of the Construction Operations Engineer should be sought.

**J. Embankment Failures -- Causes and Corrective Measures**

Embankment failures or displacements are due mainly to improper design or construction, or both. Four major causes of embankment failures are discussed below. The design should be based on a thorough exploration of foundation conditions and available embankment materials. Serious failures occurring or expected during project construction should be corrected on the basis of subsurface investigation and analysis. The Project Engineer should consult the Construction Operations Engineer to arrange this.

**(1). Failure due to weight of the embankment displacing soft foundation material**. This failure is usually characterized by an en masse drop and lateral movement of a portion of the fill. To provide a satisfactory embankment over a soft foundation, three approaches may be taken:

- **Removal and replacement of soft soil with suitable material.** This may be the most economical method to depths of about 3 meters.

- **Reduction of applied shearing forces**. This can be accomplished by reducing the height of the embankment, using light-weight material in the embankment, and by either flattening the side slopes or by using toe berms.

- **Strengthening of the soft foundation soil.** This can often be accomplished through consolidation. Drainage ditches may be used to lower the water table and consolidate the foundation soil under its own weight. Foundation strength may be allowed to keep pace with increase in load by providing adequate time for foundation consolidation. A sand blanket placed directly on the soft foundation soil, or vertical sand drains in combination with a sand blanket, will increase the allowable rate of consolidation. This rate must be controlled by field measurements during construction.

  Pavement failures due to excessive consolidation of the soft foundation soil may be reduced by removing the soft material, providing sufficient time for consolidation before paving, or by accelerating the consolidation by the use of a temporary surcharge and one of the drainage methods noted above.

**(2). Failure due to loss of stability of embankment through impounding of hillside seepage water causing saturation**.

This type of failure is usually identified by characteristic sloughing of part or all of the fill. When opened up, the impounded water will usually gush out until the hydrostatic pressure is relieved. Prevention of such failures usually lies in providing for escape of seepage water by means of subdrains or placement of very porous material in the lower part of the fill.

**(3). Failure due to the weight of embankment causing movement on a well defined slippage plane in the underlying foundation**.

This type of embankment failure is generally characterized by bodily movement of the fill, without sloughing. The usual correction is to intercept and remove the subsurface water by trenching or placing subdrains above the fill

(**4). Failure due to horizontal stresses produced by the weight of the fill being greater than the corresponding shearing resistance.**

This condition occurs when the slopes are too steep for the height of the fill and the type of the material, or when the material is insufficiently compacted. Proper compaction and correct slope design are both essential for permanent fill stability.

**K. Embankment Compaction**

The need for adequate compaction of embankments should be strongly emphasized. Compaction of the lower portions is necessary to prevent settlement and provide stable slopes. It is important in the upper portions and subbases to provide bearing capacity, control volume change, and provide uniformity.

All embankments are to be compacted in accordance with the Contract specifications. The specifications normally do not prescribe the type of compaction equipment to be used. Unless otherwise specified in the special contract requirements, the Contractor is free to use equipment of its own choice, provided it will compact the embankment in accordance with the Contract requirements.

The Contractor is required to bring the embankment material to a uniform moisture content suitable for compaction and to compact the embankment until it consistently meets the Contract requirements.

It is the responsibility of the Project Engineer to verify that the moisture-density relationship of each type soil to be used in embankments is determined in accordance with the test methods specified. In most contracts the actual sampling testing and documentation will be the responsibility of the Contractor. As discussed in Section 9-2.3 of this manual, this will require use of preliminary soil data and supplementary sampling and testing of any soils encountered during construction which are different from those sampled during the preliminary soil survey.

The specifications usually require density tests of compacted embankment material to be made in accordance with AASHTO T 238, or other approved methods. In place moisture is determined by AASHTO T 239. The Project Engineer should make observations and reviews of density tests to insure that prescribed procedures are being used, required density is being attained, and adequate documentation is being maintained.

If more than one type of soil is being compacted into embankments, the selection of the proper moisture-density curve becomes as important as the density test itself. It may be necessary to use a family of curves (AASHTO T272) in combination with a one point proctor in order to select the proper curve.

In gravelly or rocky soils a coarse particle correction (AASHTO T224) or a family of curves may be necessary to correct for differing percentages of coarse particles in the field as compared to the original proctor. This is especially true when a nuclear gauge is used in gravelly soils. A sample may be required in order to compute a coarse particle correction each time a density test is taken.

During construction, a record of all relative density tests should be maintained on a chart drawn to convenient scale. This may be done on a roll of cross-section paper with both plan and profile plotted as horizontal lines. Depth and location tests and retests can thus be easily shown in relation to grade and centerline station.

The success of compaction operations is dependent to a large extent on proper moisture control. If the proper amount of moisture is uniformly distributed throughout the embankment layer, rarely will there be any difficulty in obtaining satisfactory compaction, provided the thickness of the layer does not exceed the capabilities of the roller being used. The common tendency to construct earth embankments at moisture contents on the dry side of *optimum* makes the task of securing uniform moisture distribution and satisfactory compaction more difficult. Usually, it is better to begin compaction with the moisture content slightly high; however, in humid areas it may be better to begin with the moisture content near optimum.

The mixing and blending of soils and water should be thorough. Large clods and lumps must be broken down to insure a uniformly moist condition. Whenever it is necessary to blend moisture into very plastic clays, heavy plowing and turning of the soil will usually do the job satisfactorily; however, in certain extreme cases some type of mechanical mixer may be needed.

When adding water to a layer of material, care must be taken to avoid overlapping or gapping between successive passes of the water distribution equipment. Wet or dry streaks are undesirable and should be avoided. Application of water should begin on one side of the embankment and progress across to the other side to avoid having wet or dry streaks in the center of the embankment. It is better to make several light applications rather than one heavy application of water.

In lieu of applying water to material in the embankment to attain the proper moisture content for compaction, the excavation or borrow areas may be prewatered as discussed in e. of this subsection.

In using density tests to determine the adequacy of compaction, recognition should be given to causes of variations in test results which are to be expected in using this method of compaction control. Exact representative samples are seldom possible. When it is not possible to properly perform meaningful tests due to high rock content or for other reasons, explanation as to why the tests were not made should be entered on the form provided for recording the test results

**L. Disposal of Surplus Material (when off-site disposal is not a Contractor responsibility)**

Unavoidable waste or surplus from roadway and structure excavation is to be utilized, to the maximum extent practical, to widen embankments, flatten slopes, and provide parking areas. Proper distribution is necessary to secure uniform appearance of the finished roadway. Boulders or rocks brought to the surface by scarifying generally are to be covered in embankments or disposed of as authorized by the Contract.

The necessity for widening of embankments should ideally be determined early enough that such widening may be incorporated in the originally planned embankment. If surplus material is developed after the nearby embankments have been completed, it should be used to fill pockets on the uphill side of embankments, or hauled and wasted in other suitable disposal areas.

Proposed disposal sites for any significant quantity of unanticipated surplus material should be discussed with the Construction Operations Engineer and representatives of cooperating agencies. There may be need for permit consideration in accordance with State or Federal regulations.

**M. Finishing Earthwork**

Before the finishing operations begin, the Project Engineer should carefully check the roadway to see that the earthwork is in reasonably close conformity with the staked lines, grades and cross sections. The Standard Specifications require the roadway to be finished to reasonably smooth and uniform surfaces. Refer to Chapter 1 for a discussion of tolerances not explicitly specified.

### 3. Measurement

Refer to Subsection 8-1.3, of this manual, and to the appropriate measurement sections in the Contract. The Standard Specifications detail what is and is not to be included as excavation and embankment.

Most excavation and embankment items are paid as staked quantities, i.e. the computer generated quantities based on field cross section and slope stakes. Often secondary measurements are taken to modify the original quantities, e.g. when a slope is laid back.

Adjustments to authorized quantities may also be appropriate, if for example the Contractor wastes material which could be used, or uses excavation for rip-rap which necessitates it being replaced by borrow or expanded excavation.

Some quantities are measured in place. For example subexcavation is often inspected as it is excavated and the limits of the excavation determined at that time.

### 4. Documentation

Refer to Subsection 8-1.3, of this Manual

Generally basic documentation will consist of the computer generated quantities. The computer run should be dated and cross referenced to the Summary Book. Obsolete versions of computer runs should be destroyed or clearly marked as "superseded". Adjustments to the computerized quantities should be in field books or supplementary computer runs and also cross referenced to the Estimate Book. It should be possible at any time for someone unfamiliar with the project to pick up the Estimate Book and to follow the cross references back to the detailed quantities authorized and accomplished.

### 9-2.4 Soil Erosion Control

#### 1. Preliminary Review and Approval

Construction activities that are subject to high erosion risk include clearing and grubbing, earthwork, ditch construction, haul roads, culvert installation, channel changes, pier or abutment work in streams, temporary stream crossings, borrow pit operation, and hydraulic or mechanical dredging.

The Contract will contain an erosion control plan that reflects special concerns, measures to protect resources, and permit requirements. The Contractor may submit an alternate plan for approval, but the alternate plan must comply with Contract requirements, constraints and permits. No work on any segment of the project may begin until the required erosion control devices associated with that segment are installed.

Approval of alternate plans should be based on compliance with the requirements and constraints in the Contract, and, if applicable, requirements and constraints in the permit, and in the regulatory requirements of local water quality agency. If the Project Engineer encounters approval/disapproval issues which are not addressed by these documents, the subject should be discussed with the COE.

It is required that the Contractor incorporate all permanent erosion control features into the project at the earliest practicable time. This commitment should be reflected in the proposed progress schedule. If the Contractor subsequently fails to adhere to the schedule and is forced to install additional temporary devices or seeding because the site is not ready for permanent devices or seeding, FLH may take the position that the cost of the additional devices are not compensable under the Contract.

The effectiveness of erosion control should be reviewed and updated prior to any winter shut down or expected erosion potential. Sediment traps, settling basins, stage seeding, mulching, temporary slope drains, special berms, terraces, ditches and/or dikes, temporary seeding, sodding, contouring, benching, serrated slopes, and erosion control mesh may be placed in the construction contract to control soil erosion and stream pollution.

#### 2. Construction Inspection

Prior to beginning each major construction operation phase, the Project Engineer should make a detailed inspection of the project with the Contractor's representative to verify that the approved schedule remains adequate and to go over details not covered in that schedule. Once the devices are installed, additional inspections should also be made periodically to verify the adequacy of the plan.

NPDES permits require inspections at least once per week and after rainfall greater than 10 millimeters. These inspections must be documented and maintained in a separate file. The Contract may require the Contractor to conduct, participate in, and/or document these inspections. Otherwise the Project Engineer is responsible for them.

#### 3. Measurement

Measurement for erosion control devices normally starts with the quantities authorized in the Contract which are based on the specified Erosion Control Plan. If the plan is modified or quantities are adjusted, written authorization for the modifications is required. Once the devices are installed there should be documentation in the IDR's or a field book that each of the authorized installations has been accomplished. If additional quantities, beyond those authorized in the Contract are required, a contract modification may be necessary.

#### 4. Documentation

Basic documentation for erosion control items consists of the following:

- The Contract or alternate approved plan for erosion control devices.

- Documentation/authorization for quantities in excess of those provided in the Contract..

- Inspection documentation that the required devices have been installed and maintained for the duration of need.

The Estimate Book documentation should be cross referenced to these items.

### 9-2.5 Structural Excavation

#### 1. Preliminary Review and Approval

Excavation for structures is usually bid at prices considerably higher than unclassified excavation. This is largely due to the smaller quantities, difficult access and special foundation preparation and backfill requirements which are included in the bid price for structural excavation. It is the latter requirement which require the most inspection and approval efforts.

#### 2. Construction Inspection

Inspection is required after excavation and foundation preparation has occurred to verify that the foundation materials and their compaction meet the Contract requirements. During backfill, verify that the backfill materials meet contract requirements and that compaction also meets those standards.

Inspection frequency should be random until it is verified that the Contractor is doing a good job controlling the quality process. Inspection frequencies can then be reduced further. Major, critical structures should receive more inspection, especially the approval of the foundation prior to placement of forms for footings.

When backfilling structures, particular attention should be paid to drainage behind such structures. The plan usually require weepholes. The material adjacent to weepholes should be permeable but not erodible. The Contract may require filter fabric to assure separation of coarse rock immediately adjacent to the hole, from finer erodible materials further away.

#### 3. Measurement

Structural excavation is often not included as a bid item and no measurement is performed. When it is included, measurement is usually *as staked.* That is, quantities are computed based on the dimensional limits in the Contract including the elevations of footings regardless of the quantities actually excavated. Sometimes additional excavation is ordered because the foundation does not meet design expectation. These quantities may be ordered to a specific depth - say 200 millimeters, or excavation may be performed under inspection and measured after a suitable foundation is exposed.

If there is no item for structural excavation, then measurement is not an issue. When structural excavation is a pay item, measurement is usually a staked quantity controlled by ground elevation [after unclassified excavation is removed], and vertical planes 450 millimeters from the structure. There is no remeasure of quantities outside those vertical planes, nor is there remeasure of quantities inside the planes not excavated [e.g. adjacent to a footing].

#### 4. Documentation

If structural excavation is a pay item, documentation requirements include original ground elevation, or computed elevations after unclassified excavation is removed if that is appropriate.

Actual computations of structural excavation should be the theoretical volumes below the natural ground or unclassified excavation. These quantities should be verified in the field after being performed. Volumes not excavated should not be paid for, e.g. if the Contractor excavated against natural ground instead of forming. Additional quantities should not be paid for unless the Engineer ordered a footing lowered or expanded.

**9-2.5 Watering**

See 9-2.3 for a discussion concerning watering for embankment construction.

Unless otherwise provided in special contract requirements, only that water necessary for dust control is measured for payment. Documentation may be a tally of loads of haul vehicles. This may be maintained by the Contractor, so long as the Project Engineer performs verification at checks at reasonable intervals. The tally of loads should include the time of complete discharge of each load to discourage accidental double counting. The determination of haul vehicle capacity should be witnessed by an FLH inspector. Determination should preferably be by weight if scales are available, or otherwise by meter, or computed volume (least preferred).

### 9-2.7 Finishing Roadbed

#### 1. Preliminary Review and Approval

On new grading construction, finishing of the roadbed is usually a subsidiary obligation of the Contractor under other items of the Contract. Similarly, on projects providing for a base or surface course on a previously constructed roadbed, the *finishing* or preparation, of the previously constructed roadbed is usually a subsidiary obligation.

When a project includes a section of new grading, plus construction of a base or surface course on a previously graded section as well as on the new work, it is common though not universal practice to include a bid item for *finishing previously constructed roadbed*. This is done for the primary purpose of permitting a Contractor to bid the surfacing items without the necessity of prorating the costs of preparation of the old roadbed. In such cases, payment will be limited to the length of the old roadbed. If no such item is provided, the work is a subsidiary obligation.

#### 2. Construction Inspection

The work required to be performed in accordance with specifications, whether there is a pay item, or the work is subsidiary to other items. Inspection should include surface tolerances, compaction, a visual inspection for soft spots and unsuitable materials.

#### 3. Measurement

Unless there is a pay item for this work, there is no measurement for payment.

#### 4. Documentation

Documentation should verify that each section of roadbed has been inspected, tested if necessary, measured if necessary and accepted prior to construction of subsequent layers.

**SECTION 9-3 - AGGREGATE BASE AND SUBBASE COURSES**

## 9-3.1 AGGREGATE BASE AND SUBBASE COURSES

### 1. Preliminary Review and Approval

### A. General

Prior to placing base or subbase materials the subgrade must meet grade and template requirements. This can usually be checked well enough with sight levels (see Section 4-2). Sight levels are especially useful when fine grading stakes have been knocked out. And, they are useful for checking *quarter crown* and critical superelevation transition sections, whether or not stakes remain.

The subgrade should also be checked for large rocks (over 150 millimeters) in the surface. These will *shine* or reflect through subsequent aggregate and paving courses placed over them.

The thickness of bases, as shown on the typical sections of the plans, is based on the type of subgrade soil, amount of subgrade stabilization, climatic conditions, traffic, and other factors. Base courses should be placed to the thickness shown on the plans unless subsequent determination indicates a different thickness is required, as might be the case if subgrade material proved significantly different than design expectation. Documentation provided with the design package should indicate the assumption made by the pavement designer. Discuss with the COE. when in doubt as to subgrade adequacy.

The Contractor's QC personnel should develop a spread rate for the aggregate course prior to starting the spreading operation. The spread rate converts the tonnage of each truck to the number of meters along centerline which that tonnage should cover. These computations should be checked by the Engineer. The spread rate should be based on the wet density at two percent or so above minimum density.

***Example:***

*Maximum Density (Dry) - 2160 kg/m$^3$*
*Optimum Moisture - 8.0%*
*Maximum Density (Wet) - 2333 kg/m$^3$*
*Target Density (97%) - 2263 kg/m$^3$*
*Spread Depth - 150 mm*
*Bottom Width - 9.2 m*
*Top Width - 8.0 m*
*Area - 1.29 m$^2$*
*Spread Factor - 2263 × 1.29 = 2919 kg/m*

*So a truck with a 30,000 kg net load would cover a spread of 10.28 meters.*

Once laydown has started, the Contractor should perform depth checks and width measurements in order to verify the computed spread rate. When the operation is fine tuned to the point that plan dimensions are being achieved, the Project Engineer must consider *yield*. It is necessary to calculate as early as possible how well the yield, in say stations per metric ton, will match the contract quantity for the item, if the entire course is completed at the same rate. This information will bear on questions of project funding adequacy, materials source capacity, and any necessity to negotiate relative to significant variation from plan quantity.

### B. Materials.

It is the responsibility of the Project Engineer to see that required samples are taken and tested in accordance with the specifications. This applies whether the sampling and testing is to be performed by the Government or the Contractor.

#### (1). Preliminary Sampling and Testing

Laboratory tests for a source approval determination of quality will be made before base or surface course material is produced or shipped. Where the source proposed for use has not been previously explored, tested, and approved, it is the responsibility of the Project Engineer to coordinate the approval process. The Construction Operations Engineer, as well as Division materials specialists, etc. will usually be involved in the approval decision. If the source has been proposed by the Contractor, the specifications may require submission of exploration and test data. The Construction Operations Engineer will advise the Project Engineer on the status of the Contractor's submission, and how any approval letter is to be written when the decision is made.

**(2). Sampling and Testing by the Contractor.**

Whether or not contractor testing is specified, it is the responsibility of the Contractor to effectively control the quality and contract compliance of the material being produced. The specifications include requirements for a contractor inspection system, pursuant to Federal Acquisition Regulations.

It is to the mutual advantage of the Contractor and the Government that the product comply with the specifications at the time of production. However, in the event of deficiencies, blending of filler and other adjustments by the Contractor prior to final mixing and blending may correct those deficiencies. Conversely, material which is found to comply with specifications at the time of sampling at the crusher may be degraded during further handling so that it fails when tested for acceptance.

While base and subbase specifications are for the most part *end result* type, the Contract will often specify proper handling and storage of materials. Therefore, if the Project Engineer comes to believe a Contractor's handling and storage processes will result in quality problems, there is contractual basis for requiring process improvements. The Construction Operations Engineer should be consulted if there is disagreement with the Contractor.

**(3). Sampling and Testing for Acceptance**

Gradation, liquid limit, plastic limit, plasticity index, moisture and density, and other job control sampling and testing required by the specifications will typically be performed in the field. The Contractor is usually responsible for establishing specification target values. For stockpiled materials, the computed composite gradation is most often proposed as the target.

There are at least three methods of adding water and mixing aggregate materials. Regardless of the method used the aggregates will be tested for acceptance based on samples taken from the windrow or roadway after final blending and prior to compaction. The frequency of samples and tests can be determined from the Contract specifications and/or the FLH Field Materials Manual.

## 2. Construction Inspection

### A. Inspection Intensity

The inspection of a high production base or subbase operation will usually require the full attention of one competent inspector even if personnel furnished by the Contractor are testing, weighing, and recording the receipt of materials on the grade. This inspector will be busy verifying the work of the Contractor personnel, designating and monitoring samples and inspecting subgrade ahead, in addition to verifying dimensions of materials placed, keeping complete records of Contractor equipment and personnel usage, and consulting with the Contractor and Project Engineer.

If Government personnel are testing compaction, or are receiving materials, these personnel will be able to relieve the inspector of part of the duties described above, perhaps to the point the inspector can monitor some other project operation also.

### B. Mixing with Water

The Contractor may mix the base course by the stationary plant method, the travel plant method, or the road mix method. When the Contractor elects to use the road mix method, special attention should be given to the following:

- That excess water is not added in such a manner that the subgrade bearing capacity is detrimentally affected.

- That water is added uniformly and not in a manner which might promote segregation.

If the Contractor uses a stationary pugmill plant and storage hopper, it may be necessary to baffle the flow into the hopper to reduce segregation of the aggregates.

**C. Compacting**

The moisture density relationship for base and subbase materials is commonly determined in a central laboratory but a field laboratory can usually perform the tests if time is short.. The laboratory requires a sample of the aggregate, and knowledge of the Contractor's target values. The laboratory usually requires some time for the determination. Aggregates with moisture in the range indicated below can usually be compacted with usual effort.

The Project Engineer should require sufficient moisture determinations of the base course material to assure proper compaction. With the typical material, this moisture content will be between 5 and 8 percent at the time of compaction. The amount necessary will vary with the specific gravity, surface texture, and grading of the aggregate. Preliminary tests made in the Division or other designated laboratory will show the percentage of moisture necessary for proper compaction and maximum dry density. It is essential that the proper amount of water be uniformly mixed with the aggregate before spreading and compaction is started. Base course must be rolled sufficiently and with such weight and type of roller as will assure specified compaction. Excess water will cause flushing of fines to the surface under compaction. Rolling should be stopped in such cases until the excess water is removed, or allowed to run off and evaporate. Water draining from haul vehicles is usually a sign of excessive water in the mixture.

**D. Stockpiling Aggregates**.

The Contractor may elect to stockpile base course aggregate prior to placement. However since testing for acceptance does not take place until placement, this is frequently a situation where a Contractor may initially test the material and document compliance but is later unable to meet gradation requirements.

With or without observing proper stockpiling techniques, the Contractor is responsible for providing aggregate which meets the specified grading requirements upon incorporation into the project. However, compliance with specified handling and storage requirements might mean an overall pay factor of l.0, as opposed to say 0.75 if proper procedures are not followed. .

**3. Measurement**

The method of measurement will be in accordance with the Contract. If the measurement is by the metric ton, the scales must meet the requirements of the specifications. Project Engineers should not confuse checks of *contractor weighing*, with checking the scales. One is a personal integrity issue, the other relates to equipment.

**4. Documentation**

The area of documentation is one which is closely scrutinized by internal and external reviews, and deserves the Project Engineer's careful attention.

Delivery records should be checked against weigh records to verify that material weighed was incorporated into the project. As a minimum the number of loads invoiced should be checked against the number of loads delivered every day. Spot checks of actual tickets against the invoice summary should also be performed routinely.

Weight and delivery records, as described for bituminous mixes in Section 9-4.1a., are also suitable for this work. When the specifications stipulate Contractor weighing, the Project Engineer should periodically verify weights recorded. For platform scales, this is accomplished by taking a truck weighed under normal circumstances and circulating that truck back across the scales and reweighing the vehicle in the presence of an FLH inspector.

This verification process is to be documented in the permanent weigh records. Verification loads are to be selected so as to preclude knowledge or anticipation by Contractor personnel. The Project Engineer and Contractor should have a documented understanding of acceptable tolerances, and what is to be done if they are exceeded. The recommended tolerance for a single check is 50 kg, but the average of several checks should be 15 kg or less. If there is evidence of biased or erratic weighing, the COE should be consulted. The Government may want to considered requiring the removal of the weigh person, and/or applying a correction factor to all invoiced weights.

For belt-scale weighing, a previously weighed truck should also be periodically directed to a properly certified platform scale. This verification should be documented in the permanent scale records. In rural areas this may require a long trip to find such a scale.

In all cases if the Contractor has an English unit scale which otherwise meets Contract requirements, there is no requirement to provide a metric scale if invoices and other documentation are submitted in metric units.

Occasionally it may be necessary to haul material by the cubic meter when measurement is specified by the metric ton. The Project Engineer should keep this type of variation from the specified measurement to a minimum. Where such variation is approved, the Contractor should be required to establish the metric ton per cubic meter ratio by weighing a load of known volume on certified scales. This documentation along with truck volume measurements should become a part of the permanent record.

When the specifications stipulate volumetric measurement in the hauling vehicle, the Project Engineer should verify the measurement of the volume to be hauled by each hauling vehicle. In certain instances, it may be necessary to haul less than the capacity of the truck. When this occurs, the volume being hauled and documented should be accompanied by a written agreement between the Government and Contractor as to the volume to be paid per hauling vehicle.

## 9-3.2 DUST PALLIATIVES

### 1. Preliminary Review and Approval

Review the Contractor's plan for controlling traffic during application and curing. Review supplier certifications to insure that the specified palliative is being provided.

### 2. Construction Inspection

The roadbed to be treated should be brought to the proper template and compacted. Just prior to treatment, the surface should be dampened. Application rates should be determined and equipment calibrated as in Section 9-4.10.2. Runoff is to be avoided, particularly in the vicinity of lakes and streams.

### 3. Measurement

Dust palliative materials are paid by the metric ton. If materials are not used the Contractor should be requested to document the quantities involved and to remove them from the project without payment. However, if the Contractor makes a convincing argument that such materials are not returnable and have no further value, the Project Engineer may have to consider paying for all or part of the leftover quantities and ordering them removed under a Contract Modification. For this reason it is important to plan quantities carefully and communicate with the Contractor as to what will be needed and what will happen to leftovers.

Application of dust palliatives will be paid separately by the square meter, or by the station. The Project Engineer or Inspector should reach agreement with the Contractor on the quantities involved in each application.

### 4.Documentation

Required documentation includes certifications or other acceptable quality documentation.

Invoices or weigh ticket should be submitted to document quantity of materials. Daily records of applications should be included in a field book to document that item.

## SECTION 9-4 - ASPHALT CONSTRUCTION

## 9-4.1 HOT ASPHALT CONCRETE PAVEMENT

### 1. Preliminary Review and Approval

The contract defines the Contractor's responsibility with respect to the production and placement of asphalt mixes. It behooves the Project Engineer to also be prepared with knowledge of proper construction procedures.

As a part of the Quality Control Plan approval process the Contractor's process control procedures should be reviewed both from a procedural standpoint and from a quantitative view. Equipment, screens, scales etc., should be inspected and the test methods examined. Care must be taken to insure that the Contractor testing personnel do not construe the approval of QC equipment and methods as acceptance of the material produced.

The Project Engineer should insure that the mix design samples are adequate in size, representative of the material being produced, and that they are submitted as soon as reasonably possible. The shipment of the asphalt and antistrip agent samples should be coordinated through the suppliers, and the central laboratory notified of their impending arrival.

After the mix design is completed, the Project Engineer should review and compare it with the design criteria to understand the approval process/criteria. The Project Engineer should make certain that the Contractor understands that the asphalt cement content used in FLH mixes is a percentage of the total mix, not a percentage of the dry aggregate.

Before production of the mix begins, the statistical evaluation procedures should be thoroughly discussed with the plant personnel and any problems or questions concerning the procedures resolved before conflicts arise.

Prior to the commencement of paving operations, it is desirable for the Project Engineer and the Contractor to get together for a pre-paving conference. This is an opportunity for both parties to familiarize themselves with the contract requirements and share their plans for proceeding with paving operations. This goes a long way toward minimizing surprises during paving and promotes good working relations.

### 2. Construction Inspection

### A. Plant Operations

**(1) General**. There are, in general, two types of plant operations: (1) the permanently located commercial plant with multiple production operations; and (2) the portable plant, erected on or near the project to produce solely for the project.

The inspection and quality control of asphalt plant operations is typically a Contractor or producer responsibility and covered in the Contractor QC plan. The Project Engineer may ask for documentation and verification that this QC process is effective and may perform verification inspections. Generally FLH oversight of Contractor QC is less necessary at commercial plants.

At the commercial plant site, or as soon as the portable plant is set up and ready to operate, the Contractor QC specialist should make a thorough examination of the plant layout, including storage areas and component parts of the equipment. If the storage areas or any part of the equipment fails to comply with the requirements, corrective measures must be taken before operations begin.

There are two general types of asphalt concrete mixing plants: the batch plant and the continuous mixing plant. Continuous mixing plants include pugmill mixing plants (very rare) and dryer drum plants. In the batch plant, the aggregates are proportioned by weight and the bituminous material proportioned by weight or volume. In the continuous plants, the aggregates and bituminous materials are proportioned by volume based correlated to weight; or in the case of the dryer drum plant, provided with positive weight measurement (belt scales) to allow regulation of the feed gates and permit automatic correction for variations in load.

**(2). Inspection of Plant Equipment**

**(a). Pugmill Mixer**. In order to properly understand the asphalt plant, it is necessary to become thoroughly familiar with the specification requirements and with the particular type of equipment being used. The components of a batch plant and continuous mix plant utilizing a pugmill for mixing are essentially the same. The main difference is the method used to proportion the components into the pugmill mixer. The dryer drum mixer uses an entirely different concept for mixing the aggregates and bitumen and will be discussed separately. As an additional aid for plant inspections, the functions of the most important components of the batch and continuous bituminous plants and some of the factors to be considered during the inspection are discussed below.

- **Bituminous Storage Tanks**. Storage tanks must be of sufficient capacity to maintain continuous operation while allowing for delay in asphalt shipments. They must be equipped with heating devices and must be able to hold the material at the required temperatures.

  Storage tanks must be inspected by Contractor or producer QC personnel to see that they are free of foreign material and any bituminous material other than that to be used in the mix. They must also not admit water, fuel oil or other foreign substances. Steam coils used for heating should be checked for leaks before any asphalt is unloaded and again when the material is first heated. The asphalt cement lines and fittings must be adequate to provide proper circulation between the storage tanks and the plant. All pipes and fittings should be steam or oil-jacketed or otherwise insulated to prevent heat loss.

- **Cold Aggregate Feeder**. The cold aggregate feeder used with a portable plant is generally equipped with four bins, adjustable gates, reciprocating feeders and an endless belt to carry the proportioned aggregate to the dryer elevator. A commercial plant is generally equipped with separate bins, adjustable gates and a tunnel and conveyor system. In either system, the gates must be adjusted so that the aggregates, in the proper amount and size, are delivered to the plant to maintain uniform production.

- **Dryer**. From the cold feeder the aggregate is elevated to the dryer where it is heated and dried to the required temperature and moisture content. The component parts of the dryer are: (1) a revolving cylinder, usually from 1 to 3 meters in diameter, and from 6 to 12 meters long; (2) a burner which is either gas or oil fired; and (3) a fan which may be considered part of the dust collector system, but its primary function is to provide the draft air for combustion in the cylinder. The cylinder is equipped with longitudinal cups or channels, called *lifting flights* which lift the aggregate and drop it in veils through the burner flame and hot gases. The slope of the cylinder, its speed of rotation, diameter, length, and the number of flights, control the length of time required for the aggregate to pass through the dryer.

  The aggregate passes from the dryer to the hot elevator through a discharge chute near the burner end of the dryer. The sensing element of a thermometric instrument should be located in this discharge chute to record or indicate the temperature of the aggregate as it passes from the dryer.

  Dryers must heat the aggregate

uniformly. To prevent coating the aggregate with fuel oil, the burners and draft must be adequate for total combustion of the fuel. Because of possible damage to the bituminous materials, the heating system should be checked to make certain that overheating of the aggregates is avoided.

- **Dust Collector**. All plants are required to be equipped with dust collectors. This is necessary to reduce air pollution and to return dust to the hot elevator when needed to meet aggregate grading requirements.

  In operation, a fan exhausts the draft air from the upper end of the dryer into the dust collector system. This draft air, containing dust particles, vapor, and gases enters the dust collector at the upper periphery and goes upward. The heavier dust particles are separated by centrifugal force into the collector shell and fall to the bottom. The heavier dust will be reintroduced into the flow of aggregate or wasted as required by the specifications or grading requirements.

  To comply with established air pollution limitations, the use of a scrubber or other suitable device to practically eliminate dust particles from the exhaust air of bituminous plants is sometimes required. The Contractor is to comply with all Federal, State, and local laws and ordinances. The more stringent rules normally apply.

- **Hot Elevators**. Hot elevators must be protected so as to prevent chilling of the aggregate or the blowing away of fines.

- **Screening Unit**. The heated aggregates are elevated, usually by a bucket elevator, to a screening unit, which separates the aggregate into the required number of size fractions and deposits the various sizes into the graded aggregate bins. The screening unit on most plants is the flat table vibrating type, usually equipped with four decks. The size of the screens on the decks varies with the type of bituminous mixture to be produced. The top deck is covered with a scalping screen which removes all oversize material and discharges this material into a reject chute.

  Screens should be examined and a record made of their dimensions, length, size, and rotation or vibrating speed. They should not clog nor overflow during normal operations. Holes or breaks in a screen should be repaired promptly.

- **Hot Aggregate Bins**. These bins hold the heated and screened aggregates in various size fractions required for the type of mixture being produced. The bottom of each bin is fitted with a discharge gate which can be operated manually or automatically. Each bin must be equipped with an adequate overflow pipe.

  Inspection of the bins should include an examination of the partitions to see that they are tight, free of holes, and of sufficient height to prevent the intermingling of aggregate sizes. The closure of discharge gates must be positive enough to prevent leakage into the weigh box. Other leakage from bins and the accumulation of aggregates in the corners or elsewhere is to be avoided.

- **Scales (Batch Plants).** On batch plants, a weigh hopper for the aggregates is located directly under the graded aggregate bins. The weigh hopper is suspended on the weighing mechanism, generally equipped with a springless dial. scale on which the weight of aggregate from each bin is marked accumulatively so that the last mark will read the total amount of aggregate in each batch. The hopper must be large enough to hold the batch of dry aggregate without overflowing or reaching the bin gates.

The bituminous material can be weighed in a special bucket or can be measured by a meter for each batch.

The scales are required to be inspected and sealed. When the plant is ready to operate, the scales should be cleaned and each part carefully checked. It is imperative that the bitumen scales and the aggregate scales be checked daily. The indicating heads must be functioning properly, that is, balanced with the dial at zero. The scale levers and knife edges must move freely. If the weigh hopper is rubbing against some part of the plant or is being supported by one of the structural members, the indicated weight of the material in that hopper will be incorrect.

- **Graded Aggregate Bin Control Gates (continuous plants)**.Up to the point of discharge from the graded aggregate bins, the function of the continuous mix plant and the batch plant are essentially the same. In continuous mixing plants, the proportioning of the separate sizes of aggregate is accomplished through the adjustable gates on the feeder of the gradation unit which deposits the aggregates onto the elevator to be delivered to the pugmill. The asphalt cement is delivered to the pugmill through a calibrated metering pump. The aggregate feeder and the asphalt cement pump are generally geared to a common power source to assure that proportions of aggregate and the bituminous material remain constant, regardless of variations in the power supply. Before production begins, calibration of the flow of aggregates from each feeder gate must be made.

- **Pugmill Mixer**. After proportioning, the aggregate and the asphalt cement are introduced into the pugmill for mixing. The asphalt plant is equipped with a pugmill mixer, which consists of twin shafts equipped with paddles for mixing the ingredients into a homogeneous mass. Efficient mixing is dependent upon the number and shape of the paddle tips, speed of the mixing shafts, length of mixing time, temperature of the materials, quantity of materials in the mixer, and the clearance between the paddle tips and the liner plates. The mixers of batch mix plants and continuous plants are essentially of the same design, except for the variation in arranging the paddle tips.

In the batch plant mixer the materials are dumped into the center of the mixer and paddle tips are arranged to give an end to center mixing or a run-around (figure eight) mixing pattern. The material is held in the mixer for the required mixing time and then discharged through the discharge gate into the transporting vehicles or storage hopper. The mixer must be equipped with an automatic timing device to automatically regulate the dry-mixing and wet-mixing periods, and a batch counter to accurately record the number of batches produced.

In a continuous mix pugmill the materials are introduced in one end of the mixer and the paddle tips are set to transport the materials to the discharge end as the mixing is accomplished. The mixing pressure varies with the height or weight of material in the pugmill, which can be controlled by: (1) raising the dam on the discharge end of the mixer to hold the material in the mixing unit for a longer period of time at a depth that will intensify the mixing action; and (2) adjusting or reversing the pitch of the paddles to retard movement of material through the pugmill.

Linings, sides, bottoms, and gates of the mixer should be inspected to see that there are no leaks. Paddle tips and/or liner plates must be replaced or adjusted when they show excessive wear or when clearance exceeds the specified amount.

**(b). Dryer Drum Mixers**

In dryer drum mixers the aggregate is coated with the asphalt by spraying asphalt into the veil of aggregate during the drying process as opposed to the mechanical mixing of a pugmill in the batch plant. The most important components of the dryer drum plants and some of the factors to be considered during the inspection are discussed below.

- **Cold Aggregate Feeder**. The cold aggregate feeder is basically the same as that used with a batch type plant discussed above with the exception that the main belt feeding the dryer is equipped with a weigh bridge, which is used to monitor the amount of aggregate being fed into the plant at any given time. This weigh bridge is interconnected with the asphalt pump so that the required amount of asphalt is added for the mix. Weights obtained from the weigh bridge include moisture in the aggregates which must be taken into account to arrive at the dry weight of aggregate. Since dryer drum plants do not have screening units and hot aggregate bins, it is very important that the stockpiled aggregates be of the proper grading, are not segregated, and that the gate openings on the cold feeders are properly calibrated for the mix design.

- **Dryer.** The dryer in this type plant not only heats and dries the aggregate, but is also the mixing chamber for the asphalt and aggregate. The aggregate enters the drum at the burner end and is lifted by the flights and veiled through, and in front of the flame, thus protecting the asphalt from direct flame contact. Newer dryer drum plants are equipped with a flame shield to protect the asphalt from the flame, but even with these plants good veiling of the aggregate is also necessary. In order to assure a good veil of aggregate, the plant must be operated within the capacity range recommended by the manufacturer. The asphalt is introduced into the middle one-third of the drum through a spray pipe. Moisture being driven off the aggregate reacts with the asphalt, causing it to foam and thus facilitates the coating of the aggregate.

- **Dust Collector**. Dust collectors on a dryer drum plant are the same as for batch plants as discussed above.

- **Storage Silo**. Since a dryer drum is a continuous operation, the asphalt mixture is transported from the drum by a hot elevator to a storage silo. The silo should be of sufficient size to allow continuous operation of the plant and should be insulated to prevent temperature drop in the mix during storage. Silos should be designed so that segregation of the mixture will be minimized during charging. This is accomplished by using a rotating chute, batcher, or ladder.

- **Controls.** Modern plants are fully automated with control panels that can furnish a variety of data pertaining to the plant operation. The inspector should become familiar with the data output available for the plant to be used.

**(3) Calibration of Plants**. It is not intended that FLH personnel take the lead in the calibration of plants. Commercial plants approved by a State highway agency should not have to be recalibrated for FLH mixes provided documentation of their calibration and accuracy is available. For portable plants, calibration should be a part of the Contractor's QC Plan and subject to the review of the Project Engineer.

The scales (both aggregate and asphalt on batch plants, and the apron feeders and asphalt on continuous plants) should be calibrated before production is started. General information and/or suggestions for consideration by the Engineer are as follows:

**(a). Batch Plants**. The specifications require that noncommercial (project) plant scales be inspected, tested, and sealed after relocation but not less than once per year. Commercial plant scales must be sealed in accordance with acceptable local/industry practice. However, portable plants may be used for a reasonable period of time prior to sealing, providing field testing indicates compliance with the accuracy specified.

For batch plant scales, field testing may be performed as follows: Asphalt and aggregate hoppers should first be balanced with the dial or beam reading zero, making sure that all weighing equipment operates freely. Accuracy of the scales should then be checked at various points within the anticipated operating range, using standard weights required to be furnished by the Contractor. Since it is not required that the Contractor have sufficient standard weights to reach full capacity of the aggregate hopper, the maximum number of weights available should first be placed in the hopper and the weigh beam balanced or the dial read. The weights should then be removed and aggregate dumped in the hopper to bring the beam back to balance or to give the same reading on the dial. The standard weights should again be placed in the hopper and a new balancing or reading obtained. The operation of adding weights, balancing, and replacing weights by an equivalent amount of aggregate is then repeated until the full capacity of the hopper is reached.

**(b). Continuous Plants**. Continuous plants use a positive displacement asphalt pump. Discharge is measured through a meter similar in operation to the ordinary water meter. Rate of discharge is varied either by an adjustment on the pump or by changing the sprocket drive combination. The pump may be calibrated at different rates of discharge by taking initial and final meter readings for a measured length of time. This should be done with the specified grade of asphalt brought to the required temperature and after the pump has been run long enough to eliminate all air from the lines and for the pump to reach operating temperature.

The asphalt meter may be checked from time to time by comparing the difference in meter readings with the known amounts of asphalt that have been run through the plant. These known amounts may be obtained from the weights of asphalt delivered to the job or by asphalt storage tank measurements using the appropriate calibration curves.

Proportioning of aggregates in a continuous plant is by volume rather than by weight as in the batch plant. Calibration involves converting these volumes to weights. Discharge from the different bins is obtained by varying the rate of discharge by adjustments of a gate over an apron feeder. Continuous plants are normally equipped with gates for simultaneously diverting the discharge from its normal path to the pugmill to sampling cans - one can for each bin. The amount of aggregate discharged into each can for a given number of shaft revolutions and at various gate openings is weighed. From this data, calibration charts can be prepared which will show the proportionate rate of discharge for each particular type and grading of aggregate used in the calibration. The aggregate for calibration should be dried and screened in the same manner as will be used during construction. In other words, a "dry run" will be made with aggregate fed to the dryer, with dryer screens operated the same manner as for actual plant-mix production. Calibration will normally start with the gate openings set at about 50 millimeters and then graduated to openings corresponding with the maximum capacity of the plant.

To facilitate calibration, the Contractor should have available a copy of the manufacturer's operating instructions, which will show the operating speed of the feeder and the asphalt pump delivery rate for the various sprocket sizes. The sprocket size for the asphalt pump must be checked, for the delivery rate required, by weighing the amount of material pumped into a container over a carefully timed interval.

**(c). Dryer Drum Plant**. Calibration of a dryer drum plant consists of setting the cold feeder gates for each aggregate size and setting the asphalt pump for the proper asphalt content. The pump should be set for the desired percent asphalt based on rate of the aggregate feed as determined from the cold feed weigh bridge, remembering that the percent moisture in the aggregate must be deducted from the cold feed weight.

**(4).Inspection of Plant Operations**.

**(a). General**. With today's fully automated hot plants, it is not often that the plant is found to be the cause for construction of poor quality hot asphalt concrete pavements. The plant QC specialist should be familiar with the operation of the plant, and be able to monitor gate openings, scale settings, timer settings and temperature controls. Such things as screening units, bins, mixers and overflow vents should be checked to assure they are functioning properly.

End result specifications place the responsibility for quality control with the Contractor. The Project Engineer should be familiar with the Contractor's quality control plan and monitor the results for any indication of change which could be expected to affect the quality of the work being produced. It is important that FLH personnel and the Contractor cooperate fully in order to produce a high quality, acceptable paving material.

During production, the QC specialist should make periodic checks of:

- Cold feeder gates and overflow vents for any overflow of the graded aggregate bins
- Temperature of aggregates, bituminous material, and mixture
- Proper dryer operation
- Weighing and mixing operations; and
- Mixture in trucks for uniformity in appearance.

The Project Engineer should see that the haul tickets are properly made out and issued for each truckload of mixture delivered, and must see that the daily totals are promptly obtained, checked, entered on the daily report, and made a part of the permanent project records.

**(b). Operation of Cold Feeders**. The first and most important aggregate proportioning is done at the cold feeders. To provide the proper flow of the right sizes of aggregates, the proper sizes of aggregate must be in the stockpiles and kept from segregating and intermixing, and the feeder gates must be kept adjusted and free from obstruction. Enough material must be maintained in all bins to provide a positive and uniform flow.

Plant QC should include observation of the equipment feeding the plant from the stockpiles and be sure that the material is uniform when it is fed to the dryer unit. Segregated aggregates fed through the dryer will result in uneven drying and heating which, in turn, result in nonuniform screening and ultimately in a nonuniform mix.

The specifications will normally require that the materials be separated into a minimum of two stockpiles. One pile will normally contain that fraction retained on a 4.75 mm sieve, and that the other fraction passes the 4.75 mm sieve. The cold feed bin must be so constructed so that there is no intermingling of the two sizes of material.

**(c). Screens and Bins**. The size and relative amount of fine aggregate controls the voids in the mix, which in turn controls the proper proportion of asphalt in the mix. Every effort should be made to hold the grading uniform. Segregation occurring in the fine-aggregate bin can be corrected by properly placed combining chutes and baffles.

The coarse aggregate bin should be inspected occasionally for a carryover of the fine material. Carryover can be corrected by installing a section of larger-opening screen, reducing the rate at which the material passes over the screen, or changing the length, diameter, pitch or speed of the screen. The presence of more than 5 percent of smaller sized material in any bin, is an indication that excessive carryover is occurring and screens are either clogged or overloaded.

Sampling of aggregates prior to mixing with bituminous material may most conveniently be made of the dried and screened aggregates in the different bins. Most plants, either of the batch or continuous types, are equipped with sampling trays that make sampling from each bin quite easy.

**(d). Checking of Asphalt Content.** Probably the most common cause of failure in asphalt paving mixtures is the incorrect asphalt content. Incorrect asphalt content can be caused by inaccurate scales (asphalt and/or aggregate), variation in aggregate grading, absorptive qualities of aggregates used, or poor interpretation of preliminary test results. Attention must be paid to the lever systems of the scales on the mixing plant to be sure they are functioning properly.

**(e). Mixing**. The method of charging the mixer, which gives a homogeneous mixture in the least possible time, is the desired method to adopt for the job. The most commonly used method of charging is by dropping the weighed batch into the mixer and thoroughly mixing dry for a period of a few seconds before adding the asphalt.

The mixer should produce a uniform distribution of asphalt throughout its length. The introduction of the asphalt by means of a spray bar over the entire length of the mixer aids in obtaining uniform distribution.

Temperature of the aggregate has a marked effect on the mixture. If the aggregate is too cold, a nonuniform distribution of asphalt through the mixture will result. If too hot, the aggregate will cause excessive hardening of the asphalt and will result in a too thin coating on the coarse aggregate with a corresponding excess of asphalt in the fine aggregate portion.

The requirements for limiting the temperature of the aggregates are in the specifications. The temperature can be measured most conveniently on the mixture immediately after discharge from the plant.

During the actual mixing process the QC process should include frequent observation of the operations from the mixing platform with notation of the care used by the operator in weighing each size of aggregate and the asphalt; the time interval for mixing the dry aggregate; whether or not the asphalt bucket is well drained; and the time of mixing the asphalt and aggregate. The inspector should also note the action of the mixture in the mixer box to determine uniformity of mixing and the tendency toward segregation. The movement of the mixture is controlled by the position of the mixer blades. Variations in uniformity can usually be eliminated by changing the position of the blades. This must be done by trial. When the blades are satisfactorily set, they seldom need further attention.

Attention should also be given to the mixer-box to see (1) that the liners and blades are so set that all of the material will be incorporated into the mixture and that none lies in the bottom of the box to be dropped out eventually as an unmixed or partially mixed combination, and (2) that the discharge gate of the mixer box is neither unduly worn nor improperly seated. Its condition can usually be determined by observing the bottom of the box from the time the dry aggregate is introduced until the completed mixture is dropped. If a thin stream of dust and fine aggregate sifts from the gate during the dry-mix period, or a rich mixture of asphalt and fine aggregate seeps through during the wetmix period, this indicates that the gate does not fit tightly. If, as the gate opens to discharge the mixture, a stream of dry, uncoated aggregate appears first, there is indication that the gate lining is worn, or the mixer blades are not picking up the aggregate. In either case, the Contractor should take the necessary action to eliminate the problem. No useful purpose is served by accurately preparing and weighing the components of the mixture if they are not combined properly. A satisfactory mix is of uniform coating and appearance, free from segregated areas or heavy smoking. No more mixing should be employed than is necessary to completely and uniformly coat the coarse aggregate. The manufacturer's rated capacity should not be exceeded, nor should the minimum specified mixing time be underrun.

Mixers should be cleaned daily with hot dry aggregate and with hand tools if necessary. The cleaning should not be so thorough, however, as to polish the mixer sides. This may occur with the hot dry aggregate cleaning. Cleaning with oil should not be permitted.

Where continuous mixers with volumetric proportioning devices are used, the QC process should include a check of the accuracy of the proportioning devices and require any necessary adjustments before production of the mixture is begun. The Contractor should have available descriptive literature and instructions published by the plant manufacturer for the particular plant being used in order to facilitate the checking of adjustments of the equipment.

During the operation of drum mixer plants, the inspector should review and observe operating data of the control panel and should inspect the stockpiles and cold feed for segregation and quality. Aggregate, mixture and asphalt temperatures should be checked periodically. Any deficiencies found should be pointed out to the Contractor and corrective measures taken.

**B. Road Operations**

**(1) General**. It is the responsibility of the Project Engineer or the paving inspector to verify that the paving operations are performed in accordance with the contract. They must be thoroughly familiar with the plans and specifications, the Contractor's plan of operations, necessary traffic control procedures, and construction equipment to be used.

Prior to paving operations, the paving inspector should thoroughly check the surface on which the pavement is to be placed.. The surface should be checked for correct grade and template and all damaged areas, depressions or potholes repaired to give a firm and unyielding paving base. If the surface is a base or subgrade, a prime coat is often required. If so, it must be thoroughly cured. When an existing pavement is to be resurfaced, the surface must be cleaned of dirt and other extraneous matter and all weak areas repaired. If a leveling course is to be applied, the existing surface should be checked and the roughest areas marked to received that course. A tack coat, when required, should be applied to paved surfaces. The tack coat should be applied to the width and length required for not more than the day's operation.

For prime and tack coats Contractor QC personnel should document that equipment including meters is in proper repair and the coverage rates are properly calculated and applied.

The pavement edges should be marked by

stringline or paving guideline sufficiently in advance to assure continuity in the paving. These should be set and nailed to the surface at intervals that will permit the line to be held taut, and checked to be sure that the required pavement width is secured. When necessary, an electronic sensor line is set rigidly supported to the required grade.

**(2) Inspection of Paving Equipment** The paving inspector should make an inspection of the Contractor's paving equipment, checking the condition and adjustment of the component parts of the laydown machine and rollers. This equipment should have already been subject to the Contractor's QC process. Therefore if deficiencies are noted the Contractor should be advised to modify that process. By making this inspection prior to beginning paving operations, obvious deficiencies in the condition of the equipment may be discovered and corrected, thus avoiding delays once the work is underway and assuring that the best possible surface is obtained.

Listed below are some of the more important details the inspector should check during the inspection of the paving equipment.

(**a) Paving Machines**. The inspector should become familiar with the mechanical features of the paver to be used on the project, so that an intelligent appraisal of the condition and adjustment of the machine may be made. Operating details and instructions for adjustments are contained in the manufacturers' handbooks. These handbooks should be available to Contractor QC personnel as well as the Engineer and inspectors. The Contractor QC person should check the general features listed below before starting paving operations:

- On all paving machines the operating motor should be checked for proper governor operation and vibration at operating speeds.
- On track mounted machines, track linkage must be correctly adjusted and checked for excessive wear.
- On pneumatic-tired machines, all tires should be inflated to the recommended pressures, and the drive chains checked for correct adjustment and for excessive wear.
- The screed should be free from excessive play, and have the correct adjustment for crown and tilt.
- Check screed plates for excessive wear, and screed heating burner's operating efficiency. Screed extensions must be in the same true plane and flush with the screed bottom. Check vibrators on the vibrating screed for proper operation.
- Automatic grade or thickness control, should be checked for proper operation with ski or other device(s) as required.

**(b) Rollers**. Check steel-wheel rollers to see that the wheels are capable of rolling in a true plane and are free from flat spots or ridges. The steering and driving mechanism must be free of excessive play or backlash; and the motor and driving transmission free of oil leaks. The rollers must have scrapers for keeping the rollers clean and wetting pads to keep the rollers wet so they do not pick up asphalt during the rolling operation. Water and a wetting agent should be used, not a petroleum based product.

With the widespread use of vibratory rollers for compaction at asphalt mixtures, the laydown inspector should become familiar with their operation. A variety of information is available covering the use of vibratory rollers and the effects of vibratory compaction variables such as frequency, amplitude, mixture and construction parameters such as gradation, aggregate characteristics, type and amount of asphalt, environmental conditions, lift thickness and type of base. The inspector should become familiar with the rollers to be used and the adjustments that can be made to control frequency and amplitude. The adjustment of these two variables can have a marked effect on the compaction of the mixture. Roller operators have a tendency to "set it and forget it," so the QC process should require frequent verification that settings are correct..

**(3) Spreading and Finishing**. The specifications require the use of a asphalt paver for spreading and finishing the mixture. In irregular areas the mixture may be spread and finished by other suitable tools or equipment.

The paving inspector's routine duties are to collect load tickets from the Contractor's laydown foreman, and to verify that they are complete and that depths and spread distances are being controlled effectively. At the end of the day the inspector must sign a daily weight record attesting to the acceptance of the total weight. The inspector's principal duty is to assure construction of a pavement to the correct grade and template as set forth in the plans, and with a surface texture and riding surface as required by the Contract.

To achieve these results, the inspector must monitor the Contractor's QC process and periodically check the surface to be paved, the mixture in the trucks, surface texture behind the machine, rolling operations, and paved surface with a straight-edge or string line for the proper crown and smoothness.

When ready to start paving operations, the screed should be heated to the proper temperature and the grade controls set to construct the transverse joint. This must be carefully checked to insure good riding qualities and conformity with the tolerance requirements before the paver is allowed to proceed. Particular care should be exercised in setting the thickness control device to assure attainment of the spread and crown desired. When matching the edge of a previously laid section of pavement, the paver screed should overlap the existing edge from 25 to 50 millimeters and the thickness controls should be adjusted to leave the material slightly higher than the previously laid section of pavement. Overlapping this edge will force enough material into this area to insure that the joint is completely filled and moisture proof. The height of the material above the previously laid edge should adjusted so that when the longitudinal joint is properly compacted, the pavement will be uniform in cross section and within the tolerances specified.

The use of any hauling unit with a frame that comes into contact with the paving machine or which bears down on the machine while dumping, should not be permitted. The result either or both of these conditions will be a rough surface.

As the paving proceeds, the grade or thickness control devices must be adjusted to give the spread as required by the plans. As continuity of operations is essential to secure a good pavement surface, the speed of the paver should be regulated to avoid stopping and starting.

By observing the surface texture behind the machine, and checking the surface with a straightedge, a malfunction in the paver or segregation of mixture may be detected. The inspector should insist on prompt action to locate and correct any trouble that occurs. Some of the most common difficulties encountered are listed below with the possible cause:

- **Wavy Surface (short choppy waves)**. Worn or poorly adjusted tracks or drive chains; truck driver setting brakes too tightly; excessive paving machine speed.

- **Wavy Surface (long waves)**. Excessive variation in the amount of mix carried in the auger box; rolling too early; roller operating too fast; over controlling the screed.

- **Excessively Open Surface Texture**. Improper adjustment of the tamper bar; improper speed of tamper bar; screed plate rough or galled; excessive machine speed.

- **Varying Surface Texture**. Insufficient mixing; over mixing; overheating of the mixture; dry mixing period too long; segregation of mix in trucks; worn or damaged screed plate.

- **Bleeding Patches on Surface**. Asphalt not uniformly mixed; excessive moisture in mix; excessive prime or tack coat..

- **Irregular Rough Spots in Pavement**. Roller standing on fresh surface; abrupt reversing of roller; trucks backing into machine; poor workmanship on transverse joints.

All pavers are required to be equipped with automatically controlled screeds. Automatic control of transverse slope as well as proper elevation must be maintained to obtain the required surface. When this unit malfunctions, it tends to compound its errors; therefore, the paver must be stopped immediately, the pavement corrected, and the malfunction located and corrected before preceding with the operations. Essentially, the automatic grade control unit divorces the screed from the upward and downward movement of the floating arms which attach the screed to the machine, and transfers this control to the unit equipped with a sensor element which travels on a rigidly set or traveling guideline.

When the pavement is constructed in more than one course, the longitudinal joint should be offset from each preceding course with the surface course joint being in the center of the pavement. The screed should overlap the previously laid lane from 25 to 50 millimeters to insure that enough material is available to completely fill the joint.

**(4) Compaction**. The Contractor is required to furnish the rollers and establish the rolling pattern required to arrive at the density necessary to meet the specifications. The compactive effort should be completed at the highest temperature possible within the mix design limits. The relationship between rolling and temperature must be maintained consistently in order to get consistent compaction results. It is recommended that the breakdown rolling be completed at temperatures above 95°C and that pneumatic rollers be included in the compaction process.

**(5) Smoothness.** Most paving or overlay projects include a profilograph smoothness specification with incentives and disincentives. Refer to the FLH Field Materials Manual for test methods and data compilation guidelines. Generally the Contractor will run the profilograph under the supervision of FLH personnel. The trace or printout will then be turned over to FLH for analysis.

Bumps or rejected areas are required to be corrected before the final profilograph and pay factor are determined, but the method of correction is subject to approval of the Government. Often grinding or grinding with an emulsion flush is not an acceptable correction because the appearance and physical characteristics of the surface are even less desirable than the rough payment.

**3. Measurement**

Payment is normally made on a metric tonnage basis for all material delivered, incorporated in the work and accepted. The appropriate specification should be reviewed concerning the testing and inspection of the scales. It should be understood that payment is to be made for the weight of the complete mixture with no deductions for any required additives, and the measurements should be made on this basis. See Chapter 8 for details of weight measurement.

Asphalt cement, when paid for separately, may be measured in one of two ways. The preferred method, and used if the project is the sole user of the plant, measurement is made using the suppliers weigh tickets, with any asphalt not utilized (waste or returned) being deducted from the total.

For commercial plants when asphalt used for the project is not isolated from other production, the asphalt usage should be determined by averaging the asphalt content test results.

**4. Documentation**

The requirements for documentation fall into two categories quality and quantity.

The quality of asphalt cement will be documented using the certificate of compliance that accompanies each shipment and the test results of the samples taken at the hot plant.

The quality of the mix is documented with the gradation and asphalt content test results and the verification or independent assurance tests performed in a separate laboratory. All tests should be noted on control charts or other production records so that when result are available there is a clear visual representation as to when problem occurred and where the material is on the project.

Quantity documentation for asphalt cement consists of the suppliers weigh tickets or quantity computations based on asphalt content tests.

The weigh tickets for the loads of mixture with the signature of both the weigh person and the spread person will serve as documentation of quantities involved in the project. These tickets should show the project number, the item number, the date delivered, and the truck number. A record of the empty truck weights is also necessary. Two weighings per shift of the empty trucks is required - at least one with the fuel tank full or nearly so. An adding machine tape or computer printout, with the item number, date and project indicated will serve as documentation for each days production. It should also indicate the persons who computed and checked the quantity.

A copy of the QL-Pay printout should be included in the project documents for each estimate and for final payment.

For final payment a copy of the smoothness data summary and computation worksheet is necessary. Paving quantities to which smoothness pay adjustments are made are determined in accordance with the Contract.

When estimates are paid, quantities should not include tonnage for which Contractor test results are delinquent.

**5. References**

The following are suggested source and/or reference materials for Engineers and inspectors on Hot Asphalt paving projects.

**National Asphalt Pavement Association**

TAS-15 *Rolling and Compaction of Asphalt Pavement*

**Asphalt Institute**

MS-4 *Asphalt Handbook*
MS-6 *Asphalt Pocketbook of Useful Information*
ES-9 *Factors Affecting Compaction*

**Federal Highway Administration**

*ED-88-028 Hot Mix Bituminous Paving Manual*

**Center for Transportation Research, Bureau of Engineering Research, the University of Texas at Austin**

*Compaction of Asphalt Mixtures and the Use*

## 9-4.2 OPEN-GRADED ASPHALT FRICTION COURSE

### 1. Preliminary Review and Approval

See Section 9-4.1.1.

### 2. Construction Inspection

The guidelines given in Section 9-4.1.2. should be followed in the inspection of the plant and laydown equipment. Because of the characteristics of the mix, some points will merit special emphasis.

Normally the depth of the course will be only slightly thicker than the size of the largest aggregate, so the elimination of all over size aggregate is a must. The nature of the mix makes repair work behind the screed almost impossible, so it is imperative that control of the mixing and laydown operations is such that problems are corrected before the mix reaches the screed.

Necessary consolidation will be normally attained with one pass of a nonvibrating steel roller. Care must be exercised to avoid over rolling of the mix. Traffic, especially hauling units, must be kept off the newly placed mat until it has completely hardened or shoving and/or rutting will occur.

The temperature constraints given in the specifications should be strictly observed. Experience has shown that the quality of the completed mat is directly related to the weather conditions at laydown the warmer the better.

### 3. Measurement

The same steps outlined in the asphaltic concrete sections are required for this item.

### 4. Documentation

See 9-4.1.4.

## 9-4.3 OPEN-GRADED EMULSIFIED ASPHALT PAVEMENT (OGEAP)

### 1. Preliminary Review and Approval

### A. General

The Project Engineer may obtain from the Federal Lands Division an excellent reference publication entitled, *A Basic Asphalt Emulsion Manual*, coded FHWA-lP-79-1 (Two volumes). Volume 1, entitled *Understanding and Using Emulsions* should be of particular interest to project personnel. Volume 2, *Mix Design Methods* may also be of value.

Many of the practices used for hot asphalt concrete pavement are also applicable to open-graded emulsion cold mixes. Only significant differences will be discussed in this section. The reader should therefore consult Part 9-4.1 in conjunction with this section.

The major difference is that an open-graded emulsion cold mix has few fines and requires no heat for mixing and placing. Mixture handling characteristics of hot mixes are controlled by the temperature of the material. The thickness of the emulsified asphalt coating controls these characteristics in the cold mix. As the emulsion *breaks,* the mixture viscosity increases rapidly, thereby making these mixes less forgiving than hot mixes during construction. They do, however, produce a very flexible pavement when properly placed.

Both aggregate gradation and moisture content can affect the behavior of the emulsion as it is mixed into the aggregate. These will also affect the behavior of the mixed material as it is transported to the grade and placed through the paving machine.

Emulsified asphalt is composed of finely chopped particles of asphalt cement suspended in a solution of water, emulsifying agent, and oil distillate. Emulsified asphalt specifications place a minimum limit on the percent of asphalt cement residue; a minimum and maximum limit on the percent of oil distillate and the penetration of the asphalt cement residue; and a minimum limit on the ductility of the asphalt cement residue. Other values are also specified for particle charge, coating ability and water resistance. All of these characteristics of the emulsified asphalt affect the behavior of the emulsion during the handling, mixing and laydown operations when producing an open-graded emulsified asphalt pavement. The effects of these emulsified asphalt properties are not all the same.

The stability of the emulsified asphalt prior to incorporation into the aggregate will be determined primarily by the type and amount of emulsifying agent. The stability referred to is the ability of the emulsified material to remain an emulsion. In other words, the emulsion's resistance to the coagulation of the asphalt particles to form the residual asphalt cement. This coagulation is generally called "breaking". Primary factors influencing the behavior of the mixed emulsified asphalt and aggregate are:

- The type and amount of emulsifying agent;
- The amount of moisture in the aggregate;
- The gradation of the aggregate and,
- The amount of manipulation the mixture is subjected to between introduction of the emulsion and placement through the paver.

These factors, along with the influence of the other emulsified asphalt properties, will generally be reflected in the performance of the completed pavement.

Controlling the moisture in the aggregates is area of critical concern. Excellent results have been obtained when dryers were used to dry wet aggregates. However, for economic reasons, drying is usually not specified. A uniform, low aggregate moisture content is necessary to use the specified amount of emulsified asphalt in the mix. As in all asphaltic mixes it is important to have a positive interlock between aggregate and asphalt feed systems.

The adherence to aggregate gradation specifications is also extremely important, more so than for standard hot mixed asphaltic concrete. A fractional percent more than the specified amount of minus 75 $\mu$m material can greatly increase mixture viscosities in the mixing chamber and/or paver. These increased mixture viscosities are sufficient to cause operational difficulties which result in rough riding pavements. Because its viscosity changes with temperature, it is advisable to maintain uniform emulsified asphalt temperatures. A 10$^\circ$C change in emulsified asphalt temperature will produce a noticeable viscosity change. Higher emulsified asphalt viscosities will permit the aggregate to hold more asphalt. The temperature of the aggregate should also be kept uniform and compatible with the asphalt temperature. Changes in either temperature will affect uniformity of the pavement.

**B. Source Approval**

The requirement for a very clean, surface dry aggregate at the time of mixing with emulsified asphalt should be kept in mind when reviewing Contractor proposed material sources. This requirement should be particularly stressed when writing source approval letters to the Contractor. This is especially so if the proposed source will require special handling to produce aggregates which are both clean and surface dry. Refer to more detailed discussion of source approval elsewhere in this manual.

**C. Mix Design**

The mix design is a process to determine how much emulsion the proposed aggregate can hold and to determine the compatibility of aggregate and emulsion (electrostatic charge). Visual observations are made on the mixing characteristics in the laboratory. These tests generally are simple processes. There should be no delay in furnishing materials to the FLH laboratory which is doing, or reviewing, the design. Emulsions may react negatively to certain aggregates due to their chemical composition; therefore, the aggregate or the emulsion may need changing. Maximum possible time for adjustments should be provided by early submission of materials for mix design or mix design review.

**D. Pre-Operations Conference**

The Project Engineer should confer with the Contractor prior to laydown operations. In addition to the usual topics of a prepaving conference, there is need to insure adequate sand or other suitable blotter material is available, as well as proper application equipment. This is necessary both to apply material to the surface of the newly placed mix, as is usually specified; and to quickly cover any problem area to facilitate traffic and/or environmental protection. The potential traffic need would include any roads used to haul from the plant to the project, because leakage from the haul vehicles can be expected to occur.

**2. Construction Inspection**

**A. General**

It is desirable to have a materials specialist available from the Division to assist the Project Engineer during the initial paving start-up, through field testing of the design.

The Project Engineer should plan for at least as large an inspection force as for a hot mix operation, and to spend much personal time at inspection. This is due to the sensitivity of the material to minor changes in mix composition and in changes in the weather. It also relates to the extreme difficulty that might occur as a result of such sensitivity.

**B. Plant Operations**

The comparatively simple plant usually used for OGEAP is one of its strong points. The inspector needs to be concerned mainly with feed operations to the pugmill. These include the usual concerns for any uncontrolled mixing of separate piles of aggregate through stockpile overlap or misfeeding of separate cold feed bins. Aggregate moisture content also needs to be watched closely. Small changes in aggregate gradation or moisture content can be very critical with these mixes. For example, when working from a stockpile having wet and dry areas, a careless loader operator can vary the moisture content of the aggregate entering the pugmill. The non-uniform moisture content will vary the asphalt content of the mix because it is controlled by the aggregate belt scale feeding the pugmill. An increase in aggregate moisture content over that established during plant calibration will increase the percent of emulsified asphalt to the aggregate. The more free moisture, the less emulsion the mix will hold. Too much water on the aggregate will therefore mean excessive dripping from the trucks and less asphalt for binder in the mix.

If the loader operator were to load aggregate with too many fines, a different problem might result. With finer aggregate in the mix, the emulsion might break too early. If it breaks in the pugmill, the Contractor might be delayed while cleaning up the mess. If it breaks in the paver or prior to raking, some very rough pavement might be laid because of the severe handling problems.

The point of introduction of emulsion into the pugmill is important. This is one adjustment to be considered when the emulsion is breaking either too early or too late, or if the aggregates are not being properly coated.

**C. Roadway Operations**

Vertical joints at connections to existing pavement must be square cut since the comparatively coarse aggregate will not accommodate "feathering". It is, however, sometimes possible to make special mixes using 9.5 mm or 6.3 mm minus dense graded aggregates for preleveling or for making approaches where feathering is necessary. These mixes will probably require a different type emulsion than that used for the mainline paving. Otherwise, these preleveling and feathering operations might best be done with a dense graded hot mix if it is available. In either case, a contract modification should be considered unless this was covered in the specifications.

Ideally, the OGEAP should begin to change from a brownish color to black, within about 30 meters of the paver. This color change signals the emulsion *breaking*. That is, the separation of the asphalt and the water. If this is not occurring in that distance, there are several adjustments which can be made. Probably the most important consideration is whether or not the emulsion will have broken sufficiently to withstand rainfall within four hours after placement. A check for this condition is pouring water from a gallon jug onto the completed pavement. One should look for the water to flow out from the pavement edge where it contacts the lower non-porus layer. When the water runs out, a paper towel is placed in it to determine if asphalt is being carried out of the pavement with the water. It is difficult to tell if the water contains asphalt because it may be discolored by the emulsifiers. After the paper towel has dried, it is possible to see any asphalt. It is not uncommon for some emulsion and/or emulsifier to discolor water for several days after laydown. Actions must then be taken to prevent damage to the environment, especially waterways.

If it is determined from the above test that the break is too slow, the mixing time should be increased slightly. The additional shearing action on the emulsified asphalt in the mix, as it is mixed more, will accelerate the break. This can be accomplished by:

- Introducing the emulsion into the pugmill nearer to the aggregate entrance, and/or

- Placing a dam at the output of the pugmill.

If the break is still too slow in occurring, the next step would normally be to change the emulsion formula slightly. The Project Engineer cannot make this change nor can the Contractor. For this reason it is advisable for the Contractor to have a representative from the emulsion supplier on the project until the operation is running smoothly. A final *last resort* adjustment is to add portland cement to the aggregate prior to the introduction of the emulsified asphalt. A very small amount, usually not more than 0.3 percent by weight of the dry aggregate, is normally sufficient to dehydrate the aggregate enough to permit continued operation. The portland cement is usually added to the aggregate feed belt by a screw auger feeding from a small hopper. The screw auger should be interlocked with the aggregate feed belt in the same manner as the asphalt supply pump.

It is okay if the emulsion turns black during the transport or laydown operation, provided it passes through the paver and can be laid without causing irregularities in the pavement surface. These irregularities usually will take the form of the mat tearing under or behind the paver screed. Occasionally, it may be difficult to maintain proper lift thickness because of the harshness of the mix. When these conditions occur, the emulsion is breaking too soon and mixing time should be reduced. This can also be done by introducing the emulsion more toward the output end of the pugmill. If the pugmill has a dam installed in the output, it should be removed. If these adjustments do not provide the necessary increase in break time, other places in the process should be considered where a reduction can be made in the physical manipulation of the mix prior to its passing under the paver screed. When all of these measures have been implemented and the emulsion is still breaking too early, a change in the emulsion formula will usually be required to correct the condition. Again, this change will require the assistance of the emulsion supplier's representative and will result in a loss of time.

Traffic can usually be accommodated immediately after the addition of the blotter or choker aggregates following the initial rolling. The pavement should soon develop enough stability to support even heavily laden logging trucks, provided the aggregate particles have the specified fracture percent. The load carrying capability of the pavement is determined by the interlock of aggregate particles, not by the type and/or amount of asphaltic binder. The asphaltic binder serves only to keep the aggregate particles in place in the pavement. The type and amount of asphaltic binder determines how well and how long these particles will remain in place. The stability of the placed and compacted mix should continue to increase with time as the asphaltic binder stiffens with age.

The pavement can be expected to remain much more flexible than a hot mix for a comparatively long time. Problems may occur with turning, stopping, and any other traffic pattern exerting extreme stress on the mat. For example, a truck with a locking brake might gouge the pavement seriously, several hours after placement. For this reason, traffic control should be established which will minimize the occurrence of these stresses. Reshaping and compaction is sometimes possible while the mix is in this state. However, the results are never as good as prevention would have been. If cement has been added, the set will be quicker and harder and it will be more difficult to correct rough areas.

**3. Measurement**

OGEAP will be measured by the metric ton of total mix, with the emulsion and mineral filler [portland cement] also paid separately by the ton. If emulsion is invoiced or metered by the liter it is converted to metric tons at the rate of 1000 liters per metric ton. Refer to Part 9-4.1 for additional measurement instruction.

**4. Documentation**

See above. Refer to Subsection 9-4.1 for documentation instructions.

## 9-4.4 DENSE-GRADED EMULSIFIED ASPHALT PAVEMENT

### 1. Preliminary Review and Approval

Dense-graded emulsified asphalt concrete is a mixture similar to hot asphalt concrete except that the bituminous material and additives, when required, are of such a nature that the mixture may be transported, stockpiled, and placed cold. The contract specifications designate the types of materials to be used in the mix. The special contract requirements will provide the combinations of materials, based on local conditions. There are some special kinds of dense-graded emulsified asphalt concrete which are patented and hence their use is subject to approval of the patent owner and to the payment of a royalty.

The controls expressed in Section 9-4.1.1. also apply to this section with the following additions and/or exceptions:

Mixing Temperature. Control of the temperature will be in accordance with the contract requirements.

### 2. Construction Inspection

See Section 9-4.1.2.

### 3. Measurement

See Section 9-4.1.3.

### 4. Documentation

See Section 9-4.1.4.

## 9-4.5 ASPHALT TREATMENTS

Asphalt treatments include the use of asphalts as a prime coat, a tack coat, a single course surface treatment [chip seal] or a multi-course surface treatment. Because the methods used are the same for all treatments, when the application of asphalt is discussed, the information is valid for all usages.

### 1. Preliminary Review and Approval

For a chip seal or multi-layered treatment, if required by the Contract involved, a representative sample of this aggregate and asphalt should be sent to the Division laboratory for a mix design, i.e. application rate of asphalt and aggregate. This design should be reviewed to insure that the application rates are sufficient to produce enough residual asphalt to provide proper imbedding of the aggregate.

A good rule of thumb is that 40 percent of the most prevalent size aggregate will be embedded in the residual asphalt. It is important to remember when using emulsified asphalt, that it is normally shipped at a 70/30 ratio of asphalt to water, with the water being only a carrier and has no effect on the holding of the aggregate. A chip seal with insufficient asphalt applied has little or no chance of success.

The traffic control plan should be discussed thoroughly prior to the start of the work, since keeping the traffic off the newly worked area is important to both the success of the treatment and to public relations. An asphalt splattered car or a broken windshield is no laughing matter.

### 2. Construction Inspection

Prior to commencing operations, it is imperative that the distributor and aggregate spreader, are inspected, so that the material can be uniformly applied throughout the project. Areas of particular interest include the following:

#### A. Asphalt Distributor

**(1). Spray Bar -**

All nozzles same size
All nozzles at same angle - (15° to 30° - as recommended by manufacturer)
Bar height constant regardless of load
Proper height for coverage required double or triple coverage

**(2). Bitumeter**

No build up on wheel
Dial easily readable

**(3). Pumps and Circulation System**

Instantaneous shut off
Pressure variations with relative ease

#### B. Aggregate Spreader

**(1). Storage Bin**

Truck hook functioning properly
Feeder belts operating

**(2). Spreader Box**

Gates spreadable
Spreader wheel operable
Speedometer or tachometer functioning
Oversize or scalping screens in place

#### C. Application Rates

When the Inspector/Project Engineer is satisfied that the equipment is functional, the calculations necessary to obtain the desired rate of application can be made. The variables in the application rates of asphalts from a distributer are: vehicle speed, spray bar width, and the pump discharge rate. Normally the spray bar width is held constant throughout the passes. Often the alignment and grade of the roadway will limit the speed of the vehicle. For a typical prime coat application, the sequence could be as shown below.

**(1). Establish bar width:** 10.5 meter roadway plus widening--use three passes at 3.5 meters each.

**(2) Establish practical vehicle speed:** For this example, use 8 kph. 8 kph/60 min per hour = 133 m/min.

**(3). Asphalt characteristics:** Desired application 1.6 L/m$^2$ of CRS-2 at 15°C. Asphalt as delivered = CRS-2 with specific gravity of 0.966 at a temperature of 80°C.

**(4). Correct asphalt for temperature:** 1.6 ÷ 0.971 (factor from Asphalt Institute Pocketbook) = 1.65 liters at 80°C.

**(5). Calculate pump discharge rate required:**

(1.65 L/m$^2$) x (133 m/min) x (3.5 m$^2$/m) = 768 L/min

**(6). Shoot test section:** ~30 m. Observe coverage and penetration, adjust rate if needed, note liters used and distance covered. Complete distributer load.

**(7). Check applied rate:**

(___L)÷(___m x 3.5 m) = ___ L/m$^2$

If the existing roadway is paved, brooming will be required prior to the application of a tack or seal coat. The broom should be checked for uneven wear, and observed during operation to insure that no ridges of dirt are left on the roadway. The brooming should start at centerline and proceed toward the shoulder.

When the construction requires the spreading of aggregates over the freshly sprayed asphalt, the specifications will usually require a self-propelled, two-axle, pneumatic-tired spreader. The application rate is controlled by the speed of the spreader. Trial and error is the only available method of establishing the desired rate. Placing a container of known area (e.g. 1 m$^2$), and weighing the stone deposited will give the Project Engineer a starting place. Adjust the speed until desired rate is attained. When placing aggregates on the freshly applied asphalt, it is imperative that the spreader be as close to the asphalt distributor as possible. At no time should more than 1 minute elapse between the asphalt spray and the chip spread. The rolling should take place using rubber-tired rollers, treadless tires only, as close to the spreader as possible. All rolling must be completed before the asphalt has set. Over rolling or late rolling can break the bond between the stones and asphalt. If the application rate of asphalt and aggregate is rapid, more than one roller will be required.

The application of chips should be a single layer of stones, with small separation between stones. Avoid over-application of aggregate; this will result in none of the stones being correctly embedded. After the chips have been applied, brooming with light, even pressure may be required to remove the excess aggregate.

Application of a chip seal should never be attempted under adverse weather conditions. The stones should be as free of dust as possible and dry or only slightly damp. There are many factors that will effect the success or failure of a chip seal. Any combination of them can cause a less than satisfactory result. Things to look out for are:

- **Cool weather.** Slow setting or "break" of the asphalt bonding action interrupted by cold nights are a particular hazard.
- **Dirty aggregate.** Fine particles soaking up too much asphalt with remainder insufficient for proper embedding.
- **Insufficient asphalt.**
- **Excessive asphalt.** Bleeding, slick areas, loss of friction.
- **Excessive aggregate.** Too much competition for asphalt.
- **Over-diluted emulsion.** Same as insufficient asphalt.
- **Dust, dirt, moisture on roadway.** Bond between roadway and chips prevented.

**3. Measurement**

If payment for asphalt is by the metric ton, measurement can be made by weighing or by using weights from the suppliers weigh tickets. If payment is by the liter, measurement can be made either by converting the weight to liters at 15°C or by measuring the liquid in the tanks or hauling units and converting to liters at 15°C. For emulsions no correction for temperature is required. The factor of 1000 liters per metric ton is always used. In any event, there must be a deduction for unused or wasted material.

Aggregates, if paid for by the cubic meter, are to be measured in the hauling units or by converting weights to cubic meters. If payment is by the metric ton, material must be weighed in accordance with the procedures in Chapter 8.

**4. Documentation**

Documentation requirements are similar to those in Section 9-4.1.4. In addition, if aggregates are measured in hauling units, a system for documenting measurement and delivery must be devised to fit the circumstances involved.

During the course of the work there should be periodic comparisons of the materials spread on the road vs. those invoiced for payment. If, due to the difficulty in controlling storage tank quantities, wasted materials and those not used, the Project Engineer decides the weight based invoices are unreliable, the use of daily spread computations/tabulations may be directed to be used for payment instead.

**5. References**

Useful reference materials for asphalt treatments.

**Asphalt Institute**


ES-ll *Asphalt Surface Treatments*
ES-12 *Asphalt Surface Treatments Construction Techniques*
MS-6 *Asphalt Pocket Book of Useful Information*
MS-19 *A Basic Asphalt Emulsion Manual*

### 9-4.6 MINOR ASPHALT CONCRETE

This item is to provide materials from local or commercial sources where the use or quantity involved does not justify the use of more comprehensive FLH materials specified in Subsection 9-4.1.

#### 1. Preliminary Review and Approval

The contract requirements define the required certifications and documentation to be submitted by the Contractor prior to the supplying of the mixture. These should be reviewed and approved if the proposed mix meets contract requirements. If the mixture is designed to meet a local agency specifications, contact should be made with the agency and the adequacy of the mix for the purposes intended verified. If serious doubts as to the quality of the product arise, an alternate submittal should be requested, or mix design and quality tests should be taken per Subsection 9-4.1.

#### 2. Construction Inspection

See Subsection 9-4.1.

#### 3. Measurement

Weigh tickets from the material producer can be used as measurement of the amount delivered.

#### 4. Documentation

Copies of the producer's certifications for the asphalt and the mixture will serve to document the quality of the product. Signed weight tickets will document the quantity delivered.

## SECTION 9-5 - CONCRETE AND STRUCTURES



### FIGURES

## 9-5.1 PORTLAND CEMENT CONCRETE

### 1. Preliminary Review and Approval

**A. Mix Design**.

Responsibility for concrete mix design is normally assigned to the Contractor. Documentation is submitted by the Contractor to FLH. The mix design data is approved, rejected or conditionally approved by Project Engineer (if so delegated) or the COE, after concurrence of materials specialists. Normally, FLH will not do verification testing of the mix. However, if the FLH elects to do verification testing, the Contractor should be so advised and samples requested as early as possible. The procedure may be appropriate when the following occurs:

- The specified concrete is required to have unusually high strength or other characteristics for which the producer has no historic records or data.
- The concrete is composed of components from sources not previously used for structural concrete by FLH or another organization.
- The concrete contains an admixture or additive; e.g. super water reducer or fly ash for which the producer has no experience or production data.

In any case, it is the FLH's prerogative whether or not to do mix design testing.

Approval is based on the quality and other specification requirements of the component materials; and whether the mix will comply with the strength, air and water/cement ratio requirements during production. As a minimum the proposed mix design should include cylinder strengths at least from 7-day cylinders which indicate that the 28-day strength will not be a problem. If strengths are marginal, and especially if air and water are on the low side of the specifications, the Contractor should be advised of the potential risks of nonspecification concrete. Regardless of air, water and strength indicators under laboratory conditions, the Contractor remains obligated to comply with these specifications during production.

**B. Batching Procedures.**

The Contractor is generally assigned responsibility for batch plant procedures. The Project Engineer may elect to perform occasional batch plant inspections prior to the start of production or at other times during production. The FLH will not normally perform full time plant inspection during every batching operation. The Contractor's/supplier's QC plan should address batch plant quality control.

**Batch Plant Inspection Checklist:**

- Storage, uniformity and identification of aggregates, cement and admixtures.
- Quality Control tests and their documentation.
- Facilities to weigh or otherwise measure components.
- Batch ticket documentation procedures.
- Facilities to measure, control and adjust for aggregate moisture.
- Facilities to heat or cool concrete during adverse weather operations.
- Facilities to mix and deliver concrete.
- Truck cleanout facilities and procedures.

**C. Volumetric Batching**

Volumetric batching, where aggregates, cement, water and admixtures are metered and mixed continuously is permitted by the specifications. Since volumetric batching eliminate most variability in batching and mixing time it can result in more consistent mixes, especially when high range water reducers are used. Detailed requirements for volumetric batching are contained in AASHTO M 241. Some of the pertinent sections of AASHTO M 241 are reproduced here for information:

- **Control Devices**. If volume proportioning is employed, devices such as counters, calibrated gate openings, or flowmeters must be available for controlling and determining the quantities of the ingredients discharged. In operation, the entire measuring and dispensing mechanism must produce the specified proportions of each ingredient.

- **Manufacturer's Recommendations**. The recommendations of the equipment manufacturer in the operation of the equipment and in calibrating and using the various gauges, revolution counters, speed indicators, or other control devices should be followed.

- **Visibility and Access**. All indicating devices that bear on the accuracy of proportioning and mixing of concrete shall be in full view and near enough to be read by the operator while concrete is being produced. The operator shall have convenient access to all controls.

- **Checking.** The proportioning and indicating devices shall be individually checked by following the equipment manufacturer's recommendations as related to each individual concrete batching and mixing unit.

- **Accuracy**. Adequate standard volume measures, scales, and weights shall be made available for checking the accuracy of the proportioning mechanism. The device for the measurement of the added water shall be capable of delivering to the batch the required quantity within the accuracy of +l percent; the device shall be so arranged that the measurements will not be affected by variable pressures in the water supply line.

- **Yield Check** - Essentially, the volume of concrete discharged from the mixer is checked by first weighing the amount of concrete discharged during some number of revolutions, or as determined by some other output indicator. This is followed immediately by a determination of the mass of concrete per cubic meter. The mass of concrete discharged divided by the mass per cubic meter is equal to the number of cubic meters mixed and discharged during the chosen interval. The accuracy of the output indicator is thus checked by this expedient.

- **Yield Sample**. It is recommended that about 0.07 to 0.09 cubic meters be discharged for this purpose. This amount of concrete will weigh from 170 to 220 kilograms and can be discharged into, and contained in a small steel drum or other suitable container which in turn can be placed on a scale of adequate capacity. The output of a batcher-mixer unit may be indicated by the number of revolutions, travel of a belt, or changes in gauge readings; if so, these figures should be used as a measure of output.

- **Proportioning Check -** Whenever the sources or characteristics of the ingredients are changed, or the characteristics of the mixture are noted to have changed, the Engineer may require a check of the fine aggregate content and the coarse aggregate content by use of the washout test. Essentially, in the washout test, 0.025 cubic meter of concrete is washed through a 4.75 mm sieve and 150 $\mu$m sieve; that retained on the 4.75 mm sieve is normally considered coarse aggregate, and that passing the 4.75 mm and retained on the 150 $\mu$m sieve is considered fine aggregate. The mass of the retained aggregates should then be compared to theoretical masses computed from the mix design data. Significant differences suggest that the design mix is no longer being produced..

- **Water**. The rate of water supplied the continuous mixer shall be measured by a calibrated flowmeter coordinated with the cement and aggregate feeding mechanism, and with the mixer. The rate shall be capable of being adjusted in order to control slump at the desired levels and to determine that the maximum water/cement ratio is being met.

- **Admixtures.** Liquid admixtures shall be dispensed through a controlled flowmeter.

## 2. Construction Inspection

See Sections 9-5.2, 9-5.3 and 9-5.4 for procedures relative to falsework, forms, reinforcing steel and other incidentals.

During concrete placement inspection operations, the Project Engineer or Inspector is normally concentrating on the placement at the structure while the Contractor's QC personnel should assume responsibility for completion of the batch ticket, quality control of discharge operations and all required tests. During the first one or two placement operations, extra attention by the Project Engineer may be needed to assure that the Contractor properly assumes this responsibility. The Contractor, however, should not be permitted to rely indefinitely on FLH for quality control. After the first few placement operations, intermittent monitoring of concrete inspection should be sufficient.

**Concrete Discharge Inspection Checklist:**

- Completion and receipt of batch ticket.
- Control of additional water or admixtures.
- Control of time of mixing and discharge.
- Temperature and slump of mix.
- Control of air content.
- Quality assurance tests to document acceptance.

## 3. Measurement

Concrete is normally included in the contract item in which it is incorporated. When concrete is paid as structural concrete, it is complete and in place in the structure. Quantities are usually determined by the theoretical dimensions of the structure and paid as a contract quantity or lump sum. The Project Engineer should have access to design computations, and should not have to recompute concrete quantities in the absence of evidence that they are in error.

## 4. Documentation

See FLH Field Materials Manual for guidelines for materials related documentation.

## 5. References


*Design and Control of Concrete Mixtures*, Portland Cement Association.

*ACI Manual of Concrete Inspection*. American Concrete Institute.

*CRSI Manual of Standard Practice*, Concrete Reinforcing Steel Institute

## 9-5.2 CONCRETE STRUCTURES

### 1. Preliminary Review and Approval

The following items normally require attention before concrete placement.

**A. Contract Requirements**.

The Project Engineer and inspectors should have reviewed in detail all requirements of the contract. Any questions should be resolved with the Construction Operations Engineer, in consultation with Bridge Engineer as may be necessary.

**B. Submittals.**

The Contract will normally require a number of submittals for approval prior to certain work commencing. It is important that the Contractor and the Project Engineer communicate as to the schedule for these submittals, the estimated time it will take to review and approve them, and what the criteria for approval will be. Sometimes these approvals go beyond the stated requirements in the Contract, and are required to be based on industry standards or even regulatory requirements.

At the same time the Project Engineer and the COE must be in agreement on the issue of submittals. Specifically which ones will be approved by the COE or Bridge Engineer and which ones the Project Engineer will approve. .

The COE or Division policy may require the Project Engineer to review submittals for completeness prior to transmitting to the Division. Be sure to keep the Contractor advised of the status of submittals. If the Engineer knows there are serious problems with a submittal, but the Bridge Engineer hasn't officially disapproved it yet, the Contractor should be told verbally so that plans and schedules can be adjusted.

**C. Falsework and Forms**.

**(1) Falsework Design.** Contractor's submittal should include:

- All loads (such as finishing machine), location of loads, and loadings assumption, e.g. associated with rate of concrete placement for vertical members.
- Species and grade of lumber, all dimensions (span, width, thickness) of members and forms, allowable stresses used, calculated deflections, type and size of bracing.
- Type, size and capacity of connections (bolts, hangers, spikes, nails etc.).
- Manufacturer's recommendation or tests for manufactured assemblies.
- Bearing value of supporting materials, wind and other external load assumptions.

If the drawings are not complete, they should be returned to the Contractor to be completed before forwarding to the Bridge Engineer. Unless the special contract requirements waive the standard requirement, the drawings must be prepared and sealed by a licensed registered professional Engineer.

**(2) Contractor's Schedule and Equipment**.
The Contractor's intentions for scheduling, rate of placement, equipment to be used, curing material, etc., should be discussed in order to adequately plan inspection and testing and to be sure the Contractor has adequately planned the placement operation.

**(3) Foundation Bearing Capacity**. The bearing capacity of foundation material is required to be determined by the Contractor and reflected in the design assumptions of the falsework. The determinations may be based on standard tables, or in cases of marginal material or disputed assumptions, the Engineer may insist on actual tests. **Figures 9-5.2a, Allowable Bearing on Sandy Soils; and Figure 9-5.2b, Allowable Bearing on Clayey Soils,** may be used by the Engineer to confirm Contractor assumptions.

Tests and assumptions must be based on a *worst case* condition. I.e. if the foundation may become saturated during construction, the design must be based on that condition. Alternatively the Contractor should include a drainage plan in the falsework drawings submitted for approval. The plan must provide an effective means of draining the area around the falsework for the duration of its use.

When tests are required, they may be simple static load vs. settlement tests, or more in-depth tests as may be suggested by the Contractor, and concurred in by the Engineer. The Engineer should be confident that the test reflects the capacity of the foundation, and not just a layer of good material overlaying poorer material. Steel scaffolding type falsework is particularly vulnerable to foundation problems because of its sensitivity to differential settlement/loading.

**(4) Used Materials**. When used materials are anticipated for the falsework design, it is the Contractor's responsibility to identify and reflect appropriate reductions in sections or maximum working loads. The documentation should be a part of the falsework submittal. When the materials are finally incorporated into the falsework structure, it must be verified that the assumptions on which the design was based, are consistent with the apparent condition of those materials. If the Engineer has a basis to question any of these materials, they should be rejected unless the Contractor conducts tests or otherwise clearly demonstrates their validity.

**D. Stakeout**.

The Government should furnish the Contractor data on the permanent or semipermanent control points by which the structure is to be staked and constructed. If the initial control points will not be usable for checking during construction, then the Project Engineer should set and check additional control points o reference lines for checking. The Contractor should be held responsible for all control points, reference lines and other surveying for the proper layout of the structure.

**E. Quality Control Plan**

See Subsection 9-5.1 for concrete requirements.

The Quality Control Plan should have been submitted and approved prior to concrete placement. The QC plan should address the duties, responsibilities and authority of all management and QC personnel. The plan should adequately address the responsibility of supplier QC personnel.

**2. Construction Inspection**

**A. Excavation**

The excavation and foundation for both the structure and the falsework must conform to the contract requirements or design assumptions and must be excavated to the required elevation. The excavation for footings must be dewatered prior to concrete placement unless underwater placement is approved.

**B. Falsework**

**(1) Consistency with Approved Design**. The Contractor is required to arrange for inspection of the falsework prior to concrete placement by a licensed professional engineer; and to certify in writing that the installation conforms to the approved design, contract requirements and acceptable engineering practice. The Engineer should coordinate with the Contractor to participate in this inspection. **Figure 9-5.2d, Checklist For Falsework Inspection**, is a good outline for the inspection of falsework prior to concrete placement. Deviations from the approved drawings must be approved and concisely documented in the files with a copy to the Bridge Engineer, through the COE. Any changes to the materials, type of manufactured assembly, connections, footings or dimensional configurations of the various components of the falsework must also be approved and documented.

**(2). Changes**. Requests for approval of all changes will normally be through the COE to the Bridge Engineer. When the Project Engineer has substantial experience and structural knowledge, the COE may delegate the authority to approve minor deviations to suit field conditions or the availability of materials, if it is evident by inspection that the deviation neither increases the stress in, nor the deflection of any falsework member beyond the maximum value allowed by the specifications; and does not reduce the load-resisting ability of the falsework system as a whole. Substantial (other than minor) changes may not be informally field approved. The following are examples of substantial changes which would entail a formal request and submittal from the Contractor with all supporting calculations and literature:

- A change in the size, spacing or placement of any primary load carrying member.
- A change in the method of providing lateral or longitudinal stability.
- Any change, however minor, which affects the falsework to be constructed over or adjacent to traffic opening.
- A revised concrete placing sequence, if it materially affects the stresses in load-carrying members.

All changes must be formally documented. The internal form, **Report of Field Changes to Falsework/Formwork, (Figure 9-5.2c)**, is provided as the mechanism to accomplish this documentation or initiate approval.

**(3). Piling**. Piles driven for falsework should be inspected for bearing capacity and alignment. The procedures in Section 551 of the Standard Specifications should be used to estimate bearing capacity.

**(4). Timber Members.** Timber members should be checked to verify that they are the proper grade (if a grade is required or assumed) and dimension, and are not damaged or defective. The dimensions in question should be actual dimensions, not the nominal dimensions, unless the design is based on nominal dimensions.

Required blocking should be included in the design submittal. Additional blocking, shimming and wedging should be kept to a minimum; and should be used primarily to assure full bearing and to make fine adjustments in elevation.

**(5). Steel Members.** Steel members must be inspected carefully for loss of section due to welding, holes or web openings. Welded splices, should be inspected visually for obvious defects: however, radiographic inspection or other methods of nondestructive testing are not required unless the Engineer's visual inspection suggests the welds are defective. If the falsework design is based on steel other than AASHTO M 183M [A36M] grade, the Contractor must produce a certification or other evidence that actual steel furnished is the required grade.

Field welds designed up to 150 Newtons per millimeter of 3 millimeter fillet weld may be accepted based on visual inspection. If higher values are required, welding and inspection must be in accordance with AWS D1.1.

**(6). Manufactured Assemblies.** Steel shoring components should be inspected before assembly to verify that all components are a part of the approved system. Components should also be inspected for dents, bent members, cracked welds, rewelding and corrosion. Such members must be rejected. After erection, the systems must be plumb, jacks installed at the top and bottom and in firm contact, all connections fitted together evenly, and locking devices in good working order. Screw jacks must not be extended beyond the manufacturer's recommendations, and must be fitted with the proper hardware to be compatible with the frame legs and held firmly in line with the axis of the leg. Other manufactured assemblies should similarly be inspected and verified as being used consistently with the approved drawings and the manufacturer's recommendations.

**(7). Exterior Bracing.** Exterior bracing must be included in the falsework design when multi-tiered structures, wind loading or other factors cause concern with respect to lateral loads and stability. Exterior bracing should be checked for adequate sizes and for adequacy of connections. Cable connections must be tight and secure.

**(8). Traffic Openings.** Openings through falsework for public traffic requires enhanced design standards in the vicinity of the opening to minimize the risk of damage due to errant vehicles. Falsework members installed adjacent to, or over traffic openings must be immediately temporarily braced until the entire system is in place and permanent restraints in place. Minimum vertical and horizontal clearance should be provided at all times and verified immediately upon erection.

**(9). During Concrete Placement.**

**(a) Tell Tales.** Prior to concrete placement, the Contractor should install tell-tales under the structure. A tell-tale is a rigid strip of vertical wood, metal or fiberglass (25 mm by 50 mm lumber is common) reaching from the underside of the formwork to a pin or stake driven firmly into the ground. The end of the pin is free, and is marked before concrete placement so that during placement settlement can be monitored. Tell-tales should be installed near the vertical supports for the falsework, but sufficiently away from falsework foundations which may settle.

**(b) Incipient Failure.** As concrete is being placed, the falsework and tell-tales should be inspected at frequent intervals. The following items, in particular, are indications of incipient failure, where immediate response is required.

- Excessive compression at the tops and bottoms of posts and under the ends of stringers.
- Pulling of nails in lateral bracing; movement or deflection of braces.
- Excessive deflections of stringers; tilting or rotation of joists or stringers.
- Excessive settlement of tell-tales (10 mm more than the anticipated settlement).
- Posts or towers that are moving out of plumb.
- The sound of falling concrete, cracking timbers or popping welds.

Any response to these problems should address safety issues first, including the possible evacuation of the site.. The safety of workers and the public is more important than technical issues.

**C. Form Layout**

Contractor's surveyors should have checked all forms as to exact location and elevation. The Project Engineer or Inspector may review this process or make spot checks. After initial process check type reviews, comprehensive checking by FLH should not be necessary,

**D. Reinforcing Steel.**

See Section 9-5.4

**E. Deck Forms**.

The Contractor is responsible for setting deck forms and reinforcing steel and screed rails to grade. If all of these items are not set properly, they will not relate properly and the deck will be too thick, too thin, or the steel will not have sufficient cover.

After the screed rails are set, the entire deck placement plan should be checked in the presence of the Project Engineer or Inspector. Note that when the screed is supported by the deck overhang rather than by girders, these supports must be firm enough so there is no significant variability or *bounce* in the screed elevation. The deck should be checked on a 3 to 5 meter grid over the entire deck surface. The Contractor should check the thickness of the deck (from the screed to the deck form) at each grid point as well as the reinforcing steel cover. Minor adjustments should be made by raising or lowering the deck forms (assuming the screed rails and settings have previously been verified as good).

If the adjustments are of such number and magnitude as to indicate the deck is not ready to be checked, the Inspector should arrange with the Contractor to come back at a later time or day when the Contractor believes the deck will be ready. It is inappropriate for the Engineer or FLH inspector to be a part of the routine deck grade setting process.

**F. Cleanup.**

All debris, water, ice, etc. should be removed from the forms before concrete placement is authorized.

**G. Concrete Placement**

The Contractor is responsible for quality control during concrete placement. FHL's role should be one of overview and verification. If the Contractor is not properly assuming the quality control responsibility, the problem should be addressed in specific terms. See the contract clauses relative to inspection of construction and material and workmanship.

Normally, small and medium sized placement operations should require only one FLH Inspector once initial starting problems are worked out. The inspector should not be reluctant to request Contractor assistance whenever necessary.

The following items require attention during concrete placement.

**(1). Concrete Discharge**.

See Section 9-5.1.

**(2). Placement and Vibration**.

Concrete should be placed near its final location by pump, bucket, buggy or chute. Vibration is essential to avoid air pockets under re-steel and in corners.

**(3). Form Alignment**.

Tall or slender forms such as those for columns should be monitored for alignment as the placement progresses.

**(4). Deck Surfaces**.

The Contractor should be making spot checks with a 3 meter straight edge to assure proper surface tolerances. Particular attention must be paid to surfaces beyond the limits of the finishing machine.

**(5). Scheduling of Concrete Delivery**.

Occasionally, due to poor scheduling of trucks or equipment breakdowns, the delivery of concrete may not be continuous as is required by the specifications. If this happens, it is important that the Contractor take all appropriate action to minimize damage due to *cold joints*. Such action may consist of the following:

- Shading and/or fogging exposed concrete faces to prevent drying.
- Using a vibrator to keep the exposed concrete face plastic. This can be done for 2 hours or more if the concrete is cool (less than 20 °C).

It is emphasized that these are emergency actions of limited useful duration. More drastic action, such as constructing an emergency construction joint or a total washout of a partial concrete placement operation, should be required whenever the structure may have been weakened.

When the Contractor's scheduling problems are chronic and avoidable, the Project Engineer should communicate the deficiencies in writing and direct the Contractor to take corrective action such as furnishing standby equipment.

**H. Curing and Protection**

Curing materials and water must be available to begin curing as soon as initial set has taken place and the water sheen has disappeared.

In cold weather, the equipment required by the Contractor's approved cold weather concreting plan must be available and ready to install.

Curing compound, mats, water, etc. must be applied as soon as possible. The Contractor should not wait until a large deck pour is completely finished before starting to apply these materials.

When forms are stripped before the curing period is over, curing materials must be applied immediately.

When a curing compound is used there should be periodic verification that it is being applied full strength at the required rate.

Particular attention must be given to sidewalk and curb construction joints that are obstructed by steel during the deck placement. A curing compound is normally not usable in these areas. Wet burlap or other acceptable procedures must be used to ensure that these areas are kept moist during placement and continuously during the curing period.

**I. Hot Weather Concreting.**

Before concreting in hot weather, the Contractor should be required to compare the proposed procedures with the requirements of the Contract to determine if procedures are adequate. The following factors affect the evaporation rate of surface moisture from concrete:

- **Air Temperature -** If anticipated daytime air temperature is too high, night time (lighted) operations may be the only alternative.
- **Wind Speed -** Wind screens may be necessary to insure relatively calm conditions and reduce evaporation.
- **Humidity -** In dry areas, fogging equipment may be used up wind from the placement operations to raise the humidity.
- **Concrete Temperature -** Through the use of ice as part of the mixing water, or other means, the concrete temperature should be held low enough to conform to anticipated conditions.

**Figure 9-5.2e, Evaporation Rates in Hot Weather**, shows the relationship among these factors.

**J. Cold Weather Concreting**.

Before concrete placement, when air temperatures might be less than 2°C during the curing period, the Contractor must have an approved plan for maintaining the minimum temperature. This plan should address the following:

- **Concrete Temperature -** Provisions may be required at the plant to heat mixing water or aggregates in order to achieve minimum temperature.
- **Forms and Insulation -** Depending on circumstances, forms may have to be designed with insulation, or similar precautions such as flooding of footings or layers of straw may be used to avoid freezing.
- **Heat -** If artificial heat is required, the Contractor should have a comprehensive system of monitoring and maintaining. There should also be special precautions to be sure that moisture is maintained for curing during the heating process.
- **Thermometer -** Depending on contract requirements, either the Contractor or the Government is required to furnish a thermometer to monitor temperature during curing.

**K. Removal of Forms and Falsework.**

Falsework must not be removed so as to produce excess stresses in the concrete. The contract may require minimum percentages of 28-day strength be reached prior to form removal. It is permissible to use statistically based prediction techniques to determine if the minimum strengths have been achieved.

The specifications may contain specific requirements regarding the removal of falsework, or a removal plan may be required as a part of the falsework submittal. Whether or not an approved removal plan is required, to prevent damage to the completed structure, and to maintain the safety of the public and onsite personnel, the Contractor's removal plan should be discussed with the Engineer ahead of time. This is particularly important with respect to removal operations adjacent to, or over traffic openings. If temporary bracing was required during installation, then it is also required during removal unless another method of maintaining stability is provided.

Waterproof (metal, sealed etc.) forms which are part of the curing process may not be removed during the curing period unless provisions are made for continuing that process during stripping and finishing. These provisions may include curing compound, water spray, and wet burlap, or combinations thereof.

**3. Measurement**

**A. Contract Quantities**.

Structural concrete is normally paid as a part of a lump sum item or on the basis of quantities computed by the designer and specified in the plans. It should not be necessary to recompute or verify these quantities unless discrepancies are brought to the attention of the Project Engineer. If discrepancies are alleged, the Project Engineer may elect to check only the parts of the structure in question, or all concrete may be recomputed. The designer may be asked for assistance if checking becomes necessary.

**B. Staked or Ordered Quantities.**

When final quantities are not specified in the plans, or when these quantities are adjusted or corrected, payment is normally on a staked or ordered quantity basis. The Engineer should determine in the field the required minimum dimensions of the structural element involved (e.g., a subfooting), and provide the Contractor with these authorized dimensions. These dimensions become the basis of the computed quantity. Upon completion, the inspection verifies that the structural element has be constructed within acceptable tolerances, but no detailed remeasurement is required.. If the Contractor elects to construct slightly greater dimensions, no additional payment is necessary.

**C. Measured Quantities**

Occasionally the contract may authorize payment on a measured quantity basis. This method implies a higher level of control during construction, since the Government is going to pay for all concrete placed. This method is usually used when concrete is authorized to fill a void of unknown or odd dimensions. Measurement may be simply based on the quantity of concrete batched and placed if dimensions are inaccessible.

**4. Documentation**

The following is a list of minimum requirements for documentation of construction of concrete structures:

**A. Falsework**

All changes to actual falsework as compared to the approved design should be documented on the form, **Report of Field Change to Falsework/Formwork (Figure 9-5.2c).**

The **Checklist for Falsework Installation (Figure 9-5.2d)**, is an outline of what the Contractor's QC and inspection personnel should be checking to document compliance with FAR Clause 52.246-12, with Section 552 of the Contract, and with OSHA Regulations, Sections 1926.700, 1926.701 and 1926.702. This checklist is provided to assist the inspector in documenting an independent check of the Contractor's procedures and the ultimate conformity of the falsework to the approved drawings. If the Contractor is not competently performing these functions, a Directive ordering corrective action must be issued. At that point, if the Engineer thinks it would be helpful to provide the Contractor with a copy of the checklist for guidance, that is permissible. However, the Engineer should be wary of moving toward a situation where the Contractor's inspection/quality control responsibilities are usurped by comprehensive FLH inspection procedures.

Prior to the beginning of concrete placement the Contractor is required to provide a certification by a licensed Professional Engineer that the installation has been inspected and conforms to the approved design.

**B. Forms and Steel.**

A notation is appropriate in IDR. in field book or placement records that falsework, forms and steel have been checked for compliance with the contract.

**C. Quantities**.

If payment is by contract or plan quantity, that quantity should be referenced in the estimate book. If payment is by ordered (computed) quantity, complete documentation of these computations is required.

If payment is by measured quantities, batched quantity with deduction for estimated non-usage, should be documented. Except if the contract provides that payment be made for all quantities which the Government orders, wastage will not be deducted.

Approximations are adequate for progress payments if plan quantities are used for final payment. Usually approximations are based on an approximate breakdown of the plan quantities. Use of batched quantities for approximation is discourage since errors may accumulate over several placement operations.

**D. Placement Record.**

The placement record should detail the structural component placed, conditions, problems, time, etc. This information should be filed with or cross referenced to load tickets and test reports.

**E. Curing and Heating**.

Diary entries or supplemental records must document inspection during curing/heating periods to verify temperatures and presence of moisture.

**5. References**

Same as Section 9-5.1, plus:

*Form Work for Concrete*, American Concrete Institute

## 9-5.3 PRESTRESSED CONCRETE

### 1. Preliminary Review and Approval

**A. Shop Drawings**.

All prestressed components must have shop drawings approved by the Bridge Engineer prior to fabrication.

**B. Equipment and Facilities**.

Equipment and facilities, especially in the case of temporary fabrication sites, must be approved. Facilities for curing require special attention. See below relative to remote sites.

**C. Inspection and Testing.**.

For remote fabrication sites inspection and testing may be arranged commercially or through a State highway department. The Materials Engineer will arrange this when requested.

**D. Moving, Transporting and Stressing**.

It will be necessary to have an approved procedure for evaluating concrete strength in preparation for transporting or stressing the elements. A statistically based early strength prediction procedure is acceptable for this purpose.

### 2. Construction Inspection

Intermittent inspection is required at each stage of the operation. Comprehensive inspection is usually necessary during concrete placement and tensioning of steel.

**A. Beds and Forms.**

Forms should be inspected for dimensions and stability. Anchorage tie downs should be available as required.

**B. Reinforcing Steel and Inserts**.

See Section 9-5.4. Ducts and inserts for voids must be located accurately and tied down to counteract buoyancy.

**C. Pretensioning**.

Strands must be clean and acceptably free of corrosion immediately prior to concrete placement. Tensioning systems must be supported by approved calculations and verification after tensioning. Thermal effects, slippage and elongation must be considered.

**D. Concrete Placement**.

See Section 9-5.2. High frequency internal and/or external vibrators are often necessary to consolidate low slump concrete in congested forms for prestressed elements. High slump concrete utilizing a high-range water reducer is sometimes appropriate if requested by the fabricator and approved in accordance with the Contract.

**E. Post Tensioning**.

Tensioning should comply with the approved shop drawings. Ten to twenty percent of ultimate load should be applied to take up slack before measurement of elongation. Anchorage and tensioning devices must perform without apparent defects.

**F. Grouting**.

A guide to good practice is that grouting should be performed within 5 days of tensioning unless special anticorrosion precautions are taken. Ducts should be flushed and blown out with compressed air before grouting. Components of the grout shall have been previously approved prior to use. Pumps and gauges must be in proper working order with backups available.

### 3. Measurement

Prestressed elements are normally paid as a lump sum or plan quantity item. No additional measurement is required. If post tensioning is paid separately, the Contractor may be requested to furnish a breakdown for progress payment purposes. Even if it is not paid separately, the value of the post tensioning should not be paid in progress payments until the work is actually done.

**4. Documentation**

In addition to normal concrete and reinforcing steel documentation required by Subsections 9-5.1.4. and 9-5.4.4., the following items should be addressed:

**A. Materials Records and Certifications**.

Documentation should include prestressing wire and grout components.

**B. Tensioning Records**.

Identification of member and prestressing wire used, jacking equipment, elongation calculations, gauge readings or other verification computations showing assumed slippage, compression, etc.

**C. Stress Transfer**.

Concrete records should indicate that the required concrete strength has been achieved prior to stress transfer.

**D. Equipment**.

Calibration records should be available and checked for all jacking equipment used in the operation.

**5. References**

*Manual for Quality Control for Plants and Production of Precast Prestressed Concrete Products*, Prestressed Concrete Institute.

*Post-Tensioning Manual*, Post-Tensioning Institute.

## 9-5.4 REINFORCING STEEL

### 1. Preliminary Review and Approval

The Contractor should submit shop drawings or *cut sheets* for all reinforcing steel prior to fabrication. It is normally not necessary to submit routine cut sheets to the Bridge Designer for approval. They should be fully reviewed and approved or noted differences marked and returned to the Contractor by the Project Engineer.

If the plans include a design reinforcing steel detail, these sheets may be used to compare to and approve the cut sheets. However, the fabricator may make minor changes in bar lengths to account for shortening at bends, etc.

The epoxy coating process should be subject to independent inspection arranged by the Materials Engineer. This inspection may be by FLH specialists, State inspectors or a commercial testing firm.

Upon delivery of the steel, the Project Engineer should be furnished certifications and mill test reports for all reinforcing steel. The documentation must be provided before the steel is paid for. Bars must be identified by markings as to grade, mill, size, and type of steel. **Figure 9-5.4(a), Identification Marks - ASTM Standard Bars,** may be used to verify that the bars and certification grades indicated are the same.

It is not necessary for the Project Engineer to check dimensions of all steel upon delivery, as it is often difficult until it is placed in the forms. A cursory check should be made to verify the entire shipment has been received as represented by the documentation.

### 2. Construction Inspection

Except for epoxy coated bars, reinforcing steel requires only intermittent inspection until a portion of a structure is complete and ready for concrete placement. Inspection should then be comprehensive in conjunction with approval to proceed with the placement. Upon delivery, epoxy coated bars should be checked for cracks, pinholes, and coating thickness. Special equipment may be obtained for checking the thickness and completeness of coating.

**A. Storage and Handling**.

Reinforcing steel must be stored where it will be protected from dirt and grease. Minor rust is not normally a problem for non-coated steel, but it should be protected when stored in marine environments where major rust and scaling is likely.

**B. Placing and Tying**.

Bars must be supported and tied so as not to deflect significantly under construction and concrete placement conditions. Refer to CRSI guidelines for specifics. Deck steel should not be used to support buggy ramps or other heavy equipment. CRSI and ACI contain tolerances for minimum cover, vertical and lateral placement, as well as minimum frequency of ties.

Proper placement of deck steel is particularly important. The procedure described in Subsection 9-5.2.E. should be used to verify proper placement and cover for deck reinforcing steel.

**C. Placement of Concrete**.

Prior to concrete placement, steel must be cleaned of form release agents or any other detrimental substances. In hot weather it may be necessary to shade reinforcing steel and/or spray with fresh water to cool it to less than 32 °C.

After concrete placement, splice bars and other protruding bars must be cleaned of concrete splatter.

### 3. Measurement

Reinforcing steel is normally paid on a plan quantity basis. No remeasurement or computational checks are necessary. However, if changes are ordered by the Government or significant errors are discovered in the plans, the quantities should be adjusted to provide for these changes or errors. Minor adjustments in bar lengths to conform to fabrication standards are not considered significant.

**Figure 9-5.4(b), ASTM Standard Reinforcing Bars**, may be used to compute quantity changes in reinforcing steel.

## 4. Documentation

The following are minimum documentation requirements for reinforcing steel.

- Certification and mill test reports must be on file covering all reinforcing steel.

- For epoxy coated reinforcing steel inspection reports covering the coating process, as well as inspection reports on condition after delivery should be on file.

- Prior to each concrete placement, diary entries or a placement report must document that all steel to be incorporated in that placement has been checked as to size, location, cover, etc.

- All changes in contract quantities must be documented by detailed computations.

## 5. References

*Placing Reinforcing Bars*, Concrete Reinforcing Steel Institute (CRSI).

*Manual of Standard Practice*, CRSI

## 9-5.5 PILING

### 1. Preliminary Review and Approval

**A. Test Piles.**

Test piles are several ordinary piles driven in advance of ordering the remainder of the piles, in order to better estimate the order length of the remainder and to minimize cutoffs and splices. Test piles are normally *tested* only by their driving characteristics. If test piles are required, it must be determined if the test pile lengths are specified or if they must be ordered. If the latter is the case, the Project Engineer should consult with the Construction Operations Engineer to agree on the order lengths.

**B. Load Tests**.

Load tests are when a previously driven pile is tested by loading to its design load, or to failure to determine if driving characteristics give an accurate estimate of actual capacity. Load tests are very expensive and not normally performed in highway structure construction, except for experimental work and under unusual [usually friction pile] situations..

If one or more load tests are required, all equipment as well as the layout of the tests must be approved by FLH prior to the test.

**C. Pile Lengths**.

Some contracts may specify the order lengths of piles, or minimum tip elevations, but normally the Project Engineer must furnish order lengths based on the test piles (dynamic formula or wave equation analysis) and/or load tests. The determination of pile length often involves economic decisions. For example, if the cost of splices is considerable, it may be wise to order slightly excess lengths to minimize splices. Some contracts require the Contractor to determine lengths but provide payment only for the piles actually driven.

**D. Piling Hammers and Equipment**.

Proposed pile hammers and equipment must be submitted to FLH for approval prior to driving. Geotechnical personnel should be available to assist in evaluating equipment. Hammers must be large enough to assure some penetration (usually at least 3 mm per blow) at the design bearing; however, too large a hammer can damage some piles, or may not be able to reach full energy at the pile capacity. **Figure 9-5.5b, Pile Driving Equipment Data Sheet**, shows the information required to approve pile driving equipment.

### 2. Construction Inspection

Pile driving requires essentially continuous inspection in order to verify bearing.

**A. Equipment**.

Check hammer weight, cushion, leads and pile alignment.

**B. Preparation**.

Have the Contractor mark piles and provide a stationary scale on the leads in order to monitor penetration. The inspector should have computed or otherwise know the minimum blows per 25 mm necessary for design bearing.

**C. Driving**.

The hammer must operate at full stroke in order to attain the specified energy. This is important when determining the blow per 25 mm from which bearing capacity is determined. Low pile resistance may initially cause the hammer to function at less than full energy. **Figure 9-5.5a, Pile Driving Record** is a convenient form for recording pile driving information.

Once a pile has reached design tip elevation and the specified bearing has not been reached, it may be prudent to wait a period of time and try driving again. Often, in granular soils, consolidation will have taken place and bearing will have been achieved.

**D. Splicing**.

Splicing procedures must be approved and splicing must be performed in a skillful manner. Welding, in particular, must be performed under controlled conditions by a certified welder..

**E. Drilled Piles**.

Some piles must be drilled or augered. Examples are concrete piles that are cast in place, and some steel and concrete piles that are predrilled to a specified tip elevation, or installed in a newly constructed embankment.

If the specifications require drill holes and casings to be inspected, the Contractor's QC plan should cover most of this effort. Minimum embedment in rock may be a specified criterion. Periodically the inspector should make verification inspection and the Contractor should be asked to furnish assistance.

Often, cast-in-place piles must be cast in a dry casing or hole. This can require difficult sealing and dewatering.

**3. Measurement**

Measurement requirements depend on how pile related contract items are structured. The specifications must be read carefully before setting up a documentation system. Generally, all piles ordered by the Government must be paid for, but if the Contractor is required to determine order lengths only pile lengths driven are paid for.

Often splices are paid for, but not always. Usually splices in piles less than the order length are not paid for.

**4. Documentation**

Comprehensive documentation is necessary for all pile driving operations. Following are minimum requirements:

- Pile layout, structure and numbering system

- Type of hammer and other equipment

- Material certifications for piling

- Driving log for each pile

  - Penetration/blow counts
  - Pile lengths
  - Splices
  - Computed tip elevation
  - Computed Bearing
  - Summary of Pay Items

**5. References**

*Design and Installation of Driven Pile Foundations,* by Hal W. Hunt, Associated Pile and Fitting Corporation.

*Inspectors Manual for Pile Foundations,* Deep Foundations Institute, P.O. Box 359, Springfield, New Jersey 07081.

*Design and Construction of Pile Driven Foundations*, FHWA, Demonstration Projects Division.

*A Pile Inspector's Guide to Hammers,* Deep Foundations Institute, as above.

## 9-5.6 STEEL STRUCTURES

### 1. Preliminary Review and Approval

**A. Shop Drawings**.

All shop drawings for major steel structures should be submitted for approval to the Bridge Engineer.

**B. Fabrication**.

The Materials Engineer or Bridge Engineer will arrange for inspection of fabrication.

**C. Falsework**.

Falsework for steel structures must be approved as required by Section 9-5.2.

**D. Welding**.

If field welding is required, the Bridge Engineer should evaluate the need for specialized field inspection or testing if appropriate.

**E. Bolts.**

If a calibrated torque wrench is necessary for inspection of high strength bolts, the Project Engineer should arrange for the required calibration equipment.

**F. Certifications**.

All materials must be accompanied by certifications. Structural plate and associated welds should be documented by mill test results and other required tests.

### 2. Construction Inspection

Intermittent inspection of all operations is normally adequate except for welding and bolt tightening which require comprehensive inspection.

**A. Delivered Steel**.

Upon delivery, steel should be checked for proper documentation including mill test reports, certifications, and inspection reports.

Any significant damage may require repairs. The Bridge Engineer should be consulted if this is the case. Steel should be stored to be protected from the weather. This is especially true if it is to be stored for a long duration. If at the time of erection, excessive mill scale and rust has built up on unpainted bearing surfaces, these surfaces may require sandblasting prior to assembly.

**B. Falsework and Erection Equipment**.

Facilities for erection must be installed to conform to the approved working drawings and erection plan.

**C. Erection**

All bearing plates and rockers must be placed within acceptable tolerances. Bearing surfaces must match or be ground smooth. Required gaps in expansion joints should be checked prior to securing the fixed end of spans..

**D. Bolted Splices.**

If splice plates are temporarily removed, match marking should be checked to insure proper replacement.

When heavy hexagon bolts and heavy semifinished hexagon nuts are used, a hardened washer must be installed under the bolt head or nut, whichever is the element being turned. Heavy hexagon bolts can be identified by three radial lines, the legend A-325, and the manufacturer’s mark on the top of the head. Heavy semifinished hexagon nuts can be identified by three circumferential marks, or by the number "2" and the manufacturer’s mark on at least one face. The bolts and nuts may be washer faced but these faces do not take the place of a hardened washer.

See **Figure 9-5.6(a), ASTM Standard Structural Bolts**, for standard markings of A-325 bolts. Washer dimensions can be found in the Standard Specifications.

Calibrated torque wrenches must be used to check all tightening operations. When impact wrenches are used, a constant check should be maintained on the initial phase of the work to ascertain that the bolt tensioning is slightly in excess of the minimum value given in the table on bolt tension and torque values in the Standard Specifications. Once the procedure is satisfactorily established, less frequent checks should may performed if permitted by the Project Engineer.

AASHTO M 164M bolts, nuts, and washers are used with AASHTO M 183M steel and other steels which are to be painted. AASHTO M 253M bolts, nuts, and washers are to be used with AASHTO M 222M steels. M 253M bolts are manufactured of steel, which is more corrosion resistant than M 164M.

The Contractor is required to conduct quality assurance checking the torque of bolts in each connection. Generally, not less than 10 percent or two bolts per connection should be checked. Quality assurance checking must be in the presence of the Engineer.

**E. Welding.**

All field welding must be performed by welders certified for the specific types of welds to be performed. The Project Engineer may request documentation of welder certification.

**F. Painting**.

See Section 9-5.7

**3. Measurement**

Structural steel is always paid by lump sum or plan quantity. No remeasurement or computations are necessary. If an error is discovered or change is made, weights specified in the *AISC Manual of Steel Construction*, may be used to compute changes. However, it is likely some additional cost data may be necessary to more accurately assess the increase or decrease in the Contractor's costs.

**4. Documentation**

Mill test reports, certifications and shop inspection reports are required for all structural steel. Diary entries made during erection of steel should indicate all problem areas and solutions.

The systematic means of checking bolt tightening should be documented.

**5. Reference**

*Steel Construction Manual*, American Institute of Steel Construction (AISC)

## 9-5.7 PAINTING OF STRUCTURES

### 1. Preliminary Review and Approval

Paint certifications must be provided prior to beginning painting.

If color samples and approval of color are required, this must be coordinated with the Contractor and the approving official.

Environmental concerns may have to be addressed, especially if there is nearby private property, traffic, or if lead or other highly toxic paints are used. In any case, the Contractor should be asked how any problems or potential problems will be mitigated.

If removal of old paint is a part of the Contract, the Contractor may be required to test, and if necessary dispose of the debris as hazardous waste. Laws and regulations may put constraints on how such debris is collected and stored prior to disposal. Negative pressure enclosures may also be required. In enclosure workers, and FLH inspectors may have to take special health precautions to address the presence of lead and other toxins.

### 2. Construction Inspection.

Inspection is normally intermittent at each stage of construction.

**A. Surface Preparation**.

The specifications should contain specific requirements as to surface preparation. Mill scale, dirt, and loose paint must always be removed. Sandblasting of deteriorated areas and perhaps the entire structure may be required. The specific requirements must be reviewed with the Contractor to be sure they are understood. In the event that Steel Structures Painting Council's (SSPC) sandblasting standards are specified, these standards should be obtained for reference. The presence of oil or grease may necessitate a solvent cleaning.

For some paints and conditions, neither surface preparation nor actual painting can be done outside certain ranges of air temperature, humidity, and dew point. For marginal cases the necessary equipment and expertise should be obtained. Generally, final surface preparation and coating application should not proceed unless the surface temperature is at least 3°C higher than the dew point. Or, if a spot on the steel is moistened with a damp cloth, it should dry within 15 minutes if the dew point is low enough to paint.

When there are airborne pollutants in the area (steam, dust, chemicals), additional precautions may be necessary.

**B. Equipment**.

The equipment selected by the Contractor should comply with the specifications, be clean, and in good working order. The equipment used to measure film thickness is usually furnished by the Government. The procedure for determining thickness should be discussed with the Contractor. Initial readings should be taken on bare surfaces and the prime coat to use as a base for measuring subsequent coats.

**C. Paint**.

Mixing of paint together with all specified additives is the single most important operation prior to application. Paint must be mixed until it becomes smooth, homogeneous, and free of surface "swirls" or pigment lumps. All settlement in the bottom of cans must be thoroughly mixed with the liquid.

It is often useful to tint second coats of prime or other intermediate coats in order for the painter to monitor coverage.

**D. Paint Application.**

Paint must be applied in a uniform and consistent manner. Special attention to coverage is necessary in corners, behind stiffeners and bolts. Brush application may be necessary in these areas.

**E. Film Thickness**.

Wet film thickness gauges may be used by the Contractor for process control. Dry film thickness gauges are used by the Inspector for acceptance. Chalk is useful to mark deficient areas. If deficient areas are numerous, the Contractor should be advised that the job is deficient, and ordered to check and correct it; i.e., the Inspector is not obligated to spend many hours identifying deficiencies if it is clear that the job is not ready for acceptance. Remember that the thickness gauge measures total thickness, so it is necessary to establish average readings for the prime coat(s) in order to calculate the thickness of the finish coat.

**F. Multiple Coats**.

When more than one coat is to be applied and dust and pollution are in the air, it may be necessary to clean the surface before each coat is applied.

**G. Special Tests**.

In addition to dry film thickness readings, some projects may require special tests such as pinhole/holiday detection, or adhesive testing (ASTM D-3359). The ASTM test may be obtained from the Materials Engineer. The pinhole/holiday detection test requires special equipment.

**H. Samples.**

Although paint is normally accepted by certification, FLH may, at its discretion, take samples and have them tested (usually commercially).

**3. Measurement**

Painting is normally a subsidiary obligation or paid as a lump sum. That being the case, no measurement of quantities is necessary. Changes or added quantities may be negotiated based on changes in areas painted.

**4. Documentation**

Certifications are required for all paint. Certifications and paint containers should be marked as to lot number and date of manufacture. The contract may require specific test data supporting the certifications.

For surface preparation, the IDR's should document inspection results and approvals. Photograph of passing and failing surfaces are helpful. Photographs of corners, splices, bolts and other hard to clean areas are more so.

The Project Engineer should maintain documentation of the intermittent inspections leading up to the dry film thickness measurements after each coat. The results of dry thickness readings should be documented as well as retesting (if necessary) and final acceptance.

**5. References**

*Steel Structures Painting Manual, Volume 1, Good Painting Practice*, Steel Structures Painting Council (SSPC)

*Steel Structures Painting Manual, Volume 2, Systems and Specifications*, Steel Structures Painting Council (SSPC)

## 9-5.8 REHABILITATION OF CONCRETE STRUCTURES

### 1. Preliminary Review and Approval

Rehabilitation specifications are normally detailed and method oriented. The Project Engineer should go over them in detail with the Contractor to establish necessary controls at each phase. There are normally areas shown on the plans designated for removal or corrective action. The Project Engineer must ascertain if these are ”estimated" areas requiring extensive rechecking prior to authorizing the Contractor to proceed with the work, or if they have already been checked and it is acceptable to begin work.

All materials and equipment used by the Contractor are usually subject to approval prior to commencement. Traffic control procedures must also be reviewed in detail to determine if all potential problems have been properly anticipated. Equipment approval is particularly important because if such equipment is too heavy or too large it may damage additional portions of the structure as defective areas are removed.

When the specifications say ”all unsound concrete is to be removed", it is important to reach an understanding with the Contractor as to who has the authority to designate this concrete. If the Contractor can perform responsibly, there is nothing wrong with giving Contractor QC personnel limited authority to expand designated areas if they are defective, with the understanding that such areas will be added to pay quantities. If, however, the Government wants to retain complete control of the removal process; it will be necessary to assign Inspectors to the operation nearly full time to approve removal or to expand areas as necessary.

In any case, it is important to discuss these problems and reach at least tentative understandings before work begins.

### 2. Construction Inspection

Inspection required for rehabilitation work is nearly continuous. Problems, changes, and the frequent necessity to approve each stage of the work necessitate this.

**A. Bridge Decks**.

Removal operations, using approved equipment, must remove all defective concrete without significant damage to the structure. Milling must be deep enough to accommodate the overlay. Defective areas must be identified by sounding or more sophisticated procedures. Usually two stages are necessary: one to identify initial removal areas and one to check/or identify additional areas.

The Construction Operations Engineer and the Bridge Engineer (designer) should be apprised if the conditions during removal are drastically different from conditions depicted in the contract.

Joints, reinforcing steel, and miscellaneous hardware often require repair, and the actual conditions are often not as depicted in the plans.

Replacement concrete should be inspected as required by Subsections 9-5.1 and 9-5.2 as modified by any additional requirements in the contract.

**B. Concrete Pavement**.

The contract normally has specific requirements as to slab removal, replacement, and sealing. As with bridge decks, it is necessary to respond to conditions as they actually exist if those conditions are different than those depicted in the plans.

Repair of expansion joints in concrete pavement is particularly important. Dowels which are out of line or installed improperly will defeat the purpose of the repair work.

### 3. Measurement

The contract will normally have a wide variety of pay items for rehabilitation work. The most important consideration is the determination of how additional quantities will be measured; i.e., will the Contractor have authority to perform numerous quantities of additional work and expect that work to be measured for payment. Or will only the Engineer have authority to authorize additional work. The answers are different for different situations, but understandings should be reached before work is started.

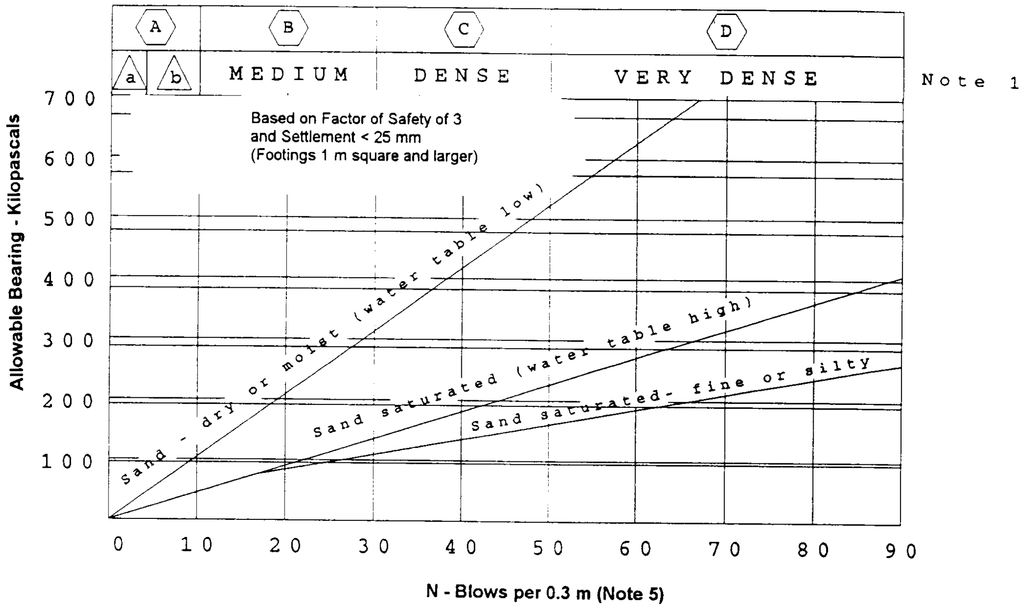
**4. Documentation**

Complex documentation is required for rehabilitation work. Removal, replacement, and repair items must be documented in detail, usually with drawings or sketches.

All material must be documented with certifications or test and inspection results.

Photographs are particularly important for rehabilitation work because they provide good feedback so that future designs can be improved.

## Allowable Bearing on Sandy Soils




a Very Loose
b Loose

A Easily penetrated with 12 mm rod pushed by hand

B Easily penetrated with 12 mm rod driven with a 2 kg hammer

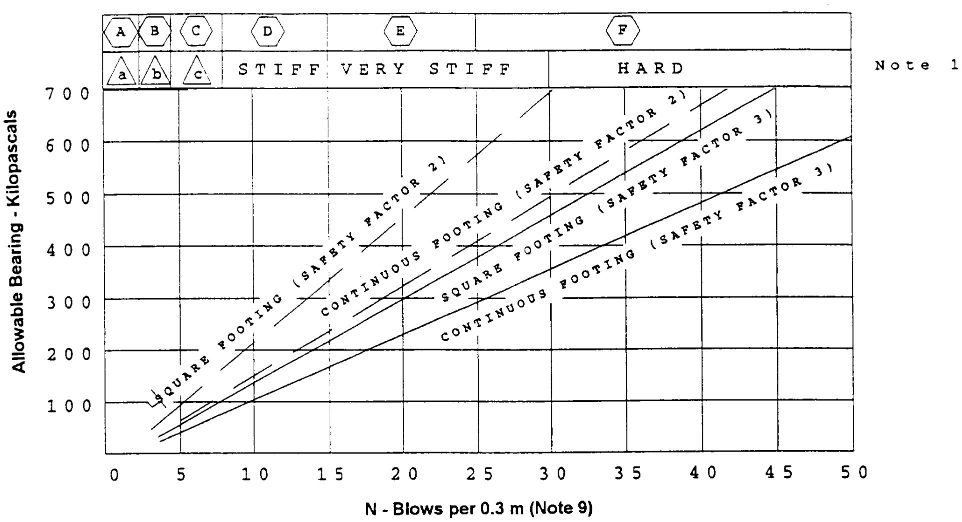
C Penetrated 0.3 m with 12 mm rod driven with 2 kg hammer

D Penetrated 0.1 m with 12 mm rod driven with 2 kg hammer

**Notes**
1) Terzaghi & Peck Classification
3) Settlement governs over bearing capacity when footing least dimension exceeds about 1 m.
4) An average or representative blow count over a depth below footing equal to the least width of the footing should be used.
5) N represents the blows per 0.3 m to drive a 35 mm diameter (ID) sampler using a 63.5 kg hammer freely falling 0.76 m.

**Allowable Bearing on Sandy Soils**
**Figure 9-5.2a**

**Allowable Bearing on Clayey Soils**




- (a) VERY SOFT
- (b) SOFT
- (c) MEDIUM
- (A) Squeezes between fingers when fist is closed
- (B) Easily moulded by fingers
- (C) Moulded by strong pressure of fingers
- (D) Dented by strong finger pressure Penetrated by thumb only with great effort
- (E) Readily indented by thumbnail. Dented slightly by strong finger pressure
- (F) Dented only slightly by pencil point

See Notes Next Page

**Allowable Bearing on Clayey Soil**
**Figure 9-5.2b**

**Notes** 1) Terzaghi & Peck Classification

3) Weak strata at some distance below footings may in cases cause more settlement than soil layers immediately below the footings.

4) Desiccation of clay near the surface will result in higher blow counts. An average or representative blow count over a depth below footing equal to the least width of the footing should be used.

5) For same unit pressure, large footings settle most. This is particularly so where clay strata are involved.

6) Greatest settlements may generally be expected at centers of loaded areas.

7) Consolidation and settlement tend to increase with the following:

- Softness of the clayey material.
- Thickness of the compressible strata.
- Closeness of clay stratum to ground surface.
- Amount proposed loading exceeds past loading.
- Width of footing or loaded area.
- Height of water table.
- Liquid limit.
- Time.

8) Shear failures are most apt to occur when:

- Footings are small.
- Settlements are large.

9) N represents the blows per 0.3 m to drive a 35 mm diameter (ID) sampler using a 63.5 kg hammer freely falling 0.76 m.

**Allowable Bearing on Clayey Soils (Continued)**
**Figure 9-5.2b**

## REPORT OF FIELD CHANGE TO FALSEWORK/FORMWORK

Project: ________________________________________________ Date: ___________

Portion of Structure: ____________________________________________________________

Description of Change: ______________________________________________________________

_________________________________________________________________________________

_________________________________________________________________________________

_________________________________________________________________________________

_________________________________________________________________________________

_________________________________________________________________________________

__________________________________________________

Action Taken:____________________________________________________________________

_________________________________________________________________________________

_________________________________________________________________________________

_________________________________________________________________________________

_________________________________________________________________________________

______________________________________________________

Change: _____ Approved By____ Discussed With __________________ Date _____________

______ Waiting Approval ______ Contractor Proceeding ____ Work on This Item Suspended

______ Need Decision By ______________(Date) ______ See Drawings or Attachments

______ Other Comment: ___________________________________________________________

_________________________________________________________________________________

_________________________________________________________________________________

_________________________________________________________________________________

___________________________________________________________

Distribution: Construction Operations Engineer, Bridge Engineer, Project Files

**Figure 9-5.2c**

## CHECKLIST FOR FALSEWORK INSPECTION

Project:_______________________ Portion of Structure: ________________________

Partial:________ Final: ________ Date:_________

### A. All Falsework

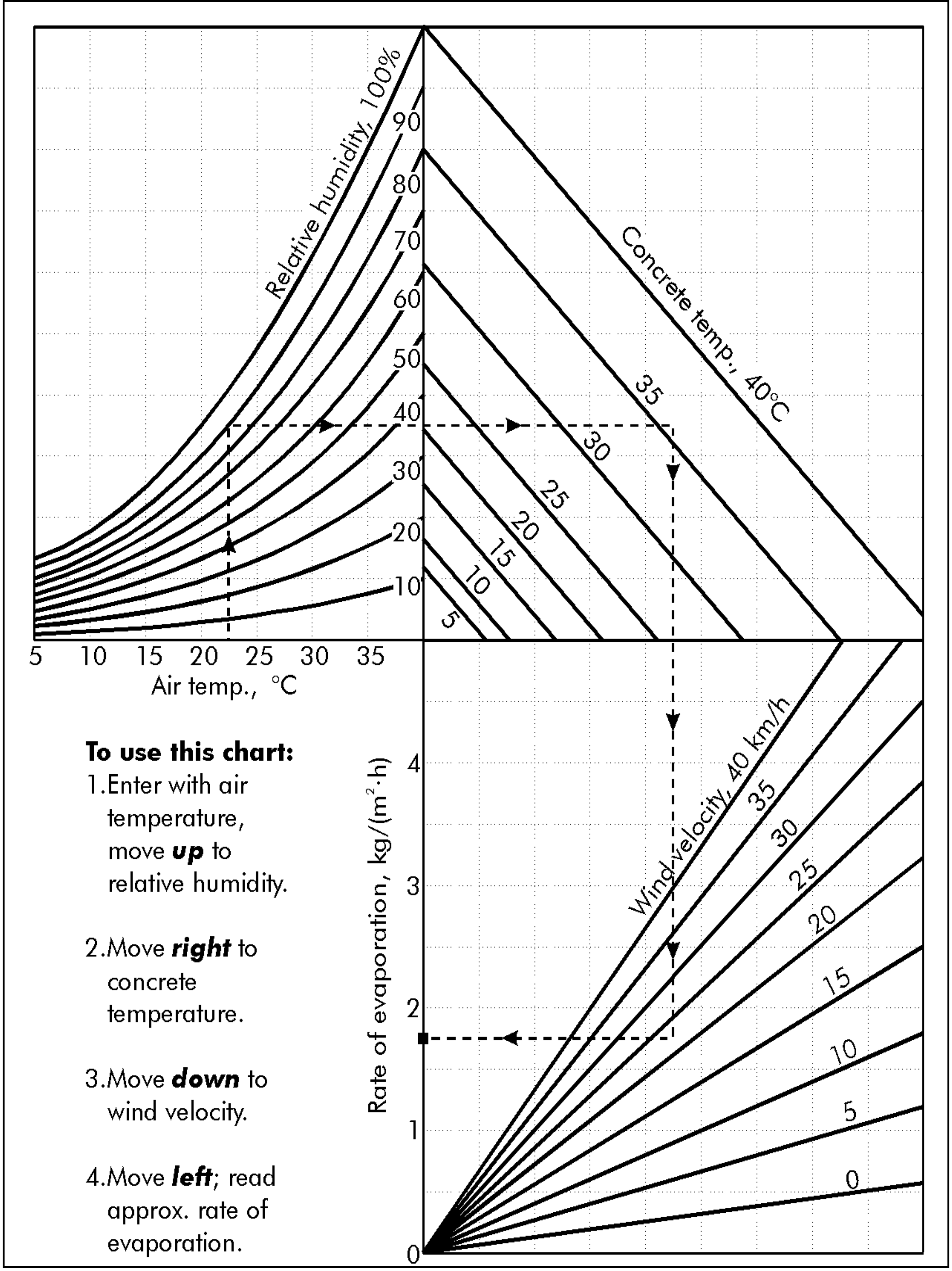
| Item | Insp | Date |
|---|---|---|
| 1. Approved shop drawings with all appendices and attachments available onsite. | | |
| 2. All components identified as consistent with approved drawings. Identification should be by dimensional checks and/or manufacturers model numbers when available. Special grade lumber should be verified by markings. No significant damage (repairs, welds, holes cut, etc.) to any component unless the damage is considered in the design computations | | |
| 3. Bearing capacity of footing foundations checked and confirmed consistent with design assumptions. | | |
| 4. No standing water or washouts in vicinity of foundations which may have reduced their bearing capacity. | | |
| 5. Footings, beams and leveling blocks dimensionally correct and in firm contact. | | |
| 6. Elevation adjustments made with full contact shims or paired/properly sized wedges. | | |
| 7. Columns, towers and vertical members checked for maximum spacing and plumbness in both directions. Plumbness should be within 3.5 millimeters in one meter. | | |
| 8. Lateral and diagonal bracing in place and attached per approved drawings. | | |
| 9. All components protected from adjacent traffic and construction vehicles. | | |
| 10. Tell-tales in place and checked. | | |

**Checklist for Falsework Inspection**
**Figure 9-5.2d**

**B.  Steel Tower/Screw Jack Falsework**

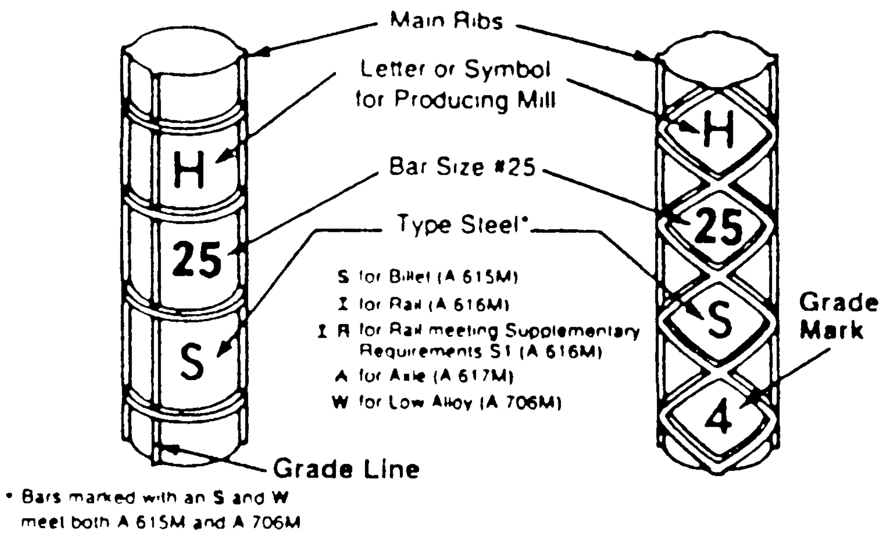
| Item | Insp | Date |
|---|---|---|
| 1. All steel support frames, jacks and assembly parts are in accordance with manufacturer's model numbers and as approved in the falsework drawings.  All components are free of dents, bends, cracked welds and corrosion. | | |
| 2.  Base plates in firm contact with footing or sill, and with decking support system.  Plates should be attached if required by the approved drawings. | | |
| 3.  Adjustment screws snug against frame legs.  Alignment devices in place inside legs to prevent rotation.  Screws not over extended. | | |
| 4.  No gaps between adjacent tiers of frame legs.  If gaps cannot be closed by adjustment screws without putting the frame out of plumb, the frame may be out of square and should be replaced. | | |
| 5. Each tier of frames must have cross bracing or diagonal bracing. | | |
| 6.  Locking devices on bracing are properly closed and tight, and not damaged. | | |
| 7.  If exterior bracing for lateral stability is required, the devices which fasten this bracing to the frame system must be securely attached in accordance with manufacturer's recommended standards and as required by the approved falsework drawings.  Check cable clamps, tubing clamps and timber to steel connections. | | |

**Checklist for Falsework Inspection (Continued)**
**Figure 9-5.2d**




Note: Example shown by dashed lines is for an air temperature of 22.5°C, relative humidity of 90 percent, concrete temperature of 36°C, and a wind velocity of 22.5 kilometers per hour. This results in a rate of evaporation of 1.75 kilograms per square meter per hour.

**Evaporation Rate in Hot Weather**
**Figure 9-5.2e**




**Grade 400 and above**

**Standard Bar Markings**
**Figure 9-5.4a**

| MINIMUM YIELD STRENGTH OR GRADE ($f_y$) | | GRADE MARK |
|---|---|---|
| English (ksi) | Metric(MPa) | |
| 40.0 | | None |
| 43.5 | 300 | None |
| 50.0 | | None |
| 50.8 | 350 | None |
| 58.0 | 400 | 4 or one line |
| 60.0 | | 60 or one line |
| 60.9 | 420 | 4 or one line |
| 72.5 | 500 | 5 or two lines |
| 75.4 | 520 | 5 or two lines |

**Standard Grade Marks**
**Figure 9-5.4b**

| BAR SIZE MARK | | | NOMINAL DIAMETER (mm) | NOMINAL AREA (mm²) | NOMINAL MASS (kg/m) |
|---|---|---|---|---|---|
| US (Standard) AASHTO M 31, M42 or M53 | US (Metric) ASTM A 615M-96a | Canadian (Metric) AASHTO M31M, M42M or M53M | | | |
| 3 | 10 | | 9.5 | 71 | 0.560 |
| | | 10 | 11.3 | 100 | 0.785 |
| 4 | 13 | | 12.7 | 129 | 0.994 |
| 5 | 16 | | 15.9 | 199 | 1.552 |
| | | 15 | 16.0 | 200 | 1.570 |
| 6 | 19 | | 19.1 | 284 | 2.235 |
| | | 20 | 19.5 | 300 | 2.355 |
| 7 | 22 | | 22.2 | 387 | 3.042 |
| | | 25 | 25.2 | 500 | 3.925 |
| 8 | 25 | | 25.4 | 510 | 3.973 |
| 9 | 29 | | 28.7 | 645 | 5.060 |
| | | 30 | 29.9 | 700 | 5.495 |
| 10 | 32 | | 32.3 | 819 | 6.404 |
| | | 35 | 35.7 | 1000 | 7.850 |
| 11 | 36 | | 35.8 | 1006 | 7.907 |
| 14 | 43 | | 43.0 | 1452 | 11.38 |
| | | 45 | 43.7 | 1500 | 11.76 |
| | | 55 | 56.4 | 2500 | 19.61 |
| 18 | 57 | | 57.3 | 2581 | 20.24 |

**Standard Bar Sizes**
**Figure 9-5.4b**

# Pile Driving Record

| | | | |
|---|---|---|---|
| PROJECT: | | DATE: | |
| CONTRACTOR: | | INSPECTOR: | |
| STRUCTURE: | | PILE LOCATION: | |
| SAXIMETER NO.: | | TIME: START | STOP |
| PILE NO.: | PILE TYPE / SIZE: | LENGTH (m): | BATTER: |
| GROUND ELEV.: | PILE TIP ELEV.: | CUTOFF ELEV.: | |
| HAMMER MAKE/MODEL: | | | |
| THROTTLE SETTING: | ENERGY/BLOW: | BLOWS/MIN.: | |
| HAMMER CUSHION TYPE/THICKNESS: | | | |
| PILE CUSHION TYPE/THICKNESS: | | | |

| DEPTH (0.25m) | BLOWS (/ 0.25m) | STROKE / PRESSURE | DEPTH (0.25m) | BLOWS (/ 0.25m) | STROKE / PRESSURE | DEPTH (0.25m) | BLOWS (/ 0.25m) | STROKE / PRESSURE | DEPTH (0.25m) | BLOWS (/ 0.25m) | STROKE / PRESSURE |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0.25m | | | | | | | | | | | |
| | | | | | | | | | | | |
| | | | | | | | | | | | |
| 1.00m | | | 8.00m | | | 15.00m | | | 22.00m | | |
| | | | | | | | | | | | |
| | | | | | | | | | | | |
| | | | | | | | | | | | |
| 2.00m | | | 9.00m | | | 16.00m | | | 23.00m | | |
| | | | | | | | | | | | |
| | | | | | | | | | | | |
| | | | | | | | | | | | |
| 3.00m | | | 10.00m | | | 17.00m | | | 24.00m | | |
| | | | | | | | | | | | |
| | | | | | | | | | | | |
| | | | | | | | | | | | |
| 4.00m | | | 11.00m | | | 18.00m | | | 25.00m | | |
| | | | | | | | | | | | |
| | | | | | | | | | | | |
| | | | | | | | | | | | |
| 5.00m | | | 12.00m | | | 19.00m | | | 26.00m | | |
| | | | | | | | | | | | |
| | | | | | | | | | | | |
| | | | | | | | | | | | |
| 6.00m | | | 13.00m | | | 20.00m | | | 27.00m | | |
| | | | | | | | | | | | |
| | | | | | | | | | | | |
| | | | | | | | | | | | |
| 7.00m | | | 14.00m | | | 21.00m | | | 28.00m | | |

REMARKS:

**Pile Driving Record**
**Figure 9-5.5a**

# Pile Driving Equipment Data Sheet

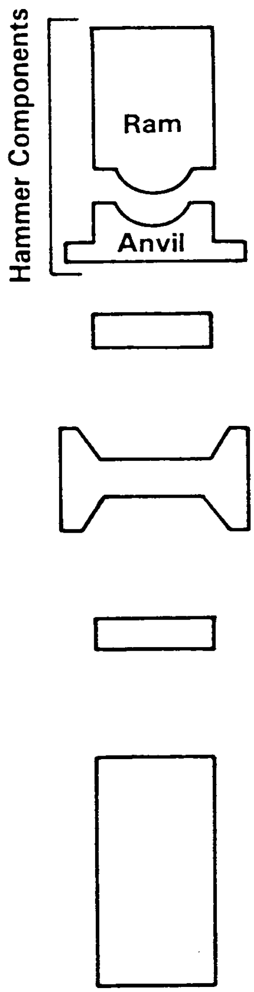
Contract No.: ______________________ Structure Name and/or No.: ______________________

Project: ______________________ ______________________

______________________ Pile Driving Contractor or Subcontractor: ______________________

County: ______________________ ______________________

(Piles driven by)




**Hammer**

Manufacturer: ______________________ Model: ______________________

Type: ______________________ Serial No.: ______________________

Rated Energy: ______________ at ______________ Length of Stroke

Modifications: ______________________

______________________

______________________

______________________

______________________

**Capblock (Hammer Cushion)**

Material: ______________________

Thickness ______________________ Area: ______________________

Modulus of Elasticity — E ______________________

Coefficient of Restitution-e ______________________

**Pile Cap** — Helmet / Bonnet / Anvil Block / Drivehead — Weight: ______________________

**Pile Cushion**

Cushion Material: ______________________

Thickness: ______________________ Area: ______________________

Modulus of Elasticity — E ______________________

Coefficient of Restitution ______________________

**Pile**

Pile Type: ______________________

Length (in Leads) — ______________________

Weight/meter ______________________

Wall Thickness: ______________________ Taper: ______________________

Cross Sectional Area ______________________

Design Pile Capacity: ______________________ (Tons)

Description of Splice: ______________________

______________________

Tip Treatment Description: ______________________

______________________

Note: If mandrel is used to drive the pile, attach separate manufacturer's detail sheet(s) including weight and dimensions.

Submitted By: ______________________ Date: ______________

Pile Driving Equipment Data Sheet
Figure 9-5.5b

## SECTION 9-6 - MISCELLANEOUS CONSTRUCTION



**Figure**

## 9-6 MISCELLANEOUS CONSTRUCTION

### 9-6.1 Drainage Structures

#### 1. Preliminary Review and Approval

#### A. Pipe Culverts and Storm Drains

After the project has been slopestaked, it will be necessary for the Project Engineer to analyze the approximate design of drainage culverts as shown on the plans, and if required, to make or recommend adjustments or redesign to meet field conditions.

The contract may require that the Contractor perform this analysis and submit proposed adjustments to the Engineer for approval; or it may be silent on this issue which means the Engineer must perform the analysis and make the adjustments prior to authorizing the Contractor to order materials and install the culvert.

The analysis will usually require that stakeout data at the culvert installation be taken and plotted in order to verify the design.

Careful consideration should be given to the following pertinent factors:

**(1). Location of Structure.**

The alignment and grade of the channel adjacent to the inlet and outlet of the proposed structure should be carefully studied to assure efficient operation. If the location for any structure as indicated on the plans appears incorrect, the Project Engineer must take the necessary action to properly correct the situation, contacting the Construction Operations Engineer if there are technical or procedural questions.

**(2). Type and Size of Structure**.

Based on actual field conditions, the Project Engineer may come to question the type of a structure, arch vs. round culvert perhaps, or the size. The Project Engineer should review design information in these situations, and should consult the Construction Operations Engineer if the question persists.

Prior to establishing the lengths of manufactured culverts, the Engineer should review with the Contractor how culvert length are cut or manufactured. If culverts only come in say 0.25 meter or 1.0 meter increments, they should be ordered that way if possible. However, if this would involve technical compromises or waste, the culvert should be staked as necessary and the Contractor should deal with the odd length, and cutting problem.

**(3). Limiting Heights of Fill.**

The Project Engineer must see that the design gauge or strength of culvert pipes meets the prescribed design criteria for the heights of fill to be placed over them, if either the fill or culvert vary from what was anticipated by the designer. The design criteria are normally shown on the plans. If not, this information will be furnished by the Construction Operations Engineer.

Past culvert design methods increased metal thickness to control pipe deflection. The present emphasis is for the use of proper bedding and backfill as the best method for controlling pipe deflection. This method has produced fill height tables with less pipe thickness for corresponding maximum fill heights. It has also, of course, increased the need for care in inspecting bedding and backfill.

#### B. Underdrains

Adequate design of underdrains at the time of preliminary engineering and preparation of plans is often difficult or impossible due to scant information and time. The Engineer must therefore carefully evaluate the conditions on the project as the work progresses, and provide underdrains as conditions warrant.

The location and depth of underdrains are governed by the characteristics of the particular soil involved, the location of the water to be intercepted, and the terrain. Numerous alternate perforated pipe materials are acceptable and have been approved for use. Prior to installation, it should be determined which material the Contractor intends to furnish from the list of specified alternates. Then their properties should be reviewed for compliance with specifications.

All available alternate pipe materials are not approved for installation beneath the traveled way. The Project Engineer must check to insure any proposed pipe materials different from those designated on the plans are acceptable. This information can be obtained from the Construction Operations Engineer.

When geotextile fabric is used, the certified physical properties as well as the performance tests require review prior to installation, to insure specification compliance. Division procedures may require samples for additional testing.

Granular backfill material is a vital component to the complete system. The Project Engineer is responsible for arranging evaluation of the location and volume of underground water to be carried and the permeability of the intended granular backfill material when there is any doubt the true situation was known to the designer. A change in the design of the system may be required. Assistance should certainly be requested when failure of an expensive or environmentally sensitive portion of a project seems possible. Assistance from Geotechnical, hydraulics and other design personnel, may be arranged through the Construction Operations Engineer.

**2. Construction Inspection**

Once the Project Engineer and/or Inspector have reached an understanding with the Contractor on proper installation, inspection of routine installations should be an occasional, as opposed to a constant task. Underdrains may require closer attention. If the *design* is being done as excavation proceeds, this is a frequent occurrence.

**A. Pipe Culverts and Storm Drains**

The Project Engineer is responsible to insure a stable foundation is being prepared for all structures. Stable foundation, rock foundation, and yielding foundation all require different methods of bedding. Construction requirements and instructions will usually be found in the specifications and project plans. Information on good practice may be obtained from any of several publications available to the Project Engineer.

Silting around an inlet or outlet is caused by retarding the velocity of the stream just above or below the culvert. If sedimentation is anticipated, erosive velocities should be reduced by means of a broken grade line, stilling basins, or spillways. In unusual situations, the matter should be referred to the Construction Operations Engineer for special consideration. For pipe installation and construction procedures, reference should be made to the AISC publication, *Handbook of Steel Drainage & Highway Construction Products.*

**B. Underdrains**

In general, the underdrain gradient should be not less than 2 percent, and stringline or grade points set by instrument should be used to eliminate pockets.

Installation for underdrain systems often reveal sources of underground water adjacent to the excavated trench and the inspector should be alert to the need for branch connections.

Outlets to underdrain pipes should be located so as not to interfere with future maintenance, be subject to damage or blockage, and not cause erosion problems.

**3. Measurement**

Methods of measurement are described under the appropriate section of the Standard Specifications, Special Contract Requirements, and/or Project Plans. They should be reviewed with the Contractor in the early stages of the project, to avoid arguments later when the Contractor compares invoice length to pay length. Any confusion should be resolved early, before a significant quantity of pipe is buried, making resolution awkward.

**4. Documentation**

The Project Engineer should insure there is a record of the field check for compliance of materials to specifications, normally by signed and dated notes and copies of invoices or certifications.

Field measurement records are required along with records of computation of all pay quantities. Special sheets or books are usually available for records of these items (Culvert Books). As a minimum, the record should show installation dates, survey records for excavation volumes, and names of FLH personnel making the records.

## 9-6.2 Guardrail and Concrete Barriers

### 1. Preliminary Review and Approval

Field conditions unknown to the designer and/or changes in the design may result in changes in guardrail needs for the project. The Project Engineer must carefully evaluate all field situations to determine if guardrail can be eliminated or if guardrail should be installed in areas where changes have occurred.

Field changes that affect drainage or slope flattening should be consistent with the 404 Permit, or an amended permit secured. The Project Engineer should notify the Construction Operations Engineer as soon as any permit deficiencies are known or suspected. The permit process can be a long time, so early review is best.

The AASHTO publication *Roadside Design Guide*, is the guide for the Project Engineer when evaluating changes.

### 2. Construction Inspection

Once the Project Engineer has approved the location, length and termini of all installations, inspection should be intermittent.

Culverts and structures near guardrail areas should be checked to prevent damage during guardrail post or anchor installation.

Wooden guardrail post installation should be monitored to discourage installers shortening post lengths upon encountering impenetrable objects. Look for saw dust or cut off ends. Also areas with extra length posts specified will require extra monitoring. If problems are encountered, they should be dealt with as violations of the Contractor's QC management responsibilities.

In areas of contorted geometrics and unusual superelevation configurations, rail must be checked to insure design height above ultimate finished grade.

### 3. Measurement

Methods of measurement must be done in accordance with instructions found in specifications.

## 9-6.3 Fence

### 1. Preliminary Review and Approval

The right-of-way line is nominally the fence line, however, unless otherwise directed, the fence will be located 0.3 meter inside the right-of-way line. The purpose for installing fence is usually to keep livestock off of the highway. For the fence to be most effective, the wire and the livestock should be on the same side of the post. One exception to this rule is when placing fence on sharp curves the wire must be on the outside of the curve. Another exception is when the cooperating agency wants the fence on the road side for aesthetic reasons.

### 2. Construction Inspection

Fence inspection requires the Engineer to assure that the fence is properly installed. He/she is responsible for checking post and wire spacing and gate, cattleguard, and brace panel locations. He/she must verify that the Contractor has a QC system to check all fence materials delivered to the project for compliance with specifications. Wood posts need to be checked for soundness, quality, straightness and physical dimensions. Wire certifications must be checked to assure it is of the proper gauge and that it meets contract requirements. Steel posts and certifications must be checked to assure the posts have the proper weight, length, cross section and finish. Cattleguard materials must be checked to assure they comply with contract requirements.

It is usually necessary to grade the fence line before installing fence, particularly if woven wire is being installed. The amount of grading to be done depends on the terrain and cover and should be held to a minimum. The unnecessary removal of native vegetation encourages weed growth and erosion. The Contractor will probably be inclined to do too much grading rather than too little, particularly if equipment such as a motor patrol is used. To prevent unnecessary disturbance, it may be necessary to require grading be accomplished by hand tool methods. Care must be taken to preserve stakes, reference points, bench marks, etc.

It is the Contractor's responsibility to establish post locations, and the inspector is responsible for checking to see that the spacing is correct. When checking post location and spacing, it is advisable to keep in mind that the brace panels are the "anchors" for runs of fence and strong vertical post installation is necessary to provide an adequate anchorage. Line posts should be checked to make sure they are on line and plumb. Vertical alignment can be checked quickly with a makeshift plumb bob, and occasional post holes should be checked for proper depth

Posts should be set vertical, tightly tamped or set in concrete. Those set in concrete should be properly cured for 7 days before having wire stretched to them. The top of the concrete should be crowned to provide drainage away from the post.

When stretching and fastening wire to the posts, several things must be remembered. Wire should be stretched from panel to panel and not between single posts. The top wire should be stretched first, wrapped around the post, and fastened back on itself. Removal of enough barbs or stays to allow for wrapping the wire around the post and back on itself will make for a nice tight wrap splice. Stretching the top wire first places the maximum pull on the post and the lower wires can then be added without loosening the first wires. Stapling should begin in the middle of the runs and progress to the ends to assure a uniformly tight fence. Staples should be driven at about a 45° angle to the centerline of the post to minimize splitting. Staples should be driven slightly downward on level runs and over hills and slightly upward into the post in draws or depressions where the wire has a tendency to lift. Staples should not be driven over barbs and not driven deep enough to pinch the wire. This allows the wire to move freely through the staple to allow for expansion and contraction.

When crossing ditches or gullies, *deadmen* should be installed to keep the fence in position. This helps keep the wire from pulling posts out of the ground and plugs holes that livestock might otherwise use to go through the fence.

Wire spacing should be checked periodically. The use of a notched lath or stick can be used to simplify this procedure.

Appearance of a fence is very important. A sound fence can be an attractive fence, but a fence that does not provide a pleasing appearance is a detriment to the project whether or not it is structurally sound.

**3. Measurement**

Fence is usually measured by the meter along the top wire from outside to outside of end post for each run of fence. Gates are usually measured by the each for the type and size specified in the contract. Cattleguards are usually measured by the each for the type and size specified in the contract.

Unless the plans and specifications indicate otherwise, any related work necessary to construct fence, gates, and cattleguards is not paid for separately but is considered to be included in the price paid for these items. Examples of work for which the Contractor may feel he/she is entitled to extra pay might be the installation of *deadmen* and any clearing and grubbing necessary to construct the fence.

**4. Documentation**

Clear, concise records must be kept of each type of fence, gate, and cattleguard installed. Information to be kept should include location, installation date, type, size, or length installed as well as any special details of construction. This might include the removal and disposal of existing facilities, any changes in type or locations, labor and equipment used, or any other information that may be considered pertinent. Certifications of compliance for manufactured materials incorporated in the work must also be included.

## 9-6.4 Curb, Gutter, Waterways and Sidewalk

### 1. Preliminary Review and Approval

Curbs primarily contain, control, and direct surface runoff to inlets, catch basins, outlet ditches, and other drainage control features, but they also serve to define the limits of the roadway and help confine vehicular traffic to the traveled way. They are a part of the roadway that is most visible to the public and as such, finished appearance is of utmost importance.

The inspector should begin by becoming familiar with the layout details shown on the plans. Curb and gutter profile should be closely checked to minimize constructing *birdbaths*. The location of curb and gutter must be closely coordinated with other drainage features to assure construction of an efficient functioning drainage control system.

### 2. Construction Inspection

#### A. Preparation

It is the Contractor's responsibility to set stakes for these items, but it is the inspector's responsibility to check the accuracy of those stakes. Particular care must be taken on checking the profile grade when roadway grades are relatively flat. Steeper grades tend to minimize the potential for *birdbaths*, but grades are still important from the standpoint of appearance. Steeper grades tend to magnify irregularities in profile grade. Horizontal alignment is primarily important from the standpoint of appearance. Existing edges of pavements or sidewalks cannot be depended on for accurate line and grade and often, the final alignment must be an *eyeball* adjustment.

Waterways will often have to be slightly deeper where steep downhill slopes transition to flatter slopes. Waterways may also need special treatment on the outside of horizontal curves where water may have a tendency to overflow.

The typical curb and gutter cross section will normally show a gutter cross slope intended to keep the water in the gutter and away from the roadway. With gutter installations on the high side of a superelevation the design should provide for an inlet or ditch to get rid of the water before it crosses the road. Then the slope on the gutter should be transitioned to match the superelevation of the roadway.

Curb, gutter, and sidewalk is normally placed on a foundation of compacted crushed aggregate base course. Before placing this crushed aggregate, the existing soil must be brought to the proper grade and compacted. Any soft, muddy or unstable material must be removed, replaced, and compacted with good stable material. Nonuniform or inadequate compaction of the crushed aggregate or underlying soil will result in settlement of the curb, gutter, and sidewalk creating drainage problems and increased maintenance costs.

When waterways and similar structures are placed on very steep slopes, the use of highly permeable foundation material should be avoided; otherwise piping under the structure can undermine destroy large sections.

#### B. Concrete Placement and Finishing.

Concrete design, production, placement, and testing is to be performed in accordance with the appropriate sections of the specifications as indicated on the plans.

Immediately prior to placing concrete, the forms and compacted base course should be moistened with water. It is desirable for the material with which the plastic concrete comes into contact to be damp, but standing water (puddles) should not be allowed. For proper curing of the concrete to occur, the mixing water in the concrete must be retained. This is achieved through prewetting and proper curing procedures.

Proper consolidation of the concrete is important and often neglected. Proper vibration of such a small (shallow) mass of concrete is not easily accomplished and often not attempted.

The reason for consolidating (compacting) the concrete is to mold it in and around the forms and imbedded parts such as reinforcement, and to eliminate rock pockets and entrapped air.

Placement is more easily accomplished if the slump is to the high side of the specification range but finishing and forms stripping may be delayed. Concrete should be placed in the forms as close as possible to its final position. Any vibration or manipulation of the mixture should be only that necessary to form a dense, consolidated mass.

Strikeoff or screeding is the process of striking off excess concrete to bring the top surface to the proper grade. In manual methods, the device used is called a straightedge, however, in some instances it may be curved to achieve the desired template. It may be desirable, for instance, for a sidewalk to have a slightly curved surface to facilitate drainage. The screed, or straightedge, is moved across the concrete in a sawing motion as it progresses with a slight surplus of concrete ahead of it to fill the low areas as it passes.

Edging, jointing, and floating all must take place somewhat simultaneously. Edging densifies and compacts the concrete slab next to the form where floating and troweling are less effective, making it more durable and less vulnerable to spalling and chipping. Jointing, when properly done, can control unsightly random cracking. Contraction joints can be formed with the use of a jointing tool or form material and should be approximately 3 mm wide. Expansion joints are normally 20 mm and formed with some type of preformed joint material. Spacing should be as indicated on the plans.

Floating accomplishes several things. It imbeds the aggregate particles just beneath the surface; it removes imperfections in the surface and it keeps the surface open so excess moisture can escape. Floating produces a relatively even texture that has good slip resistance and is a good finish for sidewalks. In some cases it may be necessary to lightly roughen the surface with a broom to achieve a good nonskid surface. Overworking of the surface during finishing should be avoided, as this will bring an excess of water and fine material to the surface and defects can result. Floating, or finishing, should not commence until the plastic concrete has lost its initial sheen of moisture. No water should be added to the surface during the finishing. The tendency is to float the surface too soon while the concrete is too soft.

If slip form installation is used, the Contractor QC plan should address significant quality issues, particularly grade control, foundation preparation and density. Sometimes slipform crews have a tendency to overtake the grading crews.

**C. Final Finishing and Curing**

Forms should be removed as soon as the concrete has taken its initial set. This will permit the timely repair of minor defects in the surface with mortar (1 part cement/2 parts sand). The curbs should be inspected for irregularities in line and grade. Since the concrete is still plastic, minor adjustments in alignment can be made by placing a long board against the curb and striking it with a sledge hammer.

After final finishing and while the concrete is still moist, it should be cured in accordance with specification requirements. If curing is accomplished with the use of some form of covering to retain the moisture (moist burlap or mats), they must be checked periodically to assure the concrete remains moist for the required curing period (usually 3 days). If curing compounds or seals are used, care must be taken to assure it is sprayed uniformly over the entire exposed surface area of the concrete. The purpose is to seal in the moisture in the concrete so care must be taken to achieve this result. During the curing period, the concrete must also be protected from damage by people and vehicles. Sidewalks being cured with clear or lightly pigmented curing compound are particularly susceptible to pedestrian traffic because to some, it may not appear to be fresh concrete. Clear curing compound normally has a slight pigment that aids in monitoring proper coverage but will dissipate soon after application.

**D. Asphalt Installations**

Asphalt curbs and waterways usually require an experienced crew and special equipment. Increase asphalt content is necessary since compaction will not be as high as with paving mixes. However, the Contractor should have a mean to get reasonably good compaction and a tight surface texture.

### 3. Measurement

Concrete curb and curb and gutter combination is usually paid for by the meter measured along the front face of the curb at finished grade elevation. While, in theory measurement should be on an *as staked* or *as ordered* basis, in reality it is easier to measure after construction. However lengths and areas clearly not authorized by the Engineer, should not be paid for.

Measurement is normally continuous through drainage structures and curb cuts (driveways). Sidewalks are usually measured and paid for by the square meter of finished surface. Items often found in a sidewalk such as junction boxes, valve boxes, etc. are normally not deducted from the measured quantity for sidewalk as long as these individual appurtenances have a surface area of one square meter or less. It is always advisable to check the method of measurement for these particular items in the specifications to determine how they should be measured.

### 4. Documentation

Records should show the date the forms were ready, dates concrete was placed, type of curing utilized, weather conditions, name of inspector and description of work inspected, quantities placed, and any corrective actions that may be taken. A brief narrative of the concrete placement operations becomes invaluable in the event it is necessary to retrace events should some type of failure occur.

Concrete quality records should be kept to reflect the specification requirements in the contract. Should the specifications permit certification acceptance, the certification should be checked to assure specification requirements are met.

**9-6.5 Signing, Delineators, And Striping**

**1. Preliminary Review and Approval**

**A. Signing**.

The Engineer should, when possible, review the plans and specifications applicable to the permanent signing well in advance of the actual placement. The following areas should be reviewed:

- Inspect sign location for possible obstructions to visibility, and possible right-of-way problems.
- Inspect for effectiveness of locations.
- Check to see if sign message is appropriate for situation.
- Check to see if additional signs may be needed to adequately convey guidance, regulation or needed information to the traveling public.

If there are any changes considered to be necessary for complete and accurate signing, the Engineer should coordinate these matters with the appropriate Designer and Construction Operations Engineer.

**B. Delineators.**

Although delineators are one of the last items to be constructed, it is important to generally review the standards and specifications early on with the Contractor so it is known exactly what hardware is needed from the supplier. The Contractor should also be made aware of its responsibilities related to staking and placing the delineators.

**C. Striping**.

Although striping is one of the last items to be constructed, it is important to generally review the applicable standards and specifications early on with the Contractor so he/she is aware of the material and equipment needs.

The plans should contain a striping location plan. If not, the Engineer should consult with the Designer for help in arriving at a suitable plan. In some situations the applicable State Highway agency will perform the necessary layout when requested.

If the striping location plan does not provide detailed information concerning location for no-passing zones, the Engineer should not *eyeball* such. *The Manual On Uniform Traffic Control Devices* is very specific concerning layouts for no-passing zones. Special equipment and know how is required to determine where the no-passing zones should be located. Again, consult with the Central Designer or possibly the State Traffic Engineer for help.

**2. Construction Inspection**.

**A. Signing**.

The construction inspection should generally consist of the following:

**(1). Specifications.** Check the sign hardware for conformance with the applicable standard plan and specifications.

**(2). Layout & Legend.**. Check the sign locations and applicability of sign legends as per the approved plans.

**(3). Alignment**. Check the sign panel alignment as per applicable standard plan and/or the *Manual On Uniform Traffic Control Devices.*

**(4). Night Check**. When permanent signing is complete, drive the project at night as a final check as to the clarity and visibility of the signing network.

**B. Delineators**.

Prior to actual placement of the delineators, the Engineer should discuss with the Contractor the appropriate horizontal spacing and lateral offset for the delineators. Usually the actual staking of the delineators will be done by the Contractor using the spacing guide provided in the plans.

The Engineer should be assured during the course of delineator placement that the placement locations are adequate. In the absence of a Standard Plan for delineator placement, the Engineer should use the *Manual On Uniform Traffic Control Devices* for delineator placement criteria.

The Engineer should take the necessary precautions to insure that the delineator posts are materially acceptable.

**C. Striping**.

Prior to actual placement of pavement markings, the Engineer should discuss with the Contractor the general process that will be required to develop a specification product. This discussion should include the following:

**(1). Equipment**. The requirements for the paint application machine.

**(2). Geometrics**. The geometrics of the paint stripe, including the stripe width and skip pattern.

**(3). Application Rates**. The application rates for the paint and beads.

**(4). Temperature**. The application temperatures.

**(5). Preparation**. Necessary preparatory work prior to striping.

During the actual placement of paint stripes, the Engineer should randomly check the application rates for the stripes and beads. This check should be recorded appropriately.

**3. Measurement**

Signs and delineators are usually paid for by each; therefore, no physical measurement is required for pay quantities.

When payment is by the square meter, computations should be based on the dimensions shown in the plans, after occasional verification.

Striping materials are normally paid by the meter for each type of striping. Measurement of broken lines includes gaps. Measurement based on centerline stationing is adequate for conventional roadways.

When paint for striping is paid for by the liter, measurement should be based on the quantity used after a yield check to verify coverage in an acceptable range (plus or minus 10 percent recommended). Wastage or quantities outside the acceptable range should be deducted.

**4. Documentation**

Adequate recorded notes in a field book bearing a validated acceptance statement for each sign installation along with appropriate certification for sign face material is acceptable as a source document for payment justification. The source document should be referenced in the progress estimate journal when payment is made.

The installed delineators should be physically counted and the actual number recorded in a field book. The field book entry should contain a validated acceptance statement which will be used as the source document for payment justification. The source document should be referenced in the progress estimate journal when payment is made.

The record should also include documentation concerning FLH's physical evaluation of the weight and cross-section properties of the delineator posts. This does not have to be part of the source document.

Documentation should include certifications for beads and paint based on AASHTO standards.

The Contractor should furnish the Engineer with correspondence documenting the total liters of paint used. The Engineer should check the application rate with a yield analysis. The actual quantity for payment along with the yield analysis should be documented in a field book. This and the certifications as discussed above will be source documents for payment justification.

The source documents should be referenced in the Project Summary Book when payment is made.

**9-6,6 Slope Protection**

**1. Preliminary Review and Approval**

Section 404 of the Clean Water Act requires permits for the alteration of banks within waters or wetlands. The Project Engineer must be aware of conditions that require a permit and verify that the 404 permit was obtained. Stipulated conditions contained in the permit should be reflected in the plans, and in any event should be adhered to during construction.

Riprap is discussed in the specifications and will generally call for a certain gradation and quality requirements and will probably be paid for under a riprap item. Slope protection may be used to accomplish the same intent but will more than likely be produced from unclassified excavation and may be specially sorted or preserved material paid for as a normal unclassified excavation or embankment item. It will probably not have a specified gradation or quality requirement. References to riprap that follow will also generally pertain to slope protection.

Field conditions unknown to the designer and/or changes in the design may result in change of beginning and ending points for riprap. The area where riprap is to be placed should be reviewed after field staking to be sure intended bank stabilization or erosion prevention will be accomplished. Field changes should fit the 404 Permit, or an amended permit secured. The Project Engineer should notify the Construction Operations Engineer as soon as any permit deficiencies are known or suspected. The permit process can take a long time, so early review is best.

Sources proposed by Contractors for rock riprap should be considered as described in Chapter 5 herein, and the project specifications.

**2. Construction Inspection**

Foundation trenches, when required, must be constructed and measured for payment as detailed on the project plans prior to placement of riprap. Filter blankets and/or filter fabric, when required, must be placed on the prepared slope prior to placement of riprap. Except as inspector presence is required for these purposes, or to make or review riprap quantity records depending on basis of payment, slope riprap need only be inspected at critical points.

**3.Measurement**

Method of measurement must be in accordance with instructions found in the specifications. Riprap may be measured in place, weighed, or perhaps be incidental to the excavation item.

**4. Documentation**

The Project Engineer is responsible for arranging documentation of the required compliance with specifications and for the field measurement notes and computation for all pay quantities. This is often done in a specially designated field book. However, if payment is incidental to another item(s), diary records may well be adequate. If measured in the haul vehicle, ticket books or weighing and receiving ledgers are appropriate. Photographs are particularly helpful after a flood in documenting that subsequently covered riprap was placed.

The source documents should be referenced in the Project Summary Book when payment is made.

## 9-6.7 Landscaping

### 1. Preliminary Review and Approval

Commercially produced landscaping materials including seed, fertilizer, mulch and irrigation hardware are normally accepted by certification. Topsoil, sod, and plants may be inspected and accepted on delivery or agreement may be reached with the Contractor for inspection and preliminary approval of the source. The Project Engineer may request assistance from the Construction Operations Engineer if the source is a long way away or if more expertise is needed.

It is important to meet and reach agreement with the landscaping Contractor prior to beginning work. Such agreement should include:

- Use of previously approved or certified materials only.
- Final layout or staking of limits of the work.
- Level of inspection and notice to the Government when work is to be done.
- Limitations of planting seasons.
- Groupings of plant areas for purpose of acceptance and/or beginning of plant establishment period.

If there is a separate landscaping contract related to a construction contract, it is important that the construction contractor be advised of the landscaper's schedule and intentions in order to prepare all areas for planting in a timely manner. Although the two contractors are obligated to cooperate, the Government is obligated to provide reasonable site availability to the separate landscape contractor.

### 2. Construction Inspection

Landscaping requires intermittent inspection at the completion of various phases. Comprehensive inspection is normally required at the beginning of seeding operations and perhaps for the duration of such operations if the Contractor seems incapable of functioning responsibly without inspection.

**A. Seeding and Sod.**

The limits of the work must clearly be communicated to the Contractor by stakes or by the continuous direction of the Inspector.

Quantities for seeding should have already been computed by the Inspector so that yield and quantity checks of seed, fertilizer, mulch, etc. can be made.

**B. Plants**.

The Engineer may locate and stake each individual plant or group of plants, or the Contractor may simply be advised to rely on the plans if the plans are detailed enough to use without staking.

Holes for plants must be prepared in accordance with the plans and specifications including all topsoil, mulch, and fertilizer as required.

Plants that are significantly damaged through mishandling, drying or freezing must be rejected even if they were previously accepted.

**C. Establishment Periods**.

The beginning and end of establishment periods for each plant or group of plants should be clearly understood by the Contractor and so documented. On large, complex projects, acceptance by large groupings is recommended to avoid the necessity of keeping track of individual plants. Normally, replacement of dead plants is required only at the end of the establishment period, and there is only one establishment period; i.e., a new establishment period is not started if a dead plant is replaced. However, all plants must be simultaneously alive at final acceptance.

**D. Watering and Maintenance**.

Normally, if there is an establishment period, the Contractor is responsible for watering and maintenance during that period without additional compensation. If payment is provided for watering, the Inspector must exercise some control over when it is needed and how much is needed.

### 3. Measurement

Items paid by the square meter or area measurement are measured parallel to the ground surface. Measurement should be made prior to installation of the work and copies of computation furnished to the Contractor for use in settlement with its subcontractor.

Plants are normally paid by the unit of each. Payment may be made for planting except that if there is an establishment period, the contract may authorize a retent until the end of the establishment period. A 25 percent retent is suggested if none is specified.

If watering is measured for payment, the Contractor may be requested to keep a daily log of quantities and placement locations. Occasional checks on the adequacy of this log will usually suffice unless there is reason to suspect it is not being properly kept.

### 4. Documentation

Certifications or inspection reports are required for all materials. Quantity computations for items paid by area may be in field books or computerized computations may be used.

Plants require documentation as to:

- When planted
- Scheduled end of establishment period
- Condition at end of establishment period
- When replaced (if so ordered)

For water, the log completed by the Engineer, or the Contractor if authorized, should show each load, quantity, time, and where placed. If the Contractor is keeping the log, it should be collected and reviewed daily.

## 9-6.8 Maintenance of Traffic

### 1. Preliminary Review and Approval

At the time of the Preconstruction Conference, the Contract Traffic Control Plan should be reviewed with the Contractor. Modifications within the latitude of the contract will be made depending on the Contractor's plan of operations and existing field conditions. The Project Engineer will then direct the Contractor in writing, to furnish the required devices.

Prior to beginning construction, the Engineer will reach an understanding with the Contractor relative to the following items:

- The identity of Contractor personnel directly responsible for traffic control and maintenance of devices.
- Procedures for anticipating the need for, and ordering, of signs and traffic control devices. In situations where there is high attrition or substantial lead time in ordering replacements, spare signs and replacements should be ordered and stockpiled.
- Procedures for setting up and removing groups of devices.
- Procedures for inspecting, cleaning and maintaining devices.
- Procedures for off-duty hours inspections.
- Procedures for covering or removal of unnecessary signs.
- Training and procedures to be followed by flaggers.
- Training and instruction of other Contractor personnel.
- Procedures for movement of Contractor equipment through the project.
- Facilities for employee parking.
- Emergency (accident) procedures.
- Storage of equipment and materials.

Substantive points deriving from these discussions should be documented in the project files.

The continuing effectiveness of the Contractor's traffic control procedures will require monitoring by the Project Engineer. This monitoring will be systematic and thorough until it is determined that the Contractor's procedures are adequate. At that point, the Project Engineer's efforts can be reduced to periodic monitoring. Monitoring efforts will include after hours, nighttime, and nonworkday situations.

A dialog should be established between FLH personnel and the local policing authority which will result in feedback on the effectiveness of the traffic control schemes, warnings of potential deficiencies, and advice on possible improvement. The police will be supplied with emergency telephone numbers of the Contractor and FLH personnel who can take action to restore major traffic control devices that are destroyed or damaged.

As a part of normal field reviews, Construction Operations Engineers and other FLH personnel will review the adequacy of the traffic control procedures, discuss findings, and insure necessary corrective actions are taken by the Contractor.

### 2. Construction Inspection

#### A. General

All FLH project staff should be cognizant of the quality and effectiveness of the Contractor's traffic control. On complex projects with high exposure, an experienced inspector should be assigned to have primary responsibility for monitoring the Contractor's traffic control. The Contractor however, should not be allowed to let FLH assume responsibility for the traffic control. If this seems to be happening due to lack of commitment by the Contractor, written notice should be provided. The following are guidelines for evaluation of construction traffic control.

Work sites should never present a surprise to the motorist. Thus, frequent or abrupt changes in geometrics should be avoided. Well-delineated transitions, long enough to accommodate driving conditions and the speeds vehicles are realistically expected to travel, should be provided at lane drops, reductions in roadway or lane width, detours, etc.

The roadway should be kept clear of obstacles as much as possible. Flaggers, other workers, and objects such as traffic-control devices and construction equipment should not be permitted in the roadway except when their useful presence clearly outweighs the hazards they present.

Obsolete pavement markings should be removed in such a manner as to eliminate any misleading cues to drivers under all conditions of light and weather. Where temporary pavement markings are required, consideration should be given to use of highly visible markings that can be easily placed and removed, such as raised reflective markers. On very short-term maintenance projects, removing existing markings for the projects' duration may be more hazardous to both workers and motorists than leaving the markings in place. If so, special attention must be paid to providing additional guidance by other traffic control measures to overcome the misleading effect of the markings left in place. Special treatment should be given to areas where a joint between pavements of different colors or textures may create a misleading cue.

All devices used in the traffic-control setup should be clearly visible to motorists at all times. This means they must be adequately reflectorized or illuminated, as appropriate, and kept clean and in good repair. All devices should be removed immediately when no longer needed. Signs that do not apply to the existing conditions should be removed, completely covered, or turned so as not to be read by passing motorists.

Areas outside the traveled way should be designed to accommodate errant vehicles. Equipment, materials, and debris should be located as far from the roadway as possible, and protected by effective, safe barriers when within 10 meters of the roadway. Barriers are warranted at work site locations where the severity of a collision with a roadside feature would be greater than with the barrier or where encroaching traffic may threaten workers safety.

All vehicles, including workers' and Contractor's, should be prohibited from parking adjacent to the traffic lanes. Special parking areas, well out of the recovery area, should be designated.

Provisions should be made for disabled vehicles or other emergency situations on all but the shortest projects. If it is impossible to provide a continuous, substantial shoulder throughout the project, other alternatives should be provided, such as periodic turn-outs or heavy patrolling of the project.

When a firm schedule and final traffic control plan have been decided on, a public information campaign should be conducted to alert motorists. Often the local government or cooperating agency will assist in such efforts. The amount and type of effort will depend on the type of control (short time, off-peak periods, etc). In addition, cooperation of the responsible enforcement agencies should be enlisted.

Work sites should be carefully monitored under varying conditions of traffic volume, light, weather, etc., to ensure that traffic-control measures are operating effectively.

**Figure 9-6.8** is a **Basic Checklist for Construction Traffic Control**, usable by inspectors and Contractor personnel in the monitoring of work zones. Consult the project plans, specifications and design narrative for additional requirements.

Adverse answers to any of these questions should result in action to eliminate or minimize the problem.

**B. Analysis of Accident Data**

On all projects, and in particular complex projects with high exposure, the Protect Engineer should analyze the circumstances of accidents occurring in and around the work zone.

- This procedure should involve contacts with the policing agency including a request to obtain copies of accident reports.

- Analysis should be critical of the Contractor's traffic control; i.e., even if an accident was caused by driver error, a better traffic control scheme may have prevented it.

- There should be periodic feedback to Project Development as to the effectiveness of standards for construction traffic control.

**C. Detours**

For the protection of the public, or for the protection of the highway from damage during storms or particular construction operations, the Contractor may find it advisable to bypass traffic over detours in lieu of maintaining traffic along the improvement as provided by the contract documents. Such a change will require the issuance of a contract modification. The detour may be opened to traffic after the general plan has been approved by proper authority and the contract modification approved. In order that the State or County may be advised, and the public in turn notified several days in advance of the opening, the Project Engineer should notify the COE of the exact date that the highway will be closed and the detour put into use. The same procedure of notification will be followed in the case of special detours shown on the plans. This procedure need not be followed when traffic is bypassed around a structure, or other work, for comparatively short distances and for short periods of time. This type of bypass will generally be considered as maintaining traffic along the traveled way.

Under emergency conditions the Project Engineer may close a highway to traffic for the protection of life and property without prior approval, but the Construction Operations Engineer should be notified as soon as possible. Should such circumstances arise, the Project Engineer must immediately notify the local authority having jurisdiction over the road.

If a highway is closed without prior warning to the public, the Contractor should be required to station flaggers at each barricade to advise the public that the road is closed, why it has been closed, what detours can be used to best reach desired destinations, and the approximate length of time the highway will be closed.

Detours and temporary roads must be adequate to accommodate the volume and type of traffic using them. Unless otherwise proved in the plans, they should be two-way roads of sufficiently high standard that traffic may be maintained with safety and without undue inconvenience to the traveling public. The Contractor cannot be expected to improve the standards or raise the surface of an existing road used as a detour, without compensation. Whenever a detour is to be discontinued and the highway opened to traffic, the Engineer must so notify the jurisdictional authority.

The permission to close or not close a public road to traffic is considered a condition of the Contract and therefore, the Contractor should not be permitted to close a road solely for convenience unless:

(1) The Construction Operations Engineer obtains approval

(2) The cooperating agency concurs and

(3) An equitable price reduction or determination that the closure is in the Government's interest is made.

**D. Nonconstruction Traffic Control**

No FLH survey or other activities should be attempted on or adjacent to a traveled roadway without traffic warning/control procedures conforming to Part VI of the *Manual on Uniform Traffic Control Devices* and other FLH standards. When such activities are performed adjacent to a construction project the Contractor may be ordered (and paid) to provide proper signing and control. Otherwise the party chief or team leader should arrange for such signs and devices prior to embarking on the assigned task.

**3. Measurement**

At the beginning of the project the Engineer should direct the Contractor in writing to order all necessary traffic control devices. Upon delivery of the devices, this document becomes the basis of measurement of quantities. If payment is provided on a lump sum basis, the Engineer should still issue the directive telling the Contractor specifically what is required.

Orders for traffic devices should include replacement or standby devices if high attrition is expected and delays in ordering replacements are anticipated. Once ordered, the Contractor is responsible for reordering and replacing devices at no additional cost.

If the Contractor's maintenance of traffic control devices is deemed unsatisfactory, the Government may withhold payment for such devices and ultimately may make permanent deductions in accordance with FAR Clause 52.246-l2(f). If this is done, there must be written notice of the deficiency giving the Contractor the opportunity to take corrective action.

**4. Documentation**

Primary documentation includes the directives ordering all traffic control devices and documentation of delivery and acceptance of the devices.

Inspections and deficiencies should be documented in the project diaries or IDR's along with corrective action ordered and accomplished.

## Basic Checklist
## for
## Construction Traffic Control

### Advance Signing

1. Are signs clean, visible, and well maintained?

2. Are inappropriate signs removed or completely covered?

3. Do the signs concisely tell the driver exactly what to do (preferred) or what to expect?

4. Is delineation and channelization adequate if the driver fails to heed the advance signing?

### Hazards

1. Are hazards in the construction zone delineated properly?

2. Is it clear how pedestrians, bicycles as well as cars are to pass through the construction zone safely?

3. Are there hazardous conflicts with construction traffic?

4. Is opposing traffic clearly and effectively separated?

5. Are "blind" or unexpected hazards given special attention?

6. Is the roadway surface being properly maintained?

### Delineation

1. Is the path through the construction zone clearly delineated with drums or other suitable devices.?

2. Is delineation adequate in nighttime or bad weather conditions?

### Flaggers

1. Are flaggers clearly visible with advance signing?

2. Are flaggers effectively in control of traffic?

**Basic Checklist for Construction Traffic Control**
**Figure 9-6.8**