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A Survey of the States on Problems Related to Bridge Approaches

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A questionnaire was sent to the states concerning problems with bridge approaches. Seven questions were included in the survey, including questions on the use of integral end bents and spread footers. This report summarizes the responses. Appendix A contains the detailed responses received, and Appendix B contains specifications and standard drawings used by some of the states.
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A Survey of the States on Problems Related to Bridge Approaches

by

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in cooperation with
Department of Highways
Commonwealth of Kentucky

and

Federal Highway Administration
U.S. Department of Transportation

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October 1985
INTRODUCTION

Settlement and movement of bridge approaches have been major problems in Kentucky. Many approach slabs have been repaired repeatedly, and one approach has been completely reconstructed. Hopkins (1) has indicated that approach settlements and movements occur throughout the state, however, the largest number and the severity of approach problems appear to be concentrated in regions where clay shales are predominate.

To determine if other states have problems with bridge approach movements, and to determine the methods that are used to minimize these problems, a questionnaire was sent to each state. Also, a question concerning the use of integral end bents, and spread footers was included in the questionnaire. Standard drawings and/or specifications concerning bridge approaches and approach slabs were requested from each state.

The following is the list of questions included in the questionnaire.

1. Is settlement of bridge approaches a major problem in your state?

2. Do you use some form of reinforced approach slab? If so, are they successful?

3. Also, if reinforced slabs are used, how long are they?

4. Are integral end bents used in your state? If so, have they performed well?

5. Are special procedures used when backfilling around the end bent? What are these procedures?

6. Are abutments on spread footers used in your state? If so, are they successful?

7. Are there any other methods that your state uses to minimize this problem?

SUMMARY OF RESPONSES

Forty states responded to the questionnaire, although all states did not answer all the questions. Table 1 is a summary of responses to each question. Appendix A contains the detailed responses to each question. The responses are reported exactly as they were received, and no editing was done. Appendix B contains all the standard drawings and specifications that were received. Some of the material in Appendix B is a very poor quality copy, even though attempts were made to reproduce them as clearly as possible.

Figure 1 illustrates the responses to Question 1. It shows that the settlement of bridge approaches is a widespread problem. However, it should be noted that most of the northeast and north central states reported little or no problems.

Figure 2 shows the responses to Question 2. All states that responded use some form of reinforced approach slab except Maryland.
Figure 3 shows that all states except Montana, Wisconsin, and Oklahoma appear to have complete success with reinforced approach slabs.

Table 1 summarizes the responses to Question 3. Approach slabs ranged in length from 10 feet to one case of 120 feet. However, most reinforced approach slabs were less than 40 feet.

Responses to Question 4 are shown in Figure 4. Of the states that responded, only six states east of the Mississippi River indicated that integral end bents had been used.

Most responding states indicated that integral end bents were successful, as seen in Figure 5. South Carolina stated that only one site had been tried at the time of the questionnaire, and that it was not successful.

Most states tabulated in Figure 6 indicated that special backfilling procedures are used around end bents.

Question 6 concerned the use of abutments on spread footers. Figure 7 indicates their use is widespread, although eight states indicated they had not used spread footers. Figure 8 shows that all responding states except Ohio indicated that abutments on spread footers are at least partially successful.

Figure 9 shows that many states use other methods not covered in this questionnaire to minimize bridge approach settlements. These other methods are discussed under Question 7 in Appendix A.

CONCLUSIONS

The following conclusions are based upon very generalized responses indicated in Figures 1 through 9. However, many states gave answers that were highly qualified. These answers included in Appendix A should be studied very carefully.

1. Bridge approach settlement is a widespread problem.
2. Most states use some form of reinforced approach slabs.
3. Most users of reinforced approach slabs feel they are successful.
4. Most users of integral end bents and spread footers feel they are successful.
REFERENCE

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**Notes:**
- 41 states responded to this questionnaire
- Some questions were not answered by all states responding
FIGURE 3  RESPONSES TO QUESTION 2A
FIGURE 5  RESPONSES TO QUESTION 4A
APPENDIX A

RESPONSES TO QUESTIONNAIRE
QUESTION #1
IS SETTLEMENT OF BRIDGE APPROACHES A MAJOR PROBLEM IN YOUR STATE?

ARIZONA—It appears that the problem of settlement of bridge approaches is common to nearly all states. The majority of our structures have approach settlement and there does not seem to be any clear cut answers to the problem. Our most severe cases are structures of greatest superstructure depth, i.e., where the backfill requirements are the greatest. We also have the problem regardless of whether approach slabs are used or not.

ARKANSAS—Settlement is not a major problem but does produce some maintenance problems.

CALIFORNIA—It is a general problem rather than a major problem.

COLORADO—Settlement of bridge approaches is a problem in Colorado.

CONNECTICUT—No.

DELAWARE—I would consider bridge approach settlement a minor problem in Delaware except where scouring occurs due to excessive clearing of drainage tax ditches.

GEORGIA—The end abutments of most bridges are founded on piles and settlement is not a major problem. At abutments in cut section where rock or very dense material is encountered, spread footers are used and settlement is usually very small.

IDAHO—Bridge approach settlements in this State have ranged from undetectable to extreme and expensive to correct.

ILLINOIS—The Illinois Department of Transportation has a long history of bumps at the end of bridges resulting from settlement of the approaches.

INDIANA—Settlement of bridge approaches has been somewhat of a problem but not a major problem.

KANSAS—Settlement at the end of bridges is a problem in our State. We feel that we support our abutments and expect no settlement, however, there is settlement of the fills which have to be repaired from time to time.

KENTUCKY—Yes.

LOUISIANA—The state of Louisiana has experienced some problems with the settlement of bridge approaches.

MAINE—Settlement of bridge approaches has not been a major problem in our State.

MARYLAND—Settlement of bridge approaches is a problem in our State, but not a major one.

MASSACHUSETTS—No, not a major problem.
MICHIGAN--We do not have a major state-wide approach settlement problem.

MINNESOTA--Settlement of bridge approaches does occur but is not a major problem for bridges under our jurisdiction. The problem is minor in nature for our design and construction procedures.

MISSISSIPPI--In some areas of the state—particularly on the Gulf Coast.

MISSOURI--Settlement of bridge approaches continues to be somewhat of a problem in Missouri although it seems to have abated in recent years. This abatement is probably due to the cumulative effects of several changes in procedures directed toward the solution of the problem.

MONTANA--Yes, settlement of approach fills to bridges is a major maintenance problem.

NEVADA--It has been.

NEW HAMPSHIRE--Settlement of bridge approaches in most locations in New Hampshire does not present a major problem.

NEW JERSEY--Settlement of bridge approaches is not a major problem in New Jersey primarily due to control of approach fills and the use of a concrete approach slab system for which standard details are enclosed.

NEW YORK--Settlement of bridge approach pavements is not a major problem in New York State. If significant settlement is anticipated in the approaches, it is reduced by various construction procedures (refer to response No. 7) so that any settlement remaining will be insignificant.

NORTH CAROLINA--With the bridge approach slab details we are currently using we feel that we have overcome settlement problems at bridge ends.

NORTH DAKOTA--No—cannot be completely eliminated.

OHIO--The settlement of bridge approaches is not a major problem in Ohio.

OKLAHOMA--It is a problem; however, we do not regard it as "major".

OREGON--A problem exists, but it would not be classed as major.

PENNSYLVANIA--Settlement of bridge approaches is a major problem in Pennsylvania only on old bridges; on rare occasions, new bridges (because Pennsylvania uses reinforced approach slabs on new bridges.)

RHODE ISLAND--Settlement of bridge approaches is not a major problem in Rhode Island.

SOUTH CAROLINA--Yes.

TENNESSEE--Settlement of bridge approaches is a major problem.
TEXAS—Settlement of bridge approaches is a problem in Texas; seldom a critical problem but a considerable maintenance problem. The worst problem occurs where the bridge approach swells and rises. Approach slabs aggravate this problem.

UTAH—Settlement at bridge approaches in Utah is a common major problem. Large portions of Utah were once the floor of prehistoric Lake Bonneville. Also, other geologic features and soil characteristics cause significant settlement problems.

VERMONT—Approach settlement is a potential problem at many sites. However, analysis of the conditions at each site enable us to take corrective measures, which reduce the problem to a minor one.

WASHINGTON—We have occasionally had problems with bridge approach settlement in the western part of our State.

WEST VIRGINIA—Settlement of bridge approaches are a problem in our State.

WISCONSIN—Settlement of bridge approaches is not a major problem in this State.

WYOMING—Settlement of bridge approaches in Wyoming has been a significant problem, although not what would be considered major.
QUESTION #2
DO YOU USE SOME FORM OF REINFORCED APPROACH SLAB? IF SO, ARE THEY SUCCESSFUL?

ARIZONA—Most structures designed and constructed in Arizona over the past 20 years have reinforced concrete approach slabs. They are not completely successful; however, an approach slab does assist in bridging the soft zone directly in front of abutments and in ramping up to the bridge. It also permits the abutment wingwalls to be designed without surcharge.

ARKANSAS—Yes, we use the approach slab shown on the enclosed drawing on some projects. I believe they are successful in removing the bump from the end of the bridge. There are locations where settlement or swell occurred causing a bump to develop in spite of the approach slab. Others do not agree with me on the need for these slabs; therefore, there has been some compromise and they are not used on all construction.

I prefer to have the impact from the bump absorbed by the approach slab rather than the bridge; therefore, if the bump cannot be eliminated it is better to move it away from the bridge.

CALIFORNIA—A reinforced approach slab is used with PCC approach pavements. A reinforced approach slab is also used under certain circumstances on AC approaches to act as a ramp in the event of settlement of approach fills due to earthquakes. The reinforced approach slab is not a complete solution, but it does mitigate the problem.

COLORADO—Colorado uses reinforced approach slabs on structures where no provisions for movement are provided on the bridge. In our opinion, it is beneficial. However, we realize that a bump does still occur at the end of the approach slabs.

CONNECTICUT—Yes, on all rigid approach pavements—Yes.

DELAWARE—Yes, Yes.

GEORGIA—Reinforced concrete approach slabs, 10 inches thick and 30 feet long, are used at all sites with good results. The approach slabs rest on the soil with the end at the abutment bearing on a paving rest of the abutment or bridge end wall. At a few sites the fills and approach slabs have settled, requiring asphalt leveling over the approach slabs.

IDAHO—Current practice is to use approach slabs for all bridges carrying Interstate traffic, all bridges with concrete approach pavement, and otherwise at the discretion of the District Engineer in whose District the bridge is to be built. Foregoing applies to bridges on State system. On locally-sponsored projects, approach slabs are used at the discretion of the local sponsor; the result is that they are rarely used on locally-sponsored projects. In my opinion, approach slabs are usually successful, and where not successful, the lack of success can usually be traced to faulty design, specifications, or compliance with specifications.

ILLINOIS—The remedial scheme developed to improve the situation consisted of employing a 20 foot structural slab, the intent being to transition the
settlement over a distance of 20 feet and thus reducing the abrupt change. The use of the single 20 foot slab was designated a method 1 approach, and supplemented with a method 2 approach for more severe (high embankment) conditions, the latter consisting of two 20 foot approach slabs supported at the 20 foot joint by a pile bent. The piles were to be driven to 15 ton bearing, and the intent was to transition the settlement over a distance of 40 feet.

In 1962, the Bridge and Traffic Structures Section of the Bureau of Design made a performance study of 100 randomly selected bridge approaches, selected to provide a good cross-section of both approaches and geographical location. The study compiled information of embankment height, approach type, soil conditions, and a plot depicting 100 feet of the approach beginning at the abutment and showing the as built grade with the current centerline profile.

The data compiled presented a considerable scatter, but it did show a rather poor history of success in alleviating the problem. Often times the piles in method 2 approach never settled at all, thus only moving the bump 20 feet further from the bridge. While there was a broad range in behavior, it was possible to modify our past practices to be more in line with the performance. Accordingly a chart was developed (copy attached) to guide our designers in the choice of the approach treatment to be used for any given situation.

This chart was used until November 1973, at which time the Department did away with the use of the approach pile concept in favor of a 100 foot continuously reinforced pavement which was thickened for the first 20 feet as a structural slab, there being no joint at the 20 foot point. This pavement was to be built 1.5" low, and brought to design grade when the deck of the new structure was provided with the waterproofing +1.5" of bituminous surface. This design also provided, as will be noted in the attachments, with a 1.5" ledge at the end of the approach section so that the bituminous material did not have to be "feather edged" out.

INDIANA--We use a reinforced approach slab. In our opinion they are successful in correcting settlement problems adjacent to the bridges.

KANSAS--We have an approach slab off the end of our bridges when concrete pavement is used. We are enclosing a Standard Sheet indicating how it is reinforced. This is a rather typical detail and has to be modified from structure to structure. The approach slab is constructed as a part of the surfacing for a project and is not a bridge item.

KENTUCKY--Reinforced approach slabs are being used on a selected basis. They are presently being evaluated.

LOUISIANA--These (settlement) problems have been minimized by the use of reinforced concrete approach slabs of appropriate length to satisfactorily transition from roadway to bridge.

MAINE--We utilize a reinforced approach slab on our abutment backwalls for major bridge projects with medium to heavy traffic and feel that they have been very successful in reducing the effects of approach settlements.

MARYLAND--We do not use reinforced concrete approach slabs.
MASSACHUSETTS—Yes—Yes.

MICHIGAN—We are at this time using a double reinforced slab adjacent to a structure. This Standard has been in effect for two years.

MINNESOTA—We use a reinforced concrete slab and this has been very successful.

MISSISSIPPI—Yes. Yes, in a limited manner.

MISSOURI—Reinforced approach slabs were among the first efforts to solve the problem of settlement. They have been successful to a fair degree but have been more successful when coupled with changes in the practice of embankment construction.

MONTANA—For about six years beginning in 1970, we used approach slabs on all projects. About 1976 we stopped the use of the slabs because their success appeared doubtful. At this time, we feel that there has been little success in solving the bridge end bump.

NEVADA—Yes, and the use of the approach slabs has been helpful.

NEW HAMPSHIRE—We use concrete approach slabs to minimize settlement problems. The approach slabs reduce the settlement effect to where only minor periodic pavement shimming is needed to maintain a smooth riding surface.

NEW JERSEY—See answer for Question #1.

NEW YORK—We use a one foot thick reinforced concrete approach slab that is supported at one end on top of the abutment backwall. The approach slab is normally 40 feet long. Slab lengths may be reduced to 20 feet for the following types of construction:
   a. Integral abutment design
   b. Rehabilitation of an existing structure where the roadway subgrade and width are to remain the same
   c. An approach slab that is continuous with the deck slab.
      This design eliminates a joint at the abutment. We are satisfied with the performance of our reinforced concrete approach slabs. Our Standard Details for both concrete and asphalt approach pavements are attached.

NORTH CAROLINA—Yes (see attached material).

NORTH DAKOTA—On concrete pavements. Many have been replaced.

OHIO—Ohio uses approach slabs on most major highways and they are successful, as far back as they extend. Sometimes where a bridge is replaced at a site where the approach embankment is well consolidated, the approach slabs will be eliminated.

OKLAHOMA—We have used approach slabs in some forms. Presently, we are using only a short "impact" slab. I don't feel we would call any of them a success.
OREGON—A reinforced approach slab is used. This design has been in use for over eleven years and is considered successful.

PENNSYLVANIA—We do use reinforced approach slabs and, in our opinion, these slabs are successful.

RHODE ISLAND—We use a reinforced concrete approach slab on all bridges.

SOUTH CAROLINA—Yes, on primary and interstate routes and freeways. Yes, they are successful.

TENNESSEE—See attached Standard Drawing K-86-144.

TEXAS—Approach slabs are used on approximately half of our bridges. They are usually not completely successful.

UTAH—We do use reinforced concrete approach slabs, and they are usually successful for their intended function; namely, to bridge the settlement area behind the abutment backwall.

VERMONT—Yes, and they are successful.

WASHINGTON—It is not our practice to use reinforced approach slabs, unless determined to be necessary by our soils engineers. Approximately 60% of our new bridges have approach slabs in the western part of the State and relatively few have them in the eastern part.

WEST VIRGINIA—We use a 12" thick, 20' long reinforced concrete approach slab that rests on a notch in the abutment backwall. The approach slab does provide a transition from the fill to the bridge and does prevent direct wheel impact on the backwall.

WISCONSIN—For many years we made extensive use of the reinforced approach slab. The design was intended for the approaches to bridges on highways such as freeways where we expected high traffic volumes including large percentages of trucks. However, eventually it became common practice to use the reinforced slabs on most state truck highways having P.C. concrete pavement.

In our opinion they were not successful. Many of these slabs have cracked and settled despite the heavy reinforcing and of course they are very costly to build.

Our current practice is to construct the bridge approach slab to the same thickness and design as the adjacent highway pavement. Generally, we specify non-reinforced P.C. concrete. The reinforced slab is still occasionally used where settlement of the bridge approach has proven to be a problem and traffic volumes are high.

WYOMING—We use reinforced concrete approach slabs on all of the bridge structures on the state and federal highway systems. We have been using three different types of approach slabs, which are shown in the attached details. These approach slabs have been in use for approximately three years, so our experience is somewhat limited; however, they appear to be working successfully.
QUESTION #3

ALSO, IF REINFORCED SLABS ARE USED, HOW LONG ARE THEY?

ARIZONA—We are enclosing a copy of our Standard Drawing No. BM-1 which shows dimensional and reinforcement details for approach slabs.

ARKANSAS—Thirty-five feet.

CALIFORNIA—10'-6" or 30'-0". See attached Standard Drawing A35-B and Memo to Designers 5-3.

COLORADO—Our reinforced approach slabs are 14". A copy of our standard is attached.

CONNECTICUT—Varies (see attached drawings).

DELAWARE—Twenty-five (25) feet; however, it would depend on the height of the abutment.

GEORGIA—Same as answer for Question #2.

IDAHO—At zero-skew bridges, approach slabs are 20 feet long. At skewed bridges, the end of the approach slab abutting the roadway is normal to the roadway centerline, and the 20-foot dimension is applied at the outer edge of the travelled way, on the "short" side of the approach slab.

ILLINOIS—Same as answer for Question #2.

INDIANA—The reinforced approach slabs are 20'-6" long. Details are enclosed.

KANSAS—There is reinforcing in the concrete approach slab and its length is 33' from the end of bridge wearing surface.

KENTUCKY—From 30 to 60 feet.

LOUISIANA—Generally, two lengths of approach slabs are used: 20 feet long slabs where the anticipated settlement is small; and 40' long where moderate settlement is expected. In some locations, where excessive settlements are indicated, pile supported approach slabs of 80' to 120' long are used. These slabs are supported on timber piles which provide full support adjacent to the abutment and taper to almost no support at the end of the slab.

MAINE—I have attached hereto a copy of our standard details for approach slabs.

MARYLAND—Not Applicable.

MASSACHUSETTS—10'- measured perpendicular to the abutment wall. 10" Deep Slab with #7@6 parallel to CL. construction top & bottom of slab. Slab is placed with bottom 24" below finished roadway grade and extending 6" behind curb line each side of the roadway.
MICHIGAN--Same as answer to Question #2.

MINNESOTA--See enclosed details for information on slab construction. Slab length is 20 feet.

MISSISSIPPI--20 ft.

MISSOURI--Reinforced approach slabs are 20" in length. At skewed bridges the short side is 20" in length. A copy of the appropriate standard is attached.

MONTANA--We used 20 feet long slabs.

NEVADA--24 feet and occasionally 12 feet depending on foundation requirements.

NEW HAMPSHIRE--the reinforced concrete approach slabs are 20" long.

NEW JERSEY--See answer for Question #1.

NEW YORK--See answer for Question #2.

NORTH CAROLINA--See attached material.

NORTH DAKOTA--40".

OHIO--Reinforced approach slab length varies from 15" to 30" along the centerline of highway.

OKLAHOMA--20 feet.

OREGON--20'-0".

PENNSYLVANIA--See details of our Standard Drawing RG23, Bridge Approach Slab (attached).

RHODE ISLAND--The approach slabs are 14'-0" long.

SOUTH CAROLINA--Our standard is 30" but may vary with geometrics.

TENNESSEE--See attached Standard Drawing K-86-144.

TEXAS--The approach slabs are 20" long, measured along the short side of the trapezoid for skewed structures.

UTAH--The typical approach slab is about 1'-6" longer than the wingwalls. The average length is about 15 to 20 feet.

VERMONT--Normally 20 feet along roadway centerline, but not less than 15 feet perpendicular to centerline of bearing.
WASHINGTON--The approach slabs are 25 feet long and are supported by a corbel, or bridge seat, at the end of the bridge.

WEST VIRGINIA—See answer for Question #2.

WISCONSIN—The length of the reinforced slab we use is 20'-6" minimum. You can see on the enclosed standard drawing that the length of one side of the slab increased as the skew angle of the bridge increases.

WYOMING—Refer to the attachments for the length of approach slabs.
QUESTION #4

ARE INTEGRAL END-BENTS USED IN YOUR STATE? IF SO, HAVE THEY PERFORMED WELL?

ARIZONA—We are using integral abutments in all cases where span lengths or overall bridge lengths are not too long to cause expansion/contraction difficulties. Eliminating bridge end deck joints and bearings is the major advantage.

ARKANSAS—No.

CALIFORNIA—Integral end-bents are used with satisfactory results.

COLORADO—We use integral end-bents on both concrete and steel girder bridges. They seem to perform well; however, our history is only six years old.

CONNECTICUT—On one bridge only—Yes.

GEORGIA—Question was not answered.

IDAHO—We do use them, and they have generally been successful. Where unsuccessful, their lack of success could be traced to an error in design. In one case where success was not initially attained, the bridge was a relatively short and wide steel-girder bridge with substantial skew; insufficient attention was given to the horizontal moment resulting from girder expansion and resultant passive earth pressures. At several bridge sites, significant though not disastrous damage has resulted from failure to provide adequate expansion joints between approach slabs and concrete approach pavement.

ILLINOIS—We have utilized integral end bents at several locations. We have not yet evaluated their performance and are not actively pursuing the development of this type of design.

INDIANA—Integral abutments have not been used in Indiana.

KANSAS—Kansas has used integral end abutments for many years. We have good success with this type of construction. We use it in practically all bridge structures up to approximately 500' in length. We are attaching several sheets from various projects, one indicating a pile bent abutment in which we have set steel beams on the abutment beam and made them integral with the superstructure. Another detail enclosed is a reinforced concrete box girder structure which is cast in place. This particular structure had pedestal poured into the rock with the joint to provide some movement for the superstructure. Concrete box girders are not presently being used due to the higher cost in formwork. A more typical type of construction is where we use prestressed beams. The enclosed detail indicates a T-beam section, however, it applies to the I-section as well.

KENTUCKY—Yes. They have performed well.
LOUISIANA—Integral abutments and abutments on spread footings are not used in this state.

MAINE—Integral end-bents have not been utilized in our State.

MARYLAND—We do not use integral end-bents in this State.

Massachusetts—No.

MICHIGAN—We do not use the integral end-bent design.

MINNESOTA—No.

MISSISSIPPI—No.

MISSOURI—Integral end bents are used in Missouri. They have only been in service in recent years but so far they appear to be performing well.

MONTANA—Yes, we use integral end bents and feel that they work very well.

NEVADA—Occasionally. Their performance has not been evaluated for the settlement problem.

NEW HAMPSHIRE—Integral end-bents are not used in New Hampshire.

NEW JERSEY—Integral end bents are not used in this State.

NEW YORK—Integral abutments or end bents have been used on some of our structures.

Since integral design has only been used for the past three or four years, we are reluctant to make any definite statements about the advantages of this type of construction. However, because of the stubby abutments used in this design, we anticipate savings in materials and labor.

NORTH CAROLINA—No.

NORTH DAKOTA—Yes. Well.

OHIO—Integral end bents are used and perform well, for the most part. Diagonal cracks in the end corners of the deck slab sometimes occur.

OKLAHOMA—Yes, Yes.

OREGON—To some extent. No problems have arisen to date.

PENNSYLVANIA—Pennsylvania does not use integral end-bents.

RHODE ISLAND—We do not use integral end bents.

SOUTH CAROLINA—Used on one project only. No—beam rotation cracked abutment.

TENNESSEE—See attached Typical Integral Abutment Details.
TEXAS--Completely integral end-bents are seldom used. Partially integral end-bents at the ends of long continuous units have created further bridge end problems.

UTAH--We do not use integral end bents.

VERMONT--Yes, and they do perform well.

WASHINGTON--We rarely use integral end bents. We do, however, use pre-cast girders with cast-on end diaphragms, which act very much the same as integral end bents in terms of the effect on potential approach settlement. These have performed very well in this State.

WEST VIRGINIA--We do not use integral end-bents.

WISCONSIN--Integral end-bents are not used in this state.

WYOMING--Our policy is to embed steel girders into the abutments on bridges 300' or less in overall length when piling is used as a foundation at the abutments. This type of structure has performed well in Wyoming, and a typical abutment detail for this type of bridge is shown in the attachments.
QUESTION #5

ARE SPECIAL PROCEDURES USED WHEN BACKFILLING AROUND THE END-BENT? WHAT ARE THESE PROCEDURES?

ARIZONA---We are enclosing copies of our Standard Specifications for Special Backfill.

ARKANSAS---See Enclosures.

CALIFORNIA---No special procedures are used; however, we require backfill with pervious material directly behind the end-bents.

COLORADO---Material placed around the end-bents is specified as Structure Backfill. We use Class I, which is good gravel, placed in 6" layers and compacted to 95% of AASHTO T-180.

CONNECTICUT---No.

DELAWARE---Yes. Backfilling shall be with material meeting the requirement of Borrow Type C (graduation of 85-100% by weight passing the 1" sieve and maximum of 25% by weight passing the #200 sieve) and compacted to 95% or more. Compaction shall be built in continuous horizontal layers not more than 8" in thickness, loose measurement, and shall be thoroughly tamped and compacted to the specified density.

GEORGIA---Embankments at bridges are compacted to at least 100% of the maximum laboratory dry density for 100 feet beyond the bridge ends.

IDAHO---According to our Contract Administration Engineer, no large rock is permitted in backfill and backfill is placed in 8-inch layers, compacted with vibratory compactors after each layer is placed; granular borrow is preferred as backfill material but is not always available at reasonable cost.

KENTUCKY---Yes. Select granular backfill is used.

LOUISIANA---Regarding special backfilling requirements around end-bents, the only requirement is the use of a coarse aggregate plug against the end-bent and under the approach slab.
MAINE—We pay particular attention to proper backfill material and drainage of the backfill which we feel has adequately provided protection of the abutment to minimize frost damage, excessive hydrostatic pressures and to minimize settlement problem.

MARYLAND—The backfilling procedures used are one of careful compaction for as great a density as possible in the areas immediately adjacent to the abutments. Every effort is given by our inspection personnel to guarantee that compaction is as good or better than that required for the approach embankment.

MASSACHUSETTS—Not used.

MICHIGAN—The backfill is compacted to 95% and placed in layers of not more than 9” thick.

MINNESOTA—Not applicable.

MISSISSIPPI—No, the bridge end fill is constructed to grade before the end bent is put in place.

MISSOURI—Embankment at end bents is required to be placed in advance of bent construction to the elevation of the bottom of the bearing beams. Compaction requirements are increased from 90% to 95% of standard density within 100° of each end of the structure. Backfill to the excavation necessary for bent construction is carefully controlled to maintain uniform pressures on the structure and to assure adequate compactions.

MONTANA—Yes, we have a special procedure. Attached is our standard for approach fills.

NEVADA—Yes, selected borrow is used to obtain better compaction.

NEW HAMPSHIRE—Not applicable.

NEW JERSEY—See answer for Question #4.

NEW YORK—We are not presently using any special backfill procedures for our integral abutments. However, if performance of these structures dictates a special backfill procedure, we will provide for it in our Standard Details.

NORTH CAROLINA—See attached material.

NORTH DAKOTA—Granular Backfill next to abutment is used.

OHIO—Procedures for backfilling around abutments, of the integral or non-integral type, are given in ODOT CMS Section 503.10. Compaction requirement is from 98% to 102% of maximum dry density per AASHTO T99, depending on the maximum laboratory dry weight.

OKLAHOMA—No special precautions. We expect to regrade the approach after it is stabilized. We do construct a gutter out of asphalt to reduce the water draining behind the wingwalls.
OREGON—Yes. Backfill which becomes part of the roadway must have 95 percent Proctor density in the top three feet, and 90 percent Proctor density below that. In the event that the excavated material is not suitable for backfill, Special Wall Backfill is specified which is non-colusive, pervious material.

PENNSYLVANIA—Not applicable.

RHODE ISLAND—We specify a 95% soils density for the compacted soil under the approach slab which helps to minimize the settlement of the slab. See attached Specification.

SOUTH CAROLINA—Use same procedures as for compacting embankments. Place backfill in 6” layers, compact to 95% max. density.

TENNESSEE—See attached Standard Drawing K-85-150.

TEXAS—Some districts use granular backfill behind abutments with drains through to the riprap. Others use cement stabilized backfill. Others use regular embankment backfill.

UTAH—Not applicable in our area.

VERMONT—No special procedures are used; end bents are backfilled with granular material to the same specifications as regular abutments.

WASHINGTON—Our specifications require 90% compaction in several “lifts”. This is most commonly accomplished by the use of hand compactors.

WEST VIRGINIA—Our bridge abutments are founded on rock and accepting that the approach fills will settle we intend to restore the grade with an overlay.

WISCONSIN—Granular backfill is specified where necessary to assure adequate abutment drainage. Backfill is placed and compacted in continuous horizontal layers not more than 12 inches thick. Additional information on this subject is provided in the enclosed photocopy of Section 206 of our Standard Specifications and paragraph 12.6 from our Bridge Manual.

WYOMING—Pervious backfill material behind the abutments and between the wingwalls is sloped to drain into weep holes placed in the abutment backwall.
QUESTION #6

ARE ABUTMENTS ON SPREAD FOOTERS USED IN YOUR STATE? IF SO, ARE THEY SUCCESSFUL?

ARIZONA—As a general policy, we do not use spread footings perched in the terminal ends of highway embankments. Piling is driven into in-situ material through prebored holes in the embankment.

ARKANSAS—Abutments are used occasionally and are considered successful, but a bump may develop if an approach slab is not used.

CALIFORNIA—Yes, abutments on spread footings are used when recommended by the Geology Section. Each site is inspected by the geologist prior to design. The abutments on spread footings have been satisfactory.

COLORADO—Abutments on spread footers are rarely used in Colorado.

CONNECTICUT—Yes, Yes.

DELAWARE—Yes, Yes.

GEORGIA—See answer to Question #1.

IDAHO—Abutments on spread footings are used with discretion. As in the case of Question #1, success has ranged from excellent to unsatisfactory. When unsatisfactory, poor performance can usually be traced to inadequate specifications or compliance therewith, or to faulty judgment in choosing to use them.

ILLINOIS—We do not use abutments on spread footings in a fill situation. Spread footings are allowed in non-fill situations where the supporting material has adequate support capacity for the design load.

INDIANA—We have not used abutments founded on spread footings recently.

KANSAS—No. 6 is as described in Item No. 4.

KENTUCKY—Yes. In most cases they are successful.

LOUISIANA—Integral abutments and abutments on spread footings are not used in this state.

MAINE—Abutments on spread footings are used where subsoils will adequately handle the loads imposed by a spread footing and embankment fills. Where soils analysis has indicated spread footings to be adequate, we have had no particular problems. I have attached hereto excerpts from our Bridge Design Manual describing our footing cover requirements and a Supplemental Specification, Section 203, which is utilized for preparation of foundation embankments with deep fills.

MARYLAND—Abutments on spread footers are used in our State where they may be founded in undisturbed ground with expectation of minimal settlement. Footings on embankments are always supported by piling.
MASSACHUSETTS—Yes, Yes.

MICHIGAN—We successfully use a large number of spread footing abutments placed on fill. The abutment fill is compacted to 100% density. (See Standards 2.08.11 to 2.08.13 attached).

MINNESOTA—Yes—where soil bearing is adequate—generally dense, sandy soils where approach settlement is minimal. We do not design bridges to settle with approach fills. There is no relationship in our state between use of spread footings and likelihood of approach fill settlement. Spread footings have been very successfully used. However, our bridges are designed for minimal settlement of structure. Where high settlements are anticipated the bridge would be lengthened or measures taken (lightweight fill, excavation of poor soils, etc.) to reduce amount of settlement.

MISSISSIPPI—Not as a uniform practice.

MISSOURI—Normally not.

MONTANA—We avoid the use of spread footings in approach fills whenever possible. Our experience indicates settlement of end bents to some extent whenever it is necessary to bear on the approach fill.

NEVADA—Yes, and so far we have no real problems.

NEW HAMPSHIRE—Abutments on spread footing are used when the bearing soils are adequate for support. At some locations a gravel structural fill is constructed below the spread footing to increase the bearing capacity of the foundation soils to an acceptable level.

NEW JERSEY—Abutments on spread footings are frequently used in New Jersey.

NEW YORK—Structures supported on spread foundations have generally performed very well in our State. Post construction settlement of these structures has generally been negligible or within projected limits. Spread foundations are seldom used for stream crossings because of the possibility of scour.

NORTH CAROLINA—Only for special situations. Spill thru end bents are our standard method.

NORTH DAKOTA—No.

OHIO—Abutments, particularly stub abutments on fills, on spread footings are not often used. Some massive settlements have occurred in the past with stub abutments on spread footings.

OKLAHOMA—We have founded abutments on spread footings. The term "spread footers" is unfamiliar.

OREGON—Yes. They are successful since they are only specified if the foundation material is adequate based on the soil exploration.
PENNSYLVANIA—Abutments on spread footers are used and are successful.

RHODE ISLAND—We do use abutments on spread footings in Rhode Island. We also use abutments on piles when the soil conditions warrant. Both types of abutment foundations have been successful.

SOUTH CAROLINA—Rarely. No known serious problems.

TENNESSEE—Abutments on spread footings are employed only where rock or shale exists at or near the plan bottom of footing or where rock embankments are required for geologic considerations. In these instances the installations are successful.

TEXAS—Spread footings are not used to support abutments, unless there is rock at the bottom of csp.

UTAH—We have successfully used abutments on spread footings on both natural ground and compacted embankments.

VERMONT—Yes, and they are successful.

WASHINGTON—The majority of our abutments are supported on spread footings. This support method has been quite successful.

WEST VIRGINIA—Our abutments are either placed on spread footings, on rock, or are placed on piles driven to rock.

WISCONSIN—Abutments on pile footings are preferred. Generally abutments on spread footings are used only in cut sections where the original soil can sustain reasonable pressures without excessive settlement. The use of spread footings is given more consideration for simple spans than for continuous spans. We have not experienced problems with the few spread footings that have been used.

WYOMING—Where foundation conditions require, abutments will be placed on spread footings. This type of abutment foundation has been successful, although it is considerably more expensive than a piling foundation. Generally, when an abutment is supported by spread footings, an expansion device is provided in the deck to accommodate movement of the bridge due to changes in temperature.
QUESTION #7

ARE THERE ANY OTHER METHODS THAT YOUR STATE USES TO MINIMIZE THIS PROBLEM?

ARIZONA—Minimizing approach settlement is a difficult problem to solve because of the wide range of variables involved. We use varying lengths of approach slabs where needed, call for the embankment to be constructed to subgrade prior to construction of end-bents, and in some cases where construction sequencing permits, the structure and embankment are built "grade and drain" with final adjustment of approaches and approach slabs made in a later contract.

ARKANSAS—No.

CALIFORNIA—We require the fill at the abutment to be compacted to 95% relative compaction, while the requirement for roadway is 90%. We also utilize fill surcharge and settlement periods prior to construction to reduce the eventual fill settlement.

COLORADO—We do not have any other special methods. However, we make an effort to use good fill material in the abutment area.

CONNECTICUT—No.

DELAWARE—No.

GEORGIA—See answer to Question #1.

IDAHO—I think we have learned from our past errors, and are in one stage or another of correcting same. We have started using relatively wide expansion joints between approach slabs and concrete pavements, plus massive anchor blocks integral with concrete pavements abutting approach slabs. A change in standards is contemplated, "when we can get to it," to eliminate all protrusions on the inner faces of wingwalls and earth faces of backwalls, to minimize compaction difficulties, and to minimize moments transmitted from approach slabs to abutments when approach slabs settle.

ILLINOIS—Question not answered.

INDIANA—We have not used any other methods to minimize this problem beyond proper soil compaction, peat removal, etc.

KANSAS—We recognize that settlement does exist at the abutments and we are studying ways in which we can minimize the problem. A study such as yours can be considered a step in the right direction.

KENTUCKY—Some other procedures include special compaction requirements, surcharging the embankment and foundation, and wick drains in the foundation.

LOUISIANA—Question not answered.

MAINE—Question not answered.
MARYLAND--There are no other specific methods used to minimize settlement at abutments than those noted, however, we do go to great care to make sure that drainage is not allowed to build up behind abutments which would cause heaving problems in the winter. Drainage pipes and porous backfill is placed behind abutment backwalls for their full length. Also, our District Maintenance personnel normally make great effort to overlay the approaches to maintain smooth riding surfaces. A 75' length of flexible approaches is left on all bridges.

MASSACHUSETTS--In addition to the slab, a bituminous concrete berm is placed against the back wall and over the approach slab to minimize the abrupt change between the gravel fill over the slab and the concrete back wall. The upper surface of the approach slab is also coated with bituminous damp-proofing.

MICHIGAN--We have no special methods, but we do employ a continuous testing of materials and workmanship during construction.

MINNESOTA--Our basic approach to minimize bridge approach settlement is thorough foundations borings and analysis. We do frequently require a waiting period or surcharge to accelerate fill settlement prior to bridge construction. The reinforced concrete approach panel is used to provide a smooth transition and reduce impact loads in case a small amount of settlement (or consolidation of fill) occurs after construction.

MISSISSIPPI--In fills where excessive settlement is anticipated, undercutting cutting and backfilling good material may be specified, or some type of presettlement program such as the use of sand or wick drains or a pre-loaded embankment, or a combination may be used.

MISSOURI--Placement of passive pressure berms in front of abutments where integral end bents cannot be used.

MONTANA--We have tried buried approach slabs with no success. We have placed emphasis on the construction of approach fills in our construction manuals. The problem still exists and we do not have a solution.

NEVADA--Yes, a foundation study at the location of the abutments.

NEW HAMPSHIRE--New Hampshire's standard backfill material behind abutments is gravel. The gravel is compacted to at least 100% of maximum density.

NEW JERSEY--Removal of unsuitable material and replacement with quality fill is utilized where economically feasible.

NEW YORK--When the Department's Soil Mechanics Bureau determines approach embankment settlement may be excessive, one of the following special procedures may be used:

a. Surcharge the approach embankment for a specified waiting period.

b. Build approach embankments to roadway subgrade (this may or may not include the area occupied by the abutment) and observe a specified waiting period.

c. Use lightweight fill (75 to 80 pcf) in lieu of the normal embankment material.
d. Remove unsuitable surface material under the approach embankment area before constructing them.

NORTH CAROLINA—We feel that the special drainage pickup incorporated into our approach slab details have greatly assisted in overcoming settlement problems at the bridge end.

NORTH DAKOTA—Problem cannot be eliminated. Our settlements are manageable.

OHIO—Waiting periods between embankment construction and bridge construction have been used, with some success.

OKLAHOMA—No other methods.

OREGON—Approach fills are sometimes required to be in place for a year before the bridge ends are placed. Fills have been surcharged to accelerate settlement of the foundation material.

PENNSYLVANIA—No other methods are used.

RHODE ISLAND—We also specify a 95% soils density for the compacted soil under the approach slab which helps to minimize the settlement of the slab. See attached Specifications.

SOUTH CAROLINA—No—only to correct by building up approaches with asphalt.

TENNESSEE—No other methods than those stated above are employed.

TEXAS—We have tried various sealers for the joint between approach slab and concrete pavement to prevent water ingress. None are successful.

UTAH—We developed a three span continuous steel girder design with the end spans cantilevered so as to avoid abutment supports. This design concept was published in the 1967 AASHTO Proceedings and may be used to advantage in both unstable and stable earth conditions.

VERMONT—When severe settlement is anticipated, surcharge preloading is specified to minimize the problem. Also, lightweight aggregate (expanded shale) is sometimes used as a backfill material to reduce the load and therefore reduce the settlement.

WASHINGTON—We do occasionally prefill, overload (25 to 35%), and have, on rare occasions, used jackable abutment or sand drains.

WEST VIRGINIA—We are developing a detail that will require our concrete approach slabs and a length of concrete pavement to be built with a 2" overlay of bituminous concrete. Then when fill settlement occurs we can remove part of the overlay and place more bituminous concrete to restore the grade.

Our bridge abutments are founded on rock and accepting that the approach fills will settle, we intend to restore the grade with an overlay.
WISCONSIN—Settlement of bridge approaches is reduced if the pavement construction can be delayed until the year after the embankment and bridge is constructed. This allows additional time for the embankment and its foundation to consolidate.

WYOMING—In areas where high fills are encountered at abutments and subsurface conditions are such that long-term settlement may occur, the subsurface material may be preloaded with the fill for a specified period of time prior to bringing the fill to final grade and starting the abutment construction. This time period generally ranges from two to four months.
APPENDIX B

STANDARD DRAWINGS AND SPECIFICATIONS
SECTION 208 - STRUCTURAL EXCAVATION and SPECIAL BACKFILL:

Superceding the Requirements of the Standard Specifications:

208-1 Description:

208-1.01 Structural Excavation:

Structural Excavation shall consist of the excavation and removal of all materials necessary for the construction of structures, pipelines and pipe culverts, including foundations and substructures, in accordance with the details shown on the plans and these specifications.

208-1.02 Special Backfill:

Special Backfill shall consist of furnishing complete in place an approved material used as bedding material, fill or backfill in the excavated area immediately adjacent to or around, structures, pipelines and pipe culverts and shall include excavating, loading, hauling, placing and compacting, all in accordance with the details shown on the plans and these specifications.

208-2 Materials:

Materials for special backfill shall conform to the requirements of Section 707.

Bedding material for pipe culvert shall conform to the requirements of Section 727 of these Supplemental Specifications.

208-3 Construction Details:

208-3.01 Structural Excavation:

(a) General requirements:

The contractor shall notify the engineer a sufficient time in advance of the beginning of excavation to allow measurements to be taken of the undisturbed ground. The required excavation shall then be performed in reasonably close conformity to the lines, grades and cross sections established or shown on the plans.

The sides of excavations may be sloped as required by soil conditions to stabilize the sides for safe working conditions. Such excavation shall be limited to the amount considered necessary for safety. When trenching in excess of four feet is required, the contractor shall submit to the engineer at the preconstruction conference a detailed description of his proposed trenching, installing, constructing and backfilling operations, including boring diagrams.

Where a fire bearing material is not encountered at the elevation established for bearing, due to soft, spongy or otherwise unstable soil, all such unstable soil shall be removed to the extent directed.

(b) Structural Excavation for Structures:

Where concrete is to be placed on an excavated surface other than rock, special care shall be taken not to disturb the bottom of the excavation. When the nature or condition of the bearing material upon which concrete is to be placed is determined to be such that the use of heavy excavating equipment will reduce the stability of the soil, the final one foot of excavation to grade shall be performed either by means of light equipment or by hand labor methods.

Where rock, in either ledge or boulder formation or other unyielding material, is encountered in one portion of structural excavation for a box culvert and a yielding material is encountered in an adjacent area of the structural excavation for the same box culvert, such unyielding material shall be removed for a minimum depth of two feet below grade and replaced with special backfill.

Where such unyielding material is encountered in excavation other than for box culverts or where an entire excavation for a box culvert bears on such material, the rock or other unyielding material shall be cleared of all loose fragments and cut to a firm surface as directed.

The placing of concrete shall follow as closely as practicable the structural excavation.
(C) Structural Excavation for Pipelines and Pipe Culverts:

Where pipe culverts are placed and rock, in either ledges or in either ledges or boulder formation or other unyielding material encountered, such unyielding material shall be removed for a minimum distance of six inches on each side of the pipe. In all types of installation, such unyielding material shall be removed for a minimum depth of 12 inches below the grade line of the pipe. This unyielding material shall be replaced with either bedding material or with special backfill up to the grade line of the pipe and such material shall be compacted to the density required hereinafter under 208-3.02(A).

208-3.02 Disposal of Material:

Excavated material shall be placed in embankments in accordance with the requirements of Section 211. Surplus material shall be disposed of in accordance with the requirements of Section 212 and in such a manner as not to obstruct any stream or impair the efficiency or appearance of any structure. Excavated material shall not be placed at any time in a manner that will endanger a structure.

208-3.03 Coferdas:

Wherever waterbearing strata are encountered above the elevation of the bottom of the excavation and coferdas are used, such coferdas shall be suitable and practically watertight.

The contractor shall, on request, submit detailed drawings for approval showing his proposed method of coferdas construction and other pertinent features not shown in detail on the plans. No construction shall be started until such drawings are approved; however, such approval shall not operate to relieve the contractor of any responsibility for the successful completion of the construction.

No labor or bracing which will extend into the concrete shall be left in coferdas or cribs.

Any pumping from the interior of any foundation enclosure shall be done in such a manner as to preclude the possibility of any portion of the concrete material being carried away. No pumping will be permitted during the placing of concrete for a period of at least 12 hours thereafter, unless it is done from a suitable sump separated from the concrete work by a watertight wall. Pumping to remove water from an unsealed coferda shall not begin until the seal has been sufficiently to withstand the hydrostatic pressure.

Coffers or cribs, including all sheeting and bracing, shall be removed by the contractor after the completion of the superstructure. This removal work shall be carried out in such a manner as not to disturb or injure the concrete.

208-3.04 Backfilling:

(A) General:

The material to be used for special backfill shall be obtained either from the sources designated in accordance with the requirements of Section 701 or from other approved sources. If the material is obtained from sources other than the ones designated, a supplemental agreement providing for an adjustment in compensation will not be required.

Special backfill shall be placed as fill or backfill in the areas required and in reasonably close conformity to the lines, grades and dimensions shown on the plans. Special care shall be taken to keep rocks away from structures.

Special backfill, bedding material and other fill and backfill material shall be compacted to a density of at least 95 percent of the maximum density determined in accordance with the requirements of the Materials Testing Manual of the Materials Services.

Water shall be added to the material, by wetting or by applying uniformly to each layer, when required for compaction, but only in sufficient quantity to insure proper compaction.

(B) Special Backfill for Structures Other Than Pipe Culverts:

Material shall be placed in layers of not more than eight inches in depth before compaction, and each layer shall be compacted by means of mechanical or pneumatic tamping devices or other suitable equipment to the density required hereinafter under (A).

The layers of material placed around structures shall be placed on opposite sides to approximately the same elevation at the same time.

Material shall not be placed against any concrete abutment, wing wall, retaining wall, box culvert or similar structure until the concrete has been in place at least 14 days unless otherwise authorized.
Special Backfill for All Types of Corrugated Metal and Reinforced and Reinforced Concrete Pipe Culverts:

1. Shaped Foundation and Backfill (Graveline to Springline):

   All pipe culverts shall be placed on a bed of and encased in bedding material up to the springline of the pipe culvert. The springline for circular pipe is defined as an imaginary line passing thru the central axis of the pipe and parallel to the gradeline.

   When pipe culverts are placed in trenches, bedding material shall be placed for the full width of the trench and for a minimum depth of six inches under the pipe.

   When pipe culverts are placed other than in trenches, bedding material shall be placed for a width not less than 18 inches for each side of the pipe and for a minimum depth of three inches under the pipe culvert.

   There shall be at least three inches of bedding material under the bells of bell and spigot pipe.

   When abasing material has been removed and replaced in accordance with the requirements of subsection 308-1.01(c), no bed of material required under this subsection will be necessary.

   The contractor may shape and compact bedding material by jetting with a minimum amount of water, when the surrounding existing soil in the trenches is of a permeable type. When jetting is used the jetting probe shall be inserted into the material at intervals not to exceed 12 inches, unless otherwise directed by the engineer.

   When pipe culverts are placed other than in trenches, the contractor may shape and compact bedding material by means of approved pneumatic or hydraulic equipment by which the bedding material, along with a minimum amount of water, is discharged under pressure to consolidate the material.

   The density of the bedding material shall be at least 95 percent of the maximum density determined in accordance with the requirements of the Materials Testing Manual of the Materials Services.

   Special backfill shall be taken as placing, shaping, and compacting material under all pipe to prevent moving or raising the pipe from its bedding.

2. Backfill (Above Springline):

   Backfill material above the springline shall be special backfill when required by the details shown on the plans. In all areas where special backfill is not required, fill or backfill shall be in accordance with the requirements of Section 211. The source for this material shall be designated for embankment under Section 211.

   Backfill material shall be placed in layers not more than eight inches in depth before compaction. Rocks over three inches in approximate diameter shall not be placed within six inches of the pipe culvert.

   Backfill material shall be compacted to a density of at least 95 percent of the maximum density determined in accordance with the requirements of the Materials Testing Manual of the Materials Services.

3. Special Backfill for Structural Plate Structures:

   All structural plate structures shall be placed on a bed of bedding material. The bedding material shall be placed for a width of not less than 18 inches on each side of the structure and for a minimum depth of six inches under the structure.

   Special backfill shall be placed as fill or backfill in the areas required and in reasonably close conformity to the lines, grades, and dimensions shown on the plans. Special care shall be taken to keep rocks away from structures.

   Material shall be placed in layers not more than eight inches in depth before compaction, and each layer shall be compacted by means of mechanical or pneumatic tamping devices or other suitable equipment to a density of at least 95 percent of the maximum density determined in accordance with the requirements of the Materials Testing Manual of the Materials Services.

   Water shall be added to the material by spraying or by applying uniformly to each layer, when required for compaction, but only in sufficient quantity to insure proper compaction.

   The layers of material placed around structures shall be placed on opposite sides to approximately the same elevation at the same time.
(F) Filter Material:

When required, filter material shall be placed in backfilling structures in accordance with the details shown on the plans. Filter material shall conform to the requirements for fine aggregate under subsection 706 (C) (2).

(F) Replacement of Unsuitable Material:

Where excavation has been performed below the limits shown for structural excavation in order to remove unsuitable material, the additional excavated material shall be replaced with special backfill.

208-8 Method of Measurement:

208-8.01 Structural Excavation:

Structural Excavation will be measured by the cubic yard and the quantity to be allowed for payment will be the calculated volume within the limits designated on the plans as payent limits.

Where it is necessary to excavate to a greater depth than shown on the plans for a footing, or to remove unsuitable material in accordance with the requirements of subsection 208-3.01, such additional excavation which is less than three feet below the elevation shown on the plans will be measured for payment as Structural Excavation.

No measurement for payment will be made of excavation:

Not authorized.

For debris, the bars and cables.

In the embankment placed under the same contract as the structure or pipe for which the excavation is being made, except for the imperfect trench installation of reinforced concrete pipe.

Required because of slides, cave-ins, slippings or filling due to the lack of support of slabs, the action of the elements or the carelessness of the contractor.

Water will not be classed as Structural Excavation.

208-4.02 Special Backfill:

Special Backfill will be measured by the cubic yard and the quantity to be allowed for payment will be the calculated volume of unsuitable material in the roadway for payment, including bedding material, placed in accordance with the details shown on the plans.

The quantity of Special Backfill shown on the plans will be considered as correctly representing the quantity of Special Backfill, including bedding material, actually required; however, should evidence show or should there be good reason to believe that the actual quantity of Special Backfill varies from the quantity shown on the plans by ten percent or more, the actual quantity of Special Backfill, including bedding material, will be computed by the engineer and measurement for payment will be based on this computation.

208-5 Basis of Payment:

The accepted quantities of Structural Excavation and Special Backfill, measured as provided above, will be paid for at the contract unit price.

Payment will be made under:

<table>
<thead>
<tr>
<th>Pay Item</th>
<th>Pay Unit</th>
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<tbody>
<tr>
<td>Structural Excavation</td>
<td>Cubic Yard</td>
</tr>
<tr>
<td>Special Backfill</td>
<td>Cubic Yard</td>
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</tbody>
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Payment for Overhaul of Structural Excavation will be made as specified under Section 209.

Payment for Watering used in Special Backfill will be made as specified under Section 215.

Payment for additional excavation where it is found necessary to excavate to a depth greater than three feet below the elevation shown on the plans for a footing or to remove unsuitable material in accordance with the requirements of subsection 208-3.01 will be made in accordance with the provisions of Subsection 104.02.

No payment will be made for furnishing and placing filter material or for material placed in replacement of unsanctioned excavation.
SECTION 707

either size or combining of the two sizes prior to proportioning.
At the time of proportioning for mixing, the aggregate in each stockpile shall be measured by weight and proportioned in the proper amounts so that the resulting mixture of coarse aggregate shall meet the requirements for Size No. 357.
The percent of wear of coarse aggregate at 500 revolutions, when tested in accordance with the requirements of AASHO T 96, shall not exceed 40.

706(D) Admixtures:
(1) General:
The contractor shall furnish certificates conforming to the requirements of subsection 106.04 for each type of admixture furnished.
(2) Air-Entraining Admixture:
Air-entraining admixtures shall conform to the requirements of AASHO M 154 for seven and 28 days compressive and flexural strength and resistance to freezing and thawing. Tests for bleeding, bond strength and volume change will not be required.
(3) Retarding and Accelerating Admixtures:
Retarding and accelerating admixtures shall conform to the requirements of AASHO M 194. The use of such admixtures shall be at the direction of the engineer.

SECTION 707 - SPECIAL BACKFILL

707(A) General Requirements:
Materials for special backfill shall be obtained as provided under Section 701 and shall conform to the following requirements:
Rock of such size that cannot be accommodated in the compacted lift of material being placed shall be removed.

SECTIONS 708, 709

The sum of the plasticity index and the percent of the material passing a No. 200 sieve shall not exceed 23.
The plasticity index will be determined in accordance with the requirements of AASHO T 90.
The amount of material passing a No. 200 sieve will be determined in accordance with the requirements of AASHO T 27.

SECTION 708 - EXPANSION JOINT FILLER

708(A) Preformed Expansion Joint Filler:
Preformed expansion joint filler for concrete structures, pavements and incidental items shall conform to the requirements on the plans. When not specified, either one of the following joint fillers may be used.
(1) Bituminous Joint Filler:
Bituminous joint filler shall conform to the requirements of AASHO M 213.
(2) Nonbituminous Joint Filler:
Nonbituminous joint filler shall conform to the requirements of AASHO M 153, Type II, with the following modifications. The joint filler may be formed as a premolded strip from suitable fibers. The compression test specimen of the premolded fiber joint filler shall recover to at least 65 percent of its thickness before testing.

SECTION 709 - JOINT SEAL

709(A) Joint Seal (Hot-Poured):
Joint seal shall be hot-poured, elastic type conforming to the requirements of AASHO M 173.
The pouring device shall be of the pressure type and shall be capable of filling the joint without the formation of either voids or entrapped air. Any material that has been overheated, heated for over three hours or has remained in the applicator at the end of the day's operation shall be withdrawn and wasted.
ARKANSAS
Pumping to dewater a sealed cofferdam shall not commence until the seal has set sufficiently to withstand hydrostatic pressure.

801.07 Inspection. After each excavation is completed, the Contractor shall notify the Engineer, and as concrete shall be placed until the Engineer has approved the depth of the excavation and the character of the foundation material.

801.08 Backfill. Material used for backfill shall be of a quality acceptable to the Engineer and shall be reasonably free from large or frozen lumps, wood or other extraneous material.

Spaces excavated for and not occupied by abutments, piers, or other permanent work shall be refilled with sand and compacted to the general level of the surrounding ground. This work shall be performed immediately after completion of each unit of concrete work and the removal of forms.

Backfill immediately adjacent to bridge abutments, culverts, retaining walls or other places inaccessible to refills shall be placed in approximately four inch horizontal layers, loose measurement, at near optimum moisture content and compacted with mechanical equipment to 95% of the maximum density as determined by AASHTO T-99. The specific density will not be required immediately adjacent to the walls of box culverts. The backfill in front of such walls shall be placed first to prevent the possibility of future movement. Special precautions shall be taken to prevent wedging action against the concrete and the slope boundaries of the excavation for abutments and wingwalls shall be stepped or roughened to prevent wedge action. Jetting of the space behind abutments and wingwalls will not be permitted.

Fill placed around piers shall be deposited on both sides to approximately the same elevation at the same time.

Adequate provision shall be made for the thorough drainage of backfill material. French drains shall be placed at weep holes when shown on the plans.

No backfill shall be placed against any abutment, retaining wall or culvert until permission shall have been given by the Engineer, but not until the concrete has been in place 14 days, or until tests cylinders show the strength specified.

Backfilling of structural plate pipe and arches shall be in accordance with subsection 608.03(d).

801.09 Approach Embankment. When the contract for a bridge structure requires the placement of approach embankments, they shall be constructed and paid for in accordance with the specifications governing this class of construction.

801.10 Classification of Excavation. Where excavation is classified, all excavation will be grouped under the following:

- Unclassified Excavation for Structures-Bridge or Unified Excavation for Structures-Roadway, and these shall include the removal of all materials encountered regardless of their nature or the manner in which they are removed.
- Common Excavation for Structures-Bridge, Common Excavation for Structures-Roadway, Rock Excavation for Structures-Bridge, or Rock Excavation for Structures-Roadway, in accordance with the following criteria:
  - Common Excavation for Structures-Bridge and Common Excavation for Structures-Roadway shall include the removal of all materials encountered regardless of their nature, other than rock as defined in the items Rock Excavation for Structures-Bridge and Rock Excavation for Structures-Roadway.
  - Rock Excavation for Structures-Bridge and Rock Excavation for Structures-Roadway shall include the removal of firm and compact materials as cannot be excavated with clam shell or orange peel bucket, slip, pick and shovel, or wedge without first being loosened or broken by blasting, wedging or drilling.

801.11 Method of Measurement. Plan quantities and adjustments thereof are based on vertical planes parallel to and 18 inches outside the neat lines of the footing or bottom slab and wings when in material other than rock, and vertical planes parallel to and 4 inches outside the footing or bottom slab and wings in rock for all foundations except seal concrete. Plan quantities and the adjustments thereof for foundation seals are based on vertical planes and parallel to the neat line of seal.

The quantities do not include the volume of any material which lies within the typical roadway cut section or within a channel change section as shown by the plans. Nor is it classified as a material.

Where cofferdams are not required, quantities for
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stockpiling of selected material will be made, unless such stockpiling is ordered by the Engineer.

Topsoil placed along the tops of slopes in connection with erosion control work will not be considered as stockpiled material when determining quantities of earthwork to be paid for.

19-2.08 Measurement.—The following earthwork operations will be measured and paid for as roadway excavation for the quantities of material involved and no additional compensation will be allowed therefor:

- Excavating the roadway prism including slope rounding, public and private road approaches, connections and driveways; excavating unsuitable material when shown on the plans or specified in the special provisions; excavating surplus material; excavating selected material and topsoil from within the limits of the project and removing such materials from stockpiles when stockpiling is ordered; excavating channels having a bottom width of 12 feet or more as provided in Section 19-4, “Ditch Excavation,” and excavating local borrow as provided in Section 19-7, “Borrow Excavation.”

Quantities of roadway excavation will be computed by means of average areas and distances between these areas, except as provided in the following paragraph.

Where due to changed conditions or the nature of a particular operation or for any other reason, it is impossible or impractical to measure quantities of roadway excavation by means of average areas, the Engineer will compute the quantities of material excavated by a method which in his opinion is best suited to obtain an accurate determination.

When quantities of roadway excavation are computed by means of average end areas and center line distances, a correction for curvature will not be applied to quantities within the roadway prism. In computing the quantity of material outside the original roadway prism, where the roadway center line is used as a base, correction will be made for curvature if the center line radius is 1,000 feet or less.

Excavation in excess of the planned or authorized cross section will not be paid for, except as provided in Section 19-2.04, “Slides and Slipouts.” The Contractor shall backfill and compact as directed by the Engineer unauthorized excavated areas to the original ground elevation or authorized section at his expense.

19-2.09 Payment.—Quantities of roadway excavation, measured as specified in Section 19-2.08, “Measurement,” will be paid for at the contract price per cubic yard. Such price shall include excavating, sloping, rounding tops and ends of excavations, loading, hauling, depositing, spreading and compacting the material complete in place, and preparing subgrade at the grading plane as specified in Section 19-1.03, “Grade Tolerance.”

The above price and payment shall include full compensation for furnishing all labor, materials, tools, equipment, and incidentals, and for doing all the work involved in performing roadway excavation work completely as shown on the plans, and as specified in these specifications and the special provisions and as directed by the Engineer.

19-3.01 Description.—Structure excavation shall consist of excavation
for the construction of foundations for structures; excavation of trenches for the construction of culverts, pipes, rods, deadmen, cutoff walls and other facilities; other excavation designated on the plans or in these specifications or in the special provisions as structure excavation; the control and removal of water and the construction or installation of all cofferdams and other facilities as necessary to accomplish construction of the work; and the subsequent removal of such facilities, except when they are required or permitted by the plans and specifications to remain in place.

Structure backfill shall consist of furnishing, placing and compacting backfill material around structures to the lines designated on the plans or specified or directed by the Engineer.

Structure excavation and structure backfill may be classified on the plans or in the Engineer's Estimate into various types or classifications. When there is a contract pay item for structure excavation (Type A), such excavation shall include all excavation for footings where seal courses are shown on the plans. The requirements of the specifications pertaining specifically to earthwork for culverts shall apply only to earthwork which is classified on the plans as structure excavation (culvert) and structure backfill (culvert).

When shown on the plans or directed by the Engineer, recesses at culvert inlets shall be excavated in excavation slopes to the dimensions designated and the resulting material disposed of in roadway embankments as directed by the Engineer and such work will be paid for as structure excavation for the quantities involved.

Material from structure excavation not used as structure backfill shall be deposited in roadway embankments as provided in Section 19-6, "Embankment Construction," or disposed of as provided in Section 19-2.06, "Surplus Material," all as directed by the Engineer.

19-3.02 Excavation for Culverts.—When the plans require embankment construction prior to culvert excavation the embankment shall first be constructed to the required height as shown on the plans, and for a distance each side of the culvert of not less than 5 times the diameter or height of the culvert, after which the trench shall be excavated and the culvert installed. Where such embankments are to be constructed on a deep slope or at a difficult location, the height of new embankments may be varied as directed by the Engineer before installing culverts.

19-3.025 Culvert Beddings.—Culvert beddings shall consist of shaped bedding, sand bedding, or soil cement bedding and shall be constructed, where shown or specified, in accordance with the details shown on the plans and these specifications. When more than one type of bedding is permitted, the same bedding shall be used throughout the length of the culvert.

Culvert beddings shall conform to the following requirements:

19-3.025A Shaped Bedding.—The trench bed shall be shaped to fit the bottom of the culvert, as shown on the plans, and shall provide uniform support throughout the entire length of the culvert. The trench may be excavated below the bottom of the culvert and the shaped bedding constructed by backfilling and compacting culvert backfill material to the required line, grade and shape. Shaping shall be accomplished by use of a template conforming to the outside shape of the culvert and guided by headers set parallel to the grade of the culvert established by the Engineer. Such headers may be left in place.
for the construction of foundations for structures; excavation of trenches for the construction of culverts, pipes, rods, deadmen, cutoff walls and other facilities; other excavation designated on the plans or in these specifications or in the special provisions as structure excavation; the control and removal of water and the construction or installation of all cofferdams and other facilities as necessary to accomplish construction of the work; and the subsequent removal of such facilities, except when they are required or permitted by the plans and specifications to remain in place.

Structure backfill shall consist of furnishing, placing and compacting backfill material around structures to the lines designated on the plans or specified or directed by the Engineer.

Structure excavation and structure backfill may be classified on the plans or in the Engineer's Estimate into various types or classifications. When there is a contract pay item for structure excavation (Type A), such excavation shall include all excavation for footings where seal courses are shown on the plans. The requirements of the specifications pertaining specifically to earthwork for culverts shall apply only to earthwork which is classified on the plans as structure excavation (culvert) and structure backfill (culvert).

When shown on the plans or directed by the Engineer, recesses at culvert inlets shall be excavated in excavation slopes to the dimensions designated and the resulting material disposed of in roadway embankments as directed by the Engineer and such work will be paid for as excavation for the quantities involved.

Material from structure excavation not used as structure backfill shall be deposited in roadway embankments as provided in Section 19-6, "Embankment Construction," or disposed of as provided in Section 19-2.06, "Surplus Materia," as directed by the Engineer.

19-3.02 Excavation for Culverts.—When the plans require embankment construction prior to culvert excavation the embankment shall first be constructed to the required height as shown on the plans, and for a distance each side of the culvert of not less than 5 times the diameter or height of the culvert, after which the trench shall be excavated and the culvert installed. Where such embankments are to be constructed on a deep slope or at a difficult location, the height of new embankments may be varied as directed by the Engineer before installing culverts.

19-3.025 Culvert Beddings.—Culvert beddings shall consist of shaped bedding, sand bedding, or soil cement bedding and shall be constructed, where shown or specified, in accordance with the details shown on the plans and these specifications. When more than one type of bedding is permitted, the same bedding shall be used throughout the length of the culvert.

Culvert beddings shall conform to the following requirements:

19-3.025A Shaped Bedding.—The trench bed shall be shaped to fit the bottom of the culvert, as shown on the plans, and shall provide uniform support throughout the entire length of the culvert. The trench may be excavated below the bottom of the culvert and the shaped bedding constructed by backfilling and compacting culvert backfill material to the required line, grade and shape. Shaping shall be accomplished by use of a template conforming to the outside shape of the culvert and guided by headers set parallel to the grade of the culvert established by the Engineer. Such headers may be left in place.
19-3.025B Sand Bedding.—Sand shall be free from clay or organic material, suitable for the purpose intended, and shall be of such size that 90 percent to 100 percent will pass a No. 4 sieve and not more than 1 percent will pass a No. 200 sieve.

19-3.025C Soil Cement Bedding.—Portland cement used in soil cement bedding shall conform to the provisions in Section 90, “Portland Cement Concrete,” except that testing will not be required.

Water used for soil cement bedding shall be free from oil, salts, or other impurities which would have an adverse effect on the quality of the bedding material.

Aggregate for soil cement bedding shall be either material selected from the excavation, imported material, or a combination thereof, free of organic material and other deleterious substances, and meet the following grading requirements when tested in accordance with California Test 202:

<table>
<thead>
<tr>
<th>Sieve Sizes</th>
<th>Percentage Passing</th>
</tr>
</thead>
<tbody>
<tr>
<td>$1\frac{1}{2}$</td>
<td>100</td>
</tr>
<tr>
<td>1&quot;</td>
<td>60-100</td>
</tr>
<tr>
<td>$\frac{3}{4}$</td>
<td>60-100</td>
</tr>
<tr>
<td>$\frac{1}{2}$</td>
<td>50-100</td>
</tr>
<tr>
<td>No. 4</td>
<td>40-80</td>
</tr>
<tr>
<td>No. 100</td>
<td>10-40</td>
</tr>
</tbody>
</table>

The aggregate, cement and water shall be proportioned either by weight or by volume. Not less than 282 pounds of cement shall be used for each cubic yard of material produced. The water content shall be sufficient to produce a fluid, workable mix that will flow and can be pumped without segregation of the aggregate while being placed.

Materials for soil cement bedding shall be thoroughly machine-mixed in a pugmill, rotary drum, or other approved mixer. Mixing shall continue until the cement and water are thoroughly dispersed throughout the material. Soil cement bedding shall be placed in the work within one hour after mixing.

Soil cement bedding shall be placed in a uniform manner that will prevent voids in, or segregation of, the bedding, and will not float or shift the culvert. Foreign material which falls into the trench prior to or during placing of the soil cement bedding shall be immediately removed.

Backfilling with earth on culverts set in soil cement bedding shall commence until 8 hours after the soil cement bedding has been placed.

19-3.03 Cofferdams.—Cofferdams for foundation construction shall be carried well below the bottom of the footings and shall be well braced and as watertight as practical. The interior dimensions of cofferdams shall provide sufficient clearance inside the wales for constructing forms and driving piles and to permit pumping outside the forms.

If in the judgment of the Contractor, the clearance provided on the plans between the outside line of the footing and any pile or interior wall or surface is not sufficient to permit the driving of piles or building of forms, he may provide such necessary clearance by constructing the cofferdam sufficiently large to provide such clearance as he may deem necessary. Any such enlargement in excess of one foot outside the dimensions of the footing as shown on the plans shall be considered as being for the
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In the purpose of expediting the work of the Contractor, and the quantities of such excavation and backfill will not be included in the quantities to be measured.

Cofferdams which are tilted or moved out of position by any cause during the process of sinking shall be righted or enlarged so as to provide necessary clearance and proper pier location and such work shall be done by the Contractor at his expense.

In tidal waters or in streams at a time of probable flood, cofferdam walls may be vented at low water elevation to insure equal hydrostatic head inside and outside of the cofferdam during the period of placing and setting of seals.

No shoring will be permitted in cofferdams which will induce stress, rock or vibration in the permanent structure.

When permitted by the Engineer, cross struts or bracing may extend through foundation concrete. Such struts or bracing below low water will be permitted to remain in place, except in navigable streams or when specified in the special provisions or shown on the plans, to be removed. Struts or bracing above low water shall be removed and the resulting holes filled with concrete of the same mix as that specified for the surrounding concrete.

In accordance with the provisions in Section 5-1.02, "Plans and Working Drawings," the Contractor shall submit to the Engineer, for approval, drawings showing his proposed method of cofferdam construction and any details left open to his choice or not fully shown on the plans. These drawings shall be submitted at least 2 weeks in advance of the time the contractor begins construction of the cofferdams.

After completion of the substructure, the cofferdams with all sheeting and bracing shall be removed at least to 2 feet below the level of the embankment, the Contractor at his expense, and such removal shall be performed in a manner that will not disturb or mar the finished concrete masonry.

2-3.04 Water Control and Foundation Treatment.—The methods to be used to control and remove water at excavations where seal courses are shown on the plans shall be at the option of the Contractor and may vary, but are not limited to, well point systems, pumping sumps, coffer dams or concrete seal courses. If the Contractor elects to use a concrete course at such locations, the provisions of the fourth paragraph and last 2 sentences of the fifth paragraph of Section 51-1.10, "Concrete Placed Under Water," shall not apply for spread footings and the first 4 paragraphs of Section 51-1.10 shall not apply to pile footings. The successful performance of such seals, if used, shall be solely the responsibility of the Contractor.

All locations where concrete seal courses are shown on the plans, and the Engineer determines that a seal course shall be used, control and removal of water shall be accomplished by the use of a cofferdam, a concrete seal shall be placed in accordance with the requirements of said Section 51-1.10, and dewatering pumps.

When no piles are used and footing concrete, culverts or other structures are to rest on an excavated surface other than rock, the following apply:

Care shall be taken during excavation to prevent disturbing the foundation. If ground water is encountered during excavation and a concrete seal course is not to be used, dewatering shall be commenced and
shall proceed in advance of or concurrently with further excavation. The foundation shall be free of water at the time footing concrete or pipes are placed, and water control shall continue as necessary to prevent damage to the work.

If suitable foundation material has been disturbed by the Contractor's operations, has been damaged by water or has been removed for the Contractor's convenience in dewatering the foundation, the foundation shall be restored by the Contractor, at his expense, so that the undisturbed foundation as determined by the Engineer. For culverts, the material used to replace such damaged or removed foundation material shall be Class 2 aggregate base, conforming to the provisions in Section 26, "Aggregate Bases," and shall be compacted as required for structure backfill, unless the Engineer determines that a different type of material is required to provide the equivalent bearing capacity.

When undisturbed original material at the planned grade of the excavation is determined by the Engineer to be unsuitable material, as defined in Section 19-2.02, "Unsuitable Material," the Engineer will direct corrective work and the cost of such corrective work, other than structure excavation and backfill within the limits described in Section 19-3.07, "Measurement," will be paid for as extra work as provided in Section 4-1.03D.

When footing concrete or masonry is to rest upon rock, the rock shall be fully uncovered and the surface thereof shall be removed to a depth sufficient to expose sound rock. The rock shall be roughly leveled or cut to steps, and shall be roughened. Seams in the rock shall be grouted under pressure or treated as the Engineer may direct and the cost thereof will be paid for as extra work as provided in Section 4-1.03D.

When excavating for culverts, other than arch culverts, and solid rock or other unyielding material is encountered at the planned elevation of the bottom of the culvert, the material shall be removed below the bottom of the culvert to a depth of \( \frac{3}{4} \) of the height of embankment over the top of culvert, but in no case less than one foot nor more than 5 feet. The resulting trench below the bottom of the culvert shall be backfilled with suitable backfill material in accordance with the provisions in Section 19-3.06, "Structure Backfill." Such excavation and backfill below the planned elevation of the bottom of the culvert will be paid for as extra work as provided in Section 4-1.03D.

When footings are to be supported on piles, excavations shall be completed to the bottom of the footings before any piles are drilled or driven therein. When swell or subsidence results from driving piles, the Contractor shall, at his expense, excavate, or backfill with suitable material, the footing area to the grade of the bottom of the footing as shown on the plans. If material under footings is such that it would mix into the concrete during footing placement or would not support the weight of the fluid concrete, the Contractor shall, at his expense, replace the material with suitable material, install soffit forms or otherwise provide a suitable platform on which to cast the footing.

19-3.05 Inspection.—In order to determine the character of the foundation material, the Contractor shall, if directed by the Engineer, dig test pits and make test borings and foundation bearing tests, and the cost thereof will be paid for as extra work as provided in Section 4-1.03D.

Whenever any structure excavation is completed substantially to grade,
Contractor shall notify the Engineer who will make an inspection of the foundation. No concrete or masonry shall be placed until the foundation has been approved by the Engineer.

6. Structure Backfill.—Backfill material shall be placed in uniform layers and shall be brought up uniformly on all sides of the structure footing. The thickness of each layer of backfill shall not exceed 0.67 foot. Compaction except that when compaction is done by ponding and jetting the compaction shall consist of stones or lumps exceeding 3 inches in greatest dimension, and no damage from hydrostatic pressure will result to the structure backfill shall be placed in the back of concrete abutments, concrete retaining walls, or the backwalls of cast-in-place concrete structures until the concrete has developed a strength of not less than 2,500 pounds per square inch in compression, or until the concrete has been in place for 28 days, whichever is first.

Backfill at the inside of bridge wingwalls and abutments shall be placed before curbs or sidewalks are constructed over the backfill and before the wingwalls are constructed.

Compaction of structure backfill by ponding and jetting will be permitted when determined by the Engineer, the backfill material is of such character that it will be self-draining when compacted and that foundation materials will not soften or be otherwise damaged by the applied pressure and no damage from hydrostatic pressure will result to the structure backfill. Ponding and jetting of the upper 4 feet below finished grade will not be permitted. The work shall be performed without damage to the structure embankment, and in such a manner that water will not be ponded. Compaction and jetting methods shall be supplemented by vibratory or other compaction equipment when necessary to obtain the required compaction.

<table>
<thead>
<tr>
<th>Percentage Passing</th>
<th>100</th>
</tr>
</thead>
<tbody>
<tr>
<td>Percentage Passing</td>
<td>50</td>
</tr>
</tbody>
</table>

Structure backfill placed at the following locations shall be compacted to a relative compaction of not less than 90 percent and shall consist of material free of stones or lumps exceeding 3 inches in greatest dimension, organic and other unsatisfactory material:

- Overside drains.
- Footings for slope protection, slope paving, and aprons.
- All headwalls, endwalls, and culvert wingwalls.
- Retaining walls, except for portions under any surfacing, and except for crib walls.
- Inlets in median areas or in traffic interchange loops.
6. Footings and pumping plants not beneath any surfacing.

7. Other locations where 90 percent relative compaction for structure backfill is shown on the plans.

At locations where directed by the Engineer, the material used to backfill the outer 2-foot portion of structure backfill adjacent to pipe and culvert inlets and outlets, and structure backfill placed within 2 feet of finished grade around abutments, abutment wingwalls, retaining walls, and other portions of structures shall be a compacted impervious material. The impervious backfill shall be an earthy material, as determined by the Engineer to be suitable for such purpose. The Sand Equivalent requirement shall not apply to such material used for structure backfill.

The cells formed by the crib members of crib walls and the space between the crib wall and the limits designated for structure excavation, as shown on the plans or specified, including any space due to material being removed outside said limits, shall be backfilled with material conforming to the following grading, quality, placement and compaction requirements:

Structure backfill placed for crib walls shall be of such character that it will not sift or flow through the openings in the wall and shall conform to the type or types listed below for the height of wall.

Backfilling shall progress simultaneously with the erection of the crib wall. Backfill material shall be so placed as to not disturb or damage the crib members, shall be placed in uniform layers before compaction not exceeding the thickness listed in the following table, and shall be compacted by hand tamping, mechanical compaction or other means approved by the Engineer.

<table>
<thead>
<tr>
<th>Height</th>
<th>Material Type</th>
<th>Backfill</th>
<th>Layer of Backfill Material Before Compaction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Under 10 feet</td>
<td>C, D or E</td>
<td>1 foot</td>
<td></td>
</tr>
<tr>
<td>10-25 feet</td>
<td>D or E</td>
<td>2 feet</td>
<td></td>
</tr>
<tr>
<td>Over 25 feet</td>
<td>E</td>
<td>4 feet</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Backfill Material Type</th>
<th>Sieve Size</th>
<th>Percent Passing</th>
<th>Sand Equivalent</th>
<th>Relative Compaction</th>
</tr>
</thead>
<tbody>
<tr>
<td>C</td>
<td>3</td>
<td>100</td>
<td>None</td>
<td>90% Min.</td>
</tr>
<tr>
<td>D</td>
<td>3-5</td>
<td>100</td>
<td>35-100</td>
<td>90% Min.</td>
</tr>
<tr>
<td>E</td>
<td>5-10</td>
<td>100</td>
<td>None</td>
<td>90% Min.</td>
</tr>
<tr>
<td>No. 40</td>
<td>25-70</td>
<td></td>
<td>None</td>
<td></td>
</tr>
<tr>
<td>No. 80</td>
<td>5-20</td>
<td></td>
<td>None</td>
<td></td>
</tr>
<tr>
<td>No. 200</td>
<td>0-3</td>
<td></td>
<td>None</td>
<td></td>
</tr>
</tbody>
</table>

Structure backfill placed at bridge piers in waterways and water channels, not beneath any embankment, pavement or slope protection, need not be compacted and shall consist of soil which is free of vegetable matter, trash or other unsatisfactory material.

Where structure excavation is performed and material is removed outside the pay limits designated for structure excavation, as shown on the plans or specified in these specifications or the special provisions, all backfill material placed in said excavation areas shall be compacted to a relative compaction of not less than that required for the adjacent structure.
Material for structure backfill shall be furnished by the Contractor except that the Contractor may use material found in excavation in accordance with the requirements of Section 4-105, "Use of Materials Found on Work." When there is an item for imported borrow, imported borrow shall be backfilled with structure backfill. No deduction in the quantities of imported borrow to be paid shall be made provided that an equivalent amount of material conforming to the requirements of imported borrow is replaced by the Contractor. The material from structure excavation which is not suitable for use as structure backfill may be used to replace imported borrow or other excavated material.

Slurry Cement Backfill.—Slurry cement backfill shall consist of a mixture of aggregate, cement, and water. The option of the Contractor, slurry cement backfill may be used as structure backfill for pipe culverts, except that slurry cement backfill shall be used as structure backfill for aluminum and aluminum-coated pipe culverts where slurry cement backfill is used for structure backfill, the width of excavation shown on the plans may be reduced so that the clearance between the outside of the pipe and the side of the excavation, except for the side of the pipe, is a minimum of 6 inches for pipes up to and including 42 inches in diameter or span, or one foot for pipes over 42 inches in diameter or span.

Structure backfill shall be placed only for that portion of the structure excavation below the original ground or the grading plane or the top of the embankment placed prior to excavating for the culvert pipe. Where necessary, earth plugs shall be compacted at each end of the pipe prior to backfilling in a manner that completely contains the slurry in the trench. Slurry shall be portland cement conforming to the provisions in Section 2.01, "Portland Cement," except that testing will not be required. It used for slurry cement backfill shall be free from oil, salts and impurities which would have an adverse effect on the quality of the material.

1.01 - Slurry Cement Backfill: Slurry cement backfill shall consist of a mixture of aggregate, cement and water. The option of the Contractor, slurry cement backfill may be used as structure backfill for pipe culverts, except that slurry cement backfill shall be used as structure backfill for aluminum and aluminum-coated pipe culverts.

<table>
<thead>
<tr>
<th>Size (mm)</th>
<th>Percentage Passing</th>
</tr>
</thead>
<tbody>
<tr>
<td>50</td>
<td>100</td>
</tr>
<tr>
<td>200</td>
<td>60-100</td>
</tr>
<tr>
<td>400</td>
<td>40-80</td>
</tr>
<tr>
<td>1000</td>
<td>10-40</td>
</tr>
</tbody>
</table>

Aggregate, cement and water shall be proportioned either by weight or by volume. Not less than 188 pounds of cement shall be used for each cubic yard of material produced. The water content shall be sufficient to produce a fluid, workable mix that will flow and can be pumped.
without segregation of the aggregate while being placed.

Materials for slurry cement backfill shall be thoroughly machine-mixed in a pugmill, rotary drum, or other approved mixer. Mixing shall continue until the cement and water are thoroughly dispersed throughout the material. Slurry cement backfill shall be placed in the work within one hour after mixing.

Slurry cement backfill shall be placed in a uniform manner that will prevent voids in or segregation of the backfill, and will not float or shift the culvert. Foreign material which falls into the trench prior to or during placing of the slurry cement backfill shall be immediately removed.

Backfilling over or placing any material over slurry cement backfill shall not commence until 4 hours after the slurry cement backfill has been placed, except that when concrete sand is used for the aggregate and the in-place material is free draining, backfilling may commence as soon as the surface water is gone.

Slurry cement backfill used as structure backfill for pipe culverts will be considered structure backfill for compensation purposes.

19-3.065 Pervious Backfill Material.—Pervious backfill material shall be placed behind bridge abutments, wingwalls and retaining walls as shown on the plans and in accordance with the following requirements.

Pervious backfill material shall consist of gravel, crushed gravel, crushed rock, natural sands, manufactured sand, or combinations thereof. Pervious backfill material, except for sacked material at wall drain outlets, shall conform to the following grading requirements:

<table>
<thead>
<tr>
<th>Sieve Sizes</th>
<th>Percentage Passing</th>
</tr>
</thead>
<tbody>
<tr>
<td>2&quot;</td>
<td>100</td>
</tr>
<tr>
<td>No. 50</td>
<td>0-100</td>
</tr>
<tr>
<td>No. 100</td>
<td>0-8</td>
</tr>
<tr>
<td>No. 200</td>
<td>0-4</td>
</tr>
</tbody>
</table>

Wall drain outlets shall be backed with sacked pervious backfill material, except that the grading for the sacked material shall conform to the grading for the 1/2" x 1/4" primary aggregate size specified in Section 90-3.02, "Coarse Aggregate Grading.

Pervious backfill material shall be placed in layers along with and by the same methods specified for structure backfill. Pervious backfill material at any one location shall be approximately the same grading, and at locations where the material would otherwise be exposed to erosion shall be covered with at least a one-foot layer of earthy material approved by the Engineer.

19-3.07 Measurement.—Quantities of earthwork to be paid for as structure excavation, structure backfill and pervious backfill material will be measured by the cubic yard.

The quantities for payment will be determined from limits shown on the plans or specified or directed by the Engineer.

No deduction in structure excavation or structure backfill pay quantities will be made where the Contractor does not elect to excavate material which is outside the limits of the actual structure but within the limits shown on the plans or specified or directed by the Engineer.

No compensation will be made for the removal and use or disposal of material which may come into an excavation from outside the designated limits or for the volume of backfill occupied by the new structure or for the removal and disposal of material resulting from swell caused by
The horizontal limits for computing pay quantities will be vertical planes one foot outside of the neat lines of footings or structures.

The upper limit for payment of structure excavation shall be the finish surface as it existed prior to the start of construction operations, except where structure excavation is performed within roadway excavation or ditch excavation areas, the upper limit shall be the planes of the sides and top slopes of said excavated areas. Also, where it is required that the structure excavation be made in new embankment, the upper limit shall be the planes of the new embankment at the elevation specified for construction in advance of performing the required structure excavation, but in no case shall the upper limit be above the planes of the new embankment.

(2) The upper limit for payment of structure backfill, when not otherwise specified, shall be the finished grading plane or the finished grade lines, as directed by the Engineer. If structure backfill is ordered as a higher limit by the Engineer, said limit for payment shall be the higher limit ordered.

(3) The lower limit for computing pay quantities of structure excavation or structure backfill shall be a plane at the bottom of the completed footings or structures or the lower outside surface of rods or deadmen, as necessary, as determined by the Engineer, to increase the depth of structure excavation beyond the limits shown on the plans for structures other than culverts, excavation to a depth of 2 feet below said plane and for a width up to 3 times the outside width of the footing as shown on the plans for foundations. The Engineer will be paid at the contract price per cubic yard for structure excavation. Excavation to depths or widths greater than those above provided will be paid for at the contract price for structure excavation, unless the Engineer directs the removal of excavation outside the limits of the excavation to be removed and paid for as extra work as provided in Section 4.1.03.D. When the limits of structure excavation are so increased, the pay for structure backfill will be similarly increased and the additional fill within said limits will be paid for at the contract price for structure backfill.

The depth of structure excavation for footings, where a seal course is shown on the plans, will be paid for at the contract price per cubic yard for structure excavation (Type A). If the depth of the structure excavation (Type A) is reduced because site dewatering efforts or lower than expected water levels permit a reduction or elimination of the seal, such decrease will not be considered to be a change in the dimension of structure excavation (Type A) within the meaning of Section 4.1.03.D. "Final Pay Quantities," and no decrease in the quantity of struc-
SECTIONS 19.

19.4 DITCH EXCAVATION

0.01 Description.—Ditch excavation shall consist of excavating ditch or outside the right of way, including channels for changing course of streams, all as shown on the plans or specified by the Engineer. Excavation required to construct a ditch or channel designated with a width of less than 12 feet will be classed as ditch excavation. Excavation required to construct a ditch or channel designated with a width of 12 feet or more will be classed as roadway excavation. Material resulting from excavating ditches or channels shall be used to construct roadway embankments, dikes, or for other purposes, or disposed of as directed by the Engineer. Care shall be exercised to prevent excavating below the face of the ditch or water channel, and areas excavated below grade shall be filled with suitable material and thoroughly compacted by the contractor at his expense.

0.02 Measurement.—Quantities of ditch excavation to be paid for shall be computed by means of average areas and the distances between areas.

0.03 Payment.—The excavation of ditches and channels which have a width of less than 12 feet, as shown on the plans, except as otherwise provided, will be paid for at the contract price per cubic yard of ditch excavation. The above price and payment shall include full compensation for furnishing labor, materials, tools, equipment, and incidentals, and for all the work involved in excavating ditches completely, as shown on the plans, and as specified in these specifications and the special provisions as directed by the Engineer.

Excavation of gutters within the median area of a divided highway, gutters between the roadbed shoulder and an adjacent excavation, and gutters in excavation benches, and side gutters contiguous to embankment slopes, all as shown on the plans, will be paid for as roadway excavation and payment will not be made as ditch excavation for such work.

19.5 COMPACTION

5.01 Description.—Earthwork compaction consists of obtaining the required compaction in all earthwork described in these specifications or special provisions, except structure backfill.

5.02 General.—Embankments shall be constructed in layers. The thickness of each layer of embankment material before compaction
ture excavation (Type A) will be made.

The volume of pervious backfill material, measured and paid for within the limits of payment for structure excavation, will be deducted from the pay quantities of structure backfill.

19-3.06 Payment—Unless otherwise provided, quantities of earthwork, measured as specified in Section 19-3.07, “Measurement,” will be paid for by the cubic yard for structure excavation, for structure backfill, and for pervious backfill material of the types shown in the Engineer’s Estimate.

The above prices and payments shall include full compensation for furnishing all labor, materials, tools, equipment, and incidentals, and for doing all the work involved in excavating for and backfilling structures completely, as shown on the plans, and as specified in these specifications and the special provisions, and as directed by the Engineer.

The quantities of structure excavation, structure backfill and culvert beddings required for the installation of culverts, will not be paid for as separate items. Full compensation for structure excavation, structure backfill and culvert beddings for culvert installations shall be considered as included in the contract prices paid per linear foot for pipe culverts or per cubic yard for the concrete and per pound for the bar reinforcing steel involved in constructing reinforced concrete box and arch culverts, whichever applies.

No adjustment in compensation will be made if the actual depth of structure excavation for a culvert is within 0.5-foot of the planned depth as calculated from the data shown on the plans. The actual depth of structure excavation shall be the vertical distance between the ground plane prior to excavating for the culvert and the bottom of the culvert trench. If the increase or decrease in structure excavation depth greater than 0.5-foot from the planned depth as calculated from the data shown on the plans, an adjustment in compensation will be made in accordance with Section 4-1.03C, “Changes in Character of Work,” provided the Contractor requests an adjustment, in writing, due to the increased depth of structure excavation or the Engineer orders an adjustment due to the decreased depth of structure excavation. Any increased depth of excavation due to the removal of unsuitable material, or rock or other unyielding material below the planned grade of the bottom of the culvert as provided in Section 19-3.04, “Water Control and Foundation Treatment,” will be considered in determining the actual depth of structure excavation for a culvert.

*Full compensation for controlling and removing water from excavations and for furnishing and installing or constructing all cofferdams and all other facilities necessary to the operations (except concrete seal courses, when such are shown on the plans) and their subsequent removal, required by the Engineer, shall be considered as included in the contract price paid for structure excavation or the contract price paid for the item of work requiring the excavation when the excavation is not paid separately.

Full compensation for hauling, placing and compacting surplus structure excavation in roadway embankments or otherwise disposing of the material along the roadway as directed by the Engineer, shall be considered as included in the contract price paid for excavating the material; or the contract price paid for the item of work requiring the excavation when the excavation is not paid separately.
shall not exceed 0.67-foot, except as provided in the following paragraph for rocky material.

When embankment material contains rock, the loose thickness of each layer of embankment material before compaction below a plane 3 feet below finished grade shall conform to the following:

(1) When embankment material contains, by volume, over 50 percent of rock larger than 0.5-foot in greatest dimension, the loose layers of embankment shall not exceed the maximum size of rock in the material.

(2) When embankment material contains, by volume, between 25 percent and 50 percent of rock larger than 0.5-foot in greatest dimension, the loose layers of embankment shall not exceed 3 feet in thickness, however, said layers are not to exceed the maximum size of rock in the material.

(3) When embankment material contains, by volume, up to 20 percent of rock larger than 0.5-foot in greatest dimension the loose layers of embankment shall not exceed 0.67-foot thickness in the area between the rocks larger than 0.67-foot.

The interstices around the rock in each layer shall be filled to the greatest extent practicable with earth or other fine material, after which the layer shall be compacted until there is no visible evidence of further consolidation of the material being compacted.

19-5.03 Relative Compaction (95 Percent).—Relative compaction of not less than 95 percent shall be obtained for a minimum depth of 0.5-foot below the grading plane for the width between the outer edges of shoulders, whether in excavation or embankment.

In addition, relative compaction of not less than 95 percent shall be obtained for a minimum depth of 2.5 feet below finished grade for the width of the traveled way and auxiliary lanes plus 3 feet on each side thereof, whether in excavation or in embankment.

Relative compaction of not less than 95 percent shall be obtained for embankment under bridge and retaining wall footings without pile foundations within the limits established by inclined planes sloping 1.5:1 out and down from lines one foot outside the bottom edges of the footing.

19-5.04 Relative Compaction (90 Percent).—Relative compaction of not less than 90 percent shall be obtained in all material in embankment, except as specified herein to be 95 percent.

19-5.05 Foundation Preparation—Preparation of the foundation to receive material shall be the responsibility of the Contractor. If the Contractor fails to excavate and replace basement material to facilitate compaction, before replacement has begun and when ordered by the Engineer, a layer of material below the excavated material shall be compacted to the depth, width and degree of compaction ordered by the Engineer, and such ordered work will be paid for as extra work as provided in Section 4-1.03D.

19-5.06 Payment.—Payment for earthwork compaction will be considered as included in the various contract items of work requiring compaction of earthwork and no separate payment will be made therefor. If the Contractor fails to excavate and replace basement material to facilitate compaction, full compensation for such work will be considered as included in the contract items of work requiring the compaction of earthwork.
SECTION 19

the finished slope extended to the grading plane before excavating for the footing, or when foundation piling is shown on the plan before driving the piles or excavating for the footing.

19-6.02 Compacting.—Embankments shall be constructed in layers of uniform thickness and each layer shall be compacted in accordance with the requirements specified in this Section 19-6.02 with the following exceptions:

1. Sidehill embankments, where the width including bench cuts for bonding existing and new embankments is too narrow to accommodate compacting equipment, may be constructed by end dumping if permitted by the Engineer, until the embankment, including benching, is wide enough to permit the use of compacting equipment, after which the remainder of the embankment shall be placed in layers and compacted as specified.

2. Where embankments are to be constructed across low, swampy ground which will not support the weight of hauling equipment, the lower part of the embankment may be constructed by dumping successive loads in a uniformly distributed layer of a thickness not greater than that necessary to support the equipment while placing subsequent layers, after which the remainder of the embankment shall be constructed in layers and compacted as specified.

Unless specified herein, or in the special provisions, or directed by the Engineer, the construction of dikes, the placing and compacting of approved material within the right of way where unsuitable material has been removed, and the filling of holes, pits and other depressions within the right of way, shall conform to all of the requirements herein and in Section 19-5, "Compaction." Trenches, holes, depressions and pits outside of areas where embankments are to be constructed shall be graded to provide a presentable and well-drained area.

Embankments shall be constructed so that each layer shall have a cross fall not to exceed one foot in 20 feet.

At locations where it would be impractical to use mobile power compacting equipment, embankment layers shall be compacted to the specified requirements by any method that will obtain the specified compaction requirements.

At the time of compaction, the moisture content of embankment material shall be such that the specified relative compaction will be obtained and the embankment will be in a firm and stable condition. Embankment material which contains excessive moisture shall not be compacted until the material is dry enough to obtain the required compaction. Full compensation for any additional work involved in drying embankment material to the required moisture content shall be considered as included in the contract price paid for excavating or furnishing the material and no additional compensation will be allowed therefor.

Embankments shall be maintained to the grade and cross section shown on the plans until the acceptance of the contract.

Surcharge material when required shall be placed in uniform layers and shall be compacted by routing the grading equipment over the full width of the embankment. Following removal of surcharge material above the grading plane, and before placing subsequent layers of subbase or base, the embankment below the grading plane shall conform to the relative compaction requirements in Section 19-5, "Compaction."
A separate payment will be made therefor. If such basement material is used in embankment or used in other planned or authorized work, or replaced with planned excavated material or imported borrow material, will be made for the quantity of replacement material used at contract unit price for the type of excavation involved or imported as the case may be.

**19.6 EMBANKMENT CONSTRUCTION**

19.6.1 Placing—Embankment construction shall consist of constructing roadway embankments, including the preparation of the areas upon which they are to be placed; the construction of temporary surcharge embankments above the grading plane; the construction of dikes within or outside the right of way; the placing and compaction of approved material in roadway areas where unsuitable material has been removed; and placing and compacting of embankment material in holes, pits and depressions within the roadway area.

Attention is directed to Sections 19-5, "Compaction," and 19-2.05, "Reclamation Construction Works." Where rock, broken concrete, or other solid materials, which are larger than 12 inches in greatest dimension, shall not be placed in embankment areas.

An embankment is to be made and compacted on hillsides or where a embankment is to be compacted against existing embankments or structures, is built one-half width at a time, the slopes of original embankments and old or new embankments shall be cut into a minimum of 10 feet horizontally as the work is brought up in layers. Material thus cut out shall be recompacted along with the new embankment material at the contractor's expense, unless the width of excavation required by the Engineer exceeds 10 feet, in which case the excavation of material in excess of 10 feet horizontally will be measured and paid for as roadway excavation.

Embankment is to be made and compacted on original hillsides, new embankments, and end dumping is permitted, the slopes of the original embankment shall be plowed or cut into before starting dumping.

Embankment is to be placed on an existing roadway, the existing embankment shall be graded, watered, graded and rolled in advance of placing embankment material thereon. Where selection is possible; borrow or excavation material having a compaction value less than 10 shall not be placed within 2.5 feet of the grade, and shall be placed in the lower portions of embankments. Hard lumps of earth over 0.5-foot in greatest dimension shall be cut out before compacting the material in embankment, except as provided in the following paragraph:

When the embankment material consists of large rocky material, or lumps, such as hardpan or cemented gravel which cannot be broken up, such material shall be well distributed throughout the embankment. Sufficient earth or other fine material shall be placed around the lumps as it is deposited so as to fill the interstices and produce a compact embankment.

Embankment construction shall not be performed when material is watered or a blanket of snow prevents proper compaction.

When bridge footings are to be constructed in embankment, the embankment shall be constructed to the elevations of the grading plane and
SLOPE BEHIND WALL

RETAINING WALL IN FILL, ON SLOPE

REINFORCED CONCRETE or TIMBER CRIB WALL

RETAINING WALL IN FILL

METAL CRIB WALL

RETAINING WALL IN FILL & CUT

GENERAL NOTES:
1. This drawing illustrates a section of the bridge embankment surcharge.
2. The embankment, if any, must be in place before structure construction begins.
3. If the embankment is to be constructed or modified, its elevation must be equal to or less than the original surface elevation.
4. The embankment must be designed for the proposed embankment fill and must be in place at the time of structure construction.
5. When an embankment is required at the cut-off point, the proper number of embankment fill must be placed to provide the necessary support for the embankment fill and to ensure stability of the embankment fill and adjacent structure.
NOTE TO DESIGNERS: Fill in MR dimensions in Detail "G"

Do not exceed the following:
- MR = 2" for Abut. with backwall
- MR = 1 1/2" for 9" Paving Notch
- MR = 1 1/2" for 12" Paving Notch

Fill in MR dimensions in Detail "G"
Typical Section
2.16.01

The final gross load in tons shall be equal to 48 times the maximum design load, in tons per square foot, for Group loading, at the location to be tested.

Incremental loads, including the weight of the device, shall be approximately as follows:

Initial incremental load = 15% of final gross load
Second incremental load = 20% of final gross load
Third incremental load = 30% of final gross load
Fourth incremental load = 35% of final gross load

The Contractor shall provide a rod or pipe extending from the top of the base to a height of two (2) feet above the top of the load for the purpose of observing settlements. He shall construct a temporary, rigid platform if necessary on which a man can stand with a surveyor’s level and read the elevation of the rod described above.

Test loadings may be performed at more than one (1) location but need not be made simultaneously. Only one (1) loading device will be required. After the first test has been completed, the load shall be removed; and if other such tests are required by the Engineer, the device may be taken to the other locations and the foregoing procedure repeated.

2.15.04—Method of Measurement: Each soil loading test will be measured for payment as a unit. A unit will consist of one complete soil loading test and shall consist of furnishing, loading, unloading and removing the device and necessary accessories at each required location.

2.15.05—Basis of Payment: This work will be paid for at the contract unit price each for “Soil Loading Test,” which price shall include all materials, equipment, tools and labor incidental thereto.

The load device and accessories shall remain the property of the Contractor and shall be removed by him from the project site upon completion of soil loading tests shown on the plans or ordered by the Engineer.

Pay Item                  Pay Unit
Soil Loading Test         EA.

SECTION 2.16
PERVIOUS STRUCTURE BACKFILL

2.16.01—Description: Pervious structure backfill shall include the furnishing, placing, and compaction of pervious material adjacent to structures.
2.16.03—Materials: Pervious structure backfill shall conform to the requirements of Article M.02.05.

2.16.03—Construction Methods: Pervious structure backfill shall be placed adjacent to abutments, retaining walls, box culverts, and elsewhere as called for. It shall be placed above a plane extending on a 2 to 1 slope from the upper edge of the footing to the top of the embankment, or as shown on the plans. Where the face of undisturbed material is above or beneath this slope plane, the amount of pervious structure backfill shall be decreased or increased accordingly, if ordered by the Engineer.

In filling behind abutments, retaining walls, box culverts, or other structures, the fill shall be built up in horizontal layers so that at all times the fill is placed against undisturbed material, or against compacted embankment having a length in a direction at right angles to the abutment wall or culvert not less than twice the height of the structure against which the fill is placed. The slope of the embankment on which the pervious structure backfill is to be placed shall be plowed deeply or cut into steps before and during the placing of pervious structure backfill so both types of material will be thoroughly bonded and compacted.

Each layer of pervious structure backfill shall be spread to a thickness not exceeding 6 inches in depth after compaction and shall be thoroughly compacted as directed by the Engineer by the use of power rollers or other motorized vehicular equipment, by tamping with mechanical rammers or vibrators, or by pneumatic tampers. Any equipment not principally manufactured for compaction purposes and equipment which is not in proper working order in all respects shall not be used within the area described above.

Special attention shall be given to compaction in places close to walls where motorized vehicular equipment cannot reach. Within 3 feet of the back face of walls and within a greater distance at angle points of walls, each layer of pervious structure backfill shall be compacted by mechanical rammers, vibrators, or pneumatic tampers.

The dry density of each layer of pervious structure backfill, after compaction shall not be less than 100 percent of the dry density for that material when tested in accordance with AASHTO T180, Method D, except that the mold used in the test shall be 6.11 inches high. In this test, material retained on the % inch sieve shall be replaced with material retained on the number 4 sieve, as noted as an option in the specifications for this test.

Each layer of the pervious structure backfill should be
2.18.05

sprayed with just enough water to obtain optimum moisture content for proper compaction.
Where weep holes are installed, bagged stone shall be placed around the inlet end of each weep hole, to prevent movement of the pervious material into the weep hole.

2.16.04—Method of Measurement: Payment lines for pervious structure backfill shall coincide with the limits of the compacted pervious structure backfill as actually placed and ordered by the Engineer.

2.16.05—Basis of Payment: Pervious structure backfill will be paid for at the contract unit price per cubic yard for "Pervious Structure Backfill," complete in place.

<table>
<thead>
<tr>
<th>Pay Item</th>
<th>Pay Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pervious Structure Backfill</td>
<td>c.y.</td>
</tr>
</tbody>
</table>

SECTION 2.18
SEDIMENTATION CONTROL BALES

2.18.01—Description: This work shall consist of furnishing, placing, maintaining and removal of hay bales for sedimentation control as shown on the plans or as directed by the Engineer.

2.18.02—Materials: Bales shall be made of hay with forty pounds minimum weight and one hundred and twenty pounds maximum weight. Wood stakes shall be a minimum of 1 inch by 1 inch nominal size by a minimum of 3 feet long.

2.18.03—Construction: Bales shall be placed as shown on the plans or as directed by the Engineer. They shall be held in place by two wooden stakes in each bale. Bales shall be maintained or replaced until they are no longer necessary for the purpose intended or are ordered removed by the Engineer.

2.18.04—Method of Measurement: This work will be measured for payment by the actual number of linear feet of "Sedimentation Control Bales" installed and accepted. Measurement shall be made along the centerline of the bales. Replacement bales shall not be measured for payment.

2.18.05—Basis of Payment: Payment for this work will be made at the contract unit price per linear foot for "Sedimentation Control Bales" complete in place, which price shall include all materials, equipment, tools and labor incidental to the placement, maintenance, replacement, removal and disposal of the bales and surplus material.
M.02.01

SECTION M.02
GRAVEL FILL
SUBBASE
GRAVEL BASE AND SURFACES
STONE BASE
PERVIOUS STRUCTURE BACKFILL
FREE-DRAINING MATERIAL
CALCIUM CHLORIDE STABILIZED BASE
CRUSHER-RUN STONE

M.02.01—Gravel Fill: For this purpose, the material shall consist of broken or crushed stone, gravel or a mixture thereof.

1. Broken or crushed stone shall consist of sound, tough, durable stone of such size that will meet the requirements of Grading "A" indicated in Article M.02.06. It shall meet the requirements of soundness and loss on abrasion indicated in Article M.02.02.2(a) and (b).

2. Bank or crushed gravel shall consist of sound, tough, durable particles of crushed or uncrushed gravel, free from soft, thin, elongated or laminated pieces and vegetable or other deleterious substances. It shall meet Grading "A" and the requirements for plasticity and soft particles indicated in Article M.02.06.

M.02.02—Subbase: Materials for this work shall conform to the following requirements:

1. Bank or crushed gravel shall consist of sound, tough, durable particles of crushed or uncrushed gravel, free from soft, thin, elongated or laminated pieces and vegetable or other deleterious substances. It shall be hard and durable enough to resist weathering, traffic abrasion and crushing. It shall meet Grading "B" and the requirements for plasticity and soft particles indicated in Article M.02.06.

2. Crusher-Run Stone shall consist of sound, tough, durable broken stone. It shall be free from soft, disintegrated pieces, mud, dirt or other injurious material.

   (a) Loss on Abrasion: The crusher-run stone shall show a loss on abrasion of not more than fifty percent using AASHTO Method T-96.

   (b) Grading: The crusher-run stone shall meet Grading "B" and the requirements for plasticity indicated in Article M.02.06.
M.02.03—Gravel Base, Rolled Bank Gravel Surface and Traffic Bound Gravel Surface: The materials for this work shall consist of sound, tough, durable particles of bank or crushed gravel mixed with approved binding material and shall be free from thin or elongated pieces, lumps of clay, soil, loam or vegetable matter. Binder may be added and incorporated by approved methods as specified elsewhere. It shall meet Grading "A" except that the top course of the rolled bank gravel surface shall conform to Grading "C". It shall also meet the requirements for plasticity and soft particles which, with grading, are indicated in Article M.02.06.

M.02.04—Gravel Shoulders: Gravel shall meet Grading "A" except that the upper three inches shall conform to Grading "C". It shall also meet the requirements for plasticity and soft particles which, with grading, are indicated in Article M.02.06.

M.02.05—Pervious Structure Backfill: Pervious structure backfill shall consist of broken or crushed stone, bank or crushed gravel, or mixtures thereof.

Materials for this work shall conform to the following requirements:

1. Broken or crushed stone shall consist of sound, tough, durable stone of such size that will meet the requirements for Grading "B" indicated in Article M.02.07. It shall meet the requirements of soundness and loss on abrasion indicated in Article M.02.02-2(a) and (b).

2. Bank or crushed gravel shall consist of sound, tough, durable particles of crushed or uncrushed gravel free from soft, thin, elongated or laminated pieces and vegetable or other deleterious substances. It shall meet Grading "B" and the requirements for plasticity and soft particles indicated in Article M.02.06.

M.02.06—Gradation, Plasticity and Resistance to Abrasion Requirements:

1—Gradation:

<table>
<thead>
<tr>
<th>Square Mesh Sieves</th>
<th>Grading A</th>
<th>Grading B</th>
<th>Grading C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pass 5&quot;</td>
<td>percent passing by weight</td>
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<td>Pass 1½&quot;</td>
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<td>Pass ¾&quot;</td>
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<td>90-100</td>
<td>100</td>
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Continued
<table>
<thead>
<tr>
<th>Square Mesh Sieves</th>
<th>A</th>
<th>B</th>
<th>C</th>
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<tr>
<td>Pass #200</td>
<td>0-5</td>
<td>0-5</td>
<td>0-5</td>
</tr>
</tbody>
</table>

The grading percentages specified in the above table shall apply to the material after it has been delivered to the construction site as well as when tested at the pit or other source of supply.

When the fraction of the dry sample passing the No. 100 mesh sieve is greater than eight percent by weight, the sample will be washed as indicated. The amount obtained from washing shall be added to that obtained by dry sieving; and the total amount passing each sieve shall meet the above gradation.

2—Plasticity:
(a) When the fraction of the dry sample passing the No. 100 mesh sieve is four percent or less by weight, no plastic limit test will be made.
(b) When the fraction of the dry sample passing the No. 100 mesh sieve is greater than four percent and not greater than eight percent by weight, that fraction shall not have sufficient plasticity to permit the performing of the plastic limit test using AASHTO Method T90.
(c) When the fraction of the dry sample passing the No. 100 mesh sieve is greater than eight percent by weight, the sample will be washed; and the additional material passing the No. 100 mesh sieve shall be determined by AASHTO Method T-146, except that the No. 100 mesh sieve will be substituted for the No. 40 mesh sieve where the latter is specified in AASHTO Method T-146. The combined materials that passed the No. 100 mesh sieve shall not have sufficient plasticity to permit the performing of the plastic limit test using AASHTO Method T90.

3—Test for Resistance to Abrasion. Gravel materials shall show a loss on abrasion of not more than fifty percent using AASHTO Method T96.

M.02.07—Free-Draining Materials: Free-draining material shall consist of sand, gravel, rock fragments, quarry run stone, broken stone or mixtures thereof. This material, or the material from any one source of a mixture, shall not have more than 70 percent, by weight, passing the No. 40 mesh sieve and not more than 10 percent, by weight, passing the No. 200 mesh sieve.
Approach Slabs-General

Approach Slabs, 15" thick, in general, shall approximately span the pervious structure backfill assumed to be placed on a 1½° slope from bottom of subbase in earth fill or cut situations. For rockout and other special situations, this span of pervious structure backfill shall be determined by the Designer.

Approach Slabs-Roadway

Shoulder approach slabs are required in areas adjacent to U-wings except where the length of wings is less than that required to give a 15" minimum length of approach slab.

Shoulder approach slabs shall be terminated at wing ends. Where the length of 15" thick approach slabs is excessive, 10" thick approach slabs shall be used in conjunction with the 15" thick slabs applying the criteria for roadway approach slabs given above.

See PLATE 4-2.3 for section "C-C" section "E-E", and Typical Longitudinal Section.

For details, see "Road Standards.

*See Roadway Plans for bituminous shoulder cross slope transition.

See PLATE 4-2.2-1 for section "D-D", "E-E", and "F-F".
For further details, see Plate 4-2.2-1

**TYPICAL LONGITUDINAL SECTION**

(d) Top of approach slab to conform to cross-slopes or banks of bridge slab.

SECTION "A-A"

(d) At acute corners, eliminate splice and vary this length-up to 12'-10' to omit short bars in the adjacent slab.

SECTION "B-B"

**PLAN NOTES:**

For details of load transfer unit, see "Road Standards."

**DESIGN INFORMATION:**

Reinforcing steel to be included in the roadway item for "Deformed Steel Bars."
Concrete to be included in the roadway item for "Class 'A' Concrete."
Joint filler to be included in the bridge item for "(Thickness) Preformed Expansion Joint Filler for Bridges."
Joint seal to be included in the bridge items for Class 'F' and Class 'A' Concrete.

(d) Denotes design information

<table>
<thead>
<tr>
<th>BRIDGE APPROACH SLAB DETAILS</th>
<th>CONN. DEPARTMENT OF TRANSPORTATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>REVISED: 2-66, 11-66, 12-69, 4-70, 1-74, 6-75, 7-80</td>
<td>PLATE: 4-2.2</td>
</tr>
</tbody>
</table>
**SECTION D-D**

- Bit Conc Overlay
  - See Approach Slab Note

1.25' Approach slab to 833' Approach slab

**SECTION E-E**

- 1.25' Approach slab
- 833' Approach slab
- Joint Seal (Roadway Item)
- Bit Conc Overlay

**SECTION F-F**

- 1.25' Approach slab
- 833' Approach slab

**NOTES:**

For NOTES and details not shown, see PLATE 4-2.1 & PLATE 4-2.2.

For concrete bridges with bituminous concrete overlays, approach slabs shall also have bituminous overlays and will be indicated on the plans:

Approach Slab Note: "Bituminous Concrete "on" Bituminous Material for Tack Coat" (Rdwy. Items)
For reinforcement & details see PLATE: 4-1.4

For detail see PLATES: 4-4.4 and 4-4.5

1" x 1" Joint Seal (Type A) see Note "B" PLATE: 4-2.3

For approach slab details see PLATE: 4-2.2

Construction Joint *

WITHOUT OVERLAY

See SLAB NOTE "A" PLATE: 4-1.1

1.25' header

See Approach Slab Note PLATE: 4-2.2-1

1" Preformed Exp. Jt. Filler

Construction Joint *

0.5'

1.5' min. Abutment backwall normal section

WITH OVERLAY

PLAN NOTE:
* Backwall above construction joint shall be placed after the slab has been poured

DESIGN INFORMATION: End diaphragms to be placed on skew.

NORMAL SECTION AT END OF SLAB (PRESTRESSED CONCRETE BEAMS) (WITH APPROACH SLAB)

CONN. DEPARTMENT OF TRANSPORTATION
SPANS - NOT EXCEEDING 135 FEET

* Reinforcing similar to PLATE 4-3.1
See SLAB NOTE "A", (d) Type of expansion joint to be designed and detailed.

SPANS EXCEEDING 135 FEET

Notes:
* For Notes and Details, see PLATE 4-2.4
* For Header Details and Notes see PLATE 4-4.2

(d) Denotes design information

| NORMAL SECTIONS AT EXPANSION ENDS | CONN. DEPARTMENT OF TRANSPORTATION |
| STEEL STRINGERS (WITH OVERLAY) | PLATE: 4-2.4-1 |
| REvised: 6-77, 7-80 |
DELAWARE
IDAHO
Before pouring the approach slab, provide a two-foot deep base of granular material compacted to meet Class "A" compaction requirements.

Lay all asphalt pavement before constructing the approach slab. Extend the pavement three to four feet beyond the point of abutment with the slab. Make a vertical saw cut in the pavement to serve as a form for the end of the approach slab.

When bridge abutments are skewed, the slab and adjoining the pavement shall be perpendicular to the centerline of the roadway.

Place longitudinal reinforcement parallel to the centerline of the roadway, place the transverse reinforcement perpendicular to the centerline of the roadway, regardless of skew of the bridge abutments.

KEYED CONSTRUCTION JOINT

SECTION C-C

SECTION D-D

SECTION A-A FOR CONCRETE PAVEMENT

SECTION A-A FOR ASPHALT PAVEMENT

APPENDIX DRAWING 1

STATE OF IDAHO
DIVISION OF HIGHWAYS
BOISE, IDAHO OCT., 1979

APPROACH SLAB

SEC. B-B

FACE OF CURB

BRIDGE DECK

Removable Construction Joint

Edge of Pavement

APPROACH SLAB PLAN

KEYED CONSTRUCTION JOINT

DETAIL A

Pavement End

Polyethylene Bond Breaker

8 in.

6 mil Polyethylene Bond Breaker

30 mil Polyethylene Bond Breaker

8 in.

6 mil Polyethylene Bond Breaker

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6 mil Polyethylene Bond Breaker

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30 mil Polyethylene Bond Breaker

8 in.
ILLINOIS
### Quantities for 50-Foot Approach Slab

#### 24-Foot Width Pavement

<table>
<thead>
<tr>
<th>Bar Size</th>
<th>Bottom</th>
<th>Top</th>
<th>Weight</th>
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<tbody>
<tr>
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#### 36-Foot Width Pavement

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<th>Bar Size</th>
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<th>Top</th>
<th>Weight</th>
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<tbody>
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#### Top of Slab Bar Arrangement

![Top of Slab Bar Arrangement Diagram]

---

### Bridge Approach Pavement

For use with asphaltic concrete pavement.
### CRITERIA FOR DETERMINATION OF LENGTH OF APPROACH PILES

(For Method II Approach)

<table>
<thead>
<tr>
<th>Fill Height</th>
<th>Sub Soil Qu &lt; 1.0</th>
<th>Sub Soil Qu &gt; 1.0</th>
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</thead>
<tbody>
<tr>
<td>0' To 4'</td>
<td>Use Method I</td>
<td>Use Method I</td>
</tr>
</tbody>
</table>

Piles shall be driven to the elevation of the mid-height of any soft layer of subsoil underlying the fill except no approach pile shall penetrate natural ground more than ten (10) feet.

| 4 to 11'    | Use Method I     | Use Method I     |

Same as Above (See Note III)

| 11' To 48'  | Use 45' Piles    | Use 45' Piles    |

Same as Above

| Over 48'    | Use 45' Piles    | Use 45' Piles    |

*Fill Height is measured from Sub. Grade Elevation to Natural Ground

**Note I**
No Piles should be driven into Subsoils with Qu ≥ 2.0

**Note II**
No Piles are to be used less than eight (8) feet in Length.

**Note III**
No Piles are to be used in excess of forty-five (45) feet in Length.

**Note IV**
Sandy or gravelly soils falling into HRB Classifications A-1-a, A-1-b, A-2 or A-3 are not to be considered as low bearing soils. Reference Qu > 1.0.

**Note V**
A Special Provision should call for Sub Grade compaction (Sec. 23 Standard Specs.) under all approach embankments.
### Quantities for 100 Foot Approach Slab

#### 18 Foot Width Pavement

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<th>Reinforcement</th>
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#### 24 Foot Width Pavement

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<th>Reinforcement</th>
<th>Top Reinforcement</th>
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<tbody>
<tr>
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#### 36 Foot Width Pavement

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<th>Reinforcement</th>
<th>Top Reinforcement</th>
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</thead>
<tbody>
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<td></td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

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### Top of Slab Bar Arrangement

1. 

2. 

3. 

---

STATE OF ILLINOIS
DEPARTMENT OF TRANSPORTATION

[Signature]

[Stamp] Sheet 2 of 2
INDIANA
KANSAS
LOUISIANA
END BENTS AND APPROACH SLABS

INTRODUCTION:

The end bent, as its name suggests, is located at the end of a bridge structure where the transition is made from the normally deep founded bridge structure to a surface soil founded pavement via the approach slab. The typical end bent to be discussed, unless otherwise noted, is constructed of reinforced concrete with a breast wall and wingwalls to contain a soil backfill and a pile supported cap.

SCOPE:

This article is a guide to some of the analysis criteria and design considerations given to end bends and approach slabs. It is intended as a general policy statement and a supplement to the AASHTO Specifications.

COMMENTARY:

Negative skin friction is an important factor to be evaluated or avoided when the end bent is constructed on a compacted fill with its piling driven through the fill. The negative skin friction is caused by the consolidation of the fill and insitu soils.

The approach slab serves as a transition apron from the soil supported slab and the pile supported structure. It is intended to smoothly bridge minor differential settlements between the roadway slab and the bridge structure. When large differential settlements (one (1) foot) between the roadway slab and the bridge structure are expected, long, flexible, pile supported approach slabs are considered. Two (2) advantages are realized with this solution: a smooth transition is maintained for improved riding characteristics for large expected settlements and the length of conventional bridge
structure may be reduced by replacement with the less expensive approach slab.

**ANALYSIS:**

1. The short approach slab that is founded directly on the paving base is designed as a one-way slab with its main reinforcement parallel to traffic. The soil is assumed to be settled away from the slab out from the breast wall support to a point such that the effective design span is one-half the slab length.

2. The long pile supported approach slab is designed to transition differential settlements of approximately one (1) foot between the shallow foundation roadway pavement and the deep foundation bridge structure at the end bent. The total length of the approach slab varies from fifty (50) to one hundred fifty (150) feet depending on the amount of expected settlement. The assumed permanent deflection due to settlement is assumed to be either a reverse parabola or a single parabola as shown. Piling are usually designed to carry the full live load and dead load near the end bent and are shortened progressively towards the roadway pavement end of the approach slab. This configuration is intended to cause a progressive transition from the expected deep foundation behavior to the shallow foundation behavior. The slab is also designed to carry the additional moment caused by the assumed parabolic deformation.

![Diagram](image-url)

**CONDITION 1 OF DESIGN DEFLECTION FOR LONG PILE SUPPORTED APPROACH SLABS**
\[ L \text{= Length of Approach Slab} \quad \Delta \text{= Expected Settlement} \]

**CONDITION 2 OF DESIGN DEFLECTION FOR LONG PILE SUPPORTED APPROACH SLABS**

3. Wingwalls, breast walls and the bent as a unit shall be designed to resist active earth pressure under the group loads to be considered.

4. The reaction of the approach slab to the shelf of the end bent is based on the same assumption as in Items 1 and 2.

**DESIGN DETAILS:**

1. Wingwalls with the stabilizing piles are required for all end bends on fills with the exception of slab span bridges and concrete girder span with Type II girders.

2. Double-row, battered piles are required on all end bends except those for slab spans. Pile batter shall be 1-1/2 on 12.

3. On double-row pile end bent caps, a one (1) foot thick baffle shall extend two (2) feet below the cap between rows of piling to prevent the movement of the soil confined by the bent.

4. End bends at stream crossings subject to potential bank erosion, are to be designed as interior bents assumed to carry a continuing span of the same type and length.

5. On skewed or normal end bends, the end of the approach slab is to be squared off at both rigid and flexible pavements.

6. The most common method to negate potential negative skin friction on end bent piling penetrating an approach fill is to jet through the fill.
Another acceptable method is to bore holes through the fill prior to driving and backfill the hole with sand after the piles are driven. Treatment of negative skin friction should be limited to fills over ten (10) feet high.

7. Piled approach slabs are continuous slabs supported by rows of timber piles on ten (10) foot centers and transverse to the roadway. The distance between the piles usually varies between seven (7) and ten (10) feet. The timber piling shall be varied in length from row-to-row by a constant amount. Piling shall penetrate the footing to resist the tension required to hold the slab in its deformed configuration after settlement has occurred. Piled approach slabs are designed as one-way slabs spanning between transverse grade beams at the pile rows, or as two-way slabs with small footings (two (2) foot diameter) at each pile location.

8. End bent caps shall have a minimum depth of 2'-3".

9. As a general rule, header banks will consist of 2:1 slopes in cut on existing established sections and 3:1 slopes in fill on new sections. A three (3) foot berm measured from centerline bent will be used for bridges in all cases when no abutment wing walls are utilized in the end bent.
TYPE II GIRDERS

*NOTE:
Wingwall lengths shown are for bents on 90° crossings only. Adjust lengths as required for skewed bents.

NOTE:
Sketch illustrates slab span bridge. However slope & berm shown should be used where no abutment walls are utilized in the end bent.

EARTHWORK TREATMENT AT END BENT
**WINGWALL DETAILS**

**DATE:** Sept., 1979

<table>
<thead>
<tr>
<th>REVISIONS</th>
<th>STATE OF LOUISIANA</th>
</tr>
</thead>
<tbody>
<tr>
<td>DATE</td>
<td>DESCRIPTION</td>
</tr>
</tbody>
</table>

**DEPARTMENT OF TRANSPORTATION & DEVELOPMENT**

**OFFICE OF HIGHWAYS**

**BRIDGE DESIGN SECTION**

---

*NOTE:

Wingwall lengths shown are for Bents on 30° Crossings only. Adjust lengths as required for skewed Bents.*
MAINE
DESIGN OF CONCRETE ABUTMENTS, WINGWALLS, AND RETAINING WALLS

The information in this chapter is for the purpose of providing answers to commonly asked questions about design policy concerning concrete abutments, wingwalls and retaining walls. This is not a textbook or a specification, but is only a supplement to the AASHO Specifications, available literature, and the Designer's experience and judgment. Opinions on all of the subjects have been gathered from Engineers in the Department, from bridge contractors in the AGC, and from the Bridge Engineer of the Federal Highway Administration. The information presented is the design policy of the Bridge Design Section and is the considered opinion of the Bridge Design Engineer.

Supporting data, explanatory information and reasons for the conclusions are not included, however, supervisors in the Bridge Design Section are knowledgeable on the subjects and are available to explain background information.

A. Footing cover is defined as the minimum distance from the ground surface to the bottom of footing.

1. For structures not exposed to water currents, minimum footing cover shall be as follows:

   Spread footings - 6' - south of a line through Carrabassett Valley, Guilford and Medway

   Spread footings - 7' - north of a line through Carrabassett Valley, Guilford and Medway

   Spread footings - on ledge - no minimum

   Pile footings - 5' - south of a line through Carrabassett Valley, Guilford and Medway

   Pile footings - 6' - north of a line through Carrabassett Valley, Guilford and Medway

2. For structures where footing is under water, but not necessarily under water during the cold month of the year, use the criteria in 1, except the design shall be adequate to withstand scour effects.

3. For structures where footing is always under water, minimum footing cover shall be 4' and also, the design shall be adequate to withstand scour effects. Footings on ledge have no minimum footing cover.
Approach Slab

Plan:
- AS400 @ 12" (For App. Slab over 30'-0" wide)
- AS600 @ 6"
- Tube Drains (Typ.)
- Approach Slab Seat

Section:
- 6" at Curb (Typ.)
- Backwall (Typ.)
- Face of Rail
- Pavement
- Level
- AS600
- AS400 (i.e. AS401)

1.5' + 1" plastic tube drain @ 5'-0"

3' or match roadway grade whichever is greater.

Approach Slab

Maine
SUPPLEMENTAL SPECIFICATIONS

SECTION 203

EXCAVATION AND EMBANKMENT

(Preparation of Foundation and Construction of Embankments in the Abutment and Pier Areas)

PREPARATION OF FOUNDATION

Prior to placing the embankment, the foundation areas under the Abutments and Piers as indicated on the plans shall be prepared by removing the top soil and sod and all existing unsuitable material including surface boulders larger than twelve (12) inches. The entire area from which the top soil has been removed shall be rolled until the underlying soil is thoroughly compacted. The soil to a depth of eight inches shall be compacted to 95 percent of the maximum density in accordance with the first paragraph of sub-section 203.12.

Payment for compacting the soils in the Abutment and Pier areas, after the top soil has been removed will not be made directly but will be included in the unit prices of the contract items.

MATERIALS

Granular Borrow placed below the elevation of the bottom of the abutments and piers shall conform to the gradation for Aggregate Subbase Course - Gravel, Subsection 703.06(b).

CONSTRUCTION OF EMBANKMENT

Placing and compacting of Granular Borrow at abutments and piers, from foundation area up to the elevation of the bottom of the concrete shall be as follows:

The material shall be placed in uniform layers not exceeding eight (8) inches in thickness, loose measure. Each layer shall be compacted by means of suitable compaction equipment to a minimum dry density of 98 per cent of the maximum density.

The maximum density shall be determined in accordance with the first paragraph of sub-section 203.12.

When the moisture content of the layer is within the limits as determined by the Engineer for proper compaction, the entire surface shall be rolled until the specified density has been obtained. No successive layers shall be placed until the layer under construction has been brought to the required density and has been approved by the Engineer.

The Engineer will make known to the Contractor, upon request, both the maximum density and the optimum water content for the various materials to be used in the embankment construction. It shall be the responsibility of the Contractor to notify the Engineer not less than 48 hours in advance as to which material he proposes to use.

The remainder of the embankment shall be compacted as indicated on the plans or as stated in the specifications.
B. Adequate drainage of fill behind structures is of great importance and shall be provided for as follows:

1. Where possible, French Drains shall be used at the back face of walls with 4" diameter drain pipes through the walls.

2. Walls in fill shall, in general, be backfilled with gravel or granular material for a horizontal distance of at least 10' from the back of the wall.

3. Underdrains or other means may be used where necessary to provide adequate drainage.

4. Total drainage design shall be studied. For example, water should not drain into the underside of slope protection.

C. Design Section

1. In general, the Design Section shall be at the highest third point of the wall, that is, the transverse cross section of the wall with the larger of the two heights at horizontal third points. In the case of a long wall with a variable height, the wall should be divided into more than one design length.

D. Wall Dimensions

1. Bridge seats shall have a minimum of 1'-0" between the centerline of bearings and the face of breastwall for lengths of superstructure up to 100'. For lengths of superstructure exceeding 100', use 1'-3" minimum. The masonry plate of the bearings shall be no closer to the face of breastwall than 3". Major structures shall have wider bridge seats than indicated above.

2. Bridge seats shall have a minimum of 1'-3" between the centerline of bearings and the face of backwall. The masonry plate of the bearings shall clear the face of backwall by at least 2".

3. Bridge seats which are protected from roadway drainage by sealed bridge joints shall be level and stepped to match bearing elevations, except where access to the space between end diaphragms and backwalls is a problem, then the concrete pedestal type bridge seat may be used.
MICHIGAN
2.08.09

a large diameter disk, a motor grader, or other equipment meeting the approval of the Engineer.

After the subgrade material has been thoroughly mixed to the satisfaction of the Engineer, it shall be compacted to not less than 95 percent of Maximum Unit Weight.

2.08.10 Earth Excavation.—All excavated materials, except as provided for under Salvaging Materials, 2.08.03-c, shall become the property of the Contractor.

Unless otherwise shown on the plans, or in the proposal, the subgrade shall be compacted to not less than 95 percent of the Maximum Unit Weight to a depth of at least 9 inches. If, in the opinion of the Engineer, the subgrade cannot be compacted to 95 percent of Maximum Unit Weight, the Engineer may authorize use of other methods to attain compaction. Where natural soil meets subbase requirements, as determined by the Engineer, it shall be left in place and shall be compacted to not less than 95 percent of Maximum Unit Weight to a minimum depth of 12 inches.

The roadbed and ditches shall be maintained in such condition that the work will be well drained at all times. If it is necessary, in the prosecution of the work, to interrupt existing surface drainage, sewers or underdrainage, temporary drainage facilities shall be provided until the permanent drainage work is completed.

The grading shall be so conducted as to avoid removing or loosening any material outside of the required slopes, and any such material which may be removed or loosened shall be replaced and thoroughly compacted to the required cross section.

Any surplus or waste material resulting from ditch construction shall be spread in a uniform layer in such a manner as not to obstruct drainage. All roots, stumps and other objectionable materials in the slopes and bottom of the ditch shall be removed and the holes backfilled with suitable material, or they shall be cut to conform to the cross section shown on the plans. All ditches constructed on the project shall be maintained and kept reasonably free from debris until final acceptance.

2.08.11 Roadway Embankment:

a. Stepping Steep Side Slopes.—Where embankments are to be constructed on existing side slopes steeper than 1 vertical to 6 horizontal, steps with a horizontal dimen-
2.08.11

...tion of not less than 3 feet shall be formed in the slope before any of the embankment is placed.

b. Borrow.—Borrow shall consist of approved material secured from locations outside the roadway. The Contractor shall perform all work and provide all materials and equipment necessary to excavate, transport, and place the borrow material in accordance with the requirements as specified under Natural Material Sources, 1.06.03.

c. Winter Grading.—All ice and snow shall be removed from the surface of the ground before the embankment is placed therein.

Original ground containing more than 0. 3 foot of frost within limits of 1 on 1 slopes spreading outward from the finished shoulders shall be removed.

No frozen material will be allowed in the embankment area being constructed. Any frozen material on a partially completed fill shall be removed before placing any more fill on the embankment. This frozen material shall be stockpiled outside of the grading limits until thawed. The embankment outside the 1 on 1 slopes may be completed by the 12-inch Layer Method using the thawed material resulting from the stockpiled frozen lumps. No frozen lumps shall be deposited in any portion of the embankment. Embankments may be built by the "romp" method during freezing weather.

d. Placing and Compacting Embankment.—After the ground area affected has been prepared as specified under Preparing Roadway Foundation, 2.08.03, embankments shall be constructed with sound earth or a mixture of sound earth and stones, broken rock, concrete or masonry except as provided for in the disposal of peat excavation material or topsoil and as restricted for the top 3 feet of the subgrade. Sound earth shall be any natural or other approved material which can be compacted to the required density, contains no organic material, and shall have a Maximum Unit Weight of at least 95 pounds per cubic foot. The materials shall be deposited and compacted by the Controlled Density Method unless some other method is specified or authorized. Other methods which may be specified or authorized are the 12-inch layer method, rock embankment method, methods for treatment of peat marshes, or hydraulic consolidation method.

The Contractor shall not construct embankments by
methods which create an unstable slope condition by reason of placing impervious material on the outside of embankments blocking the internal granular drainage or placing a combination of pervious and impervious material in the embankment creating potential seepage pockets. The Contractor may be required to revise his embankment construction methods, construct intermittent bleeders, place a granular blanket, install bank drains or use other approved methods to avoid or correct such conditions when so directed by the Engineer.

Subject to the above restrictions, the Contractor may place topsoil in embankments outside a 1 on 1 slope from the earth grade shoulder point where the finished slope will be 1 on 4 or flatter. The topsoil shall be compacted according to the Twelve-Inch Layer Method.

Stones and boulders occurring within construction limits and broken rock from rock cuts that are not required for the construction of cobble gutter, riprap, or like structures, may be placed in embankments. The stones, broken rock and boulders shall be placed in layers, and all voids shall be completely filled with sound earth, thoroughly compacted, but no layer of such material shall be placed within 12 inches of the surface of the subgrade between the outside edges of the shoulders.

Where filling in layers of the specified thickness is not feasible, as in the case of filling in water or constructing on poorly drained soil, the embankment may be constructed in one layer of Granular Material Class III to the minimum elevation at which the equipment can be operated as determined by the Engineer. The fill material placed in this manner shall be thoroughly compacted. Above this elevation, the embankment construction shall be in accordance with the Controlled Density Method.

 Portions of the embankment adjacent to any structure shall be backfilled and compacted as specified under Excavation and Backfill for Structures, 2.09.06, 2.09.07, and 2.09.08, and in accordance with Structure Embankment, 2.08.13. All other embankment construction shall be as follows:

1. Controlled Density Method.—The material shall be deposited and spread in layers not more than 9 inches in depth, loose measure, and extending to the full width of the filled area, except that granular material may be spread and compacted in
layers not more than 15 inches in thickness if the
specified density is obtained.

The material shall have a moisture content of
not greater than 3 percent above optimum, as
determined by the Engineer, at the time of com-
paction, except that the moisture content of the
top 3 feet of embankment shall not exceed optimum
by more than 2 percent. If the material contains
an excess of moisture, it shall be dried to the
required moisture content before being compacted.

Each layer of material shall be compacted to not
less than 95 percent of the Maximum Unit Weight.

Rutting or distortion caused by the Contractor's
operation shall be corrected by the Contractor at
his expense before any succeeding layers are
placed.

In the event that the specified percentage of
maximum unit weight and the specified moisture
content have been attained but the compacted
material is not sufficiently stable to provide proper
support for the subbase, the Engineer may direct
that the material be dried by aeration and recom-
pacted. The aeration shall be accomplished by
disking or manipulation by other approved means.

2. Twelve-Inch Layer Method.—The material shall be
deposited and spread in layers not more than 12
inches in depth, loose measure, parallel to the
finished grade, and extending to the full width of
the embankment. The material shall be deposited
by operating the conveying equipment over the
layer being placed, insofar as feasible. Each
layer shall be compacted to not less than 95 per-
cent of the Maximum Unit Weight as determined
at the existing moisture content. The maximum
unit weight will be determined as specified under
Maximum Unit Weight, 1.01.02, except that the
method shall be modified to comply with the exist-
ing moisture content of the material at the time of
placing.

3. Rock Embankment.—Rock embankment shall be
constructed of shattered rock obtained by blasting
or ripping in rock cuts. Shattered rock shall not
exceed a maximum size of $\frac{1}{2}$ cubic yard and shall
be deposited on the fill and pushed over the end
of the fill by means of bulldozers or other equip-
ment. The rock embankment shall be placed in

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layers which shall not exceed 3 feet in thickness. Depositing the shattered rock directly over the end of the fill from the hauling equipment will not be permitted. The surface of the rock embankment shall be so choked with small rock fragments and rock fines that there will be no infiltration of the earth embankment placed on the surface of the rock embankment. Where insufficient rock fines are available to properly choke the surface of the rock embankment, sand or fine gravel and sand shall be used. This method shall not be used in fills less than 4 feet in depth and in no case shall the rock embankment be placed within 2 feet of the earth grade. Where structures are located under rock embankment they shall be covered with not less than 2 feet of Granular Material Class III before the rock embankment is placed over the structures.

2.08.12 Placing Top 3 Feet of Embankment.—Frost heave textured materials shall not be placed in the top 3 feet of embankment below subgrade. Frost heave textured material is defined as material containing more than 50 percent silt with a plasticity index less than 10. Silt is defined as material having a particle size of 0.074 to 0.005 mm. Within the top 3 feet, the embankment shall be constructed to a stable non-rutting condition by using a uniformly textured material. A minimum 50-foot longitudinal transition shall be used between two different uniformly textured materials.

2.08.13 Structure Embankment:

a. Compaction of Original Ground.—In fill areas on which a structure is to be built, the topsoil shall be removed from the area within limits of 1 on 1 slopes spreading outward in all directions from the bottom of structure footings as specified under Removing and Salvaging Topsoil, 2.08.03-b. After removal of the topsoil the area shall be compacted to not less than 90 percent of the Maximum Unit Weight, to a depth of 9 inches. If, in the opinion of the Engineer, the subgrade cannot be compacted to 95 percent of Maximum Unit Weight, the Engineer may authorize use of other methods to attain compaction.

b. Placing Structure Embankment.—Structure embankment shall be constructed of Granular Material Class III within the limits as shown on the plans.
2.08.14

Structure embankments, constructed under structural footings that are to be supported by piling, shall be deposited and compacted by the Controlled Density Method, 2.08.11-d-1. Structure embankments, constructed under structural footings for which piling is not specified, shall be deposited and compacted by the Controlled Density Method except that the compaction required will be 100 percent of the Maximum Unit Weight.

Structure embankments shall be placed and compacted to the limits shown on the plans prior to casting overlying footings. Structure embankments shall be protected from freezing until overlying footings are cast.

c. Winter Grading for Structure Embankment.—All ice and snow shall be removed from the surface of the ground before the embankment is placed thereon.

Before placing an embankment to support a structure, all ground containing frost within limits of 1 on 1 slopes spreading outward in all directions from the bottom of structure footings, shall be removed.

This frozen material shall be stockpiled outside of the grading limits until thawed. Embankment construction during winter weather shall conform to the requirements specified under Roadway Embankment, 2.08.11-c.

2.08.14 Test Rolling.—When called for on the plans or authorized by the Engineer, the compaction of the subgrade in embankments and cut sections shall be tested by the use of a tractor-drawn pneumatic-tired test roller.

The test roller shall consist of 4 pneumatic-tired wheels mounted on a rigid steel frame. The wheels shall be evenly spaced in one line across the width of the roller and shall be arranged in such a manner that all wheels will carry approximately equal loads when operated over an uneven surface. The maximum spacing between adjacent wheels shall not exceed the tire width.

The equipment shall have a suitable body for ballast loading with such capacity that the gross load may be varied from 25 to 40 tons.

Ballast to obtain the weight required by the Engineer shall consist of ingots, concrete blocks, sand bags, or other approved material, with a uniform, known unit weight, so that the total weight of the ballast used can be readily determined at all times. There shall be a sufficient amount of ballast available to load the equipment to a maximum gross weight of 40 tons.
When applicable, do not place backfill above this elevation until structural steel is erected, and adjacent deck slab is poured. Refer to Guide 5.11.01.

**Limits of "Structure Backfill C.I.P."**

When applicable, do not place backfill above this elevation until structural steel is erected, and adjacent deck slab is poured. Refer to Guide 5.11.01.

**Limits of "Structure Embankment C.I.P." under abutments.**

To end of wingwall. Applicable when wingwall length is 20' or less, and distance between wingwalls is 75' or less.

Applicable when wingwall length is >20' and/or distance between wingwall is >75'.

**Limits of "Structure Embankment C.I.P." under abutments.**

Normal Section

Special Section if requested by construction

*Applicable for trunkline structures and crossroads with concrete pavement. Use 1 on 2 for others.

**Quantities are included in bridge quantities.*

Prepared by Design Div. 5.46.01
WHEN APPLICABLE, DO NOT PLACE BACKFILL ABOVE THIS ELEVATION UNTIL STRUCTURAL STEEL IS ERECTED AND ADJACENT DECK SLAB IS Poured REFER TO GUIDE 5.11.01.

LIMITS OF FOUNDATION EXCAVATION

NORMAL SECTION

NOTE: FOR ADDITIONAL INFORMATION SEE GUIDES 3.25.01 AND 5.11.01

*APPLICABLE FOR TRUNKLINE STRUCTURES AND CROSSROADS WITH CONCRETE PAVEMENT. USE 1 ON 2 FOR OTHERS.

**QUANTITIES ARE INCLUDED IN BRIDGE QUANTITIES.

NOTE: CUT AND FILL TREATMENT SIMILAR FOR CURTAINWALLS.

SPECIAL SECTION IF REQUESTED BY CONSTRUCTION
STRUCTURE BACKFILL FOR
ABUTMENTS IN CUT

LATERAL LIMITS OF STRUCTURE BACKFILL (C.I.P.)
WINGWALL REFERENCE LINE

SHOULDER LINE

TOP OF FILL SLOPE
TOP OF CUT SLOPES
LONGITUDINAL LIMIT BELOW NATURAL GROUND
SHOULDER LINE

WINGWALL REFERENCE LINE
LATERAL LIMITS OF STRUCTURE BACKFILL (C.I.P.)
FOR SPECIAL SECTION IF REQUESTED BY CONSTRUCTION
FOR NORMAL SECTION

TO END OF WINGWALL OR 20° MAX.
SEMI-RETURN WINGWALL (TREAT FILL LIMITS THE SAME)

FULL WINGWALL
LIMITS OF STRUCTURE BACKFILL (C.I.P.)

1'-6" (TYP.)

SEE GUIDE 5.46.02 FOR LONGITUDINAL SECTION
*APPLICABLE FOR TRUNKLINE STRUCTURES AND CROSSROADS WITH CONC. PAVT. USE 1 ON 2 FOR OTHERS.
STRUCTURE BACKFILL AND EMBANKMENT FOR ABUTMENTS ON FILL (SLOPE WALLS)

SECTION A

SECTION B

NOTE TO DESIGNER: COMPUTE DIMENSION FROM TOP OF WALL TO TOP OF BACKWALL SO UPPER LIMIT OF FILL WILL APPROXIMATELY FOLLOW TOP OF PAVEMENT.

FOR DIVIDED HIGHWAY - BOTH SECTION A AND SECTION B SHOULD APPEAR ON PLANS.

FOR SINGLE ROADWAY - SECTION A SHOULD APPEAR ON PLANS.

PREPARED BY DESIGN DIV. 5.46.03
See Detail PLATE: 4-4.4
See Approach Slab Note, PLATE: 4-2.2-1

SPANS NOT EXCEEDING 135 FEET

* Reinforcing similar to PLATE 4-3.1
See SLAB NOTE "A", (d) Type of expansion joint to be designed and detailed.

For Notes and Details, see PLATE: 4-2.4
For Header Details and Notes See PLATE: 4-4.2

(d) Denotes design information
SECTION THRU BACKFILL

APPLICABLE WHEN LENGTH OF VINGWALL IS 20' OR LESS,
AND DISTANCE BETWEEN VINGWALLS IS 75' OR LESS.

*QUANTITIES ARE INCLUDED
IN BRIDGE QUANTITIES

SECTION THRU BACKFILL

APPLICABLE WHEN LENGTH OF VINGWALL IS GREATER THAN 20' 
AND/OR DISTANCE BETWEEN VINGWALLS IS GREATER THAN 75'.
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pavement, the top consolidated rock layer for the full width between roadbed slopes shall be finished to the same limits as shown on the plans for undergrading in rock cuts. If rigid pavement is to be constructed without an aggregate base, the material requirements of Sec 203.2.5.2 shall govern for the construction of the area between the bottom of the pavement and the top of the top consolidated rock layer. Any embankment necessary outside the limits of the pavement shall be constructed of suitable earth or as otherwise specified in the contract.

(b) If the specified or proposed surfacing consists of a treated or untreated earth surface, or any aggregate type surface, the top 6 inches of finished roadbed embankment shall be constructed of suitable earth. If subgrade scarifying is then considered necessary, the engineer will so order and payment will be made under the item of Subgrade Scarifying.

203.3 Compaction of Embankment and Treatment of Cut Areas with Moisture and Density Control. AASHTO T 99, Method C, replacing any material retained on a 3/4-inch sieve, as provided therein, or MHTD Test Method T40 will be used as the Standard Compaction Test for determining the moisture density relations of soils. The optimum moisture as determined by the Standard Compaction Test may be used as a guide in determining the proper moisture content at which each soil type should be compacted. Water shall be added or removed as necessary to permit obtaining the required density and moisture control. The field density of the embankment after compaction will be determined in accordance with AASHTO T 191 or T 205, using the total material or T 238, Method B Direct Transmission, for wet density. The volume of the test hole may be reduced as necessary to accommodate available testing equipment. If nuclear density methods are used, moisture content will be determined in accordance with AASHTO T 239, except that a moisture correction factor will be determined for each soil in accordance with MHTD Test Method T35. The calculated density obtained in a field density test will be compared with the maximum density as established by the Standard Compaction Test to determine the percent compaction attained.

203.3.1 If payment of compaction is specified as a pay item of the contract, compaction to at least 90 percent of maximum density, as determined by the Standard Compaction Test, will be required in the following areas:

(a) All roadway embankments except as otherwise provided in the following sections: Sec 203.2.15, 203.2.16, 203.2.17.2, 203.3.3, 203.3.4, 203.3.5, and 203.3.7.

(b) All backfilled undergraded cuts, except as modified by Sec 203.3.3.

(c) Certain portions of the roadbed in cuts specified in Sec 203.3.8, except as modified in Sec 203.3.3.

203.3.2 The moisture content of the soil at the time of compaction shall be as herein specified.

203.3.2.1 When necessary to eliminate rubbery condition of the embankment, it may be required that some soils have a moisture content below the optimum during compacting work; except that Class A material having liquid limits of 40 or more where placed in embankments within 5 feet of the top of the finished subgrade or where encountered in areas of cut compaction, shall be compacted at not less than optimum moisture content. The liquid limit determination will be as set forth in AASHTO T 89. Some Class A materials including heavy clays and materials commonly known as shales

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and fireclays will require breaking down so that the moisture can be uniformly distributed.

203.3.2.2 Loessial soils shall have moisture controlled so as not to exceed optimum plus 3 percentage points when placed in embankments less than 30 feet high. Such soils when placed in embankments 30 feet high or more shall have moisture controlled so as not to exceed optimum moisture. If wet foundation conditions contribute to the embankment moisture while compacting, the engineer may waive this specified moisture content for a height not to exceed 3 feet above the embankment foundation. In the event of conflict of provisions of this section with provisions in Sec 203.3.2.1, Sec 203.3.2.1 shall govern.

203.3.3 If a flexible type surface is proposed, at least 95 percent of maximum density will be required for the upper 18 inches of the earth subgrade extending the full width between roadbed slopes.

203.3.4 Roadway embankment within 100 feet of each end of a structure on which the top slab or deck is to be used as the riding surface, and the spill fill under such a structure, shall be compacted to not less than 95 percent of maximum density.

203.3.5 Density requirements will not apply to portions of embankments constructed of material so rocky that they cannot be satisfactorily tested in accordance with AASHTO T 191 or T 205. Material of a gradation having more than approximately 20 percent retained on a 3/4-inch sieve will generally be considered too rocky for satisfactory density testing. In lieu thereof, compactive effort on rock and rocky material shall consist of making four complete coverages of each layer with a tamping-type roller or two complete coverages of each layer with a vibratory roller. The tamping-type roller shall have tampers or feet protruding not less than 6 inches from the surface of the drum and have a minimum load on each tamper of 250 pounds per square inch of tamping area. The vibratory roller shall have a manufacturer's rating of 16 to 20 tons compacting power. During compaction, each layer shall have the moisture content controlled such that, in the judgment of the engineer, any silt and clay fraction is in a plastic state. Simple diagnostic tests to establish such a plastic state include ability to indent with thumb or heel or to roll a short thread of soil between the hands. Material which crumbles under pressure will be considered too dry.

203.3.6 Each layer shall be wetted or dried, as necessary, and shall be compacted to the required density. Regardless of the type of equipment used, the roadway shall be compacted uniformly and the surface kept reasonably smooth at all times. If large pieces of heavy clay are encountered, the material shall be broken down by suitable manipulation to permit satisfactory embankment construction. If shale is encountered, it shall be broken down as much as is practicable and compacted at or above optimum moisture.

203.3.7 Compaction to at least 95 percent of maximum density will be required for that portion of any embankment below an elevation 50 feet below the top of the finished subgrade. If, because of embankment foundation conditions, the 95 percent of maximum density cannot be obtained after reasonable compactive effort has been expended, the engineer may waive the 95 percent requirement for a height not to exceed 3 feet above the embankment foundation.

203.3.8 Compacting in Cut. Cut compaction shall be performed in all Class A material areas, after removal of the roadway excavation material to the required section. A surface parallel to the pavement slope, 12 inches below the bottom of the pavement or lowest base course, shall be temporarily exposed for the full width
MONTANA
to the staking out and cross sectioning of the site. All borrow areas shall be finished and left in such shape as to permit accurate measurements after excavating has been completed. The finished borrow areas shall meet the requirements of Article 06.02(E).

11.04 CONSTRUCTION REQUIREMENTS (EMBANKMENT).

(A) General. Stumps, trees, logs, rubbish, vegetation, or other unsuitable materials shall not be placed in embankments. Sod mixed with surface soil and soil containing large amounts of humus or other organic materials shall be spread over the embankment slopes or incorporated into the embankments outside of the shoulder lines. Pockets of rock or muck will not be permitted. Frozen material shall never be placed in embankments.

Compaction of embankments, including backfilling and preparation of embankment foundation areas, shall meet the requirements of Article 11.05, unless otherwise specified.

(B) Embankment at Structures. Rocks, broken concrete, or other solid materials shall not be placed in embankment areas where piling is to be placed or driven.

If embankment can be deposited on one side only of abutments, wing walls, piers, or culvert headwalls, care shall be taken that the area immediately adjacent to the structure is not compacted to the extent that it will cause overturning of or excessive pressure against the structure.

Fill adjacent to end bents of bridges may be completed up to the bottoms of backwalls before the superstructure is in place. Fill shall not be placed against backwalls or abutments before the superstructure is in place. The height of fill against backwalls and abutments shall be kept approximately equal at both ends of structures.

Embankment and backfill shall be placed in layers of 8 inches or less loose thickness and compacted adjacent to structures, around columns and similar structural supports, and on both sides of concrete walls, box type structures, and similar structures. Backfill material placed within the excavation limits shall be compacted. Backfill material placed above the excavation limits or ground line shall extend at least 10 feet from the structure or structural support and shall be compacted. Structures or structural members that have moved or become distorted as a result of placing embankment shall be adjusted, repaired, and restored by the contractor at no cost to the Department.

Embankment at structures and at those areas inaccessible to rollers
shall be compacted by mechanical tampers or other means until the
density conforms to that specified under Article 11.05, provided, how­
ever, that for embankment other than at structures, the compaction
required shall not exceed that of the adjacent embankment, compacted in
accordance with these specifications.

The ground upon which the backfill is placed shall be compacted to a
depth of at least 8 inches by rolling or mechanical tamping to a density of
at least 90 percent of maximum density as determined by MT-210.

(C) Preparation of Embankment Foundations. When embank­
ment is to be placed and compacted on hillsides or when new embank­
ment is to be constructed against existing embankments, or when
embankment is built one-half width at a time, the slopes that are 6:1 or
steeper when measured at right angles to the roadway shall be continu­
ously benched in not less than 8-inch rises over those areas where it is
required as the work is brought up in layers. Benching shall be of
sufficient width to permit operations of placing and compacting
equipment.

Each bench shall be cut as close to the one below as the ground slope
will permit. Acceptable material cut out of benches shall be incorp­
orated into the new embankment. The contractor will not be paid for excav­
ations less than one-half the width of standard equipment. Payment will be mad­
for excavation greater than one-half the width of standard equipment.

Where embankment is to be placed and compacted and end dumping
is permitted, the slopes of the original ground or embankment shall be
deeply plowed or cut into before starting end dumping.

Where embankment of less than 4 feet below subgrade is to be made,
all sod and vegetable matter shall be removed from the surface upon
which the embankment is to be placed and the cleared surface shall be
completely broken up by plowing, scarifying, or stepping to a minimum
depth of 8 inches. The area shall then be recompacted until a relative
compaction of 90 percent of maximum density, as determined by MT-210,
is reached in these 8 inches. Sufficient water shall be added during
compaction to obtain optimum moisture content plus or minus two
percentage points.

Whenever the surface of a proposed cut or the site of an embankment is
frozen or is covered with snow or ice sufficient to impair the stability of the
work, the frozen earth material and snow and ice must be removed and
deposited beyond the slope stakes at no cost to the Department. Work of
this nature shall be completed at least 300 feet in advance of the
excavation and placing of the embankment material. Frozen excavation or
that lying under a blanket of snow of such extent as to preclude its

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The grading contractor shall not place this portion of the roadway embankment until after the bridge contractor has completed the backwall and deck slab. All material shall be layer placed and compacted in accordance with Article 11.04(b) of the standard specs.
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NEW HAMPSHIRE
as recommended in the AASHO "Standard Specifications for Highway Bridges."

2.2 Steel Sheet Piling shall conform to AASHO M 202 (ASTM A 328). The use of foreign steel will be permitted only after approval by the Engineer upon suitable certification from a recognized domestic laboratory. Used steel sheet piling in good condition will be acceptable.

**Construction Requirements**

3.1 Timber Sheet Piling.

3.1.1 The piles shall be of the thickness specified or directed and shall be provided with tongue and groove of ample proportions, either cut from the solid material or made by building up the piles with planks securely fastened together. The piles shall be drift sharpened at their lower edges so as to wedge the adjacent piles tightly together.

3.1.2 The tops of the piles shall be cut off to a straight line at the elevation indicated and shall be braced with waling strips, properly lapped and jointed at all splices and corners. The wales shall preferably be in one length between corners and shall be bolted near the tops of the piles unless otherwise permitted. Wales shall not be spliced except when permitted.

3.2 Steel Sheet Piling.

3.2.1 The sections when assembled in place shall be practically watertight at the joints.

3.2.2 The tops of the piles shall be cut off to a straight line at the elevation indicated.

**Method of Measurement**

4.1 Timber sheet piling will be measured by the thousand feet board measure (MBM) computed to the nearest 0.01 of an MBM, based on nominal widths and thicknesses. Necessary and accepted wales will be measured as timber sheet piling, except that no allowance will be made for splices.

4.2 Steel sheet piling will be measured by the pound.

3 Cut-offs of timber sheet piling will be measured by the thousand feet board measure (MBM), and cut-offs of steel sheet piling will be measured by the pound. No allowance will be made for timber sheet pile cut-offs less than 3 feet in length or for steel sheet pile cut-offs less than 1 foot. The cut-off shall be the difference between the length of pile called for and the length actually driven below the cut-off elevation.

**Basis of Payment**

5.1 The accepted quantity of piling will be paid for at the contract unit price per MBM for timber piling and per pound for steel piling, all complete in place.

5.2 Cut-offs will be paid for at the actual cost per MBM for timber sheet piling and at the actual cost per pound for steel sheet piling.

Pay items and units:

<table>
<thead>
<tr>
<th>Item Description</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>506.1 Timber Sheet Piling</td>
<td>MBM</td>
</tr>
<tr>
<td>506.11 Timber Sheet Piling, Treated</td>
<td>MBM</td>
</tr>
<tr>
<td>506.2 Steel Sheet Piling</td>
<td>Pound</td>
</tr>
</tbody>
</table>

**SECTION 508 — STRUCTURAL FILL**

**Description**

1.1 This work shall consist of the formation of embankments which are intended to support structures.

**Materials**

2.1 Structural Fill shall consist of crushed gravel unless gravel (bank-run) or other material is
specified or permitted on the plans. When not otherwise limited, the word gravel as used below will refer to both gravel (bank-run) and crushed gravel.

2.1.1 Crushed Gravel for Structural Fill.
2.1.1.1 Required Grading:

<table>
<thead>
<tr>
<th>Sieve Size</th>
<th>Percentage by Weight Passing</th>
</tr>
</thead>
<tbody>
<tr>
<td>8&quot;</td>
<td>100</td>
</tr>
<tr>
<td>2&quot;</td>
<td>95 - 100</td>
</tr>
<tr>
<td>1&quot;</td>
<td>85 - 85</td>
</tr>
<tr>
<td>No. 4</td>
<td>75 - 85</td>
</tr>
<tr>
<td>No. 200 (Based on the fraction passing the No. 4)</td>
<td>0 - 12</td>
</tr>
</tbody>
</table>

2.1.1.2 At least 50 per cent by weight of the materials retained on the 1-inch sieve shall have a fractured face.

2.1.2 Gravel (Bank-Run) for Structural Fill shall be graded as follows: Twenty-five to 70 per cent shall pass a No. 4 sieve. Not more than 15 per cent of the portion which passes to No. 4 sieve shall pass a No. 200 sieve. No stone shall be included which cannot be incorporated in a 6-inch course.

2.1.3 Weight. Gravel shall weigh not less than 125 pounds per cubic foot when compacted to its Maximum Dry Density as determined by AASHO T 99, Method C.

2.1.4 Wear. The per cent of wear of gravel shall not exceed 50 unless otherwise specified.

Construction Requirements

3.1 The area upon which the fill is to be constructed, regardless of the height of the proposed fill, shall be stripped of all loam, refuse, roots, stumps, boulders, and the like and shall be backfilled with the same type of material as that found at the site. All excavation shown on the plans or ordered shall be completed before constructing the fill. When fills are to be made on hill sides or when fill is built one-half width at a time, the slopes of the original hillside or new fill shall be cut into or terraced as the work is brought up in layers.

3.1.1 Before the first layer of structural fill is placed, the entire work area of the original ground shall be compacted with approved compacting equipment.

3.2 Structural fill to be placed adjacent to new embankment material shall be placed concurrently with the embankment material to obtain lateral support.

3.3 The fill shall be placed in horizontal layers not exceeding 8" loose measurement and shall be compacted to a relative density not less than 98 per cent of the Maximum Dry Density. If necessary, water shall be added to assist in compaction.

3.4 When gravel is specified, density determinations shall be made in one of the following manners:

3.4.1 To determine the In-Place Wet Density, a hole having a volume of not less than 0.10 cubic foot shall be dug in the area to be tested. The material removed shall be weighed immediately and placed in an air-tight container for future determination of moisture content. The volume occupied by the sample prior to removal shall be determined by AASHO T 191. The In-Place Wet Density in pounds per cubic foot equals the weight of soil removed divided by the volume of the hole in cubic feet. Additional material taken from the immediate vicinity of the hole shall be brought to approximately the optimum moisture content and compacted in a standard 4-inch mold having a capacity of 1/30 cubic foot. The material shall be compacted in 3 equal layers by 35 blows on each layer from a 6-pound hammer dropping 12 inches.
The weight of the material contained in the mold multiplied by 30 gives the Maximum Wet Density.

3.4.2 The per cent compaction is found by dividing the In-Place Wet Density by the Maximum Wet Density. Generally, the per cent compaction on a wet basis is acceptable for free draining gravel. However, in case of dispute, the per cent compaction on a dry basis shall be calculated. Corrections for different stone contents shall be made by Department laboratory methods.

3.4.3. As an alternative to the above, the relative density may be determined by the use of nuclear density equipment. At the beginning of the compaction operation, the Maximum Wet Density shall be determined by compacting a control section or layer at a suitable moisture content until no further increase in density is obtained on the nuclear gage. The remainder of the course shall be compacted to a density not less than 98 per cent of the test density.

3.5 Each layer of fill material shall be compacted with power rollers, power tampers or vibratory compactors until the required density is obtained. Each layer shall be spread to a uniform thickness and compacted to the required density prior to placing the next layer. The surface of the fill shall be kept approximately level at all times and the portion of the fill to be occupied by the structure shall be maintained at the proper density by moistening and tamping if necessary, until the concrete or structure is in place.

3.6 The Contractor shall notify the Engineer of the anticipated date of completion of the structural fill at least 3 working days prior to completion of the fill. Upon completion, the Contractor shall not proceed with any further operations on the fill until the Engineer has taken all proof borings he desires. When approval has been given, the Contractor shall backfill any drilled holes with saturated sand or other approved material.

Method of Measurement
4.1 Structural fill will be measured by the cubic yard as determined from the ground elevation immediately before the placement of any fill and the neat lines for the compacted material as shown on the plans.

Basis of Payment
5.1 The accepted quantity of structural fill will be paid for at the contract price per cubic yard complete in place.

5.2 Excavation in preparation for this item will be paid for under Item 504 unless otherwise indicated on the plans. Any excavation for terracing and any backfilling of proof boring holes will not be measured but will be incidental to the work.

5.3 No overhaul will be paid for.

Pay item and unit:
508 Structural Fill Cubic Yard

SECTION 510—BEARING PILES

Description
1.1 This work shall consist of furnishing the material, furnishing the equipment for driving, and driving all types of bearing piles to the required penetration, and when required, test loading, splicing, and cutting, as shown on the plans or ordered.

Materials
2.1 Timber Piles shall conform to ASTM D 25, Class B, clean-peeled, and shall be preservative-treated.
NEW JERSEY
NEW YORK
4. PIER ON SOIL OR PILE FOUNDATION - SOIL CUT
5. PIER ON ROCK, SOIL AND/OR ROCK CUT
6. WALLS ON ROCK, SOIL AND/OR ROCK CUT
7. WALLS ON SOIL OR PILE FOUNDATION - SOIL CUT

8. BOX BRIDGE - SOIL CUT
9. UNSUITABLE MATERIAL REMOVAL
10. ABUTMENT ON FILL PILE FOUNDATION

II. STRUCTURE BACKFILL PLACEMENT LIMITS FOR POROUS DRAINAGE AGGREGATE
TYPICAL EMBANKMENT PLAN
SINGLE ABUTMENT

TYPICAL CROSS SECTION
THRU SINGLE ABUTMENT

TYPICAL CENTERLINE SECTION
SINGLE OR TWIN ABUTMENTS

LEGEND

STATE OF NEW YORK
DEPARTMENT OF TRANSPORTATION
DIVISION OF CONSTRUCTION

PLACEMENT LIMITS OF ITEM 2.52
FOR ABUTMENTS FOUNDED ON 5' READ FOOTINGS REQUIRING NO CONSOLIDATION
OF FOUNDATION SOIL

TYPICAL CROSS SECTION
THRU TWIN ABUTMENTS
TYPICAL EMBANKMENT PLAN
SINGLE ABUTMENT - STAGE 1
EMBANKMENT DETAILS PRIOR TO WAITING PERIOD

TYPICAL CROSS SECTION
THRU SINGLE ABUTMENT

TYPICAL CENTERLINE SECTION
SINGLE OR TWIN ABUTMENTS

STATE OF NEW YORK
DEPARTMENT OF TRANSPORTATION
DIVISION OF CONSTRUCTION
PlACEMEnT LIMITS OF Item 203.02
FOR ABUTMENTS REQUIRING EMBANKMENT CONSTRUCTION TO SUBGRADE ELEVATION, EXCLUDING ABUTMENT AREA, TO CONSOLIDATE FOUNDATION SOIL PRIOR TO ABUTMENT CONSTRUCTION

REVIEWED 5/17/79

DATE OF APPROVAL

DEPUTY COMMISSIONER (STRUCTURAL)
NORTH CAROLINA
872-4 COMPENSATION.

All work covered by this section will be paid for at the contract lump sum price for "Railroad Advance Warning and Crossing Signs at Station _______." Such price and payment will be full compensation for all work covered by this section at each installation, including but not limited to furnishing all signs, and erecting the signs.

Payment will be made under:

Railroad Advance Warning and Crossing Signs at Station _______.

Lump Sum

SECTION 874

BRIDGE APPROACH SLABS

874-1 DESCRIPTION.

The work covered by this section consists of the construction of reinforced concrete approach slabs at bridge approach, along with non-reinforced concrete approach drainage slabs, grates and frames, and subsurface drainage systems, all in accordance with these specifications and the details shown on the plans.

874-2 MATERIALS.

All materials shall meet the requirements of Division 9 shown below:

- Portland cement concrete
- Curing agents
- Joint filler
- Joint sealer
- Reinforcing steel
- Stone, No. 78M
- Aggregate base course
- Structural steel
- Gray iron castings

874-3 CONSTRUCTION METHODS.

A stone drain consisting of 1 cubic foot of No. 78M stone contained in porous fabric bag shall be placed at each pipe drain located in the end bent cap or abutment and shall be securely tied. Subdrain fine aggregate shall be placed in conjunction with the stone drain as shown on the plans.

The subdrain fine aggregate shall be placed and compacted in accordance with Article 410-10.

The subgrade shall be constructed in accordance with Section 500.

The aggregate base course shall be constructed in accordance with Section 520.

The provisions of Section 420 shall be applicable to all concrete except as otherwise provided herein. Class AA concrete shall be used for all reinforced concrete. Class A concrete shall be used for all non-reinforced concrete.

The reinforced concrete bridge approach slabs shall be screeded, finished, and cured in accordance with those requirements of Section 420 which are applicable to bridge floors.

The approach drainage slab shall be given a light broom finish with the brush marks parallel to the gutter line, or any other finish acceptable to the Engineer. The finished surface of the approach drainage slab shall not vary from a straight line by more than 1/2 inch when checked longitudinally with a 10 foot straightedge. The approach drainage slab shall be cured in accordance with those requirements of Section 420 which are applicable to bridge floors.

874-4 COMPENSATION.

All work covered by this section will be paid for at the contract lump sum price for "Bridge Approach Slabs, Sta. _______." Such price and payment will be full compensation for all work covered by this section at each bridge installation, including but not limited to furnishing and placing subsurface drainage materials; constructing the subgrade, furnishing and placing the aggregate base course; furnishing and placing concrete, reinforcing steel, joint filler and sealer, grates and frames, and any other materials, and finishing and curing the concrete.

Payment will be made under:

Bridge Approach Slabs, Sta. _______.

Lump Sum
CHAPTER 13
MISCELLANEOUS ITEMS

13-1 BRIDGE APPROACH SLABS

13-1-1 GENERAL

(a) Approach slabs are now a part of the structure plans. They are to be used when the design year ADT is 800 or greater. Approach slabs consist of the full width approach slab and when required an approach drainage slab. These items should be carefully coordinated with Roadway Design.

(b) Four standard drawings are available and should be used in plan development. They are:

1. Standard No. BAS1 = "Bridge Approach Slab For Rigid Pavement".
2. Standard No. BAS2 = "Bridge Approach Slab For Flexible Pavement".
3. Standard No. BAS3 = "Approach Drainage Slab Details".
4. Standard No. BAS4 = "Grates and Frames For Approach Drainage Slab".

(c) In general, Standard No. BAS1 or BAS2 is used each time full width approach slabs are called for. When type of pavement is not known at the time of structure contract letting, Standard No. BAS1 should be used. Standard No. BAS3 and BAS4 should be included in the plans following the approach slab sheet where special drainage is required at one or more corners of a bridge.

(d) Approach slabs are paid for on a lump sum basis.

13-1-2 FULL WIDTH APPROACH SLABS

(a) Approach slabs are to be full width from gutter line to gutter line. End of approach slab shall be parallel to fill face of end bent, with constant length as specified below.

1. For structures with 60° thru 120° skew, use 10-foot length of approach slab measured along with centerline of bridge.

2. For structures with skew other than specified in paragraph (1) above, use 15-foot length of approach slab measured along the centerline of bridge.

3. For special situations, e.g., very deep superstructures etc., consideration shall be given to increased length of approach slab.

(b) Approach slabs should be detailed separately for dual bridges.

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(b) Four standard drawings are available and should be used in plan development. They are:

1. Standard No. BAS1 - "Bridge Approach Slab For Rigid Pavement".
2. Standard No. BAS2 - "Bridge Approach Slab for Flexible Pavement".
3. Standard No. BAS3 - "Approach Drainage Slab Details".
4. Standard No. BAS4 - "Grates and Frames for Approach Drainage Slab".

(c) In general, Standard No. BAS1 or BAS2 is used each time full width approach slabs are called for.

When type of pavement is not known at the time of structure contract letting, Standard No. BAS1 should be used.

Standard No. BAS3 and BAS4 should be included in the plans following the approach slab sheet where special drainage is required at one or more corners of a bridge.

(d) Approach slabs are paid for on a Lump Sum basis.

Chapter 13-1-2

(a) Approach slabs are to be full width from gutter line to gutter line. End of approach slab shall be parallel to fillface of end bent, with constant length as specified below.

1. For structures with 60° thru 120° skew, use 10' length of approach slab measured along the centerline of bridge.

2. For structures with skew other than specified in paragraph (1) above, use 15' length of approach slab measured along the centerline of bridge.

3. For special situations e.g. very deep superstructures etc., consideration shall be given to increased length of approach slab.

(e) Reinforcement - Use #6 bars at 6" maximum centers for longitudinal reinforcement. Use #4 bars at 18" maximum centers for transverse reinforcement. Transverse reinforcement shall be placed parallel to fillface of end bent with spacing of 18" measured along the centerline of bridge as shown in figure 13-J. Bars shall have 2" clearance in top and bottom of slab.
(c) On dual lane highways where a wide bridge is used rather than separate bridges, four approach slabs will be required using the full width approach slab concept. On the median side, extend the approach slab to the edge of the approach paved shoulder but not less than six feet from the median edge of pavement.

(d) Class AA concrete will be used in the approach slab. It will be necessary to compute this quantity and show the quantity in the Approach Slab Bill of Material.

(e) Reinforcement - Use #6 bars at 6-inch maximum centers for longitudinal reinforcement. Use #4 bars at 18-inch maximum centers for transverse reinforcement. Transverse reinforcement shall be placed parallel to fill face of end bent with spacing of 18 inches measured along the centerline of bridge as shown in figure 13-3. Bars shall have 2-inch clearance in top and bottom of slab.

(f) Show horizontal curve offsets for left and right edge of approach slabs on a horizontal curve.

(g) Construction elevations - Construction elevations for approach slabs are to be computed as described in Chapter 7-2-9(c).

13-1-3 APPROACH DRAINAGE SLABS

(a) It is necessary to coordinate the location of the special drainage with Roadway Design. It is the responsibility of the Hydrographic Unit to determine where this special drainage is required.

(b) Roadway Design will determine the type grate to be used at each bridge location. The grate which will not be used should be crossed out on the standard.

(c) The location of the centerline of the grates and drop inlet will be shown in the plan of the approach slab where special drainage is required. The criteria for establishing this location will be the larger of the following:

(1) Three feet from the end of the curved end block to the centerline of the grates and drop inlet.

(2) Four feet from the end of a swept back wing to the centerline of the grates and drop inlet.

(3) Eight feet (normal) from the fill face of the end bent to the intersection of the centerline of the grates and drop inlet with the edge of the approach slab.

It is suggested that the dimension locating the centerline of grate and drop inlet be rounded to a three-inch increment where shown on the plans.

(4) End of approach slab.

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drainage. See Figure 8-2 in this manual for the pipe drain details.

For bridges without approach slabs, in addition to the specifications, provide continuous layer of 1'-6" thick sub drain fine aggregate behind the fill face of end bent.
(d) Class A concrete will be used in the approach drainage slab details. It will be necessary to compute this quantity and show the quantity in the Approach Slab Bill of Material.

(e) The approach drainage slab details will not apply where standard curb and gutter ties into the ends of the bridge. Approach slabs will be handled in the usual manner where standard curb and gutter approaches are used.

(f) Details are provided on the Curved End Block Standard (Standard No. GRA1) to handle the curb transition for approach drainage slab curb or standard curb and gutter approaches.

(g) In those cases where the roadway contract will be let earlier than the bridge, Structure Design Unit should furnish to Roadway Unit a sepia of the plan view of the approach slab showing the location of the drop inlet. See Figure 13-3 for example.

13-1-4 DRAINS

(a) Three inch diameter PVC plastic pipe drains should be located at 10 feet maximum centers in the end bents to facilitate drainage. Pipe drains shall be extended through end bent caps whether or not slope protection is used. See Figure 8-2 in this manual for the pipe drain details.

For bridges without approach slabs, in addition to the specifications, provide continuous layer of 1'-6" thick sub drain fine aggregate behind the fill face of end bent.

(b) Use judgement in placing these drains in the end bent. Watch for cone of earth spilling around wing and covering drain. Locate if possible in region of negative moment adjacent to piles.

13-2 MEDIAN PIER PROTECTION

(a) In median having piers less than 30 ft. from the edge of pavement, guardrail shall be placed. Special consideration will be given when barrier-shape protection is justified. When barrier-shape protection is called for, use Class A concrete reinforced similar to the barrier rail used on bridge deck. Reinforcing steel and Class A concrete quantities are included in the bent bill of material. No separate pay item is required.

(b) If the pier offset is between 30 ft. and 40 ft., then an earth berm shall be placed. When berms are placed, pier footing shall be designed accordingly and slope protection placed according to the applicable standard.

(c) Piers with an offset over 40 ft. require no impact protection.

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PENNSYLVANIA
RHODE ISLAND
203.03.4 PERVERSIVE FILL ADJACENT TO STRUCTURES.

(a) The material placed adjacent to, or in contact with arches, culverts, retaining walls, wingwalls, secondary structures, and all other areas indicated on the plans shall be pervious fill as specified that will freely conduct to weepholes, wall drains or subdrains any moisture that may penetrate the embankment. This material shall be carefully placed to avoid damage to the masonry and waterproofing treatment.

(b) Pervious fill shall be placed in layers not over 12 inches in depth before compaction and shall be compacted to 95 percent of maximum density as determined by AASHO T-180, Method A or D. In locations not accessible for normal placing and rolling it shall be compacted by means of mechanical rammer, or suitable vibratory equipment. For minor operations, hand tamping with heavy iron tampers, the tamping face of which shall be approximately 25 square inches in area, may be used.

(c) Mechanical tampers shall be either air or gas-driven. The air-driven mechanical tampers shall be operated at an air pressure of not less than 75 pounds per square inch.

(d) Protection of Structures from Unbalanced Loading.

In all cases proper precautions shall be taken to ensure that the method of operation does not cause movement of or undue strain on any part of the structure. Fill material shall be deposited and compacted behind abutments, walls and miscellaneous structures as hereinafore specified. Special precautions shall be taken when placing fill around slender foundations, rigid frame legs, piers or over and around arches and box culverts, to deposit the material on both sides of such structures to approximately the same elevation at the same time.

No fill material shall be placed against any structure until permission to place fill has been granted by the Engineer and in no case until the masonry has obtained the specified strength.

203.03.5 COMMON BACKFILL. All spaces excavated and not occupied by abutments, piers or other permanent units including pervious fill material, shall be backfilled with sufficient earth up to the surface of the surrounding ground, but not above subgrade, except that sufficient allowance shall be made for settlement. After the removal of form from the toes of footings for abutments, wings and retaining walls, the excavated space shall be backfilled and compacted before proceeding with embankment fill. All backfill shall be thoroughly compacted and nearly graded. No separate payment will be made for this item of work.

203.04 METHOD OF MEASUREMENT.

203.04.1 STRUCTURE EXCAVATION. Structure excavation will be measured by taking the difference in elevation between the existing ground surface or the bottom of roadway excavation or channel excavation, whichever is lower, and the surface of the completed structure excavation at plan grade or approved revised plan grade.

Structure excavation in roadway cuts or embankment areas where the removal of muck is indicated on the plans shall include only that portion below the bottom of the muck or the subgrade, shoulder foundation and cut slope lines, as the case may be, or as may be more specifically shown on the plans.

Before starting any excavation the Contractor shall notify the Engineer so that elevations and measurements of the work may be obtained. When ledge rock is encountered the Contractor shall notify the Engineer and shall strip or expose the rock to such an extent that in the Engineer's opinion the necessary measurements can be taken for structure excavation. If the contractor shall fail to give such notice or notices, or remove any material prior to the taking of measurements, the Engineer shall presume that measurements taken at the time he first sees the material in question will give the true quantity of excavation. Horizontal payment limits will be measured between plumb lines and 2 feet outside of the nearest lines of the original foundations only, unless otherwise shown on the plans and unless the size of the footing is increased more than 2 feet in any direction. In which case, the area of the footing that extends beyond the original payment lines, as established hereinafore, will be used for determining the additional amount of excavation. No allowance for rock overbreak will be made beyond the above limits or more than 6 inches below bottom of footing, unless indicated otherwise on the plans. However, when underwater concrete is specified, the horizontal payment limits will be those specified for the cofferdam indicated on the plans. When underwater concrete is not specified, but is required, the horizontal payment limits will be extended to the actual inside face of the cofferdam.
SECTION E-E
APPROACH PAVEMENT WITH CRUSHED STONE BASE

*FIXED JOINT AS SHOWN

EXPANSION JOINTS AS NOTED ABOVE

* FOR UNLIMITED SPAN LENGTHS
TEXAS
EXISTING RESTRICTIVE WIDTH BRIDGE

CROWN WIDTH BRIDGE

ELEVATION OF VARIOUS BRIDGE RAIL ALTERNATES
ELEVATION OF VARIOUS BRIDGE RAIL ALTERNATES

NORMAL CROWN WIDTH BRIDGE

EXISTING RESTRICTIVE WIDTH BRIDGE

NORMAL SKEWED CROWN WIDTH BRIDGE

SKEWED CROWN WIDTH BRIDGE

TYPE - TIOI

TYPE - T2 OR C2

TYPE - T30 OR C4C

TYPE - T4 OR C4

POST TREATMENT AT STRUCTURES

STATE DEPARTMENT OF HIGHWAYS AND PUBLIC TRANSPORTATION
BRIDGE END DETAILS
(DIVIDED HIGHWAY)
BED - (DH) - 75
VERMONT
WEST VIRGINIA
Note:
Hf and Hc to be measured at the back of abutment.
WISCONSIN
excavation and the other in embankment, such that the distance between them equals 2000 feet and the included quantities of excavation and embankment balance. All materials within this free haul limit will be eliminated from further consideration. The quantity of backfill will be the product of the backfill distance, in stations of 100 feet or in miles, multiplied by the quantity of backfill per cubic yard. In general, when the backfill distance is not more than one-half mile the quantity of backfill will be measured on a station yard basis; and when the backfill distance is more than one-half mile, the quantity of backfill will be measured on a yard-mile basis.

The engineer will determine the necessity for overhauling and shall be furnished ample time to take the necessary cross sections and measurements to determine the volume of excavation for which overhaul will be paid.

205.3.3 Presplitting Rock. Presplitting rock will be measured by the linear foot of drill hole, including test section holes, drilled along the face of acceptable presplit rock slopes. The measurement will be made from the top of the drill hole at the rock surface to the elevation of the roadway ditch, to a predetermined bench elevation or to the bottom of the rock ledge or mass where such rock does not extend to the roadway ditch or predetermined bench elevation, as the case may be.

205.6 Rate of Payment.

205.6.1 Excavation. Roadway and Drainage Excavation, measured as provided above, will be paid for at the contract unit price per cubic yard for the class of excavation involved (Common Excavation, Rock Excavation, Stone Piles and Stone Fences, Marsh Excavation or Unclassified Excavation) which price shall be payment in full for all work specified under Roadway and Drainage Excavation and also for all items of work designated under the general heading Part II, Earth Work. For which no separate unit prices are included in the contract. The cost of removing walls, foundations, etc., the satisfactory disposal of material resulting therefrom, and the backfilling of basements or openings resulting from the removal of walls, foundations, etc., will be construed to be included in the contract unit price for Excavation items, and no extra or additional compensation will be made for such work, except that payment for furnishing and placing the required Granular Backfill will be made at the contract unit price for that item. Such payment shall include full compensation for all equipment, tools, labor and incidentals necessary to complete the work. The contract unit price per cubic yard shall include all haul except as outlined in Subsection 205.4.

205.6.2 Overhaul. Payment for overhaul on Roadway and Drainage Excavation will be made at a unit price per station yard or per yard mile to be agreed upon in writing by the contractor and engineer before the work is started, which price shall be full compensation for all labor, equipment, tools and incidentals necessary due to the additional haul or transportation involved beyond the limit of free haul as herein defined.

In no case will Overhaul be allowed on unsuitable materials from Roadway and Drainage Excavation disposed of by the contractor beyond the right-of-way limits as specified.

205.6.3 Presplitting Rock. Presplitting Rock, measured as provided above, will be paid for at the contract unit price per linear foot. This price shall be full compensation for all drilling, charging, stemming and blasting; for furnishing all materials, including explosives; and for all labor, equipment, tools and incidentals necessary to complete the work.

SECTION 206. EXCAVATION FOR STRUCTURES

206.1 Description. Excavation for Structures shall consist of all excavation, of whatever nature encountered, for culverts, structural plate pipe and structural plate pipe arches, bridges and retaining walls except as otherwise provided herein. It shall include all necessary cleaning and grubbing within the area defined by lines connecting the extremities of the end substructure units regardless of whether or not excavation is involved; the removal of old substructure units from the space occupied by the new structure; the removal of all logs, stumps, rocks, and other materials and obstructions necessary to place the foundations and structure in conformity with the plans and specifications; the disposal of all material obtained from excavation and the necessary shaping, sloping, backfilling, compacting and cleaning of the site.

This item does not include excavation for culvert pipe or pipe arches.

Cofferdams shall consist of the construction of all necessary cofferdams and crib or well-point systems and their subsequent removal, and all necessary sheeting, shoring, bracing, draining and pumping to permit the construction of the substructure, above the seal, in the dry. Stream diversions and earth moves shall not be used in lieu of specified cofferdams or well-point systems, unless expressly permitted by the engineer in writing and must comply with the requirements of Subsections 107.18 and 107.20.

206.2 Classification. Excavation for Structures will be classified for measurement and payment as Excavation for Structures, Bridges, Excavation for Structures, Culverts: Excavation for Structures, Structural Plate Pipe or Pipe Arch or Excavation for Structures. Retaining Walls; as the case may be, and such classes shall include all material of whatever nature encountered. Excavation for Structures will not be classified as Common Excavation, Rock Excavation or Marsh Excavation nor will it be classified as dry excavation or wet excavation.

206.3 Construction Methods.
206.3.1 Depth of Excavation. The elevation of the bottoms of footings, as shown on the plans, shall be considered as approximate only, and the engineer may order, in writing, such changes in dimensions or elevation of footings as may be necessary to secure a satisfactory foundation.

206.3.2 Cofferdams and Cribs. Cofferdams and cribs for foundation construction shall be carried to adequate depths and heights, be safely designed and constructed, and be made as watertight as is necessary for the proper performance of the work. The interior dimensions of cofferdams and cribs shall be such as to give sufficient clearance for the construction of forms and the inspection of their exteriors, and to permit pumping from sumps outside the forms. Cofferdams or cribs which are tilted or moved laterally during the process of sinking shall be righted, reset or enlarged so as to provide the necessary clearance, and this work shall be at the sole expense of the contractor. The contractor shall be responsible for any claims for damages resulting from the use of a well-point system.

206.3.3 Protection of Concrete. Cofferdams and cribs shall be constructed so as to protect fresh concrete against damage from a sudden rising of the stream and to prevent damage to the foundation by erosion. Wakes and cross braces shall be located so that the substructure unit can be constructed without construction joints other than those shown on the plans. If wakes or braces must be left in place, only pipe, precast concrete, or rolled steel sections will be permitted. Boxing out of timber braces will not be permitted.

206.3.4 Drawings Required. The contractor shall submit drawings showing his proposed method of cofferdam or crib construction. Such drawings will be approved by the engineer before construction is started, but such approval shall not in any way relieve the contractor of his responsibility to secure a safe and satisfactory cofferdam or crib.

206.3.5 Removal. Unless otherwise provided, cofferdams or cribs, with all sheeting and bracing, shall be removed after the completion and curing of the substructure unit, care being taken not to disturb or otherwise injure the finished masonry.

206.3.6 Excavation. The contractor shall notify the engineer sufficiently in advance of the beginning of excavation for structures so that elevations and measurements may be taken of the existing ground before it is disturbed and of existing substructure units before they are removed.

206.3.7 Preparation of Foundation for Footings. Rock or other hard foundation material shall be freed of all loose material, cleaned and cut to a firm surface, either level, stepped or serrated. All seams shall be cleaned out and filled with cement mortar or grout.

When masonry is to rest on an excavated surface other than rock, special care shall be taken not to disturb the bottom of the excavation, and the final removal of the foundation material to grade shall not be made until just before the masonry is placed. Such surfaces shall be protected from freezing after excavation and prior to placement of concrete masonry for the footing.

When foundation piles are used, the excavation of each pit shall be substantially completed before beginning pile-driving operations therein. After pile-driving operations in a given pit are completed, all loose and displaced material therein shall be removed to the elevation of the bottom of the footings.

When footings can be placed in dry foundation pits, footing forms may be omitted, when approved by the engineer, and the entire excavation filled with concrete to the elevation of the top of the footing. No payment will be made, however, for concrete placed outside the footing dimensions shown on the plans.

Footings founded on sound rock shall be keyed into the rock when and as required by the plans. Such keyway when required shall conform to plan dimensions. All footing excavations in sound rock shall be filled with concrete to the elevation of the top of the rock or the top of the footing, whichever is lower. No payment, however, will be made for concrete placed outside the footing dimensions shown on the plans.

206.3.8 Pumping. Whenever practicable, foundation excavations shall be unwatered before depositing masonry therein.

Pumping from the interior of foundation enclosures shall be done in such a manner as to preclude, as far as practicable, the removal of foundation material or concrete ingredients.

There shall be no pumping from the interior of a foundation enclosure during the placing of concrete therein for a period of at least 24 hours thereafter, unless it be done from a suitable sump outside the forms. There shall be no pumping from within any foundation enclosure while concrete is being deposited under water therein. Pumping to unwater a sealed cofferdam shall not commence until the seal has set sufficiently to withstand the hydrostatic pressure.

206.3.9 Subfoundation Course.

206.3.9.1 Bridges and Retaining Walls. If the surface upon which masonry is to be placed is soft, muddy, or covered with muck and will not dry out and harden when the excavation has been kept unwatered for a reasonable length of time, the contractor shall furnish and place the hereinafter described subfoundation course when so ordered by the engineer. The subfoundation course shall consist of Granular Backfill or other materials approved by the engineer, and shall be placed directly below the elevation of the bottom of the footings to the depth designated by the engineer.

206.3.9.2 Culverts. The contractor shall place a six inch subfoundation course of Granular Backfill or other approved material directly below the elevation of the bottom of the slab between the cutoff walls of all culverts.

206.3.9.3 Structural Plate Pipe and Pipe Arches. Placement of subfoundation courses, including cushion courses, for structural plate pipe and pipe arches shall conform to Subsection 527.4.1.

206.3.10 Foundation Seal. When conditions are encountered which render it impractical to unwater the foundation excavation before placing masonry therein, the engineer may require the construction of a concrete foundation seal of such dimensions as deemed necessary. After the seal has been placed, the contractor shall notify the engineer when ready to unwater the excavation for construction of the footing. The engineer shall then prescribe the method of unwatering the excavation in such manner as to secure a sufficient seal of concrete for the placement of the foundation masonry.
net, the foundation excavation shall then be watered and the balance of
the masonry placed in the dry.

Foundation seals not shown on the plans shall be placed below the
elevation of the bottom of footing shown thereon, unless otherwise
authorized.

Concrete in foundation seals shall be placed in accordance with the
requirements of Subsection 502.3.6.3, for concrete deposited under water.

206.3.11 Impervious. Masonry shall not be placed nor any form or
structural plate pipe or pipe arch erected in any excavation until the
engineer has approved the depth thereof and the character of the foundation
material.

206.3.12 Backfill. Material used for backfill shall be of a quality
acceptable to the engineer and shall be free from frozen lumps, wood or
other extraneous or perishable material. Approved material from
excavation may be used for backfilling unless Granular Backfill is specified.

When Granular Backfill is specified, material from excavation meeting the
requirements therefor may be used for backfilling in accordance with the
provisions of Subsection 104.8. Stone used in backfilling shall be entirely
enveloped by finer material.

All spaces excavated and not occupied by the new structure shall be
backfilled to the elevation and section existing prior to excavation, except
that backfill shall not be placed above the required section for the finished
work. Backfill shall be sufficient to provide allowance for settlement.

Backfill shall not be placed against any Concrete Masonry retaining
wall or abutment of the retaining wall type, except as provided in the
following paragraph, or culvert wall; until the masonry has been in place 14
days or until test cylinders show the strength of the masonry to be at least
3000 pounds per square inch; nor shall High-Early-Strength Concrete in
such units be backfilled before six days after the date of pouring or until test
cylinders show the strength of the masonry to be at least 3000 pounds per
square inch. Backfill shall not be placed against any portion of any
substructure unit until the required curing and protection, surface finishing,
damp-proofing and waterproofing of the work to be covered by backfill has
been completed, provided however, that in no case shall Concrete Masonry,
except as provided in the following paragraph, be backfilled before the
seventh day after the date of pouring thereof, nor shall High-Early-
Strength Concrete be backfilled before the third day after the pouring thereof.

When so permitted by the engineer, footings may be backfilled to the top
of the footings, sill abutments may be backfilled to the beam elevation and
retaining walls may be backfilled uniformly and simultaneously on both
sides to the elevation of the front ground surface immediately upon removal
of the forms.

Abutments for rigid frame structures and abutments which are not
designed as self-sustaining shall not be backfilled until concrete in the
superstructure has been poured and cured.

Substructure units shall not be backfilled until the area involved shall
have been cleared of all falsework, sheet piling, cribbing, shoring, bracing,
forms and rubbish, except that cofferdams shall be backfilled prior to
removal of sheeting, unless otherwise permitted by the engineer.

Backfilling shall be so performed as to prevent wedging action against
the structure. Existing slopes shall be stepped, terraced or otherwise treated
as necessary to prevent slippage and wedging of the backfill.

Unless otherwise provided, backfill shall be placed in continuous
horizontal layers not more than 12 inches thick that are brought up
uniformly, as far as practicable, on all sides of each substructure unit or
culvert. Each layer shall be adequately compacted, before the next layer is
placed, by means of approved rollers or portable mechanical or pneumatic
tampers or vibrators.

If there is water in an excavation, backfilling operations therein shall be
so performed that such water will be displaced by the backfill and not
trapped therein. Water shall not be used to expedite settlement of backfill
except with the written approval of the engineer, but this provision shall not
be construed to require an excavation to be watered before placing
backfill. When the use of water is permitted, the entire excavation shall be
kept inundated during the period that backfill is placed, except when jettison
is allowed.

Backfilling operations shall be conducted in such a manner that no
portion of the structure is damaged or deflected out of alignment.

Backfilling material transported in trucks or other vehicles shall be
dumped so that the contents of each vehicle are gradually deposited instead
of simultaneously dumping the entire contents as one mass. Insofar as
practicable, all clams, dippers and similar containers of backfill shall be
lowered to within five feet of the surface of the previously deposited backfill,
or of the water surface, before they are dumped.

Backfill may be end dumped from the structure or approach
embankment if the material is spread and placed in the above-described 12-
inch horizontal layers after it is end dumped. Backfill shall not be placed in
or from narrow ramps or driveways up to or from the structure.

Backfilling of structural plate pipe and pipe arches shall be
accomplished as provided in Subsection 327.4.2.

Backfill along the front face of abutments, retaining walls and wing
walls shall extend to within six inches of the weep holes, unless otherwise
designated.

When weep holes are designated on the plans for culverts, abutments
and retaining walls there shall be placed behind the culvert, abutment or
retaining wall at the level of the weep holes a deposit or deposits of coarse
gravel or broken stone. The dimensions of such deposits shall conform to the
dimensions indicated on the plans.

206.3.13 Disposal of Excavated Material. Excavated material which is
suitable for use as riprap may be so placed if such use is appropriate.
Excavated material which is not used as riprap and which is suitable for
backfilling may be so utilized. Excavated material which is not used for
riprap or backfilling and which is suitable for the construction of
embankments shall be used therefor in accordance with the requirements of
Roadway and Drainage Excavation and Embankments.
The contractor shall dispose of all surplus excavated material in accordance with the pertinent requirements of Subsection 206.3.14.

206.3.14 Presumption of Channels and Waterways. Unless otherwise permitted, no excavation shall be made outside of caissons, cribs, cofferdams, or sheet piling, and the natural stream bed adjacent to the structure shall not be disturbed without permission from the engineer. If any excavation or dredging is performed at the site of the structure before caissons, crib, or cofferdams are sunk in place, the contractor shall, after the foundation is in place, backfill all such excavations to the original ground surface or stream bed with material satisfactory to the engineer.

Upon completion of work within cofferdams, cribs or sheet piling, the contractor shall backfill any excavated area within such cofferdams to the stream bed elevation, unless otherwise provided.

Excavated material and debris resulting from the contractor's operations and occurring in stream channels, ditch lines or waterways shall be removed to the level of the finished stream bed or ground line at the expense of the contractor.

206.4 Method of Measurement.

206.4.1 Excavation for Structures. Excavation for Structures will be measured as a unit for each specific bridge, culvert, structural plate pipe or pipe arch or retaining wall designated in the proposal as a bid item, completed in accordance with the contract.

206.4.2 Cofferdams. When the contract does not contain a specific item for cofferdams, then all the work hereinbefore prescribed, required and performed for cofferdams or cribs will not be separately measured for payment, but will be considered incidental to the item of Excavation for Structures.

When the contract contains the item of Cofferdams, such item will be measured as a single complete unit of work, acceptably performed.

206.5 Basis of Payment.

206.5.1 Excavation for Structures. Excavation for Structures, measured as provided above, will be paid for at the contract lump sum price for Excavation for Structures, Bridges; Excavation for Structures, Culverts; Excavation for Structures, Structural Plate Pipe or Pipe Arches; or Excavation for Structures, Retaining Walls: as the case may be, which price shall be full compensation for all clearing or grubbing; cofferdams, cribs, sheeting, shoring, bracing, pumping and unwatering, unless otherwise provided; for removing and disposing of all excavation not included in bid items pertaining to the removal of existing structures, including excavation for faults, girders, projections and subfoundation courses; for preparing foundation; for backfilling and compacting all space excavated and not occupied by the new structure including subfoundation course and Granular Backfill when specified; and for furnishing all material, labor, tools, equipment and incidentals necessary to complete the work.

The contract lump sum price for Excavation for Structures shall apply to all such excavation removed to an elevation between planes one foot above and below the elevation of the bottom of the footings or floor of culverts or the invert of structural plate pipe or pipe arches as given on the plans for the specific units.

In the event the footing is stepped or on a slope, the lump sum price for Excavation for Structures shall apply to all such excavation removed to an elevation between planes one foot above and below the plan elevation of the bottom of the footing, for each stepped section, or between planes one foot above and below and parallel to the slope established by the plan elevations for the bottom of the footing, as the case may be.

Any excavation ordered by the engineer to be performed to elevations in excess of one foot above or below the elevation of the bottom of the footings or floor or invert as indicated on the plans will be considered and paid for as provided in Subsection 109.4. Extra Work.

206.5.2 Cofferdams. Cofferdams, measured as provided above, will be paid for at the contract lump sum price, which price shall be full compensation for furnishing all cofferdams and cribs, including well-point systems, sheeting, shoring and bracing; for constructing, maintaining, backfilling and removing such cofferdams and cribs; for pumping and unwatering, and for furnishing all labor, tools, equipment and incidentals necessary to complete the work.

206.6 Compensation for Foundation Seal. Concrete necessary for foundation seals called for on the plans or ordered by the engineer, will be measured and paid for as provided in Section 502.

SECTION 207. EMBANKMENT

207.1 Description. This item shall consist of placing in embankments and in miscellaneous backfills material obtained from Roadway and Drainage Excavation, Borrow Excavation or Excavation for Structures, all in accordance with these specifications and in reasonably close conformity with the lines, grades, thicknesses and typical cross sections shown on the plans or established by the engineer.

207.2 Materials. Materials for embankment shall consist of approved materials and shall contain no logs, stumps, brush or other perishable material. Sand and humus-bearing soils, in excess of the quantity needed for salted (top) requirements, and other soils not suitable for roadbed construction may be placed in the outside edges of the embankment, beyond the limits of an assumed one-to-one slope extending outward from the outer limits of the finished shoulder line. Frozen loams of soil shall not be permitted to be placed in embankments inside the above designated assumed slope limits.

Materials to be incorporated in the top 12 inches of earth embankments shall be free from stone, broken concrete or other materials which would significantly affect scarifying, compacting and finishing the subgrade.
12.6 ABUTMENT DRAINAGE AND BACKFILL

(1) Abutment Drainage

Abutment drainage is necessary to prevent hydrostatic pressure and frost pressure. Hydrostatic pressure, soil and water included, can amount to an equivalent fluid pressure of 85 pounds per cubic foot. Frost action, which can occur in silty backfill, may result in extremely high pressures. On high abutments these pressures will produce a tremendous force which could result in structural damage or abutment movement.

To prevent these additional pressures on abutments it is necessary to drain away whatever water accumulates behind the body and wings. This is accomplished by using a pervious granular fill on the inside face of the abutment. Pipe underdrains will be necessary to drain the fill if it rests upon an impervious soil or rock.

Most of central and northern Wisconsin has a native sandy soil which is quite pervious and it is not necessary to call for a special granular backfill. Southern and eastern Wisconsin have more clay type soils which may be rather impervious. The soil borings at the abutment will give some indication of the permeability of the underlying soils.

The following factors are considered by the designer in determining if granular backfill and pipe underdrains should be called for:

(1) Perviousness or drainability of the material at the bottom of the footing.
(2) Type of material available within the right-of-way for the construction of the roadway. If pervious material is available it will be used for backfilling the inside of the abutments. Obtain information about available material from the district soils section if not known.
(3) Height of the abutment. Lower sill abutments are capable of withstanding hydrostatic pressure on their full height. Semi and full retaining abutments generally will be overstressed or may slide if subject to large hydrostatic pressure.
When it is necessary to drain the backfill material with pipe underdrains, 6 inch corrugated metal pipe is used. Perforated pipe is used behind the abutment and unperforated is used outside the abutment to drain the water away. The best elevation at which to place the pipe underdrains is at the same elevation as the bottom of the footing. However, if it is not possible to discharge the water to a lower elevation, it must be placed higher. In general, less unperforated pipe outside the abutment is required when the perforated pipe behind the abutment is placed at higher elevations. Some pipe underdrains have been installed high enough so they can be extended directly through the wing walls and discharge water above the side slopes.

Pipe underdrains and weepholes may discharge water during freezing temperatures. In urban areas this may create a problem due to the accumulation of ice on sidewalks.

(2) Abutment Backfill

When the designer feels that a special material is necessary to insure adequate abutment drainage, he specifies "Granular Backfill - Grade 1" as listed in the standard specifications for road and bridge construction. Since Grade 1 Granular Backfill is not always available, an alternate is also specified. The alternate is a material meeting the requirements of fine aggregates for concrete masonry. In general, granular backfill is specified for full and semi retaining abutments, but is not for sill abutments.

When granular backfill is called for, its limits are shown on the abutment plans. It is only placed behind the abutment, between the wings. The limits are as shown on the following sketch.
12.7 SELECTION OF STANDARD ABUTMENT TYPES

From past experience and investigations the following types of abutments are generally most suitable and economical for the given conditions. Although piles are shown for each abutment type, spread footings may be utilized. The following chart is a guide only and need not be rigidly followed.
WYOMING
212.11 BACKFILL. All material used for backfill shall be of a quality acceptable to the Engineer and shall be free from large or frozen lumps, wood, or other extraneous material.

All spaces excavated and not occupied by abutments, piers, or other permanent work shall be backfilled up to the surface of the surrounding ground, unless designated otherwise on the plans. All backfill shall be compacted to the density of the adjacent material. Backfill placed below water level will not require compaction. The top surface shall be neatly graded to blend with the adjacent area.

The fill behind abutments, wingwalls, retaining walls, and similar structures shall be deposited in horizontal layers of approximately eight inches (205 mm) in thickness and compacted to the density required for the adjacent material. The backfill in front of such units shall be placed first to prevent the possibility of forward movement. Special precautions shall be taken to prevent any wedging action against the concrete and the slope bounding the excavation for such structures shall be stepped or roughened to prevent wedge action. Jetting of the fill behind abutments, wingwalls, and retaining walls will not be permitted.

Fill placed around piers shall be deposited on both sides to approximately the same elevation at the same time.

Adequate provision shall be made for the thorough drainage of all backfilling above the existing water table.

Unless otherwise provided, backfill that would cause unequal stresses in abutments or wingwalls shall not be placed until the concrete has been in place 14 days or until test cylinders indicate the compressive strength to be at least equal to 80 percent of the ultimate design compressive strength for the class of concrete used.

212.12 PERVERUS BACKFILL MATERIAL. Placing of the Pervious Backfill Material shall be in accordance with Subsection 212.11 of the Specifications. Pervious Backfill Material at any one location shall be of approximately the same grading and, at locations where the material would otherwise be exposed to erosion, shall be covered with at least a one-foot (0.3 m) layer of job excavated pervious backfill material approved by the Engineer. The pervious backfill material shall meet the requirements of Subsection 703.19.

212.13 EMBANKMENT. When the contract for any structure requires the placement of embankments, they shall be constructed in accordance with the specifications governing this class of construction.

212.14 METHOD OF MEASUREMENT. The quantity to be paid for under this item will be the number of cubic yards, measured in its original position of the material acceptably excavated.

The total yardage, unless otherwise noted on the plans or staked, shall be the calculated volume included within vertical planes located 18 inches (460 mm) outside of the footings and parallel thereto and included between the bottom of the footing and the existing ground line. Existing ground line will be the natural ground line, roadway excavation line, or roadway embankment line in place at the time excavation is made.

The measurement shall not include any additional yardage required as a result of slips, slides, cave-ins, slippings, or fillings.

Measurement for pervious backfill material will be the number of cubic yards based on the actual dimensions used, not to exceed the plan dimensions.

Clearing and grubbing, unless paid for under some other item, furnishing all necessary equipment, and the construction of all cribs, cofferdams, and the subsequent removal of cofferdams and cribs, dewatering, and other miscellaneous work required for the excavation will not be measured for determination of a pay quantity but will be considered subsidiary to other items of the work.

212.15 BASIS OF PAYMENT. The accepted quantities of structure excavation will be paid for at the contract unit price per cubic yard. The unit price per cubic yard includes the placing and compacting of all backfill, form-
Index is non-plastic the liquid limit shall not be more than 30. The material placed in the stockpile shall meet the following gradation requirements for the maximum size specified:

<table>
<thead>
<tr>
<th>Sieve Designation</th>
<th>Percentage Passing</th>
</tr>
</thead>
<tbody>
<tr>
<td>2&quot; (50 mm)</td>
<td>100</td>
</tr>
<tr>
<td>No. 4 (4.75 mm)</td>
<td>95-100</td>
</tr>
<tr>
<td>No. 8 (2.36 mm)</td>
<td>85-100</td>
</tr>
<tr>
<td>No. 200 (0.075 mm)</td>
<td>3-12</td>
</tr>
</tbody>
</table>

(b) Type B aggregate shall consist of clean, hard, durable particles of crusher-run gravel or stone free from soft, thin, elongated, or laminated pieces or organic material. Material shall be obtained from designated portions of the pit. The plasticity index shall not be greater than six. The material placed in the stockpile shall meet the following gradation requirements for the maximum size specified:

- Not less than 95 percent of the material shall pass a sieve of the maximum size designated on the plans;
- Not more than 75 percent of the material shall pass a No. 4 (4.75 mm) sieve;
- Not more than 15 percent of the material shall pass a No. 200 (0.075 mm) sieve.

(c) Type C aggregate shall consist of crusher-run scoria. Not less than 95 percent of the material placed in the stockpile shall pass a one-half inch (12.5 mm) sieve.

d) Type D aggregate shall consist of clean, hard, durable particles of screened sand free from soft, thin, elongated or laminated pieces, or organic material. The plasticity index shall not be greater than six. The material placed in the stockpile shall meet the following gradation requirements:

703.19 Pervious Backfill Material. Pervious Backfill Material shall consist of gravel, crushed gravel, crushed rock, natural sands, manufactured sands, or combinations thereof. Pervious Backfill Material shall meet the following gradation requirements:

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<tbody>
<tr>
<td>2&quot; (50 mm)</td>
<td>100</td>
</tr>
<tr>
<td>No. 4 (4.75 mm)</td>
<td>95-100</td>
</tr>
<tr>
<td>No. 40 (0.425 mm)</td>
<td>85-100</td>
</tr>
<tr>
<td>No. 200 (0.075 mm)</td>
<td>3-12</td>
</tr>
</tbody>
</table>

In addition, the fraction passing the No. 40 (0.425 mm) sieve shall have a liquid limit not greater than 30 and shall be non-plastic.

703.20 Aggregate for Riprap. Aggregate for riprap shall be hard, durable, crushed, quarried, or natural stone, or broken concrete having an apparent specific gravity of not less than 2.4. The absorption shall not exceed four percent, unless otherwise approved by the Engineer. The stone shall be free of weak laminations and cleavages, and shall be of a quality that will not disintegrate on exposure to water or weathering. The aggregate for the various types of riprap shall meet the following additional requirements:

(a) Class 1 riprap stone shall consist of two sizes of stone.

1. Primary stone shall be not less than three inches (75 mm) thick and shall weigh not less than 50 pounds (23 kg). At least 60 percent of the stone shall weigh more than 80 pounds (36 kg).

2. Choked stone shall be fragments or spalls of the proper size to satisfactorily wedge between the primary stones as placed.
212.11 BACKFILL. All material used for backfill shall be of a quality acceptable to the Engineer and shall be free from large or frozen lumps, wood, or other extraneous material.

All spaces excavated and not occupied by abutments, piers, or other permanent work shall be backfilled up to the surface of the surrounding ground, unless designated otherwise on the plans. All backfill shall be compacted to the density of the adjacent material. Backfill placed below water level will not require compaction. The top surface shall be neatly graded to blend with the adjacent area.

The fill behind abutments, wingwalls, retaining walls, and similar structures shall be deposited in horizontal layers of approximately eight inches (205 mm) in thickness and compacted to the density required for the adjacent material. The backfill in front of such units shall be placed first to prevent the possibility of forward movement. Special precautions shall be taken to prevent any wedging action against the concrete and the slope bounding the excavation for such structures shall be stopped or roughened to prevent wedge action. Jetting of the fill behind abutments, wingwalls, and retaining walls will not be permitted.

Fill placed around piers shall be deposited on both sides to approximately the same elevation at the same time.

Adequate provision shall be made for the thorough drainage of all backfilling above the existing water table.

Unless otherwise provided, backfill that would cause unequal stresses in abutments or wingwalls shall not be placed until the concrete has been in place 14 days or until test cylinders indicate the compressive strength to be at least equal to 80 percent of the ultimate design compressive strength for the class of concrete used.

212.12 Pervious Backfill Material. Placing of the Pervious Backfill Material shall be in accordance with Subsection 212.11 of the Specifications. Pervious Backfill Material at any one location shall be of approximately the same grading and, at locations where the material would otherwise be exposed to erosion, shall be covered with at least a one-foot (0.3 m) layer of job excavated material approved by the Engineer. The pervious backfill material shall meet the requirements of Subsection 703.19.

212.13 EMBANKMENT. When the contract for any structure requires the placement of embankments, they shall be constructed in accordance with the specifications governing this class of construction.

212.14 METHOD OF MEASUREMENT. The quantity to be paid for under this item will be the number of cubic yards, measured in its original position of the material acceptably excavated.

The total yardage, unless otherwise noted on the plans or staked, shall be the calculated volume included within vertical planes located 18 inches (460 mm) outside of the footings and parallel thereto and included between the bottom of the footing and the existing ground line. Existing ground line will be the natural ground line, roadway excavation line, or roadway embankment line in place at the time excavation is made.

The measurement shall not include any additional yardage required as a result of slips, slides, cave-ins, silting, or fillings.

Measurement for pervious backfill material will be the number of cubic yards based on the actual dimensions used, not to exceed the plan dimensions.

Clearing and grubbing, unless paid for under some other item, furnishing all necessary equipment, and the construction of all cribs, cofferdams, and the subsequent removal of cofferdams and cribs, dewatering, and other miscellaneous work required for the excavation will not be measured for determination of a pay quantity but will be considered subsidiary to other items of the work.

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index is non-plastic the liquid limit shall not be more than 30. The material placed in the stockpile shall meet the following gradation requirements for the maximum size specified:

<table>
<thead>
<tr>
<th>Sieve Designation</th>
<th>(\frac{3}{4}''(19.0\text{ mm})) Max</th>
<th>(\frac{3}{8}''(9.5\text{ mm})) Max</th>
</tr>
</thead>
<tbody>
<tr>
<td>(\frac{3}{4}''(19.0\text{ mm}))</td>
<td>100</td>
<td>95-100</td>
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<tr>
<td>(\frac{1}{2}''(12.5\text{ mm}))</td>
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<td>45-65</td>
<td>50-70</td>
</tr>
<tr>
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<td>37-57</td>
<td>33-63</td>
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(c) Type C aggregate shall consist of crusher-run scoria. Not less than 95 percent of the material placed in the stockpile shall pass a one-half inch (12.5 mm) sieve.

(d) Type D aggregate shall consist of clean, hard, durable particles of screened sand free from soft, thin, elongated or laminated pieces, or organic material. The plasticity index shall not be greater than six. The material placed in the stockpile shall meet the following gradation requirements:

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(a) Class I riprap stone shall consist of two sizes of stone.

(1) Primary stone shall be not less than three inches (75 mm) thick and shall weigh not less than 50 pounds (23 kg). At least 50 percent of the stone shall weigh more than 80 pounds (36 kg).

(2) Choked stone shall be fragments or spalls of the proper size to satisfactorily wedge between the primary stones as placed.