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CHAPTER SEVENTEEN

Quantity Estimating

In addition to preparing clear and concise plans, as described in Chapter Fourteen, the designer should compile an accurate summary of the project quantities. This information leads directly to the project cost estimate, which combines the computed quantities of work and the estimated unit prices. An accurate summary of quantities is critical to prospective contractors interested in submitting a bid on the project. In addition to the INDOT *Standard Drawings* and the INDOT *Standard Specifications*, Chapter Seventeen provides additional guidelines on calculating quantities for a highway, bridge, or traffic project.

17-1.0 GENERAL

17-1.01 Guidelines for Preparing Quantity Computations

When preparing quantity computations, the designer should consider the following guidelines.

1. Specifications. Cross check all items against the INDOT *Standard Specifications* to ensure that the appropriate pay items, methods of measurement, and bases of payment are used. If an item is not described in the *Standard Specifications* or recurring special provisions, a unique special provision must be included in the contract documents to cover the item. Chapter Nineteen discusses how to prepare special provisions.

2. Pay Item Code Number. Every pay item has a unique number assigned to it for data processing. This code number is located in the computer programs CES and Estimator. Section 20-2.01 describes these programs. Only the official pay item name and description should be used in the contract documents, special provisions, or summary of quantities.

3. Rounding. The quantity of any item should check exactly with the figure on the computation sheets. Indicate any rounding of the raw estimated figures on the computation sheets. Unless stated otherwise, rounding of the calculations should not be done until the value is incorporated into the Quantity Summary Tables.

4. Significant Digits. When calculating quantities, consider the implied correspondence between the accuracy of the data and the given number of digits.

5. Cost Estimate. Only use the total values from the Quantity Summary Tables to develop the cost estimate. Show all items described in the plans that will be included in the cost estimate. The designer will be responsible for inserting these values into either CES or Estimator.

17-1.02 Computation Records

Quantity-computation sheets may be generated by computer or by hand. Combine all computation sheets and bind them with a cover sheet. The preparer will sign or initial and date each sheet. The checker will also be required to sign or initial and date each sheet.

Check all values obtained through computations or use of standardized tables. For those pay items where agreements may be reached to make payment on the basis of plan quantities, an independent check should be performed and noted. The resolution of any differences between original and check computations should be identified. Where computations are performed by computer, an independent check is not required. However, check the input and review the computation output sheet for mistakes. Also, sign and date the computer output similarly to hand computation sheets.

Retain the quantity computations within the project file.

The contractor may request copies of the quantity calculations subsequent to the letting. Requests prior to the letting from contractors should be directed through the Legal Services Division.

17-1.03 Units of Measurement

Quantities for all contract pay items should be estimated using the measurement units shown in the INDOT *Standard Specifications* or the special provisions. The values determined from the computations should be rounded as described below and shown in the quantities-summary tables and elsewhere in the plans as required.

Rounding of values should be as follows.

1. Small Quantity. For a quantity of 10 or less, round to the nearer whole unit (i.e., 3.2 to 3, 5.5 to 6, or 9.8 to 10).

2. Large Quantity. For a quantity greater than 10, round up to the next whole unit (i.e., 27.8 to 28, or 146.2 to 147).

3. Linearly-Measured Work. Round each linear-measure quantity up to the next higher 0.5 m.

4. Earthwork. For an individual cross-section area, round to the nearer 0.1 m^2. For an individual end-area volume, round to the nearer 1 m^3. For a total pay quantity, round up to the next multiple of 5 m^3.

5. Structural Concrete. Round each structural-concrete quantity to the nearest 0.1 m^3. This includes each individual pour or structure portion and the total quantity for each concrete class shown in bills of materials and the Bridge Summary sheet.

The values shown in the Estimate of Quantities and Cost Estimate developed by the designer should reflect this rounding procedure. The Engineer's Estimate and Schedule of Pay Items developed by the Contract Administration Division's Estimating Office will also reflect this procedure.

17-1.04 Non-Defined Work

17-1.04(01) Lump-Sum Pay Unit

Only use a lump-sum pay unit where the scope of work for the item is clearly defined, and the amount of work has a minimal chance of changing during construction. The INDOT *Standard Specifications* defines which quantities may be estimated as lump sum. Where practical, list the quantities for the separate work that will be included within the lump-sum item. The list should note that the separate quantities are for estimating purposes only. Where there is a significant chance of quantity changes, the work must be by the unit and not lump sum.

17-1.04(02) Item Included in Other Work

No work should be shown as incidental to another pay item or the contract. If any work will be included as part of another item, it must be addressed by the specifications or with a special provision. The designer should only include an item of work in another pay item where the scope of work for both is clearly defined and the probability of the quantity of either item changing is minimal. Minimize the amount of work to be included in other pay items. It is impossible for bidders, or the Department, to prepare an estimate for a project which contains incidental items for which quantities or the scope of work is indeterminable.

17-1.05 Proprietary Material

To ensure competitive bidding, the designer should restrict the use of proprietary materials on a project. A proprietary material is defined through specifications that are so specific that only one product will satisfy the requirements, or that the name of the product is actually specified. However, if a situation occurs where the use of a proprietary material will enhance safety, control costs, or will otherwise improve the project design, the use of a proprietary material may be justifiable. Where this is applicable, the designer should consider the following.

1. Justification. The designer must prepare a justification for the use of the proprietary material. The justification should include a description of the circumstance being addressed by the proprietary material, alternative solutions considered, and the reasoning why the proprietary material was chosen. Figure 17-1A, Justification for Use of Proprietary Material, illustrates the form that should be used to request approval for the proprietary material. An editable version of this form may also be found on the Department's website at www.in.gov/dot/div/contracts/design/dmforms/.

2. Existing Facility. A proprietary material may be justified where it are essential for synchronization with an existing highway facility, for which there is no equally suitable alternative.

3. Experimental. A proprietary material may be justified for research purposes or for a distinctive type of roadway. A justifications for an experimental or research item must include a work plan detailing the evaluation to be conducted. Each project on the State highway system must follow the procedures described in the *INDOT Guidelines for Initiating and Reporting Experimental Features Studies*.

4. Approval. Submit the justification to the Production Management Division director for approval. This may occur anytime between Design Approval and Final Plans submittal. Use of a proprietary material on a non-exempt NHS project will require FHWA approval. This will occur when the PS&E is submitted for the letting.

5. Approved Proprietary Material. A list of approved proprietary materials which have been found to be in the public interest for use may be found on the Department's website, at www.in.gov/indot/div/M&T/appmat/appmat.htm. Figure 17-1B lists approved proprietary materials which do not appear on the website's list. No justification is required if such a material is specified for use.

17-2.0 EARTHWORK QUANTITIES

17-2.01 Computerized Computations

Earthwork computations can be determined using a computer and special design software packages. Earthwork quantities for a small project, approach, S-line, side road, ditch, or additional-grading feature may require manual calculations (see Section 17-2.02). For computer calculation of mainline earthwork quantities, the information required is as follows:

1. cross section showing existing and proposed ground surfaces;
2. shrinkage and swell factors; and
3. identification of sections not to be included (e.g., bridge section).

The computer can generate a computation of end areas and volumes for each cross section. Show the actual computed end areas and volumes on the plans cross sections.

17-2.02 Manual Computations

For a small project, or, to calculate special features on a larger project (e.g., approach, ditch), it may be necessary to calculate the earthwork quantities manually. The following procedures apply.

1. Computation Sheet. See Figure 17-2A, Computation Sheet, for that used by the Department. This form can be used for documenting cross-sectional areas and volumes between cross sections. An editable version of this form may also be found on the Department's website at www.in.gov/dot/div/contracts/design/dmforms/.

2. End Areas. The end areas used to compute the quantities are defined by the ground lines and typical-section template. See Figure 17-2B, End Area Template. After the cross sections have been plotted, determine the areas of cut and fill for each cross section using a planimeter. Include the waste of unsuitable soils, undercut, rock excavation, trench excavation, or special excavation or embankment on the section. Record the cut and fill areas for each cross section on the computation sheet.

3. Sum of End Areas. The Sum of End Areas columns are the sum of adjacent cross-section areas for the Cut and Fill columns. The line in the figure is offset between the two end areas. This line indicates that two areas are to be added together.

4. Length. Record the distance between stations in this column.

$$V = \left(\frac{A_1 + A_2}{2} \right)(D)$$ (Equation 17-2.1)

5. Volume Computation. Volumes for excavation (cut) and embankment (fill) are determined using the average-end-area formula,

Where: V = volume, m^3

$A_1 + A_2$ = sum of cut or fill end areas of adjacent sections from the Sum of End Areas, m^2

D = distance between sections, m

These values are recorded in the appropriate Volume of Cut and Volume of Fill columns on the computation sheet.

17-2.03 Shrinkage and Swell Factors

Fill quantities calculated manually or by a computer must be adjusted by the appropriate shrinkage factor to account for the compaction of material, loss from hauling, subsidence of the existing ground caused by the overburden, erosion, and clearing operation. The factors used in the calculations will depend on the soil type, quantity to be moved, and engineering judgment. Sand or gravel has smaller shrinkage factors than clay or silt. For rock excavation, it may be necessary to apply an expansion or swell factor. Figure 17-2C, Shrinkage and Swell Factors, provides factors that may be used for preliminary design purposes. A more definitive value may be available from other sources (e.g., the Geotechnical Report).

Only use one shrinkage factor for the entire project or for each individual balance within the project. The district office may provide guidance in choosing the applicable factor(s) to be used in the calculations. The designer may need to adjust the shrinkage factor to account for smaller quantities.

17-2.04 Balancing

For a large project, it is desirable to approximately balance the earthwork (cut and adjusted fill) for the project. An unbalanced project will require the contractor to haul extra material (borrow) or remove the excess (excavation) from the project site, which will typically increase construction costs. Balancing within the project limits can be accomplished by revising the

profile grade line, revising cut and fill slopes, revising ditch profiles, etc. To determine if balancing is appropriate, the designer should consider the following.

1. Rural New Construction or Reconstruction. It is desirable to make a reasonable effort to balance the earthwork quantities.

2. Rural 3R Project. The need for balancing will be determined for each project as required.

3. Other Project. For an urban-area, interchange, or partial 3R projects it is impractical to provide a balanced grading design. Therefore, it will not be necessary to balance the earthwork.

For a long project, the designer should provide several intermediate balance points. The length of each balance section should not exceed 600 m unless an interchange, rest area, or area of deep cut or fill are included. A bridge is not included within the balance limits.

17-2.05 Earthwork Tabulation

To allow the contractor to determine the amount of excavation, borrow, etc., required, the designer should include an earthwork balance table in the plans. For a long roadway project, provide a separate table for each balance section. Quantities for benching should be included in the earthwork balance. This table should be included on a Road Plan and Profile sheet, typically in the profile half of the sheet. Figure 17-2D, Earthwork Balance Table (Road Project), illustrates the typical format that should be used. For a bridge project, one earthwork tabulation table will be required for the entire project. Show this table on the Layout sheet. Figure 17-2E, Earthwork Tabulation (Bridge Project) illustrates the typical format that should be used.

17-2.06 Linear Grading

The use of the linear grading pay item is generally limited to a project with a minimal amount of earthwork. This will only include the applications as follows.

1. Preventative Maintenance, Functional, or Structural Pavement Treatment. Linear grading consists of earth wedging at the outside edge of each shoulder where the pavement is to receive one of these treatments. If this type of earthwork is significant enough to require benching, linear grading should not be considered.

2. Guardrail. Linear grading consists of earth wedging behind guardrail to obtain the required earth backup for the posts. If this type of earthwork is significant enough to require benching, linear grading should not be considered.

3. Median. Linear grading consists of earth filling a median required for paving shoulders and placement of a concrete median barrier where travel lanes are not being added.

All other earthwork should be paid for as common excavation and borrow.

Where linear grading is being considered, the measurement for payment will be based on the length of roadway per meter measured along the centerline actually constructed to the lines and grades shown in the typical cross section. Measurement will be made once per centerline per area. Typical cross sections should be separated.

The pay-quantity limits should be measured along the roadway centerline, with deductions for bridges, etc. For example, a divided-roadway project length is 8000 m, and includes two bridges with a combined length of 200 m. Linear grading is to be done in the median and beyond the outside shoulders. The linear-grading pay length is 7800 m. The plans should indicate which work is to be included in the linear-grading pay item, both by typical section and in estimated quantities per area of linear grading, i.e., cubic meters of common excavation.

The pay unit for linear grading is meter.

17-2.07 B Borrow

Where B borrow is specified, it should be considered as a separate pay item. All locations where B borrow is to be placed should be shown on the plans. When estimating the quantity of B borrow, the designer should consider the following.

1. Mechanically Stabilized Earth Retaining Wall. B borrow is placed outside of the limits of structure backfill (e.g., beyond the reinforcing straps). Section 17-4.05 provides additional information for determining backfill material quantities for a retaining wall.

2. Unsuitable Materials. B borrow is used to replace unsuitable materials (e.g., peat) within the roadway structure. Section 18-2.06 provides guidance for determining the locations for the placement of B borrow with peat excavation.

3. Culvert Replacement. Where a culvert is to be removed for an existing roadway, replace the culvert excavation material with B borrow.

17-2.08 Structure Backfill

17-2.08(01) Structure-Backfill Types

Structure backfill has been subdivided into types. Each type should be specified as described below.

1. Type 1. This type should be specified for a location as follows:

    a. longitudinal or transverse structure placed under, or within 1.5 m of, the back of paved shoulder or back of sidewalk of a new facility, or

    b. such a structure for an existing facility where all existing pavement is to be replaced.

2. Type 2. This type should be specified for a location as follows:

    a. longitudinal or transverse structure placed under, or within 1.5 m of, the back of paved shoulder or back of sidewalk where undisturbed existing pavement is to remain; or

    b. precast-concrete three-sided or four-sided structure with height of cover of 0.6 m or greater.

3. Type 3. This type should be specified for use behind a mechanically-stabilized-earth retaining wall.

4. Type 4. This type should be specified for a location as follows:

    a. trench where a utility line is present; or

    b. behind a reinforced-concrete slab-bridge end bent.

5. Type 5. This type should be specified for a location as follows:

    a. precast-concrete three-sided or four-sided structure with height of cover of less than 600 mm;

    b. filling voids in an underground facility;

    c. filling in an abandoned pipe or structure; or

d. other application that does not require excavation.

17-2.08(02) Information to be Shown on Plans

Structure backfill is a separate pay item. The pay-item name should include the type. The pay unit is square meter. In estimating the quantity of structure backfill, the following should be considered.

1. Drainage Structure. Section 17-3.0 discusses the procedure for estimating structure-backfill quantities for a drainage structure.

2. Abutment. The quantity of structure backfill should be determined and shown similarly to that for a concrete retaining wall, i.e., 1:1 backslope to a point 0.5 m outside the neat lines of the abutment footing. See Section 17-5.05(01).

3. Retaining Wall. The quantity of structure backfill should be determined and shown on the cross sections at each retaining-wall location. Section 17-5.05(02) provides additional information regarding retaining-wall structure backfill.

17-2.09 Flowable Backfill

Flowable backfill is a separate pay item. It is required for backfilling behind the end bents of a reinforced-concrete slab bridge, or behind the wingwalls of a precast-concrete three- or four-sided structure. It is also required for backfilling a new cross-culvert placed under an existing roadway.

Flowable backfill for use other than as structure backfill should be specified as either removable flowable or non-removable flowable backfill. R should be entered in Structure Data sheet's Flowable Backfill column if the material is removable. N should be entered in the column if the material is non-removable.

17-3.0 DETERMINING PIPE-BACKFILL QUANTITIES

The determination of pipe-backfill quantities is based on the pipe shape, pipe-interior designation, backfill method, and backfill material.

For additional guidance on determining pipe-backfill quantities, see the INDOT *Standard Specifications* or the INDOT *Standard Drawings*, or contact the Production Management Division's Design Resources Team.

17-3.01 Background Information

17-3.01(01) Pipe Shape

The pipe shape is either circular or deformed.

17-3.01(02) Pipe-Interior Designation

The interior of a pipe is either smooth or corrugated. For most pipe structures and pipe types, the contractor will have a choice of pipe materials, of either interior designation. For the purpose of determining backfill quantities, a corrugated interior should be assumed.

17-3.01(03) Backfill Method

The standard backfill methods are described below, and also shown on the INDOT *Standard Drawings*.

1. Method 1. This method should be used for a structure to be placed under a new- or replacement-roadway mainline or public road approach, for a structure to be placed under a median embankment, or for a new structure to be placed under an existing roadway mainline or public road approach.

2. Method 2. This method should be used for a structure to be placed under a drive in new or replacement work, or under an existing drive.

3. Method 3. This method should be used for a structure to be placed under a new- or replacement-roadway's median trench.

17-3.01(04) Backfill Material

Unless instructed otherwise, structure backfill is required for each culvert or storm-drain structure, except a field-entrance culvert which is to be backfilled with suitable excavated material.

The contractor may substitute coarse aggregate as an option for structure backfill for backfilling a concrete culvert, pipe, structural plate pipe, pipe-arch, or arch. However, the backfill material should always be identified as structure backfill. If coarse aggregate is used, the ends and top of the trench are to be capped with geotextile as shown on the INDOT *Standard Drawings*. The geotextile is not a separate pay item.

A specific backfill type should be specified only if, for example, a pipe is to be placed in the vicinity of utilities. Then, flowable backfill should be specified. If structure backfill or flowable backfill are both acceptable alternates, the material should be identified and quantified as structure backfill.

See the INDOT *Standard Drawings* to determine the appropriate backfill materials for the structure based on the backfill method required.

17-3.02 Hand-Calculation of Backfill Quantities

Figure 17-3A identifies the values described below which are required for determining backfill quantities.

For a metric-units project, the English-units procedure described below should be used, with English-units pipe sizes. The final cubic-yards backfill quantities should be converted to cubic meters.

17-3.02(01) Circular Pipe, Earth Foundation

C_t = corrugations thickness = 0.5 in.

$$B_c = H_c = \frac{Inside\,Dia. + 2C_t}{12}$$

T_c = trench cover depth over pipe

V_c = 1 ft for $B_c \leq 1.5$ ft, or 1.5 ft for $B_c > 1.5$ ft

For backfill method 1 or 2, $L_B = 2(5) + Pvmt.\ Width + 2\left[2(T_c + H_c)\right]$,
where $T_c = V_c$. The pavement width is that of the travel lanes plus shoulders.

For backfill method 3, or method 1 in a median embankment,

$L_B = Median\ Width - 2[2(T_c + H_c)] - 2(5)$. The median width excludes the shoulder widths.

$$A_c = \frac{\pi(B_c)^2}{4}$$

$W = 0.3B_c$ or 0.75 ft, whichever is greater

$W_b = 2W + B_c$

$$K = 2W + B_c + \frac{2H_c}{12}$$

For backfill method 3, $K_3 = 2W + B_c + \frac{2(H_c + V_c)}{12}$

$$W_t = K + \frac{2T_c}{12}$$

All methods, backfill quantity, B_{BC}, per linear foot from trench bottom to pipe crown:

$$B_{BC} = \frac{[0.5H_c(W_b + K)] - A_c}{27}$$

Method 1 or 2 backfill quantity, B_{CT}, per linear foot from pipe crown to top of trench:

$$B_{CT} = \frac{T_c(K + W_t)}{54}$$

Method 3 backfill quantity, B_{CV}, per linear foot from pipe crown to top of V_c dimension:

$$B_{CV} = \frac{V_c(K + K_3)}{54}$$

Method 3 backfill quantity, B_{VT}, per linear foot from top of V_c dimension to top of trench:

$$B_{VT} = \frac{(T_c - V_c)(K_3 + W_t)}{54}$$

Method 1 backfill per linear foot = $B_{BC} + B_{CT}$.
Method 1 total backfill quantity = $L_B(B_{BC} + B_{CT})$.

For backfill method 2, B_{BC} and B_{CT} each represent different materials, so the quantities should not be added. The total quantity for method 2's B_{BC} material is $(L_B)(B_{BC})$. The total quantity for method 2's B_{CT} material is $(L_B)(B_{CT})$.

For backfill method 3, B_{BC} and B_{CV} are the same material, so the total method 3 quantity of this material is $L_B(B_{BC}+ B_{CV})$. B_{VT} represents a different material, so it should not be added to $B_{BC}+ B_{CV}$. The total quantity for method 3's B_{VT} material is $(L_B)(B_{VT})$.

17-3.02(02) Circular Pipe, Rock Foundation

The total backfill quantity is that required for an earth foundation plus the foundation backfill required below the pipe. The additional volume is determined as follows:

A = 8 in. or 2/3 ft. The entry in the formula below for W_F must be made in feet.

$$W_F = 2W + B_c - \frac{2A}{12}$$

Backfill quantity, B_F, per linear foot of foundation area:

$$B_F = A\left(\frac{W_b + W_F}{2}\right)$$

Total foundation-backfill quantity = $(L_B)(B_F)$

17-3.02(03) Deformed Pipe, Earth Foundation

C_t = corrugations thickness = 0.5 in.

$$B_c = \frac{Span + 2C_t}{12}$$

$$H_c = \frac{Rise + 2C_t}{12}$$

For backfill method 1 or 2, $L_B = 2(5) + Pvmt.\ Width + 2\left[2(T_c + H_c)\right]$, where $T_c = V_c$. The pavement width is that of the travel lanes plus shoulders.

For backfill method 3, or method 1 in a median embankment, $L_B = Median\ Width - 2[2(T_c + H_c)] - 2(5)$. The median width excludes the shoulder widths.

$$A_c = \frac{(Pipe\ Opening)(C_t)(P)}{12}$$

$W = 0.3B_c$ or 0.75 ft, whichever is greater

$W_b = 2W + B_c$

$$K = 2W + B_c + \frac{2H_c}{12}$$

All methods, backfill quantity, B_{BC}, per linear foot from trench bottom to pipe crown:

$$B_{BC} = \frac{[0.5H_c(W_b + K)] - A_c}{27}$$

Method 1 or 2 backfill quantity, B_{CT}, per linear foot from pipe crown to top of trench:

$$B_{CT} = \frac{T_c(K + W_t)}{54}$$

Method 3 backfill quantity, B_{CV}, per linear foot from pipe crown to top of V_c dimension:

$$B_{CV} = \frac{V_c(K + K_3)}{54}$$

Method 3 backfill quantity, B_{VT}, per linear foot from top of V_c dimension to top of trench:

$$B_{VT} = \frac{(T_c - V_c)(K_3 + W_t)}{54}$$

Method 1 total backfill per linear foot = $B_{BC} + B_{CT}$.
Method 1 total backfill quantity = $L_B(B_{BC} + B_{CT})$.

For backfill method 2, B_{BC} and B_{CT} each represent different materials, so the quantities should not be added. The total quantity for method 2's B_{BC} material is $(L_B)(B_{BC})$. The total quantity for method 2's B_{CT} material is $(L_B)(B_{CT})$.

For backfill method 3, B_{BC} and B_{CV} are the same material, so the total method 3 quantity of this material is $L_B(B_{BC}+ B_{CV})$. B_{VT} represents a different material, so it should not be added to $B_{BC}+ B_{CV}$. The total quantity for method 3's B_{VT} material is $(L_B)(B_{VT})$.

17-3.02(04) Deformed Pipe, Rock Foundation

The total backfill quantity is that required for an earth foundation plus the foundation backfill required below the pipe. The additional volume is determined in the same manner as for a circular pipe.

17-3.03 Computer Program for Determining Backfill Quantities

The computer program, Backfill Calculation Software, is now available on the Department's website at www.in.gov/dot/div/contracts/standards/07Bkfl-qt.xls. The program, along with its related reference sheets and examples, is currently available in English measurement units only. Use of the program precludes the need for hand-calculations. For a metric-units project, the final cubic-yards backfill quantities determined from use of the program should be converted to cubic meters.

For a circular pipe, the input data include pipe diameter, pavement or median width as required, and T_c.

For a deformed pipe, the input data include pipe size, pavement or median width as required, T_c, span, rise, and perimeter P. Span, rise, and P can be determined from the reference sheets included with the program.

The following backfill-quantities calculation examples are included with the program.

1. Method 1, Circular Corrugated Pipe, Rock Foundation
2. Method 1, Deformed Smooth-Interior Pipe, Earth Foundation
3. Method 1, Circular Smooth-Interior Pipe, Earth Foundation
4. Method 2, Circular Corrugated Pipe, Earth Foundation
5. Method 2, Circular Corrugated Pipe, Structural-Plate Metal, Rock Foundation
6. Method 2, Deformed Corrugated Pipe, Earth Foundation
7. Method 3, Circular Corrugated Pipe, Earth Foundation
8. Method 3, Deformed Corrug. Pipe, Structural-Plate Aluminum Alloy, Earth Foundation
9. Method 3, Deformed Corrugated Pipe, Structural-Plate Steel, Rock Foundation

17-3.04 Video Inspection

Video inspection will be required for each pipe that cannot be visually inspected. A structure which will require video inspection is 100% of the length of a pipe deemed by the designer to be difficult or impossible to visually inspect or is inaccessible for visual inspection. This includes each location considered to be in a confined space. Commercial- and private-drive pipes will not be video inspected. This is a pay item, and should be applied as necessary to each non-underdrain pipe pay item, without regard to INDOT *Standard Specifications* reference number.

17-3.05 Information to be Shown on Plans

The backfill method, material, and quantity; geotextile quantity if applicable; and video-inspection quantity if applicable, should be shown in the Structure Data table for each pipe structure. For a metric-units project, the metric pipe sizes should be shown on the plans, though English pipe sizes were used to determine the backfill quantities.

17-4.0 ROADWAY QUANTITIES

17-4.01 Pavement Materials

Chapter Fifty-two discusses INDOT pavement design criteria. It also provides information for quantity determinations of subgrades, asphalt materials, concrete materials, underdrains and geotextile wraps. Figure 17-4A, Roadway Factors, provides factors that can be used to determine asphalt pavement and other roadway quantities.

The following method should be used to determine quantities for shoulder corrugations. For an Interstate route, it is sufficient to multiply the number of shoulders requiring corrugations, usually four, by the gross project length in meters. For another type of facility, it is acceptable to multiply the number of shoulders that require corrugations by the gross project length in meters by 0.8 to account for the gaps in the intermittent corrugation pattern. It is not necessary to subtract the length of gaps at bridge approach slabs and bridge decks, driveways, median crossovers, or public road approaches when calculating the quantity. It is also not necessary to subtract the length of non-corrugated shoulder less than 2.1 m wide adjacent to a roadside barrier.

17-4.02 Subgrade Treatment

The subgrade is defined as the top surface of a roadbed upon which the pavement structure and shoulders are constructed. The subgrade area should be computed for all areas of new pavement or shoulders, including cuts and fills. The width of the treatment is between points which are 0.6 m, or as determined, outside the edges of paved shoulders or back faces of curbs, as shown in Chapter Fifty-two, or as instructed by the Production Management's Office of Geotechnical Services. The lateral limits and type of subgrade treatment should be shown on the Typical Cross Sections on the plans.

17-4.02(01) Subgrade-Treatment Types

For each of the subgrade treatment types described below, the contractor is to choose from the applicable options for each type. Where subgrade treatment other than that described here is recommended by the Office of Geotechnical Services, a special provision should be prepared.

The subgrade treatment methods are as follows:

1. Type I**.** The contractor's options are as follows:
   a. 400 mm chemical soil modification;
   b. 300 mm of the subgrade excavated and replaced with coarse aggregate No. 53; or
   c. 600 mm of soil compacted to density and moisture requirements.

2. Type IA. The contractor's options are as follows:
   a. 400 mm chemical soil modification; or
   b. 300 mm of the subgrade excavated and replaced with coarse aggregate No. 53.

3. Type II. The contractor's options are as follows:
   a. 200 mm chemical soil modification;
   b. 150 mm of the subgrade excavated and replaced with coarse aggregate No. 53; or
   c. 300 mm of soil compacted to density and moisture requirements.

4. Type IIA. The contractor's options are as follows:
   a. 200 mm chemical soil modification; or
   b. 150 mm of the subgrade excavated and replaced with coarse aggregate No. 53.

5. Type III. The contractor's options are as follows:
   a. 150 mm of soil compacted to density and moisture requirements; or
   b. 150 mm of the subgrade excavated and replaced with coarse aggregate No. 53.

6. Type IIIA. This treatment consists of 150 mm of the subgrade excavated and replaced with coarse aggregate No. 53.

7. Type IV. This treatment consists of 225 mm of the subgrade excavated and replaced with coarse aggregate No. 53 on geogrid.

17-4.02(02) Subgrade-Treatment Type Determination

1. Project With Subgrade-Treatment Type Determined per Former Practice. The designer should transmit a memorandum to the Office of Geotechnical Services. Such memorandum should request that the Office of Geotechnical Services review the pavement design to determine the subgrade-treatment type or types required as described herein. Once the Office of Geotechnical Services transmits its determination to the designer, the designer must revise the plans, pay items, and pay quantities accordingly.

   A project that did not require subgrade treatment per former practice will likely do so now.

2. Project With Subgrade-Treatment Type Yet to be Determined. The preliminary field check plans should include projected AADT figures and subgrade-treatment areas tabulated for each survey line as shown in Figure 17-4B. During the field check, the Office of Geotechnical Services should be informed of possible shallow utilities, temporary pavement, need for a temporary runaround, or night construction so that it can make suitable recommendations for subgrade type. Such considerations should be documented in the field check minutes.

   The type or types of subgrade treatments described in Section 17-4.02(01) to be used will be specified in the Geotechnical Report. If the Geotechnical Report does not specify the subgrade-treatment type, the designer should send a memorandum requesting the subgrade treatment to the Office of Geotechnical Services.

   The field check may have already been conducted, but the Geotechnical Report may not yet have been received by the designer. For this situation, the designer should submit to the Office of Geotechnical Services the tabulation and information regarding shallow utilities, temporary pavement, need for a temporary runaround, or night construction so that it can make suitable recommendations for subgrade type.

17-4.02(03) Determining Pay Items and Quantities

A divided highway may have parallel but separate subgrade-treatment areas, likely of the same type, depending upon the width of the median. An isolated area such as that on an S-line, median crossover, or possibly a portion of the mainline, may be of a different treatment type than that of the mainline. Quantities should be determined for each required subgrade-treatment pay item.

17-4.03 Placing Pipe Under Existing Pavement

Pay quantities for backfill and pavement replacement work at an installation or replacement of a pipe, culvert, structure, or utility line placed either transversely or longitudinally under an existing paved-roadway alignment will be determined as described below.

17-4.03(01) Determining the Longitudinal Pay Limits of the Pavement Replacement

The following equations, along with the INDOT *Standard Drawings*, should be used to determine the longitudinal pay limits, *L*, in meters, of the pavement replacement.

1. Structure of 750 mm Diameter/Span or Smaller.

$$L = 1.6 + \frac{d}{6} + \frac{B_c}{1000} \qquad \text{[Equation 17-3.1]}$$

where d = vertical distance from flow line to profile grade, meters
B_c = inside diameter or span, millimeters

2. Structure of Diameter/Span of Greater Than 750 mm.

$$L = 1.2 + \frac{d}{6} + 0.0016 B_c \qquad \text{[Equation 17-3.2]}$$

17-4.03(02) Determining Pavement Quantities

The pavement material to be placed should match the existing pavement section as closely as possible. If the existing section is shallower than the minimum section shown on the INDOT *Standard Drawings*, such minimum section should be specified. The designer will determine the existing pavement section from the most recent approved pavement design or existing typical cross sections details. If the existing asphalt pavement section cannot be determined, the minimum HMA section shown on the INDOT *Standard Drawings* with 240 kg/m^2 HMA Base

should be specified. If the existing concrete pavement section cannot be determined, a minimum PCCP section of 225 mm depth should be specified. The same new pavement section should be used for both travelway and shoulders.

1. Asphalt Pavement. Hot mix asphalt (HMA) pavement quantities should be determined for Surface, Intermediate, or Base courses. The thickness of each course should approximate that in place with consideration given to current practice in determining course thicknesses. If a thicker section than the minimum is required, the additional thickness should consist of HMA Base 25.0 mm. The courses and lay rates should be shown on the plans.

   The pay unit is megagram. The type should be determined as described in Section 52-9.02(03). Quantities should be determined for each course and summed to obtain a total quantity of HMA for structure installation to be shown on the plans on the Structure Data sheet in the Pavement Replacement, HMA columns.

2. Concrete Pavement. The required portland cement concrete pavement (PCCP) quantity is the travelway and shoulder widths times *L* as determined above. The pay unit is square meter. The same pay item should be specified without regard to the required pavement depth. The required depth should be shown on the plans. The new subbase should match the existing thickness and type, whether the existing subbase is open graded or dense graded. The PCCP quantity should be shown on the plans on the Structure Data sheet in the Pavement Replacement, PCCP column.

3. Composite Asphalt over Concrete Base. HMA of the thickness in place should be placed on PCCP of the minimum or greater thickness if required. The HMA material should consist of HMA for Structure Installation as required. The new subbase should match the existing thickness and type, whether the existing subbase is open graded or dense graded. The quantities should be determined and shown on the plans as described in Items 1 and 2 above.

17-4.03(03) Determining Backfill Quantities

Quantities for backfill should be determined based on the section shown in the INDOT *Standard Drawings*, and as described in Section 17-3.01(03). The backfill quantities should be shown on the Structure Data sheet in the appropriate Backfill column. If no Structure Data sheet is included with the plans, the backfill quantities should still be shown on the plans.

17-4.03(04) Determining Underdrain Quantities

Underdrains, if present, should be perpetuated. The only pay quantity will be for the linear measure of underdrains based on the existing configuration. The pay unit is meter. Quantities should not be determined for underdrain pipe, aggregate for underdrains, geotextile for underdrains, HMA for underdrains, outlet protector if required, video inspection for underdrains, and all other incidentals for underdrains, as this work is included in the cost of the pay item.

17-4.04 Subbase and Underdrains for Cement Concrete Pavement

17-4.04(01) Subbase

The subbase under cement concrete pavement consists of two aggregates. Coarse Aggregate Size No. 8 on top of Compacted Aggregate Base, Type O, No. 53. The INDOT *Standard Specifications* provides the criteria for thickness of these aggregates. The bottom layer of this composite subbase should be designated on the plans as a separation layer. Include this separation layer in a cement-concrete mainline, S-line, or approach pavement except a drive. For estimating and payment purposes, combine the quantities for both aggregate types and designate them together as Subbase for Cement Concrete Pavement. For additional guidance, see Chapter Fifty-two and the INDOT *Standard Specifications*.

17-4.04(02) Underdrains

Underdrains are required under new pavement. Locate the underdrain in the pavement structure as shown in Chapter Fifty-two and provide a detail in the construction plans. For additional guidance, see Chapter Fifty-two and the INDOT *Standard Specifications*. Where underdrains are used, include the following pay items.

1. Underdrain. The underdrain will consist of the pay items as follows:

    a. Pipe, Type 4, Circular, *(size)* mm;

    b. Geotextile for Underdrains; and

    c. Aggregate for Underdrains. Only the aggregate placed below the subgrade is included as aggregate for underdrains.

2. Underdrain Outlets. Underdrain outlets will consist of the pay items as follows:

    a. Pipe Underdrain Outlet, *(size)* mm;

b. Outlet Protector, *(type)* ; and
c. Delineator Post.

17-4.05 Non-Standard Concrete Median Barrier

A non-standard concrete median barrier may be required on a horizontal curve, superelevation transition, or other locations where the barrier height varies from the standard dimensions, or where the median barrier is attached to a concrete footing or wall cap. Identify these locations on the plans and include the pay items Concrete, Class A and Reinforcing Steel, on the plans. Also, include a special provision in the contract.

A short length of irregular concrete median barrier section used in conjunction with the standard shape, a barrier at an approach to a bridge pier, sign foundation, or other similar support should be considered concrete median barrier and quantified as concrete barrier.

17-4.06 Concrete Curb Ramps

The pay limit for each curb ramp type is shown on the INDOT *Standard Drawings*. The approximate pay quantity for each type of curb ramp is described in Figure 17-4D, Quantities for Curb Ramps. Quantities for curb or curb and gutter within the curb-ramp limits should be incorporated into the project's appropriate curb or curb-and-gutter quantities. Quantities for sidewalk required outside the curb-ramp pay limit, including those for additional landing area or improved access area, should be incorporated into the project concrete sidewalk quantities. If flared sides are sod instead of concrete, such sodding should be incorporated into the project sodding quantities.

17-4.07 Sodded, Paved, or Riprap Ditch

A longitudinal-ditch slope of flatter than 1% will be seeded. A slope of 1% or steeper, but flatter than 3%, will require sodding. A slope of 3% or steeper will require a paved side ditch or riprap lining. However, in an area of poor soil, a slope of flatter than 3% may be paved or lined with riprap. A riprap ditch is typically used in a rural area and should be avoided in an urban area. The final ditch-protection type will be determined at the field check in consultation with the district office. The following discusses how to estimate the quantities for each ditch type.

17-4.07(01) Sodded Ditch

A standard sodded ditch is that which is parallel to the pavement profile grade line. A special sodded ditch is that which varies in elevation with respect to the pavement profile grade line. Depending on the side slopes, either ditch type may be used within the clear zone. Do not use a ditch with side slopes of 3:1 or steeper within the clear zone.

A ditch should be sodded to a point 300 mm above the flow line. Figure 17-4E, Sodded Ditch Quantities, provides the factors that can be used to determine the sodding quantities for a 1.2-m wide sodded ditch based on various side slopes.

17-4.07(02) Paved Side Ditch

The INDOT *Standard Drawings* and Figure 17-4F, Paved Side Ditch, illustrate the types of paved side ditch used by the Department. To determine the type of paved side ditch, use the criteria provided in Section 30-3.03(02).

When computing quantities, the designer should consider the following.

1. Limits. Where a paved side ditch meets a sodded or unsodded ditch flowing in the same direction, extend the limits of the paved side ditch 8.0 m beyond the theoretical point of termination. A longer distance may be required under special circumstances.

2. Measurement. Paved side ditch is measured from station to station in meters. For a grade of 20% or flatter, increase the measured distance from the plans by 5% to compensate for grade. For a grade steeper than 20%, increase the measured distance by 10%.

3. Transition. A paved-side-ditch transition is required at an intersection with an earth ditch or pipe culvert. Convert the transition to an equivalent length of the type of paved side ditch specified. A transition of 3 m or shorter is also required between two different types of paved side ditches. The transition is provided for in the pay length of the larger type of paved side ditch type specified.

4. Cutoff Wall. A cutoff wall is required at the beginning and end of each paved side ditch. Each cutoff wall is considered to be equivalent to 2.5 m of the paved-side-ditch type specified at a location. Therefore, add an additional 2.5 m to the measured paved-side-ditch quantity for each cutoff wall required.

5. Lug. A lug is provided to prevent sliding on a steep slope. Each lug is considered equivalent to 2.5 m of the paved-side-ditch type specified at a location. Therefore, add an

additional 2.5 m to the measured paved-side-ditch quantity for each lug required. Lugs should be provided at the locations as follows:

a. 3 m downslope from a grade change;

b. 3 m downslope from the intersection of two different types of paved side ditches;

c. at the downslope end of a transition between two different types of paved side ditches; or

d. at the intervals shown in Figure 17-4G, Lug Intervals.

6. Sodding. Provide sodding next to a paved side ditch as shown in Figure 17-4F, Paved Side Ditches. To determine the sodding quantity, use a factor of 0.8 m^2 per meter of paved side ditch. This factor is applicable for all paved-side-ditch types.

17-4.07(03) Riprap-Lined Ditch

When designing a riprap-lined ditch, consider the following:

1. Revetment riprap may be used for a slope of 3% or steeper, but 10% or flatter. Class I or class II riprap should be used for a slope steeper than 10%.

2. At a bridge cone, use the riprap type specified for the bridge cone.

3. Where a riprap ditch meets a sodded or unsodded ditch flowing in the same direction, extend the limits of the riprap 8.0 m beyond the theoretical point of termination.

4. Place geotextile under the riprap.

5. Show the ditch details on the plans.

6. Use uniform riprap for a ditch which is within the clear zone.

17-4.08 Mailbox Assembly and Mailbox Approach

A project on a rural non-Interstate-route will require mailbox assemblies. Section 51-11.0 provides guidance on the design and location of a mailbox approach. If mailbox locations are not shown on the topographic survey, the designer should not assume that mailboxes are not present on the route. In the absence of survey information, the designer should check for

mailboxes at the field check review. The use of the videolog will also aid in determining the location and number of mailboxes.

Figure 17-4H, Mailbox Summary Table, illustrates the mailbox quantities that should be used. If the designer is certain that mailboxes are not located within the project limits, there is no need to include the work in the plans.

17-4.09 Monuments

17-4.09(01) General

A monument is set to define a certain civil boundary such as a section line, or to permanently establish a vital survey point. Monuments used by the Department are shown in the INDOT *Standard Drawings* and are defined as follows.

1. Monument Type A. Use this type with vitrified brick or asphalt surface on concrete base.

2. Monument Type B. Use this type with an asphalt pavement.

3. Monument Type C. Use this type where a monument is required outside the pavement area.

4. Monument Type D. Use this type with a concrete pavement.

5. Benchmark Post. Use this type to establish a Department benchmark.

6. Section Corner Monument. Use this type to monument a section corner.

It is the responsibility of the designer to select the type of monument that best suits the location where a monument is required.

17-4.09(02) Civil Boundary

The following will apply.

1. Location. Provide a monument at each section corner or quarter-section corner that appears within the right of way for a new facility, or for a facility to be reconstructed except as described in Item 2 below. Where a section line crosses a limited-access

facility, provide a monument at the intersection of the right-of-way line and the section line. For fenced, limited-access right of way, place the monument outside the fence at each point where the section line crosses the limited-access right-of-way line.

2. Responsibilities. The district office will request the county surveyor to establish each section corner or section line not already defined by a monument at the time of construction. If the county surveyor fail to establish each such point as requested, the district office will eliminate each monument provided for this purpose from the contract.

3. Plans. Designate each monument by type and show it on the plans with an arrow to its approximate location.

17-4.09(03) Survey-Line Control Point

A survey-line control point and its respective monument are used as the basis for the description of all right of way that is acquired. With respect to right-of-way description, it is as significant as a section corner. A survey-line control-point monument must be set by a registered land surveyor. A partial 3R project or a project not requiring additional right of way is exempt from this requirement. The following will apply.

1. Monumenting PI, PC, or PT. The following will apply.

   a. Where a PI appears within the right of way, provide a monument at the PI.

   b. Provide a monument for each PC or PT.

   c. Designate each monument by type and show it on the plans with an arrow to its approximate location.

2. Monumenting Beginning and End Point of Project. Place a monument on the survey centerline at each of these points.

3. Monumenting POT or POC. The following will apply.

   a. It is not necessary to monument each POT or POC. These intermediate points are to be monumented as necessary so that the maximum interval between adjacent monuments does not exceed 300 m.

   b. The designer must inspect the plans and select intermediate points to be monumented so that an instrument operator can see a tripod with a target set on an

adjacent monument in at least one direction. For this purpose, use a line-of-sight of 1.2 m above adjacent monuments.

c. Locate each monument such that the line-of-sight between adjacent monuments will appear within the right of way.

d. Where practical, a monument required to define a POC or POT should coincide with a POC or POT established during the original survey for greater accuracy in locating the monument.

e. Designate each POC or POT monument by type and station and show it on the plans with an arrow to its approximate location.

17-4.09(04) INDOT Benchmark

A benchmark should be provided at least every 2.5 km. It should be located as follows.

1. Structure. Include a benchmark on each bridge, slab-top culvert, or box culvert. Where twin structures or dual structures are constructed at the same location, a benchmark is required only on one structure.

2. Non-Structure. Where the spacing of structures is in excess of 2.5 km, show benchmark posts on the plans and space them such that the maximum spacing between benchmarks is 2.5 km.

3. Plans. Designate each benchmark post required under Item 2 by station on the plans with the note as follows:

   Benchmark Post Required
   Station _____ + _____

17-4.09(05) Correcting Plans

The district construction engineer will notify the Production Management Division's Survey Team if monuments are to be eliminated from the contract or the location of a monument is changed. The as-built plans are to reflect any changes made to the monument locations shown in the construction plans.

17-4.09(06) Right-of-Way Marker

See Section 85-7.0 for information.

17-4.09(07) National Geodetic Survey Benchmark

Each National Geodetic Survey (NGS) benchmark disturbed by highway construction must be re-established. It is the responsibility of the Contractor to secure the replacement disk for such a benchmark. In addition, the construction plans should include the note as follows:

> N.G.S. Benchmark Post No. _____,
> Station _____, (Rt.) (Lt.) shall be re-established by the Contractor.

Information for field procedures on resetting a NGS benchmark may be obtained by making the contacts as follows:

For Illinois benchmark:

Illinois Geodetic Advisor
IDOT Administration Building, Room 005
2300 South Dirksen Parkway
Springfield, IL 62764
(217) 524-4890

For Indiana benchmark:

Coordinator for Indiana
Area of Surveying Engineering
School of Civil Engineering
Purdue University
1284 Civil Engineering Building
West Lafayette, IN 47907-1284
(765) 494-2165

17-4.09(08) NGS Horizontal-Control Point (formerly Triangulation Point)

The designer is responsible for notifying the NGS if a NGS horizontal-control point must be re-established due to proposed highway construction. This notification will be by letter from the Production Management Division director and should be made at the time the plans are sent to the district office.

It is not necessary to include a monument in the plans for use in re-establishing a NGS horizontal-control point. However, the appropriate monument should be requested from the NGS to replace the existing monument being re-established. The NGS address is as follows:

> National Geodetic Survey
> NOAA RC

325 Broadway
Boulder, CO 80303

17-4.09(09) United States Geological Survey Benchmark

Each United States Geological Survey (USGS) benchmark disturbed by highway construction must also be re-established. Information on resetting such may be obtained by contacting the following:

U.S. Geological Survey
Mid-Continent Mapping Center, MS 309
1400 Independence Road
Rolla, MO 65401
Telephone: (573) 308-3808
Fax: (573) 308-3652

17-4.10 Seeding and Sodding

17-4.10(01) Seeding for Grading and Paving Project

The following will apply.

1. Rural Area of 4000 m^2 or Larger. An area within the right of way that is not sodded or paved should be seeded as follows.

    a. Seeding. Use Seed Mixture R as specified in the INDOT *Standard Specifications*. Estimate the quantity assuming an application rate of 190 kg/ha.

    b. Mulching. Use the pay item Mulching Material and estimate it at a rate of 4.5 Mg/ha.

    c. Fertilizer. For estimating purposes, assume an application rate of 900 kg/ha.

2. Urban Area of 4000 m^2 or Larger. An area within the right of way that is not sodded or paved should be seeded as follows.

    a. Seeding. Use Seed Mixture U as specified in the INDOT *Standard Specifications*. Estimate the quantity assuming an application rate of 165 kg/ha.

b. Mulching. Use the pay item Mulching Material and estimate it at a rate of 4.5 Mg/ha.

c. Fertilizer. For estimating purposes, assume an application rate of 900 kg/ha.

3. Rural Area of Smaller Than 4000 m^2. For an area within the right of way which is not sodded or paved, use the pay item Mulched Seeding R. Estimate the area and pay quantity in square meters.

4. Urban Area of Smaller Than 4000 m^2. For an area within the right of way which is not sodded or paved, use the pay item Mulched Seeding U. Estimate the area and pay quantity in square meters.

17-4.10(02) Seeding for Grading Project

The following will apply.

1. Shoulder Point to Shoulder Point. The area between the outside shoulder points should be seeded as follows.

   a. Seeding. Use Seed Mixture P as specified in the INDOT *Standard Specifications*. Estimate the quantity assuming an application rate of 90 kg/ha.

   b. Fertilizer. For estimating purposes, assume an application rate of 450 kg/ha.

2. Shoulder Point to Right-of-Way Line. The area between the outside shoulder point and the right-of-way line should be seeded according to the requirements for a grading and paving project as discussed in Section 17-3.10(01).

17-4.10(03) Temporary Seeding [Rev. Mar. 2008]

Temporary seeding is used to establish seeding where temporary cover is required for soil disturbed during construction operations (e.g., temporary runaround). and where late-season soil stabilization and temporary ground cover is required. The following will apply.

1. Seeding. Use seed mixture T, conventional mix, as specified in the INDOT *Standard Specifications*. Estimate the quantity assuming an application rate of 80 lb/ac.

2. Mulching. Use the pay item Mulching Material and estimate it at a rate of 2 t/ac.

3. Fertilizer. For estimating purposes, assume an application rate of 200 lb/ac.

The designer should be alert to recognize each work area where soil will be disturbed by construction operations, and is likely to remain in an uncovered state, especially on a multi-phase project, for an extended period of time. Temporary-seeding locations should be shown on the plans, and temporary-seeding-related pay items and quantities should be included to eliminate the need for the negotiation of a contract change order.

17-4.10(04) Seeding for Environmental Mitigation

Where environmental mitigation is required by the environmental document, the Design Summary, or as determined from a field check, specify one of the following seed mixtures.

1. Seed Mixture Grass. The following will apply.

   a. Type 1. Specify this mixture where a special grass is required in addition to the regular seed mixture. The pay item is Seed Mixture Grass Type 1. For estimating purposes, assume an application rate of 220 kg/ha.

   b. Type 2. This mixture is to be furnished at the contractor's expense instead of the regular seed mixture in an urban area that has been disturbed beyond the construction limits.

2. Seed Mixture Legume. The following will apply.

   a. Type 1. Specify this mixture where a special legume mixture is required in addition to the regular seed mixture. The pay item is Seed Mixture Legume Type 1. For estimating purposes, assume an application rate of 214 kg/ha.

   b. Type 2. This mixture is to be furnished at the contractor's expense instead of the regular seed mixture in a rural area that has been disturbed beyond the construction limits.

   c. Signs. Include "Do Not Spray" signs where this mixture is specified.

17-4.10(05) Wildflower Seed Mixture

Where a wildflower seed mixture is specified, prepare the necessary special provisions so that at least three alternatives of equal cost, type, and growing condition are available for the contractor to select. These alternates may be designated by alternate vendors' formulations, by the designer's own non-proprietary formulations, or any combination thereof that results in three equal alternatives. Ensure that alternate component varieties for non-proprietary formulations allow the contractor to make substitutions for component varieties that may be in short supply. If the designer has any questions regarding application rates, method of measurement, or pay item descriptions, he or she should contact the Production Management Division's landscape architect.

17-4.10(06) Sodding

In determining the need for sodding, the designer should consider the following.

1. Sod. Sod should be included as described as follows:

    a. in an earth ditch with longitudinal slope of 1% or steeper but flatter than 3%;

    b. along a paved side ditch (see INDOT *Standard Drawings*);

    c. at a bridge-cone area near a bridge structure as shown in Figure 17-4 I, Riprap and Sodding Limits with Barrier Transitions on Bridge, or Figure17-4J, Riprap and Sodding Limits with Barrier Transitions on RCBA;

    d. in a median ditch of a divided highway; see Figure 17-4 I, Sodding Locations; and

    e. at side-slope break points; see Figure 17-3 I.

2. Nursery Sod. Nursery sod will be required for all exposed surfaces within the right of way of a developed area (i.e., commercial, industrial, residential). A maintained lawn expected to be disturbed by construction a rural area will also require nursery sodding.

3. Estimates. Estimate the area of sod and nursery sod in square meters.

4. Water. To estimate the amount of additional water required for sod and nursery sod, assume a rate of 18 L/m^2. The pay unit is kiloliter, symbol kL.

17-4.10(07) Mobilization and Demobilization for Seeding

If pay items for seeding are required, at least one each of the pay item Mobilization and Demobilization for Seeding is required. If the project includes a temporary runaround, add at least one additional unit to the estimate. Additional units may be added as required for the likely progression of work (e.g., for the various construction phases).

17-4.11 No-Passing-Zone Pavement Markings

If a no-passing zone extends beyond the project limits, striping quantities should include required solid-yellow lines and adjacent broken-yellow lines to the ends of such no-passing zone.

17-4.12 Spare Parts Package for Guardrail End Treatment or Impact Attenuator

If a guardrail end treatment or impact attenuator is required, the designer should contact the appropriate district Office of Roadway Services regarding the number of each type and stage of spare parts packages desired. The Office will provide the number of each required, along with the delivery location. Only one delivery address will be permitted. The appropriate recurring special provisions should be modified to incorporate this information and included in the contract documents. The appropriate pay items and quantities should be incorporated into the estimate of quantities and cost estimate.

17-4.13 Temporary Traffic Barrier (TTB)

The total pay quantity of each type of TTB should be computed only once, regardless of how may traffic-maintenance phases it is to be used in, or how many times it must be moved.

The length of the longitudinal portion of TTB should be taken from the beginning point of where it is required to the ending point of where it is required. Gaps required to accommodate public road approaches or drives should be subtracted out. The length of each such gap should be taken as the approach or drive width plus its radii. The lengths of each flared portion should be measured along the flare.

A construction-zone energy-absorbing terminal, if required for use with TTB type 1 or type 3, is a separate pay item to be quantified only once, regardless of how many traffic-maintenance phases it is to be used in, or how many times it must be moved. The length of each construction-zone energy-absorbing terminal, if required for use with TTB type 2 or 4, should be taken as 11.43 m where used along an outside shoulder, or 3.81 m where used along a median shoulder. Such lengths should be included in the linear quantities of TTB.

Delineation, and anchoring or other means required to control deflection, are included in the TTB quantities, so they should not be considered when determining the pay quantities.

17-4.14 High-Tension Cable-Barrier System (CBS) [Added May 2008]

1. Plans. The longitudinal and transverse CBS locations should be shown on the plans. A geotechnical investigation of the soil conditions will be required for the approximate locations of the safety terminal and the representative locations of the intermediate line-post foundations at the respective sites throughout the entire length of the proposed barrier installation. The geotechnical-investigation results should be incorporated into the contract documents.

2. Quantities. The length of each end terminal should be included in the quantities for CBS. A safety terminal should be included for each end of each CBS run. One spare-parts set should be included. The plans should show all necessary linear-grading work to be done in the median. The quantities should be included in a pay item for linear grading. A traffic-control plan should be included, along with a pay item for maintaining traffic.

17-5.0 BRIDGE QUANTITIES

17-5.01 Structural-Concrete Quantities

17-5.01(01) Cast-In-Place Concrete

Measure concrete quantities, in cubic meters, based on the theoretical volume for the class and use specified. Do not deduct for the volume of piles, joint material, or reinforcing steel within the concrete.

17-5.01(02) Concrete Structural Members

Prestressed I beams and bulb-tee beams will be measured by the meter. There is no measurement per each or lump sum. Prestressed box beams will be measured by the square meter.

17-5.02 Excavation Quantities

Structure excavation can consist of several types of excavation. In addition to the INDOT *Standard Specifications*, Figure 17-5A, Structure Excavations, and the following discuss the various structure-excavation types and how to determine the applicable quantities.

1. Class X Excavation. Specify the pay item Excavation, X, where solid rock, loose stones, boulders of more than 0.4 m^3 in volume, concrete footings from old structures not shown on the plans, timber grillages, piles, or other similar materials are encountered within the limits of foundation excavation. The volume of class X excavation is determined as follows:

   Class X Excavation = L x W x D

   Where: L = length of footing, meters
   W = width of footing, meters
   D = depth of class X excavation, meters (See note * in Figure 17-5A)

   D extends from the bottom of the footing to the top of the rock elevation.

2. Wet Excavation. Specify the pay item Excavation, Wet, where foundation excavation is encountered below a horizontal plane designated on the plans as the upper limit of wet excavation. The limits for wet excavation quantities are defined as the theoretical volume bounded by the bottom of the footing, the upper limit of wet excavation and vertical planes which are 0.5 m outside the neat lines of the footing and parallel thereto. The elevation of the upper limit of wet excavation is the low-water elevation plus 0.3 m. The volume of any class X excavation encountered within these limits must be subtracted from the wet excavation quantities. The volume of wet excavation is determined as follows:

   Wet Excavation = $(L+1)(W+1)(D)$

   Where: L = length of footing, meters
   W = width of footing, meters
   D = depth of wet excavation, meters (See note * in Figure 17-5A)

   Additional quantities may be required outside these limits for the following conditions.

   a. The plans show a cofferdam with dimensions that exceed 0.5 m outside the footing and the cofferdam is not a pay item. The theoretical volume for wet excavation will be based on the dimensions of the cofferdam as shown in the plans.

b. A foundation seal is required. The wet-excavation limits will be extended to the bottom elevation of the foundation seal.

If a portion of the present structure lies wholly or partially within the limits of wet excavation, do not alter the pay quantities for wet excavation.

3. Dry Excavation. The volume of dry excavation is the amount of excavation required from the top of wet excavation to the top of proposed ground line (see note ** in Figure 17-5A). Only include the pay item Excavation, Dry, if the quantity exceeds 200 m^3. Where dry excavation is not included as a pay item, the quantity is included the concrete quantity. The volume of dry excavation is determined as follows:

$$\text{Dry Excavation} = (L+1)(W+1)(D)$$

Where: L = length of footing, meters
W = width of footing, meters
D = depth of dry excavation, meters (See note ** in Figure 17-5A)

4. Waterway Excavation or Common Excavation. This excavation is the amount of excavation required from the existing ground line to the proposed ground line (see note * in Figure 17-5A). If this excavation is in the main-channel area, the pay item is Excavation, Waterway. Otherwise it is Excavation, Common. If it is as common excavation, add this quantity to the previously computed quantity for the road work. If extensive channel work is required, compute the waterway excavation separately.

5. Foundation Excavation (Unclassified). If there are no other types of structure excavation, the excavation pay item required at each end bent is Excavation, Foundation, Unclassified. The volume of foundation excavation (unclassified) is determined as follows:

$$\text{Foundation Excavation (Unclassified)} = (L+1)(W+1)(D)$$

Where: L = length of footing or end bent cap, meters
W = width of footing or end bent cap, meters
D = depth of excavation from the natural ground line to bottom of the foundation, meters

17-5.03 Piling

In addition to the criteria shown in the INDOT *Standard Specifications*, the designer should consider the following.

1. Exposed or Buried Piles. Piles which consist of an exposed portion and a buried portion should be measured as two pay items. The buried portion of a steel encased concrete pile is Pile, Concrete, Steel Shell Encased, *(shell thickness)* mm, *(diameter)* mm. The exposed portion is Pile, Reinforced Concrete, Steel Shell Encased, Epoxy Coated, *(shell thickness)* mm, *(diameter)* mm.

2. Pay Items. The pay items defined in the INDOT *Standard Specifications* should be used. The pay item names will include information on the pile diameter or size, the type of encasement, reinforcing-steel requirements, and the wall thickness of the steel shell.

3. Measurement. The minimum pile tip elevation shown on the General Plan sheet for a stream crossing is established to provide adequate penetration to protect against scour and does not necessarily indicate the penetration needed to obtain the required bearing. The estimated elevation needed to obtain the required bearing is shown only in the Geotechnical Report. The billed length of piling should be computed based on the lower of the minimum tip elevation shown on the General Plan sheet or the estimated bearing elevation shown in the Geotechnical Report.

4. Incidental Items. Do not include separate pay items for pile encasement, reinforcing steel, or concrete filling. These are included in the pay items for the piles.

5. Oversized Predrilled Pile Holes. For an integral end bent structure, include a special provision to define the additional payment breakdown required for oversized predrilled holes and uncrushed gravel backfill. The piles themselves should be measured as described in the INDOT *Standard Specifications*. Include the special provision where the blow count (N) exceeds 115 blows per meter within the 3-m interval below the bottom of the cap.

17-5.04 Steel Sheet Piling

Steel sheet piling required for railroad protection should be shown on the plans. Sheet piling with a higher section modulus than that specified may be required by the railroad company or by the contractor's bearing design. Sheet piling is cut to 0.3 m below the final ground elevation, and left in place after construction is complete. The sheeting is not required for permanent support, but disturbance caused by its removal may be damaging. Steel sheet piling to be left in place is measured by the square meter.

The specified section modulus should be included in the pay item name.

17-5.05 Backfill for a Structure

17-5.05(01) Backfill at Bridge Support

1. End Support.

    a. Beam or Girder Type Superstructure. Backfill behind an end bent should consist of coarse aggregate wrapped in a geotextile as shown in the INDOT *Standard Drawings*. An end bent drain pipe should also be included. A structure over water should have the outlet located on the downstream side wherever possible.

    b. Reinforced Concrete Slab Bridge. Flowable backfill should be used to backfill behind an end bent as shown in the INDOT *Standard Drawings*. End bent drain pipes will not be required.

2. Interior Support.

    a. Railroad or Roadway Grade Separation Structure. The area to a point 0.45 m outside the neat lines of each footing should be backfilled with structure backfill as shown on the INDOT *Standard Drawings.* The neat-line limits and estimated quantities should be shown on the Layout sheet for each support location.

    b. Bridge Over Waterway. The area to a point 0.45 m outside the neat lines of each footing should be backfilled with common fill or borrow material.

17-5.05(02) Backfill for Retaining Wall

Chapter Sixty-eight provides the design criteria and warrants for the placement of a retaining wall.

Figure 17-5B, Cast-in-Place Concrete Retaining Wall Earthwork Quantities Limits; Figure 17-5C, MSE Retaining Wall Earthwork Quantities Limits; and Figure 17-5D, MSE Retaining Wall Earthwork Quantities Limits Showing Foundation Treatment, each illustrate the typical pay limits for excavation and backfill material quantities for a retaining wall. The contractor may select an alternate wall design. However, the earthwork quantities should be calculated based on the outermost neat-line construction limits for the wall type shown on the plans.

All excavation quantities required for placement of retaining walls should be incorporated into the project's earthwork quantities tabulation and balancing. The required pay items for a cast-in-place concrete wall are common excavation and structure backfill. The required pay items for an MSE wall are common excavation, structure backfill, and B borrow.

17-5.06 Roadway Items

Where bridge construction is to be included within road-project limits, the bridge designer should provide the road designer with a Layout sheet and a General Plan sheet indicating the proposed roadway construction near the bridge. In addition, the bridge designer will be responsible for providing the road designer with the quantities for the pay items listed in Figure 17-5E, Bridge Pay Items in Road Plans, so that they can be included with the roadway quantities.

17-5.07 Pavement Markings

A bridge project should include pay items and quantities for traffic-lane stripes, edge lines, and signs. A detail or a table illustrating permanent pavement-marking limits and quantities should be shown in the plans; see INDOT *Typical Plan Sheets*. The designer should consider the following.

1. Edge and Center Lines. Determine the quantity for solid-white edge lines and for broken-yellow center lines directly from the plans.

2. No-Passing Zones. The quantity for solid-yellow lines to denote a no-passing zone is an undistributed item. New solid-yellow lines for a no-passing zone should be provided for the entire no-passing zone, even if the no-passing zone extends beyond the limits of the bridge project. Approximate lengths may be determined during the field check. However, actual limits will be determined by the district Office of Traffic.

17-5.08 Regulatory or Warning Traffic Signs

The designer, in conjunction with district-office personnel during the field check review, should determine whether new traffic signs will be required or if the present ones can be reset.

The method of determining quantities for new regulatory or warning traffic signs is as follows.

1. Posts. Sign posts are measured by the meter and specified by type.

2. Signs. Sheet signs are measured by the square meter, according to the sheeting type and thickness.

Figure 17-5F, Sign Post and Sheet Sign Summary (Bridge Project), illustrates the signing tables that should be placed on the Bridge Summary sheet or on the Approach Details sheet. For a project with a small number of signs, the totals may be omitted.

Sign codes, description, size, location, post length, and type are listed in the tables according to the guidelines in the *Manual on Uniform Traffic Control Devices*, the INDOT *Standard Drawings* and Chapter Seventy-five. The type and quantity of posts should be determined according to the procedures described in the INDOT *Sign Design Guide*.

17-5.09 Reinforced Concrete Bridge Approach (RCBA)

17-5.09(01) Summary of Bridge Quantities

Quantities for the following pay items should be included in the Summary of Bridge Quantities table on the Bridge Summary sheet.

1. PCCP of the required thickness in the RCBA and extensions is measured by the square meter. See the INDOT *Standard Drawings* for the required RCBA thickness.

2. Epoxy coated reinforcing steel in the RCBA and extensions is measured by the kilogram.

3. Dense-graded subbase placed under the RCBA and extensions is measured by the megagram.

17-5.09(02) RCBA Details

The designer may not be able to use the details and bill of materials shown in the INDOT *Standard Drawings.* The designer should therefore consider providing complete RCBA details on the bridge plans. Complete details should be provided on the plans where the conditions are present as follows:

1. a bridge that will be constructed in two or more phases;

2. a bridge where the RCBA width must be sufficient to provide for more than two travel lanes, auxiliary lanes, or a median;

3. where variable or nonstandard RCBA length, thickness, or details are used; and

4. where concrete sidewalks, median barrier, center curb, lip gutter, etc. must be accommodated.

17-5.09(03) Reinforcing-Steel Quantities

Quantities for epoxy-coated reinforcing steel in the RCBA and extensions should be shown separately from other reinforcing-steel quantities in the Summary of Bridge Quantities table. See the INDOT *Standard Drawings* for details and material quantities for standard RCBA and extensions.

The INDOT *Standard Drawings* provide the dimensions and reinforcement details for a 6200-mm-long RCBA. The INDOT *Standard Drawings* also provide the, size, length, and quantity of reinforcing bars for commonly-used RCBA widths. See Figure 17-5G, RCBA Reinforcing-Steel Detailing Requirements, for guidance on showing RCBA reinforcing-steel details on the plans.

17-5.09(04) Miscellaneous Considerations

The designer should also consider the following.

1. Anchoring. The RCBA should be anchored to the end of the superstructure where integral end bent construction is used. The RCBA should be anchored to the adjacent mudwall where a bridge deck expansion joint is used at the end of the superstructure. See Chapter Sixty-seven for connection details.

2. Polyethylene Fabric. Two layers of polyethylene fabric, each of 0.150 mm minimum thickness, should be placed between the concrete bridge approach slab and the subgrade where the RCBA is anchored to the superstructure.

3. Terminal Joint. A terminal joint or pavement relief joint of 600 mm width should be provided at the roadway end of the RCBA if any portion of the adjacent pavement section is PCC. No such joint is required if the entire adjacent pavement section is HMA.

4. Dimensions. The RCBA length, width, and thickness should be shown on the plans.

   The length and width are typically shown on the General Plan sheet. The RCBA thickness may be shown on a superstructure or end-bent details sheet.

17-5.10 Riprap and Sodding Limits at Bridge Cone

Figure 17-5 I, Riprap and Sodding Limits with Barrier Transitions on Bridge, and Figure17-5J, Riprap and Sodding Limits with Barrier Transitions on RCBA, illustrate the placement of riprap and sodding at a bridge cone to control erosion. Figure 17-5 I illustrates the placement where the barrier transitions are on the bridge and Figure 17-5J where they are on the RCBA. Riprapping the surfaces of the bridge cones and fill slopes adjacent to the RCBA (Figure 17-5J) is recommended for a new bridge at a stream crossing. Where mowing equipment experiences difficulty traversing riprap drainage turnouts for a grade separation structure (e.g., at an interchange), the bridge cone surfaces may be sodded instead.

For a bridge-rehabilitation project, the designer should review proposed erosion control techniques (e.g., erosion control mat, riprap drainage turnout, sodded flume, curb inlet/piping) with the Production Management Division's Bridge Rehabilitation and Ratings Team and the district office.

17-5.11 Structural-Steel Painting [Added June 2008]

Steel-bridge painting and partial-bridge painting are designated by type. The type refers to the location of the steel to be painted. The types are as follows.

17-5.11(01) Type 1 [Added June 2008]

The steel to be painted at this location is entirely beneath the bridge deck. A beam or girder bridge is a representative example.

17-5.11(02) Type 2 [Added June 2008]

The majority of the steel to be painted at this location is beneath the bridge deck. However, some steel extends above, but not over the bridge deck. A pony-truss bridge is a representative example.

17-5.11(03) Type 3 [Added June 2008]

The majority of the steel to be painted at this location is above and over the bridge deck. There is also some steel to be painted beneath the bridge deck. A through-truss bridge is a representative example.

A particular structure should have only one Type designation. For example, a through truss with beam-approach spans has a Type 3 designation.

17-5.11(04) Structural-Steel Cleaning [Added June 2008]

Bridge cleaning and partial-bridge cleaning are designated by the same types as for painting, but are also designated by QP type. The QP designation refers to the contractor's certification level. If the structure was built in 1995 or later, the QP-1 designation should be used. If all or a portion of the structure was built in 1994 or earlier, the QP-2 designation should be used. The Department's *Bridge Inventory Log Book*'s Year Built should be used to determine the QP type.

17-5.11(05) Quantities Determination [Added June 2008]

The pay quantity is computed as the surface area of the bridge deck, or the out-to-out coping width multiplied by the out-to-out bridge-floor length for each type. The same quantity applies if all or a portion of the steel is to be painted. The portions of the steel to be painted should be identified on the plans.

If only the bearings, end diaphragms, beam ends, etc., are to be cleaned and painted, the work should be identified as painting a portion of the structural steel. Additional clarification should be provided via a unique special provision, or details should be shown on the plans.

A pay item for maintaining traffic should be included. Corresponding pay items for other traffic-maintenance appurtenances, such as construction signs, temporary traffic barrier, attenuator truck, etc., should also be included.

The designer should discuss the need for the inclusion of other site-specific work such as clearing, tree trimming, guardrail removal and replacement, working platform, or other unique items that may be required, with the district Office of Construction's project engineer or supervisor who typically handles painting contracts.

If possible, the number of bridge sites in one contract should be limited to not more than three. This will result in more contracts, but it should result in more-competitive bidding. It will also provide a better opportunity of completing the contract within the temperature and humidity

restrictions and within the construction season. Summarization 17-5K shows the information that should be provided in the Contract Information book, along with a sample english-units entry. An editable version of this document is available on the Department's website, at www.in.gov/dot/div/contracts/design/dmforms/.

17-6.0 MATHEMATICAL FORMULAS

Figure 17-6A provides mathematical formulas to be used for various quantity determinations.

PROPRIETARY MATERIAL
USE JUSTIFICATION

ROUTE: _____ DES NO.: _____

PROJECT NO.: _____ COUNTY: _____

FHWA OVERSIGHT: YES NO *[Click on one]*

PROPRIETARY MATERIAL:
_____
_____
_____
_____
_____
_____
_____

[Include a description of the project, situation being addressed, alternative solutions considered, and reason(s) why the proprietary item was chosen. Include an evaluation work plan for each experimental or research item.]

PREPARED BY: _____ Date: _____

Based upon the above justification, the use of the proprietary material listed is in the public interest and is hereby approved.

APPROVED: _____ _____
Production Management Division Administrator, FHWA
Division Director, INDOT

Date: _____ Date: _____

[FHWA approval is required for project with FHWA oversight.]

OPTICALLY PROGRAMMED SIGNAL LENSES
Optically Programmed Signal Lens by 3M
PAVEMENT EXPANSION JOINT SEALING SYSTEMS
Flexcon 2000 Joint Sealing System Dow Corning Expansion Joint System
POLYMER MODIFIED ASPHALT BRIDGE EXPANSION JOINT SYSTEMS
Pavetech International, Inc. Linear Dynamics, Inc.

APPROVED PROPRIETARY MATERIALS

Figure 17-1B

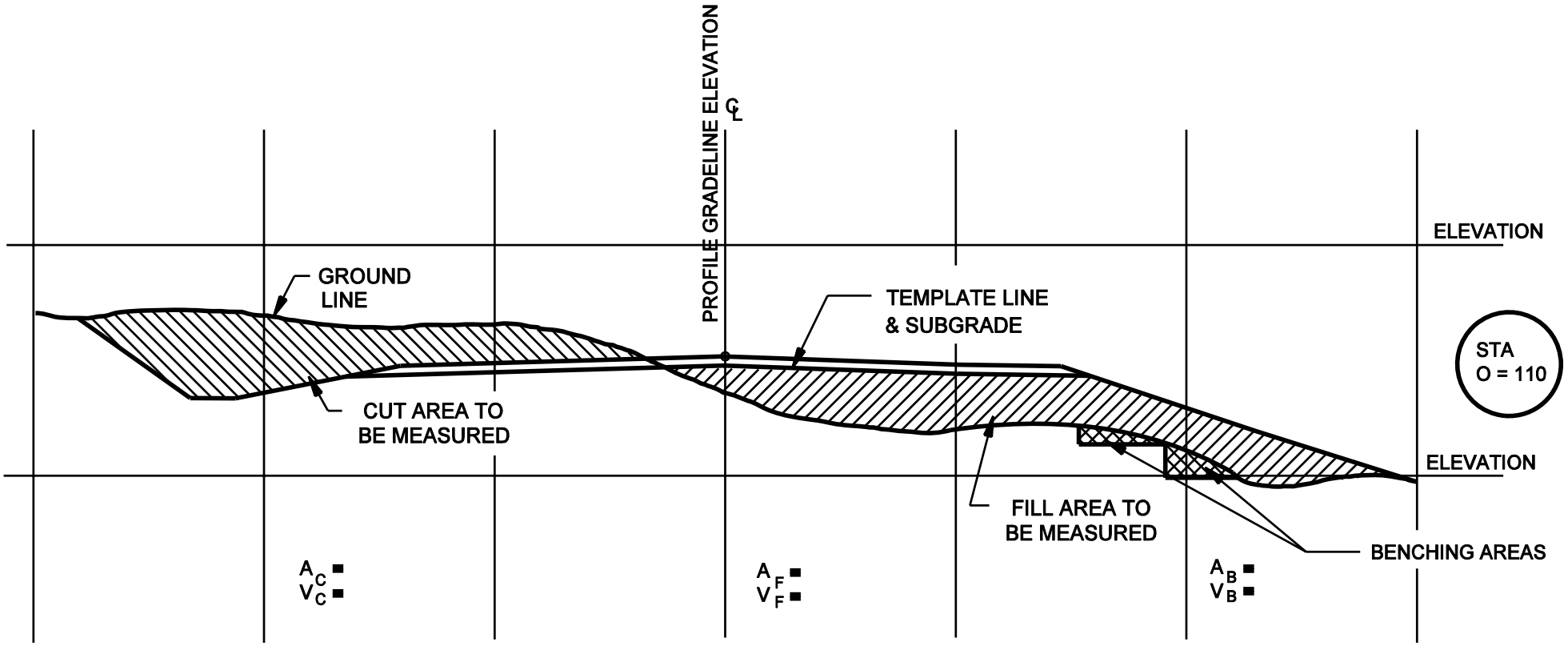
EARTHWORK COMPUTATION

ROUTE __________ DES. NO. _______________ PAGE NO. ___ OF____

BY _______________ DATE _______________ SUBJECT ________________________________

CHKD BY _________ DATE _______________ ________________________________

STATION	AREA CUT (m^2)	AREA FILL (m^2)	CUT, SUM END AREAS (m^2)	FILL, SUM END AREAS (m^2)	LENGTH (m)	VOL. CUT (m^3)	VOL. FILL (m^3)



END AREA TEMPLATE

Figure 17-2B

Recommended shrinkage factors to be used for divided roadway projects:

0-1000 m^3/20 m	=	25%
1000-2000 m^3/20 m	=	20%
2000+ m^3/20 m	=	15%

Recommended shrinkage factors to be used for single-lane projects:

0-500 m^3/20 m	=	25%
500-1000 m^3/20 m	=	20%
1000+ m^3/20 m and over	=	15%

Recommended shrinkage factors to be used for shoulder widening projects:

30% - 35%

Recommended swell factors to be used for rock fills:

30% - 35%

SHRINKAGE AND SWELL FACTORS
Figure 17-2C

Earthwork Balance

Fill +____①②	_____ m^3
Common Excavation②③④⑤	_____ m^3
Unclassified Excavation②③④⑤	_____ m^3
Rock Excavation②③④⑤	_____ m^3
Borrow or Waste	_____ m^3
Peat Excavation	_____ m^3
Benching②③⑤	_____ m^3

Note:

① *For shrinkage and swell factors to be used, see Figure 17-2C.*

② *When the project is on new alignment, increase both the excavation and fill quantities to include any benching required. See Figure 18-2J for typical benching procedures.*

③ *Where benching is required for construction of a new embankment over an existing embankment, no direct payment is made for benching.*

④ *Excavation for subgrade treatment is not included in the excavation quantities.*

⑤ *If applicable, include a note that the _____ excavation quantity includes _____ m^3 of unsuitable material and/or _____ m^3 of benching.*

EARTHWORK BALANCE TABLE
(Road Projects)
Figure 17-2D

Earthwork Tabulation

Fill +20%	_____ m^3
Common Excavation ℵ	_____ m^3
Usable Waterway Excavation (_____%) ℑ	_____ m^3
Surplus Foundation Excavation ℜ	_____ m^3
Borrow or Waste	_____ m^3
Total Waterway Excavation ℘	_____ m^3
Benching (Estimated) ⊗ (No direct payment. Benching will not be paid for as Common Excavation.)	_____ m^3

ℵ *Excavation for subgrade treatment is not included in the above excavation quantities.*

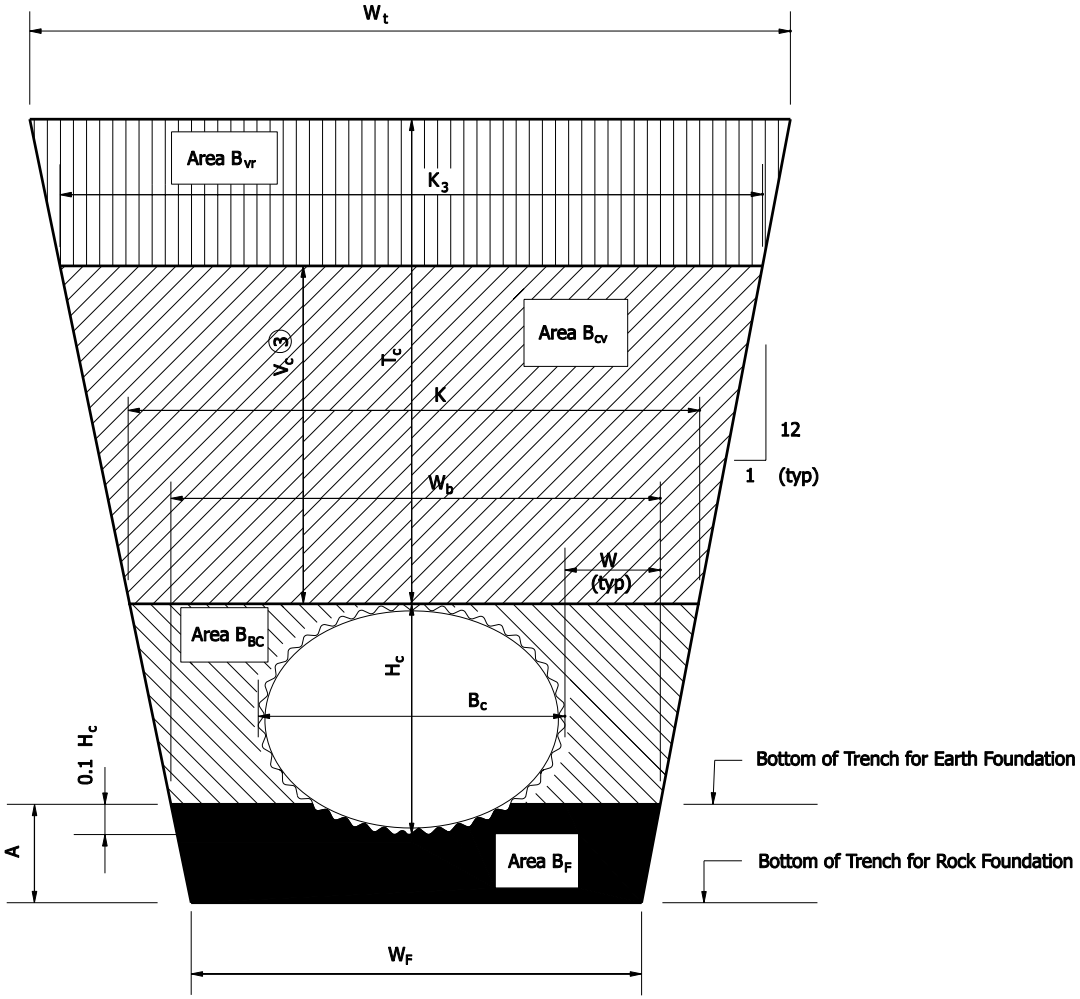
ℑ *Show the actual usable portion on the plans (_____%). Estimate the percentage during the field check. If no other information is available, use 70%.*

ℜ *Includes earth volume displaced by substructure concrete and/or B Borrow for Structure Backfill at foundation excavations. If this volume is small (i.e., < 75 m^3), do not include this item in earthwork tabulation.*

℘ *Include all material excavated to shape channel under structure reduced by the estimated concrete volume of existing piers or abutments above the channel clearing lines. Abutment backfill above the clearing lines should be included in waterway excavation.*

⊗ *Benching is to be shown on the cross sections. Benches are to be 2.4 m to 3.0 m wide where practical. Volume should be estimated and shown in the earthwork tabulation with a note indicating that no direct payment is made for benching.*

EARTHWORK TABULATION
(Bridge Projects)
Figure 17-2E



Notes:

1. Area A_C is the pipe area to the outside edge of the corrugations.
2. For a circular pipe, $B_C = H_C$.

③ For backfill method 1 or 2, $V_C = T_C$.

BACKFILL AREA PER LINEAR FOOT OF PIPE, EARTH FOUNDATION

Method 1 Structure or flowable backfill as required, $B_{BC} + B_{CV} + B_{VT}$

Method 2 Structure or flowable backfill as required, B_{BC}
Compacted earth backfill, $B_{CV} + B_{VT}$

Method 3 Structure or flowable backfill as required, $B_{BC} + B_{CV}$
Compacted earth backfill, B_{VT}

BACKFILL AREA PER LINEAR FOOT OF PIPE, ROCK FOUNDATION

Method 1 Structure Backfill, B_F
Structure or flowable backfill as required, $B_{BC} + B_{CV} + B_{VT}$

Method 2 Structure backfill, B_F
Structure ofr flowable backfill as required, B_{BC}
Compacted earth backfill, $B_{CV} + B_{VT}$

Method 3 Structure backfill, B_F
Structure or flowable backfill as required, $B_{BC} + B_{CV}$
Compacted earth backfill, B_{VT}

VALUES REQUIRED FOR DETERMINING BACKFILL QUANTITIES

Figure 17-3A

Asphalt Mixtures	
Pavement Thickness	Factor
25 mm	60 kg/m^2 = 0.060 Mg/m^2
31 mm	75 kg/m^2 = 0.075 Mg/m^2
38 mm	90 kg/m^2 = 0.090 Mg/m^2
42 mm	100 kg/m^2 = 0.100 Mg/m^2
50 mm	120 kg/m^2 = 0.120 Mg/m^2
58 mm	140 kg/m^2 = 0.140 Mg/m^2
63 mm	150 kg/m^2 = 0.150 Mg/m^2
69 mm	165 kg/m^2 = 0.165 Mg/m^2
75 mm	180 kg/m^2 = 0.180 Mg/m^2
83 mm	200 kg/m^2 = 0.200 Mg/m^2
91 mm	210 kg/m^2 = 0.210 Mg/m^2
113 mm	270 kg/m^2 = 0.270 Mg/m^2
200 mm	480 kg/m^2 = 0.480 Mg/m^2
Asphalt for Prime Coat	2.8 L/m^2 = 0.0028 Mg/m^2
Asphalt for Tack Coat	0.25 L/m^2 = 0.00025 Mg/m^2

Riprap	
Riprap	1.8 Mg/m^3

Water for Sodding	
Water	18 L/m^2 = 0.018 kL/m^2

Pavement Markings	
Permanent Broken Centerline	0.250 m/m

Compacted Aggregate	
Aggregate Thickness	Factor
75 mm	0.178 Mg/m^2
100 mm	0.237 Mg/m^2
125 mm	0.297 Mg/m^2
150 mm	0.356 Mg/m^2
175 mm	0.415 Mg/m^2
200 mm	0.475 Mg/m^2
225 mm	0.534 Mg/m^2
300 mm	0.712 Mg/m^2

B Borrow for Draintile	
Pipe Dia.	Factor
150 mm	0.643 m^3/m
200 mm	0.672 m^3/m
250 mm	0.694 m^3/m
300 mm	0.760 m^3/m
450 mm	1.254 m^3/m

Aggregate for Underdrains	
Pipe Dia.	Factor
150 mm	0.226 m^3/m
200 mm	0.276 m^3/m
250 mm	0.339 m^3/m

Shoulder Drains	
Flat Terrain	14.0 Mg/km
Rolling Terrain	17.0 Mg/km
Hilly Terrain	20.0 Mg/km

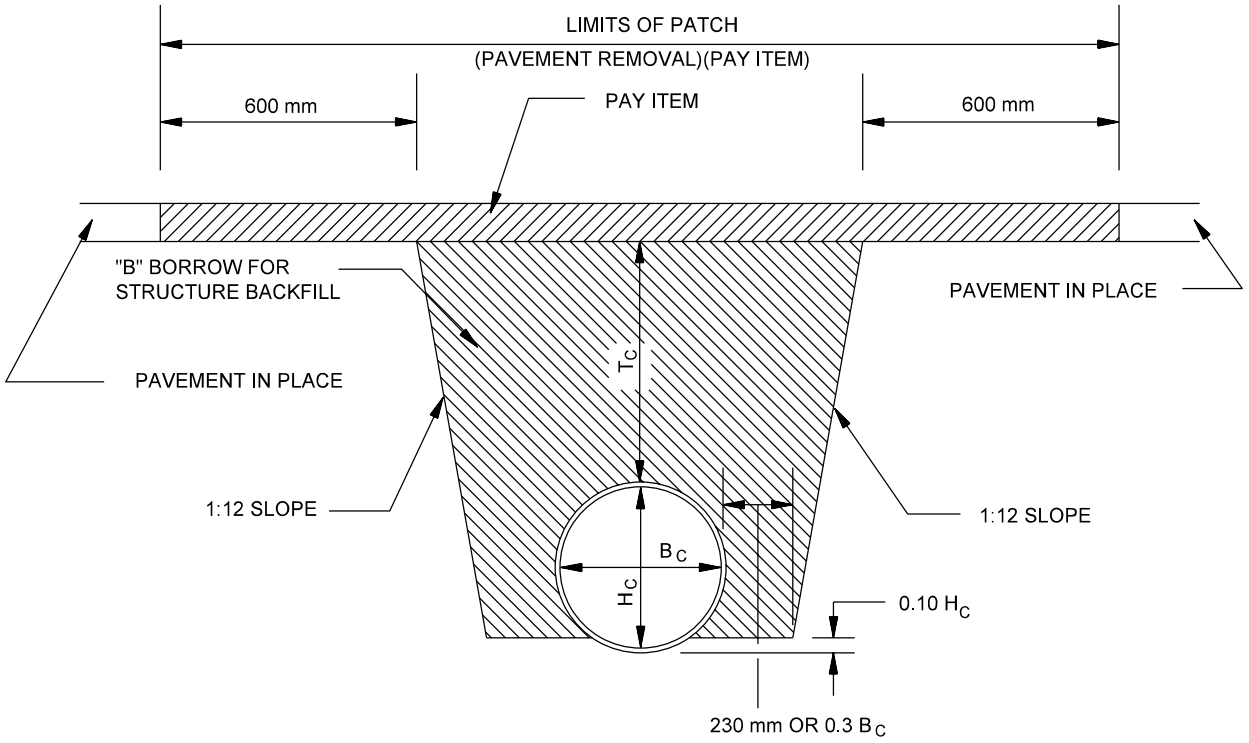
ROADWAY QUANTITIES FACTORS

Figure 17-4A

Line	Design-Year AADT	Treatment Area, m^2
"A"	20,000	9000
"S-1-A"	300	450
"S-2-A"	400	850

EXAMPLE TABULATION OF SUBGRADE TREATMENT INFORMATION TO ACCOMPANY MEMORANDUM TO MATERIALS AND TESTS DIVISION

Figure 17-4B



Note:

B_C = Overall diameter or span
H_C = Overall diameter or span
T_C = Trench cover depth

PLACING PIPE UNDER EXISTING ROADWAY

Figure 17-4C

Curb Ramp Type	150-mm Curb		200-mm Curb	
	Assumptions for Calculation Purposes (Top Landing Not Incl. in Area), All Dimens. m	Area (m^2)	Assumptions for Calculation Purposes (Top Landing Not Incl. in Area), All Dimens. m	Area (m^2)
A	Sdwk. width 3.6	5.4	Sdwk. width 4.5	8.6
B	Sdwk. width 4; R = 3 Sdwk. width 5.5; R = 7.5	13.6 18.0	Sdwk. width 4.5; R = 3 Sdwk. width 6; R = 7.5	18.2 25.5
C	Utility-strip width 1.8	2.2	Utility-strip width 2.4	2.9
D	Utility-strip width 1.8	2.2	Utility-strip width 2.4	2.9
E	Utility-strip width 3 (one side only); Sdwk. W = 1.2, R = 3 Sdwk. W = 2.1, R = 7.5	8.9 4.8	Not possible to construct on utility-strip width of 3	n/a
F	Sdwk. width 1.2; R = 4.5 Sdwk. width 1.2; R = 7.5	12.0 18.0	Sdwk. width 1.2; R = 4.5 Sdwk. width 1.2; R = 7.5	13.0 20.0
G	Sdwk. 1.5, Util. 1.8; R = 7.5	4.0	Sdwk. 1.5, Util. 1.8; R = 7.5	5.0
H	Sdwk. Width 1.8; R = 7.5	5.3	Sdwk. Width 1.8; R = 7.5	6.4
K	Sdwk. width 1.5	7.4	Sdwk. width 1.5	9.3
L	Grass median width 5	8.0	Grass median width 5	8.0

QUANTITIES FOR CURB RAMPS

Figure 17-4D

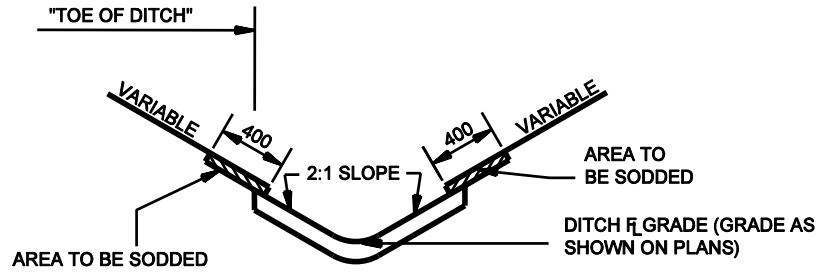
Foreslope	Backslope	Sodding Factor (m^2/m)
6:1	4:1	4.2
4:1	4:1	3.6
4:1	3:1	3.3
3:1	3:1	3.0
3:1	2:1	2.7

Notes:

1. *Sodding factor assumes a 1.2-m wide ditch bottom.*
2. *Sodding factor assumes sodding is placed to a height of 300 mm above the flow line.*
3. *For sodding next to paved side ditch, use a sodding factor of 0.8 m^2/m.*

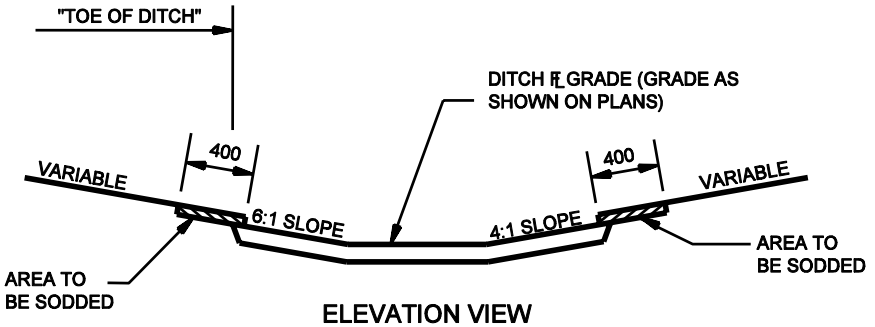
SODDED DITCH QUANTITIES

Figure 17-4E



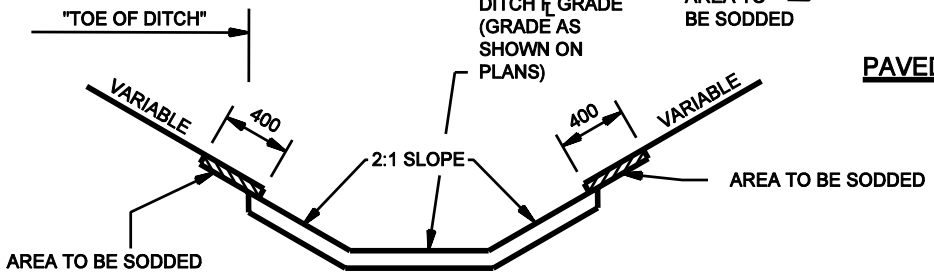
ELEVATION VIEW

PAVED SIDE DITCH TYPES A THROUGH D



ELEVATION VIEW

PAVED SIDE DITCH TYPES J THROUGH M



ELEVATION VIEW

PAVED SIDE DITCH TYPES E THROUGH H

Notes: 1. Do not use n2:1 side slopes within the clear zone.
2. All units in millimeters.

PAVED SIDE DITCHES

Figure 17-4F

Grade	Interval
3% to 5%	60 m
5% to 8%	45 m
8% to 10%	30 m
10% and greater	15 m

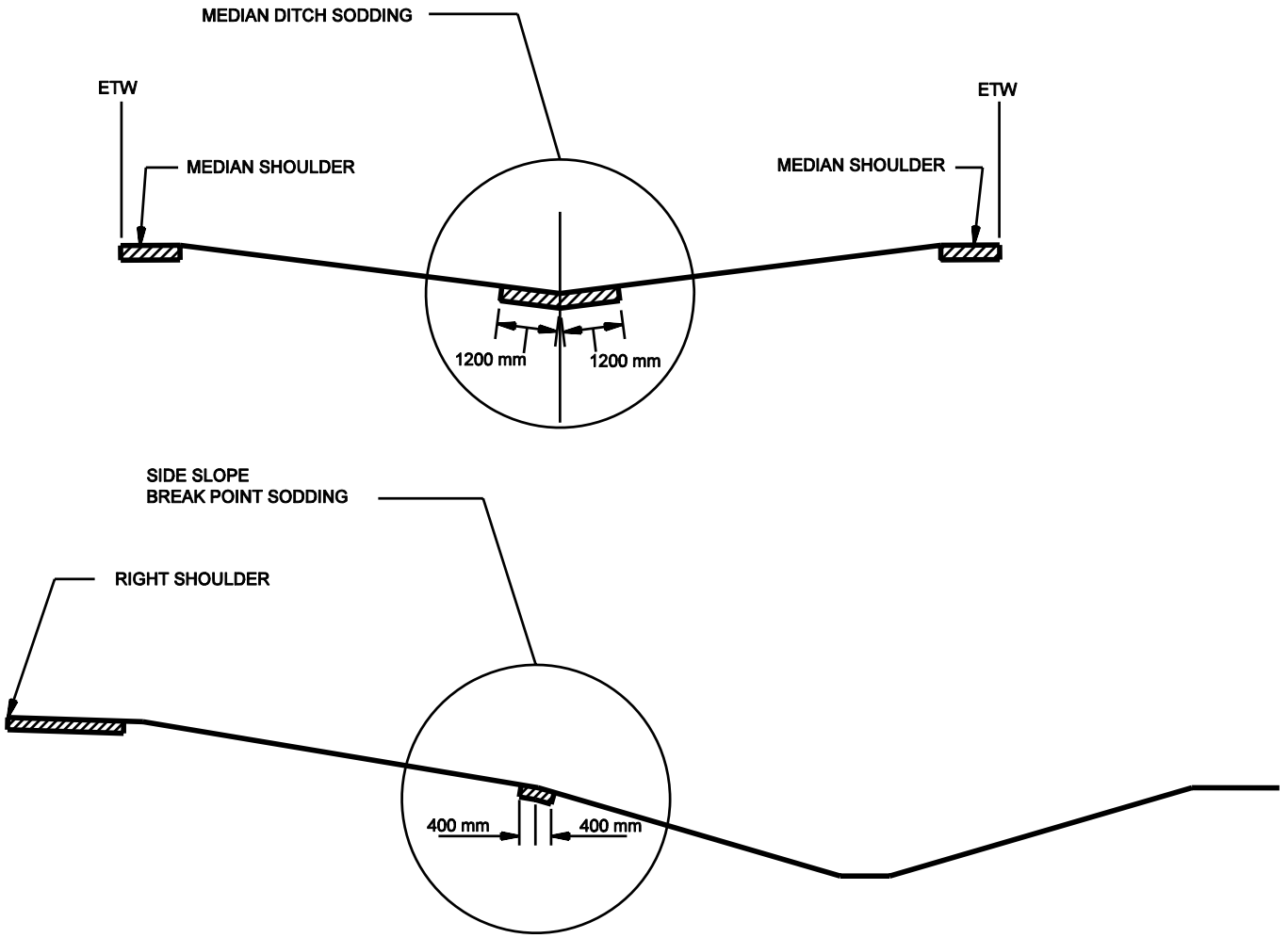
LUG INTERVALS
Figure 17-4G

MAILBOX APPROACHES *					
LOCATION		DESCRIPTION	WIDTH (m)	MAILBOX ASSEMBLY REQUIRED	
LT / RT	℄ BOX STATION			SINGLE	DOUBLE
LT	6+341	Paved Shoulder, Mailbox Beyond Drive	3.0	--	1
RT	6+354	Paved Shoulder, Mailbox Before Drive	3.0	1	--
LT	8+132	Paved Shoulder, Mailbox Beyond Drive	2.4	2	1

* See INDOT *Standard Drawings*.

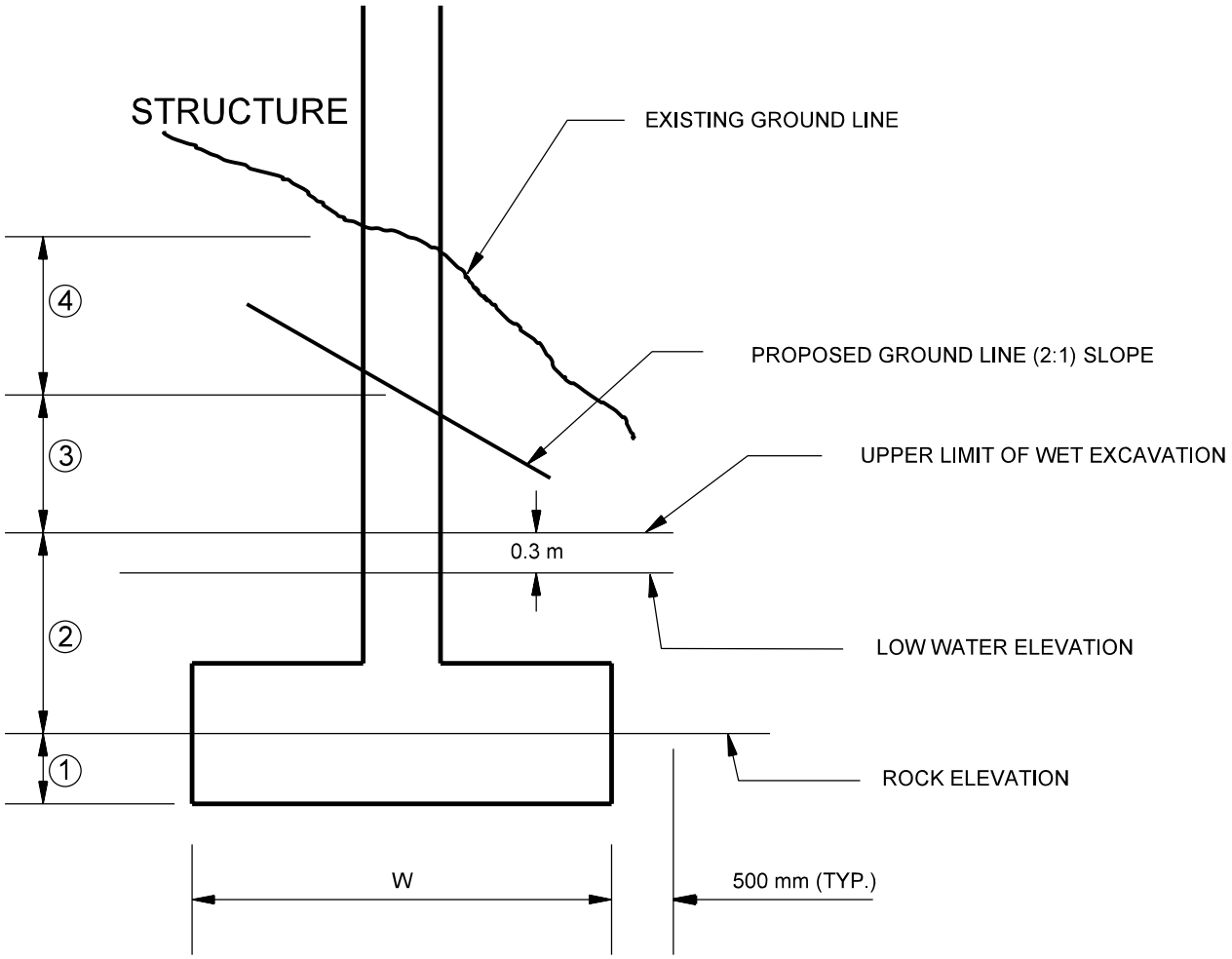
SAMPLE MAILBOX-SUMMARY TABLE

Figure 17-4H



SODDING LOCATIONS

Figure 17-4I

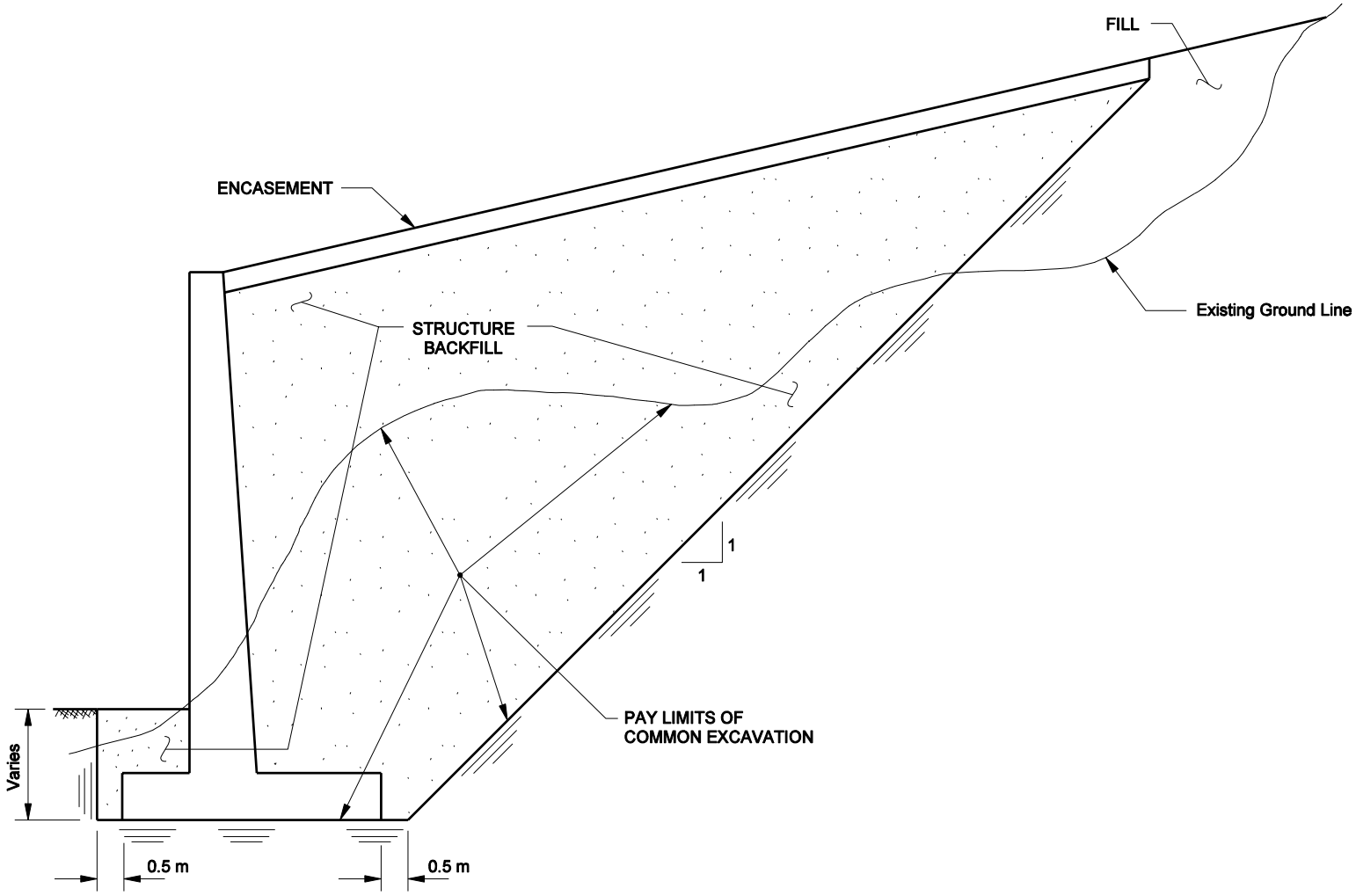


① Class "X" Excavation
② Wet Excavaton
③ Dry Excavation
④ Waterway Excavation or Common Excavaton

Note: See Section 17-4.02 and INDOT Standard Specifications for additional guidance

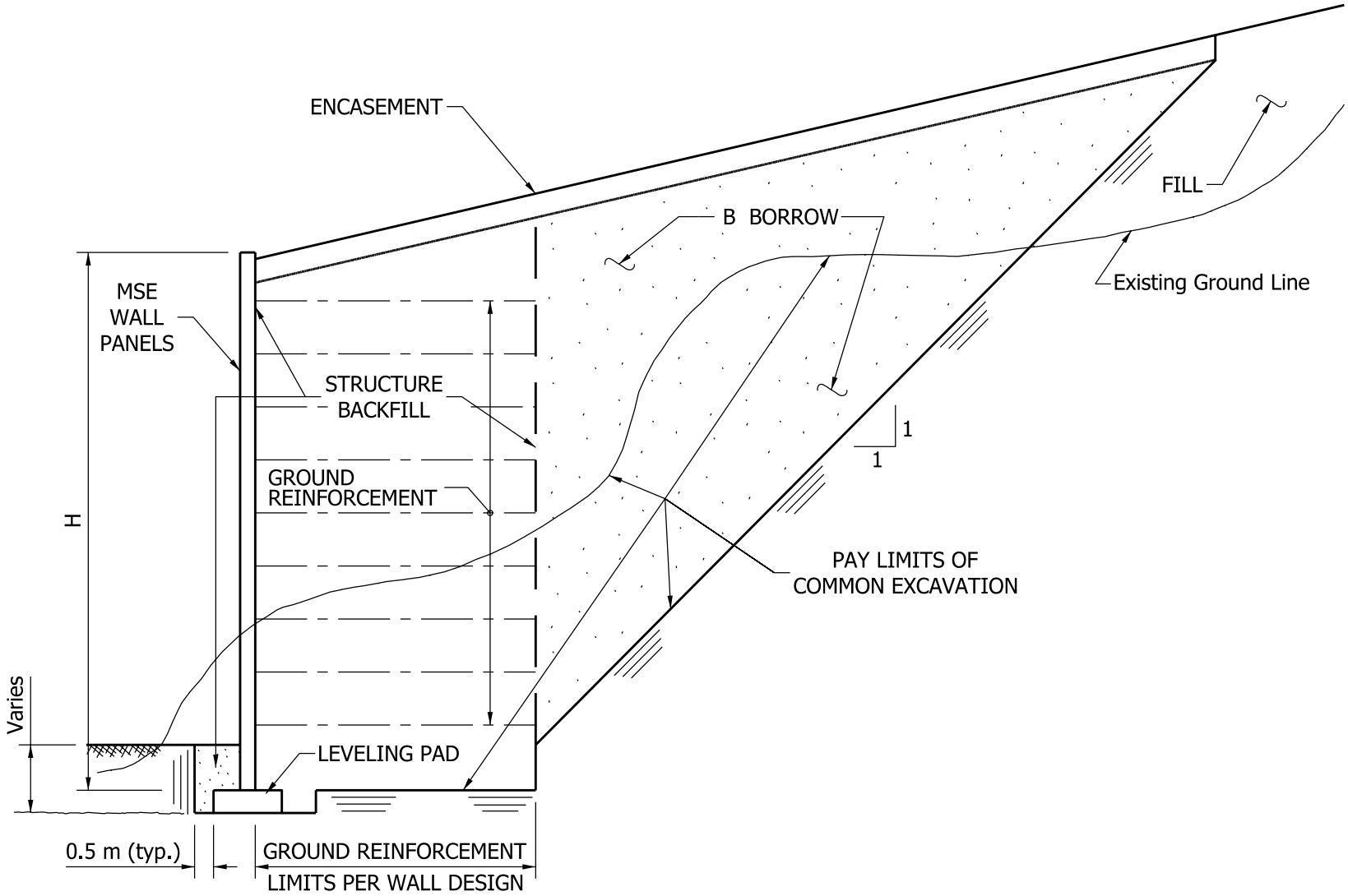
STRUCTURE EXCAVATION

Figure 17-5A



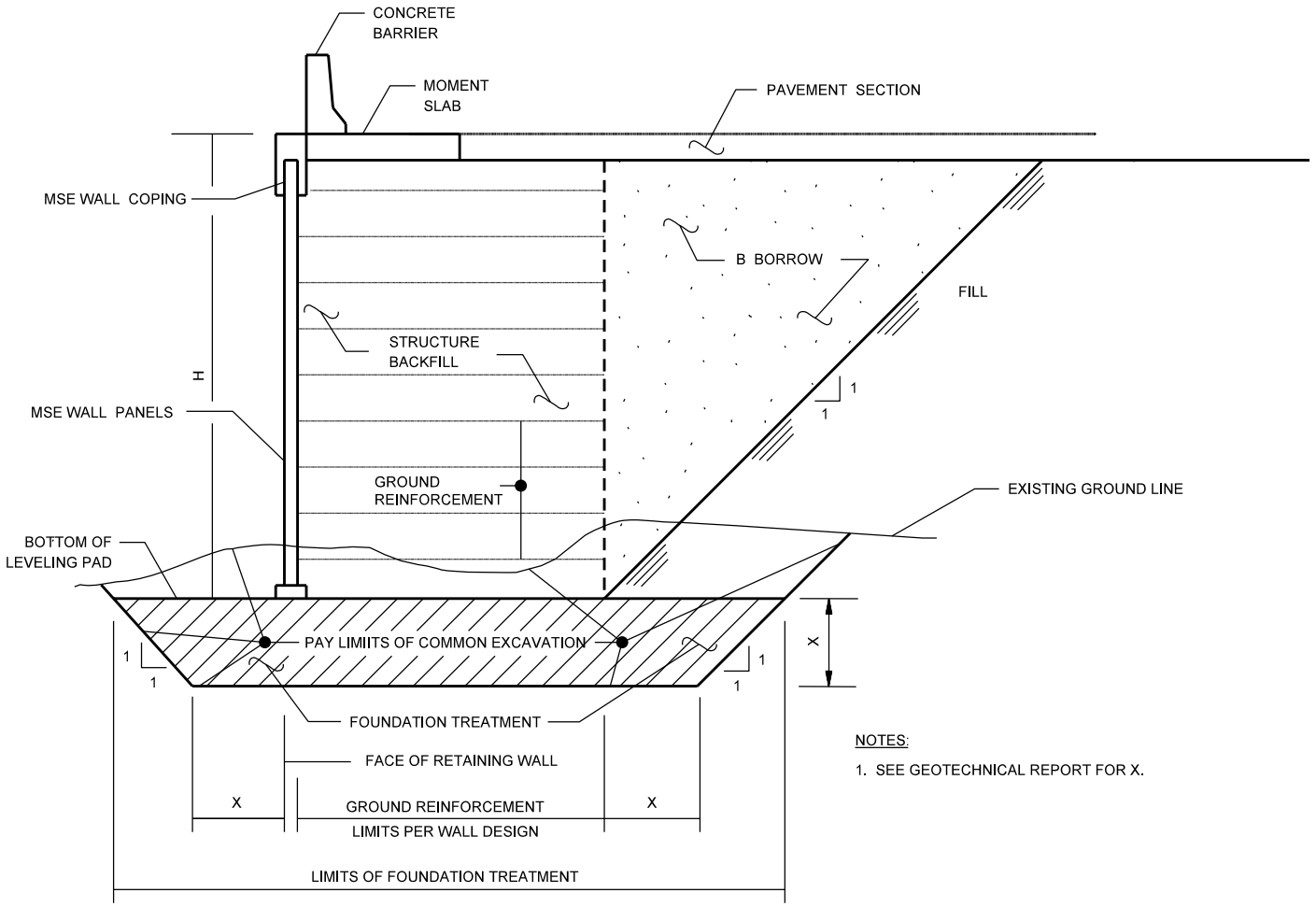
CAST-IN-PLACE CONCRETE RETAINING WALL EARTHWORK QUANTITIES LIMITS

Figure 17-5B



MSE RETAINING WALL EARTHWORK QUANTITIES LIMITS

Figure 17-5C



MSE RETAINING WALL EARTHWORK QUANTITIES LIMITS
(Showing Foundation Treatment)
Figure 17-5D

Spec. Ref.	Item	Unit	Quantity
203	Excavation, Waterway	m^3	
211	B Borrow	m^3	
211	Structure Backfill	m^3	
211	Flowable Backfill	m^3	
302	Dense Graded Subbase	m^3	
503	Terminal Joint	m	
601	Bridge Railing Transition, TGB	each	
601	Bridge Railing Transition, WGB	each	
609	Reinforced Concrete Bridge Approach, _____ mm	m^2	
703	Reinforcing Steel	kg	
704	Grates, Basins, and Fittings, Cast Iron	kg	
715	Pipe, Type 4, Circular, 150 mm	m	
715	Pipe, Type 5, Circular, 300 mm	m	
203	Surplus Foundation Excavation [not a pay item]	m^3	

BRIDGE PAY ITEMS IN ROAD PLANS

Figure 17-5E

SIGN POST SUMMARY					
SIGN CODE	LOCATION		NO. OF POSTS	POST TYPE	TOTAL LENGTH (m)
	STATION AND LINE	LT./RT.			
			TOTAL	A	
			TOTAL	B	
			TOTAL	1	
			TOTAL	2	

Note: Sign location and post lengths are approximate. Exact location and length to be determined in the field in accordance with the Manual on Uniform Traffic Control Devices.

SHEET SIGN SUMMARY					
SIGN CODE	SIGN DESCRIPTION	NO. OF SIGNS	SHEETING TYPE*	THICKNESS (mm)	TOTAL AREA (m^2)
		TOTAL	I	2.03	
		TOTAL	II	2.03	
		TOTAL	I	2.54	
		TOTAL	II	2.54	
		TOTAL	I	3.18	
		TOTAL	II	3.18	

**Type I – "Enclosed lens" reflective sheeting*
Type II – "Encapsulated lens" reflective sheeting

SIGN POST AND SHEET SIGN SUMMARIES
(Bridge Projects)
Figure 17-5F

	RCBA Reinforcing Steel Details Included in the Plans	
	Square Structure	Skewed Structure
Standard RCBA width	No	Yes
Nonstandard RCBA width	Yes	Yes

Notes:

1. *An RCBA width is considered standard if it is shown in the Bill of Materials table in the INDOT* Standard Drawings. *All other widths are considered nonstandard.*

2. Reinforcing steel details, where required, should include the following:

   a. Bill of materials
   b. Bending diagrams
   c. Cutting diagrams where RCBA is on skew.

RCBA REINFORCING STEEL DETAILING REQUIREMENTS

Figure 17-5G

SKEW / WIDTH (mm)	REINFORCING STEEL (kg) AND CONCRETE (m^2)									
	0	5	10	15	20	25	30	35	40	45
	Steel	Steel	Steel	Steel	Steel	Steel	Steel	Steel	Steel	Steel
	Conc.	Conc.	Conc.	Conc.	Conc.	Conc.	Conc.	Conc.	Conc.	Conc.
7200	581	635	666	699	735	775	820	873	936	1012
	44.6	46.9	49.2	51.6	54.1	56.7	59.6	62.8	66.4	70.6
7600	617	676	710	747	787	832	882	941	1010	1095
	47.1	49.6	52.2	54.9	57.6	60.6	63.8	67.3	71.4	76.0
7800	630	691	727	766	807	854	907	968	1041	1129
	48.4	51.0	53.7	56.5	59.4	62.5	65.9	69.7	73.9	78.8
8200	665	732	772	815	861	912	971	1038	1118	1216
	50.8	53.8	56.8	59.8	63.1	66.5	70.3	74.4	79.1	84.5
8800	714	788	834	883	936	995	1062	1139	1230	1342
	54.6	57.9	61.4	64.9	68.7	72.6	76.9	81.7	87.0	93.3
9400	763	845	898	953	1014	1081	1156	1243	1347	1473
	58.3	62.1	66.1	70.1	74.4	78.9	83.8	89.2	95.4	102.5
10000	811	903	962	1025	1093	1168	1253	1351	1467	1609
	62.0	66.4	70.8	75.4	80.2	85.3	90.9	97.0	104.0	112.0
10600	860	960	1027	1097	1173	1258	1353	1462	1592	1750
	65.7	70.6	75.6	80.8	66.2	91.9	98.2	105.1	112.9	121.9
11200	908	1018	1092	1171	1256	1349	1455	1577	1721	1896
	69.4	74.9	80.5	86.2	92.3	98.7	105.7	113.4	122.1	132.2
11800	957	1077	1159	1246	1340	1443	1560	1695	1853	2047
	73.2	79.3	85.4	91.8	98.5	105.6	113.4	121.9	131.6	142.8
12100	981	1106	1193	1284	1382	1491	1614	1755	1921	2124
	75.0	81.4	87.9	94.6	101.7	109.2	117.3	126.3	136.4	148.2
12400	1014	1347	1440	1540	1649	1771	1910	2072	2265	2500
	76.9	83.6	90.4	97.5	104.9	112.7	121.3	130.7	141.4	153.8
13600	1111	1486	1598	1717	1848	1993	2158	2350	2578	2856
	84.3	92.4	100.6	109.1	118.0	127.4	137.7	149.1	161.9	176.8

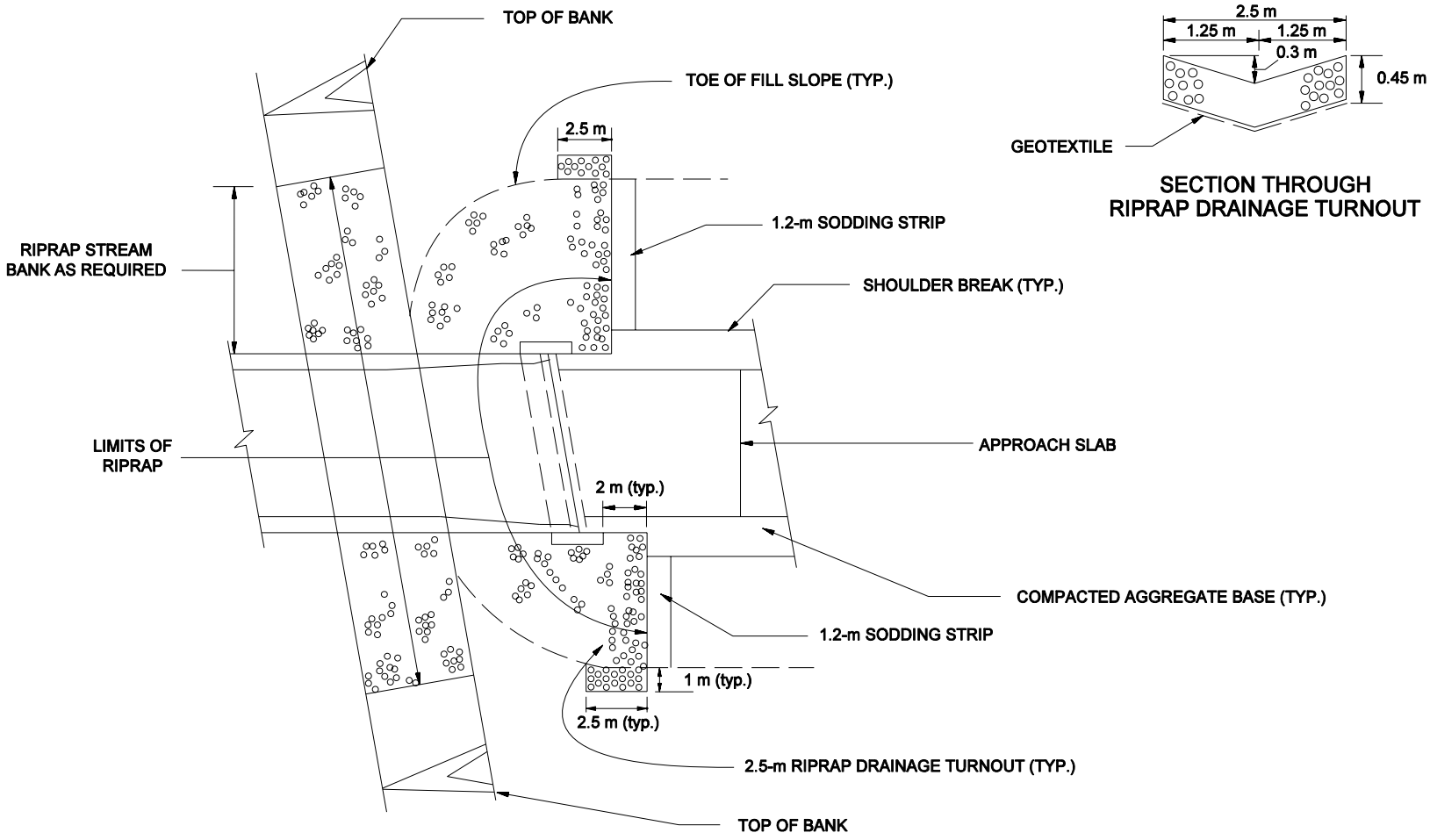
Notes:

1. *Quantities shown are for one RCBA and do not include the quantities for the RCBA extensions.*

2. *Interpolate for RCBA widths and skew angles not shown in table.*

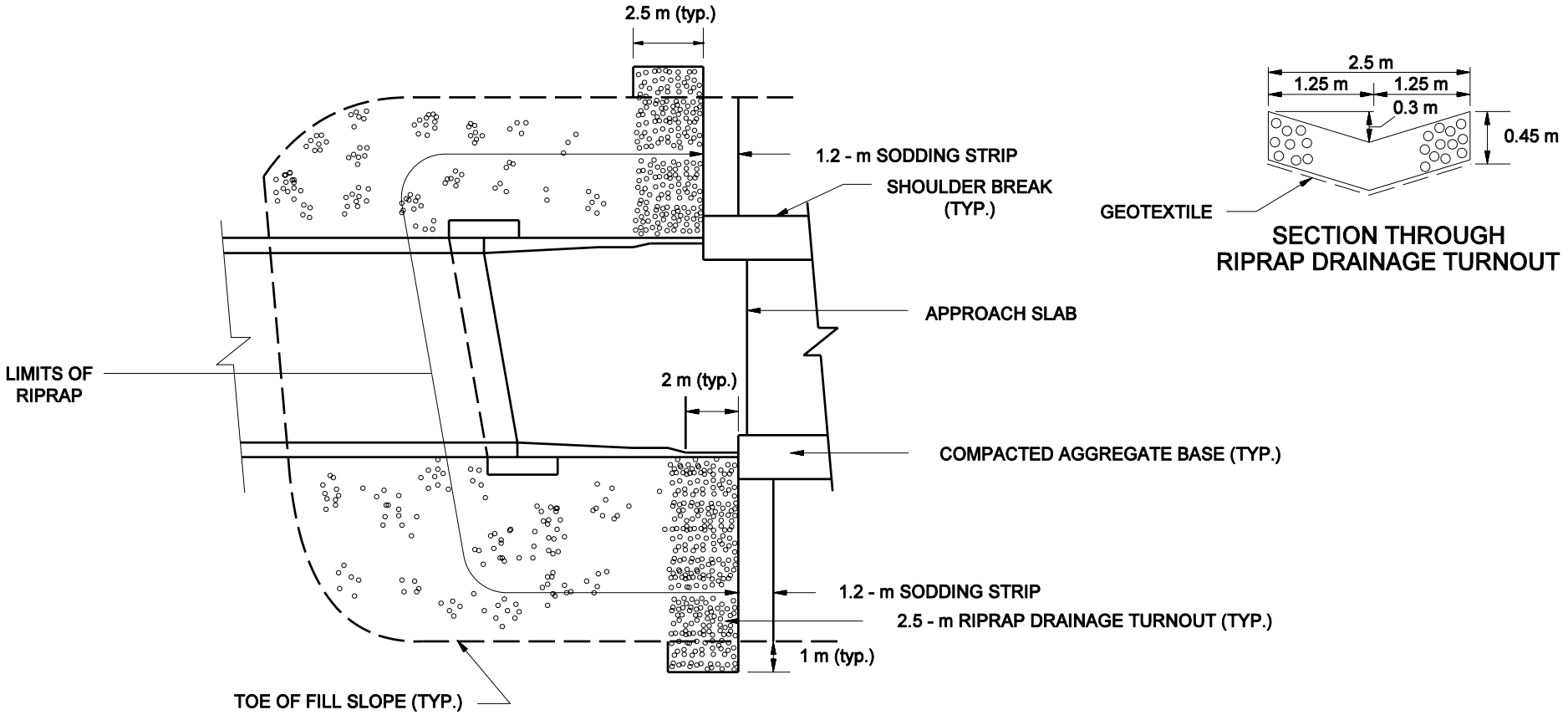
RCBA QUANTITIES

Figure 17-5H



RIPRAP AND SODDING LIMITS WITH BARRIER TRANSITIONS ON BRIDGE

Figure 17-5I



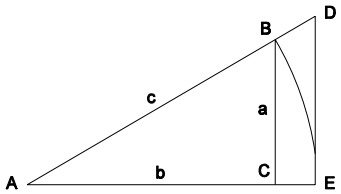
RIPRAP AND SODDING LIMITS WITH BARRIER TRANSITIONS ON APPROACH SLAB

Figure 17-5J

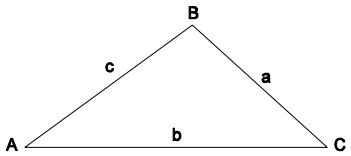
Bridge Painting Locations and Information								
Contract Structure Number	Road Number	Structure Number	NBI Number	Ref. Post	County	Feature Crossed	Location	No. of Spans
1	US 421	421(37)-58-8859 DRA	55203	249+96	Montgomery	Branch of East Fork White River	5.21 mi. E of I-465	5

Bridge Painting Locations and Information (continued)										
							Sealing		Drainage	
Contract Structure Number	Length of Steel Spans*	Existing Primer Type	Year Last Painted	Year Built	Bridge Type	New Paint Color	Number of Interior Piers/Bents	Number of Abutments/End Bents	Clean & Paint Castings	PVC Drain Extensions
1	45,51-6,60-6,51-6,45	Zinc	1988	1969	1	Lt. Green	4	2	10	10

* Length shown is approximate. It shall be the Contractor's responsibility to determine the area upon which to base his bid.



RIGHT TRIANGLE



OBLIQUE TRIANGLE

RIGHT TRIANGLES

$\sin A = \frac{a}{c} = \cos B$

$\cos A = \frac{b}{c} = \sin B$

$\tan A = \frac{a}{b} = \cot B$

$\sec A = \frac{c}{b} = \text{cosec } B$

$\text{cosec } A = \frac{c}{a} = \sec B$

$\cot A = \frac{b}{a} = \tan B$

$a = c \sin A = c \cos B = b \tan A = b \cot B = \sqrt{c^2 - b^2}$

$b = c \cos A = c \sin B = a \cot A = a \tan B = \sqrt{c^2 - a^2}$

$c = \frac{a}{\sin A} \quad \frac{a}{\cos B} \quad \frac{b}{\sin B} \quad \frac{b}{\cos B}$

OBLIQUE TRIANGLES

Given	Sought	Formula
A, B, a	b, c	$b = \frac{a}{\sin A} * \sin B$ $\quad c = \frac{a}{\sin A} * \sin (A + B)$
A, a, b	B, c	$\sin B = \frac{\sin A}{a} * b$ $\quad c = \frac{a}{\sin A} * \sin C$
C, a, b	$\frac{1}{2}(A + B)$	$\frac{1}{2}(A + B) = 90° - \frac{1}{2} C$
	$\frac{1}{2}(A - B)$	$\tan \frac{1}{2}(A - B) = \frac{a - b}{a + b} * \tan \frac{1}{2}(A + B)$
a, b, c	A	Given $s = 1/2 (a + b + c)$, then: $\sin \frac{1}{2} A = \sqrt{\frac{(s - b)(s - c)}{bc}}$ $\cos \frac{1}{2} A = \sqrt{\frac{s(s - a)}{bc}}$ $\tan \frac{1}{2} A = \sqrt{\frac{(s - b)(s - c)}{s(s - a)}}$ $\sin A = 2 \frac{\sqrt{s(s - a)(s - b)(s - c)}}{bc}$
	Area	$\text{Area} = \sqrt{s(s - a)(s - b)(s - c)}$
C, a, b	Area	$\text{Area} = \frac{1}{2} ab \sin C$

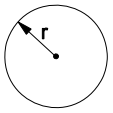
MATHEMATICAL FORMULAS

Figure 17-6A

Nomenclature

A = total surface area
d = distance
h = height
p = preimeter
r = radius
s = side (edge) length, arc length
V = volume
θ = vertex angle, in radians
ϕ = central angle, in radians

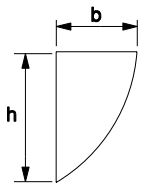
Circle



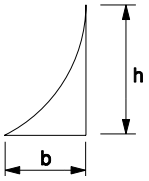
$p = 2\pi r$

$A = \pi r^2 = \frac{p^2}{4\pi}$

Parabola

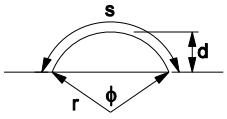


$A = \frac{2bh}{3}$



$A = \frac{1}{3}bh$

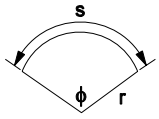
Circular Segment (1)



$A = \frac{1}{2}r^2(\phi - \sin\phi)$

$\phi = \frac{s}{r} = 2\left(\arccos\frac{r-d}{r}\right)$

Circular Sector

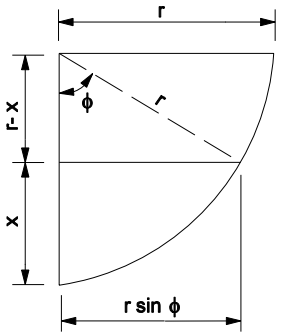


$A = \frac{1}{2}\phi r^2 = \frac{1}{2}sr$

$\phi = \frac{s}{r}$

Circular Segment (2)

$\cos\phi = \frac{r-x}{r}$



Area of Circle Segment

$\frac{\phi}{360°}\pi r^2$

Area of Triangle

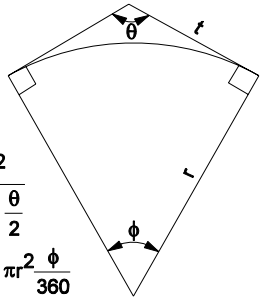
$\frac{1}{2}(r-x)(r\sin\phi)$

External Area

Total Area - Area of Circle Segment = External Area

$t = \frac{r}{\tan\frac{\theta}{2}}$

$\phi = 180° - \theta$



Total Area = $rt = \frac{r^2}{\tan\frac{\theta}{2}}$

Area of Circle Seg. = $\pi r^2\frac{\phi}{360}$

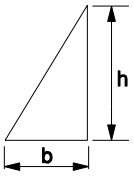
Ext. Area = $r^2\left[\frac{1}{\tan\frac{\theta}{2}} - \pi\frac{\phi}{360}\right]$

MATHEMATICAL FORMULAS

Figure 17-6A (Continued)

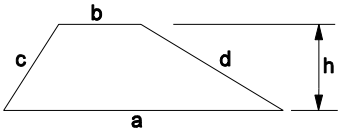
Number of Sides	Name of Polygon
3	triangle
4	rectangle
5	pentagon
6	hexagon
7	heptagon
8	octagon
9	nonagon
10	decagon

Triangle



$$A = \frac{1}{2} bh$$

Trapezoid

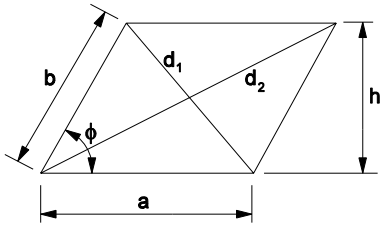


$$p = a + b + c + d$$

$$A = \frac{1}{2} h (a + b)$$

The trapezoid is isosceles if c = d.

Parallelogram



$$p = 2(a + b)$$

$$d = \sqrt{a^2 + b^2 - 2ab\ (\cos\phi)}$$

$$d_2 = \sqrt{a^2 + b^2 + 2ab\ (\cos\phi)}$$

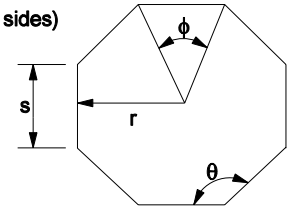
$$d_1^2 + d_2^2 = 2(a^2 + b^2)$$

$$A = ah = ab(\sin\phi)$$

If a = b, the parallelogram is a rhombus

Regular Polygon

(n equal sides)



$$\phi \quad \frac{2\pi}{n}$$

$$\theta \quad \frac{\pi\ (n - 2)}{n}$$

$$p = ns$$

$$s = 2r\left[\tan\left(\frac{\phi}{2}\right)\right]$$

$$A = \frac{1}{2} nsr$$

MATHEMATICAL FORMULAS

Figure 17-6A (Continued)