DELDOT

# QUANTITY CALCULATIONS GUIDELINES

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# Quantity Calculations

**This document is a narrative on the methodology of calculating quantities. It is a living document and will be periodically updated based on questions, comments and issues discovered, please contact George Spadafino at George.Spadafino@state.de.us.**

**Background**
The payment for all materials and labor needed to construct a project needs to be represented by a bid item. It is the responsibility of the project engineer and project manager to assure that all the items of work needed to implement a project have been accounted for. The project engineer is responsible to accurately quantify the amount of material needed for each item of work and estimate the unit bid cost of the item.

- **Identify all items**
    - Read the Standard Specifications, Special Provisions and Supplemental Specifications to understand how each item is measured and paid. If the design engineer has questions he or she should ask the project manager, Construction or the Quality Section.
        - Revise Special Provisions to meet the needs of your project
        - Work with Specifications Engineer to apply changes to your project
        - MAKE SURE SPECIFICATIONS, DETAILS AND PLAN NOTES ARE IN AGREEMENT!
        - Make sure all items mentioned in the project notes are also included in the quantities -such as 208000.
        - Try to minimize the use of incidental items on the plans; they only make it more difficult to estimate the cost of an item.
    - Review Standard Construction Details and plan details to determine what items are needed and what is included.
    - Look for references to other items that will be required.
    - The project engineer and the project manger should review all of the above.

- **Quantify each item**
    - The quantity calculations should be neat thorough, and progress in logical order. Calculations should be reviewed and checked by another engineer and the project manager.
    - These calculations will be given to Construction Inspection personnel for use during the construction of the project so they must be neat easy to follow and complete.
    - Construction personnel will use quantity calculations to understand how the design engineer calculated the quantities for specific operations and to understand how a quantity is split between multiple operations. This will allow the construction engineer to be able to quickly and easily determine if an item of work was included in the engineer's estimate. It is important to break items out by sheet and by stationing so the construction engineer can accurately track item usage on a project and compare them to the estimated quantity.

## Minimum Requirements

Units shall be shown on all numeric values except when quantifying items whose unit of measurement is each. When using conversion factors each calculation shall be shown completely. It is important to the quality control process that every step of all the calculations be shown. The quantities shall be broken down **per construction plan sheet**.

## Guidelines

The following discussion will summarize different types of measurements and the typical methods for calculating the quantity. It will also identify items that will need particular attention when calculating quantities.

## Volume Calculations

These calculations consist of mainly earthwork but can also include concrete, stone, and borrow items. It is very important that the project engineer detail the methodology used in obtaining the earthwork quantities. A detailed description should be provided for each area being quantified. This can be accomplished either by listing specific station limits or by a detailed area description. For linear projects, an end area volume report may be used. It is important for the project engineer to quantify any unique or non-typical areas, such as removal of temporary pavements or stripping topsoil in a fill area. Each designer and project manager should review the earthwork calculation guidelines and determine what earthwork schedule should be included in their project. That document provides all the information needed to make an assessment on the earthwork for any project. Care shall be taken when determining quantities for backfill and excavation. Some items have templated backfill quantities, templated quantities are preset sections run through a computerized program that calculates excavation and backfill. Others quantities are incidental to an item, this information can be found in the Standard Specifications or Special Provisions.

**202- Excavation and Embankment:**

The work under this item consists of the removal, final disposal and redistribution of all materials taken from within the limits of construction as necessary for the construction of the project.

The quantity of excavation and embankment is a measured volume between existing and proposed surfaces. Currently DelDOT software enables the designer the ability to use three methods: Grid, Triangle and End Area. It is recommended using the Triangle or Average End Area method. The units are to be in cubic yard. All excavation, except the removal of topsoil should be included in excavation. The removal of organic material is covered under item 201 Clearing and Grubbing. Under the item 202 Excavation and Embankment, **embankment is not** included as a pay item in the quantity calculation. Most projects will have a fixed quantity for excavation and embankment. In cases where it can be shown that the quantities indicated on the plans are in error by more than 5%, additions or deductions will be made in excess of the deficient of the 5%, with payment adjusted in accordance with the excavation and embankment bid price item. The burden of proof of the error in calculation is the responsibility of the contractor.

**203- Channel Excavation**

This work consists of widening and deepening existing stream channels and waterways, reconstructing channel and stream configurations and locations, shaping and finishing channel and stream beds and banks, and backfilling of old channels and streams. This work also consists of the disposal or the approved utilization of the excavated material.

The quantity of channel excavation will be estimated by comparison of original surface model or cross-sections compared to final surface modal or cross-sections. The volume will be computed on a cubic yard basis, by the Triangle or Average End area method between the limits shown on the Plans. Excavation for rip-rap is not included in this item, but is paid under the respective rip-rap item.

**204- Muck Excavation:**

This work consists of the removal and disposal of mixtures of soil and organic matter, commonly called muck. This work also consists of backfilling the area where muck is excavated. Muck excavation is difficult to estimate, soil borings and delineation of possible muck areas should be field verified and surveyed. Many times muck excavation occurs in wetland areas therefore coordination with DelDOT's Environmental Section is a must.

The quantity of muck excavation is measured in cubic yards. The volume is computed by the Triangle or Average End area methods. During construction field measurements will be based on cross-sections taken of the original ground prior to muck excavation and cross-sections taken after unsuitable muck materials have been excavated. It is very important that the existing area is well surveyed with and an accurate surface model developed. DelDOT's Soil Engineer should be contacted to review the soil boring information to help estimate the vertical limits of the muck that is to be removed.

**205 Rock Excavation for Roadway**:

This work consists of bedrock, ledge rock and large boulder removal for roadway construction that cannot be accomplished without either blasting or using rippers. This work also consists of the use or disposal of such excavated material and backfilling the excavation with suitable material.

Estimating the quantity of Rock excavation can be challenging. Soil borings should be done in areas of excavation where rock may be encountered. Generally in Delaware rock is not is encountered in many place except northern New Castle County. Old as-built plans in the vicinity of the project should be examined and reviewed. Close coordination should also be done with DelDOT's Soils Engineer for guidance in estimating the amount of rock that may be encountered. When a project has a large amount of excavation and rock excavation is expected, ground penetrating radar may be used as an additional tool to help estimate the volume of rock that will need to be excavated. The quantity of rock excavation for roadway will be measured in cubic yards. The volume of rock excavation will be measured to the limits of excavation shown on the plans computed by the Triangle or Average End areas method. Areas will be based on original **cross-sections or surface.** It is very important that the existing area is well surveyed with and an accurate surface model developed. When it is impractical to measure rocks or boulders by the cross-section method, three-dimensional measurement using a pre-approved method of calculation may be used. **Rock is limited to 12" below the subgrade. Rock excavated from depths in excess of 12" below the subgrade will not be measured**. The designer should estimate the rock excavation limits up to 12" below the subgrade an additional contingency quantity of rock excavation should be added to cover the unexpected, generally at least 30%, this percentage should be reviewed by the project manager.

When a very small quantity or a contingency quantity is estimated for rock excavation is estimated use the fix price **item 206500 Rock Excavation for Structures and Trenches**. The first 10 C.Y. are paid at a fixed price, if more rock excavation is encountered the price is negotiated.

**207 Excavation and Backfilling for Structures:**

This work consists of the excavation, removal, and replacement or disposal of all materials necessary for the construction of box and pipe culverts, pipe headwalls, bridge structures, bridge approach slabs, and other structures. This work also consists of placing and compacting backfill material; furnishing and placing of shoring, sheeting, bracing, and cofferdams; and dewatering of these areas, unless otherwise specified. Cofferdams for bridge projects are usually paid for separately under item **207500 Cofferdams.**

The quantity of excavation and backfilling for structures, excluding rock excavation, is measured in cubic yards based on field measurements. The volume is computed by taking the difference in elevation between the existing ground surface, or the bottom of roadway excavation, or the bottom of channel excavation, whichever is lower, and the bottom of the structure excavation at plan grade. If the excavation overlaps an existing structure that has been removed, then the existing ground surface shall be estimated for the condition after the structure is removed. All excavation necessary to remove the existing structure is included in the lump sum price for 211 – Removal of Structures and Obstructions. Volume measurements will include, between the upper and lower limits defined above, the volume contained inside vertical planes located 18" outside of the neat line perimeter of the vertical faces of the footing or structural unit for which the excavation is made. Borrow Type C backfill material placed outside the 18" vertical planes just described shall not be measure. For inclined footings or unusual foundation conditions, the method of measurement will need to be described in the contract. The volume of excavation will be measured to the limits of excavation shown on the plans computed by the Triangle or Average End areas method. Areas will be based on original **cross-sections or surface.** It is very important that the existing surface is well surveyed with and an accurate surface model developed.

**Section 207 Temporary Sheeting**

Temporary sheeting used as a cofferdam or for phasing, such as the stabilization of a deep excavation adjacent to traffic, shall be paid under either item 207500 – Cofferdams or 207501 – Sheeting and Shoring as appropriate. These are lump sum items. The engineer shall design an approximate length of temporary sheeting needed, based on PZ22 or PZ27 sheeting, times the plan LF of sheeting shown on the construction phasing plan to find the SF of temporary sheeting. The area of sheeting times a price per SF to find a total lump sum price. Note that the contractor shall submit their own design and shop drawings for each of these items.

Do not use Item 622500 – Temporary Steel Sheet Piles for temporary sheeting.

**Section 265500 Stream Diversion**

This item gives the contractor their choice of method for maintaining stream flow around the work site. Generally this is accomplished either by a sandbag dike and a temporary pipe through the work area or by a sandbag dike and pumping stream flow around the work area.

For estimating a lump sum price, calculate the size of sandbag dike needed to block the stream flow and determine its volume x 300 sand bags/CY. If using a pipe, add LF of pipe x price per foot. If using a pump around, estimate a price from a past project of similar stream flow and duration and add it to the sandbag estimate. See item 266500 – Water Pumping for additional historical data (although we no longer use this item).

Note to Construction: This specification has been used for a few years now. Its intent was to eliminate haggling over inadequate pump sizes, flow from storm events and other miscellaneous problems that arose on a number of projects. The contractors would replace the sandbag and temporary pipe with a pump around system, but then there were no details or spec from which the problems could be addressed when something went wrong. Has this been accomplished with this item? Please comment.

**209 / 210 Borrow**

This work consists of furnishing and placing additional material from approved borrow areas on the project or other approved sources when suitable material available from the excavation is not of sufficient quantity for construction purposes.

The quantity of borrow is estimated by comparison of original surface model or cross-section compared to final surface modal or cross-sections**.** It is very important that the existing area is well surveyed and an accurate surface model developed. The volume will be computed on a cubic yard basis, by the Triangle or Average End area method. A compaction factor will need to be added to the quantity. Different materials have different compaction factors. As a general rule for most soils, a compaction factor 1.25 - 1.30 is generally used. Contact DelDOT'S Materials and Research Section for a list of compaction factors. The quantity for borrow paid under 210 to fill excavations under 207 and 208 cannot exceed the quantity as measured for 207 and 208 by more than 1.30. Once this limit is reached, additonal borrow must be 209 items. The reason for this is that placement of 210 items is paid for under 207 and 208.

**208 Excavation and Backfilling for Pipe Trenches**

This work consists of the excavation, removal, and replacement or disposal of all materials necessary for the placement of pipes. This work also consists of placing and compacting backfill for pipe trenches.The quantity of excavation and backfilling for pipe trenches will be measured as the volume of excavation included between a line from the bottom of the proposed pavement excavation to the bottom of the pipe trench at the time of pipe placement. Do *not include the depth of the pavement box or any proposed excavation above the proposed pipe in the calculation*. A normal horizontal measurement of outside pipe diameter plus 12" each side is the outside limits of trench excavation and shall extend to the exterior wall of drainage inlets and

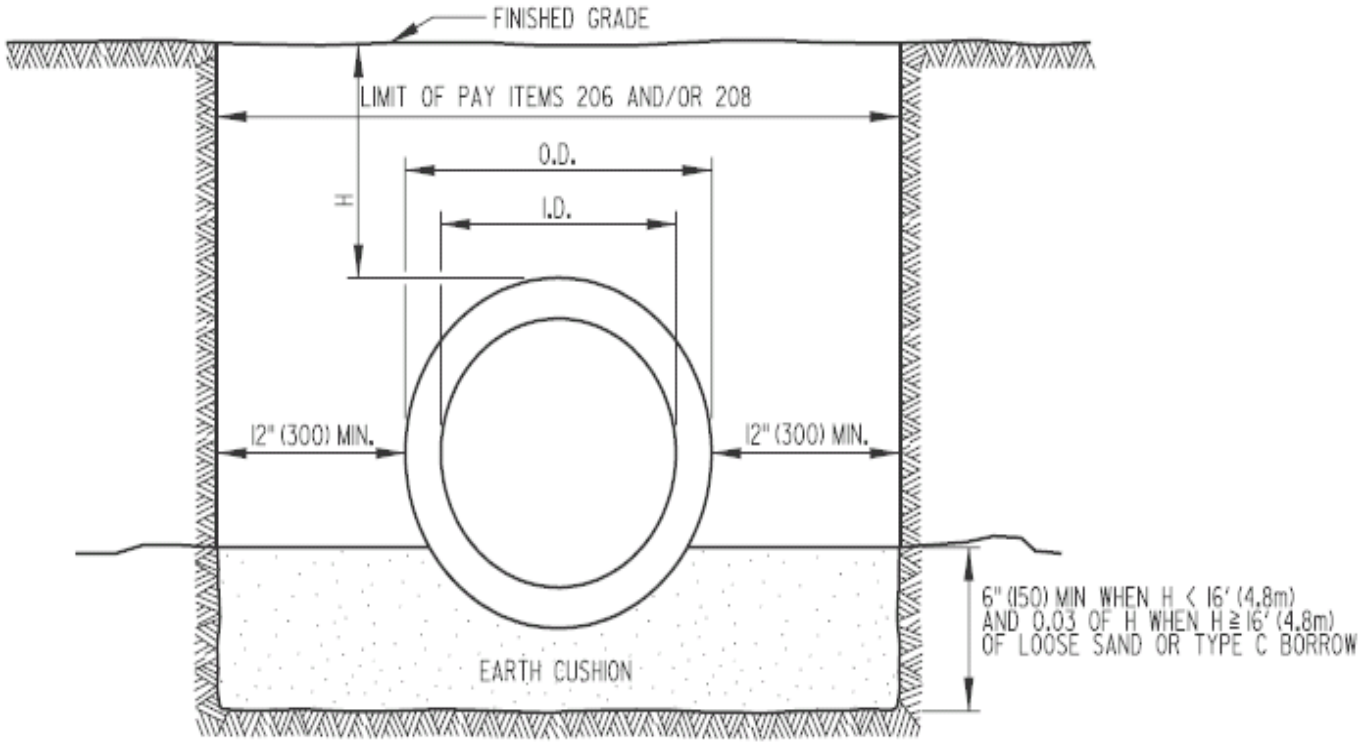
manholes. When the trench intercepts a "normal" structure, such as a headwall, culvert, etc. (where payment for structure excavation is applicable), the trench payment limit will terminate at the point where structure excavation begins [normally 18" outside the structure]. For pipe placement **in a fill area**, the trench payment limit extends to **12" above the pipe** all other fill material needed to reach grade will be covered under the borrow item used**.** For round pipe less than 24" nominal inside diameter, and elliptical pipe with a less than 24” nominal inside horizontal dimension, the excavation, backfill, and backfilling will be included in the price of the pipe and should not be included in the quantity calculation under 2080000.

## 208 EXCAVATION AND BACKFILLING FOR PIPE TRENCHES

| REINFORCED CONCRETE PIPE CLASS III | | | |
|---|---|---|---|
| PIPE SIZE in inches | Wall Thickness in inches | O.D.in FT | TRENCH WIDTH O.D. + 2 FT |
| 12 | 2.00 | 1.33 | 3.33 |
| 15 | 2.25 | 1.63 | 3.63 |
| 18 | 2.50 | 1.92 | 3.92 |
| 21 | 2.75 | 2.21 | 4.21 |
| 24 | 3.00 | 2.50 | 4.50 |
| 27 | 3.25 | 2.79 | 4.79 |
| 30 | 3.50 | 3.08 | 5.08 |
| 33 | 3.75 | 3.38 | 5.38 |
| 36 | 4.00 | 3.67 | 5.67 |
| 42 | 4.50 | 4.25 | 6.25 |
| 48 | 5.00 | 4.83 | 6.83 |
| 54 | 5.50 | 5.42 | 7.42 |
| 60 | 6.00 | 6.00 | 8.00 |
| 66 | 6.50 | 6.58 | 8.58 |
| 72 | 7.00 | 7.17 | 9.17 |
| 78 | 7.50 | 7.75 | 9.75 |
| 84 | 8.00 | 8.33 | 10.33 |
| * 208000 IS INCLUDED IN THE PRICE FOR PIPE THAT ARE LESS THAN 24" IN DIA. | | | |

| REINFORCED CONCRETE PIPE CLASS IV | | | |
|---|---|---|---|
| PIPE SIZE in inches | Wall Thickness in inches | O.D.in FT | TRENCH WIDTH O.D. + 2 FT |
| 12 | 2.00 | 1.33 | 3.33 |
| 15 | 2.25 | 1.63 | 3.63 |
| 18 | 2.50 | 1.92 | 3.92 |
| 21 | 2.75 | 2.21 | 4.21 |
| 24 | 3.00 | 2.50 | 4.50 |
| 27 | 3.25 | 2.79 | 4.79 |
| 30 | 3.50 | 3.08 | 5.08 |
| 33 | 3.75 | 3.38 | 5.38 |
| 36 | 4.00 | 3.67 | 5.67 |
| 42 | 4.50 | 4.25 | 6.25 |
| 48 | 5.00 | 4.83 | 6.83 |
| 54 | 5.50 | 5.42 | 7.42 |
| 60 | 6.00 | 6.00 | 8.00 |
| 66 | 6.50 | 6.58 | 8.58 |
| 72 | 7.00 | 7.17 | 9.17 |
| 78 | ** | ** | ** |
| 84 | ** | ** | ** |
| * 208000 IS INCLUDED IN THE PRICE FOR PIPE THAT ARE LESS THAN 24" IN DIA. | | | |
| ** REQUIERES MODIFIED OR SPECIAL DESIGN | | | |

## 208 EXCAVATION AND BACKFILLING FOR PIPE TRENCHES




## 211 Removal of Structures and Obstructions

This work consists of removal, wholly or in part, and satisfactory disposal of all buildings, foundations, fences, structures, and other obstructions which are not designated or permitted to remain within the right-of-way. Not included are items which are to be removed and disposed of under other Sections of these Specifications. This work also includes the salvaging of designated materials and backfilling of resulting cavities. All excavation necessary to remove the existing structure is paid under item 211. Backfilling cavities are limited to 24” around the plan limits of the structure; payment for material is paid under item **210 Borrow**.

The estimate for removal of structures and obstructions is a lump sum payment. Care must be taken that all items to be removed are clearly identified on the plans. Estimating the contract price may be difficult for this item on some projects. The designer should review old plans and bids for comparison of prices of similar items to be removed.

**212 Undercut Excavation**

This work consists of excavation to correct unstable sub-grades and embankment foundations and disposal of the excavated material.

The quantity of undercut excavation is estimated in cubic yards. This is a very difficult quantity to estimate; generally a percentage of 202 will have undercut excavation. The amount of undercut is determined by subsoil conditions during construction. The designer can review the soil borings to determine the subsoil type but the main factor, if not in a known wet area, is the amount of rain that will be affecting the subsoil during construction. Time of year should be considered and review of old projects in the area may help. The unit bid price for this item may not be more than 150% of the bid amount for item 202 Excavation and Embankments. Backfill material for undercut area for structures (bridge projects) type B borrow is generally used. Consult DelDOT's Material Section for additional guidance.

**250000 Sediment Removal**

This work consists of the excavation, hauling, and disposal of accumulated sediment from temporary sediment control items, such as sediment traps, sediment basins, silt fences, stone check dams, dewatering basins, dikes, swales, and diversions.

The quantity of sediment removal is paid for per cubic yard. Included in the price is full compensation for excavating, hauling, and disposing of accumulated sediment and for all labor, equipment, tools, and incidentals required to complete the work.

The sediment removal quantity is difficult to estimate. The designer must take into consideration duration of the contract and the type of construction. A project with a lot of excavation and embankment (202) will more than likely have a greater amount of sediment removal than a typical intersection improvement project. The 250000 sediment removal quantity historically has been under estimated and it is recommended adding a contingency to the quantity of 1.30.

**271 Stormwater Management Pond**

This work consists of constructing the foundation, dam, reservoir, and emergency spillway for a stormwater management pond.

The quantity of stormwater management pond is estimated in cubic yards of excavation. The unit price includes the full compensation for all work and materials (other than outfall structure) to complete the stormwater management pond in a neat and clean manner. When estimating the stormwater management pond quantity the typical approach for volume calculations should be used by comparison of original surface model or cross-section compared to final surface model or cross-sections**.** The additional work required under the 271 stormwater management pond item will require a higher estimated price for the excavation. A list of some of the additional work required for this item that is included in the cubic yard bid price:

Clearing, grubbing, and disposing of all obstructions within the pond area **(DO NOT include the Stormwater Pond area in the 201 clearing and grubbing estimate)**
Removing and disposing of all unsuitable material
Dewatering
Backfilling all areas from which unsuitable materials have been removed
Foundation Cutoff Clay Borrow, Type 1
Dam Clay Borrow, Type 2
Constructing the foundation
Constructing the reservoir
Constructing the emergency spillway
Excavating the foundation cutoff trench
Salvaging and stock piling topsoil for re-use
***The additional work that is included in this item will increase the cost of the unit price. Consult recent projects bid tabulations and review the plans for similar pond design to help determine the unit cost for the*** **STORMWATER MANAGEMENT POND** ***item.***

**401 Hot-Mix Hot-Laid Bituminous Concrete**

The method of measurement in the **field** is the actual hot-mix hot-laid bituminous concrete placed and accepted in the field, hot-mix is measured in Tons.

The engineer shall use the most recent hot-mix yield chart found on DELDOT's DRC - Design Resource Center to calculate the estimated quantities. Please note the yield charts are periodically updated and the most recent available chart should be used.

The method of estimating the tons of hot-mix used on a project is based on the areas in square yards divided by the square yards per ton. Many projects have multiple typical sections with varying widths and depths for the hot-mix items. It is important to check and double check to insure the proper quantity is calculated. This item is routinely incorrectly estimated; one reason may be the project limits were extended during construction another may be miscalculation. It is important to use the typical sections to determine the proper depths of the different hot-mix items.

## 401 Hot-Mix Hot-Laid Bituminous Concrete (continued)

### *Sample*: Hot-Mix Yield Chart (USE MOST RECENT ON DRC)

| | | | Type C | | | |
|---|---|---|---|---|---|---|
| WT ( lb/ft$^3$) | BCBC 151.5 | Type B 151.5 | 9.5mm Stone 151.5 | 12.5 mm Stone 151.5 | 4.75mm Stone 143.6 | SMA 149.5 |
| | SQUARE YARD/TON | | | | | |
| DEPTH (in) | DEEP LIFT | TYPE B | TYPE- C | TYPE-C | TYPE-C | SMA |
| 0.50 | | | | | 37.14 | |
| 0.75 | | | | | 24.76 | |
| 1.00 | | | | | 18.57 | |
| 1.25 | | | 14.08 | | 14.86 | |
| 1.50 | | | 11.73 | 11.73 | 12.38 | 11.89 |
| 1.75 | | | 10.06 | 10.06 | 10.61 | 10.19 |
| 2.00 | | | 8.80 | 8.80 | 9.29 | 8.92 |
| 2.25 | | 7.82 | | | | |
| 2.50 | | 7.04 | | | | |
| 3.00 | 5.87 | 5.87 | | | | |
| 3.50 | 5.03 | | | | | |
| 4.00 | 4.40 | | | | | |
| 4.50 | 3.91 | | | | | |
| 5.00 | 3.52 | | | | | |
| 5.50 | 3.20 | | | | | |
| 6.00 | 2.93 | | | | | |

### Sample Calculation

**The design is for a 1 mile long pavement, 24 feet wide, and 2 inches of Type C Hot-Mix.**

**[(5280 ft) x (24 ft)] / 9 ft$^2$ per yd$^2$ = 14080 yd$^2$**

**Using the above chart, for Type C - 9.5 mm Stone Hot-Mix @ 2 inches, the value is 8.80 yd$^2$ per ton**

**14080 yd$^2$ / 8.80 yd$^2$ per ton = 1600 tons of Type C Hot-Mix**

## Section 601 Timber Structures

Items that measure volume of timber structures are calculated in the unit of MFBM, which stands for Thousand Feet of Board Measure. It is based on the construction unit of Board Feet = 144 cubic inches of lumber. To calculate, take L x H x W (in inches) of the timber structure / 144 cubic inches = board feet. Board Feet / 1000 = MFBM. Add 15% for waste due to defects in the lumber.

Example: A timber wingwall 10’ long and 6’ high is planked with 3” x 12” (full-size dimensions) boards.

120” long x 72” high x 3” thick = 25920 in$^3$ / 144 in$^3$ = 180 board feet
180 board feet / 1000 = 0.18 MFBM

**Section 602 Precast Concrete**

For typical precast structures such as box culverts and rigid frames, use Item 602506 – Precast Concrete Culvert. Payment for this item shall include the box culvert of rigid frame and all associated precast items, such as wingwalls, toewalls, headwalls and/or parapets, as well as all reinforcing bars and items incidental to the installation of the culvert, such as joint wrap, grouting of shear keys, etc. The estimate shall be calculated by finding the volume of precast concrete time $750-$1000 per CY, depending on market conditions.

Note that there are a number of other items available that are associated with precast concrete, but generally they are project specific.

For Precast Prestressed Concrete members, see section 623.

**Section 602 Cast-in-Place Concrete**

All cast-in-place concrete items shall use a Fixed Quantity.

## Section 602 – Sealers and Waterproofing Membranes

These items and specifications were revised in 2007. This is a summary of the current and discontinued items. All units are SF and calculated by the area for application.

**Item 602547 - Waterproofing Bridge Deck**

Used for applying a membrane on a timber or concrete bridge deck for use between the deck and a hot mix overlay. Please pay close attention if you have used this item prior to 2007. The spec is now completely different.

**Item 602616 - Waterproofing P.C.C. Masonry Surfaces**

Used for applying a membrane to a vertical surface or a horizontal surface that is not under traffic.

**Item 602546 - P.C.C. Concrete Masonry Deck Sealer**

This item is used to seal cracking in existing concrete decks that do not have a hotmix overlay.

**Item 602518 - Water Based Acrylic Concrete Sealer**

General sealer primarily used to overcoat existing concrete or when you need a quick, easy, inexpensive sealer.

**Item 602646 - Silicone Acrylic Concrete Sealer**

This is a more effective sealer with a specification that requires better surface preparation. The cost will be much more significant than Water Based.

**Item 602588 - Anti-graffiti Coating**

This item will be found on many older bridge projects, but is now being phased out. Water Based and Silicone sealers can both be pigmented. Maintenance does not clean graffiti; they usually overcoat. Anti-graffiti coatings are usually more expensive and since we don't clean them, we don't get the benefit of that investment. We also usually have more problems in the field with Anti-graffiti coatings than with the sealers.

**Discontinued Items**

401501 - Waterproofing Membrane
401503 - Waterproofing Concrete Deck, Type I
401507 - Waterproofing Concrete Deck, Type II
602520 - Epoxy Protective Coating for Concrete - Epoxy coatings have a lot of problems and are expensive. The use of epoxy coatings is no longer supported by the department.
602521 - Waterproofing Portland Cement Concrete Masonry
602546 - Waterproofing P.C.C. Masonry – old spec
602616 - Waterproofing P.C.C. Masonry Surfaces – old spec

**Bridge Rehabilitation Items**

Items pertaining to bridge rehabilitation are often a challenge to quantify. The extent of deteriorated concrete or the limits of areas to be repaired are difficult to determine in the preconstruction phase. The full extent of the repairs will not be known until the work is actually performed. However, estimates can have some improved rationale behind them.

**Repair of deteriorated concrete (Items 602572 – Repairing Existing PCC Structures and 602586 – Rehabilitation of Concrete Structure)**

These items are used to repair spalled, delaminated and deteriorated concrete. 602572 is used for shallow spall repairs that are less than 2" deep and do not go deeper than the reinforcing bar. It is paid for in LB. 602586 is used for deep spalls that are deeper than 2" and fully expose a portion of the reinforcing bar and is one of the few items paid in CF. The same material is often used for both items. The material yield (how many LB of mix yields how much volume of patch material) can be found in the product literature of the materials listed in the special provision.

Estimating these quantities can be quite difficult. During the design phase, the engineer should sound all areas of concrete to identify areas in needed of repair. These can be estimated as potential shallow or deep repairs and an estimated volume can be determined. For shallow spalls, take the area measured x 2" depth x product yield rate = LB of material. For deep spalls, use area measured x 4" depth (1" below rebar) = volume of repair, unless areas of deeper repair are indentified in the inspection. But since the full extent is unknown until the contractor starts chipping concrete, add a 25-50% contingency. In addition, Bridge Management can provide inspection records detailing deteriorated areas and provide access by boat or UBIV if necessary for the engineer to inspect the structure. M&R can take horizontal cores to determine the depth of cracks, concrete strength, etc.

**Item 602611 – Repair of Concrete Structures by Epoxy Injection (LF)**

Use this item instead of Item 602514 - Repair of Concrete Structures by Epoxy Injection (Gal) as it is much easier to quantify. Cracks below any repair areas, surrounded by sound concrete, shall be repaired by epoxy injection. Cracks to be injected are to be a maximum of 1/16" thick and 1" wide. Cracks to be injected shall also have injection ports and tees installed.

**Item 610502 – Pointing Existing Stone Masonry**

For repair of existing stone masonry structures, this item is used to repair mortar joints between stones in an otherwise stable and sound wall. Quantity can be estimated by taking a typical area (or several areas) of stone masonry, measuring the LF of joints within the area and identifying the LF in need of repair. Add a 25-50% contingency.

For areas where the stone masonry wall has deteriorated further (such as loose, dislodged or missing stones), use either 610503 – Reconstruction of Wall (CY) or 610505 – Reconstruction of Stone Structure (CF) as appropriate. For very small volumes, use the CF item.

Note: Item 610001 – Stone Masonry is a SF item. This unit of measure is not well suited for the repair of a volume of wall. Typically the area item is used for placement of stone veneers.

**Section 603/604 Reinforcing Bars**

All reinforcing bar items shall use a Fixed Quantity.

**Section 605 Steel Structures**

For any structural steel, use Item 605002 – Steel Structures (LS). To estimate a lump sum price, the engineer shall calculate the total weight of the beams and then add 15%-20% to account for all hardware, such as diaphragms, stiffeners, sole plates, nuts, bolts, washers, etc. Then take the total number of LB of steel times the price per LB = lump sum price.

Do not use Item 605001 – Steel Structures (LB). Since the unit of measure is LB, this requires the inspector to weigh all steel materials used from whole beams to every nut, bolt and washer. This is very difficult to accomplish in the field.

**Section 618/619 Furnishing and Installation of Piles**

The total LF of piling needed for a project is straightforward (# of piles x length of each pile). The number of test piles shall be determined from AASHTO Table 10.5.5.2.3-3. For estimating purposes, the engineer should be aware that the contractor will often 'front-load' their estimate with a higher price on the material than the installation. This is because they will get paid material for the total quantity delivered to the jobsite, but installation is paid to only the material driven and used in the finished structure.

**Item 619519 – Dynamic Pile Testing by Contractor**

PDA monitoring of test pile drives is now being performed by the contractor instead of by in-house personnel. This is an EA item. Include quantity for the initial test pile drive and for a possible re-strike.

## Stream Restoration Items

The restoration of the stream in the vicinity of the bridge construction has become a very important part of securing environmental permits. This has led to several new procedures such as the use of channel bed fill and placing topsoil and seeding over riprap.

**712Rip-Rap**

The quantity of rip-rap is measured as the actual number of cubic yards of rip-rap incorporated into the finished construction and accepted. The quantity of stone riprap (more commonly used) is measured as either the actual number of square yards or the actual number of tons of riprap for each class placed and accepted. If stone riprap is measured by the square yard, the quantity will be determined by computations based on field measurements taken on and along the completed finished surfaces (no horizontal projection) and the specified placement thickness for the class. Payment for geotextile will be made under the appropriate Section and **not** included in the Rip-Rap item no matter if measured in square yards or tons.

All cost associated with excavation and preparation of the bedding and placing of the material is included in the bid price for Rip-Rap

**712Rip-Rap**

**Example**

**Calculating the Rip-Rap by the TON:**

**The general rule of when calculating the WT of Rip-Rap.**

**1 Cubic Foot of Rip-Rap = 110LB -120LB (Contact the lab for guidance on WT)**

**An out fall pipe is calculated to have to have an area of 75 Square Feet of R-4 Rip-Rap for scour protection. The Rip-Rap is placed to a depth of 24" (2 feet) how many Tons of Rip-Rap are needed.**

**75 SQFT X 2 FT = 150 CF**

**150 CF X 120 LBS per CF = 18000 LBS**

**18000LB / 2000LB per Ton = 9 Tons**

**Area Calculations**

These calculations consist of mainly pavement materials, topsoil, sidewalk, etc. It is very important that the project engineer detail the methodology used in obtaining the area quantities. A detailed description should be provided for each area being quantified. This can be accomplished either by listing specific station limits or by a detailed area description such as a sketch of the area. Many of these areas are going to be measured in MicroStation. Care needs to be taken to make sure that when measuring in MicroStation that we also take into account the additional length of a non-planer surface. Such as when measuring a topsoil surface area we cannot just measure the top view area because the actual length of the front and back slope is greater. Pavement slopes are negligible on flat terrain but the slopes for topsoil need to be accounted for. If you are in a rolling terrain the calculations need to reflect the actual surface area. Also when calculating items such as hot-mix wedges the use of cross sections will be needed to accurately determine the quantity.

**Item 732500 - Topsoil (ton)** to be used on riprap. This began as an aesthetic concern for a bridge in a park setting and a request to make the finished product a better fit into a natural setting. From there it has become popular with the environmental agencies and aids in the permit process. To calculate a volume, assume a 6" depth of topsoil over the area of riprap to be covered (include distance along slopes). This will allow for some of the topsoil to be worked into the voids between stones and leave approximately 2" to cover the stones and establish grass.

Note to Construction: The methods in this section have never been checked against actual quantities. Please advise if there have been large discrepancies in these items.

**Item 712531 - Channel Bed Fill**

This item provides for the excavation of natural channel bed material and, after installation of the bridge and riprap, the placement of existing and/or additional channel bed material to re-establish a natural channel bottom. The bottom of slab of any culvert or any scour protection shall be placed 12" below the stream grade. This 12" recess shall be filled with channel bed fill. The quantity is calculated as the volume of fill to be placed. Note there is a preference to use existing material, but there is typically not enough at a project site and material will have to be furnished.

Riprap below channel bed fill shall be choked with B borrow prior to placement of channel bed fill. The volume of B borrow shall be estimated as 30% of the riprap volume.

In locations where the natural channel bed material consists of silt or muck, the existing material is impossible to stockpile. Instead, excavate as part of other items (207/211) and replace with B Borrow or Sand (Item 756000).

**734017 Temporary Seed**

The quantity of re-fertilization and the temporary seeding will be paid for at unit price per square yard. Included in the bid price is preparing the ground. The Temporary Seeding item is routinely under estimated. Many times the same area needs to be reseeded multiple times. This can be due to poor weather conditions, lack of water and extension of the project through multiple growing seasons. The designer needs to take all this into consideration when developing the estimate. This item is also used to stabilize stock piles of material and should be included in the estimate when calculating erosion and sediment control items. The designer should estimate double the area that needs to be temporary seeded in most cases.

**735 XXX Mulch**

The quantity of Straw Mulch will be paid for at unit price per square yard. Included in the bid price is preparing the ground. The Straw Mulch item is routinely under estimated. Many times the same area needs to be reseeded and mulched multiple times. This can be due to poor weather conditions, lack of water and extension of the project through multiple growing seasons. The designer needs to take all this into consideration when developing the estimate. Mulch may also be used in stockpile areas.

**Linear Calculations**

These calculations are typically for Curb, Pipe, Guardrail, E&S measures, Striping, etc. Most of these items are quantified on the plan sheets in the schedules. Care should be taken when determining the lengths of these linear elements. In some cases the slope of the element may be such that the measurement straight from MicroStation will not be accurate. Also, the Method of Measurement in the Standard Specifications will indicate what lengths are to be included. You will need to review the basis of payment for other items because in some cases the linear items such as curb ramps where the curb is incidental to the curb ramp.

**612XXX Pipe:**

The quantity of pipe will be paid for at the unit price per linear foot for each type of pipe. The unit price includes full compensation for furnishing, hauling, and installing pipe; for all cribbing or foundation treatment necessary to prevent settlement; for all shoring and sheeting; required to install the pipe.

For round pipe less than 24” nominal inside diameter, and elliptical pipe under 24" nominal inside horizontal dimension, the excavation (excluding rock), backfill, and backfilling **will be** included in the price for the pipe. For pipe of nominal inside diameter or horizontal dimension of 24” and over, payment for excavation and backfill will be in accordance with Section 208 and payment for furnishing of Borrow Type C will be under Section 210.

Pipe is measured from the inside of drainage inlet wall to inside of inlet wall. The lengths of pipe should be in increments of 8’ whenever possible and for HDPE pipe in 20’ increments. The length of pipe should be measured from the profile. If no profile is included in the plan set adjustments to the length to account from slope should be made. In an open drainage system the length of pipe shall be calculated to enable proper grading of 4:1 or 6:1 slopes at the end of pipes. This includes driveway pipe extensions.

**720XXX Guardrail:**

Galvanized Steel Beam guardrail is paid for by the linear foot of guardrail. The quantity of guardrail **components** such as guardrail over culverts and end-treatments are paid for at the unit price per each component. The item includes full compensation for furnishing and placing all materials, including reflectorized washers; for burring of bolts; for excavating, backfilling, compacting, and disposing of surplus materials; and for all labor, equipment, tools, and incidentals required to complete the work.

The designer should not include the lengths of guardrail components in the calculation for the length of guardrail. Components should be separated out on the plan sheets and identified in the guardrail schedule.

**748XXX Striping:**

The quantity of temporary and permanent pavement markings is measured by the linear foot of 4" or 6" line and by the square foot for symbols, installed. Measuring of striping is broken up by plan sheet per LF of each type of striping. Many different styles of striping are paid for under the same item 748506 Permanent Pavement Striping Epoxy Resin 4". Although an area measurement, the same consideration must be observed when measuring item 748015 Permanent pavement Striping, Symbol Legend Alky-Thermo. The designer should break out the length and types of pavement markers per line per plan sheet as shown bellow.

**Example:**
**Item 748506 - Permanent Pavement Striping Epoxy Resin, 4"**

| Category | Legend<br>Pavement Markings |
|---|---|
| A | 4" Solid White Epoxy Resin Pavement Striping |
| B | 4" Dashed White Epoxy Resin Pavement Striping (10'-30') |
| C | 4" Dashed White Epoxy Resin Pavement Striping (2'- 6') |
| D | 4" Solid Yellow Epoxy Resin Pavement Striping |
| E | 4" Solid Double Yellow Epoxy Resin Pavement Striping |

| Plans Sheet | A LF | B LF | C LF | D LF | E LF | Total LF |
|---|---|---|---|---|---|---|
| SSO1 | 169 | 400 | 260 | 807 | 500 | 2136 |

**MOT Items**

**Maintenance of Traffic (Each per Day/ Per Hour) items**
To determine the quantity for these items, contract timing will have to be estimated. This draft contract timing should be broken down into phases to match the sequence of construction. The Delaware MUTCD shall be referenced to determine which MOT items and how many are required for each specific traffic control case needed for the project. It is important to revisit each per day / per hour items once the Timing Statement is complete to ensure that the calculated quantities match the contract duration.. Every effort should be made to provide the safest possible plans for construction workers and the traveling public. MOT items are routinely under estimated for a number of reasons. One of the main reasons is under estimating contract time during the development of the quantities. If the contract time increases betwee semi-final, final and PS&E the MOT quantities should be adjusted. For example; if at final plans the estimate is 100 calendar days for a particular phase and at PS&E the contract time for that phase was estimated to be 120 days your MOT quantities are 20% low for that phase. The estimate for the MOT items for that phase must be revised before advertisement.

Utility work needs to be taken into account when doing the MOT quantity calculations and should be clearly separated out in the estimate to provide payment if that work is chargeable to the utility company. All MOT for utility work will be included in the contracts MOT items.

**Always use the most recent edition of the Delaware Department of Transportation Manual on Uniform Traffic Control Devices (MUTCD) when determining traffic control needs. (DelDOT's MUTCD)**

**720527 Plastic Drums**

Plastic drums are Each/Day items.. This includes relocation(s) of the drum as directed by the Engineer or as noted on the plans. Drum spacing is based on the speed limit of the roadway. The requirements can be found in DelDOT's MUTCD. Keep in mind that the spacing for tapers is shorter than the spacing in tangent sections. (See DelDOT's MUTCD Section 6F.58 Channelizing Devices).

See DelDOT's MUTCD Section 6F.58 Channelizing Devices for guidance on channelization necessary for pedestrian MOT.

**720527 Plastic Drums**

In calculating the number of drums as per DelDOT's MUTCD six channelizing devices drums or cones are to be provided for each arrow panel or message board within the shoulder during the day and night. When an unattended arrow panel will be on site at night, drums shall be utilized, and one (1) amber Type B light shall be provided on each of the first two drums. If all drums meet the new sheeting requirements, lights shall not be utilized.

Traffic cones are included in the lump sum price of MOT and do not get estimated.
**See** DelDOT's MUTCD Section 6C.08 Tapers for guidance on **calculating Taper Lengths for MOT.**

**743 Warning Lights**

Warning Lights, Types A and B will be measured in units of Each/Day for each type, actually furnished and used, and approved by the Engineer. This item is used in direct correlation with Drums, Warning Signs and Barricades. Please follow the DelDOT's MUTCD for applications. Also remember to increase or decrease the quantity accordingly if the timing changes.

**743507 Temporary Barricades**

The number of temporary barricades, shall be paid for at the Contract unit price bid per LF/Day barricade for the item "Temporary Barricades, Type III" which prices and payments includes furnishing, placing, maintaining, and relocating the barricades as required. See DelDOT's MUTCD for guidance on the use of temporary barricades. **Type III barricades shall have a minimum width of 6'**.

The Temporary Barricades item is frequently under estimated. Reasons maybe because there was a change in contract time between semi-final, final and PS&E and the timing changes was not reflected in the quantity or a time extension was granted to the contractor. Please take the time to update quantities as timing changes.

**743514 Furnishing and Maintaining Message Boards**

This item consist of furnishing, placing, operating and maintaining trailer mounted message board during the construction of the project. The message board shall be placed and relocated on the job site at location(s) as determined by the Engineer.

The Furnishing and Maintaining Message Board is an item identified as being continuously under estimated. Some reasons why this could happen is if there was a change in contract time between semi-final, final and PS&E or a time extension was granted to the contractor. Please take the time to update quantities as timing changes and include the increase in associated items such as lights and drums. The engineer should work with construction during semi-final submission to determine how long before start of construction and changes in traffic patterns message boards should be placed. The engineer should also contact DelDOT's public relations department for possible additional use of message boards.

**743525 Temporary Warning Signs**

Temporary Warning Signs are those signs erected for a particular operation or phase of the project and remain in place just during working hours such as "Flagger Ahead" signs or may remain in place for several days or more such as "Right Lane Closed" signs. Temporary Warning Signs shall be measured in unit of Each/Day furnished and erected.

It is important for the Engineer to review the DelDOT's MUTCD. To estimate the number of warning sign the Engineer should review each phase of work and the traffic control case proposed to determine the number of signs per phase. Timing needs to update and quantity revised accordingly at each submittal.

**763505 Traffic Officers**

This item shall consist of providing off-duty police officers to direct and control traffic at any location as designated by the Engineer. The traffic officers will be used to provide traffic control for active construction operations, as a means of providing enforcement to the work zone speed restrictions, to initiate rolling road block closures, to stop traffic when needed and as directed by the Engineer. The payment for this item is based on hours.

This item is routinely under estimated; It is recommended that the design engineer work with construction during design phase to determine the amount of traffic officers that will be needed. In some cases more than one officer will be needed on a project. One way of estimating the number of hours for traffic officers is to estimate a 10 hour day for each day a traffic officer will be on a project. This will cover a typical workday on a project during good working conditions and may also provide somewhat of a buffer in the estimate.

**This is a fixed price item at $75/hr.**

**7425XX Flaggers**

Flagger shall consist of furnishing personnel and necessary equipment for the controlling of traffic through work areas. Flagger shall be paid for at a unit price per hour for each Flagger required. The designer must also estimate the number of overtime flagger hours that will be needed on a project. This is a very difficult item to estimate some phases of work may require multiple flaggers some locations such as intersections and others locations only one or two flaggers per day. Depending on the number of work operations going on at the same time, there could be 4, 6, or more flaggers on the job at any given time.The design and construction engineers should follow the requirements set forth in DelDOT's MUTCD and estimate at a minimum the number of flaggers required in the MUTCD per phase. The design engineer should use a 10 hour workday. You will need to add an additional 20 % of the total for overtime flagger item. Also the design engineer should update the estimate based on changes in timing.

**The Flagger rates change once a year. If you have a Federal project, choose the higher rate -State or Federal Flagger.**

**FUTURE ADDITIONS: SIDEWALK, CURB AND CURB RAMPS.**