**VIRGINIA DEPARTMENT OF TRANSPORTATION**

# LOCATION AND DESIGN DIVISION

## INSTRUCTIONAL AND INFORMATIONAL MEMORANDUM

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| GENERAL SUBJECT:<br>EARTHWORK QUANTITIES | NUMBER:<br>IIM-LD-138.6 |
| SPECIFIC SUBJECT:<br>COMPUTATION AND SUMMARIZATION OF EARTHWORK QUANTITIES | DATE:<br>DECEMBER 8, 2006 |
| | SUPERSEDES:<br>IIM-LD-138.5 |
| DIVISION ADMINISTRATOR APPROVAL: Mohammad Mirshahi, P.E.<br>State Location and Design Engineer<br>Approved December 8, 2006 | |

Changes are shaded.

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CURRENT REVISION

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- This memorandum has been revised to add a sample Grading Diagram and Summary Sheet.

- Please note that efforts are underway to implement methods for producing phased construction cross sections. Until those efforts are complete, grading diagrams will continue to be required.

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EFFECTIVE DATE

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- This memorandum is effective upon receipt.

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POLICY

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- Projects containing Regular Excavation and Borrow as pay items shall have compaction (shrinkage or swell) factors, as furnished by the Materials Division, applied to Regular Excavation and Borrow quantities.

- When Regular Excavation is to be paid for on a plan quantity basis, and Embankment is a pay item, the contractor shall be responsible for determining the effect of the shrinkage or swell of the material. Reference VDOT's Road and Bridge Specifications, Section 303.

## PROCEDURE

- The Materials Division will generally estimate the shrinkage or swell in each cut and recommend an average shrinkage or swell factor to be used throughout the project. On a project having differing soil types, the Materials Division may recommend more than one factor to be applied to the applicable areas of the project. The Materials Division will recommend a compaction factor for borrow based on average shrinkage or swell for the general vicinity.

- In the event that the shrinkage or swell factor is not received from the Materials Division by Preliminary Field Inspection Stage, an estimated factor (as provided by Materials Division) shall be used in the interim.

- This procedure has been developed to apply shrinkage or swell to excavation quantities in lieu of fill quantities and should prevent large overruns of Borrow quantities during construction.

## PLAN SUMMARY NOTE

- For projects with a pay item for Borrow, the following note is to be shown on the Grading Summary sheet:

  "The borrow quantity shown was computed on the basis of the estimated average shrinkage or swell factor for the general vicinity of the project. The contractor will be responsible for determining the actual factor for the site(s) from which he proposes to secure borrow material and shall determine the actual quantity of borrow material needed to complete this project."

- For projects with a pay item for Embankment, the following note is to be shown on the Grading Summary sheet:

  The embankment quantity shown has not been adjusted for shrinkage or swell factors. The contractor will be responsible for determining the effect of the shrinkage or swell factor of the embankment material, and no adjustment will be made in pay quantities for this factor. The contractor shall determine the actual quantity of embankment material needed for complete this project."

## GRADING DIAGRAM AND SUMMARY

- In development of the Grading Diagram and Summary it is essential that the project sequence of construction be taken into consideration to avoid specifying use of material which may not be available until a later phase of construction. On complex projects, it may be necessary for the designer to develop rough grading diagrams and summaries for each phase of work to accurately determine the grading effort required. This may include making provision for stockpiling material for phased construction, protecting stockpiled material from moisture, provisions for second hauls, timing of excavation for stormwater management/erosion and sediment control, etc.

- The Grading Diagram is to be on a scale that enables the entire limits of the project to be shown on a single sheet, if practicable. Straight line alignment is to be used to graphically depict all baselines on this sheet. List all earthwork quantities (computer, manual, or estimated quantities) on the GRADING DIAGRAM AND SUMMARY Sheet. Cut and fill quantities should be adjusted (for compaction factor, root mat and unsuitable material to be removed) on a print or rough draft. Adjusted cut and fill quantities are not to be shown on the final Grading Diagram.

- Symbols shall be used to identify quantities shown in the grading diagram. Notes and formulas (with corresponding letters applied to grading items) shall be shown with the grading summary to demonstrate how earthwork quantity totals were derived. If any of the notes or symbols on the GRADING DIAGRAM AND SUMMARY insertable sheet are not applicable for a particular project they should be deleted or lined through. The same applies for any column in the Grading Summary. If any of the columns are deleted the formulas on the bottom of the sheet should be revised.

- In several locations on the insertable sheet (specify material) appears. The designer must fill in the appropriate material in these locations.

- The Designer should modify notes as necessary to reflect different conditions applying to his/her particular project.

- Pay items shall be designated in accordance with the Engineer's Estimate Item Code Listings. Plan quantity items shall be specified in accordance with the current version of Instructional and Informational Memorandum IIM-LD-135.

- "The plan quantity symbol is to be shown for "Roadway Cut" and other appropriate cut quantities. The "Total Regular Excavation" quantity is subject to change during construction and may include some non-plan quantity items. Therefore, do <u>not</u> show the plan quantity symbol for "Total Regular Excavation" in the Grading Summary. The plan quantity symbol should <u>not</u> be shown on the "Regular Excavation" quantity in the engineer's estimate if any part of the total includes non-plan quantity items.

Fill Quantities

- Material removed from locations in fill (root mat, unsuitable material, demolition of pavement) is to be backfilled with Regular Excavation, Borrow material, Embankment, etc.

- Include the quantity for backfill with the quantity for roadway fill (if same type material) to obtain the fill quantity needed for applicable locations.

Usable Cut Quantities

- To obtain usable cut to make fills, subtract root mat and/or unsuitable material above subgrade from individual cut quantities. Then, for borrow projects, apply shrinkage or swell factor received from Materials Division. The resulting quantity will be usable cut.

Earthwork Hauls

- In diagramming earthwork hauls, care must be taken to specify only usable materials, which are available for use in the same stage of construction, and not materials, which will be needed in a different phase of work.

- Usable excavation should be hauled the shortest distance possible to make fills. Balance points should be established and locations that require additional material (Borrow or Embankment) should be held to a minimum.

- Haul material shown in grading diagram is C.Y. of non-compacted material.

EARTHWORK COMPUTATIONS (PAY ITEM FOR BORROW)

Example Roadway #1: Compaction Factor of 20% Shrinkage

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|---|---|
| Fill (Measured) = | 5,000 C.Y. |
| Cut (Measured) = 5,000 C.Y. | |
| Cut (Adjusted) = (5,000 C.Y. x 80%) = | -4,000 C.Y. |
| *Borrow (Measured) = | 1,000 C.Y. |

* To comply with the plan note for borrow material this quantity must be converted to measured cut to meet borrow requirements. The compaction factor as furnished by the Material Division must be applied to determine the computed borrow as follows:

Sample Borrow Site: Compaction Factor of 20% Shrinkage

| | |
|---|---|
| Borrow (Measured) = | 1,000 C.Y. |

Borrow (Computed) = (1,000 C.Y. ÷ 80%) = 1,250 C.Y.**

-or-

Sample Borrow Site: Compaction Factor of 20% Swell

Borrow (Measured) = 1,000 C.Y.
Borrow (Computed) = (1,000 C.Y. ÷ 120%) = 833 C.Y.**

** This is the measured cut required to meet borrow requirements.

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Example Roadway #2: Compaction Factor of 20% Swell

| | |
|---|---|
| Fill (Measured) = | 5,000 C.Y. |
| Cut (Measured) = | 5,000 C.Y. |
| Cut (Adjusted) = (5,000 C.Y. x 120%) | -6,000 C.Y. |
| Surplus (Adjusted) = | 1,000 C.Y. |

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EARTHWORK COMPUTATIONS (PAY ITEM OF EMBANKMENT)

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|---|---|
| Fill | 10,000 C.Y. |
| Cut (usable) | -4,000 C.Y. |
| Embankment | 6,000 C.Y. |

Fill quantity includes mainline, connections, entrances, etc., plus any area such as material removed from below fill that needs to be replaced.

Cut (usable) includes plan and non-plan quantity minus any unsuitable material.

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COMPUTATIONS FOR GRADING DIAGRAM:

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Example: Compaction Factor of 18% Shrinkage

Right Side of Roadway

| | |
|---|---|
| 3679 C.Y. | cut (measured) |
| - 561 C.Y. | rootmat in cut (unusable material) |
| 3118 C.Y. | usable excavation (measured) |
| x 0.82 | (18% Shrinkage factor) |
| 2557 C.Y. | usable excavation (adjusted) |

| | |
|---|---|
| 395 C.Y. | fill (measured) |
| +141 C.Y. | rootmat in fill (to be backfilled) |
| 536 C.Y. | fill (measured) |

2557 C.Y. usable excavation (adjusted)
-536 C.Y. fill (measured)
2021 C.Y. extra usable excavation (adjusted)

2021 C.Y. usable excavation (adjusted) = **2465 C.Y. haul** (measured)
0.82

**Left Side of Roadway**

177 C.Y cut (measured)
-177 C.Y. rootmat in cut (unusable material)
0 C.Y. usable excavation

4093 C.Y. fill (measured)
+198 C.Y. rootmat in fill (to be backfilled)
4291 C.Y. fill (measured)

**2465 C.Y. haul** (measured)
x 0.82
2021 C.Y. haul (adjusted)

4291 C.Y. fill (measured)
-2021 C.Y. haul (adjusted)
2270 C.Y. Borrow (measured)

Computation Factor for Borrow Site = 18%

2270 C.Y. = 2768 C.Y. Borrow Material (computed)
0.82

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INSERTABLE SHEET

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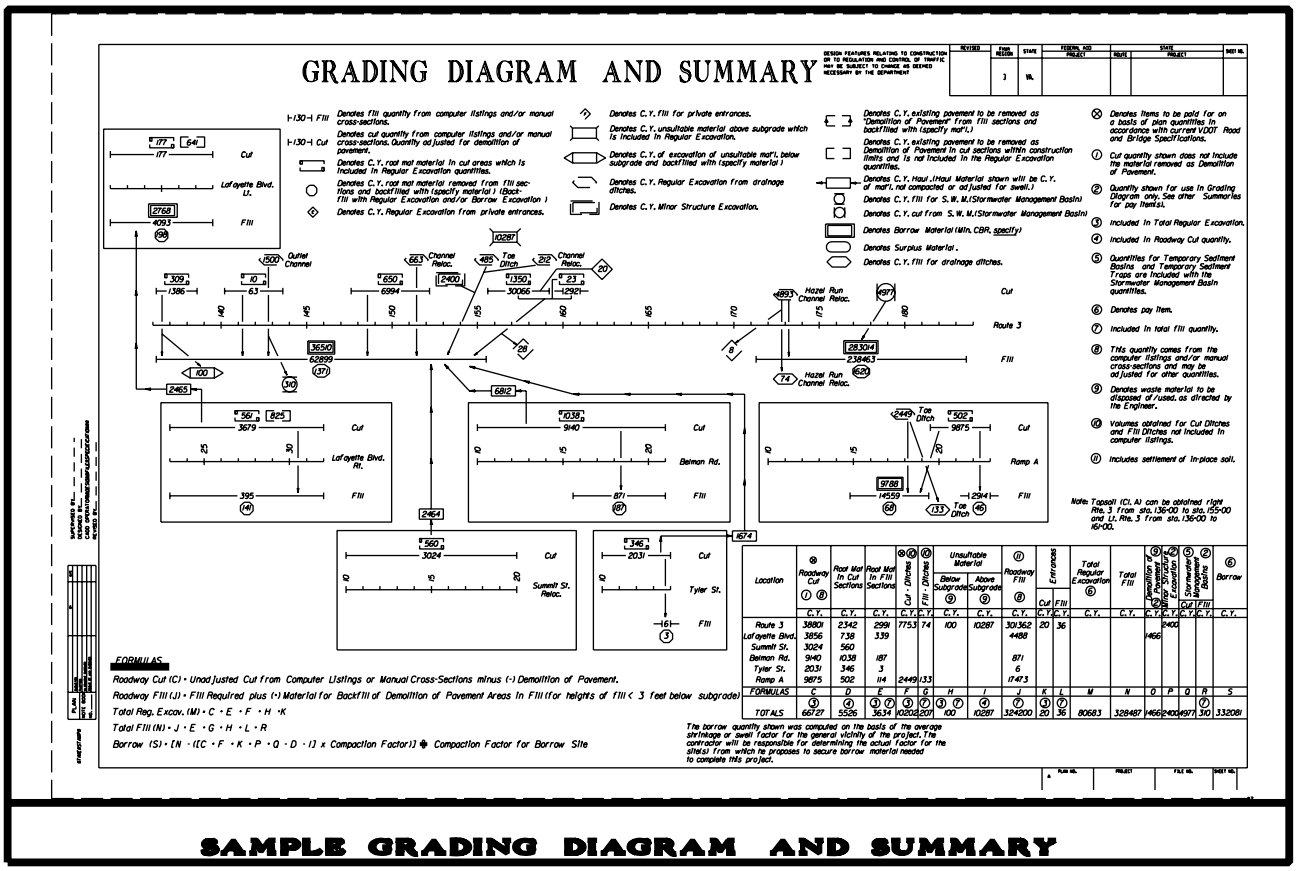
- See Insertable sheet number A-71 GRADING DIAGRAM AND SUMMARY. This sheet contains standardized notes, formulas and symbols applicable to a typical Grading Summary. Designers should use only notes, which are applicable to their project.

  The insertable sheets are available on Falcon/DMS, eng-ser, file name “minsert” (Metric) or “insert” (Imperial) for insertion into applicable plan assemblies.

For the current insertable sheet,
See the Insertable Sheet Directory.




EXAMPLE