

Chapter 300

Bases - 21

This chapter is not part of the Project's specifications but is a guide for project personnel in interpreting CDOT specifications, understanding ASTM, AASHTO, and Colorado Procedures (CPs) for testing, and for completing CDOT forms.

The design and construction of a pavement structure may include one or more base courses. A base course is a layer of material below the wearing surface of a pavement. Bases may be constructed of gravels, mixtures of soil and aggregate, mixtures of asphalt and aggregate, mixtures of cement and aggregate or soil, or other innovative materials. Bases may be made of unbound materials, such as gravel, or bound materials, such as lime treated subgrade.

Base courses under concrete pavements provide a drainage layer, reduce pumping, provide protection against frost damage, and provide support for the heavy equipment used for placing concrete pavements. There is some increase in structural capacity when a base is placed under a concrete pavement, but it is typically not a significant amount.

Base courses under flexible pavements provide a significant increase in structural capacity. Pavement design of flexible pavement depends on the wheel loads being distributed over a greater area as the depth of the pavement structure increases. There are the added benefits of improved drainage and protection against frost damage.

ITEM 206 STRUCTURE BACKFILL

ITEM 304 AGGREGATE BASE COURSE

Compaction of unbound bases is important for the stability of the pavement it supports. The maximum dry density is established in the laboratory before construction. During construction measurements of the base dry density is compared to the maximum dry density. The requirements for compaction of aggregate base course (ABC) are shown in Subsection 304.06 of the Standard Specifications for Road and Bridge Construction. Structure Backfill has similar requirements as shown in Subsection 206.03.

Two methods to determine the maximum dry density of soils are AASHTO T 99 and AASHTO T 180. AASHTO T 99 is similar to ASTM D 698 and is commonly referred to as the Proctor Test, as it was first proposed by R. R. Proctor in 1933. AASHTO T 99 uses a 5.5 lb. rammer dropped from 12 in. When a 4 in. mold is used, three layers are compacted with 25 blows on each layer. When a 6 in. mold is used, three layers are compacted with 56 blows on each layer. AASHTO T 99 results in a compactive effort of 12,400 ft-lbf/ft³. AASHTO T 180 is similar to ASTM D 1557 and is commonly referred to as the Modified Proctor Test. AASHTO T 180 uses a 10 lb. rammer dropped from 18 in. When a 4 in. mold is used, five layers are compacted with 25 blows on each layer. When a 6 in. mold is used, five layers are compacted with 56 blows on each layer. This results in a compactive effort of 56,000 ft-lbf/ft³. Comparing compactive efforts, AASHTO T 180 produces four and a half times the compactive effort than a sample receives compacted according to AASHTO T 99.

AASHTO T 99 is the appropriate standard for compaction of cohesive soils, particularly if there is the potential for swelling when saturated. AASHTO T 180 is appropriate for granular soils, such as aggregate base course and Structure Backfill, Class 1.

There are four methods of determining moisture-density relationships by AASHTO T 180:

- Method A uses a 4 in. mold and the fraction of the soil passing a No. 4 sieve. AASHTO states that this is applicable to soil mixtures that have 40% or less retained on a No. 4 sieve.
- Method B uses a 6 in. mold and the fraction of the soil passing a No. 4 sieve. AASHTO states that this is applicable to soil mixtures that have 40% or less retained on a No. 4 sieve.
- Method C uses a 4 in. mold and the fraction of the soil passing a 3/4 in. sieve. AASHTO states that this is applicable to soil mixtures that have 30% or less retained on a 3/4 in. sieve.
- Method D uses a 6 in. mold and the fraction of the soil passing a 3/4 in. sieve. AASHTO states that this is applicable to soil mixtures that have 30% or less retained on a 3/4 in. sieve.

The Gradation requirements for Class 1 Structure Backfill and ABC are shown in Subsections 703.08 and 703.03 respectively. A review of the Gradation requirements shows that many granular materials will meet the Gradation requirements and exceed the limits of application stated in AASHTO T 180.

Colorado has developed a rock correction formula in Colorado Procedure 23 (CP 23) when AASHTO T 180 is used:

$$\text{MDD} = (P_f \times D_f + P_c \times 0.95 D_c) / 100$$

The standard practice within the Department follows:

- 110 lbs. of granular material are sampled and sent to the laboratory before construction begins. This would typically require two standard sample bags.
- The material is separated into two fractions, material retained on a No. 4 sieve and material passing a No. 4 sieve.
- The specific gravity and absorption of the material retained on a No. 4 sieve is determined according to AASHTO T 85 Specific Gravity and Absorption of Coarse Aggregate.
- The maximum dry density and optimum moisture of the material passing a No. 4 sieve is determined according to AASHTO T 180, Method A.
- For bases with crushed concrete or reclaimed asphalt pavement (RAP), an accurate specific gravity determination is difficult to make. For these materials T 180, Method D is used.
- Method D may be used if more than 30% of the material is retained on the No. 4 sieve, but has 30% or less of the material retained on the 3/4 inch sieve. When Method D is used, use the above procedure but substitute the 3/4 inch sieve for the No. 4 sieve.

During construction, the control of compaction follows according to the plans, specifications, and the Frequency Guide Schedule for Minimum Materials Sampling, Testing, and Inspection. Each field test must include a separation of the sample into the two fractions, material retained on a No. 4 sieve, and material passing a No. 4 sieve. Percent relative compaction is determined according to CP 25. CP 23 is used to correct the maximum dry density and optimum moisture for soil-rock mixtures with more than 5% material retained on a No. 4 sieve.

ITEM 308 PORTLAND CEMENT & FLY ASH

Sources of Portland cement and/or fly ash are listed on the Department's Approved Product List. To verify a specific cementitious material that may be considered for a project check if the supplier/manufacturer of the cement or fly ash is on the Approved Products List at the web site address of:

<https://www.codot.gov/business/apl>

If a manufacturer wants to add a cement or fly ash source use the same web site and follow the instructions within Notice to Manufacturers: <https://www.codot.gov/business/apl/manufacturers.html> and also follow all references within CP 11:

CDOT Materials Forms - Applicable for Bases

<https://www.codot.gov/library/forms/form-numbers-broken-down>

Materials Forms, Instructions & Examples Chapter

NOTE: The example forms are still in development, as they are completed they will be entered into the chapter. Use the relevant example forms from the The electronic version of the 2018 FMM.

Form	Title
157	Field Report for Sample Identification or Materials Documentation
6	Field Tests of Base Aggregate, Fillers, Paving and Miscellaneous Aggregates
38	Aggregate Test Report - [<i>computer output</i>] SiteManager
194	Structure Backfill Density Report
564	Soils and Aggregate Sieve Analysis When Splitting On the No. 4 Sieve
565	Sieve Analysis For Aggregate Not Split On the No. 4 Sieve
633	Sample Tag (Sacks)
1126	Stabilometer Record of Item 304 Aggregate Base Course
1296	Granular Materials Moisture – Density Report - [<i>computer output</i>] SiteManager

COLORADO DEPARTMENT OF TRANSPORTATION FIELD REPORT FOR SAMPLE IDENTIFICATION OR MATERIALS DOCUMENTATION			FS# = (Contract ID-Seq.#)		
			Region		
			Contract ID	Date Submitted	
			Project No.		
Project Location					
Material Type		Field Lab phone	Cell Phone		
Material Code (LIMS)	Item	Class	Grading	Special Provisions <input type="checkbox"/> yes	
Previously used on Project No.:		Previous CDOT Form #157 F/S No.(s):		<input type="checkbox"/> CDOT Form #633 (sack) <input type="checkbox"/> CDOT Form #634 (can)	
● Sample Identification: Quantity & Unit of material submitted, describe tests required, precise location sample remove from (Stationing), etc. ● Materials Documentation: Field inspected (describe appearance, weight/dimensions, model/serial number), COC &/or CTR provided etc.					
Central Lab use only:					
Sample ID (#1)		Sample ID (#2)		Sample ID (#3)	
Sample ID (#4)		Sample ID (#5)		Sample ID (#6)	
APL/QML Acceptance: APL Ref. No.	Product name:			Date checked:	
APL/QML Acceptance: APL Ref. No.	Product name:			Date checked:	
Preliminary <input type="checkbox"/> Construction <input type="checkbox"/> Maintenance <input type="checkbox"/> Emergency <input type="checkbox"/>				Date needed	
Contractor			Supplier		
Sampled from <small>(Pit, roadway, windrow, stock, etc.)</small>			Pit name or owner		
Quantity represented		Previous quantity		Total quantity to date	
Sample submitted: <input type="checkbox"/> Yes <input type="checkbox"/> No		Shipped specified quantity to: <input type="checkbox"/> Central lab <input type="checkbox"/> Region lab <input type="checkbox"/> Consultant lab		Date	
Sampled or inspected by (print name)		Title		E-mail	
Supervisor (Pro./Res./Mets. Engr./Maint. Supt.) (print name)		Title		Residency	

Distribution: Chemical Lab: cdot_chemlab@state.co.us
 Concrete Lab: cdot_conc.lab@state.co.us
 Flexible Pavement: cdot_flex.lab@state.co.us
 Physical Properties: cdot_phpr.lab@state.co.us
 Soils Lab: cdot_soils.lab@state.co.us
 Region Labs: Send completed form with sample

Previous editions are obsolete and may not be used. CDOT Form #167 04/18

Project File: SMM – Upload completed form into the attachment icon on the sample record

COLORADO DEPARTMENT OF TRANSPORTATION FIELD TESTS OF BASE AGGREGATES, FILLERS, PAVING AND MISCELLANEOUS AGGREGATES						Contract ID				Region				FS# - (Contract ID-Seq#)							
						Project No.								Date Submitted							
						Project Location								Item							
SMM/LIMS Sample ID (or Test # [Date])	Station	Tons (t) or Yards (y)	Field density	Lab max density	% Rel. Comp.	Total moist.				#4	#8	#30	#50	#100	#200	L.L.	P.I.				
Sheet Total		Previous Total		Total to Date		Specifications: _____															
						Final report: yes <input type="checkbox"/> no <input type="checkbox"/>															
Spec. deviations: yes <input type="checkbox"/> no <input type="checkbox"/>			P= _____ % for lot # _____																		
Items: 206 Structure Backfill Class 1 _____ 206 Filter Material Class _____ 304 ABC Class _____ 307 Treated Subgrade _____ 403 HMA Grading _____ 403 SMA _____ 409 Cover Coat _____ Other Material: _____			Remarks									Source (pit)									
												Project Tester (print name)		Title							
												PE Approved by (print name)		Title							

Distribution: SMM/LIMS: Form is not required to be completed
 Non-LIMS: Completed form in project material book

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CDOT Form #8 11/17

COLORADO DEPARTMENT OF TRANSPORTATION STRUCTURE BACKFILL DENSITY REPORT	Region	Date Submitted
	Contract ID	
	Project No.	
	Project Location	

Major Structures

Number of Structures: (1 test/200 cu. yds.; minimum 1/structure)	Class 1 (cu. yds.)	No. of tests	Class 2 (cu. yds.)	No. of tests
Total cu. yds. structure backfill:				

Cross Drains

Number of Cross Drains: (1 test/200 cu. yds.; minimum 1/structure)	Class 1 (cu. yds.)	No. of tests	Class 2 (cu. yds.)	No. of tests
Total cu. yds. structure backfill:				

Side Drains

Number of Side Drains: (1 test/200 cu. yds.; minimum 1/structure)	Class 1 (cu. yds.)	No. of tests	Class 2 (cu. yds.)	No. of tests
Total cu. yds. structure backfill:				

Other

	Class 1 (cu. yds.)	No. of tests	Class 2 (cu. yds.)	No. of tests

Remarks		
Print name	Signed 	Title

Resident Engineer

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CDOT Form 194

04/2020

COLORADO DEPARTMENT OF TRANSPORTATION SOILS AND AGGREGATES SIEVE ANALYSIS WHEN SPLITTING ON THE No. 4 SIEVE	Contract ID Project No. Item Class
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Pit name			Station			Test no.	Sample weight	Date
Sieve	Wet wt.	Dry wt.	Individual percentage		Percent passing	Specs	Sample ID	
							Liquid limit	Moisture correction
							Plastic limit	Plus #4 moisture sample
							Plastic index	Wet weight
							Soil class.	Dry weight
							"R" value	Loss
								% moisture
								Minus #4 moisture sample
+ #4				#			Sampled by	Wet weight
- #4				#				Dry weight
Total				#			Tested by	Loss
				#200				% moisture
Minus #4 wash								
Wet weight (grams)	Sieve	Weight (grams)	Individual percentage		Percent passing			
	#							
	#							
Dry weight (grams)	#200							
	- #200							
	Total							

NOTE: Save all material until calculations are completed in case a check is necessary

Pit name			Station			Test no.	Sample weight	Date
Sieve	Wet wt.	Dry wt.	Individual percentage		Percent passing	Specs	Sample ID	
							Liquid limit	Moisture correction
							Plastic limit	Plus #4 moisture sample
							Plastic index	Wet weight
							Soil class.	Dry weight
							"R" value	Loss
								% moisture
								Minus #4 moisture sample
+ #4				#			Sampled by	Wet weight
- #4				#				Dry weight
Total				#			Tested by	Loss
				#200				% moisture
Minus #4 wash								
Wet weight (grams)	Sieve	Weight (grams)	Individual percentage		Percent passing			
	#							
	#							
Dry weight (grams)	#200							
	- #200							
	Total							

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Colorado Department of Transportation					Contract ID: _____		Region: _____																										
Sieve Analysis for Aggregates CP31					Project Number: _____																												
Atterberg Limits T89 and T90					Project Location: _____																												
Material Description: _____					Pit: _____																												
Prime Contractor: _____					Item: _____ <small>Do not use this form for Item 203 - Soils or Item 206 - Structure Backfill Class 2, use Form 564 Split over the #4 - CP 21</small>																												
Sample ID SMM: _____			Lab Ref Number SMM: _____		Class: _____		Test No: _____	Test Date: _____																									
Gradation Specimen Dry Weight (SDW):		Washed Dry Weight (WDW):			Sample Information																												
Sieve	Weight	Percent Retained	Percent Passing	Specs	Sampled From: _____																												
6"					Supplier Ticket No: _____																												
4"					Time Sampled: _____																												
3"					Station: _____																												
2½"					Lane: _____																												
2"					Quantity Sample Represents: _____																												
1½"					Sampling witnessed by: _____																												
1"					Sample Tested By: _____																												
¾"					Sample % Moisture and Dry Weight																												
½"					Pan ID: _____																												
⅓"					Pan Weight (g): _____ A																												
5/16"					Pan & Sample - Wet Weight (g): _____ B																												
¼"					Pan & Sample - Dry Weight (g): _____ C																												
#4					Sample - Wet Weight (g): _____ D=(B-A)																												
#8					Sample - Dry Weight (g): _____ E=(C-A)																												
#16					Moisture Loss (g): _____ F=(D-E)																												
#30					Moisture Content (MC) %: _____ G=(F/E) x 100																												
#50					Specimen Dry Weight: E																												
#100					If gradation sample and moisture sample are the same sample, use the dry weight (SDW) in the sieve analysis calculations.																												
#200					Gradation Remarks: _____																												
- #200		(WDW - TSW) ÷ WDW x 100 = % Diff (Spec: ≤ 0.3%)																															
Total Sieved WT (TSW):		(_____ - _____) ÷ _____ x 100 = _____ %																															
Wet Weight ÷ (100 + MC %) x 100 = Specimen Dry Weight					If a split moisture sample is used to determine dry mass of gradation sample, use calculation to determine dry weight.																												
Wet WT. _____ ÷ (100 + _____) x 100 = _____ SDW																																	
Atterberg Limits:		Liquid Limit T89	Plastic Limit T90	Place IA Stamp Here:																													
Tin ID:				<table border="1" style="width:100%; border-collapse: collapse;"> <tr> <td>Number of Blows</td> <td>Multiplier</td> <td>IA Sample ID:</td> </tr> <tr> <td>Moisture Content %:</td> <td>22</td> <td>0.9850</td> </tr> <tr> <td>Number of Blows:</td> <td>23</td> <td>0.9900</td> </tr> <tr> <td>Plasticity Index</td> <td>Specifications</td> <td>24</td> <td>0.9950</td> </tr> <tr> <td>Liquid Limit %:</td> <td>25</td> <td>1.0000</td> </tr> <tr> <td>Plastic Limit %:</td> <td>26</td> <td>1.0050</td> </tr> <tr> <td>Plasticity Index:</td> <td>27</td> <td>1.0090</td> </tr> <tr> <td>LL % = Moisture Content @ number of blows X multiplier</td> <td>28</td> <td>1.0140</td> </tr> </table>					Number of Blows	Multiplier	IA Sample ID:	Moisture Content %:	22	0.9850	Number of Blows:	23	0.9900	Plasticity Index	Specifications	24	0.9950	Liquid Limit %:	25	1.0000	Plastic Limit %:	26	1.0050	Plasticity Index:	27	1.0090	LL % = Moisture Content @ number of blows X multiplier	28	1.0140
Number of Blows	Multiplier	IA Sample ID:																															
Moisture Content %:	22	0.9850																															
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Plasticity Index	Specifications	24	0.9950																														
Liquid Limit %:	25	1.0000																															
Plastic Limit %:	26	1.0050																															
Plasticity Index:	27	1.0090																															
LL % = Moisture Content @ number of blows X multiplier	28	1.0140																															
Mass of Tin:				Electronic Signature of IA Personnel																													
Mass of Tin + Wet Soil:																																	
Mass of Tin + Dry Soil:				Sample Remarks:																													
Moisture Content %:																																	
Number of Blows:																																	
Plasticity Index		Specifications	24						0.9950																								
Liquid Limit %:			25						1.0000																								
Plastic Limit %:			26						1.0050																								
Plasticity Index:			27	1.0090																													
LL % = Moisture Content @ number of blows X multiplier			28	1.0140																													

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CDOT Form #565

5/18

+	Contract ID		Region	Material Code
	Sample ID			FS #
	Test #	Proj Special Provision	<input type="checkbox"/> YES	Lab Ref #
	Item #	Cell #	Sample	of
	E-mail			
	Colorado Dept of Transportation 4670 N. Holly St. Denver CO 80216-6408			

CDOT Form 633 8/19

Contract ID		Region
Sample ID		
FS #	Test #	
Station	Depth	
Item #	Sample	of

Detach Stub and Submit with Sample

Colorado Dept of Transportation 4670 N. Holly
St. Denver CO 80216-6408

CDOT Form 633 8/19

COLORADO DEPARTMENT OF TRANSPORTATION STABILOMETER RECORD OF ITEM 304 ABC					Contract ID		Region		
					Project No.				
					Proj. location				
Pit name		Date	Sample ID		Lab #				
Represents			LL	PL	PI	SE	Class		
GRADATION				Stabilometer "R" value:					
As run		Set up		% moisture at _____ lbs. per cu. ft.					
Seive size	% passing	Scalp		% Moisture - #4 Material	_____ X				
4"				Weight of - #4 Material	_____ =				
3"				Weight of H ₂ O	_____ +				
2½"				Initial H ₂ O added	_____ =				
2"				Total initial H ₂ O	_____ (A)				
1½"				COMPACTION					
1"				Cylinder #					
¾"				H ₂ O added (B)					
½"				Exudation pressure, lbs					
⅜"				Exudation pressure, PSI					
#4				Ht. of briquette (H)					
#8				Wt. cylinder & wet sample					
#16				Cylinder tare					
#50				Wet wt. of sample (W _w)					
#100				¹ Weight of H ₂ O (C)					
#200				² Dry wt. (D)					
Set up weights				³ % Moisture (M)					
-¾" + ½"	_____			⁴ Density					
-½" + ⅜"	_____			Height correction by wt.					
-⅜" + #4	_____			STABILOMETER					
- #4	_____			Total load	PSI				
$\begin{aligned} &^1 (A) + (B) = (C) \\ &^2 (W_w) - (C) = (D) \\ &^3 (C) \div (D) = (M) \\ &^4 (W_w) \times 30.3 \\ & \quad (100 + M) \times H \end{aligned}$				1000	80				
				2000	160				
				Displacement turns					
				"R" value					
				Drainage					
Exp. pressure dial reading									

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CDOT Form #1126 4/14

