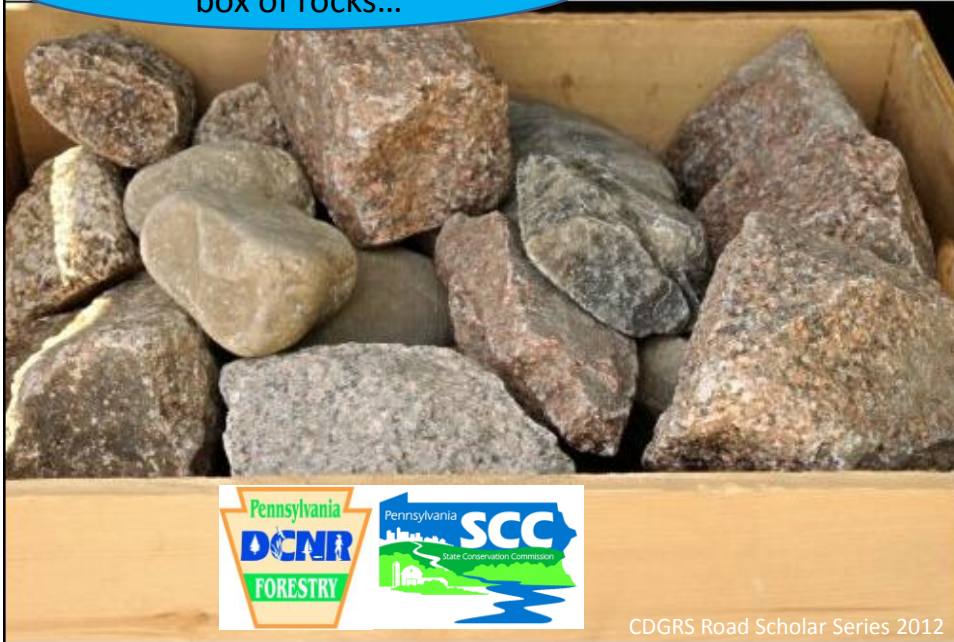


Don't be dumber than a
box of rocks...

Road Aggregate 101



CDGRS Road Scholar Series 2012

Road Aggregate 101:


Important Stuff

- **Source** - Geologic Origin
- **Properties** - Type/Quality & PI
- **Gradation** - Size Max & Min, Mixture
- **Certifications** - PennDOT & DGRMP
- **Specs & Uses** - AASHTO & PennDOT
- **Handy Formulas** - Convert & Estimate

Road Aggregate 101: **Source or Geologic Origin**

TYPICAL ROAD AGGREGATE MATERIALS IN PA

- Limestone
- Sandstone
- Bankrun Gravel
(Pit Run)
- Shale
(mud-rock)



Road Aggregate 101: **Source or Geologic Origin**

TYPICAL ROAD AGGREGATE MATERIALS IN PA

- Limestone
- Sandstone
- Bankrun Gravel
(Pit Run)
- Shale
(mud-rock)

SOFT-----HARD

| | |
|------------------|-----------|
| SHALE | ●-----● |
| SANDSTONE | ●-----● |
| LIMESTONE | ●-----● |
| BANKRUN ? | ●-----● ? |

Thumb rule. There are exceptions.

Road Aggregate 101:

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- **Handy Formulas** - **Convert & Estimate**

Road Aggregate 101:

Properties of Type/Quality PennDOT Aggregate Types A,B & C

| | Type A | Type B | Type C |
|--|------------|------------|--------|
| 1 Soundness, Max. % | 10 | 12 | 20 |
| 2 Abrasion, Max. % | 40 | 45 | 55 |
| Thin and Elongated Pieces, Max. % | 15 | 20 | — |
| Material Finer Than No. 200 Sieve, Max. % | * | * | 10 |
| Crushed Fragments, Min. % | 55** | 55** | 50 |
| Compact Unit Weight Min. lbs./cu. ft. | 70 | 70 | 70 |
| Deleterious Shale, Max. % | 2 | 2 | 10 |
| Clay Lumps, Max. % | 0.25 | 0.25 | 3 |
| Friable Particles, Max. % (excluding shale) | 1.0 | 1.0 | — |
| Coal or Coke, Max. % | 1 | 1 | 5 |
| Glassy Particles, Max. % | 4 or 10*** | 4 or 10*** | — |
| Iron, Max. % | 3***** | 3***** | 3***** |
| Absorption, Max. % | 3.0***** | 3.5***** | — |
| 3 Total of Deleterious Shale, Clay Lumps, Friable Particles, Coal, or Coke Allowed, Max. % | 2 | 2 | 15 |

1 - **Soundness** (PTM No. 510) - This test method furnishes information helpful in judging the durability of an aggregate when subject to weathering action.

2 - **Abrasion** (AASHTO T-96) - Resistance of a Smaller Sized Aggregate to Degradation by Abrasion and Impact using the Los Angeles Machine. A test of "hardness," or the relative ability to resist traffic wear.

3 - **Unwanted Junk** - Maximum allowable amount by weight of undesirable material for road related purposes.

Road Aggregate 101:

Property of Plasticity

Plasticity Index (PI)

- The plasticity index (PI) is a measure of the plasticity of a soil. *Soils with a high PI tend to be clay*, those with a lower PI tend to be silt, and those with a PI of 0 (non-plastic) tend to have little or no silt or clay¹.
- 0 - Nonplastic
- (1-5)- Slightly plastic
- (5-10) - Low plasticity
- (10-20)- Medium plasticity
- (20-40)- High plasticity
- >40 Very high plasticity

Watch for signs of high clay content –
“Your eye doesn’t lie”

1) http://en.wikipedia.org/wiki/Atterberg_limits



Road Aggregate 101:

Property of Plasticity

Plasticity Index (PI)

- If the fines are sticky, or cause the larger particles to stick together, the fines are primarily clay.
- **Try to make a thread** – Take approx 1 cubic inch of soil and work it into a thread (mix it with a small amount of water if needed).
 - If it is very difficult or impossible to roll a thread, the mix is *low plasticity*.
 - If you can easily roll a thread, the mix is *moderately plastic*.
 - The mix is *highly plastic* if it is very stiff, but you can roll a thread.

...But the only way to really know is to have the aggregate lab tested!

DCNR has adopted a maximum PI of 6
For their DSA specification. The Center
is reviewing this specification change
for the DGRMP. More to come...



Road Aggregate 101:

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Road Aggregate 101:

Gradation or distribution of different sized stones



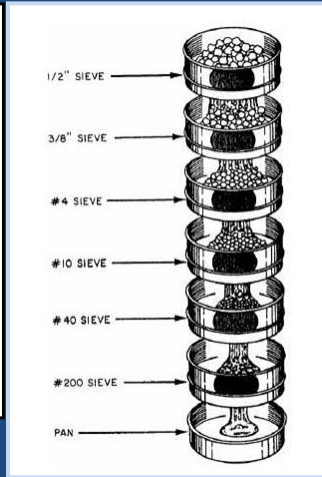
Road Aggregate 101:

Gradation – size does matter!

Determined by sieve analysis and washing



Material Finer than the 75 µm (No. 200) Sieve. Determine the loss by washing according to PTM No. 100



Road Aggregate 101:

Gradation or distribution of different sized stones

Reported on table or chart

| AASHTO Number | Total Percent Passing | | | | | | | | | | | | | |
|---------------|-----------------------|----------------|----------------|------------|------------------|--------------|----------------|----------------|---------------|-----------------|-----------------|------------------|------------------|---------------------|
| | 100 mm (4") | 90 mm (3 1/2") | 63 mm (2 1/2") | 50 mm (2") | 37.5 mm (1 1/2") | 25.0 mm (1") | 19.0 mm (3/4") | 12.5 mm (1/2") | 9.5 mm (3/8") | 4.75 mm (No. 4) | 2.36 mm (No. 8) | 1.18 mm (No. 16) | 150 µm (No. 100) | 75 µm (No. 200) *** |
| 1 | 100 | 90-100 | 25-60 | | 0-15 | 0-15 | 0-5 | | | | | | | |
| 3 | | | 100 | 90-100 | 35-70 | 0-15 | 0-5 | | | | | | | |
| 467 | | | | 100 | 95-100 | | 35-70 | | 10-30 | 0-5 | | | | |
| 5 | | | | | 100 | 90-100 | 20-55 | 0-10 | 0-5 | | | | | |
| 57 | | | | | 100 | 95-100 | | 25-60 | | 0-10 | 0-5 | | | |
| 67 | | | | | | 100 | 90-100 | | 20-55 | 0-10 | 0-5 | | | |
| 7 | | | | | | | 100 | 90-100 | 40-70 | 0-15 | 0-5 | | | |
| 8 | | | | | | | | 100 | 85-100 | 10-30 | 0-10 | 0-5 | | |
| 10 | | | | | | | | | 100 | 85-100 | | | 10-30 | |
| 2A** | | | | 100 | | | 52-100 | | 36-70 | 24-50 | 16-38* | 10-30 | | |
| OGS** | | | | 100 | | | 52-100 | | 36-65 | 8-40 | | 0-12 | | |

* Applies only for bituminous mixtures.

** PENNDOT Number

*** For 75 µm (No. 200), see Table D.

From PennDOT Publication 408, Section 703 .2 – Coarse Aggregate

The AASHTO system ranks specs according to size (1-10), with 1 being the largest (all material must pass a 4" sieve) and 10 being the smallest (all material passing a 3/8" sieve). Multi-digit specs represent a blend of one or more of the ten basic specs (i.e. AASHTO 57 is a blend of AASHTO 5 and AASHTO 7). AASHTO Specifications are technically open graded aggregate.

Road Aggregate 101:

Nominal maximum and/or minimum sized stone in mix



The *nominal* size distribution of an aggregate specification is defined as the range of sieve openings through which 100% of the aggregate can pass.

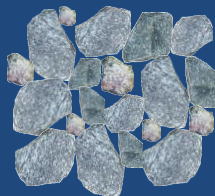
| Size # | Nominal Size | Amounts finer than each laboratory sieve (square openings), percentage weight | | | | | | | | | | | | | | | | | |
|--------|---------------------------|---|--------|------|--------|--------|--------|--------|--------|--------|--------|--------|--------|---------|---------|----------|--|--|--------|
| | | 4" | (3½") | (3") | (2½") | (2") | (1½") | (1") | (¾") | (½") | (¾") | (No.4) | (No.8) | (No.16) | (No.50) | (No.100) | | | |
| 1 | 3½ to 1½ | 100 | 90-100 | | | | | | | | | | | | | | | | |
| 2 | 2½ to 1½ | | | 100 | 90-100 | 35-70 | 0-15 | | | | | | | | | | | | |
| 24 | 2½ to ¾ | | | 100 | 90-100 | | 25-60 | | | | | | | | | | | | |
| 3 | 2 to 1 | | | | 100 | 90-100 | 35-70 | 0-15 | | | | | | | | | | | |
| 357 | 2 to No. 4 | | | | 100 | 95-100 | | 35-70 | | 10-30. | | 0-5 | | | | | | | |
| 4 | 1½ to ¾ | | | | | 100 | 90-100 | 20-55 | | | 0-15 | | 0-5 | | | | | | |
| 467 | 1½ to No. 4 | | | | | 100 | 95-100 | | 35-70 | | 10-30. | 0-5 | | | | | | | |
| 5 | 1 to ½ | | | | | | 100 | 90-100 | 20-55 | | | 0-10 | 0-5 | | | | | | |
| 56 | 1 to ¾ | | | | | | 100 | 90-100 | 40-75 | 15-35 | 0-15 | 0-5 | | | | | | | |
| 57 | 1 to No. 4 | | | | | | 100 | 95-100 | | 25-60 | | | 0-10 | 0-5 | | | | | |
| 6 | ¾ to ¾ | | | | | | | 100 | 90-100 | 20-55 | | 0-15 | 0-5 | | | | | | |
| 67 | ¾ to No. 4 | | | | | | | 100 | 90-100 | | 20-55 | 0-10 | 0-5 | | | | | | |
| 68 | ¾ to No. 8 | | | | | | | 100 | 90-100 | | 30-65 | 5-25. | 0-10 | 0-5 | | | | | |
| 7 | ½ to No. 4 | | | | | | | | 100 | 90-100 | 40-70 | 0-15 | 0-5 | | | | | | |
| 78 | ½ to No. 8 | | | | | | | | 100 | 90-100 | 40-75 | 5-25. | 0-10 | 0-5 | | | | | |
| 8 | ¾ to No. 8 | | | | | | | | | 100 | 85-100 | 10-30. | 0-10 | 0-5 | | | | | |
| 89 | ¾ to No. 16 | | | | | | | | | 100 | 90-100 | 20-55 | 5-30. | 0-10 | 0-5 | | | | |
| 9 | No. 4 to No. 16 | | | | | | | | | | 100 | 85-100 | 10-40. | 0-10 | 0-5 | | | | |
| 10 | No. 4 to 0 ⁽²⁾ | | | | | | | | | | | 100 | 85-100 | | | | | | 10-30. |

Road Aggregate 101:

Gradation or distribution of different sized stones

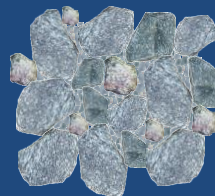
Open graded aggregate vs. well graded aggregate.
What's the difference?

Open Graded



Drains Well, Displaces Easily
good base or sub-base

Well Graded



Compacts Well, Maintains Shape
good surface aggregate

Road Aggregate 101: **Important Stuff**

- **Source** - **Geologic Origin**
- **Properties** - **Type/Quality & PI**
- **Gradation** - **Size Max & Min, Mixture**
- **Certifications** - **PennDOT & DGRMP**
- **Specs & Uses** - **AASHTO & PennDOT**
- **Handy Formulas** - **Convert & Estimate**

Road Aggregate 101: **Material Certification - PADOT**

A PennDOT certified lab technician attests that the product **meets Penn DOT** Pub. 408, Section 703 **requirements for Gradation and Properties.**

CS-4211N (2-12)

MATERIAL TEST RESULTS AGGREGATE NO. 2A

PLEASE TYPE OR PRINT IN BLUE OR BLACK INK ALL INFORMATION

| DATE | | MASS (WGT) % PASSING | | MASS (WGT) % PASSING | | MASS (WGT) % PASSING | | MASS (WGT) % PASSING | | MASS (WGT) % PASSING | |
|----------------------|--------------------------|----------------------|-----------|----------------------|-----------|----------------------|-----------|----------------------|-----------|----------------------|-----------|
| SIEVE | BAND | MASS (WGT) | % PASSING | MASS (WGT) | % PASSING | MASS (WGT) | % PASSING | MASS (WGT) | % PASSING | MASS (WGT) | % PASSING |
| 50mm (2") | 100 | | | | | | | | | | |
| 19.0mm (3/4") | 52-100 | | | | | | | | | | |
| 9.5mm (3/8") | 36-70 | | | | | | | | | | |
| 4.75mm (#4) | 24-50 | | | | | | | | | | |
| 1.18mm (#16) | 10-30 | | | | | | | | | | |
| 75µm (#200) | DRY | | | | | | | | | | |
| WASH | 0-10 | | | | | | | | | | |
| CRUSH | (A) 55-100 (C) 50-100 | | | | | | | | | | |
| ORIGINAL MASS (WGT.) | | | | | | | | | | | |
| % MASS (WGT.) LOSS | | | | | | | | | | | |
| TESTED BY | | | | | | | | | | | |
| REMARKS | | | | | | | | | | | |

NOTE: MTD RECOMMENDED BREAKER SIEVES: 37.5mm (1 1/2") AND 12.5mm (1/2")
NOTE: DRY 75µm (#200) SIEVE FOR INFORMATION ONLY (NOT REQUIRED SPEC. SIEVE)

Road Aggregate 101:

Specifications and Uses

A rock by a different name:

Gravel – unconsolidated rock fragments formed as a result of the weathering and erosion of larger rocks. PennDOT requires gravel used for road construction to be durable with a minimum of 85% crushed particles and at least two faces resulting from fracture.

Stone - a piece of rock quarried and worked into a specific size and shape for a particular purpose. PennDOT requires that stone be durable and free from slate texture or cleavage planes.

Sand – Mined or manufactured rock particles predominately smaller than 3/16".

Aggregate – a mixture of specific types and sizes of crushed rock or gravel. Generally used with a binder in pavements. Also used as road base and sub-base.

Rip-Rap – a loose assemblage of large stones (rubble). Often used for erosion control and stabilization of roadside features, or as road sub-base on soft ground.

AASHTO – American Association of State Highway and Transportation Officials

Road Aggregate 101:

Common Specifications & Uses

Name:

AASHTO 1 (PA #4 or Ballast)
 AASHTO 3 (PA 3A)
 AASHTO 57 (PA 2B)
 AASHTO 8 (PA 1B)
 AASHTO 10 (Grit, Screenings)
 PennDOT 2A (2A Modified)
 PennDOT 2RC (Reclaim, Misc)
 PennDOT 3A (3A Modified)
 PennDOT Anti-Skid Type II
 DSA (DGRMP Developed)
 TSA (DGRMP Developed)

Use:

Road Base, Buried Drains
 Road Base, Haul Surface
 Buried Drains
 Chip Surfacing
 Trail Surface
 Road Base, Road Surface
 Fill, Bedding, Road Surface
 Haul Road Surface, Choke
 Winter Traction
 Road Surface
 Trail Surface

Road Aggregate 101:

Common Specifications & Uses*If you prefer tables instead...*

| AGGREGATES | | | TOTAL PERCENT PASSING | | | | | | | | | | | | | PA availability | |
|----------------|---------------------|-----------------------------|-----------------------|--------|-------|--------|-------|--------|--------|-------|--------|--------|--------|-------|-------|-----------------|------|
| Aggregate Name | General Size | General Uses | 4" | 3.5" | 2.5" | 2" | 1.5" | 1" | 3/4" | 1/2" | 3/8" | #4 | #8 | #16 | #100 | #200 | |
| AASHTO #1 | 4" - 3/4" clean | Road Base, Drainage | 100 | 90-100 | 25-60 | | 0-15 | | 0-5 | | | | | | | | |
| AASHTO #3 | 2.5" - 1 1/2" clean | Road Base, Haul Surface | | | 100 | 90-100 | 35-70 | 0-15 | | 0-5 | | | | | | | Good |
| AASHTO #57 | 1.5" - #8 clean | Subsurface Drainage | | | | | 100 | 95-100 | | 25-60 | | 0-10 | 0-5 | | | | Good |
| AASHTO #8 | 1 1/2" - #8 clean | Chip Surfacing | | | | | | | | 100 | 85-100 | 10-30 | 0-10 | 0-5 | | | Good |
| AASHTO #10 | 3/8" - fine | Trail Surface, Anti-skid | | | | | | | | | 100 | 85-100 | | | 10-30 | | Good |
| PennDOT 2A | 2" - fine | Road Base and Surface | | | 100 | | | | 52-100 | | 36-70 | 24-50 | 16-38* | 10-30 | | 0-10 | Good |
| PennDOT 2BC | varies widely | Fill, Pipe Bedding, Surface | | | 100 | | | | | | | 15-60 | | | 0-30 | | Good |
| PennDOT DSA | 1 1/2" - fine | Unbound Road Surface | | | | | 100 | | 65-95 | | | 30-45 | | 15-30 | | 10-15 | Good |
| DGRMP TSA | 1 1/2" - fine | Unbound Trail Surface | | | | | | | | 100 | 90-100 | 50-85 | 35-60 | 25-50 | | 12-18 | Fair |

Don't strain your eyes!
This is in the hand-out.

Road Aggregate 101:

Rip-Rap Sizes and UsesName:Average Size:Use:

| | | |
|-----------------|-----------|-------------------------------|
| R-8 | 28" | Bridge Abutments |
| R-7 | 20" | Streambank (14.5'/sec) |
| R-6 | 14" | Streambank (13'/sec) |
| R-5 | 11" | Streams (11.5'/sec)/Ditches |
| R-4 | 7" | Ditches, Not Streams |
| R-3 | 3.5" | Sub-grade Stabilization |
| *Surge | 10"- dust | Fill, Sub-grade Stabilization |
| *Gabion (clean) | 4"-8" | Baskets, Ditches, Diffusers |
| *Shot Rock | 24" | Bridge Abutments |

*Will vary by location/supplier. Surge is 1st run material off the crusher. Gabion is clean/washed material within a size range. Shot Rock is unprocessed rubble from the quarry wall (select sized/shaped stones can be harvested).

Road Aggregate 101:

Rip-Rap Sizes and Uses

2. Size and Gradation.

| Class, Size No. (NCSA) | Percent Passing (Square Openings) | | | | | |
|---|-----------------------------------|-------|-------|-------|-------|-------|
| | R-8** | R-7** | R-6 | R-5 | R-4 | R-3 |
| Rock Size (Inches) | | | | | | |
| 42 | 100* | | | | | |
| 30 | | 100* | | | | |
| 24 | 15-50 | | 100* | | | |
| 18 | | 15-50 | | 100* | | |
| 15 | 0-15 | | | | | |
| 12 | | 0-15 | 15-50 | | 100* | |
| 9 | | | | 15-50 | | |
| 6 | | | 0-15 | | 15-50 | 100* |
| 4 | | | | 0-15 | | |
| 3 | | | | | 0-15 | 15-50 |
| 2 | | | | | | 0-15 |
| Nominal Placement Thickness (inches) | 48 | 36 | 30 | 24 | 18 | 12 |

*Maximum Allowable Rock Size.
**Use Class 2, Type A Geotextile

Must be well graded, hard and angular rock with no seams. Neither the rock width nor the thickness can be less than one third its length.

Road Aggregate 101:

Important Stuff

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Road Aggregate 101:

Handy Formulas for Field and Office

Converting cubic yards to tons of:

Large Open Graded Aggregate (AASHTO 1, Rip-Rap) = $\text{yd}^3 \times 1.4$

Well Graded Aggregate (2A, 2RC) = $\text{yd}^3 \times 1.5$

Driving Surface Aggregate or TSA = $\text{yd}^3 \times 1.55$

Shale = $\text{yd}^3 \times 1.35$

Topsoil /Dirt = $\text{yd}^3 \times 1.2$

Quick formulas for estimating tonnage of DSA required:

For 6" loose lift compacted to $\sim 4 \frac{1}{2}$ " = $\text{Rd Length}' \times \text{Rd Width}' \times .029$

For 8" loose lift compacted to ~ 6 " = $\text{Rd Length}' \times \text{Rd Width}' \times .038$



Road Aggregate 101:

Rock of different sizes, different mixtures and different names for different uses. Simple! Right?



Road Aggregate 101:

THE END

Please submit all questions to the Brian Trust...

