Informational Bulletin

Driving Surface Aggregate

7/2017

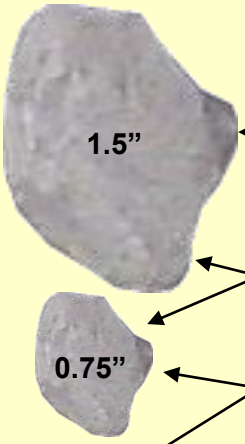
Driving Surface Aggregate (DSA): Developed by Penn State's Center for Dirt and Gravel Road Studies, DSA is a mixture of crushed stone developed specifically as a surface wearing course for unpaved roads. DSA has a unique particle size distribution designed to maximize packing density and produce a durable road surface that performs better than conventional aggregates.

Figure 1: Placement of DSA through a paver.

Inside the DSA: Larger particles locked tightly in place by smaller particles and fines.

DSA Components, ACTUAL SIZE

The percentages below represent a "midline" or average DSA. Allowable ranges for each size are give inside.



100% of the aggregate in DSA is <u>smaller than</u> this 1.5" stone.

20% of the aggregate in DSA is <u>between</u> 1.5" and ¾"

33% of the aggregate in DSA is <u>between</u> and ¾" and #4

25% of the aggregate in DSA is <u>between</u> #4 and #16

10% of the aggregate in DSA is <u>between</u> #16 and #200

12.5% of the aggregate in DSA is <u>smaller than</u> #200

The dot you may or may not see here is 0.003" in diameter

The above illustration shows how the various size components of DSA lock together when compacted to produce the most dense and durable aggregate surface possible. The specification is well graded from large pieces that give support, all the way down to the "fines", rock particles less than 1/300th of an inch. This well graded mix including fines allows DSA to achieve a very high density. The box to the left illustrates the actual sizes of a "midline" or average DSA specification.

DSA Key Facts:

- Designed for maximum compacted density;
- Contains 10%-15% "minus #200" fine material;
- Fine material is crushed rock, not silt or clay;
- Must be delivered at "optimum moisture";
- Should be placed using a motor-paver;
- Should be compacted with 10-ton vibe roller;
- Can be placed at in an 8" depth and compacted to 6", or in a 6" depth and compacted to 4½".

The publishers of this publication gratefully acknowledge the financial support of the PA State Conservation Commission. For additional information or assistance, contact: Center for Dirt & Gravel Roads Studies, Penn State University, 201 Transportation Research Building, University Park, PA 16802 (Toll-Free Phone: 1-866-668-6683, Fax: 814-863-6787, Email: dirtandgravel@psu.edu). Additional copies available on our website at: www.dirtandgravelroads.org.

Center for Dirt and Gravel Road Studies

DSA Material Specification

All Driving Surface Aggregate (DSA) shall be derived from natural rock formations that meet program specification for abrasion resistance, pH and freedom from contaminants. If fines need to be added to the aggregate to meet gradation requirements, the added material passing the #200 sieve must be derived from rock material that conforms to program specifications. **No mineral clay or silt soil may be added**. The amount of particles passing the #200 sieve shall be determined using the washing procedures specified in PTM No. 100.

- **Size**: The required sizes and allowed ranges, determined by weight, for various size particles are shown in Table 1.
- **Abrasion Resistance**: The loss of mass (LA Abrasion) shall be less than 40%. Determine the resistance to abrasion using the Los Angeles Abrasion test, ASTM C 131. Existing data from tests made for and approved by PENNDOT will be accepted.
- **pH**: Aggregate shall be in the range of pH 6 to pH 12.45 as measured by EPA 9045C.

Sieve Size	Percent Passing
1.5"	95 – 100
0.75"	65 – 95
#4	30 – 65
#16	15 – 30
#200	10 – 15

Table 1. DSA size gradation.

- **Moisture**: Upon delivery to the site, material shall be well mixed and placed at optimum moisture content or up to 2% below that value as determined for that particular source. The optimum percentage moisture is to be determined using Proctor Test ASTM D698, Procedure C, Standard.
- **Plasticity**: Material shall not exceed Plasticity Index (PI) of 6. The laboratory test required for these results is ASTM D4318.
- **Soundness**: Determine the percentage of mass (weight) loss of each fraction of the coarse aggregate after fives cycles of immersion and drying using a sodium sulfate solution according to PTM No. 510. The maximum weighted percent loss allowed is 20%.
- **Mixing**: DSA shall be properly mixed and at the proper moisture content before it is loaded onto the transport vehicles.

Aggregate producers are required by the program to certify that the aggregate they deliver conforms to the Program specifications (See DSA Certification and Specification document). A new certification is required for each project, or whenever the source of aggregate changes.

How much DSA should I order?

DSA Needed = (tons) **Road Width (ft)** x **Road Length (ft)** x

0.04 for 8" loose compacted to 6"

0.03 for 6" loose compacted to 4½"

DSA Sampling and Testing

To insure aggregate quality, DSA must be sampled and tested by an independent lab before it is delivered to a project site. This pre-delivery testing is key to catching any potential problems with the aggregate before it is placed. The three tests below must be run on every DSA sample collected from a stockpile as results can vary based on quarry conditions and procedures.

- **Sieve Analysis with Wash:** Analysis to show the percentages of the material passing the five sieve sizes. These gradations should fall within the corresponding specification range for each sieve size in accordance with the material specifications. (~$150, 2-3 days to run)
- **Standard Proctor Analysis:** Test to determine the optimum moisture and maximum density for the specific material, determined in accordance with Proctor Test ASTM D698, Procedure C Using this information, on-site compaction testing can be conducted. Information obtained from the Proctor analysis can be used to calibrate a Nuclear Density Meter in the field. Maximum densities of 95% or better (of theoretical maximum density determined during proctor test) should be realized on the aggregate in the field. (~$200, 2-3 days to run)
- **Plasticity:** Plasticity is an approximation of the amount of clay in an aggregate. DSA must not exceed a Plasticity Index (PI) rating of 6. The laboratory test required for these results is the ASTM-D4318. (~$175, 2-3 days to run)

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Preparation for DSA Placement

The Driving Surface will reflect the shape of the road base.

1. The performance of any aggregate or pavement will be limited by the stability of the base it is placed on. Road base instability issues MUST be completed where needed before application of DSA.
2. Address surface drainage improvements prior to the use of DSA.
3. The "Environmentally Sensitive Maintenance Practices" used to improve drainage vary widely, but may include the addition of: road fill to elevate an entrenched road, crosspipes or culverts to disperse drainage, underdrains and/or French mattresses to address subsurface water.
4. Establish proper drainage in existing base (*figure 2*). Recommended crown or cross-slope is ½ to ¾ inch per horizontal foot. Proper shape may be a flat "A" crown profile, an in-slope or out-slope. If exposed bedrock or insufficient material prevents proper shaping of the road base, additional base material should be added before aggregate placement.
5. For tightly packed existing road surfaces, it is important to scarify the road surface so the DSA will bind better with the base layer.
6. A 3"-4" "key" should be cut along the existing road edge when grading. DSA should be placed against this key to support the aggregate edge, prevent a large drop-off, and facilitate compaction.

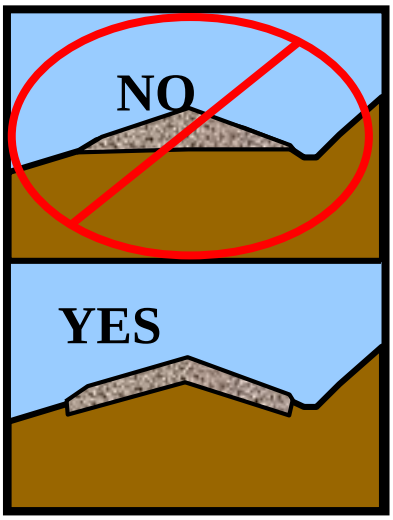

Figure 2. Road base preparation.

DSA Placement

Tarps are to be used to cover 100% of the load's exposed surface from the time of loading until immediately before dumping. An un-compacted uniform depth of 6 to 8 inches of DSA is to be used to establish the driving surface (*figure 3*). Placement is to be in a single lift. The preferred method of application is through a track mounted paver. Set the paver adjustments on application thickness and width so it is unnecessary to use a grader. The required crown or side slope is ½" to ¾" rise per horizontal foot. This slope is to be achieved by properly preparing base and placing aggregate in a uniform lift (*figure 2*). When the paver is applying aggregate, care should be taken to keep the paver at or near capacity at all times.

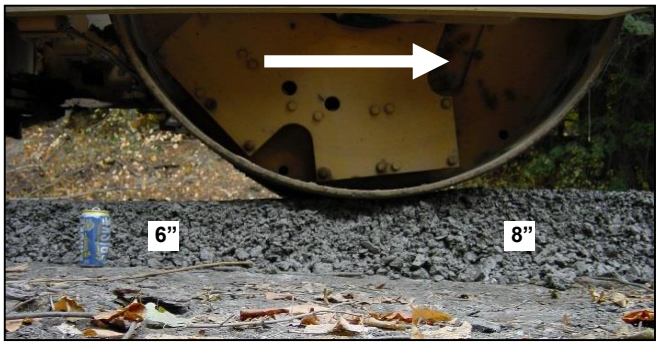

Figure 3: A roller moving from left to right compacts the 8" lift of loose DSA down to 6".

Individual projects can be placed at either 8" or 6" depth. Factors such as traffic volume, traffic weight, and available budgets play a role in determining aggregate depth. 8" aggregate placements will provide more material to re-work into the road over time, while 6" placements will allow a longer length of road to be surfaced. DSA should be allowed to dry or "cure" before being exposed to traffic, otherwise deformations or rutting may occur. If the weather is not conducive to drying for a few days after placement due to low temperatures or precipitation, placement shall be postponed by the road owner, Conservation District, or aggregate supplier, especially if traffic cannot be kept off the road during the drying period.

Figure 4: Compaction Testing with Nuclear Density Gauge

DSA Compaction

DSA must be compacted by a minimum 10-ton vibratory roller. Verify that moisture is optimum for compaction. If the material has dried out, re-wet the DSA surface with a water truck. If clumps of aggregate adhere to the roller drum, the aggregate may be too moist. Allow drying time before rolling. Do not use the vibratory rolling mode if that action brings water to the surface of the aggregate.

1A. SUPPORTED EDGE: *If edge of placed aggregate is supported by an existing bank or berm*: First pass: Roll slowly in static mode on the outside edge of placed aggregate.

1B. UNSUPPORTED EDGE: *If the edge of the placed aggregate is not supported*: First Pass: Roll slowly in static mode near but not over unsupported outside edges. Once that path is firm, move progressively closer to the outside edge with static passes until unsupported edge is firm.

2. SEQUENCE: As in all rolling operations, compaction is achieved making overlapping lengthwise passes beginning at the ditch or berm-side and working toward the crown or the top edge. In no case should the roller be run lengthwise on the top of the road crown.

3. VIBRATORY ROLLER: The initial pass over un-compacted aggregate should be completed in static mode. All successive passes should be made in vibratory mode. The final pass over each area should be made in static mode to remove all roller edge marks. Vibration should be turned off during steep downgrade passes to prevent creating a "wave" of aggregate movement in front of the roller.

4. DESIRED COMPACTION: DSA is designed to be compacted to between 95% and 100% of the maximum dry-mass (dry-weight) density determined according to ASTM D698, Procedure C. Standard. On-site compaction testing is recommended to confirm actual moisture content and density (*figure 4*). The costs of on-site density testing can be incorporated into the grant. Adequate compaction is achieved when the aggregate is at 95% of its maximum dry density.

DSA Maintenance

DSA provides a durable road surface with longer maintenance cycles but it is not maintenance free. DSA is a different type of material requiring a different maintenance approach:

- Because uniform distribution of particle sizes is critical, loosening DSA to sufficient depth during grading operations is very important to reestablish the proper blend of particle sizes and achieve maximum compaction density. The use of a "carbide-tipped grader blade" may be necessary for maintenance grading. See Center's related technical bulletins.
- Optimum moisture content is essential during DSA maintenance operations. DSA dries out quickly and is prone to separation under dry conditions. Damp drizzly conditions are ideal for maintenance grading.
- In order to preserve the environmental benefits of DSA, care should be taken to avoid mixing material pulled out of the ditches with the surface material during grading.

Other Considerations

- **Dirt and Gravel Road Program Notes:**
  - PA's Dirt and Gravel Road Program does NOT require the application of surface material on funded projects. However, if a surface material is applied, DSA is the only Program-approved material.
  - The use of fabric and dust suppressants is allowed, but not required on Program projects.
  - DSA placement using a paver is strongly encouraged, and required on projects over 1,000 tons. Mobilization costs may preclude the use of a paver for short projects with small quantities of DSA.
- **Environmental Benefits:**
  - Preliminary studies completed by the Center have shown a 80-90% reduction in sediment runoff from DSA compared to existing road surfaces, even after 3 years of exposure and use.
  - Because DSA is so densely packed, less loose material is available to generate dust. Dust generation and dispersal is also reduced because the fines in DSA are crushed rock, not silt or clay.
  - DSA further reduces dust and sediment pollution by lengthening road maintenance cycles. Road maintenance loosens the aggregate surface, resulting in periods of increased dust and sediment loss.

The full DSA handbook and other information such as specification, certification and maintenance practices can be found under "general resources" at www.dirtandgravelroads.com.