Technical Bulletin

Driving Surface Aggregate

3/2013

Center for Dirt and Gravel Road Studies

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.

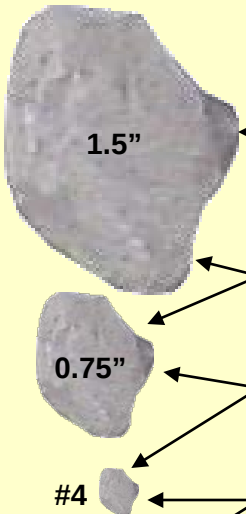
Figure 1: Placement of DSA through a paver.

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

The above illustration shows how the various size components of DSA lock together when compacted to produce the most dense and durable surface possible. The specification is well graded from large pieces that give support, all the way down to the "fines", rock particles less than 1/200th 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 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 0.005" in diameter

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";
- As of 2006, DSA is a PENNDOT approved aggregate in publication 447 (MS-0450-0004).

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, 215 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 Purchasing

All Driving Surface Aggregate (DSA) is to be derived from natural stone formations. For use in this program, aggregate sources are restricted to that which has been mined or quarried from existing geologic bedrock formations. Ninety-eight percent (98%) of fines passing the #200 sieve must be rock material. No clay or silt soil may be added. Limestone material passing the #200 sieve may be used to make up a deficit in the distribution of sandstone aggregate rock, and vice versa. All added material passing the #200 sieve must be derived from rock material that conforms to program specifications. Lime kiln dust and cement kiln dust may be added to DSA to account for up to 50% of the fines passing the #200 sieve. 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.
- **LA Abrasion**: The acceptable hardness as measured by weight loss is "less than 40% loss". Los Angeles Abrasion test, AASHTO T-96 [ASTM C 131] shall be used to determine this property. Existing data from tests made for and approved by PENNDOT will be accepted.
- **pH**: Aggregate must be in the range of pH 6 to pH 12.45 as measured by EPA 9045C.
- **Optimum Moisture**: Material is to be delivered and placed at optimum moisture content as determined for that particular source. The optimum percentage moisture is to be determined using Proctor Test ASTM D698, procedure C, Standard.
- **Transport**: Tarps are to be used to cover 100% of the load's exposed surface from the time of loading until immediately before dumping. This requirement includes standing time waiting to dump.

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

Table 1. DSA size gradation.

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

0.040 for 8" loose compacted to 6"

0.030 for 6" loose compacted to 4½"

Note factors have been slightly reduced in 2009 based on field experience.

Preparation for DSA Placement

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

1. Prepare subsurface drainage, including drain tile, French drains (porous fill), and crosspipes where necessary.
2. Address surface drainage structures, such as broad-based dips, grade breaks, crown, and side-slope.
3. 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.
4. For tightly packed existing road surfaces, it is important to scarify the road surface so the DSA will bind better with the base layer.
5. If required, class 2A separation fabric should be evenly placed according to manufacturer's recommendations.
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.

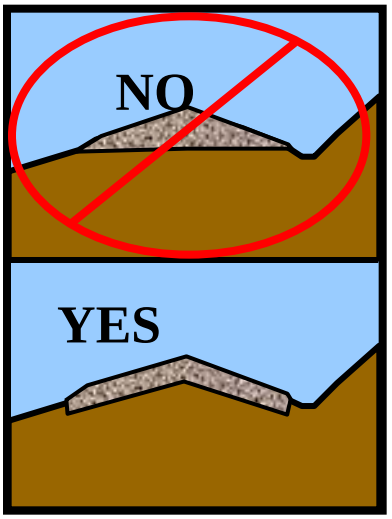


Figure 2. Road base preparation.

DSA Placement

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 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. To fill driving surface areas outside the specified width (e.g. driveway entrances, pull-offs, and passing lanes), additional DSA is to be added and tapered to grade or butted against a precut channel of the same depth. If berm or bank edges don't exist to hold the new DSA surface, then sufficient material is to be placed, tapered, and compacted to form protective edge berms. 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.

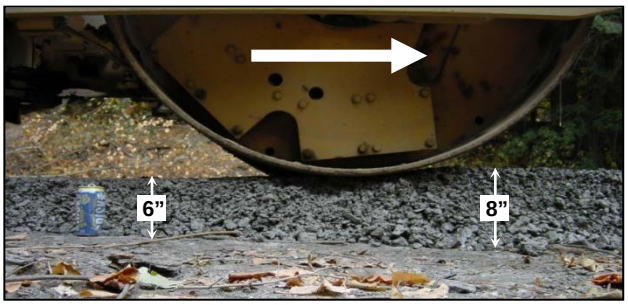


Figure 3: A roller moving from left to right compacts the 8" lift of loose DSA down to 6".

DSA Compaction

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: A minimum 10 ton vibratory roller should be used at a speed of approximately 2-3 miles per hour. 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: Unless compaction testing equipment is available (see last page), adequate compaction is indicated when no further depressions are created with a roller or loaded dump tuck. Cracking of larger stones in the road surface is another indication of adequate compaction.

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.

Insuring Quality Aggregate

An ounce of prevention is worth a pound of cure. To insure aggregate quality, it is recommended to visit and work with the quarry prior to aggregate placement. You may want to consider using an independent lab to test the aggregate to insure it will perform as expected. When considering an independent laboratory for analyzing the DSA material, there are two recommended tests:

- **The Sieve Analysis with Wash**, (~$130) shows the percentages of the material passing the five sieve sizes. These gradations should fall within the corresponding specification range for each sieve size.
- **The Standard Proctor Analysis**, (~$145) determines the optimum moisture and maximum density for the specific material. Using this information, on-site compaction testing can be conducted by a lab technician, (~$50/hour). Information obtained from the Proctor analysis is used to calibrate a Nuclear Density Meter in the field (*figure* 4). Maximum densities of 95% or better (of theoretical maximum density determined during proctor test) should be realized on the aggregate in the field.
- If there are concerns about the type of material in the DSA, a Hydrometer test (particle size analysis), (~$140) is also recommended. This test will determine the percentages of gravel, sand, silt, and clay in the aggregate.
- The cost of testing from the independent laboratory and related on site compaction testing can be included in the grant application under "Project Expenditures" for Dirt and Gravel Road Program Projects. When spending $10,000 to $40,000 on DSA, the ~$500 in up-front testing seems like a bargain compared to dealing with bad stone!

Figure 4: A Nuclear Density Meter calculates density and moisture.

Other Considerations

- As of 2006, DSA is approved for purchase by PENNDOT, and can be purchased by townships using Liquid Fuels Money. See PENNDOT publication 447 (MS-0450-0004) for details.
- DSA Parent material may be limestone, sandstone, or any other natural stone that meets the standards.
- DSA can be placed directly onto separation fabric if needed. The use of separation fabric in wet areas will stabilize the road base and lead to better long term aggregate performance.
- **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, especially on larger projects. 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.
- **DSA Recipe:** While many quarries can make DSA through their crushing and screening process, it is also possible to mix some commonly available aggregates to create DSA. This mixing process can be accomplished with a front end loader and a water source.
- Many other technical documents about DSA such as certification and maintenance practices can be found under "resources" at www.dirtandgravelroads.com.

A "Recipe" for DSA:

8 parts PENNDOT 2A
+
1-1.5 parts PENNDOT #57
+
1 part "minus #200" fines

NOTE: Because the gradations used have a range, the recipe shown here may differ slightly. For this reason, it is important to conduct a sieve analysis after mixing to insure that the DSA gradation in Table 1 is met.