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Approved Drainfield Aggregate Technical Guidance

Code Requirement:

Section 5.10.1 Aggregate/Filter Material of the Marquette County Superior Environmental Health Code of 1998 states:

"1. Aggregate shall be washed stone ranging in size from one-half inch (½") to two and one-half inches (2½") with a total fines content not exceeding five-tenths percent (0.5%) loss by washing. Stone aggregate must rate three or more on Mohs scale of hardness. Sizing and hardness specifications and testing methodology shall be defined in the technical manual."

Determination of Compliance:

When compliance of drainfield aggregate is in question, the Environmental Sanitarian may require an official sieve analysis to be conducted on the aggregate in question with a report of analysis provided to the department for review and approval.

Stone Size:

One hundred percent (100%) of aggregate must pass a 2.5 inch (63 mm) sieve. When ninety percent (90%) of stone aggregate is retained by a 7/16" standard mesh during sieve analysis it is considered to meet the one-half inch minimum sizing requirement.

Classifying fine grained soils:

If soil that will pass through a 3 inch sieve is passed through a No. 200 sieve, it will be divided into two portions based on particle size. The particles retained on the No. 200 sieve are sand and gravel size and are called coarse-grained. The particles passing the No. 200 sieve are termed fines. There cannot be more than 0.5% fines in the aggregate as indicated on the sieve analysis results.

Sieve Analysis:

The tables below provide a general overview of some of the standard screen sizes used in sieve analysis. The highlighted values are for screens that would be used to determine drainfield aggregate acceptability. The goal is to have 90% of the aggregate retained by the 7/16" (or 16 mm) standard mesh, 100% passing the 2.5 inch (63 mm) mesh and 0.5% or less of the aggregate passing the number 200 mesh.

Commonly used US Standard commercial sieve and mesh dimensions

Source: http://www.engineeringtoolbox.com

Sieve size	Opening		Standard Mesh
(mm)	*(in)*	*(10^{-6} m)*	*US*
11.2	0.438	11200	7/16”
6.35	0.250	6350	1/4”
5.6	0.223		3.5
4.75	0.187		4
4.0	0.157		5
3.35	0.132		6
2.80	0.110		7
2.36	0.0937		8
2.0	0.0787		10
1.7	0.0661		12
1.4	0.0555		14
1.18	0.0469		16
1.0	0.0394		18
0.841	0.0331	841	20
0.71	0.0278		25
0.595	0.0232	595	30
0.50	0.0197		35
0.400	0.0165	400	40
0.355	0.0139		45
0.30	0.0117		50
0.250	0.0098	250	60

Commonly used US Standard commercial sieve and mesh dimensions

Source: http://www.engineeringtoolbox.com

Sieve size	**Opening**		**Standard Mesh**
(mm)	*(in)*	*(10^{-6} m)*	*US*
0.210	0.0083	210	70
0.177	0.0070	177	80
0.149	0.0059	149	100
0.125	0.0049	125	120
0.105	0.0041	105	140
0.088	0.0035	88	170
0.074	0.0029	74	200
0.063	0.0024	63	230
0.053	0.0021	53	270
0.044	0.0017	44	325
0.037	0.0015	37	400
0.025	0.0010		500
0.020	0.0008		632

Nominal apertures and permissible variation for a selection of US woven wire sieves Source: Powder Sampling and Particle Size Determination, Terrance Allen, 2003				
Standard (mm)	Alternative (in)	Tolerance (+ or – mm)	Intermediate (mm)	Maximum (mm)
125.0	5	3.7	130.00	
63.0	2.500	1.9	65.6	66.2
31.5	1.250	1.0	32.9	33.2
16	0.625	0.5	16.7	17.0
8	0.312	0.25	8.41	8.58
4	0.157	0.13	4.23	4.35
2	0.0787	0.070	2.135	2.215
1	0.0394	0.040	1.080	0.135

Terminology regarding aggregate:

There is some confusion regarding terminology used to describe aggregate as there are multiple conventions used including ISO, ASTM and Michigan Department of Transportation standards. The following are examples of sizing terminologies.

Crushed Stone Grades (http://www.braenstone.com/2013/05/crushed-stone-grades/)

The following list gives a rundown of crushed stone grades and their best uses. While there may be slight variances in the naming convention of crushed stone the following are the most common names and sizes. The highlighted sizes of crushed rock would be suitable for aggregate use under the condition that fines content is 0.5% or less.

- Crushed stone #5 – Sizes are from 1″ down to fine particles. For road and paver base.
- Crushed stone #67 – Sizes from 3/4″ down to fine particles. For fill, road and slab base.
- Crushed stone #1 – Sizes are from 2″ to 4″. The largest of the crushed stone grades. For larger jobs such a culvert ballast.
- Crushed stone #8 – Sizes from 3/8″ to 1/2″. For concrete and asphalt mix.
- Crushed stone #3 -Sizes from 1/2″ to 2″. For drainage and railroad projects.
- Crushed stone #10 (also called stone dust) – Screenings or dust. For fabrication of concrete blocks and pavers and for riding arenas.
- Crushed stone #57 – Sizes of about 3/4″. For concrete and asphalt mix, driveways, landscaping and French drains.
- Crushed stone #411 – A mixture of stone dust and #57 stone. For driveways, roads and as a base for retaining walls. It can also be used to patch holes in paved areas. The dust mixes with the larger stone and settles well

Table of Crushed Rock Sizes from http://www.rbsinc.com/limestone/pageone.htm

SIZE NUMBER	NOMINAL MAXIMUM	NOMINAL MINIMUM	TYPICAL USE	DENSITY,PCF (ESTIMATE)
1	3-½"	1-½"	FREE DRAINING HEAVY FILL, ROAD BASE	80-90
2	2-½ "	1-½"	ROAD BASE, DIFFICULT TO PLACE	100
3	2"	1"		100
4	1-½"	¾"	ROAD BASE, EASIER TO PLACE / GRADE	100
57	1"	#4	FREE DRAINING FILL, USED UNDER CONCRETE SLABS	110
67	¾"	#4		110
7	½"	#4		100-110
8	3/8"	#8	PIPE BEDDING	100-110
9	#4	#16	DRAINAGE BED, SNOW & ICE	120
SAND (#10 MOD)	#4	#100		130
3" CRUSHER RUN	3"	#100	DRIVEWAYS, ROADS, COMPACTION REQUIRED	130
1-½ " CRUSHER RUN	1-1/2"	#100	DRIVEWAYS, ROADS, COMPACTION REQUIRED	140
¾" CRUSHER RUN	¾"	#100	DRIVEWAYS, ROADS, COMPACTION REQUIRED	140
RIP-RAP	10"	4"		

Field screening tool for fines – Jar Test

A tool known as the 'jar test' can be used to evaluate the relative fines content in a load of drainfield rock (or sand fill) delivered to a construction site. This tool has also been used by licensed installers and local inspectors to help evaluate fines in mound sand and single pass sand filters. For drainfield rock, the procedure can be used as a 'quick check' on fines in a load of drainfield rock. The jar test is not to be used as a replacement for sieve analysis.

After settling for several hours, if the layer of fines that settle on top of the aggregate is thicker than 3.2 mm (1/8 inch), the aggregate contains too many fines and is not suitable for use in a drainfield. An **8 hour jar test** must be conducted for best results.

When in doubt the aggregate supplier should provide an aggregate analysis report to confirm the product meets the sieve specification.

Jar test procedure:

- Place approximately 2 inches of aggregate in a glass quart jar.
- Fill the jar with water.
- Shake the jar vigorously to mix the aggregate and water.
- Set the jar on a level platform and allow to settle for several hours (4 - 8 hours).

- Upon settling, after several hours (4 - 8 hours), the layer of fines that settle out of the aggregate should not be thicker than 1/8 inch (3.2 mm).

TIPS:*

- Take a sample from the middle of the pile.
- It may be necessary to jar test a composite sample.
- It may be necessary to conduct two jar tests.
- When in doubt, obtain the sieve analysis report from the aggregate supplier or send a sample to the laboratory. Be sure to ask the laboratory to include the No. 200 sieve size.

Michigan Department of Transportation (MDOT) Standards:

Many contractors and pit operators will use the MDOT terminology when describing and classifying their aggregate. Below is a table describing the characteristics of each MDOT aggregate classification. Per the Marquette County Superior Environmental Health Code requirements ONLY the 4AA meets the sizing requirements, but ONLY under the condition that it is washed to reduce the fines to a max of 0.5%. The standard 2.0 maximum MDOT allowable fines content is not acceptable for drainfield aggregate.

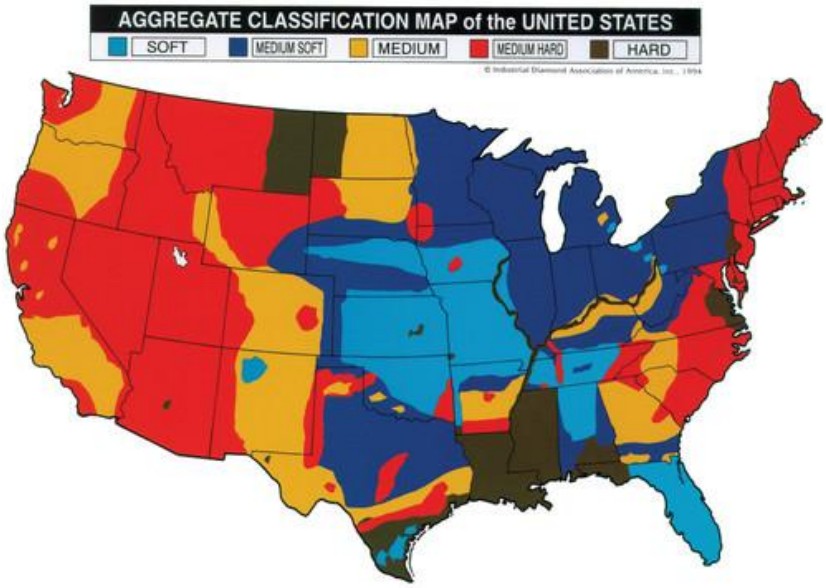
Michigan Department of Transportation (MDOT) Grading Requirements for Coarse Aggregates, Dense-Grade Aggregates and Open-Graded Aggregates

Material Type	Class	Item of Work by Section Number (Sequential) (a)	Sieve Analysis (MTM 109) Total Percent Passing										Loss by Washing (MTM 108) % Passing No. 200 (b)
			2.5 in	2 in	1.5 in	1 in	3/4 in	1/2in	3/8in	No. 4	No. 8	No. 30	
Coarse Aggregates	4 AA (c)	602	100	90-100	40-60		0-12						2.0 max
	6 AAA (c)	602			100	90-100	60-85	30-60		0-8			1.0 max (d)
	6 AA (c)	601,602 706,708,806			100	95-100		30-60		0-8			1.0 max (d)
	6 A	205, 401,402,601,602,603,706,806			100	95-100		30-60		0-8			1.0 max (d)
	17 A					100	90-100	50-75		0-8			1.0 max (d)
	25 A	508					100	95-100	60-90	5-30	0-12		3.0 max
	26 A	706, 712					100	95-100	60-90	5-30	0-12		3.0 max
	29 A	508						100	90-100	10-30	0-10		3.0 max
Dense-Graded Aggregates	21 AA	302,304,305			100	85-100		50-75			20-45		4-8 (e)(f)
	21 A	302,305											
	22 A	302,305,306,307				100	90-100		65-85		30-50		4-8 (e)(f)(g)
	23 A	306,307				100			60-85		25-60		9-16 (f)
Open-Graded Aggregated	2 G	303(h)			100	85-100		40-70			0-10	0-8	5.0 max
	3 G				100	85-100		40-70			0-30	0-13	5.0 max
	4 G (i)	303			100		60-80	35-65			10-25	5-18	6.0 max
	34 R	404						100	90-100		0-5		3.0 max
	34 G	404						100	90-100		0-5		3.0 max

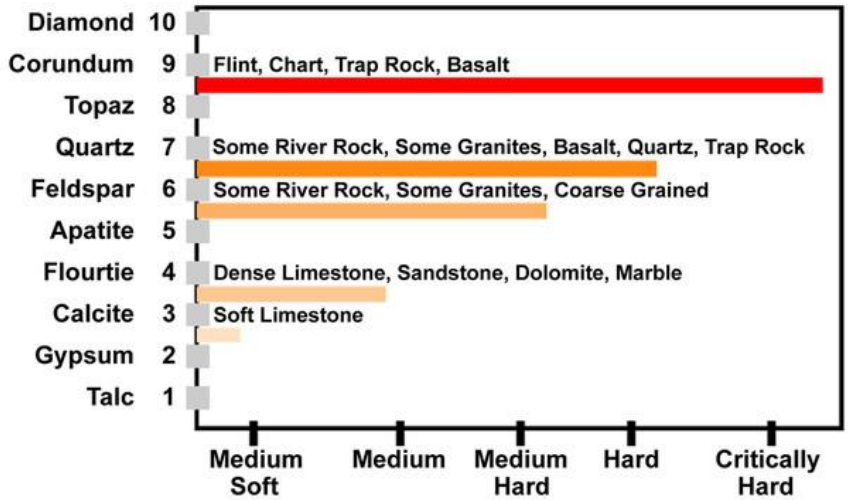
Hardness:

Based upon the graph and the map shown below, all aggregate available in Marquette County should meet the requirement of rating at 3 or higher on Mohs scale of hardness. Calcite (soft limestone) is considered to be a standard for 3 on Mohs scale and is technically acceptable under the Marquette County Superior Environmental Health Code of 1998.

Source: http://www.forconstructionpros.com/article/10745911/aggregate-hardness-map-of-the-united-states



Mohs Hardness Scale 1 through 10



Verifying Hardness during production

Limestone and other potentially soft rocks can decay or deteriorate when exposed to sewage and soil causing premature drainfield failure. There are two specified tests to determine sufficient hardness for suitability of use as drainfield aggregate. The standard tests are loss of abrasion and loss of soundness. The purpose of these two tests is to help ensure that limestone and other potentially soft rock does not break down when transported and used in sewage treatment systems.

The limestone aggregate should be tested at the quarry to ensure the material meets the required specifications in the table below.

Limestone testing requirements for 'hardness'	**Method**	**Results required**
Abrasion determines if rock breaks down when moved around	AASHTO Method T 96 (Los Angeles Abrasion Test)	Not more than 40 percent loss
Soundness determines if rock breaks down over time	AASHTO Method T 104 (magnesium sulfate)	Not more than 15 percent loss at end of five cycles

Field screening tool for rock hardness – Mohs Test

Another field tool that can be used to help evaluate the suitability of drainfield rock is the Mohs Test (Mohs Hardness, 2008). Drainfield rock would typically have a hardness of three or more on the Mohs Scale of Hardness. Hardness is a measure of a rock's resistance to abrasion and is measured against a standard scale called the Mohs Scale of Hardness. The scale consists of ten fairly common minerals of known hardness, which are numerically ordered from the softest rock (1) to the hardest rock (10), as follows:

1. Talc (H=1)	2. Gypsum (H=2	3. Calcite (H=3)	4. Fluorite (H=4	5. Apatite (H=5)
6. Orthoclase (H=6)	7. Quartz (H=7)	8. Topaz (H=8)	9. Corundum (H=9)	10. Diamond (H=10)

The Mohs Scale of Hardness is based on the fact that a harder material will scratch a softer one. By using a simple scratch test, you can determine the relative hardness of drainfield rock. Please be advised this simple test is not suitable for all rock types. For example, chert and shale, which would 'pass' using this field tool would, in fact, break down using the American Associations of State Highway and Transportation Officials (AASHTO) Methods for loss of abrasion and soundness tests because of the structure of the rocks.

There are several simple tools that can be used in determining the relative hardness of drainfield rock. For example, your *fingernail* has a hardness of 2.5. If you can scratch the surface of a rock with it, its hardness is less than 2.5; slightly harder than gypsum (H=2) but softer than calcite (H=3). A *penny* has a hardness of 3.0. If you cannot scratch the rock with your fingernail (H=2.5), but can with a penny, the rock is at least as hard as calcite (H=3). The *steel blade* of the average knife commonly has a hardness of about 5.5. If a penny does not scratch your rock but the knife blade does, then it is harder than calcite (H=3) but softer than orthoclase (H=6).

If your drainfield rock	Give it a hardness number
Can be rubbed off on the fingers	1
Can be scratched with a fingernail	2
Can be scratched with a penny1	3
Can be scratched easily with a butter knife	4
Can be scratched with a steel nail but not glass	6
Can be used to scratch glass	7
Too hard to be tested in this scale	8 – 10

Proper Transport and Handling of Aggregate

Some basic handling practices can be used to minimize contamination of drainfield rock with fines, dust, clods of silt and clay, wood and other undesirable materials. These practices should be be used by both equipment operators loading drainfield rock at the pit or quarry and by licensed installers moving rock around the construction site.

Best Handling Practices Pit and Quarry

- Leave a bottom layer of rock (six inches) when loading the truck. Do not scoop up all the rock on the ground because it will mix with the underlying soil and the load will become contaminated with soil and/or fines.
- Don not let the rock get too dusty – it may need to be washed again due to excess fines. For example, if a stock pile sits in the pit for a number of years, it will likely be contaminated with fines because of dusty conditions found at these facilities.

Best Handling Practices Construction Site

- Take rock directly from the truck to the soil treatment system, do not store or stockpile drainfield rock, just place it immediately.
- If rock is stockpiled, use a clean, undisturbed area for temporary storage of drainfield rock. Consider covering stockpiled materials if conditions are excessively dusty.
- If stockpiled, make sure different materials are kept separate (i.e. clean sand, pea rock and drainfield rock).
- Make sure the bucket is clean before scooping up materials.
- Take care not to mix any soil in with drainfield rock when moving it around.
- Carefully place drainfield rock into the excavation; make sure soil is at the proper moisture content. Make sure the bottom and sides of the excavation are not smeared; minimize walking in the excavation. Place drainfield rock into the excavation by minimizing drop distance into the excavation.