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ANALYSIS OF LIMESTONE AGGREGATE SAMPLES AND SUITABILITY OF THE PRODUCTS FOR ROAD CONSTRUCTION

Materials Limestone aggregate samples 0/4 mm and 0/32 mm delivered by the customer at 26th June and 6th of July.

Tests The grain size distribution and water absorption of the samples were analyzed according to EN 933-1 and EN 1097-6. Capillarity of the 0/4 mm fine aggregate samples was analyzed according to Finnish standard method. The resistance for fragmentation of the 0/32 mm sample was analyzed with Los Angeles test (EN 1097-2).

Results Results are presented in the table below. The particle density was measured using 4/31.5 mm fraction.

<i>Test</i>	<i>Result</i>
LA-value(EN 1097-2)	23
Capillarity	5 cm
Water absorption (EN 1097-6)	0.98
Particle density (ρ_{rd} EN 1097-6)	2.66

Evaluation of the results Aggregate 0/32 mm is fulfilling the grading requirements for base course and sub base aggregate normally used in Finland. Also the LA value is filling the Finnish requirement (< 30). The water absorption value is very near to the limit value of 1 %. According to the results of these samples the 0/32 limestone aggregate is suitable for base course and sub base. However, the water absorption should be controlled frequently and if the results exceed the limit value a freeze-thaw test according to EN 1367-1 or 1367-6 should be performed.

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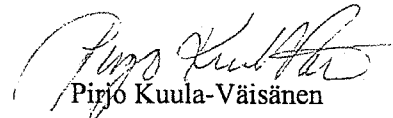
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Aggregate 0/4 mm is fulfilling the grading requirement of filter layer aggregate normally used in Finland. The capillarity of the material is very low. According to these test results the 0/4 limestone aggregate is suitable for filter layer material. The final decision of the material usage should be done when the grading of the sub-base and base is known.

The results are valid only on samples analyzed. Copying this test report is allowed only as a whole document.

Laboratory Engineer


Pirjo Kuula-Väisänen

Appendices

1. The grain size distributions (two pages)
2. The Finnish requirements for aggregates in road construction (4 pages)

Distribution

Customer
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THE QUALITY REQUIREMENTS FOR AGGREGATES IN ROAD CONSTRUCTION IN FINLAND

The aggregate quality requirements in Finland are mainly based on European aggregate standards anyhow some national requirements are used in cases where standards are not appropriate or the aggregate material is not covered by the scope of the standard. The general requirements for aggregates in road construction are published in national application standards, InfraRYL (2006) and Asfalttinormit (2008). In some contracts also special requirements can be produced mainly because of technical or economical reasons.

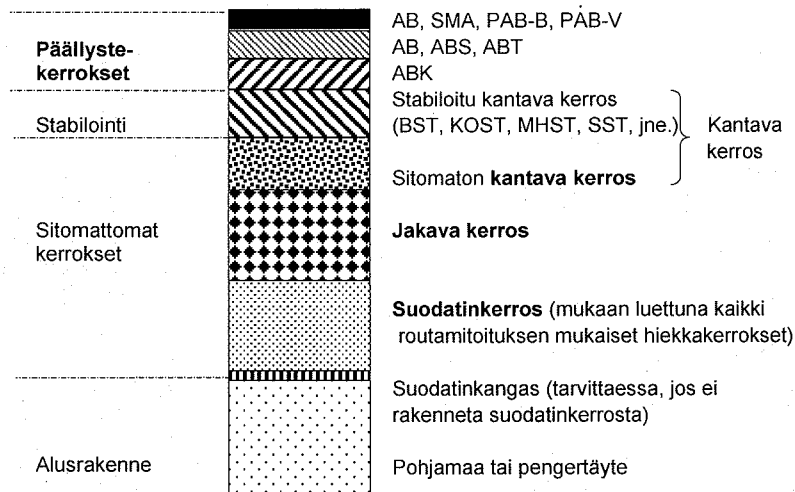


Figure 1. The designation of the layers used in the road construction. All the layers are not used in one construction.

Asphalt pavements (Päällystekerrokset)

The aggregate quality in asphalt pavements is determined according to EN 13043 and CE-marking. The main properties in selecting the proper aggregate are grading, Nordic Ball mill value and flakiness index. Also the petrography and water absorption are measured to determine the suitability of the aggregate for asphalt pavements. The preliminary selection of the aggregate is always based on the Nordic ball mill value and the amount of traffic flow. However, the final decision of aggregate selection for high quality roads (motorways) is always done according to the abrasion value of the bituminous mixture or pavement (Table 1).

Table 1. Preliminary selection of aggregate according to Nordic ball mill value and traffic flow.

Speed limit (km/h)	Traffic flow *)			
	Mean daily traffic flow (cars/d)			
>60	500-2000	2000-5000	5000-10000	> 10000**)
≤ 60	500-3000	3000-7500	7500-15000	> 15000**)
Asphalt type	Minimum category of aggregate (nordic ball mill)			
AC, SMA, MA	A _N 19	A _N 14	A _N 10	A _N 7
AC sub, AC binder	A _N 19	A _N 19	A _N 19	A _N 19
Soft AC	A _N 19	-	-	-
SIP (surface dressing)	A _N 19	A _N 14	-	-
SOP (gravel roads)	A _N 19	-	-	-

*) If mean traffic flow is below 500 cars/day, category A_N30 can be used.

***) The selection of aggregate is always based on the abrasion category of the asphalt.

Base course (Kantava kerros)

The base course (kantava kerros) aggregate requirements are based on standards EN 13242 and EN 13285. The resistance for fragmentation of the aggregate is determined by Los Angeles-test. The LA-value of the aggregate must be ≤ 30 (LA₃₀). In some contracts even categories LA₃₅ or LA₄₀ may be used due to economical reasons. The decision of the exceptional category is always done by the subscriber.

The grading requirements are based on EN 13285, the aggregate can be 0/32, 0/40, 0/45, 0/56 or 0/63 mm. The amount of grains bigger than D must be < 15 %, the material must not contain grains bigger than 1.4*D. The amount of fines (0.063 mm) must not exceed 7 % when crushed rock aggregate is used; when natural gravel is used the amount of fines must be < 9 %. The grading categories G_O and G_A are used, of which G_O is normally used.

The base course aggregate must be unweathered and not sensitive for weathering. The durability properties of aggregate are determined either by petrographic analysis, water absorption (< 1 %) or freeze-thaw testing with NaCl (< 4 %). One of the previous tests is adequate to prove the durability properties.

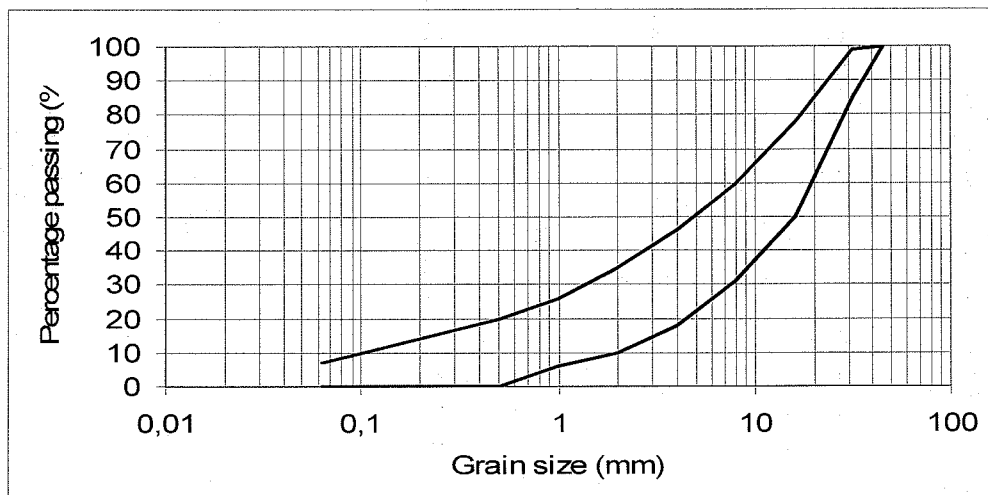


Figure 2. Typical grading requirements of the 0/32 mm aggregate used in base course, category G_0 .

Sub-base (Jakava kerros)

The aggregate for sub-base must not contain impurities. The grading requirements for crushed rock are based on EN 13285, categories G_P or G_C . The aggregate grading used are typically 0/32, 0/40, 0/45, 0/56, 0/63 or 0/80. The percentage passing the upper sieve size D must be 80...99 and the $2 \cdot D$ must be 100 %. The amount of fines (< 0.063 mm) must not exceed 7 % when crushed rock aggregate is used; when natural gravel is used the amount of fines must be < 9 %.

The sub-base aggregate must be unweathered and not sensitive for weathering. The durability of aggregate is determined either by petrographic analysis, water absorption (< 1 %) or freeze-thaw testing with NaCl (< 4 %). One of the previous tests is adequate to prove the durability properties.

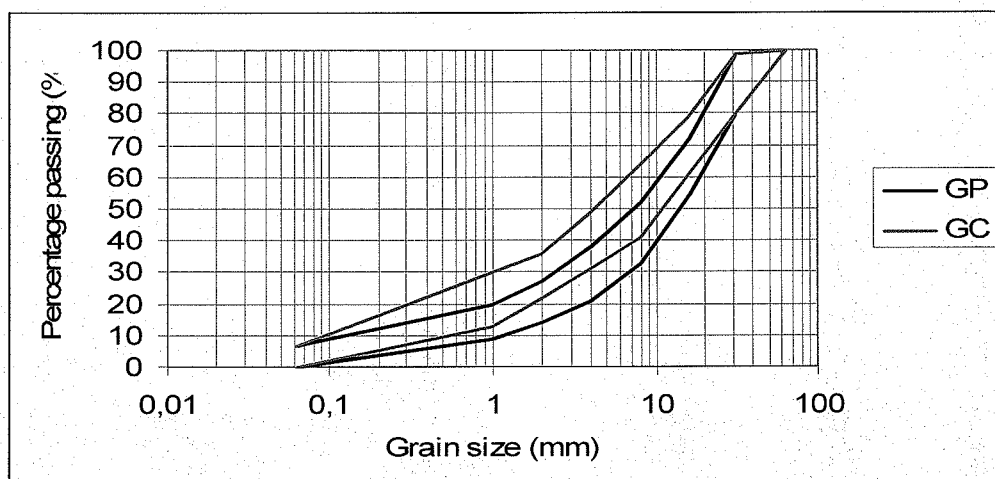


Figure 3. Typical grading requirement for sub-base when 0/32 mm crushed rock aggregate is used (categories G_P and G_C).

Filter layer (suodatin kerros)

The grading requirement for filter layer is presented in Figure 4. The aggregate for filter layer must not contain any impurities (clay or humus). The capillary rise of the material must be below 0.7 m.

The material must also fulfill the following requirements. The symbol d_{20} is determined from grain size distribution; d_{20} is the grain size when the percentage of passing is 20 %.

$$\frac{d_{20} \text{ filter}}{d_{20} \text{ base}} \leq 40$$

$$\frac{d_{20} \text{ sub - base}}{d_{20} \text{ filter}} \leq 40$$

These values can be calculated only when the grading of the sub-base and base materials are known.

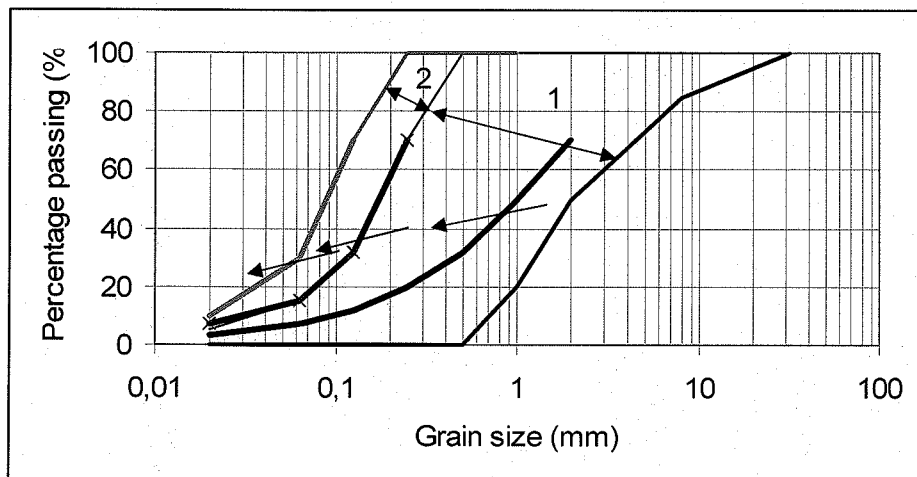


Figure 4. The grading requirements for filter layer. Normally the grading should be in area 1. The grading in area 2 can be used if the drainage of the construction is good enough. The grading curve must not cross the bold lines.

RAKEISUUSMÄÄRITYS

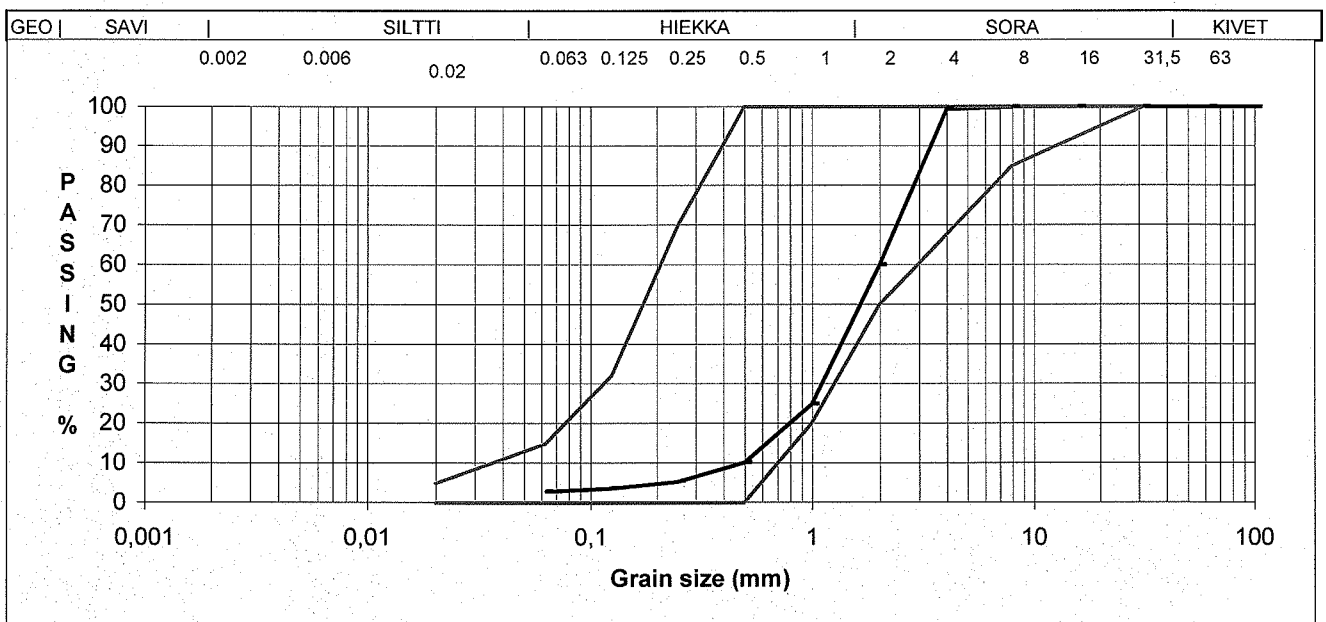
SEULASARJA
 NÄYTE
 TUTKI

32

Kalkkikivi 0/4 mm (TTY:n työnnumero 1894/238/2009)
 ST, MV

KARKEA-AINES			
- PAINO MÄRKÄNÄ (g)			
- PAINO KUIVANA (g)			
- KOSTEUSPITOISUUS (%)			
- PAINO ENNEN PESUA (g)			762,55
- PAINO PESUN JÄLKEEN (g)			742,48
- PESUHÄVIÖ (g)			20,07
- PAINO ENNEN SEULONTAA (g)			742,48
- SEULONTAHÄVIÖ (%)			-0,08
- H-LUKU			706
- Hienoainesmäärä (%)			2,8
SEULONTA			
SEULA mm	SEULALLE JÄI		LÄPÄISY %
	g	%	
125	0,0	0,00	100
63	0,0	0,00	100
31,5	0,0	0,00	100
16	0,0	0,00	100
8	0,0	0,00	100
4	4,5	0,59	99
2	301,2	39,47	60
1	267,5	35,05	25
0,5	113,0	14,81	10
0,25	36,0	4,72	5
0,125	13,0	1,70	4
0,063	6,7	0,88	2,8
POHJA/PESUT	21,3	2,79	
YHT.	763,2		H= 706

The red curves are the requirements (area 1) for filter layer used in Finland



Grain size analysis

SEULASARJA
 NÄYTE
 TUTKI

0
 0/31,5 mm Kalkkikivi (TTY:n työnnumero 1894/238/2009)
 ST, MV

KARKEA-AINES			
- Koko materiaali märkänä (g)			
- Koko materiaali kuivana (g)			
- KOSTEUSPITOISUUS (%)			
- PAINO ENNEN PESUA (g)	10956,8		
- PAINO PESUN JÄLKEEN (g)	10681,5		
- PESUHÄVIÖ (g)	275,3		
- PAINO ENNEN SEULONTAA (g)	10681,50		
- SEULONTAHÄVIÖ (%)	0,00		
- H-LUKU	500		
- Hienoainesmäärä (%)	2,8		
SEULONTA			
SEULA mm	SEULALLE JÄI		LÄPÄISY %
	g	%	
125	0,0	0,00	100
63	0,0	0,00	100
31,5	282,5	2,58	97
16	4085,8	37,29	60
8	1449,4	13,23	47
4	1202,3	10,97	36
2	1356,9	12,38	24
1	1001,9	9,14	14
0,5	545,2	4,98	9
0,25	349,4	3,19	6
0,125	285,6	2,61	4
0,063	94,8	0,87	2,8
POHJA/PESUT	302,8	2,76	
YHT.	10956,6		H= 500

The red curves are presenting the grading category GO for base course used in Finland
 The blue curves are presenting the grading category GC for sub base used in Finland

