The study of dry sand

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INTRODUCTION

The aim of this study to find out is it possible to manufacture dry sand (dried sand) from natural sand. This study is based at harmonized standard **EVS-EN 12620:2002+A1:2008 Aggregates of concrete; EVS-EN 13139:2002+ AC:2005 Aggregates for mortars** and the declaration of performance of AS Silikaadi and OÜ Kuiv Liiv.

USES

Dry sand is used in construction mixtures, preserving produce in the winter, in home and garden, for making kinetic sand and filter sand.

AVAILABLE FRACTIONS AND ITS USES

In tabel 1 shows the most used fractions with its uses. There are 4 common fields where dry sand is used [1].

Table 1. The most common fractions and its uses [1].

	Home and garden	**Construction and construction mixtures**	**Sandblasting works**	**Specifics**
0 - 0,8	airing grass - filling the joints of pavement stones	mortars and plasters - joint filler for pavement stones	cleaning softer structured metal products - car wheel rims with light rust	for making kinetic sand
0 - 2,0 mm	covering pathways or designing borders - children's sand boxes	mortars and plasters	cleaning granite tiles and other such details	beach volleyball courts - hipodromes - graveyards
0,63 - 2,0 mm	levelling under pavement - cat litter boxes - houseplant pots (including designing miniature terrariums) - aquariums	stove setting - concrete aggregate - levelling under pavement	primary processing of tin rims and metal products with rust and a thick layer of paint	filter sand

1,0 - 2,0 mm		concrete aggregate - filtering layers - covering tarred road sections - load-bearing layer for floating floors	cleaning the water line of ships, speedboats and other such vehicles when docking	filter sand - filter system for trams and locomotives - covering tarred road sections in the summer
2 - 20 mm	coating pathways and squares - gardening and landscaping - building drainage systems	building drainage systems		aggregate for wetlands and clay soil - gardening and landscaping

KEY FEATURES

Key features of dry sand are:

- Grain size;
- Grain composition;
- Fine particles;
- Bulk density;
- Chloride content;
- Humus content;
- Radioactive radiation.

RESULTS

There are many different test in harmonized standard EVS-EN 12620:2002+A1:2008 Aggregates of concrete; EVS-EN 13139:2002+ AC:2005 Aggregates for mortars that shall be based on the evaluation of factory production control under system 2+. In this study we have natural sand that is why we cannot confirm key features are correct.

Based on the declaration of performance of AS Silikaadi and OÜ Kuiv Liiv it is important to know grain size, shape, density, cleanliness, water absorption and release of other dangerous substances.

HUMUS CONTENT

The cleanliness of the aggregate is very important because excessive organic substances in concrete and mortarts can effect on stiffening time and compressive strength [2].

Humus is organic substance that forms in soil when dead plant and animal matter breaks down [2].

The presence of organic matter determined in accordance with determination of humus content. In this test humus reacts with sodium hydroxide. The result is assessed by colour. If the supernatant liquid in these tests is lighter than the standard colours the aggregates shall be considered to be free from organic matter [2].

Only the top layers of boreholes were tested because there should be highest humust content. Positive results were in Pa 35, Pa 36, Pa 39, Pa 40 and Pa 41 because supernatant liquid were darker than standard colours. This means that those layers of boreholes are not suitable for manufactoring. The results of boreholes Pa 30, Pa 31, Pa 32, Pa 33, Pa 34, Pa 37, Pa 38, Pa 42 and Pa 43 were negative which means supernatant liquid in these tests is lighter than the standard colours.

As a recommendation do not to use the top layers of boreholes for manufacturing because cleanliness is very important. Probably top layers were polluted by soil. It is important to supervise a technique how soil is removed.

Table 2. The results of humus content.

Borehole	**Colour**	**Result**
Pa 30-1	Ligther	Negative
Pa 31-1	Ligther	Negative
Pa 32-1	Ligther	Negative
Pa 33-1	Ligther	Negative
Pa 34-1	Ligther	Negative
Pa 35-1	Darker	Positive

Pa 36-1	Darker	Positive
Pa 37-1	Ligther	Negative
Pa 38-1	Ligther	Negative
Pa 39-1	Darker	Positive
Pa 40-1	Darker	Positive
Pa 41-1	Darker	Positive
Pa 42-1	Ligther	Negative
Pa 43-1	Ligther	Negative

Table 3. The results of additional samples.

Reg number	**Colour**	**Result**
Suur Ladu	Lighter	Negative
Sisse Ladu	Lighter	Negative

Suur Ladu ja sisse ladu humus content were negative which means both are suitable for manufactoring dry sand.

CHLORHIDE CONTENT

The chloride content of aggregate must be 0,01% or lower to be used in mortar and concrete mixtures. The chlorhide ion content of sand samples were tested in TalTech laboratory of Chemical Analysis. Chloride content of sand samples were tested for fraction 0/4 based on EVS-EN 1744-1, clause 7 and 8. Chlorides are extracted with water. The method of analysis is based on titration using a suitable electrode as a potentiometric indicator.

The cleanliness of aggregate is very important. Chlorides may be occur in the aggregates, if the aggregate is in or in contact with seawater [2].

Chloride salts can cause salt stains on the free surfaces of the mortar. In addition, the chloride content of all components in mortar and concrete mixtures is usually limited to minimise the risk of corrosion of embedded metal. The conditions are complied if the content of water-soluble chloride ions in the aggregates does not exceed 0.15% in simple mortars, 0.06% in mortars with embedded metals and 0.01% in concrete mixtures [2].

Chloride content were determined in every other sample. All borehole layers were mixed toghether.

Table 4. The results of chloride content.

Borehole	Chloride, mg/kg	Chloride, weight%	≤ 0,01%
PA 30	10,2	0,0010	0,00
PA 32	3,4	0,0003	0,00
PA 34	12,9	0,0013	0,00
PA 36	4,1	0,0004	0,00
PA 38	2,7	0,0003	0,00
PA 40	17,9	0,0018	0,00
PA 42	3,7	0,0004	0,00

The chloride content were lower than 0,01% in every tested borehole. Those natural sand samples are suitable for using in mortar and concrete mixtures.

GRAIN COMPOSITION AND FINE PARTICLES

GRAIN SIZE

All aggregates shall be described in terms of aggregate sizes using designation of aggregate in terms of lower (d) and upper (D) sieve sizes expressed as d/D [3].

The grain size of dry sand is important to know because it determines fields of application.

The most common fractions:

- 0-0,8 mm
- 0-2,0 mm (construction sand)
- 0,63-2,00 mm

In this study we tested natural sands which were not sieved specific dry sand's fractions.

Table 5. The grain sizes of natural sand.

Borehole	Water level	Grain size
Pa-30-1	Above	0/12,5
Pa-30-2	Under	0/8
Pa-31-1	Above	0/6,3
Pa-31-2	Above	0/8
Pa-31-3	Above	0/8
Pa-32-1	Above	0/8
Pa-32-2	Above	0/4
Pa-32-3	Under	0/8
Pa-32-4	Under	0/8
Pa-33-1	Above	0/20
Pa-33-2	Above	0/8
Pa-33-3	Under	0/12,5
Pa-34-1	Above	0/16
Pa-34-2	Above	0/8
Pa-34-3	Under	0/12,5
Pa-35-1	Above	0/16
Pa-35-2	Above	0/16
Pa-35-3	Under	0/8
Pa-35-4	Under	0/12,5
Pa-36-1	Above	0/8
Pa-36-2	Above	0/6,3

Pa-36-3	Under	0/4
Pa-36-4	Under	0/8
Pa-37-1	Above	0/12,5
Pa-37-2	Above	0/8
Pa-37-3	Under	0/12,5
Pa-37-4	Under	0/4
Pa-38-1	Above	0/12,5
Pa-38-2	Above	0/6,3
Pa-38-3	Under	0/8
Pa-39-1	Above	0/12,5
Pa-39-2	Above	0/8
Pa-39-3	Above	0/2
Pa-39-4	Under	0/8
Pa-40-1	Above	0/6,3
Pa-40-2	Above	0/8
Pa-40-3	Under	0/8
Pa-40-4	Under	0/4
Pa-41-1	Above	0/8
Pa-41-2	Above	0/6,3
Pa-41-3	Under	0/6,3
Pa-41-4	Under	0/8
Pa-42-1	Above	0/12,5
Pa-42-2	Under	0/8
Pa-43-1	Above	0/8

Pa-43-2	Under	0/16

Table 6. The grain sizes of additional samples.

Suur ladu	0/12,5
Sisse ladu	0/12,5

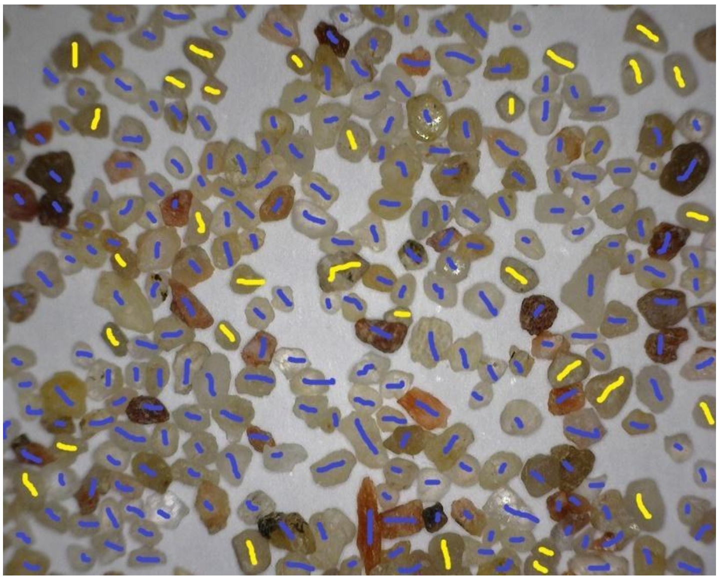
GRANULOMETRIC COMPOSITION AND PETROPGRAPHIC DESCRIPTION

Granulometric composition were determined accordance with EN 933-1. The samples of natural sand were tested with alternative sieving method [3].

Samples were dried before testing. The samples of natural sand were sieved with 4 mm sieve and then washed [3].

Category for granulometric composition is selected by fraction. The category for coarse sand is $G_c85/20$ and for fine sand is G_f85. Granulometric composition's category is important if dry sand is used in concrete mixtures. In this study, it is not correct to determine granulometric composition's category because the samples of sand are natural.

Simpliplied petrographic description were determined in borehole Pa 35-2.



The sample of sand consists light gray and white sendimentary rocks and light toned igneous- and metamorphic rocks. Quarts and delspar's particles are visible. Limestones edges are rounded but igneous- and metamorphic rocks' edges not.

Table 7. The results of petrographic descpription.

PA 35-2	**Igneous and metamorphic (%)**	**Sendimenatry (%)**
4/8	28,3	71,7
2/4	45,7	54,3
1/2	84,8	15,2
0,5/1	88,7	11,3
0,125/0,5	96,1	3,9

FINENESS MODULUS

Fineness modulus (FM) is used to check contancy. Fineness modulus is normally calculated as the sum of cumulative percentages by mass retained on the following sieves (mm) expressed as a perstange [4][5]:

$$FM = \frac{\sum[(>4)+(>2)+(>1)+(> 0,5)+(>0,25)+(>0,125)]}{100}, \quad \text{[formula 1]}$$

The content of fine particles significantly affects the numerical value of the fineness modulus.

Fineness modulus was determined in accordance with EVS-EN 13139:2005 annex A and EVS-EN 12620:2005+A1:2008 annex B.

Fineness modulus for construction sand should be 1,3 or more and fraction 0-2 mm [1].

Table 8. The values of fineness modulus.

Borehole	FM	Fineness	Borehole	FM	Fineness
Pa-30-1	2,9	CF	Pa-37-1	2,7	CF
Pa-30-2	2,6	CF	Pa-37-2	2,6	CF
Pa-31-1	2,3	MF	Pa-37-3	2,2	MF
Pa-31-2	2,6	CF	Pa-37-4	2,1	MF
Pa-31-3	1,8	MF	Pa-38-1	2,7	CF
Pa-32-1	2,5	MF	Pa-38-2	2,5	MF
Pa-32-2	2	MF	Pa-38-3	2	MF
Pa-32-3	2,4	MF	Pa-39-1	2,5	MF
Pa-32-4	1,9	MF	Pa-39-2	2,3	MF
Pa-33-1	2,6	CF	Pa-39-3	1,9	MF
Pa-33-2	2,1	MF	Pa-39-4	1,7	FF
Pa-33-3	2	MF	Pa-40-1	2,5	MF
Pa-34-1	2,8	CF	Pa-40-2	2,6	CF
Pa-34-2	2	MF	Pa-40-3	2,3	MF
Pa-34-3	2	MF	Pa-40-4	2,2	MF
Pa-35-1	2,5	MF	Pa-41-1	2,6	CF
Pa-35-2	2,7	CF	Pa-41-2	2,7	CF
Pa-35-3	2,2	MF	Pa-41-3	2,6	CF
Pa-35-4	2	MF	Pa-41-4	2,1	MF

Pa-36-1	2,6	CF	Pa-42-1	2,7	CF
Pa-36-2	2,2	MF	Pa-42-2	2,3	MF
Pa-36-3	1,9	MF	Pa-43-1	2,3	MF
Pa-36-4	1,9	MF	Pa-43-2	1,7	FF

Coarseness or fineness is based on the fineness modulus. [check table 9]

Table 9. Coarseness of fineness based on the fineness modulus.

Fineness modulus		
CF	MF	FF
3,6...2,4	2,8...1,5	2,1...0,6

The results showed that the most of sands are medium and coarse graded. Only a few of them were fine-grained.

Table 10. The fineness modulus of additional samples.

Borehole	**FM**	**Fineness**
Suur ladu	2,6	CF
Sisse ladu	2,4	MF

Fineness modulus were determined in additional samples. The sand of suur ladu was coarse-graded and sand of sisse ladu medium graded.

DUST CONTENT

Dust content were calculated by percent. The samples of sand were weighted before and after washing.

If dry sand is used like construction sand then dust content should not be over 10% and fraction 0-2,0 mm [6].

Table 11. The dust content in samples.

Borehole	**Dust %**	**Borehole**	**Dust %**
Pa-30-1	2,04	Pa-37-1	2,00
Pa-30-2	6,96	Pa-37-2	2,62

Pa-31-1	3,28	Pa-37-3	1,74
Pa-31-2	2,88	Pa-37-4	2,86
Pa-31-3	**11,36**	Pa-38-1	1,97
Pa-32-1	3,87	Pa-38-2	1,68
Pa-32-2	3,95	Pa-38-3	3,18
Pa-32-3	3,75	Pa-39-1	1,77
Pa-32-4	7,08	Pa-39-2	3,01
Pa-33-1	3,41	Pa-39-3	2,31
Pa-33-2	3,58	Pa-39-4	3,75
Pa-33-3	5,30	Pa-40-1	2,35
Pa-34-1	3,32	Pa-40-2	2,38
Pa-34-2	5,52	Pa-40-3	1,61
Pa-34-3	8,03	Pa-40-4	3,61
Pa-35-1	2,72	Pa-41-1	1,59
Pa-35-2	4,01	Pa-41-2	1,41
Pa-35-3	4,75	Pa-41-3	2,02
Pa-35-4	**11,68**	Pa-41-4	6,56
Pa-36-1	2,74	Pa-42-1	1,94
Pa-36-2	3,26	Pa-42-2	2,33
Pa-36-3	3,89	Pa-43-1	4,33
Pa-36-4	**16,49**	Pa-43-2	**12,85**

Dust content were calculated to natural sand. Dust content were too high for contruction sand in a few samples.

Exemplary calculations were calculated for fraction 0/2 mm considering the same amount dust were washed out.

Table 12. The dust content comparison

Borehole	**Dust %**	**Fraction 0/2**	**borehole**	**dust %**	**Fraction 0/2**
Pa-30-1	2,04	2,10	Pa-37-1	2,00	2,03
Pa-30-2	6,96	7,10	Pa-37-2	2,62	2,67
Pa-31-1	3,28	3,28	Pa-37-3	1,74	1,76
Pa-31-2	2,88	2,93	Pa-37-4	2,86	2,86
Pa-31-3	**11,36**	**11,43**	Pa-38-1	1,97	2,01
Pa-32-1	3,87	3,91	Pa-38-2	1,68	1,68
Pa-32-2	3,95	3,95	Pa-38-3	3,18	0,48
Pa-32-3	3,75	3,78	Pa-39-1	1,77	1,79
Pa-32-4	7,08	7,25	Pa-39-2	3,01	3,04
Pa-33-1	3,41	3,54	Pa-39-3	2,31	2,30
Pa-33-2	3,58	3,59	Pa-39-4	3,75	3,76

Pa-33-3	5,30	5,31	Pa-40-1	2,35	2,35
Pa-34-1	3,32	3,51	Pa-40-2	2,38	2,38
Pa-34-2	5,52	5,53	Pa-40-3	1,61	1,62
Pa-34-3	8,03	8,07	Pa-40-4	3,61	3,62
Pa-35-1	2,72	2,76	Pa-41-1	1,59	1,60
Pa-35-2	4,01	4,15	Pa-41-2	1,41	1,42
Pa-35-3	4,75	4,81	Pa-41-3	2,02	2,04
Pa-35-4	**11,68**	**12,15**	Pa-41-4	6,56	6,62
Pa-36-1	2,74	2,77	Pa-42-1	1,94	1,96
Pa-36-2	3,26	3,27	Pa-42-2	2,33	2,35
Pa-36-3	3,89	3,85	Pa-43-1	4,33	4,37
Pa-36-4	**16,49**	**16,55**	Pa-43-2	**12,85**	**13,26**

Calculations did not show big differences. Significantly high dust content were in boreholes Pa 36-4 and Pa 35-4 because those were the layers of a bed. Dust content depends how dry sand is wanted to use.

Dust content were also calculated in additional samples „Suur ladu" and „Sisse ladu". Results are shown table 13.

Table 13. The dust content of additional samples.

Borehole	**Dust %**	**Fraction 0/2**
Suur ladu	1,95	1,99
Sisse ladu	2,13	2,22

BULK DENSITY AND WATER ABSORPTION

In this study bulk density was not determined because natural sand is not a product. Bulk density shall be determined in accordance with EN 1097-3.

Dry sand must be dry. Humidity must be ≤0,1%. Water absorption shall be determined in accordance with EN 1097-6.

RADIOACTIVITY

Radioactive radiation is dimensionless value (I) which describes radioactivity of aggregate.

$$I = \sum_i \frac{C_i}{A_i},$$

Ci is measured concentrations of radionuclide activity (B_q/kg) and Ai is a parameter which depends the use of radionuclide index I (B_q/kg). Values are submitted in Riigiteataja annex 1 (Keskkonnaministri 26. mai .2005. a määruse nr 45 "Kiirgustöötaja ja elaniku efektiivdooside seire ja hindamise kord ning radionukliidide sissevõtust põhjustatud dooside doosikoefitsientide ning kiirgus-ja koefaktori väärtused) [7].

The value of radioactive radiation shoud be I<1.

CONCLUSIONS

Those sands are suitable for manufactoring dry sand if it is washed and dried. Humidity should be close to zero.

The cleanliness of aggregate is very important. To minimize the risk of corrosion of embedded metal it is necessary to limit the total quantity of chloride ion contributed by all the constituent materials in the concrete. The organic substances in concrete and mortarts cannot be too high because it can effect on stiffening time and compressive strength that is why it is important to supervise a technique how soil is removed.

The chloride content were lower than 0,01% in every tested borehole. Those natural sand samples are suitable for using in mortar and concrete mixtures. However, as a recommendation do not to use some of the top layers for manufacturing because humus content might be too high as shown in a few of the boreholes. Probably top layers were polluted by soil.

Dust content can be varied by field of use. Excess dust from aggregate must be removed or processed accordingly. The results of fineness modulus showed that the most of sands are medium and coarse graded.

This sand is suitable for maufactoring dry sand if the recommendations are followed.

REFERENCES

[1] AS Silikaat, „Kõik Fraktsioonid,‟ 2020. Saadaval: https://silikaat.ee/toode/kuivliiv/#saadavad-fraktsioonid-ja-kasutusalad [Kasutatud 22.12.2021].

[2] Eesti Standardikeskus, „ EVS-EN 1744-1:2010+ A1:2012 Tests for chemical properties of aggregates Part 1, Chemical analysis‟. Eesti standardikeskus, 2013.

[3] Eesti Standardikeskus, „EVS-EN 933-1:2012 Tests for geometrical properties of aggregates. Part 1, Determination of particle size distribution ; Sieving method‟. Eesti standardikeskus, 2012.

[4] Eesti standardikeskus, „EVS-EN 12620:2005+A1:2008 Aggregates for concrete‟. Eesti standardikeskus, 2008.

[5] Eesti Standardikeskus, „ EVS-EN 13139:2005 Aggregates for mortars‟. Eesti Standardikeskus, 2005.

[6] Riigiteataja, „Üldgeoloogilise uurimistöö ja maavara geoloogilise uuringu tegemise kord‟.

[7] Riigiteataja, „Keskkonnaministri 26. mai .2005. a määruse nr 45 Kiirgustöötaja ja elaniku efektiivdooside seire ja hindamise kord ning

radionukliidide sissevõtust põhjustatud dooside doosikoefitsientide ning kiirgus-ja koefaktori väärtused".