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Report about mineral wool waste composition and quality variability

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DELIVERABLE 1.1 REPORT ABOUT MINERAL WOOL WASTE COMPOSITION AND QUALITY VARIABILITY

Representative mineral wool wastes were sampled from all sourcing sites involved in WOOL2LOOP (DEL / Finland, REAS / Belgium, TREE / Poland, TER / Slovenia, and SGE / Sweden). The aim was to collect different kinds of mineral wools (sheets, loose, ceiling tiles, mineral wool manufacturing by-products etc.). Sampling was conducted by forming a composite sample (~ 50 kg / site) of small discrete samples taken during a building demolition and from mineral wool manufacturing plants. If sampling was conducted from a pile of (mixed) mineral wool waste, a split-spoon sampler can be used or, alternatively, the was discharged on a small conveyer belt from which sampling was conducted on regular intervals. The aim of the subtask was to find out the variation in mineral wool waste composition, which might affect alkali activation.

In total 29 mineral wool samples were analyzed (Table 1). Mineral wool waste samples are separated into 6 categories in this report: Glass wool demolition waste, Glass wool process waste, Stone wool demolition waste, Stone wool process waste, Mix of glass and stone wool demolition waste and Others. The exact age of some samples is known, but not for all. However, the variation of age (1-50 years) of analyzed samples gives a good presentation of the composition of mineral wools in Europe. Compiled results of the moisture content, loss-on-ignition, and major oxides of all samples are presented in Tables 2-7. Glass and stone wool fiber lengths and widths are presented in Table 8.

Table 1. The type, age and number of mineral wool waste samples.

		Number of samples	**Age of samples (years)**
Demolition waste	Glass wool	6	5-50
	Stone wool	10	5-50
	Mix of glass and stone wool	2	>25
Process waste	Glass wool	8	1-4
	Stone wool	2	1-5
	Others	1	1
	Total	29	

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There is very little variation in the chemical composition of glass wool demolition and process waste samples. Glass wool depicts typical composition of soda-lime-silicate glass i.e. ~62 % SiO_2, ~16 % Na_2O and ~8 % CaO. In addition to oxides reported in Tables 2 and 3, glass wool may contain 1-6 % of B_2O_3 which is not detectable with the XRF method used here. The average content of organic resin as determined by the loss-on-ignition 525°C varies between 5-10 wt.%, but there was also one process waste sample which does not contain any organic resin showing that new, organic resin-free glass wool products are being manufactured nowadays.

Table 2. Glass wool demolition waste.

	Glass wool		
	Demolition waste		
	Average	Min	Max
Moisture content [%]	0.6	0.3	0.9
Loss-on-ignition 525°C [%]	6.7	4.9	9.2
Loss-on-ignition 950°C [%]	N/A	N/A	N/A
CaO, [%]	8.0	7.6	8.5
SiO_2, [%]	62.3	59.9	64.1
Al_2O_3, [%]	2.2	1.8	2.9
Fe_2O_3, [%]	0.9	0.3	2.1
Na_2O, [%]	16.9	15.5	17.7
K_2O, [%]	0.8	0.5	0.9
MgO, [%]	2.6	2.1	3.3
P_2O_5, [%]	0.0	0.0	0.1
TiO_2, [%]	0.1	0.0	0.2
SO_3, [%]	1.1	0.3	1.8
Cl, [%]	0.1	0.1	0.1

Table 3. Glass wool process waste.

	Glass wool		
	Process waste		
	Average	Min	Max
Loss on 105°C [%]	0.6	0.1	1.0
Loss-on-ignition 525°C [%]	7.1	0.6	10.3
Loss-on-ignition 950°C [%]	N/A	N/A	N/A
CaO, [%]	8.1	7.6	8.4
SiO_2, [%]	63.3	62.7	63.8
Al_2O_3, [%]	1.6	1.5	1.9
Fe_2O_3, [%]	0.5	0.3	1.0
Na2O, [%]	16.9	16.1	17.1
K_2O, [%]	0.6	0.5	0.6
MgO, [%]	2.5	1.8	3.0
P_2O_5, [%]	0.3	0.0	0.5
TiO_2, [%]	0.1	0.0	0.1
SO_3, [%]	0.4	0.1	0.7
Cl, [%]	0.1	0.1	0.1

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Also the chemical composition of stone wool demolition and process waste samples is homogenous despite their age or source location. The main finding from the results is the variation in CaO (14-23 %) and MgO (6-14 %) contents, which can have effect on the reactivity and binder phases formed in alkali activation. The organic resin content varies between 2-7 % showing slightly lower content compared to glass wools.

Table 4. Stone wool demolition waste.

	Stone wool		
	Demolition waste		
	Average	Min	Max
Moisture content [%]	0.2	0.1	0.3
Loss-on-ignition 525°C [%]	3.3	1.5	7.4
Loss-on-ignition 950°C [%]	2.0	1.0	3.2
CaO, [%]	18.3	14.4	22.6
SiO_2, [%]	40.6	39.1	42.9
Al_2O_3, [%]	16.6	14.0	17.7
Fe_2O_3, [%]	7.0	5.5	8.3
Na_2O, [%]	2.2	1.4	2.9
K_2O, [%]	0.8	0.4	1.1
MgO, [%]	9.8	7.7	14.2
P_2O_5, [%]	0.3	0.1	0.5
TiO_2, [%]	2.0	1.0	3.3
SO_3, [%]	0.4	0.1	1.7
Cl, [%]	0.1	0.1	0.2

Table 5. Stone wool process waste.

	Stone wool		
	Process waste		
	Average	Min	Max
Moisture content [%]	0.1	N/A	N/A
Loss-on-ignition 525°C [%]	3.1	N/A	N/A
Loss-on-ignition 950°C [%]	2.5	N/A	N/A
CaO, [%]	19.3	17.9	20.6
SiO_2, [%]	41.6	40.4	42.7
Al_2O_3, [%]	17.4	16.3	18.5
Fe_2O_3, [%]	8.2	7.7	8.8
Na_2O, [%]	1.8	1.4	2.2
K_2O, [%]	0.6	0.6	0.6
MgO, [%]	8.6	6.0	11.2
P_2O_5, [%]	0.1	0.1	0.2
TiO_2, [%]	1.1	1.0	1.3
SO_3, [%]	0.1	0.1	0.1
Cl, [%]	0.0	0.0	0.0

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The mix sample compositions depicted composition between glass wool and stone wool. In fact, due to the small variation in glass wool and stone wool waste composition (Tables 2-5) it might be possible to calculate the mineral wool type ratio of mixed samples. In the rightmost column a theoretical chemical composition of 50% glass wool + 50 % stone wool mix is presented, which was calculated by using the average composition from Tables 2 and 4. It can be seen that the composition is very close to the actual mix sample composition.

Table 6. Mix of glass and stone wool demolition waste.

	Mix of glass wool and stone wool			
	Demolition waste			Theoretical 50:50 mix
	Average	Min	Max	
Moisture content [%]	0.7	0.3	1.0	
Loss-on-ignition 525°C [%]	5.2	4.0	6.4	
Loss-on-ignition 950°C [%]	6.2	6.2	6.2	
CaO, [%]	13.9	12.2	15.6	13.2
SiO_2, [%]	51.6	48.9	54.4	51.4
Al_2O_3, [%]	9.0	8.4	9.6	9.4
Fe_2O_3, [%]	3.7	3.7	3.8	4.0
Na_2O, [%]	8.6	8.1	9.2	9.5
K_2O, [%]	0.8	0.5	1.0	0.8
MgO, [%]	7.5	5.5	9.4	6.2
P_2O_5, [%]	0.2	0.1	0.3	0.2
TiO_2, [%]	0.8	0.6	1.0	1.1
SO_3, [%]	0.3	0.3	0.4	0.7
Cl, [%]	0.1	0.1	0.2	0.1

There was a sole process waste sample of a new type mineral wool which showed composition between glass wool and stone wool. The chemical composition is likely suitable for alkali activation due to its high silicon, aluminium, and calcium content.

Table 7. Other type mineral wool.

	Other
Moisture content [%]	0.5
Loss-on-ignition 525°C [%]	6.2
Loss-on-ignition 950°C [%]	6.2
CaO, [%]	14.2
SiO_2, [%]	41.6
Al_2O_3, [%]	21.7
Fe_2O_3, [%]	5.6
Na_2O, [%]	7.2
K_2O, [%]	3.2
MgO, [%]	1.7
P_2O_5, [%]	1.2
TiO_2, [%]	0.7
SO_3, [%]	0.1
Cl, [%]	0.1

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Both glass and stone wool waste fibers have similar average fiber length and width as determined by tube-flow fractionation method, but there is a quite large variation (450-870 µm) between the averaged shortest and longest fibers lengths. The fiber length would mostly affect the milling process i.e. longer fibers may require longer milling time. Fiber width can have effect on the total surface area of the material which consequently affects the reactivity of the material. However, after milling fiber width is likely homogenous between different mineral wool samples. Further aspect to take into account is the possible existence of dangerous respirable fibers (that is, those with the ability to reach the lungs, particularly their alveolar regions) using the World Health Organization (WHO) criteria: fibers longer than 5 µm and less than 3 µm in diameter with aspect ratios greater than 3. The proportion of those fiber dimensions is likely low, but should be controlled nevertheless.

Table 8. Mineral wool fiber length and width.

	Glass wool				**Stone wool**		
	Demolition waste				Demolition waste		
	Average	Min	Max		Average	Min	Max
Average fiber length [µm]	689.7	448.0	845.0		666.3	560.0	866.0
Average fiber width [µm]	9.1	7.0	12.2		8.3	6.7	10.8

Conclucions:

Based on the results presented, mineral wool wastes in Europe (and likely also globally) present very little variation in their chemical composition despite the age or country of origin. This might simplify the overall Wool2loop-concept as no drastic homogenisation process steps are needed. However, the chemical composition of glass wool and stone wool are very different from each other which has major impact in the final geopolymer material properties. Thus, if glass and stone wool wastes are mixed prior to alkali activation, the mix ratio should be known in order to ensure selection of suitable alkali activator and co-binder. Also new types of mineral wools are coming to the market which should be taken into account in the future.

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