Working Report 2007-54

Results of Monitoring at Olkiluoto in 2006

Foreign Materials

Piia Juhola

June 2007

POSIVA OY
FI-27160 OLKILUOTO, FINLAND
Tel +358-2-8372 31
Fax +358-2-8372 3709

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ABSTRACT

This report focuses on foreign materials introduced to ONKALO. These foreign materials are not part of the multi-barrier system or the natural environment. All the allowed materials introduced to ONKALO are included in the material handbook. All material used in ONKALO 2006 are listed in this report. During 2006 the ONKALO access tunnel was excavated from chainage 990 to chainage 1683 and the total excavated volume was 31966 m^3. This report also summaries the total amounts of foreign materials used in ONKALO since 2004.

Keywords: foreing materials, disposal of spent fuel, monitoring, Olkiluoto, ONKALO

ONKALON monitorointiraportti 2006: Vieraat aineet

TIIVISTELMÄ

Tässä raportissa käsitellään ONKALOn vuoden 2006 aikana vietyjä materiaaleja. Vieraat materiaalit eivät kuulu moniesteperiaatteeseen eivätkä kallioperään. Kaikki ONKALOon sallitut materiaalit on listattu materiaalikäsikirjassa. Tässä raportissa on esitetty kaikki vuoden 2006 aikana käytetyt materiaalit. Vuoden 2006 aikana ONKALOn ajotunneli eteni paalulta 990 paalulle 1683 louhitun kalliotilavuuden ollessa 31966 m^3. Tässä raportissa esitetään myös kaikki rakentamisen aikana käytetyt vieraat materiaalimäärät rakentamisen alusta vuodesta 2004 lähtien.

Avainsanat: Vieraat materiaalit, käytetyn ydinpolttoaineen loppusijoitus, monitorointi, Olkiluoto, ONKALO

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1 INTRODUCTION

In July 2004 Posiva began to construct an underground rock characterization facility called ONKALO, which is planned to reach the repository level –420 m by the end of year 2009. The construction of ONKALO and subsequently the construction of the repository, will affect the surrounding rock mass and the groundwater flow system as well as the environment. In December 2003 a programme for monitoring at Olkiluoto during construction and operation of ONKALO was presented (Posiva 2003). A summary of the observations and measurements is reported annually for each discipline. Foreign materials is one part of the monitoring system, others are rock mechanic, hydrogeology, hydrogeochemistry and environment.

The aim of this report is to give an overview of the progress of monitoring the foreign materials. This report presents the monitoring of foreign materials introduced into ONKALO since the start of construction in June 2004. Juhola 2005 and Vuorio 2006 presented the earlier results and progress of the foreign materials monitoring.

The underground parts of ONKALO consist of a system of exploratory tunnels accessed via a tunnel and two shafts, a ventilation shaft and a transport shaft. It has been assumed that in the future ONKALO will be part of the spent nuclear fuel repository (Saanio et al. 2006). At the end of 2006 ONKALO's access tunnel was situated at chainage 1683. Each tunnel chainage is one metre long. In 2006 the mined volume was 31966 m^3. The total mined volume of ONKALO was 76823 m^3.

2 FOREIGN MATERIALS AND MATERIAL HANDBOOK

2.1 Foreign materials

Foreign materials referred also as engineering or stray materials, are those that are neither part of the engineered barrier system (e.g. bentonite, copper canister) nor of the natural environment (rock material or groundwater). Some of the introduced foreign materials will be removed in different cleaning processes before backfilling, but some will necessarily remain in the future repository (Hjerpe 2003).

The amounts of foreign materials have been estimated in Hjerpe (2003). These estimations have been recently updated by Hagros (2007). The updated estimations are based on the new repository layout produced in 2006 and consider the latest plans for grouting and rock support. Also amounts of foreign materials used until September 2006 have been taken into account. The most significant updates are the amounts of materials used in grouting, shotcreting and in support bolts.

Foreign materials remaining in ONKALO mostly consist of the cement used for grouting and for shotcreting to stabilise the ceilings and the walls of the excavation (Vieno et al 2003). The estimated amount of grouting and shotcrete cement introduced in ONKALO is about 2900 tons (Hagros 2007). Approximately 20-25 % of pre-grouting materials are estimated to be removed during the excavation process. In this report the total amounts are reported, because the estimation of the removed amounts is difficult. According to present knowledge it is possible to remove shotcrete before backfilling.

Another potentially harmful group of foreign materials consists of hydrocarbons, urine and nitrogen compounds from explosive residues and organic materials. The majority of the organic materials are estimated to originate from the ventilation air, other major sources of organic materials that will remain in ONKALO include cement additives, superplasticisers. Superplasticiser are used to improve the workability of shotcrete and grouting cement (Posiva 2003). Disadvantages of use of foreign materials are discusses in Vuorio 2006 and in Juhola 2005.

As all the materials are not measurable, the amounts of these are based on estimations. These materials include rubber from tyres, exhaust fumes from diesel engines, hydraulic and lubricants oils, urine and other human waste. These amounts are not estimated here but are available in Hagros 2007.

2.2 Material handbook

The material handbook is a list of materials allowed in ONKALO. It includes separate instructions for all materials, material safety data sheets (MSDS) and other relevant information. These materials have been divided into two safety levels: Safety level A (the highest safety level) includes materials, which could have impact on long-term safety. Materials in safety class B have no detrimental influence on long-term safety according to present knowledge. Safety level A includes cementitious materials and additives, organic compounds, inorganic nitrogen compounds and other inorganic compounds. Safety level B includes metals and other materials.

Material handbook is saved electronically in Posiva's Kronodoc-system and is so available when needed. Every worker in ONKALO is obliged to check that the material needed is included in the material handbook and in the list of allowed materials.

The instructions for introduction a new material are found in the material handbook. A new material can be approved for use in ONKALO if it is not harmful for long-term safety and it has to be suitable to ONKALO conditions. Its functionality must have been tested. For material in safety level A the disadvantages of its use must be less than the disadvantages of it not being use.

2.3 Allowed foreign materials

At the end of 2006 the material handbook listed 64 allowed materials, 57 in safety level A and 7 in safety level B. All the allowed materials at the end of 2006 are listed in Table 1. In the Table 1 there is also the name of the manufacturer, afterwards products are named only by trade name. Some materials could be allowed only for short period and these materials are not presented here. Some restrictions may also apply to the use of the allowed materials; for example, materials may only be used for the purpose they are designed, i.e. motor oils may only be used in vehicles. Permission to use the material may be in restricted in certain area, i.e. Purgel can be use only at open cut area.

Table 1. *Allowed materials in ONKALO 2006 by safety levels and subgroups.*

Safety Level A

Cement, Concrete and additives

Manufacturer	Material
Finnsementti Oy	Parmix-Silika
SIKA	SIKA Mighty 150
Finnsementti Oy	Rapid Cement
Finnsementti Oy	Super-Parmix
Rescon Mapei	Mapequick AF-2000
Finnsementti Oy	SR-Cement
Cementa	Ultrafin 16
Elkem	Grout Aid
SIKA	SP-40
Cementa	Set Control II
Semtu Oy	Gededral F300

Nitrogen compounds

Manufacturer	Material
Forcit Oy	Anite
Forcit Oy	Firex VA-T
Forcit Oy	F-17x460 pipecharge
Forcit Oy	Kemix A pipecharge
Zuazo s/n	Riocord
Forcit Oy	Nonel detonators
Forcit Oy	Fordyn dynamite
Forcit Oy	Kemix A cartridge
Forcit Oy	Pendex
Forcit Oy	F-cord 10 detonating cord
Forcit Oy	Kemiitti 810
Forcit Oy	Nobel Prime

Inorganic compound

Manufacturer	Material
Tikkurila	Falu Red Ochre paint

Organic compounds

Manufacturer	Material
Rescon Mapei	Purgel
Shell	Donax TA
Maston	Zinc spray
Shell	Torcula
Shell	Tellus Oil S 68
Shell	Form 5
Exxon	Mobil Nuto H32
Berner Oy	Lasol 100
Shell	GlykoShell
Shell	Helix Ultra motor oil 5W-40
Shell	Spirax AX
Shell	Grease Centra W
JS-Tuotteet Oy	PS-10 washing liquid
AT-tuote	AT-marking paint
Shell	Retinax Grease HDX2
Shell	Rimula X Oil 10W-30
Shell	Universal Engine Oil
Shell	Donax YB brake fluid
Shell	Thermo City, winter/summer
Kärcher	RM 110 ASF Ultra
Almacon Oy	Drainage pipe (PE foam)
Densit a/s	Densiphalt
Bestolife Co	Bestolife 3000
CRC Industries Sweden AB	CRC
Svenska Statoil	Gear Way G5 80 W-90
Gotlands Bioenergi AB	Rapsgul
Shell	Tellus TX 46
Shell	Retinax EP 2
Berner Oy	Korrek Coolant G30
Nordic Lubricants	Castrol SMX-S
Nordic Lubricants	Castrol Response DOT 4
Nordic Lubricants	Castrol TQ Dextron III
Land Rover	Swivel Housing Grease STC 3435

Safety Level B

Metals

Manufacturer	Material
Ørsta Stal AS	CT-rock bolt
Fundia	Deformed reinforcement bar
Fibco GmbH	Shotcrete fibers CF-03-35
Tammet Oy	Mine net

Other

Manufacturer	Material
Berner Oy	Absodan universal
Stanford NA	Peel Off China Marker
Merck kGaA	Fluorescein sodium

2.4 Forbidden foreign materials

At the end of 2006 there were 20 forbidden materials listed and these are presented in Table 2. Only one material was forbidden in 2006. This Würth WIT-C100/200 adhesive for masonry anchor was later allowed using only outside ONKALO at sustaining wall.

The forbidden materials were unsuitable for ONKALO conditions and may be harmful for long-term safety. All the suggested material for introduced in ONKALO if not accepted is listed in the forbidden materials list. Reasons for not allowing the use of material may vary, e.g., if a material contains more harmful components than a similarly functioning substitute, obviously the material containing fewer harmful components will be accepted. Sometimes, a substitute material, which is better for long-term safety, was found.

***Table 2**. Materials forbidden to be used in ONKALO.*

Name of the material	Reason for rejection
Finnsementti Perus-Parmix	Includes lignosulphate, may be harmful for radionuclide transport
Rescon Mapei Sprut 34	Better alternative found
Masterbuilders Rheocem 800T	Better alternative found
Masterbuilders Rheocem 800SR	Better alternative found
Masterbuilders Rheobuilt 2000PF	Better alternative found
Rescon Mapei Mikrocem 800	Better alternative found
Rescon Mapei Mikrocem 650 SR	Better alternative found
Rescon Mapei Mapefluid 400 N	Better alternative found
Windscreen washing agents	Only Lasol allowed
Würth marking paint	Better alternative found
AQUA Master marking paint	Better alternative found
Marking paint Mercalin RS	Better alternative found
Tikkurila Oil based red paint	Better alternative found
Tikkurila Siroplast 2 roofpaint	Better alternative found
Finnsementti VB-Parmix	Includes polycarboxylate, may be harmful for radionuclide transport
Hilti HIT-HY 150	Forbidden in ONKALO design plan
Semtu Oy Structuro 111X	Includes polycarboxylate, may be harmful for radionuclide transport
CC-Company CC deicing agent	Includes chlorides, causes copper corrosion and disturbs ONKALO monitoring
Finnsementti Megacement	Better alternative found
Würth WIT-C100/200	Includes organic material

2.5 Quality control

As a part of ONKALO quality control, the use of foreign materials is controlled. Twice a year have been fulfilled an internal auditing. In 2006 these internal auditing has been done in January and May. In both times there was only slight negligence. No undeclared materials in ONKALO were found.

The acceptance limits for the use of foreign materials have been redefined. These limits have been recalculated by estimations by Hagros (2007). Instructions have been provided for cases where limits are exceeded and for the application of the CEIC procedure. CEIC procedure has been discussed in Juhola 2005.

Migration of foreign materials in groundwater has been monitored in sedimentary basin. All water used in ONKALO is pumped to the surface into sedimentary basin. Residue oil is removed from the water before it enters the sedimentary basins. In sedimentary basin is four sampling points and water samples were taken every second week. Results are reported in Lehtinen and Hirvonen (2007).

Also leaking fractures after grouting have been monitored. In 2005, 14 samples and in 2006 seven samples were taken from leaking structures, fractures or leaking rock bolt-holes. Most of the samples were taken in area used normal cement and one in low-pH cement area. Results are reported in Lehtinen and Hirvonen (2007).

3 MATERIALS AND AMOUNTS USED IN ONKALO

Hagros (2007) has re-estimated the quantities of foreign materials remaining in the different part of ONKALO and the repository at the time of backfilling. These estimations per excavated cubic meter are included in Tables 3 and 4.

The categorization of the materials is similar to the one used in the material handbook. In the following chapters are reported the materials used in ONKALO during 2006.

3.1 Safety level A

3.1.1 Cement, concrete and additives

In the ONKALO tunnel Cementa Ultrafin 16 was used as grouting cement. Also SR-cement was used if the fractures were larger. The additives in both cases were Grout Aid and Mighty 150. The amounts are given in Table 3. In Appendix 1 are presented figures for used amounts per chainage.

To avoid high pH cementitious plume, lower pH cement have been developed. Posiva has been developing low-pH (≤11) cement as a joint project between SKB, Posiva and NUMO (Ahokas et al. 2006). In this project Posiva was responsible for developing a low-pH cementitious grout for fractures of hydraulic aperture over 100 μm. Posiva has continued the development work within the R20 programme by further laboratory testing and field tests. For grouting in ONKALO low-pH cement was tested twice in 2006. First test was in June at chainage 1064 and the second at chainage 1105. These amounts are including in Table 3 and also in Appendix 1.

SR-cement was used for plugging only once in 2006 at chainage 1162. SR-cement was also used for soldering anchor and support bolts. These amounts are presented separately in Table 3.

Since 2005 ONKALO has been shotcreted systematically. The material used is SR-cement and the additives used are Structuro 111x, Mapequick AF2000 and Parmix Silica. No fibers were used in 2006. The amounts are given in Table 3. Shotcrete accelerator Gecedral F300 was tested once at chainage 980, but it was not compatible with the other additives. Almost all of that test shotcrete was washed away.

***Table 3**. Cementitious materials and additives used for grouting, plugging and soldering anchor and support bolts in 2006. The total amounts used from the beginning of construction are detailed separately for ONKALO and for ONKALO including open cut. Estimations are made by Hagros (2007).*

Materials		ONKALO 2006		Total ONKALO 2004-2006		Total ONKALO and open cut 2004-2006		ONKALO 2006	
		Amount [kg]	Dry weight [kg]	Amount [kg]	Dry weight [kg]	Amount [kg]	Dry weight [kg]	Used 2006 [kg m^{-3}]	Estimated [kg m^{-3}]
Grouting									
Cements	Ultrafin16	46209		374155		393817		1.45	
	SR-Cement	7607		18880		18880		0.24	
	Grouting cement total	53816		393035		412697		1.68	1.41
Additives	Set Control II	0		3480.4		3740.8			
	SP-40	0		3176		3241.6			
	Grout Aid	21978	10989	49091.1	24546	49091.1	24546	0.69	
	Mighty150	1840.7	736	2218.4	887	2218.4	887	0.06	
Plugging									
Cements	Ultrafin16	0		6161		6161			
	SR-Cement	402		402		402		0.01	
	Rapid-cement	0		0		7122			
	Plugging cement total	*402*		*6563*		*13685*		0.01	
Shotcrete									
Cements	Megacement	0		0		1290			
	Rapid-cement	0		29660		29660			
	SR-Cement	422420		532880		532880		13.21	
	Shotcrete Total	***422420***		***562540***		***563830***		13.21	6.63
Additives	Structuro 111X	1161.3		1713.6		1713.6		0.04	
	AF2000	16896.4	8617	21314.8	10871	21314.8	10871	0.53	
	Parmix Silica	21121		26644		26644		0.66	
	Super-Parmix	2937.9	1175	2937.9	1175	2937.9	1175	0.09	
	Shotcrete additives total	***42116.6***		***52610.3***		***52610.3***		1.32	
Cement for anchor and support bolts									
Cements	SR-Cement	4093.5		12398.5		12398.5		0.13	
	Rapid-cement	0		0		2135.5			
	Cement for solders total	***4093.5***		***12398.5***		***14534***		0.13	

3.1.2 Organic compounds

Some of the cement additives can also be organic compounds but these have been classified to the same group with cement.

Geological measurement points were marked in ONKALO with AT-marking paint. In 2006 68,4 L of paint was used, the total amount used during construction is 400,8 L.

Purgel have been used 17 kg for grouting in open cut area. Purgel is polyurethane based grouting resin, which is suitable for grouting into moist cracks.

Densiphalt road surface is in open cut area about 800 m^2 and in ONKALO first 50m^2.

There are drainage pipes under shotcrete at chainage 850 – 975. Measured and certified location drawings are available on Kronodoc, but amounts of these are not available.

Different kind of organics oils, such as lubricants, anti-freeze solutions and fuel were used in the vehicles in ONKALO. The amounts of these and the amount that probably stayed in ONKALO have not been calculated or estimated in this report.

3.1.3 Nitrogen compounds

Nitrogen compounds are mainly explosives. Explosives manufactured by Forcit Oy were used in the ONKALO tunnel. Bulk-emulsion explosives were taken in use in ONKALO. These bulk-emulsion explosives included Kemiitti 810 as matrix and fumigant, and Nobel Prime as bottom charge. Depending of the recipe, also acetic acid could be used. It is a catalyst of blasting and without acetic acid the fumigation of blasting could be incomplete. Acetic acid is organic material and it's long-term safety effects should be investigated before fracture R20.

Amounts of all used explosives are presented in Table 4. Although acetic acid is an organic compound it is also presented in this group. A summary of the explosives used in tunnel in 2006 is provided in Appendix 2. The amounts of explosives per chainage meter are given in graphical form.

There is shaft access at chainage 915 and investigation niche at chainage 1475 as seen in increasing amounts of caps and cartridges in Figures 3 and 4. Also at chainage 1296 more than usual Kemix-A cartridge have been used. This was due to the correction blasting of the tunnel.

***Table 4**. Amounts of used explosives. Estimations are made by Hagros (2007).*

Materials [unit]	ONKALO 2006	Total ONKALO 2004-2006	Total ONKALO and open cut 2004-2006	ONKALO 2006	
	Amount	Amount	Amount	Used 2006 [kg m^{-3}]	Estimated [kg m^{-3}]
Caps [pcs]	27548	63204	63917	0.86	0.6
Cords [m]		27563	29404		
Anite [kg]		2401	3728.3		
F-pipe [kg]		2399.3	2400.3		
Kemix-A cartridge [kg]	6046	27539	27539	0.19	
Kemix-A pipecharge[kg]	83056	188819.5	188835.5	2.60	
Dynamite [kg]			743.9		
Kemiitti 810 matrix [kg]	19375.7	19375.7	19375.7	0.61	
Kemiitti 810 fumigant [kg]	400.5	400.5	400.5	0.01	
Nobel Prime [kg]	3120	3120	3120	0.10	
Explosives total [kg]	**111998.2**	**244055**	**246143.2**	**3.50**	**3.0**
Acetic Acid 100% [kg]	9.1	9.1	9.1	0.00	

3.1.4 Other inorganic compounds

Coordinate measured support bolts have been paint with Falu red ochre paint. Paint have been used in 2006 about 5 litre in whole ONKALO.

3.2 Safety level B

3.2.1 Metals

Support bolts and hot-dip galvanized reinforcement bars were used for rock reinforcement. In 2006 metal fibers in the shotcrete weren't used. Used amounts are reported in Table 5.

Mine net is hot-dip galvanized steel net for rock reinforcement. It have been used in ONKALO around chainage 870 about 20 meters.

***Table 5**. Metal component and amounts used in ONKALO.*

Material [pcs]	2006	Total ONKALO 2004-2006	Total ONKALO + open cut 2004-2006
A500HW kzn 25*3000	33	1062	1152
A500HW kzn 25*4000			308
A500HW kzn 32*2500			2
A500HW kzn 32*3000			2
A500HW kzn 32*4000			21
A500HW kzn 32*4500			123
A500HW kzn 32*6000		8	62
A500HW kzn 16*400	1365	1365	1365
CT-bolt L3000 kzn	61	338	338
Sormat PFG M10 wedge anchor		200	200
Brass sleeve (150 mm * 28 mm)		3	3
Shotcrete fibres [kg]		90	90

3.2.2 Other materials

Fluorescein sodium has been used for tracer in drilling water. Measurements results are reported in Partamies et al (2007). Amounts of it hasn't been reported, almost all of it are sluiced away.

Absodant universal is an absorbent and has been used after oil leak if needed. Used absodant universal has been removed from ONKALO and amounts of use were not reported.

4 DISCUSSION

The most common foreign material in ONKALO is cement and its additives. These amounts have been re-estimated since last foreign material monitoring report. Hagros (2007) estimated grouting amounts and proportion of tunnel to be grouted after chainage 1360. These amounts are presented in Table 6.

Table 6. *The assumed consumption of grouts to be used after 1 Sep 2006 in the ONKALO and in the repository (Hagros 2007).*

Tunnel section (chainage) [m]	**Proportion of tunnel to be grouted**	**Grout take per 20 m fan [m^3]**	**Grout take per tunnel section [m^3]**
1360−1500	30 %	3	21
1500−3000	20 %	6	450
3000−4000	10 %	2	100
Other parts of ONKALO	10 %	2	
Actual repository	10 %	1−2*	

* The grout take depends on the dimensions of the opening; tunnels with a smaller radius have a smaller grout take. Grout takes have been scaled by assuming a 5 m thickness of grouted zone around the opening.

Furthermore cement have been used in shotcreting, plugging and for support and anchor bolts. The shotcrete amounts are 25 % greater than estimated.

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APPENDIX 1

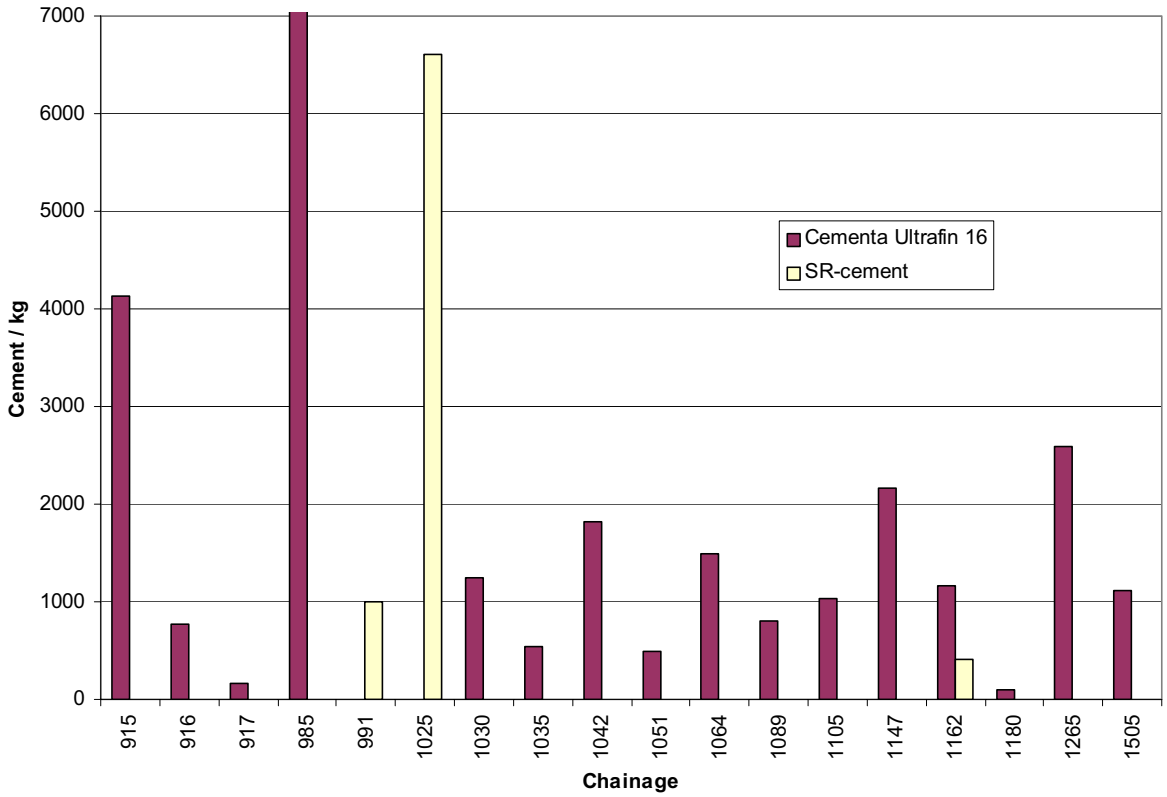

Figure 1. *Grouting cements in ONKALO used per chainage.*

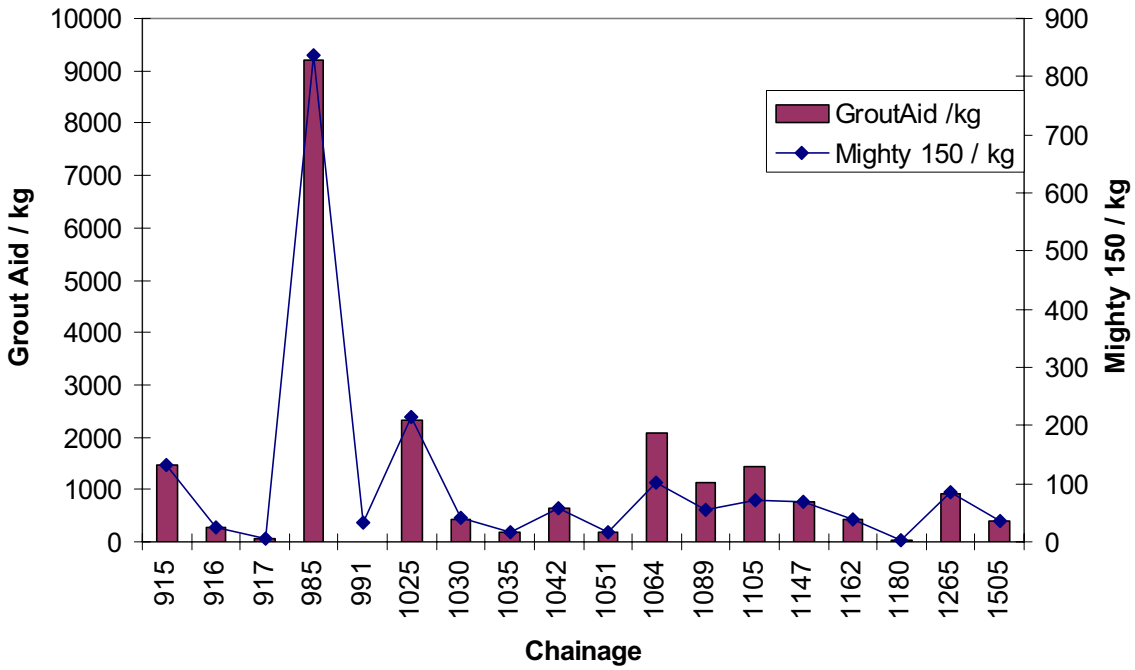

Figure 2. *Additives in grouting cement per chainage used in ONKALO. Note two Y-axels.*

APPENDIX 2

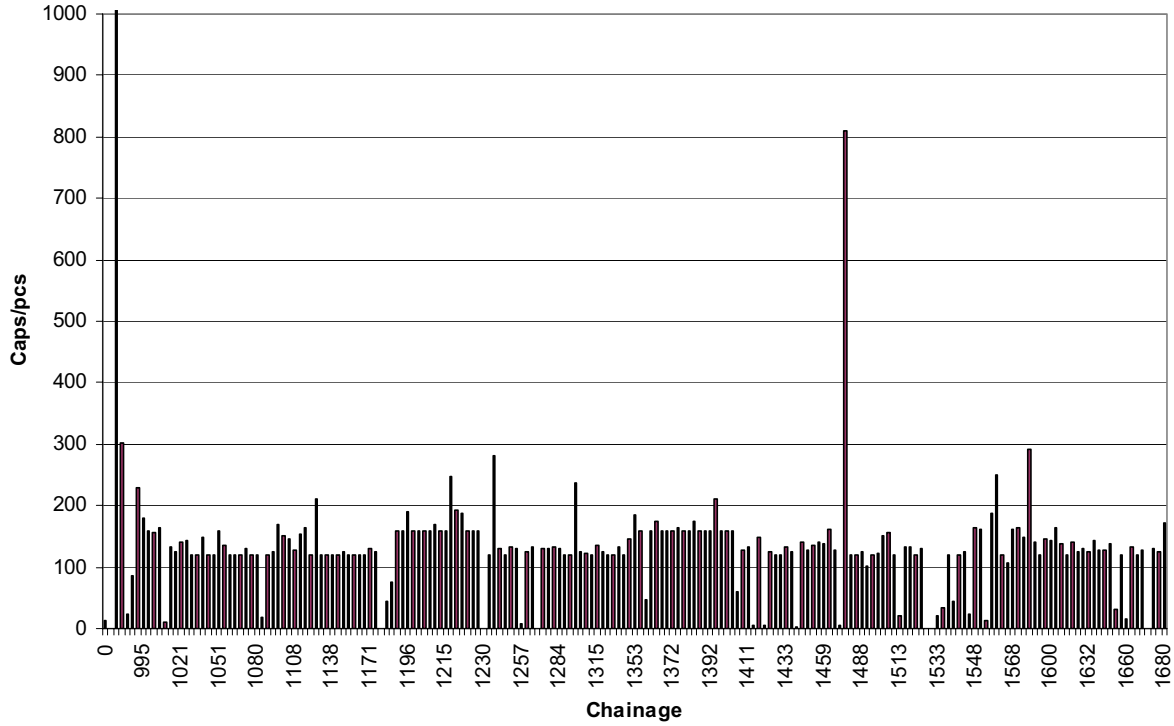

Figure 3. *Caps amounts per chainage used in ONKALO 2006. At chainage 915 (shaft access) the amount is 1958 cps.*

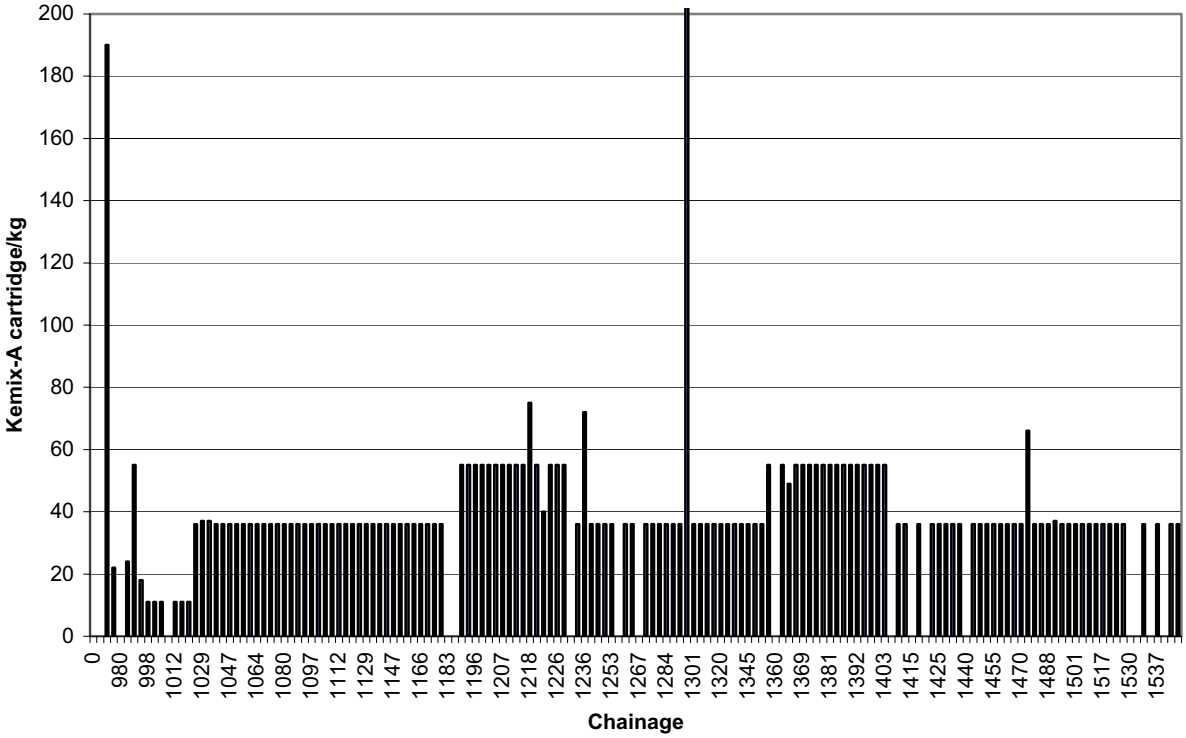

Figure 4. *Kemix-A Cartridge amounts used per chainage in 2006. At chainage 1296 the amount is 296 kg.*

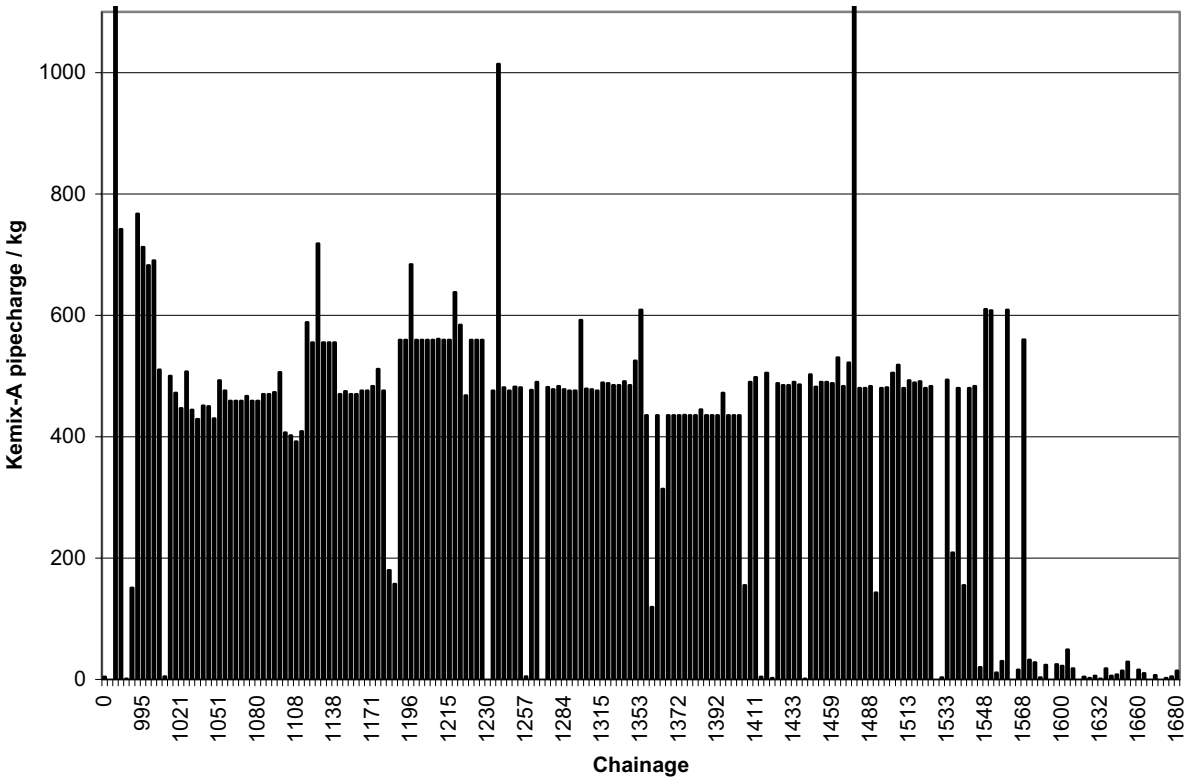

Figure 5. *Kemix-A pipecharge amounts used per chainage 2006. At chainage 915 (shaft access) the amount is 6953 kg and at chainage 1475 (investigation niche) the amount is 2688 kg.*

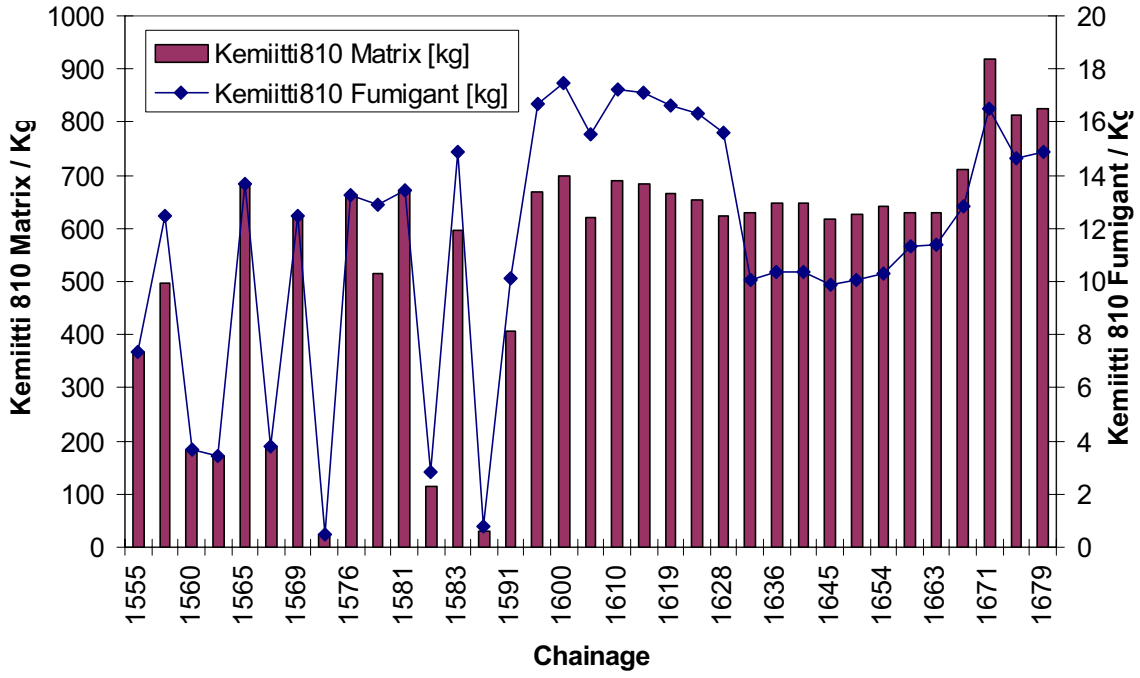

Figure 6. *The amounts of Kemiitti 810 matrix and Fumigant. Note two Y-axels.*

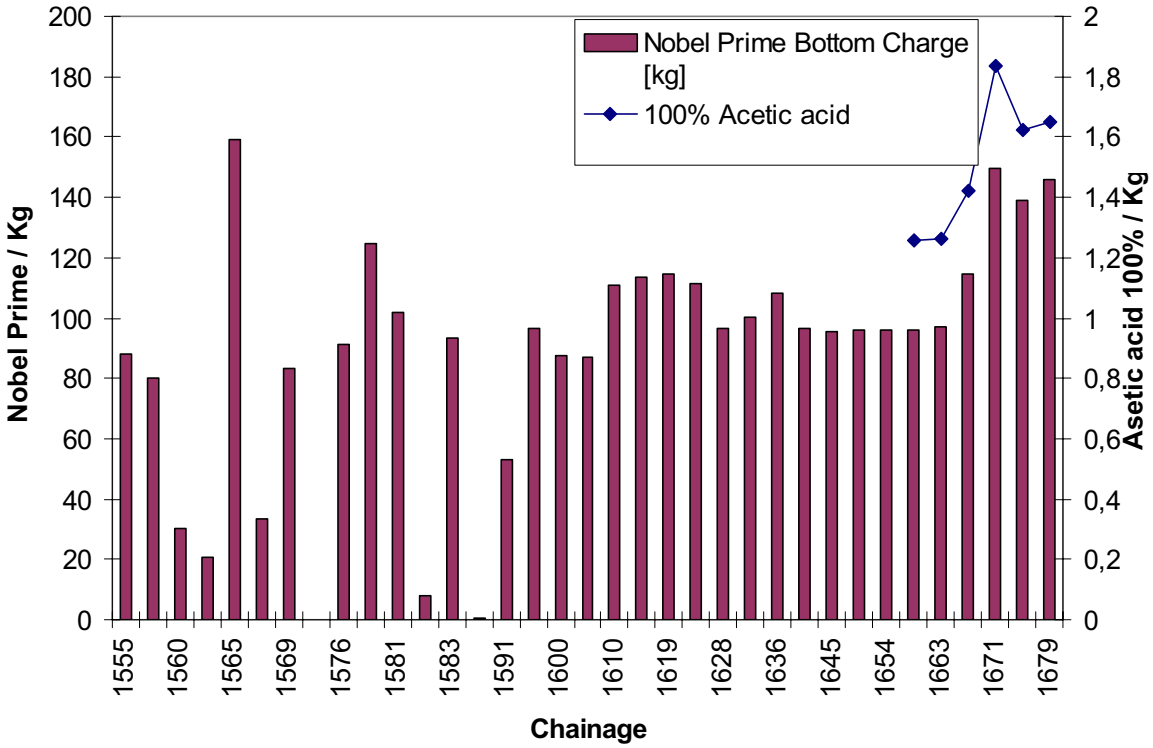

Figure 7. *The amounts of Nobel Prime and acetic acid per chainage. Note two Y-axels.*