Environment Agency

Evidence

Material comparators for end-of-waste decisions

Construction materials: concrete blocks

Report – SC130040/R10

Version 2

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Executive summary

This report details the work carried out to characterise concrete blocks, a key comparator. This information will inform end-of-waste assessments for waste-derived materials intended to replace concrete blocks used in construction.

The Waste Framework Directive (Article 6) provides criteria for identifying when a waste material has become a product and no longer needs to be regulated as a waste. Through Article 6 the case law requires the Environment Agency to consider the environmental and human health impacts from materials in comparison with their non-waste material alternatives.

> ‘It should be enough that the holder has converted the waste material into a distinct, marketable product, which can be used in exactly the same way as a [non-waste material], and with no worse environmental effects.’

Market research was used to define non-waste concrete blocks as an ordinary comparator and a literature review was used to identify any existing published data.

No suitable pre-existing datasets were found during the literature review.

Twenty samples of concrete blocks were collected from various suppliers across England. Analytical data from these samples are presented in this report.

We recommend comparing the concentrations of analytes in the comparators dataset to the concentrations in the waste-derived material, paying attention to the higher values. This comparison does not constitute a pass/fail test or an end of waste view. It will provide an indication of whether the waste material contains similar levels of analytes to non-waste materials and whether an end-of-waste application may be appropriate or that further analysis or improved treatment processes may be warranted.

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Contents

1 Introduction

To define end-of-waste criteria, the Environment Agency requires a set of ordinary material comparator data for use as a benchmark against which other materials and wastes can be assessed.

The Waste Framework Directive (Article 6) provides criteria for identifying when a waste material has become a product and no longer needs to be regulated as a waste. Through Article 6 the case law requires the Environment Agency to consider the environmental and human health impacts from materials in comparison with their non-waste material alternatives.

> ‘It should be enough that the holder has converted the waste material into a distinct, marketable product, which can be used in exactly the same way as a [non-waste material], and with no worse environmental effects.’

The purpose of this report is to provide an evidence base of the composition and characteristics of concrete blocks which are defined as an ordinary material comparator that is currently permitted for use in construction.

This report provides the results from the primary analysis of 20 concrete block samples.

Two other reports cover ordinary material comparators for construction materials:

- natural limestone aggregate
- non-waste wood for construction and manufacturing

2 Definition

2.1 Material properties relevant to use

Concrete blocks are masonry units manufactured from cementitious binder, aggregates and water which may contain admixtures and additions and colouring pigments and other materials incorporated or applied during subsequent to unit manufacture (BSI 2011). Concrete blocks are also known as cinderblocks, breeze blocks, hollow blocks, besser blocks, clinker blocks and foundation blocks depending on constituents.

Concrete blocks are used throughout buildings from foundation walls, through cavity walls, monolithic walls, partition walls, separating walls and as a component of ‘beam and block’ flooring (Greenspec 2013).

Constituents of concrete blocks may be primary or recycled. Products are available on the market that incorporate recycled aggregate to replace virgin quarried aggregate. A specific type of recycled aggregate is recycled concrete aggregate (RCA), the performance of which is superior to recycled aggregates generally and enables replacement of up 20% of virgin aggregates in concrete. The most effective alternative to cement is ground granulated blast furnace slag (GGBS), which can typically replace up to 50% of Portland cement in a concrete mix. Pulverised fuel ash (PFA) is now routinely used as a cement substitute – 15% being the optimum in maintaining the compressive strength of aggregate blocks and 50% in aerated blocks (Greenspec 2013).

Within this project only concrete blocks that have been manufactured with virgin materials or materials that have been prepared in accordance with a Quality Protocol [aggregates (WRAP 2005) and PFA (WRAP and Environment Agency 2010)] are considered to be comparators. Concrete blocks that contain waste materials were not included in the project.

There are three main types of concrete block: dense, lightweight and aerated/aircrete.

2.1.1 Dense blocks

Dense blocks are durable and strong. They can be suitable for different types of load-bearing walls. Dense aggregate concrete blocks are manufactured from cement, sand and aggregates (WRAP and Environment Agency 2010).

2.1.2 Lightweight blocks

Lightweight blocks are less strong than dense blocks. Lightweight blocks are used in both internal and external walls where loading is slightly more restricted or as infill blocks in beam and block flooring. Their main advantage over dense aggregate blocks comes from a combination of higher insulating properties and a lighter unit weight. The lighter block enables time and material cost savings through easier handling and larger units.

Lightweight blocks are manufactured from cement together with one of a variety of natural or man-made expanded aggregates including:

- granulated/foamed blast furnace slag
- expanded clay or shale
- furnace bottom ash (FBA)
- pulverised fuel ash (PFA)

Less common are pumice (a volcanic material) and vermiculite.

The density of the aggregate is generally proportional to the strength of the block. For example, ‘super-lightweight’ aggregates such as pumice and vermiculite used for their excellent thermal performance feature a relatively low compressive strength (Greenspec 2013).

2.1.3 Aerated/aircrete blocks

Aerated concrete or ‘aircrete’ blocks are the lightest of the family of concrete blocks. Aerated blocks are distinguished by their capacity to perform a dual structural/insulation function. Although limited to structural applications in low-rise construction and partitions as well as a component of curtain walling in higher buildings, aerated blocks can perform a similar range of functions as dense and lightweight blocks.

The blocks are made from cement, lime, sand, PFA and water. PFA is mixed with sand and water to form a slurry. This is then heated before being mixed with cement, lime and a small amount of aluminium sulphate powder (Greenspec 2013).

3 Comparator sub-types

A total of 20 concrete block samples were obtained from a variety of suppliers across England to provide a cross-section of the main types of concrete blocks used in construction. The samples can be further divided into sub-types. Figure 3.1 shows a breakdown of the samples by sub-type.

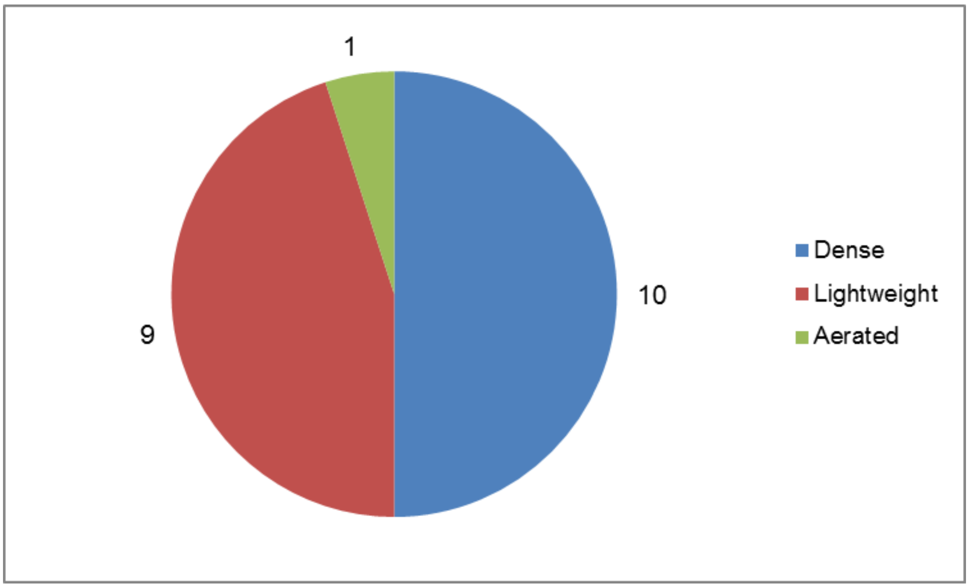

Figure 3.1 Number of concrete block samples by sub-type

4 Material sources and sampling procedure

An internet search and the Concrete Block Association supplier list (CBA, undated) were used to produce a list of concrete block suppliers. Concrete block samples were requested from all these suppliers to ensure a cross-section of concrete block types were sampled. Samples were collected from those willing to participate.

Samples were taken in accordance with BS EN 771-3:2011 (BSI 2011).

5 Analytical parameters

The main parameters determined, together with units of measurement, are summarised in Tables 5.1 to 5.4.

Testing was carried out in accordance with in-house methods documented by the Environment Agency’s National Laboratory Service (NLS) which meet the requirements of the performance standards of the Environment Agency’s monitoring certification scheme (MCERTS). Specific tests used are outlined in the tables. Other test methods are available.

In the tables, ‘LE’ refers to the NLS Leeds laboratory.

Table 5.1 Analysis: physical properties

Parameter/ determinand	Test method used	Unit
pH	LE I pH and EC 01 pH and conductivity – water extracted, determined by specific electrode from ‘as received’ sample	–
Electrical conductivity	LE I pH and EC 01 pH and conductivity – water extracted, determined by specific electrode from ‘as received’ sample	mS/cm
Dry solids @ 30°C	LE P soil preparation 01 – sample air dried at <30ºC in a controlled environment until constant weight is achieved	%
Dry solids @ 105°C	LE I dry solids (105ºC) – thermally treated, determined by gravimetry	%
Loss on ignition (LoI) @ 500°C (organic matter content)	Loss on ignition (500ºC) – thermally treated, determined by gravimetry	%
Moisture content	Parameter by calculation	%

Table 5.2 Analysis: metals

Parameter/ determinand	Test method used	Unit
Aluminium, antimony, arsenic, barium, beryllium, boron, cadmium, calcium, chromium, cobalt, copper, iron, lead, lithium, magnesium, manganese, mercury, molybdenum, nickel, phosphorus, potassium, selenium, silver, sodium, strontium, thallium, tin, titanium, vanadium, zinc	LE I metals (ICP-OES) 01– digestion block aqua regia extracted under reflux; determined by inductively coupled plasma optical emission spectrometry (ICP-OES)	mg/kg
Chromium VI	Hexavalent chromium by spectrophotometry	mg/kg

Table 5.3 Analysis: organic contaminants

Parameter/ determinand	Test method used	Unit
Polycyclic aromatic hydrocarbons (PAHs) (USEPA16)[1]	Organics dichloromethane (DCM) extracted; hexane exchange determined by gas chromatography–mass spectrometry (GCMS) (scan mode)	μg/kg
Benzene, toluene, ethylbenzene and xylenes (BTEX)	Organics DCM extracted; hexane exchange determined by GCMS (scan mode)	μg/kg
Polychlorinated biphenyls (PCBs)	LE O HRMS3 – dioxins; furans – toluene accelerated solvent extraction (ASE); three-stage clean-up; determined by high resolution GCMS	μg/kg
Hydrocarbons (C5–C44)	LE O EPH >C5-C44 (GC-FID) 01 – hydrocarbon screen including aromatic/aliphatic banding by gas chromatography-flame ionisation detector (GC-FID) from 'as received' sample	mg/kg
Hydrocarbons (C10–C40)	LE O EPH >C5-C44 (GC-FID) 01 – hydrocarbon screen including aromatic/aliphatic banding by GC-FID from 'as received' sample	mg/kg

Notes: [1] List of 16 PAHs classified by the US Environmental Protection Agency (USEPA) as priority pollutants.

6 Existing data

No relevant existing data were identified during the literature review.

7 Primary data

7.1 Statistical analysis of data

All 'less than' values were taken as the measured value. The mean, median, minimum, maximum and 90th percentile were calculated for each analyte.

Box plots can be used to graphically represent groups of quantitative data. The sample minimum, lower quartile (Q1), median (Q2), upper quartile (Q3) and sample maximum are used. The median is indicated by the horizontal line that runs across the box. The top of the box is 75th percentile (upper quartile or Q3). The bottom of the box is the 25th percentile (lower quartile or Q1). The interquartile range is represented by the height of the box (Q3 – Q1). A smaller interquartile range indicates less variability in the dataset while a larger interquartile range indicates a variable dataset. Whiskers extend out of the box to represent the sample minimum and maximum. Outliers are plotted as asterisks and are defined as data points that are 1.5 times the interquartile range.

Outliers can adversely affect the statistical analysis by:

- giving serious bias or influence to estimates that may be of less interest
- increasing the error variance and reducing the power of statistical tests
- decreasing normality (if non-random) and altering the odds of type I and II errors

A box and whisker plot of potassium concentration in concrete blocks is shown in Figure 7.1. This diagram demonstrates the issue of outliers in the dataset.

It is important to provide a reasonable sized dataset for comparison purposes. Where there is sufficient sample size (≥10) to calculate a 90th percentile of the data, the 90th percentile has been calculated.

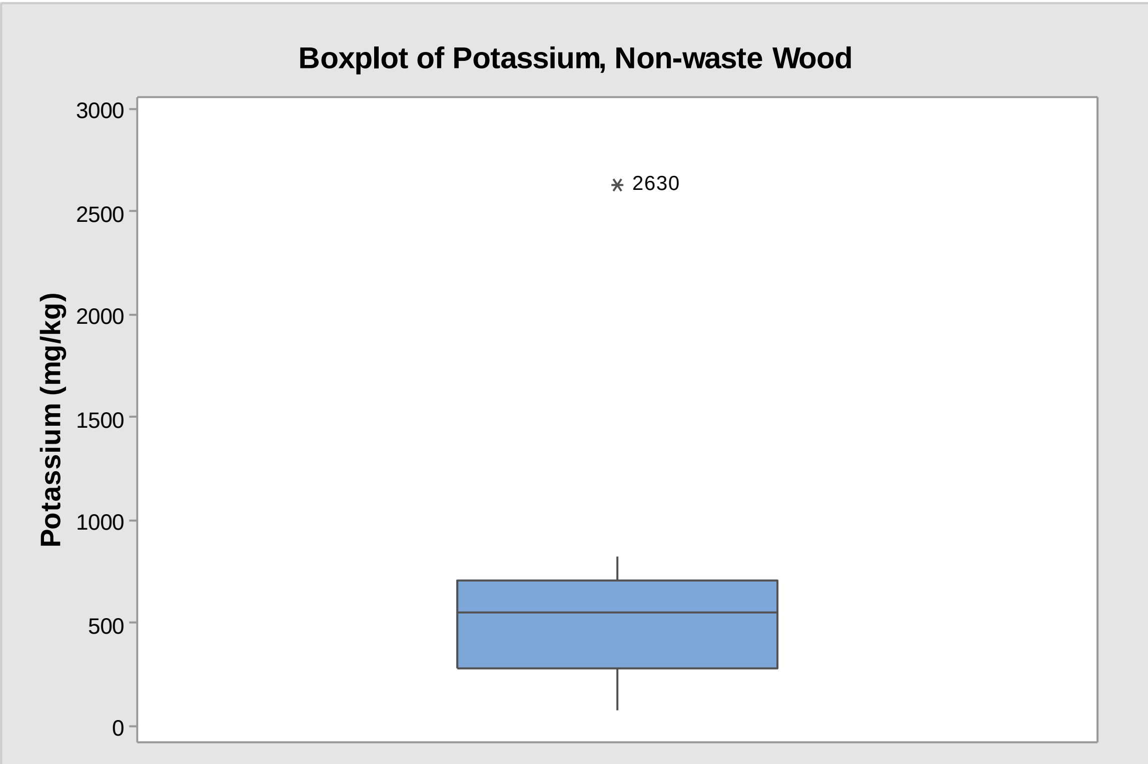

Figure 7.1 Boxplot of potassium, concrete blocks

7.2 Using the data tables

Data are presented in tables summarising:

- physical properties
- metals
- organic contaminants
- leachability

We recommend comparing the concentrations of analytes in the comparators dataset to the concentrations in the waste-derived material, paying attention to the higher values. This comparison does not constitute a pass/fail test or an end of waste view. It will provide an indication of whether the waste material contains similar levels of analytes to non-waste materials and whether an end-of-waste application may be appropriate or that further analysis or improved treatment processes may be warranted.

Due to difficulties encountered during sample preparation, the limit of detection (LOD) for some analytes was elevated above the target limit of detection.

7.3 Primary data tables

Primary data are shown in Tables 7.1 to 7.26.

Table 7.1 Primary data for concrete blocks: physical properties

Sample ID	Moisture content air dried @ 105°C	Dry solids @ 30°C	Dry solids @ 105°C	LoI @ 500°C	Conductivity	pH
	%	%	%	%	mS/cm	
Concrete 01	4.1	95.8	95.9	<0.50	4.360	12.5
Concrete 02	3.9	96.8	96.1	<0.50	2.120	12.1
Concrete 03	9.3	91.0	90.7	2.80	6.020	12.2
Concrete 04	3.7	97.1	96.3	<0.50	1.810	11.9
Concrete 05	7.0	91.5	93.0	1.29	5.260	12.5
Concrete 06	3.3	96.6	96.7	<0.50	4.430	12.4
Concrete 07	6.0	92.1	94.0	21.90	4.030	12.3
Concrete 08	8.2	91.2	91.8	4.82	0.581	10.9
Concrete 09	29.4	71.8	70.6	6.50	2.160	11.6
Concrete 10	16.6	84.1	83.4	3.62	3.710	12.3
Concrete 11	2.6	96.6	97.4	0.74	3.300	12.3
Concrete 12	22.6	77.9	77.4	6.32	2.230	11.2
Concrete 13	10.4	95.2	89.6	9.73	1.290	11.7
Concrete 14	10.9	86.1	89.1	5.34	0.721	10.0
Concrete 15	8.6	92.7	91.4	1.41	2.720	12.2
Concrete 16	17.3	79.7	82.7	3.59	1.470	11.8
Concrete 17	15.7	88.5	84.3	5.75	5.230	12.5
Concrete 18	21.0	79.2	79.0	5.55	2.030	11.6
Concrete 19	17.0	80.5	83.0	14.90	3.150	12.3
Concrete 20	4.7	96.8	95.3	0.70	5.770	12.5
Mean	11.1	89.1	88.9	4.85	3.120	11.9
Median	9.0	91.4	91.1	3.61	2.935	12.2
Minimum	2.6	71.8	70.6	0.50	0.581	10.0
Maximum	29.4	97.1	97.4	21.90	6.020	12.5
No. of samples	20	20	20	20	20	20
90th percentile	21.2	96.8	96.3	10.25	5.311	12.5
LOD	n/a	0.5	0.5	0.50	0.01	0.2

Table 7.2 Primary data for concrete blocks: metals (mg/kg DW)

(a)

Sample ID	Al	Sb	As	Ba	Be	Bo	Cd	Ca	Cr	Cr VI	Co	Cu	Fe	Pb	Li
Concrete 01	2740	<1.00	2.27	66.7	0.105	3.48	<0.200	377000	7.96	0.805	1.03	2.75	4150	2.52	5.2
Concrete 02	18700	4.70	3.26	119.0	0.560	10.60	<0.200	72200	17.90	<0.600	19.70	46.00	33200	9.20	28.9
Concrete 03	21100	3.30	5.99	242.0	1.230	39.20	<0.200	79700	27.00	<0.600	15.10	45.70	31700	8.53	28.8
Concrete 04	16700	3.70	3.22	217.0	0.516	10.40	<0.200	109000	18.70	<0.600	18.10	49.50	23500	8.73	23.1
Concrete 05	19500	2.78	6.15	357.0	0.581	12.20	<0.200	104000	22.40	0.702	12.20	36.00	21300	8.85	27.1
Concrete 06	5250	<1.00	5.87	69.5	0.279	20.60	0.741	271000	10.20	<0.600	2.61	11.80	5270	19.70	9.2
Concrete 07	17000	1.92	6.82	194.0	1.140	42.60	0.540	120000	22.70	<0.600	7.99	25.60	17400	16.00	23.2
Concrete 08	17400	2.23	9.01	227.0	1.250	42.40	0.282	73600	23.80	<0.600	11.00	30.20	20000	13.70	24.8
Concrete 09	40900	3.99	24.90	567.0	2.350	281.00	0.978	125000	38.80	1.410	14.40	38.60	20000	35.80	50.3
Concrete 10	26300	2.50	16.70	315.0	1.340	69.10	0.301	75700	28.50	<0.600	16.50	34.30	22500	13.50	43.4
Concrete 11	2280	<1.00	1.04	33.7	<0.100	2.53	1.310	389000	8.11	<0.600	1.24	12.40	2040	31.30	5.9
Concrete 12	51700	7.03	57.30	663.0	4.500	225.00	1.830	116000	58.50	0.985	20.80	84.00	41600	67.00	90.2
Concrete 13	22800	2.73	10.20	279.0	1.370	59.90	<0.200	63700	24.60	<0.600	17.90	41.00	21600	10.70	29.5
Concrete 14	20600	2.35	10.70	337.0	1.200	69.00	0.216	58900	22.70	<0.600	10.40	28.50	20400	9.88	26.0
Concrete 15	5370	<1.00	4.18	61.0	0.260	22.30	0.547	292000	7.61	<0.600	2.36	12.60	4500	9.40	10.3
Concrete 16	26700	2.75	17.20	241.0	1.310	64.70	0.373	71900	29.90	<0.600	22.00	31.20	20200	13.70	41.6
Concrete 17	19700	2.16	7.50	276.0	1.550	46.10	0.320	128000	26.10	0.761	11.00	35.40	22900	14.70	26.8
Concrete 18	50000	7.11	55.70	631.0	4.400	194.00	1.930	115000	53.70	1.140	20.30	83.80	40400	70.80	91.3
Concrete 19	27600	2.66	17.10	289.0	1.360	79.10	0.361	78200	31.80	<0.600	15.40	30.90	20100	14.90	29.1
Concrete 20	1920	<1.00	0.81	30.8	<0.100	1.73	0.909	388000	7.29	<0.600	0.91	6.11	1700	22.10	4.9
Mean	20713	2.85	13.30	260.8	1.275	64.80	0.592	155395	24.41	0.710	12.05	34.32	19723	20.05	31.0
Median	19600	2.58	7.16	241.5	1.215	42.50	0.341	112000	23.25	0.600	13.30	32.75	20300	13.70	27.0
Minimum	1920	1.00	0.81	30.8	0.100	1.73	0.200	58900	7.29	0.600	0.91	2.75	1700	2.52	4.9
Maximum	51700	7.11	57.30	663.0	4.500	281.00	1.930	389000	58.50	1.410	22.00	84.00	41600	70.80	91.3
No. of samples	20	20	20	20	20	20	20	20	20	20	20	20.0	20	20	20
90th percentile	41810	4.93	27.98	573.4	2.555	197.10	1.362	378100	40.29	1.001	20.35	52.93	33920	38.92	54.3
LOD	50	1	0.50	0.5	0.1	1	0.2	60	0.5	0.6	0.1	1	200	1	1

(b)

Sample ID	Mg	Mn	Hg	Mo	Ni	P	K	Se	Ag	Na	Sr	Tl	Sn	Ti	V	Zn
Concrete 01	2170	458	<0.200	<1.00	3.49	100	347	<1.00	<1	95	539	<1	<1.00	92	8.59	32.30
Concrete 02	11300	839	<0.200	<1.00	13.00	610	2690	<1.00	<1	661	182	<1	2.32	2250	65.60	121.00
Concrete 03	8370	519	<0.200	2.18	23.90	512	2800	<1.00	<1	1180	354	<1	2.48	1150	53.00	98.20
Concrete 04	10500	909	<0.200	<1.00	14.00	535	2710	<1.00	<1	985	204	<1	2.18	1500	48.50	84.60
Concrete 05	9170	737	<0.200	<1.00	17.00	495	2490	<1.00	<1	524	199	<1	1.86	917	40.10	99.10
Concrete 06	10700	236	<0.200	2.18	7.13	126	1150	<1.00	<1	503	201	<1	1.35	152	16.70	100.00
Concrete 07	7900	286	<0.200	3.60	19.40	1370	2730	<1.00	<1	1120	215	<1	1.52	715	41.90	132.00
Concrete 08	3310	290	<0.200	3.44	26.90	2270	2600	<1.00	<1	1290	220	<1	1.83	730	47.80	121.00
Concrete 09	7740	291	<0.200	5.89	31.80	1830	7010	<1.00	<1	3460	1180	<1	3.10	1490	75.80	124.00
Concrete 10	4810	245	<0.200	3.71	31.60	459	4440	<1.00	<1	2040	328	<1	1.54	746	49.30	82.60
Concrete 11	2050	164	<0.200	<1.00	3.28	57.5	1120	<1.00	<1	249	248	<1	<1.00	98	8.31	84.50
Concrete 12	7670	585	<0.200	19.50	56.30	1060	12300	4.18	<1	3390	655	<1	3.77	1830	149.00	247.00
Concrete 13	6100	279	<0.200	2.83	30.80	487	3270	<1.00	<1	1780	351	<1	1.71	728	41.60	87.40
Concrete 14	4390	276	<0.200	3.26	27.00	579	3300	1.04	<1	1150	392	<1	1.40	712	42.10	78.90
Concrete 15	47300	316	<0.200	1.47	5.72	122	1300	<1.00	<1	420	198	<1	<1.00	124	11.00	66.80
Concrete 16	4770	237	<0.200	4.15	31.20	419	4340	<1.00	<1	1770	227	<1	1.87	732	51.50	89.60
Concrete 17	3530	312	<0.200	2.75	28.50	455	3200	<1.00	<1	1240	297	<1	1.28	800	49.10	150.00
Concrete 18	7520	516	0.301	18.80	55.70	811	11400	4.41	<1	3500	617	<1	3.75	1740	152.00	260.00
Concrete 19	4520	226	<0.200	5.59	30.80	412	2610	<1.00	<1	1230	271	<1	1.51	812	51.10	83.80
Concrete 20	1410	133	<0.200	<1.00	2.69	51.6	693	<1.00	<1	172	272	<1	<1.00	81	8.01	66.40
Mean	8262	393	0.205	4.27	23.01	638	3625	1.33	1	1338	358	1	1.87	870	50.55	110.46
Median	6810	291	0.200	2.79	25.40	491	2720	1.00	1	1165	272	1	1.63	739	48.15	93.90
Minimum	1410	133	0.200	1.00	2.69	51.6	347	1.00	1	95	182	1	1	81	8.01	32.30
Maximum	47300	909	0.301	19.50	56.30	2270	12300	4.41	1	3500	1180	1	3.77	2250	152.00	260.00
No. of samples	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20
90th percentile	10760	747.2	0.200	7.18	34.19	1416	7449	1.35	1	3397	620.8	1	3.17	1749	83.12	159.70
LOD	20	2	0.2	1.00	0.60	10	50	1	1	10	1	1	1	3	0.1	2

Table 7.3 Primary data for concrete blocks: hydrocarbon screen (mg/kg DW)

Sample ID	Hydrocarbons C5–C44	Hydrocarbons C10– C40
Concrete 01	1990	<300
Concrete 02	1910	<300
Concrete 03	452	<300
Concrete 04	917	<300
Concrete 05	630	<300
Concrete 06	1520	<300
Concrete 07	793	<300
Concrete 08	264	<300
Concrete 09	563	<300
Concrete 10	309	<300
Concrete 11	1860	<300
Concrete 12	274	<300
Concrete 13	155	<300
Concrete 14	149	<300
Concrete 15	555	<300
Concrete 16	178	<300
Concrete 17	321	<300
Concrete 18	447	308
Concrete 19	264	<300
Concrete 20	1280	<300
Mean	742	300
Median	504	300
Minimum	149	300
Maximum	1990	308
No. of samples	20	20
90th percentile	1865	300
LOD	50	50

Table 7.4 Primary data for concrete blocks: PAHs (USEPA 16) (μg/kg DW)

(a)

Sample ID	**Acenaphthene**	**Acenaphthylene**	**Anthracene**	**Benzo(a)anthracene**	**Benzo(a)pyrene**	**Benzo(b)fluoranthene**	**Benzo(ghi)perylene**	**Benzo(k)fluoranthene**
Concrete 01	1.69	<2.00	<40	<40	<40	<40	<10	<40
Concrete 02	1.88	<2.00	<40	<40	<40	<40	<10	<40
Concrete 03	7.10	2.00	<40	<40	<40	<40	<10	<40
Concrete 04	1.38	<2.00	<40	<40	<40	<40	<10	<40
Concrete 05	2.50	<2.00	<40	<40	<40	<40	<10	<40
Concrete 06	2.86	<2.00	<40	<40	<40	<40	<10	<40
Concrete 07	5.95	<2.00	<40	<40	<40	<40	<10	<40
Concrete 08	9.00	2.21	<40	<40	<40	<40	13	<40
Concrete 09	9.33	<4.00	<80	<80	<80	<80	<200	<80
Concrete 10	13.30	<2.00	<40	<40	<40	<40	15	<40
Concrete 11	10.10	<2.00	<40	73	59	115	56	<40
Concrete 12	10.80	6.46	<40	<40	<40	<40	<900	<40
Concrete 13	17.50	2.98	<40	<40	<40	<40	<10	<40
Concrete 14	20.80	6.37	<40	<40	<40	<40	<60	<40
Concrete 15	5.40	<2.00	<40	<40	<40	<40	17	<40
Concrete 16	17.40	5.59	<40	<40	<40	<40	<10	<40
Concrete 17	9.34	<2.00	<40	<40	<40	<40	<10	<40
Concrete 18	14.20	<2.00	<40	<40	<40	<40	<10	<40
Concrete 19	16.20	2.21	<40	<40	<40	<40	<6	<40
Concrete 20	3.09	<2.00	<40	<40	<40	<40	12	<40
Mean	8.99	2.791	42	44	43	46	69	42
Median	9.17	2.00	40	40	40	40	10	40
Minimum	1.38	2.00	40	40	40	40	6	40
Maximum	20.80	6.46	80	80	80	115	900	80
No. of samples	20	20	20	20	20	20	20	20
90th percentile	17.41	5.67	40	43	42	44	74	40
LOD	0.1	1	20	20	20	20	6	20

(b)

Sample ID	Chrysene	Dibenzo(ah)anthracene	Fluoranthene	Fluorene	Indeno(1,2,3-cd)pyrene	Naphthalene	Phenanthrene	Pyrene
Concrete 01	<60	<6	<40	<20	<60	<20.0	<40.0	<40
Concrete 02	<60	<6	<40	<20	<60	<20.0	<40.0	<40
Concrete 03	<40	<6	<40	<20	<60	22.6	<40.0	<40
Concrete 04	<60	<6	<40	<20	<60	<20.0	<40.0	<40
Concrete 05	<60	<6	<40	<20	<60	<20.0	<40.0	<40
Concrete 06	<60	<6	<40	<20	<60	<20.0	<40.0	<40
Concrete 07	<60	<6	<40	<20	<60	37.5	<40.0	<40
Concrete 08	<60	<6	<40	<20	<60	35.0	40.9	<40
Concrete 09	<80	<600	<80	<40	<300	<40.0	<80.0	<80
Concrete 10	<60	<6	<40	<20	<60	55.6	<40.0	<40
Concrete 11	88	12	178	<20	<60	<20.0	112.0	140
Concrete 12	<60	<400	<40	<20	<200	81.4	<40.0	<40
Concrete 13	<40	<6	<40	<20	<60	52.7	44.3	<40
Concrete 14	<60	<40	<40	<20	<40	139.0	55.5	<40
Concrete 15	<60	<6	62	<20	<60	<20.0	47.1	50
Concrete 16	<60	<10	<40	<20	<60	76.4	43.5	<40
Concrete 17	<60	<6	<40	<20	<60	30.5	<40.0	<40
Concrete 18	<60	<6	<40	<20	<200	48.7	<40.0	<40
Concrete 19	<60	<6	<40	<20	<60	65.0	<40.0	<40
Concrete 20	<60	<6	43	<20	<60	<20.0	<40.0	<40
Mean	60	58	50	21	85	42.2	47.2	47
Median	60	6	40	20	60	32.8	40.0	40
Minimum	40	6	40	20	40	20	40.0	40
Maximum	88	600	178	40	300	139.0	112.0	140
No. of samples	20	20	20	20	20	20.0	20	20
90th percentile	62	76	63	20	200	76.9	58.0	53
LOD	30	3	20	10	30	10	20	20

Table 7.5 Primary data for concrete blocks: PCBs (μg/kg DW)

(a)

Sample ID	PCB-008	PCB-020	PCB-028	PCB-035	PCB-052	PCB-077	PCB-101	PCB-105	PCB-118
Concrete 01	<4	<4	<4	<4	<2	<4	<4	<2	<2
Concrete 02	<4	<4	<4	<4	<2	<4	<4	<2	<2
Concrete 03	<4	<4	<4	<4	<2	<4	<4	<2	<2
Concrete 04	<4	<4	<4	<4	<2	<4	<4	<2	<2
Concrete 05	<4	<4	<4	<4	<2	<4	<4	<2	<2
Concrete 06	<4	<4	<4	<4	<2	<4	<4	<2	<2
Concrete 07	<4	<4	<2	<4	<2	<4	<4	<2	<2
Concrete 08	<4	<4	<4	<4	<2	<4	<4	<2	<2
Concrete 09	<8	<8	<8	<8	<4	<8	<8	<4	<4
Concrete 10	<4	<4	<4	<4	<2	<4	<4	<2	<2
Concrete 11	<4	<4	<4	<4	<2	<4	<4	<2	<2
Concrete 12	<4	<4	<4	<4	<2	<4	<4	<2	<2
Concrete 13	<4	<4	<2	<4	<2	<4	<4	<2	<2
Concrete 14	<4	<4	<4	<4	<2	<4	<4	<2	<2
Concrete 15	<4	<4	<4	<4	<2	<4	<4	<2	<2
Concrete 16	<4	<4	<4	<4	<2	<4	<4	<2	<2
Concrete 17	<4	<4	<4	<4	<2	<4	<4	<2	<2
Concrete 18	<4	<4	<4	<4	<2	<4	<4	<2	<2
Concrete 19	<4	<4	<4	<4	<2	<4	<4	<2	<2
Concrete 20	<4	<4	<4	<4	<2	<4	<4	<2	<2
Mean	4	4	4	4	2	4	4	2	2
Median	4	4	4	4	2	4	4	2	2
Minimum	4	4	2	4	2	4	4	2	2
Maximum	8	8	8	8	4	8	8	4	4
No. of samples	20	20	20	20	20	20	20	20	20
90th percentile	4	4	4	4	2	4	4	2	2
LOD	2	2	2	2	1	2	2	1	1

(b)

Sample ID	PCB-126	PCB-128	PCB-138	PCB-149	PCB-153	PCB-156	PCB-169	PCB-170	PCB-180
Concrete 01	<2	<2	<2	<2	<2	<2	<2	<4	<2
Concrete 02	<2	<2	<2	<2	<2	<2	<2	<4	<2
Concrete 03	<2	<2	<2	<2	<2	<2	<2	<4	<2
Concrete 04	<2	<2	<2	<2	<2	<2	<2	<2	<2
Concrete 05	<2	<2	<2	<2	<2	<2	<2	<4	<2
Concrete 06	<80	<2	<2	<2	<2	<2	<2	<2	<2
Concrete 07	<2	<2	<2	<2	<2	<2	<2	<4	<2
Concrete 08	<2	<2	<2	<2	<2	<2	<2	<4	<2
Concrete 09	<4	<4	<4	<4	<4	<3	<3	<8	<4
Concrete 10	<2	<2	<2	<2	<2	<2	<2	<4	<2
Concrete 11	<20	<2	<2	<2	<2	<2	<2	<4	<2
Concrete 12	<2	<2	<2	<2	<2	<2	<2	<4	<2
Concrete 13	<2	<2	<2	<2	<2	<2	<2	<4	<2
Concrete 14	<2	<2	<2	<2	<2	<2	<2	<4	<2
Concrete 15	<2	<2	<2	<2	<2	<2	<2	<4	<2
Concrete 16	<2	<2	<2	<2	<2	<2	<2	<4	<2
Concrete 17	<2	<2	<2	<2	<2	<2	<2	<4	<2
Concrete 18	<2	<2	<2	<2	<2	<2	<2	<4	<2
Concrete 19	<2	<2	<2	<2	<2	<2	<2	<4	<2
Concrete 20	<2	<2	<2	<2	<2	<2	<2	<4	<2
Mean	7	2	2	2	2	2	2	4	2
Median	2	2	2	2	2	2	2	4	2
Minimum	2	2	2	2	2	2	2	2	2
Maximum	80	4	4	4	4	3	3	8	4
No. of samples	20	20	20	20	20	20	20	20	20
90th percentile	5.6	2	2	2	2	2	2	4	2
LOD	1	1	1	1	1	0.9	0.9	2	1

Table 7.6 Primary data for concrete blocks: BTEX (μg/kg DW)

Sample ID	1,2-Dimethylbenzene [*o*-Xylene]	Benzene	Dimethylbenzene sum of (1,3- 1,4-)	Ethylbenzene	Toluene [Methylbenzene]
Concrete 01	<3	<3	<5	<1.0	<8
Concrete 02	<3	<3	<5	<1.0	<8
Concrete 03	<3	<3	<6	<1.0	<8
Concrete 04	<3	<3	<5	<1.0	<8
Concrete 05	<3	<3	<6	<1.0	<8
Concrete 06	<3	<3	<5	<1.0	<8
Concrete 07	<3	<3	<5	<1.0	<8
Concrete 08	<3	<3	<6	<1.0	<8
Concrete 09	<4	<4	<7	<2.0	<10
Concrete 10	<3	<3	<6	<1.0	<9
Concrete 11	<3	<3	<5	<1.0	<8
Concrete 12	<3	<3	<6	<2.0	<9
Concrete 13	<3	<3	<5	<1.0	<8
Concrete 14	<3	<3	<6	<1.0	<9
Concrete 15	<3	<3	<5	<1.0	<8
Concrete 16	<1	<1	<2	<0.5	<3
Concrete 17	<3	<3	<6	<2.0	<10
Concrete 18	<3	<3	<6	<2.0	<9
Concrete 19	<3	<3	<6	<2.0	<9
Concrete 20	<3	<3	<5	<1.0	<8
Mean	3	3	5	1.2	8
Median	3	3	6	1.0	8
Minimum	1	1	2	0.5	3
Maximum	4	4	7	2.0	10
No. of samples	20	20	20	20	20
90th percentile	3	3	6	2.0	9
LOD	1	1	2	0.5	3

Table 7.7 Primary data for concrete blocks: phenol (mg/kg DW)

Sample ID	Monohydric phenols (total) Day 0.25	Monohydric phenols (total) Day 1	Monohydric phenols (total) Day 2.25	Monohydric phenols (total) Day 4
Concrete 01	<0.1	<0.1	<0.1	<0.1
Concrete 02	<0.1	<0.1	<0.1	<0.1
Concrete 03	<0.1	<0.1	<0.1	<0.1
Concrete 04	<0.1	<0.1	<0.1	<0.1
Concrete 05	<0.1	<0.1	<0.1	<0.1
Concrete 06	<0.1	<0.1	<0.1	<0.1
Concrete 07	<0.1	<0.1	<0.1	<0.1
Concrete 08	<0.1	<0.1	<0.1	<0.1
Concrete 09	<0.1	<0.1	<0.1	<0.1
Concrete 10	<0.1	<0.1	<0.1	<0.1
Concrete 11	<0.1	<0.1	<0.1	<0.1
Concrete 12	<0.1	<0.1	<0.1	<0.1
Concrete 13	<0.1	<0.1	<0.1	<0.1
Concrete 14	<0.1	<0.1	<0.1	<0.1
Concrete 15	<0.1	<0.1	<0.1	<0.1
Concrete 16	<0.1	<0.1	<0.1	<0.1
Concrete 17	<0.1	<0.1	<0.1	<0.1
Concrete 18	<0.1	<0.1	<0.1	<0.1
Concrete 19	<0.1	<0.1	<0.1	<0.1
Concrete 20	<0.1	<0.1	<0.1	<0.1
Mean	0.1	0.1	0.1	0.1
Median	0.1	0.1	0.1	0.1
Minimum	0.1	0.1	0.1	0.1
Maximum	0.1	0.1	0.1	0.1
No. of samples	20	20	20	20
90th percentile	0.1	0.1	0.1	0.1
LOD	0.1	0.1	0.1	0.1

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List of abbreviations

Ag	Silver
Al	Aluminium
As	Arsenic
B	Boron
Ba	Barium
Be	Beryllium
BTEX	Benzene, toluene, ethylbenzene, xylene
C	Carbon
Ca	Calcium
Cd	Cadmium
Chromium VI	Chromium Hexavalent
Co	Cobalt
Cr	Chromium
Cu	Copper
DCM	dichloromethane
DW	dry weight
EC	electrical conductivity
Fe	Iron
GC-FID	gas chromatography-flame ionisation detector
GCMS	gas chromatography–mass spectrometry
Hg	Mercury
HPLC	high performance liquid chromatography
ICP	inductively coupled plasma
ICP-AES	inductively coupled plasma atomic emission spectrometry
ICP-MS	inductively coupled plasma mass spectroscopy
K	Potassium
LE	Leeds laboratory of NLS
Li	Lithium
LOD	limit of detection
LoI	loss on ignition
MCERTS	Environment Agency's Monitoring Certification Scheme
Mg	Magnesium

Mn	Manganese
Mo	Molybdenum
N	Nitrogen
Na	Sodium
NEN	Netherlands Standardization Institute
Ni	Nickel
NLS	National Laboratory Service [Environment Agency]
P	Phosphorus
PAH	polycyclic aromatic hydrocarbon
Pb	Lead
PCB	polychlorinated biphenyl
PFA	pulverised fuel ash
SAL	Scientific Analysis Laboratories Limited
Sb	Antimony
Se	Selenium
Sn	Tin
Sr	Strontium
Ti	Titanium
Tl	Thallium
USEPA	United States Environmental Protection Agency
V	Vanadium
Zn	Zinc

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