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APPENDICES

Appendix A: Life Cycle Impact Assessment (LCIA)

Table A1 Results of the impact assessment 1 kg hot-mixed asphalt production and raw material by using CML 2 baseline 2000 V2.03 / World, 1995

Impact category	Unit	Total
abiotic depletion	kg Sb eq	1.2840819
global warming (GWP100)	kg CO2 eq	43.659266
ozone layer depletion (ODP)	kg CFC-11 eq	3.70E-05
human toxicity	kg 1,4-DB eq	18.215193
fresh water aquatic ecotox.	kg 1,4-DB eq	1.7648351
marine aquatic ecotoxicity	kg 1,4-DB eq	7602.3209
terrestrial ecotoxicity	kg 1,4-DB eq	0.1133853
photochemical oxidation	kg C2H4	0.0410696
acidification	kg SO2 eq	0.3814992
eutrophication	kg PO4--- eq	0.0609151

Table A2 Results of the impact assessment 1 kg hot-mixed asphalt production by using Eco-indicator 95 V2.03 / Europe

Impact category	Unit	Total
greenhouse	kg CO2	-25.09101822
ozone layer	kg CFC11	-1.21E-04
acidification	kg SO2	0.370522409
eutrophication	kg PO4	0.053428289
heavy metals	kg Pb	-2.1061E-05
carcinogens	kg B(a)P	2.55E-06
winter smog	kg SPM	7.842502154
summer smog	kg C2H4	-0.06238035
Pesticides	kg act.subst	0
energy resources	MJ LHV	580.5774274
solid waste	kg	0.007277287

Table A3 Results of the impact assessment 1 kg warm-mixed production and raw material by using CML 2 baseline 2000 V2.03 / World, 1995

Impact category	Unit	Total
abiotic depletion	kg Sb eq	1.2762551
global warming (GWP100)	kg CO2 eq	42.5928644
ozone layer depletion (ODP)	kg CFC-11 eq	3.59E-05
human toxicity	kg 1,4-DB eq	18.368256
fresh water aquatic ecotox.	kg 1,4-DB eq	1.801274
marine aquatic ecotoxicity	kg 1,4-DB eq	7730.0873
terrestrial ecotoxicity	kg 1,4-DB eq	0.11689866
photochemical oxidation	kg C2H4	0.039929392
acidification	kg SO2 eq	0.35022333
eutrophication	kg PO4--- eq	0.053891372

Table A4 Results of the impact assessment 1 kg warm-mixed asphalt production and raw material by using Eco-indicator 95 V2.03 / Europe

Impact category	Unit	Total
greenhouse	kg CO2	2.56E+01
ozone layer	kg CFC11	-1.17E-04
acidification	kg SO2	0.3313949
eutrophication	kg PO4	0.046626193
heavy metals	kg Pb	-2.61E-06
carcinogens	kg B(a)P	2.63E-06
winter smog	kg SPM	7.840324916
summer smog	kg C2H4	-0.06003205
pesticides	kg act.subst	0
energy resources	MJ LHV	558.2471135
solid waste	kg	0.007106675

Table A5 Results of the impact assessment 43 kg asphalt binder transportation in full load of hot-mixed asphalt by using CML 2 baseline 2000 V2.03 / World, 1995

Impact category	Unit	Total	Transport_rawmat_Asphalt bineder	Diesel I
abiotic depletion	kg Sb eq	1.63E-03	0	1.63E-03
global warming (GWP100)	kg CO2 eq	0.2973039	0.27642058	0.020883281
ozone layer depletion (ODP)	kg CFC-11 eq	0	0	0
human toxicity	kg 1,4-DB eq	0.0151576	0.014767527	3.90E-04
fresh water aquatic ecotox.	kg 1,4-DB eq	3.48E-05	3.18E-05	2.92E-06
marine aquatic ecotoxicity	kg 1,4-DB eq	0.1604652	0.14738942	0.013075828
terrestrial ecotoxicity	kg 1,4-DB eq	6.01E-06	2.41E-06	3.60E-06
photochemical oxidation	kg C2H4	4.42E-05	3.77E-05	6.51E-06
acidification	kg SO2 eq	1.96E-03	1.69E-03	2.65E-04
eutrophication	kg PO4--- eq	4.53E-04	4.25E-04	2.78E-05

Table A6 Results of the impact assessment 968 kg aggregate transportation in full load of hot-mixed asphalt by using CML 2 baseline 2000 V2.03 / World, 1995

Impact category	Unit	Total	Transport_rawmat_Aggregate	Diesel I
abiotic depletion	kg Sb eq	0.0275883	0	0.027588346
global warming (GWP100)	kg CO2 eq	5.030529	4.6771754	0.35335365
ozone layer depletion (ODP)	kg CFC-11 eq	0	0	0
human toxicity	kg 1,4-DB eq	0.2564808	0.2498808	0.00659996
fresh water aquatic ecotox.	kg 1,4-DB eq	0.0005885	0.000539051	4.94E-05
marine aquatic ecotoxicity	kg 1,4-DB eq	2.715349	2.4941006	0.22124836
terrestrial ecotoxicity	kg 1,4-DB eq	0.0001017	4.08E-05	6.09E-05
photochemical oxidation	kg C2H4	0.0007472	0.000637107	0.000110139
acidification	kg SO2 eq	0.0331679	0.028678258	0.004489638
eutrophication	kg PO4--- eq	0.007662	0.007192385	0.000469658

Table A7 Results of the impact assessment 7.12 kg fuel-oil transportation in full load of hot-mixed asphalt by using CML 2 baseline 2000 V2.03 / World, 1995

Impact category	Unit	Total	Transport_rawmat_Fuel oil	Diesel I
abiotic depletion	kg Sb eq	0.0003106	0	0.000310563
global warming (GWP100)	kg CO2 eq	0.0482082	0.044230507	0.003977714
ozone layer depletion (ODP)	kg CFC-11 eq	0	0	0
human toxicity	kg 1,4-DB eq	0.0021975	0.002123195	7.43E-05
fresh water aquatic ecotox.	kg 1,4-DB eq	6.61E-06	6.05E-06	5.56E-07
marine aquatic ecotoxicity	kg 1,4-DB eq	0.0305111	0.028020457	0.0024906
terrestrial ecotoxicity	kg 1,4-DB eq	1.14E-06	4.58E-07	6.85E-07
photochemical oxidation	kg C2H4	6.13E-06	4.89E-06	1.24E-06
acidification	kg SO2 eq	0.0002883	0.000237796	5.05E-05
eutrophication	kg PO4--- eq	6.42E-05	5.89E-05	5.29E-06

Table A8 Results of the impact assessment 0.00106 kg hot-oil transportation in full load of hot-mixed asphalt by using CML 2 baseline 2000 V2.03 / World, 1995

Impact category	Unit	Total	Transport_rawmat_Hot oil	Diesel I
abiotic depletion	kg Sb eq	1.53E-07	0	1.53E-07
global warming (GWP100)	kg CO2 eq	2.27E-05	2.07E-05	1.96E-06
ozone layer depletion (ODP)	kg CFC-11 eq	0	0	0
human toxicity	kg 1,4-DB eq	1.88E-06	1.85E-06	3.66E-08
fresh water aquatic ecotox.	kg 1,4-DB eq	3.25E-09	2.97E-09	2.74E-10
marine aquatic ecotoxicity	kg 1,4-DB eq	1.50E-05	1.38E-05	1.23E-06
terrestrial ecotoxicity	kg 1,4-DB eq	5.62E-10	2.25E-10	3.37E-10
photochemical oxidation	kg C2H4	8.05E-09	7.44E-09	6.10E-10
acidification	kg SO2 eq	5.76E-08	3.27E-08	2.49E-08
eutrophication	kg PO4--- eq	9.66E-09	7.06E-09	2.60E-09

Table A9 Results of the impact assessment 0.00179 kg grease transportation in full load of hot-mixed asphalt by using CML 2 baseline 2000 V2.03 / World, 1995

Impact category	Unit	Total	Transport_rawmat_grease	Diesel I
abiotic depletion	kg Sb eq	2.57E-07	0	2.57E-07
global warming (GWP100)	kg CO2 eq	3.81E-05	3.48E-05	3.30E-06
ozone layer depletion (ODP)	kg CFC-11 eq	0	0	0
human toxicity	kg 1,4-DB eq	3.17E-06	3.10E-06	6.16E-08
fresh water aquatic ecotox.	kg 1,4-DB eq	5.45E-09	4.99E-09	4.61E-10
marine aquatic ecotoxicity	kg 1,4-DB eq	2.52E-05	2.31E-05	2.06E-06
terrestrial ecotoxicity	kg 1,4-DB eq	9.46E-10	3.78E-10	5.68E-10
photochemical oxidation	kg C2H4	1.36E-08	1.25E-08	1.03E-09
acidification	kg SO2 eq	9.69E-08	5.50E-08	4.19E-08
eutrophication	kg PO4--- eq	1.62E-08	1.19E-08	4.38E-09

Table A10 Results of the impact assessment 1000 kg Asphalt concrete transportation in full load of hot-mixed asphalt by using CML 2 baseline 2000 V2.03 / World, 1995

Impact category	Unit	Total	Transport_product_Asphalt concrete	Diesel I
abiotic depletion	kg Sb eq	0.0113759	0	0.011375919
global warming (GWP100)	kg CO2 eq	1.7625488	1.6168451	0.14570365
ozone layer depletion (ODP)	kg CFC-11 eq	0	0	0
human toxicity	kg 1,4-DB eq	0.0803395	0.077618012	0.002721461
fresh water aquatic ecotox.	kg 1,4-DB eq	0.0002416	0.00022122	2.04E-05
marine aquatic ecotoxicity	kg 1,4-DB eq	1.1154974	1.0242667	0.091230678
terrestrial ecotoxicity	kg 1,4-DB eq	4.19E-05	1.68E-05	2.51E-05
photochemical oxidation	kg C2H4	0.0002243	0.000178928	4.54E-05
acidification	kg SO2 eq	0.0105474	0.00869611	0.00185128
eutrophication	kg PO4--- eq	0.0023461	0.002152475	0.000193661

Table A11 Results of the impact assessment 3.7 kg water transportation in full load of hot-mixed asphalt by using CML 2 baseline 2000 V2.03 / World, 1995

Impact category	Unit	Total	Transport_rawmat_water	Diesel I
abiotic depletion	kg Sb eq	3.90E-05	0	3.90E-05
global warming (GWP100)	kg CO2 eq	0.0060585	0.005558455	0.000500055
ozone layer depletion (ODP)	kg CFC-11 eq	0	0	0
human toxicity	kg 1,4-DB eq	0.0002762	0.000266887	9.34E-06
fresh water aquatic ecotox.	kg 1,4-DB eq	8.30E-07	7.61E-07	6.99E-08
marine aquatic ecotoxicity	kg 1,4-DB eq	0.0038329	0.003519837	0.000313104
terrestrial ecotoxicity	kg 1,4-DB eq	1.44E-07	5.76E-08	8.61E-08
photochemical oxidation	kg C2H4	7.71E-07	6.15E-07	1.56E-07
acidification	kg SO2 eq	3.62E-05	2.99E-05	6.35E-06
eutrophication	kg PO4--- eq	8.06E-06	7.40E-06	6.65E-07

Table A12 Results of the impact assessment asphalt binder transportation in no load of hot-mixed asphalt by using CML 2 baseline 2000 V2.03 / World, 1995

Impact category	Unit	Total	Transport_rawmat_Asphalt binder no load	Diesel I
abiotic depletion	kg Sb eq	9.32E-07	0	9.32E-07
global warming (GWP100)	kg CO2 eq	0.000136079	0.000124146	1.19E-05
ozone layer depletion (ODP)	kg CFC-11 eq	0	0	0
human toxicity	kg 1,4-DB eq	7.03E-06	6.80E-06	2.23E-07
fresh water aquatic ecotox.	kg 1,4-DB eq	1.99E-08	1.83E-08	1.67E-09
marine aquatic ecotoxicity	kg 1,4-DB eq	9.20E-05	8.45E-05	7.47E-06
terrestrial ecotoxicity	kg 1,4-DB eq	3.44E-09	1.39E-09	2.06E-09
photochemical oxidation	kg C2H4	2.10E-08	1.73E-08	3.72E-09
acidification	kg SO2 eq	9.19E-07	7.68E-07	1.52E-07
eutrophication	kg PO4--- eq	2.07E-07	1.91E-07	1.59E-08

Table A13 Results of the impact assessment aggregate transportation in no load of hot-mixed asphalt by using CML 2 baseline 2000 V2.03 / World, 1995

Impact category	Unit	Total	Transport_rawmat_Aggregate no load	Diesel I
abiotic depletion	kg Sb eq	7.05E-07	0	7.05E-07
global warming (GWP100)	kg CO2 eq	0.000102348	9.33E-05	9.04E-06
ozone layer depletion (ODP)	kg CFC-11 eq	0	0	0
human toxicity	kg 1,4-DB eq	5.30E-06	5.13E-06	1.69E-07
fresh water aquatic ecotox.	kg 1,4-DB eq	1.50E-08	1.37E-08	1.26E-09
marine aquatic ecotoxicity	kg 1,4-DB eq	6.92E-05	6.35E-05	5.66E-06
terrestrial ecotoxicity	kg 1,4-DB eq	2.60E-09	1.04E-09	1.56E-09
photochemical oxidation	kg C2H4	1.58E-08	1.30E-08	2.82E-09
acidification	kg SO2 eq	6.92E-07	5.77E-07	1.15E-07
eutrophication	kg PO4--- eq	1.55E-07	1.43E-07	1.20E-08

Table A14 Results of the impact assessment fuel-oil transportation in no load of hot-mixed asphalt by using CML 2 baseline 2000 V2.03 / World, 1995

Impact category	Unit	Total	Transport_rawmat_Fuel oil no load	Diesel I
abiotic depletion	kg Sb eq	5.92E-07	0	5.92E-07
global warming (GWP100)	kg CO2 eq	8.55E-05	7.79E-05	7.59E-06
ozone layer depletion (ODP)	kg CFC-11 eq	0	0	0
human toxicity	kg 1,4-DB eq	3.91E-06	3.77E-06	1.42E-07
fresh water aquatic ecotox.	kg 1,4-DB eq	1.26E-08	1.15E-08	1.06E-09
marine aquatic ecotoxicity	kg 1,4-DB eq	5.81E-05	5.34E-05	4.75E-06
terrestrial ecotoxicity	kg 1,4-DB eq	2.18E-09	8.74E-10	1.31E-09
photochemical oxidation	kg C2H4	1.11E-08	8.70E-09	2.36E-09
acidification	kg SO2 eq	5.17E-07	4.21E-07	9.64E-08
eutrophication	kg PO4--- eq	1.14E-07	1.04E-07	1.01E-08

Table A15 Results of the impact assessment hot-oil transportation in no load of hot-mixed asphalt by using CML 2 baseline 2000 V2.03 / World, 1995

Impact category	Unit	Total	Transport_rawmat_Hot oil no load	Diesel I
abiotic depletion	kg Sb eq	3.26E-09	0	3.26E-09
global warming (GWP100)	kg CO2 eq	4.71E-07	4.30E-07	4.18E-08
ozone layer depletion (ODP)	kg CFC-11 eq	0	0	0
human toxicity	kg 1,4-DB eq	3.90E-08	3.82E-08	7.80E-10
fresh water aquatic ecotox.	kg 1,4-DB eq	6.95E-11	6.37E-11	5.84E-12
marine aquatic ecotoxicity	kg 1,4-DB eq	3.21E-07	2.95E-07	2.62E-08
terrestrial ecotoxicity	kg 1,4-DB eq	1.20E-11	4.82E-12	7.19E-12
photochemical oxidation	kg C2H4	1.68E-10	1.55E-10	1.30E-11
acidification	kg SO2 eq	1.21E-09	6.84E-10	5.31E-10
eutrophication	kg PO4--- eq	2.02E-10	1.47E-10	5.55E-11

Table A16 Results of the impact assessment grease transportation in no load of hot-mixed asphalt by using CML 2 baseline 2000 V2.03 / World, 1995

Impact category	Unit	Total	Transport_rawmat_grease no load	Diesel I
abiotic depletion	kg Sb eq	3.26E-08	0	3.26E-08
global warming (GWP100)	kg CO2 eq	4.71E-06	4.30E-06	4.18E-07
ozone layer depletion (ODP)	kg CFC-11 eq	0	0	0
human toxicity	kg 1,4-DB eq	3.90E-07	3.82E-07	7.80E-09
fresh water aquatic ecotox.	kg 1,4-DB eq	6.95E-10	6.37E-10	5.84E-11
marine aquatic ecotoxicity	kg 1,4-DB eq	3.21E-06	2.95E-06	2.62E-07
terrestrial ecotoxicity	kg 1,4-DB eq	1.20E-10	4.82E-11	7.19E-11
photochemical oxidation	kg C2H4	1.68E-09	1.55E-09	1.30E-10
acidification	kg SO2 eq	1.21E-08	6.84E-09	5.31E-09
eutrophication	kg PO4--- eq	2.02E-09	1.47E-09	5.55E-10

Table A17 Results of the impact assessment Asphalt concrete transportation in no load of hot-mixed asphalt by using CML 2 baseline 2000 V2.03 / World, 1995

Impact category	Unit	Total	Transport_product_Asphalt concrete no load	Diesel l
abiotic depletion	kg Sb eq	1.51E-07	0	1.51E-07
global warming (GWP100)	kg CO2 eq	2.18E-05	1.99E-05	1.93E-06
ozone layer depletion (ODP)	kg CFC-11 eq	0	0	0
human toxicity	kg 1,4-DB eq	9.96E-07	9.60E-07	3.61E-08
fresh water aquatic ecotox.	kg 1,4-DB eq	3.19E-09	2.92E-09	2.70E-10
marine aquatic ecotoxicity	kg 1,4-DB eq	1.48E-05	1.35E-05	1.21E-06
terrestrial ecotoxicity	kg 1,4-DB eq	5.55E-10	2.22E-10	3.33E-10
photochemical oxidation	kg C2H4	2.81E-09	2.21E-09	6.02E-10
acidification	kg SO2 eq	1.32E-07	1.07E-07	2.45E-08
eutrophication	kg PO4--- eq	2.90E-08	2.64E-08	2.57E-09

Table A18 Results of the impact assessment water transportation in no load of hot-mixed asphalt by using CML 2 baseline 2000 V2.03 / World, 1995

Impact category	Unit	Total	Transport_rawmat_water no load	Diesel l
abiotic depletion	kg Sb eq	1.42E-07	0	1.42E-07
global warming (GWP100)	kg CO2 eq	2.07E-05	1.88E-05	1.82E-06
ozone layer depletion (ODP)	kg CFC-11 eq	0	0	0
human toxicity	kg 1,4-DB eq	9.46E-07	9.12E-07	3.40E-08
fresh water aquatic ecotox.	kg 1,4-DB eq	3.05E-09	2.79E-09	2.54E-10
marine aquatic ecotoxicity	kg 1,4-DB eq	1.41E-05	1.29E-05	1.14E-06
terrestrial ecotoxicity	kg 1,4-DB eq	5.25E-10	2.11E-10	3.13E-10
photochemical oxidation	kg C2H4	2.67E-09	2.10E-09	5.67E-10
acidification	kg SO2 eq	1.25E-07	1.02E-07	2.31E-08
eutrophication	kg PO4--- eq	2.75E-08	2.51E-08	2.42E-09

Table A19 Results of the impact assessment 43 kg asphalt binder transportation in full load of hot-mixed asphalt by using Eco-indicator 95 V2.03 / Europe e

Impact category	Unit	Total	Transport_rawmat_Asphalt bineder	Diesel I
greenhouse	kg CO2	0.29535675	0.27448247	0.020874284
ozone layer	kg CFC11	0	0	0
acidification	kg SO2	0.002620666	0.002338834	0.000281832
eutrophication	kg PO4	0.000452826	0.000425069	2.78E-05
heavy metals	kg Pb	3.92E-08	3.56E-08	3.66E-09
carcinogens	kg B(a)P	2.67E-10	2.53E-10	1.31E-11
winter smog	kg SPM	0.000207292	5.00E-05	0.000157292
summer smog	kg C2H4	0.000225045	0.00014021	8.48E-05
pesticides	kg act.subst	0	0	0
energy resources	MJ LHV	3.3845141	0	3.3845141
solid waste	kg	0.000345455	0	0.000345455

Table A20 Results of the impact assessment 968 kg aggregate transportation in full load of hot-mixed asphalt by using Eco-indicator 95 V2.03 / Europe e

Impact category	Unit	Total	Transport_rawmat_Aggregate	Diesel I
greenhouse	kg CO2	4.9975829	4.6443815	0.35320143
ozone layer	kg CFC11	0	0	0
acidification	kg SO2	0.044342977	0.03957426	0.004768717
eutrophication	kg PO4	0.007662044	0.007192385	0.000469658
heavy metals	kg Pb	6.62E-07	6.00E-07	6.19E-08
carcinogens	kg B(a)P	4.51E-09	4.29E-09	2.22E-10
winter smog	kg SPM	0.003507479	0.000846032	0.002661447
summer smog	kg C2H4	0.003807859	0.002372418	0.001435441
pesticides	kg act.subst	0	0	0
energy resources	MJ LHV	57.267364	0	57.267364
solid waste	kg	0.005845235	0	0.005845235

Table A21 Results of the impact assessment 7.12 kg fuel-oil transportation in full load of hot-mixed asphalt by using Eco-indicator 95 V2.03 / Europe e

Impact category	Unit	Total	Transport rawmat Fuel oil	Diesel 1
greenhouse	kg CO2	0.04796424	0.04398824	0.003976
ozone layer	kg CFC11	0	0	0
acidification	kg SO2	0.000380152	0.00032647	5.37E-05
eutrophication	kg PO4	6.42E-05	5.89E-05	5.29E-06
heavy metals	kg Pb	7.45E-09	6.75E-09	6.97E-10
carcinogens	kg B(a)P	3.95E-11	3.70E-11	2.50E-12
winter smog	kg SPM	3.94E-05	9.48E-06	3.00E-05
summer smog	kg C2H4	6.34E-05	4.72E-05	1.62E-05
pesticides	kg act.subst	0	0	0
energy resources	MJ LHV	0.64466059	0	0.64466059
solid waste	kg	6.58E-05	0	6.58E-05

Table A22 Results of the impact assessment 0.00106 kg hot-oil transportation in full load of hot-mixed asphalt by using Eco-indicator 95 V2.03 / Europe e

Impact category	Unit	Total	Transport rawmat Hot oil	Diesel 1
greenhouse	kg CO2	2.23E-05	2.03E-05	1.96E-06
ozone layer	kg CFC11	0	0	0
acidification	kg SO2	6.91E-08	4.27E-08	2.64E-08
eutrophication	kg PO4	9.66E-09	7.06E-09	2.60E-09
heavy metals	kg Pb	3.66E-12	3.32E-12	3.43E-13
carcinogens	kg B(a)P	4.27E-14	4.15E-14	1.23E-15
winter smog	kg SPM	1.94E-08	4.64E-09	1.47E-08
summer smog	kg C2H4	3.72E-08	2.92E-08	7.95E-09
pesticides	kg act.subst	0	0	0
energy resources	MJ LHV	0.000317265	0	0.000317265
solid waste	kg	3.24E-08	0	3.24E-08

Table A23 Results of the impact assessment 1000 kg Asphalt concrete transportation in full load of hot-mixed asphalt by using Eco-indicator 95 V2.03 / Europe e

Impact category	Unit	Total	Transport_product_Asphalt concrete	Diesel I
greenhouse	kg CO2	1.7536572	1.6080163	0.14564088
ozone layer	kg CFC11	0	0	0
acidification	kg SO2	0.013904407	0.01193805	0.001966357
eutrophication	kg PO4	0.002346136	0.002152475	0.000193661
heavy metals	kg Pb	2.74E-07	2.48E-07	2.55E-08
carcinogens	kg B(a)P	1.45E-09	1.35E-09	9.16E-11
winter smog	kg SPM	0.001445235	0.0003478	0.001097435
summer smog	kg C2H4	0.002318697	0.0017268	0.000591897
pesticides	kg act.subst	0	0	0
energy resources	MJ LHV	23.613917	0	23.613917
solid waste	kg	0.002410254	0	0.002410254

Table A24 Results of the impact assessment 0.00179 kg grease transportation in full load of hot-mixed asphalt by using Eco-indicator 95 V2.03 / Europe e

Impact category	Unit	Total	Transport_rawmat_grease	Diesel I
greenhouse	kg CO2	3.74E-05	3.41E-05	3.29E-06
ozone layer	kg CFC11	0	0	0
acidification	kg SO2	1.16E-07	7.17E-08	4.45E-08
eutrophication	kg PO4	1.62E-08	1.19E-08	4.38E-09
heavy metals	kg Pb	6.15E-12	5.57E-12	5.78E-13
carcinogens	kg B(a)P	-7.18E-14	6.97E-14	2.07E-15
winter smog	kg SPM	3.26E-08	7.81E-09	2.48E-08
summer smog	kg C2H4	6.25E-08	4.91E-08	1.34E-08
pesticides	kg act.subst	0	0	0
energy resources	MJ LHV	0.000534147	0	0.000534147
solid waste	kg	5.45E-08	0	5.45E-08

Table A25 Results of the impact assessment 3.7 kg water transportation in full load of hot-mixed asphalt by using Eco-indicator 95 V2.03 / Europe e

Impact category	Unit	Total	Transport_rawmat_water	Diesel I
greenhouse	kg CO2	0.006027848	0.005528008	0.00049984
ozone layer	kg CFC11	0	0	0
acidification	kg SO2	4.78E-05	4.10E-05	6.75E-06
eutrophication	kg PO4	8.06E-06	7.40E-06	6.65E-07
heavy metals	kg Pb	9.37E-10	8.49E-10	8.76E-11
carcinogens	kg B(a)P	4.97E-12	4.66E-12	3.14E-13
winter smog	kg SPM	4.96E-06	1.19E-06	3.77E-06
summer smog	kg C2H4	7.96E-06	5.93E-06	2.03E-06
pesticides	kg act.subst	0	0	0
energy resources	MJ LHV	0.081043046	0	0.081043046
solid waste	kg	8.27E-06	0	8.27E-06

Table A26 Results of the impact assessment asphalt binder transportation in no load of hot-mixed asphalt by using Eco-indicator 95 V2.03 / Europe e

Impact category	Unit	Total	Transport_rawmat_Asphalt binder no load	Diesel I
greenhouse	kg CO2	0.000135203	0.000123275	1.19E-05
ozone layer	kg CFC11	0	0	0
acidification	kg SO2	1.22E-06	1.06E-06	1.61E-07
eutrophication	kg PO4	2.07E-07	1.91E-07	1.59E-08
heavy metals	kg Pb	2.25E-11	2.05E-11	2.09E-12
carcinogens	kg B(a)P	1.26E-13	1.18E-13	7.50E-15
winter smog	kg SPM	1.18E-07	2.86E-08	8.99E-08
summer smog	kg C2H4	1.15E-07	6.64E-08	4.85E-08
pesticides	kg act.subst	0	0	0
energy resources	MJ LHV	0.001933982	0	0.001933982
solid waste	kg	1.97E-07	0	1.97E-07

Table A27 Results of the impact assessment aggregate transportation in no load of hot-mixed asphalt by using Eco-indicator 95 V2.03 / Europe e

Impact category	Unit	Total	Transport_rawmat_Aggregate no load	Diesel I
greenhouse	kg CO2	0.000101689	9.27E-05	9.03E-06
ozone layer	kg CFC11	0	0	0
acidification	kg SO2	9.16E-07	7.94E-07	1.22E-07
eutrophication	kg PO4	1.55E-07	1.43E-07	1.20E-08
heavy metals	kg Pb	1.69E-11	1.54E-11	1.58E-12
carcinogens	kg B(a)P	9.48E-14	8.91E-14	5.68E-15
winter smog	kg SPM	8.96E-08	2.15E-08	6.81E-08
summer smog	kg C2H4	8.66E-08	4.99E-08	3.67E-08
pesticides	kg act.subst	0	0	0
energy resources	MJ LHV	0.001464301	0	0.001464301
solid waste	kg	1.49E-07	0	1.49E-07

Table A28 Results of the impact assessment fuel-oil transportation in no load of hot-mixed asphalt by using Eco-indicator 95 V2.03 / Europe e

Impact category	Unit	Total	Transport_rawmat_Fuel oil no load	Diesel I
greenhouse	kg CO2	8.51E-05	7.75E-05	7.58E-06
ozone layer	kg CFC11	0	0	0
acidification	kg SO2	6.79E-07	5.77E-07	1.02E-07
eutrophication	kg PO4	1.14E-07	1.04E-07	1.01E-08
heavy metals	kg Pb	1.42E-11	1.29E-11	1.33E-12
carcinogens	kg B(a)P	7.08E-14	6.60E-14	4.77E-15
winter smog	kg SPM	7.51E-08	1.80E-08	5.71E-08
summer smog	kg C2H4	1.18E-07	8.75E-08	3.08E-08
pesticides	kg act.subst	0	0	0
energy resources	MJ LHV	0.00122946	0	0.00122946
solid waste	kg	1.25E-07	0	1.25E-07

Table A29 Results of the impact assessment hot-oil transportation in no load of hot-mixed asphalt by using Eco-indicator 95 V2.03 / Europe e

Impact category	Unit	Total	Transport_rawmat_Hot oil no load	Diesel I
greenhouse	kg CO2	4.63E-07	4.21E-07	4.17E-08
ozone layer	kg CFC11	0	0	0
acidification	kg SO2	1.45E-09	8.90E-10	5.64E-10
eutrophication	kg PO4	2.02E-10	1.47E-10	5.55E-11
heavy metals	kg Pb	7.83E-14	7.10E-14	7.32E-15
carcinogens	kg B(a)P	8.84E-16	8.58E-16	2.63E-17
winter smog	kg SPM	4.14E-10	9.93E-11	3.15E-10
summer smog	kg C2H4	7.83E-10	6.14E-10	1.70E-10
pesticides	kg act.subst	0	0	0
energy resources	MJ LHV	6.77E-06	0	6.77E-06
solid waste	kg	6.91E-10	0	6.91E-10

Table A30 Results of the impact assessment grease transportation in no load of hot-mixed asphalt by using Eco-indicator 95 V2.03 / Europe e

Impact category	Unit	Total	Transport_rawmat_grease no load	Diesel I
greenhouse	kg CO2	4.63E-06	4.21E-06	4.17E-07
ozone layer	kg CFC11	0	0	0
acidification	kg SO2	1.45E-08	8.90E-09	5.64E-09
eutrophication	kg PO4	2.02E-09	1.47E-09	5.55E-10
heavy metals	kg Pb	7.83E-13	7.10E-13	7.32E-14
carcinogens	kg B(a)P	8.84E-15	8.58E-15	2.63E-16
winter smog	kg SPM	4.14E-09	9.93E-10	3.15E-09
summer smog	kg C2H4	7.83E-09	6.14E-09	1.70E-09
pesticides	kg act.subst	0	0	0
energy resources	MJ LHV	6.77E-05	0	6.77E-05
solid waste	kg	6.91E-09	0	6.91E-09

Table A31 Results of the impact assessment Asphalt concrete transportation in no load of hot-mixed asphalt by using Eco-indicator 95 V2.03 / Europe e

Impact category	Unit	Total	Transport_product_Asphalt concrete no load	Diesel I
greenhouse	kg CO2	2.17E-05	1.97E-05	1.93E-06
ozone layer	kg CFC11	0	0	0
acidification	kg SO2	1.73E-07	1.47E-07	2.61E-08
eutrophication	kg PO4	2.90E-08	2.64E-08	2.57E-09
heavy metals	kg Pb	3.61E-12	3.28E-12	3.39E-13
carcinogens	kg B(a)P	1.80E-14	1.68E-14	1.21E-15
winter smog	kg SPM	1.91E-08	4.59E-09	1.46E-08
summer smog	kg C2H4	3.02E-08	2.23E-08	7.85E-09
pesticides	kg act.subst	0	0	0
energy resources	MJ LHV	0.000313121	0	0.000313121
solid waste	kg	3.20E-08	0	3.20E-08

Table A32 Results of the impact assessment water transportation in no load of hot-mixed asphalt by using Eco-indicator 95 V2.03 / Europe e

Impact category	Unit	Total	Transport_rawmat_water no load	Diesel I
greenhouse	kg CO2	2.06E-05	1.87E-05	1.82E-06
ozone layer	kg CFC11	0	0	0
acidification	kg SO2	1.64E-07	1.39E-07	2.45E-08
eutrophication	kg PO4	2.75E-08	2.51E-08	2.42E-09
heavy metals	kg Pb	3.43E-12	3.11E-12	3.19E-13
carcinogens	kg B(a)P	1.71E-14	1.60E-14	1.14E-15
winter smog	kg SPM	1.81E-08	4.36E-09	1.37E-08
summer smog	kg C2H4	2.86E-08	2.12E-08	7.39E-09
pesticides	kg act.subst	0	0	0
energy resources	MJ LHV	0.000294702	0	0.000294702
solid waste	kg	3.01E-08	0	3.01E-08

Table A33 Results of the impact assessment 1.9 kg sasobit transportation in full load of warn-mixed asphalt by using CML 2 baseline 2000 V2.03 / World, 1995

Impact category	Unit	Total	WMA-Transport_rawmat_Sasobit	Diesel I
abiotic depletion	kg Sb eq	0.000184985	0	0.000184985
global warming (GWP100)	kg CO2 eq	0.027431302	0.025062005	0.002369297
ozone layer depletion (ODP)	kg CFC-11 eq	0	0	0
human toxicity	kg 1,4-DB eq	0.00228216	0.002237907	4.43E-05
fresh water aquatic ecotox.	kg 1,4-DB eq	3.94E-06	3.61E-06	3.31E-07
marine aquatic ecotoxicity	kg 1,4-DB eq	0.018166603	0.016683095	0.001483508
terrestrial ecotoxicity	kg 1,4-DB eq	6.81E-07	2.73E-07	4.08E-07
photochemical oxidation	kg C2H4	9.77E-06	9.03E-06	7.39E-07
acidification	kg SO2 eq	6.97E-05	3.96E-05	3.01E-05
eutrophication	kg PO4--- eq	1.17E-05	8.55E-06	3.15E-06

Table A34 Results of the impact assessment sasobit transportation in no load of warn-mixed asphalt by using CML 2 baseline 2000 V2.03 / World, 1995

Impact category	Unit	Total	WMA-Transport_rawmat_Sasobit no load	Diesel I
abiotic depletion	kg Sb eq	3.26E-07	0	3.26E-07
global warming (GWP100)	kg CO2 eq	4.71E-05	4.30E-05	4.18E-06
ozone layer depletion (ODP)	kg CFC-11 eq	0	0	0
human toxicity	kg 1,4-DB eq	3.90E-06	3.82E-06	7.80E-08
fresh water aquatic ecotox.	kg 1,4-DB eq	6.95E-09	6.37E-09	5.84E-10
marine aquatic ecotoxicity	kg 1,4-DB eq	3.21E-05	2.95E-05	2.62E-06
terrestrial ecotoxicity	kg 1,4-DB eq	1.20E-09	4.82E-10	7.19E-10
photochemical oxidation	kg C2H4	1.68E-08	1.55E-08	1.30E-09
acidification	kg SO2 eq	1.21E-07	6.84E-08	5.31E-08
eutrophication	kg PO4--- eq	2.02E-08	1.47E-08	5.55E-09

Table A35 Results of the impact assessment 1.9 kg sasobit transportation in full load of warn-mixed asphalt by using Eco-indicator 95 V2.03 / Europe e

Impact category	Unit	Total	WMA-Transport_rawmat_Sasobit	Diesel I
greenhouse	kg CO2	0.026947928	0.024579652	0.002368276
ozone layer	kg CFC11	0	0	0
acidification	kg SO2	8.36E-05	5.16E-05	3.20E-05
eutrophication	kg PO4	1.17E-05	8.55E-06	3.15E-06
heavy metals	kg Pb	4.43E-09	4.02E-09	4.15E-10
carcinogens	kg B(a)P	5.18E-11	5.03E-11	1.49E-12
winter smog	kg SPM	2.35E-05	5.63E-06	1.78E-05
summer smog	kg C2H4	4.50E-05	3.54E-05	9.62E-06
pesticides	kg act.subst	0	0	0
energy resources	MJ LHV	0.38398748	0	0.38398748
solid waste	kg	3.92E-05	0	3.92E-05

Table A36 Results of the impact assessment sasobit transportation in no load of warn-mixed asphalt by using Eco-indicator 95 V2.03 / Europe e

Impact category	Unit	Total	WMA-Transport_rawmat_Sasobit no load	Diesel I
greenhouse	kg CO2	4.63E-05	4.21E-05	4.17E-06
ozone layer	kg CFC11	0	0	0
acidification	kg SO2	1.45E-07	8.90E-08	5.64E-08
eutrophication	kg PO4	2.02E-08	1.47E-08	5.55E-09
heavy metals	kg Pb	7.83E-12	7.10E-12	7.32E-13
carcinogens	kg B(a)P	8.84E-14	8.58E-14	2.63E-15
winter smog	kg SPM	4.14E-08	9.93E-09	3.15E-08
summer smog	kg C2H4	7.83E-08	6.14E-08	1.70E-08
pesticides	kg act.subst	0	0	0
energy resources	MJ LHV	0.000676894	0	0.000676894
solid waste	kg	6.91E-08	0	6.91E-08

Table A37 Results of the impact assessment paver of hot-mixed asphalt by using CML 2 baseline 2000 V2.03 / World, 1995

Impact category	Unit	Total	HMA-Pavement paver	Diesel I
abiotic depletion	kg Sb eq	0.006615	0	0.00661499
global warming (GWP100)	kg CO2 eq	0.5227139	0.43798861	0.0847253
ozone layer depletion (ODP)	kg CFC-11 eq	0	0	0
human toxicity	kg 1,4-DB eq	0.006176	0.004593526	0.001582504
fresh water aquatic ecotox.	kg 1,4-DB eq	1.18E-05	0	1.18E-05
marine aquatic ecotoxicity	kg 1,4-DB eq	0.0530498	0	0.05304978
terrestrial ecotoxicity	kg 1,4-DB eq	1.46E-05	0	1.46E-05
photochemical oxidation	kg C2H4	5.82E-05	3.18E-05	2.64E-05
acidification	kg SO2 eq	0.0028945	0.00181797	0.001076502
eutrophication	kg PO4--- eq	0.0005717	0.000459069	0.000112612

Table A38 Results of the impact assessment breakdown of hot-mixed asphalt by using CML 2 baseline 2000 V2.03 / World, 1995

Impact category	Unit	Total	HMA-Pavement breakdown	Diesel I
abiotic depletion	kg Sb eq	0.0007831	0	0.000783062
global warming (GWP100)	kg CO2 eq	0.0609735	0.050943972	0.010029521
ozone layer depletion (ODP)	kg CFC-11 eq	0	0	0
human toxicity	kg 1,4-DB eq	0.000733	0.000545672	0.000187332
fresh water aquatic ecotox.	kg 1,4-DB eq	1.40E-06	0	1.40E-06
marine aquatic ecotoxicity	kg 1,4-DB eq	0.0062799	0	0.00627987
terrestrial ecotoxicity	kg 1,4-DB eq	1.73E-06	0	1.73E-06
photochemical oxidation	kg C2H4	6.95E-06	3.82E-06	3.13E-06
acidification	kg SO2 eq	0.0003433	0.00021582	0.000127433
eutrophication	kg PO4--- eq	6.79E-05	5.45E-05	1.33E-05

Table A39 Results of the impact assessment Finish rolling of hot-mixed asphalt by using CML 2 baseline 2000 V2.03 / World, 1995

Impact category	Unit	Total	HMA-Pavement finish rolling	Diesel I
abiotic depletion	kg Sb eq	0.001067	0	0.001067005
global warming (GWP100)	kg CO2 eq	0.0951921	0.081525831	0.013666287
ozone layer depletion (ODP)	kg CFC-11 eq	0	0	0
human toxicity	kg 1,4-DB eq	0.0012086	0.00095333	0.00025526
fresh water aquatic ecotox.	kg 1,4-DB eq	1.91E-06	0	1.91E-06
marine aquatic ecotoxicity	kg 1,4-DB eq	0.008557	0	0.00855699
terrestrial ecotoxicity	kg 1,4-DB eq	2.35E-06	0	2.35E-06
photochemical oxidation	kg C2H4	1.96E-05	1.53E-05	4.26E-06
acidification	kg SO2 eq	0.0005264	0.00035277	0.000173641
eutrophication	kg PO4--- eq	0.0001074	8.92E-05	1.82E-05

Table A40 Results of the impact assessment paver of hot-mixed asphalt by using Eco-indicator 95 V2.03 / Europe e

Impact category	Unit	Total	HMA-Pavement paver	Diesel I
greenhouse	kg CO2	0.5209941	0.4363053	0.0846888
ozone layer	kg CFC11	0	0	0
acidification	kg SO2	0.003658928	0.00251551	0.001143418
eutrophication	kg PO4	0.000571681	0.000459069	0.000112612
heavy metals	kg Pb	1.48E-08	0	1.48E-08
carcinogens	kg B(a)P	5.33E-11	0	5.33E-11
winter smog	kg SPM	0.001110748	0.0004726	0.000638148
summer smog	kg C2H4	0.000450448	0.000106266	0.000344182
pesticides	kg act.subst	0	0	0
energy resources	MJ LHV	13.731271	0	13.731271
solid waste	kg	0.00140154	0	0.00140154

Table A41 Results of the impact assessment breakdown of hot-mixed asphalt by using Eco-indicator 95 V2.03 / Europe e

Impact category	Unit	Total	HMA-Pavement breakdown	Diesel I
greenhouse	kg CO2	0.0607666	0.0507414	0.0100252
ozone layer	kg CFC11	0	0	0
acidification	kg SO2	0.000434034	0.00029868	0.000135354
eutrophication	kg PO4	6.79E-05	5.45E-05	1.33E-05
heavy metals	kg Pb	1.76E-09	0	1.76E-09
carcinogens	kg B(a)P	6.30E-12	0	6.30E-12
winter smog	kg SPM	0.000131742	5.62E-05	7.55E-05
summer smog	kg C2H4	5.34E-05	1.27E-05	4.07E-05
pesticides	kg act.subst	0	0	0
energy resources	MJ LHV	1.6254656	0	1.6254656
solid waste	kg	0.00016591	0	0.00016591

Table A42 Results of the impact assessment Finish rolling of hot-mixed asphalt by using Eco-indicator 95 V2.03 / Europe e

Impact category	Unit	Total	HMA-Pavement finish rolling	Diesel I
greenhouse	kg CO2	0.0943406	0.0806802	0.0136604
ozone layer	kg CFC11	0	0	0
acidification	kg SO2	0.000672805	0.00048837	0.000184435
eutrophication	kg PO4	0.000107357	8.92E-05	1.82E-05
heavy metals	kg Pb	2.39E-09	0	2.39E-09
carcinogens	kg B(a)P	8.59E-12	0	8.59E-12
winter smog	kg SPM	0.000268634	0.0001657	0.000102934
summer smog	kg C2H4	8.56E-05	3.01E-05	5.55E-05
pesticides	kg act.subst	0	0	0
energy resources	MJ LHV	2.2148696	0	2.2148696
solid waste	kg	0.00022607	0	0.00022607

Table A43 Results of the impact assessment dismantle of hot-mixed asphalt by using CML 2 baseline 2000 V2.03 / World, 1995

Impact category	Unit	Total	Dismantle_Phase2	Diesel I
abiotic depletion	kg Sb eq	0.003929109	0	0.003929109
global warming (GWP100)	kg CO2 eq	0.050324328	0	0.050324328
ozone layer depletion (ODP)	kg CFC-11 eq	0	0	0
human toxicity	kg 1,4-DB eq	0.000939961	0	0.000939961
fresh water aquatic ecotox.	kg 1,4-DB eq	7.03617E-06	0	7.03617E-06
marine aquatic ecotoxicity	kg 1,4-DB eq	0.031510004	0	0.031510004
terrestrial ecotoxicity	kg 1,4-DB eq	8.66658E-06	0	8.66658E-06
photochemical oxidation	kg C2H4	1.56859E-05	0	1.56859E-05
acidification	kg SO2 eq	0.00063941	0	0.00063941
eutrophication	kg PO4--- eq	6.68884E-05	0	6.68884E-05

Table A44 Results of the impact assessment dismantle of hot-mixed asphalt by using Eco-indicator 95 V2.03 / Europe e

Impact category	Unit	Total	Dismantle_Phase2	Diesel I
greenhouse	kg CO2	0.050302648	0	0.050302648
ozone layer	kg CFC11	0	0	0
acidification	kg SO2	0.000679157	0	0.000679157
eutrophication	kg PO4	6.68884E-05	0	6.68884E-05
heavy metals	kg Pb	8.81802E-09	0	8.81802E-09
carcinogens	kg B(a)P	3.1634E-11	0	3.1634E-11
winter smog	kg SPM	0.000379041	0	0.000379041
summer smog	kg C2H4	0.000204434	0	0.000204434
pesticides	kg act.subst	0	0	0
energy resources	MJ LHV	8.155969502	0	8.155969502
solid waste	kg	0.000832473	0	0.000832473

Table A45 Results of the impact assessment RAP transportation in full load and no load of hot-mixed asphalt by using CML 2 baseline 2000 V2.03 / World, 1995

Impact category	Unit	Total	Transport_RAP full load	Transport_RAP no load
abiotic depletion	kg Sb eq	0.015372877	0.015372864	1.27408E-08
global warming (GWP100)	kg CO2 eq	2.381849665	2.381822673	2.69917E-05
ozone layer depletion (ODP)	kg CFC-11 eq	0	0	0
human toxicity	kg 1,4-DB eq	0.108568539	0.10856724	1.29941E-06
fresh water aquatic ecotox.	kg 1,4-DB eq	0.00032647	0.000326466	3.98543E-09
marine aquatic ecotoxicity	kg 1,4-DB eq	1.507410796	1.507392352	1.84433E-05
terrestrial ecotoxicity	kg 1,4-DB eq	5.65935E-05	5.65932E-05	3.28392E-10
photochemical oxidation	kg C2H4	0.00030317	0.000303167	3.04008E-09
acidification	kg SO2 eq	0.014253377	0.01425323	1.46879E-07
eutrophication	kg PO4--- eq	0.00317049	0.003170455	3.59305E-08

Table A46 Results of the impact assessment RAP transportation in full load and no load of hot-mixed asphalt by using Eco-indicator 95 V2.03 / Europe

Impact category	Unit	Total	Transport_RAP full load	Transport_RAP no load
greenhouse	kg CO2	2.369833845	2.369807	2.68449E-05
ozone layer	kg CFC11	0	0	0
acidification	kg SO2	0.01878994	0.018789739	2.00711E-07
eutrophication	kg PO4	0.00317049	0.003170455	3.59305E-08
heavy metals	kg Pb	3.69592E-07	3.69588E-07	4.45475E-12
carcinogens	kg B(a)P	1.95331E-09	1.95329E-09	2.27846E-14
winter smog	kg SPM	0.001953027	0.00195302	7.43411E-09
summer smog	kg C2H4	0.003133405	0.003133374	3.08153E-08
pesticides	kg act.subst	0	0	0
energy resources	MJ LHV	31.91072565	31.91069921	2.64472E-05
solid waste	kg	0.003257103	0.0032571	2.69944E-09

Table A47 Results of the impact assessment hot in-plant recycling of hot-mixed asphalt by using CML 2 baseline 2000 V2.03 / World, 1995

Impact category	Unit	Total
abiotic depletion	kg Sb eq	-1.046469753
global warming (GWP100)	kg CO2 eq	-29.94496826
ozone layer depletion (ODP)	kg CFC-11 eq	-3.15774E-05
human toxicity	kg 1,4-DB eq	-15.31549828
fresh water aquatic ecotox.	kg 1,4-DB eq	-1.525720987
marine aquatic ecotoxicity	kg 1,4-DB eq	-6689.599191
terrestrial ecotoxicity	kg 1,4-DB eq	-0.09807617
photochemical oxidation	kg C2H4	-0.00962267
acidification	kg SO2 eq	-0.129880108
eutrophication	kg PO4--- eq	-0.021069024

Table A48 Results of the impact assessment hot in-plant recycling of hot-mixed asphalt by using Eco-indicator 95 V2.03 / Europe

Impact category	Unit	Total
greenhouse	kg CO2	-26.44325483
ozone layer	kg CFC11	-4.19951E-05
acidification	kg SO2	-0.148211095
eutrophication	kg PO4	-0.020974008
heavy metals	kg Pb	-0.000161824
carcinogens	kg B(a)P	-1.63043E-06
winter smog	kg SPM	-7.800786257
summer smog	kg C2H4	-0.06484085
Pesticides	kg act.subst	0
energy resources	MJ LHV	-102.7165497
solid waste	kg	0

Table A49 Results of the impact assessment hot in-place recycling of hot-mixed asphalt by using CML 2 baseline 2000 V2.03 / World, 1995

Impact category	Unit	Total
abiotic depletion	kg Sb eq	-1.048946501
global warming (GWP100)	kg CO2 eq	-9.294041987
ozone layer depletion (ODP)	kg CFC-11 eq	-3.67713E-05
human toxicity	kg 1,4-DB eq	-17.33733054
fresh water aquatic ecotox.	kg 1,4-DB eq	-1.750173776
marine aquatic ecotoxicity	kg 1,4-DB eq	-7372.809925
terrestrial ecotoxicity	kg 1,4-DB eq	-0.101310555
photochemical oxidation	kg C2H4	-0.009608321
acidification	kg SO2 eq	-0.106089464
eutrophication	kg PO4--- eq	-0.021359513

Table A50 Results of the impact assessment hot in-place recycling of hot-mixed asphalt by using Eco-indicator 95 V2.03 / Europe

Impact category	Unit	Total
greenhouse	kg CO2	-26.44325483
ozone layer	kg CFC11	-4.19951E-05
acidification	kg SO2	-0.148211095
eutrophication	kg PO4	-0.020974008
heavy metals	kg Pb	-0.000161824
carcinogens	kg B(a)P	-1.63043E-06
winter smog	kg SPM	-7.800786257
summer smog	kg C2H4	-0.06484085
Pesticides	kg act.subst	0
energy resources	MJ LHV	-105.6230342
solid waste	kg	0

Table A51 Results of the impact assessment hot in-place recycling of warm-mixed asphalt by using CML 2 baseline 2000 V2.03 / World, 1995

Impact category	Unit	Total
abiotic depletion	kg Sb eq	-1.053889879
global warming (GWP100)	kg CO2 eq	-8.975078344
ozone layer depletion (ODP)	kg CFC-11 eq	-3.6772E-05
human toxicity	kg 1,4-DB eq	-17.3486427
fresh water aquatic ecotox.	kg 1,4-DB eq	-1.750327183
marine aquatic ecotoxicity	kg 1,4-DB eq	-7377.117792
terrestrial ecotoxicity	kg 1,4-DB eq	-0.101553971
photochemical oxidation	kg C2H4	-0.009655083
acidification	kg SO2 eq	-0.107604804
eutrophication	kg PO4--- eq	-0.021516351

Table A52 Results of the impact assessment hot in-place recycling of warm-mixed asphalt by using Eco-indicator 95 V2.03 / Europe

Impact category	Unit	Total
greenhouse	kg CO2	-26.44325483
ozone layer	kg CFC11	-4.19951E-05
acidification	kg SO2	-0.148211095
eutrophication	kg PO4	-0.020974008
heavy metals	kg Pb	-0.000161824
carcinogens	kg B(a)P	-1.63043E-06
winter smog	kg SPM	-7.800786257
summer smog	kg C2H4	-0.06484085
Pesticides	kg act.subst	0
energy resources	MJ LHV	-92.3566374
solid waste	kg	0

Table A53 Results of the impact assessment cold in-place recycling of hot-mixed asphalt by using CML 2 baseline 2000 V2.03 / World, 1995

Impact category	Unit	Total	Cold in-place recycling_Phase2	Diesel I
abiotic depletion	kg Sb eq	0.006446022	0	0.006446022
global warming (GWP100)	kg CO2 eq	0.082561139	0	0.082561139
ozone layer depletion (ODP)	kg CFC-11 eq	0	0	0
human toxicity	kg 1,4-DB eq	0.001542082	0	0.001542082
fresh water aquatic ecotox.	kg 1,4-DB eq	1.15434E-05	0	1.15434E-05
marine aquatic ecotoxicity	kg 1,4-DB eq	0.051694716	0	0.051694716
terrestrial ecotoxicity	kg 1,4-DB eq	1.42182E-05	0	1.42182E-05
photochemical oxidation	kg C2H4	2.5734E-05	0	2.5734E-05
acidification	kg SO2 eq	0.001049005	0	0.001049005
eutrophication	kg PO4--- eq	0.000109736	0	0.000109736

Table A54 Results of the impact assessment cold in-place recycling of hot-mixed asphalt by using Eco-indicator 95 V2.03 / Europe

Impact category	Unit	Total	Cold in-place recycling_Phase2	Diesel I
greenhouse	kg CO2	0.082526	0	0.082526
ozone layer	kg CFC11	0	0	0
acidification	kg SO2	0.001114	0	0.001114
eutrophication	kg PO4	0.00011	0	0.00011
heavy metals	kg Pb	1.45E-08	0	1.45E-08
carcinogens	kg B(a)P	5.19E-11	0	5.19E-11
winter smog	kg SPM	0.000622	0	0.000622
summer smog	kg C2H4	0.000335	0	0.000335
pesticides	kg act.subst	0	0	0
energy resources	MJ LHV	13.38053	0	13.38053
solid waste	kg	0.001366	0	0.001366

Table A55 Results of the impact assessment landfill of hot-mixed asphalt by using CML 2 baseline 2000 V2.03 / World, 1995

Impact category	Unit	Total	Landfill_Phase2	Concrete (inert) to landfill S
abiotic depletion	kg Sb eq	0.003593	0	0.003593
global warming (GWP100)	kg CO2 eq	0.553894	0	0.553894
ozone layer depletion (ODP)	kg CFC-11 eq	7.3E-07	0	7.3E-07
human toxicity	kg 1,4-DB eq	0.135902	0	0.135902
fresh water aquatic ecotox.	kg 1,4-DB eq	0.02948	0	0.02948
marine aquatic ecotoxicity	kg 1,4-DB eq	116.9208	0	116.9208
terrestrial ecotoxicity	kg 1,4-DB eq	0.000528	0	0.000528
photochemical oxidation	kg C2H4	0.000135	0	0.000135
acidification	kg SO2 eq	0.00413	0	0.00413
eutrophication	kg PO4--- eq	0.000837	0	0.000837

Table A56 Results of the impact assessment landfill of hot-mixed asphalt by using Eco-indicator 95 V2.03 / Europe

Impact category	Unit	Total	Transport_RAP_Phase2	Transport_RAP no load_Phase2
greenhouse	kg CO2	2.369834	2.369807	2.68E-05
ozone layer	kg CFC11	0	0	0
acidification	kg SO2	0.01879	0.018789739	2.01E-07
eutrophication	kg PO4	0.00317	0.003170455	3.59E-08
heavy metals	kg Pb	3.7E-07	3.69588E-07	4.45E-12
carcinogens	kg B(a)P	1.95E-09	1.95329E-09	2.28E-14
winter smog	kg SPM	0.001953	0.00195302	7.43E-09
summer smog	kg C2H4	0.003133	0.003133374	3.08E-08
pesticides	kg act.subst	0	0	0
energy resources	MJ LHV	31.91073	31.91069921	2.64E-05
solid waste	kg	0.003257	0.0032571	2.7E-09

Appendix B: Calculation of Hot in-place Recycling Process

Energy consumption of propane for heating and mixing in hot in-place recycling process comes from the study of Miliutenko et al (2012). But the data is different between HMA and WMA. Thus, the results will be calculated by heat capacity of each method that used for heat asphalt from room temperature to mixing temperature.

Kristjansdottir et al (2007) and Olard, Héritier and Beduneau (2008) took as their standard aggregate mix 54% of coarse aggregate (defined as retained on a 2 mm sieve) with 1% water content and fine aggregate with 4% water. The higher water content of the fine aggregate was necessary to achieve bitumen foaming for the LEA method, but in any case the higher surface to volume ratio of fine material will encourage greater absorption of water. For the purposes of comparison these water contents will be assumed for all mixes to be discussed.

Ambient temperature is taken as 25°C and the mixing temperature as 160°C Initially, 1000kg of coarse dry aggregate accompanies 1000/99kg of water (ie supplied moist aggregate has 1% water by weight of water plus aggregate). 1000kg of fine dry aggregate accompanies 1000/24kg of water (moist fine aggregate initially has 4% water by weight of water plus aggregate).

Thus, a 1000 kg mix of 650kg coarse and 350 kg fine aggregate contains:

$$0.54\times1000/99 + 0.46\times1000/24 = 24.621 \text{ kg water}$$

Heating the 24.621 kg of water from 25°C to 160°C requires:

$$24.621\times[C_{H2O}\times75 + L_{vap} + C_{vap}\times60] = 24.621\times2695.325 = 66{,}362 \text{ kJ} = 66.362 \text{ MJ}$$

For HMA, $q = mc\Delta T$

$c_{agg} = 850$ J/kg.°C (95.7% of 1000 kg asphalt pavement)

$c_{bit} = 2100$ J/kg.°C (4.3% of 1000 kg asphalt pavement)

$$q_{agg} = 957 \text{ kg} \times 850 \text{ J/kg.K} \times (160 - 25 \text{ °C})$$

$$= 109.816 \text{ MJ}$$

$q_{water} = 66.362$ MJ (100%)

$= 63.508$ MJ (95.7% based on aggregate ratio)

$$q_{bit} = 43 \text{ kg} \times 2100 \text{ J/kg.K} \times (160 - 25 \text{ °C})$$

$$= 12.191 \text{ MJ}$$

$$\therefore q_{sum} = 185.515 \text{ MJ}$$

Energy consumption calculation of WMA for hot in-place recycling process is as same as the calculation for HMA but propane for heating and mixing data are different. Because WMA uses mixing temperature less than HMA, energy for heating and mixing should be reduced which was calculated by heat capacity value.

Heating the 21.150 kg of water from 25°C to 140°C requires:

$$24.621\times[C_{H2O}\times75 + L_{vap} + C_{vap}\times40] = 24.621\times2658.325 = 65{,}451 \text{ kJ} = 65.451 \text{ MJ}$$

For WMA, $q = mc\Delta T$

$$q_{agg} = 957 \text{ kg} \times 850 \text{ J/kg. K} \times (140 - 25\ ^{\circ}\text{C})$$

$$= 93.547 \text{ MJ}$$

$q_{water} = 65.451$ MJ (100%)

$= 62.637$ MJ (95.7% based on aggregate ratio)

The 43kg of binder consists of 3% Sasobit (1.29kg) and 41.71kg of bitumen. Specific heat and heat of fusion values for Sasobit wax are not available, and so are assumed to be the same as for ordinary paraffin waxes, ie 2.9kJ kg-1 °C-1 and 220kJ kg-respectively). Heating the binder to 140°C requires:

$$1.29\times([2.9\times140]+220) = 807.54 \text{ kJ} = 0.808 \text{ MJ}$$

$$q_{bit+additive} = 41.71 \text{ kg} \times 2100 \text{ J/kg. K} \times (140 - 25\ ^{\circ}\text{C}) + 0.808 \text{ MJ}$$

$$= 10.808 \text{ MJ}$$

$$\therefore q_{sum} = 166.992 \text{ MJ}$$

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