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British Precast Drainage Association

Publications from the British Precast Drainage Association (BPDA):

BPDA was formed in 2017 from the integration of the Concrete Pipeline Systems Association (CPSA) and the Box Culvert Association (BCA).

Information published by both CPSA and BCA will be rebranded and replaced as BPDA in due course. New material will be branded BPDA.

All CPSA and BCA web traffic will be redirected to the new BPDA web site at www.precastdrainage.co.uk

CPSA Pipeline Systems Comparison Report

31 May 2011

www.carbon-clear.com

1. Executive Summary

Concrete Pipeline System Association's (CPSA) members make concrete pipes and manhole systems. They conducted a study on the embodied carbon emissions within their own concrete pipelines in comparison to pipelines built by the plastics industry, using information published by Plastics Europe in 2005 to carry out this study. CPSA engaged Carbon Clear to verify the comparisons made in the study and to undertake further calculations based on the assumptions made in the study document.

Our findings show that on the whole, when comparing plastic pipes with concrete pipes, **emissions from plastic pipes are higher than those of concrete pipes.** When comparing between one of the most commonly used types of plastic pipe (HDPE Pipe) and the most commonly used bedding type with a concrete pipe (Bedding S)[1] it is evident that concrete pipes have lower embodied emissions than plastic pipes.

Size of Pipe (mm in diameter)	**HDPE Pipe** ($4kN/m^2$) (kgCO2e/m)	**Concrete Pipes** (Bedding Class S kgCO2e/m)
DN225	N/A	26.93
DN300	N/A	37.89
DN450	79.82	62.53
DN600	125.37	100.93
DN750	170.86	143.82
DN900	224.47	177.16
DN1050	270.59	231.32
DN1200	409.48	290.74
DN1350	438.55	356.44
DN1500	637.27	440.48
DN1800	790.96	576.58
DN2100	1071.57	696.75

[1] It should be noted that even if Class S is the most commonly used bedding for pipes, it is not always necessary and a bedding solution with a lower footprint may also be applicable.

2. INTRODUCTION

Concrete Pipeline System Association's (CPSA) members make concrete pipes and manhole systems. They conducted a study on the embodied carbon emissions within their own concrete pipelines in comparison to pipelines built by the plastics industry. They used information published by Plastics Europe in 2005 to carry out this comparative study. CPSA engaged Carbon Clear to verify the comparisons made in the study and to undertake further calculations based on the assumptions made by CPSA in this document, and third-party data provided by CPSA.

CPSA's objectives for this study are to:

- Verify the comparison made in CPSA's study between plastic and concrete pipes
- Obtain third-party assurance for their claims concerning the comparative benefits of their members' products

Product Comparison:

CPSA Concrete pipes (with Bedding class S, B, F, N); and **Plastic pipes** (PVC, HDPE and Polypropylene – all with class S bedding)

Unit of comparison: 1 metre of linear pipeline

Pipes of various diameters are compared.

Scope (for both types of pipes):

Includes
• Raw Materials – embodied emissions • Delivery of Raw Materials to factory (Assumptions made by CPSA for plastic pipes) • Manufacturing process • Internal transport • Gas consumption • Electricity Use • Diesel consumption • Transportation of pipes to installation site • Waste from the production process • Bedding used around the pipes • Transport of bedding to site of installation • Machinery used for mechanical lifting on site of installation • Plastic joints, seals and couplings (included only for concrete pipes)
Excludes
• Transport of machinery to site of installation • Any other emissions arising from installation • Staff transportation • End Use • Disposal • Plastic joints, seals and couplings (excluded only for plastic pipes)

Emissions Factors: Emissions factors for all pipe production are from the following sources:

- UK government – 2010 Guidelines to Defra / DECC's GHG Conversion Factors for Company Reporting (CPSA)
- UK government – 2009 Guidelines to Defra / DECC's GHG Conversion Factors for Company Reporting (CPSA)
- Bath University – Inventory of Carbon & Energy, 2008
- BRE Environmental Profile Reports
- CEMBUREAU Environmental Product Declaration report for CEM I
- Energy Consumption Guide – ECG19 (2004)
- Arup in 2009/2010
- UK Building Blackbook
- Paper comparing electric and LPG forklifts (Johnson, 2008)
- Eco-Profiles of the European plastic industry (Boustead, 2005)
- Portworld Distance Calculator – www.portworld.com

Data: All data used for this report was supplied by the Concrete Pipeline Systems Association (CPSA). CPSA's proprietary data about four factories was gathered through a questionnaire which was distributed to the factories. This survey was carried out by CPSA and the results were supplied to Carbon Clear in the form of a spreadsheet for the necessary calculations.

Data about emissions associated with plastic pipes was sourced from publicly released reports from Plastics Europe. CPSA supplied Carbon Clear with a combination of raw data from Plastics Europe, and the results of CPSA calculations that incorporate Plastics Europe data and CPSA transport and pipeline bedding assumptions. Carbon Clear has verified that the CPSA calculations included are done correctly, but not whether the assumptions on which these calculations are based are correct, nor whether the original data from the plastics industry is correct.

Data about the geographic origin of resins for the manufacture of plastic pipeline products produced in the UK was not readily available. As a result, Carbon Clear assumed that the origin of resins for the manufacture of plastic pipeline products produced in the UK is in direct proportion to the geographic share of production, as described below.

3. Assumptions Made in Plastic Pipe Production

In order to come up with a realistic carbon footprint estimate for plastic sewerage pipes manufactured in the UK the following breakdown for the original production location for resin was based on the report "PolyOlefins Planning Service: Executive Report, Global Commercial Analysis"[2]. On this basis:

- 35% of HDPE, PVC, and PP basic resins are assumed to be originally sourced from a UK cracker.
- 16% of HDPE, PVC, and PP basic resins are assumed to be originally sourced from a West European cracker. It is assumed that the resin is imported from a plant in Rosignano, Italy and shipped from La Spezia port to a UK port (say Southampton) and then taken to the Midlands to Leicester.
- 24.5% of HDPE, PVC, and PP basic resins are assumed to be originally sourced from a Middle Eastern cracker. It is assumed that the resin is imported from the Persian Gulf to a UK port (say Dover) and then taken to the Midlands to Leicester.
- 24.5% of HDPE, PVC, and PP basic resins are assumed to be originally sourced from South Asia. IT is assumed that the resin is imported from the main Indian Oil Corp cracker in Haryana 100 km north of Delhi and then imported via the main Visakhapatnam port terminal to be shipped to Dover and then transported by road to Leicester.

These assumptions will have a number of implications on results as additional transport impacts may need to be considered and incorporated into the study and a set of new conversion factors may need to be used. A value of around **8.2 kg CO_2e** (average transportation figure based on Plastic-Europe Study) will need to be removed from the carbon footprints of a tonne of finalised PVC, HDPE, and PP pipes first as the sourcing distance is recalculated. Impacts of additional transport will be as follows:

Carbon Footprint from Transportation of Italian Resin

The distance from a plant/cracker in Rosignano to La Spezia port by road is estimated to be around 134 km. It was found that the impacts associated with transporting 1 tonne of resin for such distance on finalised pipes would be around **10.44 kg CO_2e/t**. The emissions associated with shipping by a 20,000 tonne large container vessel (distance of around 4,054 km according to www.portworld.com calculator) will be **61.74 kg CO_2e/tonne of finalised HDPE, PVC and PP pipe**. A trip by articulated lorries to the advanced resin developer/ pipe manufacturer for 230 km will emit **17.92 kg CO_2e/t of finalised HDPE, PVC and PP pipe**. This is a total of **90.10 kg CO_2e/tonne of finalised HDPE, PVC and PP pipe**.

[2] http://www.chemsystems.com/about/cs/news/items/POPS09_Executive%20Report.cfm

Carbon Footprint from Transportation of Middle Eastern Resin

Emissions associated with transporting resin from the cracker to Ras Tanura port was estimated to be 50 km – this will emit no more than **3.89 kg CO_2e/tonne of finalised HDPE, PVC and PP pipe.** The emissions associated with shipping by a 20,000 tonne large container vessel (distance around 11,519 km according to www.portworld.com calculator) will be around **175.43 kg CO_2e/tonne of finalised HDPE, PVC and PP pipe.** A trip by articulated lorries to the advanced resin developer pipe manufacturer for 300 km will emit **23.38 kg CO_2e/tonne of finalised HDPE, PVC and PP pipe**. The total will be around **202.70 kg CO_2e/tonne of finalised HDPE, PVC and PP pipe**.

Carbon Footprint from Transportation of Asian Resin

Emissions associated with the road trip from the cracker to the port in India will be around **7.79 kg CO_2e per tonne of finalised HDPE, PVC, and PP pipe**. The emissions associated with shipping by a 20,000 tonne large container vessel to Dover (distance around 13,836 km according to www.portworld.com calculator) will be around **210.72 kg CO_2e/tonne of finalised HDPE, PVC and PP pipe.** A trip by articulated lorries to the advanced resin developer pipe manufacturer for 300 km will emit **23.38 kg CO_2e/tonne of finalised HDPE, PVC and PP pipe**. The total will be **241.90 kg CO_2e/tonne of finalised HDPE, PVC and PP pipe**.

Conversion Factors for Italy (Western Europe) Imported Resin

In Italy, the conversion factors used for the electricity consumed in the production of resin is 0.4768 kg CO_2e per kWh. These factors are sourced from DEFRA's 2009 Conversion factors. Using DEFRA's conversion factors for other fuels, the carbon footprints of the pipes were found to be as follows:

- PVC: **4,146 kg CO2e/t of product**
- HDPE: **3,021 kg CO2e/t of product**
- PP: **2,768 kg CO2e/t of product**.

Conversion Factors for Middle East Imported Resin

In Saudi Arabia, the conversion factors used for the electricity consumed in the production of resin is 0.8141 kg CO_2e per kWh. These factors are sourced from DEFRA's 2009 Conversion factors. Using DEFRA's conversion factors for other fuels, the carbon footprints of the pipes were found to be as follows:

- PVC: **5,909** kg CO2e/t of product
- HDPE: **3,985** kg CO2e/t of product
- PP: **3,570** kg CO2e/t of product.

Conversion Factors for South Asia Imported Resin

In India, the conversion factors used for the electricity consumed in the production of resin is 1.2705 kg CO_2e per kWh. These factors are sourced from DEFRA's 2009 Conversion factors. Using DEFRA's conversion factors for other fuels, the carbon footprints of the pipes were found to be as follows:

- PVC: **8.183** kg CO2e/t of product
- HDPE: **5,176** kg CO2e/t of product
- PP: **4,542** kg CO2e/t of product.

GHG Emissions from Plastic Pipe Production

Based on the emissions stemming from resin transportation and production of plastic pipes, the overall emissions arising from PVC, HDPE and PP production were found to be:

	PVC Pipes (kg CO2e/t)	HDPE Pipes (kg CO2e/t)	Polypropylene Pipes (kg CO2e/t)
UK Sourced Resin	4,382.77	3,119.42	2,824.52
Europe Sourced Resin	4,146.05	3,021.51	2,768.76
Middle East Sourced Resin	5,909.96	3,985.36	3,570.51
Indian Sourced Resin	8,183.53	5,176.38	4,542.19

Based on the figures shown in the table, and using the assumptions made for the production of resins abroad as having a ratio of 35:16:24.5:24.5 in the UK, Europe, Middle East and India respectively, the GHG emissions stemming from the production of PVC, HDPE and PP pipe, including transportation, were found to be **5,650**, **3.820** and **3.419** kg CO2e/tonne of products respectively.

4. Results and Key Findings

Overall Emissions – Comparing Plastic to Concrete Pipes

Carbon Clear has updated the emission factors used to calculate the emissions arising from concrete pipelines. These updated numbers were included in the PAS 2050 compliant report supplied to CPSA. Those same updated numbers for concrete pipe emissions will be included in this report for comparison to plastic pipeline data. CPSA has also performed calculations based on a number of assumptions asserted in their Carbon Footprint Report. Carbon Clear has checked the calculations done by CPSA based on their assumptions.

Comparing Updated Pipeline Data

On the whole, when comparing plastic pipes with concrete pipes, **emissions from plastic pipes are higher than those of concrete pipes.** The following table demonstrates the emissions of each type of pipe within the concrete and plastic pipe categories. Generally, the emissions from plastic pipes are higher than from concrete pipes.

Size of Pipe (mm in diameter)	Plastic Pipes				Concrete Pipes			
	PP Structured Wall Pipe (kgCO2e/m)	PP Structured Wall Pipe (kgCO2e/m)	HDPE Pipe (4kN/ m^2) (kgCO2e/m)	uPVC Structured Wall (kgCO2e/m)	Concrete Pipes (Bedding Class S kgCO2e/m)	Concrete Pipes (Bedding Class B kgCO2e/m)	Concrete Pipes (Bedding Class F kgCO2e/m)	Concrete Pipes (Bedding Class N kgCO2e/m)
DN225	24.79	N/A	N/A	30.96	26.93	22.09	21.72	21.29
DN300	37.48	N/A	N/A	47.37	37.89	32.08	31.60	31.04
DN450	N/A	61.07	79.82	N/A	62.53	52.23	51.21	50.06
DN600	N/A	83.23	125.37	N/A	100.93	86.46	84.92	83.22
DN750	N/A	153.07	170.86	N/A	143.82	125.17	123.06	120.77
DN900	N/A	171.04	224.47	N/A	177.16	153.84	151.09	148.14
DN1050	N/A	N/A	270.59	N/A	231.32	204.24	200.79	197.14
DN1200	N/A	N/A	409.48	N/A	290.74	259.75	255.52	251.14
DN1350	N/A	N/A	438.55	N/A	356.44	319.67	314.32	308.79
DN1500	N/A	N/A	637.27	N/A	440.48	397.60	390.99	384.18
DN1800	N/A	N/A	760.96	N/A	576.58	528.65	520.59	512.66
DN2100	N/A	N/A	1071.57	N/A	696.75	642.92	633.89	625.29

In an attempt to make a more direct comparison between the most commonly used type of plastic pipe (HDPE Pipe) and the most commonly used bedding type with a concrete pipe (Bedding S), it is still evident that concrete pipes have lower embodied emissions than plastic pipes:

Size of Pipe (mm in diameter)	**HDPE Pipe** ($4kN/m^2$) (kgCO2e/m)	**Concrete Pipes** (Bedding Class S kgCO2e/m)
DN225	N/A	26.93
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DN1500	637.27	440.48
DN1800	790.96	576.58
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Making Comparisons: Items of Note

1. In order to compare plastic and concrete pipes, Carbon Clear updated the emission factors for transportation for both plastic and concrete pipes to use those specified by Defra's 2010 emissions factors. These emission factors include scope 3 indirect emissions, which in this case means emissions associated with pre-combustion.

   For concrete pipes, the emission factors with fuel use were updated to include all upstream emissions, as is done in the plastic pipe calculations.

2. The concrete pipe calculations have been scaled up to represent 100% of total emissions in order to be PAS 2050 compliant. This has not been done for the plastic pipe calculations. This upscaling should make a negligible difference, but should be noted in analysing the comparisons.

3. Joints, seals and couplings were left out of plastic pipe calculations. CPSA believes they should add up to more than 1% of the overall emissions. However, if it does, it should still be a very small percentage of the total and Carbon Clear is satisfied to exclude these from the calculations, since the relative emissions of the two product types differ by more than a few percent.

Addressing Assumptions Made by CPSA about Plastic Pipes:

- CPSA cites that the Plastics-Europe report calculations are based only upon locally sourced resin. CPSA believes that the UK manufacturers use resin that is sourced from multiple locations outside of the 100 km distance that Plastics-Europe reports. CPSA have therefore made a number of differing assumptions about the sourcing of the resin for the purposes of their calculations. This includes the energy used from factories producing resin overseas.
- The main differing assumption is about the region of origin for resin used for PVC, HDPE and Polypropylene type of plastic pipes. CPSA assumes that only 35% of resin is sourced in the UK, 16% from Europe, 24.5% from Middle East and 24.5% from South Asia.
- Carbon Clear has not verified these assumptions, but rather verified the calculations made by CPSA on the basis of these assumptions.
- If the assumptions made are correct, the comparisons made by CPSA between plastic and concrete pipes are accurate. Concrete pipes perform better than plastic pipes in terms of carbon emissions.