Balfour Beatty
Ground Engineering

Green Siesta

Micropiles – The Green Choice?

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What is Sustainability?




The Challenge?

“ Carbon Accounting is the future of Sustainable construction. With increasing Legislation being introduced it is imperative that companies keep looking to lesson their carbon Footprint ”

Ground Engineering 2008

An Introduction to Green Siesta

Developed in-house by BBGE

Acronym for Stent Integrated Estimating Application

Drivers;

Supply chain pressures

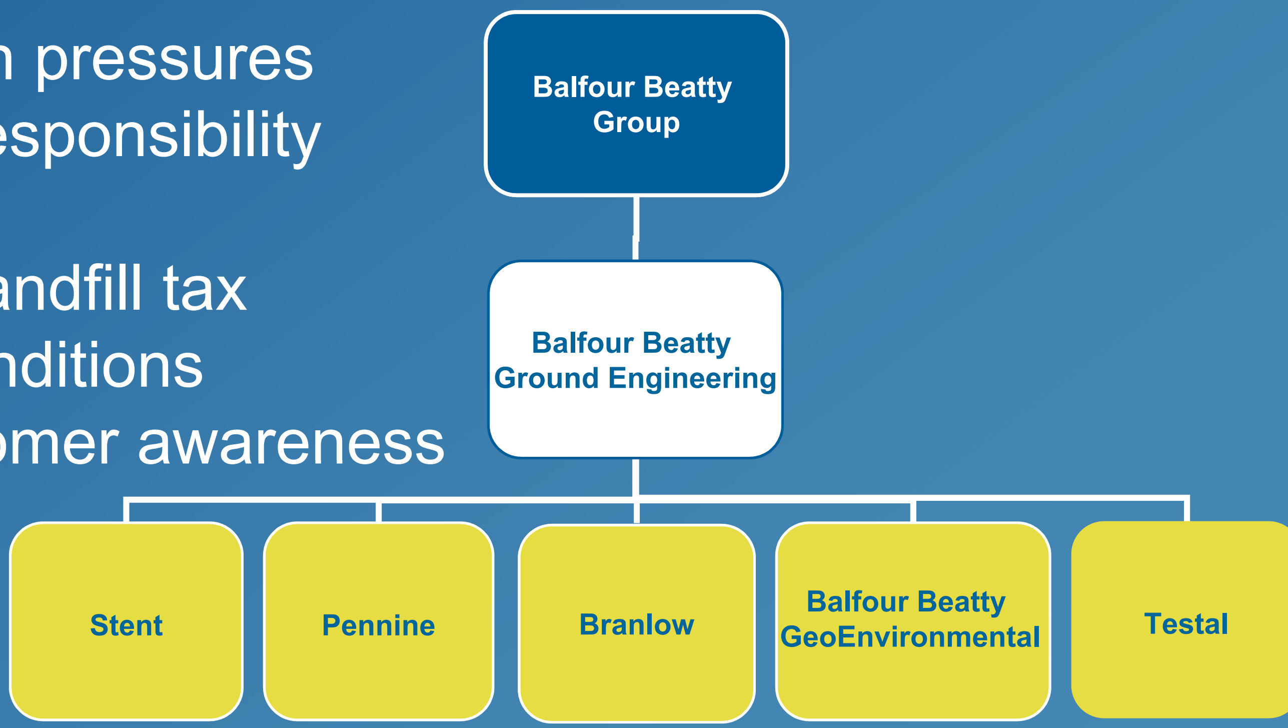
Corporate responsibility

Fuel costs

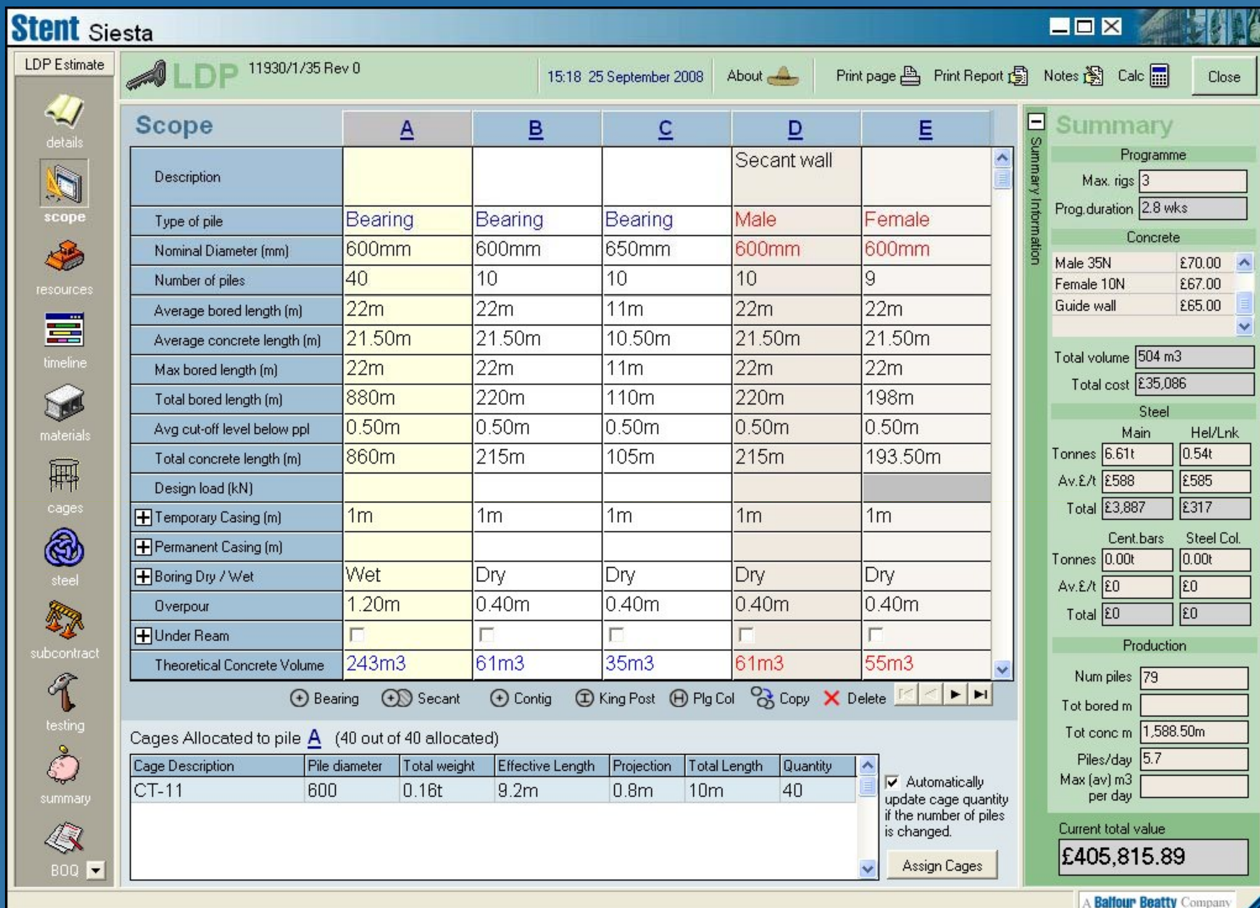
Escalating landfill tax

Planning conditions

Public/Customer awareness



An Introduction to Green Siesta



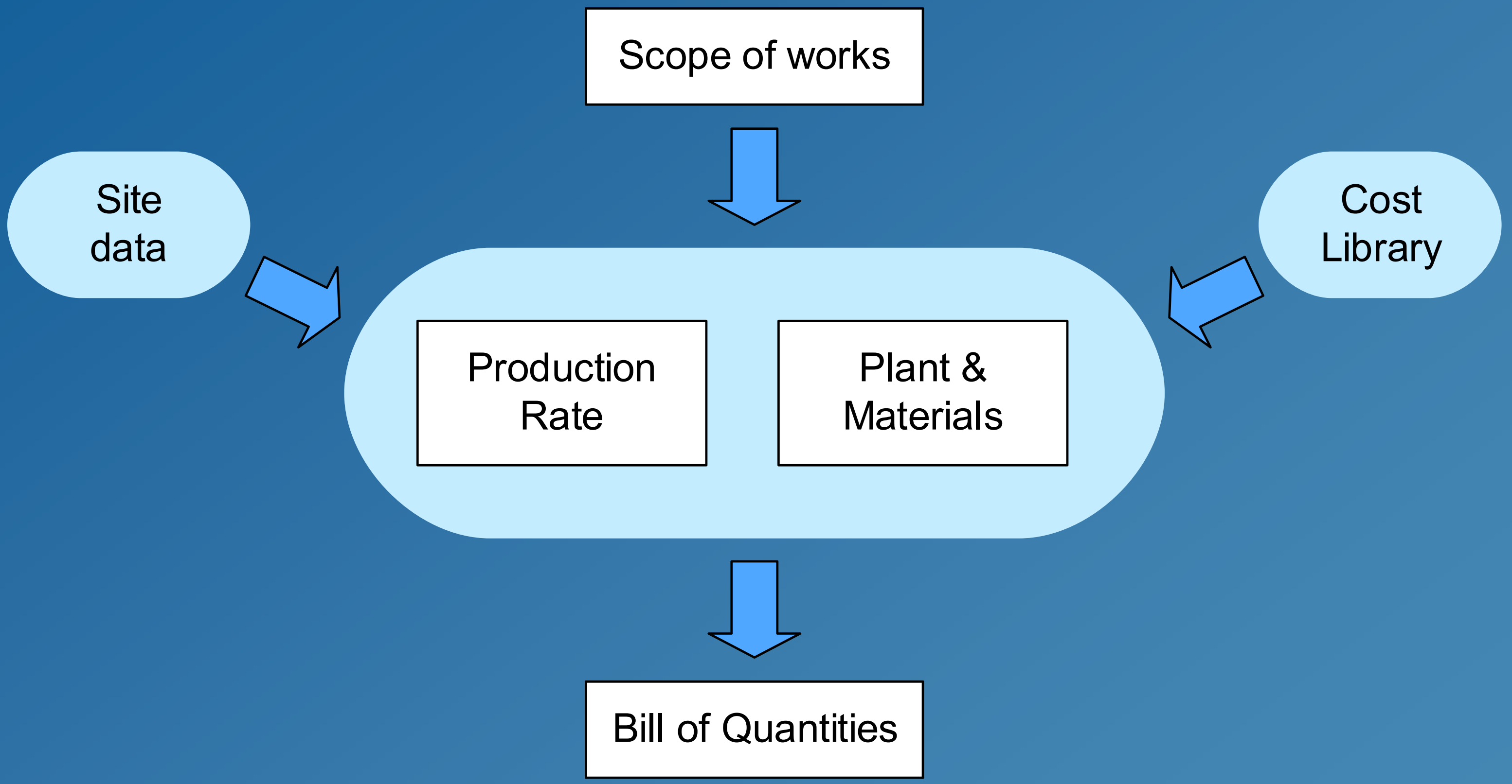
Available Techniques:

- CFA
- Pre-cast
- Sheet
- Rotary bored

In development:

- Micropile
- Bottom Driven

An Introduction to Green Siesta



Green Siesta

Key issue identified from a 2007 survey of Clients:

‘The need for clarity about sustainability and an understanding of the environmental impact of foundations, particularly in terms of reducing carbon emissions.’

It was decided a process was required that evaluated this aspect of our operations as easily as we assessed other environmental issues such as noise and vibration.

Green Siesta

How was this to be achieved?

Already had Siesta which uses a library of costs.

Which put simply:

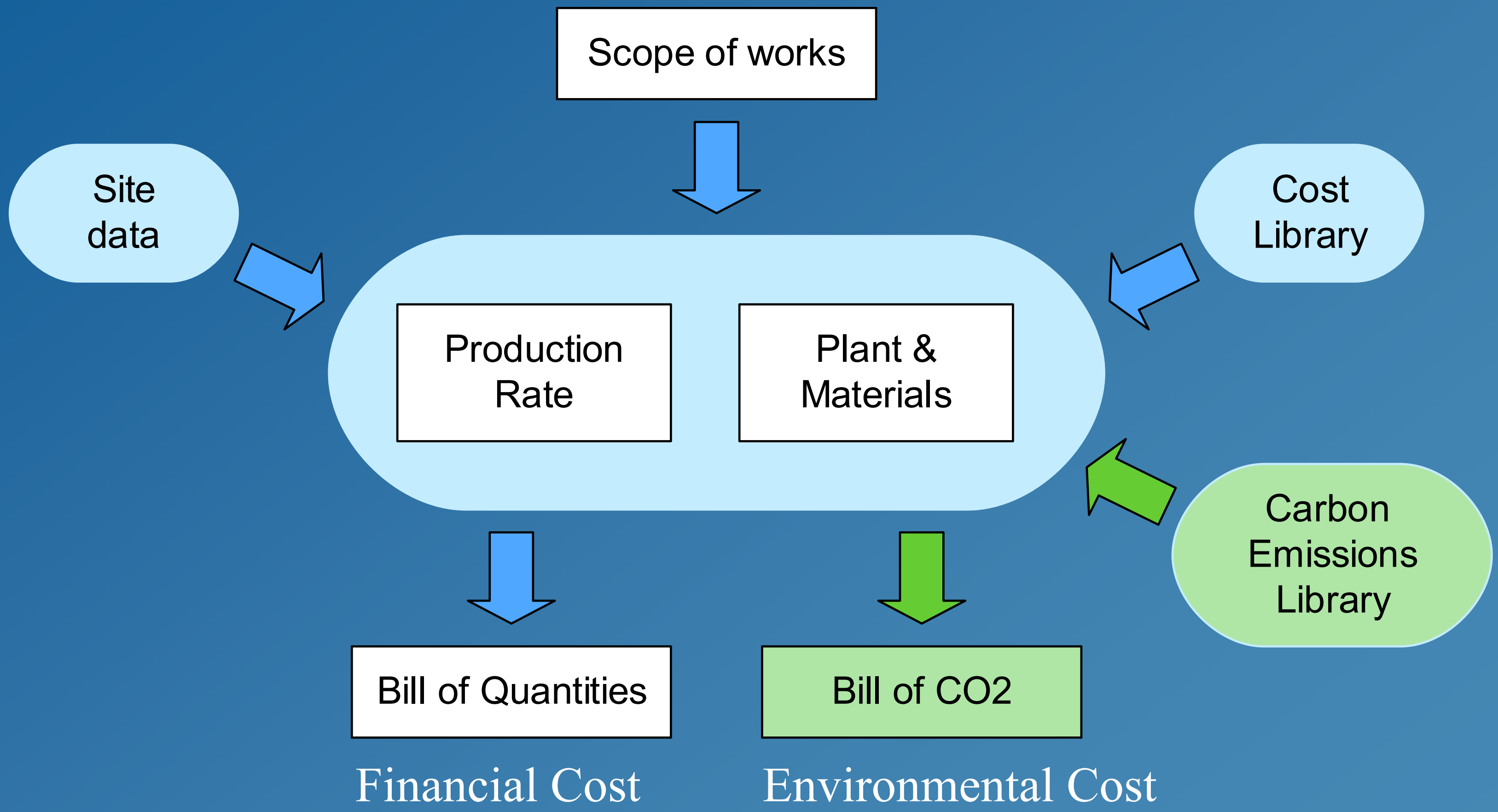
Unit Rate * Material Quantity * Productivity = Total Cost

Reasoned same approach could be used to calculate carbon emissions for a project.

Confident Siesta could be modified to include a ‘carbon calculator’

Difficult task was to identify and quantify the carbon significant elements of site operations.

Green Siesta



Identifying CO2 Emissions

Consultant: **NIFES**
National Industrial Fuel Efficiency Ltd

nifes
CONSULTING GROUP

WBCSD
World Business Council for Sustainable Development
Green House Gas Protocol - a Corporate Accounting and Reporting Standard

The Carbon Trust UK

CARBON TRUST

The Source of CO2 Emissions

ENERGY

- Concrete (60-70%)
- Steel (10-30%)
- Fuel (10-15%)

Quantifying: Cement

Large variation - plant type, fuel, age etc.

Lafarge Cement UK

Plant	Kg CO2/te
Aberthaw, S.Wales	703
Cauldron, Staffordshire	740
Hope, Derbyshire	760
Dunbar, East Lothian	810
Cookstown, N.Ireland	820
Northfleet, Kent	960
Westbury, Wiltshire	970

Quantifying: Cement

Different types of Portland cement from the ICE report

Method	Kg CO2/te
Wet kiln	970
Semi-wet kiln	930
Dry kiln	740
Semi-dry kiln	840

Siesta uses a NIFES advised average of 777 kg CO2/te

Replacement	Description	Kg CO2/te
Portland Ash cement	25-30% fly ash	585
Portland Slag cement	80-94% clinker, 8% slag	755
Portland Slag cement	20-34% clinker, 64-73% slag	279

Quantifying: Cement Replacement

London Concrete

Material	Source:	CO_2 from Transport	Embodied CO_2	Total CO_2 kg/te
PFA	West Burton	19.39	30	49.39
GGBFS	Purfleet	1.81	89	90.81

Civil and Marine: GGBFS 70 kg CO2/te
UK Quality Ash Association: PFA 25 kg CO2/te

Siesta uses NIFES recommended figures of:

Replacement	CO2 kg/te
GGBFS	89
PFA	25

Quantifying: Sand, Aggregate & Water

Figures Collated by NIFES

Material	kg CO_2/te	Data source
Sand & gravel	3.45	from Tarmac (UK average)
Crushed rock	3.23	from Tarmac (UK average)
Aggregate	3	from Hanson (UK average)
Crushed stone	3.40	from London Concrete
Sand (marine dredged)	7.79	from London Concrete
Sand (land-based)	3.49	from London Concrete

Water supply: 289 kg CO2 per 1 Million litres
(from the trade body Water UK)

Quantifying: Steel Bar & Rod

Type	Typical (UK market) kg CO_2/te	Primary material kg CO_2/te	Recycled material kg CO_2/te
General	1,820	2,820	450
Bar and rod	1,720	2,680	420

Problem: How to identify the source? How much is recycled?

Siesta uses the “typical” figure for auger bored and the “recycled” figure for Precast.

When considering steel for this exercise the typical value of 1,820kg CO_2/te was taken.

Quantifying: Fuel

Diesel: 2.630 kg CO2/litres - excludes indirect emissions (from DEFRA)

- Fuel use on site
- Transport of materials
- Mobilisation/ Demobilisation
- Spoil removal

Siesta approximates site fuel use from the Net Sales Value & the total fuel use for each technique per year

Quantifying: Fuel

Transport of Materials

Activity	Vehicle type	Load	Distance	Composition	Kg CO2 Per trip
Readymix	Rigid HGV	6m3	32km round trip	100% urban	17.23
Steel & Precast piles	Artic. HGV	24te	480km round trip	20% urban 40% rural 40% motorway	493.20
Reinforcement Cages	Artic. HGV	8te	480km round trip	20% urban 40% rural 40% motorway	493.20

Based on figures from
National Atmospheric Emissions Inventory

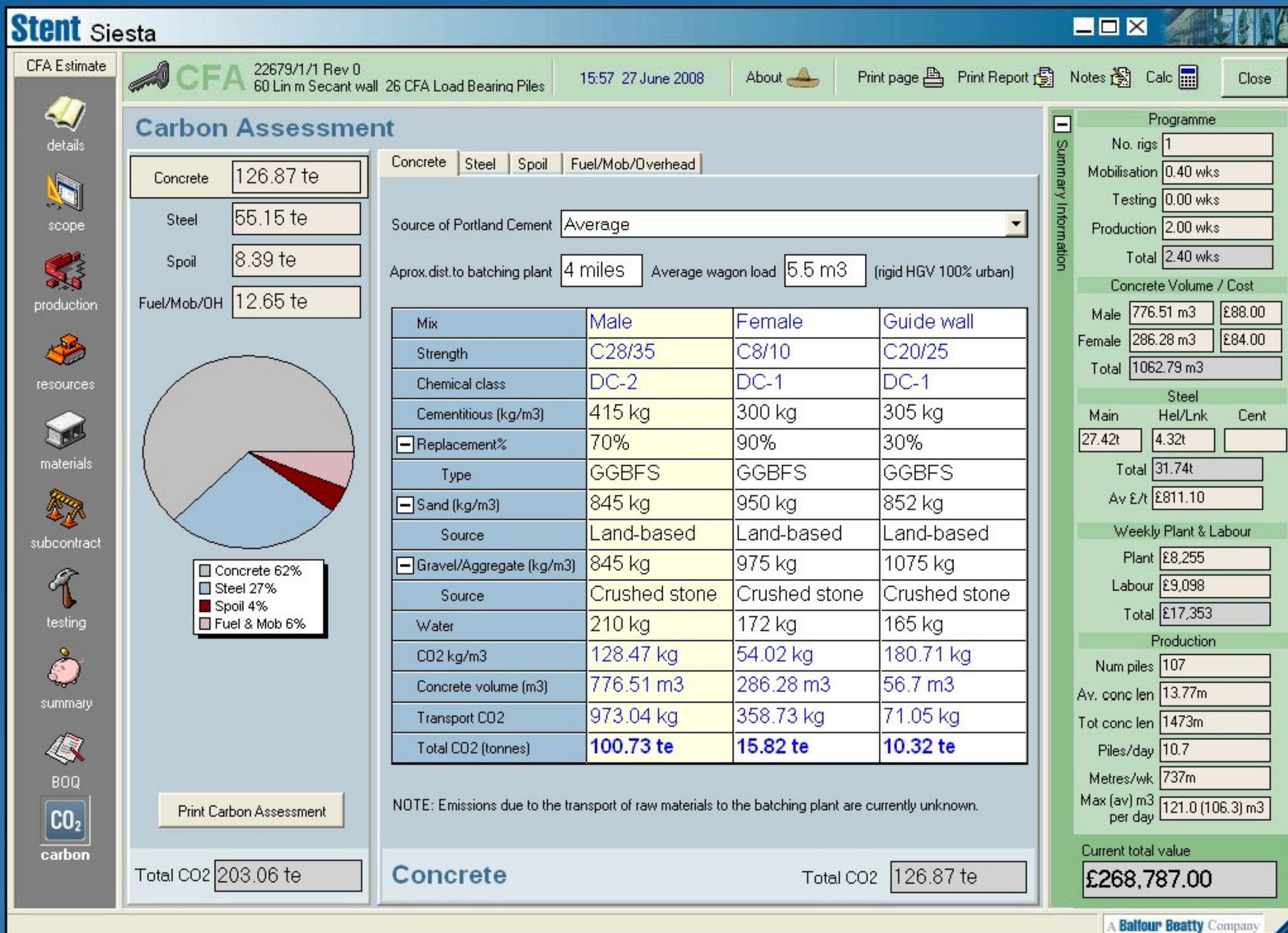
Quantifying: Fuel

Mobilisation / Demobilisation & Spoil Removal

Calculated in similar way & depends on distance:

Type of transport	Type of vehicle	Kg CO2 / km
General transport to site	Light Goods Vehicle	0.287
Machine delivery	Articulated HGV	1.022
Spoil removal	Rigid HGV	0.829

How Green Siesta calculates the CO2



Carbon Calculation Screenshot from CFA

Example CO2 Bills of Quantities

Stent CFA Carbon Assessment

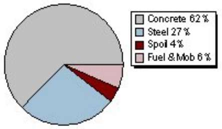
Head Office & Southern Office
Pavillion C2, Ashwood Park,
Ashwood Way, Basingstoke RG23 8BG
Tel 01256 400200 Fax 01256 400201

Estimate: 22679/1/1-CFA
Project: Grosvenor Waterside, Block A, London, SW1W 8QN
Tender: 60 Linm Secant wall & 26 CFA Load Bearing Piles
Prepared: 27/06/2008

Summary

Approximate tonnes of carbon dioxide embedded and emitted:

Concrete	126.87 te	(includes transport)
Steel	55.15 te	(includes transport)
Spoil	8.39 te	(transport only)
Fuel & Mob.	12.65 te	
Total CO_2	203.06 te	



Breakdown

Concrete

Concrete Mix	Strength/Class	Replacement	CO_2 Kg/m^3	Volume	Transport CO_2	Total CO_2
Male	C28/35 DC-2	70% GGBFS	128.47 kg	776.51 m3	973.04 kg	100.73 te
Female	C8/10 DC-1	90% GGBFS	54.02 kg	286.28 m3	358.73 kg	15.82 te
Guide wall	C20/25 DC-1	30% GGBFS	180.71 kg	56.7 m3	71.05 kg	10.32 te

Transport carbon is based on the batching plant being approximately 4 miles from site with an average load of 5.5 m3 per wagon.
Round trips are assumed by a rigid HGV and 100 % urban driving.

Steel

Reinforcement	Embedded CO_2	No. cages	Transport CO_2	Total CO_2
31.74 te	54.6 te	67	0.55 te	55.15 te

Embedded carbon is based on a UK market average for steel bar and rod of 1,720 CO_2 kg/te
Transport carbon is based on cage fabrication being approximately 50 miles from site with an average load of 20 cages per wagon.
Round trips are assumed by an articulated HGV with 40 % urban, 40 % rural and 20 % motorway driving.
Carbon emissions from the fabrication of the cages are not included.

Spoil

Total Spoil	Av. m3 per wagon	Av. haulage distance	Total CO_2
924.86 m3	9.5 m3	50 miles	8.39 te

Round trips are assumed by a rigid HGV with 50 % rual and 50 % urban driving.

Fuel

Estimated diesel use: 4,808 litres Direct CO2 emission = 12.65 te
Based on DEFRA data which currently excludes emissions from the manufacture of the fuel itself.

Mobilisation

No. articulated HGV's: 0 No. rigid HGV's: 0
Approx. mob. distance: 150 miles Transport CO_2 = 0 te
Round trips are assumed by an articulated HGV with 40 % urban, 40 % rural and 20 % motorway driving.

Calculations are based on figures provided for Stent by Nifes Consulting Group
www.nifes.co.uk

Stent Precast Carbon Assessment

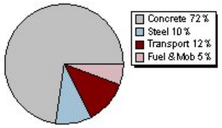
Head Office & Southern Office
Pavillion C2, Ashwood Park,
Ashwood Way, Basingstoke RG23 8BG
Tel 01256 400200 Fax 01256 400201

Estimate: 22741/1/1-PRE
Project: 25-27 Rose Kiln Lane, Reading, Berkshire
Tender: 275 sq piles in gravel
Prepared: 27/06/2008

Summary

Approximate tonnes of carbon dioxide embedded and emitted:

Concrete	59.66 t
Steel	8.31 t
Transport of piles	9.86 t
Fuel & Mobilisation	4.49 t
Total CO_2	82.33 t



Breakdown

Concrete

Strength/Class	Replacement	CO_2 Kg/m^3	Volume	Total CO_2
C45/20 DC-3	25% PFA	291.24	204.84m3	59.66 t

Transport of the raw materials for the concrete to the precast factory are included in the calculation

Steel

	Total weight	CO_2 Kg/te	Embedded CO_2
Reinforcement	19.8t	420	8.31 t
Pile joints	0 t	420	0 t

Embedded carbon is based on steel bar and rod manufactured in the UK from scrap steel* at 420 CO_2 kg/te
Carbon emissions from the fabrication of the joints and cages are not included.
*Based on assurances given to us by our suppliers.

Pile Transport

Number of wagons: 20 Approx. transport distance: 150 miles Transport CO_2 = 9.86 t
Round trips are assumed by an articulated HGV with 40 % urban, 40 % rural and 20 % motorway driving.

Fuel

Estimated diesel use: 1,709 litres Direct CO2 emission = 4.49 t
Based on DEFRA data which currently excludes emissions from the manufacture of the fuel itself.

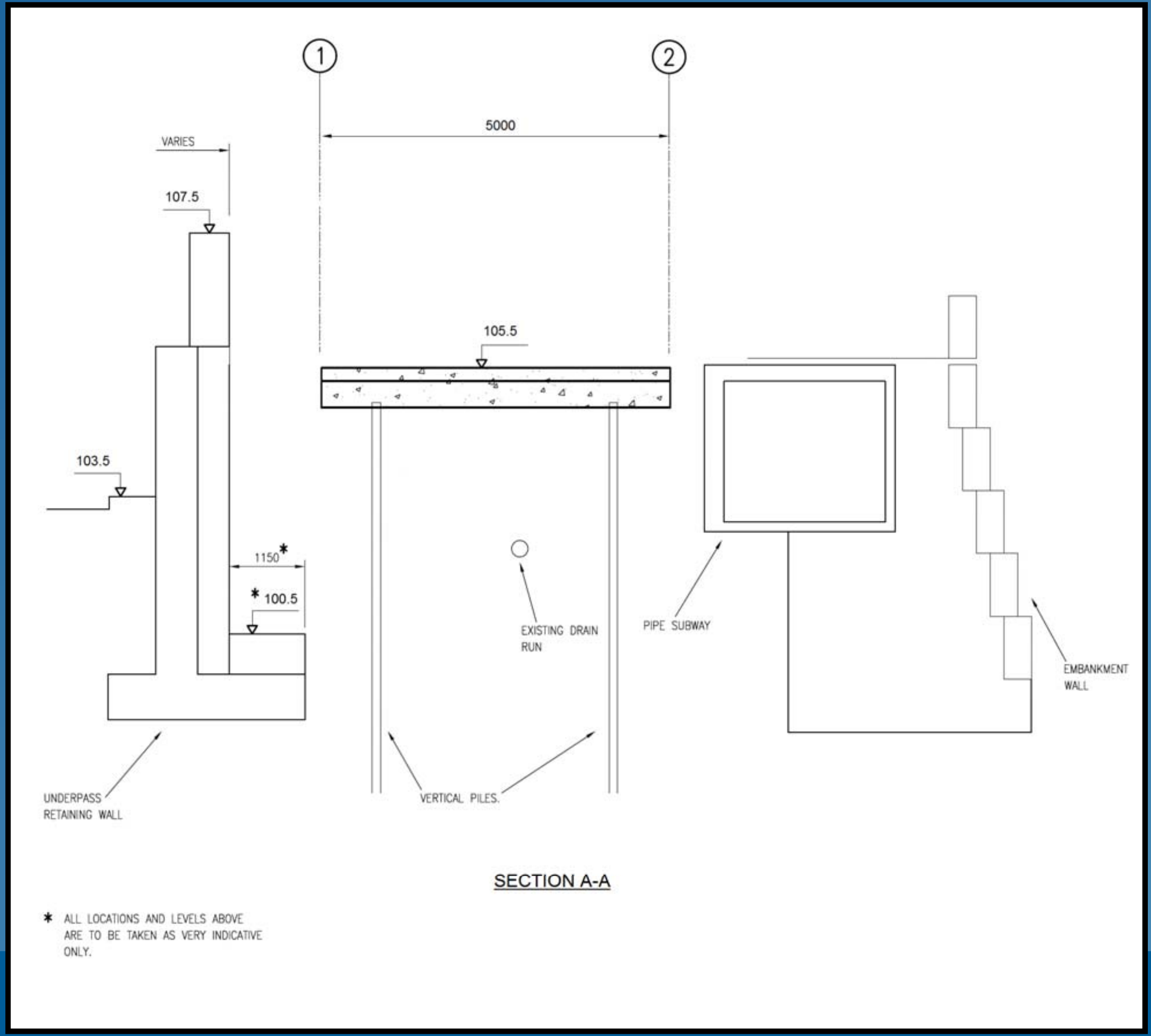
Mobilisation

No. articulated HGV's:
No. rigid HGV's:
Approx. mob. distance: 150 miles Transport CO_2 = 0 t
Round trips are assumed with 40 % urban, 40 % rural and 20 % motorway driving.

Calculations are based on figures provided for Stent by Nifes Consulting Group
www.nifes.co.uk

Case Study: Site in London

- Proposed construction of a lightly loaded two storey structure on an elevated section of walkway.
- Particularly difficult site constraints – underpass immediately north and embankment to south.
- Ground Conditions – Thickness of Made Ground and likely occurrence of obstructions
- Column Loads of 250kN



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Case Study: Site in London

Typical Geological Model:

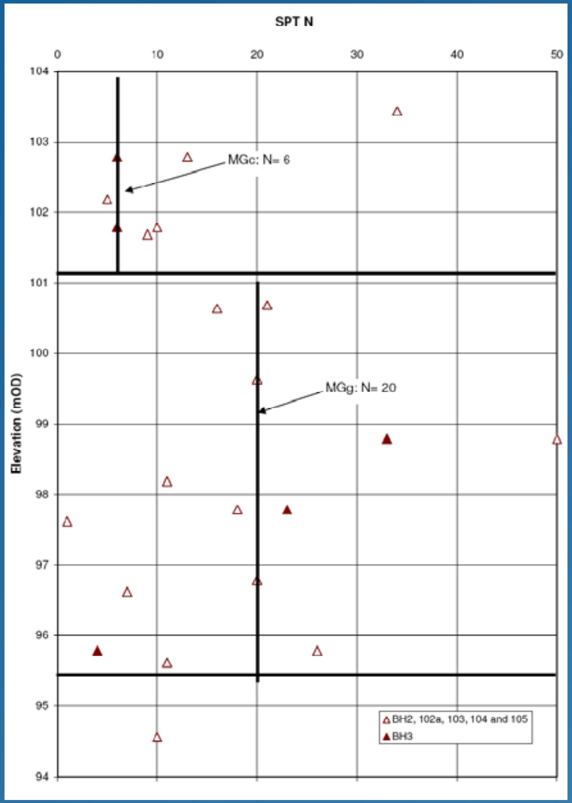
Stratum	Level of Top of Stratum mAOD	Level of Top of Stratum mBGL	Typical Thickness m	Typical Description
Made Ground	104.7	Ground Level	8.5	Brown and grey sandy fine to coarse angular and subangular gravel sized fragments of sandstone, siltstone, brick, chert, quartz and concrete.
River Terrace Gravels	96.2	8.5	4.7	Medium Dense brown fine to coarse SAND and fine to coarse angular to rounded GRAVEL of chert, quartz, sandstone and siltstone. Occasional cobbles.
London Clay	91.5	13.2	Proven to 16.8m	Stiff brown slightly sandy CLAY.

Groundwater was recorded at 100.0mAOD (approximately 5.0mBGL)

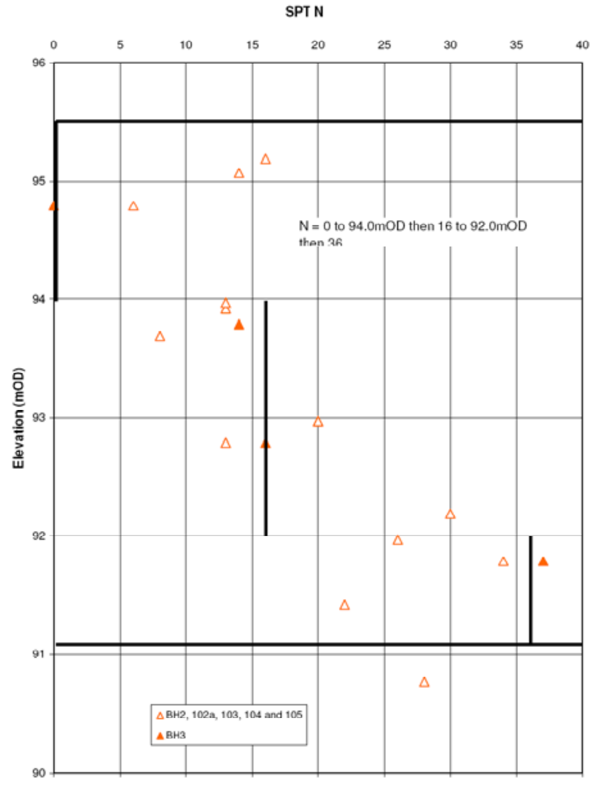
Case Study: Site in London

Design Profiles Vs Elevation:

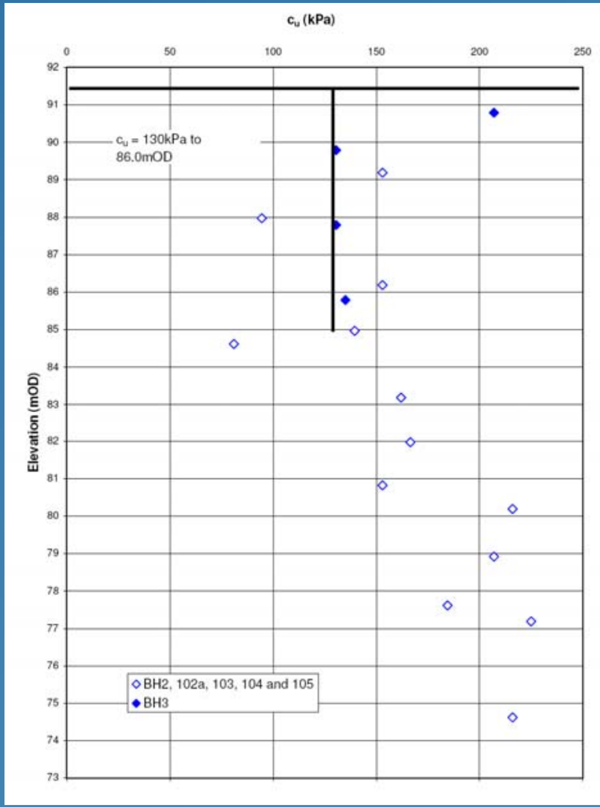
Made Ground



River Terrace Gravels



London Clay



Case Study: Site in London

Design Considerations

- Three options considered for carbon assessment comparison:

Type	Diameter mm	Length m	F.O.S.	S.W.L kN	Testing
Micropile	40/16 hollow bar with 175mm clay bit	13.3	2	250	Non working pile test
Bottom Driven	220	11.0	2.5	250	Dynamic pile test
Auger Bored	300mm	20.5	3	250	None

Case Study: Site in London

It should be noted that this exercise is solely for the comparison of carbon dioxide emissions for various restricted access piling methods.

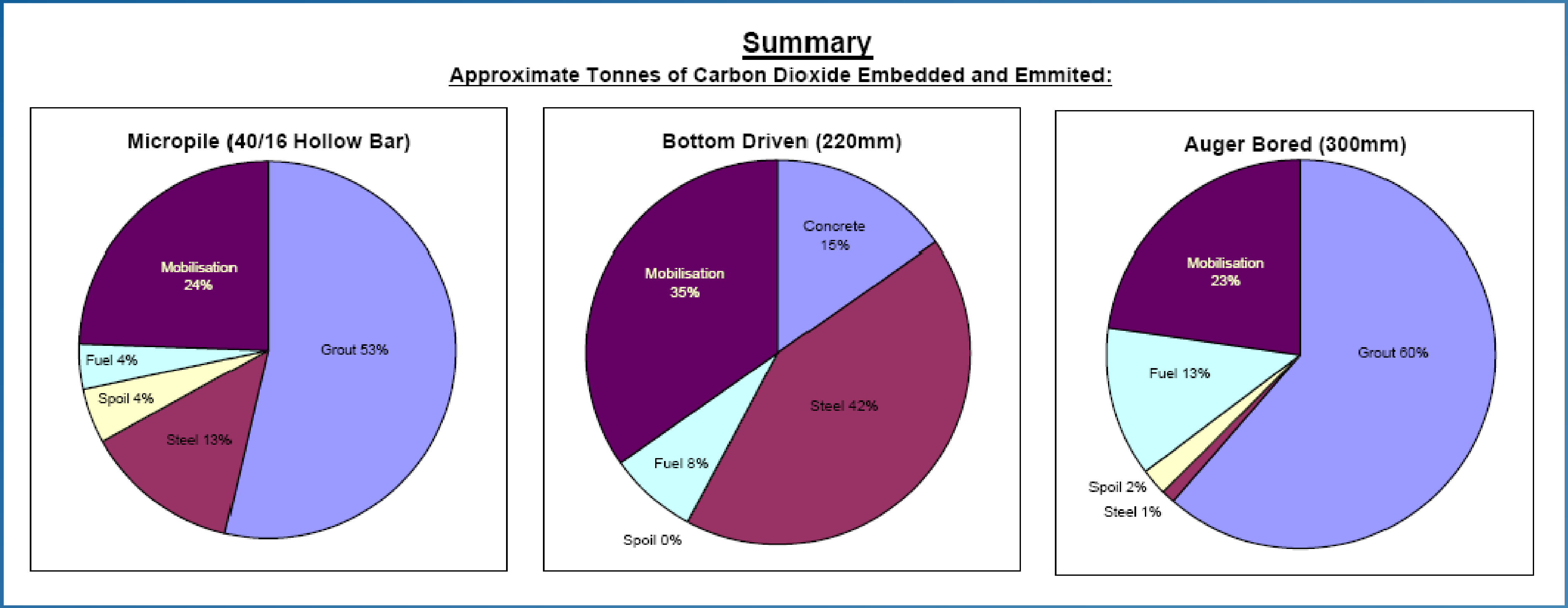
A micropile solution for this project was chosen based on the following advantages - programme, limited spoil generation and the ability to overcome the anticipated obstructions in the Made Ground.

Case Study: Site in London

Quantity of Materials Per Pile for Each Method:

Type	Grout / Concrete te	Steel te	Spoil m^3	Fuel litres	Mobilisation
Micropile	1.02 Grout	0.1	0.4	23	1 No. Rigid HGV Approximate mobilisation distance 352 km
Bottom Driven	1.2 Readymix	0.24	none	28.5	1 No. Rigid HGV Approximate mobilisation distance 352km
Auger Bored	2.50 Grout	0.024	1.8	150	1 No. Articulated HGV 1 no. Rigid HGV Approximate mobilisation distance 352km

Case Study: Site in London



Case Study: Site in London

Summary

Approximate Tonnes of Carbon Dioxide Embedded and Emmited:

Type	Grout[1] / Concrete[2]	Steel[3]	Spoil[4]	Fuel[5]	Mobilisation [6]	Total
	te CO_2	te CO_2	te CO_2	te CO_2	te CO_2	te CO_2
Micropile	0.79	0.2	0.066	0.06	0.36	1.48
Bottom Driven	0.16	0.44	None	0.08	0.36	1.04
Auger Bored	1.94	0.04	0.066	0.4	0.72	3.17

1) Siesta uses a NIFES advised average of 777kg CO_2/te
2) Siesta uses a calculated average of 328kg CO_2/m^3
3) Siesta uses a NIFES advised average of 1,820kg CO_2/te
4) Transport only. Based on 50 mile trip, 50% urban and 50% rural
5) Based on DEFRA recommendation of 2.630kg CO_2/litre
6) Round trips are assumed by an articulated HGV with 40% urban, 40% rural and 20% motorway driving

Discussion – Bottom Driven

Bottom Driven produced least carbon emissions.

Why?

Although large amount of steel used there was not a great volume of concrete.

In this instance concrete was the lesser of two ‘carbon evils’. Both the micropile and auger bored methods used a cement grout which produces three to four times as much carbon per tonne.

No spoil and therefore no carbon emissions.

Discussion – Micropile and Auger Bored

Micropile close second – Main factor was the use of cement

If a cement replacement was used e.g. PFA or a lower strength grout (0.4 w/c ratio was used) this would significantly reduce the amount of carbon emissions produced.

And lastly Auger Bored;

Worst Offender – Least design efficient i.e. longer pile length = greater materials.

Discussion – General

- Mobilisation ratios and fuel similar in comparison
- If steel is considered 'recycled' it has a dramatic effect
- Varying ratios in steel:grout/concrete for different methods
- F.O.S lower the more testing is undertaken = Lower CO_2
- Big potential for variation due to;
  - Reference data
  - Use of grout Vs. Concrete
  - Use of cement replacement (PFA) Vs. OPC
  - Use of recycled Steel Vs. General (Confidence in Source / Traceability)

CAUTION…

High variability in published figures

More work is required to determine the accuracy of the figures

Therefore Siesta is primarily a tool for COMPARISON

As such Siesta *does* give clients *choice*.

Conclusion

- Lowest $C0_2$ is nearly always lowest cost.
- Therefore SUSTAINABLE = AFFORDABLE
- With the correct choice of materials;

'Micropiles are the GREEN choice'

Dziękują

Dankeschön

Grazie

¡Gracias!

Merci

Tak for lån

Takk

Thankyou