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Technical Review

RBKC – Basements Policy Public Consultation Response

Waterman Energy Report

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Executive Summary

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Introduction

Eight Associates have been appointed to undertake a technical review of the technical reports submitted under the second Public Consultation period for the new basement policy of the Royal Borough of Kensington and Chelsea.

Specifically, this technical review intends to provide a review of the Waterman technical report submitted during the second public consultation period that has the stated objective:

" to carry out a critical review and recalculations of the claims made in a report produced by Eight Associates in February 2014:' Life Cycle Carbon Analysis of Extensions and Subterranean Development in RBKC".

In the following sections the main issues highlighted and analysed by the Waterman report are identified and discussed in further detail.

A summary of the Eight Associates' responses to key issues can be found in the left hand column of the following analysis. The technical detail is contained in the right hand column.

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Issue 1

Summary:

Use of BRE Green Guide rating incorrectly used

Eight Associates Comments summary:

Eight Associates' build-ups selection is in line with Life Cycle Analysis best practice, and are demonstrably representative of basement construction elements.

Waterman: *" The BRE Green Guide to Specification has been used to compare the materials between the case studies. Having analysed the Green Guide to Specification profile used, the element selected for the Basement external walls, floor and ground floor, is in fact a profile for a roof. As the BRE state, the embodied carbon for this element includes for the provision of plasterboard and paint to the underside, as well as assuming the thermal performance of the insulation. Such inaccuracies will therefore impact on the embodied energy of the basement, and further information is required."*

Effectively, the element selected to calculate the embodied carbon of basements floors, external walls and roofs was based on a roof build up.

The build-up selected by Eight Associates has the following description:

BRE Green Guide build up
In situ reinforced concrete slab, vapour control layer, insulation, Polyester cold applied liquid waterproofing membrane system.

The build-ups from the Cranbook Basements case study selected for the Waterman's report (49, Redcliffe Road – Dwg, TD 17) are as follows for basement walls and floors slabs:

Floor slab – Cranbrook build up
B503 mesh top, in situ reinforced concrete slab, cavity drain, insulation, screed, floor finishes.

Basement wall – Cranbrook build up
B1131 mesh, in situ reinforced concrete, A393 mesh inside face, cavity drain, insulation, wall lining

When comparing the three build-ups, the main building elements are essentially the same - in situ reinforced concrete and insulation. The additional elements are linked with the waterproofing membranes recurrently used in basements walls and floor construction. Drawing No TD 17 from Cranbook basements (as per RBKC planning applications website) shows that these membranes are also present both in the basement external walls and ground floor slab from Waterman's report case study.

Therefore, the selected Green Guide profile is suitable and representative of a basement typical build-up.

Also, the Green Guide roof build up selected targets an U-value of 0.25 W/m²K, in line with maximum Part L Building Regulations U-values allowed for these elements.

Therefore, it is our opinion that Waterman's comment stating that it was incorrect to use a roof build-up for walls and basement floors is erroneous.

Issue 1 continued

Eight Associates based all calculations on the best available methodologies. All assumptions are appropriately referenced and justified in the report.

In reference to the Waterman's comment that the selected build-ups are inclusive of plasterboard and paint, and as such they change the calculations results, we believe this not to be accurate. In the drawings from the Cranbook Basements case study used in Waterman's report it is demonstrable that basement walls include walls finishes such as plasterboard and paint. The floors, although they don't include plasterboard and paint will certainly include some type of floor finish, therefore we feel that the comment is superfluous and imbalanced.

Issue 2

Inaccurate BRE Green Guide Rating

Eight Associates Comments summary:

Eight Associates has selected the best available data to use in the study with the aim of achieving a balance between the inherent level of uncertainty, and providing a standardised and reliability methodology.

Waterman: *" Due to the Green Guide rating for a Zinc roof not being available, this was substituted for a Lead Roof. Such substitutions will impact on the embodied energy for the roof and could have either a negative or positive effect on the final figures."*

Unfortunately the Green Guide for materials specification does not offer the option of zinc roofs and therefore the best available data was used, which in this case was a lead roof. Even in the International EPD® System, companies and organisations are allowed to use a defined proportion of selected generic data and other generic data in their LCA calculation. This is because one of the main constraints of a life cycle assessment is the availability of data.

In this specific case, the calculation of the embodied carbon of a zinc roof would have to be carried out using a completely different methodology than the one used in the BRE Green Guide. Consequently the necessary assumptions would be substantial to capture a 60-year life cycle, waste and materials, and transportation to and from site. This alternative methodology would introduce many associated inaccuracies and assumptions to create a detailed material profile. Eight Associates therefore opted for a standardised methodology and used the best available data for the study.

Issue 3

Embodied carbon from transport and waste manufacturer is double counted.

Eight Associates Comments summary:

Eight Associates' methodology and LCA system boundaries are clearly and well defined in page 14 of the report. There are no double counted items.

Waterman: *" The BRE Green Guide to Specification Embodied Energy calculations include for the transport of waste away from site, and an allowance of 15% wastage for each material used. The embodied energy for transport and waste has been calculated separately as part of Eight Associates report; therefore, such items have been double counted."*

The only waste considered for the embodied carbon of construction works was spoil removal and demolition waste, which is accounted for in the BRE Green Guide. There are no double counted items.

As page 14 from Eight Associates 2014 report clarifies:

1 – Embodied carbon – "At this stage the inventory included all the carbon emissions related to the building's material processes, from raw materials acquisition to the materials' processing impacts, deliveries on site and refurbishment and end of life data for the 60 years, all provided in an aggregate CO_2eq from the BRE Green Guide tool"

2- Construction works embodied carbon – "During this stage, estimates of the quantity of electricity and fuels used on the project site are used, as well as the removal of spoil and demolition waste from the site. The fuel consumption of the machinery and vehicles used and the electricity consumed at the site during the constructions works are accounted for. The transportation for workers to and from site is excluded."

Therefore, Eight Associates has not double counted embodied from transport and waste, the author is mistaken.

Issue 4

Assumptions have been made in respect to distances waste travelled from site.

Eight Associates Comments summary:

LCA and Carbon Footprints methodologies imply assumptions, as typically information is not detailed enough and available for the complete life cycle analysis. Eight Associates assumptions are in line with LCA best practices and follow international standards guidelines.

Waterman: *" The Eight Associates report acknowledges that where data has not been available, significant assumptions have been made. Such assumptions will result in significant differences in Life Cycle Carbon outputs, therefore, influencing the results."*

This is a speculative comment. Life Cycle Assessment methodologies are not an exact science and are flexible tools that aim to compare a range outcomes assignable to process.

Uncertainty in LCA is considered to be the main flaw of the many methodologies. As per the document from UNEP/SETAC "Life Cycle Initiative Life Cycle Impact Assessment Programme", which analyses best practices in LCA assessments, the following is clear:

" It was recognized early on in the methodological development of LCA that cause-and-effect relationships are sometimes difficult, if not impossible to prove. Therefore, in contrast to more absolute approaches, such as environmental risk assessment (ERA), LCIA is a tool for comparing relative measures of impact using surrogate methods *(e.g., stressors effects concepts) (Fava et al. 1992, Barnthouse et al., 1997)."*

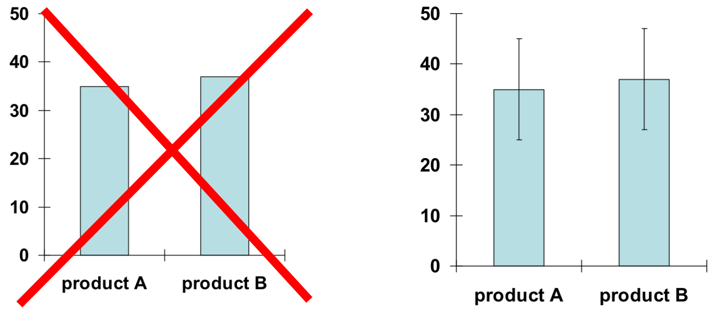
The Eight Associates report clearly states that the main goal of the presented work is to compare and contrast, using similar and standardised assumptions, the relative carbon footprint of above ground extensions and subterranean extensions.

Therefore, where uncertainty is presented in the study, Eight Associates has tried to provide the same level of certainty for both for above ground and subterranean extensions in relation to the assumptions by using standardised data sources and methodologies. Both types of extension were treated the same and no exceptions were made.

Also, one of the best tactics to mitigate uncertainty in LCA or similar technical assessments is through sensitivity analysis. Eight Associates report chapter "Sensitivity analysis of results" aims to discuss and analyse the results from previous chapters evaluating different scenarios for the selected case studies, allowing the results to be questioned with a determined level of confidence in line with the graphs shown on the following page. This means that in this chapter different scenarios were considered to weigh the precision of the results and to understand if the change of variables could significantly alter the results of the study.

Issue 4 continued

Even using the best scenarios available for subterranean extensions (i.e. use of recycled concrete), subterranean extensions still presented a higher carbon footprint than above ground extensions.



The diagrams above show the appropriate interpretation of a LCA. Note that a unanimous conclusion is not the aim, the aim is to demonstrate a range of potential outcomes.

Finally, a benchmark analysis was performed to analyse if the results from the report were in line with other scientific and similar published studies. Page 47 of Eight Associates report shows that benchmark studies (please see ref 23 and 24 from the Eight Associates references list) show that the embodied carbon impact of a building life cycle is generally around 15 - 20% of the total carbon footprint of the building. Eight Associates analysis concluded that the results of the report showed that, for extensions, the sum of the embodied carbon of materials and the carbon emissions of the construction works were approximately 24% of the building's life cycle. For basements the figures were likely to increase to 29%.

The report concluded that the results follow the trend of findings from similar studies and the higher contribution of the embodied carbon in the Eight Associates results could be attributed to the fact that end of life of materials and associated operations is included in the carbon factors used (i.e. the BRE Green Guide), while for other stages was excluded (i.e. Construction works, Operational phase).

Issue 5

Assumptions have been made regarding construction practices.

Eight Associates Comments summary:

Eight Associates considers that the Embodied Carbon from construction works was likely to present a high level of uncertainty, however this phase represents only 4-5% of the total carbon emissions of the case studies and therefore the associated uncertainty is not relevant enough to affect the study's key findings.

Waterman: *"The Eight Associates report assumes that standard construction practices have been used i.e. basement excavation included the use of intensive machinery. The use of alternative modes of transport has also not been considered."*

Eight Associates Report emphasises that the construction works results are the life cycle phase of the building where the results are most likely to be less accurate because of the lack of detailed and accurate data for each of project's construction works (please see page 20 of the Eight Associates report). However, Eight Associates report also shows that the carbon emissions from the construction works phase represent only 4-5% of the total carbon emissions of the buildings analysed and therefore, the uncertainty present in these calculations is not likely to change or affect significantly the results (please see page 45 of Eight Associates report).

The assumptions and machinery made for the construction works were based on discussions with Baxter's basement experts and the reports submitted by Baxter's under this public consultation and the Construction Method Statements and Traffic Management Plans submitted for each project planning application.

Issue 6

Change in scope for each phase of analysis impacts on overall figures.

Eight Associates Comments summary:

Eight Associates methodology and scope of analysis is clear and well defined in the report methodology. The exclusion of uncertain variables does not invalidate a study.

Waterman: *" The Eight Associates report has acknowledged that the full Life Cycle of building services has not been undertaken, and a cradle to site approach has been adopted. Although valid, due to the same approach being adopted for all case studies, this does result in the skewing of the overall data. For example the life cycle of a gas boiler is expected to be approximately 20 years, whereas the life span of a ground source heat pump can be approximately 50 years."*

This comment is speculative, does not provide a critical analysis and it is not clear in its content.

The building services life cycle analysis was not undertaken due to its level of uncertainty and lack of available and accurate public data concerning the embodied carbon of the different mechanical systems (gas boilers, heat pumps, etc). The analysis of each of the mechanical systems used for each case study would involve a detailed analysis of all the components of each system, from material extraction to manufacture, which would represent intensive data gathering and several significant assumptions would have to be made. This would have produced a myriad of outcomes within the analysis. Although this consideration would be an interesting topic for further study it was not considered to be beneficial on the whole when added to the Eight Associates study.

Therefore, in order to maintain coherence in the analysis and to mitigate uncertainty this analysis was excluded.

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Issue 7

Analysis of each phase of embodied energy.

Eight Associates Comments summary:

Eight Associates methodology and scope of analysis is clear and well defined in the report methodology. The exclusion of uncommon variables does not invalidate a study.

Waterman: *" Eight Associate reports indicates that Embodied Energy is higher for basements due to increased periods of excavation and construction. Such periods may also include the installation of ground source heat pumps or other renewable technologies, therefore, impacting on the results."*

This comment is speculative, does not provide a critical analysis and it is not clear in its content.

This comment seems to suggest that not considering the simultaneous installation of renewable technologies limits the study. As with Issue 6, this particular variable is very uncertain. Seemingly the only applicable technological consideration would be the installation of ground source heat pumps with pile foundations. Whilst this may be an interesting study, to Eight Associates' knowledge none of the case studies used within the analysis featured this and it is a very rare occurrence in reality. It did not feature in the case study chosen to further analysis by Waterman and Cranbrook Basements.

Issue 8

Impact of each Embodied Carbon Phase.

Eight Associates Comments summary:

Eight Associates methodology and scope of analysis is clear and well defined in the report methodology. A 60 year life cycle was consistently applied in the study.

Waterman: *" Eight Associate's report, research has demonstrated that embodied carbon impact of a building life cycle is generally around 15-20% of the total carbon footprint of the building, supporting more conclusive reviews of case studies undertaken by Remsh et al (2010).*
Embodied energy during operation has only been considered on a yearly basis, not over the 60 years, as required. This suggests that the embodied carbon omitted during construction is a greater proportion of carbon than it effectively should be."

The comment from Waterman is not clear. However, Eight Associates has defined a clear project boundary and a defined life cycle of 60 years for the building in line with most recent advanced research and in line with the BRE Green Guide for materials specification methodology. This also follows the recommendations provided in the critical review of the Eight Associates report from 2010 by MES Energy Services and Basement Force reports.

With the exception of the embodied carbon for the construction works phase, the whole analysis was performed for a 60-year period (embodied carbon and operational carbon). Therefore this comment is completely wrong and spurious.

Issue 9

Operationally carbon emissions are based on assumptions.

Eight Associates Comments summary:

Eight Associates have chosen the most applicable and approved software available. Cooling load is limited in the UK so the benefits of reduced cooling are not that significant.

Waterman: *" The Standard Assessment Procedure (SAP) software used to calculate the operational energy is based on regulated energy. It does not include unregulated energy i.e. supplementary heating sources, small power and equipment, room function.*
The software also doesn't take into account thermal flows, therefore, the true impact of solar gains, and use of thermal mass to reduce basement cooling load in the summer isn't accounted for. The lack of data will result in emissions being skewed."

The analysis did not include unregulated energy. This can vary significantly from dwelling to dwelling. For sustainability purposes the Code for Sustainable Homes Ene 7 calculator could be used to determine the related emissions. However, the level of accuracy for the calculation tool is limited and it is unclear what differences this would potentially highlight between above ground extensions and basements.

Eight Associates accepts that the UK Governments approved Standard Assessment Procedure software does have flaws in its methodology. However, it is the most widely available and approved tool for assessing a dwelling's carbon emissions and certifying residential dwellings under Part L of UK Building Regulations. Also, the relative impact of the solar gain and thermal mass factors, which SAP does not capture accurately enough, is not certain. In relation to thermal mass and cooling load, although basements may provide a more stable internal temperature, the cooling load in the UK is typically quite small and limited to short periods within the year so any benefit realised from this would most likely be limited.

Issue 10

Operational carbon emissions calculation method is impacted by policy.

Eight Associates Comments summary:

Eight Associates have chosen the most applicable and approved software available. The limitations of the SAP software will not disproportionately affect the basement chosen by Waterman and Cranbrook Basements for the analysis.

Waterman: *" The calculation methodology used to undertake the analysis was SAP 2009. This Government approved calculation methodology has been designed to compare the energy performance of dwellings to that of the building regulations limits. Compliance means that dwellings achieve the requirements of Building Regulations Part L. Although such a tool is the approved method by which to calculate Building Emissions, it is based on a number of assumptions, and weightings dependent on policy. The software favours materials with low thermal mass, suggesting that occupants will respond to temperature changes more quickly, and thus reduce energy consumption, when compared to developments with high thermal mass. As such this favours timber framed developments, when compared to the high thermal mass associated with basements. The software compares energy derived from gas differently to energy from electricity. However, the availability to source the electricity to operate the heat pump from low and zero carbon sources is not accounted for. In effect such a strategy could result in the operational energy for heating, cooling, and lighting to be zero."*

As the software is the most widely used and accredited software, as well as being the software required to demonstrate compliance with BREEAM Domestic Refurbishment it is the most appropriate choice for the analysis. SAP typically calculates a small improvement in associated carbon emissions for dwellings with high thermal mass relative to low thermal mass, however, it is quite small.

Issue 10 continued

It is worth noting that the Cranbrook Basements drawings for 49 Redcliffe Road show the basement wall build-up to be: wall lining, insulation, cavity drain and concrete. Thermal admittance is typically limited to approximately 100mm within the build-up. For 49 Redcliffe Road the initial 100mm of the basement wall is most lining and insulation, which has very low, thermal mass, for the basement floor, only the screed has thermal mass. Therefore, in this circumstance SAP would not impose a meaningful penalty on the chosen basement scheme.

Issue 11

Operational Energy of the extension / basement is not considered in isolation.

Eight Associates Comments summary:

Eight Associates' methodology has been designed in order to address the limitations of the previous work, as highlighted by other consultants. This considers the' net increase' in carbon.

The 2014 Waterman study does not include the operational carbon, which is typically 80% of the lifecycle carbon.

Waterman: *" The context of the life cycle of operational energy needs to be taken in either the context of the basement, and not the retrospective improvements to the existing development, or the complete development. This is because the developments are new additions to the building; therefore, the operation of them will cause carbon dioxide emissions to be omitted. Currently, the Eight Associates report has changed the parameters of the Life Cycle Assessment for the operational phase by including the performance of the existing development as well. This means that for the operational elements covers total emissions from the dwelling and not just from the extension / basement."*

This comment is flawed. It is true that adding a new part of a dwelling to an existing dwelling will reduce the emissions of the existing dwelling when considered in isolation. However, the dwelling must be considered as a whole, parts cannot be excluded intermittently. If new additions are made to a dwelling, the dwelling will still be used as one unit so it must be considered as a whole.

During the previous consultation period, criticism was made by various consultants regarding the methodology used for the Eight Associates 2010 report, here the analysis considered the basement or extension in isolation without including the existing dwelling.

The Waterman's 2013 Report submitted at the time (written by the same author as the current report) which critiqued the Eight Associates 2010 report stated the following:

" SAP methodology for extensions, as defined under Part L1b, requires the existing dwelling with a Part L defined notional extension to be compared against the existing dwelling with the proposed extension. The performance of the existing dwelling, therefore, has an impact on the overall carbon emissions for the dwelling. Unless the same performance specification has been used for both case studies, then direct comparisons cannot be made.

The Eight Associates methodology for the 2014 report is as follows:

Existing dwelling operational CO_2 – New dwelling operational CO_2 (with addition) = increase/decrease in operational carbon emissions.

It is therefore unclear what Waterman's objection is. The 2013 report and 2014 report appear to contradict each other in their view of the appropriate operational carbon methodology.

Issue 11 continued

It should be noted that the 2014 Waterman report has not calculated the operational carbon. Operational carbon is typically approximately 80% of the total carbon emissions (Remsh et al, 2010), however, Waterman have not included it in their analysis. Consequently the basis for their study focuses on approximately 15-20% of the total lifecycle carbon. Without the majority of the lifecycle carbon accounted for their analysis has limited value.

Issue 12

Energy upgrades to the existing building are included in the calculations.

Eight Associates Comments summary:

*Eight Associates' methodology is specifically designed to **not** include upgrades to the existing building. This is clearly explained in the methodology.*

Upgrades are calculated separately in the Sensitivity Analysis chapter.

Waterman: *" Any upgrades to the existing development undertaken as part of the works impact on the embodied energy of the property. Several of the case studies highlight that reductions in operational energy have occurred, however, the Eight Associate's report does not enable analysis to be undertaken to determine if this is as a result of the extension / basement or, other upgrades. There are schemes such as Green Deal, which will tackle this issue separately, and does not require the addition of an extension / basement to improve building performance."*

This comment is completely speculative and incorrect. The Eight Associates methodology chapter clearly states that the building services are identical for the existing dwelling and the extension and basement. And that no upgrades to the fabric were included, the assumption was that the existing dwelling would remain completely untouched.

This was carried out for the express reason that is highlighted in the above comment. Any impact in the carbon emissions after the addition is a purely result of the addition. The 'Sensitivity Analysis' chapter featured upgrades to the existing dwelling and was undertaken to calculate the potential of specific upgrade measures.

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Additional Comments

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Additional comments

Comment from Waterman Transport & Development Ltd – Document 65 Eight Associates Comments summary:	*" Reference 14 within the report is from Volvo Trucks Corporation document entitled Emissions from Volvo's Trucks (standard diesel fuel) dated 3rd November 2000. This document is used to calculate the fuel consumption of vehicles used during the construction works. The actual figure used in the calculations for the delivery vehicles were;*
Eight Associates carbon factors for the waste trucks used are from Defra 2012 document. The Volvo document was used only as guidance for the type of lorries to be used.	Lorries for waste removal empty 0.67 kg of CO2eq/km Lorries for waste removal full 0.78 kg of CO2eq/km" The comment is incorrect as the above carbon factors, used in the February 2014 Eight Associates report are from the document "2012 Guidelines to Defra / DECC's GHG Conversion Factors for Company Reporting", Annex 7 - Freight Transport Conversion Tables (>3.5-7.5t – 0% load and 100% load). The Volvo document was used uniquely for research about the typical size of trucks used for construction works.
Comment from Waterman on page 9 of the 2014 report stating that consequential improvements are required under Part L1B Building Regulations.	This comment is wrong. Only dwellings with a total useful floor area of over 1000m^2 are required to make consequential improvements to the existing dwelling under Part L1B, Section 6. Neither of the two dwellings included in the Waterman analysis meet this requirement.
Waterman Material Quantity Take off.	Waterman's materials calculations contain a significant number of assumptions and unjustified inputs. Eight Associates have provided annotation in the following pages highlighting these issues.
Drawings discrepancy.	There are two drawings that detail two differing methods of construction for the 49 Redcliffe Road basement: - Cranbrook Basements Drawing: TD17 Underpin Section, dated June - RHH Associates Drawing: 6783-PS-03 Section A-A, dated July. Given the nature and dates of the drawings, the RHH Associates drawing would seemingly take precedence, however, as this cannot be confirmed both details have been calculated using ICE database to produce Embodied Carbon Calculations.

Technical Review - Calculations

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Review of Waterman's Material Quantities

Eight Associates has reviewed Appendix A from Waterman's report and has the following comments on the Materials Quantities:

49 Redcliffe Road – Basement: Eight Associates' Comments

- 108m2: this is significantly lower than the actual measure when scaled off plan. It is also significantly lower than the 128m2 figure specifically stated on the ' Community Infrastructure Levy' document submitted with the planning application and available on the RBKC portal.

- Electrical skip: there is no documentation anywhere to validate an electrical skip being used for the site.

- Concrete to underpins: these underpins are a lot smaller than the underpins included for the above ground extension, this needs justification to be valid.

Construction Analysis - 49 Redcliffe Road SW10 9NJ

1.00	Gross Floor Area Constructed		90.54m2
2.00	Excavation		
2.01	108m2 x 3.67m Deep x 40% Bulkage = 555m3	555m3	
2.02	Deduct Central Basement Slab Area - See Sections	12m3	
2.03	Total Spoil Excavated	543m3	
2.04	Electrical Vehicle Skip Transfer	136no Skip	
2.05	80% Recycled Spoil	434m3	
2.06	20% Spoil to Landfill	109m3	
3.00	Concrete to Basement Slab		
3.01	90.54 x 200mm	18.1m3	C30
4.00	Concrete to Underpins		
4.01	50 Linear Metres x .350m x 2.8m High	49m3	C30
5.00	Concrete Screed to Base Slab		
5.01	90.54 x 50mm Thick	4.6m3	
6.00	Reinforcement to Base Slab		
6.01	91m2 - A393 Structural Reinforcement - 2 Layers Required and allowing 10% for Waste and Laps at 6.16kgm2	1233kg	Steel

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Technical Review - Calculations

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36 Markham Square – Above Ground Extension
Eight Associates' Comments

- Concrete Coping: Given the conservation status it is not certain that a concrete coping would be installed. A natural stone would be more suitable and in keeping with the area.

- Steel Frame: The installation of steel frame is not included on any of the drawings. The volume of steel added here is significant and must be validated. Standard construction methods for a mansard roof does not necessitate the installation of this much steel.

21.00	Concrete Coping		
21.01	7.6 lm x .3m High x .1m Thick =	.23m³	Concrete
22.00	Third Floor - Mansard Loft Roof		
22.01	Steel Frame		
	6No. 203 x 203 x 86kg x 5.25m	2709kg	Steel
22.02	Crane to lift Beams		
22.03	Timber Floor Joists - 130m x 50 x 225	1.46m³	
22.04	18mm Plywood Decking	36.30m²	
		0.6534	.6534m3
23.00	Flat Mansard Roof		
23.01	22mm Asphalt = 36.28m²	0.8m3	
23.02	Lead Flashing Perimeter 150mm	72kg	Lead
23.03	Roof Joists 94Lm x 50 x 200	.94m³	Timber
23.04	Firring Timbers 47Lm x 50 x 150	.35m³	Timber
23.05	Mansard Slope 115Lm x 50 x 100	.57m³	Timber
23.06	Slate Tiles = 9.7m² x 25	242	Slates
23.07	Lead Gutter 1m x .4850 x 1.1m	107kg	Lead
23.08	Windows 4No @ 900x 1.0		3.6m2
23.09	Flat Roof Windows - 2no - .56m2 plus .7m2 = 1.26m2		2.56m2
	Zinc roof		31.3m2
	roof insulation		31.3m2
	wall insulation		55.78
	floor insulation		40.16

Technical Review – Conclusions

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Conclusions and Comments

Basement materials limited

The materials used by Waterman for the basement are very limited; there are only 4 materials calculated. This means the waterproofing membranes in the basement have been omitted completely and the insulation thicknesses are very small. To achieve the high performance operational energy demand stated by Waterman, a significant increase in thickness would be required. It should be noted that Eight Associates modeled a U value of 0.15 W/m2.K in the operational analysis to ensure the basements had the lowest possible operational energy. This u value would require a tripling of the insulation stated on the basement drawings.

Basement areas are significantly smaller

Waterman state that the gross internal area addition is 90.54m^2. Eight Associates' scaling the drawings submitted for planning calculate the area to be 116 m^2. Moreover, the 'Community Infrastructure Levy' document submitted with the planning application and available on the RBKC portal states that the additional area is 128m^2. This is a large error for the calculations. Seemingly the drawings and documentation submitted to the council do not represent the basement accurately or the quantities used in the Waterman analysis are wrong.

Extensions drawings are limited in detail

The above ground extension drawings have limited detail and do not provide adequate detail to undertake a detailed material by material embodied carbon analysis as performed by Waterman. It was for this reason that Eight Associates chose to utilise the BRE Green Guide, as it applies the same assumptions and quantities for all case studies so basements and above ground extensions cannot be treated differently.

Waterman's calculations for the above ground extensions are based largely on the authors assumptions

The assumptions do not imply that the numbers and quantities are incorrect, however, it means that an objective analysis is more difficult to achieve, as assumptions have to be used. Moreover, there are some assumptions made in relation to the construction methods that increase the embodied carbon significantly, for example the extensive use of steel where it may not be necessary.

The inclusion of demolition in the above ground extension

Demolition should not be included in the embodied carbon calculations for two reasons. Firstly, it introduces a very inconsistent variable as the level of required demolition can vary extensively from project to project and does not materially affect the actual new dwelling. For this reason the Eight Associates analysis excluded external works and demolition for both above ground extensions and basement as it distorts the results.

Conclusions and Comments continued

Secondly, under a defined life cycle analysis study boundary the demolition is technically a part of the 'cradle to grave' lifecycle of the existing building. For example, the eventual demolition of the materials used to construct the above ground extension and basement should be included in the current embodied calculations of the present study. If the Waterman methodology was to be followed consistently then the demolition of the materials in the current study should be removed.

Eight Associates' Materials Analysis

As the review of the Waterman material calculations has demonstrated some shortcomings in the quantification and assumptions, Eight Associates has recalculated the quantities to address the issue highlighted previously. The findings are shown below, and detailed calculations are available in the appendix.

Embodied Carbon using the ICE Database

Study	Total Embodied Carbon kg/CO2	Carbon per kg CO2/m2
36 Markham Sq. (Above Ground Extension)	16,519	539.8
49 Redcliffe Rd. (Basement) – Structural Engineer Drawings	83,749	721.4
49 Redcliffe Rd. (Basement) – Cranbrook Basements Drawings	77,897	670.9

The results demonstrate that using the Waterman methodology 49 Redcliffe Rd. has approximately 25.2% more embodied carbon relative to 36 Markham Sq. under the Structural Engineer scheme and 19.5% more embodied carbon under the Cranbrook Basements scheme, on an additional per metre square basis.

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Appendix

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36 Markham Sq. - Above Ground Extension

Description	Length	Width	Area (L x W)	Height	Number	Quantity	Unit of measure	Notes
Materials								
Concrete								
RC slab on grade thickness unknown, assume 150mm			22.800	0.150		**3.42**	m3	
RC slab thickening 200mm	7.400	0.300		0.200		**0.44**	m3	Assumption - not on drawings
RC underpinning to existing walls, assume 600mm	12.100	0.600		0.600		**4.36**	m3	Assumption - not on drawings
				Total Volume:		**8.22**	m3	
				Mass density		**2371.00**	kg/m3	http://www.simetric.co.uk/si_materials.htm
				Total mass		**19,490**	kg	
Screed								
65mm screed above insulation to form floor			22.800	0.065		**1.48**	m3	Assumption - not on drawings
				Total Volume:		**1.48**		
				Mass density		**2162.00**	kg/m3	http://www.simetric.co.uk/si_materials.htm
				Total mass		**3,204**	kg	
Other cement based materials								
50mm layer of blinding concrete 1:8			22.800	0.050		**1.14**	m3	Assumption - not on drawings
				Total Volume:		**1.14**		
				Mass density		**2162.00**	kg/m3	http://www.simetric.co.uk/si_materials.htm
				Total mass		**2,465**	kg	
						283	Waterman Carbon factor result	
External walls - cavity								
External brickwork - LGF	7.400			2.940		21.76	m2	
					ddt openings	8.12	m2	
					Net area	13.64	m2	
Brickwork - 83%		0.100				**1.13**	m3	
Percentage mortar - 17%						**0.23**	m3	

Internal blockwork	7.400		2.940		21.76	m2
				ddt openings	8.12	m2
				Net area	13.64	m2
Blockwork - 93%		0.100			**1.27**	m3
Percentage mortar - 7%					**0.10**	m3
External walls - single skin to shower and plant LGF	5.150		2.940		15.14	m2
Blockwork - 93%		0.140			**1.97**	m3
Percentage mortar - 7%					**0.15**	m3
External brickwork - GF	3.730		3.100		11.56	m2
				ddt openings	1.20	m2
				Net area	10.36	m2
Brickwork - 83%		0.100			**0.86**	m3
Percentage mortar - 17%					**0.18**	m3
Internal blockwork	3.730		3.100		11.56	m2
				ddt openings	8.12	m2
				Net area	3.44	m2
Blockwork - 93%		0.100			**0.32**	m3
Percentage mortar - 7%					**0.02**	m3
External walls - single skin to party wall GF	1.550		3.100		4.81	m2
Blockwork - 93%		0.140			**0.63**	m3
Percentage mortar - 7%					**0.05**	m3
External brickwork - FF	7.500		2.600		19.50	m2
				ddt openings	1.35	m2
				Net area	18.15	m2
Brickwork - 83%		0.100			**1.51**	m3
Percentage mortar - 17%					**0.31**	m3
Internal blockwork	7.500		2.600		19.50	m2
				ddt openings	1.35	m2
				Net area	18.15	m2
Blockwork - 93%		0.100			**1.69**	m3
Percentage mortar - 7%					**0.13**	m3

External brickwork - SF	7.500		2.900		21.75	m2	
				ddt openings	2.66	m2	
				Net area	19.09	m2	
Brickwork - 83%		0.100			**1.58**	m3	
Percentage mortar - 17%					**0.32**	m3	
Internal blockwork	7.500		2.900		21.75	m2	
				ddt openings	2.66	m2	
				Net area	19.09	m2	
Blockwork - 93%		0.100			**1.78**	m3	
Percentage mortar - 7%					**0.13**	m3	
			Total brickwork volume		**5.08**	m3	
			Mass density		**1845.00**	kg/m3	http://www.engineeringtoolbox.com/bricks-density-d_1777.html
			Total mass		**9,378**	kg	
			Total blockwork volume		**7.65**	m3	
			Mass density		**742.00**	kg/m3	106 blocks per m3, 7kg per block - http://www.tarmacbuildingproducts.co.uk/products_and_services/blocks_and_mortar/blocks/lightweight_aircrete_blocks/toplite_7_73_n_mm2.aspx
			Total mass		**5,675**	kg	
			Total mortar volume		**1.62**	m3	
			Mass density		**2,162.00**	kg/m3	http://www.simetric.co.uk/si_materials.htm
			Total mass		**3,495**	kg	

Insulation							
Wall - Thickness not stated, 60mm minimum to achieve Building Regulations							
LGF					**13.64**	m2	
GF					**10.36**	m2	
FF					**18.15**	m2	
SF					**19.09**	m2	
				Total	**61.24**	m2	
			Total Volume:		**4.90**	m3	
			Mass density		**30.00**	kg/m3	
			Total mass		**147**	kg	
Insulation in Lintel, 'Catnic' type or similar LG floor	3.200	0.100	0.150	1	**0.048**	m3	Assumption. Data from: http://iglintels.com/lintels/selecting-the-correct-lintel/
Lintel, 'Catnic' type or similar LG floor	1.200	0.100	0.066	**1**	**0.008**	m3	Assumption. Data from: http://iglintels.com/lintels/selecting-the-correct-lintel/
Lintel, 'Catnic' type or similar G floor	1.350	0.100	0.066	**1**	**0.009**	m3	Assumption. Data from: http://iglintels.com/lintels/selecting-the-correct-lintel/
Lintel, 'Catnic' type or similar 1st floor	1.350	0.100	0.066	**1**	**0.009**	m3	Assumption. Data from: http://iglintels.com/lintels/selecting-the-correct-lintel/
Lintel, 'Catnic' type or similar 2nd floor	1.350	0.100	0.066	**1**	**0.009**	m3	Assumption. Data from: http://iglintels.com/lintels/selecting-the-correct-lintel/
Lintel, 'Catnic' type or similar 2nd floor	1.200	0.100	0.066	**1**	**0.008**	m3	Assumption. Data from: http://iglintels.com/lintels/selecting-the-correct-lintel/
			Total Area:		**0.091**	m3	Assumption. Data from: http://iglintels.com/lintels/selecting-the-correct-lintel/
			Mass density		**30.00**	kg/m3	
			Total mass		**3**	kg	

Roof timber

Timber wall plate 100mm x 50mm	5.200	0.100		0.050	2	**0.05**	m3
Timber ceiling joists/ties	7.000	0.050		0.200	13.00	**0.91**	m3
Timber rafters high pitch 100mm x 50mm	2.500	0.050		0.100	26.00	**0.33**	m3
ddt for dormer openings	1.200	0.050		0.100	4	**0.02**	m3
					Net	**0.30**	m3
Timber rafters low pitch 100mm x 50mm to create fall	6.200	0.050		0.100	13.00	**0.40**	m3
Timber braces to low pitch rafters (horizontal) to allow headroom 1	6.200	0.050		0.100	13.00	**0.40**	m3
Partition stud framing under dormers 100mm x 50mm	1.600	0.050		0.100	12.0	**0.10**	m3
Dormer posts 75mm x 75mm	1.800	0.075		0.075	8	**0.08**	m3
Dormer sill, head and trimmer 100mm x 75mm	0.900	0.075		0.100	12	**0.08**	m3
Plywood decking to form flat roof deck, 18mm			30.200	0.018		**0.54**	m3
Timber battens for slates, 38mm x 25mm, spaced at 115mm	5.200	0.038		0.025	30	**0.15**	m3
Timber joists for flat roof (lead) 2nd floor 150mm x 50mm	2.200	0.050		0.150	6	**0.10**	m3
Timber firrings ave thickness 50mm	2.200	0.050		0.050	6	**0.03**	m3
Plywood decking to form flat roof deck at 2nd floor, 18mm			5.600	0.018		**0.10**	m3
Timber joists for flat roof (lead) Ground floor 150mm x 50mm	2.200	0.050		0.150	3	**0.05**	m3
Timber firrings ave thickness 50mm	2.200	0.050		0.050	3	**0.02**	m3
Plywood decking to form flat roof deck at Ground floor, 18mm			2.850	0.018		**0.05**	m3
Timber joists for flat roof (lead) Lower Ground floor 150mm x 50mn	2.000	0.050		0.150	3.00	**0.05**	m3
Timber joists for flat roof (lead) Lower Ground floor 150mm x 50mn	0.400	0.050		0.150	6.00	**0.02**	m3
Timber firrings ave thickness 50mm	2.000	0.050		0.050	3	**0.02**	m3
Timber firrings ave thickness 50mm	0.400	0.050		0.050	6	**0.01**	m3
Plywood decking to form flat roof deck at Ground floor, 18mm			3.800	0.018		**0.07**	m3
				Total Area:		**3.52**	
				Mass density		**510.00**	kg/m2
				Total mass		**1,797**	kg

Sizes and structural build-ups taken from:
Building Construction Handbook (2010) 8th Edition, Roy Chudley and Roger Greeno
Barry's Introduction to Construction of Buildings (2006) 1st Edition, Stephen Emmitt and Christopher A Gorse,
Carpentry and Joinery for Advanced Craft Students: Site Practice (1985), Peter Brett

http://www.google.co.uk/url?sa=t&rct=j&q=&esrc=s&source=web&cd=6&ved=0CFUQFjAF&url=http%3A%2F%2Fww.ascinfo.co.uk%2FASCContent%2F16612%255CProductUploads%255CProductOthers%255CMS20_DeltaMS20BBA.pdf&ei=mqVCU7_2O6Ov7Qa3moHwCg&usg=AFQjCNFUOXS52uM_428N-MMSPRA6ewuXLA&sig2=6pVOMQXkfAq5jcw2yGt03g&bvm=bv.64125504,d.ZGU

Steel								
Reinforcement for concrete not known, assume 0.15% of mass of concrete						**0.12**	m3	https://www.concretecentre.com/codes__standards/eurocodes/eurocode_2/phenomena/flexure/flexural_design_aids.aspx
				Total Volume		**0.12**	m3	
				Mass density		**7850.00**	kg/m3	
				Total mass		**968**	kg	
Lintel, 'Catnic' type or similar LG floor	3.200	0.003		0.640	1	**0.007**	m3	Assumption. Data from: http://iglintels.com/lintels/selecting-the-correct-lintel/
Lintel, 'Catnic' type or similar LG floor	1.200	0.002		0.462	**1**	**0.001**	m3	Assumption. Data from: http://iglintels.com/lintels/selecting-the-correct-lintel/
Lintel, 'Catnic' type or similar G floor	1.350	0.002		0.462	**1**	**0.001**	m3	Assumption. Data from: http://iglintels.com/lintels/selecting-the-correct-lintel/
Lintel, 'Catnic' type or similar 1st floor	1.350	0.002		0.462	**1**	**0.001**	m3	Assumption. Data from: http://iglintels.com/lintels/selecting-the-correct-lintel/
Lintel, 'Catnic' type or similar 2nd floor	1.350	0.002		0.462	**1**	**0.001**	m3	Assumption. Data from: http://iglintels.com/lintels/selecting-the-correct-lintel/
Lintel, 'Catnic' type or similar 2nd floor	1.200	0.002		0.462	**1**	**0.001**	m3	Assumption. Data from: http://iglintels.com/lintels/selecting-the-correct-lintel/
				Total Area:		**0.012**	m3	Assumption. Data from: http://iglintels.com/lintels/selecting-the-correct-lintel/
				Mass density		**7850.00**	kg/m3	
				Total mass		**95**	kg	
Steel beams to act as purlin for mansard, assume 203 x 203 x 46kg	5.200				2	**10.40**	m	Assumption - not shown on drawings - http://www.parkersteel.co.uk/Product/0853631/Universal+Column/203+X+203+X+46KG+S355JR+White
Steel beam for second floor knock through	1.500					**1.50**	m	
				Total length:		**11.90**	m	
				Mass length		**46.00**	kg/m	Weight per linear metre: http://greensteel.com.au/products/beams-columns/
				Total mass		**547**	kg	
Roof coverings								
Lead Code 5 to dormers			0.300	0.0022	8	**0.00**	m3	
Lead Code 5 to dormers	1.200	0.500		0.0022	4	**0.01**	m3	
Lead Code 5 to dormers	1.100	0.200		0.0022	12	**0.01**	m3	
Lead flashing and soakers to dormers	1.200	0.150		0.0022	8	**0.00**	m3	
Lead flashing and soakers to dormers	1.300	0.150		0.0022	8	**0.00**	m3	
Lead flashing to mansard	2.800	0.300		0.0022	2	**0.00**	m3	
Lead flashing to chimney and mansard	4.800	0.150		0.0022	1	**0.00**	m3	
Lead flashing to form gutter	5.200	0.550		0.0022	2	**0.01**	m3	
Lead flashing to GF rooflight	8.000	0.300		0.0022	1	**0.01**	m3	
				Total		**0.04**	m3	
				Mass density		**10583.00**	kg/m3	http://www.britishlead.co.uk/sizing.htm
				Total mass		**440**	kg	

Asphalt roof covering	27.800			**0.020**		**0.56**	m3	http://www.ribaproductselector.com/products/mastic-asphalt-roofing-insulation-finishes/J21.aspx
				Mass density		**721.00**	kg/m3	http://www.simetric.co.uk/si_materials.htm
				Total mass		**401**	kg	
Zinc roof coverings			16.30	**0.008**		**0.13**	m3	http://www.simetric.co.uk/si_metals.htm
				Mass density		**7135.00**	kg/m3	
				Total mass		**930**	kg	
Slate roof covering, double lapped	2.500	5.200			4	**52.00**	m2	
ddt for dormers	1.300	1.200			4	**6.24**	m2	
				0.008	Net m3	**0.37**	m3	
				Mass density		**2691.00**	kg/m3	
				Total mass		**985**	kg	
Coping stone heritage	17.100	0.300		0.038		**0.19**	m3	
				Mass density		**2,323**	m3	
				Total mass		**452.85**	kg/m3	

Windows and openings

Windows

WLG-1		1.76			
WLG-2		1.73			
DLG-1		3.06			
DLG-1		1.57			
WG-1		9.21			
WG-2		0.60			
WG-3		0.60			
W1-1		1.35			
W2-2		1.47			
W2-3		1.19			
W3		1.21			
W3		1.21			
W3		1.09			
W3		1.09			
RL		0.64			
RL		0.77			
	Total new glazed area	28.556		m2	
Glass pane area			**0.24**	m3	70% glazing, and double glazed
Timber frame area			**0.49**	m3	30% of area, width of frame average of 57mm
Glazed roof area at GF		7.650		m2	
Glass pane area			**0.06**	m3	70% glazing, and double glazed
		Total Volume of GLASS:	**0.30**	m3	
		Mass Volume	**2579.00**	kg/m3	
		Total mass	**784**	kg	
		Total Volume of TIMBER:	**0.49**	m3	
		Mass Volume	**510.00**	kg/m3	
		Total mass	**249**	kg	
Aluminium frame, weight assumed	19.100		**19.10**	m	
		Mass metre	**0.77**	kg/m	http://gddaming.en.alibaba.com/product/741928031-218286700/double_glazing_cost_best_Aluminum_Sliding_Window_frame_china.html
		Total mass	**15**	kg	

SUMMARY OF MATERIALS				ICE CO2	Total CO2
Concrete	Total Mass	**19,490**	kg	0.14	2729
Screed	Total Mass	**5,669**	kg	0.14	794
Other cement based materials	Total Mass	**2,465**	kg	0.14	345
Bricks	Total Mass	**9,378**	kg	0.24	2251
Blocks	Total Mass	**5,675**	kg	0.307	1742
Mortar	Total Mass	**3,495**	kg	0.174	608
Insulation	Total Mass	**150**	kg	4.26	638
Roof timber	Total Mass	**1,797**	kg	0.59	1060
Steel	Total Mass	**642**	kg	1.95	1252
Lead	Total Mass	**440**	kg	1.67	735
Zinc	Total Mass	**930**	kg	3.09	2875
Asphalt and bitumen	Total Mass	**401**	kg	0.49	196
Slate	Total Mass	**985**	kg	0.035	34
Sandstone coping	Total Mass	**453**	kg	0.06	27
Windows and openings - glass	Total Mass	**784**	kg	1.35	1059
Windows and openings - frame timber	Total Mass	**249**	kg	0.59	147
Windows and openings - frame aluminium	Total Mass	**15**	kg	1.81	26
					16,519
				/m2	**539.8**

Technical Review RBKC – Basements Policy Public Consultation Response Waterman Energy Report - Material Quantities

49 Recliffe Road - Basement

Description	Length	Width	Area (L x W)	Height	Number	Quantity	Unit of measure	Notes
Materials - Structural Engineer Drawings								
Concrete								
RC slab on grade 350mm			139.300	0.350		**48.76**	m3	
RC wall for basement, 340mm (see notes)	64.600	0.330		3.200		**68.22**	m3	Drawing 6783-PS-03 Section A-A by RHH Associates states 300mm wide or thickness to match existing, whichever is wider. Drawing's width of existing is 330mm thick.
RC roof in rear garden 150mm			45.500	0.150		**6.83**	m3	Drawing TD17 Underpin Section by Cranbrook Basements states 150mm C30 concrete floor slab.
				Total Volume:		**123.80**	m3	
				Mass density		**2371.00**	kg/m3	
				Total mass		**293,524**	kg	
Screed								
65mm screed under insulation to slab			116.100	0.065		**7.55**	m3	
65mm screed above insulation to form floor			116.100	0.065		**7.55**	m3	
				Total Volume:		**15.09**		
				Mass density		**2162.00**	kg/m3	
				Total mass		**32,631**	kg	
Other cement based materials								
Dry packing	64.600	0.330		0.075		**1.60**	m3	
Dry packing over lintels	16.200	0.100		0.050	10	**0.81**	m3	Packing is approximately 50mm on drawing
50mm layer of blinding concrete 1:8			139.300	0.050		**6.97**	m3	See section 2.4 of R H Horwitz Associates Structural design philosophy Report
				Total Volume:		**9.37**		
				Mass density		**2162.00**	kg/m3	
				Total mass		**20,266**	kg	
Precast Concrete lintels	16.200	0.100		0.100	10	**1.62**	m3	Spacing on drawing is approximately 500m, existing dwelling is 5m wide
				Total Volume:		**1.62**	m3	
				Mass density		**2371.00**	kg/m3	
				Total mass		**3,841**	kg	
Insulation								
Floor - Thickness not stated, 80mm minimum according to drawing scale			116.100	0.080		**9.29**	m3	
Wall - Thickness not stated, 40mm minimum according to drawing scale. 80mm will be required	64.600	0.080		2.850		**14.73**	m3	40mm is not adequate to achieve Building Regulations and is much less than the thickness required to achieve the high performance u values needed to achieve the claimed lower operational energy.
Roof - To garden, insulation thickness unknown, minimum of 100mm to achieve Building Regulations			45.500	0.100		**4.55**	m3	
				Total Volume:		**28.57**		
				Mass density		**30.00**	kg/m3	
				Total mass		**857**	kg	

Cavity Drain								
Floor - 1mm thickness			116.100			**116.10**	m2	
Wall - 1mm thickness	64.600			3.055		**197.35**	m2	
Roof to garden - 1mm thickness			45.500			**45.50**	m2	
				Total Area:		**358.95**		
				Mass density		**1.00**	kg/m2	http://www.google.co.uk/url?sa=t&rct=j&q=&esrc=s&source=web&cd=6&ved=0CFUQFjAF&url=http%3A%2F%2Fwww.ascinfo.co.uk%2FASCContent%2F16612%255CProductUploads%255CProductOthers%255CMS20_DeltaMS20BBA.pdf&ei=mqVCU7_2O6Ov7Qa3moHwCg&usg=AFQjCNFUOXS52uM_428N-MMSPRA6ewuXLA&sig2=6pVOMQXkfAq5jcw2yGt03g&bvm=bv.64125504,d.ZGU
				Total mass		**359**	kg	
External Water Proof Membrane								
Dimplex type sheet as cavity drain			391.520			**391.52**		Not shown on drawings, but recommended by Delta Membrane Systems - the system installed for the basement: http://www.deltamembranes.com/help-advice/ http://www.deltamembranes.com/products/delta-terraxx-2/
				Total Area:		**391.52**		
				Mass density		**1.00**	kg/m2	
				Total mass		**392**	kg	
Filtration layer			391.520			**392**		
		0.003		**Total Volume**		**1.10**		
				Mass density		**910.00**	kg/m2	http://www.google.co.uk/url?sa=t&rct=j&q=&esrc=s&source=web&cd=1&ved=0CDEQFjAA&url=http%3A%2F%2Fwww.geosyntheticssociety.org%2Fresources%2Farchive%2Fgi%2Fsrc%2Fv7i456%2Fgi-v7nos4-5-6-paper3.pdf&ei=pJ9LU_yhE4SK7AagkYHACQ&usg=AFQjCNG4ecJaXd_XDIWeKvHZj8cld_cR5g&sig2=e7b_ituBNZHXwG7GdVr43g&bvm=bv.64542518,d.ZGU
				Total mass		**998**	kg	
Steel								
H16 'L' bar long	2.670				431	**1149.88**	m	
H16 'L' bar short	1.460				431	**628.77**	m	
H16 Dowels	0.600				215	**129.20**	m	
H16 Dowels	0.600				215	**129.20**	m	
				Total Length:		**2037.05**	m	
				Mass length		**1.58**	kg/m	Weight per linear metre: 1.58 kg http://www.google.co.uk/url?sa=t&rct=j&q=&esrc=s&source=web&cd=3&ved=0CFUQFjAC&url=http%3A%2F%2Feurossteel.com%2Fproducts%2FReinforcement.pdf&ei=VE08U8HLHqeI7AadsYGIBQ&usg=AFQjCNEQBzSBbW-Hwluy0rinskyKHYstaA&sig2=8J6rI1OXHN-u3upxUUDJEA
				Total mass		**3,219**	kg	
A393 Mesh in RC slab, 50mm cover ddt			132.840		4	**531.36**	m2	
A393 Mesh in RC wall, 50mm cover between slab ddt			64.600	3.100	3	**600.78**	m2	
				Total Area:		**1132.14**	m2	
				Mass Area		**6.16**	kg/m2	Weight per m2: 6.16 http://www.lemon-gs.co.uk/shop/a393-reinforcing-mesh.html
				Total mass		**6,974**	kg	
Steel reinforcement for roof over garden - 1.1%						**0.01**	m3	1.1% is the reinforcement to concrete volume ratio for the RC wall and slab
				Mass Density		**7850.00**	kg/m3	
				Total mass		**59**	kg	
Steel beams to support existing floor, 100mm cover over underpinning	5.200				7	**36.40**	m	Spacing not shown, assumed to be 2400mm as per the linear length of PCC lintels. Steel dimensions not shown, drawing scale indicates approximately 160mm from flange to flange, type assumed to be 152 UC 46
				Total length:		**36.40**	m	
				Mass length		**46.00**	kg/m	
				Total mass		**1,674**	kg	

Windows and openings

Glazed doors - gross area (rear lightwell)	1.450		2.250	4	**13.05**	m2	
Glass pane area	0.550	0.006	2.050	8	**0.05**	m3	
Timber frame area	0.550	0.057	2.050	8	**0.51**	m3	
			Percentage of glazing to frame		**69%**	%	Note: this is in line with the SAP standard frame factor of 70%
Frame area					**13.00**	m2	
Glazed windows - gross area (front lightwell), height not confirmed	0.600		1.000		**0.60**	m2	
Glass pane area					**0.01**	m3	
Timber frame area					**0.01**	m3	
			Percentage of glazing to frame		**70%**	%	Note: SAP standard frame factor of 70%
Glazed windows - gross area (front lightwell), height not confirmed	0.950		1.000		**0.95**	m2	
Glass pane area					**0.01**	m3	
Timber frame area					**0.02**	m3	
			Percentage of glazing to frame		**70%**	%	Note: SAP standard frame factor of 70%
Glazed windows - gross area (front lightwell), height not confirmed	0.600		1.000		**0.60**	m2	
Glass pane area					**0.01**	m3	
Timber frame area					**0.01**	m3	
			Percentage of glazing to frame		**70%**	%	Note: SAP standard frame factor of 70%
			Total Volume of Glass:		**0.07**	m3	
			Mass Volume		**2579.00**	kg/m3	
			Total mass		**186**	kg	
			Total Volume of Timber:		**0.55**	m3	
			Mass Volume		**510.00**	kg/m3	
			Total mass		**281**	kg	

SUMMARY OF MATERIALS - Structural Engineer Drawings				**ICE CO2**	**Total CO2**
Concrete	Total Mass	**293,524**	kg	0.14	41093
Screed	Total Mass	**32,631**	kg	0.14	4568
Other cement based materials	Total Mass	**20,266**	kg	0.14	2837
Precast concrete	Total Mass	**3,841**	kg	0.169	649
Insulation	Total Mass	**857**	kg	4.26	3651
Cavity Drain	Total Mass	**750**	kg	1.93	1448
External Drainage/membrane - geotextile or similar	Total Mass	**998**	kg	3.43	3422
Steel	Total Mass	**11,926**	kg	1.95	23255
Windows and openings - glass	Total Mass	**186**	kg	1.35	251
Windows and openings - frame	Total Mass	**281**	kg	9.16	2574
					83,749
				/m2	**721**

Materials - Cranbrook Drawings

Concrete								
RC slab on grade 150mm			116.100	0.150		**17.42**	m3	
RC slab thickening 350mm	63.800	1.400		0.350		**31.26**	m3	
RC wall for basement, 350mm (see notes)	64.600	0.350		2.350		**53.13**	m3	Drawing TD17 Underpin Section by Cranbrook Basements states 350mm concrete wall.
RC lower ground floor - 150mm			81.920	0.150		**12.29**	m3	Drawing TD17 Underpin Section by Cranbrook Basements states 150mm C30 concrete floor slab.
RC to holorib deck for rear garden			45.500	0.250		**11.38**	m3	
				Total Volume:		**125.47**	m3	
				Mass density		**2300.00**	kg/m3	
				Total mass		**288,589**	kg	
Screed								
65mm screed above insulation to form floor			81.920	0.065		**5.32**	m3	
				Total Volume:		**5.32**		
				Mass density		**2162.00**	kg/m3	
				Total mass		**11,512**	kg	
Other cement based materials								
Dry packing	64.600	0.350		0.075		**1.70**	m3	
Dry packing over steel beams	32.000	0.154		0.020	10	**0.99**	m3	Packing is approximately 20mm on drawing
50mm layer of blinding concrete 1:8			148.990	0.050		**7.45**	m3	See section 2.4 of R H Horwitz Associates Structural design philosophy Report
				Total Volume:		**10.13**		
				Mass density		**2162.00**	kg/m3	
				Total mass		**21,903**	kg	
Insulation								
Floor - Thickness not stated, 50mm minimum according to drawing scale, 80mm assumed			116.100	0.080		**9.29**	m3	50mm is not adequate to achieve Building Regulations and is much less than the thickness required to achieve the high performance u values needed to achieve the claimed lower operational energy.
Wall - Thickness not stated, 50mm minimum according to drawing scale, assumed	64.600	0.080		2.900		**14.99**	m3	50mm is not adequate to achieve Building Regulations and is much less than the thickness required to achieve the high performance u values needed to achieve the claimed lower operational energy.
Roof - To garden, insulation thickness unknown, minimum of 100mm to achieve Building Regulations			45.500	0.100		**4.55**	m3	
				Total Volume:		**28.83**		
				Mass density		**30.00**	kg/m3	
				Total mass		**865**	kg	

Cavity Drain							
Floor - 1mm thickness			116.100		**116.10**	m2	
Wall - 1mm thickness	64.600			3.015	**194.77**	m2	
Roof to garden - 1mm thickness			45.500		**45.50**	m2	
				Total Area:	**356.37**		
				Mass density	**1.00**	kg/m2	http://www.google.co.uk/url?sa=t&rct=j&q=&esrc=s&source=web&cd=6&ved=0CFUQFjAF&url=http%3A%2F%2Fwww.ascinfo.co.uk%2FASCContent%2F16612%255CProductUploads%255CProductOthers%255CMS20_DeltaMS20BBA.pdf&ei=mqVCU7_2O6Ov7Qa3moHwCg&usg=AFQjCNFUOXS52uM_428N-MMSPRA6ewuXLA&sig2=6pVOMQXkfAq5jcw2yGt03g&bvm=bv.64125504,d.ZGU
				Total mass	**356**	kg	
External Water Proof Membrane							
Dimplex type sheet as cavity drain			391.520		**391.52**		Not shown on drawings, but recommended by Delta Membrane Systems - the system installed for the basement: http://www.deltamembranes.com/help-advice/ http://www.deltamembranes.com/products/delta-terraxx-2/
				Total Area:	**391.52**		
				Mass density	**1.00**	kg/m2	
				Total mass	**392**	kg	
Filtration layer			391.520		**392**		
		0.003		**Total Volume**	**1.10**		
				Mass density	**910.00**	kg/m2	http://www.google.co.uk/url?sa=t&rct=j&q=&esrc=s&source=web&cd=1&ved=0CDEQFjAA&url=http%3A%2F%2Fwww.geosyntheticssociety.org%2Fresources%2Farchive%2Fgi%2Fsrc%2Fv7i456%2Fgi-v7nos4-5-6-paper3.pdf&ei=pJ9LU_yhE4SK7AagkYHACQ&usg=AFQjCNG4ecJaXd_XDIWeKvHZj8cld_cR5g&sig2=e7b_ituBNZHXwG7GdVr43g&bvm=bv.64542518,d.ZGU
				Total mass	**998**	kg	

Steel							
H12 'L' bar	1.375			323	**444.13**	m	
			Total Length:		**5913.58**	m	
			Mass length		**0.89**	kg/m	Weight per linear metre: 0.89 kg http://www.google.co.uk/url?sa=t&rct=j&q=&esrc=s&source=web&cd=3&ved=0CFUQFjAC&url=http%3A%2F%2Feurossteel.com%2Fproducts%2FReinforcement.pdf&ei=VE08U8HLHqeI7AadsYGIBQ&usg=AFQjCNEQBzSBbW-Hwluy0rinskyKHYstaA&sig2=8J6rl1OXHN-u3upxUUDJEA
			Total mass		**5,263**	kg	
H16 'L' bar	1.375			323	**444.13**	m	
			Total Length:		**444.13**	m	
			Mass length		**1.58**	kg/m	Weight per linear metre: 1.58 kg http://www.google.co.uk/url?sa=t&rct=j&q=&esrc=s&source=web&cd=3&ved=0CFUQFjAC&url=http%3A%2F%2Feurossteel.com%2Fproducts%2FReinforcement.pdf&ei=VE08U8HLHqeI7AadsYGIBQ&usg=AFQjCNEQBzSBbW-Hwluy0rinskyKHYstaA&sig2=8J6rl1OXHN-u3upxUUDJEA
			Total mass		**702**	kg	
B142 Mesh in RC slab, 35mm cover ddt		113.839		1	**113.84**	m2	
			Total Area:		**113.84**	m2	
			Mass Area		**2.22**	kg/m2	Weight per m2: 2.22 http://www.lemon-gs.co.uk/shop/a393-reinforcing-mesh.html
			Total mass		**253**	kg	
B1131 Mesh in RC wall, 50mm cover between slab ddt		64.600	2.275	1	**146.97**	m2	
			Total Area:		**146.97**	m2	
			Mass Area		**10.90**	kg/m2	Weight per m2: 10.9 http://www.lemon-gs.co.uk/shop/a393-reinforcing-mesh.html
			Total mass		**1,602**	kg	
A393 Mesh in RC wall, 50mm cover between slab ddt		64.600	2.300	1	**148.58**	m2	
			Total Area:		**148.58**	m2	
			Mass Area		**6.16**	kg/m2	Weight per m2: 6.16 http://www.lemon-gs.co.uk/shop/a393-reinforcing-mesh.html
			Total mass		**915**	kg	
B503 Mesh in RC slab, 50mm cover ddt	63.800	1.300		1	**82.94**	m2	
			Total Area:		**82.94**	m2	
			Mass Area		**5.93**	kg/m2	Weight per m2: 5.93 http://www.lemon-gs.co.uk/shop/a393-reinforcing-mesh.html
			Total mass		**492**	kg	
B1131 Mesh in RC slab, 50mm cover ddt	63.800	1.300		1	**82.94**	m2	
			Total Area:		**82.94**	m2	
			Mass Area		**10.90**	kg/m2	Weight per m2: 10.9 http://www.lemon-gs.co.uk/shop/a393-reinforcing-mesh.html
			Total mass		**904**	kg	
Steel beams to support existing floor, 100mm cover over underpinning	32.000				**32.00**	m	152 UC 46
			Total length:		**32.00**	m	
			Mass length		**46.00**	kg/m	Weight per linear metre taken from : http://polsteel.co.uk/steel-guide/steel-sections/uc/
			Total mass		**1,472**	kg	
Holorib decking for rear garden roof, plus 150mm overlap		48.680			**48.68**		
			Mass area		**12.91**	kg/m2	Weight per square metre: http://www.fischerprofil.com/verbunddecke-product.aspx?productID=9732ca23-7260-4db6-8906-19fbe0623128&articleID=7530667e-1792-434a-8678-bcce291c5194
			Total mass		**628**	kg	

Windows and openings

Glazed doors - gross area (rear lightwell)	1.450		2.250	4	**13.05**	m2	
Glass pane area	0.550	0.006	2.050	8	**0.05**	m3	
Timber frame area	0.550	0.057	2.050	8	**0.51**	m3	
			Percentage of glazing to frame		**69%**	%	Note: this is in line with the SAP standard frame factor of 70%
Frame area					**13.00**	m2	
Glazed windows - gross area (front lightwell), height not confirmed	0.600		1.000		**0.60**	m2	
Glass pane area					**0.01**	m3	
Timber frame area					**0.01**	m3	
			Percentage of glazing to frame		**70%**	%	Note: SAP standard frame factor of 70%
Glazed windows - gross area (front lightwell), height not confirmed	0.950		1.000		**0.95**	m2	
Glass pane area					**0.01**	m3	
Timber frame area					**0.02**	m3	
			Percentage of glazing to frame		**70%**	%	Note: SAP standard frame factor of 70%
Glazed windows - gross area (front lightwell), height not confirmed	0.600		1.000		**0.60**	m2	
Glass pane area					**0.01**	m3	
Timber frame area					**0.01**	m3	
			Percentage of glazing to frame		**70%**	%	Note: SAP standard frame factor of 70%
			Total Volume of GLASS:		**0.07**	m3	
		12.895	Mass Volume		**2579.00**	kg/m3	
			Total mass		**186**	kg	
			Total Volume of TIMBER:		**0.55**	m3	
			Mass Volume		**510.00**	kg/m3	
			Total mass		**281**	kg	

SUMMARY OF MATERIALS - Cranbrook Drawings

		Total Mass		ICE CO2	Total CO2
Concrete	Total Mass	**288,589**	kg	0.14	40402
Screed	Total Mass	**11,512**	kg	0.14	1612
Other cement based materials	Total Mass	**21,903**	kg	0.14	3066
Insulation	Total Mass	**865**	kg	4.26	3684
Cavity Drain	Total Mass	**748**	kg	1.93	1443
External Drainage/membrane - geotext or similar	Total Mass	**998**	kg	3.43	3422
Steel	Total Mass	**12,231**	kg	1.95	23851
Windows and openings - glass	Total Mass	**186**	kg	1.35	251
Windows and openings - frame	Total Mass	**281**	kg	0.59	166
					77,897
				/m2	**671**