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Technical Review:

‘Life Cycle Carbon Analysis of Extensions and Subterranean Development in RBK&C’ – Eight Associates, February 2014

March 2014

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This document has been prepared and checked in accordance with Waterman Group’s IMS (BS EN ISO 9001: 2008, BS EN ISO 14001: 2004 and BS OHSAS 18001:2007))

Issue	Date	Prepared by	Checked by	Approved by
First	March 2014	Chris Illman Principal Consultant	Chris Illman Principal Consultant	Richard Stockwell Regional Director

Comments

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EXECUTIVE SUMMARY

Waterman was commissioned by Cranbrook Basements to carry out a technical review and undertake recalculations of the claims made in a report produced by Eight Associates in February 2014 entitled '*Life Cycle Carbon Analysis of Extensions and Subterranean Development in RBK&C'.* The report was produced to support the proposed changes to planning policy within the Royal Borough of Kensington and Chelsea (RBKC).

This report is in reference to paragraph 34.3.53 of RBKC 'Basements Policy Publication Final', which states that *"the carbon emissions of basements are greater than those of above ground developments per square metre over the building's life cycle. This is because of the extensive use of concrete which has a high level of embodied carbon. In particular multi storey basements are more carbon intensive when compared to above ground extensions or single storey basements during their life cycle. Limiting the size of basements will therefore limit carbon emissions and contribute to mitigating climate change."*

This report aims to demonstrate through the use of more appropriate project assumptions that this statement is misleading. Of the sixteen case studies presented by Eight Associates, two have been re-calculated by Waterman based on more accurate site specific data. The case studies are as follows:

- Case study 1 is an above ground extension at 36 Markham Square; and
- Case study 2 is a subterranean single storey basement development.

This report has determined the following key points:

- The embodied carbon from the case studies used has been recalculated and determines that basement developments emit less carbon over a 60 year lifespan than an above ground extension;
- The use of BREEAM Green Guide to Specification Rating embodied energy figures has led to an inaccurate classification of materials, and an over estimating in embodied carbon;
- Waste figures for materials have been doubled counted by Eight Associates, leading to an increase in embodied carbon figures;
- The calculation methods used by Eight Associates have not been standardised throughout the calculations, therefore, direct comparisons cannot be made over the sixty year period;
- Energy upgrades to the existing developments have been included, thus masking the true impact of both basements and extension; and
- The methods of basement construction used has not been assessed by Eight Associates, therefore, the carbon generated at the phase of development has influenced the results.

On the basis of our technical review of the Eight Associates report, it is considered that there are significant number of issues for debate surrounding the calculation of the lifecycle carbon of both the basement and the extension. The recalculation of the case studies indicate that embodied carbon as a result of the basement development is less than that generated by an above ground extension. Having reviewed the available information, our conclusion is that the statement made in paragraph 34.3.53 of RBKC's Basements Policy Publication Final is based on inconsistent and inaccurate lifecycle carbon calculations and the Eight Associates report is not considered to present a sound basis for such an argument. Further, more detailed analysis is recommended.

1. Introduction

Waterman was commissioned by Cranbrook Basements to carry out a technical review and recalculations of the claims made in a report produced by Eight Associates in February 2014 entitled *Life Cycle Carbon Analysis of Extensions and Subterranean Development in RBK&C.* The report was produced to support the proposed changes to planning policy within the Royal Borough of Kensington and Chelsea (RBKC).

RBKC undertook a partial review of their Core Strategy and the Basements Publication Planning Policy during the summer of 2013. In the consultation document, the Council highlighted issues in relation to the noise impacts and disturbance during the construction of basements from traffic and plant, as well as concerns about the structural stability of nearby buildings. To support the policy change, RBKC undertook an Embodied Carbon analysis to compare the difference in embodied carbon between extensions and subterranean development. The findings were based on a report undertook by Eight Associates in July 2010.

As part of the consultation process, Cranbrook responded to the research paper, highlighting inaccuracies in the data and methodology. Subsequent to the consultation further reports were commissioned by Eight Associates to update their findings. This report was issued by RBKC in February 2014, and initiates a further period of consultation.

The revised Eight Associates report, issued 10 February 2014, compares 16 case studies including both subterranean and above ground extensions. This report aims to review the assumptions and raw data utilised by Eight Associates as well as their carbon calculations, conclusions and findings presented in the abovementioned report. We will also recalculate the embodied carbon for two case studies.

This report has been undertaken by Waterman carbon specialists, with input from structural engineers, in order to provide an informed review of the Eight Associates Report.

A CV of Chris Illman, reviewer of this report, has been included in Section 2. The findings of the critical review are detailed in section 3 and re-calculations of embodied carbon are presented in section 4.

2. CV of Report Author

Chris Illman

Principal Sustainability Consultant

Waterman Energy, Environment & Design Ltd

Profile

Chris is currently a Principal Sustainability Consultant for Waterman EED. He previously headed up the BREEAM and Commercial departments at Energist UK. He has excellent technical knowledge and experience across the full range of BREEAM schemes in addition to an in depth understanding and experience of delivering Carbon Footprinting, Low Carbon Design, Building Regulations and Part L requirements.

As part of the Waterman's sustainability team Chris is a BREEAM Accredited Professional and a licensed BREEAM assessor in a number of schemes, including Commercial, Education, Bespoke and International Bespoke.

Qualifications: BSc (Hons) MSc AIEMA BREEAM AP

Key Skills

- **Licensed BREEAM Commercial Assessor**
- **Licensed BREEAM International Assessor**
- **Licensed BREEAM Bespoke Assessor**
- **Licensed BREEAM Education Assessor**
- **BREEAM Accredited Professional**
- **Extensive Sustainability and Carbon Design Experience**

Project Experience:

Project	Details
Finsbury Circus	Delivering analysis and consultation to Cambridge Consultants in order to reduce the company's carbon footprint. Reporting on a monthly basis, key actions and pathways have been identified to enable reductions to be achieved. **Client: Cambridge Consultants**
Cremorne Wharf, Royal Borough of Kensington and Chelsea	To support a planning application for the proposed mixed use development a Sustainability Statement was required to demonstrate compliance with the London Plan. As part of a multi-disciplinary approach the design incorporated sustainability features to reduce carbon emissions, enhance biodiversity and enhance social wellbeing. Client: Royal Borough of Kensington and Chelsea
MTC Ansty, Warwickshire	Currently working with Morgan Sindall to reduce the Contractors site carbon emissions as part of delivering wider sustainability measures for the site. An BREEAM 'Excellent' rating has been awarded for the new state of the art research and development complex, outside Coventry. **Client: Morgan Sindall**
Siemens Relocation, Lincoln	The new factory and office development for Siemens achieved an BREEAM Outstanding and BREEAM 'Excellent' rating respectively. Siemens sustainability policies are reflected in the design through the use of Photo-Voltaic panels, and rain water harvesting. Key operational metrics are being recorded in order to establish the difference between design and operational value. **Client: St Modwen on behalf of Siemens Real Estates Plc**
Kelaty House, Wembley	Working with Londonnewcastle to develop the proposals for a new mixed use development in the heart of Wembley. The design includes a Hotel, Student Accommodation, and Retail space. We are working in the capacity of Sustainability Consultants and BREEAM assessors to maximise the sustainability credentials of the site. A sustainability statement has also been produced to support the planning application. The design includes minimising reliance on mains water consumption, the selection of low and zero carbon technologies based on life cycle analysis, and the enhancement of ecology. **Client: Londonnewcastle**

3. Analysis of Data Collection Methods

Analysis of Eight Associates Methodology

In order to provide context to the embodied energy calculations, we have undertaken a review of Eight Associates methodology in order to highlight key areas where the embodied carbon can be significantly influenced.

Summary	Commentary	Recommendations
Use of BRE Green Guide rating incorrectly used.	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.	More accurate embodied energy data is required for the materials.
Inaccurate BRE Green Guide rating.	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.	More accurate embodied energy data is required for the materials.
Embodied carbon from transport and waste manufacturer is double counted.	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 Associate's report; therefore, such items have been double counted.	Undertake more accurate embodied energy calculations, and count waste and transport once.
Assumptions have been made in respect to distances waste travelled from site.	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.	More accurate data needs to be provided.
Assumptions have been made regarding construction practices.	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.	More accurate data from the case studies needs to be provided.
Change in scope for each phase of analysis impacts on overall figures.	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.	Either the complete cradle to grave life cycle should be considered, or cradle to site. Use of both methodologies should not be used.

Summary	Commentary	Recommendations
Analysis of each phase of embodied energy.	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.	Embodied energy should be considered in its entirety, and only compared at each stage for interest purposes.
Impact of each Embodied Carbon Phase.	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)[1]. 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.	Embodied carbon should be considered over the full 60 year life span.
Operationally carbon emissions are based on assumptions.	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.	More accurate data based on case studies should be provided.
Operational carbon emissions calculation method is impacted by policy.	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 dependant 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.	More accurate data and the ability to adapt to climate change should also be considered.

[1] T.Ramesh, R.Prakash, & K.K. Shukla (2010). Life cycle energy analysis of buildings: An overview. *Energy and Buildings, 42 (10), pp1592-1600*

Summary	Commentary	Recommendations
	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.	
Operational Energy of the extension / basement is not considered in isolation.	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.	Operational energy should be considered either in isolation or the context of the whole dwelling. It should not be considered in terms of floor space added.
Energy upgrades to the existing building are included in the calculations.	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.	Operational energy should be considered either in isolation or the context of the whole dwelling. It should not be considered in terms of floor space added.

4. Recalculation of Case Studies

Summary of our approach

This section details a summary of our approach. More detailed calculations are included in Section 5.

Due to the limited consultation period, the delay in provision of information, as requested by a Freedom of Information submission, we have only had sufficient time to undertake a recalculation of the Life Cycle Assessment for two of the sixteen case studies. The case studies were selected based upon the most substantial amount of information being made available. These are as follows:

- 36 Markham Square – a 36.40m^2 multi storey extension, giving a total dwelling floor area of 234.2m^2; and
- 49 Redcliffe Road – a 116.10m^2 basement development, giving a total dwelling floor area of 428.5m^2. Please note this is a Cranbrook Basement scheme, therefore, detailed information was available.

It should be noted that the floor areas used in this study differ to those areas cited by Eight Associates. This report has used the net added floor area which was included in the construction analyses. The revised figures are as follows:

Case Study	Extension Area (m^2)	Total post development floor area (m^2)
36 Markham Square	28.86	234.20
49 Redcliffe Road	90.54	428.50

A summary of our methodology for both is details in the paragraphs below.

Life Cycle Approach

Due to the data available, and the fact that the operational carbon does not include for replacement / repairs, a cradle to site approach has been considered across all aspects of the embodied carbon analysis. The scope of the assessment now includes:

- Embodied carbon of materials from cradle to factory gate;
- Embodied carbon of waste removed from site including transport from site;
- Embodied carbon of building services in operation; and
- Embodied carbon of transport from site and machinery / power used on site to construct the basement / extension.

As part of the Life Cycle Analysis, all existing building fabric, unless removed i.e. demolished is not considered.

Materials and Waste

The methodology used for this carbon analysis has been based on real quantities of materials used, as summarised in an Appendix A to this report, and waste produced for the two case studies. These data values have been approved by a quantity surveyor.

The carbon factors have been taken from the most recent version of Bath University's Inventory of Carbon and Energy (ICE) (V2.0 January 2011)[2]. This has values for specific materials, such as RC 28/30 concrete with 30% fly ash replacement, as opposed to a whole value for a construction element, such as a ground floor, as found in the BRE Green Guide. The factors are more specifically 'kg carbon dioxide equivalent' (kgCO_2e) which considers all greenhouse gases released in the lifecycle of the material.

The CO_2e factors for demolition, spoil and exaction are taken from the UK Government's conversion factors for company reporting (Defra, 2013). Where the values provided in the construction analyses are not applicable to the ICE factors, suitable conversion factors have been applied, such as m^3 to kg or tonnes. For certain materials, the ICE has a range of values rather than one definitive figure. This is due to the variety in production methods and travel distances, among other factors. Where this is the case the analysis has undertaken a low, middle and high scenario.

Where assumptions have needed to be made, the average ICE value has been used for the material.

Waste transport

The DEFRA figures for waste include an allowance for the disposal of waste, and transport of waste from site. These have been included as part of the overall embodied energy figure. There is insufficient embodied carbon data to enable the waste removal from site to be broken down any further, therefore, the analysis has not included the potential for transport to be minimised using waste transfer stations in the vicinity of each site, or the use of the River Thames to transport goods / waste.

Construction Practices

Construction of the basement at 49 Redcliffe Street was undertaken with small electric machinery, and manual labour. In the absence of sufficient data, standard construction practices for the extension have been adopted. It has been assumed that the build programme for the extension will be 3 months, therefore, emissions associated with this will be 6,000kgCO_2. The programme for the basement development was ten months, which emissions are estimated at being 20,000kgCO_2.

Operational Energy

Despite Cranbrook Basement's repeated requests and formal Freedom of Information applications, insufficient information has been provided to substantiate Eight Associates claims that there are significant differences in post development operational energy emissions.

Having acknowledged the fact that the initial analysis does not include the full life cycle of building services, such an approach has not been adopted for the review.

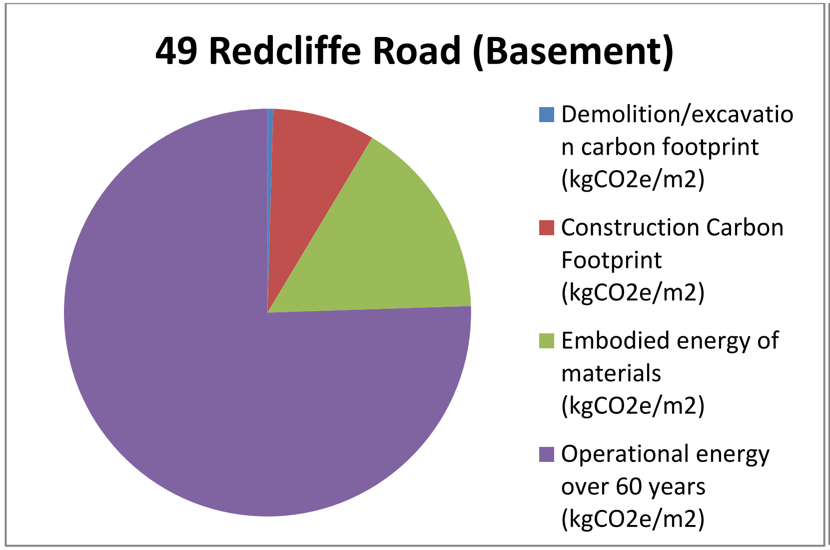
[2] Accessed at http://www.circularecology.com/ice-database.html

Under the current building regulations, there is a requirement for those undertaking any extension to include consequential improvements as part of the development. This promotes energy efficiency in the existing built environment, whilst also limiting development to those which meet the energy performance requirements.

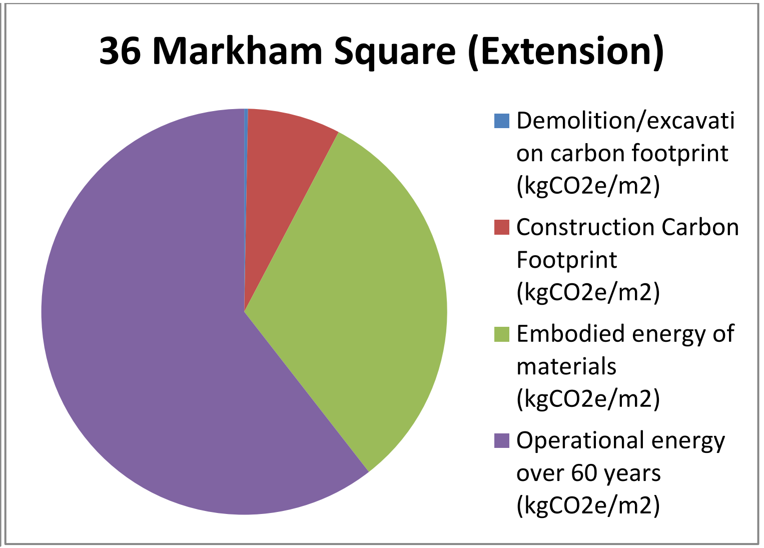
Eight Associates do not detail if the total post operational figures include such measures. If they do, then such measures will impact on carbon performance, and thus skew the differences between the impact of the extension / basement on 60 years operational carbon performance. Published findings need to be provided to confirm the data is accurate. Furthermore, for 36 Markham Square it is acknowledged that some demolition of current extensions was undertaken prior to works commencing on the new extension. Thus, the changes will also significantly alter the embodied energy before and after. Due to the difficulties in isolating the operational energy from the basement, the total operational energy for the dwelling, post development, has been used. This is to be normalised per m^2 of floor area.

Summary of Results

	Basement	**Extension**
	49 Redcliffe Road	36 Markham Square
Demolition/excavation carbon footprint ($kgCO_2e/m^2$)	11.90	8.39
Construction Carbon Footprint ($kgCO_2e/m^2$)	220.90	207.90
Embodied energy of materials ($kgCO_2e/m^2$)	430.00	891.73
Operational energy over 60 years ($kgCO_2e/m^2$)	2,044.20	1,699.32
Total	**2,707.00**	**2,807.34**



49 Redcliffe Road (Basement)
Demolition/excavation carbon footprint (kgCO2e/m2)
Construction Carbon Footprint (kgCO2e/m2)
Embodied energy of materials (kgCO2e/m2)
Operational energy over 60 years (kgCO2e/m2)



36 Markham Square (Extension)
Demolition/excavation carbon footprint (kgCO2e/m2)
Construction Carbon Footprint (kgCO2e/m2)
Embodied energy of materials (kgCO2e/m2)
Operational energy over 60 years (kgCO2e/m2)

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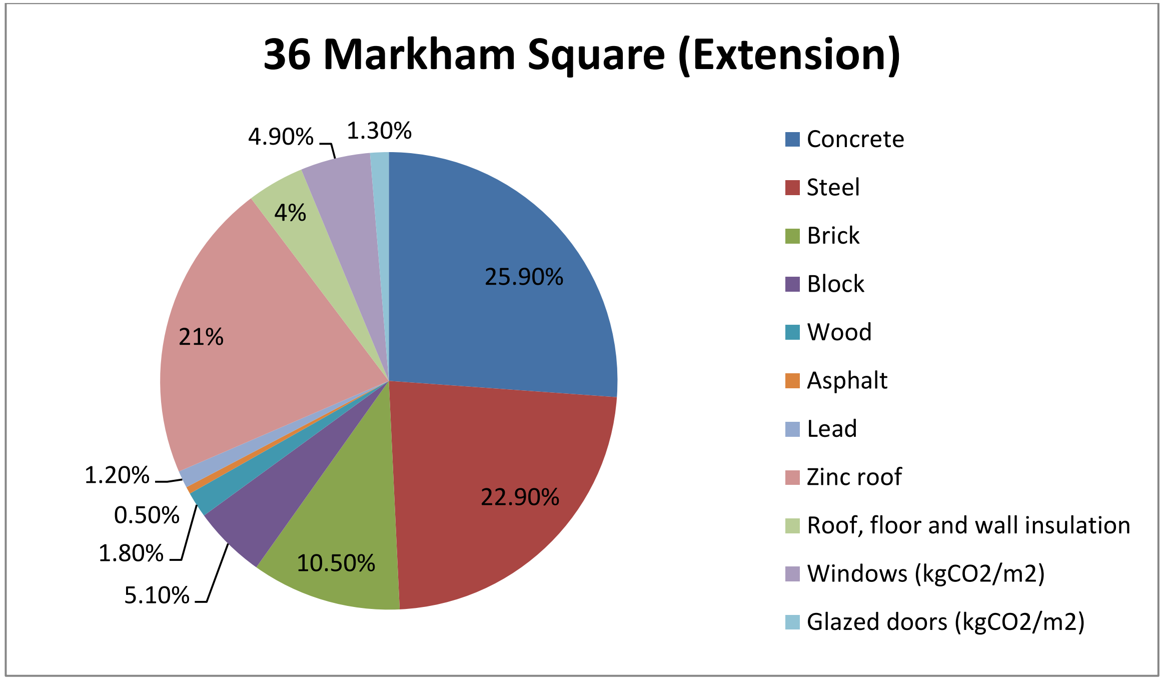
5. Detailed Calculations

The final calculations are based on analysis of each of the building fabrics, construction processes, and the implications for development.

Embodied Carbon in Materials

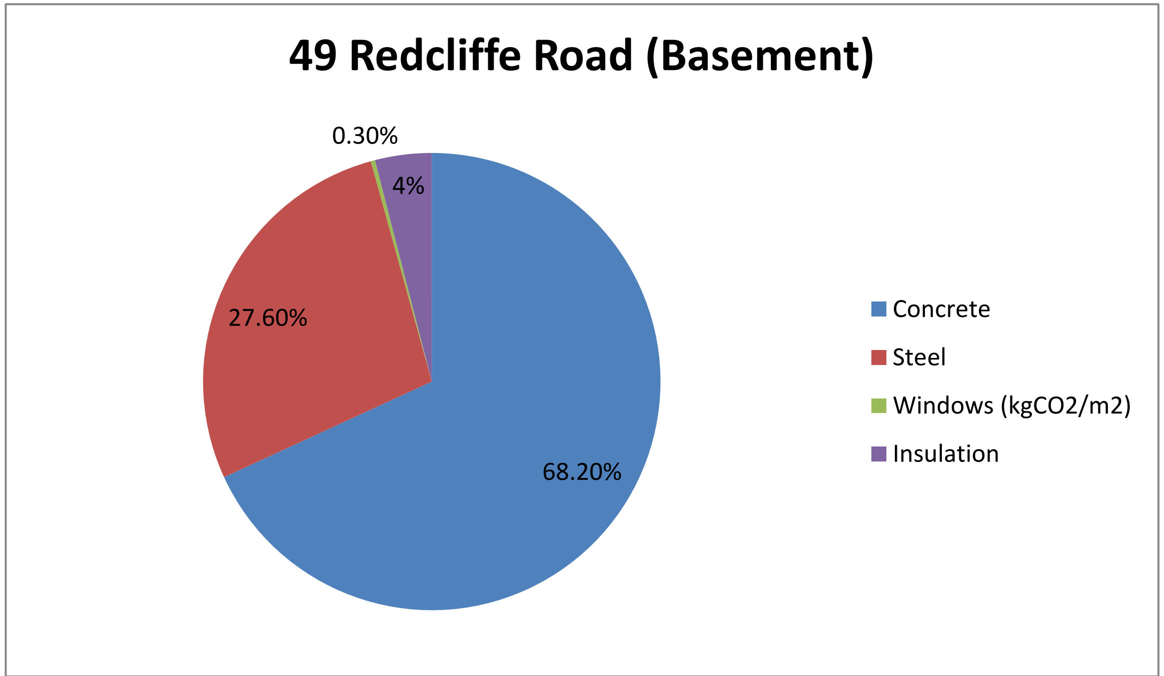
The embodied carbon for the materials used in the construction of 36 Markham Square is outlined in the table below.

	Carbon factor ($kgCO^2e/kg$ unless stated otherwise)	Carbon impact ($kgCO^2e$)	Proportion of total
Concrete	0.115	6,669	25.9%
Steel	1.460	5,906	22.9%
Brick	0.240	2,703	10.5%
Block	0.078	1,300	5.1%
Wood	0.310	470	1.8%
Asphalt	0.076	122	0.5%
Lead	1.670	299	1.2%
Zinc roof	3.09	5,416	21%
Roof, floor and wall insulation	1.97	1,003	4%
Windows ($kgCO^2/m^2$)	205.38	1,265	4.9%
Glazed doors ($kgCO^2/m^2$)	13.62	346	1.3%
Total		**25,735**	


36 Markham Square (Extension)
25.90%
22.90%
10.50%
5.10%
1.80%
0.50%
1.20%
21%
4%
4.90%
1.30%
Concrete
Steel
Brick
Block
Wood
Asphalt
Lead
Zinc roof
Roof, floor and wall insulation
Windows (kgCO2/m2)
Glazed doors (kgCO2/m2)

The embodied carbon for the materials used in the construction of 49 Redcliffe Road is outlined in the table below.

	Carbon factor (kgCO^{2}e/kg unless stated otherwise)	Carbon impact (kgCO^{2}e)	Proportion of total
Concrete	0.115	26,579	68.2%
Steel	1.460	10,738	27.6%
Windows (kgCO^2/m^2)	13.62	124	0.3%
Insulation	1.97	1,533	4%
Total		**38,973**	



Comparisons of the materials show that concrete has the highest carbon impact of all materials for both case studies. It is responsible for 68.2% of the impact at Redcliffe Road and 25.9% at Markham Square. Steel has nearly all the remaining impact at Redcliffe Road and 22.9% at Markham Square. The zinc roof is responsible for 21% while bricks and blocks contributed 10.5% and 5.1%, respectively, to Markham Square's impact. Insulation (roof, floor and wall at Markham Square and floor and wall at Redcliffe Road) contributed 4% to both buildings. The remainder is made up by wood, asphalt, lead and glazing. Windows contributed less than 1% of the carbon impact of Redcliffe Road.

Embodied Carbon in Excavation and Demolition Waste

The embodied carbon for the excavation and demolition waste in the construction of the extension at 36 Markham Square is outlined in the table below.

	Carbon factor	Carbon impact (kgCO^{2}e)
Demolition	2kgCO^{2}e/tonne	70
Soil excavation	1.49kgCO^{2}e/tonne	75
Total		**145**

The embodied carbon for the excavation waste generated during the construction of the basement at 49 Redcliffe Road is outlined in the table below.

	Carbon factor	Carbon impact (kgCO^{2}e)
Excavation – recycled	1.49kgCO^{2}e/tonne	808
Excavation - landfill	2kgCO^{2}e/tonne	273
Total		**1,081**

Comparisons of the materials show that, as predicted, large amounts of excavation waste are generated as part of the basement construction. Although not reflected, due to insufficient carbon factor data being available, the waste removed from site is taken as far of the River Thames, and then transferred using barge.

Embodied Carbon during Construction

The embodied energy during construction has been estimated, based on the expected programme for each development. As detailed in Eight Associates 2010 report, they assumed an average construction length of two months for an extension, and 15 months for a basement. Following consultation with a Structural Engineer, the works were recalculated to be 3 months for an extension of the magnitude of 36 Markham Square, and 10 months for a basement of the magnitude of 49 Redcliffe Road. The total emissions and emissions per m^2 of development are as follows:

Project	Total Kg CO_2 Generated during Construction	Total $KgCO_2/m^2$
35 Markham Square	6,000	207.90
49 Redcliffe Road	10,000	220.90

6. Analysis

The recalculated case studies have produced a figure less than half that of the Eight Associates report for 49 Redcliffe Road: 38,973 kgCO_2e compared to 87,795 kgCO_2e. The results for 36 Markham Square are closer, though still significantly different: 25,735 kgCO_2e compared to 20,406 kgCO_2e.

The difference between the two reports in the absolute carbon suggests that Eight Associates considerably overestimated the materials' embodied energy. This may have been due to a number of reasons including the wrong selection of materials from the Green Guide and/or inaccurate quantifying of materials and their impacts, or there are maybe other reasons we are not aware of This is quite possible as Eight Associated generated their quantities from planning stage drawings and the materials were selected from those closest matching in the Green Guide. That the two reports' absolute figures for 36 Markham Square are closer suggests both methodologies are robust so long as the correct material quantities and carbon factors are used. However, where such a report is being used to support a change to planning policy, more accurate data should be used.

The floor areas provided in the construction analyses used in this study are significantly different to those used in the Eight Associates report. The Eight Associates report states that 49 Redcliffe Road increased in floor area by 116m^2 whereas the construction analysis provides a figure of 90.54$m^{2.}$ The Eight Associates report produce a normalised carbon impact of 832 kgCO^2e whereas this study's equivalent figure of 430 kgCO^2e is approximately 50% lower. This is despite using a smaller increase in floor area.

Eight Associates have given an increase in floor area of 36.4m^2 for Markham Square yet the construction analysis states this to be only 28.86m^2. This is a reduction of around 23%. It makes a note that the total floor area of the extension (40.16m^2) is not the total increase in floor area as the existing extension was demolished as part of the building works. Eight Associates also appear to have incorrectly measured a double height space as an additional floor level. This explains why the normalised figure this study has generated of 891.73 is significantly higher than the Eight Associates report 372 kgCO^2e. It seems logical that building a completely new basement will result in more of an increased floor area than partially rebuilding an existing part of a building. A significant proportion of the carbon impact of the extension will therefore be generated without adding any additional floor area.

7. Conclusion

The findings of our assessment using the information provided for the two named projects demonstrate that over a 60 year lifespan, the basement case study will emit fewer carbon emissions than the extension.

Further analysis should be undertaken across a greater number of theoretical and existing case studies, based on site data. This will enable a complete analysis of embodied carbon to be undertaken.

Paragraph 34.3.54 of RBKC's Basements Policy Publication states that "*the carbon emissions of basements are greater than those of above ground developments per square meter over the building's life cycle. This is because of the extensive use of concrete which has a high level of embodied carbon. In particular multi storey basements are more carbon intensive when compared to above ground extensions or single storey basements during their life cycle. Limiting the size of basements will therefore limit carbon emissions and contribute to mitigating climate change.*"

Based on the information above, it is considered that is based on deficient and incomplete lifecycle carbon calculations and the Eight Associates report is not considered to present a robust basis for such an argument. The lack of information provided by RBKC to substantiate the detailed calculations prevents a full technical analysis from being undertaken. Further evidence based analysis and benchmarking of projects would be beneficial to determine the true impact of the developments' on carbon emissions. Following such assessment, the RBKC statement may have to be reviewed.

Appendices

Appendix A Material Quantities

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

7.00	Reinforcement to Underpins		
7.01	3 Layer A393 @ 6.16kgm2		
7.02	50 Linear Metres x 2.8 high x (6.16kg x3 layer) x 110%	2845kg	Steel
7.03	L' Bar Reinforcement @ 200c/c F&B T16 x 1600mm @ 1.58kg linear metre	1238kg	Steel
8.00	Replace Lower Ground Floor Slab		
8.01	82m2 x 250mm thick - concrete :-	20.5m3	C30
9.00	Steel Deck Holorib - Lower Ground Floor Slab		
9.01	82m2 x 13.30kgm2	1086kg	Steel
10.00	Reinforcement - Lower Ground Floor Slab		
10.01	Reinforcement A393 @ 6.16kgm2	553kg	Steel
10.02	Miscellaneous Reinforcement	400kg	Steel
11.00	Floor Screed - Lower Ground Floor Slab		
11.01	50mm Thick	4.1	Concrete
	wall insulation	104	PIR
	floor insulation	90.54	
12.00	Windows		
12.01	Basement - Rear	6.93m2	
12.02	Basement - Front	2.16m2	
		Total glazir	9.09
	Note :		
	Heating to Basement is via ground source, heat pump, borehole		

36 Markham Square SW3 4XA - Construction Analysis

1.00	Demolition - Existing Rear Extensions		
1.01	Take off from approved demolition drawings - Zero Recycle due to material contamination	40m³	10No Skip
2.00	Reduce Garden Level		
2.01	6.30 x 5.00 x (.66 x .25) + 40% Bulkage	40.13m³	10No Skip
3.00	Mansard Roof & Floor Demolition		
3.01	Floor = 7.2 x 4.85 x .300 Thick - Plus 40% Bulkage	14.67m³	4No Skip
3.02	Roof = 11.00 x 4.85 x .300 Thick - Plus 40% Bulkage	22.41m³	6No Skip
	Total demolition		
4.00	Foundations to Lower Ground Floor Extension		
4.01	4.7m x 1.5 deep x .5m wide = 4.23		
	2.45 x 105 x .6m = 2.20		
	6.43m³ x 40% =	9m³	3 No Skip
5.00	Concrete to Foundations C30	7m³	Concrete
6.00	Reinforcement to Foundations		
6.01	T16 3T & 3B = 48LM @ 1.58kg	76kg	Steel

7.00	Mass Concrete Underpins to External Walls		
7.01	Spoil (3.85 + 2.2 + 1) = 7.05 x .6 wide x 1.5m deep		
	= 6.34m^3 x 40% bulkage = 9m^3	9m^3	3 No Skip
8.00	Mass Concrete C30 x (6.34m^3)	7m^3	Concrete
9.00	Brick to DPC Level		
9.01	7.05m run x 600mm high = 4.23m^2	516	Class B Eng Brick
10.00	Floor slab - 20.34m^2		
10.01	200mm Type 1 Granular Fill	4m^3	concrete
10.02	200mm C30 Concrete	4m^3	concrete
10.03	100mm Floor Screed Concrete	2m^3	concrete
10.04	A393 Slab Reinforcement		
	20.34m^2 x 6.16kgm^2 x 110% =	138kg	Steel
11.00	Masonry Walling		
	7.05 Lm x 3m = 21.15m^2		
	Ddt openings 7.45m^2		
11.01	Brick 13.70m^2 x 62	849no	Brick
11.02	Block 13.70m^2	13.70m^2	Block
	Block area 215mm x 440mm = 0.095m2		144.2
12.00	Block Partition Walls		
12.01	2.2m x 2.4 - 5.28m^2	5.3m^2	150 Block
			55.8
13.00	Steel Frame		
13.01	A & B - 2No 203 x 203 x 86 kg @ 4m	344kg	Steel
13.02	C & D - 1No 203 x 203 x 86 kg @ 4.3m	369kg	Steel

14.00	Steel Lintels		
14.01	1no 3.2 + 1no 1.2 = 4.4m		
	4.4m x 203 x 203 x 46kg	202kg	steel
15.00	Ground Floor Level Masonry		
15.01	100mm Brick (2.25 + 1.8) x 2.9		
	Ddt 2/.45 x 1.2 - <1.08m^2> - 10.66m^2	661 No.	Brick
15.02	100mm Block Cavity Wall	10.7m^2	100 Block
			112.63
15.03	100mm block - Partition Wall	7m^2	100 Block
			73.68
15.04	150mm Block - Insulating Wall	4.40m^2	150 Block
			46.32
16.00	First Floor Level Masonry		
16.01	25.08m^2 Wall ddt - Windows at 1.8m2 = 23.28m2		
16.02	100mm Brick Walling 23.28m^2	1443No	Brick
16.03	100mm Block Walling	23.3m^2	100 Block
			245.26
17.00	Second Floor Level Masonry		
17.01	19.76m^2 Wall Ddt Windows at 3.6m2 = 16.16m2		
17.01	100mm Brick Walling 16.16m^2	1001 No	Brick
17.02	100mm Block Walling 16.2m2	16.20m^2	100 Block
			170.53
18.00	Steel Beam to Second Floor Knock Through		
18.01	1.5m x 203 x 203 x 46kg	69kg	Steel
19.00	Steel Lintels to Second Floor Level		
19.01	2No @ 1.5m x 46kgm	138kg	Steel
20.00	Masonry Parapet		
20.01	.45m x 7.6 + 3.42m^2 1 Brick Thick Wall	417	Brick

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

	General Project Data		
	Total Area Windows + Doors + roof		
	roof 5.99		
	LGF 7.81		
	GFL 8.16		
	FFL 1.14		
	2FL 2.38		
	25.38m^2 of glass wall	23.9% of External Wall Area	
	Total Construction		
	Total / added m2		
	Area of Rear Extension		
	Lower GFL 20.36		
	GFL 14.71		
	FFL 0.00		
	2FL 5.11		
	Total Floor Area of Extensions 40.16m^2		
	Note: THIS IS NOT TOTAL NETT AREA DUE TO DEMOLITION OF EXISTING EXTENSIONS		
	Glass Roof = 5.98m^2 = 14.90% of Floor Area		
	External Wall Surface Area		
	LGF 7.05 x 2.4	16.92	
	7.75 x 2.7	20.92	
	7.60 x 3.0	22.8	
	7.60 x 2.7	20.52	
	Total Surface Area External Walls of Extension	81.16m^2	
	AREA CALCULATION		
	Demolished Floor Area: LGF 6.52m^2		
	GFL 4.27m^2		
	<10.79m^2>		
	Loft Area <34.80m^2>		
	Extensions News 39.66		
	Loft New 34.79m^2		
	Total Floorspace Added 28.86m^2		

UK and Ireland Office Locations