

Appendix 01 New materials, buildings & extensions

Building element group	Building element (NRM level 2)	Basis for information
Demolition	0.1 Toxic/hazardous/contaminated material treatment	Not currently included in cost plan. Therefore not allowed for until more information is know.
	0.2 Major demolition works	An allowance for site excavation and demolition works was included in the assessment and used the average intensity of 1.39 kg CO2e/m ³ cleared debris, as developed by OneClick LCA software.
0. Facilitating works	0.3 & 0.5 Temporary/enabling works	Not currently included in cost plan. Therefore not allowed for until more information is known.
	0.4 Specialist groundworks	No specialist ground works were included separately, with individual ground works accounted for in the relevant substructure / external landscaping sections.
1. Substructure	1.1 Substructure	The specific foundation material quantities were determined by the structural engineer following detailed analysis and optioneering.
2. Superstructure	2.1 Frame	The specific frame material quantities were determined by the structural engineer following detailed analysis and optioneering.
	2.2 Upper floors incl. balconies	The specific upper floor material quantities were determined by the structural engineer following detailed analysis and optioneering. This includes for strengthening of existing structure where necessary.
	2.3 Roof	Material quantity and composition of the roof were calculated based structural material quantifies, and reference areas / typical build ups provided by the project architect.
	2.4 Stairs and ramps	Material quantity and composition of the roof were calculated based structural material quantifies, and reference areas / typical build ups provided by the project architect.
	2.5 External walls	Material quantity and composition were calculated based structural material quantifies, and reference areas / typical build ups provided by the project architect.
	2.6 Windows and external doors	Material quantity and composition of the roof were calculated reference areas / known product types provided by the project architect.

Building element group	Building element (NRM level 2)	Basis for information
2. Superstructure	2.7 Internal walls and partitions	Material quantity and composition were calculated based structural material quantifies, and reference areas / typical build ups provided by the project architect.
	2.8 Internal doors	Material quantity and composition were calculated based structural material quantifies, and reference areas / typical build ups provided by the project architect.
3. Finishes	3.1 Wall finishes	Material quantity and composition were calculated based structural material quantifies, and reference areas / typical build ups provided by the project architect.
	3.2 Floor finishes	
	3.3 Ceiling finishes	
4. Fittings, furnishings and equipment (FF&E)	4.1 Fittings, furnishings & equipment incl. building related and non-building related	Known fittings, furnishings & equipment were included in the assessment based on the Cat A design only.
5. Building services/MEP	5.1-5.14 Services incl. building-related and non-building-related	Building services data uses inputs provided from the Building Services engineers which approximately align with the proposed services strategy for the project. The lengths of ducts', electrical distribution and water distribution were calculated on a m ² GIA basis using the built in estimator Carbon Designer within OneClick LCA.
6. Prefabricated Buildings and Building Units	6.1 Prefabricated buildings and building units	No prefabricated elements are applicable.
7. Work to Existing Building	7.1 Minor demolition and alteration works	No minor works were applicable.
8. External works	8.1 Site preparation works	External works were included based on the landscape architects proposals, known products (where known) and typical build-ups provided by the landscape architect.
	8.2 Roads, paths, paving and surfacing	
	8.3 Soft landscaping, planting and irrigation systems	
	8.4 Fencing, railings and walls	
	8.5 External fixtures	
	8.6 External drainage	
	8.7 External services	
	8.8 Minor building works and ancillary buildings	

Appendix 01 Refurbished buildings

Building element group	Building element (NRM level 2)	Basis for information	Building element group	Building element (NRM level 2)	Basis for information
Demolition	0.1 Toxic/hazardous/contaminated material treatment	none	2. Superstructure	2.7 Internal walls and partitions	Retained materials have been estimated based on similar and available project specific information as identified by the project architect. New materials as per previous table.
	0.2 Major demolition works	none		2.8 Internal doors	Retained materials have been estimated based on similar and available project specific information as identified by the project architect. New materials as per previous table.
0. Facilitating works	0.3 & 0.5 Temporary/enabling works	Not currently included in cost plan. Therefore not allowed for until more information is known.	3. Finishes	3.1 Wall finishes	Retained materials have been estimated based on similar and available project specific information as identified by the project architect. New materials as per previous table.
	0.4 Specialist groundworks	No specialist ground works were included separately, with individual ground works accounted for in the relevant substructure / external landscaping sections.		3.2 Floor finishes	
1. Substructure	1.1 Substructure	The specific foundation strengthening material quantities were determined by the structural engineer following detailed analysis and optioneering. Retained materials have been estimated based on similar and available project specific information.		3.3 Ceiling finishes	
	2.1 Frame	The specific frame strengthening material quantities were determined by the structural engineer following detailed analysis and optioneering. Retained materials have been estimated based on similar and available project specific information.	4. Fittings, furnishings and equipment (FF&E)	4.1 Fittings, furnishings & equipment incl. building related and non-building related	Known fittings, furnishings & equipment were included in the assessment based on the Cat A design only.
2. Superstructure	2.2 Upper floors incl. balconies	Retained materials have been estimated based on similar and available project specific information.	5. Building services/MEP	5.1-5.14 Services incl. building-related and nonbuilding-related	All building services are to be replaced. See previous table.
	2.3 Roof	Retained materials have been estimated based on similar and available project specific information. New materials as per previous table.	6. Prefabricated Buildings and Building Units	6.1 Prefabricated buildings and building units	No prefabricated elements are applicable.
	2.4 Stairs and ramps	Retained materials have been estimated based on similar and available project specific information.	7 Work to Existing Building	7.1 Minor demolition and alteration works	No minor works were applicable.
	2.5 External walls	Retained materials have been estimated based on similar and available project specific information as identified by the project architect. New materials as per previous table.	8 External works	8.1 Site preparation works	External works were included based on the landscape architects proposals, known products (where known) and typical build-ups provided by the landscape architect.
	2.6 Windows and external doors	All windows and doors are to be replaced. See previous table.		8.2 Roads, paths, paving and surfacing	
				8.3 Soft landscaping, planting and irrigation systems	
				8.4 Fencing, railings and walls	
				8.5 External fixtures	
				8.6 External drainage	
				8.7 External services	
				8.8 Minor building works and ancillary buildings	

Appendix 01

ENVIRONMENTAL PRODUCT DECLARATION (EPD) SOURCES

Appendix 02 EPD sources



During this stage of the design individual manufacturers have not yet been fully identified. To carry out a representative WLC Assessment, able to illustrate the impact of the different building elements, the materials database and EPDs used were taken from the approved OneClickLCA library.

Priority was always given to UK products. In the absence of such data, material information from neighbouring countries has been prioritised.

Below is a list of materials taken from Plot F, that is representative of materials across the development at this Stage.

Resource name	Technical specification	Product	Manufacturer	EPD program	EPD number	Environmental Data Source	Standard	Verification	Year	Country	Upstream database	Density	Product Category Rules (PCR)
Air handling unit, with heat recovery through indirect liquid circulation heat recovery	1000 m3/h (588.6 ft3/min), 92 kg/unit (203 lbs/unit)			One Click LCA	-	One Click LCA	EN15804+A1	Internally verified	2019	LOCAL	ecoinvent		EN15804+A1
Air handling unit, with heat recovery through plate heat exchanger	10 000 m3/h (5885.8 ft3/min), 1256 kg/unit (2769 lbs/unit)			One Click LCA	-	One Click LCA	EN15804+A1	Internally verified	2019	LOCAL	ecoinvent		EN15804+A1
Aluminium frame sliding windows and patio doors	25.28 kg/m2		SNFA	INIES	INIES_CFEN2019 0710_104909, 10884	FDES	EN15804+A1	Third-party verified (as per ISO 14025)	2019	france	ecoinvent		EN15804+A1
Aluminium framed windows, double leaf	26.55 kg/m2		SNFA	INIES	INIES_CFEN2019 0710_102448, 10883	FDES	EN15804+A1	Third-party verified (as per ISO 14025)	2019	france	ecoinvent		EN15804+A1
Bituminous waterproofing system - Single layer	5.44 kg/m2	AXTER, DERBIGUM, MEPLE, SIPLAST-ICOPAL, SOPREMA	Chambre Syndicale Française de l'Etanchéité	INIES	INIES_CTOI20180219_105730, 8349	FDES	EN15804+A1	Third-party verified (as per ISO 14025)		2017france	ecoinvent		EN15804+A1
Ceramic bathroom sink	9.54 kg/unit	GROHE Essence Undermount Sink	LIXIL Water Technology	UL Environment	4789961563.125.1	EPD Fine Fire Clay Sanitary Ceramic Undermount Sink	EN15804+A1	Third-party verified (as per ISO 14025)		2021turkey	ecoinvent		UL PCR for Sanitary Ceramics; v.2.0 January (2018)
Ceramic tiles, incl. underlayment membrane				One Click LCA		One Click LCA generic construction definitions				europa	Other		
Wooden decking, cladding and planed timber for joinery applications	755kg/m3, Moistr. 3-5%	Accoya Beech	Accsys Technologies PLC	EPD Norge	NEPD-376-262-EN	Accoya Wood - decking, cladding and planed timber for joinery applications, Beech, NEPD-376-262-EN, Accsys Technologies PLC	EN15804+A1	Third-party verified (as per ISO 14025)		2015netherlands	ecoinvent		NPCR 015 Wood and wood-based products for use in construction, rev1, 08/2013

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Resource name	Technical specification	Product	Manufacturer	EPD program	EPD number	Environmental Data Source	Standard	Verification	Year	Country	Upstream database	Density	Product Category Rules (PCR)
Ceramic toilet	19.6 kg/unit	- DURAVIT : Starck 3 (420009; 452709; 220209). ME by Starck (452909; 453009). DuraStyle (455209; 457109). // - KOHLER : Struktura (EDE101-00 ; EDF101-00). Patio (EDV101-00 ; E1534-00). Brive (E4345-00) // - ROCA : DEBBA (A346998000 ; A34699L000). VICTORIA (A34630300S).	Association Française des Industries de la Salle de Bains	INIES	INIES_CCUV20200303_175319, 14206	FDES	EN15804+A1	Third-party verified (as per ISO 14025)	2020	france	ecoinvent		EN15804+A1
Ceramic wall tile	6 mm, average density 2000 kg/m3		Mosa	MRPI	11.1.0002.004	EPD Wandtegelcollectie Koninklijke Mosa	EN15804+A1	Third-party verified (as per ISO 14025)	2013	unitedKingdom	ecoinvent	2000	EN15804+A1
Ceramic wall tiles	7.5 mm, 3000 kg/m2		Seranit Granit Seramik	International EPD System	S-P-00676	EPD for For Floor Tiles in accordance with EN15804 and ISO14025	EN15804+A1	Third-party verified (as per ISO 14025)	2015	turkey	ecoinvent	3000	PCR 2012:01 Construction products and Construction services, ver.1.2, 15/03/2013
Concrete assembly for elevator shaft per one metre height				One Click LCA		One Click LCA generic construction definitions				LOCAL	Other		
Concrete assembly for stairs per one metre height				One Click LCA		One Click LCA generic construction definitions				LOCAL	Other		
Concrete block wall, with cellular high density solid blocks, per m2 of wall including mortar	140 mm thickness wall			ICE	-	ICE database August 2019, V3.0	EN15804+A1	Self declared	2019	unitedKingdom	-		EN15804+A1
Concrete columns and beams, incl. reinforcing, per m3 of element	C35/45			One Click LCA		One Click LCA generic construction definitions				europe	Ecoinvent		
District heat distribution center	per 1kW			One Click LCA	-	One Click LCA	EN15804+A1	Internally verified	2019	LOCAL	ecoinvent		EN15804+A1

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Resource name	Technical specification	Product	Manufacturer	EPD program	EPD number	Environmental Data Source	Standard	Verification	Year	Country	Upstream database	Density	Product Category Rules (PCR)
Doors with wooden frame, interior		DONNEE PAR DEFAULT	DED	INIES	INIES_DPOR20180830_104138, 8591	MDEGD_FDES	EN15804+A1	Third-party verified (as per ISO 14025)	2018	france	ecoinvent		EN15804+A1
Double metal door (for technical premises, cellars, service ...)	ép.42mm	DONNEE PAR DEFAULT	DED	INIES	INIES_DBLO2018113_151608, 31518	MDEGD_FDES	EN15804+A1	Third-party verified (as per ISO 14025)	2022	france	ecoinvent		EN15804+A1
Drainage floor underlay from EPS	ép.25 mm	DONNEE PAR DEFAULT	DED	INIES	INIES_DCOU20191220_144652, 31818	MDEGD_FDES	EN15804+A1	Third-party verified (as per ISO 14025)	2022	france	ecoinvent		EN15804+A1
Drainage layer for green roofs from pozzolona and conifer bark, biogenic CO2 not subtracted (for CML)	971 kg/m3	Couche de drainage SOPRALITHE Z	SOPREMA SAS	INIES	INIES_ISUB20200921_161831, 30801	FDES	EN15804+A1	Third-party verified (as per ISO 14025)	2020	france	ecoinvent	971	EN15804+A1
Drinking water supply piping network, per m2 GIFA (residential buildings)				One Click LCA	-	One Click LCA	EN15804+A1	Internally verified	2019	LOCAL	ecoinvent		EN15804+A1
EPS foam insulation	0.034 W/mK, 25 kg/m3, max. 8000 x 1300 x 1000 mm		EUMEPS	IBU	EPD-EUM-20160275-IBG1-EN	EPD Expanded Polystyrene (EPS) Foam Insulation (density 25 kg/m³) EUMEPS	EN15804+A1	Third-party verified (as per ISO 14025)	2017	belgium	GaBi	25	PCR Insulating materials made of foam plastics, 07/2014
Electricity distribution system, cabling and central, for all building types				One Click LCA		One Click LCA generic construction definitions				LOCAL	Ecoinvent		
Electricity distribution system, cabling and central, for all building types	per m2 GFA			One Click LCA	-	One Click LCA	EN15804+A1	Internally verified	2019	LOCAL	ecoinvent		EN15804+A1
Emulsion matt paint for allround interior use	Pigment: Lightfast Pigments, binder: PVA Copolymer emulsion , solvent: Water, 1.443 kg/l, 18m2/l, 0.16 kg/m2	Supermatt White, Almond White, Gardenia, Magnolia, Light Base, Medium Base	Dulux Trade	MRPI	1.1.00023.2017	EPD Dulux Trade Supermatt	EN15804+A1	Third-party verified (as per ISO 14025)	2017	unitedKingdom	ecoinvent		EN15804+A1
Fan coil unit	50 kg/unit, P=1 kW		One Click LCA	One Click LCA	-	One Click LCA	EN15804+A1, EN15804+A2	Internally verified	2021	LOCAL	ecoinvent		EN15804+A1

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Resource name	Technical specification	Product	Manufacturer	EPD program	EPD number	Environmental Data Source	Standard	Verification	Year	Country	Upstream database	Density	Product Category Rules (PCR)
Flooring screed	C20/25 - XC1 - S3 - 20 CEM I, 50mm, 116.8kg/m2, 2336 kg/m3		SNBPE	INIES	INIES_CCHA201812_17_151718, 12450	FDES	EN15804+A1	Third-party verified (as per ISO 14025)	2018	france	ecoinvent		EN15804+A1
Fresh water distribution system				One Click LCA		One Click LCA generic construction definitions				LOCAL	Ecoinvent		
Galvanized steel joists for drywall	Steel type: X51D+ Z 100 g/m2, steel sheet: 0.5 mm	Gypsteel ELPR, ELR, GK, GKC, SLIM, SK, SKP, SKF, SKE, SKT, ATR, XR.	Lundell	EPD Norge	NEPD-1904-832-EN	EPD Gypsteel profiles	EN15804+A1	Third-party verified (as per ISO 14025)	2019	finland	ecoinvent		NPCR 013: 2019 Part B for Steel and Aluminium Construction Products, ver. 3.0
Geocellular system for sub-base drainage		Permavoid 150 (PVPP150)	Polypipe Civils & Green Urbanisation	EPD Hub	EPD HUB-0131	EPD Permavoid 150 Polypipe Civils & Green Urbanisation	EN15804+A1, EN15804+A2	Third-party verified (as per ISO 14025)	2022	unitedKingdom	ecoinvent		EPD Hub Core PCR version 1.0, 01.02.2022
Geotextile from polypropylene	300 g/m2		MDEGD	INIES	INIES_DGÉO20180223_161025, 7993	MDEGD_FDES	EN15804+A1	Third-party verified (as per ISO 14025)	2018	france	ecoinvent		EN15804+A1
Glass wool insulation	R=5.0 m2K/W, L=0.040 W/mK, ép. 200 mm, 2.295 kg/m2, Lambda=0.04 W/(m.K)	ISOLANT TOITURE 200	ISOVER	INIES	INIES_IISO20170504_091653, 12203	FDES	EN15804+A1	Third-party verified (as per ISO 14025)	2017	france	ecoinvent	11.475	EN15804+A1
Glass wool/mineral wool insulation with ECOSE Technology	0.040-0.046 W/mK		Knauf	BRE	BREG EN EPD000059	EPD Glass Mineral Wool Insulation with ECOSE Technology (0.040-0.046 W/mK), Knauf Insulation 2015	EN15804+A1	Third-party verified (as per ISO 14025)	2015	unitedKingdom	ecoinvent	10.5	EN15804+A1
Gypsum plasterboard	12.5 mm, 8.985 kg/m2 (average product weight)		Etex Building Performance	BRE	BREG EN EPD 000204	EPD GTEC Plasterboard	EN15804+A1	Third-party verified (as per ISO 14025)	2018	unitedKingdom	ecoinvent	718.8	EN15804+A1
Heat distribution piping network, per m2 heated area, all building types				One Click LCA	-	One Click LCA	EN15804+A1	Internally verified	2019	LOCAL	ecoinvent		EN15804+A1
Heat distribution system				One Click LCA		One Click LCA generic construction definitions				LOCAL	Ecoinvent		
Waterproofing membrane	1.8 mm, 2090 g/m2	BlueProof BASTA	Protan	EPD Norge	NEPD-1845-790-EN	EPD Protan BP-B (BlueProof BASTA roofing membrane) Protan AS	EN15804+A1	Internally verified	2019	norway	ecoinvent	1161.1	NPCR 022 Part B for Roof waterproofing, ver. 2.0, 06/2018

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Resource name	Technical specification	Product	Manufacturer	EPD program	EPD number	Environmental Data Source	Standard	Verification	Year	Country	Upstream database	Density	Product Category Rules (PCR)
Particleboard	660 kg/m3		Norbord	International EPD System	S-P-01856	EPD Particleboard	EN15804+A1	Third-party verified (as per ISO 14025)	2020	unitedKingdom	GaBi	660	PCR Construction products and construction services. PCR 2012:01 Version 2.3 (Date: 2018-11-15), SUB-PCR to PCR 2012:01: Wood and wood-based products for use in construction. PCR 2012:01-SUB-PCR-E (Date: 2018-11-22)
Polyethylene sealing film for slabs	ép. 150 micron	Donnee par default	MDEGD	INIES	INIES_DFIL20180427_114145, 8228	MDEGD_FDES	EN15804+A1	Third-party verified (as per ISO 14025)	2018	france	ecoinvent		EN15804+A1
Polypropylene vapour membrane, French average	0.18 kg/m2		MDEGD	INIES	INIES_DPAR20180223_160939, 7991	MDEGD_FDES	EN15804+A1	Third-party verified (as per ISO 14025)	2018	france	ecoinvent		EN15804+A1
Precast concrete paver	60 mm, 135.78 kg/m2		CENTRE D'ETUDES ET DE RECHERCHES DE L'INDUSTRIE DU BÉTON	INIES	INIES_CHRI20220228_111833, 29323	FDES	EN15804+A1	Third-party verified (as per ISO 14025)	2022	france	ecoinvent		EN15804+A1
Raised access flooring panels, chipboard in galvanized steel envelope, per m2	600 x 600 mm, 28.6 kg/m2	RG3	Kingspan Access Floors	International EPD System	S-P-02804	EPD RG3 Access Floor Panels Kingspan Access Floors Limited	EN15804+A1, EN15804+A2	Third-party verified (as per ISO 14025)	2021	unitedKingdom	ecoinvent		EN 15804+A2
Ready-mix concrete	GEN3 (C20/25), C III A, (36-65%GGBS)		Hanson HCG	BRE	BREG EN EPD 000194	EPD GEN 3 C III A	EN15804+A1	Third-party verified (as per ISO 14025)	2018	unitedKingdom	ecoinvent	2400	EN15804+A1
Ready-mix concrete for ground slabs	C25/30 XC1/XC2 CEM II/A, 2387.04kg/m3		SNBPE	INIES	INIES_CBÉT20190724_131702, 22908	FDES	EN15804+A1	Third-party verified (as per ISO 14025)	2019	france	ecoinvent	2387.04	EN15804+A1
Ready-mix concrete, normal strength, generic	C32/40 (4600/5800 PSI) with CEM III/A, 60% GGBS content in cement (300 kg/m3; 18.7 lbs/ft3 total cement)		One Click LCA 2022	One Click LCA	-	One Click LCA	EN15804+A1, EN15804+A2	Internally verified	2022	LOCAL	ecoinvent	2400	EN15804+A1, EN15804+A2

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Resource name	Technical specification	Product	Manufacturer	EPD program	EPD number	Environmental Data Source	Standard	Verification	Year	Country	Upstream database	Density	Product Category Rules (PCR)
Ready-mix concrete, normal strength, generic	C35/45 (5000/6500 PSI) with CEM III/A, 50% GGBS content (340 kg/m ³ ; 21.2 lbs/ft ³ total cement)			One Click LCA	-	One Click LCA	EN15804+A1, EN15804+A2	Internally verified	2020	LOCAL	ecoinvent	2400	EN15804+A1, EN15804+A2
Ready-mix concrete, normal strength, generic	C32/40 (4600/5800 PSI) with CEM III/A, 50% GGBS content in cement (300 kg/m ³ ; 18.7 lbs/ft ³ total cement)		One Click LCA 2022	One Click LCA	-	One Click LCA	EN15804+A1, EN15804+A2	Internally verified	2022	LOCAL	ecoinvent	2400	EN15804+A1, EN15804+A2
Ready-mix concrete, normal-strength, generic	C40/50 (5800/7300 PSI), 0% recycled binders in cement (400 kg/m ³ / 24.97 lbs/ft ³)			One Click LCA	-	One Click LCA	EN15804+A1, EN15804+A2	Internally verified	2018	LOCAL	ecoinvent	2400	EN15804+A1
Ready-mix concrete, normal-strength, generic	C30/37 (4400/5400 PSI), 10% (typical) recycled binders in cement (300 kg/m ³ / 18.72 lbs/ft ³)			One Click LCA	-	One Click LCA	EN15804+A1, EN15804+A2	Internally verified	2018	LOCAL	ecoinvent	2400	EN15804+A1
Reinforced concrete shear wall, 200 mm, C32/40, with One Click LCA data				One Click LCA		One Click LCA generic construction definitions				LOCAL	Ecoinvent		
Reinforced concrete shear wall, 200 mm, C35/45, with One Click LCA data				One Click LCA		One Click LCA generic construction definitions				LOCAL	Ecoinvent		
Reinforcement steel (rebar), generic	97% recycled content (typical), A615			One Click LCA	-	One Click LCA	EN15804+A1	Internally verified	2018	LOCAL	ecoinvent	7850	EN15804+A1
Reinforcement steel (rebar), generic	90% recycled content, A615			One Click LCA	-	One Click LCA	EN15804+A1	Internally verified	2018	LOCAL	ecoinvent	7850	EN15804+A1
Rock wool insulation for ETICS and flat roofs	R=1 m ² K/W, L=0.044 W/mK, 44 mm, 0.97 kg/m ² , 22 kg/m ³ , Lambda=0.044 W/(m.K)		Rockwool	-	-	EPD Stone Wool Thermal Insulation for buildings	EN15804+A1	Third-party verified (as per ISO 14025)	2021	unitedKingdom	ecoinvent	22	EN15804+A1

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Resource name	Technical specification	Product	Manufacturer	EPD program	EPD number	Environmental Data Source	Standard	Verification	Year	Country	Upstream database	Density	Product Category Rules (PCR)
Rock wool/mineral wool insulation	L = 0.035-0.037 W/mK, 33-45 kg/m3, Fire resistance class = A1		Knauf Insulation (2019)	BRE	BREG EN EPD000095, Issue 02	EPD Rock Mineral Wool Insulation 33-45 kg/cu.m, Knauf Insulation	EN15804+A1	Third-party verified (as per ISO 14025)	2019	unitedKingdom	ecoinvent	39	EN15804+A1
Sewage water drainage piping network, per m2 GIFA (residential buildings)				One Click LCA	-	One Click LCA	EN15804+A1	Internally verified	2019	LOCAL	ecoinvent		EN15804+A1
Single skin wall from bricks, including mortar	with Mortar 1:3 cement:sand mix (Using CEM I cement)			ICE	-	ICE database August 2019, V3.0	EN15804+A1	Self declared	2019	unitedKingdom	-		EN15804+A1
Soil substrates for green roofs			MDEGD	INIES	INIES_DSUB20180223_161051, 7994	MDEGD_FDES	EN15804+A1	Third-party verified (as per ISO 14025)	2018	france	ecoinvent		EN15804+A1
Tile adhesive, all round, for ceramics	1-5 mm, 1400 kg/m3	Verlegemörtel	PCI Augsburg	IBU	EPD-PCI-20160141-IBE1-DE	Oekobau.dat 2017-I, EPD Flexibilisierter Fliesenkleber PCI Verlegemörtel für keramische Fliesen PCI Augsburg GmbH	EN15804+A1	Third-party verified (as per ISO 14025)	2016	germany	GaBi	1400	PCR Mineralische Werkmörtel, 07/2014
Ventilation ducting	per m linear, D: 500 mm (19.69 in)			One Click LCA	-	One Click LCA	EN15804+A1	Internally verified	2019	LOCAL	ecoinvent		EN15804+A1
Ventilation system for office and care buildings				One Click LCA		One Click LCA generic construction definitions				LOCAL	Ecoinvent		
Wastewater drainage system				One Click LCA		One Click LCA generic construction definitions				LOCAL	Ecoinvent		
Water circulation radiator	per 1kW / unit			One Click LCA	-	One Click LCA	EN15804+A1	Internally verified	2019	LOCAL	ecoinvent		EN15804+A1
Water-based epoxy floor paint	1.44 kg/l, 6 m2/l, 0.48 kg/m2	Dulux Trade High Performance Floor Paint	AkzoNobel	MRPI	1.1.00283.2022	EPD DULUX TRADE HIGH PERFORMANCE FLOOR PAINT	EN15804+A1	Third-party verified (as per ISO 14025)	2022	unitedKingdom	ecoinvent	1440	EN15804+A1
Waterproof, protective, flexible coating	1.5 kg/l	Lastogum	PCI Augsburg	IBU	EPD-PCI-20150039-IBE1-DE	Oekobau.dat 2017-I, EPD Wasserdichte, flexible Schutzschicht PCI Lastogum unter Keramikbelägen in Dusche und Bad PCI Augsburg GmbH	EN15804+A1	Third-party verified (as per ISO 14025)	2015	germany	GaBi	1500	PCR Beschichtung en mit organischen Bindemitteln, 07/2012

Appendix 02 EPD sources

Resource name	Technical specification	Product	Manufacturer	EPD program	EPD number	Environmental Data Source	Standard	Verification	Year	Country	Upstream database	Density	Product Category Rules (PCR)
Rock wool/mineral wool insulation	L = 0.035-0.037 W/mK, 33-45 kg/m3, Fire resistance class = A1		Knauf Insulation (2019)	BRE	BREG EN EPD000095, Issue 02	EPD Rock Mineral Wool Insulation 33-45 kg/cu.m, Knauf Insulation	EN15804+A1	Third-party verified (as per ISO 14025)	2019	unitedKingdom	ecoinvent	39	EN15804+A1
Sewage water drainage piping network, per m2 GIFA (residential buildings)				One Click LCA	-	One Click LCA	EN15804+A1	Internally verified	2019	LOCAL	ecoinvent		EN15804+A1
Single skin wall from bricks, including mortar	with Mortar 1:3 cement:sand mix (Using CEM I cement)			ICE	-	ICE database August 2019, V3.0	EN15804+A1	Self declared	2019	unitedKingdom	-		EN15804+A1
Soil substrates for green roofs			MDEGD	INIES	INIES_DSUB20180223_161051, 7994	MDEGD_FDES	EN15804+A1	Third-party verified (as per ISO 14025)	2018	france	ecoinvent		EN15804+A1
Tile adhesive, all round, for ceramics	1-5 mm, 1400 kg/m3	Verlegemörtel	PCI Augsburg	IBU	EPD-PCI-20160141-IBE1-DE	Oekobau.dat 2017-I, EPD Flexibilisierter Fliesenkleber PCI Verlegemörtel für keramische Fliesen PCI Augsburg GmbH	EN15804+A1	Third-party verified (as per ISO 14025)	2016	germany	GaBi	1400	PCR Mineralische Werkmörtel, 07/2014
Ventilation ducting	per m linear, D: 500 mm (19.69 in)			One Click LCA	-	One Click LCA	EN15804+A1	Internally verified	2019	LOCAL	ecoinvent		EN15804+A1
Ventilation system for office and care buildings				One Click LCA		One Click LCA generic construction definitions				LOCAL	Ecoinvent		
Wastewater drainage system				One Click LCA		One Click LCA generic construction definitions				LOCAL	Ecoinvent		
Water circulation radiator	per 1kW / unit			One Click LCA	-	One Click LCA	EN15804+A1	Internally verified	2019	LOCAL	ecoinvent		EN15804+A1
Water-based epoxy floor paint	1.44 kg/l, 6 m2/l, 0.48 kg/m2	Dulux Trade High Performance Floor Paint	AkzoNobel	MRPI	1.1.00283.2022	EPD DULUX TRADE HIGH PERFORMANCE FLOOR PAINT	EN15804+A1	Third-party verified (as per ISO 14025)	2022	unitedKingdom	ecoinvent	1440	EN15804+A1
Waterproof, protective, flexible coating	1.5 kg/l	Lastogum	PCI Augsburg	IBU	EPD-PCI-20150039-IBE1-DE	Oekobau.dat 2017-I, EPD Wasserdichte, flexible Schutzschicht PCI Lastogum unter Keramikbelägen in Dusche und Bad PCI Augsburg GmbH	EN15804+A1	Third-party verified (as per ISO 14025)	2015	germany	GaBi	1500	PCR Beschichtung en mit organischen Bindemitteln, 07/2012

Appendix 02 EPD sources

Landscaping EPD sources

Resource name	Technical specification	Product	Manufacturer	EPD program	EPD number	Environmental Data Source	Standard	Verification	Year	Country	Upstream database	Density	Product Category Rules (PCR)
Concrete paving blocks, semi dry mix	60 mm, 138 kg/m2		Marshalls Plc	EPD Hub	EPD HUB-0305	EPD Concrete Block Paving - Pigmented Semi Dry Mix Marshalls Plc	EN15804+A1, EN15804+A2	Third-party verified (as per ISO 14025)	2023	unitedKingdom	ecoinvent		EPD Hub Core PCR version 1.0, 1 Feb 2022
Plastic slab for surface reinforcement	27.19 kg/m2	TTE®-MultiDrainPLUS	HUEBNER-LEE GMBH & CO. KG	INIES	INIES_INOU20210819_154510, 29461	FDES	EN15804+A1	Third-party verified (as per ISO 14025)	2021	germany	GaBi		EN15804+A1
Resin bound aggregate decorative paving system	3-10 mm grain size, 100 - 150 mm, 1060 kg/m3	Addaset, Addabound, Terrabound and Terrabase	Addagrip Terraco	BRE	BREG EN EPD000209	EPD Addagrip Resin Bound Decorative Surfacing System	EN15804+A1	Third-party verified (as per ISO 14025)	2018	unitedKingdom	ecoinvent	1060	EN15804+A

Appendix 02

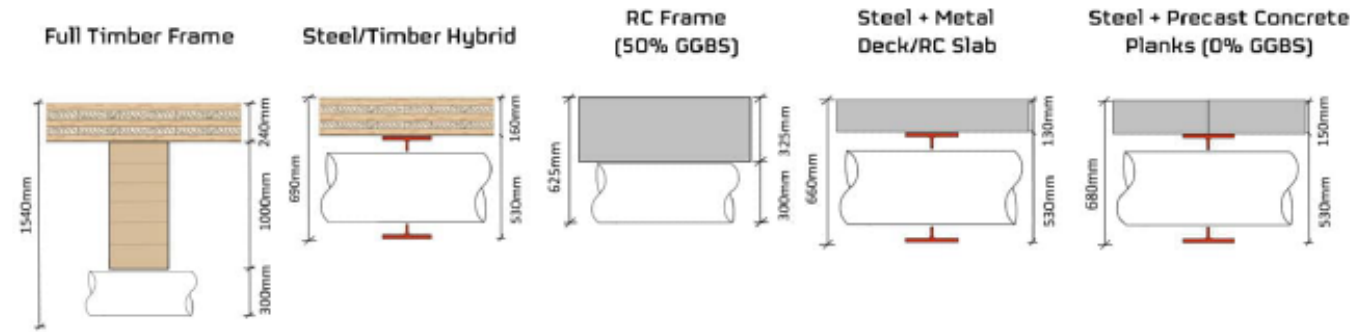
EARLY UPFRONT CARBON ANALYSIS OF STRUCTURE
CONSIDERING THE STRUCTURAL CONTEXT
EARLY WHOLE LIFE CARBON ANALYSIS OF SYSTEMS

Initial Structural Options Comparison

5.2 Structural Options

Five different structural options were assessed for both the new build and extension schemes.

- + Full timber frame
- + Steel frame with cross laminated timber (CLT) slabs
- + Reinforced concrete (RC) frame with flat slabs
- + Steel frame with precast concrete planks
- + Steel frame with RC slabs on profiled metal decking



5.3 New Builds

An efficient grid of 9m x 9m was adopted for the assessment of new build options and this grid adopted for the buildings on Plot A and F where possible. A summary of the options is given in Table 1.

A reinforced concrete (RC) frame with flat slabs has been selected as the most appropriate form of construction for the two new build plots. This form of construction offered the best balance of low upfront embodied carbon, longevity, future adaptability, and maximising clear head heights.

The concrete specification will consist of minimum 50% GGBS content in the superstructure and 70% GGBS content in the substructure. Ground granulated blast furnace slab (GGBS) is a cement replacement that reduces the upfront embodied carbon of RC construction.

Concrete grades will be selected to optimise the steel reinforcement design to further reduce the embodied carbon.

Transfer structure has been avoided where possible, however wider planning considerations have meant that set-backs exist on Plot A which have necessitated some transfer slabs to avoid negative impact to the internal space.

Structure/Services Zone (services assumed as 300mm)	1540mm	690mm	625mm	660mm	680mm
Weight	185 kg/m ²	180 kg/m ²	800 kg/m ²	365 kg/m ²	345 kg/m ²
Embodied Carbon	100 kgCO ₂ e/m ²	164 kgCO ₂ e/m ²	140 kgCO ₂ e/m ²	180 kgCO ₂ e/m ²	170 kgCO ₂ e/m ²
Embodied Carbon Including Sequestration	-176 kgCO ₂ e/m ²	-14 kgCO ₂ e/m ²	140 kgCO ₂ e/m ²	180 kgCO ₂ e/m ²	170 kgCO ₂ e/m ²
Construction Risk	+ Insurance premium + Fire during construction + Water ingress on terraces and flat roofs	+ Insurance premium + Fire during construction + Water ingress on terraces and flat roofs	+ Availability of GGBS at time of build	+ Availability of GGBS at time of build + Aesthetic of metal decking outdated at time of build	+ More complex detailing on site

Note: The services zone may increase from 300mm but the relative comparison of total floor depth between the different structural options would remain approximately the same.

Image 22 - Superstructure options table new build

Initial Structural Options Comparison

5.4 Extensions

All new columns for vertical extensions will be built up directly off an existing one below. A grid of 6m x 6m was used for the options study based on an approximate average of the existing column grids across the site. A summary of the five options is given in Table 2.

The use of CLT slabs was also considered in detail, however the principal concern was the risk of undetected water ingress on flat roofs or terraces. There is a high proportion of flat roofs and terraces compared to internal space across the site. Concrete floors were deemed more suitable for longevity, durability and consistency across the site.

The full timber frame was ruled out due to the deep structural build up required, the resulting impact on service routing, and the risk of water damage on flat roofs and terraces.

A full RC frame was discounted due to the weight of the materials resulting in more strengthening to the existing structure and foundations, and in-situ concrete construction would be more challenging.

Steel frame with precast planks has been selected as the most appropriate form of construction for the roof extensions as it offers the best balance of the various design considerations. Plot J should be re-considered at the next stage; the geometry of the proposed extension building and the modular width of the precast slabs mean there would be significant areas of infill slab. It may be preferable to adopt concrete slabs on profiled metal decking in this instance.


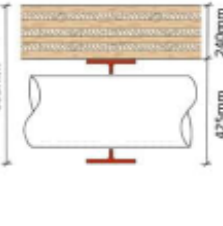
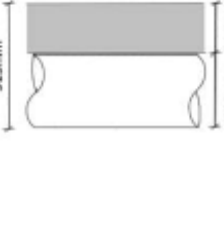
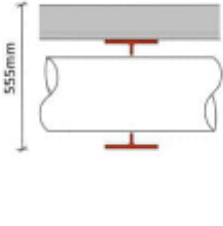
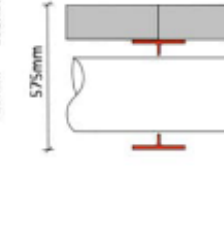
	Full Timber Frame	Steel/Timber Hybrid	RC Frame (50% GGBS)	Steel + Metal Deck/RC Slab	Steel + Precast Concrete Planks (0% GGBS)
					
Structure/Services Zone (services assumed as 300mm)	1015mm	665mm	525mm	555mm	575mm
Weight	185 kg/m ²	180 kg/m ²	580 kg/m ²	355 kg/m ²	315 kg/m ²
Embodied Carbon	91 kgCO ₂ e/m ²	128 kgCO ₂ e/m ²	99 kgCO ₂ e/m ²	165 kgCO ₂ e/m ²	155 kgCO ₂ e/m ²
Embodied Carbon Including Sequestration	-186 kgCO ₂ e/m ²	-62 kgCO ₂ e/m ²	99 kgCO ₂ e/m ²	165 kgCO ₂ e/m ²	155 kgCO ₂ e/m ²
Construction Risk	+ Insurance premium + Fire during construction + Water ingress on terraces and flat roofs	+ Insurance premium + Fire during construction + Water ingress on terraces and flat roofs	+ Availability of GGBS at time of build	+ Availability of GGBS at time of build + Aesthetic of metal decking outdated at time of build	+ More complex detailing on site
Note: The services zone may increase from 300mm but the relative comparison of total floor depth between the different structural options would remain approximately the same.		Note: The embodied carbon numbers refer to the new build floors only and do not consider the GIA of the existing floors.			

Image 23 - Superstructure options table extensions

Appendix 02 Early WLC analysis

Early analysis of structure

Initial analysis undertaken by HTS at early RIBA Stage 2 sought to estimate the upfront carbon of the proposed structure and strengthening structure required to achieve the proposed extensions.

Carbon reduction measures are highlighted in the main report.

Results suggest the structural strategy is currently aligned with 2030 embodied carbon targets for super- and sub-structure on a site wide basis and for each individual refurbished and extended building.

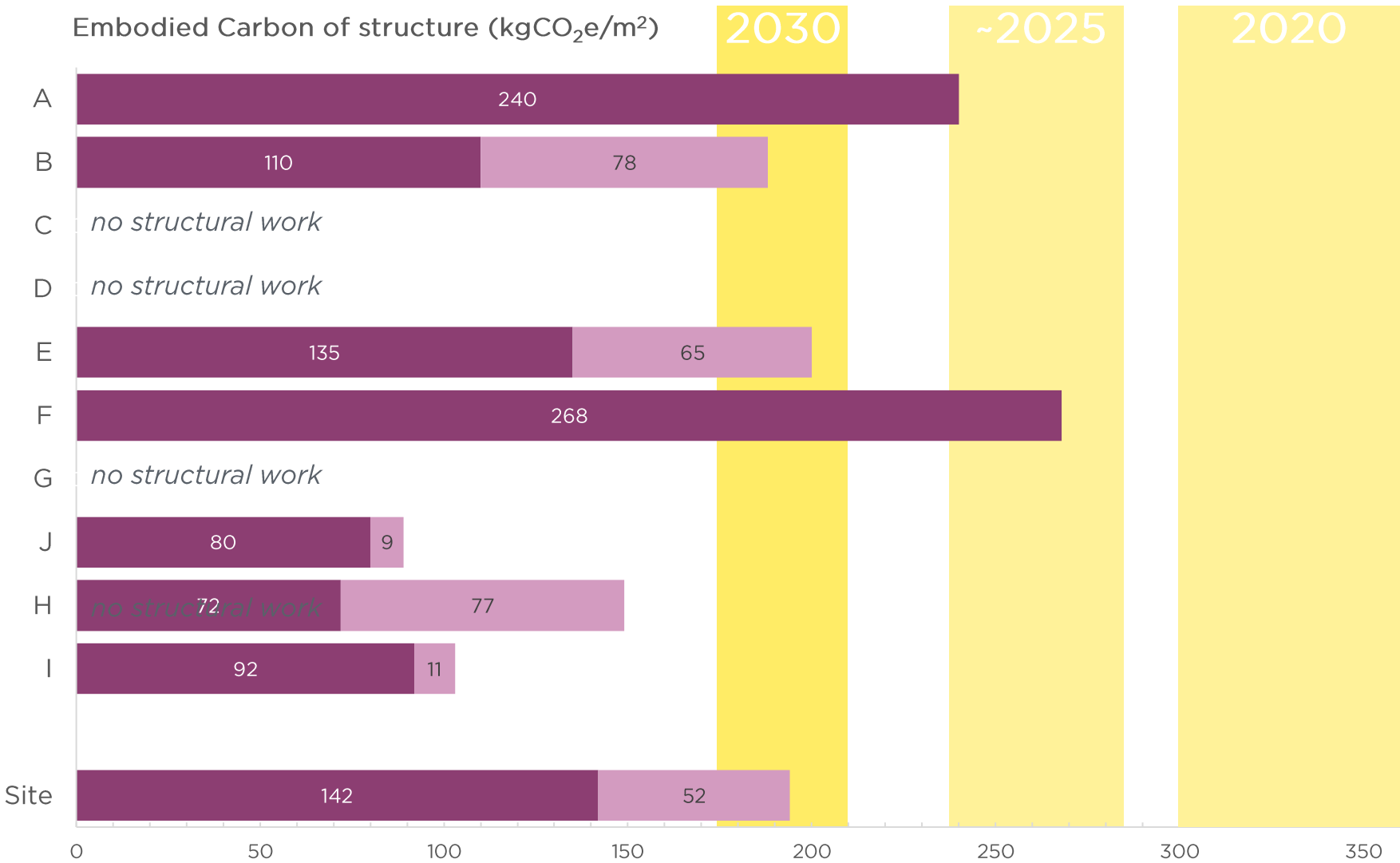
Both new buildings also currently align a projected 2025 target estimated from the LETI best practice 2020 and 2030 benchmarks.

This assessment has since be updated and included within the analysis reported above.

New Structure

Strengthening

SCORS/LETI Embodied Carbon Target Ranges for sub- and super-structure, calculated from LETI best practice guidance for embodied carbon of new offices (projected from 2020/2030 targets for 2025). Based on the SCORS assumption that structures contribute to 50-60% of the total upfront carbon of a project.



Appendix 03 Early WLC analysis

Considering the structural context

During the concept design stage multiple forms of construction were considered.

This included mass timber and hybrid timber structure, i.e., steel/concrete framed building with timber CLT or soft wood joist floors.

These solutions have their benefits, principally their lower weight which could minimise the extent of strengthening required to the existing structure to accommodate the desired massing.

The result is lower embodied carbon in the material itself and the reduced volume of strengthening material.

However, timber floors also carry risks associated with the operation and longevity of the design.

The main risks of timber floor construction were identified as:

- + Fire.

There was concern about the statutory approvals risk and building insurance implications of adopting timber construction.

- + Vibration and sound.

Timber floor construction typically requires additional finishes to achieve the required sound performance. This adds weight, cost, carbon, and reduced floor-to-ceiling height.

Anti-vibration treatment is also more onerous for roof plant.

- + Water ingress and blue roofs.

The proposed roofs are flat, support plant in places and are proposed to incorporate a blue roof system. Any damage to the waterproofing system over the lifetime of the development would risk ingress of water into a timber CLT panel. This would likely track and remain undetected until significant deterioration had occurred. Repair would be onerous (see example below).

If the timber structure were to be timber joists with ply over, then water ingress would be easier to spot but you would have to (a) provide more framing structure to support the plant loading, and (b) encapsulate the joists for fire. The later point affects the appearance of the space and was deemed unacceptable by the client and advising agents.



Designing out risk

The adjacent project example shows a timber roof construction formed using an engineered timber stress skin (glulam beams with LVL skins top and bottom).

An investigation into cracking and damp on the underside of the ceiling after completion of the new building led to the discovery of extensive water damage with significant loss of structural integrity.

The result of significant and undetected water ingress caused by retrospective damage to the water proofing system by tradesmen maintaining the building.

The implications were:

- + extended closure of part of the building
- + back-propping to avoid collapse
- + removal of rotten timber
- + new engineered timber fixed and glued to sound substrate

Our intention is to design out this management risk and provide a long lasting structure that could potentially exceed the typical design life.

Appendix 03 Early WLC analysis

Early WLC analysis of systems

RED engineering undertook a holistic assessment of various HVAC system options at early RIBA Stage 2 for the new and refurbished buildings. This assessment included a WLC analysis assessment completed in line with the CIBSE TM65 methodology.

This assessment has since be updated and included within the analysis reported above.

Option No.	System Name	Maintenance Costs	Control	Noise Level	Energy Efficiency	Lifespan	Flexibility	Cost (£/m²)	Whole Life Carbon (kgCO ₂ e)
1	Hybrid VRF	Average to High	Good	Low	Good	15 years	Very High	215	406,064
2	VRF	Average to High	Good	Low	Very good	15 years	Very High	195	1,312,435
3	High Level 4 Pipe FCU	High	Good	Low	Good	15 years	Medium	220	797,249
4	Displacement	Average	Average	Very Low	Very good	20 years	Medium	270	461,224
5	Low level 4 pipe FCU	High	Good	Low	Good	15 years	Medium	195	652,091
6	CAM V Underfloor	Average to High	Good	Low	Good	15-20 years	High	245	533,835
7	CAM C Underfloor	Average to High	Good	Low	Good	15-20 years	Low	245	524,322
10	Active Chilled Beams	Average	Good	Low	Very good	20+ years	Low	345	920,215



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