# Project Documentation Gebäude-Dokumentation



# 1 Abstract / Zusammenfassung



Residential development with 3 terraced houses and 6 flats at Luckham Road, Bournemouth, UK

## 1.1 Data of building / Gebäudedaten

### Block 01 (terraced houses)

Year of construction/ Baujahr	2021	Space heating /	15
U-value external wall/ U-Wert Außenwand	0.208 W/(m²K)	Heizwärmebedarf	kWh/(m²a)
U-value basement ceiling/ U-Wert Kellerdecke	0.201 W/(m <sup>2</sup> K)	Primary Energy Renewable (PER) / Erneuerbare Primärenergie (PER)	42 kWh/(m²a)
U-value roof/ U-Wert Dach	0.102 W/(m²K)	Generation of renewable energy / Erzeugung erneuerb. Energie	0 kWh/(m²a)
U-value window/ U-Wert Fenster	1.01 W/(m²K)	Non-renewable Primary Energy (PE) / Nicht erneuerbare Primärenergie (PE)	105 kWh/(m²a)
Heat recovery/ Wärmerückgewinnung	82 %	Pressure test n <sub>50 /</sub> Drucktest n <sub>50</sub>	0.6 h-1
Special features/ Besonderheiten	Ground source heat	pump for domestic warm water and heating	)

### Block 02 (flats)

Year of construction/ Baujahr	2021	Space heating /	10
U-value external wall/ U-Wert Außenwand	0.208 W/(m²K)	Heizwärmebedarf	kWh/(m²a)
U-value basement ceiling/ U-Wert Kellerdecke	0.201 W/(m²K)	Primary Energy Renewable (PER) / Erneuerbare Primärenergie (PER)	45 kWh/(m²a)
U-value roof/ U-Wert Dach	0.102 W/(m²K)	Generation of renewable energy / Erzeugung erneuerb. Energie	0 kWh/(m²a)
U-value window/ U-Wert Fenster	1.01 W/(m²K)	Non-renewable Primary Energy (PE) / Nicht erneuerbare Primärenergie (PE)	114 kWh/(m²a)
Heat recovery/ Wärmerückgewinnung	82 %	Pressure test n <sub>50 /</sub> Drucktest n <sub>50</sub>	0.6 h-1
Special features/ Besonderheiten	Ground source heat	pump for domestic warm water and heating	)

### 1.2 Description

### Passive House Affordable Housing, Luckham Road, Bournemouth

This project was the redevelopment of a brownfield site to provide affordable homes for local residents in Bournemouth. Two separate blocks with three new terraced houses and 6 new flats were constructed and completed in 2021.

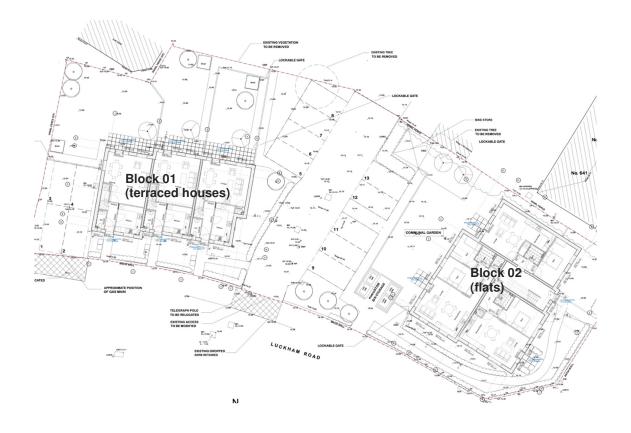
The architecture references local forms which are prominent within the surrounding estate to blend in with the existent. The designs feature simple layouts, forms and fenestration with all glazing sized for best practice daylight levels.

Both the flats and houses have an identical services strategy for heating, hot water and ventilation and share the same construction detailing for the building envelope.

The construction features a simple monolithic poroton clay block construction. This method allows for simplified construction sequencing, increased construction speed, reduction in number of trades involved and reduced construction waste as off cuts could be used as fill or aggregate on site and as a result could be diverted from landfill. An insulated suspended floor construction was specified to reduce the use of concrete.

The client, Bournemouth City Council, also acted as the contractor and developer via their in-house team from Seascape.

**Site Plan** showing the three new terraced houses to the East and a block with 6 new flats to the West of the site. (top of plan faces North).



## 1.3 Responsible project participants / Verantwortliche Projektbeteiligte

Architect/ Entwurfsverfasser	Tomas Gaertner http://www.se3de		
Implementation planning/ Ausführungsplanung	Tomas Gaertner http://www.se3d		
Building systems/ Haustechnik	Wessex Ducting	Ltd, Bournemouth	
Structural engineering/ Baustatik	RJWatkins, Bou	rnemouth	
Building physics/ Bauphysik	Tomas Gaertner http://www.se3d		
Passive House project planning/ Passivhaus-Projektierung	Tomas Gaertner http://www.se3d		
Construction management/ Bauleitung	Seascape, Bour	nemouth	
Certifying body/ Zertifizierungsstelle	Mead Ltd, Londo	on	
Certification ID/ Zertifizierungs ID	33445- 33447_MEAD_P H_20220211_KM	Project-ID (www.passivehouse-database.org) Projekt-ID (www.passivehouse-database .org)	7046

Author of project documentation / Verfasser der Gebäude-Dokumentation Tomas Gaertner, SE3D http://www.se3design.co.uk

Date, Signature/ Datum, Unterschrift Exeter, 26/10/2022

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# 2 Views



View of terraced houses from South West



### View of terraced houses, Streetview



View of terraced houses from South



View of flats from South East

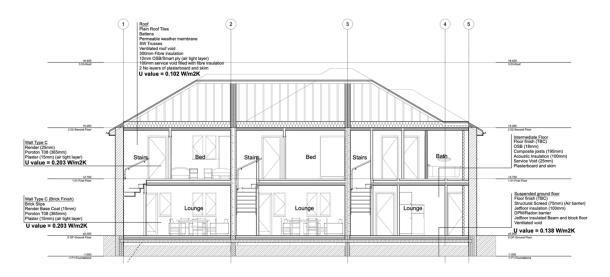


View of flats, Street Elevation

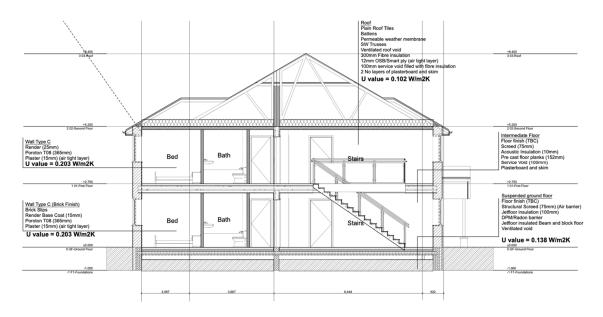


View of flats from South

# 3 Sections



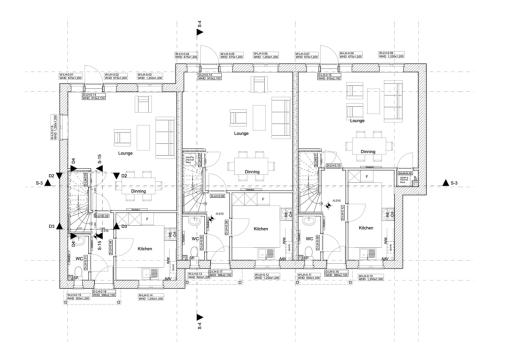
### Section of terraced houses



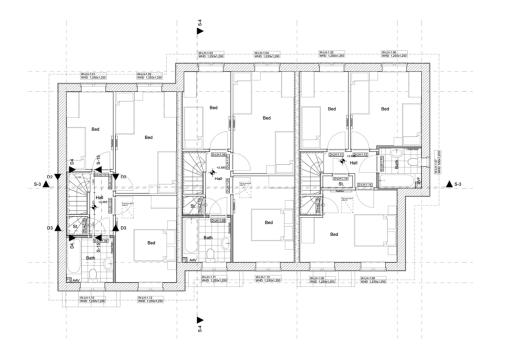
### Section of block of flats

# 4 Floor plans

**Terraced Houses - The terraced houses** were designed as 3 bedroom 5 person homes with living rooms, dining and kitchens on the ground floor and bedrooms and family bathroom on the first floor. Each home has it own MVHR and GSHP system for heating and domestic hot water.

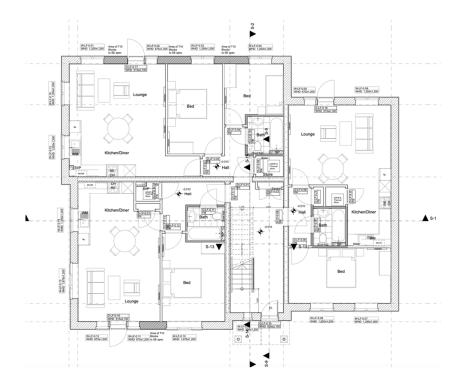


### Ground floor plan, terraced houses

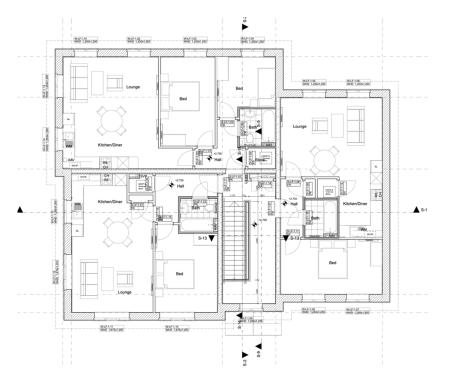


### First floor plan, terraced houses

**Block of flats** - A two storey block of 6 flats including 2 2bed flats with 61m2 and 4 1bed flats with 50m2. The flats are accessed via a communal stair. Each flat has its own MVHR and heating/DHW system and the components used were identical to the terraced houses.



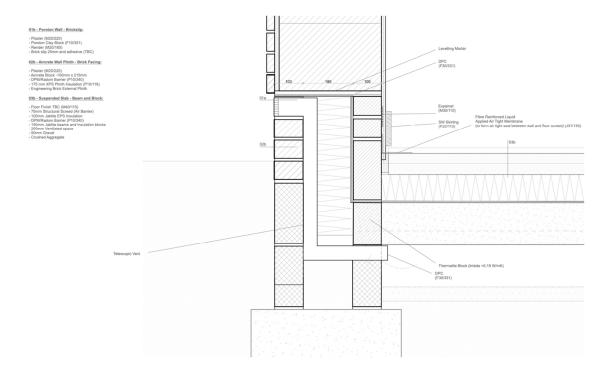
### Ground floor plan, flats



### First floor plan, flats

# 5 Building fabric construction details and Passivhaus technology

### 5.1 Floor construction



**Ground floor junction detail** showing suspended floor construction, warm foot detail and monolithic external wall construction.



Floor construction showing the different insulation layers, DPC and warm foot detail.

The floor is formed by an insulated beam and block floor with 175mm neopor insulation between beams, a DPC, a continuos layer of 100mm neopor insulation, PE membrane and screed over (air barrier). The specified system features a warm edge detail using aerated concrete blocks to reduce thermal bridging.

## 5.2 Wall construction



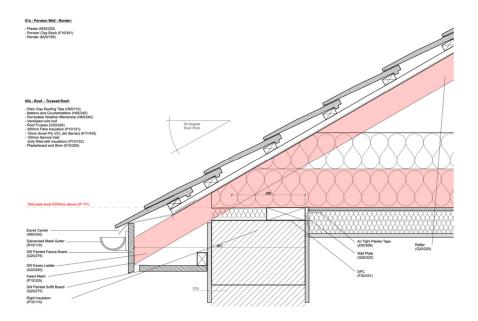
Walls were constructed using a monolithic poroton masonry construction consisting of a 15mm internal plaster layer (air tight layer), 365mm deep poroton blocks and a 20mm external silicate render with additional brick slips on ground floor. A warm foot detail featuring aerated concrete blocks form the plinth. The roof is formed by traditional A frame trusses, insulated at ceiling level.





## 5.3 Roof/ceiling construction

The roof has been designed and specified as a cold roof using A frame trusses insulated at ceiling level with 300mm of mineral fibre over a 12mm OSB board (air barrier) with a 100mm mineral fibre insulation filled service void below and a plasterboard and skim finish.



The wall plate has been set inwards with a continuous dense wood fibre insulation packer on the outside to reduce thermal bridge and increase surface temperatures.

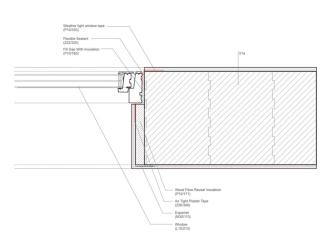


### 5.4 Windows

The project is located in the 'warm temperate' PH climate zone and the temperatures are generally fairly mild. Higher Uw-installed are acceptable than in a central European climate.

Outward opening, aluminium clad, timber framed, triple glazed windows (not PH certified) were specified for this project with frame u values of 1.01 W/m2K (1.20 W/m2K at thresholds) and warm spacers with 0.032 W/mK. The argon filled, low e coated triple glazing (4/16/4/16/4) achieved a g value of 0.52 and a Ug value of 0.51 W/m2K.

01a - Poroton Wall - Render: - Plaster (M20/220) - Poroton Clay Block (F10/351) - Render (M20/165)



**The windows** have been located towards the external skin of the building to maximise solar gains. Outward opening aluminium timber windows have been specified with an internal wood fibre reveal insulation to minimise thermal bridging and increase surface temperatures.



Openings were formed in poroton with preinsulated thermally broken lintels.



Outward opening windows were installed with an external permeable weathertightness tape. Internal reveals were insulated with woodfibre insulation overlapping the frames.



An air tight plaster tape was installed around windows to form a durable and flexible air tight junction



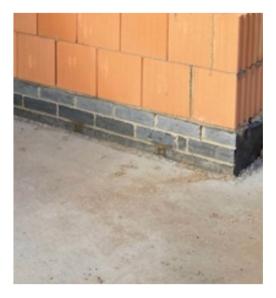
Walls and reveals were plastered to create the air barrier.

# 6 Air tightness

The air barrier is formed by the following elements:

Walls:	15mm Internal plaster layer
Roof:	12mm OSB board to underside of A frame trusses
Floor:	65mm Screed

### 6.1 Air tightness detailing



**Ground floor junction** the air tightness in the floor is formed by a continuous screed. The air barrier in the wall is formed by the internal plaster which is simply continued to the floor screed to form an air tight seal



**Windows** the air tight junction between walls and windows/doors was formed using a specialist air tight plaster tape.



**Ceiling/wall junctions** were treated with a liquid applied air tight membrane (black areas shown on photo) prior to installation and before these areas became inaccessible. The liquid membrane was then plastered over to continue the air barrier.



**Sockets** socket boxes were chased out 25mm deeper and bedded in mortar. Trunking was cut 30mm short to allow for plaster to encase all cables.



**Ceiling junction** The air tightness junction between the wall (plaster) and the ceiling (OSB board) was formed using a plaster tape. Joints in the ceiling were taped using a specialist air tight tape.

## 6.2 Air tightness test

Low Energy Summary Air Permeability Tests	of	The Air Tightness Testing &	A CEL	Low Energy Summary of Air Permeability Tests Cairtite
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Building Details				46.19 272.55 234 2 Text Decals
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Test Details				Notifications:
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Air Flow Coefficient (Cenv):	12.481	12.670		Building Details Building identifiar: 3
Air Leakage at 50 Pa (Q <sub>50</sub> ):	129,549	137.622		Site address:         1 Luckham Road, Bournemouth, Hampshile, BH9 3ET           Size:         Footprint (m <sup>2</sup> )         Envelope (m <sup>2</sup> )         Volume (m <sup>3</sup> )
Air Flow Exponent (n):	0.60	0.61		48 270 234 2
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Depressurisation Test: - 0.59	m <sup>3</sup> .h <sup>-1</sup> .m <sup>3</sup> @50Pa			Air Permeability Pass
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**BCTA** 

ATTMA is part of the Building Compliance Testers Association (BCTA). The BCTA is a trade association for companies that conduct on-site testing and operate within controlled, audited schemes. Enquiries should be made to: BCTA, Unit 3, Tannery Road, Loudwater, Buckinghamshire, HP13 7EQ or visit www beta aroun

Air permeability test report prepared by Airtite Ltd. The three terraced houses were tested individually. The completed buildings achieved the following pressurisation, depressurisation and average air test results:

House No	1	2	3	
Pressurisation	0.55	0.61	0.55	
Depressurisation	0.59	0.60	0.53	
Average	0.57	0.61	0.54	0.57

ATTMA is part of the Building Compliance Testers Association (BCTA). The BCTA is a trz for companies that conduct on site testing and openate within controlled, audited schemes applicies global the made to: BCTA, the 2. Tarrany Road, Lucideater, Buildingamenher.

### Low Energy Summary of Air Permeability Tests





Test Undertaken By	Adam	n Oliver of Airtite Lt	d				
Building Details							
Building identifier:	4-9		_				
Site address:		7-639 Charminster	Rd. Bournem	outh, Hamp	shire, BH8 9RH		
Size:	Footprin		nvelope (m <sup>2</sup> )		Volume (m <sup>3</sup> )	St	orey
	221		712		870		2
Details						-	
Test Details Report reference:			_				
Date:	02/11/2021		Build p	rogress:	Completed		
Temporary sealing:	MVHR Terminals		and b		Compiciou		
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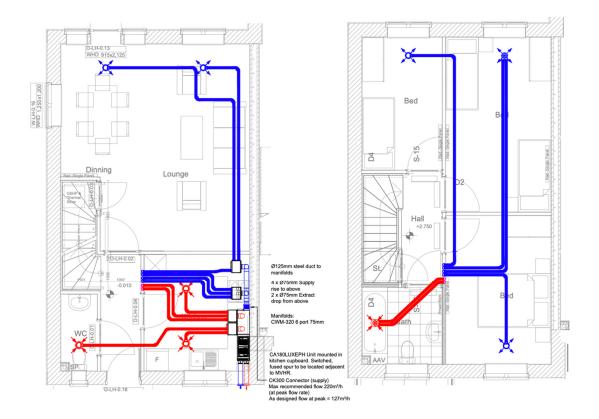
Air permeability test report prepared by Airtite Ltd. The block of flats was tested as a single entity with test fan installed in the main entrance and all internal and flat entrance doors fully open during the test.

Project Documentation

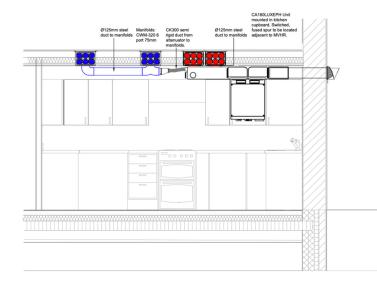
Page 1 of 3

7 Ventilation design

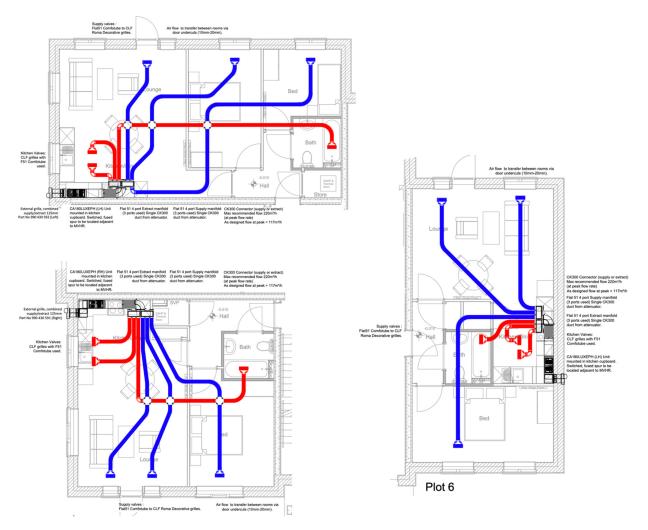
## 7.1 Ventilation layout



### Suppliers installation drawings of ventilation duct layout for the terraced houses



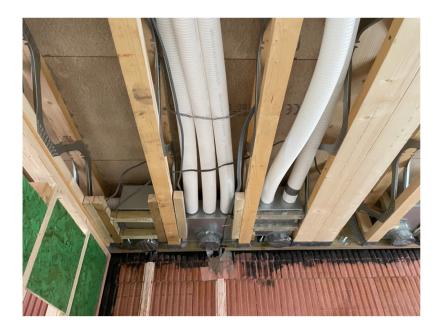
Each home is served by its own MVHR system. The ventilation unit is located in a kitchen wall cupboard, close to an external wall allowing for short cold duct runs. A flexible duct system (Zehnder comfotube) with central manifolds which also act as cross talk silencers for supply and extract was specified. Air is supplied to bedrooms and lounge and extracted from the kitchen and WC on ground floor and bathroom on first floor. The hall, stairs and corridors are designed as transfer zones with all doors being undercut by 10mm as a minimum.



Suppliers installation drawings of ventilation duct layout for the flats (GF and FF are identical)



On the houses composite metal web joists were specified for ceilings to allow for simpler installation and routing of ducts.



Manifold and ducts were installed within the ceiling zone between composite joists.





Supply/extract ducts to flats: Oval comfotube ducting was used to allow for increased ceiling heights

## 7.2 Ventilation unit and efficiency

A Passivhaus certified whole house ventilation unit was specified and this is identical for both the flats and houses:

Ventilation unit: Whole system efficiency (PHPP): Electrical Efficiency: Zehnder Comfoair 180 79.9% 0.31Wh/m3



**MVHR;** The MVHR unit was incorporated into the kitchen design to neatly fit in. Ducts were taken across the top of the wall units and covered with plasterboard.





Internal supply grilles



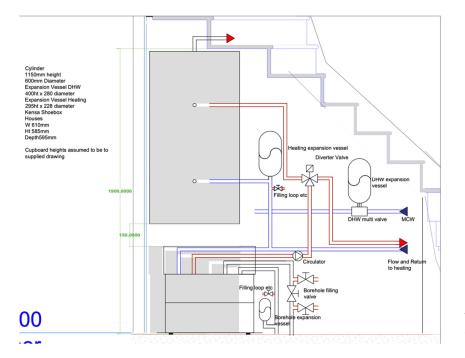
**External intake and exhaust** A combined external grille for both intake and exhaust was specified for each home.



# 8 Heating and DHW system

The scheme features a decentralised system for DHW and heating and each home has its own thermal store and heat pump. Heating and domestic hot water is provided via a thermal store. In the houses this is located under the stairs on the ground floor, fort he flats this is located in a plant cupboard. The thermal store is connected to a ground source heat pump with an immersion back up.

Heating is provided via small wet radiators in the lounge and bedrooms. Additional towel radiators within all wetrooms are connected to the thermal store.



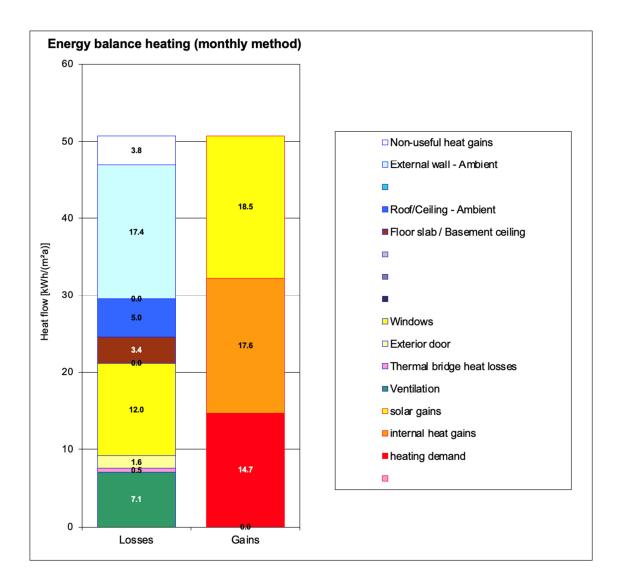
Suppliers schematic of thermal store and GSHP set up.



Thermal store and ground source heat pump including buffer vessels and circulation pumps were installed under the stairs on the ground floor.

Passive H	ouse Verification	on						
				Building:	Houses			
					Luckham Roa	d		
				Postcode/City:		Bournemouth		
				Province/Country:	······		GB-United Kingdo	om/ Britain
					Terraced Hou	se		
		ALL CONTRACTOR		Climate data set:				
				Climate zone:	4: Warm-temp	erate Altitu	de of location:	20 m
				Home owner / Client:	BCP Council			
	CI protection of the second	ALL PROPERTY			Bourne Avenu	10		
		A DE LA DE L		Postcode/City:		Bournemouth		
		and the second sec		Province/Country:			GB-United Kingde	om/ Britain
Architecture	SE3D			Mechanical engineer:	Wessey Duct	ng I td		
	t: 21 Canon Street			-	3 Telford Roa			
Postcode/City				Postcode/City:	·	Wimborne		
Province/Country		GB-United Kingdom	/ Britain	Province/Country:			GB-United Kingd	om/ Britain
Energy consultancy	·			Certification:	,			
	t: 21 Canon Street			4	3 Harvey Roa	d		
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No. of occupants Specific building character Space heating Space cooling	istics with reference to the treated floo Treated floor area r Heating demand F Heating load \ Cooling & dehum. demand F	m² kWh/(m²a) W/m² kWh/(m²a) W/m²	259.0 15	s s	Criteria	Alternative criteria	nical cooling:	yes
No. of occupants Specific building character Space heating Space cooling	istics with reference to the treated floo Treated floor area r Heating demand F Heating load \ Cooling & dehum. demand F Cooling a	m² kWh/(m²a) w/m² kWh/(m²a) w/m² w/m² w/m² w/m² w/m² kWh/(m²a) w/m² kWh/(m²a) w/m² kWh/(m²a) w/m² kWh/(m²a) w/m² kWh/(m²a) kWh/(ma)	259.0 15 10 -	s s	Criteria 15 - - -	Alternative criteria	nical cooling:	yes -
No. of occupants specific building character Space heating Space cooling Frequency of ex	istics with reference to the treated floor Treated floor area r Heating demand H Heating load N Cooling & dehum. demand H Cooling load N Cooling load N	m²	259.0 15 10 - - 0	s s s s s	Criteria 15 - - 10	Alternative criteria	nical cooling:	yes - yes
No. of occupants ipecific building character Space heating Space cooling F Frequency of ex Nirtightness	istics with reference to the treated floor area of Treated floor area of Heating demand if Heating load N Cooling & dehum. demand if Cooling load N requency of overheating (> 25 °C) ° cessively high humidity (> 12 g/kg) ° Pressurization test result n <sub>50</sub> °	m <sup>2</sup> ( kWh/(m <sup>2</sup> a) ( kWh/(m <sup>2</sup> a) ( kWh/(m <sup>2</sup> a) ( % ( % ( 1/h (	259.0 15 10 - - 0 0	5 5 5 5 5 5	Criteria 15 - - 10 20	Alternative criteria	nical cooling:	yes - yes yes
No. of occupants Specific building characteri Space heating Space cooling F Frequency of ex Airtightness Non-renewable Primary	istics with reference to the treated floor Treated floor area in Heating demand if Heating load N Cooling & dehum. demand if Cooling load N Cooling load N C	m² (	259.0 15 10 - - 0 0 0 0	5 5 5 5 5 5 5 5 5 5 5	Criteria 15 - - 10 20 0.6	Alternative criteria	nical cooling:	yes - yes yes yes
No. of occupants specific building characteri Space heating Space cooling Frequency of ex Airtightness Non-renewable Primary Primary Energy	Istics with reference to the treated floor area of Treated floor area of Heating demand if Cooling & dehum. demand if Cooling & dehum. demand if Cooling load 1 Cooling loa	m² (	259.0 15 10 - - 0 0 0 0 0.6 105 42	s s s s s s s s s s s	Criteria 15 - - 10 20 0.6	Alternative criteria	nical cooling:	yes - yes yes yes
No. of occupants Specific building character Space heating Space cooling Frequency of ex Airtightness Non-renewable Primary Primary Energy	istics with reference to the treated floor Treated floor area r Heating demand H Heating load N Cooling & dehum. demand H Cooling & dehum. demand H Cooling load N Cooling Load N Cool	m² (	259.0 15 10 - 0 0 0 0 0.6 105	5 5 5 5 5 5 5 5 5 5 5	Criteria 15 - - 10 20 0.6	Alternative criteria	nical cooling:	yes - yes yes yes
No. of occupants specific building characteri Space heating Space cooling Frequency of ex Airtightness Non-renewable Primary Primary Energy	Istics with reference to the treated floor area of Treated floor area of Heating demand if Cooling & dehum. demand if Cooling & dehum. demand if Cooling load 1 Cooling loa	m² (	259.0 15 10 - - 0 0 0 0 0.6 105 42	s s s s s s s s s s s	Criteria 15 - - 10 20 0.6	Alternative criteria	nical cooling:	yes - yes yes yes
No. of occupants specific building characteri Space heating Space cooling Frequency of ex Airtightness Non-renewable Primary Primary Energy	istics with reference to the treated floor Treated floor area r Heating demand H Heating load N Cooling & dehum. demand H Cooling & dehum. demand H Cooling load N Cooling Load N Cool	m² (	259.0 15 10 - - 0 0 0 0 0.6 105 42	s s s s s s s s s s s	Criteria 15 - - 10 20 0.6	Alternative criteria - 10 - - -		yes - yes yes yes -
No. of occupants Specific building character Space heating Space cooling Frequency of ex Airtightness Non-renewable Primary Primary Energy Renewable (PER)	istics with reference to the treated floor Treated floor area r Heating demand H Heating load N Cooling & dehum. demand H Cooling & dehum. demand H Cooling load N Cooling Load N Cool	m² kWh/(m²a) W/m² W/m² % % 1/h kWh/(m²a) kWh/(m²a) kWh/(m²a)	259.0 15 10 - - 0 0 0 0 0 6 105 42 0	s s s s s s s s s s s s	Criteria 15 - - 10 20 0.6 135 - -	Alternative criteria - 10 - - - - -	mpty field: Data miss	yes - yes yes yes -
No. of occupants Specific building characteri Space heating Space cooling F Frequency of ex Airtightness Non-renewable Primary Primary Energy Renewable (PER) confirm that the values of he building. The PHPP c	istics with reference to the treated floor area of Treated floor area of Heating demand if Gooling & dehum. demand if Cooling & dehum. demand if Cooling load 1 Cooling loa	m <sup>2</sup> kWh/(m <sup>2</sup> a) W/m <sup>2</sup> kWh/(m <sup>2</sup> a) % % % kWh/(m <sup>2</sup> a) following the PH ication.	259.0 15 10 - - 0 0 0 0 0 6 105 42 0	s s s s s s s s s s s s	Criteria 15 - - 10 20 0.6 135 - - ristic values of	Alternative criteria - 10 - - -	mpty field: Data miss	yes - yes yes yes - sing: ${\sim}$ No requirem
No. of occupants Specific building characteri Space heating Space cooling F Frequency of ex Airtightness Non-renewable Primary Primary Energy Renewable (PER) confirm that the values g he building. The PHPP c Tasis	Istics with reference to the treated floor Treated floor area of Heating demand if Heating demand if Cooling & dehum. demand if Cooling & dehum. demand if Cooling load 1 Cooling load	m <sup>2</sup> KWh/(m <sup>2</sup> a) W/m <sup>2</sup> KWh/(m <sup>2</sup> a) % 1/h KWh/(m <sup>2</sup> a) following the PH	259.0 15 10 - - 0 0 0 0 0 6 105 42 0	s s s s s s s s s s s s s s s s s s s	Criteria 15 - - 10 20 0.6 135 - -	Alternative criteria - 10 - - - - -	mpty field: Data miss	yes - yes yes yes yes - sing: \le No requirent yes
No. of occupants Specific building characteri Space heating Space cooling F Frequency of ex Airtightness Non-renewable Primary Primary Energy Renewable (PER) confirm that the values of he building. The PHPP c	istics with reference to the treated floor area of Treated floor area of Heating demand if Gooling & dehum. demand if Cooling & dehum. demand if Cooling load 1 Cooling loa	m <sup>2</sup> kWh/(m <sup>2</sup> a) W/m <sup>2</sup> kWh/(m <sup>2</sup> a) % % % kWh/(m <sup>2</sup> a) following the PH ication.	259.0 15 10 - - 0 0 0 0 0 6 105 42 0	s s s s s s s s s s s s s	Criteria 15 - - 10 20 0.6 135 - - ristic values of	Alternative criteria - 10 - - - - -	mpty field: Data miss	yes - yes yes yes -

PHPP verification sheet for the three terraced houses.



**Heating energy balance calculated using the PHPP;** energy losses from external walls and windows proportionally represent the highest losses. Overall window solar gains exceed losses from transmission resulting in a positive energy balance without affecting summer comfort levels. Ventilation heat losses are elevated due to the relatively high occupancy.

Passive Ho	ouse Verificat	tion					
				Building:	Houses		
	and a strength of the			Street:	Luckham Roa	d	
				Postcode/City:	BH9 3ET	Bournemouth	
	- Aller			Province/Country:	UK	GB-United Kin	gdom/ Britain
				Building type:	Block of flats		
		The state		Climate data set:	GB0004a-Effe	ord	
				Climate zone:	4: Warm-tem	Altitude of location	20 m
				Home owner / Client:	BCP Council		
	the de		2	Street:	Bourne Aven	ле	
		1		Postcode/City:	BH26DY	Bournemouth	
	A COLORED AND AND AND AND AND AND AND AND AND AN			Province/Country:	Dorset	GB-United Kin	gdom/ Britain
Architecture:	SE3D			Mechanical engineer:	Wessey Duct	ing I td	
	21 Canon Street			) –	3 Telford Roa		
Postcode/City:				Postcode/City:		Wimborne	
Province/Country:		GB-United King	ndom/ Britain	Province/Country:		GB-United Kin	adom/ Britain
-						GB-Onited Kin	
Energy consultancy:				Certification:			
	21 Canon Street			}	3 Harvey Roa	d	
Postcode/City:				Postcode/City:	·		
Province/Country:	Somerset	GB-United King	gdom/ Britain	Province/Country:	London	GB-United Kin	
Year of construction:			In	terior temperature winter [°C]:	20.0	Interior temp. summer [°C]	: 25.0
No. of dwelling units:	6			ns (IHG) heating case [W/m <sup>2</sup> ]:		IHG cooling case [W/m <sup>2</sup> ]	3.0
No. of occupants:	9.4		Specific	capacity [Wh/K per m <sup>2</sup> TFA]:	132	Mechanical cooling	:
Specific building characteris	tics with reference to the treated	floor area					
Specific building characteris	tics with reference to the treated Treated floor are		336.3	}	Criteria	Alternative	Fullfilled? <sup>2</sup>
Specific building characteris		ea m²	336.3 10	5	Criteria	Alternative criteria	Fullfilled? <sup>2</sup>
	Treated floor are	ea m² nd kWh/(m²a)		ے د			Fullfilled? <sup>2</sup>
	Treated floor are Heating demar	ea m² nd kWh/(m²a) ad W/m²	10	-		criteria -	
Space heating	Treated floor are Heating demar Heating loa	ea m² nd kWh/(m²a) ad W/m² nd kWh/(m²a)	10 9	≤		criteria -	
Space heating	Treated floor are Heating demar Heating loa Cooling & dehum. demar	aa m² nd kWh/(m²a) ad W/m² nd kWh/(m²a) ad W/m²	10 9	5		criteria -	
Space heating Space cooling	Treated floor arr Heating demar Heating loz Cooling & dehum. demar Cooling loz	ea m² nd kWh/(m²a) ad W/m² nd kWh/(m²a) ad W/m² C) %	10 9 - -	ے ج	15 - - -	criteria -	yes -
Space heating Space cooling	Treated floor are Heating demar Heating loa Cooling & dehum. demar Cooling loa aquency of overheating (> 25 °	ea m² nd kWh/(m²a) ad W/m² nd kWh/(m²a) ad W/m² C) % g) %	10 9 - 0	ے ج	15 - - - 10	criteria -	yes - yes
Space heating Space cooling Frequency of exce	Treated floor are Heating demar Heating loa Cooling & dehum. demar Cooling loa squency of overheating (> 25 % essively high humidity (> 12 g/k Pressurization test result n	ea m² nd kWh/(m²a) ad W/m² nd kWh/(m²a) ad W/m² C) % g) %	10 9 - 0 0	s s s s	15 - - - 10 20	criteria -	yes - yes yes
Space heating Space cooling Frequency of exc Airtightness Non-renewable Primary E	Treated floor are Heating demar Heating loa Cooling & dehum. demar Cooling loa aquency of overheating (> 25 % essively high humidity (> 12 g/k Pressurization test result n inergy (PE) PE demar PER demar	22 m <sup>2</sup> hd kWh/(m <sup>2</sup> a) hd kWh/(m <sup>2</sup> a)	10 9 - 0 0 0 0.6	s s s s s s	15 - - 10 20 0.6	criteria -	yes - yes yes yes
Space heating Space cooling Frequency of exco Airtightness	Treated floor are Heating demar Heating loa Cooling & dehum. demar Cooling loa equency of overheating (> 25 % essively high humidity (> 12 g/k Pressurization test result n inergy (PE) PE demar PER demar Generation of renewab	22 m <sup>2</sup> md kWh/(m <sup>2</sup> a) ad W/m <sup>2</sup> md kWh/(m <sup>2</sup> a) ad W/m <sup>2</sup> C) % g) % J/h md kWh/(m <sup>2</sup> a) hd kWh/(m <sup>2</sup> a) he	10 9 - 0 0 0 0 0 114 45	s s s s s s s	15 - - 10 20 0.6	criteria -	yes - yes yes yes
Space heating Space cooling Frequency of exce Airtightness Non-renewable Primary E Primary Energy	Treated floor are Heating demar Heating loa Cooling & dehum. demar Cooling loa aquency of overheating (> 25 % essively high humidity (> 12 g/k Pressurization test result n inergy (PE) PE demar PER demar	aa m² had kWh/(m²a) had kWh/(m²a) had kWh/(m²a) had kWh/(m²a) had kWh/(m²a) he hed kWh/(m²a)	10 9 - 0 0 0 0 114	s s s s s s	15 - - 10 20 0.6	criteria -	yes - yes yes yes
Space heating Space cooling Frequency of exce Airtightness Non-renewable Primary E Primary Energy	Treated floor are Heating demar Heating los Cooling & dehum. demar Cooling los equency of overheating (> 25 ° essively high humidity (> 12 g/k Pressurization test result n inergy (PE) PE demar PER demar Generation of renewab energy (in relation to pro-ject	aa m² had kWh/(m²a) had kWh/(m²a) had kWh/(m²a) had kWh/(m²a) had kWh/(m²a) he hed kWh/(m²a)	10 9 - 0 0 0 0 0 114 45	s s s s s s s	15 - - 10 20 0.6		yes - yes yes yes
Space heating Space cooling Frequency of exc Airtightness Non-renewable Primary E Primary Energy Renewable (PER)	Treated floor are Heating demar Heating los Cooling & dehum. demar Cooling los aquency of overheating (> 25 ° essively high humidity (> 12 g/k Pressurization test result n inergy (PE) PE demar PER demar Generation of renewab energy (in relation to pro-ject building footprint are	ea m <sup>2</sup> hd kWh/(m <sup>2</sup> a) hd kWh/(m <sup>2</sup> a) he kWh/(m <sup>2</sup> a) he he he he he he he he he he	10 9 - 0 0 0.6 114 45 0	s s s s s s s	15 - - 10 20 0.6 135 - -	criteria - 10 - - - - - - - - - - - - -	yes yes yes yes yes
Space heating Space cooling Frequency of exc Airtightness Non-renewable Primary E Primary Energy Renewable (PER)	Treated floor are Heating demar Heating los Cooling & dehum. demar Cooling los equency of overheating (> 25 ° essively high humidity (> 12 g/k Pressurization test result n inergy (PE) PE demar PER demar Generation of renewab energy (in relation to pro-ject building footprint are	a m <sup>2</sup> hd kWh/(m <sup>2</sup> a) hd kWh/(m <sup>2</sup> a) he he kWh/(m <sup>2</sup> a) he he kWh/(m <sup>2</sup> a) he he kWh/(m <sup>2</sup> a) he kWh/(m <sup></sup>	10 9 - 0 0 0 0 0 114 45 0	s s s s s s s	15 - - - 10 20 0.6 135 - - -		yes yes yes yes yes
Space heating Space cooling Frequency of exce Airtightness Non-renewable Primary E Primary Energy Renewable (PER)	Treated floor are Heating demar Heating los Cooling & dehum. demar Cooling los equency of overheating (> 25 % essively high humidity (> 12 g/k Pressurization test result n energy (PE) PE demar Generation of renewab energy (in relation to pro-ject building footprint are	ea m <sup>2</sup> hd kWh/(m <sup>2</sup> a) hd kWh/(m <sup>2</sup> a) he kWh/(m <sup>2</sup> a) he he he he he he he he he he	10 9 - 0 0 0 0 0 114 45 0	≤ ≤ ≤ ≤ ≤ ≤ ≤ ≤ ≥	15 - - 10 20 0.6 135 - -	criteria - 10 - - - - - - - - - - - - -	yes yes yes yes yes
Space heating Space cooling Frequency of exc Airtightness Non-renewable Primary E Primary Energy Renewable (PER)	Treated floor are Heating demar Heating los Cooling & dehum. demar Cooling los aquency of overheating (> 25 ° essively high humidity (> 12 g/k Pressurization test result n inergy (PE) PE demar PER demar Generation of renewab energy (in relation to pro-ject building footprint are	a m <sup>2</sup> hd kWh/(m <sup>2</sup> a) hd kWh/(m <sup>2</sup> a) he he kWh/(m <sup>2</sup> a) he he kWh/(m <sup>2</sup> a) he he kWh/(m <sup>2</sup> a) he kWh/(m <sup></sup>	10 9 - 0 0 0 0 0 114 45 0	s s s s s s s	15 - - - 10 20 0.6 135 - - -	criteria - 10 - - - - - - - - - - - - -	yes - yes yes yes yes - 

PHPP verification sheet for the block of flats..

# 10 Construction costs

Construction costs including all building structures, access, drainage and landscaping were  $\pounds$ 2,400/m2 TFA.

# **11** User experience and actual consumption

All nine homes have only been fully occupied since February 2022 and no data on energy consumption is available as yet.