

Insulating Solid Walls:  
Findings from pre and post refurbishment  
performance monitoring from the SPAB Building  
Performance Survey

Coleman Court  
25<sup>th</sup> March 2014

Caroline Rye



# The SPAB Building Performance Survey

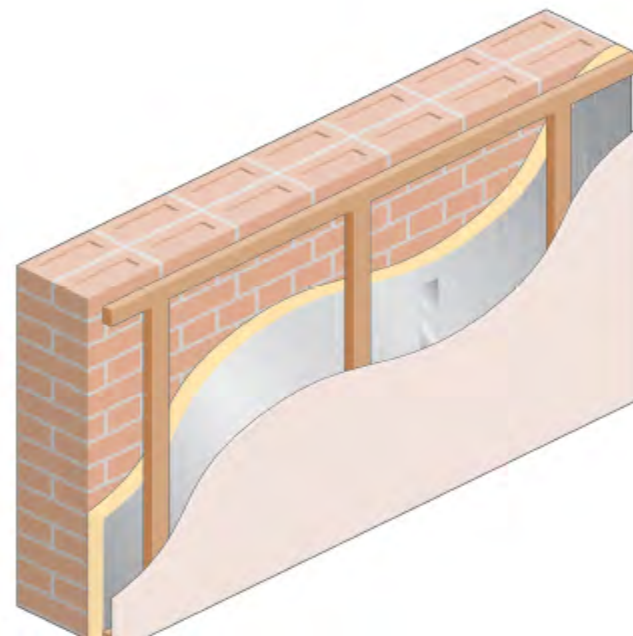


# The SPAB Building Performance Survey



- Fabric heat loss through the U-value measurement of wall elements both in the form of *in situ* and calculated U-values.
- Air infiltration through air permeability testing and thermographic survey.
- Indoor air conditions and comfort levels via the measurement of CO<sub>2</sub>, interior temperature and relative humidity.
- Moisture; room and wall moisture including wall surface and interstitial moisture behaviour.

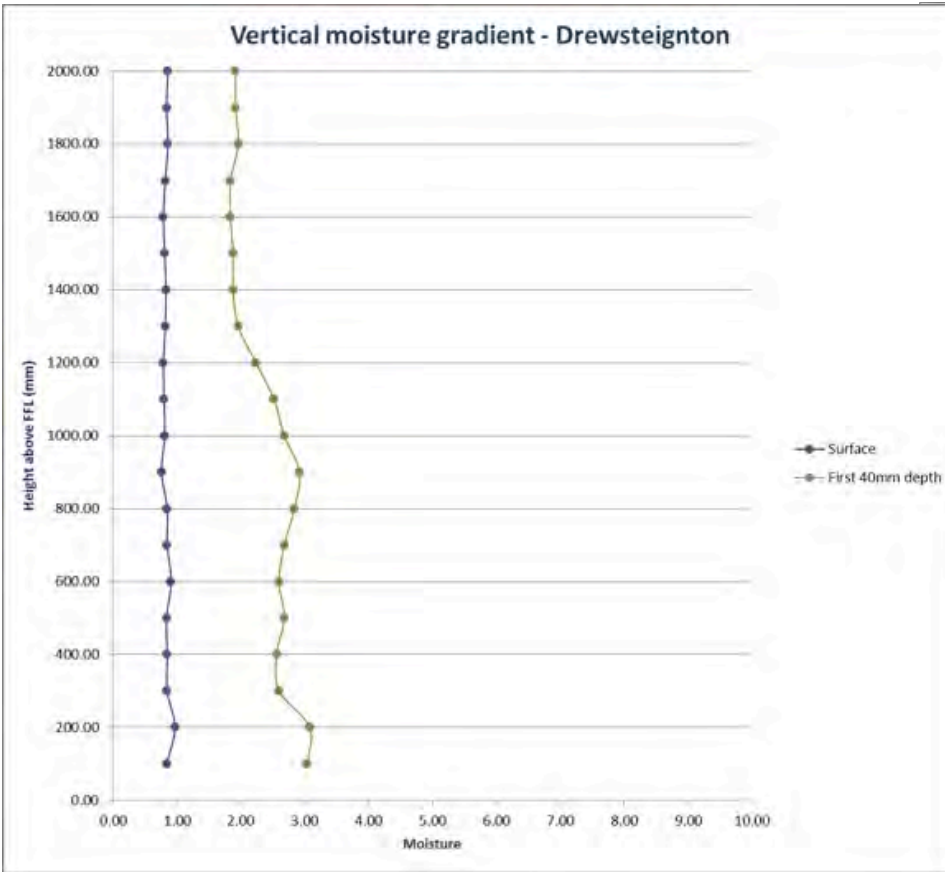
## Real Retrofits – Granite Wall - IWI



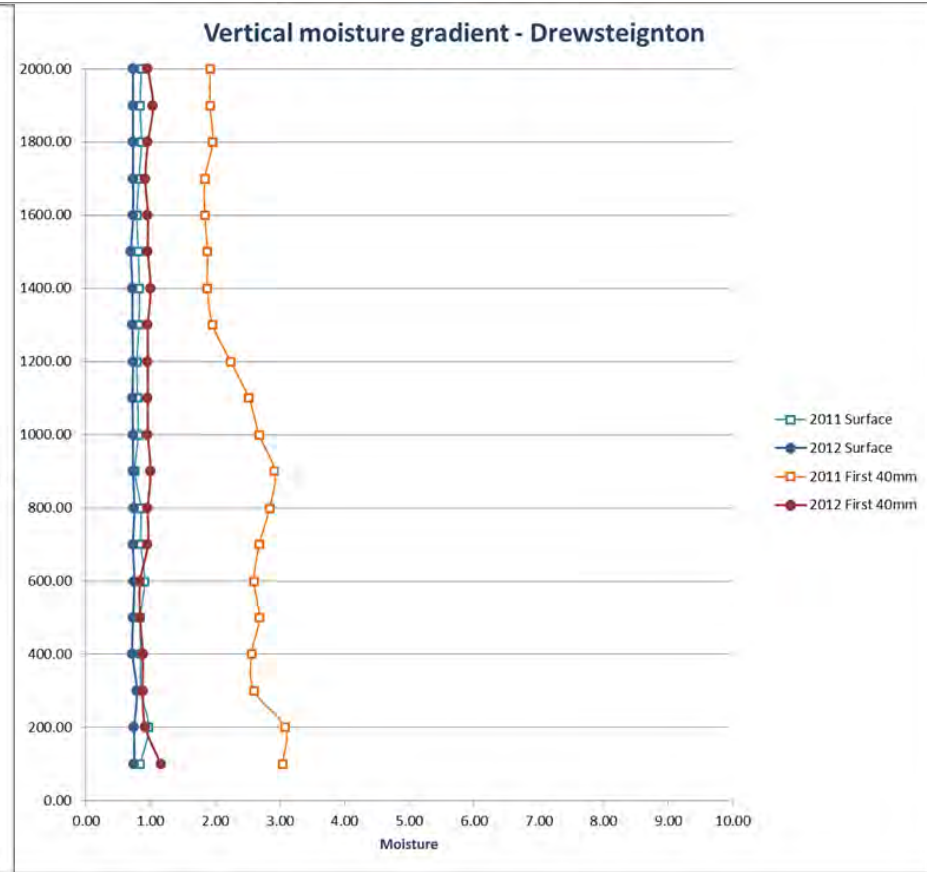
IWI - Drewsteignton - Granite Wall 600mm thick insulated with 100mm PIR following manufacturers guidelines – P/B - Air gap-Foil-faced, PIR taped joints,

U-value - Granite	Uninsulated	Insulated	% Reduction
Measured	1.20 W/m <sup>2</sup> K	0.16 W/m <sup>2</sup> K	87%
Calculated	2.45 W/m <sup>2</sup> K	0.19 W/m <sup>2</sup> K	92%
Targets	SAP = 2.3	Part L = 0.30	87%

# Surface & Sub surface Moisture

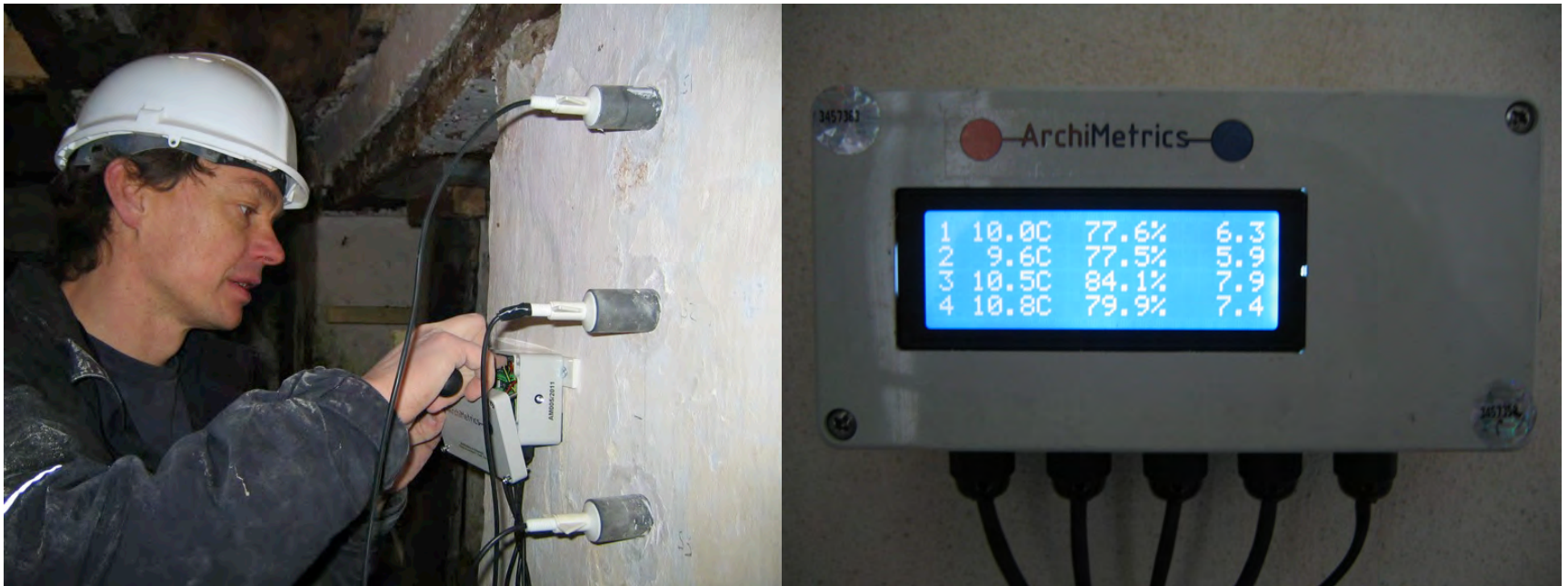


Uninsulated



Insulated

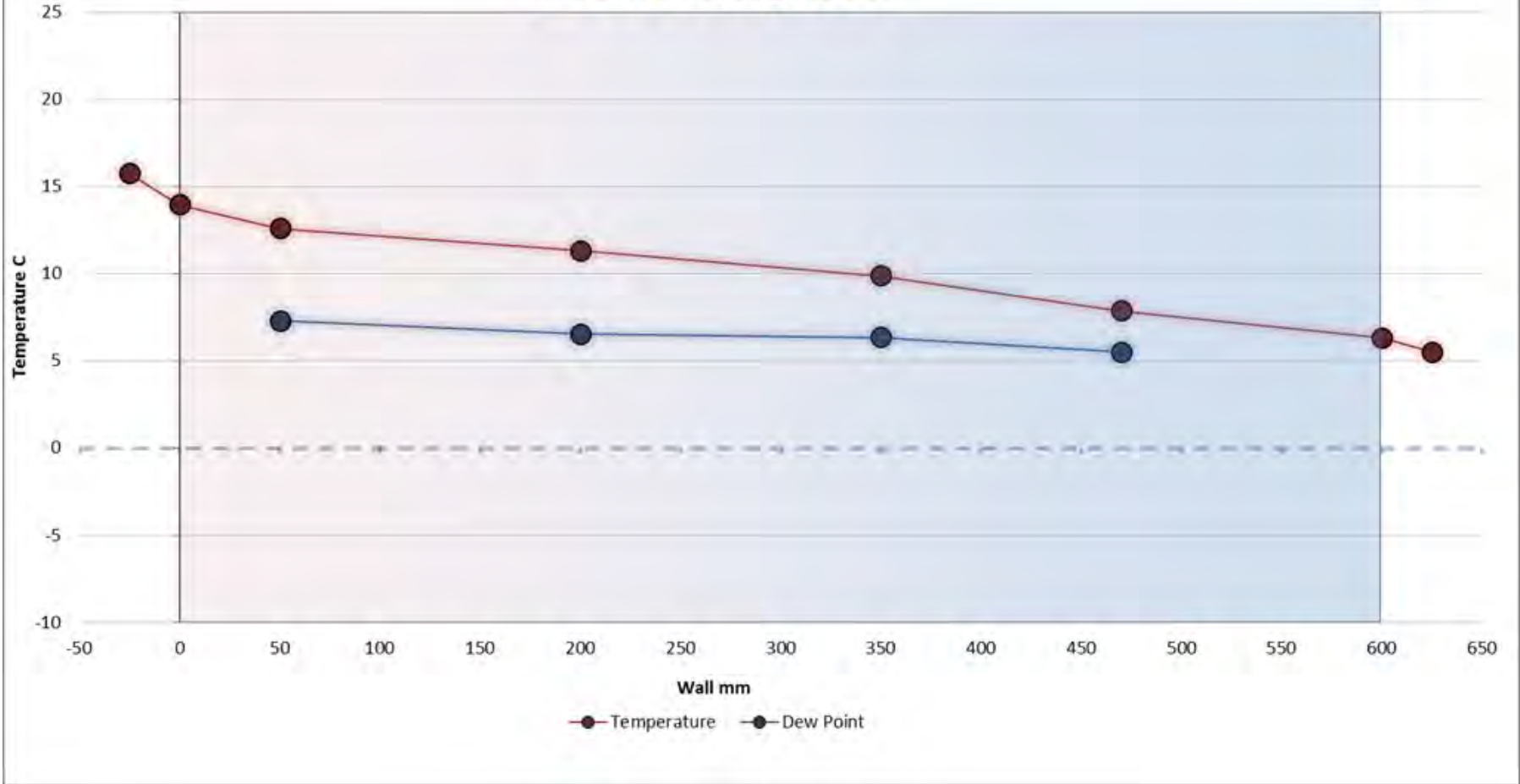
# Interstitial moisture monitoring



Temperature and humidity sensing at four points through wall profile

# Granite – Hygrothermal Wall section - Static Average Pre-insulation

## Drewsteington



Dewpoint Margins	Average	4 <sup>th</sup> Node
Uninsulated	4.01°C	2.98°C

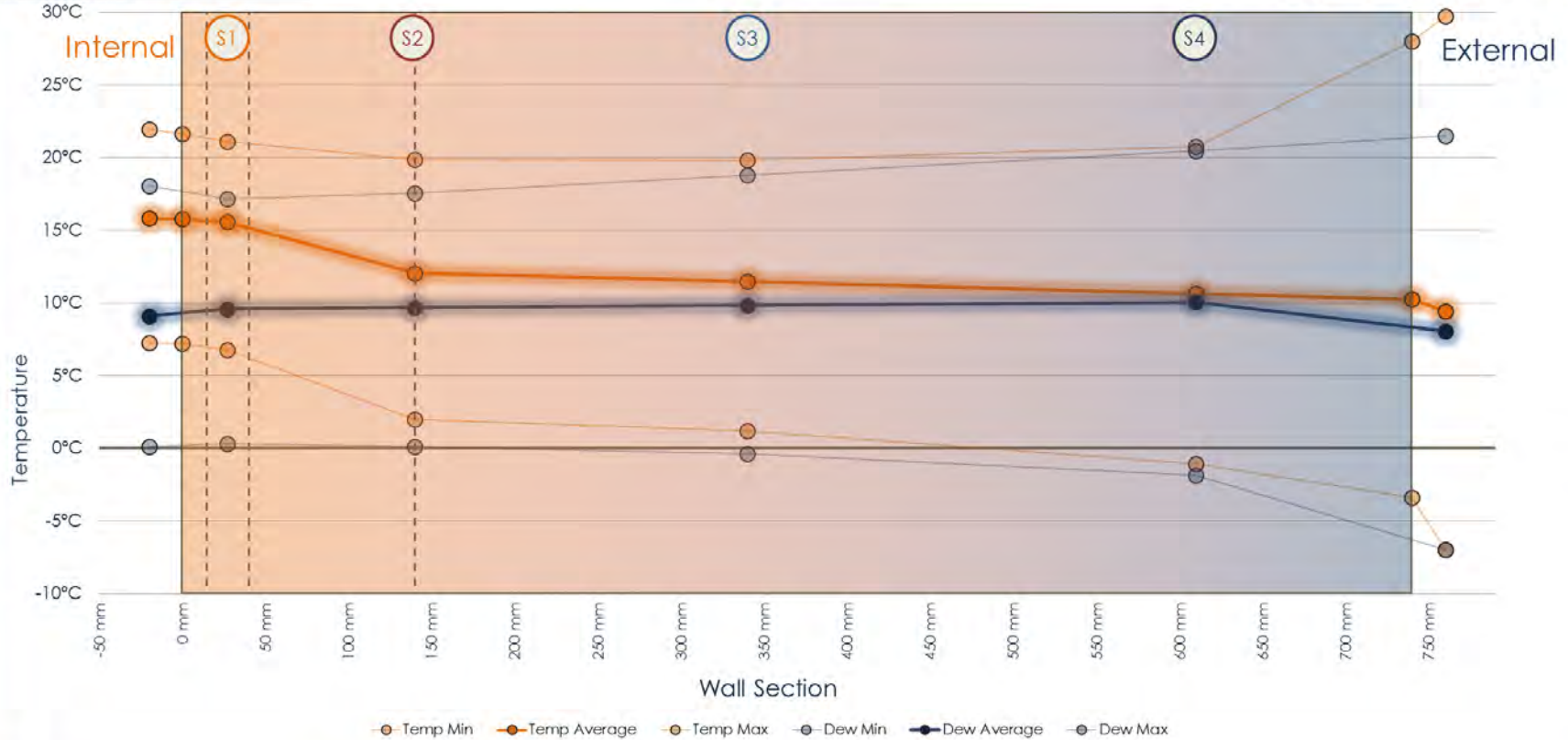


Project: SPAB BPS  
 Building: Drewsteignton  
 Location: Office  
 Start: 08/02/2012  
 End: 28/02/2013  
 Logger: AMIG/06  
 Material: Granite & PIR IWI  
 Thickness: 740mm

# ArchiMetrics

Hygrothermal section

Dew Point Margins			
	Minimum	Maximum	Average
S1	0.66°C	9.43°C	5.60°C
S2	1.50°C	6.62°C	2.23°C
S3	0.98°C	4.91°C	1.53°C
S4	0.01°C	2.42°C	0.57°C
<b>Average</b>	<b>0.79°C</b>	<b>5.85°C</b>	<b>2.48°C</b>



Dewpoint Margins	Feb 2011	Feb - Sept 2012	Feb 2012 - Feb 2013
Average	4.01°C	2.77°C	2.48°C
4 <sup>th</sup> Node	2.98°C	0.64°C	0.57°C



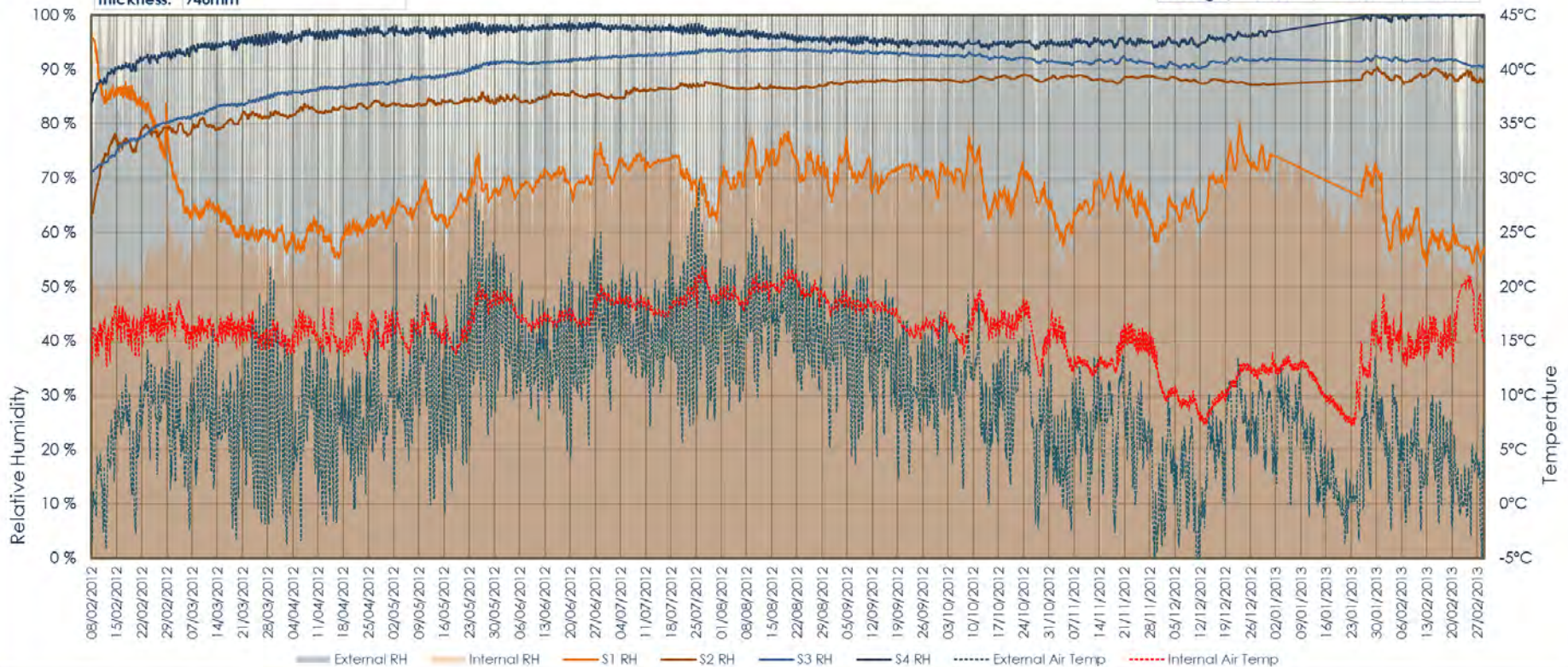


Project:	SPAB BPS
Building:	Drewsteignton
Location:	Office
Start:	08/02/2012
End:	28/02/2013
Logger:	AMIG/06
Material:	Granite & PIR IWI
Thickness:	740mm

# ArchiMetrics

## Relative Humidity Over Time

RH %	Minimum	Maximum	Average
Internal	45.08	86.13	64.57
S1	53.72	95.73	67.83
S2	63.24	90.38	85.45
S3	71.14	94.06	89.74
S4	84.09	100.00	96.01
External	28.54	100.00	92.31
Average	57.63	94.38	82.65



IWI - Drewsteignton - Granite Wall 600mm thick insulated with 100mm PIR – foil-faced, taped joints, air gap, plasterboard & skim

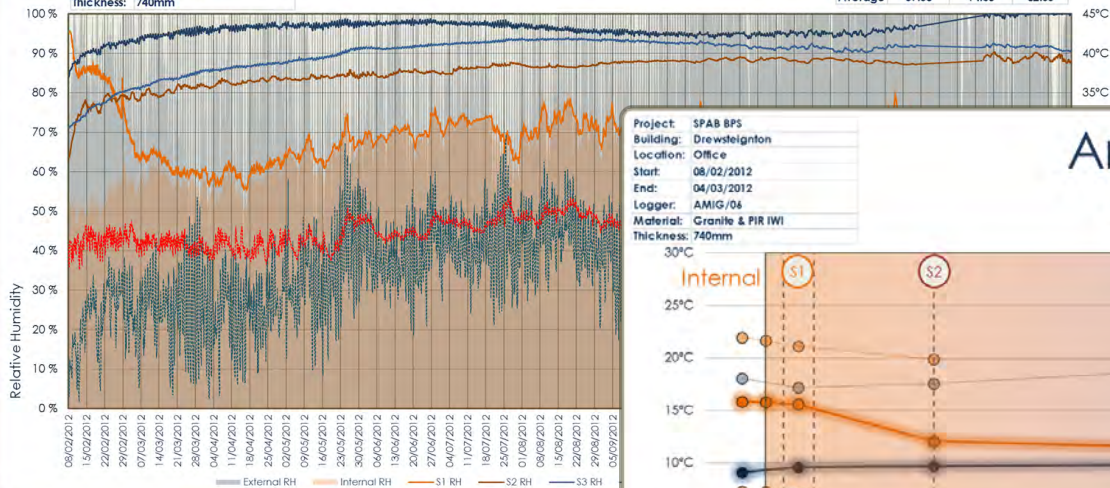


Project: SPAB BPS  
 Building: Drewsteignton  
 Location: Office  
 Start: 08/02/2012  
 End: 04/03/2012  
 Logger: AMIG/06  
 Material: Granite & PIR IWI  
 Thickness: 740mm

# ArchiMetrics

Relative Humidity Over Time

RH %	Minimum	Maximum	Average
Internal	45.08	86.13	64.57
S1	53.72	95.73	67.83
S2	63.24	90.38	85.45
S3	71.14	94.06	89.74
S4	84.09	100.00	96.01
External	28.54	100.00	92.31
Average	57.63	94.38	82.65

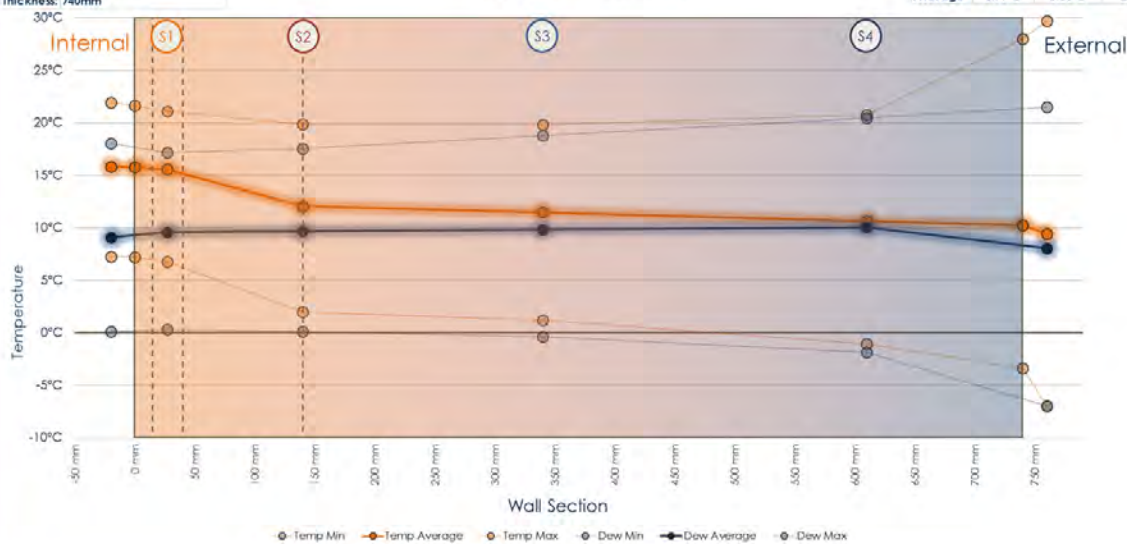


Project: SPAB BPS  
 Building: Drewsteignton  
 Location: Office  
 Start: 08/02/2012  
 End: 04/03/2012  
 Logger: AMIG/06  
 Material: Granite & PIR IWI  
 Thickness: 740mm

# ArchiMetrics

Hygrothermal section

	Dew Point Margins		
	Minimum	Maximum	Average
S1	0.66°C	9.43°C	5.98°C
S2	1.50°C	6.62°C	2.38°C
S3	0.98°C	4.91°C	1.64°C
S4	0.00°C	2.42°C	0.61°C
Average	0.79°C	5.85°C	2.65°C



Dewpoint Margins	Average	4 <sup>th</sup> Node	In situ U-value	% reduction
Uninsulated	4.01°C	2.38°C	1.20 W/m <sup>2</sup> K	87%
Insulated	2.48°C	0.57°C	0.16 W/m <sup>2</sup> K	



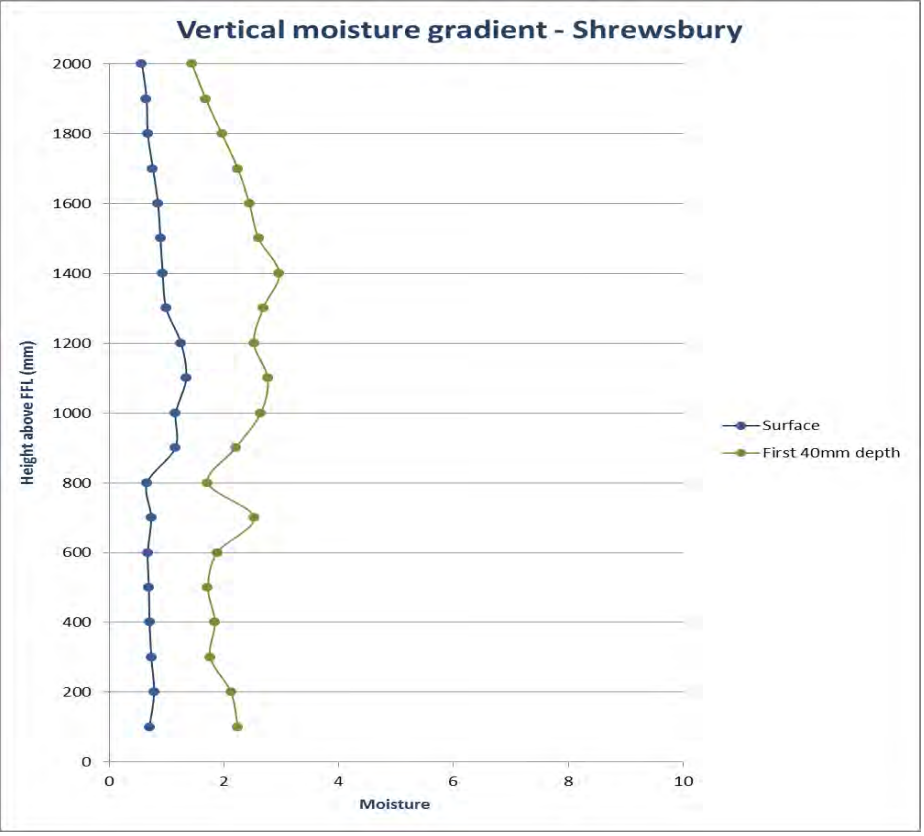
## Real Retrofits – Brick Wall - IWI



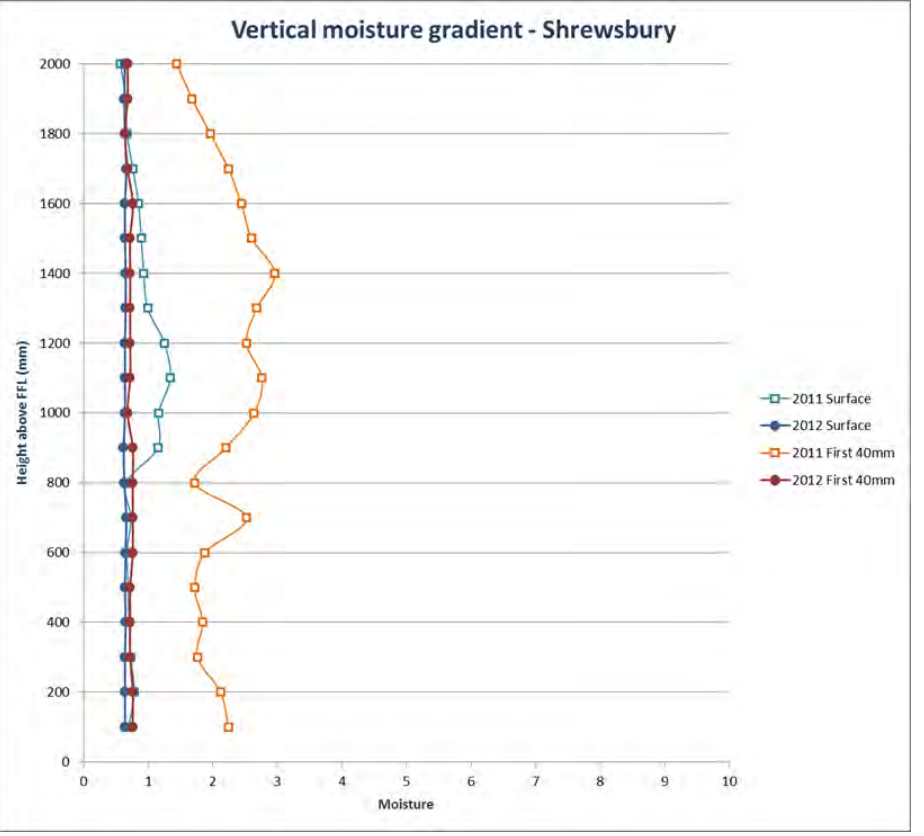
Thickness not 220mm but 345mm - a brick and a half -  
 Insulated with 40mm woodfibre – 8mm lime plaster - without a VCL

U-value - Brick	Uninsulated	Insulated	% Reduction
Measured	1.48 W/m <sup>2</sup> K	0.48 W/m <sup>2</sup> K	68%
Calculated	1.52 W/m <sup>2</sup> K	0.52 W/m <sup>2</sup> K	66%
Targets	SAP = 2.1	Part L = 0.30	86%

# Surface & Sub-surface Moisture



2011 Uninsulated



2012 Insulated

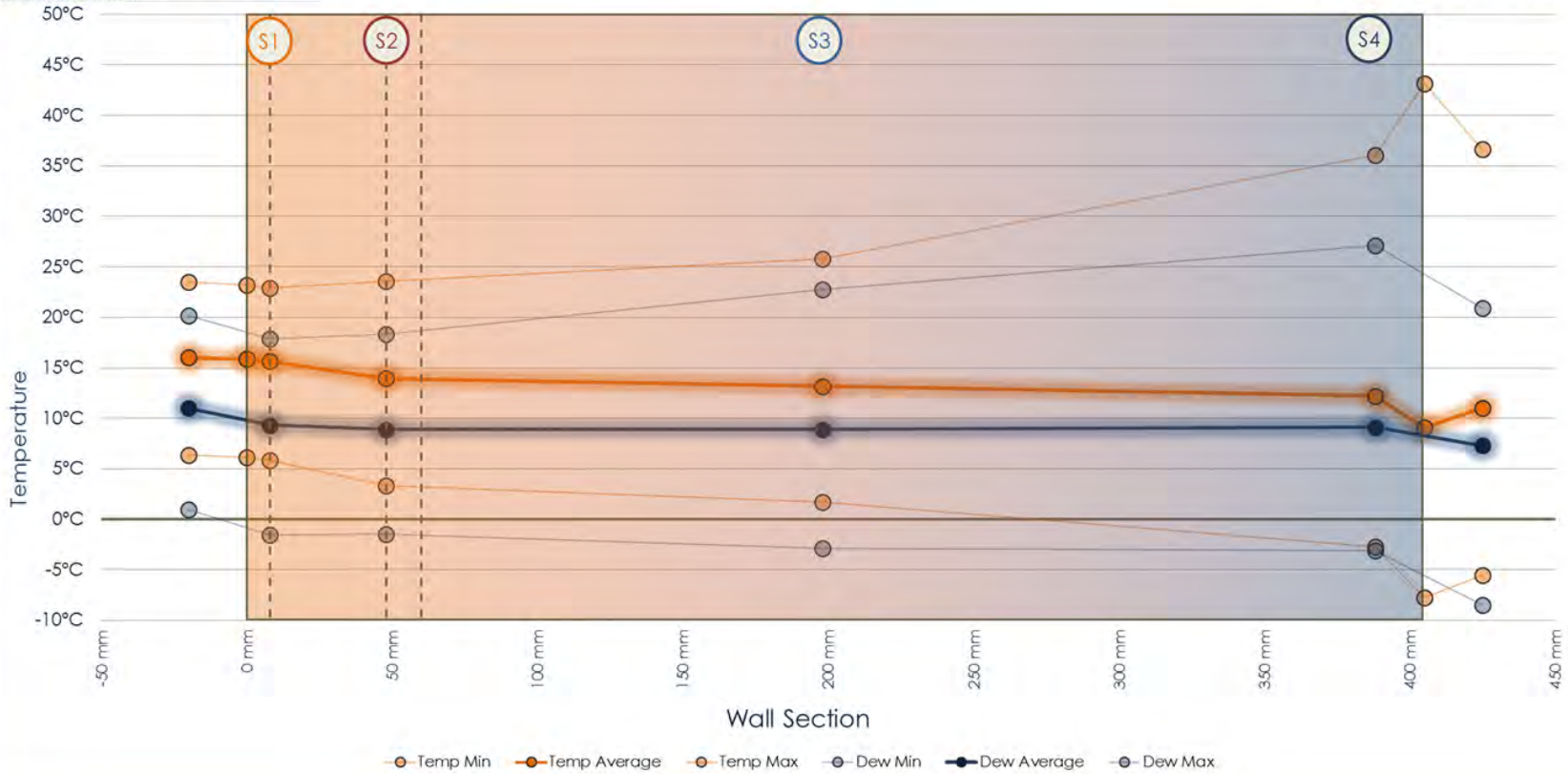


Project: SPAB BPS  
 Building: Shrewsbury  
 Location: Living Room  
 Start: 09/05/2012  
 End: 11/04/2013  
 Logger: AMIG/04  
 Material: Solid brick with IWI  
 Thickness: 405mm

# ArchiMetrics

## Hygrothermal section

	Dew Point Margins		
	Minimum	Maximum	Average
S1	3.16°C	11.27°C	6.34°C
S2	2.70°C	6.89°C	5.08°C
S3	0.77°C	6.49°C	4.30°C
S4	0.00°C	15.26°C	3.08°C
<b>Average</b>	<b>1.66°C</b>	<b>9.98°C</b>	<b>4.70°C</b>



Dewpoint Margins	Feb 2011	Feb - April 2012	May '12 – April '13
Average	5.49°C	3.18°C	4.70°C
4 <sup>th</sup> Node	3.96°C	4.37°C	3.08°C

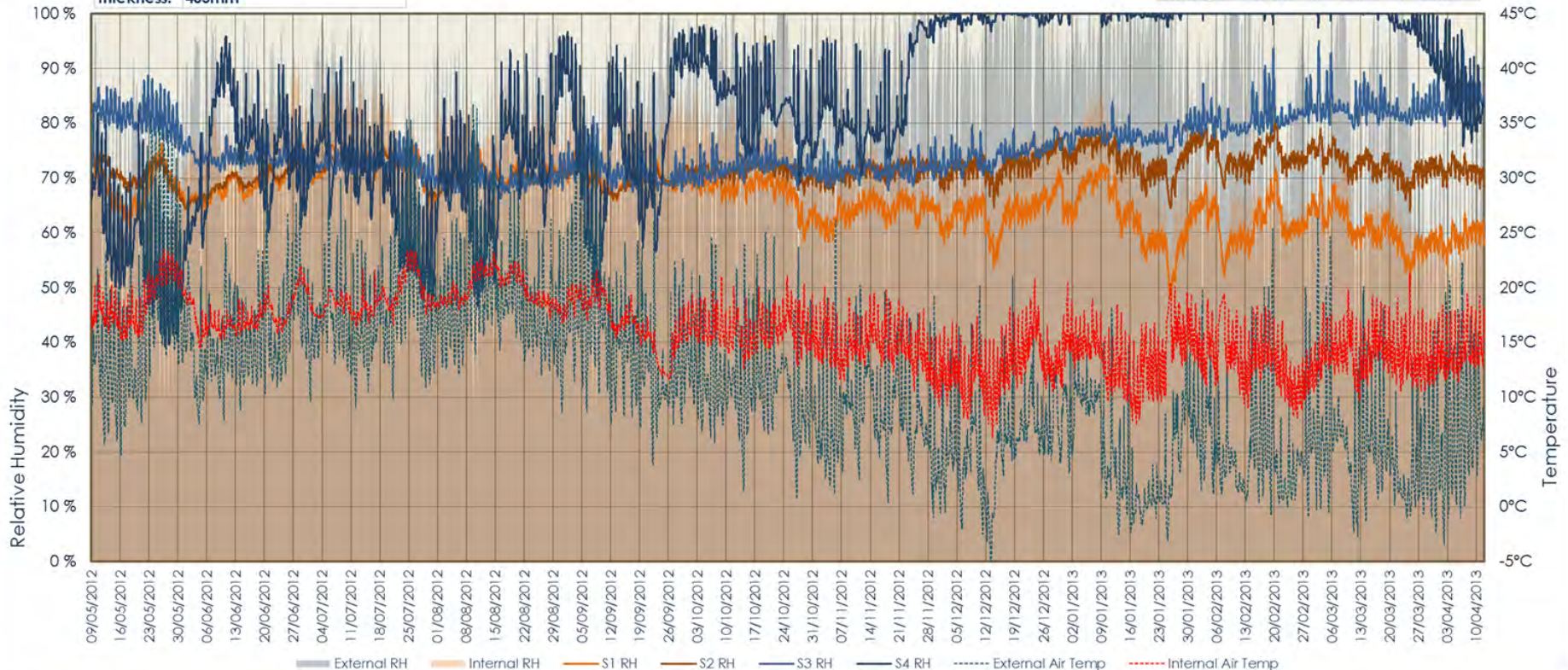


Project:	SPAB BPS
Building:	Shrewsbury
Location:	Living Room
Start:	09/05/2012
End:	11/04/2013
Logger:	AMIG/04
Material:	Solid brick with IWI
Thickness:	405mm

# ArchiMetrics

## Relative Humidity Over Time

RH %	Minimum	Maximum	Average
Internal	48.50	93.40	72.38
S1	48.22	81.48	66.12
S2	63.82	83.97	71.56
S3	66.20	95.08	75.43
S4	39.30	100.00	83.49
External	20.20	100.00	80.55
Average	47.71	92.32	74.92



IWI – Shrewsbury - Brick Wall 345 mm thick insulated with 40 mm woodfibre – 8mm lime plaster – no vcl

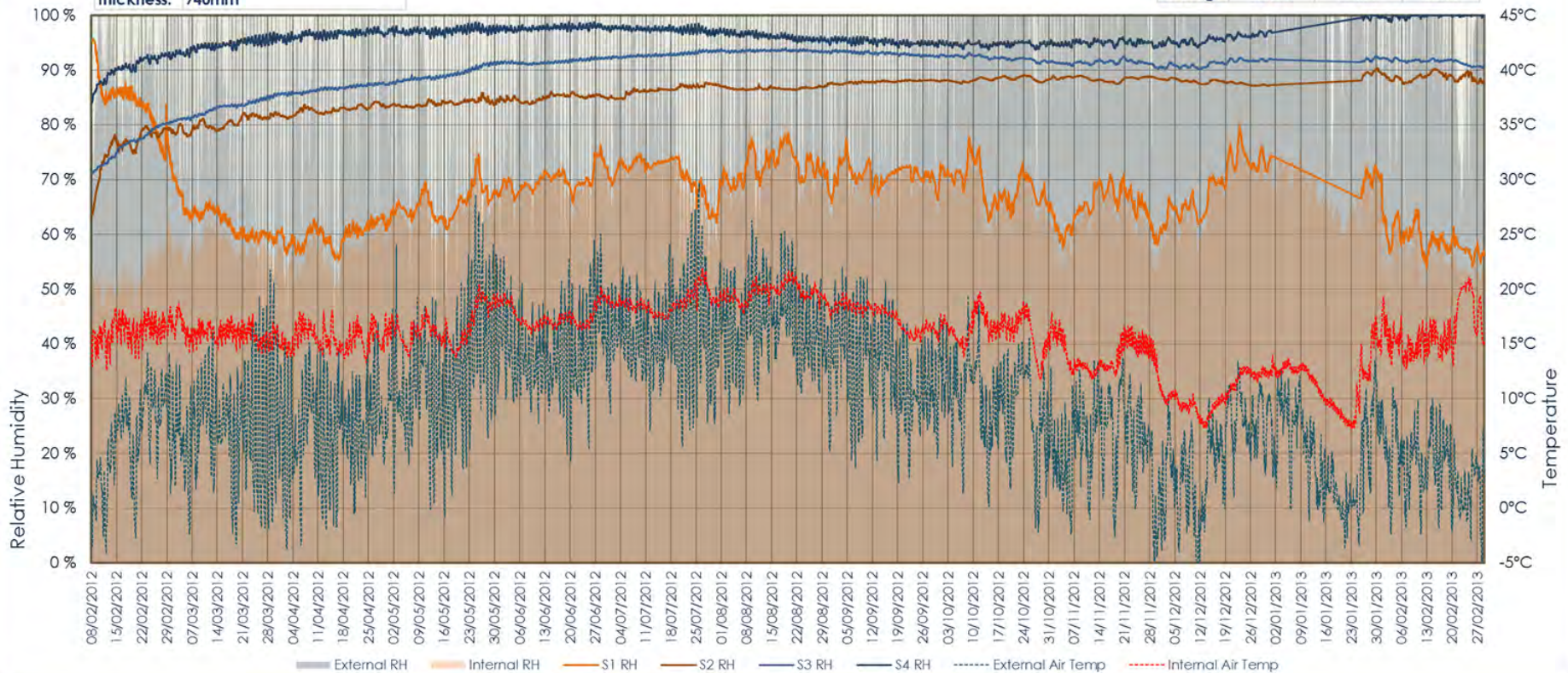


Project:	SPAB BPS
Building:	Drewsteignton
Location:	Office
Start:	08/02/2012
End:	04/03/2012
Logger:	AMIG/06
Material:	Granite & PIR IW1
Thickness:	740mm

# ArchiMetrics

## Relative Humidity Over Time

RH %	Minimum	Maximum	Average
Internal	45.08	86.13	64.57
S1	53.72	95.73	67.83
S2	63.24	90.38	85.45
S3	71.14	94.06	89.74
S4	84.09	100.00	96.01
External	28.54	100.00	92.31
Average	57.63	94.38	82.65



IWI - Drewsteignton - Granite Wall 600mm thick insulated with 100mm PIR following manufacturers guidelines – P/B - Air gap-Foil-faced, PIR taped joints,

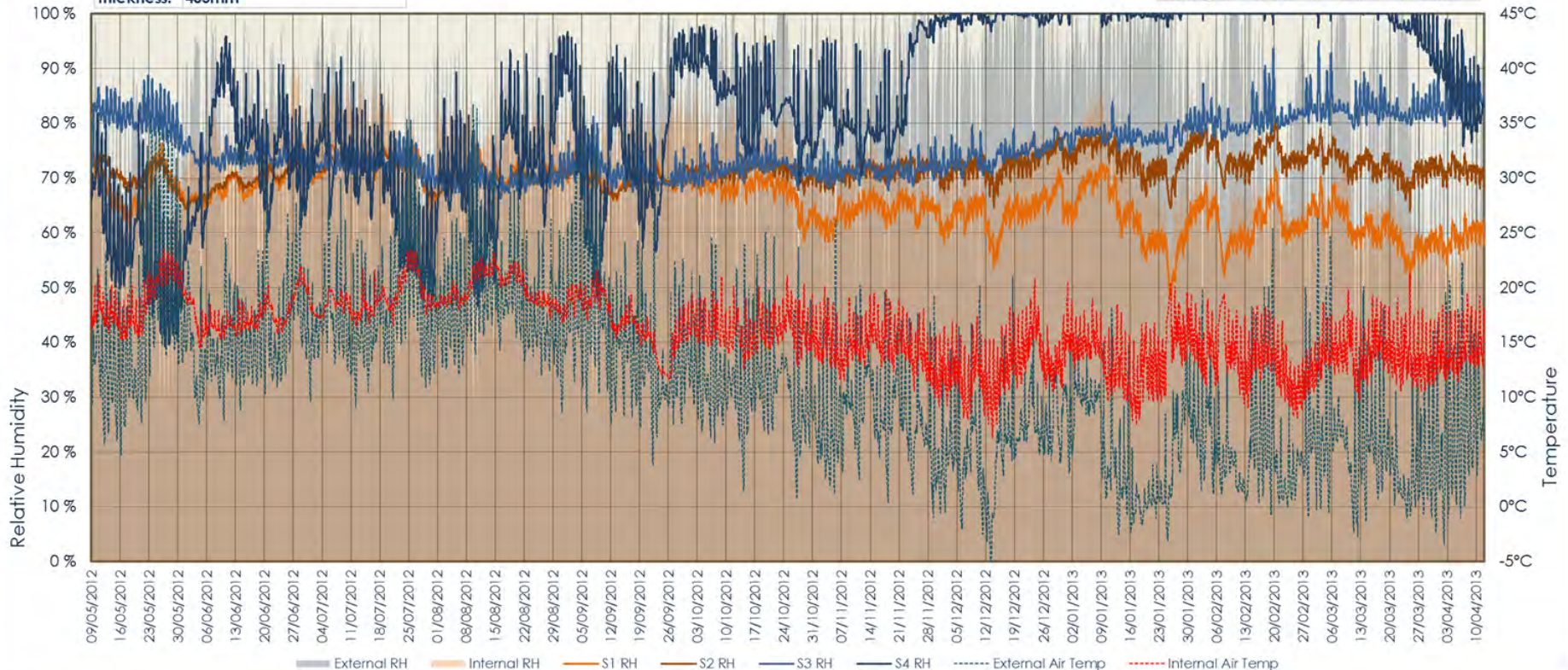


Project:	SPAB BPS
Building:	Shrewsbury
Location:	Living Room
Start:	09/05/2012
End:	11/04/2013
Logger:	AMIG/04
Material:	Solid brick with IWI
Thickness:	405mm

# ArchiMetrics

## Relative Humidity Over Time

RH %	Minimum	Maximum	Average
Internal	48.50	93.40	72.38
S1	48.22	81.48	66.12
S2	63.82	83.97	71.56
S3	66.20	95.08	75.43
S4	39.30	100.00	83.49
External	20.20	100.00	80.55
Average	47.71	92.32	74.92



IWI – Shrewsbury - Brick Wall 345 mm thick insulated with 40 mm woodfibre – 8mm lime plaster – no vcl



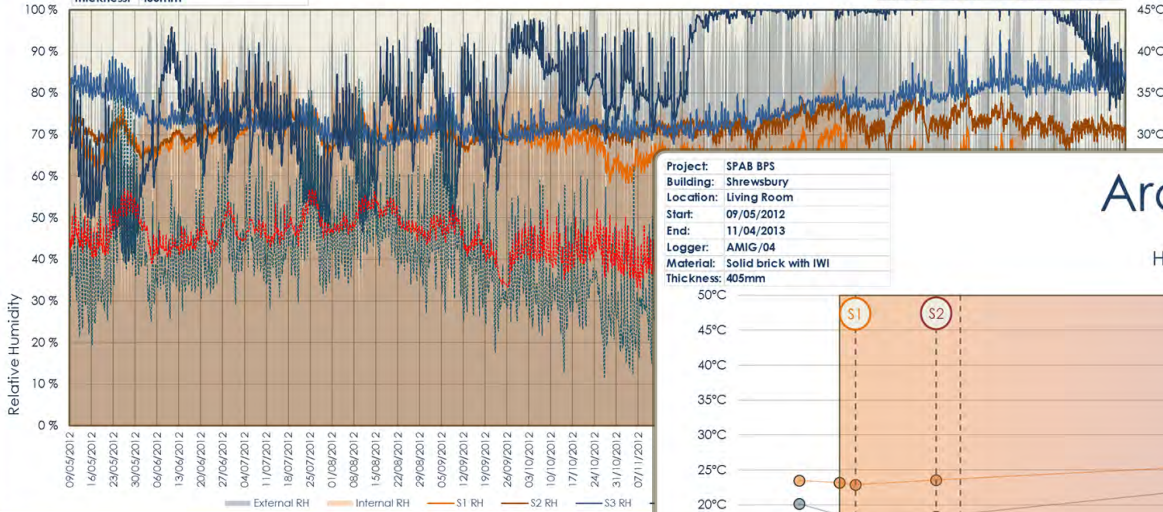


Project: SPAB BPS  
 Building: Shrewsbury  
 Location: Living Room  
 Start: 09/05/2012  
 End: 11/04/2013  
 Logger: AMIG/04  
 Material: Solid brick with IWI  
 Thickness: 405mm

# ArchiMetrics

Relative Humidity Over Time

RH %	Minimum	Maximum	Average
Internal	48.50	93.40	72.38
S1	48.22	81.48	66.12
S2	63.82	83.97	71.56
S3	66.20	95.08	75.43
S4	39.30	100.00	83.49
External	20.20	100.00	80.55
Average	47.71	92.32	74.92

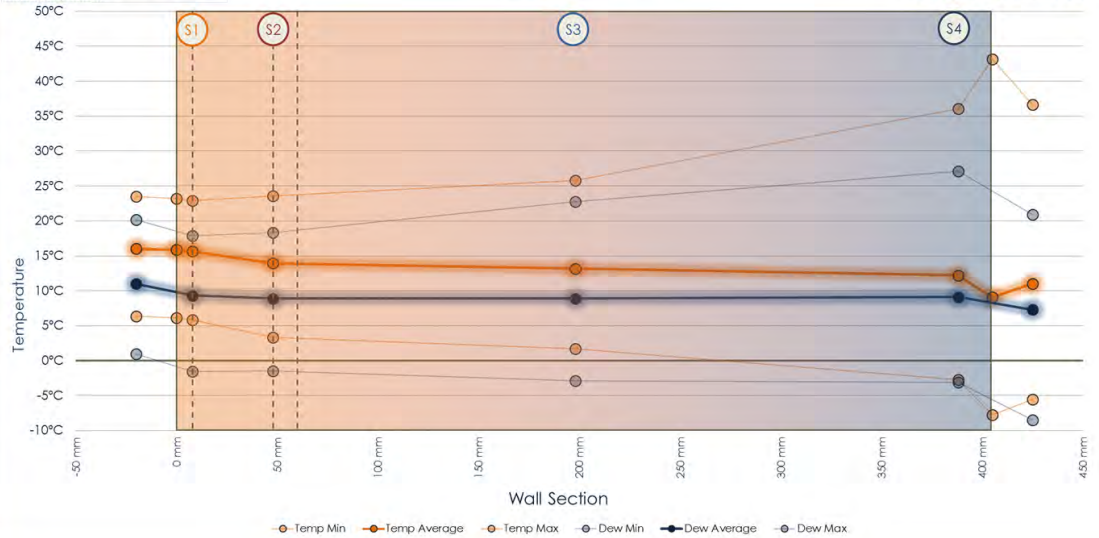


Project: SPAB BPS  
 Building: Shrewsbury  
 Location: Living Room  
 Start: 09/05/2012  
 End: 11/04/2013  
 Logger: AMIG/04  
 Material: Solid brick with IWI  
 Thickness: 405mm

# ArchiMetrics

Hygrothermal section

	Dew Point Margins		
	Minimum	Maximum	Average
S1	3.16°C	11.27°C	6.34°C
S2	2.70°C	6.89°C	5.08°C
S3	0.77°C	6.49°C	4.30°C
S4	0.00°C	15.28°C	3.08°C
Average	1.66°C	9.98°C	4.70°C



Dewpoint Margins	Average	4 <sup>th</sup> Node	In situ U-value	% reduction
Uninsulated	5.49°C	4.70°C	1.48 W/m <sup>2</sup> K	68%
Insulated	3.96°C	3.08°C	0.48 W/m <sup>2</sup> K	



# Skipton – U-values

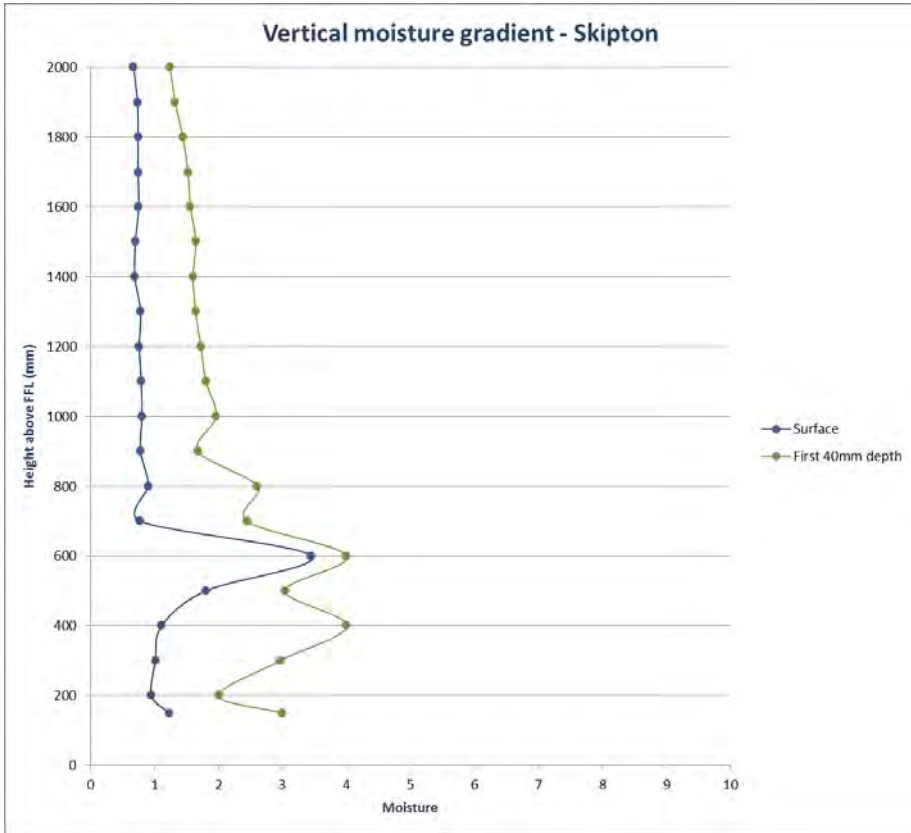


IWI – Skipton – Sandstone wall 540 mm thick insulated with 35 mm Hemp/lime plaster and finished with 5mm lime plaster = 580 mm OA

U-value - Sandstone	Uninsulated	Insulated	% Reduction
Measured	1.63 W/m <sup>2</sup> K	1.00 W/m <sup>2</sup> K	38%
Calculated	2.31 W/m <sup>2</sup> K	1.17 W/m <sup>2</sup> K	49%
Targets	SAP 2.0 W/m <sup>2</sup> K	0.3 W/m <sup>2</sup> K	85%

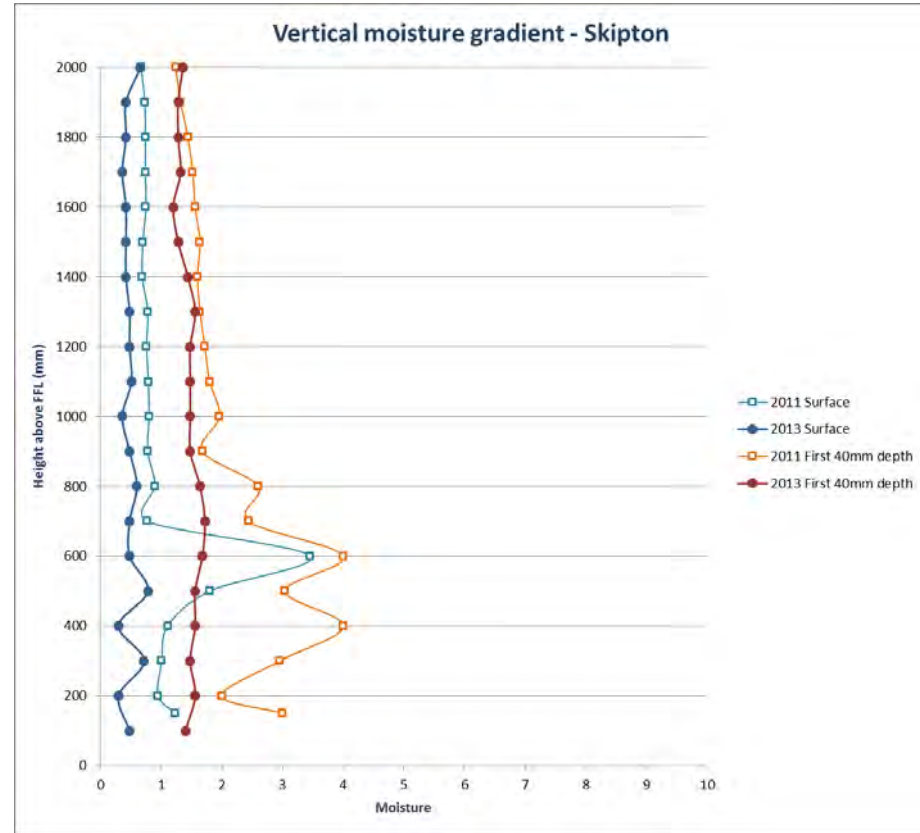
# Surface & Sub-surface Moisture

Vertical moisture gradient - Skipton



2011 Uninsulated

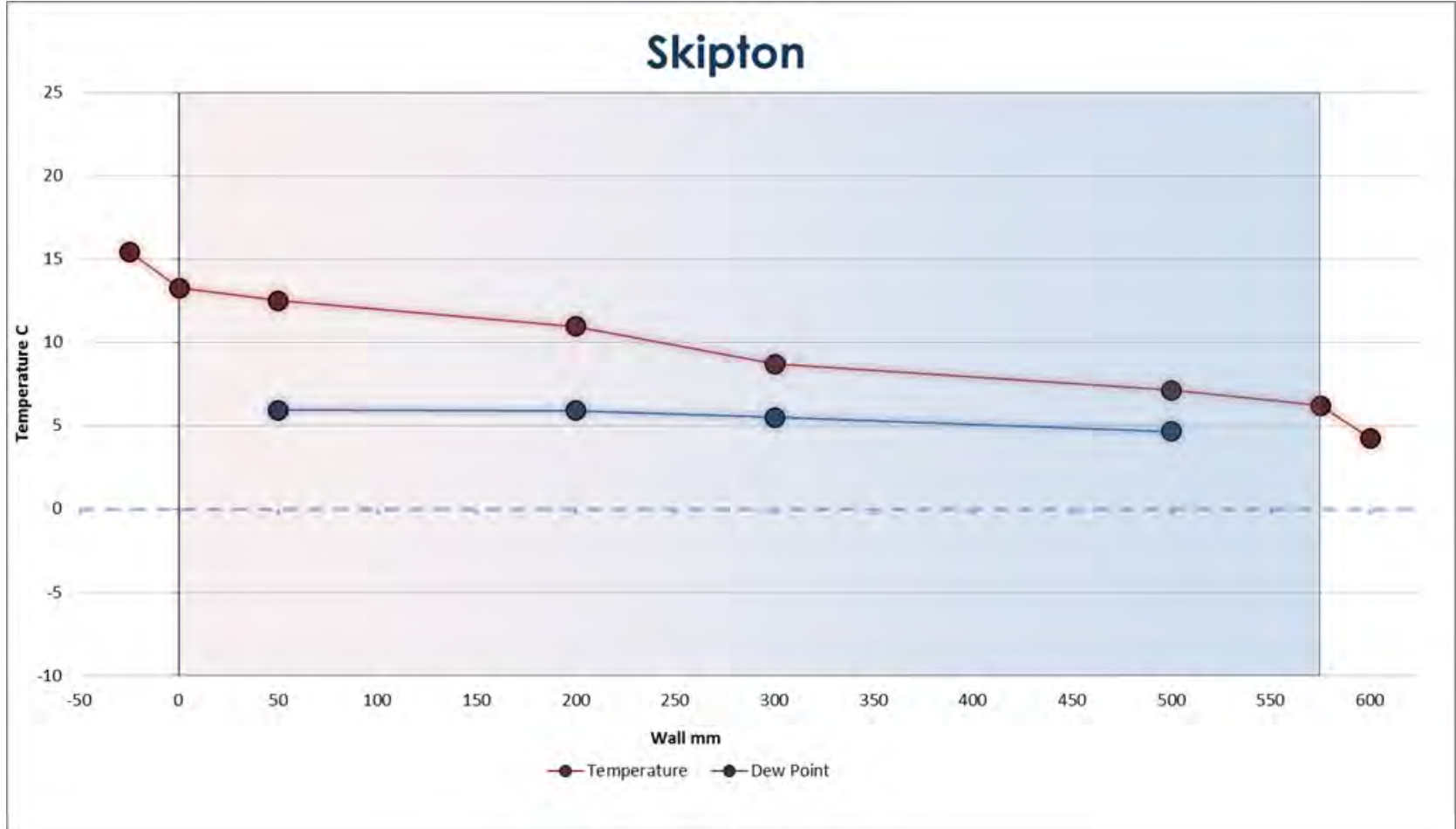
Vertical moisture gradient - Skipton



2013 Insulated



# Sanstone – Hygrothermal Wall section - Static Average Pre-insulation



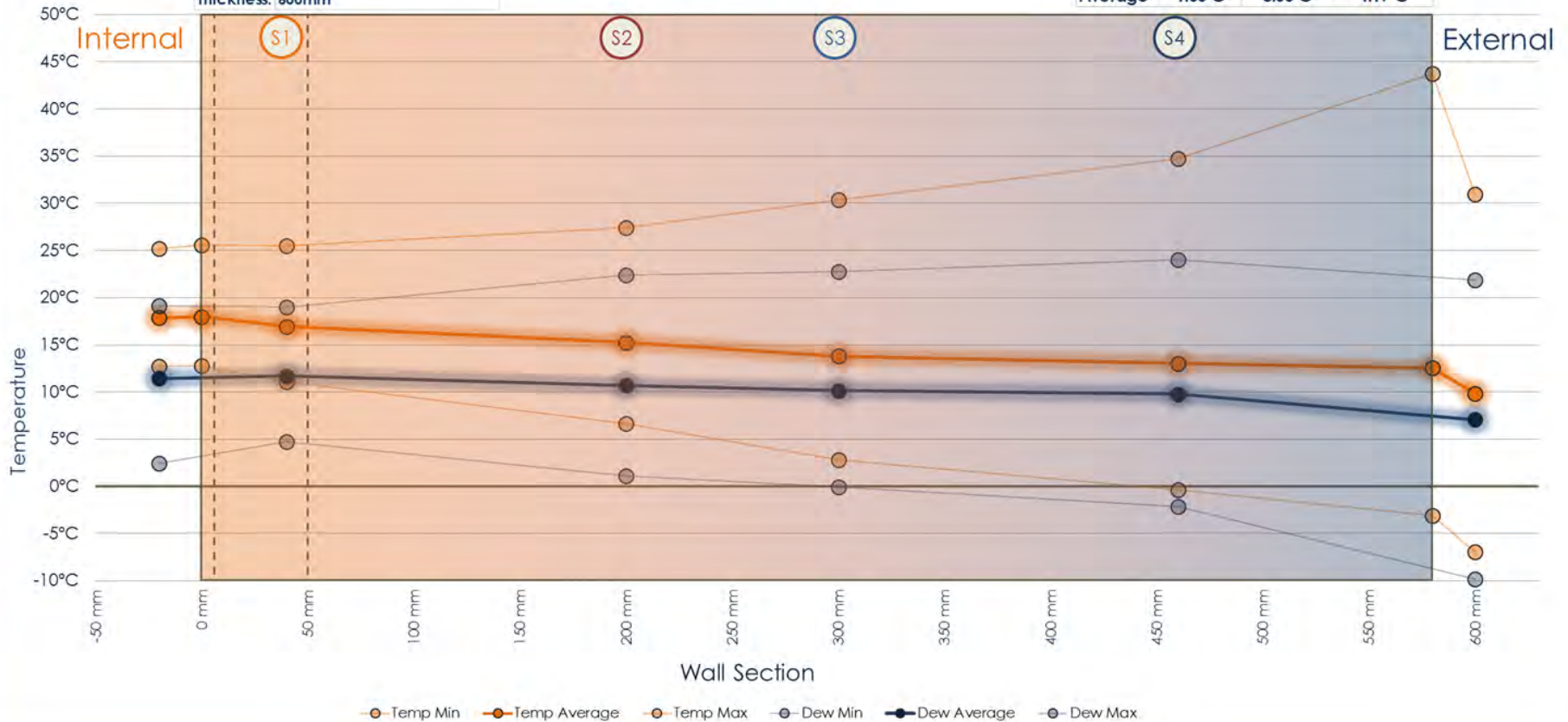
Rubble core - inhomogeneous wall – steeper gradient – no condensation event

Project:	SPAB BPS
Building:	Skipton
Location:	Kitchen
Start:	01/07/2012
End:	31/08/2013
Logger:	AM008
Material:	Sandstone + hemp/lime IW1
Thickness:	600mm

# ArchiMetrics

## Hygrothermal section

Dew Point Margins			
	Minimum	Maximum	Average
S1	2.28°C	7.91°C	5.26°C
S2	2.03°C	7.06°C	4.54°C
S3	1.72°C	7.83°C	3.67°C
S4	0.10°C	11.71°C	3.27°C
Average	1.53°C	8.63°C	4.19°C



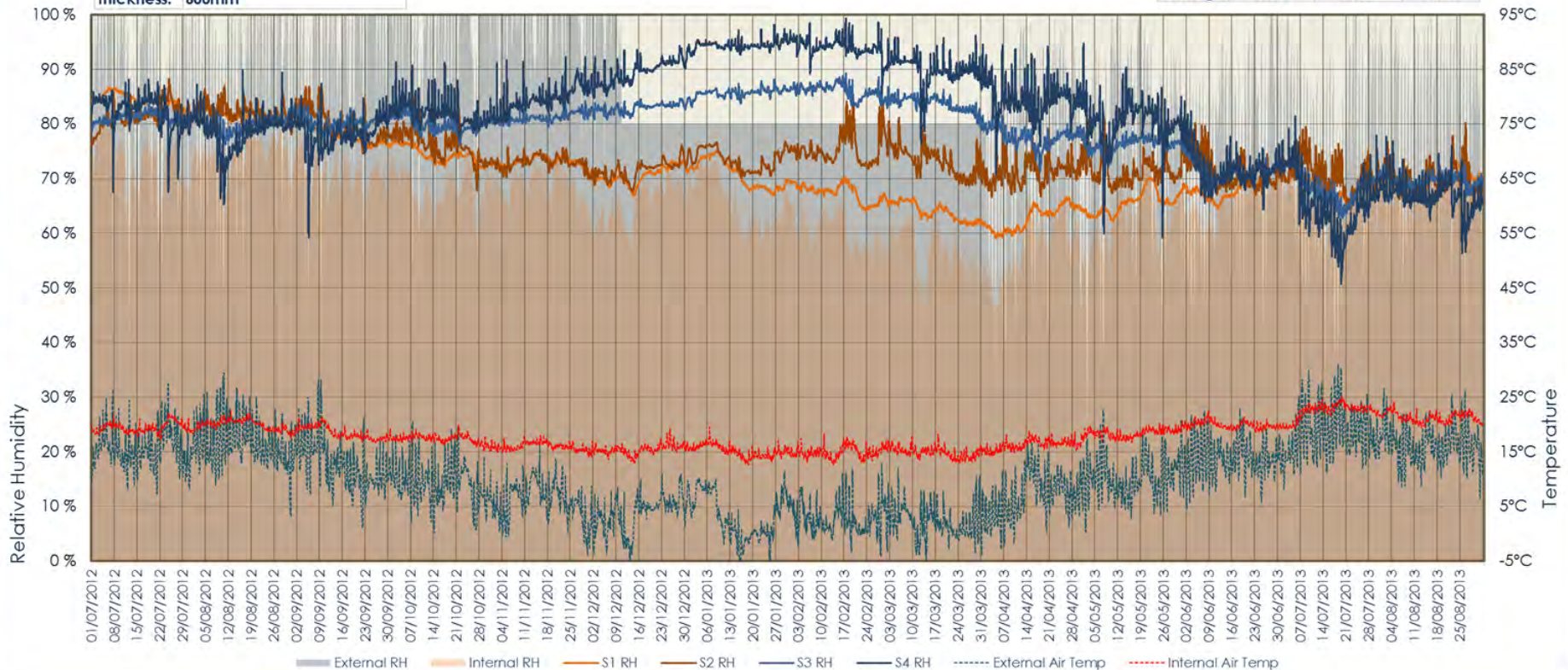
Dewpoint Margins	Feb 2011	June 2012 – Jan 2013	July 2012 – Aug 2013
Average	4.34°C	3.50°C	4.19°C
4 <sup>th</sup> Node	2.49°C	2.74°C	3.27°C

Project:	SPAB BPS
Building:	Skipton
Location:	Kitchen
Start:	01/07/2012
End:	31/08/2013
Logger:	AM008
Material:	Sandstone + hemp/lime IWI
Thickness:	600mm

# ArchiMetrics

## Relative Humidity Over Time

RH %	Minimum	Maximum	Average
Internal	38.90	88.20	66.37
S1	59.09	86.66	71.38
S2	64.18	88.28	74.42
S3	62.79	89.27	78.90
S4	50.73	99.39	81.43
External	24.10	100.00	84.05
Average	49.97	91.97	76.09



IWI – Skipton – Sandstone wall 540 mm thick insulated with 35 mm hemp/lime plaster and finished with 5mm lime plaster = 580 mm OA

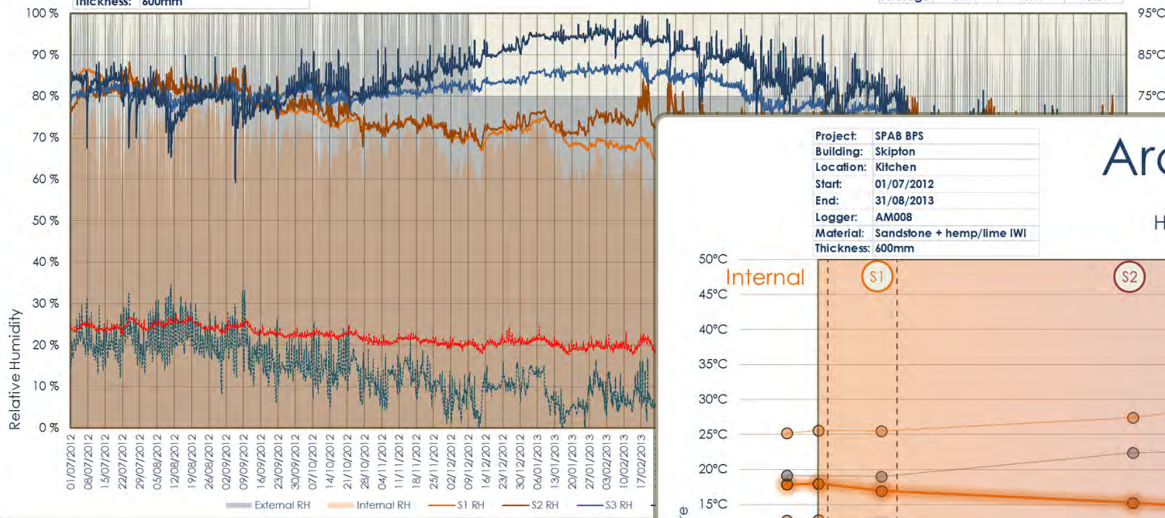


Project: SPAB BPS  
 Building: Skipton  
 Location: Kitchen  
 Start: 01/07/2012  
 End: 31/08/2013  
 Logger: AM008  
 Material: Sandstone + hemp/lime IWI  
 Thickness: 600mm

# ArchiMetrics

Relative Humidity Over Time

RH %	Minimum	Maximum	Average
Internal	38.90	88.20	66.37
S1	59.09	86.66	71.38
S2	64.18	88.28	74.42
S3	62.79	89.27	78.90
S4	50.73	99.39	81.43
External	24.10	100.00	84.05
Average	49.97	91.97	76.09

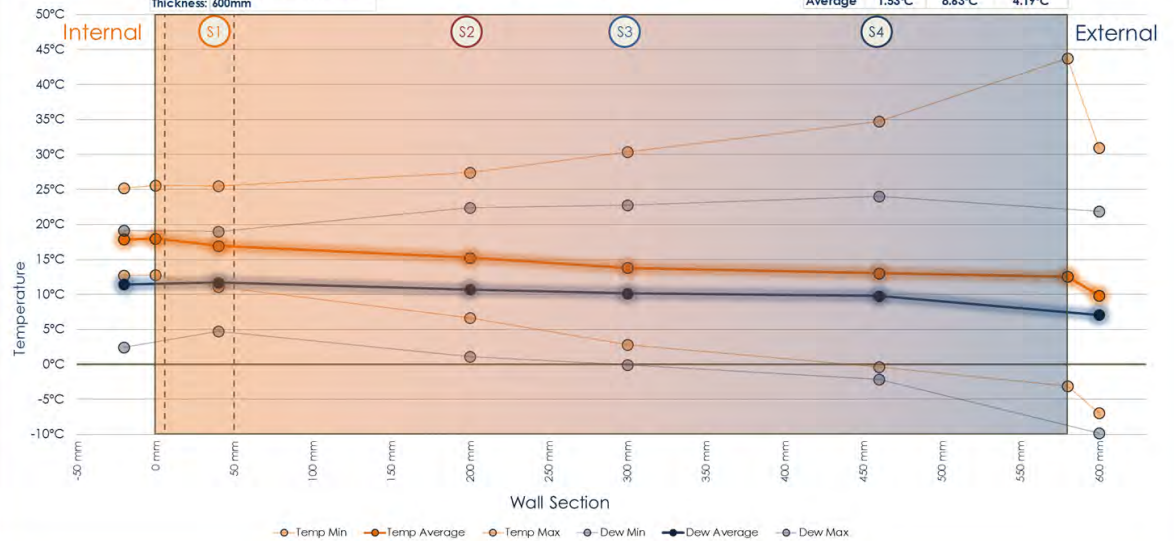


# ArchiMetrics

Hygrothermal section

Project: SPAB BPS  
 Building: Skipton  
 Location: Kitchen  
 Start: 01/07/2012  
 End: 31/08/2013  
 Logger: AM008  
 Material: Sandstone + hemp/lime IWI  
 Thickness: 600mm

	Minimum	Maximum	Average
S1	2.28°C	7.91°C	5.26°C
S2	2.03°C	7.06°C	4.54°C
S3	1.72°C	7.83°C	3.67°C
S4	0.10°C	11.71°C	3.27°C
Average	1.53°C	8.63°C	4.19°C



Dewpoint Margins	Average	4 <sup>th</sup> Node	In situ U-value	% reduction
Uninsulated	4.34°C	4.19°C	1.63	38%
Insulated	2.49°C	3.27°C	1.00	



## Real Retrofits – Cob Wall - EWI



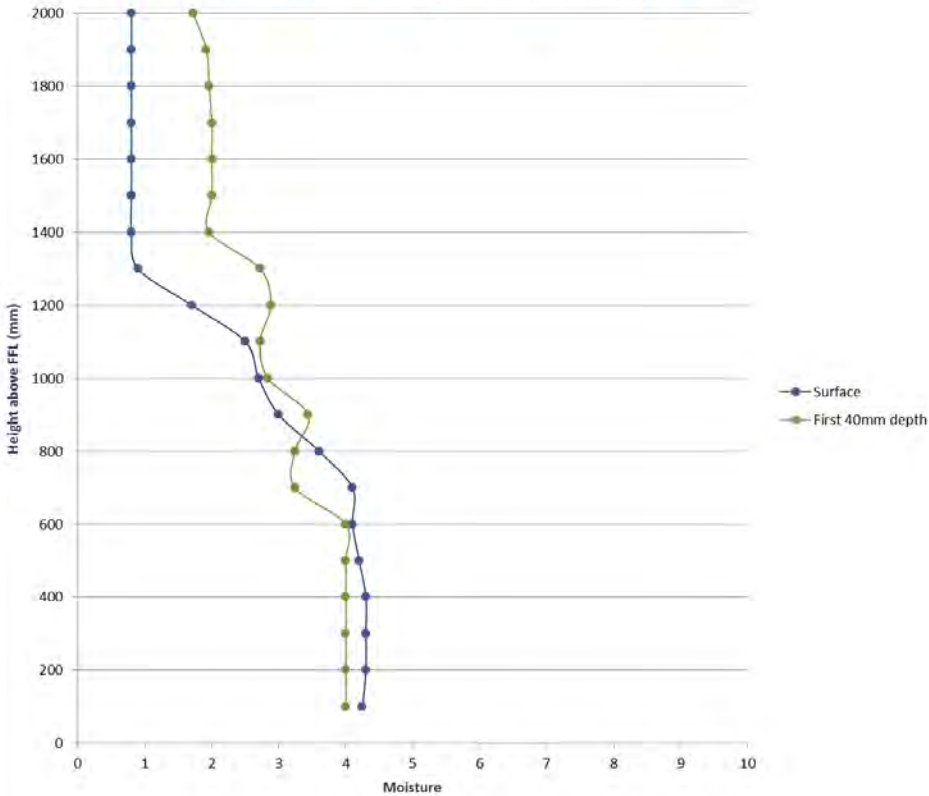
Cob wall - 725 mm - external insulating render (35mm) to replace failing existing cement render.

U-value - Cob	Uninsulated	Insulated	% Reduction
Measured	0.76 W/m <sup>2</sup> K	0.72 W/m <sup>2</sup> K	5%
Calculated	0.93 W/m <sup>2</sup> K	0.60 W/m <sup>2</sup> K	35%
Targets	SAP = 0.8	Part L = 0.30	63%



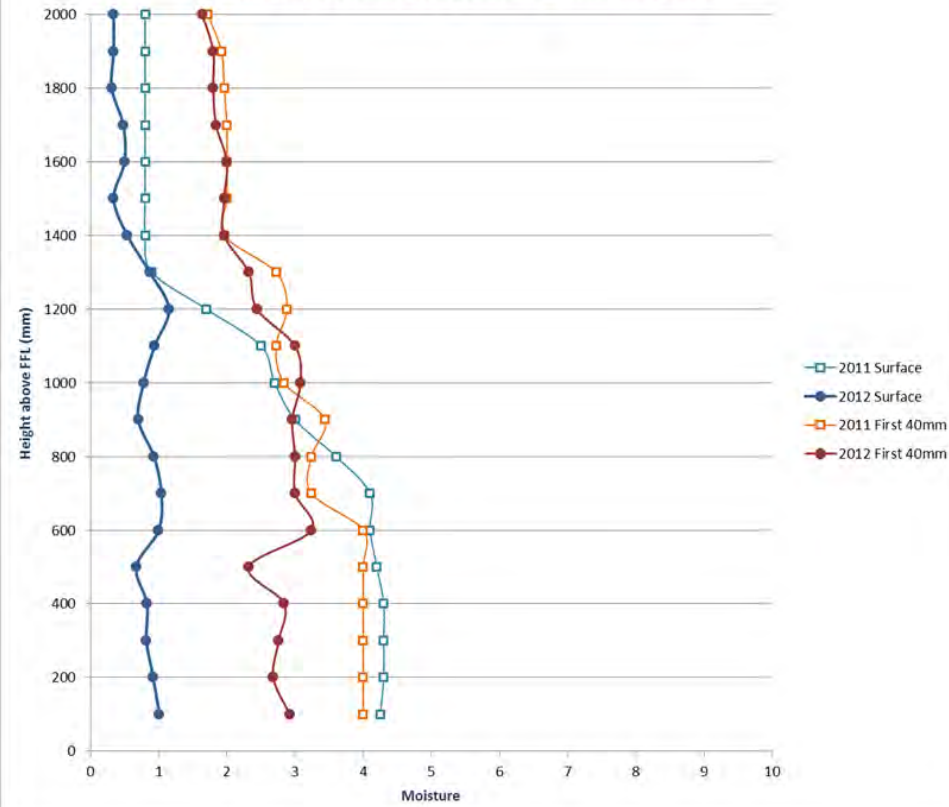
# Surface & Sub surface Moisture

Vertical moisture gradient - Riddlecombe



2011 Uninsulated

Vertical moisture gradient - Riddlecombe

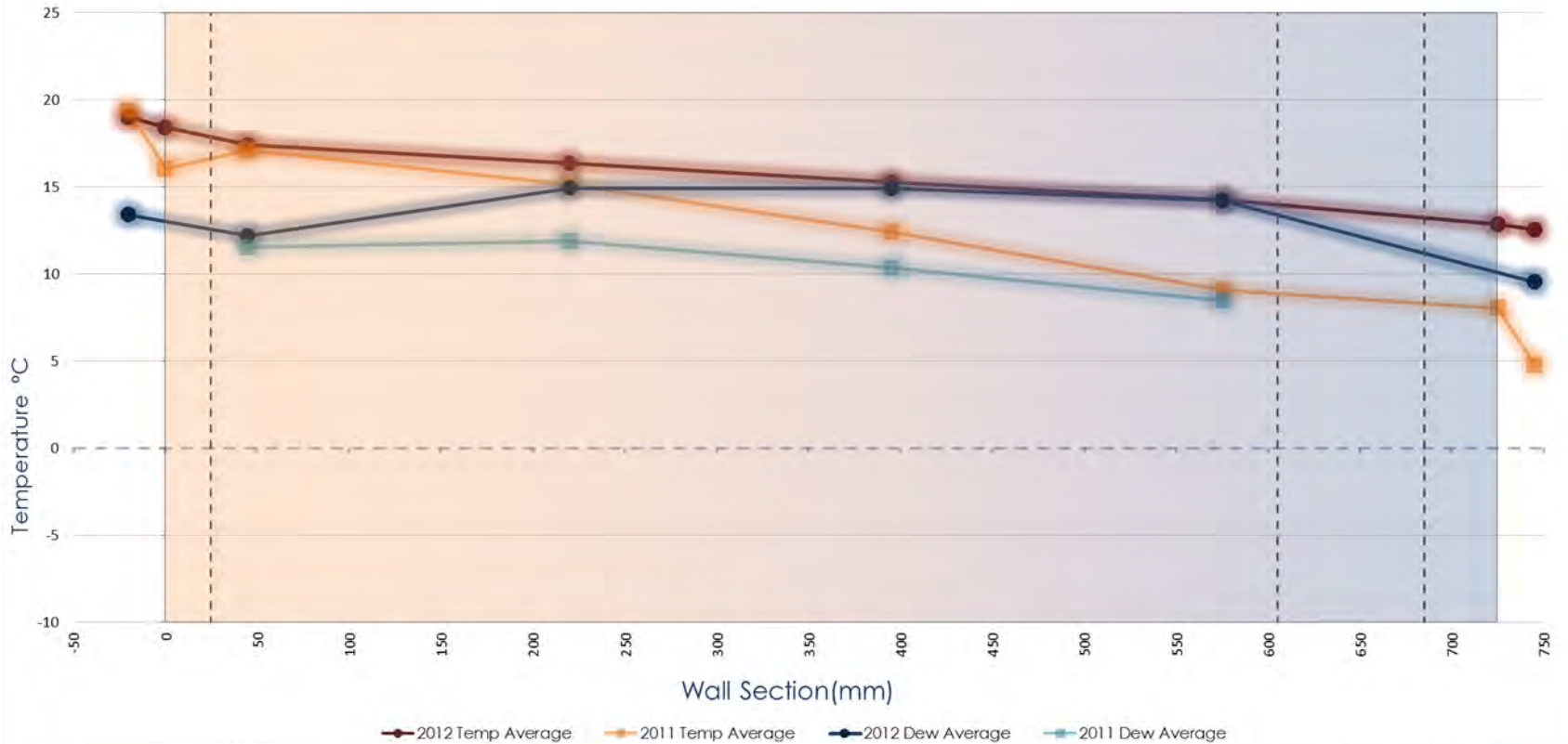


2012 Insulated

Project: SPAB  
 Building: Riddlecombe  
 Location: Office

# ArchiMetrics

## Hygrothermal Section Comparison



2011 Margins	S1	S2	S3	S4	Average	2012 Margins	S1	S2	S3	S4	Average
	5.57	3.22	2.06	0.60	2.86		5.19	1.40	0.35	0.03	1.74

Dewpoint Margins	Average	4 <sup>th</sup> Node
Uninsulated °C	2.86°C	0.60°C
Insulated °C	1.74°C	0.03°C

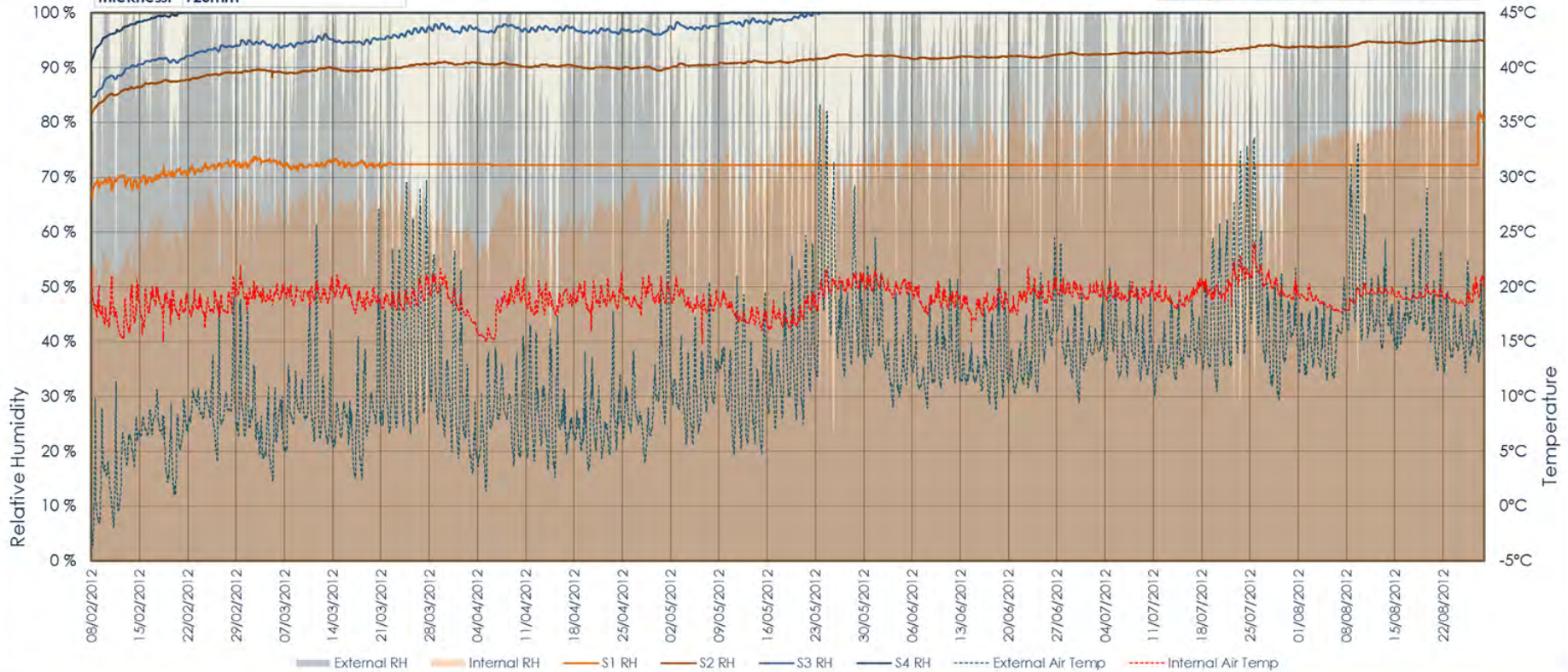


Project:	SPAB BPS
Building:	Riddlecombe
Location:	Office
Start:	08/02/2012
End:	27/08/2012
Logger:	AMIG/10
Material:	Cob with insulating render
Thickness:	725mm

# ArchiMetrics

## Relative Humidity Over Time

RH %	Minimum	Maximum	Average
Internal	39.25	96.71	70.11
S1	66.38	81.87	72.08
S2	81.62	95.06	91.22
S3	84.37	100.00	97.65
S4	90.96	100.00	99.84
External	19.39	100.00	84.45
<b>Average</b>	<b>63.66</b>	<b>95.61</b>	<b>85.89</b>



EWI – Riddlecombe – Cob wall with 50mm insulating lime render externally – lime plaster internally – 715 mm overall.

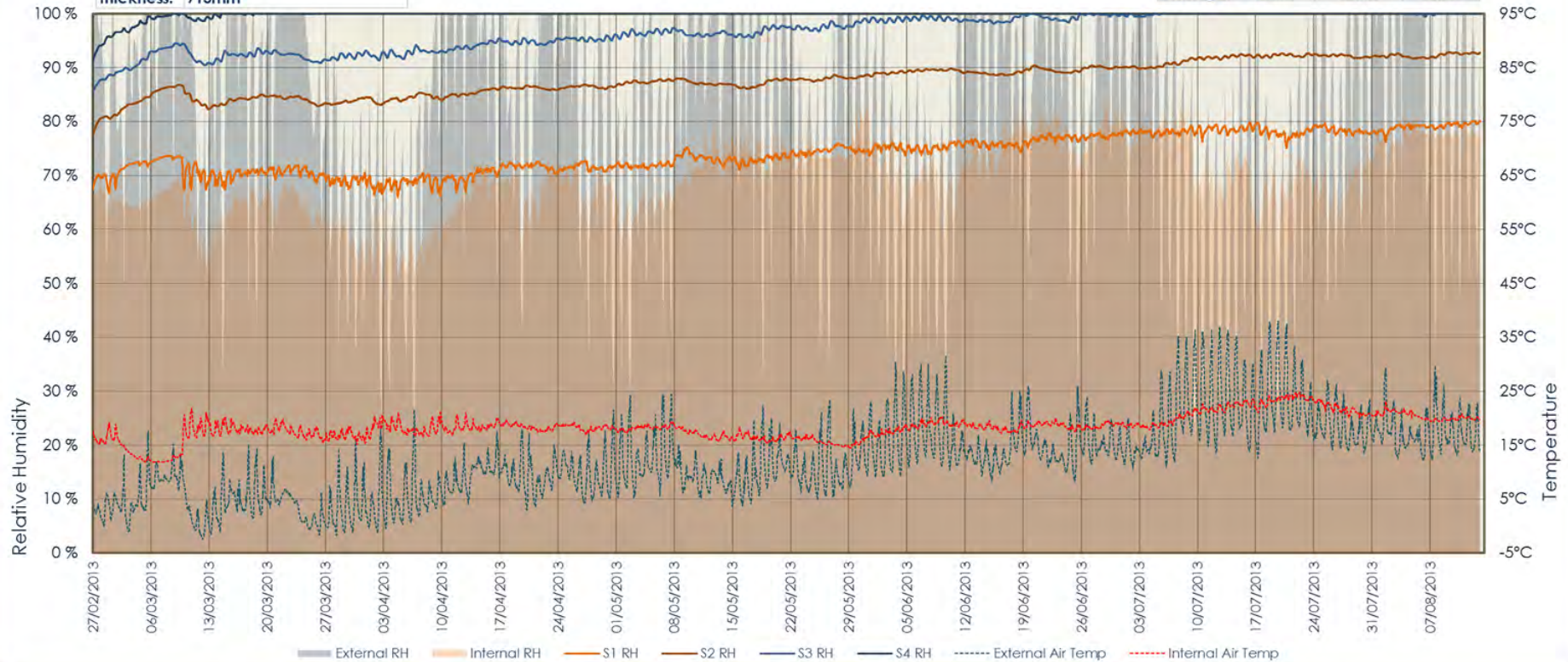


Project:	SPAB BPS
Building:	Riddlecombe
Location:	Office
Start:	27/02/2013
End:	13/08/2013
Logger:	AM007
Material:	Cob with EWI
Thickness:	715mm

# ArchiMetrics

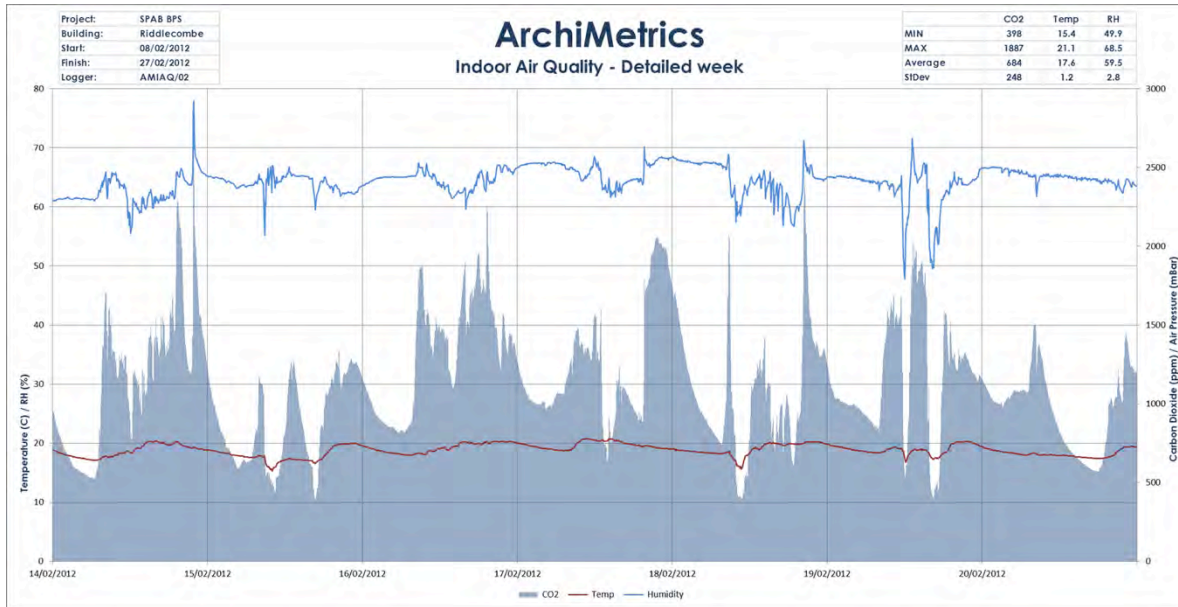
## Relative Humidity Over Time

RH %	Minimum	Maximum	Average
Internal	40.20	91.50	69.78
S1	66.01	80.14	74.08
S2	77.68	92.88	87.87
S3	85.60	100.00	96.57
S4	91.28	100.00	99.82
External	17.70	100.00	81.18
<b>Average</b>	<b>63.08</b>	<b>94.09</b>	<b>84.88</b>



EWI – Riddlecombe – Cob wall with 50mm insulating lime render externally – lime plaster internally – 715 mm overall.





Riddlecombe CO<sub>2</sub>  
 Ave = 950 ppm  
 Max – 2824 ppm

Air Changes	Riddlecombe 2012
Air changes per hour @ 50 Pa	6.9
Air changes per hour @ ambient pressure	<b>0.3</b>

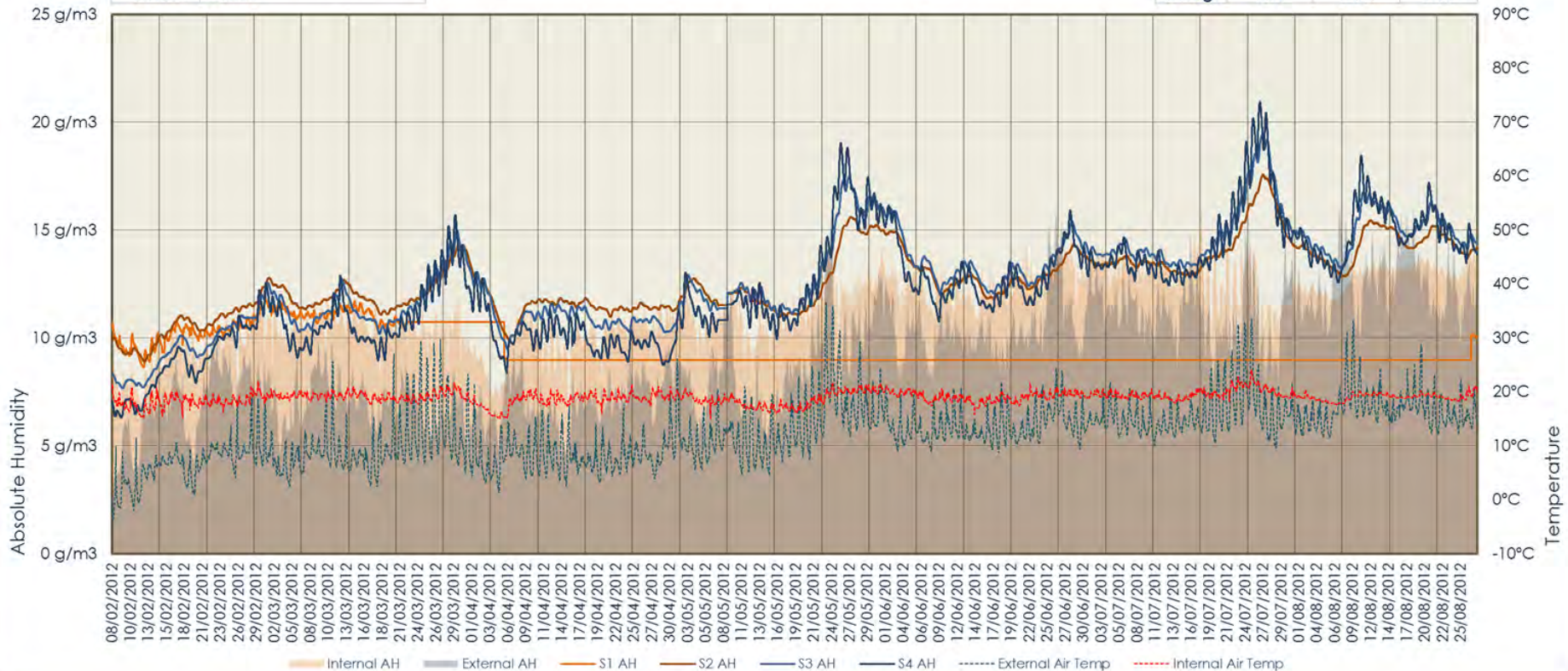


Project:	SPAB BPS
Building:	Riddlecombe
Location:	Office
Start:	08/02/2012
End:	27/08/2012
Logger:	AMIG/10
Material:	Cob with insulating render
Thickness:	725mm

# ArchiMetrics

## Absolute Humidity Over Time

AH g/m <sup>3</sup>	Minimum	Maximum	Average
Internal	6.06	17.03	11.40
S1	8.64	11.99	9.47
S2	8.89	17.58	12.66
S3	7.67	19.40	12.74
S4	6.31	20.95	12.27
External	2.99	16.47	9.23
Average	6.76	17.24	11.29



EWI – Riddlecombe – Cob wall with 50mm insulating lime render externally – lime plaster internally – 715 mm overall.

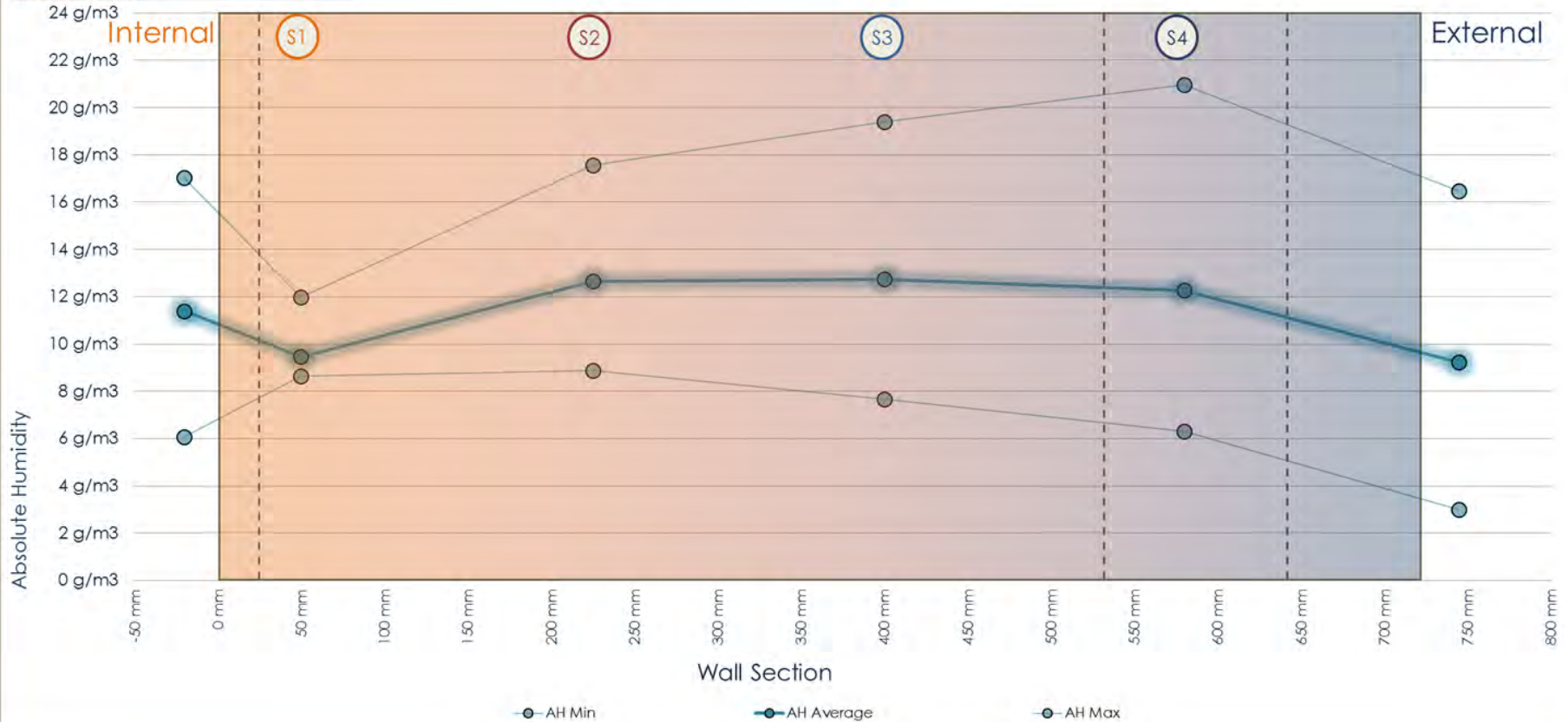


Project: SPAB BPS  
 Building: Riddlecombe  
 Location: Office  
 Start: 08/02/2012  
 End: 27/08/2012  
 Logger: AMIG/10  
 Material: Cob with insulating render  
 Thickness: 725mm

# ArchiMetrics

	Ahi	AH S1	AH S2	AH S3	AH S4	AHe
Minimum	6.06	8.64	8.89	7.67	6.31	2.99
Maximum	17.03	11.99	17.58	19.40	20.95	16.47
Average	11.40	9.47	12.66	12.74	12.27	9.23

## Absolute Humidity Section



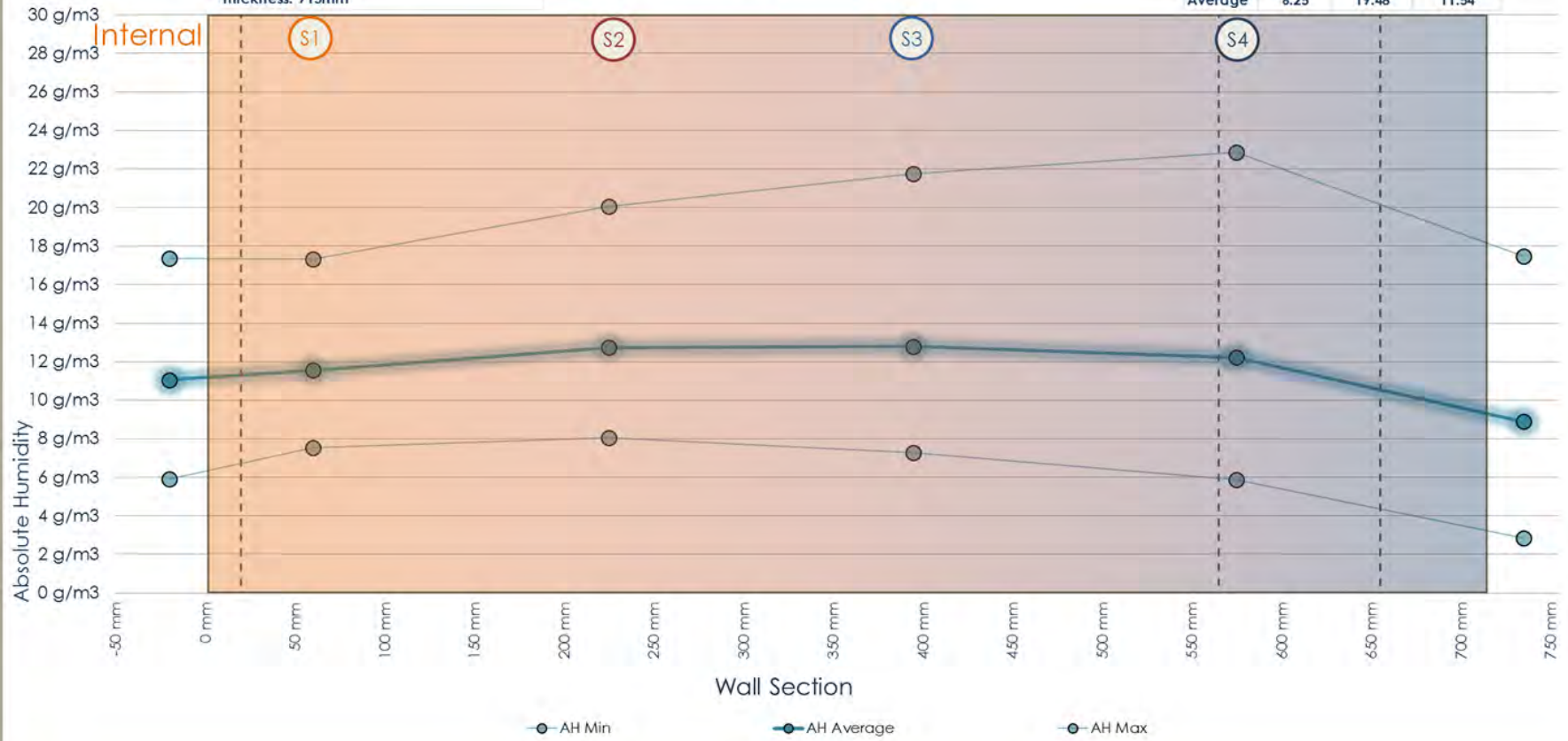
EWI – Riddlecombe – Cob wall with 50mm insulating lime render externally – lime plaster internally – 715 mm overall.

Project: SPAB BPS  
 Building: Riddlecombe  
 Location: Office  
 Start: 27/02/2013  
 End: 13/08/2013  
 Logger: AM007  
 Material: Cob with EWI  
 Thickness: 715mm

# ArchiMetrics

## Absolute Humidity Section

	Absolute Humidity (g/m <sup>3</sup> )		
	Minimum	Maximum	Average
Internal	5.92	17.38	11.06
S1	7.55	17.33	11.56
S2	8.05	20.05	12.73
S3	7.29	21.76	12.80
S4	5.87	22.85	12.22
External	2.84	17.48	8.90
<b>Average</b>	<b>6.25</b>	<b>19.48</b>	<b>11.54</b>



EWI – Riddlecombe – Cob wall with 50mm insulating lime render externally – lime plaster internally – 715 mm overall.



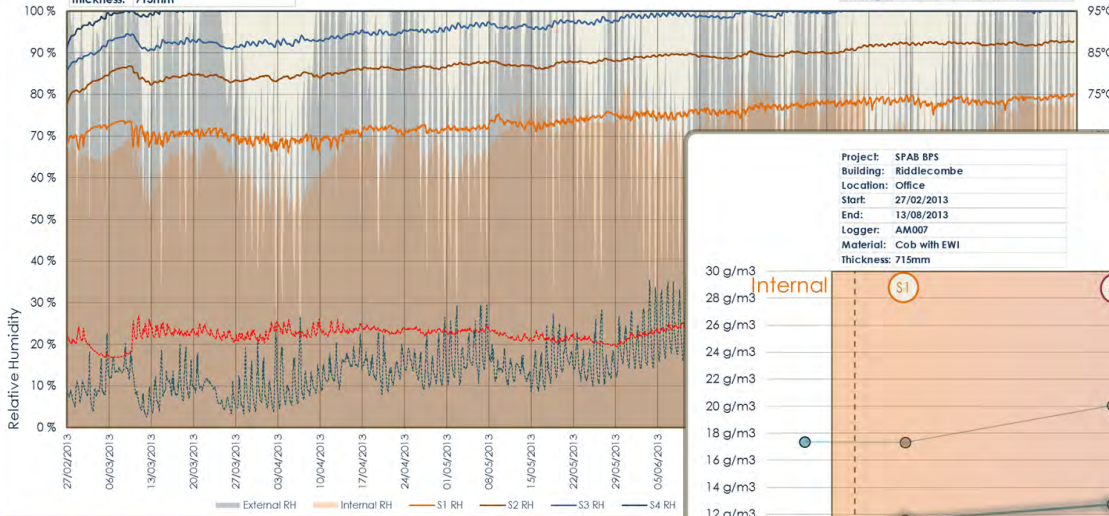


Project: SPAB BPS  
 Building: Riddlecombe  
 Location: Office  
 Start: 27/02/2013  
 End: 13/08/2013  
 Logger: AM007  
 Material: Cob with EWI  
 Thickness: 715mm

# ArchiMetrics

Relative Humidity Over Time

RH %	Minimum	Maximum	Average
Internal	40.20	91.50	69.78
S1	66.01	80.14	74.08
S2	77.68	92.88	87.87
S3	85.60	100.00	96.57
S4	91.28	100.00	99.82
External	17.70	100.00	81.18
Average	63.08	94.09	84.88

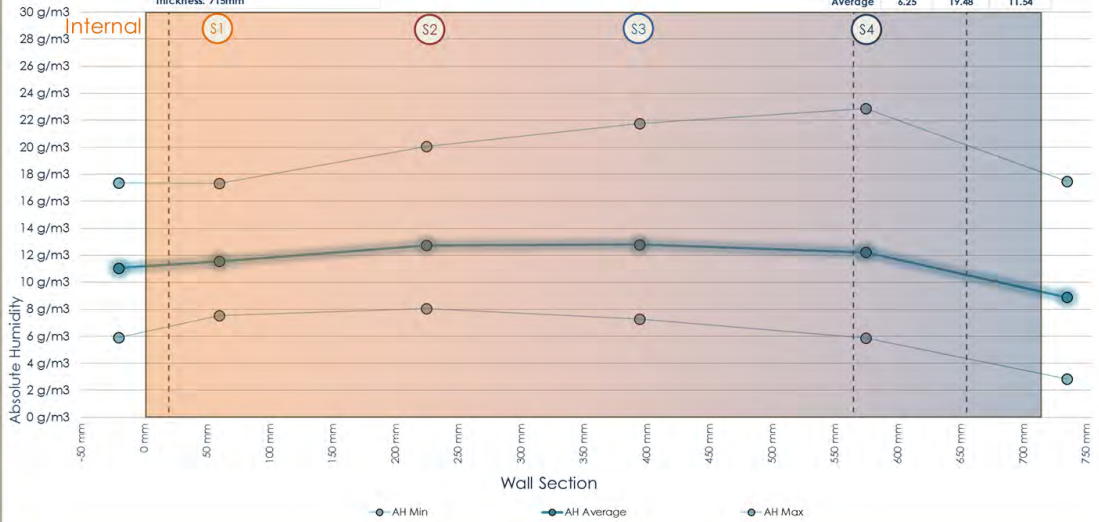


# ArchiMetrics

Absolute Humidity Section

Project: SPAB BPS  
 Building: Riddlecombe  
 Location: Office  
 Start: 27/02/2013  
 End: 13/08/2013  
 Logger: AM007  
 Material: Cob with EWI  
 Thickness: 715mm

	Absolute Humidity (g/m <sup>3</sup> )		
	Minimum	Maximum	Average
Internal	5.92	17.38	11.06
S1	7.55	17.33	11.56
S2	8.05	20.05	12.73
S3	7.29	21.76	12.80
S4	5.87	22.85	12.22
External	2.84	17.48	8.90
Average	6.25	19.48	11.54



Dewpoint Margins	Average	4 <sup>th</sup> Node	In situ U-value	% reduction
Uninsulated	2.86°C	0.60°C	0.76 W/m <sup>2</sup> K	5%
Insulated	1.74°C	0.03°C	0.72 W/m <sup>2</sup> K	



**L1B**

APPROVED DOCUMENT

L1B Conservation of fuel and power in existing dwellings

Coming into effect 1 October 2010

ONLINE VERSION

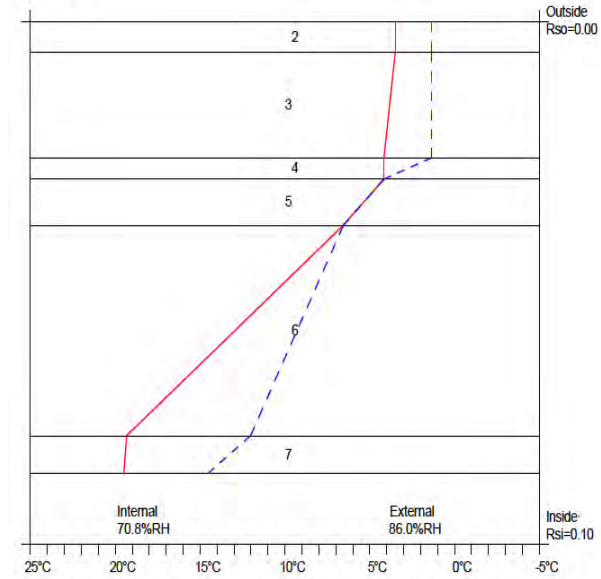
2010 edition

SAP 2009

The Government's Standard Assessment Procedure for Energy Rating of Dwellings



Scale 1:2



Material	Calculated U-value	SAP U-value W/m2K
Granite/Whin	2.9	2.3
Sandstone	2.6	2.0
Brick	2.2	2.1
Cob	1.1	0.8
Timber Frame	2.7	2.5



## Research Reports & Contacts

*The SPAB Research Report 1: The U-value Report*

*The SPAB Research Report 2: The Building Performance Survey 2013*

*The SPAB Research Report 3: The SPAB Hygrothermal Modelling 2012*

<http://www.spab.org.uk/advice/energy-efficiency/>

The SPAB Technical Helpline: 0207 456 0916

*Historic Scotland Technical Paper 10: U-values and Traditional Buildings*

*Sustainable Traditional Buildings Alliance (STBA)*

*Responsible Retrofit of Traditional Buildings: A Report of Existing Research and Guidance with Recommendations* [www.stbauk.org](http://www.stbauk.org)

Moisture Guidance & Guidance Wheel.

This research has been carried out by Cameron Scott & Caroline Rye

[www.archimetrics.co.uk](http://www.archimetrics.co.uk)