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Upgrading of roof space to habitable roof

ROBUST Project: WP 4.2 and 4.3

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ROBUST Project: WP 4.2 and 4.3

Author(s): Israel Adetunji

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This document

1. Overviewed residential building typology in Europe along with typical floor areas and dimensions.
2. Illustrated creation of habitable room in the existing roof along with an indication of possible usable area resulting from roof conversion of various building typologies
3. Discussed typical dimensions and available roof space based on any given roof pitch and span
4. Described parameters for thermal analyses. The thermal analyses were carried out by RWTH and outcome presented elsewhere.

Customer: RFCS
Programme manager: Simon Vaughan

Approved by: Samir Boudjabeur

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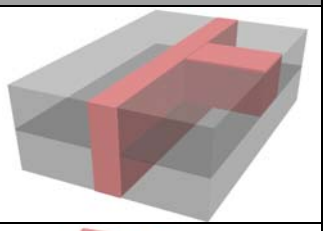
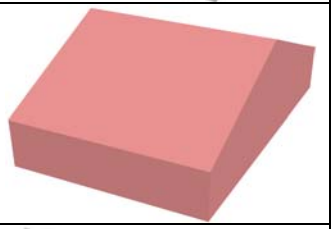
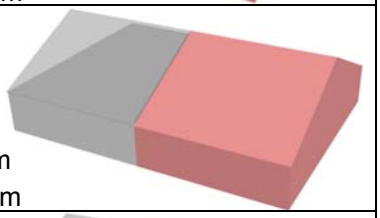
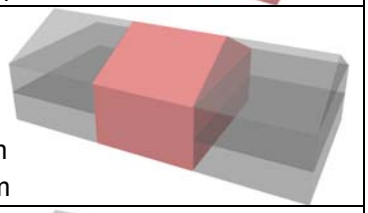
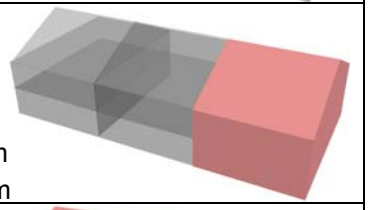
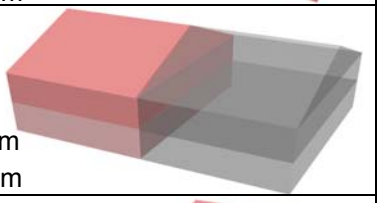
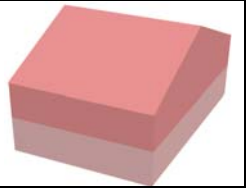
Upgrading of roof space to habitable roof

1. Residential building typology in Europe

This section overviews various residential building typologies in Europe and typical floor area.

Table 1: Building Typology and Typical Floor Area

Dwelling Type	Floor Area[1] (m2)	Sketch
Flat	61	 L = 10 m B = 6.1 m
Detached bungalow	67	 L = 10 m B = 6.7 m
Semi-detached bungalow	64	 L = 10 m B = 6.4 m
Mid-terrace house	79	 L = 5.0 m B = 7.9 m
End-terrace house	79	 L = 5.0 m B = 7.9 m
Semi-detached house	89	 L = 6.0 m B = 7.4 m
Detached house	104	 L = 6.5 m B = 8.0 m

[1]Data Source for typical floor areas: *CE189 (2006) "Refurbishing dwellings – a summary of best practice", Carbon Trust, UK*

2. Creation of habitable roof

Table 2 collates various dwelling types with associated typical floor area and possible usable area resulting from loft conversion.

Figures 1, 2 and 3 illustrate typical existing roof space and room in the roof conversion.

Table 2: Floor areas for typical dwelling types and usable room-in roof area

Dwelling Type	**Floor Area[1] (m2)**	**Assumption**	**Usable roof Area (m2)**
Flat	61		
Detached bungalow	67	Existing roof pitch is generally steep and very spacious. Usage area after loft conversion can be up to 70% of the existing dwelling area	47
Semi-detached bungalow	64	Similar to the above	45
Mid-terrace house	79	Typically pitched @ 35 – 40^{o}. Usage area after conversion of 40% is assumed as the dwelling is situated at the middle of the building.	32
End-terrace house	79	As above. 40% for gable roof shape and 30% usage area for hipped roof is assumed as one side of the roof is hipped.	(32) 24
Semi-detached house	89	As above but 30% usage area is assumed as one side of the roof is hipped	27
Detached house	104	Existing roof shapes are either hipped roof or gable roof and typically pitched @ 35 – 45^{o}. Usage area after conversion of 40% is assumed.	42

[1]Data Source for typical floor areas: *CE189 (2006) "Refurbishing dwellings – a summary of best practice", Carbon Trust, UK*

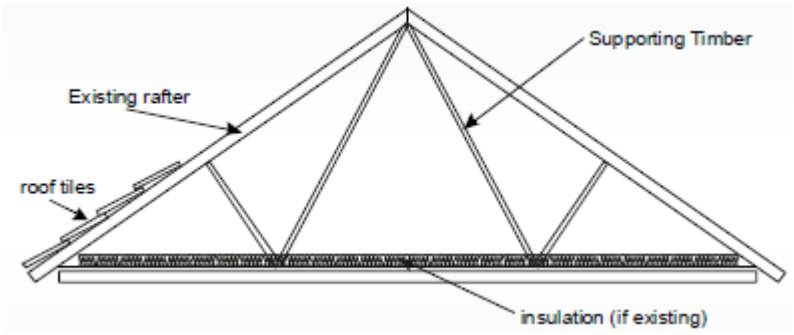


Figure 1: Typical existing roof space

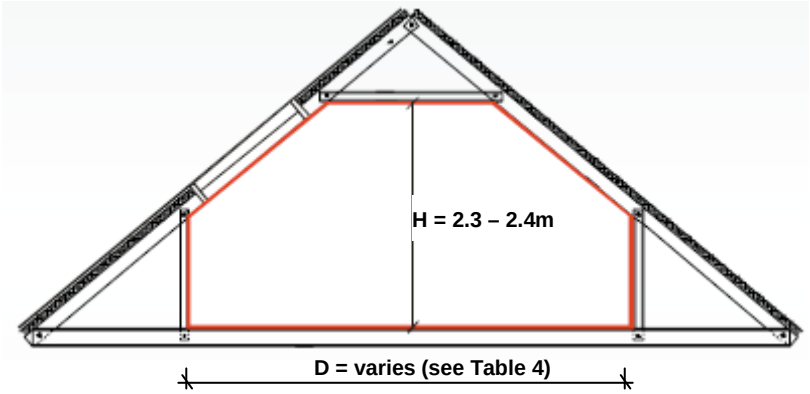


Figure 2: Typical room in the roof conversion

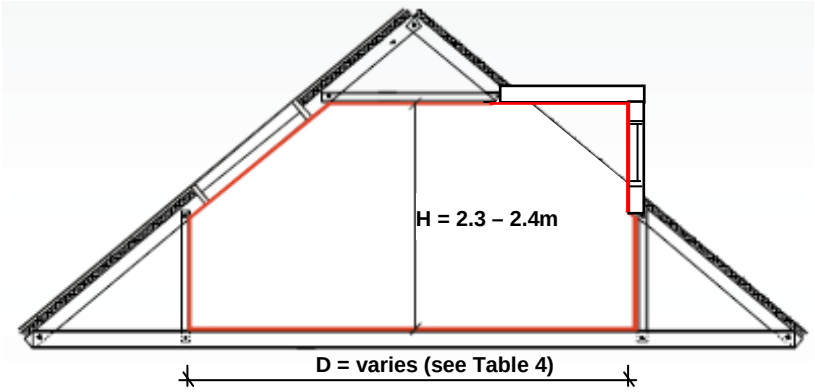


Figure 3: Typical room in the roof conversion with dormer window

3. Dimensional planning for room in the roof

In the UK, there is no regulatory minimum headroom requirement for loft conversion. However, typical practices demands headroom (H) between 2.3 – 2.4m. Typically, dormer windows are used for shallow pitched roof to increase the width of the usable space as shown in Figure 3 above.

Generally, the available headroom height (defined as the height from the ridge at the apex of the roof to the floor joists). The available headroom is a critical parameter to any loft conversion. Therefore, for any given roof pitch and span, the maximum available headroom can be mathematically derived. Based on real life experience of loft conversion, a simple excel spreadsheet has been written to derive key dimensions for roof space. Further detail of this analysis is included in the Appendix. Table 3 and 4 together with Figure 4 and 5 collate available headroom and useable spaces.

As can be seen from the Table 3 below, a roof with 35° pitch needs a minimum span of 8.0m to reach enough height at the ridge to make it convertible, whereas it can be achieved with a span of 6.0m with roof pitch of 45°.

Table 3: Available Headroom for Loft Conversion*

Pitch \ Span	Available Headroom (A_h) m							
	5	6	7	8	9	10	11	12
30°	1.44	1.73	2.02	2.31	2.60	2.89	3.18	3.46
35°	1.75	2.10	2.45	2.80	3.15	3.50	3.85	4.20
40°	2.10	2.52	2.94	3.36	3.78	4.20	4.62	5.03
45°	2.50	3.00	3.50	4.00	4.50	5.00	5.50	6.00

*Note

- Spans are measured between the wall plates.
- Available Height (A_h) is the maximum ceiling heights available beneath the ridge (apex of the roof)
- Approximately 400mm needs to be allowed for floor joists, ridge beam and finishings.
- No allowance has been made for raised collar ties

Not suitable as available headroom is limited

Possible But headroom ≤ 2.3 m after deduction of 400mm for floor joists, ridge beam and finishings

Suitable as headroom ≥ 2.3 m

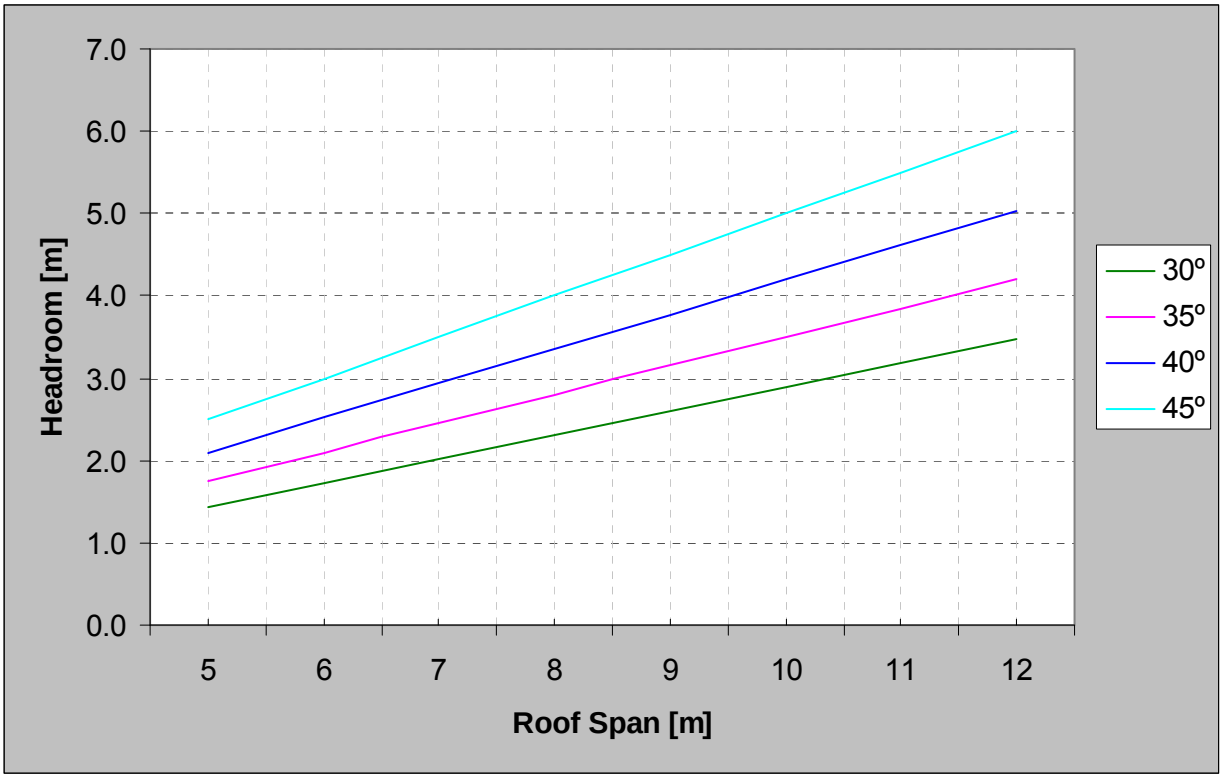


Figure 4: Roof Span Vs Available Headroom

Table 4: Available Room Depth for Loft Conversion

Pitch / Span	Available Room depth (d) m							
	5	6	7	8	9	10	11	12
30°	1.88	2.88	3.36	4.36	4.84	5.84	6.32	7.32
35°	2.43	3.43	4.0	5.00	5.57	6.57	7.14	8.14
40°	2.85	3.85	4.50	5.50	6.14	7.14	7.78	8.78
45°	3.20	4.20	4.90	5.90	6.60	7.60	8.30	9.30

Not suitable as available headroom is limited

Possible But headroom ≤ 2.3 m after deduction of 400mm for floor joists, ridge beam and finishings

Suitable as headroom ≥ 2.3 m

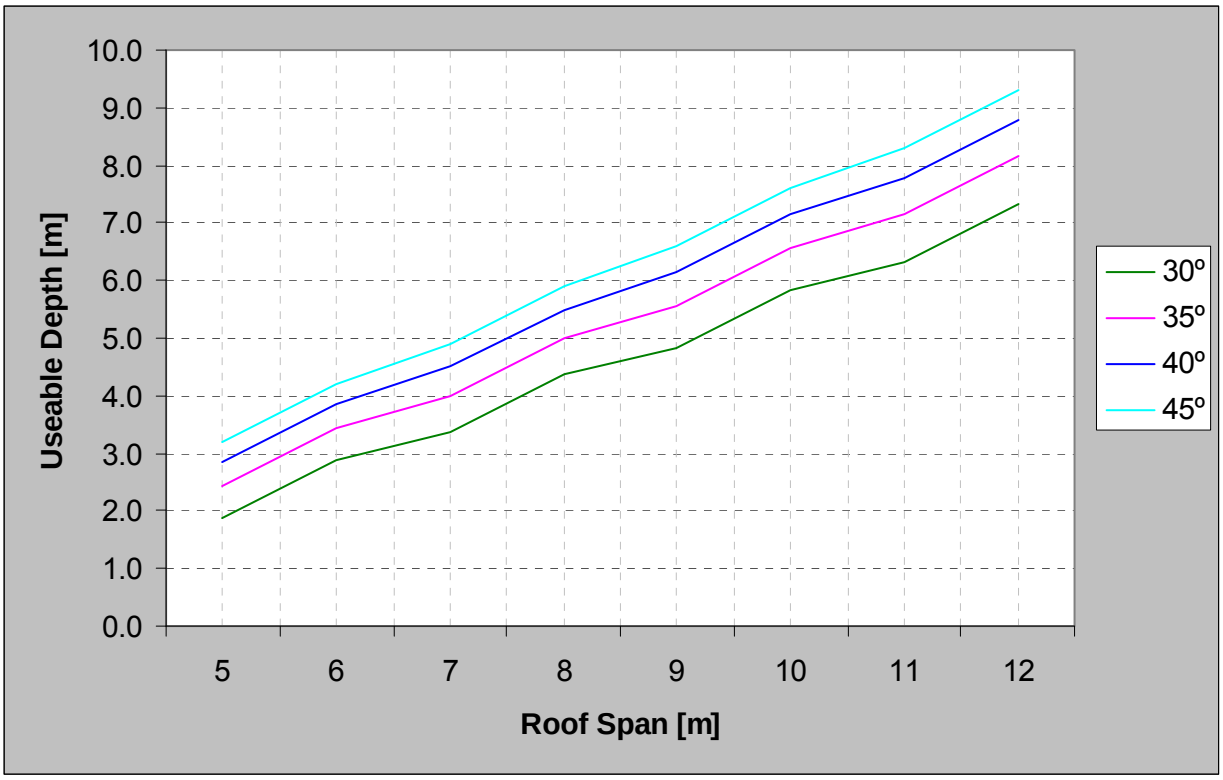


Figure 5: Roof Span Vs Useable Depth

4. Parameter for Thermal Analysis

This section describes the parameter for thermal simulation for the whole building (before and after creation of habitable). Table 5 collates the recipe for thermal simulation and Table 6 provides an overview of the proposed parametric studies.

Table 5: Recipe for thermal simulation

Element	Description	Base Case (before loft conversion)	Good practice (with loft conversion)	Best practice (with loft conversion)
		U-value (W/m^2k)		
Pitched roof	Uninsulated timber roof	1.9	0.20	0.15
Loft floor	Timber joists, minimal insulation	0.85	0.25	0.2
External wall	Uninsulated solid block	2.1	0.30	0.15
First floor	Uninsulated timber floor	3.0	0.25	0.2
Ground floor	Uninsulated solid floor	0.45 – 0.7	0.25	0.2
Window	Partly double glazed	3.5	2.0	0.7
Window area (%)	Wooden frame window	12 -15%	12 -15%	12 -15%
Airtightness	$m^3/(hm^2)$ @50P	15	10	3

Table 6: Proposed Parametric Studies

	Simulation Stages	Building				Zones			Direction		Window	
		Detached	Semi- Detch	Mid-Terrace	Flat	Helsinki	London	Berlin	NS	EW	12%	15%
1	Carry out simulation for the whole building using base case scenario	*	*	*	*	x	x	x	*	*	*	*
2	Re-run simulation for the whole building by adding insulation to loft floor only	*	*	*	*	x	x	x	*	*	*	*
3	Re-run simulation for the whole building changing the parameters to reflect room-in-roof elements (Good practice – roof, loft floor, room in the roof wall and windows)	*	*	*	*	x	x	x	*	*	*	*
4	Re-run simulation for the whole building changing the parameters to reflect roof in the roof elements (Best practice – roof, loft floor, room in the roof wall and windows)	*	*	*	*	x	x	x	*	*	*	*
5	Re-run simulation assuming that the whole building along with the room in the roof is renovated to Good practice	*	*	*	*	x	x	x	*	*	*	*
6	Re-run simulation assuming that the whole building along with the room in the is renovated to Best practice	*	*	*	*	x	x	x	*	*	*	*

*** – Number of analyses to be agreed with RWTH**

Appendix A: Dimensional Planning for Room-in-Roof

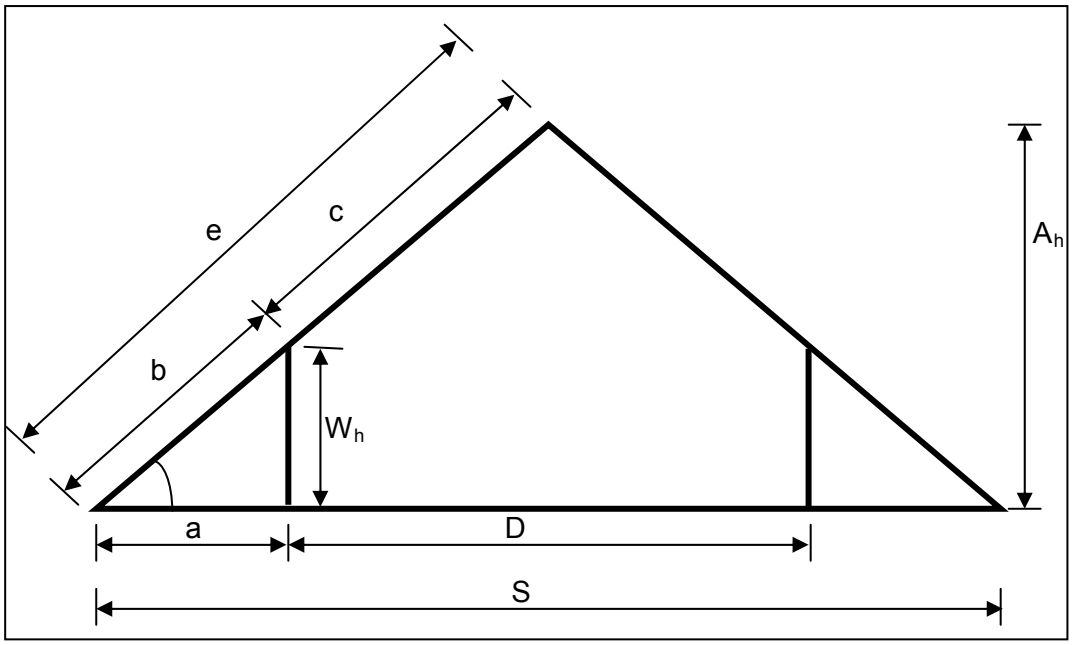


Figure 6: Sketch of Roof Space

Table 7: Spreadsheet Input and Output for the roof dimensions

Roof span [S]	5	6	7	8	9	10	11	12
Roof pitch [°]	30							
Wall height [W_h]	0.9	0.9	1.05	1.05	1.2	1.2	1.35	1.35
Wall position [a]	1.56	1.56	1.82	1.82	2.08	2.08	2.34	2.34
Available headroom [A_h]	1.44	1.73	2.02	2.31	2.60	2.89	3.18	3.46
Room depth [D]	1.88	2.88	3.36	4.36	4.84	5.84	6.32	7.32
Roof length [e]	2.89	3.46	4.04	4.62	5.20	5.77	6.35	6.93
Upto window [b]	1.80	1.80	2.10	2.10	2.40	2.40	2.70	2.70
Max window [c]	1.09	1.66	1.94	2.52	2.80	3.37	3.65	4.23

Roof span [S]	5	6	7	8	9	10	11	12
Roof pitch [°]	35							
Wall height [W_h]	0.9	0.9	1.05	1.05	1.2	1.2	1.35	1.35
Wall position [a]	1.29	1.29	1.50	1.50	1.71	1.71	1.93	1.93
Available headroom [A_h]	1.75	2.10	2.45	2.80	3.15	3.50	3.85	4.20
Room depth [D]	2.43	3.43	4.00	5.00	5.57	6.57	7.14	8.14
Roof length [e]	3.05	3.66	4.27	4.88	5.49	6.10	6.71	7.32
Upto window [b]	1.57	1.57	1.83	1.83	2.09	2.09	2.35	2.35
Max window [c]	1.48	2.09	2.44	3.05	3.40	4.01	4.36	4.97

Roof span [S]	5	6	7	8	9	10	11	12
Roof pitch [°]	40							
Wall height [W_h]	0.9	0.9	1.05	1.05	1.2	1.2	1.35	1.35
Wall position [a]	1.07	1.07	1.25	1.25	1.43	1.43	1.61	1.61
Available headroom [A_h]	2.10	2.52	2.94	3.36	3.78	4.20	4.62	5.03
Room depth [D]	2.85	3.85	4.50	5.50	6.14	7.14	7.78	8.78
Roof length [e]	3.26	3.92	4.57	5.22	5.87	6.53	7.18	7.83
Upto window [b]	1.40	1.40	1.63	1.63	1.87	1.87	2.10	2.10
Max window [c]	1.86	2.52	2.94	3.59	4.01	4.66	5.08	5.73

Roof span [S]	5	6	7	8	9	10	11	12
Roof pitch [°]	45							
Wall height [W_h]	0.9	0.9	1.05	1.05	1.2	1.2	1.35	1.35
Wall position [a]	0.90	0.90	1.05	1.05	1.20	1.20	1.35	1.35
Available headroom [A_h]	2.50	3.00	3.50	4.00	4.50	5.00	5.50	6.00
Room depth [D]	3.20	4.20	4.90	5.90	6.60	7.60	8.30	9.30
Roof length [e]	3.54	4.24	4.95	5.66	6.36	7.07	7.78	8.49
Upto window [b]	1.27	1.27	1.48	1.48	1.70	1.70	1.91	1.91
Max window [c]	2.26	2.97	3.46	4.17	4.67	5.37	5.87	6.58