



The
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The Measurement of the Acoustical Performance of Green Roofs

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1. Introduction

In this report, the guidelines of the measurement, including the measurement box design rules and the testing configurations, are given and followed by two detailed design plans of the measurement box. The report is end with the presentation of the measuring procedures, including the list of the measuring instruments and the measuring method.

2. Guidelines of the measurement

To obtain the sound insulation capacity of green roofs, the sounds transmitting through the walls should be perfectly blocked, which means the walls must be designed to reduce the sounds by a value higher than that insulated by green roofs. Two design plans of the walls, ensuring the sound insulation capacity as larger as possible, will be presented in the next section of this report.

It has been reported by some previous researchers that the green roofs have an 8~18 dB extra sound insulation capacity, up to the configurations ^[1]. The extensive green roof will be selected as the research object and it will be tested with 8 configurations, which are listed in Table 2.1. These 8 configurations are essential tests and could be extended to more configurations. The sound insulation capacity of a conventional roof (without green roof) can be obtained by comparing the results tested with Conf_1 and Conf_2. The sound insulation tested with Conf_3 is the minimum one. The effect of the wet-dry growing medium can be obtained by comparing the results tested with Conf_4 and Conf_5. The effect of the drainage layer with or without water can be obtained by comparing the results tested with Conf_5 and Conf_6. The effect of the thickness of the growing medium can be obtained by comparing the results tested with Conf_6 and Conf_7. It is noticed that only Conf_8 has vegetation and the effect of the vegetation layer can be obtained by comparing the results tested with Conf_7 and Conf_8. The extra sound insulation due to green roofs (from Conf_3 to Conf_8) can be obtained by comparing with the result tested with Conf_2.

Table 2.1 The configurations of under test green roofs

Number	Drainage Layer(Water)		Growing Medium		
	With	Without	Thickness(mm)	Wet	Dry
Conf_1	Without Roof Top				
Conf_2	Conventional Roof (without Green Roof)				
Conf_3		√	50		√
Conf_4		√	75		√
Conf_5		√	75	√	
Conf_6	√		75	√	
Conf_7	√		100	√	
Conf_8	√		100	wet and with vegetation	

Note: The type of the drainage layer used here is Floradrain FD 25-E, which is 25mm thick and can store water at a maximum of 3 liters/m².

Only Conf_8 has vegetation.

3. The wall design

The wall is designed to meet the demand of the great sound insulation capacity. The structure could be explained as box-in-box, as shown in Fig. 3.1. The inner box consists of five walls, without roof top. Each wall of the inner box consists of three timber layers spaced with mineral wool. The structure of the inner box wall and the junction treatment between walls are show in Fig. 3.2. About half of the gap between the timber layers is filled with mineral wool. The interior surfaces of the inner box should be covered by thin mineral wool sheets.

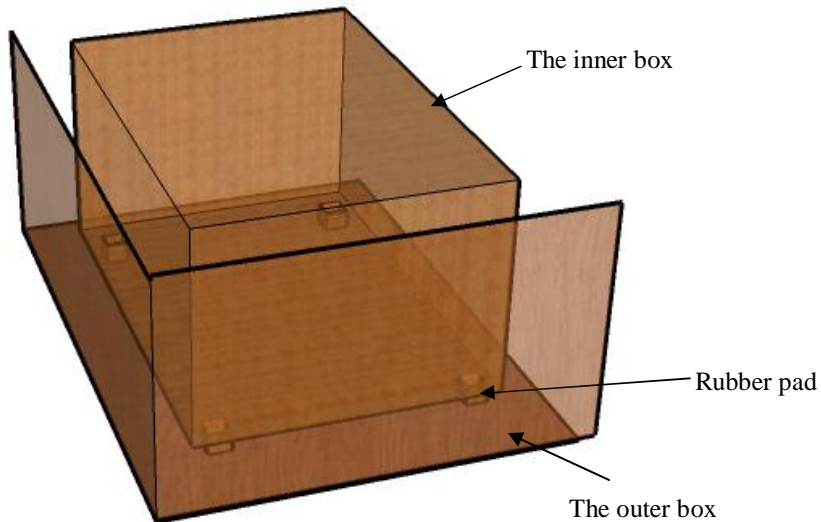


Fig. 3.1 The box-in-box structure used for test

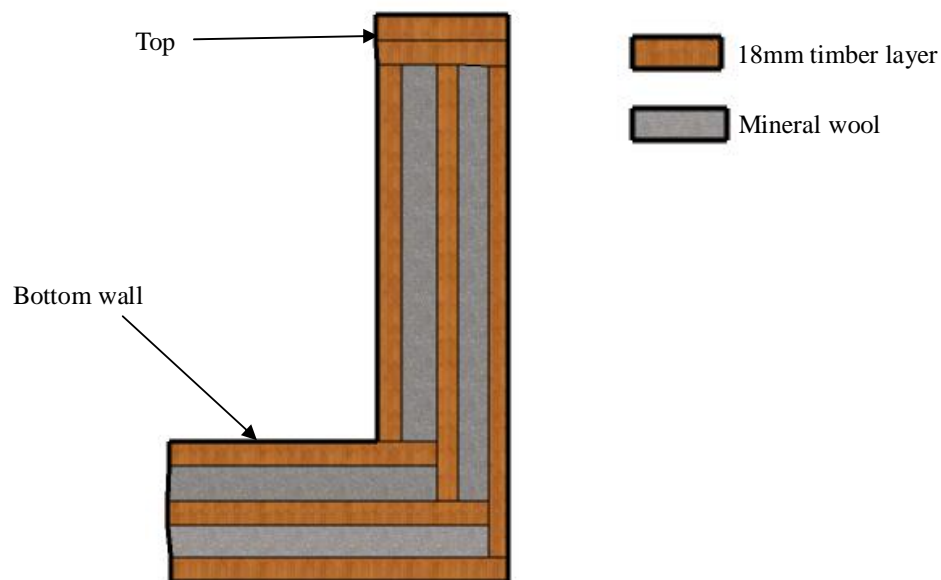


Fig.3.2 The construction of the wall of the inner box

The inner box is encased in the one timber layer outer box. The inner box is held by four (or more) rubber pads at the bottom wall. Half of the gap between the inner box and the outer box is also filled with mineral wool. In Fig. 3.3 shows the construction details.

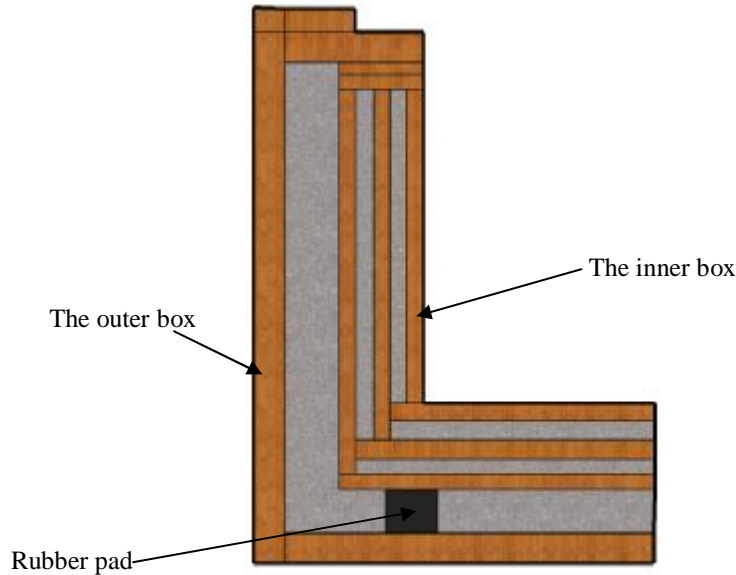


Fig. 3.3 The construction of the outer box

The interior dimensions of the inner box are supposed to be $900\text{mm} \times 800\text{mm} \times 700\text{mm}$ (*length* \times *width* \times *height*). The boards used are 18mm thick. The spaces between the timber layers of the inner box are 20mm wide and those between the inner box and the outer box are 35mm wide, leading to a $18 \times 4 + 20 \times 2 + 35 = 147\text{mm}$ thick of the wall of the box-in-box structure. With such a configuration, the sound insulation capacity of the wall should be at least 60 dB at 600 Hz.

For other purpose, a window should be installed on one side wall of the inner box, as shown in Fig. 3.4. It can be designed as the following procedures.

- 1) Cut a rectangle hatch, say $350\text{mm} \times 350\text{mm}$, on the inside timber layer;
- 2) Cut a coaxial $400\text{mm} \times 400\text{mm}$ rectangle hatch on the middle and the outside timber layers;
- 3) For the green roof test, a $400\text{mm} \times 400\text{mm}$ block, the thickness of which equals to the depth of the $400\text{mm} \times 400\text{mm}$ hatch, is placed into the hatch of the outside timber layer;
- 4) For the active noise control window test, a $400\text{mm} \times 400\text{mm}$ window, the thickness of which equals to the depth of the $400\text{mm} \times 400\text{mm}$ hatch, is placed into the hatch of the outside timber layer.

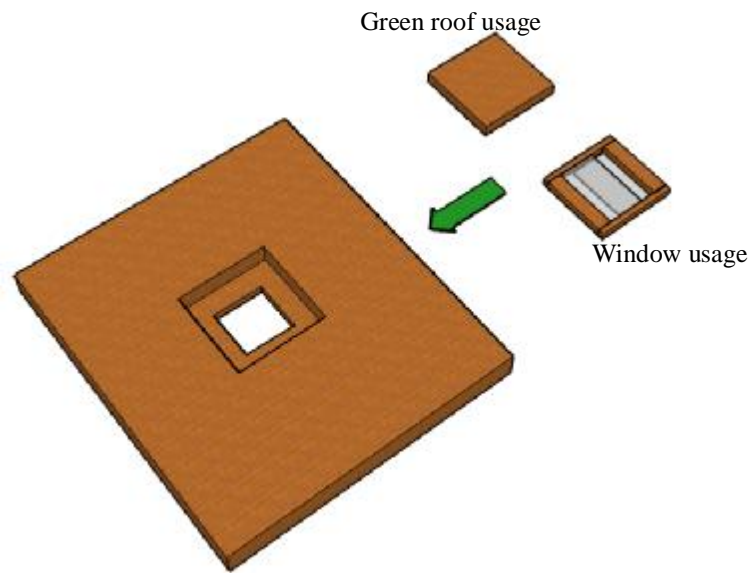


Fig. 3.4 The design of the window system

4. Measuring procedures

The measurement will be carried out in the semi-anechoic chamber at the University of Sheffield. The length and the width of the chamber are all about 3.5m. A 01 dB Symphonie system, with one output channel and two input channels, is used for testing. An omni-directional noise source will be used. Two microphones will be placed inside the box to measure the sound pressure level (SPL). The placement is shown in Fig. 4.1. The microphone cables will cross through a hole on the box, which will be sealed during the test. The measuring instruments are listed in Table 4.1.

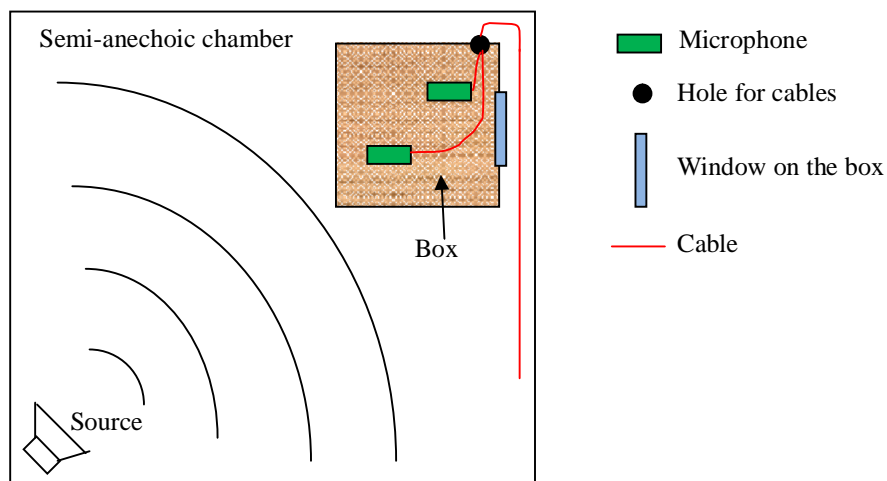


Fig. 4.1 The sketch of the measurement configurations

Table 4.1 The measuring instruments

Label	Instrument	Quantity
Measuring system	01 dB Symphonie system	1
Noise Source	Omni-directional source	1
Microphone	Measuring microphone	2
Calibrator	Acoustic calibrator	1
Amplifier	Power amplifier	1
Cable	Cables for microphones, source and amplifier	N/A

First, the source is turned off and the background noise will be measured. Then turn on the source. The output power of the source should satisfy that the SPL at the microphones, tested with Conf_1, i.e. no roof top, are at least 60 dB higher than the background SPL. Finally, carry out the test listed in Table 2.1 in turn. The 1/3 octave band SPL and the overall SPL will be analyzed. The SPL of each configuration is obtained by averaging the values of the two microphones.