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Acoustic insulation capacity of Vertical Greenery Systems for buildings

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ABSTRACT

Vertical Greenery Systems (VGS) are promising contemporary Green Infrastructure which contribute to the provision of several ecosystem services both at building and urban scales. Among others, the building acoustic insulation and the urban noise reduction could be considered. Traditionally vegetation has been used to acoustically insulate urban areas, especially from the traffic noise. Now, with the introduction of vegetation in buildings, through the VGS, it is necessary to provide experimental data on its operation as acoustic insulation tool in the built environment. In this study the acoustic insulation capacity of two VGS was conducted through *in situ* measurements according to the UNE-EN ISO 140-5 standard. From the results, it was observed that a thin layer of vegetation (20–30 cm) was able to provide an increase in the sound insulation of 1 dB for traffic noise (in both cases, Green Wall and Green Facade), and an insulation increase between 2 dB (Green Wall) and 3 dB (Green Facade) for a pink noise. In addition to the vegetation contribution to sound insulation, the influence of other factors such as the mass factor (thickness, density and composition of the substrate layer) and type of modular unit of cultivation, the impenetrability (sealing joints between modules) and structural insulation (support structure) must be taken into account for further studies.

1. Introduction

The acoustical environment in and around buildings is influenced by numerous interrelated and interdependent factors associated with the building planning – design – construction process. The architect, the engineer, the building technologist, and the constructor all play a part in the control of the acoustical environment. With some fundamental understanding of basic acoustical principles, how materials and structures control the sound, many problems can be avoided altogether or, at least, solved in the early stages of the project at greatly reduced cost. "Corrective" measures are inevitably more costly after the building is finished and occupied [1].

On the other hand, Green Infrastructure (GI) is a successfully tested tool for providing ecological, economic and social benefits through natural solutions for the built environment. Compared to single-purpose grey infrastructure, GI has many benefits, offering sometimes an alternative or being complementary to standard grey solutions. Generally, GI could be defined as a strategically planned network of natural and semi-natural areas with other environmental features designed and managed to deliver a wide range of ecosystem services. It incorporates green spaces (or blue if aquatic ecosystems are concerned) and other physical features in terrestrial (including coastal) and marine areas. On land, GI is present both in rural and urban settings [2]. Among the multiple eco-system services provided by GI in the built environment, such as runoff control, energy savings, support to biodiversity, roof materials protection, etc., it is said that some acoustic insulation at building scale whilst also some city noise reduction at urban scale are provided [3].

The types of physical features that contribute to GI are diverse, specific to each location or place and very scale-dependent. On the local scale, biodiversity-rich parks, gardens, green roofs and green walls, ponds, streams, woods, hedgerows, meadows, restored brownfield sites and coastal sand-dunes can all contribute to GI if they deliver multiple ecosystem services. Between those GI

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features, Vertical Greenery Systems (VGS) and Green Roofs for buildings are promising contemporary construction systems which contribute to the provision of ecosystem services both at building and urban scales [3].

Some authors highlight the contribution of VGS and green roofs on the improvement of urban environment by means of the reduction of noise. Thus, while hard surfaces of urban areas tend to reflect sound rather than absorb it, green construction systems can absorb sound, with both substrate and plants making a contribution, the former tending to block lower sound frequencies and the latter higher ones. However, few case studies and even less experimental data were found in the literature regarding to the actual contribution of these systems to noise reduction [4,5]. In addition, regarding the acoustic insulation effects of vegetation when it is incorporated in buildings, previous studies usually consider the contribution of green roofs to acoustic insulation, while references to vertical green systems are scarce.

An interesting example of the use of vegetation in order to improve the acoustic insulation of a building is the Almeida Theatre in London (Fig. 1) by Haworth Tompkins studio. To achieve the required level of sound insulation, the roof and gables of the building were turfed in Sedum, a hardy cactus-like plant. The resulting pitched roof garden, full of wild flowers in the centre of a busy urban block, has become a local landmark [6].

Traditionally large masses of vegetation to acoustically insulate different urban areas, especially from the traffic noise, have been employed (Fig. 2). In this regard, vegetation is attributed with some acoustic noise reduction up to 8 dB, and occasionally more [7]. Recent studies, relating to road traffic noise shielding by vegetation belts, already stressed that for an equal amount of biomass per unit surface area, there is a preference for shrubs, either low shrubs (0.5 m) or higher shrubs (2 m). In these studies it was concluded that a 2 m-high shrub zone with a length of 15 m, for a total above-ground dry biomass of 4 kg/m^2, gives an average road traffic noise insertion loss of 4.7 dBA for a light vehicle at 70 km/h at typical ear heights when referenced to sound propagation over grassland. Relating to the acoustic insulation properties of green systems, it is said that vegetation can reduce sound levels in three direct ways. First, the sound can be reflected and scattered (diffracted) by plant elements, such as trunks, branches, twigs and leaves. As a second mechanism there is the sound absorption by vegetation. This effect can be attributed to mechanical vibrations of plant elements caused by sound waves, leading to dissipation by converting sound energy to heat. As a third mechanism, could be also mentioned that sound levels can be reduced by the destructive interference of sound waves by the soil layers presence [8].

Studying the sound propagation through vegetation other authors concluded that the effect of a belt of vegetation on sound propagating through it is highly frequency dependent so that at frequencies below 1 kHz the vegetation is almost transparent whereas above 1 kHz attenuation results from the interaction of scattering and absorption [9].

From these previous studies about green belts of vegetation emerges the conclusion that the most influential factors on their operation for sound insulation are multiple, such as the kinds of species, the green screen dimensions, its shape as well as its location with respect to the noise source.

Furthermore, on these studies one worked with the assumption that plant screens thickness can be around few meters, while in the case of VGS for buildings, it will be difficult to achieve these thicknesses. Consequently, it is very important to know what could be the contribution to the sound insulation from plant element when working with thin vegetation layers, usually less than a meter.

Thus, the incorporation of vegetation to buildings through the use of green infrastructure, i.e. VGS and green roofs, with acoustic insulation purposes, implies the definition and control of multiple factors relating not only to the vegetation layer but also to the support structure and the materials used.

Therefore, with the incorporation of vegetation to buildings, i.e. urban Green Infrastructure through Green Roofs and VGS, it is

Fig. 1. Building greenery as acoustic insulation. Almeida Theatre. London.