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SOUOND ATTENUATION BY TRUNKS IN THE GROUND WITH THICK SNOW

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ABSTRACT

A main way for sound reduction by tree belts is to scatter sound waves by trunks while previous studies of sound absorption by trunks always contain the ground effects. This study aims to examine the difference of reverberation time in different kinds of tree belts through eliminating the influence from ground effect. In order to estimate the scattering of sound waves by trunks, this study investigates sound (Impulse sound) attenuation by three woodlands with same tree species and one woodland with mixed species in the ground with thick snow. The effect of receiver distance from the sound source was also investigated (5 m,10 m and 20m). The results showed that reverberation time can be used to describe the sound propagation over snow cover through tree belts. The reverberation time in different kinds of forests is different, but the variation shows a similar trend with the increase of frequency. The distance between the receiver and sound source affects the reverberation time. The species with higher ability of sound scattering can be used in urban green space to reduce urban noise.

Keywords: Sound propagation, Reverberation time, Tree belts, Ground effect

1. INTRODUCTION

Sound propagation outdoor is obviously affected by the surrounding environment. Compared with open ground, the effect from tree belts on sound propagation is complex, which includes ground effect, sound scattering by trunks and leaves, etc.

For the short distance propagation of sound waves in tree belts, multiple scattering is an important influential factor. Wunderli found that the sound reflection from tree belts mainly occurs in the fringe[1]. Some studies found that the sound attenuation effect is affected by the physical properties (length, width, height, etc.) of tree belts[2-5]. Further studies explored the influence from species, leaf shape, bark roughness[6-9]. Karbalaei found that the noise reduction effect of arbor shrub mixed forest land and coniferous broad-leaved mixed forest land is relatively large, by studying the influence of tree belt width and plant species diversity on the noise reduction effect[10]. For tree belts with similar physical properties, the influence from other factors including plant species and tree age on the noise reduction effect is important[11-12]. However, ground effect is always incorporated in the process of field investigation.

Furthermore, Aylor found that the influence from ground effect is inevitably involved in the noise reduction by tree belts in outdoor[13]. By studying the sound propagation over the snow cover, Sidler found that the sound attenuation effect decreases with the increase of snow surface depth[14]. Albert further demonstrated that in the snow, cover parameter associated with snow surface shows dominant impact, by studying low frequency pulse sound propagation in the forest[15]. Therefore, the test on the next day of heavy snow can reduce the ground effect on sound propagation through tree belts.

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Yang et al. found that reverberation time is applicable in the measurement of the sound scattering effect of a single tree in the open ground[16]. Reverberation time is further authenticated to be applicable in the forest[17]. This study aims to estimate the scattering of sound waves by trunks, by investigating reverberation time by three woodlands with same tree species and one woodland with mixed species in the ground with thick snow. In this research, the influences from plant species and the distance between the sound source and receiver on the reverberation time are specified. The findings can be used to guide the urban tree belt design.

2. METHODOLOGY

2.1 Site Condition

The site in this study should be a forest with no less than 40m in length and 25m in width. The test site is 121 ° 12 ′ to 127 ° 00 ′ E, 50 ° 10 ′ to 53 ° 33 ′ N, and the average altitude is 573m, located in the Northeast China. The temperature condition in test is -24℃, and the wind speed is less than 2m/s. The test is carried out on the day after a heavy snow.

The photo taken in the test is shown in Figure 1, which are Pinus sylvestris seedling, Birch, Shrub, and Forest Mixed with Conifer and Broadleaves, respectively. The parameters representing the trees in the test site are shown in Table 1.

Table 1 – The parameters representing the trees in the test site

Plant species	Average Breast-height Diameter, cm	Average height, m
Pinus sylvestris seedling	31.23	3.3
Birch	25.19	6.5
Shrub	19.43	2.8
Mixed with Conifer and Broadleaves	70.57/13.4	11.2/5.5

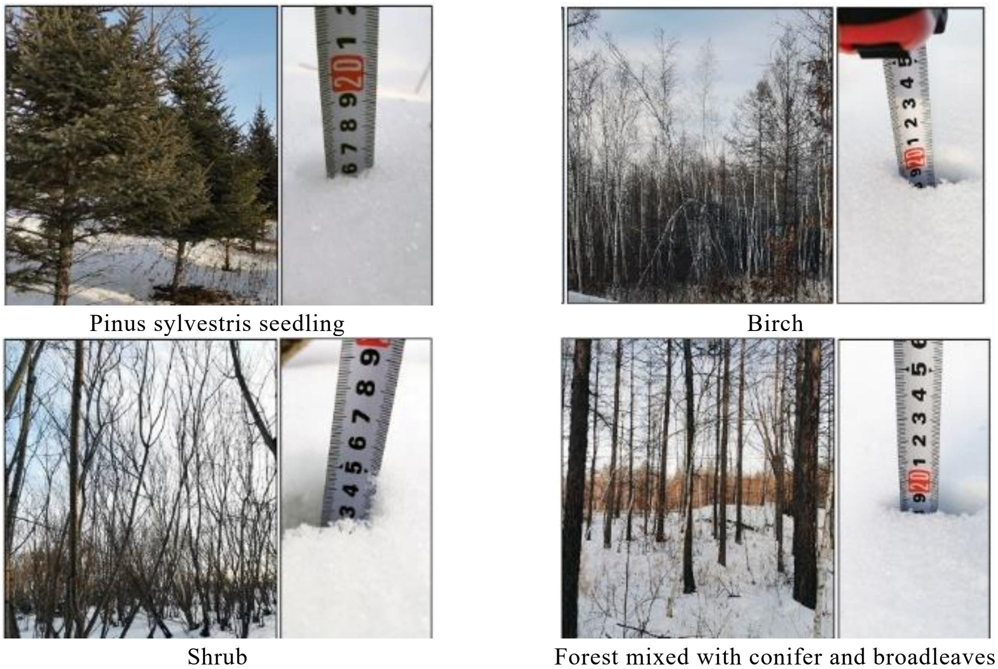
Pinus sylvestris seedling
Birch
Shrub
Forest mixed with conifer and broadleaves

Figure 1 – Photos of the testing site

2.2 Measurement method

The measuring point arrangement is shown in Figure 2. This research measured the reverberation time of the microphone when the height is 1.5m, and the distance with the sound source are 5m, 10m and 20m, separately. The measurement of all settings of distance repeated for 5 times, and the average value is used for analysis.

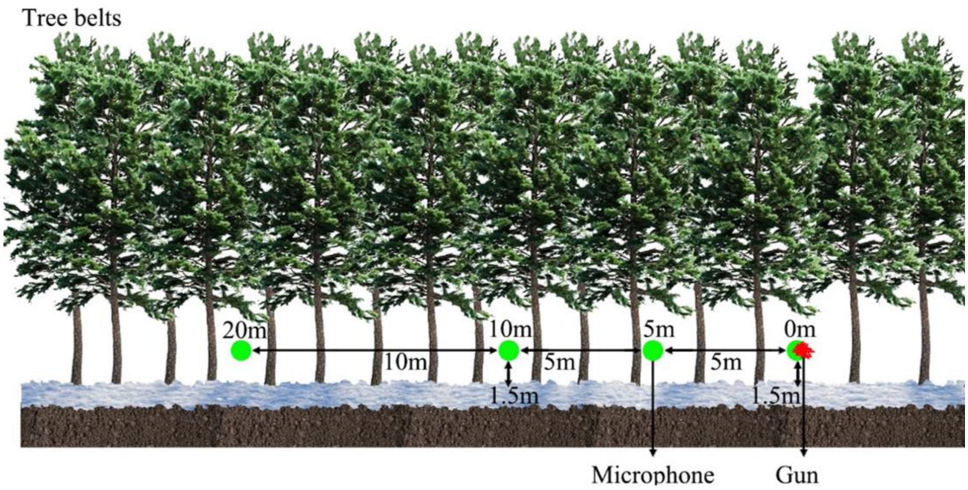

Figure 2 – Schematic diagram of measuring point arrangement

Because measuring T60 needs a high signal to noise ratio, which is difficult to implement outdoor, T60 is not measured in this study. T10, T20 and T30 are widely used for outdoor sound propagation, and this study chooses T20 as the index of reverberation time. The site in this study is far away from urban area and roads, so it is relatively quiet. The SPL of the gun is about 55dB higher than the background noise, so it is feasible to measure T20 under this the signal to noise ratio. The software 'DRIAC' is used to analyze the data.

3. RESULTS

3.1 The variation trend of T20，T20 and T30

Figure 3 shows the variation of T10, T20 and T30 of Birch and Shrub when the distance is 20m. Though the reverberation time of the two sites is different, the trend of variation with the increase of frequency is identical, which complies previous findings. The reverberation time measured over the snow cover can validate that the software 'DRIAC' is precise enough in the analysis. In the following part of this study, T20 is selected to analyze sound propagation over snow cover through tree belts.

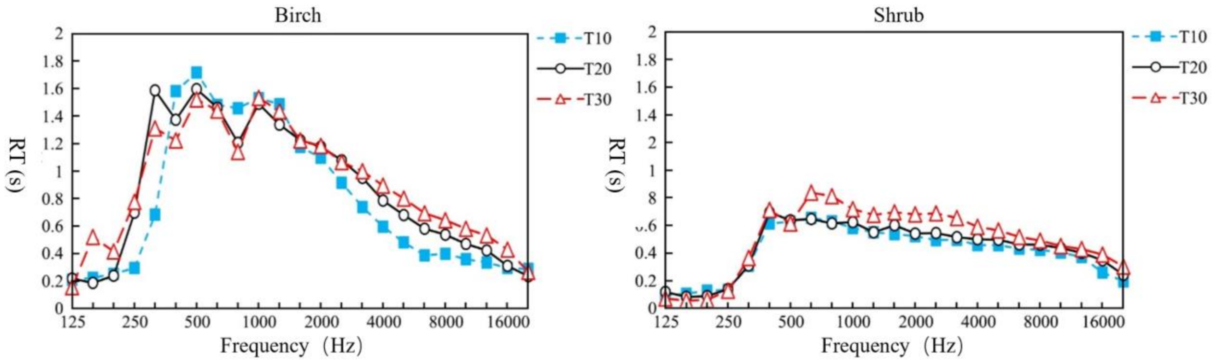

Figure 3 – T10, T20 and T30 of Birch and Shrub when the distance between receiver and sound source is 20m

3.2 The influence from species on T20

Figure 4 shows the spectral characteristics of T20 in site of different plant species. The T20 of all kinds of tree belts share a similar trend of variation with the frequency. When the frequency is below 200Hz, the T20 of all kinds of tree belts are relatively low. For the condition of the frequency between 200Hz and 400Hz, the T20 of all the tree belts increase significantly with the increase of frequency. When the frequency is above 400Hz, the relationship between the frequency and T20 of Pinus sylvestris seedlings and Shrub reaches to a stable trend, and the T20 of Forest mixed with conifer and broadleaves and Birch decreases slightly with the increase of frequency.

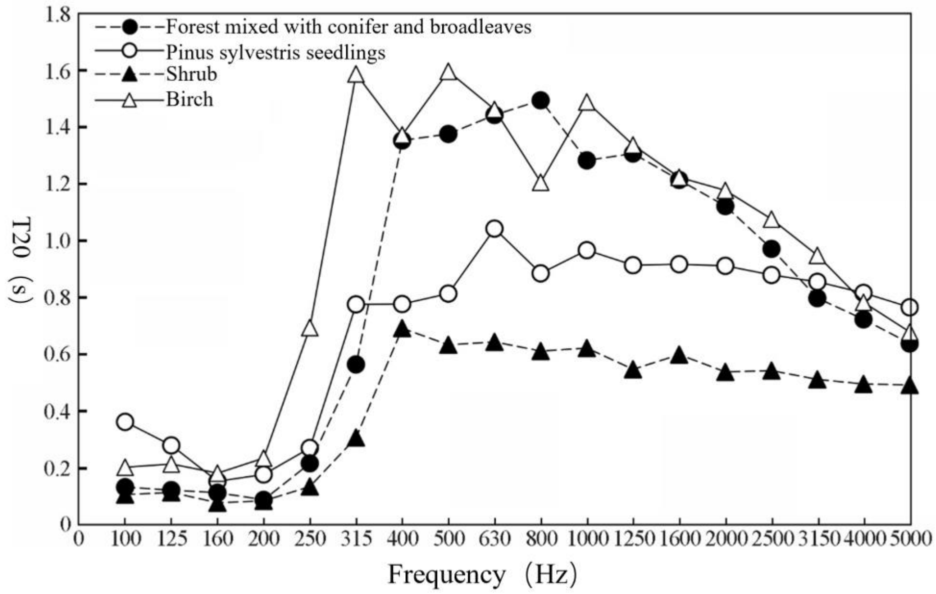

Figure 4 – Spectral characteristics of T20 in site of different plant species

The T20 of Forest mixed with conifer and broadleaves and Birch are largest, which can be caused by the large age, bark roughness and Breast-height Diameter of these two kinds of tree belts. The T20 of Pinus sylvestris seedlings is larger than Shrub. This phenomenon can be caused by two reasons. First, the trunks of Shrub are small, and cannot insulate sound effectively. Second, the barks of Shrub are smooth, which leads to a lower sound absorption coefficient than Pinus sylvestris seedlings.

3.3 The influence from distance on T20

The spectral characteristics of T20 of Forest mixed with conifer and broadleaves with different kinds of distance between receiver and sound source is shown in Figure 5. The T20 of different kinds of distance show a similar trend of variation with the increase of frequency. When the distance increase form 5m to 10m, the change in T20 is negligible.T20 shows an obvious increasing trend, when the distance increases from 10m to 20m.

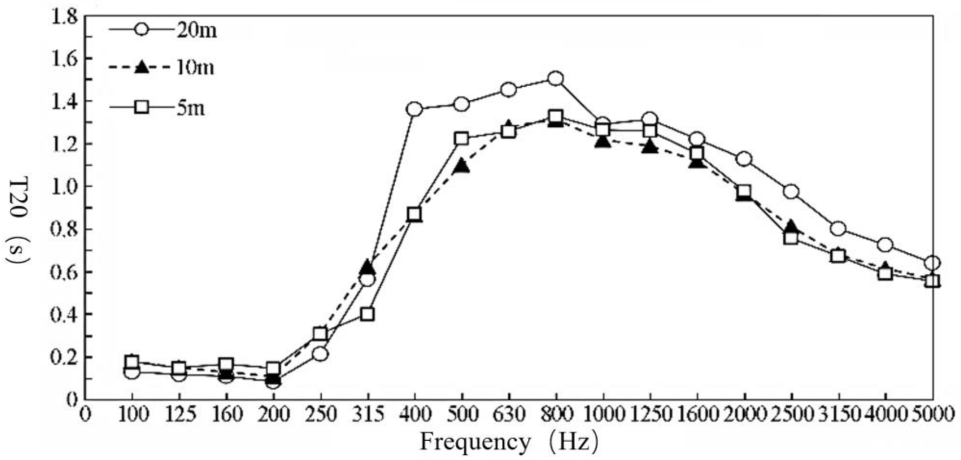

Figure 5 – Spectral characteristics of T20 of Forest mixed with conifer and broadleaves with different kinds of distance between receiver and sound source

4. CONCLUSIONS

This research found that the reverberation time of sound propagation over snow cover through different kinds of tree belts is different, but the reverberation time shows a similar variation trend with the increase of frequency.

When the plant species is different, the reverberation time varies. In this study, 4 plant species are tested, and Birch and Forest mixed with conifer an broadleaves has the longest reverberation time.

The planting density of Birch is obviously larger than Forest mixed with conifer an broadleaves, which can demonstrate that forest consisted of trees with smoother barks needs larger planting density in order to attain a similar reverberation time to forest consisted of trees with rough barks. The reverberation time of Pinus sylvestris seedlings and Shrub is less, and Pinus sylvestris seedlings has a longer reverberation time than Shrub, which is caused by the fact that Pinus sylvestris seedlings has trunk to insulate sound. Moreover, the distance between receiver and sound source can affect the reverberation time, and the reverberation time reach the peak when the distance is 20m in this study.

Plant species, planting density and bark roughness affect the sound propagation outdoor, but the effect is not quantified. Further studies can measure the sound propagation in more kinds of forests and find the dominant influential factors.

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