Effects of platform screen doors on noise characteristics in train stations

Yoshiharu Soeta\textsuperscript{a} and Ryota Shimokura\textsuperscript{b}

\textsuperscript{a}Health Research Institute, National Institute of Advanced Industrial Science and Technology (AIST), Ikeda, Osaka 563-8577, JAPAN, e-mail: y.soeta@aist.go.jp

\textsuperscript{b}Deptartment of Otorhinolaryngology, Nara Medical University, Kashihara, Nara 634-8521, JAPAN

ABSTRACT

Railway companies are encouraged to install platform screen doors (PSDs) for safety reason in Japan. Although the PSDs might have an effect on train noises in stations, the effect of PSDs on the train noise in stations is not well understood. The aim of the present study is to clarify the effects of PSDs on acoustical characteristics in train stations. PSDs can be principally classified by three types, i.e., mobile full-height (MFH), mobile half-height (MHH), or fixed half-height (FHH). Train noises were recorded in ground and underground train stations with MFH, MHH, FHH and without PSDs. The noises were evaluated by the $L_{Aeq}$, the width of the first decay ($W_\Phi(0)$) of the autocorrelation function, and the maximum peak of the interaural cross-correlation function (IACC). In underground stations, $L_{Aeq}$ was decreased 3-5 dB by MFH and MHH, however, $L_{Aeq}$ was not influenced by PSDs in ground stations. IACC was decreased by PSDs in both ground and underground stations, suggesting that PSDs made train noises more diffused. $W_\Phi(0)$ was decreased by PSDs in both ground and underground stations, which means that the train noises in station with PSDs have higher spectral centroid. This suggests that the PSDs blocked the lower frequency components of train noises.

1. INTRODUCTION

Train noise can annoy passengers and reduces the speech intelligibility of public address systems in stations. Thus, the control of train noise in stations is important for the comfort, convenience and safety of passengers, transit workers and operators.

Train stations can be principally classified by their locations, i.e., above-ground or underground stations, and by their platform styles, i.e., side or island platforms. The effects of station style on acoustical characteristics in train stations have been clarified recently [1]. Railway companies are encouraged to install platform screen doors (PSDs) for safety reason in Japan. PSDs can be principally classified by three types, i.e., mobile full-height (MFH), mobile half-height (MHH), or fixed half-height (FHH) as shown in Fig. 1. The PSDs might have an effect on train noises in stations. The aim of the present study is to clarify the effects of PSDs on acoustical characteristics.
The train noise was recorded in 12 aboveground and 16 underground stations with MFH, MHH, FHH or without PSDs (NSD) on 14 railway lines. They are styles of island platforms. The FHH was not available in underground stations. In each station, three receiver positions were set up, at the entrance end (r1), in the middle (r2), and at the exit end (r3) of the platform.

The noise was recorded using a dummy head (Neumann; KU100) or binaural microphones (Type 4101; B&K) positioned approximately 1.6 m above the floor level. The data from the microphones were analogue-to-digital converted with a 32-bit sound card and a sampling rate of 48 kHz. The recorded data were analyzed by autocorrelation function (ACF), \( \phi(\tau) \), and interaural cross-correlation function (IACF), \( \phi_{lr}(\tau) \) [2, 3]. ACF and IACF parameters are closely related to the sound quality of noises [4]. From the ACF analysis, (1) the energy represented at zero delay, \( \Phi(0) \), which corresponds to the equivalent continuous A-weighted sound pressure levels, L_{Aeq}, (2) the time delay of the first maximum peak, \( \tau_1 \), which corresponds to pitch, (3) its amplitude, \( \phi_1 \), which corresponds to pitch strength, and (4) the width of the first decay, \( W_{\Phi(0)} \), which corresponds to the spectral centroid, were analyzed. From the IACF analysis, the interaural cross-correlation coefficient (IACC), which is defined as the maximum of the IACF and related to subjective diffuseness [5], were analyzed. The ACF and IACF parameters are shown in Fig. 2.

Considering the moving noise source, the train noise was analyzed for three train conditions. The train condition is defined as either “come”, “stop”, or “go”. The interval “come” started when the L_{Aeq} of the train noise increased to 60 dB and ended when the door of a train was opened. The interval “stop” was the duration the door was open. The interval “go” started when the door was closed and ended when the L_{Aeq} decreased to 60 dB.
3. RESULTS AND DISCUSSIONS

Figure 3. $L_{A_{eq}}$ for each type of platform screen door (PSD) and train conditions in (a) underground and (b) aboveground stations.

Figure 4. $W_{\phi(0)}$ for each type of PSD and train conditions in (a) underground and (b) aboveground stations.

Figure 5. IACC for each type of PSD and train conditions in (a) underground and (b) aboveground stations.

Figures 3 show $L_{A_{eq}}$ for each type of PSDs and train conditions. In underground stations, MFH and MHH reduced $L_{A_{eq}}$ by approximately 5 dB in come and go intervals. In aboveground stations, the effects of PSDs on $L_{A_{eq}}$ were not clear. Although multiple
reflections between ceilings and walls exist in underground stations, they can be blocked by the PSDs and contribute to the reduction of the $L_{Aeq}$.

The pitch of the train noise, $\tau_1$, was not affected by the PSDs. In underground stations, the effects of PSDs on the pitch strength of the train noise, $\phi_1$, were not observed. In aboveground stations, PSDs reduced $\phi_1$, suggesting the reduction of subjective annoyance [6]. Figures 4 show $W_{\phi(0)}$ for each type of PSDs and train conditions. In both underground and aboveground stations, PSDs reduced $W_{\phi(0)}$. The reduction of $W_{\phi(0)}$ means the shift of the spectral centroid of the noises from low to high. This suggests the obstruction of low frequency components by PSDs.

Figures 5 show IACC for each type of PSDs and train conditions. PSDs reduced IACC in come and go intervals. This trend is prominent in aboveground stations because train noises are diffused by lateral walls and ceilings in underground stations.

4. CONCLUSIONS

In this study, effects of PSDs on acoustic characteristics in train stations were evaluated by $L_{Aeq}$, ACF and IACF factors. MFH and MHH reduce $L_{Aeq}$ by approximately 5 dB when a train comes or goes to the station in underground stations. PSDs cause the shift of the spectral centroid of noises in stations from low to high. In aboveground stations, PSDs increase the diffuseness or ambiguity of the noise source when a train comes or goes to the station. The PSDs change the acoustic characteristics in train stations, however, acoustic treatments are not installed in the PSDs. These suggest that installation of PSDs with acoustic treatments produce considerable improvement of acoustic environments in train stations.

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5. REFERENCES


