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Annoyance due to railway noise before and after the opening of the Kyushu Shinkansen Line

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ABSTRACT

The development of the Shinkansen railway network in Japan has continued since 1964; however, associated noise and vibration have seriously affected communities located beside the lines. The Kyushu Shinkansen Line (KSL) was opened in 2011 and a second temporary conventional railway line (STL) was operated in 2012. The purpose of this study was to compare community responses to railway noise and vibration before and after the opening of these two lines. Socio-acoustic surveys were performed in Kumamoto from 2009 to 2012, where the conventional and Shinkansen lines are adjacent. The noise and vibration exposures were increased slightly after the opening of the KSL but decreased slightly after the opening of the STL. When multiple logistic regression analysis was applied using highly annoyed/annoyed as the dependent variable and using day–evening–night sound level (L_{den}) and a dummy variable of before or after the opening of the KSL as independent variables, high annoyance was not changed significantly but moderate annoyance decreased significantly following the opening. There was no significant difference in either high or moderate annoyance between the periods before and after the opening of the STL.

1. Introduction

Noise and vibration from the Shinkansen railway network has been a serious social problem in Japan since the opening of the Tokaido Shinkansen Line in 1964. Noise, vibration, and low-frequency noise caused by the running of high-speed trains continue to annoy people living alongside the Shinkansen railway lines. To overcome this problem, the Japanese government implemented the "Environmental Quality Standards for Shinkansen Superexpress Railway Noise" [1] and "Measures for Noise and Vibration Caused by Shinkansen Trains" [2] policies. In the period following the establishment of the environmental standards and measures, the noise and vibration along the Shinkansen lines have been improved markedly by the countermeasures.

Toida et al. [3] compiled survey data of noise and vibration from the Tokaido Shinkansen Line that have been recorded in Nagoya for 30 years. They showed that since the opening of the line, noise and vibration exposure had decreased by about 20 and 2–3 dB, respectively, by 1995. Yano et al. [4] conducted a social survey and noise/vibration measurements along the Sanyo Shinkansen Line, and based on the finding that the Shinkansen line emitted a higher level of vibration than the conventional line at the same noise level, they suggested that noise annoyance was increased by vibration. Yokoshima et al. reported a series of noise and vibration surveys of Shinkansen lines. They found that community response to the noise of Shinkansen lines had moderated from 1985 to 2002 because of the implementation of effective noise countermeasures but that the response to vibration was unchanged [5]. They suggested that L_{Amax} was a better index for consistent exposure–response relationships among the three surveys than L_{Aeq} [6]. However, this latter finding is reversed when recent surveys are considered [7]. They proposed not only a noise exposure–response relationship but also a vibration exposure–response relationship [8]. Yokoshima et al. compared the exposure–response relationships for transportation noise with datasets accumulated in Japan and they showed that the noise of Shinkansen lines was equally as annoying as commercial aircraft noise but more annoying than conventional railway and road traffic noise [9].

As a part of the development of the Shinkansen network, the Kyushu Shinkansen Line (KSL) was opened in 2011. This line runs from Fukuoka to Kagoshima via Kumamoto, which lies at the midpoint between the two cities. The conventional railway and Shinkansen lines are adjacent around Kumamoto station. Following the opening of the KSL, a second temporary conventional railway

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line (STL) was operated in 2012. The Shinkansen network continues to be expanded in Japan; the Hokuriku and Hokkaido Shinkansen Lines were partially opened in 2015 and 2016, respectively, and a Nagasaki Shinkansen Line is being planned. Therefore, accumulating data of community responses to noise and vibration from the Shinkansen lines is of considerable strategic importance in Japan. However, rapid transit railway networks have been constructed in European countries such as France, Spain, and Germany and in Asian countries such as China, Taiwan, and Korea. It is also expected that the expansion of rapid transit railway networks will occur in developing countries such as Brazil and India. Therefore, impact assessments of rapid transit railways are urgently required, not only in respect of a steady-state scenario but also in consideration of step-change conditions.

The focus of many step-change studies has been whether people overreact to a change in the level of noise exposure compared with steady-state conditions. In their reviews, Brown and van Kamp [10,11] called this effect an "excess response" but they acknowledged in a footnote that the term "overreaction" is often more appropriate [10]. The opposite case is called an "under response." In the current paper, the terms "excess response" and "under response" have been adopted. Fidell et al. [12] investigated community response to a step change in aircraft noise exposure following the opening of a new runway and they determined an excess response. However, Fidell et al. [13] indicated no excess sleep disturbance following changes in exposure to nighttime aircraft noise. Öhrström [14] reported a large decrease in annoyance following a reduction in road traffic noise but did not specify whether it was an excess reduction. Nilsson and Berglund [15] investigated road traffic noise annoyance both before and after the erection of a noise barrier. They found that while indoor exposure–response curves agreed with steady state exposure–response curves, outdoor exposure–response curves did not. Brink et al. [16] investigated the effects of a step decrease and a step increase in aircraft noise exposure on the exposure–annoyance relationship and found an excess response with the step increase. Brown and van Kamp [11] listed 11 explanations interpreting the excess response and identified 3 as plausible: changes in modifiers of exposure–response relationships, differential response criteria, and retention of coping strategies. Brown and van Kamp [10] systematically reviewed 43 step-change studies and found an excess response in comparison with steady-state exposure–response relationships, at least for road traffic noise change at source. Of the reviewed studies, six focused on railway noise, including one that considered noise from Shinkansen lines.

The purpose of this study was to provide fundamental data for deciding future noise and vibration policy by comparison of community responses to railway noise and vibration between the periods before and after the opening of the KSL and STL in Kumamoto.

2. Method

2.1. Survey site

The KSL opened in March 2011. At that time, the KSL and the conventional railway line were adjacent in the area around Kumamoto Station, as shown in Fig. 1. An elevated section of the conventional railway line was then constructed in an area from about 5 km north to 1 km south of Kumamoto Station. The stages of the construction process of the elevated conventional railway line over a period of more than 10 years are shown in Fig. 2(c)–(f). In March 2011, conventional trains were operated on the first temporary line (Fig. 2(c)) and then moved to the STL in August 2011 (Fig. 2

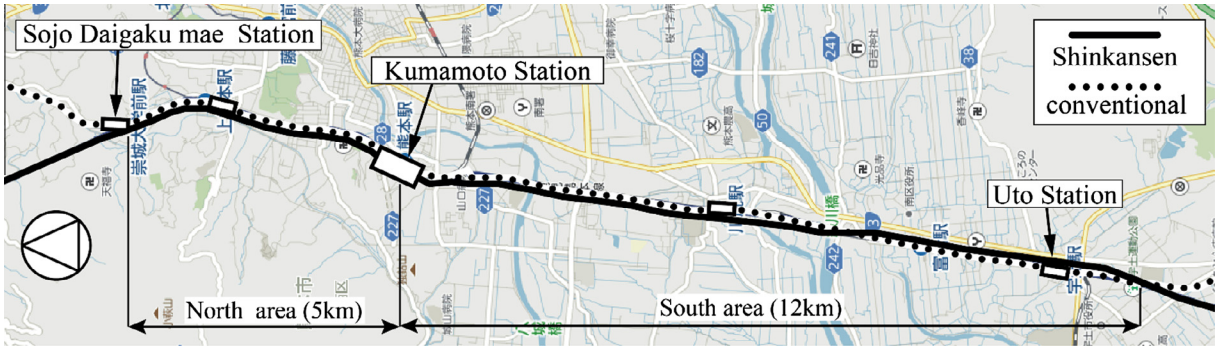

Fig. 1. Survey area for Shinkansen and conventional railway noise and vibration.

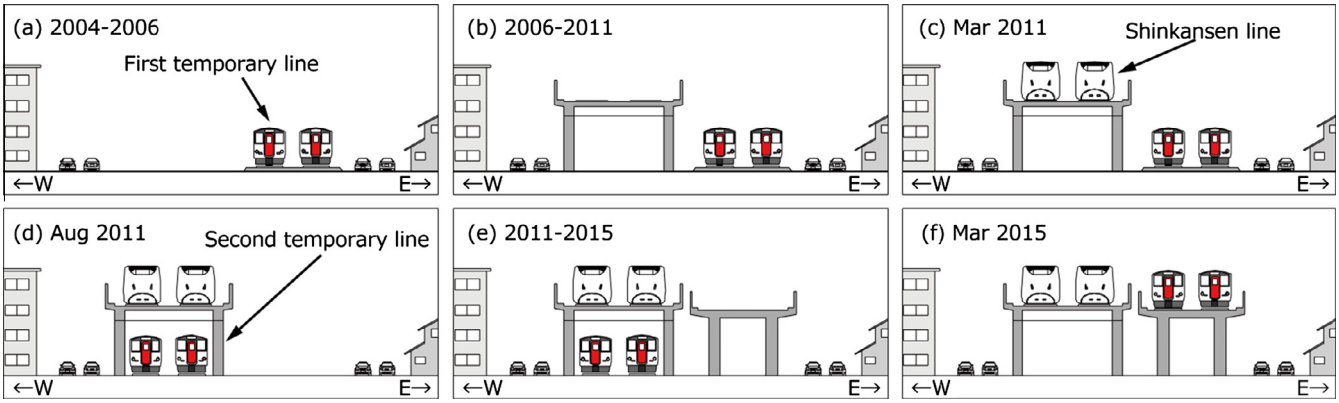

Fig. 2. Process of constructing railways in North area (Survey I in 2009–2010, Survey II in 2011, and Survey III in 2012).