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GFRP posts for railway noise barriers – Experimental validation of load-carrying performance and durability

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Abstract

As part of a 15-year railway noise remediation plan, 300 km of noise barriers will be installed in Switzerland over the next few years. To enable pultruded glass fiber-reinforced polymer (GFRP) materials to be used for the noise barrier posts, a specification concerning design and installation was prepared for their technical approval. The approval of a first GFRP-post system confirmed that the requirements defined in the specification are reasonable and can be met. A coherent system of design values for strength and stiffness resulted from the process that differentiates between environmental impact (inside or outside the concrete foundation) and short- or long-term loading. The GFRP posts, composed of glass fibers and a polyester matrix with a protective coating, showed that even a small number of scratches in the coating may strongly affect the long-term strength of the GFRP material inside the concrete foundation. The post-foundation system stiffness decreased by only 7% during 12 million fatigue cycles due to concrete cracking and remained below the 10% limit prescribed in the specification.

Keywords: Alkalinity; Durability; Fatigue; Glass-reinforced plastics; Pultrusion; Specifications

1. Introduction

Switzerland is a densely populated country with a well-developed railway system that is continuously being expanded. To protect the population from increasing railway noise, a law concerning noise remediation was passed in 2000. Between now and 2015, roughly 1.2 billion Euros will be invested to upgrade rolling stock and install noise-protection windows and noise barriers. Approximately 300 km of noise barriers will be installed during the next few years. A noise barrier normally reduces the railway noise level by 10 dB, corresponding to a noise reduction of approximately 50% for human ears.

For the planned 300 km of noise barriers, roughly 70,000 posts at 4–5 m distances will be required to support the concrete or timber noise barriers, which can be as high as 5 m. Until now, only steel posts (I-shapes) have been used. These present several disadvantages however. Owing to corrosion, they are normally not embedded in concrete foundations, but are fixed to the latter with steel plates and bolts. Since these connections are also sensitive to humidity and thus cannot be put into the ground, the concrete foundations must be raised from the ground, as shown in Fig. 1a. Further drawbacks are that the piles below the foundation blocks become longer and more expensive and the visibility of the foundations is not at all satisfactory from an aesthetic point of view. Finally, installation is hampered by the relatively high weight of the steel posts.

Posts made of glass fiber-reinforced polymers (GFRP) offer an alternative to steel posts. GFRP posts can be directly embedded in the concrete foundations, which no longer need to be raised above the ground, as shown in Fig. 1b. Shorter piles combined with the much easier installation due to the light weight of the posts offer important cost savings. Furthermore, since foundations are no longer visible, as shown in Fig. 2, GFPR posts are aesthetically more pleasing.

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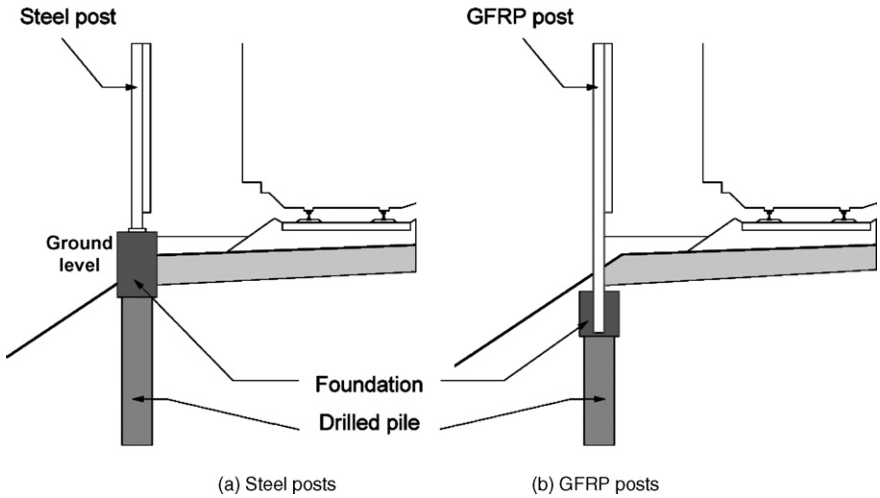

Fig. 1. Cross-section of typical SBB noise barriers.

Fig. 2. GFRP post during installation of noise barrier.

To enable GFRP shapes (henceforth referred to as profiles) to be used as posts for noise barriers, the Swiss Federal Railway (SBB) authorities set forth a specification for the design and installation of pultruded GFRP profiles for noise barriers [1]. This paper presents the SBB specification and how it is applied for the approval of the first GFRP-post system.

2. SBB specification

The SBB specification for pultruded GFRP noise barrier posts spells out the materials to be used, the design procedure (verification of structural safety and serviceability), the durability requirements and the construction details. GFRP post manufacturers have to provide test results for all these requirements from accredited testing laboratories to receive the SBB's final approval of the system. Strength, stiffness and fatigue resistance must be verified not only for the pultruded post profile, but also for the concrete foundation with embedded post system.

The profiles have to meet the requirements of class E23 of EN 13706 (European Committee for Standardization [2]) for temperatures from −40 °C up to +60 °C. The EN 13706 specifies the two standards E17 and E23 for pultruded profiles based on material properties. The required material properties are listed in the third column of Table 1. Characteristic values correspond to 5% fractile values. Regarding verification of structural safety, the main load cases that must be considered are wind, pressure/suck from trains, and earth thrust on lower barrier parts in slopes (SBB [3]) with the corresponding (partial) load factors according to Swiss Code SIA 260 (Swiss Standards Association [4]). With regard to resistance, two (partial) resistance factors are preset: $\gamma_M = 1.8$ for short- term loading and $\gamma_M = 3.2$ for long-term loading, which were determined on the basis of Eurocomp (Clarke [5]). The long-term value accounts for environmental effects and loading duration but it does not account for fatigue or alkaline attack on GFRP parts embedded in the concrete. Regarding bending resistance at the bearing point due to possible premature buckling of the compression flange and web, a sufficient cast-in depth to provide full post fixation and barrier fixation at the GFRP flanges must be provided.

As for serviceability, the short-term deflections (including shear deformations) at the top of the posts (of height h) are limited to $h/120$ in the specification. Regarding fatigue from train pressure/suck loading, the decrease in stiffness of the foundation-post system after 80 years is limited to 10%. The 80-year service life corresponds to 12 million cycles of pressure/suck loading. For testing, a minimum to maximum load ratio of $R = 0.1$ with an upper boundary