RAIL MOVEMENT AND GROUND WAVES CAUSED BY HIGH-SPEED TRAINS APPROACHING TRACK-SOIL CRITICAL VELOCITIES

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ABSTRACT
During the last decade Railways have become one of the most advanced and fast developing branches of transportation technology. The reason is very high speeds achievable by the most advanced modern trains (French TGV, German ICE, Italian Pendolino, Swedish X2000, Spanish AVE, Belgium Thalys, the Eurostar) and very low air pollution per passenger compared with road vehicles. Unfortunately, the increased speeds of modern trains are normally accompanied by increased transient movements of rail and ground that are especially high when train speeds approach some critical wave velocities in a track-ground system. These transient movements, being predominantly of low-frequency range, may cause large rail deflections, as well as structural vibrations and associated noise in nearby buildings.

There are two main critical wave velocities in a track-ground system: the velocity of Rayleigh surface wave in the ground and the minimal phase velocity of bending waves propagating in a track supported by ballast, the latter velocity being referred to as track critical velocity. Both these velocities can be easily overcome by modern high-speed trains, especially in the case of very soft soil where both critical velocities become very low. As has been earlier predicted by one of the authors [1-3], if a train crosses the Rayleigh wave barrier, i.e., its speed exceeds the Rayleigh wave velocity in supporting soil, then a ground vibration boom occurs which is associated with very large increase in generated ground vibrations, as compared to the case of conventional trains. The existence of a ground vibration boom has been recently confirmed experimentally on the newly opened high-speed railway line in Sweden for train speeds of only 160 km/h [4]. If train speed increases further and approaches the track critical velocity, the rail deflections due to applied axle loads become especially large and an additional growth of generated ground vibrations takes place, as compared to the case of ground vibration boom [2, 3]. Possible very large rail deflections at this speed may result even in train derailing, thus representing a serious problem also from the point of view of train and passenger safety [5]. The discussion in this paper focuses on the effects of amplitudes and shapes of transient rail deflections and their effects on associated ground vibrations in the cases of trains crossing Rayleigh and track wave barriers. The obtained theoretical results are illustrated by numerical calculations for TGV and Eurostar high-speed trains travelling along typical tracks built on soft soil.

REFERENCES

