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LETTERS TO THE EDITOR

COMMENTS TO "GROUND VIBRATION GENERATED BY A LOAD MOVING ALONG A RAILWAY TRACK"

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The authors have presented [1] an interesting paper on the analysis of ground vibrations related to railway traffic. Their work has extended previous presented analyses to take into account the effect of a layered supporting soil as well as the transient nature of ground vibrations related to railway traffic. Results from calculations show the displacement pattern on the soil surface from a moving constant load as well as from a moving harmonic load. Different relations between the load speed and the Rayleigh wave velocity of the supporting half-space or an upper layer on a half-space are investigated. The deformation pattern around a constant load travelling with sub-Rayleigh speed was found to be of "quasi-static" nature while for super-Rayleigh speeds of the load a MACH-cone developed behind the load. In the latter case, waves inclined to the railway track normal developed.

Here some experimental findings on the problem of ground vibrations related to railway traffic are presented. Further details will be published in the near future. Measurements of ground vibrations related to railway traffic have been conducted at a site with a deep layer of soft and relatively homogeneous clay soil. The depth to bed rock was about 40 m. The test area was located at a distance of 4·8 m from the railway track and response in terms of vertical acceleration was simultaneously recorded at 44 nodes on the soil surface. The centre-to-centre spacing of the nodes was 2×2 m parallel and perpendicular to the railway track. Thus, an area of 124 m^2 was covered, see Figure 1.

In the following sections, a passage of a freight train has been chosen to discuss briefly some observations. The recorded train speeds were 25·6 m/s and the soil surface phase velocity was estimated to be around 71 m/s. The train passage was captured in a time window of 20·48 s using 4096 time samples. The full bandwidth, after applying an anti-aliasing filter is 76·625 Hz with a lowest frequency of 0·5 Hz. In Figure 2, bandpass-filtered data, with a lowest frequency of 0·5 Hz and a highest frequency of 20 Hz, is used to follow vibrations in time along a line perpendicular to the railway track (nodes 30–35 in Figure 1). A time delay is observed with increasing distance from the railway track and clear wave crests with an angle, θ, to the track normal can be observed. The angle is proposed to be calculated as

$$\theta = \operatorname{atan} \frac{v}{c_R}, \tag{1}$$

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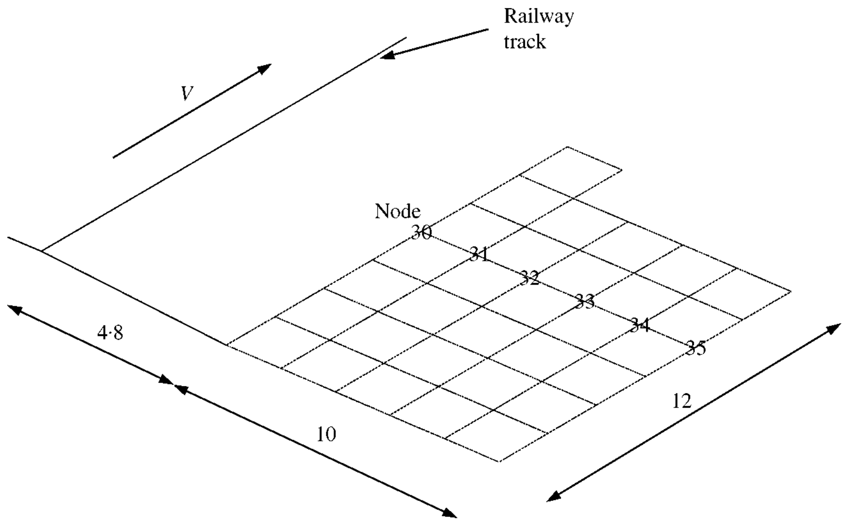

Figure 1. Mesh on the test area and dimensions (m).

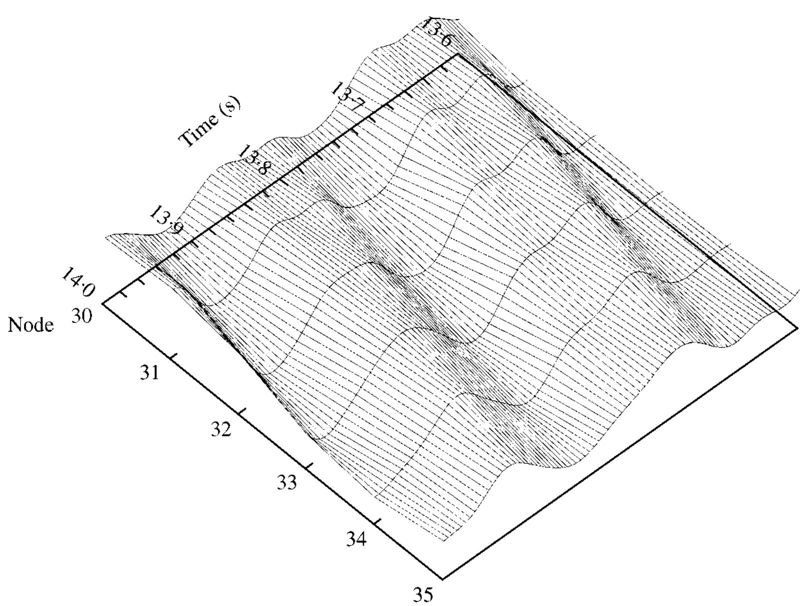

Figure 2. A 0·4 s time window of vertical acceleration in nodes 30–35.

where v is the speed of the train and c_R is the soil surface phase velocity. By using the recorded train speed and the estimated soil surface phase velocity the angle to the track normal was estimated to be 0·35 rad. By using the time delay observed in Figure 2 the angle can be calculated to 0·30 rad. In Figures 3 and 4, vertical acceleration is followed at all nodes simultaneously and snapshots are shown at a specific time, $t = 13{\cdot}93$ s. Clear wave crests to the track normal can be seen. Depending on the bandwidth chosen the wave crests become more pronounced. Here this is illustrated by using two different bandwidths. In Figure 3, frequency components between 0·5 and 20 Hz are included and in Figure 4 a more

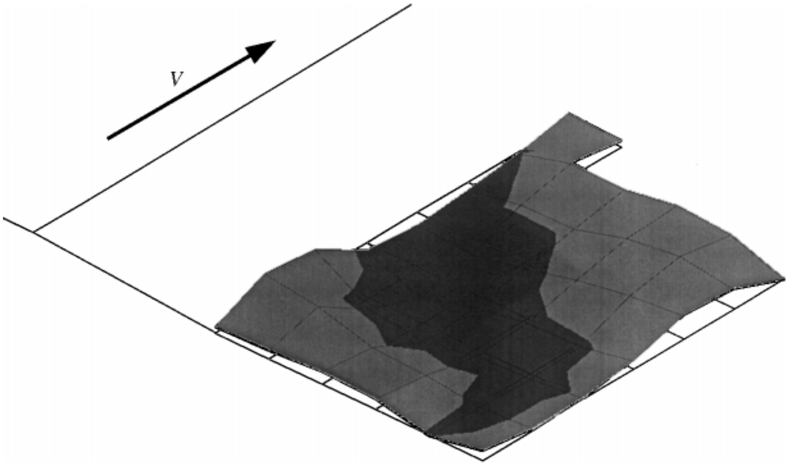

Figure 3. Snapshot of the vertical acceleration taken at $t = 13{\cdot}93$ s. The highest frequency component considered is 20 Hz. The travelling direction of the train is shown with an arrow.

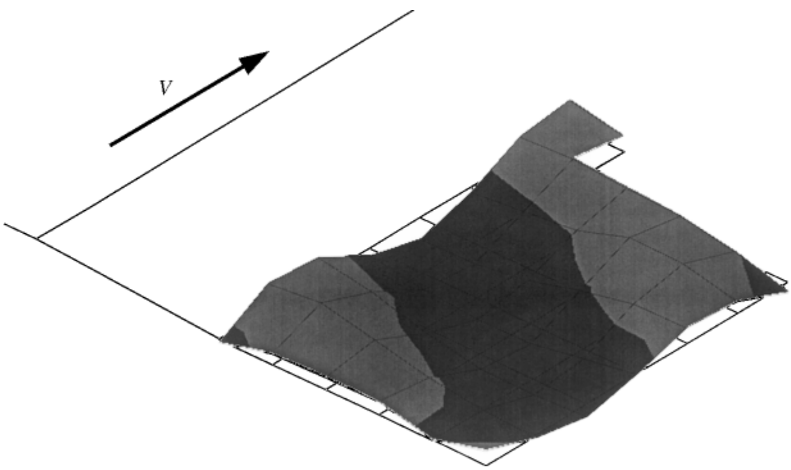

Figure 4. Snapshot of the vertical acceleration taken at $t = 13{\cdot}93$ s. The bandwidth is 0·1 Hz with a lowest frequency of 7 Hz. The travelling direction of the train is shown with an arrow.

narrow bandwidth with frequency components between 7·0 and 7·1 Hz are included. For bandpass filtering a Kaiser window was used.

Experimental data from measurements of ground vibrations from railway traffic have been presented. Despite the fact that the train travelled with a speed of one-third of the estimated soil surface phase velocity, clear wave crests inclined to the track normal were observed. It would be interesting to have the authors view on the differences between the simulations and the observations presented here.

REFERENCES

1. X. Sheng, C. J. C. Jones and M. Petyt 1999 *Journal of Sound and Vibration* **228**, 129–156. Ground vibration generated by a load moving along a railway track.