High speed lines on soft ground: dynamic soil-track interaction and ground borne vibrations

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HIGH SPEED LINES ON SOFT GROUND:
DYNAMIC SOIL-TRACK INTERACTION AND
GROUND BORNE VIBRATIONS

Gothenburg, Sweden, 16–17 March 2000

On 16–17 March 2000 the first international seminar on
dynamic effects of high-speed trains on soft ground took
place in the city of Gothenburg, on the Western coast of
Sweden. The seminar was organised by the Swedish Rail
Administration (Banverket), and the chosen venue was not
far away from the site where strong dynamic effects and
intensive ground vibrations from high-speed trains had
been first observed in 1997–98 (for details see the article
by the present author Ground vibration boom from high-
speed trains prediction and reality, Acoustics Bulletin, 23
(4), 15–22 (1998)). The aim of the seminar, which has
attracted about 50 participants from 10 European coun-
tries, USA and Japan, was to discuss new problems in the
field of railway-generated vibrations occurring when train
speeds approach and exceed certain critical velocities of
track and ground. For railways built on soft soil these
critical velocities may be especially low (40–50 m/s). There-
fore, the associated dynamic effects can be observed for
train speeds of only 160–180 km/h.

The culmination of the seminar was the visit of all the
participants to the site where strong track and ground
vibrations had first been observed (Ledsgard, 25 km
south of Gothenburg). A temporary speed limit of 140
km/h has been recently imposed on this part of the line
to avoid undesirable speed-related dynamic effects. This
has been done following the series of recent investiga-
tions conducted by the Banverket in collaboration with
several Scandinavian Institutions (Chalmers University
of Technology, Royal Institute of Technology, Swedish
and Norwegian Geotechnical Institutes). However, in spite
of this speed limitation, two test runs of the Swedish high-
speed train X2000 at a speed of 200 km/h were spe-
cially arranged by the Banverket to demonstrate the phe-
nomenon to all the participants of the seminar. Since
conventional commuter trains continued to travel on this
part of the line at speed of 140 km/h it was possible for
everyone to make a direct comparison of ground vibra-
tions from the 'low speed' commuter trains, which were
just about normal, with those associated with high-speed
train X2000 running at a speed of 200 km/h, i.e. satis-
fying the condition of ground vibration boom.

When the first run of the train X2000 took place in the
direction to the South of Gothenburg, most of the par-
ticipants were standing near the embankment. During the
train passage, very strong ground vibrations could be felt
through the legs. Apart from this, one could see high
amplitude bending vibrations of the masts carrying elec-
tric wires above the tracks. Such very strong electric mast
vibrations may result in the interruption of electric power
supply to the electric engines of a locomotive. This is why
they represent one of the major concerns for railway
companies. Another major problem is very large rail
deflections which may cause premature wear of the rails
and even train derailment.

During the second run of the high-speed train, which
was performed by the same train returning to Gothen-
burg, some of the participants, including the author of
these notes, were standing on the open flat field covered
by grass at distances 15–20 m from the track. A very
strong sensation of ground vibrations was present there
as well. Moreover, it was even possible to see the Ray-
leigh surface waves in the grass-covered ground. As
expected, the waves were propagating at a certain
speed-dependent angle relative to the train. This was cer-
tainly an unforgettable and unique experience!

According to the members of Swedish and Nor-
wegian research teams, who had these propagating
Rayleigh surface waves video-recorded, the displacement
amplitudes of the associated ground vibrations at ground
vibration boom are very large – around 20 mm, with
particle velocity of 80 mm/s. Comparison of these values
with the level of 10 mm/s, considered in many vibration
related standards as the level causing structural damage,
demonstrates that no building could withstand vibrations
like these for a long time. Fortunately, the nearest build-
ings in Ledsgard are at distances of about 200–300 m
from the track, so that ground vibrations might reach
them highly attenuated.

Among the presentations given in the seminar a sig-
nificant part was dedicated to studying the particular
case of Ledsgard ground vibrations which represents the
worst case from the point of view of hazardous dynamic
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Several presentations gave an insight into the theory of the phenomena which is now fast progressing. This included the role of surface Rayleigh wave velocity in the ground, contributions of bending waves propagating along the track, speed resonance effects and amplification of vibrations, effect of layered geological structure of the ground, etc.

The rest of the talks described the results of measurements undertaken outside Scandinavia. In particular, the effects identical to those observed in Sweden were reported from Holland, Switzerland and Japan. All these clearly indicate that, with the general trend of increase in operating train speeds, the problems discussed in the seminar will appear sooner or later in many countries in Europe, Asia and North America. It has been recognised that international co-ordination of efforts is needed to tackle the problem.

The first example of such co-operation is now under way between the Scandinavian countries Sweden, Norway and Finland. The next step apparently will be European co-operation in the framework of one of the EC programmes.

Victor V Krylov FIOA

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