Aerodynamic effects on railway infrastructure

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- A bit more detail
  - Tunnel pressures
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  - Ballast flight
  - Environmental effects
The issues

- Train drag
- Crosswind stability
- Tunnel pressures
- Sonic booms
- Pressures on structure
- Train slipstreams
- Ballast flight
- Environmental effects
Keep back from the platform edge
Passing trains cause air turbulence
Stand behind yellow line
The tools

- Full scale testing
- Physical model testing
- Computational Fluid Dynamics
- Codification
Railway applications — Aerodynamics —
Part 1: Symbols and units

ANNEX
DIRECTIVE 96/48/EC — INTEROPERABILITY OF THE TRANS-EUROPEAN HIGH SPEED RAIL SYSTEM
TECHNICAL SPECIFICATION FOR INTEROPERABILITY
‘Rolling stock’ Sub-System

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The European Standard EN 14067-1:2003 has the status of a British Standard

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British Standards

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A bit more detail

- Tunnel pressures
- Sonic booms
- Pressures on structure
- Train slipstreams
- Ballast flight
- Environmental effects
Tunnel pressures

- As trains enter tunnels, pressure waves pass up and down the tunnel
- These may be of discomfort to passengers
- Code limits for pressure transients
- How can pressure transients be determined?
Sonic booms

- At very high speeds for long tunnels – pressure waves steepen
- Strong pressure waves from exit – sonic boom
- How can these effects be eliminated?
Micro-pressure waves: mitigation
Main tunnel

Holes

Adjustable cover plate

Hood
Trackside pressures

- Pressure transients occur around trains
- These can load trackside structures significantly
- Important in fatigue terms
- How can these loads be determined
- Codified values for European conditions
All vehicles, 10m wide 4.5m high y=0m

Class 390
Class 158
Class 66
Train slipstreams

- Code requirements for maximum slipstream velocities at trackside and on platform to avoid possibility of accident
- How can these slipstream velocities be determined?
- Major EU project - AeroTRAIN
Freight train slipstreams
Slipstream velocities

Class 52 and containers

ICE2
CCTV clip: A platform safety incident at Nuneaton
Ballast flight

- At very high speeds (>300kph), ballast is lifted off the track
- Variety of effects in different countries – catastrophic damage, snow and ice issues, track and wheel pitting
- Need to understand these effects to eliminate them
Full scale experiments
Full scale experiments
Figure 3. The upside-down ground plain with Class 373 Eurostar model and measuring instrumentation. It extends 10 m in length and is set at a height of ?? mm above the normal running track. The setup represents one half of a typical twin track section of high speed railway modelled at 1/25th scale. The bed of ballast particles at full-scale creates a surface roughness boundary condition for the flow underneath a train. It was found, after analysing typical ballast particle sizes, that fish tank gravel was a suitable size to simulate individual ballast particles at 1/25th scale. A single thickness layer of gravel was roughly glued to the ground plain to represent the ballast bed and create a scaled surface roughness. The ground plain enabled measuring instrumentation to be easily set up in the space between the ballast level and the underside of the model train. A 2.5 mm gap, through which instrument could be set up, was cut across the ground plain at a position 7 m from the start of the plain. The position 7 m from the plain start was chosen to allow the boundary layer between the train and the ground plain to be well defined.
Ballast forces

![Graph showing ballast forces over a dimensionalless time. The graph includes lines for weight, mechanical force, and shear force.]
Full scale measurements - velocities
TRAIN Rig
measurements
- velocities
Comparison of techniques - velocities

Figure 16. A comparison of ensemble horizontal velocities $U_{res}$ for CFD, full- and model-scale data for the rake of measuring positions at 0 m and 1.085 m from centre of track.

a) 0.05 m above TOR at 0 m from centre of track
b) 0.02 m above TOR at 1.085 m from centre of track
c) -0.02 m above TOR at 0 m from centre of track
d) -0.09 m above TOR at 1.085 m from centre of track
e) -0.14 m above TOR at 0 m from centre of track
f) -0.14 m above TOR at 1.085 m from centre of track
Environmental effects

- Air Quality
- Flooding
- Bird strike
- Tree fall
- Station canopies
Environmental effects – Air Quality

Network Rail

RSSB
Environmental effects - flooding
Environmental effects - flooding
Environmental effects – bird / bat / butterfly strike
Environmental effects - Tree fall
Environmental effects – Station canopies