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# The measurement and codification of aerodynamic forces due to passing trains on railway infrastructure

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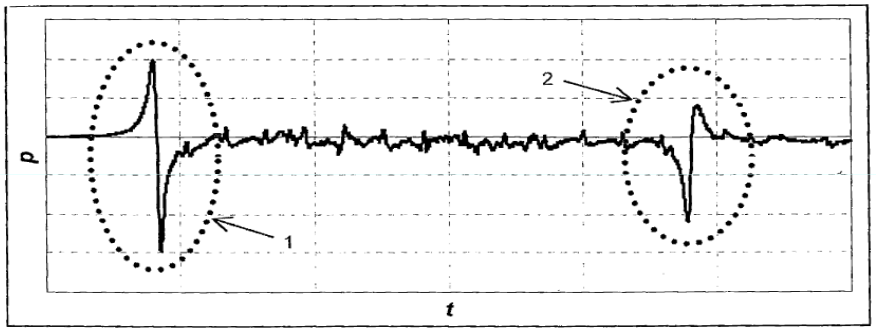
## The problem – pressure pulses from passing trains




Key
1 Head of train passing
2 Tail of train passing

Potential to cause direct and fatigue failure on trackside structures, or adversely affect passing trains

**Figure 1 — Pressure signal at a point on a vertical wall caused by train passing**

## The problem

- The current CEN code "Railway applications — Aerodynamics — Part 4: Requirements and test procedures for aerodynamics on open track" BS EN 14067-4:2005 includes some information on the loading of trackside structures due to the pressure transients from passing trains.
- This data has been obtained for continental loading gauges
- Information required for GB gauges for use in National Annex to code.

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## The project

- To meet the needs RSSB commissioned a series of TRAIN Rig tests as part of project T750 "Review Of Euronorm Design Requirements For Trackside And Overhead Structures Subjected To Transient Aerodynamic Loads"
- Phase 1 – the review stage – completed, and recommended that experiments be carried out to determine loadings on trackside structures typical of those found in Great Britain

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# The project

- Phase 2 has objectives
  - To acquire pressure curves of the type in BS EN 1991-2:2003 that can be trusted to reflect GB conditions, and which RSSB can use to propose specific advice for the UK National Annex to BS EN 1991-2:2003 to meet the project objectives.
  - To acquire factors for adjusting existing design curves in BS EN 1991-2:2003 for GB gauge rolling stock and for applying to continental gauge rolling stock.
  - 3To identify the degree of variance between the existing pressure curves in BS EN 1991-2:2003 and potential new GB-specific pressure curves, to inform RSSB's decision on committing to additional work packages planned for design work and full-scale testing

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- Outline of experimental results
- Validation of TRAIN Rig
- Comparison of results with code values
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- Conclusions

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# Who did the work?

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# The TRAIN Rig

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# The trains

Class 390

Class 158

Class 66

# Train models

Class 158

Class 390

Class 66

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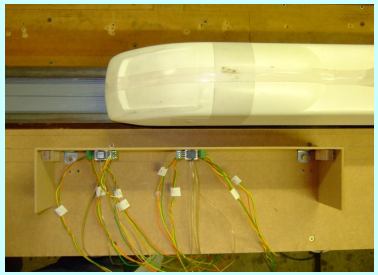
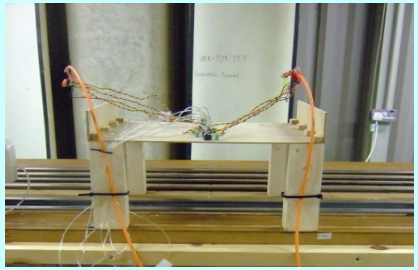
# The structures

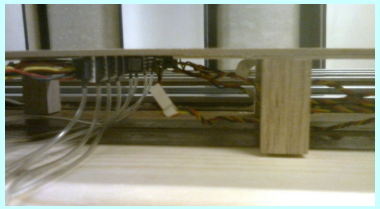
# The infrastructure models



Hoarding



Overbridge



Trestle platform

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# The infrastructure models

Canopy models

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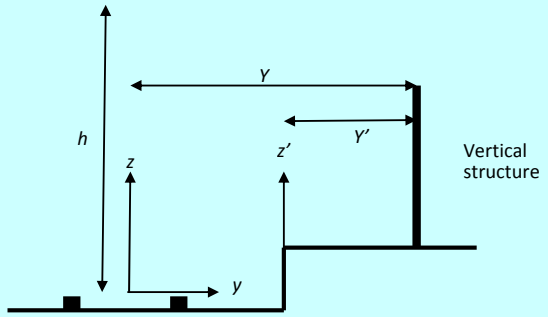
# Notation

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# Pressure coefficient

- Pressure is expressed in a non-dimensional form – the pressure coefficient

$$C_p = \frac{p - p_r}{0.5\rho v^2}$$

- If measured accurately at model scale, then the results can be applied directly at full scale

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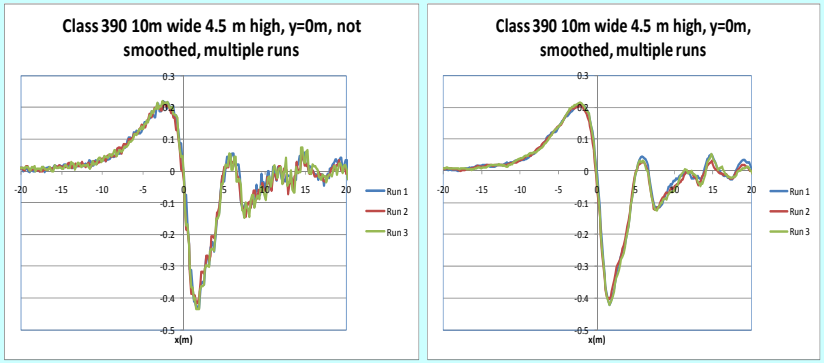
# Initial runs – overbridge case

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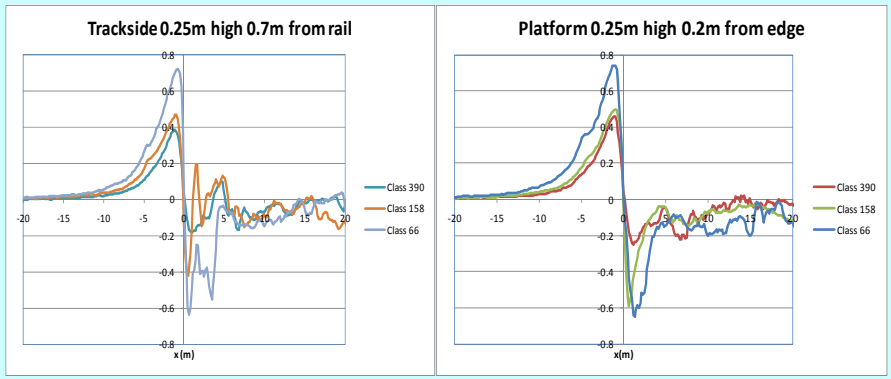
# Hoarding results – all trains

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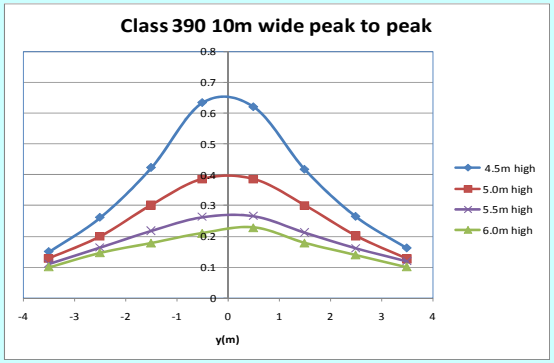
# Bridge results – lateral variation

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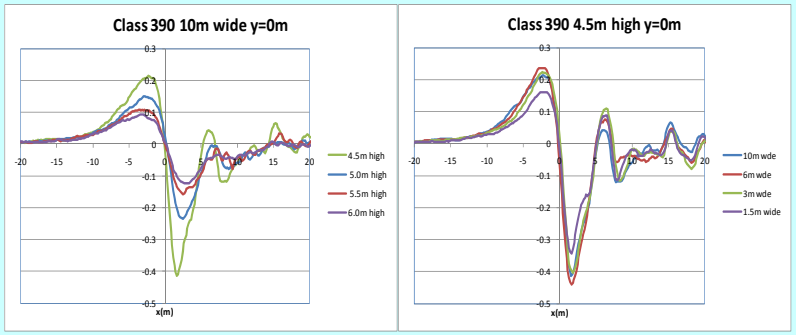
# Bridge results – variation of height and width

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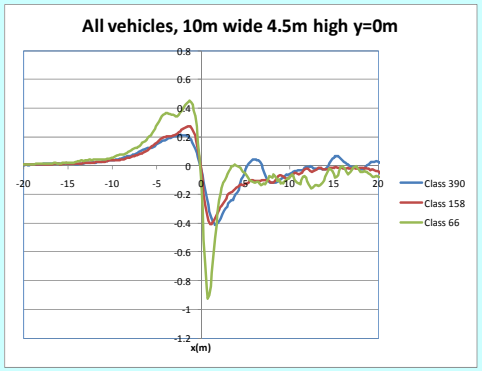
# Bridge results – all trains

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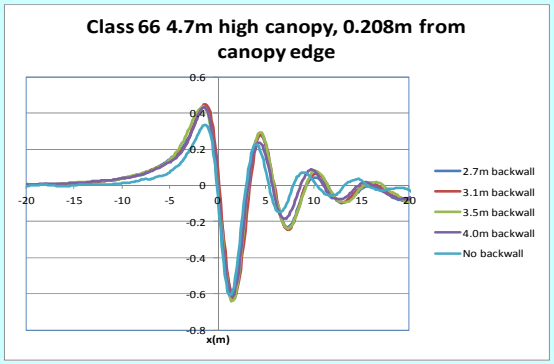
# Canopy results – backwall variation

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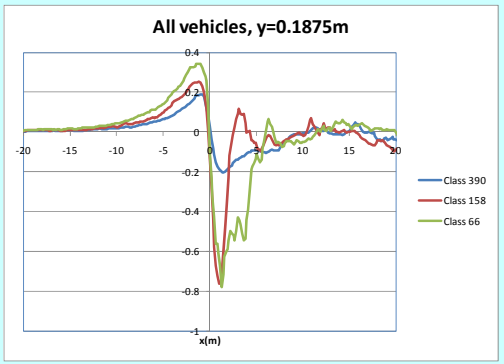
# Canopy results – all trains

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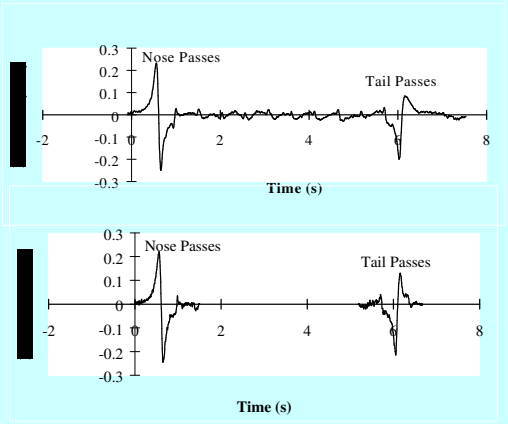
# Validation of TRAIN Rig




Full scale

TRAIN Rig

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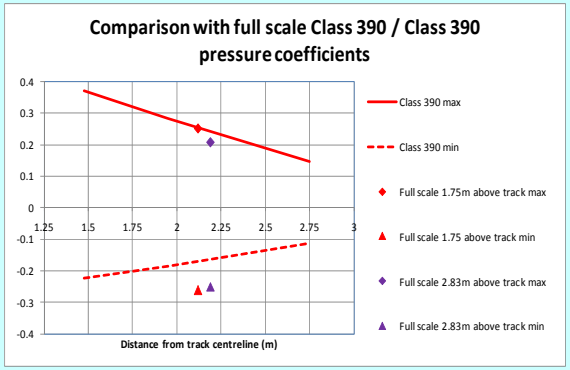
# Validation of TRAIN Rig




Pressures on stationary Class 390 passed by a Moving Class 390

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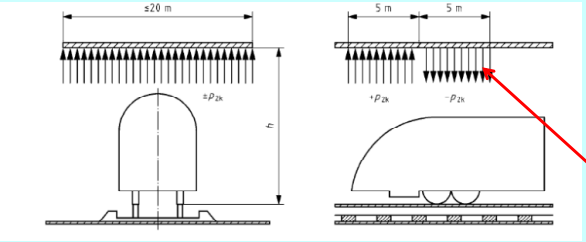
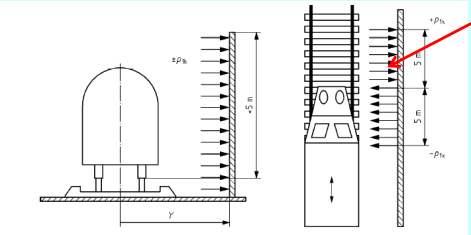
# Code formulation




Symmetric pressure transient 5m long

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# Code formulation

- Loads obtained in early 1990s from full scale tests and simple "panel method" CFD calculations.
- Transient load assumed to be symmetric i.e. positive and negative peaks the same.
- Constant positive and negative loads over 5m lengths (effectively an averaging of data)

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# Code formulation

- Basic formula for freight train shapes.
- For passenger trains pressures multiplied by 0.85
- For "streamlined" high speed trains pressures multiplied by 0.60

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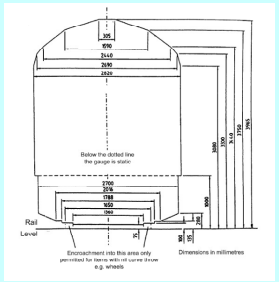
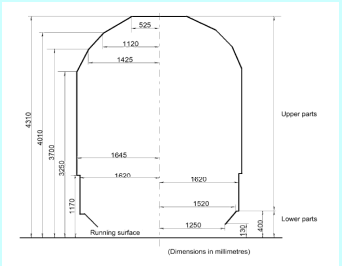
# Corrections of code




GB W6 gauge




Continental G1 gauge

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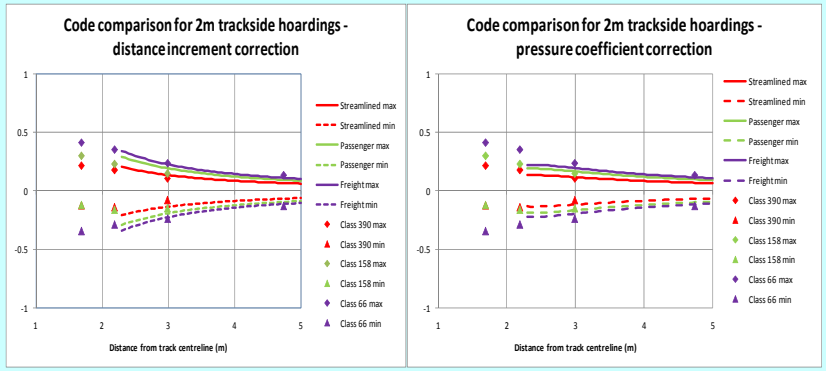
# Corrections of code

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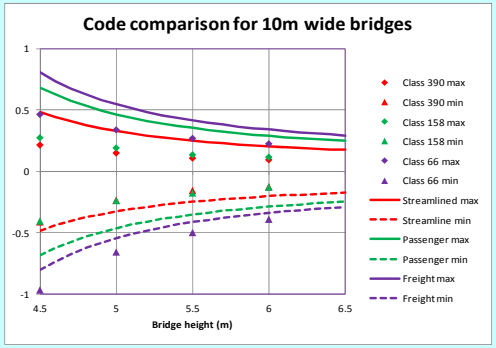


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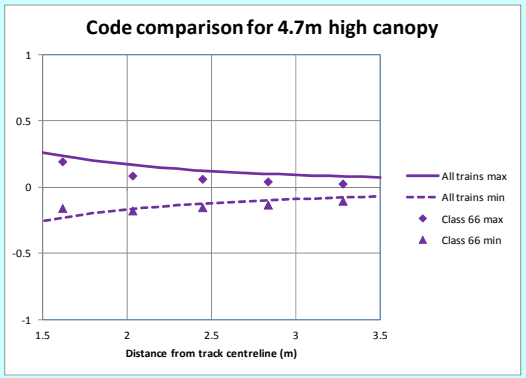


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# Derivation of GB design curves

- From an analysis of all test data
  - Class 158 pressures = 0.53 x Class 66 pressures
  - Class 390 pressures = 0.43 x Class 66 pressures
- Not fully consistent with assumptions made in the current code
- Data for all trains normalised with the above figures
- Assumption of symmetry maintained

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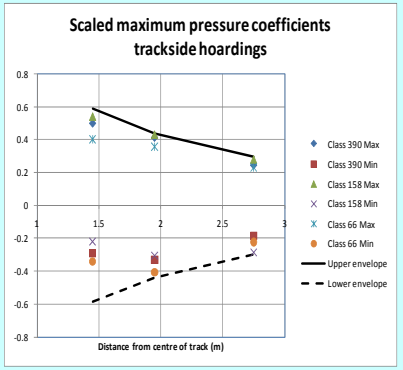
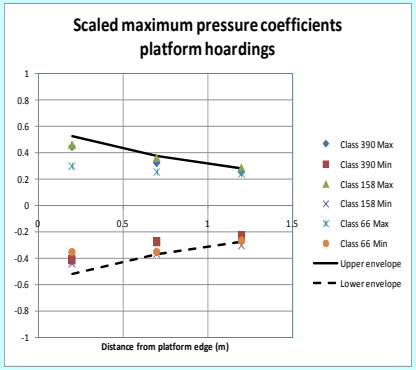
# Derivation of GB design curves

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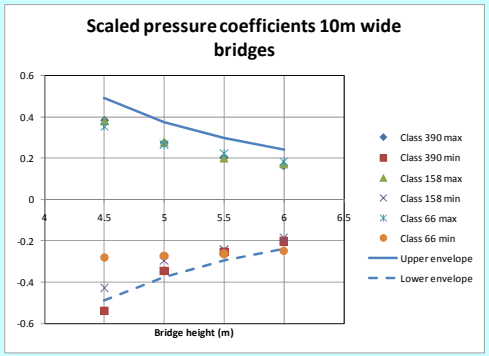


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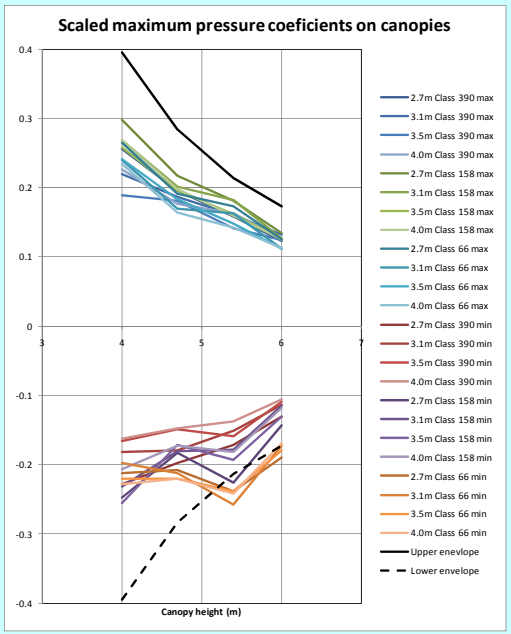


# Derivation of GB design curves

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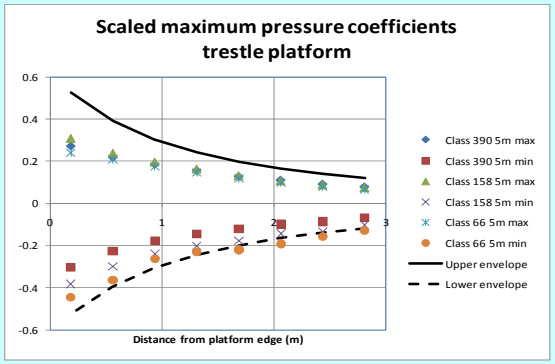


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# Conclusions

- The TRAIN rig proved to be a viable method for measuring the loads on trackside structures due to passing trains
- Pressure distributions of expected form although
  - The positive and negative peaks are not in general symmetric, as assumed in current code
  - The ratio of the pressures between trains of different types was rather different from that assumed in the current code.

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# Conclusions

- In general the pressures are consistent with the values in the current code, provide that the latter is corrected to allow for the different train / structure displacement in the UK.
- Provisional design curves are derived that can form the basis for the development of the National Annex to the code.

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