17th Nordic Seminar on Railway Technology, Oct. 3-4, 2012, Bro, Sweden

Wheel/rail friction loss during tram braking when using $MgCl_2$ as a dust binding agent

Presented by

Kjell Arne Skoglund, Dr. Eng.

SINTEF Building and Infrastructure, Road and Railway Engineering

Contact: E-mail Kjell.Arne.Skoglund@sintef.no, mobile +47 916 72 718

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Introduction

Accident in Trondheim Nov. 5, 2009: A tram ran into a bus form behind, 4 persons injured

SINTEF was engaged by the Accident Investigation Board Norway to look into the track conditions.

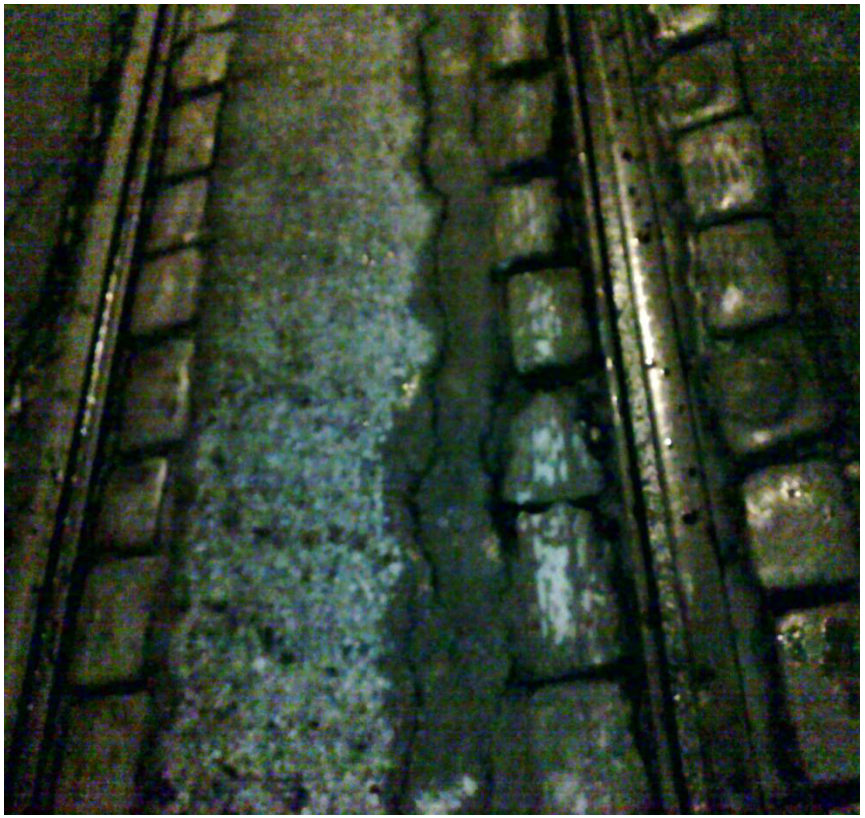
Test set up and test conditions

Primary suspect: $MgCl_2$-solution as a dust binding agent

- To test this hypothesis, braking tests for four different track conditions were conducted by means of an ordinary tram:
  - Dry track
  - Wet track (water)
  - Track wet with $MgCl_2$ in the same way as for dust binding, followed by immediate testing
  - Dried $MgCl_2$ – allowing some half day of traffic and of drying before testing (similar conditions as in the accident)
- Three different braking procedures: Normal (disk brakes, friction controlled/skid protected), emergency (electromagnetic track brakes), emergency with one of four brakes disconnected
- Three different target velocities: 5, 15, 30 km/h

A total of approx. 110 individual braking tests were conducted

Test location



Droplets of $MgCl_2$ spread on the track (25 g/m^2)

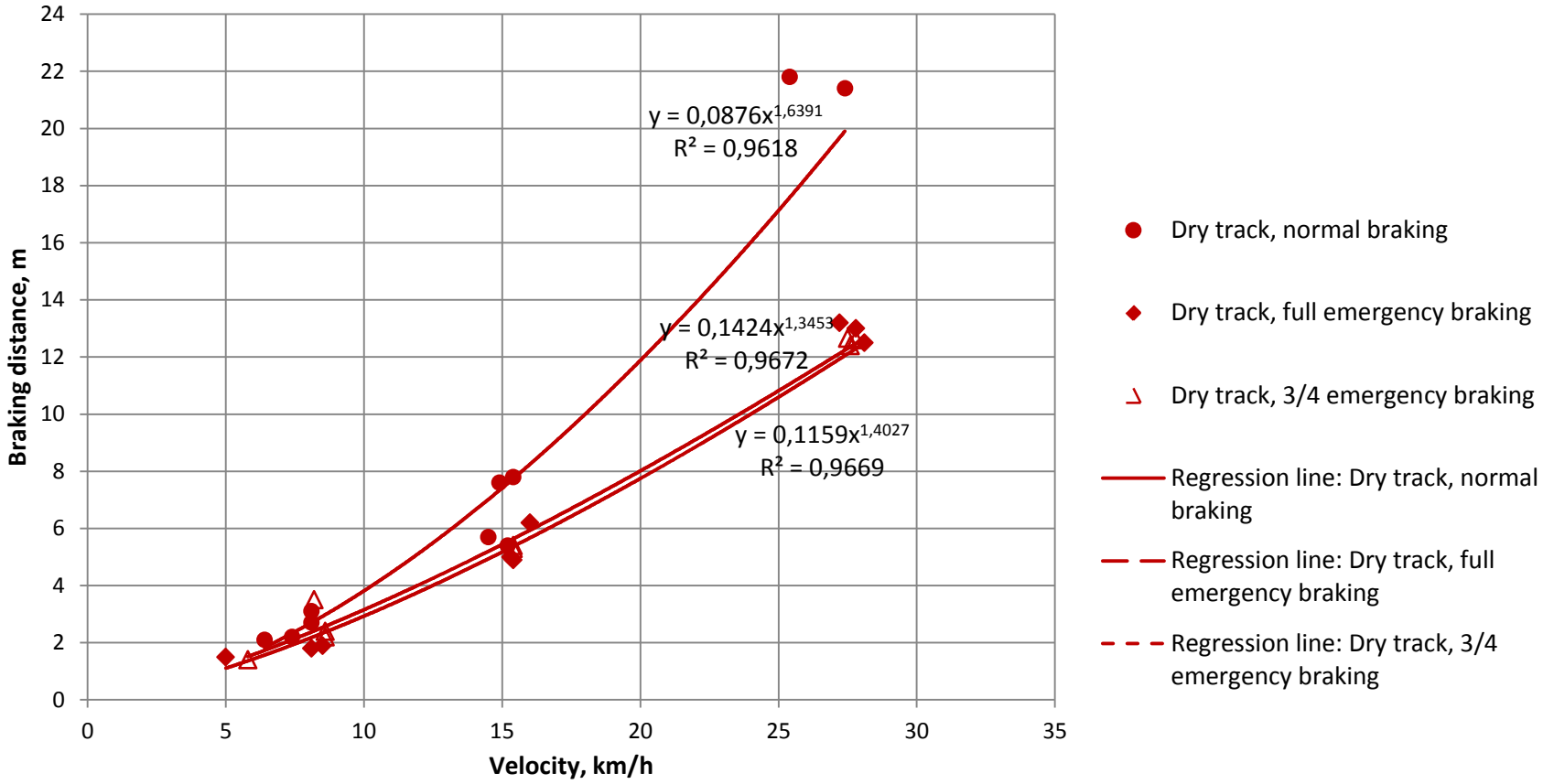
Test conditions, cont.

Magnesium chloride:

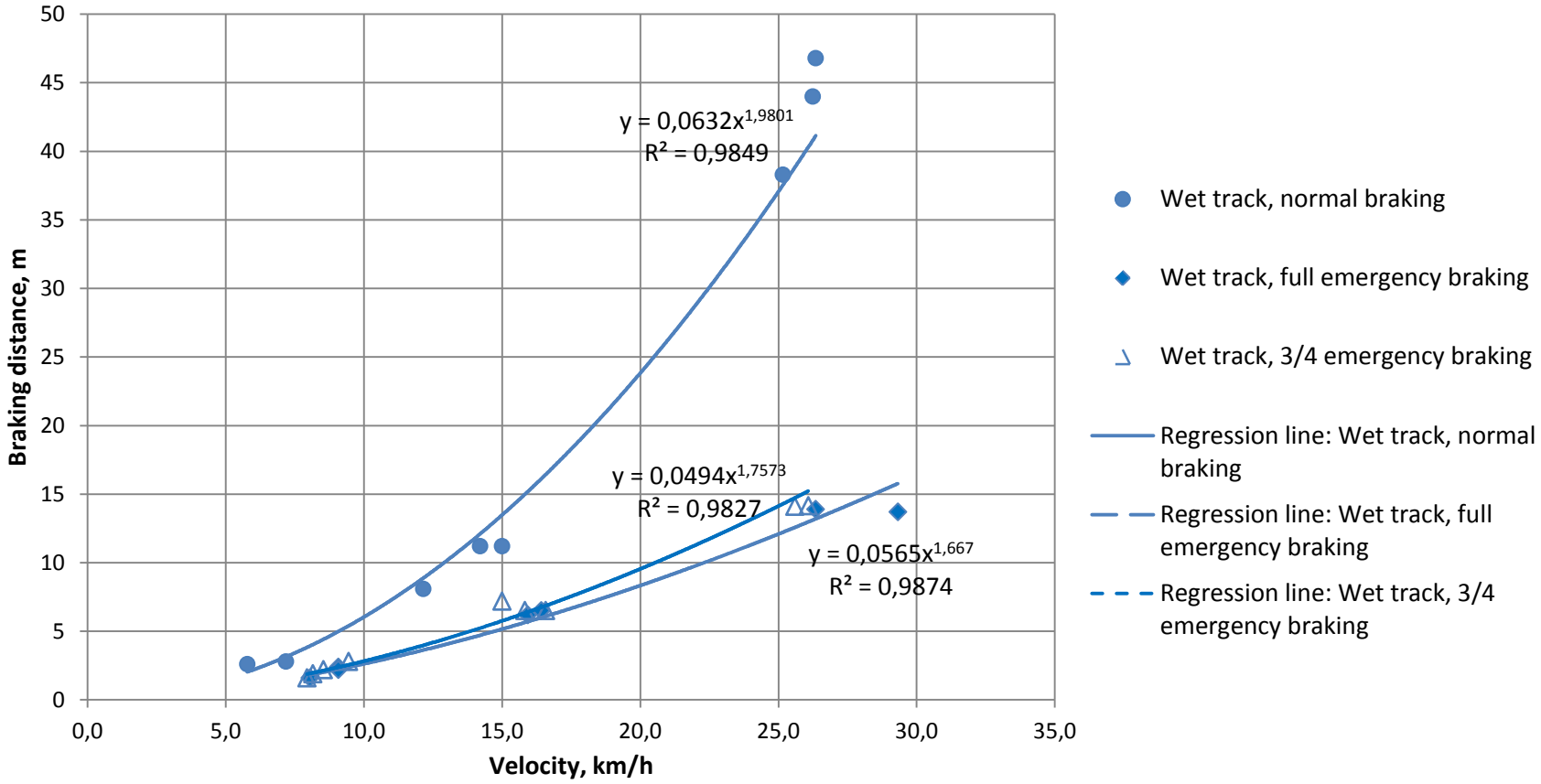
- 20 % $MgCl_2$ solution
- Applied at an amount of 25 g/m^2
- (Freezing temp. of -27,4 °C)

Dark coating forming when $MgCl_2$ is drying

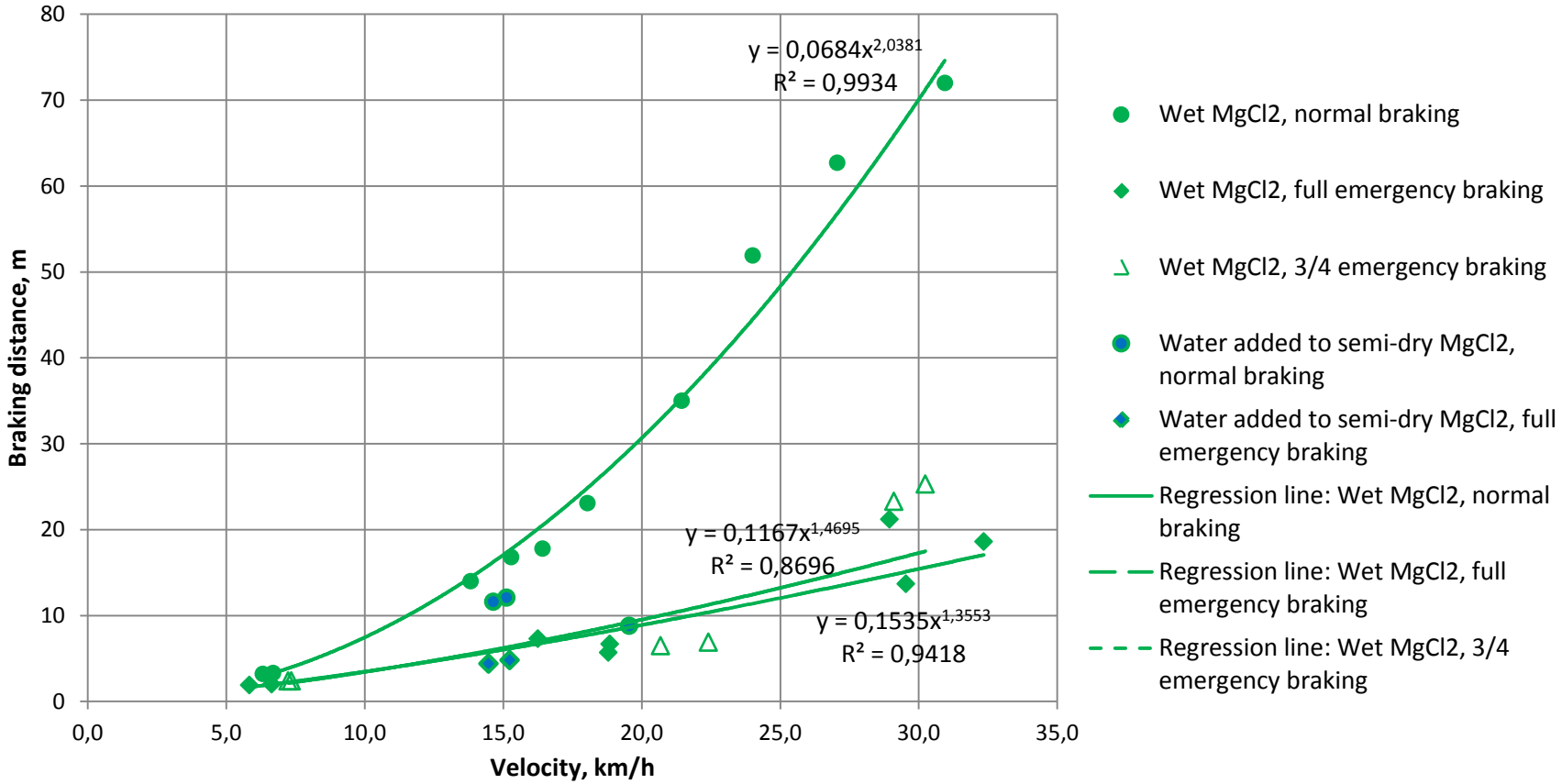
Test results: Dry track



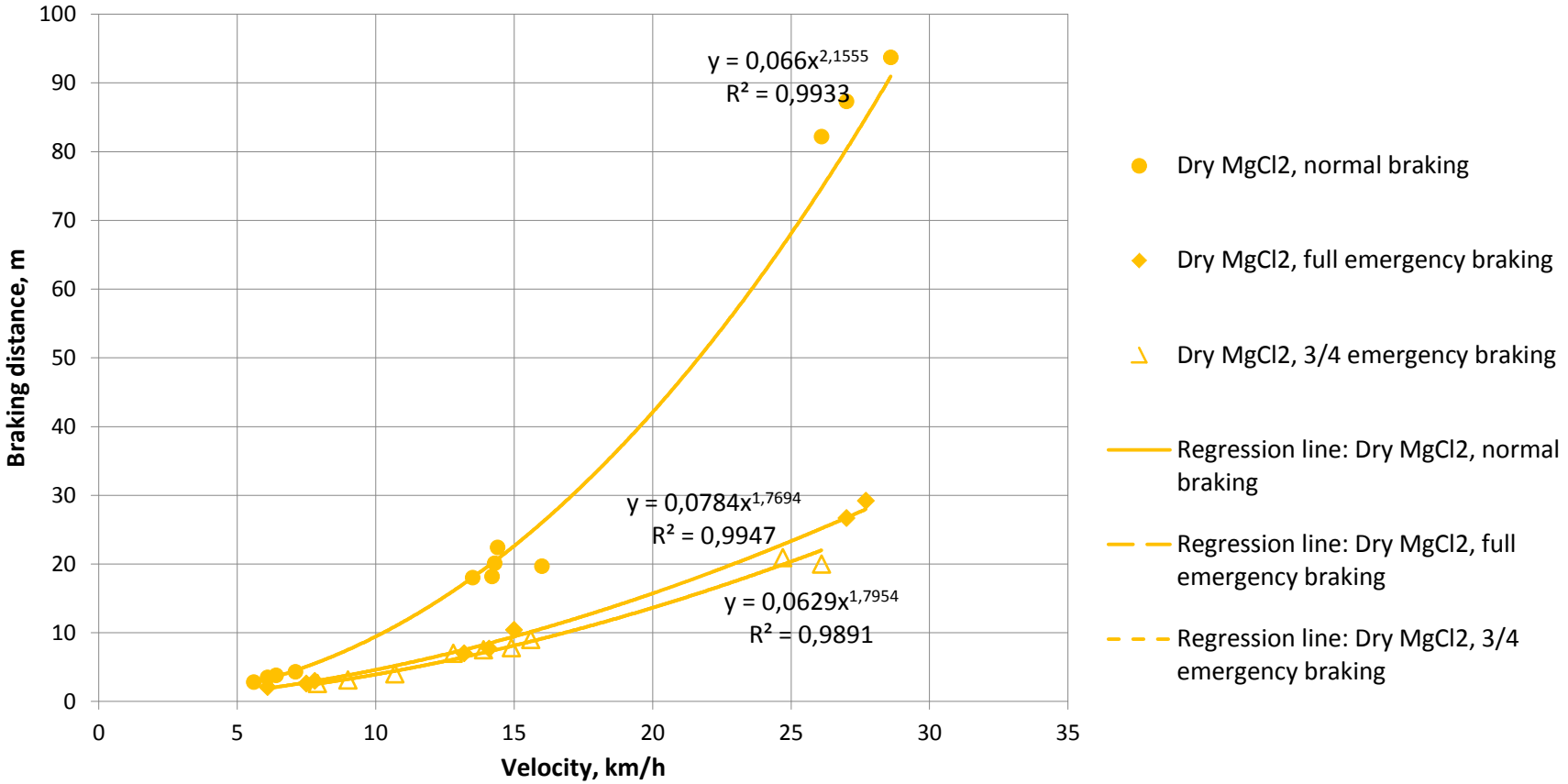
Test results: Wet track



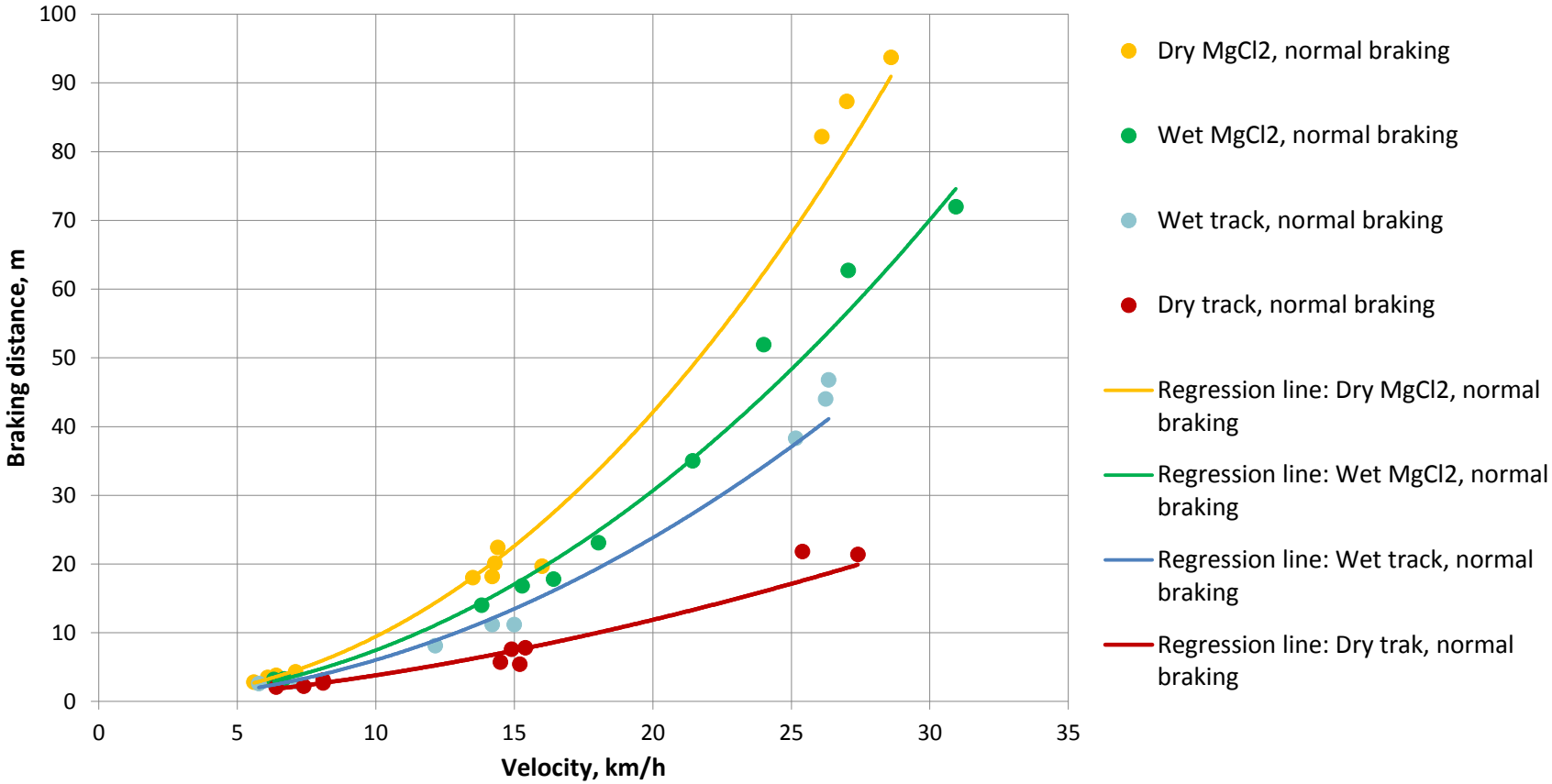
Test results: Wet $MgCl_2$



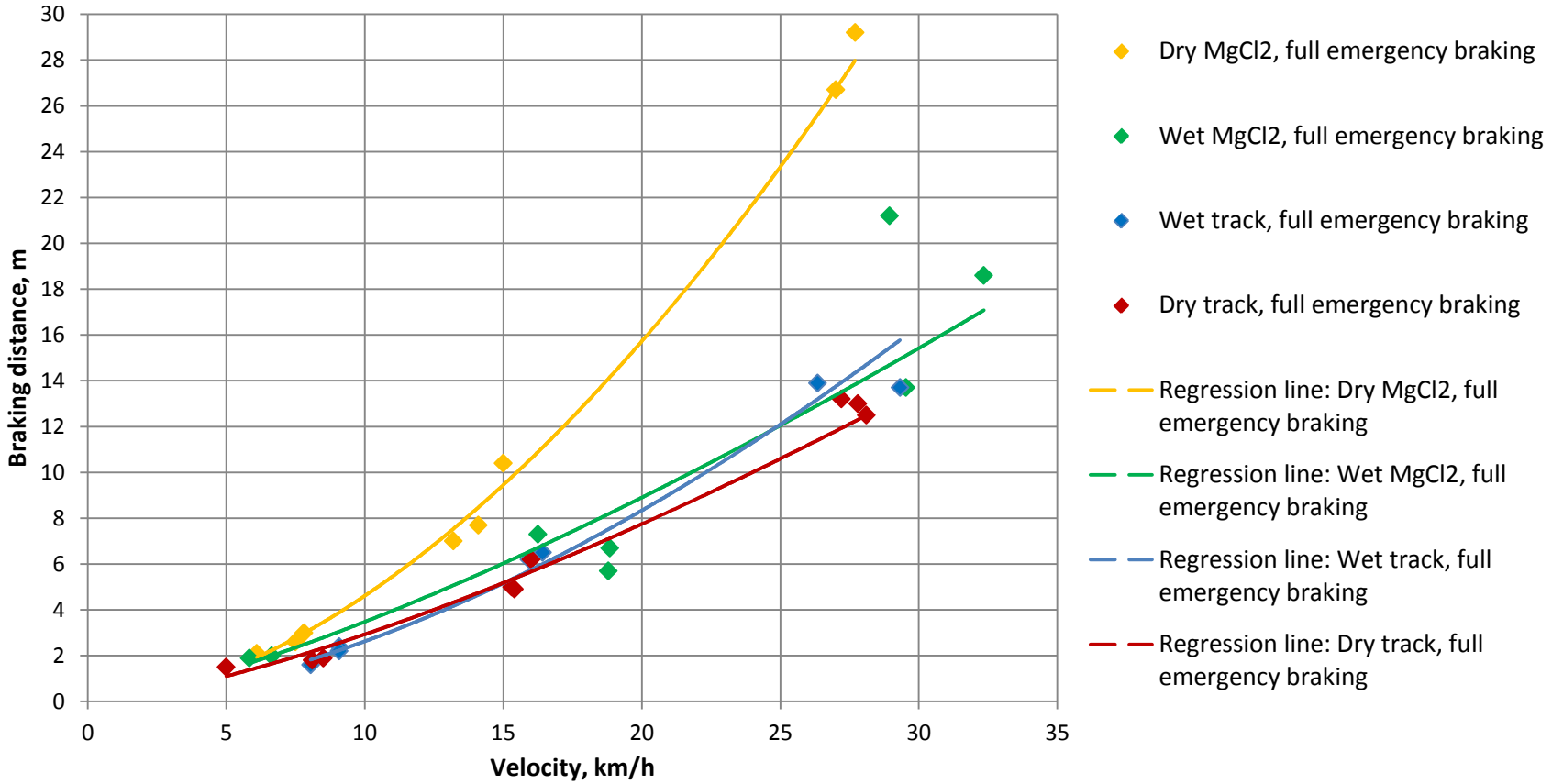
Test results: Dried $MgCl_2$



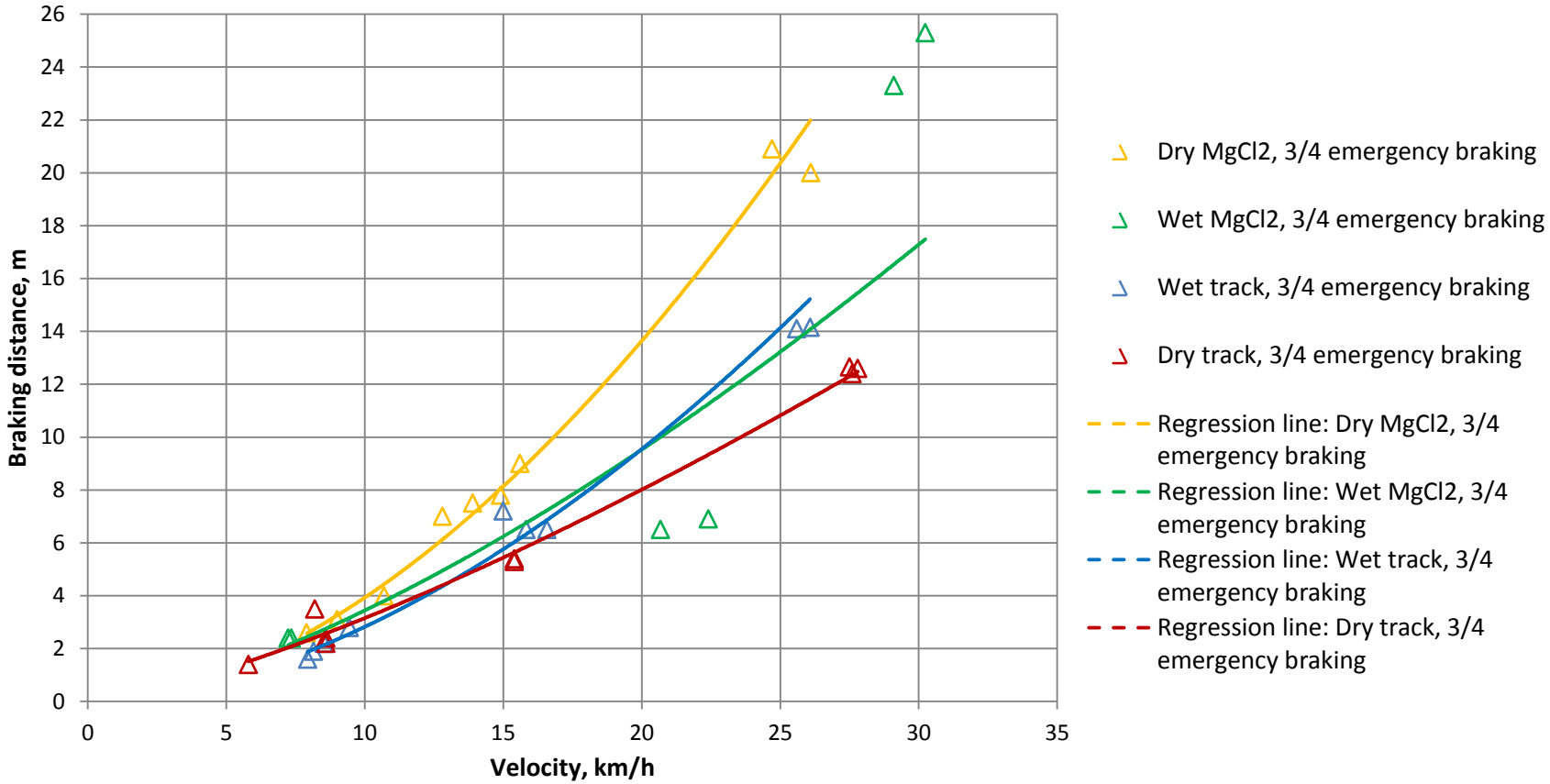
Test results: Normal braking



Test results: Full emergency braking



Test results: 3 of 4 emergency brakes in operation



Conclusions from the tests

- $MgCl_2$ added to the track gives substantial longer braking distances
- Dried $MgCl_2$ generates the longest braking distances – longer than for wet $MgCl_2$
- Electromagnetic emergency braking substantially reduce the braking distances, and also the differences in braking distances, for all track conditions.
- The relative differences in braking distances are less for all track conditions when using emergency braking as opposed to normal braking – emergency braking compensate somewhat the adverse effect of $MgCl_2$
- If one out of four emergency brakes is out of operation, the effect on the braking distance is notable, but not substantial
- The exact mechanism behind the effect of MgCl2 was not investigated, but is believed to be connected to the amount of bonded water in the layer containing $MgCl_2$
- Lab tests of the black layer on top of rail were inconclusive

Same problem in other cities – or in other circumstances?

- Trams in Nordic countries: Helsinki, Göteborg, Stockholm, Norrköping, Oslo, Bergen, Trondheim, (Tampere and Turku form 2016?)
- Studded tyres allowed in Finland, Norway and Sweden

→ A potential for the need of dust binding agents

- Oslo is also using $MgCl_2$, but restrictions imposed

- What about level crossings, quay tracks or other embedded tracks with road traffic?
- What about other compounds used as dust binding/ice melting agents like calcium magnesium acetate (CMA), salt (NaCl), sugar compounds etc.?

Acknowledgements

- Financing of the study: Statens havarikommisjon for transport (Accident Investigation Board Norway)
- Some lab tests: Forsvarets forskningsinstitutt

Link to full report: http://www.aibn.no/Jernbane/Rapporter/2011-01

Lesson to be learned:

Don't use $MgCl_2$-solution for dust binding in streets where you have trams!

Thank you for your attention!