Optimisation of trackbed design and maintenance

SUP&R ITN
Sustainable Pavement & Railway Initial Training Network

IFSTTAR

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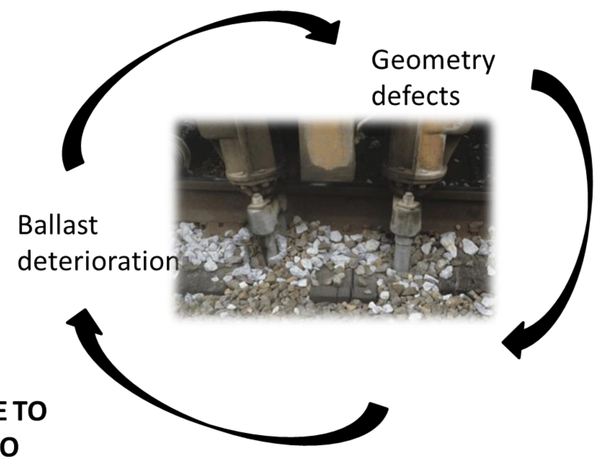
BACKGROUND OF THE PROBLEM

BALLAST RELATED PROBLEMS:

- Fast tendency to settle and deteriorate
- Frequent maintenance is needed to restore geometry
- High costs and material consumption
- Relatively low trackbed durability



RE-THINK RAILWAY SUBSTRUCTURE TO IMPROVE TRACKBED RESISTANCE TO PERMANENT DEFORMATION AND DURABILITY

Proposed stabilisation method: BSB

Solution	*Reduction in ballast settlement*	*Decrease in stress transmitted to sublayers*	*Decrease in rail deflection*	*Reduction in ballast deterioration*	*Reduction in trackbed maintenance*	*Possible reduction in trackbed thickness*	*Easy in installation and deployment*	*Easy in track geometry maintainability*	*Increase in initial costs*	*Expected reduction in lifecycle costs*
Elastic elements (UPSs, UBMs, etc.)	✻	✓	✻	✓	✓	✓	×	✓	€€	✓
Geosytnthetics (Geogrids, Geocells, etc.)	✓	✓	×	✓	✓	✓	×	✓	€€	✓
Polyurethane stabilisation	✓	✓	✻	✓	✓	✓	✻	✻	€€	✓
Bituminous layers (HMA)	✓	✓	✓	✓	✓	✓	×	✓	€€	✓
Ballast bonding by resins	✓	?	✓	✓	✓	✓	✓	✻	€€	×
Grout stabilisation	✓	?	✓	✓	✓	✓	×	×	€€	?
Bitumen Stabilised Ballast (BSB)	✓	✓	✓	✓	✓	✓	✓	✻	€	✓

✓: it has a positive influence
×: it does not have sensible influence
✻: the influence depends on the specific solution among the those of the category
?: not enough information are available to quantify the influence
€/€€: relative small increase/ relative high increase

METHODOLOGY

Use of Pneumatic Unbound Material Analyser (PUMA) test to analyse in small scale the influence of bitumen emulsion on ballast mechanical behaviour
PUMA TEST

Use of Flowability test to evaluate the ability of different bitumen emulsions to penetrate and quickly set into the aggregate skeleton
FLOWABILITY TEST

Full-scale evaluation of the effectiveness of tamping and stoneblowing on ballast (clean, moderately fouled and highly fouled) post-maintenance mechanical behaviour
BALLAST BOX (UNOTT)

Full-scale analysis of bitumen emulsion ballast stabilisation (clean and fouled) for newly constructed and existing track bed (during tamping and stoneblowing); assessing its effectiveness on resistance to permanent deformation, degradation, stress distribution, stiffness and energy dissipation
BALLAST BOX (UGR)

Evaluation of the influence of temperature on bitumen stabilised ballast mechanical behaviour
PUMA TEST

Field trials
TRIAL PIT

LCA and LCCA of the proposed technology

GOAL: DEVELOP A MORE SUSTAINABLE TRACKBED

Literature review on ballasted track main problems and current technologies proposed to mitigate them

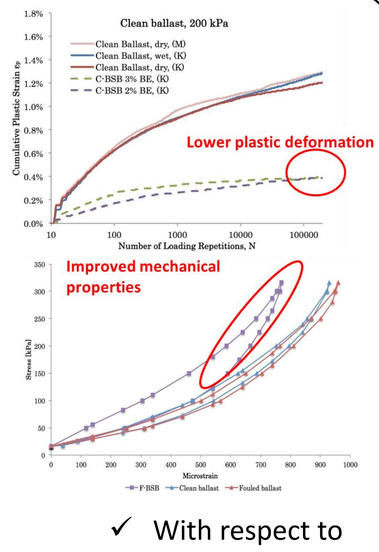
Identification of ballast testing methods which reflect field performance

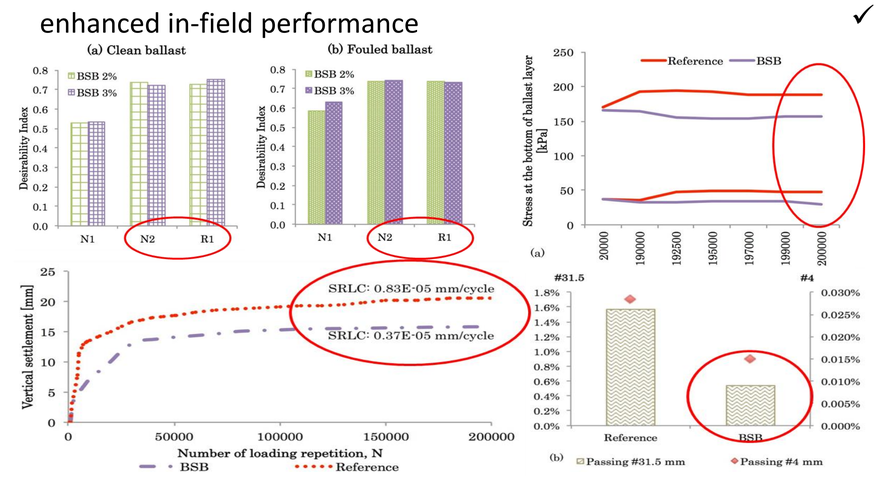
Evaluation of the effectiveness of current routine maintenance operations to restore track geometry

Study of bitumen emulsion as ballast stabilisation method for newly constructed or exiting track (during a maintenance task)

HIGHLIGHTS

- ✓ PUMA tests showed that bitumen stabilisation has the potential for increasing resistance to accumulation of permanent deformation and deformation rate, especially increasing the dosage
- ✓ Stabilisation process increased also the capacity of ballast to dissipate energy, highly desirable for damping dynamic loads
- ✓ Comparing different bitumen emulsions by an optimisation methods showed that scenarios with higher dosage of bitumen emulsion having higher viscosity, quicker setting behaviour, and harder base bitumen seems to be the most desirable to achieve enhanced in-field performance





- ✓ With respect to conventional ballast, this technology, by reducing stress transmitted to the sublayers and the degradation of ballast particles, has shown also the potential of increasing trackbed durability
- ✓ Full-scale box tests highlighted the potential for BSB to reduce ballast problems associated with its unbound nature such as settlement and particle deterioration, limiting therefore the need for maintenance and increasing trackbed durability

Dissemination

- G. D'Angelo, N. Thom, D. Lo Presti, ***Using the PUMA Test to predict Performance of Stabilised Ballasted Trackbed***, in J. Pombo (Editor), *Proceedings of the Third International Conference on Railway Technologies: Research, Development and Maintenance, Civil-Comp Press, Stirlingshire, UK, doi:10.4203/ccp.110.10*
- G. D'Angelo, N. Thom, D. Lo Presti, ***Bitumen stabilised ballast: A potential solution for railway track-bed***, *Article in* Construction and Building Materials 124(2016):118-126 · July 2016 doi: 10.1016/j.conbuildmat.2016.07.067
- G. D'Angelo, D. Lo Presti, N. Thom, ***Optimisation of bitumen emulsion properties for ballast stabilisation***, *Article* accepted in Materiales de Construciones
- G. D'Angelo, M. Sol-Sanchez, N. Thom, D. Lo Presti, Ma Carmen Rubio-Gamez, ***Bitumen stabilized ballast: a full-scale investigation on its use for existing and newly constructed railway trackbeds***, Proceedings of TRB 2017, Washington, USA,
- G. D'Angelo, M. Sol-Sanchez, F. Moreno-Navarro, D. Lo Presti, N. Thom, ***Use of bitumen stabilised ballast for improving the effectiveness of conventional maintenance processes***, *Article* submitted to Geotechnique

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