Centre for Geomechanics and Railway Engineering (CGRE)

Background: The Centre for Geotechnics and Railway Engineering (GRE) was established at the University of Wollongong under the leadership of Professor Buddhima Indraratna more than a decade ago and as a result of several geotechnical and rail track projects funded by the ARC since the mid-1990s. GRE has continued to prosper through numerous external grants (ARC DP and Linkage, CRC for Rail Manufacturing), and is one of the 3 nodes forming the ARC Centre of Excellence for Geotechnical Sciences and Engineering. The CGRE is well equipped with state-of-the art rail geotechnical laboratories and excellent technical staff support. The CGRE is actively engaged in a number of key areas, including the dynamic modelling and prediction of track performance in poor soils, automated monitoring of track defects, assessment of wheel-rail-ballast degradation, effect of slope movements on rail tracks, improvement of soft coastal clay subgrade foundations, remediation of acid sulphate soils to prevent corrosion of track components, decision support systems applied to track maintenance scheduling, stability assessment of rail corridors and embankments, use of synthetic materials for improving sub-surface drainage and reducing track deflection, and the role of filtration in eroded soil retention.

Fig. 1. *CGRE staff and students portrayed in seminars, and in the Rail laboratory.*

Nature of Research Projects: Currently GRE has 15 full-time researchers including 6 postdoctoral fellows, plus 5 dedicated technical staff trained in rail geotechnology testing. It has been recently acclaimed by Engineers Australia as the most prominent base for rail transportation geotechnics in Australia, with a worldwide reputation for its fundamental and applied research. It carries one of the highest research student numbers of a single research unit at UOW including 37 ARC, CRC-Rail and Endeavour PhD scholars. The Centre's national and international reputation hails from a number of key strengths such as: computational modelling and performance prediction of high-speed rail on poor ground conditions, ground improvement and stabilisation of soft and problematic soils for rail infrastructure development, as well as design innovation in rail corridors (e.g. Fig 2 and 3).

Fig 2. *CGRE research involving mud pumping, ballasted rail track improvement through the use of geogrids and real time performance monitoring.*

Key Outcomes and Impact to Industry: Through proven excellence by an active group of researchers, it executes a wide range of geotechnical research and consulting projects. Their impact on industry over the years has been significant, particularly in the revision of existing Australian standards for rail ballast (AS 2758.7) that has already been adopted in rail practices in NSW.

Sources of Funding: Major funding sources are from the Australian Research Council (ARC), Cooperative Research Centre (CRC) for Railways and direct Industry funding through linkage and partnership grants. As a result, the CGRE has now grown to attract an average annual budget exceeding $2.5M. The research of CGRE was crucial for initiating $10M grant from RailCorp in 2009 for rail research, and ARC has recently contributed over $4M of grants for National Facility for High Speed Rail Testing and associated industry Linkage projects.

Railway research Projects:

: (i) Cooperative Research Centre for Rail Manufacturing (2014-2020) co-supported by Australian Rail Industry partners such as Sydney Trains, Australian Rail Track Corporation Ltd. (ARTC), Aurizon.

CGRE is involved in a project on "Track Performance assessment capturing ballast degradation at high train speeds and use of shock mats". Large cyclic loads and impact loads exerted by heavy haul freight train traffic can cause significant deformation and degradation leading to poor track geometry. Therefore, it is essential to study the load-deformation behaviour under high cyclic frequencies. In this project these mechanisms will be studied along with the utilization of shock mats. Large scale laboratory tests will be conducted using unique large scale testing facility designed and built at the University of Wollongong.

(ii) Other selected National Competitive Grants for Transportation Infrastructure

(1) Performance of soft clay consolidated by biodegradable and geosynthetic vertical drains under vacuum pressure for transport infrastructure.
(2) Use of stone columns for stabilising transport infrastructure.
(3) The role of vegetation and associated root suction and reinforcement on the stabilisation of transport corridors and sloping ground.
(4) Cyclic behaviour of unstable soils stabilised by lignosulfonate for rapid transport infrastructure.
(5) Use of geosynthetics to improve performance of ballasted tracks
(6) Constitutive modelling of ballast and sub-ballast breakage and cyclic densification
(7) Use of geocells to increase confining pressure in track
(8) Computational modelling of track geotechnology using DEM and FEM simulations
(9) Large-scale process simulation testing and physical modelling of track behaviour under high speed rail
(10) Soft subgrade soil stabilisation with physical, chemical and bioengineering methods
(11) Native vegetation for applying tree root suction for increased subgrade stability
(12) Optimisation of rail operational speeds based on track performance at high cyclic loads
(13) Assessment of subgrade soil liquefaction under high cyclic load and frequencies.
(14) Ground improvement methods for subgrade liquefaction prevention
(15) Effect of ballast contamination by coal and subgrade pumping on track performance including drainage
(16) 3D modelling of particle angularity to optimise ballast gradation
(17) Use of energy-absorbing materials for improved track performance and reduced track degradation
(18) Experimental and numerical study of impact loads contributing to track damage
(19) Field monitoring and Instrumentation of Rail Tracks for Performance Verification
(20) Filtration and Drainage properties of Sub-ballast or capping layer to prevent ballast contamination
(21) Use of prefabricated vertical drains to minimise subgrade soil liquefaction
(22) Shakedown of ballast under vibrational loads and the implications on track design
(23) Modern track design methods capturing particle degradation and time-dependent volume changes
(24) Stabilisation of railway foundations by chemical treatment including waste materials


Port Kembla Project


Port of Brisbane


Installation of pressure cells at Singleton

Fig 3. *Compaction Field Trial at Port Kembla Reclamation Project, vertical drains installation in Port of Brisbane and field monitoring of track behaviour at Singleton.*

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