

## Case Analysis

# Western Belfast Bypass (SH1) Christchurch NZ

### Market Sector

**INFRASTRUCTURE**



### Application

**DEEP IMPACT COMPACTION**



### Project Phase

**SUSCEPTIBLE TO DIFFERENTIAL  
SETTLEMENTS AND POTENTIAL  
LIQUEFACTION**



**LANDPAC**

INTELLIGENT GROUND ENGINEERING SOLUTIONS

## Project

The proposed motorway extension alignment was categorised as inadequate subgrade in terms of strength for its potential use and potential future differential settlements. Liquefaction deformation limits were also categorised as requiring ground improvements from 1.5m to 3m depth. Landpac was engaged as the ground improvement contractor for the trial using High Energy Impact Compaction (HEIC) or (IC) to improve the ground by the in-situ densification of the upper soil in-situ sand stratum and reduce differential settlements and reduce the liquefaction potential at the site using HEIC).

## Soil Conditions

Based on the pre CPT's the material predominantly comprised of sand mixtures (silty sand to sandy silt) and clean sands to silty sands however the presence of silt mixtures (clayey silt & silty clay bands) was present in each of the CPT locations at varying depths and varying band thicknesses. The existing top soil was removed and replaced with a 200mm layer of shingle for the machine to traverse over.

**Client: New Zealand Transport Agency**

**Engineering Consultant: OPUS**

**Main Contractor: Fulton & Hogan**

**Ground Engineering Contractor: Landpac**

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Soil Conditions cont.

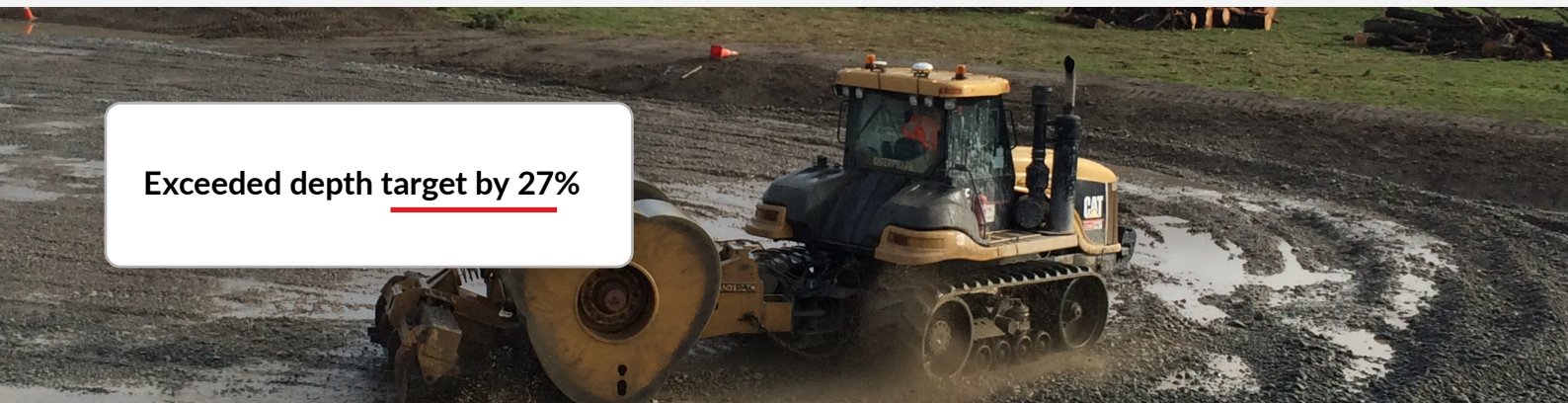
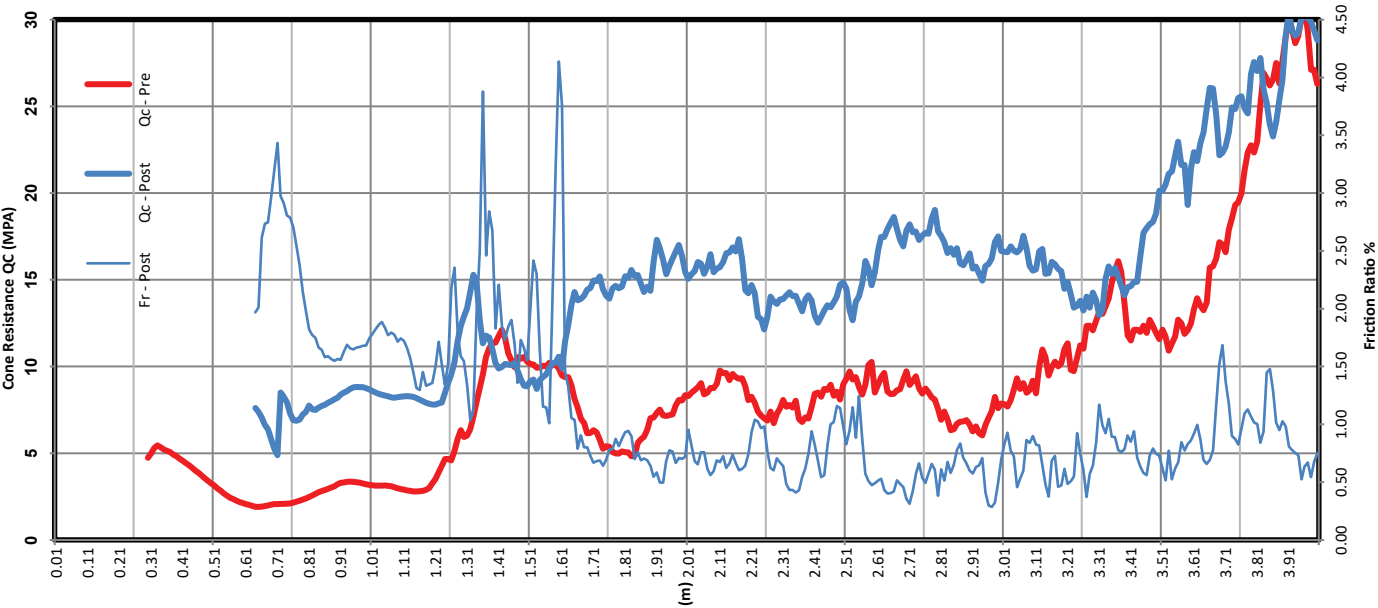
The subgrade was categorised as inadequate subgrade in terms of strength for its intended use due to potential future differential settlements and potential liquefaction deformation limits so considered as requiring ground improvement. Several clay lenses were also identified throughout the CPT's within the potential ground improvement influence zone. The potentially liquefiable sand stratum and inadequate strength material for the proposed project was predominantly within the upper 3m of the soil profile with water levels at 1.8m below OGL at the time of the pre geotechnical site investigation. During HEIC works it was evident that the water table was much higher than the indicated levels.

Geotechnical Solutions

Landpac was engaged as the ground improvement contractor for the trial using High Energy Impact Compaction (HEIC) or (IC) to improve the ground by the in-situ densification of the upper soil in-situ Sand stratum and reduce differential settlements and reduce the liquefaction potential at the site using HEIC.

The requirement was to use HEIC for the proposed motorway extension to improve the ground upto 3m depth due to potential liquefiable soil profile from 1.5 – 3m depth. Dynamic loads from HEIC operations (dynamic drum impacts) induce substantially greater stresses and strains in the ground than those associated with tri-axle trucks or comparable future heavy load road traffic. Vast improvements were achieved in the soil profile down to 4m depth. This was evident from the differential and overall average settlements achieved as well as the post CPT test results. Additionally, the increase in relative stiffness across the site was substantial.

CPT QC Pre vs Post



Exceeded depth target by 27%



## Monitoring & Verification/QA

During the works a relatively high water table was present so works were carefully monitored throughout the 70 passes that were completed. The 70 passes were done strategically at different sets and time intervals throughout the project to ensure pore pressures were taken into account as not to have adverse effects on the overall ground improvement works. Water was brought to the surface after 25 passes, exhibiting sand-boil-like behavior and flooding most of the area so we could not operate until the water had receded. These works were monitored with Landpac's ICM system during the HEIC process.

Throughout the works, assessments of relative soil stiffness and visual observations of sand boils were used to set the incremental pass sequence and the necessary rest periods to facilitate pore pressure dissipation. Overall settlements varied from the north to the south indicating the heterogeneity

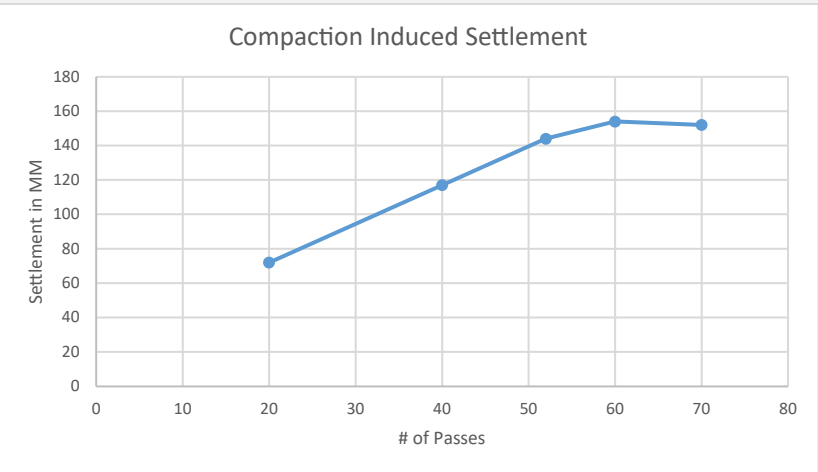
state of subgrade materials present in their untreated condition. HEIC ensured that a homogeneous subgrade profile was achieved up to 3m depth although average CPT's showed improvements upto 3.82m depth. The average recorded settlements across the area were significant and it is inferred from the settlement results that 60 to 70 passes was sufficient for this application.

A reduction in soil response (relative stiffness values) was evident in the southwest corner, where ICM indicated that excess pore pressures had likely developed, particularly after 40 and again after 70 passes. From both the settlement observations and the recorded relative stiffness values, 60 passes would have been sufficient

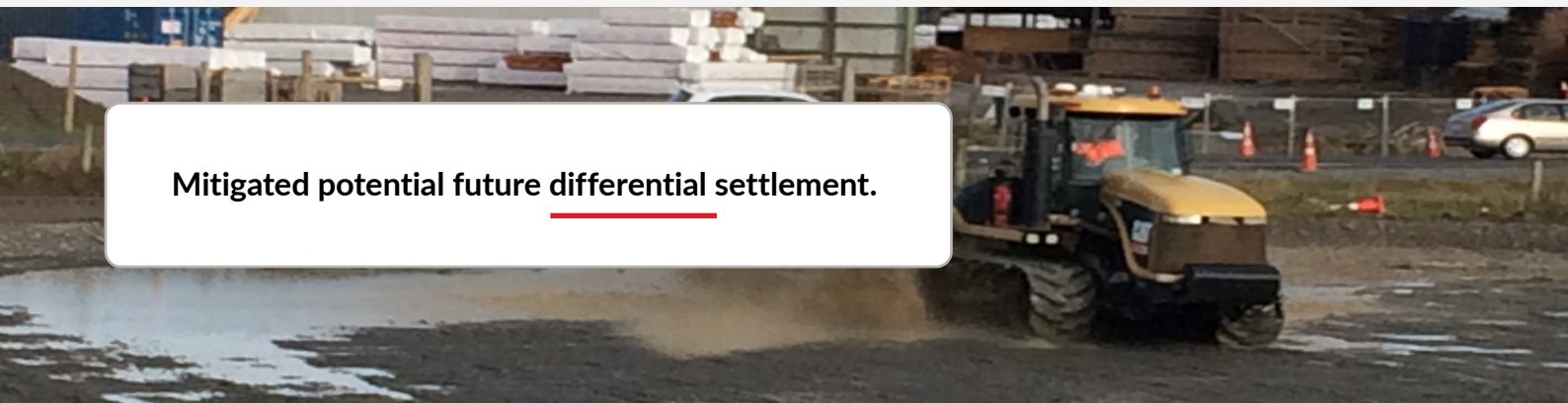
ICM is used and implemented so that localised zones with residual average settlement potential can be identified and treated with additional HEIC surface passes to ensure differentials are mitigated.

### Settlement

Compaction Induced Settlement



Mitigated potential future differential settlement.

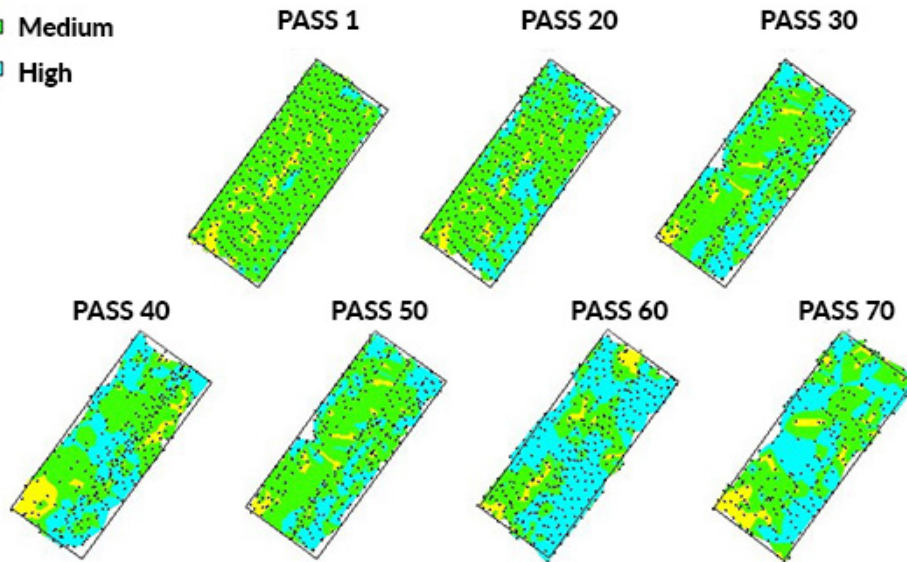


## ICM - Soil Response

### Verified optimal 60-pass compaction sequence

#### Soil Response

- Low
- Medium
- High



### Summary

- ✓ Remediated 3m liquefiable sand stratum.
- ✓ Improved soil strength to 3.82m.
- ✓ Managed high-water table and boils.
- ✓ Converted heterogeneous soil to uniform.

### Construction

Western Belfast Bypass is a proposed motorway extension along State Highway 1 (SH1) linking Johns Road to the existing Christchurch Northern motorway near Belfast, Christchurch in Canterbury, New Zealand.

### Get in touch

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