LANDPAC®

Intelligent Ground Engineering Services

CHSR Trial 1

CASE STUDY

☑ TRAIL ☐ OPERATIONAL

PROJECT INFORMATION

Project	California High Speed Rail CHSR
Location	Fresno, California
Client/Consultant	Dragados/Flatirons Joint Venture
Date	Jan 2017

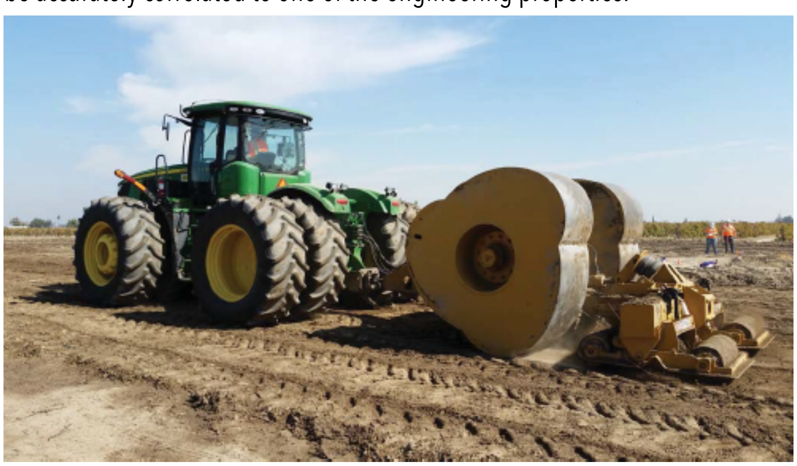
PROJECT DETAIL

The project entails the construction of one of the several rail construction phases, with the trial predominantly concentrating on the in-situ soil improvement

LANDPAC OBJECTIVES

The following objectives are critical:

- Improve the current bearing capacity of the soil with an overall goal of possibly reducing the embankment design requirements.
- Prove that the impact compactor will assist with advancing the planned project schedule.
- Achieve maximum primary settlement.
- Mitigate against potential future differential settlement.
- Prove that the Continuous Impact Response (CIR) measurement system can be accurately correlated to one of the engineering properties.



SOIL PARAMETERS/ANALYSIS

Geotechnical Data Report and Geotechnical Baseline Report (GBR) indicated the embankment test section mapped with Sand Dune deposits and recent Alluvial Fan deposits. The Sand Dunes were characterized as being cross-bedded, well-sorted medium to coarse sand and very fine to fine sand and silt. The Recent Alluvial Fan deposits underlie the Dune Sand and consist of granitic sand and silt deposits from highlands surrounding the area. Previous geotechnical data gathered from the vicinity indicate the materials encountered in the upper 20 feet of the subgrade generally consists of loose to medium dense Sand (SP) and Sand with Silt (SP-SM).

LANDPAC IN-SITU TRIAL

OVERVIEW

The in-situ trial was conducted by both a Landpac 3-sided 25kJ Impact Compactor and the Impact 3000 4-sided roller. The Landpac Impact Compactor was fitted with their proprietary GPS and axle accelerometer instrumentation to allow Continuous Impact Response (CIR) measurements throughout compaction operations.

LANDPAC 3-SIDED 25KJ IMPACT COMPACTOR

The Landpac roller was pulled by a John Deere 9460R tractor, at a speed ranging from about 7.5 to 9 miles per hour (12-14.5km/h). The Landpac equipment required a number of runs with the compactor to complete one coverage of the trial area (one pass). The drum configuration of the Landpac compactor allowed the compactor to be offset by one drum width with each longitudinal traverse of the test section by the compactor. In this way, by the time the compactor had covered the test area one time, the soil had received two full compactor passes. The methodology used would ensure that the section was 100% covered by the roller.

4-SIDED IMPACTOR 3000

The Impactor 3000 roller was pulled Case 350hp articulated tractor and the roller was a single drum roller with outside riding wheels which would generally leave a section between two alongside passes untreated by the compactor. In most cases, this is generally left untreated as, on the return pass, the outside wheels would have to run on the undulated and uneven compacted sections which would not be possible. In this case, this untreated section was in fact compacted to result in 100% coverage but in having to do this, a grader was used in order to level the pre-compacted sections.

CONVENTIONAL TEST RESULTS

During the Compaction trial for the Landpac test 30 passes of the 3-sided 25kJ was conducted whilst all compaction was halted after 20 passes with the Impactor 3000. The reason for the continued compaction with the Landpac Impact Compactor was due to the fact that the results had been achieved and continued improvement was clear with an increase in the number of passes whereas, with the Impactor 3000, very little improvement was visible beyond 15 passes, halting continued operations after 20 passes.

Each of the different compactors were given a trial section and the following tests were monitored.

Productivity was reported as follows:

Landpac 3-sided 25kJ Impact Compactor

Number of Passes	2	4	6	10	16	20	30
Time (minutes)	12	26	38	66	104	131	198

4-sided Impactor 3000

Number of Passes	3	5	7	10	15	20
Time (minutes)	31	85	106	135	219	304

The trial proved that the 4-sided Impactor 3000 took up to 2.3 times longer to compact the same number of passes as the Landpac 3-sided 25kJ Impact Compactor. This comparison was done on both methods having achieved 100% coverage, as explained above. If cost comparisons were to be done, the cost of a grader to support the 4-sided Impactor 3000 compaction process would have to be included.

Other Results with the Landpac 3-sided 25kJ Impact Compactor were reported as follows:

Density

Density results were achieved but, at some stage, it was clearly visible that the moisture content was increased without an increase in the density results with an increase in the number of passes. This was also experienced with the 4-sided Impactor 3000.

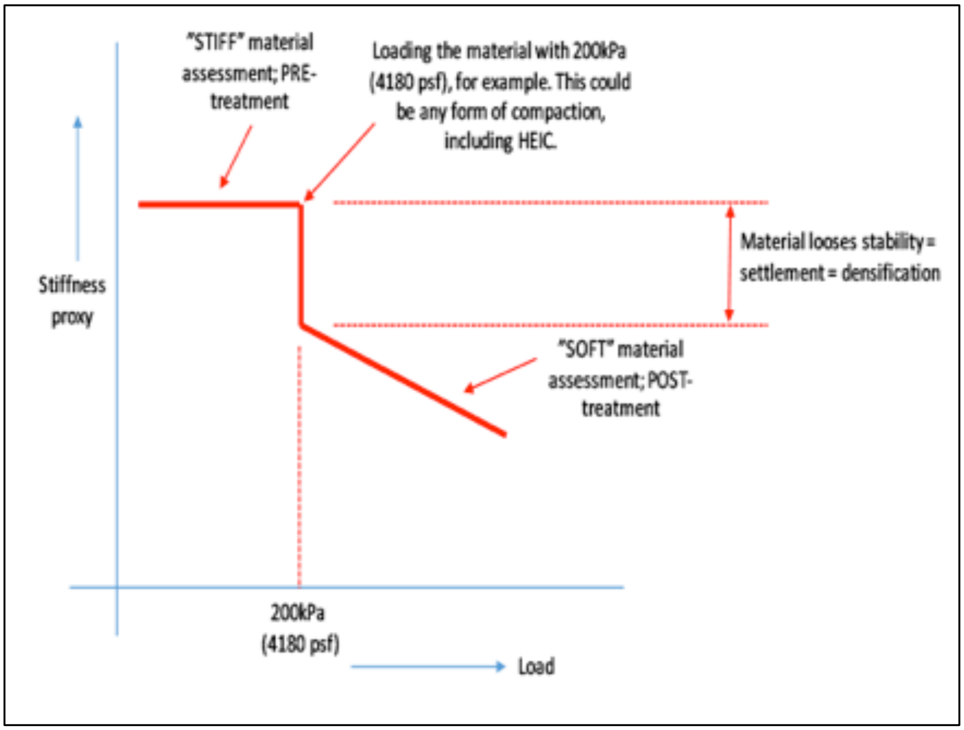
Plate Load Tests

Plate Load Tests were performed on the exposed subgrade and at a depth of 4 to 6 inches below the subgrade. It was established that an average EV2 of 10,000psi (69 MPa) was achieved, superseding the specification requirement of 6,500psi (45 MPa)

Shear Wave Velocities

The Shear Wave Velocities decreased post impact compaction, when compared to the velocities before compaction. A decrease in shear wave velocities post compaction is not an uncommon "phenomenon". Material particles are generally lightly cemented together or they are held together by "suction. When compaction takes place there is essentially a reduction in this suction or there is a break up in the cementation between the particles and this leads to some level of stability reduction and, eventually, some collapse. If the material is wetted, this will actually aid the collapse as the particles are more free to move with the added moisture. What this actually means is that any tests done prior to compaction would indicate a much stiffer layer but when compacted with dynamic load and, in addition, wetted, the material will collapse and then start building up stability again with further compaction. This phase may show a softer material when compared to the stiffer initial results but some densification has in fact occurred.

In other words, a shear wave velocity may show some deterioration but through the shifting in particles through compaction, we have actually achieved a higher density. This is exactly what happens, for example, on highly collapsible sands experienced in desert like environments with similar temperatures. Initial testing may, and generally will, indicate that there is no need for further improvement but when a dynamic load is applied with a wetting agent, the material collapses and becomes denser but some of the post compaction tests may show worse results where, in fact, there was a need for further densification.



Dynamic Loading impact on Shear Wave Velocity results

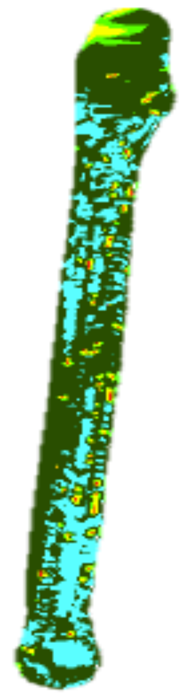
It has been reported that Shear Wave Velocities showed an increase measured several weeks post the completion of the trial.

CONTINUOUS IMPACT RESPONSE (CIR)

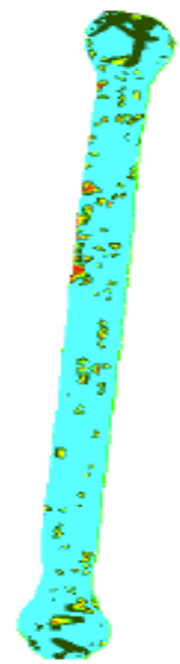
The following was reported for the 1.5-10ft (0.45-3.0m) Depth Range:

Color	CIR Deceleration	Qc [TSF]	Qc [MPa]
	<6.24	<100	<10
	6.24-7.21	101-110	10.1-11.0
	7.22-10.15	111-120	11.1-12.0
	10.16-15.05	121-130	12.1-13.0
	>15.05	>130	>13.0

IMPACT COMPACTION PASS NUMBER				30
	CIR g (m/s2)	EQUIV Qc (tsf)	EQUIV Qc (psf)	EQUIV Qc (MPa)
MIN	4	79.4	158,726	7.9
AVE	12.37	121.7	243,310	12.2
MAX	23.025	208.9	417,700	20.9
10TH PERC	10.3227	110.7	221,381	11.1
90TH PERC	14.316	134.2	268,372	13.4
CIR RECORDINGS	TOTAL	1740	100.00%	
	BELOW 10TH PERC	173.0	9.94%	
	BETWEEN 10TH-90TH PERC	1391	79.94%	
	ABOVE 90TH PERC	176.0	10.11%	



Pass 10 Mapping: 1.5-10ft



Pass 30 Mapping: 1.5-10ft

The following was reported for the 1.5-14ft (0.45-4.25m) Depth Range:

Color	CIR Deceleration	Qc [TSF]	Qc [MPa]
	<7.04	<100	<10
	7.05-9.94	101-110	10.1-11.0
	9.95-12.30	111-120	11.1-12.0
	12.31-14.11	121-130	12.1-13.0
	>14.11	>130	>13.0

IMPACT COMPACTION PASS NUMBER				30
	CIR g (m/s2)	EQUIV Qc (tsf)	EQUIV Qc (psf)	EQUIV Qc (MPa)
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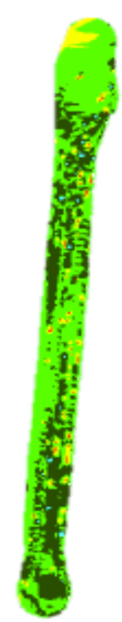
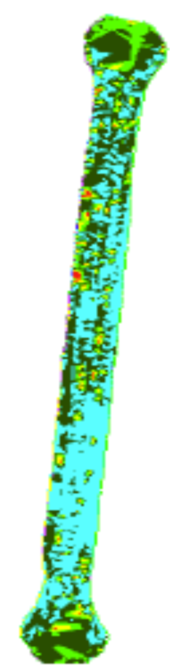


Pass 10 Mapping: 1.5-14ft



Pass 30 Mapping: 1.5-14ft

As extracted from the geotech engineer's report:

> "Landpac have correlated the response of the compactor instrumentation system (CIR) with average cone resistance in the upper 10 feet and 14 feet. For 30 passes the CIR output demonstrates that uniform compaction has been achieved throughout the upper 10 feet across the test section. These data illustrate the value of such instrumentation and how they would be used to target say quality control CPTs to sample the poorest area of the site, rather than simply selecting location either randomly or based on visual observations alone. Implementing continuous monitoring in this way could reduce the amount of in process quality control inspection necessary to assure the quality of the compaction."