

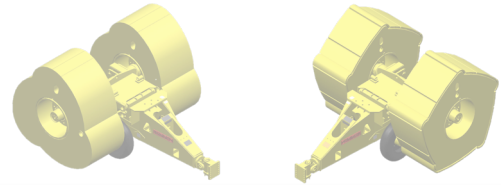
GEN-ICS022013

IMPACT COMPACTION SPECIFICATION

This specification is applicable to the process of tendering for and operating impact compaction on projects that have identified the process as a ground improvement alternative.

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1.0 SCOPE

This is a High Energy Impact Compaction (HEIC) Specification that covers the in-situ treatment of soil by means of impact roller compaction.

2.0 IMPACT COMPACTION PLANT

The rating of the impact compactors shall be determined by measuring the energy expended per fall of the compactor and shall be calculated by multiplying the mass of the rotating drums, by the lift and by the gravitational constant. There are several configurations of impact compactors including a 5-sided 10kJ, a 5-sided 15kJ, 5-sided 22kJ, and a 3-sided 25kJ.

The compactor shall be self-propelled or towed by a 4-wheel drive tractor of sufficient engine power (not less than 200 Kilowatts) and of sufficient capacity to maintain an optimal compactor towing speed (12 - 15 km/hr) on a maximum uphill gradient of 5 %.

All plant and equipment shall be maintained in good operational order and shall conform to the project's health and safety requirements.

3.0 SECONDARY COMPACTION PLANT

Due to a high energy dynamic force of the impact roller, a secondary compaction of the surface layer is required for roadbed preparation. A conventional type smooth circular vibratory drum roller is required to finish off the loosened material in the surface layer (top 100 mm to 200mm).

4.0 ADDITIONAL PLANT

The process of impact compaction needs to be supported by a water truck and a grader to assist with the leveling process during compaction.

Some impact compactors come fitted with specialized blading units behind the compactor to serve this exact purpose.

5.0 WATERING REQUIREMENT

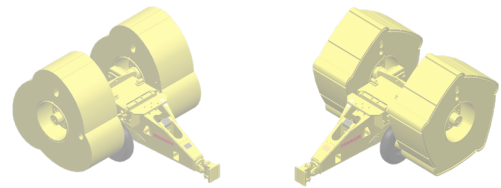
Although the process of Impact Compaction is suitable to drier conditions (2 – 4% below OMC) and requires less water than conventional plant (40-50% less), watering still remains a requirement during the compaction process. In addition to the compaction requirement, the process tends to dry the material out, resulting in the creation of dust, and regular watering will aid the control of dust during the compaction process.

6.0 DEFINITION OF AN IMPACT COMPACTOR PASS

A "pass" for the dual drum 3-sided impact compactor is defined as two runs of the compactor over a 4 meter wide lane such that one drum of the compactor during its second run travels in the middle of the inter-drum space created by the first run of the run of the compactor. Overlapping of drum paths in two consecutive runs (i.e. in one pass) will not be permitted.

7.0 SETTING OUT

The area to be treated with impact compaction shall be as defined in the drawings or as indicated by the Engineer on site. The Main Contractor shall control the compaction operations by employing appropriate setting out markers to ensure that all areas designated for impact compaction receive the specified number of impact compactor passes.



8.0 PREPARATION AND MAINTANANCE OF COMPACTING SURFACE

Compaction shall be carried out as soon as possible after clearing and grubbing operations to exploit any moisture available in in-situ material, which will facilitate the compaction process. Compaction will be done dry of Optimum Moisture Content (OMC).

The Main Contractor will assess the moisture conditions and compaction requirements of the subgrade's in situ water content. Water shall be applied in sufficient quantities to the surface as compaction proceeds to prevent the crumbling of the surface, to promote efficient compaction and to contain dust.

The area being impact compacted shall be lightly graded by means of a grader unit. The latter can be fitted to the back of the impact roller or a conventional grader can be utilised. This is to maintain a good operating surface for the compactor. Where substantial compaction of in-situ material occurs, additional material will be required as fill layers in maximum lift heights to be specified after the completion of the trial section.

9.0 COMPACTION SEQUENCE AND RESTRICTIONS

The Engineer reserves the right to determine priorities regarding the sequence of compaction at different sites.

10.0 STANDING TIME

Standing time can be caused by the following:

- (i) Areas not made available for compaction;
- (ii) Lack of watering and/or grading;
- (iii) Waiting for decisions to be taken by the Engineer; and
- (iv) Plant Breakdown.

Standing time related to points (i) through to (iii) will be for the account of the Main Contractor whereas point (iv) shall be for the account of supplier of the impact compaction plant.

11. LOCATION, PROTECTION AND DAMAGES TO EXISTING SERVICES

The Engineer shall furnish the Main Contractor with locations and routes of sub surface services within an accuracy of ± 5 m. The Main Contractor shall excavate up to a depth of 2 meters to expose such services if deemed necessary by the Engineer.

Repair of damages to under/above ground services shall be for the account of the Main Contractor once the position of such service was known to the Main Contractor or indicated by the Engineer.

All damages are to be reported to the Engineer within 1 (one) hour of occurrence. The Main Contractor needs to submit a full damage report within 24 hours.

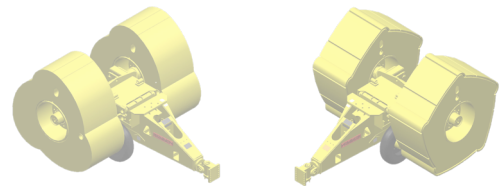
12.0 SITE ESTABLISHMENT

Site establishment shall include provision on the site of required equipment and personnel ready for work at the first site of work. It shall also include removal from the site of the aforementioned equipment and personnel and all costs related thereto.

The Engineer reserves the right to terminate the impact roller work at any time if, to his discretion, the required effect, is not obtained. In the event of termination, the cost of Site Establishment plus the completed work measured as area compacted or time on hire, shall be deemed as full payment of work executed.

13.0 MOVEMENT ON SITE

No additional payment shall be made for the movement on site of equipment within the designated areas indicated on the tender drawing for treatment or as indicated on site by the Engineer. The onus rests with the Main Contractor to have programmed his work as per the compaction sequences and restrictions stated in the project specifications.



All costs related to movement of equipment between and within the designated treatment areas shall be deemed to be included in the rates for impact compaction.

14.0 IMPACT COMPACTION TRIALS

Before commencement of the full-scale impact compaction works, compaction trials shall be carried out on a representative section, identified by the Engineer, of between 40-80 m in length and 8 m in width. The impact compactor turning circles shall lie outside the trial section and sufficient length shall be allowed for to ensure that the compactor compacts at optimum speed.

The objective of these trials is to determine the number of passes to be applied and to confirm the adequacy of the Main Contractor's plant and methodology to achieve a relative improvement in the in-situ soil bearing characteristics of the in-situ soil. These trials will also be used to calibrate the lift heights of material that may be required as fill layers.

The trials may be classified as HEIC Class I and Class II trials. A Class I trial is generally referred to a trial conducted in a small area of compaction whereby the cost of a full Class II trial would be deemed expensive in relation to the actual compaction cost. In this case, a Class I trial would be treated much the same as a Class II trial, with the difference being that only a single conventional test, such as DCPs or densities, shall be conducted. A Class II trial, generally conducted for larger areas of compaction requirement, shall demand more conventional testing, as indicated in the testing regime shown below. The standard trial testing regime for in-situ compaction shall be as follows:

Pass Number	0	10	20	30	40
Settlement		X	X	X	X
Density	X		X		X
DCPs	X	X	X	X	X
Plate Load				X	
CIR	X	X	X	X	X

If the material is of a high collapse potential, then the trial shall be extended through to 60 passes. Plate Load tests shall only be conducted if requested by the Engineer. Additional testing can be done but must be pre-arranged with an external laboratory.

For layerworks, trials are generally stopped at 20 passes for layer thicknesses up to, and including, 800mm.

The target compaction state shall be based on the number of passes, which results in soil substantially attaining its near elastic state condition. The target coverage required will be determined by means of the settlement results or other proprietary measure and shall be presented to the Engineer for approval.

The Engineer shall approve or reject the recommendation within one working day as to ensure that compaction operations are not held back. A trial report shall furthermore be compiled by the Main Contractor and submitted to the Engineer after all laboratory results have been received.

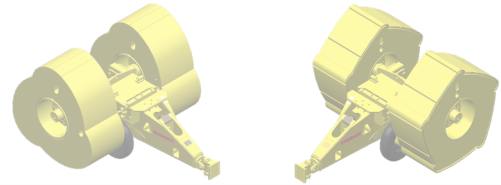
15.0 COMPACTION

General Impact Compaction must be carried out before services, drainage pipes or culverts are installed.

Adequate supervision shall be provided and undertaken by the Main Contractor to ensure that the specified method of compaction is strictly adhered to.

As a guideline, the following number of passes are applicable:

- 3-sided 25kJ / 5-sided 22kJ
 - In-Situ (Low collapse potential): 30 passes
 - In-Situ (Medium collapse potential): 30-45 passes
 - In-Situ (High collapse potential): 45-60 passes



- 5-sided 22kJ / 5-sided 15kJ
 - Layerworks - <500mm thick: 10-15 passes
 - Layerworks – 500-750mm thick: 15-20 passes
 - Layerworks – 750-1000 mm thick: 20-25 passes

Variation in Compactive Effort: Should more or less passes be ordered, adjustment in compensation to the Main Contractor shall be made either as an additional payment to the Main Contractor in respect of the increased number of passes or as a reduction in payment in respect of a reduced number of passes.

Recording Procedure: The Impact compaction work carried out shall be recorded each day in the Compaction Record Book. The record book shall be presented to the Main Contractor on a daily basis for his verification and approval of the information recorded.

16.0 QUALITY CONTROL: TESTING PRIOR TO, DURING, AND POST COMPACTION

Vibration Monitoring: Should there be structures within a 40m radius of where compaction takes place, vibration monitoring shall be done. It is the Main Contractor's responsibility to ensure that the vibration levels (Peak Particle Velocity PPV) are kept below a limit of 25mm/s. Should a cut-off trench be required to mitigate the vibrations, the Main Contractor shall be asked to dig such a trench.

Crack Survey: Should there be structures within a 40m radius of where compaction takes place, it is advised that the Main Contractor arrange for a crack survey of such structures to be done by an external company, both before and after the process of impact compaction. It is not the responsibility of the impact compaction specialists to arrange for and subsidise such tests.

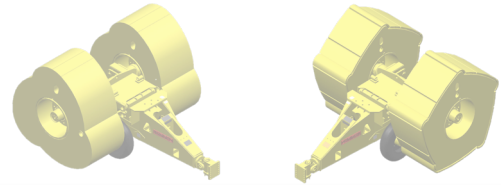
General Testing supporting Impact Compaction:

There are a few conventional tests that are generally used in association with the process of impact compaction, as detailed below. Each of these can be conducted by Landpac on site.

Dynamic Cone Penetration (DCP) Tests: 2 m DCP testing shall be conducted before compaction commences and after it is completed. The testing is generally done on a 25 or 50 m grid as per standard method TMH 6:1984 Method ST6. DCP testing shall furthermore be done in areas shown to be relative weak as indicated by the Continuous Impact Response measurement system.

Relative Density Testing: Density testing shall be done according to TMH1:A10 after compaction has been completed. Density positions shall be tested to depths of 0 – 300 mm, 300 – 600 mm, and 600 – 900mm generally on a 50 m grid. The grid selection and measurement depths shall be determined by the Engineer. Moisture corrections shall be done according to TMH1:17. Sufficient modified AASHTO dry density samples shall be sampled and tested in method TMH 6:1984 Method ST6. The grid selection shall be determined by the Engineer.

Plate Load Tests: Plate load tests shall be done with either a 450mm or 600mm diameter rigid circular plate in stress increments from 0 through to 450 kPa, recording settlement results at different time gradations. Plate load tests can either be performed at natural ground level or a pit can be dug down to a predetermined depth, not exceeding 400mm. On highly collapsible materials, it is advised to dig a pit and then have the pit soaked with water in order to simulate the worst case scenario. The number of plate load tests to be conducted shall be determined by the Engineer.



Continuous Impact Response (CIR) measurement system: The CIR is a Landpac proprietary measurement system that shall monitor and record the deceleration of the rotating drum of an impact compactor at impact. Such recorded decelerations shall be correlated to a conventional testing method, as determined by the Engineer, including density measurements, penetration testing (CPT, DCP, etc) and direct load testing (Plate Load, Zone Load, etc), with the geographical position of the compactor as determined by a GPS receiver. These measurements shall be recorded during the last three passes and other repetitions as may be requested by the Engineer. Colour coded limits shall be established, based on the specification required and shall be presented to the Engineer as a colour coded mapping of the improvement achieved.

17.0 MEASUREMENT AND PAYMENT

Establishment

Unit: Lump

Establishment of impact compaction equipment, Personnel and ancillary equipment necessary to complete Impact compaction operations lump sum. The tendered lump sum shall include full compensation for establishing and de-establishing the impact compactors, tow-tractors, personnel and ancillary equipment necessary to complete impact compaction operations.

Compaction: Square Meter Rate

Unit: Square Meter [m²]

The unit of measurement shall be the square meter of soil compacted in accordance with the provisions of this specification. The quantity will be computed in accordance with the authorized dimensions of the area to be treated. The quantity shall be based on a tender coverage of the specified number of passes. The tendered rates shall include full compensation for impact rolling the soil by the number of passes as approved by the Engineer and for any interruptions to

the work necessitated by the taking of control tests. It shall, however, exclude compensation for grading and watering the surface as required.

Compaction: Hire Rate

Unit: Hourly Rate

The unit of measurement shall be an hourly rate, as quoted. It shall be based on a 5 day working week, excluding weekends, and 9.5 hours per day minimum hire. Standing time, as per Section 10 above, is applicable.

Variations in the compaction requirement

Unit: Square Meter Pass [m²p]

The unit of measurement for the increased or decreased number of impact compactor passes shall be the square meter pass rate and the quantity shall be calculated by multiplying the area in square meters to which the variation applies by the increase or decrease in number of compactor passes.

Impact Compaction Trial

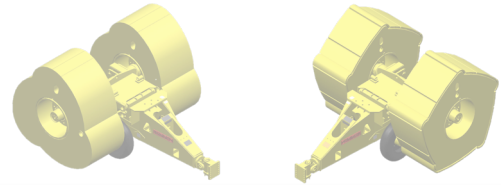
Unit: No.

The unit measurement shall be number of completed trial sections as described in Section 14. The tendered rate shall include full compensation for constructing the trial section as specified.

Continuous Impact Response (CIR)

Unit: Square Meter [m²]

The unit measurement shall be the square meter of compacted area as measured. The work shall be performed as described in Section 16. The tendered rate shall include the cost of procuring, furnishing, installing operating and maintaining all additional equipment to enable the electronic monitoring of the deceleration as detailed above. The cost of processing, back calculating and providing the information to the Engineer (in report format) including all consumables, software and other incidental costs incurred is to be included in the tendered rates. In



remote areas, the Main Contractor shall make email facilities available to Landpac personnel for transmitting the data back to the office for processing.

setting out, conducting testing, recording and processing the test values and presenting the test results to the Engineer in report format.

Dynamic Cone Penetration (DCP) Tests

Unit: No.

The unit measurement shall be the number of DCP tests done as described in Section 16. The tendered rate shall include full compensation for the transportation of the test team, setting out of test positions, conducting testing, recording and processing the test values and presenting the test results to the Engineer in report format.

Relative Density Tests

Unit: No.

The unit measurement shall be the number of relative density tests done as described in Section 16. The tendered rate shall include full compensation for transportation of the test team, setting out of test positions, conducting testing, recording and processing the test values and presenting the test results to the Engineer in report format. The rate shall exclude maximum dry density tests and OMC tests, which shall be supplied by the Main Contractor for correction purposes.

Plate Load Tests

Unit: No.

The unit measurement shall be the number of plate load tests done as described in Section 16. The tendered rate shall include full compensation for transportation of the test team, setting out of test positions, conducting testing, recording and processing the test values and presenting the test results to the Engineer in report format.

Vibration Monitoring

Unit: Lump

The unit measurement shall be a lump sum amount, as described in Section 16. The tendered rate shall include full compensation for transportation of the test team,

Other Tests

Unit: No.

All other tests that may be requested by the Engineer shall be outsourced to an external laboratory and the costs thereof shall be covered by the Main Contractor. Such costs may be included in the tender from Landpac or may, alternatively be arranged by the Main Contractor, Engineer, or Client. Such tests include Soaked CBRs, FWDs, etc.

18.0 TENDER REQUIREMENTS

Requirements for Establishment of a Tender

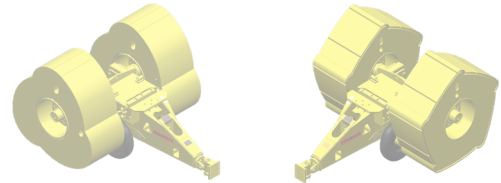
Landpac will need to have access to the following in order to establish an accurate tender for the client:

- Project Location
- Geotechnical Report
- Site Drawings
- Specification requirements
- Structural plans

Tender Detail

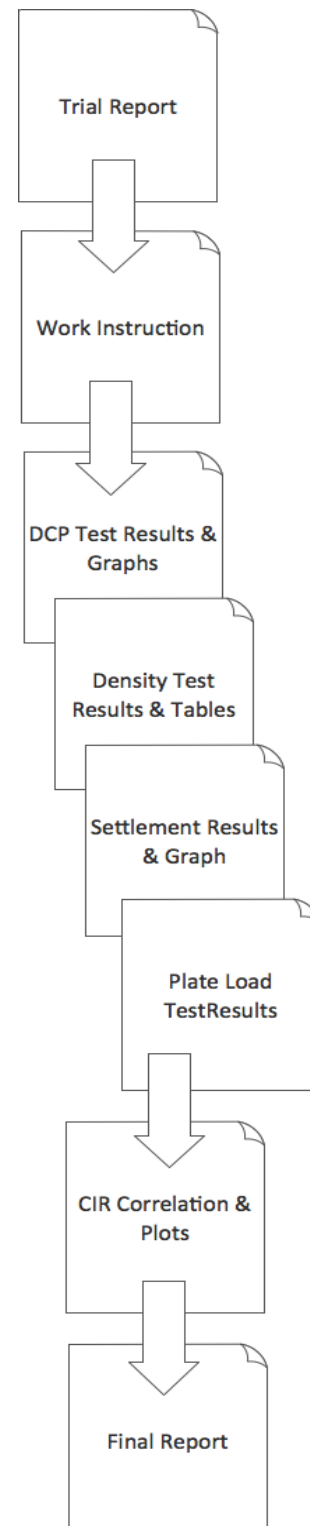
The tender document from Landpac shall include the following:

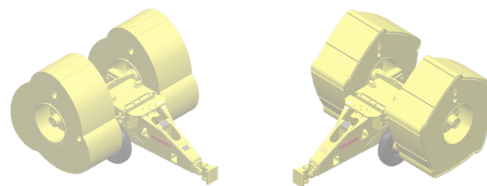
- Establishment (and Dis-Establishment) costs for Plant, personnel and equipment.
- Cost of Compaction based on:
 - Impact Compaction plant selection (25kJ, 15kJ, etc)
 - Area to be compacted (planned or specified)
 - Number of passes (planned or specified)



- Working hours
- DRY or WET clarification
- Rate per m²
- Standing time rate
- If quoted on a hourly rate then the following applies:
 - Impact Compaction plant selection (25kJ, 15kJ, etc)
 - Hourly Rate
 - Minimum hours
 - Working hours
 - DRY or WET clarification
 - Standing time rate
 - Inclement weather rate
- Additional Plant
 - Requirement to be quoted for or left to be arranged for by the Main Contractor (Requirement to be clearly identified).
 - If quoted:
 - DRY or WET clarification
 - Rate per m² or Hourly Rate
 - Minimum hours
 - Working hours
 - Standing time rate
- Compaction Trial costs.
- Testing and Certification - cost of:
 - DCPs: Unit rate and quantity
 - Density Tests: Unit rate and quantity
 - Plate Load Tests: Unit rate and quantity
 - CIR: Unit rate and quantity
 - External testing – Identification of test, Unit cost and quantity.
- Additional: costs related to
 - Medical tests
 - Site Induction
 - Accommodation
 - Visas, permits, duties, etc
 - Specific project information.

19.0 QUALITY CONTROL DOCUMENTATION





20.0 QUALITY CONTROL FLOW

