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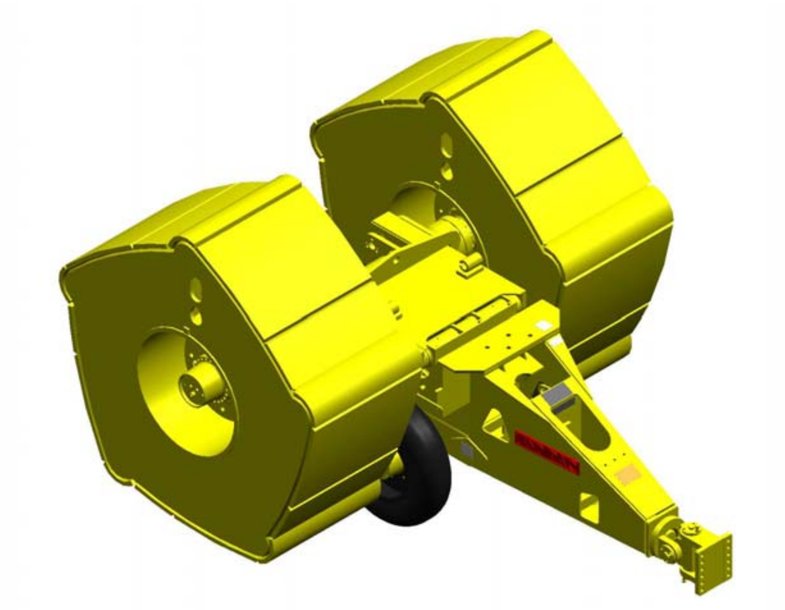
# CLIENT METHOD STATEMENT



## GROUND IMPROVEMENT ALTERNATIVE USING IMPACT COMPACTION AND THE CONTINUOUS IMPACT RESPONSE SYSTEM

Estimate Ref : N/A
Date : 26.10.2007
Document type : Client Method Statement

Approved: ____________________
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## 1.0 SCOPE

This is a specific client method specification and proposes the in situ and layerworks treatment of soil by means of the Landpac Impact Compaction process for the ESKOM Bravo Power Station Project.

## 2.0 INTRODUCTION TO IMPACT COMPACTION

### 2.1 IMPACT COMPACTION EXPLAINED

Impact compaction is the transfer of compactive energy into the soil by means of the lifting and falling motion of a non-circular rotating mass. The rotation of this mass to its highest point results in an effective potential energy. Further rotation of the mass results in the conversion of this potential energy into a falling kinetic energy, which is transferred to the soil upon impact of the lowest point of the mass with the surface of the soil. The value of energy transferred, in the form of compactive effort, is closely related to the potential energy value. Impact compaction is thus a process capable of transferring impact loads similar to those found in dynamic compaction on a continuous basis.

Impact compaction is thus generally described as the process whereby high levels of energy are imparted into the ground at a low frequency, to achieve higher degrees of compaction at greater depth than would be possible with traditional compaction equipment. Unlike conventional compaction, large parcels of energy are imparted at high amplitude and low frequency. Impact compactors vary in relation to shape, (3-, 4-, or 5-sided), compactor mass and configuration. The frequency of compacting blows varies between approximately 90 to 130 blows per minute while the energy delivered per blow varies between 10 and 25kJ, depending on the type of compactor (Pinard, 1996). The high energy levels of impact compactors ensure that the maximum plastic deformation is removed from the soil and that the soil is stressed to a higher level than would occur under conventional compaction. This improves the load–settlement characteristics of the in-situ soil, without the requirement of excavation and re-compaction.

Figure 1a: A Self Propelled 5 sided 15kJ Impact Compactor

Figure 1b: A Towed 3 sided 25kJ Impact Compactor

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## 2.2 IMPACT COMPACTION FEATURES

- Higher Energy

The energy rating of the different impact compaction equipment ranges from 10kJ to 25kJ. This equipment is capable of generating compaction loads of up to 250 tonnes. Because of the higher energy, relative to conventional rollers, a higher maximum dry density is achievable and that allows impact compactors to work over a wider range of moisture contents.

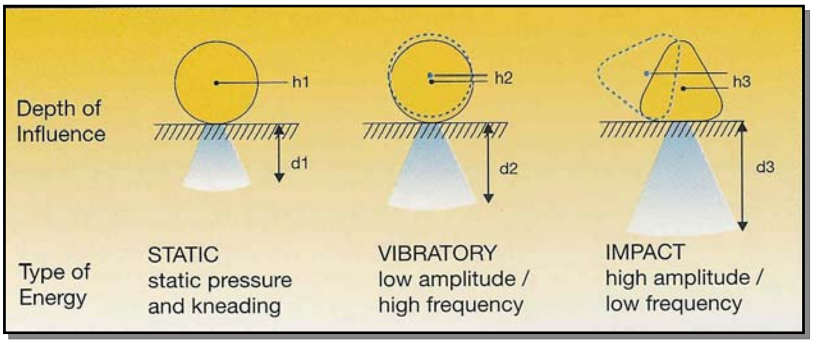


Figure 1c: Impact roller compaction mechanism

- Increased Depth of Influence

The depth of influence is a function of two factors, namely: the contact stress and the contact area. The contact stress is determined by the deceleration experienced by the falling mass during impact multiplied by the weight of the falling mass divided by the contact area. The contact stress of the impact compactor is in the region of 300kPa to 1200kPa, dependent on the soil stiffness. Although deceiving, the contact area of the impact compactor exceeds that of the conventional roller. The impact roller's profile radius is not referenced to the centre of the drum and therefore greatly exceeds that of the conventional rollers, resulting in a greater contact area. The net result of he increased surface stress and surface area is a superior depth of influence, enabling compaction in layer thicknesses exceeding 1m.

- Increased Load Duration

The impact compactor's load duration has been measured to be approximately 10-15 times longer than that of conventional rollers. This allows for a softer soil response and hence enhanced compressibility is attainable.

- Increased Productivity

  Landpac Impact Compactors travel at speeds up to five times faster than conventional equipment, allowing them to compact up to 10 times greater volume per day (7,000-10,000m$^3$ per day per machine).

### 2.3 KEY WORDS ASSOCIATED WITH IMPACT COMPACTION

The following keywords are generally associated with the process of impact compaction:

- Impact loads on a continuous base.
- Increased energy and contact stresses.
- Increased maximum dry unit weight of compaction.
- Increased depth of influence.
- Thicker lift compaction.
- Increased load duration and therefore reduced shear stiffness response.
- Increased area of contact.
- Enhanced compressibility.
- Continuous strength balanced profile.
- Higher operating speeds – increased productivity.
- 7,000-10,000m$^3$ per shift per machine.
- ±120,000 m$^2$ passes per shift per machine.
- Many different applications.
- CIR certification.

## 3.0 BASIC ANALYSIS

Impact compaction is the process whereby a high dynamic load is applied to the material which needs to be compacted by a falling weight. The load pulses that are caused by the impact cause shock waves in the material to a considerable depth and also in the horizontal direction.

The compaction of cohesive, fine material depends largely on the moisture content, the plasticity and the particle size distribution. The shear strength of the material depends on its cohesion. The fine soil particles have a large specific surface area and therefore a high water absorption capacity. The compactability is dependent on the moisture content and the plasticity of the gravel and it generally has to be well controlled during the compaction process. Although it is sometimes recommended that the moisture content should be lower than optimum, practise has shown that because of the high forces which are applied by the impact roller, it is more effective than other types of rollers during the compaction of material of which the moisture content is higher than optimum in a sandy type of material.

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From the information supplied, the following is summarised:

- Material consists of high percentages of sand and where sand is less, clay content tends to be a high.
- Liquid Limits are generally >25% but <50%.
- Grading Modulus ranges between 0.1 and 1.29, with the majority at 0.5.
- Plasticity Index is between 6 and 29, with the majority averaging at approximately 12.
- Unified Classification: Mostly CL.
- AASHTO Classification: Mostly A4 and A6.
- Swell potential ranges between 0.2% to 2.6%, averaging at approximately 1.1%.
- OMC ranges between 9.3% and 20.9%, averaging at approximately 14.5%.
- Dry densities < 2000 $kg/m^3$.

The main concern from an impact compaction point of view is the ability to compact material with a high clay content. If the risks of water rising to the surface are eliminated, there shouldn't be too much of a concern. This can be achieved by ensuring that drainage systems are constructed so that the water can be easily dispersed and should this not be sufficient during the compaction process, the programme may have to be scheduled to allow for some drying time during the process (possibly 2-3 days drying time after every 10th pass).

## 4.0 DEFINITIONS

### IMPACT COMPACTOR PASS

A "pass" for the dual drum impact compactor is defined as two runs of the compactor over a 4 metre 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 compactor. Overlapping of drum paths in two consecutive runs (i.e. in one pass) will not be permitted.

### CONTINUOUS IMPACT RESPONSE (CIR)

A measurement and certification system developed by Landpac to quantify the improvement achieved by using an impact compactor. The system is coupled to GPS and measures the soil's response to the energy part into the ground, correlated back to an engineering property.

### CONTINUOUS INDUCED SETTLEMENT (CIS)

An extension of the CIR allowing for surface profile position and settlements to be easily recorded and monitored.

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GLOBAL POSITIONING SYSTEM (GPS)

The Global positioning System (GPS) is a satellite based navigation system made up of a network of 24 satellites placed into orbit by the US Department of Defence. GPS was originally intended for military applications, but in the 1980s, the US government made the system available for civilian use. Up to 2000, "Selective Availability" was used to degrade the civilian positioning system. Once removed, the system's accuracy improved considerably. Each GPS satellite transmits data that indicates its location and the current time. All GPS satellites synchronize operations so that these repeating signals are transmitted at the same instant. The signals, moving at the speed of light, arrive at a GPS receiver at slightly different times because some satellites are farther away than others. The distance to the GPS satellites can be determined by estimating the amount of time it takes for their signals to reach the receiver. When the receiver estimates the distance to at least four GPS satellites, it can calculate its position in three dimensions.

DIFFERENTIAL GLOBAL POSITIONING SYSTEM (GPS)

Differential correction requires a second GPS receiver, a base station, collecting data at a stationary position on a precisely known point (typically it is a surveyed benchmark). Because the physical location of the base station is known, a correction factor can be computed by comparing the known location with the GPS location determined by using the satellites. The differential correction process takes this correction factor and applies it to the GPS data collected by a GPS receiver in the field. Differential correction allows GPS positions to be computed at a much higher level of accuracy.

## 5.0 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.

The compactor shall be 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 equipment shall be maintained in good working order.

## 6.0 IMPACT COMPACTION PROCESS PROPOSAL

### 6.1 SETTING OUT

The area to be treated with impact compaction shall be as defined in the drawings. Landpac 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.

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## 6.2 PREPARATION AND MAINTENANCE 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.

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 fitted to the back of the impact roller, to maintain a good operating surface for the compactor, to level out surface undulations and to prevent the formation of deep “footprints” of the compactor. Undulations may not be very prominent with the 5 sided impact compactor, thus eliminating the need for the grader unit.

## 6.3 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 at least 40m in length and 4m 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 optimum number of passes to be applied and to confirm the adequacy of the Landpac’s plant and methodology to achieve a relative improvement in bearing characteristics of the in-situ soil. Trails also allow for the establishment of correlations between decelerations measured and an engineering property, as explained later.

Should the material be extremely variable on site, it may be necessary to perform additional trials. Specific to this project, the indication is that at least two trials will have to be conducted; one for the in-situ material and another on the fill material at a specified layer thickness.

- General Testing Regime: Diagram of Layout

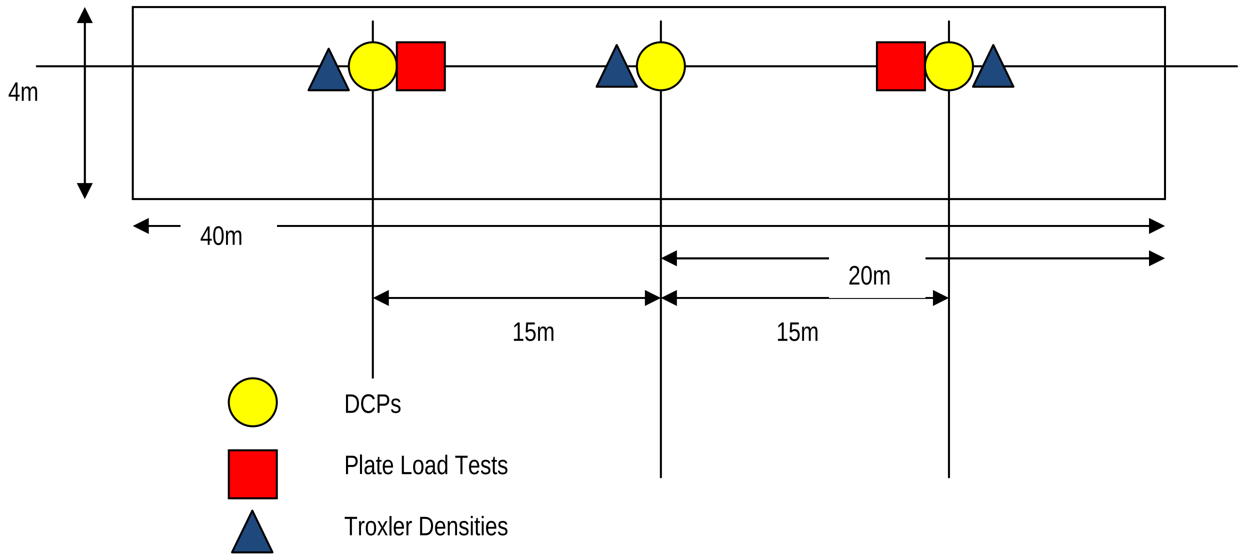


Figure 2: Trial testing Regime: Basic Layout

- General Testing Regime: List of Tests to be Performed

  - In – Situ Treatment

| Test | No | P0 | P10 | P20 | P30 | P40 | P50 | P60 |
|---|---|---|---|---|---|---|---|---|
| Settlement, 20m length at 1m intervals, every 10 passes | - | X | X | X | X | X | X | X |
| DCPs (2m DCP length) | 3 | X | X | X | X | X | X | X |
| Plate Load Test | 2 | X | | | X | | | |

Table 1: In-Situ Treatment Trial Testing Regime

- Fill Treatment

  - A layer is to be brought in and properly levelled for this trial.

| Test | No | P0 | P10 | P20 | P30 | P40 | P50 | P60 |
|---|---|---|---|---|---|---|---|---|
| Settlement, 20m length at 1m intervals, every 10 passes | - | X | X | X | X | X | X | X |
| DCPs (2m DCP length) | 3 | X | X | X | X | X | X | X |
| Plate Load Test | 2 | X |  |  | X |  |  |  |

Table 2: Fill Treatment Trial Testing Regime

The target compaction state for the entire site shall be based on the number of passes required to achieve the necessary results, as determined by this trial section. The reason the trial is generally conducted to 60 passes, albeit that we anticipate the achievement of the results after, say, 30 passes on thein-situ section and between 12-20 passes in the fill section, is to determine the point at which further settlement is minimal with an increase in the number of passes. If after the 60 passes there is a strong belief that further settlement will occur with an increase in the number of passes, then the trial will be extended as required.

## 6.4 SERVICES

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

## 6.5 WATERING AND WET CONDITIONS

Although the indication is that the material will be fairly moist, the process of impact compaction has a tendency to dry the material out, as long as it's not too wet or there isn't a lot of subsurface water.

If the material is considerably dried out, dust can be controlled through light watering and the control thereof will improve operator visibility. Very dry material also posses a problem from a compaction point of view and watering will assist consolidation. Past experience has indicated the need to water every $10^{th}$ roller pass on most materials.

If there is a lot of subsurface water, the process of impact compaction will force the water to the surface, posing a problem for compaction. This can be minimised, and even eliminated, by employing the following techniques:

- Ensure that there are sufficient drainage canals that will ensure that the water will easily flow out as the material is compacted and/or

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- Schedule the impact compaction process such that the material is allowed to dry out over a few days upon the completion of every 10-15 passes, or as required. This should not reduce production if sections are made available timeously.

## 6.6 COMPACTION OF ROCKFILL

The high intensity and depth capability of Landpac Impact Compactors makes them well suited for effectively compacting rock fill. This is achieved by subjecting the rock fill to a substantial dynamic compaction force which is able to rearrange the rock fragments into a dense, interlocking stable mass well able to resist lesser service loads without deformation.

The exposed rock on the surface must, however, be covered by a blinding layer of soft material of up to 150mm, which is placed to prevent damage to the tubeaxle and masses of the impact rollers.

Rockfill can be placed in layers ranging from 750-1000mm and the maximum size of any boulder should not exceed 2/3rd of the layer thickness in size.

## 6.7 PRODUCTION RATES

For project scheduling purposes, an impact compactor can generally compact 120,000$m^2$passes per 9.5 hour shift, equating to the following:

- o 4000 $m^2$ for 30 passes.
- o 6000 to 10000 $m^2$ for 20 to 12 passes respectively.

## 6.8 RECORDING

The impact compaction work carried out shall be recorded each day in the Compaction Record Book. The Compaction Record Book shall make provision for the recording of:

- The date on which any compaction was carried out.
- The area and section on which the compaction was carried out.
- The lane on which the compaction was carried out.
- The number of passes at which the compaction on those lanes commenced and ended on that day – inclusive.
- The number of passes carried out on that day on that lane (e.g. 10).
- The width of the area being compacted.
- The length of the area being compacted.
- The square metre passes compacted on that day (i.e. the area compacted x the number of passes).
- The record book shall be presented to the Engineer on a daily basis for his verification of the information recorded.

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# 7.0 QUALITY CONTROL PROCEDURE

## 7.1 GENERAL TESTING

Landpac is able to offer the below mentioned general testing on site. Note, however, that Landpac remains a ground improvement service orientated company and testing is really only performed as a certifier of the impact compaction process.

### 7.1.1 DYNAMIC CONE PENETRATION (DCP) TESTS

Soil penetration resistance is an important mechanical property that can be used as an indicator of soil compaction. The Dynamic Cone Penetrometer (DCP) is an instrument designed to provide a measure of the in-situ strength of fine-grained and granular sub-grades, granular base and sub-base materials, and weakly cemented materials. Penetrometer measurements can be done relatively quickly and easily, with the ability of providing very valuable data. Herrick and Jones (2002) described a dynamic penetrometer for use in soil science, enabling cheap, repeatable soil strength assessments in the field. It consists of a metal rod with a conical tip at one end, an anvil or strike plate around the rod and a sliding hammer with a fixed mass at the other end. The cone is pushed into the soil at a reasonably constant rate of strain and the cone end resistance to penetration is measured, calculated as a penetration rate.

The testing shall be done in accordance with the standard method TMH 6:1984 method ST6. Because of the increased depth of influence, relative to conventional compaction, Landpac utilises a 2m long DCP for this test.

DCP testing shall be conducted on the trial sections but additional requirements need to be identified by the client. If the process of CIR (explained in Section 7.2 below) is employed, the general testing regime can be reduced drastically leaving general testing only for the areas identified by the CIR as being relatively weaker.

### 7.1.2 RELATIVE DENSITY TESTING

Field density testing is a combination of nuclear testing and laboratory dry density testing that allows the consultant/engineer to estimate soil behaviour such as settlement, bearing capacity, and collapse/compressible properties over specific depth ranges.

Nuclear density metres are used extensively for determining the compacted dry unit weight of the soil. The instrument used for this test basically measures the weight of wet soil per unit volume and the weight of water present in a unit volume of soil. The dry unit weight of compacted soil can then be easily determined. The apparatus utilised for this test, the

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Troxler, basically consists of a radioactive source and a radiation detector, offering a non-destructive and relatively quick method for determining density.

Density testing shall be done according to TMH1: A10 after compaction has been completed. Density positions are generally tested to depths of 0-300mm and 300-600mm, with moisture corrections done according to TMH1:A17. Sufficient modified AASHTO dry density samples shall be sampled and tested in order to determine the relative density. Testing to depths 600-900mm can also be arranged for.

### 7.1.3 PLATE LOAD TESTS

Plate Load Testing is a standard method of conducting field load tests to determine the soil bearing capacity of foundations. This method of conducting field load tests is very desirable, albeit a rather lengthy operation. A diagram of the load test is shown in the figure below and the test is conducted as per ASTM D-1194.

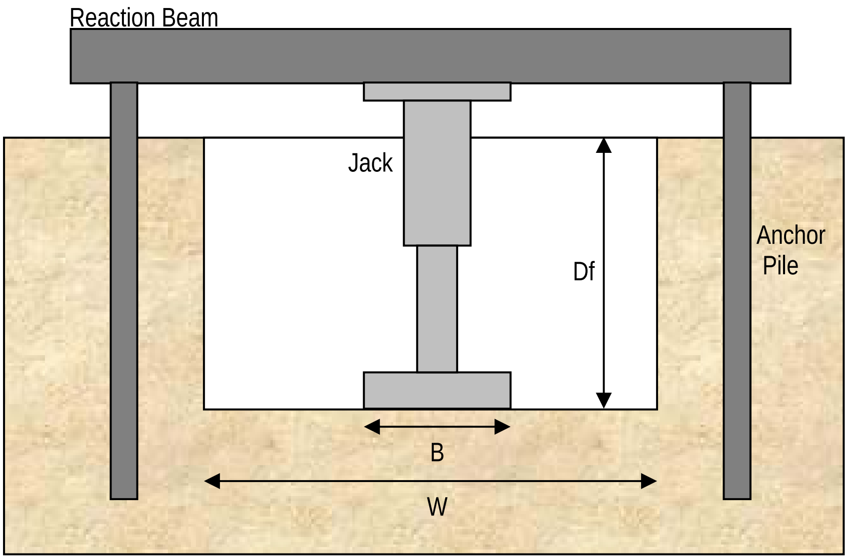


Figure 3: Plate Load Test Diagram.

Plate Load tests can be conducted directly on the compacted surface (Df=0) or below the compacted surface. Below the compacted surface allows the opportunity to estimate the settlement at a greater depth. Plate load tests are done with either a 450mm or 600mm diameter rigid circular plate in stress increments of 0, 45.4, 0, 45.4, 90.9, 136.3, 181.8, 227.2, 272.7, 318.1, 363.5, 409.0, 454.4 & 0 kPa. Settlement results are recorded with three settlement gauges at 30s, 1min, 2min, 4min, 8min & 16min. If the tests are to be conducted with a 600mm diameter plate (B=600mm) and conducted 400mm below the natural ground level (Df=400mm), the results obtained would be representative of the expected settlements at a depth of 1.3m below natural ground level ((1.5 x 600mm) + 400mm).

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### 7.1.4 SETTLEMENT MEASUREMENT

One difficulty associated with deep in situ compaction in general is that of judging when compaction can be terminated. In conventional compaction, where the soil is placed and compacted in consecutive, relatively thin layers, the result of compaction is usually checked by measuring the degree of compaction (i.e. compaction relative to a known standard such as modified AASHTO density). However, this only shows the result obtained just below the compacted surface and is seldom representative of the effect deeper down in the soil. Approximate information can be obtained by measuring the average settlement on the surface due to compaction. This is generally quantified by means of a "dumpy" level.

The most important factors that influence settlement include soil permeability, soil drainage, load to be placed on the soil, history of loads placed upon the soil (normally or over-consolidated?), and the water table. Settlement is caused both by soil compression and lateral yielding (movement of soil in the lateral direction) of the soils located under the loaded area. Cohesive soils usually settle from compression while cohesionless soils often settle from lateral yielding - however, both factors may play a role. Some other less common causes of settlement include dynamic forces, changes in the groundwater table, adjacent excavations, etc. Compressive deformation generally results from a reduction in the void volume, accompanied by the rearrangement of soil grains. The reduction in void volume and rearrangement of soil grains is a function of time. How these deformations develop with time depends on the type of soil and the strength of the externally applied load (or pressure). In soils of high permeability (e.g. coarse-grained soils), this process requires a short time interval for completion, and almost all settlement occurs by the time construction is complete. In low permeable soils (e.g. fine-grained soils) the process occurs very slowly. Thus, settlement takes place slowly and continues over a long period of time.

In addition, the greater portion of the final settlement value generally occurs in the early stages of compaction, which is characterised by plastic deformation. Elasto-plastic deformation occurs during the second stage of the impact compaction process and the final third stage of the settlement is characterised by elastic deformation. Normally, the economic cut-off point for the number of passes will be when the material starts reacting elastically or when a substantial portion of total settlement has been achieved (taken as 85 to 90% of final settlement value on structures).

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## 7.2 CONTINUOUS IMPACT RESPONSE (CIR) MEASUREMENT SYTEM

### 7.2.1 INTRODUCTION TO THE CONTINUOUS IMPACT RESPONSE (CIR) MEASUREMENT SYSTEM

Landpac has developed and patented a Continuous Impact Response (CIR) measurement system. It is possible to use the impact compactor as a proof roller and to measure the soil's response to the dynamic loading of the impact compactor. The Continuous Impact Response (CIR) system is capable of measuring and recording the soil response to every impact of the roller, resulting in a direct measurement of soil stiffness, which is a function of the soil density.

Response during impact

The Continuous Impact Response system employs an accelerometer, which is fitted to axle that links the two masses. Deceleration is measured on a continuous basis and peak deceleration with each impact is recorded. While the material is still in a loose state most of the initial compaction energy will lead to plastic deformation of the soil. At this stage, the soil has a soft response to the load applied and low decelerations of the compaction masses are measured. Decelerations in the order of 3-6a/g's are normally measured. Further compaction of the soil results in densification of the soil. Since the stiffness of the soil is a function of the soil's density, a more rigid soil response is experience as the soil moves towards the elastic state. Higher decelerations (in the order of 6-10a/g's) will therefore be measured as the soil reaches the elastic stage. Typical before and after deceleration graphs are shown in Figure 4 below (Wilken, 2001).

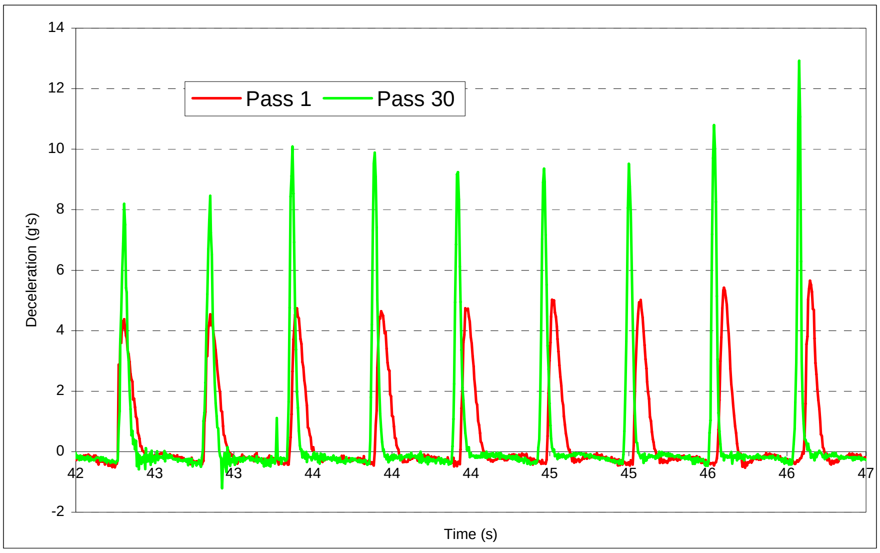


Figure 4: First and final pass decelerations comparison of a 25kJ Landpac Impact Compactor.

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Use of GPS

The Global Positioning System (GPS) is a satellite-based navigation system made up of a network of 24 satellites placed into orbit by the U.S. Department of Defence. GPS was originally intended for military applications, but in the 1980s, the government made the system available for civilian use. Selective Availability (SA), which is an intentional degradation of the signal, was imposed by the U.S. Department of Defence. SA was intended to prevent military adversaries from using the highly accurate GPS signals. Selected Availability was turned off in May 2000, which significantly improved the accuracy of civilian GPS receivers.

The CIR employs a GPS receiver to locate the position of the impact roller. Each of the peak decelerations is recorded relative to its position on site as determined by an integrated GPS receiver.

### 7.2.2 SITE PLOTTING

Correlations

Correlations are developed for the CIR during the trial section, following the analysis of the general testing results achieved. What this really means is that the decelerations measured by the Impactometer on the tractor can be correlated to most engineering properties, with the most common being equivalent CBR.

Colour Coding and CIR Plotting

From the correlations, colour coded limits can be established and CIR plots can be generated, providing the customer with an indication of whether a certain CBR value is generally achieved over the entire site. Note that the codes are established from specification requirements and are generally advised by the consulting engineer. Examples of the coding and relevant plotting are shown below.

| Colour | CBR Equivalent (%) | Deceleration Measured (g – m/s2) |
|---|---|---|
| Red | <10% | <6.7 |
| Yellow | 10-20% | 6.7-11.0 |
| Green | >20% | >11.0 |

Table 3: Colour Coding Example

It is thus possible to produce a “map” of the deceleration values, correlated to an engineering property, over the entire site.

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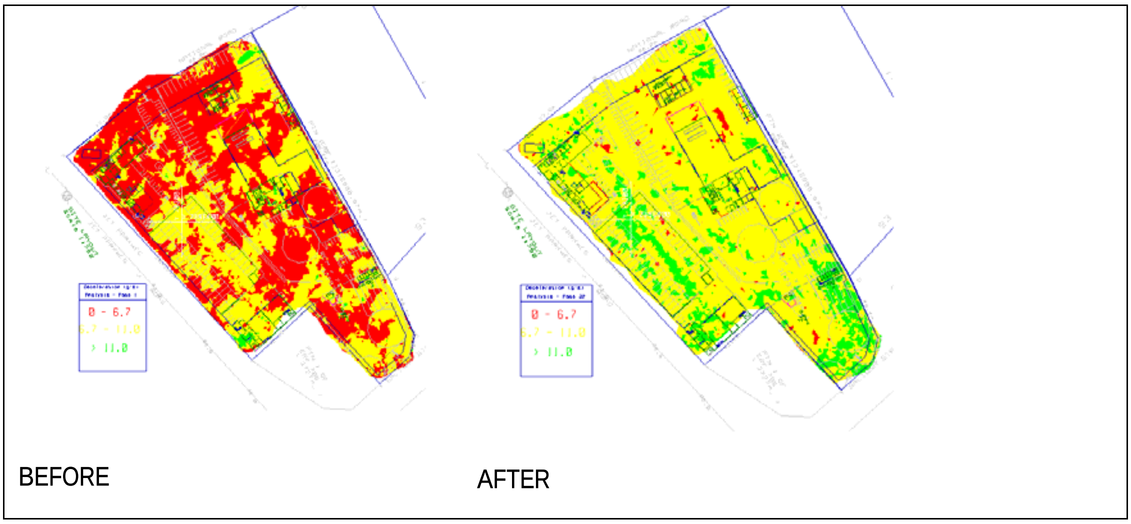


Figure 5: Typical before and after impact compaction CIR measurements.

### 7.3 CONTINUOUS INDUCED SETTLEMENT (CIS) MEASUREMENT SYTEM

As an extension of the well proven Continuous Impact Response (CIR) measurement system, Landpac have introduce the Continuously Induced Settlement (CIS) measurement system which, with the combination of the hardware used for the CIR measurement system, a differential global positioning system (DGPS) and surveying software, surface profile position and settlements can be easily recorded and monitored. The system can be used for the purpose of compaction control in conjunction with the CIR and it also has the added feature of monitoring volumes on site.

## 8.0 PROJECT PROCESS PROPOSAL

### 8.1 COMPACTION

For the reasons detailed below, the heavier five sided impact compactor (roller) is proposed:

- The three sided roller may cause excessive undulations that will be difficult to remove using the blader attachment on these materials, especially with clays. For this reason, a five sided roller would probably be the preferred option.
- The five sided roller is also better suited to fill work and the layer thicknesses can be increased to between 750 and 1000mm by using the heavier five sided roller, being the 22kJ as opposed to the 15kJ energy rated plant.

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For pricing and project scheduling purposes, the following is proposed:

In-Situ Compaction

| | |
|---|---|
| Impact Compaction Plant | 22 kJ 5-sided roller |
| Number of passes | 30 (minimum) |
| Watering | Every 10th pass if dry |
| Wet conditions | Allow material to dry out if:<br>- Excessive water is present on the surface; and/or<br>- Heaving is experienced<br>This may require 2-3 days of drying time after every 10 roller passes.<br><br>There may also be a need for some subsurface drainage systems to be constructed by the main contractor. |

Layerworks

| | |
|---|---|
| Impact Compaction Plant | 22 kJ 5-sided roller |
| Number of passes | 12-20 (15 average) |
| Watering | Every 10th pass if dry |
| Thickness of Layers | 750mm to start off with, with the possibility of increasing this to between 1000-1200mm following the analysis of the initial trial results. |

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Rockfill Compaction

| | |
|---|---|
| Impact Compaction Plant | 22 kJ 5-sided roller |
| Number of passes | 20 |
| Watering | Every 10th pass |
| Thickness of Layers | 750mm-1000mm |
| Max Rock Size | 2/3rd of layer thickness |

## 8.2 QUALITY CONTROL

For quality control, the following is proposed:

Trials

During trials, the testing regime as detailed in Section 6.3 shall be implemented.

In-Situ Compaction

This compaction process should be controlled by the Continuous Impact Response System with identified weaker areas tested using the Dynamic Cone Penetrometer Test (2m).

Layerworks Compaction

This compaction process should be controlled by the Continuous Impact Response System with identified weaker areas tested using the Dynamic Cone Penetrometer Test (2m).

The final layer should possibly be supported by a few plate load and relative density tests.

Rockfill Compaction

This compaction process should be controlled by the Continuous Impact Response System and supported by a few plate load tests performed on the compacted surface.

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# 9.0 MEASUREMENT AND PAYMENT

## 9.1 ESTABLISHMENT

Establishment and of impact compaction equipment, personnel and ancillary equipment necessary to complete impact compaction operations

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. The amount tendered will be payable upon arrival on the project site.

## 9.2 COMPACTION

Compaction of in-situ and layerwork material by means of a 5-sided 22kJ Impact Compactor

The unit of measurement shall be the square meter of in-situ 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 30 passes for the in-situ material and an average of 15 passes for the layerworks. Since these will only be established after a trial, a variation shall be estimated as well (refer below).

The tendered rates shall exclude surface preparation, watering the surface as required, any form of work interruption and any control testing required.

Variations in the compaction of the in-situ and layerwork material applicable to the above item

The unit of measurement for the increased or decreased number of impact compactor passes shall be the square metre pass and shall be computed by multiplying the surface area in square metres of the soil compacted by the number of 4 metre wide compactor passes. For clarity, a lane 100m long and 4m wide given one pass, i.e. 2 runs of a 3 or 5-sided impact compactor, will be measured as $400m^2$-pass.

The quantity shall be calculated by multiplying the area in square metres to which the variation applies by the increase or decrease in number of compactor passes.

Impact compaction trial section

The unit measurement shall be the number of completed trial sections as described in Section 6.3.
The tendered rate shall include full compensation for constructing the trial section as specified.

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Standing Time

The unit measurement shall be the number of days or part thereof that the unit is standing awaiting instruction from the client. Standing time due to inclement weather is generally calculated at 50% of the standard time.

## 9.3 QUALITY CONTROL

Continuous Impact Response measurements

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 customer (in report format) including all consumables, software and other incidental costs incurred is to be included in the tendered rates.

Dynamic Cone Penetration Tests

The unit measurement shall be the number of DCP tests done as described in Section 7.1.1.

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 customer in report format.

Relative Density Tests

The unit measurement shall be the number of relative density tests done as described in Section 7.1.2.

The tendered rate shall include full compensation for transportation of the test team, setting out of test positions, conducting testing (including maximum dry density tests), recording and processing the test values and presenting the test results to the customer in report format.

Plate Load Tests

The unit measurement shall be the number of plate load tests done as described in Section 7.1.3.

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.