Clegg Impact Soil Tester Overview by Jim Crandell at Dr Baden Clegg

The Clegg Impact Soil Tester, also known more commonly as the Clegg Hammer, was originated by Dr Baden Clegg and developed in the Department of Civil Engineering at the University of Western Australia in the 1970s while Dr Clegg was a senior lecturer there in soil mechanics. The first commercially available units were sold in early 1977.

Manufacturing of the Clegg Hammer under license to Dr Clegg began in the US and the UK in the next decade, alongside manufacture in Australia, based on the same principles but with versions that look slightly different. Manufacture continues in Australia today by the company founded in 1993 by Dr Clegg. The Australian models are designed and constructed to perform best in Australian conditions and in remote and tropical regions.

The Clegg Hammer reflects and responds to characteristics that relate to soil strength/stiffness or, when it comes to testing of sports turf, this is typically referred to as assessment of ground hardness or shock attenuation.

All other things being equal, the primary considerations are the density and moisture condition in relation to the strength/stiffness of the material under test or to the hardness of the ground.

The Clegg Hammer does not measure density directly, but through field trials or lab testing, the density may be inferred for materials typically used in road construction based on the strength/stiffness observed and the moisture condition suitable for the compactive effort. As such, with knowledge, judgment and experience, the Clegg Hammer may be used as a control tool in the field during or immediately following compaction. Monitoring during compaction can identify weak spots or areas that are under or over compacted so that remedial action may be taken on the spot.

The Clegg Impact Test requires only one person to carry out with each test taking less than 30 seconds, with learning how to carry out the test requiring not much more time than this.

The "standard" 4.5 kg Clegg Hammer was the first Clegg Hammer developed, as it was found to be suitable for testing the full range of soils, including those lightly stablised. used in earthworks and roadworks construction, from subgrades up through to basecourses, e.g. when compaction is to standard effort (standard Proctor) or to modified effort (modified Proctor).

The Clegg Hammer impacts the soil directly, with nothing as an interface which possibly might bias or affect the results.

When it comes to using a penetrometer, such as the penetrometer introduced by Scala, now commonly known as the Dynamic Cone Penetrometer (DCP), seating to some depth is often needed and therefore the immediate surface layer may not be properly assessed; whereas, the Clegg Hammer tests from the very top on down.

The 4.5 kg Clegg Impact Soil Tester, with its 50 mm hammer diameter, is considered suitable for testing of finished compacted layers on the order of 150 mm thick. While good results at the surface may be an indication of good compaction at greater depth, this may not always be the case. If there is a need to check to a greater depth, then testing in layers not greater than 200 to 250 mm in thickness is advised when using the 4.5 kg Clegg Hammer.
For testing double lift thicknesses, i.e. down to a depth of around 300 to 500 mm, then a Clegg Hammer with a 130 mm hammer diameter is used. These larger diameter Clegg Hammers have hammer masses of either 9.1 kg or 10 kg or else 20 kg.

The 20 kg version was introduced by Dr Clegg on the initial concept of it being a Clegg Hammer for testing on the top of the running course of flexible pavements, as an alternative method to Benkelman Beam or the Falling Weight Deflectometer (FWD), or at least as providing some means of control during construction before Benkelman Beam or FWD tests are carried out.
Because of the rapid nature of carrying out a Clegg Impact Test (CIT), a good sense of the uniformity of the construction can be ascertained, an important consideration in itself. A great number of tests can be carried out in a relatively short time when using the Clegg Hammer. This allows for statistical concepts to be applied to find a meaningful mean, standard deviation and coefficient of variation in relation to the uniformity achieved.

Good correlation has been found between the 4.5 kg Clegg Hammer and percent California Bearing Ratio (CBR), for unsoaked, non-surcharge conditions, where the Clegg Hammer can be thought of and used as a rapid, cost-effective alternative to field CBR with the added advantage that the same test apparatus and procedure can be used in a soils lab, unlike the test for CBR, where the field method differs somewhat from the lab method.

Irrespective of a density specification, a construction can undergo rutting or failure if there is insufficient strength/stiffness prior to opening to traffic.

This is one area where the Clegg Hammer can be put to advantage, to ensure that adequate strength exists after the moisture needed to achieve the specified percent Maximum Dry Density (MDD) has begun to leave the system by monitoring the increase in the strength/stiffness via an increase in the Clegg Hammer output, known, for the 4.5 kg Clegg Hammer, as the Clegg Impact Value (CIV).

One example of this is a specification by the Main Roads Department of Western Australia that a minimum Characteristic CIV (CIV_C) is obtained after compaction and prior to sealing.

CIV is based on the peak deceleration of the drop-hammer as it impacts the surface. As the peak deceleration is also related to the peak penetration into the soil and peak force, Dr Clegg considered the CIV to be a soil property, i.e. one can speak in terms of the CIV of a soil.
Using tens of gravity units peak deceleration to equal one clegg unit in the CIV scale was found to be both adequate and convenient as it provided a scale from 1 to 100 which suitably covered the range of material strengths when using the 4.5 kg Clegg Hammer to test soils used in earthworks and roadworks.

In addition to testing of earthworks and roadworks, the 4.5 kg Clegg Hammer has been found useful for testing of unsealed runways after rain to ensure adequate strength has returned before opening a runway to use.

Apart from the Clegg Hammer masses mentioned above, there are also lighter versions.

The 0.5 kg Clegg Hammer, also referred to as the Light Clegg Hammer, was introduced by Dr Clegg to test weaker materials and compaction of hot mix and was adopted by the sports and recreation turf industry to test the hardness of football grounds (soccer) and cricket pitches. From there, its usage expanded into testing of grass tennis courts and golf putting greens, these being the prime usage today for the Light Clegg Hammer.

The 2.25 kg version was developed from the Standard Proctor Hammer. However, since the 4.5 kg Clegg Hammer was found to be sensitive enough to test earthworks compaction as well as roadworks compaction, the 2.25 kg version has also become a Clegg Hammer primarily used for testing in the sports turf realm. Applications include horse race tracks and testing ground hardness prior to matches for the AFL in Australia and the NFL in the USA.

Output from these lighter two Clegg Hammers, which also have a 50 mm hammer diameter, is often seen in terms of gravity units peak deceleration upon impact, referred to in the past as G_{max} (which may be seen abbreviated as Gm) and more recently as g-max.

To give an example though of earthworks testing, the Medium Clegg Hammer was successfully used to obtain field CBRs, for CBR values less than 50%, prior to the construction of the Dublin Light Rail Network, which opened in 2004.

Dr Clegg introduced the concept of a quasi-elastic or quasi-Young's modulus which he called the Clegg Hammer Modulus (CHM). With the output of the Clegg Hammers being in clegg units (or else maybe instead in gravity units in the case of those used for turf testing), the output of one mass of Clegg Hammer cannot be taken as one-for-one with the output of a Clegg Hammer with a different mass due to the laws of physics. Converting the output of a Clegg Hammer to its related CHM, according to theory and certain assumptions, allows a comparison with the CHM of another mass of Clegg Hammer. Where there isn't unity, then it is taken that there is either more strength/stiffness nearer the surface or else deeper down, depending on whether the lighter drop-hammer in question returns a higher CHM or a lower CHM than the heavier drop-hammer used in the same situation.

Dr Clegg also suggested that the CHM may be used as a seed modulus for iterative analysis, comparing calculated deflections with field observations as a means to refine the coefficients found in the CHM equations for the different Clegg Hammer types based upon their masses.

The 4.5 kg Clegg Hammer is covered by Australian Standard AS1289.6.9.1 for CIV and all Clegg Hammers are covered by US ASTM Standard D5874 (where CIV is simply referred to as IV, for Impact Value). There is also ASTM Standard F1702 which is specifically for testing of turf with the 2.25 kg Clegg Hammer. The 9.1 kg Clegg Hammer can be supplied to conform to ASTM F1936 for the testing of gridiron or rugby fields with artificial turf.

Australian-made or supplied Clegg Hammers from Dr Baden Clegg Pty Ltd, located in Perth, Western Australia, have the Australian C-Tick approval. Further to this, and as importantly, a NATA certified load-cell device is used as part of the calibration procedure. The Clegg Hammer comes with a one-year manufacturer's warranty, with servicing and calibration carried out by ourselves in Western Australia.

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