ISSN 1178-5888

CETANZ

Civil Engineering Testing Association of New Zealand

CETANewZ

The official newsletter of the Civil Engineering Testing association of NZ

Issue 19, December 2013

In this issue...

"Our position is that testing should only be carried out by persons with appropriate training, support, quality systems, ongoing interlab comparisons and those that are up-to-date with best practise and regulation."

From the Chair...

Welcome to the December issue of CETANewZ. Summer is here and with it some warmer weather of late. A lot has happened since the last newsletter. The Americas cup has slipped from our grasp and Australia has a new Prime Minster and Mainzeal went into liquidation along with many others. The government started selling state assets on the stock market, house prices started rising and the Reserve Bank has placed controls on first home buyers home loan lending. A new government department called Worksafe New Zealand has been created as part of the new health and safety reform and New Zealand is doing well in the cricket.

Change ……. and more change. Get used to it! There's a lot more to come and It's the way of the new world. And how do we keep up with all this change
I hear you ask??? By becoming a CETANZ member and staying in the loop!

Since our last newsletter CETANZ members working on your behalf have covered a lot of ground. Some of the initiatives and events that have taken place include:

- The AGM – full reports sent out
- SNZ MBIE submission – completed, waiting for decision.
- Qualification review – started, a few small changes to be made. Reduction in Independent Training Organisations (ITO), InfraTrain has merged with ESITO (Electricity Supply ITO).
- Proficiency scheme organisation – next round about to start.
- Various best guides and technical reports - see the CETANZ website
- Consultation on PSV and Control Stone for NZTA
- Review of NZTA T/19, F/1, B/9 for the NPTG
- AGS working group
- CCANZ – IB72 review (sampling and testing concrete cores)
- Organisation of the next conference.
- We are also looking into setting up a subsidised training day or days on statistical analysis for proficiency schemes.

One recent success story involved a member that had asked the CETANZ Technical Group for help. It turned out that in this member's neck of the woods the roading authority had allowed for non IANZ accredited testing for field work while laboratory work was to be IANZ accredited. CETANZ through its profile, recognition and contacts, was able to get the authority to correct the contract wording via a notice to tenderers. A fantastic outcome for that member. As we know this is not an isolated case and CETANZ

From the Chair Continued...

continues to highlight these issues with officials. Our position is that testing should only be carried out by persons with appropriate training, support, quality systems, ongoing interlab comparisons and those that are up-to-date with best practise and regulation. IANZ accreditation and CETANZ membership are in our view two very good ways of ensuring this.

Looking forward to the next twelve months you can expect to hear a lot more about the upcoming conference and one or two initiatives that arose from our AGM. It looks like it's going to be a busy year.

If you would like to know more, or you want to get involved, feel free to get in touch anytime. Contact us here at info@cetanz.org.nz if you would like to learn more

I hope you enjoy this issue.

Jayden Ellis

Chair - CETANZ

Announcement of the Standards review outcome

Earlier this year you provided input to our Standards and Conformance Infrastructure Review.

I am writing to let you know that the Minister of Commerce, Hon. Craig Foss, has announced new arrangements to maintain and strengthen the development and delivery of New Zealand Standards to ensure they meet the needs of industry, regulators and consumers into the foreseeable future.

During the review, Stakeholders emphasised that the independence and integrity of the Standards approval and development functions are vital to ensuring that we maximise the contribution of Standards to a productive and competitive economy. Stakeholder submissions and detailed engagement helped to shape the final proposals and further strengthen the independence and integrity of the new Standards model.

The new arrangements will also improve the efficiency and effectiveness of New Zealand Standards and include:

- a new Standards model - with an approval function, a development function and links to the international Standards community - will replace the Standards Council and Standards New Zealand.
- Standards approval undertaken by an independent statutory board that will provide advice to the Minister for Commerce.
- Standards development undertaken by an independent statutory officer within the Ministry of Business, Innovation and Employment (MBIE), using independent committees
- the independent committees continue to comprise industry and technical experts, consumer representatives and regulators in accordance with ISO and IEC guidelines for balanced committees.

Some of these changes will require a change to legislation, which is expected to be introduced to Parliament in early 2014. The Bill will go through the usual parliamentary process including select committee consideration.

The new arrangements will not come fully into force until legislation is in place; but there are some changes, such as opportunities to improve processes, that can be implemented sooner.

In the meantime Standards New Zealand will continue to provide support for standards development and approval as the transition process continues.

MBIE in its role as the building regulator is, separately to the Standards review, undertaking a policy review including identifying and prioritising strategically important building Standards cited in the Building Code. Work will be progressed on assessment of the feasibility of providing an online portal for improved online access to a range of regulatory documents in the building sector, including cited Standards.

Further information on the new arrangements for the development and delivery of New Zealand Standards is available on the MBIE website http://www.med.govt.nz/business/standards-conformance. Over the next week a report summarising our response to Submissions received will also be available on the MBIE website.

Ground Penetrating Radar (GPR)

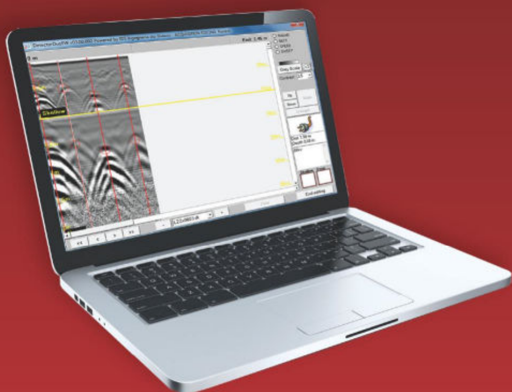
GEOTECHNICS

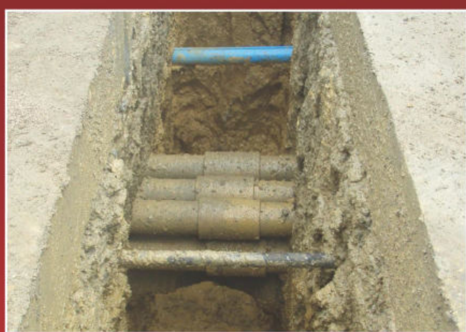
Applications

- Locating underground services
- Locating burst pipes
- Measuring pavement thickness
- Measuring concrete slab thickness
- Identifying geological or manmade anomalies.

Advantages

- Detects non-metallic services eg. fibre optic, water pipes, ceramic pipes, drainage pipes
- Non-destructive
- Rapid setup, locating and mark-out
- Compact and manoeuvrable
- Real time detection
- Post processing of data available.





PRODUCTS • TESTING • HIRE • MEASUREMENT • CALIBRATION

GEOTECHNICS LTD

Auckland, Hamilton, Tauranga, Wellington and Christchurch **P.** 0508 223 444 | www.geotechnics.co.nz

Technical Group Update

Last meeting was in November 2013.

Proficiency Program

Schemes underway

Category	Test	Volunteer Laboratories
Aggregate	Clay Index	Winstone & Stevenson - **DONE**
Aggregate	ASTM Density and Absorption	Fulton Hogan Nelson - **DONE**
Soil	Standard Compaction & Triaxial	Stevenson & OPUS - **STARTED**
Concrete	Compression & Density Tests	Stevenson – Jayden **20141**
Field	NDM	Stevenson (North Island) - Jayden **2014/2015**
Asphalt	Marshall Compaction	Downer – Frank -**2014**

Proficiency Program Update

•Weathering quality index report is completed and is on the website.
•Sand equivalent proficiency report is completed and is on the website.
•PSV proficiency report – report getting checked now.
•Clay Index proficiency – final data distributed. Report to be done.
•Standard Compaction, solid density and triaxial permeability proficiency – results being returned now.

TNZ T/1 Review

The technical group has produced drafts for TNZ T/1 and an additional guide for the measurement of deflection bowls. The NPTG has reviewed and made some comments. The technical group will now review and accommodate where we think appropriate. Once this process is completed the standard and guideline will be handed over to NZTA.

Roading Testing Standards Steering Group (RTSSG)

•Waiting to hear from NZTA to see if they will fund.
•NZS 3111, 3121, 3112 proposal. CCANZ, CETANZ, AQA looking at working together to review. CETANZ has committed $10K and volunteers to help work through NZS 3111 and NZS 3112, we are happy if work gets done on all three. We are waiting to hear from the AQA, likely that this will be discussed early in the new year as part of their budget review.

IANZ /PPAC Report

•The group was looking at the way signatory status was assigned in NZ and thinking of adopting the Australian NATA model. However the review has concluded that there is no drivers/need in NZ to warrant adoption of this process

Accreditation and Reporting of Derived Assumed and Subsequent Data.

•We have devised a list of scenarios where derived or subsequent data is reported in IANZ reports and are now working on recommendations for treatment of such issues.

NDM Guideline

•The Group is working on creating an NDM use guideline. This should help fill the gap between standards and instruction manuals for users.

OPUS Three thousand minds per hour.

SENIOR LAB TECHNICIAN

Opus International Consultants have the deserved reputation of being New Zealand's leading professional consultancy. We have consolidated our rich heritage and our services are increasingly in demand both in NZ and internationally. The Opus name is synonymous with innovation, professionalism and a solid track record of delivering a timely and quality service.

We are looking for a Senior Lab Technician to be an integral part of our Tauranga Laboratory. The role will include:

- Carrying out laboratory and investigation testing and provide advice on testing matters to the client.
- Assisting in the preparation of expressions of interest and project proposals.
- Liaising with other sections of the consultancy business to provide a total service to clients.

To be successful in this role, you will have excellent interpersonal and communication (verbal and written) skills, great client management skills, ideally a relevant National Certificate or relevant qualification and good knowledge of the relevant codes, standards, legislation and practices.

At Opus, our greatest strength is the quality of our people. Our expertise and dedication is the foundations of our success, and this is reflected by our supportive, fun work environment, the exciting projects we are engaged in, the personal growth and training opportunities we offer and the excellent conditions of employment and competitive remuneration packages.

FOR FURTHER INFORMATION ABOUT THIS ROLE, PLEASE VISIT OUR WEBSITE HTTP://RECRUITMENT.OPUSINTERNATIONAL.COM

Close Date: 5th January 2014

CETANZ Conference

On behalf of the Civil Engineering Testing Association of New Zealand (CETANZ) and the organising committee, I would like to invite you to the 4th biennial CETANZ conference "Raising the Standards". This event is the first of its kind to be held outside of Auckland taking place in Hamilton between the 13th to the 15th of August 2014.

A key objective of this event is to raise the standards of our industry and promote progression towards a more professional and widely acknowledged, well respected sector. Since its inception in 2006, CETANZ has made a number of great achievements including updating of standards, proficiency testing and the industry wide qualification framework to name a few. Over these few years our organisation has developed greatly to meet the ever evolving needs of our membership and has quickly become the voice for the civil engineering testing industry in New Zealand. CETANZ and this conference are here to ensure the on-going professional development of our industry and the theme of 'raising the standards' will address this and the significant change to a more professional and widely acknowledged, well respected sector into the future.

The organising committee is already well underway in preparing this event and it's my genuine ambition that the 4th CETANZ conference will become an even bigger and better forum for sharing key observations and experiences, research and discoveries and learning between like-minded people. We are sure you will enjoy and benefit from this fantastic opportunity and are confident this event will be the best and most comprehensive yet.

I look forward to seeing you all in Hamilton in August.

Michael McGlynn
Conference Convenor

TC3 Project

People are known to pull together during times of crisis to build resilience and overcome challenges. The communities affected by the Christchurch earthquakes are evidence of this human disposition. Through our experience working on laboratory testing for the Christchurch Earthquake recovery we have learnt that organisations also need to pull together in a similar way to cope with the consequences of a crisis.

The Canterbury earthquakes of 2010 and 2011 presented new challenges and opportunities for the Civil Laboratory Testing industry. In early 2012, when investigations on the ground in Christchurch were starting to ramp up, we got word that large quantities of laboratory testing would be required as a part of the investigation and remediation work for damaged properties. We set about preparing ourselves to step up to the opportunity where our Tauranga laboratory was expected to manage a laboratory testing component of ground investigations. Our Tauranga laboratory was selected for managing this testing because the laboratory testing resources in the Canterbury region were already over-capacity with other earthquake recovery work.

When the first few batches of sample arrived at our laboratory we proceeded to perform testing on relatively manageable quantities. We would subcontract testing to other players in our industry occasionally when quantities and expected turnaround times dictated. Initially we were receiving one or two boxes of sample with each delivery. Each box would have a number of boreholes in it and each borehole would contain 5-6 samples. Each sample required determination of the water content, the fines content* (fraction less than 63/75microns) and Atterberg limits if significant fines were measured. The objective of the testing was to provide data to our clients for their interpretation of liquefaction hazard.

Folks on the ground in Christchurch depended on a quick turnaround of lab testing to meet the expectations of the EQC, the Local and National Government and the Christchurch public. The pressure started to build when 3 boxes would arrive on our doorstep with each delivery, then five, then eight! This meant at any one time we were receiving up to 250+ individual samples with each delivery. The rate of delivery ramped up as additional drilling rigs and site personnel became active as a part of the fieldwork effort in Canterbury. A quick turnaround of results became a top priority and the laboratory testing was starting to become a bottleneck in the process.

We arrived at point where we came to the realisation that we weren't going to keep up without the help and input of some of our fellow industry players. From about mid 2012 we reached out for help from other labs. An invitation was sent out to a number other civil testing laboratories to gauge their interest in participating in some of the ground investigation laboratory testing. In all, seven laboratories said they would be keen to help us out. We setup a system from our Tauranga office to manage distribution of samples to these labs. Our clients indicated that they demanded value from laboratories testing on this project therefore required us to provide special rates for testing to account for the large volumes on offer. A tender process was carried out and resultantly we all agreed to a collective test price that was fair for parties involved and delivered value to the client.

We continued to receive sample into our Tauranga laboratory but at this point had a collaborative network supporting our efforts. For a period of months we were distributing testing among seven labs spanning from Whangarei to Alexandra.

The result of this banding together was that we collectively completed 822 Plasticity Index tests over a number of months. Our pulling together increased our ability as an industry to meet the challenge of providing quality laboratory test results in a timely fashion for Christchurch.

A big thanks must go out to all the laboratories that helped us out on this project. Collectively we can be proud of our contribution to the earthquake recovery effort.

*Fines content testing is an adapted version of the PSD test in NZS4402, where the washing and weighing components are used to determine the percentage lost during the washing process. The reason for this instead of a PSD test was that the client was primarily interested in what percentage of the material sits below the sand/silt boundary at either 63/75microns. Throughout testing it became apparent to our clients that international studies around liquefaction frequently referenced ASTM laboratory testing methods which differ slightly from New Zealand Standards. Primarily we ended up swapping out the 63micron sieve for a 75micron sieve to represent the sand/silt boundary as described in ASTM. We were also required to commission testing of Atterberg limits using ASTM D4318 – 10 instead of NZS4402: 1986 Test 2.2.1-2.2.3. for comparative purposes.

JACKJAW

Patented Peg Puller

The new lightweight way to remove your stubborn scala rods, waratahs, steel pins, tent pegs, sign posts and more...

The Jack Jaw is made from high-grade steel and has replaceable bisalloy 360 laser cut jaws.

The ideal tool for lab testers, formworkers, fencers, surveyors & concreters

- Saves time
- Saves money
- Saves wastage
- Saves your back
- Replaceable jaws
- No need for extra force
- Easy to handle
- Safe operations

Distributed By:
WALK"N"ROLL INTERNATIONAL LTD
Contact: Paul Herbison 0272908306
www.jackjaw.co.nz

JACKJAW®

Technology use in Geotechnical Testing

Graeme Duske
Coffey Information Pty Ltd
Manager Specialty Testing ANZ

Abstract
Technology is playing a major part in the development of Laboratory testing in Australasia.

The paper explains the use of Laser Diffraction Particle Sizing using equipment developed by Malvern, Horiba and Cilas Scientific companies to develop a fast, reliable and highly automated technique to determine the particle size analysis of soils as used in geotechnical engineering classification testing. A comparison is made of the principles associated with the existing sieving and hydrometer testing of medium and fine grained soils, and the evaluation of alternate microscopy and laser diffraction, explaining the principles of the Mie Theory as used in the laser diffraction determinations.

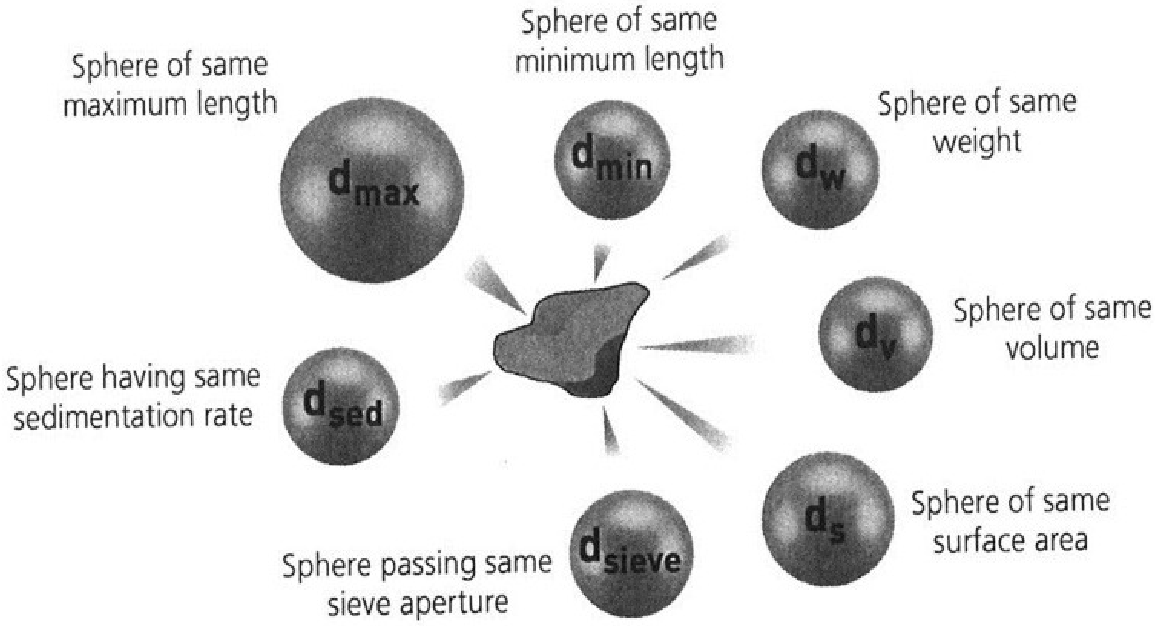
Comment is given of the development of a Kinexus Rotational Rheometer as developed by Malvern to research the relationship with the Liquid Limit. Defined as a specific shear strength of fine grained soils, using a new instrument design with a revolutionary software, it delivers consistent and accurate rheological properties of a soil slurry deemed at the Liquid Limit shear strength.

Christchurch Earthquakes have required an extensive geotechnical evaluation of gravels and alluvial silts before future re-construction of demolished or damaged buildings. Where Dynamic Penetrometer probes are requested for residential sites, an automatic field testing dynamic penetrometer machine has been obtained from Germany, reducing the laborious and risk of repetitive strain injuries as required of many blows from conventional hand operations.

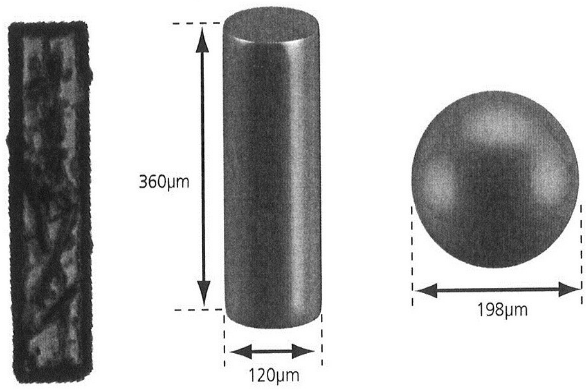
Introduction
Technology in geotechnical testing is advancing the productivity and accuracy of both laboratory and field testing in ways that could hardly be imagined some 20 years ago. The development of computing power and the availability of software have made testing more economic with a reduction in testing time, yet ensure reliability with greater monitoring of the test as it performs.
In Australasia the development of automation is expanding.

Strength and Consolidation
Testing equipment being introduced into Advanced geotechnical laboratories is permitting automation of sample testing that expands the testing time from an 8 hour timeframe to a 24 hour operation. Triaxial and Oedometer testing to determine the strength and consolidation properties of soils can now be automated so that successive stages can be pre-programmed to continue after “stop” criteria have been met for each stage. Remote control and email status reporting can ensure that confirmation of the predicted result has been attained.

Particle Size Distribution
In geotechnical engineering the nature of deposits and there formation is very dependent on the distribution of particles of different sizes. Much of the world’s surface, is covered in thick deposits of sedimentary deposits – gravel, sand, silt and clay. Grain-size distribution is a fundamental tool in soil classification and understanding soil behavior.
Different instruments have been developed to measure attributes of a particle’s size, based on how fast a particle settles, or the surface area of a particle or its length.
How do we define particle size?
Soil particles are different shapes and sizes, are 3-dimensional, and unless they are perfect spheres they cannot be described by a single dimension such as a radius or diameter. It is convenient to define particle size using the concept of equivalent spheres as shown in Fig 1. However different measurement techniques use different models and will not give the same result for the particle diameter.

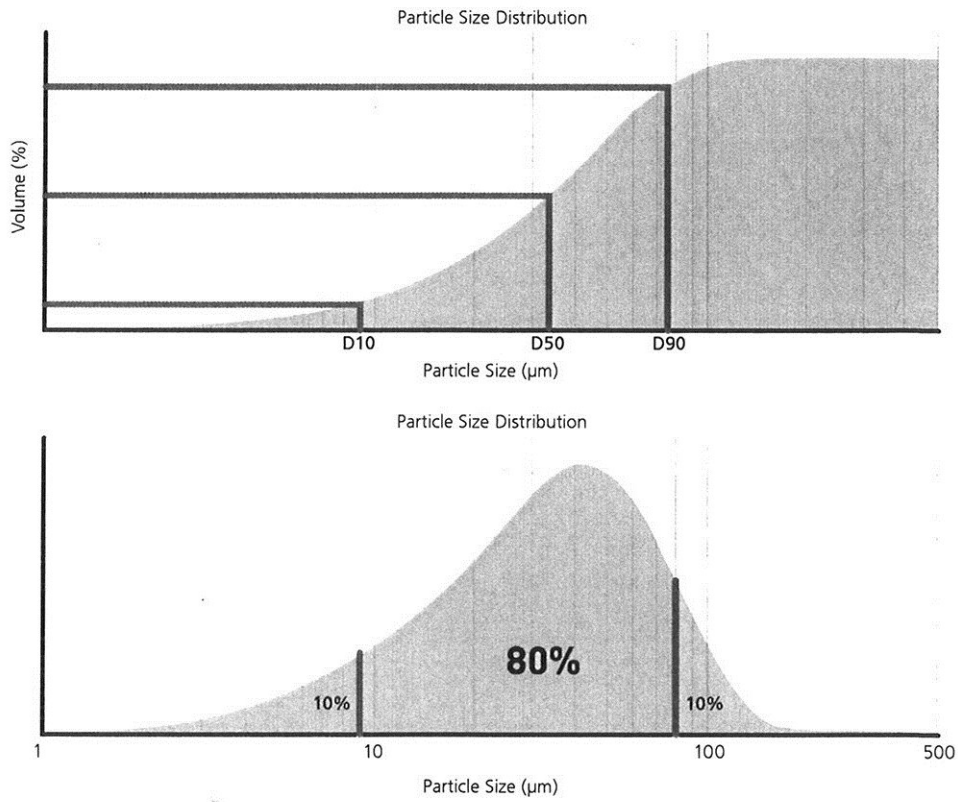


The equivalent sphere concept works well for regular shaped particles, but for irregular shapes of needles or plates, one dimension can differ significantly from the other dimension. Fig 2 gives the volume of an equivalent sphere which is not an accurate description of its dimensions.



Size Distributions

Soil samples consist of a statistical distribution of particles of different sizes. Common practice represents this distribution in the form of a frequency distribution curve, or in engineering a cumulative (undersize) distribution curve, as shown in Fig 3.



Comparison of 4 different methods for Particle Size distributions for soils
Sieving
In geotechnical engineering, sieving is the most widely used method of particle sizing. Testing of a dry sample measures the mass of material retained on a series of sieves.
A wide range of sieves are available with woven wire sieves from 60ųm to 125mm, and punched hole sieves available to the cm range.
Advantages are that it is relatively low cost and collects a sample of different size fractions.
Dis-advantages are that it is laborious with the need to wet sieve fine particles to prevent agglomerates forming or adherence to larger particles. The results depend on shaking time and motion, and are shape dependent.

Sedimentation
The method for Pipette sampling and Hydrometer measurements uses Stokes Law to account for differential settling times of a homogeneously dispersed sample where a spherical particle of a particular size and density will settle a certain distance through a liquid of a particular viscosity in a certain amount of time, ie. particles attain a terminal velocity of deposition.

$$u_{st} = \frac{(\rho_s - \rho_f) g d^2}{18\eta}$$

-where u_{st} =Particle terminal velocity
ρ_s =Density of solid
ρ_f =Density of fluid
η =Viscosity of liquid
g = Acc^n due to gravity
d =Effective particle diameter

Advantages are that it is relatively cheap technique to make a dispersed settling column and can produce re-

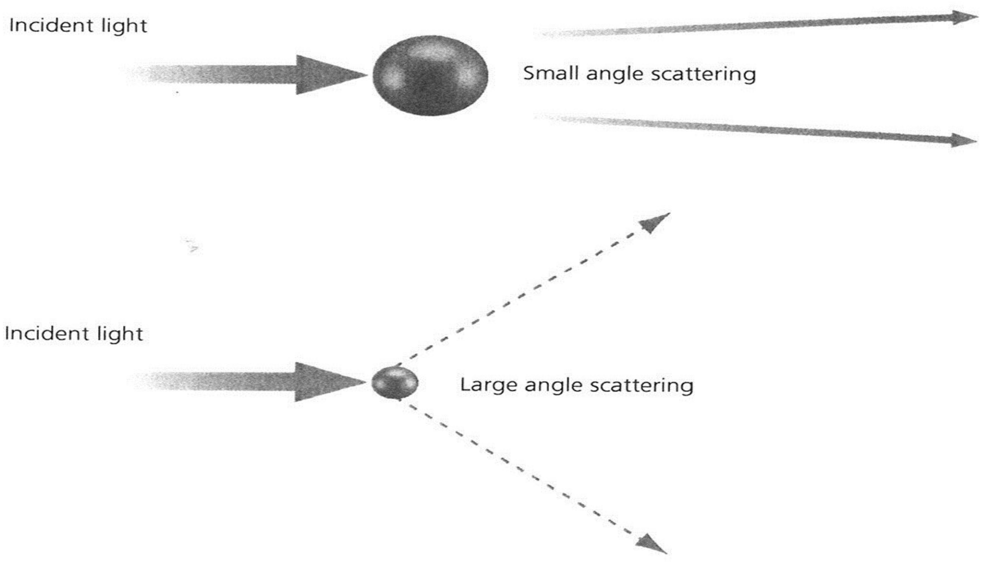
producible results with a consistent procedure.
Dis-advantages are that it is slow (24 hours to reach clay size), temperature dependent (viscosity of fluid can change with temperature), disturbance from inserting the hydrometer, not suitable for larger particles as turbulence can occur, effect of Brownian motion on the extremely fine particles, and can underestimate platy clay particles.

Microscopy

Scanning electron microscopy requires a stub sample be prepared by either a sprinkling technique or a dipping method, gold coated and grain-size measured in microns using a point-to-point measuring tool. The technique allows the direct observation of particles between the size range 1-150 microns, producing a number distribution based on projected area diameters.
Advantages of the method are that it allows a direct observation of the particles and measurement, and provides information on the particle shape.
Dis-advantages are that the sampling of the distribution is poor due to the stub sampling method not always retaining the larger particles, the sample preparation elaborate, and the result determined is a number distribution not a volume distribution with few images/particles measured of the whole sample.

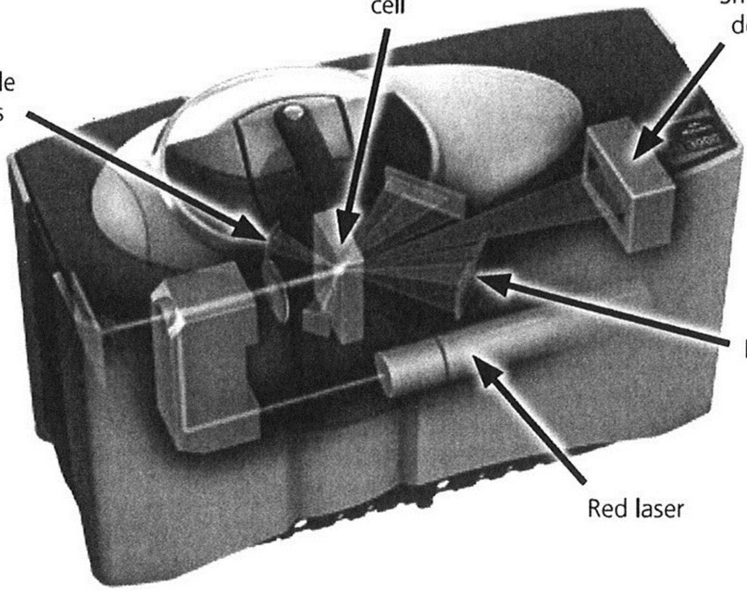
Laser Diffraction

Laser diffraction measures particle size distributions by measuring the angular variation in intensity of light scattered as a laser beam passes through a dispersed sample. The technology is based on the principle that large particles scatter light at small angles to the laser beam, and small particles scatter light at large angles, as shown in Fig 4. The angle scattering intensity data is then analyzed to calculate the size of the particles responsible for creating the scattering pattern.
Using Mie theory of light scattering, the particle size is reported as a volume equivalent sphere diameter.



Mie theory requires knowledge of the optical properties (refractive index) of both the dispersant and the sample being measured, generally found from published data or measured and held in the instrument database.

A typical laser diffraction system is made up of 3 elements:
a) Optical bench. A laser beam illuminates the particles as they pass through the optical bench as shown in Fig 5. The intensity of light scattered by the particles is measured by a series of detectors over a wide range of angles.



b) Sample dispersion units. For wet dispersion, disaggregated samples with a 1% Sodium Hexametaphosphate (NaHMP) solution as a dispersant, are continuously agitated and pumped to the measurement area of the optical bench at the correct concentration.
Dry powder dispersion suspends the sample in a flowing gas stream, usually dry air. However the data captures at rapid speeds as the entire sample passes only once through the measuring zone.
c) Instrument Software. The software controls the system and the measurement process, analyzing the scattering data and calculates the particle size distribution.

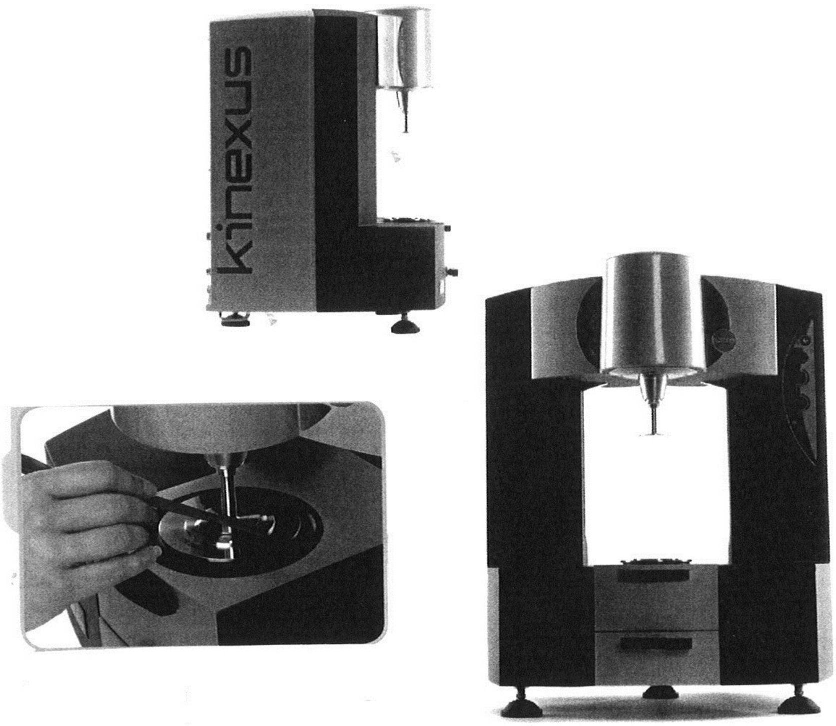
Advantages are that it is very rapid, repeatable and reproducible, on a size range from 0.5 micron to 2000microns. It can be applied to a wide range of samples, either wet or dry, and has a ISO Standard technique (ISO13320)
Dis-Advantages are that the refractive indices if the solid particles need to be known or measured, and the platy nature of clay sized particles and their orientation while entrained in the flow, can underestimate the fine fraction as they can be measured as larger particles.

Some of the Scientific companies who have developed Laser Diffraction equipment are:
Malvern Instruments Ltd with the Mastersizer 3000 Particle Size Analyzer
Horiba Instruments, Inc. with the LA – 950 Particle Size Analyzer
Cilas (Orleans, France) with the 1190 Particle Size and Shape Analyzer

Liquid Limit Determination
Professor John Atkinson in his book “The mechanics of Soil and Foundations” indicates that the shear strength of a soil at the Liquid limit is approximately 1.8 kPa, from research undertaken at Imperial College, London.
The conventional equipment is to use the Cassagrande bowl that is able to fall a distance of 10mm onto a rubber base of a specific hardness. A pat of soil is leveled into the bowl and a groove of a specific shape and width is created in the soil. The blow-count of 25 to close the base of the groove for a distance of 13mm is the consistency of the soil deemed to be at the Liquid Limit.
An alternative method for medium plasticity soils is to use a cone of a 30^{deg} included angle having a preset mass to freely fall for a 5 second period into the soil contained in a small cup, for a distance of 20mm, is again the consistency of the soil deemed to be at the Cone Penetration Limit.
For soils with a water content less than 50, the Liquid and the Cone Penetration Limits are considered the

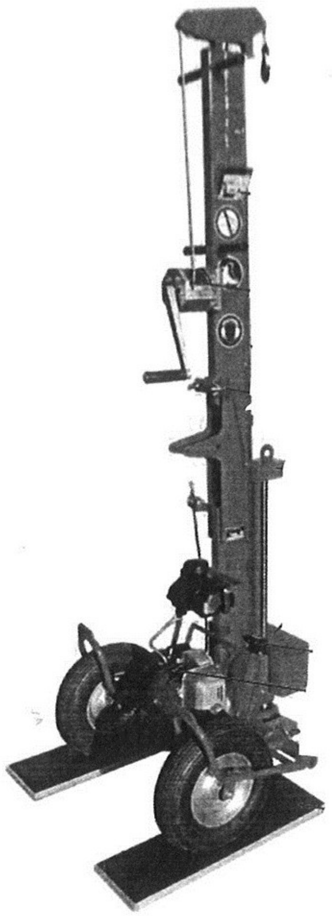
same.
Both methods are in effect conducting a Shear strength test to determine one of the parameters for a Soil Classification system.

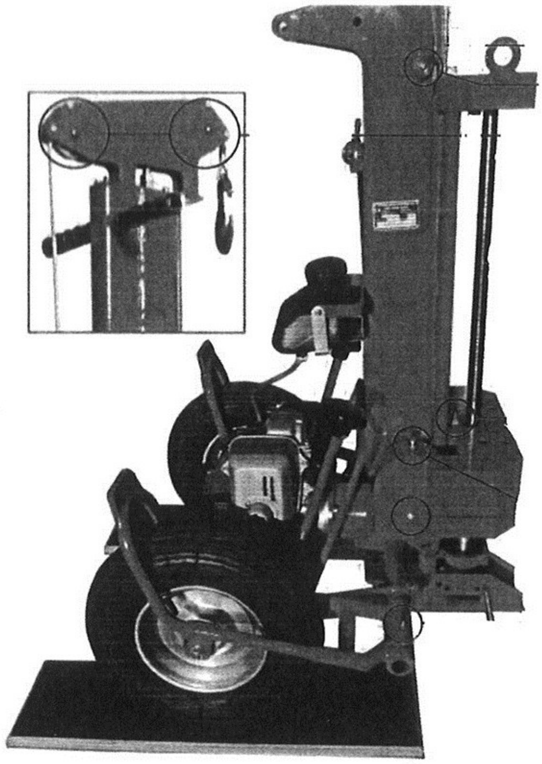
A Rotational Rheometer is another device that is used in industry to revolutionize the process of determining Viscosity and Shear stress of thixotropic materials. The Kinexus Rheometer is in effect a miniature Ring-Shear apparatus that measures the torque on a rotating disc, being computer controlled, to determine the Shear Viscosity, as shown in Fig 6.
Research is being undertaken to establish the parameters to measure the the Shear stress applied to a soil at the Liquid limit, and to verify the Atkinson values of 1.8kPa. One-point Liquid Limit measurements may be the norm in the future, with accurate and repeatable technology.



Automatic Dynamic Cone Penetrometer

Christchurch Earthquakes of 2011/12 have revolutionized the geotechnical investigation industry in the region. One of the investigative tools is to undertake Dynamic Cone penetrometer probes at 5 locations about a residential site to a depth of 2 meters. For the numerous sites (2000-3000) the task becomes a laborious one with the risk of repetitive strain injuries from the conventional hand operations, particularly where the blow count can get to more than 40 blows per 100mm penetration.
An automatic hammer lifting device has been obtained from Germany, as shown in Fig 7. The GLG Lindenmeyer Dynamic probe from Carl Hamm of Essen, is designed to lift a falling hammer of 50 Kg. For the NZ operation the lifting hammer was reduced to 9 kg falling a distance of 510mm using the conventional 16mm rods with a 20mm diameter cone. (no conversion is required as the cone, rods and hammer meet the requirements of NZS test 4402:6.5.2:1988.)





A single person operation allows the operator to concentrate on the penetration measurements as the test proceeds. The retraction of the probe utilizes a 3 ton “Farm” mechanical jack with a 1m overall stroke. The unit permits easy movement between sites as it is on pneumatic tyred wheels and handles at the top of the folded mast for ease of transportation.

Because the rods are guided and kept vertical, the number of breakages has considerably reduced, when compared with the similar hand operation.

Acknowledgements
The author acknowledges the assistance of:

Ryan Shaw and Bryn McDonagh of ATA Scientific Pty Ltd for the demonstration of the Malvern Mastersizer 3000 unit and the support scientific papers and slides.

Dr Adrian Hill of Malvern Instruments (UK) Ltd.,for information on the Kinexus Rheometer.

Adam Rae and Stephen Gardner of Coffey Information NZ Ltd Christchurch office for the details of the Dynamic probe operation.

References

Agrawal, Y.C., McCave, I.N. and **Riley, J.B.** (1991) Laser diffraction style analysis. In *Principles, Methods and Applications of Particle Size Analysis.* University Press, Cambridge.

Cheetham,M.D., Keene, A.F., Bush, R.T., Sullivan, L.A. and **Erskine, W.D.** (2008)
A comparison of grain-size analysis methods for sand-dominated fluvial sediments.
School of Environmental Science, Southern Cross University, Lismore, NSW, Australia.

Malvern Instruments Worldwide (2012) Inform White Paper *A Basic Guide to Particle Characterization.*