Understanding Laboratory Testing of Cricket Wicket Soils

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When assessing the suitability of a soil to perform as a quality cricket wicket soil a suite of tests is used. It is very important to use the collective group of tests to make this selection rather than using single tests, such a particle size distribution. The current tests used, together with methodology and explanations are outlined in some detail in McIntyre and McIntyre (2001).

Test	Desired Range
Mechanical analysis	Clay – 50-70%; 0.002mm- 0.25mm – 20-50; 0.5mm-1.0mm – 0-10%; >1mm 0%
Crushing strength	0.8 – 1.6 MPa
Shrinkage	0.08 – 0.15 strain (8 – 15%)
Cracking pattern	2 – 14 pieces
pH	6.0 – 7.0 in water; 5.0 – 6.0 in $CaCl_2$
Organic matter	<8%

Table 1. Shows most of the current tests which are carried out on cricket wicket soil, together with the acceptable range for each test

How we eventually make the decision about which soil is more suitable over another is not a simple process, particularly when one of the tested elements is not within a desired range. So we need to investigate the scenario does one test, one specific characteristic make a soil unsuitable. What we first need to understand is:

a What influence does each physical characteristic play in the final wicket product?

b Does the variability in the wicket preparation play more of a role in the wickets performance than the physical characteristic itself as a measured item?

c How accurately does the laboratory test reflect the insitu performance of the soil?

d What are the repeatability levels of the current test methods?

I feel that there are some within the industry that do not consider the holistic approach to the selection of cricket soils suitability and rather accept a project specification as the ultimate selection process without deviation. If one element is outside the set criteria, the material is deemed not capable of performing as a suitable wicket table. In saying that, there is purpose in setting a material specification but answers to (a), (b), (c) and (d) need to be considered.

Clay content

Clay content: is probably one of the most critical components of a wicket soil. Clay is a particle less than 2um in size. Due to the small nature of a clay particle a clay soil holds large amounts of water (the surface area of a set volume of clay particles far exceed that of an equivalent volume of sand particles). There are many types of clay minerals, with the most common including Kaolinite,. Illite, and Smectite Montmorillonite. Ideally wicket soils should contain more Montmorillinite and Illite. The clay content provides strength to a wicket. One of the most important features of high Montmorillinite clay content is that it causes the soil to crack. The cracks in the wicket soil are essential to allow water to penetrate and to allow air to reach the grass roots. These soils decompact themselves after wetting and drying, which is essential for continued grass growth after use. Kaolinite clay does not crack, hence if this clay is dominant you will have poor root growth, poor soil strength, and the soil will not decompact itself.

The most common test used to measure clay content is by mixing the soil into water (generally approximately 50grams of soil diluted into 1 litre of water). A hydrometer is placed into the soil water mix. Due to the small nature of the clay particles they remain suspended for longer periods than the heavier silt and sand particles. The hydrometer bulb is held in suspension by the particles suspended in the liquid. As the heavier particles start to fall out of suspension and settle on the bottom of the cylinder the hydrometer start to sink lower and lower into the liquid. Details calculations are performed to determine to particle size and quantity to provide a particle size distribution plot.

During the preparation of the particle size analysis by hydrometer method, the clay soil must be thoroughly dispersed. If the soil is not dispersed appropriately to produce individual particles, the particles adhering to one another act as a larger particle falling out of suspension sooner and the test will indicate higher silts contents. It must also be noted that black soils are generally black due to the high organic content. Organics are typically lighter particles and once dispersed in the hydrometer test may influence the result. It is therefore necessary to remove the organics in a pretreatment process using hydrogen peroxide which affectedly burns off the organics.

In any laboratory test, repeatability and uniformity are the key elements in achieving a true result. The initial process of preparing a wicket soil for analysis in current test methods allows the practitioner a large variation in the consistency of the mix which in my view has a substantial influence on the result. The problems begin when a wicket soil may arrive in a laboratory in three possible conditions;

- a Moist / wet clods
- b Dry lumpy clods
- c Dry manufactured crumbles (<5mm)

Tests such as cracking pattern, shrinkage and crushing strengths rely on the wicket soil being in a paste condition. The consistency of the paste needs to be made into two different levels of stiffness to perform these tests. The cracking pattern and shrinkage cores require a paste that is able to be smeared into an evaporating dish or smeared into a 10mm diameter cylinder tube and extracted to form a core, i.e. a paste of a similar consistency to peanut butter. The crushing strength requires a stiffer paste. The soil needs to be at a moisture condition that allows spherical balls to be rolled on a glass plate without being too wet where the material sticks to the surface or too dry where the ball crumbles before a ball is formed. The rolled balls need to be between 5mm and 20mm diameter and not have any flat spots, surface cracks or imperfections. The difficult element in this preparation is, understanding that different clay types and clay contents will govern the amount of water required to create these pastes. It may vary considerably with soil types.

Some questions that may need answering in relation to the most appropriate moisture content include:

- What is the correct moisture condition?
- Is there a range that is acceptable and what is the range?
- How do we determine the ideal moisture condition?
- Should we dry the soil to less than 1% moisture and grind the soil to a powder of less than 425um, then moisture condition the soil back to a predetermined value say 45% for crushing strength and 55% for cracking patterns?
- Does drying and grinding the soil alter the structure creating a different shrinking behavior to that that occurs in a wicket table?

It is obvious that the moisture content, at which these two pastes are formed, will influence the outcome of the test. When we look at a model of soil we have three components, air, water and solids. When we create a paste, the amount of water and the size of the pore spaces are the two elements that are going to change once the specimen dries. In a shrinkage test this is easy to appreciate as we are measuring the reduction in size due to the moisture loss. If a paste is made wetter, there is more water to loose and potentially a greater measure of shrinkage.

In the crushing strength test, where an air dried ball is placed in a press and increasing pressure is applied until the ball breaks, the moisture allows us to achieve a compact ball of soil and the optimum moisture will allow us to achieve the maximum compaction level. To determine the optimum moisture content for remoulding crushing strength balls, I believe we have two options.

Option 1 - AS1289 5.1.1 Standard compaction test

We can utilize the laboratory test AS1289 5.1.1 Standard compaction test which uses 525 kilojoules of energy to compact the soil. The test provides the Maximum Dry Density (MDD) in t/m^3 of the soil at the Optimum Moisture Content (OMC). It is this moisture content that we can use as our basis for establishing the range in which we remould the soil for the crushing strength test. If we decide to utilize OMC as our target moisture content with a possible tolerance o +3% then we have controlled the potential for larger deviations in results.

Advantages	**Disadvantages**
• Common test readily available • Provides a (OMC) moisture condition specific to the soil type • Provides a strict tolerance of 0 – 3% moisture variation • The test is reproducible • Confidence in the test result • The MDD & OMC may be useful data for using a Nuclear density / moisture meter for determining compaction levels in a wicket table during preparation (refer to discussion later in article)	• Adds approximately $65.00 +GST to the cost of the crushing strength test • Takes 24 hours to determine, plus another day to cure the sample at the appropriate moisture content before the drying process can commence • Approximately 12kg of soil is needed

Option 2

A skilled laboratory technician with experience in performing the AS1289 5.1.1 standard compaction test estimates OMC by feel and rolls the balls when they believe they have the soil in a desirable condition.

Advantages	Disadvantages
• No extra cost of the crushing strength test • May only take 10 -20 minutes to determine • No extra soil is needed Common test readily available	• The moisture variation between labs would be large • Different operators – different opinions • Variation between operators may be up to 10% • The test may not be reproducible • No confidence in test result

The moisture content of a specimen during preparation has been the main area of focus up to this point, but we now need to consider the moisture content of the specimen at the point of placing the prepared ball into a crushing press (load frame). Current test methods suggest 7 days of air dry curing. The moisture condition of the ball at this point is also very important and may influence a result and the final selection/ acceptance of a product.

Air drying a soil in Melbourne during summer and winter is very different as is air drying a sample in Cairns or Perth during different times of the year. The instruction of a seven day air dry may not be sufficient to reduce the experimental errors evident in this process. In order to achieve a dry sample without the risk of cracking we need to dry the specimen slowly, but we need to be confident that the drying has allowed the soil in the centre of a 20mm ball to be consistent with the rest of the ball. A smaller ball will dry quicker and will be a uniform moisture throughout while the larger ball may still contain moisture in the middle. This may produce a lower crushing value.

It is suggested that drying occurs at room temperature provided it is within 20 – 25^{o}C for a period of 6 days and then the balls are placed into a low temperature drying oven at 25 - 35 ^{o}C for a further 24 hours. Once the crushing strength test is complete, the remnants of the test are placed in a tin and after-test moisture content determined at 105 - 110 ^{o}C. It is a good idea to inspect the crushed portions of the larger balls to determine if there is any evidence of damp material in the centre, generally indicated by a darker colour. If the after-test moisture content of the combined specimens are (is?) greater than say 0.5-1% the test may be considered invalid and would need to be repeated.

Cracking pattern

The consistency of the paste used in the cracking pattern and shrinkage test is somewhat wetter than that used for the crushing strength. Again what we would ideally like to be able to achieve is a simulation of what happens in the field. What we need to remember is that a wicket table is a body of soil generally 200mm thick.

The current method of measuring a soils cracking pattern is to wet up the soil into a toothpaste like consistency and then smearing it into a 100mm diameter porcelain drying dish. The material is then left to air dry and crack at room temperature.

We need to ask ourselves does this reflect the conditions that occur in the field. I would say not. It is suggested that maybe since we have the choice of adopting the standard compaction test to determine *Maximum Dry Density (MDD) and **Optimum Moisture Content (OMC) for the crushing strength paste then maybe we can utilize this test in determining the soils cracking pattern.

The standard compaction test requires the compaction of five specimens in a metal mould one litre in volume with the dimensions of 105mm diameter by 115mm in height. This provides a solid core of soil at five differing moisture contents which will be spread either side of OMC by 2% - refer to Figure 1 below. The specimen remoulded closest to OMC on the wetter side could be utilized to determine the cracking pattern.

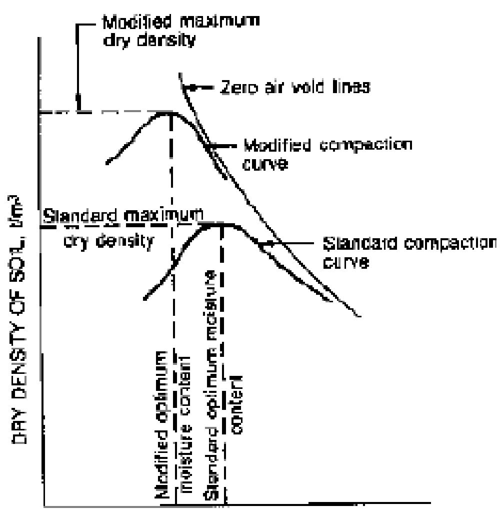

Figure 1 Compaction test results plot

*** Maximum Dry Density (MDD)**

The MDD. of a material is the maximum density at which a material can be compacted using a standard amount of energy and is obtained from the plot of the compaction test.

****Optimum Moisture Content (OMC)**

The OMC. is the moisture content at which a material can achieve the highest dry density and is obtained from the plot of the compaction test.
Refer to Figure 1.

This larger / deeper core would more closely reflect a wicket table. The specimen could be dried at room temperature 20 - 25 ^{o}C for a 7 day period to reflect the slow drying of a wicket table. Alternatively the specimen could be place under drying lights to reflect the suns drying of the surface soils and would be a quicker process. (Some consideration must be given to the fact that typically cricket soils dry more readily from the surface once most of the turf leave matter is shaved and rolled). The number of surface cracks could be counted with the largest crack measured for its width and possibly its depth. It is obvious that trials would need to be conducted to determine if the resulting cracks would in fact prove to be able to be counted.

It may even be appropriate to wrap the outer faces of the specimen in cling wrap to prevent the side walls cracking as this would not occur in the field. A soil in the field environment is confined by surrounding soils and would not tend to dry from the sides other than from within deeper cracks. Ideally if this method was adopted, duplicate of even triplicate specimens would need to be formed.

Shrinkage

The shrinkage test paste is probably the most critical in achieving a repeatable result between operators within a company and within laboratories the world over. As previously discussed it is the moisture loss that provides the shrinkage to the specimen. We must understand that the shrinkage cores test is not the same as the Linear Shrinkage test and the two produce very different results. It is apparent that the soil preparation method to produce a paste for the shrinkage test must be refined and tightened to limit the possible variations that currently occur. Measuring soils shrinkage from an unknown variable moisture condition to a dry state is not favorable, which is what occurs in the current method.

It is suggested that the soils shrinkage characteristics are determined by the Australian Standard test method AS1289 7.1.1 Shrink Swell index. This method takes into consideration a soils ability to shrink and swell and the two measured values are converted into a shrinkage index. Again what we want to do is simulate field conditions in a wicket table. The soil would be remoulded in a split mould with the dimensions of 2 to 1 ratio (height to diameter ratio preferably at 50mm diameter) at the soils previously determined MDD and OMC using standard compactive effort as per AS1289 5.1.1. By remoulding a specimen at SOMC we would be creating a specimen which is typical of the moisture content found in a wicket soil on about day 5 or 6 of an eight day preparation period. The remoulded specimen would provide the shrink component of the test. We would then need to create a second smaller specimen of the same density for the swell test. This could be cut from a specimen remoulded in the compaction test with the use of a thin walled sampling tube or swell cutting ring. The smaller ring of soil is placed in the swell apparatus as detailed in AS1289 7.1.1.

The determination of the shrink swell index as compared to the current shrinkage test means that the variability and measurement of uncertainity between operators in achieving an appropriate moisture content are potentially removed. The shrink swell test effectively tells us how wide the soils boundaries of movement are, refer to Figures 2 and 3 below.

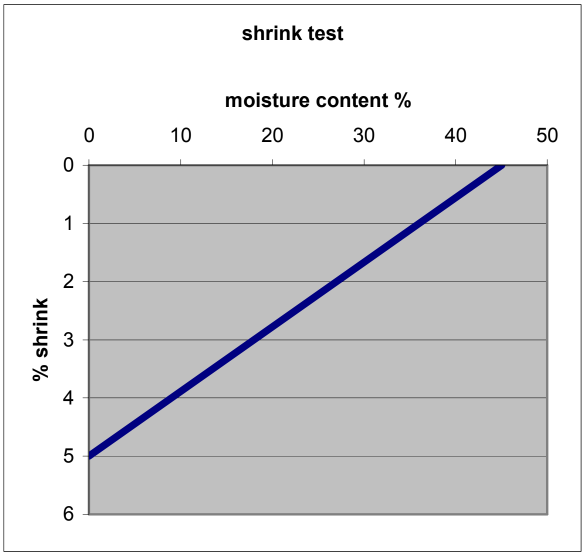

Figure 2. Shrink test – specimen commenced at 45% moisture and on drying shrunk by 5%

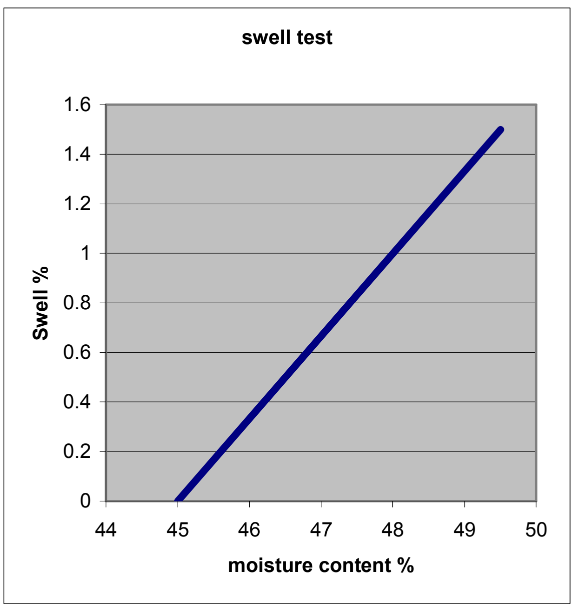

Figure 3. Swell test – specimen commenced at 45% moisture and on swelling increased in moisture to 49.5% and swelled by1.5%

The combined shrink and swell test gives us a shrink swell index of 3.2%. Ideally the moisture content of the specimen at the start of the test is less critical using this method. A drier sample will shrink less but will swell more and conversely a wetter specimen will shrink a lot more and have minimal swell. Either way the shrink swell index will determine the soils reactivity characteristics.

Summay

With any proposed changes to industry adopted test methods, a certain amount of trials need to be conducted. We also need to consider that the industry has a level of understanding and appreciation for the past test results on certain cricket soils. The historical data gained over the last thirty years on these supplies is extremely beneficial. To introduce new test methods which may or may not replace the old ones would possibly make these records obsolete. There would need to be some ability to correlate the data.

With the adoption of research trials and industry consultation, any changes should be formatted into a National recognized method in the form of the development of an Australia Standard test method.

The first step is to agree that change is necessary and to conduct some trials. The results could be presented at future cricket wicket seminars.

The process in selecting a cricket wicket soil or determining whether a soil meets a project specification must be done with a holistic understanding of the importance of each assessed element and whether any unfavourable element within the suite of the tests is going to substantially affect the overall playability of the final product. If we were to review cricket materials world wide from major stadiums, we would find that not many if any would meet all the criteria commonly found in Australian specifications (this is because only South Africa use cracking clays). Refer to Table 2 below.

Test type	Australian specification	English soil Ongar binder loam	English soil Gostd	Pakistan soil	United Arab Emirates
Cracking pattern	2 – 5	2	1	2	1
Clay content	50 – 80	50	43	66	56
Crushing Strength	0.8 – 1.6	0.7	0.63	1.2	0.75
Organic Matter	< 5	3.7	3.1	2.1	22.3
Linear Shrinkage	8 – 15	9	6	18	8.4
pH	6 - 7	7.8	6.6	8.7	8.6
Ec ppm	600	1090	5120	545	5120

Table 2 – Results of some international cricket soils tested in 2007

References

McIntyre, Keith, and McIntyre, Don 2001.***Cricket Wickets - science v fiction*** Horticultural Engineering Consultancy Canberra 282pp

Standards Australia 199; ***Methods of Testing Soils for Engineering Purposes, Australian Standard 1289*** (AS1289 5.1.1 Standard compaction test and AS1289 7.1.1 Shrink Swell index)