DEPARTMENT OF MINES AND ENERGY

GEOLOGICAL SURVEY

SOUTH AUSTRALIA

REPORT BOOK NO 93/17

PHYSICAL PROPERTIES OF SOUTH AUSTRALIAN BUILDING STONES

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Disclaimer

The information contained in this report is presented in good faith. While every attempt was made to ensure that samples were representative, sampling was limited. Stone is a natural material and often shows considerable variation in properties even from within a single quarry. Therefore, the product may vary with time. The results presented in this report should be used as a guide only, and not as a substitute for careful evaluation by the user at the time.

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Physical Properties of South Australian Building Stones

D A YOUNG

A program of testing of physical properties of South Australian building stones has been carried out on a total of thirty samples representing:

- **Seven granite samples from four localities**
- **One marble sample**
- **Thirteen slate and flagstone samples from nine localities**
- **Three sandstone samples**
- **Six Mount Gambier Limestone samples.**

Testing procedures generally followed draft Australian Standards which were issued in 1986-87.

All samples were orientated with respect to geological features having potential to impact on stone properties, such as bedding in sandstone and limestone, fissile parting in slate and flagstone and layering or foliation in granite and marble.

Testing of building stones which have come onto the market since this testing program is recommended.

Rigorous testing such as was undertaken for this report can only be done when samples are available from established quarries. Preliminary investigation of new quarry sites by diamond coring to obtain samples for petrography, ultrasonic pulse velocity, water absorption and compressive strength testing is highly advisable. The adoption throughout Australia of the standard procedures for preliminary testing outlined in this report is strongly recommended.

INTRODUCTION

In 1985 the Department began work on a long-term project designed to assist the South Australian building stone industry by promoting a greater awareness and understanding of its products. The results of the first phase of this work are presented in this report which is intended to provide designers and specifiers with a guide to the properties of South Australian stones.

The modern testing of the properties of stone used for building, decorative and monumental purposes owes much to the work of D W Kessler at the US Bureau of Standards. Kessler conducted an extensive series of laboratory tests on United States stones, providing a vast body of data of considerable value for comparative purposes. The widely used American Society for Testing Materials (ASTM) standards for testing stone draw heavily on Kessler's work of sixty years ago.

Many national organisations have carried out testing of their building stones. Notable amongst these are the work of the Building Research Establishment (BRE) at Garston England and the Turin Polytechnic, Italy.

In Australia, major work on the testing of stone has been undertaken in Victoria by Finch and in New South Wales by Wallace. More recently, the CSIRO Division of Building Research has commissioned Amdel Limited to undertake testwork and reviews of available stone on an Australian-wide basis. To date reports have been produced on sandstone and on marble but a lack of funds has prevented further work on other stone types.

The first substantial body of stone-testing in South Australia was undertaken in the period 1974-1981 by Amdel on behalf of the Department of Mines and Energy resulting in 14 progress reports. This work included tests on commercially available material and also on stones which, though no longer quarried, had been frequently used in older buildings. Information of considerable value to the conservation of historic stone structures was produced as a result.

The 1974-1981 work had several shortcomings which limit the validity and application of the results obtained. There was a lack of rigour in the sampling, some test procedures were changed during the work making comparisons difficult, and some procedures were found to produce inconsistent results. When the current project was being planned the decision was made to undertake a completely new series of tests, many of which had not been carried out in the earlier work.

The post 1985 testing was undertaken at Amdel Limited (Frewville, SA) and at the Geomechanics Laboratory, Department of Civil Engineering, University of Melbourne. The test procedures and the basic test result data are contained in unpublished reports to the Department (Spry *et al.*, 1986-1989).

This report is a compilation and presentation of the test results together with brief explanations of the test procedures. While some discussion of the significance of the results is included, it is by no means the comprehensive analysis that the extent and detail of the data deserves.

Summary test results are presented in Table 3. Individual and composite data sheets for all samples form Appendix A. Recommendations for preliminary testing of building stone deposits are included in Appendix B. A list of current operating building stone quarries in South Australia is incorporated as Appendix C.

CLASSIFICATION OF SOUTH AUSTRALIAN BUILDING STONES

The term 'building stone' used in this report includes all natural stones used as building, monumental and ornamental materials. A less commonly used term is 'dimension stone'. This refers to natural building stone trimmed or cut to specified shapes or sizes. It should be distinguished from 'diminuted stone': stone that is crushed and used as an aggregate, industrial mineral or chemical raw material.

Much confusion results from geologists and the building industry using different terms when describing building stones. The following classification of South Australian stones into six major types is based on terms that are commonly used in the building industry, and not on strict geological nomenclature. It thus reflects the *use* of a stone in addition to providing some clues as to its geological origin.

Granite

All macrocrystalline igneous (and some metamorphic) rocks including granite, adamellite, diorite, gabbro and norite are known to the building stone industry simply as granites. Thus the Black Hill Granite (the term used in this report), which geologically is a norite, is known commercially as *Imperial Black Granite*. Granites are generally composed of three main minerals: grey quartz, coloured feldspar and lesser amounts of black mica, hornblende or pyroxene; it is the feldspar which may be white, red, pink, green, blue or black, which is principally responsible for the overall colour of the stone.

Marble

The term covers all carbonate rocks capable of taking a good polish. Fine-grained dense chemical and detrital limestone and dolomite (which are really sediments) are included in addition to true marble, which is metamorphically recrystallised limestone. The most widely used South Australian marble is that from Angaston; like the Carrara marble from italy, it is a true marble. Unlike granites which are a mixture of silicate minerals, marbles are almost wholly composd of the single mineral calcite (calcium carbonate). Minor impurities give rise to colour variations and highlight the often diffuse pattern in the stone.

Slate and Flagstone

Slate is a term applied to many paving stones whose natural form is thin planar slabs. Most are more correctly termed flagstone: siltstone, fine-grained sandstone or schist with regular well-developed parting or fissility along bedding planes. These can have properties similar to true slates and are often referred to as such; eg Mintaro Slate. Because of their ability to be split into very thin sheets, true slates have been used as roofing shingles: examples include Willunga and Penrhyn (Wales) slates. Most slates are fine-grained stones with a uniform and characteristic grey colour, though pale purples and greens are also found. The coarser materials are described as flagstone; eg Kanmantoo and Wistow Flagstones. Flagstones show a greater colour variation and often have yellow brown iron-oxide coatings on their surfaces.

Bluestone

Bluestone is a broad term related to slate and flagstone. It includes siltstone, fine-grained sandstone, limestone and shale (sedimentary rocks) and meta-siltstone, schists and gneiss (metamorphic rocks). Most are dense and internally dark grey coloured; some are bluish. Regular joints or cleavage planes, which facilitate quarrying and dressing, are often naturally coated with iron-oxides giving rise to the characteristic yellow-brown and black colours. Note, that the geology of some quarries, including Kanmantoo and Wistow, is such that they produce both thin paving stone (slate and flagstone) and thicker walling stone (bluestone).

South Australian bluestones should not be confused with those of Victoria which are generally basalts; volcanic igneous rocks formed by the cooling of molten lava.

Sandstone

Sandstone is a sedimentary rock composed predominantly of quartz grains, though many have high proportions of feldspar and clay. The natural cements that bind the granular material include silica, clay, calcium carbonate and iron-oxide. Sandstones are generally light coloured off-whites, creams, pale pinks and browns. They often show stronger colours associated with iron-oxide figuring which, unlike bluestones, is dispersed through the body of the stone and gives rise to banding and wavy patterns which are often mistaken for the natural bedding of the stone (eg. Basket Range Sandstone).

Limestone

Limestone is a sedimentary rock consisting chiefly of calcium carbonate. Limestones used for building in South Australia are commonly pale coloured calcarenites (compacted masses of shell or coral fragments); such as Mount Gambier Limestone; or oolitic limestones (composed of minute concretionary spheres of calcium carbonate), such as Bath Limestone (England). These are aqueous deposits. Aeolian (wind-blown) limestones occur in coastal areas of western and southern Australia. Though mostly calcium carbonate they can have the granular appearance of, and are often mistakenly described as sandstones; examples include the coastal limestones of the South East, eg. Robe. Another variety of limestone is the near surface material, calcrete (formerly known as kunkar) which is developed within the soil profile as a result of chemical action. It is widespread throughout South Australia and its rough nodular appearance is commonly seen in nineteenth and early twentieth century buildings.

Note: Freestone

The traditional international use of the term freestone is to describe fine-grained sandstones or limestones that can be readily worked in any direction. Locally the term has also been applied to stone that is loose on the surface (fieldstone), or is naturally joined into easily-quarried pieces, and is thus 'free'. Freestone is also used to describe a style of walling in which the pieces are laid in an apparently random or free pattern.

To avoid confusion between sandstones and limestones, it is recommended that the term not be used to classify stone types.

Terminology

In this report stones are identified by a geographic name (the locality of the quarry) followed by the stone type as classified above; eg Jones Hill Slate. Commercial or trade names are often derived in the same way. Where they differ, the current trade name is shown in Table 1; eg Jones Hill Slate is sold as *Parachillna Slate.*

SAMPLING

All stone samples are recorded in the Department's Rock Sample index system. This is based on 1:100 000 scale map sheet areas followed by an accession number; eg Auburn Bluestone - 6629 RS 59. The Department maintains a series of 1:100 000 scale maps on which rock sample locations are accurately plotted.

Thirty samples of seventeen South Australian stones were tested in this programme. They are listed in Table 1 together with trade names and rock sample index numbers. Quarry locations are shown in Figure 1.

Not all currently available stones have been tested. Funding limits prevented every operating quarry being sampled, and there have a number of new developments since the sampling and testing programmes were devised in 1985. In particular, new red and pink granite deposits have been opened on Northern Eyre Peninsula (Minnipa, Wudinna and Tcharkuldu Granites) and green granite deposits have opened in the Southeast of the State (Padthaway Granite). A list of currently available building stones, their producers and localities is incorporated as Appendix C.

Funding constraints generally limited the number of samples to one per quarry. More samples were obtained from deposits with known variation in lithology and from the larger more significant quarries.

Ideally, samples should be representative of a deposit or a particular quarry's output. In practice this is difficult to achieve. Because of natural variation across a deposit (irrespective of stone type) it is most unlikely that a single sample can be truly representative. Hence the need for caution when using the test results for design purposes.

All samples were orientated with respect to geological features that may have some impact on stone properties. There is generally a dominant planar structure such as bedding in sandstones and limestones, and fissile partings (often coincident with bedding) in slates, flagstones and bluestones. In addition to bedding plane partings, the slate samples were orientated with respect to their grain. The granites and marbles were orientated with respect to layering or foliation and to geographic co-ordinates.

In order to provide sufficient specimens for testing, substantial amounts of stone are required. The largest samples were 1.3m^3 blocks of black granite, weighing nearly 4 tonnes. The collection, primary and secondary sawing, and preparation of test specimens from such samples is a considerable undertaking not to be entered lightly. The costs are substantial, being the greater proportion of the overall expenditure.

Samples were generally collected by Departmental staff. Primary and secondary sawing was carried out by S D Tillett Memorials Pty Ltd of Brompton, SA.

STANDARDS FOR TESTING

Standards for testing and selecting building stone have been produced by many national bodies. The procedures of the American Society for Testing Materials (ASTM) have formed the basis of much Australian testwork. Others of note include those of the British Standards Institution and the French RILEM (International Union of Testing and Research Laboratories for Materials and Structures).

In the mid 1980s the Standards Association of Australia established a committee to devise local standards on methods for sampling and testing building stone. Five Draft Australian Standards were issued for public comment in the period December 1986 - February 1987. At present these remain in draft form.

The test procedures used for this work were devised by Amdel in conjunction with the Department of Mines and Energy. They generally follow the Draft Australian Standards, though there are some differences: the test procedures and the draft standards were being developed simultaneously. Where no draft standard was being prepared, procedures were mainly based on standards of ASTM, RILEM and ISRM (International Society for Rock Mechanics). A brief explanation of each test procedure is included in this report. A full description of the test methods forms Appendix K to Progress Report 2 (Spry *et al.*, 1986-1989).

Perhaps inevitably, test procedures specified in standards vary from country to country. While the same property may be under test, the procedural differences can be such as to render direct comparison of the results difficult and sometimes invalid. For example, the measurement of compressive strength is found to produce very different results, depending on whether the test specimens are cubes or cylinders.

Great care should be exercised when drawing inference on properties of stones tested under different standards.

In addition, some tests are difficult to repeat with precision (even by the same laboratory) and comparison of results should then be confined to each batch of samples tested. This has been found to apply particularly to resistance to salt crystallisation tests.

TESTING SCHEDULE

Table 2 lists the range of tests undertaken and the standard number of specimens per test. Note that a sample is comprised of specimens which are prepared to suit each particular test. Not all samples were comprised of the standard number of specimens. Surplus, or more often shortage, of sample material in part determined the number of specimens that could be prepared. Cores, 125mm in length for compressive strength and related testing, could not be cut from some of the slates on account of their thinly bedded nature. In some cases where there was more than one sample of each stone (Black Hill Granite and Mintaro Slate) the number of specimens per sample was reduced. Full details are included on the data sheets for each sample in Appendix A.

Most of the testing was undertaken at Amdel. Five of the tests (Compressive strength, Young's modulus of elasticity, Poisson's ratio, Shore hardness and Ultrasonic pulse velocity of cores) were carried out at the Geomechanics Laboratory, Department of Civil Engineering, University of Melbourne.

TEST PROCEDURES

A full description of the test methods forms Appendix K to Progress Report 2 (Spry *et al.*, 1986-1989). A brief explanation of each test procedure follows, together with some interpretation of the significance of the test results. This is not a fully developed discussion: readers are referred to the bibliography for further information. Recommendations for a range of tests suitable for preliminary evaluation of building stone deposits are presented in Appendix B.

Compressive strength

This test measures the strength of a material in compression. Draft Australian Standard DR 86226 requires cylindrical specimens, cored from the sample block or prepared from diamond drillcore. Their axes should be normal to the dominant planar structure such as bedding, foliation or layering. They should have a diameter not less than ten times the largest mineral grains present and a length to diameter ratio of 2.5:1. The recommended standard specimen diameter is 50mm giving a length of 125mm. Corrections are applied to the results of short cores. Accurate and careful preparation of the specimens (particularly the ends) is critical to achieving good results.

In this work, specimens were nominally 50mm in diameter except the granites and marble which were cored at 100mm diameter on account of their coarse grainsize, and the Mount Gambier Limestone, which because of its coarse open texture, was cored at 70mm diameter. Short-core corrections were applied when the length to diameter ratio was 2.35 or less.

Half the specimens were tested after oven drying and half after a 48 hour soak in water at atmospheric pressure. A progressively increasing load is applied to the ends of the cylindrical specimens. As the load has a single axis coincident with that of the specimen, and since the specimen is not otherwise restrained, the test is described as uniaxial or unconfined. The compressive strength of each specimen is the applied stress (load per unit area) at failure and is measured in megapascals (MPa). Stones are generally strong materials in compression, but as this work shows, they vary widely, the lowest result being 1.5 MPa and the highest 220 MPa. Structural concrete is specified by minimum compressive strength, typical figures being 20, 25, 32, 40 and 50 MPa. The lower strengths are used for normal building work and the higher for engineering applications such as bridges. Australian Standard 1225-1984 specifies that 95% of a batch of clay bricks should have compressive strengths not less than 7 MPa. Note that the test methods for stone and bricks differ, and the caution about comparison of results applies.

All stones show a reduction in compressive strength when wet: the presence of water in the pore structure of a material weakens bonds between grains and lubricates likely failure planes. With care in interpretation, the ratio of wet to dry compressive strengths can be a guide to durability.

Young's modulus of elasticity

Young's modulus of elasticity is paradoxically a measure of the stiffness of a material. It is the amount of stress (applied load per unit area) required to produce a given amount of strain (resulting deformation: measured as change in length per unit length). The higher the required stress, the stiffer is the material. Conversely a lower stress indicates a less stiff or more elastic material. Young's modulus can be measured in both compression and tension.

In this work, Young's modulus of elasticity was measured in conjunction with the compressive strength testing. The compression machine was equipped with sensors that measure the reduction in length of the cylindrical specimen (and hence strain) and record it as a function of the applied load (and hence stress). The results presented are the elastic moduli derived from the middle third of the stress/strain plots where the curve is most linear. The units of measurement are gigapascals (GPa=10^3MPa).

In the design of structures Young's modulus is used to calculate the amount of axial deformation in a material under anticipated loads. The stones tested ranged from material of low stiffness (0.7 GPa) through to very stiff material (93 GPa). By comparison, the range for concrete of the compressive strengths previously mentioned is approximately 20-32 GPa. Steel, which is extremely stiff, has an elastic modulus of 210 GPa.

Poisson's ratio

Poisson's ratio is also a measure of the elastic properties of a material. It is the lateral strain that results in response to a given amount of longitudinal strain. Like Young's modulus, Poisson's ratio can be measured both in compression and in tension. In compression it is a measure of the lateral bulging of a specimen relative to its reduction in length; while in tension it is a measure of the thinning of a specimen relative to its increase in length. Poisson's ratio is the unit-less ratio of lateral strain to longitudinal strain.

Poisson's ratio was generally measured in conjunction with the compressive strength testing. Sensors on the equipment measured both the increase in diameter (and hence lateral strain) of the cylindrical specimen, and its reduction in length (and hence longitudinal strain) as noted above. This is a static measure of Poisson's ratio.

Large diameter cores (granites and marble) prevented the use of the lateral sensors. Poisson's ratio for these materials was derived from measurements of ultrasonic pulse velocities undertaken on the cores prior to compressive strength testing. This is a dynamic measure of Poisson's ratio. The different methods are indicated in Table 3 and on the data sheets in Appendix A.

Poisson's ratio enables designers to calculate the amount of lateral deformation in a material under anticipated loads. For engineering materials like stone, concrete and metals, Poisson's ratio (measured on dry specimens) is generally in the range of 1/4 - 1/3. This testing produced dry results in the range of 0.21-0.40.

Flexural strength

This is the strength of a material in flexure or bending. Specimens for flexural strength testing are elongate thin slabs and are subjected to a 'four-point-load test'. The specimens are supported near their ends on two parallel round bars or knife edges, and loaded on their upper surfaces by a force applied through two further parallel round bars or knife edges. (See Fig. 2).

The spacing between the four bars varies amongst test standards: some procedures use spacings of 1/4: 1/2: 1/4 while others use 1/3: 1/3: 1/3. An important factor is the ratio of span length to slab thickness. Ideally this should be similar to that used in practice, but this may produce too thin a specimen if its size is to be kept reasonable for sampling and testing. A small ratio of span length to slab thickness will lead to arching of stresses within the slab and the results recorded will not represent a true bending strength. To avoid this, a ratio of at least 6:1 (span length to slab thickness) is recommended.

In this work, bar spacings of 1/3: 1/3: 1/3 and a span length to a thickness ratio of 6:1 were used. Specimen dimensions were determined according to the ratio 6:3:1 (span length: width: thickness). Note that the actual length of the specimen is approximately seven times the thickness to allow for overhangs. Standard thickness was 50 mm for sawn slabs (granites and marble), and variable natural splitting thicknesses for the slates (for details see individual data sheets in Appendix A). The draft Australian Standard DR 87007 proposes similar ratios for specimen dimensions but recommends bar spacings of 1/4: 1/2: 1/4. Note that the recommendations for future testing (Appendix B) propose further modification of these procedures.

In this work the specimen slabs were all cut with their largest surface parallel to the dominant plane. The load direction (z) was normal to this plane (ie. the same load direction as for compressive strength). The specimens were divided into two right-angular orientations; parallel (x) and perpendicular (y) to any grain in the case of slate, or with respect to geographic coordinates for granite and marble. Note that the correct way of describing such test specimens is with respect to the bending axis which is at right angles to the long direction of the elongate slab. Thus a slab of slate cut with its long direction parallel to its grain (x) is correctly described as having its bending axis perpendicular to the grain.

As with compressive strength, half the specimens were tested after oven drying and half after a 48 hour soak in water at atmospheric pressure. The flexural strength of each specimen is calculated from the applied load at failure and is measured in megapascals (MPa).

Knowledge of the flexural strength of stone slabs is critical to design and detailing of applications such as panelling on building facades and also paving. Of the stones tested in this program, the granites and marble being broadly isotropic materials have moderate flexural strengths (9-16 MPa) whereas the slates which have minerals strongly orientated in the bedding and cleavage planes behave more akin to laminated or fibrous materials and have high flexural strengths (33-50 MPa).

Modulus of rupture

Modulus of rupture or transverse strength is similar to flexural strength but the specimens are more brick-shaped rather than being thin slabs, and a 'three-point-load test' with a single (centrally-placed) upper bar or knife edge is used. The test is more appropriate for stone used as blocks in masonry walls and is thus applied to bluestone, sandstone and limestone, while flexural strength is determined for granite, marble, slate and flagstone.

Draft Australian Standard DR 86216 was closely followed in this work. Specimens were cut to nominal dimensions of 200 x 100 x 60 mm and tested over a span length of 180 mm. The ratio of the tested dimensions is thus 3:1.67:1 (span length: width: thickness). The specimens were all cut with their largest surface parallel to the dominant plane (bedding or bedding plane foliation) and their long dimension generally related to observed features such as jointing or grain. Thus they were tested with the axis of bending perpendicular to any apparent jointing or grain in the stones (x orientation). Auburn Bluestone was also tested with the bending axis parallel to the grain (y orientation.

Again, half the specimens were tested after oven drying and half after a 48 hour soak in water at atmospheric pressure. The modulus of rupture of each specimen is calculated from the applied load at failure and is measured in megapascals (MPa).

Modulus of rupture (or transverse strength) provides a guide to the resistance to transverse loads of a masonry element (eg a corbel-stone or a lintel over a door or window). The stones tested in this work gave results in the range 1.0-19 MPa. As a comparison, Australian Standard 1225 - 1984 specifies that 95% of a batch of clay bricks should have transverse strengths of not less than 1.0 MPa.

Ultrasonic pulse velocity

This test measures the velocity of an ultrasonic pulse through the stone specimen. A high frequency impulse is transmitted through the specimen and the first arrival time at a receiving transducer is recorded. Velocity is calculated simply as distance traversed (ie. length of specimen) divided by the travel time, the units being m/sec. Properties that affect the pulse velocity in a stone include: mineralogy, texture, density, porosity and pore structure, anisotropy and moisture content. Hence, interpretation of results requires care, but pulse velocity has been shown to be proportional to compressive strength. Comparisons are best restricted to stones of similar types.

In this work pulse velocity was measured in two ways:

(a) with portable equipment on large blocks cut from the samples, prior to subdivision or coring into specimens, and

(b) on cores in conjunction with the compressive strength and related testing.

In the latter case a slight load was applied to the transducers in order to improve contact between transducer and specimen. Good contact is an important aspect of this test and can be difficult to achieve in the field. This would explain the higher results obtained on cores than on blocks in 8 out of the 9 samples that were tested both ways. Overall the results ranged from 1660-7130 m/sec.

The pulse velocity of longitudinal (compressive or primary) waves and traverse (shear or secondary) waves are related to Young's modulus of elasticity and Poisson's ratio. These properties are often obtained this in way and are then described as 'dynamic' elastic values in contrast to the 'static' elastic values obtained from strain measurements taken during compressive strength testing.

Bulk density

This is the density of a stone: its mass per unit volume, the units being kg/m^3. It can be expressed as dry or saturated (wet) density. It is thus a composite of the absolute densities of the mineral components, air in the pores or void spaces, and (if wet) the contained water. Bulk density, water absorption, and saturation coefficient are interrelated properties derived from weighing 50mm cubes of stone in air when dry, in air when saturated, and when saturated and immersed in water.

In this work bulk density has been calculated from the data for both atmospheric pressure and in-vacuo water absorption specimens: the results presented are dry bulk densities.

A knowledge of bulk density is important in calculating the weight or mass of stone in a wall or constructional element. The stones tested have densities ranging from the extraordinarily low (1110 kg/m^3) to the very high (2970 kg/m^3).

Water absorption

Water absorption is expressed as a percentage either by weight or by volume. Common practice it to express water absorption by weight; for design purposes it gives an immediate understanding of the increase in weight of a material due to saturation. However, when expressed by volume, the result is independent of the density of the mineral components and thus gives a better impression of the amount of water absorbed and the pore space it occupies. Comparison between stones should be based on absorption by volume.

Water absorption was measured in two ways in this work:

(a) after a 48 hour soak in water following immersion at atmospheric pressure, and

(b) after a 48 hour soak in water following immersion under a vacuum.

The former is a guide to the maximum absorption likely to be observed in buildings while the latter approaches filling of all pore spaces (the exceptions being those pores that are closed and those with pore throats smaller than a water molecule) and can thus be used as a guide to the total porosity of a stone. Draft Australian Standard DR86215 uses the term 'effective porosity' for the porosity measured following immersion under a vacuum. In this work it is reported as water absorption under vacuum.

Water absorptions measured in these tests were in the range of 0.1-44% for atmospheric pressure and 0.2-59% under vacuum. The water absorption characteristics of a stone are strongly linked to its durability. The more water that can be readily absorbed the more likely is a stone to be susceptible to salt attack, which is the principal mechanism of stone decay in this country.

Saturation coefficient

This is the proportion of the total pore space that is occupied by water when saturated (after a 48 hour soak) at atmospheric pressure. It is a measure of the pore-size distribution and the degree to which the pores are connected (ie. the permeability of the stone).

In this work it was calculated as the unitless ratio of water absorption by volume at atmospheric pressure to water absorption by volume under vacuum (with the assumption noted above, that the latter represents total porosity). Results ranged from 0.21 to 0.99.

In countries where freezing conditions are common, saturation coefficient has been used as a guide to the risk of damage caused when trapped water expands upon freezing, a higher saturation coefficient indicating a greater risk.

Another way of using this data focusses on the proportion of very small pores which are inaccessible to water except under vacuum. This is called microporosity and can be defined as 1 minus the saturation coefficient. It has been argued that the greater the number of small pores the less distance there will be between them, and the prevalence of thin pore walls will increase susceptibility to ice and salt crystallization damage: i.e. the higher the microporosity the greater the risk.

Clearly these two approaches are contradictory, and a thorough understanding of the pore structure within a stone is necessary to determine which of the two is the more valid in that particular case.

Resistance to salt crystallisation

This test has evolved over the years from the sodium sulphate soundness test applied to aggregates used in concrete and roadmaking. By simulating salt attack, the test provides a measure of the durability of a stone. 50 mm cubes are suspended (fully immersed) in a 14% solution in water of the decahydrate of sodium sulphate and allowed to soak for two hours. The specimens are then dried in a humid oven for 18 hours. With cooling, weighing and preparation times a complete cycle takes 24 hours: this is repeated until either 15 cycles are completed or the specimen crumbles. The loss of weight of the specimen over the 15 cycles is measured and quoted as a percentage. Draft Australian Standard DR 87001 describes the procedure.

By simulating cyclic wetting and drying in the presence of soluble salts, this test provides a relative measure of resistance of materials to decay caused by salt crystallisation within the pore structure of the material. A more porous and permeable stone will be less resistant than low-porosity stones. Thus porous limestone is much less resistant than low-porosity stones like granite and marble. Equally a weakly-bonded stone (such as a clay-rich sandstone) will be less resistant than one of the same porosity but which is strongly bonded (eg. a silica-cemented sandstone).

Workers in this field consider this test to be most applicable to the relative ranking of sandstones. Low-porosity stones such as granite, marble and slate give such low results that ranking them this way is inappropriate. However, for completeness all stones sampled in this project have been subjected to this test: the results ranged from 0.01% to 22%. Difficulties with accurate reproduction of results from this test suggest that it should only be used for comparison within the batch of samples being tested.

Abrasion resistance

This test is intended to measure the resistance of a material to abrasion and is appropriate for evaluating stones for paving applications. It utilises a Taber abrading machine and standardised abrading wheels, equipment commonly used in evaluating other paving materials such as ceramic and vinyl tiles. Thin discs or slabs with the corners cut off are fixed to a table which is rotated beneath the abrading wheels for a fixed number of revolutions. The loss of weight of the specimen is recorded. The Taber index of abrasion resistance is calculated from the weight loss and the density of the specimen. It is a number which is inversely proportional to the volume of specimen removed during the test. Thus the higher the index, the more abrasion-resistant the material. The index incorporates a factor which makes the results comparable to those produced by an alternative test known as the Kessler method. The Kessler method, while based on a more realistic simulation of abrasion by foot traffic, produces results which are not as reproducible as the Taber method.

Results from this testing range from 3.1 to 133 on the Taber index.

Care should be taken when selecting paving materials on the basis of tests such as these. The most abrasion-resistant surface may at first seem the obvious choice, but other factors such as slipperiness need to be considered. These may suggest selection of a less resistant but also less slippery surface.

Shore hardness

Several methods exist for evaluating the hardness of a material. These have been applied mostly to metals where there is a demonstrable relationship between hardness and tensile strength. This does not hold for brittle materials such as stone. Hardness tests include those based on measuring indentation of the specimen by a standard object (eg Brinell, Knoop Microhardness and Rockwell) and those based on elastic rebound from the specimen of a standard object (eg. Schmidt Rebound Hammer, Shore Scleroscope and Sklerograf).

In this work, the hardness of the cylindrical specimens used for compressive strength and related tests was measured with a Sklerograf Hardness Tester, Model D. The results were then converted (by use of a comparison chart) to the Shore D hardness numbers that are more widely known in the English speaking world. Shore D hardness numbers in the range 13-57 were recorded in this program.

Dimensional stability

This is the dimensional change after a number of cycles of fluctuating temperature and moisture content. It is measured on 150 mm long prisms with square sections of about 20 mm. The length of these specimens is measured with a vertical comparator before, during and after a 24 hour cycle which includes a three hour soak in water under a vacuum and 15 hours in an oven at 65°C. Ideally the process is repeated for ten cycles and the total change in length is reported as a percentage of the original length.

This test provides an indication of the presence (or absence) of unstable minerals in the stone and a guide to the constructional tolerances required in good design. Results obtained in this testing ranged from a shrinkage of 0.18% to an expansion of 0.005%. Apart from the two extreme values all the results were shrinkages in the range 0.05-0.002%. As a comparison, clay bricks expand 0.02 to 0.1% in their first five years, while concrete has an ultimate drying shrinkage of about 0.07 to 0.08%.

Coefficient of linear thermal expansion

This is a measure of the change in size as a result of a change in temperature and is an important consideration in building design: allowance must be made for expansion and contraction of components due to variation in temperature. Testing was carried out on the same specimens as dimensional stability. The vertical comparator is used to measure the initial length, the length after cooling to -10° C and again after heating to 80°C. For accurate results the cycle is repeated several times and an average change in length calculated. The coefficient of linear thermal expansion is formally the change in length per unit length per degree celsius.

Coefficient of linear thermal expansion measured in this program were in the range of 2.5 to 11.3 x 10^{-6} mm/mm/°C. Both results were recorded (in different directions) on the one stone - Angaston Marble - an indication of the anisotropy possible in some materials. Most stones tested had coefficients in the range 7 to 10 x 10^{-6} mm/mm/°C.

As a comparison, the coefficient of linear thermal expansion of concrete is in the range 7.5 to 13 x 10^{-6}/mm/mm/°C, and that of mild steel, 11 to 12 x 10^{-6}/mm/mm/°C.

Microcrack density

This is a measure of the frequency of microcracking in granites. Microcracking can significantly reduce flexural strength of granite panels and lead to strongly anisotropic properties. It is measured microscopically, by line counting cracks intersecting a given traverse line on either a polished surface or a thin section of the granite. Results are reported as a frequency of cracks per unit length, eg. 100 mm. A range of 4-29 cracks per 100 mm was recorded in this program.

TEST RESULTS

Test results are presented in Appendix A as individual data sheets for each sample, together with composite data sheets for those stones where more than one sample was obtained of a similar variety. A summary of the test results is presented as Table 3.

Individual data sheets

Individual data sheets are presented for all 30 samples. For ease of reading between data sheets all tests are listed on each sheet even though some tests may not have been carried out on that sample. For each test undertaken, the mean result is presented together with the range of values obtained, the number of specimens tested, and where appropriate the standard deviation of the data.

Some samples consisted of sub-samples: separate blocks or slabs from which the specimens were cut. Where specimens were cut from more than one sub-sample, each sub-sample was equally weighted in deriving the mean result. Thus the mean for the sample is the mean of the sub-sample means. In such cases it is not valid to present a standard deviation as there may be more than one statistical population involved. In any case standard deviations are not presented where less than four specimens were tested.

One of the difficulties encountered by the need to use sub-samples relates to the number of specimens tested. In this work five specimens were used for most tests (much previous testing had been undertaken on three specimens per test, but this had been found not to give an adequate sampling of the natural variability of many stones). With two or three sub-samples five specimens are inevitably distributed unevenly among the sub-samples. In future testing of this kind the use of six specimens per test is recommended.

Composite data sheets

Five composite data sheets have been compiled for stones with more than one similar sample. These were compiled on a simple mean-of-means basis, giving equal weight to each sample. The range of sample means is shown together with the standard deviation of the data for the two composites having four or more samples. The grand range of all specimens is presented on the composite sheets to give an understanding of the variability of the material.

The composite data sheets have been compiled to enable presentation of a single set of data for a stone where multiple samples were taken to test the natural variability expected in any deposit. The composite data provides a better representation of a stone's properties and should be used in preference to the results for individual samples for any comparative purposes.

The five composite data sheets are as follows:

Stones	Composite
Black Hill Granite	4 samples (6728 RS 69-72)
Mintaro Slate	3 samples (6630 RS 404-406)
Jones Hill Slate (light & dark)	2 samples (6737 RS 1206, 1207)
Kanmantoo and Wistow Bluestones	2 samples (6627 RS 687, 688)

Mt Gambier Limestone (1st grade)	5 samples (7022 RS 160, 1, 3, 4, 5).

Note that there are stones with multiple samples which have not been combined into composites. This is because the samples represent distinctly different materials: their combination with others would be invalid. These are:

Jones Hill Slate - 'iron' (6737 RS 1208).

Basket Range Sandstone - average product & hard band (6628 RS 2665, 2666).

Mount Gambier Limestone - 2nd grade (7022 RS 162).

Summary of Results

Table 3 is a summary of the test results, showing only the mean results from each stone. This enables ready comparison between stones of the same major groups, but should be used only for this purpose. For design and selection purposes, an understanding of the natural variability of the stone in question is critical. Reference should be made to the range and standard deviation information presented on the data sheets. In turn this should only be used as a guide and not as a substitute for careful evaluation by the user.

Table 3 is divided into three parts based on the three groupings of stones shown in Table 2 (Testing Schedule). These are:

Table 3.1 Granites and marble
3.2 Slates and flagstones
3.3 Bluestones, sandstones and limestone.

Some salient features of the results are discussed under each group.

Granites and Marbles

The granites and marble are strong durable materials. Strongest, stiffest, most dense, least porous and most dimensionlly stable is the Black Hill Granite.

Compressive strengths range from the extremely strong Black Hill Granite (220 MPa) to the strong Kingston Granite (98 MPa) and Angaston Marble (75 MPa). The slight reduction in strengths when wet suggests durable materials.

The flexural strength results suggest that Black Hill and Sedan Granites will perform better as thin panels than Kingston or Calca Granites. Alternatively the latter stones could be used in panelling but would require larger slab thicknesses to achieve the same strengths as the first two stones. The slight increase in flexural strength when wet is commonly observed but not understood.

The low flexural strength of Kingston Granite suggests that its consitituent minerals are not tightly bonded or that incipient failure planes exist in the large blue feldspar crystals. The first interpretation is supported by the water absorption data; note the very high microporosity (proportion of pore space that is only accessible to water under a vacuum) indicated by the low saturation coefficient. This is further reinforced by the lower than average abrasion resistance.

Sedan Granite can be seen in the field to be slightly anisotropic: it has a weak near vertical foliation running north-south. This anisotropy was tested by way of a third orientation of flexural strength specimens. In addition to the two standard orientations within the foliation plane, the third orientation was across the foliation plane. The dry flexural strength results were 16.1 MPa and 14.8 MPa in the foliation plane, and 12.3 MPa across the foliation plane; clear evidence of significant anisotropy, and an indication of the need to specify orientation of quarry blocks and hence slabs in order to achieve maximum strengths.

Also demonstrably anisotropic is the Angaston Marble. This is most apparent in the coefficient of linear thermal expansion results (where the marble recorded both the highest and lowest readings of all stones tested) and indicates a strong alignment of calcite crystals. The dimensional stability results reinforce this picture. Because the marble is comprised of calcium carbonate (and not silicate minerals) it is not as strong in compression nor as abrasion resistant as the granites.

Slates and flagstones

Not all slates could be tested for compressive strength and related properties (for which 125 mm long cores are required) on account of their thinly bedded nature. Those that were show the very high strengths expected of such laminated materials in compression. Note that their reduction in strength when wet is significantly greater than for the granites, due in part to their relatively higher (but still low) water absorptions. The slates are less stiff than the granites.

High flexural strengths (33-50 MPa) characterise the slates which have platy minerals strongly orientated in the bedding and cleavage planes and behave somewhat akin to laminated or fibrous materials.

The most striking feature of the slates is the effect of grain on flexural strength. Grain is an elongation of platy minerals in a particular direction within the bedding plane: it is an additional feature to the strong orientation of those minerals in the bedding or cleavage planes. This elongation is sufficiently pronounced to produce flexural strengths from 33 to 100% higher in slabs cut with their long dimensions parallel to the grain than in those cut across the grain. Of the slates tested in two different directions only one failed to show this feature. That sample (Spalding Slate) was the one in which the grain was identified with least confidence. Experienced quarry-workers can readily identify grain direction from a slate's behaviour during splitting. In the Spalding case the grain identified by the quarry-workers was about 45° from that chosen on geological parameters, and subsequently tested on the grounds that the quarry had not long been in operation. Retesting may well show that the quarry-workers were right.

The effect of the grain can be seen in the ultrasonic pulse velocity results for Mintaro and Jones Hill Slates. In the direction of elongation the pulse velocity is significantly faster than across the grain; while the velocity normal to the normal bedding plane is much lower than either, thus demonstrating the laminar nature of these materials.

Clearly the direction of the grain may be of some importance in an application in which maximum flexural strength is required, such as in stair treads, paving and panelling where large spans are sought.

Another notable feature of the slates is the broad uniformity of results. Though widely dispersed geographically, most come from the same geological formation.

Abrasion resistance is an important property of materials intended for paving applications. Those slates and flagstones tested have Taber abrasion index values in the range 10.2 - 21.7. ASTM standard C629 (structural slate) requires a minimum abrasion index of 8.0.

Bluestones, sandstones, and limestone

This is a very diverse group of stones ranging from dense strong bluestones of low porosity to lightweight soft limestones of very high porosity.

Some of the test results (particularly dimensional stability, water absorption and resistance to salt crystallisation) suggest that caution should be used when designing with Auburn Bluestone. Nevertheless the stone has performed adequately in buildings for over 100 years. Good detailing and execution may be important ingredients to its successful use.

The Kanmantoo and Wistow Bluestones were combined into a composite sample because of the similarity of the two materials. This is due to the fact that both come from the same geological rock unit: they are stratigraphic equivalents.

The testwork higlighted an important aspect of the Kanmantoo and Wistow materials: their performance under transverse load is limited by naturally occurring defects. These were not apparent on the surfaces of the blocks at the time of sampling but became obvious as the blocks were sawn into smaller units during specimen preparation. Of the 20 specimens tested for modulus of rupture, three had observable defects (irregular iron-stained fractures) which produced substantial reductions in transverse strength. These defects are real characteristics of the stones and need to be considered when assessing the results. Because of them, the procedure mentioned under individual data sheets for giving equal weighting to each sub-sample was not followed for these samples. To do so would have meant introducing a new bias as a result of distorting the representation of the defective specimens.

The practical implications of the results are these: three defects were found in twenty specimens cut from six sub-samples. No sub-sample had more than one defect. The sub-samples were large blocks that might otherwise have been used in a building application, whereas the specimens were small rectangular prisms 200 x 100 x 60 mm. The impact of the defects is not to reduce the overall transverse strength to that of the defective specimens, but to reduce it more in proportion to the frequency of the defect. However, even if the lowest recorded result were to be used as the modulus of rupture value it would still be 8.7 MPa, while the characteristic minimum transverse strength required of clay bricks is only 1.0 MPa.

The two samples of Basket Range Sandstone illustrate the importance of understanding the variation that may exist within one quarry. The sample that represents a hard band is three times stronger in compression, three times stiffer, twice as strong transversely, absorbs half the water, and is much more resistant to salt crystallisation than the sample that represents the average product of the quarry.

Mount Gambier Limestone is an extraordinary material. Lighter than any known building material (except perhaps blocks of pumice) the stone is both cheap to quarry and quick and easy to build with. Because much of it is air (nearly 60% by volume) it has excellent insulation qualities. These advantages come at a price: it has low strength and very high water absorption. Despite these limitations it has been successfully used for building for over 150 years. Provided that design and detailing is sympathetic to its properties, it should continue to find application in domestic and small scale buildings.

The five samples of first grade Mount Gambier stone are all from different quarries. They have been combined into a composite data sheet because the natural variation within and between quarries is such that no single sample can be considered representative of the stone type or of a particular quarry's output. The sample of second grade material is distinctly different from first grade stone. Detailed anlaysis of the Mount Gambier Limestone data is the subject of a separate forthcoming report.

CONCLUSIONS & RECOMMENDATIONS

The program described in this report is the most rigorous sampling and testing program ever undertaken in a suite of South Australian Building Stones. Whilst there has been some discussion of the significance of results, the breadth of the data warrants a much more detailed analysis than has been possible to date.

The results presented in this report should be used as a guide only, and not as a substitute for careful evaluation by the prospective user. Stone being a natural material may show considerable variation in properties even from within a single quarry no quarry output may vary from time to time.

Testing is recommended of stone from deposits which have opened since the current program; in particular the red and pink granites from northern Eyre Peninsula and the green granites from near Padthaway in the South-East of the State.

In the current program test procedures generally followed the Draft Australian Standards. However the spacing of the four bars used in the Flexural Strength Test was varied from the Draft Australian Standard DR87007. A further change to this standard is recommended to ensure that the test more accurately reflects the trend towards the use of thinner panels, and to ensure testing is comparable with the latest ASTM test for flexural strength (C880-1992). Details are provided in Appendix B.

In future test programs, six rather than five specimens per sample should be tested to overcome any potential bias that may result from the need to use two or three sub-samples as a complete sample.

Re-testing of one or two granites from the existing program using the proposed new Flexural Strength Test specification should be undertaken to provide a link between the current data and future test programs.

The adoption of a common standard for preliminary testing of new granite, marble, sandstone and limestone deposits is recommended. This should entail at least two 20 m deep diamond holes with core diameter of 50 mm or greater to enable petrographic examination and determination of ultrasonic pulse velocity, water absorption and compressive strength. Details are provided in Appendix B.

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TABLE 1

SAMPLING SCHEDULE

Material	*Trade Name*	Samples	Rock Sample numbers
Black Hill	*Imperial Black Granite* *Austral Black Granite*	4	6728 RS 69-72
Kingston Granite	*Kingston Blue Granite*	1	6824 RS 28
Sedan Granite	*Sienna Brown Granite*	1	6729 RS 48
Calca Granite	*Calca Red Granite*	1	5731 RS 58
Angaston Marble		1	6728 RS 73
Willunga Slate		1	6627 RS 686
Mintaro Slate		3	6630 RS 404-406
Spalding Slate	*Broughton River Slate*	1	6630 RS 403
Oladdie Slate	*Flinders Slate*	1	6633 RS 105
Jones Hill Slate	*Parachillna Slate*	3	6737 RS 1206-1208
Freestone Hill Flagstone		1	6326 RS 11
Auburn Bluestone		1	6629 RS 59
Kanmantoo Bluestone		1	6627 RS 687
Wistow Bluestone		1	6627 RS 688
Basket Range Sandstone		2	6628 RS 2665, 2666
Carey Gully Sandstone		1	6628 RS 2667
Mount Gambier Limestone		6	7022 RS 160-165

Note: Trade Names are shown where they differ significantly from the sample name used in this report.

TABLE 2

TESTING SCHEDULE

TEST	STANDARD NUMBER OF SPECIMENS PER TEST [a] Granites & Marble	Slates & Flagstone	Bluestones, Sandstones & Limestone
COMPRESSIVE STRENGTH (MPa) [b] Uniaxial unconfined, dry and wet	10 x 2	5 x 2	5 x 2
YOUNG'S MODULUS OF ELASTICITY (GPa) [b] Static, mid third, dry and wet	10 x 2	5 x 2	5 x 2
POISSON'S RATIO [b] Dynamic (D) or static (S), dry and wet	10 x 2 D	5 x 2 S	5 x 2 S
FLEXURAL STRENGTH (MPa) Two perpendicular directions, each dry and wet	5 x 4	5 x 4	—
MODULUS OF RUPTURE (MPa) One direction, dry and wet	—	—	5 x 2
ULTRASONIC PULSE VELOCITY (m/sec) [b] Cores (C) dry and wet, and Blocks (B) dry	10 x 2 C, 1 B	5 x 2 C	5 x 2 C
BULK DENSITY (tonnes/m^3) [c]	10	10	10
WATER ABSORPTION (%) At atmospheric pressure and under vacuum	5 x 2	5 x 2	5 x 2
SATURATION COEFFICIENT	Calculated from water absorption data		
RESISTANCE TO SALT CRYSTALLISATION (% weight loss)	3	3	3
ABRASION RESISTANCE Taber index	3	3	3 [d]
SHORE HARDNESS [b] Dry and wet	10 x 2	5 x 2	5 x 2 [e]
DIMENSIONAL STABILITY (% linear change)	3 (orthogonal)	1	1
COEFF. OF LINEAR THERMAL EXPANSION (mm/mm/^oC x 10^{-6})	3 (orthogonal)	1	1
MICROCRACK DENSITY (cracks per 100 mm)	1	—	—

NOTES

a) Not all samples were comprised of the standard number of specimens - for details see individual data sheets in Appendix A.

b) These five tests (Compressive strength, Young's modulus of elasticity, Poisson's ratio, Shore hardness and Ultrasonic pulse velocity of cores) were all performed on the same specimens (cores).

c) Bulk density was calculated from the data for the water absorption specimens - five at atmospheric pressure and five under vacuum.

d) Abrasion resistance was measured on bluestones but not sandstones or limestone.

e) Shore hardness was not measured on limestone.

TABLE 3.1
SUMMARY OF PHYSICAL PROPERTIES
GRANITES AND MARBLE

TEST	BLACK HILL GRANITE	KINGSTON GRANITE	SEDAN GRANITE	CALCA GRANITE	ANGASTON MARBLE
COMPRESSIVE STRENGTH (MPa)					
Unaxial unconfined					
Dry	219	97.7	197	150	75.3
Wet	192	90.4	181	148	74.6
Ratio wet/dry	0.88	0.93	0.92	0.99	0.99
YOUNG'S MODULUS OF ELASTICITY (GPa)					
Static, mid-third					
Dry	92.6	44.6	58.4	61.8	53.2
Wet	89.5	52.0	53.8	61.3	50.6
POISSON'S RATIO					
Dynamic					
Dry	0.35	0.39	0.32	0.28	0.37
Wet	0.33	0.42	0.29	0.29	0.34
FLEXURAL STRENGTH (MPa)					
Orientation x					
Dry	15.5	9.3	16.1	10.9	11.3
Wet	18.5	8.7	16.4	11.5	11.4
Ratio wet/dry	1.19	0.93	1.01	1.05	1.00
Orientation y					
Dry	15.0	9.2	14.8	9.5	9.5
Wet	17.7	9.1	15.2	10.6	12.1
Ratio wet/dry	1.18	0.98	1.02	1.11	1.28
Ratio top-bottom/east-west, dry	0.96	0.99	0.92	0.87	0.84
ULTRASONIC PULSE VELOCITY (m/sec)					
Cores, normal to dominant plane					
Dry	7128	5492	5592	6213	5520
Wet	6874	5911	6739	6243	5537
Block					
Normal to dominant plane	6700	5390	5640	5620	5430
Orientation x	6665	5430	5735	5500	5640
Orientation y	6660	5280	5640	5190	5750
BULK DENSITY (kg/m^3)	2970	2710	2630	2610	2720
WATER ABSORPTION (%)					
By volume					
At atmospheric pressure	0.17	0.11	0.46	0.43	0.15
Under vacuum	0.21	0.54	0.68	0.46	0.25
By weight					
At atmospheric pressure	0.06	0.04	0.18	0.17	0.06
Under vacuum	0.07	0.20	0.26	0.18	0.09

TABLE 3.1 (Continued)

TEST	BLACK HILL GRANITE	KINGSTON GRANITE	SEDAN GRANITE	CALCA GRANITE	ANGASTON MARBLE
SATURATION COEFFICIENT	0.81	0.21	0.68	0.95	0.62
RESISTANCE TO SALT CRYSTALLISATION (% weight loss)	0.03	0.02	0.01	0.06	0.04
ABRASION RESISTANCE Taber index	126	96.0	131	133	15.2
SHORE HARDNESS					
Dry	52	52	54	57	35
Wet	52	53	56	56	35
DIMENSIONAL STABILITY (% linear change)					
Normal to dominant plane	-0.002	+0.005	-0.004	-0.002	-0.018
Orientation x	-0.003	+0.001	-0.004	-0.004	-0.003
Orientation y	-0.002	-0.002	-0.003	+0.001	-0.010
COEFF. OF LINEAR THERMAL EXPANSION (mm/mm/°C x 10^{-6})					
Normal to dominant plane	5.2	8.5	7.0	7.5	11.3
Orientation x	4.6	8.2	6.9	7.0	4.5
Orientation y	5.4	8.8	7.2	7.9	2.5
MICROCRACK DENSITY (cracks per 100 mm)	4	7	29	15	

A. All samples were orientated with respect to a dominant planar structure (layering for Black Hill Granite, and foliation for Sedan Granite and Angaston Marble) or to a horizontal plane if no structure was apparent (Kingston and Calca granites). The test specimens were orientated with respect to these planes:
  1. Compressive strength and related tests (Modulus of elasticity, Poisson's ratio) were undertaken on cores drilled normal to the dominant plane.
  2. Flexural strength was measured on two sets of elongate thin slabs orientated at right angles to each other (designated x & y). All slabs were cut with their largest surface parallel to the dominant plane. The load direction was the third orthogonal axis (designated z).
  3. Ultrasonic pulse velocity (on blocks) was measured in three orthogonal orientations:
     1) Normal to the dominant plane; i.e. the same orientation as the compressive strength cores (z); 2) & 3) Orientations x & y, corresponding to the orientation of the flexural strength samples.

B This table is only a summary of the test results: for full details for each stone reference should be made to the individual data sheets.

C. Note that some results are an average of several samples while others represent only one sample: see data sheets for details.

D. For design purposes these results should be used as a guide only, and not as a substitute for careful evaluation by the user.

TABLE 3.2
SUMMARY OF PHYSICAL PROPERTIES
SLATES AND FLAGSTONE

TEST	WILLUNGA SLATE	MINTARO SLATE	SPALDING SLATE	OLADDIE SLATE	JONES HILL 'LIGHT & DARK' SLATE	JONES HILL 'IRON' SLATE	FREESTONE HILL FLAGSTONE
COMPRESSIVE STRENGTH (MPa)							
Unaxial unconfined							
Dry		183	197		210		157
Wet		136	134		133		116
Ratio wet/dry		0.75	0.68		0.63		0.74
YOUNG'S MODULUS OF ELASTICITY (GPa)							
Static, mid-third							
Dry		28.8	29.9		39.3		22.8
Wet		20.5	19.2		28.5		20.9
POISSON'S RATIO							
Static							
Dry		0.40	0.31		0.33		0.23
Wet		0.75	0.57		0.41		0.25
FLEXURAL STRENGTH (MPa)							
Bending axis perpendicular to grain (x)							
Dry	36.8	37.2	34.1	33.1	50.0	49.8	23.4
Wet	32.4	25.8			41.3	47.8	16.1
Ratio wet/dry	0.88	0.69			0.83	0.96	0.69
Bending axis parallel to grain (y)							
Dry	28.1	26.3	33.8		27.7	25.6	
Wet	18.8	18.3	24.7		22.2	28.4	
Ratio wet/dry	0.69	0.70	0.73		0.80	1.11	
Ratio parallel/perpendicular, dry	0.76	0.71	0.99		0.55	0.51	
ULTRASONIC PULSE VELOCITY (m/sec)							
Cores, normal to bedding							
Dry		4995	4486		5542		4262
Wet		5488	4674		5677		4589
Block							
Normal to bedding (z)		3910			2855		
Parallel to grain (x)		5445			5765		
Perpendicular to grain (y)		5190			5105		

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TABLE 3.2 (Continued)

TEST	WILLUNGA SLATE	MINTARO SLATE	SPALDING SLATE	OLADDIE SLATE	JONES HILL 'LIGHT & DARK' SLATE	JONES HILL 'IRON' SLATE	FREESTONE HILL FLAGSTONE
BULK DENSITY (kg/m^3)	2710	2760	2750	2660	2670	2730	2580
WATER ABSORPTION (%)							
By volume							
At atmospheric pressure	1.91	0.84	0.68	1.78	1.76	0.81	3.39
Under vacuum	1.93	0.93	0.70	2.01	2.16	0.89	4.32
By weight							
At atmospheric pressure	0.70	0.30	0.25	0.67	0.66	0.30	1.31
Under vacuum	0.71	0.34	0.26	0.75	0.81	0.33	1.68
SATURATION COEFFICIENT	0.99	0.90	0.97	0.89	0.82	0.91	0.78
RESISTANCE TO SALT CRYSTALLISATION (% weight loss)	0	0.07	0.06	0.02	0.03	0.04	0.04
ABRASION RESISTANCE							
Taber index	10.3	12.3	11.6	10.2	14.4	21.7	21.3
SHORE HARDNESS							
Dry		34	30		32		32
Wet		34	25		30		35
DIMENSIONAL STABILITY (% linear change)							
Parallel to bedding	-0.008	-0.03	-0.02	-0.03		-0.002	-0.01
COEFF. OF LINEAR THERMAL EXPANSION (mm/mm/°C x 10^{-6})							
Parallel to bedding	9.1	10.0	8.7	8.2		9.0	9.7

A. All samples were orientated with respect to a dominant planar structure (bedding or bedding plane foliation). The test specimens were orientated with respect to these planes:
  1. Compressive strength and related tests (Modulus or elasticity, Poisson's ratio) were undertaken on cores drilled normal to the dominant plane.
  2. Flexural strength was measured on two sets of elongate thin slabs orientated at right angles to each other (designated x & y; where x is parallel to grain and y across the grain -if observed). All slabs were cut with their largest surface parallel to the dominant plane. The load direction was the third orthogonal axis (designated z).
  3. Ultrasonic pulse velocity (on blocks) was measured in three orthogonal orientations:
     1) Normal to the dominant plane; i.e.the same orientation as the compressive strength cores (z); 2) & 3) Orientations x & y, corresponding to the orientation of the flexural strength samples.

B This table is only a summary of the test results: for full details for each stone reference should be made to the individual data sheets.
C. Note that some results are an average of several samples while others represent only one sample: see data sheets for details.
D. For design purposes these results should be used as a guide only, and not as a substitute for careful evaluation by the user.

TABLE 3.3
SUMMARY OF PHYSICAL PROPERTIES
BLUESTONE, SANDSTONES AND LIMESTONES

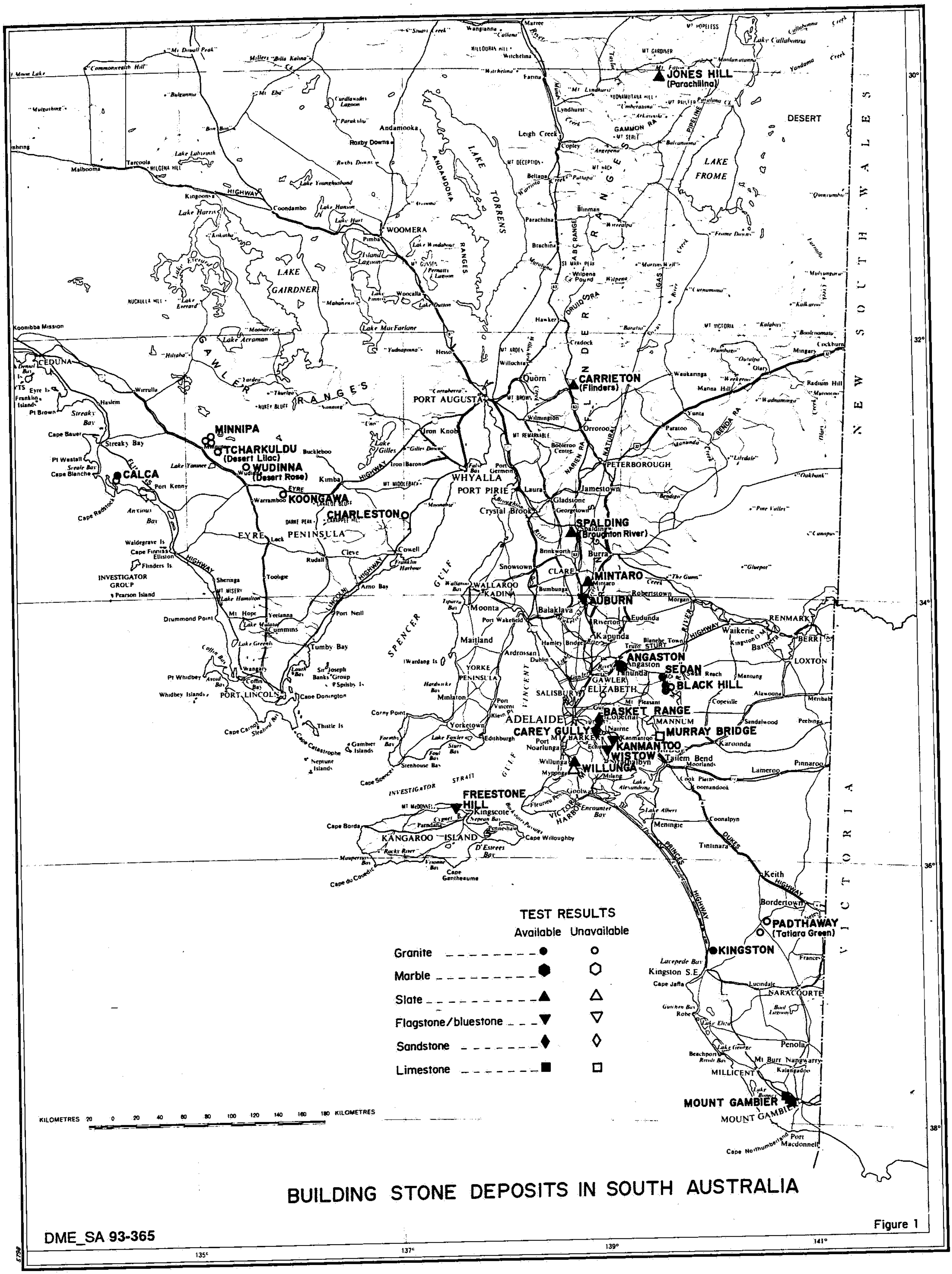
TEST	AUBURN BLUESTONE	KANMANTOO WISTOW BLUESTONES	BASKET RANGE SANDSTONE 'average'	BASKET RANGE SANDSTONE 'hard'	CAREY GULLY SANDSTONE	MOUNT GAMBIER LIMESTONE '1st grade'	MOUNT GAMBIER LIMESTONE '2nd grade'
COMPRESSIVE STRENGTH (MPa)							
Unaxial unconfined							
Dry	27.1	211	25.3	80.0	91.1	3.96	1.50
Wet	17.3	151	18.2	47.5	61.6	3.44	1.72
Ratio wet/dry	0.64	0.72	0.72	0.59	0.68	0.87	1.15
YOUNG'S MODULUS OF ELASTICITY (GPa)							
Static, mid-third							
Dry	4.22	48.3	4.01	11.68	14.7	2.46	0.71
Wet	2.66	39.0	2.70	8.99	10.7	1.66	0.50
POISSON'S RATIO							
Static, mid-third							
Dry	0.26	0.35	0.31	0.35	0.35	0.21	0.01
Wet	0.50	0.44	0.34	0.46	0.62	-0.08	0.63
MODULUS OF RUPTURE (MPa)							
Dry	11.4 (x)	19.1	5.5	12.6	15.1	1.88	1.08
Wet	4.9	20.5	3.5	8.8	9.7	1.49	0.79
Ratio wet/dry	0.43	1.07	0.64	0.69	0.64	0.79	0.73
Dry	6.1 (y)						
Ratio y/x, dry	0.53						
ULTRASONIC PULSE VELOCITY (m/sec)							
Cores, normal to bedding							
Dry	2989	6427	2377	4214	3410		
Wet	2474	6748	2168	4209	3165		
Block							
Normal to bedding						2036	1660
Parallel to bedding						2195	1850
BULK DENSITY (kg/m^3)	2110	2700	2200	2470	2490	1210	1110
WATER ABSORPTION (%)							
By volume							
At atmospheric pressure	11.53	0.86	9.77	4.65	4.07	39.21	43.52
Under vacuum	23.19	1.05	17.41	8.32	7.33	55.62	58.52
By weight							
At atmospheric pressure	5.46	0.32	4.55	1.87	1.66	32.37	39.47
Under vacuum	10.98	0.39	8.17	3.40	2.98	46.49	52.64

TABLE 3.3 (Continued)

TEST	AUBURN BLUESTONE	KANMANTOO WISTOW BLUESTONES	BASKET RANGE SANDSTONE 'average'	BASKET RANGE SANDSTONE 'hard'	CAREY GULLY SANDSTONE	MOUNT GAMBIER LIMESTONE '1st grade'	MOUNT GAMBIER LIMESTONE '2nd grade'
SATURATION COEFFICIENT	0.50	0.81	0.56	0.56	0.56	0.70	0.74
RESISTANCE TO SALT CRYSTALLISATION (% weight loss)	6.6	0.02	1.7	0.25	0.9	10.6	3.2
ABRASION RESISTANCE Taber index	3.1	47.6					
SHORE HARDNESS							
Dry	13	42	17	24	27		
Wet	12	39	14	23	25		
DIMENSIONAL STABILITY (% linear change) Parallel to bedding	-0.18	-0.015	-0.05	-0.05	-0.02	-0.05	
COEFF. OF LINEAR THERMAL EXPANSION (mm/mm/°C x 10^{-6}) Parallel to bedding	10.7	10.3	10.1	10.0	9.9	4.53	

A. All samples were orientated with respect to a dominant planar structure (bedding or bedding plane foliation). The test specimens were orientated with respect to these planes:
   1. Compressive strength and related tests (Modulus of elasticity, Poisson's ratio) were undertaken on cores drilled normal to the dominant plane.
   2. Modulus of rupture was measured on brick shaped specimens cut with their largest surface parallel to the dominant plane and their long dimension generally related to observed features such as jointing or grain. Two sets of measurements were made on specimens of Auburn Bluestone cut parallel (x) and across the grain (y) - similar to the slates. For all samples the load direction was normal to the dominant plane.

B. This table is only a summary of the test results: for full details for each stone reference should be made to the individual data sheets.
C. Note that some results are an average of several samples while others represent only one sample: see data sheets for details.
D. For design purposes these results should be used as a guide only, and not as a substitute for careful evaluation by the user.

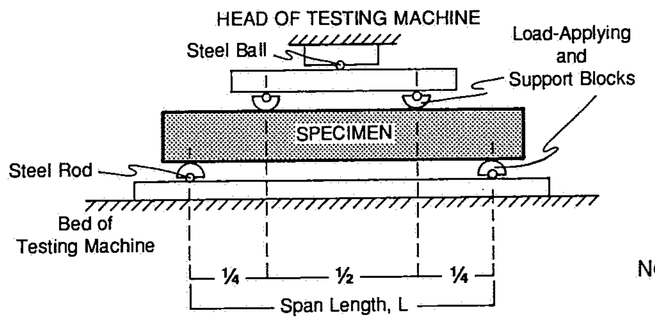


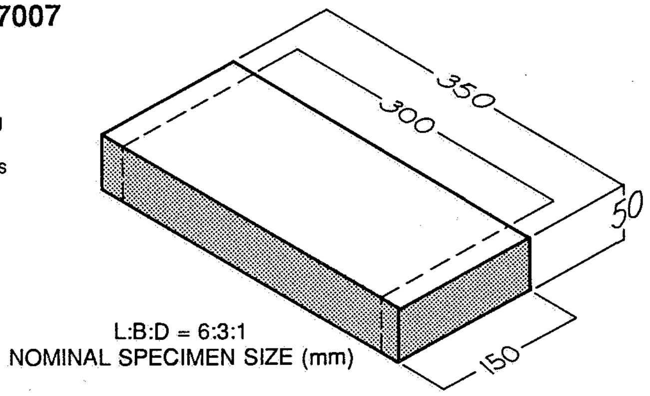
BUILDING STONE DEPOSITS IN SOUTH AUSTRALIA

Figure 1

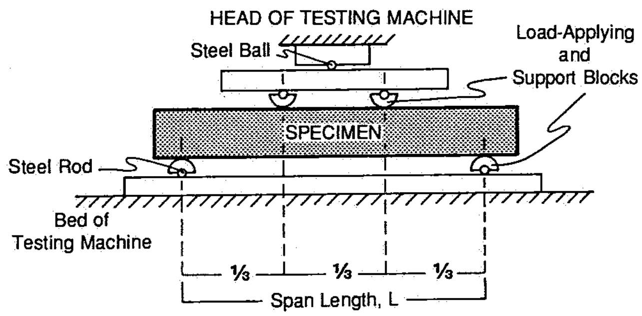
DME_SA 93-365

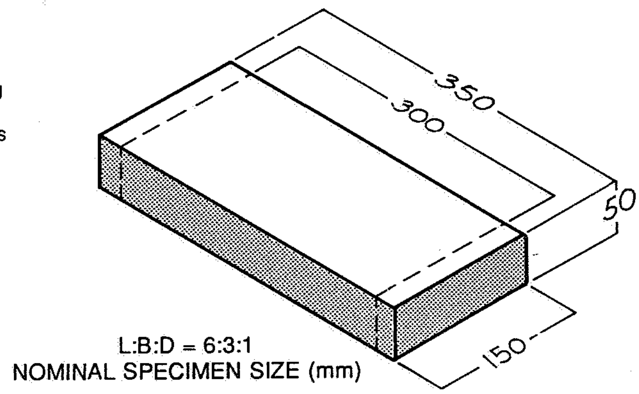
DRAFT AUSTRALIAN STANDARD DR 87007



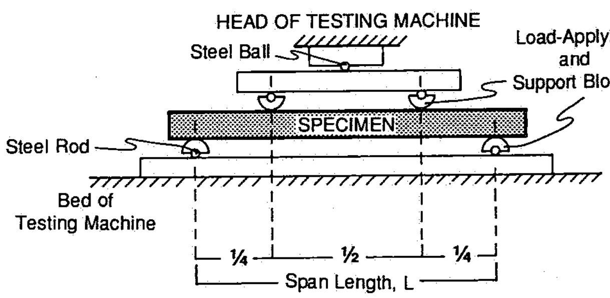


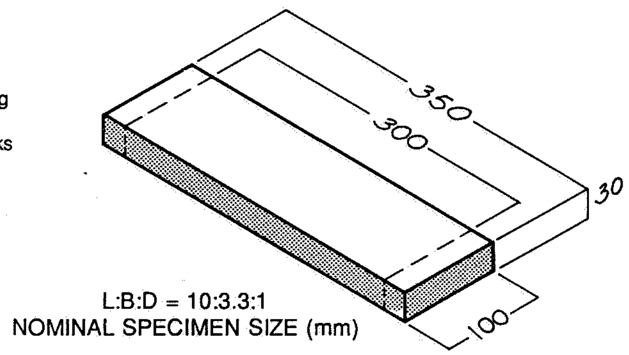
SADME TESTING (This Report)





RECOMMENDED NEW STANDARD





Note: L = Span
B = Sample Breadth
D = Sample Depth

DIAGRAMMATIC REPRESENTATION

PHYSICAL TESTING OF S.A. BUILDING STONES FLEXURAL STRENGTH TEST

Figure **2**
DME_SA **93-366**

APPENDIX A

DATA SHEETS - PHYSICAL PROPERTIES

APPENDIX A

DATA SHEETS - PHYSICAL PROPERTIES

BLACK HILL GRANITE - 'AUSTRAL + IMPERIAL BLACK'

COMPOSITE OF SADME 6728 RS 69-72
Date of sampling: 1986 & 1987

TEST	MEAN	STANDARD DEVIATION	RANGE OF SAMPLE MEANS	NO. OF SAMPLES	GRAND RANGE OF SPECIMENS	
COMPRESSIVE STRENGTH (MPa)						
Unaxial unconfined						
Dry	219	18	200-243	4	191-251	
Wet	192	14	175-207	4	148-214	
Ratio wet/dry	0.88					
YOUNG'S MODULUS OF ELASTICITY (GPa)						
Static, mid-third						
Dry	92.6	13.9	75.0-109	4	70.1-128	
Wet	89.5	6.3	80.7-95.3	4	70.0-122	
POISSON'S RATIO						
Dynamic						
Dry	0.35		0.34-0.36	2	0.33-0.38	*
Wet	0.33		0.29-0.37	2	0.27-0.41	*
FLEXURAL STRENGTH (MPa)						
East-west bending axis, load north-south						
Dry	15.5	1.5	13.4-16.9	4	12.4-17.8	
Wet	18.5	1.3	17.2-19.7	4	15.8-20.7	
Ratio wet/dry	1.19					
Top-bottom bending axis, load north-south						
Dry	15.0	1.7	13.5-16.9	4	12.1-17.7	
Wet	17.7	1.0	16.4-18.7	4	14.5-21.2	
Ratio wet/dry	1.18					
Ratio top-bottom/east-west, dry	0.96					
ULTRASONIC PULSE VELOCITY (m/sec)						
Cores, normal to layering						
Dry	7128		6952-7303	2	6863-7396	*
Wet	6874		6647-7100	2	6607-7604	*
Block						
North-south (normal to layering)	6700		6610-6790	2	6530-6840	*
Top-bottom	6665		6605-6720	2	6525-6740	*
East-west	6660		6540-6780	2	6475-6860	*
BULK DENSITY (kg/m^3)	2970	20	2940-2980		2929-3075	
WATER ABSORPTION (%)						
By volume						
At atmospheric pressure	0.17	0.06	0.13-0.25	4	0.07-0.27	
Under vacuum	0.21	0.07	0.14-0.27	4	0.07-0.29	
By weight						
At atmospheric pressure	0.06	0.02	0.04-0.08	4	0.02-0.09	
Under vacuum	0.07	0.02	0.05-0.09	4	0.02-0.10	
SATURATION COEFFICIENT	0.81					
RESISTANCE TO SALT CRYSTALLISATION (% weight loss)	0.03	0.01	0.02-0.04	4	0.02-0.06	
ABRASION RESISTANCE						
Taber index	126	5	120-131	4	104-150	
SHORE HARDNESS						
Dry	52		52-53	2	51-55	*
Wet	52		51-52	2	49-56	*
DIMENSIONAL STABILITY (% linear change)						
North-south (normal to layering)	-0.002	0.003	-0.006 to 0	4		
Top-bottom	-0.003	0.002	-0.005 to 0	4		
East-west	-0.002	0.003	-0.006 to 0	4		
COEFF. OF LINEAR THERMAL EXPANSION (mm/mm/°C x 10^{-6})						
North-south (normal to layering)	5.2	0.7	4.5-6.1	4	4.2-6.8	
Top-bottom	4.6	0.4	4.2-5.0	4	3.4-5.7	
East-west	5.4	0.6	4.9-6.3	4	4.2-6.8	
MICROCRACK DENSITY (cracks per 100 mm)	4	2	2-7	4	1-8	
DOMINANT PLANAR STRUCTURE	Weak compositional layering, dipping 50-55° to the south southwest.					

Additional comments: The orthogonal axes are - north-south (actually normal to the inclined compositional layering), east-west (along strike) and top-bottom (down dip), the latter two being in the plane of compositional layering.

These data are a composite of the results for the four samples 6728 RS 69-72. As a guide for design purposes, they should be used in preference to the results for the individual samples.

* RS 71, 72 only

BLACK HILL GRANITE - 'IMPERIAL BLACK'

SADME 6728 RS 69
Date of sampling: Early 1987

TEST	MEAN	STANDARD DEVIATION	RANGE	NO. OF SPECIMENS	COMMENTS
COMPRESSIVE STRENGTH (MPa)					
Unaxial unconfined					Cores nominally 100 mm diameter
Dry	215	14	191-229	5	
Wet	175	19	148-188	4	One defective result (61.8) omitted
Ratio wet/dry	0.81				
YOUNG'S MODULUS OF ELASTICITY (GPa)					
Static, mid-third					
Dry	109		89.7-128	2	
Wet	95.3	22.6	70.0-122	4	One defective result (8.4) omitted
POISSON'S RATIO					
Dynamic					
Dry					
Wet					
FLEXURAL STRENGTH (MPa)					
East-west bending axis, load north-south					
Dry	13.4	0.7	12.4-14.0	5	
Wet	17.2	1.0	15.8-18.1	4	One defective result (5.8) omitted
Ratio wet/dry	1.28				
Top-bottom bending axis, load north-south					
Dry	13.6	0.8	12.1-14.4	7	
Wet	16.4	0.6	15.4-17.0	5	
Ratio wet/dry	1.21				
Ratio top-bottom/east-west, dry	1.01				
ULTRASONIC PULSE VELOCITY (m/sec)					
Cores, normal to layering					
Dry					
Wet					
Block					
North-south (normal to layering)					
Top-bottom					
East-west					
BULK DENSITY (kg/m^3)	2940	7	2929-2954	10	
WATER ABSORPTION (%)					
By volume					
At atmospheric pressure	0.25	0.02	0.22-0.27	5	
Under vacuum	0.27	0.01	0.27-0.29	5	
By weight					
At atmospheric pressure	0.08	0.01	0.08-0.09	5	
Under vacuum	0.09	0.004	0.09-0.10	5	
SATURATION COEFFICIENT	0.90				
RESISTANCE TO SALT CRYSTALLISATION (% weight loss)	0.04		0.02-0.06	3	Measured as weight of residue
ABRASION RESISTANCE					
Taber index	126	10	114-142	9	
SHORE HARDNESS					
Dry					
Wet					
DIMENSIONAL STABILITY (% linear change)					
North-south (normal to layering)	-0.002			1	}
Top-bottom	-0.003			1	}Total change after ten cycles
East-west	0			1	}
COEFF. OF LINEAR THERMAL EXPANSION (mm/mm/°C x 10^{-6})					
North-south (normal to layering)	5.1	0.5	4.2-5.7	1	}
Top-bottom	4.2	0.5	3.4-4.9	1	}Ten cycles per specimen
East-west	4.9	0.4	4.2-5.6	1	}
MICROCRACK DENSITY (cracks per 100 mm)	3	1	2-3	1	Five traverses
DOMINANT PLANAR STRUCTURE	Weak compositional layering, dipping 50° to the south south-west.				

Additional comments: The orthogonal axes are - north-south (actually normal to the inclined compositional layering), east-west (along strike) and top-bottom (down dip), the latter two being in the plane of compositional layering.

As a guide for design purposes the composite data for the four samples 6728 RS 69-72 should be used in preference to the data on this sheet.

BLACK HILL GRANITE - 'AUSTRAL BLACK'

SADME 6728 RS 70
Date of sampling: Early 1987

TEST	MEAN	STANDARD DEVIATION	RANGE	NO. OF SPECIMENS	COMMENTS
COMPRESSIVE STRENGTH (MPa)					
Unaxial unconfined					Cores nominally 100 mm diameter
Dry	243	8	235-251	4	One defective result (65.2) omitted
Wet	187	5	179-190	5	
Ratio wet/dry	0.77				
YOUNG'S MODULUS OF ELASTICITY (GPa)					
Static, mid-third					
Dry	92.1	4.0	87.9-97.5	4	One defective result (4.7) omitted
Wet	92.5	19.5	70.1-119	5	
POISSON'S RATIO					
Dynamic					
Dry					
Wet					
FLEXURAL STRENGTH (MPa)					
East-west bending axis, load north-south					
Dry	15.8	1.1	14.4-17.4	5	
Wet	19.7	0.8	18.8-20.7	5	
Ratio wet/dry	1.25				
Top-bottom bending axis, load north-south					
Dry	13.5	0.6	12.5-14.2	5	
Wet	17.6	0.4	17.1-18.2	5	
Ratio wet/dry	1.31				
Ratio top-bottom/east-west, dry	0.86				
ULTRASONIC PULSE VELOCITY (m/sec)					
Cores, normal to layering					
Dry					
Wet					
Block					
North-south (normal to layering)					
Top-bottom					
East-west					
BULK DENSITY (kg/m^3)	2960	12	2947-2978	10	
WATER ABSORPTION (%)					
By volume					
At atmospheric pressure	0.18	0.02	0.16-0.20	5	
Under vacuum	0.26	0.03	0.22-0.29	5	
By weight					
At atmospheric pressure	0.06	0.01	0.05-0.07	5	
Under vacuum	0.09	0.01	0.07-0.10	5	
SATURATION COEFFICIENT	0.67				
RESISTANCE TO SALT CRYSTALLISATION (% weight loss)	0.02		0.02	3	Measured as weight of residue
ABRASION RESISTANCE					
Taber index	120	10	104-133	9	
SHORE HARDNESS					
Dry					
Wet					
DIMENSIONAL STABILITY (% linear change)					
North-south (normal to layering)	-0.001			1	}
Top-bottom	0			1	}Total change after ten cycles
East-west	-0.001			1	}
COEFF. OF LINEAR THERMAL EXPANSION (mm/mm/°C x 10^{-6})					
North-south (normal to layering)	4.5	0.3	4.2-5.1	1	}
Top-bottom	4.4	0.5	3.7-5.0	1	}Ten cycles per specimen
East-west	5.0	0.4	4.3-5.7	1	}
MICROCRACK DENSITY (cracks per 100 mm)	7	2	4-8	1	Five traverses
DOMINANT PLANAR STRUCTURE	Weak compositional layering, dipping 50° to the south south-west.				

Additional comments: The orthogonal axes are - north-south (actually normal to the inclined compositional layering), east-west (along strike) and top-bottom (down dip), the latter two being in the plane of compositional layering.

As a guide for design purposes the composite data for the four samples 6728 RS 69-72 should be used in preference to the data on this sheet.

BLACK HILL GRANITE - 'IMPERIAL BLACK'

SADME 6728 RS 71
Date of sampling: Early 1986

TEST	MEAN	STANDARD DEVIATION	RANGE	NO. OF SPECIMENS	COMMENTS
COMPRESSIVE STRENGTH (MPa)					
Unaxial unconfined					Cores nominally 100 mm diameter
Dry	200	4	194-204	5	
Wet	207	4	203-213	5	
Ratio wet/dry	1.04				
YOUNG'S MODULUS OF ELASTICITY (GPa)					
Static, mid-third					
Dry	75.0	4.2	70.1-79.3	5	
Wet	80.7	5.0	72.9-86.7	5	
POISSON'S RATIO					
Dynamic					
Dry	0.36	0.02	0.34-0.38	5	
Wet	0.37	0.03	0.32-0.41	5	
FLEXURAL STRENGTH (MPa)					
East-west bending axis, load north-south					
Dry	16.0	0.4	15.5-16.6	5	
Wet	17.7	0.5	17.1-18.2	5	
Ratio wet/dry	1.10				
Top-bottom bending axis, load north-south					
Dry	16.0	0.8	15.0-17.2	5	
Wet	18.2	1.3	16.9-20.1	5	
Ratio wet/dry	1.14				
Ratio top-bottom/east-west, dry	1.00				
ULTRASONIC PULSE VELOCITY (m/sec)					
Cores, normal to layering					
Dry	6952	108	6863-7112	5	
Wet	7100	286	6926-7604	5	
Block					
North-south (normal to layering)	6790		6765-6840	1	}
Top-bottom	6720		6670-6740	1	}Six measurements
East-west	6780		6730-6860	1	}
BULK DENSITY (kg/m^3)	2980	6	2972-2991	10	
WATER ABSORPTION (%)					
By volume					
At atmospheric pressure	0.13	0.03	0.10-0.17	5	
Under vacuum	0.16	0.04	0.11-0.20	5	
By weight					
At atmospheric pressure	0.04	0.01	0.03-0.06	5	
Under vacuum	0.05	0.01	0.04-0.07	5	
SATURATION COEFFICIENT	0.80				
RESISTANCE TO SALT CRYSTALLISATION (% weight loss)	0.03		0.03	3	Measured as weight of residue
ABRASION RESISTANCE					
Taber index	131	10	120-150	9	
SHORE HARDNESS					
Dry	52	1	51-53	5	
Wet	51	1	50-52	5	
DIMENSIONAL STABILITY (% linear change)					
North-south (normal to layering)	0			1	}
Top-bottom	-0.003			1	}Total change after ten cycles
East-west	-0.001			1	}
COEFF. OF LINEAR THERMAL EXPANSION (mm/mm/°C x 10^{-6})					
North-south (normal to layering)	5.0	0.5	4.3-5.9	1	}
Top-bottom	5.0	0.5	4.2-5.7	1	}Ten cycles per specimen.
East-west	5.3	0.5	4.8-6.2	1	}
MICROCRACK DENSITY (cracks per 100 mm)	2	1	1-4	1	Five traverses
DOMINANT PLANAR STRUCTURE	Weak compositional layering, dipping 50° to the south.				

Additional comments: The orthogonal axes are - north-south (actually normal to the inclined compositional layering), east-west (along strike) and top-bottom (down dip), the latter two being in the plane of compositional layering.

As a guide for design purposes the composite data for the four samples 6728 RS 69-72 should be used in preference to the data on this sheet.

BLACK HILL GRANITE - 'AUSTRAL BLACK'

SADME 6728 RS 72
Date of sampling: Early 1986

TEST	MEAN	STANDARD DEVIATION	RANGE	NO. OF SPECIMENS	COMMENTS
COMPRESSIVE STRENGTH (MPa)					
Unaxial unconfined					Cores nominally 100 mm diameter
Dry	218	15	191-225	5	
Wet	198	11	184-214	5	
Ratio wet/dry	0.91				
YOUNG'S MODULUS OF ELASTICITY (GPa)					
Static, mid-third					
Dry	94.6	1.3	92.6-96.1	5	
Wet	89.4	13.8	78.0-112	5	
POISSON'S RATIO					
Dynamic					
Dry	0.34	0.01	0.33-0.34	5	
Wet	0.29	0.01	0.27-0.30	5	
FLEXURAL STRENGTH (MPa)					
East-west bending axis, load north-south					
Dry	16.9	0.6	16.3-17.8	5	
Wet	19.4	1.1	18.2-20.1	4	
Ratio wet/dry	1.15				
Top-bottom bending axis, load north-south					
Dry	16.9	0.7	15.9-17.7	5	
Wet	18.7	2.5	14.5-21.2	5	
Ratio wet/dry	1.11				
Ratio top-bottom/east-west, dry	1.00				
ULTRASONIC PULSE VELOCITY (m/sec)					
Cores, normal to layering					
Dry	7303	74	7203-7396	5	
Wet	6647	31	6607-6687	5	
Block					
North-south (normal to layering)	6610		6530-6640	1	}
Top-bottom	6605		6525-6715	1	}Eight measurements
East-west	6540		6475-6630	1	}
BULK DENSITY (kg/m^3)	2980	37	2948-3075	10	
WATER ABSORPTION (%)					
By volume					
At atmospheric pressure	0.13	0.05	0.07-0.21	5	
Under vacuum	0.14	0.06	0.07-0.19	5	
By weight					
At atmospheric pressure	0.04	0.02	0.02-0.07	5	
Under vacuum	0.05	0.02	0.02-0.06	5	
SATURATION COEFFICIENT	0.91				
RESISTANCE TO SALT CRYSTALLISATION (% weight loss)	0.03		0.03		Measured as weight of residue
ABRASION RESISTANCE					
Taber index	128	13	108-147	9	
SHORE HARDNESS					
Dry	53	2	51-55	5	
Wet	52	3	49-56	5	
DIMENSIONAL STABILITY (% linear change)					
North-south (normal to layering)	-0.006			1	}
Top-bottom	-0.005			1	}Total change after ten cycles
East-west	-0.006			1	}
COEFF. OF LINEAR THERMAL EXPANSION (mm/mm/°C x 10^{-6})					
North-south (normal to layering)	6.1	0.4	5.4-6.8	1	}
Top-bottom	4.9	0.5	4.2-5.6	1	}Ten cycles per specimen.
East-west	6.3	0.4	5.8-6.8	1	}
MICROCRACK DENSITY (cracks per 100 mm)	3	2	2-6	1	Five traverses
DOMINANT PLANAR STRUCTURE	Weak compositional layering, dipping 50° to the south.				

Additional comments: The orthogonal axes are - north-south (actually normal to the inclined compositional layering), east-west (along strike) and top-bottom (down dip), the latter two being in the plane of compositional layering.

As a guide for design purposes the composite data for the four samples 6728 RS 69-72 should be used in preference to the data on this sheet.

KINGSTON GRANITE - 'KINGSTON BLUE'

SADME 6824 RS 28
Date of sampling: Early 1985

TEST	MEAN	STANDARD DEVIATION	RANGE	NO. OF SPECIMENS	COMMENTS
COMPRESSIVE STRENGTH (MPa)					
Unaxial unconfined					Cores nominally 100 mm diameter
Dry	97.7	4.4	88.1-103	10	
Wet	90.4	1.8	88.1-93.3	10	
Ratio wet/dry	0.93				
YOUNG'S MODULUS OF ELASTICITY (GPa)					
Static, mid-third					
Dry	44.6	6.2	30.6-51.0	10	
Wet	52.0	1.3	49.8-53.9	10	
POISSON'S RATIO					
Dynamic					
Dry	0.39	0.01	0.37-0.42	10	
Wet	0.42	0.02	0.40-0.44	10	
FLEXURAL STRENGTH (MPa)					
North-south bending axis, load vertical					
Dry	9.3	0.6	8.5-9.9	5	
Wet	8.7	0.4	8.2-9.3	5	
Ratio wet/dry	0.93				
East-west bending axis, load vertical					
Dry	9.2	0.4	8.7-9.8	5	
Wet	9.1	0.4	8.8-9.7	5	
Ratio wet/dry	0.98				
Ratio east-west/north-south, dry	0.99				
ULTRASONIC PULSE VELOCITY (m/sec)					
Cores, vertical					
Dry	5492	38	5397-5546	10	
Wet	5911	150	5717-6115	10	
Block					
Top-bottom	5390		5290-5460	1	}
North-south	5430		5360-5490	1	}Eight measurements
East-west	5280		5230-5340	1	}
BULK DENSITY (kg/m^3)	2710	13	2676-2721	10	
WATER ABSORPTION (%)					
By volume					
At atmospheric pressure	0.11	0.03	0.07-0.15	5	
Under vacuum	0.54	0.06	0.49-0.64	5	
By weight					
At atmospheric pressure	0.04	0.01	0.03-0.06	5	
Under vacuum	0.20	0.02	0.18-0.23	5	
SATURATION COEFFICIENT	0.21				
RESISTANCE TO SALT CRYSTALLISATION (% weight loss)	0.02		0.02-0.03	3	Measured as weight of residue
ABRASION RESISTANCE					
Taber index	96.0		83.7-108	3	
SHORE HARDNESS					
Dry	52	2	49-56	10	
Wet	53	3	49-58	10	
DIMENSIONAL STABILITY (% linear change)					
East-west	+0.005			1	}
North-south	+0.001			1	}Total change after ten cycles
North-south	-0.002			1	}Top-bottom not measured
COEFF. OF LINEAR THERMAL EXPANSION (mm/mm/°C x 10^{-6})					
East-west	8.5	0.5	8.0-9.7	1	}
North-south	8.2	0.5	7.7-9.2	1	}Ten cycles per specimen
North-south	8.8	0.5	8.1-9.8	1 }	Top-bottom not measured
MICROCRACK DENSITY (cracks per 100 mm)	7	1	6-9	1	Five traverses
DOMINANT PLANAR STRUCTURE	Not known - assumed to be horizontal.				

Additional comments:

SEDAN GRANITE - 'SIENNA BROWN'

SADME 6729 RS 48
Date of sampling: Mid 1986

TEST	MEAN	STANDARD DEVIATION	RANGE	NO. OF SPECIMENS	COMMENTS
COMPRESSIVE STRENGTH (MPa)					
Unaxial unconfined					Cores nominally 100 mm diameter
Dry	197	10	181-210	10	
Wet	181	11	164-195	10	
Ratio wet/dry	0.92				
YOUNG'S MODULUS OF ELASTICITY (GPa)					
Static, mid-third					
Dry	58.4	3.1	55.2-63.7	10	
Wet	53.8	3.1	47.6-56.7	10	
POISSON'S RATIO					
Dynamic					
Dry	0.32	0.02	0.28-0.34	10	
Wet	0.29	0.01	0.27-0.30	10	
FLEXURAL STRENGTH (MPa)					
North-south bending axis, load east-west					
Dry	16.1	0.8	15.1-17.2	5	
Wet	16.4	0.5	15.8-17.1	5	
Ratio wet/dry	1.01				
Top-bottom bending axis, load east-west					
Dry	14.8	0.8	13.9-15.9	5	
Wet	15.2	0.6	14.7-15.9	5	
Ratio wet/dry	1.02				
Ratio top-bottom/north-south, dry	0.92				
ULTRASONIC PULSE VELOCITY (m/sec)					
Cores, normal to foliation					
Dry	5592	116	5395-5727	10	
Wet	6739	74	6591-6845	10	
Block					
East-west (normal to foliation)	5640		5545-5745	1	}
Top-bottom	5735		5660-5840	1	}Eight measurements
North-south	5640		5595-5705	1	}
BULK DENSITY (kg/m^3)	2630	1	2625-2629	10	
WATER ABSORPTION (%)					
By volume					
At atmospheric pressure	0.46	0.02	0.43-0.48	5	
Under vacuum	0.68	0.02	0.65-0.70	5	
By weight					
At atmospheric pressure	0.18	0.01	0.16-0.18	5	
Under vacuum	0.26	0.01	0.25-0.27	5	
SATURATION COEFFICIENT	0.68				
RESISTANCE TO SALT CRYSTALLISATION (% weight loss)	0.01		0.01	3	Measured as weight of residue
ABRASION RESISTANCE					
Taber index	131		122-141	3	
SHORE HARDNESS					
Dry	54	2	50-58	10	
Wet	56	3	53-61	10	
DIMENSIONAL STABILITY (% linear change)					
East-west (normal to foliation)	-0.004			1	}
Top-bottom	-0.004			1	}Total change after ten cycles
North-south	-0.003			1	}
COEFF. OF LINEAR THERMAL EXPANSION (mm/mm/°C x 10^{-6})					
East-west (normal to foliation)	7.0	0.5	6.4-7.9	1	}
Top-bottom	6.9	0.5	6.3-7.7	1	}Ten cycles per specimen
North-south	7.2	0.6	6.5-8.2	1	}
MICROCRACK DENSITY (cracks per 100 mm)	29	4	24-33	1	Five traverses
DOMINANT PLANAR STRUCTURE	Weak foliation, near vertical, striking approximately north-south				

Additional comments: The anisotropic effect of the foliation was investigated by testing flexural strength in a third orthogonal direction, ie. a top-bottom bending axis with load north-south. Results are:

Dry	12.3	0.5	11.5-12.9	6
Wet	13.4	0.3	13.1-13.8	6
Ratio wet/dry	1.09			

CALCA GRANITE - 'CALCA RED'

SADME 5731 RS 58
Date of sampling: Early 1986

TEST	MEAN	STANDARD DEVIATION	RANGE	NO. OF SPECIMENS	COMMENTS
COMPRESSIVE STRENGTH (MPa)					
Unaxial unconfined					Cores nominally 100 mm diameter
Dry	150	16	127-166	10	
Wet	148	19	107-164	10	
Ratio wet/dry	0.99				
YOUNG'S MODULUS OF ELASTICITY (GPa)					
Static, mid-third					
Dry	61.8	6.1	49.8-68.0	10	
Wet	61.3	8.1	40.8-67.7	10	
POISSON'S RATIO					
Dynamic					
Dry	0.28	0.06	0.20-0.34	10	
Wet	0.29	0.03	0.23-0.32	10	
FLEXURAL STRENGTH (MPa)					
East-West bending axis, load vertical					
Dry	10.9	0.8	9.8-11.7	4	One defective result (4.3) omitted
Wet	11.5	0.4	11.0-12.0	5	
Ratio wet/dry	1.05				
North-south bending axis, load vertical					
Dry	9.5	0.4	9.1-9.9	5	
Wet	10.6	0.6	10.0-11.5	5	
Ratio wet/dry	1.11				
Ratio north-south/east-west, dry	0.87				
ULTRASONIC PULSE VELOCITY (m/sec)					
Cores, vertical					
Dry	6213	142	6021-6378	10	
Wet	6243	131	6015-6509	10	
Block					
Top-bottom	5620		5530-5700	1	}
North-south	5500		5460-5520	1	}Eight measurements
East-west	5190		5100-5320	1	}
BULK DENSITY (kg/m^3)	2610	2	2604-2611	10	
WATER ABSORPTION (%)					
By volume					
At atmospheric pressure	0.43	0.02	0.41-0.45	5	
Under vacuum	0.46	0.02	0.43-0.48	5	
By weight					
At atmospheric pressure	0.17	0.01	0.16-0.17	5	
Under vacuum	0.18	0.01	0.17-0.18	5	
SATURATION COEFFICIENT	0.95				
RESISTANCE TO SALT CRYSTALLISATION (% weight loss)	0.06		0.05-0.07	3	Measured as weight of residue
ABRASION RESISTANCE					
Taber index	133		117-153	3	
SHORE HARDNESS					
Dry	57	2	53-59	10	
Wet	56	2	53-59	10	
DIMENSIONAL STABILITY (% linear change)					
Top-bottom	-0.002			1	}
North-south	-0.004			1	}Total change after ten cycles
East-west	+0.001			1	}
COEFF. OF LINEAR THERMAL EXPANSION (mm/mm/°C x 10^{-6})					
Top-bottom	7.5	0.4	6.9-8.3	1	}
North-south	7.0	0.4	6.5-7.9	1	}Ten cycles per specimen
East-west	7.9	0.5	7.3-8.8	1	}
MICROCRACK DENSITY (cracks per 100 mm)	15	4	10-20	1	Five traverses
DOMINANT PLANAR STRUCTURE	Not known - assumed to be horizontal.				

Additional comments:

ANGASTON MARBLE

SADME 6728 RS 73
Date of sampling: Late 1985

TEST	MEAN	STANDARD DEVIATION	RANGE	NO. OF SPECIMENS	COMMENTS
COMPRESSIVE STRENGTH (MPa)					
Unaxial unconfined					Cores nominally 100 mm diameter
Dry	75.3	1.2	73.3-76.9	10	
Wet	74.6	2.0	71.4-77.7	10	
Ratio wet/dry	0.99				
YOUNG'S MODULUS OF ELASTICITY (GPa)					
Static, mid-third					
Dry	53.2	5.5	43.3-60.2	10	
Wet	50.6	4.7	43.8-58.7	10	
POISSON'S RATIO					
Dynamic					
Dry	0.37	0.03	0.33-0.40	10	
Wet	0.34	0.01	0.33-0.37	10	
FLEXURAL STRENGTH (MPa)					
Top-bottom bending axis, load east-west					
Dry	11.3	1.6	9.5-13.7	5	One defective result (6.5) omitted
Wet	11.4	1.9	8.5-13.5	6	
Ratio wet/dry	1.00				
North-south bending axis, load east-west					
Dry	9.5	1.2	7.0-10.5	6	
Wet	12.1	0.6	11.8-12.9	6	
Ratio wet/dry	1.28				
Ratio north-south/top-bottom, dry	0.84				
ULTRASONIC PULSE VELOCITY (m/sec)					
Cores, vertical					
Dry	5520	335	5076-5930	10	
Wet	5537	62	5442-5658	10	
Block					
East-west (normal to foliation)	5430		5230-5660	1	Twelve }
North-south	5640		5380-5800	1	Fourteen } measurements
Top-bottom	5750		5390-5870	1	Twelve }
BULK DENSITY (kg/m^3)	2720	4	2710-2722	10	
WATER ABSORPTION (%)					
By volume					
At atmospheric pressure	0.15	0.05	0.09-0.22	5	
Under vacuum	0.25	0.06	0.18-0.33	5	
By weight					
At atmospheric pressure	0.06	0.02	0.03-0.08	5	
Under vacuum	0.09	0.02	0.07-0.12	5	
SATURATION COEFFICIENT	0.62				
RESISTANCE TO SALT CRYSTALLISATION (% weight loss)	0.04		0.04	3	Measured as weight of residue
ABRASION RESISTANCE					
Taber index	15.2		14.3-15.6	3	
SHORE HARDNESS					
Dry	35	2	32-38	10	
Wet	35	2	31-39	10	
DIMENSIONAL STABILITY (% linear change)					
East-west	-0.018			1	}
North-south	-0.003			1	}Total change after ten cycles
Top-bottom	-0.010			1	}
COEFF. OF LINEAR THERMAL EXPANSION (mm/mm/°C x 10^{-6})					
East-west (normal to foliation)	11.3	0.6	10.4-12.4	1	}
North-south	4.5	0.6	3.9-6.1	1	}Ten cycles per specimen
Top-bottom	2.5	0.4	2.0-3.2	1	}
MICROCRACK DENSITY (cracks per 100 mm)					
DOMINANT PLANAR STRUCTURE	Foliation, near vertical, striking approximately north-south.				

Additional comments:

WILLUNGA SLATE

SADME 6627 RS 686
Date of sampling: Early 1986

TEST	MEAN	STANDARD DEVIATION	RANGE	NO. OF SPECIMENS	COMMENTS
COMPRESSIVE STRENGTH (MPa)					
Unaxial unconfined					
Dry					
Wet					
Ratio wet/dry					
YOUNG'S MODULUS OF ELASTICITY (GPa)					
Static, mid-third					
Dry					
Wet					
POISSON'S RATIO					
Static					
Dry					
Wet					
FLEXURAL STRENGTH (MPa)					
Bending axis perpendicular to grain					
Dry	36.8		28.7-46.6	5}	Specimens nominally 26, 29 and 31mm thick
Wet	32.4		27.5-35.9	5}	
Ratio wet/dry	0.88				
Bending axis parallel to grain					
Dry	28.1		24.2-33.4	5}	" " " " "
Wet	18.8		12.0-21.2	5}	
Ratio wet/dry	0.69				
Ratio parallel/perpendicular, dry	0.76				
ULTRASONIC PULSE VELOCITY (m/sec)					
Cores,					
Dry					
Wet					
Block					
BULK DENSITY (kg/m^3)	2710		2704-2723	10	Specimens 26, 29 and 31mm thick
WATER ABSORPTION (%)					
By volume					
At atmospheric pressure	1.91		1.79-2.02	5}	" " " " "
Under vacuum	1.93		1.80-2.13	5}	
By weight					
At atmospheric pressure	0.70		0.66-0.75	5}	" " " " "
Under vacuum	0.71		0.66-0.79	5}	
SATURATION COEFFICIENT	0.99				
RESISTANCE TO SALT CRYSTALLISATION (% weight loss)	0		0	3	Measured as weight of residue Specimens 26, 29 and 31mm thick
ABRASION RESISTANCE					
Taber index	10.3		8.3-11.4	3	
SHORE HARDNESS					
Dry					
Wet					
DIMENSIONAL STABILITY (% linear change)					
Parallel to bedding, perpendicular to grain	-0.008			1	Total change after ten cycles
COEFF. OF LINEAR THERMAL EXPANSION (mm/mm/°C x 10^{-6})					
Parallel to bedding, perpendicular to grain	9.1	0.8	8.0-10.1	1	Ten cycles per specimen
DOMINANT PLANAR STRUCTURE	Bedding.				

Additional comments:

Standard deviations have not been calculated where specimens number less than four, or where specimens were cut from more than one sub-sample.

MINTARO SLATE

COMPOSITE OF SADME 6630 RS 404-406
Date of sampling: Late 1985

TEST	MEAN	RANGE OF SAMPLE MEANS	NO. OF SAMPLES	GRAND RANGE OF SPECIMENS	
COMPRESSIVE STRENGTH (MPa)					
Unaxial unconfined					
Dry	183	178-187	2	148-192	*
Wet	136	129-144	2	120-146	*
Ratio wet/dry	0.75				
YOUNG'S MODULUS OF ELASTICITY (GPa)					
Static, mid-third					
Dry	28.8	27.8-29.8	2	20.9-31.7	*
Wet	20.5	19.3-21.6	2	18.1-22.5	*
POISSON'S RATIO					
Static					
Dry	0.40	0.39-0.40	2	0.34-0.45	*
Wet	0.75	0.67-0.82	2	0.51-0.89	*
FLEXURAL STRENGTH (MPa)					
Bending axis perpendicular to grain					
Dry	37.2	35.4-38.4	3	27.6-40.7	
Wet	25.8	23.4-29.4	3	22.8-30.9	
Ratio wet/dry	0.69				
Bending axis parallel to grain					
Dry	26.3	25.0-28.2	3	23.1-30.3	
Wet	18.3	16.9-20.7	3	16.2-23.0	
Ratio wet/dry	0.70				
Ratio parallel/perpendicular, dry	0.71				
ULTRASONIC PULSE VELOCITY (m/sec)					
Cores, normal to bedding					
Dry	4995	4870-5120	2	4407-5332	*
Wet	5488	5363-5613	2	5191-5727	*
Block					
Normal to bedding	3910	3865-3955	2	3770-4110	*
Parallel to grain	5445	5390-5500	2	5310-5530	*
Perpendicular to grain	5190	4975-5405	2	4950-5540	*
BULK DENSITY (kg/m^3)	2760	2759-2772	3	2.758-2.779	
WATER ABSORPTION (%)					
By volume					
At atmospheric pressure	0.84	0.76-0.96	3	0.68-1.07	
Under vacuum	0.93	0.82-1.07	3	0.73-1.13	
By weight					
At atmospheric pressure	0.30	0.27-0.35	3	0.25-0.39	
Under vacuum	0.34	0.29-0.39	3	0.26-0.41	
SATURATION COEFFICIENT	0.90				
RESISTANCE TO SALT CRYSTALLISATION (% weight loss)	0.07	0.04-0.10	3	0.04-0.12	
ABRASION RESISTANCE					
Taber index	12.3	11.9-12.6	3	8.7-15.7	
SHORE HARDNESS					
Dry	34	32-36	2	29-39	*
Wet	34	33-36	2	27-39	*
DIMENSIONAL STABILITY (% linear change)					
Parallel to bedding	-0.03	-0.03	1		ϕ
COEFF. OF LINEAR THERMAL EXPANSION (mm/mm/°C x 10^{-6})					
Parallel to bedding	10.0	10.0	1	8.9-12.1	ϕ
DOMINANT PLANAR STRUCTURE	Bedding				

Additional comments: These data are a composite of the results for the three samples 6630 RS 404-406. As a guide for design purposes they should be used in preference to the results for the individual samples.

* RS 404, 405 only
ϕ RS 406 only

MINTARO SLATE

SADME 6630 RS 404
Date of sampling: Late 1985

TEST	MEAN	STANDARD DEVIATION	RANGE	NO. OF SPECIMENS	COMMENTS
COMPRESSIVE STRENGTH (MPa)					
Unaxial unconfined					
Dry	178	17	148-190	5	
Wet	129	5	120-133	5	
Ratio wet/dry	0.72				
YOUNG'S MODULUS OF ELASTICITY (GPa)					
Static, mid-third					
Dry	27.8	4.0	20.9-30.6	5	
Wet	19.3	0.8	18.1-20.3	5	
POISSON'S RATIO					
Static					
Dry	0.39	0.05	0.34-0.45	5	
Wet	0.82	0.05	0.77-0.89	5	
FLEXURAL STRENGTH (MPa)					
Bending axis perpendicular to grain					
Dry	38.4	1.4	37.6-40.0	3}	Specimens nominally 44mm thick
Wet	23.4	0.9	22.8-24.4	3}	
Ratio wet/dry	0.61				
Bending axis parallel to grain					
Dry	25.0	1.9	23.2-27.0	3}	" " " " "
Wet	16.9	0.8	16.2-17.9	3}	
Ratio wet/dry	0.68				
Ratio parallel/perpendicular, dry	0.65				
ULTRASONIC PULSE VELOCITY (m/sec)					
Cores, normal to bedding					
Dry	5120	188	4921-5332	5	
Wet	5363	168	5191-5618	5	
Block					
Normal to bedding	3955		3770-4110	1	Six }
Parallel to grain	5500		5440-5530	1	Three } measurements
Perpendicular to grain	5405		5270-5540	1	Three }
BULK DENSITY (kg/m^3)	2759	1	2758-2760	10	
WATER ABSORPTION (%)					
By volume					
At atmospheric pressure	0.79	0.02	0.78-0.82	5	
Under vacuum	0.90	0.02	0.88-0.92	5	
By weight					
At atmospheric pressure	0.29	0.01	0.28-0.30	5	
Under vacuum	0.33	0.01	0.32-0.33	5	
SATURATION COEFFICIENT	0.88				
RESISTANCE TO SALT CRYSTALLISATION (% weight loss)	0.04		0.04-0.05	3	Measured as weight of residue
ABRASION RESISTANCE					
Taber index	11.9		8.7-15.7	3	
SHORE HARDNESS					
Dry	36	3	32-39	5	
Wet	36	5	27-39	5	
DIMENSIONAL STABILITY (% linear change)					
COEFF. OF LINEAR THERMAL EXPANSION (mm/mm/°C x 10^{-6})					
DOMINANT PLANAR STRUCTURE	Bedding.				

Additional comments: As a guide for design purposes the composite data for the three samples 6630 RS 404-406 should be used in preference to the data on this sheet.

MINTARO SLATE

SADME 6630 RS 405
Date of sampling: Late 1985

TEST	MEAN	STANDARD DEVIATION	RANGE	NO. OF SPECIMENS	COMMENTS
COMPRESSIVE STRENGTH (MPa)					
Unaxial unconfined					
Dry	187	5	181-192	5	
Wet	144	2	141-146	5	
Ratio wet/dry	0.77				
YOUNG'S MODULUS OF ELASTICITY (GPa)					
Static, mid-third					
Dry	29.8	1.2	28.4-31.7	5	
Wet	21.6	1.3	19.3-22.5	5	
POISSON'S RATIO					
Static					
Dry	0.40	0.04	0.36-0.44	5	
Wet	0.67	0.09	0.51-0.74	5	
FLEXURAL STRENGTH (MPa)					
Bending axis perpendicular to grain					
Dry	35.4	5.3	27.6-40.7	5}	Specimens nominally 28mm thick
Wet	24.5	0.9	23.6-26.0	5}	
Ratio wet/dry	0.69				
Bending axis parallel to grain					
Dry	25.7	1.8	23.1-27.9	5}	" " " " "
Wet	17.4	1.2	16.2-19.5	5}	
Ratio wet/dry	0.68				
Ratio parallel/perpendicular, dry	0.73				
ULTRASONIC PULSE VELOCITY (m/sec)					
Cores, normal to bedding					
Dry	4870	280	4407-5095	5	
Wet	5613	105	5481-5727	5	
Block					
Normal to bedding	3865		3800-3950	1	Three }
Parallel to grain	5390		5310-5470	1	Two } measurements
Perpendicular to grain	4975		4950-5000	1	Two }
BULK DENSITY (kg/m^3)	2760		2760-2766	20	10/20 specimens 50x50x28mm
WATER ABSORPTION (%)					
By volume					
At atmospheric pressure	0.96		0.93-1.07	10}	5/10 specimens 50x50x28mm
Under vacuum	1.07		0.98-1.13	10}	
By weight					
At atmospheric pressure	0.35		0.34-0.39	10}	" " " "
Under vacuum	0.39		0.36-0.41	10}	
SATURATION COEFFICIENT	0.90				
RESISTANCE TO SALT CRYSTALLISATION (% weight loss)	0.08		0.04-0.12	6	Measured as weight of residue 3/6 specimens 50x50x28mm
ABRASION RESISTANCE					
Taber index	12.4		10.7-15.3	3	
SHORE HARDNESS					
Dry	32	2	29-33	5	
Wet	33	2	31-35	5	
DIMENSIONAL STABILITY (% linear change)					
COEFF. OF LINEAR THERMAL EXPANSION (mm/mm/°C x 10^{-6})					
DOMINANT PLANAR STRUCTURE	Bedding.				

Additional comments: As a guide for design purposes the composite data for the three samples 6630 RS 404-406 should be used in preference to the data on this sheet. Standard deviations have not been calculated where specimens number less than four, or where specimens were cut from more than one sub-sample.

MINTARO SLATE

SADME 6630 RS 406
Date of sampling: Late 1985*

TEST	MEAN	STANDARD DEVIATION	RANGE	NO. OF SPECIMENS	COMMENTS
COMPRESSIVE STRENGTH (MPa)					
Unaxial unconfined					
Dry					
Wet					
Ratio wet/dry					
YOUNG'S MODULUS OF ELASTICITY (GPa)					
Static, mid-third					
Dry					
Wet					
POISSON'S RATIO					
Static					
Dry					
Wet					
FLEXURAL STRENGTH (MPa)					
Bending axis perpendicular to grain					
Dry	37.7	2.9	33.7-40.4	5}	Specimens nominally 24mm thick
Wet	29.4	1.7	26.6-30.9	5}	
Ratio wet/dry	0.73				
Bending axis parallel to grain					
Dry	28.2	3.0	23.2-30.3	5}	" " " " "
Wet	20.7	1.8	18.0-23.0	5}	
Ratio wet/dry	0.78				
Ratio parallel/perpendicular, dry	0.75				
ULTRASONIC PULSE VELOCITY (m/sec)					
Cores,					
Block					
BULK DENSITY (kg/m^3)	2772	5	2766-2779	10	Specimens 50x50x24mm
WATER ABSORPTION (%)					
By volume					
At atmospheric pressure	0.76	0.04	0.68-0.79	5}	" " "
Under vacuum	0.82	0.05	0.73-0.87	5}	
By weight					
At atmospheric pressure	0.27	0.02	0.25-0.29	5}	" " "
Under vacuum	0.29	0.02	0.26-0.31	5}	
SATURATION COEFFICIENT	0.93				
RESISTANCE TO SALT CRYSTALLISATION (% weight loss)	0.10		0.07-0.12	3	Measured as weight of residue, Specimens 50x50x24mm
ABRASION RESISTANCE					
Taber index	12.6		9.4-15.6	3	
SHORE HARDNESS					
Dry					
Wet					
DIMENSIONAL STABILITY (% linear change)					
Parallel to bedding	-0.03			1	Total change after ten cycles
COEFF. OF LINEAR THERMAL EXPANSION (mm/mm/°C x 10^{-6})					
Parallel to bedding	10.0	1.0	8.9-12.1	1	Nine cycles per specimen
DOMINANT PLANAR STRUCTURE	Bedding.				

Additional comments: As a guide for design purposes the composite data for the three samples 6630 RS 404-406 should be used in preference to the data on this sheet.

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SPALDING SLATE - 'BROUGHTON RIVER'

SADME 6630 RS 403
Date of sampling: Late 1985

TEST	MEAN	STANDARD DEVIATION	RANGE	NO. OF SPECIMENS	COMMENTS
COMPRESSIVE STRENGTH (MPa)					
Unaxial unconfined					
Dry	197	16	180-222	5	
Wet	134	11	116-144	5	
Ratio wet/dry	0.68				
YOUNG'S MODULUS OF ELASTICITY (GPa)					
Static, mid-third					
Dry	29.9	3.5	26.1-34.4	5	
Wet	19.2	1.1	17.3-19.9	5	
POISSON'S RATIO					
Static					
Dry	0.31	0.03	0.26-0.34	5	
Wet	0.57	0.05	0.52-0.63	5	
FLEXURAL STRENGTH (MPa)					
Bending axis perpendicular to grain (?)					
Dry	34.1	2.9	31.4-36.8	4}	One defective result (21.9) omitted
Wet					Specimens nominally 30mm thick
Ratio wet/dry					
Bending axis parallel to grain (?)					
Dry	33.8	3.1	28.6-36.8	5}	Specimens nominally 30mm thick
Wet	24.7	3.3	21.3-28.8	5}	
Ratio wet/dry	0.73				
Ratio parallel/perpendicular, dry	0.99				
ULTRASONIC PULSE VELOCITY (m/sec)					
Cores, normal to bedding					
Dry	4486	423	4177-5223	5	
Wet	4674	485	4067-5187	5	
Block					
BULK DENSITY (kg/m^3)	2750	1	2747-2751	10	Specimens 50x50x30mm
WATER ABSORPTION (%)					
By volume					
At atmospheric pressure	0.68	0.05	0.64-0.76	5}	" " "
Under vacuum	0.70	0.03	0.66-0.76	5}	
By weight					
At atmospheric pressure	0.25	0.02	0.23-0.28	5}	" " "
Under vacuum	0.26	0.01	0.24-0.28	5}	
SATURATION COEFFICIENT	0.97				
RESISTANCE TO SALT CRYSTALLISATION (% weight loss)	0.06		0.04-0.08	3	Measured as weight of residue Specimens 50x50x30mm
ABRASION RESISTANCE					
Taber index	11.6		10.9-12.6	3	
SHORE HARDNESS					
Dry	30	4	27-35	5	
Wet	25	4	18-29	5	
DIMENSIONAL STABILITY (% linear change)					
Parallel to bedding	-0.02			1	Total change after ten cycles.
COEFF. OF LINEAR THERMAL EXPANSION (mm/mm/°C x 10^{-6})					
Parallel to bedding	8.7	1.2	7.1-11.1	1	Nine cycles per specimen.
DOMINANT PLANAR STRUCTURE	Bedding.				

Additional comments:

OLADDIE SLATE - 'FLINDERS'

SADME 6633 RS 105
Date of sampling: 1985 & 1988

TEST	MEAN	STANDARD DEVIATION	RANGE	NO. OF SPECIMENS	COMMENTS
COMPRESSIVE STRENGTH (MPa)					
Unaxial unconfined					
Dry					
Wet					
Ratio wet/dry					
YOUNG'S MODULUS OF ELASTICITY (GPa)					
Static, mid-third					
Dry					
Wet					
POISSON'S RATIO					
Static					
Dry					
Wet					
FLEXURAL STRENGTH (MPa)					
Bending axis perpendicular to grain					
Dry	33.1	5.7	26.6-38.5	4	One defective result (16.8) omitted Specimens nominally 34mm thick
Wet					
Ratio wet/dry					
Bending axis parallel to grain					
Dry					
Wet					
Ratio wet/dry					
Ratio parallel/perpendicular, dry					
ULTRASONIC PULSE VELOCITY (m/sec)					
Cores,					
Dry					
Wet					
Block					
BULK DENSITY (kg/m^3)	2660	8	2643-2673	10	
WATER ABSORPTION (%)					
By volume					
At atmospheric pressure	1.78	0.34	1.25-2.18	5	
Under vacuum	2.01	0.46	1.23-2.35	5	
By weight					
At atmospheric pressure	0.67	0.13	0.47-0.82	5	
Under vacuum	0.75	0.17	0.46-0.88	5	
SATURATION COEFFICIENT	0.89				
RESISTANCE TO SALT CRYSTALLISATION (% weight loss)	0.02		0.02-0.03	3	Measured as weight of residue
ABRASION RESISTANCE					
Taber index	10.2		8.0-15.5	6	
SHORE HARDNESS					
Dry					
Wet					
DIMENSIONAL STABILITY (% linear change)					
Parallel to bedding	-0.03			1	Total change after ten cycles
COEFF. OF LINEAR THERMAL EXPANSION (mm/mm/°C x 10^{-6})					
Parallel to bedding	8.2	0.6	7.3-8.9	1	Nine cycles per specimen
DOMINANT PLANAR STRUCTURE	Bedding				

Additional comments:

JONES HILL SLATE - 'PARACHILLNA'

COMPOSITE OF SADME 6737 RS 1206-1207
Date of sampling: Mid 1985

TEST	MEAN	RANGE OF SAMPLE MEANS	NO. OF SAMPLES	GRAND RANGE OF SPECIMENS	
COMPRESSIVE STRENGTH (MPa)					
Unaxial unconfined					
Dry	210	210	1	191-217	*
Wet	133	133	1	103-157	*
Ratio wet/dry	0.63				
YOUNG'S MODULUS OF ELASTICITY (GPa)					
Static, mid-third					
Dry	39.3	39.3	1	38.4-39.9	*
Wet	28.5	28.5	1	26.6-29.3	*
POISSON'S RATIO					
Static					
Dry	0.33	0.33	1	0.27-0.48	*
Wet	0.41	0.41	1	0.30-0.49	*
FLEXURAL STRENGTH (MPa)					
Bending axis perpendicular to grain					
Dry	50.0	47.6-52.4	2	43.2-59.6	
Wet	41.3	39.2-43.4	2	33.1-49.3	
Ratio wet/dry	0.83				
Bending axis parallel to grain					
Dry	27.7	26.2-29.3	2	24.0-31.2	
Wet	22.2	21.7-22.8	2	13.1-27.0	
Ratio wet/dry	0.80				
Ratio parallel/perpendicular, dry	0.55				
ULTRASONIC PULSE VELOCITY (m/sec)					
Cores, normal to bedding					
Dry	5542	5542	1	5053-5835	*
Wet	5677	5677	1	4989-6098	*
Block					
Normal to bedding	2855	2855	1	2840-2870	*
Parallel to grain	5765	5765	1	5740-5790	*
Perpendicular to grain	5105	5105	1	4970-5240	*
BULK DENSITY (kg/m^3)	2670	2670-2680	2	2661-2690	
WATER ABSORPTION (%)					
By volume					
At atmospheric pressure	1.76	1.48-2.04	2	1.38-2.27	
Under vacuum	2.16	1.68-2.63	2	1.51-2.84	
By weight					
At atmospheric pressure	0.66	0.55-0.76	2	0.52-0.85	
Under vacuum	0.81	0.63-0.99	2	0.56-1.07	
SATURATION COEFFICIENT	0.82				
RESISTANCE TO SALT CRYSTALLISATION (% weight loss)	0.03	0-0.05	2	0-0.06	
ABRASION RESISTANCE					
Taber index	14.4	14.1-14.7	2	13.4-15.4	
SHORE HARDNESS					
Dry	32	32	1	28-36	*
Wet	30	30	1	27-32	*
DIMENSIONAL STABILITY (% linear change)					
COEFF. OF LINEAR THERMAL EXPANSION (mm/mm/°C x 10^{-6})					
DOMINANT PLANAR STRUCTURE	Bedding				

Additional comments: These data are a composite of the results for the two samples 6737 RS 1206 and 1207 (Light and Dark). As a guide for design purposes they should be used in preference to the results for the individual samples.

* RS 1207 only

JONES HILL SLATE (LIGHT) - 'PARACHILLNA'

SADME 6737 RS 1206
Date of sampling: Mid 1985

TEST	MEAN	STANDARD DEVIATION	RANGE	NO. OF SPECIMENS	COMMENTS
COMPRESSIVE STRENGTH (MPa)					
Unaxial unconfined					
Dry					
Wet					
Ratio wet/dry					
YOUNG'S MODULUS OF ELASTICITY (GPa)					
Static, mid-third					
Dry					
Wet					
POISSON'S RATIO					
Static					
Dry					
Wet					
FLEXURAL STRENGTH (MPa)					
Bending axis perpendicular to grain					
Dry	47.6	3.5	43.2-51.7	5}	Specimens nominally 36mm thick
Wet	39.2	3.8	33.1-42.7	5}	
Ratio wet/dry	0.82				
Bending axis parallel to grain					
Dry	26.2	2.5	24.0-30.3	5}	" " " " "
Wet	21.7	6.8	13.1-27.0	5}	
Ratio wet/dry	0.83				
Ratio parallel/perpendicular, dry	0.55				
ULTRASONIC PULSE VELOCITY (m/sec)					
Cores,					
Dry					
Wet					
Block					
BULK DENSITY (kg/m^3)	2670	3	2661-2670	10	Specimens 50x50x36mm
WATER ABSORPTION (%)					
By volume					
At atmospheric pressure	2.04	0.15	1.87-2.27	5 }	" " "
Under vacuum	2.63	0.23	2.25-2.84	5 }	
By weight					
At atmospheric pressure	0.76	0.06	0.70-0.85	5 }	" " "
Under vacuum	0.99	0.09	0.84-1.07	5 }	
SATURATION COEFFICIENT	0.77				
RESISTANCE TO SALT CRYSTALLISATION (% weight loss)	0		0	3	Measured as weight of residue Specimens 50x50x36mm
ABRASION RESISTANCE					
Taber index	14.7		13.7-15.4	3	
SHORE HARDNESS					
Dry					
Wet					
DIMENSIONAL STABILITY (% linear change)					
COEFF. OF LINEAR THERMAL EXPANSION (mm/mm/°C x 10^{-6})					
DOMINANT PLANAR STRUCTURE	Bedding				

Additional comments: For design purposes the composite data for the two samples 6737 RS 1206 and 1207 (Light and Dark) should be used as a guide in preference to the data on this sheet.

JONES HILL SLATE (DARK) - 'PARACHILLNA' SADME 6737 RS 1207

Date of sampling: Mid 1985

TEST	MEAN	STANDARD DEVIATION	RANGE	NO. OF SPECIMENS	COMMENTS
COMPRESSIVE STRENGTH (MPa)					
Unaxial unconfined					
Dry	210	11	191-217	5	
Wet	133	24	103-157	5	
Ratio wet/dry	0.63				
YOUNG'S MODULUS OF ELASTICITY (GPa)					
Static, mid-third					
Dry	39.3	0.7	38.4-39.9	5	
Wet	28.5	1.1	26.6-29.3	5	
POISSON'S RATIO					
Static					
Dry	0.33	0.09	0.27-0.48	5	
Wet	0.41	0.09	0.30-0.49	5	
FLEXURAL STRENGTH (MPa)					
Bending axis perpendicular to grain					
Dry	52.4	6.2	43.7-59.6	5}	Specimens nominally 23mm thick
Wet	43.4	4.6	37.1-49.3	5}	
Ratio wet/dry	0.83				
Bending axis parallel to grain					
Dry	29.3	2.1	26.0-31.2	5}	" " " " "
Wet	22.8	1.6	20.9-25.0	5}	
Ratio wet/dry	0.78				
Ratio parallel/perpendicular, dry	0.56				
ULTRASONIC PULSE VELOCITY (m/sec)					
Cores, normal to bedding					
Dry	5542	330	5053-5835	5	
Wet	5677	425	4989-6098	5	
Block					
Normal to bedding	2855		2840-2870	1}	
Parallel to grain	5765		5740-5790	1}	Two measurements
Perpendicular to grain	5105		4970-5240	1}	
BULK DENSITY (kg/m^3)	2680	5	2678-2690	10}	Specimens 50x50x23mm
WATER ABSORPTION (%)					
By volume					
At atmospheric pressure	1.48	0.07	1.38-1.55	5}	" " "
Under vacuum	1.68	0.10	1.51-1.76	5}	
By weight					
At atmospheric pressure	0.55	0.03	0.52-0.58	5}	" " "
Under vacuum	0.63	0.04	0.56-0.66	5}	
SATURATION COEFFICIENT	0.88				
RESISTANCE TO SALT CRYSTALLISATION (% weight loss)	0.05		0.05-0.06	3	Measured as weight of residue Specimens 50x50x23mm
ABRASION RESISTANCE					
Taber index	14.1		13.4-14.4	3	
SHORE HARDNESS					
Dry	32	4	28-36	5	
Wet	30	2	27-32	5	
DIMENSIONAL STABILITY (% linear change)					
COEFF. OF LINEAR THERMAL EXPANSION (mm/mm/°C x 10^{-6})					
DOMINANT PLANAR STRUCTURE	Bedding				

Additional comments: For design purposes the composite data for the two samples 6737 RS 1206 and 1207 (Light and Dark) should be used as a guide in preference to the data on this sheet.

JONES HILL SLATE ('IRON') - 'PARACHILLNA'

SADME 6737 RS 1208
Date of sampling: Mid 1985

TEST	MEAN	STANDARD DEVIATION	RANGE	NO. OF SPECIMENS	COMMENTS
COMPRESSIVE STRENGTH (MPa)					
Unaxial unconfined					
Dry					
Wet					
Ratio wet/dry					
YOUNG'S MODULUS OF ELASTICITY (GPa)					
Static, mid-third					
Dry					
Wet					
POISSON'S RATIO					
Static					
Dry					
Wet					
FLEXURAL STRENGTH (MPa)					
Bending axis perpendicular to grain					
Dry	49.8	8.6	39.5-63.0	5}	Specimens nominally 26mm thick
Wet	47.8	5.0	42.3-55.8	5}	
Ratio wet/dry	0.96				
Bending axis parallel to grain					
Dry	25.6	3.5	20.3-28.9	5}	" " " " "
Wet	28.4	2.5	24.5-30.6	5}	
Ratio wet/dry	1.11				
Ratio parallel/perpendicular, dry	0.51				
ULTRASONIC PULSE VELOCITY (m/sec)					
Cores,					
Dry					
Wet					
Block					
BULK DENSITY (kg/m^3)	2730	2	2724-2730	10	Specimens 50x50x26mm
WATER ABSORPTION (%)					
By volume					
At atmospheric pressure	0.81	0.08	0.75-0.96	5}	" " "
Under vacuum	0.89	0.05	0.81-0.95	5}	
By weight					
At atmospheric pressure	0.30	0.03	0.27-0.35	5}	" " "
Under vacuum	0.33	0.02	0.30-0.35	5}	
SATURATION COEFFICIENT	0.91				
RESISTANCE TO SALT CRYSTALLISATION (% weight loss)	0.04		0.03-0.04	3	Measured as weight of residue Specimens 50x50x26mm
ABRASION RESISTANCE					
Taber index	21.7		20.5-24.0	3	
SHORE HARDNESS					
Dry					
Wet					
DIMENSIONAL STABILITY (% linear change)					
Parallel to bedding, parallel to grain	-0.002			1	Total change after ten cycles
COEFF. OF LINEAR THERMAL EXPANSION (mm/mm/°C x 10^{-6})					
Parallel to bedding, parallel to grain	9.0	1.1	7.3-10.3	1	Ten cycles per specimen
DOMINANT PLANAR STRUCTURE	Bedding				

Additional comments: 'Iron' slate constitutes approximately 10% of the output of the Jones Hill quarry. These data should not be used as a guide for design purposes unless 'Iron' slate is specified.

FREESTONE HILL FLAGSTONE

SADME 6326 RS 11
Date of sampling: Late 1985

TEST	MEAN	STANDARD DEVIATION	RANGE	NO. OF SPECIMENS	COMMENTS
COMPRESSIVE STRENGTH (MPa)					
Unaxial unconfined					
Dry	157		148-170	5	
Wet	116		104-126	5	
Ratio wet/dry	0.74				
YOUNG'S MODULUS OF ELASTICITY (GPa)					
Static, mid-third					
Dry	22.8		21.5-24.5	5	
Wet	20.9		20.1-21.7	5	
POISSON'S RATIO					
Static, mid-third					
Dry	0.23		0.15-0.31	5	
Wet	0.25		0.20-0.36	5	
FLEXURAL STRENGTH (MPa)					
Bending axis w.r.t. grain unknown					
Dry	23.4		16.7-28.6	5}	Specimens nominally
Wet	16.1		13.2-19.4	5}	42 and 45mm thick
Ratio wet/dry	0.69				
Bending axis					
Dry					
Wet					
Ratio wet/dry					
Ratio					
ULTRASONIC PULSE VELOCITY (m/sec)					
Cores, normal to bedding/foliation					
Dry	4262		4202-4412	5	
Wet	4589		4489-4722	5	
Block					
BULK DENSITY (kg/m^3)	2580	5	2569-2584	10	Specimens 50x50x45mm
WATER ABSORPTION (%)					
By volume					
At atmospheric pressure	3.39	0.08	3.34-3.52	5}	" " "
Under vacuum	4.32	0.38	4.05-4.98	5}	
By weight					
At atmospheric pressure	1.31	0.03	1.29-1.36	5}	" " "
Under vacuum	1.68	0.15	1.57-1.94	5}	
SATURATION COEFFICIENT	0.78				
RESISTANCE TO SALT CRYSTALLISATION (% weight loss)	0.04		0.03-0.04	3	Specimens 50x50x45mm and 50x50x40mm
ABRASION RESISTANCE					
Taber index	21.3		19.6-24.3	3	
SHORE HARDNESS					
Dry	32		30-34	5	
Wet	35		32-37	5	
DIMENSIONAL STABILITY (% linear change)					
Parallel to bedding/foliation	-0.01			1	Total change after ten cycles
COEFF. OF LINEAR THERMAL EXPANSION (mm/mm/°C x 10^{-6})					
Parallel to bedding/foliation	9.7	0.9	7.6-10.5	1	Nine cycles per specimen
DOMINANT PLANAR STRUCTURE	Coincident bedding and foliation planes.				

Additional comments: Standard deviations have not been calculated where specimens number less than four, or where specimens were cut from more than one sub-sample.

AUBURN BLUESTONE

SADME 6629 RS 59
Date of sampling: Late 1985

TEST	MEAN	STANDARD DEVIATION	RANGE	NO. OF SPECIMENS	COMMENTS
COMPRESSIVE STRENGTH (MPa)					
Unaxial unconfined					
Dry	27.1		20.2-31.7	5	
Wet	17.3		11.7-19.9	5	
Ratio wet/dry	0.64				
YOUNG'S MODULUS OF ELASTICITY (GPa)					
Static, mid-third					
Dry	4.22		3.89-4.49	5	
Wet	2.66		1.58-3.06	5	
POISSON'S RATIO					
Static					
Dry	0.26		0.13-0.37	5	
Wet	0.50		0.35-0.60	5	
MODULUS OF RUPTURE (MPa)					
Bending axis perpendicular to grain					
Dry	11.4	2.1	9.3-14.6	5	
Wet	4.9	0.4	4.4-5.4	5	
Ratio wet/dry	0.43				
Bending axis parallel to grain					
Dry	6.1	0.3	5.8-6.4	5	
Ratio parallel/perpendicular, dry	0.53				
ULTRASONIC PULSE VELOCITY (m/sec)					
Cores, normal to bedding					
Dry	2989		2918-3143	5	
Wet	2474		2302-2534	5	
BULK DENSITY (kg/m^3)	2110	6	2104-2123	10	
WATER ABSORPTION (%)					
By volume					
At atmospheric pressure	11.53	0.63	10.77-12.17	5	
Under vacuum	23.19	0.20	22.98-23.39	5	
By weight					
At atmospheric pressure	5.46	0.31	5.07-5.77	5	
Under vacuum	10.98	0.11	10.86-11.10	5	
SATURATION COEFFICIENT	0.50				
RESISTANCE TO SALT CRYSTALLISATION (% weight loss)	6.6	0.6	6.0-7.3	5	
ABRASION RESISTANCE					
Taber index	3.1		2.7-3.4	3	
SHORE HARDNESS					
Dry	13		13-15	5	
Wet	12		9-14	5	
DIMENSIONAL STABILITY (% linear change)					
Parallel to bedding	-0.18			1	Total change after ten cycles
COEFF. OF LINEAR THERMAL EXPANSION (mm/mm/°C x 10^{-6})					
Parallel to bedding	10.7	2.9	5.6-16.5	1	Nine cycles per specimen
DOMINANT PLANAR STRUCTURE	Bedding				

Additional comments: The sample consisted of two discrete blocks. Specimens for shore hardness, ultrasonic pulse velocity, compressive strength and related tests were cored from both blocks. The raw data shows discernible variation between the blocks. Consequently means were calculated to give equal weight to each block and no standard deviation is given. Perpendicular modulus of rupture specimens were cut from one block and the parallel from the other. This may partly explain the differing results, though the grain exists and the substantial difference is considered to be real (c.f. Mintaro Slate and see text). The remaining tests (except abrasion resistance) were undertaken on specimens from a single block. Caution is required in comparing the data.

KANMANTOO + WISTOW BLUESTONES

COMPOSITE OF SADME 6627 RS 687 and 688
Date of sampling: Early 1986

TEST	MEAN	RANGE OF SAMPLE MEANS	NO. OF SAMPLES	GRAND RANGE OF SPECIMENS
COMPRESSIVE STRENGTH (MPa)				
Unaxial unconfined				
Dry	211	202-219	2	158-245
Wet	151	133-170	2	100-183
Ratio wet/dry	0.72			
YOUNG'S MODULUS OF ELASTICITY (GPa)				
Static, mid-third				
Dry	48.3	47.1-49.4	2	39.3-51.6
Wet	39.0	34.2-43.8	2	28.3-47.0
POISSON'S RATIO				
Static				
Dry	0.35	0.32-0.37	2	0.28-0.40
Wet	0.44	0.38-0.51	2	0.32-0.54
MODULUS OF RUPTURE (MPa)				
Dry	19.1	16.4-21.8	2	8.7-26.9
Wet	20.5	18.9-22.2	2	13.6-26.6
Ratio wet/dry	1.07			
ULTRASONIC PULSE VELOCITY (m/sec)				
Cores, normal to foliation				
Dry	6427	5658-7195	2	5509-7660
Wet	6748	5989-7506	2	5750-9167
BULK DENSITY (kg/m^3)	2700	2700-2710	2	2642-2730
WATER ABSORPTION (%)				
By volume				
At atmospheric pressure	0.86	0.84-0.87	2	0.53-1.33
Under vacuum	1.05	1.02-1.08	2	0.59-1.90
By weight				
At atmospheric pressure	0.32	0.31-0.32	2	0.20-0.50
Under vacuum	0.39	0.38-0.40	2	0.22-0.71
SATURATION COEFFICIENT	0.81			
RESISTANCE TO SALT CRYSTALLISATION (% weight loss)	0.02	0.02	2	0.01-0.04
ABRASION RESISTANCE				
Taber index	47.6	45.1-50.1	2	28.3-62.3
SHORE HARDNESS				
Dry	42	41-43	2	39-46
Wet	39	37-41	2	34-44
DIMENSIONAL STABILITY (% linear change)				
Parallel to foliation	-0.015	-0.01 to -0.02	2	
COEFF. OF LINEAR THERMAL EXPANSION (mm/mm/°C x 10^{-6})				
Parallel to foliation	10.3	8.8-11.9	2	6.7-14.1
DOMINANT PLANAR STRUCTURE	Bedding plane foliation.			

Additional comments: These data are a composite of the results for the two samples 6627 RS 687 (Kanmantoo) and 688 (Wistow). As a guide for design purposes they should be used in preference to the results for the individual samples.

KANMANTOO BLUESTONE

SADME 6627 RS 687
Date of sampling: Early 1986

TEST	MEAN	STANDARD DEVIATION	RANGE	NO. OF SPECIMENS	COMMENTS
COMPRESSIVE STRENGTH (MPa)					
Unaxial unconfined					
Dry	202	28	158-233	5	
Wet	170	15	152-183	5	
Ratio wet/dry	0.84				
YOUNG'S MODULUS OF ELASTICITY (GPa)					
Static, mid-third					
Dry	47.1	5.2	39.3-51.6	5	
Wet	43.8	2.4	41.4-47.0	4	
POISSON'S RATIO					
Static					
Dry	0.32	0.03	0.28-0.35	5	
Wet	0.38	0.08	0.32-0.49	4	
MODULUS OF RUPTURE (MPa)					
Dry	21.8		8.7-26.9	5	Median result is 24.9*
Wet	22.2		18.8-26.6	5	
Ratio wet/dry	1.02				
ULTRASONIC PULSE VELOCITY (m/sec)					
Cores, normal to foliation					
Dry	5658	196	5509-5983	5	
Wet	5989	145	5750-6107	5	
BULK DENSITY (kg/m^3)	2710		2642-2730	10	
WATER ABSORPTION (%)					
By volume					
At atmospheric pressure	0.84		0.58-1.33	5	
Under vacuum	1.02		0.91-1.22	5	
By weight					
At atmospheric pressure	0.31		0.21-0.50	5	
Under vacuum	0.38		0.33-0.46	5	
SATURATION COEFFICIENT	0.83				
RESISTANCE TO SALT CRYSTALLISATION (% weight loss)	0.02		0.01-0.02	3	Measured as weight of residue
ABRASION RESISTANCE					
Taber index	50.1		47.3-55.2	3	
SHORE HARDNESS					
Dry	43	2	41-46	5	
Wet	41	2	39-44	5	
DIMENSIONAL STABILITY (% linear change)					
Parallel to foliation	-0.01			1	Total change after ten cycles
COEFF. OF LINEAR THERMAL EXPANSION (mm/mm/°C x 10^{-6})					
Parallel to foliation	8.8	2.0	6.7-11.8	1	Nine cycles per specimen
DOMINANT PLANAR STRUCTURE	Bedding plane foliation.				

Additional comments: As a guide for design purposes the composite data for the two samples 6627 RS 687 (Kanmantoo) and 6627 RS 688 (Wistow) should be used in preference to the data on this sheet. Standard deviations have not been calculated where specimens number less than four, or where specimens were c ut from more than one sub-sample.

* Full results: 8.7 23.3 24.9 25.2 26.9

WISTOW BLUESTONE

SADME 6627 RS 688
Date of sampling: Early 1986

TEST	MEAN	STANDARD DEVIATION	RANGE	NO. OF SPECIMENS	COMMENTS
COMPRESSIVE STRENGTH (MPa)					
Unaxial unconfined					
Dry	219		205-245	5	
Wet	133		100-147	4	One defective result (48.5) omitted
Ratio wet/dry	0.61				
YOUNG'S MODULUS OF ELASTICITY (GPa)					
Static, mid-third					
Dry	49.4		47.7-50.9	5	
Wet	34.2		28.3-36.7	4	
POISSON'S RATIO					
Static					
Dry	0.37		0.35-0.40	5	
Wet	0.51		0.46-0.54	3	One result (2.17) omitted
MODULUS OF RUPTURE (MPa)					
Dry	16.4		9.3-21.5	5	Median result is 16.8*
Wet	18.9		13.6-21.9	5	
Ratio wet/dry	1.15				
ULTRASONIC PULSE VELOCITY (m/sec)					
Cores, normal to foliation					
Dry	7195		6895-7660	5	
Wet	7506		5921-9167	4	
BULK DENSITY (kg/m^3)	2700		2684-2713	10	
WATER ABSORPTION (%)					
By volume					
At atmospheric pressure	0.87		0.53-1.28	5	
Under vacuum	1.08		0.59-1.90	5	
By weight					
At atmospheric pressure	0.32		0.20-0.47	5	
Under vacuum	0.40		0.22-0.71	5	
SATURATION COEFFICIENT	0.80				
RESISTANCE TO SALT CRYSTALLISATION (% weight loss)	0.02		0.01-0.04	3	Measured as weight of residue
ABRASION RESISTANCE					
Taber index	45.1		28.3-62.3	3	
SHORE HARDNESS					
Dry	41		39-44	5	
Wet	37		34-40	4	
DIMENSIONAL STABILITY (% linear change)					
Parallel to foliation	-0.02			1	Total change after ten cycles
COEFF. OF LINEAR THERMAL EXPANSION (mm/mm/°C x 10^{-6})					
Parallel to foliation	11.9	1.7	8.4-14.1	1	Nine cycles per specimen
DOMINANT PLANAR STRUCTURE	Bedding plane foliation.				

Additional comments: As a guide for design purposes the composite data for the two samples 6627 RS 687 (Kanmantoo) and 6627 RS 688 (Wistow) should be used in preference to the data on this sheet. Standard deviations have not been calculated where specimens number less than four, or where specimens were c ut from more than one sub-sample.

* Full results: 9.3 16.8 16.8 17.9 21.5

BASKET RANGE SANDSTONE

SADME 6628 RS 2665
Date of sampling: Late 1985

TEST	MEAN	STANDARD DEVIATION	RANGE	NO. OF SPECIMENS	COMMENTS
COMPRESSIVE STRENGTH (MPa)					
Unaxial unconfined					
Dry	25.3	1.7	22.8-27.3	5	
Wet	18.2	1.9	16.8-21.5	5	
Ratio wet/dry	0.72				
YOUNG'S MODULUS OF ELASTICITY (GPa)					
Static, mid-third					
Dry	4.01	0.28	3.70-4.33	5	
Wet	2.70	0.31	2.16-2.91	5	
POISSON'S RATIO					
Static					
Dry	0.31	0.07	0.25-0.42	5	
Wet	0.34	0.06	0.26-0.42	5	
MODULUS OF RUPTURE (MPa)					
Dry	5.5	2.5	3.8-9.2	4	
Wet	3.5	0.8	2.8-4.5	5	
Ratio wet/dry	0.64				
ULTRASONIC PULSE VELOCITY (m/sec)					
Cores, normal to bedding					
Dry	2377	75	2257-2446	5	
Wet	2168	85	2108-2315	5	
BULK DENSITY (kg/m^3)	2200	180	2055-2423	10	
WATER ABSORPTION (%)					
By volume					
At atmospheric pressure	9.77	2.95	6.25-12.12	5	
Under vacuum	17.41	6.30	9.86-22.18	5	
By weight					
At atmospheric pressure	4.55	1.67	2.58-5.88	5	
Under vacuum	8.17	3.44	4.09-10.79	5	
SATURATION COEFFICIENT	0.56				
RESISTANCE TO SALT CRYSTALLISATION (% weight loss)	1.7	1.4	0.3-3.8	6	Measured as weight of residue
ABRASION RESISTANCE					
Taber index					
SHORE HARDNESS					
Dry	17	3	13-20	5	
Wet	14	2	11-15	5	
DIMENSIONAL STABILITY (% linear change)					
Parallel to bedding	-0.05			1	Total change after ten cycles
COEFF. OF LINEAR THERMAL EXPANSION (mm/mm/°C x 10^{-6})					
Parallel bedding	10.1	1.1	8.6-11.4	1	Nine cycles per specimen
DOMINANT PLANAR STRUCTURE	Bedding				

Additional comments: This sample is typical of the average product from the quarry. Sample 6628 RS 2666 was taken from a hard band within the same quarry.

BASKET RANGE SANDSTONE

SADME 6628 RS 2666
Date of sampling: Late 1985

TEST	MEAN	STANDARD DEVIATION	RANGE	NO. OF SPECIMENS	COMMENTS
COMPRESSIVE STRENGTH (MPa)					
Unaxial unconfined					
Dry	80.0	10.3	68.7-92.3	5	
Wet	47.5	7.5	36.0-54.7	5	
Ratio wet/dry	0.59				
YOUNG'S MODULUS OF ELASTICITY (GPa)					
Static, mid-third					
Dry	11.68	2.64	8.71-14.95	5	
Wet	8.99	0.54	8.12-9.55	5	
POISSON'S RATIO					
Static					
Dry	0.35	0.22	0.20-0.73	5	Median result is 0.29 *
Wet	0.46	0.24	0.27-0.87	5	Median result is 0.37 ϕ
MODULUS OF RUPTURE (MPa)					
Dry	12.6	1.9	10.7-15.5	5	
Wet	8.8	2.1	5.5-10.6	5	
Ratio wet/dry	0.69				
ULTRASONIC PULSE VELOCITY (m/sec)					
Cores, normal to bedding					
Dry	4214	213	3881-4465	5	
Wet	4209	206	3937-4443	5	
BULK DENSITY (kg/m^3)	2470	47	2409-2547	10	
WATER ABSORPTION (%)					
By volume					
At atmospheric pressure	4.65	0.70	3.78-5.56	5	
Under vacuum	8.32	1.51	6.28-9.93	5	
By weight					
At atmospheric pressure	1.87	0.31	1.49-2.27	5	
Under vacuum	3.40	0.67	2.50-4.12	5	
SATURATION COEFFICIENT	0.56				
RESISTANCE TO SALT CRYSTALLISATION (% weight loss)	0.25	0.21	0.10-0.54	6	Measured as weight of residue
ABRASION RESISTANCE					
Taber index					
SHORE HARDNESS					
Dry	24	2	22-26	5	
Wet	23	1	22-24	5	
DIMENSIONAL STABILITY (% linear change)					
Parallel to bedding	-0.05			1	Total change after ten cycles
COEFF. OF LINEAR THERMAL EXPANSION ($mm/mm/^{\circ}C \times 10^{-6}$)					
Parallel to bedding	10.0	1.0	7.9-11.6	1	Nine cycles per specimen
DOMINANT PLANAR STRUCTURE	Bedding				

Additional comments: This sample came from a hard band within the quarry for which sample 6628 RS 2665 is typical of the average product.
* Full results: 0.20 0.22 0.29 0.30 0.73
ϕ Full results: 0.27 0.35 0.37 0.42 0.87

CAREY GULLY SANDSTONE

SADME 6628 RS 2667
Date of sampling: Late 1985

TEST	MEAN	STANDARD DEVIATION	RANGE	NO. OF SPECIMENS	COMMENTS
COMPRESSIVE STRENGTH (MPa)					
Unaxial unconfined					
Dry	91.1		73.8-111	5	
Wet	61.6		33.4-79.3	5	
Ratio wet/dry	0.68				
YOUNG'S MODULUS OF ELASTICITY (GPa)					
Static, mid-third					
Dry	14.7		10.7-21.9	5	
Wet	10.7		5.1-16.1	5	
POISSON'S RATIO					
Static					
Dry	0.35		0.32-0.40	5	Median result is 0.48
Wet	0.62		0.32-1.56	5	
MODULUS OF RUPTURE (MPa)					
Dry	15.1		10.3-18.7	5	
Wet	9.7		5.3-14.4	5	
Ratio wet/dry	0.64				
ULTRASONIC PULSE VELOCITY (m/sec)					
Cores, normal to bedding					
Dry	3410		2854-3943	5	
Wet	3165		2539-4032	5	
BULK DENSITY (kg/m^3)	2490		2395-2606	10	
WATER ABSORPTION (%)					
By volume					
At atmospheric pressure	4.07		1.79-6.98	5	
Under vacuum	7.33		4.52-9.62	5	
By weight					
At atmospheric pressure	1.66		0.69-2.91	5	
Under vacuum	2.98		1.75-4.02	5	
SATURATION COEFFICIENT	0.56				
RESISTANCE TO SALT CRYSTALLISATION (% weight loss)	0.9	1.2	0.1-2.9	6	Measured as weight of residue
ABRASION RESISTANCE					
Taber index					
SHORE HARDNESS					
Dry	27		24-35	5	
Wet	25		22-28	5	
DIMENSIONAL STABILITY (% linear change)					
Parallel to bedding	-0.02			1	Total change after ten cycles
COEFF. OF LINEAR THERMAL EXPANSION (mm/mm/°C x 10^{-6})					
Parallel to bedding	9.9	0.78	9.1-11.3	1	Nine cycles per specimen
DOMINANT PLANAR STRUCTURE	Bedding				

Additional comments: The sample consisted of three discrete blocks. Specimens for Shore hardness, Compressive strength and related tests were cored from two of the blocks. Specimens for Modules of Rupture, Density, Water absorption and Salt crystallisation were cut from the three blocks. The wide ranges of results reflect the considerable variation between blocks. Means were calculated to give equal weight to each block. Consequently no standard deviation is given.

MOUNT GAMBIER LIMESTONE

COMPOSITE OF SADME 7022 RS 160, 161, 163, 164, 165
Date of sampling: Mid 1985

TEST	MEAN	STANDARD DEVIATION	RANGE OF SAMPLE MEANS	NO. OF SAMPLES	GRAND RANGE OF SPECIMENS
COMPRESSIVE STRENGTH (MPa)					
Unaxial unconfined					
Dry	3.96	0.33	3.55-4.32	5	3.02-5.71
Wet	3.44	0.57	2.81-4.36	5	2.58-4.71
Ratio wet/dry	0.87				
YOUNG'S MODULUS OF ELASTICITY (GPa)					
Static, mid-third					
Dry	2.46	1.67	1.58-5.42	5	0.67-7.70
Wet	1.66	0.51	0.99-2.32	5	0.80-3.00
POISSON'S RATIO					
Static					
Dry	0.21	0.15	0.03 to 0.36	5	-0.14 to 0.64
Wet	-0.08	0.49	-0.85 to 0.37	5	-1.05 to 0.41
MODULUS OF RUPTURE (MPa)					
Dry	1.88	0.34	1.38-2.23	5	1.27-2.73
Wet	1.49	0.26	1.15-1.83	5	1.07-2.10
Ratio wet/dry	0.79				
ULTRASONIC PULSE VELOCITY (m/sec)					
Block					
Normal to bedding	2036	132	1880-2225	5	1880-2225
Parallel to bedding	2195	167	1978-2443	5	1975-2445
BULK DENSITY (kg/m^3)	1210	50	1170-1290	5	1117-1325
WATER ABSORPTION (%)					
By volume					
At atmospheric pressure	39.21	1.93	36.36-41.19	5	35.25-42.26
Under vacuum	55.62	1.85	52.84-57.48	5	52.34-58.43
By weight					
At atmospheric pressure	32.37	2.82	27.86-34.83	5	26.61-36.85
Under vacuum	46.49	3.27	41.64-49.93	5	40.70-52.30
SATURATION COEFFICIENT	0.70				
RESISTANCE TO SALT CRYSTALLISATION (% weight loss)	10.6	7.3	1.8-21.6	5	1.2-25.9
ABRASION RESISTANCE					
Taber index					
SHORE HARDNESS					
Dry					
Wet					
DIMENSIONAL STABILITY (% linear change)					
Parallel to bedding	-0.05	0.02	-0.06 to -0.02	5	
COEFF. OF LINEAR THERMAL EXPANSION (mm/mm/°C x 10^{-6})					
Parallel to bedding	4.53	0.96	3.4-5.6	5	3.0-6.3
DOMINANT PLANAR STRUCTURE	Bedding				

Additional comments: These data are a composite of the results for the five samples 7022 RS 160, 161, 163, 164 and 165 which were taken from material sold as first grade stone. As a guide for design purposes these data should be used in preference to the results for the individual samples.

Because of the considerable inhomogeneity of the limestone both laterally and vertically and between and within quarries no single sample can be considered representative of the stone type or of a particular quarry's output.

MOUNT GAMBIER LIMESTONE

SADME 7022 RS 160
Date of sampling: Mid 1985

TEST	MEAN	STANDARD DEVIATION	RANGE	NO. OF SPECIMENS	COMMENTS
COMPRESSIVE STRENGTH (MPa)					
Unaxial unconfined					Cores nominally 70mm diameter
Dry	3.55	0.28	3.23-3.92	5	
Wet	2.81	0.21	2.58-3.09	5	
Ratio wet/dry	0.79				
YOUNG'S MODULUS OF ELASTICITY (GPa)					
Static, mid-third					
Dry	1.58	0.36	1.01-1.93	5	
Wet	1.71	0.44	1.06-2.25	5	
POISSON'S RATIO					
Static					
Dry	0.08	0.15	-0.14 to 0.24	5	
Wet	0.11	0.14	-0.07 to 0.32	5	
MODULUS OF RUPTURE (MPa)					
Dry	1.38	0.12	1.27-1.57	5	
Wet	1.15	0.06	1.07-1.22	5	
Ratio wet/dry	0.84				
ULTRASONIC PULSE VELOCITY (m/sec)					
Block					
Normal to bedding	1880			1	
Parallel to bedding	1978		1975-1980	1	Two measurements at right angles
BULK DENSITY (kg/m^3)	1190	19	1155-1212	10	
WATER ABSORPTION (%)					
By volume					
At atmospheric pressure	40.60	0.72	39.98-41.79	5	
Under vacuum	56.20	0.51	55.82-56.93	5	
By weight					
At atmospheric pressure	34.10	1.21	33.27-36.18	5	
Under vacuum	47.57	1.00	46.79-49.02	5	
SATURATION COEFFICIENT	0.72				
RESISTANCE TO SALT CRYSTALLISATION (% weight loss)	8.3	3.8	4.2-12.5	6	
ABRASION RESISTANCE					
Taber index					
SHORE HARDNESS					
Dry					
Wet					
DIMENSIONAL STABILITY (% linear change)					
Parallel to bedding	-0.06			1	Total change after five cycles
COEFF. OF LINEAR THERMAL EXPANSION (mm/mm/°C x 10^{-6})					
Parallel to bedding	3.8		3.3-4.2	1	Two cycles per specimen
DOMINANT PLANAR STRUCTURE	Bedding				

Additional comments: This sample was taken from material sold as first grade stone. As a guide for design purposes the composite data for the five samples 7022 RS 160, 161, 163, 164, 165 should be used in preference to the data on this sheet.

Because of the considerable inhomogeneity of the limestone both laterally and vertically and between and within quarries no single sample can be considered representative of the stone type or of a particular quarry's output.

MOUNT GAMBIER LIMESTONE

SADME 7022 RS 161
Date of sampling: Mid 1985

TEST	MEAN	STANDARD DEVIATION	RANGE	NO. OF SPECIMENS	COMMENTS
COMPRESSIVE STRENGTH (MPa)					
Unaxial unconfined					Cores nominally 70mm diameter
Dry	4.32	0.91	3.37-5.71	5	
Wet	3.38	0.40	2.81-3.78	5	
Ratio wet/dry	0.78				
YOUNG'S MODULUS OF ELASTICITY (GPa)					
Static, mid-third					
Dry	1.60	1.67	0.67-4.58	5	
Wet	0.99	0.09	0.92-1.14	5	
POISSON'S RATIO					
Static					
Dry	0.36		0.15 to 0.57	2	
Wet	-0.85	0.13	-1.05 to -0.69	5	
MODULUS OF RUPTURE (MPa)					
Dry	1.88	0.18	1.72-2.13	5	
Wet	1.48	0.15	1.33-1.73	5	
Ratio wet/dry	0.79				
ULTRASONIC PULSE VELOCITY (m/sec)					
Block					
Normal to bedding	2105			1	
Parallel to bedding	2170		2150-2190	1	Two measurements at right angles
BULK DENSITY (kg/m^3)	1220	35	1161-1276	10	
WATER ABSORPTION (%)					
By volume					
At atmospheric pressure	38.31	1.07	37.06-39.69	5	
Under vacuum	54.78	1.27	52.70-55.67	5	
By weight					
At atmospheric pressure	31.42	1.91	29.48-34.18	5	
Under vacuum	44.90	2.21	41.29-46.43	5	
SATURATION COEFFICIENT	0.70				
RESISTANCE TO SALT CRYSTALLISATION (% weight loss)	13.0	2.0	10.1-15.6	6	
ABRASION RESISTANCE					
Taber index					
SHORE HARDNESS					
Dry					
Wet					
DIMENSIONAL STABILITY (% linear change)					
Parallel to bedding	-0.02			1	Total change after five cycles
COEFF. OF LINEAR THERMAL EXPANSION (mm/mm/°C x 10^{-6})					
Parallel to bedding	4.7		4.7	1	Two cycles per specimen
DOMINANT PLANAR STRUCTURE	Bedding				

Additional comments: This sample was taken from material sold as first grade stone. As a guide for design purposes the composite data for the five samples 7022 RS 160, 161, 163, 164, 165 should be used in preference to the data on this sheet.

Because of the considerable inhomogeneity of the limestone both laterally and vertically and between and within quarries no single sample can be considered representative of the stone type or of a particular quarry's output.

MOUNT GAMBIER LIMESTONE

SADME 7022 RS 163
Date of sampling: Mid 1985

TEST	MEAN	STANDARD DEVIATION	RANGE	NO. OF SPECIMENS	COMMENTS
COMPRESSIVE STRENGTH (MPa)					
Unaxial unconfined					Cores nominally 70mm diameter
Dry	4.27	0.36	3.88-4.72	5	
Wet	4.36	0.26	4.10-4.71	5	
Ratio wet/dry	1.02				
YOUNG'S MODULUS OF ELASTICITY (GPa)					
Static, mid-third					
Dry	2.09	0.82	1.43-3.46	5	
Wet	2.32	0.56	1.81-3.00	5	
POISSON'S RATIO					
Static					
Dry	0.03		0.02-0.03	2	
Wet	0.37	0.05	0.29-0.41	5	
MODULUS OF RUPTURE (MPa)					
Dry	2.23	0.29	2.05-2.73	5	
Wet	1.83	0.17	1.63-2.10	5	
Ratio wet/dry	0.82				
ULTRASONIC PULSE VELOCITY (m/sec)					
Block					
Normal to bedding	2225			1	
Parallel to bedding	2443		2440-2445	1	Two measurements at right angles
BULK DENSITY (kg/m^3)	1290	25	1249-1325	10	
WATER ABSORPTION (%)					
By volume					
At atmospheric pressure	36.36	0.98	35.25-37.95	5	
Under vacuum	52.84	0.47	52.34-53.46	5	
By weight					
At atmospheric pressure	27.86	1.14	26.61-29.74	5	
Under vacuum	41.64	0.90	40.70-42.81	5	
SATURATION COEFFICIENT	0.69				
RESISTANCE TO SALT CRYSTALLISATION (% weight loss)	1.8	0.34	1.2-2.1	6	
ABRASION RESISTANCE					
Taber index					
SHORE HARDNESS					
Dry					
Wet					
DIMENSIONAL STABILITY (% linear change)					
Parallel to bedding	-0.04			1	Total change after five cycles
COEFF. OF LINEAR THERMAL EXPANSION (mm/mm/°C x 10^{-6})					
Parallel to bedding	3.4		3.0-3.7	1	Two cycles per specimen
DOMINANT PLANAR STRUCTURE	Bedding				

Additional comments: This sample was taken from material sold as first grade stone. As a guide for design purposes the composite data for the five samples 7022 RS 160, 161, 163, 164, 165 should be used in preference to the data on this sheet.

Because of the considerable inhomogeneity of the limestone both laterally and vertically and between and within quarries no single sample can be considered representative of the stone type or of a particular quarry's output.

MOUNT GAMBIER LIMESTONE

SADME 7022 RS 164
Date of sampling: Mid 1985

TEST	MEAN	STANDARD DEVIATION	RANGE	NO. OF SPECIMENS	COMMENTS
COMPRESSIVE STRENGTH (MPa)					
Unaxial unconfined					Cores nominally 70mm diameter
Dry	3.83	0.46	3.35-4.44	5	
Wet	3.32	0.24	2.99-3.65	5	
Ratio wet/dry	0.87				
YOUNG'S MODULUS OF ELASTICITY (GPa)					
Static, mid-third					
Dry	5.42	1.88	3.57-7.70	5	
Wet	1.35	0.35	0.80-1.76	5	
POISSON'S RATIO					
Static					
Dry	0.31	0.21	0.07-0.62	5	
Wet	0.25	0.12	0.05-0.35	5	
MODULUS OF RUPTURE (MPa)					
Dry	2.15	0.31	1.84-2.64	5	
Wet	1.62	0.20	1.40-1.87	5	
Ratio wet/dry	0.75				
ULTRASONIC PULSE VELOCITY (m/sec)					
Block					
Normal to bedding	1990			1	
Parallel to bedding	2225		2200-2250	1	Two measurements at right angles
BULK DENSITY (kg/m^3)	1180	27	1147-1242	10	
WATER ABSORPTION (%)					
By volume					
At atmospheric pressure	41.19	0.78	40.17-42.26	5	
Under vacuum	56.81	0.67	55.79-57.41	5	
By weight					
At atmospheric pressure	34.83	1.62	32.34-36.85	5	
Under vacuum	48.42	1.32	46.42-49.59	5	
SATURATION COEFFICIENT	0.73				
RESISTANCE TO SALT CRYSTALLISATION (% weight loss)	21.6	3.4	18.1-25.9	6	
ABRASION RESISTANCE					
Taber index					
SHORE HARDNESS					
Dry					
Wet					
DIMENSIONAL STABILITY (% linear change)					
Parallel to bedding	-0.06			1	Total change after five cycles
COEFF. OF LINEAR THERMAL EXPANSION ($mm/mm/^{\circ}C \times 10^{-6}$)					
Parallel to bedding	5.3		4.8-5.8	1	Two cycles per specimen
DOMINANT PLANAR STRUCTURE	Bedding				

Additional comments: This sample was taken from material sold as first grade stone. As a guide for design purposes the composite data for the five samples 7022 RS 160, 161, 163, 164, 165 should be used in preference to the data on this sheet.

Because of the considerable inhomogeneity of the limestone both laterally and vertically and between and within quarries no single sample can be considered representative of the stone type or of a particular quarry's output.

MOUNT GAMBIER LIMESTONE

SADME 7022 RS 165
Date of sampling: Mid 1985

TEST	MEAN	STANDARD DEVIATION	RANGE	NO. OF SPECIMENS	COMMENTS
COMPRESSIVE STRENGTH (MPa)					
Unaxial unconfined					Cores nominally 70mm diameter
Dry	3.81	0.51	3.02-4.39	5	
Wet	3.34	0.17	3.06-3.46	5	
Ratio wet/dry	0.87				
YOUNG'S MODULUS OF ELASTICITY (GPa)					
Static, mid-third					
Dry	1.60	0.37	1.17-2.10	5	
Wet	1.91	0.41	1.31-2.38	5	
POISSON'S RATIO					
Static					
Dry	0.26	0.24	-0.02 to 0.64	5	
Wet	-0.28	0.07	-0.37 to -0.18	5	
MODULUS OF RUPTURE (MPa)					
Dry	1.74	0.09	1.65-1.85	5	
Wet	1.35	0.12	1.20-1.50	5	
Ratio wet/dry	0.77				
ULTRASONIC PULSE VELOCITY (m/sec)					
Block					
Normal to bedding	1980			1	
Parallel to bedding	2158		2155-2160	1	Two measurements at right angles
BULK DENSITY (kg/m^3)	1160	25	1117-1197	10	
WATER ABSORPTION (%)					
By volume					
At atmospheric pressure	39.58	0.77	38.76-40.57	5	
Under vacuum	57.48	0.69	56.70-58.43	5	
By weight					
At atmospheric pressure	33.63	1.28	32.38-35.40	5	
Under vacuum	49.93	1.60	48.24-52.30	5	
SATURATION COEFFICIENT	0.69				
RESISTANCE TO SALT CRYSTALLISATION (% weight loss)	8.4	1.8	5.9-10.1	6	
ABRASION RESISTANCE					
Taber index					
SHORE HARDNESS					
Dry					
Wet					
DIMENSIONAL STABILITY (% linear change)					
Parallel to bedding	-0.05			1	Total change after five cycles
COEFF. OF LINEAR THERMAL EXPANSION (mm/mm/°C x 10^{-6})					
Parallel to bedding	5.6		4.8-6.3	1	Two cycles per specimen
DOMINANT PLANAR STRUCTURE	Bedding				

Additional comments: This sample was taken from material sold as first grade stone. As a guide for design purposes the composite data for the five samples 7022 RS 160, 161, 163, 164, 165 should be used in preference to the data on this sheet.

Because of the considerable inhomogeneity of the limestone both laterally and vertically and between and within quarries no single sample can be considered representative of the stone type or of a particular quarry's output.

MOUNT GAMBIER LIMESTONE

SADME 7022 RS 162
Date of sampling: Mid 1985

TEST	MEAN	STANDARD DEVIATION	RANGE	NO. OF SPECIMENS	COMMENTS
COMPRESSIVE STRENGTH (MPa)					
Unaxial unconfined					Cores nominally 70mm diameter
Dry	1.50	0.36	1.08-2.01	5	
Wet	1.72	0.28	1.29-2.03	5	
Ratio wet/dry	1.15				
YOUNG'S MODULUS OF ELASTICITY (GPa)					
Static, mid-third					
Dry	0.71	0.19	0.57-1.04	5	
Wet	0.50	0.13	0.38-0.72	5	
POISSON'S RATIO					
Static					
Dry	0.01			1	
Wet	0.63	0.22	0.42-0.88	5	
MODULUS OF RUPTURE (MPa)					
Dry	1.08	0.12	0.98-1.27	5	
Wet	0.79	0.17	0.62-0.98	5	
Ratio wet/dry	0.73				
ULTRASONIC PULSE VELOCITY (m/sec)					
Block					
Normal to bedding	1660			1	
Parallel to bedding	1850		1850	1	Two measurements at right angles
BULK DENSITY (kg/m^3)	1110	9	1095-1119	10	
WATER ABSORPTION (%)					
By volume					
At atmospheric pressure	43.52	0.76	42.91-44.58	5	
Under vacuum	58.52	0.30	58.26-58.97	5	
By weight					
At atmospheric pressure	39.47	0.85	38.73-40.70	5	
Under vacuum	52.64	0.66	52.14-53.67	5	
SATURATION COEFFICIENT	0.74				
RESISTANCE TO SALT CRYSTALLISATION (% weight loss)	3.2	1.9	0.7-5.3	6	
ABRASION RESISTANCE					
Taber index					
SHORE HARDNESS					
Dry					
Wet					
DIMENSIONAL STABILITY (% linear change)					
Parallel to bedding					
COEFF. OF LINEAR THERMAL EXPANSION (mm/mm/°C x 10^{-6})					
Parallel to bedding					
DOMINANT PLANAR STRUCTURE	Bedding				

Additional comments: This sample was taken from material sold as second grade stone.

Because of the considerable inhomogeneity of the limestone both laterally and vertically, and between and within quarries, no single sample can be considered representative of the stone type or of a particular quarry's output.

APPENDIX B

RECOMMENDATIONS FOR PRELIMINARY TESTING OF BUILDING STONE DEPOSITS

APPENDIX B

RECOMMENDATIONS FOR PRELIMINARY
TESTING OF BUILDING STONE DEPOSITS

The following recommendations are intended to assist the preliminary evaluation of potential building stone deposits. They are not intended as a comprehensive exploration manual, but as a guide to just two important aspects: diamond drilling and physical testing.

They have been prepared to encourage all those involved in the stone industry in Australia to adopt a common standard of preliminary testing. Acceptance of the need for testing, and the more reliable comparison between different materials that common testing will permit are important for further development of the Australian stone industry. With time, a substantial body of data will encourage designers to specify Australian stone which for too long has been seen as somehow inferior to imported products.

These recommendations have been devised in consultation with the following organisations:

Department of Minerals and Energy, New South Wales
Department of Resource Industries, Queensland
Amdel Limited, Frewville, South Australia
Arup Facade Engineering, Sydney, New South Wales

Drilling

In the past, trial blocks have often been the only sampling undertaken on potential stone deposits. Today, the use of diamond drilling early in the investigation phase is strongly recommended. Vertical variation due to the effects of surface weathering, together with any lateral variation, can be conveniently assessed with the aid of diamond drilling which can also provide cores suitable for preliminary testing. At least two drillholes, to a depth of 20 m, are recommended for the initial investigation of granite, marble, sandstone and limestone deposits.

Diamond drilling systems and their core sizes are described by alphabetical codes: for example NQ and BQ and core sizes commonly encountered in mineral exploration. For building stone exploration, the triple-tube NMLC conventional type drill systems are recommended. The NMLC system was specifically designed for engineering geology work in which a minimum of drilling-induced damage to the core is required. This criterion applies equally well to building stone investigations. Although cheaper to obtain, core sizes smaller than 50 mm are not recommended as drilling induced damage becomes more significant as core diameters are reduced. NMLC drilling produces core of about 52 mm in diameter which is ideal for subsequent testwork.

Larger core sizes should be considered for coarse-grained stones, a rule of thumb being for the core diameter to be ten times the size of largest grain or crystal. HQ3, which has a triple tube core barrel like NMLC and produces 61 mm core, is a reasonable compromise between the ease of use of wireline systems that are used in a deep hole exploration and the conventional drilling systems which are best for engineering and building stone work. A skilled drilling crew is an important factor in obtaining good, undamaged core.

Testing

These tests are designed to be undertaken on diamond drillcore, enabling evaluation at an early stage of investigation. Four different tests can be carried out on a 250 mm length of 50 mm diameter core as follows:

1. Petrography (thin section microscopy and hand specimen study) and analysis of microstructure and for deleterious minerals, on a 50 mm length; leaving 200 mm of core for:

2. Ultrasonic pulse velocity: with several samples per drillhole, this can give valuable information on downhole variation such as degree of weathering, but care is required in interpreting results. The 200 mm length is then cut into two pieces: one 50 mm, the other at least 125 mm.

3. Water absorption at atmospheric pressure (and hence bulk density) is measured on the 50 mm piece.

4. Compressive strength is measured on the 125 mm section.

Several samples should be tested, spread downhole to assess variation due to weathering and ideally with samples from other holes to assess lateral variation. If there are sufficient samples tested (ie. 8-10), wet and dry testing of compressive strength can be undertaken. With care in interpretation the ratio of wet to dry compressive strengths can be a guide to durability.

If the results of drilling are encouraging trial blocks should be removed for the next stage of testing and evaluation. Testing of flexural strength is recommended particularly if the intended product is thin slabs.

5. Flexural strength testing should in future be undertaken with bar spacings of 1/4: 1/2: 1/4 on the 'four-point-load apparatus' and a span length to thickness ratio of 10:1. The proportions of the tested specimens should be 10:3.3:1 (span length: width: thickness). With a recommended thickness of 30 mm and span overhangs of 25 mm at each end this gives nominal specimen dimensions of 350 x 100 x 30 mm.

   These changes to both the method used in this report and that proposed in the Draft Australian Standard will ensure that the testing is comparable with the latest ASTM test for flexural strength (C880-1992). More importantly they reflect the trend in modern cladding systems towards the use thinner panels. The span-length to thickness ratio of 10:1 is more realistic and overcomes any concerns about stress-arching within the specimen.

   Flexural strength testing should be carried out on specimens with at least two different orientations as significant differences can occur. These may be such that panels must be cut in one particular orientation in order to meet specifications.

As a quarry site is further developed, more detailed testing should be considered through evaluation of the stone. Particular attention should be given to variation with increasing depth which may warrant repeat sampling and testing. The prior evidence of diamond drilling is the best guide to such variation.

Major building projects will generally require detailed testing as part of the selection and design process. It is important that the samples to be tested are representative of the material that will be supplied to that project. Any variation in quarry output is thus predetermined for each major project.

APPENDIX C

CURRENT OPERATING BUILDING STONE QUARRIES IN SOUTH AUSTRALIA

OPERATING BUILDING STONE QUARRIES IN SOUTH AUSTRALIA

Compiled by Mineral Resources Branch
South Australian Department of Mines and Energy

March 1993

STONE TYPE	AREA	LOCATION	OPERATOR	TENURE	PRODUCT
1. GRANITE	Black Hill 30 km N.E. of Mannum	Sec. 240 Hd. Ridley	Rocla Quarry Products Baulderstone Road GEPPS CROSS 5094 Tel. (08) 262 5622 Fax. (08) 349 5807	EML 3223 " 3360 " 4383	Black Hill Granite *Imperial Black Granite* *Austral Black Granite*
2. GRANITE	Black Hill 30 km N.E. of Mannum	Sec. 240 Hd. Ridley	Martins Granite Quarries P/L PO Box 627 UNLEY 5061 Tel. (08) 352 6337 Fax. (08) 352 2918	EML 3072 " 3073 " 3075 " 3085 " 3086 " 3087	Black Hill Granite *Imperial Black Granite* *Austral Black Granite*
3. GRANITE	Black Hill 30 km NE of Mannum	Secs. 235,241 248 Hd. Ridley	Calca Quarries P/L P.O. Box 10 STREAKY BAY 5680 Tel. (086) 26 1087 Fax. (086) 26 1087	EML 5544 EML 5545	Black Hill Granite *Imperial Black Granite* *Austral Black Granite*
4. GRANITE	Calca 35 km S.E. of Streaky Bay	Sec. 46 Hd. Rounsevell Sec. 48 Hd. Wrenfordsley	Calca Granite Pty. Ltd. P.O. Box 10 STREAKY BAY 5680 Tel. (086) 26 1087 Fax. (086) 26 1087	EML 4469 EML 5469	Calca Granite *Calca Red Granite*

STONE TYPE	AREA	LOCATION	OPERATOR	TENURE	PRODUCT
5. GRANITE	Calca 35 km S.E. of Streaky Bay	Sec. 46 Hd. Rounsevell	Rocla Quarry Products (As above)	EML 4469 EML 5501	Calca Granite *Calca Red Granite*
6. GRANITE	Calca 40 km SE of Streaky Bay	Sec. 31 Hd. Rounsevell	Rocla Quarry Products (As above)	EML 5650	Calca Granite *Calca Red Granite*
7. GRANITE	Pine Hill 60 km SW of Whyalla	Sec. 40 Hd. Charleston	Rocla Quarry Products (As above)	EML 5674	Charleston Granite - *new lease*
8. GRANITE	Koongawa 30 km E of Kyancutta	Sec. 4 Hd. Koongawa	Rocla Quarry Products (As above)	EML 5608	Koongawa Granite - new lease (Banded grey 'multicolour' granite)
9. GRANITE	Minnipa 13 km NE of Minnipa	Sec. 9 Hd. Pildappa	Calca Quarries P/L (As Above)	EML 5560	Minnipa Granite *Minnippa Red Granite*
10. GRANITE	Minnipa 6 km NE of Minnipa	Sec. 23 Hd. Minnipa	Calca Quarries P/L (As Above)	EML 5590	Minnipa Granite *Minnipa Red Granite*
11. GRANITE	Minnipa 6 km NNE of Minnipa	Sec. 131, Hd. Minnipa	Rocla Quarry Products (As Above)	EML 5728	Minnipa Granite *Minnipa Red Granite*
12. GRANITE	Minnipa 9 km ENE of Minnipa	Sec. 21 Hd. Minnipa	Rocla Quarry Products (As above)	EML 5651	Tcharkuldu Granite *Desert Lilac*

STONE TYPE	AREA	LOCATION	OPERATOR	TENURE	PRODUCT
13. GRANITE	Wudinna 9 km NE of Wudinna	Sec. 49 Hd. Wudinna	Rocla Quarry Products (As Above)	EML 5676	Wudinna Granite *Desert Rose*
14. GRANITE	Sedan 30 km E. of Angaston	Sec. 216 Hd. Bagot	Rocla Quarry Products (As above)	PM 130	Sedan Granite *Sedan Brown Granite*
15. GRANITE	Kingston S.E. 19 km N. of Kingston S.E.	Sec. 9 Hd. Duffield	Rocla Quarry Products (As above)	EML 5086	Kingston Granite *Kingston Blue Granite*
16. GRANITE	Padthaway 20 km NW of Padthaway	Sec. 12 Hd Willalooka	Calca Quarries P/L (As above)	ML 5760 MC 2627 MC 2748	Padthaway Granite *Tatiara Green Granite*
17. GRANITE	Padthaway 13 km NW of Padthaway	Sec. 31 Hd Marcollat	Finska Australia P/L 1/141 Burswood Road VICTORIA PARK WA 6100 Tel. (09) 472 3144 Fax. (09) 472 3168	ML 5722 ML 5830 EML 5829	Padthaway Granite
18. MARBLE	Angaston 2 km S. of Angaston	Sec. 339 Hd. Moorooroo	Rocla Quarry Products (As above)	PM 128	Angaston Marble *Barossa White Marble*
19. SLATE & FLAGSTONE	Willunga 2.5 km S. of Willunga	Sec. 756 H. Willunga	D.M. Roberts 22-24 St. Andrews Tce., WILLUNGA 5172 Tel. (085) 56 2078 Murray Roberts	PM 273	Willunga Slate and Bluestone

STONE TYPE	AREA	LOCATION	OPERATOR	TENURE	PRODUCT
20. SLATE & FLAGSTONE	Mintaro 1.5 km W. of Mintaro	Sec. 178, 307 Hd. Clare	Mintaro Slate Quarries P.O. Box 8, MINTARO 5414 Tel. (088) 43 9077 Adelaide office & depot 3 Coglin Street HINDMARSH 5007 Tel. (08) 346 0971 Fax. (08) 346 0884	PM 124	Mintaro Slate and Bluestone
21. SLATE & FLAGSTONE	Spalding 2.5 km S.W. of Spalding	Sec. 347 Hd. Andrews	P & S Gresch 15 Railway Terrace SPALDING 5454 Tel. (088) 45 2191	EML 5372 EML 5373	Spalding Slate *Broughton River Slate*
22. SLATE & FLAGSTONE	Oladdie 11 km E.S.E. of Carrieton	Sec. 111 Hd. Oladdie	Carrieton Slate CARRIETON 5432 Tel. (086) 589 042 or (086) 589 020	EML 5269	Oladdie Slate *Flinders Slate*
23. SLATE & FLAGSTONE	Jones Hill 90 km E.N.E. of Lyndhurst	Out of Hundreds North Flinders Ranges	Parachillna Slate 5 Westport Road ELIZABETH WEST 5113 Tel. (08) 252 1299	EML 4992	Jones Hill Slate *Parachillna Slate*
24. SLATE & FLAGSTONE	Freestone Hill 21 km W.N.W. of Kingscote, Kangaroo Island.	Sec. 324 Hd. Menzies	M.R. Hurst 'Freestone' Emu Bay Service, via Kingscote, KANGAROO ISLAND 5223 Tel. (0848) 35 216	EML 5225	Freestone Hill Flagstone

STONE TYPE	AREA	LOCATION	OPERATOR	TENURE	PRODUCT
25. SLATE & FLAGSTONE	Andamooka Stn. 70 km N.N.E. of Woomera	Out of Hundreds Block 876	B.R. Durman Andamooka Station via Woomera 5920 Tel. (086) 71 0754	EML 5416	Andamooka Flagstone
26. SLATE & FLAGSTONE	Willunga 2 km S. of Willunga	Sec. 1007/8 and 1242 Hd. Willunga	Stone & Slate Quarries Aust Ltd (As above)	PM 117 EML 5775	Willunga Slate and Bluestone
27. SLATE & FLAGSTONE	Nackera	Sec. 283 Hd. Nackara	D R Hucks 83 Victoria Street PETERBOROUGH 5422	EML 5820	New lease

SLATE & FLAGSTONE - See also entries under 'Bluestone' Nos. 28-31

STONE TYPE	AREA	LOCATION	OPERATOR	TENURE	PRODUCT
28. BLUESTONE	Kanmantoo 3 km W. of Kanmantoo	Sec. 4416 Hd. Kanmantoo	Kanmantoo Bluestone C/- Albern Slate Pty. Ltd. 290 Military Road GRANGE 5022 Tel. 356 8835 Quarry (085) 385 155	EML 4712 EML 5713	Kanmantoo Bluestone
29. BLUESTONE	Wistow 11 km S.E. of Mt Barker	Sec. 1376 Hd. Strathalbyn	Wistow Stone Products PO Box 564 MOUNT BARKER 5251 Tel. (08) 398 2999 Fax. (08) 398 3077 Mark Teakle	PM 194	Wistow Bluestone

STONE TYPE	AREA	LOCATION	OPERATOR	TENURE	PRODUCT
30. BLUESTONE	Wistow 11 km S.E. of Mt. Barker	Sec. 2202 Hd. Strathalbyn	Stone & Slate Quarries Aust Ltd 2A Charles Street NORWOOD 5067 Tel. (08) 362 9646	PM 170	Wistow Bluestone
31. BLUESTONE	Auburn 2.5 km N. of Auburn	Sec. 216 Hd. Upper Wakefield	D.L. Scott & Son 20 Pine Street STIRLING 5152 Tel. (085) 38 5091	EML 5778	Auburn Bluestone
BLUESTONE	See also entries under 'slate and flagstone' Nos 19-27.				
32. SANDSTONE	Basket Range 1.3 km S.S.E. of Basket Range	Sec. 133 Hd. Onkaparinga	D.L. Scott & Son 20 Pine Street STIRLING 5152 Tel.(085) 38 5091	PM 97	Basket Range Sandstone
33. SANDSTONE	Basket Range 0.7 km S.S.E. of Basket Range	Sec. 135 Hd. Onkaparinga	Basket Range Sandstone Products P.O. Box 248 BASKET RANGE 5138 Tel. (08) 390 3420	PM 119	Basket Range Sandstone
34. SANDSTONE	Carey Gully 2.5 km S.E. of Carey Gully	Sec. 120 Hd. Onkaparinga	Carey Gully Quarry PO Box 181 BALHANNA SA 5242 Tel. (08) 390 3644	PM 110	Carey Gully Sandstone
35. SANDSTONE	Manoora 2 km N.W. of Manoora	Sec. 310 Hd. Saddleworth	D.L. Scott & Son (as above)	PM 122	Manoora Sandstone

STONE TYPE	AREA	LOCATION	OPERATOR	TENURE	PRODUCT
36. LIMESTONE	Mount Gambier 13 km W. of Mount Gambier	Sec. 26 Hd. Blanche	R.L. Butler 1 Sutton Avenue MOUNT GAMBIER 5290 Tel. (087) 25 1691	PM 261	Mount Gambier Limestone
37. LIMESTONE	Mount Gambier 13 km W. of Mount Gambier	Sec. 28 Hd. Blanche	Limestone Products P.O. Box 179 MOUNT GAMBIER 5290 Tel. (087) 39 9212 (quarry) (087) 26 8328 (A.H.)	PM 115	Mount Gambier Limestone
38. LIMESTONE	Mount Gambier 14 km W. of Mount Gambier	Sec. 29 Hd. Blanche	R.M. & J. Lawson 108 Jubilee Highway East MOUNT GAMBIER 5290 Tel. (087) 25 1292	PM 134 PM 132	Mount Gambier Limestone
39. LIMESTONE	Mount Gambier 10 km W. of Mount Gambier	Sec. 192 Hd. Blanche	Stafford and Earl, Building Stone, P.O. Box 943, MOUNT GAMBIER 5290 Tel. (087) 23 0594	PM 125	Mount Gambier Limestone
40. LIMESTONE	Mount Gambier 9 km W. of Mount Gambier	Sec. 134 Hd. Blanche	Bruhn Distributors PO Box 412 MOUNT GAMBIER 5290 Tel. (087) 25 5333	PM 153	Mount Gambier Limestone
41. LIMESTONE	Mount Gambier 11 km W. of Mount Gambier	Sec. 136 Hd. Blanche	Bruhn Distributors (As above)	PM 14 PM 15	Mount Gambier Limestone
42. LIMESTONE	Sunnyside 13 km NE of Murray Bridge	Sec. 199 Hd Burdett	D.L. Scott & Son (As above)	EML 5709	Murray Bridge Limestone