MICHAEL ADLER AND ASSOCIATES
Consulting Geotechnical Engineer

PO Box 91
Church Point, NSW 2105
AUSTRALIA

Tel: +61 412 904 349
Fax: (02) 9999 5770
Mobile: 0412 904 349
EMAIL: michael@madler.com.au

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Our Reference: 22/07822

SMR Builders
Level 1, Suite 105
658 Pittwater Rd.,
BROOKVALE, NSW 2100

Attention: **Predrag Loncar**
Managing Director

Geotechnical & Stability Assessment
Proposed Residential Additions & Alterations
2/20 Clifford Avenue, Fairlight

1) background

This report presents the results of a geotechnical assessment, site classification and preliminary stability assessment for No. 2/20 Clifford Avenue, Fairlight. The work was requested by Mr. Predrag Loncar of SMR Builders.

The purpose of the investigation was to provide information on:

- The subsurface conditions below the site
- Allowable bearing pressures for foundation design
- Site classification
- Site Stability Assessment
- Depth to groundwater.

At this time no detailed subsurface investigation has been undertaken. There are considerable rock exposures in many places across the site.

It should be noted that this is not a contamination investigation.

2) Proposed Construction

It is understood that at this site it is proposed to undertake various additions and alterations to the existing dual occupancy residence. The construction will likely be reinforced blockwork walls and reinforced concrete floors.

The works will include extensions to existing rooms, new roofing and a new lift shaft. There will be no excavation required. The new works will be supported by existing foundations.

3) Present Site Conditions

The site is located on the southern foothills to the Manly Peninsular. In this area the land falls relatively steeply down to the south.

No. 2/20 is on the northern side of Clifford Avenue.

The lot is 620 m^2 in area. It is rectangular shaped with over all dimensions of some 15 m by 40 m. Locally it slopes down to the south with an overall relief of some 10 m.

An existing three storey brick dual occupancy residence is located close to the centre of the block. The remaining area is landscaped with paving, some low height retaining walls, grass and small trees. There was no obvious distress observed in the external walls of the building.

4) Geology and Subsurface Conditions

Reference to the Sydney geological series sheet, at a scale of 1:100,000, indicates that the site is underlain by Triassic Age Hawkesbury Sandstone. Both our experience and observations of the many rock exposures in this area and on the site confirm these conditions.

There is considerable rock exposed on this site. There is a 1.5 m high rock face at the Clifford Avenue road frontage and other similar exposures at the rear, northern end, of the basement garage, below the existing house. Where observed neither of these exposures were exhibiting any obvious signs of instability. There is also rock exposed in the drainage works in the rear garden.

Groundwater was observed in the rock exposures at the rear of the basement garage. This is controlled by various existing drainage works.

5) Comments on Geotechnical Conditions

The following comments are based on the assumption that the conditions described above are representative of the subsurface conditions at this site. When making an assessment of the subsurface conditions across a site from a limited number of observations it should be recognised that variations may occur between these locations. The data derived from the site investigation program are extrapolated across the site to form a geotechnical model and then an engineering opinion is provided about overall subsurface conditions and their likely behaviour with the proposed development. The actual conditions may differ from those inferred herein particularly in areas where there has been previous construction. No subsurface exploration program, no mater how comprehensive, can reveal all subsurface details and anomalies.

It is important to note that no boreholes or test pits were put down, though there are considerable exposures of the underlying sandstone. The following comments have been provided on the basis that geotechnical conditions are as inferred above, in the area of the proposed works comprising very shallow soil cover over insitu sandstone.

5.1) Site Classification

The site has been classified in accordance with the guidelines set out in the "Residential Slabs and Footings", AS2870-1996.

Based on the subsurface conditions observed the site is classified as a *Stable Non Reactive (A)* provided that the existing and any new development bear on or in the underlying rock.

5.2) New Retaining Wall Support

Any new retaining walls that may be proposed as part of these works can be designed assuming an Active earth pressure coefficient of 0.4 in the soil strength materials and a nominal pressure 10 kPa in rock of very low strength or greater. If stiff retaining walls are used which can not move they should be designed for an At Rest earth pressure of 0.55 in soil strength materials. A soil density of 20 kN/m^3 is recommended.

Adequate allowance must also be made for water pressures if appropriate drainage is not included, and also for the loading affects from adjacent buildings or sloping ground.

5.3) Foundations

It is good practice to found all parts of the same structure on materials of similar stiffness. This will help to reduce the potential for cracking due to differential settlement.

Assuming the existing strip or pad footings are bearing on the rock then they can be assumed to have an allowable bearing pressure of 1 MPa.

If it is proposed to apply significant additional loading to the existing foundations it is recommended that some shallow exploratory excavation is made to confirm that these footings are bearing on competent insitu rock.

5.4) Assessment of risk of slope instability

Purpose of Assessment & Proposed Development

The purpose of this preliminary stability assessment is to ensure that the owner, potential owner or other parties interested in the property are aware of the level of risk associated with potential slope movements within and immediately surrounding the property. This risk is assessed considering the existing development of the property, and proposed developments of which we have been informed and are summarised in this report. The onus is on the owner, potential owner or other party to decide whether the level of risk presented in this document is acceptable in the light of the possible economic consequences of such risk.

Assessment of Risk

It is not technically feasible to assess the stability of a particular site in absolute terms such as stable or unstable. However, a qualitative risk assessment can be undertaken by the recognition of surface features supplemented by limited information on the regional and local subsurface profile, and with the benefit of experience gained in similar geological environments.

Natural hill slopes are formed by processes, which reflect the site geology, environment and climate. These processes include downslope movement of the near surface soil and rock. In geological time all slopes are unstable. The area of influence of these downslope movements may range from local to regional and are rarely related to property boundaries. The natural processes may be affected by human intervention in the form of construction, drainage, excavation, placement of fill and other activities.

The risk assessment in this report is based on the methods outlined in the paper "Landslide Risk Management" published in Australian Geomechanics in March 2000. Risk is estimated by assessing the *likelihood* of an event and the *consequences* if such an event takes place. A risk matrix determines the relationship between likelihood, consequence and risk. The risk categories and implications are shown below in Table 1 below and the terms used in the risk assessment are defined in Appendix G from the above paper (Appendix G is reproduced at the end of this current report).

Consequences of Hillside Construction

It must be accepted that the risks associated with hillside and cliff top construction are greater than when the proposed construction is on level ground in the same geological environment. The impact of a proposed development may be adverse, and imprudent construction techniques can increase the potential for movement. Areas of instability rarely respect property boundaries and poor practices on one lot can trigger instability in the surrounding area on adjacent lots.

Definitions

The following defines some of the terms that may be used in this report.

A rockfall is a downslope movement of a piece of rock or soil mass resulting from toppling or shear failure at the boundaries of the moving mass. The dominant movement is vertical, the rate of movement is very fast, and there is generally very little warning of the failure.

A landslip (or landslide) is a downslope movement of a soil or rock mass as a result of shear failure at the boundaries of the moving mass. The dominant movement is lateral and failure takes place over a relatively short period. Soil creep, which is slow and occurs without a well defined failure surface, is not included as a landslip.

Table 1 details the risk categories referred to in this assessment.

TABLE 1
RISK LEVEL CATEGORIES

Risk Level		Implications *
VH	Very High Risk	Extensive detailed investigation, planning and remedial works essential to reduce risk to acceptable levels. These works may be uneconomic or not practical.
H	High Risk	Detailed investigation, planning and remedial works required to reduce risk to acceptable levels.
M	Moderate Risk	Generally tolerable provided risk is managed. May require investigation, planning and remedial works to further reduce or maintain risk level.
L	Low Risk	Usually acceptable. May require investigation, planning and remedial works to maintain risk level.
VL	Very Low Risk	Acceptable. Manage by slope maintenance procedures.

* The above implications are a general guide only. The acceptable risks should be determined by consultation with all parties.

Stability Assessment

At the time of our site visit there was no obvious evidence of recent slope instability on the property, or on the adjacent properties.

The risk of slope instability is a function of three factors:

- Slope angle,
- Soil strength, and
- Water concentrations.

Our assessment (See Table 1 above and the attached copy of Appendix G) is that a landslide would be rare, given that no excavation is proposed as part of the new additions. Its consequence could be medium. Accordingly, the site is assessed to have a very low to low risk of slope instability.

At this time we see no reason from a geotechnical point of view, why the proposed new additions can not proceed.

Limitations

The following limitations should normally be incorporated into the design when building in areas of low to medium risk of instability:

- Adopting good engineering practices when undertaking any work on hill sides (see Appendix J from the Australian Geomechanics publication, copy attached).

- All new loading is transferred down to the underlying insitu rock via the existing foundations.

- Any new retaining walls are designed by an engineer and bear on insitu rock.

Provided the above are incorporated into the presently proposed site development, we see no reason why the building on No. 20 Clifford Avenue should not perform satisfactorily during its design life.

FINAL COMMENT

The above comments has been provided on the basis that the conditions observed during our visit are representative of the subsurface conditions at this site. Should the actual conditions vary from those assumed a suitably experienced geotechnical engineer should review both the site and this report in the light of the construction being undertaken.

Given the above comments it is considered that:

a. The insitu Hawkesbury sandstone at this site is capable of withstanding the proposed loading from the new works

b. If the recommendations made in this report are followed then adequate protection and support will be provided for adjacent properties

c. Given the minor works proposed there are no obvious signs of instability/landslip, the site is therefore assessed to have an acceptable very low to low risk of slope instability.

The attached *Notes Relating To Geotechnical Report* are an intrinsic part of this report.

We do note that we have assumed in our costing for this investigation that you, the client, will contact us by phone on a number of occasions to discuss the proposed works, especially in regards to the findings presented in this report.

Yours Sincerely

Michael A Adler BSc, BE, MSc, DIC, MIEAust, CPEng

NOTES RELATING TO GEOTECHNICAL REPORTS
Michael Adler & Associates

Introduction

These notes outline some of the methodology and limitations inherent in geotechnical reporting. The issues discussed are not relevant to all reports and further advice should be sought if there are any queries regarding any advice or report.

When copies of reports are made, they should be reproduced in full.

Geotechnical Reports

Geotechnical reports are prepared by qualified personnel using information supplied or obtained. They are based on current engineering standards of interpretation and analysis.

Information may be gained from limited subsurface testing, surface observations, previous work often supplemented by knowledge of the local geology and experience of the range of properties that may be exhibited by the materials present. For this reason, geotechnical reports should be regarded as interpretative rather than factual documents, limited to some extent by the scope of information on which they rely.

Where the report has been prepared for a specific purpose (e.g.. design of a three-storey building), the information and interpretation may not be appropriate if the design is changed (e.g.. a twenty storey building). In such cases, the report and the sufficiency of the existing work should be reviewed by Michael Adler & Associates in the light of the new proposal.

Every care is taken with the report content, however, it is not always possible to anticipate or assume responsibility for all situations such as:

- Unexpected variations in ground conditions. The potential for this depends on the amount of investigative work undertaken.
- Changes in policy or interpretation by statutory authorities.
- The actions of contractors responding to commercial pressures.
- Interpretation by others of this report.

If these occur, Michael Adler & Associates would be pleased to resolve the matter through further investigation, analysis or advice.

Unforeseen Conditions

Should conditions encountered on site differ markedly from those anticipated from the information contained in the report, Michael Adler & Associates should be notified immediately. Early identification of site anomalies generally results in most problems being more readily resolved, and allows reinterpretation and assessment of the implications for future work.

Subsurface Information

Logs of a borehole, rock core, test pit, excavated face or cone penetration test are an engineering and/or geological interpretation of the subsurface conditions. The reliability of the logged information depends on the drilling/testing method, sampling and/or observation spacing and the ground conditions. It is not always possible or economic to obtain continuous high quality data. It should also be recognised that the volume or material observed or tested is only a fraction of the total subsurface profile.

Interpretation of the available subsurface information and application to design/ construction should take into consideration the spacing of the test locations, the frequency of observations and testing, and the possibility that geological boundaries may vary between observation points.

Groundwater observations and measurements not based on specially designed and constructed piezometers should be treated with care for the following reasons:

- In low permeability soils groundwater may not seep into an excavation or bore in the short time it is left open.
- A localised perched water table may not represent the true water table.
- Groundwater levels vary according to rainfall events or season.
- Some drilling and testing procedures such as rock coring or penetration testing mask or prevent groundwater inflow.

The installation of piezometers and long term monitoring of groundwater levels may be required to adequately identify groundwater conditions.

Supply of Geotechnical Information For Tendering Purposes

It is recommended that tenderers are provided with as much geological and geotechnical information as there is available. It is best practice to provide copies of all geotechnical related reports, opinions and data.

APPENDIX G

LANDSLIDE RISK ASSESSMENT – EXAMPLE OF QUALITATIVE TERMINOLOGY FOR USE IN ASSESSING RISK TO PROPERTY

Qualitative Measures of Likelihood

Level	Descriptor	Description	Indicative Annual Probability
A	ALMOST CERTAIN	The event is expected to occur	$>\approx 10^{-1}$
B	LIKELY	The event will probably occur under adverse conditions	$\approx 10^{-2}$
C	POSSIBLE	The event could occur under adverse conditions	$\approx 10^{-3}$
D	UNLIKELY	The event might occur under very adverse circumstances	$\approx 10^{-4}$
E	RARE	The event is conceivable but only under exceptional circumstances.	$\approx 10^{-5}$
F	NOT CREDIBLE	The event is inconceivable or fanciful	$<10^{-6}$

Note: "≈" means that the indicative value may vary by say ± ½ of an order of magnitude, or more.

Qualitative Measures of Consequences to Property

Level	Descriptor	Description
1	CATASTROPHIC	Structure completely destroyed or large scale damage requiring major engineering works for stabilisation.
2	MAJOR	Extensive damage to most of structure, or extending beyond site boundaries requiring significant stabilisation works.
3	MEDIUM	Moderate damage to some of structure, or significant part of site requiring large stabilisation works.
4	MINOR	Limited damage to part of structure, or part of site requiring some reinstatement/stabilisation works.
5	INSIGNIFICANT	Little damage.

Note: The "Description" may be edited to suit a particular case.

Qualitative Risk Analysis Matrix – Level of Risk to Property

LIKELIHOOD	CONSEQUENCES to PROPERTY				
	1: CATASTROPHIC	2: MAJOR	3: MEDIUM	4: MINOR	5: INSIGNIFICANT
A – ALMOST CERTAIN	VH	VH	H	H	M
B – LIKELY	VH	H	H	M	L-M
C – POSSIBLE	H	H	M	L-M	VL-L
D – UNLIKELY	M-H	M	L-M	VL-L	VL
E – RARE	M-L	L-M	VL-L	VL	VL
F – NOT CREDIBLE	VL	VL	VL	VL	VL

Risk Level Implications

Risk Level		Example Implications(1)
VH	VERY HIGH RISK	Extensive detailed investigation and research, planning and implementation of treatment options essential to reduce risk to acceptable levels; may be too expensive and not practical
H	HIGH RISK	Detailed investigation, planning and implementation of treatment options required to reduce risk to acceptable levels
M	MODERATE RISK	Tolerable provided treatment plan is implemented to maintain or reduce risks. May be accepted. May require investigation and planning of treatment options.
L	LOW RISK	Usually accepted. Treatment requirements and responsibility to be defined to maintain or reduce risk.
VL	VERY LOW RISK	Acceptable. Manage by normal slope maintenance procedures.

Note: (1) The implications for a particular situation are to be determined by all parties to the risk assessment; these are only given as a general guide.

(2) Judicious use of dual descriptors for Likelihood, Consequence and Risk to reflect the uncertainty of the estimate may be appropriate in some cases.

APPENDIX J

SOME GUIDELINES FOR HILLSIDE CONSTRUCTION

	GOOD ENGINEERING PRACTICE	*POOR ENGINEERING PRACTICE*
ADVICE		
GEOTECHNICAL ASSESSMENT	Obtain advice from a qualified, experienced geotechnical consultant at early stage of planning and before site works.	Prepare detailed plan and start site works before geotechnical advice.
PLANNING		
SITE PLANNING	Having obtained geotechnical advice, plan the development with the risk arising from the identified hazards and consequences in mind.	Plan development without regard for the Risk.
DESIGN AND CONSTRUCTION		
HOUSE DESIGN	Use flexible structures which incorporate properly designed brickwork, timber or steel frames, timber or panel cladding. Consider use of split levels. Use decks for recreational areas where appropriate.	Floor plans which require extensive cutting and filling. Movement intolerant structures.
SITE CLEARING	Retain natural vegetation wherever practicable.	Indiscriminately clear the site.
ACCESS & DRIVEWAYS	Satisfy requirements below for cuts, fills, retaining walls and drainage. Council specifications for grades may need to be modified. Driveways and parking areas may need to be fully supported on piers.	Excavate and fill for site access before geotechnical advice.
EARTHWORKS	Retain natural contours wherever possible.	Indiscriminant bulk earthworks.
CUTS	Minimise depth. Support with engineered retaining walls or batter to appropriate slope. Provide drainage measures and erosion control.	Large scale cuts and benching. Unsupported cuts. Ignore drainage requirements
FILLS	Minimise height. Strip vegetation and topsoil and key into natural slopes prior to filling. Use clean fill materials and compact to engineering standards. Batter to appropriate slope or support with engineered retaining wall. Provide surface drainage and appropriate subsurface drainage.	Loose or poorly compacted fill, which if it fails, may flow a considerable distance including onto property below. Block natural drainage lines. Fill over existing vegetation and topsoil. Include stumps, trees, vegetation, topsoil, boulders, building rubble etc in fill.
ROCK OUTCROPS & BOULDERS	Remove or stabilise boulders which may have unacceptable risk. Support rock faces where necessary.	Disturb or undercut detached blocks or boulders.
RETAINING WALLS	Engineer design to resist applied soil and water forces. Found on rock where practicable. Provide subsurface drainage within wall backfill and surface drainage on slope above. Construct wall as soon as possible after cut/fill operation.	Construct a structurally inadequate wall such as sandstone flagging, brick or unreinforced blockwork. Lack of subsurface drains and weepholes.
FOOTINGS	Found within rock where practicable. Use rows of piers or strip footings oriented up and down slope. Design for lateral creep pressures if necessary. Backfill footing excavations to exclude ingress of surface water.	Found on topsoil, loose fill, detached boulders or undercut cliffs.
SWIMMING POOLS	Engineer designed. Support on piers to rock where practicable. Provide with under-drainage and gravity drain outlet where practicable. Design for high soil pressures which may develop on uphill side whilst there may be little or no lateral support on downhill side.	
DRAINAGE SURFACE	Provide at tops of cut and fill slopes. Discharge to street drainage or natural water courses. Provide general falls to prevent blockage by siltation and incorporate silt traps. Line to minimise infiltration and make flexible where possible. Special structures to dissipate energy at changes of slope and/or direction.	Discharge at top of fills and cuts. Allow water to pond on bench areas.
SUBSURFACE	Provide filter around subsurface drain. Provide drain behind retaining walls. Use flexible pipelines with access for maintenance. Prevent inflow of surface water.	Discharge roof runoff into absorption trenches.
SEPTIC & SULLAGE	Usually requires pump-out or mains sewer systems; absorption trenches may be possible in some areas if risk is acceptable. Storage tanks should be water-tight and adequately founded.	Discharge sullage directly onto and into slopes. Use absorption trenches without consideration of landslide risk.
EROSION CONTROL & LANDSCAPING	Control erosion as this may lead to instability. Revegetate cleared area.	Failure to observe earthworks and drainage recommendations when landscaping.
DRAWINGS AND SITE VISITS DURING CONSTRUCTION		
DRAWINGS	Building Application drawings should be viewed by geotechnical consultant	
SITE VISITS	Site Visits by consultant may be appropriate during construction/	
INSPECTION AND MAINTENANCE BY OWNER		
OWNER'S RESPONSIBILITY	Clean drainage systems; repair broken joints in drains and leaks in supply pipes. Where structural distress is evident see advice. If seepage observed, determine causes or seek advice on consequences.	

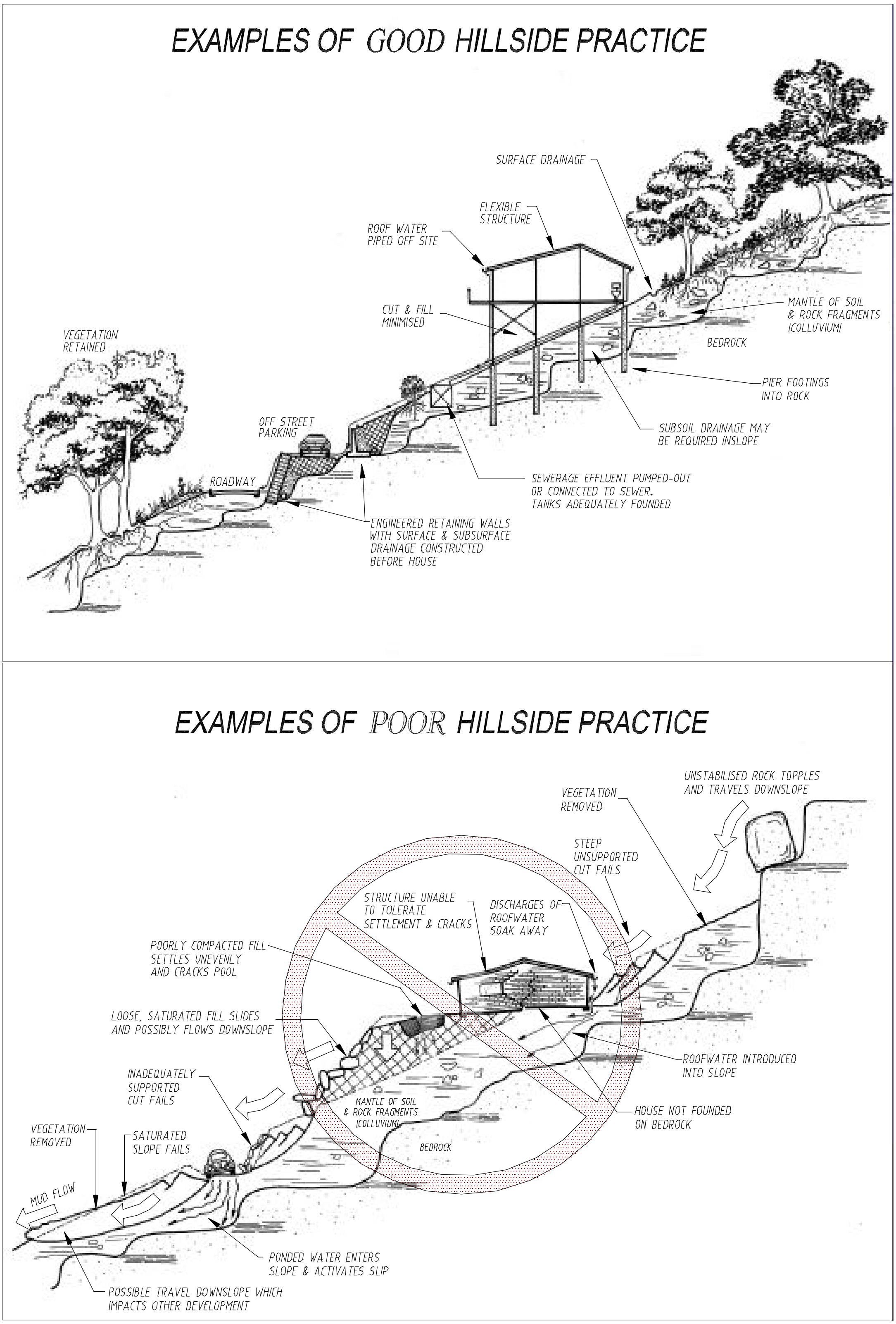

Figure J1 Illustrations of Good and Poor Hillside Practice

EXPLANATION SHEETS

1. CLASSIFICATION OF SOILS

1.1 Soil Classification and the Unified System

The descriptions presented on the attached geotechnical logs are essentially based on the visual observations made by the supervisor in the field. They are dependent on his interpretation of the subsurface conditions as indicated by the various drilling, insitu testing and sampling methods used.

The system used in this report for the identification of soil is the Unified Soil Classification system (USC) which was developed by the US Army Corps of Engineers during World War II and has since gained international acceptance and has been adopted in its metricated form by the Standards Association of Australia.

The Australian Site Investigation Code (AS1726-1981, Appendix D) recommends that the description of a soil includes the USC group symbols which are an integral component of the system.

The soil description normally contain the following information:

Soil composition

- SOIL NAME and USC classification symbol
- plasticity or particle characteristics
- colour
- secondary and minor constituents (name, estimated proportion, plasticity or particle characteristics, colour etc)

Soil condition

- moisture condition
- consistency or density index

Soil structure

- structure (zoning, defects, cementing)

Soil origin

interpretation based on observation e.g. FILL, TOPSOIL, RESIDUAL, ALLUVIUM.

1.2 Soil Composition

(a) Soil Name and Classification Symbol

The USC system is summarised in the Australian Code. The primary division separates soil types on the basis of particle size into:

. Coarse grained soils - more than 50% of the material less than 60 mm is larger than 0.06 mm (60µm).

. Fine grained soils - more than 50% of the material less than 60 mm is smaller than 0.06 (60µm).

Initial classification is by particle size as shown in Table 1. Further classification of fine grained soils is based on plasticity.

TABLE 1 - CLASSIFICATION BY PARTICLE SIZE

NAME	SUB-DIVISION	SIZE
Clay		< 2 µm
Silt		2 µm to 60 µm
Sand	Fine Medium Coarse	60 µm to 200 µm 200µm to 600 µm 600 µm to 2 mm
Gravel	Fine Medium Coarse	2 mm to 6 mm 6 mm to 20 mm 20 mm to 60 mm
Cobbles		60 mm to 200 mm
Boulders		> 200 mm

Where a soil contains an appropriate amount of secondary material, the name includes each of the secondary components (greater than 12%) in increasing order of significance, e.g. sandy silty clay.

Minor components of a soil are included in the description by means of the terms "some" and "trace" as defined in Table .2.

TABLE 2 - MINOR SOIL COMPONENTS

TERM	DESCRIPTION	APPROXIMATE PROPORTION (%)
Trace	presence just detectable, little or no influence on soil properties	0-5
Some	presence easily detectable, little influence on soil properties	5-12

The USC group symbols should be included with each soil description as shown in Table 3

TABLE 3 - SOIL GROUP SYMBOLS

SOIL TYPE	PREFIX
Gravel	**G**
Sand	**S**
Silt	**M**
Clay	**C**
Organic	**O**
Peat	**Pt**

The group symbols are combined with qualifiers which indicate grading, plasticity or secondary components as shown on Table 4

TABLE 4 - SOIL GROUP QUALIFIERS

SUBGROUP	SUFFIX
Well graded	W
Poorly Graded	P
Silty	M
Layered	C
Liquid Limit <50% - low to medium plasticity	L
Liquid Limit >50% - medium to high plasticity	H

(b) Grading

"Well graded"	Good representation of all particle sizes from the largest to the smallest.
"Poorly graded"	One or more intermediate sizes poorly represented
"Gap graded"	One or more intermediate sizes absent
"Uniformly graded"	Essentially single size material.

(c) Particle shape and texture

The shape and surface texture of the coarse grained particles are usually described.

Angularity may be expressed as "rounded", "sub-rounded", "sub-angular" or "angular".

Particle **form** can be "equidimensional", "flat" or elongate".

Surface texture can be "glassy", "smooth", "rough", pitted" or striated".

(d) Colour

The colour of the soil is described in the moist condition using simple terms such as:

Black	White	Grey	Red
Brown	Orange	Yellow	Green
Blue			

These may be modified as necessary by "light" or "dark". Borderline colours may be described as a combination of two colours, e.g. red-brown.

For soils that contain more than one colour terms such as:

- Speckled Very small (<10 mm dia.) patches
- Mottled Irregular
- Blotched Large irregular (>75 mm dia.)
- Streaked Randomly oriented streaks

(e) Minor Components

Secondary and minor components are often individually described in a similar manner to the dominant component.

*1.3 **S**oil Condition*

(a) Moisture

Soil moisture condition is described as "dry", "moist" or "wet".

The moisture categories are defined as:

Dry (D) - Little or no moisture evident. Soils are running.
Moist (M) - Darkened in colour with cool feel. Granular soil particles tend to adhere. No free water evident upon remoulding of cohesive soils.

(b) Consistency

The consistency, or strength, of a soil is estimated from manual examination, hand penetrometer tests, Standard Penetration Tests (SPT) results and other insitu tests, plus if appropriate laboratory tests. These are used to estimate the undrained shear or unconfined compressive strengths. The classification is given in Table 5.

TABLE 5 - CONSISTENCY OF FINE GRAINED SOILS

TERM	**UNCONFINED STRENGTH, q_u (kPa)**	**FIELD IDENTIFICATION**
Very Soft	<25	Easily penetrated by fist. Sample extrudes between fingers when squeezed in fist
Soft	25 - 50	Easily moulded in fingers. Easily penetrated 50 mm by thumb
Firm	50 - 100	Can be moulded by strong pressure in fingers. Penetrated 50 mm with moderate effort by thumb
Stiff	100 - 200	Cannot be remoulded in fingers. Indented by thumb but penetrated only with great effort
Very Stiff	200 400	Very though. Difficult to cut with knife. Readily indented by thumb nail
Hard	>400	Brittle, can just be scratched with thumb nail. Tends to break into fragments

Unconfined compressive strength is approximately twice the undrained shear strength ($q_u = 2\ c_u$)

(c) Density Index

The insitu density index of granular soils can be assessed from the results of SPT or cone penetrometer tests. Density index is not normally estimated visually. Table 6 applies.

TABLE 6 - DENSITY OF GRANULAR SOILS

TERM	**SPT N VALUE**	**STATIC CONE VALUE q_c (MPa)**	**DENSITY INDEX (%)**
Very Loose	0 - 3	0 - 2	0 - 15
Loose	3 - 8	2 - 5	15 - 35
Med Dense	8 - 25	5 - 15	35 - 65
Dense	25 - 42	15 - 20	65 - 85
Very Dense	>42	>20	>85

1.4 Soil Structure

(a) Zoning

A sample may consist of several zones differing in colour, grain size or other properties. Terms to classify these zones are:

Layer - continuous across exposure or sample
Lens - discontinuous with lenticular shape
Pocket or Nodule- irregular inclusion

Each zone can be described, with their distinguishing features, and the nature of the interzone boundaries.

(b) Defects

Defects which are present in a sample can include:

- fissures
- roots (containing organic matter)
- tubes (hollow)
- casts (infilled)

Defects can be described giving details of dimensions and frequency. Fissure orientation, planarity, surface condition and infilling are often noted. If there is a tendency to break into blocks, block dimensions this is usually noted

1.5 Soil Origin

Information which may be interpretative but which may contribute to the usefulness of the material description can be included. The most common interpreted feature is the origin of the soil. The assessment of the probable origin is based on the soil material description, soil structure and its relationship to other soil and rock materials.

Common terms used are:

"Residual Soil" - Material which appears to have been derived by weathering from the underlying rock. There is no evidence of transport.

"Colluvium" - Material which appears to have been transported from its original location. The method of movement is usually the combination of gravity and erosion.

"Landslide Debris" - An extreme form of colluvium where the soil has been transported by mass movement. The material is obviously distributed and contains distinct defects related to the slope failure.

"Alluvium" - Material which has been transported essentially by water. usually associated with former stream activity.

"Fill" - Material which has been transported and placed by man. This can range from natural soils which have been placed in a controlled manner in engineering construction to dumped waste material. The description normally includes the constituents and a general preliminary assessment of the possible method of placement and level of compaction. It is not practical to accurately assess the level of compaction, this is usually provided by documentation and certification from the testing authority who was present when the fill was placed and compacted.

1.6 Fine Grained Soils

The physical properties of fine grained soils are dominated by silts and clays.

The definition of clay and silt soils is governed by their Atterberg Limits. Clay soils are characterised by the properties of cohesion and plasticity with cohesion defines as the ability to deform without rupture. Silts exhibit cohesion but have low plasticity or are non-plastic.

The field characteristics of clay soils include:

- dry lumps have appreciable dry strength and cannot be powdered
- volume changes occur with moisture content variation
- feels smooth when moist with a greasy appearance when cut.

The field characteristics of silt soils include:

- dry lumps have negligible dry strength and can be powdered easily
- dilatancy - an increase in volume due to shearing - is indicted by the presence of a shiny film of water after a hand sample is shaken. The water disappears upon remoulding. Very fine grained sands may also exhibit dilatancy.
- low plasticity index
- feels gritty to the teeth

1.7 Organic Soils

Organic soils are distinguished from other soils by their appreciable content of vegetable matter, usually derived from plant remains.

The soil usually has a distinctive smell , low bulk density and often has a high moisture content.

The USC system uses the symbol Pt for partly decomposed organic material. The O symbol is combined with suffixes "O" or "H" depending on plasticity.

Where roots or root fibres are present their frequency and the depth to which they are encountered is usually recorded. The presence of roots or root fibres does not necessarily mean the material is an "organic material" by classification.

Coal and lignite are normally described as such and not simply as organic matter.

2. CLASSIFICATION OF ROCKS

2.1 Uniform Rock Classification

The aim of a rock description for engineering purposes is to provide an indication of the expected engineering properties of the material

In a similar manner to soil materials, the assessment of site conditions where rock is encountered is usually based on the use of a rational descriptive method which is uniform and repeatable. The description typically:

- provides a clear identification of the rock substance and its engineering properties
- includes details of the features which affect the engineering properties of the rock mass

There is no internationally accepted system for rock description, Michael Adler and Associates have adopted a method that incorporates terminology that is commonly used in the engineering profession. Most feature definitions are as recommended by the International Society of Rock Mechanics and the Standards Association of Australian.

For uniform presentation the different features are usually described in order:

Rock Substance:

- NAME (In blocks)
- Mineralogy
- Grain Size
- Colour
- Fabric
- Strength
- Weathering/Alteration

Rock Mass:

- Defect Type
- Defect Orientation
- Defect Features
- Defect Spacing

2.2 Rock Substance

(a) Rock Name

Each rock type has a specific name which is based on:

- Mineralogy
- Grain Size
- Fabric
- Origin

The only method of precisely determining the rock name is by thin mineralogy.

Field identification of rocks for engineering purposes is normally based on the use of common, easily understood, simple geological names. In many cases knowledge of the precise name is of little consequence in the assessment of the site conditions. If required the "field name" can be qualified by reference to a petrographic report. Reference to local geological reports or maps often provides information on the rock type which may be expected

(b) Mineralogy

The rock description usually includes the identification of the prominent minerals. This identification is usually restricted to the more common minerals in medium to coarse grained rocks.

(c) Grain Size

Rock material descriptions often include general grouping of the size of the prominent mineral grains as defined in Table 7. The maximum size, or size range, of the largest mineral grain or rock fragments is often recorded.

TABLE 7 - GRAIN SIZE GROUPS

TERM	GRAIN SIZE (mm)
Very Coarse	> 60
Coarse	2 - 60
Medium	0.06 - 2
Fine	.0.002 - 0.06
Very Fine	< 0.002
Glassy	

(d) Colour

The colour is normally described in the moist condition using simple terms such as:

Black	White	Grey	Red
Brown	Orange	Yellow	Green
Blue			

These are often modified by "light" or 'dark". Borderline colours are described by a combination of two or more colours, e.g.: red brown

(e) Fabric

The fabric of a rock includes all the features of texture and structure, though the term refers specifically to the arrangement of the constituent grains or crystals in a rock. The fabric can provide an indication of the mode of formation of the rock:

- in sedimentary rocks bedding indicates deposition conditions
- in igneous rocks the texture indicates the rate of cooling
- in metamorphic rocks the foliation indicates the stress conditions

Descriptions of fabric typically include orientation, either with reference to north or horizontal, or to a plane normal to the core axis.

Tables 8, 9 and 10 list common textural features of sedimentary, igneous and metamorphic rocks with the subdivision of stratification spacing given in Table 11.

TABLE 8 - COMMON STRUCTURE IN SEDIMENTARY ROCK

STRATIFICATION (Planer)	STRATIFICATION (Irregular)
Bedding	Washout
Cross Bedding	Slump Structure
Graded bedding	Shale Breccia
Lamination	
Cross Lamination	

TABLE 9 - COMMON STRUCTURE IN IGNEOUS ROCK

	FINE GRAINED ROCK	COARSE GRAINED ROCK
Uniform Grain Size	Massive	Massive
	Flow Banded	Granitic
	Vesicular	Pegmatic
Different Grain Size	Porphyritic	Porphyritic

TABLE 10 - COMMON STRUCTURE IN METAMORPHIC ROCK

FINE GRAINED ROCKS	COARSE GRAINED ROCKS
Slatey Cleavage	Gramoblastic
Spotted	Porphyroblastic
Hornsfelsic	Lineated
Foliated	Gneissic
Mylonitic	Mylonitic

TABLE 11 - STRATIFICATION SPACING

TERM	SEPARATION (mm)
Very Thickly Bedded	> 2000
Thickly Bedded	600 - 2000
Medium Bedded	200 - 600
Thinly Bedded	60 - 200
Very Thinly Bedded	20 - 60
Laminated	6 - 20
Thinly Laminated	< 6

(f) Strength

Substance strength is one of the more important engineering features of a rock, descriptions usually include an estimate of the rock strength class of the material. This estimate is often calibrated by test results, such as Point Load Strength Index or by Unconfined Compressive Strength.

The rock strength class in AS 1726-1981 is defined by the Point Load Strength Index Is (50). The relationship between Point Load Index and the Unconfined Compressive Strength (Qu) is often assumed to be about 20, though it can range from 4 (in some carbonate rocks) to 40 (in some igneous rocks). The classification is normally based on material at field moisture content, as some rocks give a significantly higher strength when tested dry. In thinly bedded sedimentary rocks, such as shale the axial point load strength may provide a better estimate of the rock strength class, rather than the diametral value.

Table 12 defines the rock strength, with indicative field tests listed in Table 13. These can assist in classification when testing apparatus is not available.

TABLE 12 - CLASSIFICATION OF ROCK STRENGTH

SYMBOL	TERM	POINT LOAD STRENGTH (MPa)	APPROX Qu (MPa)
EL	Extremely Low	< 0.03	< 1
VL	Very Low	0.03 - 0.1	1 - 3
L	Low	0.1 - 0.3	3 - 10
M	Medium	0.3 - 1	10 - 30
H	High	1 - 3	30 - 70
VH	Very High	3 - 10	70 - 200
EH	Extremely High	> 10	> 200

TABLE 13 - FIELD TESTS FOR ROCK STRENGTH CLASSIFICATION

STRENGTH CLASS	FIELD TEST
Extremely Low	Indented by thumb with difficulty
Very Low	Scratched by thumb nail
Low	Easily broken by hand or paired with a knife
Medium	Broken by hand or scratched with a knife
High	Broken in hand by firm hammer blows
Very High	Broken against solid object with several hammer blows
Extremely High	Difficult to break against solid object with several hammer blows

(g) Weathering/Alteration

In addition to the description of the rock substance as examined, an assessment of the extent to which the original rock material has been affected by subsequent events is often important. The usual processes include:

- Weathering - Decomposition due to the effects of surface or near surface activities

- Alteration - Chemical modification by the action of materials originating from within the mantle below

The classification of weathering/alteration presented in Table 14 is based on the extent/degree to which the original rock substance has been affected. This classification often has little engineering significance, as the properties of the rock as examined may bear no relationship to the properties of the fresh rock.

TABLE 14 - CLASSIFICATION OF ROCK WEATHERING/ALTERATION

TERMS	DEFINITION
Fresh (Fr)	Rock substance unaffected
Fresh Stained (Fr.St)	Rock substance unaffected, staining on defect surfaces
Slightly (SW)	Partial staining or discolouration of rock substance
Moderately (MW)	Partial staining or discolouration extends throughout entire rock substance
Highly (HW)	Rock substance partially decomposed
Completely (CW)	Rock substance entirely decomposed

2.3 *Rock Mass*

The engineering properties of the rock mass reflect the effect which the presence of defects has on the properties of the rock substance. Description of the rock mass properties consists of supplementing the description covered by Section 2.2 with data on the defects which are observed.

It is important to note that the defects described in the Geotechnical Logs for Cored Boreholes include both natural defects and those in the recovered rock cores that were caused by the drilling process. Unless there is definitive evidence to the contrary, no attempt is made to differentiate between natural defects and drilling breaks.

The drilling breaks between the individual core runs are not described in the logs as these are known drilling induced defects.

(a) Defect Type

The different defect types are described in Table 15.

TABLE 15 - ROCK DEFECT TYPES

TYPE	SYMBOL	DESCRIPTION
Parting	Pt	A defect parallel or subparallel to a layered arrangement of mineral grains or micro-fractures which has caused planer anisotropy in the rock substance
Joint	Jt	A defect across which the rock substance has little tensile strength and is not related to textural or structural features with the rock substance
Sheared Zone	SZ	A zone with roughly parallel planer boundaries or rock substance containing closely spaced, often slickensided joints
Crushed Zone	CZ	A zone with roughly parallel planer boundaries of rock substance composed of disoriented, usually angular, fragments of rock
Bedding	Bd	Stratification from original layering in the sediments that formed the rock.
Seam	Sm	A zone with roughly parallel boundaries in-filled with by soil or decomposed rock

(b) Defect Orientation

Descriptions of defects usually include orientation, either of individual fractures or of groups of fractures. Orientation is often referenced to north, to the horizontal, or to a plane normal to the core axis (Hz = Horizontal)

(c) Defect Features

The character of a defect is usually described by its continuity, planarity, surface roughness, width and infilling.

Continuity: In an outcrop of rock it is the extent of a joint, bedding plane or similar defect both along and across the strike. In a core continuity measurement is restricted to defects nearly parallel to the core axis.

Planarity: Described as “Planer” (P), “Irregular” (I), “Curved” (C) or “Undulose” (U).

Roughness: Described as “Rough” (R), “Smooth” (S), “Polished” (P) or “Slickensided” (S).

Width; Measured in mm normal to the plane of the defect.

Infilling: Described as “Clean” (Cl), “Stained” (St), “Veneer” (<1 mm) (Vn) or “Infill” (>1 mm) (In). The coating or infill is sometimes identified.

(d) Defect Spacing

The spacing of defects, particularly where they occur in parallel groups or sets, provides an indication of the rock block size which:

- have to be supported in the face or roof of an excavation
- will be produced by excavation

Often discontinuity spacing is grouped as shown in Table 16.

TABLE 16 - DISCONTINUITY SPACING

DESCRIPTION	SPACING (mm)
Extremely widely spaced	> 6000
Very widely spaced	2000 - 6000
Widely spaced	600 - 2000
Medium Spaced	200 - 600
Closely spaced	60 - 200
Very closely spaced	20 - 60
Extremely closely spaced	< 20

(e) Results of Point Load Testing

Point Load test results for Is (50) are presented when available in MPa:

Id = Diametral Value
Ia = Axial Value