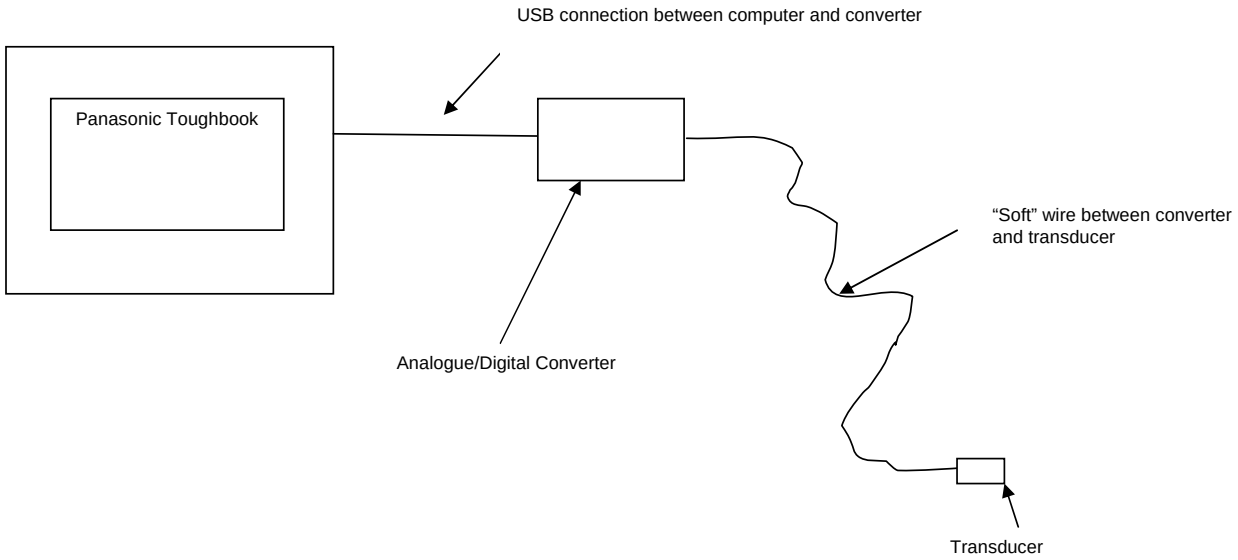
The Mod Shock System For Auditing Bolt/Cable Support Systems

John Naylor MAusIMM
Mining Manager

Austress Freyssinet Pty Ltd

Sketch Showing Layout of Mod Shock System



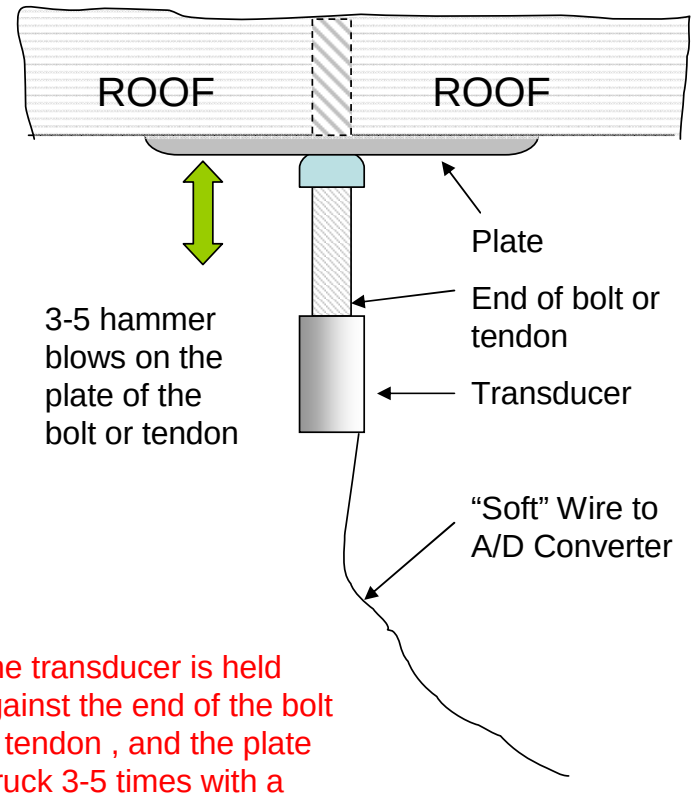
The Mod Shock System

•Is an auditing/investigational tool, capable of testing a significant number of bolts per day.

•Does not require compressed air supply or special adaptors for different types of bolts and as such, thread condition is not critical

•The number of bolts that can be tested depends on the travelling time between sites and the battery life. We can expect to get 4-5 hours life out of the battery of the notebook.

• In essence, it only takes a matter of seconds to actually test a bolt, so we are looking at productivity rates of around +100 bolts tested per day, all things being equal



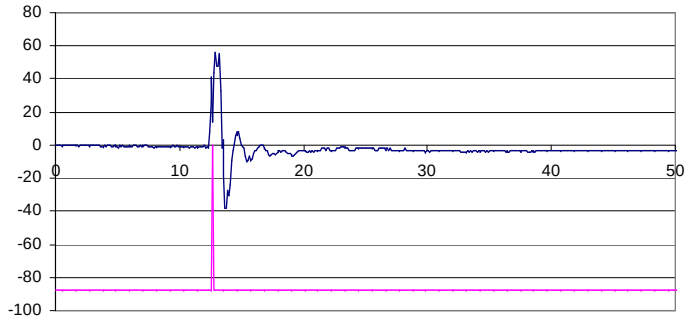
The transducer is held against the end of the bolt or tendon , and the plate struck 3-5 times with a hammer

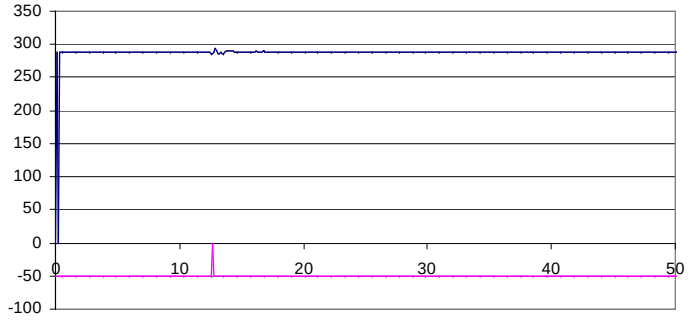
The Mod Shock System

Test the bolt

- The transducer is held against the bottom of the test bolt, the program informed that a test is about to take place by clicking an icon
- The plate is struck 3-5 times with a hammer, until satisfactory data is received by the computer.

Good Signal





Unacceptable Signal

The Mod Shock System

•At the end of the days testing, the files are transferred onto this computer and the data of all the bolts are analysed

• The results are analysed and categorised as per the file already presented

•Typically for a 100 bolts –analysis usually takes about a day, depending upon the quality of the element being tested

The Mod Shock System

- The Mod Shock test system is a complex “Stress Wave Analysis” package based on the processing of clear seismic signals imparted into whatever element is under test.
- The seismic signals are processed by “Fourier Transform” into various criteria which can be used to produce models of the element such as Mechanical Admittance, Frequency Spectra, Velocity and other less important aspects; all being used in the final modelling of the element under analysis

Head Stiffness

One of the vital pieces of information obtained from the Mod-Shock test is the “Head Stiffness” as this is the basis of all the load predictions and it also indicates the serviceability of the total bolt system.

Head Stiffness - is the “E” prime of the bolt, measured as a direct measurement of the first part of the “mechanical admittance plot”, and is similar to a load/deflection graph for a pull out test.

Head Stiffness (Contd).

The stiffness calculation is not always an accurate result as we would desire and as such is only used to determine the overall assessment of the bolt.

The “bolt head stiffness (t/mm)” is compared to the two model stiffness values “E” min and “E” max.

- “E” min is a bolt model with the bolt pinned at its toe but with no clamping along its length.
- “E” max is a bolt model with an infinite rigid base and clamped along its length.

These models are based on the work carried out by Davis & Dunn and they summed up the theory with descriptions as follows:-

Head stiffness Contd.

- For a serviceable bolt, with good anchorage at the toe and with good encapsulation into good rock, the stiffness should lie between the "E" max and "E" min values.
- A serviceable bolt can also have a stiffness value slightly below the "E" min value if it has good anchorage, but either the encapsulation of the length of the bolt is poor grout/incorrectly mixed resin, or the rock the bolt is in does not have good load bearing capacities.
- With the same model in mind a bolt with point anchorage would have a stiffness value well below the " E " min, but if this is the design, then this would still be serviceable.
- Non serviceable bolts would have a stiffness value well below the "E" min values, such as less than 70 % of the "E" min value. This indicates either poor anchorage or large loss of section and no support along the shaft.
- Non serviceable bolts can also have what we describe as overstressed areas in the system, where the Head Stiffness is far in excess of the "E" max value. What occurs in this scenario is that due to some defect in the bolt system a part of the system is being overstressed. An example of this would be that corrosion of the bolt has occurred at the interface of the grout and the bolt. This reduced section of the bolt is taking more load than it was designed for and as such is overstressed and at risk of failure.

Head stiffness Contd.

- There are variations on the points noted on the previous slide and categorisation of the bolts serviceability needs not only the stiffness to be considered but also the loss of section in the model.
- In addition to this some knowledge of the bolt systems used are an advantage and for even greater accuracy some geotechnical information of the ground the bolts are going through is also very helpful

The Mod Shock System

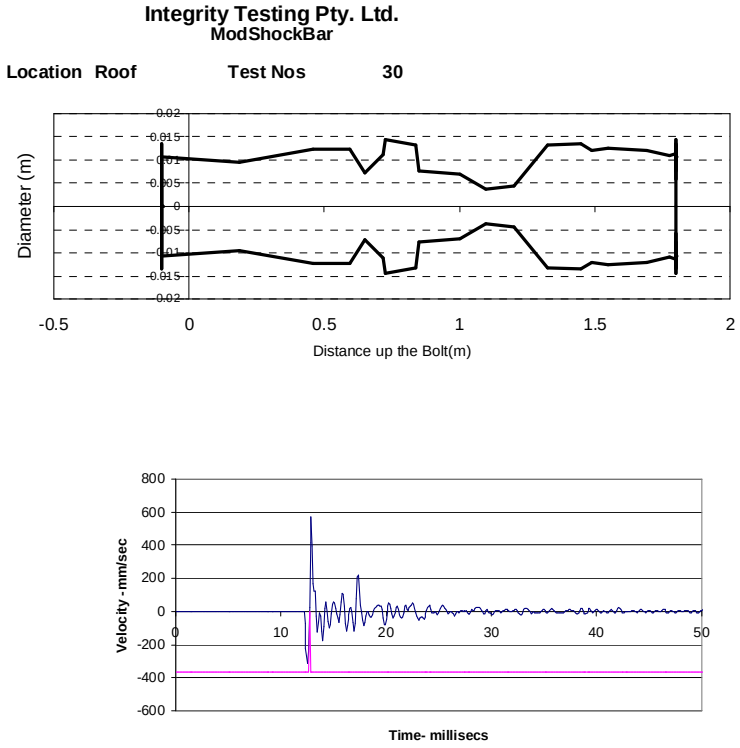
Categories

At present it must be considered that this is a "QA" test which eliminates good bolts and identifies bolts that may have some deficiency, be it in low load capacities (load transfer) or loss of section of the bolt.
Individual analysis of bolts in detail can take significant amounts of time and so at present, we have opted to use simplified acceptance criteria as shown below.

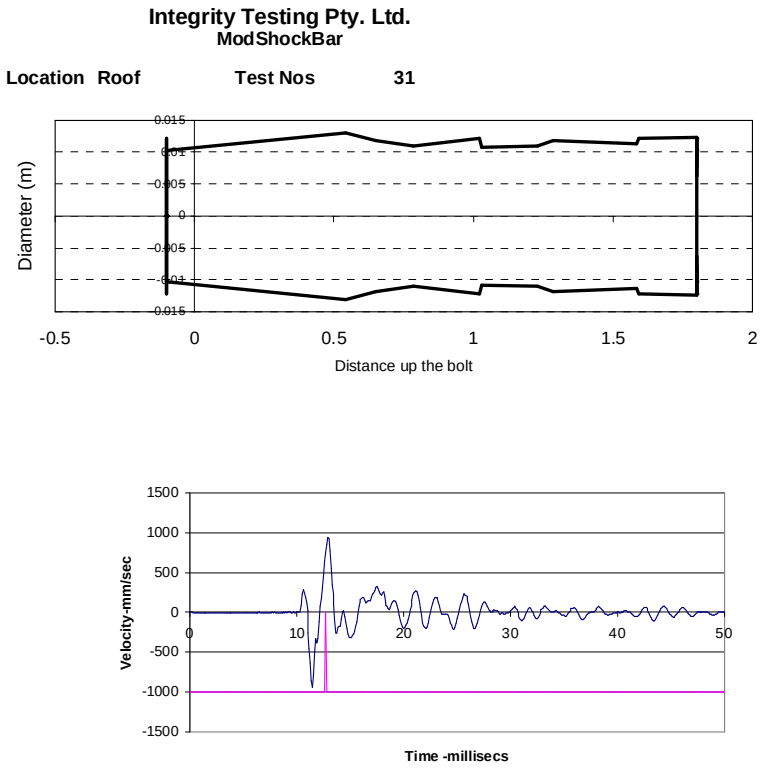
Category 1.	A perfect bolt in perfect rock conditions –in our opinion this will rarely occur
Category 2.	A bolt which we consider is serviceable in that it has good anchorage, good clamping along the length of the bar and reasonable rock/resin contact.
Category 3.	A bolt that has some deficiencies in reduced anchor strength, poor resin/rock contact or loss of bolt section. The remarks section will identify the possible source of the deficiency.
Category 4.	A bolt that has either failed, is loose or at a point where additional load on the bolt could lead to failure, or a loss of bolt section which is critical.

Examples

The print out provides a 2D model of the bolt under test and a number of criteria are examined such as the “stiffness” of the bolt which is compared to two models of fixity of the bolt. Therefore information is available for the Engineer to study if, for example, the bolt has an anomaly such as a low “stiffness” result or large loss of section on the 2D model



Example of the 2D plot of an Unserviceable Bolt, produced by the software. In this case there isn’t enough resin to fully encapsulate the bolt



Example of the 2D plot of a Serviceable Bolt produced by the software

Questions?