This brochure for Secura R27 bolts

Bolt Extension Monitor (BEM)

Instrumented bolts are installed in groups or clusters.

There are four components of a BEM system:
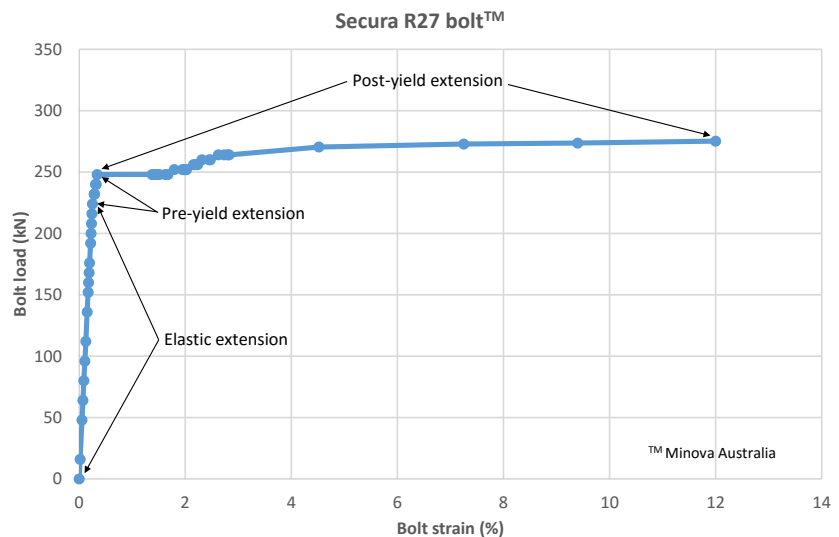
- *a strain sensor that is attached to a rock bolt*

- *a radio "donut" that is situated on, or near a bolt with strain sensor*

- *a portable radio to Wi-Fi translation unit*

- *iPad mini that receives strain data from a cluster of bolts and displays and stores this data.*

ROCK BOLTS IN UNDERGROUND MINING

An essential part of ground support in underground mining and tunnelling is to control movement of the near surface layer around excavations with a system comprising some form of pattern rock bolting. As the surface layer of rock deforms under the prevailing static or dynamic stress conditions, bolts become loaded and extend in length. For rock stability to be maintained, it is important that the bolts do not become overloaded and exceed their tensile strength.

Modern rock bolts have high post-yield extension capability - up to 15% - 20% strain—and this extension can form an important component of overall bolt performance. Measurement of bolt load and extension up to the point of bolt failure provides a factual basis of the need for support rehabilitation and the remaining energy absorption capacity of the support system in areas prone to seismicity.

The TRT rock bolt extension monitoring system can accurately measure strain, or extension, over the full operational range of a rock bolt, i.e. the elastic, pre-yield and post-yield behavior, until bolt failure.

Secura R27 bolt™ — Bolt load (kN) versus Bolt strain (%), showing Elastic extension, Pre-yield extension, and Post-yield extension. ™ Minova Australia

BASIC PROCEDURE

Instrumented rock bolts can be installed in groups, or clusters in areas where bolt performance data is required. 1 to 20⁺ bolts can be defined as a cluster. Bolts are allocated a unique mine defined identification tag then allocated to a mine defined cluster. Bolt strain sensors are supplied in a form that can be applied by mine technical personnel to standard rock bolts as used in relevant production areas. It is suggested that strain sensors are attached to a group of 5 to 20 bolts in one application.
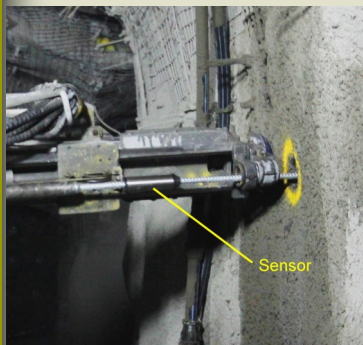
Strain sensor with rear centralizer installed on bolt

Sensors with protection tubes ready for installation

Ø100 mm reamer bit to increase dimeter of bolt hole at collar

BEM bolt being installed by Jumbo

Major procedural components for Secura R27 bolts:

- remove the nut and collar plate from a bolt and clean the bolt as required. Glue a strain sensor to the bolt and allow the glue time to cure

- after the glue has cured fit a protection tube over sensor and fix front and rear centralisers to the bolt. Connect the sensor to a radio donut and the donut to a laptop computer. Use supplied custom software to set bolt identification tag and initialise the strain sensor

- replace domed nut on bolt and replace retained high strength steel pin

- use 90-100 mm diameter purpose reamer bit to drill hole at collar to depth of approximately 500 mm, then use standard drill steel to drill bolt hole to required length

- install instrumented bolt using conventional rock bolt installation equipment

- fit connection cable to socket in rear centraliser. Feed other end of connection cable through hole drilled in collar plate as the collar plate is fitted over threaded end of bolt. Fit and tighten domed nut by hand

- further tighten domed nut with stillsons. If a jumbo is used to tighten the nut the collar plate must be prevented from rotating during this process

- fit connection cable to the donut and either fit donut over threaded section of bolt and retain using M24 nut or fix donut to mesh or collar plate using cable ties

- the donut will broadcast bolt tag identification and strain data at 32 second intervals.

DATA ACQUISITION AND DISPLAY

- A portable radio to Wi-Fi translator, small enough to be carried in an overall pocket, picks up the radio transmissions and converts these data to Wi-Fi protocol

- A data display and acquisition BEM app is available for iPad, iPad mini, iPhone or iPod touch. This app collects data from BEM clusters and displays individual bolt strain and bolt condition for immediate assessment
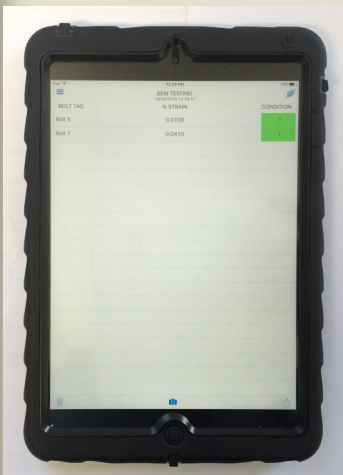
Radio donut cable tied to collar plate

Radio to Wi-Fi translator

iPad mini in protective case

- Total bolt strain—for the bolt type used—is divided up into eight zones: three for the elastic strain range of the bolt, one for the pre-yield zone and four for the post-yield zone and these bolt conditions are shown in eight different colours: for Secura R27 rock bolt:

  - condition 1: 0-0.083%, low elastic range
  - condition 2: 0.083% - 0.166%, mid elastic range
  - condition 3: 0.166% - 0.250%, high elastic range
  - condition 4: 0.250% - 0.330%, pre-yield zone
  - condition 5: 0.330% - 2%, low-yielded zone
  - condition 6: 2% - 5%, mid-yielded zone
  - condition 7: 5% - 9%, high-yielded zone
  - condition 8: >9%, failure onset zone
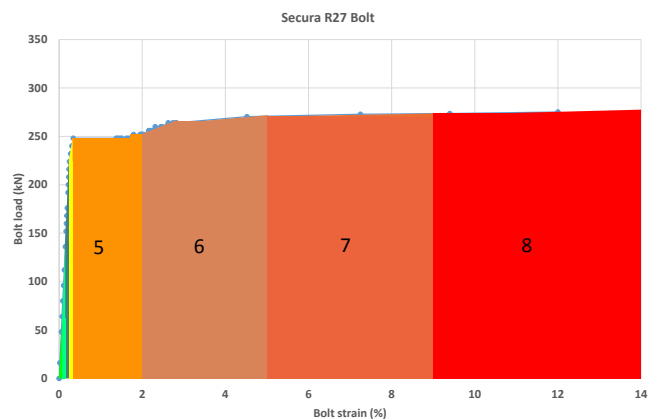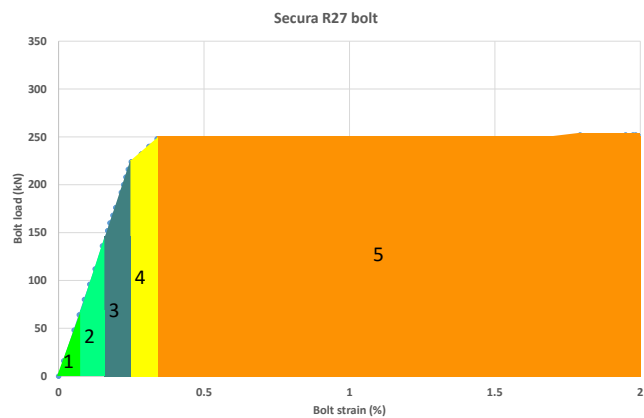
SPECIFICATIONS & USER INFORMATION

- Strain sensor: high elongation epoxy resin containing two diametrically opposed high elongation (20%) linear strain gauges in additive half-bridge configuration. Average linear strain is measured, correcting for any bending. A digital circuit that holds bolt tag identification, sensor calibration and zero offset information is embedded in the epoxy body. Reading resolution: 0.000225% strain up to 7.3% strain; 0.000450% strain above 7.3% strain

TOP ROCK TECHNOLOGIES PTY LTD

15 Margate Street
Beaumaris Vic 3193
Australia

T: +61 3 9584 2155

F: +61 3 9584 2135

M: 0418 363 390

robwal26@ozemail.com.au

Excellence in Geotechnical Measurement

- Donuts contain rechargeable batteries and a license free radio unit. The radio broadcasts every 32 seconds; strain readings are updated every 4½ hours. Line-of-sight transmission range: 50 - 100m. A radio repeater is available. Donut batteries have a life of about 300 days before recharge is required. A donut can be changed over without losing bolt tag and sensor zero offset information. A recharging station to accept up to 12 donuts is available

- To calculate bolt load (kN) up to the onset of pre-yield (0.25% strain) multiply the recorded % strain by 897. Resolution of bolt load measurement: 0.20 kN.

ADVANTAGES OF TOP ROCK TECHNOLOGIES BOLT EXTENSION MONITOR

- BEM sensors applied on-site by mine technician to unmodified standard bolts, i.e. **bolts retain design stiffness and maximum load specifications**

- BEM measures strain in elastic and yielded range of bolt performance

- BEM sensors available for Ø20mm and Ø24mm bolts from various bolt manufacturing companies

- Instrumented bolts can be installed with mine defined tags in mine defined clusters

- Bolt strain information available as clusters on iPad Mini (or iPhone, etc.) with instantly identifiable colour coded strain condition; 3 zones in the elastic range, 5 zones for pre and post yield condition

- Time stamped strain readings saved as screen shots or as .csv data for retention and display.

iPad 🖵	1:30 PM	86% 🔋
☰	**4455-204** 18/11/2015 13:30:15	🪢
BOLT TAG	**% STRAIN**	**CONDITION**
4455-204-S2	0.0000	1
4455-204-W2	0.0383	1
4455-204-W1	0.0284	1
4455-204-S1	0.0223	1

iPad mini screen shot of 4 x BEM bolt cluster 4455-204