OVERALL CONCEPTS IN DRILLING FOR ROOF BOLTING

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ABSTRACT

The lack of objective data on roof bolting machines, bits, rods and overall system has created the need for an objective assessment of roof bolting. This work outlines a test rig for such objective assessment of component parts of the roof bolting system.

INTRODUCTION

The predominant means of roof support used today in the Australian Coal Mining Industry is roof bolting, and the increased demand for safety, coal productivity and speedy rates of heading development have placed greater emphasis on safe, effective and speedy roof bolting procedures.

Numerous roof bolting machines, drill rods, bits and bolts are available. The selection of a roof bolting system is governed by the prevailing geological conditions, availability of the appropriate power system, machine efficiency, and the adoption of safe and conservative support practice; however, the ultimate selection in many cases is based upon personal choice rather than objective assessments.

To date trials of roof bolting materials and equipment have been carried out in the work place, and consequently, results obtained have had limitations. Controlled research in a laboratory has not been attempted; to this end a roof bolting test rig has been designed and installed in the laboratories of the Department of Civil and Mining Engineering at the University of Wollongong.

The rig has been designed to test most aspects of roof bolt drilling practice.

DESCRIPTION OF TESTING FACILITY

Figure 1 illustrates the laboratory roof bolt drilling test rig.

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Many considerations were taken into account in the design and construction of the drilling rig; these included the ability to use any type of drilling machine, the ability to have complete control over the type of material being drilled and the hole spacing between drill holes.

The rig consists of a roof bolter contained within a framework which is designed to lift and install in an overhead position the drilling medium. The bottom section of the framework acts as a water sump.

The interchangeability of bolters is achieved with the use of a cradle. The cradle has two functions; firstly it contains the thrust, torque, speed and displacement sensors; secondly, it holds the roof bolter safely in position. Figure 2 shows the cradle holding a roof bolt.

The necessity to have complete control over the drilling medium was achieved by the development of a system to test blocks of material. The ability to artificially create in the laboratory the material to be drilled, and have detailed knowledge of the drilling material characteristics is a necessity in the monitoring of roof drilling. Blocks of material are cast in a 1m² mould. The mould enclosing the drilling medium can be hoisted into position on the rig.

Drill spacing on the 1m² face was set at 50mm to maximize the number of holes drilled in each block. Drill hole diameter is normally 27mm, and the effect of the hole proximity, if any, was left to be determined by investigation.

Situated immediately under the block of drilling material is a heavy steel guide plate drilled to allow the correct pitch of holes to be maintained. At floor level is a matching guide so that the drilling machine is always kept in a vertical position whilst drilling.

MONITORING

The following parameters are monitored as drilling takes place:
1. **Air pressure.** This is normally maintained in the range 700-800 kPa as advised by the roof bolter manufacturers for optimum performance.

2. **Air flowrate.** This is generally 75-80 l/s, again the optimum range for roof bolter performance.

3. **Water pressure and water flowrate** are recorded to indicate the water available to flush cuttings from the drilled hole.

4. **The bit diameter and weight** are recorded before and after each hole is drilled. Diameter reduction and weight loss indicate the durability of the bit. Drill hole diameters are determined by a set of diameter gauges, Figure 3.

5. **Drilled medium.** Provision is made to catch the cuttings from each hole for sieve analysis. Evaluation of the sieve analysis results provides an insight into the drill bit characteristics as the bit wears out.

6. **Torque, thrust, displacement and speed.** The dynamic characteristics of the roof bolter are continuously logged during each test.

Data logging is carried out by a Hewlett Packard Data Acquisition Unit controlled by a Hewlett Packard Desk Top Computer, Figure 4. The data acquisition system logs torque, thrust, displacement and speed every second over a sixty second period. Each of the readings is taken over an interval of 4.5 milliseconds. Upon completion of reading data.
the computer automatically processes the readings. Total time for the drilling of a test hole to the availability of results is four minutes.

**EXPERIMENTAL PROCEDURE.**

During the commissioning period of the data logging system a number of experimental runs were undertaken, the aim being to log the parameters of the roof bolter.

The following general experimental procedures were adopted:

1. Weigh the drill bit.
2. Measure the bit diameter.
3. Commence drilling (the data logger commences reading automatically).
4. Clump the speed and thrust controls of the bolter (this allows the bolter to run unattended).
5. Record the air and water pressure and the air and water flowrates as drilling proceeds.
6. Allow the drilling to continue until maximum displacement has been reached. Shut the bolter down.

**RESULTS.**

Upon completion of a typical experimental test...
various results were produced. Table 1 shows the parameters recorded during the drill run.

Table II shows the sieve analysis of the cutting fragments from the drilled hole.

Figures 5 to 8 show the computer processed data from the drill run, being the rotational speed, bit displacement, drill torque and drill thrust in relation to time.

Figures 9 to 12 show the burst readings at the thirty second interval. These graphs show the actual dynamic readings over the sampling time of 4.5 milliseconds.

The penetration rate was calculated to be 1.33 metres per minute. On visual inspection of the drill bit the cutting edge was observed to be blunt, reflecting the low penetration rate.

Change in hole diameter was observed over the length of the drill hole. Hole diameter at the start of the hole was 28.8mm which linearly decreased to 27.8mm at a point 0.6m from the beginning of the hole.

<table>
<thead>
<tr>
<th>Hole No.</th>
<th>Air Pressure (MPa)</th>
<th>Water Pressure (MPa)</th>
<th>Air Consumption (l/min)</th>
<th>Water Consumption (l/min)</th>
<th>Hole Length (mm)</th>
<th>Drilling Time (seconds)</th>
<th>Penetration Rate (m/minute)</th>
<th>Bit Diameter (mm)</th>
<th>Gauge Loss (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>700</td>
<td>1000</td>
<td>78</td>
<td>18</td>
<td>640</td>
<td>38</td>
<td>1.33</td>
<td>29.00</td>
<td>0.1</td>
</tr>
</tbody>
</table>
Figure 4 Computer Controlled Data Logging Equipment

Figure 5 Rotational Speed v's Time of Drilling Run

Figure 6 Displacement v's Time of Drilling Run

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### Table 2: Sieve Analysis

<table>
<thead>
<tr>
<th>Sieve Size (mm)</th>
<th>Weight Retained (g)</th>
<th>Percent Retained</th>
<th>Percent Passed</th>
<th>Special Limits</th>
</tr>
</thead>
<tbody>
<tr>
<td>+4.75</td>
<td>0.83</td>
<td>0.20</td>
<td>99.80</td>
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<tr>
<td>2.36</td>
<td>1.14</td>
<td>4.42</td>
<td>95.38</td>
<td></td>
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<tr>
<td>1.18</td>
<td>56.19</td>
<td>14.17</td>
<td>85.83</td>
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<tr>
<td>0.60</td>
<td>88.19</td>
<td>21.48</td>
<td>78.52</td>
<td></td>
</tr>
<tr>
<td>0.30</td>
<td>143.23</td>
<td>34.88</td>
<td>65.12</td>
<td></td>
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<tr>
<td>0.15</td>
<td>73.39</td>
<td>17.87</td>
<td>82.13</td>
<td></td>
</tr>
<tr>
<td>0.075</td>
<td>19.92</td>
<td>4.85</td>
<td>95.15</td>
<td></td>
</tr>
<tr>
<td>-0.075</td>
<td>8.73</td>
<td>2.13</td>
<td>97.87</td>
<td></td>
</tr>
</tbody>
</table>

**Figure 7** Torque vs Time of Drilling Run

**Figure 8** Thrust vs Time of Drilling Run

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CONCLUSIONS

The laboratory roof bolt drilling test rig can also be used for demonstration purposes and with its associated drilling machine test bench being developed, will allow complete identification of problems associated with drill bits, the drilling medium, and operating characteristics of roof bolt drilling machines. In fact, the test set up will allow the drilling cycle to be optimised for any medium to be drilled. In parallel with this experimental programme, drill bits are being modelled on the computer, with a view to studying the mechanism of the cutting action.

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