MIPS EQ – Low frictional impact surface study

Contact details for project participants

<table>
<thead>
<tr>
<th>Name</th>
<th>Position</th>
<th>Phone</th>
<th>E-mail</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kim Lindblom</td>
<td>Technical Engineer</td>
<td>+46 70 394 35 36</td>
<td><a href="mailto:kim@mipshelmet.com">kim@mipshelmet.com</a></td>
</tr>
</tbody>
</table>

Summary

MIPS have studied the helmets ability to attain MIPS movement during impact vs. low frictional surfaces in oblique impacts. A total of eight MIPS EQ1 helmets were tested in this study. The outer fabric of the helmets was removed, leaving a smooth surface of PVC. Four of the EQ1 helmets had the liner glued to the outer shell. The remaining four helmets were equipped with MIPS layer and energy absorbing rubber strap in place.

The horizontal plate was fitted with a 2mm thick Teflon sheet to assure minimal friction between plate and helmet. Three of the glued helmets and three of the MIPS helmets were tested in the oblique test rig, impacting the Teflon fitted plate at 7mps at an angle of 30 degrees.

The remaining untested glued helmet and the untested MIPS helmet were impacted against the movable plate fitted with frictional tape, simulating pavement, at 7mps at an angle of 30 degrees.

The reduction of the rotational acceleration for the impacts against the rough frictional tape is 50,5% with the MIPS helmet. The MIPS reduction of rotational acceleration for impacts vs. Teflon layer is 42,1%. The reduction of rotational velocity for impacts vs. frictional tape and Teflon layer is 22,7% and 12,8% respectively. The results from the six impacts against the Teflon layer and the two tests against the frictional tape can be seen in Table 1.

The tests show that the friction between helmet and plate is significant for how much rotational energy is transferred to the helmet and head. Still, a considerable amount of rotational energy is transmitted to the head at impacts vs. the low frictional surface. A clear MIPS movement (relative movement between the outer shell and the low frictional layer) is observed during impacts against the Teflon sheet, resulting in a reduction of both rotational acceleration and rotational velocity.
### Method

The oblique test rig is presented in Figure 1. A free falling instrumented head form impacts a horizontally moving steel plate. The oblique impact results in a combination of linear and rotational acceleration that is more realistic than common methods. Speeds of up to 10 m/s (36 km/h) can be achieved both in horizontal and vertical direction. This means that an impact speed of up to 14 m/s (50 km/h) can be reached. In the dummy head there is a system of nine (9) accelerometers mounted to measure the translational accelerations and rotational accelerations around all axes.

![Image of the oblique test rig](image)

**Figure 1.** The oblique test rig.

In the current test the helmets are dropped from 0.7 meter. This results in a vertical speed of 3.7 m/s. The horizontal speed was chosen to 6.7 m/s, resulting in an impact speed of 7.7 m/s and an impact angle of 29 degrees, Figure 2.

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Other</td>
<td>MIPS</td>
<td>Other</td>
<td>MIPS</td>
</tr>
<tr>
<td>Max Amp.</td>
<td>130.8</td>
<td>9.5</td>
<td>29.9</td>
</tr>
<tr>
<td>Difference %</td>
<td>0.3</td>
<td>50.5</td>
<td>22.7</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Other</td>
<td>MIPS</td>
<td>Other</td>
<td>MIPS</td>
</tr>
<tr>
<td>Max Amp.</td>
<td>131.3</td>
<td>5.7</td>
<td>15.8</td>
</tr>
<tr>
<td>Difference %</td>
<td>0.2</td>
<td>42.1</td>
<td>12.8</td>
</tr>
</tbody>
</table>

**Table 1.** Summarized results from the impact tests
The method has been utilized since year 2001 and several different prototypes have been tested.

Test of MIPS EQ1

The horizontal plate was fitted with a 2mm thick Teflon sheet to assure minimal friction between plate and helmet. Teflon has a static coefficient of friction against the helmet shell of 0.10-0.15 while the friction tape (grinding paper) has a coefficient of friction of 0.5.

Figure 3. A 2mm Teflon sheet was placed on the horizontally moving plate to assure minimal friction between helmet and plate.
A total of eight MIPS EQ1 helmets were tested in this study. The outer fabrics of the helmets were removed, leaving a smooth surface of PVC, Figure 4. Four of the EQ1 helmets had the liner glued to the outer shell. The remaining four helmets were equipped with MIPS layer and energy absorbing rubber strap in place.

![Figure 4. The outer fabric was removed from the helmet, leaving a smooth surface of PVC.](image)

In this study the helmets were tested for the frontal (VII) impact direction (Figure 5). The choice of impact direction and location on the helmet are chosen in order to evaluate the MIPS function in the helmet.

![Figure 5. Definition of frontal impact direction (30 degree impact).](image)

**Results**

Figure 6-11 shows the translational acceleration, rotational acceleration and rotational velocity for the performed tests. The helmets with MIPS protection system show a reduction of the rotational acceleration, and rotational velocity. Presented first are the results from the two impacts against frictional tape. Following are the results from the six tests with impact surface of Teflon.
Figure 6. Translational Acceleration – impact on frictional Tape (MIPS in red, Original in black).

Figure 7. Rotational Acceleration - impact on frictional Tape (MIPS in red, Original in black).
Figure 8. Rotational Velocity - impact on frictional Tape (MIPS in red, Original in black).

Figure 9. Translational Acceleration – impact on Teflon Layer (MIPS in red, Original in black).
Figure 10. Rotational Acceleration - impact on Teflon Layer (MIPS in red, Original in black).

Figure 11. Rotational Velocity - impact on Teflon Layer (MIPS in red, Original in black).
Discussion

The tests show that the friction between the helmet and plate is significant for how much rotational energy is transferred to the helmet and head. Comparing the rotational acceleration for the glued helmet at impact against frictional tape vs. glued helmet at impact against a Teflon layer, the impact against frictional tape shows a peak of 9.5 krad/sec² whereas impact against Teflon tape has a peak of 5.7 krad/sec².

Nonetheless, it can be seen that a considerable amount of rotational energy is transmitted to the head at impacts against the low frictional Teflon surface. An obvious MIPS effect (relative movement between the outer shell and the low frictional layer) is observed during impacts against the Teflon sheet, resulting in a reduction of rotational acceleration by 42.1% and rotational velocity by 12.8%.

Stockholm 2010-12-02

.....................................
Kim Lindblom
Technical Engineer, MIPS AB
Appendix A

FAQ - How do we know that it works?

• 15 years of academic research, testing helmets and validating the system.
• 3 doctoral thesis and multiple scientific articles independently verify the MIPS function and technology. Downloads at;

http://www.mipshelmet.com/facts-and-tests/research-documentation

• World leading and state of the art computer simulations of the human brain.
• Close cooperation with the Karolinska Hospital and Hans von Holst; neurosurgeon with 30 years experience.
• MIPS have a unique test rig for oblique impact testing.
• MIPS use a hybrid III crash test dummy head with 9 accelerometers to measure the rotation around each axis.
• Reconstruction of real life accidents using:
  o Real life video documentation.
  o Medical reports.
  o Simulations between the actual outcome and MIPS verifying our technology.

References

