Fig. 1. A Hong Kong Police Force report in a local newspaper.

[Image: A police report with a photo of a bicycle on a tree.]
Fig. 1.3 A typical accident showing the risk for head and neck injuries
Fig 1.4 The risk of head injury and brain injury in helmeted cyclists compared to unhelmeted cyclists.

![Diagram of helmet with text](image)

All parts of the helmet work together to help prevent injury.

- Every approved helmet contains a dense liner that absorbs most of the energy upon impact.
- The straps and buckle keep the helmet secure during a crash.

Fig. 1.5 A schematic diagram of a bicycle helmet.
ANATOMY OF PROWELL HELMET

In-Mold Rigidity - found on every Prowell helmet. The outer shell is 100% bonded to our advanced EPU shock-absorbing foam during our unique EPU in-mold foaming process, which greatly helps the quality, safety, and durability of a helmet. Prowell even molds a lower shell to wrap around the weakest lower liner part for enhanced durability!

C-Rib Design - found on the Raptor™ helmet. The molded C-shape ribs could provide the best ventilation and light-weight without sacrificing any safety.

ITW’s Best Buckle - To guarantee the best safety and stability, Prowell is using the ITW’s best buckle to couple with such a great helmet!

LocWELL RS - The most easy and practical retention system, enhancing the fit and stability of Prowell helmets.

Real Aerodynamic Vents - the vents on all Prowell helmets are engineered to meet the aerodynamics, to provide the best ventilation, and to complete the excellent designs.

Tubular Nylon Straps - our soft and flexible tubular straps will touch your skin more tenderly and comfortably.

Fig 1.6 A typical bicycle helmet structure of Prowell™ Helmet

Fig 1.7 A typical bicycle helmet structure of Giro™ Helmet
Fig. 2.1 Various strikers used in impact and penetration tests

Flat Striker
Hemispherically-nosed Striker
Penetration Striker

Fig. 2.2 Different Impact cases

Fig. 2.3 Stress–strain curve for compression test of EPU foam with 96 kg/m³
Fig. 2.4 Stress-strain curve from tensile test of EPU foam with 96 kg/m³.

Fig. 2.5 Load vs. time for flat striker.

Fig. 2.6 Load vs. time for hemispherical-nosed striker.
Fig. 2.7 Load vs. time for penetration striker

Fig. 2.8 Load vs. vertical displacement for flat striker

Fig. 2.9 Load vs. vertical displacement for hemispherical-nosed striker
Fig. 2.10 Load vs. vertical displacement for penetration striker

Fig. 2.11 Energy vs. vertical displacement for flat striker

Fig. 2.12 Energy vs. vertical displacement for hemispherical-nosed striker
Fig. 2.13 Energy vs. vertical displacement for penetration striker

Fig. 2.14 Average peak load vs. impact energy level for different strikers
Fig. 2.15 Specimens after of the quasi-static tests

Fig. 2.16 Crack occurred after impact by the hemispherical-nosed striker

Fig. 2.17 Crack occurred after impact by the penetrationstriker
Fig. 2.18 Load vs. time for the hemispherical-nosed striker with different shell thickness

Fig. 2.19 Load vs. vertical displacement for the hemispherical-nosed striker with different shell thickness

Fig. 2.20 Energy vs. vertical displacement for the hemispherical-nosed striker with different shell thickness
Fig. 2.21 Impact-damaged area versus depth of dent by impact

Fig. 2.22 Impact-damaged area versus incident kinetic energy
Fig. 2.25 Load vs. vertical displacement with different foam thickness (Quasi-static)

Fig. 2.26 Energy vs. vertical displacement with different foam thickness (Quasi-static)
Fig. 2.27 Load vs. vertical displacement with different foam thickness (Impact)

Fig. 2.28 Energy vs. vertical displacement with different foam thickness (Impact)
Fig. 2.29 The photos showing the various failure patterns with different foam thickness

Fig. 2.30 Initial peak load vs. foam thickness

Fig. 2.31 Energy absorbed till the initial peak load vs. foam thickness

Fig. 2.32 Energy absorbed till the initial peak load per mass vs. foam thickness
Fig. 2.33 Comparison of the load vs. vertical displacement for samples of 26 mm thickness under fully-backed and simply-supported conditions, impacted at initial velocity of 2.7 m/s (25J)

Fig. 2.34 Load vs. vertical displacement with skin effect on 13 mm thickness samples
Fig. 2.35 Load vs. vertical displacement with skin effect on 26 mm thickness samples

Fig. 2.36 Energy vs. vertical displacement with skin effect on 13 mm thickness samples
Fig. 2.37 Energy vs. vertical displacement with skin effect on 26 mm thickness samples

Fig. 2.38 Initial peak load vs. Foam thickness

Fig. 2.39 Energy absorbed to the initial peak load vs. Foam thickness
Fig. 3.2 A Schematic diagram of our bicycle helmet testing machine
Fig. 3.3 A tested helmet holds on a standard headform and drop arm

Fig. 3.4 An accelerometer inside the headform
Fig. 3.5 Three different anvils (Flat, Hemisphere and Curbstone)

Fig. 3.6 Velocity sensor (transmitter and receiver)
Fig. 4.1 Schematic diagram for whole helmet impact

Fig. 4.2 Maximum head acceleration as a function of impact energy
Fig. 4.4 The relationship between acceleration and time of bicycle helmets tested on flat anvil

Fig. 4.5 The relationship between energy absorbed and time of bicycle helmets tested on flat anvil

Fig. 4.6 a) The cross-section of 25J-tested sample (tested on flat anvil)
Fig. 4.6 b) The cross-section of 50J-tested sample (tested on flat anvil)

Fig. 4.6 c) The cross-section of 100J-tested sample (tested on flat anvil)

Fig 4.7 a) 25J-tested sample (tested on flat anvil)

Fig 4.7 b) 50J-tested sample (tested on flat anvil)

Fig 4.7 c) 100J-tested sample (tested on flat anvil)
Fig. 4.8 The relationship between acceleration and time of bicycle helmets tested on hemispherical anvil

Fig. 4.9 The relationship between energy absorbed and time of bicycle helmets tested on hemispherical anvil
Fig. 4.10 a) The cross-section of 25J-tested sample (tested on hemispherical anvil)

Fig. 4.10 b) The cross-section of 50J-tested sample (tested on hemispherical anvil)

Fig. 4.10 c) The cross-section of 100J-tested sample (tested on hemispherical anvil)
Fig. 4.11 a) 25J-tested sample (tested on hemispherical anvil)

Fig. 4.11 b) 50J-tested sample (tested on hemispherical anvil)

Fig. 4.11 c) 100J-tested sample (tested on hemispherical anvil)

Fig. 4.12 The relationship between acceleration and time of bicycle helmets tested on curbstone anvil
Fig. 4.12 The relationship between energy absorbed and time of bicycle helmets tested on curbstone anvil.

Fig. 4.13 a) 50J-tested sample (tested on curbstone anvil)

Fig. 4.13 b) 100J-tested sample (tested on curbstone anvil)
Fig. 4.14 The relationship between acceleration and time in the second impact at 100J (first impact on flat anvil)

Fig. 4.15 The relationship between energy absorbed and time in the second impact at 100J (first impact on flat anvil)
Fig. 4.16 The outlook of the tested helmet after the second impact on flat anvil at 100J (first impact on flat anvil at 25J)

Fig. 4.17 The outlook of the tested helmet after the second impact on flat anvil at 100J (first impact on flat anvil at 100J)
Fig. 4.18 The relationship between acceleration and time in the second impact at 100J (first impact on hemispherical anvil)

Fig. 4.19 The relationship between energy absorbed and time in the second impact at 100J (first impact on hemispherical anvil)
Fig. 4.20 The outlook of the tested helmet after the second impact on flat anvil at 100J (first impact on hemispherical anvil at 25J)

Fig. 4.21 The outlook of the tested helmet after the second impact on flat anvil at 100J (first impact on hemispherical anvil at 50J)

Fig. 4.22 The outlook of the tested helmet after the second impact on flat anvil at 100J (first impact on hemispherical anvil at 100J)
Fig. 4.23 The relationship between acceleration and time in the second impact at 100J (first impact on curbstone anvil)

Fig. 4.24 The relationship between energy absorbed and time in the second impact at 100J (first impact on curbstone anvil)
Fig. 4.25 The outlook of the tested helmet after the second impact on flat anvil at 100J (first impact on curbstone anvil at 25J)

Fig. 4.26 The outlook of the tested helmet after the second impact on flat anvil at 100J (first impact on curbstone anvil at 50J)

Fig. 4.27 The outlook of the tested helmet after the second impact on flat anvil at 100J (first impact with curbstone anvil at 100J)
Fig. 5.2 Impact of a bicycle helmet on a flat anvil

Fig. 5.3 The normal force and the friction between the comfort foam and the headform
Fig. 5.4 Schematic diagram of the MSDG model

Fig. 5.5 The force-strain curve of a comfort foam, for a contact area of radius 65mm
Fig. 5.6 The quasi-static compression curve for EPU foam of density 96 kg/m³

Fig. 5.7 Modeling of crushed liner of bicycle helmet under impact
Fig. 5.8 Predicted contact force between a flat anvil and a foam liner of radius \( R = 150 \text{mm} \), as a function of the central displacement. An unloading path is shown with an arrow.

Fig. 5.9 Compression of the comfort foam; liner crush and elastic deflection of the shell vs. time for an impact on a flat anvil at 6.32 m/s.
Fig. 5.10 Predicted headform and the helmet acceleration under the same conditions as Fig. 5.8

Fig. 5.11 The numerical simulation for headform acceleration from the model
Fig. 5.12 Experimental result from the whole helmet impact test

Fig. 5.13 Comparison between the simulated results for the predicted headform's acceleration on the damping effect at 6.32 m/s impact
Fig. 5.14 Comparison between the simulated results for the predicted headform's acceleration with various physical gap at 6.32 m/s impact

Fig. 5.15 Comparison between the simulated results for the predicted headform's acceleration with various yield stress at 6.32 m/s impact
Fig. 6.1 The schematic diagram of grid-domed TC

Fig. 6.2 Computerized structure of grid-domed TC

Fig. 6.3 Load vs. vertical displacement of grid-domed TC and EPU under static compression

Fig. 6.4 Energy vs. vertical displacement of grid-domed TC and EPU under static compression
Fig. 6.10 Four small strips of TC slots

Fig. 6.11 Three large pieces of TC layers as liner

Fig. 6.12 Impact result of 1 layer structure TC helmet under different energy level
Fig. I.1 The schematic diagram of wind tunnel

Fig. I.2 Wind Tunnel

Fig. I.3 The tested helmet inside the test section

Fig. I.4 Three brunch of the Aerogo™ samples
Fig. 1.5  a) Front view and b) side view of 338 series

Fig. 1.6  a) The whole flow pattern, b) Flow pattern at the real portion, c) A close-up of the front portion, d) The stagnation point, e) Air goes in underneath
Fig. 1.7 a) Front view and b) side view of 368 series

Fig. 1.8 a) The whole flow pattern, b) Flow pattern at the front portion, c) Flow pattern around the top vent, d) A close-up on the front portion, e) Air goes in underneath
Fig. I.9 a) Front view and b) side view of 388 series

Fig. I.10 a) The whole flow pattern, b) Shooting from another view, c) A close-up on the front portion, d) The stagnation point, e) Air goes in underneath
Fig. 1.12 Measuring the wind speed with wind speed meter

Fig. 1.13 The four measurement locations
Fig. I.14 a) $T(P_1)$ of EPS and EPU helmets

Fig. I.14 b) $T(P_2)$ of EPS and EPU

Fig. I.14 c) $T(P_3)$ of EPS and EPU helmets

Fig. I.14 d) $T(P_4)$ of EPS and EPU

Fig. I.15 The temperature difference of $T(P_1)$ and $T(P_4)$ at different wind speeds.