HOW HELMETS WORK

The Impact of Impacts

By Bill Wood

Thunk!

The sound was violent, but curiously undramatic. I had expected the complete destruction of a motorcycle helmet to be more spectacular. I had braced myself for some noise that would signal disaster—like the squealing of tires and wrenching of metal in a traffic accident. But as my helmet ended its 10-foot drop on the testing stand at the Head Protection Research Laboratory at the University of Southern California, there was just a dull, lifeless sound that was, in a way, more ominous.

Fortunately, there was little to worry about in this collision. The "head" inside the helmet was no more than an 11-pound metal headform—the motorcycling equivalent of those crash-test mannequins who have become "spokes-dummies" for seat-belt use among car drivers.

Like those test dummies, this headform had a story to tell. Inside it, in place of a living human brain, were electronic sensors capable of measuring the damage that would have been inflicted in a real motorcycle crash.

"That's a good helmet," said Harry Hurt, looking at the oscilloscope's presentation of the sensor data.

More correctly, that was a good helmet. I had worn it for years. But I knew that once I delivered it to Harry Hurt's lab, its fate was sealed. The lab has been in operation since 1961, and during that time, Hurt and Dave Thom, the two lead researchers, have destroyed thousands of helmets. In the process, they've learned exactly what makes a helmet work.

Most of us tend to think of a helmet as a hard shell that forms an impenetrable barrier around the skull, much like the metal helmets worn by troops during World War II. As long as that shell remains intact, we figure the helmet is doing its job.

But a modern motorcycle helmet is much more complex than that. Sure, it does have a hard outer shell designed to prevent objects from striking the head, but that's not the most important part. The vital piece in saving your life in most accidents is the part that most of us see—and appreciate—least. It's the layer of expanded polystyrene (Styrofoam to most of us) just underneath the shell that works like a braking system for the brain. The testing stand at USC's lab gives an accurate picture of how well that system works.

To understand how a helmet does its job, you have to picture a typical motorcycle accident: A car turns left in front of a motorcyclist. The rider hits the brakes, but he can't stop in time.

If you could watch the next fractions of a second in slow motion, you'd see not just one collision between bike and car, but a whole series of collisions. First, the front wheel of the motorcycle hits the car and the bike comes to a stop. But the rider doesn't. He still has most of the forward momentum he had just before the crash. So he's launched off the motorcycle toward the car—on the way to his own collision with it.

For a moment, let's forget about the rider's arms, legs and chest and concentrate just on his head, which is still moving at full speed. In the next instant, that head is going to hit something—the car, the ground, whatever—and come to an immediate halt.

Without a helmet, the force of the collision can fracture the skull and cause severe damage to the brain. This is a common problem in car accidents in which the victim isn't wearing a seat belt and slams into the windshield with tremendous force.

But a simple hard-shell helmet would do little more to protect the rider, since it won't help dissipate the momentum built up in the head and brain. An instant after the helmet hits the car, the head is going to hit the inside of the helmet. And the rider's brain, with all of its momentum, is going to hit the inside of the skull. So there are going to be two more collisions—almost like a chain-reaction accident—with the brain taking the brunt of the hit.

Obviously, the brain isn't designed for such abuse. So what you need is a system that will bring the head to a gradual, controlled stop rather than an instantaneous, violent one. Over the years, scientists have studied the amount of force the brain can take and survive. That force is measured in terms of gravity, or Gs—just like the acceleration force astronauts feel when they take off in the space shuttle. Researchers have learned that a human brain can withstand quite a lot of acceleration or deceleration force for a brief period of time. While the astronauts may experience 10 or 11 Gs for a minute or two during takeoff, the brain can survive several hundred Gs for a millisecond or so without permanent injury.

But in a collision, G forces can easily rise much higher than that. If the head hits an immovable object and instantly stops, the deceleration forces can rise to thousands of Gs, and the result is likely to be death due to brain injury.

That's why you'll find a Styrofoam liner in motorcycle helmets. In a crash, this liner crushes slowly, just the way you can crush the Styrofoam of a coffee cup between your thumb and forefinger. As it crushes, the liner absorbs the momentum of the head, cutting down the G forces and giving it some "braking distance" after the helmet has struck an immovable object like a car or the street. Instead of hitting the inside of a the Jicarilla Apache Indian Reservation, where huge rock formations stand like stone fortresses on the hills.

But there was a price to pay for my enjoyment: As I neared the crest of the Continental Divide, a biting cold set in. Snow was still piled in spots along the road and my faceshield frosted up in the frigid breeze. I had always thought of New Mexico as hot desert, but this trip destroyed that illusion forever.

I followed Route 64 all the way to Taos, where I hoped to see the Pueblo de Taos Indian Reservation. But Taos is also the gateway to the Enchanted Circle, one of the best motorcycling loops in northern New Mexico, or anywhere else, for that matter.

I headed east out of town on Route 64, riding into the Sangre de Cristo Mountains and the Carson National Forest. The long, sweeping curves tightened until I was laying the bike over in one direction, then the other. A runner using the shoulder of the road saw me heeled over in a turn and smiled. I waved and continued onward.

The Enchanted Circle turns north on state Route 38. There, the terrain changes from mountain scenery to ranch country. But soon the road dips back into the national forest and the scenery kicks into high gear again.

The final section of the Enchanted Circle consists of state Route 522. According to the map on my tankbag, it looked like a mostly straight shot back into Taos—with nothing particularly enchanting about it. So I made a quick decision and turned the bike around, riding my own Enchanted Semi-Circle backward to Taos. Any great road should always be ridden at least twice, once to appreciate the scenery and once to enjoy the road itself.

●

The Pueblo de Taos shows just how strong an influence the Anasazi may have had on their neighbors. Its adobe buildings, which offer living space for 150 people, rise five stories above a central square. It is the largest multi-story pueblo in the U.S., and it's estimated that it has been inhabited for approximately 1,000 years.

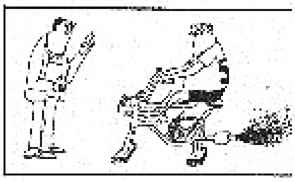
The people of Taos live the way they always have—without running water, electricity or other conveniences we take for granted. And they continue to practice the rich traditions of their ancestors, although their oral history is seldom explained or revealed to outsiders.

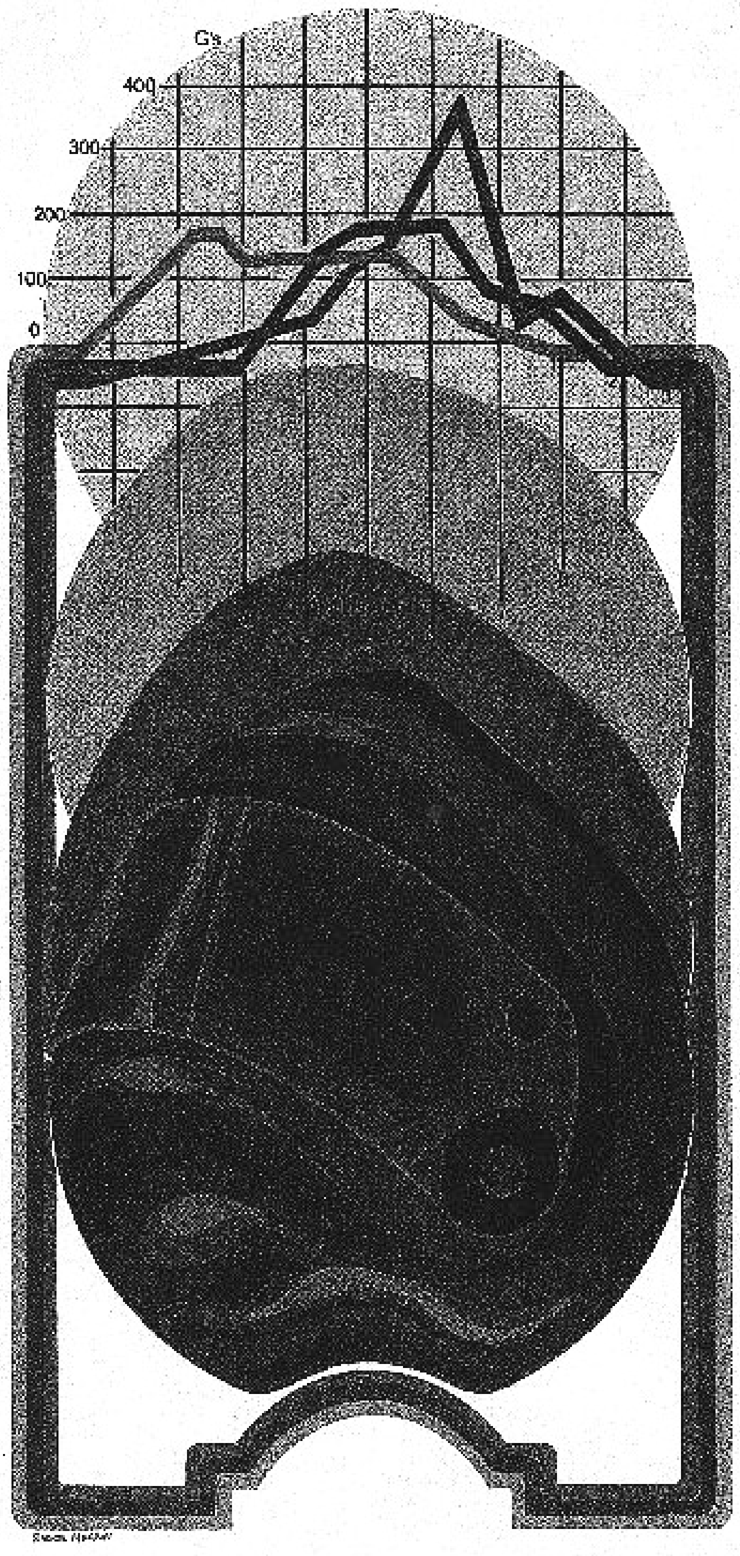
Taos Pueblo was made a National Historic Landmark in 1965 and was nominated as a significant historical site to the World Heritage Society in 1987, which would place it on a par with Chaco Culture National Historic Park and the Great Pyramids of Egypt.

While built of a different material, the structure at Taos looks strikingly similar to Pueblo Bonito and the other ru
Chaco Canyon. It might just be a c
different groups independently d
ering a similar construction metho
works in the area where they live. B
also entirely possible that Taos P
represents the living legacy o
Anasazi—nearly 1,000 years after
disappearance.

Taos also made a fitting conclus
my trip back in time in northern
Mexico. At Sandia Cave, I had c
vered the beginnings of a cultur
sprang up 10,000 years ago. At C
Canyon, Zuni Pueblo and Aztec R
found remains of that culture at its
And in Taos, I saw something even
rare: Instead of examining the ske
left behind by that culture, I saw a l
vibrant example of an original Am
civilization.

It's been there all along—since b
most of our ancestors even knew
was an America. And I hope it w
there for a long time to come, as a l
that American history didn't begi
Christopher Columbus. ■





hard helmet shell, the rider's head
the Styrofoam liner, which slows i
gradual stop. That liner is only abou
inch to an inch-and-a-quarter thic
most helmets, which may not seem
a lot, but that crushable layer is us
all that's necessary to save a moto
clist's head.

"You can take it as a given that w
good helmet, the basic architectu
the skull and brain are going to survi
says Hurt. "You might suffer some i
ies that the helmet can't prevent,
deep brain injuries from rotation,
you're not going to get fractured sl
and extrusion of the brain out of
skull. The head's still going to be in g
shape."

Hurt knows that because he ha
just studied helmets in a lab. His
search into real-world motorcycle a
dents in the 1970s, commonly know
the Hurt Report, is the most comp
hensive examination of the topic
undertaken. And although helmet te
nology has progressed in the y
since, Hurt found that even 15 years
helmets worked in almost every cas

"People do die with helmets
Hurt admits, "and it can happen due
brain injury. But it's so rare that it's
ridiculous. The more usual thing is
the people who died while wearin
helmet died from serious injuries to
chest and other parts of the body."

A case in point is a helmet on
windowsill next to Hurt's desk. The
face helmet was hit so hard that it li
ally cracked in half.

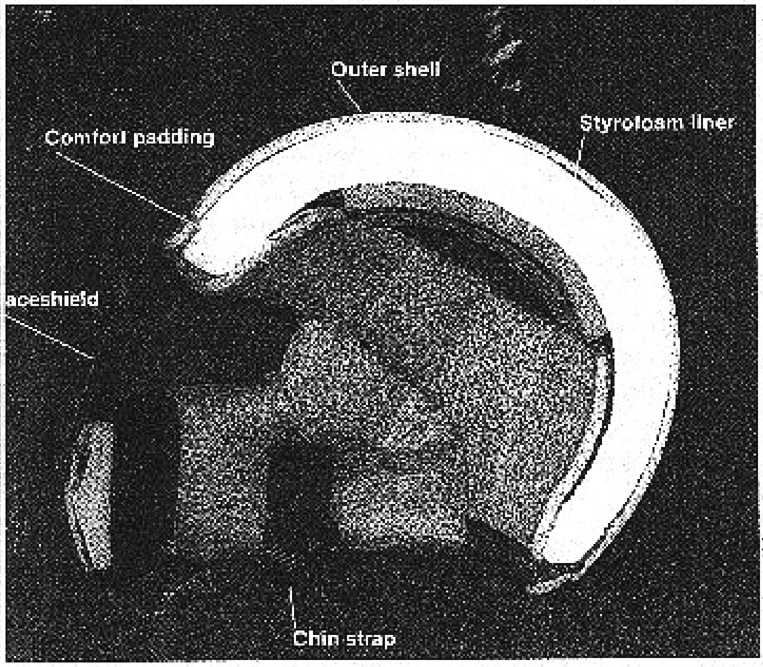
No, Hurt said, the rider didn't surv
"But he died of chest injuries, not s
or brain injuries. The helmet did its j

Motorcycle safety isn't just an
demic interest for Hurt and Thom. B
own and ride their own bikes, and
result, they understand the importa
of real-world experience in any sa
research.

Studies of actual accidents are
best way to determine what a hel
needs to do in a crash. But to see h
well an individual helmet performs
job, you need a consistent, repeata
test. And that's where the Head Prot
tion Research Lab comes in. The
contains three helmet testing sta
allowing Hurt and Thom to judge h
met effectiveness according to sev
different standards including the
partment of Transportation (DOT) sp
fication required of all helmets sold
street use in the U.S., the voluntary S
Memorial Foundation standard and E
pean helmet standards.

All of the tests result in violent hel
impacts. There are no glancing blow
lucky breaks in the testing lab. In ev
test, the helmet is strapped to the he
headform, raised up several feet

Cont



Photos by Cleary Blair

Researcher Harry Hurt examines a helmet's inner lining after testing.

dropped directly onto a solid chunk of metal appropriately known as an anvil. The force of the collision is enough to make a believer out of anyone.

The results appear as a line on the oscilloscope screen showing the G forces on the head. In the case of my helmet, that line showed a steady rise in G forces as the headform compressed the helmet's foam rubber comfort pads, then encountered the Styrofoam liner. The forces rose to about 180 Gs, then the liner began crushing at a constant rate, slowing the headform at about 150 Gs for three milliseconds—just like hitting the brakes for a smooth, controlled stop.

As Hurt noted, my helmet had performed perfectly. It didn't approach the Snell Memorial Foundation's limit of 300 Gs and it didn't violate the DOT requirement that G forces not exceed 200 Gs for more than two milliseconds.

I asked Thom what would happen if he dropped the bare headform onto the anvil from the same height. He said he couldn't do that because it would destroy the instruments and dent the metal. Replace that metal headform with an unhelmeted head and you've got an idea of the damage that could be caused.

But the test wasn't over. The standards call for a second direct hit on the same spot. So Thom raised the helmet again—this time 6.7 feet above the anvil—and let it drop.

Once again, the helmet hit with tremendous force—hard enough to visibly damage the outer shell. And the Styrofoam liner, compressed somewhat by the previous collision, was thinner now. So the headform took longer—about three milliseconds—before it encountered that liner and the G forces st
to rise. The compressed Styrofoar
also a little denser than it used to
the oscilloscope line rose to near
Gs before leveling out. But the for
the head was still smooth and
trolled.

I asked Thom if that helmet w
safe to use. For a dramatic repl
raised it and dropped it again. Wi
Styrofoam liner now severely
pressed by the two previous hit
headform sailed along for about
milliseconds before encounterin
resistance. Then the oscillos
showed a spike in which force
immediately to over 300 Gs befor
ering off. Like an old set of shoc
your motorcycle, the helmet's line
bottomed out dangerously and ne
to be replaced.

Thom then disassembled the h
taking out the Styrofoam liner. Fro
inside, the part you can see lookin
the helmet, it looked just fine. B
outer surface, the layer against th
met shell, was seriously crushed
measuring only about a half-inch

I don't wear that helmet anymo
I haven't thrown it out, eithe
mounted it—disassembled—on r
fice wall, with a photo of the test
right below. Every time I pull on m
helmet for the ride home from v
look at that crushed liner and he
"chunk" all over again. It usually
me pull the chin strap just a
tighter. ■

Getting the most from your helmet

How good is your old helmet? How do you know when it's used up? And what should you look for in a new helmet?

Those are the questions motorcyclists most often face when considering head protection. And researchers Harry Hurt and Dave Thom are among those in the best position to provide the answers.

For instance, Thom says the old notion that a helmet won't protect you after a few years of use just isn't valid. Some helmets can last many years, he says, while others may be used up in months.

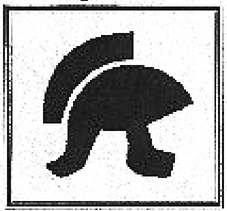
If you've been in an accident and your helmet has been hit, it's time to replace it, regardless of its age. Even if

See HELMET on page 67

BRAIN BUCKETS

The first modern safety helmets were developed during the 1950's for airplane pilots. Today's brain buckets are still produced according to those basic principles founded over 40 years ago. To be effective a helmet must do three things. First, it must furnish a barrier to prevent objects like bumpers and pavement from contacting the head. Secondly, it should distribute the impact or have a lining that will absorb the energy from the impact. Lastly, it must stay on to be effective.

In an accident there is not one, but three separate impacts involving the rider. For example: The hard outer shell strikes the object, say the pavement. This is followed by the riders head, still carrying momentum, striking the inner liner of the helmet. Finally, the brain itself, which "floats" inside the head, strikes the skull. Note that there is usually more than one "impact" per accident. Rider hits vehicle (1), falls to pavement (2), and then stops when he hits the curb(3).



Obviously the brain is not designed for this abuse. However, research has shown that the brain can take a great deal of acceleration or deceleration provided it is delivered in a very short time frame. How high? "G" forces can climb to over 300 for a few milliseconds during an impact with no permanent damage.

Manufacturers have taken many different approaches to shell structure. The most expensive helmets are made from Kevlar and Carbon Fiber. The most common are made with fiberglass, laminated being stronger than chopped or sprayed fiberglass. Other materials include ABS, injection molded plastic and Ronfalin. The one thing they all have in common is a liner of expanded polystyrene foam. Since the foam can be custom blended to each manufacturers specifications a good deal of research is poured into the foam to insure it meets the required specifications.

Chin straps are almost always found to be "D" rings. They are simple and they work! A few quick release systems, like those found on BMW's are available, but steer clear of plastic imitations. Several cases of injury or death have been attributed to helmets having come loose between the first and second impacts (car, pavement).

Snell or DOT, which standards are better? Tests have shown that some Snell helmets may fail one or more DOT testing standards. Proponents of Snell claim that the Snell tests represent a more "real world" approach to testing in motorcycle accidents. Regardless, researchers say that any DOT helmet should provide the motorcyclist with adequate protection in 90% of the accidents he may encounter. (If you've noticed, the better helmets carry both the DOT and Snell ratings).

Helmet fit is equally as important as the quality of the helmet. A good helmet should fit snuggly. It should fit squarely on the head and shouldn't push away at the rear causing it to roll down over the eyes. Check pads should not cause excessive pressure points. Like shoes, helmets will break in a little with wear. The biggest mistake people make is buying a helmet that is too large.

Maintenance on your helmet is simple. Wash with mild soap and water only. Solvents, like gasoline or paint thinner can damage the shell. Should you fall off the bike, even if you did not hit very hard, have the helmet inspected anyway. If in doubt, replace it.

"The contemporary M/C helmet provides a spectacular reduction of head and neck injury, without any adverse effect on vision or hearing"

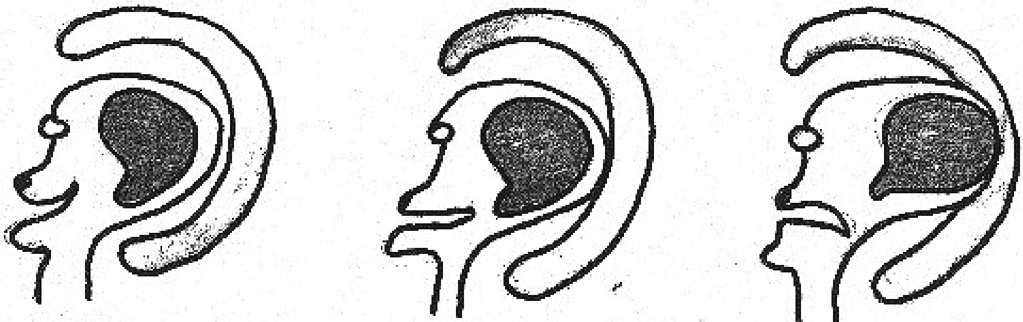
Hurt Report

Among the findings of the "Hurt Report", injuries were most common to the ankle-foot, lower leg, knee and upper thigh. The most deadly injuries to the accident victim were injuries to the head and chest. Safety helmet use caused no attenuation of critical traffic sounds, no limitation of pre-crash visual field, and no fatigue or loss of attention. Helmeted riders and passengers showed significantly lower head and neck injuries for all types of injury, at all levels of injury severity. No element of an accident's cause was related to helmet use.

Remember, all safety equipment has limits. They improve chances for survival but don't guarantee it. There is no substitute for good, safe riding practices. NHTSA estimated that helmets saved 66 lives in 1998, in Florida alone. A significant figure, especially if you were one of the 66.

Ride Safe,

HOW HELMETS WORK



SHELL HITS OBJECT | SKULL HITS FOAM | BRAIN HITS SKULL