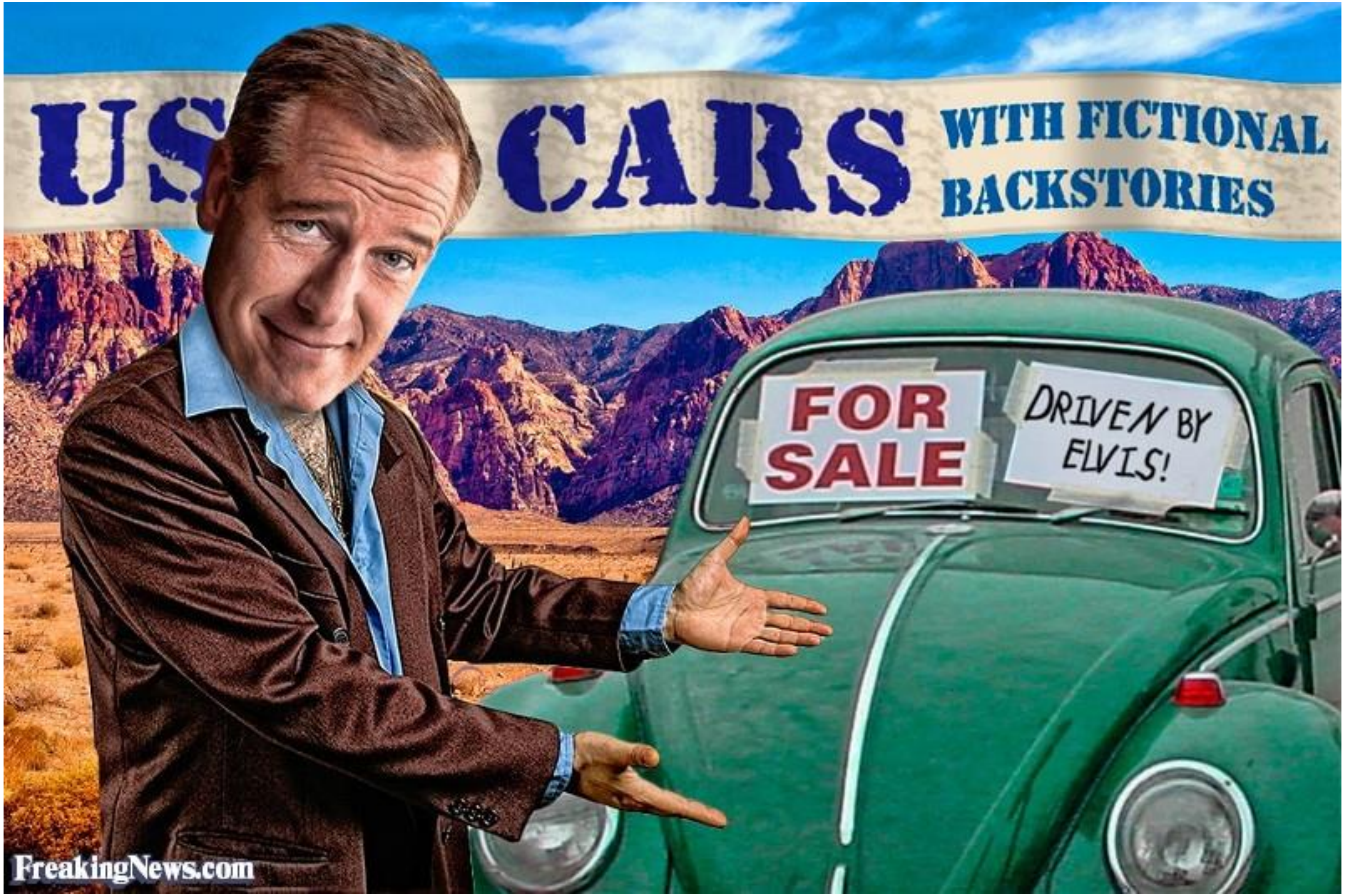
Hard Hats to Helmets

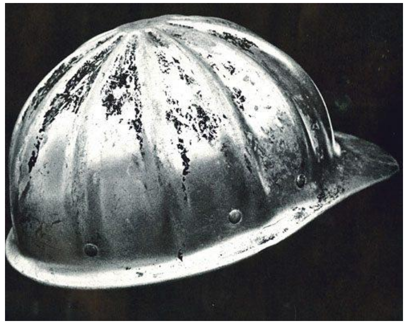
Scott Greenhaus and Seth Randall


US CARS
WITH FICTIONAL BACKSTORIES
FOR SALE
DRIVEN BY ELVIS!
FreakingNews.com

Looking At The Past

1919

Bullard for mining and then Navy ship building. Made from boiled canvas, black paint and glue



1930's

Hard hats evolved and were made from metals

1940's

MSA Skullguard fiberglass


1969
MSA in Space
MORE INFO
1960s
International
MORE INFO
1961
New Helmets Introduced
In 1961, the Topgard® Helmet was introduced, which was the first polycarbonate hardhat. Polycarbonate is an extremely durable plastic that is very difficult to crack or break. A year later in 1962, the V-Gard® Helmet launched. Today, both helme
are part of the family of "best-selling helmets."
1960s
Gas Masks for the military
MORE INFO
1960 - 19
VIEW ALL EVENTS THIS
20s 1930s 1940s 1950s 1960s 1970s 1980s

OSHA Requirement

- **Part Number:** 1926
- **Part Title:** Safety and Health Regulations for Construction
- **Subpart:** E
- **Subpart Title:** Personal Protective and Life Saving Equipment
- **Standard Number:** 1926.100
- **Title:** Head protection.
- **Applicable Standards:** 1910.135
- **GPO Source:** e-CFR

In Short: Provide ANSI Z89.1 *OR* Prove Equivalent

1926.100(a)

Employees working in areas where there is a possible danger of head injury from impact, or from falling or flying objects, or from electrical shock and burns, shall be protected by protective helmets.

1926.100(b)

Criteria for head protection.

1926.100(b)(1)

The employer must provide each employee with head protection that meets the specifications contained in any of the following consensus standards:

1926.100(b)(1)(i)

American National Standards Institute (ANSI) Z89.1-2009, "American National Standard for Industrial Head Protection," incorporated by reference in §1926.6;

1926.100(b)(1)(ii)

American National Standards Institute (ANSI) Z89.1-2003, "American National Standard for Industrial Head Protection," incorporated by reference in §1926.6; or

1926.100(b)(1)(iii)

American National Standards Institute (ANSI) Z89.1-1997, "American National Standard for Personnel Protection-Protective Headwear for Industrial Workers-Requirements," incorporated by reference in §1926.6.

1926.100(b)(2)

The employer must ensure that the head protection provided for each employee exposed to high-voltage electric shock and burns also meets the specifications contained in Section 9.7 ("Electrical Insulation") of any of the consensus standards identified in paragraph (b)(1) of this section.

1926.100(b)(3)

OSHA will deem any head protection device that the employer demonstrates is at least as effective as a head protection device constructed in accordance with one of the consensus standards identified in paragraph (b)(1) of this section to be in compliance with the requirements of this section.

[77 FR 37600, June 22, 2012; 77 FR 42988, July 23, 2012]

Weaknesses in the U.S. Standards, Regulations, and User Understanding

- ANSI Z89.1:
  - Type I hard-hats are only designed for impacts to the crown of the helmet
  - Type II hard-hats offer more protection, but still about an object impacting the helmet, not a fall.
  - Retention systems such as chin straps are completely optional

- OSHA:
  - Only addresses minimum standards:
  - Leaves hazard assessment and additional protection measures up to the employer.

- The User:
  - Doesn’t have an awareness of the different types of helmets or technologies.
  - Assumes that OSHA and the standards have accounted for the relevant hazards.
  - Type I hard-hats become the de-facto helmet of the industry.

Relevant International Standards

- European Standard(s)
  - EN 12492 – Helmets for Mountaineers
  - EN 397 – Specification for Industrial Safety Helmets (ANSI Type 1)
  - EN 14052 – High Performance Industrial Helmets (ANSI Type 2)

Comparison of All Standards

Tested For	**ANSI Type 1 (OSHA Min)**	**ANSI Type 2**	**EN 397 Industrial Helmet**	**EN 14052 HP Industrial Helmet**	**EN12492 Mountaineering**
Top Impact	Yes	Yes (Same as Type 1)	Yes	**Yes** (2x ANSI)	Yes
Lateral Impact	No	Yes	No	Yes	**Yes**
Top Penetration	Yes (Conical)	Yes (Same as Type 1)	Yes (Conical)	**Yes** (Flat Blade)	**Yes** (Conical)
Lateral Penetration	No	Yes (Conical)	No	**Yes** (Flat Blade)	**Yes** (Conical)
Helmet Retention	No	Opt.	Opt.	Yes	**Yes**

Bold indicates more stringent requirement

Isn’t There Something Better?

Innovation In Fall Protection

First Chance

- August 2012 – City Center DC
- Employee fell 4 feet while dismantling a 2 tier scaffold
- Hard hat fell off
- Induced coma for 3 nights
- No return
- Direct cost of $367,133


MSA

Safety+Health
The Official Magazine of the NSC Congress & Expo

From 2003 to 2010, 2,210 fatal TBIs occurred in construction at a rate of 2.6 per 100,00 FTE workers.

Home

NIOSH: Construction workers at high risk for traumatic brain injuries

March 29, 2016

Morgantown, WV – Construction workers sustain more traumatic brain injuries than employees at any other type of workplace in the United States, according to a recent report from NIOSH.

Safety interventions must be emphasized in the construction industry, in which more than 2,200 workers died of a traumatic brain injury from 2003 to 2010, researchers said.

Traumatic brain injuries represented one-quarter of all construction fatalities during the eight-year study period, according to the report. More than half of fatal work-related traumatic injuries were a result of falls – particularly from roofs, ladders and scaffolds. Workers 65 and older were nearly 4 times more likely to sustain a fatal traumatic brain injury than workers 25 to 34 years old. Meanwhile, workers at organizations with fewer than 20 employees were more than 2.5 times more likely to die from a traumatic brain injury than those who worked for organizations with more than 100 employees.

Srinivas Konda addressed the findings in a March 21 NIOSH blog post. Konda is an associate service fellow in the NIOSH Division of Safety Research

AMERICAN JOURNAL OF INDUSTRIAL MEDICINE 59:212–220 (2016)

Fatal Traumatic Brain Injuries in the Construction Industry, 2003–2010

Srinivas Konda, MPH,* **Hope M. Tiesman,** PhD, **and Audrey A. Reichard,** MPH

Background *Research on fatal work-related traumatic brain injuries (TBIs) is limited. This study describes fatal TBIs in the US construction industry.*
Methods *Fatal TBIs were extracted from the Bureau of Labor Statistics Census of Fatal Occupational Injuries.*
Results *From 2003 to 2010, 2,210 fatal TBIs occurred in construction at a rate of 2.6 per 100,000 full-time equivalent (FTE) workers. Workers aged 65 years and older had the highest fatal TBI rates among all workers (7.9 per 100,000 FTE workers). Falls were the most frequent injury event (n = 1,269, 57%). Structural iron and steel workers and roofers had the highest fatal TBI rate per 100,000 FTE workers (13.7 and 11.2, respectively). Fall-related TBIs were the leading cause of death in these occupations.*
Conclusions *A large percentage of TBIs in the construction industry were due to falls. Emphasis on safety interventions is needed to reduce these fall-related TBIs, especially among vulnerable workers.* Am. J. Ind. Med. 59:212–220, 2016. Published 2016.

Breakdown Of The NIOSH Study

- 388 (24%) fell from roofs
- 301 (24%) fell from ladders
- 212 (17%) fell from scaffolds/staging
- 19 employees fell and dies from the same walking/working surface

Falls	n (%)
Fall to lower level	1,221 (96)
Fall to lower level, unspecified	28 (2)
Fall to down stairs or steps	14 (1)
Fall from floor, dock, or ground level	73 (6)
Fall from ladder	301 (24)
Fall from roof	388 (31)
Fall from scaffold, staging	212 (17)
Fall from building girders or other structural steel	50 (4)
Fall from nonmoving vehicle	66 (5)
Fall to lower level, not elsewhere classified (n.e.c)	89 (7)
Fall on same level	25 (2)
Fall to floor, walkway, or other surface	19 (2)
All other[a]	6
Other[b]	23 (2)
Total	1,269 (100)

Breakdown Of The NIOSH Study

TABLE III. Number and Rate of Fatal TBIs per 100,000 FTE Workers in the Construction Industry by Age and Event Type—US, 2003–2010

	Contact with objects and equipment		Falls		Transportation incidents		Other[a]	
Age group (in years)	n (%)	Rate	n (%)	Rate	n (%)	Rate	n (%)	Rate
16–19	—	0.9	38 (51)	2.3	20 (27)	1.2	—	0.1
20–24	46 (24)	0.6	99 (52)	1.3	39 (20)	0.5	8 (4)	0.1
25–34	95 (21)	0.4	247 (54)	1.1	107 (23)	0.5	11 (2)	0.1
35–44	92 (18)	0.4	299 (58)	1.3	101 (20)	0.4	22 (4)	0.1
45–54	62 (12)	0.3	315 (59)	1.6	114 (21)	0.6	47 (9)	0.2
55–64	40 (14)	0.5	183 (62)	2.1	57 (19)	0.7	16 (5)	0.2
65 and older	—	0.8	88 (65)	5.2	25 (19)	1.5	—	0.5
Total	363 (16)	0.4	1269 (57)	1.5	463 (21)	0.6	115 (5)	0.1

- 366 (16%) Fatalities from contact with objects and equipment. “Falling Objects”
- 463 (21%) Fatalities from transportation incidents
- 1269 (57%) Fatalities from FALLS!

Breakdown Of The NIOSH Study

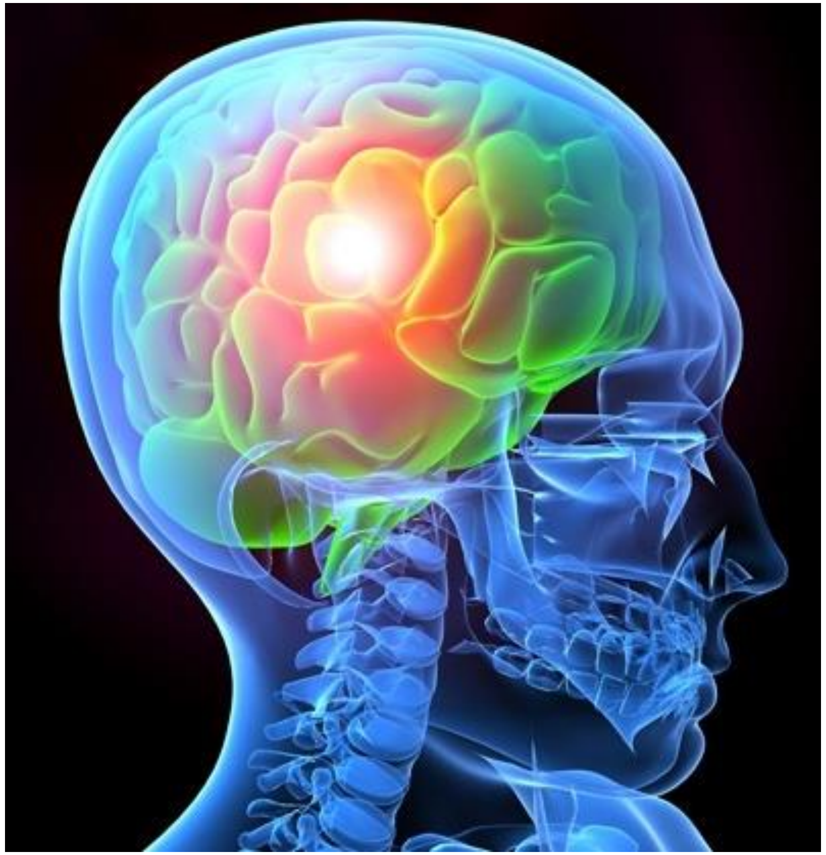
TABLE IV. Number and Rate of Fatal TBIs per 100,000 FTE Workers in the Construction Industry by Select Occupations—US, 2003–2010

Occupation	Contact with objects and equipment n (%)[a]	Falls n (%)	Transportation incidents n (%)	Total n (%)[b]	Rate
Structural iron and steel workers	10 (18)	39 (68)	—	57 (3)	13.7
Roofers	—	176 (93)	8 (4)	190 (9)	11.2
Paving surfacing and tamping equipment operators	—	—	12 (86)	14 (<1)	7.9
Electrical power-line installers and repairers	—	11 (73)	—	15 (<1)	7.6
Construction laborers	143 (26)	306 (55)	96 (17)	559 (25)	5.5
Light/heavy truck drivers	—	8 (11)	58 (79)	73 (3)	5.0
Welding, soldering, and brazing workers	8 (24)	17 (52)	—	33 (1)	4.6
Highway maintenance workers	—	—	22 (85)	26 (1)	3.7
Cement masons and concrete finishers	—	7 (35)	8 (40)	20 (1)	2.8
First-line supervisors/managers of construction trades and extraction workers	27 (15)	92 (51)	39 (22)	179 (8)	2.8
All other occupations	155 (15)	612 (59)	209 (20)	1,044 (47)	1.7
Total	363 (16)	1,269 (57)	463 (21)	2,210 (100)	2.6

- 176 falls involving roofers
- 306 falls involving construction laborers
- 92 falls involving First-line Supervisors or managers of constructions trades

Traumatic Brain Injury

- CDC defines TBI as:
  - Blow or jolt to the head or penetrating head injury that disrupts the normal function of the brain
  - Ranges from “mild” i.e., a brief change in mental status or consciousness to “severe” i.e., an extended period of unconsciousness or amnesia after the injury. Potentially fatal.



Traumatic Brain Injury vs “Other Injury”

- “Other Injury” usually limits the affected body part
  - Fractures and lacerations

- TBI can be acute but mostly occurs chronically.

- TBI affects brain function with symptoms such as headaches, memory lost, concentration, loss of balance, depression and seizures.

- Not easily diagnosed

- Prolonged onset of symptoms

Second Opportunity

U.S. Department of Labor
Email Subscription Service

Safety Pays, Falls Cost: Clark Construction Group LLC hosts OSHA Fall Safety Stand-Down event at National Museum of African American History and Culture on June 5

United States Department of Labor sent this bulletin at 06/04/2014 02:18 PM EDT

- 2014 introduction to the “helmet”
  - “You won’t catch me dead wearing that.”
  - “Did you ride you bicycle to work?”
  - “I’ll stick to my hard hat I’ve had for years.”

Third and Final……

- January 2016
- Employee fell from trailer while unloading
- Hard hat fell off an employee struck his head off the pavement
- Transported by ambulance to ER
- Lacerations to head, fracture to the orbit, diagnosed TBI
- Suffered sensitivity to sunlight, headaches and loss of sleep

Wants & Needs

- Decided to move forward with a chin strap policy with Clark Concrete
- Ensure effectiveness without sacrificing comfort
- Current protection has to be met
- We wanted to “Up the Ante”


CLARK
CONSTRUCTION
CHINSTRAP XL
CHINSTRAP XL
BUILDING SAFELY
CHINSTRAP XL

Expanded Polystyrene (EPS)

- First Law of thermodynamics (Law of Conservation of Energy) states that energy can neither be created nor destroyed; energy can only be transferred or changed from one form to another.

- Energy from impact involving EPS is absorb during the crushing of foam creating heat and limiting energy from reaching the head/brain.

EPS vs 4 Point Suspension

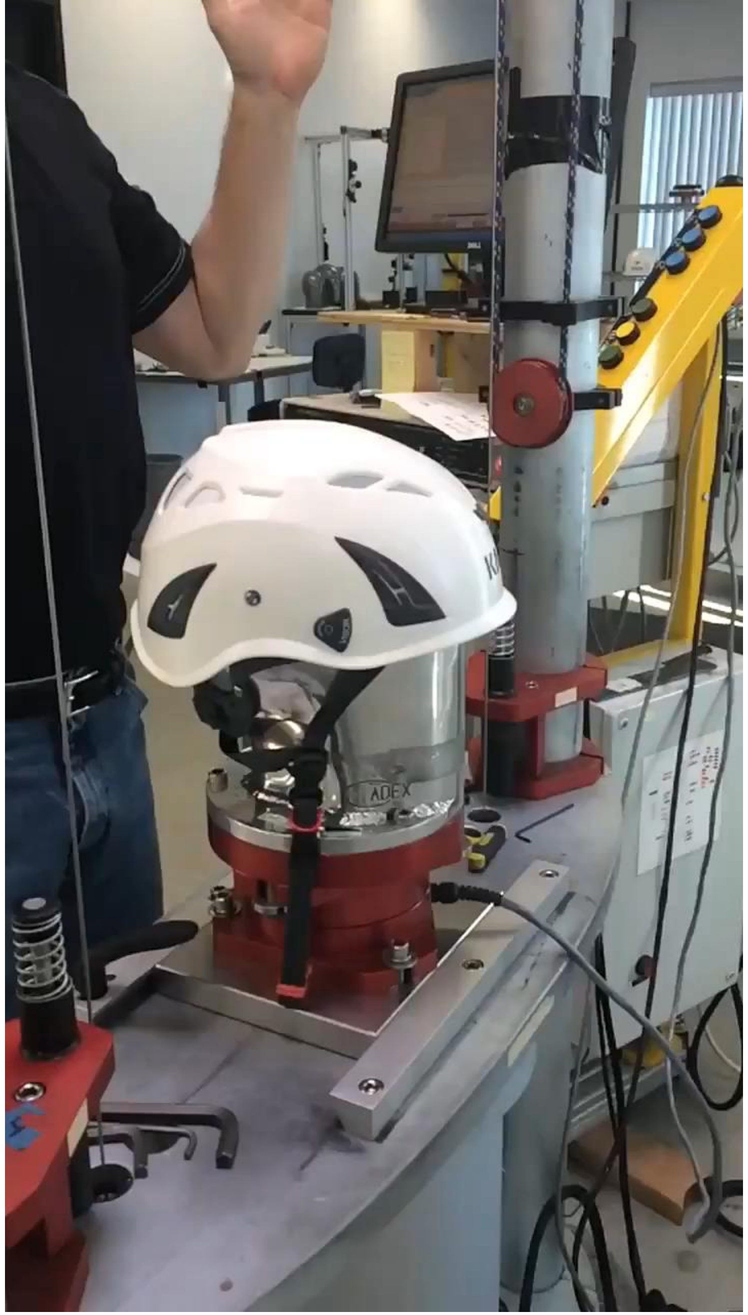
Third Party Testing

- **Force Transmission**
  - Dropping an 8-lb steel ball from height of 5 feet on top of the hard hat/helmet as it sits on a head form. No more then 1,000 lb (4,400 N) of peak force can be transmitted to the head form and no more then 850 lb (4,000 N) of average force can be transmitted.

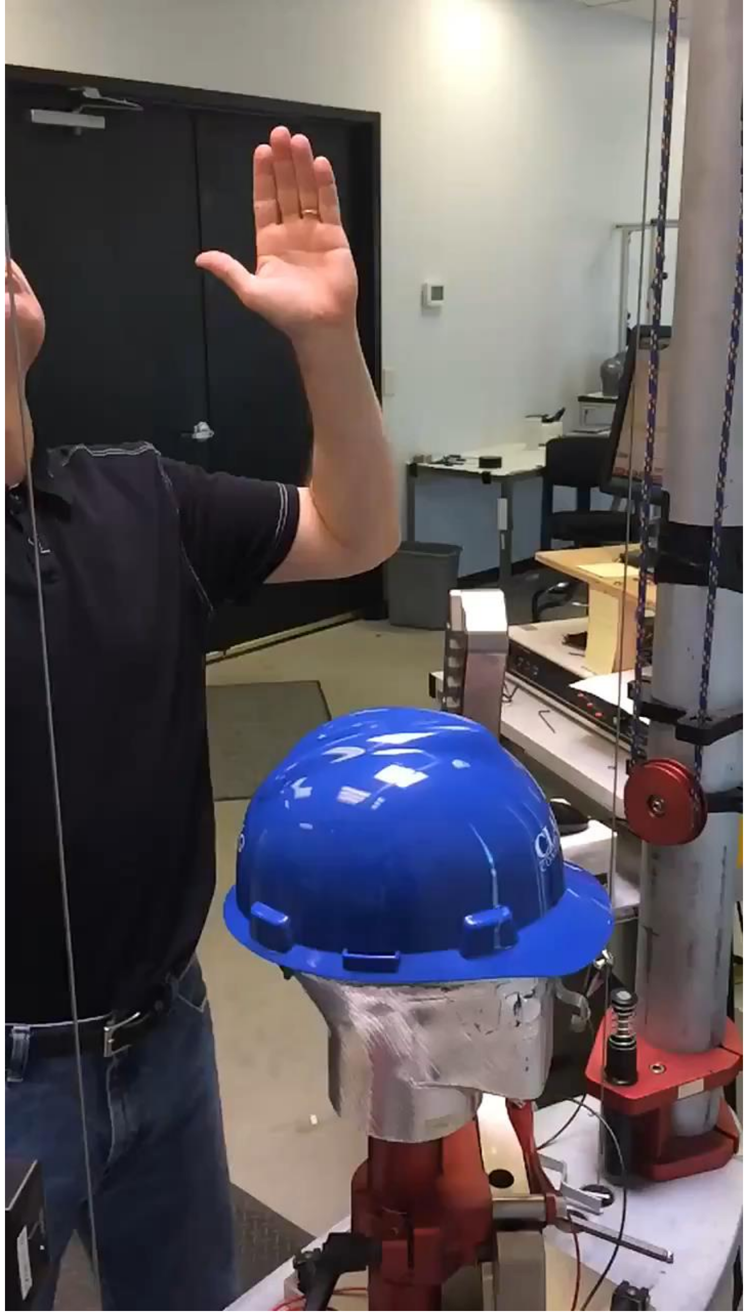
- **Apex Penetration**
  - Involves dropping a 2.2-lb pointed steel penetrator with a 60 degree angle on top of the hard hat/helmet from a distance of 8 feet. It must not contact the head.

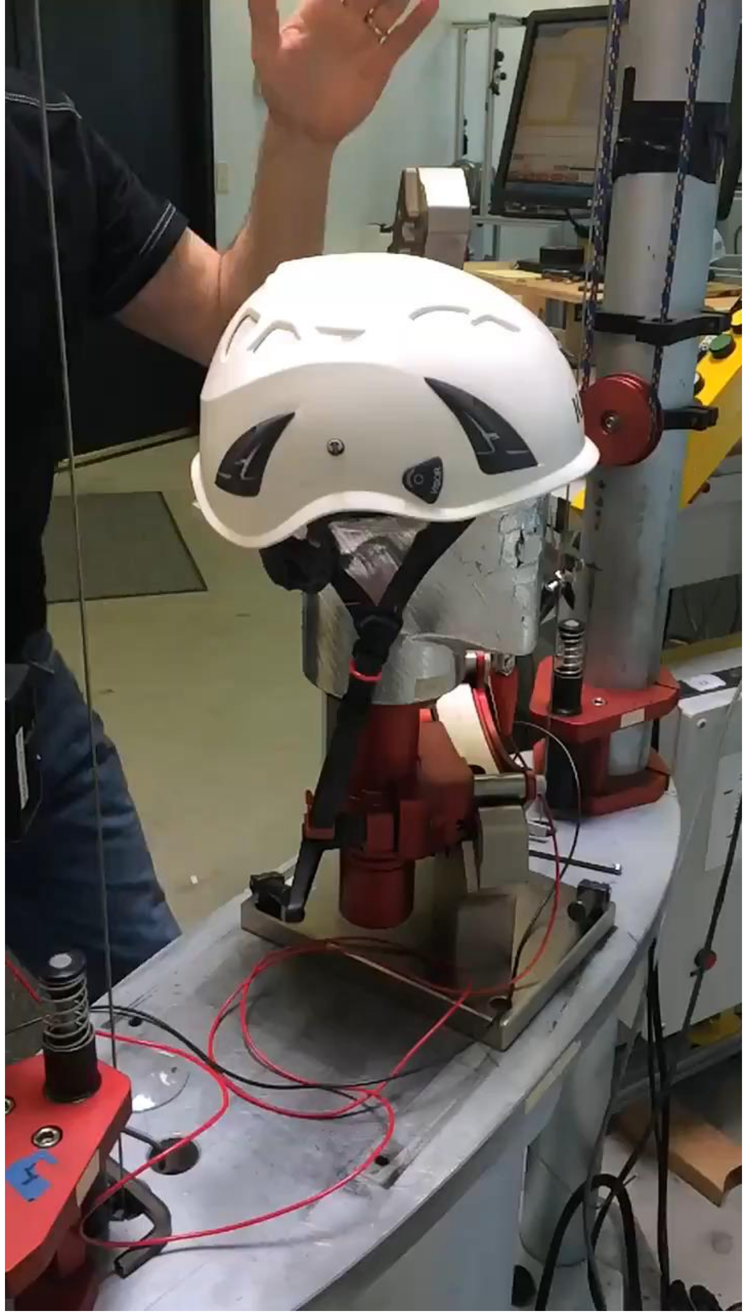
- **Impact Attenuation**
  - Helmet is attached to a head form and dropped onto a steel anvil. Velocity is constant at 3.5 m/s and results have to be less then 150 (g – gravitational constant) An accelerometer is used measure just like measuring a car crash with test dummies. 150-200 g is an acceleration limit during a bicycle crash while wearing a helmet.

Force Transmission



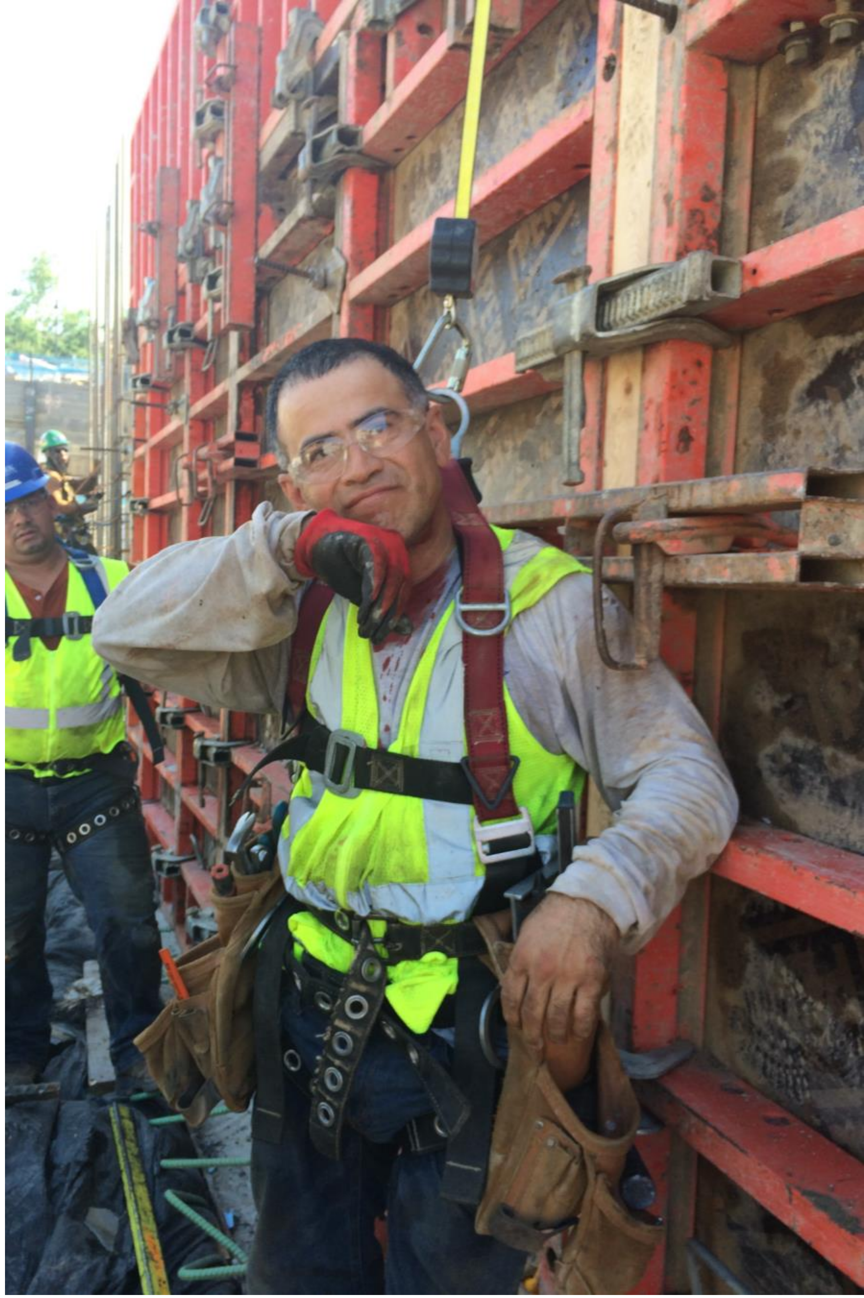
Apex Penetration





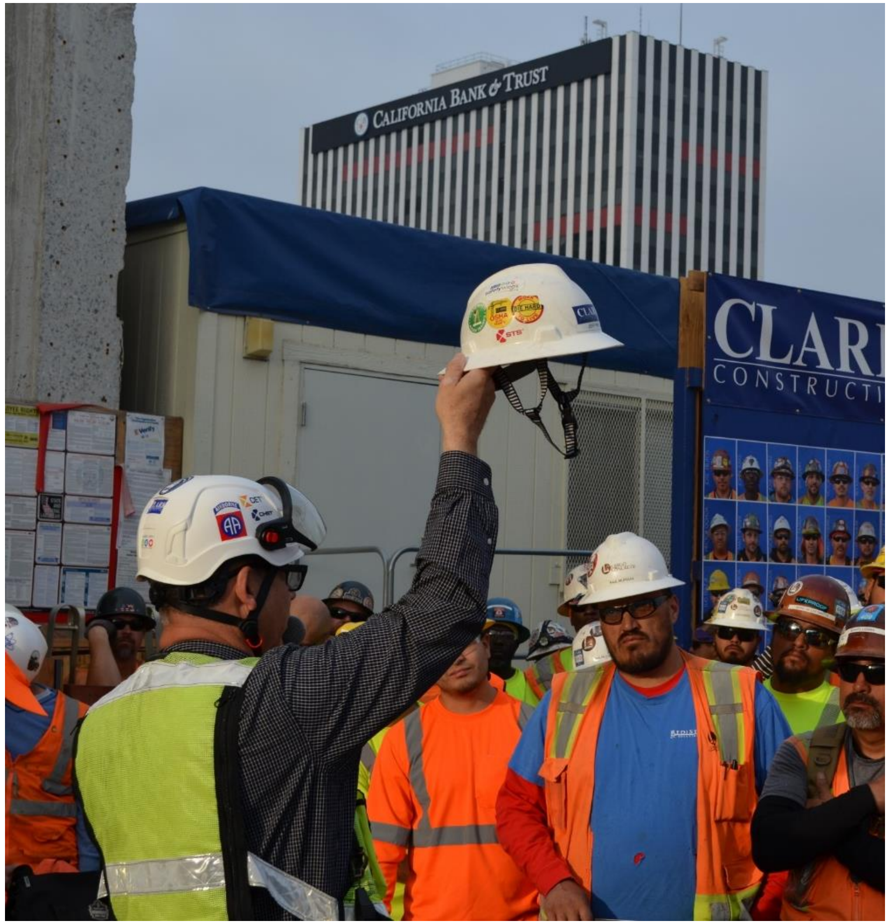
Impact Attenuation





June 30th, 2016

April 2017



- Clark Construction distributed over 3,000 helmets coast to coast
- Led the way with head protection
- Distributed 500 helmets to employees during 2018 Safety Week
- Expanding to trade partners, owners and peers

Goals:

For **Structural Technologies** and for our Industry:

- This is about **saving lives**.
- We're trying to connect all the different pieces of a solution to provide the industry a **much better** solution.
- We want to share our vision, and hope you feel passionate about being part of this.

Our Call to Action

The U.S. Market – Our Take

- U.S. Standards aren’t complete, and OSHA doesn’t require more.
- Therefore, there hasn’t been a strong U.S. market with Manufacturers haven’t been developing great solutions.
- Solutions are imported from Europe because of more complete standards, and suppliers are charging a premium for better protection.
- So companies are forced to deal with high cost, or selectively protecting people.

To save lives, all these factors need to change.

Recommendations from our Research

- Minimum; Find a helmet that meets:
  - ANSI Z89.1 Type 1, Class G **AND**
  - EN 12492 Mountaineering

- Optional: added certifications or options to provide a total solution:
  - ANSI Z89.1 Type 1 Class C option:
    - Vented option, potentially cooler for work that doesn't require class G or E.
  - ANSI Z89.1 Class E option (or instead of Class G):
    - Highest electrical rating for certain scopes of work.
  - Also Meets ANSI Z89.1 Type 2:
    - Additional certification for compliance with facility / market / client requirements.
  - Also Meets EN 14052: High performance industrial helmets.
    - Certain impact benefits above and beyond other standards.

Note: Certain standards have competing clauses, so it is not possible to hold multiple certifications in all applicable standards. Instead, you have a core certification(s), and prove compliance with key clauses of other standards. For instance Kask Zenith claims they meet "ANSI Z89.1 + CSA Z94.1, EN 12492 Shock Absorbing Capacity (clauses 4.2.1.2; 4.2.1.3; 4.2.1.4)"

Safety Helmet Initiative: What we want to do

1. *Make a significantly lower cost solution available in the U.S. Market.*
   - ANSI Certification
   - Meets performance reqs of EN 12492
   - $25-$30 target
2. *Start saving lives*: Market the solution within the industry and ensure there is supply to all interested parties. Target industry organizations, industrial clients, and major general contractors to create a trickle-down affect in their specialty contractors.
3. *Lobby for Change*: With low cost solutions, we can push for change to Standards and OSHA reqs without negative impact to the industry. Not cost prohibitive and great success from early adopters.
4. *Watch the Market Adapt*: With growing interest and changing reqs, other manufactures will bring solutions to the table. Product innovation and cost reduction will follow.

Lobby for Change- Industry Efforts

- Summary of activities:
    - Met with national representatives from LIUNA and Ironworkers.
    - Onboard, ready to help reach key industry committees.
    - Excited about a company with progressive views in this space, focused on worker safety.
    - Attended Ironworkers Safety Roundtable in July to continue to spread message to a national audience and identify actual tactics.
    - Key tactic identified is changing the ANSI/ASSP A10 Construction and Demolition Operations Standards.
        - OSHA will change with time and demand from the industry.
        - Product standards are driven by manufacturers.
        - The A10 standards are driven by the industry, apply directly to field operations, and can be seen as establishing best practices and awareness with some immediacy, well ahead of any regulatory change.

Safety Helmet Initiative: Our Efforts So Far

- In parallel to exploring major manufacturers, we looked at alternate sources.

- Research and found an OEM / ODM supplier with an existing Mountaineering helmet.
  - Similar form and function to existing helmet manufacturers
  - Existing EN12492 Certification
  - Face Shield, Visor, hearing protection and other accessories
  - Vented, potential Class C Solution.
  - Cost within range

Key Things We Learned- History and Focus

- Technology / R&D focused at their core with 25 years helmet design experience.
- Sales Mix:
  - 60% ODM – Concept to final product – Specialty designed product.
  - 40% OEM – Direct sales of a helmets for bike and ski.
  - Prefer growth of ODM – their ability to create and manufacture unique solutions is their differentiator.
  - Focus on middle and upper segments of the market. Not interested in competing in the low cost, low quality, commodity helmet production.

Key things we learned - Quality

- Every process had procedure with the equipment and the worker.
- Every model had unique specs and instructions that followed it through the manufacturing process.
- Didn’t observe any worker that didn’t have (what seemed like) the appropriate information to complete their step in the process per spec.
- QC is inherent in what they do, dedicated staff at the end of every process confirming quality. None-the-less, open to any additive qc we might desire. In house or thirds part testing, random sampling, etc.

Testing Facility

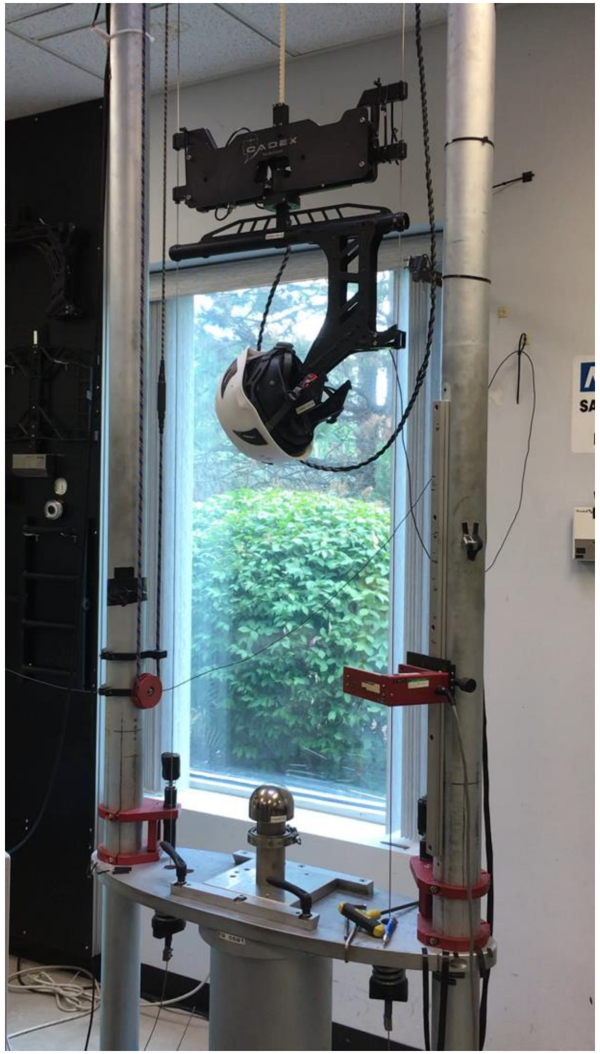
Design

Workshopping our Helmet

Helmet Testing

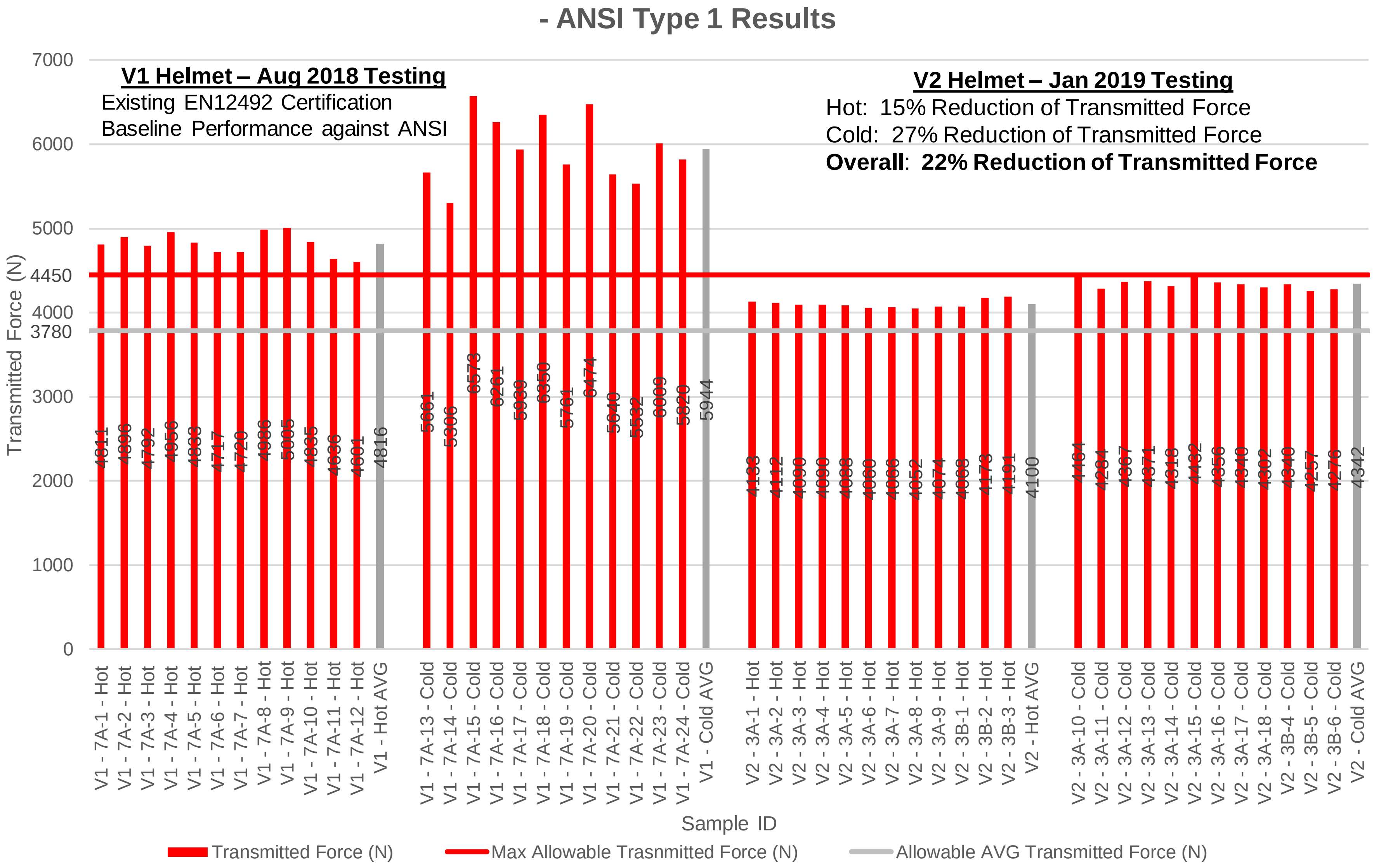
Electrical Resistivity Test

Top Impact Test



Front Attenuation Test

Helmet Development - Our Testing



Safety Helmet Design Initiative: Our Efforts So Far

- Validated EN certification

- Conducted ANSI Type 1 and 2 testing, some successes but ultimately failure of both.

- Several months of iteration, and we're at a new version with successful in-house testing by Manufacturer. Biggest changes are in foam density.

- Additional units are in production.

Helmet Samples – Assessing the most cost effective solution

Aroura

Kask

Hex Armor

3M

Petzl

Iron Wear

JSP/PIP

MSA

New Helmet Temperature Evaluation

8/8/2019

Objective

- To evaluate the internal air temperature for new safety helmets when exposed to a sunny summer day. Evaluation criteria includes: helmet color, helmet air vents, and internal foam liner.

Test Samples

Vented

No Vent

Original

With Foam Liner

Foam Liner Removed

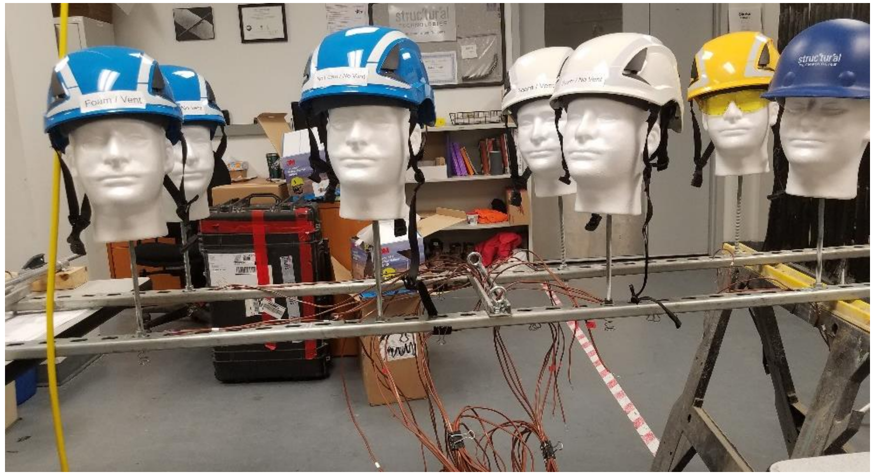
Test Matrix

- 7 total helmets evaluated

Mfg.	Color	Foam	Vent
3M	Blue	X	X
	Blue	X	
	Blue		X
	Blue		
	White	X	X
	White	X	
Fibre Metal	ST Blue		

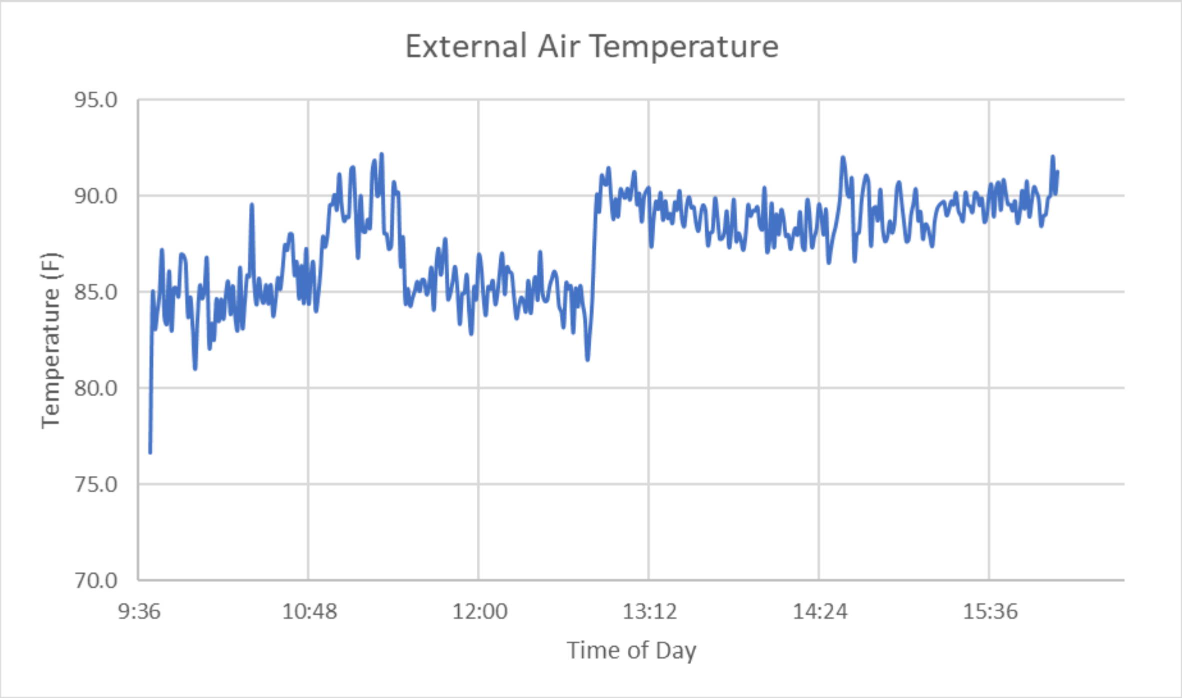
Test Setup

- Test performed from 9:41am until 4:05pm
- Helmets under evaluation were placed on foam heads
- Temperature readings:
  - Recorded every 1 minute using data acquisition system
  - Type K thermocouples used
  - Placed in the air void between helmet and head
    - In the air void between helmet and foam head
    - Between strap webbing and foam head



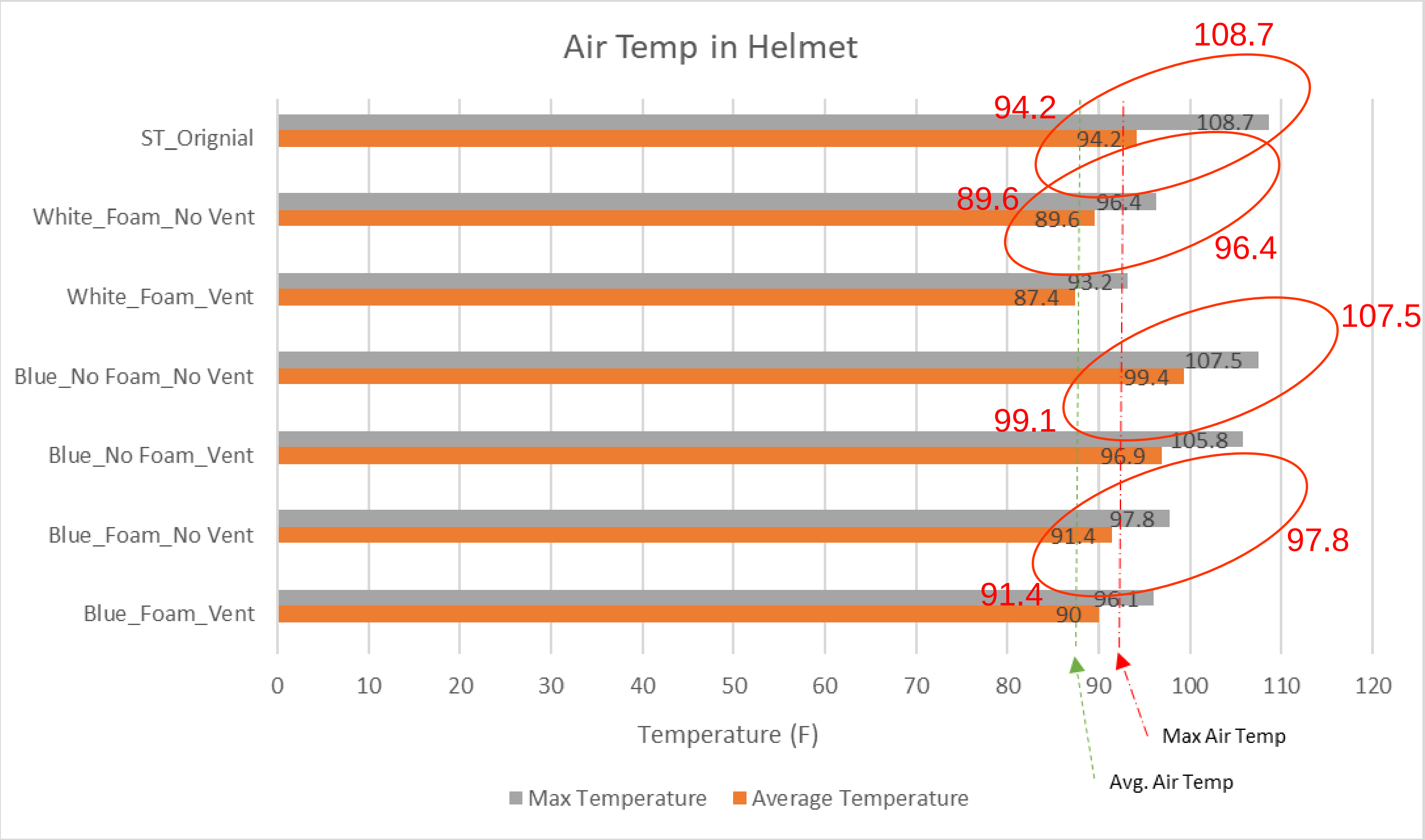
Test Conditions

- Mostly sunny day
- Max temperature = 92ºF
- Average temperature = 88ºF



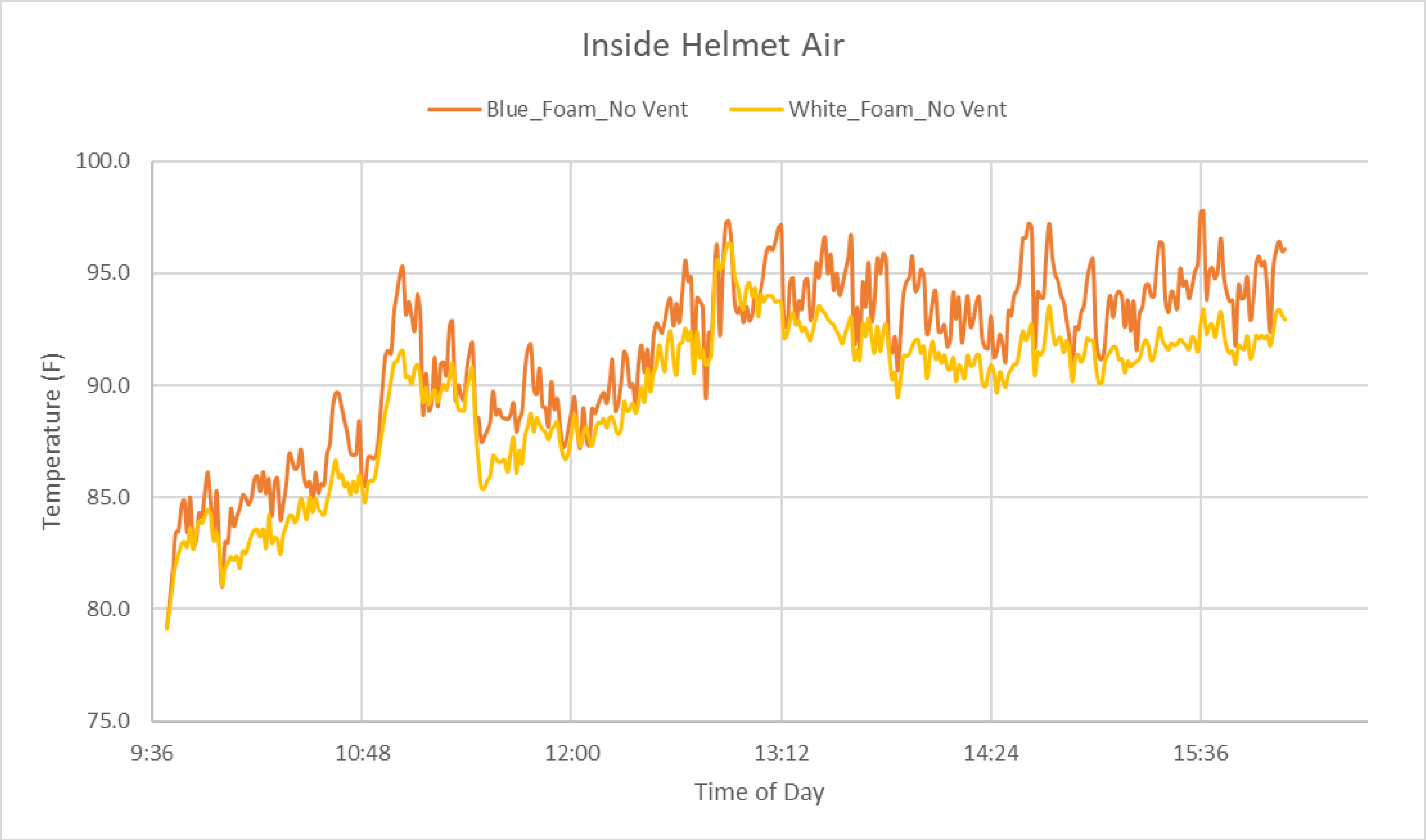
Test Results

Max & Average Temperatures



Test Results

No Vent Helmets



Conclusions

Foam liners are effective

- Helmets with a foam liner have a 8-12% lower inside air temp.
- 7-8ºF difference for blue
- 7-8ºF difference for white

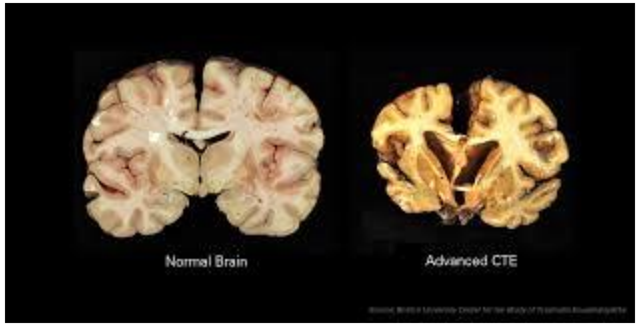
Air vents are slightly effective

- Helmets with an air vent have a 2-3% lower inside air temp.
- 1-2ºF difference for blue helmets
- 2-3ºF difference for white helmets

White colored helmets are cooler than blue

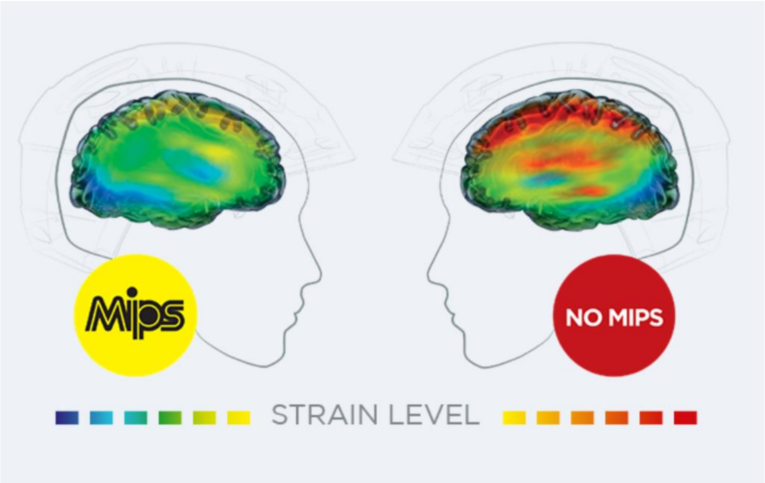
- White colored have a 3% lower inside air temp. (both with foam liner)
- 3ºF difference for white helmets

New Technology



MIPS Technology

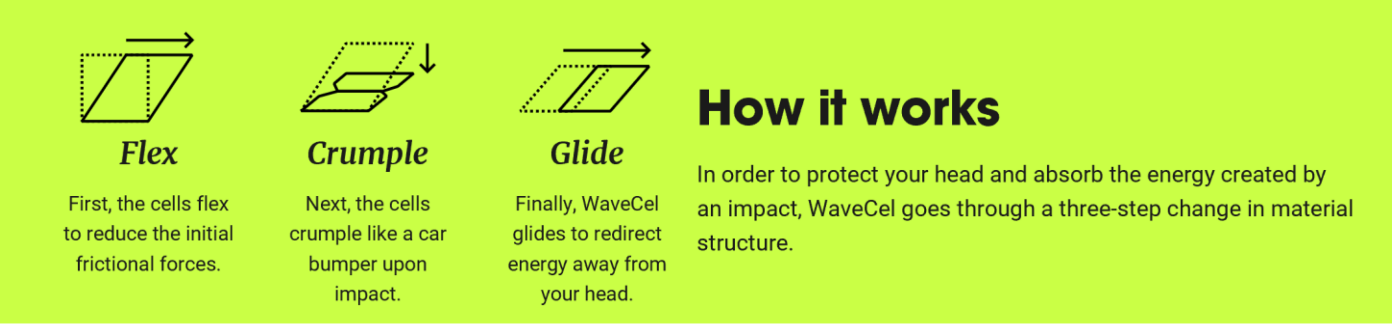
- **M**ulti-Directional **I**mpact **P**rotection **S**ystem
  - Reduces rotational forces caused by angled impacts to the head.
  - A helmet's shell and liner are separated by a low friction layer which allows the helmet to slide, noticeably reducing trauma to the brain in the case of oblique impacts.
  - MIPS layer is located between the liner and the user's head.

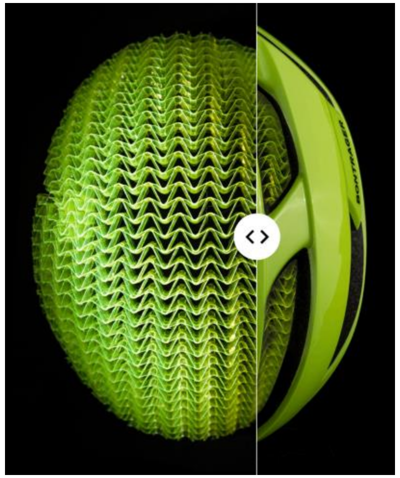


MIPS Technology

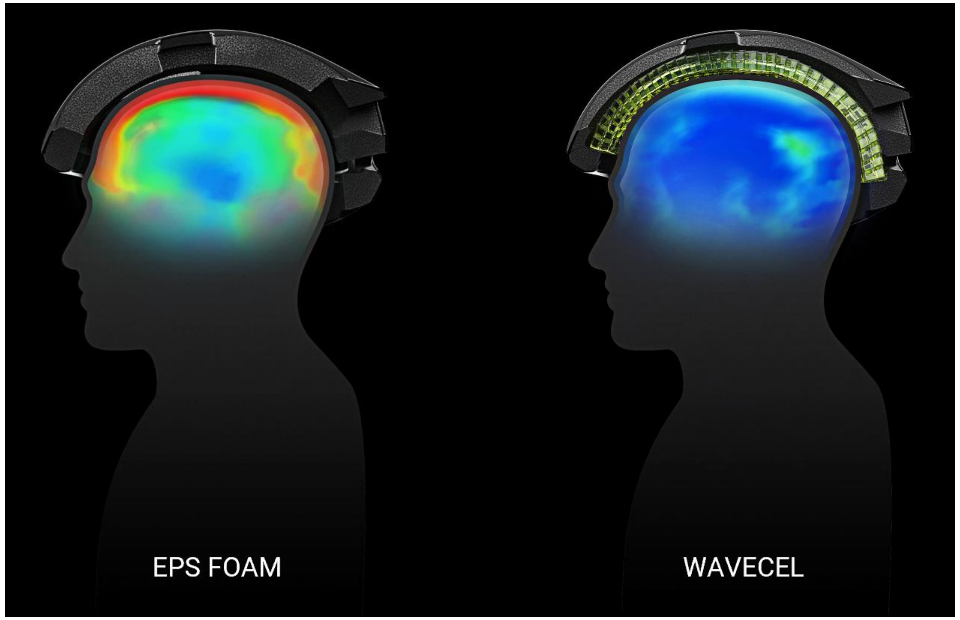
Wavecel Technology

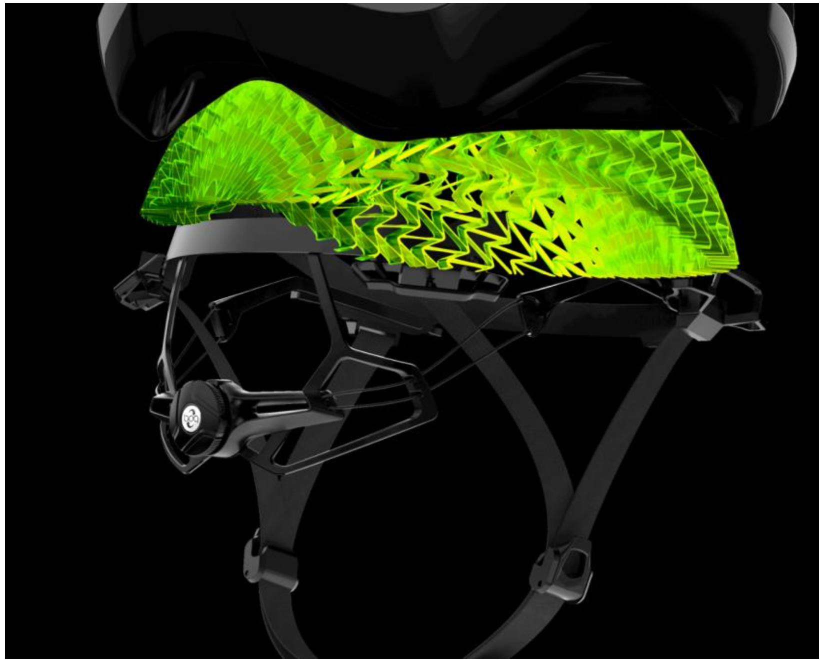
- WaveCel is a collapsible cellular structure that lines the inside of a helmet.
- It works like a crumple zone that absorbs the force of an impact before it reaches your head



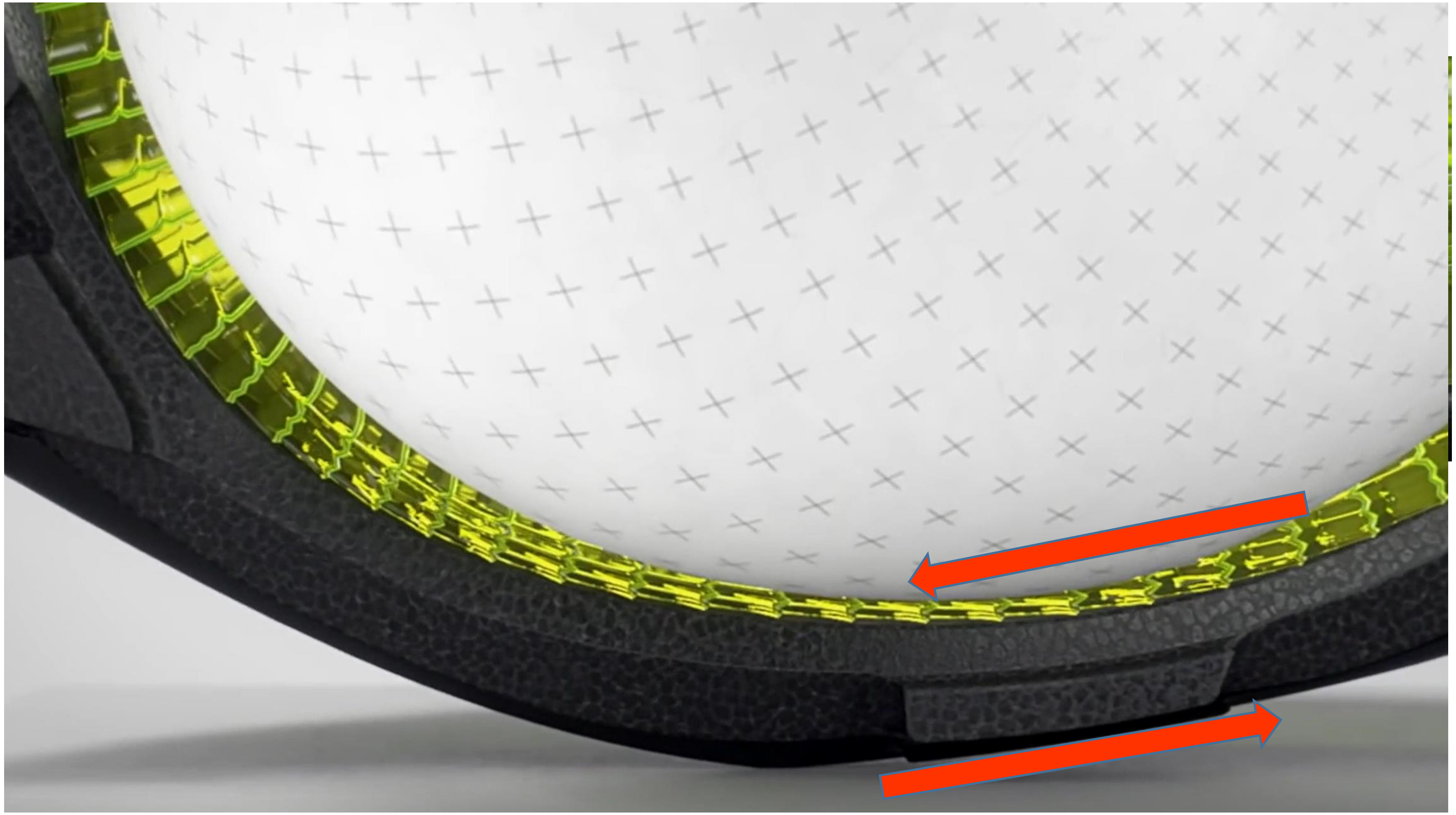


Wavecel Technology

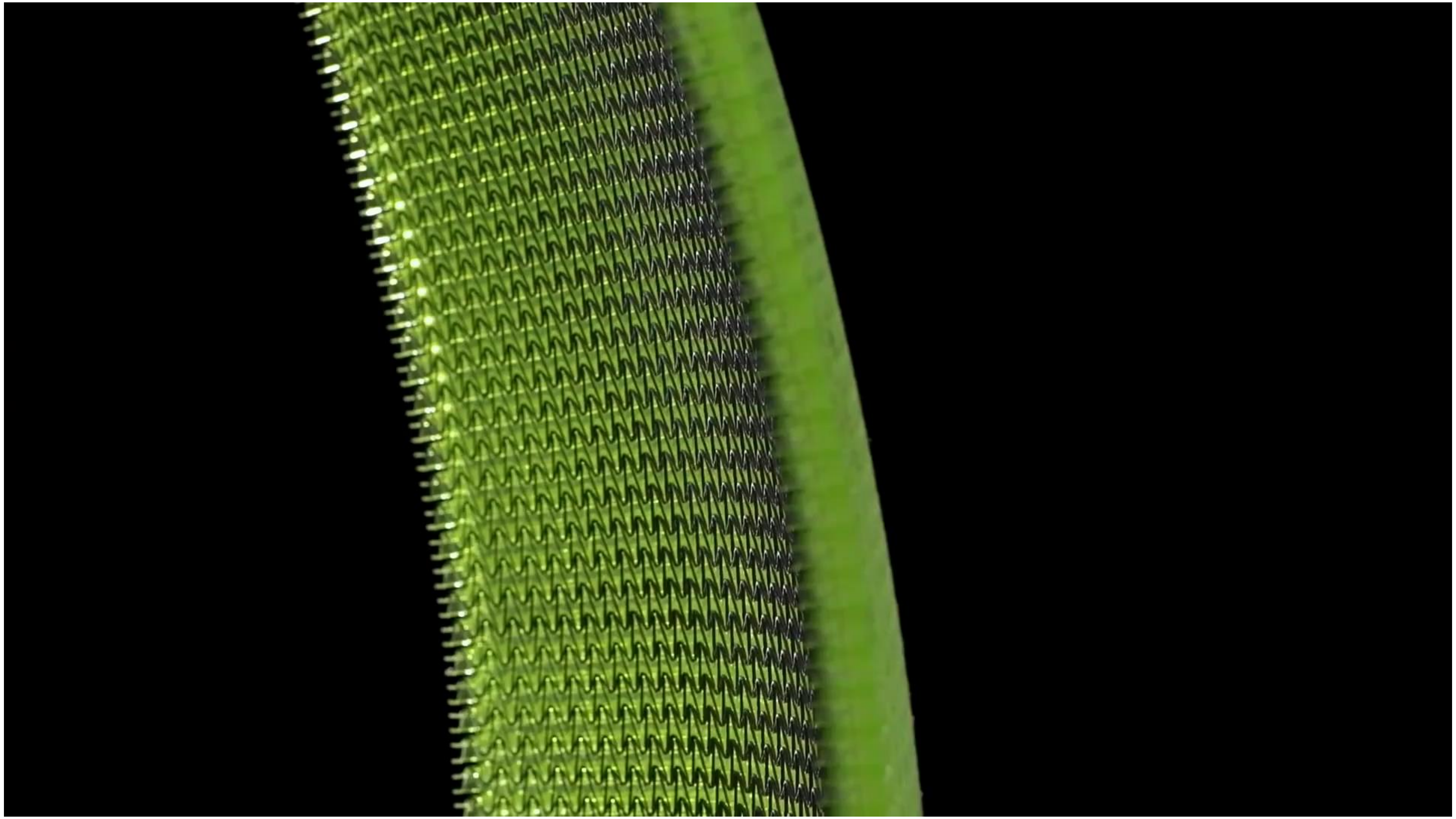




Wavecel Technology

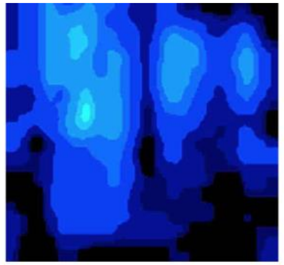


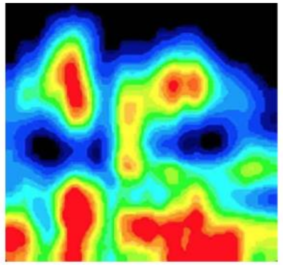
Wavecel Technology



Football Helmet Technology

- Deformable shell
- Columns absorb energy and take rotational forces
- The helmet features a soft outer shell and an underlying layer of columns designed to mitigate collisions from multiple directions.





BLUE = LOW PRESSURE

RED = HIGH PRESSURE

Football Helmet Technology

- Deformable shell
- Columns absorb energy and take rotational forces

Hard Hats to Helmets: We Are not Alone

CLARK CONSTRUCTION

Balfour Beatty

Scaffold Resource LLC

SKANSKA

CEMEX

Gilbane

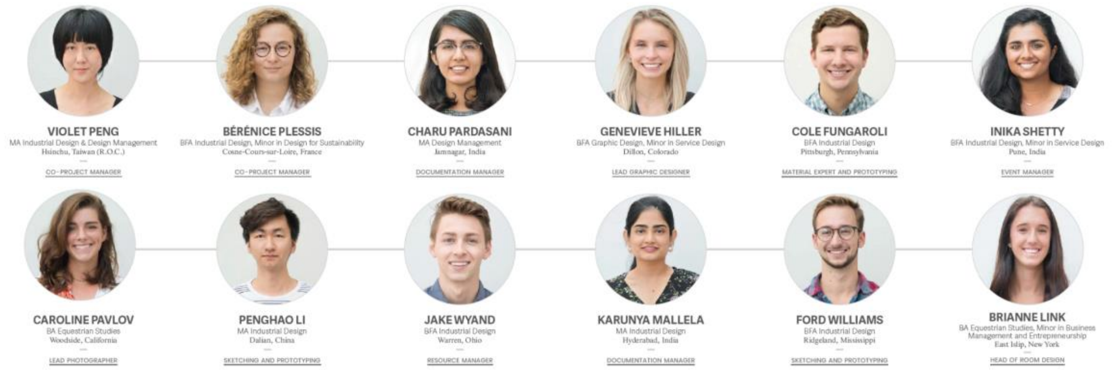
BAKER CONCRETE CONSTRUCTION

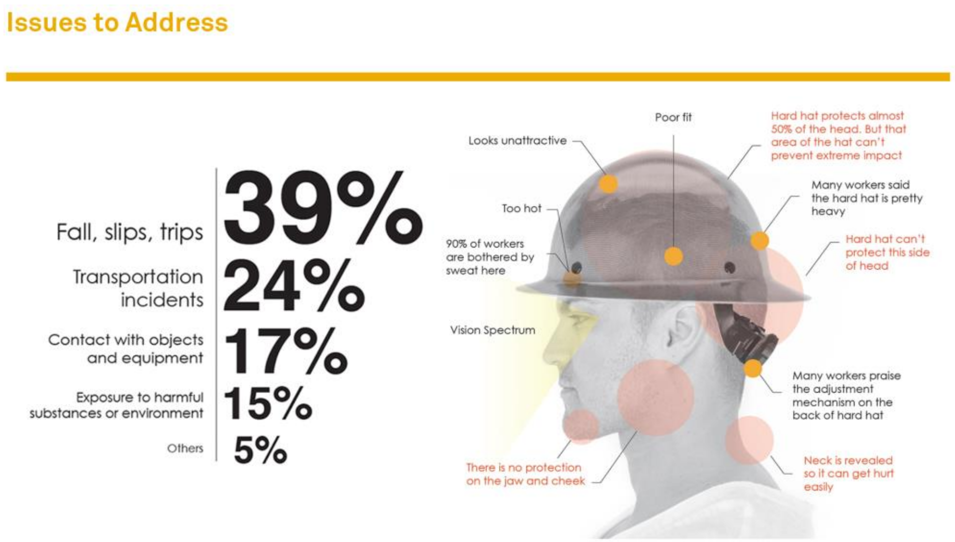
Turner

AMERICAN SOCIETY OF CONCRETE CONTRACTORS
Enhancing the Capabilities of Those Who Build with Concrete

Construction Industry Round Table

Industry Leadership – Design Development



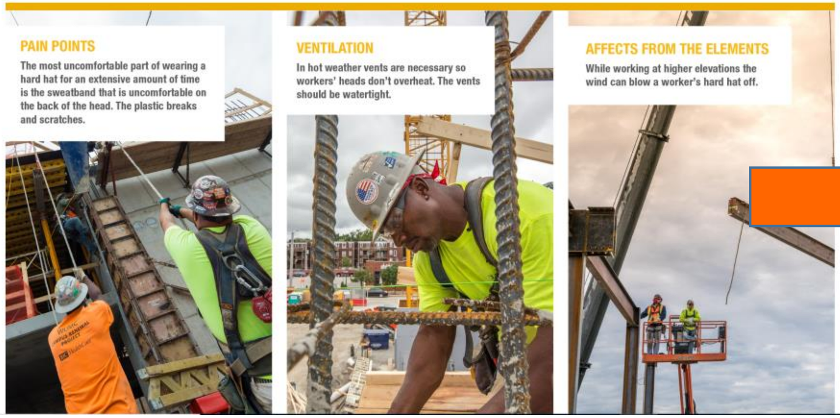


- Construction Site Observations
- Construction Interviews
- Comparative Study
- Biomimicry Studies
- Ideation
- Modeling Prototypes
- Final Designs

CLAYCO
THE ART & SCIENCE OF BUILDING

Construction Site Observations

While interacting with Clayco employees and experiencing a large-scale construction site, we gained many insights.



Construction Interviews

Through interviews we are able to learn more about workers' personal opinions, thoughts and questions about their current hard hats and the future design of them.

*What are your **immediate feelings** when you think about wearing a hard hat?*

Comparative Study

To understand the existing market for safety helmets, we conducted a comparative study. This allowed us tc understand the key features between the helmets being studied which aided in our understanding of creatir entered features to eliminate pain points.

Ideation

The students conducted two rounds of revised ideation sketches. F ese sketches, they formulated a list of user needs and possible solutions to their problems.

Biomimicry Studies

Modeling Prototypes

Feedback from the Clayco team lead SCADpro to reiterate the design process for specific features and combine favored concepts to produce the final three designs. They then began creating their designs in a 3D space so they could truly evaluate its shape and form and how it looks in reality.

CAPTAIN

POLLUX

JUPITER

Hard Hats to Helmets: What we want to do

- Our goal is to dramatically reduce the frequency and severity of Traumatic Brain Injuries in the U.S. Construction industry by:

  - Lobbying for change in the standards and regulations.
    - ANSI + EN12492

  - Partnering with others to drive the awareness and adoption of superior solutions.

  - Making low cost solutions readily available to the entire market.
    - Direct relationships with manufacturers.
    - Market adaptation from growing interest and changing reqs., Other manufactures will bring solutions to the table. Product innovation and cost reduction will follow.

change.
challenge.
opportunity.

Return On Investment