WORKING at HEIGHT
CONFERENCE & AWARDS

Traumatic Brain Injury & New Technologies in Safety Headwear

ACCESS, LIFT & HANDLERS ALH

IPAF.org

Luke Sylvia

Mips

Short about me

- Bachelor of Science from NC State University in Human Bio w/ Minor in chemistry
- Background in Industrial Sales and Account Management through distribution, overseeing major accounts in the aggregate sector
- Longstanding passion for motorcycling

Luke Sylvia
Regional Sales Manager, Southeast U.S.

Agenda - 1

- Statistics and reports on fatalities and TBIs in construction
- Evolution of head safety in construction – Type 1 vs. Type 2
- OSHA, ANSI and EN standards
- Traumatic Brain Injury and the effect of rotational motion
- Questions

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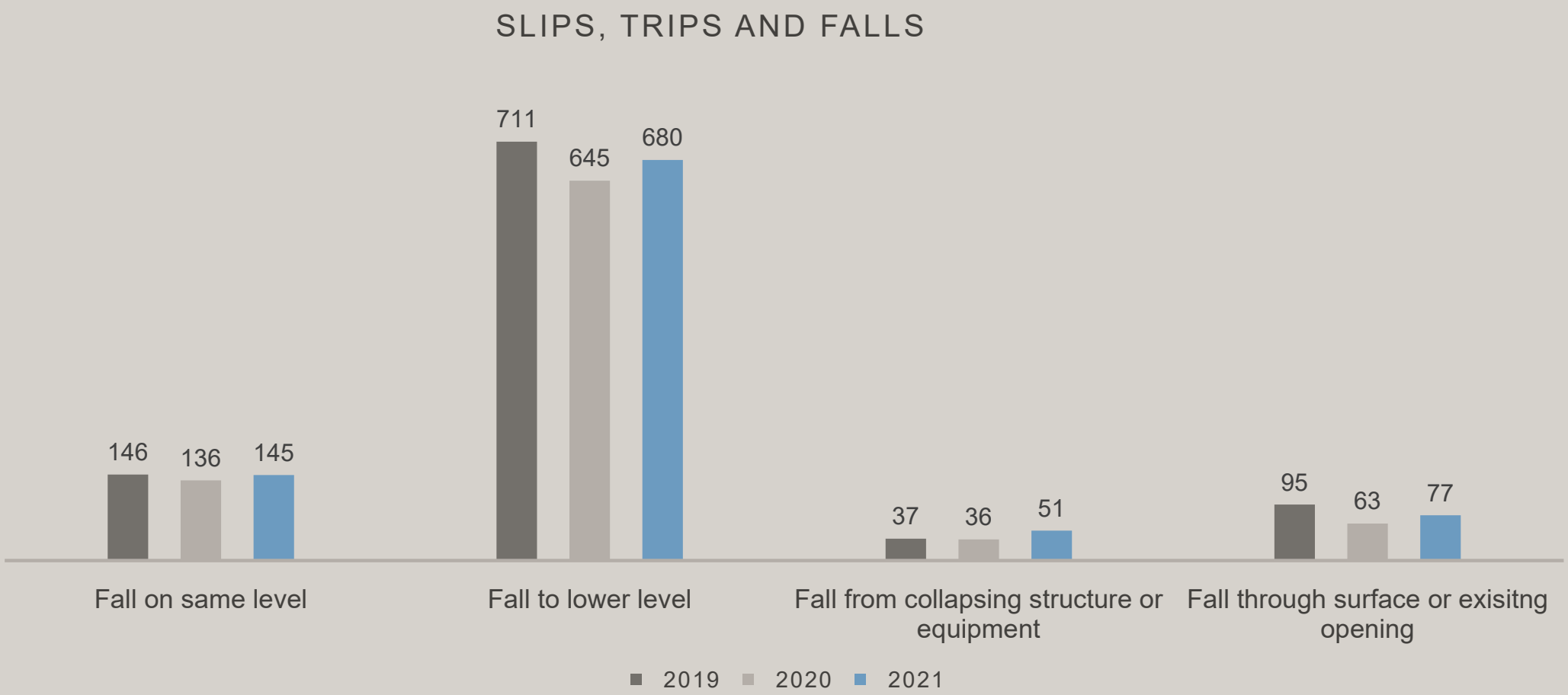
Construction jobsites commonly have potential trip hazards

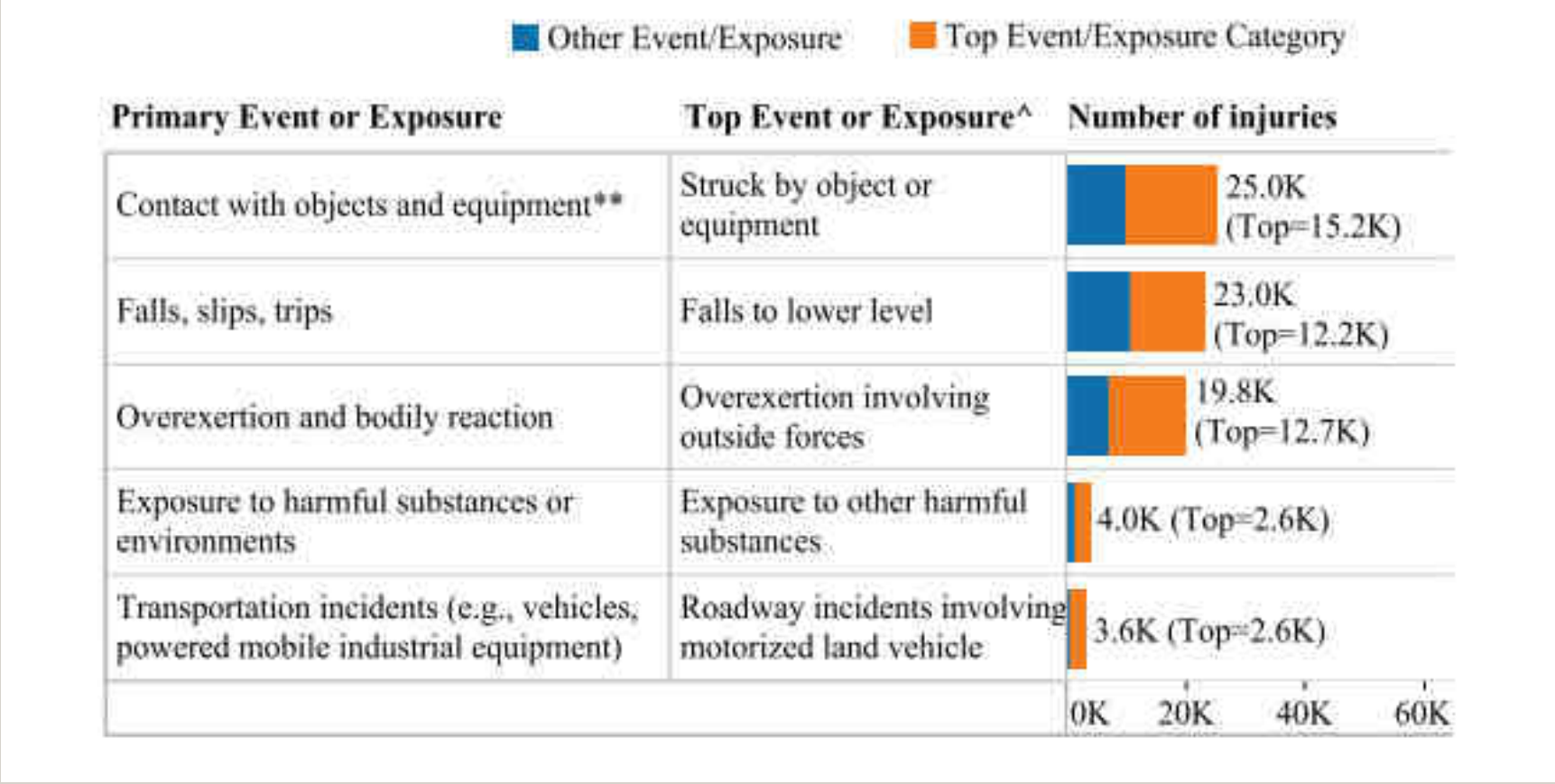
Fatal occupational injuries by event



Number of incidents; National Census of Fatal Occupational Injuries in 2021, Bureau of Labor Statistics

Non-Fatal occupational injuries by event, average of 2018-2020

U.S. BUREAU OF LABOR STATISTICS, 2018-2020 SURVEY OF OCCUPATIONAL INJURIES AND ILLNESSES

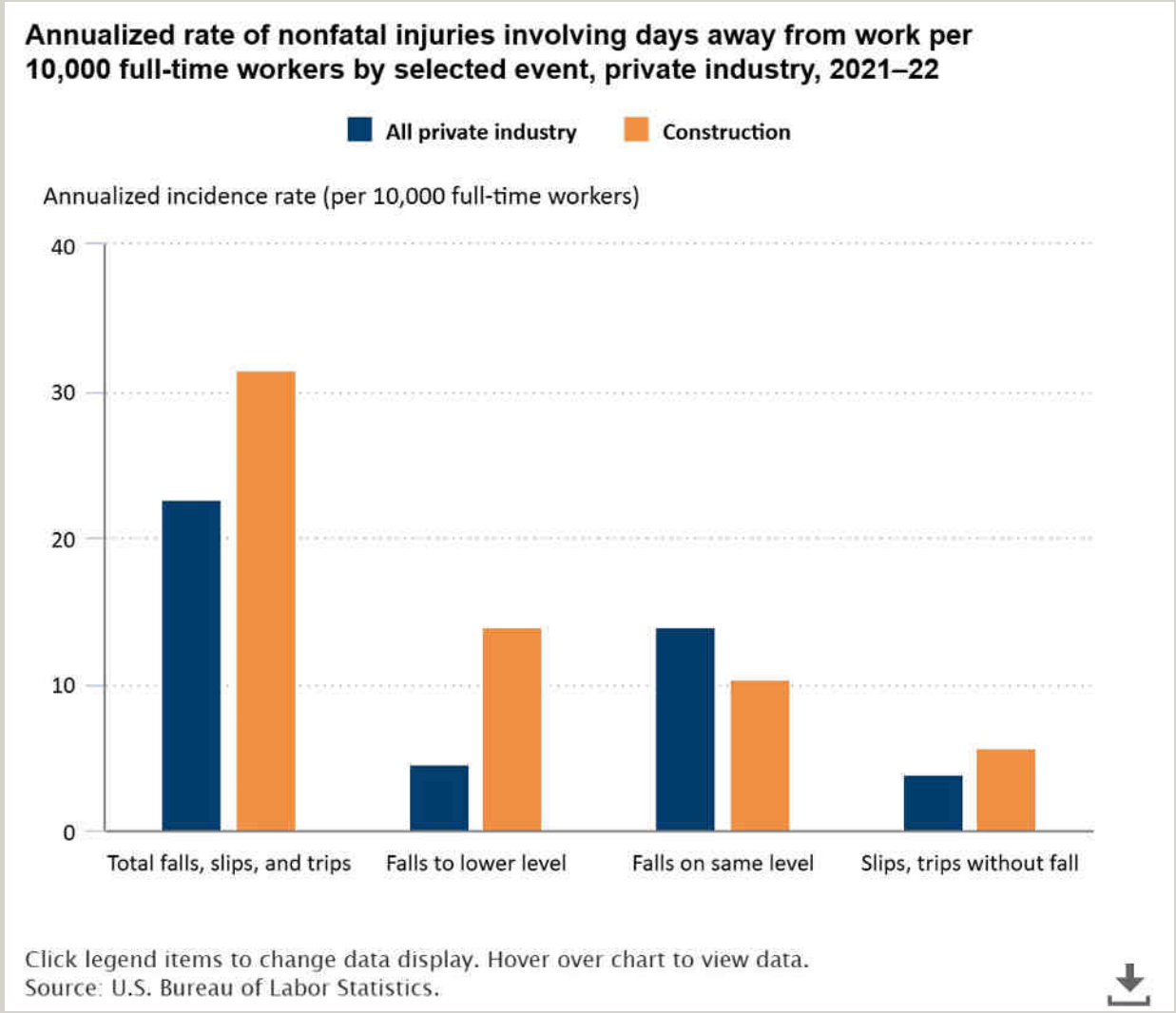


^Defined as the most common category within the primary event or exposure category.

**Contact injuries involving a fall, transportation incident, fire, explosion, or violence are included in those categories. Primary event or exposure categories are mutually exclusive.

Lost Time – Days away from work

NUMBER OF INCIDENTS; NATIONAL CENSUS OF FATAL OCCUPATIONAL INJURIES IN 2023, BUREAU OF LABOR STATISTICS



The average direct costs associated with a concussion are $54,571

OSHA, https://www.osha.gov/safetypays/estimator-text

Agenda - 2

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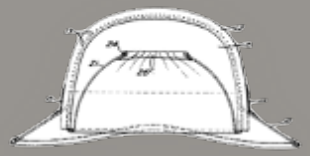
History of Hard Hats

Shipyard Hard Hat

Hard Boiled Hat – Bullard creates leather and metal hat for the US Navy.

1919

Inner Suspension



Inner Suspension invented by EW Bullard.

1928

Aluminium

Aluminum Hard Hats become standard for their greater durability and lighter weight.

1938

Fiberglass

Fiberglass hard hat are intro. These were the best choice for high heat applications.

1940's

Plastic

Injection-molded plastic hard hats are introduced as a less expensive option than aluminum or fiberglass.

1951

What's new in the last 60 years?

Attachment for Face shields

Hearing Protection

Integrated Eyewear

Rated Chinstraps

SHOCK, IMPACT, & PENETRATION TESTING

Industrial hard hats are subjected to many types of testing to provide the best protection possible. Learn about shock and impact testing requirements for ANSI and EN.

TYPE I

ANSII Z89.1-2014 R2019

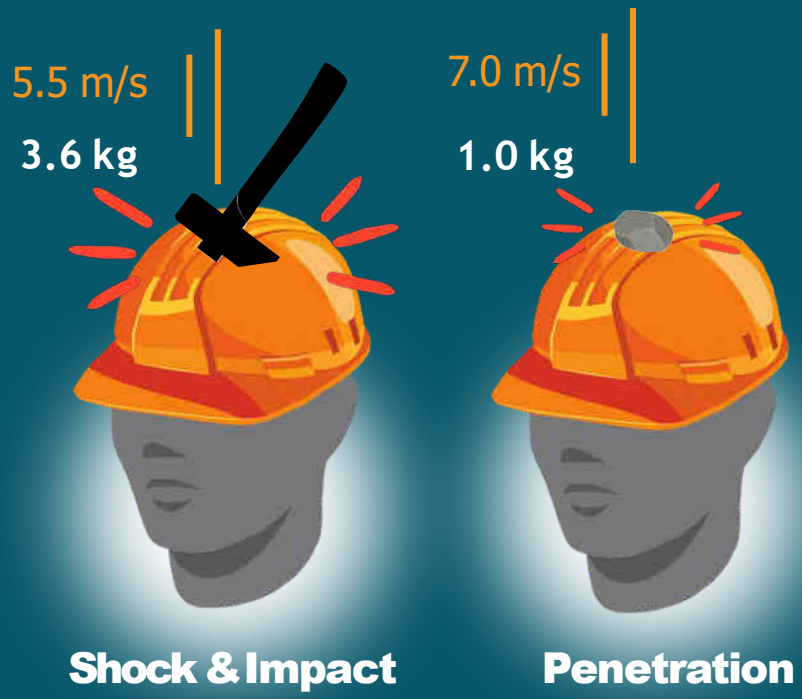
TYPE II

ANSII Z89.1-2014 R2019

EN12492

EN 12492::2012

ANSI Z89.1-2014 R2019

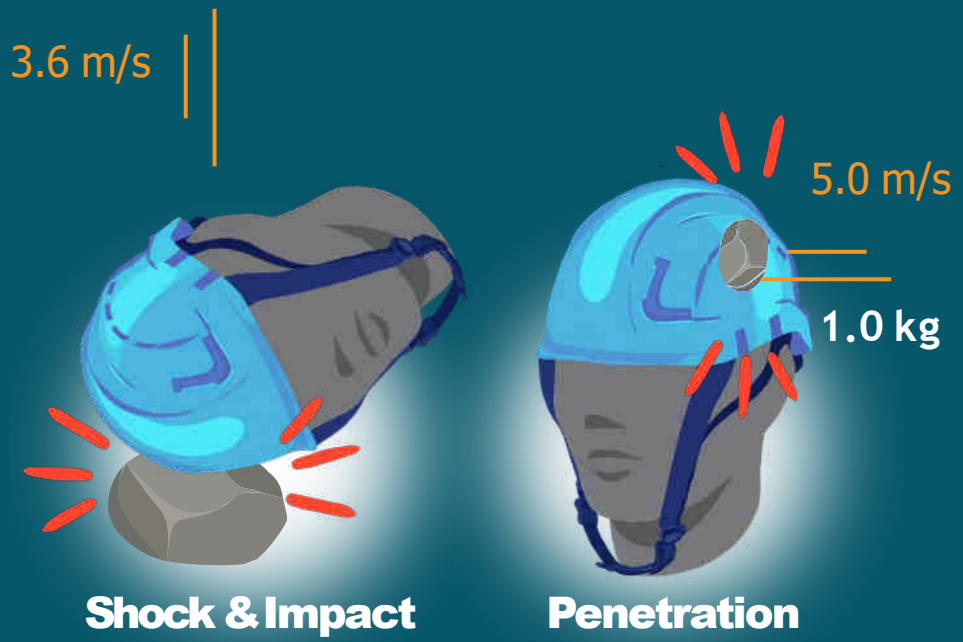


Test Zone

TYPE I

Test: Force Transmission	**Test:** Impact Energy Attenuation
Equivalent: Hammer falling from over 21 ft. (6.4 m)	**Equivalent:** Hammer falling from nearly 12 ft. (3.7 m)
Impact Force: 54.5 Joules (40.2 ft.-lb.)	**Impact Force:** 30.6 Joules (22.6 ft.-lb.)
Pass Criteria: Transmitted force < 4450 N (1000 lb.) Sample average < 3780 N (850 lb.)	**Pass Criteria:** **Maximum acceleration ≤ 150 g***

ANSI Z89.1-2014 R2019



TYPE II

Test: Apex Penetration	Test: Off-Center Penetration
Equivalent: Hammer falling from over 10 ft. (3.0 m)	**Equivalent:** Hammer falling from nearly 4.9 ft. (1.5 m)
Impact Force: 24.5 Joules (18.1 ft.-lb.)	**Impact Force:** 12.5 Joules (9.2 ft.-lb.)
Pass Criteria: Penetrator shall not make contact with top of test headform.	**Pass Criteria:** Penetrator shall not make contact with top of test headform.

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- **OSHA and ANSI standards**
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Current OSHA standards for head protection

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.

Considerations when selecting head protection

Hazard Assessment – Conduct a formal hazard assessment with frequent job hazard analysis (JHA) to ensure appropriate PPE is utilized. **29 CFR 1910.132(d)(2)*

Construction Sites. For construction sites, especially those with high risks of falling objects and debris, impacts from equipment, awkward working positions, and/or slip, trip, and fall hazards: consider Type II head protection with chin straps.

Oil and Gas Industry. For oil and gas industry worksites where workers face multiple hazards, including potential exposure to chemicals and severe impacts: consider Type II head protection with integrated eye and face protection, like face shields and googles.

Working from Heights. For tasks or jobs that involve working from heights: consider head protection with chin straps to prevent the head protection from falling off.

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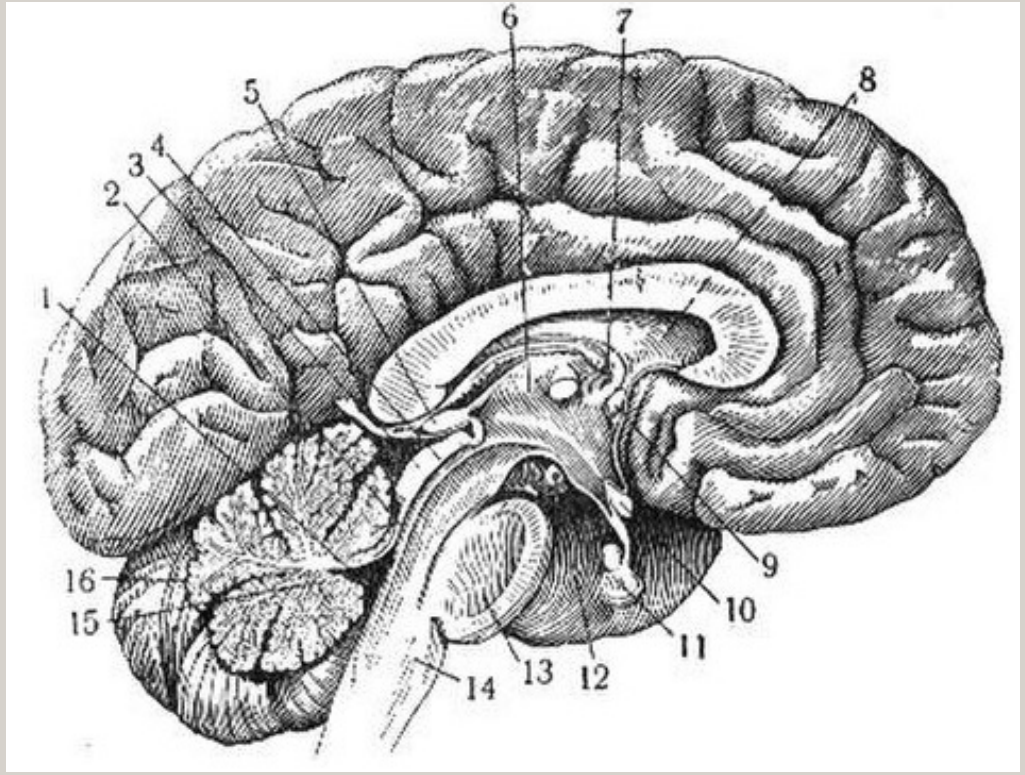
What is a TBI?

- A traumatic brain injury, or TBI, is an injury that affects how the brain functions. There are 3 types of TBIs: mild, moderate and severe.
- There were over 64,000 TBI-related deaths in the U.S. in 2020 according to the CDC. On average: about 176 per day.
- Falls lead to nearly half of the TBI-related hospitalizations.
- Several of the effects that may be associated with traumatic brain injuries are not visible to others.



Centers for Disease Control and Prevention (CDC), https://www.cdc.gov/traumaticbraininjury/get_the_facts.Html

Why is brain injury sometimes referred to as an invisible disability?

Several of the effects that may be associated with brain injury are not visible to others.

Many individuals who have sustained a brain injury do not use assistive devices that would immediately signal that they have a disability. They may appear to be functioning in the same way that they did before the injury, even though they may be physically, emotionally, or cognitively impaired.

Brain Injury Association of America

How Common Are TBIs in Construction?

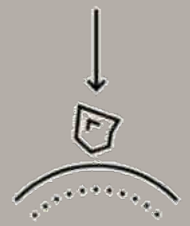
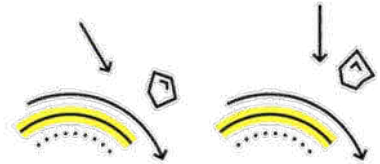
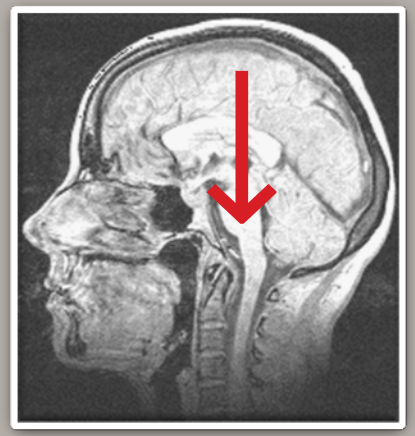
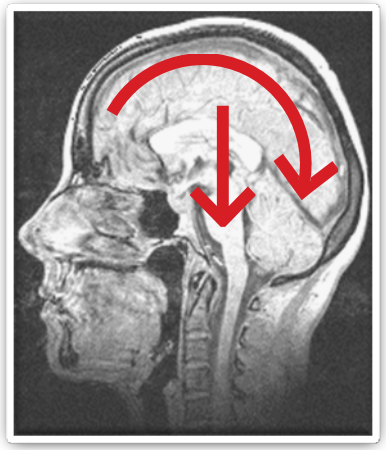
- Structural iron and steel workers and roofers had the highest fatal TBI rate, and TBIs related to falls caused most of their deaths.[1]

- Falls, especially from roofs, ladders, and scaffolds, led to >50% of fatal work-related TBIs.[2]

1 KONDA S, REICHARD A, TIESMAN HM, HENDRICKS S, 2015

2 KONDA S, TIESMAN HM, REICHARD AA, 2016

Type of Injury dependent on Impact

	Linear	Angled & Tangential
IMPACT DIRECTION:		
ACCELERATION DIRECTION:		
TYPE OF INJURY:	• Fracture • Epidural hematoma (EDH) • Contusion	• Concussion • Subdural hematoma (SDH) • Diffuse axonal injury (DAI)

Holbourn 1943
Ommaya et al. 1967
Ommaya and Hirsch 1971
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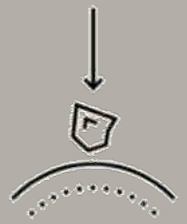
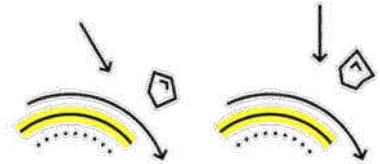
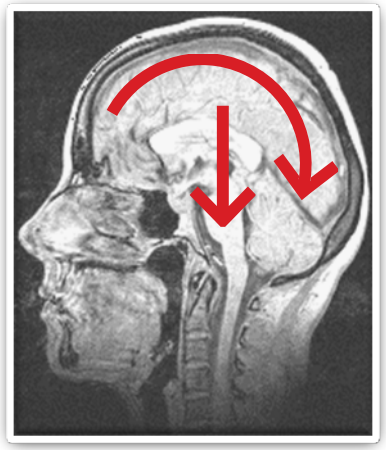
IMPACT DIRECTION:		
ACCELERATION DIRECTION:		
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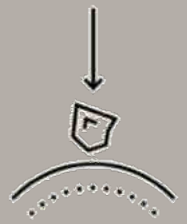
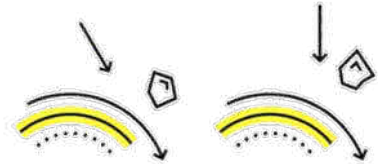
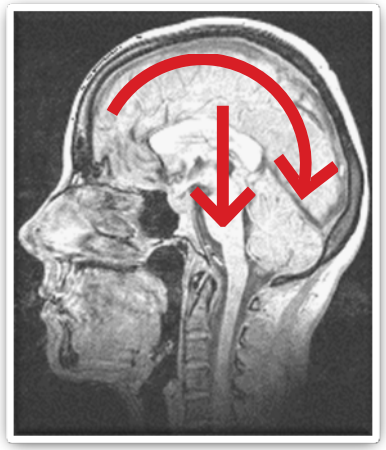
IMPACT DIRECTION:		
ACCELERATION DIRECTION:		
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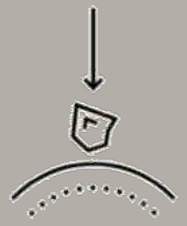
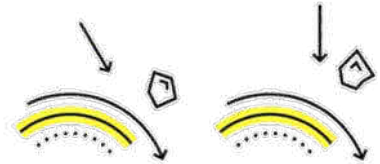
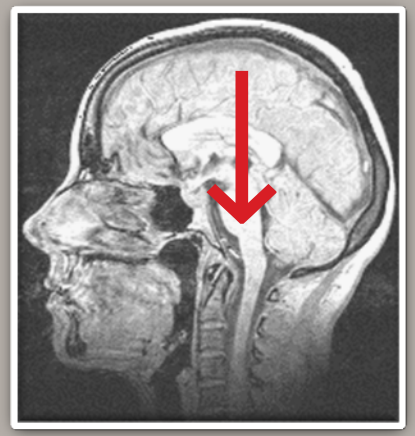
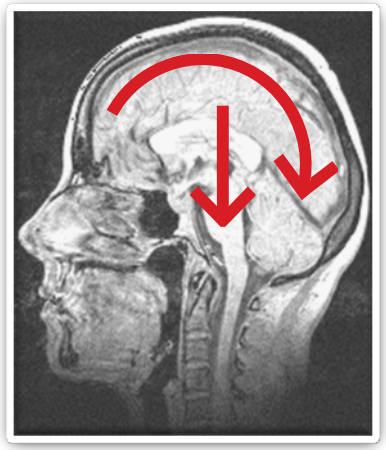
IMPACT DIRECTION:		
ACCELERATION DIRECTION:		
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1* Patrick J. Lynch, medical illustrator; C. Carl Jaffe, MD, cardiologist

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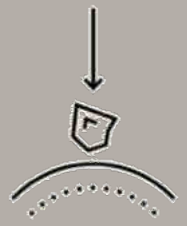
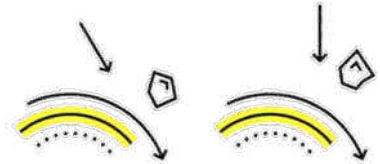
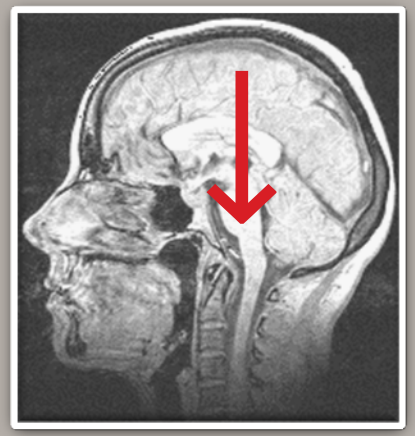
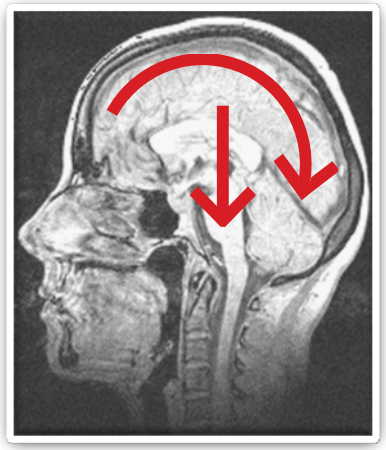
IMPACT DIRECTION:		
ACCELERATION DIRECTION:		
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Type of Injury dependent on Impact

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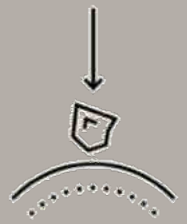
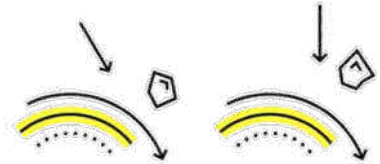


Angled & Tangential



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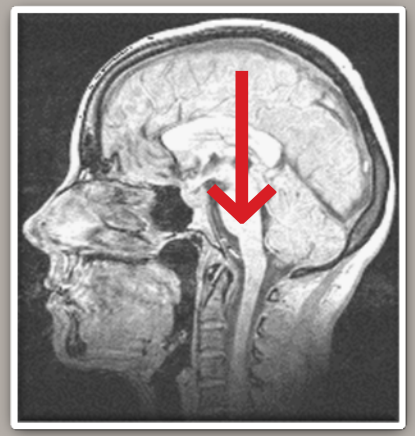

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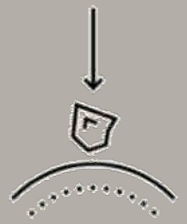

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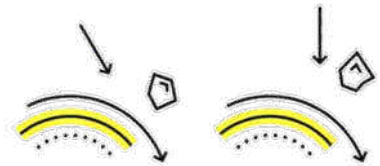

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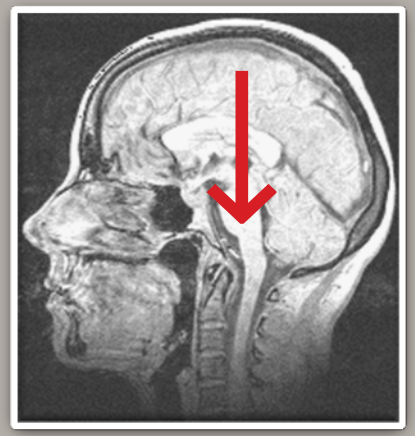

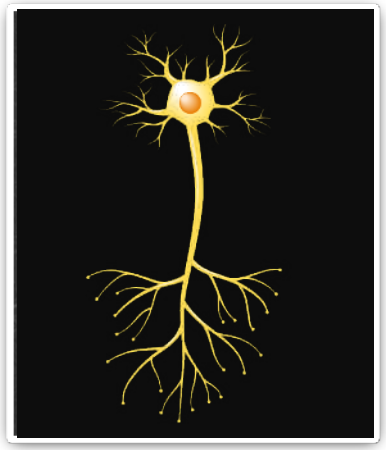

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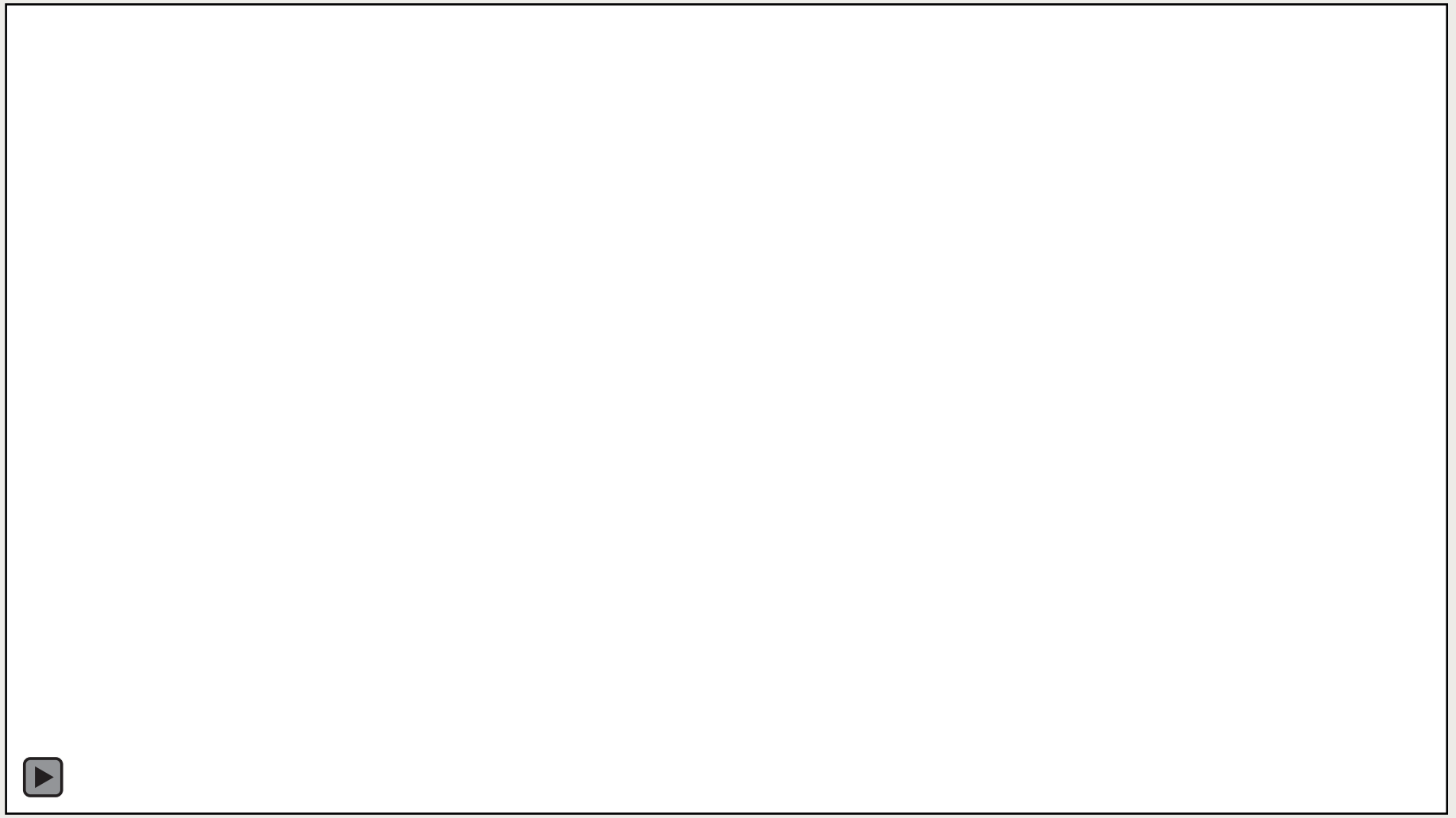
The science of head injuries

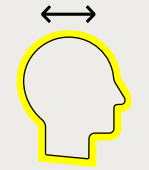
Rotational motion is a combination of rotational energy (angular velocity) and rotational forces (angular acceleration) that may result from oblique impacts to the head. As the rotational motion is transferred to the brain it can start to deform and shearing can occur which may cause damages to the axons in the brain, amongst other damage.

During most impacts both linear and rotational motions occur and gives an increased risk of injury.

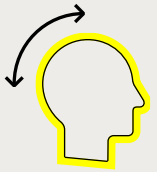
Concussions and Traumatic Brain Injuries (TBIs) are commonly caused by **rotational motion** and **strain** to the brain.

Injury statistics demonstrate that when someone trips, falls, or is struck by a fallen object, the impact is more likely to be at an angle instead of directly on top of the head.



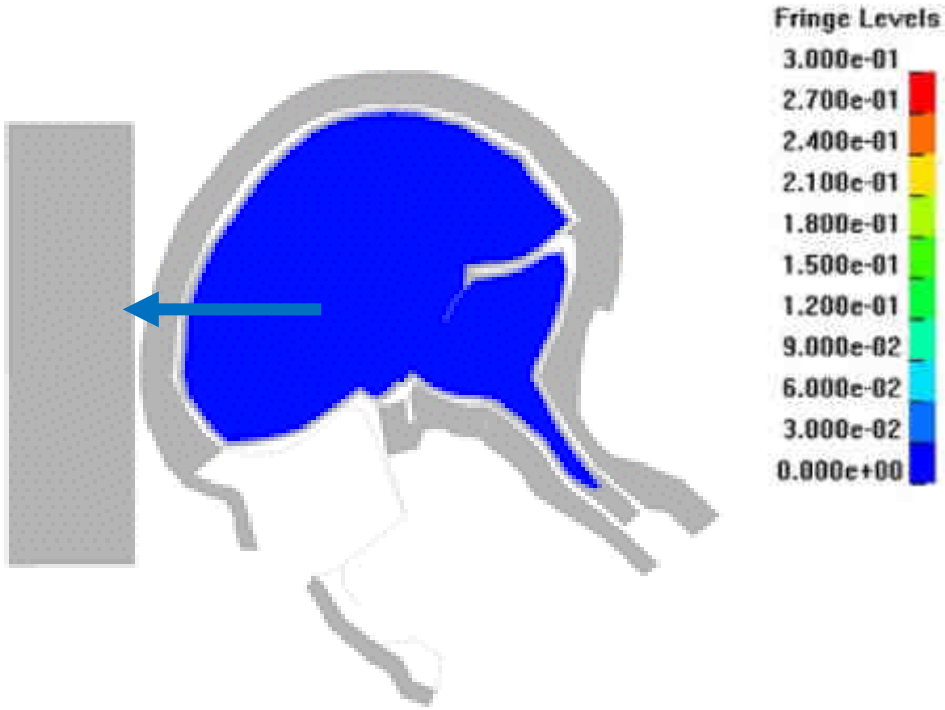


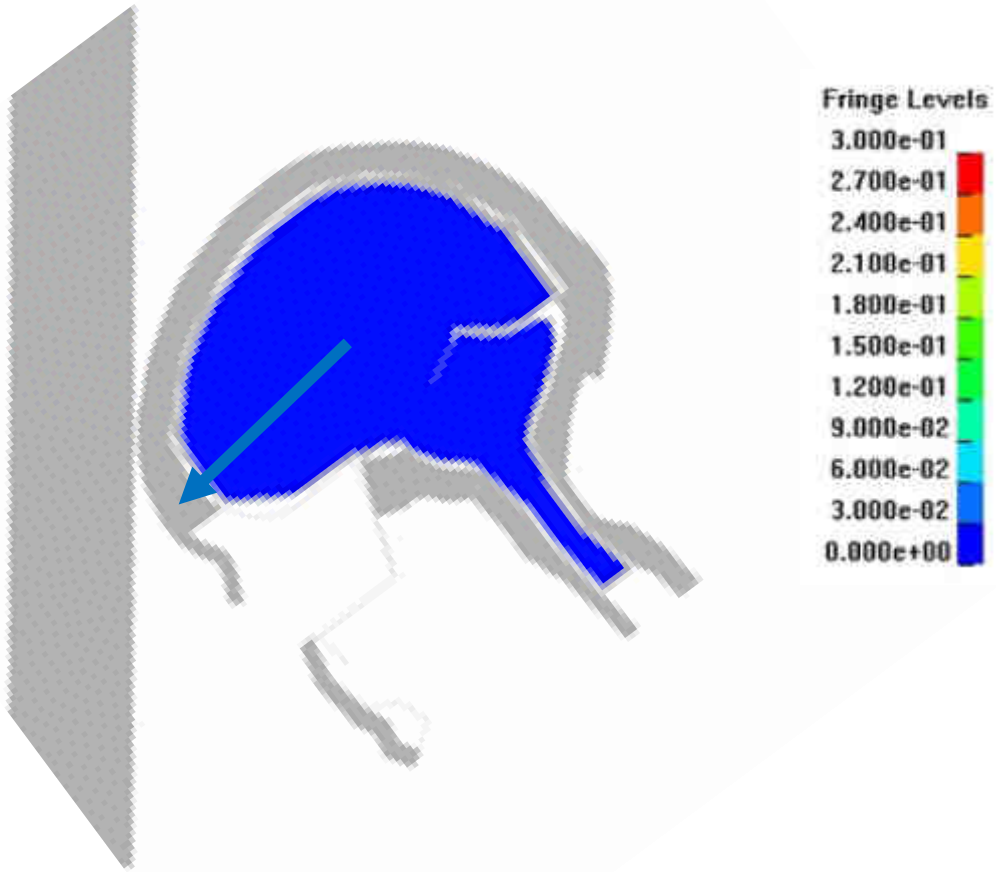
Linear Impacts =
No rotational energy



Angled Impacts =
Rotational energy

Simulation comparing Linear vs. Angled impact @ same impact velocity

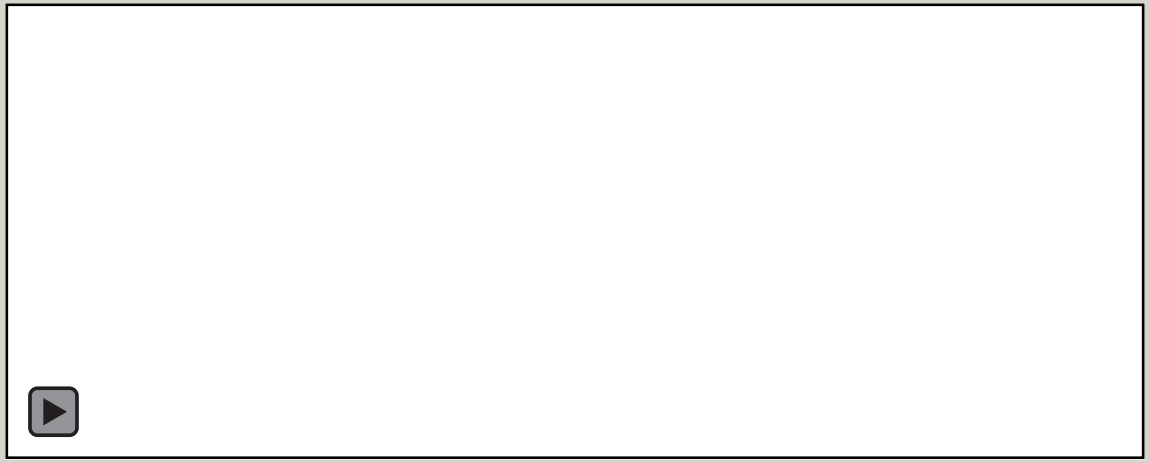




FE model simulation from Kleiven, Enhanced Safety of Vehicles 2007

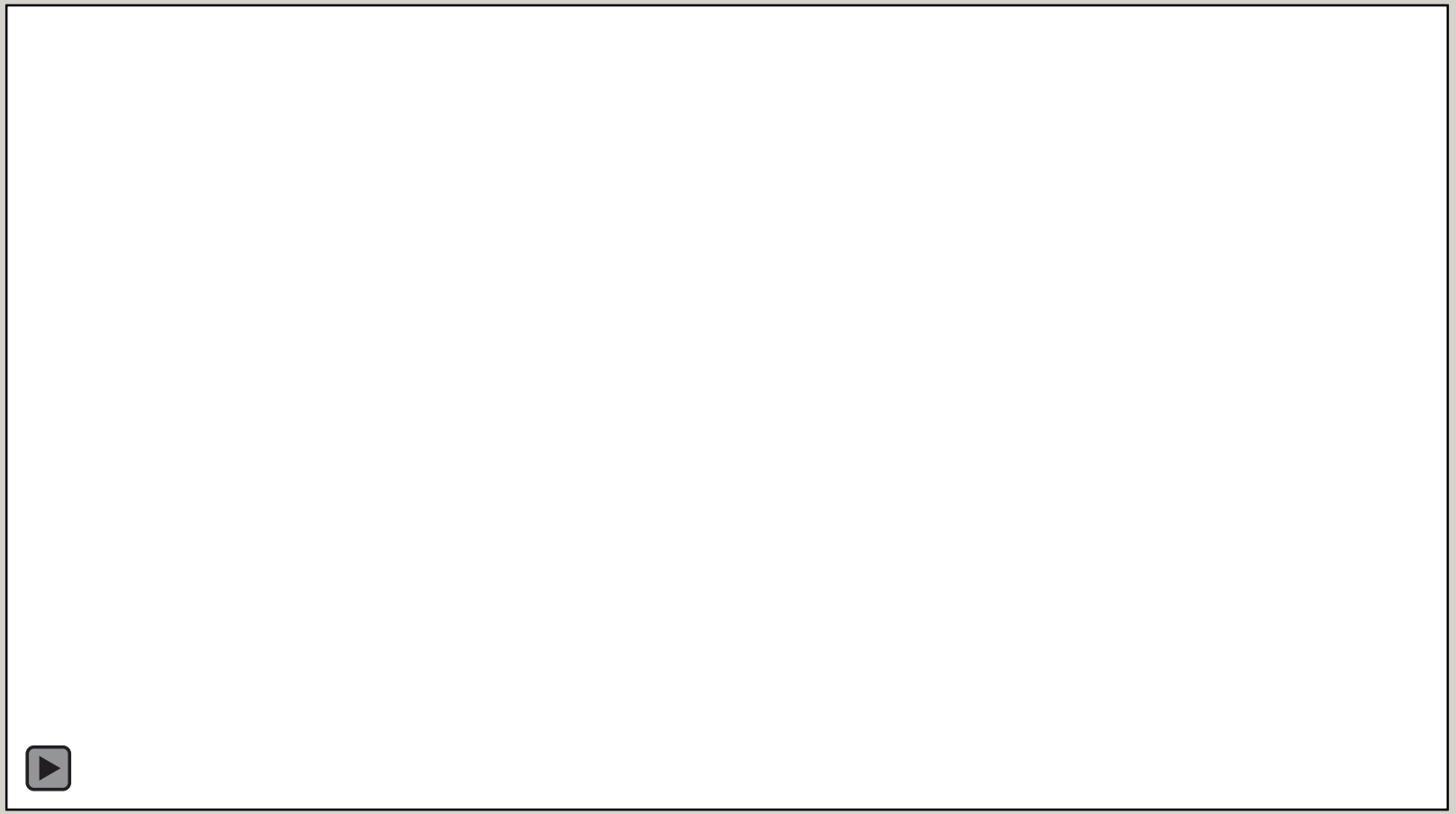
Mips® Brain Protection System for Industrial Safety Helmets

- At impact, the Mips® system is designed to help reduce the rotational motion transferred to the head by redirecting these forces that are generated by the impact
- The Mips® system allows a 10-15mm relative movement between the helmet and the head during the first critical 5-10ms of the impact
- It is not uncommon that the point load on the head/helmet at impact is a 2,200lbs. The Mips® system is designed to allow the helmet to move even under this kind of pressure



Case study – simulated effect of the Mips technology

THE DIFFERENCE OF WEARING A HELMET VS A HELMET WITH MIPS TECHNOLOGY IN A SLIP ACCIDENT SCENARIO



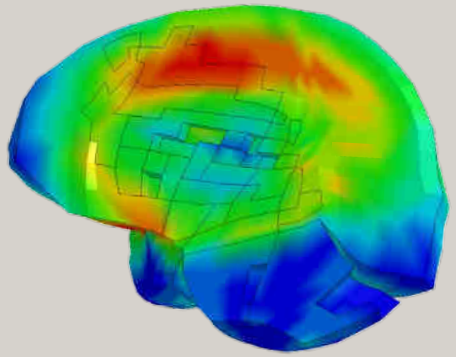
CASE STUDY – SLIP ACCIDENT

Finite Element simulations of the effect of the Mips® system based on internal proprietary testing by Mips in a safety helmet.

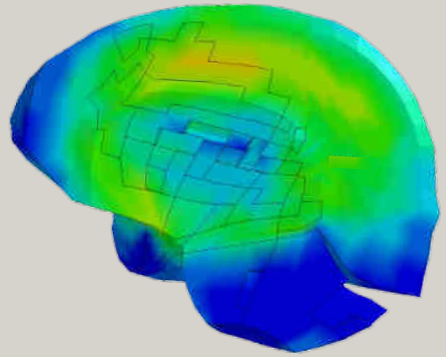
Simulated effect of the Mips® brain protection system for industrial safety helmets

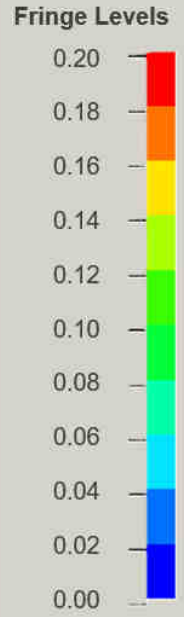
The graphic illustrates the strain in the brain during an angled impact for two different helmet configurations. The strain is computed with the KTH Brain Model (Kleiven 2007) using the acceleration data from the THUMS model.

Helmet without Mips® system



Same helmet with the Mips® system

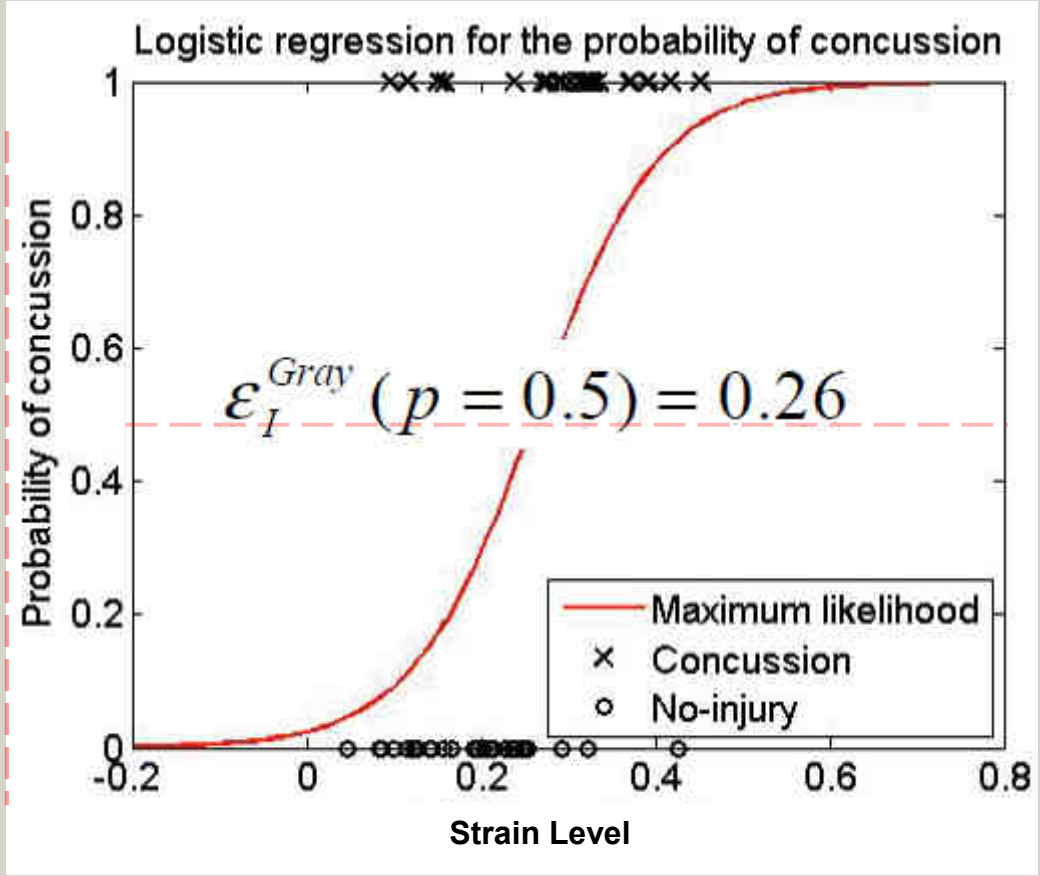




Risk of concussion according to: Fahlstedt, M., Meng, S., & Kleiven, S. (2022). Influence of Strain post-processing on Brain Injury Prediction. *Journal of biomechanics*, *132*, 110940. https://doi.org/10.1016/j.jbiomech.2021.110940

Risk of injury based on results from case study

STRAIN LEVEL IN RELATION TO PROBABILITY OF CONCUSSION



Kleiven 2007, Predictors for traumatic brain injuries, evaluated through accident reconstructions. (Stapp 2007)

Summary

- Head protection helps keep people safe at work
- Injuries comes with a cost; of health, of life and financial implications
- Different helmets are designed for different types of situations and risks – choose wisely
- Helmets are typically not designed to address angled impacts – but there are those intended to help provide added safety in this regard.

Questions?

LET'S CONNECT

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Thank you!