MEMO

Subject: Lab #5 Biomechanics of trauma

Synopsis:

This lab introduces analysis of injury probability due to various traumatic loading conditions. The objective of this lab is to understand neck and long bone injuries due to motor vehicle accidents. An engineering analysis of injury due to various loading conditions is very important to design standards for equipments, living goods, etc. If there is no guide line for automobile for example, then it would be very risky for riders who have higher possibilities to have brain damages, neck injuries which can lead to death. This lab shows that a helmet protects face, skull, and brain from injuries but also it can add mass to head which can cause neck injuries as well. Also, angular acceleration is dominates injuries than angular velocity. There are four types of neck injuries such as tension-extension, tension-flexion, compression-extension, and compression-flexion. And tension-extension might give the highest neck injuries and compression-extension might give the least neck injuries within same circumstances. For long bone fractures due to 3-point bending is more serious than 4-point bending. Because in 3 point bending case, all force is concentrated to one point but in 4 point bending case, force is distributed to two points which can cause less moment. This lab is performed with following calculations in the lab manual by biomechanics design lab. The Abbreviated Injury Scale (AIS) is an anatomical scoring system first introduced in 1969. Since this time it has been revised and updated against survival so that it now provides a reasonably accurate of ranking the severity of injury. Injuries are ranked on a scale of 1 to 6 with 1 being minor, 5 severe and 6 an unsurvivable injury. Head and neck injury criteria are less angular acceleration, less moment arm (distance from the point of rotation to center of head mass), less impulse time that head hits to ground.

Equations:

Head Injury Criterion (HIC), Severity Index (SI): $SI = \int a^{2.5}(t)dt \qquad HIC = \Delta t(\frac{1}{\Delta t}\int a \cdot dt)^{2.5}$

Angular velocity and angular acceleration $\omega = \frac{v}{r} \qquad , \alpha = \frac{a}{r}$

Neck Injury Criterion (NIC) $N_{ij} = \left(\frac{F_{Z\,i}}{F_{ZCritical}} + \frac{M_{OC\,j}}{M_{OCCritical}} \right) \; where \sum N_{ij} < 1.0$

Potential energy Kinetic energy velocity force

$PE = mgh \qquad KE = \frac{1}{2}mv^2 \qquad v = \sqrt{2gh} \qquad F = \frac{KE}{d}$

Discussion/Conclusion:

1. A helmet reduces the risk of serious head and brain injury. Also, it protects face and skull.

2. Estimated peak for F-NIC curve is 35N at 80 ms. Estimated peak for NIC curve for shear is 81N at 78ms and bending is 4.6Nm at 76ms.

3. According to frontal collision (9m/s) graph, tension is 510N, AP shear is 410 N, and bending is 113N. Joint rotation alpha is 1300 rad/sec^2 and angular velocity omega is 9 rad/s. According to rear collision (-9m/s) graph, tension is 2300N, AP shear is 510N, and bending is 24N. Joint rotation alpha is 7100rad/s^2 and angular velocity omega is 6 rad/s. Rear collision is more severe than frontal collision because rear collision shows bigger angular acceleration which is 7100rad/s^2. The angular velocity of rear collision is smaller than frontal collision. Thus, this explains that angular acceleration dominates the injuries.

4. According to FNIC and Nij graphs for Nij and F-NIC, tension-extension is the highest Nij value 0.0511, the second highest Nij value 0.376 is tension-flexion, third highest Nij value 0.0368 is compression-extension, and fourth highest Nij value 0.023 is compression-flexion.

5. Examples of sports activities that can cause a tension-extension neck injury include a football player who spears an opponent with his head. In this case head bend toward to one's chest and the behind of neck has serious tension. A gymnast who misses the high bar during a release and hits the mat head first can cause a compression-extension due to hitting the mat. A diver who hits the bottom of a pool head on can cause tension-flexion or compression-flexion. When the diver hits one's head the bottom of a pool with forehead, it would be tension-flexion. When the diver hits one's head the bottom of a pool at point between more toward to the middle of head and forehead, it would be compression-flexion.

Free body diagram
3-point bending

4-point bending

6. 4 point bending is much safer than 3 point bending because it has less moment cause at the end of bones. Because in 3 point bending case, all force is concentrated to one point but in 4 point bending case, force is distributed to two points.

This lab is successful because students understood biomechanics of trauma and calculation to analyze different injuries such as head, neck, and long bone. Students found out that a helmet protects face, skull, and brain from injuries but also it can add mass to head which can cause neck injuries as well. Also, angular acceleration is dominates injuries than angular velocity. There are four types of neck injuries such as tension-extension, tension-flexion, compression-extension, and compression-flexion. And tension-extension might give the highest neck injuries and compression-extension might give the least neck injuries within same circumstances. For long bone fractures due to 3-point bending is more serious than 4-point bending. Because in 3 point bending case, all force is concentrated to one point but in 4 point bending case, force is distributed to two points which can cause less moment. The limitation of lab was that students could not perform real experiments.

References

[1] Harris, Lab manual, March, 2006

APPENDIX A.

** Design a system component or process to meet desired meds with realistic constraints

Figure 2. Single-ended amplifier showing lack of rejection of present on non ground active terminal.

Figure 3. Biological amplifier showing how the differential amplifier rejects the common signal by subtracting the signal that is present at an equal amplitude at each active terminal. Different EMG signals are present at each electrode thus, the subtraction does not result in a cancellation.

Figure 4. Electrode design with data storage

Once the EMG signal has been amplified, it can be processed for comparison or correlation with other physiological or biomechanical signals. The need for changing the EMG into another processed form is caused by the fact that the raw EMG may not be suitable for recording or correlation. This can be a constraints for signal processing. (Winters)