Motorcycle-Guardrail Crashes:
How can the risk of severe injury and fatality be reduced?

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The Problem

Motorcyclist fatalities can occur from a variety of accidents. In the United States in 2005, motorcyclists comprised 42% of fatalities due to guardrail collisions, whereas only 3% of vehicles on the roads were motorcycles (Gabler, 2007). More motorcyclists were killed in guardrail collisions than passengers of any other vehicle type in 2005 (Gabler, 2007). Guardrails are designed to retain cars and other large vehicles such as vans and trucks. However, motorcycles also share the road with these vehicles. Motorcyclists are usually thrown from their motorcycle in the event of a collision, leaving them at the mercy of the surrounding environment, including roadside barriers, as they come to a stop. Guardrails have been very effective in saving the lives of occupants of cars and trucks, and cannot simply be removed to protect motorcyclists. However, improvements need to be made in several areas in order to keep motorcyclists, as well as car occupants, safe in guardrail collisions.

The injuries sustained in a motorcyclist-guardrail collision are dependent on the design of the barrier (Ouellet, 1982). Steel guardrails are designed to absorb the energy from an impact through deformation. With less energy present, the chances of the colliding object being redirected into oncoming traffic is significantly reduced. However, barriers are designed to retain large vehicles such as cars and trucks—not motorcycles. The posts supporting the W-beam of the guardrail are one of the most serious dangers to motorcyclists. They generally have narrow faces and sharp edges, causing the force to be highly concentrated on the motorcyclist as he/she collides with it. These posts are unforgiving to the tumbling cyclists (Domhan, 1987).

Research has been conducted in Europe and Australia to reduce the number and severity of injuries and fatalities incurred from collisions with roadside barriers. Several different modifications to roadside barriers have been designed to reduce the severity of the injuries inflicted on colliding motorcyclists. Some of these redesigns have been installed in Europe and Australia based on these findings in order to make the roads more motorcycle friendly. However, to date, little has been done to address the issue in the United States.

Injury Countermeasures

Shielding motorcyclists from the posts of the guardrail is an effective way to reduce the severity of injuries and the fatality rate since posts are the most hazardous component. The I-beam shaped post is the most commonly used post; however, it also contains the most edges and narrow faces. Different modifications to guardrails have been designed in order to ensure they are motorcycle friendly. One modification is the addition of a lower W-beam. This additional beam prevents a motorcyclist from moving under the barrier as he/she comes to a halt, preventing him/her from colliding with the harsh edges of the

posts. Several other methods of protecting motorcyclists from the I-beam posts have also been developed. SEC-Envel developed a metal shield that is attached below the W-beam and serves the same purpose as the addition of an extra W-beam (Figure 1). However, it is constructed from a flat piece of ductile metal, so it absorbs more energy upon impact than does the additional W-beam. It has been in use in France since 1997 and approximately 500 kilometers were installed across France by the year 2000 (FEMA 200).

Figure 1. Metal shield developed by SEC-Envel. The flexible metal covers the hazardous posts and prevents motorcyclists from colliding with them (FEMA, 2000 [left] and Limi et al., 2008 [right]).

The Plastrail by Sodilor is another guardrail modifier made in France (Figure 2). Constructed from plastic, it is designed to enlarge the surface area around the post, therefore the concentration of the energy transfer upon impact. The Mototub by Sodirel (Figure 3) is similar to the Plastrail; however, it is fabricated from 70% recycled material (FEMA, 2000).

Figure 2. The Plastrail by Solidor. This plastic covering provides protection to motorcyclists by covering the posts of the guardrail (Limi et al., 2008).

Figure 3. The Mototub by Sodirel. The Mototub is made from 70% recycled material and prevents motorcyclists from hitting the posts of the guardrail (FEMA, 2000).

Impact attenuators are another means of protecting motorcyclists from posts. These surround the posts and create a larger surface area to collide with as well as protect the motorcyclists from the harsh faces of the posts (Figure 4). They can be made from a variety of different synthetic materials (Duncan et al., 2000). Testing on neopolene impact attenuators has shown that they have significantly reduced the severity of injuries incurred upon collision, though they are most effective in collisions occurring between 50 and 60 km/h (Domhan, 1987). Also, other testing was done with cadavers to determine the difference in severity of the injuries incurred when impact attenuators were in use as opposed to unprotected I-beam posts. It was also found that the injuries were significantly less severe when the impact attenuators were used (Jessl, 1985 and Schuler, 1985, cited in Duncan et al., 2000).

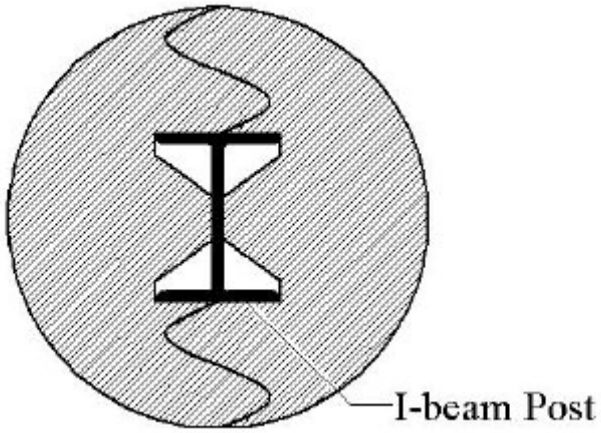

Figure 4. Sample Impact Attenuator. Impact attenuators surround posts, creating a larger surface area for impact as well as protecting motorcyclists from the sharp edges of posts (adapted from FEMA, 2000).

The shape of the post itself can also be altered to reduce the severity of an injury caused upon collision. Posts that are more rounded and have fewer exposed sharp edges have been designed to replace the I-beam posts. The sigma-post has a cross-section shaped like the capital Greek letter sigma (Σ), thus having less exposed sharp edges and a more rounded shape (Figure 5). These features do not allow for the energy to concentrate in areas as highly as it concentrates in a collision with the I-beam post. Posts with other cross sections shaped like the letters "C" and "Z" (Figure 5) have also been used to reduce the severity of injuries (Duncan et al., 2000).

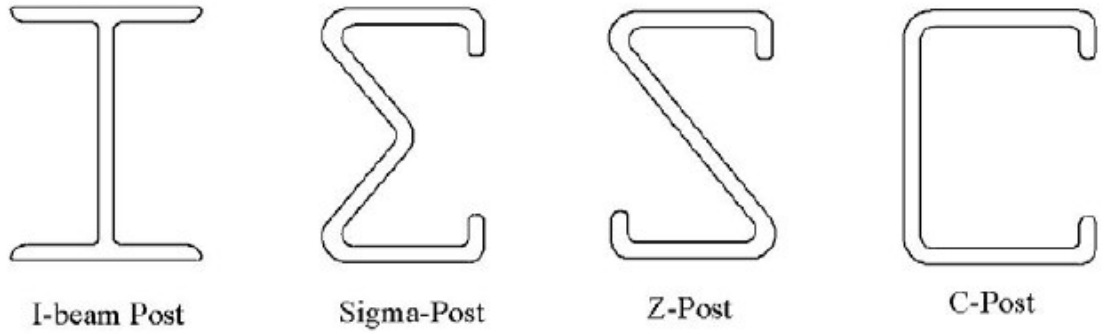

Figure 5. Various Post Designs. The I-beam post is the most commonly used post; however, it also poses the greatest threat to motorcycles. The Σ -, Z-, and C- posts have a more rounded shape and less harsh edges, making them safer for motorcyclists (adapted from FEMA, 2000).

Cost and Feasibility

Both motorcyclists and passengers of other vehicles are protected through these modifications; however, it is not economically beneficial to modify all guardrails to be motorcycle friendly. A cost analysis of replacing systems in Germany was done and it was found that the cost of updating the current systems was too high as compared with the costs of accidents. However, it was also found that if ten percent of guardrails were made motorcycle friendly, the additional safety measures would be cost effective (Domhan, 1987).

Thus, areas that pose the most danger, also known as black spots, need to be targeted for barrier improvement. Tight and non-constant curves are potential black spots due to the difficulty of maneuvering a motorcycle around them (FEMA, 2000). In addition, areas where accidents have already occurred may be considered black spots and are candidates for improved barrier systems. In Germany, several stretches of roadway seen to be hazardous were equipped with improved barrier systems.

"According to the police accident reports available for these sections, the accidents that occurred reportedly would have been much more severe or even fatal had the guardrails at the scenes not been fitted with W-beams or crash absorbers" (Domhan, 1987).

Though these modifications are proven to be effective, other actions must be taken in conjunction with them because they are too expensive to implement on every guardrail.

International Motorcycle Initiatives

Initiatives have been taken across Europe in order to make roads safer for motorcyclists. More frequently now roads are being upgraded to better accommodate motorcyclists. A stretch of highway RV 32 in Norway was opened on May 7, 2008 that had been modified to incorporate safety measures for motorcyclists that are usually overlooked in road design (FEMA, 2008).

Moreover, France has allocated over five million euros a year for the improvement of crash barriers around hazardous curves and the fitting of motorcycle friendly devices in black spots. The Provincial Council of Utrecht in the Netherlands decided to only install motorcycle friendly barriers when new barriers are erected (Baird et al., 2005).

These are just some examples of recent measures taken to protect motorcyclists; programs have been put in place in other European Countries such as Germany and Portugal to ease the severity of motorcycle accidents. If the United States were to take similar action, the severity of motorcycle crashes, as well as the frequency of fatal motorcycle crashes, could be significantly reduced. The information and technology is available in order to make a difference; however, the initiative needs to be taken.

Recommendations

Significant studies and research have been completed showing the increased severity that guardrails can add to a motorcycle collision; however, the issue has not gained widespread attention in the United States.

The seriousness of this issue needs to be emphasized in order for it to gain recognition. Guidelines have been established by the National Highway Traffic Safety Administration (NHTSA) for state motorcycle safety programs. The larger effort is concentrated on personal protection equipment, training, drunk driving, and law enforcement (NHTSA, 2006). These actions are all beneficial; they can prevent several different types of fatal accidents.

Training strengthens skills such as braking, cornering, and swerving (MSF, 2000), reducing the possibility of losing control and crashing into a guardrail or getting into a different type of accident. Moreover, increased law enforcement would ensure that more people are following the laws such as driving sober and obeying speed limits.

However, of the 224 motorcyclists fatally injured from a guardrail collision in 2005 in the United States, more than two-thirds were wearing their helmet (Gabler, 2007). Thus helmet usage is not the best preventative measure in the event of a guardrail collision. Though the preventative measures being taken are effective, other means of protecting the motorcyclists must also be considered, especially in the event of guardrail collisions. Raising the awareness of the issue in the United States would lead to more efforts taken to correct it. The Federation of European Motorcyclists' Associations (FEMA) has

effectively brought the issue to the forefront of safety in Europe with its report on motorcycle-guardrail collisions. Several safety measures were recommended in the paper, which are now being acted upon. With a greater awareness of the issue, there becomes a greater move for action, as demonstrated with the FEMA paper. Educating people about the severity of the issue would cause a drive from the public to make a difference in reducing the severity of guardrail collisions. One of the main barriers the issue is currently facing in the United States is lack of knowledge about the topic. Once the public becomes aware of the issue, policymakers will be motivated to correct it.

Lastly, regulations need to be set that consider motorcyclists in the design and testing of barriers. As of 2005, throughout Europe no regulations on crash barrier design and testing were set to consider the implications on motorcyclists (Baird et al., 2005). Moreover, based on an analysis of the methods used, motorcyclists have not been considered in the international standard testing methods of roadside barriers (Gowan, 1996, cited in Duncan et al., 2000). In 2005 Spain pioneered the development of a barrier-motorcyclist crash test which takes the first step toward such an international standard (Perandones et al., 2008).

As demonstrated above, roadside barriers pose a serious threat to motorcyclists, causing significant numbers of injuries and fatal accidents to occur. International standards should be set in order to incorporate testing with motorcycles and motorcyclists for new barrier designs. Moreover, regulations should be set on roadway designs that incorporate motorcycle friendly barriers. Regulations governing both barrier and road design would make the roads safer by reducing the total number of fatal guardrail collisions involving motorcyclists. Aside from regulations providing safety to motorcyclists, implementing motorcycle safe barriers from the beginning of a project would be cost effective. With proper safety measures taken, the need to revisit a road to make modifications is eliminated, reducing future construction costs.

Conclusion

Roadside barriers pose a serious hazard to motorcyclists. Although barriers have been proven to be extremely beneficial to car occupants, these barriers could cause more severe injuries to motorcyclists than would be incurred if the barrier was not present. Several modifications have been designed in order to reduce the severity of injuries; however, these are mostly used in Europe. The United States needs to take the initiative to start protecting its motorcyclists, such as modifying barriers in black spots so injuries are not as severe and fatalities are not as frequent. Increasing awareness of the issue in the United States would lead to measures being taken to prevent accidents. Moreover, regulations on barriers need to be set in order to ensure that new barriers are motorcycle friendly. The means of protecting hundreds of people each year exists, yet need to be acted upon in order to start saving lives.