29th International Congress on Sound and Vibration
The annual congress of the International Institute of Acoustics and Vibration (IIAV)
9–13 July 2023
ICSV29

EXPERIMENTAL ANALYSIS OF GREYHOUND RACING TRACK PADDING IMPACT ATTENUATION PERFORMANCE

David Eager* and Shilei Zhou
University of Technology Sydney, Sydney, Australia
email: David.Eager@uts.edu.au

To reduce injuries to greyhounds caused by collisions with fixed racing track objects such as the outside fence or the catching pen structures, padding systems are widely adopted. However, there are currently neither recognized standards nor minimum performance thresholds for greyhound industry padding systems. This research investigates the impact attenuation characteristics of different padding systems for use within the greyhound racing industry for the enhanced safety and welfare of racing greyhounds. A standard head injury criterion (HIC) meter was used to examine padding impact attenuation performance based on the maximum g-force, HIC level and HIC duration. Since padding impact attenuation characteristics are affected by the installation and substrate, on-site testing was conducted to obtain the padding system impact attenuation performance in actual greyhound racing track applications. The test results confirm that the padding currently used within the greyhound industry is adequate for the fence but inadequate when used for rigid structural members such as the catching pen gate supports. Thus, increasing the padding thickness is strongly recommended if it is used at such locations. More importantly, it is also recommended that, after the installation of padding on the track, its impact attenuation characteristics should be tested according to the methodology developed herein to verify the suitability for protecting greyhounds from injury.

Keywords: Greyhound racing, padding impact attenuation, injury prevention, animal welfare.

1. Introduction

In many countries, greyhound racing is a popular sporting and recreational activity. With increasing awareness of animal welfare, the injury and death of racing greyhounds have attracted public attention. Injuries to greyhounds can be caused by several mechanisms [1, 2]. Among these mechanisms are collisions with fixed objects such as the outside fence on a track bend or if the greyhounds fail to slow down after the completion of the race within the catching pen.

Most greyhound races are conducted at oval-shaped tracks where the radius of the bends and the camber on the bends are not standardised within the industry. For example, in Australia, the track radii of the bends vary from 49 m at Tamworth to 73 m at Mandurah. While navigating around a bend, greyhounds always experience centrifugal force which tends to pull them to the outside of the track [3]. If greyhounds cannot handle this dynamic centrifugal force by adjusting their posture, trajectory and speed, they experience a motion that does not follow the path of the lure but leads to impact with the outside fence. If a collision between greyhounds occurs, they can easily fall and slam into the outside fence. The tighter the bend, the greater the centrifugal force and the greater the probability of the greyhound impacting the outside fence.

Moreover, the greyhounds' stopping needs to occur after they cross the run back gate, at which point it is closed and the lure is no longer visible to the greyhounds [4]. The distance to the catching pen from the point a greyhound begins to rapidly slow down varies depending on the catching pen location at each individual track. During the catching pen slowing down period, the greyhounds decrease their speed from almost full speed, which could be more than 15 to 0 m/s [5]. There is a residual risk that one or more greyhounds would not be able to reduce their speed adequately and would collide with a component of the catching pen infrastructure. These components include the catching pen gate, gate supporting column and the catching pen fence.

To protect the greyhounds from injuries caused by colliding with the fence, protective padding is widely applied on tracks. It was found that padding used by different tracks had various sizes, thicknesses, filling materials, surface materials and installation methods, which result in totally different impact attenuation performance. The greyhound colliding pattern and padding characteristics have not been systematically researched or published in the literature. Thus, there has been no rigorously prepared and peer-reviewed information presented to date about the suitability of a certain padding specification for a particular track, the methodology to design the padding system based on the track shape, greyhound speed and expected collision patterns.

This research therefore aimed to conduct an initial, systematic investigation on greyhound racing track padding performance. On-site impact attenuation tests were conducted for different padding systems which are currently installed on greyhound racing tracks to record and analyse their impact attenuation characteristics with different applications and substrates. Finally, from the experimental results, discussions and recommendations are made regarding the importance of selecting a proper padding system and of conducting impact attenuation checks in greyhound racing tracks after installation.

2. Head Injury Criterion (HIC) definition and HIC meter

Figure 1 depicts different padding examples of various padding sizes, thicknesses, materials and installation methods at several greyhound racing tracks in Australia. The subsequent sections report the results of the investigation of the performance of some of these padding examples at the track.

Figure 1: Different padding used at greyhound racing tracks on the outside fence.

To investigate the impact attenuation performance of different padding systems, tests were conducted using the HIC impact test meter as shown in Figure 2. In the HIC meter, a triaxial accelerometer is positioned in the centroid of the semi-spherical head form. When the head form impacts with other objects, the accelerometer measures and records the head form accelerations from which the HIC is calculated in accordance with Equation (1) [6]:

$$HIC = \left\{ (t_2 - t_1) \left(\frac{1}{t_2 - t_1} \int_{t_1}^{t_2} a(t)\, dt \right)^{2.5} \right\}_{\max} \tag{1}$$

where t_1 and t_2 are the initial time and final time of the HIC calculation period, while a(t) is the measured real-time acceleration during this period.

Figure 2: The HIC impact test meter used in this research.

There is no known published research on the relationship of the severity of impacts between canines and the measured HIC and underlying accelerations. There is, however, considerable such research on the severity of impacts on humans [7, 8]. The graph of probability of Maximum Abbreviated Injury Scale (MAIS) [9] for an average adult human male, shown in Figure 3, describes the probability of different levels of injury occurring for a certain HIC value.

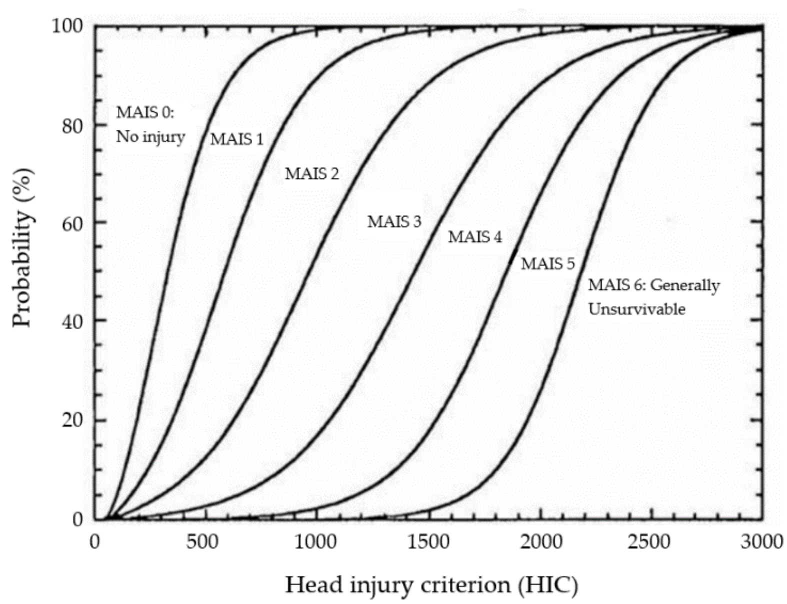
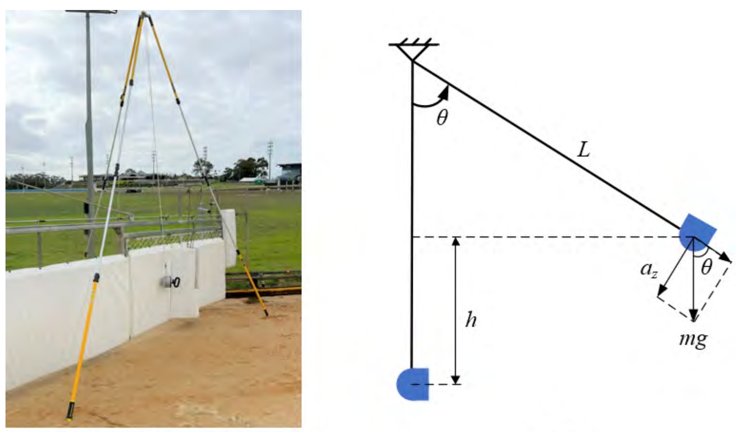


Figure 3: Prasad–Mertz probability curves of a specific injury for a specific HIC value [9, 10].

As can be seen in Figure 3, 1000 HIC indicates: a 3% probability of a critical head injury (MAIS 5); a 18% probability of a severe injury (MAIS 4); a 55% probability of a serious injury (MAIS 3); a 89% probability of a moderate injury (MAIS 2); and a 99.5% chance of a minor injury (MAIS 1). According to the commonly used international impact attenuation standards for children's playground equipment, to effectively avoid the fatal impact of falling in playgrounds, the peak acceleration during an impact test must be less than 200 g, the HIC must be less than 1000 and the duration over which the HIC is calculated must be greater than 3 ms.

3. On-Site impact attenuation test of different padding

Padding systems are installed on greyhound racing tracks using different methods and with various alternative substrates. Therefore, on-site tests, as shown in Figure 4(a), were conducted to determine the padding impact attenuation performance when installed on the track. This testing reflected the actual in-situ greyhound racing track impact attenuation conditions. Since all the padding was installed perpendicular to the ground, the HIC impact meter had to impact the padding from the side like a pendulum. During the test, the HIC meter was hung from a tripod and released from a measured height. When released, it impacted the padding from the side which was analogous to the greyhound impact conditions.



(a) (b)

Figure 4: On-site impact test setup and its model for motion analysis, (a) on-site impact test setup up; (b) model of the HIC meter motion.

According to the law of conservation of energy, the HIC meter impact velocity v can be calculated by Equation (2), assuming all potential energy is transferred to kinetic energy:

$$v = \sqrt{2gh} \tag{2}$$

where g is the gravitational acceleration 9.81 m/s^2 and h is HIC the meter height from its stationary position (HIC meter at lowest position and rope vertical).

3.1 On-site impact test of the 75 mm-thick padding at the greyhound racing track

As shown in Figure 5, the 75 mm-thick padding is used at this greyhound racing track with different substrates, which provide different impact attenuation performance as a whole system. Therefore, on-site tests were conducted to assess the padding impact attenuation performance in-situ. At the various locations, the substrate was (a) corrugate steel panel; (b) stout steel mesh which was mostly rigid; and (c) thin steel mesh which had some flexibility. During the test, the HIC meter was lifted to different heights relative to its static position and released. For each height, three repeats were conducted and the average of these results were determined. The impact velocity was calculated using Equation (2). For location (c), the minimum HIC impact meter release height was 1.15 m because the impact on the flexible mesh was insufficient to trigger the HIC impact meter data capture for release heights lower than this.

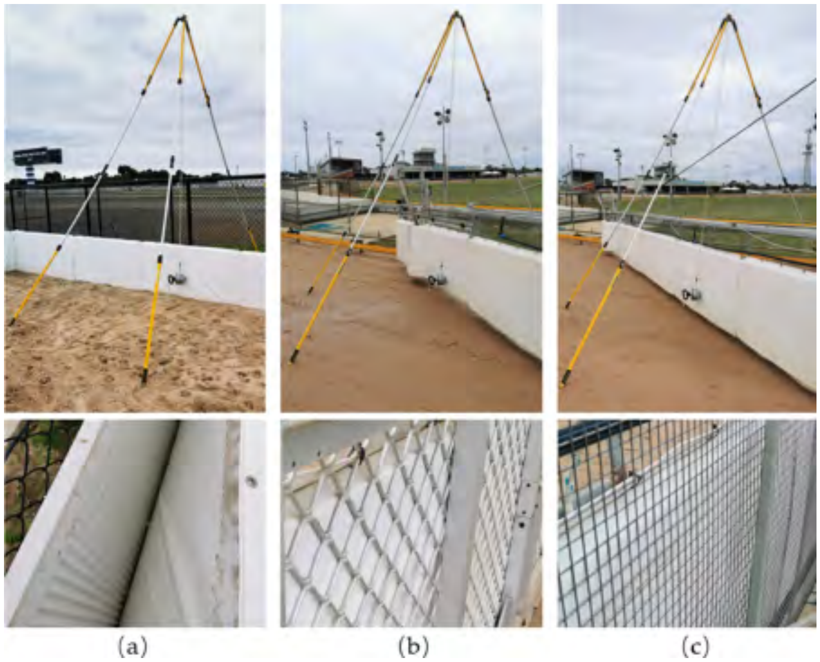


Figure 5: On-site impact test of the 75 mm thick padding with different substrates, (a) corrugated steel panel substrate; (b) stout steel mesh substrate; (c) thin steel mesh substrate.

The average HIC and maximum acceleration at each location with different release heights are plotted in Figure 6 and Figure 7. The measured values were extrapolated through second-order polynomial fit. It was found that, even with identical padding, the impact attenuation performance was affected considerably by the underlying substrate. The HIC and maximum acceleration at location (c) are smaller than at locations (a) and (b) due to the flexibility of the thin steel mesh. Thus, it is recommended that the padding should be tested after installation to ensure the impact attenuation performance meets the requirements. Furthermore, if the HIC 1000 and 200 g acceleration limits are used as the padding requirement criteria, all three locations suggest a safe greyhound impact for a 10 m/s velocity.

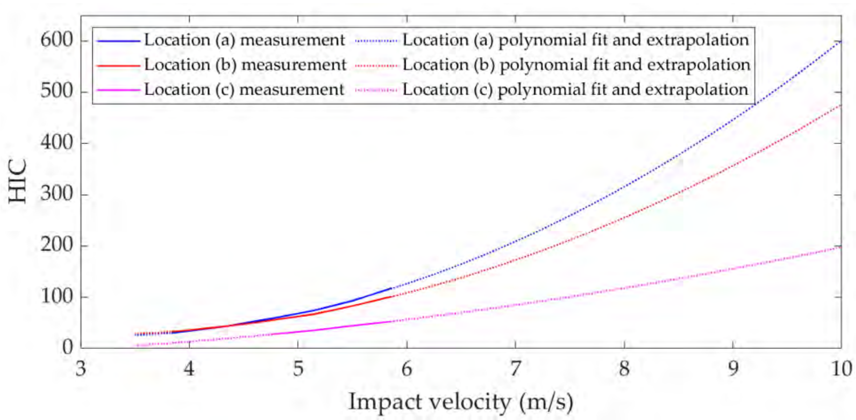


Figure 6: HIC with different substrates at a typical greyhound racing track.

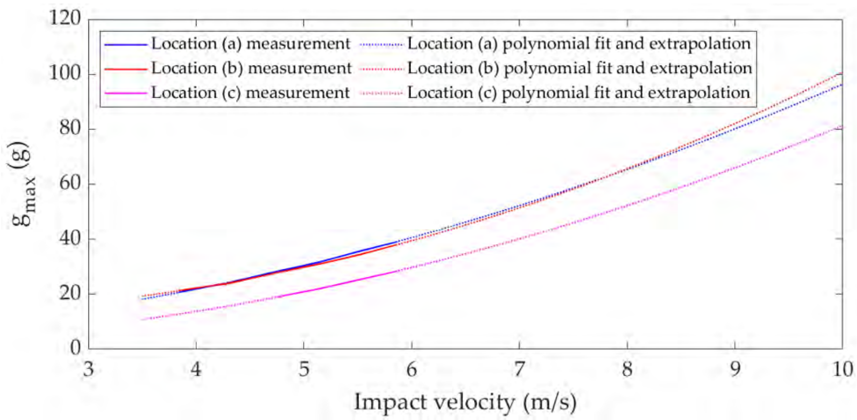


Figure 7: Maximum acceleration with different substrates at a typical greyhound racing track.

3.2 On-site impact test of other padding cases at the greyhound racing track

On-site tests were also conducted at another greyhound racing track where different padding was used, as shown in Figure 8. Tests (a) and (b) were located at poles where the padding was tightly wrapped around the steel sections which had nearly no flexibility and was thereby more similar to the concrete substrate. During the test, the HIC impact meter was released, targeting directly on the poles. Test (c), on the other hand, was located at the catching pen gate. Here, the padding was installed on the steel mesh. For all three test locations, the HIC impact meter was lifted to 2.0 m and released. The static position height was 0.7 m, resulting in a fall height of 1.3 m and an impact velocity of 5.05 m/s.

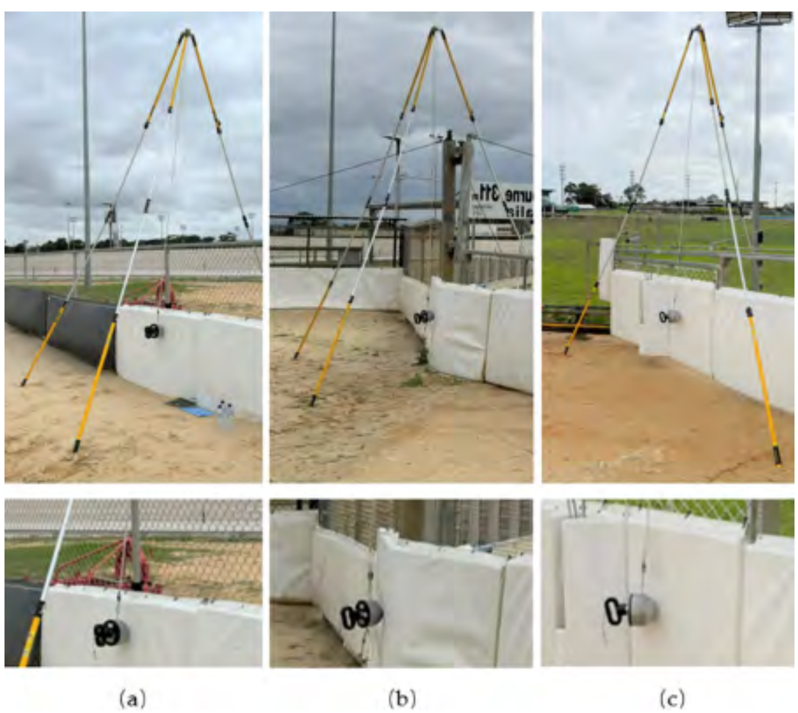


Figure 8: Impact test of other padding cases, (a) catching pen thin pole; (b) catching pen large pole; (c) catching pen gate.

A sample of the measured acceleration at each location is plotted in Figure 9. It can be observed that, when the padding was installed on the steel poles, the impact force was very large, as demonstrated by the large accelerations at location (b), indicating a potential safety hazard for greyhounds. Conversely, when the padding was installed on the steel mesh of the catching pen gate, the resulting impact force was relatively small, as shown in Figure 9(c).

The steel mesh is more flexible than the steel poles. Therefore, longer impact duration and smaller accelerations are obtained with the steel mesh as the substrate. The test results at location (b) indicate that the steel poles remain hazardous to the greyhounds even with padding. It is concluded that extra padding or wrapping is required for these rigid poles.

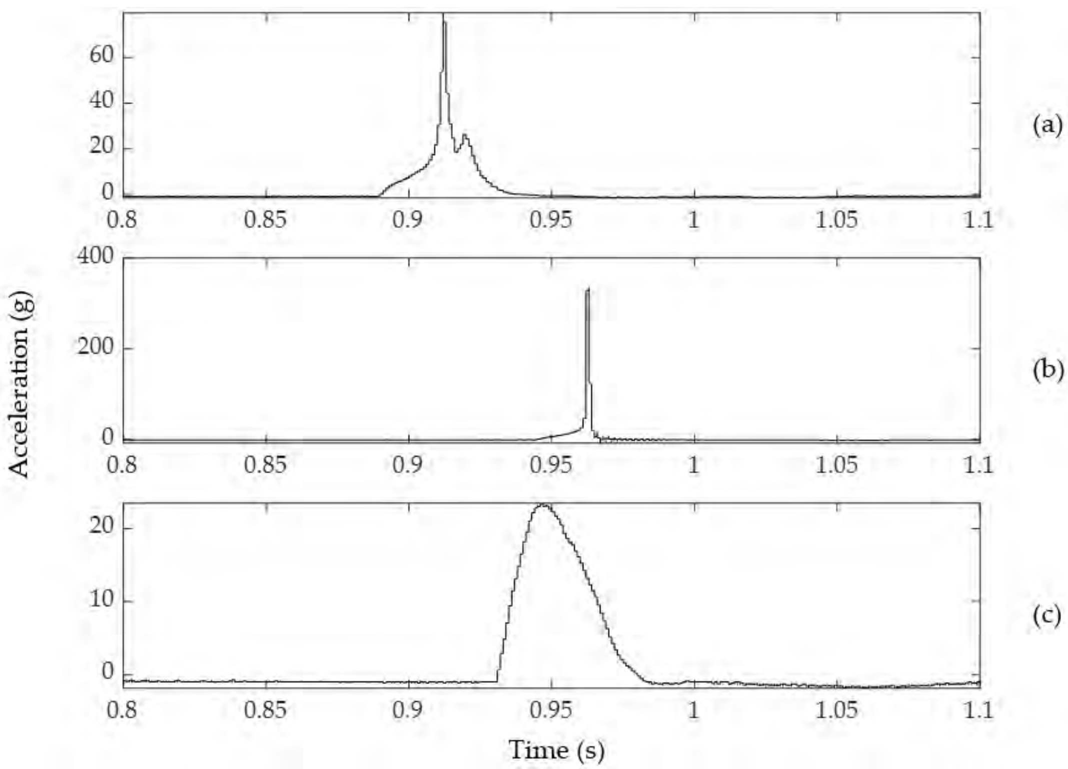


Figure 9: Impact test measured accelerations, (a) catching pen thin pole; (b) catching pen large pole; (c) catching pen gate.

4. Conclusions

This paper presents the results of an investigation into using impact-attenuating padding to reduce the likelihood of serious injuries associated with greyhounds impacting the outside fence and hard objects within the catching pens located at typical greyhound racing tracks. The in-situ test results for the greyhound racing track investigated in this study indicate that the padding currently used on the outside fence provides adequate protection from impact, owing in part to the fence flexibility and inherent impact attenuation properties. However, for harder/stiffer objects such as the steel poles, the impact forces observed with padding in place are significantly larger; this could lead to injury to greyhounds in the event of an impact. Thus, it is recommended that additional impact attenuation is required for these poles. Furthermore, considering there are no relevant standards for greyhound racing track padding, and various padding methods are adopted around the greyhound racing tracks, it is strongly recommended that, for padding to be properly deployed, it should be tested in-situ on the track to verify it provides satisfactory impact attenuation performance and sufficient protection for greyhounds.

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