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Reducing Playground Injuries By Increasing Sampling Rate From 8 kHz To 20 kHz

Introduction

When playground surfacing is tested to AS/NZS 4422:1996 the minimum sampling rate is specified as 8 kHz. This minimum is derived from motor vehicle impact standards. The objective of this project is to determine if changing the sampling rate has an effect on the calculated HIC and whether 8 kHz is appropriate to playground surface testing.

Aim

To measure the effect of sampling rate on HIC when a headform instrumented with a triaxial accelerometer experiences a free-fall drop at various heights onto various impact attenuating surfaces (Figure 1).

Figure 1: Impact attenuating surface materials. Left to right: thick rubber, thin rubber, bark and sand

Method

The drop test apparatus is set up as shown in Figures 2 and 3 for laboratory (rubber samples) or onsite testing (bark and sand). The drop test is performed and data recorded through an anti-aliasing analog filter, with 4 drops each at 2 heights.

Study 1: Using sampling rates of 80, 60, 40, 20, 10, 8, 5, 2.5 and 1 kHz.

Study 2: Recorded at 80 kHz and the data is reduced to lower sampling rates by refiltering and deleting samples during post-processing.

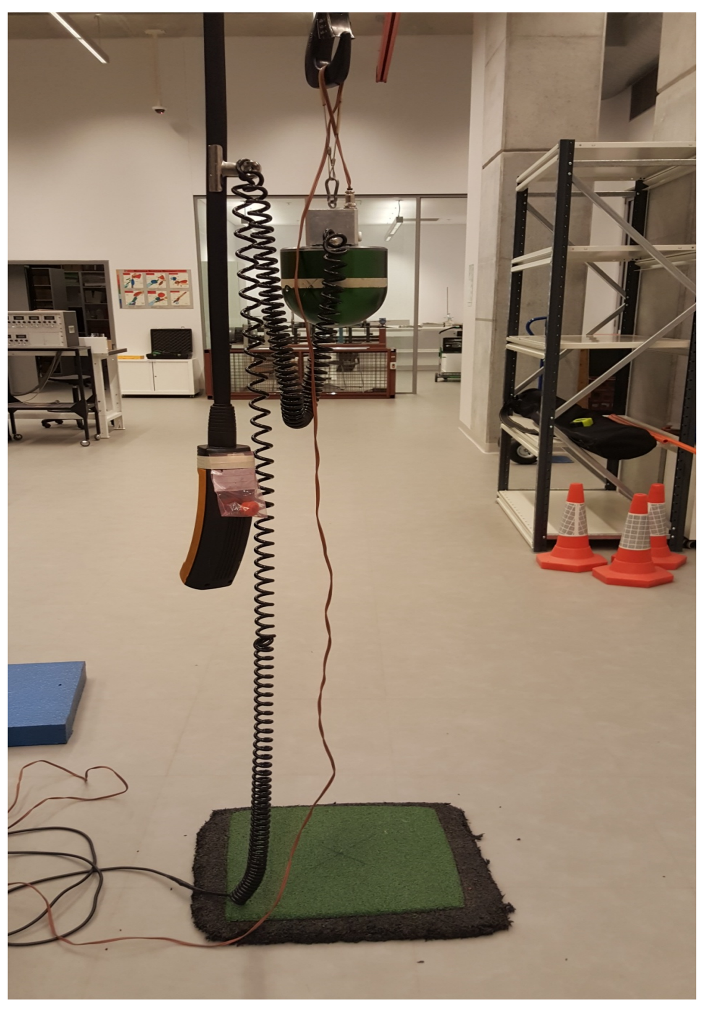

Figure 2: Drop test set up in UTS Dynamics laboratory

Figure 3: Drop test set up at Reginald St Park Mosman

Study 1 vs Study 2

Study 1: Laboratory testing of rubber impact attenuating surfaces

- Impact testing in the UTS Dynamics Laboratory allowed for changing the sampling rate in the testing software keeping the drop height and surface thickness constant.
- Time duration of HIC ($t_2 - t_1$) increased as sampling rate decreased due to less data points to maximise the HIC.

Study 2: Onsite testing of bark and sand impact attenuating surfaces

- The drop test required a portable tripod with which it was difficult to maintain a constant drop height.
- There was a natural variation in the surface level creating a variation in HIC results.
- Post-processing the test data reduced the data collection problems on site.

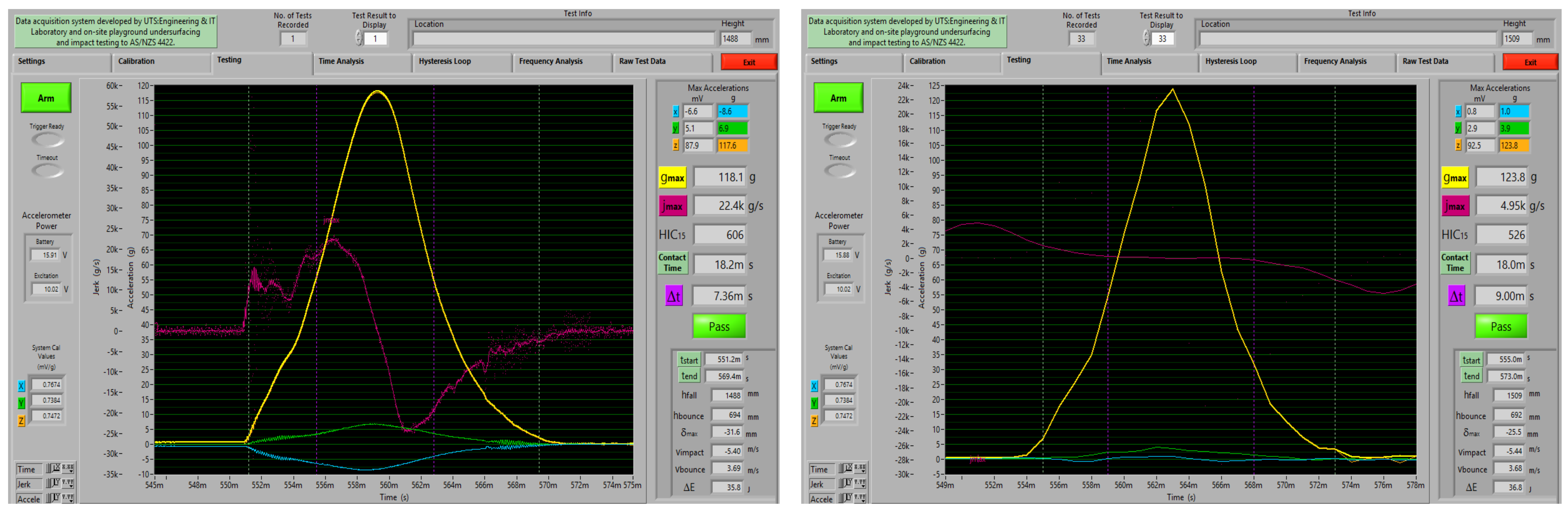

Figure 4: Acceleration curve at 80 kHz (left) and 1 kHz (right)

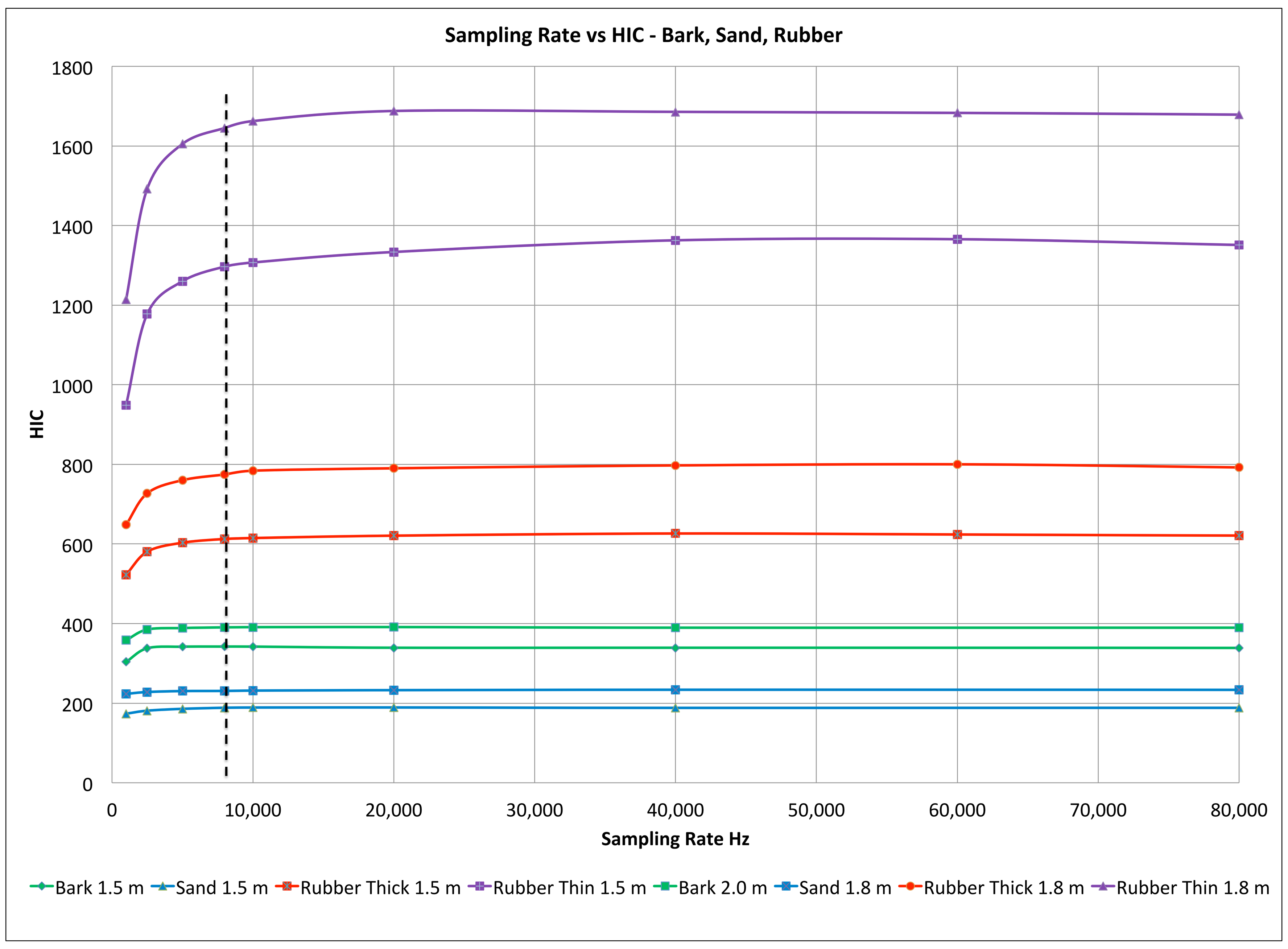

Figure 5: HIC vs sampling rate for bark, sand and rubber at two heights

Results

At sample rates > 20 kHz, the acceleration curve was smooth and the resultant HIC was insensitive to sampling rate. At lower sample rates the acceleration curve was under sampled with the peak being ill-defined (Figure 4).

The graph of sampling rate vs HIC (Figure 5) shows the large variance in HIC at sampling rates < 8 kHz (up to 30% in some cases). At sampling rates ≥ 8 kHz, variance in HIC value is 3%.

Testing at 80 kHz is no more precise than testing at 20 kHz.

Testing using a low sampling rate has the potential to pass a product that will fail at higher sampling rates. As the critical fall height (1000 HIC or g_{max} of 200) is approached, the effect of changing the sampling rate is greater.

For impact attenuating surfaces with low HIC values (bark & sand) there is less variance in results between 1 kHz and 80 kHz. For rubber, the HIC values are higher and above 1000 in the case of thin rubber. Variance in HIC results due to sampling rate is 26% from impact tests on thin samples at 1 kHz to 8 kHz, compared to 3% for thick samples.

HIC increases with drop height. **However, at greater heights, there is less variance in results than for lower heights, if any difference is shown.**

Conclusion

HIC is affected greatly by using sampling rates < 8 kHz, the minimum rate specified in AS/NZS 4422:1996. However as the critical fall height is approached 8 kHz is inadequate to properly capture the impact attenuating properties of playground surfacing materials. A sampling rate of 20 kHz is recommended to reduce potential variance in HIC results due to sample rate, ensuring the material on site will have adequate impact attenuation to prevent injuries.