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FORCE *v* DISPLACEMENT TO MEASURE IMPACT ATTENUATION PERFORMANCE IN PLAYGROUND SURFACING MATERIAL

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ABSTRACT

This work uses a novel analysis technique to compare the impact attenuation properties of different children's playground surface materials, namely: rubber of various thicknesses; sands that were wet, dry, fine and coarse; and 300 mm deep bark. Tests were performed at 2 m, 3 m and 4 m drop heights. A total of 17 individual tests are presented. The mechanical tests performed showed significant differences in the impact attenuation of the materials commonly installed within children's playgrounds.

Keywords: biomechanics, mechanical engineering, impact attenuation, playground surfacing.

INTRODUCTION

More than four decades has passed since introducing safety standards for Impact Attenuation Surfacing (IAS) used in children's playgrounds. Falls in children's playgrounds are a major source of injuries and IAS is one of the best safety interventions deployed to reduce the incidence and severity of playground injuries. EN 1177:2008 is the test method for the determination of impact attenuation performance of playground surfacing. Currently the Head Injury Criterion (HIC) is used to quantify the performance.

TEST METHOD

As per EN 1177:2008 a rigid headform fitted with a triaxial accelerometer is dropped onto the IAS. The three acceleration signals are recorded during the impact and from this the total acceleration is calculated. The total acceleration is proportional to the total force exerted by the IAS, and by double integrating the total acceleration we can calculate the surface displacement during the impact. Plotting the force against displacement produces a hysteresis loop and the area enclosed by this loop is the energy absorbed by the material. The ideal IAS keeps the HIC low and absorbs all of the kinetic energy of the headform, producing a 'dead cat bounce' (ie no rebound). Compare this with a perfectly elastic spring which returns all of the kinetic energy to the headform at the end of the impact (i.e. no net energy absorption) and the exit velocity is the same as the incident velocity. In this case the area enclosed by the hysteresis loop is zero because the loading curve is coincident with the unloading curve.

RESULTS AND CONCLUSIONS

Fig. 1 presents the results of 5 different sands at 2 m and 3 m drop heights. The dry coarse sand was noted to absorb the most energy (122 J). Fig. 2 presents the results of 2 m impacts onto 50 mm, 75 mm and 100 mm rubber, sand and bark. The energy absorption of the rubber did not increase (52-57 J) with thickness even though the HIC dropped from 1598 (50 mm), 935 (75 mm) to 593 (100 mm).

Fig. 3 presents the results of 3 m and 4 m impacts onto 50 mm, 75 mm and 100 mm rubber, sand and bark. For the rubber at 3 m the HIC dropped from 3849 (50 mm), 1977 (75 mm) to 1089 (100 mm). For the coarse dry sand at 3 m a 430 HIC and 122 J absorption were noted. For the bark at 3 m a 370 HIC and 131 J absorption were noted. For the bark at 4 m a 437 to 442 HIC and 163 to 180 J absorption were noted.

This study showed that impact attenuation performance of the 300 mm deep bark was superior to both the rubber and sand. It also showed that impact attenuation performance of coarse sand was greater than fine sand or rubber even when the rubber was 100 mm in thickness, good quality and correctly installed.

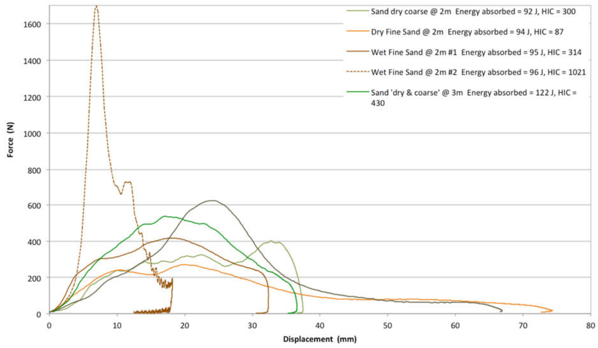

Fig. 1 - Force (N) vs. displacement (mm): energy absorbed and HIC for 2 m and 3 m impacts onto dry, wet, fine and coarse sands

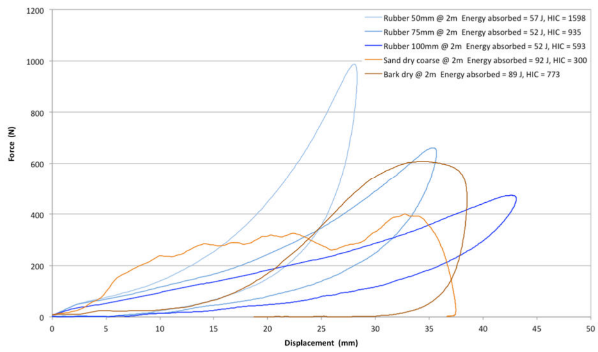

Fig. 2 - Force (N) vs. displacement (mm): energy absorbed and HIC for 2 m impacts into 50 mm, 75 mm and 100 mm rubber, fine and coarse sands and bark

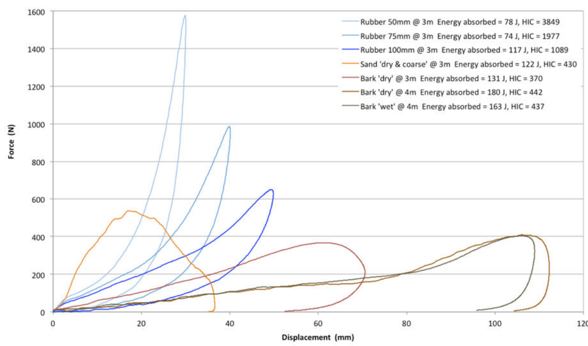

Fig. 3 - Force (N) vs. displacement (mm): energy absorbed and HIC for 3 m and 4 m impacts into 50 mm, 75 mm and 100 mm rubber, dry coarse sand and bark