Department of Mechanical Engineering

University of Canterbury
Te Whare Wānganga o Waitaha
Private Bag 4800
Christchurch 8020, New Zealand

Telephone:+64-3-366 7001
Facsimile: +64-3-364 2078
Website: www.mech.canterbury.ac.nz

Enclosure Net Test

Test subject: **Springfree Trampoline Model SF90**
Jumpsport Staged Bounce 14ft
AlleyOop Variable Bounce 14ft
Parklands 14ft

Date of Test: **20-27 August 2009**

Date of Report: **30 Aug 2009**

Test Summary: **Investigate the conditions of the scenario where ground contact occurs for a jumper impacting the enclosure net on a Springfree trampoline. Perform similar tests on traditionally designed trampolines and summarise performance according to safety standards.**

Enclosure Net Test – Experimental Report

1.1 Objectives and Background

There were certain design requirements that this test required. These requirements were that the test:

- ✓ Is easy to assemble/dismantle
- ✓ Is economically efficient in terms of materials needed
- ✓ Is safe for all those who would conduct the test
- ✓ Is a realistic representation of a real life jumper impacting the enclosure
- ✓ Used a reliable and simple method of extracting appropriate data

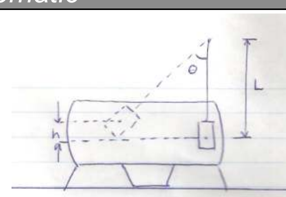
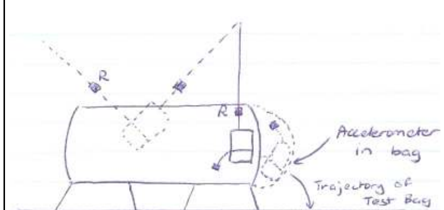
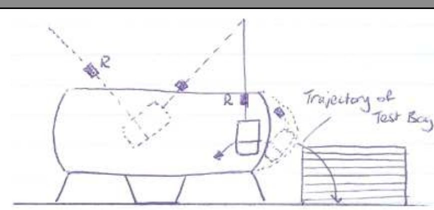
The current standard ASTM F2225-06 gives instructions for a particular test similar to the desired test in this case. This test involves a fixed test bag on a pendulum setup that impacts the enclosure (see Test Concept 1 in Table 1.1).

However, with the Springfree trampoline, the decision was made that this standard test was not sufficient in testing all possible scenarios of jumpers impacting with the enclosure net. Research showed that it is possible for a heavy jumper, with a large amount of effort, to impact the enclosure and be guided softly to the ground outside the trampoline frame. This discovery led to the decision that the impact data for a jumper impacting the ground in this situation would need to be obtained.

Several methods were suggested in regards to obtaining this impact data. The following concept matrix summarises the different test designs that were considered for use on the Springfree trampoline and traditional trampolines alike.

Table 1.1: Decision matrix used to determine the most viable and realistic procedure for the Enclosure Net Test.

Key: 1 – Ideal; 2 – Satisfactory; 3 – Average; 4 – Poor; 5 – Non-existent

Test Concept Description	Schematic	Requirements	
Test concept 1 - As described in safety standard ASTM F2225-06 'Consumer Trampoline Enclosures'		Ease of assembly Cost Safety Realism Data Acquisition	1 1 2 4 5
Score			*13*
Test concept 2 - Detachable pendulum with use of an accelerometer embedded in the test bag to obtain impact data		Ease of assembly Cost Safety Realism Data Acquisition	2 2 2 1 4
Score			*11*
Test Concept 3 - Detachable pendulum with use of a graduation board and high speed camera to obtain impact data		Ease of assembly Cost Safety Realism Data Acquisition	2 2 2 1 2
Score			*9*

R = Release mechanism
L = Pendulum length (m)
h = Drop height corresponding to kinetic energy test bag has on impact (m)
θ = Release angle (determines h) (°)

Table 1.1 shows that test concept 3 scores the lowest with 9 and this suggests that this method of testing is the optimum. Test concept 2 fails in the data acquisition requirement because mounting the accelerometer in the bag (a deformable body) is not an option if accurate acceleration data is to be obtained. Test concept 1 fails in the realism aspect of the requirements i.e. In a real situation, with a jumper impacting an enclosure, impact will not result with their mass being restrained through a pendulum motion. In reality, the jumper's mass will impact the enclosure and carry on through a trajectory similar to that of the test bag in test concept 2 and 3 schematics.

The original performance requirements detailed in the standard test were altered slightly to suit the chosen test design concept. The changes made to the standard performance requirements are outlined below:

- Instead of simply using the maximum specified user weight, two weights were used to give more representative results of a) who will actually be using the trampoline and b) a worst case scenario. The two weights were
  - 55kg – This is the weight specified (for 14 year olds) by the European Standard EN1176.1-2008 (Playground equipment and surfacing) in A.2.2 and Australian Standard AS4685.1-2004 (Playground Equipment) in A3.2.2 for playgrounds with open access to all ages.
  - The maximum specified user weight (100kg)
- The values of the release angle at 30° and pendulum length of 3.0m are being currently altered in the standard ASTM F2225-06 using information provided by Dr. Keith Alexander (see Table 1.2) for the following reasons:
  - The 3.0m pendulum length does not allow for much in terms of ceiling height for most testing laboratories.
  - A range of pendulum lengths and release angles gives the test conductor more freedom in the location of the impact of the test bag. This was ideal in the case of the Enclosure Net Test where there were three desired impact points – the centre height of each vertical third of the enclosure.
- Two extra fall heights were used, as well as the standard 400mm. Centre of mass fall height (COMFH) values 800mm and 200mm were used. The velocity of the bag at impact with the enclosure is solely governed by these COMFHs where the suggested standard fall height in ASTM F2225-06 is 400mm.

Aside from these changes, all performance requirements were as stated in the standard (ASTM F2225-06).

Table 1.2: Workable range of pendulum lengths and release angles

Pendulum Length to Center of the Mass of Bag (Feet)	Pendulum Length to Center of the Mass of Bag (Metres)	Pendulum Angle (Degrees)	COMFH (mm)
10	3.0	30.0	400
9	2.7	31.7	400
8	2.4	33.6	400
7	2.1	36.0	400

1.2 Test Apparatus

A photo of the finished setup is included in Appendix A (Figure A1) with labels showing the various components of the setup. Equipment required for the test setup was 'off-the-shelf' components which were purchased with Springfree's approval or borrowed.

The pendulum pivot system was fabricated by the author at Springfree's on-site workshop after the appropriate safety issues were addressed. No university workshop time was required for the components used in this test.

The release mechanisms are seat belts (Figure A1), used in Air New Zealand airplanes, modified appropriately. One release mechanism has twine attached to activate the release of the bag from the desired angle. The other release mechanism has an extended lever arm to reduce friction in the mechanism when releasing the bag on impact with the enclosure net at the pendulum-vertical position.

Restraints (see Figure A3 in Appendix A) are utilised in the form of timber bolted to the concrete in front of the trampoline legs to discourage sliding along the testing surface during impact. These restraints also allow the trampoline being tested to tilt if the possibility arises. This is a more realistic model of the situation of a jumper impacting the net while the trampoline is situated on grass or bark.

1.3 Test Procedure

The procedure for the Enclosure Net Test is outlined under ‘Test Procedure’ in Appendix B. A list of the test equipment component names and their functions is also included.

Four different models of trampoline were tested:

- Springfree SF90 – 100kg maximum user weight
- Jumpsport Staged Bounce 14ft – 109kg maximum user weight (Model 280 enclosure rated to 91kg)
- AlleyOop Variable Bounce 14ft – 111kg maximum user weight (Model 380 enclosure rated to 104kg)
- Parklands 14ft – 113kg (Enclosure system is unrated)

a) b) c)

Figure 2: The various trampolines tested – a) Springfree SF90, b) AlleyOop Variable Bounce 14ft, c) Parklands 14ft. The Jumpsport model was similar to the AlleyOop. The main difference was the model of enclosure system used and length of the springs.

To calculate the velocity at different points along the test bag trajectory after release, a high speed camera in combination with a graduation board (Figure A2) is used to measure the distance travelled in a certain number of frames. By slowing that video down, and using the geometry of the testing setup, the velocity of the bag at certain points can be found using the calculations set out in Appendix B under ‘Calculation of Velocity and Equivalent Fall Height.’

Optimisation of this test consisted of filming the pendulum motion using the high speed camera and ensuring the bag was releasing at a pendulum-vertical position. Once a repeatable method of ensuring the bag was releasing at a vertical position was found, the next step was to film the bag contact on the ground outside of the trampoline. Test bag ground contact data is described below in the ‘Results’ section.

Testing Certification

This test was certified by Dr. David Aitchison, Senior Lecturer at the University of Canterbury, as an impartial third party certifier. The certification procedure involved walking the certifier through each step of the test procedure and data acquisition process. Results were then presented to the certifier, who signed that this data was reliable, and the test was considered certified. The relevant paperwork regarding certification is attached at the rear of the Appendices.

1.4 Results

The results will be separated into sections based on the test bag mass with the COMFH as sub sections in Appendix C. Where a ground impact is not observed for the SF90, a full analysis of the video footage of the test will be given in Appendix C also. A comparison to the equivalent scenario on different types of traditional trampoline will also be presented. Detailed descriptions of the video footage for the tests on the traditional type trampolines can be found in Appendix C.

Performance Requirements

Damage to the trampolines that constitutes a failure under the safety standard for consumer trampoline enclosures ASTM F2225-06 is 'any permanent deformation, tearing, or breaking of any component of the enclosure barrier (net) and the barrier attachment system… (or the) enclosure support (frame) or the support (frame) attachment hardware'. These performance requirements will be incorporated in defining a failure of a trampoline under this testing procedure. The performance of the traditional type trampolines against these requirements is summarised in Table 1.5 below. The Springfree SF90 sustained no damage during testing.

Graphs of velocity during the test bag trajectory for the Springfree SF90 can be found in the 'Results' section of Appendix C in Figures C1 to C24. These graphs show the average velocities against the height range the bag has fallen (indicated by the graduation board), along the x axis. The error bars represent the magnitude of error required to fit within the polynomial trend of the data. The equivalent fall height is subject to a similar scale of errors. The final velocity (Ground contact velocity) is the velocity used to calculate the Equivalent Fall Height (EFH) for each test scenario. See Figure B1 for a schematic of the stages of the test bag trajectory with height ranges that refer to an example graph (Figure C2) for velocities. The enclosure net impact velocity is indicated in parentheses next to the corresponding COMFH in Table 1.4. A summary of the results in Appendix C is presented in Table 1.4.

The centre of mass fall height (or COMFH in acronym form) relates to how far the centre of mass of the test bag falls to gain a certain velocity at impact with the enclosure net (see Figure 3). The following Table 1.3 summarises the COMFH values used in testing and their corresponding impact velocity at the enclosure net.

Table 1.3: Summary of COMFH values used and their corresponding impact velocities

Centre of mass fall height (COMFH) (mm)	Velocity at impact with enclosure net (ms^{-1})
200	1.98
400	2.80
800	3.96

Table 1.4: Summary of EFH values for each test scenario

	COMFH	200mm (1.98ms^{-1})		400mm (2.80ms^{-1})		800mm (3.96ms^{-1})	
	Test Bag Mass	55kg	100kg	55kg	100kg	55kg	100kg
Location of impact on enclosure	Bottom Third	0	0	0	0	0	0.16
	Middle Third	0	0.37	0	0.15	0	0.22
	Top Third	0	0.65	0.22	0.56	NA	NA

These results for EFH values are also plotted in Figure 2. A larger version of this chart is given in Appendix C.

Table 1.5: Summary of performance for the traditional type trampolines

	COMFH (Centre of mass fall height) – Refers to fall height of test bag centre of mass						
		200mm (1.98ms^{-1})		400mm (2.80ms^{-1})		800mm (3.96ms^{-1})	
	Test Bag Mass	55kg	100kg	55kg	100kg	55kg	100kg
Parklands 14ft	Bottom Third	NA	NA	Pass	NA	Pass	NA
	Middle Third	NA	NA	Fail	Fail	Fail	Fail
	Top Third	NA	NA	Fail	Fail	NA	NA
Jumpsport Staged Bounce 14ft	Bottom Third	Pass	NA	Pass	NA	Pass	NA
	Middle Third	Pass	NA	Pass	Fail	Pass	Fail
	Top Third	Pass	NA	Pass	Fail	NA	NA
AlleyOop Variable Bounce 14ft	Bottom Third	NA	NA	NA	NA	NA	NA
	Middle Third	NA	NA	Pass	Fail	NA	Fail
	Top Third	NA	NA	NA	Fail	NA	NA

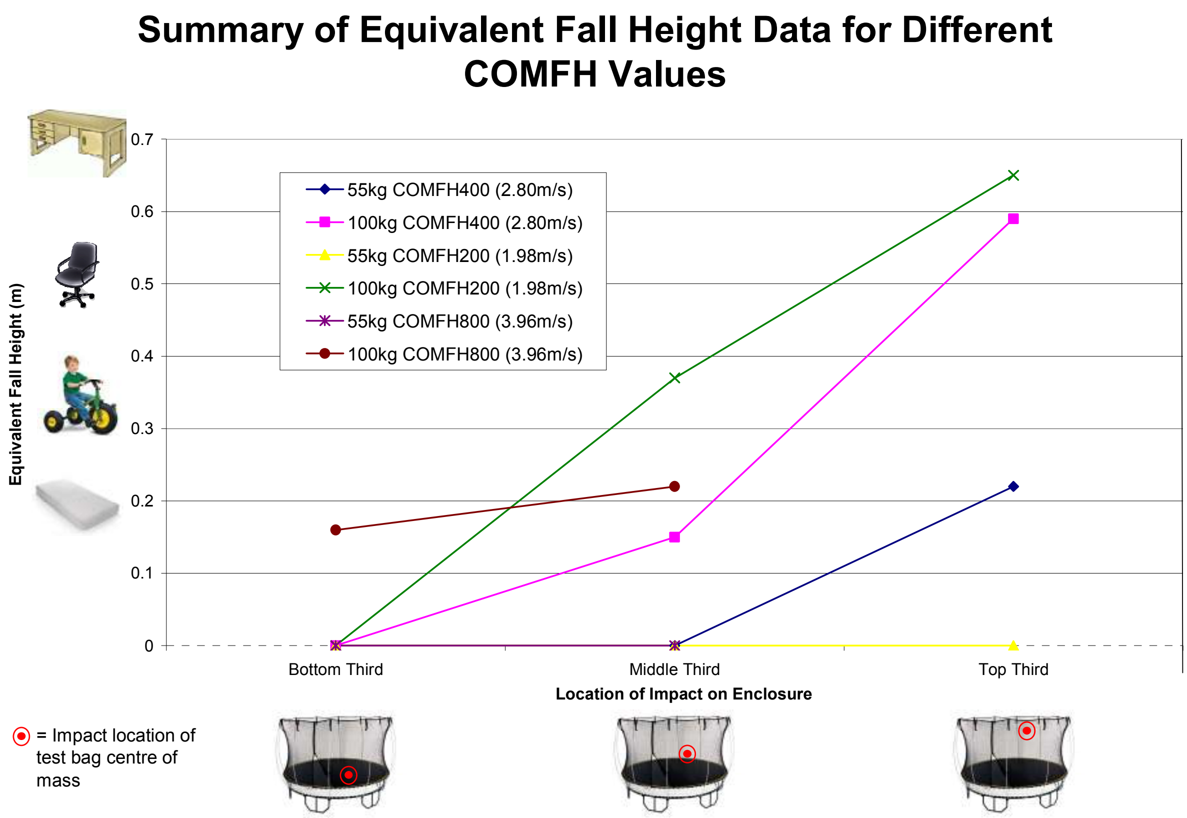


Figure 2: Summary of equivalent fall height data for the Springfree SF90

A "Not Applicable" section in Table 1.4 and 1.5 occurs for the 800mm COMFH at the top third impact location due to equipment and facility limitations. The available draw on the pulley block does not allow the test bag to be lifted this high. Even if the pulley block allowed the bag to be lifted to this height, the level of the roof would mean that the angle of release would exceed the limits stated above (Table 1.2). A final justifying reason for the absence of this data is made by performing a reality check. In the study conducted by the project team regarding feasible enclosure impact velocities, the team member impacted the net in the middle third to achieve the maximum velocity (around 4ms^{-1}) corresponding to a fall height of 800mm. In reality, this impact velocity would be much more difficult to achieve because the jumper must put substantially more energy in gaining the height to impact the top third of the enclosure net. This would have a detrimental effect on the horizontal velocity of the jumper and hence the impact velocity would be lower in the top third for the same amount of effort required in the middle third.

Video footage was obtained using the same testing procedure performed on the Springfree trampoline on several other traditional trampoline designs at the team's disposal. Tester discretion was exercised to omit some COMFH values due to the absence of damage (notably with the AlleyOop and Jumpsport models due to their similar design). This is the reason for the remaining 'NA' sections in Table 1.5. Each test only comprised of one impact due to time constraints, but this still gives a good indication as to how each trampoline fairs in comparison to the Springfree SF90. A breakdown and explanation of observations regarding the Enclosure Net Test on various traditional type trampolines can be found in Appendix C in a similar format to the video footage section for the Springfree SF90.

The majority of the testing occurred between enclosure poles. This was due to the following reasons:

- The traditional type trampolines all exhibited some sort of damage under the testing involving impacts between the enclosure poles, and therefore failed by performance requirements.
- A sample test was done on the Springfree SF90 with the 55kg test bag impacting the net in line with the enclosure rods. This test showed that an impact with an enclosure rod shows a much better case EFH than and impact with the net between enclosure rods. The worst case scenario is the scenario of interest so in interest of time constraints, the tests against the enclosure rods for the Springfree were omitted. The data for this testing showed an EFH of 0.11m with an error of 11%, although one test seemed to be an outlier with an unusually high ground contact velocity see Figures C22 to C24.

There were some tests swings against enclosure poles on the traditional type trampolines. Video footage exists for impacts with the enclosure poles for the AlleyOop trampoline. However, no damage was observed during these tests and a similar conclusion was reached: that the case of impacting the net between enclosure poles is the worst case scenario.

1.5 Discussion

Springfree SF90

55kg Test Bag

All but the 400mm COMFH at the top third of the enclosure do not show a ground impact. When the test scenarios are compared to the real life situation some valuable information is made clear. An average 14 year old child impacting the enclosure during an out of control bounce is very unlikely to impact the ground surrounding the trampoline, let alone sustain an injury. If the 14 year old jumper does manage to impact the top third of the enclosure net with a velocity of $2.81ms^{-1}$, the equivalent fall height experienced by the child will be approximately 0.22m after being slowed to $2.06ms^{-1}$ on impact. The average error on the impact velocity for this COMFH is 3.3% which corresponds to a viable range of EFH = 0.21m – 0.23m. This is equivalent to rolling off a mattress onto the floor.

Injury statistics show that most trampoline injuries occur to the five- to ten-year old age group. The results in Table 1.3 indicate that the average 14 year old child will only sustain a ground impact in the most extreme case of an out of control bounce. Then, even at the most extreme case, the equivalent fall height the child will experience is less than dangerous. Considering these factors, it can be said that it is highly unlikely that a child in the five- to ten-year old age group will sustain an injury through ground impact on a Springfree SF90 trampoline.

100kg Test Bag

Most of the test scenarios resulted in a ground impact for this test bag mass. However, the COMFH values of 200mm and 400mm in the bottom third of the enclosure resulted in no ground impact. 100kg is the maximum specified user weight for the SF90. Results show that in the worst possible case of a 100kg user experiencing an out of control bounce and impacting the enclosure net, they will experience a fall equivalent to 0.65m. The EFH (Equivalent Fall Height) for this case is falling from the arm of an armchair. This would only occur if the jumper impacted in the top third of the net.

In order to gain some perspective, an example is used where a weighty parent/sibling is experiencing an out of control bounce on the Springfree trampoline. To experience the fall height of 0.65m they would need to lose control and impact with the top third of the enclosure at a velocity of $2.8ms^{-1}$. Most opinion is that this is very unlikely.

An interesting correlation in the EFH data is that the equivalent fall height of 0.65m for a COMFH of 200mm is larger than the value, 0.56m, for a COMFH of 400mm (see shaded cells in Table 1.3). After studying the video footage of these two different test scenarios, it is of the tester's opinion that the 200mm COMFH case allows the bag to gain substantially more vertical velocity downwards due the smaller horizontal component of velocity compared to the COMFH of 400mm. In the case of the 200mm COMFH, the test bag impacts the ground base first and is then lifted back off the ground by the cradling action of the enclosure system. However, in the case of the 400mm COMFH the bag holds the enclosure system on the ground after impact. The higher horizontal component of velocity in 400mm COMFH case is thought to give the test bag less chance to develop a vertical component as large as the 200mm COMFH case.

Thought has to be given to the magnitude of errors in the analysis to truly understand this situation. In the COMFH case of 200mm the average error on the ground contact velocity is 3.7%. (These average errors are taken from the average error bar size over the 3 test graphs). Applying this error to the EFH value of 0.65m gives a possible range of EFH = 0.67m – 0.63m. Similarly applying the average error of 5% to the EFH value for the COMFH 400mm case we find a viable range of EFH = 0.59m – 0.53m. These error bands do not overlap, therefore it can be said that the EFH value for the 400mm COMFH case is definitely lower than for the 200mm COMFH case for top third.

Parklands 14ft

The Parkland model traditional type trampoline was the first to fail according to the performance requirements set out above in the 'Results' section and this failure occurred during the COMFH 400mm middle third impact location test using the 55kg test bag. The net was stretched over the course of testing. Three different enclosure pole caps were damaged. Tears in the enclosure net occurred and some of the Velcro straps that hold the enclosure in place were wrenched loose during impacts. The U-bolts that attach the enclosure poles to leg supports also underwent permanent deformation.

The way in which the test bag was guided during impact was also of concern. The enclosure net system seemed to guide the bag directly down onto the spring padding or the frame without significant resistance to the vertical component of velocity. The test scenario footage suggests that even an average weight 14 year old child would be guided down to below the plane of the springs and frame (the 'basket' position), possibly even impacting with the side of the frame.

Looking at the scenario of the weighty parent/sibling, there was a case where the 100kg test bag even fell through the gap between the enclosure and frame (although very slowly). It seems unlikely in this situation, unless the jumper has some control over their movement, that the jumper will be deflected back onto the playing surface. They are more likely to become caught between the enclosure and the frame.

The net on this model of trampoline also underwent significant stretching, even when being impacted by the 55kg test bag. This suggests that the fatigue life of this type of enclosure is minimal.

This model of trampoline came the closest to experiencing a complete 'tip over'. As seen in the video (File name 'COMFH800 - 100kg - Middle Third – Parklands' and more notably the high speed footage corresponding to this test, the trampoline is on the verge of balance during impact before settling back down onto its supports. Information such as this suggests that it could be possible to completely tip over this model of trampoline if a jumper managed to find themselves stuck in the enclosure rather than sliding downwards as the test bag does.

Although the test method used here involves incorporating a detachable pendulum, whereas the standard test is a fixed pendulum, the results show that this trampoline would most likely fail under the performance requirements outlined in the 'Results' section. The standard COMFH of 400mm at mid-height of the enclosure is used in this set of testing and even though the bag detaches and impacts the enclosure, a fixed pendulum setup would likely cause similar damage to a less severe extent which still constitutes failure under the standard.

<u>Jumpsport Stage Bounce 14ft/AlleyOop Variable Bounce 14ft</u>

The Jumpsport model of trampoline comprised of a very similar design to the AlleyOop Variable Bounce 14ft. The design is so similar that both trampolines exhibited the same behaviour during testing. The most significant difference was the method of fixing the enclosure poles to the leg supports and the length of the mat springs. The Jumpsport model uses U-bolts similar to the Parklands model and the AlleyOop uses a design that allows bolts to be located directly through the enclosure pole and leg support (see Figures C34 and C37,C39).

For all of the COMFH values tested on these models of trampoline using the 55kg test bag the enclosure system exhibited no form of permanent deformation, tearing or breaking.

However, the 100kg test bag did produce some permanent deformation in one of the enclosure poles for each trampoline which does constitute a failure under the performance requirements outlined in 'Results'. The extent of deformation looked to be more severe in the AlleyOop model trampoline, possibly due to the more rigid mounting design employed. More of a concern is the fact that one of the leg supports separated (as in Figures C34 and C37,C39) during the COMFH 800mm middle third and COMFH 400mm top third impacts. The trampolines did also lift from the testing surface on one side during impact, but less so compared to the Parklands due to their more rigid and heavy structure. **Considering that the maximum specified user weight of each of these trampolines is significantly above 100kg, these results suggest that a larger jumper may have the ability to completely tip over these trampolines with sufficient effort.**

<u>General Safety Comparison</u>

It is important to maintain perspective when comparing the results of each of the trampoline models tested. The age group sustaining the most injuries is the five- to ten-year old age group. Most trampoline manufacturers try to produce trampolines that are safe to be used by all age groups. Depending on the aim of the manufacturer, the above results could be used in several different ways. This general comparison assumes that the aim of the manufacturer is to try and reduce injury numbers where they are most often occurring which is in the five- to ten-year old age group.

Firstly, the Parklands model trampoline has the most potential to cause an injury, regarding the behaviour of the enclosure system in how it deflects a user back on to the playing surface. The 55kg test bag results are most relevant in this safety comparison. In the majority of test scenarios involving the 55kg test bag (excluding the COMFH of 400mm impacting the bottom third of the enclosure) the test bag ends its motion stuck between the enclosure and the frame. During the test swings above the bottom third, the test bag also undergoes some sort of impact with the springs or frame. These situations model an average 14 year old impacting the enclosure, so the mass of a five- to ten-year old would be substantially less than this. However, the way in which a jumper impacts the enclosure is assumed to be the same regardless of the weight of the jumper. Therefore, any jumper who is in the five- to ten-year old ages group who experiences an out of control bounce will follow a similar path of motion as the 55kg test bag and impact the frame or springs.

Secondly the Jumpsport and AlleyOop models faired well against the Parklands and were also comparable to the Springfree model in many areas. However, the nature of the impact is the largest concern for these models of trampoline once again. Unless a jumper has some control over their movement it is unlikely that he/she will be directed back onto the playing surface. The majority of impacts eventually end up with the test bag coming into contact with the spring padding system or frame, indicating a similar result for an out of control jumper. Interestingly the exception to this is the COMFH of 400mm at the top third where the test bag is cradled off the edge and flipped back onto playing surface by the enclosure net.

Finally, the Springfree SF90 showed desirable behaviour deflecting the test bag back onto the playing surface. Almost all impacts using the 55kg test bag showed the test bag being cradled into the enclosure and directed back onto the playing surface with minimal undesirable contact with the structural components of the trampoline or the ground. As the test bag is cradled after impact with the enclosure net, the test bag is guided downwards into the enclosure net before being sprung back onto the playing surface. A small amount of contact does occur with the lower frame and spring rods, but this contact is not enough to trap the bag between these structural components and the enclosure net. An average five- to ten-year old is assumed to weight less than 55kg (average 14 year old weight). Therefore a child in this problem age group for injuries would struggle greatly to achieve a ground impact on the Springfree SF90. The exception to this is the case of the COMFH of 400mm at the top third of the enclosure. In this instance ground contact might be achieved by a 14 year old hitting the top third of the net at $2.8ms^{-1}$. The EFH would be the same as rolling off a mattress onto the floor.

Sources of Error in Testing Procedure

The testing procedure is not without its own sources of error. Considering the test bag is a deformable body and that the centre of mass fall height (COMFH) values are being measured against a mark on this bag, there will be some error involved as to how this mark moves during each impact.

The method for measuring the fall height of the bag also had some inherent error due to the fact that the laser sight was being placed on the trampoline which deforms slightly under the load of the laser light. The magnitude of this error is estimated to be approximately -10mm maximum.

Possible Improvements/Suggested Alterations to Testing Procedure

- A more rigid capsule to use as the test bag. The current bag leaves too much room for deformity, adding error to fall height measurements.
- A more reliable method for measuring the fall height of the test bag. A suggested method would be to use a plum bob arrangement that measures the fall height of the bag hook. A correction would need to be calculated to account for the cosine error in using this method i.e. the test bag fall height is not the same as the fall height of the bag hook. See Figure 3.

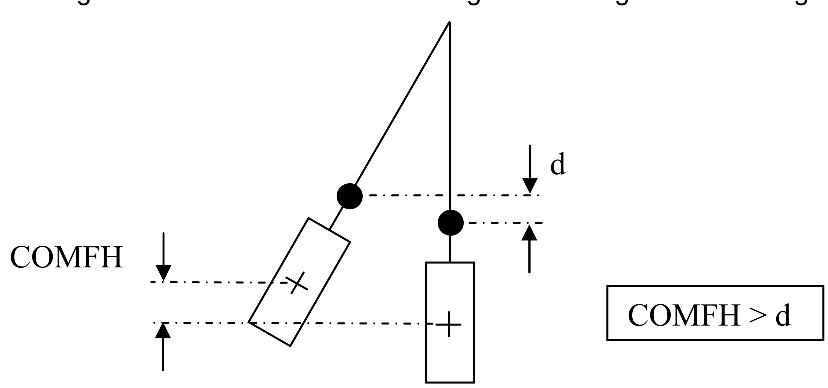


Figure 3: Schematic showing the effect of cosine error on measuring the fall height of the bag using the bag hook.

1.6 References

- ASTM F2225-06 Consumer Trampoline Enclosures
- European Standard EN1176.1-2008 (Playground equipment and surfacing)
- Australian Standard AS4685.1-2004 (Playground Equipment)
- www.springfree.com
- Springfree Trampoline White Paper v1.02 – Towards Trampolines Without Injury, April 27, 2005
- www.jumpsport.co.nz
- http://www.thewarehouse.co.nz/red/catalog/toys/outdoor-play/playground-equipment/1038242.html (Parklands 14ft Specifications)