SLIDES
ACCIDENTS AND UTILITY

An Advisory Document

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Summary

Serious accidents are unexpectedly happening on slides which comply with the recommendations of BS EN 1176 “Playground Equipment and Surfacing”. A common contributory factor is the wearing of clothing of synthetic or high synthetic content materials. The accidents generally happen when the slides are new. Over time the same slides become so slow that they do not maintain their utility as slides and are no longer fun to use.

Some risk could be reduced by making changes to the Standard EN 1176, however further research and testing is needed to increase both the safety and utility of the slides. Recommendations are made for changes in EN 1176. These include ensuring ground is level at the run-outs, making run-outs longer and making slides slightly steeper. The report calls for improved methods of testing.

Introduction

This report concerns a number of accidents which have occurred on slides and which our Consultant has investigated. He is also aware of a small number of other accidents which have happened.

The investigations were carried out by Rob Wheway who was then Play Safety Adviser for Child Accident Prevention Trust (CAPT). CAPT have agreed the transfer of the consequent reports to the Children’s Play Advisory Service. He is a competent inspector of playgrounds and has also served on the British Standards Committee (SW65) which deals with EN 1176 and other related standards. He has been inspecting playgrounds for 20 years and has worked in children’s play since 1971.

At the play equipment he has investigated there have been:

- Four instances of broken long bones at one playground plus a number of more minor bumps and scrapes;
- Four serious bangs to the head (one resulting in severe concussion at one playground) plus at least a dozen other reported minor knocks to the head;
- A snapped femur (thigh bone) at the same playground;
- A cut head at a further playground.

These accidents were at three different playgrounds on four different slides. These, together with testing at many other playgrounds by the consultant, indicate that this is a problem associated with at least three manufacturers. The accidents occurred to people who ranged from toddlers to adults.

There was no indication that weather or other environmental factors contributed to the accidents. There was no indication that those injured were using the slides recklessly or in any way that might not reasonably be expected. There was no indication that actions by third parties had contributed to the accidents.

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Information was obtained from accident reports at all the playgrounds and from interviews with children (except the toddler) and parents of the children who had sustained the serious head injuries and snapped femur. In all cases the children had been accompanied by parents at the times of the injuries, which not only indicates that the children were under some supervision, but that some particularly reckless behaviour can be ruled out. The parents interviewed were not, as far as the consultant is aware, making a claim for compensation.

The consultant carried out practical testing at the playgrounds by going down the slides a number of times wearing clothing made of different materials and also observed children and adults using the slides (see details later in this report).

In all of these accidents the speed of descent appears to have been a contributory factor, if not the direct cause, and the difference in clothing material worn by the person has been the cause of the different speeds.

He has also found that the speed of travel changes over time. The result is that some slides are hazardous when new because the person travelling down goes at a speed which is much too fast and this is likely to lead to an injury. On the other hand, when the slide is older the speed is so slow, that it cannot comply with the standard note in EN 1176-3 section 4.5 Run-out Section:

> *"It may be dangerous if users stop on the sliding section. Slides should be designed to prevent the user stopping unintentionally before reaching the run-out section."*

A slide can therefore over a one or two year period be both unsafe to use through fast speed and also too slow to be useful and unsafe to use through slow speed. It cannot comply with the standard note in EN 1176-3 section 4.1 General:

> *"This part of EN 1176 contains a number of requirements that will help limit the speed of the user whilst using slides. However, the coefficient of friction of sliding surfaces is highly dependent on the type of textile clothing worn by the user, material of the slide, weight of the user and weather conditions. It is therefore recommended that long slides are designed to ensure speed of the user is sufficiently controlled, eg changes in direction of the sliding section."*

It is this consultant's belief that there is insufficient knowledge about the effect of different types of clothing and the changes in the friction of the slide (therefore speed of user) which take place over relatively short time periods.

The information in this paper is particularly important as there has been a reaction in recent years to playground equipment which has been too "safe" and managers are now looking for playground equipment which is exciting and challenging and has a good "wow" factor. More long high slides are therefore likely to be installed and may well result in an increase in serious accidents unless modifications are made. There will also be many disappointed customers if the slides become very slow within a year or so.

The Equipment

The items of equipment on which the injuries occurred were either tunnel slides or wide Type 1 (EN 1176) slides, ie those with a run-out section of angle up to 10^{o} and having a short run-out section with a long impact area.

The fact that the slides are wide or tunnel is important as this means it is unusual for the rider to hold the sides (or impossible in tunnel slides).

It is possible the same issues might apply to wide Type 2 slides however no similar accidents are known to our consultant. It is also the case that Type 2 slides tend to be narrower so that the edge handholds will be grasped if the rider feels they are going too fast. The narrower width also tends to prevent older children or adults using them as their bottoms are usually too wide to fit into the slide.

A further factor to be considered is that adults with younger children do use the slides with children riding on their laps. It is in the opinion of the consultant that it is reasonable to expect that a parent, or an older sibling, will want to take a child down the slide in this way as it gives reassurance to the child and is also added fun.

One of the benefits of these wide and tunnel slides is that an adult or older sibling can accompany a disabled child down the slide who might otherwise not be able to enjoy the slide because of either a physical or behavioural impairment.

Recommendation 1 Designers of wide and tunnel slides should take into account the reasonable likelihood that parents and older siblings will take young or disabled children down slides holding them or with them seated on the lap.

The Accidents

1. The Long Bone Injuries

The accidents leading to broken long bone injuries occurred at a country park where three wide slides and a tunnel slide had been installed. The slides concerned were no more than 2m high. The accidents happened over a two to three month period.

The cause of the injuries was that the slides were installed on an embankment consequently the ground was sloping downwards at the run-out.

When people came down the slide too fast they came off the end of the run-out, put their feet down and over-rotated falling down the slope and this is where the broken long bones occurred. One was a parent who took the child on their lap and when they came off the end too fast not only did they over-rotate but of course the weight of the child in front of them made the over-rotation even more likely.

Whilst there were only four accidents requiring hospital treatment these injuries were consistent with a large number of other falls with bumps and scrapes which occurred on the same slide during a period of a few weeks.

The slides complied or very nearly complied with the Standard in terms of angle of descent and when originally tested by both the installers and the Consultant at the Post Installation Inspection, the speed of descent appeared satisfactory.

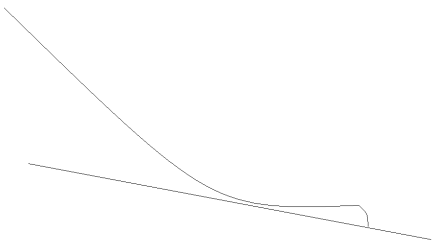
It was only when the investigations and further testing was carried out that it became apparent that the type of clothing worn by the rider was a significant contributory factor.

When bark pits were installed so that the ground was level at the run-out the bumps and scrapes were significantly reduced and the injuries ceased. This strongly suggests that making the ground level at the run-out was an appropriate modification.

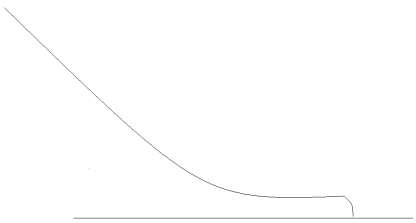
When the slides were tested approximately two years later the speed had decreased in all types of clothing to such an extent that they were barely acceptable as a slide as in some clothing the rider remained stationary even on the steepest part of the slide.

Recommendation 2

Standards such as EN 1176 should require that the ground at the run-out of a slide should be level (within reasonable tolerances) for 2m or possibly 3m. This requirement could be avoided if it is very unlikely that a rider will reach the end of the run-out before stopping.
Note: Level in this instance means as judged with a spirit level rather than in the sense of “smooth”, although of course this is also desirable.



Ground not level



Ground level at run-out

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2. The Head Injuries

The accidents causing head injuries occurred at an approximately 8.7m high tunnel slide which was of a shallow angle (below 35º throughout which is well within the recommendations of the Standard). This slide did have a bend in the bottom half of the slide (still within the tunnel) which was intended to slow the rider. This was not a sharp bend and did not look as if it could cause any problems. There was also a slight increase in angle of the slide about halfway down which felt as if it gave a significant and unexpected acceleration.

What happened was that riders were travelling so fast down the slide that when they came to this bend their head carried on in a straight line and hit the side of the tunnel slide causing severe bumps and one concussion. There were four instances requiring hospital attention however these were consistent with numerous other minor bumps to the heads of other children which happened at the same point. A member of staff who tested the slide using a synthetic carpet had a similar experience as did the consultant when testing the slide.

The type of clothing was a contributory factor as with some materials the speed was excessive and with others it was satisfactory (see tests later in this report).

Where the friction was very low the rider continued to accelerate to the bottom of the slide even though the angle of the slide was shallow, ie well under the EN 1176 permitted angle. Shallowness cannot therefore be relied on as a design method for ensuring children do not travel fast. It is the overall drop in height which is the major determining factor of speed when friction is low.

This slide within a year had slowed down to such a degree that it was barely acceptable as a slide for some children dependent on the type of clothes they were wearing. It was therefore no longer a “wow” item and was no longer fun to use.

Recommendation 3 Standards should warn that a bend in a slide may cause injuries if the travel is fast and/or the bend is tight.

3. The Snapped Femur

In this accident a young teenager went down the same slide as above. He was sitting up and then felt he was going too fast. He therefore put his shoe against the top of the slide to slow his speed and “my leg flew over the back of my head and I had to pull it back”. His femur (thigh bone) had snapped completely and necessitated him being taken to hospital and a plate fitted to the bone which will probably remain with him permanently.

What had happened was that the braking effect of his shoe had been so effective and sudden and the speed of his body so fast that the forces involved caused the injury.

His fast speed strongly appeared to be a consequence of the synthetic material of his trousers and the sudden braking a consequence of the rubber of his shoes.

The consultant can confirm from his own experiment that when travelling fast putting a rubber-soled shoe against the slide can give a tremendous kick or jarring which is surprisingly forceful. It can be easily anticipated that some children will have the combination of synthetic clothes and rubber shoes so this cannot be ignored by manufacturers.

Manufacturers cannot control the material of the users clothing or footwear therefore the reduction in speed may be the only control mechanism.

Interestingly, a similar and adjacent slide to the one causing the head injuries and snapped femur was only approximately 5m high and has no record of injuries or even minor bumps and scrapes. This strongly suggests that speed was the determining factor. The greater the drop from start to run-out, the faster the speed which may be reached (the obvious effect of gravity).

Recommendation 4 Those responsible for EN 1176 should consider whether there is a maximum height for slides above which the potential for fast speed is too high.

Note:
In all the above cases the slides were in country parks with no refreshments nearby so the slides remained clean and there was no evidence of sticky sweets or melted ice lollies causing the slowness of the slides to develop over one to two years. As the slowness occurred in tunnel slides insect droppings from trees above can be discounted. Two suggestions for the slowness have been made to the consultant. Firstly, that a gradual build -up of rubber from children's shoes may be the cause of the slowness. This is not apparent from scuff marks or similar evidence but may be visible under a microscope. Secondly, in some circumstances a surface that has become smoother through wear then gives a greater area of contact with the material and therefore paradoxically friction is increased. The consultant is not able to say if either of these reasons is the cause.

Recommendation 5 In order to maintain the utility of the slide manufacturers should provide users with a method of maintaining the slipperyness of the slide. It may be that cleaning with a brush and detergent may be sufficient, polishing may be necessary or it is possible that the application of a coating may be needed.

4. The Rotated Child

A further head injury occurred where a three-year-old child went down a tunnel slide.

The main cause of the injury was a section of the tunnel which was not flush and so gave a projection on which it is very likely he cut his head.

An exacerbating factor was that the child turned around in the descent. He started in the conventional feet first manner but emerged back first. This appeared to be caused by him wearing different materials on his legs from his body causing him to turn and him being sufficiently small so that there was sufficient room for him to turn within the tunnel.

The consultant also found at this site and many others that when wearing certain clothing he came off the run-out and bounced on his bottom across the impact absorbing surfacing. This was also observed in children using slides. This did not cause serious injuries; there was slight bruising in the case of rubber surfacing and some grazing/scratching (occasionally bleeding) in the case of wood chip/bark surfacing. Some children were shocked and upset

The shortness of the run-out also means that the child does not have sufficient time to realise they will come off the end and prepare to put their feet down quickly and thereby reduce the bump to the base of the spine.

Some years ago the consultant observed a child who went down a wide Type 1 slide just after rain had fallen. The slide had a slightly dimpled surface and the child had bare legs. She appeared to aquaplane down and shot off the end grazing her legs on the bark surfacing.

Recommendation 6 EN 1176 should be changed to recommend an extended length of the run-out required for Type 1 slides.

Tests on Slides – Methodology

Following the early injuries and his observations of numerous children using slides, the consultant realised that the materials being worn by the children was a contributing factor to the injuries. This is now mentioned in the revised EN 1176.

This is known in general terms but has not previously, as far as he is aware, been known to be associated with accidents.

He therefore started to test slides firstly by going down in denim jeans (100% cotton), secondly by going down in jogging trousers (around 35% cotton and 65% polyester of a woolly feel) and thirdly in synthetic trousers (100% nylon) (see Appendix). He did it in this sequence (slowest first) so that he was not surprised by an unexpected fast speed.

Following the head injuries at the slides, he revisited the playgrounds and re-tested the slides.

At the post installation stage of the equipment which had most injuries he had tested the slide at least four times each in jeans and in poly/cotton trousers and had travelled satisfactorily in both, though faster in the poly/cotton. The journey in the poly/cotton trousers was fast enough to be exhilarating to the point of being a little bit scary, but did not appear to be dangerous.

When revisiting to carry out the second tests at all three sites after the injuries he then repeated the tests but ensured the three types of clothing (see above) were used. The results for the jeans and the poly/cotton trousers were similar; however at the highest slide the tests in the nylon trousers were so fast that he did not complete the ride without using his feet to act as a brake. He was certain at this point that travel in 100% nylon clothing was hazardous. He also found that at the lower bend in this slide his head nearly touched the side which where the injuries had appeared to occur. He strongly recommended that this slide be not used until safe descent could be guaranteed.

The differences in speed were consistent at all these slides and at many other slides tested.

Where possible the consultant viewed the clothing worn at the times of the accidents or asked the parent specific questions about the material composition of the clothing.

As far as could be ascertained all the serious accidents were associated with the clothing in contact with the slide being 100% nylon or polyester, although it is possible that some contained a small proportion of cotton or other material. **NB** If the child travels head first or on their back the "clothing in contact" may be the jacket/pullover etc.

Approximately a year later at one site and two years later at another he carried out further tests. This time, however, he found that he could not descend the slide whilst wearing the jeans because the friction was too great. For most of the slides he hardly slid at all and had to use his heels and hands to propel himself downwards.

He tried a slide adjacent to the highest slide which was of the same design but steeper and less high and went down the slide in his jeans satisfactorily.

He changed into poly/cotton jogging trousers and top. His journey this time was barely satisfactory as the speed of travel was quite slow.

He changed then into the 100% nylon clothes and again the journey was barely satisfactory.

He repeated his test using the jeans a further time and the slide was too slow to be useable. This demonstrated the effect was not temporary and that the polishing effect of the tests did not affect the speed.

Note:
As a safety measure at the slide where the head injuries had occurred, the consultant wore a protective "hard hat" (as used on building sites). However this was worn with the peak at the back and without the strap fixed – this to protect against an impact but to avoid any jerking to the neck. Other inspectors may be able to suggest a better method.

In addition to his own tests the consultant observed numerous children travelling down slides at the playgrounds concerned and other playgrounds. The observations confirmed that the clothing the child was wearing was a much more important factor than the size or girth of the child. At two playgrounds these observations were counted and exceeded well over 50 trips down the slide and these were by over a dozen children of differing ages and sizes.

Further Tests

The consultant has carried out further tests on many slides since the above. He has regularly found that he has come off the end of the slide too fast when wearing synthetic content clothes or sitting on a piece of synthetic material. Where the slides have been relatively short (less than 2m) he has assessed that the risks have been sufficiently low to be acceptable. Children would be unlikely to sustain an injury. By "too fast" the consultant means that the speed at the run-out did not feel comfortable and he did not feel in control of his getting off the run-out.

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However in one case of 2 adjacent slides of approximately 2.5m high he “flew” off the run-outs travelling about 0.5m through the air before landing on his bottom onto thick wood chip. This happened both when he tested the slides wearing nylon trousers and poly/cotton trousers. These slides complied with the Standard in relevant aspects. If the wood chip was maintained at a good depth and “fluffy” the risks would have been of minor scratches and abrasions. If, however, this was not the case or the surface had been rubber, then there would have been risk to the base of the spine or to children putting their feet down and over-rotating very quickly with the risk of broken arms.

Conclusions

A slide within a relatively short period of its life can range from being too fast to be safe to being too slow to be useable. This is not dependant on weather conditions or other environmental factors.

The dangerous occurrences are caused by a combination of design of the slide and/or installation and the clothes the riders are wearing.

These dangerous occurrences can happen with slides that appear to comply with the recommendations of EN 1176.

Where the slides are below a certain height the hazard could be overcome with changes in EN 1176 such as level ground at the run-out and a longer run-out (the “certain height” is not known at present but is probably at least 5m.)

Where slides are above this “certain height” the acceleration caused by gravity means that speeds of descent are likely to cause injuries particularly when the slide is new.

Slide designers can have no influence on the clothing/footwear the riders may wear therefore the designs will need to allow for the different speeds likely to be achieved.

Many slides and particularly high cost slides which appear to give a “wow” factor to a playground may within a year or two of their installation give a very poor slide experience for a good proportion of their users. Manufacturers should consider treatments which maintain the utility of the slide to give acceptable value for the customer. It is possible that such treatments may need to be applied as part of routine maintenance. Care should be taken to ensure that they do not give a speed which is faster than can be achieved when the slide is new.

Until any modification to EN 1176 is issued manufacturers and/or inspectors should base their risk assessments on tests using different clothing or mats of different materials rather rely on compliance with EN 1176 alone. These tests should be carried out where slides are particularly high or challenging.

It may be possible to agree on standard “sacks” or “mats” made of different materials which can be used for testing. These might be of a similar design to the ones used on helter-skelters and long undulating slides found at fairgrounds.

It is the consultant's experience that when testing is carried out by a person who can experience the "feel" of the journey this has advantages over testing with an inanimate object. The "feel" will give a truer picture of the child's experience and how they are likely to react. He accepts that tests with a standard inanimate object covered with different materials may give a consistency of result. He does not, however, believe that an inanimate object test should completely replace on site tests by a person sliding down the slide.

It is the consultant's opinion that the consideration of these matters may lead to a limit in the height of slides to reduce potential speed but that the angle of the slides may be increased slightly to maintain utility and that the run-out length may need to be increased.

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Appendix

Synthetic clothes associated with accidents and fast descents

100% cotton denim 65%poly/cotton35% 100% Nylon

Clothing used by consultant in tests