ACTIVITY REPORT OF JIS STANDARDS DEVELOPMENT COMMITTEE ABOUT THE TEST METHODS OF SLIP RESISTANCE OF PROTECTIVE FOOTWEAR AND OCCUPATIONAL FOOTWEAR

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The background that was decided to be established the test method about the slip resistance performance of protective footwear and occupational footwear, as JIS standards again. There is the following status. 1. Fall disaster is most frequent in the different type casualties disaster generation state of the occupational accidents of Japan and is accounting for about 20 % or more of the entire. 2. Senior workers population of Japan has been increasing year by year, therefore fall disaster is becoming likely to occur. 3. As the cause of the fall disaster, fall by the "stumbling" is also more frequently occurring in addition to the fall due to "slip". 4. Test method for the "slip resistance" is defined in JIS T 8101and ISO 13287, but the test method for the "stumbling" has not been established yet. 5. Fall due to "ice" and "powder" are also occurring, but these test method also has not been established yet. Based on the current status, the contribute to the reduction of fall accidents is the aim, and we carried out that enact the JIS standards of slip resistance test method which is including the "stumbling", "ice" and "powder" in addition to the conventional slip, as the first activity.

The fall by stumbling

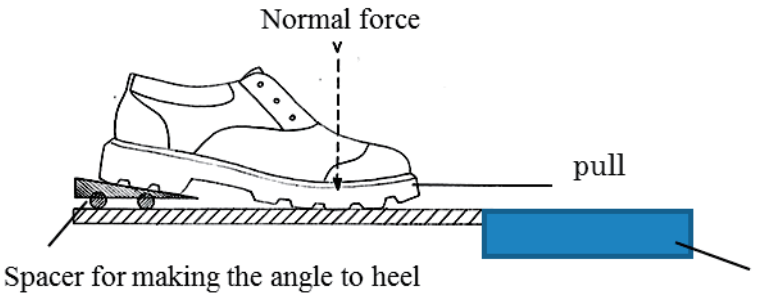
First, we considered the test methods about the "stumbling". If we analysed the situation that occurs the fall by stumbling before examining the test method for stumbling, there are two situations.

1) The case you have changed the direction suddenly or stop suddenly in the state that the friction between the floor and the sole is large, or you have stopped suddenly to come running, the shoe sole did not slip on the floor surface, therefore the leg could not be follow to the change of centre of gravity of the trunk, will tip over finally.
2) The floor has unevenness surface and if the height of the toe of shoe (toe spring) is low, the toe is caught without being step over the unevenness floor by the method of walking, will tip over.

In order to be able to validate these two states quantitatively by the coefficient of friction between the shoe and the floor, we decided to design the test apparatus for stumbling.
When we designed of the test apparatus for stumbling, the main purpose of the test is realization of the form close to the actual walking posture.

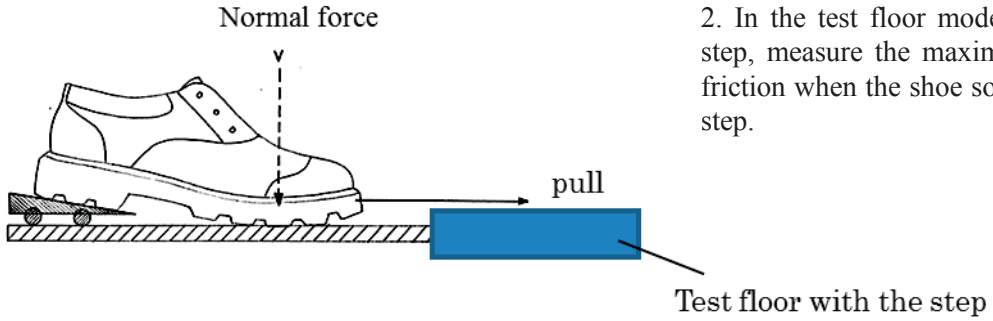
Move the shoe or the floor to the horizontally direction, with the state that lift the heel of the shoe and add a constant load to the over part of the shoe contacting to the floor, we have considered the measuring method of maximum static friction coefficient of when the shoe sole contact with the test floor. (See figure below) From the situation that causes stumbling fall, we considered the following three test methods can be carried out.

1. Test floor mode without the step



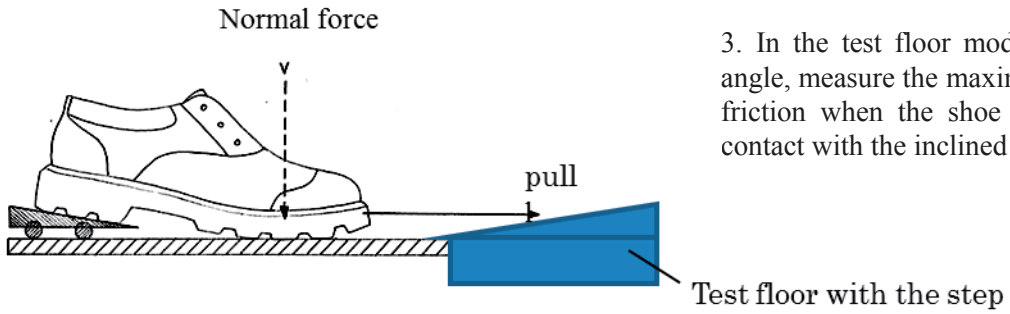
1. In the test floor mode without the step, measure the maximum static friction between the shoe sole and test floor.

2. Test floor mode with the step



2. In the test floor mode with the step, measure the maximum static friction when the shoe sole hits the step.

3. Test floor mode with an angle



3. In the test floor mode with an angle, measure the maximum static friction when the shoe sole is in contact with the inclined floor.

Figure 1. **Three test modes for the stumbling test**

In the test method specified in ISO 13287, the test conditions are defined as below.

- Contact angle of the heel is 7 ± 0.5 °.
- The normal force of shoes size 25.0 or more is 500 ± 25N, Shoes size less than 25.0 is 400 ± 20N.
- Tensile speed is 0.3 ± 0.03m / s.

From these conditions, selected conditions of the stumbling test are as below.

- The normal force (Normal load) should be 50N.
- The tensile speed of shoe should be 0.3 ± 0.03m / s.
- The angle of the wedge should be 7 °.

From these conditions, selected conditions of the stumbling test are as below.

- The normal force (Normal load) should be 50N
- The tensile speed of shoe should be 0.3±0.03m/s.
- The angle of the wedge should be 7°

And we selected condition that material, surface treatment and structure should be selected for making as small as possible the friction between the floor and the forefoot of shoes. We are making first apparatus of the stumbling test now, and doing preparation for collecting data.

The above figure is first apparatus for stumbling test. But we are trying to improve for making the load of 50N on the forefoot of shoes, with the state which last was inserted into shoes, in the actual test.

Figure 2. **An example of the stumbling test**

The slip on the powder

Next, we made study of the slip on the powder.

We have tested whether occurred difference in the perceived of the slip on the powder, by using the shoes from A to E of a different dynamic friction coefficient in slip test of JIS standard.

Finally, we have found that there is no relation between dynamic friction coefficient difference and the perceived of slip.

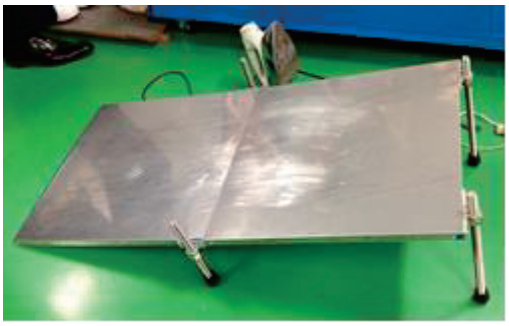


Figure 3. **An example of the steel inclined plate**

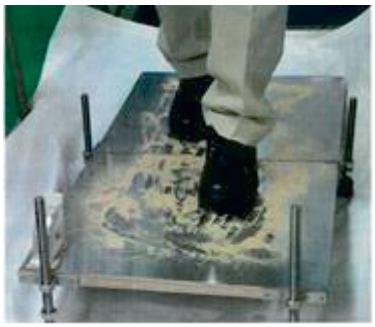


Figure 4. **An example of the slip test on the powder**

The above figure is that walking repeatedly up and down, by using safety shoes, in the state that is sprinkled powder on top of the stainless steel inclined plate, thereby confirmed the status perceived of slip.

We prepared a three types of powder as A: Toyoura sand (standard sand in construction materials), B: Baby powder (surface treated talc), C: Cake flour (flour fine particles). We tested the difference between slip perceived by varying the angle of the stainless steel inclined plate.

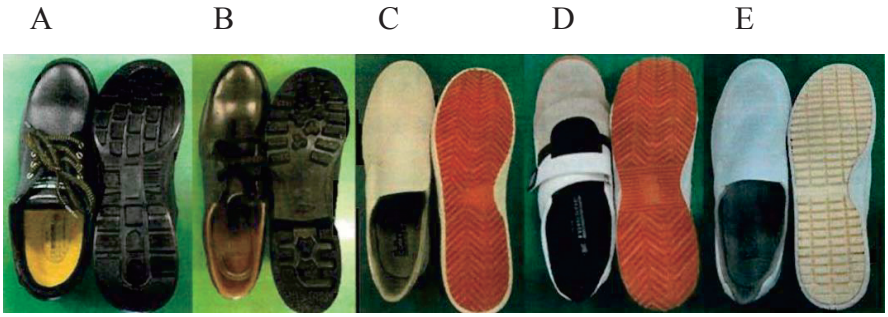


Figure 5. **Sole design image of the test sample**

Table 1. Slip experience test results of different sample different angle different powder

sample	Angle plate 10°			Angle plate 15°		
	A	B	C	A	B	C
	Toyoura sand	Baby powder	Cake flour	Toyoura sand	Baby powder	Cake flour
A	×	×	△	×	×	×
B	△	△	△	△	×	△
C	◎	◎	○	○	○	○
D	◎	◎	○	○	△	○
E	×	×	×	×	×	×

× signify the slip perceived. △ signify the slightly slip perceived.
○ signify the few slip perceived. ◎ signify not slip perceived.
We have prepared 5samples as different types of outsole material, shape and structure.
A: Protective footwear with dual-layer urethane sole. (Dynamic friction coefficient 0.25)
B: Protective footwear with single-layer rubber sole. (Dynamic friction coefficient 0.09)
C: Non-slip occupational footwear on the powder. (Dynamic friction coefficient 0.10 to 0.15)
D. Non-slip occupational footwear on the roof. (Dynamic friction coefficient 0.10 to 0.15)
E. Non-slip occupational footwear in the kitchen. (Dynamic friction coefficient 0.50)
Size is all 26.0.

From these test results, the following conclusions were derived.

1. In the perceived test of the slip on the powder, there is no correlation with the dynamic friction coefficient, but there is the case that sole with the high dynamic coefficient is rather more slipping. We considered that the ground contact area of the cleat design is affecting, and there is tendency that the sole with the large ground contact area is generally hard to slip. However, in case on the powder, we guess that the phenomenon of slipping is happened, by the occurred slip at the entire surface of the ground contact area of the sole.
2. Non slip occupational footwear on the powder showed a characteristic that is hard to slip as expected. This footwear's cleat design has become a structure that repels powder when you ground. Therefore, we have considered that there was no slip, because the powder is hard to enter between the surface of the cleat and the floor.
3. In addition, there is something unclear and clear of difference of the perceived of the slip by difference of the powder depending on the type of powder. As a standard powder of the evaluation test, Baby powder is felt most clearly difference perceived of the slip, Toyoura sand is follow as next one.
4. The angle of the inclined plate, angle 15°was felt easier the difference perceived of the slip than angle 15°. From above, the conclusion is, in the method of measuring the dynamic friction in powder slip resistance test, we found the discrepancy between perceived and dynamic friction coefficient number. Therefore, we felt the need to consider a new test method. It is not reached the stage of development of test methods at the moment. About the development of test method that matches the perceived, we are thinking continuously trying to make the effort.

The slip on the ice

At the end, we made study of the slip on the ice.

Whether happening the difference of perceived of the slip on ice, was tested using the shoes from A to F with a different dynamic friction coefficient in the slip resistance test of JIS standard. The result, we have found that there is no correlation at all between the difference of dynamic friction coefficient and the perceived of the slip. In the slip resistance test on the ice, it is hard to slip in the state in which ice is completely frozen. It was a result that it starts to slip suddenly when the surface begins to melt.

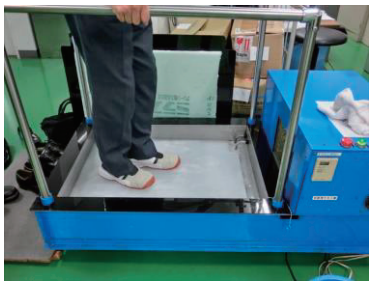


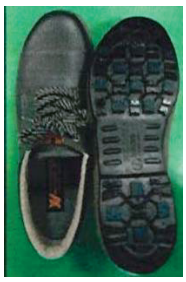
Figure 6. **An example of the ice slip test device**

Figure 7. **An example of the slip test on the ice**

The above figure is that are creating a smooth surface of ice by device to make the ice, and walking on the ice by wearing protective shoes, thereby we checked the state of perceived of the slip.

First, after experienced perceived of the slip in the state which the overall surface of the ice was started melting. Then experienced perceived of slip after changing to the state to freeze completely the surface. After that, we made the experience of perceived of slip by the creating a state of partial melts.

Table 2. Slip experience test results of different sample different states on the ice

Sample	State that the surface was melted	State that the surface was completely frozen	State that the surface was partially melted	F  A to E are the same as the powder slip resistance test
A	××	△	×	
B	××	△	×	
C	×	○	×	
D	×	○	×	
E	××	◎	×	
F	○	◎	○	

×× signify the slip perceived strongly. × signify the slip perceived.
△ signify the slightly slip perceived. ○ signify the few slip perceived.
◎ signify not slip perceived.

Sample F which was added to test new is non-slip protective shoes on the ice. (Dynamic friction coefficient 0.20) Size is 26.0.

From these test results, the following conclusions were derived.

1. In the slipping perceived test on the ice, there is completely no correlation with the dynamic friction coefficient, but is influenced on the state of the surface of the ice. Therefore, it is indicating the easy to slip on the wetted ice despite was evaluated as non-slip shoes by the slip resistance test of JIS standard.
2. Non slip safety shoes on the ice showed a characteristic that is hard to slip as expected. This footwear's cleat design has become a structure that mounting the fabric to the ground contact surface. Therefore, we have considered that there was no slip, because water is hard to enter between the surface of the cleat and the floor.
3. In fact, the state of the surface of the ice have unevenness surface and is not as same as the flat surface like the ice surface of the test, therefore ground contact surface is easy to become to the point contact, consequently we guess that it become more slippery. From above, the conclusion is, in the method of measuring the dynamic friction in ice slip resistance test, we found the discrepancy between perceived and dynamic friction coefficient number.

Therefore, we felt the need to consider a new test method, but it is very difficult to keep the

evenness surface state of the ice in the slip test, and we consider that the establishment of the reproducible test method is very difficult at this point.

Conclusion

We think that need more long term investigation for establishment of the test method of the powder slip and the ice slip.

Therefore, about standardization of the slip resistance test of JIS standard this time, from the results and consideration of the perceived test by the slip, decided that make a description to draw attention to the user about the risks of the working on the ice and the powder, by the form of Annex (Information).

Establishment of the slip resistance test is necessary for the development of the protective equipment which reduces the fall disaster.

Japan protective footwear manufacturers association will be thinking to try continually best effort for establishment of the slip test method, in the future.