Establishment of barrier-free space information
- Study on the relationship between unflat surfaces of pavements and vibration affect on human body -

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Nowadays, pavements are not necessary for satisfying everyone in Japan. Then if elderly and disabled persons were informed on walkable parts in pavements instantaneously when they want to go to their destinations, they could have comfortable walking time in city lives. It is desired to build information systems for them and it is necessary to study basic systems to examine physical and mental terms in walking pavements. As we are trying to make these terms clear, the following 3 steps are examined. 1. Selection of information indexes for barrier-free pedestrian space. 2. Field survey for the examination of the indexes and ranking the walkable area using the indexes. 3. Building up the information systems. For the first step, we examined the relationship between unflat surfaces of pavements and body vibration.

1. Introduction

Nowadays, pedestrian space is not necessary for satisfying everyone in Japan. On the other hand, in the early state, detailed mapping was introduced using GPS(Global Positioning System).

There are four barriers[1)] namely surrounding disabled persons, physical barrier, informational barrier, institutional barrier, and mind barrier. In particular, we focus on informational barrier that is also the barrier of a way[2)]. In order to establish a friendly that can make more comfortable life meaty for pedestrians, especially elderly and disabled persons, it is necessary to provide beforehand and timely barrier informations pedestrian space to a user. Though the construction of information system is desired, few people have been studied.

Therefore, we had been studying to develop 3-dimensional barrier information loading type map. Rather than 2-dimensional maps showing geographical information of the names of a roads and places, directions, etc. an advantage of a 3-dimensional map is effective in the users who sees intuitively a store, signboard, etc. and recognize importance of the known information as a mark[3].

The following three steps can be considered for this study.

1. Selection of suitable index for the barrier information of pavements.
2. To investigate present condition and to rank the condition of pavements.
3. Construction of an information system.

At first, in order to tackle the first step, we had studied the relation between the unevenness of the road surface of pavements, and the vibration to a human body.

Moreover, for a wheelchair user, vibration due to unflat surface of pavements may influence the body greatly[4]. Then, we examined the oscillation characteristic of a wheelchair.

Furthermore, there have been few studies on evaluation of vibration of equipments on human bodies during moving. Therefore, in this study, we are studying to evaluate the oscillation due to unflat surface of the pavement to examine the human body movement with installed accelerometer on a human body. All the results obtained here will be plotted on a 3-dimensional map as barrier information on pedestrian space.

2. Method

The method of this study is as follows: 1) making up a list of barriers in the date of reports to establish the pavement structure database, 2) estimation of degrees of frequencies influenced for human bodies, 3) Furthermore, an field survey on the barrier of pedestrian space is carried out by elderly, disabled persons, etc. 4) valuation standard is made based on results of an investigation. Finally, we develop 3-dimensional barrier information loading type map which includes the barrier degree.

The field survey on the barrier of pedestrian space is carried out for wheelchair users, in order to accumulate the pavement structure database. And then, we focused on the space between tiles of pavement material that influenced the movement of wheelchairs. We examined an oscillatory wave, and unflat surface level of the pavement was test using the profile meter.

2.1 Influence of changing a space between tiles (mainly wheelchair)

First of all, we examined the relationship between spaces of pavement material and to vibration of a wheelchair. At this time, we introduced an indoor test way about 3m long, varying in width of four stages, during running of a wheelchair (Fig.1, Table.1).

Moreover, in order to keep the moving speed constant, a wheelchair was pushed to study in step with the sound of a metronome. The installation positions of the accelerometer were a right-hand side footrest and a front wheel rear wheel axle in vertical direction. A vertical acceleration was influenced by unflat surface (space between tiles) [5]. The reason why installed in three places is that a difference would be in the oscillation characteristic received in each installation place. The acceleration data measured from the accelerometer installed in the wheelchair, is recorded on a data recorder by an A/D conversion vessel. Frequency analysis was performed by the high-speed Fourier analysis for the oscillatory wave form. The power spectrum was used for the analyses.

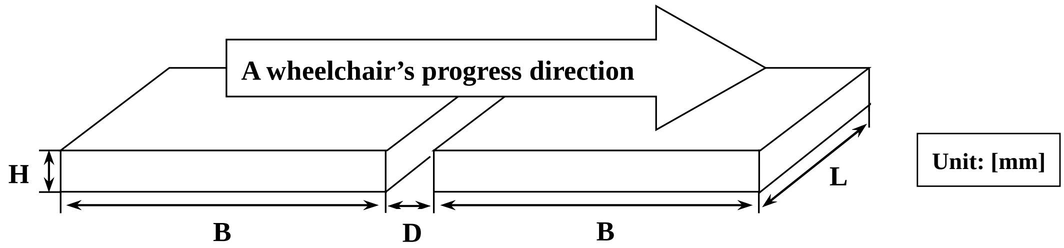

Fig.1 Test way

Table.1 The experiment condition

A kind of a wheelchair		For care (standard type)	
Maximum weight[kg]		50.0	
Form size of board material of examination way[mm]	B	250.0	
	H	12.0	
	L	900.0	
A space between tiles[mm]	D	5.0,10.0,15.0,20.0	15.0
Walk speed[step/minute]		80	72,80,88

2.2 Influence of changing speed (mainly human body)

Next, in order to examine the oscillating part of a human body, the field survey about pedestrian space was performed to the wheelchair user beforehand at May 25 2002. Consequently, we obtained by the reply that the vibration influence to a footrest and a leg that the vibration to a buttock is subsequently large. Then, we do an experiment focusing a leg and carry out comparison and examination with other parts of a human body (Table.1; notice the coloring portion).

Furthermore, it unites also about a relation with the front wheel[4] considered to be notably influenced by vibration, and we verify from an experiment on the relationship between the accelerometer was installed in the footrest of a wheelchair and the front wheel rear wheel axle, and the human body (tip of a foot, knee, buttock, shoulder, and head) portion, and measured the vertical direction. Finally, frequency analysis was performed from the measurement result.

2.3 Examination by a profile meter

We measured the flatness of road surface using the profile meter in order to evaluate the ride comfort of a wheelchair objectively. We executed it by two places in Sapporo city at December 9 2002. We measured at the two places. We chose the places where those were focused on a wheelchair user as Good, Generally, Bad in reference. The road surface shape of each spot as follows (Table.2).

Table.2 The road surface's shape

The spot	A space between tiles[mm]	pavement material's width[mm]	depth of the tiles[mm]
A	20.0	80.0	5.0
B1	2.3	150.0	5.0
B2	8.0	14.0	2.0

3. Results

The result of the examination in a space between tiles performed using the wheelchair, speed, and profile meter is summarized to as follows.

3.1 Influence of changing a space between tiles (mainly wheelchair)

The analysis result and knowledge which were acquired from the indoor examination are as follows.

1. Each part is taking out with others the value which extracted the group at the case of 20mm.
2. It is a footrest that whose value of a power spectrum was the largest among three places.
3. The value of the power spectrum which a footrest receives becomes about twice of a front wheel.
4. Frequency in case a power spectrum is max in the case of a rear wheel axle differs by each a space between tiles.
5. Frequency is about 10Hz when two power spectra take the greatest value that a rear wheel axle is removed.

3.2 Influence of changing speed (mainly human body)

The result of the peculiar frequency and acceleration of the vertical direction is as follows by speed change of each part (tip of a foot, knee, buttock, shoulder, and head) (Fig.2, Fig.3). Furthermore, the knowledge acquired from the analysis result is as follows.

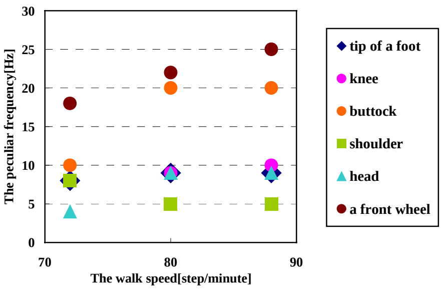

Fig.2 The peculiar frequency by speed change (vertical direction)

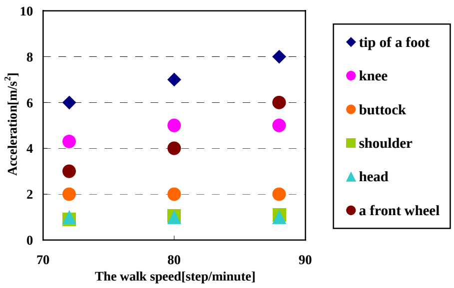

Fig.3 Acceleration by speed change (vertical direction)

1. Peculiar frequency had the high value of a front wheel, and when it was the walk speed of 72 steps per minute, other parts and the big difference were seen.
2. About acceleration, vibration of a tip of a foot was the highest. Subsequently, it was a knee. A result to which both exceed a front wheel axle was brought.
3. A big vibration was received in order of tip of a foot, knee, buttock, shoulder, and head. It's the order near the ground. A buttock and the head were fixed values even if walk speed changed.
4. The tip of a foot and the knee were filling the results of the 4-8Hz discomfort range[6)] (vertical direction).

3.3 Examination by a profile meter

The experiment showed as follows.

1. A not much big difference was not seen by the measurement result of the good way and the generally way.
2. The ride comfort evaluation of a wheelchair is proposed. It carries out based on an experiment of profile meter, the experiment of acceleration, and the opinion of a wheelchair user (Table.3).

Table.3 The unflat surface evaluation of road

Standard deviation		Ride comfort evaluation	Content of ride comfort evaluation
Acceleration	Quantity of unflat surface		
0.00	under 0.3	over 4.5	Excellent
0.00-1.00	0.3-0.8	4.5-3.5	Good
1.00-3.00	0.8-1.3	3.5-2.5	Generally
3.00-5.00	1.3-1.8	2.5-1.5	Bad
over 5.00	over 1.8	under 1.5	Too bad

4. Conclusions

The conclusion obtained from each experiment is as follows. And the conclusion which unified these is shown.

4.1 Influence of changing a space between tiles (mainly wheelchair)

Under these examination conditions, it experimented by installing an accelerometer in three places. And the oscillation characteristic of a wheelchair has been grasped. The excellence frequency of the front wheel axle and footrest whose value of a power spectrum was the maximum is about 10Hz. In order that this value may exceed 4-8Hz which is the discomfort range [6] (vertical direction), so it is guessed that those who have ridden have received a considerable vibration.

4.2 Influence of changing speed (mainly human body)

By installing an accelerometer in a human body directly, we have grasped the characteristic of vibration exerted on a human body from the unflat surface of the pavement road surface. As a result, acceleration also became large as speed became quick, and the tip of a foot expressed it most notably. The tip of a foot is filling the discomfort range. It is clear also from the result of peculiar frequency. Therefore, it was judged that the necessity of considering a safe side was indispensable.

4.3 Examination by a profile meter

So far, the acceleration experiment to which a space between tiles using the wheelchair was changed, the acceleration experiment of speed change, the field survey about pedestrian space, and the profile meter experiment were conducted. The above result was unified and ride comfort evaluation of a wheelchair was proposed. The oscillating valuation standard was expressed numerically and it was made specifically intelligible for anyone.

When the above was unified, it turns out that the wheelchair user feels very discomfort as a result. While not knowing, the talk that the leg had slipped down and sprained from the footrest is heard. We think that examine the textures of the pavement road surface, the volume of voice guidance, brightness, and tone from now on. We are plain and show everybody barrier degree of each element by numerical value as this time. And a virtual experience is to print it in 3-dimensional of possible map as barrier information.

5. References

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