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Research Progress Report

Evaluation of Accessible Design of Public Transport Facilities

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1. Overview of this research

Today, accessibility for transport is an important issue to maintain the sustainability of our society. Laws and regulations order all new transport facilities be accessible, and transport companies are now trying to introduce accessibility into existing facilities. The experience so far teaches us that it is easy to realise an accessible facility when the facility is newly constructed, but it is strenuous and expensive to introduce accessibility into existing facilities, especially large public transport facilities such as underground stations. Under such a difficult situation, a detailed evaluation tool for accessible designs may be of use to the planning/design of the introduction of accessibility.

This research intends to develop a new evaluation tool for accessibility. This research assumes that the accessible design in public transport facilities is of benefit not only to elderly or disabled people but also to all people with the diversity. The significance of the proposed model is to focus on benefits of the accessible design to a variety of people including not only elderly and disabled people but also other people. Accessibility in public transport has previously been regarded as an additional service designed specially for those who cannot manage ordinary facilities. This research suggests a new viewpoint that accessibility is not something only for limited people, but for all people. (i.e. Robust people can also easily use low floor buses.) Another significance of this research is to propose a practical evaluation tool based on the proposed model. Moreover, combining research on accessibility for transport with physiological/ occupational research should be recognised as a unique approach.

This research consists of six phases.

1) First phase involves with a literature review of the evaluation of accessibility.
2) In the second phase, a new conceptual model for the evaluation of accessibility is proposed.
3) In the third phase, based on the developed conceptual model, basic concepts for an evaluation tool are constructed. A pedestrian simulation is employed as the evaluation tool. Literature review on pedestrian studies and pedestrian simulations is conducted.
4) Forth phase focuses on the development of the pedestrian simulation. Coding of the proposed simulation is conducted.
5) Fifth phase concentrates on an experiment to test the concepts built in the third phase and to gain empirical data for the proposed tool (pedestrian simulation). Literature

review of relevant physiological studies is also performed.

6) Sixth phase is designed for validation of the proposed pedestrian simulation. This phase covers the establishment of the methodology for the validation.

2. Brief summary of the each phase

2-1. Literature review of the evaluation of accessibility

Literature on the evaluation of accessibility may fit into three categories:

a) People-oriented approach,
b) Facility/service-oriented approach
c) Conjunction approach between people and facilities.

Studies in *a) People oriented approach* have not directly shown the practical implication of the evaluation, and studies *in b) Facility/service-oriented approach* have barely considered the variety of people. Because of the similarity to my research, *c) Conjunction approach*, which has two groups of studies: Swedish studies and Tyler's studies, was carefully scrutinised. Details of the review were shown in Fujiyama (2004).

2-2. Developing a new conceptual model for evaluation of accessibility

A new conceptual model, called "Coping model", was developed in order to capture benefits of accessible facilities to all people including elderly and disabled people. The basic idea for the model is that if a person confronts a facility (environment), the less the requirement of the facility (environment) the more easily the person can manage it. For instance, suppose a person confronts a vertical difference. The lower the height of the difference, the more easily the person can go over it.

Fig.1 is a schematic representation of the *coping model* applied for the example of a vertical difference.

- X-axis of the frame means *Environmental requirement* (in this example, height), and Y-axis means the *Easiness* for a person to manage the given facility (environment) (in this example, easiness to go over the difference).
- ER_{max} means a person's unique maximum manageable level for the given facility (environment). In this example, this ER_{max} can be a person's maximum climbable height for a vertical difference. If the height of the vertical difference the person confronts is more than ER_{max}, he/she cannot manage the difference.

- Each person has his/her unique "*Environment requirement- Easiness* curve". The shape of the curve might be complicated, but for simplification this research assumes a linear relation. According to the actual "Environment requirement" (the height of the vertical difference) and his/her "*Environment requirement- Easiness* curve", *Easiness* for him/her to manage the facility (the environment) is decided.

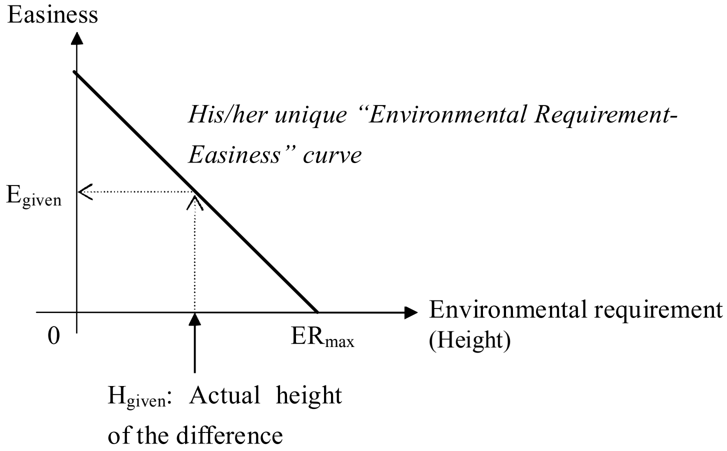

Fig.1 Coping model

Easiness in Fig.1 is an abstract notion, and it may be difficult to measure this. This research assumes that an index of the actual/consequent behaviour of a person while managing a facility (an environment) corresponds with the *easiness* for the person to manage the facility (the environment). In the example of the vertical difference, the walking speed of the person can be an index of the *easiness*. There may be many indices for the actual/consequent behaviour (i.e. energy consumption).

The relation between *Easiness* and an index of his/her actual/consequent behaviour might be complicated, but this research assumes a linear relation. For the example of a vertical difference, Fig 1 can be rewritten as Fig.2

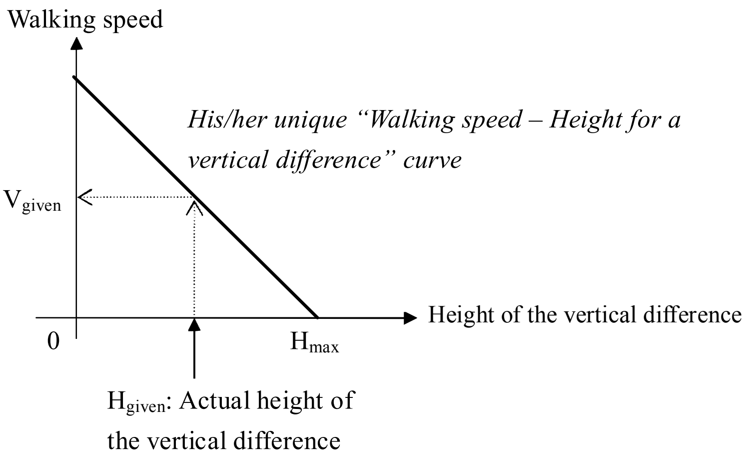

Fig.2 Coping model for the walking speed and the vertical difference

Fig.3 represents that each pedestrian has his/her unique “Walking speed- Height for a vertical difference” curve. In Fig. 4, if the height of a vertical difference (H_{real}) is around H_{Amax}, Person D cannot manage the difference. If the height is just below H_{Dmax}, Person D can go over it and also Person A can go over more faster than the case where the height is around H_{Amax}. This suggests that if the height is lowered to the level where frail people, such as elderly or disabled people, can manage, ordinary people gain faster speeds. The lower the height required by the facility, the more benefit people can receive.

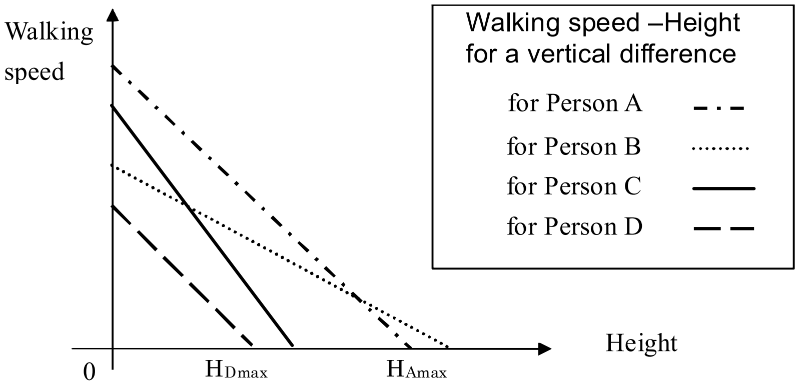

Fig.3 Coping model for a variety of people

2-3. Developing basic concepts for an evaluation tool based on the proposed conceptual model

In order to practically evaluate accessible designs with the coping model, details are given to the following three aspects.

- Target of the evaluation is expected to be large public transport facilities. This research concentrates on underground stations, because steps or vertical differences are a serious issue for accessibility for public transport systems and the underground is now trying to eliminate these steps/vertical differences. Our focus especially goes to stairs.

- In order to adapt the *coping model* for stairs, this research chooses the stair-gradient and the walking speed on stairs for *Environmental requirement* and *Easiness*, respectively.

- In coping model, each person has his/her unique “*Environmental requirement-Easiness* curve”. However, it may be difficult to examine this unique curve for each person. Therefore, this research takes following steps.

a) A set of attributes that may be related to walking speeds on stairs are employed to describe a variety of people. Attributes should also be linked to demographic data.
b) An experiment is conducted to investigate the relation between these attributes and walking speeds.

This set of works makes it possible to represent walking speeds of pedestrians with the diversity related to the demographic distribution.

Literature review of pedestrian studies and pedestrian simulations was also performed. Pedestrian simulations may be classified into three categories: Macroscopic simulation, Mesosopic simulation and Microscopic simulation. Details of the review were shown in Fujiyama (2003a)

2-4. Developing an evaluation tool (a pedestrian simulation)

Our evaluation tool takes a simulation approach. This is because this research consider a variety of people in the evaluation, and also our interest is in the output of interactions between a variety of facilities (environment) and various people. A simulation may be suitable for this situation.

Our simulation is derived from Cepolina and Tyler (2004) written in MODSIM, a programming language on which time-based simulations can be represented. Their simulation was a microscopic pedestrian simulation, where each pedestrian is modelled separately. Each pedestrian has his/her unique properties, such as the destination, the leg extensive power, the body size and the awareness area. Leg extensor power is given in the course of simulation, taking account of UK national population and a national fitness survey conducted by Sports Council *et al* (1992).

The targeted facility, an underground station, is represented by a set of horizontal areas. Each horizontal area, represented by a number of cells, describes each floor. The simulation also prepares a horizontal area to represent stairs between floors. For example, in order to represent a facility consisting of the ground floor, the first floor and stairs between the floors, our simulation prepares three horizontal areas: the ground floor, the first floor and the in-between stairs.

Stairs in our simulation also has property, such as the stair-gradient. Walking speed of each pedestrian is decided according to his/her leg extensor power, and the gradient of the stairs on which he/she is walking. Fig.4 is a schematic representation for this notion.

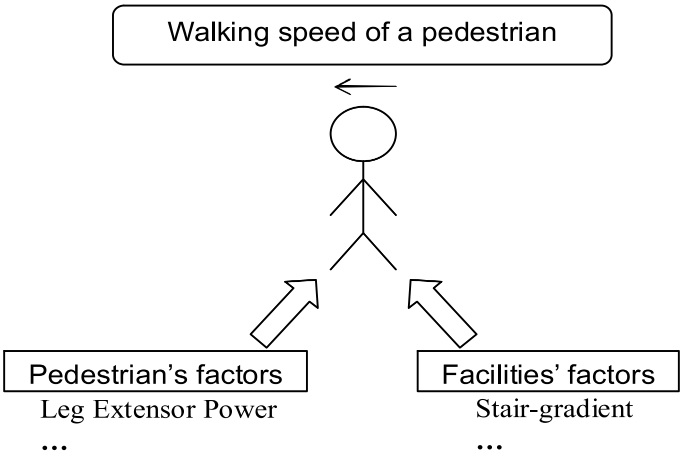

Fig 4 Schematic representation of the walking speed of each pedestrian

For the interaction between pedestrians in the simulation, this research employs the algorithm developed by Cepolina and Tyler (2004). Each pedestrian proceeds to his/her pre-defined destination, but changes his/her walking direction, if necessary, to avoid collision with another pedestrian or an obstacle. Direction change is performed according to his/her awareness area and perturbation caused by another pedestrian, an obstacle, and him/herself. Details of the algorithm can be seen in Cepolina and Tyler (2004).

2-5. Conducting an experiment to gather empirical data for the proposed tool.

An experiment was conducted in order to investigate relations between walking speeds and characteristics of pedestrians, and relations between walking speeds and characteristics of stairs. Findings were

a) Leg Extensor Power shows a strong correlation with walking speeds among elderly subjects (See Fig.5).
b) However, it doesn't among young subjects.
c) Age, height and weight don't show a strong correlation for all ages
d) There may be a linear relation between horizontal walking speeds and stair-gradients (See Fig.6).

The result infers that Leg Extensor Power can be used as an attribute to describe the variety of pedestrians in our simulation.

Literature review of physiological studies was also conducted. Details of the review were displayed in Fujiyama (2004a)

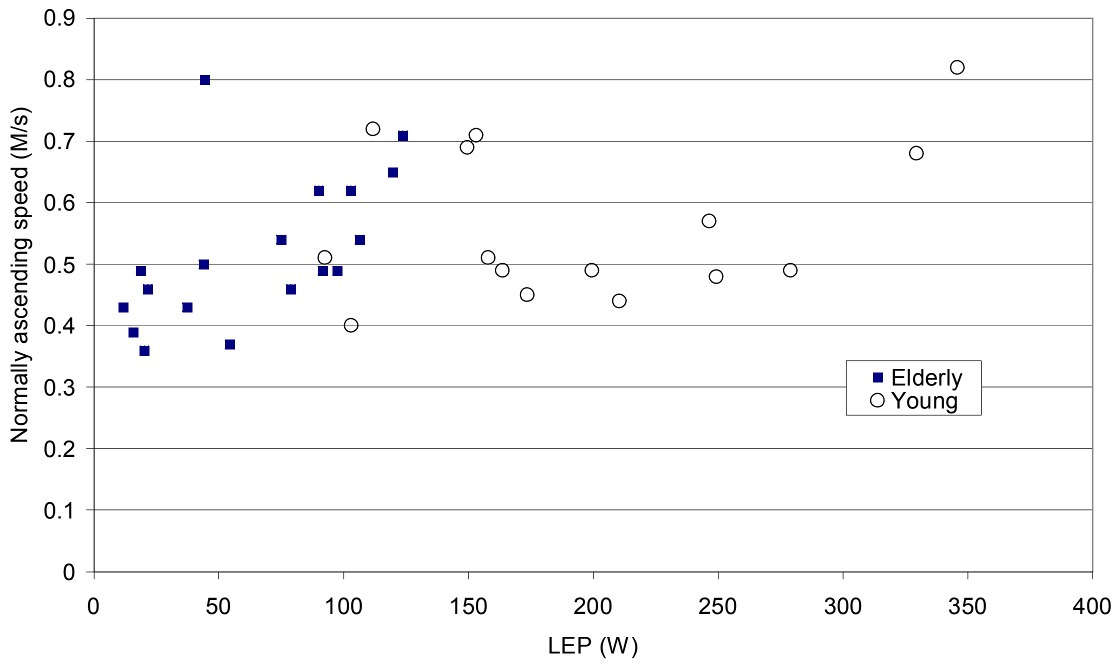

Fig 5 Relation between LEP and normally ascending speed (horizontal speed, Stair 2)

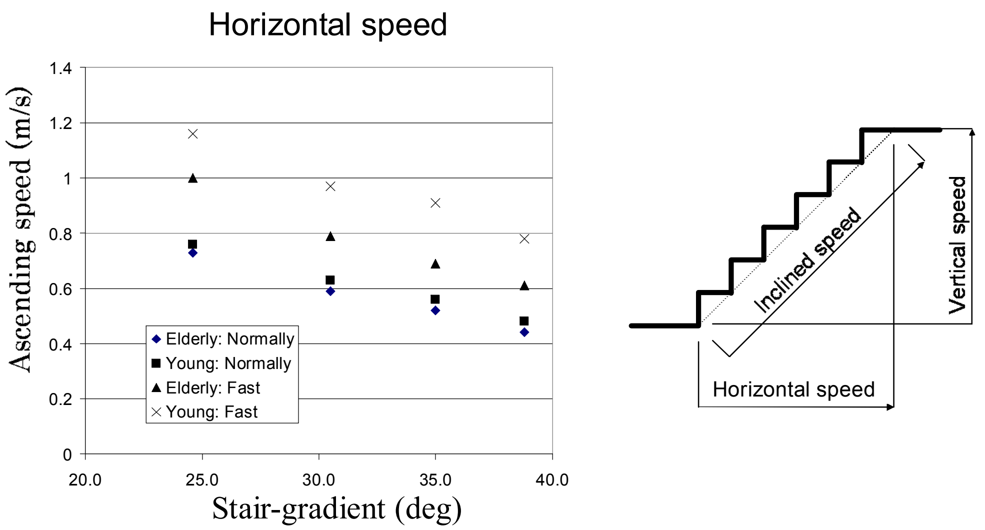

Fig 6 Relation between stair-gradients and horizontal ascending speeds on Stair 2

3. Further tasks to complete the research

3-1. Development of the proposed evaluation tool (simulation model)

Following additions will be made to the simulation of Cepolina and Tyler (2004).

1) To enlarge the simulation area to represent a multi-floor facility
2) To develop an algorithm to decide a walking speed according to the leg extensor power and the stair-gradient
3) To conjunct the experimental result with UK population data and the national fitness data.
4) To develop an algorithm to change direction in order to walk in a bending path that consists of several sets of stairs and horizontal floors.

3-2. Validation of the proposed evaluation tool (simulation model)

Methodology is now being investigated.

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