

I -22 DEVELOPMENT OF A PLANNING SUPPORT SYSTEM FOR BARRIER-FREE STREET NETWORK

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Abstract: In aging society, transportation infrastructure should be more accessible and safe for all people to encourage a participation to a society. However, an existing method and its support system for designing a barrier-free environment considering a street network structure is insufficient today. This paper presents a planning support system for designing a barrier-free street network in the central part of Morioka city. It is integrated by a geographic information system that consists of a database, a calculation program and a visual interface. The database contains the data of obstacles distributed over the street network. The data are collected from a field survey based on the guideline for barrier-free road improvement published in 2003. A route between an origin and a destination is restricted for a pedestrian because of the obstacles. The system gives us a route and its travel time for evaluating an achievement level of a barrier-free on the street network.

Key Words: barrier-free design, street network, planning support system

1. INTRODUCTION

A barrier-free design concept has been accepted over the world in recent years. The basic function of pedestrian facilities can make walking easier and prevent from hazards caused by vehicular traffic. For the purpose, sidewalks should be constructed where none exist and also existing sidewalks should be improved to reduce the hazards from obstacles and other barriers located over sidewalks. Aging society has come and requirements for barrier-free design of a transportation infrastructure are on the increase.

During the past few years, the people accepted the barrier-free design associated with transportation infrastructure in Japan as well¹⁾. “Law concerning the Promotion of Accessibility of Public Transport Systems to the Disabled and Elderly” (so called “The Transportation Barrier-free Law”) had been passed in 2000. And then, the Ministry of Construction set out “Standards on Road Structures required for Easier Transportation Access in Improvement Priority Areas

(Ordinance of the Ministry of Construction)”. The standards stipulate minimum criteria to be observed about road structures. The required quality should be rather higher than the standards. “The Guideline for Barrier-Free Road Improvement (Ministry of Land, Infrastructure and Transport)”²⁾ was published in 2003 for those who are responsible for road improvements in real world according to the standards.

It is necessary for elderly and disabled to promote a barrier-free street environment, but existing methods or support systems are not enough to implement the guideline today. In the previous studies³⁾⁴⁾⁵⁾, we presented a route choice support system for disabled and a prototype of a planning support system for barrier-free street network in the central part of Ube city, Japan. However, the data of obstacles contained by the previous systems had no standard criterion because the guideline didn’t exist before the research project started. The data were collected depend on our subjective observations. For example, a data of an inclination of a street section was measured with only 3 categories,

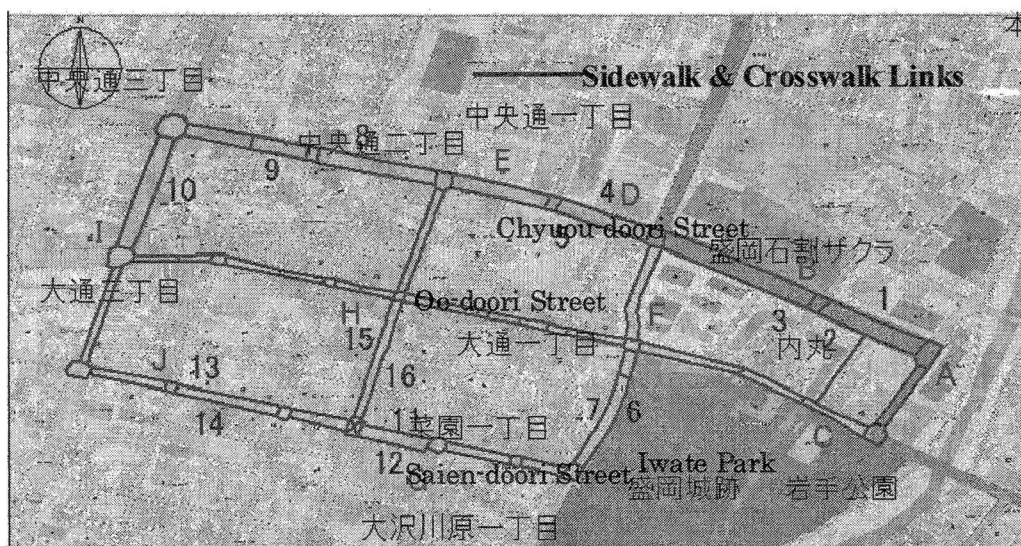
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Buildings	③ Prefectural Office & City Hall (3)
A City Hall	④ Chyuou-doori 1 (1)
B Prefectural Office	⑤ Chyuou-doori 1 (2)
C Library	⑥ Iwate Park (1)
D Bank (1)	⑦ Iwate Park (2)
E Bank (2)	⑧ Chyuou-doori 2 (1)
F Police & Fire Station	⑨ Chyuou-doori 2 (2)
G Department Store (1)	⑩ Oo-doori 3
H Book Store	⑪ Saien-Kawatoku (1)
I Bank (3)	⑫ Saien-Kawatoku (2)
J Department Store (2)	⑬ Yanagi-shindou (1)
Bus Stops	⑭ Yanagi-shindou (2)
① Prefectural Office & City Hall (1)	⑮ Eigakan-doori (1)
② Prefectural Office & City Hall	⑯ Eigakan-doori (2)

Fig.1 Study area —The central part of Morioka city—

such as steepness, slight steepness, and no steepness, in the previous systems.

In this paper, a planning support system for barrier-free street network in the central part of Morioka city is presented. The system is integrated as a geographic information system that consists of a database, calculation program and user visual interface. The database contains the data collected from field survey based on the standards revealed by “the guideline”. We developed a worksheet to collect the geometrical measurement data efficiently and accurately on the field according to the guideline. The system presented here gives us the locations of obstacles associated with their difficulties and the shortest route connecting between an origin and a destination on limited use of the street network caused by the obstacles. The route and its travel time under an allowable level of obstacles show the achievement level of barrier-free on the street network.

2. THE STUDY AREA AND THE DATABASE

(1) Study area

Fig.1 shows the study area in this research. Morioka is the capital of Iwate Prefecture with a population of around 290,000. It is a center of commerce, education and culture with its history dating back almost 400 years.

We have many urban facilities in the area that are open to the public, such as a city hall, a central post office, banks, shopping centers, restaurants and so on. Also we have a lot of transit bus stops, which serve a public transportation widely used by the citizens and tourists.

Bold dark lines in Fig.1 show the streets that are picked up for this study. The street network consists of 301 links, which includes both of sidewalks (173 links) and crosswalks (128 links). Buildings and bus stops that would be origins and destinations are located over

the street network.

(2) Data and Database

The database contains the data about geometrical structures of the streets associated with barrier-free achievement level. The data were measured and collected by a field survey within a study area according to "The Guideline for Barrier-free Road Improvement"²⁾.

We developed a worksheet for collecting street data efficiently on the field. The worksheet intended to summarize almost all contents of the guideline on each link. Data items on the worksheet about sidewalks of the guideline's chapter 2 are as follows.

- 1) Sidewalk for pedestrians or both of pedestrians and bicycles.
- 2) Passage divisions of pedestrians and bicycles.
- 3) Effective width, Length.
- 4) Pavement type, Local factor (freeze ground, sprinkler, road heating system).
- 5) Maximum gradient (incline), Maximum gradient (crossfall).
- 6) Curbstone, Fence, Plant, Manhole.
- 7) Crack (lengthways, crosswise).
- 8) Utility pole (electricity), Utility pole (phone), The other utility.
- 9) Sidewalk type (flat, semi-flat, mount-up, line).
- 10) Sidewalk height, Drop off at the curbside.
- 11) Curbstone surface gradient, Drainage (lid, grating).
- 12) Vehicle access point.
- 13) Height of bus stop, Bus stop type (bus bay, terrace, straight).
- 14) Guidance blocks for the visually impaired.
- 15) Roughness, Slippery etc.

The database contains the data collected of all sidewalk and crosswalk links. Also it includes locations of bus stops as a public transportation system and buildings that are open to the public.

(3) Barrier-free levels of the streets

Fig.2 and Table1 to Table 5 show some basic characteristics of the streets quantitatively. Fig.2 is a histogram of effective widths of sidewalks with a class interval of 0.5m. The streets of the area seem to be well designed for pedestrians from a viewpoint of street width as a face of Morioka city. However, they have a lot of obstacles from a barrier-free point of view. Table 1 to 5 show about some obstacles according to the guideline, such as drop off, incline, crossfall, cracks

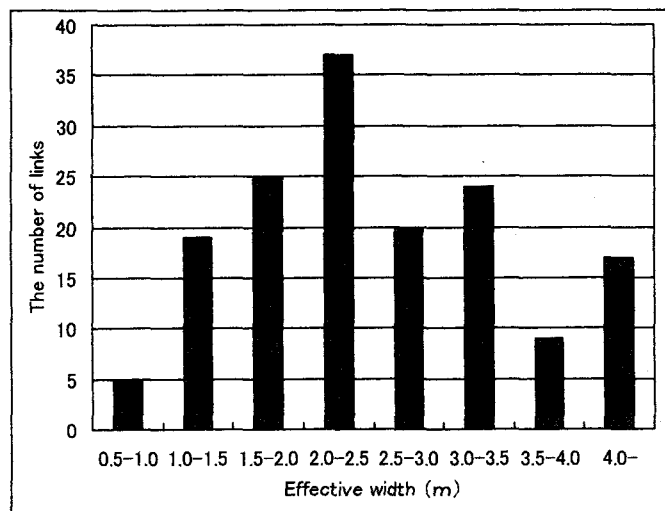


Fig.2 Distribution of Effective width of sidewalk

Table 1 Drop off at curbside

	links	%
less than 2cm	65	50.8
larger than 2cm	63	49.2
Total	128	100.0

Table 2 Incline

	links	%
less than 5%	156	51.8
larger than 5%	145	48.2
Total	301	100.0

Table 3 Crossfall

	links	%
less than 1%	36	12.0
larger than 1%	265	81.0
Total	301	100.0

Table 4 Crack (lengthways)

	links	%
Crack (lengthways)	34	11.3
none	267	88.7
Total	301	100.0

Table 5 Crack (crosswise)

	links	%
Crack (crosswise)	49	16.3
none	252	83.7
Total	301	100.0

(lengthways), and cracks (crosswise). About a half of sidewalks has drop off at the curbside larger than 2cm. Also about a half of all links has incline larger than 5%.

(4) Spatial distributions of obstacles

Fig. 3, Fig. 4 and Fig. 5 show some spatial distributions of obstacles over the street network depicted on a display. Fig. 3 is about inclines. It shows inclines are located widely in the area, but they are not so serious especially on the 'Oodoori Street' that is well designed. Fig.4 shows a spatial distribution of drop off at the curbside. Also Fig. 5 shows cracks along a street lengthways direction. Cracks can be observed on southeast side of the area. The outputs depicted here are about maximum value of each link measured on the field. We can see various types of obstacles are located widely and they would be barriers for pedestrians walking on the streets.

3. BARRIER-FREE ACHIEVEMENT LEVEL OVER THE STREET NETWORK

(1) Interactive interface

How does the system work? First of all, we can choose an allowable level of obstacles for a pedestrian walking on the area interactively. And then, the allowable links for the pedestrian are selected automatically over the network. Finally, a route and the travel time between an origin and destination are calculated on a partial street network composed of the allowable links. The route and travel time are shown on the display.

We choose an allowable level of obstacles in the first step from the following.

- 1) Sidewalk type: mount-up, semi-flat, flat, any
- 2) Minimum width: more than 1m, more than 2m, any
- 3) Incline: less than 8%, less than 5%, any
- 4) Crossfall: less than 2%, less than 1%, any
- 5) Drop off at the curbside: less than 2cm, any
- 6) Vehicle access: exist, none
- 7) Maximum crack (lengthways): less than 5cm, less than 2cm, any
- 8) Maximum crack (crosswise): less than 5cm, less than 2cm, any etc.

Pedestrians walking on the street have various types of physical conditions. The allowable level of obsta-

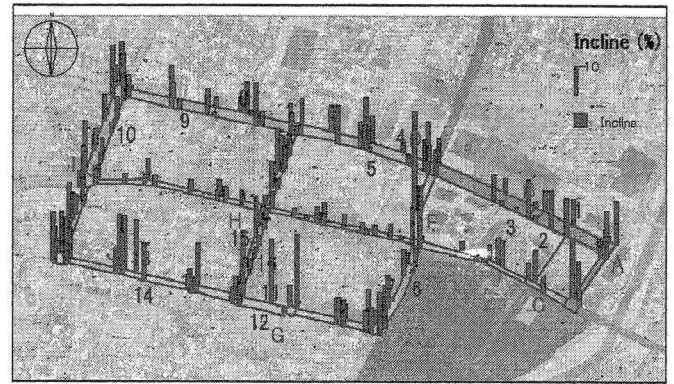


Fig.3 Spatial distribution of Incline

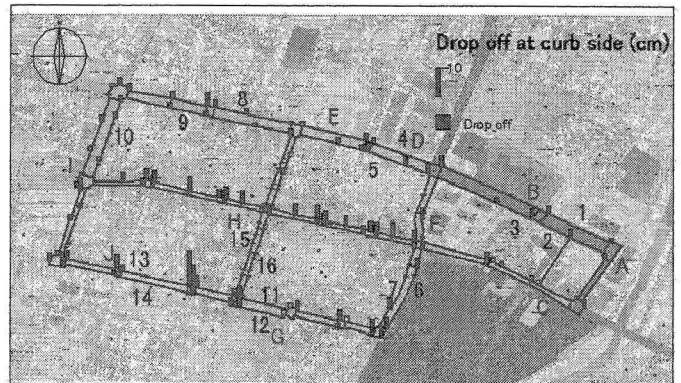


Fig.4 Spatial distribution of Drop off at the curbside

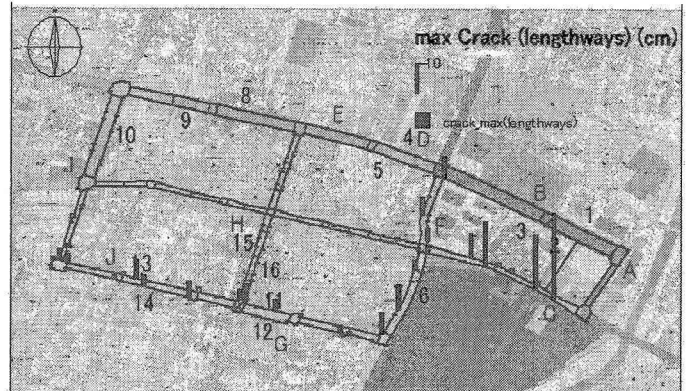
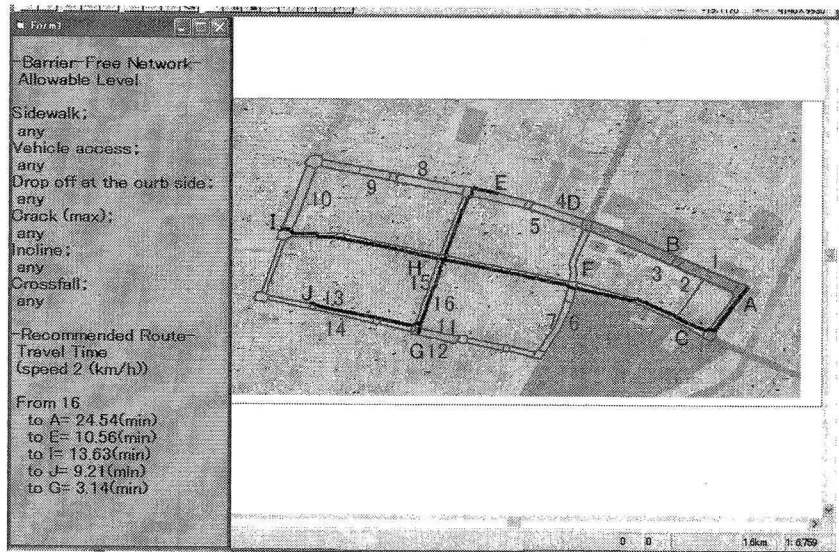


Fig.5 Spatial distribution of Cracks (lengthways)

cles is different by each pedestrian. For example, a pedestrian feels that a drop off at the curbside larger than 2cm is hard to walk. Another pedestrian feels that it is no problem.

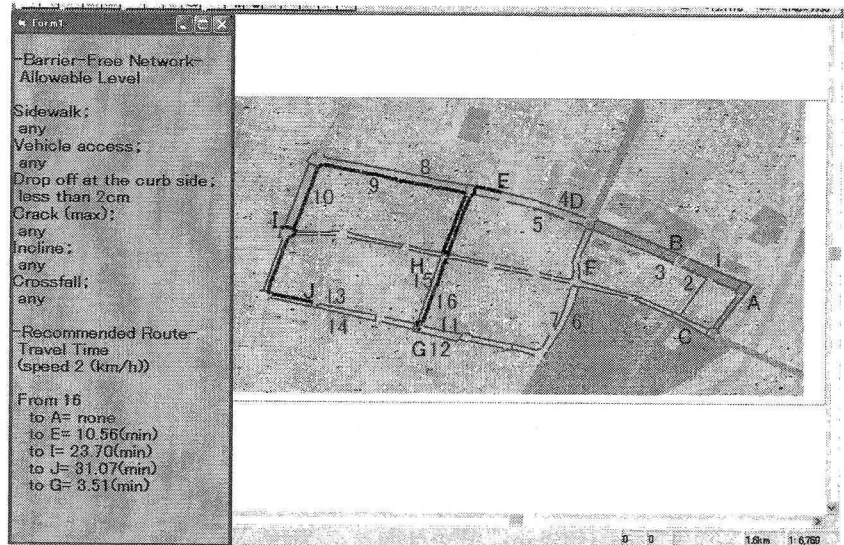
(2) Calculation of a route and its travel time

According to an allowable level of obstacles in the previous step, allowable links under the condition are selected and colored automatically in this system. A partial disconnected network composed of allowable links becomes an allowable street network for the pedestrian. The calculation program that can serve the



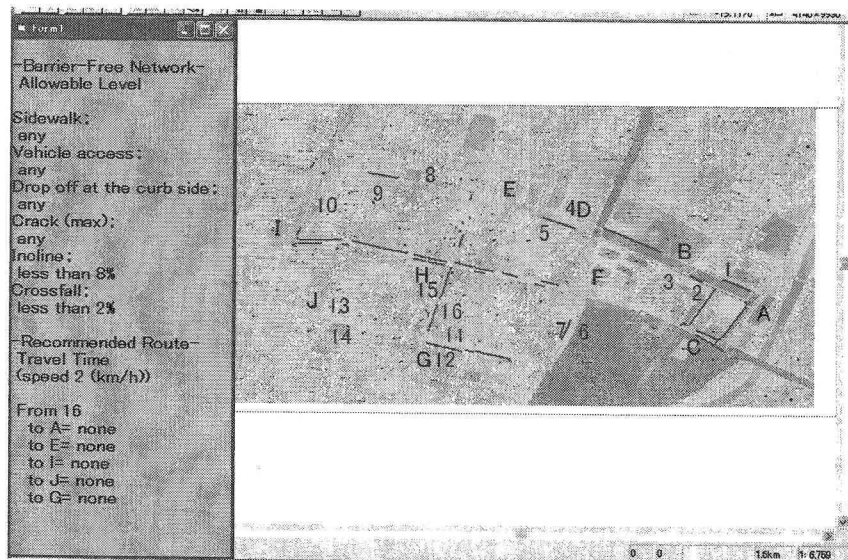
Allowable links (bold red lines) and shortest routes (bold black lines)

Fig.6 Output example 1: Pedestrian walking on the streets feels no difficulty for any obstacles.



Allowable links (bold red lines) and shortest routes (bold black lines)

Fig.7 Output example 2: Pedestrian feels difficulty for drop off at the curbside larger than 2cm.



Allowable links (bold red lines) and shortest routes (bold black lines)

Fig.8 Output example 3: Pedestrian feels difficulty for incline larger than 8% and also crossfall larger than 2% .

shortest route and its travel time on the partial street network has been developed.

- 1) Set the node numbers of an origin and a destination.
- 2) Choose an allowable level of obstacles. (as mentioned in the previous section)
- 3) Eliminate the street links dissatisfying the allowable conditions.
- 4) Make the network data by use of the remaining links.
- 5) Calculate the shortest route and its travel time on the street network.

The route and the travel time calculated here show a level of service of the street network from a viewpoint of barrier-free design. If the street network has a lot of obstacles or the allowable level of obstacles becomes lower, the route travel time would be longer to avoid the obstacles.

(3) Output examples

Output examples are shown in **Fig. 6**, **Fig. 7** and **Fig. 8**. They are the examples under the following allowable conditions.

Fig. 6: Pedestrian walking on the streets feels no difficulty for any obstacles.

Fig. 7: Pedestrian feels difficulty for drop off at the curbside larger than 2cm.

Fig. 8: Pedestrian feels difficulty for incline larger than 8% and also crossfall larger than 2%.

Under these three conditions, routes from "Eigakan Doori Bus stop "(No.16) to a city hall (A), banks (E and I), and department stores (J and G) are calculated and depicted. Bold gray lines (Red lines on a color display) show allowable links over the whole network. Bold black lines are the shortest routes connecting between the origin and destinations. Allowable levels of obstacles and route travel times are shown on the left hand side of the screen.

In **Fig. 6**, all links are available for the pedestrian because he/she feels no difficulty for any obstacles, so that the shortest routes for the destinations on the whole street network are depicted. In **Fig.7**, some crosswalk links, which has drop off at the curbside larger than 2cm, become disconnected. The pedestrian has no route for the destination A. The travel time from the bus stop to the building J becomes about three times in comparison with **Fig.6** for avoiding the obstacles. **Fig. 8** shows the pedestrian has no route be-

tween any pair of nodes under the condition of gradients revealed in the guideline.

4. CONCLUSIONS

This paper presents the planning support system for evaluating an achievement level of barrier-free street network in the central part of Morioka city. The system contains the database developed from a careful observation and geometrical survey based on the guideline for barrier-free road improvement. It shows us spatial distributions of obstacles over a street network under the conditions given. Also it gives us the shortest route and its travel time on allowable links for the pedestrian.

The travel time indicates numerically an achievement level of barrier-free within the area. If an achievement level of a street network is low, that means allowable street links are limited, a pedestrian tends to need more travel time to get to a destination. We can see which obstacle becomes a barrier and also where it exists. We can find out street links that should be improved for increasing the barrier-free achievement level in the area throughout the system according to the guideline.

In the future study, we should evaluate the efficiency of the improvement plan of a street network economically.

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