Evaluation of Pedestrian Sign System of a Shopping and Business Tower Complex

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Abstract: High standard of walking environment in city centers and their transport hubs is important to stimulate urban activities. This requires urban planners to ensure improvements to pedestrian infrastructure as well as sign systems to assist destination search and route choice processes of users. This project covers a case study of a newly developed shopping and business complex next to a large transport hub in Osaka, Japan. An experiment was carried out to investigate the compatibility of the sign system to route choice behavior of pedestrians. A measure to explain the relative number of pedestrians who sight a particular sign has been developed with the view of understanding the type of signs that are more useful to users. Routes selected by experiment subjects were compared to minimum distance routes that could have been selected by pedestrians with complete information about the network layout.

Keywords: sign system for pedestrians, shopping and business complex, transport interchange, EASTS IRG22

1. INTRODUCTION

Transport planners and service providers are beginning to realize the importance of guidance systems to travelers on roads and indoors. In this respect, static sign boards have a major role to play in guiding pedestrians to their destinations in an effortless manner. Signs are also important for vendors and industries that rely on the sign system to capture customers and retain them. The vendor site could be a retail shop, a food outlet, an education facility or a transport terminal. Nowadays vertical city developments have extended the sign system complexity to the realms of three dimensions.

In large buildings, clarity, consistency and completeness of sign systems play an important role in improving the walking experience especially for passengers unfamiliar with the layout. When the network structure is complicated, even pedestrians who are familiar with the system can be disoriented and may need direction information for their destination. This research project investigated the sign system within a large shopping and business complex which has many tenants. The site considered is named ‘Grand Front Osaka’ located next to the Osaka Station operated by West Japan Railway also known as JR West (This station will be called 'JR Osaka Station' from now on). This study has investigated characteristics of pedestrian route guidance sign system installed in selected parts of Grand Front Osaka complex and performed a physical simulation experiment of route choice process to make quantitative measurements of usefulness of individual signs with the view of understanding features that make the signs more useful to travelers.

Previously, sign systems have been studied with the focus on analyzing the relationship with destination and/or route choice behavior. For example, Mori and Iida (1997) investigated pedestrian travel behavior in order to create a pedestrian guidance system. In another example, Vandebona and Yossyafra (2005) investigated effective locations for signage by a simulation approach.

Newly developed large shopping and business complexes are generally designed with modern sign systems with standardized patterns and special care given to size of characters and lighting. Visitors may have to make an effort to find suitable routes to their destination as these networks pose challenges perhaps due to the repetitive nature of the layout elements.

The methodology of this study is illustrated using Figure 1. First, an on-site inspection of the sign system has been carried out at the site to understand types of signs used and relevant design aspects. Second, an experiment has been carried out to investigate route guidance provided by the sign system in the complex. This study employed several university students as subjects of the experiment and they were asked to visit pre-designated destinations following the sign system. They were not given the route information. Therefore the routes selected by subjects were based on the installed signs as well as sighting and interpretation of the signs by the subjects. Thirdly, a suitable minimum distance route that could be followed by a person who has complete information about the route layout is estimated. Finally routes observed in the field were compared with the selected shortest distance route to evaluate the ability of the sign system to funnel pedestrians to appropriate routes.

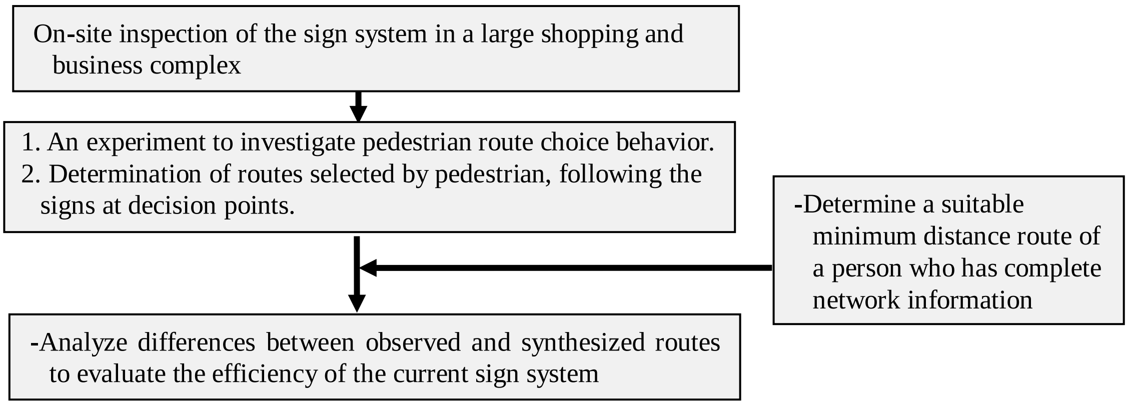


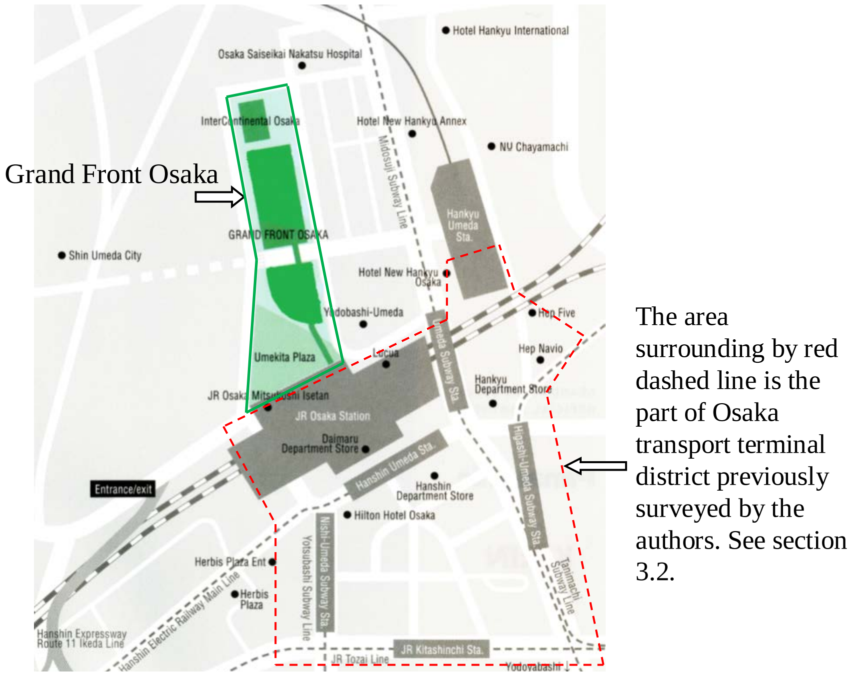
Figure 1. Sequence of research activities carried out

2. OSAKA TRANSPORT HUB AND GRAND FRONT OSAKA

2.1 Osaka transport hub

Osaka is the third largest city in Japan with a population of about 2.7 million in 2015. In the CBD of Osaka City, there is a large transport hub containing seven railway stations, namely JR Osaka Station, JR Kita-shinchi Station, Hankyu Railway Umeda Station, Hanshin Railway Umeda Station, and three stations of the Osaka Subway called Subway Umeda Station, Higashi Umeda Station, and West Umeda Station. The total number of passengers using the transport hub in a weekday is about 2.5 million.

Grand Front Osaka is a large building complex for retail shopping and commercial activities. This complex opened in April 2013 as the first stage of ongoing development of urban space surrounding the JR Osaka Station on its north side where there was a large freight terminal. The site layout is as illustrated in Figures 2 and 3.



Note: Modified from the map available at http://www.grandfront-osaka.jp

Figure 2. Location of Grand Front Osaka and Osaka Transport Hub

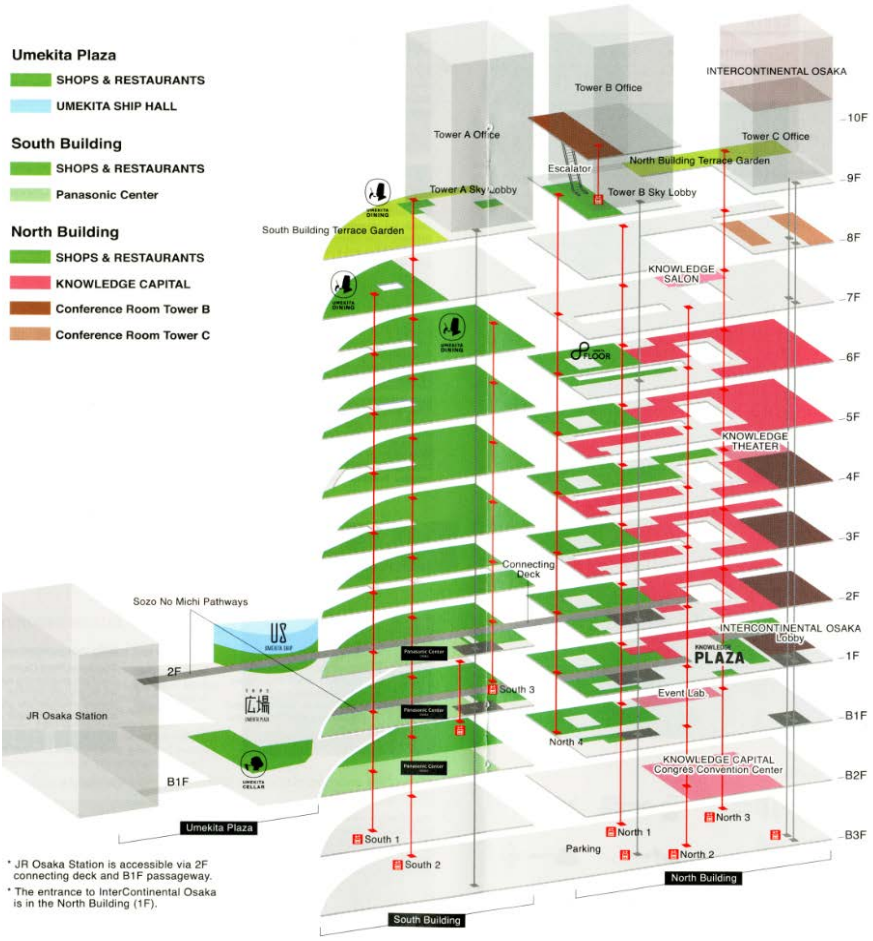
Source: http://www.grandfront-osaka.jp

Figure 3. Grand Front Osaka towers in the background of JR Osaka Station

2.2 Grand Front Osaka

The Grand Front Osaka is planned to consist of a string of four large buildings, about 40 stories tall. This research project covers parts of the North Tower and South Tower near the transport hub (See Figure 3 for a pictorial view of three towers on the skyline). 6th floor and below were selected in the North Tower whereas 9th floor and below were selected in the South Tower. Upper floors of both these buildings are classified as office space and not covered in this research work. The two Towers are connected by a skyway at the second floor level as shown in Figure 4.

Figure 4 provides a three dimensional view of floor plans of the retail and commercial space of the two towers. This area is connected to JR Osaka Station by the 2nd-floor deck and an underground path. In Figure 4, the North Tower is also referred to as Tower B.



Source: http://www.grandfront-osaka.jp

Figure 4. Layout diagram of the multistorey shopping and business complex, Grand Front Osaka

3. SIGN SYSTEM IN GRAND FRONT OSAKA AND THE TRANSPORT HUB

3.1 Sign system in Grand Front Osaka

For the purpose of this study, sign boards have been classified into three types according to the way content is presented as arrow signs, map boards and name boards. Examples of the tree types of signs are shown in Figure 5. Arrow signs have prominent arrows to guide users and may use icons and facility names in few words to describe destinations to a moving stream of pedestrians. Map boards show the layout of most facilities in the particular floor and may require the user to stop to read. These signs serve a broad range of users including sight seers and window shoppers. Name boards indicate several facilities together in a given floor as shown on the photograph on right in Figure 5. They are generally installed by the building consultant to direct users to generic facilities and may also be used to confirm to the user that he or she has arrived at the destination. Individual name boards of a facility managed by its owner are ignored here.

Also these signs are classified into following three categories from the point of view of installed location as; above eye level, at eye level, and below eye level as illustrated in Figure 6. Most above eye level signs are hung from the ceiling. At eye level signs are placed on walls and pillars. Below eye level signs are painted on the walking surface to read without slowing down.

Arrow type Map type Name board type

Figure 5. Three types of signs introduced

Above eye level At eye level Below eye level

Figure 6. Placement of signs installed

An inventory survey was carried out using the above classifications in the two towers, and results are presented in Figure 7. In the South Tower, arrow signs were more prevalent at 45.5% of the total sign boards. Map boards and name boards were 32.4 % and 22.1 % respectively. Percentages of these three type signs in the North Tower were found to be almost identical. Distribution according to the location type shows that in both towers 'at eye level' had the highest percentage of signs, i.e. 71.6 % in the North Tower and 60.7% in the South Tower.

There were many arrow signs between JR Osaka Station and Grand Front Osaka at the underground level, and at 7th floor of the South Tower which contained various types of restaurants. As the two towers are connected at the second floor, there are more than ten arrow sign locations at the second floor in the North Tower pointing to the partner building. There is a lack of signs to the transport hub from most parts of the complex indicating that tenants and Grand Front Osaka have little interest in directing pedestrians away from them to the railway stations. Signs to the transport hub are only available from the underground and second floors of the South Tower and at the first and second floors of the North Tower.

Signs installed in Grand Front Osaka were seen to be in logical sequences using consistent words and icons. One third of signs were map boards which had the possibility to provide an overview of the complex. These map boards were available near all escalators. In general the complex has provided a professional quality sign system helpful to most shoppers.

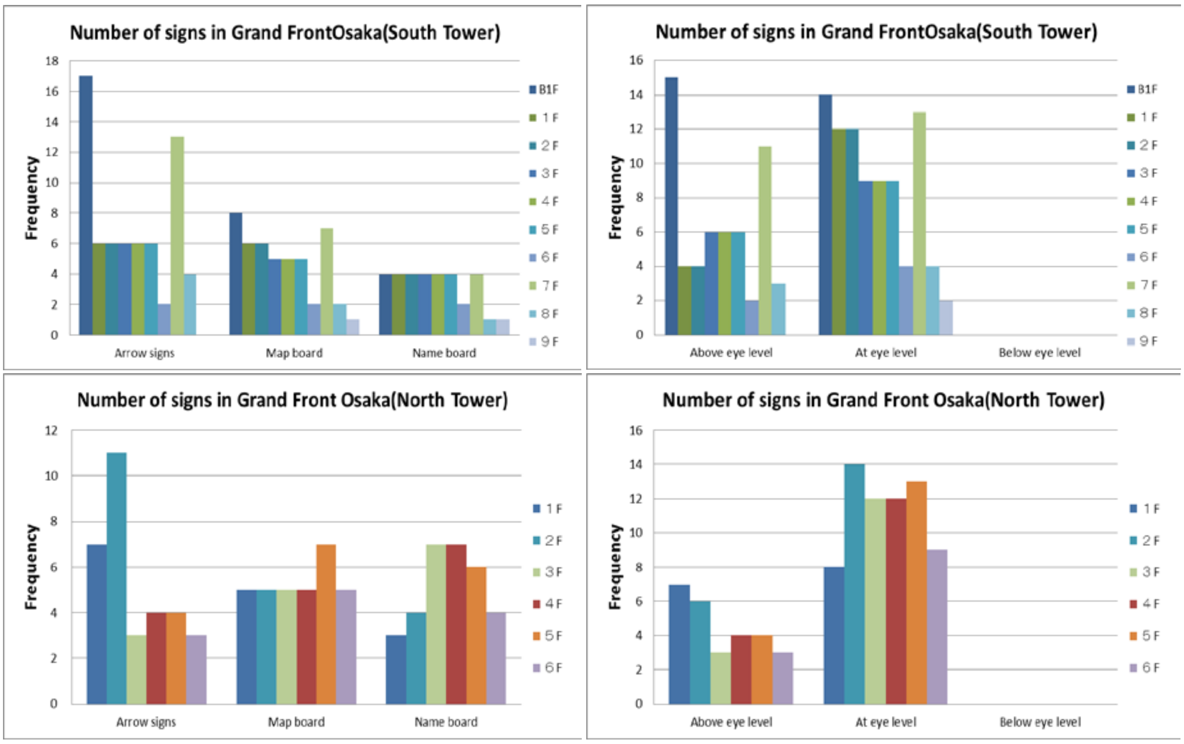


Figure 7. Types and locations of sign displays at Ground Front Osaka

3.2 Comparison between signs in the transport hub and Grand Front Osaka

As mentioned earlier, the transport hub consists of seven independent railway stations next to Grand Front Osaka. The transport hub also has number of underground shopping malls. Authors have previously conducted surveys in parts of this transport hub and the coverage area of the survey has been identified in Figure 2. The frequency of signs (according to the previous survey) by content types and location types are shown in Figure 8. Then, Figure 9 shows comparison of the two areas according to the content type classification. The percentage of arrow signs in the transport hub is larger than that in the tower complex. Therefore, the percentages of map boards and name boards are larger in the tower complex. Since passenger volumes are large among the stations, arrow signs are adequate and convenient to pedestrians in that area. In comparison, in Grand Front Osaka, there is a diverse variety of destinations such as shops, restaurants, and educational service providers sought after by different types of visitors. Such situations justify application of a high proportion of map-based signs.

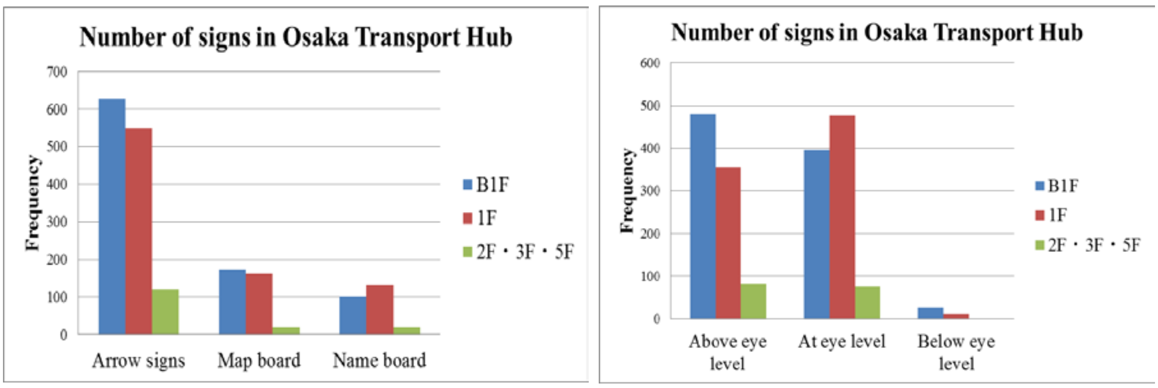


Figure 8. Types and locations of sign boards in Osaka Transport Hub

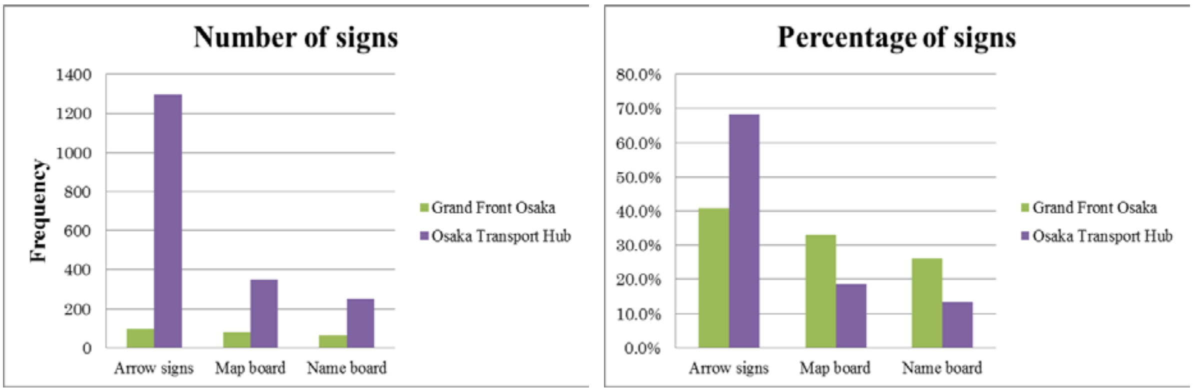


Figure 9. Comparison between the transport hub and Grand Front Osaka

4. EXPERIMENT OF ROUTE CHOICE BEHAVIOR OF SIGN USERS

4.1 Experiment description

In order to obtain behavioral data, an experiment was carried out at the two towers during three days in December, 2013. Detailed path layout of the study area spread over the South and North towers are shown in Figure 10. Subjects for the experiment were 24 male students recruited from Ritsumeikan University. As people who are familiar with the study area were not suitable for the experiment, the subject were screened beforehand to eliminate those who were familiar with the tower complex. Figure 11 shows the prior level of familiarity of selected subjects with the tower complex. 70% of subjects (17 out of 24) knew the location of Grand Front Osaka. 9 subjects had partial knowledge of the interior layout, and 15 persons no knowledge about the interior layout. Also, 10 subjects had not been to the tower complex before the experiment. Though number of subjects had some idea about the interior of the building, the study team was satisfied that no one had a good level of knowledge about the interior layout as the tower complex was rather new at time of the experiment.

The subjects were asked to visit pre-selected sites within the towers as shown by the six numbers marked on Figure 10. Subjects were asked to start from location 1 and travel to other locations in sequence according to the ascending order of location numbers. Once the subject is at location 6, he has to return to location 1 to complete the circuit. This yielded data related to six trips between the marked locations as listed below.

Trip 1: from location 1 to location 2,
Trip 2: from location 2 to location 3,
Trip 3: from location 3 to location 4,
Trip 4: from location 4 to location 5,
Trip 5: from location 5 to location 6, and
Trip 6: from location 6 to location 1 (the final destination, the tour ends here).

These destinations were selected based on an approximate proportionality with the number of different types of traders in the complex and spread of their locations. The sequence of the tour allowed for routes that require multiple floor level changes and lateral movements to the next tower.

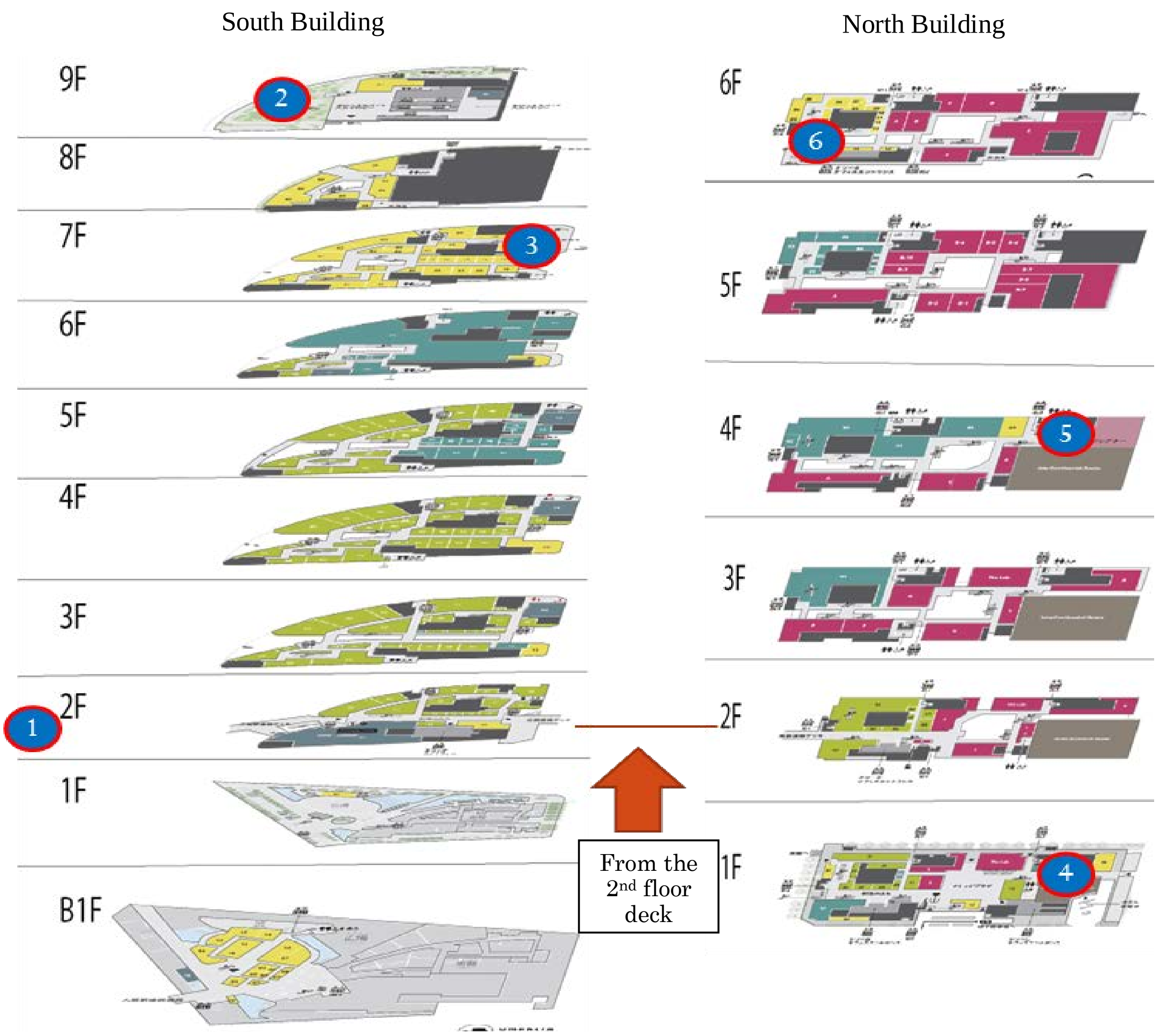


Figure 10. Six origins and destinations selected for the experiment

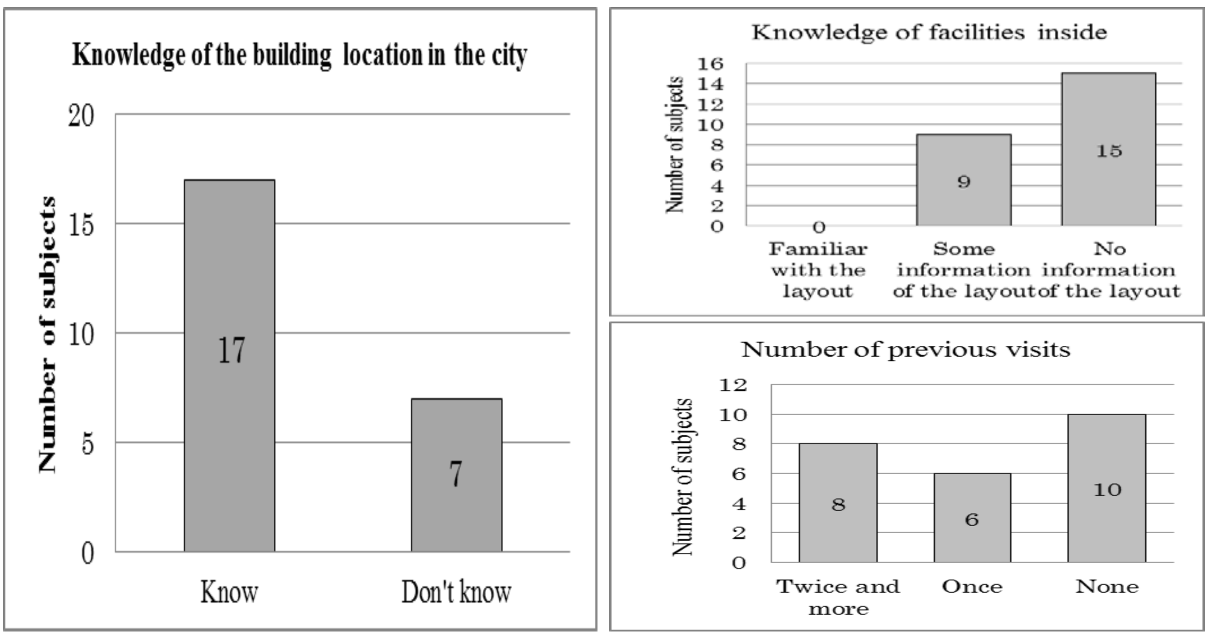


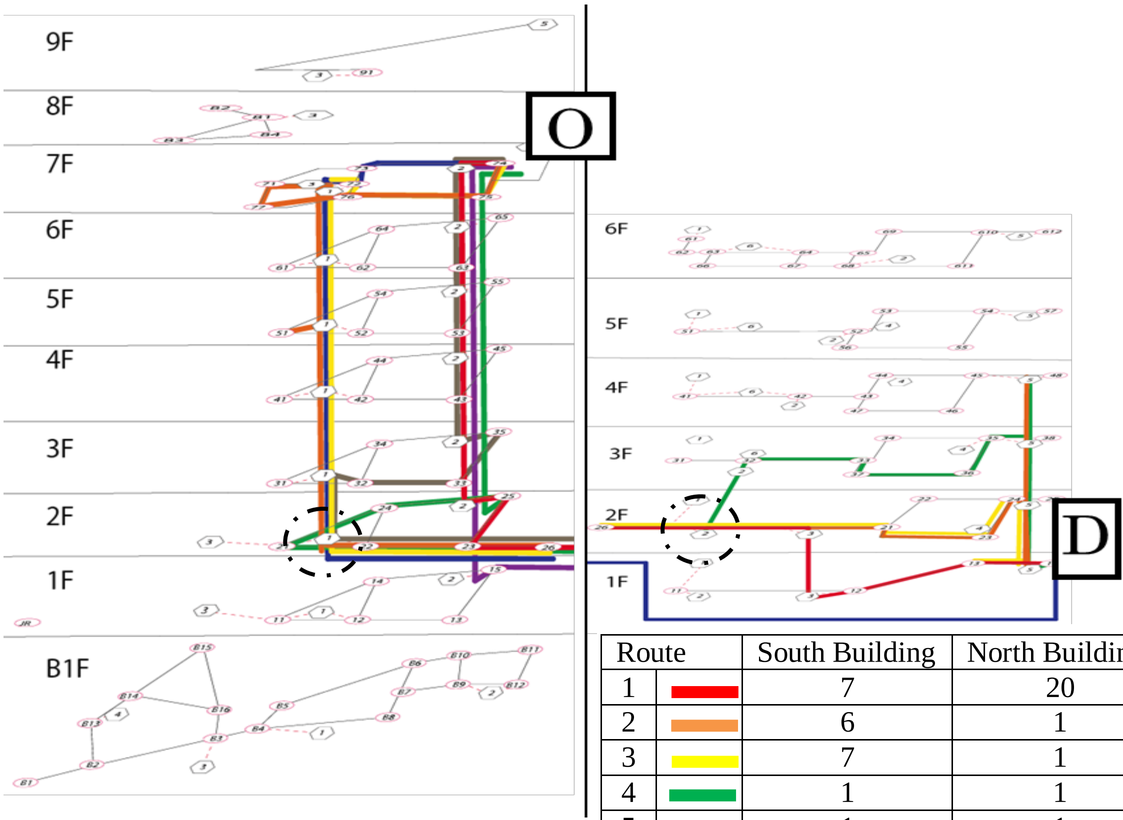
Figure 11. Attributes of subjects selected for the experiment

There were three other noteworthy aspects of the experiment:

1) Every subject had to wear a head mounted small video camera to capture signs he saw along the path he selected,
2) At the beginning subjects were told to find the destinations in sequence only using help from the signs they see along their trips (i.e. not allowed to ask someone or use a smartphone), and
3) An investigator with a clipboard and map followed each subject to record the exact route choice behavior.

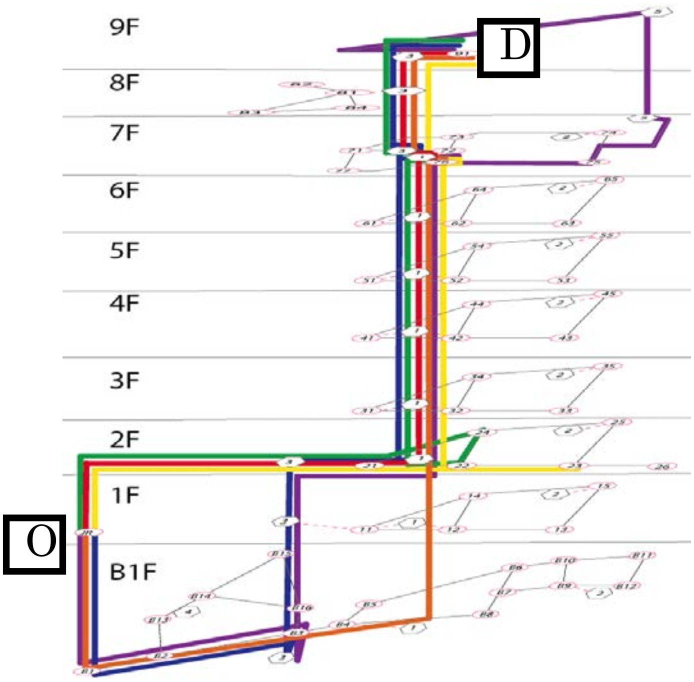
4.2 Routes selected by subjects of the experiment

Routes followed by the 24 subjects when they walk making use of the sign system from the location 3 to location 4 (i.e. Trip 3) are shown in Figure 12a. The two right hand side columns of numbers on the figure show how many subjects followed the particular path. There were seven alternative paths subjects have followed within the South Tower to reach the connector to the other tower. Then, there were five alternative paths within the North Tower to reach the destination. Routes selected by subjects have no excessive detours and appear to be reasonable selections. However, users' decisions were made at each turning point with imperfect information beyond that point, partly because map type signs only show the layout of most facilities on the floor, and do not provide the best route to their destination. Therefore, pedestrians had to obtain further information from other signs along the routes.



Route		South Building	North Building
1	(red)	7	20
2	(orange)	6	1
3	(yellow)	7	1
4	(green)	1	1
5	(blue)	1	1
6	(purple)	1	-
7	(grey)	1	-

Figure 12a. Walking paths selected by subjects for the experimental Trip 3



Route		South Building
1		12
2		8
3		1
4		1
5		1
6		1

Figure 12b. Walking paths selected by subjects for the experimental Trip 1

Figure 12b shows travel paths of subjects from location 1 to location 2. That is the experiment for Trip 1. 50% of respondents followed the first path indicated on the figure. Only one route (marked in yellow color in Figure 12b) shows overreaching on the horizontal direction and experienced some deviation from shorter paths.

4.3 Route selected under the complete information

There is more than one shortest distance path to a destination in tower structures where there are many corridor networks on the horizontal plane and vertical shafts and escalators to facilitate movement in the vertical direction. There are two particular routes from these shortest paths that are of interest to planners of sign systems particularly when we deal with networks on a single surface (Tsukaguchi et al.(2013), Hirata (2012), Tsukaguchi and Vandebona (2010) and Vandebona et al., 2005):

1) A shortest path that has the least number of turns requires less direction instructions to be given. Therefore they need less signs to direct pedestrians. Thus, such sign systems have a low construction cost. The emphasis in such systems is to maximize straight through movements. Pedestrian flows with such guidance information have low probabilities associated with left and right turns and behave as if the individual pedestrians behave under the influence of momentum concept (or inertia) in physics.
2) The other shortest path of significance stays close to the straight line connector between origin and destination. Form behavioral view point, in studies done on horizontal networks, it has been observed that humans have a tendency to minimize the angle of orientation with destination when they are regular users of a network. These pedestrians attempt to minimize the geometric angle between the current movement vector and the imaginary vector that connects the present location to the destination.

Previous research on walking between origins and destinations in different floors of buildings and terminals has shown a tendency of pedestrians to make use of the first available set of stairs and escalators to reach the destination level. This behavioral trait of trying to reach the destination level as soon as possible can be now incorporated to the two route choice strategies mentioned above.

The above route selection strategies allowed researchers to select two different shortest paths from the many shortest paths that maybe available to compare with the route taken by the experiment subjects. Figure 13 provides a summary of the two strategies. The first method is referred to as the simple shortest distance route because it has less turns. The other method is referred to as the natural shortest distance route because it similar to the path often followed by regular users of pedestrian networks.

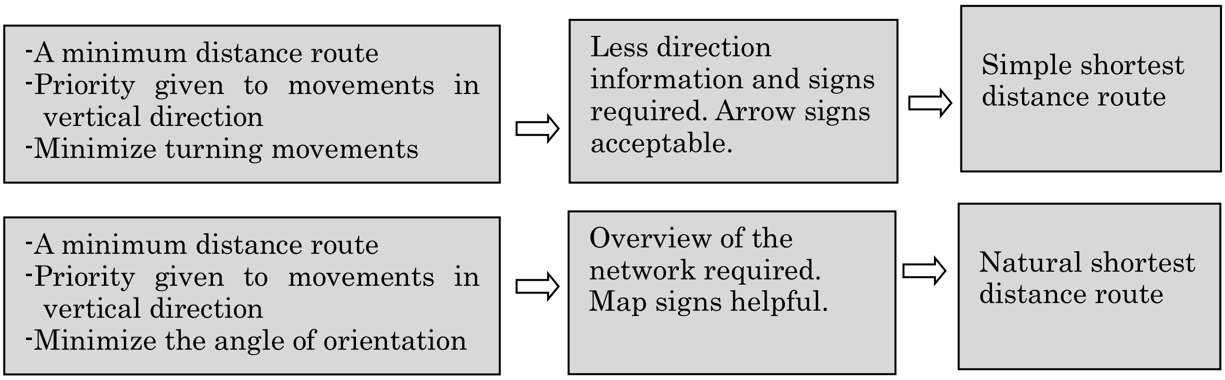


Figure 13. Two shortest distance routes considered

It is interesting to note that the Route 1 in Figure 12a followed by majority of subjects solely by using signs to perform the Trip 3 was the simple shortest distance route computed during the analysis. Similarly, Route 1 in Figure 12b using Trip 1 field data was also the simple shortest distance route. 50% of subjects performing that trip have followed that route to perform the Trip 1. These results indicate that the sign system has some success in providing information effectively to direct them to less complex routes. Also the Trip 1 data route distribution shows that about 1/3 of subjects have been able to develop a reasonable overview of the spatial distribution of the network to be able to behave in a manner similar to regular user of the network. The availability of map signs may have been a contributing factor.

At this stage, an attempt was made to quantify the level of success of the sign system in directing pedestrians to their destinations according to the intended routes of planners. For the example given below, the intended route is assumed to be the simple shortest distance route which should require less direction information and therefore less cost for sign installation. The proposed measure is focused on computing the amount of overlap between the intended route and user selected route. It was decided to perform this calculation using distance measurements of the routes and overlap sections. This measure referred to as compliance rate is given by:

$$\text{Compliance rate} = \frac{\text{Sum of overlap length of recommended route and user selected route}}{\text{Total length of the recommended route}} \quad (1)$$

This measure calculated for all origin and destination pairs covered during the experiment are shown in Table 1. The values spread between 30% and 95%. When there are more alternative shortest distance routes, the compliance rate is relatively low as expected.

Table 1. Compliance rates based on simple shortest distance route

Trip number	Compliance rate (%)	Number of other shortest distance routes
1	50.0	5
2	54.2	4
3	29.2 (South Tower), 83.3 (North Tower)	6 (South Tower), 4 (North Tower)
4	54.2	7
5	62.5	6
6	95.8 (South Tower), 66.7 (North Tower)	1 (South Tower), 3 (North Tower)

One third of signs in this complex were map type signs which provided opportunities for pedestrians to trial alternative routes to reach their destinations. This could have been acceptable to the tower managers as the sign system has exposed their customers to a wide range of retail outlets. Facilitation of window shopping and random walking is a positive outcome contributing to the commercial interests of vendors and tower managers.

In forks where many alternative routes exist, map type signs are often available, and they allow users to select different paths without having to incur much more of the walking distance. In such situations, compliance rates may be lower than in systems mainly supported by relatively more prescriptive arrow type signs.

4.4 Utilization of signs

An indicator of productivity of a sign is how many individuals actually see the particular sign. Some signs are actively noticed by almost everyone whereas others may be rarely noticed. A measurement method is suggested here based on the proportion of pedestrians who see a given sign. Data for this calculation was primarily from the head mounted camera worn by the experiment subjects. Index related to visual perception of the sign displays, using the experimental data.

$$\text{Utilization rate} = \frac{\text{Number of passengers who noticed the particular sign}}{\text{Total number of passengers who passed the sign location}} \quad (2)$$

Utilization rate assists the operator to identify signs that are low in productivity of guiding pedestrians. Minimization of signs with low utilization rates will assist operators to maximize the effectiveness of the sign system investment.

Table 2 shows the utilization rates of most used signs at forks on pedestrian paths covered by experiment subjects. Eleven such locations are listed in the table. These are locations where at least fourteen out of twenty four subjects have seen the particular sign. Signs located near entrances were more likely to be perceived.

Table 2. Examples of signs seen by more than 50% of pedestrian traffic

Trip number	Utilization rate (%)
1	85.7 (entrance of South Tower), 58.3
2	83.3 (restaurant avenue), 95.8 (restaurant avenue)
3	60.0, 91.3 (entrance of North Tower)
4	91.7 (starting point), 52.4
5	58.3, 58.3
6	57.1

Signs located near the entrances of both towers were most observed, because these signs were important for visitors to orient themselves and learn the spatial distribution of potential destinations. Average utilization rate of map boards were 79.5 % and those of arrow signs were 65.6 %. The map boards seem to be more perceived partly because that map boards deliver a broad range of information relevant to a wide range of destinations, particularly suitable for sightseers. On the other hand, arrow signs and name boards were useful for only selected group of pedestrians. Letter size also have an impact as expected, signs with relatively small letters have low utilization rates.

Ability of a sign to guide users to less complex shortest path routes is available from the compliance rate. In this study area, compliance rates were relatively high for map type signs. Low value of compliance rate generally indicates a perception of availability of many suitable routes to the specific destinations. On the other hand, utilization rate indicates whether the sign has been sighted. More productive signs indicated by the utilization measure are located near tower entrances and restaurant alleyways according to the quantitative assessment performed in this study area.

5. LESSONS FROM THE EXPERIMENT

The sign system installed in Grand Front Osaka has been able to orient visitors and efficiently guide them to their destinations. However, in this multistory complex, it is difficult to avoid having to make numerous turns even in shortest distance routes to destinations.

The signage policy within Grand Front Osaka is different from the neighboring transport hub due to differences in tenant attributes and pedestrian flow properties as discussed earlier. The tower complex relies on map signs to a certain degree as it caters for a wide range of potential destinations and different types of users such as customers of shops and restaurants, window-shoppers and sightseers. The transport hub could rely on arrow signs as it is focused on serving quickly moving pedestrian streams that need to be divided to different tributaries.

It has been observed that signs located near entrances of the complex are the most perceived. Most signs in the restaurant avenue were also well perceived. In these areas, map type signs are effective, because visitors need range of information at these locations. In this study area map boards have a higher utilization than arrow signs. However, arrow signs are more efficient in guiding pedestrians to major destinations and landmarks.

User selected routes appear to comply with sign system intentions to guide visitors through a route with minimal complexity. A quantitative analysis method suitable to evaluate the success of sign systems has been presented in section 4.3.

6. CONCLUSIONS

This study has investigated impacts of the sign system on route choice behavior of passengers based on an experiment in a newly developed large shopping and business complex in Osaka, Japan. The shopping and business complex has a sign system which has been classified into three types of signs based on their content for the purpose of this study. The sign system performed adequately and test subjects of this study arrived at nominated destinations without making long detours. The experiment was conducted in a way that subjects were constrained to make their route choices en-route.

It was possible to compare route selections made during the experiment with the minimum distance route that would have been used if complete information was available. Often there is more than one minimum path in tower configuration and two such routes were of particular interest to researchers. This comparison allowed computation of a measure referred to as a compliance rate to reflect the degree of agreement with the shortest path between a given origin and destination.

It has been observed that the proportions of different types of direction signs provided are different in different developments. In particular, a noticeable difference was observed in the composition of signs in the transport hub next to the tower complex. It was possible to derive useful guidelines based on investigation of the differences in composition of signs in the two types of land-use. The methodology presented provides a basis for evaluating the suitability of the existing composition of types of direction signs and development of new signage policies if the current system could be improved. Another quantitative measure developed during this analysis specifically addresses the usefulness of individual sign boards. This allowed the research project to identify the locations where certain types of signs are most effective in the study area.

ACKNOWLEGEMENT

The authors wish to extend appreciation to Mr. Hiroyuki Uematsu, Director of TMO (Town Management Organization) of Grand Front Osaka for his cooperation to the experiments performed by research students of the Ritsumeikan University.

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