#26
RELATIONSHIP BETWEEN VISITORS’ MOVEMENT PATH, STAYING ACTIVITY AND SPATIAL STRUCTURE IN THE LIBRARY AS A “THIRD PLACE”:
Focusing on Yamanashi prefectural library

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ABSTRACT
Public libraries have been changing with the change of lending system. In recent years, many documents have been put into digital form, and then the argument that libraries are unnecessary arose. In response to this controversy, another argument about the meaning of library arose too. Nowadays, the movement that reconsider library as a “Third place.” is also seen. “Third place” means public space coming after home and workplace. In this way, architectural planning of public libraries, particularly in browsing spaces, has been changing to be designed as a place of relief gradually, and new libraries called “stay-type library” have been built recently. Therefore, this study aims to reveal the relations between visitors’ behavior and spatial structure of public library in order to design better library for staying.

This study examines Yamanashi prefectural library. We recorded visitors’ movement paths on maps by tracking visitors and recorded visitors’ distribution by taking movies. We investigate the correlation between visitors’ movement, staying activity and spatial characteristics analyzed by space syntax theory. Space syntax values were calculated by convex analysis, Isovist, and Visibility Graph Analysis (VGA). Through these analyses, four points are revealed:

1. Correlation between visitors’ movement path and spatial indices calculated by space syntax analysis,
2. Seat selection preference between the types of activity,
3. Correlation between the seat occupancy rates divided by the type of activity and values calculated by space syntax analysis,
4. Differences of spatial configuration indices between the types of activity.
1. INTRODUCTION

Matsufuji et al. (2011) and Kitaoka et al. (2011) mentioned that the public library in Japan has been changing with the change of lending system. In Meiji era, Yukichi Fukuzawa wrote “Seiyo jijo” (affair in the Western Countries) and introduced the public library to Japan because there were few places to read books for citizens at that time. Under the influence of this introduction, the first public library was established in Japan. Before the end of WWII, library had closed stack system, so the plan of library is divided by the function, separated to browsing space and closed-stack bookshelves. But after the WWII, transition of the library planning is continuous process of trial and error. Uemura et al. (1999) explained that library system had changed from closed-shelf system to open-shelf system, therefore bookshelf had been closed to browsing space. After the change of system, the distance between people and books was becoming short and they could browse books easily. However, many people — most of them were the students — used the browsing space as a room only for study. So the browsing space was designed small by the people thinking that the situation at that time was not good. Nowadays, information put into digital form and many books are sold as an electric books. Uemura (2013) mentioned that the argument that library is unnecessary arose because of “Libraries and Librarians in an age of electronics”, written by F.W. Lancaster. In response to this controversy, another argument about the meaning of library arose too. Nowadays, the movement that reconsider library as a “Third place” is also seen. “Third place” means public space coming after home and workplace. In this way, architectural planning of public library, particularly in browsing space, have been changing to be designed as a place of relief gradually, and new libraries called “stay-type library” have been built recently. Therefore, this study aims to reveal the relations between visitors’ behavior and spatial structure of public library in order to design better library for staying. It seems that the library planning should be designed as a place to take place many kind of activity spontaneously, not only the usage as a library, — reading books or studying for example — but also as a “Third place” — getting together with friends or taking a rest, talking with the neighborhood — . We expect that a library has a potential to become a facility for making community and making better life.

We review some studies targeted the public library. Capillé et al (2015) study three libraries in Medellin, Colombia. They investigated ‘snapshot’ and ‘trace’ observation and mapped in one figure. They connected the relation among the visitors, staffs and convex spaces considering the visual association and access association. They explained the formation of informal interaction using network analysis. Zook et al (2012) focused on two type of architectural tasks, and investigated Seattle central public library from two direction, social staging and phenomenal staging. In social staging, they collected visitors’ walking routes, those that is different from some types of usage, then they analysis where the visitors walk through using space syntax analysis. In phenomenal staging, they examined what the visitors feel while walking through the library by describing the sequence of phenomena encountered by the visitors. Both of two study tried to propose the new analytic method and it serves as a reference on how we should research public facility.

2. INVESTIGATION AND SPACE SYNTAX ANALYSIS

2.1. YAMANASHI PREFECTURAL LIBRARY

This study targeted the Yamanashi Prefectural Library situated near Kofu station in Yamanashi. This library was built in 2012, designed by Kume Sekkei and Miyake Architects and Associates as a joint venture. This library is a complex facility with hall, exhibition space and many small discussion rooms. Figure 1 shows the plans of Yamanashi prefectural library. On the first floor, there are two entrances, café, exhibition room, and discussion rooms, library section (magazine, children, PC area, and counters). A lot of tables are arranged along the path connecting the two entrances like a sidewalk café. Main bookshelves section is on the second floor, and many type of browsing spaces are in various places in the plan. On the third floor, there is a room for study placed like a bridge. Library office put onto the east side of the building so as to plan a large
library section in the center of the building. Moreover, this facility has a big open ceiling space and it is connecting the different rooms visually. Moreover, this library has no border between the other sections so that visitors can walk through the building with no barrier and visitors can read books anywhere and study anywhere. Designer who planed this library describes it as “Food court of knowledge.” In this library, we can see many kind of activity. After the complete in 2012, the number of visitors increase obviously, this library is in second place in the number of visitors ranking in Japan two years in a row. This showed that many people living around recognized this library as a “Third place.”
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2.2. INVESTIGATION

We investigated the visitors’ activity in order to figure out the feature of it in Yamanashi prefectural library. We investigated the visitors’ movement path and the distribution of activity. The investigation was conducted by 6 surveyors from 11:00 to 15:00 on weekday in July of 2015. 5 surveyors investigated the visitors’ movement path, and 1 surveyor investigated the distribution of activity.

Visitors’ movement path

3 surveyors were located south entrance, 2 surveyors were located north entrance. They tracked visitors until visitor sat on a chair or stopped to read a book. Then they recorded the movement path to the map. We collected 195 movement paths in this library. Figure 3 shows the results of all paths on the plan. The atrium connected two entrances is well used by the visitors therefore this atrium is relatively restless. Moreover, we observed a lot of flows of people that pass through the magazine space, go up using the central staircase and spread in all direction of second floor. Then on the edge of second floor and third floor, we were able to observe few Movement path.

Distribution of activity

At the same time, we shot the video all over the building every 30 minutes and recorded the distribution of visitors’ activity on the map. Of course some people walked around so pedestrian distribution in the library were counted by snapshot method. Distribution was counted five times in this investigation. We collected 1301 visitors’ activity in this library. Figure 4 shows the result of distribution of activity on the plan. The visitors studying with friends or reading books casually were observed along the circulation space, particularly in the first floor atrium. The visitors studying alone or concentrating on reading were observed on the area that is far from the entrance, especially on the second floor.

Figure 3 - Visitors’ movement paths.
2.3. SPATIAL CONFIGURATION ANALYSIS BASED ON SPACE SYNTAX THEORY

We analysed the special configuration of Yamanashi prefectural library using Space Syntax Theory. In this study, we used convex analysis and calculated Isovist using depthmap (Turner, 2004), which is a software for special analysis based on space syntax. Firstly we made the plan of each floor about Yamanashi Prefectural Library using CAD software. And we use it on each analysis.

Convex analysis

We divided the space of this library into 168 polygons on the basis of psychological cost. Figure 5 shows the plan divided by convex space. Considering how they feel when they walk in the library and what they feel as a boundary of space, we divided the space by the pillar, corner, direction of bookshelf etc. Then we connected these convex space if we can access. In this analysis, we used a new program “New Convex” considering the area. So we put the convex map to this “New Convex", and analysed it.

In this study, we calculated three indices: Depth, Connectivity, global Integration value. Depth means how far the space is from the entrance, how deep the space is for the people entering from the entrance. Connectivity means the accessibility of space. The larger this value is, the more spaces the space is connected. In this study, to consider the difference of convex space area, we calculated the weighting connectivity based on the smallest convex space as minimum size. Then we calculated global integration value using connectivity considering the area. Global integration value means the centrality of space. When this value is large, it means that we can reach at all of spaces more efficiently. Figure 6, 7 and 8 are the result of Depth, Connectivity and Global integration value respectively. The larger each index is, the redder colour is and the smaller each index is, the bluer colour is.
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Figure 5 - The plan divided by convex space

Figure 6 - A result of Depth.
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Figure 7 - A result of Connectivity.

Figure 8 - A result of global integration value
Isovist calculated by depthmap

Firstly, we put the plan of each floor into depthmap, then calculated the isovist of each seat in the library. We calculated four kinds of isovist. Figure 9 expresses the method of calculation about isovist.

360° isovist was set 360° and calculated as "Viewed Range." “Viewed Range” means how large they are seen from around the seat they sit on. When we calculated, we used the plan whose furniture that obstructed the view when we sit on the seat are drawn as walls not to calculate the area over them. In addition, we did not calculate the void area as "Viewed Range" because we cannot view the seat from the void.

The other three isovist were set 180°, 120° and 90° on each isovist based on the seat direction, and calculated as “View Range.” “View Range” means how large they saw from the seat they sit on. In the same way as 360° isovist, we used the plan whose furniture were drawn as walls. And we interpreted the void area as "View Range" because we can see the void from the seat. These isovist indices were used later analysis.

Figure 9 - Calculation method of isovist.

3. RELATIONSHIP BETWEEN VISITORS’ ACTIVITY AND SPATIAL CONFIGURATION

3.1. RELATION BETWEEN VISITORS’ MOVEMENT PATHS AND SPACE SYNTAX INDICES

To reveal the relationship between the flow of people and space syntax indices, we analysed the correlation between visitors’ movement path and special configuration. First, we calculated the number of Movement path that passed through each convex space. Then we divided the number of Movement path by the area of each convex space. This index is named Movement path per unit area and means how many people pass through this convex space. By using this index, we can grasp the flow of people and how restless space that is. Figure 10 shows that the result of calculation of Movement path per unit area. The redder colour is, the larger the index is. The place whose index value is high concentrates on the first floor, especially the spaces around the entrance and near the central staircase have high value. Moreover, the values of vertical path are high. Table 1 shows the correlation coefficient. Movement path per unit area is associated with Depth and Global integration value. We use this index in later analysis.
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### 3.2. Seat Selection Preference

In the investigation, we found out that there are some deviation of visitors' distribution. In this section, we examined the seat selection preference to reveal where was used for the visitors who read a book alone, study with groups etc. First, we classified the visitors’ activity by result of observation as Table 2.

#### Table 2 - Classification of visitors’ activity

<table>
<thead>
<tr>
<th>Activity</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temporary</td>
<td>Reading a book casually, Talking, Studying with friends,</td>
</tr>
<tr>
<td>Quiet</td>
<td>Studying alone, Reading a book alone,</td>
</tr>
<tr>
<td>Vacancy</td>
<td>No one sitting on</td>
</tr>
</tbody>
</table>

After that, we made a cross tabulation and performed Chi-square test and Residual analysis to reveal what the place was used for. Figure 9 shows the result of seat selection analysis. Red space means that we observed temporary activities significantly more than the other spaces. Blue space means that we observed Quiet activities significantly more than the others.

Red spaces concentrates on the first floor, especially along the atrium. Furthermore, there are red spaces around Magazine area. On the second floor, we can observed red spaces near
the atrium, and around the vertical path. There are blue spaces in the place surrounded by the bookshelf. In these space, a lot of tables with partition or carrel are located. Therefore, it seems that visitors who perform the Quiet activity selected the seat where they do not feel someone looking at them. The third floor have studying room only thus there are only blue spaces.

Figure 11 - A result of seat selection preference.

3.3. RELATIONS BETWEEN SEAT OCCUPANCY AND SPACE SYNTAX INDICES

The previous section we focused on the seat selection preference to grasp the deviation of visitors’ distribution. In this section, to reveal the relationship between spatial configuration indices and seat occupancies of visitors in each browsing space, we performed the correlative analysis. However, there was no correlation between any space syntax indices and seat occupancy. Therefore, we used the previous classification, “Temporary”, “Quiet” and “Vacancy”, and then we calculated the seat occupancy on each activity. We calculated the seat occupancy of each category and make a correlative analysis between the occupancy and spatial configurations. Table 3 shows the result of analysis. It should be noted that we investigated visitors' distribution five times so we calculated the average of seat occupancy.

In Temporary activity, it indicates a significant negative correlation between seat occupancy and Depth. It shows that Temporary activity occupancy is high in the place where it is near the entrance. In Quiet activity, it indicates significant negative correlations between seat occupancy and Global integration value or Movement path per unit area. It shows that the place where it has high Quiet activity occupancy have low centrality of space and few people walking though. Therefore visitors reading books calmly or concentrating on studying are observed in the place that it is far from the central space or the place that is tranquil. In addition, Quiet seat occupancy is strongly associated with Depth. In Vacancy, there is no significant correlation.
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Table 3 - Correlation analysis between seat occupancy rate and special configuration.

<table>
<thead>
<tr>
<th></th>
<th>Temporary</th>
<th>Quiet</th>
<th>Vacancy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Depth</td>
<td>-.420**</td>
<td>.566**</td>
<td>-.051</td>
</tr>
<tr>
<td>Connectivity</td>
<td>.002</td>
<td>-.164</td>
<td>.196</td>
</tr>
<tr>
<td>Global integration value</td>
<td>.223</td>
<td>-.452**</td>
<td>.123</td>
</tr>
<tr>
<td>Movement path per unit area</td>
<td>211</td>
<td>-.421**</td>
<td>.067</td>
</tr>
</tbody>
</table>

**: statistically significant at the 0.05 probability level (p<0.05)
**: statistically significant at the 0.01 probability level (p<0.01)

Figure 12 - scatter plot of Seat occupancy vs Depth

Figure 13 - scatter plot of Seat occupancy vs Connectivity
3.4. SPATIAL CONFIGURATION DIFFERENCES AMONG ACTIVITIES

In this section, to reveal the influence of spatial configuration against the seat selection, we examined whether or not they have significant differences among activities. At first, we organized the spatial configuration as Table 5.

<table>
<thead>
<tr>
<th>index</th>
<th>Spatial characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>360°Isovist</td>
<td>“Viewed Range”, how much the seat is viewed</td>
</tr>
<tr>
<td>180°Isovist</td>
<td>“View Range”, how large they view from the seat</td>
</tr>
<tr>
<td>120°Isovist</td>
<td></td>
</tr>
<tr>
<td>90°Isovist</td>
<td></td>
</tr>
<tr>
<td>Depth</td>
<td>Depth from outside</td>
</tr>
<tr>
<td>Connectivity</td>
<td>The accessibility of space</td>
</tr>
<tr>
<td>Global integration value</td>
<td>The centrality of space</td>
</tr>
<tr>
<td>Movement path per unit area</td>
<td>How many people pass through the convex spaces</td>
</tr>
</tbody>
</table>

Table 5 - spatial configuration indices.
Then we used Kruskal-Wallis H test to compare three categories, Temporary, Quiet and Vacancy. Figure 8 expresses the differences of spatial configuration as box-and-whisker plot.

Figure 8 shows the significant differences between three categories in ‘Viewed Range’ and ‘View Range’. The largest is Temporary, followed in order by Vacancy and Quiet. It indicates that visitors doing Temporary activity tend to sit on the seat from which they can see the wide view. Depth in Figure 8 shows that it has differences among categories, it followed by Quiet, Vacancy and Temporary in descending order. It seems that visitors doing Quiet activity have a tendency to choose the seat which is in the place far from the entrance. On the other hand, Connectivity shows the significant difference between Temporary and Quiet or Vacancy. However, it does not have a significant difference between Quiet and Vacancy. Global integration value and Movement path per unit area in Figure 8 show the significant differences among three categories, the largest is Temporary, followed by Vacancy and Quiet in descending order. It indicates that the visitors doing Temporary activity tend to select the seat in the place where is accessed efficiently and used as circulation space.

Figure 16 - Box-and-whisker plot about spatial configuration in each activity
4. CONCLUSIONS

This study analysed the relationship between the visitors’ activity and special configuration in public library. Consequently, we obtained some tendencies about the visitors’ activity. First, we revealed that there are deviations of visitors’ distribution in each activity. Moreover, we found out some correlations between visitors’ distribution and spatial configuration. This result shows that “Quiet” activity occupancy is high in the place that it is far from the entrance. Second, we focused on each seat to reveal the tendency of seat selection. We examined whether or not they have significant differences among the type of activity using Kruskal-Wallis test. As a result, we obtained that they have differences among three categories in “Viewed Range” and “View Range”, the largest is “Temporary”, followed by “Vacancy” and “Quiet” in descending order. Moreover, visitors doing “Temporary” activity tend to select the seat whose global integration value and Movement path per unit area are high. On the other hand, visitors doing “Quiet” activity tend to sit on the seat which is the high value of Depth. They indicate that library has to be design the facility including various characteristic space in order to accept various activity. Future study is to make the equation to estimate the selection probability to reveal how and what purpose the seat is used. For the future study, we have to collect the other indices such as attribution of visitors or indoor condition. This analysis is able to be utilized for future facilities planning such as the library that people visit as “Third place”.
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