Analysis of Space Syntax Characteristics in Roads around Temporary Relief Area: Case Study of Sewol Disaster

Ji-Soo Lee, Won-Hwa Hong, and Gwi-Og Jeong

***Abstract*—**Sinking of ferry Sewol on Apr. 16, 2014 caused 294 deaths and 11 missing as of now (Jul. 6). Area around Port Paengmok close to the site of ferry disaster is being used as base for relief and rescue activities. Relief facilities in Port Paengmok are mostly makeshift facilities with hardly any planning and generated roads randomly created around relief and rescue facilities are confusingly mixed up with existing roads that were there even before the ferry accident for vehicle traffic. This study identified numerical characteristics of these roads from space syntax perspective and analyzed their relations with existing facilities. Specifically, the study computerized and analyzed road system and facilities inside relief zone through site survey and space syntax analysis model. The separation of existing roads and makeshift roads for study purpose based on integration and intelligibility revealed a clear characteristic difference between makeshift roads and existing roads.

***Keywords*—**Integration, Intelligibility, Relief space, Space syntax

I. Introduction

SEWOL ferry sank due to steep veering at approximately 9 am on Apr. 16, 2014 causing a panicking 294 deaths and 11 missing as of today (Jul. 6). Location of this horrendous manmade disaster challenges rescue and therefore causing search to take longer. Facilities to support rescue of missing passengers on shore and relief activities are arranged at approximately 26km off the site of disaster. Being a devastating disaster, not only the government but also parties and organizations in the private sector joined in to give their helping hands. It is natural to imagine that the whole nation literally jumps in for rescue and relief activities.

But, the urgency of recovery and the temporary usage keep planning of internal space in which relief activities take place far from satisfactory. In other words, absolutely no thought was given into planning for arranging facilities as in urban planning or complex planning and virtually zero analysis into flow plan.

Many relief facilities were built in Port Paengmok after the ferry disaster but other than a living space for families and the room for corpse identification most of the facilities were randomly arranged with no planning.

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Moreover, these makeshift facilities cut off an existing road used for traffic and created a makeshift road.

As a consequence, space structure is getting more complex and messed up but nothing is being done in terms of giving guidelines to arrange makeshift relief facilities in an organized manner. Purpose of this study, accordingly, is to investigate road system and analyze it from space syntax perspective to figure out their characteristics.

II. Concept And Indicators Of Space Syntax Methodology

Space syntax is a theory suggested by Hillier and others at Barlett School of Architecture in the UK[1]. It is largely defined by using relative depth of each space to calculate hierarchy inherent in each space such as their socio-cultural functions and significance in a quantitative perspective[2].

Space syntax has been mainly used in studies to understand the formation of city spaces from their origin to the present [3]-[7]. It has been applied as an interpretive tool to analyse underground spaces[9],[10], the interiors of multi-purpose structures[11]-[13], and even an online game[14]-[16].

This indicates space syntax methodology as a meaningful tool to numerically identify hierarchy of space crammed by relief facilities playing different functions and characteristics of roads. Integration, connection, control, local integration and intelligibility are general indicators used for space syntax analysis. This study mainly relied on integration and intelligibility, which are indicators in the highest-level stage, for analysis.

A. Global Integration & Local Integration

A high integration for a specific space means that it is highly accessible from all other spaces. Integration is classified into global integration – the calculation of the entire space in concern – and local integration – the calculation of a limited space depth from a headed space. In general, local integration calculates up to three depths[17].

$$I_i = \frac{1}{RRA} = \frac{Dv_n}{\frac{2}{n-2}\left(\frac{\sum_{k\in U} D_{ik}}{n-1} - 1\right)} \tag{1}$$

Where,

$$Dv_n = \frac{2(\mathrm{n}(\log_2(n+2) - \log_2 3 - 1) + 1)}{(\mathrm{n}-1)(\mathrm{n}-2)}$$

U : Universal set of nodes
N=n(U)

B. Intelligibility

Intelligibility is the mutual correlation between the local characteristic of a space (local integration) and the overall characteristic of a space (global integration). A high correlation coefficient between two factors means that the space structure is intelligible, and a low correlation coefficient means that the space structure is not intelligible.

In general, intelligibility is defined as high when the dots denoting spaces are densely formed and either local integration is high or the regression line of the correlation between connectivity and integration is greater than or equal to 45°[18].

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III. Axis Data Production via Site Survey

Site survey was performed from May 6 to May 8 during when the number of relief groups in Port Paengmok peaked and 193 facilities lined up along the roads. Fig. 1 shows activities of relief facilities in Port Paengmok during the period.

Fig. 1 View of Port Paengmok

The 193 relief facilities along the roads can be divided into nine types as shown in Table 1 below based on their roles and functions.

TABLE I
CLASSIFICATION AND THE NUMBER OF RELIEF FACILITIES BY THEIR TYPES

Classifications of types	Contents	Number of facilities
Convenience service facilities	Kitchen, Relief goods, Courier service, Cell phone battery recharging service, Financial services, etc.	55
Media Organization facilities	Media press tent	11
Situation coping facilities	Countermeasure headquarter, Local situation room, Related organization support center, Police, Army headquarter, etc.	21
Religious facilities	Prayer room, Buddhist sanctuary, Temporary chapel, etc.	9
Other service support facilities	Temporary toilet, Temporary waiting room, Emergency power supply device, Parking lots, Garbage disposal facilities, etc.	6
Medical service facilities	Doc-in-a-box, Psychology consultation center, Temporary pharmacy, Physical therapy center, etc.	16
Rescue group and Equipment storage facilities	Volunteer diver reception booth, Rescue and command post, Warehouse for rescue equipment	10
Makeshift accommodation for family members of missing passengers	Service area for families of missing people, Waiting booth for families of victims, Countermeasure center for Families of victims, Temporary barbershop, Massage service booth, shower room.	36
Accident settlement facilities	Identification tent, Mortuary, DNA collection tent, National forensic service headquarters, etc.	29
Total		193

Before making axial map for space syntax analysis, roads were divided into new ones temporarily created after relief facilities were built around the area and existing ones.

Existing roads are all paved ones with a certain width to support traffic. By contrast, most of new ones are unpaved and are primarily used for access to internal space. Facilities layout and road type were all computerized as shown in Fig. 2 through a site survey, and used as basic data for axis analysis.

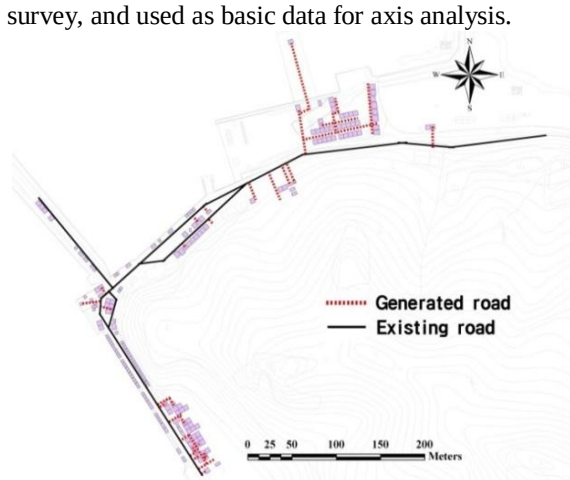

Fig. 2 Classification of road types

Basic elements of space use behavior, which serves as the basis for space theory in the process of developing axis data in

Fig. 2, can be defined as visibility and accessibility[19].

Accessibility can be gauged by the degree of contact between route and relief facilities. The entire line leading up to the point where road curve makes it invisible was split into axis. This produced 48 axes for analysis out of which 12 are existing roads and 36 are generated ones.

IV. Analysis Of Space Syntax Characteristics In Roads Around Relief Area

Results of indicators for space syntax analysis model in this study were analyzed via global integration, local integration and intelligibility. Local integration calculated depth up to the third stage, which is most commonly used, and S3 axial analyzer developed by Seoul National University was used for axis analysis. The study developed axis based on digital map by using auto cad, of which data can be exchanged with S3 axial analyzer, and converted it into S3 axial analyzer for analysis.

Fig. 3, 4 are schematization of global integration and local integration values gained from applying Arc GIS. Fig. 5, 6 point to intelligibility gained from regression equation of global integration value and local integration value.

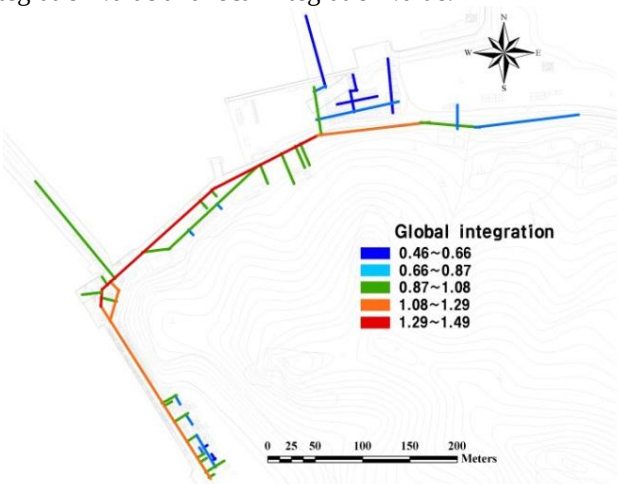

Fig. 3 Analysis result of Global integration

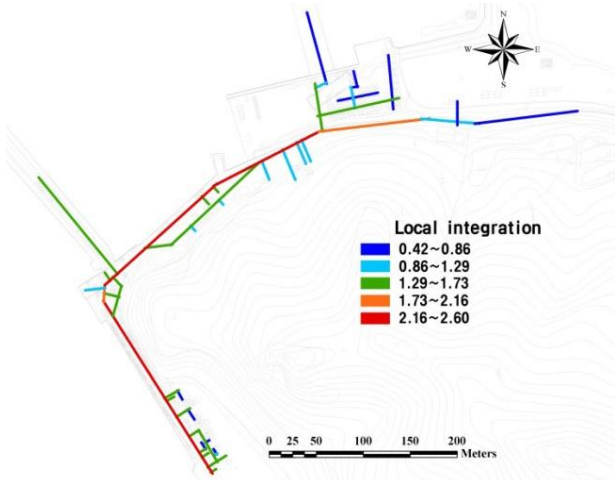

Fig. 4 Analysis result of Local integration

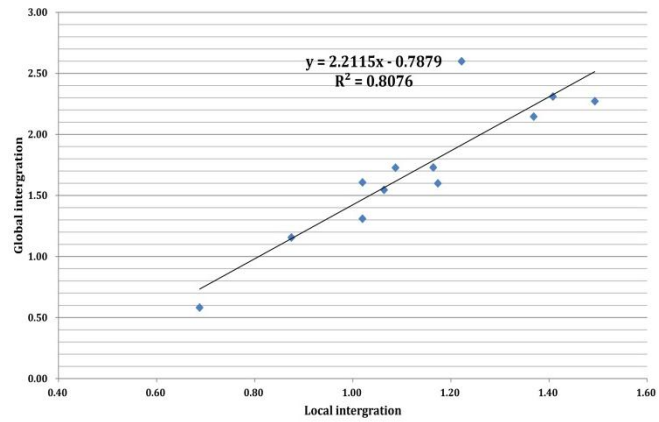

Fig. 5 Graph of existing road intelligibility

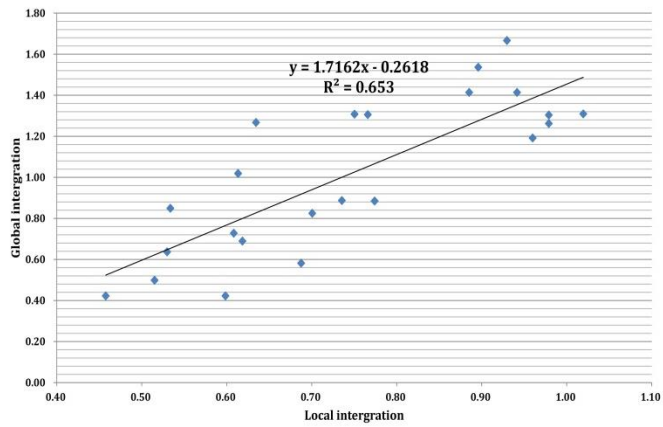

Fig. 6 Graph of generated road intelligibility

Analysis in Table Ⅱ confirms that both global and local integration values are high in existing roads. In particular, they are above average in existing roads but below average in generated roads, which signals a clear distinction in their characteristics.

Table Ⅱ
Analysis result of Space syntax indicator by Road type

Classification of indicators		Existing road	Generated road	Total(avg.)
Global integration	min	0.6876	0.4577	-
	max	1.4932	1.0195	
	mean	1.1317	0.7988	0.8820
Local integration	min	0.5817	0.4224	-
	max	2.5989	1.6667	
	mean	1.7150	1.1091	1.261
Intelligibiility		0.8076	0.6530	0.7939

Put in other words, existing roads are highly recognizable thanks to good accessibility and high intelligibility. By contrast, generated roads are separated from existing ones and have poor local accessibility. Low intelligibility of generated roads make

them an appropriate site for facilities that restrict visitors and guarantee privacy.

Integration value was the lowest in area around facilities for families and temporary morgue. These facilities are detached to a less visible and quiet area, and are close to a generated road for access.

V. Conclusions

This study findings show that existing roads have high integration and intelligibility, thus are fit for facilities to provide convenience, support and to update rescue situation to families and others. Generated roads, on the other hand, are detached from other areas since they're strongly intended for access to certain facilities. Integration and intelligibility analyzed in this study offer quite meaningful values in gauging relative recognition and accessibility in a same space. It is a particularly suitable tool in differentiating restricted areas and non-restricted ones. The study findings also make a clear difference between the two and are expected to play a big role in preventing any confusion associated with activities in relief zones.

Application of this study methodology to layout planning of relief facilities in the future will not only offer their compatibility in terms of efficiency but also will be used as an effective tool to make decisions on flow plan.

Acknowledgment

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