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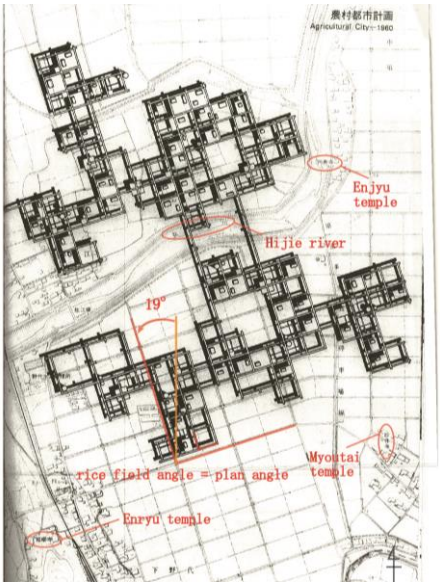
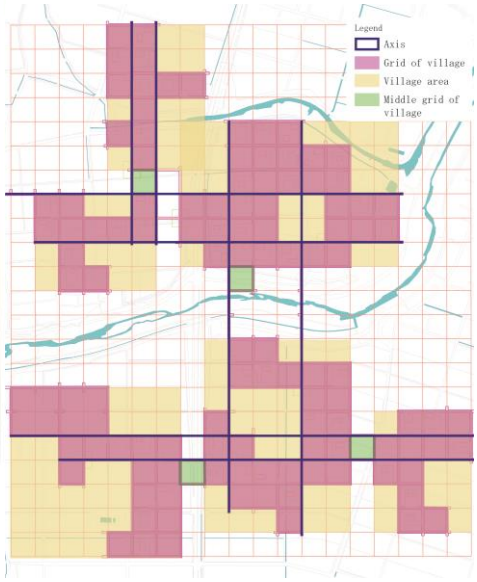
Analysis of Algorithmic Design Process – Case Study of Agricultural City Project by Kisho Kurokawa-

Introduction

When multiple architects work on a large-scale project, it is useful to build common rules or system, upon which the entire scheme can be based. The computer-aided design is able to build such an algorithmic system, which is reproducible by anybody. At the same time, however, the character and/or attraction of architecture maybe created by the indeterminate factors, which are often subjective interventions by humans. This research aims to clarify the balance between the determinate and indeterminate factors in architectural design by using the program, Grasshopper, to verify the design process of the Agricultural City Project by Kisho Kurokawa (1934-2007) as a case study (see Fig. 1).

Fig. 1. Original plan of Agricultural City Project ; Fig. 2. The Analysis of the plan





source: Kisho Kurokawa's World, 1975 *Source: Author*

The Selection of the Subject

Kurokawa's Agricultural City Project, first presented in the Metabolist booklet in 1960 issued for the World Design Conference held in Tokyo, is an unrealized, visionary project, which proposed the agricultural settlements on the

expandable and gridded street network and artificial ground, raised four-meter above the ground to avoid a damage from the flood of the river. It was designed as a reaction to Kurokawa's own experience of Ise-bay Typhoon and its damages on the actual agricultural settlements. The project received the international attentions upon the presentation at the World Deign Conference, which lead it to be exhibited at "Visionary Architecture" exhibition at the Museum of Modern Arts, New York.

Although the computer was not used for the design, due to the influence from his teacher, Kenzo Tange (1913-2005), Kurokawa was keenly interested in design process based on the algorithmic system. The key concept of the Metabolism, the responsiveness to the environment and reproducibility in the cities of growing population, suited well with the algorithmic design. Kurokawa, on the other hand, has a strong personal design sense, which is also apparent in this project. Thus, the Agricultural City project is an appropriate example, studying the balance between the determinate and indeterminate factors in architectural design.

The Procedure of the Research

First, the drawings of the project were reproduced based on the original documents. After careful reading of Kurokawa's texts on the Agricultural City Project and other relating projects and scrutinization of the plan, several hypotheses were made on his logical design rules. Those hypotheses were verified by writing the computer program according to the rules using Grasshopper. The parts which are not reproducible by the computer program can be differentiated as the indeterminate factors which may depend on Kurokawa's subjective sense.

The Analysis of the Project

The Agricultural City Project has two versions: 1. a single cluster and 2. the version which several clusters were planned onto the actual site. The single cluster consists of 5 by 5 grid, of which each square measures 100-meter by 100-meter. The artificial raised ground was made in each square, on which 20 houses were planned to be built. An average size of the existing community, approximately 340 households of 1700 people were intended to live, and the public buildings, such as Shito shrines, schools, and community centers were also designed to be built on the artificial ground. The grid acts as the streets as well as the supply lines of water and electricity. This grid of 500-meter square constituted a cluster of a community.

The second version was planned over the river in the actual site. It was designed based on the algorithmic system for the future expansion, so that close analyses were made on this version. Unlike the single cluster type, the edges of the grid in this version stretch to all directions and the formation of each cluster is not clean square. The projections from the grid reflect the metabolists' thought

Table 1. The types and number of the validation of projections *; Source : Author*

direction of the parts projected \ types of the parts projected	0. 10m	1. 15m	2. 20m	3. 25m	4. 30m	5. 35m	Total	
1. +X	0	9	8	1	0	0	18	= 33
2. -X	0	6	5	3	0	1	15	
3. +Y	0	8	9	0	1	0	18	= 40
4. -Y	2	15	5	0	0	0	22	
Total	2	38	27	4	1	1	73	

+X,-X	whole number of peripherial intersecting point : 51 locations	+X 35%, -X 29%, ±X 32%
+Y,-Y	whole number of peripherial intersecting point : 48 locations	+Y 38%, -Y 46%, ±Y 42%

of growth, and the variation of projections range from 10m to 35m as shown in Table 1.

The types of artificial ground, the edge condition of the grid, and were analysed to find the common rules.

In the written description of the project, the site was set in as Ama county Kanie town, Aichi prefecture, which was Kurokawa's hometown, but the actual site was found in Kuwana city Tado town in Mie prefecture, which was located in 20 kilometres west from the original location by matching the form of the river and location of three temples on the drawing to the current map. Also, the single cluster was configured to be 100-meter by 100-meter, but in order to superimpose the plan onto the actual site, the scale of the plan had to be reduced to 60% of the original. By doing so, grid fitted to the angle of the rice field, and the artificial ground was placed to avoid overlapping in with river.

Artificial grounds were formed on the grid, and there are 6 types as shown in Table 2: a.100-meter×100-meter, b.75-meter×75-metera, c.25-meter×25-meter, d.50-meter×75-meter, and e.100-meter×25-meter to be a type of ground exist inside the grid, and f.75-meter×75-meter is existed on the intersection point of the grid.

In the analysis of overall framework four sets of double axes were, alternatively extending to the north-south and east-west directions. The clusters were formed as a prototype of single cluster type, on the double axes, but adjusted to different conditions of the actual site and avoiding interference from the other clusters. The grid area cover 60% of the village area, and there are

Table 2. The types and number of the grid grounds ; *Source: Author*

	5 types of inside the grid land					Grid intersected land
Type	a. 100 / 100	b. 75 / 75	c. 25 / 25	d. 50 / 75	e. 25 / 100	f. 75 / 75
Number	12	28	15	14	1	5

The detailed classification and the number of b, c, d

b.		12		5		3		8
c.		2		2		7		5
d.		4		4		1		5

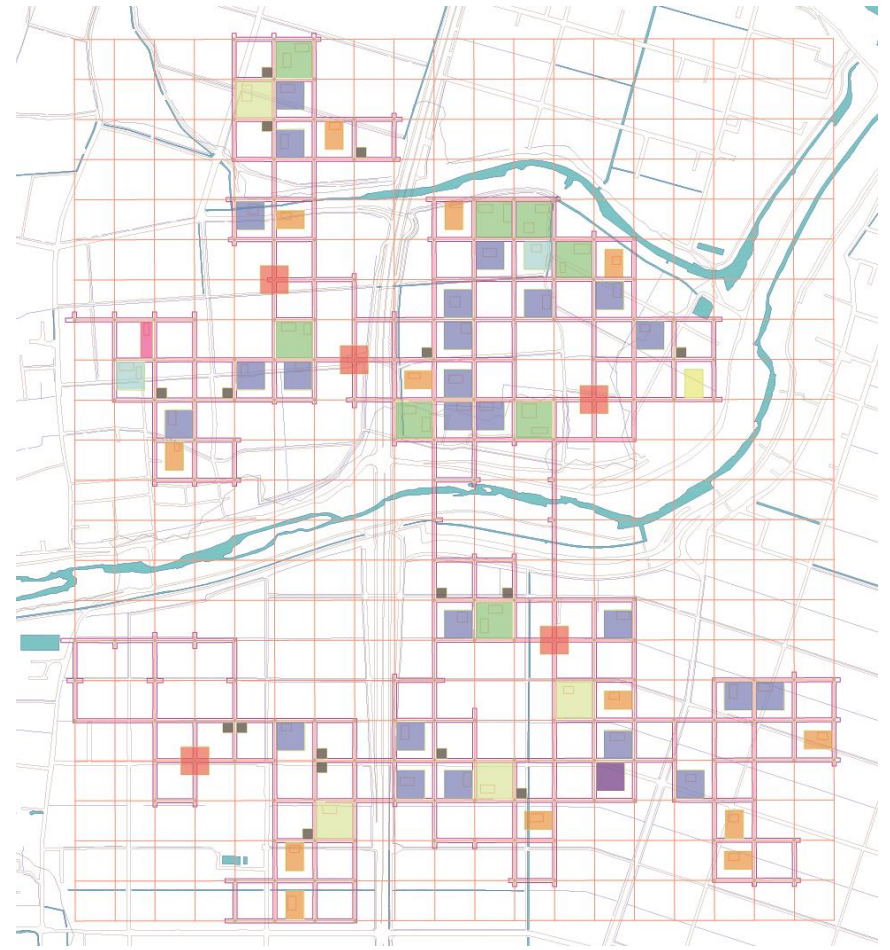


Fig. 3. The verification of the plan ; *Source: Author*

more than 1 square grid between different villages to differentiate them from each other. The hypotheses were made that the expansion of the grid and the formation of cluster were the determinate factors, while the number, type and location of the artificial ground showed that they were indeterminate factors.

Verification of the Analysis

The hypothesis of the design process based on the analysis above was verified by writing an algorithmic program to replicate the project using Grasshopper (see Fig. 4). The parts of procedure, which the project can be reproduced using the same component in Grasshopper suggest the algorithmic system. The formation of double axes and shift of central points could be reproduced in such a procedure. Also, the clusters are formed according to the different conditions of the surroundings, such as river and mound, and the distance between each other, which seem to have certain rules.

The artificial ground have several but the same types of the ground are never placed next to each other. Thus, the program to form the artificial ground was written according to the following process.

The artificial ground types were placed in order of their sizes starting from the largest type. To avoid placing in the same location, “Dispatch” command is used, at every term of setting a new type of artificial ground. The appearance of grounds b.c.d. depend on the orientation, so these 3 types were divided into four sub-types orienting to four directions, and placed in random order(see Table 2). Only f. has the center point at the intersection point of grid, so there are possibilites to be placed over the other grounds. This time a version of seed=5 was selected which has no overlap of artificial grounds (see Fig. 5, 7).

The locations of the center points of the community as well as types of artificial lands, however, could not be replicated without typing in certain numbers, which suggest that they are based on the indeterminate factors. These indeterminate factors allowed the architect to give more spontaneous and expandable appearance to the project, as well as give a room for the residents and community to have their input if the project had had been realized.

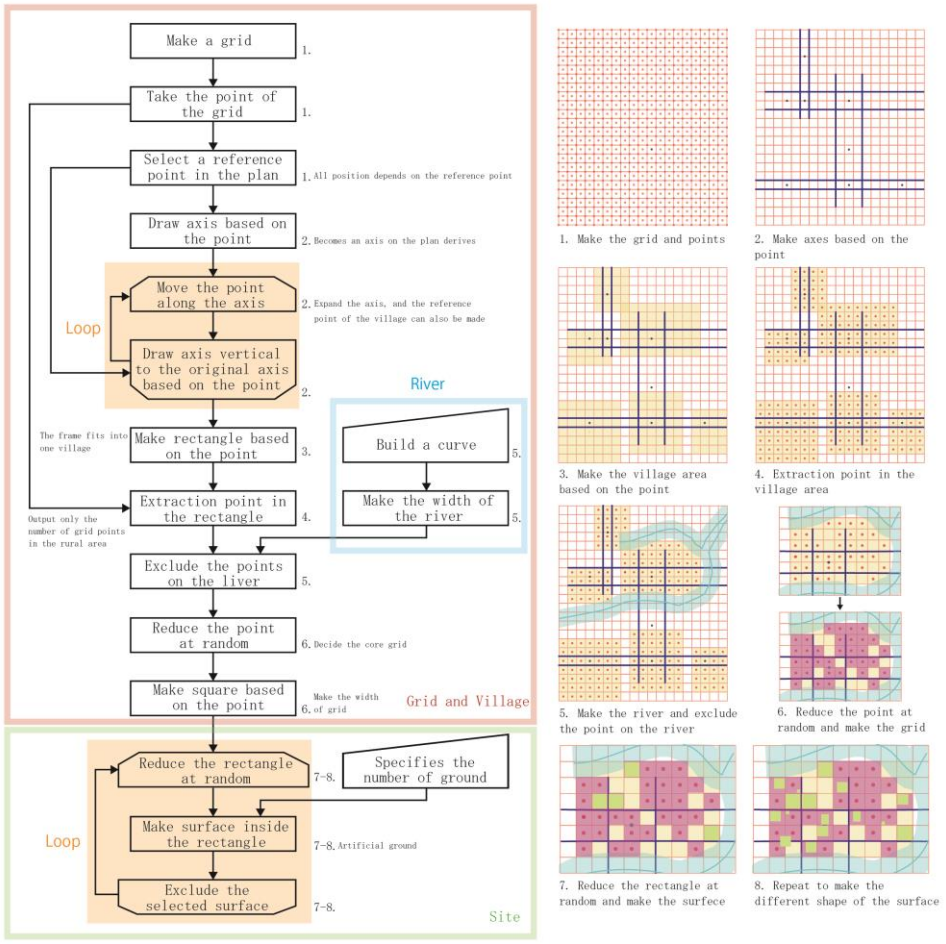


Fig. 4. The program of analyzing the plan *; Source: Author*

The procedure of making artificial grounds.

Separate the grid rectangle to 16 equal parts. Then number the split points from 1 to 16. From the numbered points, take a list of points out that through vertex of the ground to create. Make a surface using the 4 vertices. All the ground made by those 16 equal parts, so it is possible to make all the ground by using the same way. Only the ground f. has the center point at the intersection point of the grid, it should move (50m,50m) after making the surface (see Fig. 6, 7).

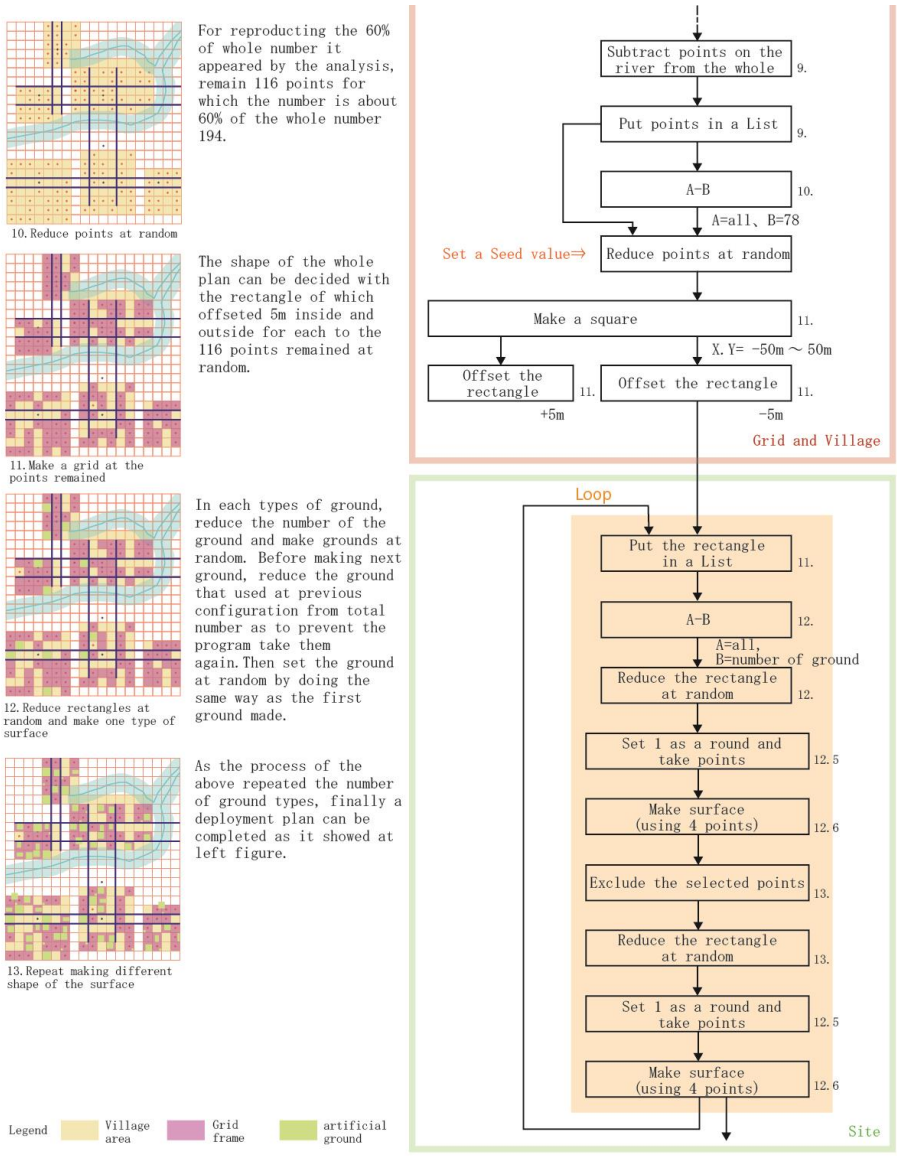


Fig. 5. The detailed program of making the grid grounds *; Source: Author*

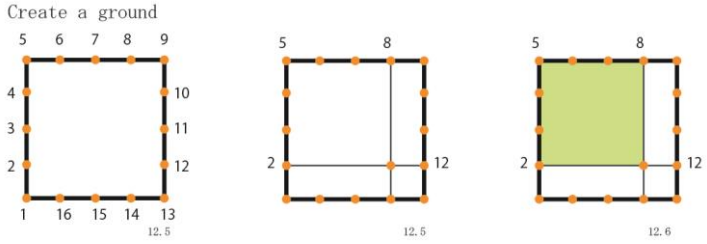


Fig. 6. The explanation of separating the grid rectangle and making the grid grounds *; Source :Author*

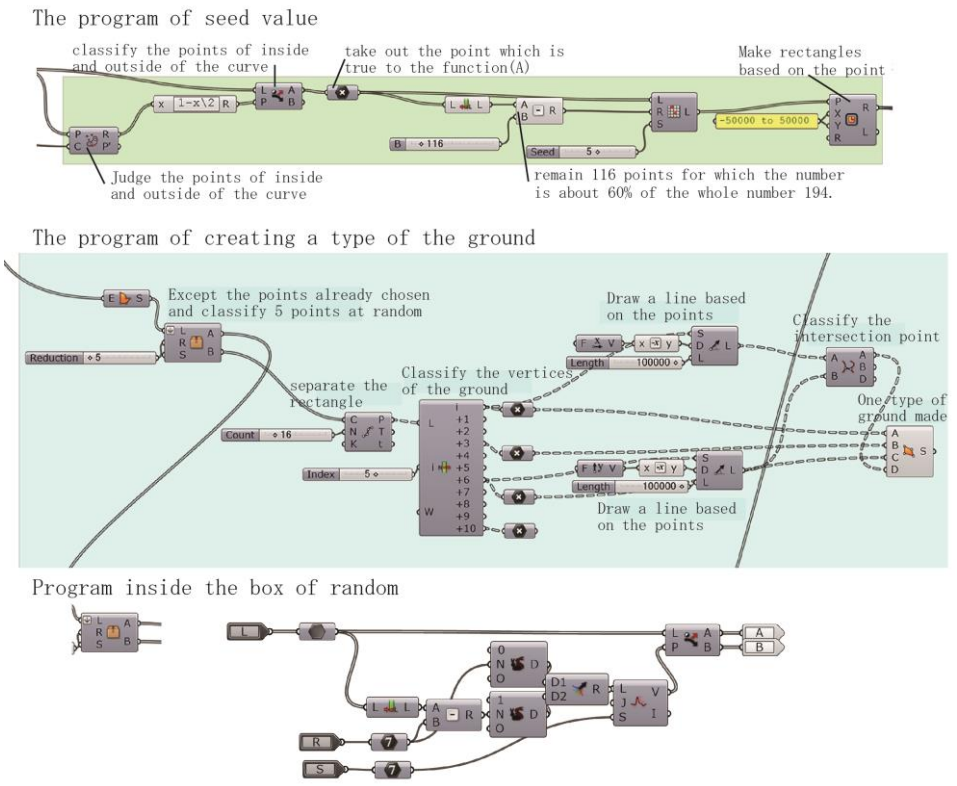


Fig. 7. The grasshopper program of the plan *; Source: Author*

Conclusion

The algorithmic program could recreate certain parts of the Agricultural City Project, but the other parts were not reproducible by the program. The results differentiated the determinate factors (double axes, clusters) from the indeterminate factors (location of grid, type and number of the artificial ground). It can be speculated that the determinate system is more apparent in the elements which relate to the fundamental design concept or the prototype, while more superficial form-related design, which may depend on the personal and subjective decision by the architect, appear in the indeterminate system. The hypothetical logic of design process of the Agricultural City Project was verified through writing the replicable program in Grasshopper. Agricultural City Project is planned about 60 years ago, although it can be reproducted by using the new technology grasshopper, so that means consciously or unconsciously some rules are based in the past as same as now make a plan of architecture. This verification method using the computer program clarifies the characteristics of the algorithmic design process, which could also be seen in Kenzo Tange and other Metabolists works.

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