



Fig. 21. Analyses of road networks. (a) Objects of analysis in Kyushu (left) and Shikoku (right) islands, where local roads are not shown here. (b) Dependences of numbers of road loops on their orders. Note that the data of Kyushu lie on the steeper line (reproduced from Takaki (1978)).

5. Branching Systems in Human Societies and Computers

It is easy to find branching structures in human societies, human cultures and artifacts. Here, two examples are introduced, which are treated by the present author.

5.1 Road networks

It was shown in Sec. 3 that an analysis similar to that by Horton is possible for such 2D network structures as leaf veins, where it is possible to classify network elements (loops) into different orders. The road networks also satisfy this requirement, because roads are classified as 1st- and 2nd-class national roads, prefectural road and local road. The present author made an analysis of roads in Kyushu and Shikoku islands in Japan, and derived bifurcation ratios for roads in these islands (Takaki, 1978).

Figure 21(a) shows the road systems in Kyushu and Shikoku islands at the time of 1980, where the 1st and 2nd national roads and the prefectural roads are drawn with different kinds of lines. In the analysis the regions surrounded by 1st class national roads were chosen. Local roads were also treated in the analysis, but are not shown in this figure. Order of a closed loop is defined as follows.

1. A loop made of local roads or of local and higher ones has an order 1.
2. A loop made of prefectural roads or of prefectural and higher ones has an order 2.
3. A loop made of 2nd class national roads or of 1st and 2nd ones has an order 3.
4. A loop made of only 1st class national roads has an order 4.

Note that loops are chosen so that a loop of a certain order does not include a smaller loop of the same order.

Numbers of loops in Kyushu and Shikoku islands were counted according to this rule, and the results are shown in Fig. 21(b). It is remarkable that the data for both is-

lands follow the Horton's law, i.e. the number of loops decreases exponentially with the order. This situation might have been realized through many years owing to the human's desire to construct a convenient road system. In addition the difference of steepness of lines in Fig. 21(b) could be understood by assuming that the social system of Kyushu is more developed than that of Shikoku, so that society in Kyushu needed more number of roads of lower orders.

It is noted here that the above results may contribute well in a planning of road system in large scale regions.

5.2 Hierarchy of organization

A representative branching system in human society would be the graphic expression of organizations, such as schools, companies and governments. Most of them have tree-type structures, otherwise they must have confusions in information transmission and requests of jobs. It will be easy to imagine that a system of network-type suffers from great confusion through receiving various requests contradicting each other from many sections.

Figure 22 shows a construction of a Japanese university (Musashino Art University in 1970s), which was made of sections with four levels. An analysis similar to that for rivers was made for this construction by the present author (Takaki, 1978), where orders of sections are determined in the following way. The sections at the right ends have order 1, and the upper sections composed of lower sections acquire higher orders, where the rules in the Horton's analysis are followed.

It is remarkable that the graph in Fig. 22 shows an exact linearity. It should be noted here that this kind of social structures are constructed so that they function in the best way through continuous improvement, where managers of the structures are not conscious of the Horton's law. However, the resulting structure satisfies this law. This situation is similar to that for construction of road networks.