A STUDY ON HILLSIDE UNIVERSITY CAMPUS PLANNING IN JAPAN

Campus location historical trend and open spaces planning methods for different ranges of site grade from a nationwide survey

日本における丘陵地大学キャンパス計画に関する研究

全国調査によるキャンパス立地変遷と敷地勾配の特徴に対するオープンスペースの計画方法

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Pietro VECCHI and Ken-ichi SUZUKI

Data for 681 Japanese university campuses was collected: campus position (rural vs. urban, plain land vs. hilly land), university governance type, foundation year, area and elevation difference. The 238 hillside campuses among the total mostly belong to private universities, were founded after 1960s, and are located in "edge" position; 64% realized open spaces in hilly terrain avoiding massive excavations through a) respecting topographic contours, b) placing open spaces in valleys or ridges, or c) placing them on roof level of other facilities. Each one of the mentioned methods is suitable to a specific range of average grade of campus’ site.

Keywords: Campus planning, Hillside areas, Open spaces, Position, Foundation year, Grade

キャンパス計画, 丘陵地, オープンスペース, 立地, 設立年, 勾配

1. Introduction

1.1. Context of the study

Japanese university space is distinctive and particular among other countries. This is due to various causes; on one side, there are several historical and social circumstances, as the extremely high number of universities and their relative small scale, the early choice of “campus” to be the sole space typology, as described by Kikata 1) (college-like spaces as in the UK or centro universitario, university in symbiosis with historic urban fabric as in continental Europe, are university spaces unknown to Japanese experience), the influences of government directions and the initiative of private universities, the lack of resources and the subsequent rapid construction growth after the Second World War, the higher education boom with hundreds of new universities founded in the 60s, the rise and fall of the Student Movement, the diminution of births, etc. On the other side, there are conditions dictated by the geographical characteristics of the archipelago: the concentration of big conurbations in small part of the territory which led to a polarization between “urban campuses” and “countryside campuses”; and the fact that roughly 70% of Japan territory is mountainous, which caused a large part of campuses to be built in hilly areas. In summary, all the depicted circumstances, on one hand, limited the availability of large and central sites and the economic resources of universities for building facilities, but, on the other hand, they required a high architectural standard to host students’ community, which can be seen in the respect for the natural context, in the realization of outdoor and indoor common spaces, in the provision of comfortable learning environments. The way of planning such complex architectures with scarce economic resources in remote or hillside sites was refined through one century and more. However, the recent years trend of universities to relocate or rebuild campuses in the most central urban zones, as reported by Saio et al.2-3)*1, together with the search for a tighter relationship between university and urban society, is probably going to continue diminishing the importance and popularity of rural, hillside campuses.

1.2. Purpose of the study

Inside the international context, the struggle against difficult site conditions and restricted budget accomplished by Japanese campus planners represents a precious source of sustainable architectural and urban planning inspiration. This is the motivation which led to the aim of the present study: to start investigating the scale, evolution, and planning consequences of the phenomenon of Japanese hillside
university campuses, and especially to identify sustainable planning approaches used in the most stringent conditions. In order to do so, after creating a database containing the vastest possible number of campuses examples, authors determined their governance and position categories, analysed the trends of site position through the history and, subsequently, concentrating on the hillside sites, organized them by harshness level (grade or pendency) and method of realization of open spaces.

1.3. Literature review

After Izawa et al. (1976) in 1976 analyzed planning and topographical features of hillside campuses in the Tōkyō areas affected by the “Kōgyō-tō seigen” law (which limited construction of new campuses within the main urban centers during 1959-2002) and the Nagoya surroundings, and Miyamoto, 1999, divided campus planning mindful of the topographical characteristics into «campus placed on hills», «campus placed on slopes» and «campuses using valleys», no studies have been found that address the spatial characteristics of hillside campuses. Two important studies which investigate the reasons behind the campus positional choices are: Marumo, 1987, who focused on the reorganization or moving of national campuses, finding that the location choice is the result of a balance between a wish of growth and a link with the local community and historical origins of institutions; and, more recently, Saio et al. (2011). The authors previously conducted researches about the planning approach of three hillside campuses in Aichi Prefecture (2012), and a study on the balance between openness to surroundings and closeness for students’ community environment (2013), building the premise to the campus categories individuated in the present paper. Some of these studies are connected to particular regions, some consider only campuses with a clear plan, and some others concern only national university campuses. The originality of the present research can be seen: in the vast range of the target, having analyzed data for any Japanese region and any university scale or type; and in the search for new parameters for the classification of hillside campuses.

2. Target campuses

Starting from the Reiwa 2 nendo zenhoku daigaku ichiran (nationwide list of universities 2020-2021) (2020), we proceeded with the choice and cataloguing of target campuses, based on the following criteria: a. Campuses of universities located in Japan (not tanki daigaku) as of March 31st, 2021; b. The target must be a campus (from Latin, “field”), therefore not a single building, unless it is located within a site that is larger than the building area; c. When a single university possesses more than one campus, each campus count as one; d. Campuses consisting mainly of hospital facilities are not considered; e. Campuses consisting mainly of sport facilities are not considered; f. Campuses consisting mainly of agricultural terrain are not considered; g. Campuses not in use as educational facilities as of March 31st, 2021 are not considered.

Presumably, the collected data does not contain all the eligible target campuses because university information sources are heterogeneous and discontinuous. A numeral overview of the data can be seen in Table 1; their distribution in each Prefecture in Fig. 1. The total number of considered campuses is 681.

3. Considerations on campus position data

3.1. Categories of the data

The 681 considered campuses were visualized on Geospatial Information Authority of Japan (hereinafter: GSI) maps and Google Earth Pro® maps; other information was collected from their respective universities web pages, and databases as Miyamoto, 1999(1999). Data categories are: 1) typology of the site’s surroundings; 2) settlement year: the year when the site started being used for higher education purposes; 3) campus site area; 4) campus site difference of altitude; 5) prefecture; 6) university governance type (national, local public or private).

3.2. Plain land campuses vs. hillside campuses

Except for Izawa et al. (1976), no other studies have been found to define numerically a “hillsite campus”. Izawa et al. collected data
from the 1/3000 scale maps issued by local governments and other 1/2500 scale urban plan maps, and defined as "hillside campuses" those with a minimum difference of altitude of 4m, based on "the height of one story of a buildings". However, in order to analyze uniformly all the target campuses, in this research authors used GSI "standard maps", which are homogeneous for the whole Country and present a minimum contour line interval of 5m. Here, therefore, campus sites which present a minimum difference of altitude of 5m are considered as "hillside campuses".

As shown in Table 2, "hillside campuses" represent more than one third of the total considered campuses of Japan. If we consider only campuses belonging to private universities, the "hillside" ratio reaches 38%; also, 190 out of 238 total hillside campuses are private (80%). Because in Japan private universities have on average a more limited access to land purchase than public ones, a first, easy conclusion we can draw is that hillside sites are less expensive to purchase than plain land sites, and that private universities face major difficulties in building their own campuses.

### 3.3. "Rural surroundings", "urban surroundings" and "edge surroundings"

We here define as "urban" those campuses surrounded on every side by built environment; "rural" those surrounded on every side by non-built environment; "edge" those which confine partly with built environment and partly with non-built environment (forest or cultivated fields, rivers, sea). See Fig. 2 for examples.

Table 3 shows that, while more than half of the plain land campuses is located in urban sites, "urban" hillside campuses are less frequent. It is necessary to note that "urban" hillside campuses were often built before 1965, when the surrounding areas of most of them were still rural. In such cases, urban development was attracted by their presence, until completely englobing them.

Another worth noting data is the high percentage of "edge" sites, which are the relative majority of hillside campuses with 42%. In total, 36% of the considered campuses possess one side which faces the city, and one side which faces forests, fields, natural escarpments or bodies of water, as it can be seen in detail in Table 4. As the authors noticed in previous researches, also in Italy and other European Countries "edge" position is common and convenient. In Japan, the reasons this particular position was adopted so often could be summarized in the two following cases: a) campus was built in a previously rural area, and subsequently attracted urban development in its access area; b) campus’ site was selected from the beginning in order to confine with a non-exploitable area. Option b) appears the most probable in the majority of Japanese "edge" hillside campuses, which often have their “shoulder” watched by mountainous, unbuildable terrain. This, architecturally speaking, made a large part of Japanese campuses capable of distinguishing between a front, open zone and a back, enclosed zone; also, it appears that "edge" campuses located in slopes which are single-oriented towards south or west are very common: for example, the richness of such topographical conditions in Hyōgo Prefecture (hills descending towards the city to the south) and Shizuoka’s Nihon Daira (hills descending towards the city to the west) was so inviting for campus planners that the majority of Hyōgo Prefecture and Shizuoka City examples are "edge" campuses.

<table>
<thead>
<tr>
<th>Governance</th>
<th>Total n. of considered campuses</th>
<th>N. of hillside campuses</th>
<th>B/A Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>National</td>
<td>107</td>
<td>28</td>
<td>26%</td>
</tr>
<tr>
<td>Local public</td>
<td>79</td>
<td>20</td>
<td>25%</td>
</tr>
<tr>
<td>Private</td>
<td>495</td>
<td>190</td>
<td>38%</td>
</tr>
<tr>
<td>Total</td>
<td>681</td>
<td>238</td>
<td>35%</td>
</tr>
</tbody>
</table>

Table 2  Hillside campuses by university governance type

<table>
<thead>
<tr>
<th>Position type</th>
<th>Plain land c.</th>
<th>Hillside c.</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Urban</td>
<td>443</td>
<td>238</td>
<td>681</td>
</tr>
<tr>
<td>Rural</td>
<td>148</td>
<td>98</td>
<td>246</td>
</tr>
<tr>
<td>Edge</td>
<td>95</td>
<td>93</td>
<td>188</td>
</tr>
</tbody>
</table>

Table 3  Campuses position types

<table>
<thead>
<tr>
<th>Edge position typology</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Confining with forests</td>
<td>95</td>
</tr>
<tr>
<td>Confining with rivers</td>
<td>18</td>
</tr>
<tr>
<td>Confined by escarpment</td>
<td>3</td>
</tr>
</tbody>
</table>

Table 4  "Edge" campuses typologies
4. Relationship between campus position and settlement year

By linking the mentioned categories (plain land or hillside position, “rural”, “urban” and “edge” surroundings) to each campus’ foundation year, we obtained the following graphs (Figs. 3-5). In this paper we will concentrate only on the analysis of hillside campuses (right half of the graphs); however, it is important to observe the general enormous amount of new settlements built in the 1960s. Also, it is noteworthy for eventual further studies that in historical periods of growth, such as the 1920s, 1960s, and 1980s, new campus establishments increased and the total balance tended toward plain land locations, while in historical periods of recession, such as the 1930s (militarization) or 1970s (Oil Shock), not only new campuses establishments decreased, but the balance also moved toward hilly terrain locations.

The total overview (Fig. 3) evidences that hillside campuses are mainly a post-war phenomenon, which began in the 1960s, had its peak during the 1980s (the number of new hillside campuses overpassed plain land ones), and started to decrease since the 1990s. The most natural explanation would cite the above-mentioned “Kōgyō-teisen” law and other government strategies for the de-localization of higher education as the main cause for this; however, by confronting data of campuses located in prefectures influenced by the law (Greater Tōkyō Area, Kinki Area and, indirectly, Aichi and Fukuoka Prefectures) with those located in other, more remote prefectures (Fig. 4), it appears that the trend of “rural”, “edge” and hillside campus position during the decades was similar everywhere; moreover, the percentage of “urban” campuses built from 1960 to 1999, when the law was effective, was respectively: Greater Tōkyō Area 35% (32 within 91 total sites), Kinki Area 36% (22/60), Aichi 32% (9/28); Fukuoka 54% (7/13); instead, in other prefectures the percentage is only 15% (32/203). This points out that law restrictions are not enough capable to explain the exit of universities from urban centers. In future studies, it may be of great interest to verify if the reasons which lie behind it are merely economic, or if it is linked to the educational atmosphere and needs of the post-war period. This graph also evidences that within 229 total “urban-plain” campuses, 45% are located in the Greater Tōkyō Area; instead, especially in post-war period, campuses of other prefectures are mostly located outside the city or in the hilly part of the city. Therefore, not analyzing non-urban, non-plain campuses would mean ignoring the actual state of Japanese university spaces outside the capital.

A most decisive difference can be seen when comparing national, local public and private universities (Fig. 5). National campuses dramatically changed the choice of
local public campuses had a boom in the 1990s, especially in “rural” and “edge” positions; instead, private campuses didn’t significantly differ from the overall trend. It is evident that central or local governments’ strategies influenced directly the “rural” and “edge” position choices of public campuses. Finally, new settlements of campuses are becoming increasingly rarer everywhere from 2010s decade; particularly, just one example between the 681 targets was built in hilly terrain since 2010.

5. Hillside campuses by topographical difficulty level: the simplified average grade of campus sites

The aim of this research is primarily that of highlighting how Japanese campus planners faced the challenge of realizing a complete educational environment in the limiting conditions of the hilly terrain. In order to be able to compare such a large variety of topographical features, and subsequently to catalogue different ranges of planning difficulty, authors searched for a numerical index capable of summarizing the pendency or grade of each campus site. Grade is defined as difference of height divided for difference of length, and it is a geometric value which can only be referred to lines (streets or sections) and not to areas, especially when they have different grades for multiple directions, as valleys or mountains. Facing the same problem, Izawa et al. used an index called “average grade” to analyze campuses areas pendency. By overlapping a 40m grid to the campus site perimetry, they collected difference of altitude data for each 40x40m square, and derived their average difference of altitude. Then, dividing such result (average difference of altitude of squares) by the square’s area root (40 m), they obtained an approximated average grade of the site. However, the vastity of the present research’s targets made impossible to collect such detailed difference of altitude data. For this reason, authors simplified the process by dividing the
whole campus site’s difference of altitude (from the lowest to the highest terrain point) by the whole site area’s root, obtaining a “simplified average grade of the site” (hereinafter, SAGS). The result may be not as precise as the previous, but it is still useful in comparing campuses topographies, especially in defining numerically terrain’s harshness: in facts, a terrain with high difference of altitude and small area would have a SAGS higher than a terrain with low difference of altitude and large area (Fig. 6). We found that the range of SAGS of the analyzed 238 hillside campuses spreads from 1% to 41%; however, campuses overpassing 20% are only 8 of the totals. We also found that the distribution of campuses in different range of SAGS through the past decades was quite homogeneous, the range from 5% to 10% being the most frequent in any decade (Fig. 7). By creating a graph with campus site area on the x axis and campus difference of altitude on the y axis, the SAGS ranges can be visualized as parabolas with increasing amplitude. When a campus presents a wide and tenue topography, it will be visualized on the right-lower part of the dispersion graph; when it has a narrow and harsh topography, on the left-upper part (Figg. 8-9).

5.1. Relations between simplified average grade of area and campus surroundings

In Figure 8, campuses are organized by surroundings type. As it was predictable, “rural” campuses are the largest, while “urban” campuses are the narrowest; in addition, the latter present on average a small difference of altitude, even if there are many cases of “urban” campuses with SAGS higher than 10%. However, the harshest and most difficult topographic conditions, exemplified by those campuses with SAGS higher than 20%, are located in "edge" areas.

5.2. Relations between simplified average grade of area and university governance

The most evident difference of topographical conditions is between private university campuses, which almost monopolize sites with SAGS higher than 10% and areas lower than 200,000 m²; and public universities, which have access to larger sites and lower pendency terrains (Figure 9). Again, in Japan, small scale private university are those which faced major difficulties in campus planning.

6. Campus planning approaches to hillside terrains by realization method of open spaces

Architectural planning of campuses in hillside terrains can be classified through various distinctions, for example according to the specific geomorphology of the site, or the building disposition, or again to the street pattern. However, these distinctions could be applied to any architectural settlement in hillside areas. What is distinctive of campus typology is the mix of open spaces and facilities, that are set in order to realize an environment characterized by commonality, something that, in Japan, is not to find easily in normal urban environment, as Ashihara stated[17]. The most decisive challenge of designing campuses in hilly areas is to find room for open spaces, plazas, multifunctional and unspecified purpose zones. In summary, the decisive classification would be: how are open spaces (hereinafter, OS) realized in slopes, valleys or ridges?

To answer this question, we proceeded to analyze the topographical features of each target campus. Takahashi et al., 2007[28] used the GSI tool “Nendai beta no shashin” (aerial photographs by decade) to realize a model of the land transformation and landfill distribution in the site of Nagoya University’s Higashiyama campus, a method which was proven to be able to compensate for the absence of data. In previous research of the authors about three Aichi prefecture campuses[19], GSI’s “Zureki (kyūban chizu)” (past topographical maps) were used to redraw contours before and after campus construction. In the present research, due to the vastity of material to analyze, at first campus sites topographies were observed through the GSI tool “In′ei kifuku-zu” (shaded ondulation map), which allowed to estimate unnatural presence of flat land; a further observation was conducted by consulting the “aerial photographs by decade” tool; finally, the cases which required a more cautious evaluation were checked through the analysis of past topographical maps[15]. This procedure, accomplished for all of the 238 hillside campuses, permitted to evaluate roughly to what extent and in which areas of each campus land flattening was accomplished. Hence, we were able to divide the targets in four typologies of methods[11]. They are described as follows: A) Sites where areas previously characterized by slopes, valleys or ridges have been flattenned through excavations and land fillings to locate units of OS and buildings, or the entire built part of the campus, are defined as using Cut/fill type method; B) Sites where existing valley and ridges have been maintained by placing there OS, and, as a consequence, buildings are placed on slopes without artificial flattening, except for the area equivalent or immediately adjacent to their foundations, are defined as using the Valley/ridge type method; C) Sites were both OS and buildings are placed in the areas of the hilly site with originally lower grade, adjusting the perimeter of the built area of the campus to them, are defined as using Contours following type method; D) Sites where OS are realized on the roof floor of buildings or in apposite architectonic structures are defined as using Artificial ground type method. Figure 10 shows schematizations of these methods and 3D models of the terrain modification of illustrative campuses. It is worth noting that Cut/fill type is the only one which is based on massive land modification; other methods, instead, take as a starting point a conscientious study of hill’s characteristics: Valley/ridge type and Artificial ground type are focused on section study, while Contours following type on plan study.

6.1. Quantitative considerations on “open space realization methods”

Figure 11 shows quantity of each of the above described OS methods. Valley/ridge type, Contours following type, Artificial ground type methods, together, constitute 64% of the total, pointing out that, overall, Japanese campus planning has been somehow environmentally-
Fig. 10 Schematic description of the four individuated methods for planning of OS in hillside campuses, with illustrative examples

Table 5  Hillside campuses by OS planning method and surroundings

<table>
<thead>
<tr>
<th>Quantity (%) referred to:</th>
<th>Cut/fill type</th>
<th>Valley/ridge type</th>
<th>Contours following type</th>
<th>Artificial ground type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rural (% referred to:</td>
<td>75 (100%)</td>
<td>26 (30%)</td>
<td>19 (25%)</td>
<td>8 (36%)</td>
</tr>
<tr>
<td>Urban (% referred to:</td>
<td>64 (100%)</td>
<td>23 (27%)</td>
<td>7 (17%)</td>
<td>6 (27%)</td>
</tr>
<tr>
<td>Edge (% referred to:</td>
<td>99 (100%)</td>
<td>37 (43%)</td>
<td>15 (47%)</td>
<td>8 (36%)</td>
</tr>
<tr>
<td>TOTAL (%) referred to:</td>
<td>238 (100%)</td>
<td>86 (100%)</td>
<td>41 (100%)</td>
<td>22 (100%)</td>
</tr>
</tbody>
</table>

Fig. 11 Percentage of each OS method

Table 6  Hillside campuses by OS planning method and university governance

<table>
<thead>
<tr>
<th>Quantity (%) referred to:</th>
<th>Cut/fill type</th>
<th>Valley/ridge type</th>
<th>Contours following type</th>
<th>Artificial ground type</th>
</tr>
</thead>
<tbody>
<tr>
<td>National university</td>
<td>28 (100%)</td>
<td>15 (17%)</td>
<td>4 (14%)</td>
<td>8 (20%)</td>
</tr>
<tr>
<td>Public university</td>
<td>20 (100%)</td>
<td>4 (14%)</td>
<td>8 (20%)</td>
<td>4 (18%)</td>
</tr>
<tr>
<td>Private university</td>
<td>190 (100%)</td>
<td>67 (35%)</td>
<td>81 (41%)</td>
<td>22 (100%)</td>
</tr>
<tr>
<td>TOTAL (%) referred to:</td>
<td>238 (100%)</td>
<td>86 (100%)</td>
<td>89 (100%)</td>
<td>22 (100%)</td>
</tr>
</tbody>
</table>
minded. The most frequent method is Valley/ridge type (89 campuses), which slightly overpasses Cut/fill type (86 campuses). When observing the OS method data crossed with the campus surroundings data (Table 5), it is interesting to notice that Contours following method is more frequent in “rural” campuses (46%), presumably because of the major availability and freedom of construction area. Cut/fill method is equally distributed in “rural”, “urban” and “edge” campuses, presumably because its premise is to ignore characteristics of the site. It is also interesting to notice that Valley/ridge method is most frequent in “urban” sites (44%). This could be linked to the convenience of this method in narrow sites with little plan freedom, which brought architects to solve university buildings design starting from section study of the terrain. “Edge” campuses present a quantity of each OS method that is not different from the total situation.

By crossing data with university governance type (Table 6), we understood that Cut/fill method is the most frequent for national universities (54%). Private universities used frequently Cut/fill method (35%), but Valley/ridge method is the most used with 43%. Because, as seen in previous paragraphs, private universities are on average the most lacking in resources, one hypothesis is that Valley/ridge type is the cheapest method, while Cut/fill type is the most expensive. Local public universities used relatively often Contours following method (40%) and Artificial ground method (20%, overwhelming national and private universities percentages), showing a predilection of local public universities for architecturally challenging OS plans.

6.2. Relation between hillside campuses open space realization methods and settlement year

The relative distribution of each of the mentioned methods in the post-war decades (as seen in paragraph 4, hillside campuses founded before Second World War are rare) does not vary significantly, except for a slight relative increase of Cut/fill method during the 1970s (Fig. 12), followed by an increase of the other three methods during 1980s. However, it is important to remember that the campus foundation data collected in this research does not allow to take into consideration an eventual discrepancy between the architectural solution adopted at the time of the campus foundation and the present-day situation. For this reason, especially Artificial ground type method, in some cases, could have been added in a period successive to that shown in Fig. 12.

6.3. Relation between open space methods and simplified average grade of the site

We re-draw the SAGS dispersion graph classifying campuses according to their OS method (Fig. 13), and derived the central tendency line of each method’s data. Central tendency is a descriptive summary of a dataset through a single value that reflects the center of the data distribution17. As a result, it is possible to state that Contours following type is used mostly for campus sites with SAGS lower than 5% (large areas and low difference of altitude); then, at increasing levels of SAGS, we observe, in order, the Cut/fill type, the Valley/ridge type and, finally, concentrated in those terrains of greater difficulty (almost every example overpasses 10% of SAGS), the Artificial ground type. The central tendency lines highlight that environmentally damaging Cut/fill method is on average used in easier hilly terrains than Valley/ridge method. This is noteworthy, because it means that, even when campus construction conditions are more challenging, excavations and land fillings are not the only possible solution.

7. Conclusions

Regarding the initial aim to analyse the phenomenon of hillside campuses in Japan and to capture sustainable planning strategies, the present research highlighted the following results and observations:

1) Private universities’ presence in hillside areas, compared to plain land
areas, is stronger than that of public universities. Furthermore, private universities have on average access to sites which are narrower and with higher difference of altitude than public ones.

2) Most of hillside campuses (42%) present one side facing urban environment and one side facing natural environment (“edge” surroundings). At the same time, those are the sites with the highest degree of topographic difficulty (higher SAGS).

3) Hillside campuses are a post-war phenomenon, but this is not explainable merely as an influence of “Kōgyō-tō seigen” law, because campus position trend was similar all over Japan, and not only in the areas which the law targeted. Also, the concentration of “urban-plain” land campuses in the Greater Tōkyō Area appears as an exceptional condition when compared to other Japanese areas.

4) Construction of campuses in previously unbuilt areas or in areas occupied by non-educational functions, or, in summary, construction of new campuses in new areas has been strongly decreasing since 2000s.

5) The large majority (64%) of hillside campuses plans, exemplified by their OS realization methods, has been enough conscient of each terrain’s own morphology to take advantage of the topography instead of modifying it. Excavations and land fillings are accomplished more often in the case of national universities; local public universities, instead, risked more sophisticated architectural solutions capable of respecting the topography. Private universities, also, were able to adopt sustainable plan methods even when facing the harshest terrains.

6) Comparison between the three graphs regarding SAGS (Figg. 8, 9, 13) allows to conclude that: campuses with SAGS below 10% and with area >250,000 m² are more frequently “rural”, national or local public, and use Cut/fill, Valley/ridge, Contours following methods; campuses with SAGS over 10% are more frequently located in “edge” position, are mostly private, and use Cut/fill, Valley/ridge and Artificial ground methods. Particularly: Contours following method is more suitable to large and tenue hillside sites; Valley/ridge method for nearly any type of terrain except for the most difficult slopes; however, in these kind of terrains, Artificial ground method allows construction of open spaces.

The way even private universities with low budget, even in periods of economic struggle, faced the task of enriching the environment for the student community with open spaces and plazas, shows that construction methods which are respectful of the hill morphology are possible also in the most challenging sites. Instead, massive modification of the topography appears to be more expensive (used by universities with access to richer resources) and still not the most efficient planning method, because the results showed that even the sole Valley/ridge method, that is to take advantage of existing valleys and ridges, can be applied to a vaster range of topographic harshness (SAGS) than Cut/ fill method. This study pointed out also that, despite the initial hypothesis, the phenomenon of hillside campus planning regarded primarily peripheral areas of Japan and private universities, both fields which rarely become object of research, but which, besides providing higher education services to the majority of Japanese students, constitute an essential part of the Japanese university architectural context.

In the future research, it is necessary to better understand the influence of historical events on campus position choice, and especially to clarify whether the exit of campuses from cities to hillside, “rural” sites have been a voluntary choice linked to educational wishes, or a forced choice linked to more economic or legal causes. Also, it is necessary to focus on the potential of “edge” position campuses. A student evaluation survey regarding the quality of some chosen examples between the analyzed ones would be useful for individuating the improvements which existing sites need, and the planning solutions which most accomplish the aim of the university campus, which is to welcome the university community and to dialogue with the society.

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REFERENCES


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Acknowledgment


NOTES

*1) Before 2002 abolition of the law Kiyū-tō seigen, 66 out of 80 campus relocations or new construction in the Tōkyō metropolitan area were directed into the central city area. See Reference 3).

*2) «Daigaku kyanpasu no kenessetsu ni kan suru nenpyo» (timeline regarding the construction of university campuses), Reference 8), pp. 19-20.

*3) The campus foundation year refers to the starting year of educational activities in the considered site. In some cases, the site was initially used for a different university or school, and then evolved into, or passed to, the present university: in such case, we considered the foundation year of the oldest institution. This information was gathered from university web pages and verified through historical maps and photographs available in GSI (Note *10).

*4) Site area data was collected only for hillside campuses. This information was available for around 90% of cases on universities websites or in other online documents. When not available, we made reference to the illustrative "campus map" (a not-in-scale map provided by the university, which we found out to be available for all the considered cases) and manually copied its perimeter on GSI maps, measuring an approximate area of the site which is still useful for data comparison. In the case of campuses conforming with natural environment, this approximation necessarily increased.

*5) With regard to elevation difference data, after verifying the presence of elevation difference higher than 5m in GSI's "standard map" in all target campuses, the difference between the highest and lowest point of the site has been measured through the Google Earth Pro™ «elevation» function.


*7) For example, Kansai University Senriyama campus, Kōbe Jogakun University campus, Takaragawa University campus, Nanzan University campus, Osaka University Toyonaka campus.


*9) Reference 13), chapter 10 (pp. 30-31), titled «Uncoordinated Land Use» declare that the excessive subdivision of land and the absence of coordination between landowners are the reasons for the confused Japanese cities' landscape.

*10) *年代別の大規模建築物* (aerial photographs by decade), *図景（新編版）* (shaded ondulation map), *図景（旧版版）* (maps edited in the past) services are all available at the GSI menu, Reference 13).

*11) The first three methods derive from the observations accomplished by the authors in Reference 10), which were found to be applicable to large part of the target sites; however, there was the necessity to add a fourth method, *Artificial Ground type*, which had not been observed in the previous research.
他国における大学空間に比べると、日本の大学キャンパスの計画に携わった者は地理的、経済的、教育的な要件がもたらす多くの困難さに直面してきたことから、キャンパス計画の全体的な現象を研究することに意義があると考えられる。本研究では特に、丘陵地に立地するキャンパスに直目し、日本における「丘陵地キャンパス」の現象の規模、変遷、計画的結果を分析すること、また最も困難な条件における持続可能な計画アプローチを読み取ることを目的としている。

全国681校のキャンパスの立地（平地・丘陵地、また都市周辺・地方周辺）、大学運営型（国立・公立・私立）、設立年、敷地面積、敷地標高差のデータを収集し、全体のうちの238校の丘陵地キャンパスに焦点を当てた。単純化敷地平均勾配（以降：SAGS、敷地の標高差を土地面積の平方根で割ったもの）により、対象キャンパス間の比較が可能となり、「困難な」・「容易な」地形的特徴を特定することができた。キャンパス計画解決策の分類は、大学キャンパスの特徴であり必要であるオープンスペース（以降：OS）の丘陵地での計画・建設方法に基づいている。研究の成果は以下のようである。

1) 私立大学キャンパスは比較的に、平地よりも丘陵地に頻繁に立地している。また、国公立大学よりも、私立大学が面積の狭く標高差の高い敷地に建つことが圧倒的に多い。
2) 丘陵地キャンパスの42％は都市と自然環境の境界線に立地している（「エッジ型」）。それは地分類の中で最も高い位置を占める。
3) 丘陵地キャンパスという現象は明らかに戦後の特有のものであるが、それが工業等制限法の影響としてのみ説明できない。その理由は、制限法が効力を持っていた地域以外も、全国的にキャンパスの立地の変遷状態が統一していることである。むしろ、首都圏に見られる都市型・平地に立地するキャンパスの集中が他地域と比べれば例外的であることがわかった。
4) 未発展地や、既存の教育施設用地以外でのキャンパスの新設立が2010年代から強く減少している。
5) 分類された4つのOS計画・建設方法のうち3つは敷地の地形を生かし、特に、「高等線沿いタイプ」方法は緩やかで広大な敷地で、「谷・尾根タイプ」方法はSAGS20％以上の敷地で採用できることがわかった。対象丘陵地キャンパス計画の大部分（64％）は、これらの方法のいずれかが実施された。土地の切盛りは様々なキャンパス敷地で行われているが、これらよりもSAGSが高い敷地であっても、上記の持続可能な方法でOSを実現することができることが明らかになった。

Summary in English

Inside the international context, the struggle against the difficulties caused by geographic, economic and educational conditions accomplished by Japanese campus planners represents a precious source of sustainable architectural and urban planning inspiration. This is the motivation which led to the aim of the present study: to start investigating the scale, evolution, and planning consequences of the phenomenon of Japanese hillside university campuses, and especially to identify sustainable planning approaches used in the most stringent conditions.

We collected data regarding position (plain land vs. hillside terrain, “urban” or “rural” surroundings), university governance type (national, local public or private), settlement year, area, difference of altitude for 681 Japanese campuses, and we focused on the 238 hillside campuses found within the totals. The simplified average grade of the site (SAGS, site’s difference of altitude divided for root of campus area) allowed comparison between the target campuses and identification of “difficult” and “easy” topographical features. Classification of campuses planning solutions has been based on the realization method in hilly terrains of open spaces (OS), which are a distinctive and necessary feature of university campuses.

The results are as follows.

1) Private universities presence in hillside areas is relatively stronger than in plain land areas. Furthermore, private universities have access to sites which are narrower and with higher difference of altitude than public ones.
2) 42％ of hillside campuses present one side facing urban environment and one side facing natural environment (“edge” position).
3) Hillside campuses are a post-war phenomenon, but this is not explainable merely as an influence of “Kōgyō-tō seigen” law, because campus position trend was similar all over Japan, and not only in the areas which the law targeted. Also, the concentration of “urban”, plain land campuses in the Greater Tōkyō Area appears as an exceptional condition when compared to other Japanese areas.
4) Construction of new campuses in empty areas or in areas which are not already in use for educational facilities has been strongly decreasing since 2010s.
5) Three out of the four classified methods for realization of OS in hillside campuses respect site’s topography, and, particularly: Contours following method is more suitable to large and tenue hillside sites; Valley/ridge method for nearly any type of terrain except for the most difficult slopes; however, in these kind of terrains, Artificial ground method allows construction of open spaces. The large majority of hillside campuses plans (64％) adopted either one of these methods.

Excavations and land filling were accomplished in various sites; however, above-described sustainable methods were largely capable of realizing OS even in sites with higher SAGS than these.