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Research article

Symbiosis Dam with Nature

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Abstract

This paper is concerned with symbiosis dam with nature, which is very useful for the ecology including human beings. A proposal has been made about the concept and design principle for symbiosis dam with nature, by referring to the Kasumiga-ike pond in the Kenroku-en garden in Japan, and the Kanan-taishu water channel network in Taiwan. It is found that the necessary conditions for symbiosis dam with nature are (a) to avoid any construction of dam, which may stop the continual water flow and motion of sediment along the primary river in the basin, and (b) to limit the number of dam only to one in the tributary river.

Keywords: Ecological dam, Symbiosis, Japanese Garden, Taiwan Dam, Water Channel, Historical Dam, Hydraulic Power

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1. Introduction

According to the ancient Chinese book of gardens, there should be six different sublime qualities to which a garden can aspire. Grouped in their traditional complementary pairs, they are "spaciousness & seclusion, "artifice & antiquity", and "splashing running water & panorama". As might be imagined, it is difficult enough to find a garden that is blessed with any three or four of these desirable attributes, let along five, or even more rarely, all six. Yet, as the name "Kenroku-en" literally means such a rare garden that harmoniously combines six characteristics, which is named by Sadanobu Matsudaira(1758-1829), the famous feudal load in Shirakawa clan, which is in the present Tohoku district, northern part of main land Japan.

It is realized that there is analogy in the water management between splashing running water channel or the Kyoku-sui in the Kenroku-en garden in Japan and great water channel network, the Kanan- taishu in Taiwan, which construction is directed by Yoichi Hatta(1886-1942): The Kyoku-sui water channel and the Kasumiga-ike pond correspond to the Sonbun-kei river and the Uzanto-dam lake, respectively. Necessary condition to maintain the splashing running water for both of the Kyoku-sui water channel and the Sonbun-kei river is to avoid any dam construction crossing and stopping the continual water flow in the primary river of the basin. None the less, the Kasumiga-ike pond and the Uzanto-dam lake play an essential part to store the water, and feed it downstream in need.

The potential energy due to the stored water in the Kasumiga-ike pond has been used to splash the water in the channel, fountain and falls in the downstream, while that in the Uzanto-dam lake is used to provide the great water channel network, called the Kanan-taishu, subsequently.

It is known that Yoichi Hatta was born in Kanazawa and was educated there before entering University of Tokyo at the age of 20 years old. Thus, it is quite natural to consider that Hatta had enough knowledge regarding to the water channel network relating to the Kenroku-en garden as well as the Tatsumi-yosui canal (Nakagawa 1997, Nakagawa & Miyae 1989). It is, therefore, hypothesized that Hatta has applied the water management system in the Kenroku-en garden as well as the Tatsumi-yosui canal to the Kanan- taishu water channel network in Taiwan.

It is getting more and more difficult to set area, in which people in a basin are prohibited to enter. On one hand, people are tending to have an opinion that the river authority must manage rivers as natural as possible. Thus, the more wider space is required to make people satisfy their living environment, and thus the river authority is obliged to arrange between the ecological demand and utility requirement.

By the way, as the result of increasing the area being covered with impermeable materials, the amount of surface runoff increases very rapidly. On the other hand, due to the extension of the sewage system, the storage capacity in the basin is decreasing continuously. The increase of the runoff water from the well managed river is caused no more than by the loss of natural flood plain, together with artificial concrete embankment, by the removal of aquatic plants, and the straightening rivers.

It is already evident that there is no river management system to meet the ecological requirement by the people as well as the counter measure for flood at the same time. For example, the current flood alleviation measure may result in not only the increase of the peak discharge, but that of flow velocity, for the difference between the time when the discharge in the tributaries takes the peak and that when the discharge in the primary river takes the peak becomes shorter.

The main purpose of the present study to propose the concept and design method for symbiosis dam with nature, together with an ideal river management for us, based on the analyses regarding to the Kyoku-sui water channel in the Kenroku-en garden in Japan and the Kanan-taishu water channel network in Taiwan.

2. Current Flood Alleviation Measure

For over the last fifty years, the environmental degradation is accelerated day by day, and it becomes evident everywhere. Main factors are desertification, green-house effect, acid rain, water pollution, urbanization, great scale development, coral bleaching, deforestation and so forth.

Alternation of river course is often required to alleviate flood, to enhance drainage, to maintain navigation channel, to generate electricity or to prevent bank erosion. However, this measure must be avoided as far as possible, for it not only contradicts to sustain bio-diversity but provides undesirable impact to river. In general, conventional river engineering countermeasure such as channel widening, straightening bank, embankment with concrete or dam construction, crossing the channel results in some problems regarding to the harmonious relation between human beings and nature. In fact, ill effects due to these countermeasures have been revealed especially in developed countries for over the last fifty years. In order to cope with this problem, at Europe Foreign Ministers' Conference in 1977, a guide line to prevent the degradation of banks for lake as well as river was adopted.

After the persisting destruction over the several centuries, an international agreement that remains of natural bio-globe near water edge including river banks and sea shores must be preserved has been firmly established. Although some European countries have already assured the consistency between the method of river engineering countermeasure and natural conservation to some extent, Broggi (1984) has proposed the following proposals to provide the supplement for insufficient measures;

1. to list up bio-phase along river,
2. to construct the plan of preservation for all of reaches in which countermeasure is necessary,
3. to prohibit any further straightening of the river banks, and to change river into drainage channel,
4. to adopt alternate countermeasures based on biological and fertile geomorphological point of views as far as possible,
5. to sustain and plant aqueous flora, and
6. to restrict and control cars for recreation near water edge.

No research has succeeded to identify environmental variables affecting to distribution of plants, and number of species, nor to quantify them. The current biological measures are far from satisfactory to identify several biological groups as well as their environmental conditions. Also, in order to know the speed of recovery of nature and biological species, information on environmental diversity is required: For example, research concerning with the prediction for the impact to nature and biological species by the change of river into drainage, and for the rehabilitating them. It must be possible for us to obtain information for improving the engineering design of river amendment so as to suppress biological impact as small as possible.

By monitoring physical, hydraulic and biological conditions before, during and after the channel construction work, it is possible to correct useful data, to be used for making critical decisions for conducting similar construction work in future. Especially, monitor after the construction work, is quite important to do the relevant evaluations including economical evaluation together with value for sightseeing.

After detailed planning based on these information obtained through the monitor, any future construction work must be started to make natural river stabilize and to amend it desirable river economically (MacBroom 1980).

Any river flowing over the alluvium plain possesses three-dimensional freedom, and thus the river controls itself to form its own characteristic morphology, so it is almost impossible to predict its motion and the resulting shape precisely (Nakagawa 2008). Considering the current stage of development in river engineering, problems relating to river could be solved in a more desirable manner by depending upon proper judgment based on past experiences, rather than using empirical formula. This results in that river channel design based conventional design technique is severely limited either to the straight reach in natural river or very short range in the curved reach.

Historically, economy of river work has been evaluated mainly on the basis of cost effectiveness analysis, but in future this may be replaced by environmental accounting, which is much more over all analyses(Nakagawa 2001). Also, preliminary evaluation for river amendment or design should be interdisciplinary approach by examining contents of every previous and future projects (Shields 1982). For this work, it is indispensable to include developer, engineers, river morphologists, biologists, organizations for nature preservation, and the other relevant local people. Such an environmental assessment procedures have already adopted by USA, UK, Germany, France and many other countries, but the degree or quality is sparse among countries.

In the novel river management, a method stating " do not govern river, but seek for a way harmonizing with it" is proposed by Winkley(1982), so this is far remote from the conventional one stating " engineering is possible to control river"(Leopold 1977). This management includes conservation of natural rivers, minimization of impact to nature during the channel construction work, practical usage of existing facilities, together with recreation activities, and it is relating to near nature river design. It is however noted that the central element for the novel channel design which takes into consideration of natural characteristics of river and let them alive vividly, is deep biological understandings for the river.

3. Concept of symbiosis dam with Nature

In this section, a new concept of symbiosis dam, which is in harmony with nature hydro-dynamically, biologically, and geo-morphologically, will be proposed. The key-point in this concept is to guarantee the continuity of the splashing water flow as well as of sediment from the river source to the mouth for the primary river in the basin, and so no dam is constructed across it, and number of dam in the basin is limited only to one in the tributaries.

Fig.1 depicts a conceptual sketch of symbiosis dam with nature. This dam may be operated as follows ;(a) several permeable net dams placed in the primary river together with the protruded bank into the water course let the water level higher than otherwise. This results in that the necessary discharge flows into the storage pond through the water gate. (b) the stored water may be used for generating electric power, drinking, or industry subsequently. It is clear that this pond is effective to control the discharge in the primary river during flood and drought as well.

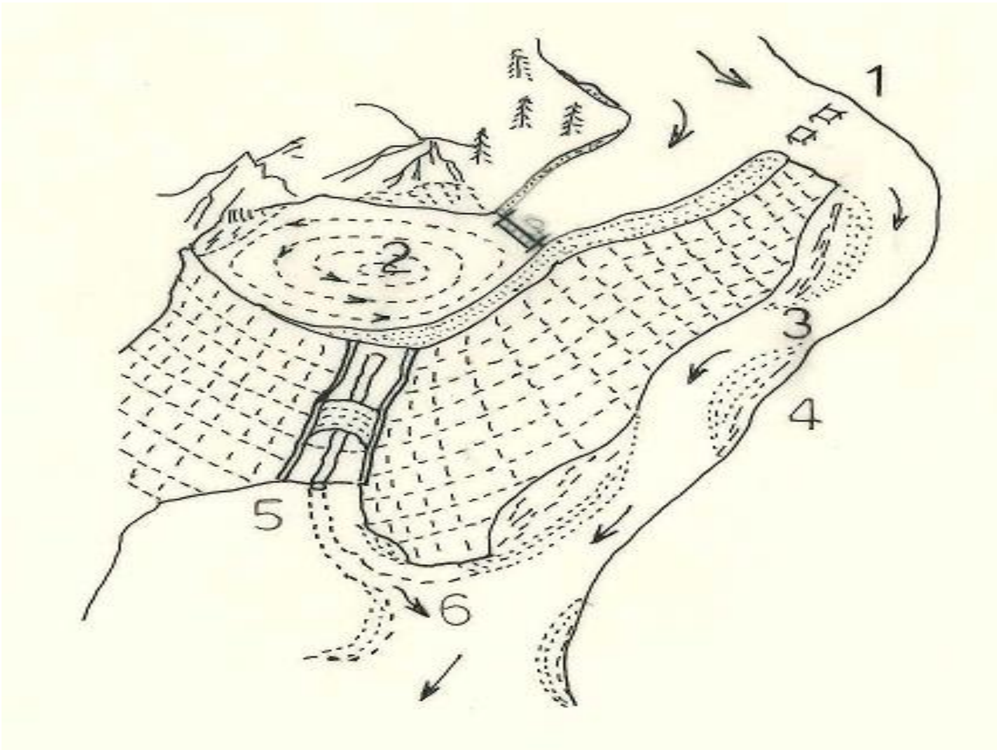

Figure 1: Conceptual sketch of symbiosis dam with nature

1: permeable net dam, 2: water storage pond, 3: primary river, 4: sand dune, 5: hydraulic power station, 6:drain water .

It is now evident that the proposed symbiosis dam with nature causes no serious environmental problem such as water pollution and sediment deposition. This is the most critical point of the symbiosis dam with nature in relation to our daily life.

True aim of science is to make people's life convenient and to bring the society and world happiness, but not merely to promote metaphysical science. Based on this view to the value of science, it is necessary to create a system that the leading scholars equipped with faithful and sincere mind write practical guidelines and handbooks that have close relation to political decision as well as environmental research together with the related activities in the nation and district public institutions. The social significance of the system is immeasurable, for this makes it possible for the charged public servant to not only apply the most advanced and useful scientific knowledge immediately, but also report precisely the decision maker the content(Brookes 1988).

4. Case Studies

4.1 Kasumiga-ike Pond in Kenrokuen-garden

In this section, as a symbiosis dam with nature, the design concept of the Kasumiga-ike pond, being connected to the Kyoku-sui water channel in the Kenroku-en garden has been discussed, where the word 'Kyoku-sui' means sinuous channel in general, and often is constructed in traditional gardens in China, Korea, Japan and other countries in South East Asia.

Construction of the Kenroku-en garden has started in the era of the second lord of Kaga clan, Toshinaga Maeda(1562-1614), and continued the change of design repeatedly during the subsequent over 200 years. The current garden has been established during Tenpo-era(1830-43). Fig.2 shows the plan view of the main part of the Kenroku-en garden, while Fig.3 shows the Kaumiga-ike pond and the Kyoku-sui water channel of the surroundings. The water flowing in the Kenroku-en garden is conveyed through the Tatsumi-yosui canal(Nakagawa 1997) , which feeds the water to the Kenroku-engarden through the Sai river at the water-intake point of Higashiiwa, Kamitatsimi, Kanazawa city. The total length of the Tatsumi-yosui canal is 10km approximately, and within it roughly 3km of the entrance conduit is tunnel, and the locus is along the right bank of the Sai river on the plateau of Kodatsuno.

The water of the Tatsumi-yosui canal enters to the Kyoku-sui water channel at the back yard of the Yamazaki-yama mountain(left upper part of Fig.2), flows along the sinuous channel of the Kyoku-sui water channel at the central part of the garden, and then goes to the counter clock-wise direction as if it delineates the Kasumiga-ike pond and finally reaches at the Hisago-ike pond through the water fountain, the oldest one in Japan.

The fountain is splashing beautiful water flowers for over 400 years incessantly with the water head difference between the water in the Kasumiga-ike pond and that at the mouth of fountain(Nakagawa & Chanson 2006). It has been reported that this

Figure 2: Plane view of the Kenroku-en garden

fountain is the model of the inverted siphon pipe, connecting the Kasumiga-ike pond and the Ishikawa-mon gate in Kanazawa-castle through the Ishikawa-bashi bridge. It is said that this pipe was originally wood and was buried in the ground to prevent the possible attack by the enemy. In the later years from 1843 to 1862, the wooden pipes were replaced with rock ones (Nakagawa 1997).

Figure 3: Magnified photo. of the Kasumiga-ike pond and its surroundings

Figure 4: The oldest fountain in Japan

It is evident from this figure that not only the Kasumiga-ike pond is not located on the channel course, but no dam to stop the water flow in the Kyoku-sui water channel exists on the course, so that throughout the Kyoku-sui water channel the vivid splashing water flow is kept. At the downstream end, the water flowing over the water level above the control gate of Hisagoike-pond becomes the renewed source of water for the spider net like water channel network in the Kanazawa-city. It is realized that the Kasumiga-ike pond is not merely for entertainment, but for storing and distributing water in order to splash the water from the mouth of the fountain and to feed the water for the falls in the downstream. In recent years, the water head, or the potential energy is easily transformed into electric energy by using turbine and generator, so that the Kasumiga-ike pond plays a role as a lake for power generation in the symbiosis dam with nature.

4.2 Kanan-taishu Water Channel Network

In this section, as one another example of symbiosis dam with nature, the Kanan-taishu water channel network has been introduced. The Kanan-taishu water

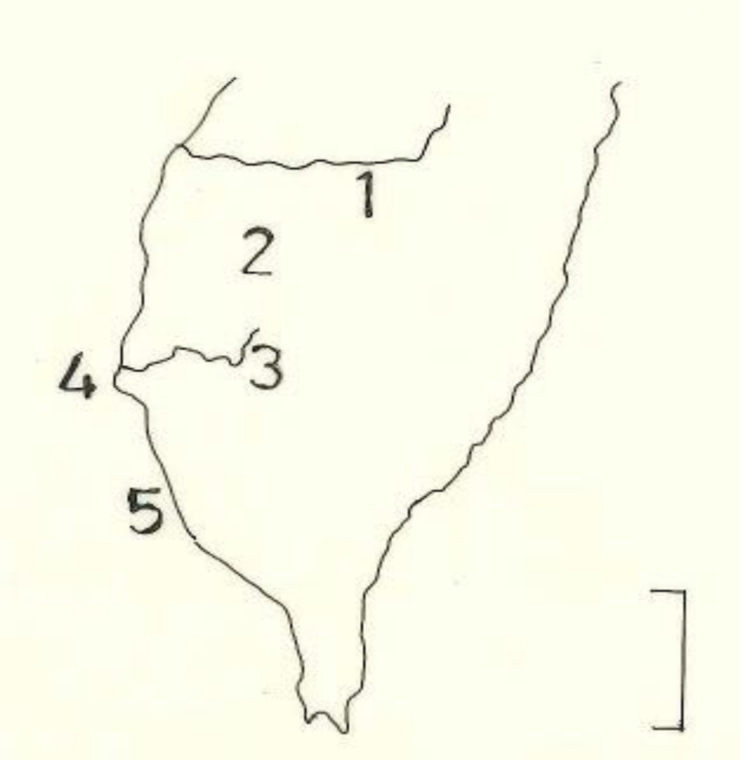

Figure 5: Location of the Uzanto-dam on the Kanan-heigen plain.
1: Dakusui-kei river, 2: Kagi City, 3: Uzanto-dam, 4: Sonbun-kei river, 5: Takao City
Inset scale=50km

channel network including the Uzantou-dam lake is delineated in Fig.5. This water channel network had been constructed by Yoichi Hatta(1886-1942) et al for about 10 years ranging from 1920 to 1930. Directorship of Hatta is so fine that people in this local district in Taiwan has erected his statue with bronze(Fig.6), and all the expense is covered with their donation. It is said that this statue was decided to remove and destroy in 1945,

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just after the end of the Second World War by the Taiwan government, being leaded by Chiang Kai-shek(1887-1975), for this land was no more belonging to Japan. However, this statue has been kept by farmers who feel strong favor to Hatta who made a great contribution to their society. Then, in 1981 this statue was reelected by the Taiwan people, and now become a symbol of friendship between these two nations.

Fig.7 shows the geography of the source of river and the Kanan-heigen plain. The primary river, the Sonbun-kei river flows along the right edge of this figure, while the tributary is the Kanden-kei river. As the result of dam construction at Uzantou on the water course of the Kanden-kei river, a dam lake called the Uzantou-dam lake appears as shown in Fig.8. The gross capacity of water storage in the Uzantou-dam lake is 150 million ton, which was the greatest amount in Eastern world at that time. The length and height of the dam bank are 1,273m and 56m, respectively. The widths of the dam bank at the base and top are 303m and 9m, respectively.

The Uzantou-dam bank is constructed in terms of 'semi hydraulic fill method', that is semi-hydraulic power and by the way of alluvium, for this method has an advantage against the possible attack of the oscillation due to the earthquake. the oscillation due to the earthquake. Fig.9 shows a picture during the construction work for refilling up the concrete core of the dam, while Fig.10 shows the picture of the standard cross section of the dam. Actually, this concrete core has been consolidated by adding clay and sand alternatively in terms of pressure equipment as well as water jet.

Figure 6: Bronze statue of Yoichi Hatta and stone tomb for him and his wife Toyoki., which are located at the water edge of the Uzanto-dam lake.

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Figure 7: The Kanan-taishu water channel network.

Figure 8: The Uzanto-dam lake, being viewed from the statue of Yoichi Hatta.

Fig.11 shows a photo of the conduit exit during discharging the water through the Sangotan-dam bank. At the East China Sea, Yoichi Hatta was killed by a torpedo, which was ejected from the US navy submarine on May 8, 1942 on the way to Philippine , where he had a mission to examine the current situation regarding to cotton harvest and irrigation network. Lamenting Hatta's death, his wife, Toyoki had jumped into the channel in the downstream of the conduit exit in 1945. This is the reason why there exists a stone pillar, on the front face of which the noble names of the couple, Yoichi and Toyoki are engraved. It is well known that Toyoki has made great support to her husband, Yoichi's work, so that Toyoki has been respected and trusted deeply by the people. The great shock of the people due to

Toyoki's sudden death caused the construction of this historical tomb at the lakeside of the Uzanto-dam lake by their donation.

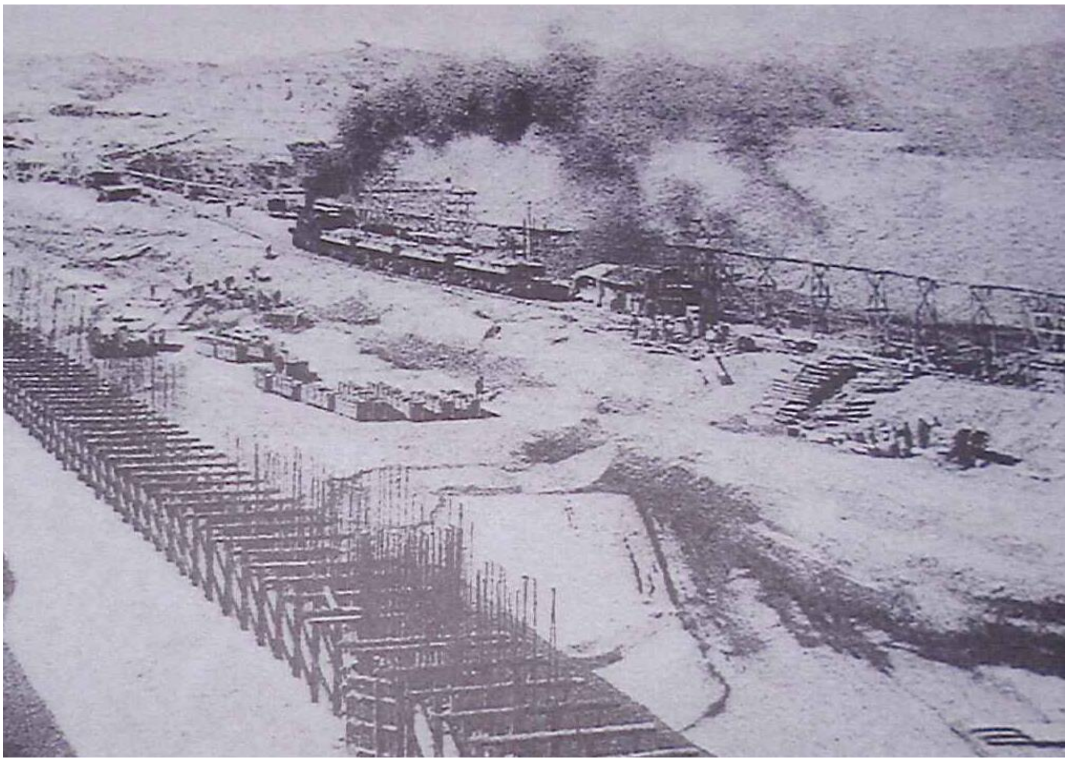

Figure 9: Refilling work for the central concrete core of the Uzanto-dam bank.

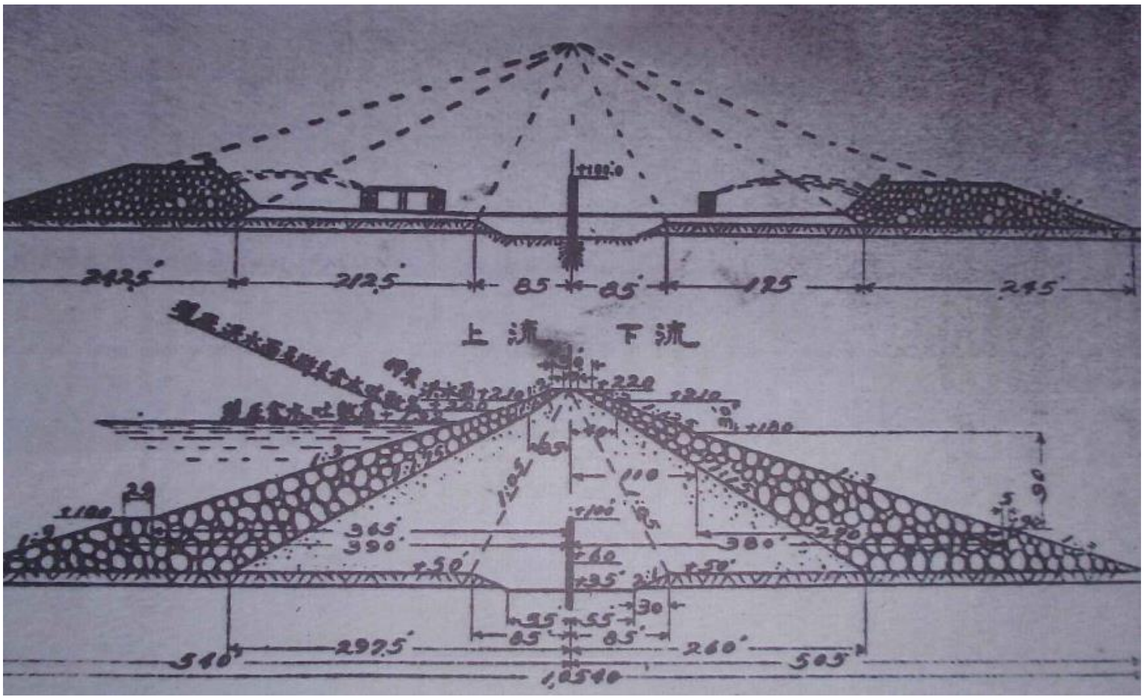

Figure 10: Typical cross section of the Uzanto-dam bank.

Fig.12 shows a photo of the fountain tower, which is operated by the potential energy or water head due to the Uzantou-dam lake and is located near the conduit through the Uzanto-dam bank. The principle of this fountain tower is exactly same as that of the water fountain in the Kenroku-en garden.

Figure 11: Discharge from the conduit exit through the Uzanto-dam bank.

Water of the Uzantou-dam lake is fed not only by the Kanden-kei river, but also through the water tunnel of 3, 078m connecting the primary river, the Sonbun-kei river and the Kanden-kei river or the Uzanto-dam lake. This has been made possible by digging the ground of the Uzan-rei mountain. Fig.13 illustrates riveting work for fixing iron pipe connecting the Sonbun-kei river and the Kanden-kei river, to convey the water to the Uzantou-dam lake through it.

Hatta have bravely proceeded this dangerous construction work of the water tunnel with a clear engineering intention, which makes it possible to avoid any dam construction crossing the primary river, the Sonbun-kei river. Accordingly, the Sonbun-kei river is kept as if it is natural river conveying transparent water as well as sediment to the mouth at the South China Sea. However, it may be worth noting here that against Hatta's will, a dam crossing the water-course of the Kanden-kei river was constructed by a Japanese construction company later.

As the result of the Uzantou-dam lake construction, though the Kanden-kei river itself have changed into an artificial water channel, the dam lake can store the great amount of water fed by the Kanden-kei river and the Sonbun-kei river, so that it becomes possible to feed the water all over the Kanan-heigen plain of 150,000 hectare, through the large and small water channel networks being expanded as if spider nets.

The Kanan-taishu water channel network is consisting of many water channels

Figure 12: Water fountain tower downstream of the Uzanto-dam bank.

having the total length of 16,000km, which corresponds to about 40% of the earth equator length, water gates, water channel bridges, dams, power stations together with banks to prevent salt intrusion to soil and discharge water gates. The Kanan-taishu water channel network has three trunk water channel lines, south trunk water channel line, north trunk water channel line and Daku trunk water channel line, and each of the trunk water channel lines is divided into many middle and small scales of water channels subsequently.

Water source of the south and north trunk water channel lines is the Uzanto-dam lake, while that of the Daku trunk water channel line is the Dakusui-kei river. The Dakusui-kei river is the largest among the rivers in the Kanan-heigen plain, and flows along the north edge of the plain. However, because this river has large amount of the suspended sediment and alluvium sediment on the river bed, the water is highly turbid and is contaminated. Thus, any dam has neither been planned nor been constructed in this basin. On one hand, the abundant water flowing in the Dakusui-kei river is used for the generation of electricity at the Dakusui power station, and for irrigation in the north area of this plain.

The total number of the structures associated with the Kanan-taishu water channel network is well over

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4,000, which have altered the ruined Kanan-heigen plain into fertile grain field. This condition of the land has sustained still now, so that the Kanan-taishu water channel network are continually providing the people in Taiwan the great fortune,

Figure 13: Riveting work for the iron pipes connecting the Sonnun-kei river with the Kandem-kei river to fill the water in the Uzanto-dam lake.

4. Discussion: Similarities between the Kenroku-en Garden in Japan and the Kanan-taishu Water Channel Network in Taiwan

5.

Let us point out one to one correspondence between the Kenroku-en garden and the Kanan-taishu water channel network firstly. This comparison is summarized in Table 1.

Table 1: Comparison between the Kenroku-en garden and the Kanan-taishu water network.

Kenroku-en garden	Kanan-taishu water network
·Kyoku-sui water channel	·The Sonbun-kei river
·Kasumiga-ike pond	·Uzanto-dam lake
·The oldest water fountain	·Water fountain tower located at the downstream of the Uzanto-dam bank
· Tatsumi-yosui water tunnel	· Water tunnel connecting the Sonbun-kei river and the Kanden-kei river

The Kyoku-sui water channel and the Sonbun-kei river are primary water courses, respectively, so that no dam is permitted to construct crossing them. This is because of the necessary condition for symbiosis dam with nature, where vivid splashing water always flows. The Kasumiga-ike pond and the Uzanto-dam lake are always maintaining water head, to be used in the downstream: The Kasumiga-ike pond feeds the water for the water channel, fountain, falls, or ponds, while the Uzanto-dam lake provides water for the fountain tower, north and south trunk water channel lines, middle and small water channels, and farm fields.

The water tunnel of the Tatsumi-yosui canal is located in the entrance range of about 3km starting from the Higashi-iwa water intake point, where on the right bank of the Sai-gawa river at Kami-tatsumi-machi town, Kanazawa city. Following the exit of this water tunnel, the Tatsumi-yosui canal becomes an open channel for about 7km, and then it flows into a sinuous channel, called the Kyoku-sui water channel in the Kenroku-en garden. As the result, part of the water in the Kyokusui water channel enters into the Kasumiga-ike pond. On the other hand, in case of the water tunnel connecting the Sonbun-kei river with the Kanden-kei river, the water in the former river directly flows into the latter. Thus, there is some discrepancy between the Tatsumi-yosui canal and the water tunnel connecting the Sonbun-kei river with the Kanden-kei river, but the basic idea, in which water tunnel is constructed to compensate the deficit of the water supply.

As being stated in the above, the similarities between the Kenroku-en garden and the Kanan-taishu water channel network are obvious. Moreover, Both of the Kenroku-en garden and the Kanan-taishu water channel network satisfy proposed two conditions associated with symbiosis dam with nature.

Hatta was born in Kanazawa, and lived there until he became at about 20 years old. Especially, for three years between 17 and 20 years old, he was a student of the fourth High School, so it is natural to consider that he must have many opportunities to visit the Kenroku-en garden. Though the reason why he had got an interest in hydraulics is not clear, but it is quite possible that he was attracted by the beauty of the Kyouku-sui water channel in which water flows vividly, together with by the beautiful splashing water flowing in the Tatsumi-yosui canal in Kanazawa city.

Apart from the detailed reasons, Hatta has majored hydraulics in the University of Tokyo, under the supervision by the respectful professor Isamu Hiroi (1862-1928), and it is believed that Hatta have made detailed investigation and learning about the Kyoku-sui water channel in the Kenroku-en garden and the Tatsumi-yosui canal after entering the university.

It is therefore natural to consider that when Hatta was appointed as the director for the construction of the Kanan-taishu water channel network, including the Uzantou-dam lake having the greatest scale in Eastern world, his brain must be filled with the model of water channel network consisting of the Kyoku-sui water channel, the Kasumiga-ike pond, together with the Tatsumi-yosui canal in Kanazawa city.

The senior author has also got a similar experience on the occasion when he has been appointed as one of the members in the expert investigation committee on the Komantsu-Tenmangu shrine and the Kakehashi river(Nakagawa et al 1996, Nakagawa 1988) : That is, knowledge about the water network of the Tatsumi-yosui canal has helped the senior author greatly to seek for an optimum solution regarding to the alleviating the flood from the Kakehashi river and to preserve the Komatsu-Tenmangu shrine harmoniously.

The second hypothesis may be that anonymous designer of the Kenroku-en garden and Hatta have reached at a common concept of the symbiosis dam with nature independently. Similar things have often occurred in the process of new findings of natural science. A typical and well-known example is to derive the basic equation in fluid mechanics, called Navier-Stokes equation, which are believed to be derived by Navier(1827) in France, and Stokes(1945) in England independently. This hypothesis does not contradict to natural consequence in scientific investigation: An idea to utilize the potential energy of the water under keeping the vivid motion of flow results in similar conclusion by the anonymous designer of the Kenroku-en garden to that by Hatta, the director of the Kanan-taishu water channel network.

Conclusion

In this section, new knowledge and insights reached through the present study have been summarized as follows,

1. The Kasumiga-ike pond as well as the Uzanto-dam lake are the model of symbiosis dam with nature or eco-dam.
2. Number of dam within a basin should be limited only to one, and this dam must be constructed crossing the water-course on one of the tributary rivers. This makes it possible that we can maintain the primary river as near-nature river.
3. It is hypothesized that the model of the Kanan-taishu water channel network is the Kyoku-sui water channel and the Tatsumi-yosui canal in Kanazawa city, where the civil engineer, Yoichi Hatta, the director of the Kanan-taishu water channel network, has studied until he became 20 years old, based on the detailed comparison used hydraulic principles and structures relating to hydraulic systems.

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