

# A historical review of aesthetic design of infrastructure and the current main issues in Japan

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**Abstract:** The scale of infrastructure projects is so large in both time and space that the projects determine the basic nature of the regional landscape. Their aesthetic design greatly influences living activities in public spaces and local identities, and they are determined in response to social needs. The purpose of this paper is to review changes in aesthetic design ideas in modern Japan and prospects for the future. The review covers four time periods according to social condition. Consequently, the concepts and systems of infrastructure design in Japan have considerably developed in the 20th century to make the facilities of civilization an expression of culture. Now, at a turning point in society, some new designs are appearing, based on the fruits of previous efforts, and aimed at creating values to meet the current needs in Japan. The author shows the prospect for an infrastructure design idea that is expanded to include promotion and activation, and proposes meanings and values embodied by the project far beyond the treatment of physical forms.

**Key words:** *Infrastructure, Civil Engineering, Aesthetic Design, Social Issues, Japan, Historical Review*

## 1. Introduction

The social mechanism of production changes with the times. The activities of production or construction for a certain purpose are promoted by a social sense of values. Infrastructure projects, usually done as public works, are strongly affected by social conditions. Their visual forms and views of them are determined by social needs rather than by the will of designers. So, we must consider how the aesthetic aspects of infrastructure have been interpreted and valued in each society through history.

In this paper, the author reviews the social trend of infrastructure design in the 20th century in Japan, when enormous modern infrastructure projects were constructed under rapidly changing conditions, and tries to clarify the main issues in contemporary design of infrastructure, hoping the discussion here will give suggestions to Asian countries where constructions of infrastructure is rapidly progressing.

This paper comprises the following: (1) concept review of design, (2) historical overview of infrastructure design projects and the idea of aesthetic design in modern Japan, (3) prospects for infrastructure design ideas under contemporary social needs.

## 2. Concept review for discussing design in the civil engineering field

### 2.1 Characteristics of design in the civil engineering field

There are many fields of design, such as clothing, daily goods, furniture, architecture, graphic, games and so on. It can be said that all artificial things are designed. Their scale is widely spread from a few centimeters to kilometers. The degree of private or public ownership and use also widely varies. Figure 1 shows conceptual mapping of the design field in two axes. The scale of size is almost proportional to the time needed for its creation and in use. Some appear in a few minutes, some in a hundred years. Structures, facilities and spaces treated in the civil engineering field are large, require time, and are public. This nature of the civil engineering field requires some specific concepts of design.

The civil engineering field itself is very wide. It covers various types of infrastructure. Figure 2 shows another conceptual map of items in the civil engineering field, according to their mode of existence and basic theory for design. Structural items, such as towers and bridges, are recognized as shapes, and those designs are based on mechanical rationality. Rivers, roads, banks and parks exist as open spaces, so that human activities and ecological appropriateness are dominant requirements in design. Land forming and reclamation determining the landscape should be discussed regarding the view and land-use sustainability. Thus, design methods for infrastructure are not common, but in this paper, the author investigates the general trend beyond each difference.

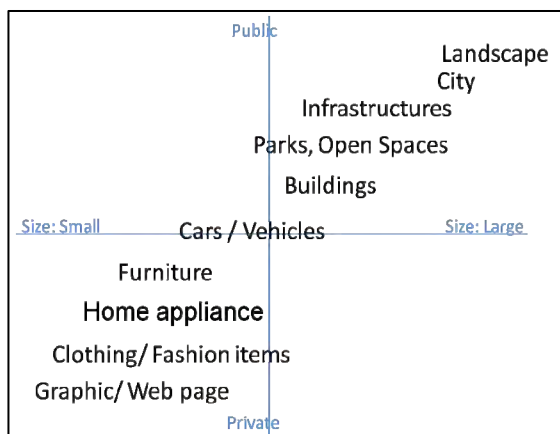


Fig.1 conceptual mapping of the design field

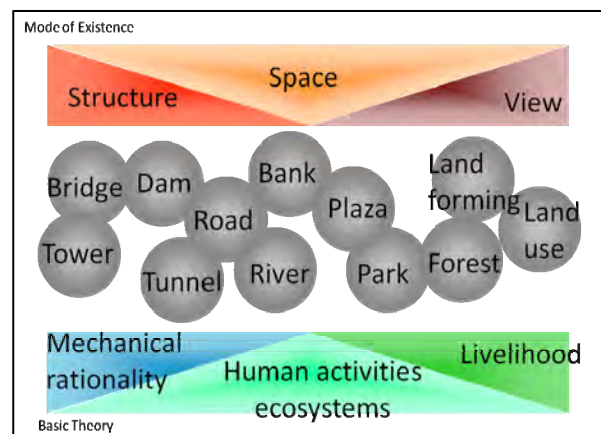


Fig.2 Various Items in Civil Engineering Field

## 2.2 Terms regarding design

The term “design” is not simple. The word comes from the Latin “designare”, whose meaning is “designate”, or “indicate”. In Japanese, the translation of the English word design is “sekkei (設計)”, which means a general action and/or result of composing and arranging something in an orderly way to satisfy functions. But as a loan-word, “design (デザイン)” has a different nuance that emphasizes the aesthetic aspects or visual impression. Sometimes, it is used with a cynical sense to mean superficial or arbitrary. As will be mentioned later, there have been roughly three types of concepts of visual aesthetic design in the civil engineering realm. Those are: literal aesthetics, functional and structural efficiency, and harmony with the landscape. Each has a rather different aspect and interpretation in different times and situations, but the common understanding of the basic idea of infrastructure design can be summarized as follows: form and function are inseparable, so visual design is not just manipulating the outer shape or color; it covers the process of integrating layout, structure and material of an infrastructure.

### 3. Brief history of infrastructure design in 20th century Japan [1, 23]

#### 3.1 From the beginning of modernization to before World War II

Japan had experienced a stable and mature period called the Edo era for three centuries under a national policy of isolation since the 17th century. In this era of population growth, farmlands were expanded and urban castle towns, flood control works, a highway network and ports were developed. The infrastructure works constructed in pre-modern Japan has recently drawn academic and popular attention because of their beauty and ecologically conscious nature (Fig.3).

But modernization started by introducing modern Western technology without any particular succession of this traditional and domestic stock. Construction of railways, large ports, wide streets and river improvements was conducted under foreign engineers at the end of the 19th century. Stone and red brick constructions with Western-style ornaments were the earliest modern infrastructure in Japan. They were regarded as symbols of civilization and Westernization. Japanese engineers rapidly acquired modern technologies and designs. Nihon-bashi, finished in 1911, is a masonry arch bridge designed by a Japanese structural engineer with classic architectural ornaments by an architect (Fig.4). It is a famous example of the collaboration of engineers and architects. The period when modern infrastructure began to be not only functional but also aesthetic is considered to be essential to express to the world that Japan was a modernized and civilized country. In other words, aesthetics was one of the important functions of infrastructure to build a modern and civilized country.



Fig.3 Tujun Bridge constructed in Edo era



Fig.4 Nihon-bashi Bridge (1911)[9]

Recoveries from disasters have been turning points in infrastructure planning and design in Japan. The Kanto Great Earthquake in 1923 and its reconstruction project was the most notable example. Important elements of urban design such as bridges, streets and parks were remarkably developed through this project that rebuilt the capital city of Tokyo. The fruits of this effort can be evaluated from viewpoint of urban design: infrastructure was planned and designed with attention reflecting the character of places, coordination with nearby elements, and improvement of amenities with greenery and water, and respect for history (Fig.5). The bridges across the Sumida River were a great technological challenge and were also carefully designed in detail (Fig.6). These are still in active service and some are designated as important cultural properties. Many short bridges in towns were designed individually, reflecting the site in style and ornaments. Small squares with greenery and street furniture were systematically arranged at the ends of each bridge that created a network of small green spaces in a densely urban area.

Around the 1930's there was an international transition in design of structures, from classic ornamentation to modernism. The discussions on design were very active, especially regarding bridges [26]. Most were based on the concept of “utility, strength and beauty”. An epoch making book was published in 1936 that showed advanced ideas on the integration of structures and landscape. It is “Bridge Aesthetics” by Kato Seihei [13] and it has had a large theoretical influence on infrastructure design since then. The theory was that a bridge should be designed to disappear, emphasize or reconcile with the landscape, according to the situation. These three types of relations of structures and landscape have been the base of discussion of infrastructure design.



Fig.5 Sumida Park along the Sumida River



Fig.6 Eitai-bashi Bridge (1926)

### 3.2 Absence due to war and the rapid post-war economic growth era

As mentioned before, the 1930's were one of the most mature periods in urban and civil engineering design in Japan. But the trend couldn't extend under the wartime regime. War damage and defeat temporarily stopped all projects. The reconstruction plans from the war disaster in more than a hundred cities nationwide were drawn with the ideal of building safe, functional, comfortable and beautiful cities. For example, wide streets with a greenbelt network were arranged sometime with eye-catching landmarks. But almost the all the plans were scaled down in the phase of realization. Another discussion on infrastructure started in the 1950's regarding Japan's needs for a nationwide highway network to develop its economy. The first expressway in Japan, Meishin Kosoku, opened in 1963. A German road engineer was invited to supervise the project and initiated Japanese engineers into road engineering and techniques of integrating large roads into the landscape harmoniously [7]. These techniques, originally used in the Autobahn project in Germany, were applied to the more undulating geography in Japan and developed into road design methods. The techniques of arranging alignment of a road to make a smooth view form, and shaping the cutting of earth and vegetation on slopes were new knowledge for road design. They led directly to research on visual environments in the civil engineering realm.

In the 1960's, during the era of rapid economic growth, a huge amount of infrastructure was built. The metropolitan expressway and the Shinkansen high-speed railway were constructed rapidly to serve the Tokyo Olympic Games in 1963. The viaduct over the Nihon-bashi Bridge in Tokyo (Fig.7), that is often considered symbolic of the issue of urban landscape problems, was built in this period. However, in the early stage of the high economic growth era, heavy cost limitations demanded various innovations so that some excellent designs in the modernist style were produced [25]. The Saikai-bashi Bridge is a good example of an engineering challenge and aesthetic masterpiece located in a beautiful natural landscape (Fig.8). But in the later stage as standardization of design was being established in many aspects, the site specific design characteristics were weakened. In this term, “more”, “cheaper” and “faster” were the most important values in infrastructure construction, as the society

required delivery of modern structures as symbols of economic growth all over the country rather than building of individual structures reflecting site uniqueness.



Fig.7 Metropolitan Expressway over Nihon-bashi



Fig.8 Saikai-bashi Bridge (1955)

### 3.3 Slow-down of economic growth and focus on the region, and postmodernism design in the bubble economy

In the 1970's, Japan twice experienced so-called oil shocks, with a slowing of economic growth, and strong pressure, from developed countries who regarded Japan's rapid economic growth as a menace, for Japan to expand its own domestic demand. These social circumstances prompted a rethinking of the purpose of development as well as of the concepts of infrastructure design. Various citizen actions demanding a higher quality living environment aroused such efforts as the conservation of traditional townscapes, pedestrian oriented spaces, preservation and improvement of green spaces, and establishment of clean and comfortable waterfronts. As a consequence of these activities, a new category of cultural properties, Preservation District for Groups of Traditional Buildings, was added in the Cultural Properties Protection Law in 1975. Some local governments enacted ordinances on landscape and urban design in the 1970's.

Every infrastructure work constructed on Earth has its own individual look, even though the structure itself may be identical to others. In other words, they are site-specific objects. When the society shifted its interest from nation to region, the discussion on infrastructure also turned toward harmony with the region. Since then, in the field of academic study, research on visual aspects of infrastructure and landscape have been developed. The key word in the research was “Keikan (景観)”. Many books related to the issue were published, including design guidelines and manuals [24]. It may be said this is the second active term of design in the civil engineering realm following the 1930's. The fruit of these efforts can be seen in the concept of Civic Design that the Ministry of Construction declared in 1991, defined as “planning and design of beautiful and user-friendly civil engineering structures with respect to regional history, culture and ecology” [4].

The later part the period of increasing social interest in landscapes was at the same time as the “bubble economy”. Decorations on structures that had been in shadow were welcomed, to present local identities despite some extra cost. Decorations on pillars and handrails on bridges, colorful graphic pavements, and drawing some animation characters on a wall at the mouth of tunnels were common examples (Fig.9). They were influenced by the postmodern design trend notable in architecture. In the 1980's, many postmodern style buildings emerged not only in large cities as Tokyo but also in the small local towns and rural areas. Striking design in public works was considered to stimulate the local culture and economy, so local governments encouraged inviting famous



designers and architects. Kumamoto Art Polis project was a typical example. Kumamoto municipality organized a design committee to promote design-oriented public works all over its prefectural area [16]. As the result of an unprecedented design challenge in Japan, works such as Ushibuka-Haiya Bridge by Renzo Piano were realized (Fig.10). But critical opinions were not silent on the projects as whole, as some felt that the structures spoiled the beautiful rural landscape or caused some functional troubles by adopting form that is too focused on expression [18].

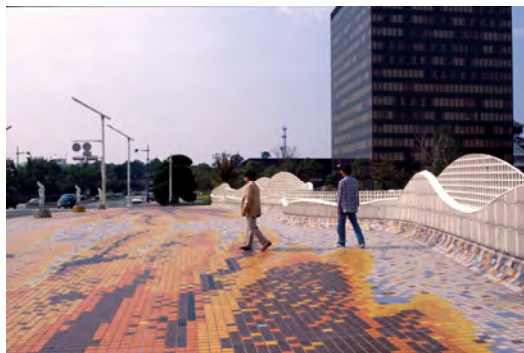


Fig.9 Striking design on bridge surface



Fig.10 Ushibuka-Haiya Bridge (1997)

Taking these opinions into account, discussions on design policy in the civil engineering realm were developed. The research committee of architecture of infrastructure was established in the Japan Society of Civil Engineering (JSCE) in 1996. A series of fundamental books on infrastructure design was published by the committee. The name of the series is “Keikan Sekkei”[10-11] (Fig.11). The term means design with respect for the view and outer forms of structures and spaces. It is sometimes misunderstood as apart from and additional to the functional design, but it spread widely both among professionals and the public. The information on contemporary design abroad represented by the bridges by Santiago Calatrava activated the discussion on infrastructure design. Visual simulations of landscape and structural design became very popular as a development of a technological tool. Interest in early modern structures constructed before the war increased in the period, with high evaluation of their beauty, regionality and ecological design especially along rivers. Decorative or postmodern style structures in projects with ample funds rapidly decreased during the economic depression. But the social need of design quality was regarded as a basic requirement in public works, even with a smaller budget.



Fig.11 Keikan-Sekkei books by JSCE, Design of Streets, Rivers, Ports [10-11]

### 3.4 The policy of “Making a beautiful country” in the 21st century

The period of the 1990's and 2000's in Japan is sometimes called “the lost decades” because of the economy depression, decreasing population, Hanshin-Awaji great earthquake and some social unrest. Criticism of public works projects was so consistent that the budget for it declined 6.7trillion Yen in 2010 from 9.7trillion Yen in 1997 [3]. The interest of citizens was shifted to steady community improvement concerning local environmental issues or the process of citizens' participation.

The Ministry of Land, Infrastructure and Transport announced the policy principle of “Making a beautiful country” in 2004 [17]. It started from reflections on the past way of infrastructure planning and construction, such as, “Are there any problems with their quality amid the large quantitative expansion?” and “Aren't we forgetting that developing infrastructure is the means and not the purpose itself?” Then, the Ministry declared that the national policy would change to making a beautiful country through developing an infrastructure of common assets of the nation. Aesthetics was set as one of the internal objectives. Consequently, the announcement of design guidelines for roads, rivers, beaches and ports were completed one after another, but they are basic, without a distinct difference from the previous discussions [5, 20].

In 2005, the first fundamental and comprehensive law on landscape, “Keikan law”, was enacted. The specific implementation is entrusted to local governments. Almost one third of municipalities in Japan have passed measures based on the law as of 2013 (Fig.12).

A new category of cultural asset, “Cultural Landscape”, was added in the Cultural Properties Protection Law in 2005. It encourages the conservation of disappearing rural landscape amid the changing social system (Fig.13). Another law concerning historical environment conservation “Rekishi Machizukuri Law” enacted in 2008 is aimed at not only historical elements but also the surrounding environment and activities for traditional events. The rising popularity of World Heritage sites makes public opinion support promoting landscape planning and regulations.



Fig.12 Work shop for making regional landscape plan



Fig.13 Tashibuno-sho as the important cultural landscape

As described above, the systems and conditions to improve landscape and infrastructure design have been enhanced at the start of 21st century in Japan. However, it cannot be said notable results are coming in infrastructure or urban design. As it takes much time the fruit of these efforts to be realized, the main reason might be that a consensus has not yet been established on what kind of infrastructure we should design and the alternative systems for public works projects in the current transforming social condition. The great disaster in March 2011 also urged us to reconsider the direction of our future in several aspects. At this turning point of society, there are

various challenging projects that give us suggestions for pursuing the essential values embodied by infrastructure design.

As a summary of this chapter I show the overview of the transition of infrastructure design in 20<sup>th</sup> century Japan in Table 1.

Table 1 The transition of infrastructure design in Japan

Term	Period	Epoch / Social Conditions	Needs for Infrastructure	Design Concept / Trends
From the beginning of modernization to the period before WW2	1890's-1920's	<ul style="list-style-type: none"> <li>Development of the country</li> <li>Starting Modernization by Westernization</li> </ul>	<ul style="list-style-type: none"> <li>Symbol of Civilization and Modernization</li> </ul>	<ul style="list-style-type: none"> <li>Importing from Western style</li> </ul>
	1920s-1930's	<ul style="list-style-type: none"> <li>The Kanto Great Earthquake</li> <li>Developing engineering &amp; industry</li> <li>Urbanization</li> </ul>	<ul style="list-style-type: none"> <li>Rebuild of the capital</li> <li>Durable structures</li> <li>Urban development</li> </ul>	<ul style="list-style-type: none"> <li>Systematic approach</li> <li>Value the identity of place</li> <li>Modernism design</li> <li>Discussions on Aesthetics</li> </ul>
Absence due to war & the rapid post-war economic growth era	1940's-19 50's	<ul style="list-style-type: none"> <li>War damage &amp; defeat</li> <li>Economic distress</li> <li>Natural disaster</li> </ul>	<ul style="list-style-type: none"> <li>Recovery from disaster</li> </ul>	<ul style="list-style-type: none"> <li>Ideal of city planning</li> </ul>
	1960's	<ul style="list-style-type: none"> <li>Rapid economic growth</li> <li>Pollution</li> </ul>	<ul style="list-style-type: none"> <li>Nationwide development</li> <li>Efficiency</li> </ul>	<ul style="list-style-type: none"> <li>"More, Cheaper, Faster"</li> <li>Standard design system</li> <li>Division of profession and works</li> </ul>
Slowdown of economic growth & postmodernism design in bubble economy	1970's	<ul style="list-style-type: none"> <li>Oil shocks/ Slowdown of economic growth</li> <li>Expansion of domestic demand</li> </ul>	<ul style="list-style-type: none"> <li>Environmental consciousness</li> <li>Amenity improvement</li> </ul>	<ul style="list-style-type: none"> <li>Harmony with the region</li> <li>Urban design by local governments</li> <li>'Keikan' improvement</li> </ul>
	1980's	<ul style="list-style-type: none"> <li>Bubble economy</li> <li>Globalization</li> </ul>	<ul style="list-style-type: none"> <li>Differentiation</li> <li>Added values</li> </ul>	<ul style="list-style-type: none"> <li>Cosmetic</li> <li>Postmodern style</li> </ul>
Policy of "Making a beautiful country" in the 21 <sup>st</sup> Century	1990's	<ul style="list-style-type: none"> <li>Low economic growth</li> <li>Aging society</li> <li>Great Earthquake</li> </ul>	<ul style="list-style-type: none"> <li>Community improvement</li> <li>Ecology</li> <li>Recovery from the disaster</li> </ul>	<ul style="list-style-type: none"> <li>Civic design</li> <li>Community participation</li> <li>Long life structures</li> <li>Eco- conscious</li> <li>Low carbon</li> <li>Design for all</li> </ul>
	2000's ~	<ul style="list-style-type: none"> <li>Depopulation</li> <li>Growth depression</li> <li>Great earthquake &amp; tsunami</li> </ul>	<ul style="list-style-type: none"> <li>Beautiful nation</li> <li>Tourism encourage</li> <li>Recovery from the disaster</li> <li>Preparation for the great disaster</li> </ul>	<ul style="list-style-type: none"> <li>Preservation of historical &amp; cultural landscape</li> <li>Community development</li> <li>Maintenance &amp; rehabilitation</li> <li>Re-design</li> </ul>



#### 4. The values embodied by infrastructure design [22]

The design of infrastructure in modern Japanese society has been developed as described in the former chapter. Learning from the process, the concept and idea of infrastructure design can be summarized as making the facilities of civilization an expression of culture. To realize it, the aim of design is to purchase the best forms in the mode of shape, space and landscape. Namely, they are to shape the forms efficiently, based on the function and mechanics, to comfortably serve the activities of users, and to integrate the view of the form into the landscape and reflect the characteristics of the site. The aims have widened to include: not only efficiency in mechanics but also reduced energy consumption and CO2 emission, universal design beyond comfort for normal people, and integration in not only color and view also ecosystem. Technology has been researched and developed to enable design that satisfies these aims.

Standing on these accomplishments in infrastructure design, designers and engineers are now required to step forward to solve such social issues as coping with the ageing society, sustainability of the environment, revitalization of urban centers, rebuilding human connections, attachment of nursing places, and so on. The form itself won't change so dramatically because it is basically determined by the mechanical and natural theory. Some examples and discussion suggest that the approaches and processes below might be important.

##### Design passing a story

Every design has some meaning. There are various ways of expressing it. There used to be many instances expressing local identity directly by adding decoration or drawings on structures in the era of the bubble economy. Expression of local identity is still an important requirement in infrastructure design. But it is not so simple or stable to be expressed visually. Then, episodes or stories people can read and imagine through the structure should be highly valued in the process of design. In each project Rindo-bashi in Nagano and Kasumi-bashi in Yokohama the author was connected with, a truss of a historical bridge was re-used as a part of a new bridge (Fig.12, 13) [21]. The old bridge reminds local residents of the history of the region and the construction process itself is a story. The form of the bridge is quite simple, but the episodes talked about by people create a cultural value and connect residents across the times.



Fig.12 Rindo-bashi bridge (2007)

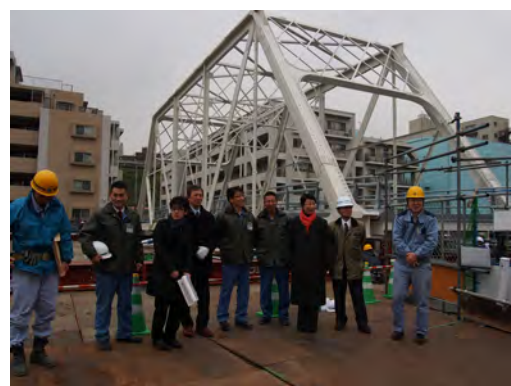


Fig.13 Historical truss reused in new Kasumi-bashi

##### Design to generate events not objects

Infrastructure is constructed to serve some use for people, so that some kinds of activities always happen in and around them. But in general, the activities estimated from a useful and practical point of view are treated as one of

the conditions to determine the form. The design is to find the best form to satisfy the conditions. Meanwhile from the user's point of view, using an infrastructure is an experience that gives some impressions. Then, design can be said to promote the impressions of people using the structure and space. In a design project of a highway tunnel, the designer intended to generate an impression for users traveling across the region [8]. The result of the design might be somewhat different from aiming for visual harmony of the structure in the landscape. The design process to generate events can draw impressive regional recognition.

### **Design to support natural environmental mechanisms**

Environmental consciousness has been a common concept of design. Reducing the impact on the environment is a main consideration in design. Nature-oriented river works have been popular. Re-naturalization is an emerging concept (Fig.14). But a new approach of infrastructure design is required to build a sustainable relationship between human activities and the natural environment. Some instances of beach and river works have realized this by supporting the natural mechanism in circulation of water, materials and living creatures [6]. A natural environment with little artificial intervention has a dynamic but stable self-organizing mechanism that gives people both resources and menaces. In the beach works in Aomori, many stones were thrown into the sand beach to weaken the wave pressure and to improve the biological diversity (Fig.15). The project won the Good Design Award in 2007, evaluated for coexistence of satisfaction of human needs and ecosystems in a natural seascape. These kinds of designs require the local residents to cope with the changing condition of the environment with deep knowledge and community activities.



Fig.14 Re-naturalized pond in Chigonokuchi Park



Fig.15 Stone works in beach in Aomori Ohata

The ideas shown above are still undergoing tentative study, though it may be certain that the idea of infrastructure design is expanding to the promotion, activation and proposal of meanings and values embodied by the project. This goes far beyond the treatment of physical forms.

### **Learning from the experience in Japan**

Finally I would like to discuss on what we can learn as the lessons from the experience of Japan infrastructure design for about a century. First of all, we, Asian countries, had been developed the different civilization and culture from Western countries. Infrastructure is one of the most typical elements of both civilization and culture, however our modernization in the 20th century was driven by importing Western style. As the result, its design reflects on the way of importing and transforming them. Our experience tells us that there are plenty of various

cases according to the social conditions. Sometimes it is essential to copy a model contrasting to the existing environment, in this term, it is said that another time to transform it to harmonize. Nevertheless, if we look far further, it is impossible to escape the influence of our environment from both social and physical. Modern infrastructures had been developed to provide worldwide functions everywhere and their support is to provide us not only a comfortable but a safe life efficiently. Yet, it generates stress on the environment and sometimes on people too.

In our era of valuing sustainability, it is indispensable that we, Asian countries, need to develop the design of infrastructure that contributes to the harmony of the each environment, and doing so, it would also be beneficial for disaster prevention.

Another lesson is that the rapid change of social conditions varies from decade by decade, and sometimes it caused infrastructure design be out of date, and the results are not only provoked the changes in taste but also in functions. Consequently, it is vital to pinpoint out what kinds of design are really durable and long term used. Basically, there are two modes in durable. One is keeping the original form and the other is the possibility of being repaired or re-designed repeatedly. In addition, the speed of social change is going to be gradually higher and higher in Asian countries so that it might be essential that the various approaches and methods acquiring the durability of design.

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