New Stations based on Philosophical Reunion of Diversed Technologies

Toshiyuki Goto

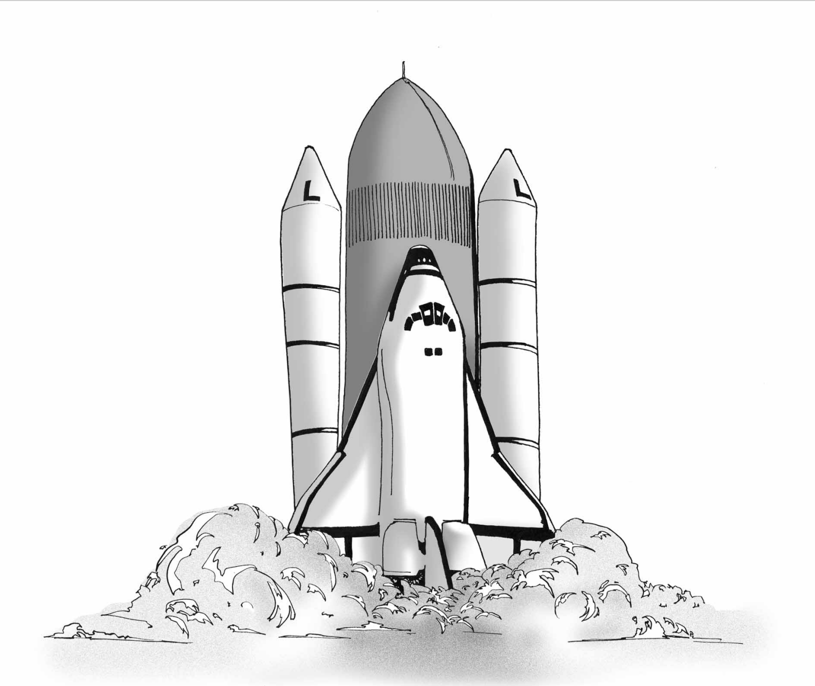
Introduction

I am a registered architect and consulting engineer and have worked for a total of 40 years for Japanese National Railways (JNR), JR Freight and Tekken Corporation on development of railway stations and station areas. In this article, I would like to explain my opinion on the philosophical concept of reunion using railway stations in Japan as examples.

Although science and technology have made many astounding advances in various fields during last century, it is important to question how these achievements were made by the combined technical talents of experts. Despite the competence of individual engineers and designers, etc., many high-technology fields, such as the nuclear and transportation industries have experienced serious accidents, suggesting that something is missing in the integration of design philosophy and technology.

Dr Hideki Yukawa (1907–81), the 1949 Nobel laureate in physics, expressed a similar strong concern about the marked trend towards specialization in science and technology saying, 'It has become difficult for persons in different disciplines to communicate with each other smoothly even though they speak the same tongue. As a result, they increasingly confine themselves within their own disciplines. True, there is a huge store of technical knowledge and technology. But, it is like a bulky book written in hundreds of different languages—each person can understand only a very small part of what is in the book. Even efforts to translate the different languages have not been made in earnest.'

Launching a Space Shuttle for the Future



(Source: Ohmsha)

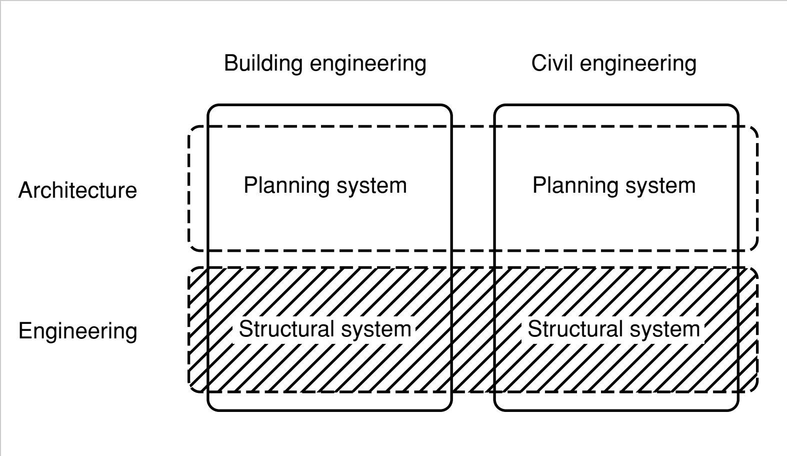
This problem of overspecialization is not a new one; in my day, all students of engineering and architecture were supposed to read the classic treatise, *De architectura* (On Architecture) written by Vitruvius around 25 B.C. Vitruvius writes, 'Architects who have made efforts to acquire skills without paying regard to learning have failed to win authority in proportion to their efforts. On the other hand, those who depend entirely on theory and learning seem to be searching for an illusion rather than an actuality. ... It is best that the architect learn the art of writing, become proficient in drawing, be well versed in geometry, know much of history, listen to as many philosophers as possible, appreciate music, be not ignorant of medicine, understand opinions of lawyers, and have ample knowledge of astrology or the theory of heavens.' Vitruvius used 'architecture' to include civil engineering, mechanical engineering, etc. In other words, he expected every 'architect' to be well rounded in both technology and philosophy.

Situations Unique to Japan

In order to facilitate a wider understanding of my thesis, I want to comment on the parts of Japan's unique situation that have bearing on this article.

First, specialization in science and technology differs from country to country, depending on the educational system, academic societies, administrative organization, national industries and development stage. In Japan, architecture and civil engineering spring from the same foundation. Nevertheless, when it comes to designing and building a structure, the two disciplines have different design standards established by different professional societies. Therefore, many Japanese students aiming to become an

Conceptual Diagram of Building Engineering and Civil Engineering



(Source: Ohmsha)

architect learn structural mechanics as well as architecture. And in order to become a licensed architect they must pass a national examination that tests knowledge in all disciplines related to architecture, including structural engineering, electrical and mechanical equipment, building methods, law, and draughtmanship. Another national examination must be passed to become a consulting engineer. This examination covers as many as 20 disciplines and general engineering was also added this year.

In these respects, the Japanese system is different from America and Europe. Namely, in the United States and most of Europe, architects are recognized as having an independent talent but are well versed in both architecture and civil engineering.

Second, the Japanese archipelago is subject to frequent natural disasters, such as severe earthquakes and typhoons. The temperature range between summer and winter is as much as 40°C. As a result, some building standards in Japan are much severer than those in N. America and Europe. I well remember how I hesitated the first time I entered office buildings and railway stations in New York and Europe—the columns and beams looked so slender by Japanese standards! Consequently, Japanese architects and civil engineers are required to maximize building safety at minimum cost.

Third, the role of railways in transportation in Japan is much greater than in the USA and Europe. Railways and railway stations still play a very important role in the development of Japanese towns, cities and rural communities. Without understanding the importance of railways in Japanese society, it is hard to imagine oneself in a big terminal station serving millions of commuters every day or in a small village railway station that also serves as a hot spa and community centre.

Principles of Philosophical Reunion of Diversed Technologies

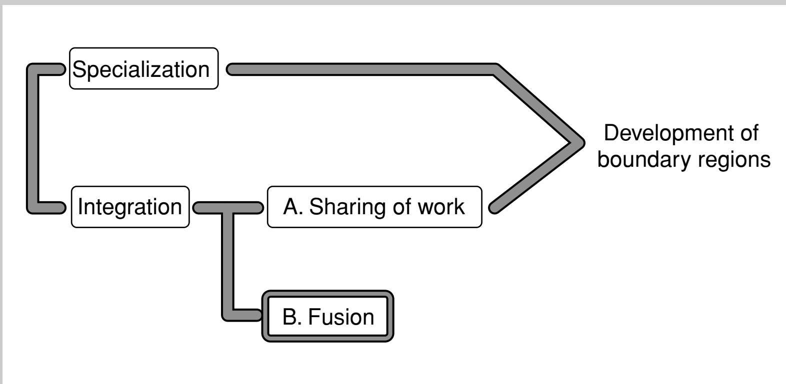
I believe there are two effective ways to reunite science and technology with a broader design philosophy:

- By assigning a specific task to each specialized field and then integrating the results of those tasks (sharing of work and integration of results)
- By reuniting similar technologies and making the most of their advantages to create something new (fusion and synergism of technology)

In most cases, each field of science and technology is a self-contained system that is proud of its achievements supported largely by the pride and diligence of experts in the field.

The first method, which harnesses the power of related fields, does not require great effort to overcome the sectionalism of each field and can be adopted much

Progress of Science and Technology



(Source: Ohmsha)

more easily than the second method. However, if the person assigned to coordinate the specific tasks is a poor manager, discords make it difficult to obtain results.

The second method demands close cooperation between the specialized fields. Since it attempts to reunite established independent systems to attain a common objective, any coordinator will find it difficult to obtain the understanding of experts in each field.

Therefore, the coordinator must ensure that everybody works in close cooperation with a common objective to produce something better than the sum of the individual parts. In this method, both the dispositions of the experts and the coordinator's ability to lead are important.

Each of these two methods should be used appropriately rather like an ensemble of musical instruments.

In implementing the fusion of specialized fields that are closely related, there are basic rules that must be followed.

- Principle of coordination—The coordinator shall clearly visualize the final aim and present the overall image of the project.
- Principle of common recognition—Each person involved in the project shall recognize the common aim that cannot be attained by mere division of labour between existing fields.
- Principle of mutual enlightenment—Experts from different fields shall exchange opinions candidly to promote mutual and deeper understanding.
- Principle of non-monopolization—Each person involved in the project shall realize that credit for success is due to all and not to a particular person(s).

Role of Railways in City Development

Railways played a leading role in the development of modern cities right from the early days of steam in the 19th century and many extant station buildings throughout the world recall these glory days. However, the 20th-century development of road and air transport in N. America and Europe saw railways decline in importance. But railways still play a central role in the life of Japanese towns and cities, although they have undergone some evolution such as elevated lines and stations to permit easier coexistence with road transport. Moreover, major stations today not only perform the central functions of access to and egress from the platforms, but also accommodate various facilities, such as shops, restaurants, hotels, sports centres, housing, offices, nurseries, banks, post offices, and culture centres. Indeed, such multipurpose stations are increasing in number because passengers and local citizens require useful facilities offering different community functions, while railway operators want to increase revenues from non-rail business opportunities

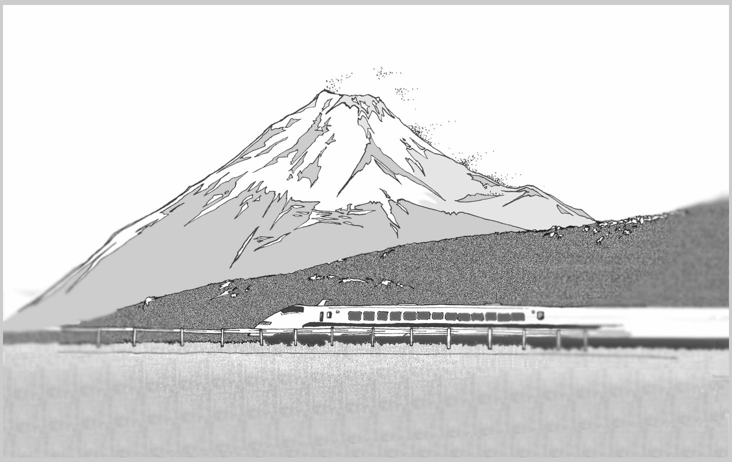
Before the JNR privatization in 1987, private railway companies in Japan were very good at harnessing this multifunctional business aspect of railways although there was no concept of fusion. After the JNR privatization, the new JR companies have been quick to promote diversification of the business functions of railway stations.

Following the JNR privatization, many countries in Europe have privatized their national railways. Unlike the JRs each of which as a clearly defined operations area, many privatized European railways were divided according to function so overall management responsibility is unclear. It will be very interesting to see which privatization method works best!

Elevated shinkansen stations

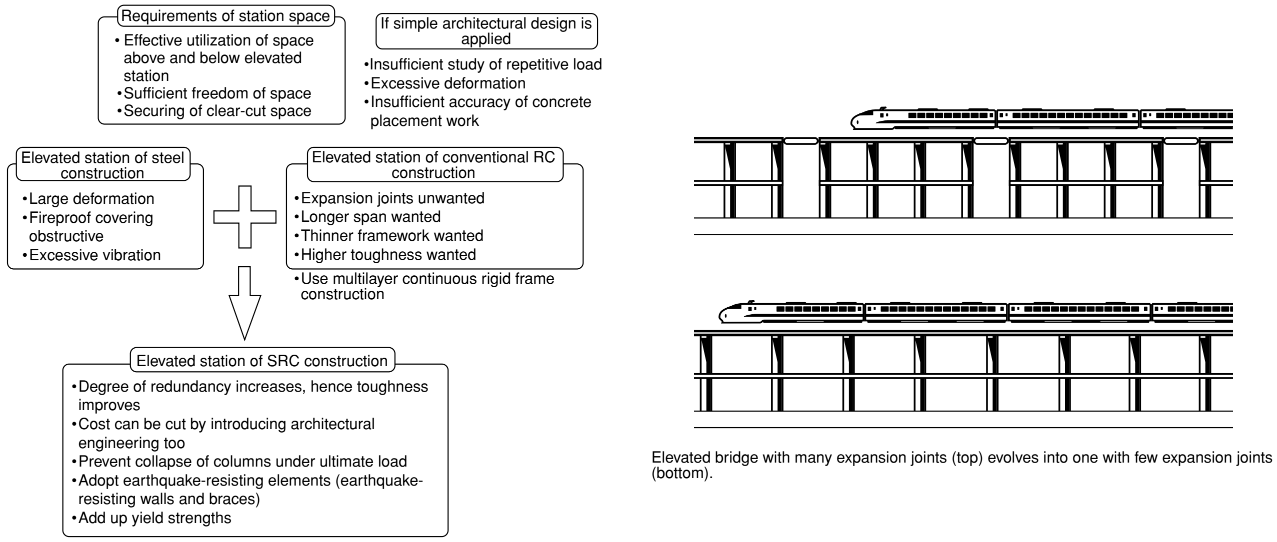
1906 saw the first elevation of Japanese urban railways on brick arches. However, the 1923 Great Kanto Earthquake caused widespread damage to the brick viaducts and reinforced

Japanese Shinkansen—Representative of New Railways Fusing Inter-related Technologies.



(Source: Ohmsha)

Elevated Railway Station Study Flow



Elevated bridge with many expansion joints (top) evolves into one with few expansion joints (bottom).

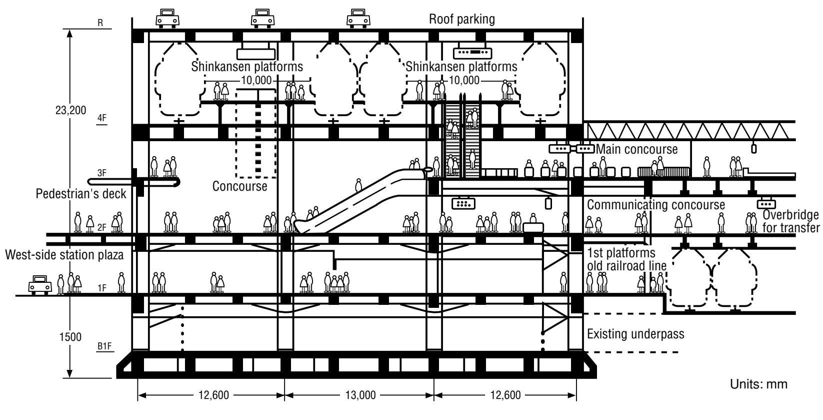
(Source: Ohmsha)

concrete (RC) had come into use for most railway viaducts by 1926, because it had shown high failure resistance during the 1906 San Francisco Earthquake.

In those days, most elevated railway structures were less than 25-m long and had joints to allow for thermal expansion caused the wide seasonal temperature range. The short lengths required columns at narrow intervals and the expansion gaps were prone to rainwater leaks, so it was difficult to design large open stations on viaducts. Rails also required expansion joints at intervals of 10 to 25 m. However, continuous rails were being adopted elsewhere in the world when it was realized that longitudinal thermal expansion/contraction could be handled over several kilometers of rail as long as lateral deformation was restrained. Unfortunately, this principle was not applied to station design because Japanese engineers of the day drew strict demarcations between civil and structural engineering. Fortunately, by the opening of the Tohoku Shinkansen in 1982, JNR's civil and structural engineers worked together on designing Sendai Station, achieving a 150-m long station with 50% wider intervals between columns than any station at that time and no expansion joints.

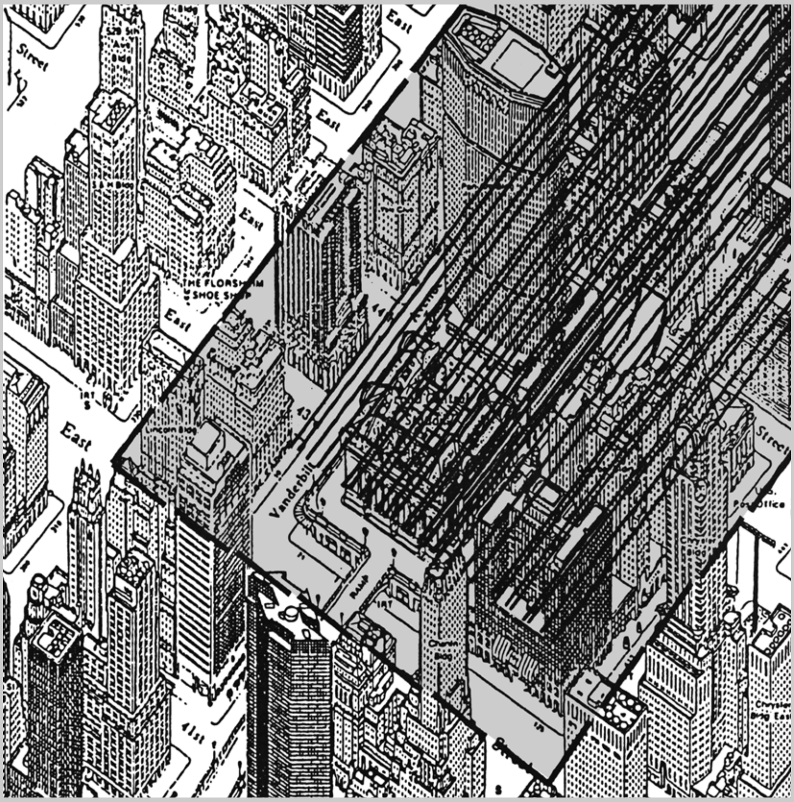
In addition, parking space for cars was provided on the shinkansen platform roof

Cross Section of New Sendai Station



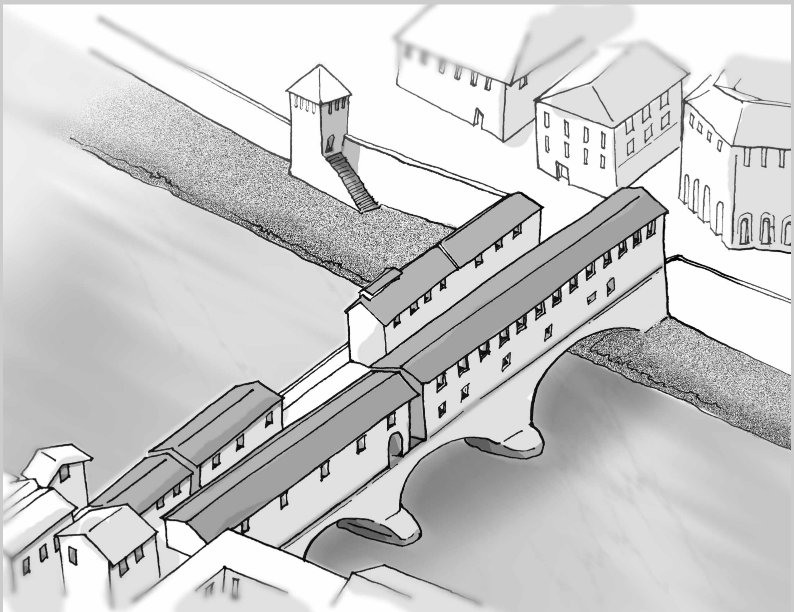
(Source: Ohmsha)

Grand Central Station in New York



(Source: Ohmsha)

Ponte Vecchio in Florence



(Source: Ohmsha)

permitting a happy coexistence between car and railway. In 1978, Sendai Station experienced a M 7.4 earthquake during its construction. While the earthquake caused huge damage to Sendai City, the station demonstrated its strength by remaining almost undamaged. This remarkable achievement is attributable to the synergistic fusion of the rigidity of RC with the toughness of steel. The station design is a good example of success achieved by reuniting highly specialized technologies and it served as a model for subsequent large, elevated railway stations.

Development of Open Space over Railway Tracks

The USA and Europe have many railway stations where the space over the tracks is covered to create new artificial ground. Just looking at Grand Central Station in New York, it is hard to imagine that there are railway tracks and platforms under the building.

Countries where railways stopped expanding relatively early and where there is no danger of earthquakes can make bold attempts to develop space over tracks, but in earthquake-prone Japan, where railways are still being expanded and improved, it difficult to do so on a large scale. Compared to the USA and Europe, in Japan, the scale of development of space over tracks is still small due to the overcrowded train schedule leaving little room for construction work and the limits on construction methods that can be used. And there are still many technical problems to be solved before large-scale development. However, there is strong demand from the public for development of space in stations. To meet this demand, a method for constructing a structure over tracks without installing underground girders (which are always used for ordinary buildings in Japan) is being considered based on an existing bridge construction method. The first idea was to omit underground girders only in one direction but the present study omits them in both directions. A mega-structure with a span up to 60 m is also being studied.

In Japan, river, railway, and road bridges, and buildings are subject to entirely different specifications and rules governing ground area usage. As a result, it is still not possible to design structures combining a bridge and building like the famous Renaissance Ponte Vecchio in Florence.

As a result of administrative reforms in 2000, the Ministry of Transport and Ministry of Construction were integrated as the Ministry of Land, Infrastructure and Transport. This fusion of administrative organizations is expected to facilitate development of space over tracks.

PC Construction

Precast, prestressed concrete (PC) with comparable vibration resistance, fire resistance, durability, etc., to RC has largely replaced RC as a new building material because it can be fabricated in a factory with high-quality control to precise dimensions. These excellent properties make it the material of choice for bridges and buildings with long spans.

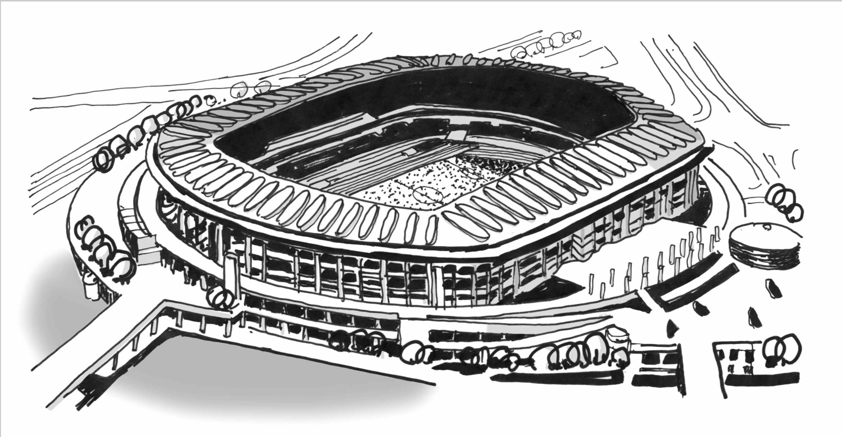
In Japan, PC-based structure is called PS structure in civil engineering and PC structure in building engineering, although the basic principles are the same. PC was chosen as the building material for three JR Freight logistics buildings in Tokyo completed in 1992, because it was more economic than the conventional steel-framed RC structure, which was rising dramatically in price during the bubble economy. Prior to this project, there were concerns about PC structure, especially regarding the strength and restoring force of column and girder joints in an earthquake or fire. It was also uncertain whether the PC structure method, which requires carrying very large heavier-than-steel prefabricated materials onto the construction site, would suit the severe working conditions in station yards. Eventually, the joint strength was confirmed by experiment and the site work progressed without a hitch based on experience from previous civil engineering works.

The total construction cost was very similar to that for a steel-framed RC structure based on the price of steel before the inflated prices of the bubble economy. In addition, the construction period was 20% shorter than that required by the conventional

F Plaza Sumidagawa

(Source: Ohmsha)

International Stadium Yokohama



(Source: Ohmsha)

method. The JR Freight station is a 5-story building with a column span of 12.5 m and a maximum floor height of 9.5 m. It is Japan's first all-PC building.

Since this first all-PC construction, the same method has been used for a number of JR Freight regional distribution centres. The design strength was finally put to the ultimate test when the 1995 Great Kobe Earthquake struck. Happily, it passed with flying colours.

International Stadium Yokohama (completed in 1998) was constructed using an improved PC method. There are no expansion joints in the entire circumference of the stadium (approximately 500 m), which has a design life of 100 years.

Many modern buildings in the USA and Europe use PC-based construction and its advantages are particularly clear in earthquake-free regions. As an example, the clear-cut form and dynamism of the Lyon Airport Station remains strongly impressed on my memory.

Using Subterranean Space

In the 1970s, I was involved in construction of JNR's underground Tokyo Station on the Marunouchi side, adapting a disaster-prevention system for a high-rise buildings to underground. I soon discovered that underground urban Japan is so crowded with subways, underpasses, sewers, water pipes, gas pipes, electric cables, underground rivers, etc., that there is very little room for construction of new infrastructure.

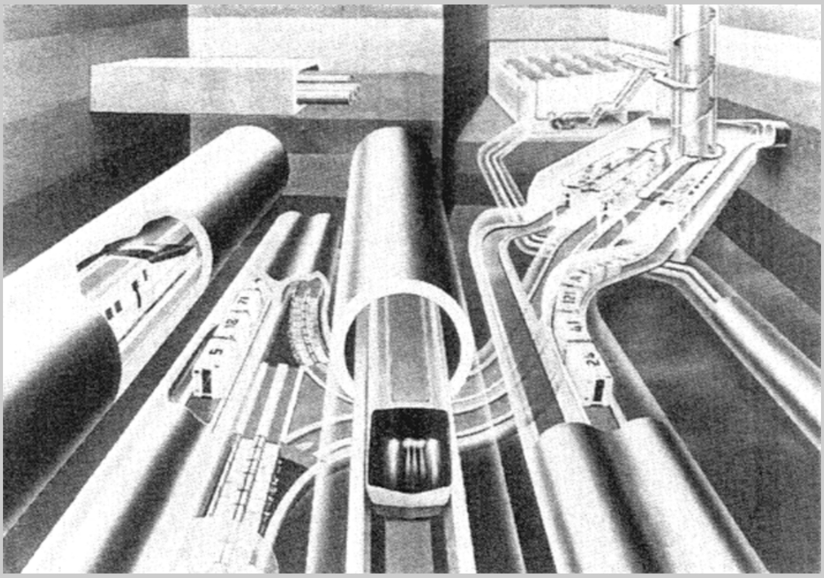
In Japan, land rights extend both above and below ground level, meaning that underground development can violate land rights and may necessitate lengthy negotiations with the land owner and compensation payments. As a result, most underground infrastructure is constructed under public land.

In an attempt to make more subterranean space available for public development, the Japanese government tried to pass a new law in 1999 limiting land ownership rights down to –50 m. However, the law was not passed.

If subterranean space could be developed by the 'fusion' of civil engineering, building engineering, electrical and mechanical engineering, human psychology, etc., underground cities where people live, work and play could become reality.

I am sure that countries with experience in construction of underground military installations and nuclear shelters are far ahead of Japan in these technologies.

Development of Deep Subterranean



(Source: Tekken Corporation)

New Railway Stations Based on New Concepts

In the latter part of this article, I want to introduce the latest examples of stations built by the JR's young talented engineers and architects, which share the same philosophy I have explained above, although I was not involved in the projects. It seems to me that one largely ignored effect of the JNR privatization has been a renaissance of railway stations and I am convinced that this is the result of the nature of the relationship between the new companies in the JR Group—a nature that promotes fusion of creativity and technologies.

Kyoto Station

As mentioned in the other article by Ms Corinne Tiry, Kyoto Station is the gateway to Kyoto, an ancient capital of Japan and a popular tourist spot. The design of the new station commemorate the city's 1200th anniversary was a Brunel Award. Construction was completed in 1997, exactly 10 years after the establishment of JR West.

The huge building is a symbol of Kyoto in the 21st century and is so magnificent that the name 'station building' does not do it justice. In Japan, many towns originally formed around a castle or temple, but the new Kyoto Station could be called a 'town

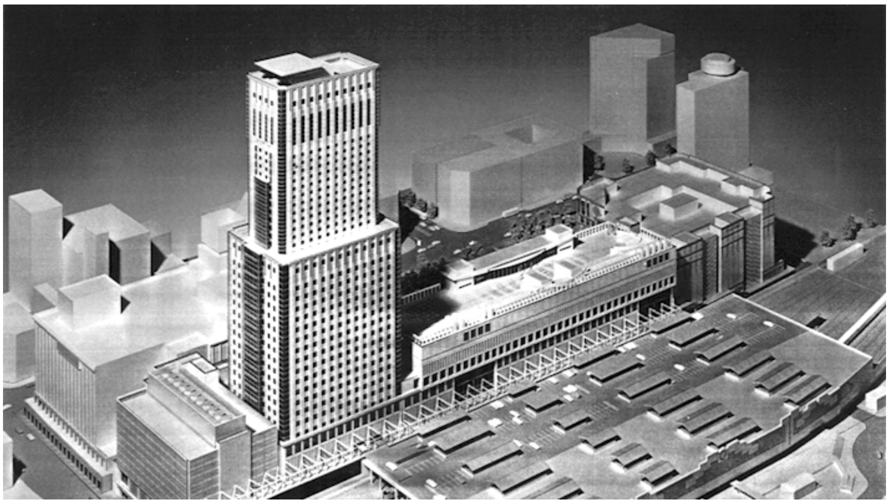
Kyoto Station. This new station building could be called a ' town at the station.' (The Association of Railway Architects)

at the station.' The huge concourse is like a self-contained town with department stores, hotels, restaurants, shops, etc., all in harmony—it gives the impression of a solid city.
In carrying out the project, the fusion of railway technologies for building a structure over the subway, constructing a large area of artificial ground over the tracks, etc., played a vital role.

Nagoya Station

Nagoya's new station opened in 1999 and the twin Central Towers rising to 245 m with a total floor area of 410,000 m^2 certainly have achieved the 'standing city' feeling planned by JR Central from the outset.
Each high tower has offices and hotels, and the lower middle tower houses department stores, restaurants, etc.
The new Nagoya Station seems like Gulliver towering over the lilliputian earlier surrounding buildings. In several respects, the new Nagoya Station is similar to the new Kyoto Station. For example, they both span a subway. On the other hand, the new Nagoya Station represents a high degree of integration of technologies for constructing high-rise buildings. The Central Towers lifting to the sky seems to boast the strength of the futuristic railway and railway station.
I had a similar feeling when I saw the Toronto Tower in Canada and Grand Central Station in New York. To me, the new Nagoya Station is just as impressive.

Nagoya Station's twin Central Towers with offices, hotels, and shopping centres create the impression of a 'standing city'. (The Association of Railway Architects)



Architectual model of the south side of Sapporo Station to be opened in 2003
(The Association of Railway Architects)

Yamagata Shinkansen terminus at Shinjo Station (The Association of Railway Architects)

Saitama Shintoshin Station, in the midst of new office buildings and community centre
(The Association of Railway Architects)

South entrance to Sapporo Station

This comprehensive regional development project started in 2000 and is scheduled for completion in 2003. It is being executed jointly by JR Hokkaido and a private developer who acquired the former JNR site.
The areas around Sapporo Station are also undergoing a dramatic change.
The plans call for facilities that are similar to those at the new Kyoto and Nagoya stations, although the background city of Sapporo is very different in its local characteristics. I am looking forward to seeing the final result.

Shinjo Station

This is the terminal station on the Yamagata Shinkansen that was opened in 1999. The Yamagata Shinkansen operates through trains between Tokyo and Shinjo City in the snowy Tohoku area. As a shinkansen terminus, the new station is not used by so many shinkansen passengers, but as a new central spot in Shinjo City, it attracts much attention from the local community. The large, well-designed building incorporates a town hall and a very spacious parking lot enables an easy change of transport mode to and from shinkansen trains. Few railway stations in Japan can boast such good parking. The overall picture of the station is so magnificent that it reminds me of large airport terminals in the USA and Europe.

Saitama

A project to create a new, large town in central Saitama Prefecture about 30 km north of Tokyo Station on the site of a former JNR freight yard is entering its final phase.
JR East's new Saitama Shintoshin Station (opened 2000) is built at the heart of the site and is designed to blend with the surrounding new office buildings and community centre.

Conclusion

Many of the new railway stations designed and built by the JR group of companies are full of new inspiration, but I would like to conclude this article by mentioning three of the current problems in designing of railway stations.

- Strict cost consciousness
  The JRs' successes over the last 13 or so years are attributable to strict cost-conscious management of their railway businesses. As a result, railway station designers and engineers must bear in mind the need to watch costs carefully. It is impossible for railway engineers to only chase their ideals. After all, there are no railway companies that can invest more money in a particular project than the expected return on investment. Besides, each railway company must always be aware of its responsibility to ensure the safety—the most important theme for every railway company.
- Barrier-free design
  Japan is an aging society and the day is coming when a large proportion of railway passengers will be disabled in one way or another. Hence, a barrier-free railway is in the interest of everyone. But technology is not the only solution. In 1970s, I was engaged in the planning and implementation of advanced barrier-free measures. In those days, I also studied measures which had been taken in the United States and Europe. I realized that they measures must be supported by kindness of thought and consideration for everyone. In this context, we require a fusion of technology and mind.
- Environment-friendliness
  We cannot afford to waste valuable natural resources and pollute the earth, or our children will pay a high price for our stupidity.
  Although trains are generally seen as being more environment friendly than cars, railways must still adopt a new attitude towards environmental friendliness. The new JRs have taken a number of steps in this regard. On the engineering side, JR East is operating new trains that consume 50% less energy than the older models.
  At railway stations, the huge volumes of waste are sorted for recycling. For example, a new technology has been developed to separate old railway tickets into iron powder and paper fibres. More than 70% of worn out rails, wiring, sleepers, concrete blocks, etc., are being recycled.
  JR East's environmental efforts have been recognized for eco-funding by the UBS Switzerland.
  My hope for the future is that fusion of new technologies and ideas will produce new results in every field of railway management and engineering. ■

JR East's Series E 231 energy-saving train on the Tohoku main line (JR East)

Acknowledgement

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